

The Convergence of Heat, Groundwater, & Fracture Permeability:
Innovative Play Fairway Modelling Applied to the Tularosa Basin

Project Officer: Michael Weathers

Mandatory slide

Principal Investigator: Gregory D Nash, Ph.D.
(& Carlon R Bennett (Co-I))

Organization: **Ruby Mountain, Inc. and Energy
& Geoscience Institute**

Track Name: Play Fairway Analysis Overview

Relevance to Industry Needs and GTO Objectives

The objectives of this project are to (1) apply, compare, and contrast knowledge-based and data-driven regional exploration models; (2) identify plays in the Tularosa Basin; (3) prioritize plays for prospect level evaluation; and (4) market identified plays

- The largest barrier is data -- play fairway analysis requires a significant spatially-distributed dataset to be effective
- An innovative hybrid PFA model has identified several plays
 - Implications for Fort Bliss, White Sands Missile Range, and NASA
- The project directly supports GTO goals
 - Lower risks and costs of development and exploration
 - Accelerate development of 30 GWe of undiscovered hydrothermal resources
 - Also supports Military Net Zero Energy and Installation Resiliency goals

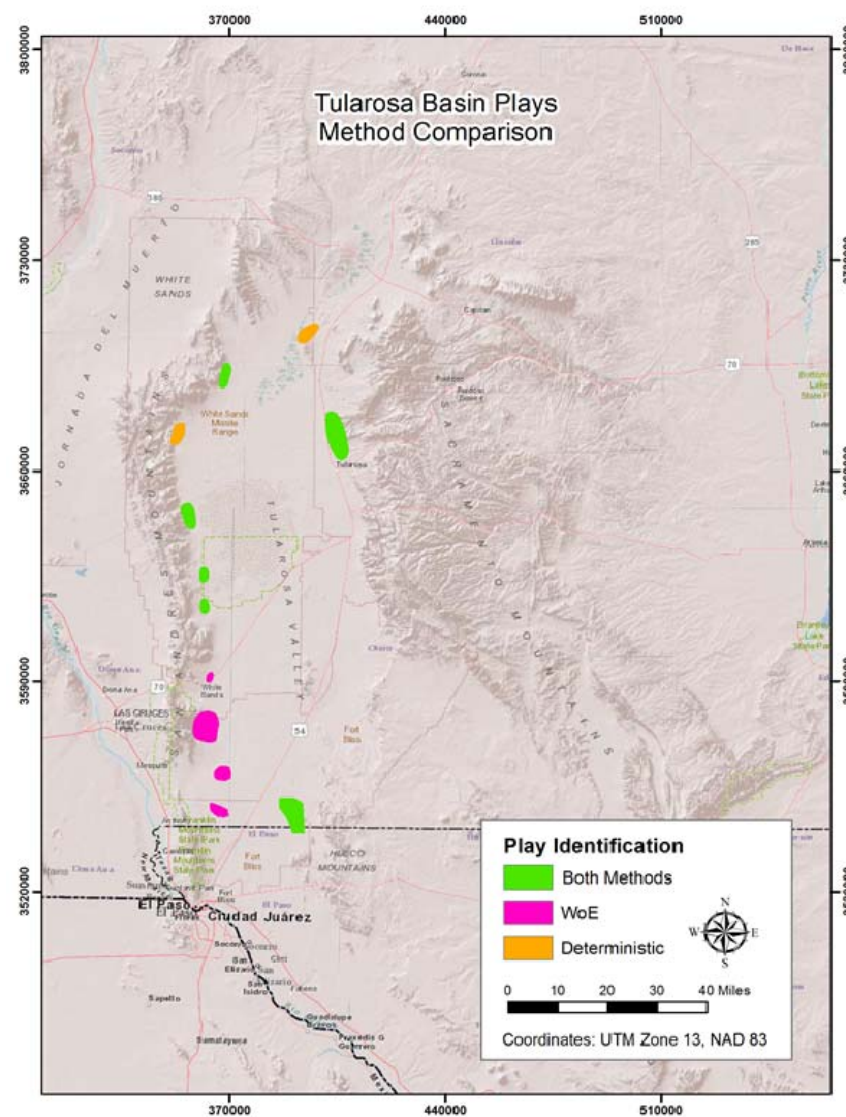
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- PFA database development
 - Heat CRS data
 - Temperature Gradients
 - Heat Flow
 - Geothermometers
 - PFA database development
 - Quaternary faults
 - Zones of critical stress
- PFAs
 - Deterministic petroleum industry method
 - Stochastic Weights of Evidence method
 - Play fusion

