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Recent Changes in Sedimentation in the Gulf of Mexico

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THAT SEDIMENTS IN THE GULF OF Mexico have changed materially in relatively recent time has been established by a recent expedition of the *Atlantis*, the oceanographic research vessel of the Woods Hole Oceanographic Institution. Deposits clearly associated with the Ice Age lie within a foot or two of the surface of the sea floor over a large part of the Gulf.

The *Atlantis* spent the months of February and March 1947 in the northwest part of the Gulf of Mexico, primarily for the purpose of investigating the environmental conditions of deposition of sediments. The expedition was sponsored jointly by the Woods Hole Oceanographic Institution and the Geological Society of America. The latter contributed a grant of $14,500 for this purpose to the authors of this communication, while the Oceanographic Institution supplied the vessel, crew, and scientific personnel for the expedition and made available laboratory facilities and personnel for working up the results.

Despite considerable rough weather, the expedition was remarkably successful. Some 550 short cores of the bottom sediments, ranging in length from 5 to 50 cm., and 100 long cores, ranging in length from 1.5 to 3.3 m., were collected. Twelve lines of samples transverse to the coast across the continental platform from the mouth of the Rio Grande to the mouth of the Atchafalaya River, and 7 lines across the continental slope out to the deepest part of the Gulf, were taken. In addition, about 100 stations were occupied for plankton tows, serial temperature, and samples of water. Several hundred temperature-depth records were made with a bathythermograph along the lines of traverse, and continuous depth records were made with a recording fathometer. The material collected is now being actively worked up at the Woods Hole Oceanographic Institution. The U. S. Bureau of Mines Experimental Station at Pittsburgh, Pennsylvania, through the courtesy of H. M. Cooper, supervising chemist of the Coal Analysis Section, is cooperating in this work by making analyses of the organic content of the sediments.

A preliminary examination of 12 long cores distributed representatively throughout the off-shore waters of the Gulf shows two distinctly different layers of sediment: (1) an upper zone of globigerina ooze, rich in calcium carbonate, 5–50 cm. in thickness, and (2) a lower zone of alternating bands of clay and extremely well-sorted, fine-grained silt, relatively poor in calcium carbonate. Although in a few places the two zones are separated by a layer of red clay or red mud of intermediate calcium carbonate content, in most cores the transition from alternating clay and silt to globigerina ooze is fairly abrupt. Cores from the area off the Rio Grande contain a few centimeters of foraminiferal ooze at the top, below which is fine silt extending to the bottom of the core. No alternating bands of clay and well-sorted silt have been noted in this area.

The lower zone of banded clay found throughout most of the Gulf consists of alternating layers of clay, 1 mm. to 30 cm. thick, and of silt, 0.2 mm. to 5 cm. in thickness. Most of the clay bands are 1–2 cm. thick; most of the silt bands, less than 1 mm. The silt is so well sorted that under a high-power binocular microscope it has the appearance of ordinary beach sand. Its average (median) diameter is estimated to range between 10 and 20 μ. Such good sorting in such a fine silt is most unusual.

Well-defined cross-bedding was noted in two cores: one, at a depth of 170 cm. beneath the sea floor in a sample taken from a sea mount near the edge of the con-

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tinental platform, and the other, 50 cm. beneath the sea floor in the abyssal deep near the edge of the continental slope off Campeche bank, north of the Yucatan peninsula. In the sample from the deep off Campeche bank, the false-bedded zone is 5 cm. thick, individual layers dipping up to 15°. The core there was not deformed, and the attitude of the bedding must be regarded as genuine.

One core (No. 143), taken in 3,546 m. of water in the middle of the Sigsbee deep in the deepest part of the Gulf, has been examined for Foraminifera. The upper foraminiferal zone, 50 cm. in thickness, is characterized by a subtropical planktonic fauna, dominated by *Globigerinoides rubra*, *Globorotalia menardii*, *G. tumida*, G. *truncatulinoides*, and *Pulleniatina obliquilata*. Between depths of 50 and 68 cm., in a zone of red clay or red mud, the fauna is transitional between cold- and warm-water forms. Between depths of 74 and 78.5 cm., at the top of the zone of banded clay and silt, the fauna is definitely sub-Arctic and is dominated by *Globigerina bulloides*, *G. pachyderma*, and small specimens of *Globigerinoides rubra*. Between 78.5 and 125 cm., the fauna is cold-water in type but is warmer than that between 74 and 78.5 cm.; and from 125 to 168 cm., at the bottom of the core, the fauna is definitely sub-Arctic. Abundant broken and seemingly eroded specimens were noted between 74 and 78.5 cm., 92 and 96 cm., and 113.5 and 116.5 cm.

