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Geochemical, magnetic susceptibility, and carbon isotopic records across the Frasnian–Famennian boundary at Fuhe, China

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The Late Devonian Frasnian–Famennian (F–F) Event is one of the five most severe biotic crises in Earth history, recording a significant step-wise decline in marine biodiversity. In many basins worldwide the F–F event is recognized by two of organic carbon-rich black shale intervals referred to as the Lower and Upper Kellwasser Events (LKE & UKE). These units commonly record several geochemical anomalies, including positive $\delta^{13}C$ excursions and accumulation of redox-sensitive trace-metals implying deposition under low oxygen conditions.

We report here the results of $\delta^{13}C$ (C_{carb} and C_{org}) analyses coupled with determinations of major and trace element geochemistry, total organic carbon (TOC) and magnetic susceptibility (MS) for an F–F boundary section in Fuhe, (south central China) that provides insight into this event. A team from IGCP 580 evaluated this section, and a short interval near the top of the section was sampled at 10 cm intervals to document geochemical and MS variations at high resolution across the UKE. Various elemental proxies for oceanographic and biotic processes were measured by wavelength dispersive X-ray fluorescence spectroscopy at the Advanced Instrumentation Laboratory, University of Alaska Fairbanks. MS measurements were conducted at the University of Liege. Proxies for paleo-redox conditions (Mo, V, U), primary productivity (Ba, Cu, Ni, P, TOC), and detrital input (Al, Si, K, Ti, Zr) were measured from carbonate facies at Fuhe and compared with MS and $\delta^{13}C$ records to better understand the F–F event in south China.

The Fuhe section was located within the offshore, spindle-shaped Yangshuo basin that was surrounded by shallow-water carbonate platforms and appears to have been isolated from significant continental siliciclastic influx (CHEN et al., 2005). The mean MS value for the upper Fuhe section is $2.80.10^{-8}$ m³/kg, with a maximum value of $5.46.10^{-8}$ near the base of the section and a minimum value of $8.69.10^{-9}$ less than a meter below the F–F boundary. In the interval below the F–F boundary, facies alternate between autochthonous mudstones and allochthonous calciturbidites. Above the F–F, autochthonous mudstone facies dominate once again and MS values increase sharply from the minimum up to $3.71.10^{-8}$ near the top of the section. Elemental proxies for detrital input largely follow the trend in MS with higher values near the base of the section, a broad low interval spanning the F–F boundary interval and higher values above, implying that MS is largely controlled by detrital input.

Our $\delta^{13}C$ data largely reproduces results originally reported by CHEN et al. (2005) but with higher resolution. The UKE at Fuhe, as is common around the world, is characterized by a significant positive carbon isotope excursion (CIE) in both $\delta^{13}C_{carb}$ (3.8 ‰) and $\delta^{13}C_{org}$ (3.3 ‰). The CIE progresses in several steps with minor negative excursions during the dominantly positive trend. The $\delta^{13}C_{carb}$ maximum occurs about one meter higher in the section than the $\delta^{13}C_{org}$ maximum.

Unlike other localities around the world, values for TOC and elemental proxies for paleoredox conditions do not display appreciable enrichments at the level of the UKE at Fuhe. TOC is generally less than 0.25 wt.% with a minor enrichment, up to 0.32 wt.%, associated with the positive CIE. The U and Mo paleoredox proxies show no clear trend as most values fall below analytical detection limits (~1 ppm). Only V displays appreciable enrichment with a very narrow peak with a maximum value of

18 ppm associated with the positive CIE. This implies that there was likely a very short interval of suboxic conditions associated with the UKE but that oxic conditions prevailed over most of the time recorded by the section. Bioproductivity proxies Ba, Ni, and P record minor enrichments associated with the positive CIE but Cu does not.

The record of the UKE in south China, with very low TOC and detrital input and lack of evidence for anoxia, differs from many of the other records worldwide. Several studies at other localities have pointed toward increased rates of biological productivity fostered by the influx of weathering products associated with the expansion of terrestrial flora as a potential driver for the F–F event. The geochemical (detrital and redox proxies), TOC, and MS records from the Fuhe section imply that such processes may not have been active in south China or that the Yangshuo basin was effectively isolated from the effects of ongoing terrestrial processes.

References

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