

MASS MORTALITY AND EXTRATERRESTRIAL IMPACTS; L.F. Jansa, F.M. Gradstein, Atlantic Geoscience Centre, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, B2Y 4A2, Canada; and M. Pierre-Aubry, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts, U.S.A.

The discovery of iridium enrichment at the Cretaceous/Tertiary boundary (1) resulted in formulation of hypothesis of a cometary or asteroid impact as the cause of the biological extinctions at this boundary. Subsequent discoveries of geochemical anomalies at major stratigraphic boundaries like the Precambrian/Cambrian (2), Permian/Triassic (3), Middle/Late Jurassic (4), resulted in the application of similar extraterrestrial impact theories to explain biological changes at these boundaries.

Until recently the major physical evidence, as is the location of the impact crater site, to test the impact induced biological extinction was lacking. The diameter of such a crater would be in the range of 60-100 km (5). The recent discovery of the first impact crater in the ocean (6) provide the first opportunity to test the above theory.

The crater named Montagnais and located on the outer shelf off Nova Scotia, Canada, has a minimum diameter of 42 km, with some evidence to a diameter of more than 60 km. The crater dimensions are thus close to the lower limit of extraterrestrial impacts thought to be associated with mass extinctions. The absolute age dating of the multiple melts at the central uplift provided 50.5 m.y. age for the impact. Over 100 oil exploratory wells are located on the Scotian shelf. Several deep sea drill holes are located on the continental slope and rise off New Jersey (7) and also penetrated coeval sedimentary sequences to the Montagnais impact event.

At the Montagnais impact site, micropaleontological analysis of the uppermost 80 m of the fall-back breccia represented by a mixture of pre-impact sediments and basement rocks which fills the crater and of the basal 50 m of post-impact marine sediments which overly the impact deposits, revealed presence of diversified foraminiferal and nannoplankton assemblages. Planktonic foraminifera include *Acarinina broedermani*, *A. aff. intermedia*, *A. senni*, *A. pentacamerata*, *A. soldadoensis*, *A. aff. densa*, *Subbotina patagonica* (abundant), *S. inaequispira*, *S. frontosa*, and *Pseudohastigerina wilcoxensis*. The assemblage indicates Zone P-9, late Early Eocene. Benthic foraminifera include *Spiroplectammina navarrona* and *Plectofrondicularia aff. paucicostata* of the *Subbotina patagonica* Zone similarly indicative of the Early Eocene on the Canadian Atlantic margin.

Nannofossils include frequent *Discoaster gemmifer*, *D. kuepperini*, *D. lodoensis*, *D. mediosus* and *Ericsonia formosa*, *Chiasmolithus eograndis*, *C. grandis*, *C. solitus*, *Cruciplacolithus delus*, *Helicosphaera seminulum*, *Toweius callosus*, *T. magnicrassus* and *T. gammation*. Less common but also characteristic of the late Early Eocene assemblages are *Reticulofenestra dictyoda*, *Helicosphaera lophota*, *Lophodolithus mochlophorus*, *L. nascens*, *Rhabdosphaera solus*, *R. truncata*, *Discoaster cruciformis* and *D. robustus*. The occurrence of *Discoaster lodoensis* and the absence of *D. sublodoensis* from a stratigraphic level 36 m below the top of the of the impact deposits to 47 m stratigraphically up into basal sediments overlying the impact, restricts the biozonal assignment of the whole interval to late Early Eocene (upper part of Zone NP-12 or Zone NP-13 of the Martini Standard Zonation (8)). A sparse assemblage from a sample which is 45 m below the top of the impact which yields *Ericsonia formosa*, *Neococolithes dubius* and *Pontosphaera pulchra* is also clearly early Eocene in age. The nannofossil assemblages are coeval with or slightly older than foraminiferal Zone P-9.

The sediments which are intercalated within the uppermost part of the fall-back breccia, had to be deposited before the meteorite impact. The post-impact deposits were laid down almost immediately after the impact as also supported by the micropaleontological data. Both, the pre-impact and post-impact sedimentary deposits enclose foraminiferal and nannofossil microfauna which at the level of resolution does not indicate sudden change (decrease or disappearance) in diversity and or abundance at the impact boundary. Similarly, studies of Lower to Middle Eocene sediments from the Scotian margin and the New Jersey slope (7) do not show any extinction event,

or other significant change in composition, diversity or abundance of benthic, and/or pelagic foraminiferal microfauna and microflora at the P-9, or NP-12/NP-13 stratigraphic level.

In conclusion, micropaleontological studies of sediments from the first submarine impact crater site identified in the ocean did not reveal any mass extinction or significant biological changes at the impact site or in the proximal deep ocean basin. Since the size of the crater studied is close to the theoretical lower boundary conditions for mass extinctions by fall of extraterrestrial object, we can not exclude the probability that bolides of significantly larger size than the Montagnais may indeed severely effect the biosphere evolution.

References

1. Alvarez, L.W., Alvarez, W., Asaro, F. and Michel, H.V. *Science*, 208: 1095-1108 (1980).
2. Hsu, K.J., Oberhänsli, H., Gao, J.Y., Chen Haihong, S.S. and Krabenbuhl, U. *Proceedings of Gwatt Conference, Switzerland* (1985).
3. Sun Yi-Ying, Chai Zhi-Fang, Mao Xue-Yin, Ma Shu-Lan, Yin Ji-Xiang, Liu Cheng-Jie, Xu Dao-Yi, Zhang Qin-Wen and Yang Zheng-Zhong. *Proceedings of Gwatt Conference, Switzerland* (1985).
4. Brochwicz-Lewinski, W., Gasiewicz, A., Melendez, G., Sequeiros, L., Suffczynski, S., Szatkowski, K., Tarkowski, R. and Zbik, M. *Proceedings of Gwatt Conference Switzerland* (1985).
5. O'Keefe, J.D. and Ahrens, T.J. *Geological Society of America Special Paper* 190: 103-120 (1982).
6. Jansa, L. F. and Pe-Piper, G., *Nature* 327, No.6123, 612-614 (1987).
7. Poag, C.W., Watts, A.B. *et al.*, *Initial Reports DSDP*, 95, 1-817 (1987).
8. Martini, E. *Proceedings of the Second Conference on Planktonic Microfossils*, 739-785, Roma (1971).