Table 1

WELLHEAD GENERATOR WELLS AT LOS AZUFRES

Well No.	Production Interval (m,asl)	Initial Total Depth (m)	Steam Production (t/h)	Steam Fraction (%)
Az-5	1407-1829	1493	65	0.59
Az-6	1918-2170	900	48	1.00
Az-13	1710-1908	1219	62	0.53
Az-17	2187-2253	627	100	1.00
AZ-19	1173-1848	1666	29	0.43

Table 2

INITIAL-PERIOD SIX-MONTHLY AVERAGED PRODUCTION DATA

Module	Well No.	Period	P_{wh} (kg/cm^2)	P_{sep} (kg/cm^2)	Q_s (t/h)	X_s (%)	H_{wh} (kJ/kg)
South	Az-6	1-82	37.88	--	13.5	1.0	2886.1
		2-82	8.56	--	44.5	1.0	2828.4
		1-83	8.19	--	42.0	1.0	2828.2
		2-83	8.38	--	42.0	1.0	2824.9
		1-84	8.23	--	42.0	1.0	2814.2
	Az-17	1-82	42.45	--	38.0	1.0	2665.0
		2-82	22.04	9.0	62.6	1.0	2769.3
		1-83	20.60	9.2	62.0	1.0	2800.0
		2-83	20.21	9.5	62.0	1.0	2799.0
		1-84	19.14	9.8	60.1	1.0	2772.5
North	Az-5	1-82	22.95	--	34.0	0.44	1825.9
		2-82	31.65	9.2	60.0	0.63	2023.4
		1-83	28.21	9.2	59.2	0.62	2052.6
		2-83	27.36	9.6	57.8	0.60	2023.0
		1-84	27.75	9.8	58.9	0.62	2010.8
	Az-13	1-82	33.38	--	26.5	0.59	1746.8
		2-82	10.93	8.7	60.0	0.60	1954.0
		1-83	8.97	8.7	61.0	0.60	1824.5
		2-83	10.28	8.7	59.2	0.59	1809.4
		1-84	9.32	8.5	60.9	0.57	1690.7
	Az-19	1-82	34.25	--	16.5	0.38	1223.4
		2-82	8.51	8.5	27.0	0.44	1625.8
		1-83	9.08	8.9	18.0	0.32	1409.9
		2-83	7.75	7.6	16.0	0.28	1321.3
		1-84			*		

*well Az-19 was shut-in January, 1984 due to insufficient production.

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Stehfest, H., "Numerical Inversion of Laplace Transforms. Algorithm No. 368," Comm. ACM, 13, No. 1, 47-49, January, 1970.

Stehfest, H., "Remark on Algorithm 368 [D5] Numerical Inversion of Laplace Transforms," Comm. ACM, 13, No. 10, 624, October, 1970.

Table 4

INPUT DATA FOR CPI SWEEP RECHARGE ANALYSIS

	Sandstone	Water
Reservoir Geometry		
Length		$L = 1900$ m
Cross sectional area		$S = 3.6\times10^5$ m^2
Porosity		$\phi = 0.18$
Mean fracture spacing		MFS = 100 m
Reservoir Conditions		
Initial temperature		$T_i = 295$°C
Sweep water temperature		$T_{in} = 150$°C
Recharge water temperature		$T_p = 52$°C
Production rate ('82-'83)		$Q = 4.85\times10^5$ kg/h
Heat transfer coefficient		$h = 1703$ W/m^{2}K
External heat transfer		$q' = 0$ kJ/m
Physical Properties		
Density (kg/m^3)	$\rho_r = 2380$	$\rho_f = 921$
Specific heat (kJ/kgK)	$C_r = 0.92$	$C_f = 4.87$
Thermal conductivity (W/mK)	$k = 2.40$	--

Table 5

RESULTS OF COOLDOWN HISTORY MATCH

Component	Input Temperature (°C)	Matched Flowrate (kg/s)	Estimated Contribution (%)
Percolation	52	55.2	41±2
Sweep	150	68.7	51±2
Hot Water	$T_{in}+\Delta T\, e^{-\lambda t}$ (see Table 3)	10.8	8±4

FOCUS ON

DRAFT

MEXICO

A GEOTHERMAL INTERNATIONAL SERIES

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GEOTHERMAL TECHNOLOGY DIVISION (GTD)

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UNDER CONTRACT NO. 9-X36-3652C

PREPARED BY:

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PREFACE

The *Focus on* Series is prepared to give the U.S. Geothermal Industry a quick profile of several foreign countries. The countries depicted were chosen for both their promising geothermal resources and for their various stages of geothermal development, which can translate into opportunities for the U.S. geothermal industry. The series presents condensed statistics and information regarding each country's population, economic growth and energy balance with special emphasis on the country's geothermal resources, stage of geothermal development and most recent activities or key players in geothermal development. The series also offers an extensive list of references and key contacts, both in the U.S. and in the target country, which can be used to obtain detailed information.

The series is available for the following countries:
Argentina, Azores (Portugal), China, Costa Rica, Ecuador, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Jordan, Mexico, St. Lucia, Thailand.

Additional countries might be available in the future.

The series is to be used in conjunction with four other publications specifically designed to assist the U.S. geothermal industry in identifying and taking advantage of geothermal activities and opportunities abroad, namely:

- The *"Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities."* Final Report, August 1987. Prepared for Los Alamos National Laboratory.

- The *"Summary Report"* of the above publication.

- *"Equipment and Services for Worldwide Applications,"* U.S. Department of Energy.

- The *"Listing of U.S. Companies that Supply Goods and Services for Geothermal Explorers, Developers and Producers Internationally,"* August 1987, prepared by GRC.

Copies of these publications can be obtained from the Geothermal Technology Division of the U.S. Department of Energy. Correspondence should be addressed to:

Dr. John E. Mock
Geothermal Technology Division (GTD)
1000 Independence Avenue
U.S. Department of Energy
Washington, DC 20585
(202) 586-5340

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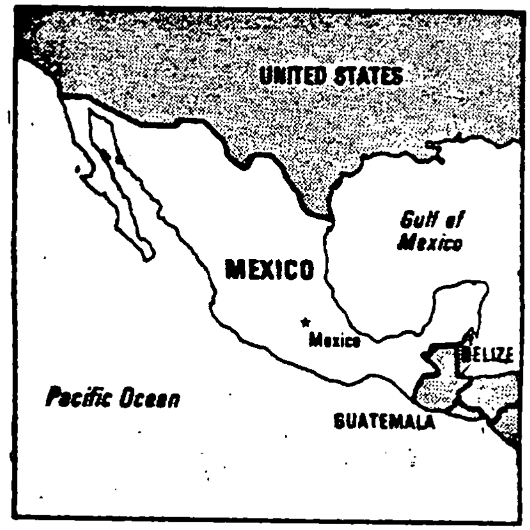
FOCUS ON

MEXICO



<u>Official Name</u>: The United Mexican States

<u>Area</u>: 1.978 million sq. km. (764,000 sq. mi.)

<u>Capital</u>: Mexico City

<u>Population (1985)</u>: 78.8 million

<u>Population Growth Rate</u>: 2.5%

<u>Languages</u>: Spanish

<u>Economic Indicators</u>:

Real GDP (1984): $185 billion
Real Annual Growth Rate (1984): 3.7%
Per Capita Income (1984): $2,350
Avg. Inflation Rate (1984): 59.2%

<u>Trade and Balance of Payments</u>:

(1984) Exports: $25.2 billion; Major Markets: U.S., EC, Japan
(1984) Imports: $11.3 billion; Major Suppliers: U.S., EC, Japan

(December 1985) Official Exchange Rate: 345 pesos = U.S. $1 (controlled rate);
490 pesos = U.S. $1 (free market rate)

<u>Energy Profile</u>: (Based on 1982 data unless otherwise indicated)

- Commercial Fuel Energy Consumption:

  Total: 92.585 million ton of oil equivalent (mtoe)
  1-Yr. Growth: 14.1%

- Commercial Fuel Breakdown:

  Liquid Fuels Pct: 59%
  Solid Fuel Pct: 5%
  Natural Gas Pct: 28%
  Electric Pct: 8%
  Commercial Fuel Consumption Growth Rate (1970-1980): 7.1%

- Electricity Generation Capacity:

(1982) Total Installed Elec. Capacity: 21,574 MW
Hydro: 37%
Hydro Potential: 25,250 MW
Steam: 48%
Gas Turbine: 9%
Diesel: 5%
Other: 1%
Note: Other sources indicate that, as of 1986, a total of 650 MWe of on-line geothermal generated electric capacity, (about 3% of the total installed capacity)

- Electricity Sales:

Total: 52,611 GWh
Residential: 18%
Commercial: 75%
Industrial: *
Government: 7%
Other: *
Average Electricity Price: 2.77 U.S. cents/kWh

- Geothermal Power Generation Status:

Reservoir Potential (MW): A possible total of 13,020 MWe
Temperature Range: 50^{o}-$355^{o}C$ depending on fields

- Geographic Locations: Northwestern Mexico and south-central Mexico.

- Development Status: Various development stages, including 650 MWe of on-line geothermal generated electricity

- Countries Actively Involved: U.S.

- General Need for Assistance: Reservoir modeling and testing, commercial power production

- International Funding: $622,568 (UN/DTCD)

* Negligible

The Cerro Prieto geothermal field, located in northwestern Mexico along the California-Mexico border in the Mexicali Valley, is the major site of geothermal development in Mexico. The field has been in production since 1973 and has the distinction of being the first liquid-dominated geothermal system in North America to provide significant electrical production.

Cerro Prieto is located along a continental spreading zone bounded by the right-lateral strike-slip Imperial and Cerro Prieto faults. The heat source is presumed to be magma bodies (dikes and sills) intruded into the recent sediments of the Colorado River Delta, and derived from gabbroic plutons rising from an oceanic-type spreading ridge. Volcanic rocks at the surface consist of two rhyodacite cones comprising the Cerro Prieto Volcano. At least five eruptive phases have occurred since late Pleistocene (110,000 years).

The Laguna Volcano area, located a short distance southwest of the developed geothermal field, is the site of many surface thermal manifestations. The area consists of low hills built up by hot spring fumarolic activity and is thought to result from reservoir leakage to the southwest along high angle fracture zones. Laguna Volcano has been the site of phreatic explosions in the past, the latest occurring in 1927.

Over 140 deep geothermal wells have been drilled at Cerro Prieto since exploration first began in 1959. Fluids at temperatures above 300°C (335°C maximum) are produced from 103 production wells at depths ranging generally between 1000 and 3500 m. The deepest well is 4,125 m deep. Reservoir production zones increase in depth from southwest to northeast partly in response to fluid migration upward along high-angle faults and increasing depth to basement to the northwest. Reservoir modeling studies have shown that the field is recharged from the east by hot (355°C) fluids, and from both the east and west by cooler (50° to 150°C) water.

Cerro Prieto has 620 MWe of installed capacity. A continued commitment by the Mexican government toward geothermal development resulted in the initial investigations within the volcanic regions of southern Mexico. Experimental farms for lobster breeding using effluents of the field are presently being tested.

In 1967, CFE began exploration at Los Azufres (Michoacan) and later in 1980 at Los Huseros (Puebla). The Los Azufres geothermal field is located in central Mexico approximately midway between Mexico City and Guadalajara. Exploration at the field began in 1976 when CFE initiated a deep drilling program to evaluate the geothermal potential of the area. Although there were many drilling problems associated with volcanic rocks and high temperatures, the program was successful in discovering a thermal reservoir with temperatures exceeding 300°C.

The field lies within the Neovolcanic belt in complex Pliocene-Pleistocene successions of basalts, andesites, trachy-andesites, decites, and rhyolites from three volcanic cycles. The reservoir is separated into two sectors, the Maritaro (or northern) sector is a liquid-dominated system and the Tejamaniles (or southern) sector is a vapor-dominated system.

Presently, over 40 wells have been completed in the two sectors of the field. In the northern sector, fluids are supplied to three 5 MWe portable

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Lippmann, M.J., Goldstein, N.E., S.E. and Witherspoon, P.S., 1984, "Exploration and Development of the Cerro Preito Geothermal Field," Journal of Petroleum Technology, Sept. pp. 1579-1591.

A. Business Climate Sources of Information

The following references are suggested for timely information on the business climate in Mexico.

U.S. GOVERNMENT PUBLICATIONS

U.S. Department of Commerce

- Foreign Economic Trends (FET) and their Implications for the U.S.
- Overseas Business Reports (OBR)

U.S. Department of State

- Background Notes

NON-GOVERNMENT PUBLICATIONS

- International Series, published by Ernst and Whinney
- Businessman's Guide to......., published by Price Waterhouse and Co.
- Information Guide: Doing Business in ......, published by Price Waterhouse and Co.
- Task and Trade Guide, published by Arthur Andersen
- Task and Investment Profile, published by Touche Ross and Co.

C. KEY CONTACTS

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Attn: Samuel Taylor
Officer in Charge
USAID Mission
Tel: 211-0042

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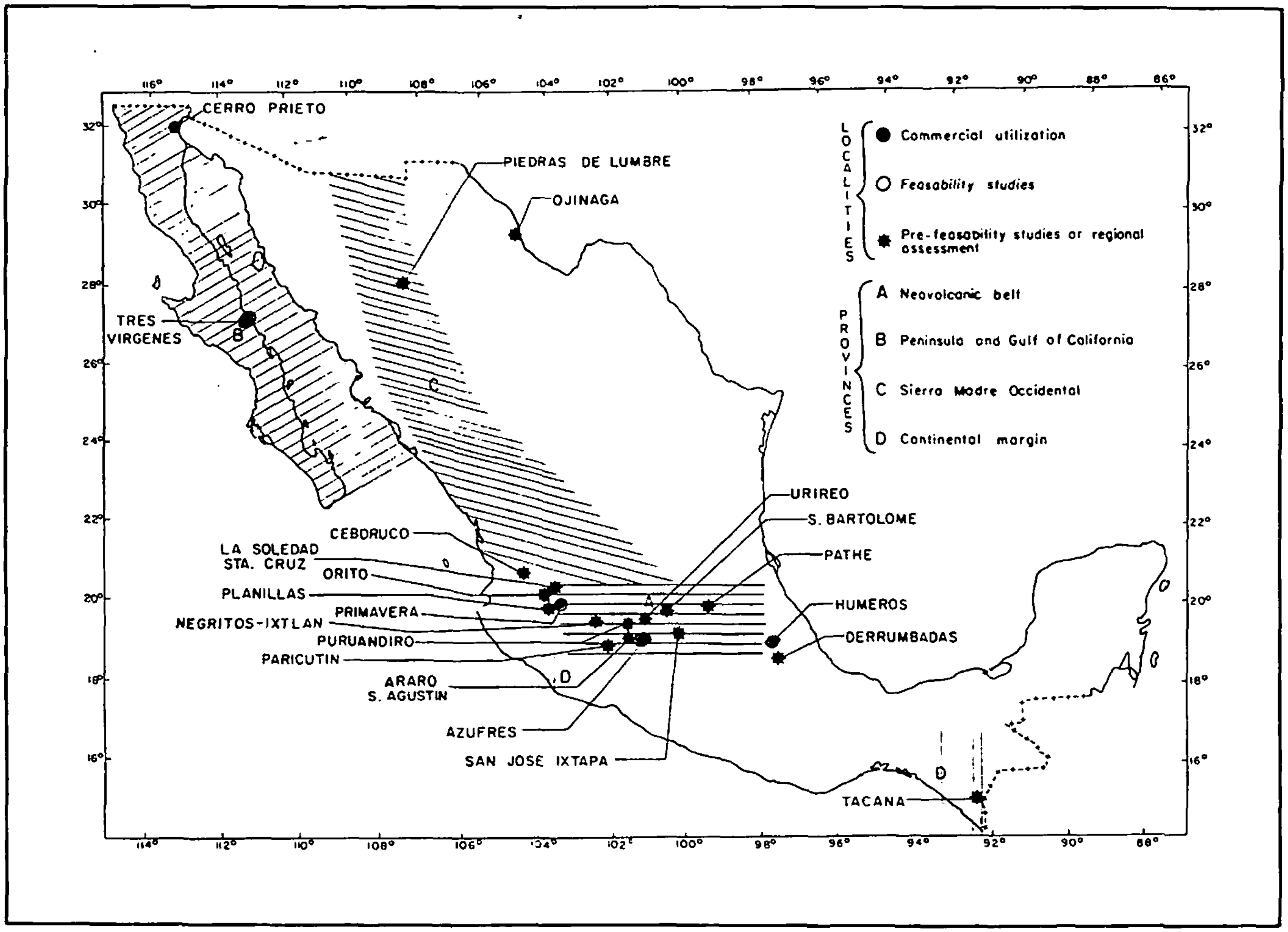
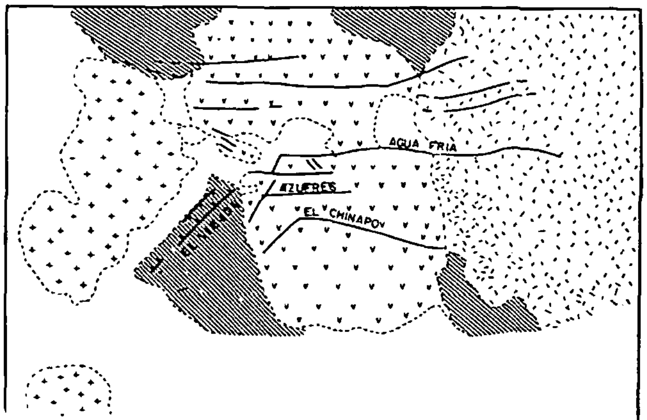


Figure 1. Geothermal provinces in Mexico and main geothermal localities

permeability. This kind of operation is considered as an alternative for other wells that had poor permeability when drilled vertically.

WELL PRODUCTION CHARACTERISTICS

In the Tejamaniles-Puentecillas area (southern portion of the field) wells, whose production zone is located between 1900 and 2200 masl, produce dry steam. In some cases, the steam is superheated. The excess of temperature ranges from 5 to 30°C. In the northern area of the field,



United States Government **Department of Energy**

memorandum

DATE: September 29, 1992

REPLY TO ATTN OF: CE-12

SUBJECT: Anticipated Trip to Mexico

TO: R. Loose (CE-121)
T. Mock (CE-122)

It appears that I will be a part of the team accompanying Mike Davis to Mexico and would represent the resource person regarding Wind and Geothermal. We are expected to meet with utility types, EPRI-types, and representatives of financial institutions.

I need the latest and best input on what we have in Mexico, any issues or problems, what we would suggest as being most suitable for their needs, and anything else you think would help me represent us adequately. Do a little role-playing, and think of questions you might raise if you were one of these types.

A handwritten response is fine.

Ron

Roland R. Kessler, Director
Office of Renewable Energy Conversion
Conservation and Renewable Energy

RRK/maf
9209018

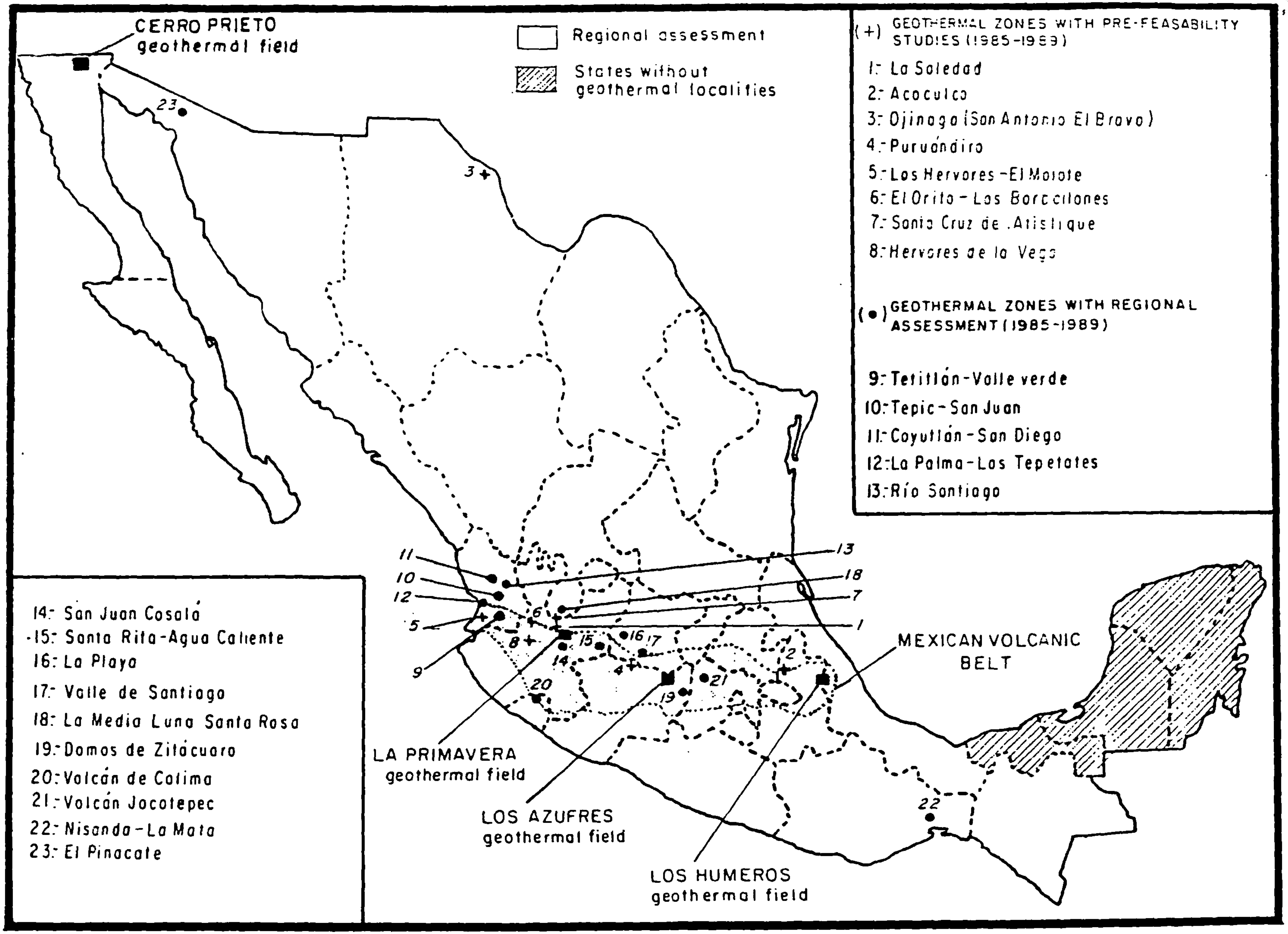


FIG. 1.- GEOTHERMAL FIELDS AND THERMAL ZONES STUDIED BETWEEN 1985 AND 1989 IN MEXICO.

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LOS AZUFRES
[illegible]

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Table 4

INPUT DATA FOR CPI SWEEP RECHARGE ANALYSIS

Reservoir Geometry		
Length		$L = 1900$ m
Cross sectional area		$S = 3.6\times10^5$ m^2
Porosity		$\phi = 0.18$
Mean fracture spacing		MFS = 100 m
Reservoir Conditions		
Initial temperature		$T_i = 295$°C
Sweep water temperature		$T_{in} = 150$°C
Recharge water temperature		$T_p = 52$°C
Production rate ('82-'83)		$Q = 4.85\times10^5$ kg/h
Heat transfer coefficient		$h = 1703$ W/m^{2}K
External heat transfer		$q' = 0$ kJ/m
Physical Properties	Sandstone	Water
Density (kg/m^3)	$\rho_r = 2380$	$\rho_f = 921$
Specific heat (kJ/kgK)	$C_r = 0.92$	$C_f = 4.87$
Thermal conductivity (W/mK)	$k = 2.40$	--

Table 5

RESULTS OF COOLDOWN HISTORY MATCH

Component	Input Temperature (°C)	Matched Flowrate (kg/s)	Estimated Contribution (%)
Percolation	52	55.2	41±2
Sweep	150	68.7	51±2
Hot Water	$T_{in}+\Delta T\, e^{-\lambda t}$ (see Table 3)	10.8	8±4

Cerro Prieto Kruger

COMISION FEDERAL DE ELECTRICIDAD

FAX

GERENCIA DE PROYECTOS GEOTERMOELECTRICOS

ENTREGUESE A:

Nombre DAVID N. ANDERSON

Cia. o Dpto. EXECUTIVE DIRECTOR, GEOTHERMAL RESOURCES COUNCIL

Ciudad DAVIS, CAL., U.S.A.

Fax No. (916) 7 58 28 39

DE PARTE DE:

Nombre DR. GERARDO HIRIART LE BERT

Departamento SUBGERENCIA DE EXPLORACION Y DESARROLLO.

FAX: 43-14.47.35

EL ENVIO CONTIENE 4 PAGINAS INCLUYENDO ESTA PORTADA SI TIENE PROBLEMAS EN LA RECEPCION COMUNIQUESE AL TEL. (43) 14 39 70 (MORELIA MICHOACAN).

Mensaje

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To Mike Wright	From David Anderson
Co.	Co.
Dept.	Phone #
Fax #	Fax #

Fecha: MARZO 4, 1993.

GEOTHERMAL RESOURCES COUNCIL

DAVID N. ANDERSON
Executive Director

1993 GRC GEOTHERMAL ELECTRICITY SURVEY

Geothermal Industry Estimates of Future-Year Generating Capacity

Company COMISION FEDERAL DE ELECTRICIDAD Respondent GERARDO HIRIART LE BERT

Title ______ Address ALEJANDRO VOLTA 655, COL. ELECTRICISTAS

MORELIA, MICH. 58290, MEXICO

Telephone (43) 14 39 70 FAX (43) 14 47 35

I. Geothermal Electricity Capacity

1. Installed Capacity On-Line 31 Dec 1991 720 MWe
2. Firm Capacity to be On-Line 31 Dec 1992 740 MWe
3. Expected Capacity On-Line 31 Dec 1993 753 MWe
4. Estimated Capacity to be On-Line by end of year:

	1995	2000	2005
a. Announced	813	913	
b. Probable, with successful technical development		1043	1103
c. Possible, with favorable institutional incentives		1073	1223

II. Geothermal Power Plant Size

5. For existing geothermal fields, expected size of new units,
   - Portable or Wellhead --- MWe
   - Central Power Plant 20 MWe
6. For new geothermal fields, expected size of new units,
   - Portable or Wellhead 3-5 MWe
   - Central Power Plant --- MWe
7. Are there plans to replace Portable or Wellhead Units with larger Central Power Plants? NO
   If yes, will the smaller Portable or Wellhead Units be used elsewhere? ______

EXISTING UNITS

NAME OF UNIT	CAPACITY (MWe)	YEAR OF INITIAL OPERATION
CP-I, UNIT-1	37.5	APRIL/73
CP-I, UNIT-2	37.5	SEPT/73
CP-I, UNIT-3	37.5	MARCH/79
CP-I, UNIT-4	37.5	MARCH/79
CP-I, UNIT-5	30.0	JAN/82
CP-II, UNIT-1	110.0	JAN/86
CP-II, UNIT-2	110.0	APRIL/87
CP-III, UNIT-1	110.0	JAN/86
CP-III, UNIT-2	110.0	AUG/86
LOS AZUFRES, U-1	5.0	JUL/82
LOS AZUFRES, U-2	5.0	AUG/82
LOS AZUFRES, U-3	5.0	AUG/82
LOS AZUFRES, U-4	5.0	AUG/82
LOS AZUFRES, U-5	5.0	AUG/82
LOS AZUFRES, U-6	5.0	DEC/86
LOS AZUFRES, U-7	50.0	NOV/88
LOS AZUFRES, U-8	5.0	DEC/89
LOS AZUFRES, U-9	5.0	APR/90
LOS AZUFRES, U-10	5.0	NOV/92
LOS HUMEROS, U-1	5.0	MAY/90
LOS HUMEROS, U-2	5.0	DEC/90
LOS HUMEROS, U-3	5.0	MARCH/91
LOS HUMEROS, U-4	5.0	OCT/91
LOS HUMEROS, U-5	5.0	OCT/92

III. Geothermal Power Plant Directory

8. For the whole Company, list existing on-line geothermal generating units and planned units below.

Company COMISION FEDERAL DE ELECTRICIDAD

EXISTING UNITS

Name of Unit	Capacity (MWe)	Year of Initial Operation
(SEE ATTACHED LIST)		

PLANNED UNITS

Name of Unit	Capacity (MWe)	Year of Initial Operation
CERRO PRIETO 3 UNIT 3	20	FEB/95
CERRO PRIETO 3 UNIT 4	20	MAY/95
CERRO PRIETO 3 UNIT 5	20	FEB/96
CERRO PRIETO 3 UNIT 6	20	MAY/96
LOS AZUFRES UNIT 13	20	MAR/97
LOS AZUFRES UNIT 14	20	JUN/97

COMMENTS:

Return Completed Form to: PAUL KRUGER
Geothermal Energy
819 Allardice Way
Stanford, CA 94305

[signature]

COMISION FEDERAL DE ELECTRICIDAD
GERENCIA DE PROYECTOS GEOTERMOELECTRICOS

FAX

ENTREGUESE A:

NOMBRE: PHILIP MICHAEL WRIGHT

CIA. O DEPTO.: UNIVERSITY OF UTAH RESEARCH INSTITUTE

CIUDAD: SALT LAKE CITY, UTAH, U.S.A.

FAX No.: (801) 584-4453.

DE PARTE DE:

NOMBRE: ING. JOSE FRANCISCO ARELLANO GUADARRAMA.

DEPARTAMENTO. DE EXPLORACION. OFNA. DE GEOFISICA

3 ENERO 1994.

MENSAJE ADICIONAL:

Tryy Holiday Inn in Golden, CO - with [illegible] call him or Joyce at 4337

COMISION FEDERAL DE ELECTRICIDAD

GERENCIA DE PROYECTOS GEOTERMOELECTRICOS

Ofic. No. J3112/JFAG/001/94.

Morelia, Mich., a 3 de enero, 1994.

MR. PHILIP MICHAEL WRIGHT
TECNICAL VICE PRESIDENT
UNIVERSITY OF UTAH RESEARCH INSTITUTE
FAX (801) 584-4453
SALT LAKE CITY, UTAH, USA.

Dear Mike:

In connection with the talks that will be held next January, for the signation of a new research and development agreement between the US DOE and the CFE of Mexico, for geothermal energy, I send you this proposal, in which are summarized the items that represent the maximum geophysical interest for us, taking account of the present status of geothermal development in Mexico.

As a general quotation I propose to focus our joint effort to solve some specific problems, more than to the general exploration strategy. Of course, the results must be applied to solve real problems of geothermal projects, for which we can provide all the available information and the cooperation of our technical staff.

The main difference with the previous agreement is that we don't want to pay special attention to the comprehensive analysis of available information in specific geothermal fields, but instead, the solution of specific problems in some of them, without concerning if this represents only an aspect of the general exploratory problem.

At present we are engaged with the exploration of geothermal prospects in which there are only minor geothermal activity at surface and no evident structural control, but certainly related to Holocenic volcanism. (El Ceboruco, Nay., Las Tres Vírgenes, B.C.S., Acoculco,Pue.)

...iled interpretations required

2.- Comprehensive digital files formation for storage, retrieve and managing of relevant data of the project. Stablishment of the standard forms for data interchange.

3.- Development of a general strategy for error analysis and propagation during the interpretation process, in order to give confidence limits to the models.

4.- Development of strategys for detailed interpretation of small size targets (1 km) or for subtle geophysical efects.

Maybe you have solved some of these problems in your institution in which case we request your advise for the stablishment of equivalent solutions in the CFE.

The specific problems that we propose to discuss with you - - next January in Mexicali are:

1.- Topografic effects on gravity, magnetics, electric dc soundings and MT surveys in rugged terrain. Data from Tres Virgenes and El Ceboruco.

2.- Modelling of anomalously oriented magnetic dipoles and isolated - - poles.Data from Laguna Salada and Cerro Prieto.

3.- Directional filtering and artificial illumination for qualitative - trend analysis of contour maps. Data from El Ceboruco.

4.- Potential fields continuations from irregular surfaces. Data from El Ceboruco.

5.- Modelling and interpretation of gravity, magnetics and MT data from El Ceboruco, Acoculco or Tres Virgenes.

6.- Pasive seismic studies. Advise in equipment, site selection, maintenance, trigger parameter adjustment and data interpretation. Data from Tres Virgenes or El Ceboruco.

7.- Advise in Remote Sensing. Equipment selection,software,and data -- processing for geothermal exploration. Data from Acoculco or El -- Ceboruco.

8.- Geographic information systems for geothermal prospecting. Data -- from Los Azufres.

- Thermal condctivity measurements in cuttings. Calibration standards for comparative measurements of samples. Difusivity and density measurements.

- Anomalous climatic and convective inner effects in gradient holes. Modelling or bound analysis.

- Design and building of fast response sensors for continuous temperature loging.

- Effect of shallow aquifers on gradient data, modelling and - interpretation.

- Thermal interpretation of temperature logs in production - - wells, with the aim of thermal exploration strategy design - for unknown areas.

- Modelling of the coolling of intrusives, life span, effects of convection, origin of the thermal energy in geothermal sys-- tems, heat transfer mecanism between the heat source and the hydrothermal system.

- Data from Laguna Salada, Araró, El Ceboruco, Los Humeros and Los Azufres.

We hope that this topics will be of your interest for their inclusion in the future agreement. We expect to have your opinion and your proposals not only on these but on any other study of your interest.

Sincerely yours,

ING. JOSE FRANCISCO ARELLANO G.
JEFE OFNA. DE GEOFISICA.

C.c.p. Ing. Saúl Venegas S.-Jefe del Dpto. de Exploración.
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Mexico

COMISION FEDERAL DE ELECTRICIDAD
GERENCIA DE PROYECTOS GEOTERMOELECTRICOS

Morelia, Mich.; 25-05-93

JOSEPH MOORE, HOWARD ROSS, AL TRIPP, MIKE WRIGHT
University of Utah Research Institute
391 Chipeta Way Suite C, Salt Lake City Utah USA.

Fax (801) ~~524-3453~~
584-4453

Dear colleague,

The Revista Mexicana de Geoenergía- "GEOTERMIA", is published every four months by the Federal Commission of Electricity in Mexico, since 1985. Spanish is the official language of the magazine. All the articles are published with an abstract in English or French. Contributions in these languages with an abstract in Spanish are also accepted. With an edition of 1000 copies, "GEOTERMIA" is distributed among individuals, institutions and universities which are in contact with geothermics or with the Earth Sciences. This includes general and specialized libraries of our country and those in other nations having geothermal developments. At present, it is the only periodic publication in Spanish, specialized in geothermal energy and diffused worldwide. The diffusion of our magazine is carried out by mail, exclusively between registered subscribers, distributed in 30 countries, the following way:

Central America --> 125	South America --> 35	USA --> 48
Europe ---> 51 (West+East)	Africa, Asia, Oceania --> 24	

TOTAL ABROAD= 283 **TOTAL IN MEXICO= 680**

"GEOTERMIA" is recognized as a magazine with referring, having international diffusion (registration No. ISSN 0186-5897). It is a corporate member of the International Geothermal Association (IGA) and cooperates closely with this organization in the diffusion of know-how and specific informations. Received mail, points out that the references made to this magazine are multiple, as is registered in several publications and bibliographical bulletins, inside and outside Mexico.

Due to the international prestige you have into the geothermal community and in order to fortify the technical supports of our magazine, I invite you to participate as adviser of the Editorial Council of "GEOTERMIA". Your participation could consist in writing from time to time some article for our magazine. In case that your response be affirmative, I request you to answer as soon as possible. Our FAX is (Mexico) + (43) 14 4735.

Best regards,

Mario César Suárez Arriaga
Editor in Chief of "GEOTERMIA"

MEXICO-UNITED STATES RENEWABLE ENERGY COOPERATION PROGRAM (PROCER)

(PROGRAMA DE COOPERACION EN ENERGIA RENOVABLE)

PROGRAM BRIEFING

SEPTEMBER 19, 1991

CHRISTOPHER ROVERO
INSTITUTE FOR ENERGY AND ENVIRONMENTAL ANALYSIS
OAK RIDGE ASSOCIATED UNIVERSITIES

COMMITTEE ON RENEWABLE ENERGY COMMERCE AND TRADE (CORECT)

TECHNICAL COMPETITIVENESS SUBCOMMITTEE

MEXICO-US RENEWABLE ENERGY COOPERATION PROGRAM (PROCER)

BACKGROUND

- o MEXICAN GOVERNMENT IS IMPLEMENTING PROGRAM OF ELECTRIFICATION WITH OFF-GRID RENEWABLES, INCLUDING SUBSIDIZED HOUSEHOLD ELECTRIFICATION AND LOAN-FINANCED PRODUCTIVE USE APPLICATIONS.

- o PRIVATE SECTOR MARKET FOR OFF-GRID RENEWABLES IS ALSO EXPECTED TO GROW SIGNIFICANTLY.

- o THE ABOVE TWO FACTORS ARE LEADING TO RAPID EXPANSION OF THE MEXICAN RENEWABLE ENERGY INDUSTRY AND SECTOR.

- o PREREQUISITES TO SUCCESSFUL PROGRAM IMPLEMENTATION AND SECTOR EXPANSION INCLUDE TRAINING, INFORMATION TRANSFER, AND RESOURCE ASSESSMENTS.

- o U.S. TECHNICAL ASSISTANCE IN ENERGY TECHNOLOGY AND INSTITUTIONAL ISSUES CAN PLAY A SIGNIFICANT ROLE IN INITIAL YEARS OF PROGRAM.

RESPONSE

PROCER IS AN ATTEMPT TO DEVELOP A PROGRAM THAT MEETS THE INFORMATION, TRAINING, AND TECHNICAL ASSISTANCE NEEDS, WHILE PROMOTING MAXIMUM INVOLVEMENT OF U.S. INDUSTRY IN THE ELECTRIFICATION PROGRAM AND MAXIMUM ACCESS TO THE MEXICAN MARKET. WHILE INITIAL FOCUS IS PRIMARILY ON ISOLATED SYSTEMS, PROCER WILL INCLUDE ACTIVITIES TO PROMOTE GRID-CONNECTED BIOMASS, WIND, AND SMALL-HYDRO.

PROCER TEAM

EXPORT COUNCIL FOR RENEWABLE ENERGY (ECRE)
SANDIA NATIONAL LABORATORY
OAK RIDGE ASSOCIATED UNIVERSITIES (ORAU)
NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION (NRECA)
OTHERS AS APPROPRIATE, FOR EXAMPLE WINROCK IN BIOMASS INDUSTRY ASSESSMENTS

MEXICAN COUNTERPARTS

PRONASOL/SECRETARIAT OF PLANNING AND BUDGET (SPP)
FEDERAL ELECTRICITY COMMISSION/ELECTRIC RESEARCH INSTITUTE (CFE/IIE)
MEXICAN SOLAR ENERGY ASSOCIATION INDUSTRY GROUP (ANES)
NACIONAL FINANCERA (NAFIN)

CHARACTERISTICS OF PROCER RELEVANT TO A.I.D.

PROCER IS MARKET AND PROJECT DRIVEN. EFFORTS ARE BEING MADE TO INSURE THE MARKET-RELEVANCE OF PROCER ACTIVITIES, TO INSURE THE INVOLVEMENT OF U.S. AND MEXICAN INDUSTRY IN ACTIVITIES, TO INSURE THE RELEVANCE OF ACTIVITIES TO SPECIFIC FIELD PROJECTS, AND TO INSURE THE AVAILABILITY OF EXTERNAL FINANCING FOR RENEWABLE PROGRAMS AND PRIVATE SECTOR ACTIVITIES.

EXAMPLES

- ECRE IS PLAYING A SIGNIFICANT ROLE IN PROGRAM PLANNING AND OPERATION, IN ORDER TO INSURE MARKET RELEVANCE AND THE PARTICIPATION OF U.S. INDUSTRY. THE INFORMATION TRANSFER AND DISSEMINATION ACTIVITY WILL BE COORDINATED BY ECRE, IN PART FOR THESE REASONS.

- THE MEXICAN RENEWABLE INDUSTRY GROUP IS ALSO PLAYING A SIGNIFICANT ROLE IN THE PROGRAM.

- THE AWEA ANEMOMETER LOAN PROGRAM WILL BE RUN THROUGH THE MEXICAN PRIVATE SECTOR (CIEDAC AND CONDUMEX). ANEMOMETER STATIONS WILL BE PLACED AT PROPOSED PRONASOL WIND PROJECT SITES WHERE THE LOCAL WIND RESOURCE MUST BE VERIFIED. WHILE THE DATA WILL BE INTEGRATED INTO THE IIE WIND RESOURCE DATABASE, THE INITIAL PURPOSE OF THE DATA WILL BE TO ALLOW FOR AN INFORMED GO/NO GO DECISION ON SPECIFIC OFF-GRID WIND PROJECTS.

- WORKSHOPS WILL INCORPORATE U.S. INDUSTRY PRESENTERS INTO THE MAIN PROGRAM, AND INCLUDE TIME AND SPACE FOR COMPANIES' EXHIBITS AND ADDITIONAL PRESENTATIONS.

- PILOT AND DEMONSTRATION PROJECTS ARE NOT RESEARCH ORIENTED. THEY WILL BE DESIGNED TO AID IN IDENTIFICATION OF STANDARDIZED OR TYPICAL SYSTEMS FOR WIDESPREAD REPLICATION BY CFE AND ELECTRIFICATION CONTRACTORS, AND WILL INCLUDE DIRECT PARTICIPATION OF U.S. FIRMS.

- PROCER WILL ASSIST IN INSURING AVAILABILITY OF EXTERNAL FINANCING FOR BOTH PUBLIC AND PRIVATE SECTOR RENEWABLE PROJECTS. IN RESPONSE TO PROCER-INITIATED DISCUSSIONS, U.S. EXIMBANK HAS AGREED IN PRINCIPLE TO SET UP A SPECIAL CREDIT FACILITY FOR MEXICO RENEWABLE PROJECTS AND EQUIPMENT IMPORTS. PROCER WILL ALSO WORK WITH PRONASOL/SPP TO DEVELOP PROPOSALS FOR WORLD BANK/IDB FINANCING, AND WILL ATTEMPT TO ARRANGE FOR WORLD BANK PREFEASIBILITY STUDIES AND INCORPORATION OF A RENEWABLES TEAM IN WORLD BANK POWER SECTOR ASSESSMENT.

- TRAINING EFFORTS WILL BE TARGETED PRIMARILY AT PRIVATE SECTOR. U.S. INDUSTRY WILL BE HEAVILY INVOLVED IN TRAINING ACTIVITIES, INCLUDING A PROGRAM PROVIDING SHORT-TERM PRACTICAL EXPERIENCE AT U.S. COMPANIES.

THE PROCER STEERING COMMITTEE HAS IDENTIFIED THE FOLLOWING COMMON OBJECTIVES AND COMPLIMENTARY MEXICAN AND U.S. OBJECTIVES

COMMON OBJECTIVES:

SUPPORT THE MEXICAN RENEWABLE ENERGY PROGRAM TO HELP INSURE PROGRAM AND PROJECT QUALITY AND SUSTAINABILITY

SUPPORT DEVELOPMENT OF A LARGE LONG-TERM RENEWABLE ENERGY MARKET, IN BOTH THE PUBLIC AND PRIVATE SECTOR

FOSTER INCREASED TIES BETWEEN MEXICAN AND U.S. RENEWABLE ENERGY INDUSTRY

MEXICAN OBJECTIVES:

INCREASE THE FLOW OF INFORMATION TO MEXICO ON RENEWABLE ENERGY TECHNOLOGY, APPLICATIONS, AND RELATED AREAS

STRENGTHEN THE HUMAN RESOURCE BASE IN MEXICO THROUGH TRAINING AND EXPERIENCE

SUPPORT RENEWABLE RESOURCE ASSESSMENT ACTIVITIES

SUPPORT DEVELOPMENT OF PILOT AND DEMONSTRATION PROJECTS FOR WIDESPREAD REPLICATION

U.S. OBJECTIVES

SUPPORT RENEWABLE ENERGY DEVELOPMENT IN MEXICO AND, BY DEMONSTRATION THERE, WORLDWIDE

LEARN FROM COOPERATIVE ACTIVITIES AND EXPERIENCE IN MEXICO

SUPPORT THE U.S. RENEWABLE ENERGY INDUSTRY, THROUGH ACCESS TO MEXICAN MARKET AND PROGRAM, AND THROUGH FOSTERING MEXICO-U.S. INDUSTRY TIES

SUPPORT DEVELOPMENT OF ENERGY POLICIES THAT MINIMIZE GREENHOUSE GAS EMISSIONS

PROCER WORK AREAS

- INFORMATION TRANSFER AND DISSEMINATION, INCLUDING SHORT-TERM TRAINING
- RESOURCE ASSESSMENT
- DEVELOPMENT OF PILOT AND DEMONSTRATION PROJECTS
- COLLABORATION BETWEEN U.S. AND MEXICAN INDUSTRY, INCLUDING JOINT PROJECT/JOINT VENTURE FEASIBILITY STUDIES, TRADE SHOWS AND MEETINGS
- INSTITUTIONAL DEVELOPMENT

INITIAL PROCER TASKS

- DEVELOPMENT OF AN INFORMATION TRANSFER AND DISSEMINATION PROGRAM (ECRE TO LEAD)
- WORKSHOP ON WIND AND SOLAR WATER PUMPING
- AWEA ANEMOMETER LOAN PROGRAM, AS FIRST STAGE OF WIND RESOURCE ASSESSMENT ACTIVITIES
- SUGAR INDUSTRY ASSESSMENT (WINROCK)
- SANDIA TECHNICAL ASSISTANCE TO SOLAR THERMAL ICE-MAKING PILOT PROJECTS
- IRRIGATION CANAL AND OTHER LOW-HEAD HYDRO TECHNICAL ASSISTANCE
- ESTABLISHMENT OF SPECIAL EXIMBANK CREDIT FACILITY FOR RENEWABLE ENERGY PROJECTS AND EQUIPMENT IMPORTS
- INITIATE FINANCING-RELATED ACTIVITIES, INCLUDING STUDY OF FINANCING ALTERNATIVES, DEVELOPMENT OF FINANCING PILOT PROJECTS

Final Agenda

Southwest Border States Solar Conference

November 14–16, 1991
El Paso, TX

SOUTHWEST BORDER STATES SOLAR CONFERENCE

AGENDA

Thursday, November 14, 1991

Exhibits | Workshops | Tours
9:00 am – 12:00 Noon

9:00 to 12:00 Noon Photovoltaic Workshop

OPENING PLENARY

12:30	Opening Remarks	Russel Smith, Executive Director Texas Renewable Energy Industries Assoc. and Texas Solar Energy Society
12:45	Welcomes	Bill Tilney, Mayor of El Paso
1:00	Keynote Address	Bob Armstrong Director of Energy Policy Tex. Gov. Ann Richards' Policy Council
1:45	World Environmental Concerns Implications for Renewable Energy Industries	Albert Bates, Author *Climate in Crisis*
2:15	External Costs of Power: Vehicle for Renewable Energy Development?	Renz Jennings, Chairman Arizona Corporation Commission
2:45	BREAK	

Session Chair Michael Osborne

2:45 pm – 7:00 pm

OVERVIEW OF APPLICATIONS

3:15	Stand Alone Systems	Dr. Gary Jones, Manager Photovoltaic Projects Sandia National Laboratories
3:25	Stand Alone Systems	Ron Pate, Project Leader Design Assistance Center Photovoltaic Systems Division Sandia National Laboratories
3:50	Village Scale Approaches	Vaughn Nelson, Director Alternative Energy Institute West Texas State University
4:15	Utility Sector Approaches	Mary Ilyin, Project Manager Pacific Gas & Electric Company
4:40	Wrap up	Dr. Gary Jones
5:30	RECEPTION IN EXHIBIT HALL	
7:30	DINNER IN BALLROOM	Dr. Narendera Gunaji United States Commissioner International Boundary & Water Commission

Session Chair Dr. Gary Jones

MC Robert Foster

Solar car session
9 to 10 p.m.

