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Editorial

Introduction to mantle to magma special issue

The focal point of this volume is the use of integrated datasets to constrain interactions between lithospheric and magmatic processes mainly within the geographical framework of the North American Cordillera. Taken together, this collection of papers presents a diverse set of methodologies that exploit integrated (e.g., geochemical, geophysical or petrological) datasets to further our understanding of plate-scale processes. Large-scale geophysical surveys such as Lithoprobe (e.g., Hammer et al., 2000), ACCRETE (e.g., Hollister and Adronicos, 1997; Morozov et al., 2001), EUROPROBE, and Earthscope provide powerful constraints for our models of lithospheric processes. However, integrated geoscience studies (e.g., "petrological imaging") are capable of sharpening these geophysical images and models. For example, studies of xenoliths (e.g., Harder and Russell, p. 1–22) give the only concrete data on the otherwise impossible-to-directly sample lower lithosphere and can provide critical constraints on rock compositions and densities for interpreting geophysical results. Combined spatial and petrological/geochemical variations within well-defined magmatic provinces such as the Cascade volcanic arc (e.g., Green, p. 23–49) provide another way of "imaging" plate positions as well as testing geophysical models for plate geometries. Knowledge of magma transport pathways from the asthenosphere through the lithosphere is critical for understanding the connections between areas of magma generation, storage and final solidification; however these paths can only reliably be imaged in areas with good geophysical datasets and high frequencies of eruption such as Kilauea volcano (e.g., Wright and Klein, p. 50–79). A general understanding of magma transport within the continental lithosphere is complicated due to the wide range of possible magma compositions coupled to large variations in crystallinity, temperature, and fluid contents, all of which impact significantly on magma viscosity (e.g., Eichelberger et al., p. 135–154; Miskovic and Francis, p. 104–134; Schmitt et al., p. 80–103). The six manuscripts that constitute this special issue are clear examples of how holistic studies of "mantle to magma" processes can provide new insights into the evolution of the North American Cordilleran lithosphere.

1. Volume overview

Harder and Russell (p. 1–22) used data from mantle-derived peridotitic xenoliths to define the thermal and structural state of the lithospheric mantle beneath northern British Columbia (e.g. Llangorse volcanic field) Two-pyroxene thermometry on 44 peridotite samples define minimum (800–850 °C) and maximum (1050–1100 °C) equilibration temperatures that are indicative of the maximum MOHO temperature and the minimum temperature for the base of the lithosphere, respectively. They use these data with published heat flow measurements to produce model geotherms that constrain the thickness of the mantle lithosphere in the northern Canadian Cordillera to between 16 and 30 km, corresponding to depths to the lithosphere / asthenosphere boundary of 52– 66 km. These results have implications for the source regions of alkaline magmas erupted over this portion of the northern Cordilleran volcanic province (Edwards and Russell, 1999, 2000).

Green (p. 23–49) uses the geochemistry of primitive, basaltic lavas from the Garibaldi volcanic belt

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(GVB), which constitutes the northern end of the Cascade volcanic arc, to assess differences in the angle of subduction of the Juan de Fuca plate beneath the North American plate. Rare Earth Element and High Field Strength Element concentrations vary in the basaltic lavas in accordance with the northward younging of the Juan de Fuca slab. Variations in types of basalt parallel the subduction zone, from olivine tholeiite in the south to basanite in the north. Green shows that all of these observations are consistent with expected variations in the thermal structure of the slab and overlying mantle wedge as they change from colder and older in the south to hotter and younger in the north.

Wright and Klein (p. 50–79) use data from long-period and short-period (brittle-failure) earthquake swarms to constrain magma transport paths from the uppermost mantle to shallow (4–7 km) crustal storage areas beneath Kilauea volcano. Their work is consistent with a non-linear magma transport path, wherein the locus of deep magma transport is linked to the position of the asthenospheric (>40 km depth) Hawaiian hotspot while movement of the shallow plumbing system is tied to the overriding Pacific plate. A style of brittle-failure earthquakes unique to Kilauea defines the connection between the deep and shallow plumbing to be deeper than 25 km. Thus the magma transport path has a deep, vertical section, a sub-horizontal middle section, and a vertical upper section. The positions of deep, long-period earthquakes are consistent with migration of Kilauea's magma source to the southwest over time. The source migration through time can explain regional and local variations in the geochemistry of Kilauea basalts.

Schmitt et al. (p. 80–103) investigate petrogenetic relationships within the volcanic–plutonic systems beneath the Geysers geothermal reservoir, in the Coast Ranges of California, using major, trace element and isotopic (Nd, Sr, Pb) geochemistry. Their work defines two major isotopic source areas: (1) basalt with compositional affinities to magmas derived from the subcontinental mantle wedge, and (2) compositionally evolved rocks with geochemical affinities to regional crustal sources. Assimilation-fractional crystallization modeling of the two end-member sources coupled with geochronometric constraints indicates long term (>1 Ma) interaction between the two reservoirs to produce the Geyers plutonic complex.

Miskovicic and Francis (p. 104–134) use a sophisticated blend of field, analytical and calculational studies to explore the connections between plutonic and volcanic processes in the Sifton Range volcanic complex (SRVC), southwestern Yukon Territory. The SVRC, which is part of the Cordilleran-long Coast plutonic complex (CPC), comprises plutonic and volcanic units. They use a combination of geochemical, thermodynamic, and physical models to explore the relationships between coexisting mantle and crustal magmas. Their work suggests that changes in crystallinity and H_2O saturation during fractionation control the onset of explosive volcanism in the SRVC. As well, highly viscous andesitic magmas are proposed to have acted as a barrier between mantle-derived basaltic magma and crustally derived, anatectic rhyolitic magma. Transfer of volatiles across the hybrid interface may have periodically triggered eruptions and subsequent crystallization due to volatile loss, enhancing "magma stagnation and plutonism".

Eichelberger et al. (p. 135–154) provide a broad summary linking geochemical observations with physical constraints to investigate the origin of seemingly continuous compositional trends in volcanic arc systems. They argue that the apparent continuity of those trends is misleading and masks the true, discrete nature of magma genesis in arc systems. As with Miskovic and Francis, Eichelberger et al. find links between rock types and crystallinity, with crystal-rich intermediate compositions showing signs of open-system genesis via mixing or mingling, and between plutonic chemical processes and styles of volcanism. Melt transport dynamics can produce "mixed" or "zoned" pyroclastic deposits of magmas that are not necessarily genetically related.

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