Tracing seawater-rock interaction in slow spreading oceanic crust: precise chlorine measurements in MORB by microprobe

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Chlorine is a key element in tracing present and past interaction between magmas/rocks of the oceanic crust and seawater due to the large differences in concentration between magmas derived from the asthenosphere and seawater.

Processes, such as assimilation of hydrothermally altered oceanic crust by mid ocean ridge magmas, which lead to higher magmatic chlorine concentrations, have been demonstrated for fast spreading ridges [e.g. 1, 2]. Similar features have, up to present, not been observed at slow spreading ridges, partly because their intrinsically low chlorine contents made this work analytically challenging and variations in concentrations could not be explored with conventional methods.

To change this situation we have developed a new method to measure chlorine in basaltic glass by electron microprobe. Using a combination of mapping and standard-sample bracketing techniques, chlorine can be measured at very low detection limits (10's of ppm's) with a precision of 1-2 ppm standard deviation. With this, the very low chlorine concentrations in Mid Ocean Ridge Basalts from slow spreading ridges can be explored, and the new method enables us to reveal variations that could not be observed before.

We have used this method to examine a sample set of basaltic glasses from the Southern Mid Atlantic Ridge at 7-10 °S, for which large variations in depth of last equilibration with a mafic mineral assemblage have previously been shown [3]. We find chlorine concentrations which decrease from about 200 to 60 ppm with this crystallisation depth. However, several samples,have much higher chlorine contents which are independent of depth (>300 ppm).

The chlorine variations observed may have multiple causes: 1) hydrothermal interaction, related to the present spreading, and subsequent assimilation of altered crust, 2) alteration of the rocks at the seafloor, or 3) a mantle anomaly, which potentially can be related to melting processes and/or older interaction of the ocean with the magmatic system. With the aid of other trace elements the nature of the observed chlorine enrichment will be determined and a distinction between the causes made.

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Polymict eucrite NWA 5232: composition of clasts

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Northwest Africa (NWA) 5232 is an 18.535 kg polymict eucrite, a member of the Howardite-Eucrite-Diogenite (HED) meteorite group, which are interpreted to come from the asteroid 4 Vesta [1]. NWA 5232 is comprised of four main constituents: eucrite (lithic) clasts, CM clasts, melt clasts, and matrix. A Petrographic microscope and JEOL JSM-6610LV scanning electron microscope at the University of Toronto were used to examine textures and mineral constituents of these phases. Clast sizes typically range from less than 0.5 mm to 3 cm and are variable in their distribution and angularity. The matrix is very fine- to coarse-grained, making up a significant proportion of this matrix-supported breccia. Various shock features were identified in the clasts and matrix, including bent pyroxene lamellae and pervasive fractures. The eucrite clasts show various textures, primarily subophitic, of varying coarseness and range in size from <0.5-30 mm, averaging 5 mm. Distinguishing basaltic and cumulate eucrite clasts on the basis of texture alone is problematic as both groups may be medium- to coarse-grained, have pyroxenes with exsolution lamellae, and consist of the same major mineral phases (pyroxene and plagioclase). Minor and accessory phases include SiO_2, ilmenite, chromite, Fe,Ni-metal, and troilite. A Horiba LabRAM Aramis confocal Raman spectrometer with SWIFT mapping stage at the Royal Ontario Museum was used to identify terrestrial weathering phases using the 532 nm laser. Pervasive fractures have been filled with calcite during terrestrial weathering.

Eucrite clasts were analyzed with a Cameca SX50 electron microprobe (EMP) with a 1 µm beam, an accelerating potential of 15 keV, and beam current of 15 nA at the University of Toronto. Eucrite clast pyroxenes have a Fe/Mn (afu) of 31.1 ± 2.3 n=329 (within the characteristic range of HED meteorites [2]) and of the 30 eucrite clasts analyzed with EMP, only one plotted on a pyroxene quadrilateral outside of the basaltic eucrite field as a cumulate eucrite [3]. Plagioclase compositions are within those expected for eucrites (An_{79-91}, avg $An_{87} \pm An_{1.8}$, and K (afu) = 0.003 ± 0.001 n=94) [3].

Two matrix samples and ten eucrite clasts were analyzed with INAA (Instrumental Neutron Activation Analysis) at the University of Toronto and generally show a ~5 x CI REE pattern with a LREE (La) depletion. The high $(Yb/La)_{CI}$ values (average 4.03 ± 1.24) may be due to dissolution of REE-rich phosphates during weathering [4]. The relatively high Co, Ni, and Ir contents of matrix samples (*e.g.* 27, 390, 0.032 ppm, respectively for a sample with mass of 229 mg) are consistent with the contribution of a chondritic component [4].

NWA 5232 is a polymict eucrite comprised of eucrite, CM, and melt clasts in a heterogenenous matrix. Lithic clasts are primarily basaltic eucrite clasts and no diogenite material was identified.

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