Tracing the source of IRD in the Heinrich Layers of the North Atlantic

B. DAVID A. NAAFS[1,2]*, JENS HEFTER[1], SHUNXIN ZHANG[3] AND RUEDIGER STEIN[1]

[1]Alfred Wegener Institute for Polar and Marine Research, (*correspondence: david.naafs@awi.de) D-27568 Bremerhaven, Germany
[2]Leibniz Center for Earth Surface and Climate Studies, Potsdam University, D-14476 Potsdam, Germany
[3]Nunavut Geosciences Office, NU X0A 0H0 Iqaluit, Canada

Heinrich Events (HEs) are among the most dramatic examples of millennial-scale climate variability. During HEs large amounts of ice-rafted debris (IRD) derived from glacial erosion of continental bedrock accumulated in the sediment of the North Atlantic, forming Heinrich Layers (HLs) [1]. One of the key issues in understanding the still poorly understood mechanisms behind HEs is the development of specific provenance indicators that provide information about the source areas of the IRD [2]. Here we present an organic geochemical study on the type, distribution and relative abundance of biomarker compounds of extractable organic matter from the different HLs of the last glacial at multiple locations in the North Atlantic.

The results demonstrate that an unique assemblage of organic 'petrogenic' compounds such as (benzo)hopanes, mono- and triaromatic steroids, and palaerenieratene and isorenieratene-derivatives characterize the HLs in the North Atlantic. The presence of aromatic counterparts and dominance of mature isomers in the hopanoids and steroids indicates that the biomarker distribution within HLs is incompatible with recent sediments [3]. Rather, these compounds derive from the transportation of ancient organic matter by icebergs because of glacial erosion of bedrock in the Hudson Bay Area. Comparison of the biomarker assemblage of HLs with available geologic and organic-geochemical data allowed narrowing down the assumed source of IRD to a sequence of Upper Ordovician oil shales and limestones outcropping in and close to the Hudson Strait, which have a strikingly similar biomarker signature to that of HLs. Monitoring the presence of these petrogenic compounds in marine sediments thus allows to distinguish organic matter in HLs from adjacent samples and can be used as specific organic-geochemical tracers for the input of continental material from the Hudson Bay Area in northern Canada.

[1] Heinrich (1988). *Quaternary Research* **29**, 142.
[2] Hemming (2004). *Review of Geophysics* **42**, RG1005.
[3] Rashid & Grosjean (2006) *Paleoceanography* **21**, PA3014

The nature of fluid flow through vertical formations in the aureole of the EJB pluton, White Mountains, California

P.I. NABELEK[1]* AND S.S. MORGAN[2]

[1]Dept. of Geological Sciences, Univ. of Missouri, Columbia, MO 65211, USA (nabelekp@missouri.edu)
[2]Dept. of Geology and Meteorology, Central Michigan University, Mt. Pleasant, MI 48859, USA (morga1ss@cmich.edu)

Petrology and stable isotope compositions of metamorphic rocks in the aureole of the Eureka Valley-Joshua Flat-Beer Creek (EJB) composite pluton, White Mountains, eastern California, were examined to determine nature of fluid flow in the aureole. The White Mountains were an arc terrain in the Jurassic and Cretaceous periods. The metamorphosed sedimentary rocks in the aureole are distinguished by having vertical orientations due to rotation and stretching resulting from forceful emplacement of magma. The sedimentary formations include Cambrian marbles, calc-silicates, schists, and quartzites. Each lithology behaved differently during contact metamorphism. Clean dolomite and calcite marbles did not equilibrate with an external fluid as revealed by unshifted $\delta^{18}O$ and $\delta^{13}C$ values of 20 to 25‰ and –1 to +2‰, respectively. Largest isotopic shifts occurred in calc-silicates where $\delta^{18}O$ decreased to ~15‰. The moderate $\delta^{18}O$ shift suggests that the calc-silicates equilibrated with an aqueous fluid whose oxygen isotope ratio was buffered by surrounding silicate metamorphic rocks. Infiltration of calc-silicates in the inner aureole by an aqueous fluid is also demonstrated by the presence of grossular garnet and vesuvianite.

Variation in mineralogy of schists reflects the variation in the Al/K ratio. Schists with higher ratios have andalusite whereas schists with lower ratios have K-feldspar. On the western side of the pluton, partial melting of inner aureole schists was driven by focused flow of aqueous fluids between the pluton and marbles. *P-T* pseudosections for the schists suggest that partial melting has occurred between 2.5 and 3 kbar and >660°C, and they predict a narrow subsolidus cordierite field. However, cordierite, feldspars, and other silicate minerals were altered by late pervasive fluid flow through the schists below 500°C. This fluid flow was probably driven by slow cooling of the large EJB pluton and/or continued magmatism in the arc terrain.

Overall, the data from the EJB aureole point to highly localized heterogenous flow in vertical calc-silicates and marbles, and pervasive and protracted flow through schists.