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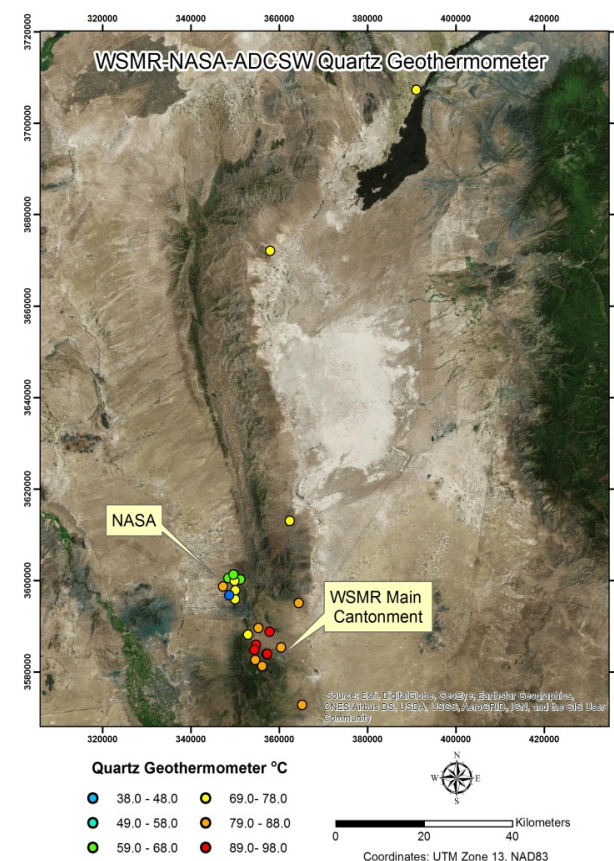
Technical Accomplishments and Progress

- Phase 1
 - Exhaustive data collection effort
 - PFA methods tested
 - Final PFA revealed 12 prospective areas
 - Plays were prioritized based upon proximity of power generation need and statistical certainty



