tions provide input for the existing geohydrologic models for fracture flow which is significantly less variable than permitted by the models' sensitivity to this parameter.

GRANT, PHILIP R., JR., Energy Resources Exploration, Inc., Albuquerque, NM

Perspectives of Energy Development in New Mexico

New Mexico ranks fourth in the nation in natural gas and natural gas liquids production. It is seventh in crude oil and lease condensate extraction, has 55% of the country's uranium, and ranks first in providing this crucial energy fuel. Over 120 billion tons of coal lie between the surface and 3,000 ft (915 m) in northern New Mexico with 3 to 6 billion tons of low-sulfur coal accessible for relatively inexpensive strip mining. The U.S. Geological Survey estimates that the Valles Caldera of the Jemez Mountains alone contains geothermal fluids capable of sustaining 2,700 Mw of electrical generating capacity for 30 years. Solar insolation in southern New Mexico is within 10% of the maximum received anywhere in the world.

Energy in all its forms will be the major force in New Mexico's economic future. More than half of the state's gross product is now derived from energy-oriented activities. It is not unreasonable to expect that, just as a century or so ago major communities and industrial enterprises developed around transportation corridors of rivers and railroads, the new commerce of the next decades will locate where assured energy supplies exist. Massive service, social, financial, and environmental burdens and impacts must be addressed by industry, government, and citizens if the state is to provide orderly, stable, and beneficial development, to avoid the potential misfortunes of "boom and bust" cycles, and to preserve its unique environment and life style.

GREEN, MORRIS W., U.S. Geol. Survey, Denver, CO

Origin of Intraformational Folds in Jurassic Todilto Limestone, Ambrosia Lake Uranium Mining District, McKinley County, New Mexico

The Todilto Limestone of Middle Jurassic age in the Ambrosia Lake uranium mining district of McKinley County, New Mexico, is the host formation for numerous small to medium-size uranium deposits in joints, shear zones, and fractures within small to large-scale intraformational folds. These folds probably were formed as a result of differential sediment loading when eolain sand dunes of the overlying Summerville Formation of Middle Jurassic age migrated over soft, chemically precipitated, lime muds of the Todilto shortly after their deposition in a regressive, mixed fresh and saline lacustrine or marginal-marine environment of deposition.

Encroachment of Summerville eolian dunes was apparently restricted to relatively narrow beltlike zones trending radially across the Todilto coastline toward the receding Todilto body of water. Intraformational folding is believed to be confined to the pathways of individual eolian dunes or clusters of dunes within the dune belts.

During the process of sediment loading by the migrating dunes, layers of Todilto lime mud were differentially compacted, contorted, and dewatered, producing both small, and large-scale plastic deformation structures including convolute laminations, mounds, rolls, folds, and small anticlines and synclines. During the processes of compaction and dewatering, the mud, in localized areas, reached a point of saturation at which sediment plasticity was lost, causing shearing, fracturing, and jointing of the contorted limestone beds. These areas or zones within the limestone became the preferred sites of uranium mineralization because of the induced transmissivity created by sediment rupture during prolonged sediment loading.

Along the Todilto coastline adjacent to the eolian dune belts, both interdune and coastal sabkha environments dominated the Summerville on the margins of the Todilto body of water. Sediment in these areas consists mainly of claystone, siltstone, sandy siltstone, and very fine grained sandstone which was apparently derived from the winnowing of the finer grained fraction of sediment from adjacent eolian dune fields during eolian activity. Most of the sabkha sediments were probably carried in airborne suspension to the low-lying, ground-water saturated, coastal areas where they were deposited as relatively uniform blanketlike layers. Deposition of sabkha deposits was apparently slow and uniform over most of the Todilto coastal and interdune areas, and did not cause the formation of other than small-scale deformation features in underlying Todilto rocks. Large-scale deformational features as well as uranium deposits are notably absent in the Todilto where it is overlain by finer textured sabkha deposits in the Summerville.

