on impermeable clay have been located away from the river floodplain. Pumping schemes for the transport of drainage water to the basins are proposed.

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ENVIRONMENTAL EFFECTS OF GEOTHERMAL ENERGY DEVELOPMENT

Most of the undesirable effects of energy usage come from the rejection of heat, waste products, and by-products during the steps of production, transportation, processing, and the conversion of chemical energy to thermal energy. Where geothermal energy can be substituted for coal, oil, or nuclear fuels, it will result in a net reduction of such adverse environmental impacts.

Geothermal developments appear to have a major impact when a field such as The Geysers or Wairakei is compared to an electric-power-production facility such as a fossil-fuel or nuclear-power plant. Industrialization, the drilling of wells and the building of pipelines and power plants, constitutes the main impact from geothermal developments. All other impact factors—noise from drilling, possible flashing of steam in separators, release of noncondensable gases, and disposal of spent fluids—can be handled by present technology with minimal investment. Many years of experience at the Larderello field in Italy show that geothermal developments can be compatible with other land uses, as farms, orchards, and vineyards cover much of the productive field with only minimal conflict between the two operations.

To give a true picture of the environmental costs from any power source, all steps from the mine to the final product must be added together. The geothermal-steam cycle has fewer steps, fewer energy inputs, and fewer hidden subsidies than any of the coal, oil, or nuclear processes. This simplicity of the geothermal-steam cycle lowers the net-environmental costs and enhances reliability. Because the geothermal-power cycle is self contained, it needs no outside support to maintain the production of electricity; there are no railroads or mines or complex processing facilities to be put out of service by a strike or natural catastrophe or by political decision in a foreign land.

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CONTROL OF EARTHQUAKES AT RANGELY, COLORADO

Following the experience with earthquakes at the Rocky Mountain Arsenal, it was recognized that there might be other places where earthquakes were triggered by fluid injection. In fact, Griggs suggested that it might be possible to control earthquakes by controlling subsurface fluid pressures. A seismic observatory at Vernal, Utah, reported many earthquakes near the Rangely oil field in northwest Colorado. The U.S. Geological Survey observed earthquakes in the field for one month in 1967 and established two active zones, both on the periphery of the field, both areas of waterflooding and high reservoir pressure.

In 1969, the U.S. Geological Survey began a four-year experiment to control earthquakes along one active fault. Through an arrangement with Chevron Oil Company, the operator of the Rangely unit, the U.S. Geological Survey gained operating control of four water-flood injection wells in one of the zones of earthquake activity. The experiment was conducted in three phases: (1) an initial phase of reducing fluid pressure, an attempt to stop the earthquakes; (2) a second phase of reinjection and increased pressure, an attempt to reactivate the fault; and (3) a fluid phase of reducing pressure, an attempt to terminate earthquake activity along the fault. The experiment was completed successfully during the summer, 1973. The results demonstrate conclusively that by controlling the effective stress through the injection and withdrawal of fluids, it was possible to control earthquakes, at least in favorable geologic environments.

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POTENTIAL FOR EXPLORATION AND DEVELOPMENT OF HYDROCARBONS IN PACIFIC COASTAL BASIN OF COLOMBIA

The Pacific Coastal basin of Colombia is an area of approximately 56,000 sq km between the Pacific Ocean and the Western Cordillera. However, it is one of the least explored potentially petroliferous areas in Colombia. Four wells (2 offshore, 2 inland) have been drilled and one (inland) is being drilled. Reasons for this low exploration effort may be found in the relative inaccessibility and inhospitable climate of the area. Unsuccessful results also may be traced to the lack of a concentrated effort at deciphering the regional geology and geologic history. Surface geology does not always reflect accurately the subsurface picture and in many cases it has masked the true underground structure.

Only after oil was found in the Putumayo (east of the Andes) during the earlier 1960s was interest renewed on the part of several of the major oil companies. This interest is revealed in the large acreage (3,660,000 ha.) and the increase in geologic and geophysical work (4,600 km of profile) recently performed both inland and offshore.

As a result of revised opinions and ideas, the area currently is regarded as one of promising potential for a country that badly needs to find new oil if it is to meet ever rising demands. Such potential appears clear, considering that sedimentary rocks in excess of 20,000 ft thick have accumulated in the basin, and that possible source rocks of both early Tertiary and Late Cretaceous age are present. Furthermore, many oil and gas seeps have been reported and noncommercial wells previously drilled had encouraging oil and gas shows.

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OIL AND GAS CONTENT OF SEDIMENTARY BASINS IN CIRCUM-PACIFIC BELT

The Circum-Pacific belt, more than 50,000 km long and from 600 to 5,000 km wide, is a complex of crustal structures which were developed at different times since the late Precambrian, have different makeup, and are confined to the common ring zone.

About 40% of all basins known in the world are within the Circum-Pacific belt. The sedimentary basins