EVOLUTION OF ALLOCHTHONOUS SALT IN THE MISSISSIPPI CANYON AREA

SHENGYU WU
Department of Geology and Geophysics
Rice University
P.O. Box 1892
Houston, Texas 77251

CARLOS CRAMEZ
Défense A Bureau 2333
Total CFP
24, Cours Michelet
La Défense 10
92800 Puteaux
92069 Paris La Défense, France

ALBERT W. BALLY
PETER R. VAIL
Department of Geology and Geophysics
Rice University
P.O. Box 1892
Houston, Texas 77251

Seismic data from Geco Geophysical Company, Inc., Western Geophysical Company, TGS Offshore Geophysical Company, and Fairfield Industries, Inc. in the Eastern Gulf of Mexico (Fig. 1) provided the data base for this study. The salt tectonics study area roughly coincides with the proximal portion of the Mississippi Fan in the Mississippi Canyon Area (Fig. 1). Well logs (Fig. 1) with check shot velocities and biostratigraphic control were integrated with sequence stratigraphic analysis of the seismic data to age-date salt movement in the area.

Both autochthonous and allochthonous salt exist in the Mississippi Canyon Area. Figure 2 shows the relationship of the autochthonous salt and its structure to widespread salt tongues and allochthonous salt sheets. No major fault separates the Florida Escarpment from the deepwater Mississippi Canyon Area as shown on the depth-converted seismic section. Approximately five degrees of dip are observed at the base of the autochthonous salt near the escarpment.

We propose a model illustrated by Figures 2 to 8 for the evolution of the allochthonous salt units as documented by seismic data. All seismic examples (see Fig. 1 and 9 for locations) are from the Mississippi Canyon and Atwater Valley Areas. *Early autochthonous salt stages* are shown in Figures 3 and 4, illustrating the structures associated with a salt pillow and a diapiric salt dome. *Salt tongue stages* are illustrated in Figures 5 and 6. Figure 5A shows a salt tongue which spreads in the downslope direction. The top of salt is overlain by approximately 850 feet of sediments, which prevent the salt from being dissolved in sea water. The connate water in the sediments may accelerate the spreading of salt. Note the bathymetric high maintained by the pressure of the deep-rooted feeder stock and by the thick salt tongue. Figure 5B is the strike section across the salt tongue in Figure 5A. Figure 6A shows a salt tongue which has been further extended in the downslope direction due to gravity spreading. Note the rotated sediments overlying the salt tongue, indicating the interaction between salt movement and sediment loading through time, and the dip change at the top of the salt tongue, implying a change of mechanical conditions from predominant downslope spreading to downslope thrusting. The thrusting is indicated by truncation of beds underlying the tip of the salt tongue. This example also illustrates the relationship of salt movement to down-to-the-basin faults, counter-regional faults and thrust faults. Note the faults with a dominant down-to-the-basin component above the feeder stock of the salt tongue, implying decreasing pressure and salt removal, and counter-regional fault system developed in sediments above the thrusting part of the salt tongue due to salt withdrawal. Figure 6B is a strike section across the same tongue. Note the same features as those shown in Figure 6A. *Allochthonous salt stages* are illustrated in Figures 7 and 8. Figure 7 shows a system of growth faults superposed on an allochthonous salt sheet.

