limestones. Uranium was produced here in the 1960s, but work was discontinued in favor of the larger deposits of Pena Blanca.

The limestones of Sierra Gomez have undergone folding and thrusting. Tertiary volcanics were deposited and subsequently eroded from most of the area. Later faulting of the Basin and Range province left Sierra Gomez as a horst bounded by bolsons.

The uraniun deposits are in massive, sometimes fossiliferous or cherty limestones overlain by thin-bedded, fossiliferous limestones. Structurally the core of Sierra Gomez is a syncline bounded by anticlinal structures. Low-angle thrust faults are present in several mines in the area.

Hexavalent uranium is present along fractures and faults. Carnotite and tyuyamaunite have been identified. There is widespread calcite, silicification, hematization, and some fluorite, gypsum, and limonite. These replace limestone, either along low-angle faults, or in solution cavities.

Trace-element data available at this time indicate anomalous values for fluorine, vanadium, arsenic, molybdenum, mercury, chromium, nickel, copper, and zinc, in mineralized zones.

The uranium apparently was diagenetically leached from overlying volcanics and moved into the limestones, primarily along fault zones, until conditions favorable for precipitations were reached. Although evidence is supportive of a leaching hypothesis, it can neither be proven or disproven at this time.

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Trace-Element Content of Northern Great Plains Subbituminous Coal and Gulf Coast Lignite, 1979

A total of 453 coal samples from Northern Great Plains subbituminous coal beds, and 92 samples from the Gulf Coast lignite beds were chemically analyzed and studied from 1975 to 1979. These samples were analyzed for major, minor, and trace elements by the U.S. Geological Survey. In addition, ultimate, proximate, and Btu analyses were performed by the Coal Analysis Section of the U.S. Department of Energy.

Of the 18 elements reported in the summary, the geometric means for F, Zn, and S are as much as two-fold higher in ligite, compared with subbituminous coal. The elements Mn, Cr, and Se are more than four-fold higher in lignite than in subbituminous coal. All other reported elements are two to four-fold higher in lignite than in subbituminous.

About 8 metric tons (8 Mg) of Gulf Coast lignite are required to produce 1 billion Btu; in contrast, approximately 6 Mg of Northern Great Plains subbituminous coal are required to produce the same quantity of Btu. According to these comparative tonnages, 1.7 Mg of ash will be produced by combusting 8 Mg of lignite and 0.5 Mg of ash by 6 Mg of subbituminous coal. During the production of 1 billion Btu from lignite, 27,000 g of sulfur will be mobilized and a similar Btu production from subbituminous coal will mobilize 76,000 g of sulfur. Approximately 2,700 g of the other elements will be mobilized during the combustion of lignite and about 730 g will be mobilized from the combustion of subbituminous coal.

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San Andres Formation, East-Central New Mexico

The lower part of the San Andres Formation in east-central New Mexico consists of three cyclical zones, commonly known as the P-3, P-4, and P-5 porosity zones. Each of these, typically, consists of a thin, widespread evaporite at the top, followed by carbonates in the middle and a thin shaly carbonate zone at the base. Locally, halite may replace anhydrite. The rest of each zone consists of carbonates; dolomite normally underlies the upper anhydrite and may be as much as 100 ft or more thick. The dolomite may contain one or more layers of anhydrite and is underlain by limestone.

Lithofacies studies of the lower San Andres indicate that where the carbonate consists entirely of dolomite, there is an above-average amount of evaporites. Lithofacies studies also indicate that porosity trends are mappable and help to determine favorable areas for petroleum exploration.

The lower San Andres of east-central New Mexico was deposited along a north to northeast-trending coast that prograded southward and eastward except during the deeper water beginning of each cycle when shale or limestone typically was deposited. The north and west limits of traceable San Andres zones seem to be gradual limits where the San Andres becomes more evaporitic. Porosity in the P-4 and P-5 zones persists farther north than in the P-1, P-2, and P-3 zones, demonstrating the general southward shift of facies with time.