HARTMAN, JOSEPH H., Univ. Minnesota, Minneapolis, MN, and New Mexico Bur. Mines and Mineral Resources, Socorro, NM

Mollusca from Upper Cretaceous Fruitland and Kirtland Formations, Western San Juan Basin, New Mexico: Review

Renewed interest in the development of substantial coal reserves in the San Juan basin has given new impetus to the determination of the potential impact of expanded mining on paleontologic resources and to a reconsideration of depositional environments of Fruitland coals.

Reanalysis of molluscan localities from the Fruitland and Kirtland Formations on lands of the Navajo Nation, in preparation for more extensive field studies, indicates that, of the 24 localities collected by C. M. Bauer in 1915, 12 are type localities for 17 species, representing a large percentage of the total fauna known from these formations. Differentiation of brackish and nonmarine environments on the basis of biostratigraphic distribution of species divides the Fruitland Formation into upper and lower units. Near the western margin of the San Juan basin, predominantly brackish environments are present near the base of the Fruitland, underlain by the littoral-marine Pictured Cliffs Sandstone, and extend up to 35.6 m in total thickness. Exclusively nonmarine sediments are present above this horizon to the top of the Fruitland and throughout the Kirtland Formation. Nonmarine molluscan diversity seems to increase markedly at approximately 35.6 m. Below this horizon, only 7 taxa indicate freshwater environments. At 35.6 m, 8 taxa are introduced, and of these 7 occur only at this level. Above 35.6 m, only 2 taxa are introduced: *Physa reesidei* at about 61 m and "*Unio*" *baueri* at 123.5 m (Kirtland Formation). The only terrestrial mollusk reported is *Planorbis chacoensis* from near the base of the Fruitland Formation.

HAWLEY, JOHN W., New Mexico Bur. Mines and Mineral Resources, Socorro, NM

Overview of Geology as Related to Environmental Concerns in New Mexico

Environmental problems in New Mexico, as elsewhere, arise from modern society's intensive use of the earth. The hallmark of environmental geology should be effective communication with nongeologists. Available information on deep-seated and surficial geologic processes and products should be clearly presented. Above all, the impact of these processes and products on human affairs must be put in proper time-space perspective. The following examples of geology-related problems discussed in this paper reflect the varied geologic terranes and physiography of the state.

Large deposits of coal, uranium, and natural gas underlie tablelands and valleys of the Colorado Plateau province. Environmental concerns include impacts of underground mining, mine and mill waste disposal, and power-plant siting. Rugged terrane, relatively cool-moist climate, and mass-wasting processes characterize high mountain areas throughout the state. Mineral and forest exploitation has affected these areas for several centuries. Modern society increasingly uses alpine terranes for intensive recreational pursuits, and development of geothermal resources is planned in several areas. Extensive Quaternary solution-subsidence features associated with Permian carbonate and evaporite terranes in the Great Plains–Pecos Valley region are being investigated in connection with evaluation of bedded salt as a repository for radioactive wastes. In the Basin and Range province traditional environmental concerns relate to management of water resources in the Rio Grande Valley and adjacent intermontane basins. Metal mining and agriculture have had significant impacts. Recent geologic investigations have focused on young faults and site selection for hazardous-waste disposal.

HAWLEY, JOHN W., New Mexico Bur. Mines and Mineral Resources, Socorro, NM, and BRUCE GALLAHER, New Mexico Environmental Improvement Div., Santa Fe, NM

Geologic and Hydrologic Criteria for Disposal of Hazardous Wastes in New Mexico

Suggested geologic and hydrologic criteria for shallow burial of hazardous wastes in New Mexico include: (1) rock type and permeability; thick, clay-rich sedimentary and volcaniclastic rocks with low permeability should be considered as the best type of waste repository; where the water table is deep (exceeding 200 ft or 62 m) thick units containing some permeable strata may be considered; (2) absence of known aquifers below or adjacent to site and minimum depths to the water-table exceeding 100 to 200 ft (31 to 62 m); (3) surface stability in terms of water and wind erosion, with minimum land-surface ages in the 10,000 to 100,000-year range; the site should also be stable in terms of seismic and solution subsidence processes; (4) absence of known mineral and geothermal resources whose development could be affected by disposal operations.

