SECOND AMENDMENT AND MION TO
ANNEX IX
OF THE
IMPLEMENTING AGREEMENT
BETWEEN
THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA
AND
THE MINISTRY OF ENERGY AND MINES OF THE REPUBLIC OF VENEZUELA
IN THE AREA OF
SUBSIDENCE DUE TO FLUID WITHDRAWAL

WHEREAS, the United States Department of Energy (hereinafter referred to as DOE) and the Ministry of Energy and Mines ot Venezuela (hereinafter referred to as MEMV) desire to cooperate in the field of energy research and development;

WHEREAS, in tne furtherance of their mutual Interest DOE and MEMV entered into the Agreement in the field of Energy Research and Development signed March 6, 1980 (hereinafter referred to as the Energy R&D Agreement);

WHEREAS, on July 12, 1983, DOE and MEMV entered into an Implementing Agreement in the area ot subsidence due to tluid withdrawal (hereinafter referred to as the Implementing Agreement);

WHEREAS, DOE and MEMV have a mutual Interest in technology exchange on the prediction ot subsidence as a result of tluid withdrawal;

WHEREAS, DOE and MEMV have a mutual interest in improving their present modeling capability to predict the occurrence of cracks produced by subsidence due to tluid withdrawal and/or removal ot subsurface material;

WHEREAS, an ability to predict the occurrence of the potentially damaging ettects ot differential subsidence is of considerable value to many DOE and MEMV programs;

WHEREAS, near-surface cracking has been observed in oil fields of the Bolrvar Coast, Venezuela, in response to discontinuous differential subsidence, providing a unique test area for the developnent and evaluation of predictive models for subsidence and horizontal deformation;

WHEREAS, some coastal dikes have been built to protect sane inland areas presently below sea level at some densely populated zones and to maintain tne oil and aquifer production trom this area of the Maracaibo basin;

WHEREAS, approximately 80% of the Venezuelan daily petroleum production oriqrnates in the Maracaibo basin;

WHEREAS, Article 7 of the Implementing Agreement and Article V of the Energy R&D Agreement ot March 6, 1980, provide that DDE and MEMV may amend the Implementing Agreement by mutual written consent;

It is agreed that the entire Implementing Agreement be replaced with the following:

ARTICLE 1

In accordance with Article V of the Energy R&D Agreement, the Venezuelan representatives of the Steering Committee have designated INTEVEP, S. A to act on behalf of MEMV under this Implementing Agreement. INTEVEP and DOE shall be hereinafter referred to as the Parties to this Implementing Agreement. The Assistant Secretary for Fossil Energy shall be primarily responsible for the programatic aspects of this Implementing Agreement for DOE. Lawrence Livermore National Laboratory shall carry out DOE's technical responsibilities under paragraph A, B, and D of Article 2 of this Implementing Agreement. Each Party shall designate one Project Manager for this Implementing Agreement; these Project Managers shall provide technical management and coordination of the tasks described ln thls implementing Agreement.

ARTICLE 2

The Parties shall cooperate ln tasks ln the area of subsidence due to fluid withdrawal as set forth below:

A detailed statement of work is provided in the Appendix to this Implementing Agreement.

A. Geophysical Probing

Task 1: LLNL shall provide INTEVEP with a detailed review of the geophysical techniques that have merit tor determining the nature ot fractures at three specific sites on the Bolivar Coast. Each of the above sites shall be considered in terms of its own underground characteristics, such as saturation, fluid composition, and material-type. The techniques to be evaluated shall include, but shall hot be limited to, surface based electromagnetic radar, electrical self-potential, two-loop mutual impedance, electrical reslstivity, seismic transmission, excitation-of-the-mass, borehole-to-borehole signal-transmission, and seismic emission.

Task 2: LLNL shall provide INTEVEP with recommendat ions for implementation of a reconnaissance system for detecting cracks and voids within the dikes along with Bolivar Coast of Lake Maracaibo.

Three metnods shall be evaluated for monitoring the dikes, Mutual Impedence, Magnetometric Resistivity, and Excitation of the Mass. The first two techniques are for detecting and delineating voids in the dikes and the third for detecting seepage paths under the dikes. Based on these evaluations, LLNL shall design a system and plan an experimental program to test it. LLNL and INTEVEP will jointly review this plan and decide whether to proceed with system fabrication and field tests, as a continuation of this task: if the decision is made to proceed, such activities shall be the subject of a future Amendment to this Implementing Agreement.

INTEVEP shall acquire samples of materials fran which dikes are made and ship these samples to LLNL for purposes of electrical characterization. Alternatively, INTEVEP shall provide to LLNL measured values or data fran which the characterization can be derived. INTEVEP shall also provide detailed drawings of a representative dike.

