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Frontier Observatory for Research in Geothermal Energy: Phase 1 Topical Report West Flank of Coso, CA

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1. OVERVIEW OF PHASE 1 ACTIVITIES

The Department of Energy (DOE) Frontier Observatory for Research in Geothermal Energy (FORGE) is to be a dedicated site where the subsurface scientific and engineering community can develop, test, and improve technologies and techniques for the creation of cost-effective and sustainable enhanced geothermal systems (EGS) in a controlled, ideal environment. The establishment of FORGE will facilitate development of an understanding of the key mechanisms controlling a successful EGS. Execution of FORGE is occurring in three phases with five distinct sub-phases (1, 2A, 2B, 2C, and 3). This report focuses on Phase 1 activities.

During Phase 1, critical technical and logistical tasks necessary to demonstrate the viability of the West Flank FORGE Project site were completed and the commitment and capability of the West Flank FORGE team to execute FORGE was demonstrated. As part of Phase 1, the West Flank FORGE Team provided an assessment of available relevant data and integrated these geologic and geophysical data to develop a conceptual 3-D geologic model of the proposed test location. Additionally, the team prepared relevant operational plans for full FORGE implementation, provided relevant site data to the science and engineering community, engaged in outreach and communications with interested stakeholders, and performed a review of the environmental and permitting activities needed to allow FORGE to progress through Phase 3. The results of these activities are provided as Appendices to this report.

The West Flank FORGE Team is diverse, with deep roots in geothermal science and engineering. The institutions and key personnel that comprise the West Flank FORGE Team provide a breadth of geoscience and geoengineering capabilities, a strong and productive history in geothermal research and applications, and the capability and experience to manage projects with the complexity anticipated for FORGE. West Flank FORGE Team members include the U.S. Navy, Coso Operating Company, Sandia National Laboratories (SNL), Lawrence Berkeley National Laboratory (LBNL), the United States Geological Survey (USGS), the University of Nevada, Reno (UNR), GeothermEx/Schlumberger (GeothermEx), and Itasca Consulting Group (Itasca). The site owners (through direct land management or via applicable permits)—the U.S. Navy and Coso Operating Company—are deeply committed to expanding the development of geothermal resources and are fully supportive of FORGE operations taking place on their lands.

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2. RESULTS

2.1. Geologic Model

The proposed West Flank FORGE project site is within the <1.0 Ma Coso Volcanic Field (CVF) in eastern California. It occupies about 1,100 acres of the North Ranges of the Naval Air Weapons Station (NAWS) China Lake. Located entirely within the fence line of a Navy research and development facility, the West Flank site is adjacent the Coso geothermal field. COC maintains this 24x7 geothermal operation with highly skilled maintenance and operations crews. COC has a skilled workforce with the hardware and infrastructure to service and support circumstances that might arise during the course of this project. The proximity of COC to the West Flank FORGE site is a valuable asset contributing to the success of the proposed FORGE project. The main COC facilities are less than 4 km to the east of the eastern margin of the West Flank. COC's other office facilities are 11 km to the west outside of the NAWS China Lake gate along the access road. Even with temporary trailers, phones, and Internet connectivity established over the course of FORGE work, COC office facilities can be made available for project support. We anticipate that workers may stay at one of the many motels or hotels in Ridgecrest, about 56 kilometers to the south. Ridgecrest is a town of 25,000 people with full amenities that can support FORGE workers. NAWS China Lake main facilities are at the northeast side of Ridgecrest. Between the base facilities and the town of Ridgecrest, ample facilities exist to house and support any size of FORGE team needed to conduct work over the life of the project.

The West Flank FORGE site lies within the volcanically and tectonically active Coso Range at the boundary between the Sierra Nevada (Sierran) microplate and the Basin and Range. The Sierran block moves 13 mm/year to the northwest with respect to stable North America. Its motion is accommodated by strike-slip and normal faulting in the Walker Lane belt, a ~100 km wide zone of active deformation that terminates to the west along the Sierra Nevada. This region is referred to locally as the Eastern California Shear Zone. The West Flank FORGE site consists of thin Quaternary sedimentary cover, Pleistocene and younger rhyolite domes, minor basalt flows, associated volcaniclastic and epiclastic rocks of the CVF, and Mesozoic plutonic basement rocks. The Mesozoic basement rocks are predominantly granitic to dioritic.

Multiple preexisting data sets were reviewed to characterize the stratigraphic and structural setting of the area and develop a 3D conceptual geologic model. The geologic data for the West Flank area includes, but is not limited to, cuttings, core, mudlogs, thin sections, geophysical downhole logs, surface geophysics, geologic mapping, microseismicity, downhole temperature data, and downhole pressure data. These data came from the archives of Coso Operating Company and the Navy Geothermal Program Office (GPO) and, where appropriate, were re-interpreted for the West Flank FORGE project before being incorporated into the conceptual geologic model. Details regarding the data, interpretations and the geologic model are provided in Appendix A.

Approximately ~15,000 m of core, cuttings, and mud logs from eight wells were analyzed and re-interpreted. Three of these wells were drilled within the proposed FORGE site and one, 83-11, is still accessible and an important testing and monitoring asset for the West Flank FORGE project. Well temperature data provide direct evidence that the West Flank FORGE site has temperatures within the specified 175 to 225°C range at the target depths required for FORGE. Well-test data provide direct evidence for low permeability conditions at the West Flank FORGE site. An analysis of cuttings, core and thin sections from the deep wells in the West Flank FORGE site demonstrates that the basement is composed of Mesozoic plutonic rocks and minor volumes of Quaternary dikes. The 83-11 static temperature profile illustrates a conductive heat flow pattern. Well tests on 83-11 indicate that it is non-commercial with very low permeability. Subsequent pressure monitoring data comparing 83-11 downhole pressure over time with other wells in the active hydrothermal field to the east indicate that a pressure connection between 83-11 and the hydrothermal field to the east does not exist. The data reviewed and analyzed during Phase 1 were incorporated into a 3D conceptual geologic model that is representative of the West Flank FORGE site; the model is illustrated in Figure 1. In the 3D conceptual geologic model, it is demonstrated that there is a significant volume of crystalline rock at depths of 1.5 to 2.5 km in the 175 to 225°C temperature range.

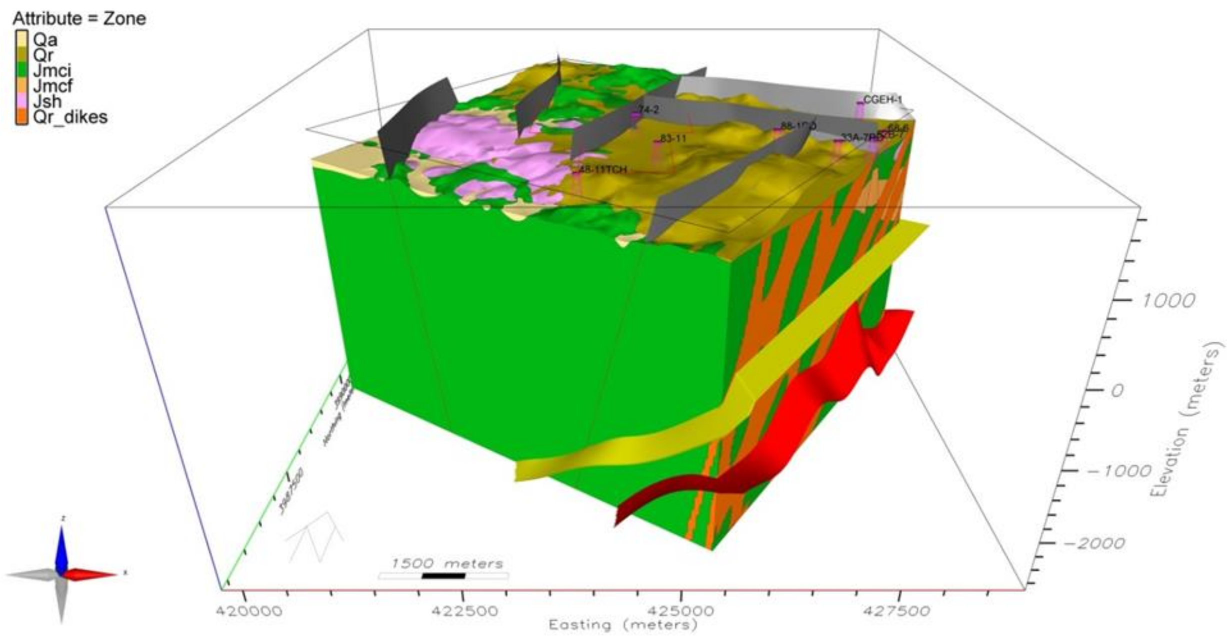

Figure 1. Oblique north- looking view of the West Flank 3D geologic model. The 175°C isotherm surface is yellow and truncated at 1.5 km beneath the ground surface and the 225°C isotherm surface is red.

The geologic, structural and thermal character of the West Flank site and the surrounding area are broadly understood based on all the preexisting data sets utilized in Phase 1 of FORGE work. Geologic maps, well cuttings, core, and petrographic analyses, well temperature data, geophysical data and well testing data were all used to create conceptual cross-sections and a conceptual 3D geologic model of the West Flank FORGE site. The relative uncertainty in the 3D geologic interpretations was calculated based on relative distance from the input datasets. The primary input datasets utilized for constraining the subsurface 3D geologic geometry are the geologic cross-sections, geologic maps, lithologic logs along well paths, and seismic reflection profiles.

In summary, while additional data will further refine the model, the West Flank site is an ideal location for FORGE. Key FORGE criteria are met at the West Flank location, specifically requisite temperatures (175-225°C) between the required depths (1.5-4 km) in competent crystalline lithologies with low permeability in a favorable stress regime and no evidence of an active hydrothermal system. The data demonstrate that the West Flank would be an outstanding location to site this important research laboratory.

2.2. NEPA

The proposed West Flank FORGE project area is within the Coso Known Geothermal Area (KGRA) located in the West Flank portion of the Coso geothermal developed field on Naval Air Weapons Station (NAWS) China Lake. The West Flank site includes portions of sections 1, 11 and 14 of Coso Operating Company's two active BLM geothermal leases which are in a "Held by Production" status, CA-11384 and CA-11385. The remainder of the West Flank project includes expired BLM leases, CA-12936 and CA-11403, which are now categorized as "BLM withdrawn lands." The Coso KGRA was subject to intense environmental and cultural investigations in order to meet National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) NEPA/CEQA requirements so that geothermal exploration could proceed. The Navy Geothermal Program Office (GPO) is surface manager for FORGE designated lands within the NAWS China Lake boundaries. Environmental protection on this land is governed by numerous documents completed before and after the Coso geothermal field production commenced in 1987.

While management of the 1.2 million acres of land at NAWS China Lake is the responsibility of the Commanding Officer (CO), the Coso development contract serves as a "revocable permit" offered by the government acting through the Secretary of the Navy for the developer to operate Coso. It further stipulates that the developer (Coso Operating Company) is responsible for all environmental and cultural resource protection. The contract also assigned GPO as the managers of all Coso activities in support of the base CO's responsibilities. Consequently, the GPO has and will continue to work closely with the CO and many of his other supporting programs including the Environmental Management Division (EMD), Real Estate (RE), Asset Management (AM), and Naval Air Weapons Center Weapons Division (NAWCWD), the primary tenant command at China Lake responsible for the base weapons mission, in its oversight of the Coso geothermal field and the adjacent West Flank FORGE project.

All FORGE activities within the West Flank will conform to the natural resources conservation and management policies and practices established for the geothermal field in the 1970s and further reinforced in the 2015 NAWS China Lake Legislative Environmental Impact Statement (LEIS) for Renewal of Naval Air Weapons Station China Lake Public Land Withdrawal.

As noted above two designations of land exist within the proposed West Flank site, two active BLM leases and two former leases, now BLM withdrawn land. Under a memorandum of understanding between the Navy and BLM, surface management responsibilities of these withdrawn lands belongs to the Navy. Most proposed FORGE work requiring permits (e.g., drilling) on the BLM withdrawn land would be approved by the Navy with BLM concurrence. If air permits are required, these would be issued through the Great Basin Unified Air Pollution Control District (GBUAPCD).

Specific tasks (e.g., drilling) would be initiated through the GPO office via Geothermal Sundry Notice (GSN) at the local base level. An approved sundry notice serves as a permit to proceed. Any work proposed on the BLM leases would be conducted by COC (a West Flank FORGE team member) or a FORGE contractor and authorized via GSN, pursuant to the Navy-COC development contract (N68711-05-C-0001). All cultural and environment work required to support proposed work would be conducted by a contractor and reviewed by the Navy. Supporting NEPA documentation, plans and drawings are included in the GSN submittal for technical and environmental approval by the GPO and NAWS China Lake environmental office, EMD. Once the GSN has been approved and signed by GPO, work can proceed.

The Navy GPO is pursuing a Real Estate agreement through the Navy Region, San Diego. This agreement will establish a time period and a framework through which FORGE activities can take place on Navy-managed ground. This agreement will be between the Navy and a responsible party representing the FORGE work (e.g., Sandia National Laboratory or the Department of Energy). The Navy will seek concurrence on this agreement with either the local BLM office or the State office in Sacramento. This agreement is anticipated to be executed in Phase 2A. An Environmental Information Synopsis is provided in Appendix C.

2.3. Plan Development

Associated with Phase 1 activities, six separate planning documents were prepared. These include the West Flank FORGE:

- Data Dissemination and Intellectual Property Plan
- Communications and Outreach Plan
- Sample and Core Curation Plan
- Preliminary Induced Seismicity Mitigation (PISM)Plan
- Environmental Safety and Health (ES&H) Plan
- Research and Development Implementation Plan

Each of these plans, inventories of data used in the development of the geologic model, data uploaded to the GDR, and permitting data are provided as appendices. Additionally, an update to the team's stakeholder engagement is included as Appendix H.

During Phase 1, the West Flank FORGE team developed its plans through careful thought and extensive discussion. The process of disseminating FORGE data in a manner that ensures data integrity and distribution to the community in a timely manner requires careful consideration, as addressed in the Data Dissemination Plan. The importance of communication and outreach to stakeholders cannot be underestimated and as the Communications and Outreach plan shows, there is a broad community that must be engaged as FORGE moves forward. The Sample and Core Curation Plan was developed on the shoulders of giants, with the processes used at the San Andreas Fault Observatory at Depth (SAFOD) serving as model for the collection, preservation, and distribution of physical samples obtained at FORGE. While a final Induced Seismicity Mitigation Plan (ISMP) will be developed in Phase 2, the information gathered to date and described in the Preliminary ISMP indicates a very low risk of any significant impact related to induced seismicity that would occur during operations at the West Flank FORGE site. Safety of the worker and the environment is paramount in the execution of FORGE. DOE requires that all work performed by the Department and its contractors follow a broad set of requirements for

Integrated Safety Management (ISM). The ES&H plan described in Appendix K complies with this DOE requirement and is structured to design or engineer safety of the worker and the environment into the execution of FORGE. The vision for FORGE is a dedicated Enhanced Geothermal Systems (EGS) field laboratory and a complementary R&D program that focuses on the science and technology necessary to bring the EGS concept to fruition and ultimately lead to commercialization. The Research and Development plan, provided in Appendix L, describes our team's plan and vision for FORGE, the structure under which site activities will be conducted, the process for issuing and managing R&D solicitations, interactions with DOE and the Science and Technology Analysis Team (STAT), and dealing with conflicts of interest.

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3. LESSONS LEARNED

During Phase 1, at least two significant lessons were learned by members of the team. The first being the importance of communication, both between team members and with interested stakeholders, which is critically important to project success. Of particular note with respect to stakeholder interaction is the need to explain stimulation activities that are integral to the development of EGS. More than any time in the past, the issue of "fracking" (the spelling reflects that of the press) is now on the broader public's radar. Making the distinction between oil & gas stimulation activities and those planned at FORGE is vital to public acceptance of FORGE. Our interactions with local stakeholders have been quite positive; however, the West Flank FORGE team knows it must remain vigilant and engaged to maintain excellent relations with the community.

The second lesson learned is that achieving the goals of FORGE will not come cheap. Working in the subsurface is neither easy nor inexpensive. Within a constrained budget, the selection of drillhole locations, construction methods, and number of holes (i.e., production, injection, monitoring, and test holes) must be carefully considered. Drilling will be the second largest expenditure (after competitive R&D solicitations) during FORGE operations. A robust geologic model becomes even more important as it will constrain targeting of wells intended for stimulation. Further, the resource depth will have a significant impact on drilling cost and, therefore, on what FORGE can accomplish with fixed annual budgets. Additionally, because of real-world budgetary constraints it is imperative to identify and focus on the most relevant variables specific to understanding and implementing EGS development and breaking down existing barriers to development—that will be a major charge for the Science and Technology Analysis Team.

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4. CONCLUSION

The vision for FORGE is a dedicated EGS field laboratory and a complementary R&D program that focuses on the science and technology necessary to bring the EGS concept to fruition and ultimately lead to commercialization. This vison has driven the planning associated with Phase 2 and Phase 3 of the West Flank FORGE team.

During Phase 2A, 2B, and 2C, the West Flank FORGE site will be instrumented and readied to test new technologies and techniques in Phase 3. In Phase 2A, an Environmental Information Volume will be completed while a schedule to complete the NEPA process and obtain required permits will be completed. Additionally, preliminary telemetered seismic monitoring of the site will be deployed to complement existing seismic monitoring activities at the West Flank FORGE site. During Phase 2B all reviews, permits, and approvals initiated in Phase 2A will be obtained in accordance with NEPA and other local and state regulations. It is anticipated that these permits will be obtained early in Phase 2B and additional site characterization allowed by NEPA and applicable permits to begin. Phase 2B will also include the completion of the Induced Seismicity Mitigation Plan that will incorporate recorded site MEQ data and associated analyses into a Probabilistic Seismic Hazard Analysis, Criteria for Damage and Vibration, and Mitigation Actions for field testing. In 2C the site is brought to readiness for FORGE implementation through, at a minimum, additional surface and subsurface site characterization, deployment of high resolution seismic monitoring, geologic model refinement, and reservoir modeling. Additionally, a Science and Technology Analysis Team (STAT) will be assembled to provide technical guidance to the FORGE team and to ensure DOE objectives are incorporated in FORGE execution. As a result of working with the STAT to assess current technology, establish technical baseline information and performance metrics for FORGE work, and review the FORGE implementation plan, topics for the first round of competitive solicitations will be developed and a draft solicitation produced. Where applicable and appropriate, DOE may elect to have the West Flank FORGE team incorporate testing of methods and tools developed by separately funded DOE researchers into FORGE activities.

Upon entering Phase 3 of the project, the West Flank FORGE site will move toward full implementation, and at least two full-diameter wells will be constructed at appropriate sites, incorporating directional and extended-reach drilling techniques as needed to best take advantage of local geological conditions (e.g., rock types, geologic structures, and in-situ stress state) determined in earlier phases. After baseline testing of each well, the subject rock mass will be stimulated to create an operating reservoir, and testing will be performed to characterize reservoir extent, hydraulic characteristics, and heat-exchange performance. Based on results of these analyses, additional stimulations will then be designed, executed, and characterized as needed. Alternative and experimental stimulation techniques will be employed as available. The project will endeavor to create the most efficient and sustainable EGS to date that can serve as a prototype for EGS development elsewhere. Alongside these EGS development efforts, R&D directed toward EGS development and subsurface science and engineering will be supported through an expansive and competitive R&D program open to the broader scientific and engineering community. To the extent practicable, existing wells at the West Flank FORGE site will be used to support these R&D efforts and additional fit-for-purpose wells will be constructed as R&D requirements evolve.

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APPENDIX A. CONCEPTUAL GEOLOGIC MODEL

CONCEPTUAL GEOLOGIC MODEL

West Flank, CA

CONTENTS

CONCEPTUAL GEOLOGIC MODEL

West Flank of Coso, CA

1 EXECUTIVE SUMMARY

The objective of the Department of Energy (DOE) Frontier Observatory for Research in Geothermal Energy (FORGE) project is to establish and manage a dedicated site where the scientific and engineering community can successfully develop, test, and improve new technologies for Enhanced Geothermal Systems (EGS) in an optimal environment with respect to target reservoir temperature, depth, lithology and permeability. The West Flank site was awarded Phase 1 of DOE FORGE. Throughout Phase 1 the technical team has compiled and interpreted large amounts of preexisting data to create a 3D conceptual geologic model of the proposed site.

Data used to build the West Flank Conceptual Model demonstrates that all site criteria established by DOE for the FORGE project are present in the West Flank. Temperature data from a well drilled in the West Flank site (83-11) provides direct evidence that required temperatures (175-225˚C) within the preferred depth window of 1.5-4.0 km are present. Core, cuttings and thin sections from the 83-11 and two other wells in the West Flank coupled with detailed basement mapping indicates that the basement in and around the West Flank is primarily an assemblage of Jurassic and Cretaceous plutons. Well testing of the 83-11 indicates that it is completed in hot but non-commercial, low permeability host rocks. These data in addition to interpretations from multiple geophysical data sets acquired over the years were systematically assessed, interpreted and incorporated into a 3D conceptual geological model of the West Flank site.

This 3D model illustrates a robust geologic, structural and thermal understanding of the West Flank site. All data used for this model were acquired to support exploration and development of the Coso geothermal field, a very large, high enthalpy field that has been continuously operational since 1987. Coso is adjacent to the West Flank to the east but multiple sets of data including well tests, petrography and geophysics indicates that the West Flank is outside of the active hydrothermal field. In addition to relevant data, Coso can serve as staging area for FORGE activities and equipment storage.

The West Flank is readily accessed via a 12 km road that connects the site to California Route 395, a major highway on the eastern side of Sierra Nevada Mountains. Ridgecrest is 56 kilometers to the south and contains ample motels, restaurants and stores to support any other needs of this long-term R&D project. The West Flank is completely contained within NAWS China Lake, a large and highly secure Navy weapons installation. Required security protocols needed to enter NAWS China Lake and the West Flank will not affect any activities within the site as site access is facilitated by the Navy GPO on behalf of the NAWS China Lake Command.

The West Flank site meets all DOE criteria required of a FORGE site. The geologic setting and other attributes yield an ideal location for the successful development, testing and pursuit of new technologies for Enhanced Geothermal Systems (EGS).

2 INTRODUCTION

The Department of Energy (DOE) Frontier Observatory for Research in Geothermal Energy (FORGE) project is designed to test and report on techniques needed to make enhanced geothermal systems (EGS) a commercially viable electricity generation option. The objective of FORGE is to establish and manage a dedicated site where the scientific and engineering community can develop, test, and improve new technologies in an optimal environment with respect to target reservoir temperature, depth, lithology and permeability.

The West Flank proposed FORGE project site is within the <1.0 Ma Coso Volcanic Field (CVF) in eastern California (Figure 1). It occupies about 1,100 acres of the North Ranges of the Naval Air Weapons Station (NAWS) China Lake. Located entirely within the fence line of a Navy research and development facility, the West Flank site is adjacent the Coso geothermal field. Infrastructure associated with the Coso geothermal field (water, staging areas, equipment, office space) in this remote region of NAWS China Lake will be available to support West Flank FORGE activities.

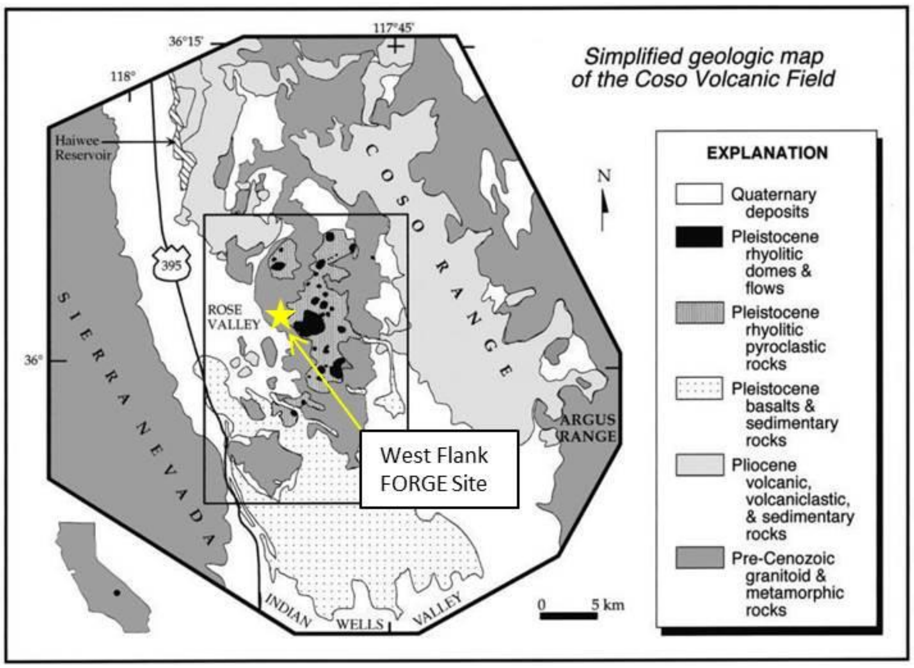


Figure 1. Location and generalized geologic map of the Coso Volcanic Field, inside the black polygon. The eastern margin of the West Flank is bounded to the east by the largest rhyolite dome in the field (yellow star) seen in the center of this image. Rose Valley is the source of Hay Ranch water for FORGE. From Duffield and Bacon (1981).

The West Flank is an outstanding candidate location for FORGE. Data demonstrates the existence of required temperatures, permeabilities and lithologies at the required depths. The institutions that comprise the West Flank FORGE Team bring a wealth of complementary experience to this project and are committed to and capable of executing the FORGE activity.

The remainder of this report describes the suitability of the West Flank in location, geologic setting, temperature and permeability, as well as, how these data were used to create the 3D geologic model and the model itself.

3 LOCATION

The West Flank FORGE location occupies over 1,100 acres in the Coso Volcanic Field (CVF), due west of the Sugarloaf rhyolite dome. The CVF is in the southwestern portion of the Coso Range (Figure 1). The primary access to the West Flank is a road into the adjacent Coso geothermal field that intersects Highway 395 roughly 12 km to the west. Most of the West Flank is flat and easily accessible via existing dirt roads.

The West Flank FORGE team will work closely with the operator of the nearby Coso geothermal field, the Coso Operating Company (COC), which is the local subsidiary of Terra-Gen Power. COC maintains this 24x7 geothermal operation with highly skilled maintenance and operations crews. COC has a skilled workforce with the hardware and infrastructure to service and support circumstances that might arise during the course of this project. The proximity of COC to the West Flank FORGE site is a valuable asset contributing to the success of the proposed FORGE project.

The main COC facilities are less than 4 km to the east of the eastern margin of the West Flank. COC's other office facilities are 11 km to the west outside of the NAWS China Lake gate along the access road. Even with temporary trailers, phones, and Internet connectivity established over the course of FORGE work, COC office facilities can be made available for project support. We anticipate that workers may stay at one of the many motels or hotels in Ridgecrest, about 56 kilometers to the south. Ridgecrest is a town of 25,000 people with full amenities that can support FORGE workers. NAWS China Lake main facilities are at the northeast side of Ridgecrest. Between the base facilities and the town of Ridgecrest, ample facilities exist to house and support any size of FORGE team needed to conduct work over the life of the project.

Water for the project will be supplied by COC and may come from a few sources. The first source is separator brine and blow down water from the cooling towers within the geothermal field 2 km to the east. Water will be transported to FORGE well(s) by temporary "Rain for Rent" pipes provided by COC. A second source of water is from a 1.5 million gallon water tank which is located adjacent to the access road into the FORGE site. This tank is on a hill that demarcates the western margin of the proposed FORGE site. Water is pumped east from Rose Valley 15 km to the holding tank where it is then gravity fed into the geothermal field. COC is also currently assessing a third water source. They are evaluating a brine aquifer in Rose Valley several thousand feet beneath their current fresh water aquifer. If this aquifer is successfully tested, these fluids will be pumped east via the same COC pipeline and augment the current outside supply of water to the geothermal area and to the proposed FORGE site.

4 GEOLOGIC SETTING

The West Flank FORGE site lies within the volcanically and tectonically active Coso Range at the boundary between the Sierra Nevada (Sierran) microplate and the Basin and Range. The Sierran block moves 13 mm/year to the northwest with respect to stable North America. Its motion is accommodated by strike-slip and normal faulting in the Walker Lane belt, a ~100 km wide zone of active deformation that terminates to the west along the Sierra Nevada (Unruh et al., 2003; Unruh and Hauksson, 2007). This region is referred to as the Eastern California Shear Zone.

South of the West Flank site, there are west-northwest to northwest-striking dextral faults—the Airport Lake and Little Lake faults—that step over to the right to the northwest-striking dextral Owens Valley and Wild Horse Mesa faults located north of the West Flank site (Figure 2). The CVF is centered within this ~20 km wide step-over with apparent pull-apart geometry (Figure 2). Within the pull-apart, the West Flank FORGE site lies on a horst block consisting of Mesozoic basement rocks. Relative uplift of the horst block is broadly controlled by north-northeast-striking east-dipping normal faults on the east side and north-northeast-striking, west-dipping faults on the west side. These faults, along with west-northwest to northwest-striking dextral-normal faults, step to the left, delineating the segmented and left-stepping geometry of a horst block (Figure 2).

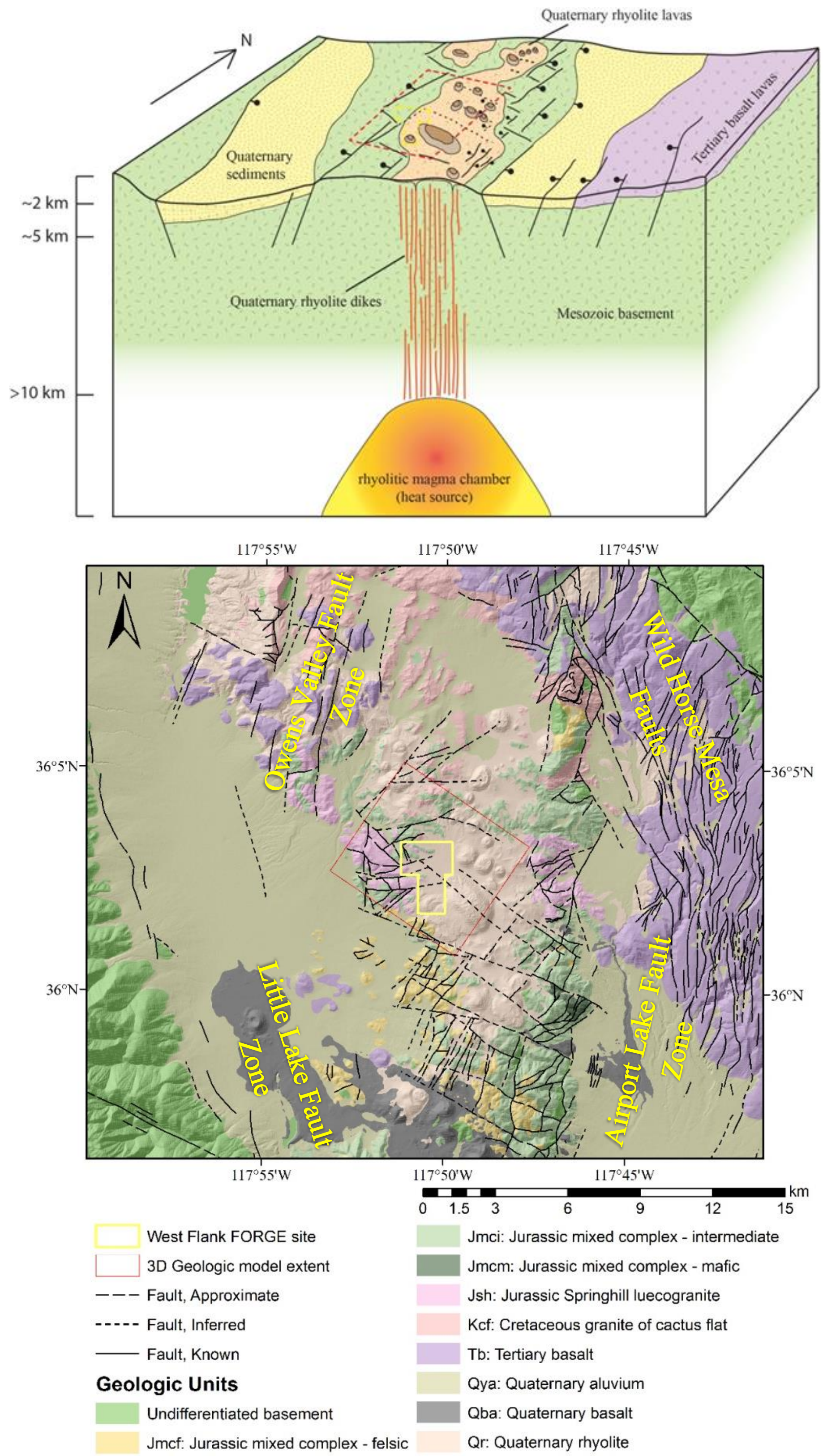


Figure 2. 3D conceptual model (*top*) of the area local to the West Flank FORGE site and geologic map (*bottom*). Map and 3D conceptual model cover roughly the same area.

Pliocene to Recent volcanic rocks of the CVF unconformably overly the Mesozoic basement rocks. The CVF is composed primarily of Pleistocene rhyolite domes, lava flows and volcaniclastic units. CVF rhyolites are derived primarily from partial melting and/or differentiation of mantle basalts (Miller et al., 1996). This magmatic system appears to be maintained by the intrusion of basaltic magmas likely associated with ongoing deformation with Basin and Range-style lithospheric extension (Duffield et al., 1980; Manley and Bacon, 1999). Shallow silicic magma chambers were the source of CVF rhyolites. The current chamber is estimated to be between ~11-16 km beneath the West Flank site (Unruh and Hauksson, 2003). Dikes sourced from this chamber transported magma to the surface and fed the eruption of the Pliocene to Recent rhyolite to basalt lava flows and rhyolite domes (Figure 2). The dikes are predominantly north-northeast striking and steeply dipping, and were intruded along pre-existing north-northeast-striking structures. Conductive heating of the crust associated with the rhyolite magma chamber is responsible for the elevated heat flow at West Flank (Duffield et al., 1980).

The West Flank FORGE site consists of thin Quaternary sedimentary cover, Pleistocene and younger rhyolite domes, minor basalt flows, associated volcaniclastic and epiclastic rocks of the CVF, and Mesozoic plutonic basement rocks. Rhyolite domes range in age from ~625 ka to ~85 ka ($^{40}Ar/^{39}Ar$ and zircon geochronology; Simon et al., 2009). The youngest dated dome is Sugarloaf dome which is the dominant topographic feature at the West Flank (Figure 3). The Mesozoic basement rocks are predominantly granitic to dioritic and correlate with the Sierra Nevada Batholith (Duffield et al., 1980; Reasenberg et al., 1980; Wilson et al., 2003; Hauksson and Unruh, 2007; Simon et al., 2009). The Mesozoic plutonic rocks intrude felsic metavolcanic and other metamorphic rocks that range from Mesozoic to Precambrian (Duffield et al., 1980; Whitmarsh, 1998a). These metamorphic rocks are not exposed at the surface at West Flank nor are they evident in the eight wells analyzed for lithologic data at West Flank.

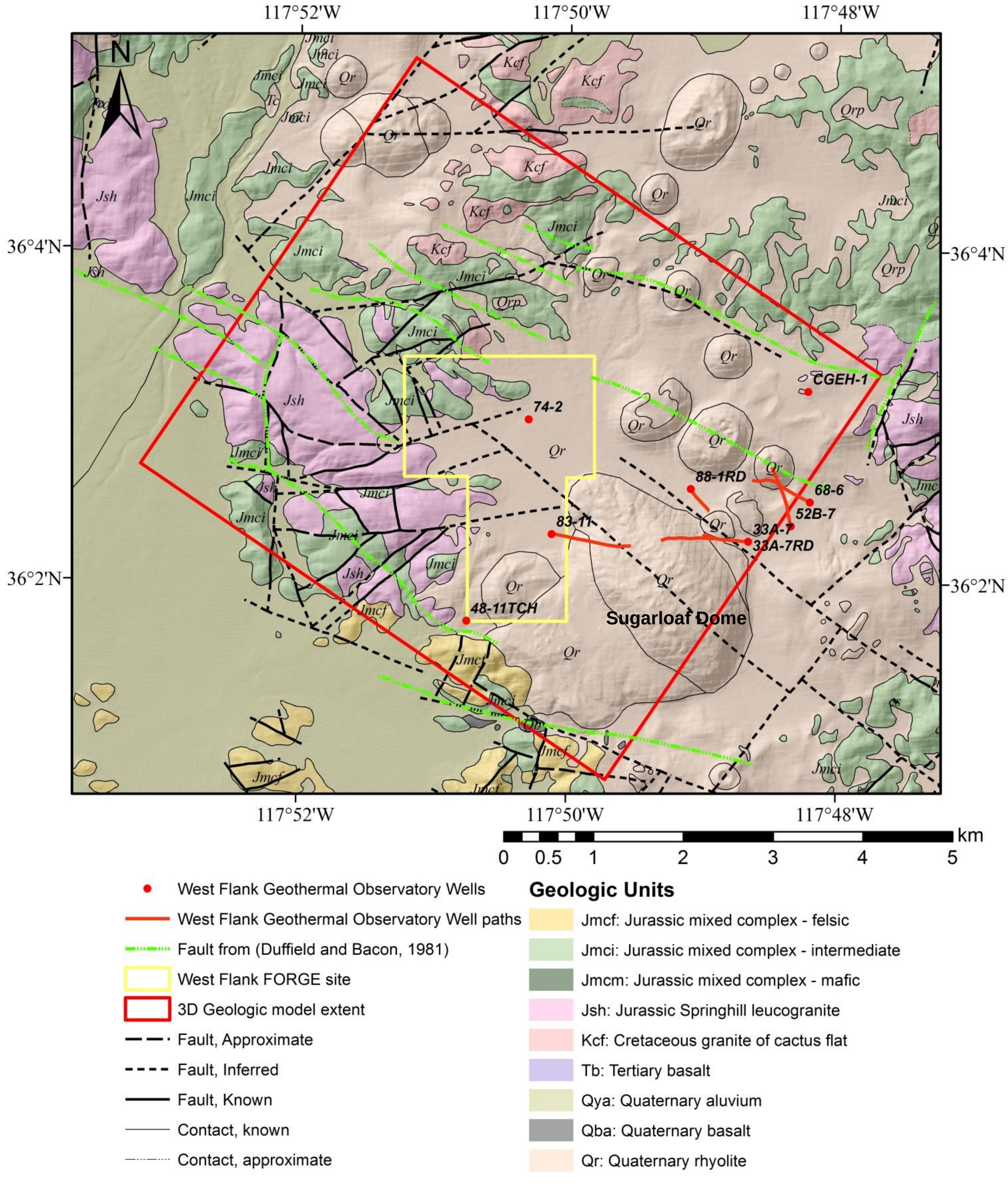


Figure 3. Geologic map of the West Flank site. Geologic map after Whitmarsh, 1998a. The West Flank site is outlined in yellow. The extent of the 3D geologic model is outlined in the red rectangle.

5 FORGE PARAMETERS

For the proposed West Flank FORGE site and the surrounding area, a large amount of preexisting data was available for Phase 1 work including both geological and geophysical data sets. These data provide a thorough understanding of the subsurface in terms of the structural, geologic and thermal setting of the West Flank. The following is a discussion of each data set in detail and a description of how each was used within the 3D geologic model. The FORGE site key characteristics and criteria are also discussed for each data set. These criteria include temperatures between 175 and 225˚C, low permeability, crystalline bedrock, depth between 1.5 and 4 km and a lack of an existing hydrothermal system.

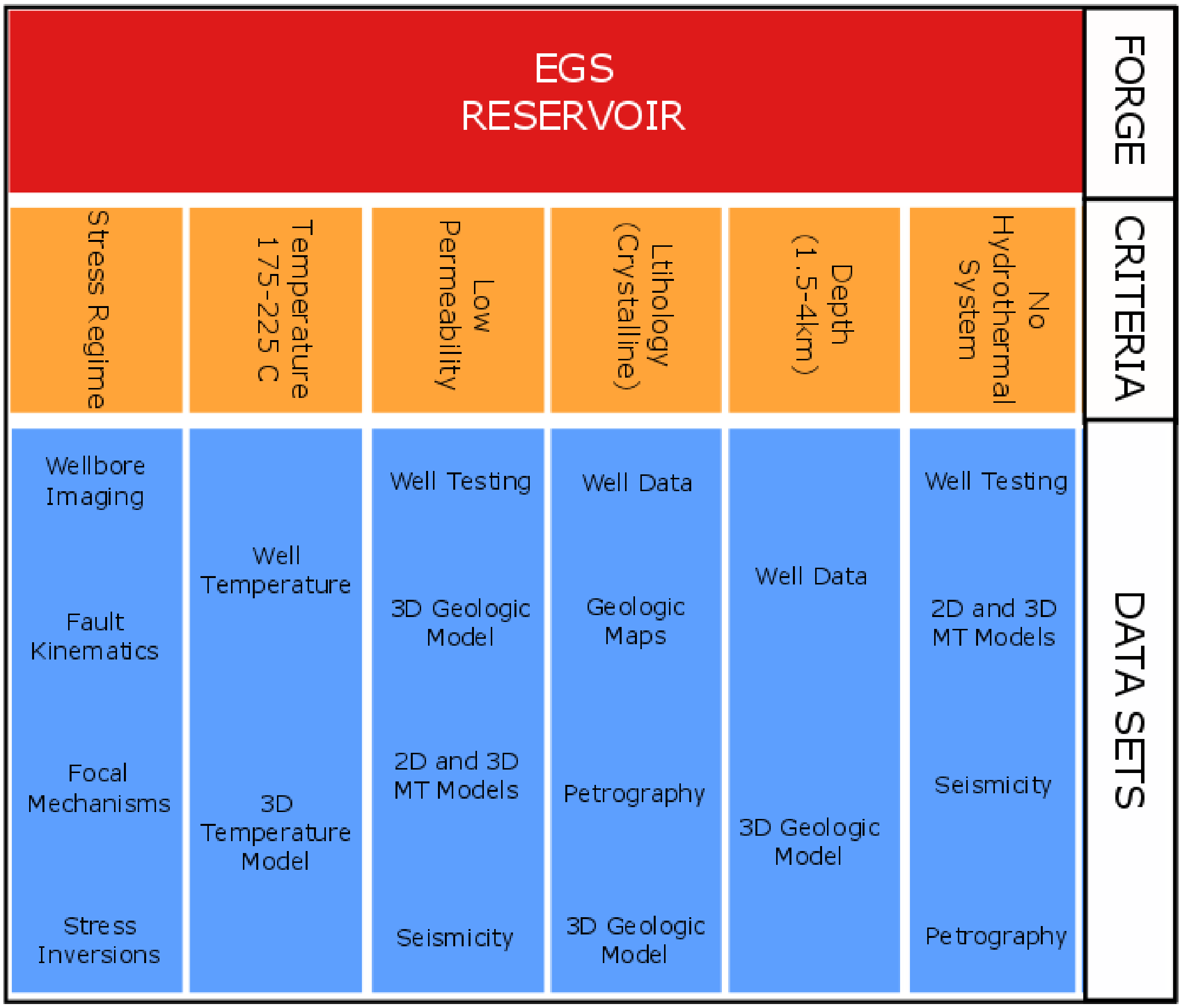


Figure 4. The criteria set forth by DOE for the FORGE project with the preexisting data sets that the West Flank site has that demonstrates these criteria were met.

5.1 DATA AND INTERPRETATION

5.1.1 Geologic and Geologic Map data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant			✓			✓

The Coso geothermal field and vicinity have been studied for decades by scientists and geothermal energy producers, yielding a vast amount of research and production data. The geologic data for the site is outlined in the following sections, that include a brief discussion of the geologic data that has been used thus far in the FORGE project.

The geologic data for the West Flank area includes, but is not limited to, cuttings, core, mudlogs, thin sections, geophysical downhole logs, surface geophysics, geologic mapping, microseismicity, downhole temperature data, and downhole pressure data. These data came from the archives of Coso Operating Company and the Navy Geothermal Program Office (GPO) and, where appropriate, were re-interpreted for the West Flank FORGE project before being incorporated into the conceptual geologic model.

Data from the two geologic maps (Duffield and Bacon, 1981, 1:50,000 scale and Whitmarsh 1998b, 1:24,000 scale) were synthesized to define the lithologic and structural framework of the West Flank site. Duffield and Bacon (1981) (Figure 1) was mapped at the 1:50,000 scale and their fault interpretations were considered representative of regional tectonic trends. Whitmarsh (1998a) mapped (Figure 3) at a 1:24,000 scale to delineate more detailed lithologic variation in the Mesozoic basement. The Whitmarsh basement units, Jmci, Jmcf, Jsh, and Kcf, were used as the basis for re-interpreting the 74-2TCH core, the 83-11 and CGEH-1 cuttings, and the 33A-7, 33A-7RD, 88-1RD, 68-6 and 52B-7 mud logs (well locations shown on Figure 5 and Figure 3).

The mapped surface geology at the West Flank site consists of Quaternary sedimentary deposits and Pleistocene basalt to rhyolite lava flows and domes unconformably overlying Mesozoic plutonic rocks. Undifferentiated Quaternary sedimentary deposits constitute ~7% of the mapped area (Figure 2). These deposits consist of alluvium and colluvium and form <10 m thick sedimentary cover in the dry washes to the west of the West Flank FORGE site. Underlying the Quaternary sediments, the Pleistocene volcanic units are predominantly rhyolite domes and associated volcaniclastic and epiclastic successions (Qr). Qr constitutes ~60% of the mapped area (Figure 2). The Qr domes and associated volcaniclastic and epiclastic successions occurs as a veneer <500-m-thick, unconformably overlying the Mesozoic plutonic rocks. Dikes sourced from the crustal magma chamber at >11-16 km depth fed the eruption of the rhyolite lava flows and domes. These dikes, the intrusive equivalent of Qr, strike predominantly north-northeast and appear to have been intruded along pre-existing structures (Duffield et al., 1980). Qr dikes are evident in wells 33A-7, 33A-7RD, 52B-7, and 68-6, and occur primarily below ~1,000 m below ground surface (bgs) and in the highest density below ~2,000 m bgs. Qr dikes represents ~2% of the lithologic section in the eight wells analyzed (Figure 6). Mafic intrusions are volumetrically insignificant and their affinity is poorly constrained as several different Mesozoic and Cenozoic mafic eruptive and intrusive are mapped throughout the area (Whitmarsh, 1998a, b). Unconformably beneath the Pleistocene rhyolite and Quaternary sediments are Mesozoic granitic to dioritic rocks. These units are exposed throughout the area surrounding the West Flank site and dominate the West Flank subsurface section at depths greater than ~500 m bgs (Figure 6).

Four distinct Mesozoic plutons have been identified in the West Flank conceptual model. These determinations are based on a correlation of existing geologic map data (Whitmarsh, 1998a) with lithologic logs from the ~15,000 m of well cuttings, core, and mud logs in the eight wells used in this model: 83-11, 74-2TCH, 88-1, 33A-7, 33A-7RD, CGEH-1, 68-6, and 52B-7. Diorite to quartz-diorite, the intermediate endmember for the Jurassic mixed intrusive complex (Jmci), is the most volumetrically abundant unit at West Flank. Jmci is defined in hand sample by an assemblage of hornblende, plagioclase ± quartz and constitutes ~14% of the West Flank area mapped by Whitmarsh (1998a) and ~78% of the downhole lithologic section (Figure 6). Downhole lithologic data from the eight wells analyzed confirm the lateral continuity of Jmci throughout the subsurface of the West Flank site. Jmci is locally intruded by and intermingled with Jmcf, Jurassic granite consisting of plagioclase, alkali feldspar and quartz, with ≤ 10% mafic minerals (primarily muscovite ±biotite) (Whitmarsh, 1998b). Jmcf is the felsic endmember of the Jurassic mixed intrusive complex. Contact relationships between Jmci and Jmcf, as defined in the field and in the 74-2TCH core, are highly diffuse, typically consisting of several meters to tens of meters of mixed and intermingled dikes and/or sills of Jmci, Jmcf, and of compositions intermediate between the two endmembers. Magmatic deformation textures are abundant, confirming that Jmci and Jmcf are likely contemporaneous. Jmcf constitutes ~2% of the geologic map area (Section 4, Figure 1) and ~17% of the downhole lithologic section. In the eight wells analyzed for lithologic data, Jmcf occurs almost exclusively at levels shallower than ~1,350 m below ground surface and rarely deeper than ~3,000 m bgs (Figure 6).

The two other Mesozoic plutonic units included in the West Flank model are garnet-bearing, quartz and feldspar leucogranite, which we equate to the Jurassic Springhill leucogranite, Jsh and the Cretaceous quartz and alkali feldspar granite of Cactus Flat, Kcf, (Whitmarsh, 1998). Jsh constitutes ~4% of the total lithologic volume in the eight wells analyzed. It is found predominately in wells CGEH-1 and 74-2TCH which are adjacent to mapped exposures of Jsh (Whitmarsh, 1998a) which cover ~14% of the geologic map area (Figure 6). Kcf constitutes ~2% of the mapped area (Figure 5) as isolated exposures to the north and west of the West Flank site. Kcf was not evident in the lithologic data from any of the eight wells.

In summary, the preexisting geologic mapping and subsequent ground truthing of lithologic contacts throughout Phase 1 provides insight into the crystalline rock necessary for the FORGE project at the West Flank. These geologic maps were also utilized to understand the structural setting of the site.

The high quality, detailed geologic maps of this region provide information spanning both the bedrock and the quaternary geology. The contacts within these geologic maps are within ±10 m due to aerial photography of the area supplementing the work. This provides an uncertainty that then overflows into cross-sections created for this Phase of work and then into the 3D geologic model.

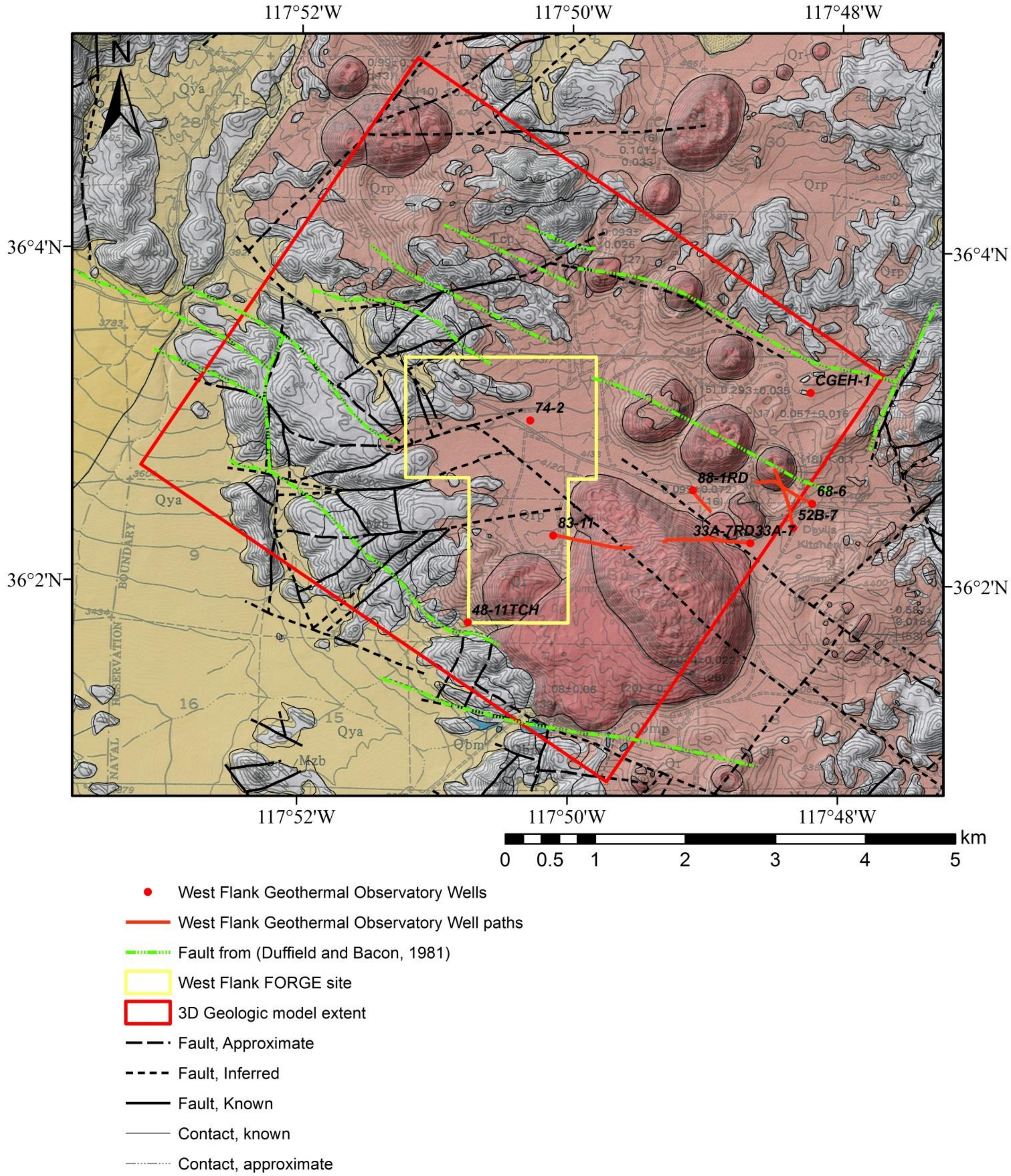


Figure 5. Geologic map of the West Flank site from Duffield and Bacon, 1980.

5.1.2 Well and Lithologic data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant	✓	✓	✓	✓	✓	✓

Approximately ~15,000 m of core, cuttings, and mud logs from eight wells were analyzed and re-interpreted. Special attention was paid to delineating basement units using the framework defined by Whitmarsh (1998a, b). The lithologic unit in each well interval was defined based on the primary rock type present along that interval of the mud log, cuttings, or core, as well as the directly adjacent intervals. Minor or intervening rock types were interpreted as dikes, sills, or larger intrusive bodies within the primary host unit. Fault zones described in mud logs and identified in core were noted. Zones of fluid losses that occurred during drilling, or the occurrence of loss of circulation material (LCM, commonly used to plug flowing intervals along the well bore), were also noted, as they tend to occur as the result of faults crossing the well bore (Figure 6).

Wells discussed in this report include 83-11, 74-2TCH, 88-11RD, 33-7, 33A-7, 33A-7RD, CGEH-1, 68-6, 48-11TCH and 52B-7. Only three of these wells, 83-11, 74-2TCH and 48-11TCH were drilled within the proposed FORGE site and only 83-11 is still accessible. The following presents information and interpretations gleaned from analyses of these wells.

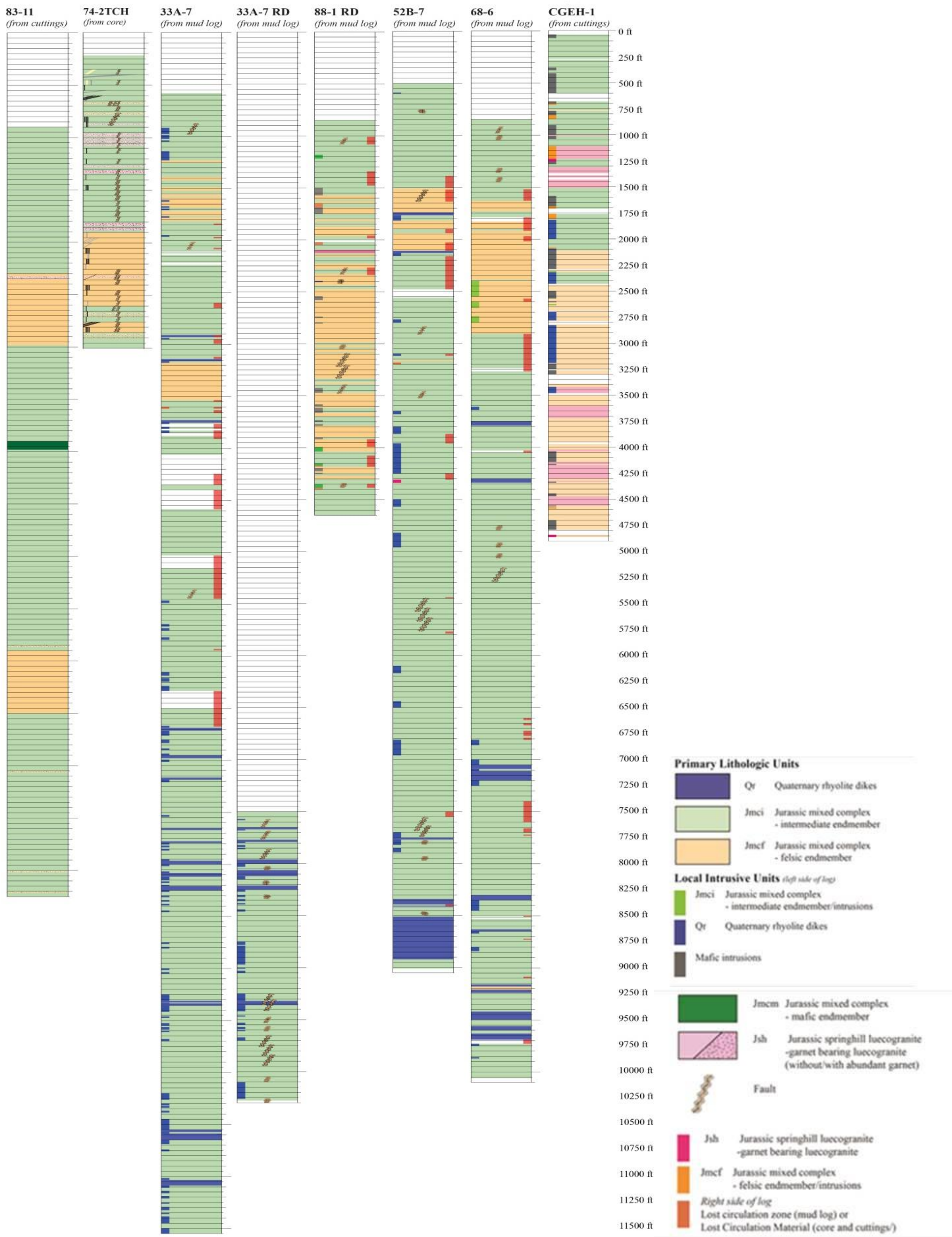


Figure 6. Lithologic logs of the eight wells used to characterize the subsurface lithology and structure at West Flank of Coso.

The following is a description of specific data that have been collected from the West Flank FORGE site and wells within the footprint of the 3D model:

83-11 Downhole pressure and temperature data were used from this well. Lithologic logs from ~2,800 m of well cuttings plus mud logs from 83-11 were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a). Well 83-11 was logged by Baker-Hughes using both an acoustic Circumferential Borehole Imaging Log (CBIL) log and the electric STAR log in the same logging run. The 604-2097 m interval was logged using the CBIL tool. The STAR tool sampled at 8 m above the CBIL tool. Similar to the Halliburton EMI tool, the Baker-Hughes STAR tool is a 6-arm electrical tool acquiring a resistivity image of the wellbore wall. It provides about 54% coverage of the 8 3/4″ wellbore wall. The data were provided as pre-processed DLIS files. Prior petrographic and XRD analysis were made available.

74-2TCH Temperature data were used. Lithologic logs from ~900 m of core from 74-2TCH were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a).

88-11RD Temperature data were used. Lithologic logs from ~1,300 m of mud logs from 88-1RD were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a).

33-7 The image log of well 33-7 from 1,886 m to 2,806 m MD was acquired using a Halliburton EMI tool. This tool uses 6 arms with an array of electrodes to image the resistivity of the wellbore wall. In the 8.5″ well, the tool provides about 70% coverage of the wellbore wall. The image log was provided as a GMI Imager file. The image log had been analyzed in an earlier study for natural and induced fractures. However, orientation of S_{Hmax} was not determined during this earlier study. Natural fracture picks from this study were also provided.

33A-7 Approximately ~3,500 m of mud logs from 33A-7 were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a). Well 33A-7 was logged using the Baker- CBIL tool. This acoustic tool provides 100% coverage of the wellbore wall for travel time and amplitude. Two runs of the tool were conducted for the same interval from about 2,133 to 3,142 m MD. The images of the two runs match very well which showcases the reliability of the image acquisition and tool orientation in the deviated well. DLIS files of raw and pre-processed data were also provided to the FORGE team. Prior petrographic and XRD analyses were made available.

33A-7RD Approximately 3,000 m of mud logs from 33A-7RD were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a). Well 33A-7 and 33A-7RD occupy the same well path to 2,200 m where a window was cut in the casing and a new well path, 33A-7RD, was deviated ~800 m to the northwest. Prior petrographic and XRD analyses were made available.

CGEH-1 Approximately 1,500 m of well cuttings from CGEH-1 were re-interpreted in the framework of the Whitmarsh basement lithologic units (1998a).

68-6 Approximately 3,000 m of mud logs from 68-6 were re-interpreted in the framework of the Whitmarsh basement units (1998a).

52B-7 Approximately 2,800 m of mud logs from 52B-7 were re-interpreted in the framework of Whitmarsh's basement units (1998a). Well 52B-7 was logged for a 169 m interval using a Schlumberger FMI tool between 2552 and 2721 m depth. This tool provides about 70% angular coverage of the 8 3/4″diameter well. The image log was generated as a GMI Imager file. The image log was analyzed for natural and induced fractures. The orientation of S_{Hmax} was not determined during this earlier study. Natural fracture picks from this study were also provided.

The preexisting well data that were interpreted for Phase 1 add to our understanding of the crystalline basement within the West Flank site, as well as, important temperature data all within the depth criteria of FORGE. The image log data collected in these wells provided insights into the stress regime of the site and the pressure data from 83-11 demonstrates that we are outside of a hydrothermal system. All of these data and how they relate to the suitability of the FORGE site are discussed in greater detail within their own data portions, but provide a stable foundation of site suitability for the West Flank site.

All of the wells studied provide contacts of lithologic units within ~3 m based on the sampling intervals of the chips which is a useful depth span of uncertainty. As depth increases, this uncertainty increases due to a longer amount of time and a larger depth span for the chips to make it back to the surface from the bottom of the well bore. Additionally, uncertainty increases due to chips falling downhole and mixing in with the unit being drilled. Wells 74-2TCH and CGEH-1 are both cored wells which also have an uncertainty in depth of ~3 m. The core lacks the mixing of rock from varying depths and thus provides a more complete representation of the rock type with depth.

5.1.3 Petrologic data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant	✓		✓	✓		✓

Petrography and XRD of select cuttings from wells 33A-7, 33A-7RD and 83-11 was performed in 2011 by the Energy and Geoscience Institute (EGI) at the University of Utah to focus on the mineralogy of zones of potential geothermal interest. These data were used by the FORGE team to further delineate the West Flank host rocks from the geothermal field. The dominant rock type in the studied wells is diorite with plagioclase, amphibole, biotite, and epidote. The more felsic samples from these wells are quartz diorites that contain both quartz and potassium feldspar (Figure 7). However, as was determined in this FORGE Phase 1 work, subtle mineral concentration changes and the subjectivity of rock identification in thin sections can yield multiple names for felsic to intermediate composition plutonic rocks. The West Flank team decided to split the basement into two end members with identifiable variation in mineralogy in hand sample, chips, and thin section. The following discussion is based on EGI data with interpretations made in Phase 1.

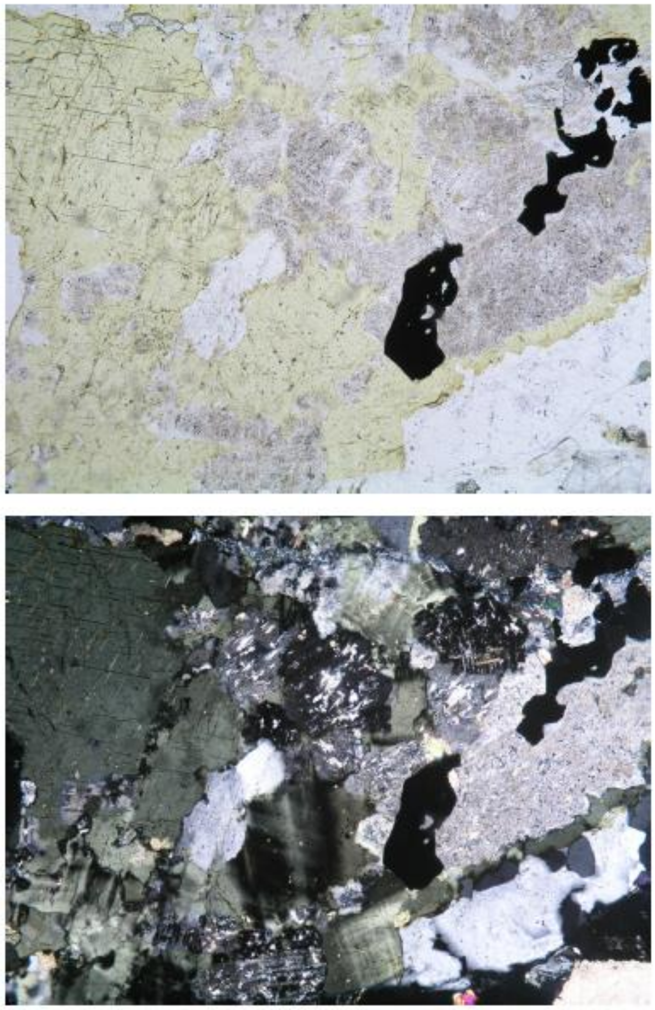


Figure 7. Coarse grained granite with potassium feldspar (stained yellow), plagioclase and quartz. The upper photomicrogaph is plane polarized light, lower is cross nicols from 83-11. 1.6 mm across.

Basement rocks in the West Flank, as determined from a core and cutting analysis of the 83-11, 74-2TCH, are locally brecciated and hydrothermally altered. Based on the petrographic analysis, 83-11 has notable differences in both rock type and veining from 33A-7 and 33-7. Specifically, 33A-7 and 33-7 exhibit abundant fracturing and porosity not observed in 83-11. XRD was performed on the cuttings from these wells, mainly for the identification of clay mineralogy. The occurrence of smectite suggests temperature less than 180˚C, interlayered smectite-illite or smectite-chlorite suggest temperatures between 180˚C and 225˚C and, finally, illite and chlorite are stable above 225˚C (Henley and Ellis, 1983; Reyes, 1990, Clay and Moore, 2013). Within the analyzed wells, the clay distribution with depth followed the temperature profile; there were samples with interlayered illite/smectite deeper than expected, but this could be the result of sloughing within the wellbore.

Pathways used by these old fluids, as represented in the petrologic analysis, provide insight for future FORGE work that may take advantage of mechanical weaknesses along hydrothermally altered veins representing past fluid conduits. As noted above, the dominant rock types below depths of ~500 m bgs in the West Flank are low-porosity granites and diorities which will be amenable to self-propping (dilatant) shearing and permeability enhancement during hydraulic stimulation. Depending on their orientation relative to the in-situ stress field, these sealed (or partially sealed) veins in the West Flank could form pre-existing planes of weakness (and perhaps limited fluid entry) that could be reactivated along with natural fractures and other planar discontinuities during hydraulic stimulation. A more robust analysis of these phenomena in additional wells to be drilled during Phase 2 will contribute to our understanding of pre-existing natural fractures, veins and other structures in relation to the in-situ stress field, including constraining past fluid flow pathways and the potential for creation of new interconnected permeable fracture networks during FORGE operation.

The manufacturing of the thin sections for petrographic analysis was of high quality. The same uncertainties as the lithologic data for the collected chips, ~3 m in either depth direction, would apply. Chips falling down the wellbore and being incorporated into thin sections would contaminate the samples by roughly 1-5%; these out of place chips under a petrographic microscope can be easily identified.

5.1.4 Structural data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant		✓			✓	✓

The Duffield and Bacon (1981) and Whitmarsh (1998a) geologic maps were used as constraints on the general structural trends in and around the West Flank site, and on the surface locations and surface geometries of discrete structures (Figure 1). Subsurface fault geometries were constrained by the locations of known faults in core, major zones of lost circulation during drilling or utilization of lost circulation material (LCM) along the well paths (Figure 4, Figure 2), the traces of surface mapped faults, faults interpreted from the seismic reflection profiles, faults interpreted based on microsiesmicity distribution, and from the relative offset of lithologic units in proximal well bores.

Unruh et al. (1996) inverted focal mechanisms for the directions and relative magnitude of principal strains for the Coso Range-Indian Wells Valley region. They infer a north-south to northeast-southwest shortening (d3) and an east-west to northwest-southeast extension (d1). From the sub-horizontal orientation of the principal strain components, they infer a strike-slip faulting regime. For the Coso range, where the seismic activity is high, a higher resolution inversion was performed showing stronger local heterogeneity in the deformation field (Figure 8).

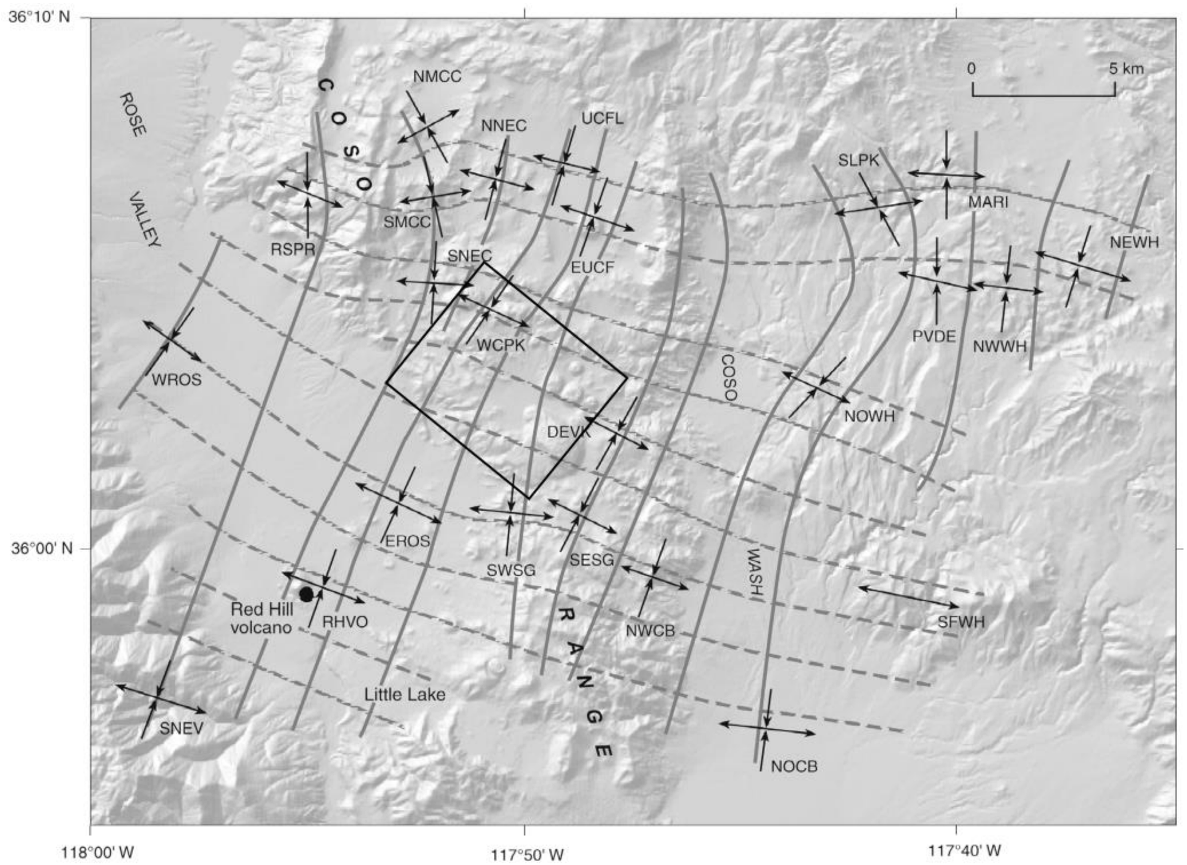


Figure 8. Seismogenic deformation field inverted from focal mechanisms. The black rectangle marks the footprint of the West Flank study area. Modified from Unruh et al. (2002).

Natural fractures were picked from the image logs of wells 33-7, 33A-7, 52A-7, 52B-7 and 83-11. Where previous analyses of natural fractures were available (GMI [2000, 2001]) for wells 33-7, 52A-7, 52B-7), those picks were used. Otherwise, a new interpretation of natural fractures was performed. Due to a variable image quality and different suitability for fracture interpretation (electric logs are much more sensitive for detecting fractures than acoustic logs) the fracture density cannot be compared between wells. To correct the sampling bias leading to under-sampling of fractures with a steep apparent dip in the wells, a Terzaghi correction was performed (Terzaghi, 1965). With that, each interpreted fracture given a weight by $w = 1/\cos(\phi)$, where ϕ is the angle between the wellbore trajectory and the fracture normal. As shown in Figure 9, both the corrected and uncorrected poles were plotted in a stereonet. Contours are drawn as exponential Kamb contours (Kamb, 1959; Vollmer, 1995).

