High-resolution $\delta^{13}C$ and lithostratigraphic profiles from Copenhagen Canyon, Nevada: clues to the behaviour of ocean carbon during the Late Ordovician global crisis

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A comparison of detailed lithostratigraphic and inorganic carbonate $\delta^{13}C$ profiles from Copenhagen Canyon, Nevada, provides insight into the behaviour of marine carbon during the Late Ordovician global crisis.. A gentle decline in $\delta^{13}C$ values occurs in a chert-bearing carbonate unit of the Hanson Creek Formation at the base of the "K" section (Finney *et al.*, 1997) (Fig. 1). $\delta^{13}C$ values drop sharply in the upper 50 cm of this unit, then stabilize near earlier values in an overlying narrow layer of grainstones. Above this, $\delta^{13}C$ values rapidly increase by over +5‰. The onset and termination of the $\delta^{13}C$ rise coincide almost precisely with a lithologic change that suggests shallower water depths. A gentle fall in $\delta^{13}C$ switched to a rapid fall coincident with the onset of massive carbonate deposition in even shallower water, culminating in an exposure surface near the 190 m level. A brief interval of unstable $\delta^{13}C$ values corresponds to another distinct lithological unit, followed by the resumption of chert deposition and a return to gently falling $\delta^{13}C$ values near the top of the section.

A number of studies have speculated on the role of changing atmospheric pCO_2 as a primary triggering mechanism for Late Ordovician glaciation. The K section results suggest, however, that the role of pCO_2 may have been relatively unimportant. If a reduction in pCO_2 was primarily responsible for triggering the glaciation, and if the reduction was caused by the enhanced sequestration of organic carbon (a reasonable assumption), then the initiation of rising $\delta^{13}C$ values would be expected *before* lithologic evidence of glacioeustatic shallowing rather than coincident with it. Furthermore, if the subsequent reintroduction of sequestered organic carbon evidenced by lowering $\delta^{13}C$ values were responsible for increasing pCO_2 and terminating the glacial epoch, it is logical that an exposure surface presumed to evidence glacioeustatic lowstand would have occurred before marine $\delta^{13}C$ values started their rapid fall from very high values. Instead, the exposure surface at about 190 m occurs well *after* $\delta^{13}C$ started to fall rapidly.

Additional observations point to a change in ocean circulation as a plausible cause for the Late Ordovician glaciation. The negative $\delta^{13}C$ values in the top of the lower chert-bearing unit may be evidence for a brief episode of warm, saline deep-waters, similar to that at the end of the Palaeocene (Kennett and Stott, 1995). An interval where vertical mixing of ocean surface and deep waters were minimal, and where organic carbon was constantly transferred from the shallow open ocean to a nearly static deep ocean carbon reservoir, could have rapidly led to very high $\delta^{13}C$ values in surface environments. The re-development of vertical circulation and/or reintroduction of sequestered organic carbon could have caused a rapid fall in $\delta^{13}C$ without necessarily abating the glacial episode; in fact, renewed circulatory vigor and thermal transfer from shallow to deep environments could well have contributed to a brief period of overall cooling of the surface ocean.

An additional observation promotes an intriguing speculation about the nature of carbon reservoirs during the glacial interval. A gentle trend towards lower $\delta^{13}C$ values in both the lower and upper chert-bearing units fall almost precisely along the same overall trend line. If it is assumed that the chert-bearing units preserve $\delta^{13}C$ values controlled by long-term evolution of the marine carbon reservoir, then it can be concluded that the sharp rise in $\delta^{13}C$ values represents an oceanographic event that left no permanent imprint on the long-term isotopic

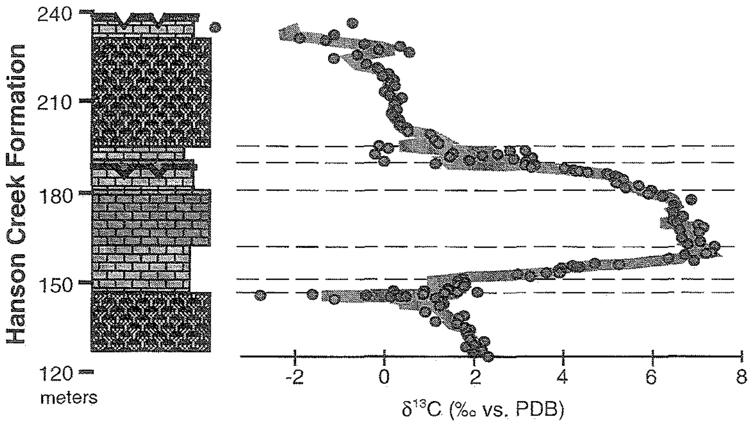

FIG. 1. $\delta^{13}C$ profile and generalized lithostratigraphy from the K section.

behaviour of marine carbon. This suggests that the development, isolation, and destruction of a labile, low-$\delta^{13}C$ carbon reservoir may have been responsible for the rapid rise and fall in $\delta^{13}C$ values. Possible reservoirs include a trapped deep ocean incapable of vertical mixing, or a metastable sedimentary component that was quickly dissipated after the collapse of environmental conditions favourable to its stability.

References

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