Neogene Shelf, Slope, and Basin-Floor Gas Plays, Laguna Madre-Tuxpan Continental Shelf, Eastern Mexico*

By
William Ambrose[1], Tim F. Wawrzyniec[2], Khaled Fouad[3], L.F. Brown, Jr. [3], Shinichi Sakurai[3], David C. Jennette[3], Dallas B. Dunlap[3], Edgar H. Guevara[3], Mario Aranda Garcia[4], Ulises Hernández Romano[4], Ramón Cárdenas Hernández[4], Eduardo Macías Zamora[5], and Suhas C. Talukdar[6]

Search and Discovery Article #10083 (2005)
Posted June 6, 2005

*Adapted from extended abstract, prepared by the authors for presentation at AAPG International Conference & Exhibition, Cancun, Mexico, October 24-27, 2004.

[1]Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX 78713
[2]Department of Earth and Planetary Sciences, The University of New Mexico, Albuquerque, NM
[3]Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX 78713
[4]PEMEX Exploración y Producción, Poza Rica, México
[5]PEMEX Exploración y Producción, Tampico, México
[6]Independent consultant, The Woodlands, TX

Abstract

Neogene shelf, slope-fan, and basin-floor-fan plays in the Laguna Madre-Tuxpan (LM-T) continental shelf reflect a variety of structural and stratigraphic controls, including gravity sliding and extension, strike-slip motion, salt evacuation, and lowstand canyon and fan systems associated with major uplift of carbonate and volcanic terrains. In a 16- month study of the eastern Mexico continental shelf, conducted jointly by the Bureau of Economic Geology (BEG) and PEMEX Exploración y Producción, more than 30 plays were defined and mapped over a 50,000-km^2 area that links the Veracruz and Burgos basins.

The south part of the LM-T area in the Veracruz Basin contains deep-seated basement faults that provided upward migration for hydrocarbons potentially to charge upper and middle Miocene canyon, slope-fan, and basin-floor-fan systems. In contrast, the Lankahuasa area north of the Veracruz Basin contains major shallow-detachment, listric faults associated with thick Pliocene shelf and inner-slope depocenters. Lower and middle Miocene plays on the Tuxpan Platform northwest of the Lankahuasa area contain thick successions of steeply dipping slope deposits, consisting of narrow slope-channel and lobate slope-fan sandstones encased in siltstones and mudstones. Plays in the north end of the LM-T area in the Burgos Basin contain intensely deformed strata associated with diapirism, salt withdrawal, and salt welds. Plays in this area are mud-rich and internally complex, including debris-flow, slump, and canyon-fill deposits.

Objective and Scope

The Bureau of Economic Geology (BEG) and PEMEX Exploración y Producción jointly defined and mapped the regional Neogene geologic and play framework of the eastern Mexico continental shelf and adjacent onshore areas. This area, known as the Laguna Madre-Tuxpan (LM-T) area, encompasses more than 50,000 km^2 and links the Veracruz and Burgos basins (Figure 1). The database consisted of six 3-D seismic surveys, collectively >8,000 km^2 as well as an array of 2-D lines (not shown), covering approximately 10,000 linear km in both the offshore and onshore. Data for the study included 27 offshore wells and 18 onshore wells (Figure 1). However, the Neogene is logged in fewer than 10 offshore wells, whereas the Neogene is not present in most of the onshore wells, which penetrate Paleogene and Mesozoic strata.

