GL04227

SAMPLE DRAFT

TEXAS HYDROTHERMAL COMMERCIALIZATION BASELINE

PREPARED FOR

DEPARTMENT OF ENERGY - IDAHO OPERATIONS OFFICE

DEPARTMENT OF ENERGY - RESOURCE APPLICATIONS,
GEOTHERMAL RESOURCE OFFICE

BY

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NOTE: This sample draft is for illustration only. Some of the information is preliminary (subject to verification) or not applicable to Texas (as indicated in the individual sections).

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ACKNOWLEDGEMENTS

A number of people from EG&G Idaho and the Earth Science Laboratory of the University of Utah Research Institute has contributed to this draft document. Input has also been provided by Western Energy Planners Ltd., Stafco Inc., and G. A. Freund (consultant).

contributed on behalf of the state-team personnel for Texas.

1. INTRODUCTION

This handbook (draft) provides a synopsis of various aspects of the geothermal program in Texas. The section on Basic State Data (Section 2) lists government personnel (both legislative and executive branches) who are most directly involved with geothermal development. Some basic demographic data are also included. The various hydrothermal resources and the pertinent geology are summarized in Section 3. Activities (ranging from leases to operational systems) that lead to commercialization are described in Section 4. Plans for various developments are summarized in Section 5, while government assistance to Texas projects is listed in Section 6. The section on energy use patterns (Section 7) summarizes existing energy use and identifies counties and industries likely to be impacted most by geothermal energy. The section on leasing and permitting policies (Section 8) deals with legal and institutional considerations and includes a time table of institutional procedures for a typical resource to show the interrelationships among various organizations involved in development and regulation of the resource.

SAMPLE FORMAT - TITLES DIFFER FROM STATE TO STATE

2. BASIC STATE DATA (TEXAS)

A. Government Contacts

Governor -

Legislature

Senate Agriculture and Natural Resources Committee: Senator , Chairman.

Senate President Pro Tem: Sen.

House Agriculture Natural Resources Committee: Rep. , Chairman.

House Speaker: Rep.

State Geothermal Team

Operations Research: , Office of Energy Policy.

Resource Assessment: , State Geologist.

State Agencies

Office of Energy Policy: , Director.

Department of School and Public Lands: , Commissioner.

Department of Water and Natural Resources:

Water Rights Division: , Chief Engineer.

Earth Resources Group:

Geological Survey:

State Geologist,

Asst. State Geologist.

Department of Agriculture, Division of Conservation:

, Program Chief.

Department of Revenue: , Secretary.

State Planning Bureau: , Commissioner.

Information to be completed

B. Statistical Data

Demographic

Population (1970:

Area:

Population Density: persons/sq. mi.

Geothermal Resources

Confirmed Reservoirs > 150°C:

Prospects > 150°C:

Confirmed Reservoirs (20°C ≮ T < 150°C):

Prospects (20°C < T < 150°C):

Identified Warm Springs & Wells (T > 40°C):

Geothermal Leases

Federal:

State:

Private:

Test Wells:

Operational Hydrothermal Systems

Spas:

Space Heating:

Others:

Major Active Developments

Direct Use:

Electric:

Government Assisted Activities

PONs:

PRDA:

Loan Guarantees:

Energy

Supply (1975): x 10^{12} Btu; % exported; % imported

Use (1975): x 10^{12} Btu

Potential Conversion to Geothermal (1975): x 10^{12} Btu

E. Hydrothermal Springs and Wells

A listing of hydrothermal springs and wells with measured temperatures in excess of 40°C is given in Table 3.1 for Texas[1,2]. (The references do not list location by county, range, and township, only by latitude and longitude. The county, range, and township information will be developed for the next update of this baseline document.)

F. References

[1] L. J. P. Muffler, (ed.), Assessment of Geothermal Resources of the United States - 1978, U.S. Geological Survey Circular 790, 1979.

[2] USGS File GEOTHERM (as of March 1979).

TABLE 3.1[1,2]

HYDROTHERMAL SPRINGS AND WELLS - TEXAS

COUNTY,* NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Big Bend National Park				
Big Bend #2 (W)[a]		41		880
Hot Springs (S)[b]		40		880
Other				
Briscoe (W)		41		810
Gulf-Presidio (W)		72	8,300	1,300
Gulf-Swafford (W)		69	5,700	1,700
Hot Springs - Ruidosa (S)		45		550
Hot Wells (W)		40		
Indian Hot Springs (Stump) (S)		47		6,800
Indian Hot Springs (Chief) (S)		44		7,300
Ojos Calientes (No. 3) (W)		90		2,200
Ojos Calientes (No. 4) (W)		69		2,300

*County not given in references
[a] (W) = Well
[b] (S) = Surface

4. COMMERCIALIZATION ACTIVITIES

A. Highlights SAMPLE FORMAT (NOT APPLICABLE TO TEXAS)

- The first deep geothermal water well was drilled to 2983 ft in Edgemont, South Dakota in 1910-13, producing 515 gallons per minute (1960 L/min) at 54°C (130°F) and 94 psi.

- The Stroppel Hotel in Midland has used geothermal waters for hot mineral baths since the 1930s.

- Many ranchers in South Dakota have utilized hot well water for stock tanks, heating barns, chicken houses, etc., for years.

- There are numerous hot wells and springs in South Dakota with temperatures in excess of the 7°C annual mean temperature. Several major aquifers (in the Madison group), underlying about 40,000 sq. mi., yield hot water at temperatures above 100°F (38°C). Many oil and gas wells have recorded temperatures in the 100°C range.

- Four DOE PONs were awarded in 1977 to the Douglas High School in Box Elder, Haakon School in Philip, St. Mary's Hospital in Pierre, and to the Diamond Ring Ranch in Haakon County.

- A study was conducted in 1976-77 by the South Dakota School of Mines and Technology on "Geothermal Application on the Madison Aquifer System in South Dakota". This study examined the geology, water quality, water treatment, and corrosion and scaling aspects of the Madison. In addition, engineering and economic analyses were performed for a Midland district heating system, Cherry Creek and Red Scaffold district heating systems on the Cheyenne River Sioux Reservation, and for other uses including irrigation, stock watering, heating of livestock buildings, greenhouses, etc.

B. Leases (INFORMATION TO BE VERIFIED)

Considerable leasing activity has been done in Texas both on federal and state lands. Tables 4.1 - 4.5 and Figure 4.1 summarize the current status of leasing activity in the state. Table 4.1 provides latest totals of Federal and State acreages leased to private organizations for geothermal development.

For federal lands in Texas, Figure 4.1 is a synopsis of various leasing summaries produced by Automatic Data Processing (ADP) of the Conservation Division[1] of the USGS. It traces the three types of federal leases (noncompetitive, competitive, and Indian Land) from inception to production. For noncompetitive leases it summarizes: (1) applications, (2) withdrawals, (3) rejections, (4) pending actions, (5) total leases, (6) terminations, (7) active leases, (8) production status, and (9) unitization. For competitive leases, the figure summarizes the lease offerings and the same items (5) through (9) of the noncompetitive leases. For Indian land leases, it shows the same items (5) - (9). Some entries appear in more than one ADP format and minor discrepancies exist for these entries, possibly because the summaries are run on different dates. These discrepancies should be correctible in updates of the baseline document. Table 4.2 is a county-by-county listing of the holders of active noncompetitive federal leases, the size and location of holdings.

Table 4.3 summarizes by KGRA the bidding history of Federal competitive geothermal lease sales in Texas. It lists the KGRA, the county, number of sale dates, number of tracts and acreage offered, number of offerings culminating in leases, acreage leased, and average cost per acre in successful bids.

Table 4.4 is a county-by-county listing of the holders of active competitive federal leases, the size and location of their holdings, the effective date, and cost per acre of the lease.

Table 4.5 lists the holders of active state leases in Texas and the size of their holdings.

TABLE 4.1

TOTAL ACREAGES OF GEOTHERMAL LEASES - TEXAS

(as of May 1979)

Federal Leases:	
Total Acreages of Competitive Leases in KGRA's:	
Total Acreages of Non-Competitive Leases:	
(leases)	
State Leases:	
Total Acreages of State Leases:	
(lease)	
TOTAL OF ALL ACREAGES LEASED	

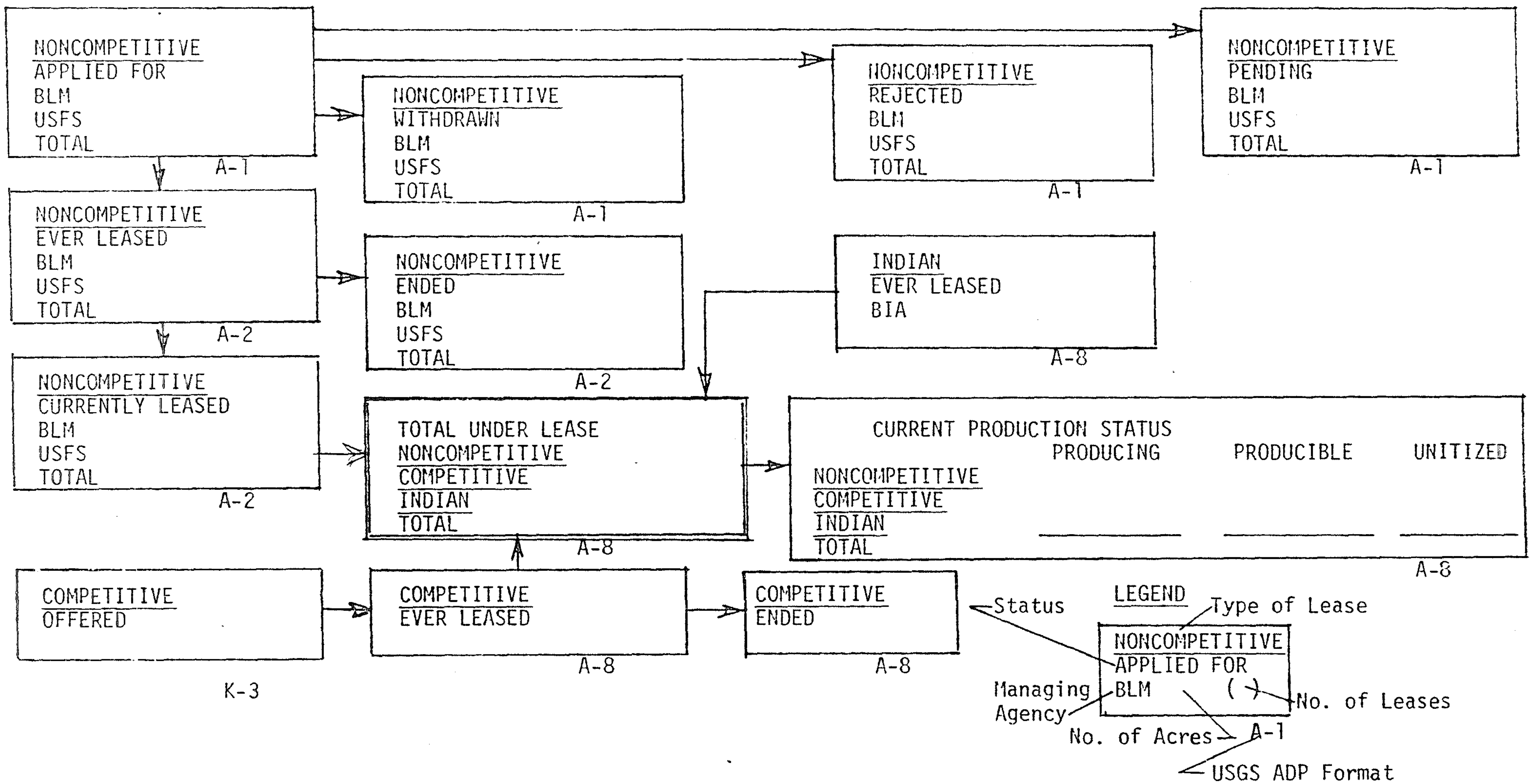


Figure 4.1 Summary of federal leasing activity - Texas

(Source - USGS ADP File)[1]

TABLE 4.2

FEDERAL ACTIVE NONCOMPETITIVE GEOTHERMAL LEASES - TEXAS

(as of May 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION

TABLE 4.3[2]

SUMMARY OF BIDDING HISTORY FOR COMPETITIVE GEOTHERMAL LEASE SALES ON FEDERAL LANDS - TEXAS
(Source USGS ADP File - Format K-4)

COUNTY	KGRA	OFFERED (INC. REOFFERS) SALES	TRACTS	ACREAGE	LEASES ISSUED NUMBER	ACREAGE	AVG. $/ ACRE

TABLE 4.4

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES - TEXAS

(as of May 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	KGRA/LOCATION	DATE ISSUED & (COST/ACRE)

TABLE 4.5

STATE LEASES - TEXAS

(as of May 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION
NONE		

C. Test Wells

Test wells in Texas are listed in Table 4.6[2,3].