Friday, November 15, 1991 (Continuation)

		Exhibits	Workshops	Tours
11:00 Panel and Forum (Continued):				
	Ing. Enrique Hill Bochelem General Manager, Solar Energy Commercializadora Condumex S.A. de C.V.			
	Ing. Jorge Guiterrez Vera Apoderado General Compania de Luz y Fuerza del Centro			
	Dr. Juan Acosta Aradillas Director, ENTEC, S.A. de C.V.			
12:30 FOOD FOR THOUGHT LUNCHEON "New Strategies"	Dr. Robert San Martin Deputy Assistant Secretary for Utility Technologies Office of Conservation and Renewable Energy U. S. Department of Energy		MC Dr. Bruce D. Hunn	

INDUSTRY AND MARKET DEVELOPMENT UPDATES I

		Exhibits	Workshops	Tours
1:30 NEW MEXICO: State Programs/ Industry Status and Opportunities/ Applications/Research	Ingrid Kelley, Bureau Chief Energy Information Service Energy Conservation & Management Div. New Mexico Energy, Minerals and Natural Resources Dept.		Session Chair JoAnne Emmel Cooperative Extension Service of New Mexico	
	Julie Stephens, President New Mexico Solar Energy Assoc.			
	Tom Volek New Mexico Solar Energy Industries Assoc.			
2:15 ARIZONA: State Programs/ Industry Status and Opportunities/ Applications/Research	Maxine Robertson Solar Economic Development Specialist Arizona Energy Office Arizona Dept. of Commerce			
3:00 MAQUILADORA TOUR/JUAREZ DINNER/JUAREZ RACETRACK		4:30 pm	New Mexico SEIA Mtg. Rm. 327 3 to 5 p.m.	3:00 pm – 6:00 pm
6:00 JUAREZ DINNER/JUAREZ RACETRACK				Dinner & Racetrack 6:00 pm – 10:00 pm

Saturday, November 16, 1991

Exhibits Workshops Tours

MEXICO/U.S. RENEWABLE ENERGY BUSINESS OPPORTUNITES AND BARRIERS II

11:15 Panel and Forum:

Lynn Hurlbert - Moderator
Regional Sales Manager
United Solar System, Corp.
(UNISOLAR)

Richard Bearden
General Manager
Apollo Energy Systems, Inc.

Ing. Jose Clareon
Solar Energy Manager
ESB de Mexico
S. A. de C. V.
Monterrey, Mexico

Ing. Rolando Guerra, President
Energia Renovable Aplicada
Cuidad Miguel Aleman

Fred Sanders
RADCO Products, Inc.

Session Moderator
Lynn Hurlbert

12:15 Summary and conclusions

Dr. Bruce Hunn, Head
Building Energy Systems Program
Center for Energy Studies
The University of Texas at Austin

1:00 pm

1:30 - TX-SES/TREIA Business Meetings

2:00 to 6:00 Renewable Energy Facilities Tour

2:00 pm

6:00 pm

SPEAKERS

JUAN ACOSTA-ARADILLAS - Mexico City

B.Sc. in Electrical Engineering from Escuela Superior de Ingenieria Mecanica y Electrica del Instituto Politecnico Nacional in Mexico City, 1973. In 1971, Juan Acosta-Aradillas joined the Comision de Tarifas de Electricidad y Gas, working on rate design for electricity and gas supplied by public utilities. Research and work on electric transformer design, manufacture, with Instituto de Investigaciones Electricas beginning in 1976. M.Sc. and Ph.D. from University of Manchester Institute of Science and Technology, 1980-1984. Returned to Instituto de Investigaciones Electricas, 1984. Formed and lead research group in electrical machines. In1990, he joined ENTEC, S.A. de C.V. as Managing Director. He is a member of IEEE.

BOB ARMSTRONG - Austin, Texas

Bachelor of Arts degree in Government and a law degree from the University of Texas. Member of the Texas House of Representatives from 1963 - 1970. Served as Commissioner of the Texas General Land Office, 1971 - 1982. Chairman of the Energy Efficiency Subcommittee of the Texas Energy and Natural Resources Advisory Council during that time. Past President of the Western States Land Commissioners Association. Currently Director of Energy Policy for Texas Governor Ann Richards' Policy Council. Mr. Armstrong was selected a 1991 winner of the prestigious Chevron Conservation Award, the United States oldest privately sponsored conservation recognition award.

ALBERT BATES - Summertown, Tennessee

Graduate of Syracuse University and New York Law School. In 1972, he joined The Farm, an experimental community of several hundred people in Summertown, Tennessee. There he managed an alternative energy program, designing and developing numerous solar innovations, including a solar car which was exhibited at the 1980 World's Fair. An active environmental attorney since 1977, he is Director of a public interest law project called, the Natural Rights Center. Currently an adviser to Solar Car Corporation of Melbourne, Florida. Mr. Bates is author of five books, including "Climate in Crisis: The Greenhouse Effect and What We Can Do," with a foreword by Senator Albert Gore, Jr.

RICHARD BEARDEN - Navasota, Texas

Employed by B&R Industries, Inc. for last 10 years as design engineer of production machinery used in manufacture of pump components for the oil industry. Began development work on water pumping systems for solar applications in 1987. Currently serves as General Manager with Apollo Energy Systems, Inc.

MICHAEL S. BERGEY - Norman, Oklahoma

President and co-founder of Bergey Windpower Company , Mr. Bergey is a mechanical engineer and an internationally recognized expert in small wind turbines. Author of more than 40 technical papers and articles in the field, he has provided testimony to Congress, and served as consultant to numerous government agencies. He is a past president of the American Wind Energy Association (AWEA), and has served on the AWEA Board of Directors since 1981. He is chairman of the AWEA Export Committee and the AWEA Performance Standards Committee. Recognized by AWEA in 1982 for "Leadership in the Development of a National Performance Standard for Small Wind Turbines."

JUDITH CARROLL - Austin, Texas

Judith Carroll directs the Alternative Energy Demonstration Program as well as the Agricultural Energy Demonstration Program at the Texas Governor's Energy Office. She is also working with the Texas Department of Commerce to develop a Product Commercialization Program. In addition, she chairs Interstate Solar Coordination Council, a national organization of state renewable energy program managers. At the Governor's Office, Carroll has also been active in developing programs for the energy efficient design of Texas public schools.

WALTER J. HESSE - Dallas, Texas

Completed B.S. M.E., M.S.M.E., and Ph.D., 1944-1951, all from Purdue University. Course work at U.S. Naval Academy, Commissioned Ensign, USNR; USN Submarine Officers School; University of California, Nuclear Engineering; and Sandia National National Laboratories. Dr. Hesse has been involved in high technology research and development work for over 40 years, including Chance Vought Aircraft Corporation (later the LTV Aerospace Corporation) beginning in 1956, was made Vice President and officer of the company in 1965, and remained with LTV until 1973. He joined Rohr Industries (1973-1977), and moved to E-Systems in 1973. There he was Vice President and General Manager of the Energy Technology Center, where a key product, the linear Fresnel lens, matured through development. Following a buy-out by management of that division, ENTECH, Inc. was formed. Dr. Hesse has served as its President, CEO, and Chairman of the Board since the company was formed in 1983. He is currently Chairman of the Board, and recent President of the Solar Energy Industries Association, formerly served as a board member of the U.S. Solar Energy Research Institute, a member of the Scientific Panel to the Congressional House Committee on Science and Astronautics, a member of the Advisory Board for Joint Task Force Two of the Joint Chiefs of Staff, a member of the Texas Commission on Atomic Energy, and was Chairman of the Board of the Aerospace Education Foundation of the Air Force Association.

ENRIQUE HILL-BOCHELEM - Tlalnepantla, Mexico

Enrique Hill-Bochelem received a B.S. in Chemical Engineering from Catholic University of America. Graduate studies in Ecole Superieur de Cheme, Mulhouse, France. Master of Business Administration at IPADE, Mexico City. Hill has served as General Manager for several factories in the CONDUMEX Group in Mexico, including INTELMEX (CATV business), MINERA KAPPA continuous casting of high conductivity copper), PLASTIQUIMICA (PVC extrusion), TELSA (automotive parts manufacture). He has served for the last six years as General Manager of COMERCIALIZADORA CONDUMEX, S.A. de C.V., Solar Energy Division, developing the photovoltaic business in Mexico.

LYNN HURLBERT - Mesa, Arizona

Graduate of the University of North Texas (BA in double major of Production and Administrative Management); American Graduate School of International Management (BA and MA in International Management). Mr. R. Lynn Hurlbert is currently the Regional Sales Manager for United Solar Systems Corporation in Troy, Michigan, a manufacturer of state-of-the-art thin film, multiple junction, flexible modules. He has extensive experience in teaching, training, and documentation of technical material as well as conducting private and public seminars in more than eight foreign countries. He has published articles on the topics of renewable energy applications, international industrial marketing, traffic and distribution, and microcomputer applications. Mr. Hurlbert has experience in international plant management, sales, distribution, purchasing, and as a technical liaison.

MARY A. ILYIN - San Ramon, California

Mary A. Ilyin is a graduate of University of California at Berkeley in Mechanical Engineering. She has been involved in wind energy work for over six years and also works with photovoltaics. She is currently a Project Manager with Pacific Gas and Electric Company's Research and Development Division.

JOHN J. JENNINGS - Washington, D.C.

John Jennings is Eximbanks principal technical consultant in the areas of nuclear power, renewable energy, fossil-fueled power stations, chemical process industries, shipbuilding, and environmental protection.

Mr. Jennings joined Eximbank in 1978, after twenty years of varied assignments in design, manufacturing, operations, mathematical modelling, and testing, with private companies. His work experiences have included the Naval Nuclear Program and Project Apollo. He received a Bachelor of Engineering Science degree from the Johns Hopkins University (1958). Mr. Jennings is a Professional Engineer registered in California.

RENZ D. JENNINGS - Phoenix, Arizona

Renz Jennings graduated Juris Doctor from Arizona State University, 1973. Served as Judge in East Phoenix Justice Court from 1971 - 1974. Mr. Jennings was elected to three terms in the Arizona House of

Renewable Energy Industries Association efforts at the Public Utility Commission of Texas, including interventions in two Notice-of-Intent hearings, and the securing of a "net energy billing" rule for small power producers of 50 kW or less, and has testified before various legislative committees and panels. Mr. Osborne is currently President of the Texas Renewable Energy Industries Association.

RONALD C. PATE - Albuquerque, New Mexico

B.S. degree in Engineering Physics from the University of Arizona, M.S. degree in Electrical Engineering from the University of Colorado, with additional graduate study in electrical engineering and business at the University of New Mexico. Mr. Pate holds several patents in pulsed power technology. He has served as a Commissioned Officer in the National Oceanic and Atmospheric Administration, has worked in product development with IBM, been an exploration geophysicist with the Shell Oil Company, and a research engineer and research manager in two small Albuquerque firms conducting R&D in electromagnetics, plasma physics, and pulsed power. Mr. Pate is currently a Senior Member of Technical Staff, and Project Leader of the Renewable Energy Design Assistance Center, within the Photovoltaic Systems Research and Development Division of Sandia National Laboratories.

STEPHEN RITER - El Paso, Texas

Graduate of Rice University (B.A. 1961; B.S.E.E. 1962) and the University of Houston (M.S.E.E. 1964; Ph.D. 1968). He has held positions with NASA (1964-1966) and WELEX (1966-1967). Dr. Riter joined the faculty of Texas A&M University where he was named Halliburton Professor of Engineering in 1979, Associate Director of the Center for Urban Programs in 1972, Associate Director of the Center for Energy and Mineral Resources in 1976, and became the first Director of the Texas Energy Extension Service in 1977. In 1980, he joined the faculty of The University of Texas at El Paso (UTEP) as Chairman and Professor of Electrical Engineering, and became Dean of Engineering in 1989. In 1990, Dr. Riter helped establish and was named the first director of UTEP's Center for Environmental Resource Management (CERM), the position he currently holds. He also serves as Chairman of the El Paso Public Utility Regulatory Board, is a member of the Texas Interagency Task Force on Border Health and Environmental Issues, and is Chairman of the Texas Deans of Engineering.

MAXINE ROBERTSON - Phoenix, Arizona

Maxine Robertson has been involved with the solar industry since 1980. She spent over seven years as Program Development Manager for an Arizona based solar thermal manufacturer before joining the Arizona Energy Office in 1988. Ms. Robertson served as Manager of Solar Programs for fourteen months, at which time the state solar budget was eliminated. Now, as Solar Economic Development Specialist, she continues to oversee solar projects and serves as the state's representative to the solar industry. In addition to her ongoing statewide community participation with the solar industry, she served on the Board of Directors, and as Vice President of the Arizona Chapter of the Solar Energy Industries Association (ARISEIA) until 1987 when the chapter disbanded. She has been instrumental this past year in the state's support in the reorganization of a new ARISEIA chapter.

ROBERT L. SAN MARTIN - Washington, D.C.

Dr. Robert L. San Martin was appointed Deputy Assistant Secretary for Utility Technologies, Office of Conservation and Renewable Energy, U. S. Department of Energy (DOE), in April of 1990. He is responsible for the formulation and implementation of DOE policies and programs which are related to efficiency and renewables in the utility sector. His extensive career in energy began in 1962 at the University of Florida, and continued when he moved to New Mexico State University to teach and perform research in solar energy, heat transfer, and thermodynamics. He received a Bachelors degree in Mechanical Engineering in 1963, a Masters in Mechanical Engineering in 1964, and his Ph.D. in Mechanical Engineering in 1969. Dr. San Martin is a member of numerous professional and technical societies, Past Chairman of the American Society of Mechanical Engineers, Solar Division, and has served on the Board of Directors of the American Solar Energy Society. He is author or co-author of over 50 technical publications and reports on solar energy, geothermal energy, and heat transfer.

SCOTT SKLAR - Arlington, Virginia

Served as military and energy aide to Senator Jacob K. Javits (1970-1979); Washington Director and Acting Research Director of the National Center for Appropriate Technology (1979-1981); and Political Director of the

OAK RIDGE ASSOCIATED UNIVERSITIES WASHINGTON OFFICE	**INSTITUTE FOR ENERGY AND ENVIRONMENTAL ANALYSIS**

Mexico Renewable Energy Technical Assistance Program

Chris Rovero
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The following material supplements and updates the attached documents (two trip reports, and draft "Mexico Energy Technical Assistance Program"). While the latter document is still a good presentation of the overall program and general tasks, some of the specific tasks and the time-table have changed. Although a program plan summary is presented below, a new program plan will be drafted over the next month, which will be widely circulated for comment.

Background

The Government of Mexico (GOM) has recently instituted a poverty alleviation and rural development program, the Programa Nacional de Solidaridad (PRONASOL, Solidaridad, or Solidarity Program), which emphasizes the delivery of social services (water, sanitation, health, education, and electricity) to historically unserved or under-served populations. Under PRONASOL, renewable energy systems have been used to electrify a number of rural villages, and preparations are under way to greatly expand the scope and pace of rural electrification based on small-scale renewable energy systems. There are many areas where U.S. technical assistance and training efforts could assist this renewable energy program.

In the utility sector, Mexico is currently not employing renewable systems for central station generation, with the major exception of large hydro facilities. There is interest, however, in using wind, solar thermal, and biomass for on-grid power generation. A number of areas have been identified where U.S. technical assistance can help lay a foundation for large-scale renewable energy activities.

The ORAU/ORNL project team travelled to Mexico at the end of March and in the beginning of April to launch a cooperative program in renewable energy technical assistance and training. The second mission, in June, included--in addition to ORAU staff--a photovoltaic specialist from Sandia National Laboratory and a wind specialist funded by the Export Council for Renewable Energy (ECRE).

OBJECTIVES

The general objectives of this activity are to support the development of a sustainable rural electrification program incorporating decentralized renewable energy systems, and to support the development of renewable energy projects for grid-connected generation. These objectives will be accomplished through a program of technical assistance and training aimed at strengthening Mexican institutional and personnel capabilities, and providing technical assistance to support field projects and programs. The overall goal of the activity is to enhance development and promote trade. The technical assistance program will involve, on the Mexican side, PRONASOL and PRONASOL contractors, Comision Federal de Electricidad (CFE), Instituto de Investigaciones Electricas (IIE), and Mexican solar energy technology companies, and on the U.S. side, the DOE and A.I.D., their contractors, and other institutions. DOE and A.I.D. are jointly funding this activity.

RECENT DEVELOPMENTS

1. Mexican Renewable Rural Electrification Program Plan

A working group (the Grupo Trabajo) composed of individuals from CFE, IIE, PRONASOL, CIEDAC, and other agencies and institutions, has been working for the past five months to plan and lay the foundation for rural electrification with renewables. The National Program for Rural Electrification with Non-Conventional Energy Program Plan (El Programa Nacional de Electrificacion Rural con Fuentes no Convencionales) for 1991-94 was presented to the Secretary of Planning and Budget on June 17, and the plan has reportedly been received very favorably by the Secretary.

The Program Plan identifies rural electrification needs, the role that renewables can play in rural electrification, and lays out an approach to pursue. The report states that an expenditure of 4 trillion pesos will be necessary (approximately $1.33 billion). While no time frame is given, it is implied that it is the 3 years remaining to the Salinas administration.

The Grupo Trabajo does not expect that the Mexican government will fully fund the 4 trillion pesos, but the fact that these figures were discussed, and the Secretary continued to respond favorably, has given them great hopes of seeing truly dramatic funding levels, in the hundreds of millions of dollars annually.

2. Highlights of Second Mexico Trip

The proposal to establish a steering committee to guide U.S. technical assistance efforts, with Mexican representation on the committee, was well-received by all relevant officials. Two Mexican counterparts have been selected as members of the Steering Committee, Dr. Juan Acosta of ENTEC, to represent PRONASOL, and Dr. Jorge Huacuz of the IIE, to represent IIE and CFE. At IIE it was agreed that J. Huacuz would be the primary counterpart, while other IIE people could fill in as appropriate. CFE also has designated J. Huacuz as its primary representative to the Steering Committee.

PRONASOL official Jorge Diez de Sollano approved of the Steering Committee suggestion and of J. Acosta's participation to represent PRONASOL.

The first Steering Committee meeting is tentatively scheduled for August. The main purpose of the Steering Committee meeting will be to amend and approve the program plan. A new draft program plan will be developed over the next month and circulated for comment.

One of the major topics of discussion with both the PRONASOL contractors and with IIE/CFE has been a series of workshops on different energy technologies and systems and related economic and institutional issues. Workshop topics receiving the most emphasis on this trip included Hybrid System Selection and Design, and Wind Energy Systems and Applications. A workshop on Hybrid System Selection and Design was tentatively scheduled for late January 1992, with IIE designated as the in-country coordinating institution and Sandia taking the lead in organizing the curriculum and agenda.

There is much interest in wind resource assessment assistance on the part of CIEDAC/ENTEC and IIE. CIEDAC/ENTEC proposed that one initial task of the U.S./Mexico collaboration be the development of a proposal for the evaluation of wind resources in Mexico. J. Acosta said he would work with J. Huacuz to ascertain possible interest or willingness on the part of Mexican agencies to support or co-fund wind resource analysis, in order to demonstrate a seriousness of intent to possible U.S. funding agencies. Enrique Caldera of IIE will work with Vaughn Nelson and other team members to draft an assessment proposal.

A near-term need for technical assistance involving a small (100 kW) low-head irrigation canal hydro pilot project was identified. There appears to be significant potential for this technology, with 300 megawatts of estimated potential capacity, often associated with economically productive agroprocessing loads. There was also strong interest in a small-hydro resource assessment, including an assessment of resources and economic potential for low-head irrigation canal small-hydro, and potential for rehabilitating mothballed grid-connected small hydro plants.

The high cost of solar home systems is seen as a potential problem, particularly because these do not significantly support productive end-uses. CIEDAC/ENTEC, PRONASOL, IIE, and CFE were all interested in trying to develop less expensive ways of providing service, and all responded positively to the idea of small battery charging services as one means of doing this, particularly in conjunction with productive and social applications.

The different Mexican institutions involved in the renewable activities have devoted a significant portion of their time and attention to institutional and social issues impacting the sustainability of the energy systems; in fact, much more time and attention than the team expected. So far, the team has detected weaknesses in certain areas, including the lack of emphasis on cost recovery and, to a lesser extent, the lack of emphasis on the private sector's role in providing maintenance and repair services.

IIE and CIEDAC both stressed the desirability of an ongoing information flow between the U.S. and Mexico, with coordination on the U.S side between the different laboratories and other technical institutions. IIE and CIEDAC were interested in obtaining much more technical material for instructional and reference purposes, and the team said it could work with them on this. J. Huacuz (IIE) also expressed a desire for stronger institutional links between IIE, Sandia, and other U.S. laboratories.

On May 17, the Secretary of Energy, Mines, and Parastatal Industries announced that the laws would be changed to allow cogenerators and autogenerators to sell power to CFE ("surplus" only for autogenerators). This was later confirmed by the SEMIP Director General for Research and Development. The Grupo Trabajo (GT) is currently forming a subcommittee to examine the issue of power sales to the grid from renewable systems. It has not yet been decided who will lead this subcommittee.

MEXICO RENEWABLE ENERGY TECHNICAL ASSISTANCE PROGRAM

Program Plan Summary

In the first year of operation, the program will undertake the following activities, in order to develop institutional and human capabilities in the Mexican renewable energy sector, and to support development of a sustainable rural electrification program that incorporates renewable energy systems and is capable of attracting multilateral development bank financing. The program will work with Mexican Government agencies, institutions, and contractors, and with Mexican private sector firms. The principal counterpart are Programa Nacional de Solidaridad (PRONASOL) and i contractors, the Comision Federal de Electricidad (CFE), and t Instituto de Investigaciones Electricas (IIE).

<u>Workshops</u> will be conducted on a number of renewable en technologies and other issues, including hybrid systems solar/wind, solar/diesel); wind energy technology, resources applications; low-head hydropower and other small hydro; fin and institutional issues (aimed at representatives of multi development banks and domestic financing entities); and s end-use applications such as water pumping, health, educat food processing and preservation. Some workshops will b alone events with mostly U.S. presenters; other worksho components of larger gatherings and will include both Mexican presenters.

<u>Technical Assistance</u> will be provided in sev including: wind resource assessment; small hydro des

installation, resource assessment, site screening, and rehabilitation of mothballed small hydro plants; assessment of potential biomass-fired power generation; analytical tools for stand-alone system selection and design; electronic controls for small systems; and hybrid system selection and design.

Program Design Assistance will be provided to help insure selection of least-cost electrification options, and help assure financial sustainability of the electrification program. In this activity, program personnel will also work with multilateral development bank staff to help insure availability of financing for renewable energy projects.

Information Dissemination efforts will provide Mexican officials, contractors, and companies with information on relevant experience and expertise available in the U.S., and information on the range of goods and services available from U.S. companies.

Wind Resource Assessment will be an area of focus in the first year, as it is a prerequisite to use of small wind turbines in rural electrification projects, and it will help build the foundation for later large-scale wind generation. In addition to technical assistance in wind resource assessment methodology, the program will work with Mexican counterparts to jointly develop a resource assessment proposal, provide additional support for resource assessment efforts, and assist in securing other necessary funding to support the resource assessment.

Mexico Energy Technical Assistance Program

BACKGROUND

In September 1990 the renewables project development team at ORNL/ORAU began an investigation of the potential for the development of renewable resource projects in Mexico. Several facts encouraged this investigation: first, preliminary surveys indicated a substantial potential for electrical production from renewable resources existed. Second, the national utility, Comision Federal de Electricidad (CFE) was required by the Government of Mexico to construct and operate a conventional, heavily subsidized rural electrification program, and, third, improving relations between the governments of the U.S. and Mexico were setting the stage for increasing trade opportunities.

The team soon learned that the Government of Mexico had embarked on a very ambitious program to provide improved services such as potable water, health, education, transportation and energy to residents in low income rural communities. The 1991 funding for the program, called Programa Nacional de Solidaridad (PRONASOL), was funded at $1.7 billion.[1] [2] Moreover, under the energy component of PRONASOL, thousands of small renewable energy systems had been installed in households, health centers, community centers, and schools. These systems were primarily small photovoltaic (PV) systems but also included micro hydro systems, small stand-alone wind systems, and larger hybrid wind/PV/diesel systems.

The ORNL/ORAU team identified the principal private sector companies and met with some of their managers in Washington during the first months of 1991. It was clear from these meetings that these companies, and the PRONASOL program in general, would profit from U.S. technical assistance.

During the same period, it was learned that CFE was attempting to scale down its rural electrification efforts due to the very small loads in rural areas and the high cost of line extensions. It appeared from first analysis that dispersed electrical power from renewables was competitive with CFE line extensions. Since the line extension program was funded at nearly $200 million annually, and since CFE was searching for lower cost sources of rural electric power, it seemed feasible that CFE would favorably consider renewable resource alternatives.

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[1] In June, 1991 the World Bank will provide an additional $350 million credit to PRONASOL to be expended over 3 years.

[2] PRONASOL is run with almost no bureaucracy. Funds are requested by States, which have identified possible infrastructure projects. With funds from PRONASOL and some of their own funds, the States then tender projects. Most of the program is implemented by the private sector. For the renewable energy projects, this has certainly been the case.

Thus, funded by the U.S. Department of Energy's Office of Solar Energy Conversion and U.S. AID's Office of Energy, the ORNL/ORAU traveled to Mexico City to discuss technical assistance and renewable resources with PRONASOL, CFE, and the private sector.

The central findings of that mission were:

a) During the past two years, about 7000 dispersed PV systems have been installed, one micro hydro system, several ~~hybrid systems, and at~~ least 4 wind machines have been purchased. CFE contracted the private firm CONDUMEX to install the first 2000 PV systems. In most States, no maintenance system is in place to keep these systems operating.

b) CY1991 funding from PRONASOL for renewables projects is $30 million.

c) Less than 10 private companies are involved in the design and installation of renewables systems under PRONASOL. In many cases, CFE managers acknowledge that small renewables systems are more economical than line extension. However, CFE has withdrawn from active participation in the PRONASOL renewables program due to union problems, but will remain as a technical advisor.

d) No country-wide biomass resource assessment has been completed, and limited data is available on the country's hydro power and wind potential. Nevertheless, it is clear that there are significant opportunities to develop commercial energy projects using biomass, hydro, wind, and other solar technologies.

e) CFE and the private sector renewables companies have little experience or capabilities in biomass, small hydro, and wind systems, but have good engineering and construction capabilities.

f) CFE, IIE, and other public and private organizations need specific technical assistance to address both general and specific design issues for decentralized renewable systems.

g) CFE has had very preliminary talks with LUZ and US Windpower about larger power plants.

h) Current law prohibits independent power producers, but Mitsubishi and Alstrom are building large power plants that will be leased to CFE. Westinghouse also has proposed financing a plant for leasing. The leasing arrangements are essentially a BOT arrangement. It appears that there is recognition that reforms are necessary, and therefore medium and larger scale renewable power projects may be legally viable in the not too distant future.

The team concluded from its first mission that technical assistance would accelerate the growth of the Mexican renewable energy industry, provide needed developmental aid, and, in the longer term, contribute to the improvement of Mexico's environment. Below a preliminary Mexico Energy Technical Assistance Program (METAP) has been defined.

OBJECTIVES

Providing technical assistance for renewable energy projects in Mexico is directly relevant to U.S. trade, development and environmental interests. Mexico is currently importing more photovoltaic products than any other single developing or newly industrialized country in the world. With strong support from local and state governments, the PRONASOL program is or will be the largest single user of renewable technologies in the world. This program has expanded 100% per year for each of the last three years, and will likely continue to do so for at least four more years.

From a development perspective, the use of tens of thousands of renewable systems will provide an opportunity to demonstrate the value of renewable energy systems to improve the quality of life of rural poor, through improved access to potable water, lighting for homes and schools, improved vaccine storage and sterilization for health clinics, and power for productive uses of electricity. The Mexico program may become a model for development in developing countries.

From an environmental perspective, use of renewable energy systems contributes to reduction of hazardous emissions contributing to both low level and upper atmospheric pollution. Together with efforts to promote and perhaps mandate energy efficiency, the integration of biomass, wind, solar, and hydro systems into future generation expansion strategies has been identified as one of the key components to reduce greenhouse gas emissions.

The environment to develop a global strategy to support the introduction of renewable systems across a broad range of applications could not be better than it is at present in Mexico. The government has supported use of renewables with a significant level of investment. Major U.S.equipment suppliers have established offices in Mexico City, and have been playing important and growing roles in the PRONASOL effort. Interest in cogeneration and discussions between medium to large-scale renewable systems producers with CFE have been evolving, with the very real potential that solar thermal, wind, and bagasse power generation systems could be providing significant blocks of power to CFE's grid.

In the face of all these positive signs, there is a compelling role for assistance agencies to play in this process. CFE and the Secretariat for Energy, Mines and State Enterprises (SEMIP) could benefit greatly from policy and planning assistance from U.S.counterparts. Resource assessments, pre-investment analyses, and design assistance will be needed to design an integrated program for medium- and large-scale renewable systems. And, to insure that the large numbers of small, isolated systems in rural areas can provide useful service for extended lifetimes, an integrated installation and maintenance program will need to be designed and implemented.

Thus, the objectives of METAP are three fold: 1) expand U.S. trade by assisting in the development of the Mexican market for renewable energy products and services, 2) assist the Mexican Government in development of rural infrastructure through the PRONASOL program, and 3) reduce greenhouse gases by promoting the use of industrial and utility scale renewable-based, electrical power.

STRATEGY

Expanding U.S. Trade Opportunities

The immediate trade opportunities lie in the development of the micro and small power systems with PRONASOL funding.[3] The first component of the overall strategy is to provide the technical assistance needed to rapidly expand the installation of micro systems. The constraints are: a) the number of installation companies is limited, b) existing installation companies are small and have limited experience, and c) no infrastructure has been developed to maintain the installed systems. Therefore, the immediate objective is to assist Mexico's private firms to expand their capabilities.

Technical assistance will be provided through workshops focused on system design and installation issues. Experts from U.S. national laboratories and industry will provide the experience and expertise to organize and operate the workshops. All workshops will be held in Mexico.

Mexican companies working on PRONASOL projects have identified institution building as a major problem area. Discussions will be held with the government and private sector on institutional issues including maintenance, training, management. It is clear that techncial assistance will be required to efficiently ~~development~~ the necessary institutional systems, but it is not yet clear what needs are most acute. One of the objectives of the next mission will be to define clearly the best strategy for assisting the formation of sustainable institutions.

[3]Power systems have been put in three categories:1) micro systems for village electrification (less than 50 kW in capacity); 2) "small" systems, such as wind and small hydroelectric (upto 1000 kW); 3) and "intermediate" power plants (1000 to 30,000 kW).

Special effort will be given to provide U.S. industry with information on Mexican markets and to provide Mexican firms with information on U.S. companies. This process is well underway, since a number of U.S. manufacturers are already actively working with Mexican counterparts.

In the longer term, effort will be focused on intermediate sized power projects. The information needed to adequately evaluate those projects has not yet been collected or analyzed. The immediate objective is to improve the resource data base. The resource data collected during the next few months will be used to identify larger projects. Based on initial information it appears that the sugar industry will be an important target.[4]

Development Assistance

Development of the micro, small, and intermediate sized projects will require different levels of effort and types of technical assistance. In the case of the micro systems, as noted above, much attention will be needed to develop institutional, technical, and managerial capabilities. For the small and intermediate-scale systems, changes in national policy will need to be explored, to allow power sales agreements to be negotiated. In all cases resource assessments, environmental assessments, project development financing, and engineering and financial analyses will be needed to enhance the program.

One approach is to assist in the development of the legal framework necessary to start an independent power producers industry. A Mexican task force has already begum work on this problem. A first target of the independent power producers might be a small hydro (100 kW to 1000 kW) rehabilitation program, to bring hundreds of abandoned hydroelectric sites back into service, and to develop those undeveloped sites that are economically attractive. It has been estimated that there may be as much as 3000 MW of undeveloped small hydroelectric potential in Mexico just at irrigation canal drops. A technical assistance program could be designed through the auspices of the IIE or SEMIP to streamline the rehabilitation process.

An assistance program for the sugar industry would take a similar but certainly different level of effort. The technical potential for biomass power generation could be determined with little difficulty, but interconnecting the first plant to the grid via a commercial, legal mechanism will probability take several years.[4] Preinvestment analyses to illustrate the financial and economic benefits to owners and CFE; standards for interconnection and plant safety; and technical managerial exchange between Mexican and U.S. plant owner/operators will all be required before a program can begin to make a larger scale impact on the Mexican power sector.

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[4]Commercial production statistics from the sugar industry indicate that the potential for power production could be more than 3000 MW.

3 GW

Reduction of Greenhouse Gases

The principal focus of the USAID program in Mexico is global warming. Efforts have been concentrated on preservation of forests. The strategy is to create and sustain protected forestry zones. This strategy is more likely to work and be sustainable if the people depending on wood have an alternative source of energy. It is possible that wind and hydro power resources existing in these protected forestry zones could be used to provide the energy needed. The energy technical assistance team will evaluate this potential as part of its resource assessments, and will attempt to assist in the development of projects which assist the forestry program.

In the longer term, the development of small and intermediate power projects could considerably lower greenhouse gas emissions by forestalling or eliminating the need for coal or oil based power plants. The extent of emissions reduction can not yet be reasonably estimated, because the resource base is too poorly defined. However, one of the outcomes of the resource evaluations will be a more refined estimate of greenhouse gas emissions which can be eliminated under various development scenerios. The energy technical assistance team will work with USAID/Mexico on the development of a strategy to promote power production which has the greatest impact on controlling global warming.

PROGRAM MANAGEMENT

Technical assistance for these categories will be provided a number of different agencies. The technical assistance effort will be led by the ORNL/ORAU project team. Assistance for photovoltaic applications, including both micro stand alone systems and hybrid systems will be provided by the Sandia National Laboratory Design Assistance Center. Small and micro hydro technical assistance will be provided by assistance from a combination of ORNL/ORAU and the National Rural Electric Cooperative Association (NRECA). Biomass technical assistance will be provided by Winrock International, while wind resource assessment assistance will be provided through the Export Council for Renewable Energy (ECRE).

A steering committee, composed of representatives from ORNL/ORAU, Sandia, U.S. AID's Office of Energy, DOE's Office of Solar Energy Conversion, NRECA ~~International~~, Winrock International, and ECRE, will provide program direction, define long term strategies, and help coordinate the participants in the technical assistance program. The steering committee will meet every three months in Washington.

PROGRAM PLAN: MAY - DECEMBER, 1991

The program plan for the first six months and an associated calendar for missions is outlined below. Detailed terms of reference will be developed for each mission.

Generally, during the next six months technical assistance and training will be provided in the following categories:

Technology design assistance and resource assessments.

Technical capabilities are impressive in Mexico, but specific experience with respect to hybrid renewable systems; biomass thermal technologies; low flow, low head hydro power; and larger wind installations is lacking at present. Specific design assistance will be provided on an as-needed basis, provided it does not conflict with U.S. industry interests. Resource assessments are necessary to determine suitable sites for wind applications, and to screen the most economic hydro sites. A biomass assessment would be useful to determine the economic potential for wood and bagasse power generation, as would a waste assessment for waste to energy projects.

Pre-investment analyses.

Analyses to assess the attractiveness and creditworthiness of specific projects will be required to move the process of developing a broad program forward. The first several projects are always perceived with greater risk than those that follow, so "high risk" capital provided through this program to perform preliminary analyses will be essential.

Technical workshops and training.

The renewable industry, including design engineers, analysts, technicians, installation and maintenance engineers, and all supporting staff is still in its infancy in Mexico. Design workshops for several technologies, seminars to provide analytic tools for analysts, long and short term training for technicians, and conferences and trade shows to exchange technical commercial information will all enhance the development of the Mexican industry. This will be beneficial for the development of the Mexican market for renewable technologies, as well as its capacity to fabricate and assemble systems for use in domestic and foreign markets.

Program design assistance.

One of the key problems facing the PRONASAL program will be the sustainability of the thousands of systems financed and installed. These systems will require a well designed maintenance program implemented on a local level. In addition, alternative financing schemes that will allow full cost recovery of these systems will be explored as a means of attracting capital from commercial and development banks for electrification programs.

Special studies.

Several studies will be conducted by over the length of this assistance effort. Perhaps the most important study initially will be a gross analysis of the environmental benefits an expanded program in renewable will provide. It will also be necessary to determine the extent to which the Mexican industry will be able to respond to a broad expansion of the micro systems program; in terms of module assembly; electronic ballast production, charge controller systems (for hybrid and micro systems); low cost, deep cycle battery production; and other renewable systems. Studies to determine the reliability of system components, such as batteries and charge controllers, which have been deployed in rural areas will be helpful to U.S. industry. As critical issues are identified in project implementation, other studies will be undertaken by the team and its Mexican counterparts.

As stated above, several activities have been identified jointly by ORNL/ORAU and PRONASOL personnel that are critical to program success, and therefore effort will be focused on these areas for the first phase of the project. These areas include wind resource assessment; hybrid systems design criteria; low head hydro design; service and maintenance programs for dispersed renewable systems; and, technology selection criteria.

In the near term, however, the project will broaden its focus to non PRONASOL related activities, especially those that have the potential to provide significant contributions of power and energy to the electric power grid. These activities will be accomplished with collaboration from both public and private sector agencies. A six month schedule has been developed to coordinate efforts over the initial phase of the project. This schedule is preliminary, and is subject to change according to the needs of Mexican counterparts, and the team's ability to respond to these needs.

Date	Task Description	Institution
May 20	Wind and PV technical assistance; hybrid design assistance, standards review; system performance review; further investigation of institutional issues	ORAU; Sandia/DAC; ECRE
July 1	Wind resource and PV design workshops, hydro screening, economic analysis	ORNL; ORAU; DAC; NRECA; ECRE/AWEA
August 26	Hydro screening; wind resource analysis; economic screening activities	ORNL; ORAU; ECRE; NRECA
October 14	Biomass assessment; hybrid design assistance; alternative financing workshop	ORAU; Winrock; DAC
December 2	Preinvestment analysis	ORAU; ECRE; NRECA; Winrock

The above tasks and schedule are subject to review and approval by the agencies providing assistance, as well as by Mexican counterparts. It is anticipated that missions will require two to three weeks of field work, although some may require less time.

In addition to activities in Mexico, support activities will be conducted in the United States. Principal among these will be to assist U.S. industry to build working relationships with Mexican counterparts. Some studies and analysis will be completed in the U.S.

SOUTHWEST BORDER STATES SOLAR CONFERENCE

Food for Thought Luncheon
"New Strategies"

November 15, 1991 - El Paso, TX

Presented by:
Dr. Robert L. San Martin
Deputy Assistant Secretary for
Utility Technologies
Office of Conservation and Renewable Energy
U.S. Department of Energy

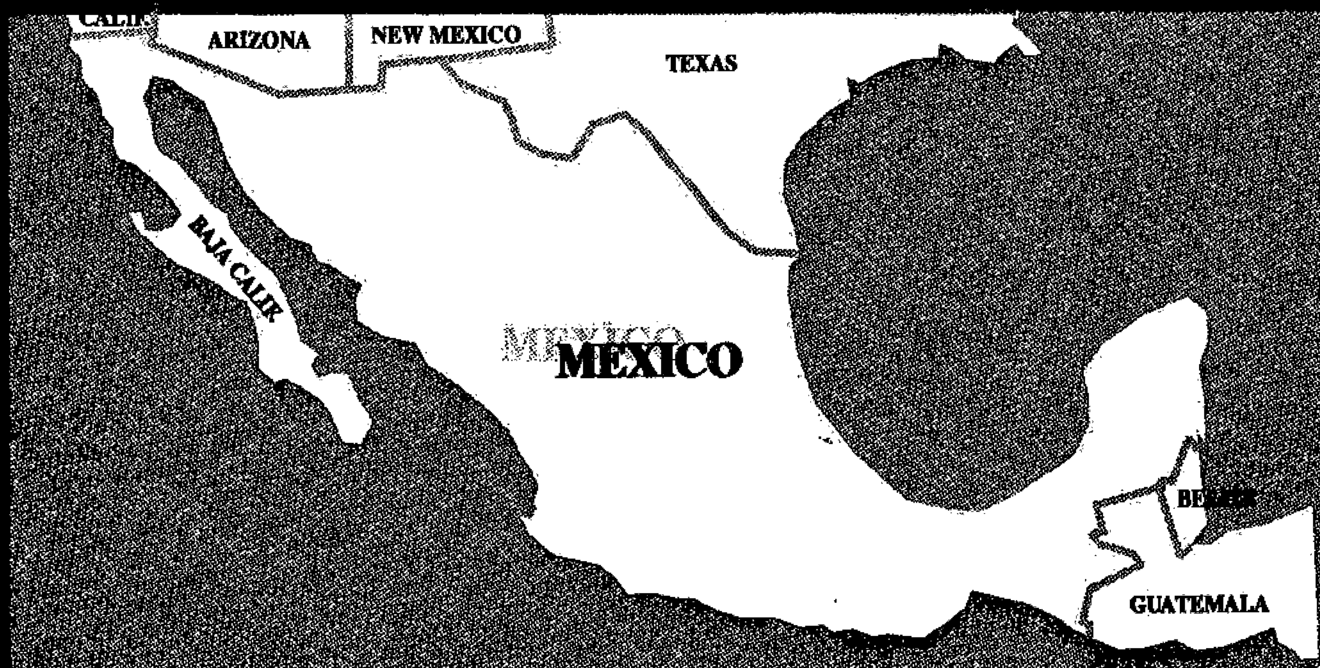
TITLE SLIDE - Introduction

- Introductory statements. It has been suggested by Gary Jones (Sandia) that you make some introductory remarks in Spanish. You may want to make the clarification that you are with the Department of Energy, not the Department of Commerce as incorrectly stated on the agenda if this mistake isn't corrected in the introduction.

- My position at the Office of Utility Technologies at the Department of Energy, affords me a national view of prospects and progress regarding renewable energy. I am particularly encouraged by events in the Southwest/Mexico region with regard to the growing interest in renewable energy and conservation.

- My talk today will focus on common needs and new strategies for accelerating the use of renewable energy technologies in the Southwest region. Specific topics addressed will include a look at new electric resource planning policies which are becoming very prevalent in the U.S. such as integrated resource planning as well as the DOE's program efforts to support these initiatives and how such efforts might be applied to the Mexican power sector; new DOE technology programs such as the Photovoltaic Manufacturing Initiative and Solar 2000; as well as continuing efforts funded by DOE to Sandia's Development Assistance Center (DAC) to assist technology transfer; and a focus on applying efforts in RETs to the southwest situation.

A 2000 Mile Opportunity



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A 2000 Mile Opportunity

- Some have made the observation that there is a new region of economic strength located along the border. The noted journalist, Bill Moyers, recently produced a documentary about the Rio Grande border of Texas, between one part of North America and another part of Mexico. It was called, *One River, One Country* because he found a country that is neither Texas or Mexico. He made the observation that there's a new country growing up between the United States and Mexico. The Mexican novelist, Carlos Fuentes, in his recent novel *Christopher Unborn* discusses a country of Mexaamerica which involves territory 100 miles both and south along the border.

- Recent developments concerning the North American Free Trade Agreement (NAFTA) promise to bring more attention by investors to the Southwest region. Prospects for a free-trade agreement with Mexico has focused attention on new opportunities to develop broader and deeper ties to Mexico. Recently, in July 1990, *Forbes* magazine told American businessmen to "forget Eastern Europe. The next great economic miracle will take place right on our borders."

- The Southwest's economic connections with Mexico constitute an important element in the region's overall economic growth. The U.S. border states of Arizona, California, New Mexico, and Texas exported over $14 billion worth of goods in 1989. Mexico is the largest trading partner for Arizona by a margin of almost two to one. Mexico is the second largest export market for California behind Japan and is the largest export market for Texas by a margin of four to one. Mexico is the sixth largest export market for New Mexico.

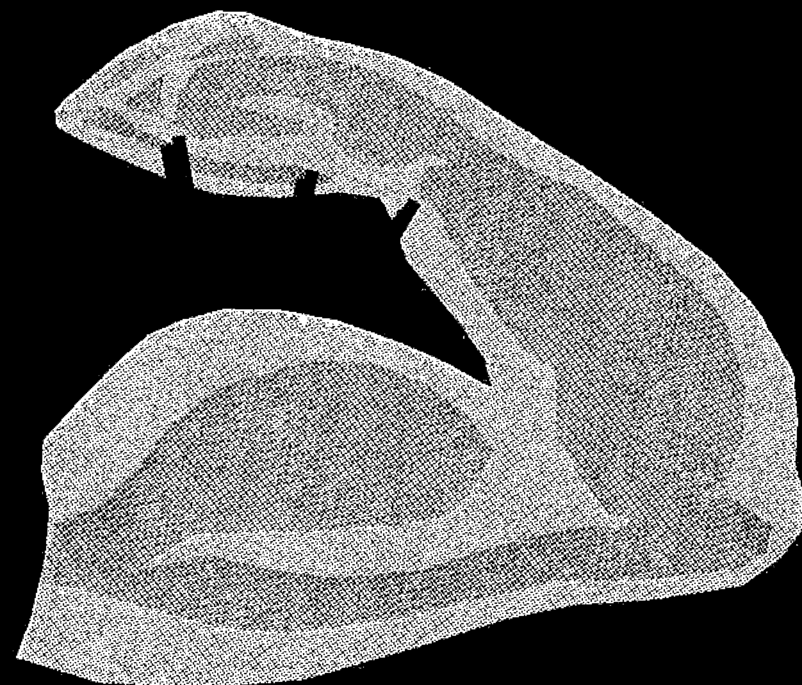
- An energy working group, including officials of the U.S. State Department, U. S. Trade Representative, U.S. Department of Energy, and U.S. Department of Commerce has been exploring avenues with their Mexican government counterparts in the NAFTA negotiations to encourage increased involvement by U.S. firms in developing Mexico's significant energy resource base. While attention has primarily been focused on hydrocarbon development as well as private power development, there are numerous opportunities to promote the use of renewable energy systems.

- The development of renewable energy projects in Mexico is directly relevant to U.S. trade, development, and environmental interests. Mexico is currently importing more photovoltaic products than any other single developing or newly industrialized country in the world.

- The environment to develop a global strategy to support the introduction of RETS across a broad range of applications could not be better than it is at present in Mexico. The government has supported the use of RETs with a significant level of investment. Major U.S. equipment suppliers have established offices in Mexico City. Interest in cogeneration and discussions between medium and large-scale renewable systems producers with the Comision Federal de Electricidad (CFE), a public electric power utility in Mexico, have been evolving, with the very real potential that solar thermal, wind, and bagasse power generation systems could be providing significant blocks of power to CFE's grid.

- In the face of these positive signs, there is a compelling role for U.S. agencies to play in this process. The CFE and the Secretariat of Energy, Mines, and State Agencies (SEMIP) could benefit greatly from policy and planning assistance from U.S. counterparts. Resource assessments, pre-investment analyses, and design assistance will be needed to design an integrated program for medium and large-scale renewable systems. And, to ensure that the large numbers of small, isolated systems in rural area can provide useful service for extended lifetimes, an integrated installation and maintenance programs will be to be designed and implemented.

NAFTA
Building Economic Muscle



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- As the world prepares for its biggest environmental meeting ever, the "Earth Summit," to be held in Rio de Janiero in 1992, there is increasing realization of the need to build economic strength without damaging the environment. By disregarding the effects of growth on the environment, the wealthy countries have used the equivalent of steroids to put on industrial muscle; we have had growth and development, but with significant environmental problems, and our own share of debt. We are now faced with a rehabilitation problem. The challenge for the United States is to continue to acknowledge that we have created environmental damage, to determine ourselves to properly account for these costs, and determine ourselves to pay these costs.

- The Mexican economy is showing signs of dramatic recovery. Four years ago, inflation in Mexico was at nearly 160 percent; now it is below 20 percent. The economy is growing at about 4% annually, which is not bad by today's standards, and Mexico has found that *there is life after debt.* And this is already helping in Mexico -- the impression that there is growth and a stable political and economic environment is attracting more investment. As Mexico pursues "Economic Muscle" , it needs to choose whether they want to do it the easy way or the hard way. The challenge is somewhat different; to pursue development, without creating an environmentally bad bargain in the process.

- In the past, the 2,200 *maquiladors*, or assembly plants, located in Mexico have had their share of pollution problems that have had significant consequences for communities on both sides of the border. Both sides are now stepping up environmental protection. At the direction of Presidents Bush and Salinas, the U.S. Environmental Protection Agency is working with Mexico to develop an integrated environmental border plan.

- These challenges are particularly large, and particularly important to solve, as we work together on NAFTA and the Border Region. Of all of North America, this region is perhaps the most important in North America in terms of balancing economic growth with environmental health. The economic opportunities here are enormous, as are the temptations to take the easy way out by avoiding environmental considerations. We are both becoming part of a global village -- and activities such as the maquiladoras are part of the new economic order -- we have a unique challenge here to make it work while protecting the global environment. Renewable energy technologies may increasingly play a role in helping to offset environmental emissions and providing jobs. Both U.S. and German studies have shown that renewable energy technologies create more jobs than conventional energy technologies because their capital requirements, with the exception of photovoltaic cells, are much more modest and their labor needs greater.

- I want to be very careful here, and make it clear that the message from the U.S. is not "do as we say, not as we do". We are well aware of our own problems, and the economic temptations that we bring to the border region. Both of our countries must avoid focusing on the other side's problems, and instead learn from them, and work together on mutually beneficial development.

Common Needs and New Strategies

- Planning for Power
- Technology Development and Commercialization
- Financing of Energy Services
- Building Institutional Alliances

- The reason that there are such dramatic opportunities along the border is that both the U.S. and Mexico have some common needs and new strategies being developed to meet their needs. I'd like to go over a few of these, and talk about what the Department of Energy brings to the table.

- **Power planning** is a major issue for us. The Department of Energy's role in the electric power sector is to provide a national perspective on the challenges and opportunities facing the electric power sector and to further national energy objectives. One element of DOE's role is defining national goals and objectives in cooperation with the public and leaders in the electric power sector.

