

## LINKS BETWEEN QUATERNARY VOLCANISM, NEOTECTONISM AND UPPER-PLATE STRUCTURAL STYLE IN THE ALEUTIAN ARC: NEW PERSPECTIVES

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The Aleutian arc extends about 3,000 km westward from central Alaska, and has often been described as being structurally simple, with downdip subduction velocity nearly constant over the majority of its length; a reasonably homogeneous subducted plate; and no complications from intra-arc or back arc rifting or spreading. Enough new data from diverse subdisciplines have accumulated to warrant reevaluation of our previous view and a new look at links between geology, geophysics and volcanology.

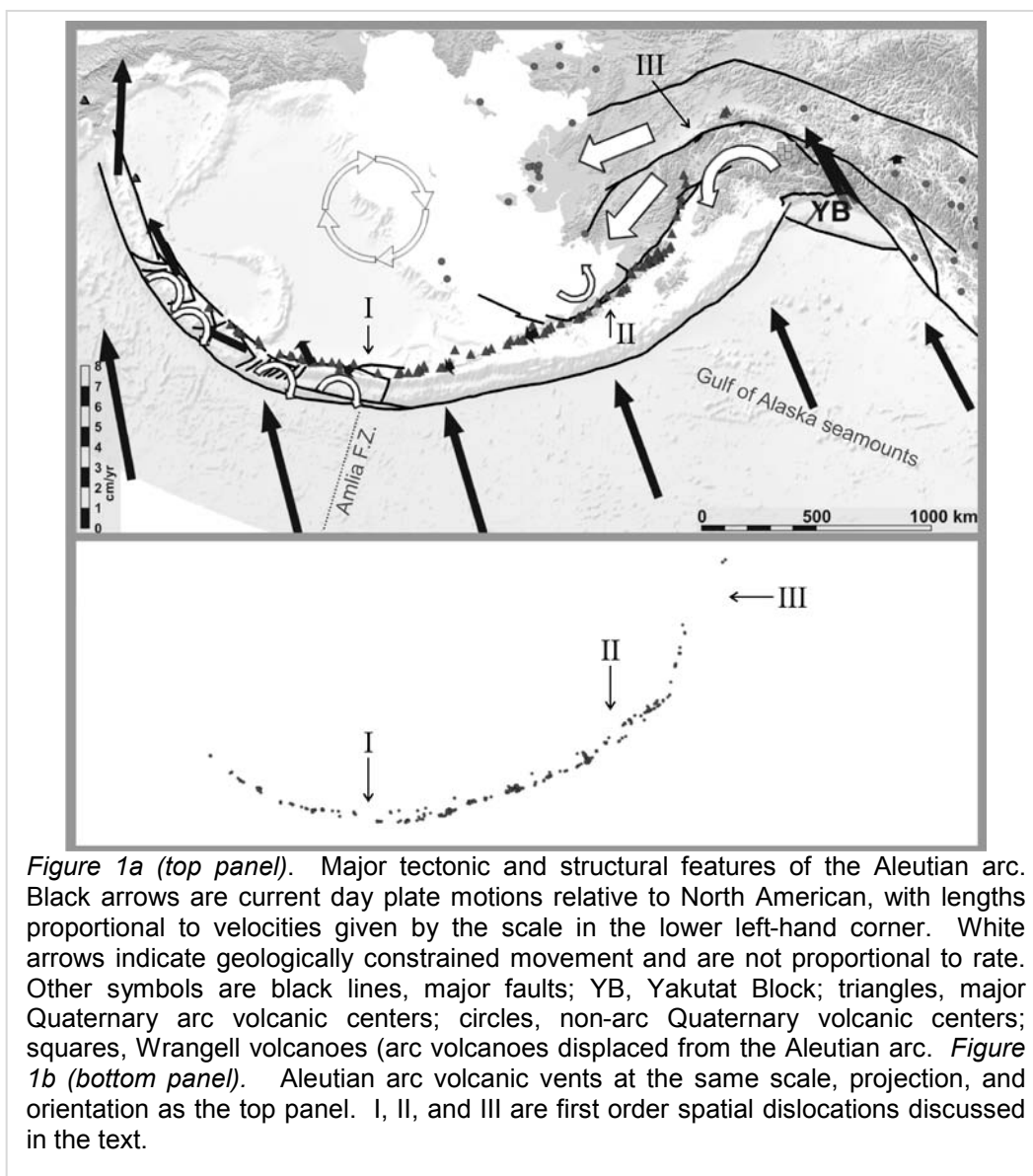
The classic view that the arc is structurally simple first started to change in the 1980's, with the demonstration that the western arc was broken up into a series of blocks which rotate clockwise and translate westward as convergence becomes more oblique and transpressional forces became more important (*cf. Geist et al. 1988, Tectonics 7:327-341*). New information about ongoing deformation, via GPS (*Freymueller et al. 2009, AGU Monograph 179:1-42*), and integrated over geologic time (*cf. Redfield et al., 2007, Geology 35:1039-1042*) shows that the entire arc is undergoing arc-parallel deformation related to westward extrusion caused by the accretion of the Yakutat Block at the eastern end of the arc.

