geochronology for Upper Cretaceous deposits in Arkansas and Texas offers another method of dating geologic events in these areas and relating them to events elsewhere.

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Chemical Changes Associated with Propylitic Alteration of Two Ash-Flow Tuffs, Datil-Mogollon Volcanic Field, New Mexico

Large-scale propylitic alteration of two texturally distinct, Oligocene ash-flow tuffs has been investigated: the crystal-poor, one-feldspar, rhyolitic A-L Peak Tuff and the crystal-rich, two-feldspar, rhyolitic to quartz latitic Hells Mesa Tuff. Initial development of a petrographic criterion with which to separate samples into groups experiencing varying degrees of alteration was followed by univariate and multivariate statistical analyses of major and trace element data, including U and Th, to identify chemical trends accompanying alteration. The extent of alteration a sample displays can be petrographically characterized by several variables including the amount of replacement of the groundmass and feldspar phenocrysts with secondary minerals, the degree of bleaching of the groundmass and the appearance of the mafic minerals.

Both the A-L Peak Tuff and the Hells Mesa Tuff showed increases in $K_2O$, Rb, and FeO, increases in the $Fe^{+2}/Fe^{+3}$ ratio, decreases in Th, and no systematic trend in U, Nb, or Zr with alteration. The two units displayed opposite behavior with alteration for MnO, Y, and Sr. Total iron, $Al_2O_3$, $Fe_2O_3$, $TiO_2$, MgO, CaO, and $Na_2O$ content showed a trend in one unit but not in the other. The mobility with alteration of Th, considered to be immobile in most geologic processes, may have been caused by the reducing environment of the prophylitic process. Such a reducing system might also explain the immobility of U during propylitization.

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Volcanism and Uranium Mineralization at Spor Mountain, Utah

Uranium-beryllium-fluorine mineralization at Spor Mountain in western Utah accompanied basin-range faulting and alkali rhyolite volcanism after major episodes of caldera-related volcanism had ended. Volcanism began about 42 m.y. ago with eruption of intermediate-composition flows, breccias, and tuffs from small central volcanoes, and culminated with eruption of intermediate-composition ash flows and subsidence of the Thomas caldera about 39 m.y. ago. Intermediate-composition volcanism was accompanied by base- and precious-metal mineralization. Eruption of rhyolitic ash flows 38 to 32 m.y. ago largely filled the Thomas caldera; some of these eruptions caused subsidence of the Dugway Valley cauldron. Alkali-rhyolite volcanism, basin-range faulting, and uranium-beryllium-fluorine mineralization began at Spor Mountain about 21 m.y. ago, at least 11 m.y. after the last cauldron subsidence. Most faulting and mineralization had ended by 6 to 7 m.y. ago, when voluminous alkali rhyolite was erupted in the Thomas Range.

Extensional tectonism was the probable cause of both alkali-rhyolite volcanism and uranium-beryllium-fluorine mineralization at Spor Mountain. Vents developed along basin-range faults and fault intersections at 21 m.y. and 6 to 7 m.y. ago, and mineralizing fluids rose through a plumbing system of vents and faults after eruption of tuff and alkali rhyolite 21 m.y. ago. Mineralizing fluids invaded faults in Paleozoic rocks and deposited uraniferous fluorite; they pervaded dolomite clast-rich tuff, which is interleaved between relatively impermeable strata, and deposited uranium in the structures of fluorite and opal and beryllium in bertrandite. Precipitation of uranium and beryllium occurred in response to breakdown to beryllium fluoride, uranium fluoride, and uranium-silica complexes as fluorite and silica were precipitated from cooling fluids. Uranium of magmatic origin in glassy tuff and that added by hydrothermal fluids was remobilized by ground water to form secondary concentrations in tuff and tuffaceous sandstone; such concentrations comprise minable deposits at the Yellow Chief mine.

