Integration of geophysical and geochemical data for the study of geothermal systems.

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Exploration geophysics and geochemistry/geochemical tools are widely used to investigate and characterize geothermal systems in the world. GIS (Geographic Information System) tools can be very useful in reservoir management as well as for site identification, coupling surface evidences (gas emissions, hot springs, etc.) with mapping of geophysical and geological informations.
Advanced geophysical and geochemical techniques are now applied to three different areas with three distinct problems:

- *Auachapan*

Presently, two geothermal fields are exploited in El Salvador, Ahuachapán and Berlín fields with installed capacity of 95 MWe and 105 MWe, respectively. The Ahuachapan geothermal field has been monitored systematically since 1975, and after 30 years of exploitation the field has experienced important changes such as pressure and temperature, plus changes in the fluids chemistry due to dilution and boiling processes. In order to study the past and present behaviour of the chemistry and some thermodynamic parameters of the Ahuachapan's geothermal reservoir, the relevant available data is being currently integrated in a GIS database. The basic aim of the ongoing study is to build maps showing spatial distribution, zoning and temporal changes of chemical, geophysical and related thermodynamic well parameters. Integration between geological, geochemical, and thermal data layers is used to determine the relationships between different reservoir parameters, and find out if such relationships are associated to likely downhole processes, e.g. boiling and dilution of the geothermal fluids.

- *Mount Endut*

Endut geothermal prospect area is located in Banten Province, Indonesia, about 70 km south from Jakarta. Geology of the area is dominated by quarternary volcanic, tertiary sediments and tertiary rock intrusion. NW-SE normal fault structures are recognized as responsible for tertiary intrusions and quarternary Endut volcano activities. A younger NE-SW faults is suggested to control thermal features of Cikawah hot spring and another NW-SE faults to control thermal features of Handeuleum hot spring (internal report). The water from Cikawah hot spring is characterized by chloride-bicarbonate composition, meanwhile the water from Handeuleum hot spring is characterized by bicarbonate. Silica and Na-K geothermometers indicate a deep temperature of about 180^{o}C. Available geophysical data include gravity, resistivity and magnetotellurics, that were obtained by the Indonesian Department of Energy and Minerals (2006).

- *Weh Island*

Weh Island is located in the northwest of Sumatra Island, Indonesia, and it is situated in the Andaman Sea, an active backarc basin. Weh Island has been interpreted as the remnant of a partially collapsed older center breached to the NW and filled by the sea. Volcanism is assumed to be of Pleistocene age.
Many typical geothermal surface manifestations such as hot springs, fumaroles and surface alteration zone are present over the island, following principal tectonic alignments. The study is based on collection and analysis of geothermal fluid samples (both hot springs and fumaroles) for chemical, gas and isotopic content. The geochemical data are integrated by the available geophysical and geological data. The data are interpreted and included in a GIS for a quantitative assessment of the geothermal potential of Weh Island through geothermal reservoir description focused on subsurface temperature, fluid origin, mixing and boiling processes and water/rock interaction.

The study is performed in the framework of ICS-UNIDO (International Center for Science and High Technology, United Nations Industrial Development Organization) geothermal program for technological transfer and research support to developing countries aiming at energy resources differentiation through the use of geothermal energy.