The classic view was also that the presence of an upper plate which is continental in the east and oceanic in the west presents a good opportunity to investigate the influence of the upper plate on volcanism because so many of the other variables are controlled. However, an along-arc seismic profile across this junction shows that the Moho is at essentially the same depth in the oceanic and continental arcs (*cf. Fliedner and Klempere 1999, JGR 104:10,667-10,694*), calling into question the role of "thickened continental crust". Additionally abundant new geochemical data have not found a geochemical offset associated with the transition from oceanic to continental crust, although some systematic along-arc variations exist.

Figure 1a shows major tectonic elements of the arc as they are currently understood. Figure 1b is at the same scale and projection and shows only known volcanic vents. The removal of all other information from Figure 1b facilitates the identification of major disjoints in the volcanic chain (smaller-scale segmentation of the arc has been addressed by others, notably the Kays, and Marsh).

The disruption of the volcanic chain at 173.3W longitude (I in Figure 1b) coincides with a change in structural style in the forearc (seen in seismic reflection data) from compressional to the west to extensional to the east. An abrupt change in the number of earthquakes at this transition suggests that the forearc is more strongly coupled to the subducting Pacific plate to the west. A mirror disruption of the volcanic chain occurs at 156.5W longitude (II in Figure 1b). To the east geologic evidence for most recent offset on the Bruin Bay Fault is thrusting, marking compression near the arc crest. To the west, geologic evidence shows that crestal arc-parallel faulting changes to normal. This also marks the eastward limit of the North Aleutian basin, a kilometers-thick Cenozoic extensional sedimentary basin immediately north of the arc crest.

The two disruptions in the volcanic front at I and II (Figure 1b) divide the arc into three first-order segments. The outer two typically have small-volume, crystal-rich calcalkaline magmas which are andesite to dacite in whole-rock composition with dacite to rhyolite groundmass glass. The central region contains those volcanoes which are larger, basaltic-andesite to andesite, tholeiitic, have dramatically lower crystal contents and more mafic groundmass glass. There are modulations of these first-order features. The central segment also has small crystal-rich calcalkaline andesite volcanoes -- it's the presence of the large mafic tholeiitic volcanoes, rather than the absence of smaller crystal-rich andesite volcanoes which is defining. West of I the average composition of individual volcanoes is more variable than east of II, perhaps reflecting stress heterogeneity associated with block rotation. (See *Kay and Kay 1994, Alaska DNAG 687-722*, and *Singer and Myers 1992, Geology 18 1050-1053*, and references therein for additional discussion of the relation between upper plate stress and volcanism.)



*Figure 1a (top panel).* Major tectonic and structural features of the Aleutian arc. Black arrows are current day plate motions relative to North America, with lengths proportional to velocities given by the scale in the lower left-hand corner. White arrows indicate geologically constrained movement and are not proportional to rate. Other symbols are black lines, major faults; YB, Yakutat Block; triangles, major Quaternary arc volcanic centers; circles, non-arc Quaternary volcanic centers; squares, Wrangell volcanoes (arc volcanoes displaced from the Aleutian arc. *Figure 1b (bottom panel).* Aleutian arc volcanic vents at the same scale, projection, and orientation as the top panel. I, II, and III are first order spatial dislocations discussed in the text.

