GEOTHERMAL RESOURCES

AAPG Distinguished Lecture

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The total installed capacity of geothermal generating plants in the world today is approximately 630 megawatts (MW), distributed among the following five countries: Italy, 340; New Zealand, 190; USA, 50; USSR, 30; and Japan, 20. Although exceedingly small in comparison with the world's total generating capacity from conventional sources, the rapid growth of this new industry is reflected by the fact that approximately half of this present geothermal capacity has been installed during the last 10 years. The success of these installations is stimulating worldwide interest in geothermal energy, and exploration projects are now underway in Mexico, El Salvador, Chile, Turkey, Kenya, China (Taiwan) and the Philippines.

Although approximately 30 thermal areas have been drilled in the western United States during the past 10 years, only two are undergoing active development: The Geysers field in northern California, and the Salton Sea field in southern California. The Geysers field accounts for all the geothermal power production in the U.S., and although its present installed power generating capacity is only 50 MW, its drilled out and proven steam producing capacity is equivalent to approximately 175 to 200 megawatts. The Salton Sea field is being developed for the extraction of sodium and calcium chlorides.

The principal incentives for development of geothermal power are: a) the lack of more conventional sources in the market area, and b) the competitive economic position of geothermal power even in those areas where other sources are available. Geothermal sources generate low cost, base-load power even at capacities under 100 MW, making them particularly advantageous in market areas where power demands are still low. Low steam pressures make it necessary to use small generating units, i.e., on the order of 25 to 50 MW, but total capacities of several hundred megawatts can be expected from a single steam field.

All the thermal areas now under investigation share a common regional geologic setting. The areas are located in orogenic zones, where late Tertiary or Quarternary volcanism has taken place. The thermal areas, however, are not necessarily in close proximity to volcanic centers. Tectonically the regions are characterized by vertical movements, both uplift and subsidence, which have taken place on normal faults. Fault blocks, tilted consistently in one direction, appear to be more common than horst and graben structures. The geometry of fault block movement appears to be an important factor in controlling the location of shallow igneous intrusions, which are believed to be the source of heat for the high temperature thermal systems now being exploited for power generation.

Variations in local structure, stratigraphy and hydrology result in considerable differences in the geologic characteristics of individual steam fields. Fault zones, permeable strata, or a combination of both, can form thermal fluid reservoirs. Although it is now generally agreed that the heat sources are shallow intrusive bodies and the thermal fluid is at least 95 per cent meteoric in origin, there are still many fundamental problems as yet only partially answered: How is the heat transfer actually accomplished? Do phase changes occur in the thermal fluid under natural conditions or only when the system is under exploitation? What are the roles of convection currents and cap rocks in forming an economically exploitable deposit? What factors determine the life expectancy of the field?

Geothermal exploitation methods have not advanced far beyond the stage of merely drilling on hot springs, except in Italy where geothermal gradient surveys have been successfully applied. Recent results from deep resistivity surveys, however, indicate that this method holds considerable promise. Much progress has been made in understanding the chemistry of thermal systems and in the near future this knowledge should form the basis of effective exploration methods.

Although the successful development of geothermal resources offers a great challenge to exploration geologists and engineers, it offers no less a challenge to power legislators, planners and administrators. Because natural steam must be utilized when and where it is produced, successful development requires the closest cooperation between the exploration groups and the power marketing and distributing sector. Rapid development of geothermal power cannot be expected until these two groups, and the legislators who control their activities, arrive at a mutual understanding of each other's problems.

MUDDY SANDSTONE DEVELOPMENT IN THE RECLUSE FIELD, CAMPBELL COUNTY, WYOMING

Delivered before the Tulsa Geological Society, November 22, 1967.

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The Powder River Basin of Wyoming is the scene of intensive exploration drilling in search of oil production from the Muddy Sandstone (Newcastle Sandstone of Lower Cretaceous Age).

In June of 1967, the Recluse Field was opened by the drilling of the Apache Corporation No. 1 U.S. Fagerness, in the NW NW of Section 15-56N-74W, Campbell County, Wyoming. The Muddy Sandstone was encountered at a depth of 7,586 feet and a drill stem test from 7,550-7,641 feet recovered oil flowing at the rate of 20 BOPH. In a period of 16 months, over 80 producing wells have been drilled on 80-acre spacing. A reserve of 30 million barrels of primary oil has been established.

Subsurface studies show an elongate sand body running over eight miles in a northwest-southeast direction. The average width is one and one-half miles. Oil accumulation is due to stratigraphic entrapment. The deposition of the Muddy Sandstone appears to be a barrier-island-type deposit. The sandstone attains a thickness of forty feet. Thinning takes place at its base in a southwest direction and thins at its top in a northeast direction. This same geometry is present in the Galveston barrier island.

Studies of modern depositional environments such as the coast of the Gulf of Mexico can be of benefit in reconstructing ancient depositional environments of the Lower Cretaceous of the Powder River Basin of Wyoming. The length, width, direction, orientation and geometry of known modern barrier island deposits can be helpful in exploration and development of the Lower Cretaceous buried sand bodies.

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