- Decisions concerning energy choices are taking on profound importance today. We are at a critical crossroads for electricity generation decision-making.

SLIDE - Wedge from Earlier Presentations

Showing Incremental Demand and Retirements of Power Plants

Power Planning - Needs and Trends

- In the U.S., the data compiled as a result of the National Energy Strategy indicates that 100 GW will be needed to meet demand and to meet retirements of capacity by the year 2000. On a regional basis, the major demand growth will occur in the South Atlantic, Southwest, and Midwest areas.

- Trends are already apparent that suggest that the Nation's electric power system will change in dramatic ways during the next 10 years to involve a more diverse set of participants and more flexibility in pricing, planning and control. These trends are:

  -- The growing demand for electricity and the threat of regional shortfalls in capacity because of the aging of existing power plants and the difficulty of siting new ones.

  -- The increased reliance by risk-averse utilities or independent power producers for new sources of supply, possible leasing to deregulation of generation;

  -- Increased acceptance of demand reduction as the cheapest source of additional supply;

  -- The impact of the Clean Air Amendments of 1990 which will tend to increased the cost of coal-based generation and encourage the use of conservation and renewable energy;

  -- Growing concern about the potential health effects of exposure to electric and magnetic fields.

IRP Slide

IRP slide

- One major thrust of the DOE electricity program is to implement Integrated Resource Planning as a deployment vehicle for cost-effective DSM technologies and to help accelerate the deployment of RETs.

- Among the most profound policy changes in the U.S. has been the redesign of electric utility planning to take advantage of energy savings and renewables. Known as integrated resource planning, this approach evaluates the cost-effectiveness of both "supply-side" resource options and "demand-side" energy-efficiency improvements in choosing utility investments. IRP also differs from traditional practices by seeking greater cooperation among the various stakeholders such as consumers, utilities, and State agencies and by giving explicit consideration to direct and indirect environmental costs and benefits when selecting suitable resource options.

- In the U.S., 30 states have changed or are changing their rules so that utilities may earn as much on steps taken to reduce demand as they would earn on building new power plants. Similar environmental issues are changing the nature of utility markets. Over 19 states are now considering external costs in their resource planning, perhaps the most significant development for renewable energy. Reinforced by the tough limits on sulfur dioxide emissions in the Clean Air Act, the new rules have created a torrent of innovation in the utility industry. The Clean Air Act has created a new reserve of sulfur emissions allowances available for renewable energy and conservation technologies which, if implemented effectively, could increase the Clean Air Act's favorable impact on alternative technology.

- Renewable energy technologies are environmentally benign with far fewer NOx, SOx, or CO2 emissions than any competing fossil technology. As the public and regulators increase the emphasis on including external costs in resource planning, the cost differential between renewable and conventional competitors will narrow.

- When viewed in this context, renewables begin to rank higher in planning scenarios. For example:

  - California has set aside a block of future capacity for conservation and renewable energy. In addition, the California utility, Pacific Gas and Electric Company, has initiated a new project called the Clean Technology Readiness Acceleration INitiative (C-TRAIN) which is targeting clean technologies such as distributed solar generation systems.

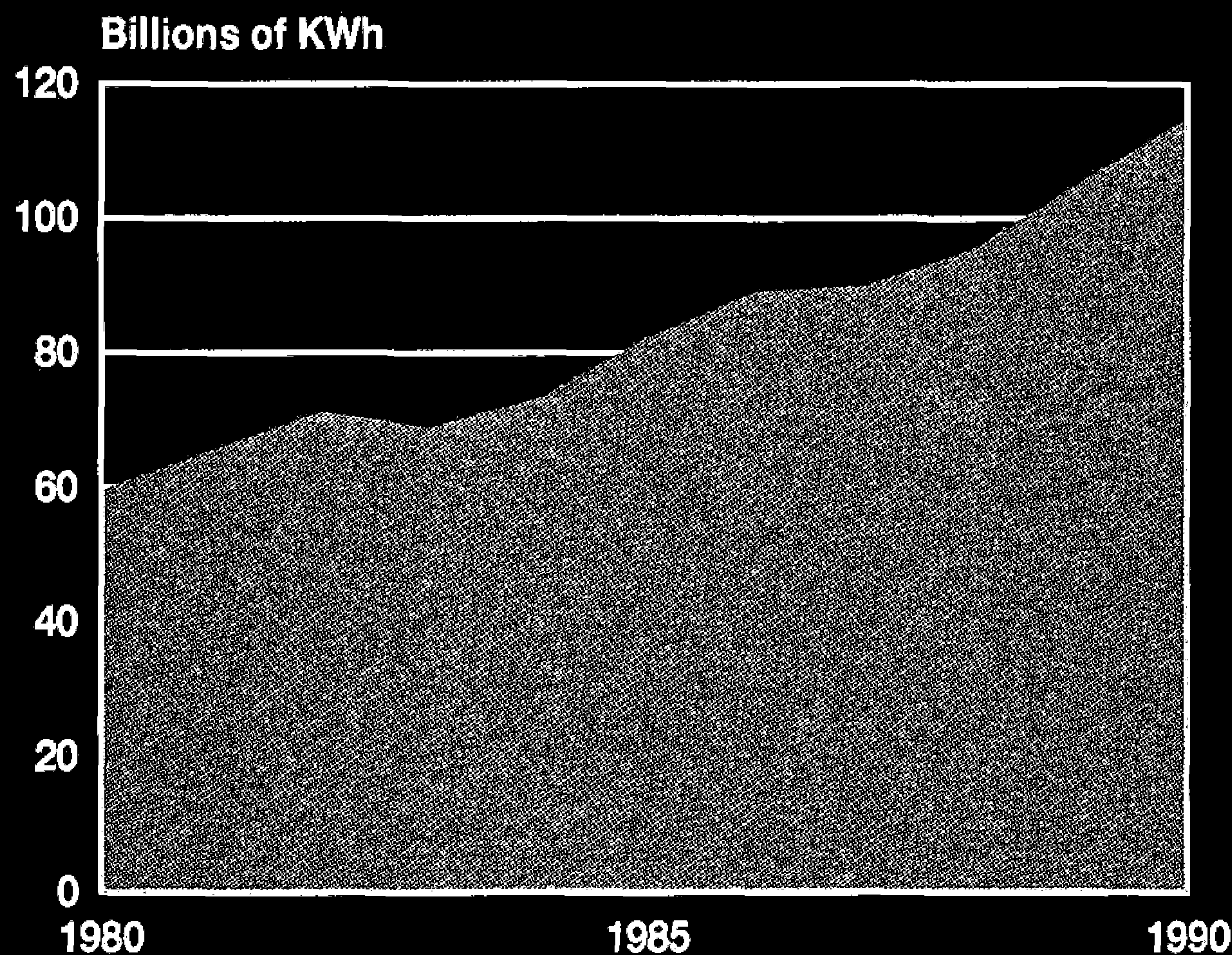
  - Renewable energy technologies ranked high in the supply option rankings of the latest Northwest Power Plan, which for the first time anticipates the need for new capacity in the Northwest.

- In Arizona, a recent energy policy report recommended that the State should identify and remove financial and regulatory impediments to the use of solar and renewable energy technologies.

- DOE's IRP program is working to help accelerate these initiatives. We are have funded activities with regard to environmental externalities which has helped certain states as Nevada and Massachusetts begin to incorporating these costs which may serve to help RETs. We are also funding work at Oak Ridge National Laboratory to examine the environmental and social costs of the total fuel cycle for a number of technologies including coal, nuclear, and renewables.

- The DOE Denver Support Office has launched a 3 year "Integrated Resource Planning Initiative for the Rocky Mountain Region to develop IRP, DSM, and new supply technologies for a 10 state area which includes Arizona and New Mexico. A regional working group will be formed to help develop the strategic plan, including members from utilities, PUCs, State Energy Offices, legislatures, industries, and the Western Area Power Administration.

Electricity Consumption in Mexico



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Planning for Power - MEXICO

- Mexico like other developing countries face massive and daunting problems in meeting its power needs for economic development in ways that are financially and environmentally acceptable.

- The primary source for generating power is and has been fossil fuel, coal, and oil. However, the hydropower electric consumption has declined over the past several years, due in part to low water levels. This has been replaced by increasing availability of electric power from geothermal and other renewable sources (see geothermal section).

- Total electric consumption in Mexico has increased by 90% over the past decade. This is due to increasing use of electricity for residential and commercial requirements. In addition to the expanding availability of the electric grid to remote or isolated areas. Currently, the demand for electricity is high and is growing at a rate of 6 percent annually.
  In some countries such as Costa Rica, studies have shown that the demand for electricity may be even greater than the statistics convey due to its use by the informal sector that is rarely accounted for.

- To what extent can energy conservation and renewable energy contribute to providing increased energy services with minimal environmental harm?

Technologies That Have Achieved Commercial Success in Niche Markets

- Passive Solar Applications
- Efficient Lighting Systems
- Geothermal Dry Steam
- Geothermal Heat Pumps
- Building Energy Management Systems
- Parabolic Trough Solar Thermal Generation
- Wind Turbines
- Photovoltaic Stand-Alone Systems
- Biomass Electric

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Renewable Energy and Energy Efficient Technologies Competitive in Niche Markets

- Energy efficient and renewable energy technologies are now competing in many energy end-use sectors in the U.S. and may have similar applications in Mexico.

- As I mentioned earlier, utilities in the U.S. are increasingly realizing that they can meet much of new demand through conservation. Utilities in several developing countries such as the Electricity Generating Authority of Thailand and Jamaica Public Service, for example are now actively addressing demand-side management options for meeting electricity service needs. With technical assistance from the World Bank's Global Environment Facility, the Mexican utility, CFE, has a project that will replace 3 million incandescent lightbulbs with **compact florescent bulbs** in two large cities (Monterrey and Guadalajara) over a period of three years.

- I would like to briefly discuss the status of some of these technologies. In the utility sector, Mexico is currently employing renewable energy systems for central station generation, with the major contributions coming from large hydroelectric plants and geothermal plants. There is also interest, however, in using **wind, solar thermal, and biomass** for on-grid power generation. I understand there have been events taking place which promise to increase the role of conservation and renewable energy. For example, on May 17, the Secretary of Energy, Mines, and Parastatal Industries announced that the laws would be changed to allow cogenerators and autogenerators to sell power to CFE. The Grupo Trabajo (GT) is currently forming a subcommittee to examine the issue of power sales to the grid from renewable systems.

    -- In the U.S., **wind energy** has proven to be an economically attractive energy technology for the bulk power market. Of the nearly 2000 MW of utility-connected wind generating capacity installed worldwide, about 1500 MW are installed in the U.S. Current machines are producing energy at a levelized cost of 7-10 cents per kilowatt-hour (in 13 mph average annual wind speeds) with an availability of 95%.

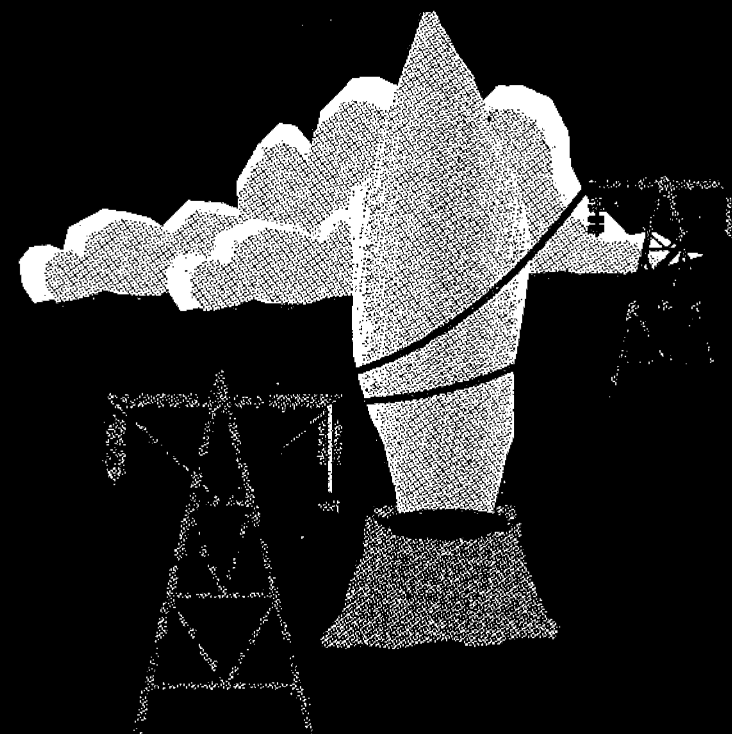
    -- **Parabolic trough solar thermal electric systems** have been proven technically feasible and there have been a number of early markets with special characteristics that have resulted in successful commercial ventures such as the hybrid solar/gas systems on the Southern California Edison grid. Although Mexico is an energy exporter and indeed, some of the U.S. states such as Texas, may be interested in use of natural gas as a clean technology and complementarities with solar thermal technologies. [A recent study conducted by one of the multilateral banks which have begun to stress natural gas as a cleaner burning alternative to coal and oil. For example, the Asian Development Bank has undertaken a study on "Increased Utilization of Natural Gas" to evaluate the natural gas resources of Asian countries and propose strategies and plans for its development. In the past two years, the World Bank has also increased its analysis of natural gas development.

-- **Biomass combustion** currently accounts for approximately 5% of total U.S. energy consumption primarily in the industrial, residential, and utility sectors. Electricity produced by biomass has from 200 MWe in the early 1980s to nearly 8,000 MWe today.

-- **Photovoltaics** are beginning to find practical niche markets in providing power to remote utility equipment and facilities. In Colorado, the Public Service Commission is ordering utilities to compare the cost of line extension with the cost of a remote solar photovoltaic system. In Mexico, the CFE is attempting to scale down its rural electrification efforts due to the very small loads in rural areas and the high cost of line extension. Dispersed electrical power from renewables may be competitive with CFE line extensions. Since the line extension program is funded at nearly $200 million annually and since CFE was searching for lower cost sources for rural electric power, it seemed feasible that CFE would favorably consider renewable resource alternatives. Several utilities are actively assessing PV equipment in central station applications and New England Electric System has good results experimenting with PV for demand-side management.

Geothermal Energy in Mexico

GEOTHERMAL PLANTS	MW
Cirro Prieto 1	183
Cirro Prieto 2	440
La Primavera	10
Los Azufres	90
Los Humeros	20
	Total 743



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Geothermal Power- Mexico

- After the U.S., Mexico has the largest available geothermal generation capacity. Current geothermal plants' capacity total 750 MW with another 400 MW under construction or planned by 1995.

- Cerro Prieto is the oldest, largest, and best known geothermal field in Mexico, located in Baja California. This can be considered a good example of U.S.- Mexico energy trade. San Diego Electric and Gas utilizes power from Cierro Prieto Geothermal field for electricity requirements. The other geothermal fields are located in central Mexico to serve the growing domestic demand for electricity.

PV Manufacturing Initiative

Slide

New DOE Programs To Accelerate Solar Technology

- DOE has expanded and accelerated its research program to reduce production costs of photovoltaics. Thus, through working with industry, DOE can help to remove an economic barrier for this environmentally-benign electricity generation technology, namely high initial cost. Projections indicate this market could reach 1000 MW by the year 2000.

- Process issues which are common to several manufacturers will be addressed with cost-shared joint ventures to provide practical solutions and maximum transfer of results. DOE is also establishing a program to provide cost-shared technical assistance to individual companies to adapt manufacturing improvement technologies to specific processes.

- DOE has also undertaken an initiative to work with industry to reduce these costs through the Photovoltaics for utility-Scale Applications Project (PVUSA), which is a public/private partnership with the primary goal of assessing promising photovoltaic technologies in a utility setting, looking toward cost-effective commercialization by the mid-1990s.

- Results from the DOE program have already identified ways to significantly improve production lines for PV products, with cost savings of 20 to 50%. Increasing the speed with which such improvements are transferred to actual manufacturing processes will assist U.S. Manufacturers in reversing the trend of the past few years of reducing market shares.

SOLAR 2000

Slide

New DOE Programs To Accelerate Solar Technology Adoption

- Solar 2000

- Through SOLAR 2000, the U.S. Department of Energy's (DOE) Office of Solar Energy Conversion (OSEC) proposes a strategy to accelerate the adoption of biomass electric, photovoltaic, and solar thermal technologies by utilities and other end-users. This strategy is based on a partnership with each of the key players in the field, including the U.S. solar electric industry, utilities, regulators, and federal and state agencies. SOLAR 2000 will facilitate the development of the U.S. industrial and technological base to provide proven world class products for a range of electric sector needs, while concurrently increasing awareness among customers to enhance their ability to identify, evaluate, and adopt these technologies as they become viable for particular applications. SOLAR 2000 centers around three major elements which build upon the technological progress of the 1980s to address the growing energy needs of the 1990s:

  - **Technology Development and Validation.** By advancing solar electric technologies through collaborative research, development, and demonstration (RD&D), SOLAR 2000 promotes more reliable, durable, and cost-competitive systems for the marketplace. This component includes synchronizing the RD&D effort with the needs of utilities and other customers, expanding the availability of resource data, and improving system performance.

  - **Market Conditioning.** By laying the groundwork with potential buyers, and in collaboration with other stakeholders, SOLAR 2000 will help overcome the remaining obstacles to market acceptance of solar electric technologies. This component dedicates resources to enhance awareness of the available solar options, achieve maximum benefits of these options, modify the current policy and existing regulatory framework, and access available financing sources.

  - **Project Development.** By leveraging resources in conjunction with private and public sector commitments, SOLAR 2000 will support a broader effort to stimulate technology adoption. OSEC can participate in a number of collaborative arrangements to support project development, industry scale-up, and enhanced penetration of the national and international energy market.

- **SOLAR 2000 heralds a new era for DOE.** Whereas DOE has traditionally supported basic and applied R&D, OSEC will help transfer these R&D results into commercial products while entering into collaborative arrangements to favorably impact the regulatory environment and the marketplace. Although DOE will continue to support a strong technology R&D program, it places new and equal emphasis on market conditioning and project development -- a commitment needed to ensure that these technologies become contenders in the energy marketplace. Without these efforts, prior public and private investments in these technologies will be lost; opportunities for environmentally sound, cost-competitive energy options will be reduced; and foreign competition will once again succeed in capturing a U.S. initiated product market.

- **SOLAR 2000** represents an ambitious program augmented by the full support and commitment of the DOE. Through this coordinated and collaborative effort, industry, stakeholders and the nation as a whole will reap the full benefits of solar electric technologies.

CORECT

Committee on Renewable Energy Commerce and Trade

14 Federal Agencies Working Together to Promote Renewable Energy Trade

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- As you can see, efforts to develop the technologies mean more than R&D; as we bring these technologies to maturity, our responsibilities and challenges have grown to include commercialization efforts to bring the technologies to market.

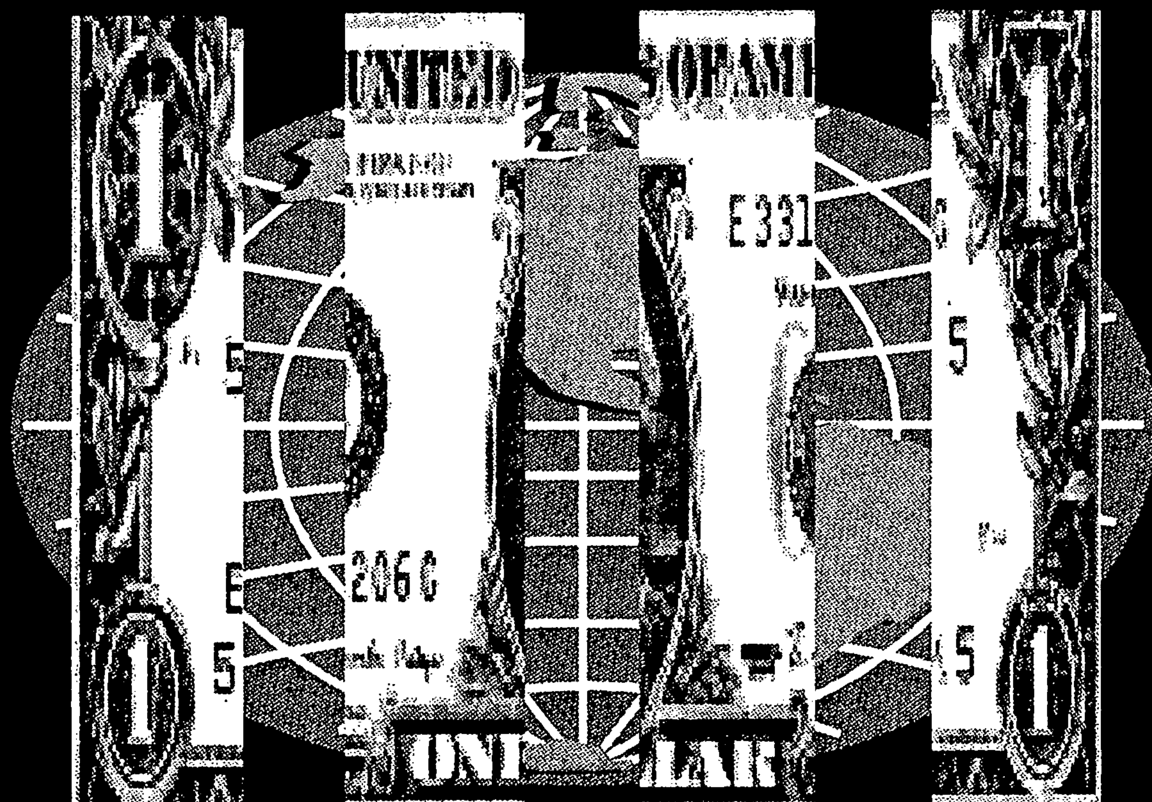
- To promote renewables internationally, we have tapped the resources and expertise of thirteen other Federal agencies through CORECT; the Committee on Renewable Energy Commerce and Trade. All of these agencies have an interest in renewable energy and energy efficiency technologies, but bring to bear unique resources in marketing and trade policy, in financing projects, in environmental issues, and development. These agencies include the Department of Commerce, The Export Import Bank, the Overseas Private Investment Corporation, and the Environmental Protection Agency, and the services provided include export counseling and assistance, market assessment, trade opportunity identification, feasibility studies and financing, insurance, financing, export licensing, trade regulations, etc.

- For the technical side of commercializing renewables, the Department of Energy also provides the services of the Design Assistance Center at Sandia National Laboratories; I will come back the DAC in a few minutes.

- We are also working closely with the U.S. Export Council for Renewable Energy; we see tremendous benefits in our future energy security through the support and development of a domestic industry, and we listen carefully to industry and try to address their particular needs. **One of the most clear-cut needs of the industry is funding for pre-feasibility and feasibility work on renewable projects.** Another is that, while many renewables now have very competitive costs on a lifetime basis, particularly in dispersed and remote applications, their up-front costs are often higher than those of conventional technologies. To address this problem, we have been working in CORECT to try and provide the unique financial vehicles that can help renewable technologies overcome their higher up-front costs.

- So, while CORECT was created to promote trade for the U.S. renewable energy industry, many of the things we are doing with CORECT can also benefit mutual exchanges; One of the important things that CORECT addresses is financing; some of these financing services are directly and indirectly coming to bear on projects in Mexico, and will help accelerate the development of renewable energy industries on both sides of the border.

Financing of Energy Services



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- One way we have tried to assist industry is through a One-Stop Financial application for U.S. industry. By filling out one form, a renewable energy firm can simultaneously apply for financing from the Export Import Bank, the Overseas Private Investment Corporation, the Trade and Development Program, and the Agency for International Development. It simplifies bureaucracy for the small renewable energy company, and gets the company lined up for all available assistance for feasibility studies through project financing.

- As an example of innovative solutions and alliances, we are finding success with a CORECT program called FINESSE; (Financing of Energy Services for Small-Scale Energy-users. One of the barriers to obtaining energy in the developing world is financing, and it is typically more difficult for renewable energy projects to obtain financing from multi-lateral or bilateral donors. These donors often prefer large-scale projects, because the donors may not be familiar with small-scale technologies, and because the administrative costs of a larger number of small loans may be higher. The FINESSE program attempts to address this bias towards large scale projects by identifying and supporting the intermediary organizations that can organize portfolios of the smaller renewable or efficiency projects so that they can be incorporated into projects the donor banks are willing to support. Through this program, we have developed financing models, performed market assessments, prepared a number of business plans for the development or expansion of alternative energy enterprises, and worked to develop a FINESSE Fund to support intermediary organizations. This program recently met with enormous success at a workshop in Malaysia, where over $800 million dollars of viable renewable energy and energy efficiency project opportunities were identified. The World Bank has agreed to create a new unit to handle FINESSE, and to perform project appraisal and preparation in order to link renewable energy and energy efficiency projects with World Bank loan packages. The U.S. will contribute financially, as will the UNDP. This model may be applicable to Mexico as well; to create new, innovative organizations that can tackle these obstacles on a piecemeal basis, and come out with large scale results that fit the country's needs.

- Through CORECT, we are in the process of developing the International Fund for Renewable and Efficient Energy, an intermediary organization financed by government agencies and other sources to provide start-up funds for projects.

- What we are doing in the U.S. can overflow into Mexico as well; the challenge is to build the institutional alliances that will extend over the borders. We have technologies that can be fit into a number of niche markets; these are ample opportunities to provide reasonable cost power and prove the technologies on a larger scale. We have trade and financing mechanisms in place; maximizing these will be facilitated by NAFTA. What is needed next is a framework for us to work together to support the more numerous applications, to take our individual needs and individual resources, and match those country to country, organization to organization, and create a mutually beneficial political, economic, and technical alliance.

PRONASOL

Programa Nacional de Solidaridad; or National Solidarity Program. A significant part of PRONASOL is Electrificacion Rural con Fuentes locales; which prioritizes rural electrification.

THE NEED	There are almost 80,000 villages in rural Mexico without power, most of them with fewer than 600 people
THE COMMITMENT	Over $1-B dedicated to this program over the next five years.
PROGRESS	Over 6,000 Photovoltaic applications to date; Wind system installation accelerating

- We are working to develop a renewable energy alliance with Mexico, and PRONASOL is the Mexican side. The Government of Mexico has instituted a dramatic rural development plan, called PRONASOL -- Programa Nacional de Solidaridad; or National Solidarity Program, to provide social services such as water, sanitation, health care, and education to historically unserved or underserved rural populations. There are 28 million rural people in Mexico without power; one of the results is a massive exodus to the urban areas, and Mexico's cities are bursting as a result. There are almost 80,000 villages in rural Mexico without power, most of them with fewer than 600 people. 1 out of 4 Mexicans depends on the land, but produce only about 8 percent of gross domestic product; Mexico's President Salinas has said that this is simply unsustainable in this form, and is attempting a bold re-structuring of the agricultural system.

- Some kind of electric power resource is often the key behind providing these services; thus a significant thrust of PRONASOL is Electrificacion Rural con Fuentes Locales; which prioritizes rural electrification. The Mexican government is going ahead with this program; and has dedicated over $1-B to this rural electrification program over the next five years. Programa de Electrificacion Rural con Fuentes Locales has been approved and funded with enough money to do the job, and will be assisting with household electrification and loan-financed productive use applications.

- Some of the technologies that have been meeting the most success in DOE programs are precisely the ones that fit Mexico's current needs: small wind machines, stand-alone photovoltaic systems, and some biomass electric systems. Agriculturally, these technologies can be of great assistance to Mexico. In the U.S., these applications are what we have been pursuing as niche markets, because they are what support the technologies at their current costs. For these Pronasol activities, these applications are the normalized markets for these technologies. Remote sites are often the norm in Mexico. While in the U.S. we are pursuing peaking power as a niche market, in Mexico the PV application may simply be a nominal amount of power for battery charging. In agriculture, the U.S. niche market might be biomass electric as a waste reduction strategy; in Mexico it may be simply a matter of economy, and perhaps to provide some power at an agricultural site for food processing or canning or refrigeration. For the Mexican end user; in homes, in small stores, community gathering places, a small amount of power is all that is needed. For a rural health center, a small vaccine refrigerator can leverage an enormous improvement in health with a very minimal amount of power.

WATER PUMPING SLIDE

- Other uses include water pumping -- as population pressures increase, it becomes more and more important to acquire sub-surface water sources to keep the people healthy. You don't need the grid for this, but you often need more than hand pumps. Additional water sources can help improve local and commercial agriculture as well. All of these uses can contribute to the alleviation of poverty -- Providing the energy to communicate, to get goods to market, to keep people healthy and give children light to read by.

- Some people say that renewables are too exotic for these applications. I would disagree; that wind systems played a major development role in the U.S. agricultural states. As for PV, it may appear exotic, but it is so inherently simple. For comparison, an imported diesel is also fairly exotic when it is at the end of the road in a remote village; it's continual demand for fuel is not exotic, but it is relentless. A World Bank report earlier this year showed that there are a number of institutional and socio-economic liabilities to diesel, the most prominent are lack of spare parts or foreign currency. But mores the trouble; the study found that these systems on average are unavailable for use about 24% of the time; in some cases is was closer to 30% and 40%. In addition, their costs averaged about 15 cents a kWh, and ran as high as 25 cents. So, diesels are not the whole solution. All over the world are diesel systems rusting away because it was just too cumbersome to get the parts to repair it in time; these systems were abandoned.

- Throughout the world, lesser-developed countries are finding that following the large-scale model of electrical grid extension just isn't sustainable; the amounts of power that are currently required just cannot amortize the astonishing cost of extending the grid there. In many instances, grid extension may be overkill, both in terms of need and in cost. So while Mexico is blessed with more than abundant oil and gas reserves, it also has enormous solar, plentiful wind, and significant micro-hydro sources, all in the rural areas where they are needed.

- I commend the Mexicans on their commitment to a program of this size, and taking on the challenge of meeting the needs of their rural residents . . .

PROCER --
The Programa de Cooperacion en Energia Renovable

Information Dissemination

Technical and Design Assistance

Training

Resource and Other Assessments

Targeted Work Areas in:
- Productive Uses
- Institutional Design
- Financing

Cooperative Development of Field Projects Embodying Innovative Applications and Approaches to Rural Electrification

Program and Project Documentation and Evaluation

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- The U.S. side of the coin in this effort will be PROCER; Programa de Cooperacion en Energia Renovable. The Department of Energy will be working with Pronasol, in a collaborative effort. This will be a mechanism to provide much of the training, technical assistance, and institutional and infrastructure development. It is much more than just the Department of Energy; I should acknowledge the participants. On the U.S. side, the Federal government will be providing about $1-M next year towards support of the program, and will put forth the resources of the Department of Energy, the services of the CORECT Design Assistance Center at Sandia National Labs; the National Rural Electric Association will also be involved.

- The Design Assistance Center of Sandia National Laboratories will provide a significant technical interface for the purposes of resource assessments, project design and development, and technical assistance, including training.

- There will be true collaboration with Pronasol, with the Mexican Federal Electricity Commission, their Electric Research Institute, the Mexican Solar Energy Association Industry Group, and the Nacional Financera. The steering committee for PROCER includes three Mexican counterparts: a representative of PRONASOL, a representative from the Secretariat of Program and Budget; and one from the Federal Electricity Commission, known as CFE.

- The level of commitment on both sides is both tremendous and unprecedented; having equivalent representatives from both countries will contribute towards more synergistic relationships.

MEXICAN OBJECTIVES --

Increase the flow of information to Mexico on Renewable Energy Technology, Applications, and Related Areas.

Strengthen the human resource base in Mexico through training and experience.

Strengthen the Mexican Renewable Energy Industry through technology transfer, sustained market growth, and strategic alliances with U.S. firms.

Support renewable resource assessment activities.

Support development of innovative pilot projects for widespread replication.

- Again, I commend the Mexicans for identifying their goals and committing to them. They recognize the importance of renewable energy's role in contributing to rural and economic development.

- They are seeking to increase the flow of information to Mexico on Renewable Energy Technology, Applications, and Related Areas.

- They see the importance of strengthening the human resource base, and building renewable energy skills and experience within Mexico, and have specifically targeted training as a critical part of the program.

- They have their own industry to build, and are seeking technology transfer, and strategic alliances with U.S. firms to sustain market growth and build their capacity to serve those markets.

- They know that they have a tremendous resource base, and are actively seeking to identify the magnitude of these resources throughout the country. Wind systems are also being installed, and while there have not yet been as many as the PV systems, they will often be an even lower cost application than PV; particularly on the coasts, for icemaking, and for water pumping. Again, resource assessments are a special need for wind power in particular, and they recognize this.

- They recognize that it's important to set the stage with pilot programs so that they can get a feel for what works best, and put the basic learning under their belts so they can pursue widespread replication. I should point out that the 6,000 PV systems that have already been installed, and serve about 35,000 people, were installed as a pilot program. This is an enormous pilot program; and it demonstrates the level of their commitment.

U.S. OBJECTIVES --

Support sustainable renewable energy development in Mexico and, by demonstration there, worldwide.

Learn from cooperative activities and experience in Mexico, and use lessons learned in other countries.

Support the U.S. renewable energy industry, through access to Mexican market and program, and through fostering Mexico-U.S. industry ties.

Support development of environmental policies that minimize greenhouse gas emissions.

U.S. Objectives

- The Department of Energy wants very much to support this effort. Both the scale of renewable energy applications in Mexico and the match of application to need is unprecedented. We also want to support the Mexican government in their commitment to renewable energy.

- This cooperative effort can demonstrate to the world the potential of renewables, and teach us how to maximize that potential. These are not simply pie-in-the-sky demonstrations; these are real-world applications that fit human and economic needs on a large scale. We can bring a lot of technical assistance to the table in this effort, but we will also learn quite a bit.

- The private sector -- in the U.S. and Mexico -- will be collaborating on planning, implementation, and investment. We are also eager for joint ventures, and believe that renewables will have a role in the maquiladoras activity along the border.

- And, we believe that renewables can have a significant role in addressing some pressing environmental problems; certainly along the border, in the heart of Mexico itself; and by providing such a large scale display of viable renewable energy technology display to the entire world, we will be addressing world-wide environmental challenges such as global warming.

Pursuing Common Objectives Through PRONASOL and PROCER

Support the Mexican renewable energy program to help insure program and project quality and sustainability.

Support development of a large long-term renewable energy market, in both the public and private sector.

Foster increased ties between Mexican and U.S. renewable energy industries.

- The steering committee has agreed upon all these goals; I haven't conjured them up. They have found some common ground, some common objective.

- Both sides recognize how important it is that this program put forth a message that renewable energy technologies are quality products, ready for the marketplace, and will fulfill their promises. We will be working together to achieve a level of technical training and assistance that we haven't had the opportunity to provide on this scale. We will be working together to provide the infrastructure behind the program that will ensure its' success -- in program design, in project implementation and replication, in spare parts networks . . . these are all critical if we are to have a sustainable program.

- Both sides know that renewables are emerging in the marketplace, and both sides see the benefits of renewables in terms of jobs, in terms of environment, and in terms of sustainable energy supplies. We both want to facilitate the development of these markets.

- And both sides know the benefits of collaboration. In some cases it will be in the form of tech transfer, in some cases it will be financial assistance. Collaboration will lead to joint ventures; there is no doubt of that. This collaboration will build the renewable energy industry on both sides of the border.

A 2000 Mile Opportunity

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2000 Mile Opportunity

- So, this brings us back to a major set of opportunities, affecting the long stretch of new communities and new economies developing along our 2,000 mile border, and extending deep into both countries.

- I began this afternoon talking about an exchange between the U.S. journalist Bill Moyers and Mexican author Carlos Fuentes. And in his book, *The Old Gringo*, Senor Fuentes wrote that the border is not really a border, but a deep scar. We have had many differences in the past; over territory and development issues, and there has been more than a little distrust. But as Senor Fuentes says, (and I quote him here), "It is possible to build bridges. In *The Old Gringo*, the bridge over the Rio Grande suddenly bursts into flames. You can build a bridge; you can also burn it. But I think we are entering an era in which we should be building bridges."

- Renewable energy is one of the materials we can build these bridges with. I think that we are building bridges here today, and the border region will not be a scar but a thriving, multicultural region of opportunity for both our countries.

MEXICO TRADE FACTS SUMMARY:

ENERGY EXPORT OPPORTUNITIES FOR CONSERVATION AND RENEWABLE ENERGY TECHNOLOGIES

Mexico represents a good potential market for U.S. based energy-related products and services that are cost effective and environmentally sound. These include energy conservation products as well as some renewables. Examples of energy product areas that should see a continuing increase in demand include:

- *Energy conservation and pollution control equipment and services;*
- *Geothermal energy for direct-use of on-line electricity generation capacity;*
- *Photovoltaics for water pumping, telecommunications and lighting; and*
- *Solar thermal applications for water heating and refrigeration.*

Applications for these products and services should be present in both rural and urban areas. Examples of applications include stand-alone photovoltaic or wind powered water pumping, or photovoltaic lighting and solar thermal water heating at resort hotels. The American Solar Energy Society anticipates that Mexico will soon be the world's largest importer of renewable energy systems. Sales U.S. photovoltaics are steadily increasing -- by as much as 25 percent per year. Exports of wind energy systems also are growing steadily.

The following summary prepared by BCS, Incorporated briefly summarizes the current energy situation in Mexico; discusses opportunities for demand-side management and renewable energy options; and briefly presents some risk factors that need to be considered prior to entering into export ventures in Mexico.

Mexico's Current Energy Resource Situation

Although Mexico is an important world oil producer and relies heavily on petroleum to meet its domestic energy demand, there is a move toward diversifying energy consumption and utilizing clean domestic energy resources. A brief discussion of Mexico's energy resources follows.

Mexico has substantial hydrocarbon reserves in the form of crude oil, natural gas and coal. Proved recoverable reserves of crude oil and natural gas liquids are approximately 53, 879 million barrels. Proved recoverable natural gas reserves are about 74,832 billion cubic feet, and coal reserves are approximately 1,886 million tonnes.

Oil represents the bulk of Mexico's energy production, however, and its share of total energy production in Mexico has increased over the last two decades -- largely at the expense of natural gas and renewable energy production. Oil production currently represents 90.3 percent of total energy production in Mexico. Mexico also relies on hydropower, geothermal, firewood/sugar cane, as well as wind and solar energy for its energy sources, yet to a much lesser extent.

The solar energy resource in Mexico is excellent. The average monthly irradiation in Mexico (calculated by averaging solar irradiation levels in nearly 60 locations) ranges from a low of 3.73 kwh per square meter per day in January, to a high of 5.85 kwh per square meter per day in May.

Geothermal energy production represents a small but growing component of the Mexican energy picture comprising 0.2 percent of overall energy production in 1985 and 0.6 percent in 1988. As of 1989, the World Energy Conference reported that there were 650 MWe of installed geothermal capacity.

Electricity produced from hydropower as well as firewood/sugar cane declined over the last two decades and comprises 2.6 percent and 4.9 percent respective of total energy produced. Mexico has approximately 7,780 MW of hydropower capacity and roughly an additional 3,000 MW planned yet not all under construction.

Petroleum consumption in Mexico increased at an average annual rate of approximately 2.5 percent from 1980 to 1989 compared to roughly 1.5 percent per year in the U.S. over the same time period. Natural gas consumption in Mexico only increased at an average annual rate of about 0.5 percent. Natural gas production has actually declined due to a lack of financial resources for exploration and extraction and Mexican imports of natural gas have increased significantly.

Outlook for Energy Conservation and Renewables

Pollution control has become a high priority in Mexico and especially in the Valley of Mexico where Mexico City is located. The government is taking measures to utilize cleaner burning fuels in all sectors of the economy, particularly in the transportation sector. Rural electrification and clean water supply are also important energy issues in Mexico.

To successfully export energy conservation or renewable energy equipment and services, specific project opportunities would need to be identified. Moreover, the terms and conditions of the export agreements would need to be acceptable financially. In looking at the general Mexican market for these products and services, however, several observations can be made. These include:

- *An area that represents a market for U.S. exporters is in the export of pollution control equipment, instruments and services. The U.S. is the largest foreign supplier in this category and this market is expected to grow 10 to 15 percent through the mid 1990's.*
- *Recent policy changes in the utility sector now allow individual power producers. This should present opportunities for renewable energy power systems, fossil fuel/renewable energy hybrid systems, and cogeneration.*
- *Currently, there are many solar water heating installations including large systems at some hotels. Other solar energy applications include: water pumping, rural electrification at schools, and seawater desalination plants. Applications of this nature should continue to be viable.*
- *BCS research of available monthly solar irradiation data for over 100 countries finds that Mexico ranks among the best in terms of the solar resource. The solar resource is strong enough to make photovoltaic and solar thermal applications viable year round. Among nearly 60 locations for which monthly irradiation are available, some of the best sites include: Acapulco, Guerrero; Colotlan, Jalisco; Huejucar, Jalisco; Manzanillo, Colima; La Paz, Baja California Sur; and Veracruz Llave, Veracruz.*
- *Recent efforts by the International Trade Administration (ITA) and the Committee for Renewable Energy Commerce and Trade (CORECT) have focused on identifying specific applications for*

renewables such as for stand-alone PV systems located at resort hotels or universities -- each viable opportunities in Mexico.

- *Rural applications of renewables also present opportunities for renewables. There are approximately 80,000 villages without electricity in Mexico. Two factors that RET applications must meet in rural areas, however, are: 1) cost -- energy systems must be affordable and cost-competitive; and 2) service -- there needs to be adequate training of local personnel to support installation and servicing of equipment.*

- *Another area of opportunity should be in the geothermal industry. The Mexican government hopes to have over 2,000 MWe over geothermal energy capacity installed by year 2000. Direct-use geothermal applications include space heating, aquariums, and refrigeration systems.*

- *As of 1989, Mexico had 265 MW of installed wind capacity for electrical and mechanical purposes. Numerous windmills are used for water pumping and electricity generation. In addition, wind machines are being used around Mexico City to improve circulation and dispersement of polluted air. Wind energy applications should continue to increase.*

- *As of 1989, Mexico had 360,000 kW of electrical capacity from bagasse in sugar refineries. The economic health of this industry in Mexico as well as the need to re-tool and upgrade existing systems could present viable export opportunities for U.S. companies in the biomass-fired equipment industries.*

Risk Factors to Consider

Prior to initiating an export venture in any country, numerous risk factors must be assessed and Mexico is no different. Several factors which should be evaluated include:

- ***What is the private power investment climate?** Through careful study, BCS has found that private investment in the power generation sector is encouraged by the current government. The country needs both power and investment for growth. Analysis of investment opportunities and project approvals can be tedious, however, for some projects.*

- ***Are there incentives for U.S. companies?** Currently, incentives in Mexico are biased toward Mexican-owned companies. Joint venture and turnkey operations, however, are encouraged.*

- ***What is the political stability of the country?** Occasionally, there are instances of political turmoil but generally, Mexico is considered fairly stable when compared to other developing nations.*

- ***What are the trade barriers?** Duties on imported equipment have declined, but there are still difficulties with licenses and other types of non-tariff barriers. In terms of U.S. companies providing services in Mexico, a local partner typically is required.*

- ***What is the history of payment for exports?** In most cases Mexico has met its payment commitments for imported U.S. products. This means that U.S. exporters should view Mexico as a relatively good risk in terms of paying for the goods it imports.*

- *What is the attitude from international financial organizations? Organizations such as the Eximbank are encouraging business in Mexico.*

- *Can a exporters monies be expropriated? The Mexican Government can impose restrictions on capital outflows to stem capital flight. However, such restrictions have not been a major issue under the current government.*

Please contact BCS, Incorporated for further Energy Technology-Country analyses.

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the First Quarter

FY 1987

March 1987

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Ninth Quarterly Progress Report:
Report of the First Quarter
(October through December)
FY-1987

MARCH 1987

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

The Salton Sea Scientific Drilling Program (SSSDP) has been documented in a series of quarterly reports. This ninth report covers the first quarter of fiscal year 1987, the period from October 1 through December 31, 1986. Subsequent to temporary repair of the damaged wellbore, emphasis has been placed upon acquisition of post-drilling temperature data and assessment of options for continuation of the SSSDP.

Studies to determine causes for collar failure and parting of the 7-inch liner in the scientific well continued in this reporting period. A draft report of failure analysis of collar and liner material by Brookhaven National Laboratory revealed that the collars probably failed by a stress corrosion and hydrogen embrittlement mechanism. Hopefully, this analysis will help reduce the possibility of reoccurrence.

Electronic memory and Kuster temperature instruments were lowered into the well in late-October in an effort to successfully complete the equilibrium temperature studies. However, the deepest temperature reading taken was at 5,822 ft. Apparently, the water injected to clean-out mud from the repair operations disappeared into the annulus at the top of the liner. Now, a viscous mud-gel probably fills the wellbore from approximately 5,800 to 8,000 ft.

During an attempt to calibrate the dewared high-temperature Kuster tool and the Madden Systems electronic temperature tool, the electronic tool was found to record closer to actual temperature, up to 204°C. Exceeding 204°C temperatures, the electronic memory tool failed to dump data. The tool was sent back to Madden Systems. Further calibration tests will be scheduled following repair.

Planning continues for the performance of a long-term (up to 30-days) flow test and continued scientific experimentation. Planning includes provision for removal and replacement of the damaged 7-inch liner, construction and operation of flow test facilities, and fluid disposal through a 1.25 mile pipeline into an injection well to be provided by Kennecott.

Analysis of scientific data and reporting of results continued during this quarter. Since SSSDP logs are needed for current investigations, the "Preliminary Report on Geophysical Well-logging Activity on the Salton Sea Scientific Drilling Project, Imperial Valley, California," by Paillet and others, has been issued as a USGS Open-file Report (No. 86-544). The first collective report of scientific results from the SSSDP will take the form of an all-day symposium at the spring meeting of the American Geophysical Union in Baltimore, MD, in the latter part of May 1987. Negotiations continue with the Journal of Geophysical Research to publish a special issue reporting these initial results.

During their October 1986 meeting with DOE in El Centro, California, representatives of Mexico's Comision Federal de Electricidad (CFE) expressed great interest in the progress made and research completed at the SSSDP. The CFE officials showed particular interest in materials used in the fabrication of SSSDP tubulars and other equipment. The usefulness of various geophysical logs run in the SSSDP well was also of interest for application in interpreting volcanic settings.

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INTRODUCTION

Drilling of the scientific well ended at a depth of 10,564 ft on March 17, 1986. During and shortly after the drilling phase, two short-duration flow-testing and fluid-sampling sessions were performed in addition to several periods of geophysical logging. While running a wireline temperature survey during the shut-in period following completion of the well, an obstruction was encountered in the wellbore at about 6,380 ft, indicating that the 7-inch liner had either parted or collapsed. Workover operations performed in August verified liner parting and provided temporary repair of the wellbore, allowing resumption of scheduled temperature surveys. The wellbore was reamed clear to 8000 ft and a temporary liner installed.

The main concern during the October 1-December 31, 1986 reporting period was completion of a primary Stage-I objective -- obtaining post-drilling equilibrium temperature logs to the greatest depth possible. The next priority will be to obtain uncontaminated fluid samples from the scientific well (State 2-14) below 10,000 ft. If the State 2-14 well cannot be reopened to this depth, fluid samples will be taken from the deepest reservoir, greater than 8,000 ft, that can be isolated and flow tested.

Stage-II of the SSSDP entails deepening the State 2-14 well, either by modification of well construction as proposed in April 1986, or by sidetracking past the broken liner. No definitive action can be taken on the Stage-II plans during this fiscal year, because additional funds beyond those available in FY-1987 would be required.

PROGRAM PLAN AND ACTIVITIES

Drilling & Engineering Program

During this reporting period, a failure analysis of the damaged casing from the SSSDP well was completed by scientists at Brookhaven National Laboratory. Samples of well casing and collar were cut from the hanging part of the parted liner (i.e. from the base of the ninth joint, upward), and the mechanical properties evaluated (Table 1). Analysis revealed that the collars probably failed by a stress corrosion and hydrogen embrittlement mechanism. This was caused by a martensitic structure, high tightening tensile stress, and the presence of H_2S and O_2 in the environment. The tendency of collar material to crack in this environment would probably be reduced substantially by tempering the martensitic collar material to increase ductility, and decrease hardness and yield strength to values below RC-20 and 75,000 psi. The chemical composition of the material used for both casing and collars was found to be of good quality and identical, except for the difference in heat treatments of the two. The higher strength of the collar steel, and cracking susceptibility, was probably enhanced by normal tightening during assembly, as well as by some untempered martensite in the collar steel.

		Hardness (Rc)			
Collar	0.2% offset Yield stress, psi	Inside Surface	Surface of Cross Section	Outer Surface	% Elogation
Sample 1	91,200	20 Range: (19.5-22)	20.5 (20-21)	24.0 (23-28)	15
Sample 2	91,650	-	-	-	-
Casing (Pipe)					
Sample 3	82,400	18.9 Range:(18-19.5)	20.0 (19.5-21)	21.0 (18.5-22.0)	19
Sample 4	82,700	-	-	-	18
Casing steel test report, N-80, quench and tempered condition (duplicate specimens)	94,940 93,140	- -	- -	- -	23 24

Table 1: Mechanical Properties of Collar and Casing Alloys Cut from Joint No. 2

Prior to failure of the collar at the tenth joint of 7-inch liner in the Salton Sea well, options for long-term flow testing and deepening the well to 13,000 or 14,000 ft were already being considered. However, the high cost and risk of inadequately controlling lost-circulation zones has tended to discourage conducting further operations in the well. In searching for better means of controlling lost circulation in the well, a mixture of bentonite, ammonium polyphosphate, borax and magnesium-oxide was suggested for use as an LCM pill. If lost-circulation zones can be sealed effectively, it should be feasible to cement-in a new hang-down liner, eliminating numerous problems associated with performing extended flow test and well deepening operations.

