GORDON RITTENHOUSE, Shell Development Company, Houston, Texas

Problems and Principles of Sandstone Body Classification

The geometry of sandstone bodies involves their shape, size, and orientation. The original geometry is subject to later modification by erosion, faulting, folding, tilting, compaction of underlying sediment, and internal "compaction."

Although orientation or "trend" has been, and will continue to be used successfully in some cases without knowledge of the origin of the sandstone bodies, greater predictability should be possible if the origin can be determined—provided the distributional patterns of sediments of various origins are known. Insofar as geometry is concerned, three major problems are (1) to reconstruct the geometry correctly, (2) to know what it implies regarding origin, and (3) to know the distributional pattern of sediment of that origin in an analogous depositional situation.

For reconstruction of sandstone body geometry, total sand thicknesses or sand-shale ratios for thick sedimentary sequences are of limited value. Isopach maps of individual sand bodies define their size and orientation, but only partially define their shape; cross-sections "hung" on a closely related underlying or overlying bed, whose original attitude relative to the sandstone body is known or can be reasonably assumed, are also required to define shape. Possible modification of original shape by compaction or other processes must be considered.

The plan dimensions of present-day deltas, barrier bars, and other sedimentary types are rather well-known, but three-dimensional data are scarce. Too often, third-dimensional data from ancient sediments are misleading because the origin has been incorrectly determined.

Such internal features as cross bedding, flow markings, grain orientation, bed or grain size sequences, and the relationship of a sandstone body to beds above, below, and laterally are important for interpreting origin particularly where control is too sparse to define the geometry.

W. A. ROLIFF, Imperial Oil Ltd., Toronto, Canada

Oil and Gas Prospects of Maritimes Region of Eastern Canada

Portions of the Provinces of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland, bordering the Gulf of St. Lawrence, are underlain by sediments of Ordovician and Mississippian age in which manifestations of hydrocarbons occur.

Although some oil is present in the Ordovician in Newfoundland, the prospects for finding commercial fields in rocks of this age do not appear to be promising. In New Brunswick one small oil and gas field has produced from the Mississippian since 1909. At several localities throughout the Maritimes region oil seepages occur and showings of oil and gas have been obtained in wells which penetrated the Mississippian rocks. In general the Mississippian consists of conglomerates and sandstones, a thick series of shales, a large percentage of which are bituminous, followed in ascending order by a carbonate-evaporite-red-bed sequence that was repeated a number of times. There are present in the basin a number of stratigraphic and structural features, namely diapir salt structures, salt domes, fault blocks, anticlines, porosity pinch-outs; sand lenses, and other types considered as favorable for the trapping of oil and gas.

The stratigraphic and structural conditions are complex, and although the results of exploration to date have not been encouraging, this region must still be considered as worthy of further investigation.

J. S. SCHLEE, University of Georgia, Athens, Georgia
R. H. MOENCH, U. S. Geological Survey, Denver, Colorado

Jackpile Sandstone: Structurally Localized Fluvial Deposit

The Jackpile sandstone of local usage—exposed near Laguna, New Mexico—is in the uppermost unit in the Morrison formation of Jurassic age. The petrography, sedimentary structures and shape of the unit, its relation to tectonic structures, and analogies to similar ancient and modern sandstones suggest that it was probably deposited by a northeast-flowing stream system that was largely confined by contemporaneous structural depression. Continued downwarping after deposition, followed by erosional truncation, emphasized the structural localization of the unit.

The sandstone is fine to medium grained, friable, and moderately well sorted; coarser grained beds are more abundant near the base of the unit. The composition ranges from a calcite-cemented subarkose near the base to kaolinite-indurated quartz sandstone near the top. Terrestrial plant remains are locally abundant.

The so-called Jackpile sandstone is a northeast-trending tabular body as much as 12 miles wide, at least 30 miles long, and up to 200 feet thick. It splits into distributary-like bar fingers to the northeast. Cross-beds in the Jackpile sandstone dip mostly northeast, suggesting that the sediments were transported northeastward. The unit wedges to the northwest and southeast along an angular unconformity bounded by the overlying Dakota sandstone, and broad folds in the strata below this unconformity parallel the southeastern limit of the Jackpile sandstone. Other stratigraphic units in the Morrison formation tend to thicken in the area of the Jackpile sandstone. This suggests that structural downwarping was active in the area before, as well as during and after Jackpile deposition.

SOL R. SILVERMAN, California Research Corporation, La Habra, California

Carbon Isotopic Evidence on Mechanisms of Petroleum Maturation

The C^{13}/C^{12} ratio of gas (largely methane) separated from crude petroleum is about 1 per cent lower than that of the whole crude. Analyses of liquid distillate fractions of petroleum indicate that the C^{13}/C^{12} ratio is highest in the lowest boiling fraction (gasoline) and decreases gradually in consecutive higher temperature fractions; the rate of C^{13}/C^{12} ratio decrease is about 0.015 per cent per 100°F. increase in boiling range.

To account for the observed C^{13}/C^{12} ratio increase in the transition from complex petroleum constituents to the simpler hydrocarbons of the gasoline fraction, we postulate that the lowest molecular weight hydrocarbons are formed by decomposition of high molecular weight components. This decomposition is accompanied by carbon isotope fractionation that enriches the lowest molecular weight products (methane and ethane) in C^{12}. The residue left behind after methane formation, therefore, has undergone a reduction in molecular weight and an increase in C^{13} content. As decomposition continues, the residual molecules become correspondingly smaller (and lower boiling) and isotopically heavier (higher C^{13} content).