POWERS, DENNIS W., Sandia Laboratories, Albuquerque, NM

Geologic Processes in Evaporites in Northern Delaware Basin

Permian evaporites of the northern Delaware basin have been studied in detail for the Waste Isolation Pilot Plant (WIPP). The WIPP is proposed for the disposal of defense radioactive waste in the Salado Formation about 30 mi (48 km) east of Carlsbad.

Boreholes in the northern part of the WIPP site confirm unusual bed thicknesses and attitudes in the Castile Formation. The Castile is ordinarily nearly flat and consists of three anhydrites and two interbedded halites with a total thickness of about 1,350 ft (411 m). WIPP 13 encountered 900 ft (274 m) between the top of Castile and total depth about 50 ft (15 m) into the lower anhydrite. The upper anhydrite dips as much as 40° and contains a small recumbent fold. The thinning and structure also occur in the lower Salado. The same stratigraphic interval in WIPP 11 is 1,230 ft (575 m) thick. The upper anhydrite at WIPP 11 is very thin (< 80 ft or 24 m) and arches; the halite below it is over 900 ft (274 m) thick. the lower Salado beds arch over the Castile. The top of the Salado Formation is not arched at either borehole. Other Castile beds in each hole vary in thickness to lesser degrees.

The major hypotheses for the origin of these features are deposition, dissolution, and halokinesis. Laminated anhydrite does not form on 40° dips. Dissolution residues do not account for thin halite beds. Delicate primary halite structures in the upper Castile in WIPP 13 should not survive later massive halokinesis. Synsedimentary deformation is invoked as a possible explanation. Investigations continue.

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Early Cretaceous Stratigraphic Sequence in Chihuahua Trough, Presidio County, Texas

Various shallow-water marine facies are recognized in four exposures of upper Neocomian to lower Aptian strata on the eastern side of the Chihuahua trough. These facies display characteristics of a fluctuating carbonate-clastic shoreline with hypersaline, normal marine, and brackish water in nearshore, subtidal, supratidal, and lagoonal environments.

The stratigraphic sequence between the Paleozoic-Cretaceous unconformity and the first occurrence of the Foraminifera *Orbitolina* was studied in the areas of the Solitario, Shafter, Pinto Canyon, and the Van Horn Mountains of southwest Texas. Due to the scarcity of environmentally indicative fossils in these sections, most environmental interpretations are based on physical structures such as cross-bedding and ripple marks, geochemistry, and the petrology of the sandstones and carbonates.

As the sea transgressed into the area during the late Neocomian, it eroded a topographically high Paleozoic terrane into a gently sloping surface. A basal conglomerate, the initial deposit in the sequence, is gradational upward into lagoonal, tidal flat, and beach facies, characteristic of a low-relief shoreline. During deposition, terrigenous clastic input was influential in sedimentation, and perhaps created turbid water, prohibiting development of a filter-feeding community. The stratigraphic sequence grades into the sequential development of milliolid biosparite and oosparite facies, followed by *Exogyra* banks and intrasparites, and finally a rudistid-bearing biosparite facies, indicating a gradual increase in water depth.

These facies patterns are recognizable in all four study localities, but were probably not synchronously deposited. The absence of correlatable biostratigraphic units makes time equivalency extremely speculative for this part of the Cretaceous section.

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Geology of Aurora Uranium Prospect, Malheur County, Oregon

The Placer Amex Aurora uranium prospect is located 2,000 ft (610 m) southwest of the old Bretz mercury mine and adjacent to the Cordex Syndicate Bretz uranium prospect, within the northern rim of the McDermitt caldera complex. Drilling has defined 17 million tons (Mg) of mineralization at a grade of 0.05% U_3O_8. The shallow mineralized zone is 500 by 1,500 ft (152 by 457 m) in area and up to several hundred feet thick. The long axis of the deposit is subparallel with the northwest-trending caldera rim fracture passing through the Bretz open pits.

