Carboniferous isotope stratigraphies for the North American and Russian Cratons: Implications for Carboniferous palaeoceanography and glaciation

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We have developed a detailed isotope stratigraphy for the Carboniferous based on analyses of more than 1000 brachiopod shells from the mid-continent region of North America, and from the Russian Platform. Specimens are thin-sectioned and photographed under plain light and cathodoluminescent microscopy. Based on these photographs, about 0.05 mg of nonluminescent (NL) shell calcite is sampled from thin-sections (Grossman *et al.*, 1993). This NL material exhibits good preservation as indicated by (1) preservation of shell microstructure, (2) low to undetectable Si, Al, Fe, and Mn contents, and (3) $\delta^{13}C$ and $\delta^{18}O$ values consistently higher than those of associated cements and matrix. We used a revised compilation for the Carboniferous timescale based on new mid-Carboniferous stage correlations (Manger and Sutherland, 1990), which makes it easier to compare North American and European isotope data sets.

The Carboniferous ^{13}C record for North America is characterized by three isotopic events. The first is a 2.0‰ increase in the Kinderhookian (C1 event; early Tournaisian), from 1.5‰ to 3.5‰, with a brief and perhaps local late-Kinderhookian excursion to 5.4‰. The $\delta^{13}C$ values remain stable at 3.5 to 4‰ during the Osagean-Meramecian (late Tournaisian-early Visean), then decrease to 2 to 2.5‰ (C2 event) during the Meramecian-Chesterian (late Visean). The third event, C3, is a 1 to 2‰ increase in the Morrowan (Serpukhovian-Bashkirian). The $\delta^{13}C$ values then fluctuate between 3 and 4.5‰ up section to the Virgilian (Gzhelian).

Russian Platform samples are sparse for the Tournaisian and early Visean, but other data from western Europe (Bruckschen and Veizer, 1997) show similar $\delta^{13}C$ values and support a Tournaisian increase in ^{13}C (C1 event). Our Russian Platform data clearly show a late Serpukhovian/early Bashkirian ^{13}C increase of 3‰ (from roughly 2.5‰ to 5.5‰), equivalent to the North American C3 event. This 3‰ shift was previously reported by Popp *et al.* (1986), but had not been documented in an isotope stratigraphy for a single region. Because only a 2‰ shift is seen in North American samples for the same time interval, we hypothesize that the ^{13}C shift reflects the combination of (1) changes in ocean circulation associated with the closing of the equatorial seaway between Laurussia and Gondwana (1‰), and (2) increases in the rate of organic matter burial (2‰; Popp *et al.*, 1986). This 2‰ $\delta^{13}C$ shift should be useful for global stratigraphic correlation. The timing of the $\delta^{13}C$ divergence between North America and Europe suggests that the isolation of Palaeotethys began in the Serpukhovian.

Major ^{18}O events recorded in North American samples generally correlate with ^{13}C events. There is a 3‰ increase during the Kinderhookian-Osagean (Tournaisian; C1 event) followed by a 3‰ decrease during the Meramecian-early Chesterian (Visean; C2 event); a 2‰ increase in the Morrowan (Serpukhovian-Bashkirian; C3 event); then values fluctuating between 1.5 and 2.5‰ up section to the Virgilian (Gzhelian). Comparison with the western European data of Bruckschen and Veizer (1997) is difficult because their early Carboniferous $\delta^{18}O$ values typically average at least 2‰ lower than our North American and Russian data. However, limited data for NL shell from the Russian Platform (this study) and Great Britain (Popp *et al.*, 1986) suggest low $\delta^{18}O$ values for the Tournaisian and higher values for the middle early Visean. If the 3‰ ^{18}O increase (C1) occurring from 352 to 342 Ma

(Tournaisian) represents a global event, then this is compelling evidence for Carboniferous low-latitude cooling and glaciation much earlier than previously thought. Additional ^{18}O shifts suggest Visean warming (C2) and Serpukhovian cooling (C3). The latter is consistent with the record of glacial sediments (Frakes *et al.*, 1992; Dickins, 1996). The general correlation between ^{13}C and ^{18}O events is consistent with the hypothesis that cooling occurred as a result of drawdown of atmospheric CO_2.

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