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GL03851

GEOPRESSURE SYSTEMS

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The United States Gulf Coast appears to contain significant areas of potential geothermal resources. These resources underlie vast areas both onshore and offshore in coastal Texas and Louisiana. See Figure 1. Although other geopressure zones are known in restricted portions of the U.S., they have been formed by different geologic processes and are not considered as potential sources of geothermal energy at this time.

Due to a unique combination of factors involving the rapid accumulation and compaction of great quantities of sands and muds in the Gulf Coast area, overpressured aquifers, commonly referred to as geopressed zones, have been created in this young sedimentary basin. The waters in these zones, occurring at 10,000 feet to 15,000 feet below the surface, possess abnormally high temperatures. Due to the fact that waters contained in these aquifers are isolated from continued permeability channels to the surface, these waters support a portion of the overburden load, causing dramatic increases in pressure. A normal pressure gradient of .465 psi/ft is found above the overpressured regions, but abnormal pressures as high as .98 psi/ft are encountered within the geopressured region. Jones (1969) and Dorfman and Kehle (1974) give a detailed description of the geology and hydrology of the northern Gulf of Mexico Basin.

The principal geothermal zones in Texas and Louisiana are long linear high volume aquifers compartmentalized by subsidence or growth faults. These zones extend inland approximately 100 miles from the coast, and occur in successive parallel bands southward into the Gulf of Mexico. The top of the zone begins at depths of about 8,000 feet to 10,000 feet, and temperatures as high as

