CONTINENTAL SCIENTIFIC DRILLING PROGRAM: A PROPOSAL FOR DEEP SCIENTIFIC DRILLING AND ASSOCIATED RESEARCH, TEXAS GULF COAST

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ABSTRACT

The Texas and Louisiana Gulf Coastal provinces are characterized by an array of scientific dilemmas ranging from the origin of the Gulf itself and the nature of the lower crust and mantle to the causes and effects of long-lasting and continuing circulation of thermobaric waters throughout the thick sedimentary section.

The Gulf Coast is correctly classified as a "passive margin," as attested by the scarcity of seismic activity. Plate tectonic theory requires that the Gulf originated by rifting related to continental drift. From the little information concerning deep structure and lithology that is available, this theory is appropriate, but by no means conclusively demonstrated. The nature of the underlying crust and its superadjacent sediments and their contained waters; the precise timing of the rifting; the fluid dynamics, geochemistry, diagenesis and early depositional history of the sedimentary sequence; the thermal history and the unusually high thermal gradient; and the fluid pressure regime in the deep sedimentary section are all too poorly known to permit quantitative analysis of processes which are of enormous scientific and practical importance.

In our opinion, the San Marcos arch is the best location for investigating these important phenomena and problems. The arch, extending southeastward from the exposed Grenville basement rocks of the Llano uplift, is situated in an area of thinning of the sedimentary cover of the Gulf Coast Basin. Immediately seaward of the Llano Uplift, highly deformed and slightly metamorphosed rocks of the Ouachita-Marathon orogen have been penetrated beneath Cretaceous sediments. The inferred edge of continental crust underlies the northeast-trending Lower Cretaceous reefs about 50 mi (80 km) to the southeast of the known Ouachita rocks. Rapid thickening of Tertiary and older sediments southeast of the reef, together with geophysical indications of a relatively shallow Moho suggest that a thin, transitional continental crust underlies sediments basinward of the reef trend. This transitional crust could consist of rifted Grenville basement, buried rocks of the Ouachita trend, an island arc related to the Ouachita trend, or exotic continental basement related to a proto-south American continent.

On the basis of our present understanding of deep structure, it appears possible to locate a drill hole southeast of the reef trend which will penetrate a thick sequence of abyssal sediments, sample sediments in an underlying rift, and enter the "transitional crust" beneath the sediments.

Of equal importance to structural problems are questions related to diagenesis, lithification, and hydrodynamics of the Tertiary and underlying Mesozoic sedimentary fill of this basin. Recent application of new techniques, including stable isotope, trace element and fluid composition analysis have shown that both the diagenetic and the hydrologic systems are dynamic, and that fluid and transport within the basin are much more extensive and complex than previously assumed. Mass flux from the Mesozoic or older basement and convective recycling of deep waters are increasingly appealing as explanations for observed pervasive diagenetic features and for deposits of ore minerals and hydrocarbons found in shallow sediments.

The Cenozoic section contains three ground water regimes: an active meteoric regime, extending to depths exceeding one kilometer, a regime at intermediate depths, characterized by normal to moderately elevated hydrostatic gradients, and a deep system in the lower portion of the basin fill, including the Mesozoic section, containing highly overpressured, thermobaric waters, apparently derived in part from mineral dehydration reactions and thermal alteration of organic matter. Evidence exists that these deep thermal waters are still escaping to the surface along structurally controlled channels, and that the diagenetic changes and deposition of ore minerals continue today. Isotopic evidence indicates that at least some of the oil being produced from Cenozoic rocks is derived from deeply buried anoxic Cretaceous sediments. The penetration and study of these deep rocks is obviously of great scientific and practical importance.

The causes of the abnormally high thermal gradient present in much of the Gulf Coast are a matter of controversy. Undoubtedly circulating thermobaric waters play an important part. However, the nature of the "transition basement" and the structure at the basement-sediment interface may also be important, particularly as the rifting process might have involved emplacement of large volumes of igneous material. Data derived from preliminary seismic and heat flow studies and from deep drilling will facilitate the modeling of the deposition rates of sediments and hence of subsidence rates related to cooling and loading of the transition crust. Furthermore, if the observed thermal gradients are essentially linear, then the planned deep drillhole should reach into the zone of greenschist metamorphism, thus providing an opportunity to collect rocks and associated fluids in a place where metamorphism and the formation of new crust are actively taking place.

The approximate location of a proposed deep seismic reflection profile to be shot as a first stage of exploration is indicated on figure 1. To achieve the best results the borehole should penetrate a relatively thin succession (100-3000 ft, 30-1000 m) of synrift, graben fill sediments at depths of less than 35,000-40,000 ft (10-12 km). For this reason a detailed seismic grid will be shot in the proposed drill site area to more clearly define the geometry and depth to basement. The detailed work may be done simultaneously with or after a deep sounding COCORP-type profile has been run which will define the major framework of the Gulf Coast along the San Marcos Arch.

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Additional research leading to selection of the most propitious drill site would include use of the abundant shallow to intermediate depth (0-16,000 ft; 0-5,000 m) well data to refine our knowledge of fluid and diagenetic regimes of the upper part of the basin fill, analysis of the thermal regime and heat flow along the crustal transition zone, and expanded geochemical and isotopic studies to better define the extent and importance of vertical flux fluids and elements through the sedimentary fill.

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