poraneous Austin-type sediments were accumulating upon an offshore bench or line of prominences. It is inferred that lowermost Austin sediments were deposited upon an offshore, relatively shallow and high-energy floor of likely high temperature and chlorinity.

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POTTSVILLE CONGLOMERATES IN PENNSYLVANIA: PALEOCURRENTS AND ORIGIN

During Pottsvillean time, two major and strikingly different conglomerates were deposited in the northern part of the Central Appalachians. These are the Pottsville formation which crops out in the anthracite area and the Olean (Sharon) conglomerate which occurs along the northern escarpment of the Allegheny Plateau. The Olean (Sharon) is equivalent stratigraphically to only part of the thicker Pottsville formation.

An integrated stratigraphic, petrologic, and paleocurrent study was made of these conglomerates to reconstruct the clastic dispersal system, the geometry of the basin, and the conditions of deposition. Isopach, lithofacies, cross-bedding, maximum pebble size, and petrographic data were used to attain these objectives.

The depositional basin—an asymmetric, elongate trough which trends northeast-southwest—consists of (1) a narrow zone of maximum subsidence (trough) along its southeastern margin, and (2) a broad stable shelf area at the northwest. The basin was bounded on the southeast by a tectonic source land composed dominantly of metamorphic and sedimentary rocks and on the north by a stable cratonic area consisting largely of sedimentary and low-grade metamorphic rocks. Both areas contributed coarse gravels to the depositional basin.

A thick (up to 1,300 feet) wedge-shape conglomeratic sequence (Pottsville formation) was deposited along the southeastern margin of the basin by alluvial fans emerging from the southeastern highland. Initially, deposition was restricted to the trough area, where deposition was uninterrupted from the Mississippian to the Pennsylvanian, but later spread to the shelf. The transport direction was northwest (300–360°), transverse to the axis of the basin and down the paleoslope. The depositional strike paralleled the axis of the basin. The stratigraphic section thins downslope from the fall line, located near Philadelphia. This "tectonic" dispersal system deposited orthoquartzitic conglomerates and lithic sandstones (protoquartzites).

The thin (generally less than 50 feet) sheet-like conglomerate deposit (Olean-Sharon) along the stable northern margin of the basin was deposited by two contemporaneous fluvial systems, one located in north-central Pennsylvania, which dispersed material toward the southwest, and one in northeastern Ohio, which dispersed material toward the south. These systems transported material obliquely and parallel with the axis of the basin across an erosional Mississippian surface. These orthoquartzitic conglomerates and sandstones were deposited by the "cratonic" dispersal system.

In the central part of the basin, three sheet-like fluvial sand bodies (protoquartzite and orthoquartzite) were deposited. The lower Connoquenessing sandstone was deposited by the "cratonic" system; this sandstone and the Olean conglomerate appear to be part of the same rock stratigraphic unit. The upper Connoquenessing and Homewood sandstones were deposited by the "tectonic" system.

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APPLICATION OF DIAGENETIC PRINCIPLES TO PETROLEUM EXPLORATION

Investigations directed toward petroleum exploration problems have shown that diagenetic parameters can be useful in mapping subtle structural features that are not otherwise apparent. The investigations are based on the premise that structural movement alters the primary character of a sediment and that the degree and extent of alteration are a function of: (1) type of movement, (2) local intensity of stress, (3) age of movement with respect to reference horizons, and (4) the number of movements. Emphasis for exploration purposes is placed on (a) analysis of the alteration within the objective or reservoir horizon, and (b) interpretation of the structural history of the objective horizon in terms of stratigraphy, textural distribution patterns, and alteration in the overlying strata.

At numerous locations in the northern Rocky Mountains, anomalous textural distribution patterns in strata of different ages are superimposed on each other. These patterns reflect the recurring influence of structural movement in the same place at different periods in geologic time. Having defined these trends in broad terms of sedimentation, the local structural anomalies can be defined more precisely by analyzing the diagenetic changes; i.e., changes in cementation, grain and crystal alteration, solution characteristics, and fracture filling. These parameters show by the stratigraphic position of the alteration the influence of compaction, downwarp, upwarp, flexing, folding, incipient faulting, and truncation.

Calcite to dolomite conversions, as mineral cement in detrital rocks or as host material, offer the most apparent type of change as an indicator of structural deformation. Examples in the Williston basin are shown from Nesson and Cedar Creek anticlines, and also from the projection of the down-warped flexure related to the Van Norman fault. Other local areas along the northern limb of the basin are presented for appraisal.

Recrystallized and injected forms of anhydrite and halite are used as supplemental criteria because of their instability under stress. As deterrents to permeability, they receive special consideration when encountered in the objective horizon. Examples are cited from the Nesson-Frobisher and Midale facies in the northern Williston basin and from the Minnelusa formation of Wyoming.

Authigenic chert and quartz mosaics in the host rock and in fractures are used to help define faulted zones and unconformable contacts related to uplift and erosion. Examples are cited from the post-Mississippian–pre-Triassic surface of central Montana.

Results of these and other investigations show that alteration criteria can help to localize exploration prospects, and that some of the better known "stratigraphic traps" in the northern Rocky Mountains have had a recurring history of structural advantage over the surrounding area throughout much of geologic time.

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ASPECTS OF REEF DEVELOPMENT AS ILLUSTRATED BY THE DEVONIAN ANCIENT WALL REEF COMPLEX, ALBERTA*

The Ancient Wall reef complex occurs in thrust sheets of the western Front Ranges of the Alberta Rocky Mountains north of Jasper. The reef complex is exposed

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in two thrust sheets for a distance of 26 miles. The reef complex consists of a lower dolomitic stromatoporoidal limestone (Cairn formation) overlain by well bedded aphanitic limestone (Southesk formation) which contain abundant non-skeletal grains locally mixed with fossil fragments. This reef is comparable to adjacent reefs in the mountains and to some of the subsurface reefs.