In all wells, fractures that are steeply dipping towards west and east dominate the fracture pattern. Comparing the corrected with the uncorrected Kamb contours it is readily apparent that this correction has a very strong effect on the interpreted fracture network (e.g., the trajectory of well 52B-7 strongly under-samples the predominant steeply dipping fracture sets relative to low-angle fractures). Applying the correction changes the fracture density contours significantly. With the correction applied, the inferred fracture networks interpreted from all wells are remarkably consistent.

The fracture picks of well 52A-7 contain a distinct population of interpreted fractures with dip direction around N145°E and dip around 45° which persists after the Terzaghi correction. This well was logged with an electric FMS tool which is sensitive even to rock fabric. Due to the poor angular coverage of the FMS tool it is difficult to distinguish between natural fractures and rock fabric. However, the strong clustering and constant fracture spacing visible in the section where these features occur suggest that these interpreted fractures are rock fabric and not actual natural fractures.

The preexisting studies on structural trends in and around the West Flank FORGE area paired with Phase 1 interpretations of natural fractures in image log data provides a thorough representation of the structure for the site. These data were then incorporated into the 3D model and continued to help demonstrate the suitability and understanding of this site.

Similar to the geologic map uncertainty, the structural uncertainty of faults identified would be ±10 m from the mapped lineation on the earth's surface. The structures identified in geophysical image logs of the borehole walls are dependent upon the quality of the image itself, which varies per well and per geophysical method used. The number of wells analyzed, though, provides overlap, and, thus, minimizes uncertainty in these data. The corrections made within the natural fracture data set also minimize the uncertainty in the interpreted data set.

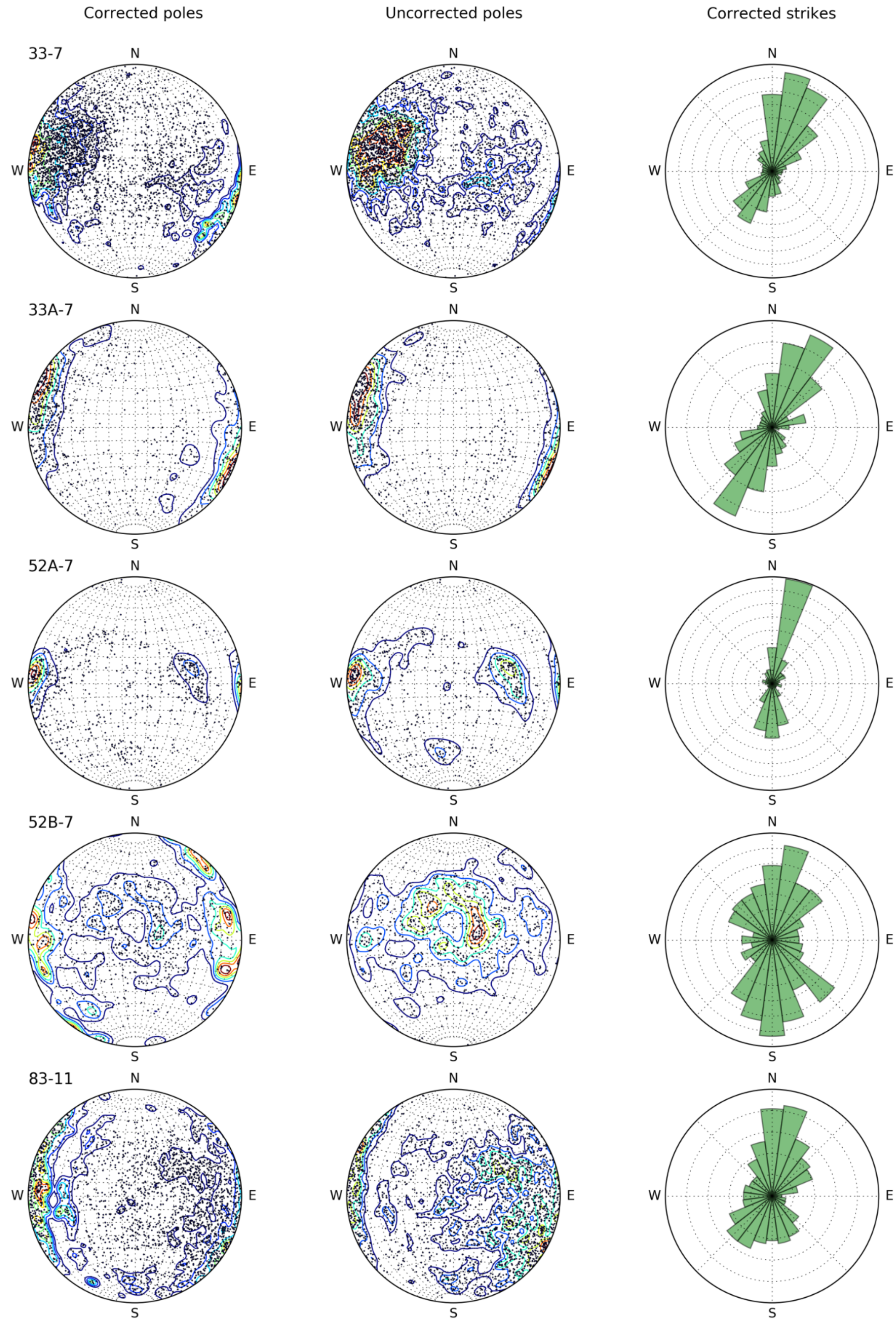


Figure 9. Natural fracture picks from image logs of the FORGE wells. Left column shows 3σ-exponential Kamb contours of poles with applied Terzaghi correction, middle column is the same contours but without correction and right column shows the fracture strikes weighted by the Terzaghi correction.

5.1.5 Temperature Data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant	✓			✓		

Within the proposed West Flank FORGE footprint, three test holes have provided additional temperature data that was incorporated into the previously created temperature model for the geothermal field: wells 74-2TCH, 48-11TCH and 83-11 (see well locations in Figure 9). The profiles of these wells, in Figure 16, demonstrate that within the West Flank site, the wellbore intersects temperatures between 175 and 225˚C at depths below 1.5 km and above 4 km. The different temperature profiles for 74-2TCH demonstrate the warming up of the well after equilibration. The different temperature profiles for 83-11 demonstrate the equilibration and smoothing of the profile a month after the other plotted dataset.

The temperature model for the Coso geothermal field used over 100 geothermal production sized wells and intermediate-depth temperature holes. At the near surface of this model, two boundary temperatures were assumed: (1) areas with surface manifestations, including fumaroles along the northeast striking normal faults and northwest striking dextral faults with the hydrothermal field, a temperature of ~104˚C was applied to datum at +1066 meters above sea level elevation, and (2) a near-surface temperature at about 10 meters depth, of 20˚C was applied below the diurnal and annual conductive temperature perturbations. These assumptions were based on heat flow studies conducted at the CVF and for the Mojave Desert (Combs, 1974).

On the edges of the hydrothermal system, a 73˚C/km (4˚F/100') temperature gradient contour was established using conductive gradient data from shallow and intermediate-depth temperature holes. This contour was continued to all elevation datums between the 20˚C surface and -1520 meters below mean sea level. Because the West Flank is outside of the geothermal field footprint, during Phase 1, the three wells inside the FORGE site were incorporated into the preexisting temperature model.

To ensure a complete model was built based on all the available data sets, measured bottom-hole temperature gradients in certain wells were downward extrapolated to the next deepest elevation datum (or a maximum of about 25% of the well depth where conductive gradients are evident in the lower portions of the wells). After assuring that the margins of the geothermal field were going to be adequately modelled, the data was contoured using the Kriging method algorithm. Although the extrapolated temperatures and boundary conditions are not rigorous, the calculated temperatures are anticipated to be within ~6˚C (20˚F), or one contour interval, of the observed data within the Coso geothermal field providing the uncertainty for the data set. Based on a lack of temperature data west of 74-2TCH, the edges of this model still seem to have an effect on West Flank modeled temperatures. Subsequent work within FORGE will help build the complete understanding of the temperature within the western portion of this site.

In summary, these preexisting temperature data from the West Flank site intersect the FORGE temperature criteria of 175-225˚C within the depth span criteria of 1.5 km and 4 km. Also, the shape of the 83-11 temperature profile itself, conductive rather than convective, helps to further demonstrate the lack of permeability in the West Flank.

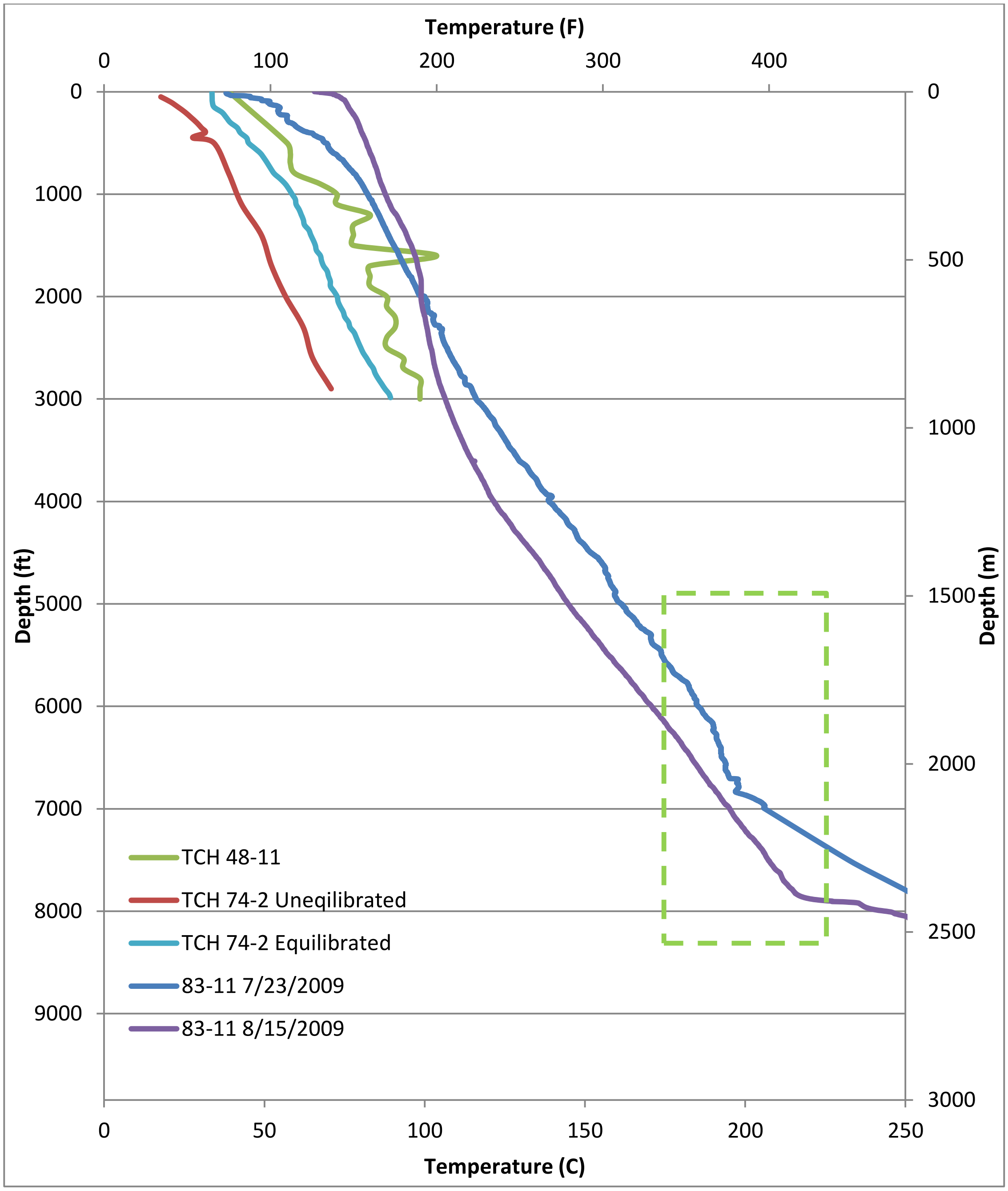


Figure 10. Temperature profiles of well 83-11, temperature core hole (TCH) 74-2 and 48-11TCH. Driller's logs indicate basement was encountered at ~600 ft bgs in 83-11. Static temperature profiles in 83-11 were run from July through November 2009 and an injection test was conducted in August 2009. Temperature profiles are thick blue, red and orange lines (48-11TCH). Note that all of the curves are conductive. Interpretations of the injection test on 83-11 suggested that there are no productive (i.e., high permeability) zones in this hole. The green dashed box outlines ideal FORGE temperature conditions in 83-11 between ~1.5 km and 2.5 km bgs.

5.1.6 Permeability Data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant		✓		✓		✓

The permeability measurements of the crystalline rocks from the West Flank FORGE site are derived from 83-11 well data. Well 83-11 was drilled to ~2,800 meters bgs. After well completion, a flow test and an injection test were performed to determine resource characteristics (Figure 11– Figure 14).

Starting on 8/13/09, drill pipe was staged into the well at intervals with air and water used to lift the well to determine if it could sustain flow. On 8/15/14, after staging pipe to a depth of ~3 km and lifting the well with air, the air was shut-off. The well was monitored for 3 hours for steam and liquid flow, and the temperature of the flow. Measurements were taken throughout the well testing (Figure 11), the conductive temperature profile of the static surveys and the lack of any significant perturbations in the spinner survey conducted after the airlift demonstrate that this well is noncommercial and has low permeability.

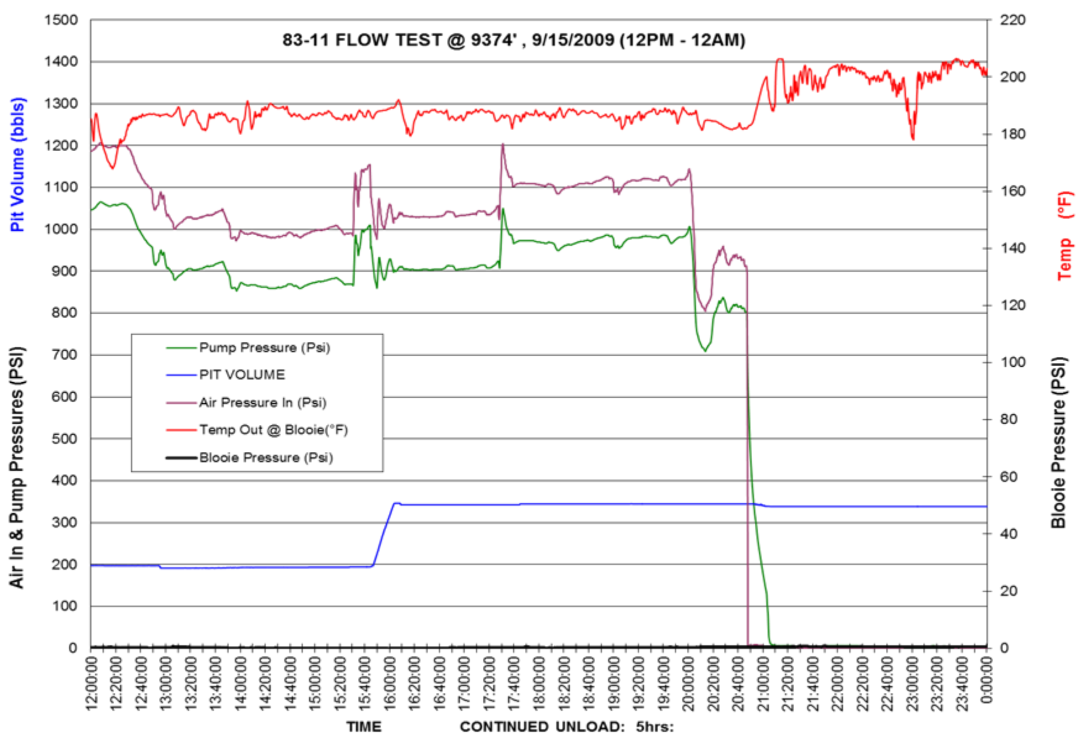


Figure 11. Flow test data for the 83-11 on 8/15/2009 (graph date is miss labeled). This graph shows the parameters being measured during the air lift test (pump pressure, pit volume, air pressure, blooie line temperature and blooie line pressure). After the air lift stopped at 20:45, there was no water flowing from the well into the pit as seen demonstrated with the blue line (pit volume).

Injection tests were performed on 8/16/09 and 8/17/09 in well 83-11. The first test was a step-rate injection test on 8/16/09 (Figure 12). With each stepped increase in injection rate from 125 to 250 to 400 gallons per minute (gpm), the casing pressure increased and injection rate versus excess (casing) pressure values were used to calculate an injectivity index ranging from ~0.2 to 1.05 gpm/psi (Figure 13). An additional test was performed for one hour on 8/16/09 injecting at 700 gpm but was suspended once the casing pressure reached 400 psig, which was the operational pressure limit for this well. A second test was conducted on 8/17/09 at an injection rate of 400 gpm until the wireline snapped at a casing pressure of 275 psi (Figure 14), confirming the final injectivity from the step-rate test on 8/16/09 at an injection rate of 400 gpm.

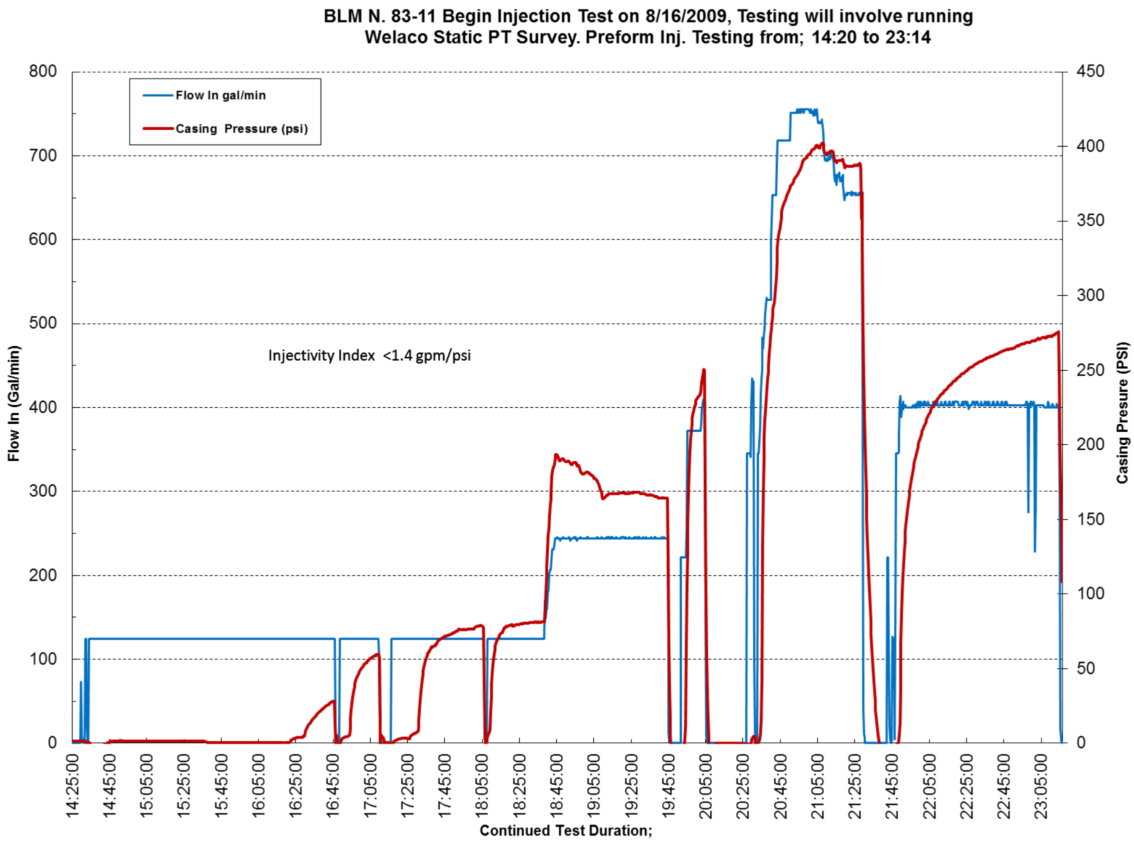


Figure 12. First injection test data for the 83-11 on 8/16/2009 showing four stages of various injection low rates. First stage was 125 gpm injection rate for fours; second stage was 250 gpm for 1 hour; third stage had a varying injection rate that peaked at 750 gpm.

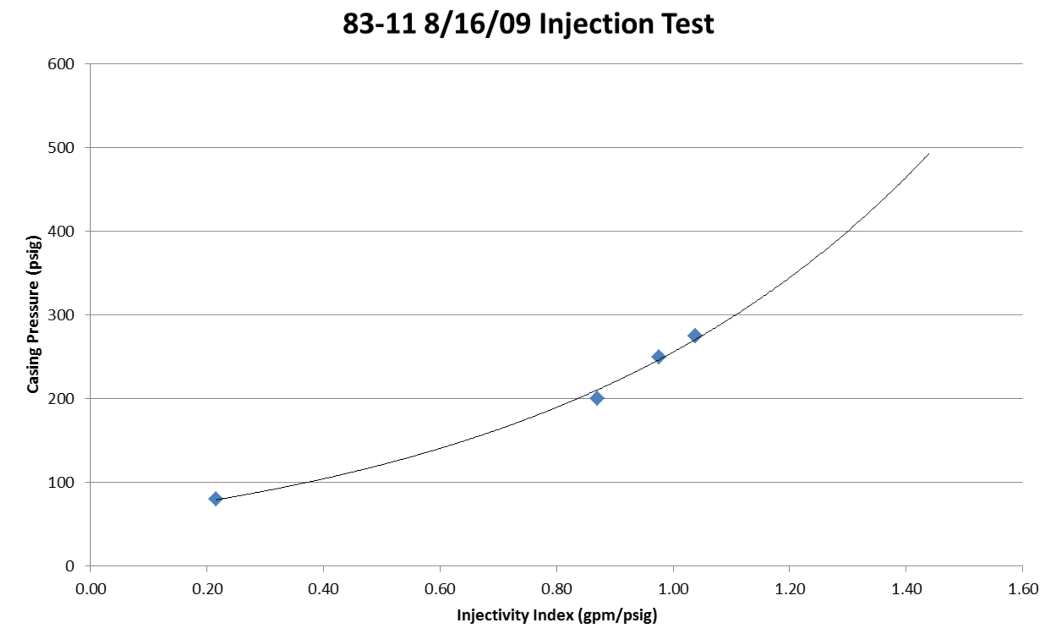


Figure 13. Injectivity index values are determined from injection test data for the various stages of this injection test (8/16/2009). These values overall indicate low permeability in this well.

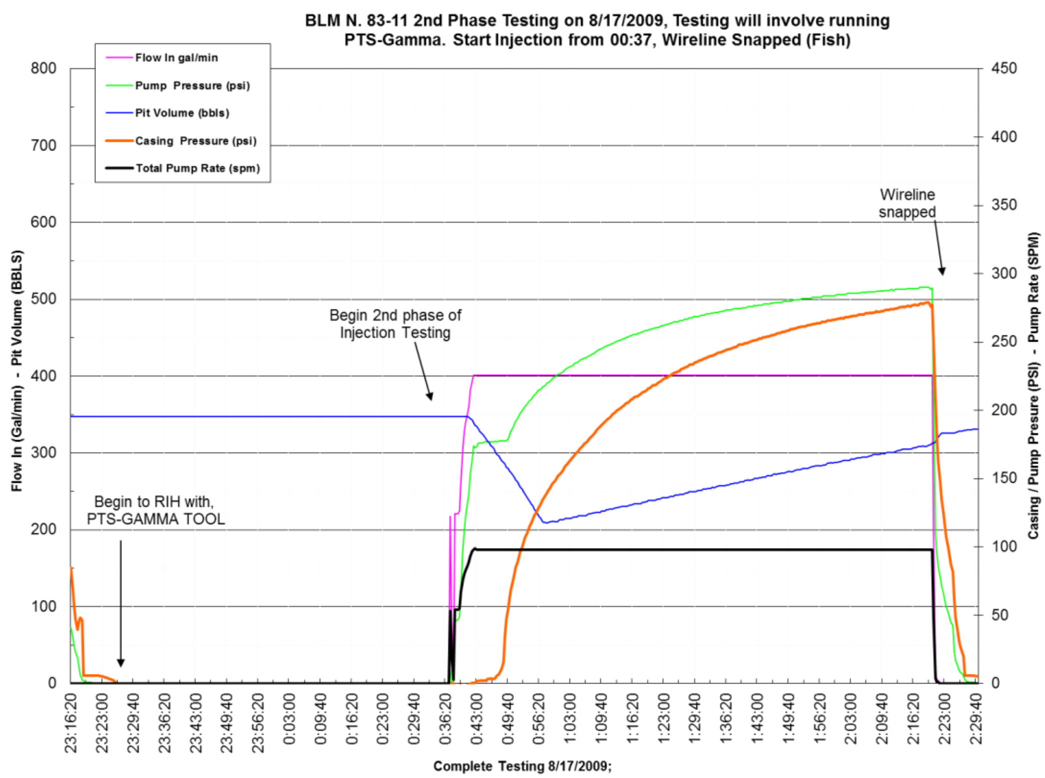


Figure 14. Second injection test data for the 83-11 on 8/17/2009. This injection test was run at a steady injection rate of 400 gpm and the pump pressure was increased accordingly to maintain this injection rate until the wireline snapped and the test was stopped.

Due to the test results demonstrating a lack of permeability, 83-11 has been utilized as a pressure monitoring well outside of the production area of the Coso geothermal field. Comparison of the 83-11 downhole pressure data over time with the pressure data from the main portion of the Coso geothermal field demonstrates a lack of pressure connection between the two (Figure 15). Seasonal changes in the pressure monitoring data from 83-11 can be seen in the data, but the decline in pressure from the main field is not reflected in 83-11.

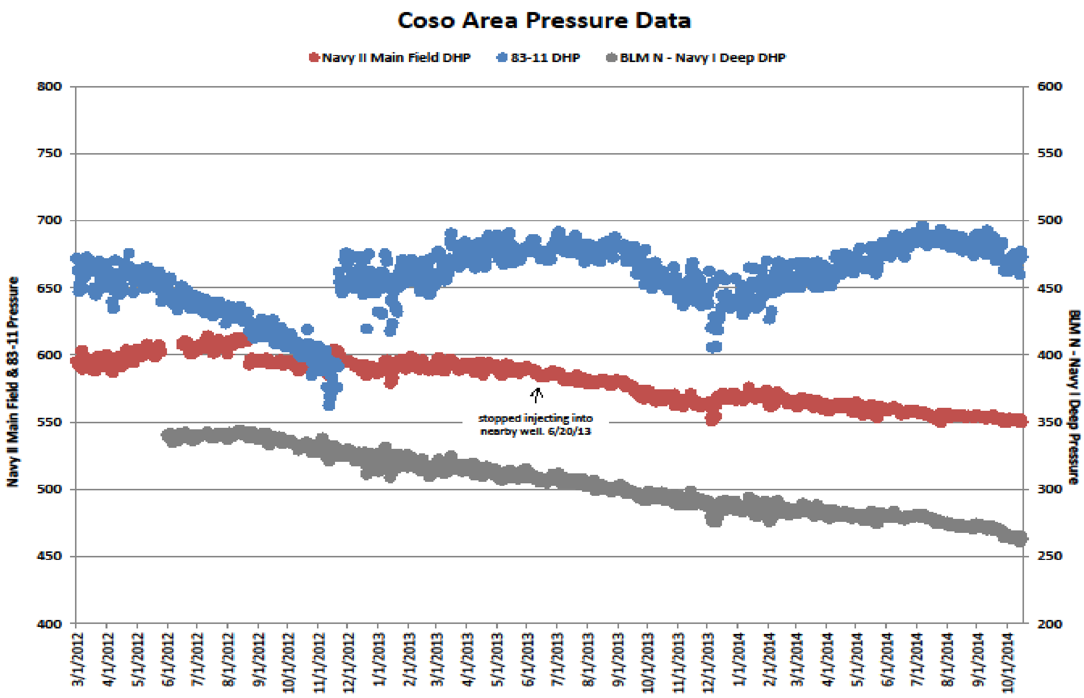


Figure 15. Downhole time-series pressures in well 83-11 (blue) compared to other portions of the Coso geothermal field. Coso geothermal field (red and grey). Note how with the exception of seasonal cycling resulting in a downward trend of pressures from Nov. 2012 through Oct. 2014, pressures in well 83-11 remain relatively unchanged while wells from the Navy II portion of the field (red) and BLM north portion of the field (grey) show a steady decline.

Finally, simple 1-D analytical solutions for advective heat transport within the undisturbed eastern margins of the Coso geothermal field under thermal and depth conditions similar to those in the West Flank were performed. These data suggest that zones with upward convex or concave temperature profiles indicative of significant hydrothermal convection have permeabilities ~10^{-15} m^2 or greater, whereas approximately linear temperature profiles indicative of dominantly conductive heat and fluid transport require permeabilities ~10^{-17} m^2 or lower (Davatzes and Hickman, 2010). Based on the conductive temperature profile seen in well 83-11 at depths of 1.3 to 2.4 km (Figure 10), it is inferred that the permeability near well 83-11 is significantly less than <10^{-16} m^2.

In summary, the injection tests paired with the pressure interference data and calculated permeability based on the conductive temperature profiles demonstrate low permeabilities in the West Flank FORGE area and a lack of connectivity between the West Flank and the Coso geothermal field.

Multiple tests were conducted on the 83-11 well and the instrumentation used throughout these tests were good quality. These data have consistent results for low permeability within the West Flank FORGE site; this consistency demonstrates low uncertainty within the permeability data.

5.1.7 Geophysical data

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant		✓	✓	✓	✓	✓

Geologic structures and contacts juxtapose rocks of differing properties, and if the rocks differ in density or magnetism it can cause a measurable change within geophysical data. At the West Flank FORGE site, the regional geologic structure includes strike-slip faults, steeply dipping normal faults, and vertical to sub-vertical dikes and intrusive contacts, all of which may be expected to be identified in the potential field, electromagnetic, seismic reflection surveys and microseismic data.

5.1.7.1 Gravity

Regional gravity data was collected across the West Flank as part of a study of southern California (Snyder et al., 1981). There are 136 gravity stations within and surrounding the West Flank FORGE site (Figure 16), with an average spacing of 500 m. More recently, Monastero conducted a higher resolution, local gravity survey across the CVF (Monastero et al., 2005). The survey contains 237 gravity stations within and surrounding the West Flank FORGE site (Figure 16), with an average spacing of 260 m.

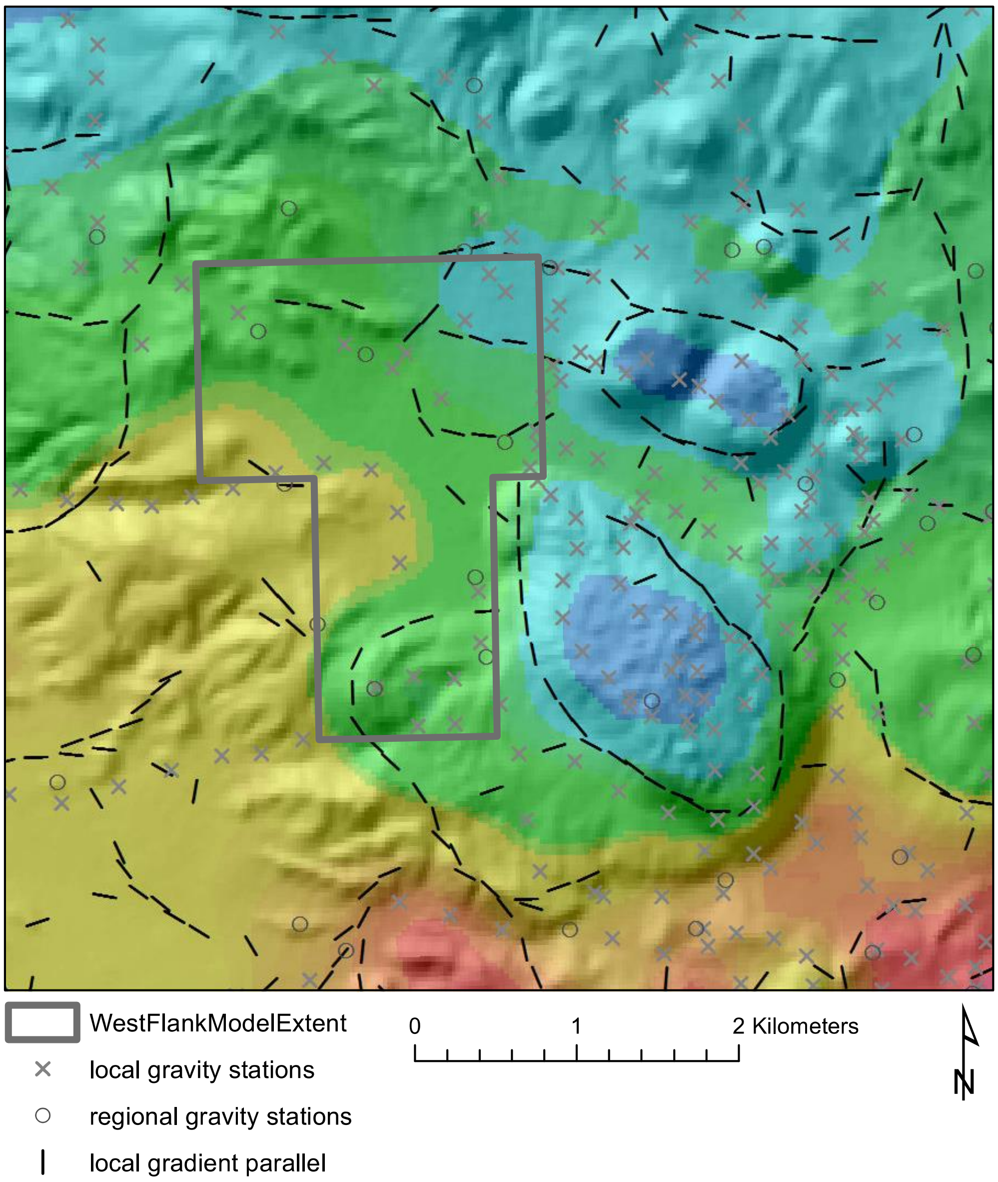


Figure 16. Isostatic residual gravity anomaly for the West Flank FORGE study site and surrounding area. Warm colors indicate higher gravity anomaly values, cool colors lower values.

The isostatic residual gravity anomaly from Snyder et al. (1981) reflects density variations in the upper 10 km of the earth's crust. It is derived from the complete Bouguer anomaly by removing the gravitational component due to isostatic compensation of topography (Jachens and Griscom, 1985). The isostatic residual gravity anomaly is inverted in this study to estimate the shape and depth of basins in the West Flank. The gravity station spacing yields a Nyquist frequency ~1 km, and therefore larger geologic structures, i.e., those that generate greater than 1 km wavelength signals have the possibility of being detected with this gravity dataset.

Regional gravity data were reduced using the Geodetic Reference System of 1967 (International Union of Geodesy and Geophysics, 1971) and referenced to the International Gravity Standardization Net 1971 gravity datum (Morelli, 1974). Gravity data were reduced to complete Bouguer gravity anomalies (Plouff, 1977) with a reduction density of 2670 kg/m^3 by applying earth-tide, instrument drift, free-air, Bouguer, latitude, curvature, and terrain corrections. An isostatic correction, following the method and parameters used by Jachens and Griscom (1985), was applied to produce the final isostatic gravity anomaly. Assuming a sea level crustal thickness of 25 km based on seismic profiles, a crustal density above sea level of 2670 kg/m^3, and a mantle-crust density contrast of 400 kg/m^3, the correction removed the long-wavelength gravitational effect caused by isostatic compensation of topography. The local gravity data are reduced to the complete Bouguer anomaly rather than the isostatic residual gravity anomaly. For study areas of a few tens of kilometers and moderate relief, as exhibited across the CVF, the two anomalies are equivalent.

Gravity data were acquired at individual locations on the ground throughout the West Flank site, resulting in a scattered data set. After the data are reduced to the complete Bouguer gravity anomaly, the scattered data are interpolated using a tension spline (Geosoft, 2016) to generate an estimate of the complete Bouguer gravity anomaly (referred to as the “gravity anomaly” for the remainder of this document) at any given point in the West Flank.

The gravity anomaly highlights regions of relatively high and low density (Figure 15), and, as noted previously, steep gravitational gradients between these regions can be indicative of steeply dipping geologic structures or unit contacts. To find regions of locally steep gradients the local curvature of the gravity anomaly was analyzed using the method of Phillips (2007). According to this method, a neighborhood of cells from the gravity anomaly grid is examined, and the best-fit 2nd order polynomial surface is returned, including the direction of elongation of the polynomial for the cell neighborhood. This direction of elongation is perpendicular to the direction of maximum gradient. The direction of elongation is estimated for every cell neighborhood in the gravity anomaly that exhibits a steep gravitational gradient. Linear gradients show up as a series of aligned elongation directions across several cell neighborhoods. These linear gradients indicate the location of abrupt changes in density from a steeply dipping geologic contact of some kind (fault, unconformity, depositional) at the surface or in the subsurface.

Figure 16 shows the gravity anomaly with local gradients symbolized by a short black line parallel to the direction of least change (maximum change occurs perpendicular to the line). The short black lines are referred to as gradient maxima. Larger geologic structures can be demarcated by an alignment of local gradient maxima into dashed lines. The aligning of gradient maxima can produce somewhat noisy patterns on the map, but larger geologic features can be distinguished. For example, the edge of Sugarloaf rhyolite dome is clearly visible, as is a major west-to-northwest trending structure that crosses the northern portion of the West Flank FORGE site. The resolution of the gravity anomaly is approximately the average data spacing, 260 m. The value of the gravity anomaly between stations can be approximated by different interpolation methods, and these different methods give rise to an estimated variability of less than 500 microGals for a station spacing of approximately 250 m (Phelps et al., 2005). The uncertainty increases where the station spacing is sparser, as it is across the West Flank FORGE site.

5.1.7.2 Magnetism

In 1994 a high-resolution aeromagnetic survey was flown over the West Flank, and the following details are available regarding the dataset from Katzenstein, Monastero, and Jachens (written communication, 1994). The dataset has a line spacing of approximately 540m with a primary direction of N65E and roughly 10% tie lines. The flight height was ~250 m, suggesting that geologic structures exhibiting a magnetic signature can be resolved at a depth ~250 m or greater. The data spacing is too great for resolving shallower structures in a direction perpendicular to the flight lines. The data were corrected for diurnal and atmospheric magnetic variations. The metadata do not indicate whether the data were leveled or not. The International Geomagnetic Reference Field was subtracted from the data to yield local magnetic anomaly values. The values were then interpolated using a tension spline (Geosoft, 2016) to generate an estimate of the total magnetic field anomaly (referred to as the "magnetic anomaly" for the remainder of this document) at any given point in the West Flank.

The magnetic anomaly, along with gradient maxima, is shown in Figure 17. A northwest trending structure that cuts across upper part of the West Flank FORGE site is visible as is a north-south structure on the west side of Sugarloaf dome.

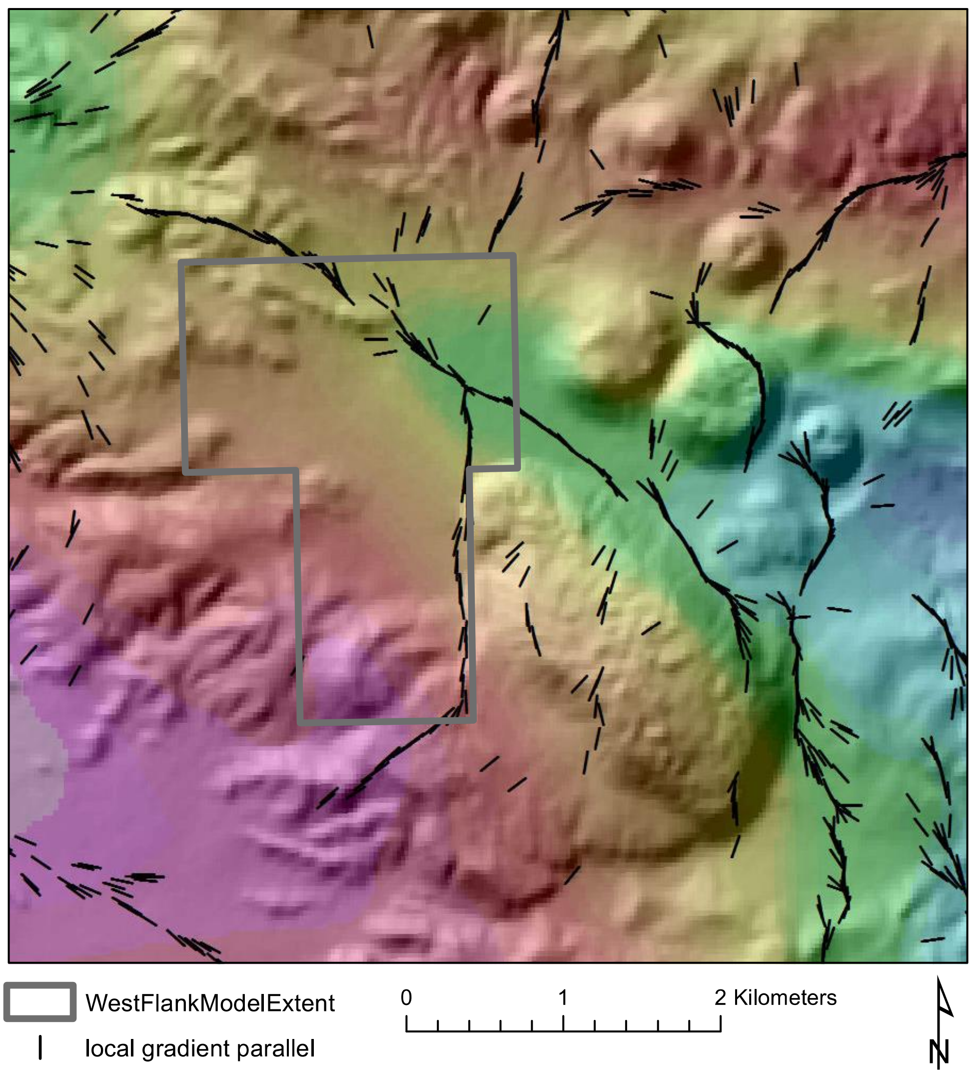


Figure 17. Aeromagnetic anomaly for the West Flank FORGE site and surrounding area. Warm colors indicate higher magnetism, cool colors lower magnetism.

5.1.7.3 Potential Fields Discussion

The gravity and magnetic anomalies highlight significant geologic structures in the West Flank FORGE area. Gradients from both gravity and magnetics demarcate many of the boundaries of mapped rhyolite domes (Figure 18). Sugarloaf is completely bounded by gravity gradient maxima and is almost completely bounded by magnetic gradient maxima. On the west side of Sugarloaf, the eastern edge of the FORGE site, the gradients are oriented north-south, supporting the concept of a structural feature, possibly a hydrologic barrier, between the West Flank FORGE site and the Coso geothermal field. This north-south structure truncates against a northwest alignment of magnetic gradient maxima that extend from the northeastern edge of Sugarloaf. Gravity gradient maxima are partially coincident with these magnetic gradient maxima, although they trend west-northwest and align with the southwestern edge of three collinear rhyolite domes north of Sugarloaf.

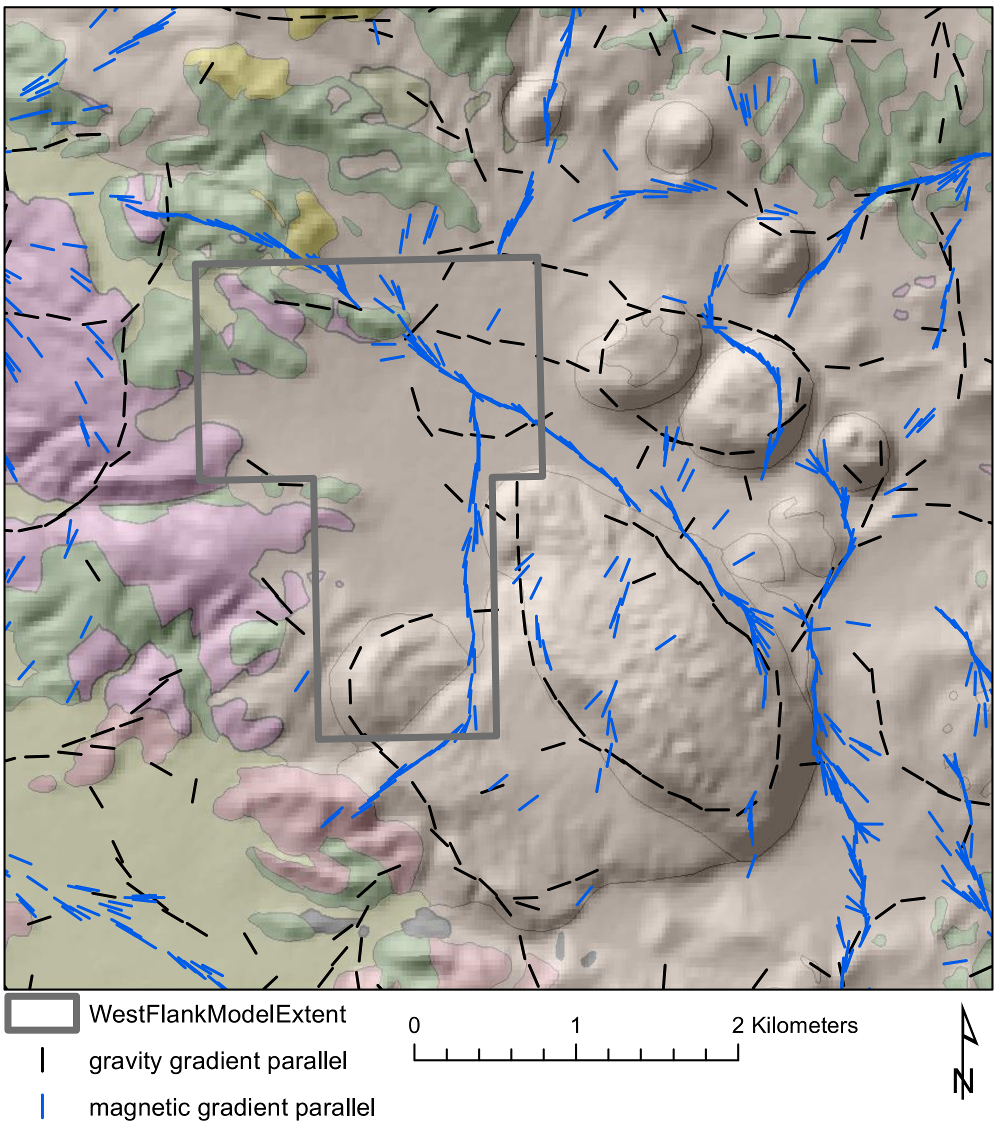


Figure 18. Local gradient maxima for the gravity (*black*) and magnetic (*blue*) anomaly in the vicinity of the West Flank FORGE site. Geology is from Whitmarsh, 1998.

The gravity gradient maxima appear to highlight the edges of rhyolitic features in the vicinity of the FORGE site. This implies that the gradient maxima observed overlying Quaternary pyroclastic material highlight the edges of rhyolitic bodies. The magnetic gradient maxima highlight the edges of some of the rhyolite domes, particularly Sugarloaf, but also align along longer, more continuous gradients. These gradient maxima are likely associated with larger geologic structures and may reflect changes in the underlying Jurassic and Cretaceous intrusive rocks.

The preexisting gravity and magnetic data sets and Phase 1 interpretations continue to provide insight into the structural setting within the West Flank FORGE site. A thorough understanding of the structure within this area is very important for the building of the conceptual model and will be important for future phases of FORGE.

5.1.7.4 Seismic reflection

Forty-five (45) line-km of seismic reflection data were collected in the Coso Range in 2001. The initial analysis and interpretation of these data was performed by Unruh et al. (2001). Optim processed these data by inverting the P-wave first arrivals to create a 2-D velocity structure. Kirchhoff images were then created for each line using velocity tomograms (Unruh et al., 2001).

Three seismic reflection profiles, lines 109, 110 and 111, are close to the West Flank FORGE site. Line 110 passes through the site (Figure 19). The acquisition of these data over an area with volcanic and intrusive rock is not the usual application of this technology. The oil and gas industry have used seismic reflection for decades to identify structures within sedimentary environments where the changes in lithology, faults and other structures are commonly imaged as strong reflectors and/or discontinuities in reflection character. In the West Flank, however, imaging is generally poor as a result of high acoustic attenuation due to the shallow volcanic material and/or low impedance contrasts within the plutonic section. However, the contact between the Pleistocene rhyolite lava flows and domes is evident is all three profiles, as are several faults (Figure 19-Figure 22). Interpretation of these data is more comprehensive when the data are integrated with regional mapping, well data, and other geophysical methods. From these preexisting data, and Phase 1 interpretations, faults and lithologic contacts provide insight into the crystalline basement criteria, as well as, continue to help build the structural framework of the West Flank.

Seismic resolution or uncertainty is the ability to distinguish separate features, or the minimum distance between two features so that they can be defined separately. Seismic resolution is controlled by wavelength (e.g., Yilmaz, 2001). In order for two nearby reflective interfaces to be distinguished well, they have to be about 1/4 wavelength in thickness (Rayleigh Criterion). The dominant frequency in profiles analyzed for this project is ~20 Hz. Typical velocities are about 4 km/sec. Since wavelength equals velocity divided by frequency, a typical wavelength would be about 200 m. This would, in turn, imply that the resolution may be as good as ~50 m in the thin basin-fill sediments, but probably significantly poorer in the underlying volcanic and plutonic rocks, where the seismic signals were largely attenuated resulting in very poor imaging of any contacts and structures in the volcanic and plutonic rocks.

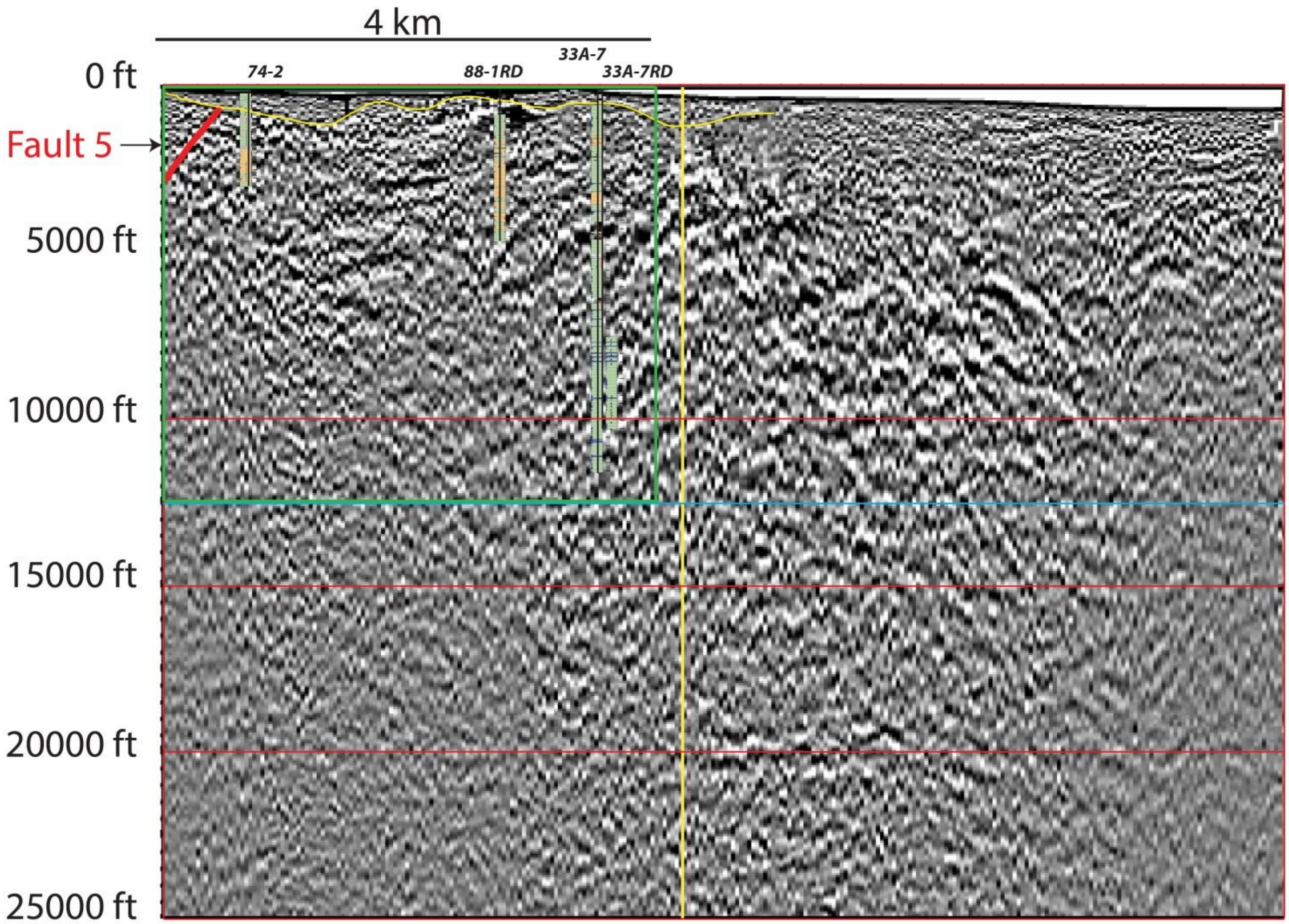


Figure 19. Seismic reflection profile 109. Horizontal blue line represents the base of the 3D geologic model. Green box indicates the section of the profile within the 3D geologic model. Vertical yellow line indicates bend in the section.

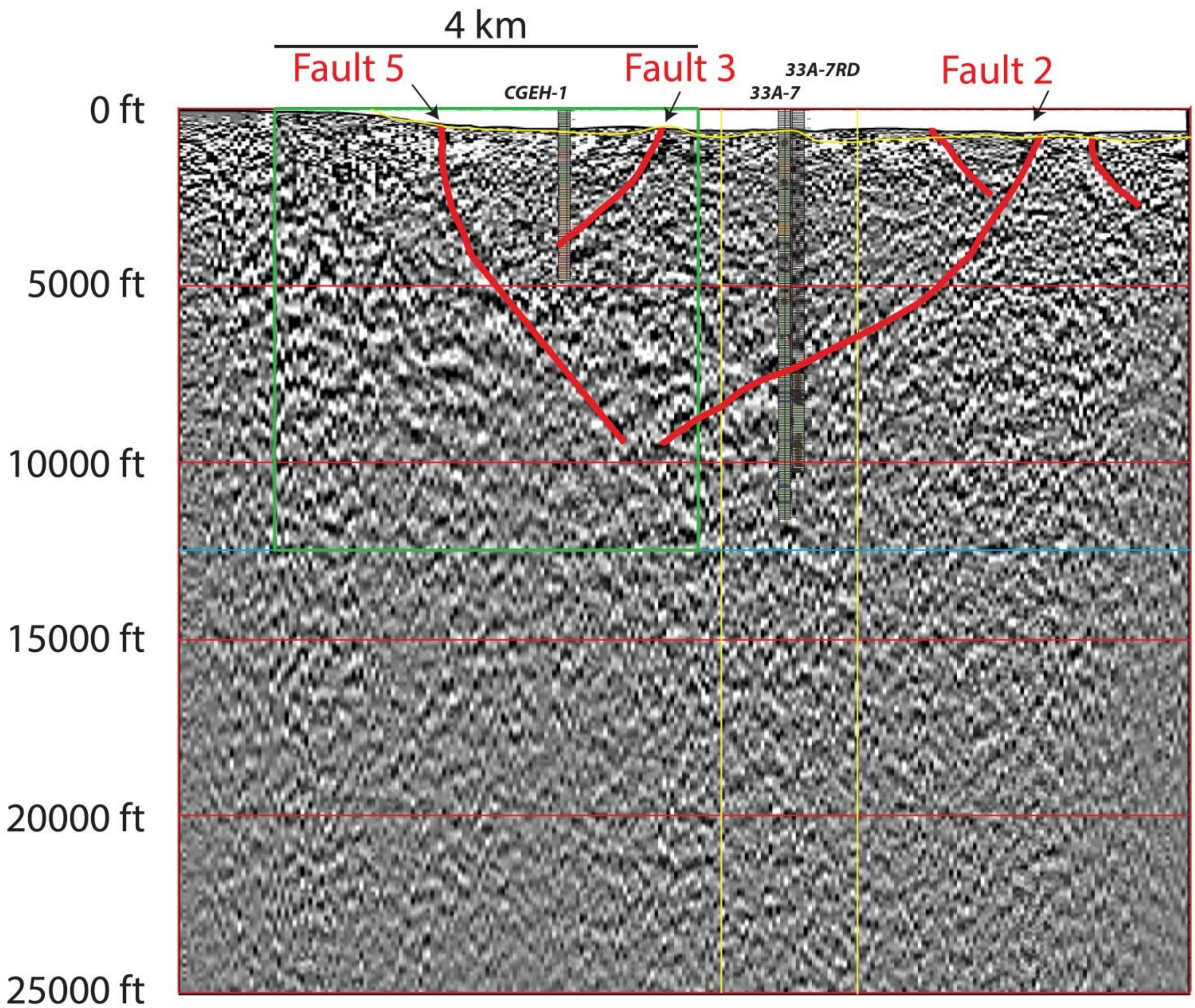


Figure 20. Seismic reflection profile 110. Horizontal blue line represents the base of the 3D geologic model. Green box indicates the section of the profile within the 3D geologic model. Vertical yellow lines indicate bends in the section.

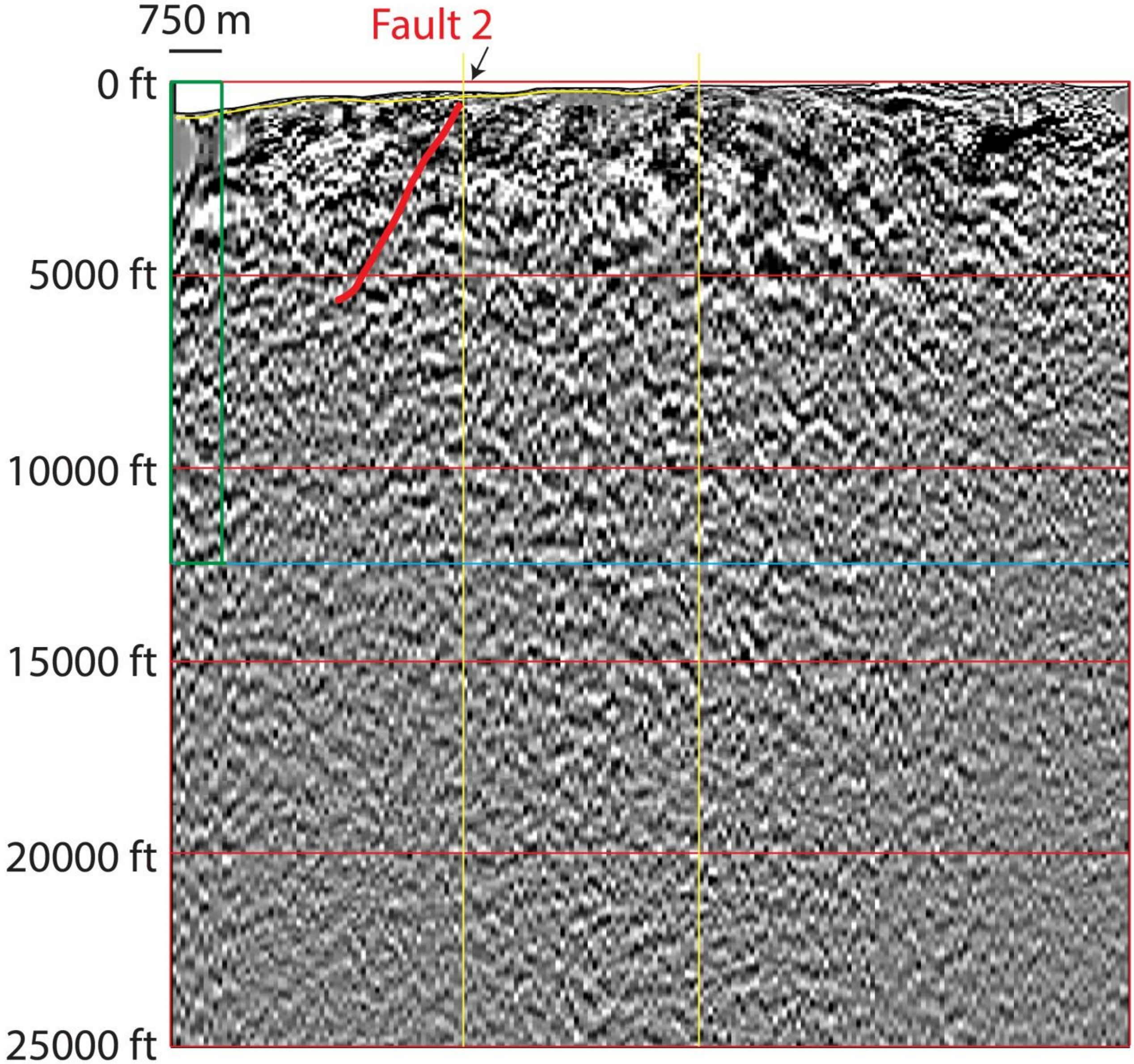


Figure 21. Seismic reflection profile 111. Horizontal blue line represents the base of the 3D geologic model. Green box indicates the section of the profile within the 3D geologic model. Vertical yellow lines indicate bends in the section.

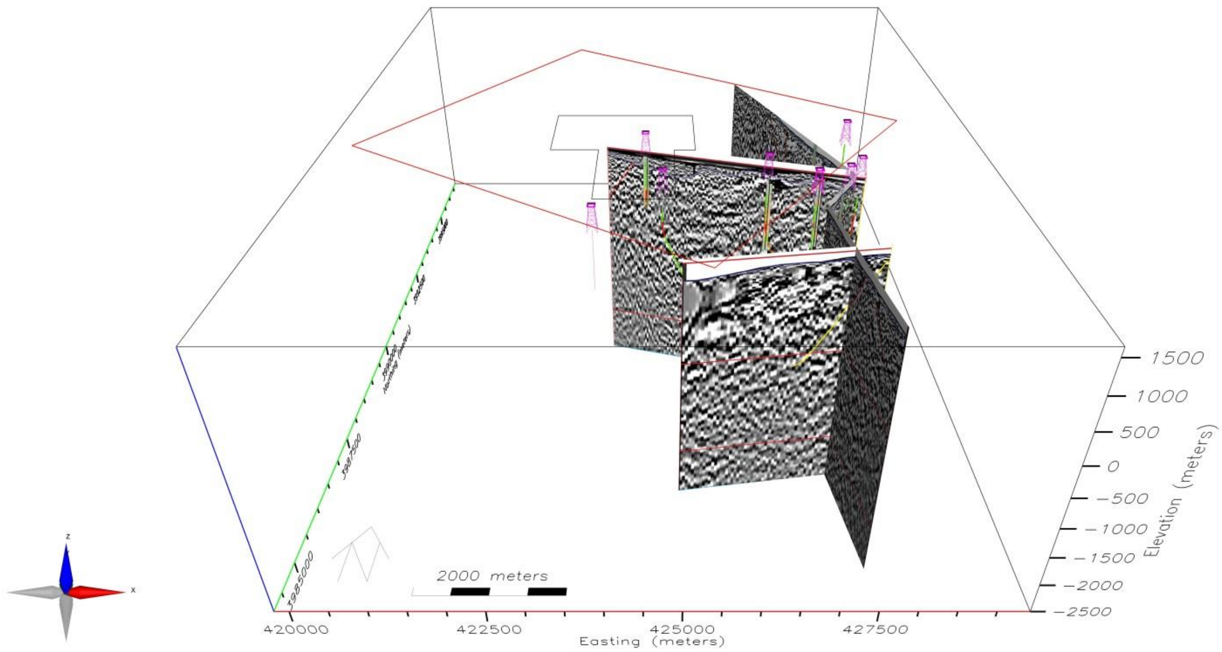


Figure 22. Seismic reflection profiles 109, 110 and 111 projected in 3D space. Red box is the extent of the 3D geologic model. Black polygon indicates the West Flank FORGE site.

5.1.7.5 Magnetotelluric (MT)

The Coso geothermal field has had three Magnetotelluric (MT) datasets collected including surveys in 2003, 2006, and 2011. The final collection, in 2011, expanded the survey to the west and covers the West Flank of FORGE area (Figure 23). This most recent data set was collected by Schlumberger/WesternGeco and inverted by the WesternGeco GeoSolutions Integrated EM Center of Excellence in Milan, Italy; the 2003 and 2006 data were integrated for these inversions in the present study.

MT data is collected to determine the resistivity or conductivity of the subsurface. The resistivity signatures of rocks can depend on the salinity of groundwater within the rock, saturation, alteration and porosity. Within the Coso geothermal field, the MT data was used to map the clay cap over a hydrothermal system and to determine areas of upflow into this system.

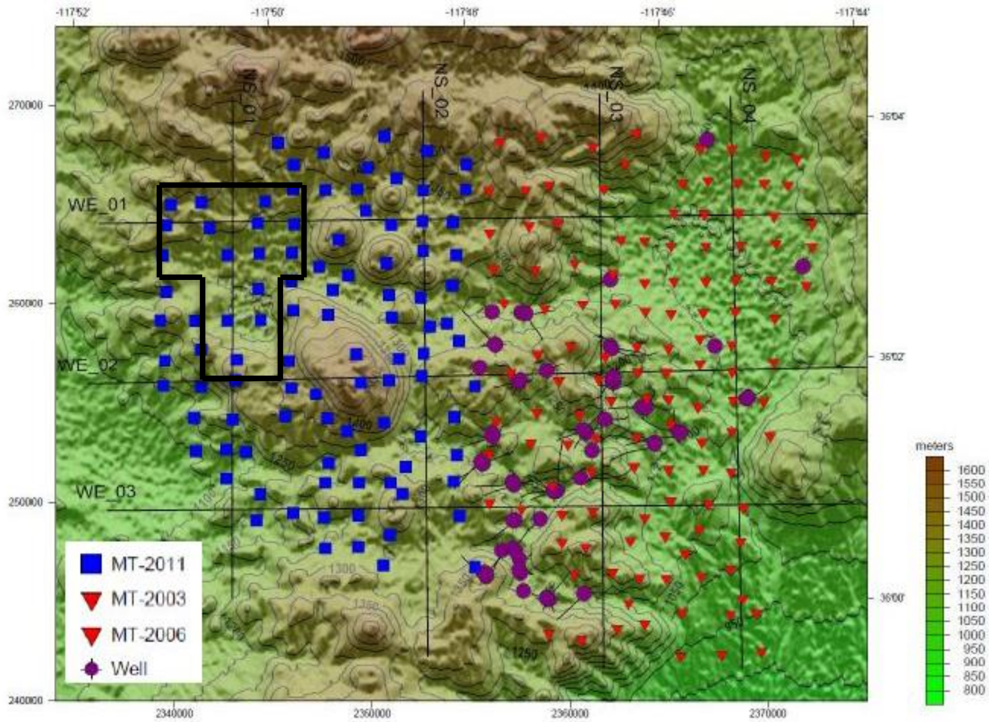


Figure 23. MT survey points throughout the Coso Volcanic Field starting in 2003 through 2011. The West Flank FORGE test area polygon is pictured for reference.

For the MT survey, full impedance tensor data were inverted in the 1-3000 Hz range. Several noise sources were identified, specifically the DC powerline that is ~6,000 meters (20,000 feet) west of the survey area, and may have affected data in the 0.02 to 10 Hz range. Subsequent analysis of the data points and modeling in the proximity of this powerline has demonstrated the effect of this noise source (Newman et al., 2008, Lindsey and Newman, 2015). However, data collected in the West Flank portion of the field is well outside the interference from this noise source. For the most recent analysis, 3D model cell dimensions of 450 x 450 x 65 feet were used to avoid computational instability. The fit between calculated and observed MT values for the final model run had an RMS value of 1.807.

The data produced interesting results within the West Flank FORGE test area. The conductive clay cap is visible in the MT data throughout the Coso geothermal field but does not seem to extend into the West Flank area (Figure 24). Interpretations of this MT data set suggest an upflow to the northwest of the Coso geothermal field with weak outflow toward the West Flank. The lack of conductivity, based on these MT data, on the West Flank suggests a lack of porosity in the site, especially when paired with the petrographic data that demonstrates a lack of fluid flow within veins in 83-11and the conductive temperature profile of 83-11; the combination of these data sets continue to suggest low permeability in the West Flank.

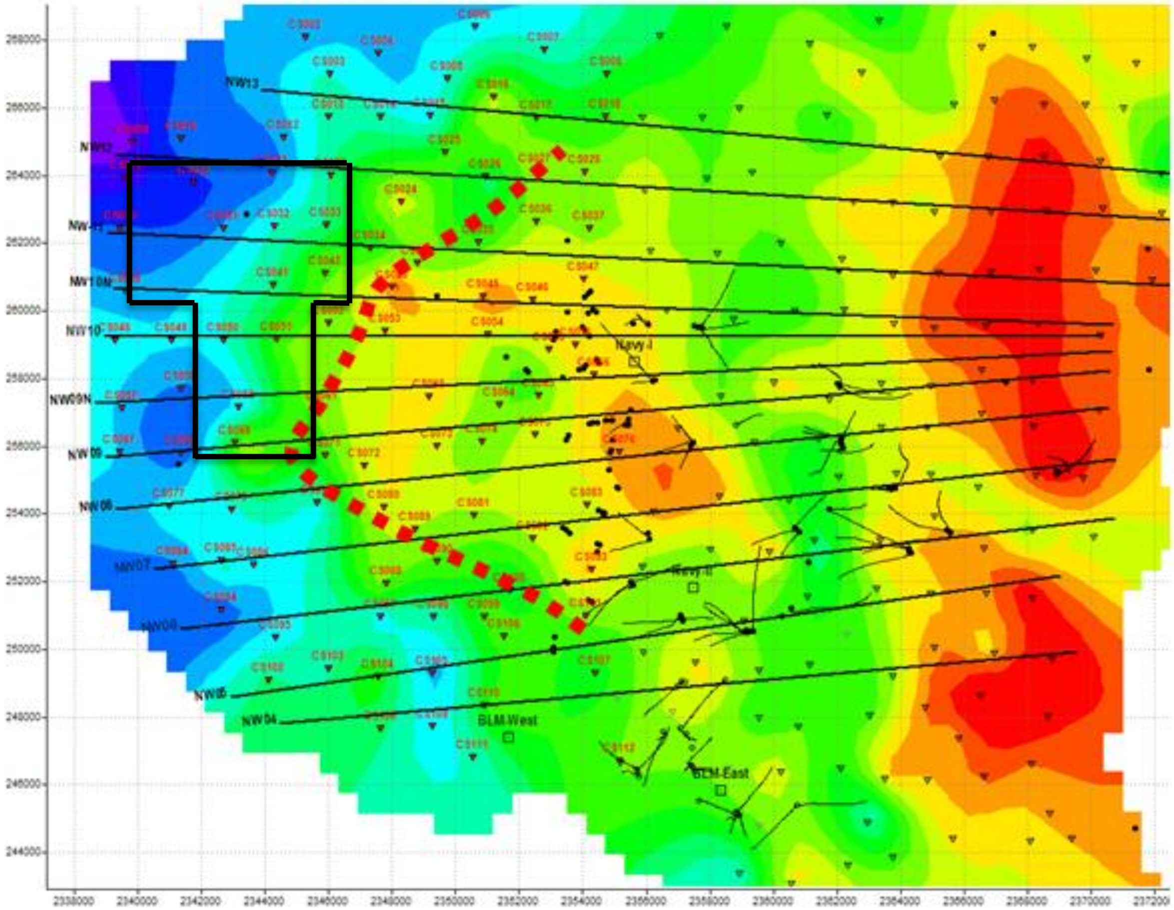


Figure 24. Map of MT conductance at ~600 meters depth of a 1D inversion. The red dashed line is the mapped extent of the hydrothermal system at Coso. The West Flank FORGE test polygon is drawn on top for reference.

The uncertainty within this data set is from the noise of the power line that runs through the middle of the Coso geothermal field. The portion of the data set that is of interest to this project is outside of the data points affected by this noise source.

5.1.7.6 Micro-earthquake (MEQ)

The microseismic network installed at the Coso geothermal field extends beyond the field into the West Flank FORGE site and provides a great data set for the FORGE project. The rate of seismicity in the greater Coso region is very high, with several earthquakes of significant magnitude as evident from the historic seismic catalog (Figure 25 and Figure 26). Figure 25 shows the past 80 years of seismicity recorded on the USGS Southern California Seismic Network (SCSN). Several significant earthquakes have occurred in the region with the two largest, 1946 and 1995, M6.3 and M5.8 (which followed a M5.4 earthquake a month prior), respectively occurring outside of the proposed West Flank site and also well outside of the neighboring Coso geothermal field. Within the adjacent Coso geothermal field no earthquakes with M>5.0 are recorded, but moderate earthquakes with M>4.0 do occur within the proposed West Flank FORGE site (Figure 25).

