Transfer of nutrients and carbon from the Southern Ocean to the Atlantic during the last deglaciation

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The interconnection of ocean circulation and nutrient cycling appears to be closely linked to atmospheric carbon dioxide and global temperature. In this abstract we make use of a novel proxy for silicic acid concentration, $d^{30}Si$ in deep-sea sponge spicules, together with new and published ^{14}C records to examine carbon and nutrient cycling in the deep Southern Ocean. We then link this cycling to intermediate and deep locations in the western basin of the Atlantic during the abrupt climate events of the last deglaciation to investigate how circulation, nutrients and CO_2 are coupled.

We have documented little difference between the silicic acid concentration of the deep Southern Ocean at the last glacial maximum compared to the modern. By contrast, it appears that circumpolar deep waters were significantly depleted in radiocarbon during the glacial period, indicative of a build up of carbon. Within the Southern Ocean itself we observe a break down of deep-water stratification during the deglaciation, at around the time of the Bolling Allerod.

Ocean circulation and nutrient cycling in the Atlantic during the three most recent Heinrich events, H2, H1 and the Younger Dryas appear to share certain characteristics, but the CO_2 response is not the same in each case. For example meridional circulation from sedimentary Pa/Th ratios appears to have been somewhat similar during H2 and H1. At the same time there is evidence for northward export of Si and low $^{14}C/^{12}C$ waters into the Atlantic. However in one case atmospheric CO_2 increased markedly, and in the other it did not. During the Younger Dryas when CO_2 was increasing, Pa/Th indicates only a partial reduction in advection but silicic acid and Cd/Ca indicate export of virtually unadulterated circumpolar deep waters throughout the intermediate depths of the Atlantic. Concurrently $^{14}C/^{12}C$ ratios at deep and intermediate depths in the North Atlantic were somewhat depleted, consistent with carbon-rich southern-source waters escaping from the Southern Ocean. We will use these similarities and differences to link our knowledge of the circulation of the ocean to atmospheric carbon records.

Deep subduction of crustal minerals in the mantle: Evidence from ophiolites

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Crustal minerals, including zircon, corundum, feldspar, almandine garnet, kyanite, sillimanite and rutile, associated with ultrahigh pressure minerals, such as coesite, diamond, kyanite, and moissanite have been recovered in varying proportions from podiform chromitites of the Luobusa and Donqiao ophiolites of Tibet and the Semail ophiolite of Oman. The UHP minerals, and some of the crustal minerals, have been found in situ; the other grains have been recovered from mineral separates. Zircon is common in all three ophiolites and occurs as rounded to subangular grains, about 50-300 microns across, typically with very complex internal textures. A few euhedral prisms have regular oscillatory zoning indicative of a magmatic origin. $^{206}Pb/^{208}U$ SIMS dates for the Luobusa zircons range from 549±19 to 1657±48 Ma, whereas those from Donqiao have ages of 484±49 to 2515± Ma, all much older than the ophiolites. Sixteen dates on zircons from the Semail ophiolite range in age from 84±4 to 1386±48 Ma. Most zircons from Oman are older than the ophiolite but 3 grains are essentially the same age as the ophiolite (92±4 to 99±5 Ma. These are euhedral prisms with oscillatory zoning. The zircons typically contain a variety of low-pressure inclusions, including quartz, rutile, orthoclase, mica, ilmenite and apatite. In addition, all of the zircons from the three ophiolites have REE and trace element compositions compatible with a crustal origin. The assemblage of crustal minerals, combined with the morphology and age of the zircon, strongly suggest derivation from crustal sediments subducted into the mantle, where they were mixed with UHP and highly reduced phases. The preservation of these minerals can be explained by their occurrence as inclusions in chromite grains.