If a material balance is attempted by redistributing the C^{13}/C^{12} abundances of the gas fraction among the various liquid distillate fractions, we arrive at an isotopic composition of the resulting gas-free petroleum that is close to the isotopic composition of the highest boiling fraction. Available data on the isotope effect accompanying the thermal decomposition of simple organic molecules indicate that C^{12}—C^{12} bonds are ruptured about 8 per cent more frequently than are C^{12}—C^{13} bonds. This fractionation is in the same direction and of the same order of magnitude as the fractionations apparently involved in the decomposition of complex petroleum constituents.

These observations, which can readily be explained by assuming that the lighter petroleum fractions are derived from high molecular weight compounds, must be considered in evaluating existing hypotheses of petroleum origin and evolution.

HOWARD A. SLACK, and CAREL OTTE, JR., Pure Oil Research Center, Crystal Lake, Illinois

Electric Log Interpretation in Exploring for Stratigraphic Traps in Shaly Sands

Two quantities which can be calculated from conventional electric logs of shaly sands provide useful reliable information on the reservoir rock and the fluid it contains.

(1) *Shaliness.*—A measure of the amount of disseminated clay material in the formation. This quantity measures the ease with which the rock gives up fluids and also makes an excellent mappable attribute for the construction of subsurface facies maps. The relative agreement between this log-derived property and the results of cation exchange capacity measurements is good.

(2) *Saturation Ratio.*—The ratio of mud filtrate saturation in the invaded zone to the interstitial water saturation in the non-invaded zone. Although it is not considered to be a mappable attribute, the magnitude of this ratio is indicative of the amount of displaceable hydrocarbon in the formation.

The value of shaliness and saturation ratio when viewed together are related to the performance of the formation under production tests. Definite ranges in the values of these quantities are associated with (a) formations which produced hydrocarbons readily, (b) formations which produced hydrocarbons in commercial quantities only when some form of artificial stimulation, such as sand fracturing, was applied, and (c) formations which produced water along with the hydrocarbons.

A single favorability criterion is developed which is a joint function of shaliness and saturation ratio. This criterion attempts to rate numerically the production performance of any given formation on the basis of electric log derived quantities only. Its use in exploration is demonstrated by maps which show how it varies throughout and around known oil fields in shaly sand. It may have value as a means of detecting from dry hole data the proximity to good oil production.

F. J. STEVENSON, University of Illinois, Urbana, Illinois

Nitrogenous Constituents of Some Paleozoic Shales

As much as three-quarters of the nitrogen in some Paleozoic shales was released as ammonia by acid hydrolysis; from 1 to 5 per cent as amino acids. The nitrogen released as ammonia occurred largely as ammonium ions held within the octahedral pores making up the crystalline nuclei of illite clay minerals. The presence of nitrogenous organic constituents within the characteristic expansible layers of silicate minerals was also indicated. The organic matter adsorbed on the internal surfaces of the clay was non-extractable with alkali, but was removed readily through decomposition of the clay with hydrofluoric acid.

A comparison of the organic constituents in shales with those in recent sediments showed that a smaller fraction of the organic matter in shales occurred in protein derivatives. The carbon-organic nitrogen ratio in shales was higher than in recent deposits. The suggestion is made that the transformation of complex organic materials in marine muds consists, in part, of the formation of aromatic compounds from sugar-amine condensation products, and that, concomitantly, nitrogen is lost as ammonia and petroleum constituents are formed.

WILLIAM LEE STOKES, University of Utah, Salt Lake City, Utah

Fluvial and Eolian Sandstone Bodies in Colorado Plateau

The Colorado Plateau has been the site of accumulation and preservation of non-marine sediments since late Paleozoic time. The climatic conditions have been desert-like for long periods and wind-blown sand is a common sedimentary type. Much of the alluvial material did not leave the source area and is still near its place of origin. The deep and intricate erosion permits excellent three-dimensional views of the sedimentary bodies.

Extensive eolian formations occur in the Permian, Triassic, and Jurassic systems. These are mainly interpreted as superposed dune fields. In many instances the edges of the formations are abrupt and comparison with modern sharply defined dune areas is obvious. Tangential cross-bedding with occasional contorted masses characterize these deposits. Chief interest attaches to the determination of wind directions; apparently the source of most of the sand lay to the north and northwest.

Fluvial deposits are common after the Pennsylvanian. These offer excellent opportunity to study sedimentary variations resulting from differences in climate, weathering, distance of transport, provenance, and energy relations of stream systems. The common occurrence of uranium deposits in the fluvial sandstones has stimulated geologic investigation. The petroleum possibilities of these beds are also receiving increased attention.

Practically every type of deposit seen in process of formation in modern rivers can be detected in the consolidated rocks. The overbank or flood-plain deposits are of less variety and interest than the channel deposits. All types of bars and channel-fill deposits are present but those formed during the building of alluvial plains are most common. Apparently the final composition of a typical fluvial formation depends on the gradient of the streams, the total amount of sediment supplied, and the relative amounts of fine and coarse material. Internal structures of channel sandstones show great variety and can be related to stream volume and velocity. Ripple-mark, festoon cross-bedding, rib-and-furrow, and lineation are the most common.