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Depositional Setting and Paragenesis of Silica Nodules from the Middle Jurassic Curtis Formation on the Eastern Flank of the San Rafael Swell, Central Utah

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Abstract

In central Utah, outcrops of the Middle Jurassic Curtis Formation contain silica nodules with a distinctive botryoidal morphology (informally referred to a “grape agates”) formed by a complicated paragenetic history. Interpretations of the Curtis Formation in central Utah commonly describe shallow marine to marginal marine depositional environments. In contrast, on the eastern flank of the San Rafael Swell, the Curtis Formation exhibits sedimentary structures and stacking patterns that suggest a terrestrial origin: Thinly bedded, ripple laminated sandstones and brown limestones are encased in thick siltstones and shales and represent deposition on an arid fluvial floodplain comprised of crevasse splays, evaporative ponds, and siliceous sinters. The complicated depositional and geochemical relationship between these facies explains why silica nodules can be found scattered over many square miles in this location.

To understand the spatiotemporal distribution of silica nodules in the Curtis Formation, two partial stratigraphic sections were measured, 30 hand samples were collected, and thin sections were made from five hand samples for petrographic and SEM analysis. Petrographic analyses of the brown limestone beds that host the silica nodules show a primary composition of coarse calcite and silt sized detrital quartz grains. Gypsum and celestite are two accessory minerals observed in thin section and hand samples from these limestone beds. Based on field relationships between depositional facies, the stratigraphic location of silica nodules, and mineralogy, it is suggested here that these silica nodules formed on an arid floodplain in siliceous sinters that became evaporative ponds when the hydrothermal flow into the siliceous sinters ceased.

In thin section, silica nodules in these beds exhibit two distinctive botryoidal morphologies: 1) a spherical crystal with radial growth rings of chalcedony and a euhedral quartz in the center and 2) a spherical crystal with bladed opal that radiates outward from a central nucleus. The multiple quartz phases observed within the botryoids suggest that each morphology formed in an environment with different silica concentrations. Botryoids composed of radial opal formed in an environment with higher silica concentrations as compared to the botryoids composed of chalcedony and euhedral quartz. Initial water chemistry in these siliceous sinters fostered the growth of spherical botryoids of opal-A and opal- CT. As the silica concentration decreased in the ponds, chalcedony and eventually euhedral quartz formed. When the silica rich hydrothermal fluids ceased flowing into the sinter, water chemistry switched from silica dominated to carbonate dominated and the ponds precipitated calcium carbonate, gypsum, and celestite marking the last phase of mineralization in these environments.

Student Posters   Tuesday, July 26   5:30 PM