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Deep plumes in the mantle: geometry and dynamics

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New finite-frequency S-wave tomographic images confirm the presence of deep plumes beneath Ascension, Azores, Canary, Easter, Samoa and Tahiti. Also the S-wave anomalies show a robust extension all the way to the core-mantle-boundary of the plumes beneath Cape Verde, Cook Island and Kerguelen. The presence of plumes rising from the base of the mantle but not reaching yet the surface in the Coral Sea, east of Solomon and south of Java is validated. Plumes beneath Eifel, Etna and Seychelles remain mostly confined to the upper mantle. Several plume images extend only down to the mid-mantle. For these plumes a deep origin cannot be simply rule out because resolution shows that they could have a very thin, not resolvable, tail. Finally, the new S-wave disagree with earlier P-wave images in the case of Iceland, which is weak in the mid-mantle but stronger in the lowermost mantle, suggestive of a pulsating behavior, and of the Galapagos plume, which may extend deeply but under a large angle.

The new S-images are suggestive of a dynamic process in which plumes develop from the base of the mantle in a doming regime, as seen for instance beneath the Coral Sea; extend all the way up to the surface and bend under the effect of the mantle wind, as observed beneath Azores, Canary and Cape Verde; and begin to die by losing their tails at depth, as seen for instance beneath Hainan. None of the imaged plumes exhibits the typical mushroom-shaped structure associate to isoviscous, thermal plumes. Such plume heads are considered to be responsible for the formation of large igneous provinces, whereas the plume tails are responsible for the presence of the typical linear volcanic chains. As shown in laboratory experiments of plumes dynamics, and in numerical models, plumes that have already reached the surface may not have a head, whereas younger plumes should. But not even the images of starting plumes are showing a plume head. Also, both in the P-model and S-model plumes are wide, with radii as large as 300–400 km. Such headless, wide plumes have recently begun to

appear in numerical models of mantle circulation either in the presence of a strongly temperature-dependent viscosity and/or compositional buoyancy variations.

We are in the process of comparing our plume conduits with the ones by O'Neill et al. (2004) obtained by reconstructing an absolute frame of reference based on moving hotspots; and we are characterizing the observed plumes with their superficial signature by looking at the correlation between their depth extent and the presence of large igneous provinces and/or volcanic chains. We shall provide a synthesis of our tomographic findings in light of existing ideas about plume characteristics and their possible revisions.