TABLE 4.6

TEST WELLS - TEXAS

COUNTY & LOCATION	COMMENTS

D. Other Exploratory Activity

Other exploratory activity in Texas for geothermal resources is given in Table 4.7.

TABLE 4.7

OTHER EXPLORATORY ACTIVITY - TEXAS

COUNTY & LOCATION	COMMENTS

E. Operational Systems

Table 4.8 provides a summary of operational systems using geothermal energy in Texas[References].

F. References

TABLE 4.8

OPERATIONAL SYSTEMS - TEXAS

COUNTY & USE	LOCATION	COMMENTS

5. DEVELOPMENT PLANS

A. Description

A contract will be negotiated with the state of Texas so that the state can participate in the Department of Energy's (DOE) Operations Research Geothermal Planning Project. One major objective of this DOE/State geothermal planning process has been to generate specific plans for prospective development and commercialization of geothermal energy through the year 2020.

The present planning process for other states consists of three categories of plans for prospective and actual geothermal developments. The three are called Area Development Plans (ADP), Site Specific Development Plans (SSDP), and Time Phased Project Plans (TPPP).

Area Development Plans are plans for prospective development of geothermal resources and utilization of the geothermal energy in a multicounty substate area. The plan encompasses several geothermal resource sites and all potential residential, commercial, industrial and agricultural uses of geothermal energy. The resource sites for an ADP include confirmed (proven) reservoirs and reservoir prospects (potential and inferred resources). In most cases no private sector action has been taken toward development or commercialization. The time table for an ADP is a best estimate of when increments of geothermal energy will come on line from the several geothermal prospects and applications in the plan area.

Site Specific Development Plans are plans for development of specific geothermal single or integrated applications of the geothermal energy. The plans are restricted to confirmed (proven) reservoirs and potential reservoirs. Applications may be for any electric and/or direct thermal use of geothermal energy which is compatible with the quality of the confirmed (proven) or potential resource. In most cases, either some level of development or commercialization activity is already underway or is deserving of consideration by the community of geothermal energy developers and users. The time schedule of events in a SSDP represents a possible sequence of technological and institutional achievements under an atmosphere generally favorable for geothermal development of the specific site and application.

Time Phased Project Plans are plans for geothermal developments that are now at a commercialization level of activity or are in advanced stages of planning by the public and private sectors. The plans are confined to site-specific confirmed reservoirs or high potential geothermal prospects and to specific energy consumptive applications, either electric or direct thermal. The TPPP portrays or reproduces as closely as possible the actual planning and construction array of events and the associated time schedule of the commercial developer and user of the geothermal energy. The TPPP reveals actions by both the private and government sectors that must be accomplished on time in order to achieve successful geothermal energy production and utilization of a specific site for a committed application.

Table 5.1 identifies for Texas the geothermal resource sites and applications for which development plans have been prepared or which are candidates (designated by asterisk) for the preparation of development plans by the State Planning Teams. (This table is to be defined during the second half of 1979).

B. References

None

TABLE 5.1

DEVELOPMENT PLANS - TEXAS

TIME PHASED PROJECT PLANS	SITE SPECIFIC DEVELOPMENT PLANS	AREA DEVELOPMENT PLANS

To be defined during second half of 1979.

6. GOVERNMENT ASSISTED ACTIVITIES

A. Geothermal Direct Use PON Program

Background: In September 1977 and April 1978, the Department of Energy, Division of Geothermal Energy, in conjunction with the San Francisco Operations Office, issued a document which indicated DOE's desire to receive and consider for partial support proposals for direct heat utilization or combined electric/direct heat utilization field experiments demonstrating single or multiple usages of geothermal energy. These documents were issued under the title, "Program Opportunity Notice - Direct Utilization of Geothermal Energy Resources - Field Experiments." The Program Opportunity Notice (PON) is the name of this offering document, but it has become common practice to call any program which results from these notices a PON.

These solicitations are part of DOE's national geothermal energy program plan, which has as its goal the near-term commercialization by the private sector of hydrothermal resources for direct use purposes. Encouragement is being given to the private sector by DOE is cost sharing of a significant portion of the front-end financial risk in a limited number of field experiments.

DOE's primary interest under these PONs is to encourage field experiments in space/water heating and cooling for residential and commercial buildings, agricultural and aquacultural uses, and industrial processing application.

Current Status: Fifteen proposals from PON No. EG-77-N-03-2047, issued in April 1978 were accepted by DOE for funding. One of these is in Texas, to Navarro College in Corsicana for water and space heating of the Student Union Building and the County Memorial Hospital.

Texas also has one project under the 1977 PON solicitation (PON-EG-78-N-03-2047). The Torbett-Hutchins-Smith Memorial Hospital at Marlin is to use geothermal fluids for space and water heating.

B. Program Research and Development Announcement

Background: This program, commonly referred to as the PRDA program, is to provide funding for engineering and economic studies for direct applications of geothermal energy. The last announcement had a closing date of January 16, 1979 for applications. The cost of the studies is up to $125,000 each, and covers a study period of 6 to 12 months.

Current Status:

C. Demonstration Projects and Experiments

None except PONs described under 6.A above.

D. Geothermal Loan Guaranty Program (GLGP)

Background: Congress authorized $300,000,000 for loan guaranties. Each loan can be up to 75% of the total development cost. Nationally, DOE has received eleven applications to date, totalling $150,000,000 in loan guaranties. Of those eleven, three have been approved (two electric and one direct application); two turned down; one withdrawn; one is obtaining more information, and four are in the review process.

Current Status: No activity thus far in Texas.

E. National Conference of State Legislatures (NCSL)

Background: After a preliminary study on geothermal energy in 1976, the National Conference of State Legislatures (NCSL) launched the Geothermal Policy Project in January 1978. The objective of the project is to stimulate and assist the review of state policies that affect the development of geothermal resources. Successful completion of the project is to facilitate state statutory and regulatory environments that are consistent with efficient development of geothermal resources.

Current Status: The project selected six states in which to concentrate its efforts in 1978. Texas is not one of these states so there has been no activity on this project in the state.

F. State Coupled Program

Background: The objectives of the State Coupled Program are: (a) to assist the US Geological Survey in its ongoing geothermal resource assessment effort, and (b) to stimulate confirmation of low- and intermediate-temperature reservoirs at sites with an apparent but unquantified potential for direct heat application development. Major energy companies have generally shown little interest in lower grade resources because of a national and industrial focus on electrical power generation.

The State Coupled Program consists of cooperative effort among: (a) DOE, (b) an agency or institution in each state, (c) the U.S. Geological Survey, (d) the National Atmospheric and Oceanic Administration (NOAA), and (e) the Earth Science Laboratory of the University of Utah Research Institute. DOE provides overall program management and direction. The State Agency manages and performs the project within the state. The

U.S. Geological Survey interfaces with the program through the local Water Resources Division Offices, through the U.S. Geological Survey Geothermal Program Office, and by providing the use of computer file GEOTHERM. NOAA will publish the state map. The Earth Science Laboratory provides management assistance to DOE.

In order to accomplish this work contracts are written between DOE and each participating state. A separate contract for overall management assistance and program coordination is negotiated between DOE and the University of Utah/University of Utah Research Institute.

Each state project consists of: (a) Phase I, geothermal data compilation, with emphasis on low- and intermediate-temperature systems, culminating in publication of state maps and reports on the location and possible viability of geothermal resources, and (b) Phase II, investigation of specific geothermal sites, with drilling to demonstrate reservoir characteristics.

Current Status: There is no present activity in the State Coupled Program in Texas.

G. Industry Coupled Program

Background: The purpose of DOE's Industry Coupled Program is to foster a viable geothermal electrical power generation industry in the United States. Development by industry has been seriously lagging due to a number of problems. Front end costs are high in geothermal development due to leasing costs, regulatory costs, and the high cost of exploration, particularly for drilling. In addition, geothermal electrical power generation is a high-risk venture given the uncertainties of reservoir longevity. As a result of these factors, industry has made only a limited commitment to the development of high-temperature resources.

The Industry Coupled Program addresses some of the above problems through: (a) cost sharing with industry for exploration, reservoir assessment and reservoir confirmation; and (b) release to the public of geoscience data which will improve our understanding of the geothermal resource. Improved understanding will decrease reservoir uncertainty and lower exploration and assessment costs.

The Program is a cooperative effort between DOE and an industrial organization engaged in geothermal exploration. Industry responds with proposals to DOE procurement initiatives. Succcessful proposers then negotiate contracts with DOE. The contracts specify: (a) an exploration and/or reservoir confirmation program which industry will manage and perform, (b) a data package which industry agrees to make public, and (c) a certain percentage of total costs (generally in the range of 20 to 50%) which DOE will contribute toward funding the work.

The Earth Science Laboratory of the University of Utah Research Institute provides assistance to DOE on the Industry Coupled Program by: (a) assisting in management of the Program, (b) releasing geoscience data generated by the program to the public open file, and (c) interpreting and supplementing the above data for the purpose of developing and publishing reservoir case studies.

Current Status: There has been no activity in the Industry Coupled Program in Texas.

H. Technical Assistance

Background: Technical assistance is provided to potential geothermal users as an on-call service by EG&G Idaho's Geothermal Program Office and by the Earth Science Laboratory of UURI. The strategy of this program is to provide a catalytic agent in fostering geothermal energy use, particularly for direct applications. The amount of assistance given is limited so as to protect the interest of private engineering organizations and others working in the field. Generally, enough information is provided so that a potential user can make an evaluation of how or where to proceed. The technical assistance activity is extensive: 115 separate requests were handled for the 10-state Rocky Mountain Basin and Range Region during the first half of FY 1979.

Current Status: There has been no activity in the Technical Assistance Program in Texas.

I. State Assisted Activities

None (to be verified)

J. References

7. ENERGY USE PATTERNS

A. Energy Use Summary - Texas

As shown in Figure 7.1, oil and natural gas produced within the state provides 99% of the state's total energy use (and roughly 40% of the total national production). Ninety percent of the state's electricity is generated from natural gas. Coal provides the remaining 1% of the total need, with 11% of that being imported.

Figure 7.1 also shows the total energy consumption in five sectors; residential, commercial, industrial, transportation, and electric losses. The largest energy user is the industrial sector, consuming 53%. Transportation uses 21%, residential and commercial combined use 12%, and electric power generation losses account for 14%. Of the industrial energy user, 95% is consumed by chemical and allied products industries, 35% by petroleum and coal industries and 10% by stone, clay and glass industries.

