120806

GLOBOROTALIA TRUNCATULINOIDES: A PALAEO-OCEANOGRAPHIC INDICATOR

By

YVONNE HERMAN

(*Reprinted from Nature, Vol.* 238, *No.* 5364, *pp.* 394–396, *August* 18, 1972)

(*Reprinted from Nature, Vol.* 238, *No.* 5364, *pp.* 394–396, *August* 18, 1972)

Globorotalia truncatulinoides: a Palaeo-oceanographic Indicator

STUDIES of living planktonic foraminifers have established that many species have limited tolerance to changes in temperature and salinity; they are adapted to various water depths and their distribution on the seafloor usually resembles that in the water layers above. Planktonic foraminifers are therefore useful in reconstructing the history of oceans and seas, and here I describe the distribution of *Globorotalia truncatulinoides* and associated fauna in the North Atlantic and Mediterranean, demonstrating their potential value as tracers of palaeocurrents and specific water masses.

At present the sinistrally and dextrally coiled forms of *G. truncatulinoides* live in different water masses and have distinct depth habitats. Sinistral populations predominate in the warm Gulf Stream, the North Atlantic Current and its branches, and in the Northern Sargasso Sea, whereas dextral forms inhabit the deep and colder water of the Equatorial Atlantic. Both varieties have peak abundances during winter months[1–3].

Ericson *et al.*[4] have charted the distribution of *G. truncatulinoides* in North Atlantic surface sediments and recognize three provinces: a left coiling one, in mid latitudes, and two right coiling provinces, one in the equatorial-subtropical latitudes and another in the North-east Atlantic (Fig. 1). According to Mann[5] the Gulf Stream proper, which flows north from Cape Hatteras along the eastern North American coast, divides in the vicinity of 40° N and 45° W, continuing under the name of "North Atlantic Current". One arm of the current bends north-west, while the main branch continues essentially east, south-east and north-east. Part of the east-flowing current enters the Mediterranean at surface (ref. 6 and Fig. 1). The distribution of *G. truncatulinoides* in surface Atlantic sediments[4] (Fig. 1) suggests strongly that the branching of the North Atlantic Current is recorded by the two forms of *G. truncatulinoides*: the sinistral variety is carried by the warm currents north-west as well as east and penetrates the Mediterranean[7–11] (Fig. 1) and the right coiling variety inhabits the colder North-east Atlantic water mass.

The vertical distribution of planktonic foraminifers in sediment cores taken beneath the North Atlantic Current near Gibraltar indicates that in postglacial sediments predominantly sinistral *G. truncatulinoides* are associated with other warm-temperate North Atlantic Current faunal elements. This population replaced colder planktonic foraminifers roughly 11–13,000 years ago[12,13]. During the last glaciation, dextral

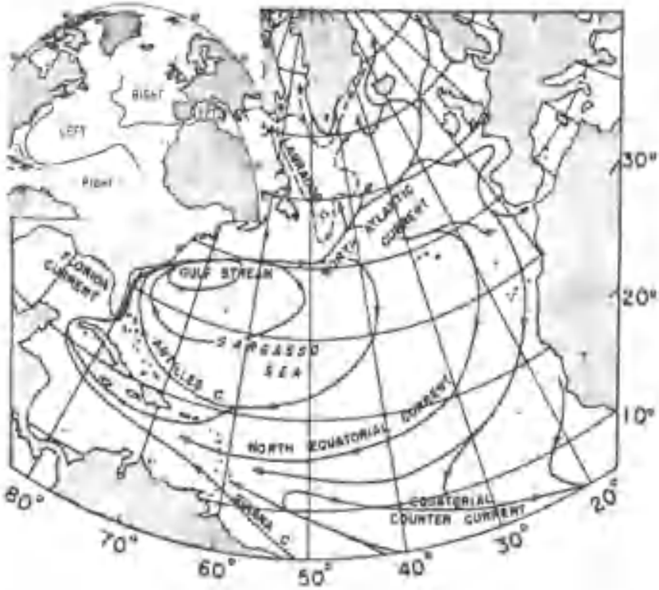

Fig. 1 Circulation of the North Atlantic according to Sverdrup *et al.*[6]. Inset, coiling of *G. truncatulinoides* in surface sediments from the North Atlantic after Ericson *et al.*[4] and in the Mediterranean[8–11].

