the southern Williston basin in North Dakota, South Dakota, and eastern Montana and adjacent parts of central Montana and northern Wyoming. They crop out in the Bighorn, Pryor, Absaroka, Beartooth, Big Snowy, and Little Rocky Mountains.

These Devonian rocks consist predominantly of marine carbonates, evaporites and shales, and attain a maximum thickness of about 2,000 feet in northwestern North Dakota. Lower Devonian rocks assigned to the Beartooth Butte formation, an estuarine channel-fill deposit as thick as 150 feet, crop out at many isolated localities in north-central Wyoming and south-central Montana. Middle Devonian rocks underlie the central Williston basin but are not present at the surface. They reach a maximum thickness of about 870 feet in north-central North Dakota. The Middle Devonian series is divided into the Winnipegosis and Prairie formations of the Elk Point group and the overlying Dawson Bay formation. Upper Devonian rocks underlie most of the area studied and make up most of the outcrops. They attain a maximum thickness of about 1,250 feet in northern Montana. The Upper Devonian series is divided, in ascending order, into the Souris River formation; the Jefferson group, consisting of the Duperow and Birdbear formations; and the Three Forks formation.

Several major anticlines and a large reverse fault have been interpreted from the isopach maps of the Devonian formations. These structural features were formed during Middle and Late Devonian and earliest Mississippian time and then buried beneath thick deposits of the Madison group (Mississippian). They controlled Devonian sedimentation and probably trapped large quantities of oil and gas in Devonian and older strata. Minor oil production has already been established from reservoir rocks in every Middle and Upper Devonian formation except the Prairie. Most of the Devonian oil fields are located on the trends of the pre-Madison features which diverge slightly from the trends of related Laramide features.

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Photogeomorphology and Oil Exploration in Rocky Mountain Region

Structure and stratigraphy at or near the earth's surface can be identified and defined by photogeomorphic mapping methods. Processes necessary to proper photogeomorphic mapping are somewhat similar to geologic mapping processes.

Some geomorphic features that contribute information with respect to structure and stratigraphy include trellis drainage, annular drainage, radial or centrifugal drainage, centripetal or interior drainage, drainage deflection, arcuate drainage, linear stream segments, barbed tributaries, channel pattern variation, antecedent and super-imposed drainage, entrenched meanders, oblate tonal variations, tone halos, fracture traces, geomorphic lineaments, curved tonal features, drainage divides, glacial land forms and landslide debris. With proper symbolization and application of these symbols to geomorphic data, structure and stratigraphy can be mapped in a manner that produces data pertinent to oil exploration programming.

When photogeomorphic criteria are delineated in areas of good or poor outcrop expression and density, the resulting map presents both areas of anticlinal folding and (or) associated fault relationships as well as stratigraphic delineation. Use of photogeomorphic interpretation in areas where surface geologic mapping is difficult is a pertinent application of this tool for exploration.

Photogeomorphic features exist at the earth's surface due to the influence of surface rocks, climate, and vegetative growth. Tectonic adjustment so subtle as to be overlooked by normal geologic mapping techniques may be apparent through the use of definitive photogeomorphic mapping. A detailed familiarity with known structure and stratigraphy within the area of study is imperative. In the Cenozoic, emphasis should be directed toward physiographic development for proper application of geomorphic data. The photogeomorphologist must be adequately prepared to discern misleading information and to concentrate on those data that are indicative of favorable conditions for oil or gas entrapment. A method of compilation for photogeomorphic analysis is suggested as well as a tentative programming for analysis of the criteria.

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Facies and Porosity Relationship in Some Mississippian Carbonate Cycles of Western Canada Basin

Case histories of textural and reservoir analyses of selected Mississippian carbonate cycles of the Western Canada Basin are presented to illustrate the relationship that exists between the occurrence and petrographic nature of an effective carbonate reservoir rock and the framework of carbonate sedimentation. Various types of carbonate rock pores are described and evaluated with respect to effective porosity.

