# Glassy foram stable isotope records of Eocene-Oligocene climate change from two latitudinal extremes: The high north Atlantic and the Indo-Pacific warm Pool

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The quality of foraminiferal calcite preservation plays a crucial role in our ability to produce accurate palaeoclimate reconstructions. This is especially true for reconstructions of Palaeogene surface ocean properties because planktonic foraminifera proxy tools that are used as tracers are highly susceptible to post burial diagenetic alteration under the influence of subsurface and pore waters that overprint a cool, deep water temperature signal on planktonic foraminiferal $\delta^{18}O$. This has set the challenge to seek exceptionally well-preserved "glassy" microfossil material preserved in impermeable hemipelagic clay sequences, which is thought to preserve unaltered isotopic compositions. Here we present new geochemical records of Eocene-Oligocene (E-O) climate change based on glassy planktonic and benthic foraminifera from two climatically extreme regions of the Earth; 1) the high North Atlantic (ODP Site 647) and 2) the Indo-Pacific warm pool (Central Java, Nanggulan Bore Hole). These regions are currently under sampled for E-O time. The Site 647 E-O section comprises small but exceptionally well-preserved foraminifera preserved in a sequence of hemipelagic clay south of Greenland (palaeolatitude ~54°N). It remains the northernmost carbonate-bearing sequence known. Available core material suggests that the E-O interval is complete at this site. The sequence recovered in the new Indonesian Nanggulan bore hole records deposition in a shallow low latitude margin setting (200 – 300 m depth, palaeolatitude ~2°N) in one of the warmest regions of the Earth. Isotope records derived from the typically tropical Nanggulan assemblages were measured on whole unfilled specimens, supplemented with samples based on isolated shell fragments where infilling occurred. Our new $\delta^{18}O$ data record the large (> 1.0 ‰) positive shift in foraminiferal $\delta^{18}O$ at both sites that is the signature of E-O glacial expansion. Consistent with previous E-O stable isotope studies using glassy foraminifera from Tanzania and the US Gulf Coast, our planktonic records show lower $\delta^{18}O$ than similar records based on deep sea ooze material, i.e. approximately - 4 ‰ and - 3 ‰ in the Eocene and early Oligocene respectively for Java and - 2 ‰ increasing to ~ -1 ‰ in the Oligocene at Site 647. These results suggest late Eocene sea surface temperatures of ca. 34°C in Java, compared to 28°C today, and 25°C in the southern Labrador Sea, compared to 8°C modern. Our data provide rare insight into ocean and climate responses to E-O climate change in high northern latitudes, as well as new constraints on E-O latitudinal thermal gradients.