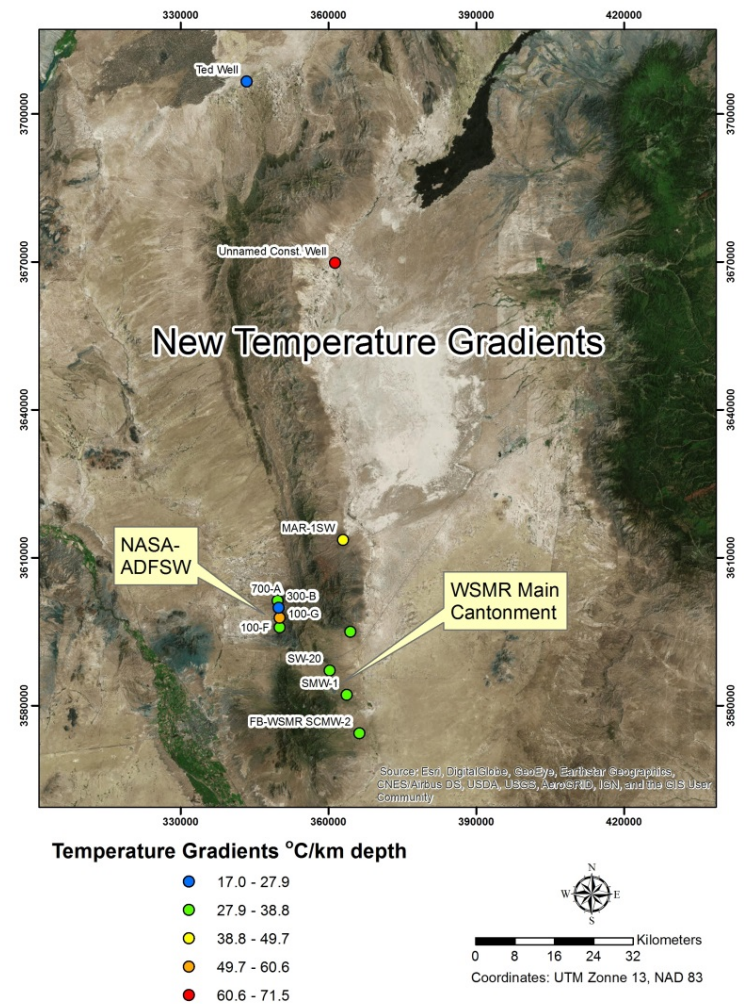
Technical Accomplishments and Progress

- Phase 2: Additional Data Collection
 - 25 water samples collected from existing wells by the Utah Geological Survey (UGS)
 - Supported geochemical analyses and geothermometry
 - Geothermometry (EGI) produced a cluster of ≥ 90 °C values near the White Sands Missile Range (WSMR) Main Cantonment
 - High value of 98 °C similar to temperature of RMI 56-5 at McGregor Range, Fort Bliss



Technical Accomplishments and Progress

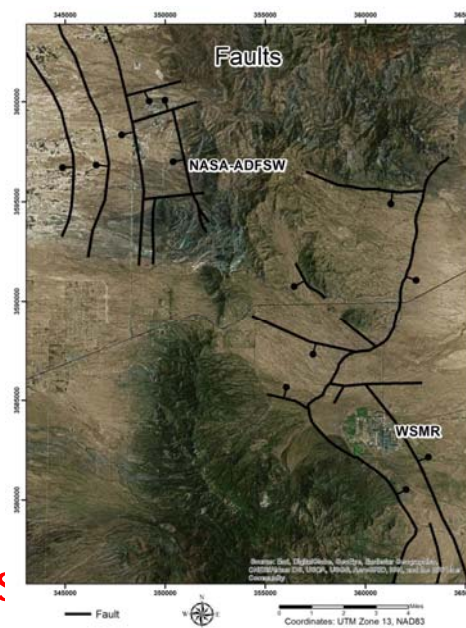
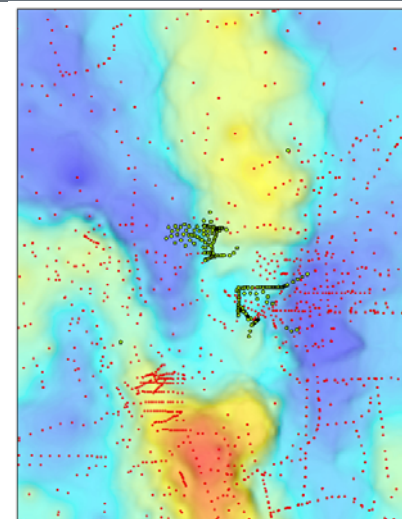
- Temperature Gradients
 - 11 existing wells logged (UGS)
 - Gradients were generally conductive, but showed modest temperatures
 - 70 °C/km, located near the USAF Ram Site, was the high
 - All tested wells were shallow and in alluvium
 - Locations not necessarily optimal



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Technical Accomplishments and Progress