Total energy use for each county is shown in Figure 7.2 and accompanying table. This value is based on the total county population and per capita energy use. Table 7.1 presents the Standard Industrial Classification (SIC) codes and present employment levels for each county that has been identified as having potential geothermal resources. As resource definition is developed, the temperature and energy needs of industrial users can be analyzed to establish the market potential, in a manner similar to that in Reference 1 for other states. (This method is described in the last two paragraphs of this section).

The Texas energy demand is expected to increase at a moderate growth rate of about 2.7% per year to the year 2000 (Figure 7.3). Relative percentages in the five sectors are expected to change somewhat by the year 2000. Industry and electric

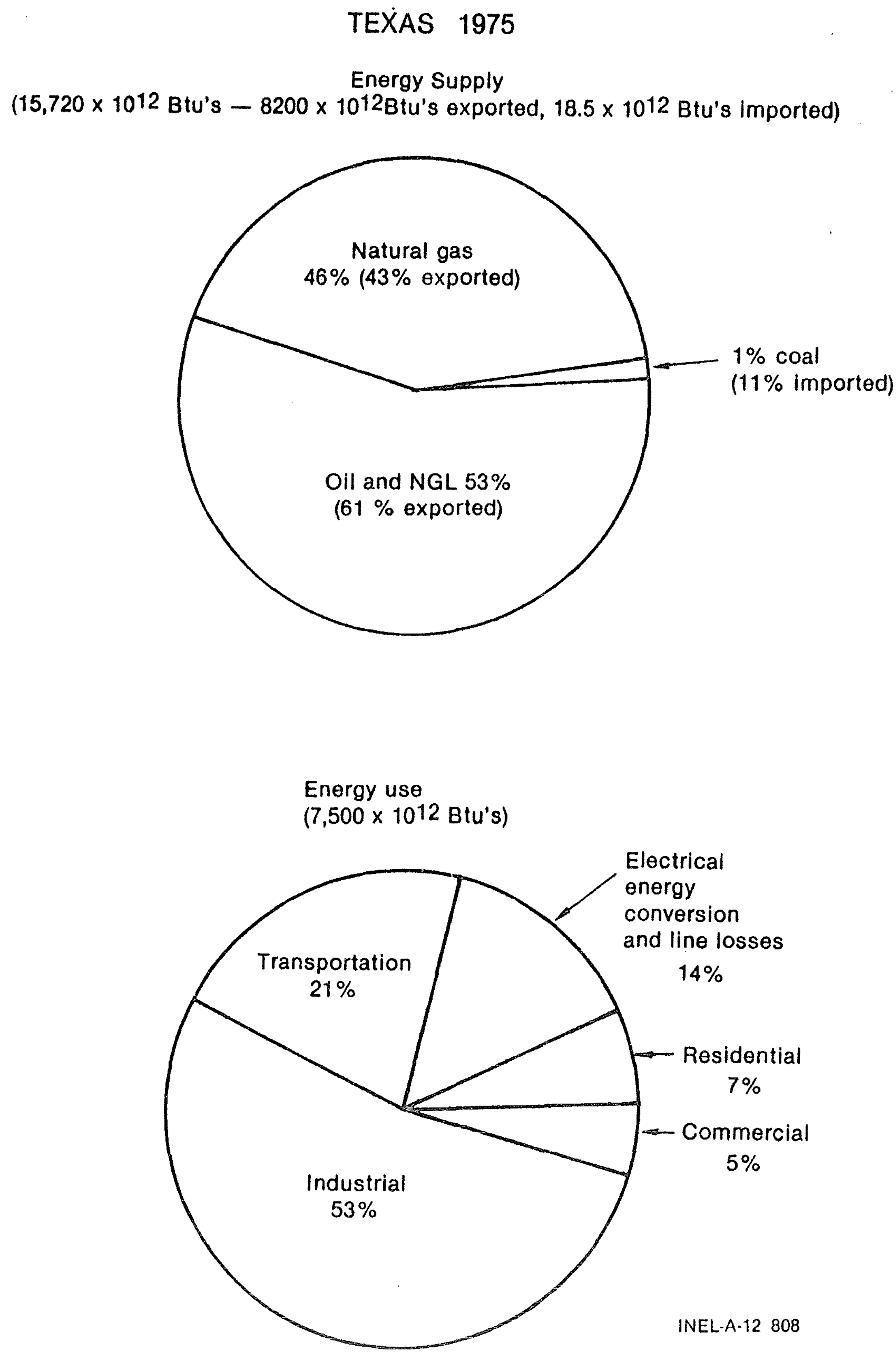
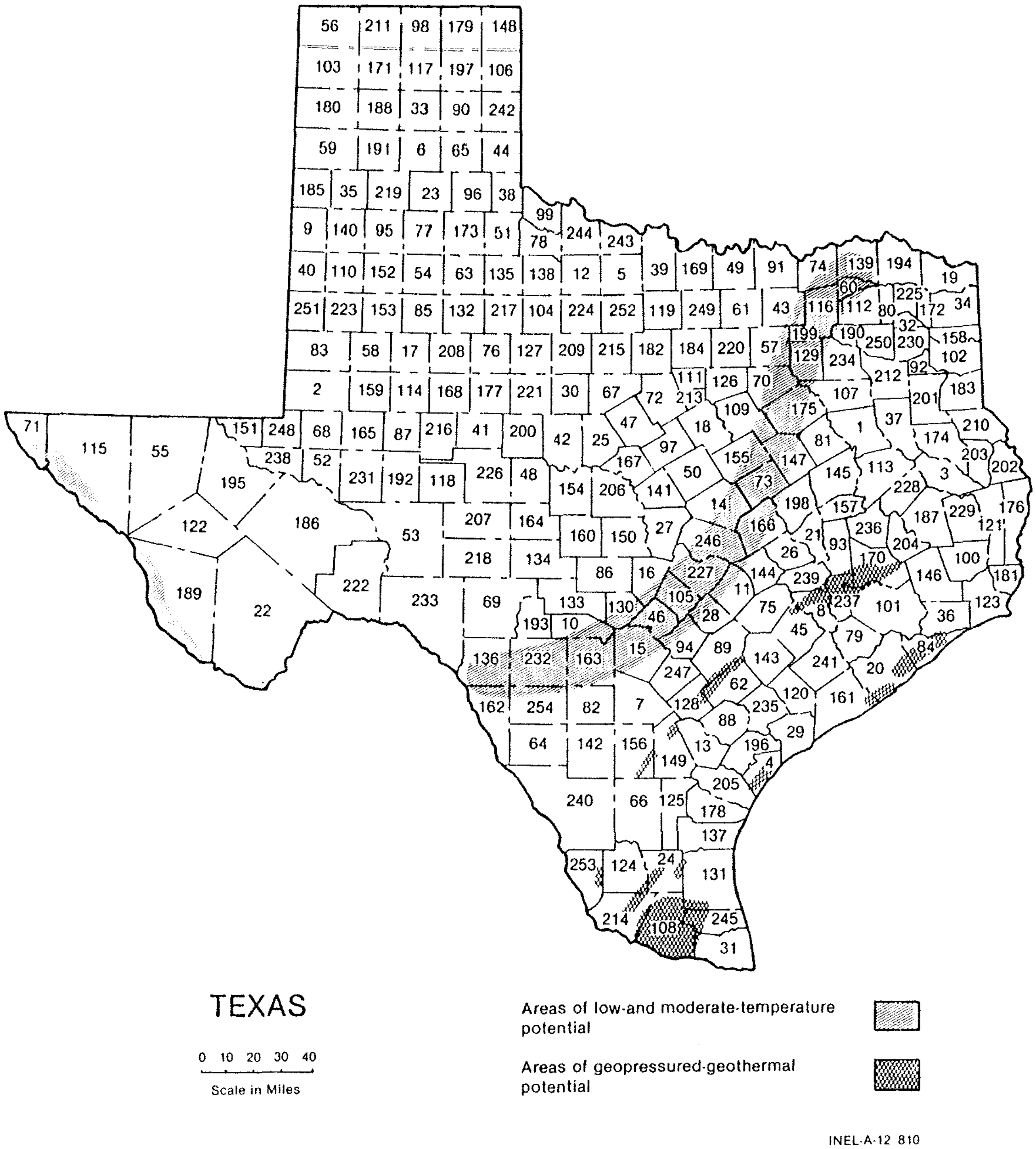


Fig. 7.1 Texas energy supply and use



NOTE: no. of county in energy tabulation on opposite page.

Fig. 7.2 Texas energy use tabulation.

