Uplift and exhumation history of the Central Aleutian Arc

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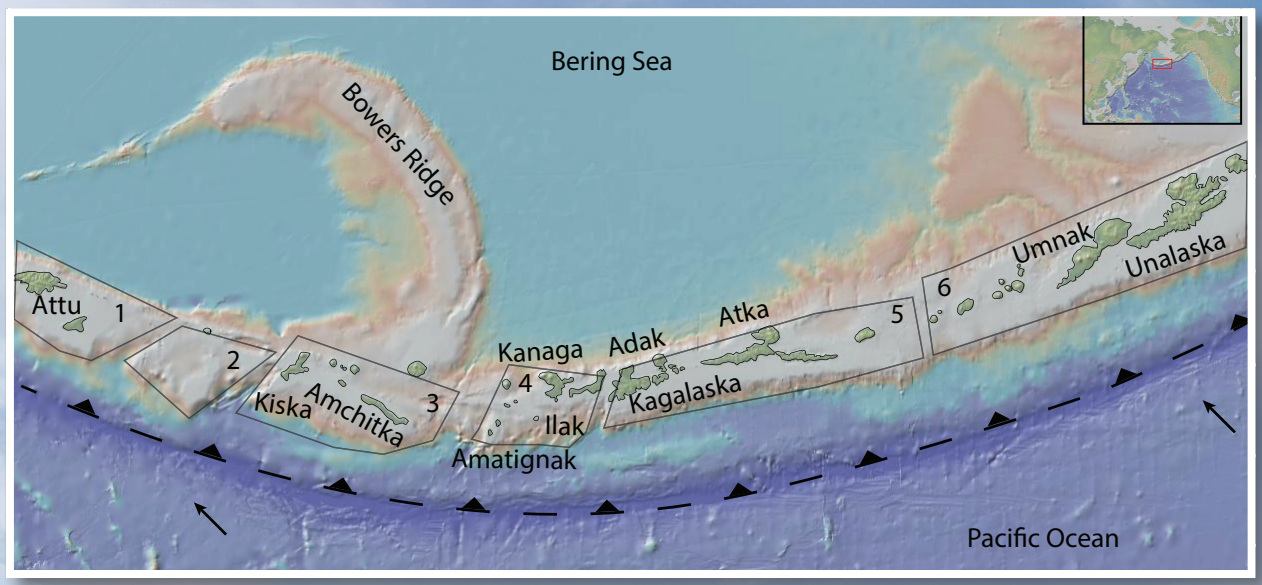
A central question surrounding island arcs is whether processes that occur deeply in the subduction zone affect processes that are observed on the surface, such as uplift, exhumation, and erosion. In many locations, the arc exhumation history is difficult to study because it may be overprinted by later thermal or physical processes. The Aleutian Arc is unique in that it is includes over fifty islands composed of both active and inactive volcanoes over 1,900 miles from Alaska to Russia, and has limited overprinting by secondary events. In addition, it has a volcanic history that spans fifty million years, so that the ancient magma chambers of past volcanoes are now exposed on the islands' surfaces today. These plutonic rocks hold a record of past island uplift, exhumation, and erosion that can address key questions regarding: When were the Aleutians uplifted? When and how much has been eroded through time? Was uplift and subsequent erosion constant or cyclical? How does it vary geographically along the length of the arc? Specifically, the answers to these questions will shed light on the link between plate-scale processes and uplift; the timing and magnitude of erosion, contributing sediment and geochemical inputs to North Pacific; and the relationship between plutonic exhumation rates, geochemistry, and emplacement depth. The Aleutians have functioned as a natural laboratory to test fundamental principles regarding subduction zone evolution for more than four decades. This study will make a novel contribution to the existing extensive geochemical and geodynamic research.

This work will place the exhumation history of the Central Aleutians in the context of 1) driving forces involving regional tectonics and subduction zone processes; and 2) geochemical inputs to the N. Pacific via erosion of arc material. In order to quantify when and by how much the Aleutians experienced surface uplift and erosion, plutonic samples from about ten islands that span 870 miles of arc length will be analyzed for emplacement depth and subsequent uplift rates (including samples collected on the 2015 GeoPRISMS sampling campaign). Samples will be characterized by crystallization age, emplacement depth, and two or more thermochronometers with different thermal sensitivities (e.g., apatite and/or zircon, (U-Th)/He and/or fission track). Thermochronology techniques, particularly the use of multiple chronometers with different temperature sensitivities within the same sample, can constrain exhumation rates and be used to estimate erosion rates over time. Coupling the thermochronological data with emplacement depth will help constrain the amount of material eroded over that time. The timing and geographic trends revealed by these data can then be related in time and space to previously proposed drivers for uplift, including plate rotation, change in convergence angle and rate, or the development of an accretionary prism. ■

Reference

Geist, D.J., J.D. Myers, C.D. Frost (1988). Megacryst-bulk rock isotopic disequilibrium as an indicator of contamination processes: The Edgecumbe Volcanic Field, SE Alaska. Contrib Mineral Petrol, 99, 105-112, doi.org/10.1007/BF00399370



Map of the Central Aleutian Arc (180° to 165°W). The research area encompasses labelled islands. Plate trench shown with dashed line and convergence vectors in black arrows. Proposed rotated tectonic blocks are outlined (from left to right): 1) Near Block, 2) Buldir Block, 3) Rat Block, 4) Delarof Block, 5) Andreanof Block, 6) Cold Bay Segment. (Blocks from Geist et al., 1988 and Kay et al., 1992).

Sampling on Unalaska Island during the 2015 GeoPRISMS field campaign. Photo credit: E.H.G. Cooperdock