Press Releases

JAMSTEC
Japan Agency for Marine-Earth Science and Technology

September 6, 2016
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New Theory for Mantle Recycling
- Traces of carbonates found in basalts from Earth's deep mantle -

Overview

A research team formed by Dr. Yaakov Weiss at Lamont-Doherty Earth Observatory of Columbia University and Dr. Takeshi Hanyu at Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) performed high-precision trace element analyses of olivine[*1] phenocrysts in ocean island basalts[*2] from the Cook-Austral Islands in the South Pacific and Grande Comore Island in the Indian Ocean. They discovered that these basalts were derived from carbonated peridotitic sources in the deep mantle.

It has been understood that carbonates in the Earth's surface have been transported into the upper mantle through subduction of oceanic crusts. This study gave the first evidence that some carbonates can be also carried down into the lower mantle after reaction of carbonated oceanic crust with surrounding mantle and stored in the lower mantle, which is the source region of the studied basalts. This finding urges reconsideration of mantle recycling models and also provides a new constraint for carbon circulation in the mantle.

The above results were published in the online version of *Nature* on September 6, 2016 (JST).

Title: Key new pieces of the HIMU puzzle from olivines and diamond inclusions
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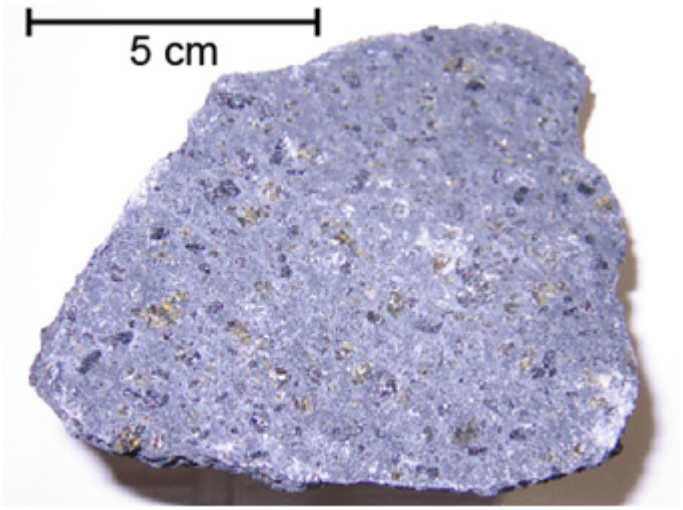
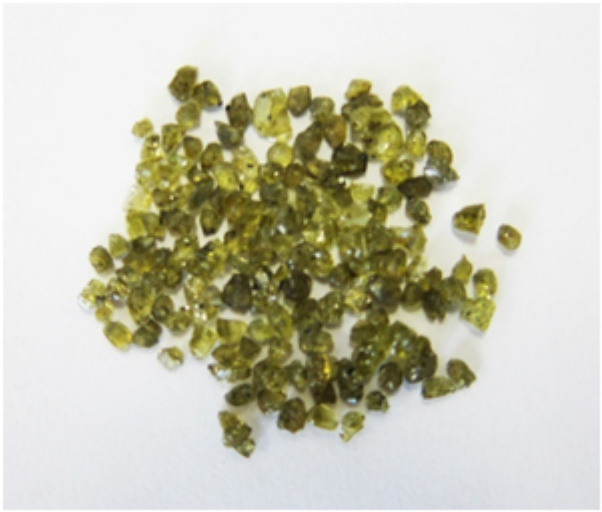
*1 Olivine
Olivine is one of phenocrysts that crystallizes at relatively early stage during cooling of basaltic magmas. Ocean island basalts often contain large olivines with several millimeters in size. The photo below on the left is a piece of basalt containing olivines (light green) together with clinopyroxenes (dark brown). Olivines separated from the rocks are shown on the right.





*2 Ocean island basalt
It is a type of basalts that appear on volcanic islands and seamounts. While mid-ocean ridge basalts and island arc basalts occur along plate boundaries, ocean island basalts generally occur away from them, thereby they are not related to plate activities. According to seismic tomography, high-temperature anomaly from the deep mantle, which is called mantle plumes, is generally observed beneath ocean islands. It indicates that the magma sources of ocean island basalts are the deep mantle material transported by upwelling mantle plumes. The basalts studied here are called HIMU ocean island basalts, which have unique feature in geochemical compositions derived from subducted oceanic crusts.

