Geochemical Vectoring of Geothermal Systems

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Geochemical vectoring was first applied to geothermal exploration and development at the Lightening Dock geothermal play in the Animas Valley, southwestern New Mexico, resulting in a successful step-out well and a fluid-conduit resource model. This geothermal system is blind and most geophysical surveys had failed to identify specific fluid conduits.

Geochemical vectoring grew out of the Magma-Metal Series Chemical Classification of Igneous Rocks and Mineral Deposits, which was originally developed for the mineral industry and directly contributed to the discovery of 21 mineral deposits on 3 continents, worth more than $60 billion in Au-Cu-Ag. The classification screens a system for economic potential and then geochemical vectoring is applied to identify drill targets.

Geochemical vectoring is based on fractional differentiation— the idea that as a fluid plume moves from its source through the earth's crust to a depositional site, its composition and mineralogy changes in a systematic way due to decreasing temperature and pressure, and changing oxidation state. The resulting "chemical trail" and element dispersion plumes can be mapped and used to risk geothermal prospects. Geochemical vectoring of geothermal systems identifies patterns in traceelement geochemistry of soils, rocks, and drill core and cuttings. Through cluster analysis, element assemblages are determined. These are plotted on maps along with single-element contours and integrated with kinematic analysis of structures to define geothermal-fluid migration paths and reservoirs. From these maps, vectors are determined between and within assemblages, a fluid migration/deposition model is constructed, and drill targets are identified.

The Lightening Dock Geothermal System was emplaced in a Basin and Range trans-tensional, N-NE-trending graben. Formational and meteoric water is heated by a Pliocene- Pleistocene dry basaltic magma series exposed 12 miles to the south. "Dry" indicates that the orthomagmatic water content of the magma is less than 1 volume percent occurring in a gas phase. Thus, very little water was involved in the generation of the magma and very little water was assimilated during the magma's ascent through the crust. The water that carries the heat is meteoric and formational water with potential for minimal mineral precipitate. Of the geothermal systems known, systems with these characteristics produce the most favorable geothermal economics. According to the geochemical-vectoring patterns and kinematic analysis, the hydrothermal fluid plume at Lightening Dock migrated along the Animas Fault, which is the eastern bounding fault of the graben. At Lightening Dock, the fault jogs northward and the hydrothermal fluid turns northwestward and migrates along NW-trending Reidel tensional shears forming the geothermal reservoirs.