ondary dolomite porosity has been destroyed by the precipitation of secondary minerals.

Porosity development and reduction by cementation can be explained by near-surface geochemical conditions which are thought to have existed in and around these topographic highs. Dolomitization occurred as meteoric waters were introduced into the subsurface from partly exposed tidal flats. Microcrystalline dolomite was precipitated as waters with high Mg/Ca ratios percolated down from the tidal flats. Rapid nucleation precluded the formation of sucrosic dolomite and porosity. As the Mg/Ca ratio dropped owing to dolomite crystallization, nucleation rates dropped and sucrosic dolomite and porosity developed downdip from the crests of the topographic highs.

In this manner, a "ring-shaped" zone, of reservoir quality porosity formed surrounding paleotopographic highs. Application of this proposed model to petroleum exploration in the Williston basin provides a significant guide for the drilling and accurate development of Ordovician Red River prospects.

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Middle and Upper Ordovician Paleogeography of Region Bordering Transcontinental Arch

Following a period of Whiterockian erosion, Middle Ordovician seas transgressed into the North American continental interior, and a diachronous sheet of clastic sediments (St. Peter, McLish, Winnipeg) lapped onto the margins of the Transcontinental arch. The arch served as a major clastic source region during subsequent deposition (especially Decorah). Middle Ordovician clastic sediments adjacent to the Transcontinental arch and in the Williston basin were probably deposited in a humid climatic regime, and carbonate deposition predominated in an arid belt that included Wisconsin, southeastern Iowa, Missouri, and Illinois, where carbonate oolites and evaporites are noted. Clastic source areas on the Transcontinental arch were inundated, as the marine transgression continued, and a continuous sheet of carbonate sediments (Galena, Viola, Red River, Bighorn) spread across most of the continental interior by the close of the Edenian. Migration of North America across latitudinally-related climatic belts brought the Williston basin area into an arid climatic regime by middle-Late Ordovician as evidenced by the deposition of upper Red River evaporites.

Widespread carbonate deposition was replaced by Dubuque-Maquoketa and Stony Mountain carbonate-clastic deposition as source regions emerged on the Transcontinental arch and Ozark uplift. The lower Maquoketa is conformable with the underlying Dubuque over most of the eastern Mid-Continent, and the joint occurrence of organic-rich shales and phosphorites is attributed to a low-oxygen, phosphate-rich water mass in the Maquoketa sea. The Ordovician closed with red clastic deposition, intermixed with carbonates and/or ironstones, adjacent to the arch.

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Model of Autocementation of Quartz Sands as Suggested by SEM Study of St. Peter Sandstone

Autocementation of quartz sand commonly involves growth of α-quartz in crystallographic continuity with the host grain (overgrowth). This mechanism is not well understood, but SEM examination of quartz grain surfaces from the St. Peter (Ordovician) sandstone suggests that overgrowths develop by recrystallization of a precursor matte or druse which covers much of the original grain surface. However, the matte is always absent along grain contact, and commonly exhibits foliation concentric with the host surface. A cyclic process is thereby suggested for the matte, but one which does not permit deposition between grain contacts. Alternating wetting and drying episodes in which dissolved material is deposited on the sand grain during each cycle is a possible mechanism. Numerous small (1 to 2 μm) euhedral kaolinite crystals scattered over and embedded in the matte are evidence of this mechanism. In the St. Peter sand, it appears that a pore fluid saturated with quartz and kaolinite, and containing numerous kaolinite crystallites, repeatedly came into contact with the sands and evaporated leaving a residue of SiO_2 and kaolinite during each cycle. Whether these cycles were diurnal, annual, or reflect rises and falls in the water table is not known, but it is likely that the cementation involved stages requiring complete removal and reinjection of pore fluid, but not as an uninterrupted process in a permanent, continuous pore fluid.

In this process, the driving forces (e.g., evaporation and a changing water table) are easy to identify and quantify. However, a static situation involving a stationary pore fluid does not present any obvious driving force for either mass transfer or recrystallization.

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Thrust Geometry of Northern Absaroka Sheet, Idaho and Wyoming

Seven major thrusts comprise the Absaroka-St. John thrust system in the Snake River Range southwest of Jackson Hole. The Absaroka thrust forms the base of this system in which earlier, higher thrusts are folded by later, lower thrusts. Shortening within the system is 17 km, excluding the basal detachment. Recent mapping requires a revised nomenclature for the thrusts to recognize that thrust sheets substitute for one another along strike.

