An Evolutionary Model of Galápagos Magma Chambers

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3 Stage Evolution:
1. Juvenile Transient
2. Mature Steady State
3. Dying Transient

Deformation Constraints

Petrologic Constraints

- Petrologic Constraints:
  - Galápagos volcanoes undergo 3 phases of evolutionary change, corresponding to juvenile, mature, and dying stages as the Nazca Plate carries them away from the hotspot.
  - In the juvenile stage, a diverse suite of picrite-to-basalt is erupted, because each batch of ascending magma undergoes a different thermal experience.
  - In the mature stage, the magmas pass through a system that is in a thermochemical steady state, due to crystal-liquid reaction and residence in a shallow, well-mixed sill. A monotonous suite of low-Mg basalt is produced. Most of the volume of the plumbing system is crystalline mush.
  - As the volcano dies, the mush column cools and solidifies, which can create fairly large volumes of crystal-poor rhyolite.

Conclusions

- Some volcanoes at the leading edge of the Galápagos hotspot erupt picrites as well as basalts (Cerro Azul, Rosa Redonda, and Volcan Ecuador).
- Fernandina, Sierra Negra, and Wolf volcanoes erupt lavas with a very small compositional range and generally lower Mg.
- Some of the “downstream volcanoes” erupt lavas with low and variable Mg (extending to rhyolite). Alcide is the best example. Terry Naumann has recently discovered young isocataclises on Darwin volcano.

Petrographic Constraints

- Submarine Fernandina:
  - There are 2 remarkable observations to be made about the phenocryst suite: (1) the mafic minerals, e.g., olivine or pyroxene, crystallize from the mafic magma, and (2) the felsic minerals, e.g., quartz or plagioclase, crystallize from the felsic magma.

Trace Element Constraints

Changes in conservative trace element ratios with time can be used to estimate the volume of the well-mixed part of the chamber, through the calculation of residence times. Application of these extreme estimates of the governing parameters means that the volume of the well-mixed magma chamber is small. For example, it cannot be a sphere with the same radius as the caldera.