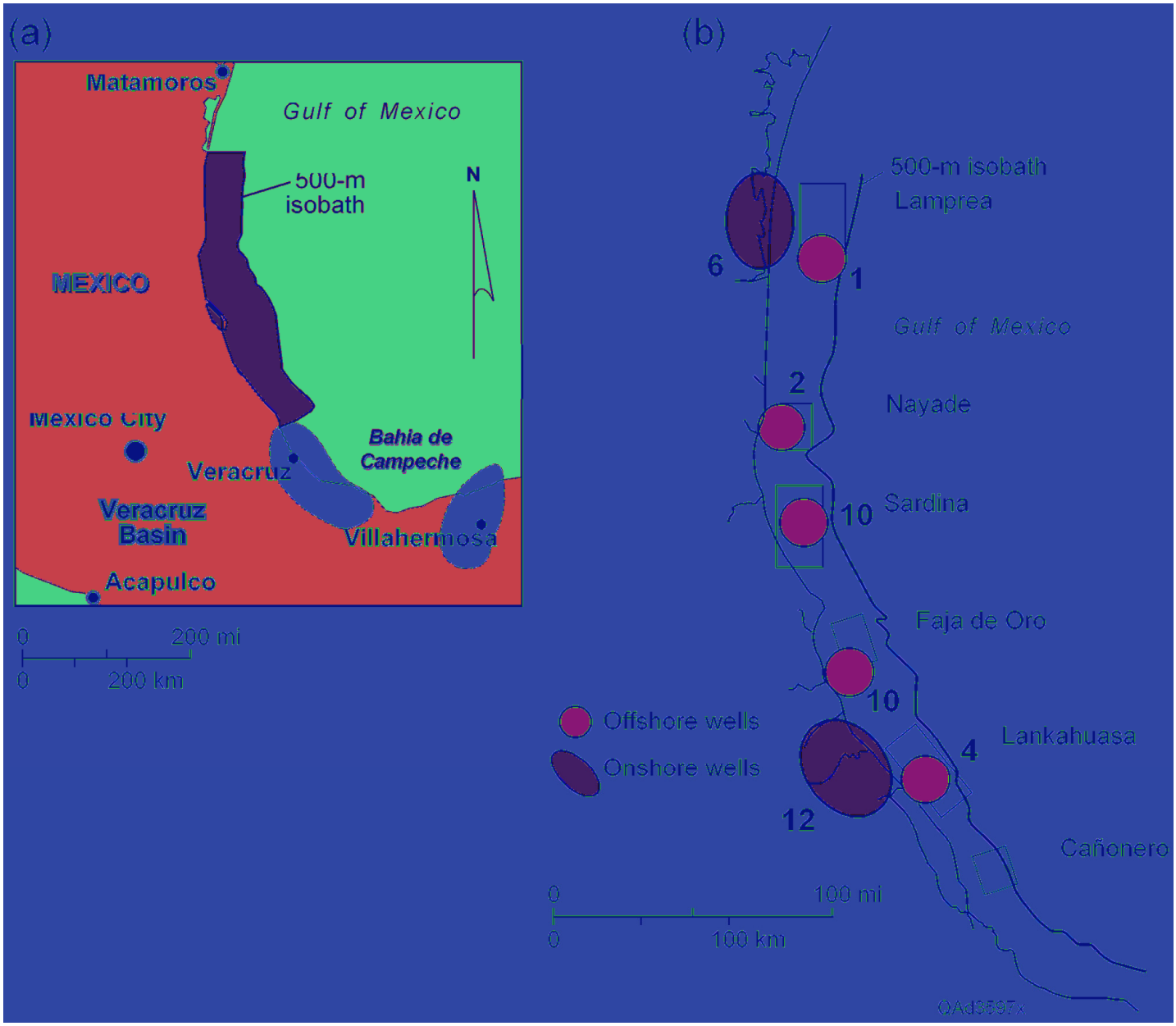

Figure 1. Location of the Laguna Madre-Tuxpan study area, with distribution of wells and 3-D seismic surveys.

Structural Setting

The LM-T area is divided into four structural trends—the Cañonero, Lankahuasa, Faja de Oro-Náyade, and Lamprea (Figure 2). Each trend is delineated on the basis of variations in timing and style of structural elements (Wawrzyniec et al., 2003). The Cañonero trend in the south part of the LM-T area is the northern continuation of the Veracruz Basin and contains deep-seated basement faults associated with compression and strike-slip motion. These faults provided upward migration paths for Mesozoic hydrocarbons potentially to charge upper and middle Miocene canyon, slope-fan, and basin-floor-fan systems.

The Lankahuasa trend is dominated by gravity-sliding tectonics, where most of the fault displacement is accommodated in Pliocene strata, consisting of a series of shallow-detachment listric faults associated with shelf depocenters. The Lankahuasa trend contains numerous synthetic faults associated with primary or multiple antithetic structures, all of which appear to be synkinematic throughout the Neogene (Wawrzyniec et al., 2003). The result is the formation of multiple wine-glass-shaped extensional grabens that grow younger and more developed toward the basin.

The Faja de Oro-Náyade trend is defined by a major regional detachment surface (the Faja de Oro fault system) in the shallow offshore that extends for >150 km throughout most of the LM-T area (Figure 2). The Faja de Oro fault commonly displaces the Miocene section by hundreds of meters, and in the area of the Tuxpan Platform, it separates steeply dipping, lower Miocene slope deposits from basin-floor-fan deposits in the deep offshore.

The Lamprea trend is transitional to the Burgos Basin and is dominated by greatly deformed strata associated with diapirism and salt withdrawal (Figure 2). This area contains Pliocene minibasins and slope-derived slump and debris-flow systems, commonly developed above upper Miocene salt welds.

Stratigraphic and Play Framework

The four main paleogeographic types that define Neogene plays in the LM-T area are shelf, slope, canyon, and basin floor. Shelf plays, such as the upper Miocene in the Lankahuasa trend, are typified by upward-coarsening successions of thin sandstones, which in map view are composed of strike-oriented sandstone and amplitude patterns, indicating wave-dominated reworking of deltaic and shoreface deposits. Reservoirs occur in thin (commonly <10-m), burrowed sandstones that pinch-out into marine siltstone and mudstone. Potential trap types in these shelf plays, especially in the Lankahuasa area, reflect a combination of structural and stratigraphic controls. Stratigraphic seal for shelf reservoirs in the Lankahuasa trend is provided by regional, third-order flooding surfaces.