There are three different thrust geometries in the area: (1) upward opening wedge-shaped imbricates; (2) horses; (3) complex systems of horses and imbricates. The St. John, Elk, Ferry Peak, and Baldy thrust sheets are wedge-shaped, thickening from about 700 m in the west to 800+ m in the east. These sheets all carry Cambrian limestones and their fault surfaces merge with the basal Absaroka detachment to the west. The Absaroka thrust sheet is isolated as a large horse between the Absaroka and St. John thrusts, which merge at depth to the west and on the surface to the east. The Thompson thrust lies at the base of a complex fault-zone of horses and imbricates resulting from the partitioning of fault slip throughout a well-developed karst and solution breccia zone in the upper Mission Canyon formation.

The Absaroka-St. John thrust system was uplifted and partly eroded as a result of later deformation associated with motion on the Darby and Prospect-Jackson thrust, and because of the uplift of the Tetons. The style of thrusting in this system then should be typical of the regional Absaroka thrust sheet.

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Whitney Canyon—A Proved Giant—Only Small Part of Rocky Mountain Overthrust Belt

The Overthrust belt of the Rocky Mountain region has been the subject of extensive exploration activity since American Quasar's discovery of oil at Pineview field in 1975. The recognition of the significant potential in previously unexplored or lightly explored parts of the thrust belt has caused more than 175 wildcats to be drilled since the discovery of Pineview field. Eleven additional fields have been discovered and 100 development wells have been drilled.

Whitney Canyon/Carter Creek field is by far the largest discovery to date with reserves exceeding 3.1 Tcf of gas and 66 MM bbl of oil. At least seven pay zones have been confirmed and a 4,500 ft (1,372 m) of gas column identified. Combined flow rates exceed 75 MMcf of gas per day at Amoco Production's 457-A well.

The potential for additional discoveries is very high. With 10 or more reservoirs and several types of structural traps productive, the success ratio should remain above average as exploration spreads out from southern Wyoming and northern Utah. During 1979 the industry will drill at least three wells north and three wells south of the currently productive area. Amoco considers these prospects to have very high potential.

A major obstacle to rapidly achieving the Overthrust belt's full production potential is the time needed to design, permit, and build the necessary natural gas processing plants.

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NPR-Alaska, an Update

One of America's last, large frontier onshore hydrocarbon exploration provinces, the vast National Petroleum Reserve in northern Alaska, continues to offer considerable hydrocarbon potential. Although commercial discoveries of oil and natural gas have yet to be found, many significant prospects remain. Several structural features have been tested, but the most promising future prospects appear to be stratigraphic.

The federal government, first through the U.S. Navy and now under the U.S. Geological Survey, has amassed a very competent, dedicated staff and a tremendous amount of excellent exploration data. The data are currently being integrated into many private industry exploration programs and files through the public release of hundreds of millions of dollars' worth of new geophysical and geologic data. Both government and private industry must continue to maintain a very positive exploration "attitude" toward this important area.

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Sonic Logs From Explorationist's Viewpoint

The sonic log is fundamental to the reflection seismologist because it represents the relation between the seismic reflection response recorded at the earth's surface and subsurface stratigraphy. Explorationists should be familiar with the development of sonic-logging tools and the accuracy with which the interval velocity can be obtained from each generation of tool development. Current tools, such as the long-spacing sonic log and the digitized sonic wave-form log, hold great promise in providing the quality of interval velocity data explorationists have long desired.

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Three-Dimensional Simulation of Geologic, Hydrodynamic, and Thermodynamic Development of a Sedimentary Basin—New Approach

An understanding of paleopressures and paleotemperatures can guide and limit the application of geologic, geochemical, hydrodynamic, and thermodynamic principles in our study of the evolution of a sedimentary basin. Although we have qualitative understanding of the influence of paleopressure and paleotemperature on the interaction of sedimentation, compaction, and subsidence, a quantitative evaluation of the system is needed to understand basin history.

Accordingly, a three-dimensional, deterministic dynamic model was constructed to quantify mass and energy transport in sedimentary sequences of a basin. A new water flow equation was derived for a compacting porous medium under moving boundary conditions, and was coupled with the heat flow equation for the transfer of heat by conduction and forced convection (due to water movement). By varying heat flux, initial physical and thermal properties of sediments, paleobathymetric estimates and sedimentation rate, this model can compute pressure, temperature, and physical and thermal properties as a function of space and time.

Studies with this model show that pressure and temperature are closely interrelated with the geologic develpent of a basin. Changes in heat flux alter relations between pressure and physical and thermal properties, and depth. For example, all the dependent and independent variables being equal, a change in heat flux affects the thickness of sediments in such a way that a 1,300-m thick clay layer subjected to a geothermal gradient of 40°C/km will compact to 1,236 m for an increase of 5°C/km, but will expand to 1,400 m with a decrease of 5°C/km to 35°C/km. Consequently, plots of pressure and physical and thermal data against depth are altered.

This dynamic model was successfully used to study a real basin. Pressures and physical and thermal data were computed with an error of less than 8%, and temperatures with an error of approximately 2°C, with respect to all other data.