and (3) hydrodynamic elements. Trap types recognized range from large closed anticlines with apparent horizontal hydrocarbon-water contacts to more obscure and subtle traps of unclosed structural/stratigraphic or stratigraphic type with notably nonhorizontal hydrocarbon-water contacts.

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OVERVIEW OF GEOTHERMAL ENERGY DEVELOPMENTS

Exploration for geothermal resources includes evaluation of the volcanic history of areas, regional hydrology, geochemistry of hot springs, and certain selected geophysical methods that determine temperature, heat flow, and structure of prospective areas.

Geothermal energy is used mostly for electric-power generation with current worldwide installed capacity of about 1,000 Mw. The only geothermal area in the world completely developed by private enterprise is at the Geysers in northern California, where it has proved to be a viable, mechanically reliable, and environmentally acceptable resource, competing economically with alternative forms of power generation in Pacific Gas and Electric Company's system.

Modern drilling for natural steam was started in the Geysers area in 1955. Pacific Gas and Electric's first power plant, with a 12.5-Mw electric-generating capacity utilizing this steam, went into operation in 1960. By 1970, four units of 82 Mw were on stream. With the annual completion of 110-Mw generating facilities beginning in 1971, the Geysers field is expanding rapidly and it produces today 400 Mw, with the field estimated to be in excess of 1,000 Mw in size.

The National Petroleum Council estimates that by 1985 about 15,000 Mw of geothermal power can be developed in the western United States. With improved exploration, drilling and utilization technology, and modification of certain institutional barriers it has been estimated that geothermal power may be of the order of 75,000 Mw by the year 2000.

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RED WING CREEK FIELD, NORTH DAKOTA—AN EXTRATERRESTRIAL HYDROCARBON TRAP

Red Wing Creek field is on the southwest flank of the Williston basin near the axis of the present basin. The field is centered in Sec. 27, T148N, R101W, McKenzie County, North Dakota. The discovery well was drilled by True Oil Company in August 1972.

Seismic and subsurface data indicate that rocks of Permian, Pennsylvanian, and Mississippian ages have undergone intensive deformation. This has resulted in steep dips and many reverse faults. Rocks of younger and older ages show relatively little tectonic disturbance. The primary trapping mechanism is the result of faulting and uplift of the producing horizons.

The field has 10 wells capable of production. There are six dry holes and one well is being drilled. Two wells have been drilled into the Red River Formation of Ordovician age. No commercial production has been found below the Mississippian.

Mission Canyon formation of Mississippian age is the primary producing zone. Some production has been found in the Kibbey, Charles, and Lodgepole formations, also of Mississippian age. The discovery well has more than 1,100 ft of net pay, making this the best well in the field. Porosities range as high as 25% but most of the reservoir has porosities in the range of 6 to 10%. Oil-water contact ranges from subsea depth of -7,300 to -7,500 ft. Reservoir studies indicate in excess of 100,000,000 bbl of oil in place.

Several theories have been advanced to explain the trap, including salt dome, reef, salt collapse, wrench faulting and astrobleme.

Present data have indicated that the field is producing from the central peak of a meteor impact structure of Jurassic age. The feature has been modified by subsequent salt collapse and differential compaction.

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U. S. GEOLOGICAL SURVEY PETROLEUM EXPLORATION RESEARCH IN ROCKY MOUNTAIN REGION

The roles of the U.S. Geological Survey relative to petroleum exploration and production commonly are ill understood by private industry. The Conservation Division of the Geological Survey is concerned primarily with regulation and supervision relative to oil and gas on public and Indian lands, whereas the Branch of Oil and Gas Resources of the Geologic Division conducts research that (1) contributes to improved exploration procedures, and (2) helps appraise the petroleum potential of frontier areas so as to advise the Executive Branch of Government. Successful cooperation between private industry and the Oil and Gas Branch clearly will further both aspects of this research.

Current research projects in the Rocky Mountain region fall into categories of "topical research" and "geographic research." Of particular regional interest are projects relating to indirect detection of hydrocarbons, generation and migration of hydrocarbons, porosity trends in sandstone reservoirs, Paleozoic source rocks, and Cretaceous structural and stratigraphic traps, among others.

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SUBSURFACE DISPOSAL OF FLUID WASTES IN SASKATCHEWAN

In the Williston basin region, deep-well disposal of industrial fluid wastes is confined largely to the Saskatchewan part of the stable, relatively shallow, tectonic shelf, which is flanked on the south by the deeper basin proper, and is delimited in the north by the Canadian shield.

As of mid-1973, 30 industrial disposal wells had been drilled in Saskatchewan: 20 were in operation, 5 suspended, and 5 abandoned. To year-end 1972, more than 118.995 million bbl of fluid wastes, exclusive of oilfield brines, had been injected into subsurface aquifers in Saskatchewan: (1) waste brines (63,440,000 bbl), resulting from shaft and solution mining, as well as experimental solution of Devonian potash deposits; (2) waste brines (50,930,000 bbl), produced during solution mining of caverns in Devonian halite for subsequent storage of liquefied petroleum gases and dry natural gas; (3) refinery effluent (3,530,000 bbl), comprising sour water and spent caustic from 2 plants; and (4) brines containing small amounts of mercury com-