Wrench Faulting as a Trigger Mechanism for Interior Salt Ridges of Mississippi

Oscar L. Paulson, Jr.
Department of Geology
University of Southern Mississippi
Hattiesburg, Mississippi

ABSTRACT

In attempting to apply the various theories which have been proposed for the growth of salt domes and ridges in the Gulf Coast Province, it has been possible to eliminate some of the theories which are incompatible with observed data. Recent evidence indicates that the movement of salt in a number of ridges began when overburden was a few hundred feet thick rather than the thousands of feet proposed in several earlier studies. Initial movement of the salt has been attributed to a number of factors but it now seems most probable that this movement was triggered by the presence of preexisting wrench faults along which deep-seated salt ridges were formed. The wrench faults appear to be related to Late Paleozoic displacement of the Ouachita thrust sheet which arches into Mississippi where it becomes the principal wrench fault.

The salt ridges of Mississippi are located in the southeastern part of the state and in the Mississippi salt basin. These structures along with the numerous domes within the basin are referred to as *interior* ridges and domes to distinguish them from the salt structures found along the coast and beneath the Gulf of Mexico. Intrusion of the salt, which lies at depths ranging from 9,500 to 16,000 feet, has produced grabens in the overlying sedimentary rocks (Fig. 1).

Age of the salt is considered to be Jurassic by many authors but Jux (1961) suggests the possibility of some of the salt being Triassic whereas Hazzard (1947), Halbouty and Handin (1956), and Andrews (1960) suggest a Permian age for at least part of the salt.

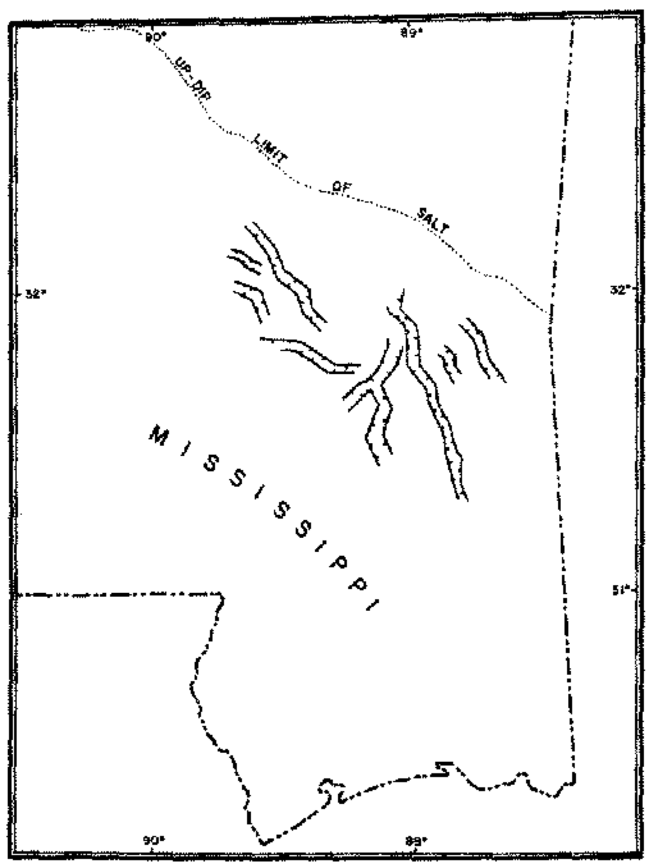

Figure 1. Grabens associated with salt ridges in southeastern portion of Mississippi salt basin.

The prevalent opinions today seem to be that salt movement is initiated by high temperature at great depths (Gussow, 1968), a gravity flow along sloping surfaces (Hubbert, 1937), or fluid mechanics (Nettleton, 1934, 1943). Bornhauser (1958) applies the fluid mechanics principle to salt ridges or anticlines of southern Arkansas where the alignment of ridges is parallel to depositional strike. This mechanism requires "2,000 to 3,000 feet" of overburden in order to increase the density of the sediments to that of salt, thereby creating the buoyant force necessary for movement.

A recent study by Hughes (1968) of oil fields located on Mississippi salt ridges, indicates that movement of the salt began when only a few hundred to one thousand feet of overburden had been laid down on the salt. The evidence given by Hughes includes thinning of the overlying Norphlet Formation, Jurassic growth faults indicated by an increased thickness of Smackover limestone in the graben and erosion of the Smackover Formation and the Haynesville Formation over the crest of ridges.

