

Textural evolution of a basaltic melt in function of cooling rate

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The evolution of textures has been quantified in run-products of basaltic composition solidified at 0.0167, 0.117, 1, 3, 30 and 150 °C/min from superliquidus to 800 °C. Three of these six cooling rates were run two times. At cooling rates ≤ 1 °C/min and ≥ 3 °C/min crystals are faceted and dendritic, respectively. Crystals and dendrites have been analyzed by image analysis, to obtain the proportion (area%), length and width (μm), aspect ratio, orientation of maximum axis ($^\circ$) and phase density (n/area) of objects.

As the cooling rate increases crystal and plagioclase contents monotonically decrease, whereas clinopyroxene content shows an asymmetric Gaussian-like trend; the amount of spinel is instead always < 6 area%.

The strength of the fabric (preferred orientation of crystals) is low, except for one experiment at 0.0167 and 150 °C/min due to the likely presence of a thermal gradient.

The aspect ratio of plagioclase and spinel smoothly decreases with decreasing cooling rate; conversely, the shape of clinopyroxene does not show a specific trend.

As the cooling rate increases, the abundance of tiny crystals progressively and exponentially increases. In general, the number of crystals per area, which reflects nucleation, exponentially increases as the cooling rate increases, except at 150 °C/min.

At 150 °C/min this basaltic melt is virtually glassy (< 2 area%), indicating that 150 °C/min is close to the critical cooling rate (R_c) for this melt.

Finally, run-products from three duplicated experiments show crystal content differences < 1 , 4 and 18 area% under 0.0167, 1 and 30 °C/min, respectively.

The evolution of textural parameters experimentally observed here allows us to calibrate geo-speedometers and design new glass-ceramics.

Experimental determination of chlorine isotope fractionation in Cl_2 - Cl_{aq}^- and $\text{ClOH}_{\text{aq}}-\text{Cl}_{\text{aq}}^-$

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In nature, the most common oxidation state of chlorine is -I (Cl^-). However, in some extreme environments such as hydrothermal systems, atmosphere or Martian soils, occurrences of other oxidized form of chlorine have been recognized. *Redox* reactions are known to produce large isotopic fractionations, that have been theoretically estimated for chlorine stable isotopes at equilibrium [1].

In order to explore both the chemistry and the isotopic effects of some of these redox processes, we designed a chloride oxidation experiment. In our apparatus, liquid HCl is mixed at $\sim 20^\circ\text{C}$ with H_2O_2 , a powerful oxidant. Under a highly complex reaction pathway, this mixture ultimately leads to the formation of Cl_2 gas. The new forming gas is directly flushed out and trapped in a KOH solution, where it disproportionates into Cl^- and ClOH . In the oxidation reaction, the maximum production of Cl_2 is about 20% of the initial HCl. This experiment allows us to explore the isotope fractionation associated with three reactions: i) the oxidation of Cl_{aq}^- into Cl_2 , ii) Cl_2 degassing, iii) Cl_2 disproportionation into Cl_{aq}^- and ClOH_{aq} .

The lack of fractionation during degassing implies that $\alpha(\text{Cl}_{2\text{gas}}-\text{Cl}_{2\text{aq}}) \approx 1.000$. Assuming batch equilibrium, we can therefore determine the fractionation factors as follows:

$$10^3 \ln \alpha(\text{Cl}_{2\text{gas}}-\text{Cl}_{\text{aq}}^-) = 3.72 \pm 0.25 \text{‰ at } \sim 20^\circ\text{C}, \text{ and}$$

$$10^3 \ln \alpha(\text{ClOH}_{\text{aq}}-\text{Cl}_{\text{aq}}^-) = 3.04 \pm 0.20 \text{‰ at } \sim 20^\circ\text{C}.$$

These two values are slightly lower than the theoretically calculated values [1][2]. We will discuss the likely hypothesis to explain these discrepancies.

[1] Schauble et al., (2003) *Geochimica et cosmochimica acta*, **67** (17), 3267-3281. [2] Czarnacki et al., (2012) *Isotopes in Environmental and Health Studies*, **48** (1), 55-64.