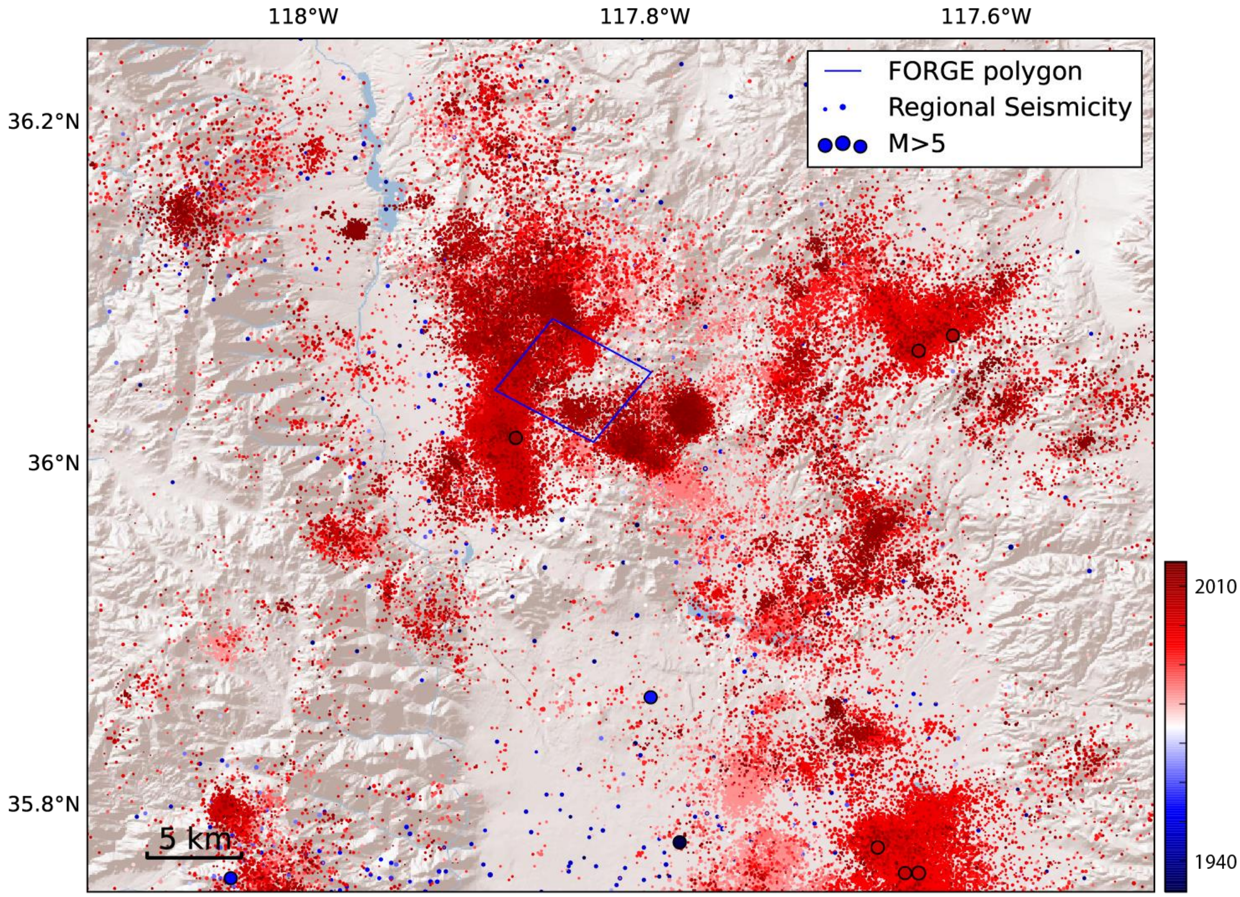


Figure 25. Seismicity in the greater Coso area recorded on the USGS Southern California seismic network from 1932-2012 showing the extent of West Flank FORGE 3D geologic model (outlined in blue rectangle). Colors indicate time (1932/ blue to 2012/red) and the size of dots indicates magnitude. Significant earthquakes (M>5.0) are plotted as larger, circled dots.

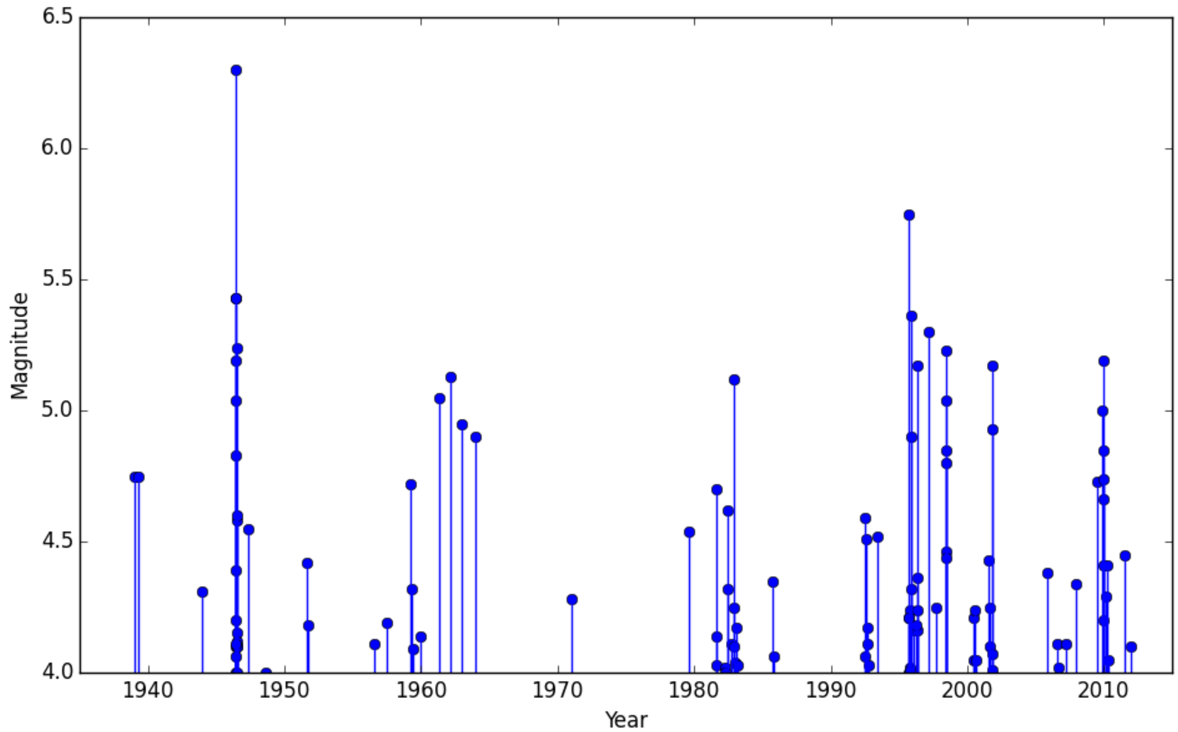


Figure 26. Significant earthquakes (M>=4.0) in the last 80 years in the greater Coso area from the USGS SCSN catalog (all within area shown in Figure 2).

Seismicity near the West Flank site occurs both tectonically and as a consequence of injection and production within the field (Monastero et al., 2005). Several studies have used data recorded by the GPO and the regional Southern California Seismic Network to analyze earthquakes within and adjacent to the Coso geothermal field, improve hypocentral locations, and invert for the velocity structure of the greater Coso area (e.g. Lees, 1998; Wu and Lees, 1999; Hauksson and Unruh, 2007; Seher et al., 2011). Other studies have focused on improving hypocentral locations and obtaining moment tensors for microseismicity associated with individual hydraulic fracturing events (Foulger et al., 2008; Julian et al., 2010). While the USGS-SCSN network captures the regional seismicity well and provides the historic catalog for the area, even lower magnitude seismicity has been recorded reliably by the Navy GPO since 1996. On average, the Navy GPO network detects roughly four times the amount of microseismic events that the SCSN does. For example, there are events as small as Ml-0.8 routinely detected and located in the proposed West Flank FORGE site (Figure 27).

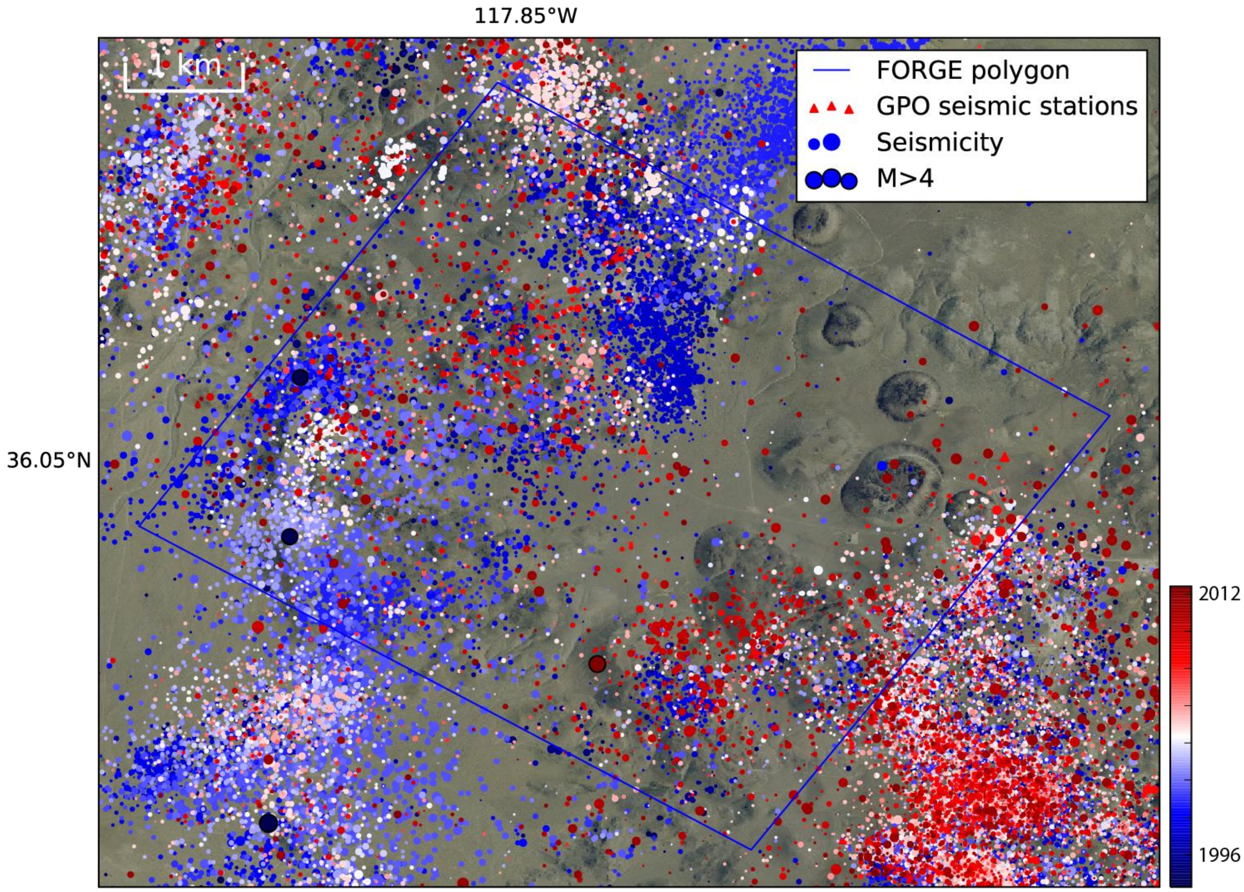


Figure 27. Seismicity in the Coso West Flank FORGE area recorded on the Navy GPO local seismic network from 1996-2012. Colors indicate years (1996 – blue to 2012 red) and size of dot indicates magnitude.

The Navy GPO passive seismic monitoring system has been in service since the 1990s and has been updated throughout its service. It currently consists of 18 stations, 14 of which are installed in boreholes, with all boreholes hosting 3-component 4.5 Hz geophones. Trigger-recorded data are telemetered to central processing system in the Navy GPO office in real-time and subsequently reviewed by the seismic analysts within the Navy GPO. Data are recorded at 250 samples a second at all stations and the network detects events with magnitudes down to roughly Ml-0.8. The system is capable of collecting data that can be used to locate events with a precision of down to 100 meters. Subsequent analyses of the data permit studies that derive source parameters and fault plane solutions.

The full GPO catalog from April 1996 to May 2012 consists of over 140,000 processed events, including regional events and teleseismic events. Kaven et al (2014) obtained absolute re-processed locations for a total of 83,790 of these events within the CGF over from April 1996 to May 2012. To ensure that hypocentral parameters (absolute locations and origin times) are of comparable quality throughout the period of interest Kaven et al. (2014) used a consistent and reliable one-dimensional velocity model derived from bootstrapping velocity inversions to locate all events (Figure 28). The analysis shows that consistent measures of hypocentral parameters and a reliable starting velocity model are indispensable ingredients in generating reliable earthquake relocations and velocity inversions, without which even single-event locations can produce flawed result (Kissling et al., 1994).

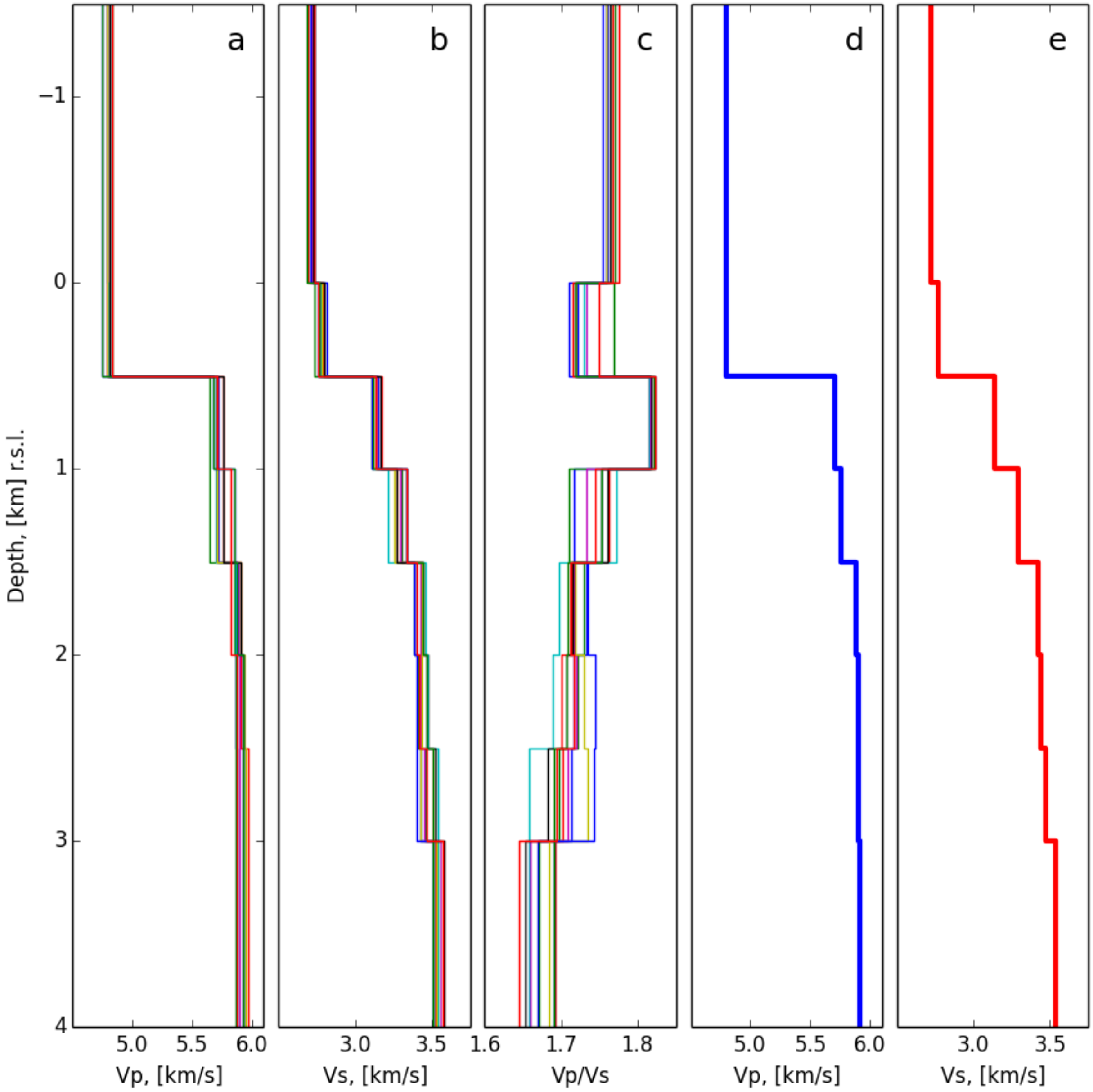


Figure 28. Bootstrap derived 1D velocity model derived using randomly selected seismic events throughout the Coso geothermal field. a) Set of P-velocity models; b) set of S-velocity models; c) resultant Vp/Vs models; d) average P-velocity from bootstrapping results; e) average S-velocity from Kaven et al. (2014).

The work by Kaven et al. (2014) reveal a sharpened image of the Coso geothermal field that includes major, and possibly minor, structures that host concentrations of seismicity not evident in the initial GPO catalog alone. However, a large portion of the seismicity remains diffuse away from major structural features. This suggests that seismicity generated throughout the hydrothermal reservoir east of the West Flank occur on small-scale features, i.e. small-displacement faults and fractures.

A large number of small to moderate seismic events occur in the southeastern portion of the proposed West Flank site (Figure 27). Seismicity is restricted to the 4-5 km depth and is predominantly microseismicity (M<2.0). This region is separated by a nearly aseismic region from the Rose Valley swarm to the west that has experienced a large amount of naturally occurring seismicity with some moderate sized earthquakes.

The hypocentral parameters of any seismic event, i.e. location and origin time, have a number of factors contributing to the location uncertainties. The major factor contributing to the location uncertainty is the velocity model used to locate seismic events. Location of seismicity and inversion of the seismic velocity structure is a nonlinear problem and thus strongly dependent on the initial 1D velocity structure. We compute the 1D velocity model solution that minimizes travel time residuals during the simultaneous velocity estimation and event location (Kissling et al., 1994). We carry this procedure out for a suite of randomly selected events within the reservoir to establish a consistent and reliable starting model for our subsequent analyses (Figure 29)

We invert for velocities over vertical increments of 0.5 km and thereby attain a finer vertical resolution than used in the reference model (Julian et al., 2008), which has varying resolution but a 1 km vertical resolution for most segments. Errors associated with the timing of arrivals are generally small, on the order of a few time samples or 5ms, and are part of the error estimation in the numerical inversion routine. We further use stringent convergence criteria for the inversion scheme to ensure stable event location solutions.

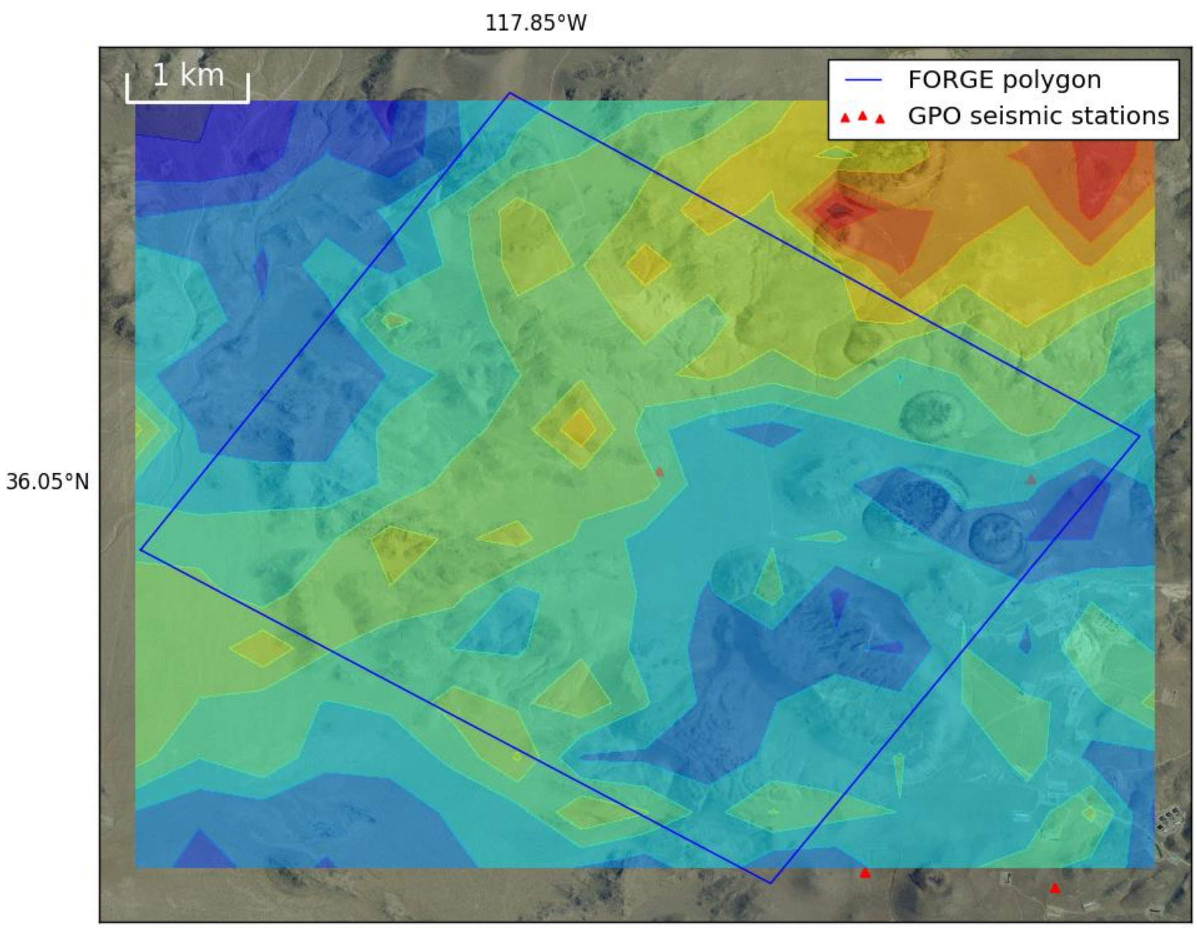


Figure 29. Horizontal uncertainty of event locations quantified by taking the logarithm of event location uncertainties within a bin normalized by the number of events in the bin. Blue regions generally have horizontal location uncertainties of less than 100m

The recording station configuration is fixed in space and distances from a seismic event origin to each station can vary significantly. The distances and network aperture affect location uncertainties by contributing to errors in the travel path (velocity model effects) and the timing of the wave arrivals. Therefore, hypocentral parameters can vary significantly in space and origin time. We quantify the location uncertainty by taking the logarithm of the location uncertainty normalized by the number of events per bin. We find that horizontal and vertical location uncertainties are similarly related, albeit with depth uncertainties roughly twice that of the horizontal uncertainty (Figure 30). The blue regions depict location errors generally less than 100m horizontally and 200m vertically. The yellow regions in the western part of the West Flank FORGE area depict individual event location uncertainties of 300-500m horizontally and roughly double that vertically. In general, the current network configuration permits seismic event location with low uncertainties both horizontally and vertically; however, a more focused network should be implemented for FORGE activities at the site.

The extensive data set from the preexisting microseismic network within the Coso region provides insight into the structural setting, geology and stress state within the West Flank FORGE area and continues to demonstrate the suitability of this site for future phases of FORGE.

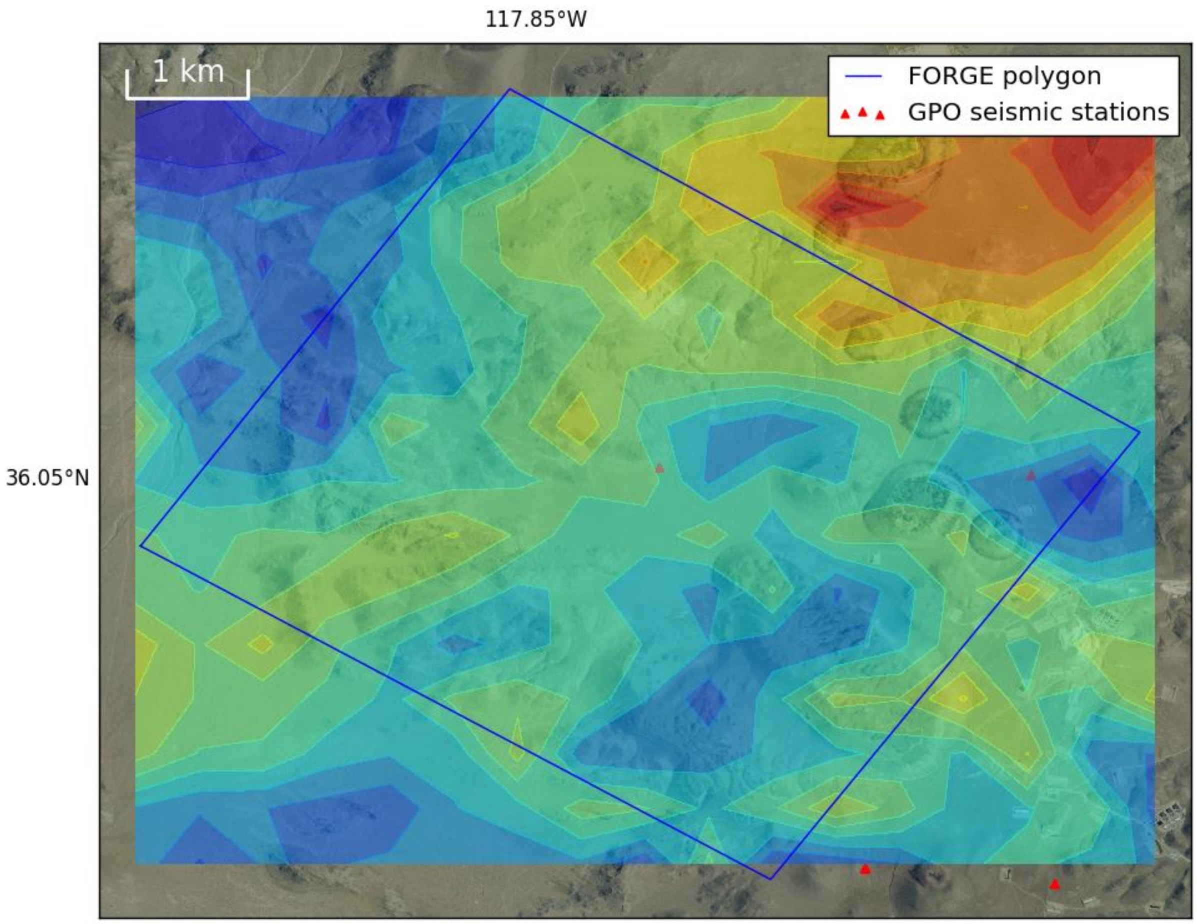


Figure 30. Vertical uncertainty of event locations quantified by taking the logarithm of event location uncertainties within a bin normalized by the number of events in the bin. Blue regions generally have vertical location uncertainties of less than 200m.

5.1.8 Stress state

Two methodologies were used to characterize the stress field at the West Flank. First, we analyzed available data from earthquake focal mechanisms. Second, we analyzed image logging data from wells 33-7, 33A-7, 52B-7 and 83-11 for stress indicators such as borehole breakouts and drilling-induced tensile fractures. Understanding the stress state from both of these methodologies builds a strong foundation for the structural setting of the site. The heterogeneity of the stress state will be important for future work in planning EGS research and gaining a full understanding the subsurface.

The stress field at the Coso geothermal field (CGF) has been studied extensively. Studies were conducted based on the analysis of borehole imagery for stress indicators such as borehole breakouts (BO) and drilling-induced fractures (DIF) (GMI, 2003; Sheridan et al., 2003; Sheridan and Hickman, 2004; Davatzes and Hickman, 2006, 2010 a, b; Blake and Davatzes, 2011; Schoenball et al., 2016) and inversion of focal mechanisms (Feng and Lees, 1998; Unruh et al., 2002). Of the West Flank wells only well 83-11 was analyzed for stress indicators before (Blake and Davatzes, 2011).

Based on stress indicators interpreted from image logs of the Coso East Flank and the Coso Wash areas, an north-south orientation ±20° of the maximum horizontal stress S_{Hmax} has been determined (GMI, 2003; Sheridan et al., 2003; Sheridan and Hickman, 2004; Davatzes and Hickman, 2006; Blake and Davatzes, 2011; Schoenball et al., 2016). Generally, a large heterogeneity along each well has been encountered, with standard deviations of the individual stress indicators on the order of 20-25° around the local mean orientation. In some sections of wells an apparent rotation of the stress field by 90° has been observed (Davatzes and Hickman, 2006) and the direction of S_{Hmax} obtained from wells 38B-9 and 83-16 are outliers with S_{Hmax} oriented at N65°E and N50°E, respectively (GMI, 2003).

Using hydrofrac tests performed in well 38C-9 (East Flank of the Coso geothermal field) Sheridan and Hickman (2004) obtained S_{hmin} = 0.62 Sv, assuming a rock density of 2630 kg/m³. Another hydrofrac test performed in well 34-9RD2 confirmed this low value for S_{hmin} (Davatzes and Hickman, 2006).

To determine the magnitude of the maximum horizontal stress, rock strength parameters are required. Various rock mechanical tests on hornblende-biotite-quartz diorite and biotite granodiorite cores from well 64-16 in the Coso Main Field were performed by TerraTek (2004) to obtain elastic and strength parameters of the tested rock samples. Further testing on granodiorite and diorite cores from well 34-9RD2 was performed by Morrow and Lockner (2006). Davatzes and Hickman (2006) and Davatzes et al. (2006) use results of tests performed on well 64-16 samples benchmarked against in-situ P-wave velocity logs to create an intact rock compressive strength model, allowing them to constrain the magnitude of S_{Hmax} from observations of borehole breakouts. They estimate an upper bound on S_{Hmax} from the absence of borehole breakouts in the East Flank wells and using S_{hmin} values measured during hydraulic fracturing tests in wells 38C-9 and 34-9RD2 to obtain an upper bound for S_{Hmax} at a depth of 2.3 km consistent with a crust that is critically stressed for strike-slip faulting for a coefficient of friction (μ) of 1.0 or less.

Earthquake focal mechanisms can be classified as normal faulting, strike-slip or thrust faulting based on the geometry of the moment tensor, i.e. the orientation of the tension (T), compression (P) and neutral (B) axes. Frohlich et al. (1992) proposed a representation of earthquake focal mechanisms using ternary diagrams to visualize the position of an earthquake in the spectrum of possible mechanisms. We use the focal mechanisms catalog by Yang et al. (2012) that covers the period from 1981 to 2014. Figure 31 shows the ternary diagram of focal mechanisms for the West Flank model area defined by the polygon given by [117.8862°W, 36.0449°N; 117.8524°W, 36.0858°N; -117.7947°W, 36.0544°N; 117.8285°W, 36.0135°N]. We see an abundance of strike-slip and trans-tensional mechanisms. Pure normal faulting mechanisms are rare and no thrust faulting mechanisms are observed.

These mechanisms are in line with the interpretation of the West Flank being situated in a step-over between two strike-slip faults as well as the strike-slip stress regime determined by Davatzes and Hickman (2006) and Davatzes et al. (2006).

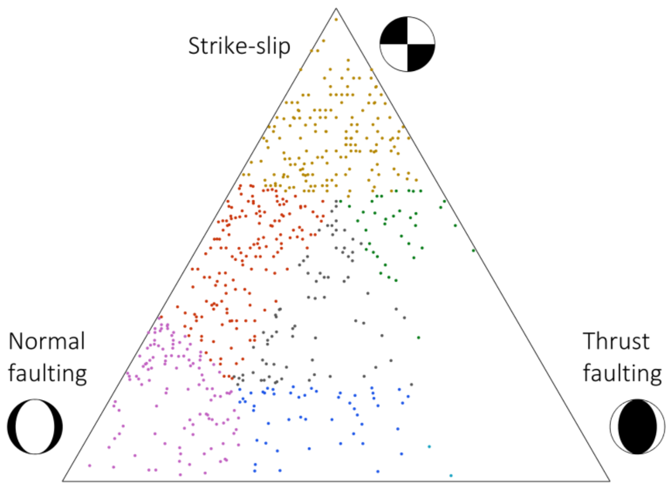


Figure 31. Ternary diagram after Frohlich (1992) of focal mechanisms from Yang et al. [2012] of the West Flank area in the period 1981-2013. Only mechanisms of quality A-C are shown. The colors correspond to the location in the ternary diagram and are the same as those used in Figure 32.

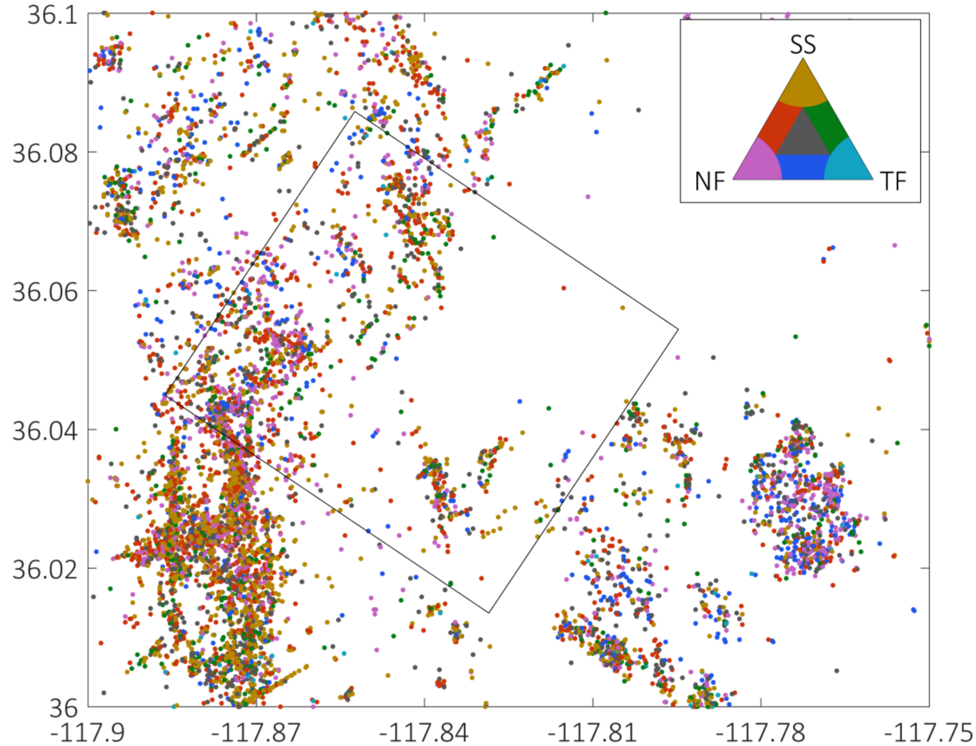


Figure 32. Earthquake focal mechanisms from Yang et al. (2012), colored based on their location in the ternary diagram (Figure 31). The extent of the West Flank 3D geologic model area is outlined by the black rectangle.

Analyses of wellbore failure data were performed for four COC wells in and near the West Flank area: 33-7, 33A-7, 52B-7 and 83-11 (Table 1). The complete methodology and results of these analyses are in Schoenball et al. (2016). The portions of the wellbores analyzed are shown in Figure 33; they span varying depths and wellbore deviations. The most reliable data and analysis came from the 33A-7 geophysical log, and the method used in this analysis are explained below. There were also a number of different geophysical logging tools used; these differences are explained in the well data portion of this report (above). Two runs of the CBIL tool were acquired in 33A-7 over the interval of 2133 to 3142 m MD (see example in Figure 34). The failure pattern in 33A-7 is characterized by long sections of breakouts visible in both the travel time and amplitude images along almost the entire logged interval (Figure 35. Distribution of stress indicators in well 33A-7. (a) Orientations of DIFs (red), PCFs (blue) and BOs (green) versus depth, with horizontal lines representing width of BOs around the borehole wall. Orientations are referenced to the high side of the well. (b) Borehole deviation angle, (c) deviation azimuth and (d) density of natural fractures. Key shows DIF: drilling induced tensile fractures, BO: breakouts, and PCF: petal centerline fractures.

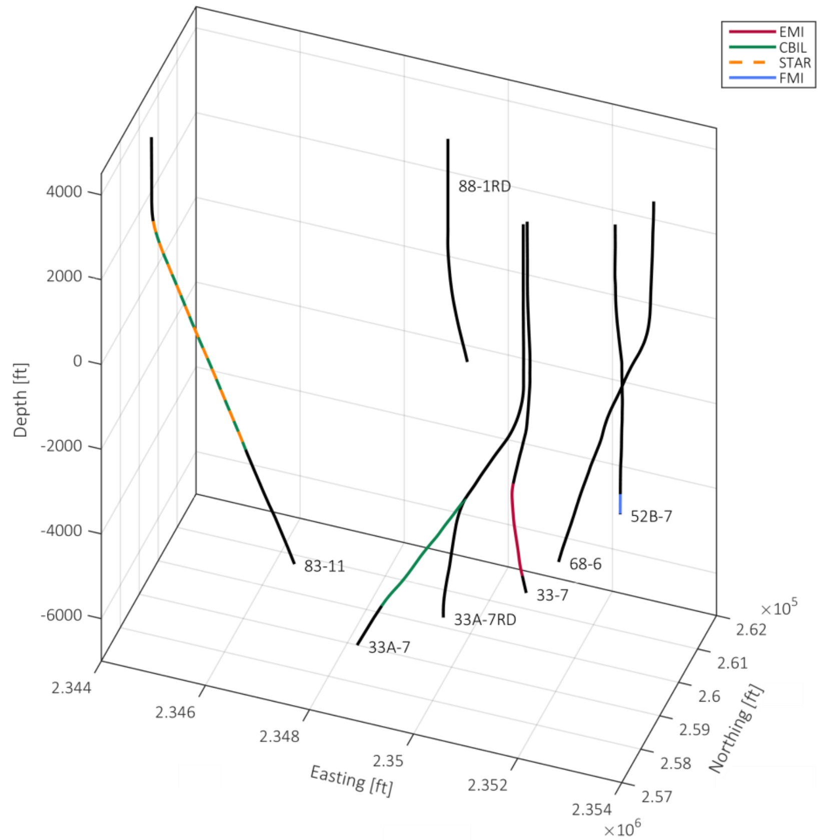


Figure 33. Well trajectories of the wells in the West Flank and the western margin of the active geothermal field. Colored sections mark available image logs that were used for stress analyses.

Table 1. Summary of available borehole image logs, interpretation of stress indicators and the inferred stress states. DIF: drilling induced tensile fractures, BO: breakouts, PCF: petal centerline fractures, WSM Quality: World Stress Map quality ranking. Log types are explained in the text, Well and Lithologic Data section.

Well	*Log type*	*Logged interval [m MD]*	*Typical deviation direction*	*Typical deviation*	*Total length DIFs [m]*	*Total length BOs [m]*	*Total length PCFs [m]*	*Standard deviation [°]*	*SHmax orientation*	*WSM Quality*
33-7	EMI	1886-2806	N340°E	12-25°	40	35	-	21	N5°E	C
33A-7	CBIL	2133-3142	N275°E	29°	71	264	4	17	N8°E	C
52B-7	FMI	2552-2721	N340°E	11°	53	5	-	17	N0°E	B
83-11	CBIL + STAR	604-2097	N100°E	24°	68	9	68	26	N1°E	D

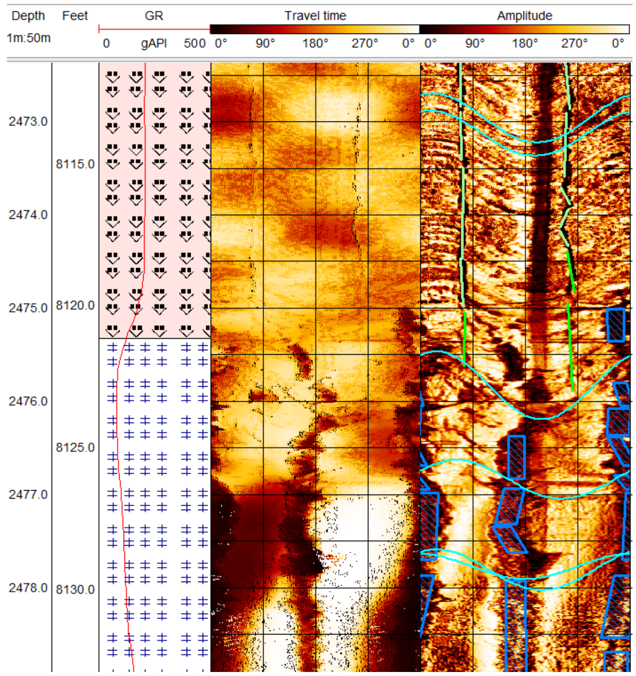


Figure 34. Sample of the CBIL log of well 33A-7 with interpretation of natural fractures (cyan sinusoids), drilling-induced fractures (green lines) and borehole breakouts (blue rectangles). The section shows a transition from a rhyolite dike above to quartz diorite below.

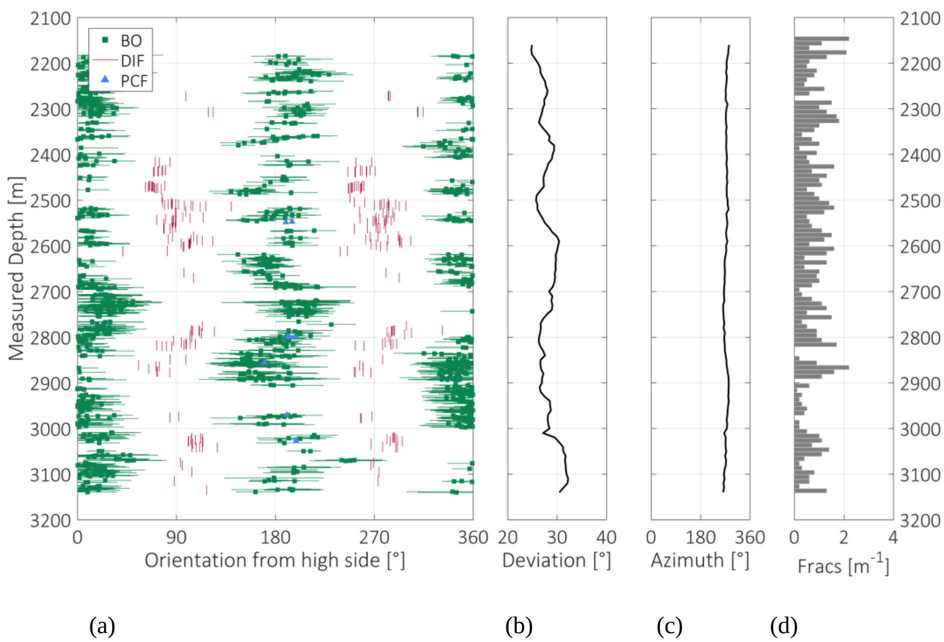
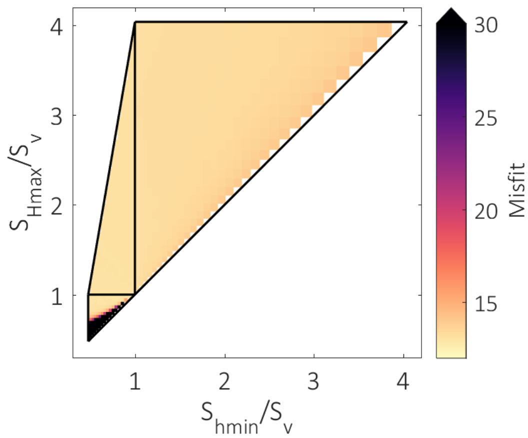
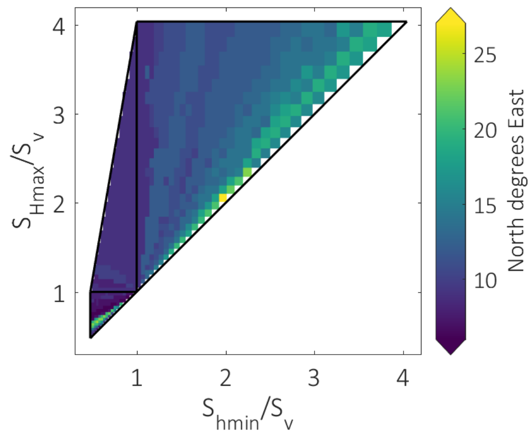


Figure 35. Distribution of stress indicators in well 33A-7. (a) Orientations of DIFs (red), PCFs (blue) and BOs (green) versus depth, with horizontal lines representing width of BOs around the borehole wall. Orientations are referenced to the high side of the well. (b) Borehole deviation angle, (c) deviation azimuth and (d) density of natural fractures. Key shows DIF: drilling induced tensile fractures, BO: breakouts, and PCF: petal centerline fractures.

Using the data analysis procedure of Schoenball et al. (2016), no strong preference for a particular stress regime can be established from these observations in well 33A-7. Only normal faulting stress states with a small S_{Hmax} magnitude are found to be inadmissible (Figure 36). The orientation of S_{Hmax} is very stable across possible stress regimes, with preferred orientations from N6°E to N9°E (Figure 36b). The standard deviation of stress indicators around the mean orientation is 17° (Figure 37) and no trend of the local stress orientation is observed (Figure 37).



(a)



(b)

Figure 36. (a) Minimum angular misfit summed up and normalized for all stress indicators within Andersonian stress states bounded by a stress polygon (black lines) for coefficient of friction of 1.0. Normal faulting, strike-slip faulting and reverse faulting stress regimes are represented by small, intermediate and large triangles, respectively, within this polygon, (b) Best-fitting orientation of S_{Hmax} within the same Andersonian stress states

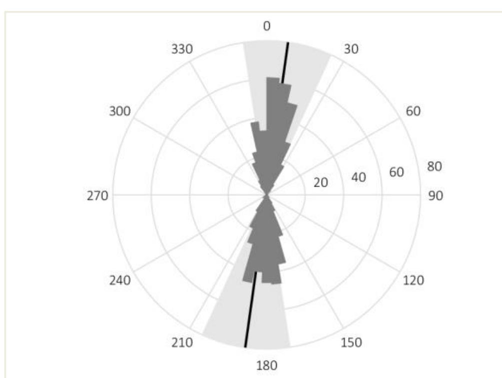


Figure 37. Rose diagram of stress indicators in well 33A-7 transformed to a geographic coordinate system as they would occur in vertical wells. The light shaded area marks one standard deviation on both sides of the best-fitting mean stress orientation.

Wells 33-7, 83-11 and 52B-7 were analyzed using the same methodology as was used for well 33A-7 above. The results of these analyses are collected in Table 1. All wells showed an abundance of stress indicators.

We can combine stress indicators for all wells to find the single stress state that fits best to observations in all wells. Figure 38 shows the minimal misfit and best-fitting stress orientation for all wells. Here, we weighted the observations in each well by the length of the interval sampled by image logs (Table 1, column 3). It is apparent that all strike-slip and normal faulting stress states with a high S_{Hmax} value are equally compatible with the observed stress indicators (Figure 38a). The best-fitting stress orientation varies between N5°E and N7°E (Figure 38b).

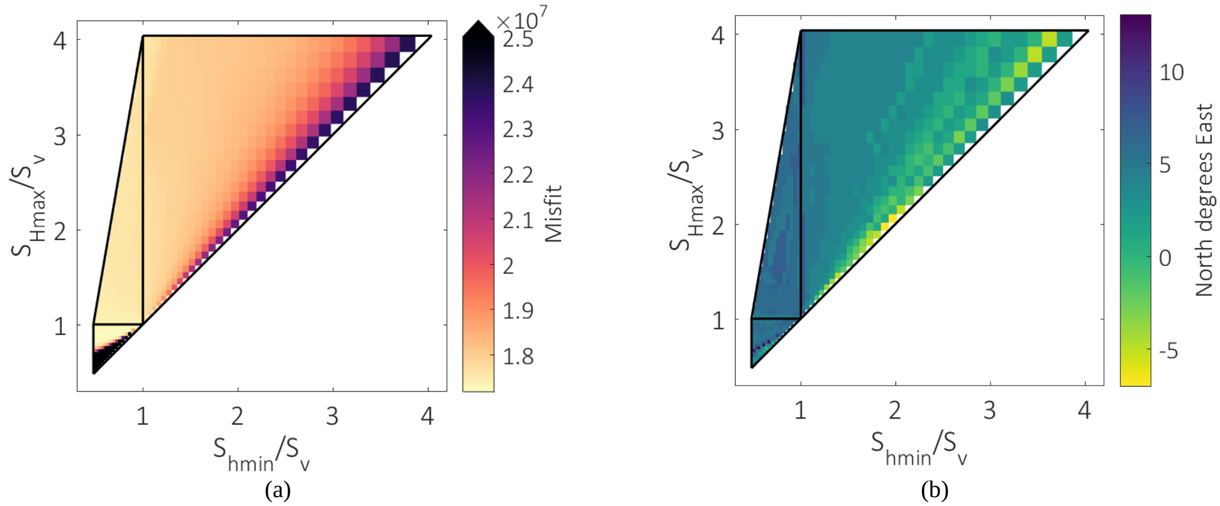


Figure 38. (a) Minimum angular misfit summed up and normalized for all wells within Andersonian stress states bounded by a stress polygon (black lines) for coefficient of friction of 1.0. Normal faulting, strike-slip faulting and reverse faulting stress regimes are represented by small, intermediate and large triangles, respectively, within this polygon, (b) Best-fitting orientation of SHmax within the same Andersonian stress states.

The compilation of stress data from image log analysis and earthquake focal mechanisms helps establish the structural setting of the 3D geologic model in the context of the current tectonic stress state. Extensive previous stress analyses as well as interpretations from Phase 1 FORGE work (Figure 39) are a great asset to the West Flank FORGE site. This understanding of the stress state will play a significant role in future phases of FORGE work, helping design wells for optimal intersection with pre-existing fractures and veins that are well oriented in the present-day stress field, and thus most amenable to EGS stimulation.

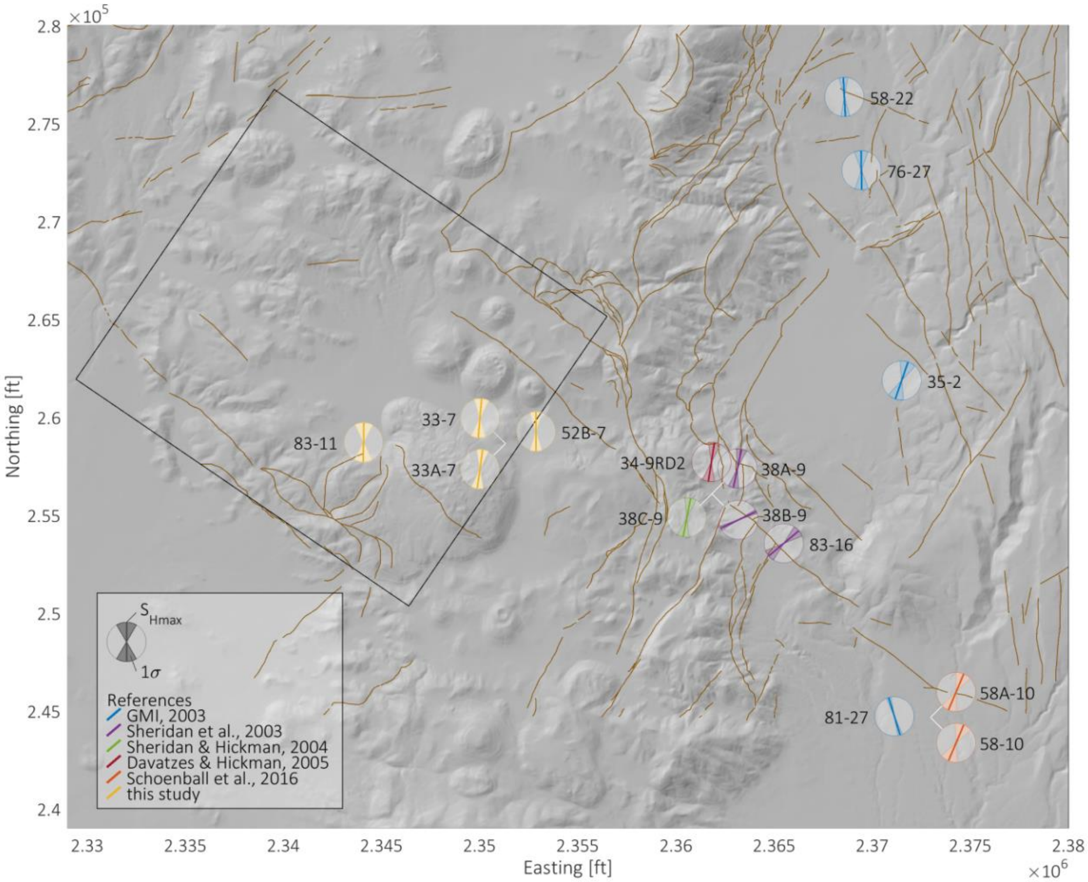


Figure 39. Summary of well stress measurements at the Coso geothermal field. The black rectangle represents the West Flank 3D geologic model area.

5.1.9 Geologic cross-sections

Relevance to FORGE Criteria						
Criteria	**Temperature**	**Low Permeability**	**Lithology (crystalline)**	**Depth (1.5-4 km)**	**Stress Regime**	**No Hydrothermal System**
Relevant	✓		✓	✓	✓	✓

Five 2D geologic cross-sections were constructed to synthesize the map, well, seismic reflection, and microseismicity datasets and to aid in construction of the 3D geologic model (cross-section traces shown in Figure 40). Lithologic logs along well paths within 1 km of cross-section profiles A-A’, B-B’, C-C’, D-D’, and E-E’ were orthogonally projected to the cross-section profiles in order to help constrain lithologic geometries in the subsurface. Once drawn, cross-sections were projected into 3D space to ensure correlation between features on nearby cross-sections. Cross-sections were than iteratively re-drawn to ensure a geologic interpretation both internally consistent and consistent with the available data. These cross-sections are also consistent with local and regional geologic and structural trends (Figure 41–Figure 46) and provide a thorough foundation for the 3D model and helps demonstrate through the compilation of the many preexisting data sets the overall suitability of the West Flank FORGE site.

Within the cross-sections, uncertainty stems from the data that was utilized to create them. As mentioned, the geologic maps used provide an uncertainty of ~10 m off of any lineation (faults or unit contacts). The input temperatures are based on a thermal model, which was created using temperature gradient drilling and then using a Kriging method of contouring. This method has an uncertainty within the West Flank portion of ~50 m. Because of edge effects of the thermal model, this uncertainty is substantial. However, future phases of FORGE work will decrease this uncertainty.

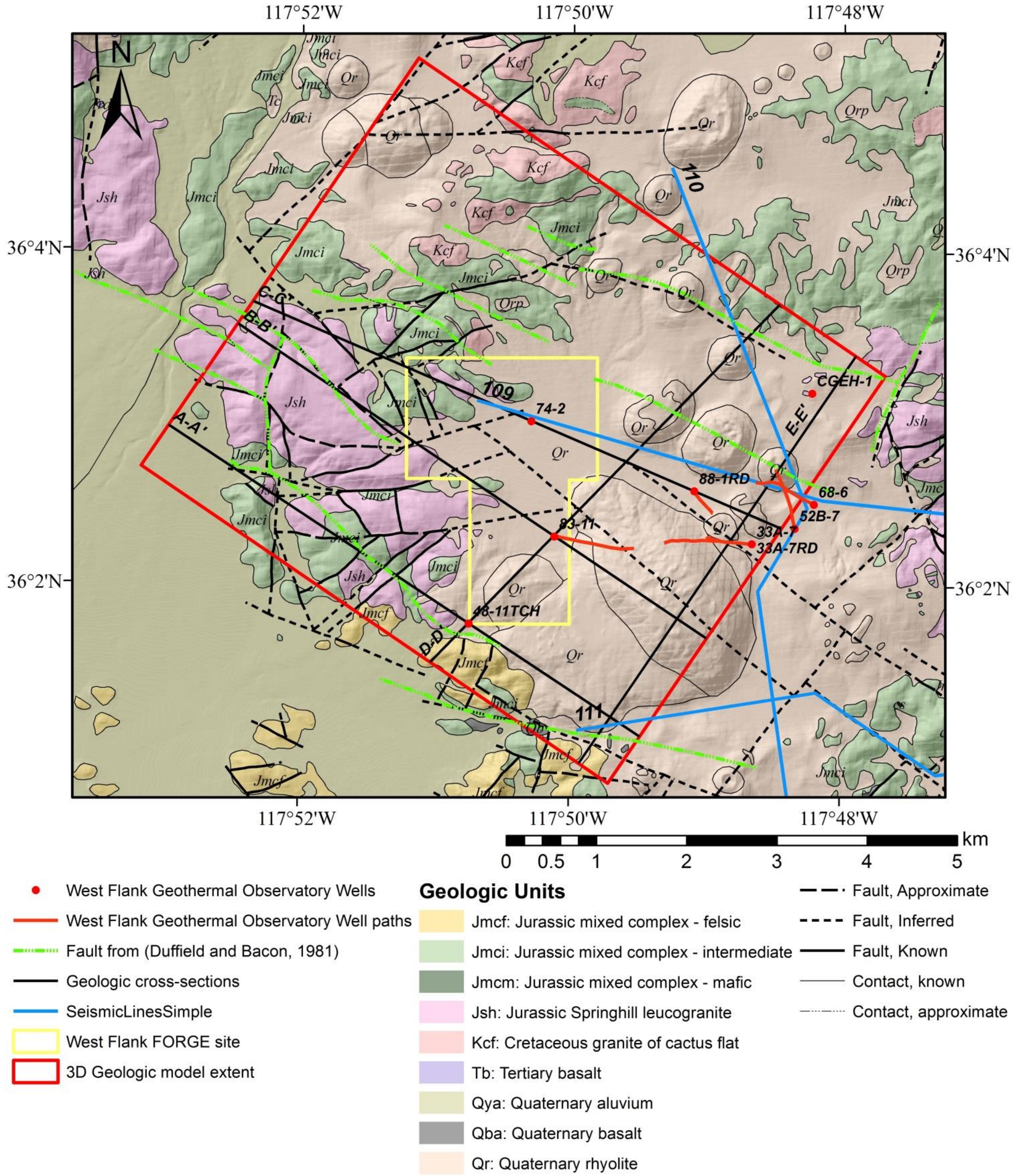


Figure 40. Geologic map of the West Flank FORGE site. Geologic map after Whitmarsh, (1998a). Geologic cross-section profiles show in black. Seismic reflection profiles that we interpreted shown in blue.

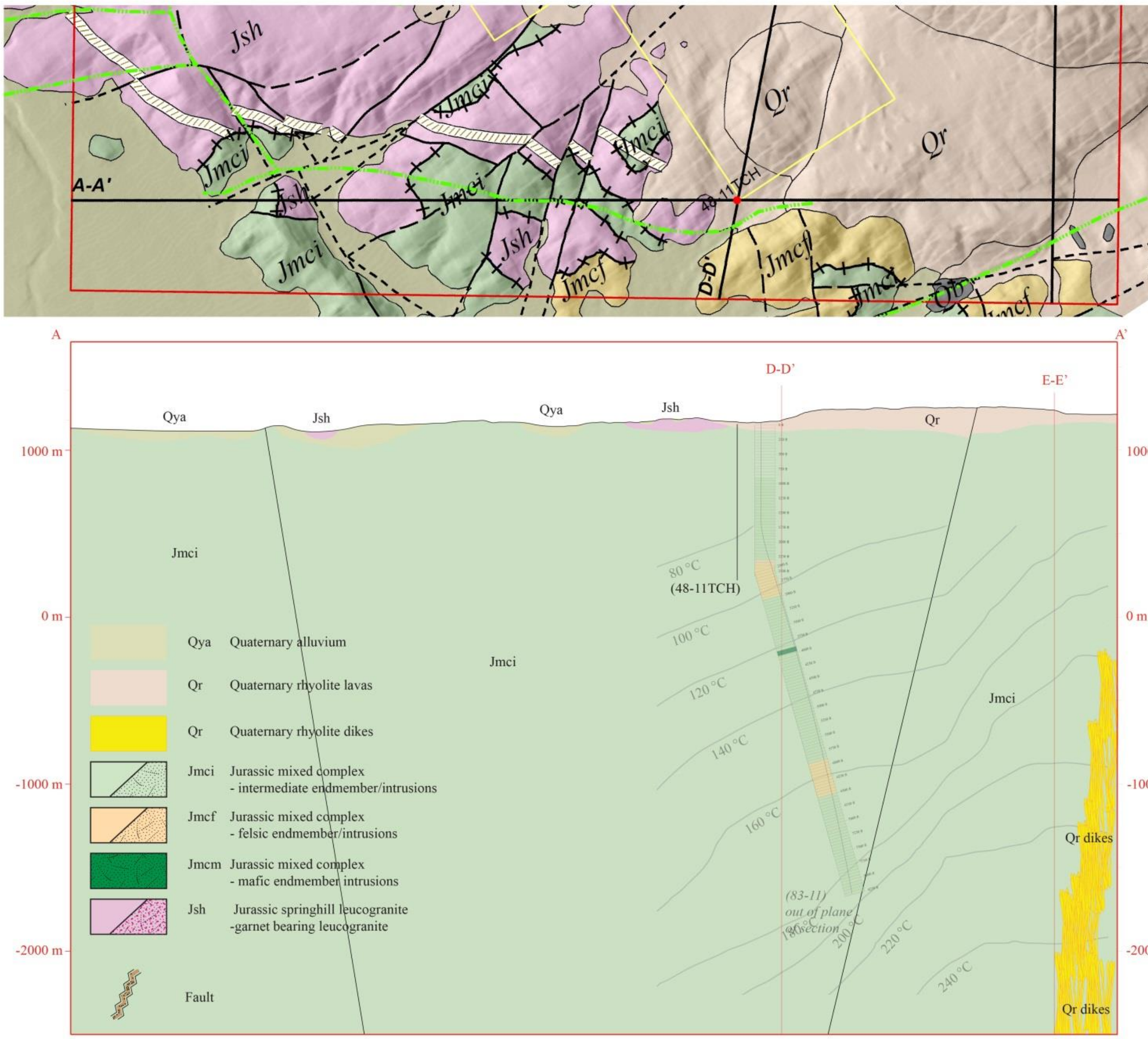


Figure 41. Cross-Section A-A' through the West Flank FORGE site. Isotherms from the 3D temperature model.

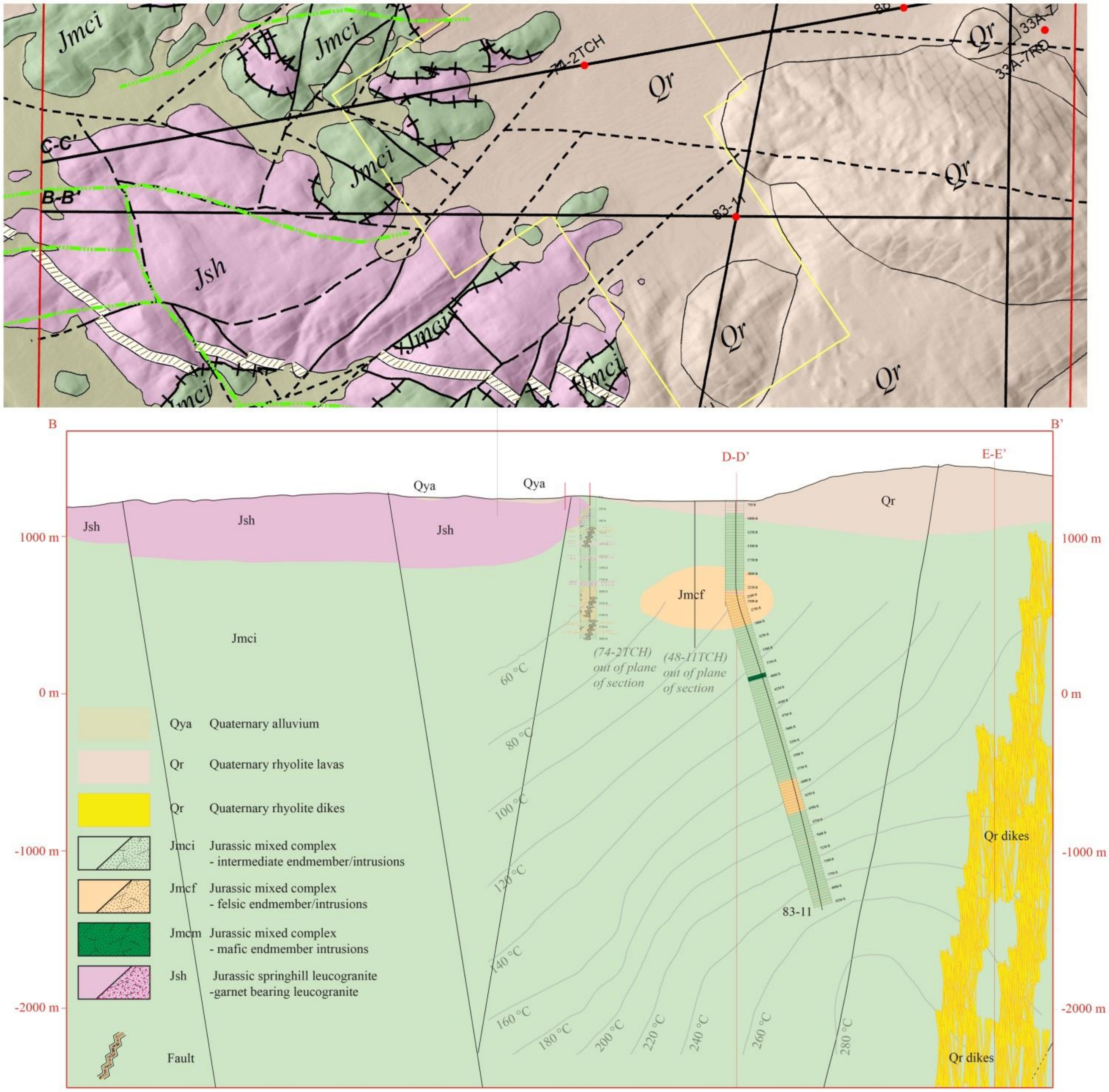


Figure 42. Cross-Section B-B' through the West Flank FORGE site. Isotherms from the 3D temperature model.

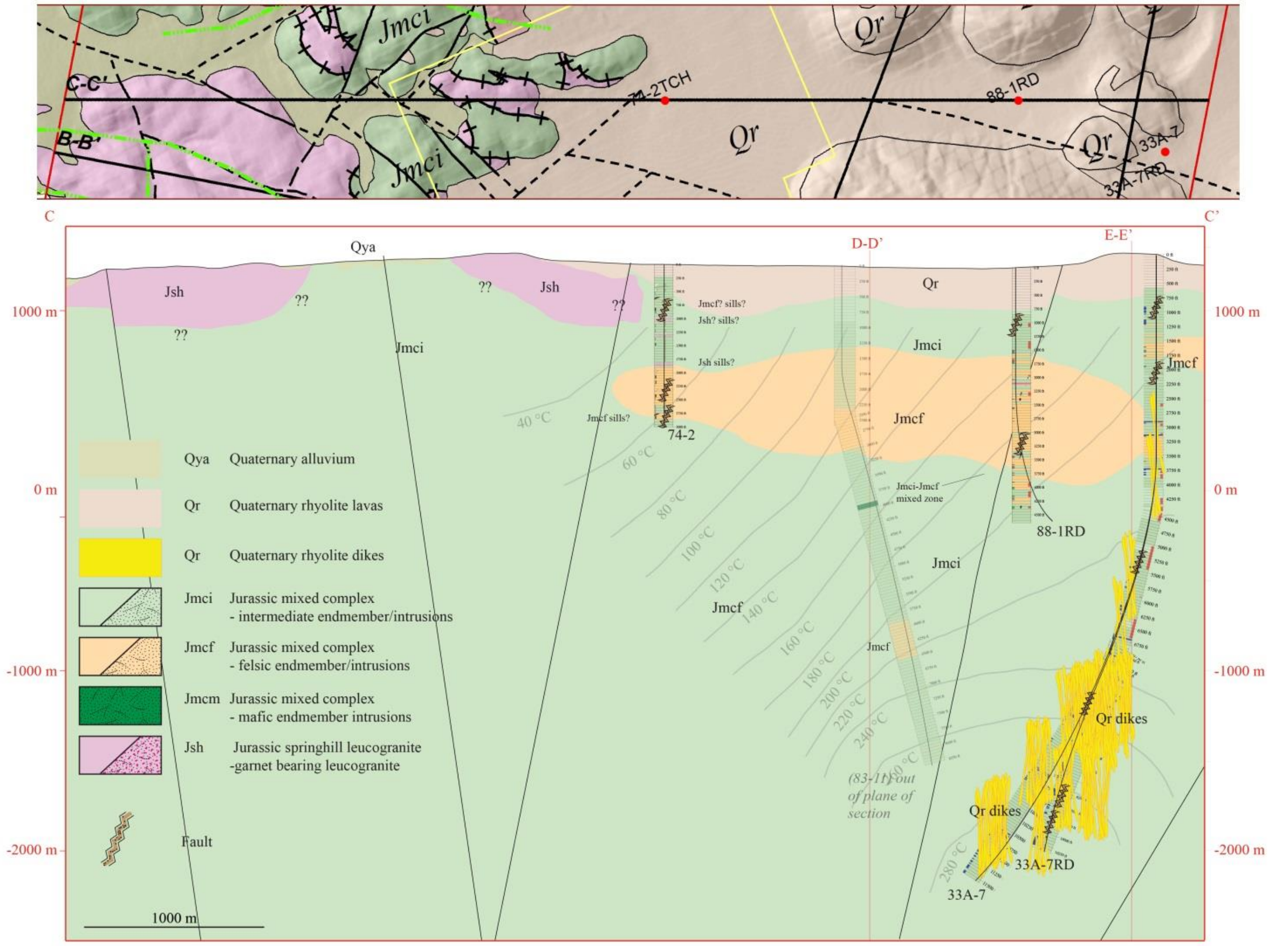


Figure 43. Cross-Section C-C' through the West Flank FORGE site. Isotherms from the 3D temperature model.

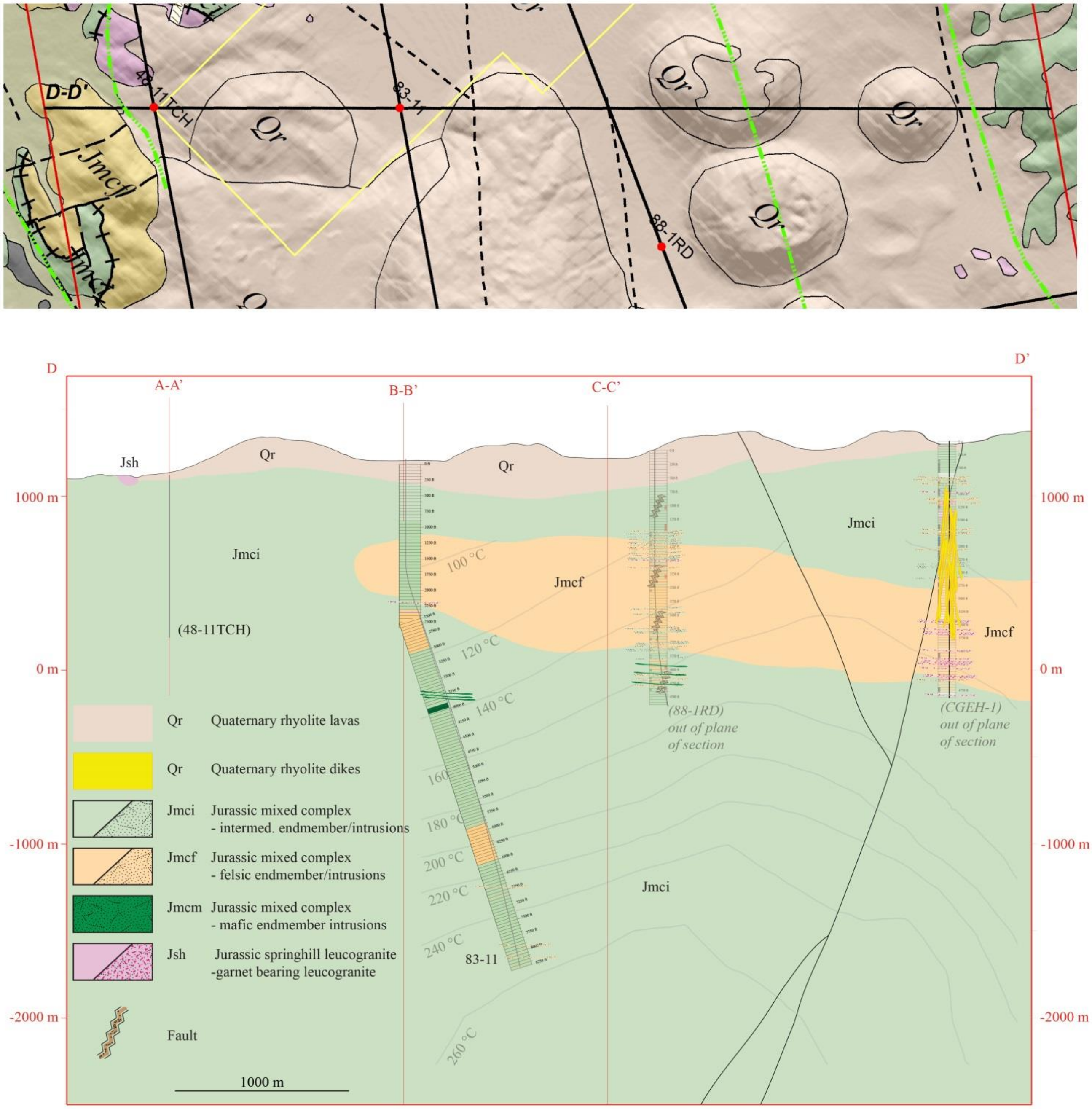


Figure 44. Cross-Section D-D' through the West Flank FORGE site. Isotherms from the 3D temperature model.

