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Active Metamorphism of Upper Cenozoic Sediments in the Salton Sea Geothermal Field and the Salton Trough, Southeastern California

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Abstract

The Salton Sea geothermal system is entirely within Pliocene and Quaternary sediments of the Colorado River delta at the north end of the Gulf of California. At the time of deposition, these sediments consisted of sands, silts, and clays of uniform original mineralogic composition, but under the elevated temperatures and pressures of the geothermal system they are being transformed to low-grade metamorphic rocks of the greenschist facies. We have studied these transformations by X-ray, petrographic, and chemical analyses of cuttings and core from deep wells that penetrate the sedimentary section.

Temperatures within the explored geothermal system range up to 360° C at 7100 feet. The wells produce a brine containing over 250,000 ppm dissolved solids, primarily Cl, Na, Ca, K, and Fe, plus a host of minor constituents.

The original sediments consisted of detrital quartz, calcite, K-feldspar, plagioclase, montmorillonite, illite, dolomite, and kaolinite. Discrete montmorillonite is converted to illite at temperatures below 100° C, and illite-montmorillonite is completely converted to K-mica at temperatures below approximately 210° C. Ankerite forms by the conversion of calcite, dolomite, or both, at temperatures as low as 120° C, possibly as low as 80° C. Dolomite, ankerite, kaolinite, and Fe^{++} (probably from the brine) react to produce chlorite, calcite, and CO_2 at temperatures as low as 180° C and possibly as low as 125° C. At temperatures greater than approximately 290° to 310° C, iron-rich epidote and K-feldspar become abundant, calcite disappears, and K-mica is sporadic. Detrital Na-Ca plagioclase persists throughout the explored system, and at depth exists out of equilibrium with metamorphic albite. The most common metamorphic assemblage at temperatures of 300° C and above is quartz + epidote + chlorite + K-feldspar + albite ± K-mica. Pyrite, sphene, and hematite are also sporadically present.

Similar metamorphism occurs in the sedimentary section penetrated by the Wilson No. 1well, drilled to a depth of 13,433 feet 22 miles south-southeast of the

geothermal field. The lower-temperature reactions observed in the Salton Sea geothermal field also occur in Wilson No. 1, but at much greater depths owing primarily to the lower temperature gradient. Temperatures in this well reach only 260° C, insufficient for the formation of epidote and the destruction of calcite and K-mica.

The mineralogical transformations taking place in the Salton Sea geothermal field are metamorphic responses to the elevated temperatures and pressures. Some transformations such as the reaction of dolomite, ankerite, and kaolinite to produce chlorite, calcite, and CO_2 are regional in extent and pose no metasomatic requirements other than that the system be open to $H2_O$ and CO_2. Other relationships, such as the destruction of calcite and K-mica and the complementary formation of epidote, may involve interchange of elements with the brine.

The Salton Sea geothermal system displays a continuous transition from sediments through indurated sedimentary rocks to low-grade metamorphic rocks of the greenschist facies. This transition encompasses transformations commonly considered as diagenetic, and takes place without the formation of zeolites.

First Page Preview

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