Press Releases

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JAMSTEC

Lavas from Petit-spot Volcanoes Presents Direct Evidence of Metasomatism
- Clue to elucidate mantle heterogeneity and plate -

Overview

Dr. Natsue Abe at the Research and Development Center for Ocean Drilling Science at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) and her colleagues analyzed samples of mantle xenocrysts and xenoliths (*1) from petit-spot lavas (*2) discovered on the subducting Plate in the northwest Pacific Ocean in 2004. It revealed that clinopyroxene observed in petit-spot mantle xenoliths is chemically similar to that from melt-metasomatized garnet or spinel peridotites from intracontinental basalts and kimberlites. It indicates that metasomatic processes (*3) that affect oceanic and continental lithospheric mantle are similar. These results present direct evidence of complex structure of the lower oceanic lithosphere, which seems to be subject to metasomatic processes. The work was carried out in collaboration with researchers from University of Lausanne, Tohoku University and Cardiff University.

Since it is still difficult to obtain samples directly from the oceanic plate deeper than 70 km, xenoliths/xenocrysts sampled by petit-spot lavas were used to elucidate the complex structure of the oceanic plate. The discovery of metasomatized xenoliths/xenocrysts extracted from the base of the Pacific Plate has fundamental implications for understanding metasomatic processes at the lithosphere-asthenosphere boundary and on the nature of subducted oceanic lithosphere. The link between lithosphere deformation and initiation of melt percolation indicates that metasomatic processes are not necessarily related to passive or active upwelling (i.e., mid-ocean ridges or mantle plume). It, however, suggests that percolation and metasomatism could be initiated by tectonic processes as extensional stresses in oceanic lithosphere such as plate bending in front of subduction zones allows low degree melts from the seismic low-velocity zone to percolate, interact and weaken the oceanic lithospheric mantle.

These study results will lead to better understanding of chemical heterogeneity in the earth's mantle. It is also expected to provide a clue to clarify the mechanism of plate flexure and fracturing that could trigger large earthquakes.

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Title: Pre-subduction metasomatic enrichment of the oceanic lithosphere induced by plate flexure

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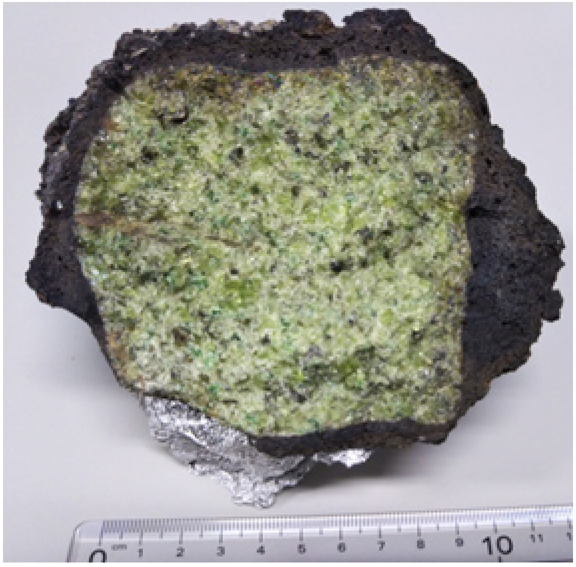
*1 Mantle xenocrysts and xenoliths
Mantle xenoliths are rock fragments captured into ascending magma bodies such as kimberlites and alkali basalts derived from the upper mantle. Usually they're peridotites, so also called peridotite xenoliths. Xenocrysts are single crystals of such rock pieces.



An example of peridotite xenoliths from Australia: The center peridotites are composed of periodites (yellow), orthopyroxene (brown), clinopyroxene (green) and spinel (not shown in this photo). The black parts surrounding the peridotite are alkali basalts.

*2 Petit-spots
Petit-spots or petit-spot volcanoes are young or extremely young volcanoes discovered on the seabed or near the trench (figure 1). They are not classified in usual volcanic types erupting in three tectonic settings: mid-ocean ridges; subduction zones where a continental and oceanic plate collides; and a hot spot where mantle plumes. Because magma rise and supply are deeply related to flexure of subducting plates in the formation process of such type of volcano (Hirano et al., 2006, Science, 313, 1426-1428), petit-spot volcanoes are likely to exist in such sea areas. In addition to off the coast of Sanriku, they have already been found off the coast of Chile, Tonga and the Sunda Trench.

*3 Metasomatic processes
Metasomatic processes or metasomatism is the chemical or mineral alteration of peridotites originally derived from the Earth's mantle or mantle residue after mid-ocean ridge basalt extraction due to addition of different types of magmas. Metasomatism is considered to be a reason of chemical and isotopic heterogeneity in the Earth's upper mantle.

