Graphite and its isotopic composition as a biomarker in highly metamorphosed Early Archean rocks

M. VAN ZUILEN[1], A. LEPLAND[2] AND G. ARRHENIUS[1]

[1]University of California, San Diego, La Jolla CA 92093-0236, (mvanzuil@ucsd.edu), (arrhenius@ucsd.edu)
[2]Geological Survey of Norway, Leiv Eirikssonsvei 39;7491 Trondheim, Norway, (aivo.lepland@ngu.no)

The principal method for studying the earliest traces of life in the metamorphosed, oldest (>3.5 Ga) terrestrial rocks involves determination of isotopic composition of carbon, mainly prevailing as graphite. However, our results on rocks from the 3.8 Ga Isua supracrustal belt point to several complications using graphite as a biomarker and highlight the need for reassessment of some earlier biologic interpretations made on Isua rocks.

It is shown by stepped-combustion-mass spectroscopy experiments that the results obtained by single-step combustion techniques (sealed tube combustion, elemental analyser flash combustion) can be unreliable. The light isotope values in graphite deficient samples can in part or in total be derived from recent contamination. Furthermore, N, O and H found in carbonaceous material, which would point to a biogenic origin, are often related to recent contamination as well.

Several abiogenic processes can form graphite during metamorphism. Theoretical and experimental studies have shown that kinetic isotope fractionation associated with graphite-producing reactions may form graphite with a light ‘biogenic’ isotope signature. Kinetic effects may explain isotopically light graphite in some Isua rocks.

The potential of graphite as a biomarker has to be considered in geologic context involving reliable protolith interpretation and control of secondary metasomatic processes. Graphite in non-sedimentary rocks, regardless of its isotopic composition, has no biological significance. The original biologic interpretations in Isua rocks were made on carbonate rich deposits, but the recent recognition of these as metasomatic formations disqualifies them for providing information about life 3.8 Ga ago.

Isotopic constraints on the origin of Heinrich event precursors

D. VANCE AND C.ARCHER

Department of Geology, Royal Holloway, University of London, Egham, Surrey TW20 OEX, UK (d.vance@gl.rhul.ac.uk, c.archer@gl.rhul.ac.uk)

The origin of Heinrich events and the associated higher frequency 1-2kyr climate cyclicity are still not fully understood (Broecker and Hemming 2001). It has been clear for some time that the main phase of Heinrich events is characterised by the collapse of the Laurentide ice-sheet. However, the realisation that the 1-2 kyr cyclicity continues into the Holocene (Bond et al. 1997), in combination with Sr-Nd isotopic constraints on the variety of sources for Heinrich layer IRD, has led to the recognition that other ice-sheets must be involved. Information on the early stages of Heinrich events is obviously crucial to understanding their trigger and, perhaps, the ultimate mechanism for millenial climate change. Recently, Grousset et al. (2001) have suggested, on the basis of Sr-Nd isotopic data that, for H1 and H2, the collapse of the European ice-sheets occurred first and that only then was the collapse of the Laurentide sheet triggered. Here we present high resolution (1-200 yrs) Sr-Nd-Pb isotope data for bulk sediments from Heinrich events 2 and 4 at DSDP Hole 609 to test whether such a conclusion extends to other Heinrich events in other geographic locations.

Background glacial sediment at site 609 represents a mixture between three sources – North America, Iceland and Europe. The data for H4 at site 609 suggests that the source of the coarse fraction of the sediment immediately prior to H4 is the same, isotopically, as background glacial sediment. The first increases in IRD at the start of H4 correspond with a dramatic shift towards the North American source. For the early stages of H2, the data plot in the same region in Sr-Nd isotopic space as the Grousset et al. data for the same time period and also appear to suggest a European contribution. However, correlations between Sr and Pb isotopes reveal this to be impossible - indeed the early part of H2 contains about the same absolute amount of the European-derived end-member as background glacial sediments. The dramatic change at the start of H2 at site 609 is the dominance of Iceland– with up to 90% of the IRD being derived from this source. The dramatic increase in the Icelandic component early in H2 is consistent with the data of Bond et al. (1999) and suggests derivation of early H2 material from an area north of Iceland that is not, ultimately, the Fennoscandian ice-sheet.

Bond G. et al., (1997), *Science* **278**, 1257-1265.
Bond G. et al., (1999), *Geophys. Monogr. Ser.* **112**, 35-58.
Broecker W.S. and Hemming S., (2001) *Science* **294**, 2308-2309.
Grousset F. et al., (2001), *Paleoceanography* **16**, 240-259.