No site should be located near a perennial stream or alluvial valley aquifer system or upwind from population centers or farming areas. Sites recommended for consideration in New Mexico have been at least 3 mi (4.8 km) from floors of perennial stream valleys. Climatic criteria should include limiting sites to areas where mean annual evaporation greatly exceeds precipitation. Permanent burial of hazardous wastes is recommended only for solid wastes that do not appear to be capable of recycling.

HOHMAN, JOHN C., Colorado State Univ., Fort Collins, CO, and ROMEO M. FLORES, U.S. Geol. Survey, Denver, CO

Gallup Sandstone: Complex of Wave-Dominated Deltaic and Low-Sinuosity Braided Fluvial Deposits, Gallup Sag, New Mexico

The Upper Cretaceous Gallup Sandstone in northwestern New Mexico is interpreted as coastal-barrier or delta-front deposits. A study of 160 closely spaced sections along nearly continuous exposures in the Gallup Sag, New Mexico, suggests that these deposits are related to wave-dominated delta and low-sinuosity braided fluvial systems.

The Gallup Sandstone in this area is divided into three prograded depositional packages. The lowermost package consists of shoreface sheetlike sandstones, siltstones, and shales, which coarsen upward into coalesced distributary-mouth-bar and beach sandstones that are locally dissected by fluvially and tidally influenced channel sandstones. This package is overlain by constructional delta-plain deposits and coastal back-barrier deposits, the latter being associated with the destructional phase of the delta system. The constructional delta-plain deposits consist of meandering distributary channels interspersed with interdistributary crevasse-splay sandstones and backswamp coals, carbonaceous shales, siltstones, and shales. The destructional coastal back-barrier deposits consist of heavily bioturbated lagoonal or bay sequences of sandstones, siltstones, shales, and carbonaceous shales. Coal beds associated with this destructional facies are as much as 4 ft (1.2 m) thick and extend laterally as much as 4.2 mi (6.7 km). These coal beds are blanketlike in contrast to the constructional delta-plain coal beds, which are thin, discontinuous, and lenticular. This overall package is overlain by an alluvial depositional package consisting of numerous stacked, overlapped, lenticular, varicolored, pebbly sandstones. These sandstones, which are blanketlike in extent and contain a few poorly developed coals, probably represent low-sinuosity braided-stream deposits.

HUNT, ADRIAN, DONALD L. WOLBERG, New Mexico Bur. Mines and Mineral Resources, Socorro, NM, and JULIE MENACK, Univ. Chicago, Chicago, IL

Upper Cretaceous Stratigraphy in Hunter Wash Area, San Juan Basin, New Mexico

The Bisti Fruitland area contains about 1,870 million tons of subbituminous low-sulfur coal beneath less than 250 ft (76.2 m) of overburden and is the largest undeveloped reserve in the San Juan basin. *To aid prudent development of these* resources intensive field investigations of the depositional environments of the strata were undertaken east and southeast of the old Bisti Trading Post.

Seventeen measured sections were made in the vicinity of Hunter Wash. The stratigraphic sequence exposed consists of interbedded shales, siltstones, channel sandstones, and coals. Coals are more prominent in the lower part of the sequence. Correlations were facilitated by the presence of a prominent, medium-grained, reddish-brown sandstone. The usefulness of coals for correlation in the study area has not been demonstrated.

The included sequence contains the Fruitland-Kirtland contact with most of the strata in the Fruitland Formation. This contact is approximately 200 ft (61 m) lower in elevation than the Pictured Cliffs Sandstone–Fruitland Formation contact about 5 mi (8 km) southeast. There are possible correlations of the rocks in this area with those of the "fossil forest" near the Split Lip Flats on the southeast.