Slope plays in the LM-T area contain slope-channel sandstones within thick, mud-dominated successions. Reservoir geometries typically consist of narrow, slightly sinuous, and dip-elongate channel and levee complexes. These channel complexes are collectively 1 to 2 km wide and consist of amalgamated and multistoried channel complexes (commonly 10 to 30 m thick), associated laterally with thin overbank sheet and lobe sandstones. Reservoir quality is a major limiting factor in LM-T slope plays, especially in Tuxpan Platform and adjacent areas, where many lower Miocene slopechannel sandstones are calcareous and have low porosity (Fouad et al., 2003).

Canyon plays in the LM-T area are well developed in the upper Miocene in the Cañonero trend, where they occur downdip of lowstand-related, incised-shelf deposits associated with sediment bypass onto the basin floor. They occur as a single lenticular feature in most strike sections, are associated with 400 to 550 ms (480 to 660 m) of downcutting of older slope deposits, and vary in width from 5 to 8 km (Ambrose and others, 2003). The upper Miocene canyon fill in the Cañonero trend contains bright amplitudes that may indicate partial fill with sandstone, although the lithology at the time of this writing has not yet been fully tested.

Basin-floor plays in the LM-T area are mainly developed in the deep offshore (water depths >500 m). These plays are inferred to contain thick (several hundred meters) of channelized lobe and extensive fan-sheet deposits. They commonly overlie regional unconformities and consist of bright-amplitude zones capped by dim-amplitude fan-abandonment surfaces that may be major seals. These regional unconformities define individual episodes of lowstand-derived submarine canyons and basin-floor fans that were largely tectonically driven and were caused by uplift in the Sierra Madre Oriental mountain belt. Sandy fan lobes and sheets, by analogy with similar deposits in the Brushy Canyon Formation in west Texas and the adjacent Veracruz Basin, are volumetrically the most significant component of the play (Beaubouef et al., 1999; Jennette et al., 2002).

