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Palaeoceanographic conditions during the Toarcian oceanic anoxic event

With the aim to provide a contribution to the uderstanding of the palaeoceanographic conditions during the anoxic event in the Tethyan realm, we have carried out a high-resolution geochemical study of the Valdorbia (Umbria-Marche Apennines) and Mount Mangart (Julian Alps, Italian-Slovenian border) sections (Figs. 1-2). We discuss and evaluate the elemental (major, trace and rare earths) distribution patterns of the two sections in terms of geochemical response to the palaeoceanographic changes through the T-OAE.

In the Early Jurassic the volcanic activity from the Karoo-Ferrar igneous province caused an increasing flux of volcanogenic CO_2 and a gradual global warming. Such effects might have destabilized the gas hydrate reservoir promoting a significant flux of methane toward the ocean-atmosphere system, followed by its rapid oxidation and subsequent global temperature rise. Lower Jurassic climate were globally 5-10°C warmer than present, with vast arid areas at low- and mid-latitudes in the interior of western Pangea, and temperate zones at high-latitude (Bailey et al., 2003; van de Schootbruggeet al., 2005). Monsoonal atmospheric circulation dominated the mid-latitude coasts of the Tethyan and Pacific oceans, causing high rainfall rates that also affected the mid-latitude eastern areas of Pangea (Chandler et al., 1992) An accelerated hydrological cycle caused by global warming might have reduced the water salinity and induced stratification of shelf waters (Bailey et al., 2003). A rise in the strontium isotope ratios ($^{87}Sr/^{86}Sr$) recorded in belemnite calcite (McArthur et al., 2000; Jones and Jenkyns, 2001) and an increase in osmium isotope ratios ($^{187}Os/^{188}Os$) measured in the black shales of the Early Toarcian (Cohen and Coe, 1999; Cohen et al., 2002; 2004) provide further evidence for an enhanced hydrological cycle and intense continental weathering.

On this basis, we can discuss some points:

1) Continental runoff. High values of the detrital flux index (D*=Al/(Al+Fe+Mn); Boström et al., 1969) in the Valdorbia and Mount Mangart sections in addition to high concentrations of REE across the black shale horizons probably reflect the influence of nearby emerged areas. The relative decrease in carbonate likely results from an increase in siliciclastic sedimen supply. The setting of both sections was controlled by rifting related to the western Tethys opening in the Early Jurassic, which caused the breakup of a large carbonate platform located along the passive African margin. The deposition of the two sections occurred in restricted basins, which reasonably received a high fluvial discharge related to an accelerated hydrologycal cycle; as a consequence a marly-argillaceous deposition replaced the predominant calcareous sedimentation typical of the Domerian. The physiogeography of the Valdorbia and Mount Mangart areas was like that of Peniche (Portugal), a subsiding “ombilic” or gutter demonstrated by the occurrence of torbiditic levels (Almèras et al., 1988; Hesselbo et al., 2006).

2) Primary productivity. Methane melting, hampering biocalcification and shallowing the CCD, favoured organic-walled and siliceous plankton productivity. Biogenic silica is expressed in this work by the Si/Al ratio. High ratios were found in the Mount Mangart section, where the radiolarian proliferation is markedly higher compared to the coeval Valdorbia section. In marginal environments the primary productivity might have been influenced by different both coastal upwelling and nutrient transport by rivers into the ocean. An indicator of nutrient availability is P/Al ratio. Phosphorus is preferentially regenerated from sedimentary organic matter (Filippelli, 2001) and the slight higher ratios in the lower part of Mount Mangart section could be indicative of an increased productivity in this interval.

3) Redox conditions at the seafloor. The development of disoxic-anoxic conditions seem to have occurred in both studied sections. V/(V+Ni) ratios for the black shale horizons fall within the range 0.54-0.80 proposed by Hatch and Leventhal (1992) as indicative of anoxic conditions. The V/(V+Ni) values are generally paralleled by maxima in detrital flux (D*), suggesting a strong relation between the development of oxygen-deficient bottom-waters and an enhanced riverine discharge. Sulphate reduction and pyrite precipitation were limited by the availability of labile organic matter and were insufficient to generate stable anoxic bottom-water conditions. Photic zone anoxia in sediments from Valdorbia, during the Early Toarcian, is indicated by the presence of green sulphur bacterial biomarkers (Pancost et al., 2004), but some samples do not contain these biomarkers and together with low organic carbon content (<2%) and low HI could be indicative of degradation of organic matter (Farrimond et al., 1988) related to an intermittent oxygenation of the water column during deposition.

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FINAL BUDGET:

Trace element analyses (34 samples from Valdorbia section) = $612
Trace element analyses (35 samples from Monte Mangart section) = $630
TOTAL AMOUNT = $1232 = €1019.32