G. truncatulinoides, together with other cold-tolerant species such as *Globigerina bulloides*, *Globorotalia inflata*, *Globigerina pachyderma*, *Globigerina quinqueloba*, *Globorotalia scitula*, and *Globigerinita glutinata*, inhabited the Gibraltar sector of the Atlantic[12]. These taxa are found in postglacial Labrador and Norwegian Sea sediments[14,15].

The faunal data suggest that fluctuations in past climates have influenced oceanic circulation: during the last glacial (Wisconsin, Würm) the Gulf Stream and the North Atlantic Current migrated south by several degrees. This migration resulted in the replacement of warm-temperate planktonic faunas by northern immigrants in the Gibraltar sector of the ocean and in the Mediterranean. These taxa now inhabit the cold Atlantic water masses north of the Gulf Stream and the North Atlantic Current.

Micropalaeontological analyses of sediment cores from the Mediterranean allow the reconstruction of the climatic and hydrological history of this sea back through the last interglacial. Two cores for which absolute ages, micropalaeontological data and $^{18}O/^{16}O$ determinations are available illustrate these oscillations[8–11] (Fig. 2).

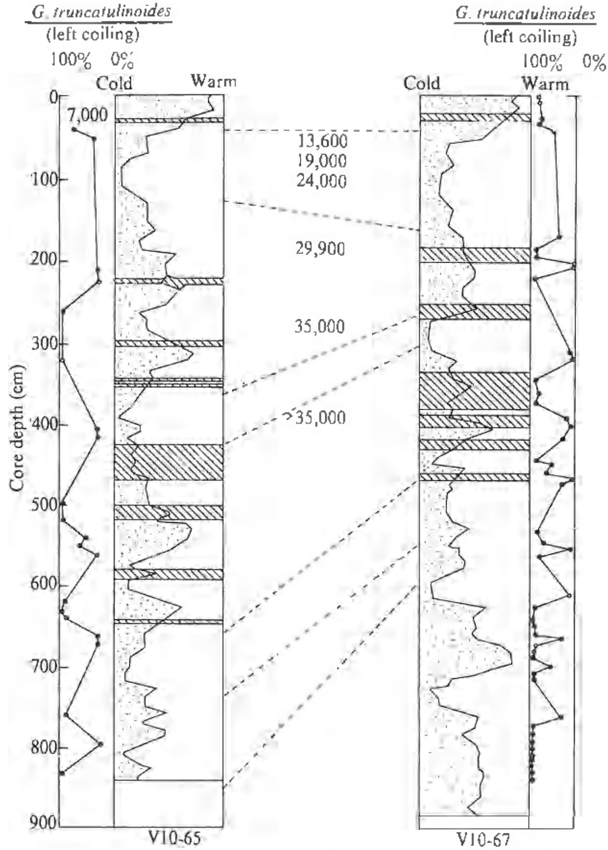

Fig. 2 Two sediment cores from the Mediterranean: V10–65, 34° 37′ N, 23° 25′ E, water depth 2,586 m; V10–67, 35° 42′ N, 20° 43′ E, water depth 2,890 m. Black sapropels (hatched areas) represent stagnant episodes. Climatic curves based on total planktonic faunal analysis (after ref. 9).

Variations in coiling direction of *G. truncatulinoides* reflect changes in surface water temperatures also inferred from other planktonic foraminifers and oxygen isotope determinations. In postglacial sediments sinistral *G. truncatulinoides* occur together with *Globigerinoides ruber*, *Globigerinoides sacculifer*, *Globigerinella aequilateralis*, *G. inflata*, and *G. bulloides*. During the last glacial, the Mediterranean supported colder water elements, including dextral *G. truncatulinoides*, *G. bulloides*, *G. scitula*, and *G. inflata*.

