Instantaneously developed crustal geochemical signatures in anatectic melts, and melt interconnection in the protolith

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One important issue to investigate in Earth Sciences is the rate of natural processes. Crustal anatexis and granite formation is key for understanding the generation and differentiation of the continental crust.

We have conducted an experimental program on the melting of solid rock cylinders of pelitic composition, 3-6 mm in diameter and 5-20 mm in length, at 690-800ºC, 200 and 700 MPa, under dry and wet conditions and for durations ranging from 1 hr to 60 days. The starting material is a schist with a mineral assemblage made of Ms+Bt+Crd+Pl+St+And, trace Kfs and accessories Gr+Ilm+Zrn+Mnz+Xen. All experiments produced variable proportions of melt that quenched to glass, and that was analyzed by electron microprobe and laser ablation ICP-MS.

Results show that granite melts can be generated, and likely interconnected throughout the entire protolith, in just hours to a few days, during anatexis at H_2O-saturated (a_{H2O}≈1) but also H_2O-undersaturated (a_{H2O}<<1) conditions. Melting starts simultaneously along Qtz-Pl and Qtz-Ms interfaces and Qtz-Pl-Ms junctions distributed throughout the entire core, resulting in rapid melt interconnection. Microstructural observations indicate that residual Pl and Crd recrystallize even at low degrees of overstepping in temperature. Typically crustal geochemical signatures in the melt are developed extremely rapid in terms of both major and trace element compositions. For instance, melts from H_2O-undersaturated experiments at 730ºC and 700 MPa show, after 7 days, mean concentrations of ≈170 (s.d.=45) ppm Rb, ≈150 (65) ppm Sr, ≈6 (1) ppm Sc, ≈12 (9) ppm Zr and ≈25 (10) ppm ∑REE. Likewise, melts generated during H_2O-saturated anatexis at 730ºC and 700 MPa show, after only 4 days, mean concentrations of ≈110 (30) ppm Rb, ≈170 (60) ppm Sr, ≈5 (2) ppm Sc, ≈22 (8) ppm Zr and ≈60 (28) ppm ∑REE. Although heterogeneous, the compositions of these melts are similar to S-type leucogranites and glasses in anatectic metasedimentary enclaves.

This data implies that granitic melts loaded with trace elements can potentially be generated and extracted rapidly from the source. The results have implications for the transport mechanisms of certain trace elements (e.g. Zr, LREE) thoroughout granite melts, as well as for the calculation of melt residence times by using the measured concentrations of these trace elements in granites. However, the effect of the rate of heat supply (infinite, in these experiments) on the rate of melting and the composition of melt might represent a limitation for the general applicability of these results.

Five years of Keck OSIRIS observations of Titan: quantifying the transport of aerosol haze

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Abstract

We present spatially-resolved observations of Titan in the near-infrared obtained with the field integral spectrograph, OSIRIS, at the W. M. Keck Observatory. Datacubes were acquired in H (1.5 μm) and K (2 μm) bands from April 2006 to January 2012. Broadband spectra reveal the aerosol vertical structure from the surface through the stratosphere. We describe the temporal and spatial variation in aerosol distribution as constrained by our radiative transfer models, which include updates to methane opacity and aerosol scattering.

Observations

The OSIRIS imaging spectrograph is behind the adaptive optics system on the Keck II telescope. The instrument uses a 2048 × 2048 pixel Rockwell Hawaii-2 detector, which in our observing mode corresponds to at a spatial plate-scale of 0.020” and a spectral resolution (λ/δλ) of ~4000. We observe in both H- and K-bands when possible, covering 1.473–1.803 and 1.965–2.381 μm, respectively. The field of view is 0.32” × 1.28”, such that four ~5min exposures are required to cover the entire ~1” diameter disk of Titan. We obtain datacubes on an approximately yearly basis between Apr 2006 and Jan 2012. Data are reduced using the OSIRIS data reduction pipeline, which includes flat-fielding, sky-subtraction, cosmic-ray rejection, wavelength calibration, spectral extraction and datacube assembly. Mosaicking of individual exposures is not performed with the pipeline due to spurious data near the edges of the field of view, likely caused by faulty lenslet masking. While individual exposures are nearly diffraction-limited in spatial resolution, assembling datacubes into mosaics is often limited by systematic offsets of up to a few pixels between exposures.

Aerosol Opacity Retrieval

Our models incorporate well-established numerical solutions to the radiative transfer equation and successfully simulate observations [1,2,3]. A discrete ordinates method is used with 16 pseudo-plane-parallel layers from 0 – 200 km altitude. The atmospheric vertical structure and aersol scattering measured by the Huygens probe is used as the default in the model. We explore several methods of scaling and varying the aersol structure for geographic locations and times when the Huygens probe measurements no longer apply.

Results

We describe an algorithm for navigating and reconstructing datacubes while selecting against lenslet masking artifacts. Mosaicked datacubes are used to retrieve the spatially-resolved atmospheric aerosol distribution on Titan with our radiative transfer model. We describe how the slow seasonal variation in the latitudinal haze gradient is punctuated by episodes of increased scattering.

[1] Ádámkovics et al. (2007) *Science* **318**, 962-965.
[2] Ádámkovics et al. (2010) *Icarus* **208**, 868-877.
[3] Mitchell et al. (2011) *Nature Geoscience* **4**, 589-592.