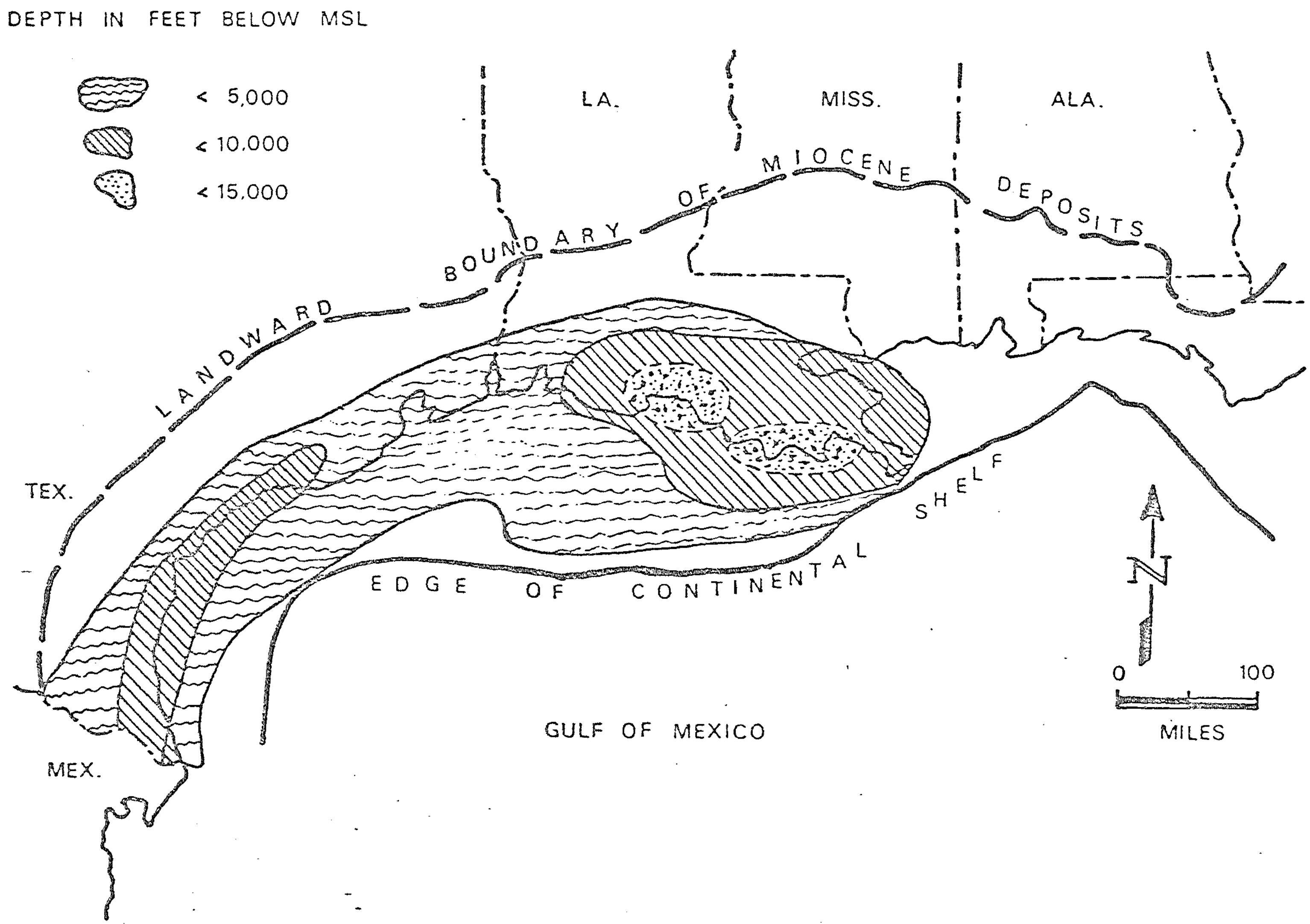

Figure 1: Areas of potential geopressure resources in the U.S.

520°F have been recorded in South Texas, although major sands generally contain temperatures in the range of 300-350°F. Waters within the geopressured zones appear to be contaminated primarily with methane in solution. Laboratory studies indicate that approximately 30-45 cubic feet of natural gas may be dissolved in each barrel of water. The solubility of methane is a function of pressure, water temperature, and salinity. Water within geopressure regions is generally much less saline than sea water, and usually contains less than 8,000 parts per million solids. In some instances, salinities as low as 1,000 parts per million have been noted. The reduction in salinity within the geopressured regions is caused by expulsion and hyperfiltration of water from adjacent shales due to thermal diagenesis of montmorillonite clays. Water is forced into geopressured sands by this process and saline connate waters in sands migrate upward along growth faults when pressures reach overburden (1 psi/ft). Thus, hypersaline water is found above geopressured zones and brackish water is found within these aquifers.

Fluids from geopressured zones have heretofore been ignored; however, recent increases in the cost of fossil fuels indicate that these low-enthalpy waters and their contained mathane may be economically attractive for exploitation for a variety of purposes. These would include the following: 1) generation of electric power utilizing hydraulic and thermal energy; 2) extraction of methane; 3) desalination of water; 4) various low grade heat and fluid processes including Frasching of sulfur, lithium-bromide refrigeration, paper and sugar processing, space heating, and others.

Drilling and well completion technology is available to allow drilling, completion, and production by processes that are standard in the petroleum industry. A very complete data base is available to locate geothermal anomalies, from well logs which have been run on every well drilled in the Gulf Coast Basin. These allow quantitative and qualitative determinations of rock and fluid characteristics to be ascertained with some confidence. Inasmuch as geothermal fluids have never been the specific objective of an exploration and testing program, there are several questions which require additional research at this time. These include the following: 1) Solubility of methane--it is assumed that geothermal waters will be fully saturated with methane. However, at this time there are incomplete data to support this assumption. 2) Well productivity--usage will require flow rates in excess of 1,000 gallons per minute which, in turn, will require sands having thicknesses of over 200 feet with good porosity and permeability. However, little information is available in the way of core and drill stem test data to assure large flow potentials. 3) Possible contaminants in water. No bottom hole fluid samples have been taken in geopressured zones, and therefore, the type and quantity of various dissolved solids are unknown. 4) Aquifer productivity. Aquifer drives may include expansion of water, compaction of rocks, influx of water from adjacent shales, and solution gas drives. These drives are complicated and have not been modeled or monitored as yet. Thus, total productivity cannot be well ascertained at this time but should be adequate to produce at least 300 M^2 bbl/well over a thirty year period. 5) Legal questions. Although the state of Texas has recently enacted legislation which defines the resources and enables rules and regulations to be established for exploration and drilling of geothermal wells, there are no provisions for well spacing or land-pooling of geothermal aquifers in either Texas or Louisiana. Commercial development will require that ownership of resources under private lands be defined, and that pooling provisions be enacted. 6) Environmental considerations. The principal environmental concern in geopressured aquifers appears to be the question of subsidence. Since reservoir drives and data on rock compressibility are not completely documented, evaluation and monitoring of potential subsidence can only be ascertained by drilling, core sampling, flow testing, and monitoring a well or wells in geopressured zones.