Large stratigraphic oil pools have been discovered, at or near the Paleozoic subcrop of the Mississippian "Midale" carbonate cycle, in southeastern Saskatchewan. Apart from scattered, vuggy, algal-encrusted strand line deposits, most of the carbonates of the "Midale" producing zone consist of skeletal and oolitic limestones which have a finely comminuted, frequently dolomitized, limestone matrix with intergranular and chalky porosity. Effective reservoir porosity is controlled by the relative distribution and grain size of this matrix.

Major hydrocarbon (oil and gas) reserves have been found in the Mississippian "Elkton" carbonate cycle, both in the Foothills Belt and along the subcrop, in southwestern Alberta. Effective reservoir material of this cycle was found to consist mainly of the dolomitized equivalent of an originally coarse skeletal limestone, with a variable amount of generally porous, finely comminuted (granular) skeletal matrix. Primary porosity was very important in the control of dolomitization which probably began with the replacement of this matrix by euhedral rhombohedrons and finally affected the coarse skeletal material (now generally indicated by leached fossil cast outlines). These porous dolomites grade laterally in a predictable way into tight, relatively undolomitized, well sorted, coarse skeletal limestones with original high interfragmental porosity now completely infilled with clear crystalline calcite. This lithification by cementation took place early in the history of carbonate sedimentation of this area and before secondary dolomitization processes took effect.

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Coyote Creek Field, Wyoming, Its Character and Significance

Coyote Creek is the largest stratigraphically trapped Dakota oil field discovered on the eastern flank of the Powder River basin. The trap is formed by an updip change from clean sand to impermeable sand, siltstone and shale in a pinch-out zone which is only a few hundred yards wide. The trap occurs in an area of homoclinal dip slightly modified by small normal faults. The sand body has a relatively flat base, is irregular in shape and loses porosity and permeability from the top downward. It appears to be a near-shore marine deposit. Permeabilities in the sand body are as great as 3,200 md, but more commonly range from 100 to 400 md. The average reservoir thickness is about 46 feet.

Development drilling continues, and to date has resulted in fifty producing wells and nine dry holes. The oil column is about 300 feet thick and recoverable oil will exceed twenty-five million barrels.

The field was discovered between two dry holes one and three-quarters miles apart. This points out the need for closely spaced wildcats to evaluate the productive potential of land in areas of rapid lateral stratigraphic changes. Exploration-wise, the field is significant because its study demonstrates stratigraphic principles which may be used in searching for new oil fields.

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Hebgen Lake, Montana, Earthquake of August 17, 1959.

The Hebgen Lake, Montana, earthquake of August 17, 1959, was marked by the reactivation of well established structural features which had been active many times in the past, and undoubtedly will be active many times in the future. At least four known normal faults were revived, of which two, the Red Canyon and Hebgen faults, are old established breaks which determined much of the topography of the area. Fundamentally, two large blocks of ground rotated on horizontal axes, with the north side of each block downdropped. One of the blocks contained Hebgen Lake and the tilting of this block caused the lake to be displaced northward. In consequence, the north shore was submerged even as the south shore emerged.

A seiche, set up in Hebgen Lake as a result of this displacement, crested Hebgen Dam four times, and oscillated for $11\frac{1}{2}$ hours. The concrete core of the dam was cracked, warped, tilted, and the earth fill of the dam settled unevenly.

At the time of the earthquake, or shortly thereafter, a mile-wide landslide occurred in Madison Canyon partly burying the Rock Creek campground with an attendant human loss of 9 dead, and 19 missing.

Many changes occurred in spring flow and rate of discharge of the various streams emptying into Hebgen Lake. Springs rising in volcanic rocks were heavily charged with sediment in colloidal suspension.

Minor effects accompanying the earthquake include movement of mudflows, the formation of sand boils, local compaction of unconsolidated materials, and churning of rocks along ridge tops.