Cardium Formation at Seebe, Alberta—Storm-Transported Sandstones and Conglomerates

The Upper Cretaceous (Turonian) Cardium Formation is one of the most productive oil-bearing formations in Alberta. As a result of detailed mapping of two outcrops near Seebe, Alberta, we have defined five coarsening-upward sequences within this formation. The sequences begin with bioturbated mudstones and coarsen into sandstones, commonly with conglomeratic veneers on top. In sequence 2, a 20-cm thick conglomerate has been molded into symmetrical gravel waves.

The sandstones are dominated by hummocky cross-stratification, occurring in the upper parts of sequences 1, 2, 3, and 5. The implication is that these sequences terminate in water deeper than fair-weather wave base (10 to 15 m). The trace-fossil assemblage, dominated by abundant *Zoophycos* and long horizontal *Rhizocorallium,* suggests similar depths. Foraminifera recovered from sequences 3 and 4 comprise a highly diverse assemblage of agglutinated species, also supporting deposition below fair-weather wave base.

In view of the physical and biologic evidence for deposition in a few tens of meters of water, and the total absence of medium-scale cross-bedding, we suggest that the entire Cardium Formation at Seebe was deposited below fair-weather wave base. The sandstones were emplaced by storm-generated density currents, the same storm both generating the flow and imprinting hummocky cross-stratification on the deposit. Finally, we suggest that the conglomerates were also moved rapidly seaward by density currents, there being no evidence for the traditional beach or transgressive lag interpretation of these rocks.

WRIGHT, V. PAUL, Open Univ., Milton Keynes, United Kingdom

Paleokarsts at Unconformities

The awareness of the importance of subaerial exposure in the diagenesis of limestones has led to the recognition of a variety of subaerial phenomena in carbonate sequences such as vadose cements and calcrete crusts. Other such phenomena include paleokarsts, of which there are surprisingly few detailed descriptions.

One problem in recognizing paleokarst is to differentiate it from both Holocene and ancient interstratal (or subadjacent) karst. This is a post-burial effect which can create subsurface karstic surfaces along unconformities or bedding surfaces. The unconformity between the Lower and Upper Carboniferous in South Wales displays karstic features which have formed interstratally and have overprinted and were controlled by the original erosional relief along the unconformity. Interstratal karst can be differentiated from true paleokarstic surfaces by simple stratigraphic criteria.

Paleokarsts are common in the Mississippian limestones of Britain, and three types can be recognized in the shelf sequences in South Wales. First, there are large clay-filled hollows interpreted as solution dolines; second, there are mammillated karstic surfaces overlain by paleosols and calcrete crusts with abundant alveolar fabrics (rootlet tubules), interpreted as a type of deckenkarren analogous to Holocene South African Makondo karsts. Third, there are unusual paleokarstic zones consisting of bands of rubbly limestones containing large, irregular fluted blocks surrounded by clay-filled solution pipes and fissures and analogous to Holocene Kavornossen karren, Puerto Rico.

The paleokarsts provide information on the paleoclimate, paleohydrology, and the vegetation cover existing at the time of their formation and are useful paleoenvironmental indicators. They are the raw material for paleogeomorphology and obviously can provide excellent sites for hydrocarbon accumulation.

WYATT, DANNY J., Mobil Oil Corp., Denver, CO

Preliminary Analysis of Depositional Environments of Tar Sand Host Rocks, Uinta Basin, Eastern Utah

Four major tar sand bodies in the Uinta basin were examined in terms of their depositional environments: (1) the Duchesne River and Mesaverde Formations at the Asphalt Ridge deposit near Vernal, Utah; (2) the Wasatch and Green River Formations at the Sunnyside deposit near Sunnyside, Utah; (3) the Green River Formation of the Hill Creek deposit in the southern Uinta basin; and (4) the Green River Formation in the P.R. Spring deposit of the southeastern Book Cliffs.

The Mesaverde Formation at Vernal is interpreted as a fluvial deposit, based on the discontinuous geometry, and the presence of large-scale trough cross-beds which grade vertically into smaller trough cross-beds and tabular foreset beds. The lower Duchesne River Formation was deposited in distributary channels, based on the discontinuous geometry, large-scale trough cross-beds, contorted bedding, and clay-chip zones. This facies is overlain by a meandering flood-plain sequence of sandstones and red shales.

The Wasatch Formation in the Sunnyside area is comprised of stream-mouth bars, point bars, and both active and partial abandonment channel fill. The Green River Formation at Sunnyside was deposited in distributary channels as evidenced by a scoured contact, calcareous clay clasts, large-scale convoluted bedding, and the geometry. This facies grades to the southeast into more laterally continuous sands in the P.R. Springs area. These sands reflect delta front deposition.

YOUASH, YOUNATHAN Y., and AMITABHA MUKHOPADHYAY, Kuwait Inst. Scientific Research, Safat, Kuwait

Geology of Minagish Oil Field, Kuwait

The Minagish oil field is located in southern Kuwait. To date, 23 wells have been drilled in this field. The discovery well, MN-1, was drilled to explore a seismic prospect in this area and was completed in May 1959. The primary aim of this wildcat well was to test all the potentially oil-bearing formations down to and including the Jurassic Arab Zone equivalent. The well established the first commercial accumulation of oil in the Minagish Oolite Formation of Early Cretaceous age. The well found oil prospects in the middle Cretaceous Wara, Mauddud, and Burgan Formations. The Minagish oolitic limestone of Early Cretaceous age is the main oil-bearing reservoir in the Minagish field. The Mishrif Limestone Formation of uppermost Middle Cretaceous has also been found productive in two of the Minagish wells. The quantitative evaluation of well logs indicate that the Upper Cretaceous Tayarat Formation and the Paleocene-lower Eocene Radhuma Formation may also be prospective in this field.

The well evidence suggests that the field is located on a north-south-trending anticlinal structure which has been cut across by a few faults. The structure is oriented north-south. It is 8 km (5 mi) wide and 14 km (9 mi) long. The structural closure is about 200 m (650 ft). The thickness, porosity, and shaliness variation of Ratawi Limestone suggest that, in all probability, the structure was existing in an incipient form at the time of the deposition of this formation. Maps of gross thickness and average effective porosity as derived from the quantitative log evaluation have been prepared for the formations of interest. The reservoir parameters show an overall conformance with the structure.

YOUN, SUNG H., Univ. Calgary, Calgary, Alberta, Canada