A series of submerged hills rise above the sea floor near the outer edge of the continental platform, just inside the 100-fathom line, off the Louisiana coast between the Sabine and Atchafalaya Rivers. Two of these hills, lying within 10 fathoms of the surface, located in N. Lat. 27° 52.5′, W. Long. 93° 49′, and N. Lat. 27° 54.5′, W. Long. 93° 36′, were studied in some detail. The fathometer trace shows that they are remarkably flat on top and that they rise rather abruptly 300–400 feet above the surrounding muddy plain. On the side of one of these two hills the depth changed from 51 to 86 fathoms within a few ship lengths.

The sediments in these areas are influenced materially by the change in topography. The flat continental platform is underlain by sandy silt; the slopes of the hills, by silty, calcareous sand; and the tops, by round Lithothamnium balls and little or no sandy material. The Lithothamnium balls, dredged from water up to 20 fathoms in depth, have a maximum diameter of 10 cm. and seem to be alive on all sides, which suggests that they are rolled around by the waves or currents. In one place in 9 fathoms of water, several genera of corals, similar to common West Indian genera, were found with these balls.

The origin of these hills arouses speculation. Shepard (*2*) has suggested that they are salt domes. Trowbridge (*3*) also has noted calcareous sediments on the side of a "salt" dome on Southwest Pass. The distribution of sediments and the topographic relations, however, suggest bioherms or calcareous reefs described by Cummings and Shrock (*1*) from the Silurian of Indiana and Wisconsin. The hills perhaps may be erosional remnants, but, if so, either they must have been eroded prior to the deposition of the sandy silt forming the present continental platform or the hills protruded far enough above the surrounding flat, muddy plain to afford a place where calcareous organisms could live. The hills also conceivably could be associated with diastrophic deformation of the Gulf of Mexico basin.

The conditions of sedimentation obviously have changed profoundly in relatively recent geologic time. The upper zone of globigerina ooze, rich in calcium carbonate and characterized by a warm-water fauna, points to subtropical conditions similar to those now prevailing in the Gulf. The intermediate zone of red clay or red mud, noted in a few samples, is intermediate in carbonate content and contains a transition fauna between warm and cold. The lower zone, poor in calcium carbonate, and characterized by a cold fauna and alternating bands of clay and well-sorted silt, indicates the effect of the glacial epoch. The sediments in this bottom zone in general are essentially unchanged to the bottom of the deepest core, 250 cm. beneath the surface of the sea floor. Seemingly, therefore, only one major glacial epoch is represented.

The explanation of (1) the well-sorted, fine silt bands, (2) the layers of broken Foraminifera, and (3) the false bedding at depth in the cores offers a challenge to the imagination. Obviously, the water must have been in motion at the time of the development of the cross-bedding and also, perhaps, when the Foraminifera were broken. The false bedding, owing to the small dimensions of the core, conceivably could represent ripple marks, but, even if that is true, the bottom water must have been in motion to form ripples. How, then, could one account for deep movement of water according to prevailing notions of the sea—by tidal currents, internal waves, or deep currents? Roughness of the sea floor, just as roughness of land affects wind, must interfere with the movement of deep layers of water. But was the sea floor rough at the time of deposition of the false bedding? Perhaps the explanation lies (1) in lowering of the sea level because of removal of water during the ice age, (2) in submarine slumping, or (3) in recent deformation of the floor of the Gulf. The presence of the numerous well-sorted silt layers 200–300 miles from the present shore poses a real problem of transport. It is possible that these layers resulted from eolian action in the final stages of the ice epoch, when so much loess was being deposited. They also might have been laid down near shore. If so, our ideas of the magnitude of ocean changes in the late Pleistocene are likely to be materially different from those we have held in the past.

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