deposits. Study of Hensel outcrops in Kimble, Gillespie, and Blanco Counties, south of the Llano uplift, reveals a facies evolution that is associated with a major marine transgression. This evolution is expressed in both a north-south facies tract and in the overall stratigraphic succession. Four major depositional systems are recognized. (1) Basal, valley-fill deposits are limited to localities proximal to the source area. (2) Low-sinuosity, bedload channel-facies overlie the valley fill and are widely distributed. (3) Low-sinuosity channel-facies evolved into more distal, somewhat finer grained, coastal-plain fluvial systems. (4) Both the fluvial and coastal-plain facies are characterized by extensive flood-basin muds and small, ephemeral arroyos. The pervasive development of calcrete, or caliche, within the overbank deposits, and the overall depositional style of the unit imply a semiarid, seasonal climate. As the marine transgression progressed, the sediment supply decreased and channel gradients lowered. Deposition of the shallow marine or lagoonal carbonates that overlie the Hensel resulted from the final inundation of the source area.

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Depositional Environments of Norphlet Formation (Jurassic) of Southwestern Alabama

The Norphlet Formation in southwestern Alabama has become a primary target for oil and gas exploration. Isopach data show that Norphlet deposition was affected by a subsiding Mississippi Interior Salt basin, early movement of the Louann Salt, and stable Appalachian ridges and paleohighs, such as the Conecuh ridge and the Wiggins arch. The formation is over 1,000 ft (350 m) thick in parts of Washington, Clarke, Baldwin, and Mobile Counties. The Norphlet thins or is absent over areas of penecontemporaneous salt movement and is absent over the stable Wiggins arch.

The Denkman Member of the Norphlet is underlain by a red-bed sequence that grades updip into a conglomerate. The Denkman consists of clean, fine-grained, well-sorted sandstone, including a lower cross-stratified unit and an upper massive unit. The red-bed sequence is mostly sandstone with shale, shaly sandstone, and siltstone at the base. The shales, present in Escambia and Choctaw Counties, were probably deposited as distal portions of alluvial fans. Wadi gravels were deposited adjacent to the Appalachian highlands and grade downdip into the red-bed sequence. Both the gravels and red beds were deposited by sediment-choked braided streams and subjected to reworking and deflation, producing the Denkman Member. The Denkman consists of eolian sands, reworked at the top by the Smackover transgression into a massive sand up to 70 ft (21 m) thick. Thin, massive and horizontally laminated units in the cross-stratified sand indicate that narrow interdunes separated the broad dune sands of the Norphlet. A generalized sequence of diagenetic events affecting porosity may have been compaction, quartz overgrowth, and carbonate cementation, and possible selective dissolution of cements followed by deep cementation.

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Geology and Log Study of Tight Gas Sandstones—Cotton Valley Group

Through a cooperative research program among Schlumberger-Doll Research (Ridgefield, Connecticut), Schlumberger Well Services (Shreveport, Louisiana, and Houston, Texas), and Delta Drilling Co. (Tyler, Texas), a whole core and a conventional (DIT*/BHC, GR/CNL*/FDC*, HDT/FIL*)[1] and experimental-prototype (Digital Sonic, CNT-G, EPT*, GST-A*, NGT*, NML*) suite of logs were examined from the lower and middle Cotton Valley sands (Upper Jurassic) of a 10,200-ft (3,100 m) well (Alice Snider 1). The well is located in the Carthage tight gas sand field, located in Panola County, about 60 mi east of Tyler, Texas. Particular attention was directed to one of the two gas-producing zones (9,354 to 9,638 ft, 2,851 to 2,938 m); a deeper gas-producing zone (9,700 to 10,027 ft, 2,957 to 3,056 m) was not cored.

A synthesis of the rock core and log data leads to the following conclusions.

1. The formation is dominantly a well-laminated and horizontally bedded unit with low-angle, planar cross-bedding, shallow-water ripple marks, and convoluted bedding. Bioturbation and diagenesis have dramatically altered these features in some parts of the core.

2. The lithology is an alternating sequence of lithic sandstones (sublitharenites) and silty shales. Minor amounts of conglomerates, coal laminae, and fossil-bearing zones are also noted.

3. The tight gas sands have low porosities (<10%) and low permeabilities (<0.1 md). Intergranular porosity (2%) is reduced by authigenic quartz and/or calcite overgrowths and/or pore-lining, filling, and bridging clay minerals—illite, chlorite, and illite-chlorite mixed layers. Relatively abundant intergranular and secondary (4%) porosity is also noted.

4. The depositional environment of the gas-producing zone is interpreted as an alternating and transgressive sequence of shallow marine water dominated by barrier bars. Interbedded with the bioturbated shoreface sediments are minor tidal-deltaic sands deposited near the northeast-southwest-trending edge of a sedimentary basin.

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"Big Look"—Future Trend of Exploration

New ideas, new techniques, and new methods of exploration must be employed in concert with the conventional methods of the past to meet the ever-increasing demands for energy and strategic minerals. The synoptic view, or "Big Look," provided by satellite imagery and augmented by high-altitude aircraft data affords the explorationist new prospectives resulting in more comprehensive interpretations on a regional basis, and assists in establishing geologic trends.

Integration of all available geologic and geophysical information with that derived from Landsat imagery and other remotely sensed data provides a method of identifying potential petroleum and mineral prospects on a regional basis. Using this consolidated information, specific areas of interest may be identified for evaluation in greater detail through additional investigation. For petroleum prospects, this may involve the designing of a detailed geophysical program. For mineral prospects, this could include a more sophisticated remote-sensing program, conventional airborne and/or ground geophysical surveys, and detailed geologic mapping.

These techniques have been applied to frontier areas as an inexpensive preliminary source to localize prospects. Prospects have also been identified by these techniques in older, mature, producing areas.

In order to integrate accurately and cost effectively the

[1]Asterisk is mark of Schlumberger.