In FY-1987, Congress continued to support the SSSDP effort by providing $1.3 million in new funding. The House had provided $2 million more for deepening the scientific well, but the Senate did not concur. The Conference Committee adopted the Senate position. Funds will be used to repair the scientific well, perform a flow test for up to 30-days and conduct limited experiments. A breakdown of prior funding, by category and funding agency through FY-1986, is provided in Table 2. Estimated liner removal and flow test costs are presented in Tables 3 and 4, respectively.

	FUNDING BY AGENCY (IN $ 000'S)				
CATEGORY	NSF	GTD	USGS	OBES	TOTAL
Drilling & Engineering	25	7,061	25	25	7,136
Geochemistry	168	--	165	103	436
Petrology	280	--	--	150	430
Geophysics (Lab)	--	105	15	132	252
Geophysics (Site)	--	--	180	170	350
Bio-Organic	--	--	70	--	70
Instrumentation	--	597	120	--	717
Science Support & Management	--	--	300	146	446
Total Funding	473	7,763	875	726	9,837
Total Activities	7	11	13	11	42

Table 2: Summary of Drilling and Engineering, and Scientific Program Funding Through FY-1986

Activity	Duration	Estimated Cost ($1,000)
Three Fishing Operations	14 days	385.6
Additional Fishing Operations	3 days (each)	58.3 (each)

Table 3: Estimated Cost for Fishing Operations to Remove Parted 7-inch Liner

Activity	Estimated Cost ($1,000)
Flow Test Facility: engineering, procurement, reconditioning shipment Flow Test Facility: construction Flow Test Pipeline: engineering, procurement, construction	482.9
Flow Test	119.2
Decommission/Decontamination	160.5
Onsite Support (telephone, water, power, trailers, etc.)	43.9
Stand-by and Final Report	45.0
Subtotals	851.5
Less contributions	<50>
Total	801.5
Estimated Budget for Remedial Work	498.5

Table 4: Estimated Cost of Flow Test (Up to 30-days)

A no-cost, 3-month extension of the Bechtel contract has been authorized through March 31, 1987. In the meantime, Kennecott will seek management approval to drill a well (Wilson 1-12) for use as an injection well during the flow test. Also, Bechtel is preparing the final report of its SSSDP activity through 1986. The first draft is in review.

The first task under the FY-1987 program will be removal of the damaged 7-inch liner, to the maximum extent possible, and installation of a new 7-inch liner, isolating the deepest production zone below 8,000 ft. In the event that the damaged liner cannot be removed completely, drilling of a sidetrack well may be an option.

The next task will be to fabricate and construct flow test facilities. Current plans are for Kennecott Corporation to drill the Wilson 1-12 well, to be located about 1.25 miles north of State 2-14, to a depth between 3,500 and 6,000 ft. This well would be tested initially by Kennecott for commercial production of geothermal energy, then be made available for injection of fluid produced from the State 2-14 well during the 30-day (maximum) flow test.

Facilities for the flow test will be constructed according to DOE provided design standards. Government-owned equipment and materials that meet the required standards will be used whenever possible. A source for the flow test equipment has been identified. Surplus pipe located at the DOE Geothermal Test Facility at East Mesa, California, according to DOE/SAN, was examined and found to be unsuitable for use in the proposed 30-day flow test. However, another source for surplus pipe has been identified. If it is necessary to purchase additional tubular goods, cost estimates may increase.

The long-term flow test will probably be the final task performed during FY-1987. The test is scheduled to be performed for a period not to exceed 30 days. A general operations schedule is as follows:

- o renovate flow test equipment - March to April
- o install pipeline between two sites - March to April
- o spud-in, drill and flow test Wilson 1-12 well - June to July, and
- o flow test State 2-14 using a full-flow separator - July to August.

Activity		Time (days)	Cumulative Time(days)
Mobilize Drilling Rig		1.5	1.5
Laydown wellhead		0.5	2.0
Make-up blow-out preventer equipment		0.5	2.5
Test blow-out preventer equipment		0.25	2.75
Mix mud, kill well		0.25	3.0
Pick-up (PU) & run in hole (RIH) with spear and 5-inch drill pipe		0.33	3.33
Pull out of hole (POOH) with 7-inch fish and lay down (Assumes recovery of temporary liner)		0.5	3.83
RIH with spear and spear 7-inch		0.33	4.16
POOH with 7-inch fish and lay down (Assumes recovery of ~4,000 ft of 7-inch, 1st pull)		1.0	5.16
Assumes 2nd pull to recover remaining 7-inch			
Release and POOH	0.33		
RIH with mill	0.33		
Mill	0.5		
POOH with mill	0.33	3.3	8.46
PU 3 1/2-inch drill pipe and RIH with cutter	0.5		
Cut, mud sweep, POOH with cutter	0.5		
RIH with spear	0.33		
POOH with fish and lay down	0.5		
Assuming Complete Recovery of Parted 7-inch Liner			
Set sand on bottom of wellbore	0.25		
PU and RIH with liner	0.5		
Rig-up (RU) Halco	0.5		
Cement liner/work liner	0.5		
Wait-on-cement (WOC)	0.33		
Make-up bit and RIH	0.5		
Drill cement and circulate sand out	0.5	5.07	13.53
POOH and lay down drill pipe	0.33		
RIH, POOH, lay down 3 1/2-inch drill pipe	0.5		
Lay-down blow-out preventer equipment	0.5		
Make-up wellhead	0.33		
Clean pits	0.33		

* Each additional fishing operation takes about 3-days.

Table 5: Planned 1987 Remedial Program

Specific activities with preliminary estimates of durations are provided in Table 5. Also, a preliminary milestone chart is given in Table 6. These plans assume that the State 2-14 well will be repaired, government-owned equipment and supplies will be available, and the Wilson 1-12 well will be available for produced-fluid injection. After use in the flow test, the State 2-14 well is planned for further use with the Wilson 1-12 well in a DOE-sponsored brine injection technology development experiment.

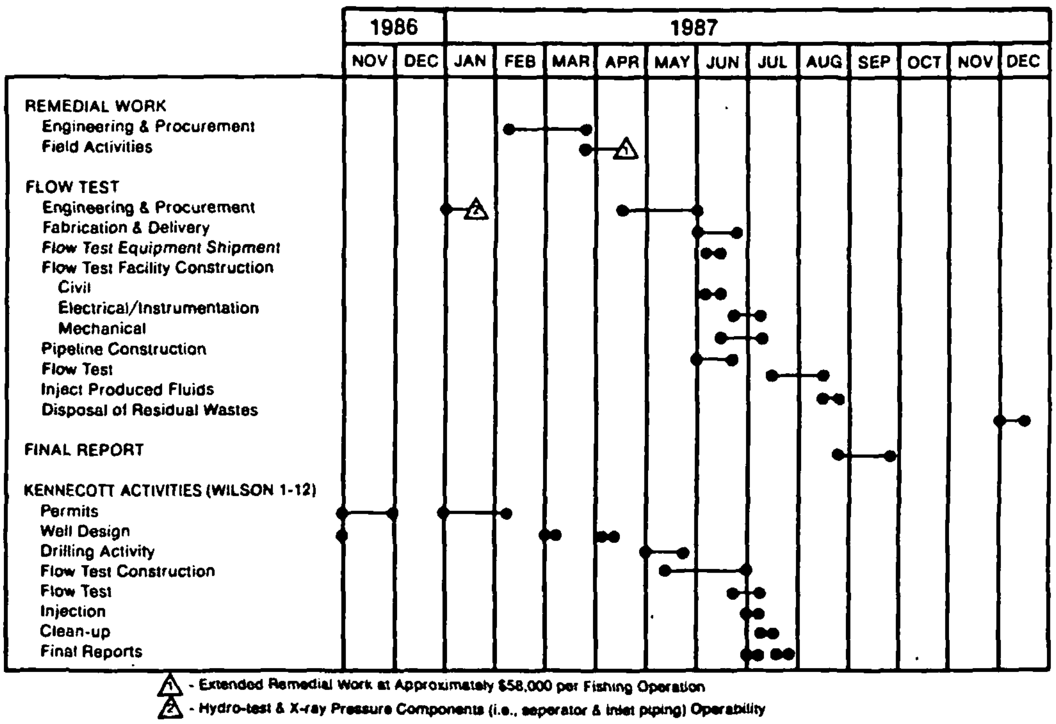

Table 6: TENTATIVE 1987 SSSDP SCHEDULE

<u>Scientific Experiments Program</u>

Partial remedial actions performed in August made possible the continuation of thermal equilibrium studies. USGS personnel coordinated with Bechtel and Cleveland Drilling Company personnel to attempt to obtain additional post-drilling temperature data on October 21. The dewared Kuster tool was run to a depth of 5,810 ft, where it encountered resistance 10-ft below a soft "bridge." It was pulled up and the deepest temperature reading was taken at 5,796 ft. On October 23 (first anniversary of the spud-in date), an 8-ft length of 2-inch sinker bar with a spade tip was lowered to 6,717 ft after 6-hours. To retrieve the bar, a pull of up-to 300 lbs over the weight of both tool and cable was required. The electronic memory temperature tool was lowered October 24 to a depth of 5,822 ft. A chronology of these operations is given in Table 7. Electronic tool results appear to verify 305 $\pm$ 5^{o}C as the temperature of the 3,127 ft reservoir.

Date	Action	Result
10/21	Ran "Dummy" Probe	Hung up on top of the 7-inch liner, because the makeshift bullnose had an insufficient bevel
10/22	Ran dewared Kuster tool	Encountered a soft "bridge" at 5,800 ft
	Worked Kuster tool down	Resistance to lowering stiffened considerably at 5,810 ft
	Pulled back up	Took deepest temperature reading at 5,796 ft
10/23	Ran 8-foot length of 2-inch sinker bar with a spade tip	After spudding on "bridge" for 6 hours, worked spear down to 6,717 feet
	Pulled out	Pull of 300 lbs over combined weight of tool and cable required to get back up to 5,800 ft, an indication that temperature tools would not get much deeper
10/24	Ran electronic temperature tool with 80 lbs of sinker bar	Significant weight loss was encountered (over 25 lbs) at 5,822 ft (only marginally deeper than Kuster tool was run). Took deepest reading and pulled out.

Table 7: Chronology of Post-drilling Temperature Survey Operations, October 1986

With benefit of hindsight (and additional funds), it can be recommended that mud be circulated-out with 2 7/8-inch drill pipe or Hydril tubing at the end of repair. It seems that flush-water injected at the time successfully eliminated this need only down to the top of the liner, where it disappeared into the annulus, leaving mud in the wellbore at greater depth. The sinker-bar spudding event of October 23rd indicates that the hole now contains viscous, gelled mud, possibly from about 5,800 to 8,000 ft. A suggestion to perform a low-cost, "coiled tubing" job to clean-out the gelled mud was considered, but rejected on the basis of unlikely success at the depths required in relation to risk.

Instrument calibration problems have produced differences in the post-drilling temperature survey data recovered from the two probes. During the second week in December, Bill Livesay, consultant, and Sue Priest, USGS, attempted to calibrate, at the Kuster Company in Long Beach, California, the high-temperature Kuster tool and the Madden Systems electronic temperature tool. Both temperature tools were immersed in oil baths while temperatures were elevated from 38 to 316^oC (100 to 600^oF), and in salt baths as temperatures were raised from 316 to 399^oC (600 to 750^oF). Data from the oil bath test are shown in Figure 1. As a result of these tests, the electronic

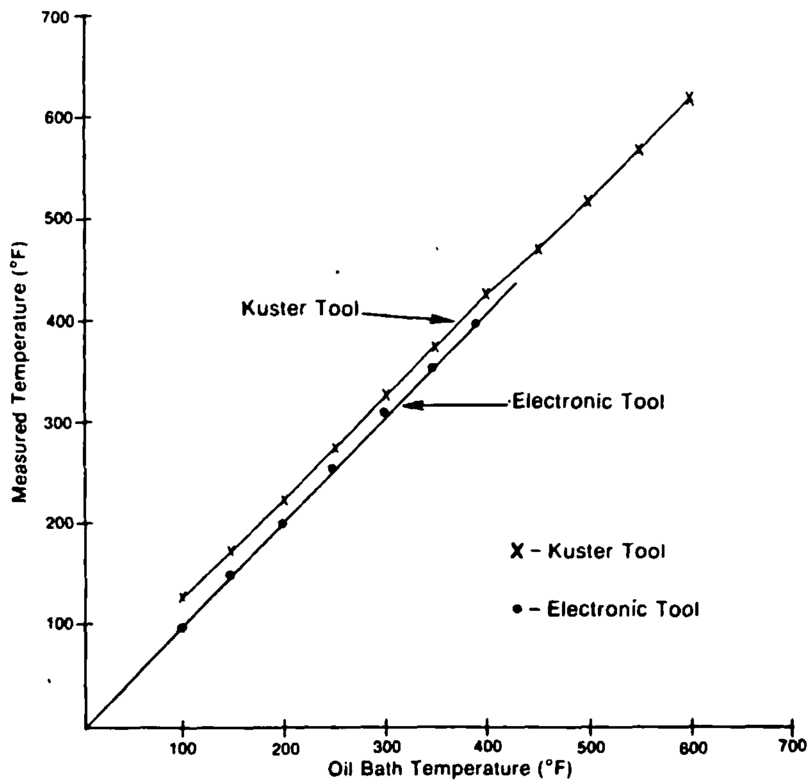

Figure 1: CALIBRATION TEST OF ELECTRONIC MEMORY AND DEWARED KUSTER TEMPERATURE TOOLS

temperature tool was shown to read closer to actual, at least to 204°C (400°F). It failed to dump its data at higher temperature and was returned to Madden Systems for repair. Completion of the calibration test will be rescheduled after repair.

In the absence of calibrated temperature data, three graphs, Figures 2-4, are provided to show preliminary results of the temperature surveys. A comparison of all the electronic memory tool temperature logging runs, along with two early runs of the USGS, Water Resources Division (WRD) tool, is provided in Figure 2. Figure 3 depicts the electronic and dewared Kuster tool temperature logs run in May, and Figure 4 depicts electronic and Kuster temperature logs run in October. Comparison of the electronic and Kuster tool results indicates that the electronic tool data are likely more reliable. Final judgement must await complete calibration results.

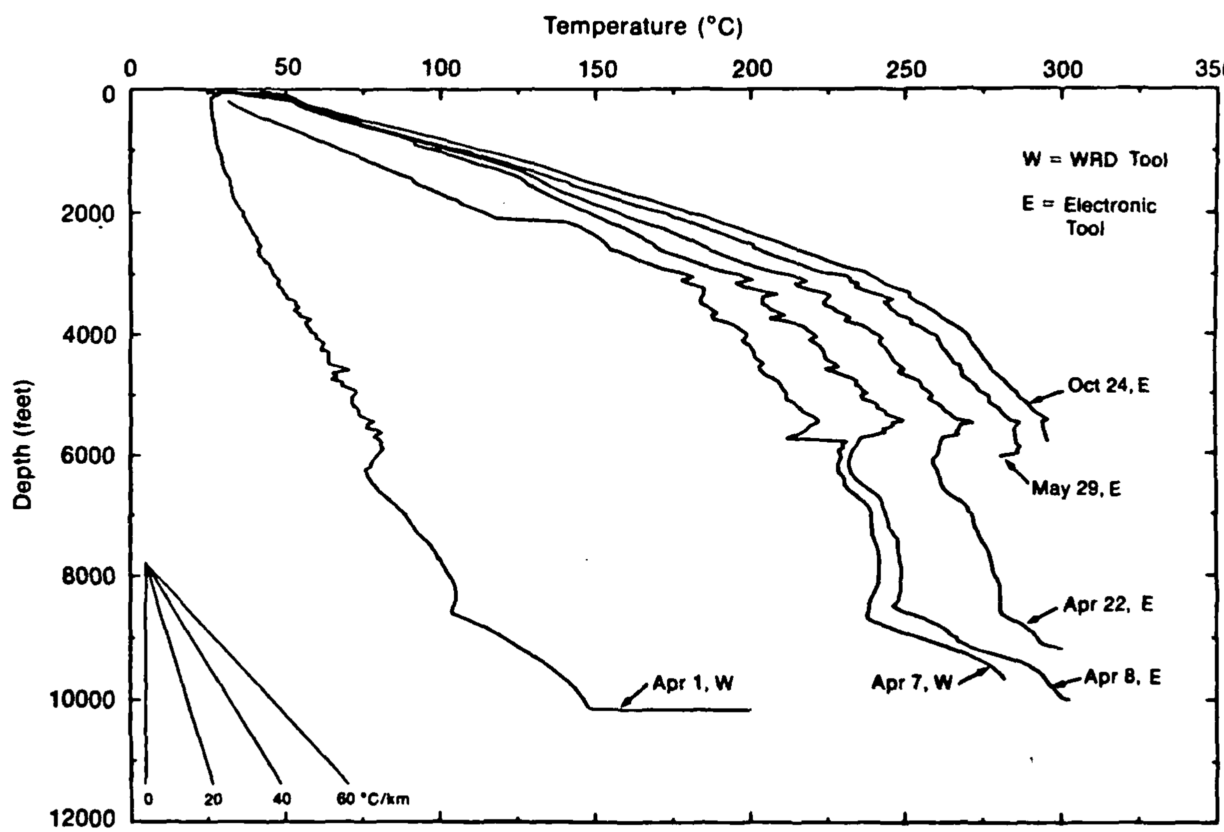

Figure 2: SERIES OF USGS TEMPERATURE LOGS FROM STATE 2-14 WELL (Uncalibrated)

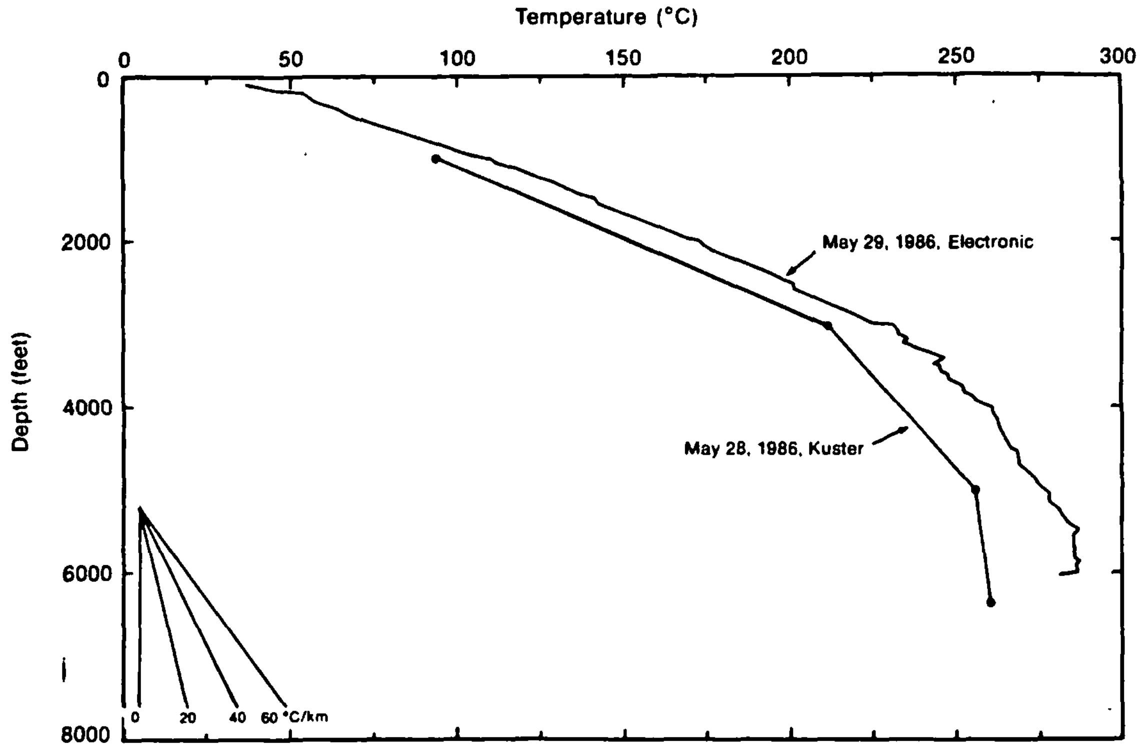

Figure 3: COMPARISON OF ELECTRONIC AND KUSTER TEMPERATURE LOGS OF MAY 1986 (Uncalibrated)

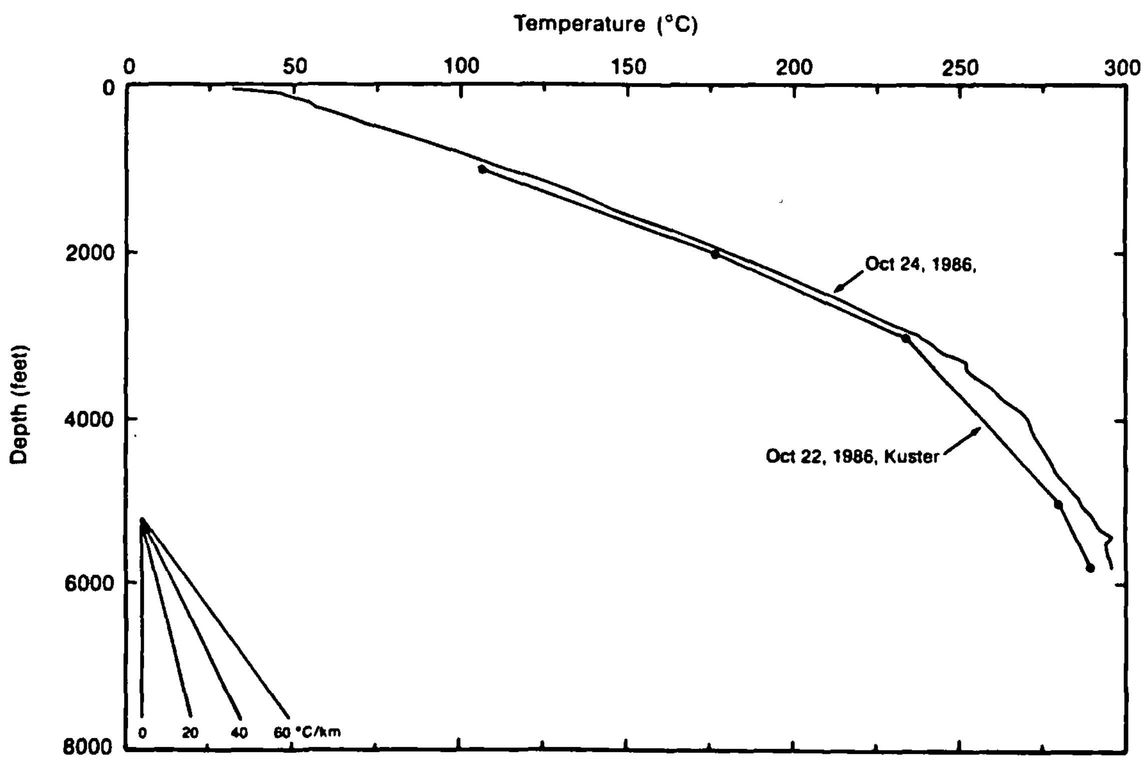

Figure 4: COMPARISON OF ELECTRONIC AND KUSTER TEMPERATURE LOGS OF OCTOBER 1986 (Uncalibrated)

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with established protocol during this reporting period. General and technical presentations were made at the Geothermal Resources Council (GRC) Annual meeting in Palm Springs, California on October 1, 1986. Technical papers of these presentations were published in the Transactions volume. The updated SSSDP bibliography follows:

(* = Status)

Aducci, A.J., Klick, D.W., and Wallace, R.H., Jr., 1986, Management of the Salton Sea Scientific Drilling Program: Geothermal Resources Council Transactions, v. 10, p. 445-448.

* Pub.

Andes, J., Jackson, J., Lilje, A., Sullivan, R., and Herzig, C.T., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Visual Core Descriptions; Herzig, C.T. and Mehegan, J.M., eds: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/1, v. 2, April, 93 p.

* Pub.

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* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Geologic Interpretation, Well State 2-14; for Bechtel National Inc., San Francisco, California, June, 158 p.

* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 20-21 March, 1986; for Bechtel National, Inc., San Francisco, California, June, 71 p.

* Draft - in Review

Goff, S., Mehegan, J.M., and Michels, D.E., 1986, Field Procedures Manual, Sample Handling, Salton Sea Scientific Drilling Project: Los Alamos National Laboratory, 34 p.

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Harper, C.A., and Rabb, D.T., 1986, The Salton Sea Scientific Drilling Project: Drilling Program Summary: Geothermal Resources Council Transactions, v. 10, p. 445-459.

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Herzig, C.T., and Mehegan, J.M., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Core Summaries: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/2, v. 2, April, 12 p.

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Los Alamos National Laboratory, 1986, Downhole Fluid Sampling at the SSSDP California State 2-14 Well Salton Sea, California; Goff, F., Shevenell, L., Grigsby, C.O., Dennis, B., White, A.F., Archuleta, J., and Cruz, J., eds.

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* Pub.

Michels, D.E., 1986, SSSDP Fluid Composition at First Flow of State 2-14: Geothermal Resources Council Transactions, v. 10, p. 461-465.

* Pub.

Nicholson, R.W., 1986, Extensive Coring in Deep Hot Geothermal Wells: Geothermal Resources Council Transactions, v. 10, p. 467-471.

* Pub.

Paillet, F.L. and Morin, R.H., 1986, Preliminary Geophysical Well Log Analysis of the Geothermal Alteration of Alluvial Sediments in the Salton Sea Basin, California: American Geophysical Union Fall Meeting.

* Draft - in Review

Paillet, F.L., Morin, R.H., Hodges, R.E., Robison, L.C., Priest, S.S., Sass, J.H., Hendricks, J.D., Kasamayer, P. W., Pawlowski, G. A., Carlson, R.C., Duba, A.G., Hearst, J.R., and Newmark, R. L., 1986, Preliminary Report on Geophysical Well-Logging Activity on the Salton Sea Scientific Drilling Project, Imperial Valley, California: Paillet, F.L., ed.: U.S. Geological Survey, Open-File Report 86-544, 79 p.

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Sass, J.H., and Elders, W.A., 1986, Salton Sea Scientific Drilling Project: Scientific Program: Geothermal Resources Council Bulletin, v. 15, no. 9, p. 21-26.

* Pub.

Sass, J.H., and Elders, W.A., 1986, Salton Sea Scientific Drilling Project: Scientific Program: Geothermal Resources Council Transactions, v. 10, p. 473-478.

* Pub.

Sass, J.H., Priest, S.S., Robison, L.C., and Hendricks, J.D., 1986, Salton Sea Scientific Drilling Project On-site Science Management: U.S. Geological Survey Open-File Report 86-397, 24 p.

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Solbau, R., Weres, O., Hansen, L., and Dudak, B., 1986, Description of a High Temperature Downhole Fluid Sampler: Geothermal Resources Council Transactions, v. 10, p. 479-483.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 23 October - 6 November 1985, Report No. 1: Geothermal Resources Council Bulletin, v. 15, no. 2, p. 15.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 7 November - 6 December 1985, Report No. 2: Geothermal Resources Council Bulletin, v. 15, no. 2, p. 15-17.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 7 December 1985 - 10 January 1986, Report No. 3: Geothermal Resources Council Bulletin, v. 15, no. 4, p. 15-18.

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U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 January - 10 February 1986, Report No. 4: Geothermal Resources Council Bulletin, v. 15, no. 6, p. 25-28.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 February - 1 April 1986, Report No. 5: Geothermal Resources Council Bulletin, v. 15, no. 8, p. 13-20.

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van Rooyen, D., and Weeks, J.R., 1986, Failure Investigation of Well Casing from the Salton Sea Scientific Drilling Project: Brookhaven National Laboratory, 26 p.

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Wolfenbarger, F.M., 1986, Battery Pack/Controller for High Temperature Applications: Geothermal Resources Council Transactions, v. 10, p. 485-489.

* Pub.

SIGNIFICANT MEETINGS & VISITS

U.S. Department of Energy (DOE)/Comision Federal de Electricidad (CFE) Meeting - October 8-11, 1986

A meeting with CFE (Mexico) to identify areas of mutual interest for bilateral agreement in geothermal research was convened in El Centro, California, October 8-11, 1986. CFE officials were extremely interested in SSSDP progress and research. The CFE staff was interested in obtaining reports on the general drilling activities and scientific research in the SSSDP well, materials used to fabricate equipment, and the usefulness of various geophysical logs in interpreting volcanic settings.

Continental Scientific Drilling, Interagency Coordinating Group (ICG) Meeting - October 17, 1986

The status of the SSSDP was discussed at the Continental Scientific Drilling ICG meeting on October 17, 1986. The DOE/GTD Program Manager summarized well workover operations performed in August to allow continuation of the thermal equilibrium studies. The goal of concluding the thermal equilibrium studies, at least to a depth of 8,000 ft, by year-end was stated. Attaining this goal was dependent upon the success of instrument runs scheduled for the following week. Next, plans and funding for continuation of SSSDP activities in FY-1987 were discussed. The long term (up to 30 days) flow test was stated to be dependent upon Kennecott's participation and successfully repairing the scientific well at reasonable cost. Continued participation by USGS, NSF and DOE/OBES was solicited through funding of follow-on scientific activities. The need for early coordination was expressed. The ICG approved tasking the Scientific Experiments Committee (SEC) to provide anticipated science support requirements.

<u>House Science & Technology (HS&T) Staff Visit - December 4, 1986</u>

HS&T staff members Nancy Jeffrey and Dave Beightol were accompanied by Harold Lechtenberg and Tom Heenan of DOE/SAN to the Salton Sea Scientific well-site and to other Imperial Valley geothermal sites on December 4, 1986. In addition, the HS&T staff members were shown equipment at geothermal power plants (reactor-clarifier, crystallizers) required for processing highly-saline brines.

<u>Meeting of the Scientific Experiments Committee (SEC), representatives of Bechtel, Kennecott and DOE, San Francisco, CA - December 9, 1986</u>

The Interagency Coordinating Group (ICG) requested input from the SEC on science support requirements for completion of Stage-I and for follow-on studies. As a result of this request, a meeting of the SEC was convened with representatives from Bechtel, Kennecott and DOE/SAN to discuss priorities for follow-on work. The scientific priorities were defined as follows:

(a) The first aim should be to complete the original objectives of Stage-I of the SSSDP rather than embark on Stage-II (i.e. deepening).

(b) Obtaining an equilibrium temperature log to the greatest depth possible in the State 2-14 well remains a high priority.

(c) The next priority should be to obtain uncontaminated fluid samples from the shallowest flow zones encountered in the Wilson 1-12 well.

(d) If repair or replacement of the liner is successful, obtaining uncontaminated fluid samples from the State 2-14 well below 10,000 ft, or failing that from 8,700 ft, is the next priority. Achieving (b), (c) and (d) would allow completion of the original Stage-I objectives.

(e) Study of drill cuttings from the Wilson 1-12 well for comparison with those from the State 2-14 well is worthwhile.

(f) Deepening the State 2-14 well, either as proposed in April 1986 or by sidetracking past the broken liner, remains a desirable goal, but would require additional funds beyond those available in FY-1987. Thus, Stage-II of the SSSDP must wait until FY-1988 or beyond. However, seeking FY-1988 funds would require immediate action and strong support from the scientific community.

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Second Quarter

FY 1987

July 1987

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Tenth Quarterly Progress Report:
Report of the Second Quarter
(January through March)
FY-1987

JULY 1987

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

Progress of the Salton Sea Scientific Drilling Program (SSSDP) has been documented in a series of quarterly reports. This tenth report covers the period from January 1 through March 31, 1987, the second quarter of fiscal year 1987. The Department of Energy, Geothermal Technology Division (DOE/GTD), has extended its prime contract with Bechtel National, Inc. Funds have been allocated, but not contracted, for wellbore repair and construction of facilities for performance of a long-term flow test (LTFT) and injection experiment. After Kennecott Corporation's management agreed to fund and drill the Wilson 1-12 well, key activities during this reporting period became the planning and scheduling of wellbore repair, reconditioning of brine treatment equipment, drilling the injection well, and performing the long-term production and injection test.

The Brookhaven National Laboratory's failure-analysis report provided observations and recommendations of significant value in planning the State 2-14 well repair. Assuming successful repair operations; reconditioning of flow-test equipment, construction of flow-test facilities, and connecting the Wilson 1-12 and State 2-14 wells by pipeline must be accomplished prior to the flow test. After drilling the Wilson 1-12 well to a depth of 3,500 to 6,500 feet, Kennecott plans to perform a short-term flow test, then allow the well to be used for injection of fluids produced during the flow test of the State 2-14 well. As of this quarter, the LTFT is planned for completion by the close of August.

Data from scientific experiments performed in the State 2-14 well and samples acquired from the well continue to be analyzed. Technical aspects of SSSDP field operations have been analyzed and reported by Robert W. Nicholson of Well Production Testing, Inc.. Conclusions and recommendations for drilling future scientific wells have been set forth in his report. The first collective reporting of SSSDP scientific results is scheduled for the spring meeting of the American Geophysical Union in Baltimore, Maryland on May 19 and 20, 1987.

A meeting was held January 19, 1987 in Bechtel's San Francisco Office to discuss and define plans for continuation of SSSDP activities. This meeting was significant both as a SSSDP-update and discussion of key issues affecting the project's future. Present at the meeting were representatives from Kennecott, DOE/GTD, DOE/SAN, DOE/IDO and INEL.

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FIGURES

INTRODUCTION

A final report entitled, "Analysis of Operational Times and Technical Aspects of the Salton Sea Scientific Drilling Project," was prepared by Robert W. Nicholson of Well Production Testing, Inc. This analysis of SSSDP well operations can be used as a basis for planning future scientific drilling operations in thermal regimes of the earth's crust. Major objectives of the SSSDP, according to this report, were achieved, including; (1) drilling the well to a depth of more than 10,000 ft, (2) attempting to core 10-percent of the borehole and obtaining 722.1-ft of core, (3) conducting two successful flow tests, (4) obtaining downhole geophysical data from logging, and (5) testing new downhole wireline tools. The percentages of time spent on various activities, by depth range, are shown in Figure 1.

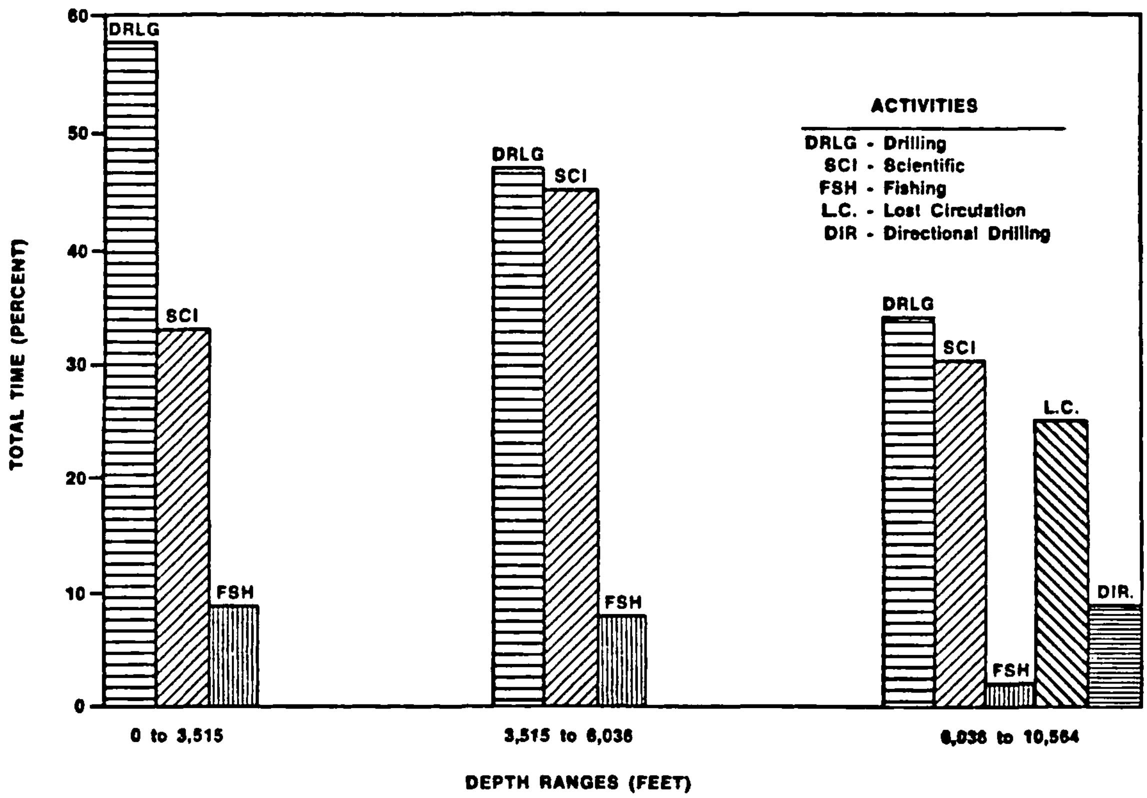

FIGURE 1: PERCENTAGES OF TIME SPENT ON STATE 2-14 WELL ACTIVITIES BY DEPTH RANGE

In August of 1986, the parted 7-inch, uncemented liner in the Salton Sea Scientific well was reamed clear to 8,000-ft and a temporary liner installed. However, access to the wellbore for technical and scientific experimentation is limited by the presence of viscous gelled-mud inside the liner-sections deeper than 5,822-ft. Repair of the State 2-14 wellbore was scheduled during this reporting period, since DOE's FY-1987 budget included funds for well repair and long-term flow testing. Kennecott Corporation received management approval to fund drilling, completion and testing of the Wilson 1-12 well. After flow testing, Kennecott will make the Wilson 1-12 well available for use as an injection well to receive fluids produced in a long-term flow test of the State 2-14 well. Without an injection well, the State 2-14 well can only be flowed for 3-days.

Access to the State 2-14 wellbore is required prior to conducting the long-term flow test and completing the remaining scientific experiments from the original program plan. These activities were precluded by lack of funds for a flow-test facility and brine injection well, and by liner-failure. The two previous flow tests indicated flow-zones with commercial reservoir potential. The first flow test produced essentially uncontaminated formation fluid, but the second test produced fluids from several zones that were contaminated by the large volumes of drilling-fluid and additives required to control lost circulation. A third flow test is expected to provide critically needed uncontaminated fluid samples from an isolated flow-zone at a depth greater than 8,000-ft. Well repair will also allow completion of SSSDP geophysical data sets needed for encouraging industry to exploit deeper, higher-quality geothermal resources in the Salton Sea Geothermal Field.

PROGRAM PLAN AND ACTIVITIES

Drilling and Engineering Program

Bechtel National, Inc., prime contractor for the SSSDP since September 1984, secured a contract extension from March 31 to April 30, 1987 during this reporting period. Granting Bechtel a sole-source contract, extending past April 30, 1987, is currently being implemented. Another option was to solicit a new contractor to repair the State 2-14 well.

In an effort to identify qualified contractors to continue work at the SSSDP site, an announcement was published in the January 23, 1987 edition of the Commerce Business Daily. The announcement solicited qualified organizations to submit written capability statements describing in-house technical capabilities, past and present work efforts demonstrating experience, available personnel and their qualifications, and cost estimate information. As a result of the announcement, two organizations submitted responses. However, the respondents failed to address properly the requirements outlined in the announcement.

Following this development, DOE/SAN management determined that acquiring a new contractor would require considerable duplication of effort, resulting in significant additional cost to the Government. Therefore, documentation for a sole-source contract with Bechtel National, Inc. was prepared and submitted. This contract extension, would require Bechtel to perform the necessary work to recomplete the State 2-14 well, recondition and construct facilities for long-term flow testing, and furnish site clean-up services after the test is terminated. Also, the contract modification would further extend the March to April contract extension already approved.

During this reporting period, planning, coordinating and scheduling repair of the wellbore, drilling the injection well, and performing a long-term flow test continued. The DOE Geothermal Technology Division (DOE/GTD) budgeted $1.3 million in FY-1987 to repair the well and construct facilities to perform the LTFT. DOE/SAN was given prime field responsibility for the effort. Kennecott Corporation, the leaseholder, received approval to drill and complete the Wilson 1-12 well, and agreed in principal to allow its use as an injection well for the LTFT of State 2-14.

Repair of the State 2-14 wellbore will be completed with full consideration of a recently completed failure-analysis of the parted well-casing. According to Bechtel's additions to the Brookhaven National Laboratory (BNL) failure-analysis report, several observations can be made regarding the liner:

1. The liner-hanger showed signs of erosion on the outside body, indicating leakage of seals which, upon examination, were all in-place, but badly charred.

2. Slip-segments had dislodged from the drag-springs, because Allen bolts connecting the slips to the drag-springs had completely corroded. Although the liner-hanger was designed for geothermal environments, the fasteners for the segments apparently were not.

3. Inspection of the polished-bore receptacle (PBR) revealed a high degree of pitting inside the bore.

4. Visual cracks were noted in the couplings, with extreme cracking in the coupling at the bottom of the fourth joint.

5. Cracks were not observed in the field in the bodies of the recovered casing. (Note: BNL indicated that no cracks were observed in the sample-sections of casing that they received).

6. Both collars and casing bodies showed signs of corrosion.

7. The wellbore was not entirely vertical. According to surveys, the well has about a 5^{o} "dogleg" near the location of initial separation (in the vicinity of the first flow-test zone). This is suspected of having increased the degree of stress in the liner-joints, resulting

from thermal cycling during flow testing and injection of produced fluids.

Recommendations made to Bechtel by tubing suppliers for minimizing well casing problems in the future are summarized below.

1. Buttress-thread casing should be used.

2. Apply less torque to the casing.

3. Heavier-weight casing and coupling should be considered for use in "dogleg" zones.

4. Use of L-80 grade casing is recommended for H_2S-rich environments at all temperatures. Maximum hardness is R_c23, which falls within recommended NACE standards for H_2S usage.

5. Premium joint-connections should be considered (i.e., Hydril connections seal threads from exposure to corrosion).

Kennecott Corporation's management, SOHIO, approved allocation and expenditure of funds for drilling the Wilson 1-12 well, and, thereby, participation by Kennecott in the LTFT of the SSSDP well. As indicated in Figure 2, Kennecott's preliminary schedule, drilling of the Wilson 1-12 well is to begin around May 15 and, after having drilled to a planned depth between 3,500 and 6,500 ft, the well is scheduled for completion by the end of June. Following well completion, Kennecott will perform a short-term flow test of about 3-days to determine the commercial resource potential of the well.

In order to test the Wilson 1-12 well and use it later for fluid injection during the LTFT of State 2-14, approximately 1 1/4-miles of pipeline connecting the two wells is scheduled to be in place by the end of June. Used materials for the pipeline may be acquired from the now-terminated Niland Geothermal Project, a part of the DOE Geothermal Loan Guaranty program. The USGS, Water Resources Division, is scheduled to run one or more suite(s) of logs in the State 2-14 well, after the old liner is removed.

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	1986 NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
SITE PREPARATION												
Lease Review (WEEKS)	1-2-3-4											
Title Abstract			2-3									
Drilling Opinion			3-4-1									
Survey	3-4											
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Electric Service				1-2								
Water Availability							1-2					
Environmental Survey							1	2-3	3		1	
Well Pad						3-4						
Mud Sump						3-4						
PERMITS												
C.U.P.	1-2-3-4											
A.P.C.D.			1-2									
R/W Pipeline				1-2								
Health Department							1-2					
State Lands - Project				1-2		1-2						
State Lands - Well			3	4		2-3						
State Lands - 40 Ac Lease				1-2								
Fish & Game - Schedule				1-2								
D.O.G.						2-3						
R.W.Q.C.B.					1	3						
WELL DESIGN												
Drilling Consultant					1							
Geologist				1								
FLOW TEST DESIGN												
Flow Test Consultant					1							
Flow Test Program					1							
Minerals Test Program					1							

Explanation
I.I.D. = Imperial Irrigation District
C.U.P. = Conditional Use Permit
A.P.C.D. = Air Pollution Control District
R/W = Right of Way
D.O.G. = Division of Oil & Gas (CA)
R.W.Q.C.B. = Regional Water Quality Control Board

B

	1986 NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
DRILLING												
Drilling Consultant					1	1	3-4-1-2-3-4					
Geologist				1				2-3-4				
Set Surface Conductor							3-4					
Drill Rig							4-1-2-3-4					
Mud Company								1-2-3-4				
Solids Control								4-1				
Clean Out Mud Sump												
Pipe/Casing Purchase					1			1-2				
Pipe Inspection								1				
Tool Rental								1-2-3-4				
Blow Out Prevention Equipment								1-2-3-4				
Baker Tank-Rental								1-2-3-4-1				
Trailer Rental								1-2-3-4-1				
Casing Crew								2-3-4				
Cement Company								1-2-3-4				
Directional Company								3-4				
Bits								1-2-3-4				
Logging Company								2-3-4				
PIPELINE - 30 DAY												
Right of Way				1-2								
Construction						1-2-3						
3 DAY FLOW TEST												
Flow Test Consultant					1							
Equipment Order								1-2				
Construction								4-1-2				
Flow Test									2			
Injection									2-3			
Clean-Up									3-4			
Final Reports										4-1		
File for Lease w/State Lands											1-2	

FIGURE 2: PRELIMINARY SCHEDULE PREPARED BY KENNECOTT FOR DRILLING THE WILSON 1-12 WELL

By the beginning of July, repairs to the production well (State 2-14) are planned to be completed and flow-test facilities installed, as shown in Kennecott's preliminary schedule, Figure 3. Reconditioning the flow-test equipment may require purchasing some long lead-time items, thereby posing possible delays to testing. A pert chart indicating critical paths and possible time-flexibility for field activities is pictured in Figure 4. Expenditures for flow-test facility construction will be deferred until well repair has been achieved. With the possibility that repair of State 2-14 cannot be accomplished, DOE must carefully schedule tasks to limit expenditure of funds.

	1986 NOV	DEC	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
PHASE I												
State 2-14 to Kennecott			4									
Kennecott Budget Approved			4-1									
Wilson 1-12 Drilled							3-4	1-2-3-4				
Flow-Test Pipeline Installed						1-2-3						
Wilson 1-12 Flow Test												
Construction								4-1-2				
Flow Test									2			
Injection									2-3			
Clean-Up												
PHASE II												
DOE Award				1								
Kennecott/Bechtel Agreement				2-3								
Bechtel/DOE Contract				2-3								
State 2-14 Rework Program					2-3							
State 2-14 Rework						1-2-3						
State 2-14 Well Assessment						3-4						
Kennecott-Refurbish Equipment						1-2						
PHASE III												
Develop Flow Test Program												
Develop Flow Test Design												
Construction of Facility							4-1					
Flow Test									3-4-1-2			
Clean-Up										3		
Reports											4-1	
												2-3

FIGURE 3: PRELIMINARY SCHEDULE PREPARED BY KENNECOTT FOR REPAIRING THE STATE 2-14 WELL AND PERFORMING THE LONG-TERM FLOW TEST

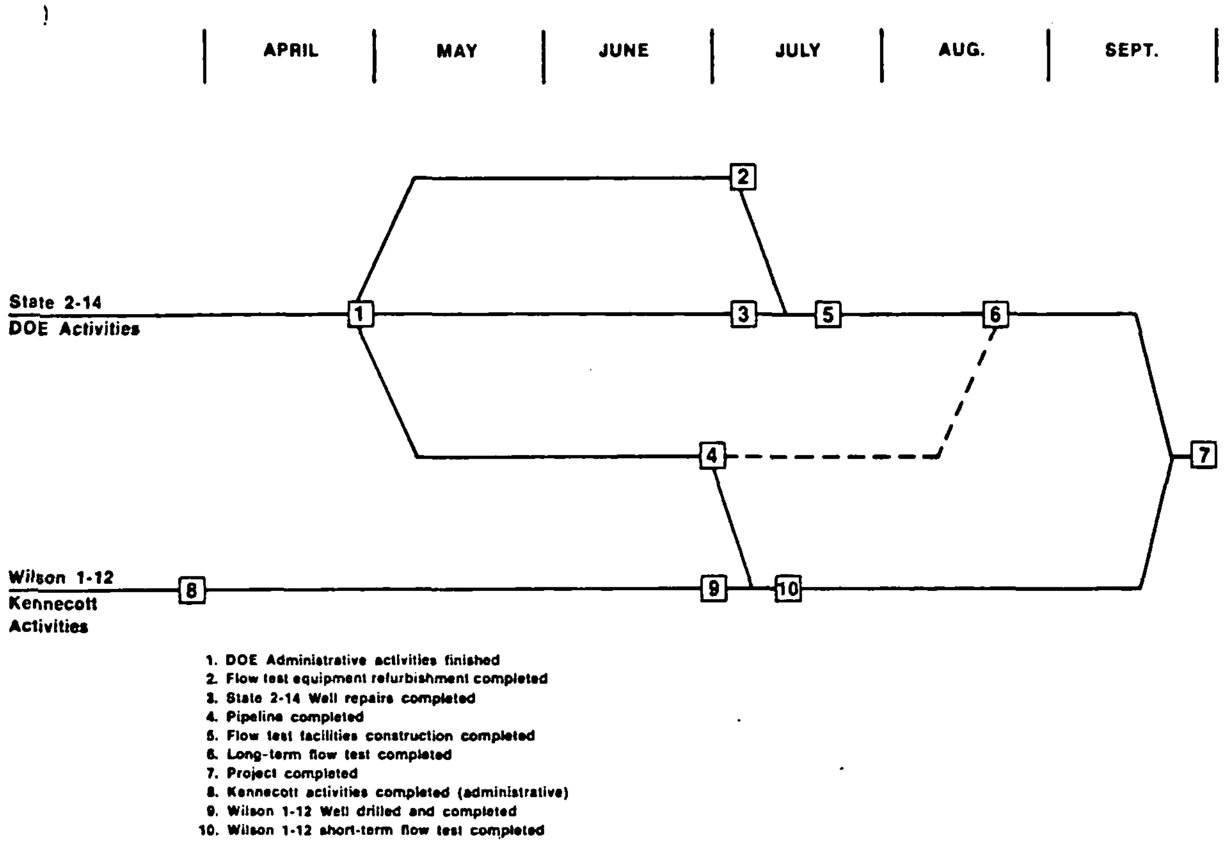

FIGURE 4: MODIFIED PERT CHART INDICATING THE CRITICAL PATH AND POSSIBLE TIME-FLEXIBILITY AVAILABLE FOR EACH FIELD ACTIVITY

According to DOE/SAN, the long-term flow test should begin around mid-July, unless the reconditioning of flow test equipment requires additional time. Planning and management of the long-term flow test and brine injection experiment will be handled by DOE/Idaho Operations Office (IDO). The electronic memory temperature and pressure tool is scheduled to be run by USGS in the State 2-14 well prior to repair. During the flow test, time will be allocated for testing the LANL/Sandia and LBL fluid sampling tools.

