Superdeep carbonate melts in the Earth

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Carbonate melts although rarely seen at the surface, may control some chemical and physical properties in the Earth's interior and may be highly mobile compared with conventionally slow mantle processes. New predicted carbonate mineral stabilities (Ca, Mg, Ba, Sr carbonates) extend their potential range and variety to encompass the entire mantle, including the core mantle boundary [1]. Melting and resupply of primary deep carbonate reservoirs is not well understood, but critically depends on their mobility. New calculations have been performed, to determine whether the remarkably low viscosity of carbonate melts, observed at shallow upper mantle pressures [2], persists through the lower mantle to core pressures. We conjecture that mass flow of even very small volumes of carbonate melt, is expected to be orders of magnitude faster than mantle convection, or mantle plumes. Deep carbonate melts could be effectively decoupled from geodynamic mantle models, in contradiction with recent models for minor grain boundary flow of carbon [3]. Detailed dynamic models should explore their potential for explaining, for example, their exceptionally high electrical conductivity [4]. If carbonate melts escape from the core mantle boundary, their high heat capacity also suggest they may provide a pathway for heat removal, and they could operate very differently from mantle plumes. Another important feature of carbonate melts is their exceptionally high solubility for water [5] greatly exceeding values for silicate melts under similar conditions. These features are self consistent with observations that ephemeral carbonate melts can leave a distinctive geochemical signature, as sometimes preserved in upper mantle diamond [6] and associated with hydrous fluids [7]. We should perhaps add superdeep carbonate melts to existing models for carbonatite petrogenesis.

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Neodymium isotope ratios of seawater along the South African margin

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The Nd isotope composition of seawater is an important tracer to study both modern and ancient ocean circulation because it fingerprints water masses as isotopically distinct entities. But its usefulness as a paleoceanographic tool depends on understanding the processes that affect it during transport. For example, a major open question is the degree that Nd isotopes behave like a conservative tracer of water mass mixing, in competition with potential overprinting by isotopic exchange near the ocean margins.

To assess the roles of water mass mixing and boundary exchange near southern Africa, we analyzed seawater Nd isotopes from three depth profiles along the South African margin, from near Durban to near Cape Town. All profiles have similar hydrographic properties, with Agulhas waters, Antarctic Intermediate Water, North Atlantic Deep Water, and Antarctic Bottom Water appearing at increasing depths. The main differences between the profiles are increased influence of Red Sea Water at intermediate depth for the easternmost profiles and variability in temperature-salinity properties of surface water in each profile.

Nd isotopes are lowest in surface waters (<250m; avg ε_{Nd} = -13.4) and range from -12.3 to -14.6. The cause of this inhomogeneity likely reflects local additions to the surface waters. Nd isotopes of intermediate waters from the two easternmost profiles are identical (ε_{Nd} = -9.1 & -9.0), but slightly lower in the profile near Cape Town (avg ε_{Nd} = -9.6), which may reflect a small degree of interaction with the margin at that depth. In the deep waters (>1500m) all profiles along the margin show identical Nd isotope ratios. All display the "zig-zag" pattern that is characteristic of South Atlantic Nd isotope depth profiles, and are consistent with conservative mixing of endmember water masses.

Southern Africa is a gateway between major oceans, where globably significant water masses from the North Atlantic, Circum-Antarctic and Indian oceans with distinct Nd isotope fingerprints come together. Our results show that margin effects on the Nd isotope ratios for intermediate and deep waters are small to negligible and the "quasi-conservative" behavior of this tracer is confirmed.