Task 3: Fullwave Recording of Data from Acoustic Emission Experiment.

A decision to include this task shall be made by the Parties at a later date and, if included, it shall be the subject of a future Amendment to this Implementing Agreement.

Task 4: Swept-Frequency Radar Development.

A decision to include this task shall be made by the Parties, based on fixed-trequency radar investigations done by INTEVEP and, if included, it shall be the subject of a future Amendment to this Implementing Agreement.

B. Seismic Hazard Studies

Task 1: Structure and Seismicity.

a) Seismic Network Installation/Data Acquisition.

LLNL shall assist INTEVEP in developing a model for relocating current and past selsnlclty aftectlng the eastern Lake Maracaibo region by temporarily deploying portable digital recorders and LLNL's central recording system to collect wavetorm data trom tne INTEVEP network. These portable recorders shall remain installed until tne INTEVEP network is operational. Cassette tapes trom these recorders shall be returned to LLNL for transcription and for preliminary processing.

b) Seismic F&traction Data Collection.

After the INTEVEP Q-log recording system is installed at permanent sites LLNL shall install additional stations with the assistance of INTEVEP personnel at up to 20 temporary sites located along refraction profile lines. Data fran several planned timed explosions (1 to 3 tons) shall be recorded using LLNL portable stations and combined with digital data from INTEVEP's digital stations in order to develop an accurate model of the shallow crustal structure.

c) Crustal Model Inversion.

LLNL snall provide INTEVEP with six computer programs and technical assistance for tne development ot a crustal model tor relocating current and historic seismicity in the area ot the Lake Maracaibo Bolivar Coast.

LLNL shall pertorm a preliminary interpretation of the data collected in Subtasks a) and b) for shallow structure in order to locate any seismicity recorded by the combined network of permanent and portable digitally recorded stations. Final interpretation and model developnent shall be done by INTEVEP upon conversion ot the SAC program to the INTEVEP IBM 4341, transter ot crustal model inversion programs, and the availability of seismic reflection protiles and velocity models near tne network.

d) Source Mechanism Studies.

LLNL Shall asslst INTEVEP personnel in the analysis ot focal mechanisms for selected events ~~trom data recorded in Subtask 6). In addition to first motion studies, moment tensor inversions and SV/P amplitude analysis shall be conducted, data allowing, on a subset ot the events. Finally, spectral~~ affecting the Bolivar Coast of Lake Maracaibo, if required.

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techniques shall be applied to estimate stress drop and other relevant source parameters. LLNL shall also determine if composite focal mechanisms can be interred on a routine basis with only the INTEVEP network.

e) Documentation and Training for Use of Canputer Programs for Geophysical Analyses.

LLNL shall provide documentation for computer programs described in Task c) above. These programs include programs for seismic data display and processing (SAC), modeling ot seismic source mechanisms, inversion of travel times tor velocity structure and location refinement, and other aspects contained in these tasks. LLNL shall provide greater detail on specific programs on request. LLNL shall also train INTEVEP's personnel to use these programs at LLNL or on their IBM computer.

f) Conversion of SAC for the IBM 4341 Cauputer.

LLNL programmers shall assist INTEVEP computer programmers and provide information necessary tor SAC to be implemented on INTEVEP's IBM 4341. LLNL shall provide SAC to INTEVEP on the understanding that SAC cannot be copied or transferred out ot the PDVSA's (Petroleos de Venezuela S.A.) system. INTEVEP shall provide LLNL with a copy of the FORTRAN source code for the version ot SAC wnich INTEVEP develops for tne IBM 4341.

Task 2): Seismic Hazard Evaluation.

a) Custanized methodology tor estimating the seismic hazard.

LLNL shall assist INTEVEP in characterizing the seismic hazards in the eastern Lake Maracaibo region. A methodology previously developed by LLNL will be moditied tor application in Venezuela.

Two types of data are necessary to perform this analysis. The tirst type is the description of the seismic activity, in the form ot a set of seismic zonation maps and their associated seismicity parameters. The second type is the description of the ground motion attenuation as a function ot distance trom the source and magnitude (or intensity) of the earthquake. These data will be provided by two sets ot experts chosen for their general knowledge of the area considered and their expertise in the fields of seismology and earthquake engineering. The tirst panel of experts will be organized by INTEVEP with the help of LLNL in the selection of tne panel members. For this panel of experts on zonation and seismicity (ZSP), no less than five (5) members will be selected. The choice of the experts will be made in concensus between INTEVEP staff and LLNL. tot the second panel on ground motion modeling (GMP), two teams will be formed. One team will consist of INTEVEP experts and the second team will be formed of LLNL staff.

