# Reports

## Pliocene-Pleistocene Boundary, Northern Gulf of Mexico

Abstract. *Changes in planktonic microfossil assemblages in Atlantic and Pacific sediment cores of Late Cenozoic age correspond in a general way with a horizon recognized in neritic sediments of the northern Gulf of Mexico. Geological evidence from the Gulf Coast indicates that the changes occurred near the end of the Aftonian interglaciation of the early Pleistocene rather than at the end of the Pliocene, as proposed by other investigators.*

Patterns of extinction and evolutionary change among Discoasteridae and certain planktonic Foraminifera described by Ericson, Ewing, and Wollin (*1*) in deep-sea cores from the Atlantic and Indian oceans are present in similar sequence in subsurface sediments of coastal and offshore Louisiana. The value of these fossil planktonic organisms as time guides is illustrated by their conformity to this sequence, whether they are found in several meters of oceanic sediments, as in deep-sea cores, or in thousands of meters of neritic deposits, as in wells drilled in the northern Gulf Coast where Quaternary and Pliocene beds exceed 3000 m in thickness.

Riedel, Bramlette, and Parker (*2*) report a microfossil sequence in Pacific Ocean deep-sea cores similar to that in the Atlantic cores. They question, however, the proposal of Ericson *et al.* (*1*) that the Pliocene-Pleistocene boundary should be defined on the basis of the discoaster extinctions and other changes in the microfossils. Although this horizon may approximate the beginning of Quaternary time as recorded in the condensed section of oceanic sediments, a wide discrepancy may exist in the thick strata deposited on the continental shelf. This is indicated in coastal and offshore Louisiana where wells penetrate the marine equivalents of alluvial terrace formations which Fisk (*3, 4*) correlated with events of the Pleistocene. The youngest three of these formations were traced by Fisk (*5*) from outcrops into the subsurface of the Atchafalaya River region. Later, Akers and Holck (*6*) correlated the entire sequence of alluvial formations with subsurface marine beds of the Louisiana tidelands by means of electrical logs from numerous shallow wells. Sidewall cores from one of these wells (*6*, no. 24, pl. 1) show microfossil relationships similar to those found by Ericson *et al.* (*1*) and Riedel *et al.* (*2*), but, according to Gulf Coast stratigraphy, the time of marked extinctions and change was between Late Nebraskan glaciation and Aftonian interglaciation (Fig. 1) or even later. These faunal changes took place during an extensive marine transgression, according to all geological evidence.

Long before publication of the data just described, Gulf Coast paleontologists and stratigraphers of the major oil companies had considered as Pleistocene the sedimentary cycles in question (*6*, pls. 1 and 2). One researcher of considerable experience in Gulf Coast Pleistocene stratigraphy includes yet an older cycle in the Pleistocene (*7*). If he is correct, the Pliocene-Pleistocene boundary occurs at a depth of approximately 1600 m in the vicinity of the mouth of the Mississippi River, and discoasters persisted into the Pleistocene until 500 m of sediments were laid down in this area.

As recognized by Wray and Ellis (*8*), the final occurrences of species of *Discoaster* form a definite pattern in the northern Gulf of Mexico, and the pattern can be correlated regionally throughout this area; however, I cannot confirm the extinction of *Discoaster exilis* and *D. hamatus* as late as Wray and Ellis indicate. I can confirm their observation that *D. brouweri* outlived all other species of *Discoaster* in this region and that the last occurrence of this species is separated from the extinction horizon of *D. pentaradiatus* and *D. surculus* by 50 to 150 m. I, too, have noticed that the abundance of *D. brouweri* decreases above the lower horizon by a factor of approximately 10. My observations were made on samples of both cores and drill cuttings from coastal and offshore wells along almost the entire length of the Louisiana coast.

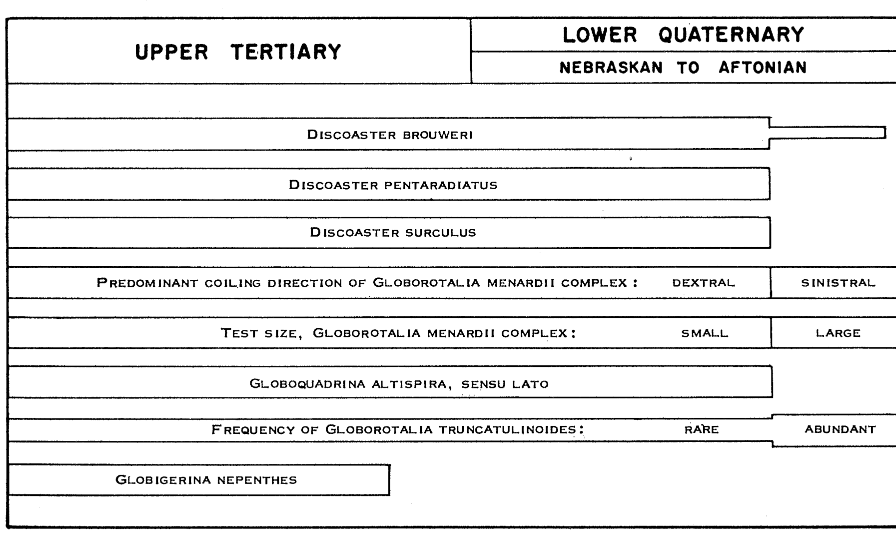


Fig. 1. Occurrence of some planktonic microfossils in the Lower Quaternary and part of the Upper Tertiary of the Louisiana Gulf Coast. Upper Tertiary is included here to show relative ranges only at the proposed Tertiary-Quaternary boundary. No subdivisions within the Upper Tertiary are proposed.

