ore-reserve correction factors have been assigned, one to each of three longitudinal zones. This use of multiple correction factors will optimize mine planning and uranium recovery.

Vertical profiles of radiometric and assay data through ore zones show dispersion of daughter isotopes away from uranium concentrations. Horizontal data plots show removal of daughter isotopes from the northeastern edge of the deposit and fixation of daughter isotopes in the central and southwestern parts of the deposit. Local loss of uranium is also suggested in the central and southwestern parts of the deposit. It is hypothesized that recent groundwater flow from east to west has redistributed the isotopic species. This flow system caused both the local vertical migration of daughter isotopes and also the transport of daughter isotopes and uranium in the direction of the hydrologic gradient. These conclusions are based wholly on chemical and gamma-equivalent uranium assays.

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Mineralogy and Geochemistry of Mariano Lake Uranium Deposit, Smith Lake District, New Mexico

The Mariano Lake uranium deposit is located on the west side of the Smith Lake district of the Grants mineral belt. Mineralization is restricted to a basal arkosic sandstone of the Brushy Basin Member of the (Jurassic) Morrison Formation. This sandstone, called the Poison Canyon sandstone (economic usage), consists of a sequence of paleochannels in which mineralization has been deposited in a roll-type tabular deposit. This roll front is directly related to an oxidation-reduction interface.

Chemically, the deposit is somewhat different from other Grants mineral belt deposits. Calcium and CO_3 content are low, but V, Ba, and S are relatively abundant. Sulfur found in pyrite is also possibly associated with uranium sulfates. Titanium is found as a secondary oxide, derived from titanomagnetites of the originally deposited mineral assemblage. Molybdenum, arsenic, and other trace elements show a regular zoning across the deposit, but cerium is slightly depleted.

The mineralogy of the Mariano Lake deposit includes abundant disseminated pyrite in mineralized reduced areas and hematite in the oxidized barren areas. Calcite, barite, gypsum, and jordisite are rare. Clay mineralogy includes kaolinite, chlorite, illite, and mixed layer illite-montmorillonite. Contrary to what has been found in other deposits of the Grants mineral belt, zonation of the clays is reversed, with kaolinite being more abundant in the downdip reduced sediments. The phenomenon is thought to be the result of backwash off the south-dipping flank of the Mariano anticline.

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Uranium in Todilto Limestone—Sabkha-Like Deposit

The Todilto Limestone was deposited in or near a large lake that at times became restricted and evaporated to dryness. The formation has two members: a lower limestone and an upper gypsum member. The limestone member has been divided informally into three zones: the lower "platy" zone, a middle "crinkly" zone, and an upper "recrystallized" zone. The platy zone is interpreted to have been deposited below wave base under anoxic conditions. The crinkly zone has thin stromatolitic laminations and may form algal domes. The upper recrystallized zone appears in part to be a collapsed breccia caused by the removal of interbedded gypsum. Uranium ore is restricted primarily to the "crinkly" and recrystallized zones. These two zones may have been formed in a sabkha-like environment.

A. R. Renfro has proposed a sabkha origin for some stratiform copper deposits. The same conditions that cause copper to precipitate would also cause uranium to precipitate. Groundwater bearing U^{+6} could be drawn upward by evaporative pumping through the decaying algal-mat zone where the uranium would be reduced to U^{+4} and precipitated. Carbonate materials lithify early destroying permeability so that uranium emplacement must occur before lithification. Radioisotope dates on uraninite in the Todilto Limestone indicate ore emplacement shortly after deposition. Uranium-bearing groundwater moved basinward in the underlying Entrada Sandstone and was drawn upward through the stromatolitic zones along the southwest margins of Lake Todilto and uranium was precipitated.

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Roll-Type Uranium Occurrence at Dennison-Bunn Claim and Possibility of Uranium Deposits in Eastern Part of San Juan Basin, New Mexico

Uranium at the Dennison-Bunn claim, south of Cuba, New Mexico, along the east margin of the San Juan basin, occurs in stacked fluvial-channel sandstones interbedded with gray-green mudstones of the Westwater Canyon Sandstone Member of the Morrison Formation of Jurassic age. Although all the sandstone units are mineralized, the greatest concentration of uranium occurs in the uppermost sandstone unit. The uranium deposits are low to medium grade, range from 0.001 to 0.07% U_3O_8, and are irregularly distributed along the margins of intertonguing oxidized and unoxidized sandstone. The configuration indicates that these are roll-type uranium deposits and that they formed at the interface between oxidizing and reducing solutions.

The host rocks dip 45° west into the basin. Reconstruction of the tectonic and sedimentologic history along the eastern margin of the basin suggests that conditions favorable for the solution, transportation, and deposition of uranium probably occurred from Late Cretaceous into Eocene time. Uranium in the mineralizing solutions may have originated from within the Morrison Formation or may have been leached from the Paleocene Ojo Alamo Sandstone or Nacimiento Formation, or from the Eocene San Jose Formation which once covered the area.

Similar uranium deposits occur in the Morrison Formation at the Goodner lease, north of Cachana Spring. The presence of oxidized sandstone in the Morrison

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.

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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.