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Eocene Erosional "Surface" and Its Relation to Onset of Basin-Range Faulting

The widespread ($2 \times 10^5$ $km^2$) infravolcanic, Eocene, allegedly planar "surface" in the Basin-Range (B/R) province is universally considered to indicate long-lasting erosion ("peneplanation"?) on vertically immobile crust deformed during the Laramide orogeny. This allegedly manifests secular tectonic stability between Laramide and B/R orogenies. Faults cutting this "surface" and the volcanic rocks overlying it are widely believed to demonstrate the onset of B/R faulting. I doubt this because: (1) the "surface" is not everywhere planar; its intrarange topographic relief exceeds 0.1 km; (2) its observed remnants lie on modern B/R range blocks; planar remnants of this surface may be parts of pediments formed on adjacent Eocene B/R ranges as regionally temporal but not necessarily widespread interrange hypsometric correlatives; (3) its unobserved alleged remnants in buried basin blocks may be depositional; (4) the pediments formed in warm, humid climates which possibly produced pedimentation rates high with respect to Eocene B/R range uplift rates, and few pediment gravels because of intense chemical weathering of mostly Paleozoic limestones; (5) in at least four B/R basins, the deeply buried (depositional) surfaces lie on drilled Eocene continental deposits over 2 km thick, but no Eocene deposits occur on adjacent B/R ranges between the Oligocene ignimbrites and the deeply eroded Paleozoic strata, thus indicating contemporaneity of B/R range uplift and adjacent B/R basin sinking in Eocene; and (6) the "surface" had been and was being formed up to the time of Oligocene volcanism. I conclude that the alleged Eocene "surface" was not one widespread static surface, but many local dynamic surfaces, formed in equilibrium with major Eocene B/R tectonism; throws of this "surface" are not necessarily manifestations of the onset time of B/R faulting.

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Geology and Volcanic Rocks Calera-Del Nido Block, Chihuahua, Mexico: Uranium Potential of Region

The Calera-del Nido block extends north from Chihuahua City for 140 km and from Highway 45 west to the next major valley. The block has a steep east-facing scarp and more gentle west-facing slopes. In Majalca Canyon, a rhyolite flow dome (oldest), rhyolite tuff, boulder conglomerates, and a felsic lava flow (Almireces volcanics, next oldest), and andesite-basaltic andesite flows (4+ km thick, Penas Azules volcanics) underlie a basal 45-m.y. old rhyolite tuff of the Rancheria volcanics. Above this, the Rancheria includes the Picos Gemelos andesite flow, a bright-red welded tuff, and the Rancheria ash-flow rhyolite which forms the prominent cliff on Cerro Rancheria, 50 km north of Chihuahua. In Bellavista Canyon these rocks are overlain by basalt flows, a rhyolite welded tuff (Acantilado tuff) and a peralkaline ash-flow rhyolite (Cryptic tuff). At Punta de Agua, rhyolite tuffs, breccias, and flows overlie these rocks on an erosion surface of considerable relief, like that of today. West of Cumbres de Majalca, flat-lying Acantilado-type (30 m.y.) ash-flow rhyolites form a dissected, westward-sloping plateau. West of Bellavista, basalt flows are overlain by the Acantilado which has a major vent in Sierra Rusia. The Sierra Campana (80 km north of Chihuahua City) is composed of Cryptic-like ash-flow rhyolites with the peralkaline Campana tuff on top. Thick ash-flow and vertically foliated rhyolites mark a vent for the Cryptic in lower Santa Clara Canyon. Flat-lying basalt and basaltic andesite, Acantilado tuff, and Cryptic tuff extend westward to Ojos Azules. Below the Acantilado, basalts are dominant in lower Santa Clara Canyon, but rhyolite tuffs and breccias become prominent westward. Small rhyolite vent complexes are exposed near Rancho Manta Negra and Las Varas. The large volumes of Tertiary rhyolites (including peralkaline types) indicate that this region has potential for those types of uranium deposits that are closely related to felsic volcanic environments.

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Volcanic Rocks of Sierra Pastorias Caldera Area, Chihuahua, Mexico

The Sierra Pastorias lie just south of Chihuahua City, Mexico. The area contains two resurgent caldera systems and one nonresurgent caldera. With minor variations, both resurgent calderas follow Smith and Bailey's model closely. The major caldera is 22 km in diameter and is characterized by a 600-m thick, densely welded, lithic-rich, two-feldspar, intracaldera facies ash-flow tuff core, surrounded by moat-zone sediments and voluminous porphyritic rhyolite flows. A minimum of 200 cu km of tuff was erupted. The smaller resurgent caldera is 10 km in diameter and it ejected at least 60 cu km of ash-flow tuffs similar to those of the major caldera. Both resurgent calderas are domal structures with apical grabens. Each dome is ringed by vertically foliated rhyolite necks which intruded along the ring-fracture zones. Nested within the major caldera is a nonresurgent caldera which erupted poorly welded, sanidine "moonstone" bearing tuffs.

