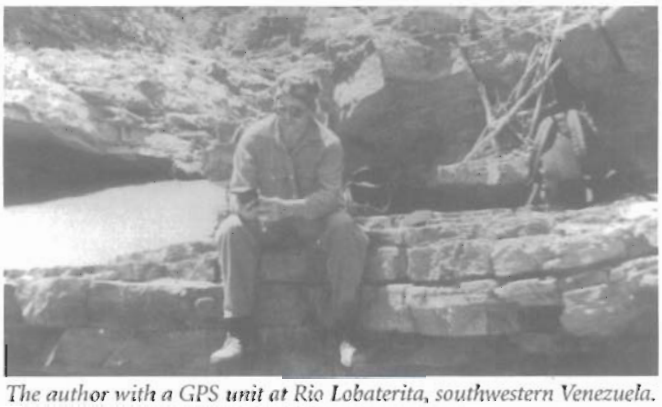
by R. N. Erlich, Burlington Resources International,
O. Macsotay I., Urbanización El Trygal Norte, Venezuela
A. J. Nederbragt, Dept. of Geological Sciences, University College London
M. Antonieta Lorente, PDVSA Exploración y Producción, Venezuela

Focus on
Sub-Andean
petroleum systems

Depositional environments of Upper Cretaceous source and reservoir rocks of western Venezuela

Abstract

The deposition of organic carbon-rich sediments of the Late Cretaceous La Luna and Navay formations resulted in the formation of a world-class petroleum system in western Venezuela. Over 33 billion barrels of oil have been produced from reservoirs charged by oil from this system, with remaining recoverable reserves of at least 22 billion barrels. Assuming 14% average recovery of original oil in place, as much as 370 billion barrels of oil may have been trapped in the *Continued on pg. 16*



The author with a GPS unit at Rio Lobaterita, southwestern Venezuela.

Biographical sketch

Bob Erlich received his Ph.D. in paleoceanography from the Vrije Universiteit of Amsterdam, The Netherlands, where he worked with Wolfgang Schlager. Bob earned his M.S. in sedimentology and stratigraphy at the University of North Carolina at Chapel Hill, and his B.S. in geology at the University of Miami, Florida. He began his career as a field geologist in Guatemala in 1975 following the early influences of Cesare Emiliani, Jerry Stipp, and Fred Nagle. Bob has since worked in the field throughout Latin America, as well as in the People's Republic of China. He worked for 19 years in various exploration positions for Amoco Production Company, first in domestic exploration in New Orleans and later in the Worldwide Exploration Business Group in Houston. He joined Burlington Resources International in early 1999 as the Geological Advisor for Latin America, where he advises on exploration projects throughout the region. Bob has published on numerous topics during his career, including the seismic stratigraphy of carbonate platforms, the petroleum geology of Eastern Venezuela, the Miocene carbonates of Trinidad, and the Late Cretaceous source rocks of Costa Rica and Western Venezuela. His current research interests are in Late Cretaceous source rocks and carbonate stratigraphy. □

Unconformable contact between the shallow water platform carbonates of the Late Cenomanian Guayacan Member of the Escandalosa Formation (right of the arrows), and the organic carbon-rich middle shelf shales of the Turonian Navay Formation (left of the arrows). Location: Rio Santo Domingo, eastern Mérida Andes, western Venezuela.

Maracaibo and Barinas/Apure basins following generation and expulsion from the La Luna and Navay formations.

The deposition of oil-prone source rocks in northwestern Maracaibo began following drowning of the Albian-Cenomanian Maraca Formation carbonate platform. La Luna/Navay deposition continued in southeastern Maracaibo after drowning of the more southerly Guayacan Member carbonate platform (Capacho and Escandalosa formations) during the late Cenomanian to early Turonian. The Maraca Formation and other shallow water Cogollo Group carbonates are important reservoirs in the western, central (Lake Maracaibo), and southern parts of the Maracaibo Basin. Arguably the best examples of this are the giant Mara-La Paz fields. Fracture-enhanced Cogollo Group reservoirs there have produced over 850 MMBO since 1923. New discoveries in the central Barinas/Apure Basin may yield a similar (aggregate) volume from slightly younger Escandalosa Formation sandstones and carbonates.

The conditions under which organic carbon-rich sediments accumulated reflect complex paleoclimatic and paleoceanographic variables, including bathymetric restriction and bottom water anoxia. Specifically, paleobathymetric barriers (Santa Marta and Santander massifs, Paraguana Block, and ancestral Mérida Andes) enhanced the development of anoxia by causing poor circulation and limited ventilation. Anoxia was also promoted by high evaporation and low precipitation rates (high salinity bottom water), and high levels of marine algal productivity (high organic matter flux).

Bottom water oxygen levels apparently increased from the late Santonian through the end of the Cretaceous, due primarily to changes in local and global climate. Increased tectonic uplift and higher rainfall rates in eastern Colombia during the Campanian and Maastrichtian contributed to lower TOC level, through delta progradation and siliciclastic dilution. Subsidence of the Paraguana paleobathymetric barrier facilitated exchange with better-oxygenated water from the Atlantic Ocean, thus ending source rock deposition in the Maracaibo Basin. Deposition of sealing Colón and Burgüita Formation shales overlying the La Luna/Navay source rocks completed the key components of the Cretaceous petroleum system.

The best areas for the future discovery of large oil fields sourced from and reservoired within Cretaceous rocks may occur along the Sierra Perijá Mountains of the western Maracaibo Basin, and along the central Mérida Andes Mountain front in the western Barinas/Apure Basin.