No.	County	Energy Use Btu x 10^9
1	ANDERSON	470
2	ANDREWS	534
3	ANGELINA	570
4	ARANSAS	460
5	ARCHER	664
6	ARMSTRONG	1079
7	ATASCOSA	413
8	AUSTIN	494
9	BAILEY	778
10	BANDERA	460
11	BASTROP	1371
12	BAYLOR	796
13	BEE	389
14	BELL	417
15	BEXAR	340
16	BLANCO	653
17	BORDEN	618
18	BOSQUE	463
19	BOWIE	526
20	BRAZORIA	819
21	BRAZOS	434
22	BREWSTER	458
23	BRISCOE	728
24	BROOKS	412
25	BROWN	543
26	BURLESON	367
27	BURNET	457
28	CALDWELL	366
29	CALHOUN	419
30	CALLAHAN	502
31	CAMERON	425
32	CAMP	434
33	CARSON	870
34	CASS	366
35	CASTRO	1039
36	CHAMBERS	821
37	CHEROKEE	1609
38	CHILDRESS	616
39	CLAY	601
40	COCHRAN	511
41	COKE	2253
42	COLEMAN	494
43	COLLIN	610
44	COLLINGSWORTH	678
45	COLORADO	598
46	COMAL	496
47	COMANCHE	625
48	CONCHO	721
49	COOKE	569
50	CORYELL	486
51	COTTLE	656
52	CRANE	490
53	CROCKETT	908
54	CROSBY	682
55	CULBERSON	960
56	DALLAM	1122
57	DALLAS	737
58	DAWSON	626
59	DEAF SMITH	1258
60	DELTA	373
61	DENTON	536
62	DE WITT	497
63	DICKENS	631
64	DIMMIT	295
65	DONLEY	732
66	DUVAL	349
67	EASTLAND	580
68	ECTOR	603
69	EDWARDS	631
70	ELLIS	545
71	EL PASO	472
72	ERATH	506
73	FALLS	464
74	FANNIN	1900
75	FAYETTE	520
76	FISHER	553
77	FLOYD	608
78	FOARD	625
79	FORT BEND	2182
80	FRANKLIN	475
81	FREESTONE	503
82	FRIO	457
83	GAINES	621
84	GALVESTON	1315
85	GARZA	587
86	GILLESPIE	479
87	GLASSCOCK	585
88	GOLIAD	487
89	GONZALES	570
90	GRAY	786
91	GRAYSON	543
92	GREGG	837
93	GRIMES	480
94	GUADALUPE	440
95	HALE	667
96	HALL	593
97	HAMILTON	582
98	HANSFORD	1198
99	HARDEMAN	852
100	HARDIN	342
101	HARRIS	704
102	HARRISON	638
103	HARTLEY	924
104	HASKELL	1119
105	HAYS	368
106	HEMPHILL	812
107	HENDERSON	1313
108	HIDALGO	383
109	HILL	563
110	HOCKLEY	472
111	HOOD	486
112	HOPKINS	615
113	HOUSTON	378
114	HOWARD	613
115	HUDSPETH	686
116	HUNT	523
117	HUTCHINSON	597
118	IRION	921
119	JACK	526
120	JACKSON	487
121	JASPER	427
122	JEFF DAVIS	501
123	JEFFERSON	1104
124	JIM HOGG	385
125	JIM WELLS	399
126	JOHNSON	486
127	JONES	633
128	KARNES	439
129	KAUFMAN	402
130	KENDALL	472
131	KENEDY	380
132	KENT	580
133	KERR	435
134	KIMBLE	638
135	KING	999
136	KINNEY	484
137	KLEBERG	373
138	KNOX	577
139	LAMAR	589
140	LAMB	1896
141	LAMPASAS	510
142	LASALLE	421
143	LAVACA	418
144	LEE	509
145	LEON	542
146	LIBERTY	500
147	LIMESTONE	390
148	LIPSCOMB	720
149	LIVE OAK	557
150	LLANO	554
151	LOVING	1823
152	LUBBOCK	582
153	LYNN	526
154	MCCULLOCH	611
155	MCLENNAN	903
156	MCMULLEN	557
157	MADISON	532
158	MARION	4679
159	MARTIN	599
160	MASON	735
161	MATAGORDA	555
162	MAVERICK	370
163	MEDINA	412
164	MENARD	617
165	MIDLAND	583
166	MILAM	438
167	MILLS	572
168	MITCHELL	7018
169	MONTAGUE	523
170	MONTGOMERY	462
171	MOORE	1500
172	MORRIS	1477
173	MOTLEY	698
174	NACOGDOCHE	501
175	NAVARRO	537
176	NEWTON	323
177	NOLAN	624
178	NUECES	603
179	OCHILTREE	944
180	OLDHAM	1196
181	ORANGE	1629
182	PALO PINTO	758
183	PANOLA	408
184	PARKER	575
185	PARMER	1399
186	PECOS	609
187	POLK	500
188	POTTER	1059
189	PRESIDIO	508
190	RAINS	378
191	RANDALL	507
192	REAGAN	615
193	REAL	451
194	RED RIVER	632
195	REEVES	558
196	REFUGIO	480
197	ROBERTS	1222
198	ROBERTSON	411
199	ROCKWALL	492
200	RUNNELS	562
201	RUSK	379
202	SABINE	407
203	SAN AUGUSTINE	361
204	SAN JACINTO	232
205	SAN PATRICIO	384
206	SAN SABA	604
207	SCHLEICHER	699
208	SCURRY	591
209	SHACKLEFORD	614
210	SHELBY	524
211	SHERMAN	2039
212	SMITH	582
213	SOMERVELL	397
214	STARR	254
215	STEPHENS	572
216	STERLING	930
217	STONEWALL	659
218	SUTTON	622
219	SWISHER	1012
220	TARRANT	724
221	TAYLOR	548
222	TERRELL	993
223	TERRY	668
224	THROCKMORTON	735
225	TITUS	554
226	TOM GREEN	626
227	TRAVIS	568
228	TRINITY	436
229	TYLER	425
230	UPSHUR	349
231	UPTON	496
232	UVALDE	500
233	VAL VERDE	383
234	VAN ZANDT	453
235	VICTORIA	1191
236	WALKER	339
237	WALLER	387
238	WARD	1705
239	WASHINGTON	457
240	WEBB	450
241	WHARTON	524
242	WHEELER	792
243	WICHITA	487
244	WALBARGER	666
245	WILLACY	334
246	WILLIAMSON	412
247	WILSON	419
248	WINKLER	469
249	WISE	525
250	WOOD	464
251	YOAKUM	1378
252	YOUNG	2830
253	ZAPATA	265
254	ZAVALA	356

void - BCL has corrections
GF 7/16/79

INEL-A-12 811

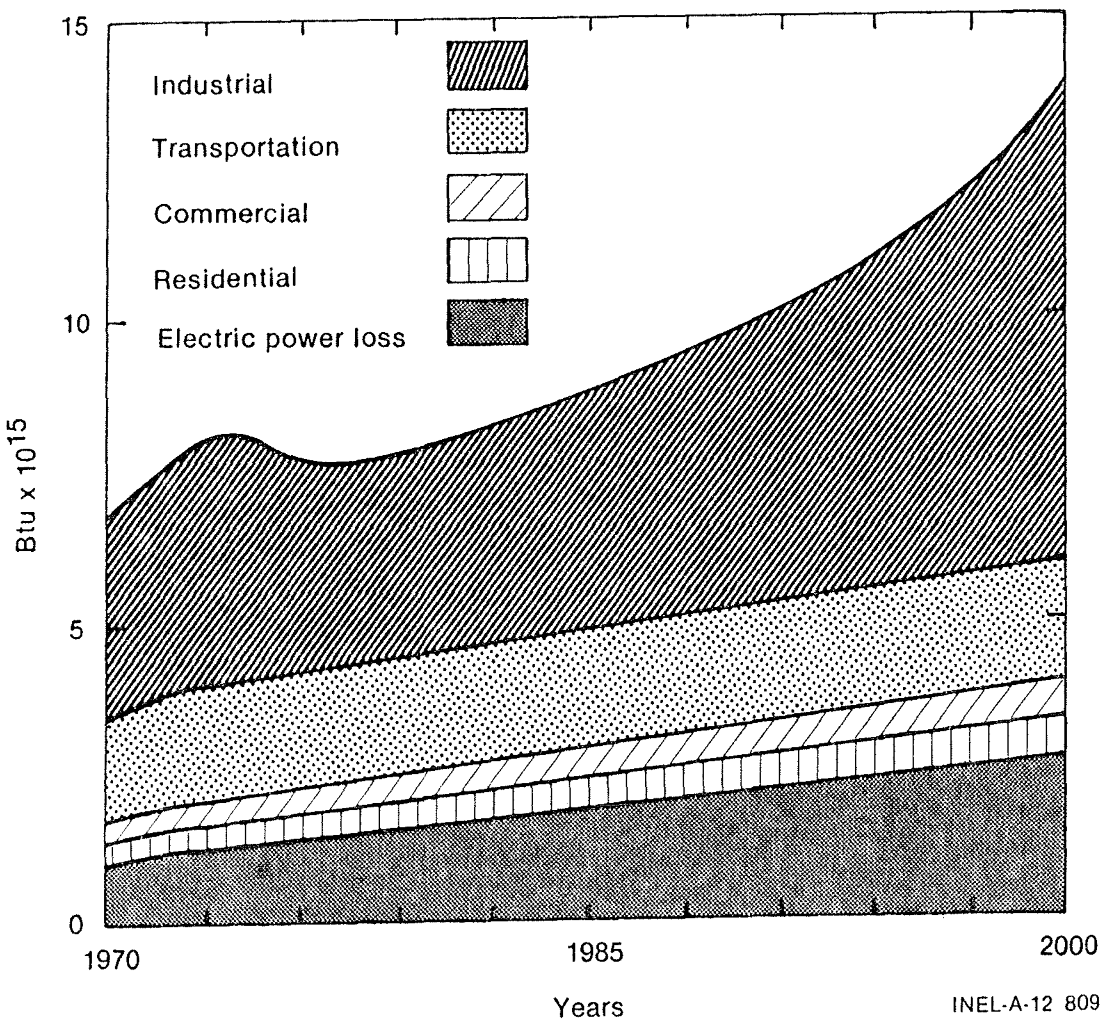


Fig. 7.3 Texas total energy use projection

losses will increase to 60 and 16% respectively of the total usage. Transportation will decrease (to 16%) as will the combination of residential and commercial (to 8%).

Table 7.1 shows employment in Texas by SIC for those counties with potential hydrothermal resources.

In other states, counties overlying hydrothermal resources have been assessed to determine how many manufacturers could use the available hydrothermal energy in their industrial processes. For these preliminary calculations, a single reservoir temperature has been assumed for each of these counties. Hydrothermal energy at this temperature is assumed to be recoverable without regards to economics. (As more detailed reservoir data becomes available, this assumed reservoir temperature may be refined or more than one temperature assumption may be used for different locations in the county. Such assumptions would then be used to recalculate potential hydrothermal energy usage.) Each Standard Industrial Classification (SIC) category is aggregated within the county. A Btu use value for each industry is determined by employing energy intensity coefficients (Btu/employee). Industrial, as well as residential/commercial, data for each such county are compiled. These data show the potential for conversion to hydrothermal energy based on 1975 usage in these counties.

Table 7.2 lists the industry, the SIC number, and the percent of the process heat used in various temperature ranges from 40 to 275°C. By use of this temperature breakdown, industries can be considered as candidates for hydrothermal energy applications, even if their total energy requirements cannot be met by hydrothermal energy.

B. References

[1] Frank Drysdale and Charles E. Calef, The Energetics of the United States of America: An Atlas, Brookhaven National Laboratory (Revised October 1977).

<u>TABLE 7.1</u>

EMPLOYMENT - TEXAS
COUNTY-BY-COUNTY & SIC-BY-SIC

COUNTY SIC	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Bandera	21							15	37											
Bastrop	121				74	191		17					417	75	42	37			32	
Bexar	8400		63		1660	1460	2050	2170	980	1200			1980	4160	3860	7910	510	2300	390	990
Brazos	240				5	940	180	68	160				110		52	270	5	180	110	115
Burleson	21					380		15	5				5		250					
Caldwell	210				75			26					5		75	37			10	
Comal	520		3200		5	175		31	5	175			360	37	180	21				5
Delta								5	5				5				37			
Ellis	80		175		100	1070	780	60	3000	32			1500	180	440	65	175	16		16
El Paso	610		16		1100	760	1000	2000	1100	550			690	1500	1900	1100	1800	16	210	180
Falls	380		180				16	37	31				16		5					37
Fayette	230				180			36	74				16	270	96	75		80		75
Franklin	5				37	75		5	37											
Freestone					32			10	26	75			117		16					

TABLE 7.1 (contd)

COUNTY SIC	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Gonzales	530							21	190	16			47		175	37			5	
Grimes	53				210	75		5					5	175	450		16			
Guadalupe	250		210		160	10		74	91				58	380	120	5	3000	21		
Hays	280				175			80	180				64	37	180	42	960		75	16
Henderson	16		5		16	58		42	21				390		140	21		5		
Hill	53				5	75		26	26				400	180		16	380			
Hopkins	420				360	5	180	37	42				120		800	37				
Hunt	620				3400	42	75	490	52	16			79		16	3200	200	550		5
Kaufman	26		16		180	230	250	46	53				5	5	670	490	37	16		16
Lee	42				120	37		5					5		10	5		380		
Limestone	16		550			180		37					190	16	37	42		15		21
McKennan	1600		5		770	1200	840	840	100	150			3500	16	1300	1600	500	480	80	610
Medina	110				5			42	5				270		10	5	5	380		
Milam	95				80	350		37					21	3000	37	5				

TABLE 7.1 (contd)

COUNTY SIC	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Navarro	410		5			58	37	110	460				430	380	58	250		32		5
Presidio	16							5					10							
Robertson	5				110			5	32	16			210	37	110					
Titus	700				90			37	5				42		16	16				
Travis	1400		90		580	1400	74	1500	390	21			1600	120	1300	3800	1400	910	380	750
Uvalde	110							26	21	150			48	180	16					
VanZandt	21							25	230				10		16	16				
Washington	200		380		37	440		16					52		37	37	42			37
Williamson	79		180		20	590	37	180	5				240	5	280	150	130	21	90	16

SAMPLE FORMAT (not applicable to Texas)

TABLE 7.2

INDUSTRIAL PROCESS HEAT REQUIREMENTS - SOUTH DAKOTA

INDUSTRY	SIC Number	40°C-60°C	60°C-80°C	80°C-100°C	100°C-120°C	120°C-140°C	140°C-160°C	160°C-180°C	180°C – 200°C	200°C	275°C
Meat packing	2011	NA	99%	100%							
Creamery butter	2021										
Natural cheese	2022	23%	100%								
Fluid milk	2026	NA	NA	100%							
Wet corn milling	2046	21.5%			36.4%	46.6%		84.1%		100%	
Prepared feeds	2048										
pellet cond.		NA	NA	100%							
alfalfa drying		NA	NA	NA	NA	NA	NA	NA	NA	100%	
Soft drinks	2086	60.9%	100%								
Concrete block	3271										
low pressure		NA	100%								
autoclaving		NA	NA	NA	NA	NA	NA	NA	100%		

[2] R. B. Kidman, et al, Energy Flow Patterns for 1975, LASL-LA-6770 (June 1977).

