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Sr, O, D, and S Isotopic Compositions of Celestine Deposits from the Tertiary Sivas Basin, Turkey

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Twenty-three of 28 different celestine deposits/mineralization/occurrences in host rocks of Eocene, Oligocene, and Miocene ages from the evaporitic Tertiary Sivas Basin have been studied. All of these deposits are associated with evaporites containing gypsum and anhydrite of sedimentary origin or as open space filling in the contact zone of sedimentary units associated with evaporites. Celestine has been classified as vuggy filling in Eocene shallow shelf-lagoon, nodular in Oligocene coastal sabkha-alluvial, and massive in Miocene shallow lagoon environments in the Ulas area. Strontium (^{87}Sr / ^{86}Sr), oxygen ($\delta^{18}O$), and sulfur ($\delta^{34}S$) isotopic ratios have been measured for 90 celestine and 5 gypsum mineral separates. $\delta^{34}S$, $\delta^{18}O$ values and $^{87}Sr/^{86}Sr$ ratios of celestine are between 20 and 40‰, 13 and 29‰, and 0.70558 and 0.70908, respectively. In contrast, $\delta^{34}S$, $\delta^{18}O$ values and $^{87}Sr/^{86}Sr$ ratios of gypsum range from 11 to 25‰, 13 to 8‰, and 0.70741 to 0.70782, respectively. A relationship between $\delta^{18}O$-$\delta^{34}S$ and $^{87}Sr/^{86}Sr$-$\delta^{34}S$ shows that only five or six of the celestine deposits and a couple of massive gypsum samples have signatures consistent with marine evaporites. High $\delta^{34}S$ values of celestine indicate that the dissolved sulfur in basinal brines had undergone partial reduction to sulfide, probably in a restricted non-oceanic environment. Seawater Sr isotope values are low in the Paleocene and get higher as the rocks get younger (Oligocene-Miocene). When compared to Cenozoic seawater, $^{87}Sr/^{86}Sr$ ratios of celestine minerals ($^{87}Sr/^{86}Sr$ = 0.70773–0.70786 in Paleocene; 0.70768–0.70788 in Eocene; 0.70776–0.70820 in Oligocene and 0.70819–0.70912 in Miocene) suggest that deep basinal brines may have mixed with other circulating fluids (meteoric hydrothermal) that had interacted with local volcanoclastic sediments and had undergone Sr isotope exchange.

$\delta^{18}O$ and δD data from celestine mineral separates of the largest open-pit celestine mine in the Sivas Basin (Akkaya, Eocene in age) have Tertiary Marine Evaporite signature, and are consistent with derivation primarily from seawater or a combination of seawater and meteoric-hydrothermal fluids.