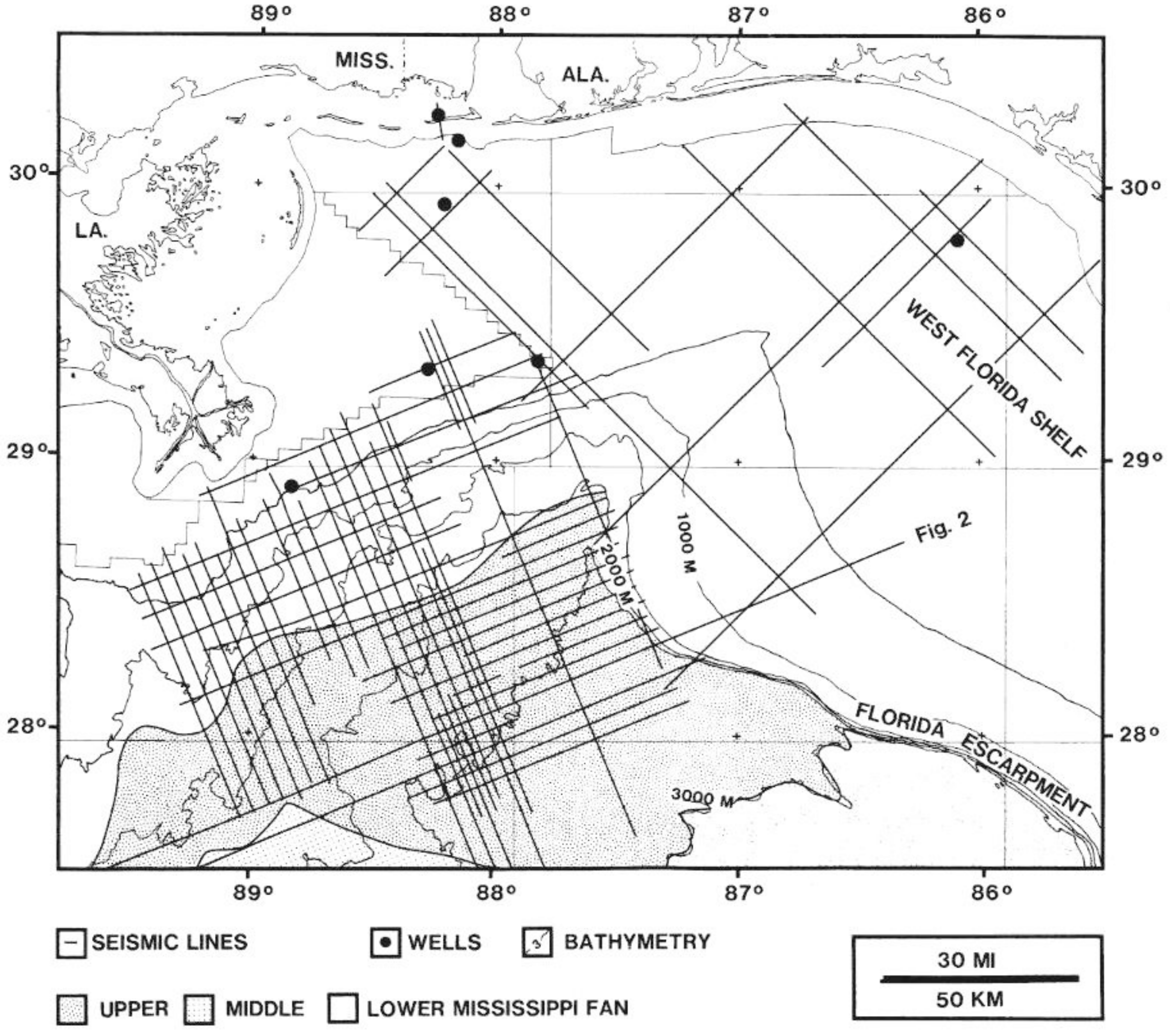

Figure 1. Index map of seismic lines and well information used in this study. Bathymetry from the Regional Map of Eastern Gulf of Mexico of NOAA, U.S. Department of Commerce, 1986. The Mississippi Fan is from G.T. Moore *et al.*, 1978, *in* A.H. Bouma *et al.* (eds.), AAPG Studies in Geology No. 7.