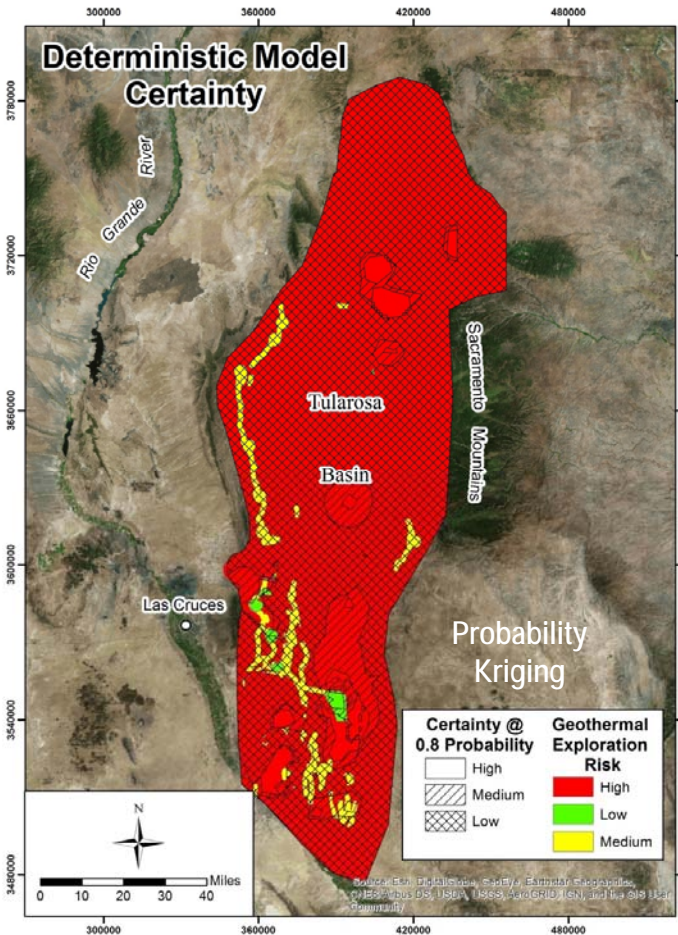
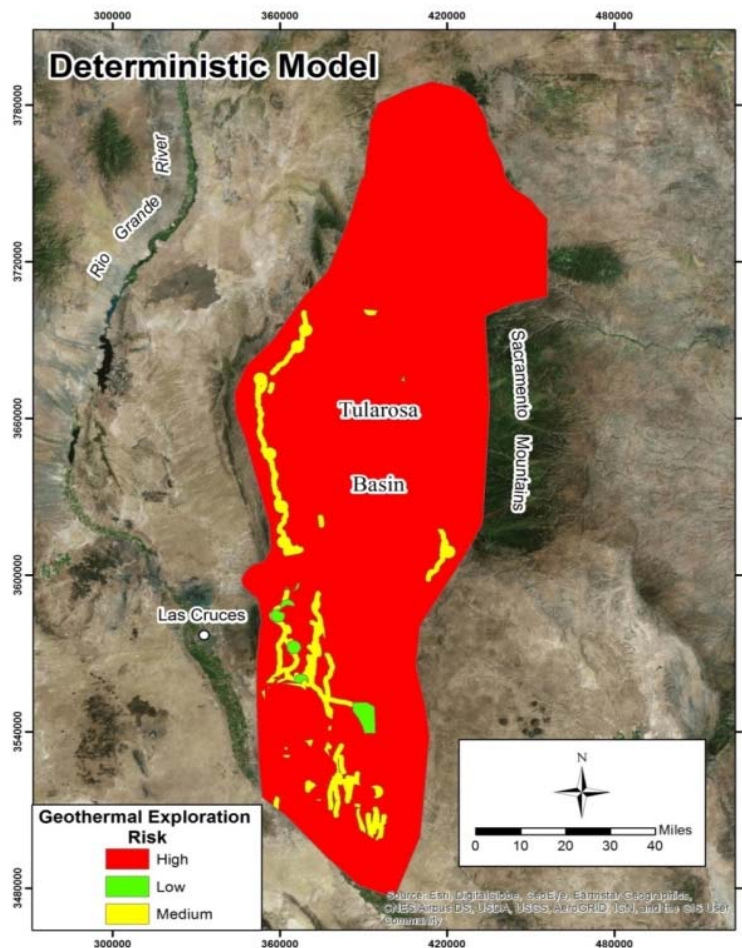
- Geology
 - Reconnaissance in all Phase 1 low priority plays (EGI)
 - No surficial evidence of hydrothermal activity was observed
 - Mapping with a structural emphasis at high priority plays (EGI)
 - Hydrothermal alteration noted along a Quaternary fault just north of the WSMR main cantonment
 - Massive silicification and silicified carbonate beds were noted at the NASA location
 - Data from 182 new gravity stations were obtained (UGS) to aid in structural model development
 - Fault mapping accomplished
 - Zones of critical stress were identified



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Technical Accomplishments and Progress