Radiometric age determinations[8–12,16], coupled with close interval inter- and intra-basinal biostratigraphic correlations between cores, indicate that during the late Cainozoic, climatic oscillations in the Mediterranean were contemporaneous with those in the Atlantic.

The fauna of the Mediterranean and Atlantic have close affinities except during periods of stagnation (Fig. 2) when the Mediterranean planktonic population was dominated by euryhaline and low salinity-tolerant species, such as *G. ruber*, *Globoquadrina dutertrei* and *G. quinqueloba*.

Several taxa living in the Atlantic did not penetrate the Mediterranean. This may be because of the shallow Gibraltar sill depth, the depth habitat of certain species and/or the higher salinities of the Mediterranean which may inhibit the survival of stenohaline taxa.

The time interval represented by the longest Mediterranean core exceeds 120,000 yr. Faunal evidence suggests that surficial water exchange between the ocean and the sea was virtually uninterrupted throughout this time. Consequently, when reconstructing the late Cainozoic climatic history of the Mediterranean, past oscillations in climates and circulation patterns of major current systems in the adjacent North Atlantic Ocean may be inferred with high degree of confidence.

This work was supported by the National Science Foundation and by funds provided by the Washington State University Graduate School Development Fund. I thank J. W. Mills and P. E. Rosenberg, Washington State University, for critically reading the manuscript. The Mediterranean cores were collected by Lamont-Doherty Geological Observatory and by the Göteborg Institute of Oceanography, and samples were provided by Mr R. Capo.

YVONNE HERMAN

Department of Geology,
Washington State University,
Pullman, Washington 99163

Received February 23, 1972.

[1] Jones, J. I., thesis, Univ. Wisconsin (1964).
[2] Cifelli, R., and Smith, R. K., in *Proc. First Intern. Conf. on Plankt. Microfossils*, **2**, 68 (edit. by Brönnimann, P., and Renz, H. H.) (Leiden, 1969).
[3] Cifelli, R., and Smith, R. K., *Smithson. Contrib. Paleobiol.*, **4**, 1 (1970).
[4] Ericson, D. B., Wollin, G., and Wollin, J., *Deep Sea Res.*, **2**, 152 (1954).
[5] Mann, C. R., *Deep Sea Res.*, **14**, 337 (1967).
[6] Sverdrup, H. U., Johnson, M. W., and Fleming, R. H., *The Oceans* (Prentice-Hall, New York, 1942).
[7] Parker, F. L., in *Repts. Swedish Deep-Sea Exp.*, **8**, 219 (Göteborg, 1958).

[8] Herman, Y., in *Micropaleontology of Oceans* (edit. by Funnell, B. M., and Riedel, W. R.), 463 (Cambridge Univ. Press, 1971).

[9] Herman, Y., in *Proc. Second Intern. Plankt. Conf., Rome, 1970* (edit. by Farinacci, A.), 611 (Rome, 1971).

[10] Vergnaud-Grazzini, C., and Herman-Rosenberg, Y., *Revue Geogr. Phys. Geol. Dynam.*, **2**, 279 (1969).

[11] Herman, Y., in *Symp. on Sedimentation in the Mediterranean Sea* (edit. by Stanley, D. J.) (in the press).

[12] Thiede, J. T., in *Proc. Second Intern. Plankt. Conf., Rome, 1970* (edit. by Farinacci, A.) (Rome, 1971).

[13] Thiede, J. T., thesis, Univ. Kiel (1971).

[14] Cushman, J. A., and Henbest, L. G., in *Geology and Biology of N. Atlantic Deep-Sea Cores*, 35 (Washington, 1942).

[15] Barash, M. S., in *The Micropaleontology of Oceans* (edit. by Funnell, B. M., and Riedel, W. R.), 433 (Cambridge Univ. Press, 1971).

[16] Ericson, D. B., Ewing, M., Wollin, G., and Heezen, B. C., *Geol. Soc. Amer. Bull.*, **72**, 193 (1961).

Printed in Great Britain by Flarepath Printers Ltd., St. Albans, Herts.