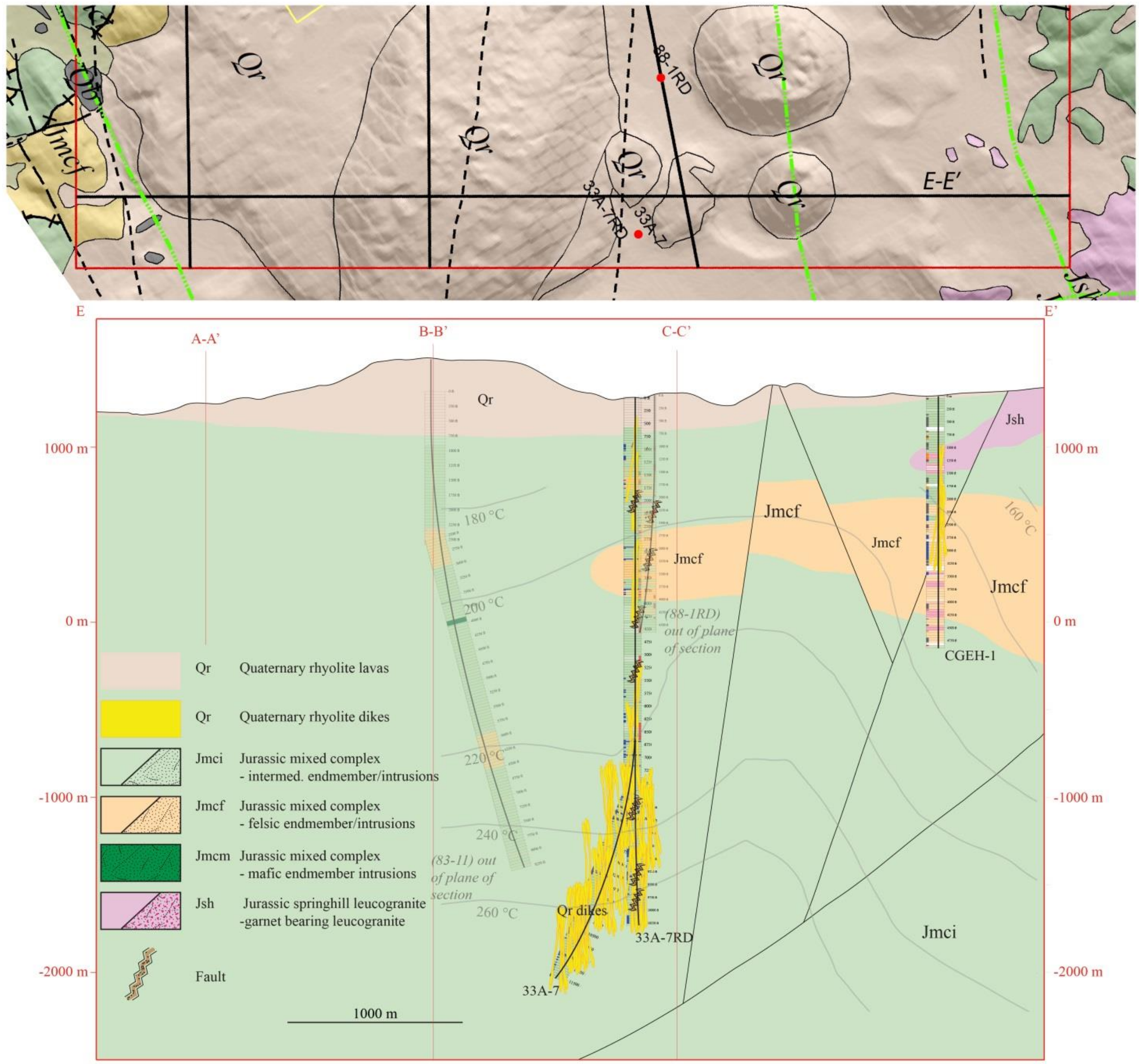


Figure 45. Cross-Section E-E' through the West Flank FORGE site. Isotherms from the 3D temperature model.

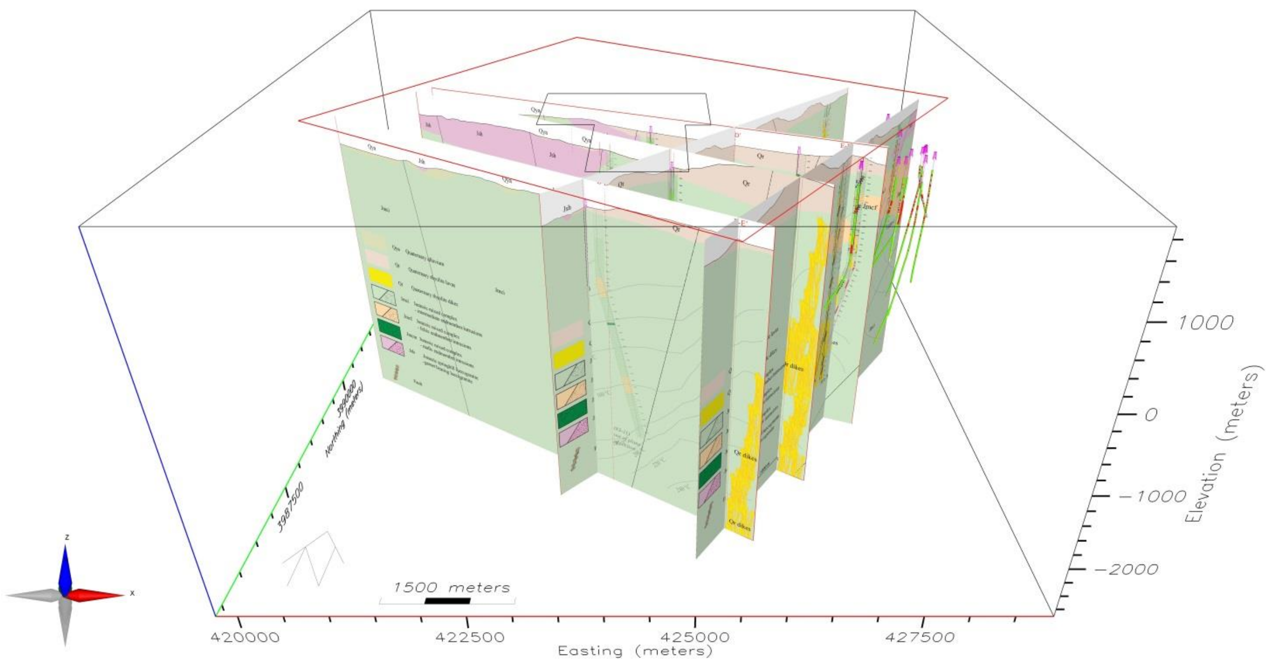


Figure 46. Cross-sections A-A', B-B', C-C', D-D' and E-E' projected in 3D space. Red polygon is the extent of the 3D geologic model. Black polygon indicates the West Flank FORGE site.

6 3D MODEL

6.1 INTEGRATION OF STRATIGRAPHIC AND STRUCTURAL FRAMEWORKS

A 3D geologic model encompassing the West Flank FORGE site was constructed based on the preexisting data, interpretation and analyses discussed. The 3D geologic model is rotated 35° counterclockwise to align with the north-northeast-striking and west-northwest to northwest-striking structural grain. The 3D geologic model spans 6.3 km in the west-northwest dimension and 4.2 km in north-northeast dimension and extends from the land surface, which varies between ~1075 m asl to ~1650 m asl, to a depth of 2500 m bsl. The 3D geologic model spans ~130 km^3 and is centered upon the West Flank site. The model comprises six lithologic units and eight faults (Figure 47).

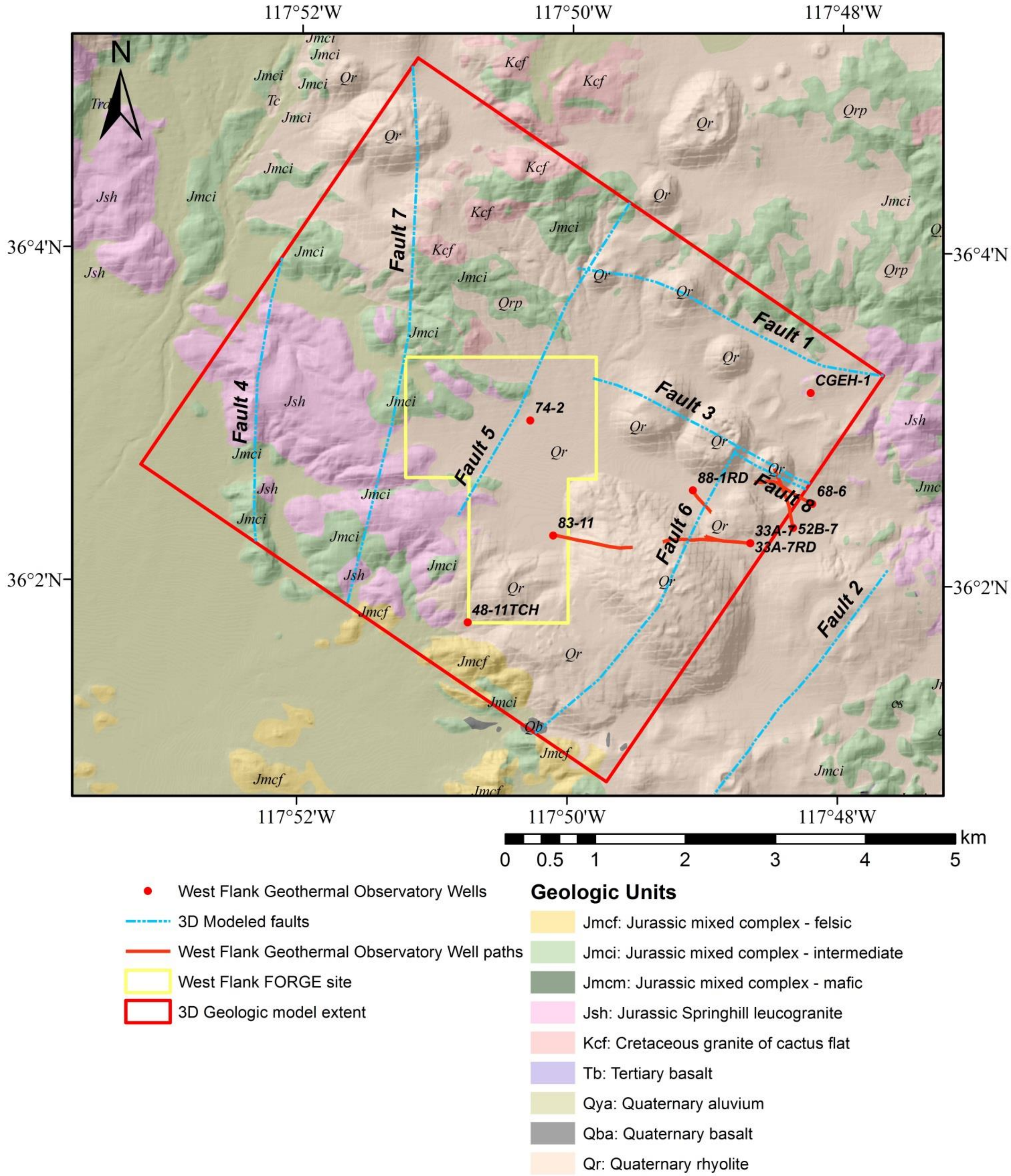


Figure 47. Geologic map of the West Flank site after Whitmarsh (1998). Blue dashed lines indicate the surface trace of 3D modeled faults. The West Flank site is shown in yellow. The boundaries of the 3D geologic mode are shown in red.

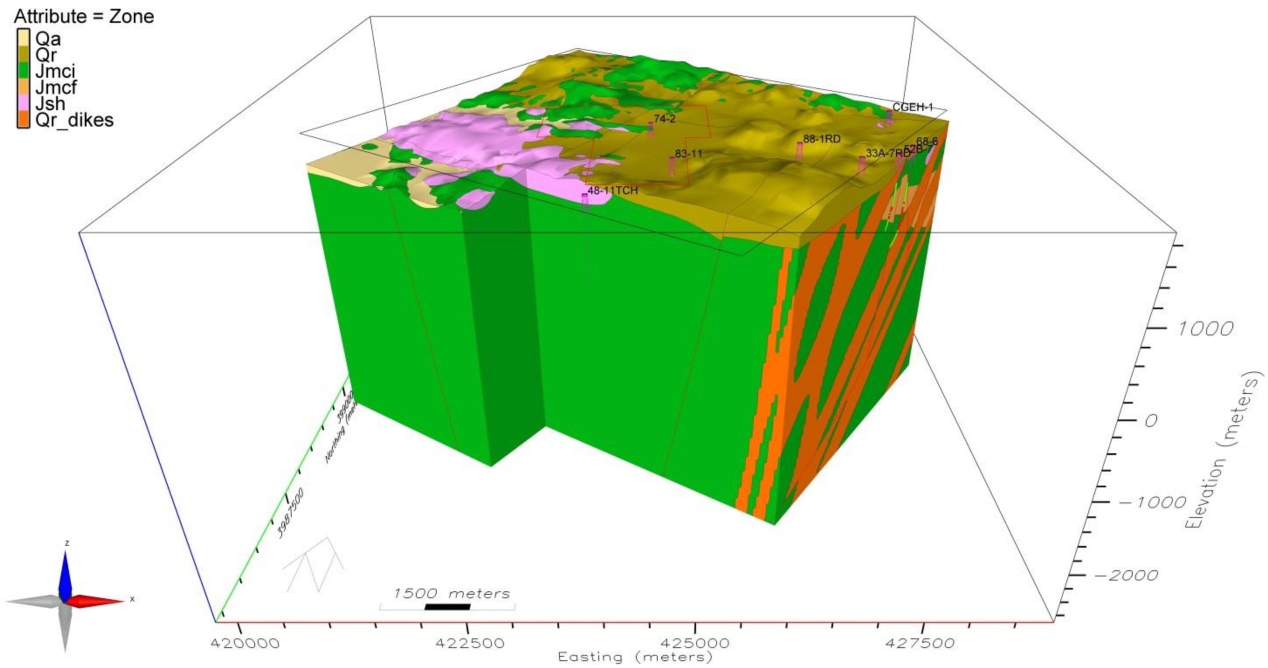


Figure 48. 3D perspective of the West Flank 3D geologic model. Boundaries of the West Flank site are shown in black with the test area polygon in red on the surface.

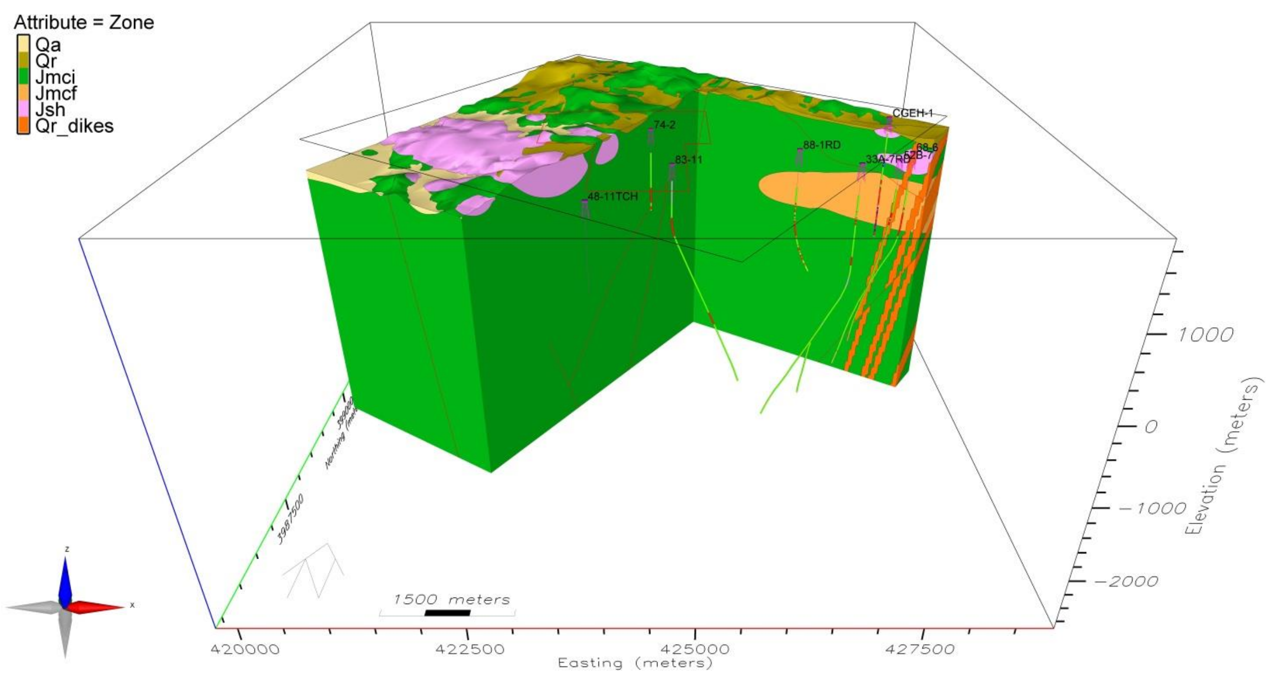


Figure 49. 3D perspective of the West Flank 3D geologic model cut to show the well data used in the model with lithology along the trace.

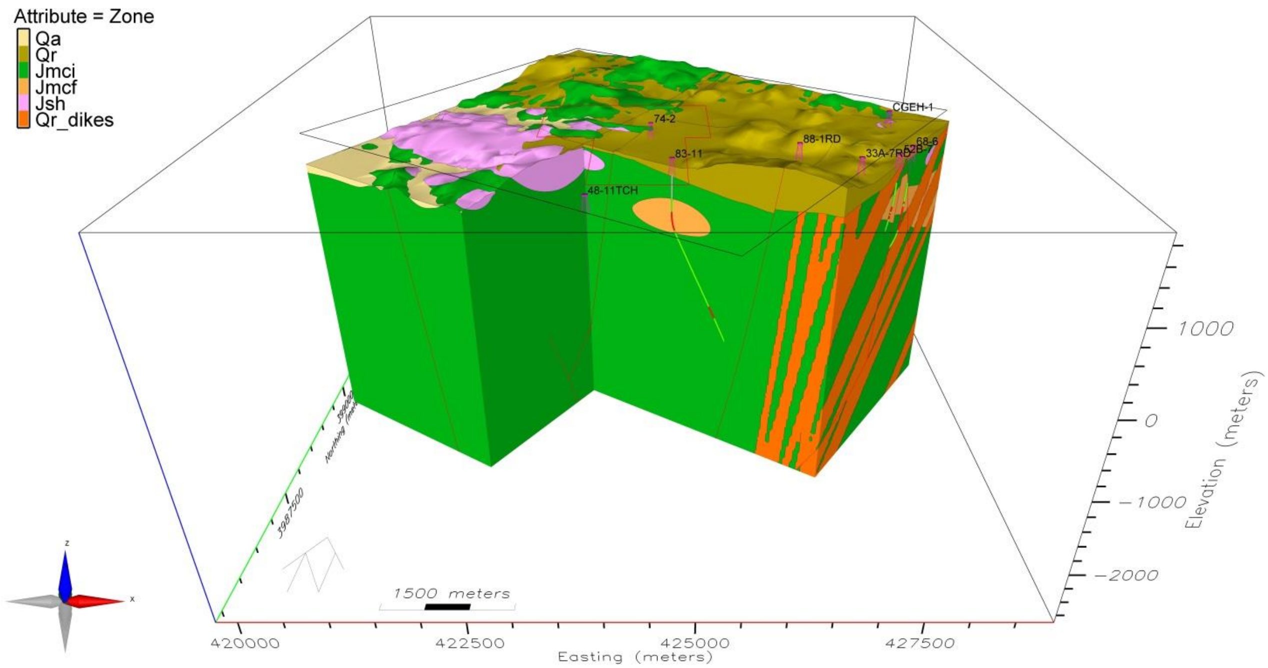


Figure 50. 3D perspective of the West Flank 3D geologic model cut to show the well data used in the model with lithology along the trace. Well 48-11TCH is within the West Flank test area footprint.

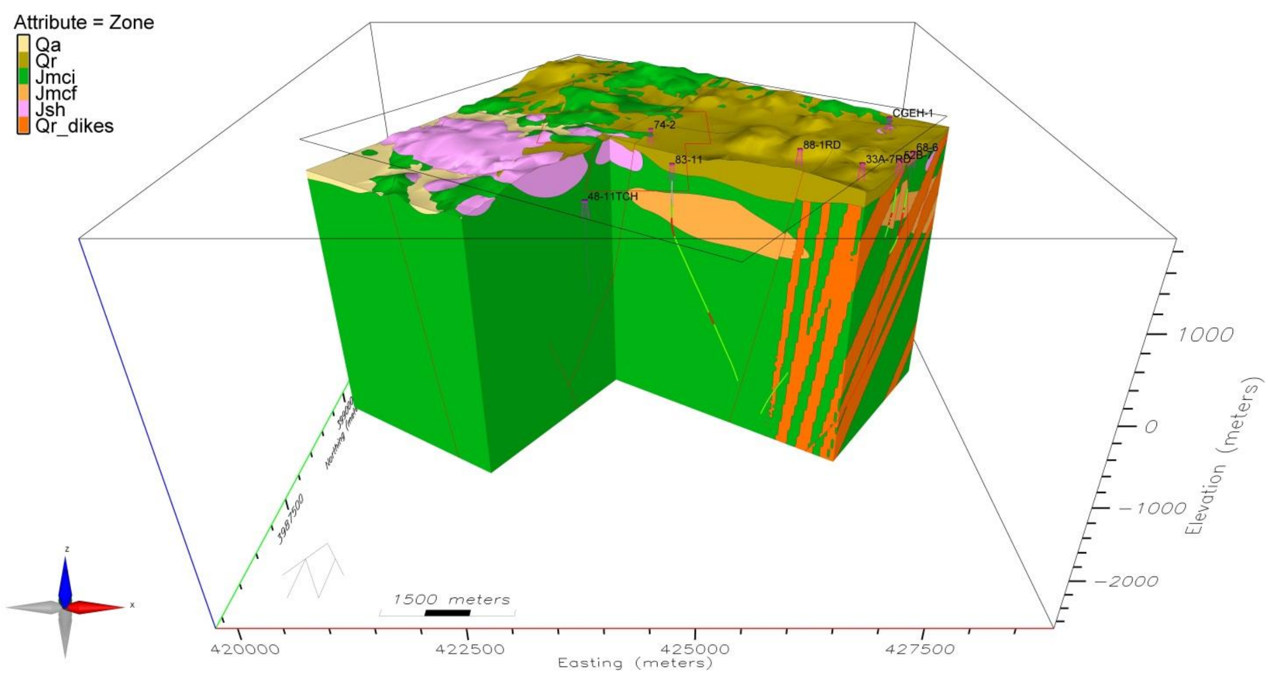


Figure 51. 3D perspective of the West Flank 3D geologic model cut to show the well data used in the model with lithology along the trace. Well 83-11 is within the West Flank test area footprint.

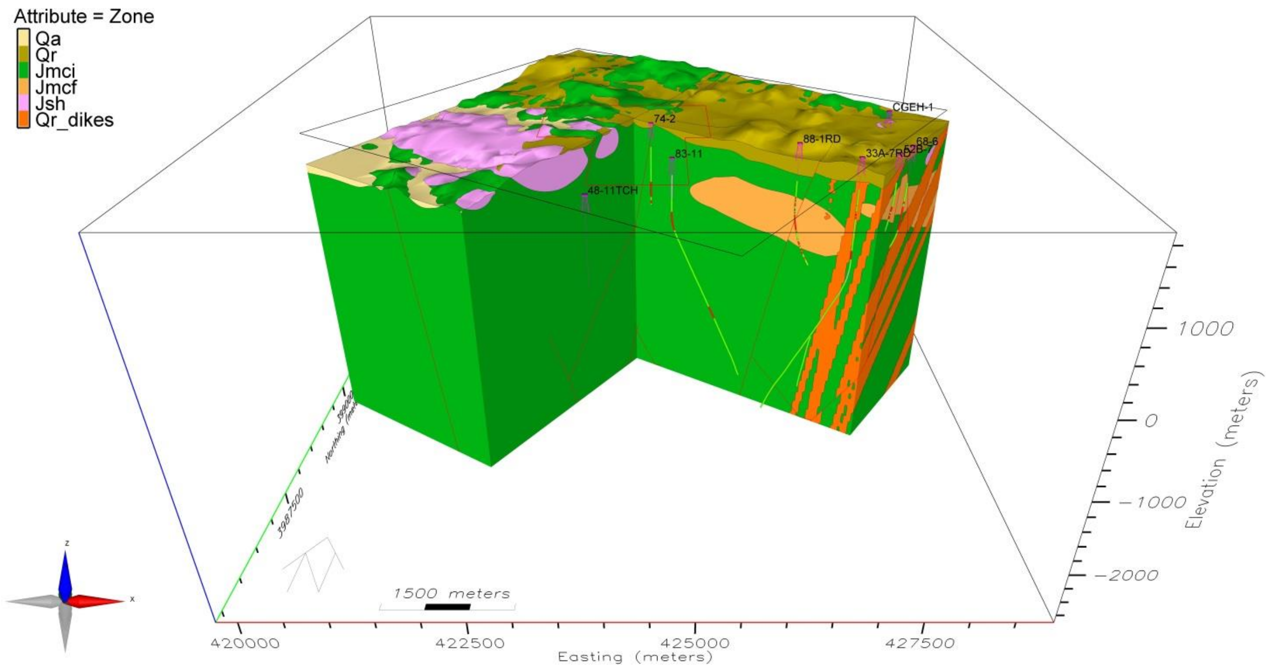


Figure 52. 3D perspective of the West Flank 3D geologic model cut to show the well data used in the model with lithology along the trace. Well 74-2TCH is within the West Flank test area footprint.

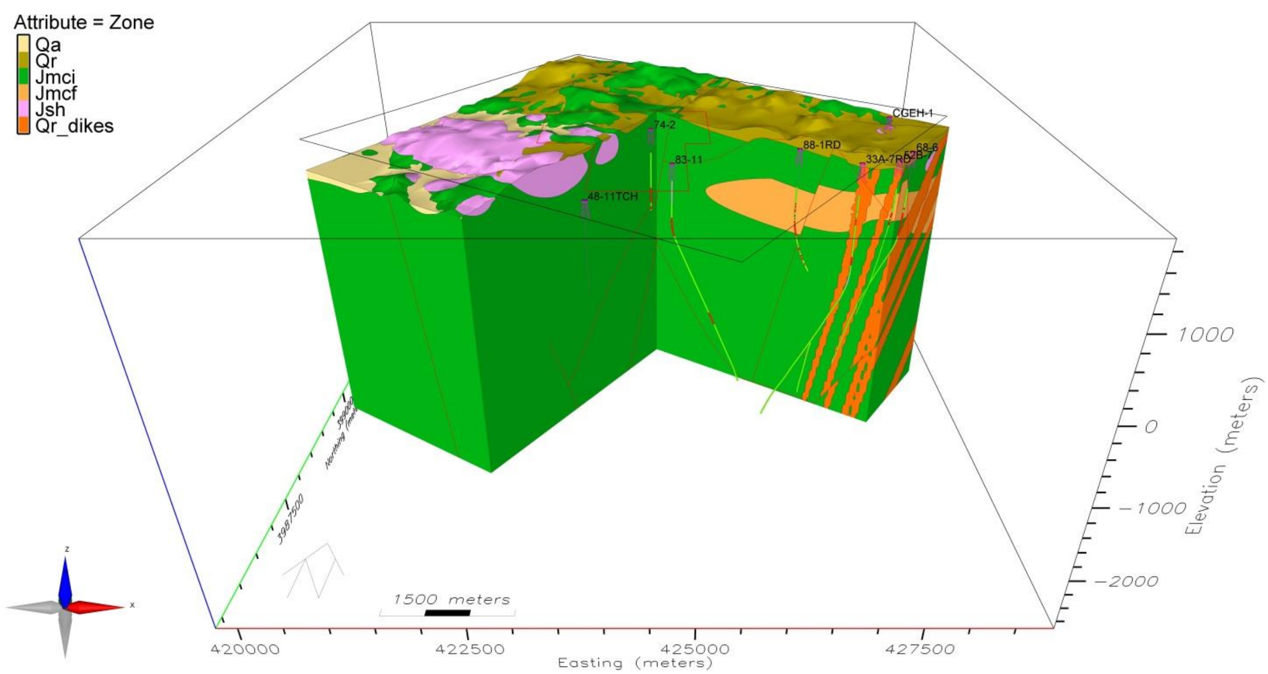


Figure 53. 3D perspective of the West Flank 3D geologic model cut to show the well data used in the model with lithology along the trace.

6.2 3D MODEL–GEOLOGIC STRUCTURE

The 3D geologic model includes eight faults, constrained by a combination of geologic maps, geologic cross-sections, seismic reflection interpretation, down hole mud logs, and borehole image (structural) data from the eight wells plus microseismicity data. Five of the modeled faults strike north to northeast and three faults strike west to west-northwest (Figure 54 and Figure 55). These orientations are consistent with the general regional structural trends and down-hole natural fracture data (Figure 56).

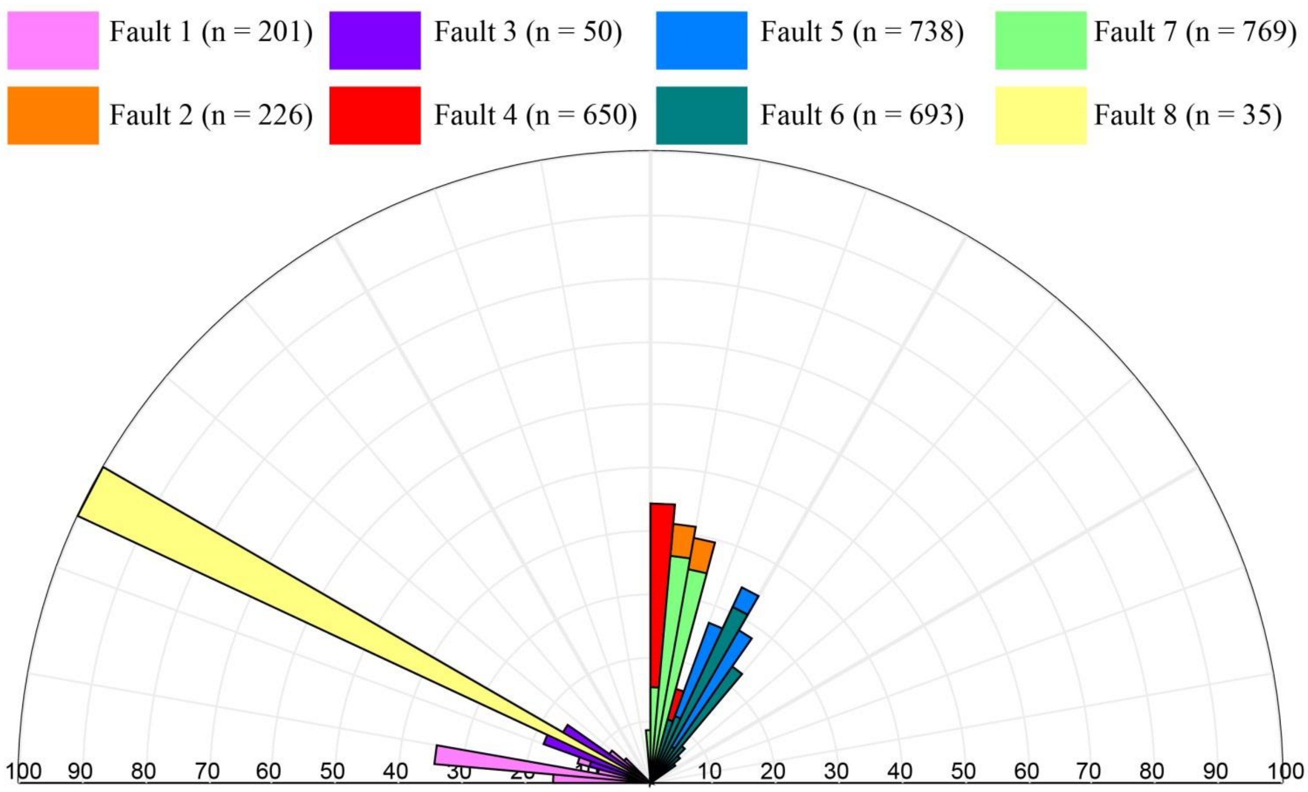


Figure 54. Rose diagram indicates the strike of the 3D modeled faults. Modeled fault surfaces were sampled at 100 m spacing for strike and dip.

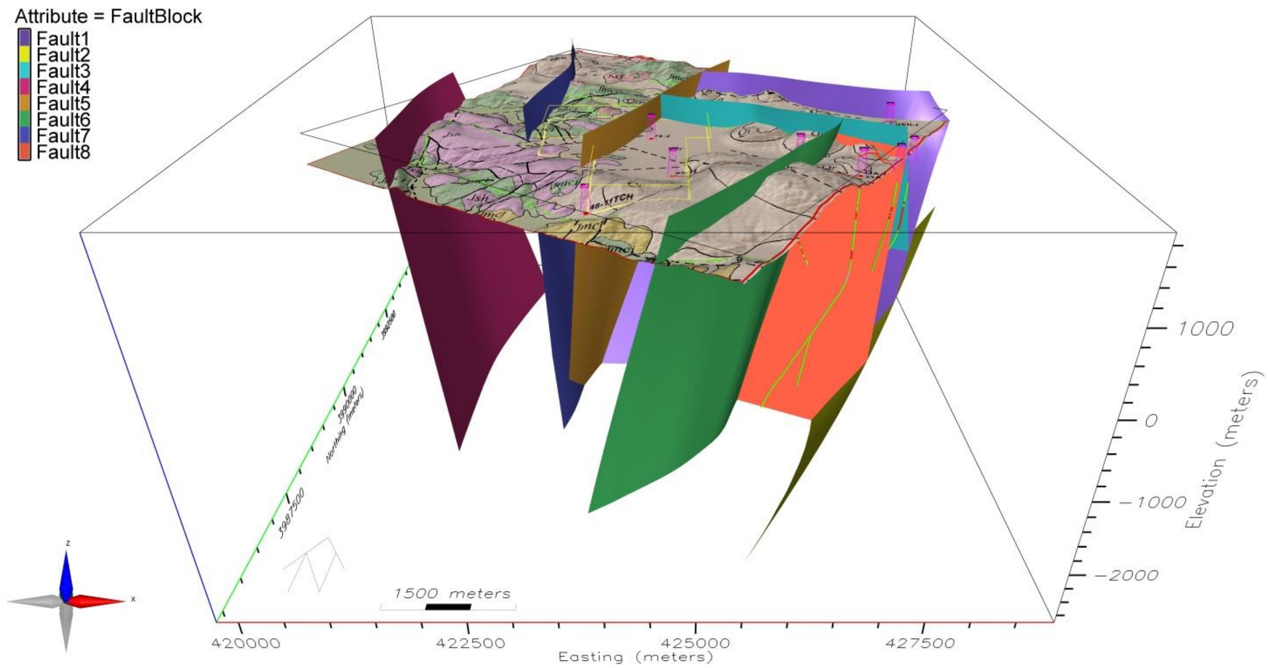


Figure 55. 3D perspective view of the 8 faults modeled at the West Flank site. Geologic map (Whitmarsh 1998a) shown projected on to the topographic surface. Boundaries of the West Flank site shown in yellow.

The geometry of Fault 1 was modeled based on geologic map data from both Whitmarsh (1998) and Duffield and Bacon (1981) and the surface trace is coincident with an alignment of Quaternary rhyolite domes. Fault 1 is also evident on seismic refection profile 110. These data constrain the strike of Fault 1 to ~090-135° and the dip to ~67-80° NNE. Geologic map relationships (Whitmarsh, 1998) suggest down-to-the-south relative offset on Fault 1 (Figure 47). The amount of offset is unconstrained. It is modeled with ~50 m of normal throw.

The geometry of Fault 2 was modeled based on map data from Whitmarsh (1998), though the mapped trace lies outside of the 3D geologic model (Figure 47). Fault 2 is also evident on seismic reflection profiles 110 and 111. These data constrain the strike of Fault 2 to ~185-210° and the dip to ~55-65° W. Additionally Fault 2 represents an important pressure barrier between the Coso geothermal field and the West Flank FORGE site. Pressure responses within the geothermal field to the east of Fault 2 and not observed in wells to the west of Fault 2 (Jess McCulloch, Coso Operating Company, personal communication; see also Figure 20). The slip sense of Fault 1 and relative offset are unconstrained. It is modeled with ~100 m of normal throw.

The geometry of Fault 3 was modeled based on map data from Whitmarsh (1998), and the surface trace is coincident with an alignment of Quaternary rhyolite domes Fault 3 is also evident on seismic reflection profile 110. These data constrain the strike of Fault 3 to ~290-305° and the dip to ~65-70° NE. Vertical separation of ~150 m (normal throw) across Fault 3 is constrained by the top of the Jmci formation in lithologic logs on either side of the fault.

The geometry of Fault 4 was modeled based on geologic map data from both Whitmarsh (1998) and Duffield and Bacon (1981). Fault 4 is also clearly evident in the subsurface based on a north-striking cloud of microseismicity occurring throughout the 1996-2012 timespan covered by the microseismicity survey (Figure 56). These data constrain the strike of Fault 4 to ~000-010° and the dip to ~80-85° E. Map exposures local to Fault 4 indicate likely down-to-the-east normal slip. Fault 4 is modeled with ~75 m of normal throw.

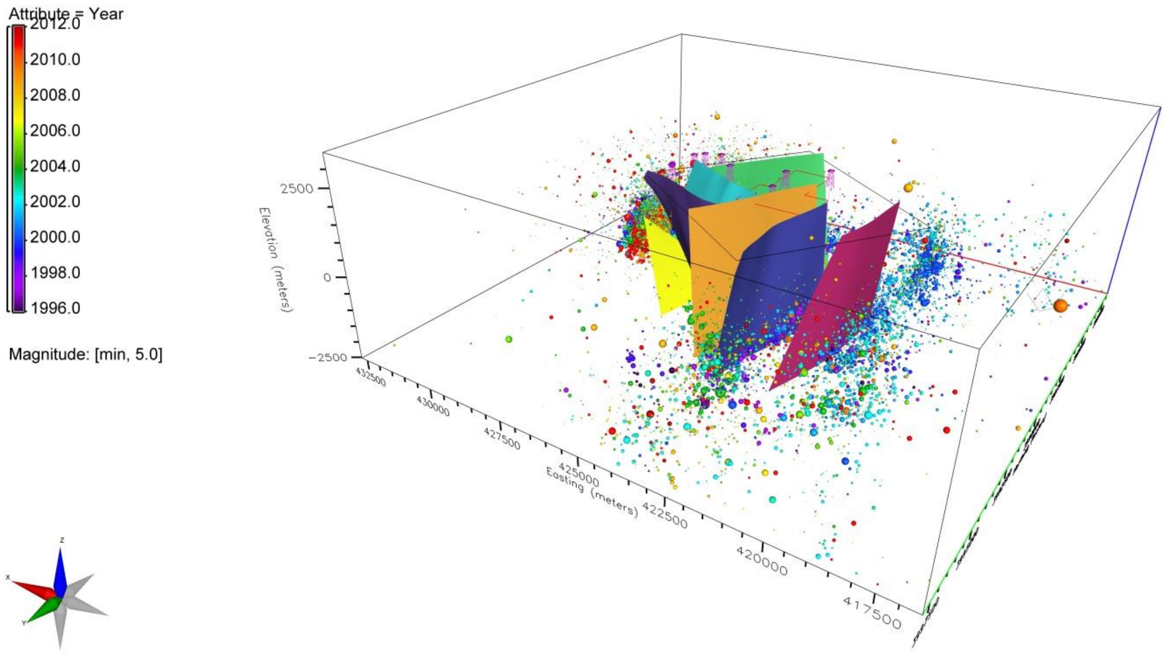


Figure 56. 3D perspective view of the 8 faults modeled at the West Flank site plotted with MEQ hypocenters. Diameter of the hypocenter is proportional to magnitude, larger spheres for larger magnitudes. Hypocenters colors represent each year.

The geometry of Fault 5 was constrained by a north northeast-striking cloud of microseismicity occurring throughout the 1996-2012 timespan, particularly a discrete set of events occurring in 2004 (Figure 56). Fault 5 is also clearly evident on the western end of seismic reflection profile 109. Fault 5 was not mapped at the surface on either Whitmarsh (1998) or Duffield and Bacon (1981), however the surface trace of Fault 5 crosses almost exclusively Qr epiclastic deposits. Qr may obscure any surface expression of a fault or post-date significant offset on the fault. These data constrain the strike of Fault 5 to ~200-220° and the dip to ~80° NW. The slip sense of Fault 5 and relative offset are unconstrained but is modeled with ~50 m of normal slip throw.

The geometry of Fault 6 was modeled based on geologic map data from Whitmarsh (1998) in the Mesozoic basement exposures to the south of the 3D geologic model. It is not mapped through the 3D geologic model area where it cuts Qr epiclastic deposits and Sugarloaf Dome. Fault 6 is also clearly evident in the subsurface based on a northeast-striking cloud of microseismicity occurring throughout the 1996-2012 timespan, particularly a discrete set of events occurring in 2010 (Figure 56). These data constrain the strike of Fault 6 to ~205-235° and the dip to ~75-85° NW. The slip sense of Fault 6 and relative offset are unconstrained but is modeled with ~50 m of normal slip throw.

The geometry of Fault 7 was modeled based on a north-striking cloud of microseismicity occurring throughout the 1996-2012 timespan, particularly a discrete set of events occurring in 2003 (Figure 56). These data constrain the strike of Fault 7 to ~355-015° and the dip to ~75-85° E. The slip sense of Fault 7 and relative offset are unconstrained but is modeled with ~50 m of normal slip throw.

The geometry of Fault 8 was modeled based on ~100 m of vertical separation in the occurrence of a ~400 m thick section of Jcmf between lithologic logs to the north and south of Fault 8. These data indicate that Fault 8 strikes ~120 and dips steeply SSW. Fault 8 was interpreted to dip 80° S. Based on vertical separation evident in the lithologic logs Fault 8 was modeled with ~100 m of normal slip throw.

6.3 3D MODEL–LITHOLOGIC STRUCTURE

The West Flank FORGE site 3D Geologic model consists of six discrete lithologic units, Qa, Quaternary sediments; Qr, Quaternary rhyolite; Qr dikes, Quaternary rhyolite dikes, Jsh, Jurassic Springhill Leucogranite, Jmcf, Jurassic mixed complex-felsic endmember; and Jmci, Jurassic mixed complex-intermediate endmember. Qr and Qa form a veneer, which is < 500 m thick and more commonly 10s-100m thick, and unconformably overlying the Mesozoic plutonic section, (Figure 49-53). At depths greater than ~100 m bgs, the 3D geologic model consists of exclusively crystalline rock; Jurassic granitic rocks (Jmci, Jmcf and Jsh) and Quaternary rhyolite dikes (QR). Diorite to quartz-diorite, Jmci, is by far the most abundant lithologic unit at West Flank. Jmci constitutes ~88% of the interpreted rock volume of the West Flank 3D geologic model. Jmcf, Jurassic granite is modeled as one intrusion into Jmci, which is a ~800 m thick intrusive body extending ~3 km x 3 km in the northeast corner of the 3D geologic model. Jmcf constitutes ~3.5% of the interpreted rock volume in the West Flank 3D geologic model (Figure 48-53). The Jurassic Springhill leucogranite, Jsh, occurs as two discrete intrusions, in the southwest and northeast of the 3D geologic model. Both Jsh intrusions are ~500 m thick, in total comprising ~1.5% of the modeled lithologic volume. Qr dikes, the feeder for the Qr lava flows and domes, occur as discrete, tabular, steeply dipping dikes on the eastern side of the 3D geologic model (Figure 48-53). Qr dikes represent ~5% of the modeled lithologic volume (see Table 2 for modeled rock volumes).

Table 2. Volume of the geologic model and each of the 6 modeled lithologic units in km3. Column 1, total modeled volume (35 km2 areal extent). Column 2 modeled volumes within the West Flank Site (4.6 km2 areal extent), Column 3 modeled volumes falling within 175-225°C within the 3D model volume. Column 4 modeled volumes within the West Flank Site and falling within 175-225°C. All volumes calculated to a depth of -2500 m bsl or ~3800 m bgs.

	Total Model Volume	Total model volume within FORGE site	Total Model Volume between 175-225°C	Model volume within FORGE site between 175-225°C
Total Modeled Volume	131.28	17.37	14.00	2.47
Qa	0.07	0.00	0.00	0.00
Qr	2.73	0.00	0.00	0.00
Qr dikes	6.30	0.00	1.44	0.00
Jmci	4.50	16.56	12.56	2.47
Jmcf	1.71	0.47	0.00	0.00
Jsh	115.97	0.35	0.00	0.00

6.4 3D MODEL–TEMPERATURE STRUCTURE

Static temperature logs indicate that the 175-225°C temperature window required for FORGE is spans ~1.7-2.4 km bgs in well 83-11 (Figure 57). Temperature modeling, incorporating data from wells within the Coso geothermal field, along with wells 83-11, 74-2TCH and 48-11TCH confirms that the 175-225°C temperature window occurs at these depths, ~1.7-2.4 km bgs, throughout the West Flank site (Figure 57). Within this temperature and depth window, extending to 2500 m depth or ~3700 m bgs (the base of the geologic model), ~14 km^3 of weakly altered to unaltered diorite to quartz-diorite Jmci, granitic Jmcf, and Qr rhyolite dikes occur (Figure 58 and Table 2). This volume of rock that lies within the FORGE parameters at West Flank, consists of ~12.5 km^3, or is ~85%, unaltered diorite to quartz-diorite Jmci formation and ~1.5 km^3, or ~15%, Qr, Quaternary rhyolite dikes.

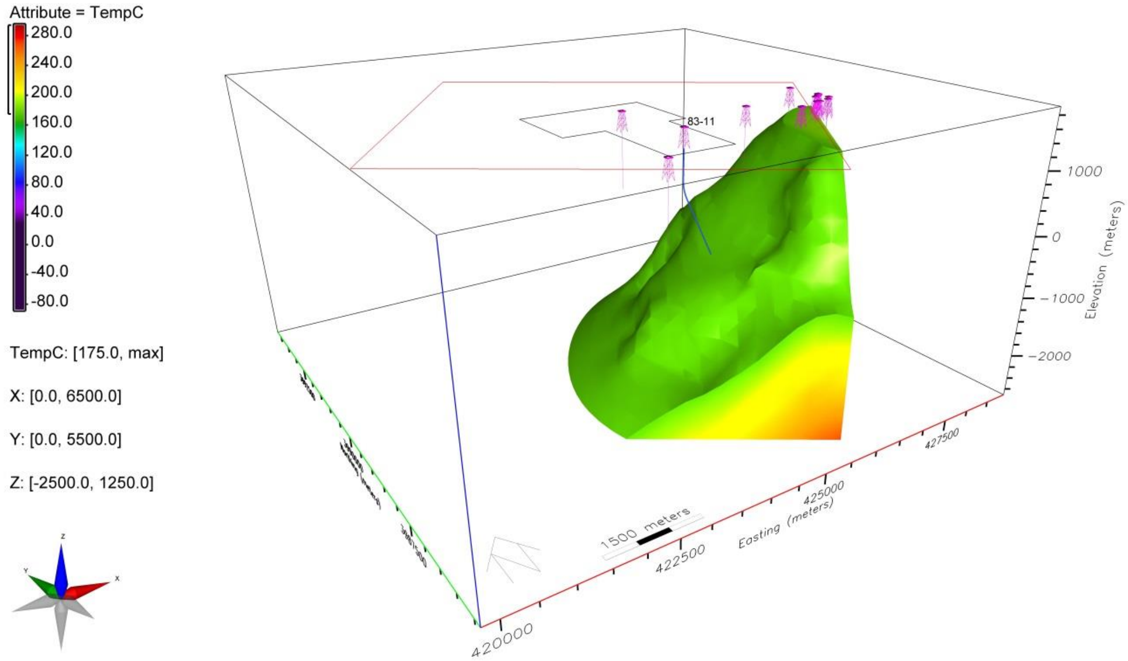


Figure 57. Perspective view of the 3D temperature model for the West Flank, showing wells from which temperature data were used to create this model. The temperature model is sliced to the 175°C isotherm.

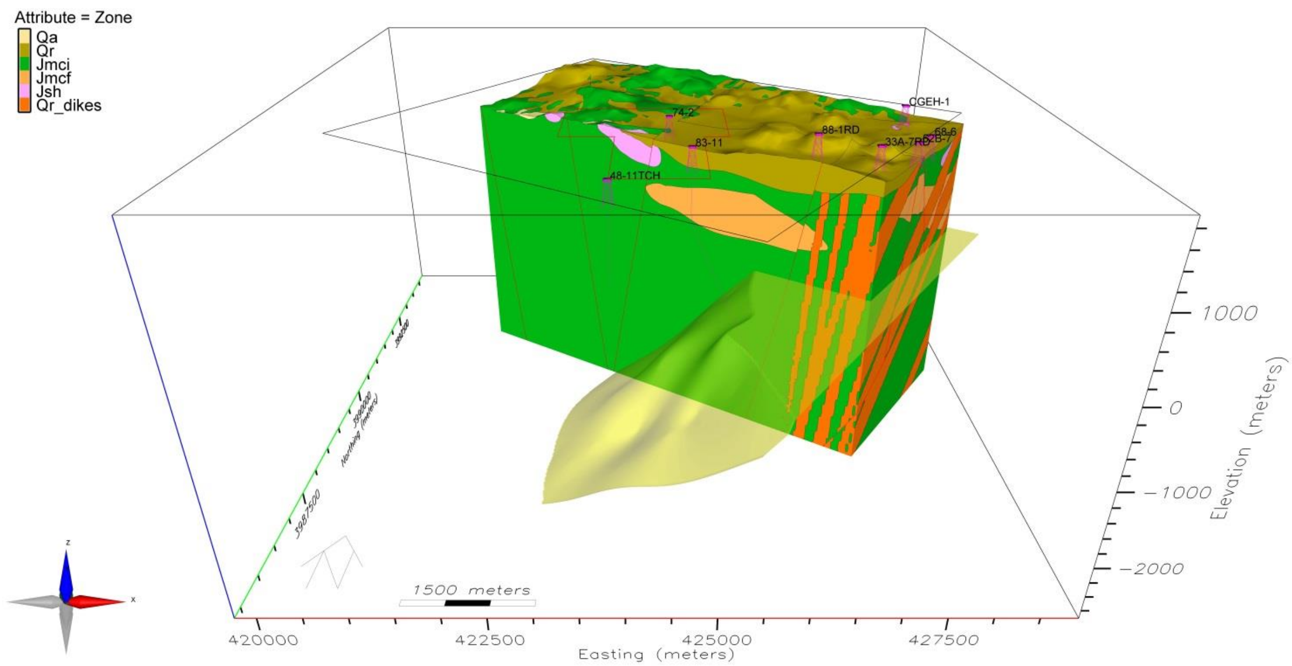


Figure 58. Slice through oblique view of West Flank 3D geologic model. The semi-transparent surface represents the FORGE target zone, i.e. the volume that lies below 1.5 km depth with temperatures higher than 175° C. Target zone is comprised of 25 km^3 of unaltered diorite to quart-diorite, Jmci, and 5 km^3 of Quaternary rhyolite dikes, Qr.

To gain a better perspective on the suitability of the West Flank FORGE site, Figure 59 and Figure 60 show the 175°C and 225°C temperature isotherms extending into the 3D geologic model. As previously mentioned, the type of analysis that has been used to build the current thermal model creates an edge effect and the temperatures fall off rapidly outside of the Coso geothermal field. In future phases of FORGE project work, we expect that this temperature model will continue to be updated through thermal gradient hole drilling and that we will expand the FORGE temperature volume to the west. However, the current model and temperature profile of 83-11 demonstrate the heat and depth suitability of this site per FORGE's current criteria.

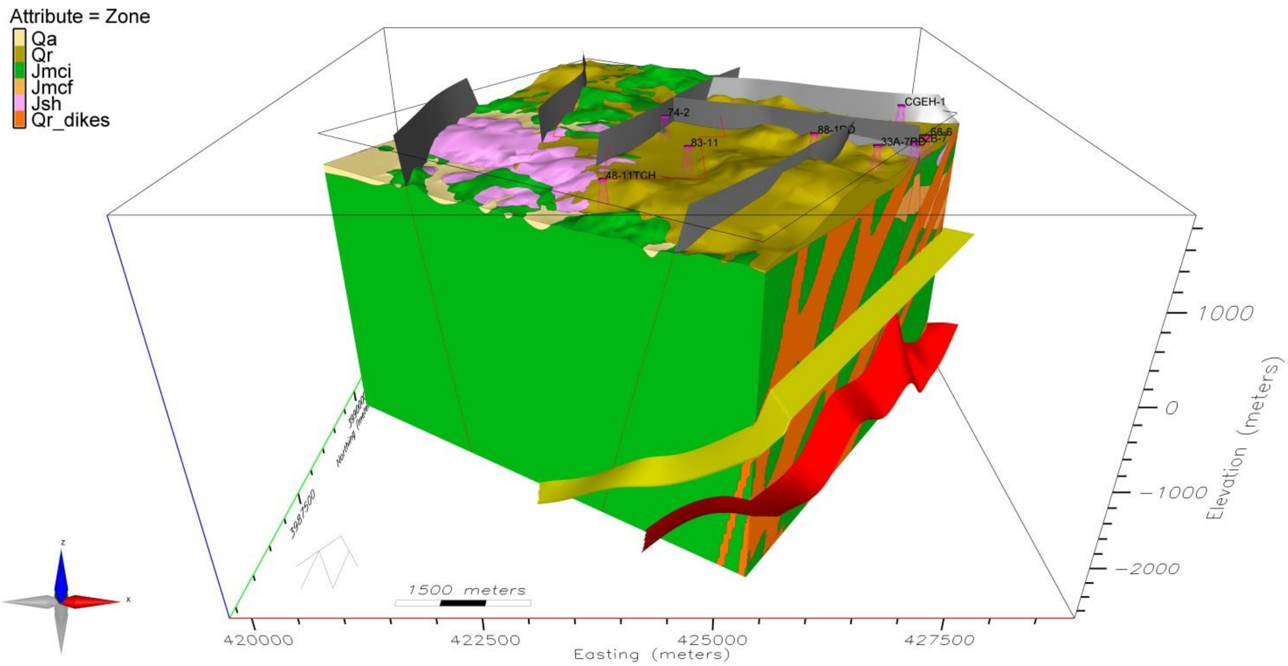


Figure 59. Oblique north- looking view of the West Flank 3D geologic model. The 175°C isotherm surface is yellow and truncated at 1.5 km beneath the ground surface and the 225°C isotherm surface is red.

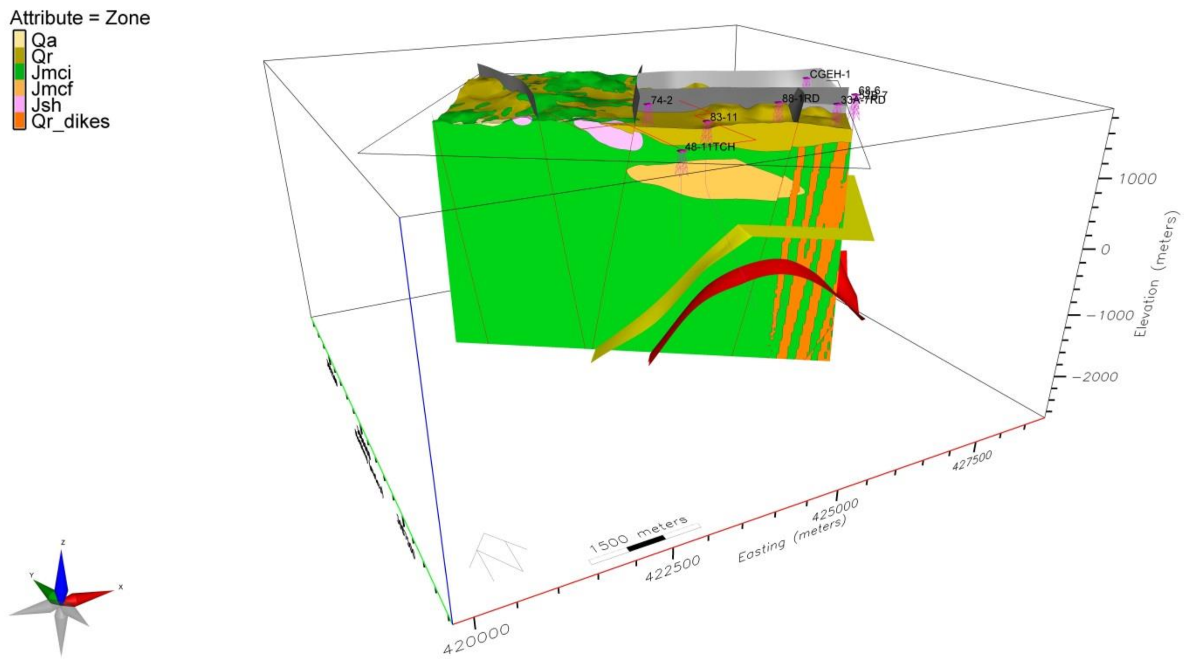


Figure 60. Oblique view looking northeast of the West Flank 3D geologic model. The model is sliced in the west-northwest direction. The 175°C isotherm surface is in yellow and truncated at 1.5 km beneath the ground surface and the 225°C isothermal is red. The 83-11 well path is in the deviated blue line that penetrates both surfaces.

6.5 CONDITIONS FOR RESERVOIR ENGINEERING

With a stress model and a structural model we can perform a basic slip tendency analysis to infer which structures are the most likely to become reactivated in a hydraulic stimulation and map through dilation tendency which structure are likely to dilate and open up fluid pathways in a faulting event (Morris et al., 1996; Ferrill et al., 1999).

The slip tendency of a fault plane is given by $T_S = \tau/\sigma_n$, where τ is the effective shear stress and σ is the effective normal stress resolved on that plane. It is a relative measure of the likelihood of fault slip on a given surface (Lisle and Srivastava, 2004). Fault slip is dependent on its cohesion and coefficient of static friction. Assuming cohesion for a pre-existing fault is negligible, a fault slips when its slip tendency equals the coefficient of static friction on that fault.

Dilation on a fault is largely controlled by the resolved normal stress σ_n. The dilation tendency is given by the resolved normal stress on a fault divided by the differential stresses: $T_D = (\sigma_1 - \sigma_n)/(\sigma_1 - \sigma_3)$, where σ_1 is the maximum principal stress and σ_3 is the minimum principal stress from Davatzes and Hickman (2010). Similar to TS, it is a relative measure and normalized to fall between 0 and 1.

Figure 61 shows the slip and dilation tendencies for fracture normals in a lower hemisphere projection. We see that the orientations with the highest slip tendency are also those of the majority of natural fractures. The dilation tendency for the dominant fracture sets is also high. That means, that the fractures that are the most likely to be reactivated by shear stimulation also have the highest tendency to dilate while shearing, which can lead to the possible opening of fluid pathways and therefore creation of permeability. In the light of the uncertainty of the stress field, only negligible variations of T_S and T_D with respect to the uncertainty of S_{Hmax} are found and we do not draw them here. This is because T_S and T_D both are normalized quantities and only relative measures. Changes of the orientation of S_{Hmax} would rotate the pattern of T_S and T_D accordingly.

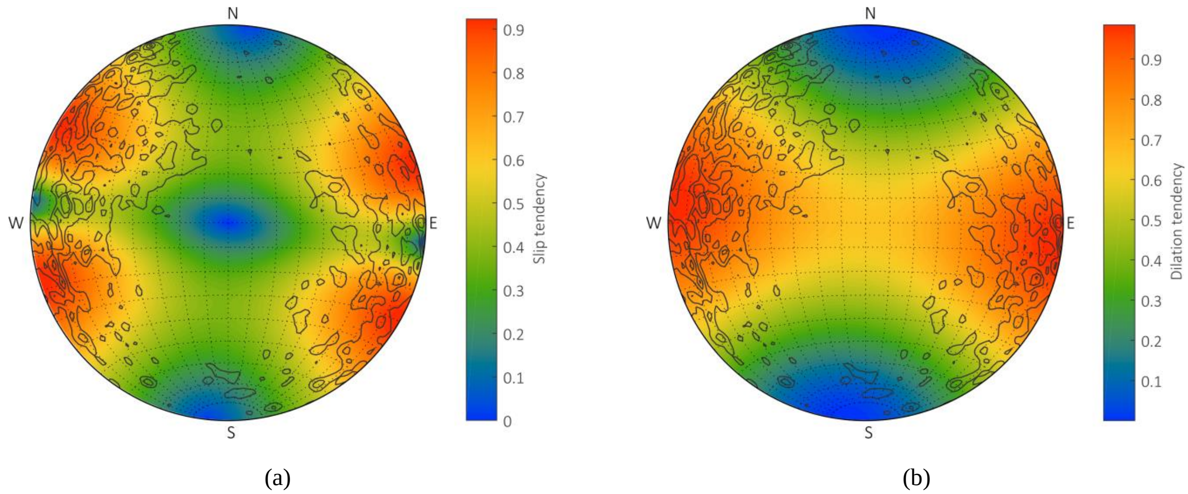


Figure 61. (a) Slip tendency and (b) dilation tendency for fracture normal for the preferred stress model with S_{Hmax} = 44 MPa/km. Terzaghi-corrected 3σ-Kamb contours of natural fractures are superimposed.

We apply the slip and dilation tendency analysis on faults 1-8 described in the geological model (Figure 62). To account for the uncertainty and especially for the natural variation of the stress field as determined from the wellbore images, we test a variation of the magnitude and of the orientation of S_{Hmax}. Again, varying S_{Hmax} does not change T_S and T_D significantly and we do not show results here. Instead, varying the orientation of S_{Hmax} has are strong effect as shown in Figure 63. We vary the orientation of S_{Hmax} from N175°E to N15°E. Especially the curved structure of faults 4 and 7 is very sensitive to these rotations. Patches that have high T_S for S_{Hmax} at N175°E have low T_S for S_{Hmax} at N15°E and vice versa. Faults 1, 3 and 8 uniformly show low values of T_S.

Dilation tendency is less affected by variations of the stress orientations, which is also obvious from Figure 61. While T_S has high values for 4 different clusters of plane normals, T_D has high values only for two broader clusters of plane normals. For all modelled stress orientations, Faults 1, 3 and 8 have low T_D and faults 2, 4, 5, 6 and 7 have large T_D. Both faults 5 and 6 show both high T_S and T_D, which provide an interesting start to our understanding of the mechanics within the West Flank FORGE site.

For future phases of FORGE, the complete and thorough understanding of the structural setting and stress state will be necessary to adequately engineer a geothermal system. Within the work performed for Phase 1, the stress state and structure of the West Flank site has been analyzed and interpreted to the best of our ability based on the preexisting data sets. With these information, the 3D model, and stress magnitudes from the eastern portion of the adjacent hydrothermal system, we can begin to understand where the current structures in the model will be the most useful and help continue to build a foundation for future work at the West Flank FORGE site.

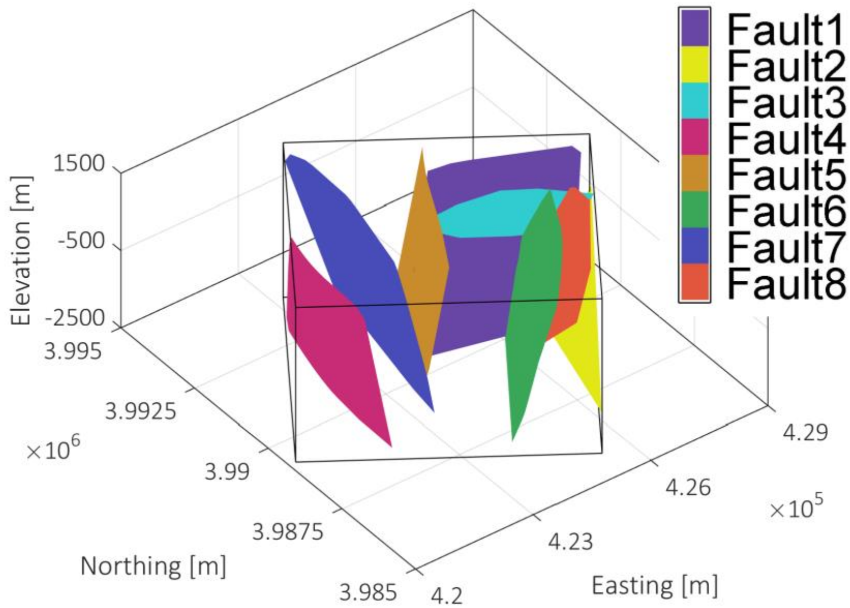


Figure 62. Simplified structural model used for slip and dilation tendency analysis.

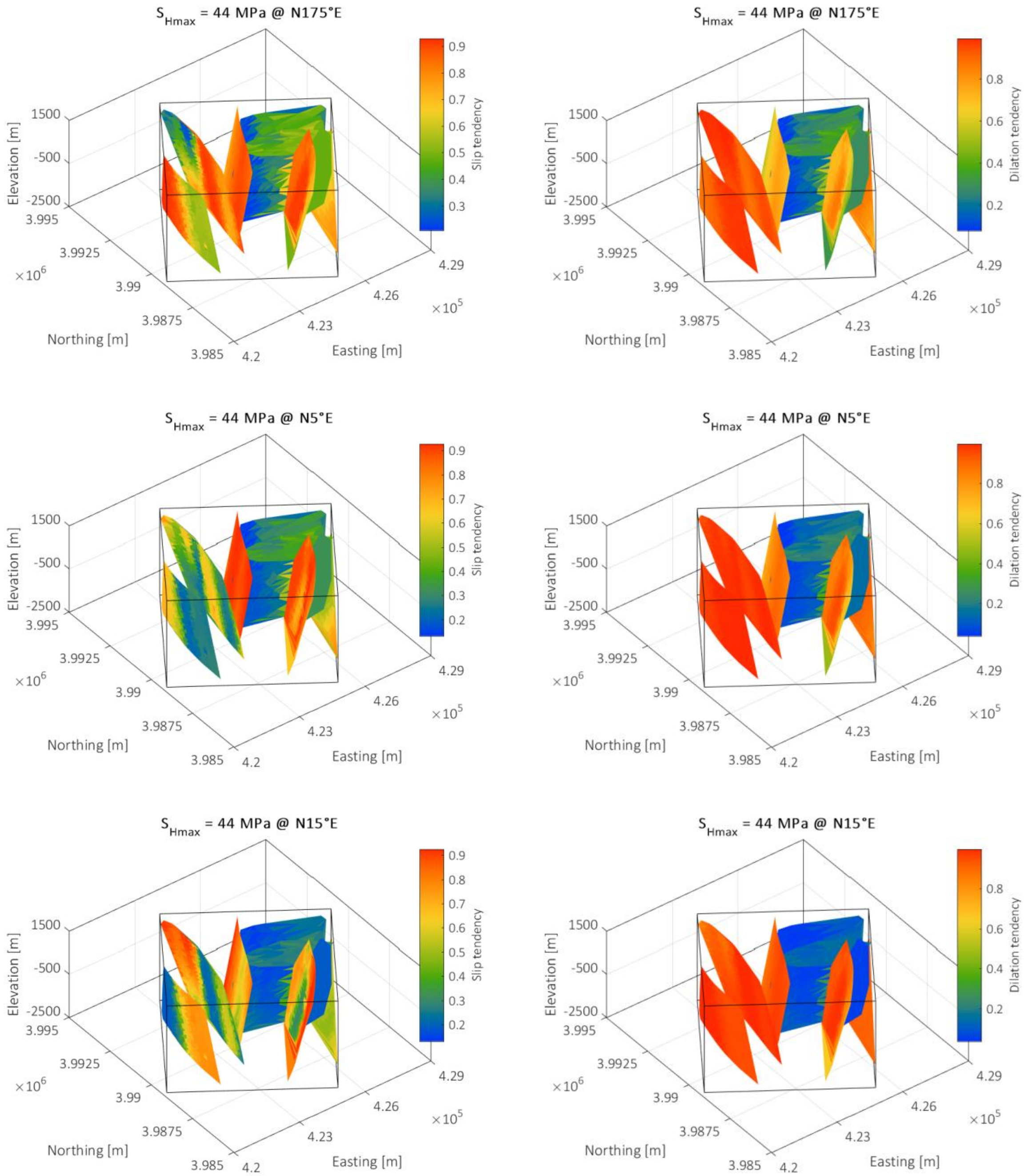


Figure 63. Slip and dilation tendency for orientations of S_{Hmax} varying from N175°E to N15°E and stress magnitudes at 1 km depth of Sv = 25.9 MPa, Shmin = 16.3 MPa and S_{Hmax} = 44 MPa.

7 DATA UNCERTAINTY ANALYSES

The relative uncertainty in the 3D geologic interpretations was calculated based on relative distance from the input datasets. The primary input datasets utilized for constraining the subsurface 3D geologic geometry are the geologic cross-sections, geologic maps, lithologic logs along well paths, and seismic reflection profiles. The distance between and the locations of these dataset and all locations within the 3D geologic model were calculated. Relative uncertainty was calculated by fitting the distances to a logarithmic relative uncertainty curve (Figure 64). At locations very near to input data, relative uncertainty in the 3D model is very low (high confidence in the geologic interpretation). With increasing distance from each input dataset, relative uncertainty increases progressively. Past a distance of 1 km, which is the mean spacing of the eight wells used for lithologic analyses and the mean spacing of the geologic cross-sections, the progressive increase in relative uncertainty with distance lessens; that is, the input data are probably too distant to make confident geologic interpretations and therefore the relative uncertainty is already high and cannot further increase. Relative uncertainty between zero and one was calculated for the eight wellbores with lithologic data, the geologic map, and the geologic cross-sections. Since constraining the Mesozoic basement geology is central to this effort, only the distance from mapped basement exposures was calculated. As a result of poor resolution, we have lower confidence in the seismic reflection interpretation than the other input data sets, so the relative uncertainty based on the seismic reflection interpretation was calculated between 0 and 2 with a distance of 1 km set to a relative uncertainty of 1 (Figure 64). The relative uncertainty volumes for all the input datasets were summed to produce a cumulative relative uncertainty for a 3D volume for which the 3D geologic model was constructed (Figure 64). The relative uncertainty analysis indicates that as a result of a high density of data, we have relatively high confidence in the modeled geologic relationships within the West Flank FORGE site. We also have relatively high confidence in the modeled geologic relationships directly to the east of the West Flank site. However, to the north and west of the West Flank site an absence of downhole lithologic data and seismic reflection data limit our confidence in the modeled geologic relationships.

Understanding the uncertainty in our data sets provide steps forward within future phases of FORGE. To eventually utilize the West Flank FORGE site, there needs to be very low uncertainty within the intersected and engineered rock volume. The preexisting data used to build the 3D conceptual model and uncertainty model help demonstrate gaps in our data sets and where the West Flank site needs to collect more geologic, structural and thermal data in subsequent phases.