The facts that (1) some of the salt ridges in Mississippi are aligned at oblique angles or even right angles to the depositional strike and (2) movement of the salt started when overburden was 1,000 feet or less in thickness, precludes the application of the afore-mentioned theories to Mississippi salt ridges.

Oxley *et al.* (1967, 1968) have called attention to the fact that the Phillips Fault Zone (Fig. 2) is in alignment with the longest of the grabens overlying a salt ridge. Oxley *et al.* (1967, 1968) have also called attention to the bending of the anticlinal folds (Appalachian) as a possible indication of strike-slip movement along the Phillips fault zone. With little difficulty, one might visualize the Phillips fault zone as a continuation of the Ouachita structural front of Flawn *et al.* (1961—see also Mellen, 1958, Fig. 3) as shown on the index map of Fig. 2.

Figure 3 shows the orientation of the grabens associated with salt ridges in Mississippi, this fault pattern being coincident with the wrench fault system of Moody and Hill. The 1st-order right lateral wrench is apparently continuous with the Phillips fault zone and the Oachita structural front. The unlabelled faults are considered lower order and drag structures of the wrench system.

In the light of the foregoing evidence, it is herein suggested that the salt intrusions which form salt ridges of Mississippi were triggered in one of the following ways: (1) If the Ouachita thrusting is

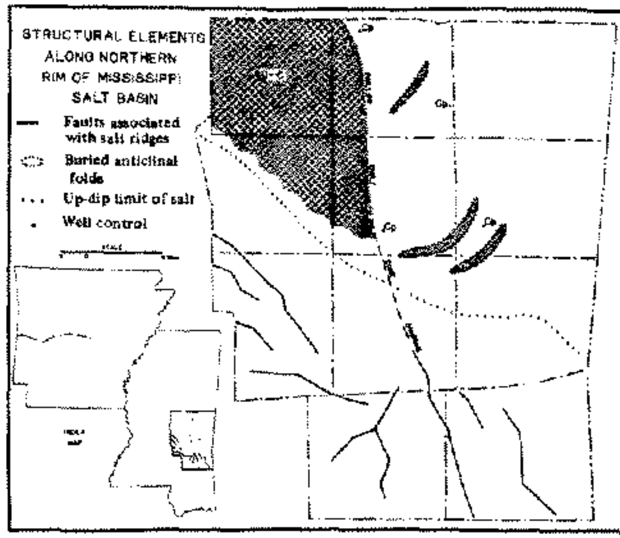

Figure 2. Structural elements along northern rim of Mississippi salt basin.

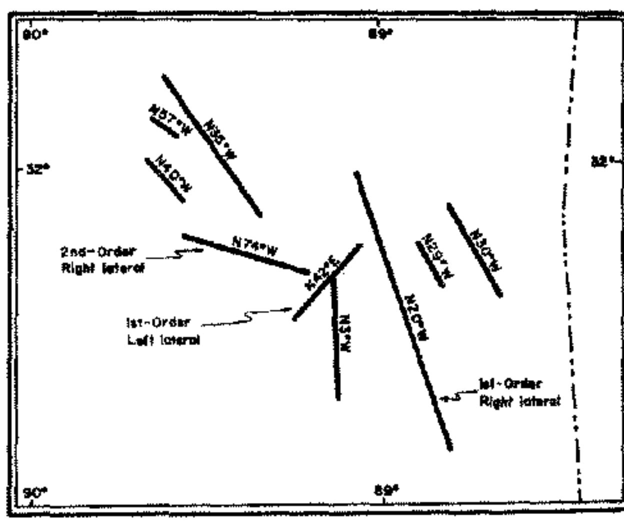

Figure 3. Orientation of grabens associated with Mississippi salt ridges.

middle to late Pennsylvanian as indicated by King (1959), and Flawn *et al.* (1961), the proposed wrench faulting of Mississippi would be of the same age. The salt, which is considered no older than Permian, was deposited over wrench faults which exhibited a certain amount of vertical displacement (Oxley, 1967, 1968). The precipitation of salt across these faults resulted in a monoclinal configuration of the salt bed, and consequently, as overburden was added to the salt, the growth of salt ridges was localized along the monoclines. (2) If the Ouachita thrusting and proposed wrench faulting continued into the Permian as it did in the Marathon region of Texas and in Mexico (Flawn *et al.* 1961), there is the possibility of concurrent faulting and salt deposition. In this case the movement of salt would be initiated by differential pressure on opposite sides of the fault as suggested by Parker and McDowell, (1955). In either case, wrench faulting is considered necessary to explain the fault patterns produced by the salt intrusion, the initiation of movement of salt with less than 1000 feet of overburden and the curvature of the buried anticlinal folds.

