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Atmospheric and Oceanographic Circulation Changes in the Northeast Pacific Concurrent with Heinrich Events: Evidence from Trace Metals and Heavy Minerals

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During ODP Leg 167 in the California Current system at Site 1017 E a complete record of the last 25 ka has been recovered. This site was of special interest with regard to the investigation of the high resolution climatic history in an open marine setting that could be compared to the results of the restricted Cariaco and Santa Barbara basins. The trace element composition of 105 samples and the heavy mineral fraction assemblages of 40 samples have been investigated to elucidate changes in the current intensity of the California Current and the weathering patterns influencing the terrestrial mineral loads deposited at this site. In this presentation only the concentrations of the element zirconium and the association of detrital heavy minerals, which have been quantified using the Rietveld method, are discussed. The investigation of the total mineral assemblage and a comparison of the calculated content of zirconium in the quantified zircon has shown that at least 90% of the zirconium is located within the mineral zircon. The Holocene is characterised throughout by low zirconium concentrations (140-170 ppm), the Younger Dryas by elevated values up to 430 ppm, the Boelling/Alleroed warm period again has low concentrations (101-177 ppm), and the last glacial is characterized by an elevated basal concentration with short spikes up to 1500 ppm. The timing of the zirconium-maxima coincides with the Heinrich events 1 and 2, intermittent maxima could be correlated to the smaller events a to c of Bond & Lotti (1995). The heavy mineral assemblage during the Holocene and the Boelling/Alleroed is characterized by a high percentage of the less weathering stable minerals tremolite and titanite, whereas the Younger Dryas and the high zirconium samples from the last glacial exhibit elevated contents of the more stable epidote and zircon. In general possible explanations for the enrichment in zircon and hence zirconium are 1) dilution by variable fluxes of other sediment phases, 2) variations in the marine or fluvial transport processes, 3) different source areas, or 4) changes in the weathering intensity in the source area. Explanation 1) is ruled out by elevated zircon contents in regard to the total sediment as well as the heavy mineral assemblage. Explanation 3) is unlikely because of the approximately constant detrital clay mineral assemblage throughout the last 25 ka and the nowadays well constrained riverine loads in the vicinity of Point Conception with the Santa Ynez river dominating. Changes in the current intensity of the California current are likely as the grain size is elevated in most of the zircon-rich layers. But this alone does not explain the increase of more weathering stable heavy minerals as there is no sorting regarding the density observed. As additional explanation the following scenario is envisaged: In contrast to the nowadays very short downstream part of the Santa Ynez river system which is flushed free of sediments in every season during the lowered sea level there was additional accommodation space on the exposed shelf available. As proposed by Einsele (1991) the downstream part of mountainous rivers may change with falling sea-level from meandering to braided river systems which would allow the temporary deposition of eroded material. After prolonged weathering this more mature heavy minerals containing sediment could be reworked during periods of changed atmospheric circulation and intense precipitation (as proposed by climate models for the last glacial in central California) and transported to Site 1017 E. Therefore the elevated zirconium and zircon contents of sediments coinciding with times of reorganisation in the North Atlantic region are interpreted as results of short term oceanographic and atmospheric changes in the California Current and the hinterland.

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