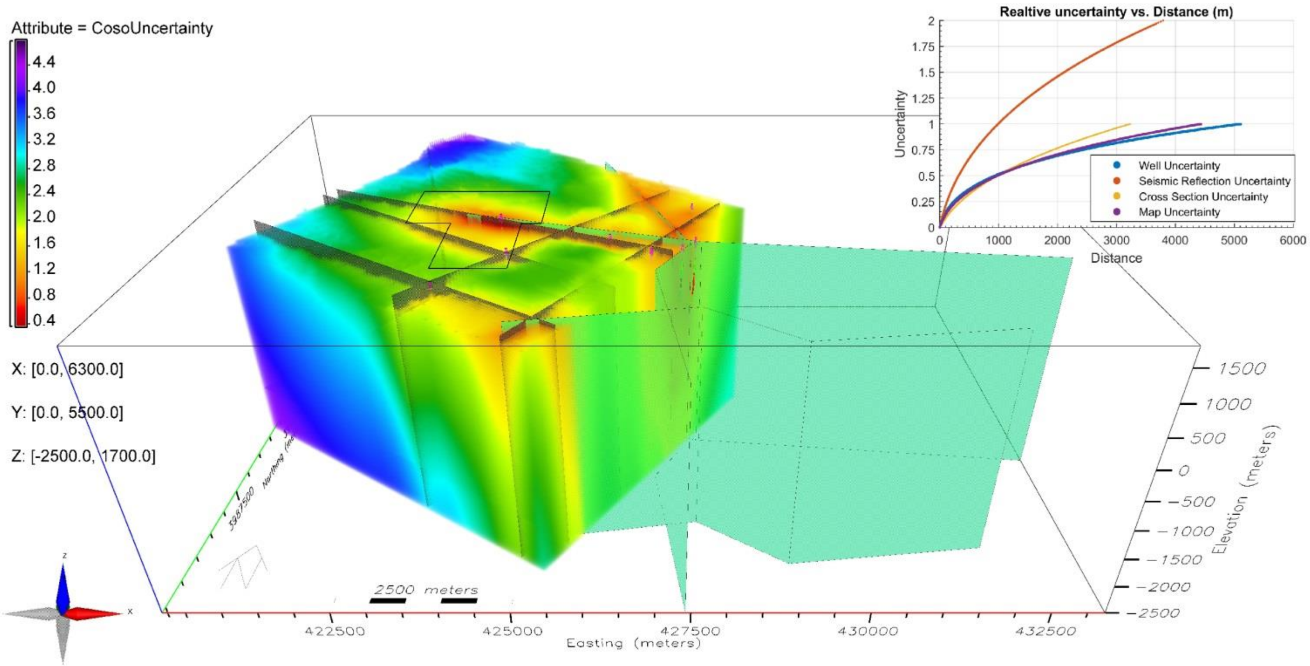


Figure 64. Relative uncertainty in the 3D geologic interpretations based on distance from the input data. Geologic cross sections shown as black planes, seismic reflection profiles shown as green planes, and the wells with lithologic data shown in pink. Warm colors correspond to relatively low uncertainty in the 3D modeled results.

8 DISCUSSION

Relevance to FORGE Criteria						
Criteria	Temperature (175-225 °C)	Low Permeability	Lithology (crystalline)	Depth (1.5-4 km)	Stress Regime[1]	No Active Hydrothermal System
Geology and Geologic Mapping			✓			✓
Well and Lithology Data	✓	✓	✓	✓	✓	✓
Petrographic Data	✓		✓	✓		✓
Structural Data		✓			✓	✓
Thermal Data	✓			✓		
Permeability Data		✓		✓		✓
Geophysical Data		✓	✓	✓	✓	✓
Geologic Cross-Sections	✓		✓	✓	✓	✓
TOTAL	✓	✓	✓	✓	✓	✓

[1]Stress regime is included here as a criteria, although it was not explicitly called out by DOE.

The geologic, structural and thermal character of the West Flank site and the surrounding area are broadly understood based on all the preexisting data sets utilized in Phase 1 of FORGE work. Geologic mapping, well cuttings, core, petrographic analyses, well temperature data, geophysical data and well testing data were all used to create conceptual cross-sections and a conceptual 3D geologic model of the West Flank FORGE site. All of these data demonstrate that this site meets all necessary criteria for a suitable FORGE location (see above table).

Temperature (175-225 °C): Well temperature data provide direct evidence that the West Flank FORGE site has temperatures within the specified 175 to 225°C range. The 83-11 well temperatures penetrates the 175°C isotherm on the West Flank FORGE site and even exceeds the 225°C temperature criteria. In the 3D conceptual geologic model, we further demonstrate that there is a significant volume of crystalline rock at depths of 1.5 to 2.5 km bgs in this temperature range. In summary, the well temperature data demonstrates that the West Flank site satisfies the temperature criteria for FORGE.

Low Permeability: Well-test data provide direct evidence for low permeability conditions at the West Flank FORGE site. Air and water lifts and an injection test were performed on 83-11 after the well was completed. These tests demonstrated a buildup of pressure in the wellbore during injection testing and a lack of flow during the air lift suggesting very low permeability. The result of the well testing determined that the well was non-commercial and has low permeability.

Crystalline Host Rock: An analysis of cuttings, core and thin sections from the deep wells in the West Flank FORGE site demonstrates that the basement is composed of Mesozoic plutonic rocks and minor volumes of Quaternary dikes. Geologic mapping in the West Flank area reinforces the conclusion that the basement is a complex assemblage of Jurassic and Cretaceous plutons, sills and dikes, all locally cut or overlain by flows, domes and dikes associated with the <1.0 Ma Coso Volcanic Field. The data demonstrate that the entire FORGE site is composed almost entirely of crystalline basement rock.

Depth (1.5-4 km): Data from wells drilled in the West Flank provides direct evidence that required FORGE temperatures can readily be found in crystalline basement rock between 1.5 and 4.0 km depths. Well 83-11 intersects temperature greater than 175°C and less than 225°C at a depth range of 1.5 to 2.5 km. The 3D thermal model indicates the top of the smoothed 175°C isotherm is at 1.5 km and deepens to the west within the West Flank FORGE site.

Not in Active Hydrothermal Field: The 83-11 static temperature profile illustrates a conductive heat flow pattern. Well tests on 83-11 indicate that it is non-commercial with very low permeability. Subsequent pressure monitoring data comparing 83-11 downhole pressure over time with other wells in the active hydrothermal field to the east indicate that a pressure connection between 83-11 and the hydrothermal field to the east does not exist. Cuttings, core and thin sections from 83-11 and 74-2TCH demonstrate a locally fractured and possibly faulted crystalline basement with no mineralogical indications of contemporary hydrothermal alteration. Observed and x-rayed clay minerals in sealed veins are likely the product of an older hydrothermal system. Interpreted MT data suggest that the low resistivity "clay cap" that is prominent in the active hydrothermal system to the east (Coso geothermal field) is not apparent in the West Flank. A zone of N-NE striking, vertical to sub-vertical Quaternary rhyolite dikes terminates just east of the eastern boundary (projected to depth) of the West Flank. Well testing of deep wells that penetrate these dikes indicates that permeability west of this dike swarm drops to non-detectable by standard well testing practices. Collectively, all of these relationships indicate that it is very unlikely that an active hydrothermal system resides within the proposed West Flank FORGE site.

All data referenced herein were incorporated into a 3D conceptual geologic model that is representative of the West Flank FORGE site. As additional work is performed, this model will be updated and modified. This model and future iterations of it will serve as the foundation for all subsequent FORGE project phases.

Finally, this site also meets many other non-technical criteria. The West Flank site is entirely within the fence line of highly secure Navy weapons research, testing, development and evaluation (RDT&E) installation. NAWS China Lake is the Navy's premier weapons RDT&E facility and it maintains some of the most important active weapons testing ranges in the country. As such the FORGE site is both remote and secure. However, it is adjacent to a geothermal field whose resource manager (Navy) and operator (COC) are members of this FORGE project team. This association leverages the facilities and expertise of both the Navy and a large and established geothermal operator, COC. The West Flank FORGE site is a one-hour drive from a town that contains the remaining infrastructure necessary to be a long-term host to workers on this project. All members of the West Flank FORGE team, including the Navy and COC, are committed to meeting and exceeding all DOE expectations for FORGE over the entire life of this project.

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APPENDIX B. UPDATE ON CHARACTERIZATION DATA UPLOADED TO THE GDR DATA ARCHIVE

UPDATE ON CHARACTERIZATION DATA UPLOADED TO THE GDR DATA ARCHIVE

West Flank of Coso, CA

UPDATE ON CHARACTERIZATION DATA UPLOADED TO THE GDR DATA ARCHIVE

West Flank of Coso, CA

All data used in characterization of the West Flank FORGE site and construction of the West Flank 3D geologic model has been uploaded to the Geothermal Data Repository (GDR). This includes downhole lithologic data interpreted from core, cuttings, and mud logs; downhole image log and geophysical data; digital elevation data; geologic map data; petrographic data; geologic cross-sections, gravity and magnetic data; magnetotelluric data; down hole temperature data; shallow temperature data; well testing data; seismic reflection data; and seismicity data.

The West Flank 3D geologic model has also been uploaded to the GDR.

The data uploaded to the GDR for the West Flank of Coso, CA, site is captured in Table 1, below.

Table 1. Data uploaded to the GDR for the West Flank of Coso, CA, site

Data Description	**File Name**	**Date Uploaded**	Details
Core/Cuttings notes, photos and notes from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	West FlankWellsPhotosandNotes.zip	12/21/2015	Core/Cuttings photos74-2 and CGEH-1, Interpreted lith logs from 33A-7,33A-7RD, 52B-7,68-6,74-2,88-1RD,CGEH-1, Written summary for CGEH-1, 74-2, Notes from 74-2 and CGEH-1
3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	CosoWellsLith.path	12/21/2015	3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7
ArcGIS data for West Flank	WestFlankArcGIS.zip	12/21/2105	Hillshade, DEM, MXD file, West Flank FORGE Outline, 3D Geologic Model extent, Whitnarsh Fault/contacts, Whitmarsh Geology
ArcGIS data for West Flank	WestFlankArcGIS2.zip	4/21/2015	Polygon of the 3D geologic model, polylines of the traces 3D modeled faults, polylines of the fault traces from Duffield and Bacon, 1980, polygon of the West Flank FORGE site, polylines of the traces of the geologic cross-sections , polylines of the traces of the seismic reflection profiles through and adjacent to the West Flank site, points of the well collars in and around the West Flank site, polylines of the surface expression of the West Flank well paths
West Flank 52B-7 image and mud log	52B-7 Mud log and Image log *(under moratorium)*	4/7/2016	52B-7 Mud log, 52B-7 Image log
West Flank 33-7 image log	33-7 Image log *(under moratorium)*	4/7/2016	33-7 Image log
West Flank 3D temperature model	WestFlank3DTemperatureModel.txt	4/21/2016	x,y,z data of the 3D temperature model for the West Flank Coso FORGE site
3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	WestFlankWellsLithData.txt	4/21/2016	3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7
West Flank 3D geolgoic model	WestFlankFORGE3DGeologicModel.txt	4/21/2016	This is an x,y,z file of the West Flank FORGE 3D geologic model
Geologic cross-sections for West Flank	WestFlank_Cross-Sections.zip	4/21/2016	Geologic cross-sections for West Flank .jpgs
Image of the West Flank site	WestFlankFORGETestArea.jpg	11/23/2015	Image of the West Flank site with aeromage data, and regional EQ data
West Flank 83-11 image and mud log data	CBIL and STAR image logs as pre-processed DLIS files, and mud log of well 83-11 *(under moratorium)*	3/31/2015	CBIL and STAR image logs as pre-processed DLIS files, and mud log of well 83-11
48-11TCH data files	48-11TCH Well Data.zip	5/13/2016	Temperature logs, pressure logs, directional survey, well history, well bore schematic, and other reports for well 48-11TCH at West Flank FORGE
74-2TCH data files	74-2TCH Well Data.zip	5/13/2016	Temperature logs, pressure logs, directional survey, well history, well bore schematic, and other reports for well 74-2TCH at West Flank FORGE
Mud logs for West Flank Wells	WestFlankMudLogs.zip	5/13/2016	Mud logs for wells 83-11,68-6,33A-7, 33A-7RD, 52B-7,88-1 at West Flank
West Flank MT	WestFlankMT.zip	5/16/2016	3D MT inversion, two maps, and blurb about collection of the MT
XRD and Petrography at West Flank	CosoFinalRpt.pdf	5/16/2016	XRD and Petographic study on 83-11, 33A-7 and 33A-7RD-1 at West Flank
West Flank Seismic Reflection	WestFlankSeismicReflection.zip	5/16/2016	PDFs of seismic reflection profiles 101,110, 111 local to the West Flank FORGE site
West Flank Natural fracture data	WestFlankNaturalFractureData.zip	5/16/2016	Natural fracture data from wells 33-7, 33A-7,52A-7, 52B-7 and 83-11 at West Flank
West Flank Magnetic and Gravity Data	WestFlankMagandGravdata.zip	5/19/2016	Gravity and magnetic data for West Flank

APPENDIX C. ENVIRONMENTAL INFORMATION SYNOPSIS

ENVIRONMENTAL INFORMATION SYNOPSIS

West Flank of Coso, CA

ENVIRONMENTAL INFORMATION SYNOPSIS

West Flank, CA

INTRODUCTION

The proposed West Flank FORGE project area is approximately 1,100 acres within the Coso Known Geothermal Area (KGRA) located in the West Flank portion of the Coso geothermal developed field on Naval Air Weapons Station (NAWS) China Lake. The West Flank site includes portions of sections 1, 11 and 14 of Coso Operating Company's two active BLM geothermal leases which are in a "Held by Production" status, CA-11384 and CA-11385. The remainder of the West Flank project includes expired BLM leases, CA-12936 and CA-11403, that are now categorized as "BLM withdrawn lands." The Coso KGRA was subject to intense environmental and cultural investigations in order to meet National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA)NEPA/CEQA requirements so that geothermal exploration could proceed

The Navy Geothermal Program Office (GPO) is surface manager for FORGE designated lands within the NAWS China Lake boundaries. Environmental protection on this land is governed by numerous documents completed before and after the Coso geothermal field production commenced in 1987. Relevant existing environmental documents are listed in Table 1.

Table 1. Select NEPA/CEQA DOCUMENTS

Issued By	Document Names
Naval Weapons Center (NWC) 1979	Final Environmental Impact Statement for the Navy Coso Geothermal Development Program, China Lake, California, Volumes 1 and 2.
BLM 1980	Proposed Leasing within the Coso Known Geothermal Resource Area (KGRA): Final Environmental Impact Statement
NWC 1981	Environmental Impact Statement for Navy Coso Geothermal Development Program, Volume 3, Supplemental EIS for Exploratory Drilling and Testing (Tier 3).
NWC 1983	Environmental Assessment for Proposed Exploration and Development within the Coso KGRA.
NWC 1984	Preliminary Environmental Assessment for Additional Surface Disturbance for Construction of the 25-Mwe Geothermal Power Plant Site and Definition of Pipeline Corridors.
NWC 1985	Environmental Assessment of the Proposed China Lake Joint Venture well 63-18, Coso KGRA, Inyo County, California.
BLM 1985	Environmental Assessment of the Proposed Plan of Exploration, Federal Lease CA-11402, Coso KGRA, Inyo County, California.
NWC 1986	Environmental Impact Statement for Navy Coso Geothermal Development, Tier 4, Field Development.

Issued By	Document Names
NWC 1988	Environmental Assessment/Initial Study of the CLJV Proposed Plan of Development on Navy Contract Lands.
NWC 1988a	Environmental Assessment/Initial Study of the Proposed CLJV Navy 2 Geothermal Development and Utilization.
BLM 1988	Environmental Assessment/Environmental Impact Report for the CalEnergy Plans of Utilization, Development and Disposal For Geothermal Development on BLM Geothermal Lease CA-11402
BLM 1989	Categorical Exclusion for Plan of Development for Federal Lease CA-11401
NWC 1993	ES General Plan of Development East Flank Development Navy I and Navy II Contract Lands
GBUAPCD 1995	Initial Study of Revision to Rule 424, Geothermal Emissions Standard
GBUAPCD/BLM 1999	GBUAPCD Initial Study and Negative Declaration and BLM finding of Categorical Exclusion for Plan of Operations for Federal Lease 11402 amendment allows Federal leases, CA-11383, 11384 and 11385 to be incorporated into the existing POO and subject to mitigation requirements of the 1988 EA/EIR for POU, development and disposal
Inyo County 2009	EIR Coso Operating Company, Hay Ranch Water Extraction and Delivery System Conditional Use Permit 2007-003 Application SCH# 2007101002
BLM 2009	EA, FONSI, ROD for the Hay Ranch Water Extraction and Delivery System (Navy was a cooperating agency)
NAWS China Lake, 2016	Legislative Environmental Impact Statement for Renewal of Naval Air Weapons Station China Lake Public Withdrawal

A 30-year geothermal development contract focusing on a subset of the >1,300 square miles covered by the 1979 FEIS was signed by both the Navy and the Coso geothermal developers in 1979 (N68711-05-C-0001). The tenets of this contract extend through the most recent contract action extending the period of performance of Coso development through 2044. While management of the 1.2 million acres of land at NAWS China Lake is the responsibility of the Commanding Officer (CO), the Coso development contract serves as a “revocable permit” offered by the government acting through the Secretary of the Navy for the developer to operate Coso. It further stipulates that the developer (Coso Operating Company) is responsible for all environmental and cultural resource protection. The contract also assigned GPO as the managers of all Coso activities in support of the base CO’s responsibilities. Consequently, the GPO has and will continue to work closely with the CO and many of his other supporting programs including the Environmental Management Division (EMD), Real Estate (RE), Asset Management (AM), and Naval Air Weapons Center Weapons Division (NAWCWD), the primary tenant command at China Lake responsible for the base weapons mission, in its oversight of the Coso geothermal field and the adjacent West Flank FORGE project.

The California Desert Protection Act (CDPA) of 1994 (Public Law 103-433) authorized the Navy’s continued use of public withdrawn lands at NAWS China Lake. This Act also required the development of a land use management plan for these withdrawn lands in accordance with the Federal Land Policy and Management Act (FLPMA) of 1976 (Public Law 94-579). Under the provisions of the CDPA and through a memorandum of agreement, the Department of the Interior assigned management responsibility of these withdrawn lands to the Navy. The Navy then developed and implemented the Comprehensive Land Use Management Plan (CLUMP) for Naval Air Weapons Station China Lake, California that supports the environmental stewardship programs at NAWS China Lake. This CLUMP serves as the NAWS China Lake guide for land management in partnership with the Bureau of Land Management (BLM) and the public.

All FORGE activities within the West Flank will conform to the natural resources conservation and management policies and practices established for the geothermal field in the 1970s and further reinforced in the 2015 NAWS China Lake Legislative Environmental Impact Statement (LEIS) for Renewal of Naval Air Weapons Station China Lake Public Land Withdrawal. Those practices are briefly described in the following text.

ENVIRONMENTAL ISSUES AND PROTECTION

The West Flank FORGE team will inform all personnel, as well as well drilling, testing, and supply contractors, of the team's policy regarding protection and undue degradation of the environment. These measures are intended to prevent all unacceptable impacts from occurring as a result of these operations, as is required under the special stipulations of the Federal geothermal leases.

AIR QUALITY

Existing air quality in the region is generally very good and is typical of unindustrialized, sparsely populated desert areas. The area is at attainment for all federal air quality standards except particulates, which exceed federal and state standards during Owens Valley dust storms. Other sources of particulate matter less than 10 microns in diameter (PM^{10}) are wind erosion of crustal material, dust from vehicular traffic on roads, and other sources, such as mining activities. These are only measured at Coso Junction, 9 miles due West of the West Flank boundary.

The West Flank is located in Inyo County within the Great Basin Valleys Air Basin, managed by the Great Basin Unified Air Pollution Control District (GBUAPCD). Permits will be obtained through the GBUAPCD which will set in place conditions of approval to be adhered to. New Source Review (NSR) requires stationary sources of air pollution to get permits before construction starts. NSR is also referred to as construction permitting or preconstruction permitting.

SOIL/EROSION CONTROL

No soil erosion problems are anticipated from this project because the topography is gentle and cut and fill for construction of the well sites and access roads have been minimized. Roads are currently maintained by Coso Operating Company to retain the natural slope of storm water runoff minimizing erosion. Water erosion in disturbed areas will be controlled by constructing cut and fill slopes to reduce runoff velocity, and by incorporating culverts, berms, and lined drainage ditches, which will direct runoff away from the fill areas into natural drainage. Wind erosion will be controlled by watering the disturbed areas and access roads during construction.

VEGETATION

Botanical surveys outlined in the listed environmental documents (Table 1) focused primarily on natural communities and plant species of special management concern. There are no wetlands on the project site. Re-vegetation will occur when a well pad or construction having needs to be stabilized. When clearing a site, top soil will be grubbed and stockpiled to be later applied for natural vegetation.

WILDLIFE AND SENSITIVE SPECIES

Wildlife habitat quality and the abundance and diversity of wildlife within the project area are typical of desert scrub habitats throughout the northern Mojave region. Species present are for the most part common and widespread in similar habitat throughout the region (1980 BLM EIS, Table 1). Sensitive species and species of management concern are the Desert Tortoise and Mohave Squirrel. Biological Opinions have been generated for the NAWS China Lake as well as the Coso geothermal area. Current operators of the geothermal field follow the guidelines of the Biological Opinions.

CULTURAL AND RESOURCES

Prior to the establishment of the Navy base at China Lake in 1943, it was known by the Navy and the California State Historic Preservation Office (SHPO) that the portion of this base in and around the Coso Volcanic Field had been a nexus of indigenous peoples' activities for many thousands of years prior. Key archeological and cultural sites within the KGRA include the Coso Hot Springs and the Sugarloaf quarry in addition to clusters of debitage and the densest accumulation of petroglyphs in North America.

The Coso KGRA has been the subject of studies on the prehistory and history of the area, and on the nature and integrity of cultural and archaeological resources within the project area. Over the years the Coso Operating Company has contracted with independent archaeologists to preform comprehensive regional surveys of cultural resources within the Coso KGRA. In order to move beyond a "piece meal " approach to cultural resource management and aid in planning, COC was required to work with archaeologists and have a Cultural Management Plan developed for the KGRA and approved by the state and federal agencies with the Navy being a cooperating agency.

Cultural requirements associated with all geothermal activities within the proposed West Flank FORGE site will be governed by the Sugarloaf Cultural Management Plan (CMP). The Coso KGRA map includes the proposed FORGE site as well as the adjacent Coso geothermal field. Depending on where within the West Flank FORGE activities are proposed, the implementation of this Plan will be initiated by either the Coso Operating Company (COC) or the NAWS China Lake Environmental Management Department (EMD) for a no adverse effect.

WATER RESOURCES

There are no perennial surface water sources in the Project area. Surface water is limited to sheet flow and concentrated runoff from rainfall events. Due to the coarse nature of area soils, runoff normally contains high levels of sediment.

The locations of the drill pads and access roads will be selected to minimize the potential for surface water pollution during construction, drilling, and testing. Only non-toxic, non-hazardous drilling mud and drilling mud additives will be utilized. Waste drilling mud, drill cuttings and any runoff from the well pad will be discharged into the lined containment basin to prevent water quality degradation. The well bores would be cased with steel casing to prevent inter-zonal migration of the fluids and reduce the possibility of uncontrolled well flow. Fluid injection that has been undertaken in nearby areas over the years has caused no negative impacts to the area.

NOISE

Noise levels in the project area are low, as is typical of uninhabited desert areas. A detailed description of the existing noise level in the area can be found in the Technical Report on the Coso Geothermal Study Area by Rockwell International (1980a).

PROTECTION OF PUBLIC HEALTH AND SAFETY

There is a possibility of encountering hazardous non-condensable gases while drilling and testing. The three main gases associated with geothermal resources in the area are steam, hydrogen sulfide (H2S), and carbon dioxide (CO2). Noxious or dangerous amounts of gases have not been associated with other geothermal wells drilled in the area; however, a contingency plan has been prepared to protect against exposure to noxious gasses such as H2S. Detection systems would be installed at the wellhead to protect against exposure.

WASTE MANAGEMENT PRACTICES (ALSO SEE BEST MANAGEMENT PRACTICES)

It is anticipated that waste associated with the FORGE project will be classified as geothermal wastes. As geothermal wastes are exempt from the California Department of Health Services (DOHS), waste classification and removal protocols are governed by the Lahontan Regional Water Quality Control Board (RWQCB). The Waste Management Plan for the nearby geothermal will be followed as a best management practice (BMP) for waste removal at the West Flank. The primary waste anticipated with FORGE includes drilling fluids and cuttings which will be placed in the sump. Sumps associated with drilling activities fall under the jurisdiction of the Lahontan RWQCB. A Sump Closure Plan insures that sumps stay open over the life of a well pad and will not be reclaimed until the well is plugged and abandoned.

The current Coso Operating Company Spill Prevention, Control and Countermeasure Plan (SPCC Plan) will be followed for BMP. The existing SPCC Plan describes the procedures and oil spill prevention measures that are in place. Because drill rigs and other machinery will be operating at the West Flank over the course of this project, the potential for spills exists and will be handled according to the Coso SPCC Plan.

Disposal of hazardous waste or used oil must be delivered to an offsite treatment, storage and disposal facility (TSDF) located in the U.S. that is a "permitted, licensed, or registered by a State to manage municipal or industrial solid waste" (40 CFR 261.5 (f)(3)). Vendors are approved and granted access through the Navy.

BEST MANAGEMENT PRACTICES

A principle component of proposed FORGE activities in the West Flank is drilling and attendant activities including but not limited to blow out prevention equipment (BOPE), casing, logging, use of drilling fluids and waste disposal. The Coso KGRA Field Drilling Rules were adapted under the authority of the Geothermal Resource Operational Order (GROs) and have been maintained since the Coso project was initiated. These rules were enacted to maintain the integrity of the NAWS China Lake mission, to protect surface water, soil, air, vegetation and other natural resources and to protect workers associated with drilling and attendant operations.

The Drilling Rules contained within the GROs describes the general responsibilities and required training for all rig personnel and includes protocols for installing casing and cement, pressure testing, liners, BOPE, drilling fluids, safety and environmental requirements. Over the almost 30 years of continuous geothermal operations, these Best Management Practices have been further refined and expanded. The weekly safety briefings that reinforce these Best Management Practices will be extended into the adjacent FORGE site.

PERMITTING PLAN AND GEOTHERMAL SUNDRY NOTICE PROCESS

Two designations of land exist within the proposed West Flank site, two active BLM leases and two former leases, now BLM withdrawn land. Under a memorandum of understanding between the Navy and BLM, surface management responsibilities of these withdrawn lands belongs to the Navy. Most proposed FORGE work requiring permits (e.g., drilling) on the BLM withdrawn land would be approved by the Navy with BLM concurrence. If air permits are required, these would be issued through the Great Basin Unified Air Pollution Control District (GBUAPCD.

Work would be initiated through the GPO office via Geothermal Sundry Notice (GSN) at the local base level and the authorization would be issued at the Navy Region level in San Diego. An approved sundry notice serves as a permit to proceed. Any work proposed on the BLM leases would be conducted by COC (a West Flank FORGE team member) or a FORGE contractor and authorized via GSN, pursuant to the Navy-COC development contract (N68711-05-C-0001). All cultural and environment work required to support proposed work would be conducted by a contractor and reviewed by the Navy. Supporting NEPA documentation, plans and drawings are included in the GSN submittal for technical and environmental approval by the GPO and NAWS China Lake environmental office, EMD. Once the GSN has been approved and signed by GPO, work can proceed. The response time to the sundry notice by the Navy is less than 30 days.

In support of FORGE, COC will request to the Navy and BLM that existing BLM geothermal leases be extended over the entire FORGE land. This would establish a uniformity of NEPA protocols throughout the duration of the project. In the interim, the FORGE team has proposed to the Navy that similar environmental and cultural protocols be followed over the entire proposed FORGE site. In order for this to be implemented, it will require the formal approval of Navy leadership at the Region level and concurrence with BLM. This process has been initiated. A decision is anticipated during Phase 2A.

The Navy GPO is pursuing a Real Estate agreement through the Navy Region, San Diego. This agreement will establish a time period and a framework through which FORGE activities can take place on Navy-managed ground. This agreement will be between the Navy and a responsible party representing the FORGE work (e.g., Sandia National Laboratory). The Navy will seek concurrence on this agreement with either the local BLM office or the State office in Sacramento. This agreement is anticipated to be executed in Phase 2A.

APPENDIX D. UPDATED SITE CHARACTERIZATION DATA INVENTORY

UPDATED

SITE CHARACTERIZATION DATA INVENTORY

West Flank of Coso, CA

UPDATED SITE CHARACTERIZATION DATA INVENTORY

West Flank of Coso, CA

Site characterization at West Flank, CA, and construction of the West Flank 3D geologic model synthesized all available surface and subsurface data. These data include downhole lithologic data interpreted from core, cuttings, and mud logs; downhole image log and geophysical data; digital elevation data; geologic map data; petrographic data; geologic cross-sections, gravity, and magnetic data; magnetotelluric data; downhole temperature data; shallow temperature data; well testing data; seismic reflection data; and seismicity data.

Data used in construction of the 3D geologic model for the West Flank of Coso, CA, site is represented in Table 1, below.

Table 1. Data used in construction of the 3D geologic model for the West Flank of Coso, CA, site

Data Description	File Name	Date Uploaded	Details
Core/Cuttings notes, photos and notes from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	West FlankWellsPhotosandNotes.zip	12/21/2015	Core/Cuttings photos74-2 and CGEH-1, Interpreted lith logs from 33A-7,33A-7RD, 52B-7,68-6,74-2,88-1RD,CGEH-1, Written summary for CGEH-1, 74-2, Notes from 74-2 and CGEH-1
3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	CosoWellsLith.path	12/21/2015	3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7
ArcGIS data for West Flank	WestFlankArcGIS.zip	12/21/2105	Hillshade, DEM, MXD file, West Flank FORGE Outline, 3D Geologic Model extent, Whitnarsh Fault/contacts, Whitmarsh Geology
ArcGIS data for West Flank	WestFlankArcGIS2.zip	4/21/2015	Polygon of the 3D geologic model, polylines of the traces 3D modeled faults, polylines of the fault traces from Duffield and Bacon, 1980, polygon of the West Flank FORGE site, polylines of the traces of the geologic cross-sections , polylines of the traces of the seismic reflection profiles through and adjacent to the West Flank site, points of the well collars in and around the West Flank site, polylines of the surface expression of the West Flank well paths
West Flank 52B-7 image and mud log	52B-7 Mud log and Image log *(under moratorium)*	4/7/2016	52B-7 Mud log, 52B-7 Image log
West Flank 33-7 image log	33-7 Image log *(under moratorium)*	4/7/2016	33-7 Image log
3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7	WestFlankWellsLithData.txt	4/21/2016	3D lithologic logs from 74-2, CGEH-1,33A-7RD, 33A-7, 88-1RD, 68-6, 52B-7
West Flank 3D geolgoic model	WestFlankFORGE3DGeologicModel.txt	4/21/2016	This is an x,y,z file of the West Flank FORGE 3D geologic model
Geologic cross-sections for West Flank	WestFlank_Cross-Sections.zip	4/21/2016	Geologic cross-sections for West Flank .jpgs
Image of the West Flank site	WestFlankFORGETestArea.jpg	11/23/2015	Image of the West Flank site with aeromage data, and regional EQ data
West Flank 83-11 image and mud log data	CBIL and STAR image logs as pre-processed DLIS files, and mud log of well 83-11 *(under moratorium)*	3/31/2015	CBIL and STAR image logs as pre-processed DLIS files, and mud log of well 83-11
48-11TCH data files	48-11TCH Well Data.zip	5/13/2016	Temperature logs, pressure logs, directional survey, well history, well bore schematic, and other reports for well 48-11TCH at West Flank FORGE
74-2TCH data files	74-2TCH Well Data.zip	5/13/2016	Temperature logs, pressure logs, directional survey, well history, well bore schematic, and other reports for well 74-2TCH at West Flank FORGE
Mud logs for West Flank Wells	WestFlankMudLogs.zip	5/13/2016	Mud logs for wells 83-11,68-6,33A-7, 33A-7RD, 52B-7,88-1 at West Flank
West Flank MT	WestFlankMT.zip	5/16/2016	3D MT inversion, two maps, and blurb about collection of the MT
XRD and Petrography at West Flank	CosoFinalRpt.pdf	5/16/2016	XRD and Petographic study on 83-11, 33A-7 and 33A-7RD-1 at West Flank
West Flank Seismic Reflection	WestFlankSeismicReflection.zip	5/16/2016	PDFs of seismic reflection profiles 101,110, 111 local to the West Flank FORGE site
West Flank Natural fracture data	WestFlankNaturalFractureData.zip	5/16/2016	Natural fracture data from wells 33-7, 33A-7,52A-7, 52B-7 and 83-11 at West Flank
West Flank Magnetic and Gravity Data	WestFlankMagandGravdata.zip	5/19/2016	Gravity and magnetic data for West Flank

APPENDIX E. UPDATED PERMITTING INVENTORY

UPDATED PERMITTING INVENTORY

West Flank, CA

UPDATED PERMITTING INVENTORY

West Flank of Coso, CA

The original Permitting Inventory was initially submitted under our response to the Funding Opportunity Announcement (DE-FOA-0000890). All new data or updates to existing data generated during Phase 1 that supports the Environmental Information Synopsis and the ability to meet NEPA and other permitting/regulatory compliance requirements by the end of Phase 2B area are reflected in this update.

No new permits have been issued for the proposed West Flank FORGE site during Phase 1 activities. There have been multiple discussions between all lease holders involved, Coso Operating Company, Navy and BLM, to ensure that all parties understand the commitment to the project and the potential for utilization of the lands for future phases of FORGE. These meetings are documented in the community outreach section of the Topical Report. All permits, as agreed upon by the parties involved, will be issued by the Navy for work in Phase 2B.

Below is the Permitting Inventory modified after the initial FOA submission. This inventory is subject to revisions throughout this project and will be updated as necessary.

SURFACE OWNERSHIP

Ownership of the 1,100 acres proposed for the major FORGE activities is the Department of Interior. Management of the 1.2 million acres of land at NAWS China Lake is the responsibility of the Commanding Officer (CO), the Coso development contract serves as a "revocable permit" offered by the government acting through the Secretary of the Navy for the developer to operate Coso. It further stipulates that the developer (Coso Operating Company) is responsible for all environmental and cultural resource protection. As outlined in the California Desert Protection Act (CDPA) of 1994 and through a Memorandum of Agreement, the Department of the Interior assigned management responsibility of withdrawn lands to the Navy.

- BLM – 3 leases inside China Lake NAWS fence, CA-11384, CA-11385 and CA-11402 (CA-11402 is outside the proposed West Flank area where drilling would occur)
- DOD – the remaining land within the 1,100 acre West Flank polygon is Navy-managed, BLM withdrawn land. The Navy is authorized to permit this land, pursuant to above legislation and BLM MOAs, in advance of drilling and other related activities; however, a Real Estate agreement between the Navy and Sandia (or DOE) will be sought. This agreement outlines the expectations, proposed timelines, NEPA requirements and any internal fees (to pay for Navy support) for the work being proposed and lists the responsible parties.
- If the need arises to instrument any land outside of China Lake NAWS fence line but within larger, instrumentation polygon (blue polygon, Fig. C1), Navy will make specific request to local BLM office and County as has been done in the past for similar instrumentation. All of this other land within blue polygon is BLM.
- Total acreage of proposed site: West Flank, gold polygon, is 1,100 acres. Larger blue polygon is 27,859.4 acres (Fig. C1).

ENVIRONMENTAL AND CULTURAL CONDITIONS

Existing environmental activities:

All proposed FORGE activities will abide by NEPA requirements. The proposed FORGE area has been subjected to the following environmental investigations, all related to geothermal exploration and development, for the Naval Air Weapons Station, China Lake (Table 1). Cultural requirements will be governed by the Sugarloaf Cultural Management Plan (CMP). Depending on where within the West Flank FORGE activities are proposed, the implementation of this Plan will be initiated by either the Coso Operating Company (COC) or the NAWS China Lake Environmental Management Department (EMD) for a no adverse effect determination.

Ground associated with the existing drill pads and roads in the proposed FORGE area (e.g., well 83-11; Fig. C1) was evaluated for all potential impacts via the contractually required (i.e., Navy-COC development contract) modified sundry process. A Sundry Notice includes maps, an explanation of proposed work and a complete analysis of cultural and environmental impacts and the mitigation measures taken, if needed. This work has been performed by consulting services with expertise in these topics (e.g., Epsilon, Ridgecrest, CA, and Far Western Archeological, Davis, CA). The Coso Mountains and specifically parts of the Coso geothermal field, according the CA State Historical Preservation Office, have been among some of the most investigated acreage for cultural and anthropological history in the western U.S. It has been determined, for instance, that the densest accumulation of petroglyphs in North America is from the Petroglyph canyons from the Wild Horse Mesa area, due east of the Coso geothermal field.

Other relevant features:

- Nearby population center density: 5 mile radius - none
- Distance to closest population: 7 miles from Coso Junction on HW 395 (store/gas station – no permanent inhabitants).
- Nearby wildlife habitats (endangered species /habitat): Mojave ground squirrel
- Nearby scenic vistas: No
- Nearby Areas of Critical Environmental Concern or Wilderness Areas: No
- Nearby wetlands or scenic waterways: Portions of Little Lake, >10 miles to the SW of the Coso Range off of CA 395 are private ground that are considered wet lands.
- Nearby Native American Tribes: China Lake NAWS actively maintains a relationship with several tribes associated with the Paiute-Shoshone. Starting with the signing of the first Coso geothermal field development contract in 1979, the Navy has maintained key Memoranda of Agreements (MOA) with Paiute-Shoshone regarding access to the nearby Coso Hot Springs (Fig. C2; east of the West Flank area). A contingency that may temporarily delay work on the West Flank would be associated with Native American visits to the Coso Hot Springs per a 1979 Programmatic MOA. Under such circumstances, which occur on average about 4-6 times/year for durations of 1-2 days, work in the West Flank would need to be suspended for ~an hour as the visitors drive past the site on the only access road to the Coso Hot Springs.

Table 1. Major NEPA/CEQA Documents

Issued By	Document Names
Naval Weapons Center (NWC) 1979	Final Environmental Impact Statement for the Navy Coso Geothermal Development Program, China Lake, California, Volumes 1 and 2.
BLM 1980	Proposed Leasing within the Coso Known Geothermal Resource Area (KGRA): Final Environmental Impact Statement
NWC 1981	Environmental Impact Statement for Navy Coso Geothermal Development Program, Volume 3, Supplemental EIS for Exploratory Drilling and Testing (Tier 3).
NWC 1983	Environmental Assessment for Proposed Exploration and Development within the Coso KGRA.
NWC 1984	Preliminary Environmental Assessment for Additional Surface Disturbance for Construction of the 25-Mwe Geothermal Power Plant Site and Definition of Pipeline Corridors.
BLM 1984	Environmental Assessment for the LADWP Coso KGRA Exploratory Drilling Project.
NWC 1985	Environmental Assessment of the Proposed China Lake Joint Venture well 63-18, Coso KGRA, Inyo County, California.
BLM 1985	Environmental Assessment of the Proposed Plan of Exploration, Federal Lease CA-11402, Coso KGRA, Inyo County, California.
NWC 1986	Environmental Impact Statement for Navy Coso Geothermal Development, Tier 4, Field Development.
NWC 1987	Environmental Assessment of the Proposed CLJV Nine Well Pad Exploratory Drilling Program on Navy 2 Lands.
NWC 1987a	Preliminary Environmental Assessment for Production Well Pads on Navy 1 Contract Lands, Coso KGRA.
NWC 1987b	Preliminary Environmental Assessment of Four Production Wells and One Exploratory Core Hole on Navy/CLJV Contract Lands, Coso KGRA.
NWC 1988	Environmental Assessment/Initial Study of the CLJV Proposed Plan of Development on Navy Contract Lands.
NWC 1988a	Environmental Assessment/Initial Study of the Proposed CLJV Navy 2 Geothermal Development and Utilization.
BLM 1988	Environmental Assessment/Environmental Impact Report for the CalEnergy Plans of Utilization, Development and Disposal For Geothermal Development on BLM Geothermal Lease CA-11402
BLM 1989	Categorical Exclusion for Plan of Development for Federal Lease CA-11401
NWC 1989	Preliminary EA of the California Energy Company, Inc. Seismic Reflection and Refraction Survey

NWC 1993	ES General Plan of Development East Flank Development Navy I and Navy II Contract Lands
GBUAPCD 1995	Initial Study of Revision to Rule 424, Geothermal Emissions Standard
GBUAPCD/BLM 1999	GBUAPCD Initial Study and Negative Declaration and BLM finding of Categorical Exclusion for Plan of Operations for Federal Lease 11402 amendment allows Federal leases, CA-11383, 11384 and 11385 to be incorporated into the existing POO and subject to mitigation requirements of the 1988 EA/EIR for POU, development and disposal
Inyo County 2009	EIR Coso Operating Company, Hay Ranch Water Extraction and Delivery System Conditional Use Permit 2007-003 Application SCH# 2007101002
BLM 2009	EA, FONSI, ROD for the Hay Ranch Water Extraction and Delivery System (Navy was a cooperating agency)

- Potential for landslides, or excessive subsidence as a result of induced seismic activity: No, and no structures are near this area.
- A review of any potential issues associated with the National Historic Preservation Act. There are 16,000 recorded archeological sites on China Lake NAWS. Only 2 are currently listed in the NRHP. These are the Coso Hot Springs NRHP District and the Coso Rock Art NHRP. The Coso Hot Springs are noted for their Native American religious significance. Both sites are outside of the proposed FORGE area.
- An indication of whether public opposition is likely (i.e., letters of support from local municipalities or County, negative or positive press surrounding existing development at the proposed site). Not likely as West Flank is entirely within China Lake NAWS.

PERMITTING STATUS

The Coso development contract serves as a "revocable permit" offered by the government acting through the Secretary of the Navy for the developer to operate Coso. This contract also charges the Geothermal Program Office (GPO) with oversight of this land and these operations on behalf of the base CO. Approximately 35% of the proposed FORGE site is included in this contract ground (under existing BLM leases).

- Existing exploration permits: None Approved well permits (select those that apply and describe):
- 83-11 well was drilled that proved no to be commercial. Geothermal Sundry Notice (OMB No. 1004-0132) was submitted for pad and road construction along with a scope of work that included the archeological and biological surveys and reports. A Geothermal Drilling Permit (OMB No. 1004-0132) was submitted for this well.
- Permits Pending approval (select those that apply and describe if relevant to proposed actions associated with FORGE): None.
- Describe any issues encountered in the past during the permitting process, including technical, logistical, social, and cultural. There have been no issues that have detrimentally impacted previous permitting processes, but it is imperative to submit the environmental (archeological and biological) requests for surveys with enough lead time to be completed prior to work being done.

MINERAL RIGHTS

- Federal

LEASE STATUS (SELECT THOSE THAT APPLY)

- No lease: Part of the land described in the polygon is Navy withdrawn land.
- Active lease: Part of the land in the polygon is included in active BLM geothermal leases
- Type: BLM geothermal lease
- Unit area: Lease 11384 and 11385
- Utilization sites: Same
- Participating areas: Same
- Expiration date: Active

WATER AVAILABILITY

In 2009, construction of Coso Operating Company's (COC) Hay Ranch Water Extraction and Delivery System was completed and put into service. Following approval of the Final EIR, the Inyo County Planning Commission granted a 30-year Conditional Use Permit (CUP No. 2007-03) for the project. The system allows water to be pumped from two wells on the Coso Hay Ranch, LLC property in Rose Valley to be transported to the Coso geothermal field for reservoir management. Both the Coso Hay Ranch property and water rights are owned by an affiliate of Coso Operating Co, LLC, the operator of the Coso geothermal field. The delivery system crosses through the proposed Coso FORGE site. Located adjacent to the FORGE site is a 1.5-million-gallon water storage tank that is also tied into the delivery system. Excess capacity in the delivery system will allow FORGE, and/or the Navy, to tie-in and provide additional water sources to the system at the Coso Hay Ranch property and extract water for use at the Coso FORGE site. The other sources of water available to this project are geothermal separator brines and cooling tower blow down water. Additionally, COC is in the process of evaluating deeper water sources beneath the Hay Ranch aquifer. Depending on results of this ongoing investigation, new wells may be drilled to extract non-potable water for use in FORGE and/or the geothermal field.

Supporting documents from the County can be found at:

1. http://www.inyocounty.us/Water/wp/wp-content/uploads/2013/01/HMMP1.pdf

2. http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/ridgecrest/ea.Par.34604.File.dat/HayRanchEAAppendix_H-Hydrology.pdf

Also, see the following attachments are included in the initial proposal:

1. Hay Ranch Property Water Rights.pdf
2. Hay Ranch CUP-EIR.pdf
3. BLM lease transfer.pdf

- Water availability on site: The West Flank and surrounding region is in Mojave Desert of CA. There is no available ground water on site. As described above, water to be used for the West Flank site would be from one or several of the following sources: (1) water pumped from Rose Valley via the Hay Ranch water pipeline; (2) separator brines and blow down water from plant cooling towers; (3) additional Hay Ranch water from a deeper, non-potable aquifer.
- Water availability to the west: There is a nearby reservoir called Haiwee Reservoir. This is controlled by the LA Dept. of Water and Power. Water from LADWP and/or privately held Owens Valley water sources may be negotiated between COC and these Inyo County entities. Nothing has been finalized yet.

STATE AND LOCAL REGULATIONS

There is up to 1,100 acres available in the West flank area for the primary FORGE activities. This area was addressed in multiple documents in support of developing geothermal within the Coso KGRA (Table 1).

The Paiute Shoshone tribes are located nearby, but must obtain Navy permission in order to enter the Navy base per previously mentioned 1979 PMOA. The areas that are utilized for religious activities are outside of the proposed FORGE acreage.

There are 3 existing wells that were drilled in the proposed FORGE area (83-11, 48-11 and 74-2 TCH).

None are commercial. There are no permits currently pending for this area.

There is no groundwater, streams, or rivers in the vicinity of the proposed FORGE area.

Other environmental concerns are listed below.

Solid waste disposal standards, Access and limitations on waste disposal:

Disposal of any hazardous waste or used oil must be delivered to an offsite treatment, storage and disposal facility (TSDF) located in the U.S. that is a "permitted, licensed, or registered by a State to manage municipal or industrial solid waste" (40 CFR 261.5 (f)(3)). Vendors are approved and granted access through the Navy.

Noise Standards:

Cal OSHA Title 8 Subchapter 7. General Industry Safety Orders, Group 15. Occupational

Noise, Article 105. Control of Noise Exposure

Air Quality Standards:

New Source Review (NSR) requires stationary sources of air pollution to get permits before

they start construction. NSR is also referred to as construction permitting or preconstruction permitting.

Drinking water and aquatic life protection:

There is no potable water source or navigable water in the area.

Compatible land use:

The entire project is located within the Naval Air Weapons Station China Lake installation.

Acceptable local effects of water re-injection:

Fluid injection that has been undertaken in nearby areas over the years has caused no negative impacts to the area.

TRANSMISSION ACCESSIBILITY

A 115 kV and a 230 kV transmission lines exist at the Coso geothermal field. Two other transmission lines, LADWP and PGE, exist due west of the western fence line of China Lake NAWS (Fig. C3).

YEAR-ROUND ACCESSIBILITY

Year round access (weather): Access into the West Flank is via the Coso gate. This is maintained 24x7 by the Navy's Geothermal Program Office. There should be no access restrictions with the exception of the infrequent periods when weapons tests are being conducted. These tests occur 20-30 times/year and require evacuation of the site for up to 2-3 hours. To illustrate the potential impacts that evacuations may have on FORGE activities, the Coso geothermal field is due east of the proposed FORGE "West Flank" site. Coso is evacuated 20-30 times/year for up to 2-3 hours per evacuation yet the Coso Operating Company has maintained on on-line electricity delivery of greater than 98% since 1987. It is anticipated that any evacuations, which are all managed by the Navy's Geothermal Program Office, would be handled similarly with little to no impact to any FORGE operations.

Proximity to all season roads: All roads within the site are open year round, as is US Highway 395 ~7 miles to the west of the proposed site.

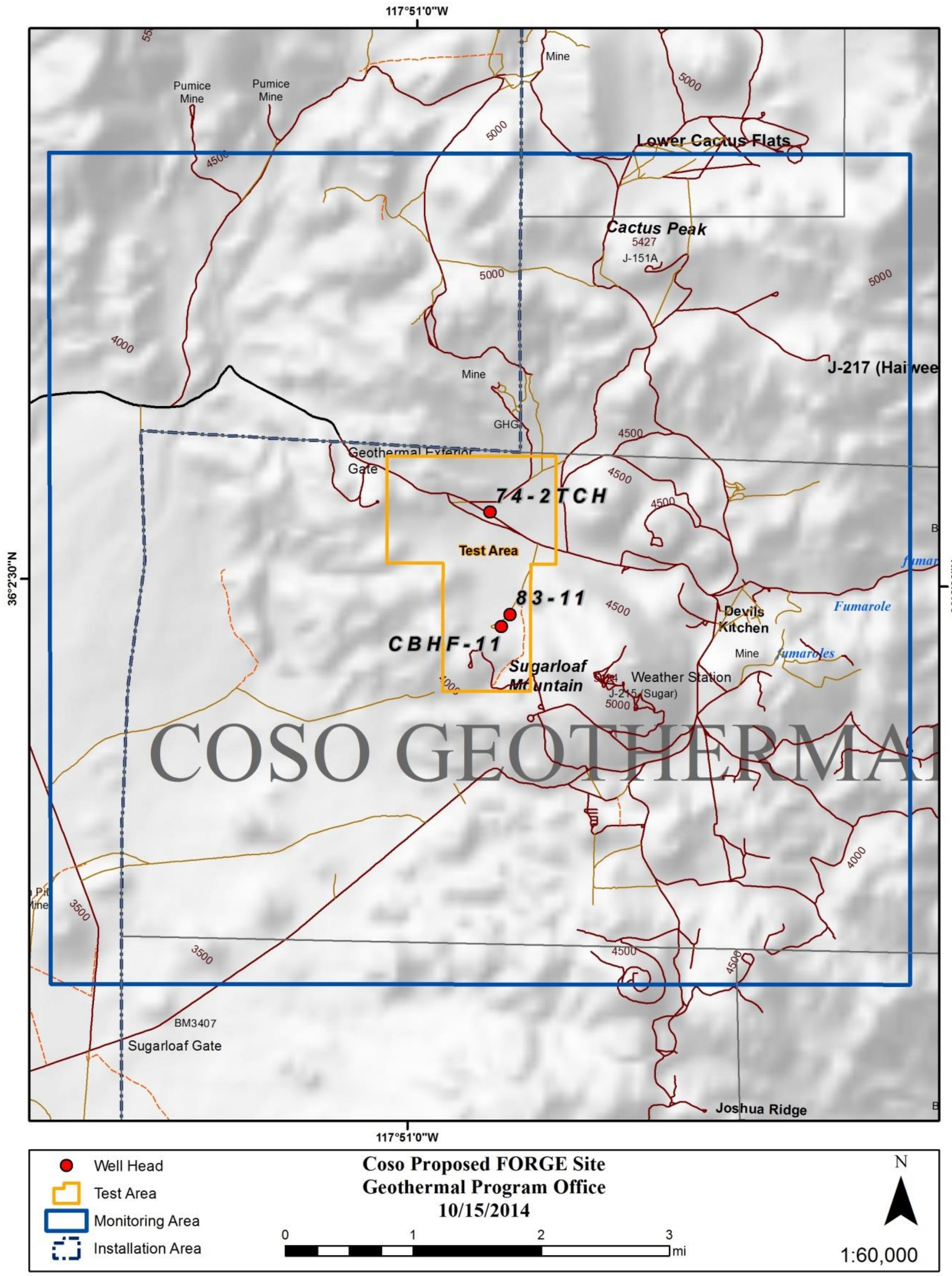

Figure C1. Proposed FORGE West Flank (gold polygon) and larger FORGE monitoring area (blue polygon).

Surface Geothermal Features

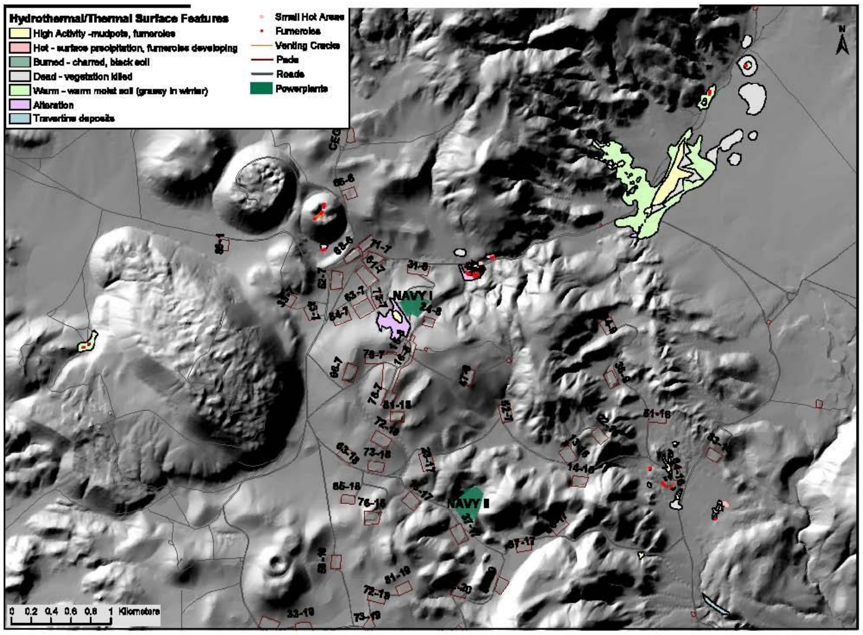

Figure C2. Shaded relief map with geothermal features superimposed from the Coso volcanic field. Several features to be noted: Sugarloaf rhyolite dome is large topographic high in central western (left) portion of the image. The proposed West Flank area is the flat ground WNW of it. Pads, wells and roads are black lines and polygons largely located east of Sugarloaf. This is the main producing portions of the Coso geothermal field. The lime green and yellow colored polygons on to the NE (upper right quadrant of image) is the NW-striking, Coso Wash fault controlled Coso Hot Springs area. This ground is not considered part of the geothermal field and is cordoned off by a fence. This ground is the focus of the 1979 MOA that authorized Native America access to the Coso Hot Springs.

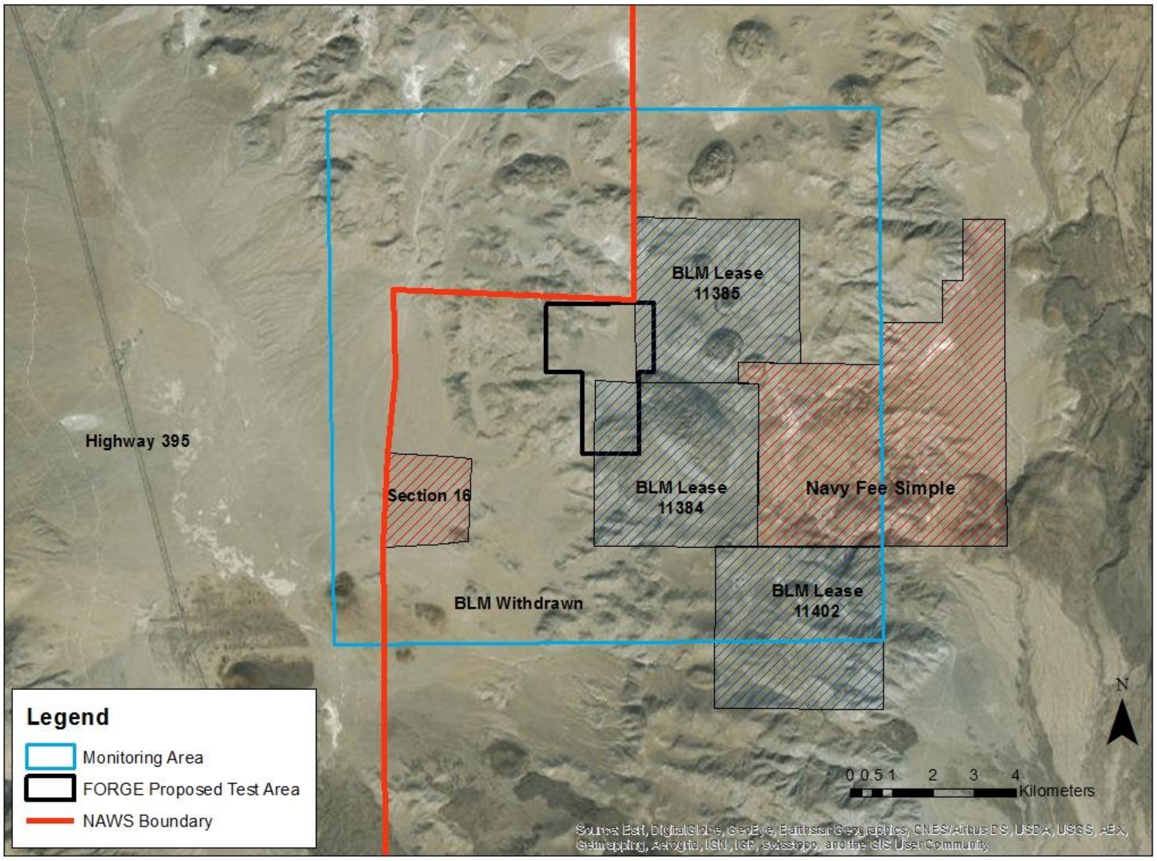

Figure C3. West Flank polygon in black, the proposed monitoring area is in light blue with the lease active lease map overlain. Currently, Coso Operating Company holds all blue BLM leases and the large Navy Fee Simple polygon to the East.

APPENDIX F. DATA DISSEMINATION AND INTELLECTUAL PROPERTY PLAN

DATA DISSEMINATION AND INTELLECTUAL PROPERTY PLAN

West Flank of Coso, CA

DATA DISSEMINATION AND INTELLECTUAL PROPERTY PLAN

West Flank of Coso, CA

DATA DISSEMINATION APPROACH AND NGDS NODE DEVELOPMENT

OVERVIEW

A data system/Node that is compatible with the NGDS will be developed in Phase 2 of the West Flank of Coso, CA, FORGE project. The Node will be a public, web-accessible interface to the NGDS that allows for structured uploading of West Flank FORGE project data. It will include appropriate options for establishment of a remote web server, a Node, and appropriate interfaces and processes for connection to the NGDS through the central aggregator. FORGE Node site maintenance and operations will be the responsibility of the West Flank FORGE Site Management Team (SMT) which will employ expertise within our institutions for node development and contracted expertise, if required. Data generated during the course of the project, either by the West Flank FORGE Team, competitively selected R&D projects, or others associated with the West Flank FORGE site will be submitted to the FORGE Node. All projects will be required to sign a letter of commitment to upload all data acquired in conjunction with the West Flank FORGE site. Data submitted to the Geothermal Data Repository before the FORGE Node is operational will be ported to the FORGE Node. The data dissemination plan is described below.

DATA DISSEMINATION PLAN

A high priority goal of our West Flank FORGE team is to ensure that all data acquired in conjunction with the site be made available to the public in as close to real time as possible. A second high priority goal is to ensure that posted data is of high quality. The guidelines for data dissemination and quality control will depend on the type of data. We have identified four types of data that will be acquired in association with the West Flank FORGE site:

1. Data that supports metadata:
   All levels of West Flank FORGE data products will have appropriate metadata available to enable users to make full use of the data or data products. Some metadata will be included with the observational data by the data loggers. Other kinds of metadata will include data quality measurements made by the FORGE team, data analysis parameters and such base parameters as the latitude, longitude and elevation of FORGE instrumentation.
2. Data acquired by the SMT for site characterization, monitoring, and R&D
3. Data acquired in conjunction with DOE FOA funded R&D projects and data acquired by International Partners that provide their own R&D funding
4. Data acquired under previously agreed upon Intellectual Property protections

All acquired data, independent of type, will be uploaded or linked to the FORGE node in near real-time, as governed by processing constraints. An example of data that will not be stored on the FORGE node is microseismic monitoring data—these data will be uploaded in real time to an LBNL server dedicated to induced seismicity. The FORGE node will provide a link to these data sets. Other continuous, large volume data sets may be handled in a similar manner. To protect the scientific integrity of the project PIs, the near real-time data uploaded to the FORGE node will have an identifying "tag" indicating that the data has not been vetted for quality control. Quality control of the data will be the responsibility of the generator. Following the upload of near real time data, the project PIs will have a four- month window in which to vet their data and, if necessary, upload revisions to the FORGE node. Data revised during the four-month vetting period will be identified by a "tag" indicating that the data has undergone quality control review and is considered to be of high quality and reliable. Data not revised during the four-month period will also be considered to be of high quality and reliable, but will be tagged to indicate that there were no revisions to the originally submitted data. There will be two exceptions. First, all data acquired by the SMT (Type 1 and 2) will be continuously vetted and updated on the FORGE node. The goal is to ensure that outside PIs or potential PIs have the most up to date information regarding the characteristics and monitoring of the FORGE site to facilitate their research and/or to help develop a research project in response to an R&D solicitation. The second exception involves data identified as protected by an Intellectual Property (IP) agreement (Type 4). Any agreements establishing IP protected data will be made in collaboration with the project leads generating the data and with the SMT, STAT, and DOE. Access to data uploaded to the FORGE node that is IP protected will remain the exclusive right of the generator for a period of five years during which time it will be password protected.

To conduct research at the West Flank FORGE site or in conjunction with the West Flank FORGE project, project leads will agree to and sign a letter of commitment to abide by the data dissemination and quality control plan defined above. In the case of a FOA call for R&D issued by DOE, acceptance of responses will be contingent upon the inclusion of the signed letter of commitment in the FOA response. For non-DOE funded projects, such as collaborations with international partners or private sector stakeholders, prior to approval of such projects by the SMT, STAT and DOE, the signed letter of commitment must be provided by the project leads.

NGDS NODE DEVELOPMENT

DATA NODE HARDWARE

A NGDS compliant FORGE node will be deployed on the Amazon Web Services (AWS) cloud. AWS is the leading cloud provider, offering a secure, reliable, and scalable computing environment. There are many computing services provided by AWS; for data node development the Elastic Compute Cloud (EC2) will provide all the computing resources necessary. An EC2 instance with 4 CPUs, 32 GB or RAM, and 6 TB of storage will be used for the initial deployment.

DATA NODE SOFTWARE

The software package "Node-in-a-Box" (NIAB) available through the NDGS will be used to implement the FORGE data node software services. NIAB was developed under the NGDS Architecture, Design, and Testing Project to allow for the easy deployment of a NGDS compliant data node. NIAB is based on open source standards and extends a storage management product called CKAN. NIAB provides the entire software infrastructure for hosting a NGDS compliant node which includes the ability to upload structured and unstructured data sets through a web interface, publish metadata information about the data sets to the central aggregator node, manage data sets and metadata over time, and host web services to expose highly structured data sets (Tier 3). NIAB is a stable platform and has been successfully deployed by number of government institutions. While a custom NGDS solution could be implemented it would be expensive and one would lose many of the benefits of using an open source solution. Functionality that is desired but not currently available in NIAB can be added by anyone and those added features will be made available to everyone.

DATA SUBMISSION

Metadata describing the data sets is a critical step in making data available to the greater scientific community. The NGDS aggregator node will harvest the metadata records stored on our data node and add those records to the NGDS Catalog. Every data set (resource) uploaded to the data node will have associated metadata that describes the contents of the data set. The metadata will conform to the NGDS standards and all required fields will be populated.

Data sets uploaded to the data node (NIAB) will fall into one of three categories:

- Tier 1 – Data that is unstructured (text, images, etc.).
- Tier 2 – Data that has some structure by does not conform to NGDS content model.
- Tier 3 – Data that is highly structured and can be validated against NGDS content model schemas.

When data is uploaded through the web interface it will be marked at the appropriate category level. Tier 3 data is structured as Excel spreadsheets and must conform to one of the NGDS content model definitions. Excel templates for Tier 3 data can be found at http://schemas.usgin.org/models/. Before uploading Tier 3 data to the node it will be validated at http://schemas.usgin.org/validate/cm. Once the appropriately structured data is successfully validated it can be uploaded to the data node as Tier 3 data. After it uploads, Tier 3 data can be published as an Open Geospatial Consortium (OGC) web service. We will encourage funded principal investigators to upload to the FORGE node data sets (resources) that conform to Tier 3 standards and which will then be made available as OGC web services (WFS or WMS).

IMPROVEMENT TO NIAB

While the NIAB provides all the capability to be a NGDS compliant data node it does lack some features. Specific to this plan will be the ability to limit the access to a data set for a given period of time (moratorium) and flags for data vetting (QA) by PIs which are not currently available. Since NIAB and CKAN is open source it will be possible to modify code to add these or other features that may become necessary. The Scrum methodology will be used to manage the software project effort. Scrum enforces iterative and incremental development and promotes daily face-to-face communication between all team members. At the end of each iteration, typically 2-4 weeks, the current state of the software being developed is presented in a demo to all stakeholders. This promotes continuous feedback from the customers/stakeholders to ensure a quality software system is delivered at the end of the development effort. All developed software will have design documents, be fully commented, reviewed by peers, and unit tested.

INTELLECTUAL PROPERTY (IP) MANAGEMENT

As a Federally Funded Research and Development Center, Sandia National Laboratories has protocols in place to address IP issues and has rights to technical data. Prior to any agreement with a funded contractor, any issues related to IP and data rights will be negotiated and plans will be developed as part of the contractual agreement. The template for the IP and data plan agreement between the Sandia Corporation and a company is provided in following Attachment.

ATTACHMENT

INTELLECTUAL PROPERTY AND TECHNICAL DATA MANAGEMENT PLAN
BETWEEN
SANDIA CORPORATION
and
COMPANY

This Intellectual Property Management Plan (the "IP Management Plan") is effective as of the date of the last signature (the "Effective Date") by Sandia Corporation ("Sandia"), manager and operator of Sandia National Laboratories ("SNL") for the United States Department of Energy ("DOE") under contract DE-AC04-94AL85000 (the "Prime Contract"), a Delaware corporation whose principal place of business is located in Albuquerque, New Mexico, and ______________________ ("________") located at __________________________________ (individually, "Party" and collectively, "Parties"). Terms in this IP Management Plan that are capitalized have the meanings set forth in Exhibit A of this IP Management Plan.

I. Background

1. This IP Management Plan is established to govern the management and disposition of INTELLECTUAL PROPERTY directly resulting from joint research and/or development between Sandia and ______________ directed to ________________________ (the "Joint Work").
2. The IP Management Plan objectives include:
   a. Promoting the patenting, licensing, and rapid commercialization of SUBJECT INVENTIONS when the public good is best served by controlling the activities of those commercializing the SUBJECT INVENTIONS and/or by providing economic rewards necessary to encourage commercial partners to make the investment required to move an early stage technology to the market, and

   b. Promoting the rapid dissemination of breakthrough scientific discoveries and technological innovations for the public good.
3. All actions by Sandia documented in this IP Management Plan are subject to available funding from DOE to Sandia.

4. This IP Management Plan shall not be used to obligate or commit funds or as the basis for the transfer of funds. This IP Management Plan does not commit any Party to take any actions; the actions of each Party are independent of the actions of the other Party. In no event shall either Party be required to perform work outside the scope of the Joint Work.
5. Each Party will bear all costs, risks and liabilities incurred by it arising out of efforts under this IP Management Plan, and neither Party shall have any right to any reimbursement, payment or compensation of any kind from the other hereunder.

II. Title to SUBJECT INVENTIONS and Other PROJECT INTELLECTUAL PROPERTY

1. Inventorship or authorship of PROJECT INTELLECTUAL PROPERTY and PROJECT TECHNICAL DATA will be determined in accordance with applicable U.S. patent, trademark and copyright law and any corresponding state laws.

2. Each Party shall retain title to their BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY used during the Joint Work. Each Party's BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY shall be identified as such and shall contain such proprietary markings pursuant to any separate non-disclosure agreement(s) governing such disclosures between the Parties.

3. The U.S. Government will not normally require delivery of confidential or trade secret-type BACKGROUND TECHNICAL DATA developed solely at private expense prior to issuance of an award, except as necessary to monitor technical progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.

4. The U.S. Government retains unlimited rights in PROJECT TECHNICAL DATA produced under Government financial assistance awards, including the right to distribute to the public. One exception to the foregoing is that invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

5. Each Party shall have the right to use the other Party's PROJECT TECHNICAL DATA, and PROJECT INTELLECTUAL PROPERTY along with the related BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY identified in Exhibit B for the sole purpose of carrying out the Joint Work, but may not disclose the other Party's PROJECT TECHNICAL DATA, PROJECT INTELLECTUAL PROPERTY, BACKGROUND INTELLECTUAL PROPERTY and BACKGROUND TECHNICAL DATA to any person or third party except with written permission of the other Party and under suitable confidentiality obligations pursuant to a separately executed non-disclosure agreement. Each Party shall establish and implement specific measures and protocol to protect such information and data from disclosure. Exhibit B will be amended to include additional BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY that the Participants mutually agree is relevant to accomplish the Joint Work.

6. Each Party shall solely own SUBJECT INVENTIONS and other PROJECT INTELLECTUAL PROPERTY developed solely by its employees and agents and shall obtain patent protection for SUBJECT INVENTIONS at its sole discretion.

7. SUBJECT INVENTIONS and PROJECT INTELLECTUAL PROPERTY and PROJECT TECHNICAL DATA jointly developed by the Parties shall be jointly owned by the Parties. Any jointly developed SUBJECT INVENTIONS and/or PROJECT TECHNICAL DATA may be protected by one or more patent applications filed by either Party. The

Party filing the patent application directed to jointly developed SUBJECT INVENTIONS and/or PROJECT TECHNICAL DATA shall notify the other Party in a timely manner.

8. Unless agreed to otherwise, the Party filing a patent application on a SUBJECT INVENTION and/or PROJECT TECHNICAL DATA, whether solely or jointly owned, shall pay all preparation and filing expenses, prosecution fees, issuance fees, post issuance fees, patent maintenance fees, annuities, interference expenses, and attorneys' fees for that patent application and any resulting patent(s). The Parties will use all reasonable efforts to cooperate with each other with respect to the preparing, filing and prosecuting any such patent applications.

9. Upon at least two weeks' notice to the other Party, any Party will be free to submit for publication the results of PROJECT INTELLECTUAL PROPERTY and PROJECT TECHNICAL DATA that the Party solely owns, provided due consideration is given to protection of patentable subject matter.

III. Licensing of SUBJECT INVENTIONS and PROJECT INTELLECTUAL PROPERTY

1. The Parties may enter into one or more separate agreements to facilitate the filing of patent applications and/or licensing of the jointly developed SUBJECT INVENTIONS and PROJECT INTELLECTUAL PROPERTY and PROJECT TECHNICAL DATA. Any such license that a Party may grant shall be subject to a reservation of certain rights to the Federal Government, which include Government use rights, march-in rights and U.S. Competitiveness.

2. Any license pursuant to Section III.1 that a Party may grant will reserve the option to permit private or public educational institutions to use the jointly developed SUBJECT INVENTIONS and PROJECT INTELLECTUAL PROPERTY on a royalty-free basis for research, development and/or education, but not for commercial purposes, subject to confidentiality requirements. Sandia shall also retain the right to non-exclusively license the SUBJECT INVENTIONS and PROJECT INTELLECTUAL PROPERTY and PROJECT TECHNICAL DATA that it solely and jointly owns as background intellectual property to cooperative research and development agreement ("CRADA") participants and work for others agreement ("WFO") sponsors.

IV. Warranties and Representations

1. Nothing in this IP Management Plan shall be construed as:
    a. a warranty or representation by either Party as to the validity or scope of any right included in the BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY;
    b. an obligation to furnish any information beyond that listed in the BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY; or
    c. creating in either Party any right, title or interest in or to the inventions, patents, technical data, computer software or software documentation solely owned by the other Party.

2. Disclaimer. ALL INFORMATION, TESTS AND RESULTS BY EITHER PARTY ARE PROVIDED "AS IS", AND NEITHER PARTY MAKES ANY REPRESENTATIONS, WARRANTIES OR GUARANTEES OF ANY KIND, EXPRESS OR IMPLIED, REGARDING ANY SERVICES, INFORMATION, TESTS OR RESULTS, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF TITLE, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, RESULT, USE, OR NON-INFRINGEMENT THEREOF.

3. Limitation of Liability. In no event shall either Party be liable to the other for any punitive, exemplary, special, incidental, consequential or other indirect damages (including, but not limited to, lost profits, lost revenues and lost business opportunities) arising out of or relating to this IP Management Plan, regardless of the legal theory under which such damages are sought, and even if the Parties have been advised of the possibility of such damages or loss.

V. Term/Termination

1. This IP Management Plan shall commence on the Effective Date and continue until completion of the Joint Work, unless terminated earlier in accordance with this IP Management Plan.

2. Either Party may terminate this IP Management Plan for any reason upon at least sixty (60) days written notice ("Notice of Termination") to the other Party. Should the IP Management Plan be terminated prior to completion of the Joint Work, the Parties may continue to use the other Party's PROJECT TECHNICAL DATA, and PROJECT INTELLECTUAL PROPERTY along with the BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY listed in Exhibit B solely to the extent needed to complete the Joint Work.

3. Sections IV, VI, VII and VIII and obligations regarding confidentiality shall survive the termination or expiration of the IP Management Plan.