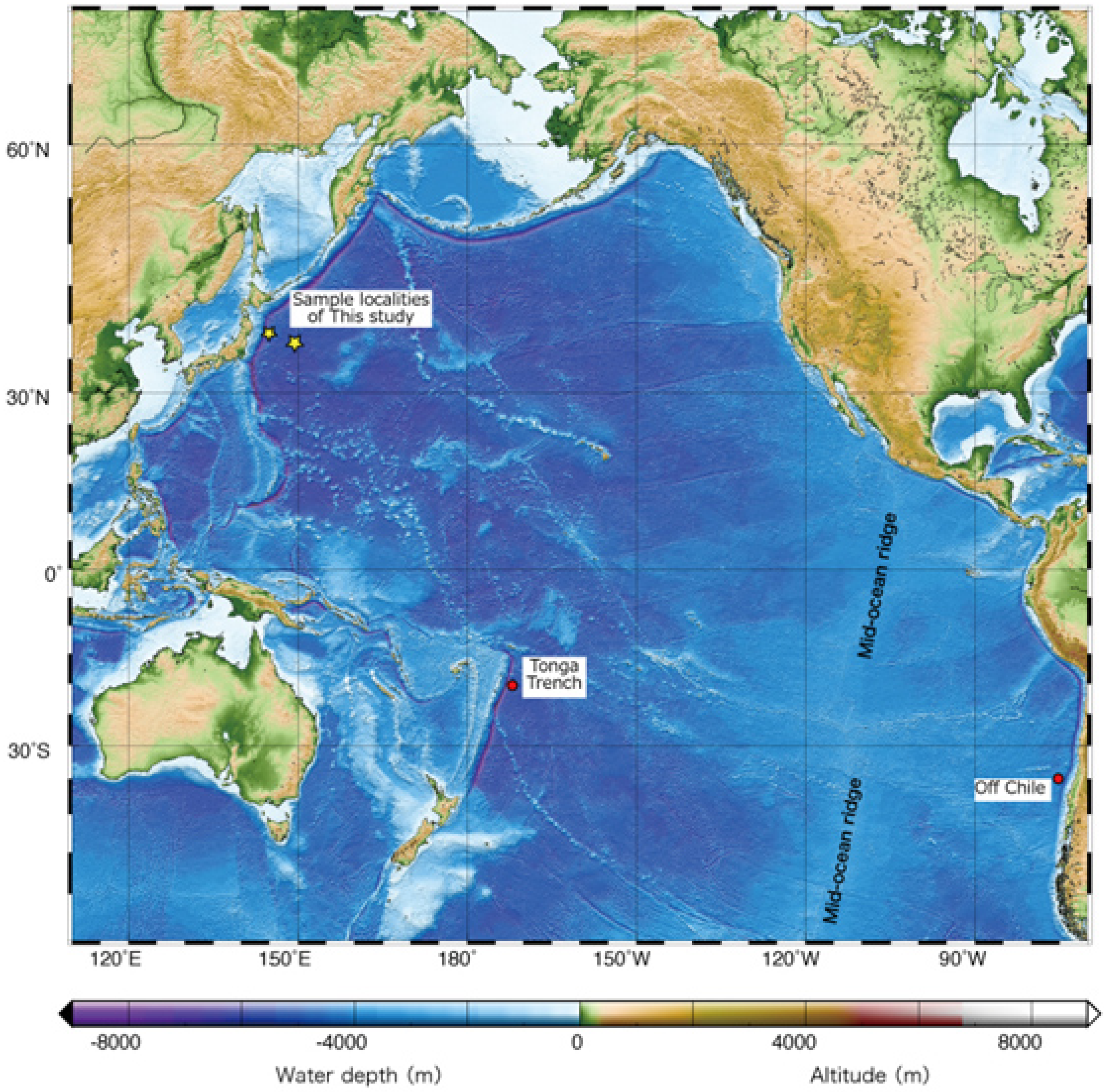


Figure 1. The yellow stars show sites where samples were collected, and the red dots other petit-spot areas.

