What do we Know about Mantle Plumes, what can Hawaiian Volcanoes tell us about the Earth's Mantle and what more can we learn by IODP Drilling?

It is almost 50 years since the first documentation of mantle heterogeneity through the study of ocean island basalts (OIB) [1]. The origin, scale and source of these heterogeneities have been the subject of debate since then. One of the most common approaches in the study of mantle heterogeneities is to analyze the geochemistry of oceanic basalts brought to the surface by mantle plumes, sampled either on oceanic islands or by drilling oceanic plateaus. The composition of these oceanic plateau and ocean island basalts is usually different from those extruded at mid-ocean ridges (MORB). Improved analytical precision for radiogenic isotopes, combined with statistical data treatment, allow for more detailed investigations into the geochemical variations of basalts related to hotspots and mantle plumes and for modeling of the shallow and deep plume structure. A key factor is the acquisition of continuous, ordered and datable sequences of lavas [2].
Identification of two clear geochemical trends (Loa and Kea) among Hawaiian volcanoes [3, 4] in all isotope systems [5], together with the recurrence of similar isotopic signatures at >350 kyr intervals identified in the HSDP cores, have implications for the dynamics and internal structure of the Hawaiian mantle plume conduit [6]. In this lecture, I will present a compilation of recent isotopic data for samples from shield lavas on Hawaiian volcanoes, focusing specifically on high-precision Pb isotopic data (MC-ICP-MS or DS, TS TIMS) and integrated with Sr, Nd and Hf isotopes. The Hawaiian mantle plume represents >80 Myr of volcanic activity in a pure oceanic setting and corresponds to a high plume flux. All isotopic systems indicate source differences for Loa- and Kea-trend volcanoes that are maintained throughout the ~1 Myr activity of each volcano and that extend back in time on all the Hawaiian Islands (to ~5 Ma). The Loa-trend source is more heterogeneous in all isotopic systems by a factor of ~1.5 than the Kea-trend source, and this can be traced to the core-mantle boundary.

These results from Hawaii will be compared to other hotspots in different tectonic settings (e.g. Kerguelen, Galapagos, and Iceland), and to oceanic plateaus (Ontong-Java, Caribbean, and Wrangellia). Some implications for mantle geodynamics will be discussed together with ideas for future IOPD and ICDP drilling campaigns.

[1] Gast et al. (1964) Science 145, 1181-1185.
[2] DePaolo and Weis (2007) Continental Scientific Drilling: A Decade of Progress and Challenges for the Future, Springer , 259-288.
[3] Tatsumoto (1978) Earth and Planetary Science Letters 38, 63-87.
[4] Abouchami et al. (2005) Nature 434, 3401-3406.
[5] Weis et al. (2009) Eos Trans. AGU, 90(52), Abstract V41F-03.
[6] Farnetani and Hofmann (2009, 2010) Earth and Planetary Science Letters 282, 314-322; 295, 231-240.