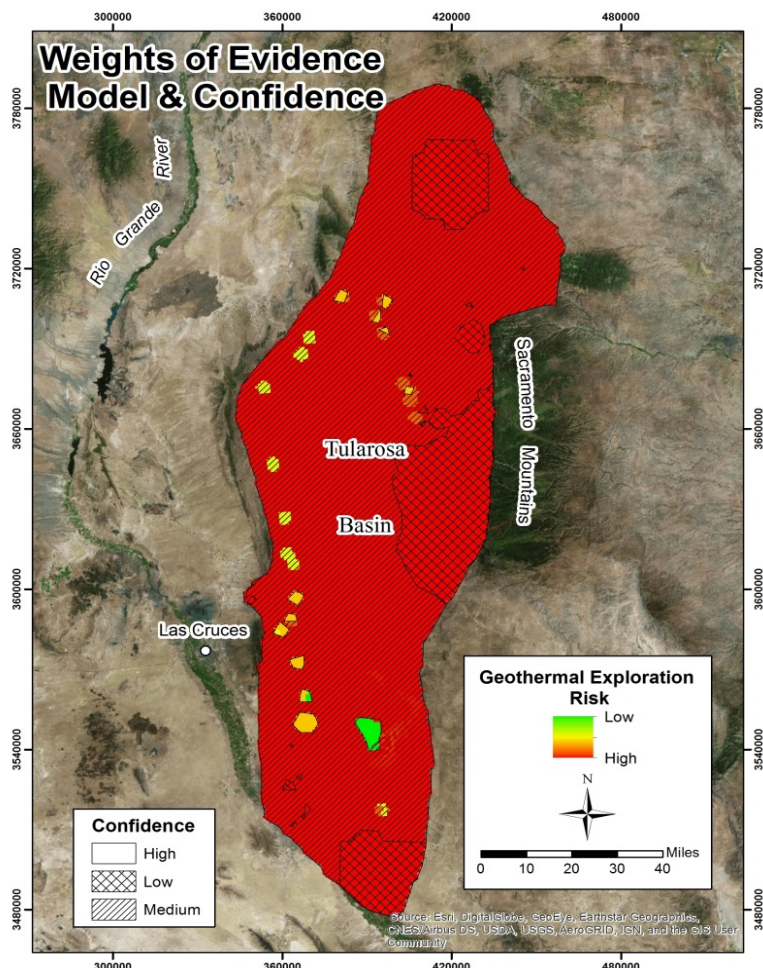
- Phase 2 PFAs: Petroleum industry logic (EGI)



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Technical Accomplishments and Progress

- Phase 2 PFAs: Weights of Evidence (EGI)

