Geochemical data on marine sediments of the Permian-Triassic boundary interval: A review

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Described as the turning point in the Pangean environmental history, the Permian-Triassic boundary interval (PTBI) records major global events as biotic crisis, variations of sea level and a large volcanic activity. The increasing number of geochemical studies across the PTBI have outlined variations of unusual amplitudes.

A survey of 13 tethyan sections across the PTBI (Baud *et al.*, 1989) confirmed that the variations of δ^{13}C values of carbonates described previously had a global character. The most detailed geochemical study across a Permian-Triassic boundary section has been carried out on the Gartnerkofel core, Southern Alps (papers in Holser and Schönlaub, 1991) with three main objectives: the calibration of the δ^{13}Ccarb and δ^{13}Corg curves, the research of rare earth and Ir anomalies and the analysis of anoxia. Among the reviews on the Permian-Triassic boundary that consider geochemical data, the most recent one has been published by Hallam and Wignall (1997).

The goal of the present note is to review the most recent literature and to discuss the use of geochemistry in problems related to the PTBI.

The δ^{13}C pattern, a stratigraphical tool.

Following the initial work on δ^{13}Ccarb, recent studies brought new results from different parts of the world.

At high palaeolatitudes of the Northern hemisphere, carbon isotope studies of organic matter have been undertaken in two areas:

(1) In the N Ellesmere Island (Otofiord) there is a gradual increase carbon isotope ratios from values of −32‰ at the base of the Blindfiord formation to values around −29‰ higher upsection (works in progress), showing a pattern similar to the Willingston Lake profile from Wang and co-authors in NE B.C.

(2) In the W Spitzberg, Wignall and co-authors provided the δ^{13}Corg profile across an Upper Permian to Lower Triassic section and interpreted the gradual decline in δ^{13}Corg values observed at the base of the Vanderbukta Formation as an evidence for continuous deposition in the late Permian interval.

At high palaeolatitude of the Southern hemisphere, in Western and Eastern Australian, carbon isotope profiles also exhibit a high magnitude drop in δ^{13}Corg values. However, Foster *et al.* (1997) concluded that the isotopic values of organic carbon are strongly influenced by the primary source of the organic matter and questioned their use in chemostratigraphic correlations.

In the NE Pangea-Pantalassa terranes, two areas have been recently investigated for the isotopic composition of organic carbon:

(1) SW Japan, where the PTBI consists of siliceous and carbonaceous shales, no well defined trend have been described.

(2) S China, where Wang and co-authors analysed three sections and indicated two successive negative shifts of 2‰ at a background of −26 to −25‰.

Zakharov *et al.* (1996) carried out geochemical investigations on Permo-Triassic carbonate sediments and fossils of Primoryie (Far-East Russia), and reported a marked negative shift at the Boundary.

Along the Northern part of Gondwana, at least two areas provide new results:

(1) The N Indian margin, the tethyan carbonate carbon isotope data set has been supplemented by Baud *et al.* (1996) with data from Salt Range, Kashmir, and Central Nepal. A negative shift of 3 to 5‰, beginning in the latest Permian, is well recorded in three sections.

(2) The Oman margin carbonate sediments, unpublished data indicate a 3‰ negative shift across the Permian-Triassic boundary from a thin bedded slope deposit profile, Sumeini area, and from basinal sections, Baid area.

Within giant P-T carbonate platforms croping out on the Cimmerian blocks, similar shift of δ^{13}Ccarb values occurs in the Abadeh section (central Iran) and according to Zakharov *et al.* (1996) there is also a 3‰ negative shift across the Permian-Triassic boundary in the Dzhulfa and adjacent sections (Azerbaidjan).

In the Western end of the Tethys (N Italy, Slovenia and adjacent Austria) the PTBI has been intensively investigated in term of Chemostratigraphy. Most of the informations will be found in the cited references. Unpublished data on PTBI δ^{13}Ccarb in the N Italy indicate a regular negative shift of moderate amplitude.

A compilation of Guadalupian to Anisian $\delta^{13}C$ data derived from unquestionable marine carbonates show that the late Permian is characterised by high $\delta^{13}C$ values, generally between 3‰ and 5‰, and only rarely higher than 5‰. Anomalously high $\delta^{13}C$ values (6‰ to 8‰) were reported from carbonates occurring in evaporitic sequences and (occasionally) from boreal brachiopod shells. Therefore, the marine carbonate record provides no evidence for a global positive excursion in the Upper Permian as it was previously suggested. The end-Permian drop is clearly marked by this compilation and the carbon isotope recovery begin most likely during the Late Griesbachian substage.

Iridium content

The high Iridium concentrations found at the K/T boundary have been used as strong arguments in favour of an extraterrestrial impact as the cause of the mass extinction. As far as the Permian Triassic boundary is concerned Ir analysis have been done for the south China stratotype candidate sections (Meishan, Shangsi, Dongluo), south Tibet (Selong), in SW Japan (Sasayama section) and in the Gartnerkofel core section. The measured Iridium concentrations are at least an order of magnitude lower than the Iridium spike at the K/T boundary, but similar to Iridium concentrations described at other major boundaries.

Palaeoenvironmental indicators

Martin and co-authors analysed the Sr and Nd isotopic composition of conodonts from the Salt Range section (Pakistan) and found a major increase in the the continentality of the weathered rocks and in the riverine flux during the latest Permian.

Foster *et al.* (1997) determined facies and organic models based on isotopic and chemical composition of organic carbon from E and W Australian basin examples.

Based on oxygen isotopic composition of carbonate, the determination of the palaeotemperatures of the seawater requires unaltered carbonates found for the PTBI only in preserved brachiopod shells or in conodont phosphate. Recent results from Transcaucasia and from Primoryie (Zakharov *et al.*, 1996) are not convincing (possibility of diagenetic alteration).

Several geochemical indicators have been used recently in Permian-Triassic strata in order to identify the occurrence of anoxic bottom waters (Cerium anomaly, carbon/sulphur ratios, Th/U ratios, sulphide Fe/ total Fe ratios). $\delta^{34}S$ values in pyrite are also believed to reflect the degree of oxygenation of the depositional environment since in oxic environments, through repeated cycles of bacterial reduction and oxidation, the $\delta^{34}S$ values become lower than under anoxic conditions. Kajiwara used such an approach on two section from Japan to show that anoxic conditions characterised the Latest Permian ocean.

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