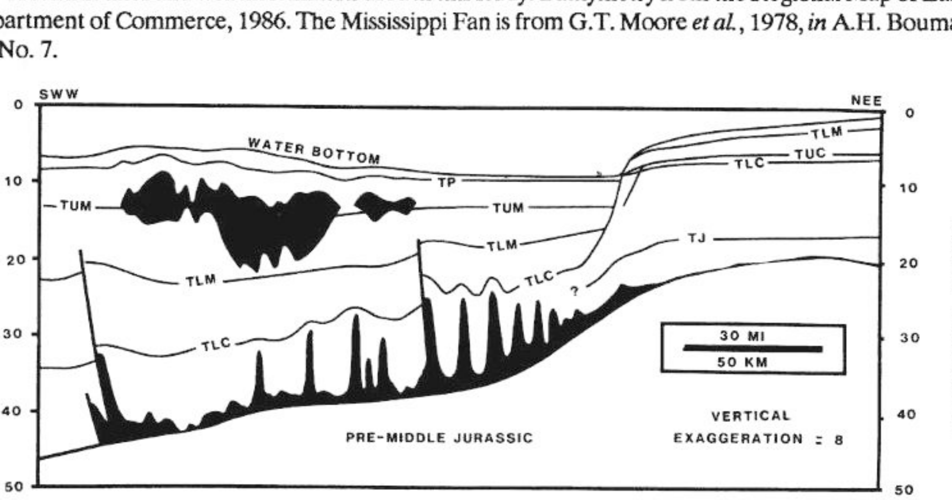

Figure 2. A depth-converted section interpreted from seismic line. Salt is illustrated by black area. TP, 1.6 Ma sequence boundary (approx. Top Pliocene). TUM, 5.5 Ma sequence boundary (approx. Top Upper Miocene). TLM, 15.5 Ma sequence boundary (approx. Top Lower Miocene). TUC, 68 Ma sequence boundary (approx. Top Upper Cretaceous). TLC, 94 Ma sequence boundary (approx. Top Lower Cretaceous). TJ, 128.5 Ma sequence boundary (approx. Top Jurassic). Ages in Ma are from P.R. Vail, 1987, Plate 1, *in* A.W. Bally (ed.), AAPG Studies in Geology No. 27.

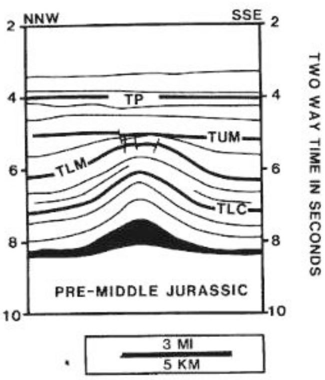

Figure 3. An example of a salt pillow.

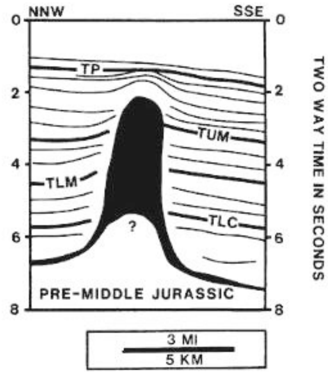

Figure 4. An example of a diapiric salt dome.

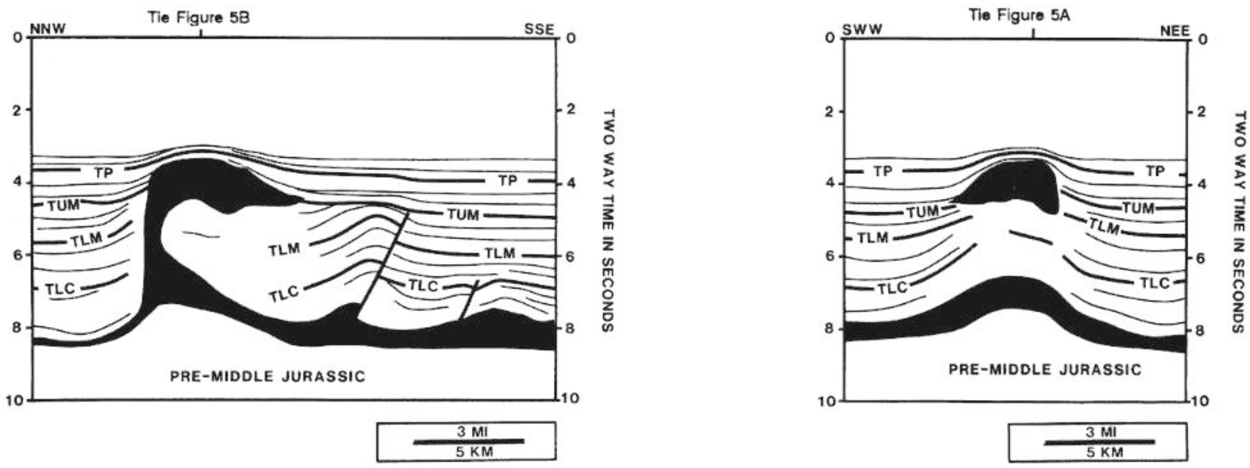

Figure 5. A (left), an example of an early stage salt tongue. B (right), a cross section perpendicular to 5A, showing the same tongue.

