Stable isotopes, Ir anomaly and other elemental markers near the Palaeocene - Eocene transition: evidence from the western Tethys

T. Dolenec
J. Pavšič

Department of Geology, University of Ljubljana, Aškerčeva 12, 1000 Ljubljana, Slovenia

S. Lojen

Department of Environmental Sciences, Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

The geological history of the Earth is characterized by several global events recording dramatic climatic, oceanographic and biotic changes. One of them is a short-term Palaeocene-Eocene (P/E) deep sea benthic foraminiferal extinction event (BEE), also marked by distinct negative $\delta^{13}C$ and $\delta^{18}O$ anomalies, recorded in several marine and terrestrial sections all over the world (see Corfield, 1994; Koch *et al.*, 1995; Stott at al., 1996 and references therein), as well as geochemical and sediment compositional changes (Lu *et al.*, 1996; Schmitz *et al.*, 1997).

In this study we present preliminary results of complex stable isotope and geochemical investigations of the P/E boundary interval in the flysch sequence from the western Tethys (Gorika Brda section, Slovenia), and discuss their implications in a view of better understanding of the nature and the causes of the of the global changes across the P/E transition in this part of the Tethys.

Results and discussion

The studied part of the 30-m thick Gorika Brda section spans the upper part of nannofossil Zone NP9 to the lower part of Zone NP 10. The well-exposed un-tectonized sedimentary boundary sequence is mostly composed of marls alternating with sandstones of the Upper Palaeocene age. This unit is overlain by a 3-m thick limestone breccia followed by an up to 11.8-m thick succession of sandstone. The first Eocene plankton species Rhomboaster bramlettei indicating the biozone NP 10 was found in the upper part of the first marl layer overlying the sandstone. Based on the lithology, micropalaeontological, isotopical and geochemical investigations, the P/E boundary is placed at the base of the limestone breccia unit.

The P/E boundary event recorded in the investigated section is characterized by multiple isotopic and elemental anomalies which roughly span an interval between 0 and −5 m. There are four distinct isotopic minima at −0.25, −1.3, −2.5 and −4 m below the P/E boundary which demonstrate a clear perturbation in $\delta^{13}C_{carb.}$ and $\delta^{18}O$ records of the whole rock samples. The corresponding $\delta^{13}C_{org.}$ record also exhibits four isotopic minima. The first one at −5 m appears before the first negative $\delta^{13}C_{carb.}$ and $\delta^{18}O$ excursion, while the last three are coeval with those of $\delta^{13}C_{carb.}$ and $\delta^{18}O$ (Fig. 1).

The most significant feature is an enrichment of the boundary sequence in Ir (0.1−2.3 ppb), PGM elements (Rh, Pd, Pt, Au), siderophiles (Fe, P, Ni, Co), chalcophiles (Sb, As, Zn, Cu) and some lithophiles (Si, Al, Mg, Na, K, Ba, Cr, V, Zr, Y, Mn and *REE*). The Ir enrichment spans a 2.7 m thick stratigraphic interval from −1.3 to −4 m. The iridium anomalies at −4 m (0.1 ppb), −2.5 m (2.3 ppb) and −1.3 m (0.6 ppb) are coincident with isotopic anomalies, while that at −2,95 m (0.3 ppb) appears after the first negative $\delta^{18}O$ and $\delta^{13}C$ shift (Fig. 1). The peak values of PGM elements are not confined to the same marl layers containing Ir anomalies, most probably indicating a different origin of Ir and/or its separation from these metals during diagenesis.

The distinct disturbance in organic carbon, as well as in whole rock C and O istopic records associated with Ir anomalies, PGM and other meteoritic and non-meteoritic element enrichments provides strong evidence that something unusual happened at the time of the P/E transition. The diverse character of the negative excursion of $\delta^{13}C$ of carbonate and sedimentary organic matter indicates a significant perturbation in the global carbon cycle and/or climatic changes, most probably controlled by a combination of volcanic activity and fluctuations in bioproductivity as indicated by the multiple character of the $\Delta\delta^{13}C_{carb.-org.}$ curve. The corresponding $\delta^{18}O$

