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Deep sea drilling project

On the Mississippi Fan

from the staff of Leg 96

LEG 96 of the Deep Sea Drilling Project took the drilling vessel *Glomar Challenger* to the Mississippi Fan where nine sites were cored from September 29 to November 8, 1983. The aims of the visit were to study the distribution of sediment types in the uppermost few hundred metres, to analyse the transport processes responsible for resedimenting shallow water sediments in the deep sea, to study the time framework required to transport such large quantities of material, and to determine the geochemical characteristics of the deposits.

The Mississippi Fan, located in the Gulf of Mexico, is one of the largest submarine fans recognized in our modern oceans. Bathymetry, side-scan sonar, and seismic reflection data show that it has an area of about 290,000 km², a volume of about 300,000 km³ and that it was constructed during the Pleistocene period. Seismic data further indicate that the broad wedge-like accumulation of Mississippi Fan deposits consists of at least seven discrete sediment units, called fan lobes. Comparison of isopach maps of each fan lobe reveals that the slightly convex upward surface of one fan lobe results in an offset of the succeeding one, and that the sediment source of each is located at a different site on the adjacent outer shelf.

Four major physiographic zones can be distinguished on the youngest fan lobe: canyon, upper fan, middle fan, and lower fan. Mississippi Canyon, which is the sediment source for the youngest fan lobe, is located on the outer shelf and upper slope,

about 60 km west of the present Mississippi Delta. It commences at a water depth of 150 m, has an average width of 12 km, and gradually merges with the upper fan at an approximate water depth of 1,200 m. This canyon formed during a period of low sea level in a relatively short period of geologic time, probably as a result of sediment instability on the slope. The upper fan is characterized by one large, nearly filled channel with poorly-developed levees. At approximately 2,000 m water depth, the upper fan changes into an elongate middle fan lobe that is about 150 km wide and nearly 400 m thick; it is convex upward in cross section. The middle fan central channel is about 3 km wide, is highly sinuous, and has broad levees that are about 20–40 m higher than the present channel floor. Downslope, the channel becomes smaller and displays less sinuosity. The lower fan begins at approximately 3,100 m water depth. The channel on the lower fan is generally less than 500 m wide, and disappears near the terminus of the fan lobe. Abandoned channels are found adjacent to the youngest channel, suggesting that channels switch through time rather than migrate laterally.

Of the nine sites drilled on the Mississippi Fan, four were in the lower fan and five were in the middle fan. Seven of the holes were drilled to a depth of about 150–200 m in the youngest fan lobe. Two deeper holes, one in the lower fan (523 m penetration) and one in the middle fan (442 m penetration), were drilled to investigate

the sedimentary characteristics of the underlying fan lobe(s). Core recovery and quality were generally excellent in the upper 100 m at each site, but decreased considerably as more consolidated clays and loose sands were encountered.

To complement the study of the cores, sonic, gamma ray, and caliper well logs were run at four sites on the middle fan and at three sites on the lower fan. The sonic tool determines the transit time of a compressional wave through the formation adjacent to the tool. The gamma ray tool measures the natural background gamma-ray emissions caused by the decay of potassium, thorium, and uranium salts commonly found in sands and muds, and is therefore a valuable indicator of sediment type. The caliper measures the diameter of the hole and keeps the logging tool more or less centered in the hole which increases the accuracy of the other measurements.

The five sites occupied in the middle fan provided a cross section from the levee, across the channel, onto the overbank region, and out to the lateral margins of the fan lobe. An unexpectedly thick section of gravel and pebbly mudstones was drilled in the channel at a depth of about 200 m. These gravels were overlain by sands that pass upsection into muds with thin sand and silt layers. The upper 50 m consist primarily of homogeneous muds. The well log through these channel fill deposits shows a fining-upward trend. The basal sand and gravel beds vary in thickness from 1 to 5 m, and show sharp bases and rather abrupt tops. Upsection, the fine sand, silt, and mud interbeds vary from 2 to 10 m in thickness, and show an irregular and ragged log response. Core recovery was generally poor in the sandy and silty units, giving a false impression of the overall sand percentage. Logging results shows that much of the non-recovered channel deposits are sands; interpretations based solely on recovered core segments indicate an erroneously low sand percentage.

The site drilled in the middle fan levee clearly documented a fining-upward trend. Basal muds contain thin sand and silt layers and become more homogeneous muds uphole. The silty and muddy sediments were generally well stratified and were deposited by low velocity density currents forming thin-bedded mud turbidites.

The site on the middle fan overbank deposits, located approximately 18 km away from the middle fan channel, was rotary cored with relatively low core recovery. Combined coring and logging results indicate that the overbank sediments are composed primarily of fine-grained sediments arranged in alternating coarsening-upward trends. Foraminifera are abundant and include bathyal benthic fauna. This suggests that the channel serves primarily as a conduit for transporting the coarser sediment downslope and that only suspended sediments are delivered overbank to build up the fan's marginal areas.

Sites drilled on the lower fan revealed a surprisingly high abundance of sand deposited by density currents. Individual sand layers range in thickness from a few centimetres up to 10 m and contain a sparse fauna of shallow water origin. Well logs were run at three of the lower fan sites and provide the means for determining accurate sand percentages. The computed total sand percentage of the logged interval is 59.5 per cent. It is apparent that the coring process selectively preserves the finer-grained intervals, as the sand percentage based on the recovered sediments is only 15.6 per cent.

Palaeontologic determinations suggest that the youngest fan lobe was deposited during the late Wisconsin glacial stage with depositional rates ranging from 6.5 to 11.7 m per 1,000 year. These extremely high depositional rates indicate that very large quantities of material have been removed from the shelf and transported to the Mississippi Fan in a short geologic time period. The upper and middle fan channel was sufficiently deep (minimum depth 221 m) to transport all the coarse material within its levees. Part of the coarse-grained load became deposited in the thalweg as part of the aggradational sediment wedge. However, the density flows were thicker than the channel depth such that large quantities of fine-grained material spilled over the confines of the channel to build levee and overbank deposits. At the termination of the channel on the lower fan, the turbidity currents decreased in velocity, spread out of the relatively shallow channels, and deposited their sediment loads in oblong lobes.

In conclusion, the combined results of core data, well logs, and palaeontologic information collected on Leg 96 provide a better understanding of the depositional processes, sediment distributions, and timing of the construction of the Mississippi Fan. These results can now be applied both to other large deep sea fans and, by using our new understanding of the present as a key to the past, to ancient rock equivalents. □

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