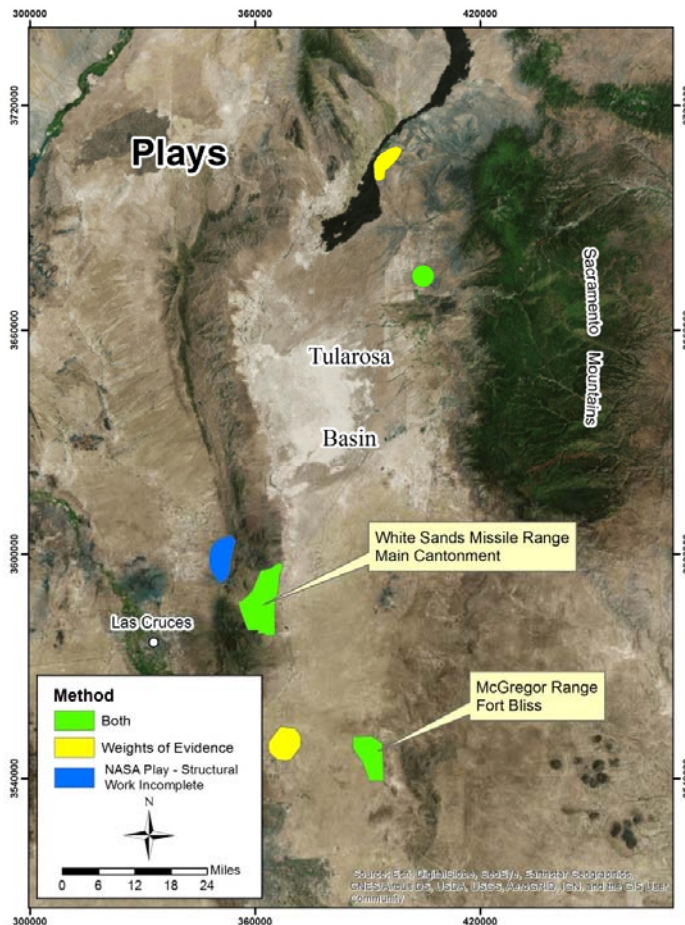


The Weights of Evidence process produces both a probability and confidence layer, which is overlain

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Technical Accomplishments and Progress

- Phase 2: Final Hybrid PFA



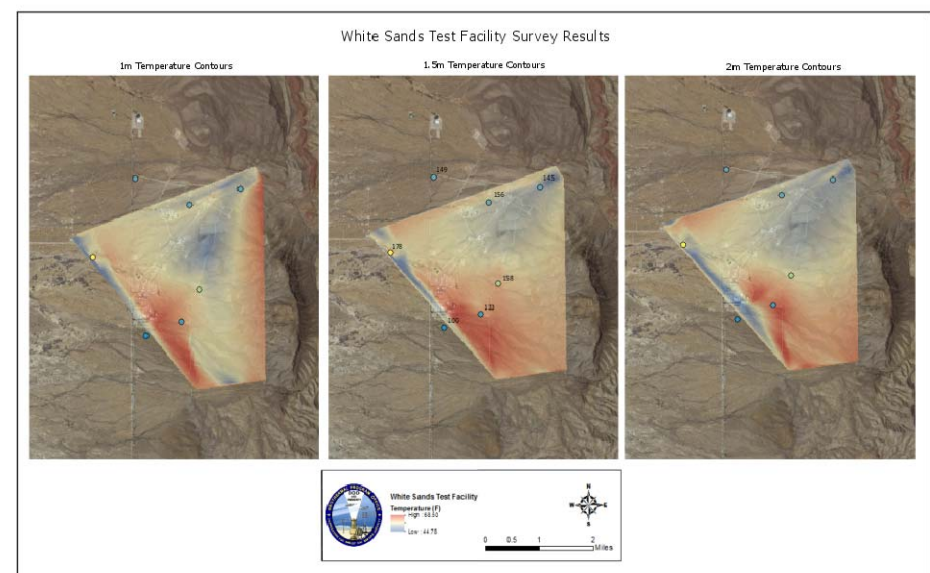
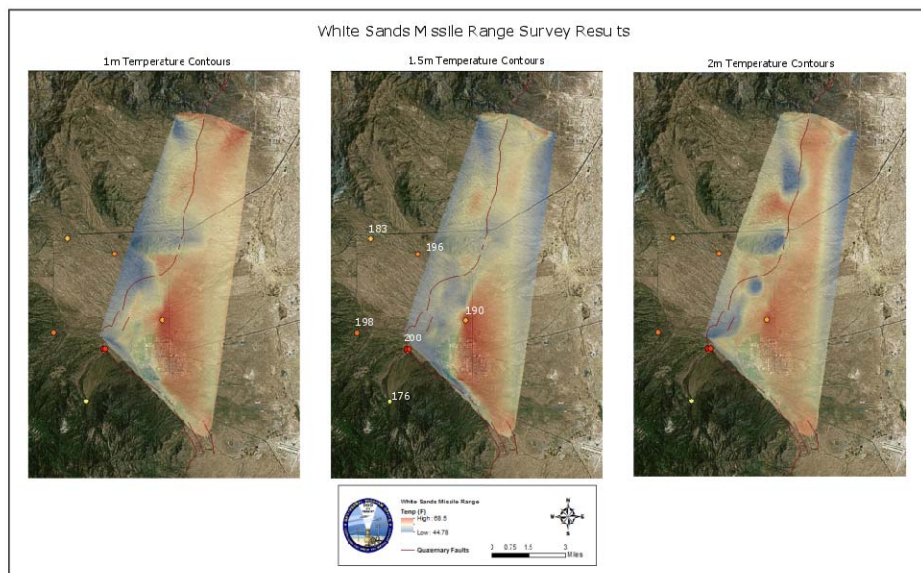
Phase 2 PFA results were similar to those of Phase 1. However, the WSMR Main Cantonment area play was strengthened. Additionally, plays that were based solely upon data extrapolation were removed to allow focus on the strongest plays.