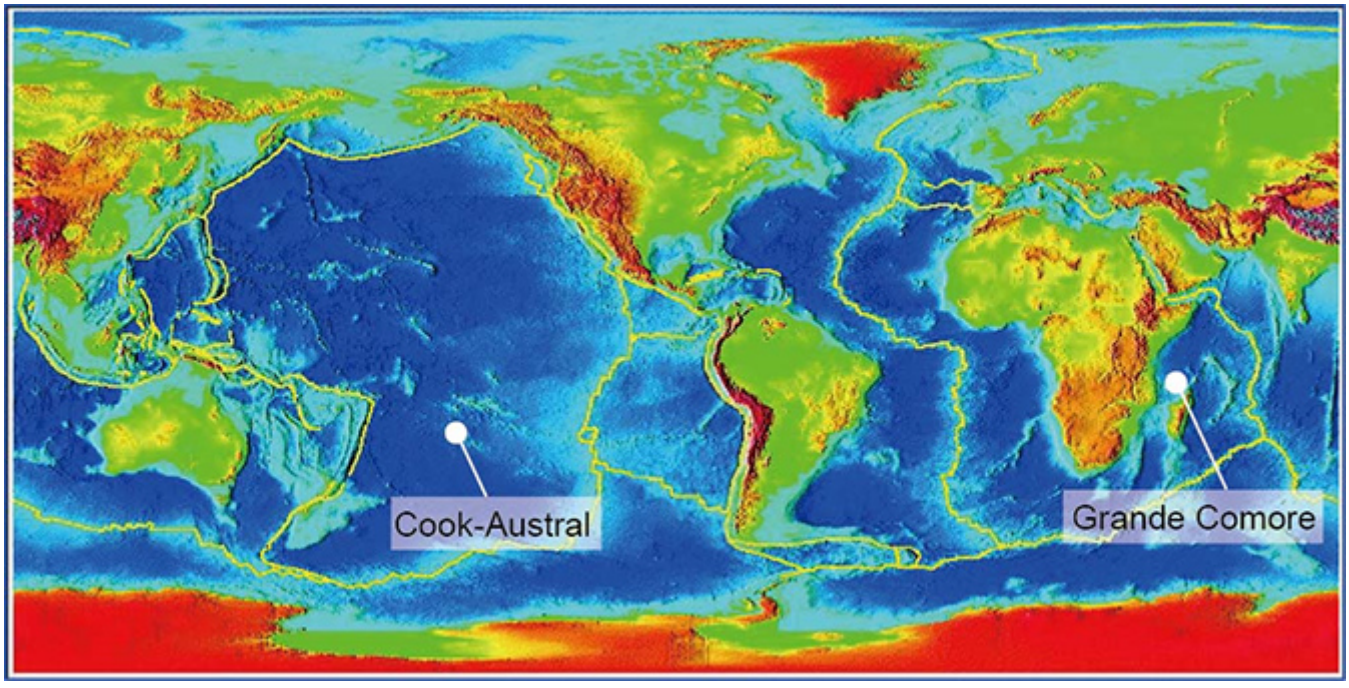


Figure 1. Cook-Austral Islands in the South Pacific and Grande Comore Island in the Indian Ocean. Beneath these volcanic ocean islands, basalts are generated by melting of deep mantle sources transported by upwelling mantle plumes. Subaerial basalts collected from these islands were used in this study.