The depositional history of the reef has been reconstructed from the stratigraphy, reef geometry, and a detailed study of the well exposed south margin. Thin argillaceous and stromatoporoidal carbonates were deposited over the entire area (Flume formation). Thicker and more fossiliferous portions of the Flume occur beneath the margin of the overlying Cairn reef and appear to represent shoals on and around which organic growth flourished. Differential subsidence combined with a rising sea level drowned most of the stromatoporoidal platform. In the relatively shallow waters above the more positive portions of the basin, stromatoporoidal growth continued. Between 400 and 500 feet of thick, massive stromatoporoidal carbonates and detritus accumulated above these more positive areas, forming the Cairn biostromes of the Ancient Wall and adjacent reefs. The surrounding basin was partly filled with black, predominantly euxinic shales (Perdrix formation). A lowering of sea-level throughout the basin caused shallowing above the biostromal area. Thus the environment was changed to one of very shallow-water bank conditions in which fine carbonate sands and muds with a pelletoid texture (Southesk formation) were deposited.

Gradual subsidence permitted the accumulation of between 500 and 600 feet of carbonate sands. The Southesk bank is flanked by brachiopod limestones and shales which contain local, small, coral biostromes. These fossiliferous carbonates grade into thin-bedded calcareous shales and limestones (Mount Hawk formation) of the surrounding basin. Basin relief was gradually decreased by influx of terrigenous muds and fine carbonate muds and detritus derived from the bank. Further shallowing and basin-filling permitted lateral extension of the bank environment and associated carbonate sands. During the Sassenach transgression the bank was emergent and the margins were eroded slightly.

The abrupt variations in thickness and character at the reef margins indicate differential subsidence during and after accumulation of the reef complex. Thus both differential subsidence and changes in sea-level have exerted control on reef development.

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BASEMENT IN THE CONTINENTAL INTERIOR OF THE UNITED STATES

Buried basement rocks of the central United States are mainly plutonic granitic rock, mafic and felsic metamorphic rock, and diabase. Rhyolite, granitic rock, and gabbro-diabase form a discontinuous belt from eastern New Mexico to eastern Missouri. The 0.5 b.y. rocks in the Wichita Mountains, Oklahoma, are the result of the last major igneous event. The Ouachita structural belt is the southern limit of petrographic knowledge of plutonic rocks.

None of these rock groups bears a simple relationship to basement topography and isotopic age. The Black Hills uplift-Cambridge arch-Central Kansas uplift is underlain dominantly by metamorphic rock with ages ranging from 1.7 b.y. in the north to 1.2 b.y. in the south. Siouxia arch contains 1.4 b.y. granitic and metamorphic rock. Nemaha uplift is underlain by 1.2–1.5 b.y. granite. Diverse rock types of 1.2–1.4 b.y. underlie Amarillo uplift and Red River–Matador arch.

Several large gravity anomalies correspond to major basement structures. The Williston basin is bounded on the south and west by a series of major west- and northwest-trending gravity anomalies and on the east by a belt of south-trending gravity anomalies extending from Canada into the central Dakotas that coincides with the boundary between the 2.5 b.y. Superior and the 1.7 b.y. Churchill Provinces of the Canadian Shield. The Sioux formation (minimum age 1.2 b.y.) lies along the west-trending anomaly in southeastern and central South Dakota. Keweenawan basaltic and sedimentary rock coincides with the mid-continent gravity anomaly and extends nearly continuously from Lake Superior to northeastern Kansas. The prominent gravity feature along the Red River–Matador arch coincides with the boundary between 1.2–1.4 b.y. rocks in the central United States and the 1.0 b.y. rocks in Texas.

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MINERALOGY, PETROLOGY, AND GEOCHEMISTRY OF PORPHYRIES AND GRANITIC ROCKS AT GREAT BEAR LAKE, NORTHWEST TERRITORIES

The Precambrian region between Great Bear and Great Slave Lakes is characterized by large bodies of granitic rocks and quartz-feldspar porphyries. In Great Bear Lake area granitic rocks, about 1,800 million years in age, range in composition from granite to diorite. Some are high in potash and have the characteristics of rapakivis. Closely related to granitic rocks are large volumes of quartz-feldspar porphyries which exhibit the peculiarities of ignimbrites. These, when in contact with granitic rocks, are recrystallized but still retain evidence of volcanic origin.

Integration of field data, qualitative and quantitative mineralogy, and distribution of 19 trace elements from 250 samples suggests that the parent magma was acidic and that the phenomena of volcanism and plutonism are closely related, the difference between them being mainly the depth of activity.

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SURVEY OF DIAPIRS AND DIAPIRISM

Diapirs, *sensu stricto*, are bodies of sedimentary material which have pierced (or appear to have pierced) overlying material as a result of their mobility at comparatively low temperatures. They are composed of evaporites, shales, mud, etc. and range in size literally from molehills to mountains and in age from Precambrain to Recent. They occur associated with marine as well as continental sedimentary sequences and in areas which have been subject to intense tectonic deformation, virtually no deformation other than basin subsidence or to all amounts of deformation in between. As a result of the numerous possible combinations of these different attributes, diapirs of many types occur dispersed over much of the earth. Among those structures which are considered to be forms of diapirs, some of the best known are the diapiric folds of Roumania; the piercement salt domes of the Middle East, the Gulf Coast of Mexico, the United States, and Russia; the salt diapirs of Australia, Europe, and South America; the salt stocks and salt walls of Germany; some of the salt anticlines of the Canadian Maritime Provinces and the western United States; the gypsum diapirs of the Cana-