[3] The Phasing Out of Natural Gas and Oil for Electric Power Generation, Southwest Power Pool and Electric Reliability Council of Texas - Part II, Federal Power Commission (July 30, 1976).

[4] Preliminary Forecast of Likely U.S. Energy/Consumption/ Production Balances for 1985 and 2000 by States, U.S. Department of Commerce, Washington, D.C. (November 1, 1978).

[5] Energy and Feedstocks: Challenges for Texas, Proceedings, College of Engineering, Texas A & M University (September 15-16, 1976).

[6] Patricia Rice, Energy Conditions in the South, Oak Ridge National Laboratory (December 1976).

[7] Texas Energy Outlook: The Next Quarter Century, Governor's Energy Advisory Council (March 1977).

[8] U.S. Department of Commerce, Bureau of Census, Annual Survey of Manufacturers 1976: Fuels and Energy Consumed, States, by Industry Group, M76 (AS)-4.2 (May 1978).

[9] Draft Regional Hydrothermal Market Penetration Analysis, Appendix B, EG&G Idaho, Inc., and Utah University Research Institute Earth Science Laboratory, October 31, 1978.

8. LEASING AND PERMITTING POLICIES

A. General[1-4]

While there has been moderate geothermal development in South Dakota, it has produced little state legislation aimed at defining geothermal resources and establishing the government policies for the development of geothermal energy. Presently, there are no policies or procedures for geothermal leasing or permitting in the state. The state has not determined if geothermal belongs to the surface land owner or the mineral right owner.

State Regulations: The state of South Dakota presently does not have set guidelines for the development of geothermal energy. There is no clarity as to which state agency has the authority to regulate geothermal. The partial reason for this is the lack of definition by the legislature as to whether geothermal is a water resource, mineral resource, or unique resource.

The Water Rights Commission and the Department of Water and Natural Resources have assumed responsibility for the regulation of geothermal energy as it is presently being developed. According to SDCL 46-2-5, the Water Rights Commission's main responsibility is to regulate rights in surface and subsurface water. This implies that geothermal is being considered as a water resource that generally belongs to the land surface owner. While there is no reference to geothermal in the enabling statutes of the Water Rights Commission, the state statutes do state that beneficial use must be made of the water.

The Water Rights Commission issues permits for drilling of wells deeper than 1,000 ft. Those wells which are less than 1,000 ft do not require permits, but the owner must own water rights. Water rights permits are required for all beneficial use of water except vested rights in reasonable domestic use. To date, beneficial use has included rural water supplies, irrigation, and municipal water supplies. A holder of the permit must put water to beneficial use within three years or lose his preferential use of the water right. In the case of the three geothermal well permits issued to date, the Commission has prescribed that the water be applied to beneficial secondary use within five years. The Commission may recognize the reinjection of the geothermal water as an alternative to beneficial use. The Commission has indicated that it does not intend to issue any more geothermal well permits for at least a year or more, until it has determined whether or not the withdrawal of water could interfere with domestic and agricultural wells.

Surface Leasing: If geothermal energy is to be developed on state land, the developer must lease the surface land from the state. The Department of School and Public Lands has full right (SDCL 5-5) to conduct all leasing of lands in mineral interests owned by the state or held in trust by the state, including schools, indemnity, and endowment land, rural credit lands, lands owned by the state and administered by the Game, Fish and Parks Commission, the Board of Regents, the Board of Charities and Corrections, or any other mineral interests of any kind in the state for any of its departments or institutions. The state presently owns approximately 900,000 acres of surface land and 5.2 million acres of mineral rights.

The Department of Schools and Public Lands issues five-year leases on lands and minerals. Most leases are for grazing and agricultural use, but the Department has issued one 37-acre mineral lease. The lessee has the option to renew his lease for an additional five years if he wishes to do so. The Department does have the option for multiple leases on the same land if the new uses do not conflict with existing uses. The lessee is not permitted to sublease land to other parties. There is no minimum or maximum size to the number of acres that can be leased.

The Department of School and Public Lands issues prospecting permits for the exploration of minerals other than oil and gas on state-owned lands, but has no established procedure for geothermal prospecting. The mineral permits are for a one-year period, with two one-year extensions allowable. The prospector then has the option to apply for a preference right lease. The royalty rate is negotiable; but if the state and prospector are unable to agree on a royalty rate, all findings are made public and a competitive procedure is initiated.

Fluid Discharge Permits: According to Chapter 26-5-1 of the State Agency Rules and Regulations, the Water Rights Commission is responsible for issuing permits to discharge fluids into rivers and streams. In the case of geothermal development, the Commission discourages the discharging of geothermal water without a secondary beneficial use. The Commission may issue permits to reinject geothermal water into aquifers.

Other Permits and Regulations: The developer of geothermal energy must follow several standards in exploratory drilling and well development. The Water Rights Commission requires guidelines to be followed concerning minimum well construction standards (Chapter 52-01-04), minimum specifications for flowing artesian wells (Chapter 52-01-02), and regulation of ground water use (Chapter 52-01-05).

The State Conservation Commission regulates mining land reclamation (SDCL 45-6A) which would probably affect geothermal exploration and development to some extent. The Commission requires plans to be submitted for reclaiming land and permits allowing for exploratory drilling, operation of mines, and possibly geothermal operations if the exploration is for an "unknown" source.

Geothermal System Development: South Dakota requires that any new facility or facility expansion designed to produce more than 100 MW of electricity go through permitting procedures with the State Public Utilities Commission. The South Dakota Energy Facility Permit Act of 1977, Chapter 390, outlines the procedures provided for siting of energy conversion and transmission facilities. Applications for permits must be filed with the Commission not less than 6 months prior to the construction of the facility. The Commission schedules a public hearing and designates a local review committee aimed at reviewing the social, environmental and economic effects of the project on the areas around the plant.

Local Permits: Counties and muncipalities regulate many activities. Most local governments in South Dakota have the option to regulate geothermal development. Control of geothermal would probably be carried out through subdivision regulations.

B. Time Table of Institutional Procedures

The detailed steps and specific times associated with state institutional processes for geothermal development will be compiled and evaluated by the State Geothermal Planning Team during the second half of 1979 (see Table 8.1).

C. References

[1] Jack J. Gerken, Department of School and Public Land, Personal Communication, May 1979.

[2] John Hatch, Department of Water and Natural Resources, Personal Communication, May 1979.

[3] Bill Harris, Division of Conservation, Personal Communication, May 1979.

[4] State of South Dakota Legislative Council, Personal Communication, May 1979.

TABLE 8.1

TIME TABLE OF INSTITUTIONAL PROCEDURES FOR A GEOTHERMAL PROJECT - TEXAS

To be prepared by State Team in 1979.

9. BIBLIOGRAPHY (SELECTED REFERENCES)

This list of selected references is not yet a complete bibliography on geothermal energy in Texas. This objective will be sought in future updates of this baseline document.

May 8, 1980

MEMORANDUM

TO: State Coupled Program Core Group

FROM: Bob Blackett and Duncan Foley

SUBJECT: Meeting with Texas Geothermal Resource Assessment Team and members of NOAA.

DATE: 25 April 1980

PLACE: Bureau of Economic Geology, Austin, Texas

PURPOSE: Discussion of Texas and New Mexico Geothermal Resources Maps

ATTENDEES: Chuck Woodruff-Bureau of Economic Geology, University of Texas, (BEG); Gerald Brophy-Department of Energy; Dave Clark, Ron Smith-NOAA: Duncan Foley, Bob Blackett-ESL/UURI.

GENERAL AND BUSINESS

1. Duncan Foley presented a discussion of the interface between the State Coupled Program and the User Coupled Confirmation Drilling Program.

TECHNICAL

1. The two most significant problems that exist with the Texas map are the ability to depict much subsurface drill data and show the lateral extent of five separate overlapping geothermal aquifers. The following steps were suggested to minimize these problems:

    a) NOAA will provide BEG with several blank mylars in order to delineate each geothermal aquifer in central Texas by either stratigraphic unit or age. The aquifers will then be transferred to the Texas base using various color shades to separate each aquifer, or the ages of each aquifer, which ever is most feasible.

    b) Gerry Brophy suggested that the map size be increased to accomodate generalized geologic cross-sections showing the vertical relationships of the various aquifers.

c) Drill data (i.e. aquifer name, thickness, depth, elevation, etc.) may be provided on a separate list to accompany the map.

2. An index showing the geologic provinces of Texas will also be included.

3. Gulf coast geopressured areas will be shown as one color without depicting separate aquifers or noting specific subsurface information. Other USGS and BEG studies will be references.

4. BEG will investigate the existence of enough data to justify a broad gray area of geothermal potential within the Rio Grande rift zone.

5. On the New Mexico map:

   a) Chuck Woodruff recommended that the "Jemez Lineament" on the New Mexico map be deleted because the concept may not be appropriate on "general public maps".

   b) Gerry Brophy suggested that the width of the iso-20^{o}C temperature line be reduced.