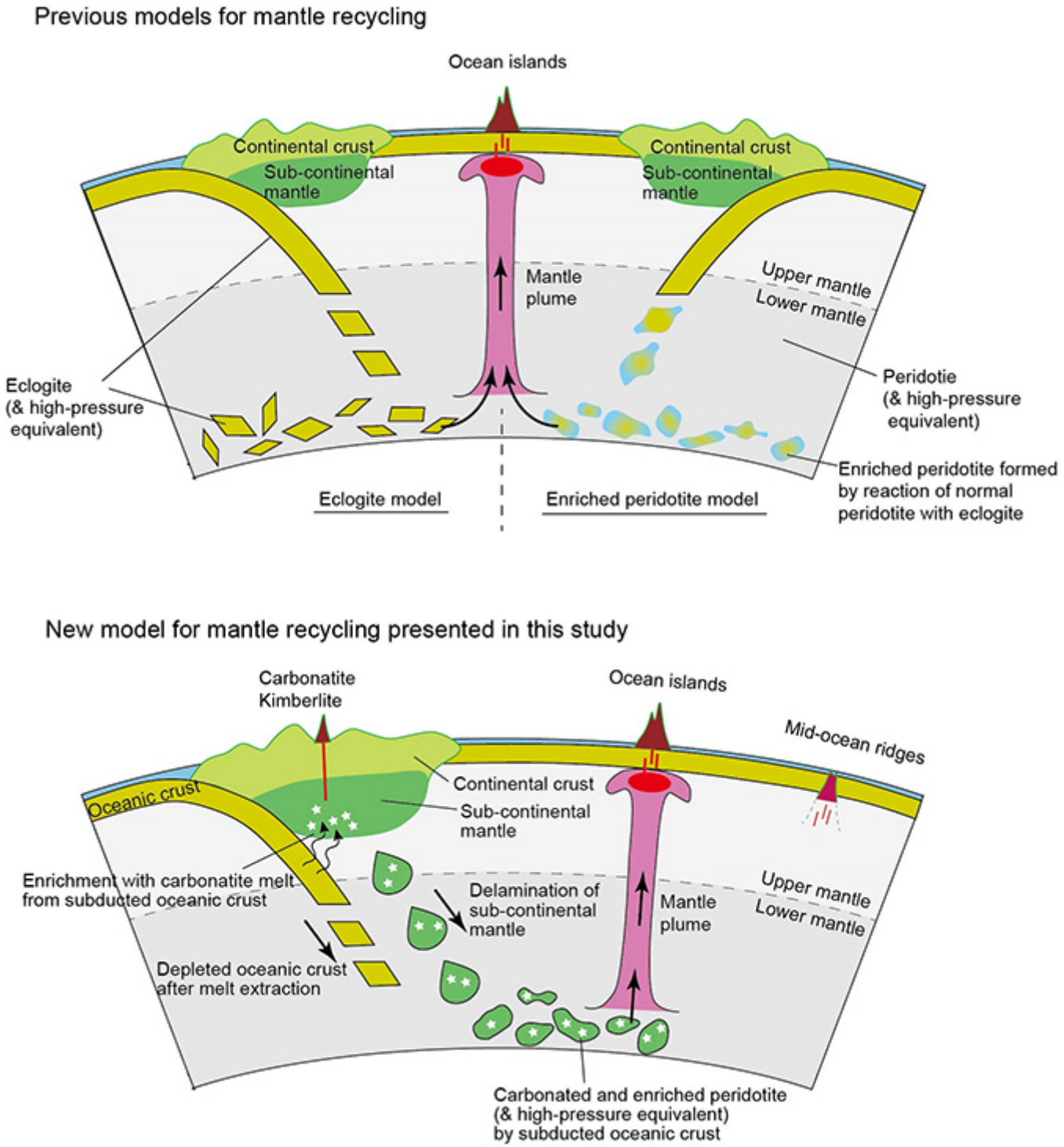


Figure 2. Models for mantle recycling
The upper illustration shows two previous models for mantle recycling under debate. In the ecologite model on the left, subducted oceanic crusts exist in the mantle as eclogite (and its high-pressure equivalents) with keeping original compositions. In the enriched peridotite model on the right, subducted oceanic crusts interact with surrounding peridotitic mantle to form enriched peridotite (and its high-pressure equivalents).
The lower illustration shows the new model proposed in this study. While the geochemical data support the enriched peridotite model, they further demonstrate that enriched and carbonated peridotite was created by interaction of carbonatitic melts from subducted oceanic crusts with surrounding mantle, followed by its sinking down into the deep mantle.

