

Sediment $^{231}\text{Pa}/^{230}\text{Th}$ as a recorder of the rate of the Atlantic meridional overturning: Insights from a simple 2-D model

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The ratio $^{231}\text{Pa}/^{230}\text{Th}$ measured in marine sediments has been used to reconstruct past changes in the rate of the Atlantic Meridional Overturning circulation (AMOC). These two isotopes are produced uniformly in the water column by decay of dissolved uranium and rapidly removed by adsorption on settling particles. Because ^{231}Pa has a residence equivalent to the residence time of deep water in the Atlantic basin and ^{230}Th is removed more rapidly, the overturning circulation effectively exports ^{231}Pa from the Atlantic into the Southern Ocean, while most of the ^{230}Th remains in Atlantic sediments. As a result, there is a relationship between $^{231}\text{Pa}/^{230}\text{Th}$ in Atlantic sediments and the rate of overturning: faster overturning produces lower sediment $^{231}\text{Pa}/^{230}\text{Th}$, while slower overturning increases this ratio. This principle has been used to explore the role of the AMOC in triggering the abrupt climate changes that punctuated the last deglaciation [1]. This study has implicitly assumed that the sediment $^{231}\text{Pa}/^{230}\text{Th}$ signal integrates the rate of overturning over the entire water column overlying the sediment analyzed, although it was clear that this integration could not be linear. A recent study, based on a 1-D model, has suggested that sediment $^{231}\text{Pa}/^{230}\text{Th}$ may only record overturning occurring in the 1000m of water overlying the analyzed sediment [2] and therefore shallow overturning could not be recorded in deep sediments. We are revisiting this question using a 2-D model to better establish the extent to which the $^{231}\text{Pa}/^{230}\text{Th}$ signal generated by shallow overturning is attenuated in sediments deposited at increasing depth.

[1] McManus *et al.* (2004). [2] Thomas *et al.* (2006).

Phase relationships of carbonate-bearing harzburgite: Implications for migration of carbonate melt and diamond formation in the mantle

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Despite considerable effort, the relationship between diamonds and clinopyroxene-free harzburgites in the Earth's mantle remains enigmatic. A recent study of diamondiferous peridotitic microxenoliths from the Diavik Diamond Mine, NWT, Canada, has documented that harzburgitic hosts of diamonds can be transformed to lherzolite subsequent to the formation of diamonds [1]. In order to constrain the behavior of possible metasomatic agents that could be responsible for this re-enrichment, it is necessary to determine the solidus of depleted harzburgite as well as that of lherzolite.

A commonly proposed metasomatic agent is carbonatitic melt, such as that produced at the solidus of carbonated lherzolite. The solidus of carbonated garnet lherzolite in the $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2\text{-CO}_2$ system has been determined previously [2,3]. Building on this body of work, I determined the solidus of carbonated garnet harzburgite in the $\text{MgO-Al}_2\text{O}_3\text{-SiO}_2\text{-CO}_2$ system. At low pressures, the solidus has a positive P-T slope at high temperature ($>1650^\circ\text{C}$ at 3 GPa). The solidus temperature decreases from 3 GPa to a minimum at 5 GPa and $\sim 1525^\circ\text{C}$. At higher pressures, the solidus resumes a positive P-T slope, increasing in temperature more rapidly than does the solidus for lherzolite in CMAS-CO_2 . The difference in the two solidi increases from $\sim 200^\circ\text{C}$ at 5 GPa to $\sim 300^\circ\text{C}$ at 7 GPa. Interestingly, the minimum in the solidus for garnet harzburgite occurs at pressures above those where magnesite is stabilized in the subsolidus assemblage.

In the diamond stability field, a carbonatitic melt produced from partial melting of a carbonated lherzolite that infiltrates harzburgite would react immediately with orthopyroxene to form clinopyroxene and magnesite at sufficiently high $f\text{O}_2$. At lower $f\text{O}_2$, diamond could precipitate instead of magnesite, consistent with one of the common models for diamond formation. In addition, the composition of the garnet would become more calcic, equilibrating with the newly-formed clinopyroxene.

[1] Creighton *et al.* (2008, in press) *Contrib. Mineral. Petrol.*
[2] Dalton & Presnall (1998) *Contrib. Mineral. Petrol.* **131**, 123-135. [3] Gudfinnsson & Presnall (2005) *J. Petrol.* **46**, 1645-1659.