The Tularosa Basin PFA Project continued long enough (through 2 phases) to achieve partial validation of methodology as evidenced by identification of the McGregor Range Resource.

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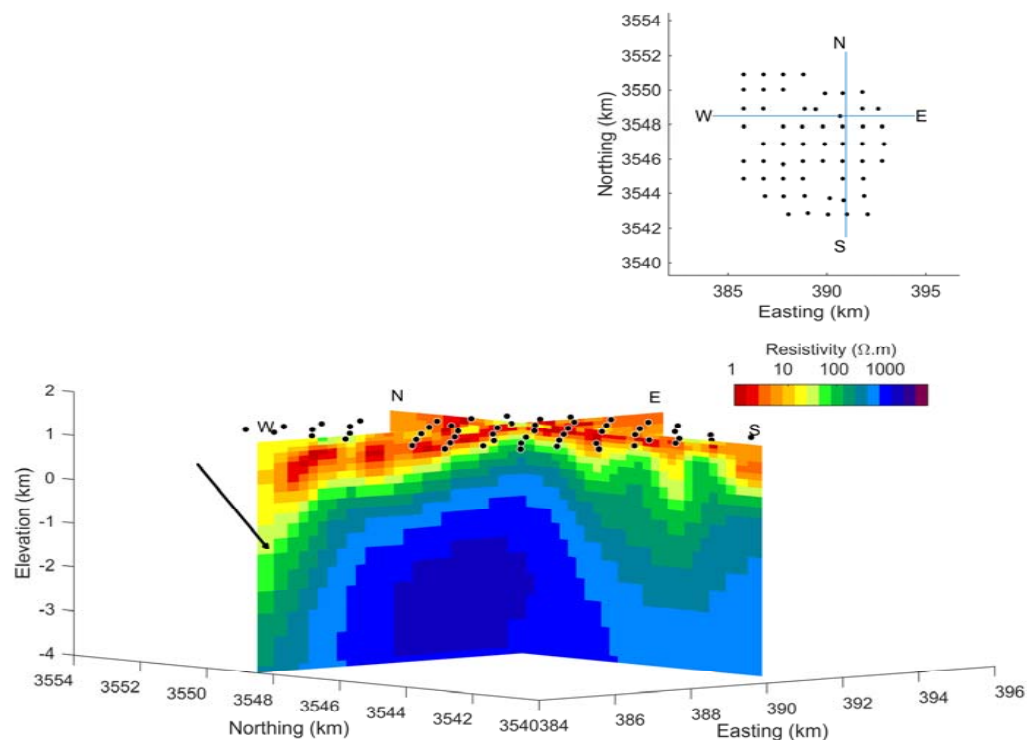
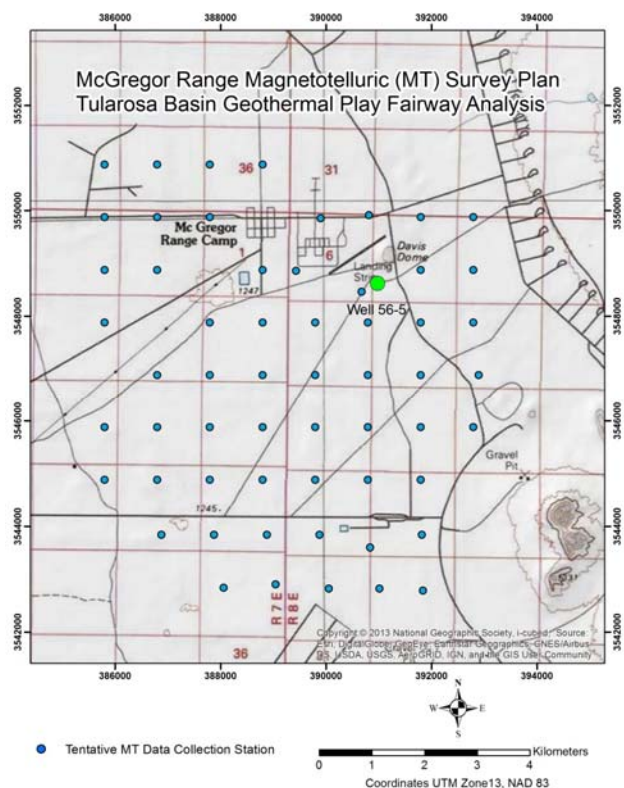
Technical Accomplishments and Progress

