least 95% of the uranium reserves in Wyoming. Wyoming reserves were estimated by the AEC at 53,270 tons of U_3O_8 as of January 1, 1967. Distribution of reserves in tons of U_3O_8 together with production to January 1, 1967 are estimated as follows: Gas Hills, 19,560± tons reserve, 17,300 tons produced; Shirley basin, 27,000± tons reserve, 3,450 tons produced; Crooks Gap, 4,000± tons reserve, 2,400 tons produced; other Tertiary basins including Powder River, 1,000± tons reserve, 1,100 tons produced.

Wind River and equivalent rocks crop out in broad areas within the intermontane Tertiary basins of central Wyoming. The sediments that comprise these lower Eocene beds were derived from mountain ranges that were uplifted during Late Cretaceous through earliest Eocene times. Two facies predominate within the major basins. A coarse arkosic sandstone and conglomerate facies with interbedded siltstone dominates near the mountain fronts. Major uranium deposits occur in this facies. Farther out in the basins the coarse-grained sediments grade into or interfinger with a variegated fine-grained facies.

Economic concentrations of uranium occur near the margins of tongues of altered sandstone within the coarse-grained facies and are classified as roll-type deposits. Character of alteration differs from basin to basin but has been recognized to some degree in all basins. Alteration consists of the oxidation products produced by mineralized ground water passing through a transmissive sandstone bed. Geometrically the deposits are tongue-shape in plan and crescent-shape in vertical section with the concave side toward the altered sandstone.

Deposition of uranium occurred at the front of an advancing aqueous chemical system which moved through the host sandstone bed. The oxygenated water rich in uranium, selenium, and other trace elements moved along the hydrologic gradient and oxidized and leached various minerals, including uranium, as it progressed. Precipitation of the uranium and associated elements occurred at a point within the aquifer where the pH and Eh of the system dropped sharply. The change in chemical environment was the result of the presence of H_2S, probably produced by anaerobic bacteria.

AN ASTRONAUT

(No abstract submitted)

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Future Role of Rocky Mountain Coal

(No abstract submitted)

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Keynote Address

(No abstract submitted)

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Devonian Geology of Canada, Montana, and Wyoming

(No abstract submitted)

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Triassic-Jurassic of Alberta, Saskatchewan, Manitoba, Montana, and North Dakota

Of the Triassic-Jurassic Systems, only Lower Triassic was deposited in southern Saskatchewan, North Dakota, and southern Montana. Thicknesses in excess of 700 ft are present in western North Dakota reflecting the depocenter of restricted salt basins. On the basis of lithologic correlation, the lower Watrous Formation in Saskatchewan is considered to be equivalent to the upper part of the Spearfish Formation in North Dakota. Lower Middle and Upper Triassic rocks in western Alberta are of marine origin, attain thicknesses in excess of 4,000 ft, and produce oil and gas.

Jurassic rocks are widespread throughout the map area as a result of Jurassic seas transgressing from the northwest along the Eastern Cordillera, then spreading east across Montana into the Williston basin. Lower Jurassic formations in the map area are restricted to southwestern Alberta. Middle Jurassic formations are the most widespread, and are thicker than 500 ft in a depocenter in southeast Saskatchewan and northwest North Dakota. Similar thicknesses are present in the Alberta trough. Upper Jurassic sediments also are widespread, reaching thicknesses of 7,000 ft in the Eastern Cordillera of Alberta and more than 700 ft in eastern Montana.

Economic deposits of coal, gypsum, oil, and gas occur in Middle and Upper Jurassic formations. Oil is the most significant, particularly in southwestern Saskatchewan where 20 fields are estimated to have ultimate production of 347 million bbl. These fields produce in stratigraphic traps, primarily from sandstone associated with shoreline facies.

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Geology of the Moon

At present, most knowledge of detailed geologic conditions on the moon is limited geographically to the photographic missions of the Lunar Orbiter program which has primarily covered the Apollo Zone. Complications caused by albedo, high sun elevations, and electronic imagery distortion hamper photo interpretation.

The lunar stratigraphy is divided into four systems: pre-Imbrian-highlands ringing the oldest mare; Imbrian—the oldest lowland mare; Eratosthenian—"eroded" crater material; and Copernicus-recent crater material.

Ubiquitous craters appear to be formed by both impact of meteors and volcanic activity. Faults, slump or creep, flowage—all appear to be present on the lunar surface.

Synoptic orbital photography of the earth is a logical outgrowth of the lunar program. Use of synoptic photography will improve exploration geologists' understanding of their individual areas of interest as they relate to the regional geologic setting.

Geologic processes and theories developed on earth will aid the interpretation of morphological and structural conditions on the moon. Likewise, technologies developed from the lunar and planetary program will aid exploration on the earth.

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Use of Nuclear Explosives in Oil and Gas Production

Nuclear explosions are currently being planned for use in oil and gas production, recovery of oil from oil shale, gas storage, and copper leaching. The current status of each of these projects is discussed with emphasis on the economics of each application.

