The Biomarker Inventory, Trace, and Source of Heinrich Events and Heinrich-type layers (MIS 8-16) in the North Atlantic

I: THE BIOMARKER INVENTORY
Example: HL4 (Site U1305)

II: THE BIOMARKER TRACE OF HEINRICH EVENTS - Proximal Site U1305
Bulk & physical characteristics

III: THE BIOMARKER SOURCE Implications from Heinrich Events

POTENTIAL SOURCE ROCKS: ORDOVICIAN OIL SHALES

CORRELATION OF SOURCE ROCKS AND HEINRICH SAMPLES

IV: DISTAL AND LONG TERM (MIS 8-16) RECORDS OF HEINRICH-TYPE EVENTS

Site U1308

BIOMARKER DISTRIBUTION OF THE BOAS OIL SHALE (PROPOSED SOURCE ROCK)

Site U1313

Figure 1: Locations of drilling sites from IODP-Expeditions 303 (circles) and 306 (squares). Sites investigated for this study are marked red. Arrows indicate major (isobazal) sources. The grey-shaded area schematically outlines the extent of the North Atlantic influenced by Heinrich events.

Figure 3: Left: Bulk geochemical and physical properties of the analyzed U1305 section. Colored data points are from this study. Black data points obtained from http://dbp.tamsu.edu/database. L* = lightness, TOC = total organic carbon, ON = TOC*total nitrogen, MS = magnetic susceptibility. The peak at ~+13.35 in the L* MS and density record is due to the presence of a large gravel.

Right: Selectively of investigated compounds and compound classes to trace the occurrence of Heinrich events.

Figure 2: GC/TOF-MS distribution of typical organic compounds from Heinrich layer 4 (3105C-2H4, 60-62 cm, 11.73 mcd). (A) - (F) = ion chromatography for indicated masses (m/z), characteristics for the compounds shown. Molecular structures and fragmentation pathways leading to distinct ions are also given.

(A) Trimethyl-ethyl-ethylisopropylbenzene: C24 = C18 = carbon atom numbers.
(B) Triacetin and (C) ring-C monomeric acid distribution. SFR on peak annotations refers to stereo-chemical configuration of carbon atom number 20.
(E) D-ring monomeric 8,14-acecoxy-acetone distribution.
(F) n-Alkanes and aliphatic diols. Numbers = carbon atom numbers.

Figure 4: Principal Ordovician oil shale - source rock localities of the central and eastern Canadian mainland.

Figure 7: Biomarker record of Heinrich Event 1, 2, 4, 5 and occurrence of Heinrich-type layers during glacial stages MIS 8 - 16 at Site U1308. Blue lines indicate distal carbonate layers based on peaks in XRF Ca/Si-ratios (D. Heslop, pers. com.)

Figure 5: Cross sections of palynostratigraphic zones of site U1308. Dashed lines indicate inferred limits of the Heinrich layers.

Figure 8: Biomarker record of Heinrich Events 1, 2, 4, 5 and occurrence of Heinrich-type layers during glacial stages MIS 8 - 16 at Site U1313. Blue lines indicate peaks in magnetic susceptibility.

Figure 6: Selected ion chromatograms for indicated masses showing the distribution of selected compound groups from a rock sample of the Boas oil shale. Notice the strong correlation to compounds observed within Heinrich Layer (Fig. 2).