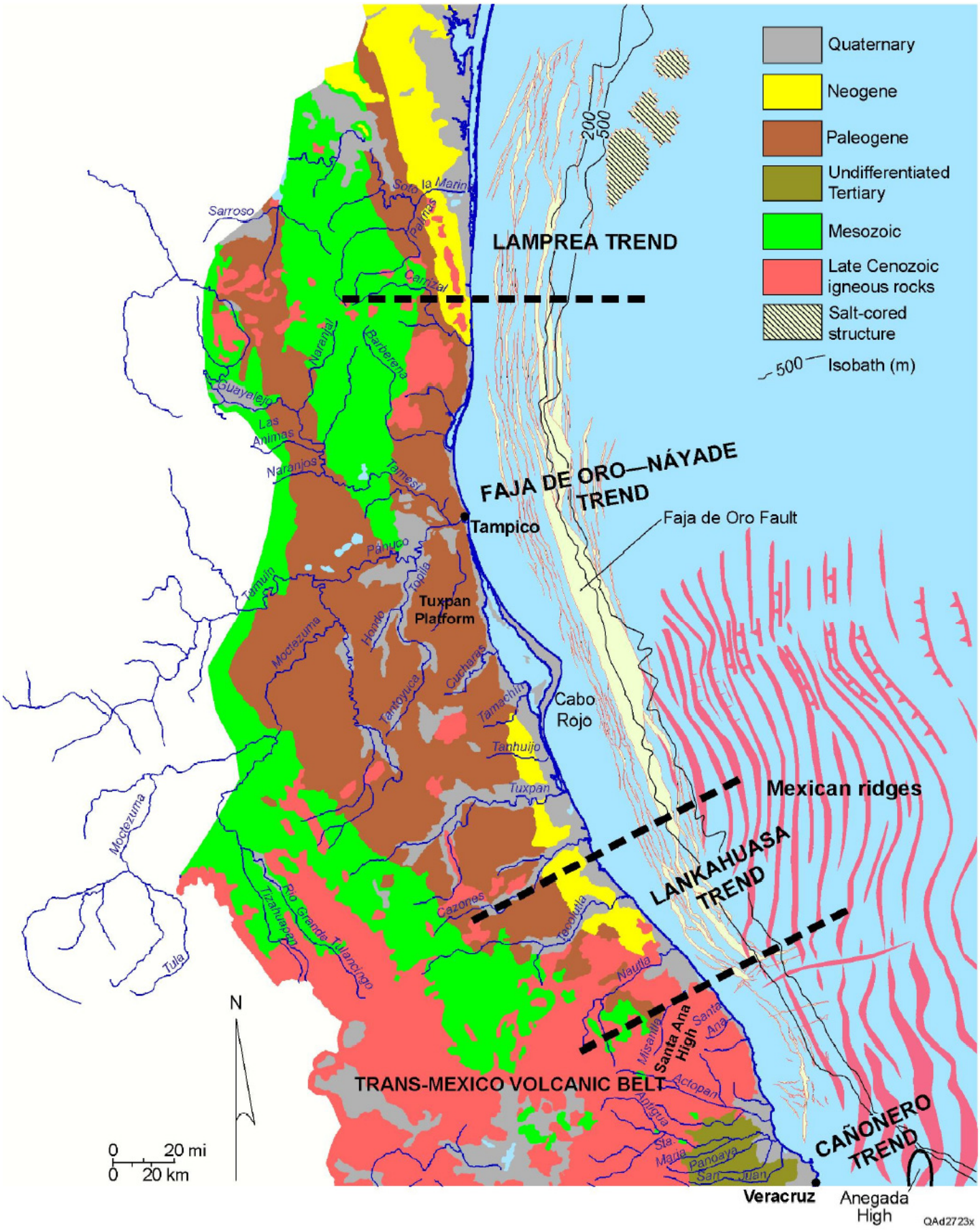

Figure 2. Main structural trends in the Laguna Madre-Tuxpan area, principal physiographic features, and outcrop map.

References

Ambrose, W.A., Khaled Fouad, David Jennette, L.F. Brown, Jr., T. F. Wawrzyniec, Shinichi Sakurai, E.H. Guevara, Mario Aranda, Juan Alvarado, Ulises Hernandez, Eduardo Macias, D. Velez, F. Sanchez, G. Lopez, and J.C. Flores,., 2003, Miocene valley-fill, slope, and submarine-canyon systems in the Laguna Madre-Tuxpan area, Mexico: Gulf Coast Association of Geological Societies Transactions, v. 53, p. 11–18.

Beaubouef, R.T., C.R. Rossen, F.B. Zelt, M.D. Sullivan, D.C. Mohrig, D.C. Jennette, J.A. Bellian, S.J. Friedman, R.W. Lovell, and D.S. Shannon, 1999, Deepwater sandstones, Brushy Canyon Formation, West Texas: AAPG Continuing Education Course Note Series, v. 40, variously paginated.

Fouad, K., W.A. Ambrose, S. Sakurai, and D. Jennette, 2003, Wave-shape classification and attribute analysis of the lower Miocene deep-water reservoirs, Laguna Madre Basin, offshore Mexico (ext. abs.): Society of Exploration Geophysics Transactions, Seventy-Third Annual Meeting and International Exposition, CD-ROM, 4 p.

Jennette, D.C., T.F. Wawrzyniec, K. Fouad, J. Meneses-Rocha, M.H. Holtz, S. Sakurai, S. Talukdar, F. Grimaldo, R. Muñoz, J.E. Lugo, D. Barrera, C. Williams, A. Escamilla, S.P. Dutton, W.A. Ambrose, D.B. Dunlap, J.A. Bellian, and E.H. Guevara, 2002, Play-element characterization of the Miocene and Pliocene Veracruz Basin, southeastern Mexico: Gulf Coast Association of Geological Societies Transactions, v. 52, p. 441–454.

Wawrzyniec, Tim, Khaled Fouad, Dan Schultz-Ela, William Ambrose, David Jennette, Shinichi Sakurai, Edgar Guevara, Mario Aranda, Juan Alvarado, Ulises Hernandez, Eduardo Macias, J. Roman, C. Rosas, K. Rosas, and L.E. Salomon, 2003, Cenozoic deformational styles of the Laguna-Madre - Tuxpan Shelf and Mexican ridges fold belt, Mexico: Gulf Coast Association of Geological Societies Transactions, v. 53, p. 843–854.

Acknowledgments

The Bureau of Economic Geology, John A. and Katherine G. Jackson School of Geosciences, The University of Texas at Austin, acknowledges support of this research by Landmark Graphics Corporation via the Landmark University Grant Program. This report was funded by PEMEX under Contract No. PEP-RN-RDIE-072/02-P. The Bureau of Economic Geology appreciates the opportunity to contribute to PEMEX's assessment of the hydrocarbon resources of the Laguna Madre-Tuxpan continental shelf and the continuous help and project participation by management and geoscientists of the Coordinación de Exploración at Poza Rica and the Asset Offices at Tampico. Significant coordination between PEMEX and BEG was facilitated by Luis Sánchez-Barreda. Manuscript editing was by Lana Dieterich. Pat Alfano prepared the illustrations under the direction of Joel Lardon, Media and Information Technologies Manager. Publication authorized by the Director, Bureau of Economic Geology.