

SHORT NOTE

Geophysical prospecting for geothermal resources in Mexico

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INTRODUCTION

Mexico is fortunate to possess a large geothermal potential. Experiments to harness this resource have been carried out since 1955, and 4 years later the first pilot plant with a capacity of 600 kW was inaugurated in Pathé, Hidalgo State. The state agency responsible for generation and distribution of electric power - Comisión Federal de Electricidad (CFE)-has plans to expand by the year 2000 the installed geothermal generating capacity to 2440 MW from the present 645 MW, which would represent 3.6 percent of the total electrical power generated in Mexico. Also other uses of geothermal resources are being developed.

At present, two geothermal fields are exploited, Cerro Prieto located in Mexicali Valley, Baja California, and Los Azufres, Michoacán. Two more fields, also of the high enthalpy type, will be brought into production in the near future (Los Humeros, Puebla; La Primavera, Jalisco). Important low-enthalpy geothermal resources are located in the Mexicali Valley (Riito and Guadalupe Victoria). CFE has gained geothermal expertise by exploration and exploitation of these geothermal fields. Considerable effort is at present directed to assessment of existing geothermal resources, exploration of key geothermal areas, reservoir engineering, and research and training activities.

Mexico possesses proven geothermal reserves for 1340 MW, and the potential is estimated at approximately 10000 MW. Exploration using geological, geochemical and geophysical techniques is conducted on a reconnaissance basis in new areas, such as Los Negritos, Michoacán; La Soledad, Jalisco; El Ceboruco Volcano, Nayarit; and Tres Vírgenes, Baja California. Detailed exploration continues in areas with economic geothermal fields such as Los Humeros and La Primavera. The studies are conducted in different geologic environments.

Several research institutes and universities are collaborating: Instituto de Investigaciones Eléctricas (IIE), Instituto de Investigación en Matemáticas Aplicadas y en Sistemas (IIMAS), and Instituto de Geofísica (IGF), all at the National University in Mexico City. Foreign and international institutions and agencies have been participating through cooperative and technical exchange agreements: the Lawrence Berkeley Laboratory in California, the National Electrical Energy Agency of Italy (ENEL), Japan International Cooperation Agency (JICA), and the United Nations Development Program (UNDP).

USE OF GEOPHYSICAL TECHNIQUES

Vertical electrical soundings, gravity, and magnetics are applied systematically in most of the geothermal areas. Recently, magnetotellurics (MT) has also been incorporated into the package of prospecting methods. Efforts are made to use thermal gradient and heat-flow measurements and geophysical well logging on a systematic basis. Other methods, such as tellurics, self-potential, induced polarization, active seismic (refraction, reflection), passive seismic (microseism, microearthquakes and teleseism), radiometrics (²²⁶Radon), and remote sensing have been applied in specific situations.

Due to its singularities, Cerro Prieto has become an experimental field where all these geophysical methods have been applied. The main objectives have been to (1) delineate the reservoir boundary and its mean depth, (2) study the effectiveness of geophysical methods in specific geothermal circumstances, and (3) investigate subsidence and temporal changes in geophysical parameters induced by the exploitation of geothermal fluids.

At present, about 30 out of over 500 geothermal areas have been studied using geological, geochemical, and geophysical methods. The results obtained with vertical electrical soundings have been satisfactory in volcanic environments. MT has been successful in areas of high surficial resistivity. Gravity and magnetics have proved useful in mapping geologic structures. Active seismic techniques (reflection and refraction) provided reliable information in sedimentary environments (Cerro Prieto). Recently, magnetics has been used for regional estimates of the depth to the Curie isotherm. Also paleomagnetism is being applied to stratigraphic, structural, and geochronological problems. Petrophysical parameters and resistivity are being studied and interesting correlations have been observed in the Los Azufres geothermal field. Also, the development of new equipment to record automatically vertical electrical soundings is high on the priority list.

PUBLICATION AND EDUCATION

Several specialized articles describing geothermal exploration in Mexico have been published in international journals, such as *Geophysics*, *Geothermics*, and *Geofísica Internacional* and in the *Bulletin of the Mexican Association of Exploration Geophysicists*. The proceedings of meetings organized by CFE presented results of geothermal research in Mexico. CFE sponsors also a new

O. Campos-Enríquez

journal, *Geotermia-Revista Mexicana de Geoenergía*, which publishes articles in all scientific fields related to geothermics.

Geothermal exploration using geophysical methods is included in the curriculum of universities in Mexico that offer degrees in geophysics. The engineering faculty at the National University in Mexico City offers a Master's degree in exploration of natural resources with geothermal exploration as one of the majors.

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