Subduction Zones and Mantle Plumes

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In its simplest form, the plate-tectonic hypothesis expects volcano chains to lie behind subduction zones, *e.g.*, the circum-Pacific belt and the Alpine-Himalaya continent-continent collision zone. Nevertheless, volcanism associated with subduction is considerably more diverse than this. In this paper I argue that this diverse volcanism reflects the real, complex stress fields associated with subduction zones. Specifically, where the lithosphere is in extension, permissive volcanism occurs. Volcanism that is more diverse and widespread than predicted by the simple, textbook model of subduction zones is thus an expected feature of real geological cases.

Back-arc extension was not originally part of plate tectonic theory. Nevertheless, when it was discovered, it fit naturally into the model. It did not violate predictions of plate tectonics and radical revision of the theory was not required. Sinking slabs lie down in the mantle at their depth of neutral buoyancy and their surface hinges thus retreat. This process results in extension as the lithosphere ahead of hinges is pulled apart and volcanism occurs as a result. In some cases this deformation and volcanism takes the form of spreading and the development of oceanic crust. In other cases, distributed volcanism occurs, time-progressions may be observed, and small flood basalts may erupt. Examples include:

* spreading in the Sea of Japan;
* the Manus back-arc basin;
* volcanic activity in eastern China;
* the Columbia River flood basalt in the states of Washington and Oregon, U.S.A.;
* volcanism in the Basin-Range province in the western U.S.A.;
* volcanism in Italy, behind the Alpine subduction zone;
* distributed, time-progressive volcanism in eastern Anatolia, Turkey; and
* time-progressive volcanism in Mexico.

In addition, volcanism has been observed behind subduction hinges, for example as “petit spots”, attributed to permissive volcanism through cracks in the lithosphere as it approaches subduction zones and bends [Hirano *et al.*, 2006]. Volcanism at Samoa is likely also associated with cracking of the Pacific plate as it approaches the Tonga trench [Natland & Winterer, 2004].

Despite the obvious association of volcanism and lithospheric extension in the neighbourhood of subduction zones, in many cases this volcanism has been attributed to deep mantle plumes. In this paper I argue instead that the diverse volcanism that occurs in the wider neigbourhood of subduction zones can be explained naturally by expected lithospheric extension of various kinds. This provides a simpler explanation of volcanism in subduction environments than appealing to two separate and independent processes–plate tectonics and mantle plumes.

References

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Keywords: mantle plumes, subduction zones, plate hypothesis

