Geochemistry and Sr-isotopic geochemistry of the F/F boundary Coumiac section (France): inferences for sea-level variations

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The Late Devonian, in particular the Frasnian-Famennian (F/F) boundary, records one of the five largest mass extinctions in the fossil record. The debate about its causes has recently been reopened by the discovery of microtektite-like glass spherules in Belgian sections (Claeys and Casier, 1994).

To better constrain the mechanisms of this extinction event and its relations to changes in the marine environment, we have undertaken a detailed geochemical study of the F/F boundary stratotype Coumiac section (Montagne Noire). This section displays 35 m of a continuous, condensed series from early Frasnian to early Famennian (about 10 Myr). The depositional setting is a distal carbonate ramp characterized by hemipelagic sedimentation located under or close to the storm wave base. The upper part of the series contains two well-known dark euxinic levels: the Lower and Upper Kellwasser horizons. The upper horizon is located exactly under the F/F boundary (Fig. 1). In both cases, numerous Fe-Mn hardgrounds preceed these horizons. Eustatic variations cannot be recognized on the basis of microfacies analysis due to the deposition depth (> 100 m) and the strong condensation of the series.

51 samples covering the whole section have been analysed for 16 major and trace elements by XRF. Factor analysis has been applied to these geochemical data to clarify the nature of the complex

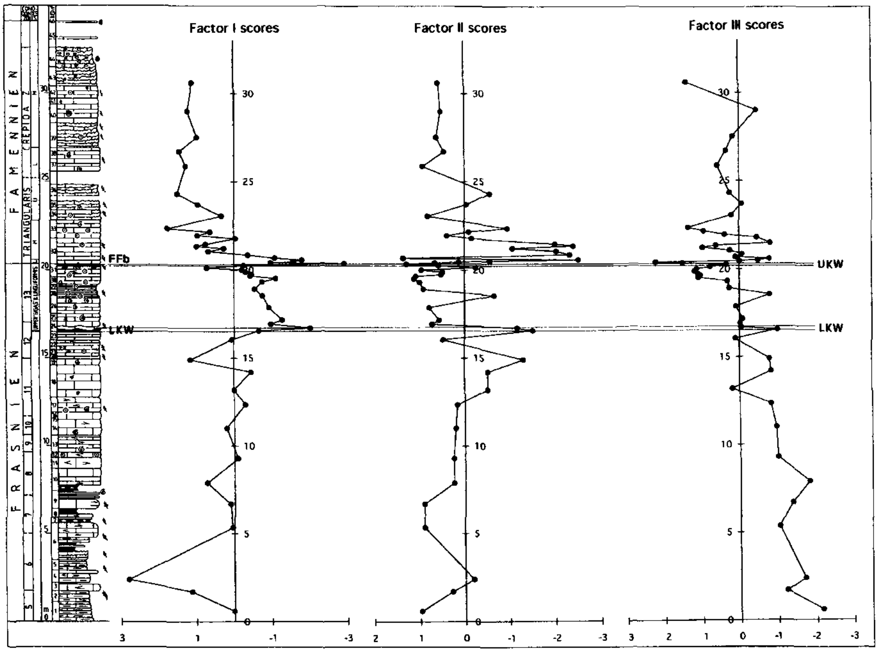

FIG. 1. Coumiac F/F boundary stratotype. Stratigraphic and lithological column and factor scores profile. Oblique R mode factor analysis on 51 samples analysed for 16 elements. UKW: upper Kellwasser; LKW: lower Kellwasser.

relationships between the chemical variables and to identify fundamental sedimentological factors that control the element distribution in these limestones. In an oblique R-mode model, four factors account for 77% of the variance of the initial data.

Factor I is a general factor loaded by all the elements related to the terrigenous phase (in opposition to the major carbonate phase): first Rb-Al-K-Si representative of the clays (mainly illite), then Y-Fe-Zr-Nb-Mn-P bounded or adsorbed. This factor must correspond to the geological control of terrigenous input. The stratigraphic evolution of factor I scores (Fig. 1) closely fits the eustatic curve of Johnson *et al.* (1988) which indicates that this factor is controlled by sea-level variations.

Factor II is bipolar and contains two opposed covariant groups: Mg-Sr *vs* Ba-Pb. The geological meaning of this factor is not yet clear but its scores present two negative peaks (Fig. 1), the first at the Lower Kellewasser level, the second corresponds to the strong regression which follows the F/F boundary.

Factor III contains the covariant group Zn-Fe. The scores of this factor evolve with the colour of the limestones, from grey at the base to red in Famennian. The two Kellwasser present small negative peaks (Fig. 1). This implies that this factor is a measure of the oxygenation of the depositional environment (Eh).

Factor IV is loaded by Ni-Pb-Mn. This statistically weak factor is moderately correlated with Factor I and reflects Mn deposition (bacterial activity?) during the important phases of eustatic rise when terrigeneous input is greatly reduced.

Sr isotopic compositions have been measured on 31 whole-rock samples. Most of the initial $^{87}Sr/^{86}Sr$ values (at 367 Ma), vary around 0.70851 (σ = 0.00017, n = 24). This corresponds to published seawater values at that time, except for several samples just above the F/F boundary, which have distinctly higher values between 0.7091 and 0.7094. These more radiogenic values could reflect increased erosion during the strong regression which follows the F/F boundary.

These results demonstrate that geochemistry is a powerful tool to register and document sea-level variations. As also reflected by C isotope variations (Joachimski and Buggisch, 1993), the two transgressive-regressive cycles characteristic of the Upper Frasnian clearly appear in the stratigraphic evolution of our four identified geological factors. Our study accurately documents the timing and importance of short-term T-R cycles in the Coumiac section as well as their strong influence on all other fundamental sedimentological parameters. This supports the hypothesis of Joachimski and Buggisch (1993) that the repeated co-occurrences of sea-level fluctuations, anoxia and climatic changes could account for the F/F boundary mass extinction rather than a bolide impact.

This is a contribution to IGCP Project 386.

References

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