Formation along the outcrop belt from Cachana Spring north to Cuba suggests that additional uranium deposits may exist at the boundaries of oxidized and unoxidized sandstone in the subsurface along the eastern margin of the San Juan basin.

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Application of Solution-Mineral Equilibrium Chemistry to Solution Mining of Uranium Ores

Modern methods of solution mining are typically accompanied by gains and losses of mass via reagent consumption by rock-forming minerals and subsequent clay-mineral formation. A systematic approach to alleviation of such problems involves the application of leach solutions which are in equilibrium with the host-rock minerals but in disequilibrium with the ore-forming minerals. This steady state can be achieved by solution composition adjustments within the systems K_2O-Al_2O_3-SiO_2-H_2O and Na_2O-Al_2O_3-SiO_2-H_2O. Uranium ores from the Grants mineral belt of New Mexico containing 0.15 to 1.0% U_3O_8 were collected for investigation. Small-scale (≤ 1 kg) column leaching experiments have been conducted to compare results of conventional leaching systematics with those obtained with solutions in equilibrium with the matrix minerals. Application of these principles will have considerable bearing on future in-situ leaching of uranium ores.

RIESE, WALTER C., Gulf Mineral Resources Co., Albuquerque, N. M., and DOUGLAS G. BROOKINS, Univ. New Mexico, Albuquerque, N. M.

Mount Taylor Uranium Deposit, San Mateo, New Mexico

The Mount Taylor uranium deposit is located at the extreme eastern end of the Ambrosia Lake district in the Grants mineral belt of New Mexico. Ores are confined to the Westwater Canyon Member of the Jurassic Morrison Formation and are spatially related to meanders in the paleochannels which deposited the arkosic sands of this member. The shape of the deposit roughly resembles the roll fronts of the Wyoming Tertiary basins.

This deposit resembles the deposits of the Wyoming basins chemically as well. Arsenic, selenium, molybdenum, and several other less commonly analyzed trace elements occur in zones across the orebody, parallel with the direction of dip and indicative of a redox cell.

Mineralogically, however, the Mount Taylor deposit differs significantly from those in the Wyoming basins and, surprisingly, from most of the other deposits in the Ambrosia Lake district. It does not reside at an iron redox interface nor is it very pyritiferous. It does have concentrations of calcite along its downdip and bottom edges. Montmorillonite, chlorite, and kaolinite show a regular zonation from the unaltered downdip sediments, through the ore zone, and into the updip altered sediments. No primary uranium-bearing minerals have been identified.

The deposit shows a complex relation to organic materials in the sediments, indicating two periods of organic enrichment of the sediments. The nature of this relation implies that organic transport mechanisms may have been as important in ore genesis as inorganic mechanisms.

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SEM Investigation of Paragenesis of Uranium Deposits, Grants Mineral Belt, New Mexico

Scanning electron microscopy (SEM) study of authigenic minerals in the Westwater Canyon Member of the Morrison Formation (Late Jurassic) indicates that mineral compositions vary within and adjacent to sandstone-type uranium deposits. Montmorillonite is the dominant clay mineral in the reduced ground downdip of the orebody; chlorite is enriched in the ore zones; and kaolinite and altered montmorillonite dominate in the "oxidized" ground updip of the ore. Our data also suggest that clay minerals, not pyrite or hematite, may locally be the iron-bearing species of importance.

Although it is not possible to make positive identification of organic materials in SEM photomicrographs, materials deduced to be organic in nature postdate the beginning of authigenic clay formation. This implies that these materials may be carriers of uranium in the groundwater system from which the ore deposits precipitated.

Identification of these patterns of clay-mineral alteration and the role that organic materials may play as transporting media may significantly alter our exploration techniques. These patterns may be especially useful tools in areas where the orebodies are known to be removed from the iron species redox interface.

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Geology of Eastern Smith Lake Ore Trend

The ore trend explored by Western Nuclear, Inc. at Smith Lake, lies in approximately six sections in T15N, R13W of McKinley County, New Mexico. All of the orebodies lie within the Brushy Basin Member of the Jurassic Morrison Formation which contains essentially three distinct sandstone units at this location. For exploration purposes this breakdown is adequate, although the sandstones do become exceedingly complex on a small scale.

The Smith Lake ore lies along the southern margin of the Chaco slope. The regional dip is quite uniform at about 2° north-northeast. North of the deposits running subparallel to the east-west ore trend is the Mariano Lake anticline. At the west end, the anticline dies out at the Pinedale monocline and does not extend to the Bluewater fault zone on the east. The Bluewater fault is a normal, high-angle fault, downthrown to the east, and essentially forms the eastern boundary of the area.

The orebodies are aligned approximately east-west and are generally arcuate. The geometry of the ore is controlled by the stream-channel systems in the Brushy Basin sandstones. Some of these orebodies coincide with the redox interfaces that have been found. Those that do can assume the geometry of a typical roll-front type of orebody.

