Grand Challenge: Why Does Volcanism Occur Where and When it Occurs in the Basin and Range?

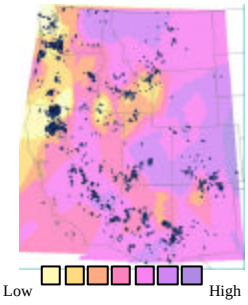
Richard W. Carlson
Carnegie Institution of Washington
Department of Terrestrial Magn(m)atism

Video decompressor are needed to see this picture.

Animation of Volcanism vs. Time produced by Allen Glazner (UNC) from the NAVDAT database (navdat.geongrid.org)

Western US Mafic Volcanism Contoured According to Potassium Content

Prepared by Allen Glazner , UNC from the NAVDAT dataset (navdat.geongrid .org)



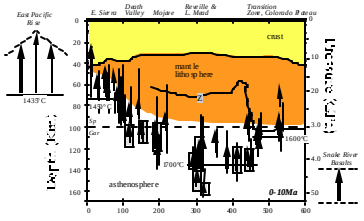
What Information Can be Extracted from the Magmatism?

- Temperature
  - Mafic magmas
    - Tholeiite - hot (wet), shallow
    - Alkalic basalt - cooler, deeper
    - Lots of crustal contamination --> warm crust
- Lithosphere Thickness
  - Mafic rock composition relates to last depth of equilibration, in order of increasing depth
    - Tholeiitic basalt < alkalic basalt < kimberlite
- Crustal Thickness/Thermal Profile
  - Depth of crystallization of mafic magmas
  - Source depth for silicic magmas

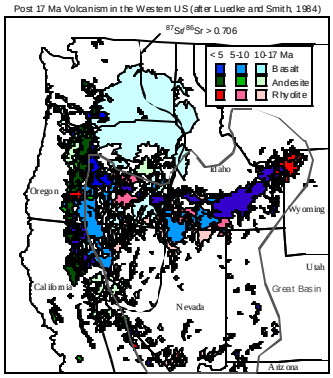
What Information Can be Extracted from the Magmatism?

- "Permiability" of Lithosphere
  - More alkaline --> deeper --> lithospheric barrier?
  - Existence - or not - of a mafic underplate
  - Amount of crystallization reflects ease of crustal transit
  - Presence or absence of bimodal basalt-silicic volcanism
  - Relation of volcanicity to faulting and extension
- Presence of Water - Subduction
  - Location of past subduction (shallow - steep)
  - Slab windows/tacos
  - Effect of non-volcanic shallow-dip subduction in "priming" the lithosphere for large volume volcanism
    - Flood basalts and ignimbrite sweeps
- Age of Magma Source
  - Identify buried terrane boundaries

Mafic magmas as a lithosphere thickness monitor



Wang, Planck, Walker and Smith, JGR, 2002



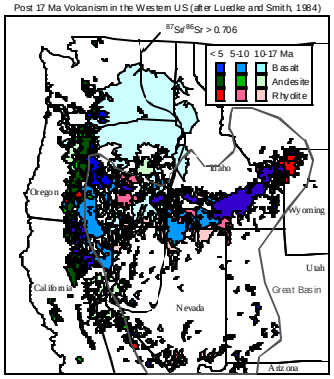
Observations

B&R does not notice PC continental boundary

Volcanism concentrated at B&R margins, particularly Northern boundary

Volcanism does not obviously correlate with amount of extension

Largest volume basalt province (CRB) has no associated silicic volcanism. Bimodal volcanism characteristic of B&R



Observations

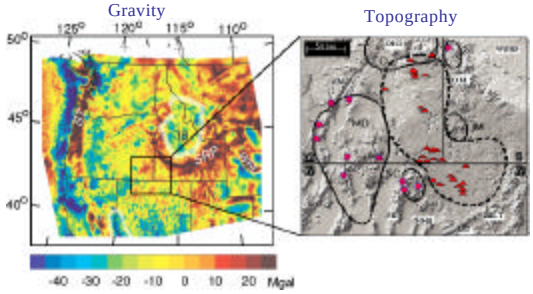
Two migrating volcanic traces, one with plate motion, the other against it

Migrating volcanism defined by rhyolites, basaltic activity continuous along both traces

Volcanism in High-Lava-Plains associated with right-lateral strike-slip faulting as extension dies out to the North

Gravity

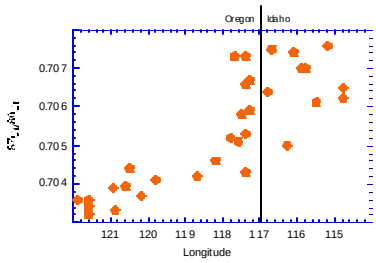
Topography



Gravity and seismology show thick mafic underplating under SRP, but not HLP. Is it there and compensated? How do you compensate with minimal ex tension?

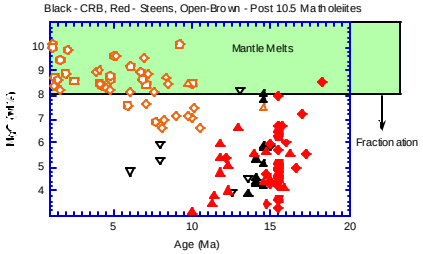
Both migrating traces start around the Owyhee Plateau, which is surrounded by silicic centers, and B&R faults, but contains neither. Is this another "Colorado Plateau" and if so, why?

Strong spatial changes in volcanic rock composition



Sr isotopic composition of post-10.5 Ma tholeiites from across central Oregon

Strong temporal changes in volcanic rock composition



Magnesium concentration as a monitor of changing extent of basalt differentiation through time, northern B&R and CRB

Conclusions (Questions) Provided by B&R Volcanism

- Extension and volcanism: some local correlations, but generally not. What is causing melting if not adiabatic ascent due to stretching? Lithosphere filter?
- Ignimbrite sweep related to steepening subduction, but how? Directly to retreating slab or caused by inflow of hot asthenosphere under hydrous lithospheric mantle?
- Plumes and migrating volcanic traces - is this the answer? Why is basaltic volcanism continuous along traces? Why is there an "anti-plate motion" trend?
- Spatially correlated compositional variation: Due to variations in lithosphere thickness, sublithospheric temperature, crustal impedance --> extension/faulting?
- Temporally correlated compositional variation: How much have lithospheric characteristics changed in 15 Myr?