LLNL will prepare and send the questionnaires to the experts and collect their answers. The actual computer files for use in the LLNL hazard code will be partly developed by LLNL and partly by INTEVEP. These will include:

- digitization ot the zonation maps (an average of two maps per ZSP, to be performed by INTEVEP).

- generate the tiles of seismicity (one file per ZSP, LLNL will develop the file for one expert and help INTEVEP in the development ot the remaining tiles).

- test these files for consistency and correctness (LLNL will review all the input files).

LLNL will update its computer codes and make changes necessary to account for the specific needs of this analysis.

An exhaustive sensitivity analysis will be performed to ascertain the relative importance ot each of the parameters used in the analysis and determine if any more work is needed. No major work in the field of ground motion modeling will be performed. Rather, the ground motion models, provided by the experts of the Ground Motion Panel, will be derived from available models.

A set of hazard curves giving the probability of exceedance, with its uncertainty, will be provided for one site. These curves will be used in other studies by INTEVEP to choose the appropriate seismic loading for performing dynamic analyses of the dikes.

b) Transfer of technology to INTEVEP.

The codes now available at LLNL have been developed for the CDC 7600 system and possess some features specific to LLNL, such as the plotting package. INTEVEP will need assistance to transfer and learn how to use these codes.

LLNL shall provide the LLNL hazard codes on tapes along wlth users manuals as early as possible in the course of the project. INTEVEP staff will set these codes on their system, however, because ot the canplexity of such codes, LLNL will provide to INTEVEP an employee knowledgeable with the codes to assist in the setting-up and training in the use of the codes for a total of two weeks. In a first step, the codes will be transferred to INTEVEP in their present form. INTEVEP will adapt these codes to their system with help fmn the LLNL staff. In the second step, a LLNL employee will deliver the customized codes and provide assistance for a period of one week at the INTEVEP location. Sane time later (approximately 1 or 2 months), LLNL will again send an employee to perfect the training of INTEVEP staff in using the codes, after they have been able to get more familiar with them.

c. Theoretical Studies on Compaction

Task 1: DOE and INTEVEP shall jointly conduct an exhaustive review of the literature to establisn the state-of-the-art with respect to conceptual and mathematical theories of compaction and its relationship to subsidence.

Task 2: DOE and INTEVEP shall jointly review the existing theories, laboratory methods, tield methods, and synthesize them into one state-of-the-art report.

D. Petrophysics Relating to Compaction

Task 1: l&oratory Measurements on Disturbed and Undisturbed Core for Parameter Evaluatron.

LLNL shall measure the effects of disturbance on the mechanical properties of clay and sandstone samples provided by INTEVEP by contrasting the behavior of the cores as furnished with the cores further disturbed by pressurization follow& by depressurization. Results shall be furnished in the fon of P-V curves and a tabulated set of PV and acoustic velocity values for each test. The data shall be Interpreted and conclusion of this task by LLNL. INTEVEP snall collect and snip appropriate amount of 4-1/2" core samples to LLNL. .

Task 2: Laboratory Determination of Parameters for Model Simulations.

LLNL shall perform three types of laboratory measurements to detine the behavior of the relatively undisturbed rock core furnished for laboratory testing by INTEVEP. Results shall be analyzed, conclusions presented and the data sets provided by LLNL to INTEVEP at the conclusion of this task, fmn which model parameters shall be determined. The data sets to be provided are Mohr-Coloumb fallure envelopes, elastic moduli and nigh pressure compressibilities. Thermal conductivities and diffusivities will not be determined as stated in the First Amendment to Annex lX due to inadequate consolidation of core material making these measurements impractical. INTEVEP shall select, prepare, and ship core samples to LLNL.

Task 3: Laboratory Studies of Long-term Creep Compaction of Reservoir Materials Under Appropriate Pressures and Temperatures.

a) Boliver Coast Samples.

LLNL shall subject rock samples provided by INTEVEP to constant stress long enough to detecmrne a constltutlve relationship useful in predicting the long-term response of the samples. LLNL shall test both sandstone and shale samples under controlled conditions of confining pressure, pore pressure, temperature and time. Acoustic velocities shall be measured periodically and the changes in sample volumes shall be determined. Data shall be reported by LLNL in qraphlcal and tabular form and shall present the creep compaction as functions of pressure, temperature and time. The data shall be analyzed and conclusions drawn. INTEVEP shall collect and ship appropriate samples to LLNL.

b) Faha Samples.

LLNL will study the time-dependant creep compaction, under appropriate conditions of pressure and temperature, experienced by the reservoir samples the Faja Petrolitera Del Orinoco.