- Additional work
 - Shallow temperature surveys at the WSMR Main Cantonment Play and at NASA (Navy GPO) – 121 stations



Technical Accomplishments and Progress

- Magnetotelluric Survey at McGregor Range, Fort Bliss
 - Help with structural, conceptual geothermal model development for future drilling (Quantec Geoscience/EGI)



- Work to be completed (Fort Bliss Flow Test)
 - Flow test of Well RMI 56-5 at McGregor Range on Fort Bliss will be completed in 2018. Final site access, scheduling and logistical issues are now being addressed.
 - Well RMI 56-5 was drilled and completed to a subsurface depth of 3,030 ft. in 2013. Multiple flow and injection tests during well completion demonstrated repeatable measurements of commercial-grade permeability in bedrock. Preliminary estimates of well capacity are in the 300+ gpm range.
 - The upcoming followup flow test will hopefully confirm early results that a reasonable flow rate can sustain power production.
 - Next step would be deployment and testing of a small power plant could then be installed and tested ($\frac{1}{4}$ to $\frac{1}{2}$ MW).
 - Potential secure, reliable power need at McGregor Range up to $3\frac{1}{2}$ MWs.

- Tularosa Basin PFA was a Collaborative Effort
 - Ruby Mountain Inc. (Lead Agency)
 - Energy & Geoscience Institute at the University of Utah
 - Utah Geological Survey
 - Navy Geothermal Program Office
 - Barker Engineering
 - White Sands Missile Range (WSMR)
 - NASA
 - Aerospace Data Facility Southwest (ADFS)
 - Fort Bliss
- Project results presented at WSMR and ADFS
- Presentations/papers given at GRC and Stanford

Technical Accomplishments and Progress



Energy Efficiency & Renewable Energy

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
1. Water sample collection	Data collected	Dec. 31, 2016
2. Geochemical evaluation	Geochemical evaluation completed	April 15, 2017
3. Well logging/temperature gradients	Well logging and temperature gradients calculated	April 15, 2017
4. Gravity data infill	Gravity surveys completed and data processed	March 15, 2017
5. Fault mapping	Fault mapping completed	April 15, 2017
6. PFA GIS Update	Data from Phase 1 & 2 integrated into GIS database	May 1, 2017
7. PFAs rerun	Phase 2 deterministic and stochastic PFA models developed	May 30, 2017
8. Shallow temperature surveys	Surveys completed and data processed	April 15, 2017
9 MT survey	MT survey and inversions completed	April 15, 2017

- DOE funding has been discontinued
 - Easy job for peer reviewers!
- DoD funding is being sought to facilitate additional work at WSMR and NASA for:
 - Temperature gradient drilling
 - Stagegate
 - Additional gravity data infill
 - Magnetotelluric surveys
 - Geothermal conceptual model development
 - Stagegate
 - Production well siting
 - Power production at Fort Bliss' McGregor Range

- Our PFA methodology works
- Several Plays have been identified in the study area
- Results of Phase 2 have suggested the potential of a geothermal system at WSMR that may be similar in temperature to the known system at McGregor Range
 - Not high enthalpy
 - Requires high flow for power production
 - Could supply power to military installations (resiliency, security and purity for 2 or 3 installations)
 - WSMR and Bliss are very interested
 - Could save money and aid installation resiliency goals
 - If the McGregor Range RMI 56-5 flow test is encouraging, a small power plant may be installed
- WSMR could also benefit from geothermal space heating
- All DOE cost sharing targets met and exceeded.

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