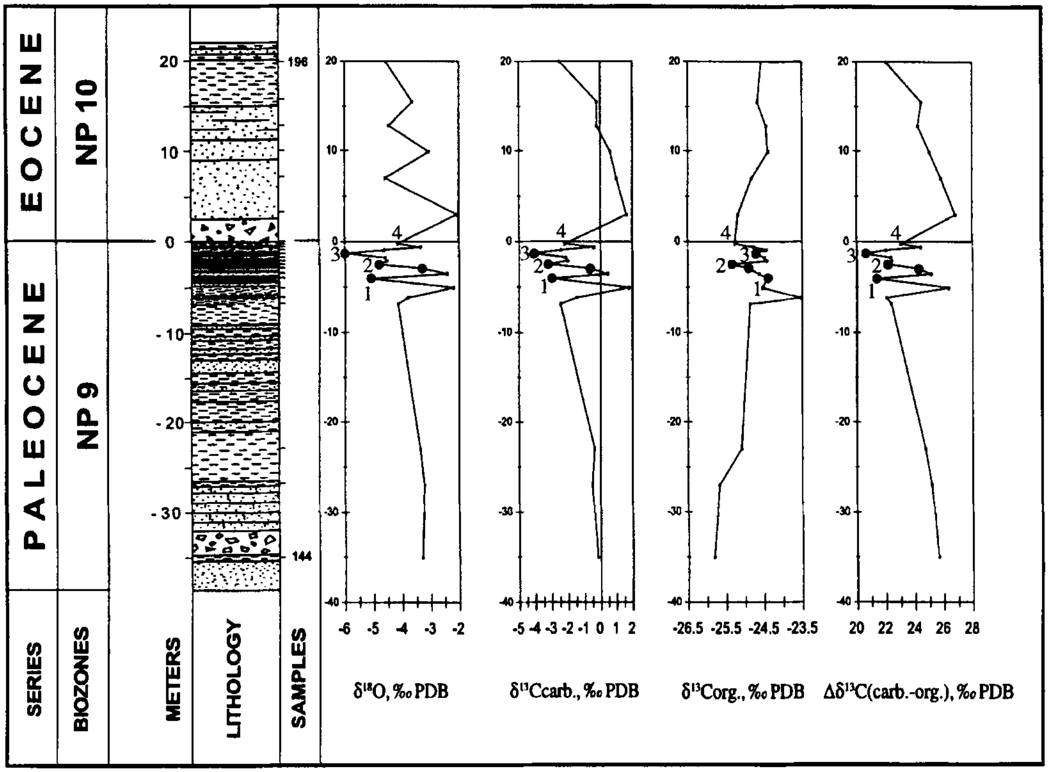

FIG. 1 Stable isotope composition of carbonates ($\delta^{18}O$, $\delta^{13}C_{carb.}$), organic carbon ($\delta^{13}C_{org.}$) and isotope fractionation between carbonate and organic carbon ($\Delta\delta^{13}C_{carb.-org.}$) across the Palaeocene-Eocene boundary in the Goriška Brda section, Slovenia, (● Ir anomaly, 1–4 isotopic minima).

variability may be related to global warming due to the greenhouse effect (see Thomas 1991; Corfield, 1994 and references therein) and/or diagenetic changes. Using petrographic and trace element abundance data (unpublished), we evaluated known diagenetic effects that may affects the carbon isotopic composition in our studied sections and we concluded that the $\delta^{13}C$ reported here are predominantly primary.

The Ir anomalies, PGM enrichment and the elevated values of meteoritic and non-meteoritic elements most probably indicate a complex source of these metals such as volcanic processes, sea floor hydrothermal activity, weathering of the continental crust, as well as diagenetic remobilization. However, an alternative hypothesis can be proposed that the Ir anomalies may be also attributed to an extraterrestrial impact(s) which could have triggered the P/E boundary events and related biotic crisis.

References

Corfield, R.M. (1994) *Earth Sci. Rev.*, **37,** 225–52.

Koch, P.L., Zachos, I.G. and Dettman, D.L. (1995) *Palaeogeogr., Palaeoclimatol., Palaeoecol.,* **115,** 61–89.

Lu, G., Keller, G., Addate, T., Ortiz, N. and Molina, E. (1996) *Terra Nova,* **8,** 347–55.

Thomas, E. (1991) *Geol. Soc. Amer., Abstr. Programs,* **23,** A141.

Schmitz, B., Charisi, S.D., Thompson, E.I. and Speijer, R.P. (1997) *Terra Nova,* **9,** 95–9.

Stott, L.D., Sinha, A., Thiry, M., Aubry, M.P. and Berggren, W. (1996) *Geol. Soc. Spec. Publ. No.* 101, 381–99.