ACTION ITEMS

1. NOAA will send BEG several blank mylars of the Texas base map.

Duncan

Duncan Foley

Bob Blackett

Bob Blackett

DS,BB:ls

TEXAS ENERGY ADVISORY COUNCIL

7703 North Lamar Austin, Texas 78752 (512) 475-5588

TO: Attendees, March 23, 1979 Trans-Pecos Geothermal Resources Meeting

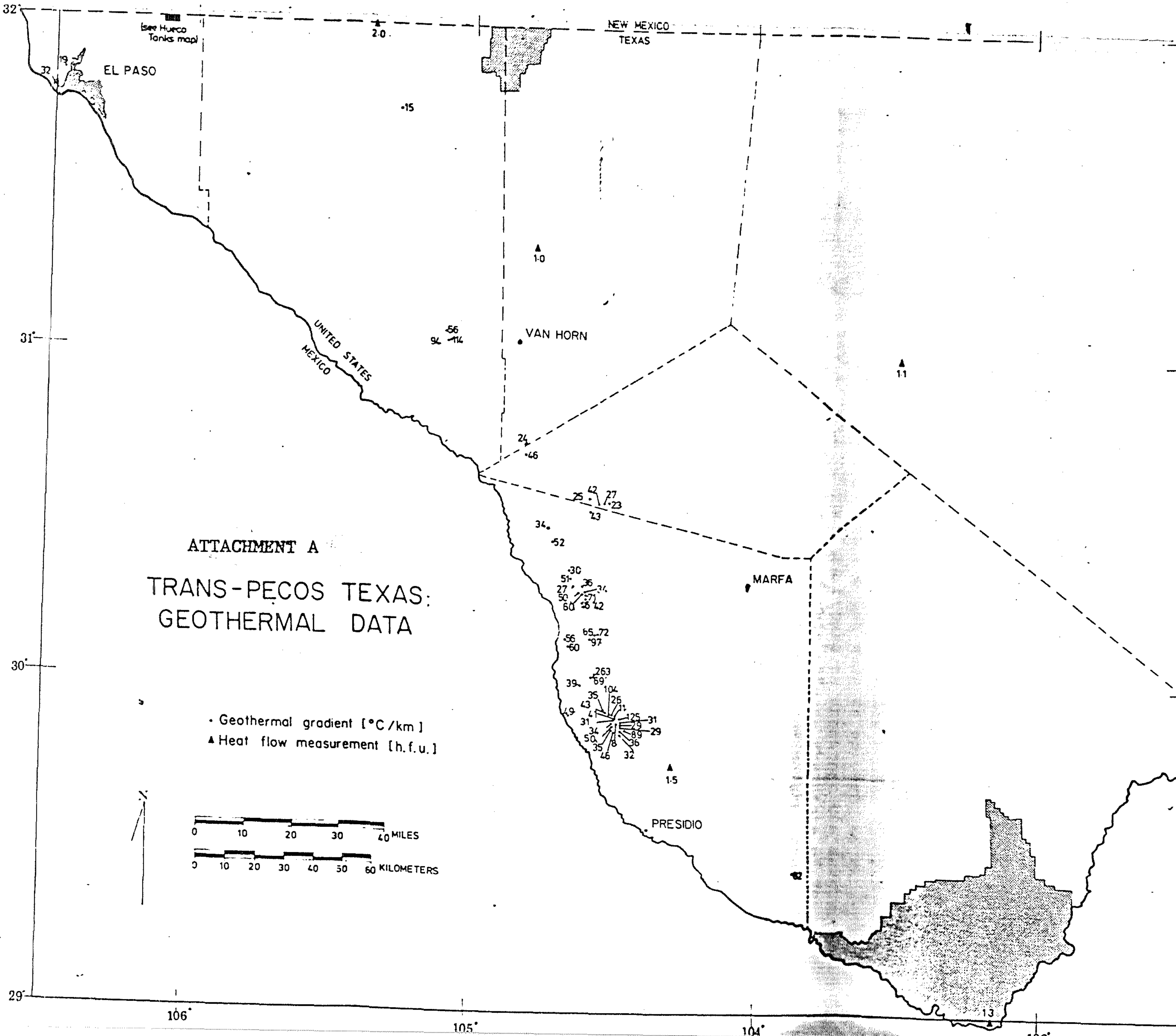
FROM: David M. White

SUBJECT: Meeting Summary and Project Update

Attached is a summary of the presentations made at the March 23, 1979 meeting on geothermal resources research in the Hueco Tanks and Presidio Bolson areas of west Texas.

Since the meeting, additional resource assessment work has been accomplished in both areas. Essentially all available holes in the Presidio Bolson area have now been logged for thermal gradient (See Attachment A). Four additional holes (3-50m, 1-125m) have been drilled in the Hueco Tanks area to the east of the holes drilled earlier. The measured thermal gradient in all four of these holes exceeded 200°C/km. Further work is being planned in both areas with primary emphasis on deeper hole drilling in the Hueco Tanks area and some targeted 50 meter holes in Presidio County.

Please let me know if you have any questions or need more information. I will inform you of significant future developments when they occur. Thanks again for attending the El Paso meeting.


ATTACHMENT A
TRANS-PECOS TEXAS: GEOTHERMAL DATA
• Geothermal gradient [°C/km]
▲ Heat flow measurement [h.f.u.]
0 10 20 30 40 MILES
0 10 20 30 40 50 60 KILOMETERS
NEW MEXICO
TEXAS
(see Hueco Tanks map)
EL PASO
VAN HORN
MARFA
PRESIDIO
UNITED STATES
MEXICO
32°
31°
30°
29°
106°
105°
104°
103°

SUMMARY OF MEETING

GEOTHERMAL RESOURCES IN TRANS-PECOS, TEXAS

PLACE: Smiley Room, University of Texas at El Paso
TIME: 9:00 a.m., March 23, 1979
ATTENDEES: See Attachment A

A research consortium composed of the Texas Energy Advisory Council, University of Texas at El Paso, Texas General Land Office, and Southwest Research Institute presented an overview of the findings to date of an assessment of the geothermal resource potential of Trans-Pecos, Texas. Mr. David White of the Texas Energy Advisory Council stated that the activities which were to be reported at this meeting stemmed from the efforts of TEAC and others to encourage the development of geothermal energy in Texas. In support of this effort, the State of Texas has provided over $225,000 in funding for studies to determine the nature and extent of geothermal resources in Trans-Pecos, Texas. The current research program involves $75,000 in direct state support and $20,000 in industrial support.

GEOTHERMAL RESOURCE ASSESSMENT

The task of assessing the nature and extent of potential geothermal resources in Trans-Pecos, Texas is under the supervision of Dr. Robert Roy of the Department of Geology of The University of Texas at El Paso. The following paragraphs are a summation of the presentation of Dr. Roy and Bruce Taylor, a doctoral candidate working under Dr. Roy's supervision.

Geothermal Resource Assessment of Trans-Pecos, Texas

Geochemical survey work by Dr. J. M. Hoffer of the University of Texas at El Paso has pointed out several areas in Trans-Pecos, Texas that have potential for geothermal resources. In his reconnaissance survey, Hoffer used silica geothermometry based upon the solubility of silica in water. The higher the temperature of the reservoir the more silica is dissolved. When cooled, however, silica remains in solution and its concentration is a measure of reservoir temperature. The results of Hoffer's survey are shown in Figure 1. The most promising areas according to the silica geothermometer are near Hueco Tanks about 25 miles east of El Paso and in the Presidio Bolson about 20 miles north of Candelaria in Presidio County.

Hueco Tanks Area

To date, UTEP has investiaged the Hueco Tanks anomaly by drilling six 50 meter geothermal gradient holes across the portion of the anomaly that is located in Texas. All of these holes have temperature gradients in excess of 100^{o}C/km with two of them over 170^{o}C/km. An abandoned water well about two miles east of the line of gradient holes shows a gradient of 252^{o}C/km (in air). The locations and gradients measured in these holes are shown in Figure 2. Two electrical resistivity soundings in the immediate area indicate about fifty meters of high resistivity (45Ω-m) material overlying at least five hundred meters of low resistivity (8Ω-m) material.

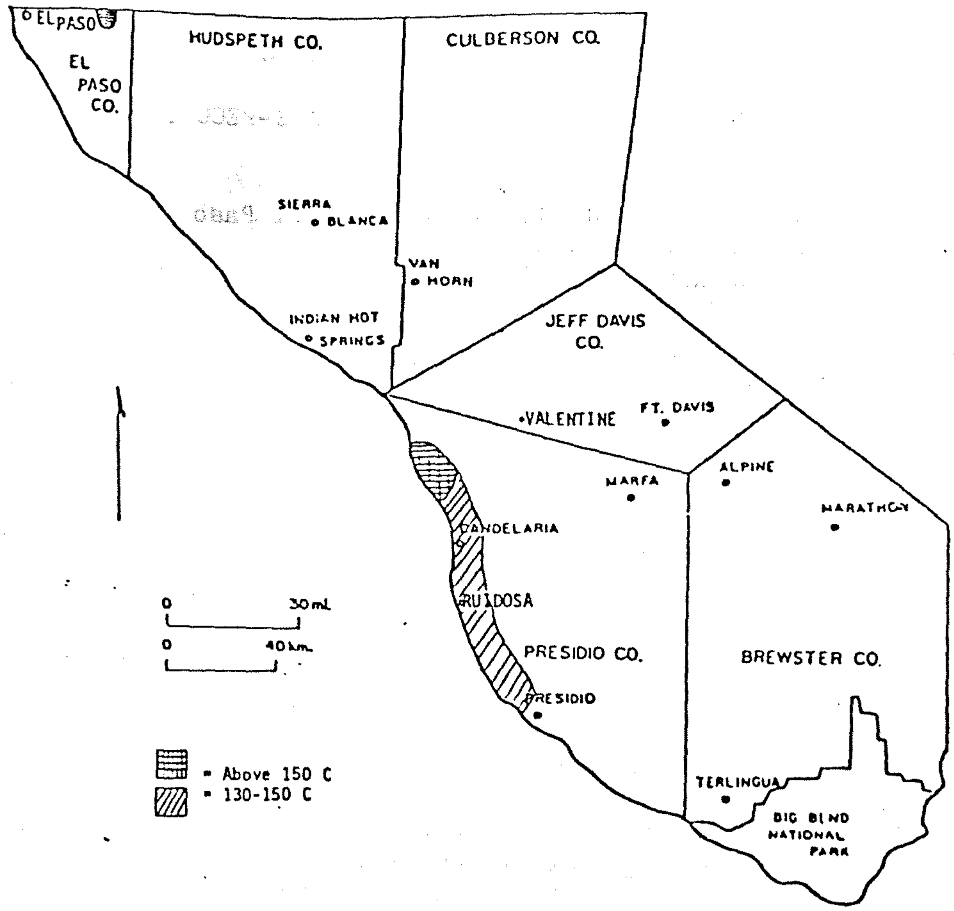


Figure 1. Geothermal gradient in Trans-Pecos, Texas as determined by silica geothermometry (after Hoffer)

The Hueco Tanks anomaly is a very promising locality for at least intermediate grade geothermal waters. To further define the resource, several more shallow gradient holes and one intermediate depth (300m) hole are planned in Texas. Extension of the current work into New Mexico is dependent upon further funding and cooperation from Fort Bliss Army Base which controls access to the area in New Mexico.

Presidio Bolson Area

Geothermal gradients have been measured in a series of approximately fifty 30 meter holes drilled several years ago by a private company doing geothermal exploration in Presidio County. These shallow holes are south of the area of higher temperature shown in Figure 1, extending from Capote Creek, near Candelaria in the north, to the Mesquite Ranch, on the western side of the Chinati Mountains, in the south. The gradients range from 10°C/km to 262°C/km. About one-third of the holes have gradients over 60°C/km. The higher gradients, in excess of 100°C/km, appear to be associated with known faults, thus providing geological targets for further exploration. Several more shallow holes in the region where the 262°C/km gradient was found are planned. In addition, the drilling and subsequent assessment of shallow gradient holes will be accomplished in the area north of Candelaria where the highest silica geothermometer readings were found.