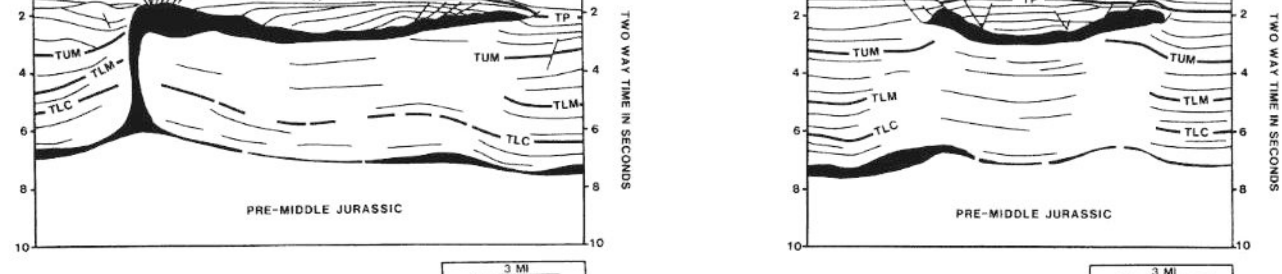

Figure 6. A (left), an example of a salt tongue further extended in the downslope direction. B (right), a strike line of 6A across the same salt tongue.

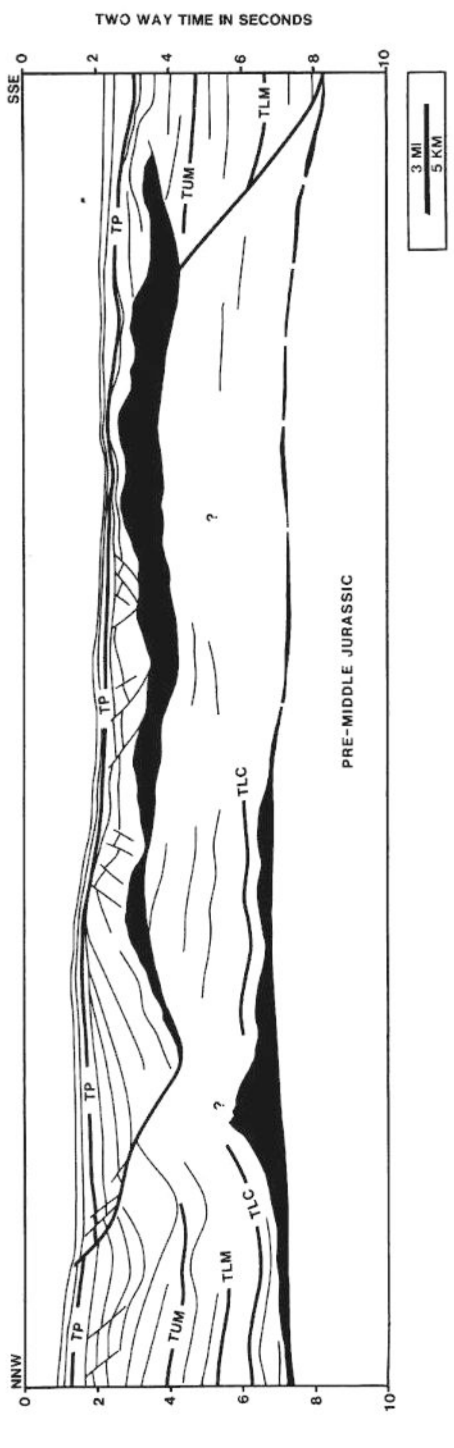

Figure 7. An example of an allochthonous salt sheet with its original feeder stock separated by a down-to-the-basin growth fault.