VI. United States Government Interests

1. It is understood that the United States Government (through any of its agencies or otherwise) has funded research, Contract No. DE-AC04-94AL85000 - United States DOE's National Nuclear Security Administration, during the course of or under which any of the PROJECT INTELLECTUAL PROPERTY was conceived or made. The United States Government is entitled, as a right, to a non-exclusive, non-transferable, irrevocable, paid-up license to practice or have practiced the PROJECT INTELLECTUAL PROPERTY for governmental purposes. The Parties also agree and understand that the United States Government retains "march-in" rights, in accordance with the procedures set forth in 37 CFR 401.6 and any supplemental regulations promulgated by the DOE.

VII. Dispute Resolution

1. Any dispute between the Parties relating to the management of Project Intellectual Property, as provided for in this IP Management Plan, or to the interpretation of this IP Management Plan, shall be referred to the Parties' respective officers, as designated below. Through the designated officers, the Parties agree to first attempt informal resolution of disputes, within a reasonable period of time and in a fair and equitable manner, taking into consideration the objectives of the Joint Work and any laws, statutes, rules, regulations or guidelines to which the involved Parties are subject.

   The designated officers and their contact information are as follows:

   For Sandia:
   Name:
   Address:
   Telephone:
   Email:

   For _______________:
   Name:
   Address:
   Telephone:
   Email:

2. If the designated officers are unable to resolve the issues presented before them, and if the dispute cannot be settled through negotiation, the Parties agree first to try in good faith to settle the dispute by mediation administered by the American Arbitration Association under its Commercial Mediation Procedures before resorting to arbitration, litigation, or some other dispute resolution. If within 30 days after service of a written demand for mediation, the mediation does not result in settlement of the dispute, then any unresolved issues shall be settled by arbitration administered by the American Arbitration Association in accordance with its Commercial Arbitration Rules, and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction thereof.

VIII. Miscellaneous

1. Except as provided herein, any commitment of funds, intellectual property rights, disclosure of proprietary information, or other resources needed to carry out the objectives set forth herein shall be made under separate agreements.

2. It is understood that any work done or actions taken by Sandia must be in accordance with the terms and conditions of the Prime Contract between Sandia and the DOE for the operation of SNL; and must be in accordance with any successor contracts for the operation of SNL. In the case of any conflict between this IP Management Plan and

the Prime Contract for the operation of Sandia, the Prime Contract shall take precedence.

3. This IP Management Plan shall be construed in accordance with the laws of the State of Delaware.

4. The Parties hereto are independent contractors and not joint venturers or partners.

5. The Parties acknowledge that they are subject to and agree to abide by the United States laws and regulations (including the Export Administration Act of 1979 and Arms Export Control Act) controlling the export of technical data, computer software, laboratory prototypes, biological material, and other commodities. The transfer of such items may require a license from the cognizant agency of the U.S. Government or written assurances that it shall not export such items to certain foreign countries and/or foreign persons without prior approval of such agency. Neither Party represents that a license is or is not required or that, if required, it shall be issued.

6. This IP Management Plan incorporates by reference **Exhibits A and B** [below] and embodies the entire understanding between the Parties with reference to the subject matter hereof, and no statements or agreements by or between the Parties, whether orally or in writing, except as provided for elsewhere in Section VI, made prior to or at the signing hereof, shall vary or modify the written terms of this IP Management Plan. Neither Party shall claim any amendment, modification, or release from any provisions of this IP Management Plan by mutual agreement, acknowledgment, or otherwise, unless such mutual agreement is in writing, signed by the Parties, and specifically states that it is an amendment to this IP Management Plan.

7. Neither Party shall use the name of the other Party or the name of any employee thereof in any sales promotion, advertising, or any other form of publicity without the prior written approval of the other Party.

IN WITNESS THEREOF, the parties hereto have executed or approved this IP Management Plan on the dates below their signatures.

COMPANY NAME	SANDIA CORPORATION
By:________________________________	By:________________________________
Date:______________________________	Date:______________________________
Name: Title:	Name: Title: Senior Manager, Industry Partnerships

EXHIBIT A

Definitions:

1. "BACKGROUND INTELLECTUAL PROPERTY" means the INTELLECTUAL PROPERTY identified by the Parties that was in existence prior to or is first produced outside of the Joint Work and is necessary for the performance of the Joint Work. BACKGROUND INTELLECTUAL PROPERTY may also include trade secrets of the Parties that were in existence prior to or are first produced by the Parties outside of work under this IP Management Plan to the extent that such trade secrets do not otherwise constitute or become SUBJECT INVENTIONS as defined herein.

2. "BACKGROUND TECHNICAL DATA" means information, in hard copy or in electronic form, including, without limitation, documents, drawings, models, designs, data memoranda, tapes, records, software and databases developed before or independent of performance under the Award that is necessary for the performance of the Joint Work.

3. "INTELLECTUAL PROPERTY" means technical information, inventions, developments, discoveries, know-how, methods, techniques, formulae, algorithms, data, processes and other proprietary ideas (whether or not patentable or copyrightable). INTELLECTUAL PROPERTY also includes patent applications, patents, copyrights, trademarks, mask works, and any other legally protectable information, including computer software.

4. "INVENTION" means any discovery or a new composition, device, method, system, software, process or design developed from study and experimentation that is or may be patentable or otherwise protectable under Title 35 of the United States Code, or any novel variety of plant that is or may be protected under the Plant Variety Protection Act (7 U.S.C. 2321 et seq.).

5. "PROJECT INTELLECTUAL PROPERTY" means and includes all INTELLECTUAL PROPERTY first conceived, discovered, developed, reduced to practice and/or generated during the performance of the Joint Work.

6. "PROJECT TECHNICAL DATA" means information (in hard copy or in electronic form) including, without limitation: documents, drawings, models, designs, data, memoranda, taps, records, software and databases developed during the performance of the Joint Work.

    7. "SUBJECT INVENTION" means any INVENTION of a Party that is conceived or first actually reduced to practice in the performance of the Joint Work.

EXHIBIT B

<u>Sandia's BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY</u>
Invention Disclosure (SD #________; Company #________)
Title: "____________________________________"
Inventors: _________________________________

<u>Company's BACKGROUND TECHNICAL DATA and BACKGROUND INTELLECTUAL PROPERTY</u>
Invention Disclosure (SD #________; Company #________)
Title: "____________________________________"
Inventors: _________________________________

APPENDIX G. COMMUNICATIONS AND OUTREACH PLAN

COMMUNICATIONS AND OUTREACH PLAN

West Flank of Coso, CA

COMMUNICATIONS AND OUTREACH PLAN

West Flank of Coso, CA

This document is a comprehensive and innovative plan for communications, education, and outreach to support efforts by the Naval Air Weapons Station (NAWS) China Lake West Flank of Coso FORGE project team to maintain sound operations and increase geothermal science and technology literacy.

INTRODUCTION

The West Flank FORGE project team maintains a fundamental commitment to strategic communications, outreach, and education related to enhanced geothermal systems (EGS) and the FORGE project. Led by Sandia National Laboratories, the team has experience managing large science-based field operations that require substantial communications with stakeholders and partners. We recognize the value of internal and external communications to maintain sound operations. Our strategic outreach efforts, begun in Phase I, will continue into Phases 2 and 3 with a range of activities designed to keep stakeholders informed. We are also committed to a robust education initiative that reaches students in grades K-12 with energy curricula based in STEM best practices and creates research and development opportunities for undergraduate, graduate, and post-doctoral students. The West Flank FORGE team takes seriously its role in reducing global reliance on fossil fuels and its responsibility for communicating the benefits of research that stimulates the commercial development of EGS systems.

COMMUNICATIONS GOALS AND OBJECTIVES

- Together with our public and private sector partners, implement a coordinated proactive outreach strategy, consistent with DOE/EERE approved branding, to support the selection and operation of the West Flank FORGE site for Phases 2 and 3.
- Provide communications support for technical teams and future activities.
- Identify and publicize best practices and success stories that will contribute to the development of a collaborative national geothermal strategy.
- Communicate the relevance of EGS to a wider community and educate those who may benefit from its value.
- Communicate the benefits of sharing EGS data and collaborating to share and disseminate EGS and FORGE information, including the results from the West Flank FORGE project.

PROGRAM BACKGROUND

FORGE, Frontier Observatory for Research in Geothermal Energy, is a U.S. Department of Energy Office of Energy Efficiency and Renewable Energy's (EERE) Geothermal Technologies Office program directed at establishing a dedicated site where the subsurface science and engineering community can develop, test and improve technologies in an ideal EGS environment. Essentially, FORGE seeks to implement an underground "rock laboratory" that will be the target of experimentation that advances EGS technology, vastly increasing the potential for geothermal power production nationwide.

Today, the United States produces about 3.5 gigawatts (GW) of geothermal electricity, which is less than 0.5% of the country's energy needs. According to the U.S. Geological Survey (USGS), the successful development of EGS techniques would open the door to more than 500GW of geothermal electricity production in the United States. The multi-year FORGE program addresses this potential, and is divided into three phases (see Figure 1). During Phase 1, the site selection process, five locations were chosen for continued planning and conceptual geologic modeling. A down select will occur in Phase 2 in preparation for full site characterization at the selected location. Full implementation of FORGE occurs during Phase 3.

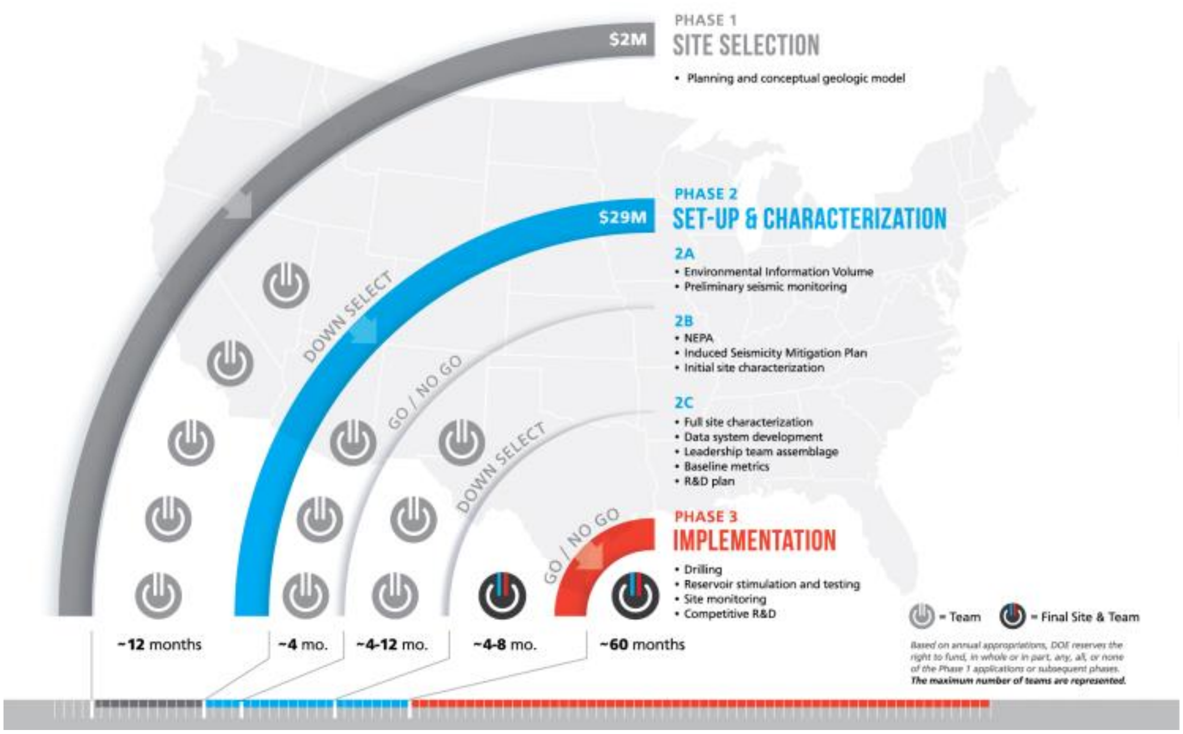

Figure 1. The three phases of FORGE: site selection, characterization, and implementation

ABOUT THE PROPOSED WEST FLANK FORGE SITE

Today, California has approximately 2,700 megawatts (MW) of installed geothermal power capacity. The USGS estimates California's geothermal heat resource potential at more than 60,000 MW.

The proposed **West Flank FORGE site** at the Naval Air Weapons Station China Lake (NAWS China Lake) is one of five sites selected by DOE for preliminary Phase 1 work. After a competitive down-select process, DOE will choose one site for the remaining 5 years of focused FORGE research and development work.

Based on a survey of dozens of areas in the western United States, the West Flank site at NAWS China Lake was chosen for FORGE because it has a target zone in granitic basement rock at depths between 1.5 and 4 km that has temperatures within the desired range (175-225°C) and low permeability. Located west of the Coso Geothermal Field, which hosts a conventional hydrothermal field with an installed capacity of 270 MW, the rock formations beneath the West Flank FORGE are hot but have very low permeability. Drilling, logging, testing and monitoring activities in the West Flank clearly demonstrate that the West Flank FORGE area lies outside of and is not hydraulically connected to the productive geothermal field to the east. The West Flank FORGE site includes a 1.7 square mile area (4.5 square kilometers) where FORGE activities will be undertaken; this area includes two existing core holes and one full-diameter well. An additional surrounding area of 43.5 square miles (112.7 square kilometers) will be used for instrumentation and monitoring of FORGE activities.

Site characterization, drilling, stimulation, testing, and the results of various subsurface experiments from the West Flank FORGE site will be made available to all interested communities through news releases, published articles, meetings, and other appropriate venues.

CRITICAL PROJECT MILESTONES

- Project deliverables: April 27, 2016
- Phase 2 application: May 23, 2016
- Oral presentation to DOE: June 2016

SITUATIONAL ANALYSIS

The following location-specific topics will be addressed in West Flank communications with target audiences. The team's approach to these topics demonstrates a keen awareness of the China Lake community and acknowledges the importance of public perception related to geothermal energy development.

1. **Water use:** Identify the source(s) of water for the project, estimate how much water will be needed, and predict the impacts, if any, of water consumption on the community and environment.
2. **Induced micro-seismicity (man-made micro-earthquakes):** Define how earthquakes might be induced by injection and production. Address how seismicity is currently monitored and reported at the nearby Coso Geothermal Field and in the West Flank FORGE project area, and what type of monitoring will be necessitated by the EGS work. Address the potential impacts of induced micro-seismicity and anticipated mitigations.
3. **Culture and environment:** Identify potential impacts to the environment and known cultural sites in the West Flank FORGE area and anticipated mitigations.
4. **NAWS China Lake mission:** Identify any potential impacts to NAWS mission and anticipated mitigations.

5. **Community relations:** Identify the local communities likely to be interested in the West Flank FORGE project and establish a plan to meet their needs for accurate and timely project information.
6. **Education:** In collaboration with NAWS China Lake, identify educational outreach opportunities for engaging K-12 students and educators. Identify and collaborate with researchers at universities and other research organizations, K-12 and higher education, in collaboration with NAWS. Identify possible internship opportunities through the national laboratories, university partners and geothermal industry partners.

TARGET AUDIENCES

Based on the situational analysis and the team's knowledge of the interested parties, we have identified both a primary and secondary audience to which we will target West Flank EGS R&D communications. These include, broadly, the following:

Primary audience

- Partners in the West Flank FORGE project (including NAWS China Lake and Naval Air Warfare Center)
- Tribal, State, and local governments and government agencies (Kern County Board of Supervisors, Planning Department, and others)
- Local communities
- Congressional delegations
- State legislators
- Federal agencies (DOE, DoD, USGS, BLM, Navy)
- U.S. Department of Energy Geothermal Technologies Office (GTO)
- California Energy Commission
- Indian Wells Valley Water District
- Energy research and development (R&D) community, including graduate students
- Geothermal developers
- Public- and private-sector geothermal research community

Secondary audience

- Public interest and watchdog groups
- Utility companies and transmission system operators
- California Public Utilities Commission
- Local media outlets
- Interested citizens

KEY MESSAGES

In response to the situational analysis, and recognizing our diverse audience, we propose a set of five key messages and supporting points to address basic concerns and present information about the West Flank FORGE project. The messaging addresses potential economic and environmental impacts and the value of EGS to the local community. The key messages will frame consistent talking points for stakeholder outreach and will be the basis for evolving targeted communications as the project moves from Phase 1 into Phases 2 and 3.

1. Sustainable EGS is a valuable addition to the energy supply of the United States and the global community, and FORGE-enabled research is critical to the widespread implementation of EGS.

- In spite of its resource potential, the technological impediments to widespread development of EGS have limited its role in the U.S. energy mix.
- The West Flank FORGE project at NAWS China Lake will allow for fundamental research and development of new technologies for EGS reservoir creation, characterization, and utilization.
- EGS offers huge potential for power production (USGS mean estimate: 518 GW) with no CO_2 emissions and could replace traditional energy sources (coal, gas, and oil generation).
- EGS research contributes to energy security by enabling long-term reliable energy sources with potential for intrastate deployment.
- Technologies developed via FORGE could significantly expand the geothermal industry in the United States.
- EGS can unlock the benefits of geothermal energy as the ultimate renewable source: it is baseload, flexible, reliable, stable, commercial, and offers the highest level of security for our energy production.
- EGS could provide employment alternatives to traditional energy sector jobs.

2. FORGE will help maintain California's position as an international leader in renewable energy.

- Implementation of technologies developed by the West Flank FORGE project at NAWS China Lake may help California achieve its goal of 50% renewable energy by 2030. The USGS estimate of EGS potential in California is nearly 50,000 MW.
- The West Flank FORGE project supports the state's reputation as an innovator, and opens the door for partnerships with high-tech and other industries in California.
- EGS R&D may demonstrate the technological feasibility of a clean energy source that can be widely deployed.
- Geothermal is baseload and flexible valuable qualities for California's future generation resources.

3. A world-class EGS research project located at NAWS China Lake would be valuable to the local community.

- Increase the community's visibility
- Provide income for local businesses
- Lead to possible workforce development opportunities
- Broaden K-12 students' knowledge of renewable energy technologies through outreach and field trips
- Offer media training opportunities
- Provide educational opportunities and beneficial experience through student internships

4. The U.S. Navy is a strong supporter of FORGE and a leading innovator for national energy security.

- EGS could be an important source of resilient energy for military bases.
- Feasibility demonstration at NAWS China Lake could pave the way for widespread implementation of EGS at other DoD facilities.
- Continued collaboration between DoD and DOE will improve energy security.
- West Flank FORGE project activity will facilitate DoD's mandate to reduce fossil fuel use.
- Use of EGS will expand DoD's geothermal resource base.
- A multi-lab and industry project associated with a DoD facility creates partnership opportunities between other government agencies, local industries, and academia.

5. West Flank FORGE is an excellent proposed FORGE site.

- Wells are already available, bedrock conditions (crystalline rock) are conducive to relatively easy drilling, and there is abundant local drilling experience.
- Subsurface conditions (geology, temperature) are well known.
- A multi-station seismic monitoring array has been operating for years, with an extensive seismic catalog that has been substantially refined through research by USGS and other organizations.
- High temperatures found at shallow depths reduce drilling costs.
- The project has developed a preliminary water use plan to minimize impact on nearby water users.
- Fundamental environmental work has been performed on both the BLM withdrawn land as well as the existing BLM leases.

COMMUNICATION TACTICS AND OUTREACH METHODS

Table 1, below, outlines the outreach methods (meetings, emails, reports, newsletters, teleconferences, websites, social media, internships, classroom engagements, etc.), the intended audience, conveyed information and material contents, the frequency of the activities, and the responsible party. With respect to educational outreach, the FORGE team intends to engage outside organizations to assist in the development of K-12 and university educational programs. We are negotiating with institutions such as the Lawrence Hall of Science, which is affiliated with the University of California, that will be engaged not only to develop STEM-based programs to reach targeted local and national schools, but also to develop programs that bring educators and students to FORGE for a hands-on learning experience. The Department of Energy's Geothermal Technology Office (GTO) requires a courtesy copy of press releases and any other external release materials prior to publication.

Table 1. West Flank FORGE project communications by method and audience

Communication Method	Intended Audience	Frequency	Responsibility
Face-to-face, Skype, and teleconference meetings with key partners and stakeholder groups	Local officials, congressional staff, research community, etc.	Quarterly or as needed	Tech team
Project web sites with additional resources (video, webinar links, PDF documents)	All targets	Ongoing	Tech team
Email and GovDelivery bulletins/newsletters	DOE, stakeholders, twelve thousand subscribers to GTO news	Quarterly or as needed	SNL/LBNL Comms, coordinate with GTO
Publications that support outreach: Fact sheets, infographics, FAQs, etc.	All targets	Available as needed	SNL/LBNL Comms
Social Media (Twitter, Facebook, Periscope) via Lab accounts and stakeholders	All targets	Ongoing	SNL/DOE Comms
Standard briefing packet: PowerPoint presentation template	Primary target	Available as needed	SNL/LBNL Comms
Site Tours	All targets	Monthly or as requested	Tech team
Science education opportunities, curriculum, collaborations with educators to increase geothermal science and technical literacy	K-12 students, teachers, parents	Ongoing	Tech Team, Comms
Professional meetings, targeted conferences/ workshops	All targets	As opportunities arise	SNL/LBNL Comms
Industry publications, news releases, blog posts	Research community; readers of Geothermal Energy Association Weekly and Think Geo Energy Blog	Ongoing	SNL/LBNL Comms
Student internship opportunity (publicize through DOE/EERE Tribal Energy Program)	Undergraduate and graduate students; post-docs; research community; Tribal entities	Annually	SNL/LBNL Comms
Government and industry events, such as Geothermal Energy Association Showcase	Research community/Congressional staff	Annually	Coordinate w/GTO
Public meetings with updates about workforce development possibilities	Local community	As opportunities arise	Tech Team
Partnering with professional communicators within the Labs and with educational specialists on planning, logistics, technical and legal documentation, etc.	All targets	Ongoing	SNL/LBNL Comms

FREQUENTLY ASKED QUESTIONS (FAQS)

Based on the key messages, the West Flank FORGE team has developed a set of FAQs designed to address questions and concerns related to the West Flank FORGE site as a location for geothermal research. A subset of the FAQs will be posted on the web site, and the complete set, included below, is also available as a stand-alone document for distribution.

Table 2. Frequently Asked Questions for the West Flank FORGE project

What is FORGE?	FORGE stands for Frontier Observatory for Research in Geothermal Energy. FORGE is a U.S. Department of Energy (DOE's) Office of Energy Efficiency and Renewable Energy's Geothermal Technologies Office program to investigate potential locations for a national enhanced geothermal systems (EGS) field laboratory. The FORGE program is divided into three phases. During Phase 1, five locations were chosen for continued planning and development of a conceptual geologic model. West Flank is one of the five sites. A down select will occur in Phase 2 in preparation for full site characterization that will include required environmental reviews. Full implementation occurs during Phase 3 at a single FORGE site, and will include testing and evaluation of new and innovative EGS technologies.
What are Enhanced Geothermal Systems (EGS)?	Conventional geothermal systems are located in areas where high subsurface heat, permeable rocks, and underground fluid all naturally coexist. As these three conditions interact—the combination creates a natural underground heat exchanger (transferring heat from the rock to the moving fluids)—that allows recovery of the earth's energy (by drilling wells and producing hot water, steam, or both) to generate electricity. Nearly all geothermal power produced worldwide is supplied by conventional geothermal reservoirs. By contrast, EGS are hot, but with low permeability and a low fluid content. Once an EGS heat source is located—typically in deep, hard rock—researchers drill deep wells and hydraulically stimulate the underground rock to increase permeability, thus creating a geothermal reservoir. Water injected into one or more wells passes through the zone of enhanced permeability, picking up heat along the way, and is extracted in a production well. After reaching the surface, the hot water and/or steam is used to produce power in the same way as in conventional geothermal systems. The practice of manipulating pre-existing fractures in the subsurface to enhance permeability, key to EGS, is the subject of active research in the United States and other countries.
Who are the key players?	With funding from the U.S. Department of Energy's Geothermal Technologies Office, the West Flank FORGE project has a team of geothermal experts led by Sandia National Laboratories. The U.S. Navy, led by the Navy Geothermal Program Office, and Coso Operating Company are key partners in the project because they manage or lease the land dedicated to the FORGE project and bring extensive geothermal experience to the team. Wells drilled in the area demonstrate very favorable conditions (temperature, depth, low-permeability rock) for advancing EGS technology. The project team also includes representatives from Lawrence Berkeley National Laboratory; University of Nevada–Reno; U.S. Geological Survey (Menlo Park, California); GeothermEx/Schlumberger; and Itasca Consulting Group, Inc.
Which organization(s) are funding this project?	Funding for FORGE is provided by the U.S. Department of Energy's Geothermal Technologies Office.

What additional costs, if any, will fall outside project funding?	The initial phase of the FORGE project is funded entirely by the U.S. Department of Energy. Future phases will involve cost sharing. FORGE recipients and sub-recipients who are domestic institutions of higher education, national laboratories, federal entities, or domestic non-profit organizations are exempt from cost sharing.
What is the relationship between the U.S. Navy and the project?	Operations will take place on lands under the control of the U.S. Navy and Coso Operating Company. The West Flank FORGE team, including DOE, will guide the activities with the consent and participation of the U.S. Navy, Coso Operating Company, and the Bureau of Land Management (BLM).
What is the role of the BLM?	BLM is responsible for permitting most geothermal activities on Federal lands, including land owned by the U.S. Navy. However, the Navy will issue any permits required on West Flank FORGE grounds not within BLM leases.
Is National Environmental Policy Act (NEPA) compliance required?	Yes, NEPA is required on all Department of Defense (DoD) installations. NEPA was conducted for the Coso known geothermal resource area (KGRA), including the proposed West Flank FORGE site. A Cultural Management Plan (CMP) developed for the entire KGRA will serve as the governing document for managing the West Flank and nearby Coso geothermal field NEPA protocols. This plan, the Sugarloaf CMP, was approved by the State Historic Preservation Office.
Is drilling anticipated as part of the project? If so, where and how deep?	In Phase 1, the project focuses on developing a conceptual geologic model and planning the activities to occur in later phases. During Phase 2, detailed plans will be developed for EGS experiments that will be conducted at the site. Permits for those activities will be acquired, if needed. In Phases 2C and 3, it is anticipated that multiple deep wells will be drilled at the site to depths ranging from 1,500 m to 3,000 m. Additional shallow wells will be drilled for monitoring subsurface activities. All wells will be drilled on lands managed by the U.S. Navy.
What types of activities are expected to occur in Phase 3 of the FORGE project?	Plans for EGS experiments and activities are still under development. Anticipated activities include, but are not limited to, the following: • drilling new wells and characterizing the rock fabric and mineralogical composition in detail • conducting injection tests • conducting stimulations of existing and new wells and circulation tests between wells • using innovative well completion techniques that allow for manipulation of fractures in multiple zones within a single well • performing tracer testing using reactive and non-reactive tracers All work undertaken at the site is aimed at understanding how to manipulate the fracture system in a way that enhances permeability while allowing sufficient fluid residence time for heat exchange as the injected water travels through the system to the production well, thus tapping the vast heat reserves in the area. All activities will be closely monitored using a variety of sophisticated techniques, contributing to a thorough understanding of initiating and controlling underground processes.
Are there similar EGS experimental sites elsewhere?	The West Flank FORGE site is 1 of 5 DOE-funded Phase 1 projects. Ultimately, DOE plans to fund only a single FORGE project. The other Phase 1 FORGE projects are in Nevada, Idaho, Utah, and Oregon. In addition to these projects, EGS is the subject of research and development by various governments, including the United States and the European Union. Dedicated EGS experimental sites have been implemented in the United States (Fenton Hill, New Mexico), the UK (Rosemanowes, Cornwall), and the European Union (Soultz-Sous Forêts, France). In addition, EGS experimentation has been undertaken at several operating geothermal project sites in Nevada (Desert Peak, Bradys), Idaho (Raft River) and California (Coso, The Geysers).

Where does the name "West Flank" come from? And where exactly is it?	West Flank refers to the western portion of the Coso Volcanic Field in Inyo County, California. A series of young volcanic domes delineates the boundary between the eastern side of the field, which hosts a conventional hydrothermal resource with about 270 MW of installed capacity, and the central portion of the field which is hot but lacks the same degree of permeability present on the eastern side. This natural phenomenon has created a prime location for conducting EGS experiments: the West Flank.
What makes China Lake's proposed West Flank a good site?	West Flank has all the required characteristics of a world-class EGS site: an existing geothermal project that has contributed significantly to researchers' knowledge of the subsurface; available wells that are hot but have very low permeability; a willing land manager and lease holder (the U.S. Navy and the Coso Operating Company, respectively) with strong interest in developing new sources of resilient power; an existing seismic monitoring network that has been collecting micro earthquake (MEQ) data 24 hours/day, 7 days/week since the early 1990s (helping to characterize the area); and a massive volume of hot granitic rock at shallow depths (200-600 ft. below ground surface), which lowers drilling costs. In addition, very high tectonic strain rates and investigated stress states in the area will facilitate hydraulic fracturing of the rock. The site is accessible year-round, offers local infrastructure support (staging areas, offices), and coexists with the Naval Air Weapons Station (NAWS) China Lake mission, which focuses on weapons testing and evaluations.
Is this project related to Coso Geothermal Area and the Coso Geothermal Field?	The project is leveraging five decades of data related to the development the Navy's geothermal project at Coso. The Coso Operating Company (COC) operates the field and is a partner on this project. However, whereas the Coso geothermal field is naturally hot and permeable, the western flank of Coso is naturally hot but has very low permeability. Previous testing showed no hydraulic communication between the geothermal field and the ground to the west (i.e., the West Flank).
How much water will this project use?	Enhanced geothermal systems need water to operate effectively. The water requirements for FORGE will be on the order of a few million gallons per stimulation, and it is anticipated that up to 3 to 6 wells may be stimulated.
Where will you get the water you need for this project?	The FORGE project will have access to three sources of water for stimulation and other activities. The first source is the separator brine and cooling tower waters from the geothermal field. The second source is from a 1.5 million gallon water tank that provides make-up water to the geothermal field. The third source is a Rose Valley deep brine aquifer currently being assessed by the COC and U.S. Navy.
How do you justify using injected fluid (water) during a long-term drought?	Fluid injection during Phase 3 will be for discreet, limited periods. The primary source of water for stimulations and other activities will be the non-potable geothermal fluid produced by the Coso Geothermal Project; therefore, FORGE activities will have a minimal impact on water use in the area.
Will injection of fluids affect seismic activity in the area?	Fluid injection at the FORGE site will cause micro-earthquakes (also referred to as micro-seismicity). Although most micro-seismicity associated with geothermal reservoirs is not felt at the surface, subsurface seismic activity will be carefully monitored by a micro-seismic monitoring network. An Induced Seismicity Mitigation Plan has been developed for the project, detailing the mitigation and communication strategies.
Will injection of fluids increase the risk of a significant earthquake?	Micro-seismicity associated with fluid removal and injection has been observed and monitored for decades around the Coso Geothermal Field. Micro-seismicity is related to minor movements along small fractures affected by injection and production activities on-going in the Coso Geothermal Field east of West Flank. Micro-seismic data helps researchers understand subsurface processes and optimize resource use. No significant earthquakes have ever been associated with production from the Coso geothermal field. As a result of detailed characterization of the subsurface, the FORGE project is designed to avoid faults that have the potential to produce damaging earthquakes.

How will the project protect local interests during each Phase?	Unimpeded by FORGE activities, local tribes will continue to access the sacred site at Coso Hot Springs. The research project will attract economic activity to the area, particularly in the drilling and hospitality sectors. After completion of the FORGE project, EGS development could have a positive impact on the area in two ways: (1) by demonstrating a new source of clean power that can be replicated in other communities; and (2) by providing the U.S. Navy with resilient power, ensuring that it can continue its important mission at NAWS China Lake.
How are you going to protect the cultural sites in and around the FORGE project areas?	Coso Operating Company has performed a complete inventory of cultural sites at Coso, confirming that the West Flank FORGE area contains known cultural sites. Because the FORGE team will use existing access roads and will build minimal infrastructure (a few well pads, wells and pipelines) in a well-surveyed area, cultural sites will be respected. Any new developments will be planned in such a way as to create no adverse effects or disturbance.
What happens to the site at the end of the 5-year research project?	The infrastructure to be developed for the FORGE project will be minimal, consisting of a few well pads, wells, and pipelines that may continue to be used for experiments, geothermal production, or injection after the FORGE project is finished. If there is no use for this infrastructure at the completion of the project, reclamation will be performed as needed.

CONCLUSION

The West Flank team is committed to supporting communications, education, and outreach efforts to maintain sound operations and increase geothermal science and technology literacy for the duration of the FORGE project.

APPENDIX H. STAKEHOLDER ENGAGEMENT STATUS UPDATE

STAKEHOLDER ENGAGEMENT STATUS UPDATE

West Flank of Coso, CA

STAKEHOLDER ENGAGEMENT STATUS UPDATE

West Flank of Coso, CA

The Stakeholder Engagement Status Update complements the West Flank of Coso, CA, Communications and Outreach Plan by detailing the FORGE Phase 1 activities by the West Flank team to develop stakeholder relationships. The following three tables detail **Media Relations Engagement, One-on-One Engagement,** and **Meetings and Conferences,** and are current as of May 10, 2016. The West Flank team lead(s) and team participant(s) engaged with media outlets, met individually with stakeholders, and attended meetings and conferences to improve communications, educate stakeholders, form agreements, navigate legal requirements, and ensure dissemination of accurate information about the FORGE project. The content of each table is organized chronologically, starting with the most recent event.

Media relations activities, detailed in Table 1, included a published magazine article, blog posts, and interviews. All events were intended primarily to educate stakeholders.

Table 1. Media Relations Engagement Status Update

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Media Activity	Location	Details	Web link or title of published article or press release	Category of Status Update
James Faulds, University of Nevada–Reno (UNR)	Wendy Calvin, UNR	Nov. 1, 2015	Gave interview for a press release or other published article. Briefed media relations, submitted content (images, text, data). Other: magazine article.	Reno, NV	John Seelmeyer reporter, Fall 2015 issue of *Nevada Silver and Blue Magazine*, University of Nevada, Reno. While this was a Nevada-focused interview, the general information about EGS and FORGE is now accessible to a national audience.	http://www.unr.edu/silverandblue/archive/2015/fall/NSB_Fall_2015_WEB.pdf Title: "Forging Geothermal Resources through Research," *Nevada Silver & Blue*, Fall 2015. Page 25.	Educating stakeholders
James Faulds, UNR	Wendy Calvin, UNR	Aug. 5, 2015	Gave interview for a press release or other published article.	Reno, NV	John Seelmeyer, *Nevada Today*, University of Nevada, Reno. Article in *Nevada Today* describing the DOE FORGE effort. While this was a Nevada-focused interview, the general information about EGS and FORGE is now accessible to a national audience.	http://www.unr.edu/nevada-today/news/2015/forging-new-geothermal-resources-through-research Title: "Forging New Geothermal Resources through Research." *Nevada Today*, August 5, 2015.	Educating stakeholders
Andy Sabin, Navy Geothermal Program Office (GPO)	Mike Lazaro and Kelly Blake, Navy GPO	Apr 12, 2015	Gave interview for a press release or other published article. Other: West Flank tour.	Naval Air Weapons Station (NAWS) China Lake, Ridgecrest, CA	Navy Public Affairs Officer; local Navy newspaper, NAWS China Lake Rocketeer.	http://www.rocketeer2.com/article/20150430/NEWS/150439969 Title: ASN visits NAWS China Lake	Educating stakeholders

The West Flank team's one-on-one stakeholder engagement, detailed in Table 2, focused primarily on meetings with congressional members and included an opportunity to develop international partnerships.

Table 2. One-on-One Engagement Status Update

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Who we met	Audience	Location	Summary of Description	Notable Mentions	Category of Status Update
Doug Blankenship, Sandia National Laboratories (SNL)	Mack Kennedy, Lawrence Berkeley National Laboratory (LBNL) Erik Ridley, SNL Jenn Tang, LBNL	Apr. 19, 2016	Anne Clement, Legislative Assistant, Office of Senator Barbara Boxer	Federal, state, and local governments and agencies	Washington, DC	Provided an introduction and overview of the DOE FORGE effort. Provided overview and infographics of the West Flank of Coso, CA, site proposed by the Sandia-led team. Responded to questions, concerns, etc. regarding FORGE and the West Flank site.	Very supportive of FORGE and our West Flank team.	Educating congressional leaders
Doug Blankenship, SNL	Mack Kennedy, LBNL Eric Ridley, SNL Jenn Tang, LBNL	Apr. 19, 2016	Rachel Carr, Legislative Fellow, Office of Senator Dianne Feinstein	Federal, state, and local governments and agencies	Washington, DC	Introduction and overview of the DOE FORGE effort. Presented introduction, overview and infographics describing the West Flank site proposed by the Sandia-led team. Answered questions and concerns regarding the West Flank site and the FORGE effort.	The Senator is very interested in geothermal energy and supports the FORGE effort, particularly the West Flank site proposed by our team.	Educating congressional leaders
Doug Blankenship, SNL	Mack Kennedy, LBNL Erik Ridley, SNL Jenn Tang, LBNL	Apr. 19, 2016	Tim Itnyre, Legislative Director, Office of Congressman Paul Cook (R-CA)	Federal, state, and local governments and agencies	Washington, DC	Introduction and overview of the DOE FORGE effort. Presented introduction, overview and infographics describing the West Flank site proposed by the Sandia-led team. Answered questions and concerns regarding the West Flank site and the FORGE effort. Congressman Cook's district includes several military institutions, including NAWS China Lake.	The Congressman is very supportive of the West Flank site. Expressed some concerns regarding water use. The concerns arise from expansion plans of geothermal production at Mammoth Lakes, CA.	Educating congressional leaders

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Who we met	Audience	Location	Summary of Description	Notable Mentions	Category of Status Update
Doug Blankenship, SNL	Mack Kennedy, LBNL Erik Ridley, SNL Jenn Tang, LBNL	Apr. 19, 2016	Jason Riederer, Legislative Director and Kyle Thomas, Legislative Assistant, Office of Congressman Mark Amodei (R-NV)	Federal, state, and local governments and agencies	Washington, DC	Introduction and overview of the DOE FORGE effort. Presented introduction, overview and infographics describing the EGS project proposed by the Sandia-led team. Answered questions and concerns regarding the FORGE effort and proposed sites. The congressman's district includes a Navy installation.	Congressman Amodei is a strong proponent of geothermal energy and very interested in the DOE FORGE effort.	Educating congressional leaders
Doug Blankenship, SNL	Mack Kennedy, LBNL Erik Ridley, SNL Jenn Tang, LBNL	Apr. 19, 2016	Ryan Mulvenon, Senior Advisor to Senator Harry Reid (D-NV)	Federal, state, and local governments and agencies	Washington, DC	Introduction and overview of the DOE FORGE effort. Presented introduction, overview, and infographics describing the EGS project proposed by the Sandia-led team. Answered questions and concerns regarding the FORGE effort and discussed progress to date on Phase 1 work.	Senator Reid is very interested in geothermal energy and is particularly supportive of the potential represented by the DOE FORGE effort.	Educating congressional leaders
Ann Robertson-Tait, GeothermEx	Kent Burton, Lobbyist, Geothermal Energy Association	Mar. 17, 2016	Mr. Vernon Baker, Legislative Analyst, Office of Rep. Mike Thompson (D-CA) District 5	Federal, state, and local governments and agencies	Washington, DC	Mr. Vernon Baker, Legislative Analyst, was receptive to and interested in the West Flank FORGE project. Explained the fundamentals of the project (summary of the talking points) and why FORGE will help California to continue to lead the green revolution by supporting the development of a new, clean, non-nuclear baseload energy source (through the West Flank site project).	CA District 5 includes a portion of The Geysers geothermal field and extends southward almost to GeothermEx's office in Richmond, CA. Followed up with another staffer more involved in energy issues (Meridith Sebring). Also contacted Rep. Zoe Lofgren (D-CA) of the 19th District (includes San Jose and environs), a known champion of innovation and technology, including renewable energy, through her staffer responsible for energy issues, Angela Ebiner.	Educating stakeholders

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Who we met	Audience	Location	Summary of Description	Notable Mentions	Category of Status Update
James Faulds, University of Nevada–Reno		Mar. 16, 2016	Ryan Mulvenon, Staff, Office of Senator Harry Reid (D-NV)	Federal, state, and local governments and agencies	Washington, DC	Presented update on the West Flank site and DOE FORGE effort; reviewed DOE criteria and site suitability.		Educating stakeholders
Mack Kennedy, LBNL	Pat Dobson, LBNL	Feb. 29, 2016	Hiroshi Asanuma, Geothermal Team Leader, Fukushima Renewable Energy Research Institute (FREA), National Institute of Advanced Industrial Science and Technology (AIST), Japan	Public research institutions, international partners	Berkeley, CA	Presented an update on the status of the DOE FORGE site selection process and an overview of the West Flank site. Asanuma presented an overview of FREA/AIST's plan for EGS research and their commitment to partnering with DOE. Specifics of the meeting regarding research interests, financials, etc., were marked confidential.		Develop international partnerships

During Phase 1, West Flank team members presented two published papers at several key scientific conferences, spoke with an education center about forming partnerships to establish programs for outreach and education, and supported STEM education, as summarized in Table 3, below. Additional engagement with key stakeholders included providing project status and overviews; answering questions; organizing on-site visits; and meeting with the general public, industry partners, and governmental and military agencies.

Table 3. Meetings and Conferences Engagement Status Update

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Name of Meeting or Conference	Audience	Location	Title of Presentation, Discussion, etc.	Summary of Presentation, Discussions, etc.	Notable mentions	Category of Status Update
Michael T. Lazaro, Navy GPO	Kelly Blake, Navy GPO	Apr. 15, 2016	STEM Day at Sherman E. Burroughs High School	Students and educators	Ridgecrest, CA		Presentation and speaking engagement to ~250 students and 20 faculty members regarding FORGE.		STEM Education and Outreach
Mack Kennedy, Lawrence Berkeley National Laboratory (LBNL)	Drew Siler, LBNL	Apr. 14, 2016	Meeting with Lawrence Hall of Science to discuss educational outreach collaboration for FORGE	Federal, state, and local governments and agencies, students and educators	Berkeley, CA	N/A	Presentation of FORGE effort and the West Flank site, and discussion of Lawrence Hall of Science's expertise and interest in collaboration.	Lawrence Hall of Science attendees: Craig Strang, Associate Director of the Lawrence Hall of Science, Director of Leadership in Science Teaching; Catherine Halverson, Co-Director of MARE, Director of Communicating Ocean Science, Director of Promoting Climate Literacy; Emily Weiss, Director of PRACTISE; Jedda Foreman, Project Manager, BEETLES Project	Potential educational outreach meeting

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Name of Meeting or Conference	Audience	Location	Title of Presentation, Discussion, etc.	Summary of Presentation, Discussions, etc.	Notable mentions	Category of Status Update
Andy Sabin, U.S. Navy Geothermal Program Office (GPO); Doug Blankenship, Sandia National Laboratories (SNL); Mack Kennedy, LBNL; Ann Robertson-Tait, GeothermEx; Michael T. Lazaro, Navy GPO; Chris Ellis, Coso Operating Company (COC)	Kelly Blake, Navy GPO; Dave Meade and Joe Greco, COC	Apr. 7, 2016		Federal, state, and local governments and agencies	Command-ing Officer's conference room, Naval Air Weapons Station (NAWS) China Lake, Ridgecrest, CA		Introduced FORGE to stakeholders with focused discussions on water, stakeholder communications, land position, Native American concerns, and induced seismicity.	Mick Gleason, Chairman, Kern County Board of Supervisors; Matt Kingsley, Inyo County Board of Supervisors	Educating stakeholders, navigating legal requirements, and other
Ann Robertson-Tait, GeothermEx		March 17, 2016	Geothermal Energy Association US and International Geothermal Showcase	Government agencies (domestic and international), geothermal developers, students	Washington, DC	Creating New Geothermal Opportunity in High Temperature, Low Permeability Rock Formations: Making a Case for EGS	Geographic limitations of conventional hydrothermal resources; EGS overview (part of the continuum of geothermal resources, estimates of worldwide power generation potential); summary of active EGS projects in the US; how the SNL/LBNL team decided to choose West Flank of Coso, CA, as a candidate FORGE site; and the importance of resilient energy for US DOD.		Educating stakeholders

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Name of Meeting or Conference	Audience	Location	Title of Presentation, Discussion, etc.	Summary of Presentation, Discussions, etc.	Notable mentions	Category of Status Update
Andy Sabin, Navy GPO		Feb. 22-24, 2016	41st Workshop on Geothermal Reservoir Engineering (Stanford Geothermal Workshop)	Private research institution, public research institutions, Federal, state, and local governments and agencies, students and educators	Stanford University, Stanford, CA	Geologic setting of the West Flank, a FORGE site adjacent to the Coso geothermal field	Similar to GRC presentation, summarized how West Flank site has geologic attributes required of DOE for FORGE and presented draft geologic model. Sabin et al. (2016) Geologic setting of the West Flank, a FORGE site adjacent to the Coso geothermal field, *Proceedings, 41st Workshop on Geothermal Reservoir Engineering*. Stanford University, SGP-TR-209. 11 p.	Presented a paper	Educating stakeholders
Andy Sabin, Navy GPO	Mike Lazaro, Navy GPO; Chris Ellis and Joe Greco, COC	Jan. 25, 2016	Visit to FORGE area by the Honorable Pete Wilson, former Governor of the State of California, Honorary Co-Chairman, Southwest Defense Alliance (SWDA).	Military, government and private sector (see Notable Mentions column)	Naval Air Weapons Station China Lake, Ridgecrest, CA	Informal tour of the West Flank site and the adjacent Coso geothermal field.		The Honorable Pete Wilson, Former Governor of the State of California, Honorary Co-Chairman, Southwest Defense Alliance (SWDA); Vice Admiral Peter M. Hekman Jr., USN (Ret), Secretary, SWDA; Lieutenant General John F. Regni, USAF (Ret), Chairman, SWDA; Major General Dennis M. Kenneally, USA (Ret), Executive Director, SWDA; Supervisor Mick Gleason, Kern County First District Board Member, SWDA; Mr. Jon McQuiston, Former Kern County Supervisor, Chairman Emeritus, SWDA; Mr. Sean T. Walsh, Principal, Morgan Lewis Consulting, accompanying Governor Wilson	Other

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Name of Meeting or Conference	Audience	Location	Title of Presentation, Discussion, etc.	Summary of Presentation, Discussions, etc.	Notable mentions	Category of Status Update
Maryann Villavert, LBNL	Mack Kennedy and Ernie Majer, LBNL	Dec. 14-18, 2015	American Geophysical Union Fall Meeting 2015, December 14-18	Private research institution, public research institutions, international partners, students and educators	San Francisco, CA	Earth and Environmental Sciences Area, Exhibitor Booth	Several research topics and activities were presented by LBNL's, EESA in the form of Meet-a-Scientist, informal presentations, videos, handouts, and social media twitter chats. Prospective postdocs, students, faculty, industry personnel visited the booth to learn more about LBNL, EESA and opportunities in doing research. Answers to questions about FORGE included opportunities for future internships, postdoc appointments, and collaborations with faculty and industry.	Interested individuals were curious about when FORGE would start.	Educating stakeholders
Andy Sabin, Navy GPO		Sep. 20-23, 2015	39th Geothermal Resources Council Annual Meeting and Geothermal Energy Association Expo	Private research institution, public research institutions, Federal, state, and local governments and agencies, international partners	Reno, NV	Geologic setting of the proposed West Flank forge site, California: suitability for EGS research and development	Geologic setting of West Flank; demonstration of how it meets all DOE FORGE geologic criteria. Sabin et al. (2015) Geologic Setting of the Proposed West Flank Forge Site, California: Suitability for EGS Research and Development. *GRC Transactions*, Vol. 39, 345-352.	Presented a paper	Educating stakeholders
James Faulds, University of Nevada–Reno		Sep. 15, 2015	Congressional briefing on geothermal energy: Energy-Water-Land Connections Briefing Series	Federal, state, and local governments and agencies	Washington, DC	Geothermal Systems: Geologic Origins of a Vast Energy Resource	Described the origins and locations of geothermal energy, conventional geothermal systems, and EGS, as well as challenges and opportunities for the geothermal industry. Also, described the FORGE effort in general. Served as panelist answering questions about geothermal energy.		Educating stakeholders

Team Lead(s), Affiliation	Team Participant(s), Affiliation	Date	Name of Meeting or Conference	Audience	Location	Title of Presentation, Discussion, etc.	Summary of Presentation, Discussions, etc.	Notable mentions	Category of Status Update
Douglas Blankenship, SNL		Aug. 25, 2015	Clean Energy Project - Nevada's Innovation System: Accelerating Clean Energy Economic Development	Stakeholders interested in Nevada energy issues	Las Vegas, NV	Panel discussion	This event was held by the State of Nevada and the U.S. Department of Energy in association with the Clean Energy Project event in Las Vegas, NV. Requested by the State of Nevada to be part of a roundtable discussion about new opportunities. Other panel members were DOE personnel, including Trak Shah, Matt Nelson, Mark McCall and Jetta Wong. While the program was focused on Nevada, held discussions about the broader FORGE effort as well as the West Flank site.		Educating stakeholders
Douglas Blankenship, SNL		Jun. 12, 2015	U.S. Senate & House Renewable Energy and Energy Efficiency Caucus FORGE Briefing	Congressional staffers and others	Washington, DC	The DOE Frontier Observatory for Research in Geothermal Energy: Candidate Sites at Fallon, NV, and Coso, CA	Presentation included an overview of the West Flank site and FORGE project. Congressional Caucus presentation.		Educating stakeholders
Andy Sabin, Navy GPO	Mike Lazaro and Kelly Blake, Navy GPO;	Apr. 21-22, 2015	Assistant Secretary of the Navy visit to NAWS China Lake	Government employees including political appointees	NAWS China Lake, Ridgecrest, CA	West Flank tour and informal discussions	Overall description of FORGE, description of two Navy FORGE areas and specific discussion and tour of the Coso geothermal field and the adjacent West Flank site.	Assistant Secretary of the Navy had heard of and was quite interested in FORGE.	Educating stakeholders

APPENDIX I. SAMPLE AND CORE CURATION PLAN

SAMPLE AND CORE CURATION PLAN

West Flank of Coso, CA

SAMPLE AND CORE CURATION PLAN

West Flank of Coso, CA

PURPOSE

The Sample and Core Curation Plan establishes procedures and guidelines for the preservation of core, cuttings, and fluid samples obtained during West Flank of Coso, CA, FORGE activities, and distribution of sample data and physical samples to investigators requiring access to these materials.

SITE SAMPLE ACQUISITION AND HANDLING

Drilled holes supporting the West Flank FORGE effort will involve sample acquisition of one form or another. The general plans for the acquisition and handling of core, cuttings, and fluids are provided below. For this significant FORGE endeavor, the process for acquiring and handling physical samples will require integration with the sampling systems, the activity-specific ES&H requirements, and the requirements of potential principal investigators engaged in sample acquisition. Thus the plan is general in nature and recognizes that detailed procedures for sample acquisition and handling will be needed as site activities evolve. Dedicated on-site space will be established for the handling, and preliminary examination of the collected samples. We expect to be able to create a digital on-line archive of image data similar to the SAFOD core viewer (http://coreviewer.earthscope.org/) or the Australian National Virtual Core Library (http://nvcl.csiro.au/).

DRILL CUTTINGS

During rotary drilling operations, cuttings will be collected, described, and logged on a 24-hour basis. The primary responsibility for this activity lies with the contracted mud logging company, but the West Flank FORGE site geologist(s) will supervise the work. Cuttings collection intervals may vary depending on the depth of the hole, penetration rate, lithological contacts, and the requirements of specific principal investigators, but generally will be collected at a maximum of 10 ft. intervals unless otherwise authorized by the West Flank FORGE project management. At each collection interval, cuttings will be collected off the shale shaker onto a collection board or trough to ensure a representative sample is obtained. Following sample collection, the collection board or tough will be cleaned to gather cuttings representing the next interval. The samples will be gently washed, screened, dried, and bagged with markings indicating the well name, depth, and time of collection. Because it takes the collected sample a measurable or calculable amount of time to move from the bottom of the hole to the surface, the recorded depth will reflect this lag time.

Cuttings will be examined in near real-time. Field microscopes will be equipped to allow digital photographs of the examined cuttings. A field log describing lithology, mineral assemblages and crystallinity, texture, alteration, fracture, vein, or fault locations, will be maintained during the course of drilling and the findings will be posted daily to the FORGE node on the NDGS. Once examined, the cuttings will be preserved and logged into a permanently retained sample log. Samples will be stored temporarily on-site until immediate access is no longer required. At that time the samples will be moved to temporary storage at a near-site warehouse location for the duration of the West Flank FORGE effort. Following the completion of project activities at West Flank FORGE, the samples will be moved to the USGS Core Research Center (CRC) in Denver, CO, or to the Nevada Bureau of Mines and Geology (NBMG) Great Basin Science Sample and Records Library (GBSSRL) in Reno, NV, for preservation and permanent storage.

DRILLED CORE

The drilling, testing, and examination of core, whether from sidewall samples, spot coring operations, or from continuous wireline coring will be an integral part of the West Flank FORGE development effort.

Depending on the drilling conditions and PI-specific sampling requirements, the core will be obtained using either triple-tube or double-tube systems. For triple-tube systems, the core is retained within a thin-walled aluminum or polymeric inner tube assembly that encases the core following its removal from the coring assembly. Double-tube systems allow the core to enter a free-floating inner barrel assembly but do not encase the core in a removable liner. When collecting core samples, a trained site geologist will work alongside the rig crew during the core extraction process to ensure proper handling of the core. For triple-tube systems, the core and liner (or core only, for double-tube systems) should be laid out in a single tray on the catwalk or similar structure and wiped down. The entire length of the liner or core will be marked in the standard red-black parallel line method with the red line to the right of the black line when looking up the hole.

Any core not in a liner should be carefully aligned and cleaned to allow the application of the red-black markings before moving the core from the catwalk. For core contained in liners, the liner/core will need to be cut in 3-foot lengths to fit in standard core boxes; likewise, it may be necessary to cut the core on the catwalk to fit in standard 3-foot core boxes. The core will then be transported to an on-site logging trailer for final cleaning with water and inspection. If the core is contained in a liner, the core must be pushed out of the liner or the liner split to allow access to the core. When the liner-housed core housed is laid out in the trailer, the core should be carefully aligned and marked with the red-black line code if the liner were removed. Integer depths will be marked along the core and a detailed field log of the core will be completed for the subject section of core.

We expect to use a multi-sensor core logger (e.g. Geotek MSCL-S) to document properties such as P-wave velocity, gamma density, magnetic susceptibility, electrical resistivity, color imaging, X-ray fluorescence, and natural gamma spectrometry. This is similar to what the International Continental Scientific Drilling Program (ICDP) makes available to its user community. Additionally, new high-resolution core infrared spectroscopy may be acquired to document mineralogy and alteration. The core will then be wrapped in cling-type plastic wrap and placed in appropriately marked core boxes. Core descriptions and associated photographs will be uploaded to the dedicated FORGE node and be available through the National Geothermal Data System (NGDS). Core samples will temporarily be stored on site until immediate access is no longer required. Samples will then be moved to temporary storage at near-site warehouse space for the duration of the FORGE project effort. Following the completion of West Flank FORGE project activities, the samples will be moved to the USGS CRC or to the NBMG GBSSRL for preservation and permanent storage.

Limited sidewall core samples may be obtained to support specific PI-related activities but will not likely be a large part of the drilling operations at the West Flank FORGE site, given the planned direct coring operations. However, in the event sidewall cores are taken, the core will be received from the service company by a West Flank FORGE site geologist. The core will be identified and preserved in a manner consistent with that used to preserve drilled core samples.

FLUID SAMPLES

Fluid samples used for testing during West Flank FORGE development and operation may be obtained through drill-stem testing through targeted sections of the drilled wells, downhole fluid sampling efforts, during flow/circulation testing, or other methods. As part of the site characterization, monitoring, and R&D conducted by the SMT, each fluid sample will be collected in quadrature. For each sample, one component will be analyzed as soon as possible after collection at an on-site laboratory managed by the SMT for pH, total alkalinity, dissolved silica, and so on. A second component will be sent to a commercial laboratory for major and minor cation and anion analyses, and non-condensable gas analyses. A third component will be sent to a reputable laboratory for stable isotopes analysis (e.g., $\delta^{18}O$ and $\delta^{2}H$). A fourth component will be archived for any further analyses that may be required and/or requested. The resulting data for all components of each fluid sample will be uploaded to the NGDS through the FORGE node. As with core samples, the fourth component of each fluid sample will be stored on-site initially and later at a nearby warehouse facility for the duration of the project and then discarded, in accordance with EH&S protocols. Because non-condensable gas samples are difficult to preserve, only liquid samples will be archived. Fluid sampling, handling (e.g. filtering, acidification), and preservation will follow conventional procedures developed for geothermal systems.

If additional samples are requested for DOE-funded R&D projects, collaboration with international partners and private sector researchers (for example, for geochemical tracer studies during stimulation and flow testing), the SMT will provide logistical support for fluid sampling. Sample collection, handling and preservation will be the responsibility of the project leads. The SMT managed on-site laboratory will be made available, if requested by the project leads. All data acquired by these projects will be uploaded to the NGDS through the FORGE node following the Data Dissemination protocols.

SAMPLE DISSEMINATION

Data collected during the course of the West Flank FORGE effort will be openly available to the scientific and engineering community. As described in the data dissemination plan, well data will be available in as close to real-time as practicable. These site derived data will be posted and will also include the raw notes and log sheets from the site geoscientists for the subject samples. The distribution of data through an open data system, as described in the data dissemination plan, is organizationally less complex than the process of distributing physical samples to the scientific and engineering community. Following the lead of the NSF sponsored

SAFOD (San Andreas Fault Observatory at Depth) program, protocols will be put in place for physical sample distribution associated with the DOE FORGE program.

During the West Flank FORGE project, all samples will remain the property of DOE and will be stored short-term at the West Flank FORGE site and longer-term (through the course of the project) at warehouse space near the FORGE facility. After the cessation of site activities, the core will be archived and preserved at the USGS CRC or the NBMG GBSSRL. The distribution processes of West Flank FORGE samples to the science and engineering community is described below.

SAMPLE DISTRIBUTION DURING FORGE OPERATIONS

A West Flank FORGE Sample Committee (FSC) will be nominated by the FORGE Site Management Team (SMT) in conjunction with the Science and Technology Analysis Team (STAT) and approved by the DOE Geothermal Technologies Office. The members of the FSC will not otherwise be involved in R&D projects being funded through the FORGE initiative. Samples will be made to any qualified investigator, but researchers being funded through the R&D portion of FORGE will be given priority. Requests for samples will be provided to the FORGE Data Manager, who is a separate member of the SMT/STAT teams; the data manager will forward the requests to the FSC for regularly scheduled reviews. The review cycle for proposals will be determined by DOE program needs, occurring regularly enough to accommodate DOE research requirements.

The FORGE project will provide a request form to be submitted by all researchers requesting samples. Requests will contain a description of the requested samples and the proposed studies for which the samples are required. Requesters will provide a description of the procedures and objective of the study, the names and affiliations of collaborators, the name of the funding agency, and the agency's point of contact. In the proposal, the requester will attest that data derived from the supplied samples will be uploaded to the FORGE node on the NGDS. The application will specify when the samples will be returned to the USGS CRC unless circumstances, as described in the proposal, merit the complete destruction of the sample (in which case a sample split or slab will be retained).

Because the FSC's primary charge is to maximize the return from the available FORGE samples, the FSC will recommend to DOE how the samples should be used and who should receive which samples. Once DOE approval is obtained, the West Flank FORGE Data Manager will distribute the samples to the subject investigators. This process is applicable for all core, cuttings, and fluid samples. A digital on-line image archive will be established to assist investigators in selecting core or cutting sections for analysis.

SAMPLE DISTRIBUTION AFTER FORGE OPERATIONS

Following the cessation of FORGE site operations, all dry samples will be shipped to the USGS CRC or the NBMG GBSSRL. The CRC/GBSSRL will accept these samples either as donated material or DOE-owned material. DOE can retain the option to maintain control of the samples and distribution to researchers, but after the project has ended, there will be recurring costs to maintain the functions of the FSC and associated support from the USGS CRC/GBSSRL. If DOE opts to retain ownership, the process for obtaining and distributing samples is the same as that during West Flank FORGE operations. Once the CRC/GBSSRL assumes ownership (which can occur at any time after the receipt of samples), there are no further costs to DOE. The USGS

CRC, a national repository for core and cuttings, will preserve and maintain the samples in perpetuity and allow all interested researches access. Once its ownership begins, CRC will control sample distribution following its own protocol. CRC and GBSSRL allow access to all interested parties and allow samples to be obtained for testing. Given its preservation mission, however, CRC does not allow for whole sections of core to be removed; they do allow (and provide the service) for sub-cores, slabs, and cutting splits.

Fluid samples will not be stored after the cessation of West Flank FORGE activities unless DOE chooses to maintain a facility to provide the climate controlled environment needed to store such samples.

APPENDIX J. PRELIMINARY INDUCED SEISMICITY MITIGATION PLAN

PRELIMINARY INDUCED SEISMICITY MITIGATION PLAN

West Flank of Coso, CA

CONTENTS

PRELIMINARY INDUCED SEISMICITY MITIGATION PLAN

West Flank of Coso, CA

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

There are two main purposes of monitoring and analyzing seismicity in Enhanced Geothermal Systems (EGS) projects: 1) assessing the hazard and risk associated with induced seismicity; and 2) using and applying seismic data to understand the dynamic response of the subsurface at the FORGE site. As described in this preliminary Induced Seismicity Mitigation Plan (ISMP), the overall approach at the West Flank FORGE site is to provide sufficient analyses and monitoring to serve both purposes. This preliminary ISMP—which will be updated in Phase 2 of FORGE—presents our approach to assessing the risk and hazard associated with induced seismicity that may occur in response to EGS activities in the West Flank area, and how seismic monitoring provides data for EGS reservoir assessment.

As stated in the FORGE Funding Opportunity Announcement (FOA), the West Flank FORGE project will follow the guidelines created by the US Department of Energy ("DOE"), including:

1. The enhanced version of the Protocol for Induced Seismicity Associated with Geothermal Systems (Majer *et al.*, 2012), hereinafter referred to as the "Protocol."
2. The latest version of the Best Practices for Induced Seismicity (Majer *et al.*, 2014), hereinafter referred to as the "Best Practices."

Both of these documents build upon an initial strategy for evaluating, monitoring and managing induced seismicity (Majer *et al.*, 2008).

The seven steps in the Protocol are:

- Step 1: Perform preliminary screening evaluation
- Step 2: Implement an outreach and communication program
- Step 3: Identify criteria for ground vibration and noise
- Step 4: Establish seismic monitoring
- Step 5: Quantify the hazard from natural and induced seismic events
- Step 6: Characterize the risk from induced seismic events
- Step 7: Develop risk-based mitigation plans

The plan presented herein is a description of the approach that we will use to address each step in the Protocol. In Phase 2 of the FORGE project, a more detailed protocol will be developed based on additional site characterization and development of detailed plans for R&D activities to be conducted at the site.

1.2 WEST FLANK SITE OVERVIEW

The West Flank FORGE project area is located in southeastern California, specifically in Inyo County, a few miles east of Coso Junction. As shown in Figure 1 below, the West Flank FORGE EGS project will be carried out along the western side of a large parcel of land controlled by the US Navy at the Naval Air Weapons Station China Lake ("NAWS China Lake").

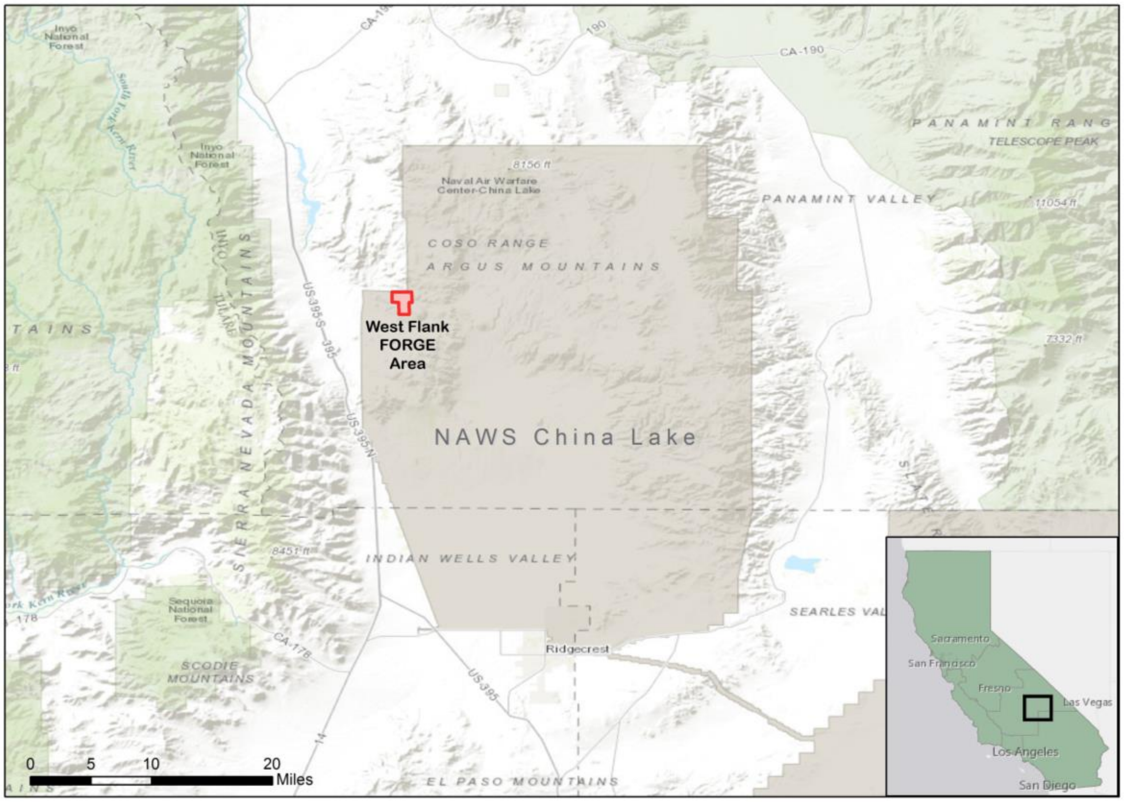

Figure 1. Map of NAWS China Lake (grey shaded area) showing the West Flank FORGE area (in red).

Additional detail of the site is presented in Figure 2 below. The 1.7 square mile area outlined in bright yellow will be dedicated to EGS activities. This area includes portions of sections 1, 11 and 14 of Coso Operating Company's two active BLM geothermal leases that are in a "Held by Production" status (leases CA-11384 and CA-11385). The remainder of the West Flank project area includes expired BLM leases that are now categorized as "BLM withdrawn lands" (CA-12936 and CA-11403). The Federal government (Department of the Interior) is essentially the "owner" of all the land dedicated to West Flank FORGE. The management of all of this ground, including the "withdrawn" land is the Navy's responsibility, as described more fully in the Environmental Synopsis.

The West Flank FORGE area includes two existing core holes (CBHF-11 and 74-2 TCH) and one full-diameter well (83-11) drilled by Coso Operating Company ("COC", which operates the geothermal projects further to the east). An additional surrounding area of 43.5 square miles (outlined in blue) will be used for instrumentation and monitoring of FORGE activities. The West Flank FORGE area is located along the western side of a chain of young volcanic domes that are part of the Coso Volcanic Field. One of these young domes—Sugarloaf Mountain—is indicated in Figure 2. The chain of domes separates the hot, low permeability West Flank from the Coso Geothermal Field further to the east, which hosts a conventional hydrothermal project with an installed capacity of 270 MW. However, drilling, logging, testing and monitoring activities in the West Flank FORGE area clearly demonstrate that the West Flank FORGE area lies outside of and is not hydraulically connected to the productive geothermal field to the east. The target rocks for EGS R&D are Cretaceous- and Jurassic-age intrusive rocks that have been fractured as a result of tectonic activity.

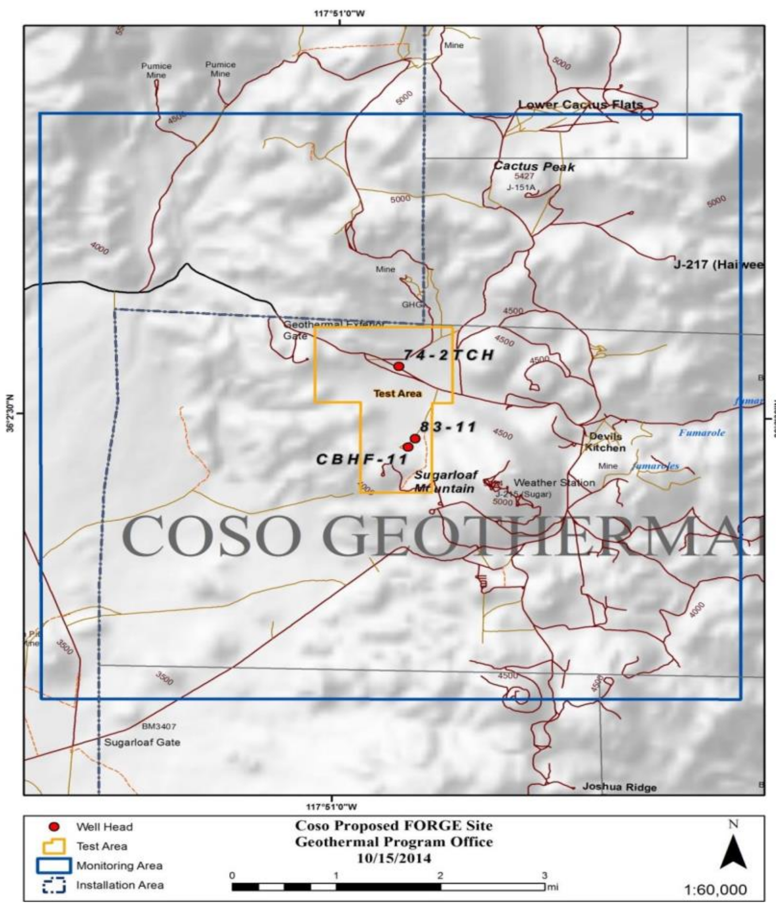

Figure 2. Map of the West Flank FORGE area. EGS operations will occur in the area outlined in bright yellow; monitoring and other activities will occur within the area surrounded by the solid blue line. The broken line is the outer boundary of NAWS China Lake.

Together with several other participants and stakeholders, Sandia National Laboratory is leading the West Flank FORGE EGS project. Currently in Phase 1—a stage of initial site characterization, planning and outreach—the West Flank FORGE EGS project will be one of 5 projects to be evaluated for advancement to Phase 2. The following sections of this preliminary ISMP discuss the progress made to date on the various steps of the Protocol and the plans for completing the ISMP in Phase 2 of FORGE.

2 PRELIMINARY SCREENING EVALUATION (PROTOCOL STEP 1)

2.1 HISTORICAL AND INDUCED SEISMICITY IN THE WEST FLANK AND SURROUNDING AREA

As shown in Figure 3 below, historic seismicity (for the past 80 years, as recorded by the USGS Southern California Seismic Network) in the West Flank and surrounding area is very high in terms of the number of earthquakes, but moderate in terms of event magnitudes, with the exception of a few natural earthquakes of higher magnitude. The largest of these had a magnitude of 6.3 and occurred in 1946; two others (with magnitudes 5.4 and 5.8) occurred in 1995. All of these events occurred outside the West Flank FORGE site and also well outside of the neighboring Coso Geothermal Field. Although higher magnitude events have occurred in the region (see Figure 4), all events occurring within the FORGE site and the adjacent Coso Geothermal Field have had magnitudes of 5.0 or less.

