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The Late Devonian biotic crisis: Impact theory revived?

McGhee, G.R. 1996. *The Late Devonian Mass Extinction. The Frasnian–Famennian Crisis*. 303 p. Columbia University Press, New York.

Wang, K., Geldsetzer, H.H.J., Goodfellow, W.D., & Krouse, H.R. 1996. Carbon and sulfur isotope anomalies across the Frasnian–Famennian extinction boundary, Alberta, Canada. — *Geology* 24, 187–191, 5 text-figs.

Great attention has been devoted to the mid-Late Devonian (Frasnian–Famennian; F-F) global event due to its connection with one of the major biotic crises in the Phanerozoic; the turnover is recorded as a loss of three quarters (or more) of all marine species as recently summarized by McGhee (1996) and Walliser (1996). The F-F ecosystem crash stimulated the introduction of the cosmic accident theory by McLaren (1970) as the prime cause of mass extinctions. The application of the giant impact theory as a credible explanation for the F-F boundary extinction was consequently developed by a group of Canadian geologists with an acme in the paper by Wang *et al.* (1996). Their detailed isotopic data are an important contribution, especially those derived from the stratigraphically extended successions in western Canada. A negative shift in the broad $\delta^{13}C$ excursion at the F-F passage interval (~1 m.y.) is interpreted as a result of the sudden marine biomass die-off and is strong evidence in support of the impact hypothesis. The data also serve to explain longer-term ocean ecosystem changes attributed to the combined effect of increased temperature and lowered oxygen levels. A protracted ecological crisis scenario was more popular recently (see review in Walliser 1996), as a first order Earth-born alternative to the impact-promoted instantaneous ('bedding-plane') biomass killing event. Wang *et al.* coupled both hypotheses modeling the F-F extinction as 'the consequence of a large bolide impact on a severely stressed, "fragile" ecosystem.'

The controversy around possible causes of the F-F turning point is thoroughly reviewed by McGhee (1996). The results of ongoing research have provided much new data to test the probability of a huge impact as a main ultimate causation of the bio-crisis. As inferred by McGhee, the geochemical data remain elusive and the work of Wang *et al.* (1996) has not supplied a decisive geochemical argument for the extraterrestrial paradigm. For example, a diagenetic artifact cannot be excluded (M. Joachimski, personal communicaton 1996) in the Canadian successions, inasmuch as lighter values of $\delta^{13}C$ correspond to the highest total organic carbon contents at the extinction level (see figs 2–3 in Wang *et al.* 1996). In addition, to support the single impact event model, a crater with a diameter on the order of 140 km or a multiple impact scenario (McGhee 1996) and/or a large diversity reduction in earlier phases of the crisis would be expected for this mass extinction.

The timing and pattern of events in fact are most significant. The concept of instant mass killing has been extensively criticized. A sharp decline in reef fauna coincided with the Late Frasnian Lower Kellwasser Event, a well-known transgressive/anoxic pulse in the Late *Palmatolepis rhenana* Zone, probably initiating the F-F bio-crisis (e.g., Narkiewicz & Hoffman 1989; Walliser 1996). Hence, McGhee (1996) strongly emphasizes the two severest (still stepwise) extinction pulses in the Late *P. rhenana* and *P. linguiformis* Zones, while Wang *et al.* (1996) focused solely on the youngest one referring firmly to the F-F boundary.

However, the biotic succession across the F-F extinction horizon is far from properly documented (Walliser 1996), particularly in impact-sensitive terrestrial domains (e.g., McGhee 1996). Pelagic faunas are the best known and only the conodont and probably goniatite crises are indeed fixed accurately at the F-F boundary. Thus, the end-Frasnian negative $\delta^{13}C$ shift, shown by Wang *et al.* (1996), may eventually prove to be a record of this biomass loss (Narkiewicz & Hoffman 1989).

Benthos extermination is implied to occur across or 'near' this boundary (e.g., among ostracods, Casier *et al.* 1996), but the overall timing is imperfect, mainly due to a common hiatuses in carbonate sequences. According to Copper (1994), susceptible reef ecosystems collapsed 0.5–1 m.y. prior to the accepted extinction boundaries (see also Fig. 2 in Wang *et al.* 1996). Also Bai *et al.* (1994) argued that 'the benthic and pelagic faunas across the F-F boundary are hardly associated with one another,' and that hermatypic corals became extinct distinctly earlier than conodonts. Thus, the F-F boundary killing pulse may correspond entirely to the final destruction of relic reefs, already decimated during the drastic global changes in the latest Frasnian.

McGhee's (1996) book is a fine review of the literature up to 1995, but he obviously favors a multiple impact model as the most viable explanation of the F-F bio-crisis. McGhee stresses with disappointment that the key physical evidence (two microtektite layers) distinctly postdates the critical extinction horizon. In South China, many Ni-silicate spherules scattered in an interval that corresponds to 1.5 m.y. have now been linked to the F-F transition (and other Devonian levels; Bai *et al.* 1994). Walliser (1996) noted that microtektites are found in many horizons lacking any indication of an unusual biotic change. The search is even more frustrating because the only impact in the Devonian, evidenced by shocked quartz, occurred in the early Frasnian of Nevada (*Alamo breccia*; Leroux *et al.* 1995) at least 3 m.y. prior to the F-F boundary.

The discussion pointed out that any explanation of the Late Devonian extinction is still highly conjectural, as indeed reliably shown by McGhee (1996). However, I regard the pulsation-tectonics model and related scenario of major rifting pulse (e.g., Veimarn & Milanovsky 1993), as a more plausible endogenous key to this global puzzle than the variously modified extraterrestrial theory. Walliser (1996, p. 238) ironically declared, 'Because it is even theoretically impossible to prove the non-existence of a non-existing impact, I prefer to presume [...] that a less complicated and a less spectacular solution must not necessarily be wrong'. Nevertheless, bolide strikes seem indeed to have participated in this ecosystem devastation (especially if the data from China are appropriate), but subordinate and perhaps only on a regional scale. This dilemma is recapitulated by Claeys *et al.* (1996): 'The F-F boundary impact differs, perhaps in magnitude or type of bolide, from the K-T boundary event, and appears more similar to the four tektite producing impacts that took place in the Cenozoic.'

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