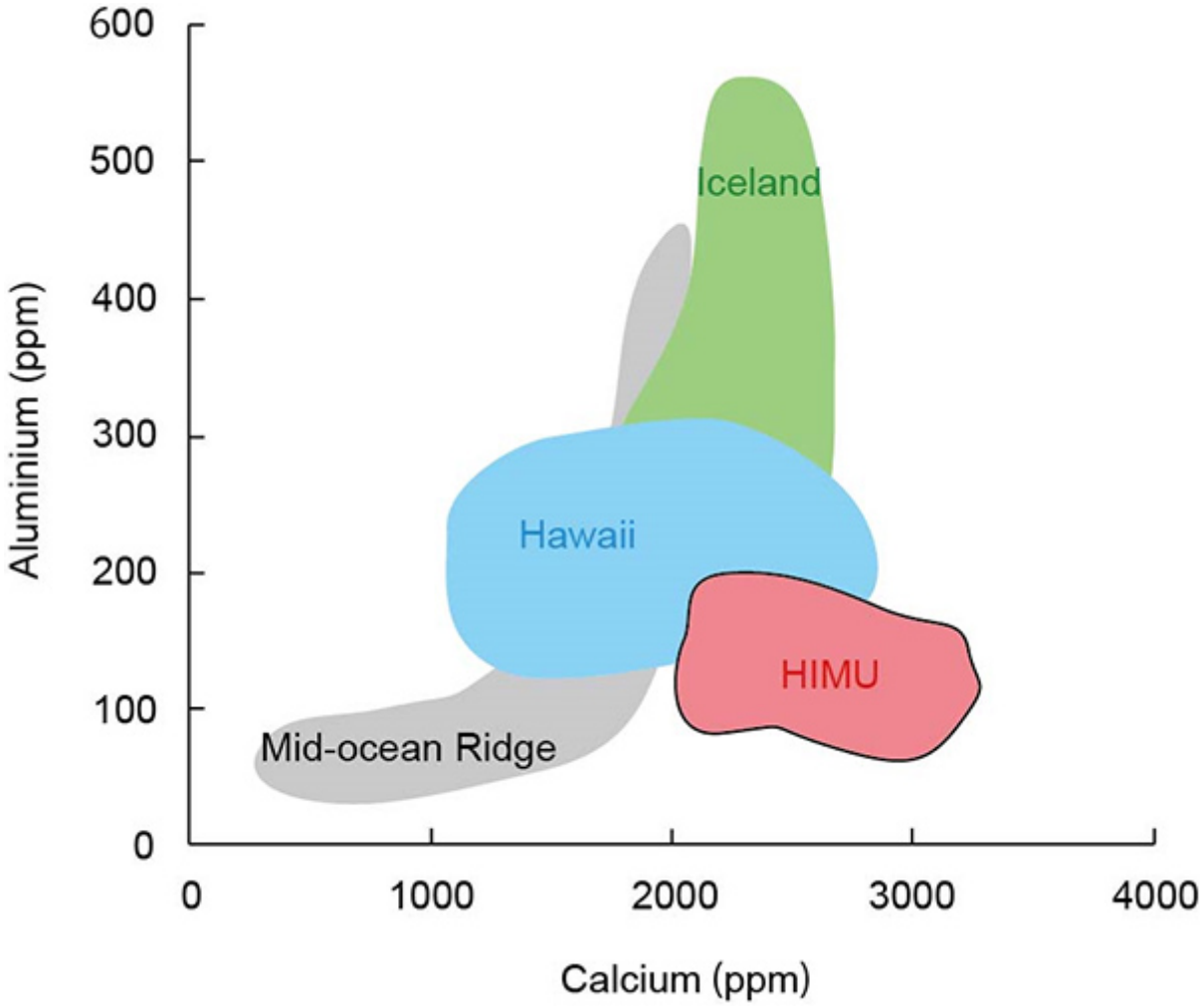


Figure 3. Aluminium and calcium concentrations in olivines.
The calcium and aluminium concentrations in olivines are key issues in this study. The authors discovered that olivines in HIMU basalts have higher calcium and lower aluminium compared to those from other ocean island basalts and mid-ocean ridge basalts. Such geochemical features suggest a contribution of carbonatitic melts during interaction between subducted oceanic crusts and surrounding peridotitic mantle.

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