I and II also mark major topographic irregularities on the subducting Pacific Plate – the Amelia Fracture Zone at I and the chain of seamounts derived from the Cobb hotspot at II. Because these are oblique with respect to plate motion their intersection with the trench migrates, the former to the west, and the latter to the east. They may be acting to decouple the subducted plate from the overriding plate as they migrate outward, causing the transition from a forearc and arc that is compressional to one that is extensional. This change may in turn allow easier passage of magmas to the surface in the central arc. Thus the stress regime in the upper plate may be an essential factor in modification of parental magmas and in the origin of calcalkaline vs. tholeiitic magmas (as previously discussed on sub-regional scales, cf. *Kay and Kay 1994* and *Singer and others 1992*). An extreme case of compression limiting volcanism is seen at III (Figure 1b), where there is a 330-km long gap in volcanism spatially associated with the uplift of the Alaska Range. The presence of Holocene and Pleistocene arc volcanism NE of this gap (north of the Denail Fault), as well as various geophysical evidence suggest that this is only a volcanic gap, not a magmatic gap, and not a cessation of arc magmatism at the eastern edge of the subduction system.

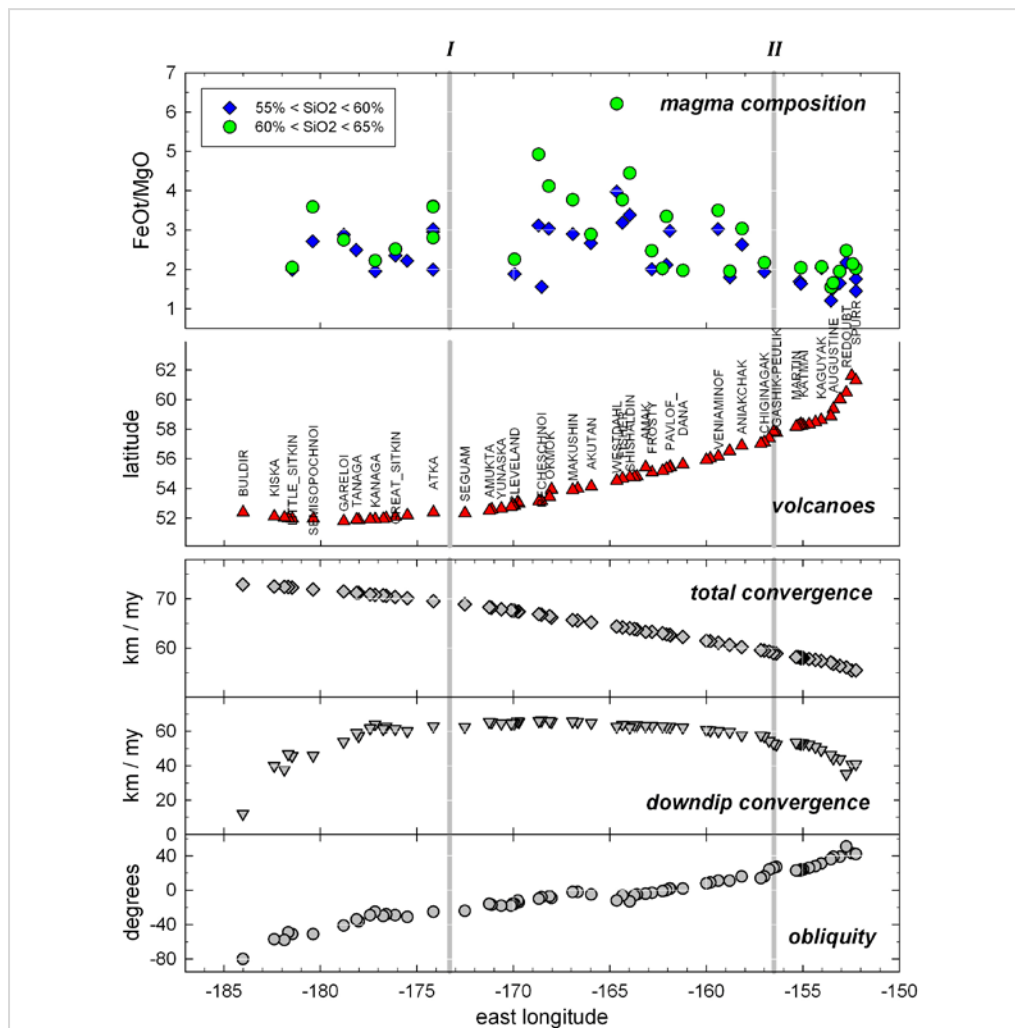


Figure 2. Tectonic and petrologic features of the Aleutian subduction system. Geochemical data are from the literature as well as ongoing AVO projects. Tectonic data are from (or derived from) *Syracuse and Abers 2006*, G3 doi:10.1029/2005GC001045. Vertical lines I and II are the breaks in the arc from Figure 1. Note that I and II do not coincide with major changes in subduction parameters.