The configuration of Cambrian and Precambrian rocks at Medicine Lake shows that the structure there formed by compaction of Cambrian sediments deposited around a hill on the Precambrian land surface. Regional-scale southeast-plunging anticlines in the eastern Montana Williston basin may also have formed by compaction of Cambrian sediments on a differential eroded Precambrian land surface.

JACOB, ARTHUR F., McMahon-Bullington, Englewood, CO

Undrilled Giant Anticline in Overthrust Belt, Broadwater and Gallatin Counties, Montana

Southeast of Helena, Montana, in the Missouri River valley, the Precambrian Belt Supergroup has been thrusted eastward over Paleozoic and Mesozoic reservoirs and source beds, and forms an undrilled anticline about 16 mi (26 km) long, 7 mi (11 km) wide, with about 1 mi (1.6 km) of structural closure. The Paleozoic and Mesozoic strata extend westward below the leading edge of the Belt, which is at the east edge of the anticline. Although the anticline is clearly evident on published cross sections, its axis does not appear on published maps. Cross sections constructed from surface data indicate that Paleozoic and Mesozoic strata may be present below the Belt in the anticline, but confirmation by geophysical work is needed.

Drill depths to Cretaceous targets should be about 8,000 to 10,000 ft (2,400 to 3,000 m). The Eagle Sandstone (Upper Cretaceous, 100 to 300 ft [30 to 90 m] thick) probably is a regressive shoreline and nearshore deposit. It is overlain and underlain by thick marine Cretaceous shale from which oil and gas were tested in nearby drill holes, and which could be a hydrocarbon source for the Eagle and other reservoirs. The Kootenai Formation (Lower Cretaceous, 400 to 1,000 ft [120 to 300 m] thick) is a coal-bearing deposit with fluvial sandstones which may form reservoirs having the coal as a gas source. Other important Mesozoic reservoirs may be the Morrison Formation and the Ellis Group.

Drill depths to Devonian and Mississippian targets should be about 15,000 to 18,000 ft (4,500 to 5,500 m). The Big Snowy Group (Upper Mississippian, 0 to 400 ft [120 m] thick) consists of marine sandstone, limestone, and black shale; many outcrops are notably petroliferous. The Mission Canyon Limestone (Lower Mississippian, 700 to 1,500 ft [210 to 460 m] thick) has abundant porosity and overlies the Lodgepole Limestone (Lower Mississippian, 300 to 750 ft [90 to 230 m] thick), which is thin bedded and dark and may be a hydrocarbon source for the Mission Canyon and other reservoirs. The Jefferson Dolomite (Upper Devonian, 400 to 700 ft [120 to 210 m] thick) is dark colored, marine, fetid, and has outcrops with oil seeps. Other important Paleozoic reservoirs may be the Phosphoria and Amsden Formations.

This geologic setting is similar to the giant Waterton field to the north just across the Canadian border where the Belt has been thrusted eastward over Mesozoic clastics and Paleozoic carbonates. The latter are the major reservoirs at Waterton and may be productive in the study area. Some drill holes at Waterton spud in the Belt.

In the study area, the Belt so much resembles younger sedimentary rocks that it has been misidentified as Cretaceous shale on sample logs available from a reputable commercial firm. It should present no great hindrance in geophysical or drilling programs.

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An Economic Appraisal of Oil Potential of Williston Basin

An economic appraisal was made of the oil potential of more than 80 producing fields in the Williston basin of Montana, North Dakota, and South Dakota. The major oil producing formations investigated were in the Mississippian, Devonian, Silurian, and Ordovician.

Data for the study came from field production and drilling statistics. An extrapolated oil production decline curve for a theoretical "average" producing well first was made for each field. The value of the total extrapolated amount of producible oil for the average well was then calculated, discounted for royalty, taxes, etc, and divided by the estimated cost for a completed producing well. This gave an estimate of the return per dollar invested. No considerations were given for exploration and land acquisition costs.

The estimated return per dollar values, after posting on Williston basin geologic maps, show relative economic comparisons of producing formations and where within the basin the best economic returns can be expected.

JOHNSON, ERIC H., Milestone Petroleum Inc., Billings, MT

Seismic Interpretation in Cordilleran Thrust Belt

Seismic data acquisition and quality are affected considerably by the rugged terrain and complex geology of the Cordilleran thrust belt. With conventional CDP gathers and batch processing, it is surprising that we get interpretable data in some areas. Other problems affecting data interpretability are velocity pull-ups and migration. Velocities can produce antiforms on seismic data that appear to have thousands of feet of closure, while migration is critically important in recreating the subsurface geologic picture.

Seismic sections across the major producing trends of the Central thrust belt illustrate the structural forms of producing fields. It is noted that the structural style is similar in other areas of the Cordilleran thrust belt.

JOHNSON, ERIC H., Milestone Petroleum Inc., Billings, MT

Williston Basin Red River Formation: Exploration Success, Development Failure

Hydrocarbon reserves in Red River limestones are typically found in porosity zones created by paragenetic dolomitization and diagenetic calcite solution and microfracturing. The porosity developed on the tops and flanks of low-relief carbonate highs in a shallow marine environment. Since basement structure and topography controlled the location and limits of porosity development, we attempt to reconstruct Ordovician topography (structure) in our search for Red River prospects. Our attempts at mapping prospects with seismic data are hampered by velocity errors and data resolution.

Most Red River fields are composed of small topographic bumps with associated pods of porosity. Clusters of bumps may be aligned locally and may form regional trends reflecting paleoshorelines. Exploration along these trends can be very successful. However, direct offsets to good discovery wells may be disappointing for several reasons: seismic data may not be able to adequately define the structure, the structure or reservoir may be too small to provide offset potential, porosity may not be developed, or acreage ownership or spacing regulations may restrict optimum well positioning. Unfortunately, lease or drilling deadlines generally have the habit of compounding these problems.

Examples of seismic structures and "porosity" anomalies illustrate the problems of offset drilling. Extension prospecting appears to be a more practical approach to development in the Williston basin.

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Paleotectonics and Sedimentation in Sweetgrass Arch, Montana

The Sweetgrass arch has been part of the stable platform known as the Alberta shelf throughout its tectonic history. This resulted in major periods of emergence interrupted by periods of shelf marine and/or fluvial deposition. The present-day Sweetgrass arch has been in a position coincident or proximate to a marine to nonmarine transition throughout geologic history. Approximately one half of geologic time is represented in the stratigraphic record of the Sweetgrass arch. The remainder of geologic time was occupied by major hiatal periods leaving significant unconformities in the sedimentary column.

Sedimentary history of the Sweetgrass arch is recorded in a stratigraphic column averaging less than 5,000 ft (1,500 m) thick. This thickness grades eastward into a Williston basin stratigraphic column of up to 15,000 ft (4,500 m) and westward into a depositional thickness of more than 100,000 ft (30 km) in portions of the Cordilleran geosyncline.

This discussion will relate tectonic history of the Sweetgrass arch to the sedimentary record, relate tectonic events in the Sweetgrass arch to those in surrounding areas and to the classic orogenic episodes of Rocky Mountain geology, draw some conclusions with respect to tectonic influence on oil and gas accumulations in the Sweetgrass arch, and examine implications for future energy exploration in the Sweetgrass arch.