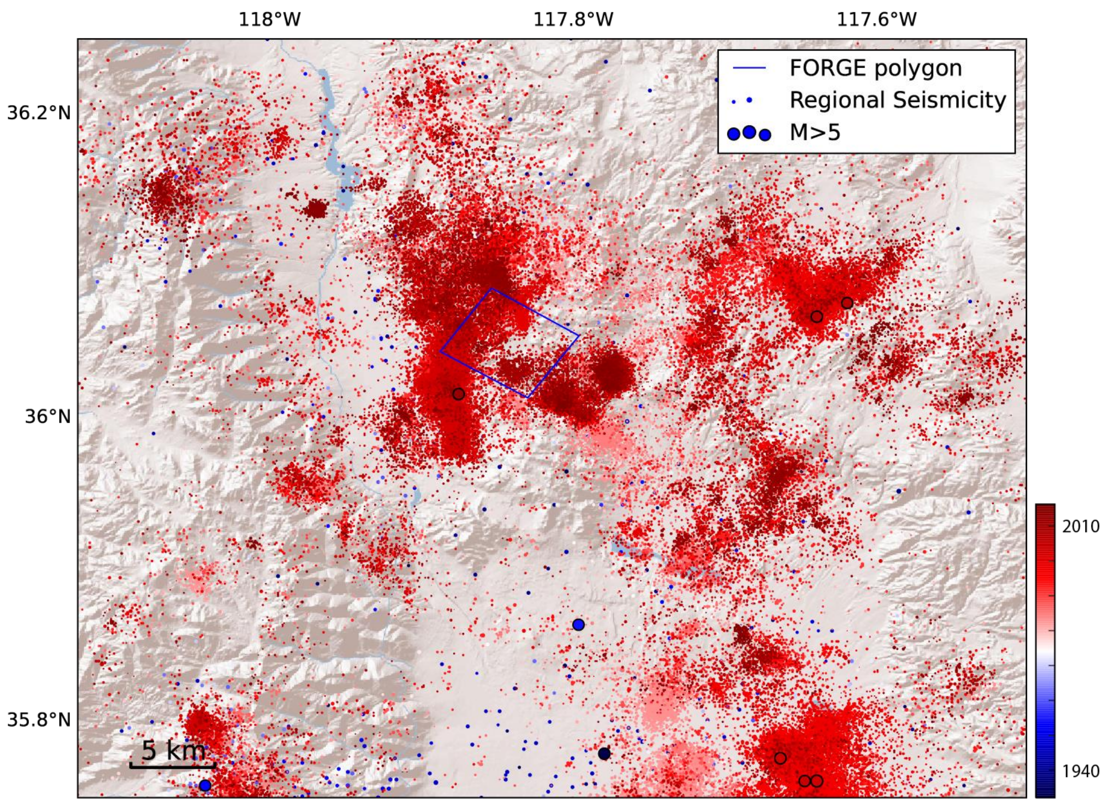

Figure 3. Seismicity in the greater Coso area from 1932 to 2012, with the age of events indicated by the color scale. Events with magnitudes > 5.0 are shown by larger, circled dots.

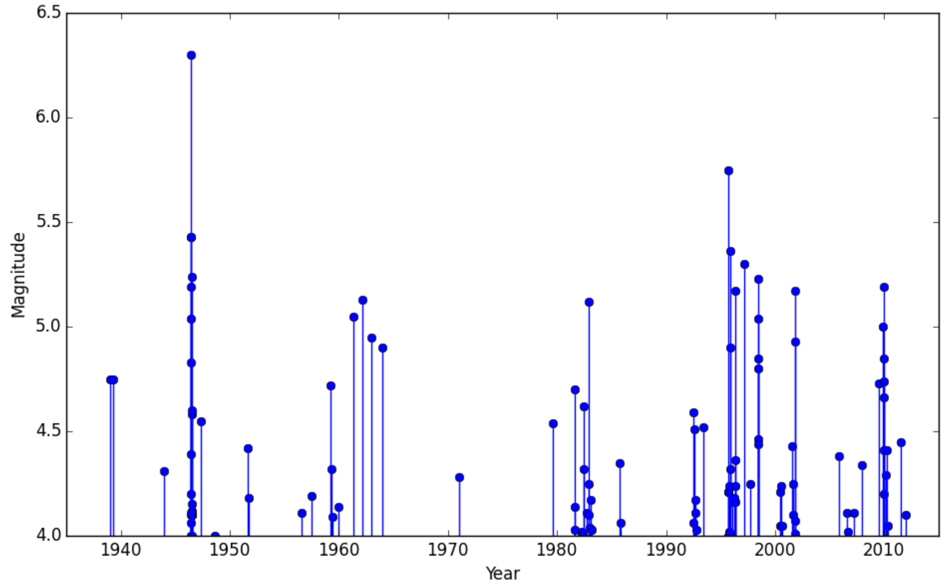

Figure 4. Historical earthquakes with magnitudes ≥ 4.0 in the area shown in Figure 3.

While the USGS' Southern California Seismic Network captures the regional seismicity well and provides a useful historic catalog for the area, a significant amount of lower-magnitude micro-seismicity has been recorded by the Navy Geothermal Program Office ("GPO") beginning in the early 1990s, and with good reliability since 1996. It currently consists of 18 stations, 14 of which are installed in boreholes, with all boreholes hosting 3-component 4.5 Hz geophones. Trigger-recorded data are telemetered through a relay site at Joshua Ridge to a central processing system in GPO's Ridgecrest office in real-time, and subsequently reviewed by GPO's seismic analysts. Data are recorded at 250 samples a second at all stations and the network detects events with magnitudes down to approximately -0.8. The system is capable of collecting data that can be used to locate events with a precision of down to 100 meters. Subsequent analyses of the data permit studies that derive source parameters and fault plane solutions.

In 2015, the system was upgraded using GPO internal funds. Obsolete field data logger equipment was replaced with new RefTek 130S digitizers, GPS antenna, and radios. A customized ANSS Quake Management System (AQMS) with Earthworm (an Open Source software system that provides a robust analysis system for automatically making phase picks, associations of picks into originating events, and locations and magnitude determinations) was also upgraded to the newest version. The AQMS/Earthworm package furnishes real-time archiving and processing of earthquake data.

The full GPO processed catalog from April 1996 to May 2012 consists of over 140,000 events, including regional events and teleseismic events. The USGS (Kaven *et al.*, 2014) obtained absolute locations for a total of 83,790 events within the CGF over from April 1996 to May 2012; these are presented above in Figure 3. The work by Kaven *et al.* (2014) shows a clearer view of major and minor structures that host concentrations of seismicity not evident in the initial GPO catalog alone. However, a large portion of the seismicity remains diffuse (i.e., is not associated with any major or minor structural features). This suggests that with the conventional hydrothermal field on the east and within the West Flank FORGE area on the west, much of the seismicity is occurring on small-scale features (i.e., small-displacement faults and fractures).

On average, the Navy GPO network detects four times more micro-seismic events than are detected by the Southern California Seismic Network. Events as small as -0.8 are routinely detected and located in the area of the proposed West Flank FORGE site. Figure 5 below shows events recorded by the GPO network from 1996 to 2012.

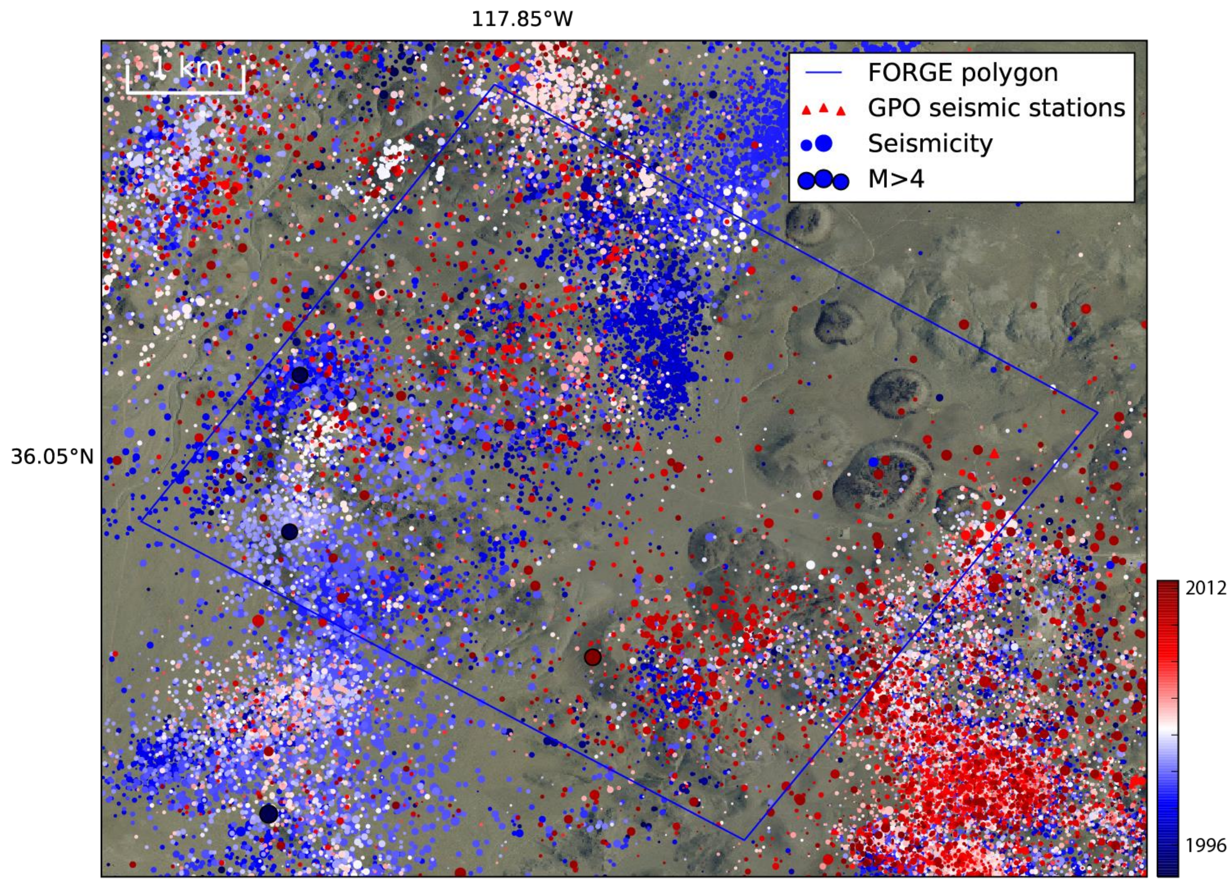

Figure 5. Seismicity in and around the West Flank FORGE area recorded on the GPO seismic network from 1996 to 2012. Like Figure 3, older events are in blue and more recent events are in red. Dot size indicates magnitude.

The presence of a local seismic network that has been recording micro-seismicity for 20 years with excellent resolution and the capacity to derive accurate moment tensor solutions provides an excellent starting point for monitoring and evaluating micro-seismicity associated with future EGS operations in the West Flank area. Temporary augmentation of the array during operations will be planned after determining the optimum number and locations of additional surface or shallow borehole stations needed to ensure location accuracy during stimulation and other operations at the site.

2.2 FAULTING IN THE WEST FLANK FORGE AREA

As shown in Figure 6 below, the West Flank FORGE area and the Coso Geothermal Field are located near the boundary of two major geologic provinces: the Sierra Nevada batholith on the west and the Basin and Range on the east. The West Flank FORGE sites lies within the volcanically and tectonically active Coso Range, located at the boundary between the two provinces. The NW movement of the Sierra Nevada (Sierran) microplate (13 mm/year) is accommodated by strike-slip and normal faulting in the Walker Lane belt, a ~100 km wide zone of active deformation that terminates to the west along the Sierra Nevada (Unruh *et al.*, 2003; Unruh and Hauksson, 2007). This region is locally referred to as the Eastern California Shear Zone.

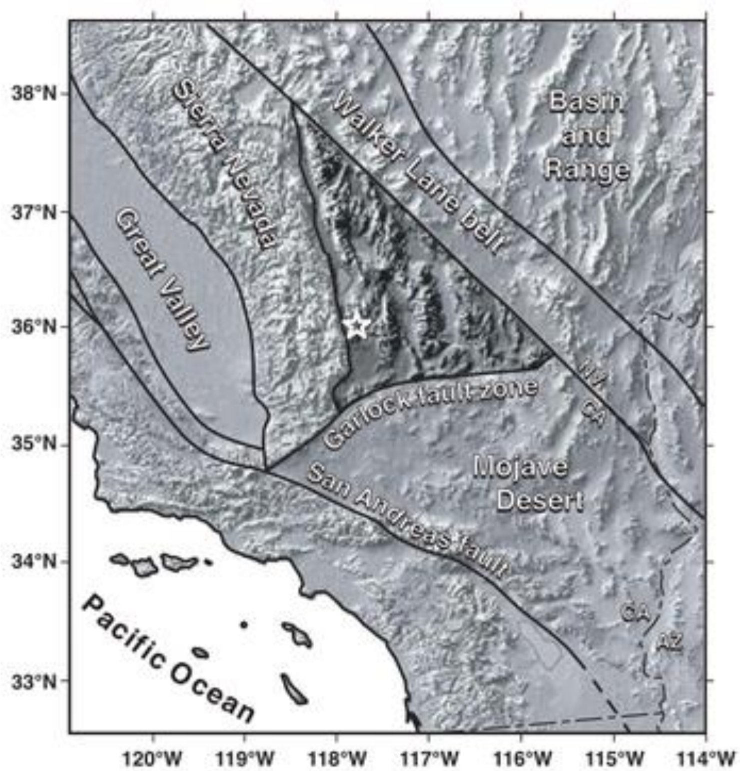

Figure 6. Location of the West Flank FORGE area and Coso Geothermal Field (white star) with respect to major faults and geologic provinces (from Monastero, 2002).

The Coso Volcanic Field (CVF) is centered within a ~20 km wide "step-over" area with apparent pull-apart geometry. Within the pull-apart, the West Flank FORGE site lies on a horst block consisting of Mesozoic basement rocks; uplift of this block is broadly controlled by E-dipping normal faults on the east side and W-dipping faults on the west side (Figure 7).

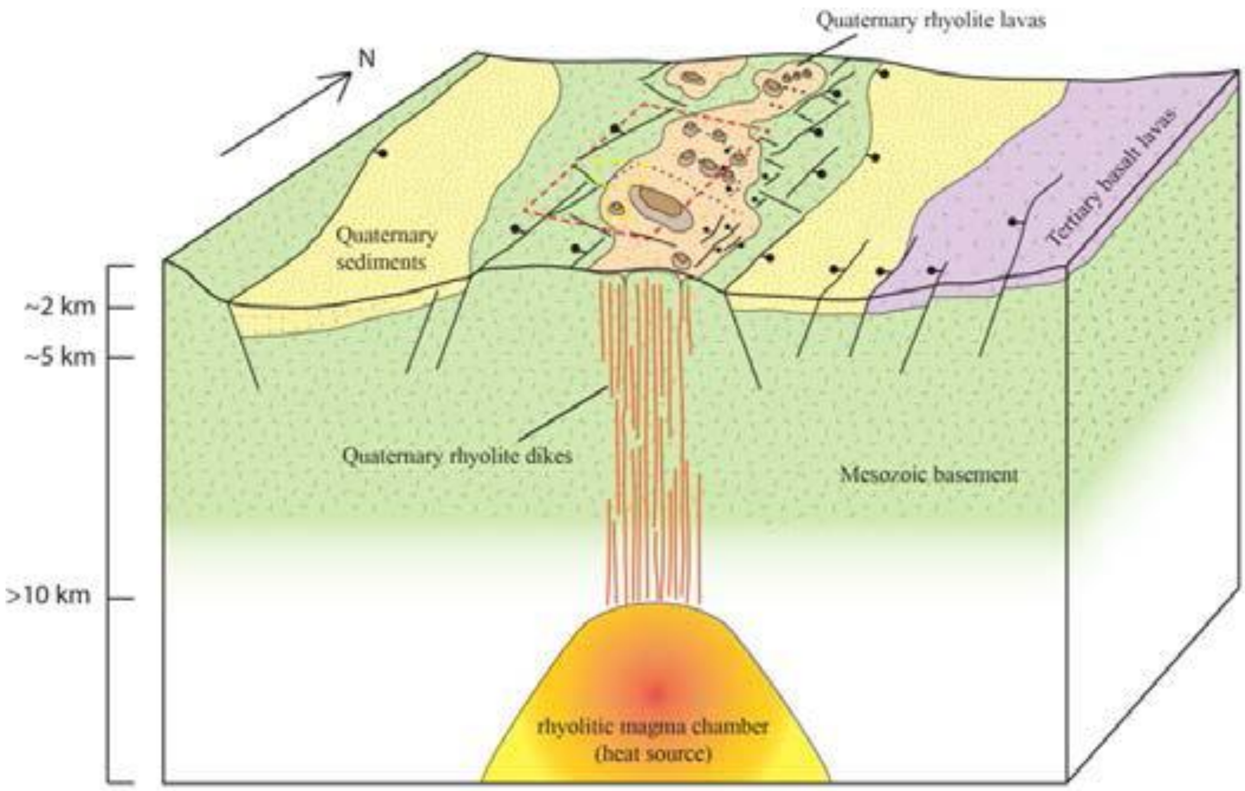

Figure 7. Schematic 3D model of the West Flank FORGE area.

Although the major tectonic features in the area have N-S or NNE-SSW trends, faults with different trends also cross the area, as shown below in Figure 8, a geologic map of the West Flank FORGE area.

Comparing Figure 8 to Figure 3, it is apparent that most of the micro-seismicity within the geologic model area occurs along the NW end of the polygon or in its SE corner. Relatively speaking, the FORGE area itself has low seismicity. In Phase 2, the West Flank FORGE team will continue to investigate geologic structure to optimize well locations with respect to major faults.

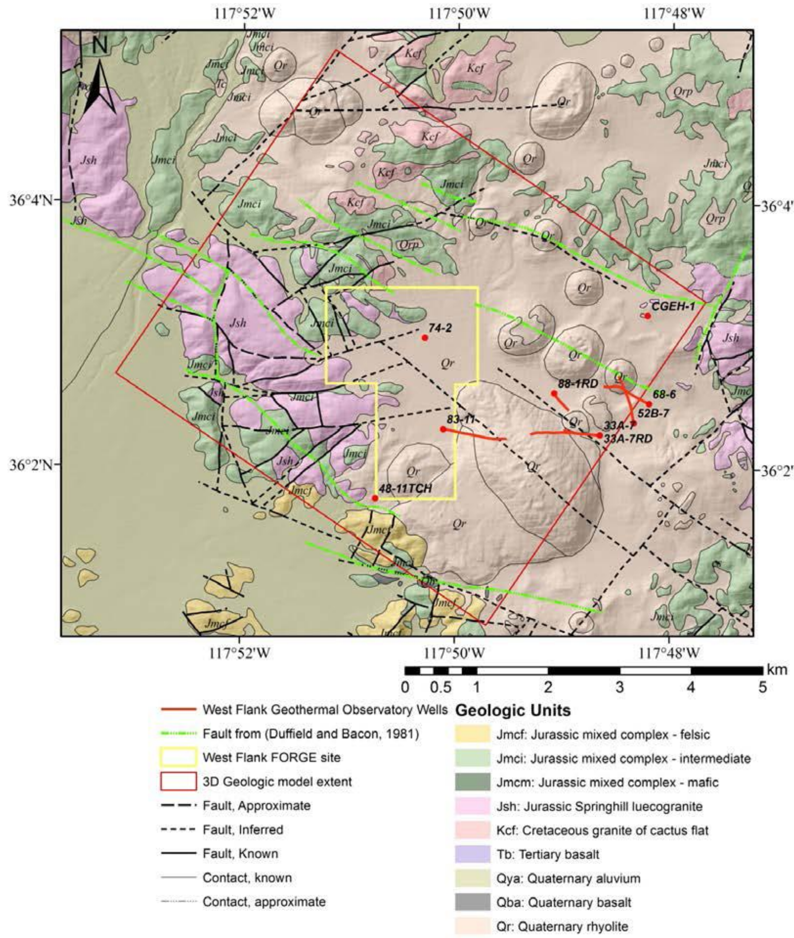

Figure 8. Geologic map of the West Flank FORGE site. Green faults are from Duffield and Bacon (1981); black faults are from Whitmarsh (1998). Dashed lines are inferred faults. The FORGE site is outlined in bright yellow; the red polygon is the area of the West Flank geologic model.

2.3 STATE OF STRESS

As described in the geologic model, there has been a great amount of work to determine the principal stress orientations at West Flank from analysis of image logs from several wells, including well 83-11, the deep well in the West Flank FORGE area (Blake and Davatzes, 2011). Wellbore image logs were evaluated to identify borehole failures (drilling induced tensile fractures and borehole breakouts) to determine the orientations of the principal stresses. As shown in Figure 9 below, the principal stress orientation is reasonably consistent within the hydrothermal field, but is rotated counter-clockwise in the FORGE area; Blake and Davatzes (2011) suggest that this is consistent with the relatively small impact of geothermal production on stress direction and stress heterogeneity, which is affected by both natural and induced seismicity.

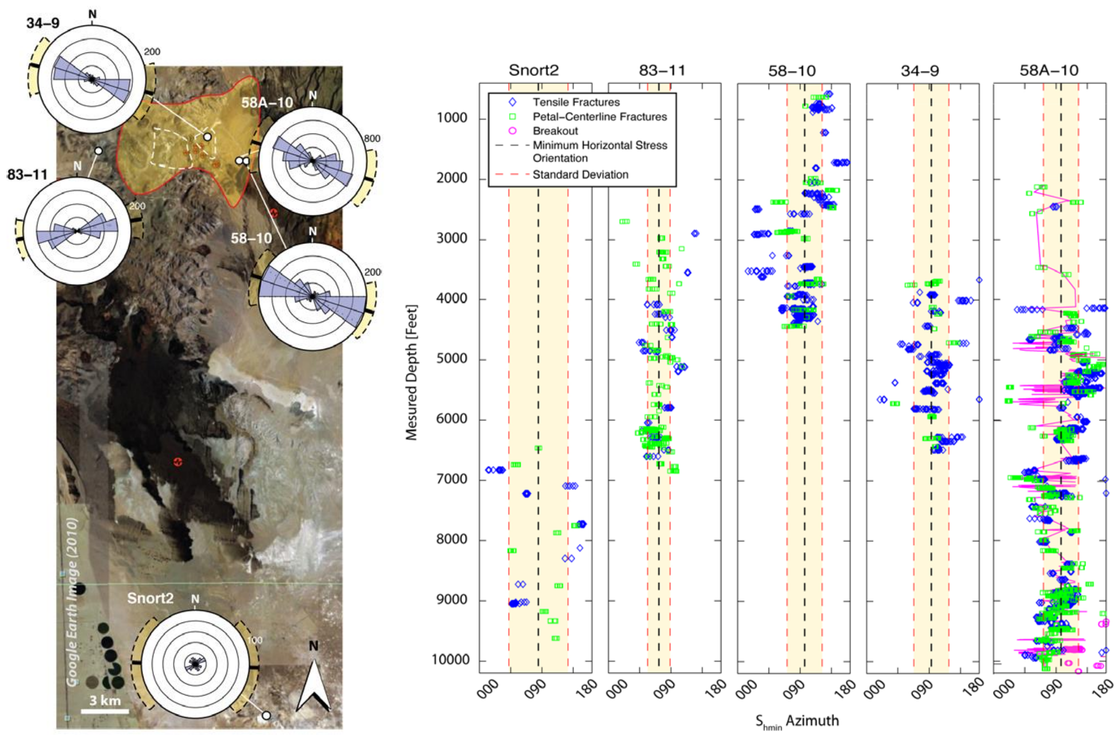

Figure 9. Stress orientations and wellbore failure data from well 83-11 (in the West Flank FORGE area) and other Fallon wells (Blake and Davatzes, 2011). The yellow area outlined in red on the left figure shows the extent of the hydrothermal field. Note the orientation of the minimum horizontal stress (S_{hmin}), which is 90° from the direction of S_{Hmax}. The direction of S_{Hmax} is therefore well aligned with the general NNE orientation of major faults.

Additional stress analyses in new wells drilled within the FORGE area will help understand the variation of stresses across the field, from the unproductive West Flank to the productive hydrothermal field to the east. Understanding the effect of these changes in stress direction will provide important context for future EGS activities at West Flank.

2.4 ASSESSMENT OF THE MAGNITUDE OF POTENTIAL INDUCED MICRO-SEISMICITY

The nearest population center is Ridgecrest, a town of about 29,000 people, located about 45 km SSE of the project area. On the basis of 1) current data that has informed the geologic model of the site and 2) experience in current and previous DOE EGS demonstration sites in northern Nevada, Idaho and California, the probability of an induced seismic event from the Coso West Flank EGS project impacting nearby communities is very low.

The size of an earthquake (or how much energy is released) depends on the amount of slip which occurs on a fault, how much stress has accumulated on the fault before slipping, how quickly it fails, and over how large an area failure occurs (Brune and Thatcher, 2002). Damaging earthquakes (usually greater than magnitude 4 or 5) require the surfaces to slip over relatively large distances (Bommer *et al.*, 2001).

Considering the distance between the West Flank FORGE area and the distance to populated areas, earthquakes generated within the West Flank FORGE area that have the potential to cause damage in Ridgecrest or other nearby communities (such as Olancha or Inyokern) would need to have Richter (M_L) magnitudes greater than 4 or 5, and would require slip over relatively large lengths of a fault (Majer *et al.*, 2007).

In addition to the size of the fault, the strength of the rock determines how large an event may potentially be. It has been shown that in almost all cases, large earthquakes (Richter magnitude 6 and above) start at depths of at least 5 to 10 km (Brune and Thatcher, 2002). It is only at depth that sufficient energy can be stored to provide an adequate amount of force to move the large volumes of rock required to create a large earthquake. Experience in other EGS projects shows that induced seismicity is significantly shallower (at depths similar to the depths of the stimulated wells) and events have low magnitudes.

Based on the location and limited spatial extent of the West Flank FORGE area, together with the long distances to nearby communities, the probability of induced seismic events at the FORGE site leading to any damage in nearby communities is exceedingly low. Furthermore, discussions with Coso Operating Company (COC) confirm that there have been no complaints about induced seismicity from residents in the area, including people living in the nearby communities of Olancha, Inyokern and Ridgecrest (Chris Ellis, COC General Manager, personal communication).

2.5 REVIEW OF LAWS AND REGULATIONS

Our review revealed no federal, state, or local laws or regulations expressly addressing induced micro-seismicity associated with geothermal activities. However, both federal and California state laws are relevant to induced micro-seismicity, as described in the following sections.

2.5.1 Geothermal Steam Act of 1970 and Regulations Promulgated Thereunder

The Geothermal Steam Act of 1970 (30 U.S.C. §§ 1001-1028) authorizes the Bureau of Land Management (“BLM”), under authority delegated by the Secretary of the Interior, to promulgate regulations that protect the public interest against activities undertaken by geothermal lessees on Federal land (30 U.S.C. § 1023[c]). The BLM’s geothermal regulations broadly define “drilling operations” to include downhole operations undertaken for the purpose of producing geothermal fluids or injecting fluids into a reservoir (43 C.F.R. § 3260.10[a]). The regulations require that all drilling operations comply with applicable law (43 C.F.R. § 3262.10[c]) and be conducted in a manner that minimizes noise and prevents property damage (43 C.F.R. § 3262.11[a][4] & [5]) and that “protects public health, safety, and property” (43 C.F.R. § 3260.11[d].

In the unlikely event that induced micro-seismicity were to pose a threat to public health or safety or to public or private property, BLM has broad authority to take corrective action. BLM can immediately issue oral (43 C.F.R. § 3260.12[e]) or written orders (43 C.F.R. § 3265.12[a]) with respect to operations causing induced micro-seismicity. BLM may also enter onto the lease and take corrective action at the lessee’s expense, draw on the lessee’s bond (see 43 C.F.R. Subpart 3214), require modification or shutdown of the lessee’s operations, and take other corrective action (43 C.F.R. § 3265.12; see 43 C.F.R. §§ 3213.17 & 3200.4).

2.5.2 Safe Water Drinking Act UIC Program

The Safe Drinking Water Act (42 U.S.C. §§ 300f-300j-26) authorizes the U.S. Environmental Protection Agency to regulate underground injection of fluids under the act’s Underground Injection Control (“UIC”) program. In the State of California, the U.S. Environmental

Protection Agency has delegated primary enforcement authority under the UIC program to the California Division of Oil, Gas and Geothermal Resources ("CDOGGR"), per the terms of a September 1982 agreement. Operators of injection wells must obtain a permit from CDOGGR, which is required to administer injection wells in close cooperation with the California State Water Resources Control Board (SWRCB).

As described in the Environmental Synopsis, all West Flank FORGE wells are and will be located on Federal land that is under the control of the US Navy, which works in partnership with the Bureau of Land Management (BLM) on management and environmental issues.

2.5.3 State Regulations for Geothermal Operations

Regulations about Well Stimulation Treatment (WST) for oil and gas wells in California (not geothermal wells) were signed into law in September 2013 (SB 4). The law requires groundwater and air quality monitoring as well as public disclosure of all chemicals used, and directs the State to complete an independent scientific study to evaluate potential risks including, groundwater and surface water contamination, greenhouse gas emissions, local air pollution, seismic impacts, and effects on wildlife, native plants and habitat. Although specifically directed to oil and gas wells, it is nevertheless relevant in terms of its representation of the current legislative tenor about stimulation activities. In SB 4 it is specifically noted that:

> *"Well stimulation treatments are not subsurface injection or disposal projects and are not subject to Sections 1724.6 through 1724.10 or Sections 1748 through 1748.3. This article does not apply to underground injection projects. If well stimulation treatment is done on a well that is part of an underground injection project, then regulations regarding well stimulation treatment apply to the well stimulation treatment and regulations regarding underground injection projects apply to the underground injection project operations."*

It is noteworthy that stimulation operations in EGS wells typically use only water, without chemicals. However, acid treatments are commonly used in hydrothermal wells and are sometimes warranted in EGS wells. Nevertheless, SB-4 does not apply to geothermal wells.

SB 4 stipulates that seismic monitoring is required (using the California Integrated Seismic Network) and sets a magnitude threshold for induced events associated with WSTs (2.7) that occurs within a radius of five times the radius of the stimulated area. If the threshold is exceeded, operator is required to notify CDOGGR, which (together with the California Geological Survey) will evaluate the indication(s) of causal connections between operations and the earthquake and review the mechanical integrity of active wells within a certain radius of the threshold-exceeding event. To enable stimulation activities to continue, this evaluation must also determine whether or not any additional stimulations within five times the radius of the stimulated area would increase the risk of further seismic activity.

In April 2015, the USGS issued a preliminary analysis of man-made earthquake risks associated with energy industry activities, stating that it considers induced seismicity to be related primarily to wastewater injection in deep disposal wells. This report has led to new considerations of induced seismicity in various states, including California, and presents a proposal for monitoring and disclosure related to induced seismicity monitoring (enabling regulators to require changes to injection when induced seismicity is observed on a susceptible fault). The report also calls for creating a publicly accessible database of injection activities and corresponding induced seismicity, as well as a fault and stress-field database, with voluntary industry cooperation.

Shortly after the USGS report was issued, a new bill (AB 1490) was approved by the California Assembly's Natural Resources Committee, but later failed to pass. The bill included the following language:

> *"A well operator shall not conduct a well stimulation treatment following an occurrence of an earthquake of magnitude 2.5 or higher, as determined by the United States Geological Survey, on a well that is within a radius of 10 miles from the epicenter of the earthquake, as determined by the United States Geological Survey, until the division completes an evaluation on whether there is a causal connection between the well stimulation treatment and the earthquake and is satisfied that the well stimulation treatment does not create a heightened risk of seismic activity."*
>
> *"...wastewater disposal wells and all well stimulation treatments, including hydraulic fracturing, within 10 miles of a recently active fault are prohibited in this state. For purposes of this section, "recently active fault" means a fault that has been active in the past 200 years."*

Although AB 1490 was not passed, it highlights the current awareness about induced seismicity, supporting the need for establishing a dialogue with the local community through various types of outreach and engagement activities (Step 2 of the Protocol) and installing an excellent monitoring and real-time feedback system (Step 4 of the Protocol), both of which are underway at the West Flank FORGE project.

CDOGGR's most recent version of the California statutes that regulate oil, gas and geothermal resources (California Department of Conservation, 2016) was published in April 2016. Chapter 4 provides all regulations for geothermal resources; there is no mention of induced seismicity in this section, although the information discussed above about SB 4 is included in the oil and gas regulations.

2.5.4 State Tort Law

Our research revealed no case law (in California or in any other U.S. jurisdiction) addressing civil liability associated with induced micro-seismicity. However, as noted in the only known scholarly review of this area of law (Cysper and Davis, 1994), cases addressing damage caused by human-induced vibrations of the earth are analogous and provide support for the application of various tort theories of liability to damage caused by induced micro-seismicity. Applicable tort theories include trespass, strict liability for abnormally dangerous activities, nuisance and negligence. As such, these theories are generally applicable in the unlikely event that induced micro-seismicity were to cause any property damage or personal injury.

The West Flank FORGE team will continue to review any legal cases related to induced seismicity throughout the life of the FORGE project.

3 COMMUNICATION AND OUTREACH PLAN (PROTOCOL STEP 2)

In Phase 1 of the West Flank FORGE project, the team has identified people and organizations (including community leaders and public safety officials) in the West Flank area that are interested in the project, and has held preliminary discussions with representatives of Kern County (where the NAWS China Lake base is located) and Inyo County (where the FORGE project site is located) about the activities that are expected to take place, including discussions about the possibility of induced seismicity. These meetings provided a venue for gauging interest in the project and identifying concerns. The response from have been positive and informing. This process will continue as the project progresses.

We report below on specific aspects of our outreach related to induced micro-seismicity that are planned for implementation in Phase 2; others will be developed as appropriate.

3.1 IDENTIFICATION OF EMERGENCY RESPONSE PROVIDERS AND STAKEHOLDERS

As part of the Phase 1 preparation work on the West Flank FORGE project, local entities with overall responsibility for emergency response have been identified in Inyo County (where FORGE activities will take place) and in Kern County (the location of the city of Ridgecrest and the NAWS China Lake base and command center. Emergency notification protocols and contact information are included in Attachment A of the West Flank ES & H plan, including information about local emergency responders in Inyo and Kern Counties

The West Flank FORGE team has already met with the two county supervisors whose district covers the project area (Matt Kingsley, Inyo County Supervisor) and the base area in Ridgecrest (Mick Gleason, Kern County Supervisor) to raise awareness about the project and confirm cooperation between the counties in the event of any emergency at the West Flank FORGE site.

In Phase 2, the details of planned activities and the associated seismic response, details of the micro-seismic monitoring system, and the process for monitoring and mitigating any risks associated with induced micro-seismicity will be presented to the emergency response providers in both counties. Using a procedure followed at two previous EGS projects in Nevada, the site operators will coordinate with county supervisors and emergency personnel periodically as the project proceeds, typically before initiating stimulation and testing activities.

3.2 DAILY COMMUNICATIONS PLAN

DOE and geothermal operators have established a well-defined communication process that addresses the needs of the local community and DOE. This process was implemented successfully at two other EGS projects in Nevada: the Desert Peak and Brady's Hot Springs EGS projects, providing a guide for future EGS sites. Therefore, the following will be undertaken to maintain daily communications from the West Flank FORGE site:

- Implementing independent, duplicated micro-seismic monitoring and reporting systems on-site and at Lawrence Berkeley National Laboratory (LBNL), allowing DOE to monitor micro-seismic activity in real time.
- Sharing the daily project reports with DOE every day. The report describes on-site activities, process analysis, the micro-seismic event log, and the associated interpretation by LBNL.

- Providing weekly update reports from the project team to DOE and its Technical Monitoring Team (TMT) covering the process results, analysis, and trends.
- Operating a real-time induced micro-seismicity web site hosted at LBNL that is open to the public, including a catalogue and map showing the locations of events.

These activities are designed to enable effective daily communication about the projects and any associated induced seismicity.

3.3 WEST FLANK FORGE PHASE 2 OUTREACH PLAN

Among others, the West Flank FORGE team is planning the following outreach activities related to the project at large, providing opportunities to introduce and discuss induced seismicity:

- Meeting with the community, stakeholders, regulators and public safety officials (including the Inyo County Sheriff and the Kern County Office of Emergency Services) to discuss technical and non-technical aspects of the project in advance of activities being initiated
- Conducting educational outreach for K-12 students and teachers in the Ridgecrest area
- Planning for visits to the FORGE site by community members and other interested stakeholders before the start of operations and during periods of drilling, hydraulic stimulations, and other technical activities (with proper consideration of associated safety issues)
- Developing a program for issuing periodic project updates and holding project-related events that celebrate EGS innovations and breakthroughs resulting from the West Flank FORGE project

In addition to dissemination of more general information about the West Flank FORGE project, these will provide opportunities for discussions about induced micro-seismicity.

4 CRITERIA FOR GROUND VIBRATION AND NOISE (PROTOCOL STEP 3)

4.1 INTRODUCTION

The Protocol identifies the steps for identifying and evaluating existing standards and criteria to understand the applicable existing regulations for ground-borne noise and vibration impact assessment and mitigation that have been developed and may be applicable to the West Flank FORGE project. These standards and criteria apply to damage to buildings, interference with human activities (including industrial, commercial, research and medical activities) and wildlife habitat. In Phase 2 of the West Flank FORGE project, existing criteria developed for other industries (i.e., not specifically for EGS projects) will be evaluated to determine their applicability, considering the proximity to EGS activities and the likely frequency (of occurrence) and magnitudes of induced micro-seismic events.

4.2 PRELIMINARY ANALYSIS OF THE IMPACTS OF MICRO-SEISMICITY AT THE WEST FLANK FORGE PROJECT

Within and around the area of the West Flank FORGE site, significant natural tectonic earthquakes with magnitudes up to 6.3 have occurred. Although these events pose a moderate to high seismic hazard, there has been no event with a magnitude of 5.0 or greater near the existing geothermal operations at the Coso Geothermal Field (see Figure 3 above). As a result of the relatively shallow depth to the brittle-ductile transition, which is thought to lie at 4 to 6 km depth (Monastero *et al.*, 2005), earthquake size is limited in this area for both moderate (M>4.0) and significant earthquakes (M>6.0).

One particularly active region is the Rose Valley seismic swarm, which borders the West Flank FORGE area to the west and abuts against the Sierra Nevada. This tectonically active region hosted a M5.17 in 2001 (Figure 3). While the Rose Valley is adjacent to the West Flank FORGE area, the seismically active region to the west (where the Rose Valley swarm occurred) is separated from the proposed EGS site by a nearly aseismic region (Figure 4). Therefore, the probability of inducing significant earthquakes within Rose Valley due to EGS operations is also very low.

The seismic data from the natural and induced events indicate that West Flank site lies in an area of very high seismicity, due to high strain rates. One of the traditional analysis methods for naturally occurring seismic events is a "B-value" plot (sometimes referred to as Gutenberg-Richter plot), which is used to assess the potential for larger size seismic events. A B-value plot consists of plotting a number of seismic events on y-axis and the Richter magnitudes on the x-axis. The slope of the B-value plot is extrapolated and the intersection of the slope with the x-axis indicates the likelihood of getting the largest event. The area around the West Flank FORGE site has B-values ranging from 1.26 to 2.4 (Kaven *et al.*, 2013; Bhattacharya and Lees, 2002), well above the usual tectonic B-value of 1.0 (Hanks, 1979). This high B-value is common in areas of hydrothermal activity, and indicates that a large portion of the seismicity in the region is of small to moderate magnitude. Earthquakes with magnitudes exceeding 5.0 are rare.

While these analyses are useful for estimating the likely maximum magnitude in a particular region, the area around the West Flank FORGE site has experienced ample and well recorded seismicity, providing many seismic events that inform our understanding of the hazard associated with induced seismic events. Given the long history of seismicity in the local area, compared to the significant earthquakes in the greater region, we conclude that the West Flank FORGE EGS site poses a similarly low seismic hazard.

Based on the location, limited spatial extent, and shallow brittle-ductile transition of the Coso Geothermal Field and the adjacent West Flank FORGE site, together with the large distances to nearby communities, the probability inducing seismic events that would disrupt nearby communities is very low.

Microseismic data from other EGS sites show that the source area (fracture area which fails) is relatively small and varies in diameter from 10 to 40m. Source lengths in this size range will produce high-frequency vibrations that are unlikely to cause any structural damage. At the European EGS project at Soultz-sous-Forêts in France, an induced event with a Richter (M_L) magnitude of 2.9 induced event had a frequency of around 80 Hz. This is relatively high frequency and is unlikely to cause any structural damage.

A direct measurement of particle acceleration (or velocity) and the frequency associated with it are more meaningful as there have been many observations and studies done to compare structural damage to these parameters. These studies are more associated with mining and subsidence; however, the correlations between with structural damage and particle acceleration/frequency component are valid for induced seismicity as well (Majer *et al.*, 2014). One of the most widely used standards for such situations is the German standard DIN 4150-3 (DIN 4150-3:1999 “Structural Vibration – Part 3: Effects of Vibration on Structures”). For example, particle velocity of up to 5mm/s at 10-50 Hz or particle velocity up to 15mm/s at 50-100Hz is unlikely to cause any structural damage, as noted in Majer *et al.* (2014). There are ranges of such calculated values for industrial, residential and old buildings that need to be preserved.

Noise is another factor that is considered at this stage of the project. Based on our initial analysis of the likely depth and magnitudes of events, observations of noise around West Flank and the distance to nearby populated areas (~ 45 km), it is highly unlikely that noise created by any induced micro-seismicity will lead to any inconvenience to the local population.

As noted above, despite significant natural and induced seismicity in the West Flank FORGE area and the operating geothermal field to the east, there have been no complaints about seismicity from residents in the area, including people living in the nearby communities of Olancha, Inyokern and Ridgecrest.

4.3 FURTHER WORK IN PHASE 2

In Phase 2, the West Flank FORGE team will undertake additional work related to ground vibration and noise, including:

- Assessing the need for ground motion sensors / accelerometers; and, if needed
- Identifying suitable locations and installing the motion sensors to establish a base line for ground motions.

5 ESTABLISH A MICRO-SEISMIC MONITORING NETWORK (PROTOCOL STEP 4)

In EGS projects like FORGE, seismic monitoring enables characterization of background seismicity, (by establishing a baseline) and helps to understand regional fault-related deformation and ambient stress/strain around the target EGS area. This has been discussed above in Step 1 (Preliminary Screening Evaluation).

As noted above, a seismic monitoring array is already established at West Flank, and has detected many regional and local events in the area, including in the FORGE area. It has detected events around the array to distances far greater than two times the radius of the FORGE target area, a distance recommended in the Protocol. This is due to the wide spacing of stations, as shown in Figure 10 below.

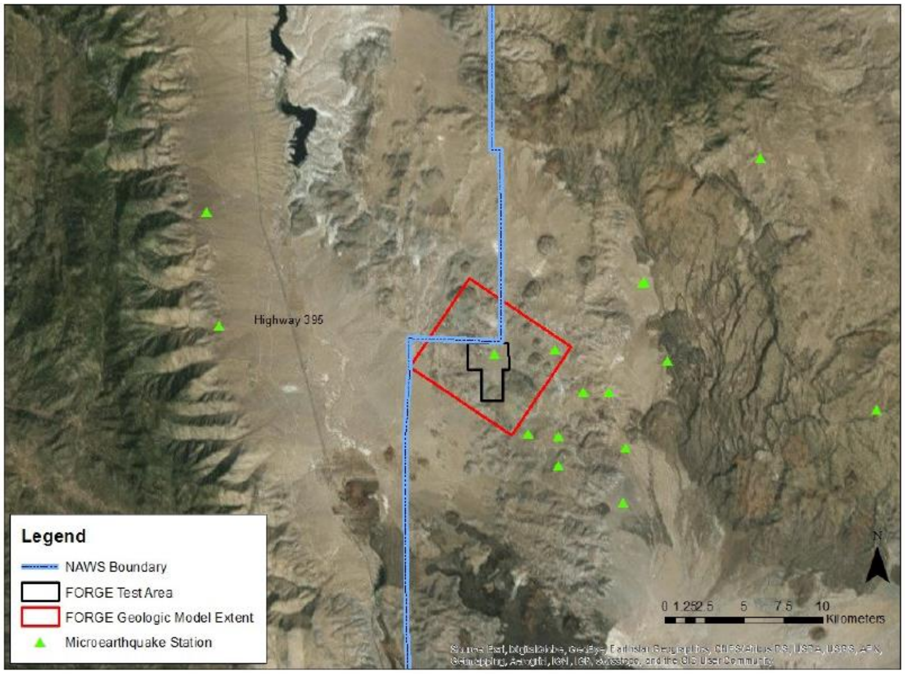

Figure 10. The NAWS China Lake seismic monitoring array, which consists of surface and borehole stations. The West Flank FORGE area is outlined in black; the blue line is the boundary of NAWS China Lake, and the red polygon is the area of the geologic model.

In Phases 2 and 3, the West Flank seismic array will be improved to enable it to be used effectively in the FORGE project. In Phase 2, we propose to expand the existing seismic monitoring network by adding new borehole seismic stations straddling the western portion of the West Flank FORGE site, and to the N and SW. These additional stations will ensure that seismicity in the area will be detected down to Ml-1.0 and provide improved focal sphere coverage, resulting in similarly complete detection as is currently done within the active reservoir to the east of the proposed West Flank FORGE site. In addition, dedicated wells will be drilled for seismic monitoring, 3-component sensors will be installed, and a refined velocity model will be developed. These improvements will provide more detail in the baseline data collected before site operations begin, and enable robust real-time monitoring during operations and improved event location accuracy. Temporary "densification" of the array during operations will be planned to determine the optimum number and locations of additional surface or shallow borehole stations that will ensure location accuracy during stimulation and other operations at the site.

During EGS stimulations and other operational activities, the monitoring array will be used to detect and map the progress of fracturing and the interconnection between fractures that enhance permeability within the low-permeability basement rock beneath the West Flank FORGE site. High quality data will be necessary to determine the success of stimulation activities, understand the "evolution" of permeability within the EGS reservoir, and provide credible scientific evidence to demonstrate that the project does not pose a threat to public safety.

It is well within the FORGE mission to have an array of seismic sensors that is capable of locating events with Richter (M_L) magnitudes as low as -1 (possibly -2) with an accuracy of 50 m at most, with a bandwidth of 0.1 Hz to 1 kHz. In addition, the array will be designed provide sufficient data coverage to produce accurate moment tensor and source mechanism information. Considering that FORGE is the site of robust underground experiments designed to understand the mechanics by which permeability can be increased to enable commercial production rates from EGS wells, the West Flank FORGE site will have an array that is suitable for all required purposes (accurate event locations, source mechanisms, accurate moment tensors) and other purposes yet to be defined. In other words, the West Flank seismic array will be highly instrumented and have a detailed velocity model that will improve our understanding of what is happening at depth.

In its current configuration, the micro-seismic monitoring system at NAWS China Lake is capable of collecting data that can be used to locate events with a precision of down to 100 meters, and subsequent analyses of the data permit a good understanding of source parameters and fault plane solutions. In addition, it detects events with magnitudes down to -0.8. Thus, the West Flank FORGE seismic monitoring system already meets the initial requirements for monitoring in Phase 2a.

6 QUANTIFY HAZARD FROM NATURAL AND INDUCED SEISMIC EVENTS (PROTOCOL STEP 5)

6.1 HAZARD ANALYSIS FOR NATURAL SEISMIC EVENTS

The high number and occasionally high magnitudes of naturally occurring earthquakes pose a significant seismic hazard in the area around the West Flank FORGE site, from greater Coso area. This elevated seismic hazard is quantified in Figure 11, using the USGS National Seismic Hazard map. This map shows the variations in peak ground acceleration (PGA) anticipated to occur in the area around the West Flank FORGE site with 98% probability during the next 50 years (there is a 2% probability that these PGA values would be exceeded in 50 years). Seismic hazard maps take into account the local and regional earthquakes and their recurrence (i.e., proximity to major faults), possible path effects, and the local site conditions that may lead to amplification of local ground acceleration (e.g., liquefaction). It is important to note, however, that this seismic hazard is based solely on the naturally occurring, tectonic seismicity in the area. Figure 11 shows PGAs up to 0.7g. The seismic hazard is locally highest outside of the active geothermal field and the proposed West Flank Coso FORGE site and the active geothermal field to the east, reflecting the locations of the large faults capable of producing significant magnitude earthquakes and the local site conditions. For example, there are lake bed sediments south of the West Flank FORGE site that may be prone to liquefaction; these areas show the highest PGA on the map. The area around the West Flank FORGE site has a moderate to high seismic hazard associated with naturally occurring tectonic seismicity.

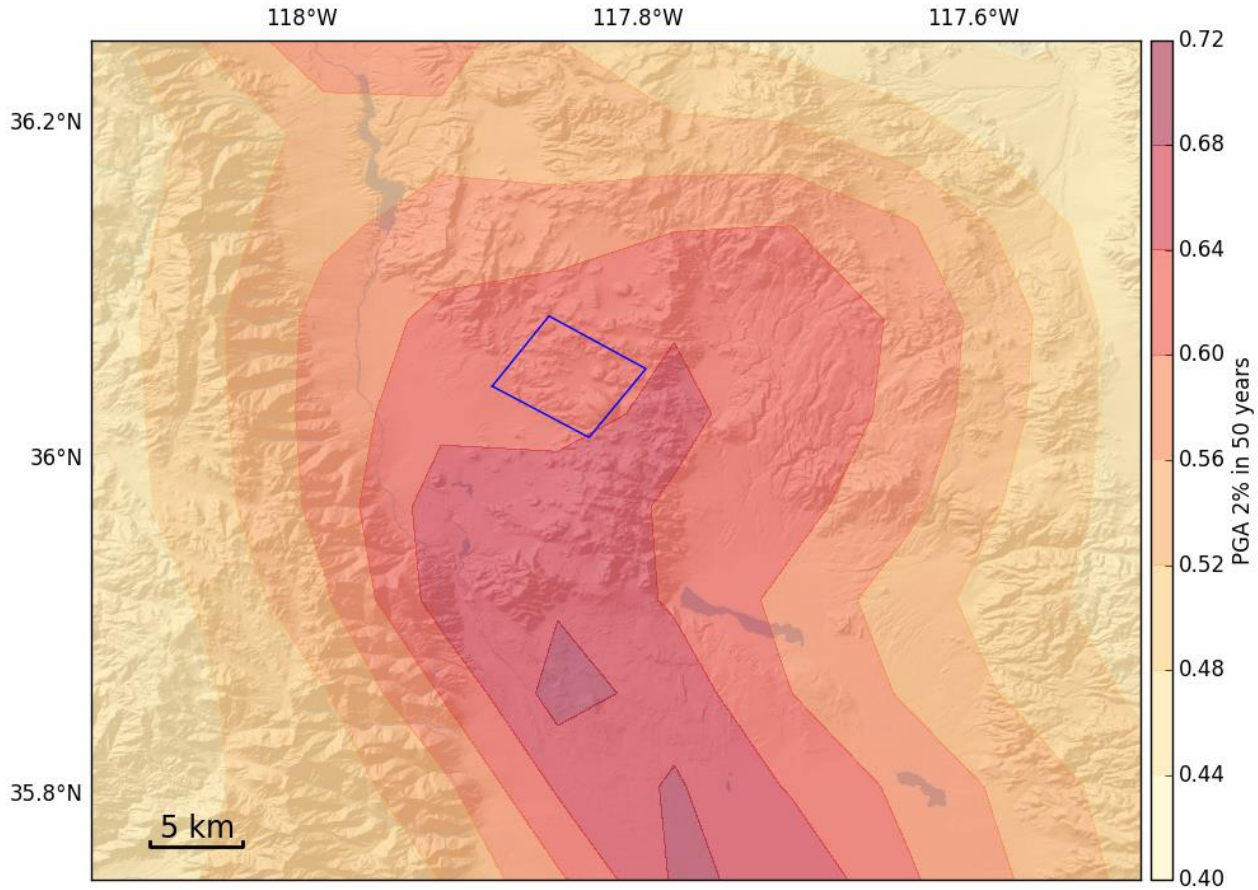

Figure 11. Map showing peak ground acceleration PGA during the next 50 years (with 98% probability) from the USGS National Seismic Hazard Map (Peterson *et al.*, 2014). There is a 2% probability that the PGAs shown could be exceeded during the next 50 years.

6.2 PHASE 2 HAZARD ASSESSMENT FOR INDUCED SEISMICITY AT THE WEST FLANK FORGE PROJECT

Probabilistic or deterministic seismic hazard analysis (PSHA and DSHA, respectively) are two methods commonly used to assess ground motions associated with seismicity. The former (PSHA) is more commonly used since it provides the probability that a specified level of ground motion (i.e., one that could lead to damage) would be exceeded. The Protocol recommends performing a PSHA for a magnitude 4 event to consider the potential for damage, and a lower magnitude to consider “nuisance” (people being disturbed by induced micro-seismicity) and/or interference with highly sensitive activities. The hazard is expressed in terms of Peak Ground Acceleration (PGA), acceleration response spectra, and Peak Ground Velocity (PGV) or Peak Particle Velocity (PPV). However, both the magnitude and duration of induced seismic events are low, and thus there is a low probability of structural damage to buildings.

The overall process of the PSHA is to undertake it first for natural seismicity, and then superimpose the induced seismicity to evaluate the incremental addition to the pre-existing, natural hazard. Background seismicity in this area has been discussed in Step 1 above. Active faults are located in the area that have had relatively large events in the last century. These events and others in the area provide useful information for a PSHA, including source fault orientation, event magnitudes and recurrence rates.

In comparison to large, natural tectonic earthquakes, the hazard associated with induced seismicity is very low. Nevertheless, micro-seismicity is anticipated. Therefore, the West Flank FORGE team has developed a detailed geologic model, including faults in the project area, and analyzed the ambient stress field around the West Flank site (see section 1 of this preliminary ISMP). Based on planned injection and pore pressure increase scenarios, and by analogy with similar EGS projects, the maximum magnitude of an induced event and the likely rates will be estimated. From this, the maximum ground motions will be calculated.

7 CHARACTERIZATION OF THE RISK FROM INDUCED SEISMIC EVENTS (PROTOCOL STEP 6)

7.1 PROBABILITY OF AFFECTING NEARBY COMMUNITIES

The project target area is defined as the effective area in which micro-seismic events are expected to occur. The West Flank FORGE target area will be defined taking the following in consideration:

- Geological and geophysical survey data
- Stress field orientation (particularly the direction of the maximum horizontal stress, S_{Hmax}) as determined from recent fault trends and analyses of wellbore failures
- Previous records of the effective distribution of induced micro-seismic events in similar EGS projects (a radius of 500 m around the stimulated well is reasonable)
- The 3D geologic model, including mapped fracture and 3D reservoir analysis
- Preliminary interpretation of ground deformation (*e.g.*, from ground leveling surveys, high-resolution GPS data or InSAR interferometry)
- All known historical seismicity
- Known faults dimensions within the target FORGE volume
- Volume, rate and pressure of injections

The observations and assessment presented above suggest that the likelihood of generating large seismic events in the specific region around the proposed West Flank FORGE site is very low. The historical data supports this observation, as there are no recorded earthquakes greater than 4.2 in the area around the West Flank FORGE site. From the perspective of seismicity, the West Flank region shares an important attribute with the adjacent hydrothermal field: it is similarly restricted in depth extent due to the shallow brittle-ductile transition and, thus, is distinctly different from regional earthquake source regions that are capable of generating significant seismic events (M>5.0). In addition, the volumes to be injected during the proposed stimulations are unlikely to accommodate large amounts of strain, and thus are unlikely to generate large induced seismic events.

The analysis described above indicates that it may not be necessary for this site to implement all aspects of the protocol. However, it will be reasonable and prudent to install strong motion seismometers in Ridgecrest (the nearest population center to the project area) to record ground velocity and frequency. This will demonstrate to the residents that all due care and attention has been taken to protect their property and that accepted criteria for structural damage will be used.

Additionally, it is noted that the nearest populated residential area is more than 40 km away from the FORGE site. Therefore, events generated during stimulation activities are unlikely to be noticed by residents at this distance from the injection site. This statement is supported by the fact that natural seismicity, including some events exceeding magnitude 5.0, has not resulted in damage in nearby communities (Hauksson *et al.*, 1995). Furthermore, there have been no reports of felt induced seismicity associated with fluid production and injection at the operating hydrothermal field to the east of the West Flank FORGE site.

7.2 POSSIBLE EFFECTS AT NAWS CHINA LAKE

The Ridgecrest base of NAWS China Lake is the nearest operating facility to the West Flank FORGE area. Considering the anticipated magnitudes of induced seismic events that may result from the FORGE project, the observations and evaluations of natural seismicity in the region, and the distance from the FORGE area to the base, the likelihood of any damage or nuisance associated with FORGE activities at the base is very low.

8 RISK MITIGATION (PROTOCOL STEP 7)

The first six steps of the induced seismicity protocol suggest various activities to address the impact of induced seismicity. If the induced seismicity exceeds the design maximum from the injection parameters (yet to be determined) or if major deviations from assumed geologic and stress conditions are encountered during the operation of the FORGE, then it may be necessary to perform additional actions.

There are two broad types of measures that could be used to mitigate any adverse or unwanted effects of induced seismicity (Majer *et al.*, 2014):

- **Direct mitigation** refers to actions engineered either to reduce the seismicity directly or relieve the effects of the seismicity. Examples of this approach include modification of the injection or production rates, and a calibrated control system that has been dubbed the "traffic light" system. This is a system for real-time monitoring and management of the induced seismic vibrations, which relies on continuous measurements of the ground motion (usually PGV) as a function of injection rates and time. The "traffic light" system may be appropriate for many FORGE operations in that it provides a clear set of procedures to be followed in the event that specific seismicity thresholds are reached (Majer *et al.*, 2007). The traffic light system and the thresholds that would trigger certain activities by the operator should be defined and explained in advance of any operations.

- **Indirect mitigation** refers to actions that are not engineered but involve such issues as public/regulatory acceptance or operator liability. The level and amount of any indirect mitigation will be specific to different activities conducted at the West Flank FORGE site. Seismic monitoring, information sharing, community support, and direct compensation to affected parties are among the types of indirect mitigation that will be considered. Early support from the developer to the community can improve the ability to respond effectively to a potentially impacted community in the event of problematic induced seismicity. This may come in the form of that may be tailored to the specific needs of the community.

In most instances at West Flank, from our present knowledge of seismicity hazard, community and Navy assets, little or no mitigation may be required to gain public acceptance. However, if there is any indication that induced micro-seismicity may affect critical facilities (such as facilities on the Navy base or in the City of Ridgecrest) or if structures are experiencing unacceptable ground motion, mitigation measures would be required. At West Flank it is anticipated that by properly carrying out the preceding six steps, mitigation will not be required in the majority of instances. However, in Phase 2, the West Flank FORGE team will develop a full set of options that can be implemented if and when needed.

9 CONCLUSION

In summary, the information gathered to date indicates a very low risk of any significant impact related to induced seismicity that would occur during operations at the West Flank FORGE site. The significant body of information about natural seismicity, including events exceeding magnitude 5.0, has not resulted in damage at nearby communities (Hauksson *et al.*, 1995), and there have been no reports of felt induced seismicity associated with fluid production and injection at the operating hydrothermal field to the east of the West Flank FORGE site. Expected micro-seismicity from EGS stimulations and other operations will be of low magnitude, well below that leading to potential damage or other risk at NAWS China Lake, the City of Ridgecrest and other communities in the area. Should a higher level of induced seismicity occur, pre-determined mitigation measures can be implemented, based on accurate, real-time monitoring of seismicity during site operations. This is a critical element in making FORGE a success.

A world-class EGS observatory must have a world-class seismic monitoring system to fully understand subsurface mechanisms associated with the manipulation and control of fractures. Although the existing GPO seismic monitoring installation is robust, with the capability to detect events down to magnitude -0.8 and the ability to derive location accuracies within 100 m, the West Flank FORGE team will improve the array to provide more complete coverage around the FORGE site and detect and accurately locate events with magnitudes less than -1.0 (ideally down to -2.0) and have a spatial coverage that is optimal for deriving accurate moment tensor solutions from the recorded micro-seismic data.

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APPENDIX K. ENVIRONMENTAL SAFETY AND HEALTH PLAN

ENVIRONMENTAL SAFETY AND HEALTH PLAN

West Flank of Coso, CA

CONTENTS

ENVIRONMENTAL SAFETY AND HEALTH (ES&H) PLAN

West Flank of Coso, CA

1 INTRODUCTION

Frontier Observatory for Research in Geothermal Energy (FORGE) is a dedicated site to enable scientists and engineers to develop, test, and accelerate breakthroughs in enhanced geothermal system (EGS) technologies and techniques. West Flank of Coso FORGE is a DOE operation with the associated prime contractor being Sandia National Laboratories (SNL). The Department of Energy (DOE) requires that all work performed by the Department and its contractors follow a broad set of requirements for Integrated Safety Management (ISM). The DOE ISM directive is the foundation for Sandia National Laboratories' Integrated Safety Management Systems (ISMS) and its approach to Environmental, Safety, and Health (ES&H); therefore, the Sandia ISMS is the basis for the FORGE ES&H Plan. Per DOE requirements, this ES&H plan and any revisions of this plan cover all West Flank team members and contractors working on this project. This plan and its attachments are subject to revisions throughout the project and will be updated as necessary. Revisions will include any new environmental safety and health requirements, new contact personnel, new training requirements, and new contractors.

The core functions of the Sandia ISMS, as applied to West Flank FORGE operations, provide the structure to mitigate risks and hazards to the public, the worker, and the environment, effectively integrating safety into all facets of work planning and execution. As illustrated in Figure 1, these functions include the following five elements:

- **Define Work Scope:** Translate the required activity into work, set expectation, identify and prioritize tasks, and allocate resources.
- **Analyze Hazards:** Identify, analyze, categorize, and communicate hazards and associated impacts associated with the work.
- **Control Hazards:** Identify controls to prevent or mitigate hazards and environmental impacts.
- **Perform Work:** Confirm readiness and then perform work safely and in an environmentally responsible manner.
- **Feedback and Improve:** Gather feedback information on the adequacy of controls, identify and implement opportunities for improving the definition and planning of work, and conduct line and independent oversight.

Figure 1. Integrated Safety Management System Core Functions associated with FORGE

These five core functions are not unique to the operations of FORGE but form the basis of any comprehensive effort to reduce project risk to personnel, the public, or the environment. As such, this plan is not a substitute for plans or requirements originating from other entities (e.g., Department of the Navy, R&D participants, vendors, FORGE Team Members, etc.). This ES&H plan, with its attachments, provides structure for participating organizations and describes how work will be carried out at West Flank FORGE.

Relative to site-specific issues, Attachment A (Emergency Response Plan) and Attachment B (Emergency Response and Evacuation Plan) provide general information regarding identification of contact personnel responsible for on-site safety, as well as general protocols for hazards communication, emergency evacuation and response, and associated ES&H training requirements required for working at the locations. Specific operational procedures (e.g., earthwork, drilling, hoisting and rigging, and elevated work) will be developed within the guidelines of U.S. Army Corps of Engineers EM-385-1-1; 15 JUL 14 Safety and Health Requirements Manual <http://www.usace.army.mil/SafetyandOccupationalHealth/EM38511,2008BeingRevised.aspx>.

2 PARTICIPATING ORGANIZATIONS

All project participants engaged in on-site FORGE activities, either through competitively funded R&D, directly contracted work, or vendor services will be required to have an approved safety plan in place to perform specific work outlined in Phase 2. Those plans will be reviewed by the FORGE project manager or his/her delegate. Such plans will need to contain the fundamental elements associated with the broader FORGE ES&H plan, and will need to comply with the Navy installation ES&H requirements outlined in Attachment A.

3 OWNERSHIP

The West Flank of Coso FORGE project manager is responsible for ensuring that the criteria in this document are implemented.

4 OVERARCHING CRITERIA

4.1 SAFE-BY-DESIGN INTENT

Safety is an attribute of a system of interconnected elements—people, procedures, facilities, equipment, and the hazards inherent in them and that to which they are applied. If one element of the system changes, the system is changed and must be reexamined in the new context. All elements must remain seamlessly tied together from the design phase through the execution phase. As different organizations are integral to the system, particular attention must be paid to early involvement and reliable communication across the organizational interfaces during project execution. Poor communication of safety-related information across organizational interfaces is a frequent contributor to accidents.

Human performance is an integral part of the system and is often overlooked in planning because of trust and respect in each other's competence. However, human performance is a common source of error. Accident pathways resulting from human error must be identified upfront and removed or blocked by design intent. Further, robustness should be built into the design of the system to compensate for uncertainties in human performance.

Safety is most effectively and efficiently achieved by designing it into the system at the conceptual or initial planning stages. However, it should not be reflexively assumed that designing safety features into an existing system will be difficult, time-consuming, or expensive. Effort expended toward this aim should be proportional (graded) to the severity of potential accident consequences.

4.2 UNDERSTAND TECHNICAL BASIS

It is vital to understand how a system design works to accomplish its performance objectives. From a safety perspective, it is vital to understand how the system design can fail and cause an accident. Formal hazard analysis appropriate to the technical complexity of the activity will inform decision-making on the number and type of controls necessary to reduce the probability of occurrence. While this analysis can be relatively straightforward for a new hazardous activity, it can be problematic for older facilities and operations. The technical basis of an existing hazardous activity must be reconstructed sufficiently to assure continued safe operations. The effort will be prioritized according to the severity of potential accident consequences.

4.3 IDENTIFY AND CONTROL ENERGY SOURCES

Stored energy in all of its forms and guises must be identified and controlled with appropriate engineered and administrative controls designed to prevent or mitigate the consequences of accidental release. Kinetic, potential, electrical, electro-mechanical, thermal, pressure, and chemical energy sources all can be released directly, or released in another form of energy, as the result of an accident. In most cases, the concern will be stored energy in the system, but lack of energy could also pose a problem if continuously energized controls are necessary to assure safe operations.

The requirement to identify and control energy sources applies not only to complex technical activities, but it also can be applied to the simplest examples of work. For example, it may be stored energy in a steel band that compresses waste material for size reduction; a chemical reaction that starts a fire; or rupture of a pressure vessel that punctures a tank containing a toxin.

In short, it will usually require some form of unplanned energy release to disturb a harmless equilibrium.

4.4 DEFINE UNACCEPTABLE CONSEQUENCES

All personnel must focus on what they do not want to happen as a result of work activities. Unacceptable consequences should be identified in the context of the activity being performed. In addition to the harmful effects of accidents on people and the environment, other consequences, such as temporary or permanent loss of capability, impact on site operations, or serious damage to the reputation of FORGE, must be consciously considered and defined up front. The effects of exposure to known health hazards must also be considered in the definition of unacceptable consequences.

4.5 RISK ASSESSMENT APPROACH

Standard practice in risk assessment requires one to judge the probability that a particular accident consequence will occur. While probability assessment is the basis of routine risk decisions, this practice is problematic for early decision-making on appropriate controls for hazardous work. If an estimate of low probability of occurrence dominates early decision-making, human nature and external pressures tend to minimize the use of an otherwise sensible set of controls based on the severity of accident consequences.

Many factors contribute to this thought pattern, such as:

- Often, there are little or no failure data to make a meaningful estimate of a specific accident probability; therefore, if the accident scenario has not occurred yet or it is not in a person’s experience base, the probability must be low.
- Even when success and failure data enable a statistically valid estimate, the uncertainty bounds or confidence limits on the estimate tend to be overlooked.
- Skill of the worker or skill of craft, combined with judgments about complexity of the work, can contribute to low probability presumptions and lack of attention to the severity of accident consequences.
- A presumption of low probability can enable the belief that the accident is more likely to occur near the last trial than during the equally probable first trial, so “not on my watch.”
- Project success, cost, and schedule pressures can influence the presumption of low probability; the need for controls may add to these pressures.

The foregoing is not an argument for dismissing consideration of the probability of accident scenarios in risk assessment, but rather a serious caution to avoid the natural pitfalls that can lead to premature dismissal of the need for appropriate controls. Credible accident scenarios should be based on credible failure-mode analyses and the professional judgment of subject matter experts.

A second risk-assessment caution is to avoid jumping directly to mitigating accident consequences without first giving due consideration to controls that would prevent the accident from happening. Prevention is the first line of defense. Mitigation is the second line of defense.

4.6 POSITIVE VERIFICATION

Because safety is a system attribute, the elements should be kept connected not only during the design phase, but also verifiably connected during the execution phase. Accidents frequently occur as a result of poor communication during the execution phase, especially across organizational interfaces. A team of people is often relied upon to assure a safe operation. Positive verification means that team members must each affirm to the person in charge (PIC) that their part of the system is in the state intended for safe operation. Otherwise, it should be assumed by the person in charge that it is not safe to proceed. Positive verification is not a one-time activity, but a concept that should be applied across the system or activity as appropriate and performed in an iterative manner.

5 DEFINE SCOPE

The purpose of defining the scope of work is to help ensure that safety concerns are adequately considered early in the decision-making process to accept, reject, or continue work. While it is recognized that more detailed analysis in subsequent steps might change these initial determinations, appropriate discipline and formality is needed when making this decision.

5.1 IDENTIFY WORK PLANNER

For work activities, a "work planner" is responsible for ensuring that all elements of this plan have been addressed, including the evaluation factors in Sections 4.3 and 4.4 and documentation of the evaluation in support of a FORGE management decision to accept, reject, or continue the work. The FORGE project manager must assign and or identify a work planner. The FORGE project manager is responsible for the quality of the work-planning effort regardless of who performs the work planner role.

5.2 ESTABLISH A WORK-PLANNING TEAM

The FORGE project manager or delegate shall establish, or assist the work planner in establishing, an interdisciplinary team consisting of subject matter experts necessary to competently address all elements in this plan. The initial task of the work planner and team is to support a FORGE management decision on the scope of work.

5.3 ROLE OF THE WORK PLANNER

The work planner, supported by an appropriate interdisciplinary team, shall address the following factors in support of a line-management decision on scope:

- Identify the hazards associated with the activity.
- Determine the highest potential unmitigated-accident-consequence.
- Determine if the work is within the operating envelope for the FORGE site.
- Identify and complete documentation that may be necessary to perform the work.
- Ensure and document that site, and equipment are in the condition to perform the work.
- Confirm and document current status of personnel qualifications to perform the work.
- Ensure that cost and schedule allotted for work have taken into account all activities associated with that work.

5.4 DECISION TO ACCEPT, REJECT, OR CONTINUE WORK

The work planner shall document the evaluation of the key factors and shall submit the evaluation to the FORGE project management having approval authority.

6 ANALYZE HAZARDS

6.1 DETAILED IDENTIFICATION OF HAZARDS

While the major hazards are identified in the Define Scope core function, the hazards may be characterized somewhat generically or enveloped to see if they fit into facility safety and environmental envelope. Once the decision is made to proceed with the work, the specifics of the hazards need to be more clearly defined to support the development of a conceptual system design or reexamination of an existing design.

6.2 IDENTIFY SAFETY THEMES, STANDARDS, AND CODES

Once all the hazards have been identified in sufficient detail, a "safety theme" shall be developed if there is a set of dominant hazards—for example, high pressure or electrical hazards. A safety theme is an overarching technical strategy aimed at stimulating upfront critical thinking on the prevention or mitigation of accident consequences. Multiple safety themes may be necessary based on the diversity of hazards present. This does not have to be a very formal exercise. In fact, informality with the right set of subject matter experts can be helpful in quickly setting the best approach. Consider bringing in subject matter experts from outside the organization to brainstorm the approach for the higher-consequence accidents.

Awareness of all standards and codes that apply to working with the particular hazards should be part of the critical thinking that goes into the development of the safety theme(s). However, use of standards and codes alone will not automatically make work safe. If multiple hazards are present, there can be conflicts in applying standards and codes that can adversely affect the safety of the activity.

6.3 PERFORM FORMAL HAZARD ANALYSIS

A failure-mode or hazard analysis shall be performed on the new or existing system design using recognized technical standards appropriate to the task. If needed, two references that describe graded approaches to failure-mode analysis are: 1) ANSI/ASSE Standard Z590.3, Prevention through Design: Guidelines for Addressing Occupational Risks in Design and Redesign Processes, and 2) the Center for Chemical Process Safety Guidelines for Hazard Evaluation Procedures. At a minimum, the analysis methodology selected must be capable of identifying the single-point failure modes in the system that can result in accidents having unacceptable consequences. The term "single-point failure mode" means that it only takes that one failure for the accident to happen, not multiple failures. Human failure can be the single-point failure and should never be automatically dismissed due to the perceived competence of the team members.

7 CONTROL HAZARDS

While the criteria for the Analyze and Control Hazards core functions are described in a linear fashion, in reality, the system-design process is likely to be iterative. The number of iterations needed is likely to be a reflection of the complexity of the operation and the severity of potential accident consequences.

7.1 ELIMINATE HAZARDS AND SINGLE-POINT FAILURES

The first priority is to eliminate a hazard rather than attempt to control it. When this is not feasible, the next priority is to eliminate single-point failures that can cause unacceptable consequences. Remove as many single-point failures as reasonable and practical. The remaining single-point failures that can cause unacceptable consequences dictate a natural priority for the development of engineered and administrative controls. Selection of personal protective equipment (PPE) is the last line of defense.

7.2 APPLY ENGINEERED AND ADMINISTRATIVE CONTROLS

Engineered and administrative controls are described in broad context as follows:

Engineered controls are physical or engineered features that provide active or passive protection to prevent or mitigate accident consequences. Traditionally, these were hardware controls; however, software controls also play an important role in assuring safety and their role needs to be carefully considered and evaluated.

Administrative controls are processes and procedures utilized to control any exposure and assure appropriate safety discipline is used to conduct hazardous work. Based on potential accident consequences, a graded approach shall be used in regard to operating procedures, critical steps in procedures, team training and qualification, hazard analysis, readiness reviews, and so on.

It is important to focus on the desired performance characteristics of engineered controls and their use in the system design. Robust and reliable engineered controls should be placed in series to block accident pathways leading to unacceptable consequences. If the reliable performance of one control is independent of another control, then the probability of both failing and realizing the accident consequence will be greatly reduced.

