pre-200-m.y.B.P. formation of the evaporite minerals and stability of the rocks since that time.

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Tertiary Mineralization in Part of Grants Mineral Belt, New Mexico

Mineralization in the Grants mineral belt, except for minor occurrences of secondary minerals, is commonly attributed to several distinct periods: (a) early epigenetic (Late Jurassic), (b) early redistributed (middle Cretaceous), or (c) late redistributed (Laramide). Previous geochronologic studies have supported the geologic data favoring these periods of mineralization. More recent geologic studies indicate post-Laramide mineralization, although the source for the uranium may well have been from an older, destroyed deposit as opposed to an entirely new supply of uraniferous solutions. Work on clay minerals formed penecontemporaneously with uranium mineralization at the Silver Spur Mine (host rocks, Dakota) and the Doris Mine (host rocks, Morrison) yield Rb-Sr isochron ages of 41 ± 9 m.y.B.P. with initial Sr(87/86) = 0.715 ± 0.001 and 44 ± 7 m.y.B.P. with initial Sr(87/86) = 0.724 ± 0.001. These clay minerals formed in the presence of fairly radiogenic ^{87}Sr as Sr(87/86) from pre-ore, host-rock calcites yields 0.709 ± 0.001; thus simple, in-situ rehomogenization of Sr isotopes did not occur. Further, at least two other suspected occurrences of Tertiary mineralization in the Churchrock district do not yield isochrons at all, but the preceding Rb-Sr data plot references 135, 120, and 90 m.y.B.P. isochrons with initial Sr(87/86) = 0.710. These data suggest incomplete rehomogenization of Sr isotopes during the Tertiary. At present the data suggest, but do not prove, a period of Tertiary mineralization in the Grants mineral belt at about 35 to 50 m.y.B.P.

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Uranium in Permian Cutler Formation, Lisbon Valley, San Juan County, Utah

The Cutler Formation is composed predominantly of fluvial arkosic sandstones, siltstones, shales, and mudstones deposited by meandering streams that flowed across a flood plain and tidal flat. Sedimentary structures indicate two types of channel deposits: meandering and distributary. The area was occasionally transgressed by a shallow sea from the west, resulting in the deposition of several thin limestones and marine sandstones. The marine sandstones were deposited as longshore bars. Wind transported sand along the shoreline of the shallow sea, forming a coastal dune field. Marine and eolian sandstones are more common in the upper part of the Cutler Formation in the southern part of the area, whereas in the central and northern part the formation is predominantly fluvial. Cross-bed orientation indicates that streams flowed S67°W on the average, whereas longshore marine currents moved sediment S36°E and N24°W, and onshore wind transported sand S80°E.

The uranium in the Cutler Formation is found in the central and northern part of the area, in the upper part of the formation, in fluvial sandstone bodies that were deposited in a distributary environment. No uranium is known in the marine or eolian sandstones. Petrographically, the uranium-bearing sandstones are identical to other Cutler fluvial sandstones except that they contain less calcite cement and more clay and are slightly coarser grained. The diagenetic sequence indicates that uranium and vanadium were introduced late in the sequence, after oxidation had formed hematite and before the formation of calcite cement. Ore formation has modified the host sandstones very little.

The uranium and vanadium minerals are finely disseminated and thus difficult to identify but seem to include some uraninite, coffinite, uranophane, and carnotite. Much of the uranium is associated with iron oxide grain coatings and matrix. The uranium and vanadium are present together and independently. Both calcium and iron are depleted, and barium is concentrated in the ore zone. No significant organic carbon was found in the ore zones, and small amounts of selenium are concentrated at the base of the ore zones.

Formation of these orebodies has occurred without any obvious reductant. Perhaps sorption of uranyl by hematite was the concentration mechanism. The time of formation is not known; evidence is present for both a Permian age and a Triassic or younger age.

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Stratigraphy and Depositional History of Thousand Pockets Tongue of Page Sandstone and Crystal Creek Member of Carmel Formation (Middle Jurassic), Southwestern Utah

Between the East Kaibab monocline and Zion National Park in southwestern Utah, gray, cliff-forming, cross-bedded quartz sandstone of the Thousand Pockets Tongue of the Page Sandstone grades northwestward into red, slope-forming, flat-bedded quartz sandstone of the Crystal Creek Member of the Carmel Formation. On the basis of stratigraphic position, both members are considered Bathonian in age. Coastal deposits of the Thousand Pockets Tongue prograded northwestward and interfingered with contemporaneous submarine deposits of the Crystal Creek Member along a northeast-southwest trending shoreline of the Middle Jurassic seaway.

The Thousand Pockets Tongue is divided into three parts characterized by distinct sedimentary features and paleoenvironments. The gray lower part contains cross-bedded eolian sandstones (cross-bedded sandstone facies) which grade into evenly laminated and cross-bedded beach sandstones (Round Valley Draw facies). The red middle part is characterized by flat laminations, echinodern fragments, and a distribution which suggest a lagoon/tidal-flat environment. In the gray upper part, cross-bedded sandstones of eolian origin (Paria Canyon facies) grade into evenly laminated and cross-bedded beach sandstones (yellow sandstone ledge facies) and locally enclose red, flat-bedded units deposited in a washover channel-wind-tidal flat complex (red lenticular sandstone facies). The Crystal Creek Member is typified by evenly laminated, massive, and cross-bedded units and a lateral facies relation which suggest a lower beach and subtidal environment where storm and tidal currents dominated.

Cross-stratification measurements from eolian facies in lower and upper Thousand Pockets Tongue indicate north-northeasterly winds during Bathonian time. The marginal-marine and submarine interpretation of the red beds in the Thousand Pockets Tongue and Crystal Creek Member, respectively, lends support to a diagenetic origin for the red color of these beds.

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