Production of geothermal fluids will determine whether the thermal energy can be harnessed to produce heat or electric power. Since the thermal energy must be utilized in close proximity to the source in order to avoid losses, power generation is the more likely use. Kinetic, or mechanical, energy readily lends itself to power generation in this instance, if a suitable hydroturbine can be developed. The natural gas can be used to generate power at the site or pipelined out of the area for use as fuel or chemical feedstock. It appears most likely that geopressured geothermal energy will, in the main, be used for electric power generation.

Technology is available, or in advanced stages of development, for generating power from this source. Hydroturbine driven generators are a proven device for recovering kinetic energy. Development will be required to adapt existing equipment to the high temperatures and high pressures and to the release of natural gas with decreasing pressure. This is known as the "total flow" concept and federally funded research is underway at the present time.

Utilizing a flashed steam cycle or a binary cycle to convert the thermal energy in a liquid heat source to electrical energy has been proven on a commercial scale for a number of years. The main problem to be resolved is the scaling propensity of the geothermal brine which can be determined by testing. The use of natural gas to fuel combined cycle power plants for high thermal efficiency is widely practiced throughout the United States today.

In the case of offshore reservoirs, power generating facilities can be erected on platforms. The availability of a limitless supply of cooling water and a ready means for disposal of the cooled geothermal water if reinjection is not required helps to offset the additional cost of the platform and the transmission facilities.

In order to provide answers to the viability of geopressured geothermal energy, various public and private research groups have initiated research which has as its ultimate goal the drilling of one or more geopressured geothermal wells and the establishment of a test bed facility for the generation of electric power and other uses. The following is a tentative timetable for this research effort:

I. Phase 0 - Management and Scope-of Work Study of the U.S. Geopressured Geothermal Resources
June 1975 - February 1976

II. Resource Assessment and Drill Site Selection
June 1975 - June 1977

III. Water Analysis (methane content)
September 1975 - December 1976

IV. Legal and Land Leasing
December 1975 - December 1976

V. First Reservoir, Initial Well
December 1976 - June 1977

VI. Production Testing
June 1977 - December 1978

VII. First Test Bed Facility
June 1977 - June 1979

VIII. Production Wells (Disposal Wells if necessary) - First Reservoir
June 1978 - June 1980

IX. Completion of One Pilot Plant Demonstration Facility
June 1981

X. Additional Exploration and Testing of Three Reservoirs, Texas and Louisiana
1980 - 1985

It is estimated that Steps I through IX will cost approximately $50 million.

Assuming that economic viability is established, and technological, legal, and environmental factors prove no impediment, commercial development might proceed in the following manner.

Assuming ten drilling rigs will be available for exploration and development, a 75 percent success ratio, and approximately five megawatts per well productivity, approximately 150 MW could be brought on line each year thereafter. The following table is an indication of the rate of estimated development:

YEAR	POWER PRODUCTION
1985	Beginning of a Commercial Development
2000	3000 MW

Commercial viability will depend upon the solution of certain critical problems. These include:

1. The ability to locate and drill reservoirs having suitable flow rates, temperatures, methane content and long range productivity to justify plant installation.

2. Demonstration that wells and surface equipment can successfully maintain sufficient mechanical and thermal efficiency over a long period of time.

3. Determination that environmental problems can be coped with successfully. These include potential subsidence, satisfactory water disposal, and resolution of thermal pollution effects.

Once commercial viability is established, the rate of growth of the resource will be dependent primarily upon the availability of drilling and production equipment and plant construction and materials.

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