Reservoir Scientific Experiments

In addition to completion of temperature and other geophysical logging planned for the State 2-14 well, plans have been made for conducting a production and injection flow test, using the State 2-14 well as the fluid source and the Wilson 1-12 well to receive injection. Long-term flow testing of the Salton Sea Scientific well, coupled with injection into the Kennecott, Wilson 1-12, will provide a mechanism to test and evaluate hydrologic properties of the geothermal reservoir in this part of the Salton Sea Geothermal Field. Testing of these wells will also provide the opportunity to validate several innovative reservoir engineering techniques developed under the DOE Geothermal Research Program. The Geothermal Reservoir Technology Program of DOE/GTD will use five laboratories to conduct the experiments and measurements: Idaho National Engineering Laboratory (INEL), Lawrence Berkeley Laboratory (LBL), Lawrence Livermore National Laboratory (LLNL), Stanford University (Stanford), and the University of Utah Research Institute (UURI).

There are a greater number of unknowns associated with fluid-injection into a geothermal system than there are with fluid-production. This test program is designed to examine reservoir injection properties in this part of the Salton Sea Geothermal Field and will quantify the capability of the reservoir to accept injected fluids. The flow test is expected to provide both early-time pressure changes and long-term pressure recovery of the reservoir. Emphasis will be placed on injection studies, and the test is planned to last at least twenty days.

The long-term test also will provide the opportunity to complete several associated scientific tasks. Downhole fluid samples will be collected under flowing and static well-conditions from an isolated production zone at a depth greater than 8,000-ft. Collection of downhole samples after completion of the flow test is advantageous to geochemists, because it provides the opportunity to sample after most, if not all, of the drilling contaminants have been removed from the well. Pressure and temperature logging will also be conducted during flowing conditions to evaluate the thermodynamics of the fluid.

The Geothermal Injection Technology project will test techniques for evaluating and predicting the thermal, chemical and hydrologic effects of injection. Techniques developed may lead to control of adverse thermal and chemical effects through effective well placement and wellfield operation. Research activities included in the program were developed in response to priorities identified by industry advisors. Project emphasis is on research and development not performed by private industry. The injection test will address the flow of injected fluids by downhole and surface measurements of pressure and temperature. These measurements will be coupled with a program of testing geophysical techniques in an attempt to track injectate movement. The research will include a non-isothermal injection and pressure fall-off test, an injection-backflow test, tracer evaluation, microseismic monitoring, and collection of fluid and solid samples to determine the scaling properties of the hypersaline brine.

Non-isothermal Injection and Fall-off Test

The injection test to be conducted in conjunction with the SSSDP long-term test provides an excellent opportunity for validating and demonstrating the usefulness of new analytical techniques. Recent theoretical advances at LBL have improved the ability to interpret non-isothermal injection test data from both porous and fractured reservoirs. Theoretical studies indicate that by conducting and interpreting these tests in a systematic manner, it is possible to track the movement of thermal fronts, detect fracture-controlled thermal sweep, detect and measure thermally-induced permeability enhancement, and in some cases, quantify fracture spacing. This powerful diagnostic tool has not been fully used, because proper field validation is lacking.

Microseismic Monitoring

As part of the DOE Geothermal Brine Injection Research program, Lawrence Livermore National Laboratory has been studying the occurrence of microseismicity for application to monitoring the migration of injected fluids. Microseismicity is known to occur at some geothermal development sites, but more case studies are needed to correlate its occurrence with fluid injection and establish its value for the study of injection.

The planned long-term flow test at the Salton Sea Geothermal Field provides an excellent opportunity to collect case history data on injection-induced microseismicity. Because it is part of an integrated flow test, survey results can be related to the structure and hydrology of the geothermal system. Relations will be investigated between seismicity, and pressure and flow distributions estimated from reservoir engineering models, and tracer studies of the injected fluid. The approach is to instrument the injection site for approximately one-month prior to injection, then continue to observe seismic events for about three months. This will provide an idea of background seismicity and allow observation of events that may occur during and shortly after the flow test. Events will be located and studies conducted to discriminate injection-induced events from natural events. The rate of occurrence and spatial distribution of induced events will be compared with estimates of flow paths from reservoir engineering studies to determine the degree to which seismicity reveals information about flow in the reservoir.

Injection-backflow Test

An injection-backflow test will be conducted in the Wilson 1-12 well near the end of the flow test. The injection segment of the test will be designed as a slug-injection with tracers. Sufficient fluid will be injected after the slug to move the tracer away from the wellbore. After a quiescent period, the injected fluid will be withdrawn from the Wilson 1-12 well and analyzed for thermal characteristics, chemistry and tracer recovery. Analytical techniques, newly developed at INEL and Stanford University, will be used to determine the heat transfer that has occurred between the formation and the injected fluid. This information will be extrapolated to provide an estimate of heat-transfer rates in the reservoir. In addition, the tracer-return profiles will be analyzed by UURI, using methods previously developed at East Mesa, to determine near-wellbore formation properties and transport characteristics. The chemistry of the injected fluid and of the return fluid from Wilson 1-12 will be analyzed for conservative and varying species, and correlated with the tracer data to identify geochemical reactions. If successful, this technique could provide the basis for predicting formation plugging, a possible long-term effect of injection that is presently poorly understood.

Tracer Evaluation

It is now generally recognized that tracers and tracer data interpretation can play an important role in well-field development. Few tracers are currently available to the geothermal operator. During the last several years, UURI has identified a number of derivatized hydrocarbons for tracking liquid and gas phases that appear to be more suitable as geothermal tracers than currently used chemical species. The stabilities of these hydrocarbons have been experimentally determined under conditions closely approximating those expected in geothermal reservoirs. However, no field tests have yet been conducted. Such tests are needed before these compounds can be confidently used by geothermal developers.

Methods for interpreting tracer-return profiles are being developed at Stanford and INEL. UURI will provide Stanford and INEL with chemical analyses and information concerning tracer stabilities. Tracers can be used to quantify chemical changes occurring in injected fluids as they move away from the wellbore. Because these chemical changes are frequently related to deposition or precipitation of specific minerals, chemical data can provide information on the potential for plugging or permeability enhancement in the reservoir rock around the injection well. In the Salton Sea Geothermal Field, dissolution and precipitation reactions are likely, because the fluids are extremely saline. Fluid samples will be collected during injection and backflow of the injection well to characterize the chemical changes that have occurred during injection.

Scientific Experiments -- Results, Conclusions and Recommendations

Analysis of data from scientific experiments performed in the State 2-14 well and samples acquired from the well, continues. Fluid temperature, thermal gradient and thermal conductivities have been approximated, based upon the initial thermal-equilibrium profiles and other data. Results from other investigations are being compiled and prepared for dissemination.

and reported by John H. Sass, John D. Hendricks, Susan S. Priest, and Lori C. Robison of the U.S. Geological Survey (USGS), Flagstaff, AZ. During breaks in drilling, downhole temperatures were measured and later used to establish an equilibrium-temperature profile. Prior to well-casing failure, the well could be logged to 3,109 meters. Currently, logging is restricted to the upper 1,800 meters of the well. The best estimate of fluid temperature below 1,800 meters is 305 $\pm$ 5^{o}C at a depth of 1,890 meters and 355 $\pm$ 10^{o}C at a depth of 3,170 meters.

According to the USGS report, "Temperatures and Heat Flow in the State 2-14 Well," an impermeable, thermally conductive "cap" on the Salton Sea hydrothermal system extends to depths greater than 900 meters. Thermal gradients were found to decrease from approximately 250^{o}C/km in the upper few hundred meters to slightly less than 200^{o}C/km near the base of the conductive cap. In general, thermal conductivities increase with depth in response to an overall decrease in porosity.

The USGS has also released the report entitled "Preliminary Report on Geophysical Well-Logging Activity on the Salton Sea Scientific Drilling Project, Imperial Valley, California" (Open-File Report 86-544). The majority of USGS activities reported relate to preparing geophysical equipment for logging the SSSDP well, obtaining the logs, and providing log analysis. The publication includes additional information, such as details of well construction, lithologic data from cuttings, and records of drilling progress that could be useful in log interpretation.

A study of seismic-velocity characteristics of geothermal alteration in sediments of the SSSDP well is being conducted and reported jointly by F.L. Paillet of the USGS and C.H. Cheng of the Massachusetts Institute of Technology (MIT). The study includes examination of USGS acoustic-waveform logs, examination of raw vertical seismic profile (VSP) data obtained by E.J. Majer of Lawrence Berkeley Laboratory (LBL), and core analysis to derive an indication of velocity-structure. Preliminary results of this study are scheduled for presentation at the March 1987, USGS McKelvey Forum in Denver, Colorado, and the spring American Geophysical Union meeting, Salton Sea Scientific Drilling Program session in Baltimore, Maryland.

As mentioned previously, an analysis of technical aspects of Salton Sea Scientific Drilling Project field operations was completed by Robert W. Nicholson of Well Production Testing, Inc. The major conclusions Nicholson reported are listed below.

1. Adaptation of common, commercial drilling methods for scientific data collection worked reasonably well. The major objectives of the project were met, with 33 percent of field operations-time spent acquiring scientific data (Figure 5).

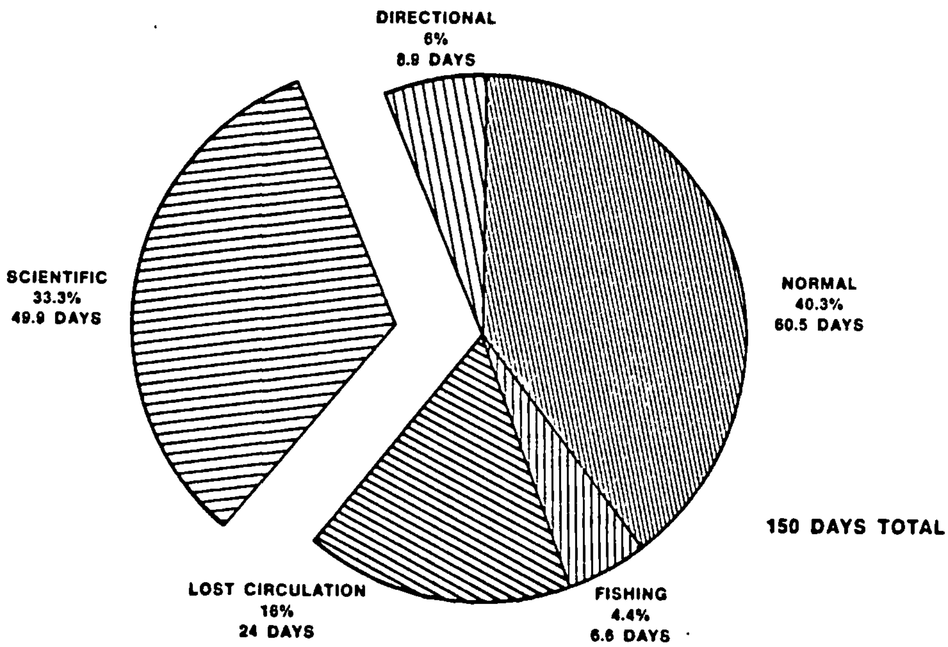

FIGURE 5: FIELD OPERATIONS ACTIVITIES FOR DRILLING THE SALTON SEA SCIENTIFIC WELL BY NUMBER OF DAYS AND PERCENTAGES OF TOTAL TIME

2. Although unusual well conditions presented difficult technical problems, these were effectively overcome.

3. Downhole problems increased with depth, directly reducing the amount of time spent on scientific data collection (Figure 1).

4. Unfortunately, budgetary concerns limited scientific efforts, especially toward the end of the project.

5. Spot-coring operations were very successful in the shallower section of the hole.

6. Core-footage recovered and coring efficiency decreased drastically with increased depth and increased well problems, as shown in Figure 6.

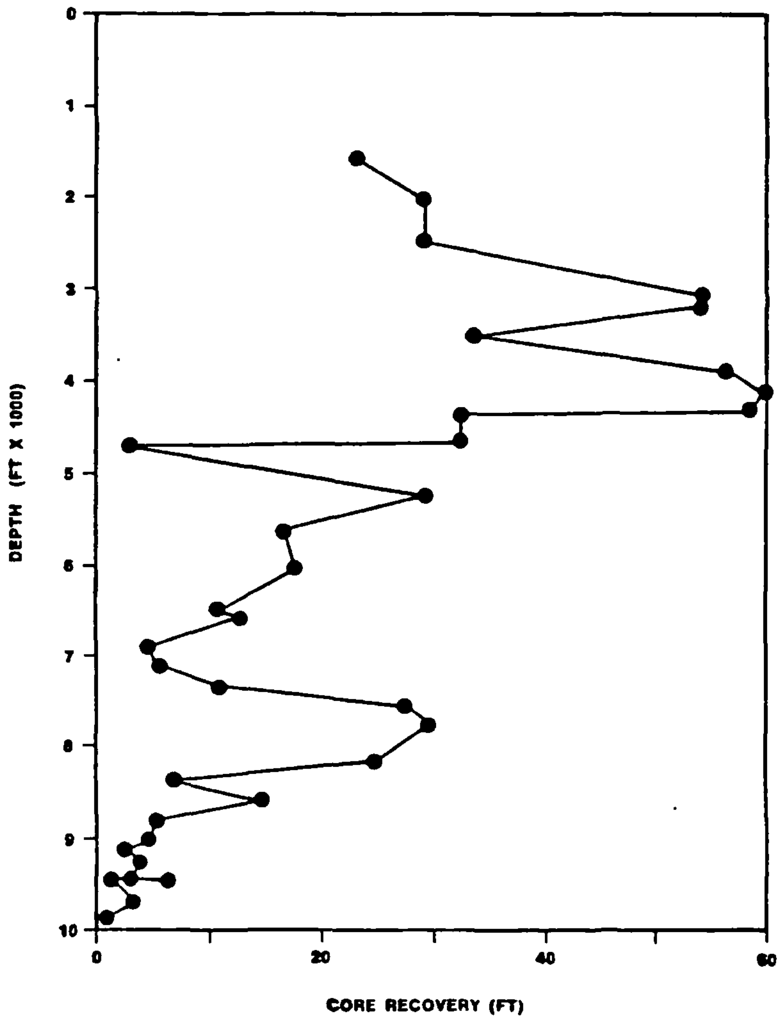

FIGURE 6: CORE RECOVERY VS. DEPTH IN THE SALTON SEA SCIENTIFIC WELL

7. As presented in Figure 5, solving major downhole problems (lost circulation, directional control and fishing) consumed about 26 percent of project time. These problems consumed 38 percent of the time at depths greater than 6,000 ft and contributed to limiting the amount of scientific data acquired.

8. High-temperature contributed directly and indirectly to difficulties in acquiring scientific data, conducting normal drilling operations and wellbore problems.

9. The final flow-test of the well provided neither pristine fluid-samples nor definitive reservoir data, because the well completion was insufficient to isolate a single uncontaminated zone.

10. The need to control natural deviation of the wellbore toward the eastern lease-boundary, 230-feet from the surface location, significantly increased project-time and downhole difficulties (Figure 7).

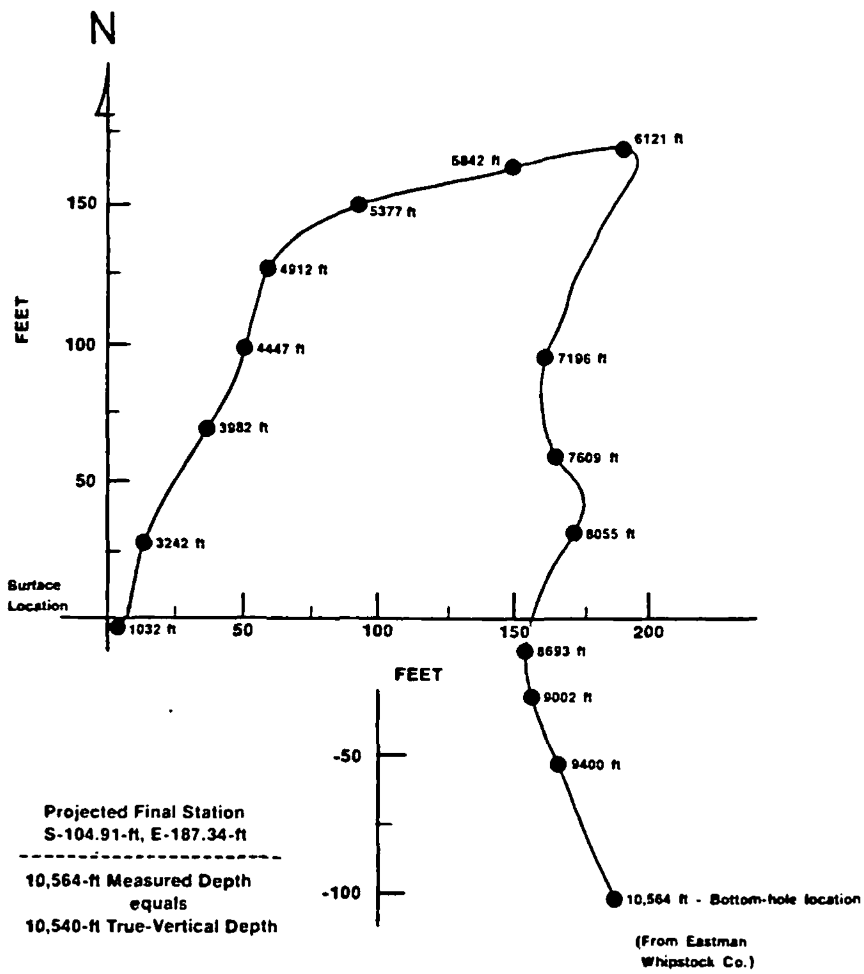

FIGURE 7: MAP-PROJECTION OF VARIATIONS IN THE DEPTH-LOCATIONS OF THE SALTON SEA SCIENTIFIC WELLBORE

11. The hardness and abrasiveness of formations deeper than 9,000 feet became a major problem, especially during coring with essentially full-sized core-heads.

For future scientific drilling activities, Nicholson made several recommendations, based upon results of this project:

1. Close coordination should be established, early in project planning, between the operational, scientific, institutional and funding agencies.
2. An integrated well-design should be planned between scientists and engineers to establish specific project goals.
3. Development of improved coring systems for continuous coring in full-sized wellbores will greatly enhance the success of future scientific drilling operations.
4. Improved core-heads (greater penetration-rate and longer life) for very hard formations need to be developed.
5. Techniques and equipment for successfully coring hot, complex, fractured formations, normally encountered in active geologic areas, need to be developed for future operations to enhance scientific return for funds expended.
6. Improved directional control must be employed for drilling effectively to great depths.

Although this project was successful, it is apparent that improvements must be made to drill (core) economically and successfully to the depths contemplated by proponents of the Continental Scientific Drilling Program (50,000 feet or more), through hard, abrasive, fractured formations. Problems similar to those encountered in the SSSDP, specifically extremely high borehole-temperatures, deviation control, control of lost circulation and fishing for equipment lost downhole, will be encountered and become more difficult and costly to overcome at greater depths.

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with established protocol during this reporting period. A summary of SSSDP activities, including FY-1987 plans, was presented by Charles A. Harper (Bechtel National, Inc.) at the Northern California chapter of the Geothermal Resources Council meeting on February 26, 1987. Informal letter summaries, reporting preliminary findings, have been distributed among the Principal Investigators. Formal presentations of papers, providing preliminary scientific results, are scheduled for May 19 and 20, 1987 at the spring American Geophysical Union meeting in Baltimore, Maryland. The full-day session of oral presentations, chaired by Wilfred A. Elders (U.C. Riverside) and John Sass (USGS), will include five invited papers. Poster presentations are also planned, according to Donald Klick, Chairman of the Science Coordinating Committee.

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SIGNIFICANT MEETINGS

Bechtel Project Review Meeting - January 19, 1987

A meeting was held in the San Francisco Offices of Bechtel on January 19, 1987 to review the SSSDP and discuss key issues regarding continuation of project activities. Senior management from DOE, Kennecott and Bechtel were in attendance at this meeting. These attendees were John Mock, Director of DOE's Geothermal Technology Division, Robert Dimock, Vice-President of Kennecott Corporation, Harold Forsen, Senior Vice-President and Manager of R&D for Bechtel and Jim Selover, Vice-President and Manager of the Research Program, also for Bechtel. Other participants included: Raymond Wallace and Marshall Reed of DOE/GTD, Harold Lechtenberg of DOE/SAN, Susan Prestwich and Susan Stiger of DOE/Idaho, Roger Andrews, Earl Tingey, Tom Probert and Larry Grogan of Kennecott, and Gus Benz, Charles Harper, Sherman May, Janet Owen and Neal Harlan of Bechtel.

SOHIO's preliminary approval of Kennecott's plan to drill a new well for eventual use as an injection well for the State 2-14 LTFT was reported. Final approval was expected by March 1987, at the latest. The Salton Sea Scientific Drilling project was summarized and future activities planned. The new Bechtel project team was announced and included:

- o A.D. Benz replaced Sam Fleming as Management Sponsor,
- o Janet Owen replaced Charles Harper as (Acting) Project Manager,
- o Sherman May replaced David Rabb as Project Engineer.

Rescheduling well abandonment and site clean-up activities were also topics for discussion.

Bechtel reported that progress continued on their Phase-I, final report. Both DOE/GTD and DOE/SAN comments had been incorporated. Liner failure-analysis data, as reported by Brookhaven National Laboratory, had also been added.

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Third Quarter

FY 1987

January 1988

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Eleventh Quarterly Progress Report:

Report of the Third Quarter
(April through June)
FY 1987

JANUARY 1988

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

The Salton Sea Scientific Drilling Program (SSSDP) was initiated by several federal agencies in 1985 as one of the first major undertakings in continental scientific drilling in the United States. Congress provided funding to the Department of Energy (DOE) Geothermal Technology Division (GTD) to drill and core this scientific research well; and National Science Foundation, U.S. Geological Survey, and DOE Office of Basic Energy Science funded additional research. As part of the first stage of activities, a borehole reaching a depth of over 3 km was made and a liner for the well was installed. From March to May 1986, numerous scientific measurements were taken downhole and 224 m of core samples were recovered for future scientific analysis. In May 1986, the liner of the well corroded and parted, preventing any additional scientific measurements from below the depth of 2000 m. The program's efforts since then have concentrated on finding ways to rehabilitate the well while planning both the successful conclusion of Stage I activities and the initiation of Stage II activities.

The progress of these efforts has been documented in a series of quarterly reports. This eleventh report covers the period from April 1 through June 30, 1987, the third quarter of fiscal year 1987. During this period, Stage I of the SSSDP officially came to a close with all the organizations involved in the program successfully fulfulling the terms of the original contract. Stage II of the SSSDP was initiated with the signing of a contract modification between the DOE and Bechtel National, Inc (BNI) for wellbore repair and for construction of facilities for a flow test and injection experiment. An agreement was also signed between Bechtel and Kennecott Australia, Ltd. for Kennecott to connect an injection well to the State 2-14 well site for the flow-test experiments. Kennecott implemented this task during this period.

Plans for repairing the State 2-14 well continued to be refined during the third quarter with Kennecott, DOE-GTD, and other related-SSSDP organizations exchanging final recommendations on repair techniques. However, no repairs were conducted during this period.

The first collective reporting of SSSDP results was conducted at a series of forums chaired by Wilfred Elders and John Sass during the spring meeting of the American Geophysical Union in Baltimore, Maryland on May 19 and 20, 1987. Participants covered a wide range of topics including geochemistry and vertical seismic profiling (VSP) data analysis.

Two key meetings were held during this reporting period. The first of these was held at Bechtel's San Francisco headquarters on June 2, 1987. Participants representing DOE's San Francisco Operations Office (DOE-SAN), DOE's Idaho Operations Office (DOE-IDO), Bechtel, University of Utah Research Institute (UURI), and Idaho National Engineering Laboratory (INEL) discussed Stage II Research and Development (R&D) coordination in general and Becthel's proposal in particular.

The second meeting was the program review session held at the end of the third quarter. Participants representing DOE-SAN, DOE-GTD, DOE-IDO, UURI, and INEL presented program updates and also discussed technical aspects of activities.

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FIGURES

INTRODUCTION

Third quarter activities of SSSDP for fiscal 1987 focused on concluding Stage I of the program while planning and developing the basic infrastructure needed for implementing the flow test and injection experiment. The development of this infrastructure began with the signing of a contract modification between DOE-SAN and BNI.

Stage I of the program was concluded after a supplementary cost request submitted by the prime contractor Bechtel was approved by DOE-SAN. This put the final cost of Stage I at $7.5 million.

The statement of work for Stage II of SSSDP was formally announced on April 13, 1987. Five main task areas were identified for project completion:

1. Wellbore Repair
2. Construction of Flow-Test Facilities
3. Flow Test
4. Clean-up Activities
5. Utilities

Following clarification of the task areas, as requested by BNI, a contract effectively extending Bechtel's role as prime contractor was signed on June 30, 1987. Expenditures to complete the remainder of the project were expected to equal $1.150 million.

As part of an amended agreement between BNI and Kennecott, Task-2 activities involve a high degree of Kennecott participation. Included in this activity is Kennecott's responsibility for the drilling and completion of the injection well and the connection of this proposed injection well to the State 2-14 well for the flow test.

PROGRAM PLAN AND ACTIVITIES

Drilling and Engineering Program

Current and Planned Courses of Action for Stage II

As earlier summarized in the Introduction, the Statement of Work (SOW) for the Stage II contract was divided into five remaining task areas. The planned course of action for each of these tasks areas and any subsequent change to the planned course of action are detailed below.

Task 1. Wellbore (State 2-14) Repair

- Removal of temporary liner (about 812 ft of pipe)
- Removal of damaged 7-inch liner to the extent possible (maximum of approximately 4,000-ft of pipe)
- Installation of new 7-inch liner constructed in such a manner as to isolate the deepest possible production zone greater than 8,000-ft depth
- Side tracking the hole, if the daily damaged-liner extraction-rate is less than the estimated daily drilling rate of 75 ft per day.
- Making the (repaired) well available for acquisition of scientific data for 3 days

Task 2. Construction of Flow-Test Facilities

- Construct flow-test facilities, using DOE-supplied design and government-owned equipment
- Inspect and test government-owned equipment
- Repair and reconditioned government-owned equipment

Figure 1 shows the location of the State 2-14 site with respect to the proposed injection site, Imperial 1-13 well and the Wilson 1-12 well. Figure 2 shows the actual site layout for the State 2-14 well as designed by Bechtel. The pipeline needed to connect State 2-14 with Wilson 1-12 belonged to RGI, from whom it was purchased by Kennecott and installed. The installation was carried out by Kennecott to gain timely access to the State 2-14 brine-holding pend for containment of fluids expected to be produced by its short-term flow

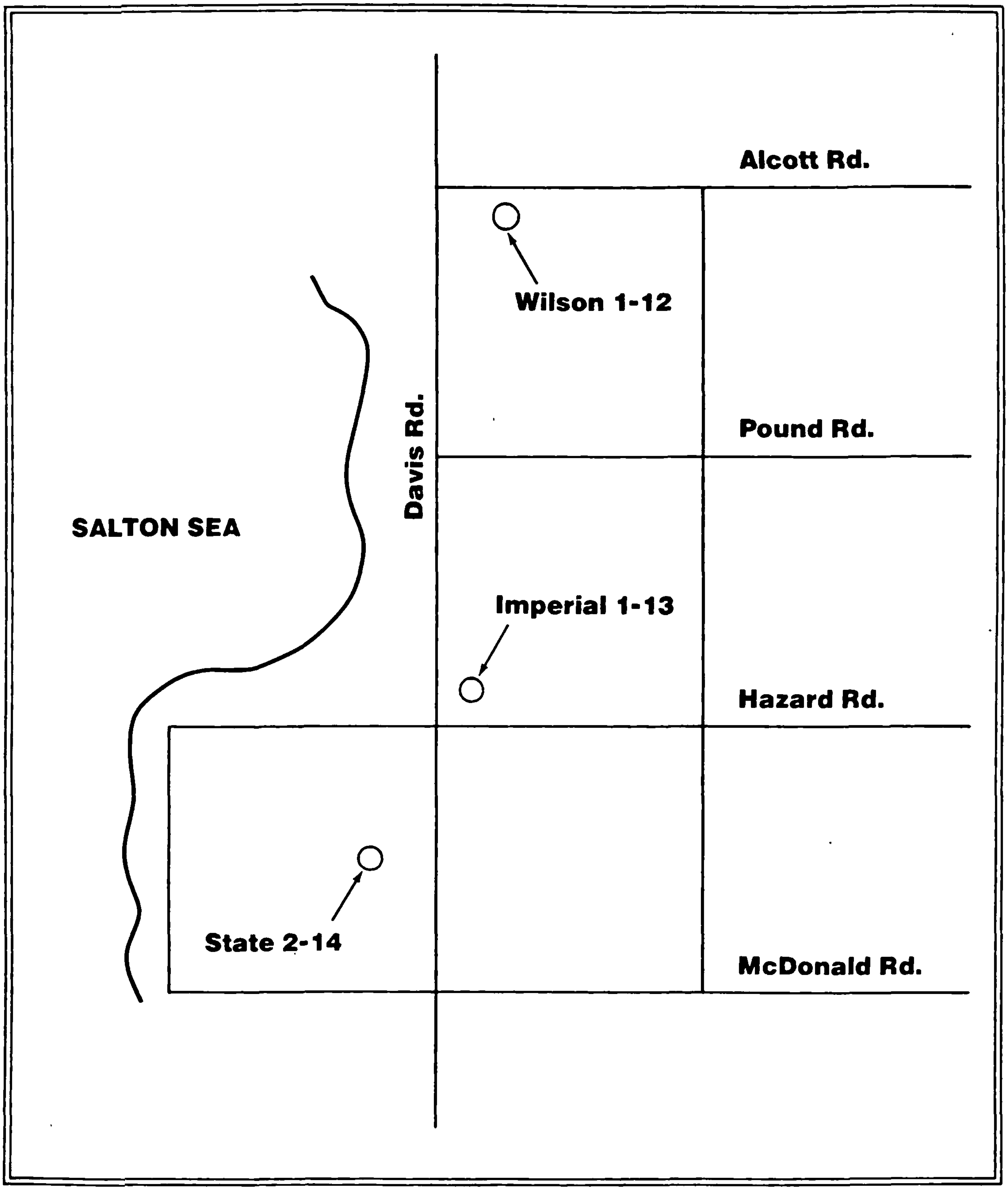

Figure 1. The SSSDP Wells

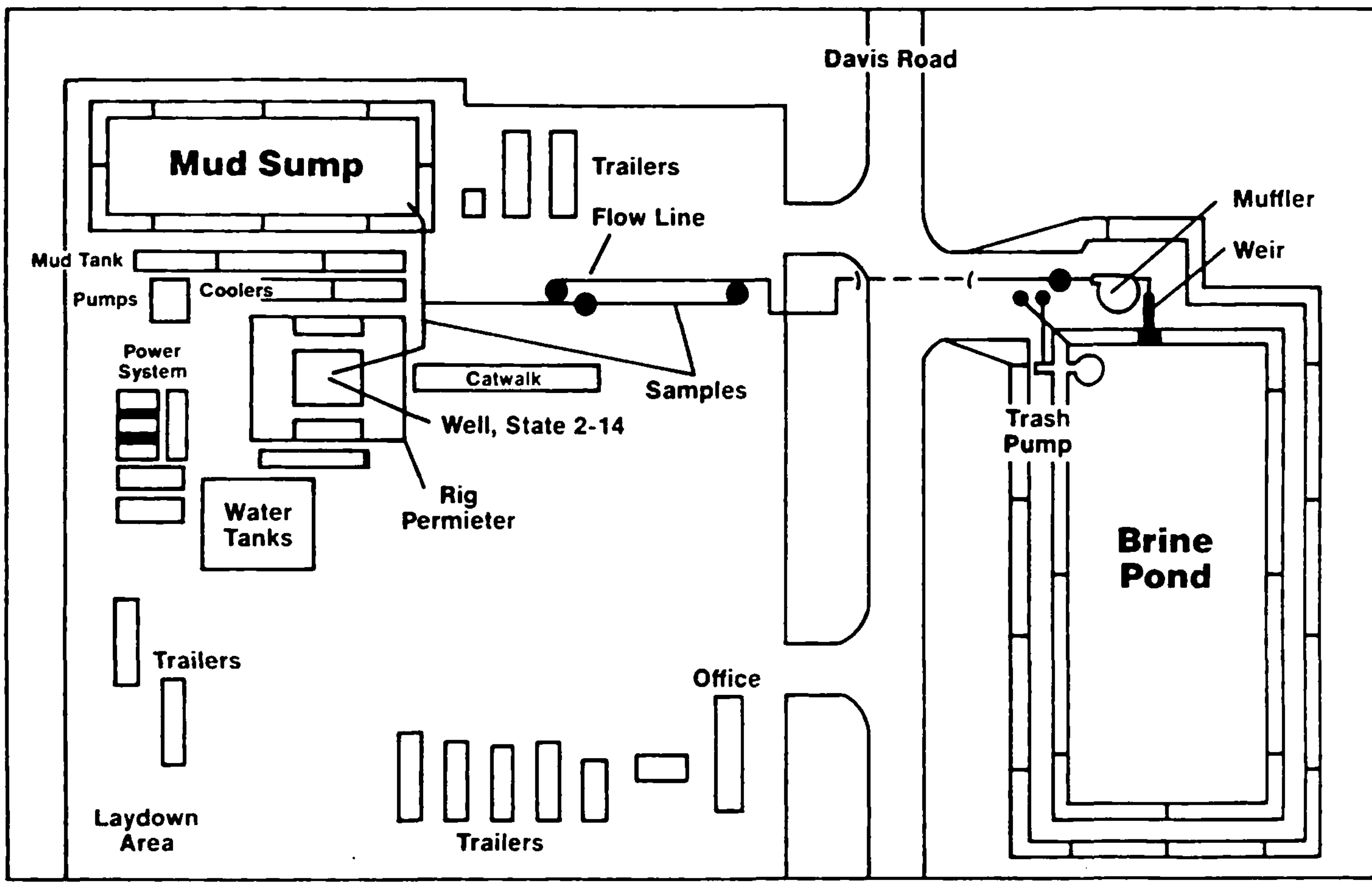

Figure 2. State 2-14 Site Layout for the LTFT

test of the Wilson 1-12 well. Most of the remaining government equipment was successfully obtained by auction from the defaulted CU-I loan guaranty program and to be reconditioned for use in Stage-II.

The DOE preliminary design for the brine-treatment facility is shown in Figure 3. The production brine passes through a number of meters to measure pressure and temperature before and after it flows through a series of separators. The exiting brine next passes through a series of media filters and polishing filters before it is metered and injected.

Task 3. Flow Test

- Provide a term of 30 days for research team to perform long-term flow test
- Test plans and operational procedures for the flow test to be developed by others (DOE)
- Personnel for operating test, equipment maintenance, and data gathering to be supplied by others (DOE)

Task 4. Clean-Up Activities

- Perform site clean-up activities as agreed with leaseholder.
- Prepare final report on well repair and flow-test activities

Task 5. Utilities

- Supply all utilities for the test center (see Figure 2 for site layout)

Bechtel's preliminary schedule for completing the five tasks is shown in Figure 4. The figure includes the completion of Stage I (Part A) on June 30, 1987 and the projected completion of Stage II (Part B) by mid-January 1988.

The Wilson 1-12 Well

The Wilson 1-12 well became an integral part of the Stage II contract in general, and Task 2, in particular. Kennecott management agreed to allow its use as an injection well, after completion and testing, but later withdrew the offer.

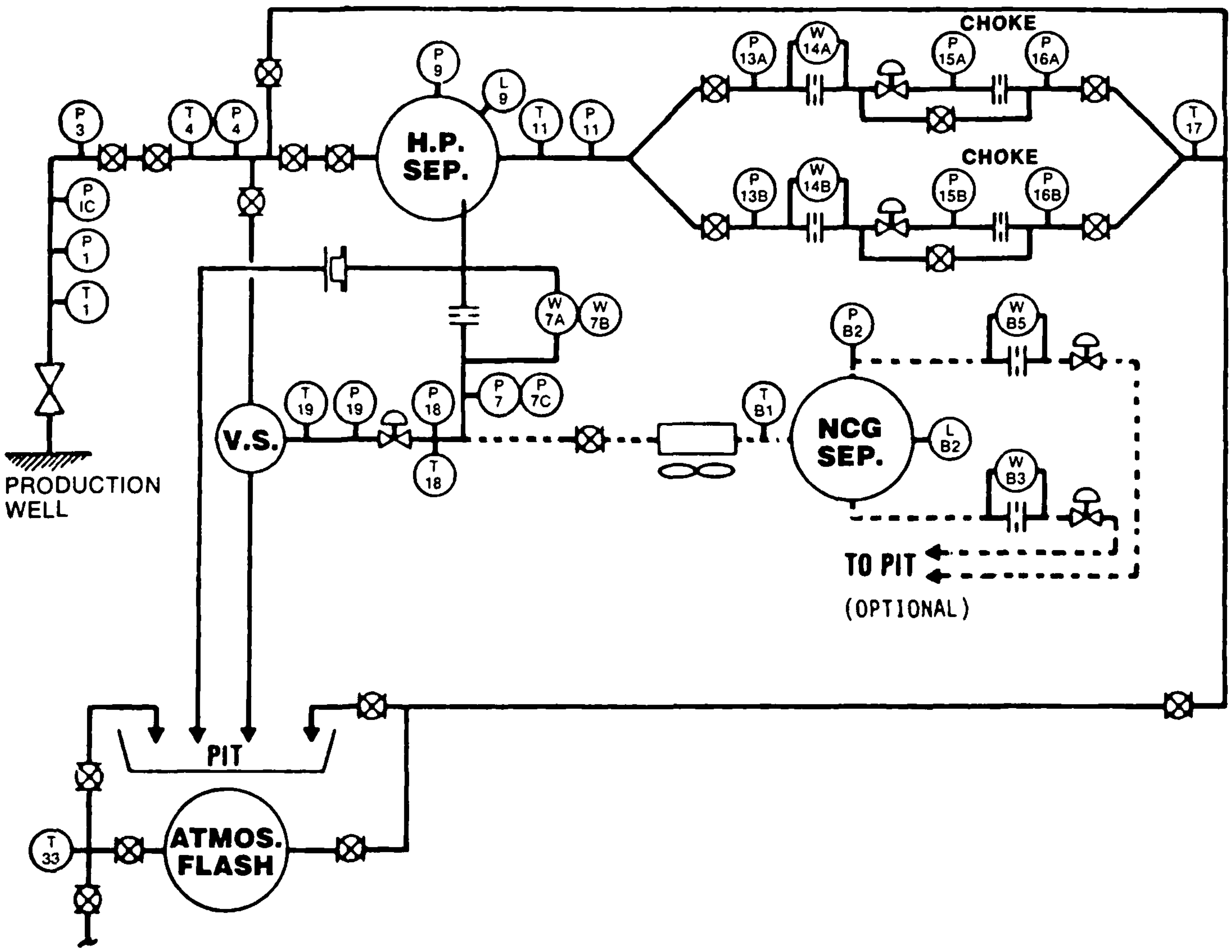

Figure 3. Preliminary Design for the LTFT

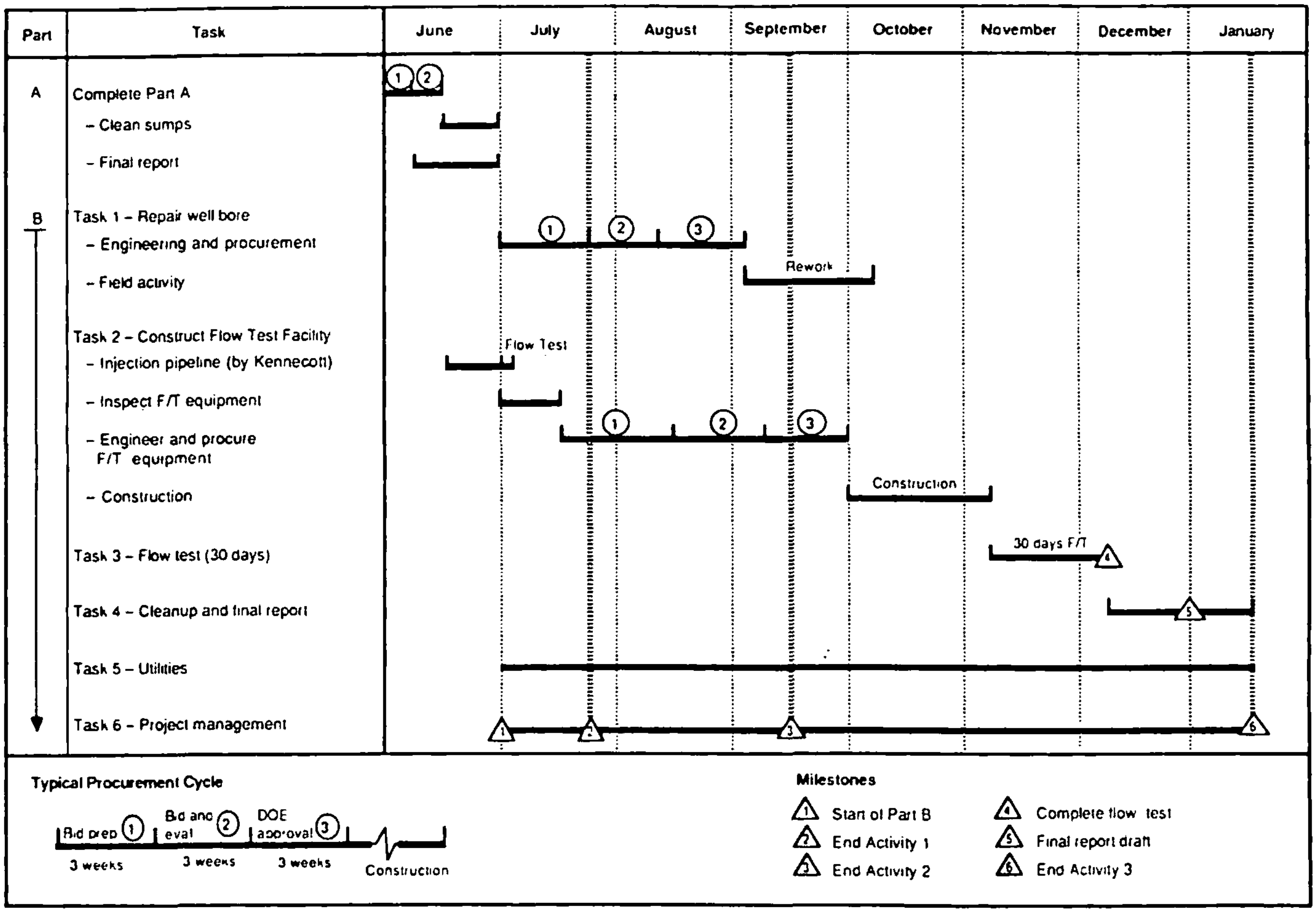

Figure 4. Schedule for Stage II of the Salton Sea Scientific Drilling Project

Results of Scientific Experiments

Several reports detailing preliminary results of scientific experiments were presented at the American Geophysical Union's (AGU) spring conference held in Baltimore, Maryland on May 19-20, 1987. These reports were the first formal presentation of SSSDP scientific research and provided the scientific community with the opportunity to not only study the geological characteristics of the Salton Sea area, but also to compare Salton Sea data with data from other geothermal resource areas.

Some of the scientific results contained in these reports are summarized below as presented in EOS, the transactions journal of the AGU. All are listed in the bibliography section of this report.

Fluid Inclusions in SSSDP Core: Preliminary Results Authors: Roeder, Edwin, and Kevin W. Howard, USGS

Eighty-six fluid inclusions were examined in calcite, quartz, and anhydride from thin (~1mm) veinlets crosscutting the SSSDP core, from 1983-7400 ft (605-2256 m) depth in the Salton Sea geothermal field, California. Preliminary data were obtained on the homogenization temperatures (Th; all in liquid phase), melting of ice (Tm), and eutectic melting (Te). No daughter minerals were seen, and no clathrates were recognized on freezing. Most inclusions adequate for both Th and Tm range in Th from 217 to 350^{o}C and vary widely in salinity (as indicated by Tm, -0.7 to -268^{o}C), suggesting a complex history of fluid circulation in the past. Te values are all in the range -40 to 62^{o}C (mean approximately 51^{o}C). The data are too few for correlation with inclusion origin or host mineral.

Extensive speculation on the origin and nature of these various fluids is premature, but several points are noteworthy: 1) with one exception, all inclusions with highly saline brines (i.e., Tm below -15°C, >18.8 wt% NaCl eq.) were from >1700-m depth; 2) very low-salinity fluids (Tm -0.7 to -2.4°C, 1.2 to 4.0 wt% NaCl eq.) circulated as deep as 1939 m; 3) the Te values almost certainly require $CaCl_2$ as a major component; 4) on a plot of Tm vs. Th, most of the data points are clustered, suggesting a series of discrete fluids. The data obtained can be explained by combinations of the processes suggested by other workers (e.g., McKibben, and Oakes & Williams, ACROFI, 1987) on the basis of fluid inclusion and other studies from other wells in the Salton Sea geothermal field. These processes include thermal metamorphism of evaporates, local igneous intrusions or fracturing of deep over-pressured zones, and mixing of water from dehydration of gypsum with partly evaporated Colorado River water.

Analysis of VSP Data at the Salton Sea Scientific Drilling Program

Daley, Thomas M., Thomas V. McEvilly, and Ernest L. Majer, Lawrence Berkeley Laboratory

As part of the Salton Sea Scientific Drilling Project, a three-component vertical seismic profile was conducted with P-wave and Shear-wave vibrator sources at both a zero-offset and a far-offset. The use of cross-polarized shear sources, along with careful rotation of the recorded geophone-motion into radial and orthogonal transverse components, allowed study of the in situ material properties and seismic response of the area surrounding the well.

Velocity models developed from zero-offset, first-arrivals show a zone of low Poisson's ratio around 2500' and a zone of anomalously high-P and low-S velocities (high Poisson's ratio) around 3000 ft. The velocity data extend from the surface to the deepest geophone location at 5500 ft. A strong reflection is observed on both P- and S-wave profiles from an approximate depth of 6800 ft.

By rotating the recordings from the two polarizations of shear sources, which were in line and normal to the direction to the well (termed "SV" and "SH" sources here), into separate SH and SV arrivals, we measured velocity anisotropy as a travel-time difference between SH and SV waves as a function of depth. This anisotropy was also observed as a shear-wave splitting, which leads to complicated particle motion within the first arrival wavelet. Comparison of particle motion between SH and SV waves shows the anisotropy. The shear wave splitting is seen strongly with the SH source, whereas waves generated with the SV source are mostly unaffected, maintaining a linear polarization at depths where the SH source produces circularly polarized waves.