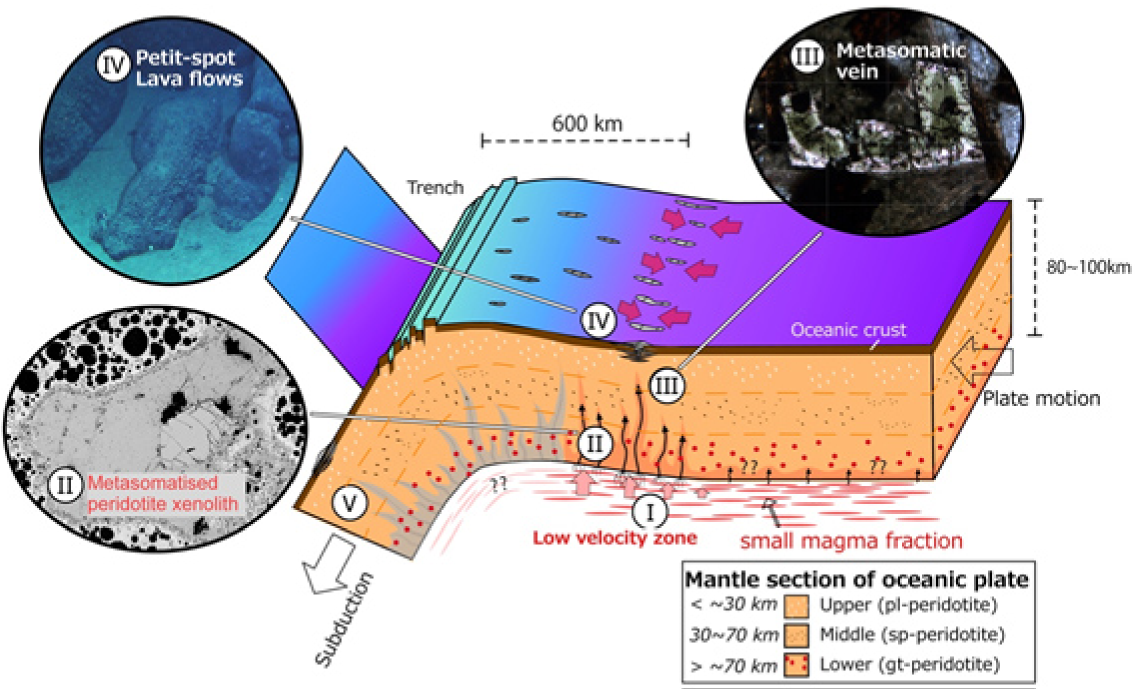


Figure 2. Schematic model illustrating the metasomatism of the oceanic lithospheric mantle associated to plate flexure. (I) Extension at the base of the lithosphere created by plate flexure allows low-degree melts present at the topof the asthenosphere to percolate into the lithospheric mantle. The percolation and differentiation of these melts produce various (an-) hydrous metasomatic veins and/or cumulates as a function of pressure and temperature, and cryptic metasomatism in oceanic lithosphere (II–III). (IV) In some cases, the reacting low-degree melts could reach the surface and generate the petit-spot sills and lavas. (The image was taken during *Shinkai 6500* dive.) (V) Recycling and storage of oceanic lithosphere into the mantle containing incompatible element-enriched metasomatized domains could produce some of isotopically enriched components observed in the source of mid-ocean ridge basalts or ocean island basalts.