Three hypotheses for depositional controls are: (1) Laramide structures are spatially associated with the ore and have been considered by some geologists as a depositional control; (2) the change of lithologies from sandstones to mudstones down the hydraulic gradient also may have affected ore deposition; and (3) stream channel systems with carbonaceous material localizing the ore is a viable control as well.

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Mineralogical and Geochemical Zonation Across Roll-Type Uranium Deposits—Mariano Lake Type

The mineralogy and chemistry of samples from the cores obtained across Mariano orebody were determined and used to develop exploration tools for roll-type uranium deposits. Preliminary interpretations regarding the physicochemical conditions of ore deposition were made on the basis of paragenetic relations.

The host sandstones are confined between the bentonitic rock units, and contain scattered intercalations of detrital montmorillonitic material in the form of clay galls, stringers, and lenses derived from these bentonites. Authigenic clay minerals identified in the host rocks include cellular montmorillonite, platy chlorite, and pseudohexagonal "books" of kaolinite. The cellular montmorillonite is concentrated in the oxidized zone and appears to have formed prior to ore deposition. Authigenic chlorite is most abundant in the ore zone and has formed at the expense of cellular montmorillonite; its formation is interpreted to be related to the ore-forming processes. Kaolinite in sandstones is the last clay mineral to form, and is enriched in the reduced zone. Calcite, considered typical of such deposits, is found to be lacking in this orebody.

Iron-titanium oxides and their alteration products are the most abundant heavy-mineral species in the host rocks. In addition to anatase and rutile, the alteration products include hematite in the oxidized zone and pyrite in the ore and reduced zones. Carbonaceous material introduced later into the potential ore zone appears to have been responsible for the decomposition of Fe-Ti oxides and formation of pyrite.

The oxidation of pyrite by mineralizing solutions, resulting in reduction and subsequent deposition of uranium, is indicated by the paragenetic relationship. The positive correlation between organic carbon and uranium suggests that carbonaceous material also acted as a reductant for uranium.

A discriminant analysis was run using the chemical data to distinguish the geochemical zones (oxidized, ore, and reduced). Of the 15 variables used in this analysis, it was determined that the three zones could be separated using only six variables (Th, U, V, Zi, Ti, and Mn). The discriminant functions thus formulated could possibly be used to classify unknown samples in the area studied.

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Tertiary Oxidation in Westwater Canyon Member of Morrison Formation

Hematitic oxidation in the Westwater Canyon Member of the Morrison Formation extends along the outcrop from the Pipeline fault northeast of Gallup, New Mexico, to the San Mateo fault north of Grants, New Mexico. The hematitic sandstone forms a broad lobe in the subsurface to a depth of 730 m (2,400 ft). The downdip edge arcs eastward from northeast Church Rock through Crownpoint, and southeastward to the west edge of the Ambrosia Lake district. The red sandstone is bordered on the downdip side by a band of limonitic oxidation which interfingers with reduced sandstones basinward. The limonitic oxidation forms a relatively narrow band along the north and west sides of the hematitic lobe, but expands progressively on the east and southeast. Weak limonitic oxidation, as indicated by the absence of pyrite and a bleached to faint yellowish-gray color, appears to extend from the San Mateo fault eastward under Mount Taylor to the Rio Puerco.

The hematitic oxidation is epigenetic and is believed to be of late Miocene to early Pliocene age. The limonitic oxidation follows the present groundwater flow pattern and probably dates from late Pliocene to recent. The oxidation patterns are important in uranium exploration because the hematitic area is essentially barren, whereas the limonitic areas contain ore deposits which are in the process of being destroyed by oxidation.

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Redistributed Orebodies of Poison Canyon Mine

Since the early 1950s Poison Canyon has been a classic example of uranium geology. At the present time, because of economic conditions, a closer examination of the redistributed mineralization is being made.

Because of the evolution of the structure and geomorphology of Poison Canyon, the primary mineralization went through further oxidation and reduction. Enriched solutions of uranium migrated downdip through permeable sandstones, with calcium replacing silica near mudstone contacts. These solutions were controlled by north-trending fracture patterns, with some vertical movement along major faults. The uranium collected in structural and lithologic traps, then oxidized, forming amoebalike orebodies with the higher grade mineralization located in the fractures. The authigenic mineral is mainly tyuyamunite in the hexavalent state in sands deficient in carbon and associated, although rarely, with pascoite and ilsemannite.

The equilibrium of the primary minerals differs from that of the redistributed minerals. The uranium has been leached from the primary minerals causing chemical values to be less than radiometric. The redistributed minerals are chemically greater than radiometric, producing a favorable equilibrium. Also, the percent extraction in the mill process is greater for the redistribut-