Possible evidence of bulk-fracturing is seen as scattered P-waves energy generated at a depth of approximately 2950 ft by the far-offset source. We observed a variation in the polarization of shear-wave particle motion, which may be indicative of fracturing near the well. Distinct and consistent polarization directions can be followed over certain depth intervals, while other depths show varying polarization directions. The presence of fracturing near the well is also inferred from scattered P-wave energy within the first arrival wavelet of SH and SV waves.

Mineralized Fractures in SSSDP Well 2-14 Core Samples

Caruso, I. J., D. K. Bird, M. Cho, and J. G. Liou, Stanford University

Mineralized fractures in SSSDP Well 2-14 core samples, between 1400 m and 2960 m, were examined using optical and backscattered electron microscopy, and electron-probe microanalysis to characterize (1) their mineralogy and mineral paragenesis, (2) the texture and composition of vein minerals, and (3) the spatial relationships among fractures. Using progressive changes in fracture mineralogy and crosscutting relationships among fracture sets, the history of fracturing and fracture sealing was developed.

Epidote (Ep) and quartz (Qz) occurs throughout the entire sample depth interval; calcite (Cc), anhydride (Anh), K-feldspar (Ksp), hematite (Hm), chlorite (Chl), and actinolite (Act) occur in restricted depth intervals. In samples from depths less than 1860 m, Ep and Cc are the dominant fracture-filling minerals with minor Hm, Qz, sulfides, and Ksp. Ep is the first mineral to precipitate in these veins. It usually occurs as euhedral crystals growing on fracture walls or incorporated in later forming Cc and Hm. A few samples contain Cc veins crosscutting fractures filled with Ep±Hm. Veins in metasediments within the 1860-2746-m depth-interval are filled primarily with one or more of the following minerals: Ep, Ksp, or Anh. Lesser amounts of Qz, Hm, sulfides, and Chl, and trace-quantities of sphene, rutile, and allanite are also present. When Ep + Ksp + Anh occur in a single fracture (at 2226 m), Ksp is usually the first mineral to precipitate followed by Ep; Anh occurs, replacing Ep. In samples with two distinct fracture sets, one containing Anh and the other filled with Ep±Ksp±Hm±Qz, the Anh veins are always younger. At greater depths (>2226 m), Ep is the most abundant and, paragenetically, the earliest mineral to precipitate in fractures; Qz, pyrite, and Act may occur with Ep.

The iron content (X_{Fe}+8=Fe^{+3}+ Al) of vein epidotes decreases systematically with increasing depth. Vein epidotes do not show the same irregular discontinuities observed in the compositional trend of the matrix epidotes. Compositional zoning, common in most vein epidotes, is defined by variations in X_{Fe}+e or, to a lesser degree, in REE content, and ranges from a uniform pattern (i.e., core to rim) to a complex mosaic.

We conclude that metasediments from the SSSDP Well 2-14 underwent episode fracturing, infiltration of reactive fluids, and fracture sealing. The minerals that seal fractures exhibit significant temporal and spatial variations resulting from a hydrothermal fluid-chemistry that varied in time and space. Fracture sealing by mineral precipitation can act as an effective barrier to fluid flow; however, a single fracture set can provide pathways for several generations of reactive fluids.

The Lithostratigraphy of the Colorado River Delta in the Active SSGF Pull-Apart Basin, California

Herzig, and Charles T., James M. Mehegan (Both at Institute of Geophysics and Planetary Physics, University of California, Riverside, CA 92521)

The lithostratigraphy of the California State 2-14 well, located in the Salton Sea Geothermal Field (SSGF), Imperial Valley, California, records the history of the Colorado River Delta in the actively developing, SSGF pull-apart basin. The 10,564-ft drilled section consists of unconsolidated muds and sands to 1,100 ft. At greater depth, the rocks are 70 percent shale and siltstone. Other lithologies include sandstone, pebble conglomerate, and a volcanic tuff at 5,591 ft. Sedimentary bedding in cored intervals, cut by mm-cm scale normal offsets, dip 20-40^{o}. Two igneous intrusions occur at 9,440-50 ft. The deeper intrusion's lower margin was cored, exhibiting a brachiated and chilled contact with shales.

Shale-siltstone intervals containing gastropods and ostrocods are up to 140-feet thick. Cross-bedded, subarkosic arenites, 1- to 36-feet thick, are inter bedded with the shale-siltstones. The pebble conglomerates contain sedimentary, volcanic, plutonic, and metamorphic rock fragments. Conglomerates were not observed deeper than 5,000 ft.

Rock texture becomes more hornfelsic with depth. Quartz, calcite, epidote, anhydride, montmorillonite, illite, chlorite, adularia, albite, sphene, white mica, and actinolite fill subvertical fractures, interstitial voids, and replace detrital grains. Hornblende occurs deeper than 10,300 ft. Ore minerals are galena, sphalerite, pyrite, chalcopyrite, pyrhotite, and specular hematite.

Geochemistry of Salton Sea Scientific Drilling Projects Hydrothermal Fluids and Comparisons to Red Sea Brines

Campbell, A.C., Edmond, J.M, T. S. Bowers, C. I., Measures, M. R. Palmer and E. T. Brown (Dept. of Earth, Atmos. and Planet, Sci., M.I.T. Cambridge, MA 02139)

Hydrothermal fluids from both flow tests of the Salton Sea Scientific well have been analyzed for all major and a number of minor elements. Many of the "minor" metals have solution concentrations 100-1000X higher than in vent-waters from ridge rest hydrothermal vents at 21-N. A more appropriate comparison may be made to the Red Sea brines (RSB) that, like the Salton Sea brines (SSB), have a high salinity due to the circulation of fluids through evaporite sequences. Both systems have very similar Cl concentrations (SSB - 4.314 M/kg and RSB - 4.40 M/kg) (Brewer & Spencer, 1969). The Na concentrations in SSB are 40 percent lower than in RSB (2.42 vs. 4.03 M/kg). Both K and Ca have higher values in SSB (10X and 5X, respectively). These differences may, in part, reflect differences in the evaporite compositions for the two regions. In addition, the reaction substrates and secondary mineral assemblages also must play a role in these differences. Some of the minor elements in the Salton Sea fluids, e.g., Zn, Cu, and Pb, are about 100X enriched relative to the Red Sea brines. Both areas have similar pH values (SSB - 5.2-5.4 and RSB - 5.5) (Shanks & Bischoff, 1977). The metal enrichments of the Salton Sea fluids may reflect greater availability of these elements in the reactions substrate.

Boron isotope measurements on fluids from the four sampling ports indicate a linear decrease in and ^{11}B, which can only be due to precipitation within the sampling system. This result, in conjunction with a concomitant decrease in silica, indicates that some sampling artifacts are present. Thus minor element values must be considered minimum numbers due to the possible effects of coprecipitation.

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with established protocol during this period. The first series of formal presentations of papers and posters detailing the activities of the SSSDP was conducted at the AGU meeting in Baltimore, Maryland on May 19. The full day of sessions was chaired by Wilfred A. Elders (UC Riverside) and John Sass (USGS) and included a total of 22 papers and 12 poster presentations on the program.

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Wolfenbarger, F.M. 1986. Battery Pack/Controller for High Temperature Applications: Geothermal Resources Council Transactions, Vol. 10. pp. 485-489.

SIGNIFICANT MEETINGS

Stage II/Flow-Test Planning Session

A meeting was held at Bechtel's San Francisco headquarters on June 2, 1987 to review coordination of SSSDP R&D with SSSDP operations. Attending the meeting were: John Crawford and Bettyanne Moore of SAN; Charles Harper, Sherman May, Neil Harlen, and Gus Benz of Bechtel; and Susan Stiger of INEL.

Discussed at length during the meeting was the view that the deletion of the media filters from the brine-treatment facility design could result in damage to the Kennecott well during injection of fluids. All parties were in relatively good agreement about the remaining proposed components of Stage II such as site-layout and set up of test equipment. It was also suggested that all experiments be carried out in the cooler, fall weather to reduce stress on personnel and equipment.

Additional discussions were held about Bechtel's contribution to the areas of site clean up, site abandonment, and final cost. An agreement was reached to complete all revisions to the proposal and sign the contract modification by the June 30 deadline.

Program Review Session

A second significant meeting finalizing the proposal was held during the program review session conducted at DOE-HQ, June 29-July 1. Present at the meeting were representatives of DOE/SAN, DOE/GTD, DOE/IDO, Lawrence Berkeley Laboratory (LBL), Lawrence Livermore National Laboratory (LLNL), UURI, and INEL. A contract outlining the Scope of Work (Tasks 1-5) was signed between Bechtel and DOE--officially starting Stage II of SSSDP.

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Third Quarter

FY 1986

September 1986

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Seventh Quarterly Progress Report:
Report of the Third Quarter
(April through June)
FY 1986

SEPTEMBER 1986

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

The progress and direction of the Salton Sea Scientific Drilling Program (SSSDP) has been outlined in a series of quarterly reports. This is the seventh report in the series. This reporting period, from April 1 through June 30, 1986, began with initiation of the 6-month shut-in period. Emphasis was placed upon conducting experiments such as downhole temperature and pressure surveys, distribution of samples to researchers, reporting and disseminating data thus far analyzed, and planning future operations in the SSSDP well.

Standby operations began with downhole temperature and pressure surveys by the USGS using Kuster temperature, and electronic memory, digital temperature and pressure tools. Successful surveys were conducted until the latter part of May, when the temperature tool being run by USGS repeatedly stopped at 6,380 ft going downhole and at 6,195 ft coming up. This was the first indication that problems, thought to be a parting of the 7-inch liner, had developed within the wellbore. In order to assess the condition of the wellbore, diagnostic testing operations were required. A Dia-Log Minimum I.D. caliper tool, and a Welex casing inspection tool and collar locator provided information about conditions in the upper part of the SSSDP wellbore. The scientific community was consulted to determine their recommended course of action, based on the diagnostic data. The consultations resulted in the development of preliminary plans for wellbore repair and preparation of cost estimates.

The reporting of scientific results was begun during this period, soon after SSSDP site operations ceased. Four reports on cores and cuttings were published in April. By June, a draft field procedures manual had been prepared by Los Alamos National Laboratory (LANL). In addition, drafts of three GeothermEx reports on flow-test results and geology were finished by mid-June. Other project reports include a geophysical well-logging report, to be released in September 1986, and various general papers for presentation at the Geothermal

Resources Council Annual Meeting in late September.

Several initiatives for additional funding have come from scientists directly involved in the SSSDP and have been directed at the three participating Federal agencies and Congress. As a result of these efforts, Congress may provide up to $3.3 million of GTD program funds in FY-1987 to continue field operations at the SSSDP site. Detailed rationales for both deepening the well and for conducting long-term flow tests have been put forward. Continued study could reveal new information about deep thermal regimes and magma-driven hydrothermal systems, contact metamorphism, resource recovery from deep hydrothermal reservoirs, behavior of high-temperature, high-salinity brine, and the performance of high-temperature materials and newly-developed high-temperature instrumentation.

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INTRODUCTION

The Salton Sea Scientific Drilling Program (SSSDP), the first major enterprise of the much broader Continental Scientific Drilling Program (CSDP), is sponsored jointly by the U.S. Department of Energy, the U.S. Geological Survey and the National Science Foundation, with Bechtel National, Inc. as the prime contractor.

The drilling phase of the SSSDP officially began on October 23, 1985 and officially ceased on March 17, 1986 at a depth of 10,564 ft. In the period covered in this quarterly report, from April 1 to June 30, 1986, the main objective was to distribute, for analysis, samples and data collected during the drilling, coring and sampling phase of the SSSDP, and to analyze, report and disseminate the results. In addition, initiatives were proposed to continue the SSSDP after the 6-month shut-in period has ended. It is evident that the principal goal of the SSSDP, to study the "roots" of a known hydrothermal system has essentially been accomplished. However, the "roots" of the hydrothermal system in the Salton Sea Geothermal Field (SSGF) were not fully penetrated. Therefore, the existing well is seen as an opportunity for obtaining further scientific knowledge.

Results of the scientific experiments conducted in this unique subsurface environment have contributed and will continue to contribute to a better understanding of Earth's thermal processes. With continuation of the SSSDP, more specific studies of magma systems, the genesis of hydrothermal ore deposits, contact metamorphism, techniques of reservoir characterization, estimates of the recoverable resource, behavior of high-temperature, high-salinity brine, and performance of high-temperature materials and improved downhole instrumentation can be implemented.

PROGRAM PLAN & ACTIVITIES

Current Program

By April 1, a number of milestones established in the original plan had been achieved. These include site and well design, site preparation and procurement, well drilling, coring and flow testing. Preparations for standby operations were made, and the site was fenced-in. From April 1 to April 22, the USGS deployed Kuster temperature, and electronic-memory, digital temperature and pressure tools to collect a series of downhole temperature and pressure measurements (a total of eleven logging runs). The series of temperature and pressure surveys, scheduled to be run to a depth of about 10,000 ft, was halted on May 28 by an obstruction in the wellbore at a depth of about 6,380 ft that prevented further lowering of the tool. Attempts to retrieve the tool were repeatedly hampered by hang-ups at 6,195 ft. After working with the tool for several hours, it was recovered with the data intact. It was suspected that the 7-inch liner had parted or collapsed.

Preliminary diagnostic testing of the 7-inch liner was performed using a minimum I.D. caliper/continuous temperature probe, a casing collar locator and a casing inspection tool. Results of the diagnostic tests were that: (1) at 6,181 ft, the liner had separated at the ninth joint; (2) open-hole existed from 6,181 ft to 6,422 ft; and (3) the liner showed little or no evidence of corrosion. If access to the bottom of the well cannot be restored, the science program, including measurement of stable downhole temperatures, could be severely limited. In order to re-establish access to the bottom of the well, and determine the location and condition of the lower 3,967 ft of liner, additional funding will be required.

Prior to conducting diagnostic tests, a leak detected around the 30-inch casing needed to be sealed in order to meet the terms of the Bechtel-Kennecott agreement. On May 30, Halliburton fulfilled this Kennecott transfer of ownership requirement by successfully sealing the leak.

Drilling and Engineering Program

Well Deepening Initiative

Although the original program goal of drilling to 10,000 ft has been exceeded, a proposal based upon scientific justification, is being considered to extend the SSSDP well depth to 13,000 or 14,000 ft. Revised cost estimates for the well deepening option and associated time estimates were developed by Bechtel, prior to well damage, and are presented in Tables 1 and 2. The average cost for well deepening was estimated to be about $2 million with a range between $1.8 million and $2.25 million. The Scientific Experiments Committee, the DOE/Office of Basic Energy Sciences (OBES) Continental Scientific Drilling Review Group and the DOE San Francisco Operations Office (DOE/SAN) have expressed support for the well deepening initiative, although concerns about lost circulation zones, cementing costs and temperatures above the limits of the scientific tools were expressed.

Program Steps	Approximate Cost Estimate ($1,000s)*
1. Mobilize rig, procure and deliver materials	120 to 300
2. Drill and core to 13,000 ft (assume average daily cost of $20,000)	640 to 720
3. Drill and core to 14,000 ft (assume average daily cost of $25,000)	425 to 500
4. Logging and temperature surveys	140 140
5. Thirty-day flow test of the open-hole interval (assume average daily cost of $10,000)	300 to 350
6. Demobilize and clean up site	160 to 200
7. Final report	30 to 40
TOTAL:	$1,800 to $2,250
TOTAL MEDIAN:	$2,000

TABLE 1: Revised Cost Estimates for Deepening the SSSDP Well and Long-Term Flow Testing (excluding additional expense of removing and replacing parted 7-inch liner).

Program Steps	Estimated Duration
1. Mobilize rig, procure and deliver materials.	30 days to 45 days
2. Drill to 13,000 ft, taking spot cores at 100 ft to 200 ft intervals, if feasible; assume 80 ft/day average drill rate (optimistic) and 70 ft/day (pessimistic).	32 days to 36 days
2a. Drill to 14,000 ft; assume 60 ft/day (optimistic) and 50 ft/day (pessimistic).	18 days to 20 days
3. Logging and temperature surveys, when and if feasible.	10 days 10 days
4. Thirty-day flow test the deepest zone.	30 days to 35 days
5. Demobilize rig and clean up site.	20 days 20 days
6. Final report.	20 days to 24 days
TOTAL:	160 days to 190 days

TABLE 2: Estimated Time Required for SSSDP Well Deepening and Long-Term Flow Testing (excluding additional time required for removing and replacing parted 7-inch liner).

The present well construction, consisting of a 7-inch liner hung inside 9 5/8-inch casing, is unsuitable for well deepening operations, since several lost circulation zones have not been adequately isolated. Control of these lost circulation zones and removal of a lost experiment package from the well bottom would be required before drilling could continue. In addition to remedial operations to repair current well damage, the well deepening initiative would require cementing the lower section of the 7-inch liner and modifying the hanger for thermal expansion. The cost of these operations, exclusive of the major repair costs, would be about $120,000 and would require 9 days to complete. The options, including cost to repair the well damage, are discussed later in this report.

In assessing the feasibility of deepening the SSSDP well, all possible situations that may arise need to be considered. The feasibility assessment should take into account the following:

1. The drilling and coring rate will be dependent upon temperature increase, additional lost circulation zones requiring cementing and drillability of the formations.

2. The wellbore will need to be cooled to accommodate the logging tools, because their temperature limits will have been exceeded.

3. Renewal of the Bechtel National Inc. contract, which expires in December of 1986, would save 3 to 6 months time and from $150,000 to $300,000 by renewal of subcontracts as opposed to spending additional funds to solicit new proposals.

4. Kennecott's continued participation will require their favorable management review to determine acceptability of the risks involved.

Considering the present poor condition of the well, deepening the well to 13,000 or 14,000 ft, though technically feasible, may be precluded because of cost.

Although only limited experience exists for drilling and coring in hard, higher-temperature rocks at depths exceeding 5,000 ft, it was recently recommended that a drilling plan be formulated based upon new and novel approaches to ultra-deep core drilling. A high-temperature turbo-drill for the positive displacement (elastomer stator) motors has been recommended for the primary drilling assembly. For deep rotary coring, a drilling rig with a tophead (power swivel) drive and TCI roller-cone core bits has also been suggested. Los Alamos National Lab and Smith Tool Co. developed a hybrid version of this type of bit for drilling in granite.

Other tools adapted to higher temperature, magma-hydrothermal regimes could be further developed by experimentation in a temperature regime exceeding 350°C. Given the technological achievements of Stage I of the SSSDP, the attitude towards developing new improved technologies for the more hostile environments remains optimistic.

Several advantages to continuing the project, separate from the scientific benefits, are seen at this time. The first advantage is that accessibility to the well, located on Kennecott Corporation's leasehold, is reasonably assured for 12 months from May 1986. Another very important factor to consider is that the orignial project team is very familiar with the field procedures developed and conditions encountered in the well, but the availability of individual team members becomes less certain with delay of follow-on activities. The DOE/OBES Continental Scientific Drilling Review Group endorsed the well deepening as an opportunity that should not be missed.

Responsibility for follow-on activities is being debated. The Geothermal Technology Division (GTD), Department of Energy (DOE), has taken the position that well deepening activities should be the responsibility of those participants involved in basic scientific research, since the justification is largely scientific. However, additional funds for FY-1986 from these sources were not available and there is, as yet, no decision on funding in FY-1987. The scientific community has solicited funds for continuation of the Salton Sea project through the Congress. The House Subcommittee on Energy Development and Applications responded by inquiring whether or not DOE's Geothermal Technology Division (GTD) could fund the well deepening initiative. The GTD maintained that their goal of penetrating the roots of a known hydrothermal system has been accomplished and that deepening the well is of lower priority in fulfilling the GTD mission. However, $1.3 million has been budgeted in FY 1987 for a long-term flow test and improvement of high-temperature downhole instruments.

The Energy and Water Development Appropriation Bill of 1987 is currently before the House of Representatives. On page 77 of the Bill, funds for the SSSDP have been increased by $2 million from $1.3 million to $3.3 million. The additional $2 million is to be used to deepen the Salton Sea well to a depth of 13,000 to 14,000 ft. The Senate has not yet considered the Bill. However, on a related matter, the Senate scheduled hearings on the Continental Scientific Drilling and Exploration Act (S. 1026) for July 24th.

Long-Term Flow Testing

The second flow test, from the deepest producing horizon, at approximately 10,475 ft (as previously reported), is considered to have been only partially successful. There was evidence during the test that flow from one or more zones behind the liner comingled and, also, that the fluid samples were contaminated. A long-term flow test is, therefore, justified in order to determine the true nature of the formation fluids, competing salinity and temperature effects on fluid-density distribution, and water-rock reactions. Determination of the three dimensional distribution of fluid density would allow modeling of heat and mass transfer, and also delineation of the extent of the reservoir(s) and permeability of the reservoir rocks. Also, with proper isolation of reservoirs, a longer term flow test could determine whether or not lower density fluids occur at greater depths, as suggested by results of earlier tests. The discovery of deep, lower density fluids would imply considerably increased economic potential at depth.

Another benefit of performing a long-term flow test is the opportunity for production technology development. High-temperature logging tools, more durable well construction materials, downhole fluid samplers, improved methods for sampling fluids at the surface, and improved techniques for handling, treating and injecting high-salinity brine are also areas where improvements could be made.

Bechtel has estimated that a long-term flow test would cost $1.3 million, if an injection well for fluid disposal is made available. The costs for well repair were not included. Anticipating joint cooperation with Kennecott, the Geothermal Technology Division plans to provide flow test equipment, a pipeline to an injection well, site support and analysis of data from the long-term flow test. Flow-test equipment may be made available from two Geothermal Loan Guaranty projects.

Well Damage, Prognosis and Repair

On May 28, the temperature tool hung-up between 6,145 and 6,330 ft, suggesting that the 7-inch liner had parted near the bottom of the ninth joint. Preliminary diagnostic testing began on June 25th with two surveys using the Dia-Log Minimum I.D. caliper tool. The logs were of poor quality due to high-temperature, but detected the 7-inch liner from 5,770 to 6,178 ft, a constriction at 6,341 ft and a blockage at 6,422 ft in what otherwise is an open hole between 6,178 and 6,422 ft. On June 26th, the Welex casing inspection tool and collar locator confirmed and amplified the Dia-Log results with minor value differences. The casing inspection log indicated that the liner appeared normal between the hanger and point of failure. The condition of the well, derived from these diagnostic tools, is shown in Figure 1.

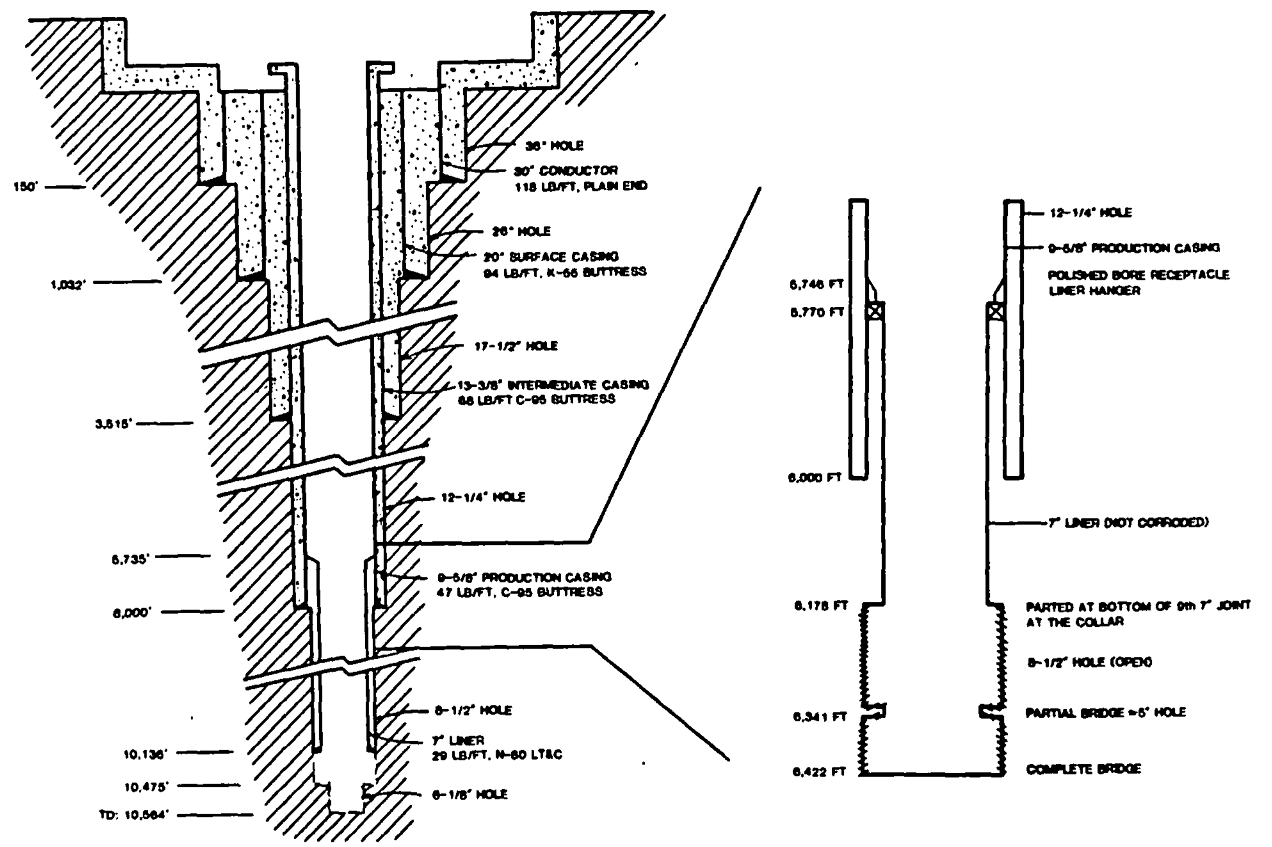

Figure 1: Condition of State 2-14 (SSSDP) Well on June 26th

A total of 4,378 ft of liner was installed. Therefore, it has been assumed that 3,970 ft of the liner has fallen. By differences, it was projected that the bottom of the liner is at 10,392 ft (83 ft above the bottom of the 8-1/2 inch hole and the beginning of the 6-1/8 inch hole). The condition of this section of the liner is unknown.

By June 27, the primary objectives were to (1) diagnose the condition of the lower 4,000 ft of 7-inch liner and repair the well; (2) continue scientific experimentation; and (3) conduct a 30-day flow test and deepen the well. Achieving these objectives will require additional funding and Kennecott's participation.

In order to complete these objectives, the necessary remedial tasks include: (1) pull-out the 7-inch liner between 5,748 and 6,178 feet, and the liner hanger; (2) leave the bottom 4,000 ft of 7-inch liner in-place with the expectation of getting instruments below 6,422 ft to total depth; (3) attempt an "overshot" of the 7-inch liner; and (4) establish the cause of failure and the integrity of the lower section of the well. The three strategies proposed, and summarized in Table 3, assume Kennecott agreement with the procedures, no severe lost circulation problems exist and the fallen 7-inch liner section is either in a usable condition or can be removed from the well.

Option	Minimum Cost (not including rig mobilization costs)	Strategy to Repair the Well	Benefits of the Strategy
1	$155,000	o enter and clean out the broken liner with a 6-inch mill bit to total depth. o insert a 5-inch scab liner between the liner hanger and the top of the fallen 7-inch liner.	permits resumption of the temperature equilibrium study, but not flow testing or drilling deeper.
2	$200,000	o remove the upper hanging part and replace it with an S95, 7-inch liner, connected to the broken stub with an overshot coupling, if the fallen liner is intact and can be cleaned out with a 6-inch mill bit.	permits equilibrium temperature study, and possibly flow testing and deepening, though the possibility of flow testing seems unlikely.
3	$570,000	o remove existing 7-inch liner and replace it. o remove fallen section in four pieces.	permits the temperature study, flow testing and deepening.

TABLE 3: Three Options for Repairing the SSSDP Well

Scientific Experiments Program

Well Deepening Initiative

The most important justification for deepening the well is to extend scientific knowledge of earth's thermal regimes in a unique tectonic setting. The complete loss of circulation below 10,460 ft led project scientists to recognize that the "roots" of the system had not been fully penetrated. Complete penetration of the hydrothermal system would help verify the existence of (1) a considerably deeper heat source, (2) a laterally displaced heat source, or (3) a conductive hot dry rock regime bordering an active dike or sill.

Deepening the well, thus determining the nature of the heat source, is an extremely important scientific goal. Entirely different mineral assemblages may be revealed by penetration of a zone with temperatures greater than the 353°C measured at 10,400 ft. If successful penetration is achieved, a rare opportunity to study the transition from hydrothermal alteration to contact metamorphism and to study more of the magmatic component of the system will be realized. Long-term flow testing from a deeper producing horizon would also enable the study of the effects of higher temperature mineral reactions on brine chemistry.

Downhole Experiments

The DOE National Laboratories conducted several downhole experiments in the SSSDP well to gather data for scientific studies. These post-drilling scientific activities fulfilled both basic science and technology development objectives. Summaries of the DOE National Laboratory activities are provided below.

Los Alamos National Laboratory (LANL): Los Alamos collected fluid samples on the surface during the flow test and obtained one successful downhole fluid sample. Failure to get downhole fluid samples occurred because of:

- o 1st run - seal malfunction causing the motor to flood
- o 2nd run - seal malfunction causing a short-circuit
- o 3rd run - an ailing motor
- o 5th run - electrical problems

The 4th fluid sample run was successful, recovering approximately 1.5 liters of fluid and 0.5 liter of gas.

The SSSDP site team ran the commercial (Leutert) mechanically-tripped flow-through sampler three times while Los Alamos and Sandia were making field repairs on the electric sampler. These attempts were unsuccessful because the Leutert sampler design limit was 177°C and the attempts were being made in a 344°C environment.

Lawrence Berkeley Laboratory (LBL): LBL personnel performed the vertical seismic profile (VSP) experiment without major complications. The downhole tool was run on the USGS 7-conductor wireline. Also, the Berkeley (GRI) flow-through sampler was deployed on the USGS single-conductor wireline. About one liter of un-pressured liquid was recovered. The sampler remained in the high-temperature downhole environment longer than planned, which could account for loss of the gas sample.

Lawrence Livermore National Laboratory (LLNL): Lawrence Livermore contributed an IBM P.C. and a Terra Station interpretive package for on-site processing and interpretation of well log data. The downhole gravity survey did not run according to plan; however, useful data were obtained.

Sandia National Laboratory (SNL): Sandia personnel supervised the design and construction of several tools and downhole deployment components. They provided the battery packs and dewars. The dewared Kuster temperature and pressure tools were resistant to heat and performed satisfactorily, but the spinner tool stopped before useful data could be obtained. The newly developed dewared, electronic-memory temperature and pressure tool worked successfully. Sandia's current problems basically involve the long-standing technological difficulty of running delicate tools in an extremely hostile environment.

The U.S. Geological Survey (USGS) also ran its own set of downhole experiments. In April and May, the USGS intermittently ran the temperature and pressure tools provided by Sandia. Plots of the temperature logs are shown in Figure 2. Other logs run by the USGS included Caliper, Dual Induction, Acoustic Televiewer, Acoustic Waveform and Gamma Ray/Neutron Logs.

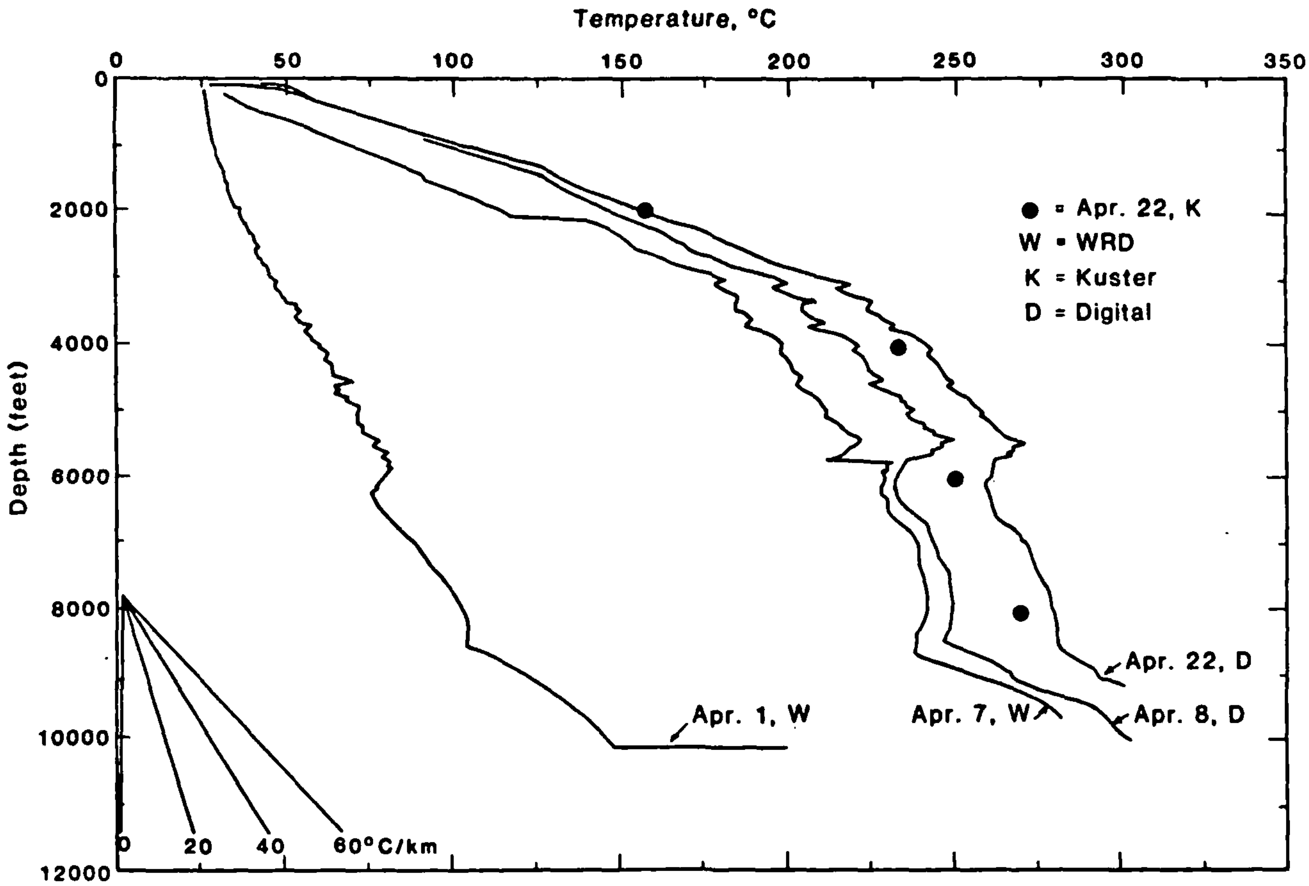

Figure 2: USGS Temperature Logs: State 2-14 (SSSDP) Well

Fluid, Core and Cuttings Samples

Fluid and/or gas samples from the Salton Sea well have been distributed to investigators by Los Alamos National Laboratory. A list of SSSDP State 2-14 fluid and/or gas sample recipients is provided in Table 4.

The Massachusetts Institute of Technology's (MIT) Earth Resources Laboratory and the U.S. Geological Survey have a joint interest in characterizing the physical properties of the SSSDP cores. A DOE/GTD funded study of the relationship between borehole acoustics and seismic velocities of cores at ultrasonic frequencies was recently funded. A proposal to do other core studies will be presented to DOE after a preliminary set of tests on the two representative cores has been performed. Other core and cutting samples from the SSSDP well were distributed to various other laboratories and research groups.

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Table 4: SSSDP California State 2-14 Well Fluid and/or Gas Sample Recipients

Reporting of Scientific Results

Now that the drilling, coring and flow-testing have been completed, distribution is now being made of the samples and data, and scientific results are being compiled and released. Table 5 provides a preliminary bibliography of SSSDP reports that have been published, are in press or are in draft form.

TABLE 5: Preliminary SSSDP Bibliography

* = Status

Aducci, A.J., Klick, D.W., and Wallace, R.H., Jr., 1986, Management of the Salton Sea Scientific Drilling Program; Geothermal Resources Council: Transactions, v. 10, 4 p.

* In press

Andes, J., Jackson, J., Lilje, A., Sullivan, R., and Herzig, C.T., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Visual Core Descriptions; Herzig, C.T. and Mehegan, J.M., eds, Institute of Geophysics and Planetary Physics, University of California, Riverside: UCR/IGPP-86/1, v. 2, April, 93 p.

* Pub.

Carson, C.C., 1986, Development of Downhole Instruments for Use in the Salton Sea Scientific Drilling Project; Geothermal Resources Council: Transactions, v. 10.

* In press

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 28-30 December 1985; for Bechtel National, Inc., San Francisco, California, June, 40 p.

* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Geologic Interpretation Well State 2-14; for Bechtel National Inc., San Francisco, California, June, 158 p.

* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 20-21 March 1986; for Bechtel National, Inc., San Francisco, California, June, 71 p.

* Draft - in Review

Harper, C.A., and Rabb, D.T., 1986, The Salton Sea Scientific Drilling Project: Drilling Program Summary; Geothermal Resources Council: Transactions, v. 10.

* In press

Herzig, C.T., and Mehegan, J.M., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Core Summaries; Institute of Geophysics and Planetary Physics, University of California, Riverside: UCR/IGPP-86/2, v. 2, April, 12 p.

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Michels, D.E., 1986, SSSDP Fluid Composition at First Flow of State 2-14; Geothermal Resources Council: Transactions, v. 10.

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* In press

Paillet, F.L., Morin, R.H., Hodges, R.E., Robson, L.C., Priest, S.S., Sass, J.H., Hendricks, J.D., Kasamayer, P., Pawlowski, G., Duba, A., and Newark, R., 1986, Geophysical Logging Activity at the Salton Sea Scientific Drilling Project: Preliminary Report, U.S. Geological Survey Open File Report.

* Draft

Sass, J.H., and Elders, W. A., 1986, Salton Sea Scientific Drilling Project: Scientific Program; Bul. Geothermal Resources Council, v. 15, no. 9, p. 21-26.

* Pub.

Sass, J.H., and Elders, W. A., 1986, Salton Sea Scientific Drilling Project: Scientific Program; Geothermal Resources Council: Transactions, v. 10.

* In press

Solbau, R., Weres, O., Hansen, L., and Dudak, B., 1986, Description of a High Temperature Downhole Fluid Sampler; Geothermal Resources Council: Transactions, v. 10.

* In press

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 23 October - 6 November 1985, Report, No. 1: Bul. Geothermal Resources Council, v. 15, no. 2, 15 p.

* Pub.

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* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 7 Dec. - 10 Jan. 1986, Report No. 3: Bul. Geothermal Resources Council, v. 15, no. 4, p. 15-18.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 Jan. - 10 Feb. 1986, Report No. 4: Bul. Geothermal Resources Council, v. 15, no. 6, p. 25-28.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 February - 1 April 1986, Report No. 5: Bul. Geothermal Resources Council, v. 15, no. 8, p. 13-20.

* Pub.

Wolfenbarger, F.M., 1986, Battery Pack/Controller for High Temperature Applications; Geothermal Resources Council: Transactions, v. 10.

* In press

SIGNIFICANT MEETINGS

<u>Continental Scientific Drilling Review Group (DOE/OBES, CSD Review Group) - May 1, 1986</u>

The Continental Scientific Drilling Review Group (CSD Review Group) viewed the Salton Sea Scientific Drilling Program as a tremendous research opportunity. According to the group's observation, having reached 355°C at a depth of 10,500 ft, a hydrothermal region never before available for scientific study was entered. The samples, thus far, have provided a fascinating record of metamorphic transitions from lake muds to hornfels with abundant ore mineralization. High enthalpy, hypersaline (25% dissolved solids), metal-rich brines flowing at up to 260,000 kg/hr have been produced according to tests of high permeability zones.

The Continental Scientific Drilling Review Group was convinced that further drilling, sampling and testing to a depth of 13,000 to 14,000 ft was an opportunity that should not be missed. For the first time, igneous rocks related to the deep heat source of the plate-spreading system could be penetrated and deep hydrothermal resevoirs with temperatures over 350°C could be examined.

A logical sponsor for deepening the SSSDP well would be the Geoscience Program in BES, but the BES budget will not allow this. Therefore, the CSD Review Group urged LBL to forward a strong endorsement to parties interested in the SSSDP.

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Fourth Quarter

FY 1986

January 1987

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Eighth Quarterly Progress Report:
Report of the Fourth Quarter
(July through September)
FY 1986

JANUARY 1987

U.S. Department of Energy
Office of Renewable Energy Technologies
Geothermal Technology Division

EXECUTIVE SUMMARY

The Salton Sea Scientific Drilling Program (SSSDP) has been documented in a series of quarterly reports. This eighth reporting period, from July 1 through September 30, 1986, began following diagnostic testing of the damaged wellbore. Emphasis during this reporting period was placed upon repairing wellbore damage and assessing options for continuation of the SSSDP.

Partial repair of the parted 7-inch liner in the scientific well was completed August 25, 1986. Nine joints of liner with cracked collars were removed, the fallen section was milled clear to 8,000 ft, and 10-ft of 5 1/2-inch liner connected to 802 ft of new 7-inch liner was placed in the well. Consequently, planned temperature and pressure gradient measurements (at least to 6521 ft) could be resumed. Further remedial options are being considered in order to allow performance of a long-term (30-day) flow test and continued scientific experimentation in the well. Industry's experience with collar cracking and liner failure was surveyed in order to determine the probable cause of the failure and reduce the possibility of reoccurrence.

Scientific data analysis and reporting continued during this quarter. Three geophysical studies have been initiated by the USGS. Results are expected to be available in the near-term. These investigations are: 1) a study and comparison of USGS and commercial logs, 2) a study of seismic velocity and geothermal alteration in the SSSDP well and 3) a study of transport properties of SSSDP cores. The number of SSSDP publications continues to grow and the first public report of scientific results from the SSSDP is planned for the spring of 1987.

Acquisition of uncontaminated brine samples under in-situ conditions was considered an important part of the scientific and technical objectives of the

SSSDP. The three downhole sampling devices used are discussed in the body of this report.

A workshop was held on September 17 to discuss technological barriers to deep continental scientific drilling in thermal regimes. Required improvements in drilling and coring, logging techniques, and instrumentation, in view of the SSSDP experience, were discussed at the workshop.

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INTRODUCTION

The Salton Sea Scientific Drilling Program (SSSDP), first major enterprise of the much broader Continental Scientific Drilling Program (CSDP), is a jointly sponsored effort of the U.S. Department of Energy, the U.S. Geological Survey and the National Science Foundation, with Bechtel National, Inc. as the prime contractor. The SSSDP scientific well site is located on the southeast shore of the Salton Sea in Southern California. The project was undertaken with the intent of penetrating the "roots" of a known hydrothermal system, evaluating the energy potential of deep geothermal zones, characterizing the hydrothermal fluids, obtaining a better understanding of ore genesis, and heat and mass transfer processes in such systems. Moreover, a publicity-available, complete data-set from a deep geothermal well would be obtained, and new instruments and testing procedures would emerge from the project.

Initiated on October 23, 1985, drilling of the scientific well officially ended at a depth of 10,564 ft on March 17, 1986. During and shortly after the drilling phase, two short-duration flow testing and fluid sampling sessions were performed in addition to several periods of geophysical logging. While running a wireline temperature survey, during the shut-in period following completion of the well, an obstruction was encountered in the wellbore at about 6,380 ft, indicating that the 7-inch liner had parted or collapsed. The main concerns during this reporting period were reactivation of the well, resumption of planned experiments, and assessment of the extent to which further scientific studies could be carried out within the available budget. Obtaining equilibrium wellbore temperature and pressure profiles, and performing a long-term flow test of a deep isolated reservoir were activities considered necessary to complete the original program objectives.

Results of the scientific experiments conducted in this unique environment have contributed, and will continue to contribute, to a better understanding of Earth's thermal processes. With continuation of the SSSDP, more specific studies of magma systems, the genesis of hydrothermal ore deposits, contact metamorphism, techniques of reservoir characterization, estimates of the recoverable resource and behavior of high-temperature, high-salinity brine can be implemented. Also, performance of high-temperature materials can be evaluated and downhole instrumentation further improved.

The SSSDP was cited on July 24, 1986 as evidence of the scientific benefit of a National continental scientific drilling program. Reference occurred in a hearing before the Senate subcommittee on Natural Resources and Production, Committee on Energy and Natural Resources, that was held concerning the Continental Scientific Drilling and Exploration Act (S. 1026). At these hearings, Donald K. Stevens, Associate Director for Basic Energy Sciences, cited the SSSDP as being "fully successful in meeting its targets for depth and recovery of samples for research." Dr. Wilfred A. Elders, geology professor at the University of California, further stated "the SSSDP epitomizes the reasons why we need to organize a national program of continental scientific drilling on a secure footing with long-term planning and funding." In addition, Carel Otte, President of Unocal Geothermal Division, supported drilling ultra-deep, high--temperature wells in order to uncover and develop the geothermal energy supplies and hydrocarbon resources of the future.

PROGRAM PLAN & ACTIVITIES

Current Program

At the end of the last reporting period (April through June, 1986), diagnostic tests were performed in order to ascertain the position and condition of the fallen 7-inch liner. Test results suggested that the liner had parted at the bottom (pin-end) of the ninth joint. Following the DOE/SAN July 15 directive to Bechtel to proceed with remedial work at the Salton Sea well, mobilization of the Cleveland drilling rig commenced August 7. Repairs included removal of about 380 ft of damaged liner and a polished-bore receptacle (PBR), completion of a tapered milling tool run to 8,005 ft and installation of 812 ft of new 7-inch liner. With the preliminary repairs completed, instrument access to about 8,000 ft was reestablished for continuation of temperature and pressure gradient measurements by USGS. Further remedial options are being reviewed for technical, scientific and financial feasibility.

Restoring wellbore integrity in order to perform a long-term flow test and recover high-quality, deep reservoir fluids continues to be a high priority for DOE, and is supported by both the Science Coordinating Committee (SCC) and the Continental Scientific Drilling Review Group (CSDRG). Kennecotts' cooperation is required prior to conducting further field operations.

FY 1986 funding for Bechtel contract activities within the Salton Sea Scientific Drilling Program (SSSDP) was increased this quarter by $290,000 from $930,000 to $1,220,000 (totals include $75,000 provided by the other participating agencies). This supplemental funding was provided for diagnosing wellbore damage and initiating repair. The first remedial repairs were completed on August 25. In addition, $105,000 was provided to the USGS in FY 1986 for conducting studies of the heat and pore fluid transport properties of rock cores recovered from the scientific well, and acoustic characterization of fractures and hydrothermal alteration in the geothermal reservoir. Funding in the amount of $50,000 was provided to Sandia National Laboratory earlier in the fiscal year for fabrication of the electronic memory, downhole temperature and pressure measuring device. Total DOE Geothermal Technology Division SSSDP funding for the fiscal year was $1,300,000, 88 percent of which was for drilling and engineering operations.

Drilling & Engineering Program

Remedial Well Work

A set of diagnostic tools, including minimum I.D. caliper, continuous temperature probe, casing collar locator and casing inspection tool, were run on June 25 and 26, 1986 to assess the mechanical condition of the 7-inch liner that had parted and fallen into the well. Based on these logging results, it was determined that the liner had parted at the bottom (pin-end) of the ninth joint, possibly from the combined effects of high salinity, high temperature and mechanical stresses. In August, preliminary repairs were completed. A chronology of events is detailed in Table 1. The first spear run into the hole stopped at 4,365 ft, but worked successfully when the solid stop-ring on top of the jar assembly was replaced with a lugged stop that was 1/4-inch smaller in diameter. At first, only 4 joints of 7-inch liner, the liner-hanger and the PBR were retrieved. However, the slips on the liner-hanger hung-up in the wellhead, in the enlarged part of the expansion spool, and damaged the seal assembly. A cement plug was required at approximately 450 ft to maintain wellbore control while dismantling the rotary table, rig floor and wellhead, removing the junk, then reassembling these components.