Uranium mineralization occurs dominantly as very fine-grained uraninite and coffinite localized in highly altered vesicular to scoriaceous flow tops and breccia layers within a complex, intermediate lava sequence. Volcanic rocks are locally covered by several hundred feet of tuffaceous lacustrine sediments. Rhyolitic rocks beneath the Aurora lavas possess an asymmetric, anticlinal upper surface, the axis of which coincides with the trend of mineralization.

Associated alteration minerals include montmorillonite, leucoxene, opal, clinoptilolite, and framboidal pyrite. Mineralization was apparently introduced by an epithermal mechanism which added altering fluids and uranium-bearing solutions along a complex, steeply dipping fracture system coincident with the axis of the mineralized zone. A supergene mechanism may then have spread the altering and mineralizing solutions laterally along the more permeable layers within the lava sequence. Mineralization may have occurred during the time of deposition of 50 to 70 ft (15 to 21 m) of uranium-enriched tuffaceous sediments which directly overlie the Aurora lavas.

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Petrochemical Characteristics of Volcanic Rocks Associated with Uranium Deposits in McDermitt Caldera, Nevada-Oregon

Rhyolitic volcanism within the McDermitt caldera complex in northern Nevada and southern Oregon occurred during four episodes in a 5-m.y. time span from 18.5 to 13.7 m.y. ago. The first three episodes were characterized by eruption of large-volume ash-flow tuffs which led to caldera collapse. Each episode began with eruption of comendite ash-flow tuff with a SiO_2 content of 75% and Al_2O_3 content of 11.2% and each ended with ash flows lower in SiO_2 content (70 to 62%) and higher in Al_2O_3 (13 to 15%). The early high-silica rhyolites show large enrichments of F, Th, U, Zr, and depletions of Ba, Ca, Mg, P, Sr, and Ti relative to the last tuffs erupted. The systematic change in chemistry of the ash-flow tuffs during each episode is believed to reflect venting from progressively lower levels of a zoned magma chamber. The fourth episode of volcanism consisted of the emplacement of small intrusives and domes with composition similar to the early high-silica rhyolite erupted in each of the previous three episodes. The last rhyolites erupted tapped only an upper part of a similarly zoned magma chamber.

Uranium ore deposits are associated with the emplacement of the last phase of comendite magma in the complex. Although these rocks are not distinct chemically from the older high-silica rhyolites, their emplacement in a nonexplosive manner resulted in the formation of the ore bodies by localizing magma and vapor in a small chamber rather than dispersing it in ash-flow sheets.

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Peterson and South Peterson Multipay Fields, Roosevelt County, New Mexico

The Peterson and South Peterson fields, located on the northside of the generally east-west-trending Matador arch in southern Roosevelt County, New Mexico, are on relatively small structural features separated by dry holes. Both fields produce from the Middle Silurian Fusselman carbonate and from bedded Upper Pennsylvanian limestone. Production from the Fusselman in the Peterson field is limited to one well whereas production in the South Peterson field covers a wider area. The Peterson field produces from the Fusselman because of structure whereas the South Peterson field produces as the result of combination structure and pinch-out of Fusselman against the granite high on the south. The field was found using common depth point (CDP) seismic data.

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Tom-Tom and Tomahawk San Andres Oil Fields, Chaves and Roosevelt Counties, New Mexico

The Tom-Tom field was discovered by Amoco in 1967 and the nearby Tomahawk field was discovered by Sundance Oil Co. in 1977. As of September 1, 1979, there were 49 wells producing at Tom-Tom and 22 wells at Tomahawk. Cumulative oil production to August 1, 1979, is 913,725 bbl at Tom-Tom and 331,917 bbl at Tomahawk. Geologic studies indicate no separation between the two fields and at the present rate of drilling activity, the fields should link up in early 1980. Both fields are stratigraphic traps in the P-2 zone of the San Andres formation. The P-3 zone is also productive from a small