Shale and sandstone samples tmn the cap rock and the reservoir will be analyzed under controlled conditions of confining pressure, pore pressure, temperature, humidity, and time. Six shale samples and two sandstone samples will be tested, at both 55 degrees C and 150 degrees C, under hydrostatic conditions. Ultrasonic measurements (VP and VS) will be performed periodically on the samples. The change in sample volume will be determined by measurement of the fluid expelled from the sample at constant pore pressure and effective stress. Data will be reported in qraphrcal and tabular form and will present the long-term deformation (compaction) as functions of pressure (effective), temperature and time. The data will be analyzed jointly by INTEVEP an LLNL personnel and conclusions will be drawn.

INTEVEP shall collect and snip to LLNL the appropriate samples by early 1986.

Task 4: Familiarization ot INTEVEP Personnel in Advanced K&oratory Techniques and Apparatus.

A decision to include this task shall be made by the Parties at a later date and, if included, shall be the subject ot a future Amendment to the Implementing Agreement.

ARTICLE 3

A. DOE shall contribute $25,000 in U.S. dollars to the cost ot carrying out Paragraph C of Article 2 of this Implementing Agreement, subject to the availability ot appropriated funds. Except for the $25,000 contribution by DOE, all costs attributable to this Implementing Agreement, including but not limited to research, reports, travel, salaries and associated expenses, shall be borne by INTEVEP.

B. INTEVEP shall provide to DOE a financial contribution in U.S. dollars to support its share ot the work in accordance with procedures to be identified by DOE prior to the first deposit.

c. Unless otherwise agreed by the Joint Steering Committee, the total amount to be pard by INTEVEP to DOE over the period of this Second Amendment and Extension, subject to the availability of appropriated funds, shall not exceed 840,000 in U.S. dollars for carrying out Sections A, B and D of Article 2 of this Second Amendment and Extension

D. LLNL shall be responsible for the transport, including satekeeping and insurance en route, of DOE components and testing equipment to be used in Venezuela under Sections A and B, trom the United States by plane or snip to an authorized port ot entry in Venezuela convenient to the ultmate destination. INTEVEP snall reimburse DOE for all expenses incurred tor the transport, including safekeeping and insurance en route, ot these canponents and equipment. INTEVEP snall be responsible tor the transport, including safekeeping and insurance en route, of these components and equipment, trom the authorized port ot entry in Venezuela to the ultmate destination and snall be responsible tor the return ot these amponents and equipments, satekeeping and insurance en route, to an authorized port ot entry in the United States convenient to the ultmate destination.

ARTICLE 4

The Parties shall support the widest possible dissemination of information arising trom this Implementing Agreement in accordance wrth Article 2 of the Annex to the Energy R&D Agreement. If a Party nas access to proprietary information as defined in Article 2 of the Annex to the Energy R&D Agreement which would be useful to the activities under this Implementing Agreement, such information shall be accepted tot the tasks only on terms and conditions as agreed in writing by the Parties.

ARTICLE 5

Rights to any invention or discovery made or conceived in the course ot or under this Implementing Agreement shall be distributed as provided in paragraph 1 ot Article VI of the Energy R&D Agreement. As to third countries, rrqnts to such inventions shall be decided by the Joint Steering Committee.

Each Party shall take all necessary steps to provide the cooperation from its inventors required to carry out this Article. Each Party shall assume the responsibility to pay awards to compensation required to be paid to its cm nationals according to its own laws.

ARTICLE 6

The existing terms and conditions of the Energy R&D Agreement shall continue and remain in full force and effect notwithstanding the terms of this Second Amendment and Extension. Articles 3, 4, 5, 6, 7, and 8 of the Annex to the Energy R&D Agreement are hereby incorporated by reference.

ARTICLE 7

This second Amendment and Extension to the Implementing Agreement shall enter into force upon the later date of signature and shall remain in force for a period of 18 months. It may be amended or extended by mutual written consent of the Parties in accordance with Article V of the Energy R&D Agreement.

12, Feb 88

ARTICLE 8

This Second Amendment and Extension may be termrnated at any time at the discretion of either Party, upon six (6) months advance notification in writing to the other Party by the Party seeking to terminate. Such termination shall be without prejudice to the rights which may nave accrued under this Second Amendment and Extension to erther Party up to the date of such termination.

Done in Washington, D.C., and Caracas, Venezuela.

THE JOINT STEERING COMMITTEE

On behalf of DOE

B & f -
& d a Keith Frye

George Stosur
Member George Stosur

Thomas C Wilson
Alternate Member Robert Folstein

Aug. 12, 1986
Date

On behalf of MEMV

Enrique Vasquez
Member Enrique Vasquez

Manuel Alayeto
Member Manuel Alayeto

Member Aldo Boccardo

AUG 12TH, 1986
Date