The cement plug was drilled out and the second spear run latched onto the next 5 joints of 7-inch liner on August 15th. All 5 joints were recovered with the pin-end of the bottom joint (9th) showing indentations resulting from

Date (August)	Major Action	Description
7,8	Activated Site	Installed water lines and utilities, and assured that equipment was on-site.
9,10	Activated Rig	Killed well, nippled-up, installed and tested the Blow-out Prevention Equipment (BOPE).
11,12	Picked-up drill collars and drill pipe	Cooled well and spotted lost circulation material(LCM) pill. Ran in hole (RIH) and tagged fish at 5782. RIH with spear.
13	Speared and recovered fish	Pulled out of hole (POH), fish became stuck in expansion spool, set cement plug at 450 ft.
14	Retrieved 4-joints of 7-inch liner, liner-hanger and polished bore receptacle (PBR)	Rigged-down rotary table & rig floor, nippled-down BOPE, including master valve and expansion spool. Nippled-up BOPE, and rigged-up floor and rotary table. Ran 8 1/2-inch bit to drill cement plug.
15	Retrieved 5-joints of 7-inch liner	Tagged top of liner at 6301 ft. POH, picked-up spear and RIH. POH with fish. RIH, tagged lower section of liner at 6519 ft.
16	Ran tapered mill (6 1/8-inch diameter)	RIH with tapered milling tool and worked to 8005 ft.
17	Ran pilot mill (8 1/8-inch diameter)	POH, layed down tapered mill. Picked-up and ran pilot mill on top of collar 6519 to 6521 ft. POH, all blades broken off bit. Ran sawtooth mill.
18	Ran 18-joints of 7-inch liner with 10-ft stinger	Worked over at 6519 ft and POH. Ran 802 ft of 7-inch liner with 10-ft of 5 1/2-inch tubing. Stabbed into lower 7-inch liner section.
19	Layed down drill pipe and collars	Set retrievable bridge plug at 260 ft. Nippled-down BOPE, master valve and expansion spool. Replaced expansion spool seal assembly. Reassembled wellhead.
20, 21, 22	Deactivated Rig	Retrieved bridge plug and deactivated both rig & site.

Table 1: Chronology of Remedial Work Completed August 1986.

having fallen 330 ft or more. Thus, the PBR, liner-hanger and 9-joints of liner were removed.

The section of parted 7-inch liner was entered with a 6 1/8-inch tapered milling tool and milled clear to 8,005 ft, where, presumably, buckling made further milling inadvisable because of the risk of cutting through the liner. Tight spots were also milled at 6,657 ft and from 6,714 to 6,754 ft. On August 17, a custom pilot milling tool was run to mill-off the collar (top) of the 10th-joint of 7-inch liner at 6,519 ft in order to install a casing bowl connection. After milling two feet, it was found that all six cutting blades were broken from the tool. The condition of the top of the liner and the location of the broken blades were unknown. The collar could have either been milled smooth or "belled-out." Financial constraints prohibited waiting for a new tool, but allowed one run in the well with an 8 1/8-inch sawtooth milling tool. The collar had not been milled-off. Therefore, the casing bowl could not be installed. As an alternative, 10-ft of 5 1/2-inch pipe (stinger) connected to the bottom of 802 ft of 7-inch, L-80, 29 lb/ft, BT&C pipe was stabbed into the lower section of parted liner at 6,521 ft depth. This temporary repair section was installed without use of a hanger assembly or PBR. A Baker retrievable bridge plug was installed on August 19th to allow repair of the expansion spool seal assembly. It was removed on August 20th. Throughout the remedial work, it was necessary to inject and circulate drilling fluids to maintain control of the wellbore. On August 25, 1986, temporary repair operations were completed. It was anticipated that temperature and pressure gradient measurements, scheduled for October, could be run at least to 6,521 ft and possibly as deep as 8000 ft. A schematic diagram of the current wellbore construction is shown in Figure 1.

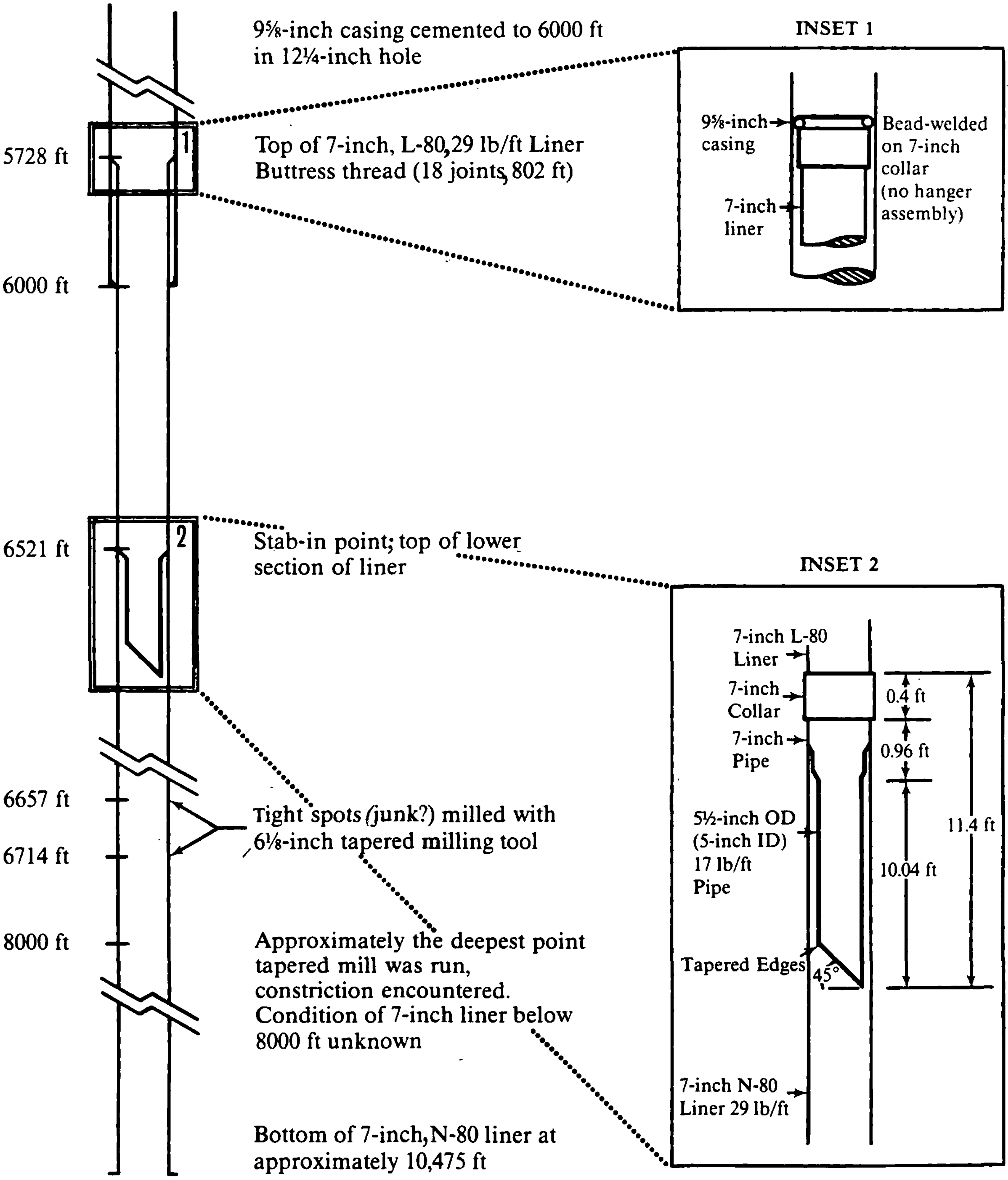

Figure 1: Schematic of Wellbore Construction after August 1986 Repairs

The collars of the 9-joints of 7-inch casing that were removed showed evidence of severe to minimal cracking, minimal corrosion was noted on these joints. Two of the collars and the pin-end of the last joint (9th) of liner were cut-off and sent to Brookhaven National Laboratory for failure analysis. According to Brown Oil Tools, the liner-hanger used was not designed for removal, once set. Although all of the slips on the liner-hanger were recovered in the expansion spool, only part of the centralizers were recovered.

To reduce the possibility of cracks developing when the old liner is replaced, it was decided to consider changing from N-80 liner with LTC threads to L-80 with buttress threads. Various methods of further strengthening the liner in the severe dog-leg sections of the wellbore are also being considered. The selection of suitable replacement liner will be subject to results of metallurgical analysis of the failed collars by scientists at Brookhaven National Laboratory and their recommendations. These results are also expected to provide insight concerning the degree of difficulty and associated expense to be anticipated in removing the remainder of the N-80 liner.

Long-Term Flow Testing and Well Deepening Initiative

The Department of Energy is continuing with plans for a long-term (30-day) flow test and possible deepening of the Salton Sea scientific well. The San Francisco Operations Office of DOE has been directed to pursue this effort with officials of Kennecott Corporation. In order to conduct a long-term flow test, an injection well is required. Kennecott has plans to drill a commercial well near the SSSDP site that could serve as an injection well for a long-term flow test.

Scientific Experiments Program

Geophysical Data Analysis

The SSSDP scientific well was logged commercially and by the U.S. Geological Survey. A comparison by the USGS of their logs to the commercial logs has been completed. Most of the initial data analysis consisted of record clean-up, log correlation and depth adjustments. The USGS will publish a comprehensive open-file report, with the intention of providing a complete package of depth-correlated (where possible) geophysical log data, lithological logs (from cuttings), and drilling and engineering data. The report, although not approved, as anticipated, in time for the GRC meeting on September 28, was in the final stages of approval and release.

The USGS, in cooperation with MIT, is conducting a DOE/GTD-funded study of seismic velocity and geothermal alteration. Integration of acoustic well logs, acoustic full-waveform log data, core velocity analysis and VSP seismic data will both: 1) verify and identify the differences in core seismic velocities that produce velocity structure observed in acoustic logs and VSP data; and 2) investigate the relationship between geothermal alteration and seismic velocities. Initial study of acoustic logs and waveform records has been completed, yielding seismic velocity estimates for use in preparing synthetic seismograms. This study could provide a direct relationship between seismic velocities and state of alteration for SSSDP lithologies.

Another USGS study funded by DOE/GTD deals with transport properties of SSSDP cores. It involves laboratory measurement of thermal and hydraulic conductivity of SSSDP core samples. Controls for hydraulic and chemical systems have been completed, and electrical and thermal control systems are in progress.

Description of Downhole Fluid Sampling Tools Used in SSSDP

Acquisition of unflashed and uncontaminated brine samples under in-situ conditions was considered to be an important part of the scientific and technical objectives of the SSSDP. A variety of downhole sampling devices were used with electrical signal-conducting cables, and a battery pack and non-conducting wireline to obtain in-situ fluid samples. A description of the tools follows.

Sandia Battery Pack-Controller

Specifically designed to operate the Los Alamos downhole sampler for use in the SSSDP, the Sandia battery pack-controller was designed to operate for 4-hours at 400^{o}C. A dewar (vacuum heat shield) houses a battery pack and electronics that are used to control the downhole motor in the Los Alamos sampler.

Los Alamos In-situ Sampler

The Los Alamos National Laboratory (LANL) fluid sampler was increased to 2-liter capacity and modified to operate on either the Sandia battery pack-controller or signal-conducting cable. Once the sampler reached the desired depth, a temperature hardened electric motor was actuated to open a valve to the pre-evacuated sample chamber that was designed to fill immediately.

Lawrence Berkeley In-Situ Sampler

The Lawrence Berkeley Sampler, originally built for the Gas Research Institute to be used in geopressured wells, was designed for 230^{o}C temperatures and internal pressures up to 137.8 MPa greater than the external pressures. The sampler has a 1-liter chamber volume, a 5.7 cm diameter, a 3 m length and a 55 kg weight.

Leutert In-Situ Sampler

This commercial flow-through sampler is 4 cm in diameter and 2 m in length, and was designed by Leutert Instruments, Inc. to sample oil field petroleum and brine, downhole, at 150°C or less. The sampler has an adapter that can be used to extract associated gas, and is easily connected to the Los Alamos gas extraction system. The sampler valves are mechanically opened at the surface and can be closed at the desired depth either by use of a timer-clock or by jerking closed using a jawhead. A higher temperature (300°C) adaptation of this tool is being developed by LANL scientists.

Los Alamos Gas Extraction System

The gas-liquid ratio, as well as the gas and liquid compositions, is needed for reconstruction of in-situ formation fluid composition in the Salton Sea reservoir. A gas extraction line was designed and constructed by Los Alamos scientists to remove the gas for analysis and to measure the volume of gas collected by the downhole sampler.

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with protocol during this reporting period. General reports were scheduled to be presented orally at the Geothermal Resources Council (GRC) Annual meeting in Palm Springs, California on October 1, 1986 and were published in the Transactions volume. Informal progress reports were presented at the GRC meeting site in a closed meeting of principle investigators on September 28. Also in this reporting period, a draft report on downhole fluid sampling was completed by Los Alamos National Laboratory. The updated SSSDP bibliography follows:

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SIGNIFICANT MEETINGS

<u>SSSDP Science Coordinating Committee (SCC) Meeting - July 23, 1986</u>

The Committee heard two briefings concerning further work at the SSSDP well; the first by Ray Wallace (DOE/GTD) on the condition of the well and efforts to solve the problem caused by the parted liner, and the second by Wilfred A. Elders (UCR) on the options for additional scientific work. Funding for additional work at the well will be considered on an individual basis by each agency.

Planning for a conference on SSSDP results early in 1987 was also discussed. A symposium in conjuction with the spring meeting of the American Geophysical Union (AGU) or the American Association of Petroleum Geologists (AAPG) annual meeting was discussed, as was the merits of a combined reporting of scientific, and drilling and engineering research. Elders and Wallace were to continue to pursue this matter.

Initial distribution of samples to scientists by UCR was begun and permanent curation at the DOE/Grand Junction facility was set. Dr. Elders reported that his group was able to process the first batch of sample requests submitted in response to early August notices. The National Science Foundation has extended the UCR-SSSDP grant through December 31, 1986. Notices announcing the availability of core, cuttings and logs appeared in early August issues of, among others, EOS, Geotimes, Geothermal Resources Council Bulletin and the Geothermal Report. Elders reported that it was necessary to limit water sample distribution to a first-come, first-served basis, with present SSSDP investigators having precedence. Also, Dr. Elders was advised that the Scientific Experiments Committee should establish criteria for reviewing and selecting requests for well materials, and send these criteria to SCC for comment.

<u>Continental Scientific Drilling (CSD): Technology Barriers to Deep Drilling Studies in Thermal Regimes Workshop - September 17, 1986</u>

The major thrust of the workshop was to identify key barriers to, and set research priorities for, DOE supported continental scientific drilling into higher temperature environments. Workshop discussions are illustrated by the following priority listing of barriers or issues:

- Drilling and Coring:
  - long-life bits are needed to reduce cost and risk of hole damage
  - need control of lost drilling-fluid circulation to maintain cooling and hole stability
  - a systems approach should be used in reducing barriers
  - side-wall coring systems should be considered as a lower cost alternative to continuous coring
  - need temperature upgrade of bits, continuous (wireline) coring hardware, and bottom hole assemblies

- Logging and Instrumentation:
  - develop reliable logging tools and other instrumentation for 350^{o}C to 400^{o}C service
  - develop higher temperature cables and alternatives
  - develop tools for in-situ fluid chemistry and mineralogy determination
  - determine drilling parameters while drilling or coring

- Downhole Sampling Testing and Experimentation:
  - develop and deploy high-temperature vertical seismic profiling (VSP) tools
  - develop borehole packers for tests of in-situ rock and formation fluid properties, and stress state
  - develop sensors for extended downhole use to meet 400^{o}C requirement

Identifying problems, limits and barriers encountered in the Salton Sea well is the first step to overcoming these difficulties in future high-temperature, deep drilling projects. Table 2 lists key problems, limits and barriers encountered in the Salton Sea well. Prior to further SSSDP scientific well operations, instrumentation and procedures should be reevaluated and improved.

Key Considerations		Remarks
1) Hierarchy of Problems		
Drilling	o	Lost circulation and well control below 6,000 ft became expensive and hazardous. Eight to nine lost circulation zones were penetrated before reaching total depth: estimated cost impact was $640,000.
	o	Bit life was generally poor because of: - the necessity to ream after coring, - accelerated bearing and button wear below 6,000 ft due to high temperatures and very hard formation, - drilling during lost circulation conditions, - inappropriate use of button bits with high-speed turbo-motors.
	o	Directional drilling was unusually costly because of short turbo-motor life in the high-temperature, saline drilling environment.
Conventional Coring (730 ft recovered)	o	Trip times to take spot cores added considerably to the project cost.
	o	Reaming after coring (down to 6,000 ft) required an extra roundtrip and resulted in excessive bit wear and core loss.
	o	Coring blind, i.e., during a lost circulation situation, resulted in accelerated bit wear due to overheating and abrasion, and in jamming of lost circulation material between the rotating and non-rotating parts of the coring assembly.
	o	Instability and bouncing of the drill string and coring assembly led to poor coring and core recovery.
	o	Very hot, very hard rock types, below about 8,000 ft, shatter when the formation pressure is removed from above and they are "chilled" by cooler drilling fluids during coring. Core barrel jamming and poor core recovery results.
Commercial Logging	o	Virtually all commercial logging tools and wirelines are temperature-limited at about 350°F, with a few able to go to 500°F.
Scientific Logging	o	Experimental high-temperature tools are difficult to calibrate, have questionable repeatability, and, especially for the more complex designs, are not fully reliable.
Sampling	o	Problems in downhole fluid sampling occurred due to: - brine flashing upon entry into sample bottle of LANL-Sandia sampler - malfunction of battery system in LANL-Sandia sampler - seal failure in LANL-Sandia fluid sampler causing motor to flood and short circuit - lost circulation material clogging the bullnose in Leutert sampler - stopped clock preventing canister closing in Leutert Sampler - O-rings failing on sample bottle in Leutert sampler - failure of sample port to open in LANL-Sandia sampler. - loss of gas sample from LBL sampler.
2) Limits and Barriers		
Barriers to Going Deeper	o	Difficulty in gaining and keeping control of multiple lost circulation zones in the deeper, hotter formations. Effective high-temperature lost circulation materials, cements, and techniques for their use is required.
	o	Early failure of rotary bits, especially loss of buttons, bearing failure, and loss of gauge cutting capability.
	o	Very slow cutting and early failure of diamond bits, resulting from poor cooling and poor removal of cuttings.
	o	Slow cutting and early failure of PDC bits in hard formations.
	o	High-temperature, efficient drill bits are needed.
	o	Poor life of mud motors in high-temperature, saline environments. Thermal operating limits must be improved.

Table 2: Problems, Limits and Barriers Encountered in the Salton Sea Well

Table 2: (continued)

Key Considerations		Remarks
Barriers to Obtaining More Core	o	See "Barriers to Going Deeper," above.
	o	Improved stability of the coring assembly and drill string.
	o	Improved core barrels and core catchers to reduce jamming and increase recovery. When the formation begins spalling and discing from thermal shock and changes in geostatic pressure, conventional equipment is ill-adapted.
	o	Ultimately, trip times for coring become prohibitively expensive. The need to make frequent stops, in and out, to cool the well contributes to major increases in trip time. When a lost circulation condition exists, where drilling-fluid weighting can not be relied upon for well control, the problem can become critical.
Barriers to Obtaining Geophysical Logs and Fluid Samples	o	Construction and packaging materials, especially seals, are temperature limited.
	o	Failure-potential of wireline increases with time of exposure to temperature and corrosivity.
	o	Signal conducting cables are subject to temperature limits of about 300°C.

SSSDP Principal Investigators meeting - September 28, 1986

The principal investigators of the SSSDP met prior to the Geothermal Resources Council annual meeting in Palm Springs, California. Presentations at the Principal Investigators meeting were given by personnel funded by the participating agencies. A list of presenters is given in Table 3. The purpose of the meeting was to inform one another about progress and plans for analysis of samples and data collected during the SSSDP. According to protocol, letter reports on progress were to be circulated among principal investigators within 6-months of drilling completion. The informal progress reports were not to be published, but were aimed at fostering an awareness of research activities among investigators.

In response to a questionnaire distributed by Wilf Elders, most investigators opted for formal presentation of results at a National meeting in the Spring of 1987. In addition, most preferred that the conference proceedings be a special issue of a professional/scientific journal.

NAME	ADDRESS	TITLE
*N. Valette-Silver	U. of Md.	Study of the 10Be isotope in the Salton Sea Geothermal Sys.
J. Mehegan	IGPP	Curation and distribution of samples from the Cal. State 2-14 well: SSSDP
M. Cho, L. Caruso	Stanford	Prograde phase relations in the SSSDP Borehole metasandstones, SSGF, Ca. Fractures in the deep core samples from the SSSDP well
M. McKibben	IGPP	Ore-forming processes in the SSGS
F. Paillet	USGS	Geophysical log analysis and core sample measurements on the SSSDP Project - progress and initial results
F. Goff, L. Shevenell, C. Grigsby, B. Dennis A. White	LANL	Downhole fluid sampling at the SSSDP Cal. State 2-14 well, Salton Sea, Cal.
A. Williams	IGPP	Oxygen isotope exchange in minerals during hydrothermal metamorphism: Salton Trough sediments
D. Hammond, T.-L. Ku J. Zukin	USC	Uranium and thorium series radionuclides in the SSSDP
W. Elders L. Cohen	IGPP	Magmatic and volcanic rocks in the Salton Trough
P. Kasameyer	LLNL	Downhole gravity measurements
D. Michels	D.M. Assoc.	Brine Chemistry from the two flow tests

* Did not attend

Table 3: Presentations for the SSSDP Principal Investigators Meeting

FOCUS ON

DRAFT

MEXICO

A GEOTHERMAL INTERNATIONAL SERIES

SPONSORED BY:

U.S. DEPARTMENT OF ENERGY
GEOTHERMAL TECHNOLOGY DIVISION (GTD)

PREPARED FOR:

LOS ALAMOS NATIONAL LABORATORY
UNDER CONTRACT NO. 9-X36-3652C

PREPARED BY:

MERIDIAN CORPORATION
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PREFACE

The *Focus on* Series is prepared to give the U.S. Geothermal Industry a quick profile of several foreign countries. The countries depicted were chosen for both their promising geothermal resources and for their various stages of geothermal development, which can translate into opportunities for the U.S. geothermal industry. The series presents condensed statistics and information regarding each country's population, economic growth and energy balance with special emphasis on the country's geothermal resources, stage of geothermal development and most recent activities or key players in geothermal development. The series also offers an extensive list of references and key contacts, both in the U.S. and in the target country, which can be used to obtain detailed information.

The series is available for the following countries:
Argentina, Azores (Portugal), China, Costa Rica, Ecuador, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Jordan, Mexico, St. Lucia, Thailand.

Additional countries might be available in the future.

The series is to be used in conjunction with four other publications specifically designed to assist the U.S. geothermal industry in identifying and taking advantage of geothermal activities and opportunities abroad, namely:

- The *"Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities."* Final Report, August 1987. Prepared for Los Alamos National Laboratory.

- The *"Summary Report"* of the above publication.

- *"Equipment and Services for Worldwide Applications,"* U.S. Department of Energy.

- The *"Listing of U.S. Companies that Supply Goods and Services for Geothermal Explorers, Developers and Producers Internationally,"* August 1987, prepared by GRC.

Copies of these publications can be obtained from the Geothermal Technology Division of the U.S. Department of Energy. Correspondence should be addressed to:

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NOTE

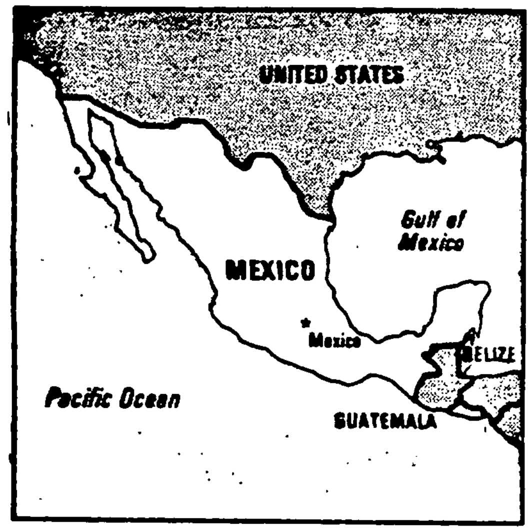
Data presented in this document are based on several U.S. government official publications as well as international organizations, namely:

- Background Notes (U.S. Department of State)
- Foreign Economic Trends (U.S. Department of Commerce)
- World Development Report 1987 (World Bank)
- International Data Base for the U.S. Renewable Energy Industry, May 1986 (U.S. Department of Energy)

The country's geothermal resources write-up is a revision and update of the Appendix in the "Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities." LANL, August 1987.

CONTENTS **PAGE**

FOCUS ON **MEXICO**



Official Name: The United Mexican States

Area: 1.978 million sq. km. (764,000 sq. mi.)

Capital: Mexico City

Population (1985): 78.8 million

Population Growth Rate: 2.5%

Languages: Spanish

Economic Indicators:

Real GDP (1984): $185 billion
Real Annual Growth Rate (1984): 3.7%
Per Capita Income (1984): $2,350
Avg. Inflation Rate (1984): 59.2%

Trade and Balance of Payments:

(1984) Exports: $25.2 billion; Major Markets: U.S., EC, Japan
(1984) Imports: $11.3 billion; Major Suppliers: U.S., EC, Japan

(December 1985) Official Exchange Rate: 345 pesos = U.S. $1 (controlled rate);
490 pesos = U.S. $1 (free market rate)

Energy Profile: (Based on 1982 data unless otherwise indicated)

- Commercial Fuel Energy Consumption:

  Total: 92.585 million ton of oil equivalent (mtoe)
  1-Yr. Growth: 14.1%

- Commercial Fuel Breakdown:

  Liquid Fuels Pct: 59%
  Solid Fuel Pct: 5%
  Natural Gas Pct: 28%
  Electric Pct: 8%
  Commercial Fuel Consumption Growth Rate (1970-1980): 7.1%

- Electricity Generation Capacity:

  (1982) Total Installed Elec. Capacity: 21,574 MW
  Hydro: 37%
  Hydro Potential: 25,250 MW
  Steam: 48%
  Gas Turbine: 9%
  Diesel: 5%
  Other: 1%
  Note: Other sources indicate that, as of 1986, a total of 650 MWe of on-line geothermal generated electric capacity, (about 3% of the total installed capacity)

- Electricity Sales:

  Total: 52,611 GWh
  Residential: 18%
  Commercial: 75%
  Industrial: *
  Government: 7%
  Other: *
  Average Electricity Price: 2.77 U.S. cents/kWh

- Geothermal Power Generation Status:

  Reservoir Potential (MW): A possible total of 13,020 MWe
  Temperature Range: 50^{o}-355^{o}C depending on fields

- Geographic Locations: Northwestern Mexico and south-central Mexico.

- Development Status: Various development stages, including 650 MWe of on-line geothermal generated electricity

- Countries Actively Involved: U.S.

- General Need for Assistance: Reservoir modeling and testing, commercial power production

- International Funding: $622,568 (UN/DTCD)

* Negligible

GEOTHERMAL RESOURCES

The geothermal areas of Mexico are located along the southern extension of the Salton Trough of California into northern Mexico, and along an east-west volcanic axis in south-central Mexico. In January of this year, Mexico moved in third place behind the U.S. and the Philippines in terms of geothermal generation capacity with a total of 650 MWe.

As part of a nationwide study to characterize certain geothermal areas, a national inventory of the geothermal areas of Mexico was performed by the Commision Federal de Electricidad (CFE). The purpose was to gather resource information and make an appraisal of the country's geothermal potential for planning and prioritization. The results of CFE's work led to a classification of Mexico's geothermal resources into three categories. The estimated geothermal energy resources of Mexico are: 1220 MWe proven, 4800 MWe probable, and 7000 MWe possible for a total of 13,020 MWe.

▲Geothermal Resources

The Cerro Prieto geothermal field, located in northwestern Mexico along the California-Mexico border in the Mexicali Valley, is the major site of geothermal development in Mexico. The field has been in production since 1973 and has the distinction of being the first liquid-dominated geothermal system in North America to provide significant electrical production.

Cerro Prieto is located along a continental spreading zone bounded by the right-lateral strike-slip Imperial and Cerro Prieto faults. The heat source is presumed to be magma bodies (dikes and sills) intruded into the recent sediments of the Colorado River Delta, and derived from gabbroic plutons rising from an oceanic-type spreading ridge. Volcanic rocks at the surface consist of two rhyodacite cones comprising the Cerro Prieto Volcano. At least five eruptive phases have occurred since late Pleistocene (110,000 years).

The Laguna Volcano area, located a short distance southwest of the developed geothermal field, is the site of many surface thermal manifestations. The area consists of low hills built up by hot spring fumarolic activity and is thought to result from reservoir leakage to the southwest along high angle fracture zones. Laguna Volcano has been the site of phreatic explosions in the past, the latest occurring in 1927.

Over 140 deep geothermal wells have been drilled at Cerro Prieto since exploration first began in 1959. Fluids at temperatures above 300^{o}C (335^{o}C maximum) are produced from 103 production wells at depths ranging generally between 1000 and 3500 m. The deepest well is 4,125 m deep. Reservoir production zones increase in depth from southwest to northeast partly in response to fluid migration upward along high-angle faults and increasing depth to basement to the northwest. Reservoir modeling studies have shown that the field is recharged from the east by hot (355^{o}C) fluids, and from both the east and west by cooler (50^{o} to 150^{o}C) water.

Cerro Prieto has 620 MWe of installed capacity. A continued commitment by the Mexican government toward geothermal development resulted in the initial investigations within the volcanic regions of southern Mexico. Experimental farms for lobster breeding using effluents of the field are presently being tested.

In 1967, CFE began exploration at Los Azufres (Michoacan) and later in 1980 at Los Huseros (Puebla). The Los Azufres geothermal field is located in central Mexico approximately midway between Mexico City and Guadalajara. Exploration at the field began in 1976 when CFE initiated a deep drilling program to evaluate the geothermal potential of the area. Although there were many drilling problems associated with volcanic rocks and high temperatures, the program was successful in discovering a thermal reservoir with temperatures exceeding 300^{o}C.

The field lies within the Neovolcanic belt in complex Pliocene-Pleistocene successions of basalts, andesites, trachy-andesites, decites, and rhyolites from three volcanic cycles. The reservoir is separated into two sectors, the Maritaro (or northern) sector is a liquid-dominated system and the Tejamaniles (or southern) sector is a vapor-dominated system.

Presently, over 40 wells have been completed in the two sectors of the field. In the northern sector, fluids are supplied to three 5 MWe portable non-condensing turbine units via 10 production wells that achieve an average depth of 1700 m. Reinjection is facilitated through three wells. Twelve wells in the southern sector, with an average depth of 1000 m, provide thermal fluid to two similar 5 MWe turbine units. Reinjection is also accomplished through three wells.

In 1987, seven additional portable turbine units are scheduled for installation at Los Azufres, bringing total on-line capacity to 65 MWe. A central 50 MWe plant, to be located in the southern sector, is under construction. Two additional 55 MWe power plants are in the advanced planning stages and may be constructed pending further reservoir testing.

The Los Humeros-Derrumbadas geothermal region is located east of Mexico City in the eastern portion of the Trans-Mexican Neovolcanic Axis. The Los Humeros Caldera, a Quaternary collapse structure along the flank of a shield volcano, is situated within the northern portion of the prospective region. Recent surface exploratory programs have indicated a high potential for geothermal development in this region. Subsequent deep exploratory drilling and testing of seven production wells has been successful, and small scale power generation is expected by 1987. If additional reservoir testing proves favorable, two 55 MWe plants are in the preliminary planning stages for installation before 1991.

In addition to the developments occurring in the major fields of Cerro Prieto, Los Azufres, and Los Humeros, other prospective thermal fields lie within Mexico's volcanic region. At La Primavera, near the of Guadalajara, exploration has begun within a volcanic caldera. Five exploratory wells have been drilled to depths of 2,000 m, and have encountered temperatures as high as 305^{o}C.

Within the state of Michoacan, two other areas have been investigated. The Los Negritos thermal area was tested via a 1000 m exploratory well, and produced steam and water intermittently. In the Ixtlan de Los Hervores area, a total of eight shallow exploratory wells have been drilled within inconclusive results.

Today, 645 MWe of generating capacity is either installed or under construction at Cerro Prieto and Los Azufres. An additional 440 MWe between the two fields is planned for installation by 1992.

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Geothermal Report, June 15, 1987 and July 1, 1987.

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Hiriart L.G., 1985, "Los Azufres Geothermal Development - Mexico," Geothermal Resources Council Bulletin, January, pp. 3-7.

Lippmann, M.J., Goldstein, N.E., S.E. and Witherspoon, P.S., 1984, "Exploration and Development of the Cerro Preito Geothermal Field," Journal of Petroleum Technology, Sept. pp. 1579-1591.

REFERENCES

AND

KEY CONTACTS

A. Business Climate Sources of Information

The following references are suggested for timely information on the business climate in Mexico.

U.S. GOVERNMENT PUBLICATIONS

U.S. Department of Commerce

- Foreign Economic Trends (FET) and their Implications for the U.S.
- Overseas Business Reports (OBR)

U.S. Department of State

- Background Notes

NON-GOVERNMENT PUBLICATIONS

- International Series, published by Ernst and Whinney
- Businessman's Guide to......., published by Price Waterhouse and Co.
- Information Guide: Doing Business in ......, published by Price Waterhouse and Co.
- Task and Trade Guide, published by Arthur Andersen
- Task and Investment Profile, published by Touche Ross and Co.

B. Geothermal-Related Sources of Information

The following reports and documents are suggested for further information regarding geothermal energy and export opportunities overseas:

Los Alamos National Laboratory:

- Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities

U.S. Department of Energy

- Equipment and Services for Worldwide Applications
- Guide to the International Development and Funding Institutions for the U.S. Renewable Energy Industry
- Federal Export Assistance Programs Applicable to the U.S. Renewable Energy Industry
- International Data Base for the U.S. Renewable Energy Industry
- Committee on Renewable Energy Commerce and Trade: CORECT's Second Year - October 1985-November 1986

California Energy Commission (CEC)

- Foreign Geothermal Energy Market Analysis
- Small Scale Electric Systems Using Geothermal Energy: A Guide to Development

U.S. Department of Commerce - International Trade Administration

- A Competitive Assessment of the U.S. Renewable Energy Equipment Industry

U.S. Export Council for Renewable Energy

- International Renewable Energy Industry Trade Policy

C. KEY CONTACTS

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Resistivity

- anomalies found @ Zunil I
- quantitative interp recommended to provide "better structural outline"
- quantitative interp - produce a "resistive substrate ceiling map" - top to resistive basement
  locate discontinuities in granodiorite basement.

Gravity

- model Zunil I using existing data - use borehole density measurements to adjust densities to use -
  use MAGIX program } cross-sections thru model 'Zunil Graben' } ZCQ-4 and -6.
- do detailed survey - (INDE?)
- interpret and report on new survey

MK

Zuni Proj

4. ~~1.~~ How much clout for Dowpratt?
3. ~~2.~~ what are their instructions from Gustavo Calderón?
1. ~~3.~~ Our current problems
   - M-K - Cato realiz that they could not handle
   - INDE data and late-delivery
     - rejection of UK gravity
     - INDE wanting to put off blame
     - poor distrib. of responsibility
     - don't know about how they did terrain corrs -- use wrong density
   - There may be little or no useful info in TP, but we need to get stuff out.
2. ~~4.~~ Introduce CDB and INDE - results, etc.
   Calderon saying "do good job" -
   Calderon vs Marinelli
   ~~Ecologic / Site~~ geotectonic model

5. Don Nichols' Work -

w/ Fraser Geoff — phone

1. Whole prog taken from ELECTROCONSULT
because they weren't doing good work.
— Bank, INDE, Mundo's Cartera, MK, --

— Fraser's not being paid -- others are --

— If he were going to present data, be up front
-- we did what you wanted
-- we don't think data is pretty good, am -
-- we're using direction recon by group, but didn't
push into right.

-- F doesn't know personalities of Mancilla + deposits

Idiras — feels project is a loser. Certainly Co doesn't
have a clear-cut plan because outside
influences

— why MK - a co w/ no geoth exp (except ~~geoth~~ Mexico)
how get interest in first place - 3, Guatemalan
law -- every co has to have local co.

- They got grove data from WDE that their grove man says

- Tobias -
~~FG his~~ impression is that mapping was not good enough - didn't like it.
Tobias may be most competent guy -- worked at Cal. time, is familiar -- level of exp and wisdom --
His prob he is an Indian - lots of stigma - they won't let him control proj
~~First Instead~~ Cascades runs proj, who is a back stopper. So they rely on Tobias but don't give him credit.
FG believes in landslide complex -- So Tobias faults wrong -- too much cover -- some scarps are land slides -
~~He~~ would hate to discredit Tobias, he sees him as one of better people -- but --

whole proj is so complicated its a loser

FG believes Dune hasn't produced a good-one map -

- Manuelle appreciates a good [illegible]. He is an old school guy — what do Linares [illegible]?

- whole prog start from scratch

- Suker will do well, whether data is good or not
  models will be wishy-washy
- need hard data
- have [illegible]
- Condor will help -

- Coldiron has been around -
  he can assess if Sancar is peddling B.S.
  he can perceive what's needed for [illegible]

FG knows can't see zero fault -

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TELEPHONE 801-524-3422

CONFIDENTIAL MEMO TO: ROY MINK

FROM: MIKE WRIGHT

DATE: AUGUST 23, 1989

SUBJECT: THOUGHTS ON PRESENTATION OF ZUNIL WORK

It occurs to me that there are four keys aspects (maybe more) to making a successful presentation of the Zunil project to INDE and the IDB review panel:

1. Giving a presentation that convinces one key individual, Gustavo Calderon of IDB, that the work we have done is good and the project is on track;

2. Making a fully coordinated and rehearsed presentation that communicates confidence in our work, conclusions and recommendations;

3. Bringing out explicitly our contracted statements of work in such a way as to defuse potential disruption of the meeting by people like Marinelli, who has his own political agenda and opinions about what should be done; and,

4. Making the presentation in such a way that INDE does not feel threatened but can be given credit for their past work and can support our work.

1. I do not know Gustavo Calderon well, but I have talked with him on a number of occasions and have some opinions that could be wrong but are worth your consideration. I perceive him to be an intelligent individual who is self assured and can readily form his own opinions on technical and political matters. When I visited him in Washington, DC, he said that the most important thing that they (IDB) expected from the new work was a structural/hydrological model of the Zunil reservoir that

would enable one to select drilling targets and develop the resource. His aim is to find enough hot fluids to get a 15 MWe power plant on line, and a smaller plant is much less desirable. He is not so much interested in the regional geology as he is in a correct and successful exploration model for the area of Zunil 1 and its immediate environs. Part of the issue here is that the IDB has invested in the project, Gustavo has supported the project, and both will look bad if the project fails. Gustavo left no doubt that he would blame the current INDE contract team if this happens.

Gustavo does not believe the Italian geologic model, based on Lardarello, that permeability is confined to certain stratigraphic horizons in the volcanic rocks. He believes that fluid flow is controlled by fractures and that flow in the basement granite must be taking place. He understands that the Italians have messed up the exploration and the resource evaluation, and he is not happy about this. However, we must remember that he has Marinelli on the review panel, and must have some confidence in him personally.

With the right presentation and discussion, Calderon could come to independent conclusions on the quality of our work and on our recommendations without relying on the opinions of the panel. This would work to our advantage because at least Marinelli and possibly others on the panel are not unbiased and are not supportive. I believe that the approach should be to direct the presentation to Calderon by giving it at his level of technical understanding and by making occasional eye contact with him while including enough detail to satisfy the panel and INDE. Calderon probably does not have enough background in the detailed scientific and technical matters required to understand a highly technical presentation. Our presentation must be simple, precise and explanatory. This is usually the best style anyway. One can not assume that Calderon, or the others, will immediately see the relevance of any particular piece of data or of any particular conclusion. We should emphasize how our data fit together and what they mean.

2. Our presentation must communicate confidence in our work. There should be unanimity of opinion in the interpretations, conclusions and recommendations. There is no room at the presentation for dissenting opinions. In order to achieve a polished presentation, it should be orchestrated and practiced before it is given.

3. There is a great potential for the presentation and the whole meeting to be disrupted by people like Marinelli and perhaps others on the panel, as has happened before. One way to combat this would be to begin each segment of the presentation with an explicit statement on a viewgraph of exactly what it was we were contracted by INDE to do. If there is any argument with our SOW, we can simply say that the problem is between the IDB and INDE, is not part of our presentation, and should be taken

up separately with INDE. I believe it will be much easier to justify our results based on the SOW than to defend our work against a bunch of opinions and suggestions about what the project should be.

4. It is important to allow INDE personnel to take as much credit as possible for the project. We want to nurture our relationship with them.

I think that INDE might be silent during the presentation until they can get a reading on how things are being accepted by the IDB and the panel. They, of course, want things to go well because we are their contractors and if we mess up, it looks bad for them. If they sense that our presentation is being well accepted, they will speak up in our favor and the ball will get rolling in a favorable direction. However, if things start to go badly, with criticism of our work, we can expect INDE to distance themselves from us and blame us for any problems, deficiencies, etc. This scenario could snowball into a very unfortunate situation.

The above comments are only how I see things. I could be wrong. You need to consider the merits of what I have written and come to your own conclusions. It is important because a dynamite presentation that convinces Calderon could be an important turning point in the project in spite of the expected criticism from Marinelli and others on the panel.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

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Questions

modify Fig 8

1. Are hydrothermal breccias really horizontal units, correlative hole to hole? - quoted in Rpt II, Stratig and Alt.
2. Several places where II has typos. -
3. p14, Rpt II. Isn't it the steam, not so much the CO_2 that produces the "steam-heated" cap.?
4. Vol III, P3 ~~says~~ unreasonable -- ~~[illegible]~~ vapor ~~[illegible]~~ rich inclusions found or not?

Notes

Palmo's resistivity report, 1977

- objective of survey - find areas of $\rho < 10$ Ω-m to indicate presence of a geothermal reservoir.
- intermediate depth gradient drilling used to check
- Schlumberger is better than Wenner because center electrodes stay fixed more -- easier and less near-~~surface~~ electrode effect
- did 4 lines w/ Schlumberger to AB/2 = 2000 m
- planned lines for flattest tops
- did longitudinal conductance map, feel its important to delimiting geoth reservoir, also abrupt changes may indicate faults.
- quantitative interp to characterize low ρ layers

Notes — Japanese Presentation

- Caldron - this presentation very important for Bank
- Second plant will be installed in Anahltlan or Zunil, depending on study.

- Defined Zunil area, "its a big area"
objective is to find best concentrated area in which to do more detailed work -
- with done geology: - regional tectonics, stratigraphy -- establish faults and structures that may carry water -- last sources of heat
- geophysics to extrapolate surface data into subsurface; VES, magnetics, gravity all used; gravity - 2-3D analyses of gravity; electrical - rewrite of VES -- 2D interp.
- Geochemistry - in whole area, only got manifest in Zunil 1. ; geochem is important because can be used for geothermometry -- 5 areas defined -- area 4 is area of Zunil 1. -

- So their work has been directed at siting deep holes not only for geology, but also to try to find fluids.

- Question on geochem studies —
A.- Only thermal features are in Zunil 1. They have also studied cold springs to see if they have a gt component, but have removed part of their study. —
Question is change of study, why was it done —
Question on use of gp in regional exploration for pick most specific/permissive area. —

- Caldwell is interested in the significance of the conductive area as shown on the VES data —

xlated by E. Lima

west Japan Consultants, Tech —

Japanese presentation — Toshio, Fujino -
- So far regional Enfoque - literature review
- WNW trend to general area w/ regional structure — divided into 3 segments, w/ NE intersecting trends.
NW structures rt lateral, NE are left lateral.
- Big map is defined area Zunil 2.
Defined 4 groups of volcanic rocks. (1) basement granite. Basement dates Miocene (?) dated by fission track
-- (Dave says granite pebs Cretaceous — 40/39 date anyway will tell). —
Also Pliocene granites (?) N of whole area, off map? —
- Units of Santa Maria correspond to those of Rose —
- Rhyolites occur S of River, SE of Zunil 1. —
~~And S of~~ Found S of River, dates of 250-350 Kma.
200 Kma pyroclastics. Interfingered ~~volcanic~~ flows and pyroclastics —
- The large, circular area E of Zunil 1, acidic volcanism is common.

- very many microearthquakes along Zunil fault. –
- Says Zunil fault is very important.
- Believes granite underlies large area of interest SE of Zunil-1

- Japanese recognize zone of lots of faulting near and around Zunil 1 –

- [illegible] – no questions?

Geochemistry –

~~Have~~ done 20 Oxy-Hydr isotope samples

S of River all manifest are favorable – from which it is not possible to tell subsurface ~~temp~~ ?

Area 1: Zunil – Samples of hot waters
- 1000 ppm -- this is smaller than comparable areas such as Mesa Valley.
- near Rio Samalá, high fluoride content. – they conclude that there is the likelihood that reservoirs occur in granite –

Area 2: SE of Zunil 1. Tritium analyses –
also for favorable CO_2/H_2S ratio -- in this area ratio is lower bec H_2S is high?

Also high concentrations HCl and SO_2 — so they believe there is a subsurface reservoir south of River Sanalá. -- perhaps only a superficial reservoir if no deep reservoir ??. Drilling needed. -

Area 3 — NE of Area 1.
Used Na-K-Ca geotherm -
Believe subsurface temp in lower 100s -

Area 4 - only found fumaroles (~~ca~~ directly S of Ouizeltango)
don't think there is a big resource under this area, at least ~~very~~ shallow, maybe very deep.

- Also found high Fl in Zunil 1. They think there is a NE trending basement high up Sanalá: so E of Sanalá in Area 1, chloride lower, fluoride higher.

- In Zunil 1, much fracturing -, wants a granite reservoir
- Found little similarity in chem of Area 1, Area 2 -- geochem shows they are not related.
— So they anxiously await drilling in Area 2 to confirm their ideas of it being a good area.

- Again emphasized that reservoir would be in fractures in granite.

Marinelli –
– we have a good topo map of all geothermal prospect
– but we don't have a tectonic map –
– this is a warning for us.

Calderon –
tectonics from microseismicity – is it better to get a microseismic survey? – –

Alvarez →
– 161 soundings –
– made a series of NW (5) & NE (4) profiles –
– took field data: automatic inversion –
– showed example – 1-D inversion –
Anchored resistivity of layers –
– also

– then projected interpreted sections onto NW & NE sections

– his prog puts in layers to map depth ≈ 350 m – below that, use resistivity –

- Duprott -

To Add ~~to~~ Gravity Section

1. Table 1 - measured density values of core from ~~Z-2, Z~~ Zeniel 1. 0
~~et~~

Figure 1 - Nettleton ~~P~~ Density Profile for Gravity Line 2

Figure 2 - Nettleton Density Profile for Gravity Line 3
~~Complete~~

Figure 3 - ~~¶~~ Bouguer Anomaly Map, $\rho = 2.00$ g/cc

Figure 4 ~~Complete~~ Bouguer Anomaly Map, $\rho = 2.20$ g/cc

Figure 5 ~~Complete~~ Bouguer Anomaly Map, $\rho = 2.30$ g/cc

Figure 6 ~~Complete~~ Bouguer Anomaly Map, $\rho = 2.67$ g/cc

Figure 7 Structural Interpretation from Bouguer Gravity maps

Figure 8 Residual Bouguer Gravity Map

Figure 9 Structures Interpreted from Residual Gravity Map

Raman — took interp data at
100, 300, 600, 900 m and contoured, using
an interp program
— Shows a low in area N of Ocuzalt, -
and also couple of anomalies near Zunil. Large
highs around V. Santa Maria. Colored contours
correspond to

Red 0-50 Ω-m
Black 100-500
Blue 1000-8000

~~The low~~

A high resistivity zone develops at depth
under Zunil, and a low "pipe" that slopes up
to surface and goes to depth — R feels
this is source area of upwelling.

- Questions about
  - 1-D interp — 2-D or 3-D would be better
  - topographic effects —

Duprat says that to him the maps are
incomplete - due to topo
- also some of R's anomalies seem to be
1 station - D complained about this

The low ρ zone extends progressively further south and depth till an goes up, then are figure of low ρ that R thinks may be due to recharge. He believes recharge area is to N of fault.

- Then R put together a 2-D finite-element model along five (?) lines - finds he is able to define deep, low ρ zone -

— Will also look @ mag and gravity when he gets the basic data - he's waiting

Notes Zunil-I Presentation 29 Aug 84

- INDE changed order of presentation this morning -- Dune first.

1. ~~Dyna~~ Roy
   - stressed integrated nature of study

2. Dune:
   - integrated study
   - greatest concentration of faults 3, 5, 6 - ZCQ -
   - our targets are open fault zones in granite
   - There is a prev- unrecognized caldera, Quetzaltenango caldera.
   - faults trend NW (Zunil fault) left lateral volcanic front - NW trending faults

Geophysics -

Palma -

1. Important to do joint resistivity / gravity interp -- I said we are in process

2. Doesn't like planar regional - I said I feel its most that can be easily done w/ data.

Joe
- Some photos of enthalpy plots, which indicate higher than 340°C? -
- Fraser - Subco is worth doing -
- has tables for estimation of future reservoir data.

Roy - Hydrology -

Calderon -
- why after all this work are we coming back to Electroconsult model? Because of tests that show prod vs time decline.
- Now after Moore's work, Saber's work, & we were supposed to be in a position to drill. But it seems that we have not decreased the risk? what have we done? -

Saber. A year ago, question was whether to work our wells, etc.? Paulo suggested interference tests - we agreed. This has been the bulk of the testing. These tests have been successful. Also we have unwrapped old chemical sampling data.

Calderon - why don't we have a model for this meeting? when can we have these. Can we

have it before green light.
Subir wants 4 months to do the model.
Initial state modeling, then predictions.