Engineered Control Characteristics

Reliable	The calculated or data-based reliability of the engineered control should not have a failure rate greater than one in a thousand.
Robust	The engineered control should have a significant design margin relative to its failure point…the goal is factor of two or more.
Independent	The engineered control has no common mode of failure.

7.3 APPROVAL OF SAFETY CASE

The safety case is a narrative explanation of how the Overarching Criteria outlined in in this document are addressed. The safety case does not have to meet a standard of rigorous proof, nor does it have to be long. However, the critical thinking and reasoning in regard to managing the safety risk must be clear and include the planning for off-normal events. In addition, evidence of technical "due diligence" should be apparent to others technically knowledgeable and reasonably familiar with the hazardous activities involved. Supporting documentation can and should be used to support the narrative addressing the criteria in this document.

In the end, it will always come down to a judgment as to whether the controls actually implemented are commensurate with the safety risk.

8 PREPARE AND PERFORM WORK

The scope of work includes the preparation and troubleshooting phases of the activity. Accidents frequently occur during these phases but they are often overlooked during the planning phase.

8.1 COMPLETE TECHNICAL WORK DOCUMENT

A technical work document (TWD) is a formally approved document that identifies activity-level work hazards along with their associated work-control measures and communicates them to the team—generally a "how to" document. TWDs clearly specify the work to be accomplished, expected outcome, and critical steps necessary for successful and safe completion of the activity. A critical step is a procedural step, series of steps or action that, if performed improperly, will significantly affect the safety of an activity. Preapproved TWDs associated with controlling specific hazards common to FORGE activities can be used if appropriate to the scope of the hazardous activity. Development of unique TWDs will usually begin in earlier phases when the system design is mature enough to make it worthwhile; however, TWDs shall be made final and placed under formal change control before the hazards are first introduced, even if the system is in set-up, shakedown, or troubleshooting mode.

Example Content of TWDs:

- Establish work scope boundaries or limits
- Identify hazards—highlight critical steps/controls
- Identify who is authorized to perform critical steps
- Provide sufficient step-by-step details
- Plan for anomalies and off-normal events
- Identify special requirements

8.2 PERFORM JOB SAFETY ANALYSIS

A job safety analysis (JSA) or equivalent should be performed in association with the development of TWDs and before the work is performed.

8.3 CONFIRM TEAM TRAINING AND QUALIFICATION

While the identification of key positions associated with performing safety-critical steps would naturally occur earlier in the development of the system design, it is necessary to confirm and document that the personnel who will actually be performing these tasks have completed the necessary training before authorizing the work to begin. In some cases, there may be a formal qualification requirement that needs to be met.

8.4 CONDUCT READINESS REVIEWS OR ASSESSMENTS

Formal readiness reviews or assessments shall be performed. If there are pre-start corrective actions from the readiness reviews or assessments, these actions must be completed.

8.5 DECISION TO AUTHORIZE WORK

Before work begins, FORGE management shall formally authorize the work and shall describe any limiting conditions placed on that authorization. FORGE management should ensure that the required PPE is provided and that personnel access is controlled when the hazards are present.

8.6 PERFORM WORK

After appropriate authorization has been received, the FORGE management is responsible for controlling the day-to-day work. This responsibility may be formally delegated to a PIC who is properly trained or qualified to perform the function. FORGE management or the delegated PIC shall do the following:

- Conduct a pre-job briefing prior to initial start-up of the work and repeat at appropriate intervals depending on the nature and frequency of the work.
- Use a "positive verification" approach to ensure that all elements of the interconnected system are as intended for performing the work.
- Define a periodic monitoring scheme using positive verification techniques
- Prepare for and manage emergencies
- Manage accountability for operational modes of facilities
- Implement conduct of operations

9 FEEDBACK AND IMPROVEMENT

A feedback and improvement process must be applied to all work performed in order to achieve the following:

- Identify and correct processes or deviations that lead to unsafe or undesired work outcomes
- Evaluate and mitigate risks associated with work processes
- Provide FORGE management and team members with information to improve the quality and safety of subsequent similar work

10 ATTACHMENT A

WEST FLANK FORGE

Emergency Response Plan

1 PURPOSE

The Emergency Response Plan covers procedures to be implemented in the event of an emergency at the West Flank FORGE Project site.

2 SCOPE

This procedure applies to all West Flank team members, contractors, and visitors.

3 RESPONSIBILITIES

COC's Emergency Response Team will be the initial point of contact for all emergencies (contact the Navy control room at 760-794-2091 or 760-764-2358).

Site Management shall be responsible for:

- The implementation and enforcement of this plan at the West Flank project site;
- Monitoring compliance with this plan by West Flank team members, and contractors working at the West Flank Project;
- Being involved in every emergency;
- Determining if or when it is necessary to involve outside specialist, such as the Fire Department or other emergency personnel;
- Designating personnel to be trained and certified in First Aid and CPR and ensuring such training is provided as required by the certifying agency;
- Ensuring all employees who may respond to an emergency will be involved in one drill or exercise per year;
- Ensuring all personnel are informed of the requirements of this plan and comply with its requirements; and
- Maintaining all documents and records as required by this plan for inspection by:
    - West Flank personnel;
    - Navy personnel;
    - Regulatory and governmental agency representatives.

The West Flank team, contractors, and visitors shall be responsible for:

- Following all directives and procedures associated with this plan.

4 LOCATION OF PLAN

Emergency Response Plans are located in the following locations:

- On site - TBD
- Entrance Gate for Outside Emergency Responders

5 INCIDENT COMMAND SYSTEM

The Incident Command System (ICS) must rely on the available on-site management for the initial handling of emergencies that require the use of the ICS. The ICS will be activated only in case of major emergency events.

Upon the onset of the emergency the most senior operations person on site will assume the role of Incident Commander (IC), and take charge of the incident. Designated Incident Commanders are listed below in descending order. If a higher rating IC becomes available, he/she will assume the role of the IC.

5.1 EMERGENCY RESPONSE TEAM

All other onsite personnel must report to the IC. The IC must work closely with the other management personnel.

The IC shall establish a Command Center. This center is where he/she will be stationed during the emergency. The command center should be located near the incident where field personnel can access the center, but be at a safe distance from the incident. The command center shall be equipped with telephones and two-way radios for fast communications with personnel, outside agencies, and other offsite West Flank personnel involved in the incident.

The IC shall assign personnel for handling key positions relating to controlling the incident. Key positions may include the following:

- Fire and First Aid Responsibilities;
- Communications;
- Evacuation of non-essential personnel;
- Traffic control and providing direction to responding agencies;
- Equipment and parts;
- Continued operation of non-effected areas; and
- Notification to Project Manager

6 SETTING PRIORITIES

People **ALWAYS** come first! Always protect employees first, regardless of the situation.

- Priority number 1- Protecting our employees
- Priority number 2- Protecting the environment
- Priority number 4- Maintaining compliance with Air Regulations
- Priority number 3- Protecting the facility
- Priority number 5- Maintaining generation

7 EMERGENCY RESPONSE, RADIO AND TELEPHONE NUMBERS

A list of Emergency Response Phone Numbers shall be posted in the following locations:

- All Work Planners Offices
- COC Control Rooms
- NAWSCL Security
- West Flank FORGE office, trailers, etc.;
- Navy Geothermal Program Office

COC's Emergency Response Team will be the initial point of contact for all emergencies (contact the Navy control room at 760-794-2091 or 760-764-2358).

Contact	Phone Number
Medical, Fire, Rescue	Navy 2 Control Room: 760-764-2091, 760-764-2358
	Navy 2 Control Room: 760-764-2091, 760-764-2358 and Mark Kolar @ 775-304-7326
NAWSCL	Police: 760-939-3323 Fire: 760-939-3323 Geothermal Program Office: Kelly Blake, office 760-939-4056, cell 845-781-6685
Hospital	Ridgecrest Regional Hospital: 760-446-3551
West Flank FORGE Team	Project Manager, Doug Blankenship, cell, 505-259-0513
	COC General Manager, Chris Ellis, cell, 760-382-5118
	COC Operations Manager, Mark Kolar, cell, 775-304-7326
	COC Maintenance Manager, Kevin Westmoreland – 760-764-1300 ext. 504
	Navy Site Manager, Kelly Blake, office 760-939-4056, cell 845-781-6685
	Navy Alternate POC, Michael Lazaro, office 760-939-0146, cell 805-651-9256
	Navy Alternate POC, Dave Meade, office, 760-939-4057, cell, 760-382-7705
	Navy Alternate POC, Andrew Sabin, 760-939-4061, cell 719-373-3531

8 EMERGENCY RESPONSE PROCEDURES

8.1 ORGANIZATION

The procedures are organized and administered by the West Flank Team.

8.2 EMERGENCY COMMUNICATIONS

Radios will be required for use by the West Flank FORGE team due to intermittent or unavailable cell phone service. Coso Operating Company will provide a radio channel and radios for communications.

The call can be given for the ER Team to respond.

The caller is to contact the Navy 2 Control Room for assistance.

The person summoning help is to let the responder know that there is an emergency, the type of emergency (fire, medical, rescue), the location and severity.

If a transport is necessary, the IC of the scene will have the Navy 2 Control Room Operator call 9-911, to have the ambulance respond.

- The caller is to provide the 911 operator with all the necessary information, and communicate that an employee will be standing by at the entrance gate for escort purposes.
- The Navy 2 Control Room Operator should remain in contact with the in-route ambulance crew until they have arrived on scene.

From the start of the emergency medical communications to the completion of the ambulance transfer, channel 5 is to remain clear for emergency communications only.

9 EMERGENCY RESPONSE TEAM

The Emergency Response (ER) Team will consist of members of COC's Operations and Maintenance crews that are trained in First Aid, CPR, AED, during the incident. ER Team members are trained and certified by Olancha Fire Department. The rescue and medical duties of the team is to render medical aid up to their level of training, to all ill or injured personnel within the project.

10 RESPONSIBILITIES OF EMERGECY RESPONSE MEMBERS

The following general guidelines are the responsibility of an employee as member of the responding team that involve a medical emergency, rescue situation, fire or vehicle incident.

- Upon arriving at the scene, secure the scene and make sure it is safe. Keep all untrained or unnecessary employees out of the area.
- Reach the victim as soon as it is safe to do so.
- Begin taking care of the patient, or initiating the rescue, following proper procedures and protocols.
- If fighting an incipient stage fire, do not leave the fire after it is extinguished until all hot spots have been found. The area should be monitored for an additional 30 minutes. If the fire is larger than an incipient stage fire, an outside agency shall be called.

11 ACCIDENTS AND INJURIES

11.1 FIRST RESPONSE

All personnel at the West Flank Project are basic First Aid, CPR and AED trained. These basic skills shall be applied immediately if required.

Whenever personnel are injured the control room shall be notified to obtain assistance.

All personnel should become familiar with the location of first aid kits and AED's at the project.

Nothing in this plan changes Contractor's responsibilities or authority for the safety and treatment of their employees.

12 FIRST RESPONDER PROCEDURE AND PROTOCOLS

The first responder procedure and protocols are set by company policy, the training agency (American Heart Association) and California State law. It is the policy of Coso Operating Company LLC to administer emergency oxygen to an employee, contractor, or visitor as a precautionary treatment when experiencing any of the following symptoms:

- An increase or decrease in heart rate, more than 100 BPM (tachycardia) or less than 60 BPM (bradycardia);
- An increase or decrease in breathing, more than 20 breaths per minute or less than 12 breaths per minute;
- Changes in level of consciousness;
- Restlessness;
- Cyanosis (bluish lips or Fingernail beds);
- Chest pain or heart attack related symptoms; and
- Stroke related symptoms.

This will be done using a nasal cannula at a flow rate of 1-6 liters per minute, with a 24-44 percent oxygen concentration.

13 MEDICAL EMERGENCY ACTIONS

Survey the Scene – Ensure the safety of the first responder.

Primary Survey – Survey the injured person(s) by checking the ABC's-Airway, Breathing, and Circulation. If not breathing start rescue breaths. If no pulse, start CPR, AED.

Secondary Survey – Take vital signs and do a head-to-toe exam.

Check for bleeding – If a person is bleeding, apply direct pressure and bandage. If the injury continues to bleed, elevate the wound. If still bleeding, apply pressure to the closest pressure point to the wound.

13.1 TREAT INJURIES

13.1.1 Strains, Sprains, Dislocations and Breaks

a. All of these injuries are treated the same way. If the person is to be moved, it is necessary to immobilize the injured area above and below the wound. If the injury is minor, apply ice and elevate to allow swelling to subside. If a back injury occurs, the employee will be seen by a physician before returning to work.

13.1.2 Burns

a. First aid for thermal burns is to cool with water and wrap in damp gauze. For a chemical burn, continue to flush for 10-20 minutes.

b. Full thickness burns (Third degree) should be wrapped in dry sterile gauze.

c. Depending on the percentage of the body burned and the severity of the burn, treat for shock, monitor vital signs and transport.

d. If the burn is an electrical burn, the major concern is breathing and heartbeat. Begin first aid for breathing and heart emergencies. All persons involved in electrical related injuries will be seen by a physician before returning to work.

13.1.2.1 Insect Bites

a. Ask the person if they are allergic;

b. If they respond affirmatively, and they are allergic, assist them in administering their medication, if available.

c. If an allergic reaction starts, transport immediately.

d. If the person is not allergic, if applicable, remove the stinger by scraping it off. Lower the sting area below the heart.

e. Apply an ice pack wrapped in a protective barrier to prevent skin damage.

13.1.3 Eye Injuries

a. For small foreign bodies, encourage the person to blink, then flush impacted eye with sterile eyewash solution.

b. For chemical injuries, flush with sterile eyewash solution for 10-20 minutes.

c. All employees with eye injuries will be seen by a physician before returning to work.

13.1.4 Deceleration Injuries

a. Any time a person's body comes to an abrupt stop or is accelerated by force, full spinal immobilization is required. To achieve this one person will hold the head in the inline stabilization position and maintain until the cervical collar is in position and secured, the person is strapped to the backboard and the head restraints are secured.

b. If the person is in full cardiac arrest, CPR is the priority.

   1) Ensure the person is on their back on a hard surface. Do your best to minimize movement of the spine.

   2) Use the chin lift or jaw thrust method for opening the airway.

13.1.5 Vehicle Incidents

a. Vehicle incidents are to be approached with caution. Be sure the scene is safe. If the vehicle is unstable, do what is needed to stabilize it first, before attempting a rescue.

b. Once you are able to reach the injured person, **begin inline stabilization and maintain it until total spinal immobilization has been achieved**. Do a secondary survey, start oxygen, and transport.

13.2 START SYSTEM – TRIAGE IN MEDICAL EMERGENCIES

Treat for Shock- When a person shows any signs of shock, maintain body temperature, and monitor vitals. All employees showing signs of shock will be seen by a physician prior to returning to work.

Transport – If the decision is made to transport the person, notify 911 for the ambulance. Secure the patient on the gurney and administer oxygen.

Air Ambulance – In the event an air ambulance is needed:

First ensure that the injury or illness meets the criteria for an airlift.

Air ambulance is a very limited commodity that is only to be used when a life threatening condition exists and

1) When the reduction in overall transport time is expected to have an impact on the patient's outcome.
2) If you cannot save a minimum of 15 minutes over an ambulance trip time, it is not necessary to request an air ambulance.

Make the request when calling 9-911. Communicate to them where the landing point is located. These points include; the West Flank Junction Office landing pad, or the approved well pad number close to the incident location. Always have the ground unit respond with the air unit in case the air unit runs into problems.

Never approach the helicopter when it lands. The crew will come out to meet you.

13.3 POST INCIDENT PROCEDURES

After every emergency response the team will hold an evaluation session to go over the events to ensure that any problems that arise will be addressed and covered in the future. If the emergency involves death or serious trauma that could cause the responder emotional trauma, a debriefing or crisis management session will be held.

14 ACTIVE SHOOTER

14.1 ACTIVE SHOOTER PREPAREDNESS

All team members shall be trained in the Active Shooter procedure and evacuation plan.

The emergency escape routes shall be posted on work site premises.

Safety meetings will be held on Active Shooter preparedness.

14.2 ACTIONS DURING AN ACTIVE SHOOTER INCIDENT

Immediately report the incident to the Navy 2 control room.

If Navy 2 is targeted first, the Navy 1 SWO will become the new Incident Command Center.

The Navy 2 control room operator will notify all sites that an active shooter scenario is in effect.

Quickly determine the most reasonable way to protect your own life. If you are working at a site other than the site where the active shooter is located, you should remain at that location in lockdown mode. This means that you should stay indoors with the doors locked, if possible.

Run – If there is an accessible escape path, attempt to evacuate the premises.

Hide – If evacuation is not possible, find a place to hide where the active shooter is less likely to find you.

Fight – As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active shooter.

14.3 WHEN LAW ENFORCEMENT ARRIVES

Law Enforcements purpose is to stop the Active Shooter as soon as possible. Officers will proceed directly to the area in which the last shots were heard. Officers will have a high level of adrenalin when they arrive on scene. Do not do anything that will cause them to think you are their target.

How to react when Law Enforcement arrives:

1) Remain calm, and follow all instructions;
2) Put down any items in your hands;
3) Immediately raise hands and spread your fingers;
4) Keep your hands visible at all times;
5) Avoid making quick movements toward officers. Do not hold on to them for safety;
6) Avoid pointing, yelling or screaming;
7) Do not stop to ask officers for help when evacuating. Just proceed in the direction in which the officers are entering the premises.

The first officers to arrive on scene will not stop to assist injured persons. Expect rescue teams comprised of additional officers and emergency medical personnel to follow the initial officers. These rescue teams will treat and move any injured persons. They may also call upon able-bodied individuals to assist in removing the wounded from the premises.

14.4 INFORMATION AND ASSEMBLY POINTS

Due to the inability to forecast where a safe location may be in the event of an Active Shooter incident at the West Flank project, the designated assembly point will be the West Flank Junction Office, or another area where Law Enforcement and the Incident Commander deem it safe.

After you have reached a safe location or your designated assembly point, you will likely be held in that area by the Incident Commander until the incident is under control, and all witnesses have been identified and questioned.

Do not leave the safe location or assembly point until Law Enforcement and the IC have instructed you to do so.

14.5 AFTER ALL TEAM MEMBERS AND CONTRACTORS ARE ACCOUNTED FOR

The IC is responsible for making sure everyone evacuates the area. All personnel, contractors and visitors must check in with the IC or their supervisor at the Coso Junction office or the designated safe location as determined by the IC and Law Enforcement. This is to ensure that all persons are accounted for.

The Incident Commander and Law Enforcement will evaluate the extent of the damage and make the decision as to whether or not to evacuate the project.

The IC will notify senior management of the status of the project.

If it is safe to do so, the IC will station an employee at the project's entrance to direct incoming emergency personnel and equipment to the incident site.

If evacuation is necessary, the IC will give directions for the designated evacuation route.

The IC is responsible for transporting any injured persons to the Coso Junction office. Ambulance transportation will be used from the Coso Junction office to the medical facility. If a person is so badly injured that ambulance transportation is required from the West Flank project, the IC will coordinate those efforts.

14.6 IF EVACUATION IS ORDERED

If anyone is missing, the IC and Law Enforcement will take the appropriate steps to coordinate their rescue.

Once all personnel are accounted for, the IC, Law Enforcement and Management will determine which personnel should stay and who can leave the project.

15 BUILDING EVACUATION PROCEDURES

15.1 BUILDING EVACUATION PLANS

All emergency exits shall be clearly marked

Building evacuation routes shall be clearly identified and posted in each building in a location that is visible to personnel.

The plan shall indicate the emergency assembly area (muster area) where personnel are to congregate following an emergency evacuation or a drill.

15.2 BUILDING EVACUATION

The senior ranking person assigned to the building will, lacking other directions, make the determination that evacuation is necessary.

All personnel shall be instructed that they will immediately evacuate the building upon notification.

Personnel shall be drilled in emergency evacuation procedures at least once annually. Range closure evacuations are considered an evacuation drill.

16 BLOWOUTS AND MAJOR WELL DAMAGE

The Onsite Incident Commander will take the following steps for any wellhead blowout. These steps are only a recommendation. The exact response will depend on the severity of the blowout condition.

16.1 INITIAL RESPONSE

1) Notify General Manager;
2) Evacuate and provide care for any injured personnel;
3) Evaluate the extent of the damage and initiate the appropriate control measures with any emergency response agency or West Flank management, if possible;
4) Secure and maintain control of the access road to eliminate unauthorized personnel;
5) Mobilize earth-moving equipment to channel the flow of fluids into a sump or other containment area. Mobilize portable pumps to transfer fluids collected during the blowout or damaged wellhead;
6) Contact the Coso Operating Compliance Department to ensure all agencies have been notified.

16.2 INITIATE CONTROL AND CONTAINMENT PLANS

1) Kill the well consistent with safe operating practices prior to starting any repair work;
2) Take steps to expose the damaged portion of the well;
3) Repair the damaged area or replace the wells casing and or wellhead;
4) Inspect the surrounding areas for any erosion that occurred to the sump, pad, roads or other areas in the well field.
5) If the well cannot be contained, the manager shall initiate a program to kill, plug and abandon the well;
6) If there is a definite threat to human life, the manager will secure the area and make arrangements for outside contractors to secure the well.
7) Written reports and cleanup efforts associated with the incident will be a joint effort between West Flank team members and the Emergency Response Team.

17 BOMB THREATS

17.1 BOMB THREAT CALLER

It is highly unlikely that a bomb threat will ever be received by one of West Flank's team members or contractors. However, if and when a bomb threat is received, the person who receives the call should get all the information that he/she can from the caller.

The receiving employee should listen quietly to the caller. Detailed notes should be taken, and the following questions should be asked:

1) What time is the bomb set to go off;
2) Where is the exact location of the bomb;
3) Description of the bomb;
4) Size, shape and color of the bomb;
5) Type of bomb, type of explosives and type of detonator;
6) When was the bomb planted;
7) What group (if any) is responsible for planting the bomb; and
8) What is the caller's name?

It is important to note any unusual speech patterns, broken language, voice quality, accents and noises in the background.

17.2 AFTER THE CALL

Under no circumstances shall any employee or contractor attempt to locate the bomb.

The control room operator who received the call will contact 911 and have the area or project evacuated.

The IC will station an employee at the gate to escort the emergency response agencies to the location.

The area or project will remain closed until the bomb has been secured or the proper authorities have cleared the area or project.

18 MILITARY BOMB DEVICE OR DEBRIS

There may be an occasion when a West Flank employee finds a military bomb, device or debris that the Navy used during one of their tests. The Navy may or may not be aware of the missing equipment. If a West Flank employee finds any type of unknown object, do the following:

Under no circumstances shall any West Flank team members or contractor touch or handle the object.

The person who finds the object shall contact the Navy 2 control room, and have the area or project evacuated.

The Navy 2 control room will contact China Lake Police Department and the West Flank Work Planner to inform them of the situation.

The IC will station an employee at the Coso entrance gate to escort the emergency response agencies to the site.

The area or project will remain closed until the object has been secured or the proper authorities have cleared the area or project.

19 DANGEROUS VIOLATION OF SAFETY POLICY OR PROCEDURE

It is expected that most team members and contractors of the West Flank site are very good at following safety policies and procedures; however, an occasion may arise where an individual commits a serious safety violation, or refuses to follow necessary safety procedures. There are several situations where intervention would be required. Use the following process if this should occur:

Is there a general, but not an immediate threat to the individual's safety? If so, notify the employee or contractor. If the employee does not respond to the warning notify the Work Planner.

Is there an immediate and serious life threatening situation? Immediately intervene to stop the unsafe act, if possible, and then notify the Supervisor/ Manager;

If others are at risk, warn them to evacuate the area, if necessary;

Notify the Work Planner of the threat and take immediate action if it is required.

20 EARTHQUAKES

20.1 EARTHQUAKE PREPAREDNESS

All team members shall be trained in the earthquake procedure and evacuation plan;

The escape routes shall be posted in all work sites; and

Safety meetings shall be held on earthquake preparedness.

20.2 ACTION - ONSET OF AN EARTHQUAKE

If inside a building, **DROP** to the floor, take **COVER** by getting under or next to a sturdy desk or table, and **HOLD ON** to it until the shaking stops.

If outside, find an area clear of falling objects and **DROP** to the ground;

Remain where you are until all movement has stopped.

20.3 ACTION - ONCE THE EARTHQUAKE STOPS

Report to your designated check point;

Attend to any injured personnel, but **Do Not Move** them unless they are in an unsafe area;

Call the Navy 2 control room if emergency assistance is required.

Be aware that there may be aftershocks that may be large enough to do additional damage to structures that were weakened during the initial earthquake.

20.4 ACTION – AFTER ALL TEAM MEMBERS/CONTRACTORS ARE ACCOUNTED FOR

Management or a designee will evaluate the extent of the damage and make the decision of whether or not to evacuate the facility.

Check water and electrical lines, buildings, pipelines, cooling towers, and tanks for damage. Barricade downed power lines, if applicable.

If evacuation is necessary, the IC will give directions for the escape route to be used.

The IC will contact senior management and provide a status report.

20.5 ACTION – IF EVACUATION IS ORDERED

The IC is responsible for making sure everyone is evacuated. He/she may designate this job to other personnel.

If transportation is a problem, the IC will notify additional resources for assistance.

If injures personnel require special transportation, the IC will make the necessary arrangements. All personnel will meet at the designated muster point upon evacuation of the facility. All employees must check in in with the manager upon arrival.

If anyone is missing, the IC is to be notified immediately so they can dispatch rescue personnel.

Once all personnel have been accounted for, the management will determine the personnel who must stay and who can leave the area.

21 EXPLOSIONS

An explosion is a sudden release of energy. The released energy may have originated from an exothermic chemical reaction or may have contained stored energy in the form of compressed air, steam, or high pressure liquid. Damage may result in shock wave radiating from the explosion or by flying debris.

21.1 ACTION - AFTER THE EXPLOSION

Report to your designated check in station. If any personnel are missing, a search will be made to determine his/her location and condition, when it is safe to do so;

Attend to any injuries, but **Do Not Move** injured persons unless they are in an unsafe area;

The control room will be used by the IC to receive calls/reports of injuries, fires or spills;

Call the Navy 2 Control room to report the explosion and for emergency assistance.

21.2 ACTION - AFTER ALL TEAM MEMBERS/CONTRACTORS ARE ACCOUNTED FOR

The IC will evaluate the extent of the damage and make the decision to evacuate the project.

The IC will notify senior management of the incident and status of the project.

The IC will station an employee at the projects entrance to direct incoming emergency equipment to the incident site.

If evacuation is necessary, the IC will give direction for the evacuation route.

22 FIRES

22.1 ACTION – ONSET OF FIRE

Any person who discovers, smells or sees smoke and believes there is a fire will immediately take the following actions:

1) Sound Alarm Locally, if applicable, otherwise contact the Emergency Response Team by calling the Navy 2 control room (760-764-2091, 760-764-2358) or by radio using the appropriate channel.
2) Verbally pass the word and actuate any available evacuation alarm system. Be sure to notify anyone in immediate area.

COC Operations and Maintenance will release employees to provide incipient stage firefighting and rescue services.

The onsite IC will ensure the following actions take place:

1) Activate emergency diesel fire pumps, open water main valves to additional water sources, etc.
2) Secure and isolate electricity, flammable liquids and gas and/or streamlines to buildings or areas involved in fire.
3) Provide vehicles and drivers to transport personnel and equipment.
4) Control vehicular traffic into, from and about the fire scene.
5) Keep spectators at a safe distance from the fire scene.
6) Safeguard property removed from buildings and prevent pilferage.
7) Establish a watch at the fire site to prevent unauthorized access pending completion of an investigation.

22.2 ACTION - AFTER THE ONSET OF FIRE

Report to your designated check in station. If any personnel are missing, a search will be made to determine his/her location and condition, when it is safe to do so;

Attend to any injuries, but **Do Not Move** injured persons unless they are in an unsafe area;

The control room will be used by the IC to receive calls/reports of injuries;

Call the Navy 2 control room to report the fire and for emergency assistance.

22.3 ACTION - AFTER ALL EMPLOYEES/CONTRACTORS ARE ACCOUNTED FOR

The IC will evaluate the extent of the damage and make the decision to evacuate the project.

The IC will notify senior management of the incident and status of the project.

The IC will station an employee at the projects entrance to direct incoming emergency equipment to the incident site.

If evacuation is necessary, the IC will give direction for the evacuation route.

23 FLASH FLOODS

23.1 ACTION - ONSET OF A FLASH FLOOD

Flash Floods can occur in response to heavy seasonal rains. In the event you are caught in a flash flood; the following should be done;

Avoid all topographic depressions which may act as a channel or receptacle for the flood water.

If you are in a vehicle and are positioned in a dry streambed and are unable to drive free of the floodwaters, abandon the vehicle and seek high ground. If you are already in a stream of water, stay with the vehicle and get on top of its roof.

Wait for the flooding to subside to move from the area.

Be aware of possible lightning.

23.2 ACTION ONCE THE FLASH FLOOD HAS STOPPED

Report to your designated check in station. If any personnel are missing, a search will be made to determine his/her location and condition, when it is safe to do so;

Attend to any injuries, but **Do Not Move** injured persons unless they are in an unsafe area;

The Navy 2 control Operator will be used by the IC to receive calls/reports of injuries;

Call 911 for emergency assistance.

Channel 5 will be used to receive calls of injuries, fires, and spills. This channel will also be used to relay other pertinent information.

23.3 ACTION - AFTER ALL EMPLOYEES/CONTRACTORS ARE ACCOUNTED FOR

The IC will evaluate the extent of the damage and make the decision to evacuate the project.

The IC will notify senior management of the incident and status of the project.

The IC will station an employee at the projects entrance to direct incoming emergency equipment to the incident site.

If evacuation is necessary, the IC will give direction for the evacuation route.

23.4 ACTION – IF EVACUATION IS ORDERED

The IC is responsible for making sure everyone is evacuated. He/she may designate this job to other personnel.

If transportation is a problem, the IC will notify additional resources for assistance.

If injured personnel require special transportation, the IC will make the necessary arrangements. All personnel will meet at the designated muster point (West Flank Junction Office) upon evacuation of the facility. All employees must check in in with their Supervisor or the IC upon arrival.

If anyone is missing, the IC is to be notified immediately so they can dispatch rescue personnel.

Once all personnel have been accounted for, the management will determine the personnel who must stay and who can leave the area.

24 HYDROGEN SULFIDE HAZARDS

The Coso Operating Company H2S Program is designed to address the risk of H2S exposure for employees, contractors and visitors. The goal of the program is to deploy safety precautions on an "as needed" basis recognizing that not all areas of the project represent the same degree of H2S risk. The two key safety precautions are personal H2S monitors and fixed monitors.

In the event that an employee, contractor or visitor breathes in a large amount of H2S, and you can safely access them, move the person to fresh air at once. If the atmosphere is not safe, **do not attempt to rescue by holding your breath. If they went down, so will you.**

Notify the Navy 2 Control room Operator to dispatch the ER Team.

Primary Survey – Survey the injured person(s) by checking the ABC's-Airway, Breathing, and Circulation. If not breathing start rescue breaths. If no pulse, start CPR, AED.

Transport – If the decision is made to transport the person, call the Navy 2 CR Operator to notify 911 for the ambulance.

The IC will station an employee at the projects entrance to direct incoming emergency equipment to the incident site.

25 LIGHTNING

25.1 ACTION-AT ONSET OF A LIGHTNING STORM

If you are inside stay inside. Avoid contact with metallic objects. Stay clear of electric power sources.

If outside find shelter. Stay clear of all pipelines, tanks, wellheads and other equipment. Try to get to a building or a vehicle.

Be prepared to extinguish small fires.

26 SPILLS AND DISCHARGES

Although the detailed procedures will vary depending of the location and severity of the spill, in all situations the Operator who discovers the spill shall report it as described below. All reported spills must have an "Accidental Spill/Discharge Notification Form" filled out. The Shift Supervisor or his designee should fill out section 1 of the form. Section 2 will be filled out by the Environmental Coordinator (EC) or his/her designee.

Brine Spills – Brine, condensate or any geothermal fluid release of 300 gallons or more must be reported to the EC immediately. If the release occurs after normal business hours, contact the EC at home (See phone list on page 6 of this Plan). Releases of less than 300 gallons must be reported by the next business day.

Hazardous Materials Spills – Hazardous materials releases of more than 5 gallons must be reported immediately to the EC. Releases of less than 5 gallons must be reported to the EC the next business day during normal office hours.

Never attempt to clean up the released material unless you have received specific HAZWOPER training. Isolate the area if it can be done safely with barrier tape or other barrier devices. Call the EC for further instructions if problems develop during the isolation of the area.

Non-Condensable Gas Line (NCG) Spills – NCG line releases can release both NCG, which can be high in H_2S and heavy metal contaminated liquids. These releases can pose a safety hazard for anyone in the area, due to the released H_2S. If the release can be secured safely, secure the release, by shutting down the equipment or plugging the leak.

Always wear your personal H_2S monitor when approaching a NCG release. If the monitor alarms, leave the area immediately.

NCG releases must be reported to the EC. However, if the release occurs after normal business hours, the release can be reported the next business day.

27 WIND STORM

27.1 ACTION-ONSET OF WIND STORM/MICRO-BURST

If inside a building, DROP to the ground, take COVER by getting under or next to a sturdy desk or table, and HOLD on to it until the high winds dissipate.

If outside, find something large and heavy that you can secure yourself to. Seek cover alongside building foundations or in trenches. Avoid well cellars. Cover head and face with arms and keep legs tightly together.

Remain there until the wind storm/tornado passes. Move only when it is safe to do so. Call for help if you cannot move.

27.2 ACTION – ONCE THE WIND STORM/TORNADO IS OVER

Report to your designated check in station. If any personnel are missing, a search will be made to determine his/her location and condition, when it is safe to do so;

Attend to any injuries, but Do Not Move injured persons unless they are in an unsafe area;

The control room will be used by the IC to receive calls/reports of injuries;

Call the Navy 2 control room for emergency assistance.

27.3 ACTION - AFTER ALL EMPLOYEES/CONTRACTORS ARE ACCOUNTED FOR

The IC will evaluate the extent of the damage and make the decision to evacuate the project.

The IC will notify senior management of the incident and status of the project.

The IC will station an employee at the projects entrance to direct incoming emergency equipment to the incident site.

If evacuation is necessary, the IC will give direction for the evacuation route.

27.4 ACTION – IF EVACUATION IS ORDERED

The IC is responsible for making sure everyone is evacuated. He/she may designate this job to other personnel.

If transportation is a problem, the IC will notify additional resources for assistance.

If injures personnel require special transportation, the IC will make the necessary arrangements. All personnel will meet at the designated muster point upon evacuation of the facility. All employees must check in in with the manager upon arrival.

If anyone is missing, the IC is to be notified immediately so they can dispatch rescue personnel.

Once all personnel have been accounted for, the management will determine the personnel who must stay and who can leave the area.

28 POST INCIDENT PROCEDURE

After every emergency response management will hold an evaluation session to go over events to ensure that any problems that arise will be covered and addressed. If the emergency involves a death or serious trauma that could cause the first responders emotional trauma, a debriefing and a crisis management session will be held.

29 TRAINING

29.1 REQUIREMENTS

Employees will receive training on this plan, the emergency response procedures, and their responsibilities under this plan, upon commencing employment with the company, whenever the plan is updated, or if the employee's responsibilities or designated actions under this plan are altered.

First responders will be re-certified every two years in basic First Aid/CPR/AED.

Each employee that may respond to an emergency will be involved in one drill or exercise per year. Participation in an actual rescue or emergency counts towards the one drill per year requirement.

Employees will receive HAZMAT training on the Awareness level. This will allow them to identify that a hazardous material incident has occurred and how to report the incident.

With this HAZMAT training, they will be able to recognize what the hazard is, know how to read the DOT Hazardous Materials handbook, how to read an SDS, learn when a rescue can be attempted and when it is not feasible, the proper use of PPE, and who to call when an incident occurs.

This training is **not** to be used for clean-up of hazardous spills.

30 INSPECTION AND OBSERVATION OF THIS PLAN

This Plan shall be audited in conformance with West Flank Audit procedures.

All West Flank team members and contractors with the training and capacity to identify violations or unauthorized deviations to this Plan that put at risk the health and safety of people shall report any such incident to facilitate immediate corrective action and/or investigation in accordance with the following notification priority list:

Immediate supervisor of the person involved;

The Work Planner; and

West Flank Environment, Health and Safety Lead, and;

All West Flank team members determined to have committed an intentional violation of this Plan, following an investigation, may be subject to disciplinary action up to and dismissal from the team.

31 ATTACHMENT B

WEST FLANK FORGE

Emergency Evacuation Response Plan

1 PURPOSE

This Policy establishes the minimum requirements for the safe, rapid, and affective evacuation of West Flank (COC) facilities in an emergency.

2 SCOPE

This plan applies to all personnel during an emergency requiring evacuation of sites operated by West Flank team members, contractors, vendors or subcontractors, while on the property of a site being utilized by the West Flank FORGE team.

3 RESPONSIBILITIES

The Site Manger shall be responsible for:

- The implementation and enforcement of this plan at the West Flank site;
- Monitoring compliance with this plan by West Flank team and contractors working on the FORGE project;
- Developing and implementing an accountability system for all on-site team members and contractors;
- Designating primary and secondary evacuation muster points;
- Designating an Incident Commander and a hierarchy of command in an emergency.

COC's Emergency Response Team will be the initial point of contact for all emergencies (contact the Navy control room at 760-794-2091 or 760-764-2358).

Maintaining all documents and records as required by this plan for inspection by:

- West Flank personnel;
- Navy personnel;
- Regulatory and governmental agency representatives.

The West Flank team, contractors, and visitors shall be responsible for:

- Complying with the requirements of this plan in the implementation of a site evacuation.

4 DEFINITIONS

Incident Commander – Individual in charge of an emergency. The role of Incident Commander shall be filled in accordance with the Emergency Response Plan.

COC's Emergency Response Team will be the initial point of contact for all emergencies (contact the Navy control room at 760-794-2091 or 760-764-2358).

Sites – Includes West Flank FORGE work site and monitoring area.

Immediately Dangerous to Life or Health (IDLH) – Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a confined space.

5 PROCEDURE

5.1 NOTIFICATIONS

Audible emergency evacuation alarms, verbal communication via an overhead paging system or two-way radio or other established notification plans shall be utilized to notify West Flank team, contractors, and visitors of the need to implement a site evacuation.

Such a notification shall clearly state the nature of the emergency and provide explicit instructions as to the nature and extent of the evacuation required in regards to West Flank personnel, contractors, and visitors.

It shall be the discretion of the Incident Commander as to the implementation and scope of the evacuation based upon the nature and extent of the emergency.

An emergency evacuation shall require all employees not involved in the emergency or assigned to the Facility Response Team to report to the designated muster area(s).

- When feasible, an Emergency Signal shall be followed by an announcement informing personnel of the nature and location of the emergency.

5.2 EVACUATION

The West Flank team shall establish muster points to be used for limited area evacuations when appropriate and both primary and secondary muster points for full site evacuations.

All contractors and visitors shall report to their designated muster point when ordered to evacuate.

Accountability

The West Flank team shall develop and implement an accountability system to track the presence of all team members and authorized contractors at the site. This may be accomplished through:

- A sign-in log book;
- Roster board;

The Managers designee at all muster locations shall determine the accountability for all personnel designated to muster at that muster point.

Accountability status shall be communicated to the Incident Commander.

It shall be the responsibility of the Contractor representative to ensure the accountability of his or her on-site employees following an evacuation.

No employees, temporary employees, contractors or visitors shall leave the designated muster point until they are accounted for and directed to do so by their supervisor or Facility contact.

5.3 CRITICAL OPERATIONS

The Incident Commander shall determine the necessity and feasibility of securing operating equipment during a site evacuation. Such equipment may include:

- Fuel handling equipment;
- Generators; and
- Auxiliary apparatus.

5.4 UNACCOUNTED FOR PERSONNEL

Upon evacuation and muster, the Incident Commander shall attempt to contact and/or locate any personnel unaccounted for.

- Personnel not present at the Muster Point may have been unaware of the evacuation order or be unable to evacuate due to physical impairment or as a result of the emergency condition.

If, after careful consideration, it is determined an employee, temporary employee, contractor, or visitor is likely still within the area of evacuation, the Emergency Coordinator may assemble a two-person search team to attempt to locate and retrieve the missing individual provided it is safe to do so.

- Under no circumstances shall COC personnel enter an Immediately Dangerous to Life and Health (IDLH) environment.
- Such a search shall start with the last known, or most likely, location of the missing individual.

6 TRAINING

6.1 REQUIREMENTS

Required training shall include:

- Emergency recognition and notification methods;
- Role and responsibilities of the Incident Commander;
- Emergency equipment shut-down procedures;
- Types and recognition of audible/visual alarms used within the facility;
- Accountability methods utilized for team members, contractors and visitors; and
- Muster points.

Personnel designated to assist in evacuation shall be trained in their respective actions and responsibilities prior to being assigned such duties.

All personnel working on the West Flank FORGE team are required to receive a range safety briefing and tortoise training from NAWSCL Environmental Management Division (EMD) personnel. Once this training has been received by team members, a G badge will be issued by the Geothermal Program Office.

Personnel shall be retrained annually.

Potential on-site emergencies are expected to be restricted to injuries to site personnel. On-site conditions are expected to be within the limits of measures, which can be taken by on-site personnel. During **any** on-site emergency, work activities will cease until the emergency is brought under control. A map to nearby medical centers can be found below, in Figure 2.

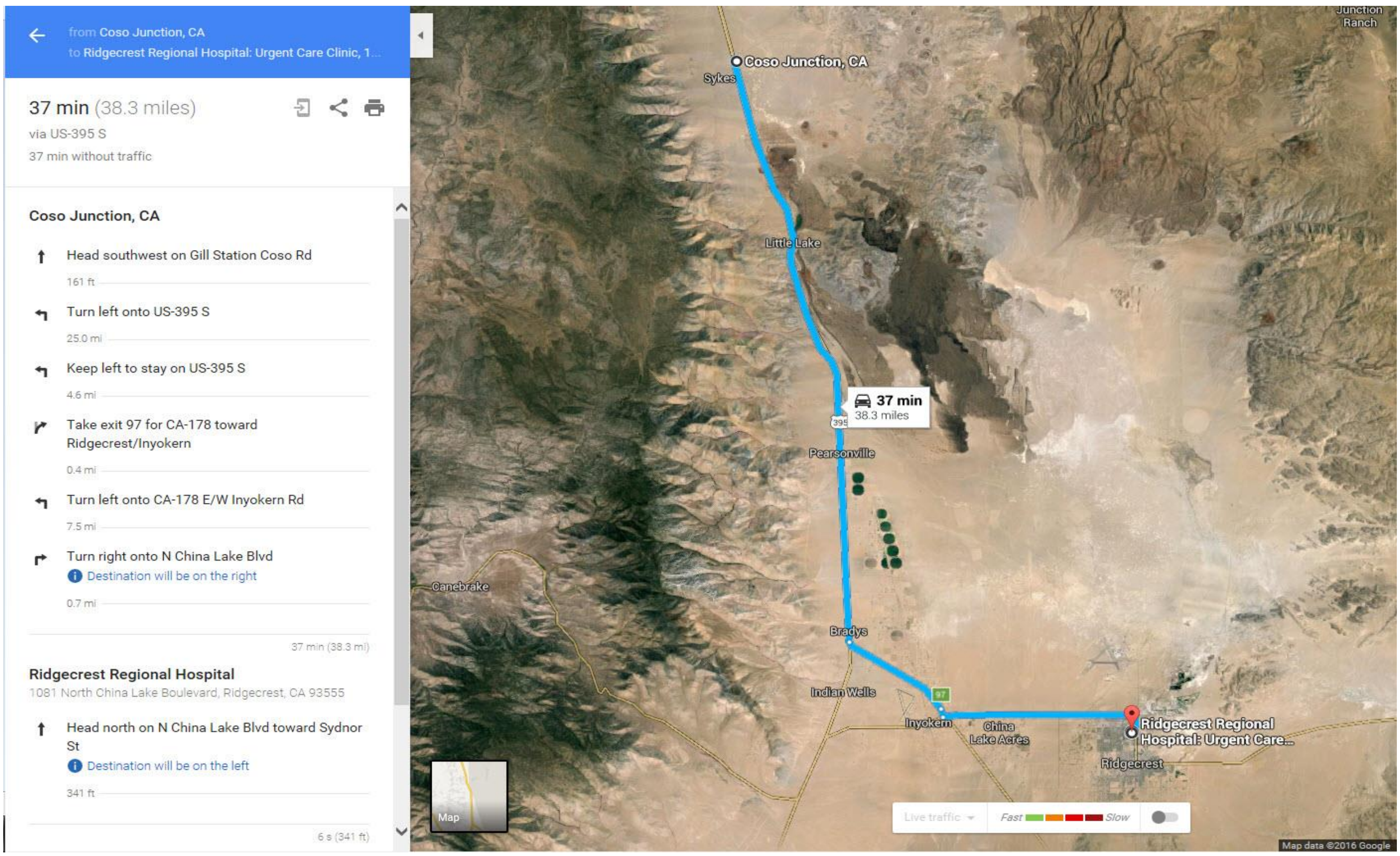

Figure 2. Directions from Coso Junction to Ridgecrest Regional Hospital

Ridgecrest Regional Hospital
1081 North China Lake Blvd. (west side of the street)
Ridgecrest, California 93555
(760) 446-3551

APPENDIX L. RESEARCH AND DEVELOPMENT IMPLEMENTATION PLAN

RESEARCH AND DEVELOPMENT IMPLEMENTATION PLAN

West Flank of Coso, CA

RESEARCH AND DEVELOPMENT IMPLEMENTATION PLAN

West Flank of Coso, CA

INTRODUCTION

This Research and Development (R&D) Implementation Plan provides the technical vision of the West Flank FORGE team and describes how that vision aligns with the goals of the U. S. Department of Energy (DOE). The plan describes the approach for managing the West Flank of Coso, CA, project site and the approach to managing the details associated with the selection and execution of competitively funded R&D.

The plan details the West Flank FORGE Team's commitment to manage and coordinate all logistical, administrative, analytical, and technical support for the planning, solicitation, review, and selection of technologies to be tested and evaluated at the FORGE site. The team will implement formal procedures to ensure that technologies selected for testing and evaluation directly support the objectives of DOE's Geothermal Technologies Office (GTO). These procedures will ensure a fair, logical, and competitive technology procurement process consistent with DOE and Federal guidelines and regulations. (Such procurement regulations are currently followed by the Prime Recipient, Sandia National Laboratories [SNL].) The R&D plan outlines recurring cycles for planning, review, and selection of FORGE-related technologies for testing and evaluation. The proposed management structure for the West Flank FORGE site will ensure close collaboration with the proposed site management team and provide a process for establishing and maintaining technical expert teams (e.g., STAT membership) to meet the project's objectives and evolving technical needs. This process of expert engagement will address management of conflicts of interest for participating members.

TECHNICAL VISION FOR FORGE AND ALIGNMENT WITH DOE GOALS

EGS: FROM CONCEPT TO COMMERCIALIZATION

The vision for FORGE is a dedicated Enhanced Geothermal Systems (EGS) field laboratory and a complementary R&D program that focuses on the science and technology necessary to bring the EGS concept to fruition and ultimately lead to commercialization. The West Flank FORGE team envisions that FORGE will result in a rigorous and reproducible methodology that will enable development of on the order of 100+ GWe of cost-competitive EGS power, thus supporting the U. S. efforts to reduce our dependency on fossil fuels and safeguard the nation's military readiness, through collaboration with the U. S. Navy. Successful development of EGS requires a thorough and fundamental understanding of how to enhance and maintain subsurface permeability via fluid injection, thermal rock-fluid interaction, chemical stimulation, or other well-engineered stimulation processes that re-open pre-existing fractures and/or create new ones.

OVERCOMING TECHNICAL BARRIERS

However, many technical barriers to commercialization have been identified. We need a multi-pronged approach to address these barriers, starting with a thorough understanding of techniques to effectively stimulate fractures in different rock types. We also need to develop techniques capable of imaging permeability enhancement and evolution from the reservoir scale to the resolution of individual fractures; effective zonal isolation for multistage stimulations; directional drilling/stimulation technologies for non-vertical well configurations; and long-term reservoir sustainability and management techniques.

Our team's goal is to manage the West Flank of Coso FORGE as a dedicated site where the eligible subsurface scientific and engineering community to develop, test, and improve new technologies and techniques in an ideal EGS environment that will address the barriers to commercialization. The West Flank FORGE site will allow the geothermal and other subsurface communities to gain a fundamental understanding of the key mechanisms controlling EGS success, in particular, how to initiate and sustain fracture networks in the spectrum of basement rock formations using different stimulation technologies and techniques. This critical knowledge will be used to design and test a methodology for developing large-scale, economically sustainable heat exchange systems, thereby paving the way for a rigorous and reproducible approach that will reduce industry development risk. Essential to this process is a comprehensive instrumentation and data collection effort that will capture a higher-fidelity picture of EGS creation and evolution processes than any prior demonstration in the world. Finally, a dedicated FORGE allows for the highly integrated comparison of technologies and tools in a controlled and well-characterized environment, as well as the rapid dissemination of technical data to the research community, developers, and other interested parties.

DEDICATED FIELD LABORATORY

As a field laboratory for EGS research, the West Flank FORGE team will conduct additional site characterization to complement the Phase 1 efforts at the earliest opportunity (all in compliance with applicable permits) to further understanding of the subsurface at the West Flank site. While the latter part of Phase 2 is designated for full site characterization, these activities will not artificially stop at the commencement of full FORGE operations in Phase 3. Refinement of the geological model will continue throughout the project as a result of continued site development activities and FORGE supported R&D efforts. Although FORGE will be well characterized before full site implementation begins, the geologic model will evolve throughout the project.

Previous EGS efforts have commonly been hampered because of limitations in site monitoring data. Throughout the operation of FORGE, the site will be continuously monitored, not only with additions to the established seismic monitoring network but also with other relevant technologies, such as borehole strain and tilt meters, microgravity, electromagnetic sensors, downhole fluid pressure sensors and geochemical tracers. Particular efforts will be made to ensure that the volumetric coverage of the site is optimized to provide the microseismic and other data needed to ensure a detailed understanding of the EGS stimulation efforts planned in Phase 3. This will include continued integration of site characterization, refinement of the velocity model of the site, as well as full areal and deep vertical coverage of the expected volume of stimulation. Permanent monitoring holes that will be constructed during the development of the site will be complemented with the construction of similar monitoring "holes of opportunity" to accommodate additional FORGE stimulation monitoring and associated FORGE R&D efforts. During the latter portion of Phase 2 and throughout Phase 3, multiple thermo-hydro-mechanical-chemical modeling tools will be used in concert with field and laboratory data from site characterization, downhole measurements/sampling and stimulation monitoring to make testable predictions of reservoir performance and inform decisions related to additional stimulation operations and long-term flow testing. As with all Phase 3 activities, evolving requirements for stimulation monitoring, modeling, and additional stimulations will be carried out through a combination of activities conducted by the broader West Flank FORGE Team and by scientists and engineers selected through the competitive Phase 3 R&D solicitations.

LOOKING AHEAD TO PHASE 3

Full implementation of FORGE begins in Phase 3. Our team envisions at least two, and probably more, full-sized wells for EGS stimulation. The geologic environment will determine well placement and orientations. Wells for EGS stimulation will be drilled using advanced directional drilling technologies to most effectively exploit pre-existing geologic structures and the in-situ stress and rock hydrologic and geomechanical properties to create a pervasive, interconnected fracture network optimal for efficient and sustained geothermal heat extraction under low-pressure injection and production. Specific well designs will be developed as site characterization activities advance and defendable modeling efforts are completed in the latter part of Phase 2. These wells will be subjected to multiple stimulation technologies applied at multiple positions along the wellbore, followed by flow, tracer, and other testing to quantify improvements in well connectivity and to evaluate the performance of the heat exchanger so created.

In addition to the drilling needed to develop and monitor the planned EGS circulation system, drilling to support defined monitoring needs and testing of innovative technologies (through the competitive R&D process) will be needed and implemented during the course of the project. The number of such wells and their proximity to the primary EGS circulation test site will depend on the evolving need to support community R&D. For example, drilling required for an innovative monitoring technology will be performed in an area to accommodate the monitoring requirements. Wells will be developed for testing of technologies that could cause normally eschewed well damage or impact the primary circulation system or required monitoring, if not vetted first. To the extent possible, all drilling will be performed using advanced drilling efficiency monitoring and advisory systems (such and monitoring and use of mechanical specific energy guide the drilling process) to advance these principles in the geothermal community and to reduce the cost of FORGE operations. Additionally, new and advanced drilling technologies will be afforded a location to test such systems while also supporting the need to develop an unprecedented level of subsurface access that FORGE requires.

ADDRESSING EGS PERFORMANCE

While EGS development efforts have implemented methods to stimulate multiple zones of an existing wellbore (e.g., Cladouhos, et. al., 2015), critical technical and commercial limitations to EGS development remain. As illustrated by Doe, et.al. (2014), the inherent heterogeneity and fracture network complexity in natural systems concentrate flow in reduced portions of the available fracture system and tend to degrade EGS performance. In general, these observations have shown that the capability to selectively and independently stimulate, inject, and produce along the intended production and injection sections of EGS wells is vital to EGS success. While R&D solicitations directed toward FORGE efforts to advance EGS technology will be developed in concert with the Science and Technology Analysis Team (STAT) and DOE, the

West Flank FORGE Team envisions that efforts will be directed to address this critical need for selectively controlling zones of injection and production along respective wellbores. Technology to isolate sections of wells and actively control flow from isolated zones exists today for the oil and gas industry, but similar technologies do not exist for geothermal applications. Existing systems provided by service companies such as Schlumberger and Halliburton are plagued by operating temperature limitations and wellbore and tubing diameters that cannot be accommodated today. While it is envisioned that R&D solicitations will address exploration, development, operation, and monitoring for EGS development, the ability to control injection and production along EGS wells is believed to be critical and development and fielding of this capability must be central to the FORGE vision.[i]

R&D PORTFOLIO

At least 50% of annual Phase 3 FORGE funding will be directed toward competitive R&D solicitations, exclusive of funds dedicated to innovative drilling and flow testing. Competitive solicitations issued annually will require a robust institutional procurement system. The annual competition will result in a broad portfolio of R&D activities in support of FORGE, involving multiple research organizations (e.g., government research labs, universities, and private companies) within the broader national and international community. It is also expected that FORGE will be an international centerpiece of the subsurface research community and will complement the current SubTER initiative at DOE. Researchers not directly connected to EGS efforts will also have the opportunity to engage in FORGE-related research that can advance EGS. The operation of FORGE during Phase 3 will require thoughtful and purposeful integration of all activities, both at the field site and in laboratories and research institutions around the world involved in EGS research. Such coordination will require regular meetings of FORGE participants, organized by the West Flank FORGE Team, to discuss recent results and develop future plans and proposals for FORGE-related science and engineering.

MANAGING AND COORDINATING LOGISTICAL, ADMINISTRATIVE, ANALYTICAL AND TECHNICAL SUPPORT

MANAGEMENT STRUCTURE

Successful management of FORGE (including the planning, solicitation, review, and selection of technologies that will be tested at FORGE) will require a management structure that provides clear lines of communication, authority, responsibility and continuity of interests and mission between DOE, the Science and Technology Analysis Team (STAT) and the Site Management Team (SMT). The SMT will be responsible for site operations and support for R&D activities needed to facilitate and advance the goals of FORGE. The schematic diagram in Figure 1 shows the proposed management structure for the West Flank FORGE project.

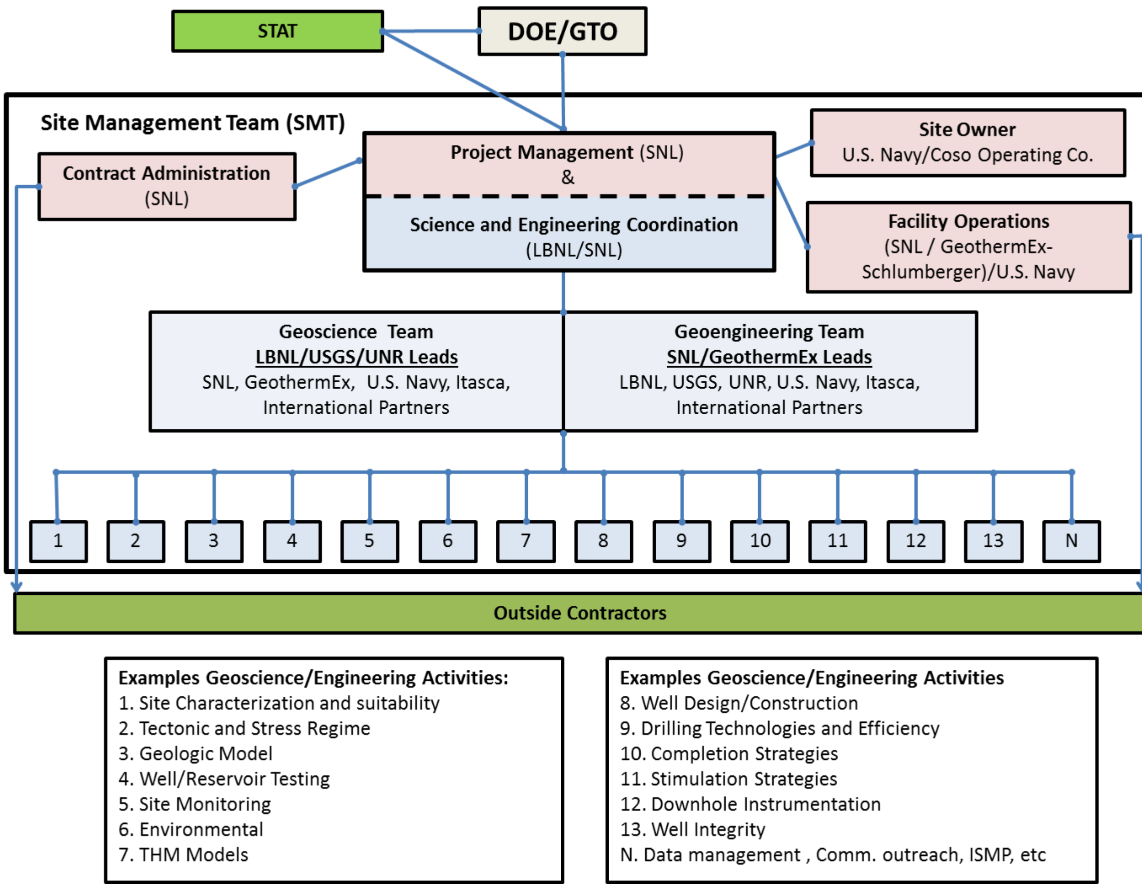

Figure 1. West Flank of Coso, CA, project management team and structure. Arrows indicate communication/interaction paths.

The SMT, shown in Figure 1 within the large box outlined in black, will consist of two primary interactive components: Project Management (denoted by pale pink boxes) and the Geoscience and Geoengineering Teams (pale blue boxes). Project Management will be overseen by the Project Manager (SNL), who in turn will preside over the Contract Administrator (SNL) and the Facility Operator (SNL, GeothermEx, U. S. Navy). The Project Manager will work directly with the Site Owners (U. S. Navy and Coso Operating Co.) on all issues relevant to site operations and logistics. The Project Manager will also participate in the Science and Engineering Coordination (SEC), a team co-led by LBNL and SNL.

The SEC will work directly with the Geoscience and Geoengineering Teams to identify, conduct and report on site activities related to characterization, environmental impact, well design, downhole measurements/sampling, stimulation design, flow testing and monitoring, and any other issues as indicated by the small blue boxes (numbered 1-14, Figure 1). The Geoscience and Geoengineering Teams will report directly to the SEC and Project Manager. In our project management structure, we have placed the DOE/GTO, STAT, contractors needed for FORGE operations, and independent researchers working under the Phase 3 R&D solicitation outside the SMT box. Recipients of competitive R&D solicitations will be contracted to the Prime Recipient (SNL).

The DOE/GTO has ultimate oversight of FORGE, relying on advice and recommendations issued by the STAT, the Project Manager, and the SEC. We have placed STAT outside the box (Figure 1) to ensure a degree of independence and autonomy with respect to the SMT. STAT will have a direct line to the FORGE Project Management and the SEC, as well as DOE/GTO. Contractors performing operational work at the FORGE site through contracts issued by the Contract Administrator also reside outside of the SMT box, and will be used if expertise or service is needed that does not reside inside the SMT. The roles, responsibilities, communication lines and team members for each box are described in more detail below. The organization and operation of STAT is described later in the plan.

MANAGEMENT TEAM

Project Manager

The project site will be managed by SNL. The manager will oversee contract administration, oversee site operations (with GeothermEx/Schlumberger) and coordinate all activities with the Site Owners. Duties will include handling of site finances; deploying, managing and maintaining site facilities; developing adequate training protocols for environmental health and safety regulations; and permitting, issuing and administering R&D FOAs as prescribed by the STAT and DOE/GTO. Furthermore, as the single point of contact with DOE, the project manager will ensure that the site mission, as defined by the DOE GTO and SEC team, is carried out.

Contract Administration

The project site will be managed by SNL. The manager will oversee contract administration, oversee site operations (with GeothermEx) and coordinate all activities with the Site Owners. Duties will include handling of site finances; deploying, managing and maintaining site facilities; developing adequate training protocols for environmental health and safety regulations; and permitting, issuing and administering R&D FOAs as prescribed by the STAT and DOE/GTO. Furthermore, as the single point of contact with DOE, the project manager will ensure that the site mission, as defined by the DOE GTO and SEC team, is carried out.

Facility Operations

GeothermEx/Schlumberger, in collaboration with SNL, will be responsible for the operation of the facility, which will be conducted in collaboration with the Site Owners (U.S. Navy and Coso Operating Co.). The operator will be responsible for all field logistics and coordinating site operations.

Science and Engineering Coordination (SEC)

The SEC team will be co-led by LBNL and SNL. The roles of the SEC will be to (1) provide clear lines of communication within the SMT and to and from the STAT and DOE; (2) coordinate geosciences and geoengineering activities conducted at the site by SMT team members and non-Team R&D projects; (3) provide recommendations and guidance to STAT and DOE regarding R&D needs and potential FOA topics identified by the SMT as necessary to meet FORGE objectives and (4) report directly to DOE on project status, problems and future directions.

Geoscience and Geoengineering Teams

These groups will have multiple leads aligned along core capabilities of their institutions. Their role will be to identify, conduct and report on the necessary site activities related to reservoir characterization, well design, etc. Examples of specific activities are given in Figure 1. It is important to note that the Team responsibilities will depend on the project Phase. For instance, the Teams will focus on site characterization during Phases 1 and 2, but in Phase 3, all site characterization and other R&D activities will be evaluated through independent FOA and proposal evaluation processes. The Geoscience and Geoengineering Team leads will report directly to the SEC team. The Geoscience Team will have three leads: Lawrence Berkeley National Laboratory (LBNL), U.S. Geological Survey (USGS) and the University of Nevada, Reno and Nevada Bureau of Mines and Geology (UNR). The UNR Team will develop the 3D model for the site in Phase 1 and continue to update the model as more data are acquired in subsequent phases. Additional participants will include Sandia National Laboratories (SNL), GeothermEx, Itasca, and international partners (presently we have a commitment of interest from Japan, through ASTI). The Geoengineering Team will be led by GeothermEx and SNL with additional participation from LBNL, USGS, UNR, Itasca, and participating international partners. GeothermEx, playing a dual role as a Facility Operator, will assist with subsurface site characterization; field activities carried out by the Geoscience Team; development of the reservoir conceptual model, the induced seismicity protocol, and supporting NEPA clearance; developing well stimulation plans in concert with the Geoengineering Team and overseeing stimulation activities. As needed, the Geoscience/Geoengineering Teams will engage outside collaborators to provide additional expertise.

ENSURING THAT TESTED AND EVALUATED TECHNOLOGIES SUPPORT GTO OBJECTIVES

COMMUNICATION WITH SITE MANAGEMENT

Our Project Management Plan is structured to ensure that DOE has a direct path of communication with site management (through the Project Manager), SEC, and STAT. Through these lines of communication, DOE will be substantially involved in project decisions, including participation in decisions related to the technical, programmatic, and/or financial aspects of the project and operation of the FORGE site. As noted above, to ensure adequate integration of DOE, the SEC team will report directly to DOE via regularly scheduled teleconferences, face-to-face meetings and quarterly and annual reports. Furthermore, the FORGE site will include office facilities for on-site DOE personnel.

COLLABORATIVE APPROACH

To adequately address critical project or programmatic issues, all West Flank FORGE management and oversight activities will be conducted in collaboration with DOE, including recommendations of alternate approaches or delaying work or shifting emphasis, if needed. DOE will review ongoing technical performance to ensure that technical progress has been achieved within sub-phases before work can proceed to subsequent phases. Principally with the Project Manager, DOE will collaborate in the allocation of funds budgeted as work progresses and as funding needs may change among the different projects undertaken. DOE will be kept appraised and participate in the reviews of contractor activities and reports related to project activities. As stated in the "Conflict of Interest" section, below, DOE will review and resolve actual and perceived conflicts of interest with the SMT, STAT and outside contractors. DOE will also serve as a scientific and technical liaison between FORGE team and other program or industry personnel and interests.

OUTLINE RECURRING CYCLES: PLANNING & REVIEW, TECHNOLOGY SELECTION, TESTING & EVALUATION

Competitive R&D solicitations will be issued on an annual basis. To support the annual solicitations, the development of the areas of interest, development of the solicitations, issuance of the solicitations, and review of the solicitation responses will be a continuous process throughout the lifecycle of the project. Assuming annual awards are made on a fiscal year basis, the timeline shown in Table 1 will be implemented.

Table 1. Timeline for annual R&D solicitations

Task Name	Start	Finish
Development of R&D Needs	Nov. 1	Mar. 1
Write Solicitation	Mar. 1	Apr. 1
Issue Solicitation	Apr. 1	Apr. 1
Proposals Due	June 1	June 1
Review Proposals	June 1	Aug. 1
Notification of Award	Aug. 1	Aug. 1
Negotiation of Award	Aug. 1	Sept. 1
Funds Distributed	Oct. 1	Oct. 1

During the course of the FOA funded R&D projects, project participants will be required to provide quarterly project reports to the FORGE Project Management Team—the reports will be provided to DOE and to the members of the STAT. In addition to the required quarterly reviews, monthly teleconferences between the FORGE Project Manager or delegate and the awardee will be established. DOE and selected members of the STAT will be invited to these calls.

Furthermore, all activities occurring within and conducted by the SMT will be reported on a recurring monthly basis to the STAT and GTO. The SMT along with the SEC and Project Management group (site owners, facility operations and contract administration) will hold weekly meetings to provide status updates for internal (SMT) and external (outside R&D) projects and identify potential logistical issues, site characterization/monitoring needs and data dissemination. As noted, activities related to FOA funded R&D projects will be reported quarterly by the funded recipients to the SMT. The reports will be used to facilitate R&D

activities at FORGE, coordinate future operations, insure completion of R&D projects in a timely manner as defined by project milestones and the reports will be compiled in condensed form for presentation to the STAT and the GTO. Using appropriate scientific/trade meeting (e.g., GRC, Stanford Workshop, ARMA, AGU, etc.) as a forum, FORGE progress and status reports will be presented regularly to the general public (semi-annually at a minimum). As outlined in the separate Communications and Outreach Plan, regular meetings with the local communities and stakeholders describing FORGE operations, progress, and plans will be conducted.

R&D IMPLEMENTATION INVOLVES CLOSE COLLABORATION WITH THE SMT

All R&D projects conducted at West Flank FORGE will have access to logistical support that can be provided by the SMT (e.g., development and/or access to monitoring and testing wells), including any necessary support from outside contractors. Data acquired by the SMT, particularly data relevant to site characterization will be made available to all R&D projects in near real time (see the Data Dissemination plan). We will encourage potential responders to FOA-funded R&D projects work closely with the SMT during conceptual stages to facilitate project design, including logistical support, site data, etc. R&D project scientists will have site access, within the guidelines outlined by the U.S. Navy Command, and access to site facilities needed for project support.

ESTABLISHING AND MAINTAINING STAT

The role of the Science and Technology Analysis Team is defined by the GTO and consists of a group of best-in-class technical experts who will provide technical guidance needed to ensure that GTO objectives are fully considered and incorporated into the execution of FORGE, including associated Phase 3 R&D projects. The STAT will play a critical role in assessing R&D needs in accordance with GTO roadmaps and goals, establishing technical baseline information and performance specifications, guiding ongoing site characterization and monitoring efforts, developing topics for Phase 3 FORGE R&D solicitations, and providing guidance for review and selection of these R&D projects. Since it is likely that institutions represented within the SMT and STAT will be involved in responding to R&D solicitations, STAT will create an independent review panel consisting of external people and unconflicted STAT members to assess and rate R&D proposals. To mitigate possible conflict of interest issues, final R&D award decisions will be made by the GPO with the help of STAT recommendations.

The STAT will also assess the progress and results of the work carried out by the SMT at West Flank FORGE as well as independent scientific and engineering R&D implemented at FORGE under the Phase 3 solicitations and provide input to the SEC team for the development of annual Topical Reports. As noted above, we have placed STAT outside of the SMT box. By remaining outside the box, and therefore maintaining a degree of independence from the SMT, STAT will be afforded a better opportunity to evaluate operations, assess needs and recommend appropriate R&D topics. The STAT will communicate directly with DOE/GTO and the SEC team. In turn, the SEC team will gather and synthesize information and recommendations from the

Geosciences and Geoengineering Teams and Facility Operations that will be passed onto STAT for further independent evaluation.

In consultation with the GTO, ten members of STAT will be selected from the geosciences and geoengineering community. Members will be drawn from the GTO, national laboratories, academia, and the private sector and will, if appropriate, be paid a stipend for their services on the committee. The Navy will also provide a Naval Facilities Engineering Command employee to participate in STAT. A lead spokesperson will be selected, preferably a member of the GTO. The STAT will be charged to develop an internal process for evaluating potential conflict of interest cases that affect the STAT members associated with potential responses to R&D solicitations. DOE will review and provide final resolution of actual and perceived conflicts of interest with the STAT.

ADDRESSING CONFLICTS OF INTEREST AMONG SMT AND STAT

The R&D needs and associated solicitation topics will be developed by the STAT with guidance and assistance from the SEC and DOE. Given that individuals and/or institutions that make up the SMT, SEC and STAT may wish to propose R&D at the West Flank FORGE site during Phase 3, it is required that potential real or perceived conflicts of interest are mitigated. In our structure, the STAT is purposefully outside the SMT structure to act independently of the SEC and SMT. Because the role for STAT includes developing topics for recurring FORGE R&D solicitations, providing guidance for review and selection of R&D projects, and developing out-year R&D strategies, we are confident that the STAT—independent of the SMT—can assist in the development of solicitations with autonomy; this is one aspect of our mitigation strategy. The FORGE Project Manager will not propose R&D during the course of the project to allow effective firewalling of his activities from his parent institution and to allow unfettered assistance to the R&D procurement process.

Another aspect of our conflict of interest mitigation strategy involves the evaluation process for independent Phase 3 R&D proposals. Responses to the R&D proposal solicitation will be reviewed and ranked by an outside, independent Proposal Review Panel convened by STAT and the DOE/GTO. This Proposal Evaluation Panel will review proposals submitted in response to the Phase 3 R&D solicitations, which will have been developed and issued by the Prime Recipient. This Review Panel will be composed of people who are experts in fields relevant to the Phase 3 solicitations, but who are not actively involved in FORGE R&D activities. Furthermore, with respect to final selections of R&D proposals, it is envisioned (with concurrence from DOE/GTO) that while the Proposal Review Panel will provide its recommendations to DOE, the source selection officer will reside within the DOE/GTO.

Within the SMT, potential conflicts of interest relative to pursuing R&D solicitations will be evaluated on a case-by-case basis by the STAT. Because the STAT committee resides outside of the SMT box and acts independently of SMT, the STAT committee, with DOE and SEC participation will evaluate potential conflict of interest cases that affect the STAT members associated with potential responses to R&D solicitations. Every effort will be made to recruit outside qualified STAT members who do not have or anticipate potential conflicts. However, if STAT members are deemed conflicted they will recuse themselves from the development of solicitation topics. DOE will review and provide final resolution of actual and perceived conflicts of interest with the SMT, STAT, as well as outside contractors. DOE's option to appoint at least 30% of the STAT will offer an additional mitigating step. In addition, we propose that no more than 50% of the STAT be from organizations that make up the SMT. As an additional mitigation, we envision that those engaged in issuing the solicitation from the SMT (primarily select individuals from the Prime Recipient) will be suitably firewalled from the potential responders and will not be eligible to participate in responses to R&D solicitations.

Cladouhos, T., Petty, S., Sawyer, M., Udderberg, M., Nordin, Y., Results from Newberry Volcano EGS Demonstration , *Proceedings*, 40th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA (2015).

Doe, T., McLaren, R., Dershowitz, W., Weston, R., Discrete Fracture Network Stimulations of Enhanced Geothermal Systems, *Proceedings*, 39th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA (2014).

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