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Diatoms and trace metals in the Southern Ocean: the interconnection between nutrient availability, utilisation and efficiency of the biological pump

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The Southern Ocean controlled climate through the last glacial-interglacial cycle by drawing down carbon dioxide from the atmosphere into the deep ocean via the "biological pump". The efficiency of this process is controlled by the interplay of the availability of macronutrients (nitrate, phosphate, silicic acid) and trace metal micronutrients (manganese, iron, cobalt, nickel, copper, zinc, and cadmium). Past climate records are typically based on the former but are not ideally suited to the High Nutrient (e.g. macronutrient), Low Chlorophyll Southern Ocean where primary production is restricted by the limited supply of micronutrients, especially leading up to and during warm periods. Therefore, sedimentary records that utilise trace metal micronutrient tracers are needed to more reliably reconstruct the efficiency of the biological pump and its regulatory role in drawing down atmospheric CO_2 in order to improve future climate projections. In the high-latitude Southern Ocean, siliceous diatoms dominate primary producer communities and therefore dominate biogenic sediment, providing a valuable archive for reconstructing Southern Ocean biogeochemistry. We present diatom-based reconstructions of micronutrient availability and demand as well as ocean circulation over the last 190 kyrs at site TAN1302-96, just South of the present-day Polar Front at the intersection of the Pacific and Indian sectors of the Southern Ocean. Our approach is based on a combination of micronutrient concentrations, selected trace metal isotope systems and macronutrient proxies. These novel records provide an improved understanding of how trace metal micronutrients regulate marine primary productivity, the efficiency of the biological pump and in turn atmospheric CO_2 levels during glacial-interglacial cycles.