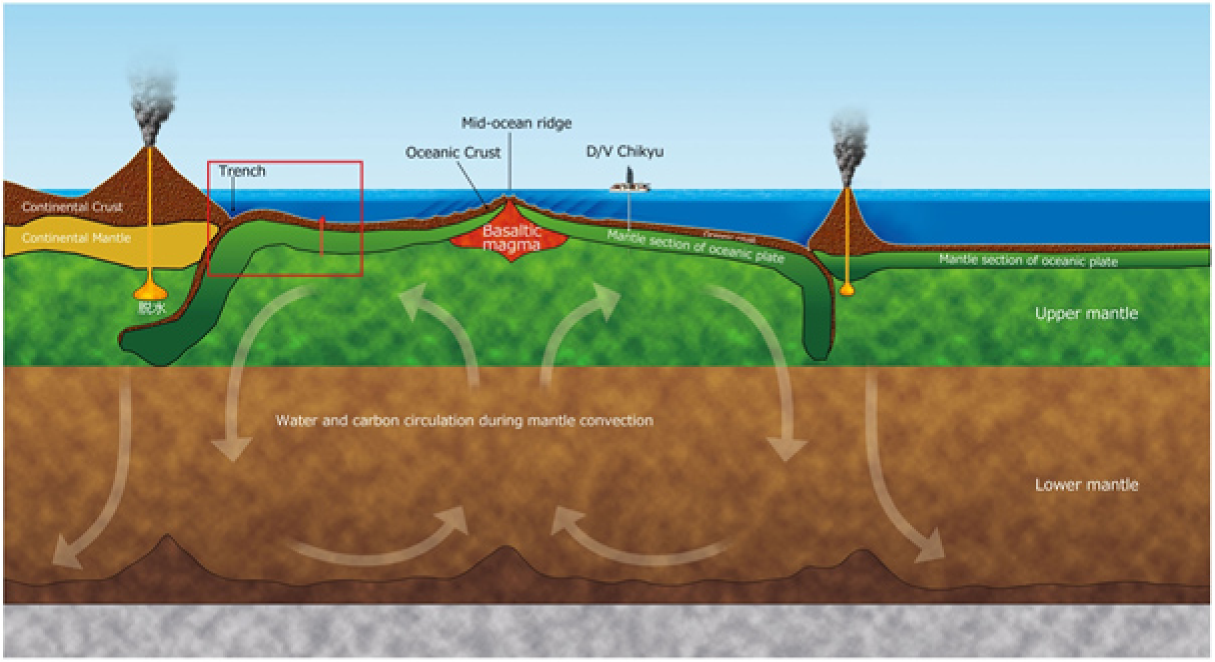


Figure 3. Schematic illustration of the internal structure of the earth. The dark brown areas are plates containing crust. The red square are is enlarged in the figure 2.

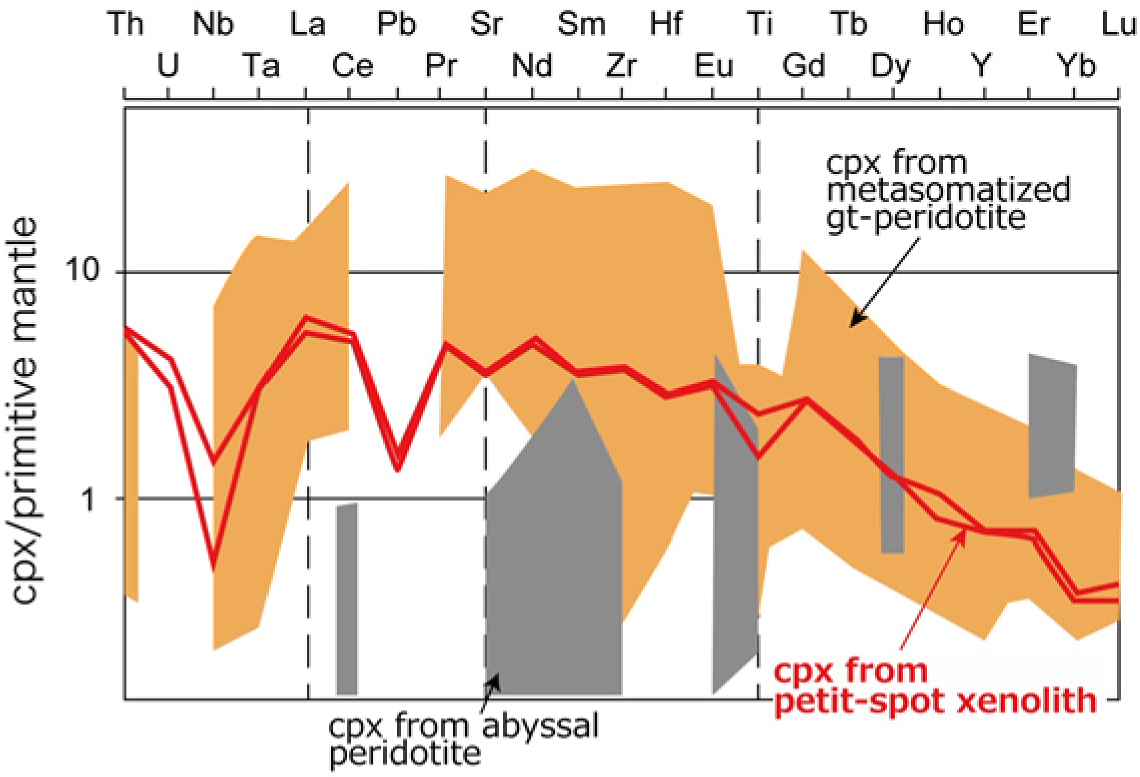


Figure 4. Clinopyroxene composition normalized to primitive mantle for petit-spot peridotite xenolith compared to abyssal or metasomatized continental peridotites. (cpx: clinopyroxene; gt garnet). Values and pattern from petit-spot xenolith (red line) is not consistent with those from abyssal peridotites, which are considered to represent mantle substances under oceanic plates, while consistent with samples from metasomatized garnet-peridotite xenoliths in kimberlite.

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