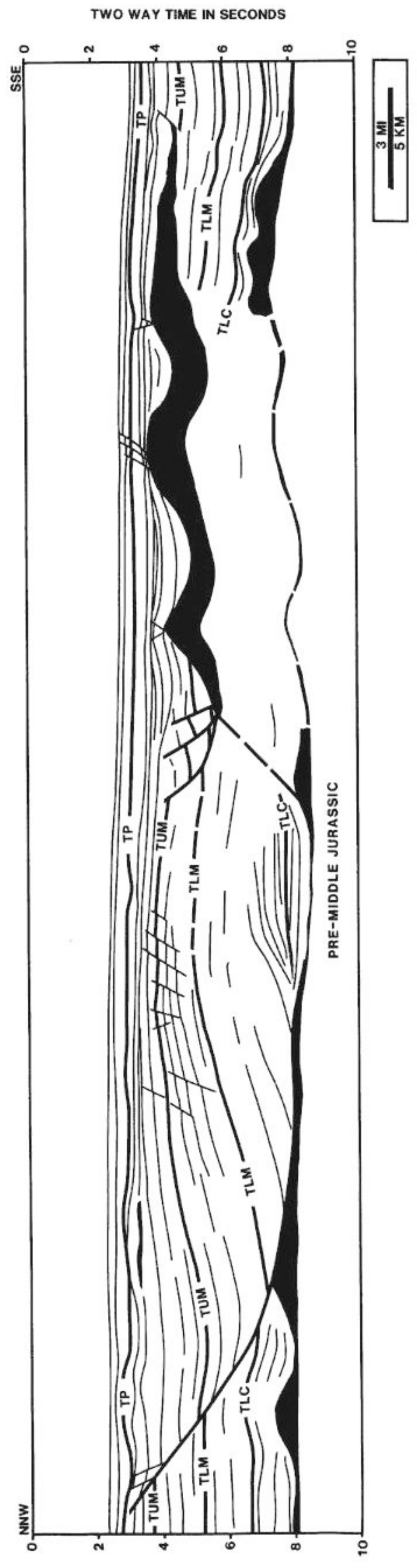

Figure 8. An example of an advanced allochthonous salt sheet and its associated growth fault systems.

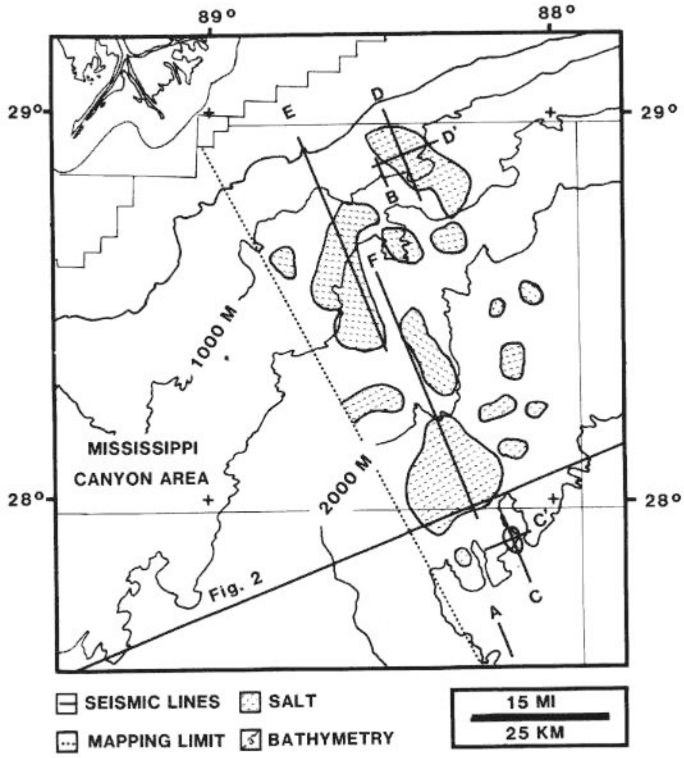

Figure 9. Map of the lateral extent of salt tongues and allochthonous salt sheets, and the locations of Figure 2 (central part) to Figure 8. A, Figure 3. B, Figure 4. C, Figure 5A. C', Figure 5B. D, Figure 6A. D', Figure 6B. E, Figure 7. F, Figure 8.

A major down-to-the-basin growth fault separates the salt tongue from its original feeder stock. Downslope withdrawal of salt accommodates expansion of sediments on the downthrown side of the major growth fault. Figure 8 illustrates two advanced down-to-the-basin growth fault systems and their related allochthonous salt sheet. Note that this allochthonous salt sheet has gone through the same evolutionary stages illustrated in Figures 3 to 7. Undulation on top of the allochthonous salt sheet due to sediment loading as well as salt movement, and counter-regional faults developed due to salt withdrawal are apparent. A map showing the lateral extent of salt tongues and allochthonous salt sheets as well as the distribution of our seismic examples is illustrated in Figure 9. Note that the salt tongues and allochthonous salt sheets extend preferentially in the downdip direction.

We conclude that the allochthonous salt sheets were formed from Middle Jurassic autochthonous salt in a slope environment during the Neogene. The allochthoneity of these salt sheets increases with the age of the associated down-to-the-basin growth fault system. Counter-regional faulting is one of the consequences of salt withdrawal.

Acknowledgments

This study is supported by Total Minatome Corporation and A.W. Bally's Research Fund. Total Minatome Corporation provided all the data used in the study. The authors thank Rene Chappaz for his generous support. S. Wu appreciates the stimulating discussions held with Don Lee, Patrick LeQuellec, Donnie Enns, J.P. Esteve, David Hall, Wynn Gajkowski, J. Pouzet, S. Starr, and many others in the Offshore Exploration Department of Total Minatome Corporation. We thank Martin Jackson for his comments during the study.