Volcanic arcs through time: High-resolution transects across 40 million years of arc evolution in the Oregon Cascades

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Key Sites: McKenzie River Drainage, Rogue River Drainage (Oregon Cascades)
Theme: Arc Evolution
Primary Data: ^{40}Ar-^{39}Ar age dates; whole rock geochemistry, mineral and melt inclusion geochemistry (including sulfur and halogens).

Long-lived arc systems can provide a deep time perspective on the evolution of single arcs through their magmatic record deposited over millions of years of activity. With data on arc output and magmatic composition through time, fundamental questions about the dynamics of magma generation at active convergent plate margins can be addressed. These questions include whether observed changes in the output are due to arc longevity and thus caused by mantle and/or crustal modifications through time, or whether they are controlled by changes in the tectonic regime as well as by changes in the subduction inputs. Suitable arc systems for obtaining the necessary data for assessing such relationships are rare because either arc activity was rather short lived (<10-20 m.y.), the existent long-lived arc has lost the context of its original subduction setting, or there is an insufficient rock record due to erosion, burial by younger strata, metamorphic overprint, or the arc is inaccessible due to remoteness or being submarine.

Since initiation of the Cascades around 45 Ma, the arc has been more or less in the same place with the same subduction setting. Yet the arc has progressively migrated slightly eastward in Oregon so that older rocks were not covered by younger activity (Fig. 1) (Verplanck and Duncan, 1987; Priest, 1990; Sherrod and Smith, 2000; Du Bray et al., 2006, Du Bray and John, 2011). This has produced an essentially continuous volcanic record from initiation to the modern, active High Cascades arc. Thus the Cascades represent a rare example of ~45 m.y. of nearly cospatial magmatism of a continental arc within a well understood tectonic framework (e.g.,Verplanck and Duncan, 1987; Severinghaus and Atwater, 1990; Du Bray and John, 2011) in an on-land setting that can be readily accessed.

We propose a project geared towards generating high-resolution records of the magmatic output of the ancestral (45-5 Ma) Cascades of Oregon. Here, geological and accessibility preconditions for study of the temporal evolution of a continental arc are particularly well met, and study conditions are further enhanced by the availability of a great deal of prior regional reconnaissance and locally detailed map and chemical data, plus auxiliary data such as LIDAR imagery. We propose to obtain geological as well as state-of-the art compositional and age data on select transects across the ancestral Cascades, building on available regional reconnaissance data as well as on prior detailed local studies. Transects will follow drainages that generally cross the volcanic stratigraphy perpendicular to strike. Our first target is the McKenzie River drainage that crosses the ancestral Cascades at the latitude of Eugene, OR. This will be complemented by a second transect farther south, along the Rogue River near the latitude of Grants Pass, OR. Additional transects are planned when results of the first two are available. The transect approach was chosen in order to capture the entire volcanic record of the ancestral Cascades at select latitudes and to obtain results on specific stratigraphic packages within a reasonable, 2-3 year, time frame that can be used to identify subsequent targets for study.

It is clear from existing data that rocks of the ancestral Cascades are not as well preserved as rocks from the young High Cascades. This is not an issue exclusive to our study but is encountered wherever older volcanic stratigraphies are needed to provide important data for evaluating processes of arc evolution. However, a careful sampling approach as well as modern instrumentation (X-ray Fluorescence (XRF), Inductively-Coupled Plasma Mass Spectrometry (ICP-MS), Portable XRF (pXRF), Electron Probe Micro Analysis (EPMA), Laser ablation Multicollector ICP-MS, Ta furnace and UV laser heating gas source Mass Spectrometry) can produce unequivocal, high quality data.

With the new transect data we will improve knowledge of magmatic fluxes and compositional changes over this forty million year age span of Cascade arc evolution. With these improved data sets, we will explore correlations and their implications for how the mantle wedge and arc crust evolved with time, whether changes varied smoothly or were more abrupt, and also the sensitivity of flux rates and compositions to changes in subduction and tectonic parameters (e.g. Verplanck and Duncan, 1987; Severinghaus and Atwater, 1990; Priest, 1990).

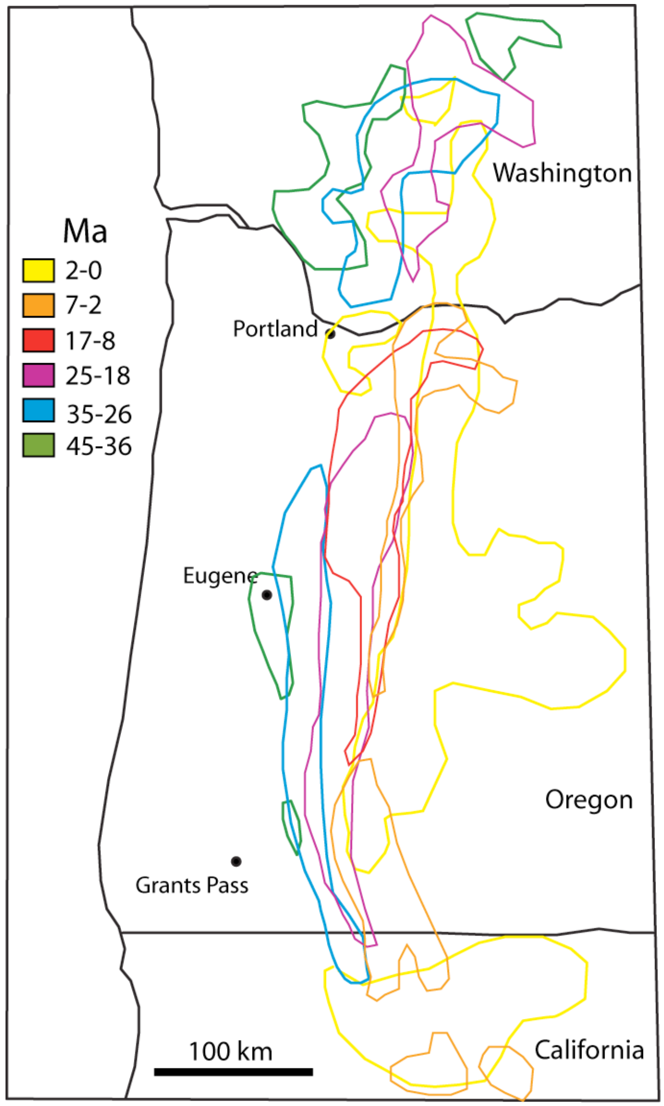

Fig 1: Age distribution of volcanic rocks along the Cascade arc in Washington, Oregon and northern California (after Du Bray and John, 2011, simplified).

References:

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