Geochemical characteristics of Toarcian sedimentation in Alpine geological domains.

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Introduction and aims

Several studies (e.g. Jenkyns, 1980; Vera, 1981) have compared the stratigraphic characteristics of Jurassic sediments deposited in continental margin environments belonging to Alpine domains. This paper is the first to undertake a comparative study of the geochemical characteristics of the Toarcian sediments in sequences from the Betic Cordilleras (SE Spain) and the Northern Apennines (Central Italy), with the aim of increasing knowledge of their palaeogeographical environments.

Materials and methods

Two stratigraphically significant lithofacies were studied. The first of these appears in the Betic Cordilleras as rhythmic alternations of marls and marly limestones (RMM) and as the marly and marly-argillaceous Marne di Monte Serrone (MS) Formation in the Apennines. The other lithofacies is Rosso Ammonitico (RA) consisting of reddish marls and nodulous limestones in both geological domains. The stratigraphic sections of the Betic Cordilleras belong to the Median and External Subbetic and those of the Apennines to the Umbria-Marche basin. Analyses of trace elements were carried out in 230 samples using XRF, NA, ICP and AAS.

Results

Previous data on the clay mineral assemblages were presented by Ortega-Huertas *et al.* (1991) and Ortega-Huertas *et al.* (1993). Tables 1 and 2 summarise the most significant geochemical results obtained in this study.

Discussion and conclusions

At the beginning of the Jurassic the thick marine series of RMM, MS and RA indicate general pelagic conditions in both geological domains. However, the geochemical data obtained lead to the following interpretations:

1. The RMM and MS facies were deposited in a pelagic marine trough environment with several swells in different parts of the basins. RMM sedimentation occurred in a homogeneous environment, whereas during deposition of the MS subenvironments with restricted circulation must have been present. Black-shale type facies were deposited here in anoxic conditions, presenting

TABLE 1. Geochemical data (p.p.m.). L = lithology (see text)

	L	Ba	Pb	Co	As	Sb	Cu	Zn
Betic Cordilleras								
mean value	RMM	160	2	6	<2	0.70	20	35
range		82–260	2–6	5–10	<2–3	0.40–0.80	9–30	20–48
mean value	RA	116	<2	6	<2	0.50	10	45
range		105–138	<2–4	6–9	<2–3	0.50–0.80	7–12	20–50
N Apennines								
mean value	MS	289	5	14	6	1	30	63
range		114–1000	2–12	5–50	2–14	0.40–2	9–47	37–130
mean value	RA	112	2	10	<2	0.70	12	48
range		100–127	2–4	7–12	<2–3	0.50–0.90	9–20	33–69

Table 2. Total *REE* content (p.p.m.) and other geochemical data. L = lithology (see text)

	L	*LREE*	Ce/Ce*	D = Al/Al + Fe + Mn	La/Lu	Eu/Sm
Betic Cordilleras						
mean value	RMM	99	0.71	0.65	11.52	0.20
range		69–206	0.53–0.84	0.60–0.71	7.78–16	0.15–0.29
mean value		98.75	0.72	0.60	12.91	0.20
range	RA	57–127	0.62–0.87	0.40–0.68	11.12–15.39	0.19–0.21
N Apennines						
mean value		125.20	0.96	0.74	10.97	0.23
range	MS	83.61–168	0.85–1	0.70–0.80	9.90–11.68	0.15–0.30
mean value		81.70	–	0.73	11.17	0.27
range	RA	50.90–102.90	0.91–absent	0.70–0.75	10.21–11.75	0.20–0.31

thicknesses of 20–500 cm and TOC values from 1% to 2.69% These facies also present significant geochemical anomalies in Ba, Pb, Co, As, Sb, Cu and Zn (Table 1). The maximum anoxia conditions are found in the upper part of the Tenuicostatum Zone, where we detected the most important geochemical anomalies, which also coincide with a general increase in radiolaria and calcareous nannofossils (Monaco *et al.*, 1994). The RA facies is geochemically analogous in both geological domains, and is characteristic of a shallower, more oxygenated environment. This is particularly so in the Apennines, as shown by the higher average *REE* content (Table 2), whereas in the Betic Cordilleras its geochemical similarity with the RMM (Table 1, and *REE* content in Table 2) should be interpreted as the result of deposition of both facies (RA and RMM) in similar conditions.

2. The values of the La/Lu ratio (Table 2) indicate that the RMM, MS and RA were deposited in conditions intermediate between those of pelagic and nearshore marine environments. However, the presence of values between 9.58 and 10.75 in some levels of the RMM and MS suggests local development of more pelagic conditions, following Ronov *et al.* (1967) and Ortega-Huertas *et al.* (1991).

3. The higher values in the Apennines of the Ce/Ce* ratio (Table 2), which is a parameter indicative of the degree of detrital influence in a basin, suggest higher detrital influence than in the sediments from the Betic Cordilleras. The same conclusion is suggested by the fact that the Ce anomaly is absent (Table 2) in several stratigraphic levels studied in the Apennines (cf. Courtois and Hoffert, 1979). These data agree with the values of the detrital index (Böstrom *et al.*, 1969) (D in Table 2), which are invariably higher in the Apennines than in the Betic Cordilleras. The presence of samples with positive Eu anomalies (Cullers *et al.*, 1975), together with others presenting varying degrees of negative anomaly (Eu/Sm ratio in Table 2) seems to imply that the Eu anomaly originated in the source area rocks and that it was modified during the sedimentary processes in which sediments with heterogeneous Eu anomaly sizes were mixed.

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