The first commercial application of nuclear explosives will be in gas stimulation. Project Gasbuggy is scheduled to be fired in early 1967 and will be rapidly followed by two additional shots, also in gas production. These three events, each in a different formation, are described in this paper with a discussion of their significance to the world's oil and gas industry.

The use of nuclear explosives in oil and gas stimulation should be a standard accepted practice within a few years. Calculations based on explosions in media such as tuff, alluvium, granite, and dolomite predict large increases in productivity where nuclear devices are used in "tight," thick formations. The broken-up rock resulting from the explosion becomes the new well bore, with a production rate of 6–12 times that of a normally completed well.

Also included in the paper is a discussion of real or possible problems associated with nuclear-explosive engineering. The only major foreseeable problem is the seismic shock wave. This limits the size of explosive which can be used near important surface structures.

A discussion is included on the radiation problem which is believed to be largely psychological in the example of contained explosions.

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Isostasy and Overthrusting in Western Wyoming

Coinciding with the frontal zone of the overthrust belt in western Wyoming is the axis of a former narrow trough along which a maximum of 25,000 ft of Cretaceous sediment accumulated. Marine and brackish-water fossils in the Adaville Formation indicate that intermittent marine deposition persisted to near the top of the system. During subsidence in this zone, the former miogeosycline in southeast Idaho was rising. Overthrusting progressed eastward in time, and the Adaville and Evanston Formations were overridden by the easternmost Hogsback thrust soon after final deposition, while the top of the system was near sea level.

Cretaceous Hilliard Shale, approximately 3,000 ft stratigraphically below the top of the Adaville, occurs at the surface at an elevation of 7,500 ft 5 mi west of La Barge, Wyoming. This locality is cratonward from the easternmost major thrust; therefore, the restored elevation of about 2 mi for the top of the Cretaceous is not attributable to thrusting, but to vertical uplift that is post-thrusting. Block faulting in southeast Idaho since late Eocene may represent subsidence in the area behind the western Wyoming salient of the overthrust belt.

These data indicate that the pre-Cretaceous surface in the miogeosyncline-shelf boundary zone subsided 25,000 ft during the Cretaceous time of sedimentation whereas the former miogeosyncline was uplifted an unknown amount. Subsequent to overthrusting, the Cretaceous frontal trough has risen 10,000+ ft and there has been possible subsidence in southeast Idaho. This oscillatory motion appears to be of sufficient magnitude to reverse dips on major thrust surfaces from down-to-the-east at the end of Cretaceous to down-to-the-west at the present time. Thus, present attitudes do not preclude gravitational gliding as the mechanism of overthrusting.

The average of 100 Bouguer gravity measurements in southeast Idaho plots 20 mgal on the positive side of Woollard's mean world curve, whereas the average of 32 Bouguer measurements over the former Cretaceous trough in Wyoming plots 32 mgal on the negative side. In terms of isostasy, the vertical movements tending to reverse the dips on overthrust faults appear to be active at present.

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Eocene Green River Formation—Multiple Mineral Resource

The Eocene Green River Formation underlies an area of about 15,000 sq mi in Colorado, Utah, and Wyoming. It consists principally of organic marlstone (oil shale), marlstone, siltstone, sandstone, and intercalated tuff beds that were deposited in fresh-water, saline-lacustrine, and associated deltaic and fluviatile environments.

The tremendous shale-oil potential of the formation is well known; oil shale that yields an average of 15 gals of oil per ton may contain about 2 trillion bbl of oil, or oil shale that yields an average of 25 gals of oil per ton may contain more than 750 billion bbl of oil. In Utah, gilsonite veins are associated with the Green River Formation, and oil and gas have been found in the shore facies. Recent discoveries, however, have shown that saline minerals are an important part of the economic potential of the formation.

The soda-ash industry in Wyoming, which mines the large deposits of bedded trona in the Green River Formation, is expanding rapidly. In the Piceance basin of Colorado, recent core holes have shown that nahcolite ($NaHCO_3$) is locally abundant, and that dawsonite ($NaAl[OH]_2CO_3$) a potential source of alumina, is disseminated in rich oil shale in significant amounts.

The discovery of large quantities of saline minerals suggests that in future exploration the Green River Formation should be considered as a multiple mineral resource. Because of the fine-grained nature of the rocks, discovery of other potentially valuable disseminated minerals like dawsonite will require advanced research tools such as X-ray diffraction and X-ray fluorescence for rapid quantitative analysis of numerous samples. With the use of such tools, the prospects seem bright for finding new mineral resources, for the major part of the Green River Formation is still virtually unexplored.

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Habitat of Oil in Rockies

(No abstract submitted)

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Western Cordillera—Alaska to Mexico

There are three longitudinal divisions of the western cordillera: the Coast Range belt along the Pacific margin, the Nevadan belt next inland, and the Laramide belt, farthest inland. A fourth tectonic division is superposed on parts of the Nevadan and Laramide belts: the Basin-Range system. Ancestral to these Mesozoic and Cenozoic mountain systems was a late