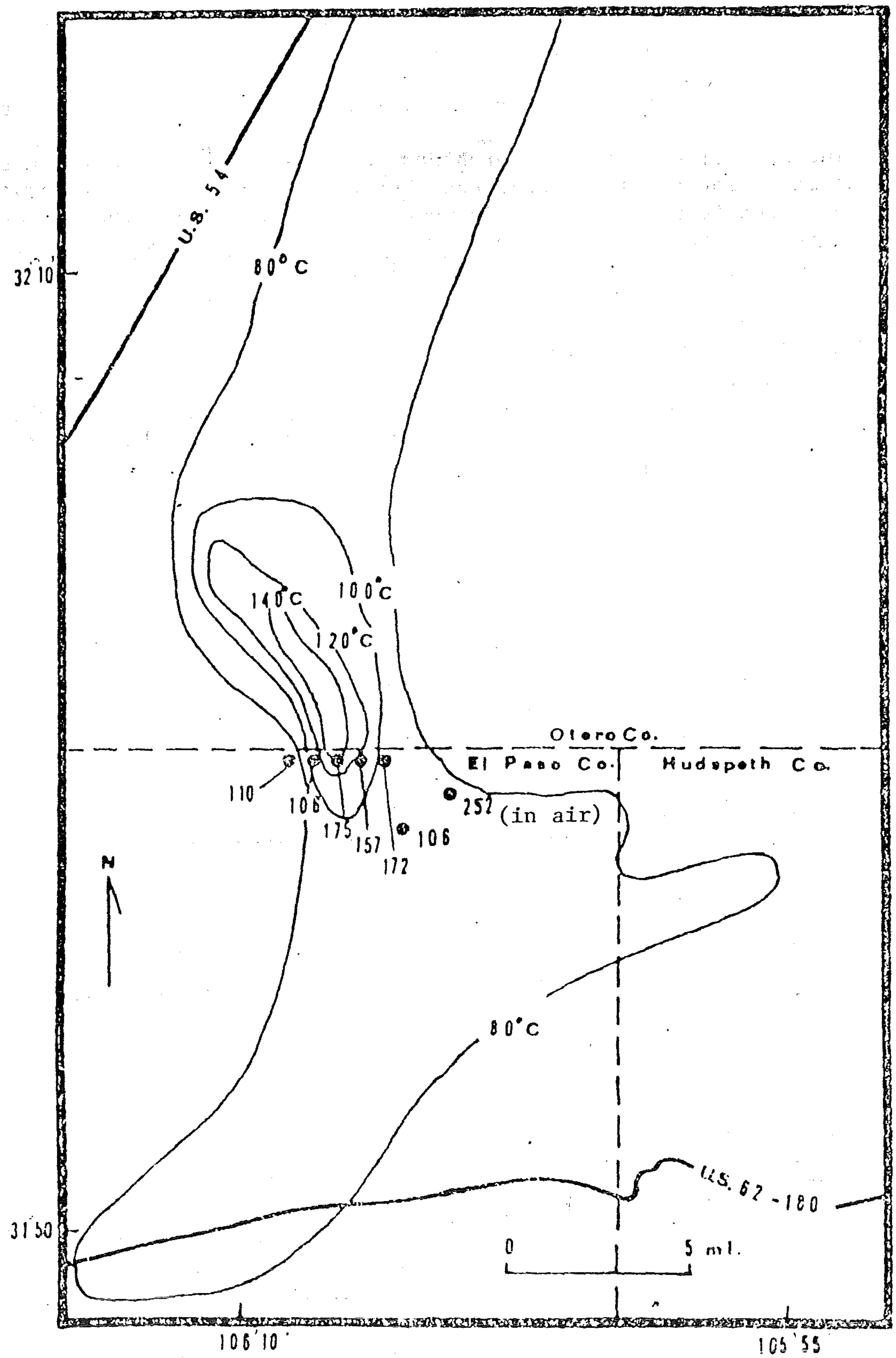


Figure 2. Location of gradient holes near Hueco Tanks. Gradients are in °C/km. Silica temperature contours after J.M. Hoffer (1979).

Hydrothermal ~~Setting~~ Resources
A. Geologic Setting

Read to Lucius
8/2/79

~~Introduction~~

There are three regions in Texas with significant geothermal potential: the Trans Pecos area along the Mexican border in west Texas, the Balcones Fault Zone in central Texas, and the geopressured regions of the Gulf Coast area.

Basin and Range Province (Trans-Pecos Region)

The Rio Grande Rift zone and associated basin and range faulting may extend into Texas along the Rio Grande River between El Paso and Presidio. This area consists of a linear series of sediment-filled basins, known as bolsons, with measured heat flows of 40-125 mW/m² (1-3.1 HFU), and thermal gradients of 30° to 70° C/km. Measured surface temperature of hot springs and wells in the area range from 47° to 80°C. Geochemical estimates of subsurface temperatures range from 60° to 160°C. These hot waters are probably the result of fault-controlled circulation of ground water to depths of 1-3 km in zones of elevated thermal gradient.

← MP Marquinal to the Trans-Pecos region, the Hueco Tanks area east of El Paso appears to be a zone of anomalously elevated thermal gradients, ranging from 100° to 250° C/km as measured within 50 meters from the surface.

The Balcones Fault Zone

The Balcones Fault zone and associated Luling-Mexia-Talco faults are a system of southwest-trending thrust faults extending from Grayson, Fannin and Lamar counties southwestward to the Austin and San Antonio areas. Measured thermal gradients along this zone range from 25° to 45° C/km within 1 km of the surface. Hot, saline well waters have been produced in this area for many years. Several wells in Marlin, Texas ~~commonly~~ produce 65° C saline water from depths of 2500 to 3500 feet. ~~[illegible]~~ In Atascosa County, deep aquifers produce saline waters as hot as 116° C. Most of the hot water in the Balcones Fault Zone comes from Cretaceous aquifers, primarily the Trinity sandstone of the Edwards formation. ~~However, the ultimate heat source of these thermal~~

This zone of anomalously warm, saline waters defined by complex faulting and Cretaceous aquifers may encompass as much as 40,000 square miles in central Texas

GEOPRESSURED

The Gulf Coast area of southern Texas consists of many ~~deep~~ sediment-filled basins. The pore fluids in these deeply buried sedimentary rocks are commonly under confining pressures greater than that attributable to the overlying load of sediments. This condition is known as a geopressured environments ~~system~~. Some geopress systems also contain hot saline water and dissolved methane gas, and are hence called geopressured-geothermal systems. [THE Average temperatures of deep, geopressured waters ranges from 140 to 160° C.] Both hot water and methane gas may be recoverable from geopressured-geothermal resources.

Shallow, lower temperature thermal waters are associated with geopressured geothermal systems along the Texas Gulf Coastal Plain (~~Figure~~ Fig). Measured gradients range from 20°C/km to more than 100°C/km at depth of 1 to 2 km. These shallow systems may be formed by water escaping from deeper, geopressured-geothermal systems.

The following are the USGS (Circular 790, p. 142) estimates of the potential geopressured-geothermal resource base in Texas.

	Sandstone	Shale	Total
Thermal	3,200	44,000	47,000
Methane	1,890	28,000	30,000
Total	5,100	72,000	77,000

(energies expressed in 10^{18} joules or Quads)

B. High-Temperature Resources (>150°C)

Confirmed Reservoirs: NONE

Prospects: Hueco Tanks area where gradients range from 100°C/km to 250°C/km, some deep geopressured systems.

C. Low-Temperature Resources (<150°C)

Confirmed Reservoirs: None

Prospects: The Trans Pecos region, especially near Presidio, the Balcones and Luling-Mexia-Talco fault zones of central Texas, some shallow geopressured systems.

D. Comments

High Temperature Resources:

Although thermal gradients in the Hueco Tanks area are promising, much more work is needed before the geothermal potential of this area can be accurately assessed. ~~Numerous problems~~ ~~face~~ The development of deep, geopressured resources requires drilling numerous deep, expensive wells. The highly saline composition of geopressured waters may ~~also~~ be a problem.

Low Temperature Resources

More work is needed before the low to moderate temperature geothermal potential of Texas is well known. Although the Presidio area in the Trans Pecos region shows promise, the low population density and high mean annual temperature may limit the potential usefulness of geothermal waters for space heating. In contrast, the poten resources in the Balcones Fault Zone ~~could be used~~ occur in populous a

References

- USGS Circular 790

- Fisher, W. L., 1978, Texas energy reserves and resources: Geologic Circular 78-5, Bureau of Economic Geology, Austin, Texas, 30 p.

REPD OVER PHONE
TO BEN LUNIS 6/26/79
DWS

Basin and Range Province (Trans-Pecos)

The Rio Grande rift zone and associated basin-and-range faulting may extend into Texas along the Rio Grande River south of El Paso between El Paso & Presidio (Figure 16). This area consists of a series of linear sediment-filled basins (bolsons) with measured heat flows of 40-125 mW/m² (1-3.1 HFU) and thermal gradients of 30° to 70°C/km. Temperatures of thermal waters in this region range from 30°-90°C. Measured thermal springs include ~~(see Figure 16)~~:

- Hot H2O due to circulation of 5.0 to depths of 1-3 km in area of high gradient
- Max spring surface temps = 47°C - 80°C
- Geothermometers subsurface T - 60°C - 160°C

Spring number[a] and name	Latitude, longitude (deg min)	Maximum temperature (°C)	Dissolved solids (mg/L)	Flow (L/s)	Heat discharge (MWt)	Minimum equilibration temperature (°C)	Local geothermal gradient (°C/km)
BASIN AND RANGE--Continued							
Texas (Trans-Pecos)--Continued							
29. Indian Hot Springs	30 49.4 105 18.9	***47	***8,230	6.7	.48	*60	**32
30. Capote Warm Spring	30 12.6 104 33.7	37	329	6.7	.45	*57	**40
31. Nixon Springs	30 08.0 104 36.1	32	507	<1	--	*60	**40
32. Hot Springs Ruidosa	30 02.3 104 35.9	45	549	1.25	.13	*55	**40
33. Las Cienagas Spring	29 47.2 104 27.7	30	723	16.7	.63	*60	**40
Big Bend National Park							
34. Big Bend #2	29 10.9 102 59.5	40	879	--	--	*40	**30
35. Hot Springs	29 10.8 102 59.7	41	884	--	--	*41	**30
36. Rio Grande Village	29 10.8 102 57.2	36	842	--	--	*36	**30
BASIN AND RANGE							
Texas (Trans-Pecos)							
28. Red Bull Spring	30 51.7 105 20.4	37	960	.8	.06	*56	**32

126 & 128. USGS Circ. 790

Marginal to the Trans-Pecos region, the Hueco Tanks area east of El Paso appears to be a zone of anomalously elevated thermal gradients. Thermal gradients range from 100° to 252°C/km measured within 50 meters from the surface.

Balcones Fault Zone

The Balcones fault zone and associated Luling-Mexia-Talco is an area of thrust faulting extending from southwest to northeast across central Texas (see Figure 16). Measured thermal gradients along this zone range from 25° to 45° C/km within 1 km of the surface. Well waters in the area ~~[illegible]~~ have temperatures as high as 70°C at depths less than 1400 m.

Hot waters been produced here for decades, generally quite saline. Example: Marlin TX 3770 ppm
Surface T° = 65°C
Well depths 2500-3500 feet

K aquifers Trinity / Edwards Fm but ultimate source may be deeper

T° of 116°C reported from deep, saline aquifers in Luling F.Z. in Atascosa Cty.
Balcones F.Z. in Waco & Austin areas

Zone of K aquifers, complex faulting & abnormally hot + saline H_2O
500 miles long / 75 miles wide extends from Grayson, Fannin & Lamar counties

Geopressured

The Gulf Coast area of southern Texas (Figure 18) consists of many deep sediment-filled basins. The pore fluids in these deeply buried sedimentary rocks are commonly under confining pressures greater than that attributable to the overlying load of sediments. This condition is known as a geopressured ~~system~~ environment. Some geopressured systems also contain hot, saline water and dissolved methane gas, and are hence called geopressured-geothermal systems. Both hot water and methane gas may be recoverable from geopressured-geothermal resources. Average temperature of deep, geopressured waters ranges from 140 to 160°C.

Shallow, lower temperature thermal waters are associated with geopressured geothermal systems along the Texas Gulf Coastal [illegible] (Figure 19). Thermal gradients range [illegible] °C/km to more than 100°C/km at depth.

of 1 to 2 km. These shallow systems may be formed by water escaping from deeper, geopressured-geothermal systems.

The following are the USGS (Circular 790, p. 142) estimates of the geopressured geothermal resource base in Texas.