An interesting corollary of this proposition is that as the salt began to move in forming the ridges, the plate of sediments overlying the salt began to "creep" (Cloos, 1968) and produced another graben system at the up-dip limit of salt.

REFERENCES

Adams, E.R., and Davis, D.C., 1962, Developments in southeastern states in 1966: Am. Assoc. Petroleum Geologists Bull., v. 46, p. 953-958.

Bornhauser, Max, 1958, Gulf Coast tectonics: Am. Assoc. Petroleum Geologists Bull., v. 42, p. 339-370.

Cloos, E., 1968, Experimental analysis of Gulf Coast fracture patterns: Am. Assoc. Petroleum Geologists Bull., v. 52, p. 420-444.

Flawn, P.T., *et al.*, 1961, The Ouachita system: Texas Bur. Econ. Geology Pub. 6120.

Gussow, W.C., 1968, Salt diapirism: Importance of temperature, and energy source of emplacement *in* Diapirism and diapirs: Am. Assoc. Petroleum Geologists Mem. 8, p. 16-52.

Guy, S.C., 1967, Developments in southeastern states in 1966: Am. Assoc. Petroleum Geologists Bull., v. 46, p. 953-958.

Halbouty, M.T., 1967, Salt domes—Gulf Coast region, United States and Mexico: Houston Gulf Publishing Co., 425 p.

———, and Hardin, G.C., Jr., 1956, Genesis of salt domes of Gulf Coastal Plains: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 737-746.

Hazzard, R.T., Blanpied, B.W., and Spooner, E.C., 1947, Notes on the stratigraphy of the formations which underlie the Smackover limestone in south Arkansas, northeast Texas and north Louisiana: Shreveport Geol. Soc., 1945 Ref. Rpt., v. 2, p. 483-503.

Hubbert, M.K., 1937, Theory of scale models as applied to geologic structures: Geol. Soc. America Bull., v. 48, p. 1459-1519.

Hughes, D.J., 1960, Faulting associated with deep-seated salt domes in the northeast portion of the Mississippi salt basin: Gulf Coast Assoc. Geol. Soc., v. 10, p. 154-173.

King, P.B., 1959, The evolution of North America: Princeton University Press, 203 p.

Mellen, F.F., 1958, Cretaceous shelf sediments of Mississippi: Miss. Geol. Survey Bull, 85, 112 p.

Mixon, R.B., Murray, G.E., and Diaz, T., 1959, Age and correlation of Huizachal Group (Mesozoic), State of Tamaulipas, Mexico: Am. Assoc. Petroleum Geologists Bull., v. 43, p. 757-771.

Moody, J.D., and Hill, M.J., 1956, Wrench fault tectonics: Geol. Soc. America Bull., v. 67, p. 1207-1246.

Murray, G.E., 1968, Salt structures of Gulf of Mexico basin—a review, *in* Diapirism and diapirs: Am. Assoc. Petroleum Geologists Mem. 8, p. 99-121.

Nettleton, L.L., 1934, Fluid mechanics of salt domes: Am. Assoc. Petroleum Geologists Bull., v. 18, p. 1175-1204.

———, 1943, Recent geophysical evidence of mechanics of salt-dome formation: Am. Assoc. Petroleum Geologists Bull., v. 27, p. 51-63.

Oxley, M.L., Minihan, E., and Ridgeway, J.M., 1967, A study of the Jurassic sediments in portions of Mississippi and Alabama: Gulf Coast Assoc. Geol. Soc. Trans., v. 17, p. 24-48; 1968, Miss. Geol. Survey Bull. 109, p. 39-77.

Parker, T.J., and McDowell, A.N., 1955, Model studies of salt-dome tectonics: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2384-2470.