Cald. - If everyone (paul + consultants) guarantee him that a deep reservoir exists, he could give green light now.

Paulo - wants addit. simple modeling of existing data to reduce risk.

Marinelli - he says granites are chlorite altered and soft, will not sustain fracts.

Dupont says why not start detailed modeling w/ 0 perm in granites and go from there.

Cald. It sounds like to him we have spent lots $ on fluid inclusions, etc, but the model is absolutely necessary to proceed and to run the field later. For Cald, a model is a prerequisite. Bank won't accept project w/o the model.

Subir - no gt system has been developed on porosity -- its thruput and permeability, because heat is in rocks.

Caicedo - if we have to do modeling, must give up something else because tight budget.

Caldisón - consultants have shown that ~~all~~ our position for drilling is better -- wants panel to address whether we are ready to drill.
-- But ultimately we need to model -- Bank will not accept project w/out model -- costs have to be identified now for this -- ~~Be~~ the wait recomm w/o model -- that's fund.

30 Aug 89 Notes on Summary and Target concept meeting

Fault detection -
mercury - open fracts at present w/ circ gt fluids
radon - open fracts w/ or w/o geoth fluids
Shallow VLF? - clays in gouge along faults from 0 - ±100 ft.
HLEM - steep faults, gouge
Dipole-Dipole - steep faults to shallow gouge

Panel (Di Pippo) - asked (Fraser, too) why not use 1 pad for 2 holes & directional drilling to save $.

Marinelli - Says there is no evidence that some faults are open or of which of the fault systems are open.

Dunne - Showed geol map.
- alt'd areas along structures fumarole field
- has seen faults in the field

(- also interference data of Subir's presentation)

Marinelli - Doesn't like idea of two open fault directions?
- Also asked why 150 m maximum well spacing. A. Subir says this is max for granite systems.

Fraser - why 2000 m drill depth? A. INDE imposed limit. A. The 2000 m is vertical depth

Caicedo - have fixed $ avail. Under contract, we could deepen past 2000 m. But may use up resources ~~fast~~ ad $ pend $ programmed for other areas.

cont.

<u>DePippo</u> - we originally had idea that #2 well was a good producer. Now that we have injected into this, can we test it to see if its a good producer now -
43 kg/sec, 240 C ~~zone at bottom of~~ well ±800', top of granite?

<u>Paulo</u> - we need an injector in any case

<u>Fraser</u> - Nothing mechanically wrong w/ well?

<u>Calderón</u> -
- Marinelli's worry about well spacing. Why are we designing wells so close
- proposal to go deeper than old to drill one less well. If it can be shown that 1 deeper well is better than 2 shallower, OK. But he feels there is no demonstration that deeper drilling would be better. But if deeper drilling is indicated on basis of geology, etc., we should go deeper.
- But he is worried about rig specs being a limiting case. Cald wants Fraser to review rig specs that are out.
- we have to do <u>best</u> w/ $, that's <u>all</u>.

Calderon - doesn't like well strategy decision tree - exp if #1 poor → 2A, if med → 2B, if good → 2A.

Tobias - how are we going to prevent damage to the upper producing zone while trying to get prod in granodiorite?

Mick - Deviate at 5000, build angle w/ light mud -- turbo drill may work on water. Run after x build, use water. We will be casing water from ~~sho~~ upper prod zone.

Tobias - all you'll know is combined effect of shallow + deep. He suggests test upper zone before drilling deeper.

Mick - It could be done, but would be extra cost.

Calderon - reinjection req is not clearly established. We propose #2, but yet want to inject everything. So we may need more capacity. ~~Also~~ So Suber's work must establish this better. Wants further analyses.

~~Zea~~ +

Mick - Also looks like candidate for injection its in outflow, deep, should take large quantity of fluid, could possibly affect Zea 3.

pmu — Copy of Direct Use Handbook for Gustavo Calderón

Future Activities
- Reservoir modeling
- Bid Docs for wells
- Critique of work to Date.

Calderón said that INDE is a group that has to be sat on, unlike their Costa Rica experience. In Costa Rica, they agree on work and it is done -- no need to look over their shoulder.

Calderón asks what more geotech work needs to be done. And how about modeling.

Mike - need to drill. We can pick drill targets from info at hand, and do not ~~want~~ need to continue geol, geoph or geochem.

Calderón asks when can we have model and drill specs.

Calderón wants to be sure FORTRAN code of model is delivered and that INDE will be trained to use it.

when will first simulation be done --

Caicedo → wants to separate drilling procurement and modeling so that drilling can proceed.
Drilling bids would be received 29 Sept -- then evaluation time and negotiations completed up around by Mar 90. Modeling would have to be done by end year, Mar at latest.

Luis - wants to clarify parameters of model that is expected. Feels need may come to negotiate w/ Caicedo re what is in contract, what is not.

Pablo - feels the first application of model should be to get quantitative estimate of interference. This is important. It's almost a coincidence that same model will be used for field management.

Caicedo - feels modeling is in present scope -- we want model twice or 2 fields modeled. He would like consultants to give a clear ~~[illegible]~~ description of modeling to avoid unnecessary expenses later on.

Calderón - re firms prequalified drilling firms - he got bid docs only yesterday. He's concerned about tech specs of bid docs.
- Drill specs are for a rig to drill to 2000 m vertical wells. Nothing specified re tech aspects

esp drilling deviations. Only a small clause to suggest non-vert drilling.
Use wants a technical addendum to bid docs to give heads-up on tech aspects.

Caicedo - This is reasonable. Bid docs were prepared by INDE, but reviewed by UK. So he wants to ask UK to include a drilling tech addendum. —

Calderón - Agrees.

Cars - This thin doc. The closed door is 2000 m limit. Decision was to go to 2000m.

Caicedo. If we decide to leave depth open, cost will go up because rig capacity must be more.

Tomas. Normally we would ask for a rig w/ double the capacity of anticipated needs.

Calderón - wants opinion from panel.

40 Caicedo - doc. UK has reviewed specs.

Calderon. – Feels ad. Isadan is very important – must be done (ASAP)^2.

Tobias. Date of tech ad. Isadan. Luis – Monday –

Calderon – Delays have damaged Guatemala. But process over which we have control are in design. First, power cycle must be acceptable to all of us. Last year, MK's plant design.

For a small plant like this one, maybe we could shortcut by only doing a conceptual design for bid offerings for a detailed design, opening possib. for bids more econ feasible.

Caicedo. Cald's alternative way be more effecid.

Defyyo feels Cald's idea is a good one. – Can shorten design process.

Mich. Feels new data makes it possib to choose a power cycle w/ less risk now –

Cald. – MK's idea is that MK does final design. He feels that MK may do just conceptual design and let power plant people do detailed design. This would save time.

DePippo - choice will be single or double flash. Gustavo wants economic analysis, so we would ~~take~~ need bids on components. ~~Gustavo wants~~

DiPippo -

Paulo - few equip manufacturers have gt experience. But optimization is very important. Thus he does not agree manufacts can or are qualified to offer a better cycle. Feels we should do design (WK) -

Caicedo - Their experience is that consulting Co presents detailed design. Now we propose this be taken away. This may give us unpleasant surprises. However, prequalify of cos will sort out those cos that have no gt experience.
- Caic wants from panel a clear understanding of scope for WK.

Cold - much esting of selection of power cycle, and is important date for next meeting.

Caicedo - maybe not whole panel next time, just experts on panel

Cold. - He doesn't agree. Wants entire panel.

Caic. → each panel meeting costs Q250K. If its essential, take it into account.

5 people, 5 days $

$300 × 25	= 7500	salaries
100 × 25	= 2500	per diem
800 × 2	= 1600	air
2000 × 3	= 6000	air
	$17,600	

Delfipo – lets stick to agreed meeting dates

Caicedo – Agrees, only received data from consultants recently etc.

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GUATEMALA

A GEOTHERMAL INTERNATIONAL SERIES

Sponsored by:

U.S. DEPARTMENT OF ENERGY
GEOTHERMAL TECHNOLOGY DIVISION (GTD)

Prepared for:

LOS ALAMOS NATIONAL LABORATORY
Under Contract No. 9-X36-3652C

Prepared by:

MERIDIAN CORPORATION
4300 King Street, Suite 400
Alexandria, Virginia 22302-1508
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FOCUS ON

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PREFACE

The ***Focus on*** Series is prepared to give the U.S. Geothermal Industry a quick profile of several foreign countries. The countries depicted were chosen for both their promising geothermal resources and for their various stages of geothermal development, which can translate into opportunities for the U.S. geothermal industry. The series presents condensed statistics and information regarding each country's population, economic growth and energy balance with special emphasis on the country's geothermal resources, stage of geothermal development and most recent activities or key players in geothermal development. The series also offers an extensive list of references and key contacts, both in the U.S. and in the target country, which can be used to obtain detailed information.

The series is available for the following countries:
Argentina, Azores (Portugal), China, Costa Rica, Ecuador, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Jordan, Mexico, St. Lucia, Thailand.

Additional countries might be available in the future.

The series is to be used in conjunction with four other publications specifically designed to assist the U.S. geothermal industry in identifying and taking advantage of geothermal activities and opportunities abroad, namely:

- The *"Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities."* Final Report, August 1987. Prepared for Los Alamos National Laboratory.

- The *"Summary Report"* of the above publication.

- *"Equipment and Services for Worldwide Applications,"* U.S. Department of Energy.

- The *"Listing of U.S. Companies that Supply Goods and Services for Geothermal Explorers, Developers and Producers Internationally,"* August 1987, prepared by GRC.

Copies of these publications can be obtained from the Geothermal Technology Division of the U.S. Department of Energy. Correspondence should be addressed to:

Dr. John E. Mock
Geothermal Technology Division (GTD)
1000 Independence Avenue
U.S. Department of Energy
Washington, DC 20585
(202) 586-5340

NOTE

Data presented in this document are based on several U.S. government official publications as well as international organizations, namely:

- Background Notes (U.S. Department of State)
- Foreign Economic Trends (U.S. Department of Commerce)
- World Development Report 1987 (World Bank)
- International Data Base for the U.S. Renewable Energy Industry, May 1986 (U.S. Department of Energy)

The country's geothermal resources write-up is a revision and update of the Appendix in the "Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities." LANL, August 1987.

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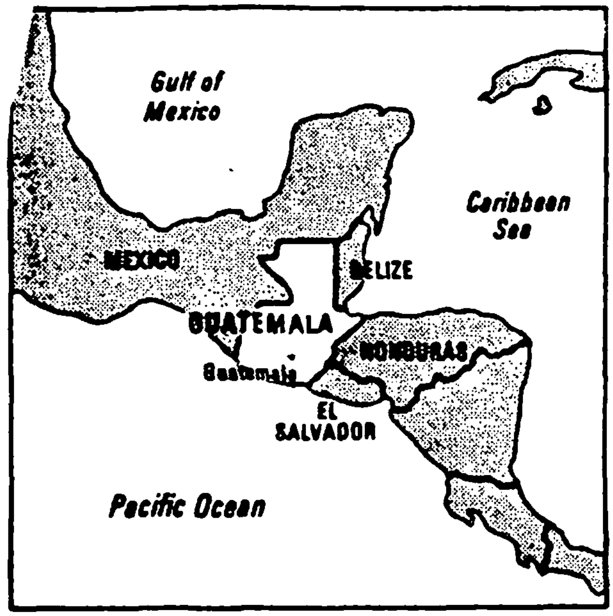
FOCUS ON GUATEMALA



Official Name: Republic of Guatemala

Area: 108,780 sq. km. (42,000 sq. mi.)

Capital: Guatemala

Population (1985): 8.0 million

Population Growth Rate: 3.1%

Languages: Spanish, 23 Indian languages

Economic Indicators:

Real GDP (1985): $8.9 billion
Real Annual Growth Rate (1985): -1.1%
Per Capita Income (1985): $1,000
Avg. Inflation Rate (1986): 18.7% change from 1980 base year

Trade and Balance of Payments:

(1985) Exports: $1.0 billion; Major Markets: U.S., Central America Common Market (CACM), FRG, Japan
(1985) Imports: $1.1 billion; Major Suppliers: U.S., Japan, CACM, FRG, Venezuela
Official Exchange Rate: 1 quetzal = US $1
2.5 quetzales = US $1 (controlled export/import rate)
2.62 quetzales = US $1 (parallel interbank rate)

Energy Profile: (Based on 1982 data)

- Commercial Fuel Energy Consumption:

  Total: 1.237 million ton of oil equivalent (mtoe)
  1-Yr. Growth: -2.9%

- Commercial Fuel Breakdown:

  Liquid Fuels Pct: 95%
  Solid Fuel Pct: *
  Natural Gas Pct: *
  Electric Pct: 5%
  Commercial Fuel Consumption Growth Rate (1970-1980): 5.9%

* Negligible

- Electricity Generation Capacity:

  (1982) Total Installed Elec. Capacity: 606 MW
  Hydro: 23%
  Hydro Potential: 5,426 MW
  Steam: 39%
  Gas Turbine: 30%
  Diesel: 8%
  Other: *

- Electricity Sales:

  Total: 1236 GWh
  Residential: 25%
  Commercial: 19%
  Industrial: 42%
  Government: 14%
  Other: *
  Average Electric Price: 13.40 US cents/kWh

- Geothermal Power Generation:

  Reservoir Potential (MW): No figures available
  Temperature Range: Low-medium enthalpy in general, 287°C at Zunil

- Geographic Locations: Southern region

- Development Status: Prefeasibility studies and preliminary resource assessment, no on-line power generation.

- Countries Actively Involved: U.S., Japan

- General Need for Assistance: Feasibility studies, further deep exploratory drilling, well testing, reservoir modelling

- International Funding: $58 million (IDB)

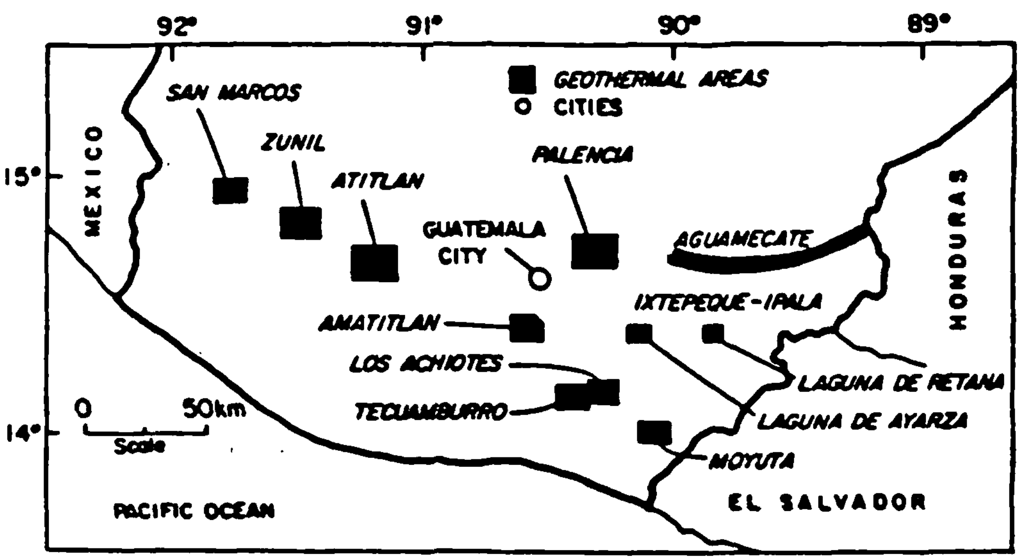
* Negligible

GEOTHERMAL RESOURCES

The southern part of Guatemala lies along the Middle Trench in a volcanically active area. Numerous hot springs area also present within the high-temperature geothermal prospects of Guatemala.

Geothermal exploration began in Guatemala during 1972. Initial studies were performed at the Moyuta and Zunil geothermal fields. The volcanic belt that hosts the geothermal areas lies in a convex strip nearly 40 km wide and containing 35 volcanoes (three of which are active). Volcanic activity has continued from the Tertiary to the present, as early fissure eruptions and lateral flows were later covered by composite volcanoes.

The Zunil geothermal field is located 120 miles northwest of Guatemala City in western Guatemala's volcanic province, near the Cerro Quemado and Volcan Santa Maria volcanoes. Preliminary exploration at Zunil began in 1973 and continued through 1977. Technical assistance was provided by the government of Japan through geophysical studies. Deep drilling began in 1977 by the National Electrification Institute (INDE) as a prelude to a power plant feasibility study. The drilling program was successful in discovering a high-temperature (287°C) reservoir encountered at 1,130 m. A total of six exploratory wells were drilled, with five eventually producing steam in commercial quantities. IDB is funding a $58 million project for the development of the Zunil geothermal site, which includes the installation of a



Geothermal areas in Guatemala

Source: R. DiPippo, 1986, "Geothermal Energy Development in Central America."

15-MW power plant. Estimates of 50 MW or more of geothermal electricity potential at Zunil are still uncertain. Meanwhile, a 15 MW demonstration plant is planned for construction. In a joint effort, Los Alamos National Laboratory (LANL), the Guatemalan Ministry of Energy and Mines (MEM), and INDE, are investigating the use of low- and medium-enthalpy geothermal heat for industrial and agricultural processes. An agricultural processing center that will use geothermal energy is under construction near Zunil. It is hoped that this demonstration plant will prove successful and would lead to the building of a commercial plant.

The geothermal reservoir is contained within a conglomeratic unit overlying a Cretaceous granodiorite basement, which in turn is overlain by Tertiary volcanic rocks. Fluids are thought to migrate "up-dip" (eastward) within the conglomerate unit and into the thermal area. Fractures within the basement granodiorite may also contribute to fluid movement. Production testing has shown that a rapid phase change from liquid to vapor (steam) occurs in the wellbores upon drawdown of formation fluids.

The Moyuta geothermal field was the first geothermal area to be explored in Guatemala. Geological, geochemical, and geophysical prospecting were performed in 1972. After surface studies were completed, two exploratory wells were drilled to a depth of 1000 m each. Maximum temperature reversals were observed below that point. Exploration at Moyuta was terminated after completion of exploratory drilling.

The Amatitlan geothermal field is located within the volcanic belt of south-central Guatemala. Preliminary surface geoscience investigations have shown that high-temperature resources may be present at depth. Geothermometers applied to fluid chemistry data have indicated a possible reservoir temperature of 280^{o}C. Shallow thermal gradient drilling has revealed a temperature of 140^{o}C at a depth of 80 m within the field. Further deep exploratory drilling by INDE was to have been performed at Amatitlan upon release of drilling equipment from the Zunil field. Preliminary estimates of geothermal electric generation is around 100 MW.

The Las Majades-Cerro Quemado area, adjacent to Zunil I, has been selected for exploratory drilling, but further prefeasibility work is necessary before a precise drilling location can be chosen.

Other geothermal areas in Guatemala have been assessed in a preliminary manner. Surface geologic mapping and geochemistry has been performed by INDE in the areas of Atitlan, Palencia, Tecuamburro, Los Achiotes, Laguna de Ayarza, and Laguna de Retana.

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LANL, 1987, The Energy Situation in Five Central American Countries, Central American Energy and Resource Project. (LA-10988-MS) June 1987, pp. 200-203.

REFERENCES

AND

KEY CONTACTS

A. Business Climate Sources of Information

The following references are suggested for timely information on the business climate in Guatemala.

U.S. GOVERNMENT PUBLICATIONS

U.S. Department of Commerce

- Foreign Economic Trends (FET) and their Implications for the U.S.
- Overseas Business Reports (OBR)

U.S. Department of State

- Background Notes

NON-GOVERNMENT PUBLICATIONS

- International Series, published by Ernst and Whinney
- Businessman's Guide to......., published by Price Waterhouse and Co.
- Information Guide: Doing Business in ......, published by Price Waterhouse and Co.
- Task and Trade Guide, published by Arthur Andersen
- Task and Investment Profile, published by Touche Ross and Co.

B. Geothermal-Related Sources of Information

The following reports and documents are suggested for further information regarding geothermal energy and export opportunities overseas:

Los Alamos National Laboratory:

- Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities

U.S. Department of Energy

- Equipment and Services for Worldwide Applications
- Guide to the International Development and Funding Institutions for the U.S. Renewable Energy Industry
- Federal Export Assistance Programs Applicable to the U.S. Renewable Energy Industry
- International Data Base for the U.S. Renewable Energy Industry
- Committee on Renewable Energy Commerce and Trade: CORECT's Second Year - October 1985-November 1986

California Energy Commission (CEC)

- Foreign Geothermal Energy Market Analysis
- Small Scale Electric Systems Using Geothermal Energy: A Guide to Development

U.S. Department of Commerce - International Trade Administration

- A Competitive Assessment of the U.S. Renewable Energy Equipment Industry

U.S. Export Council for Renewable Energy

- International Renewable Energy Industry Trade Policy

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- DOC Marketing Periodicals

  Superintendent of Documents
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Economic Section

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FAX: 586-6123

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17. GEOTHERMAL ACTIVITIES

- Everything associated with geothermal operations is governed by the law on geothermal activities (Decree-Law 126-85). This law is a public-order law: it ranks higher in hierarchy than ordinary laws. For contracts signed with the State in this sector, the State Contracts Law is not applicable either.

- Geothermal energy is the thermal energy which is found beneath the surface of the earth.

- Geothermal operations are operations carried out for the purpose of exploring, developing, extracting separating, compressing, processing, transporting and marketing geothermal energy, gases or other associated substances.

- The geothermal reservoirs found in the country, its continental shelf and its Exclusive Economic Zone are the property of the nation.

- All the information, data compilation which originates from geothermal operations, contracts, permits and execution are also the property of the nation

- Geothermal operations may be carried out by the State, through the Ministry of Energy and Mines or the National Electrification Institute (INDE) or by any person: individual or legal, Guatemalan or alien. Guatemalans and aliens enjoy equal conditions.

- Anyone who carries out geothermal operations is subject exclusively to the laws of the Republic of Guatemala. Aliens may not resort to diplomatic protection for the application, interpretation, execution and termination, for any reason, of the permit or contract, whatever the case may be.

- Competent authority: The New and Renewable Energy Sources Service, an agency of the Ministry of Energy and Mines, is the agency in charge of controlling, supervising and setting up minimum safety conditions in geothermal operations.

- Contracts: The law provides for the following types of contracts:

  i. Association and/or participation contract: Entered into between the Government and individual(s) to jointly carry out geothermal operations in the country. The State and the contractor assume the risks outlined in the contract.

  ii. Operations contract: Entered into between the government and contractors for them to carry out geothermal operations in the country.

iii. Service contract: Entered into between government contractor and a service contractor for the latter to do work which is specifically and directly related to geothermal operations.

iv. Service subcontract: Entered into between a service contractor and a service subcontractor for the latter to do specific work directly related to geothermal operations.

- Permits: The State can grant surface reconnaissance permits for preliminary exploration activities, carried out for the purpose of obtaining geochemical, geological, geophysical, hydrogeological or other types of information. These permits have a maximum duration of one year which can be extended for another period of equal time and do not award exclusive or priority rights to one of the above-mentioned contracts.

- Negotiations which are carried out under the protection of the geothermal law are not subject to the Procurement and Contract Law and can be carried out in two ways:

i. Through official bidding; or
ii. by direct negotiation.

-Contracts do not grant property rights or concessions, and rights acquired through them can be transferred to third parties with Ministry of Energy and Mines authorization.

-A typical contract should contain at least the following provisions:

i.* Royalties of not less than 5% on the geothermal energy produced. Those royalties can be paid in cash or in kind, whatever the Government chooses;

ii.* The percentage of the production which belongs to the State;

iii. The term of the contract and its maximum duration in the case of extension. In general, the maximum term for contracts is 25 years, by law;

iv.* Exploration and extraction periods, their phases and terms. For the exploration period, the minimum amount of work and guarantees required;

v.* When applicable (this is optional), the way in which the contractor will recover his investment in exploration and development, as well as operation costs. If this is agreed on, recovery is subject to there being enough production in the reservoirs;

vi. If electric energy is generated, the contractor's obligation to sell it to INDE, unless there is an agreement to the contrary;

vii. The contractor's obligation to implement appropriate control measures to avoid environmental pollution;

viii Customs, construction and other mechanisms which must be streamlined for contract terms to be met;

ix. The contractor's obligation to carry out his work programs using annual budgets previously approved by the Ministry of Energy.

* Not applicable to service contracts.

- Contracts stipulate in every contract that in case of litigation relative to its application, interpretation, execution and termination, for any cause, the holders and their partners waive the jurisdiction of their domicile and submit to the Contentious-Administrative court.

- The contracts provide that the holder will contribute the as stipulated in the contract for training programs and scholarships to train Guatemalan personnel. That contribution is, 1% according to the law, but it does not say 1% of what.

Taxes: the holders must pay all general taxes, save for exemptions in their favor for the import of the necessary materials which cannot be obtained in Guatemala of the same or better quality and in the same or greater amounts.[10]

- In addition, the holders must pay the following specific rates:

i. Contract signature fee: a minimum 0.5% of the budget for the exploration period;

ii. Surface tax: this is established in the contract. It is annual and paid by the square kilometer;

10 See note number 7.

iii. Rate for the transfer of rights: the party transferring the rights shall pay a tax equal to the one paid for the signature of the contract.

- In conclusion, the holders must pay general taxes, royalties and specific rates.

- When contracts are terminated for any cause, permanent works and facilities, and those the removal of which could cause damage or threaten the safety of the reservoir will be transferred to the State at no cost and with no liens or limitations.

- Persons wishing to sign contract for geothermal operations must previously register at the Registration Department of the Ministry of Energy and Mines.

- The State may establish national reserve areas where only the State can use geothermal resources.

- Geothermal energy, a new and renewable source of energy, is included in the law for the promotion and development of new and renewable energy sources (Decree-Law 20-86) and enjoys all the incentives of that law.

18. NEW AND RENEWABLE SOURCES OF ENERGY

- The Law for the Promotion of the Development of New and Renewable Sources of Energy (Decree-Law 20-86) was created to promote new and renewable sources of energy.

- This law is applicable to any person, Guatemalan or alien, interested in carrying out projects for new and renewable energy source.

- New and renewable sources of energy include solar radiation, wind, the tides, water, geothermal energy, biomass and any other source of energy which is not nuclear or produced by hydrocarbons or their by-products.

- Projects for new and renewable energy source to which this law is applicable are those involving one or more of the following fields: research, experimentation, education, training, promotion, information, production, the manufacture of specific equipment and for the utilization of new and renewable sources of energy and marketing of the products obtained from these activities.

-Incentives: The law contemplates two types of incentives:

i. Fiscal:[11]

a. Duty-free import, of consumable materials, machinery, equipment, spare parts and accessories which cannot be found in Guatemala of the same quality or in the same amounts;[12]

b. Temporary suspension of Customs duties on foreign machinery, equipment and accessories to be used in the projects;

c. Deduction of up to 100% of income tax from the value of the investment, in the case of persons who live in the country;

---

11 Formerly, fiscal privileges included a zero rate in the Added Value Tax (VAT). However, the VAT law currently in force (Decree 27-92 eliminated the zero rate, for which reason the Promotion Law would be in contradiction with a more recent law, nd therefore that privilege became tacitly repealed.

12 This Customs duty exemption was expressly left in force in Article 9 of Decree 52-92 of Congress.

d. 100% income tax deduction from the amount of the donations made for new and renewable energy source projects.

ii. Non-fiscal:

The Bank of Guatemala has a credit line to finance this type of project. Projects must qualify before the loans are granted and the projects will only be financed if their main objectives are the following:

a. The reduction of national hydrocarbon consumption;

b. Supplying energy to rural areas;

c. Improving the people's quality of life;

d. The rational utilization of natural resources.

-The New and Renewable Energy Source Service, an agency of the Ministry of Energy and Mines is in charge of enforcing this law.

5/31/94
Guatemala

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RUKGNHA/FAA WASHDC//ACS-400//
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RUKGNFA/NRC WASH DC//INFOSEC//
RUEANAT/NASA HQ WASH DC //CODE NIS JVERBA//
RUCJACC/USCINCCENT MACDIL AFB FL//CCJ2-JIT
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RULSJGA/COGARD INTELCOORDCEN WASHINGTON DC
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SUBJECT: GUATEMALA - WARNING
EZ05:

1. THE UNITED STATES DEPARTMENT OF STATE WARNS ALL U.S. CITIZENS TO DEFER NON-ESSENTIAL TRAVEL TO GUATEMALA AT THIS TIME. WIDESPREAD UNFOUNDED RUMORS THAT FOREIGNERS ARE INVOLVED IN THE THEFT OF CHILDREN FOR THE PURPOSE OF USING THEIR ORGANS IN TRANSPLANTS HAVE LED TO THREATS AND INCIDENTS OF VIOLENT MOB ACTION AGAINST U.S. CITIZENS IN WIDELY SEPARATED PARTS OF THE COUNTRY. WE URGE THAT U.S. CITIZENS WHO REMAIN IN GUATEMALA AVOID CROWDS, AVOID TRAVELLING ALONE, AND EXERCISE UTMOST CAUTION. U.S. CITIZENS IN GUATEMALA ARE URGED TO REGISTER WITH THE U.S. EMBASSY IN GUATEMALA CITY WHERE FURTHER SECURITY-RELATED

INFORMATION CAN BE OBTAINED. FOR ADDITIONAL INFORMATION
SEE THE CONSULAR INFORMATION SHEET.

2. MINIMIZE CONSIDERED. CHRISTOPHER
BT
#3654

NNNN

FOR: DOFLECA

ROUTINE -- UNCLASSIFIED -- DSSCS MESSAGE -- 17912 CHARACTERS
VZCZCMSS8898
ACTION = DOE,DOE AN1(2),CMS(1),EP(4)
DOE,OIN IDD(-),EETID(-)
INFO = ** UNASSIGNED **
MLN = 37458 DAN = 401-030171
RR RHEBDOE
DE RUEHC #7613 1621842
ZNR UUUUU ZZH ZEX
EZ02:
R 111838Z JUN 93
FM SECSTATE WASHDC
TO ALL DIPLOMATIC AND CONSULAR POSTS
RUEATRS/TREASURY DEPT 0000
RUEHPH/CDC ATLANTA 0000
RUCPDIR/ALL USDOC DISTDIR
RUKLDAR/U.S. ARMY MATERIEL COMMAND ALEX. VA.//AMCMI-SS//
RUWDOAA/NAVOCEANSYSCEN SAN DIEGO CA JAMES C. SHIELDS
RUEAHQA/HQ USAF WASH DC//XOXXI//
RUEABOA/BOLLING AFB DC//IVOA//
RUCNJVW/AL INOCCO 8105721076 USDOE OKRE
RUKGNHA/FAA WASHDC//ACS-400//
RULSNAA/COMNAVAIRSYSCOM WASH DC//AIR1031B//
RUKGNFA/NRC WASH DC//INFOSEC//
RUEANAT/NASA HQ WASH DC //CODE NIS JVERBA//
RUCJACC/USCINCCENT MACDIL AFB FL//CCJ2-JIT
RULSJGA/COGUARD INTELCOORDCEN WASHDC
RUCPCIM/CIMS NTDB WASHDC
INFO RUESTG/ATO GUAM 0000
BT
UNCLAS STATE 177613

INFORM CONSULS
E.O. 12356: N/A
TAGS: CASC, ASEC,
SUBJECT: CONSULAR INFORMATION SHEET - GUATEMALA
EZ05:

1. COUNTRY DESCRIPTION: GUATEMALA HAS A DEVELOPING ECONOMY AND A DEMOCRATIC GOVERNMENT. DEMOCRACY AND CONSTITUTIONAL RULE WERE SUSPENDED FOR A SHORT TIME IN LATE MAY 1993, BUT WERE QUICKLY RESTORED. EXCEPT FOR LUXURY HOTELS IN GUATEMALA CITY, PANAJACHEL, CHICHICASTENANGO AND FLORES (TIKAL), TOURIST FACILITIES ARE NOT FULLY DEVELOPED. ROAD CONDITIONS THROUGHOUT THE COUNTRY ARE POOR

2. ENTRY REQUIREMENTS: TO TRAVEL TO GUATEMALA U.S. CITIZENS MUST HAVE A PASSPORT AND EITHER A VISA OR A TOURIST CARD. U.S. CITIZENS MUST CARRY IDENTIFICATION WITH THEM AT ALL TIMES. VISAS ARE AVAILABLE FROM THE EMBASSY OF GUATEMALA AT 2220 R STREET, N.W., WASHINGTON, D.C. 20008,

WORKING PAPERS

TEL: (202) 745-4952, OR GUATEMALAN CONSULATES IN LOS ANGELES, SAN FRANCISCO, MIAMI, NEW ORLEANS, NEW YORK, HOUSTON OR CHICAGO. TOURIST CARDS CAN BE PURCHASED UPON ARRIVAL AT THE AIRPORT OR GUATEMALAN BORDER, OR AT THE AIRPORT DEPARTURE GATE FOR FLIGHTS FROM THE U.S. TO GUATEMALA.

THE GOVERNMENT OF GUATEMALA REQUIRES ALL U.S. CITIZENS, WITHOUT EXCEPTION, TO HAVE A VALID PASSPORT IN ORDER TO DEPART GUATEMALA. U.S. CITIZENS WHOSE PASSPORTS ARE LOST OR STOLEN IN GUATEMALA MUST OBTAIN A NEW PASSPORT AND PRESENT IT TOGETHER WITH A POLICE REPORT OF THE LOSS OR THEFT TO THE MAIN IMMIGRATION OFFICE IN GUATEMALA CITY TO OBTAIN PERMISSION TO DEPART GUATEMALA.

3. AREAS OF INSTABILITY: ALTHOUGH NEGOTIATIONS ARE CONTINUING BETWEEN THE GOVERNMENT OF GUATEMALA AND GUERRILLA LEADERS TO END A 32 YEAR ARMED CONFLICT, THERE ARE STILL OCCASIONAL ENCOUNTERS BETWEEN GUATEMALAN ARMY AND GUERRILLA FORCES IN THE DEPARTMENTS OF EL QUICHE, ALTA VERAPAZ, HUEHUETENANGO, SAN MARCOS, PETEN, ESCUINTLA, SUCHITEPEQUEZ, SANTA ROSA AND SACATEPEQUEZ. THERE ARE OCCASIONAL GUERRILLA ROADBLOCKS ON THE ROADS BETWEEN GUATEMALA CITY AND THE BORDER OF EL SALVADOR, AS WELL AS ALONG THE PACIFIC COAST. HOWEVER, VISITORS TO MAJOR TOURIST DESTINATIONS RARELY COME INTO CONTACT WITH GUERRILLA OR MILITARY FORCES.

4. MEDICAL FACILITIES: A FULL RANGE OF MODERN MEDICAL CARE IS AVAILABLE IN GUATEMALA CITY, BUT MEDICAL CARE OUTSIDE THE CITY IS LIMITED. CHOLERA IS PRESENT IN GUATEMALA. DOCTORS AND HOSPITALS OFTEN EXPECT IMMEDIATE CASH PAYMENT FOR HEALTH SERVICES. U.S. MEDICAL INSURANCE IS NOT ALWAYS VALID OUTSIDE THE UNITED STATES. TRAVELERS OFTEN FIND THAT SUPPLEMENTARY MEDICAL INSURANCE WITH SPECIFIC OVERSEAS COVERAGE IS USEFUL. ADDITIONAL HEALTH INFORMATION MAY BE OBTAINED FROM THE CENTERS FOR DISEASE CONTROL'S INTERNATIONAL TRAVELERS HOTLINE AT (404) 332-4559.

5. CRIME INFORMATION: VIOLENT CRIME IS A SERIOUS AND GROWING PROBLEM THROUGHOUT THE COUNTRY. CRIME VICTIMS HAVE SOMETIMES COMPLAINED OF INADEQUATE ASSISTANCE FROM THE POLICE. VISITORS WHO SUFFER CRIMINAL ASSAULTS ARE ENCOURAGED TO CONTACT THE CONSULAR SECTION OF THE U.S. EMBASSY (OR THE DUTY OFFICER AFTER HOURS) FOR ADVICE AND ASSISTANCE.

PICKPOCKETS AND PURSE SNATCHERS ARE PREVALENT IN GUATEMALA CITY, ESPECIALLY IN THE CENTRAL MARKET AREA. ARMED CAR THEFT IS ALSO A SERIOUS PROBLEM; PERSONS WHO

OFFER NO RESISTANCE WHEN CONFRONTED BY CAR THIEVES ARE

USUALLY NOT HURT. THERE ARE OCCASIONAL ARMED ROBBERIES ON CITY BUSES. THE COLONIAL CITY OF ANTIGUA, LOCATED ABOUT 30 MILES FROM GUATEMALA CITY, IS GENERALLY CONSIDERED SAFE AND IS A POPULAR DESTINATION FOR TOURISTS AND STUDENTS WHO ATTEND ANTIGUA'S MANY SPANISH SCHOOLS. THE ESTABLISHMENT OF SPECIAL TOURIST POLICE IN ANTIGUA HAS RESULTED IN A DECREASE IN CRIME AGAINST VISITORS, PARTICULARLY IN THE CITY CENTER. PERSONS WALKING, JOGGING OR BIKING ON ROADS LEADING OUT OF ANTIGUA OR TO CERRO DE LA CRUZ PARK RISK THE POSSIBILITY OF ATTACK ON DESERTED STRETCHES OF ROAD.

THE TOWNS OF PANAJACHEL (ON LAKE ATITLAN) AND CHICHICASTENANGO (SITE OF A POPULAR INDIAN MARKET) ARE GENERALLY SAFE, BUT PICKPOCKETS ARE PREVALENT IN THE MARKETS. TRAVEL BY BOAT FROM PANAJACHEL TO SANTIAGO ATITLAN AND OTHER TOWNS AROUND LAKE ATITLAN IS DANGEROUS IN THE LATE AFTERNOON BECAUSE OF FREQUENT BAD WEATHER CONDITIONS ON THE LAKE. IT IS DANGEROUS TO CLIMB GUATEMALA'S VOLCANOES, ESPECIALLY PACAYA. TWO AMERICANS DIED ON PACAYA IN 1991, AND MANY TOURISTS, INCLUDING THOSE TRAVELING IN LARGE GROUPS, WERE THE SUBJECT OF VIOLENT ARMED ROBBERIES. SEVERAL FEMALE TOURISTS WERE ALSO RAPED.

THE MAYAN RUINS AT TIKAL AND THE NEARBY CITY OF FLORES (CAPITAL OF THE PETEN DEPARTMENT) ARE GENERALLY SAFE PROVIDED THAT VISITORS FLY TO FLORES AND THEN TRAVEL BY BUS OR TOUR VAN TO THE RUINS. ROAD TRAVEL IN THE REST OF PETEN DEPARTMENT IS DIFFICULT. ROAD CONDITIONS ARE POOR, TELEPHONES, POLICE AND MEDICAL ASSISTANCE ARE USUALLY UNAVAILABLE, AND HIGHWAY BANDITS ARE OFTEN ACTIVE, PARTICULARLY ON THE ROAD BETWEEN TIKAL AND THE GUATEMALA-BELIZE BORDER AT MELCHOR DE MENCOS.

THE LOSS OR THEFT OF A U.S. PASSPORT SHOULD BE REPORTED IMMEDIATELY TO THE LOCAL POLICE AND THE NEAREST U.S. EMBASSY OR CONSULATE. USEFUL INFORMATION ON GUARDING VALUABLES AND PROTECTING PERSONAL SECURITY WHILE TRAVELING ABROAD IS PROVIDED IN THE DEPARTMENT OF STATE PAMPHLET, "A SAFE TRIP ABROAD." THIS PUBLICATION, AS WELL AS OTHERS, SUCH AS "TIPS FOR TRAVELERS TO CENTRAL AND SOUTH AMERICA", ARE AVAILABLE FROM THE SUPERINTENDENTOF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON D.C. 20402.

6. HIGHWAY TRAVEL: INTERCITY TRAVEL AFTER SUNSET (6;00 P.M.) ANYWHERE IN GUATEMALA IS EXTREMELY DANGEROUS. EVEN IN DAYLIGHT HOURS, THERE ARE OCCASIONAL INCIDENTS IN

WHICH ENTIRE BUSLOADS OF PASSENGERS ARE ROBBED OF ALL THEIR BELONGINGS, EITHER BY ARMED THIEVES WHO SET UP ROADBLOCKS OR BY THIEVES WHO POSE AS BUS PASSENGERS. ASSAILANTS ALSO SOMETIMES FORCE A CAR OFF THE ROAD OR STOP IN THE MIDDLE OF THE HIGHWAY IN FRONT OF THE INTENDED VICTIMS' CAR. LARGE CAPACITY RENTED VEHICLES AND TRAVEL AGENCY VANS ARE FREQUENT TARGETS OF HIGHWAY BANDITS. IF CONFRONTED BY ARMED BANDITS, THOSE WHO ACCEDE TO ALL REQUESTS WITHOUT ARGUING ARE USUALLY NOT PHYSICALLY HARMED.

WHEN DRIVING FROM GUATEMALA CITY TO LAKE ATITLAN AND CHICHICASTENANGO, THE SAFEST ROUTE IS THE PAN-AMERICAN HIGHWAY (CA-1) THROUGH CHIMALTENANGO AND TECPAN TO THE CROSSROADS AT LOS ENCUENTROS AND THEN EITHER CA-1 TO SOLOLA AND PANAJACHEL OR CA-15 TO CHICHICASTENANGO. TRAVEL TO LAKE ATITLAN ON ANY OTHER ROAD IS DANGEROUS. AN AMERICAN TOURIST WAS KILLED BY A GUNMAN NEAR GODINEZ IN JANUARY 1992.

WHEN ENTERING GUATEMALA BY CAR FROM MEXICO, MOST TRAVELERS USE BORDER CROSSINGS AT EITHER TECUN UMAN (HIGHWAY CA-2) ON THE PACIFIC COAST OR LA MESILLA (HIGHWAY CA-1) IN THE HIGHLANDS. WHEN TRAVELING FROM EL SALVADOR, THE BORDER CROSSING AT LAS CHINAMAS, EL SALVADOR/VALLE NUEVO, GUATEMALA IS PREFERRED. WHEN ENTERING GUATEMALA FROM HONDURAS, THE BORDER CROSSINGS ARE AT EITHER EL FLORIDO OR AGUA CALIENTE. WITH ALL CROSS-BORDER TRAVEL, TRAVELLERS NEED PLENTY OF TIME TO COMPLETE BORDER CROSSING FORMALITIES, WHICH CAN BE LENGTHY, IN ORDER TO TRAVEL TO A MAJOR TOWN BEFORE DARK.

7. DRUG PENALTIES: U.S. CITIZENS ARE SUBJECT TO THE LAWS OF THE COUNTRY IN WHICH THEY ARE TRAVELING. A NEW, TOUGHER ANTI-NARCOTICS TRAFFICKING LAW TOOK EFFECT IN GUATEMALA IN LATE 1992, AND PENALTIES FOR POSSESSION, USE OR TRAFFICKING IN ILLEGAL DRUGS WERE INCREASED. THOSE ARRESTED ON DRUG CHARGES CAN EXPECT TO SPEND SEVERAL MONTHS IN JAIL BEFORE THEIR CASE IS DECIDED, AND CONVICTED OFFENDERS CAN EXPECT LENGTHY JAIL SENTENCES AND FINES.

8. OTHER INFORMATION: UPDATED INFORMATION ON GUATEMALAN ADOPTION PROCEDURES AND THE U.S. IMMIGRANT VISA APPLICATION PROCESS IS AVAILABLE FROM THE CONSULAR SECTION OF THE U.S. EMBASSY. PROSPECTIVE ADOPTIVE PARENTS ARE ASKED TO CHECK WITH THE CONSULAR SECTION TO BE SURE THAT THEIR CHILD'S ADOPTION IS COMPLETE BEFORE TRAVELING TO GUATEMALA TO APPLY FOR THEIR CHILD'S IMMIGRANT VISA. ADDITIONAL INFORMATION IS AVAILABLE FROM THE OFFICE OF CITIZENS CONSULAR SERVICES, CA/OCS/CCS,

ROOM 4817, DEPARTMENT OF STATE, WASHINGTON, D.C. 20520, TELEPHONE (202) 647-3712.

9. REGISTRATION: AMERICANS WHO REGISTER WITH THE CONSULAR SECTION OF THE U.S. EMBASSY IN GUATEMALA CITY MAY OBTAIN UPDATED INFORMATION ON TRAVEL AND SECURITY WITHIN GUATEMALA.

10. EMBASSY LOCATION: THE U.S. EMBASSY IN GUATEMALA IS LOCATED IN AT AVENIDA REFORMA 7-01 IN ZONE 10, GUATEMALA CITY, TELEPHONE (502) (2) 31-15-41. CONSULAR SECTION HOURS FOR AMERICAN CITIZEN SERVICES ARE 8;00 A.M. - 12;00 NOON AND 1;00-3;00 P.M.

11. THIS REPLACES THE CONSULAR INFORMATION SHEET DATED MAY 28, 1993 TO NOTE THE RESTORATION OF DEMOCRATIC RULE AND THE CANCELLATION OF THE DEPARTMENT OF STATE'S TRAVEL WARNING FOR GUATEMALA.
WHARTON
BT
#7613

NNNN

Pete Smith
Manager

Central American
Rural Electrification Support Program (CARES)

National Rural Electric
Cooperative Association

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DRAFT REPORT

JOINT CFE/DOE GEOTHERMAL STUDIES

CFE/UURI REMOTE SENSING STUDIES

LOS AZUFRES GEOTHERMAL AREA, MICHOACAN

October 5, 1988

INTRODUCTION

Although techniques of remote sensing and satellite imagery interpretation are being developed for petroleum and minerals exploration and for other geological application, there has been little research and technology development aimed at geothermal exploration. This report documents a study by CFE and UURI of a Landsat 5 image of the Los Azufres geothermal area. The objective of this study is to determine if satellite imagery interpretation is useful in the volcanic environment of Los Azufres for helping to detect and map structure such as faults, fractures and volcanic structures, hydrothermal alteration, rock types and/or soil geochemical anomalies manifest in vegetation.

Landsat 4 and 5 carry an instrument package known as the Thematic Mapper (TM), which senses reflected energy in 6 bands in the visible and reflected infrared and one in the thermal infrared for a total of 7 bands. The pixel size is 30 by 30 m for the visible and reflected IR bands and 120 by 120 m for band 6, the thermal IR band. Absorption caused by OH^- in minerals, sometimes due to hydrothermal alteration, results in low reflectance in TM band 7, whereas altered rocks have high reflectance in TM band 5. Spectra of weathered iron minerals have weak reflectance in TM band 1 (blue) but strong reflectance in TM band 3 (red). Thus, the TM data have the potential of detecting geologic parameters of interest in geothermal work.

DIGITAL PROCESSING OF THE IMAGE

The Landsat image was purchased from EOSAT by UURI in digital form. An area of about 900 sq km (30x30 km) centered on the Los Azufres field was selected for study, and the digital data for this area subseted from the whole-image data file and placed in a working file on an IBM AT-compatible personal computer. The processing software installed on the PC is the ERDAS system, a commercially available, powerful digital processing system. The PC is linked to a 512x512 color video monitor and an Tektronix 4696 ink-jet color printer. This system allows interactive image processing with the results of selected images sent to the printer for hard copy.

A series of manipulations were carried out to enhance linear features and hydrothermal alteration. The Los Azufres area is highly fractured with the predominant features easily visible from the raw TM data. However, many fractures existed that were not visible at first glance and required spatial filtering. With an a priori knowledge of the fracture system, it was determined that filters emphasizing east-west trends along with north-south and northeast-southwest trends be passed over one channel of digital data. It was determined that the NIR (band 4) showed the most variation in the spatial realm. The NIR was analyzed with the above spatial 3x3 filters. The result consisted of three images (one for each of the filters) which consisted of linears in the respective directions. Cleanup filters were passed over each of the lineament images to reduce the noise commonly found. These filtered images were then digitally overlain onto the NIR channel to provide contextual information for the location of linears. This map was then interpreted by Ing. Hector Lira who identified the fracture system.

Multispectral analysis of the image consisted of creating standard color ratio images that are meant to identify altered soils. A number of ratios were attempted with only one providing understandable results. The color ratio composite of bands 5/7, 5/4, and 3/1 produced satisfactory results with OH^- bearing soils appearing as yellows, HOH (moist vegetation canopy) as magenta, and Fe^{3+} as cyan. This data however needs field verification. Geobotanical work in Los Azufres is another means by which altered soils can be detected. This procedure is based on the assumption that soil chemistry is influencing the overstory vegetation. This type of work however requires extensive field work for calibration.

INTERPRETATION

Structural Analysis

(in progress)

Hydrothermal Alteration

Several of the color images produced showed areas of known hydrothermal alteration well where there was no tree cover. The most promising band combination consisted of the MIR (band 7) to the red gun of the monitor, NIR (band 4) to the Green gun, and the visible red to the blue gun. However, most of the Los Azufres area is covered by dense, tall conifers, and standard imagery processing seems unable to detect alteration beneath this vegetation.

Geology

(in progress)

CONCLUSIONS

(in progress)