Seismic images under hotspots from global tomography Tohoku-2008 model

Yoshihiro Yamamoto[1]; Dapeng Zhao[1]

[1] RCPEV, Graduate School of Sci., Tohoku Univ.

http://www.aob.geophys.tohoku.ac.jp/

1. Introduction

On the Earth there are hotspot volcanoes such as Hawaii and Iceland, which are either intraplate volcanoes or exceptionally large volcanoes located in mid-ocean ridges. The mantle plume hypothesis was proposed forty years ago to explain hotspot volcanoes by Wilson (1963) and Morgan (1971). A mantle plume is thought to be a hot upwelling flow from the deep mantle, which looks like a mushroom. Plume heads may reach diameters of 500 to 3000 km, while plume tails are typically 100 to 300 km in diameter. Its maximum temperature seems to be 250 to 500 K higher than that of the normal mantle. However, the actual shape, size, temperature and origin of plumes remain an open question. Even the existence of mantle plumes is a debating issue.

In this work, we used global tomography to determine a new whole-mantle 3-D P-wave velocity model Tohoku-2008, and used the model to examine the 3-D velocity images under the major hotspots on Earth.

2. Data and method

In this work, we applied the global tomographic method of Zhao (2001, 2004). We used the ISC data set for earthquakes occurred during 1964 to 2004. The events are selected to keep a distribution as uniform as possible on Earth. We used arrival times from 5 kinds of waves: direct P, pP, PP, PcP and P-diff waves. By inverting the arrival time data, we determined P-wave velocity perturbations at the grid nodes arranged in the latitude, longitude and depth directions. This model has new features compared with our previous Ehime-2004 model (Zhao, 2004).

Flexible grid

In Ehime-2004 model, artificial features appear along meridians in the polar regions. This was because the number of grid nodes along each latitude line was the same. The higher the latitude is, the shorter the grid separation is. In this work we have adopted a flexible grid to solve this problem. The grid interval in longitude direction is about 200 km at every latitude. This flexible grid parameterization has greatly improved the tomographic images of the polar regions.

Data selection

It is impossible to use the ISC data from all earthquakes occurred during the last 40 years. In this work, we divided the study area into small blocks, and from each block we selected an earthquake that has most data. In this way, we could reduce the number of earthquakes in the high-seismicity regions such as subduction zones. Since we could also use earthquakes under the oceanic regions with low seismicity, the images under the oceans are improved. The latest earthquakes selected were also recorded by many OBS stations. This is also a reason to obtain the improved model.

3. Results and Discussion

We used the obtained Tohoku-2008 model to examine the seismic images beneath 60 hotspots listed in Zhao (2007). We assumed the low-velocity anomalies with velocity reductions over 0.2 % to represent mantle plumes. Our results are summarized as follows.

There are whole-mantle plumes which ascend up from the CMB under Hawaii, Tahiti and so on. There are also mid-mantle plumes which come upward from the middle of the lower mantle beneath some hotspots like Mt. Erebus. Upper-mantle plumes exist under East Australia and some other hotspots. Some hotspots share the same mantle plume as their origin, such as Iceland and Jan Mayen.

Beneath three active intraplate volcanoes (Changbai, Wudalianchi and Tengchong) in China, prominent high-velocity anomalies are visible together with deep-focus earthquakes, which represent the subducting slabs. We consider that the three volcanoes are not hotspot but intraplate volcanoes caused by the deep subduction of the Pacific slab and the Burma microplate.

Acknowledgement

We are grateful to Dr. Akira Yamada of Geodynamics Research Center, Ehime University for his kind help and suggestions during the course of this study.

Zhao, D. (2001) Earth Planet. Sci. Lett. 192, 251-265.
Zhao, D. (2004) Phys. Earth Planet. Inter. 146, 3-34.
Zhao, D. (2007) Gondwana Res. 12, 335-355.