	Sandstone	Shale	Total
Thermal	3,200	44,000	47,000
Methane	1,890	28,000	30,000
Total	5,100	72,000	77,000

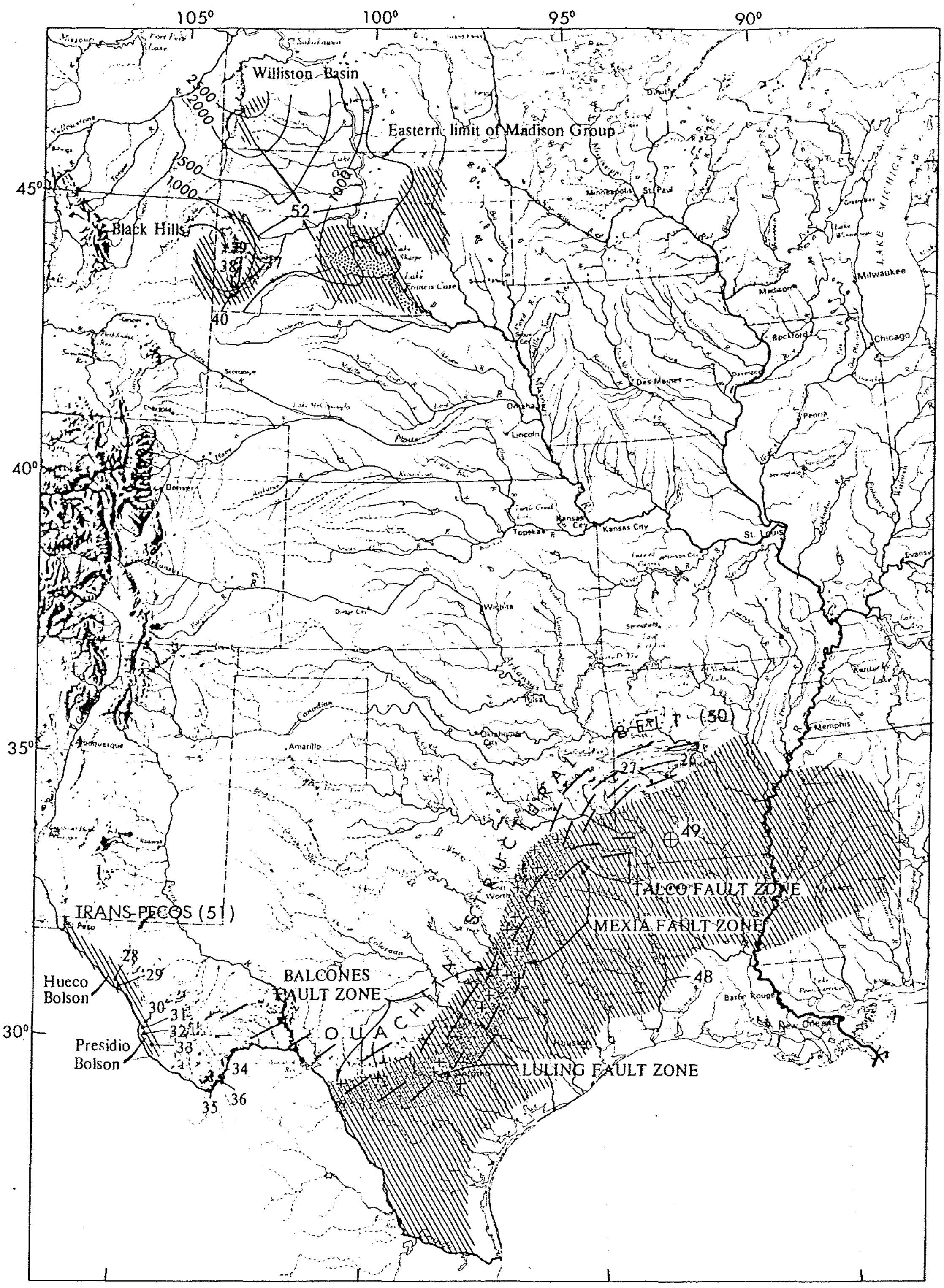


Figure 16.--Locations of known and inferred low-temperature geothermal waters in the Central United States.

FIGURE 16 LEGEND

EXPLANATION

Area most favorable for the discovery and development of local sources of low-temperature (<90°C) thermal water—Based on above-normal thermal gradients and heat flows measured in wells and test holes, and the known or inferred presence of extensive thermal aquifers at depths less than 1 km. See table 14 for description of these areas

48 Area where thermal gradients measured in wells and test holes are generally above normal and where some wells may produce thermal water from depths less than 1 km—In contrast to the "most favorable" areas, these areas have lower permeabilities in most aquifers, greater depth of occurrence or more limited areal extent of thermal waters, or inadequate information. See table 14 for descriptions of areas

Ouachita structural belt

—1000— Structure contour—Drawn on top of Madison Group, North and South Dakota. Depths in meters below land surface. Contour interval 500 m

26. Thermal spring having a surface temperature of 30°C or more (18°C or more in South Dakota)—Number refers to sequence in table 13

⊕49 Area of thermal brine wells in southwest Arkansas—Number refers to sequence in table 14

\+ Location of well in the Ouachita structural belt of Texas known to have above-normal thermal gradient and water temperature at depth less than 1 km

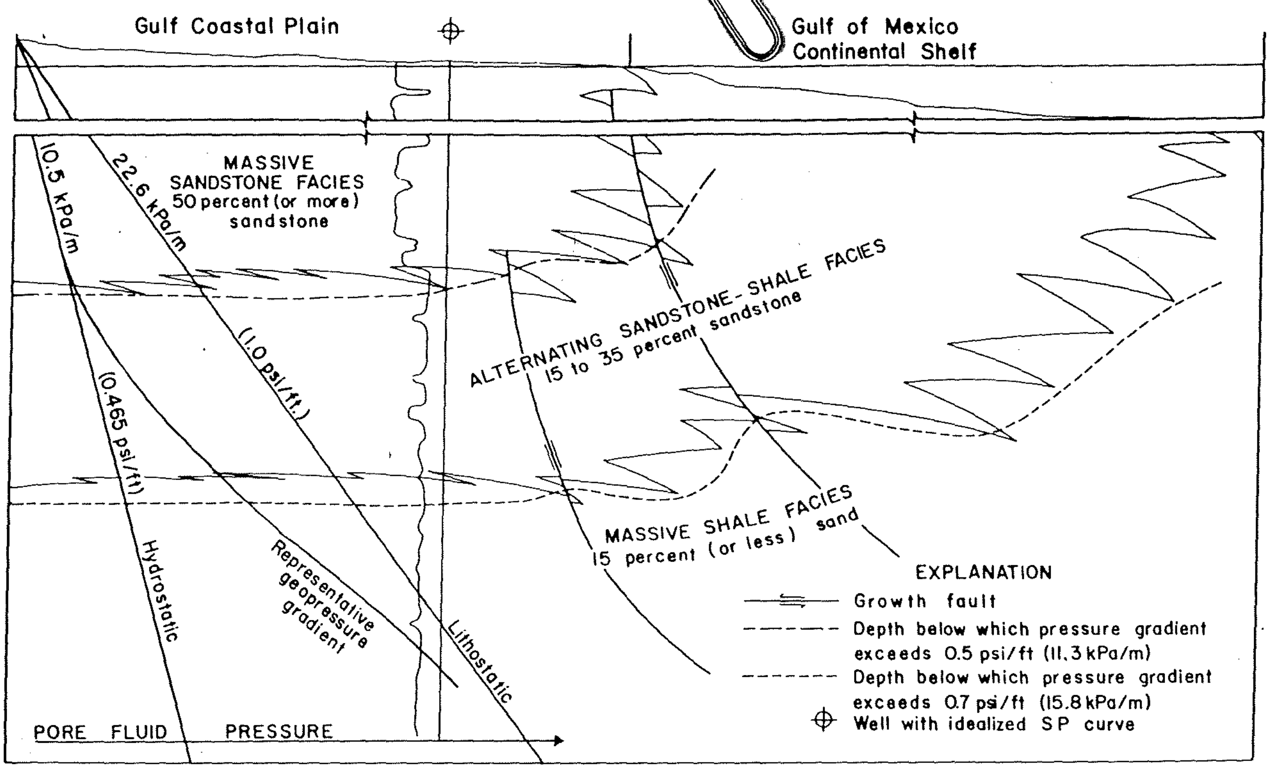


Figure 17.--Generalized sedimentary model of the northern Gulf of Mexico basin, based on percentage sandstone and showing, diagrammatically, the relation of gross lithology to fluid-pressure gradient and growth faulting (modified from Norwood and Holland, 1974).

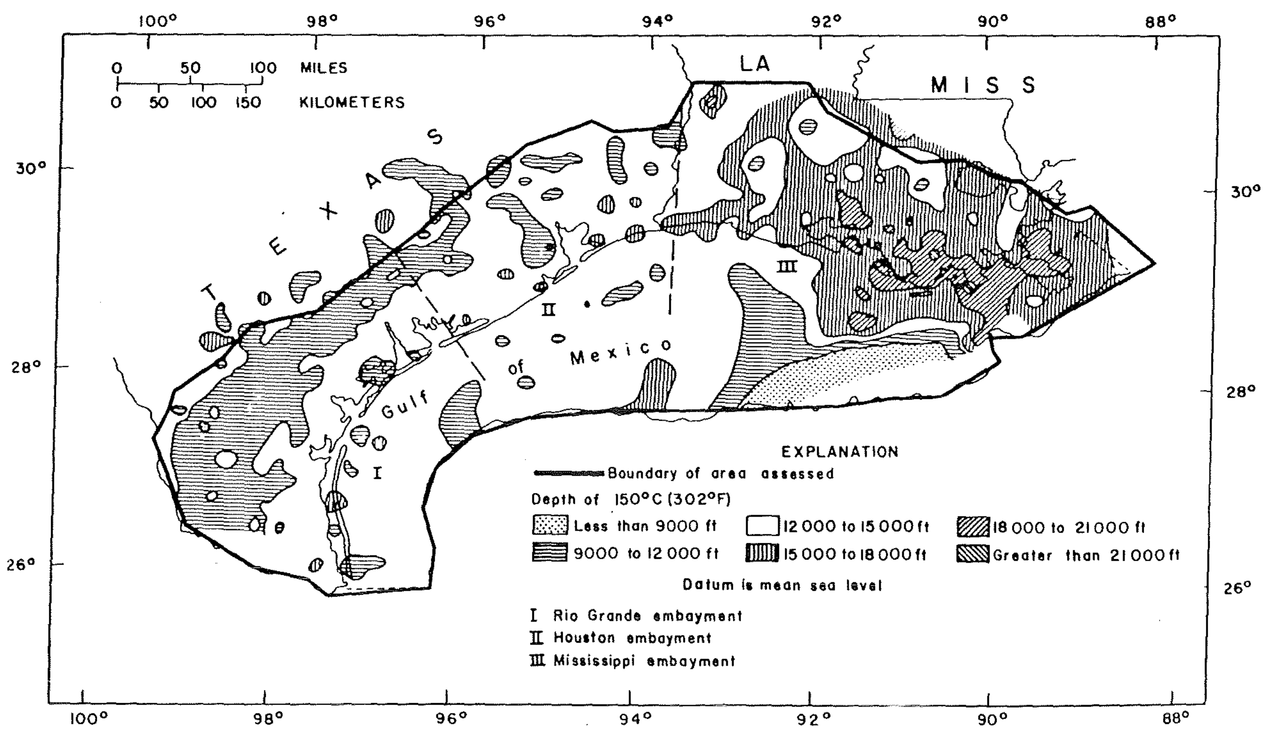


Figure 18.--Location map with assessment area boundary and showing the Rio Grande, Houston, and Mississippi embayments in relation to the depth of occurrence of the 150°C (302°F) isotherm.