The composite section has a total thickness of nearly 3,000 m. Rhyolite ash-flow tuff accounts for 80% of this, with fluvial rhyolite, volcaniclastic sediments, and olivine-augite-bearing basalt comprising the remainder. A small volume of rhyolite intrusion is also present.

Chemically, the rocks define a quartz-normative, bimodal suite composed of calc-alkaline rhyolite and basalt. The alkalinity and other chemical characteristics of these rocks fall between those typical of the Sierra Madre Occidental and eastern Chihuahua; the parental magmas were probably generated by subduction-related processes. No ages have been determined.

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Washington Ranch Morrow Field: Case History in Frontier Exploration

The Washington Ranch Morrow gas field is located 35 mi (56 km) southwest of Carlsbad, New Mexico, on the western rim of the Delaware basin 6 mi (10 km) basin-ward from the Capitan reef front.

Late Pennsylvanian orogenic forces created a structural development of such sharp magnitude that most exploration outlook condemned the area as too disturbed for commercial hydrocarbon entrapment. The northwest-southeast-trending fault on the northeast side of the field has a displacement of more than 2,000 ft (610 m), structural contours on the basal Morrow sandstone unit define 600 ft (183 m) of closure against the fault. The crest of the structure has lost 1,700 ft (518 m) of Wolfcampian and Upper Pennsylvanian section through erosion and nondeposition.

Eight deep dry holes had been drilled within an 8 mi (13 km) radius of the drill site for the discovery well. Several of these wells had encountered a significant igneous sill only 400 ft (122 m) below the basal Morrow sandstone. The presence of this sill so close to the main potential reservoir rock further detracted from the prospect. Reefing development of two separate ages in Pennsylvanian sediments caused very rapid lateral facies changes which made well log correlations difficult.

Frontier exploration philosophy and technique were employed to overcome the many negative considerations of the prospect. The discovery well was completed in June 1971 for a calculated absolute open flow potential of 54 MMCFGD natural, through Morrow perforations at 6,795 to 6,806 ft (2,071 to 2,074 m). While drilling was in progress gas flowed at the rate of 22 MMCFGD on a 2-hour and 10-minute drill-stem test from 6,791 to 6,860 ft (2,070 to 2,091 m). Major gas reserves were made available to the pipeline with the drilling of nine development wells.

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Carbonate Facies of Sierra Gomez, Chihuahua, Mexico

Sierra Gomez, approximately 20 km east of Aldama, Mexico, consists of approximately 500 m of folded and thrusted middle Cretaceous massive to thin-bedded mudstones and wackestones. Thin-bedded units are generally laminated and show local soft-sediment deformation. The laminated carbonates are dark-gray, with some bedded, black chert and contain gastropods, oysters, and the bivalve *Corbula.* Massive units are generally dark-gray to tan, with chert nodules and stylolites, and contain rudists, oysters, corals, and gastropods.

The silicified megafauna includes abundant bivalves such as radiolitid and toucasid rudists, *Ostrea* sp., *Corbula* sp., *Granocardium* sp., and several other genera. At least five species of gastropods have been found that include at least two species of *Turritella* and *Heliocryptus planorbis.* Abundant corals as well as worm encrustations and sponge borings (*Clinos*) are also recorded.

These limestones have been described as basinal facies of the Aurora Limestone. A significant portion of the megafauna has apparently not been transported. Shallow-water deposition is also indicated by the presence of rudists in apparent growth position. Normal marine conditions are established by the presence of the stenohaline coelenterates.

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Geology of Sierra Gomez, Chihuahua, Mexico

The uranium deposits of Sierra Gomez, Chihuahua, consist of hexavalent uranium mineralization in middle Cretaceous