Mélange formation, mantle-wedge diapirs and subduction zone magmatism

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Components derived from the subducting slab contribute to the source region of magmas produced at convergent plate margins. The characteristic range of compositions of these magmas is commonly attributed to three-component mixing in the source regions of these magmas: hydrous fluids derived from subducted altered oceanic crust and components derived from the thin sedimentary veneer are added to the depleted peridotite in the mantle wedge, where melt is produced. We recently proposed an integrated physico-chemical model of subduction zones that includes mélange formation at the slab-mantle interface as the dominant physical mixing process, as well as low-density mantle-wedge diapirs that transport the well-mixed materials into the hot corner of the mantle wedge beneath arcs [1].

The strong petrologic and chemical contrast at the slab-mantle interface leads to the production of hybrid rock compositions by metasomatic reactions, diffusion and mechanical mixing. The rise of low-density plumes in the mantle wedge provides a mechanism to transport these buoyant hybrid rocks from the slab-mantle interface toward the source region of arc magmas. The mélange plumes may partially melt in the hot corner of the mantle wedge due to heating and decompression, or their interior parts may dehydrate and flux-melt the overlying mantle-wedge harzburgite. The combination of these processes may produce the large range of major and trace-element compositions found in modern island arc volcanic rocks.

Consequences and predictions from our model include the following: low-velocity zones at the slab-mantle interface and in the mantle wedge may represent layers and diapirs of fluid-rich mélange material instead of hot, melt-bearing mantle. The slab components are transported as solid matter into the source region of arc magmas rather than through the classically invoked fluids and melts. The temperatures and timescales for the generation of arc magmas determined from isotope and trace-element ratios need to be revisited, as these may reflect processes in the head of the mélange diapirs rather than in the subducting slab or the harzburgitic mantle wedge.

[1] Marschall, Schumacher (2012) Nature Geosci. 5: 862–867

Raman hyperspectral imaging of carbonaceous materials and hematite: potential misinterpretations

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Raman hyperspectral imaging is becoming increasingly popular in geoscience applications, as geologists, paleontologists, and planetary and space scientists discover the wealth of non-destructive mineral data that Raman spectroscopy can provide. One common application of Raman hyperspectral imaging is identification of optically similar minerals within thin sections and their spatial distribution. For example, hematite, disordered sp^2 carbonaceous material, and graphite can co-occur within a sample and often appear as black opaque minerals that are challenging to distinguish optically [e.g., 1,2]. In order to distinguish between these three minerals geologists will typically collect a Raman spectrum in the carbon first-order region between 900-1800 cm^{-1}. Coincidently the hematite 2LO (which appear due to point defects of the α-Fe$_2$O$_3$ lattice) at ca. 1320 cm^{-1} is located in the same frequency region of the disordered sp^2 carbonaceous material D band (A$_{1g}$ mode active due to disorder and decreasing crystallite size) at ca. 1350 cm^{-1}. While some geologists are cognizant of the overlap between the broad 2LO hematite mode and the broad D band of disordered sp^2 carbon, many however remain unaware [e.g., 3,4,5,6], identifying hematite by examination of the mineral fingerprint region (200-800 cm^{-1}) only [e.g., 7]. We suggest that rather than examining the mineral fingerprint region and the carbon first-order region separately for hyperspectral 2D and 3D imaging, the entire spectral region from 200-1800 cm^{-1} should be used in order to eliminate further false identification of these two minerals. Furthermore we suggest caution when interpreting the carbon first-order region as the G band (E$_{2g2}$ mode in-plane C-C stretching LO phonon mode of an infinite crystal) from carbon is always present whatever the degree of structural order that the carbon sp^2 lattice has.

[1] Marshall *et al.* (2011) *Nat Geosci*.**4**, 240-243. [2] Marshall and Olcott Marshall (2011) *Spectrochimica Acta*.**80**, 133-137. [3] Lu *et al.* (2007) *Adv. Funct. Mater*.**17**, 3885-3896. [4] Lu *et al.* (2008) *J. Phys. Chem. C*.**112**, 7069-7078. [5] Torporski *et al.* (2004) *GIT Imaging Microsc*.**4**, 38-40. [6] Schopf *et al.* (2005) *Astrobiology*.**5**, 333-371. [7] Schopf *et al.* (2010) *Precamb Res*.**179**, 191-205.