Below the horizon of extinction of *D. pentaradiatus* and *D. surculus*, the coiling direction of the *Globorotalia menardii* complex is predominantly dextral. This complex includes *G. menardii miocenica*, *G. menardii multicamerata*, and a small biconvex form. Above this horizon the coiling direction is predominantly sinistral, and the complex is reduced to a single, larger form, the typical *Globorotalia menardii* of modern seas. *Globoquadrina altispira sensu lato* does not occur above this horizon, and abundant *Globorotalia truncatulinoides* occur only above the horizon (*9*). The former resembles *Globoquadrina altispira globosa*, which was described from the Upper Miocene of Trinidad. Typical *Globigerina nepenthes* is found in Pliocene-Miocene beds below this marked "faunal break."

From my observations I draw the following conclusions: (i) In view of the number of taxa involved, the small size of individuals, and the planktonic habit of these organisms, the horizon in question appears to be synchronous throughout the Atlantic Ocean, the Pacific Ocean, and the Gulf of Mexico. Stratigraphic evidence from numerous closely spaced wells supports this conclusion, at least for the northern Gulf of Mexico. The changes must have occurred abruptly and at approximately the same geologic time. (ii) Although Ericson *et al.* (*1*) claim that the extinctions and evolutionary changes were caused by a marked and abrupt climatic change, it is felt that too little is known of the controlling factors of life on this planet for an unequivocal conclusion to be drawn on this point. Riedel *et al.* (*2*) have pointed out that "more pronounced faunal changes have occurred at intervals through geologic time, but many of them are not clearly attributable to marked climatic change, and fewer are attributable to the onset of glacial periods." (iii) Even if the extinctions and evolutionary changes were caused by abrupt cooling of much of the earth's surface, the "faunal break" may have been Late Aftonian instead of Late Pliocene. The idea that there were alternating cooling and warming trends during the Pleistocene is not new, and it may well have been the onset of a subsequent glacial period rather than the first glacial period that resulted in the changes described. On the basis of the correlation of neritic sediments containing the horizon in question with alluvial terrace formations (*6*), which in turn have been related to Pleistocene events (*3, 4*), the "faunal break" probably occurred during the Late Nebraskan glaciation or the Aftonian interglaciation, or possibly later, rather than during the latest Pliocene. This analysis, it must be pointed out, cannot be substantiated (or disproved) paleontologically. Geochemical dating methods have confirmed the Late Quaternary age of the uppermost alluvial formations and their down-dip marine equivalents (*10*), but the older formations and marine correlatives exceed the range of the radiocarbon method. Thus, it may be argued that the exact age of lower alluvial terrace formations has not been determined.

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**References and Notes**

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## Ureyite, $NaCrSi_2O_6$: A New Meteoritic Pyroxene

Abstract. *The new mineral* $NaCrSi_2O_6$ *(ureyite) has been found as rare emerald-green grains in the iron meteorites Coahuila, Toluca, and Hex River Mountains. X-ray studies of the natural and synthetic material have established that the mineral is isostructural with jadeite,* $NaAlSi_2O_6$. *Indexed data for powder patterns obtained by x-ray diffraction and precise cell dimensions are given for the Cr, Fe, and Al members of the jadeite group. Unlike jadeite, a high-pressure phase, ureyite can be synthesized from melts at 1-atmosphere pressure.*

An emerald-green mineral found as an accessory constituent in the iron meteorites Coahuila, Toluca, and Hex River Mountains has been identified as a new chromium member of the jadeite group. Quantitative analyses by the electron-microprobe technique established the composition of the "ureyite" as $NaCrSi_2O_6$ (Table 1).

To establish the isostructural relation of the new mineral to clinopyroxene, we determined, by x-ray analysis of single crystals, the unit cell and space group of the Coahuila material and of aegirine from Narssarssuaq, Greenland. An analysis of the aegirine from this locality is reported by Böggild (*1*). The powder diffraction patterns of this material, of synthetic $NaAlSi_2O_6$ (*2*), and of synthetic $NaCrSi_2O_6$ prepared by us were indexed. The refined unit cell dimensions, obtained by the least-squares computer program of Burnham (*3*), are cited in Table 2 together with the data of Nolan and Edgar (*4*) on synthetic $NaFeSi_2O_6$. Indexed powder patterns are available for aegirine, ureyite, and synthetic $NaCrSi_2O_6$ (Table 3), jadeite (*5*), and synthetic $NaFeSi_2O_6$ (*4*). The space group of all members of the group is *C*2/*c*.

We have synthesized ureyite by fus-

Table 1. Chemical composition of ureyite, as determined by electron-microprobe analysis (*9*).

| Compound | Coahuila | | | Toluca | | | Hex River Mtns. |
|---|---|---|---|---|---|---|---|
| | Wt. (%) | Atoms per 6 atoms oxygen | | Wt. (%) | Atoms per 6 atoms oxygen | | Wt. (%) |
| $SiO_2$ | 55.5 | 1.99 | | 56.0 | 2.06 | | |
| $Al_2O_3$ | n.d.* | | | n.d.* | | | |
| $Fe_2O_3$ | 0.2 | 0.00 | | 0.4 | 0.01 | | ~ 0.9 |
| $Cr_2O_3$ | 30.6 | 0.86 | 0.90 | 22.6 | 0.66 | 0.97 | ~26.4 |
| MgO | 0.8 | 0.04 | | 5.4 | 0.30 | | ~ 1.2 |
| $Na_2O$ | 11.6 | 0.81 | 0.88 | 11.6 | 0.83 | 0.98 | ~11.0 |
| CaO | 1.7 | 0.07 | | 3.7 | 0.15 | | ~ 2.1 |

* None detected.