# Grain size vs. multi-mineral $^{40}$Ar/$^{39}$Ar thermochronology

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In the case of volume diffusion, the closure temperature of a mineral is function of, among other factors, the characteristic diffusion dimension, which can be approximated by the grain size of the mineral analysed for grains smaller than or similar in size to the diffusion domains. The theoretical possibility of single mineral grain size thermochronology had been demonstrated empirically in earlier studies, mostly using biotite. In order to examine the potential of this method, it was tested alongside the widely used multi-mineral $^{40}$Ar/$^{39}$Ar thermochronology.

The sample comes from the granitic McLean pluton, in the south section of the Grenville orogeny. Seven grain size separates of biotite (ranging between 90 and 1000 μm), eight size fractions of amphibole (between 63 and 1000 μm), and three size fractions of K-feldspar (250 to 600 μm) were extracted and dated by the laser step-heating $^{40}$Ar/$^{39}$Ar method. The total gas ages obtained behave as theoretically predicted, with increasing ages for increasing grain sizes, including for K-feldspar, but with the exception of the smallest and the largest grains for biotite and amphibole (Fig. 1). The calculated cooling rates are ca. 0.7 °C/Ma for K-feldspar, ca. 2.5 °C/Ma for biotite, and ca. 11 °C/Ma for amphibole, corresponding very well to a monotonic cooling of the McLean Pluton. A quick initial thermal re-equilibration with the cooler host-rocks is followed by a much slower cooling on a thermal path parallel to that of the Frontenac Terrain situated immediately to the southeast.

The validity of the single mineral grain size thermochronology is demonstrated by comparison with the thermal evolution of the adjacent units and with the cooling history derived from a multi-mineral thermochronology, suggesting that it can be routinely used. The application of this method can be hampered by insufficiently low analytical uncertainties.

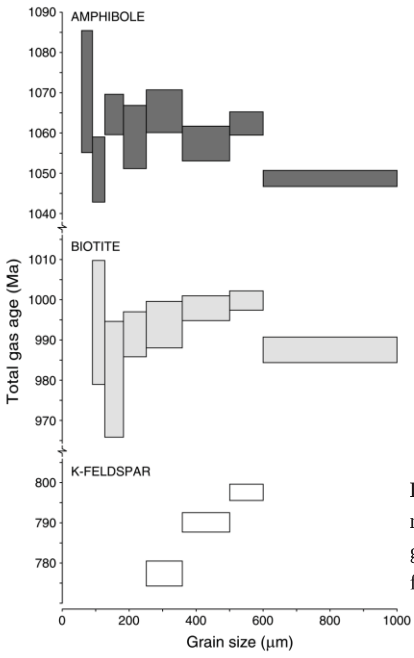

**Figure 1:** Analytical results, showing total gas $^{40}$Ar/$^{39}$Ar ages as function of grain size.

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# Volcanic impact on the silicon isotope composition of natural waters during the 2010 Eyjafjallajökull eruption, S-Iceland

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When Eyjafjallajökull volcano erupted in 2010, volcanic ash exploded through crater ice. The resulting fine grained ash and several *jökulhlaups* (glacial outburst floods), flushed volcanic material over the surrounding lowlands, towards the oceans and distributed atmospheric dust ash deposition over much of Europe. The ash and volcanic suspended matter, including dissolved solids and gases were incorporated into the surface waters surrounding the volcano and hence into the ocean. We collected natural water samples from the field, including *jökulhlaups* close to the vent south of the volcano (X), the big *jökulhlaups* in Markafljót river which is flowing from the north of the volcano, south towards the sea (Y), and ash contaminated surface waters (Z). In addition, flow-through plug experiments on pristine trachyandesitic ash samples, were performed in order to determine release rates of leachates from the ash [2].

The temperature of the natural waters ranged from 0.1 to 11°C and the pH from 5.86 to 7.95. The dissolved Si content ranged from 7 to 18 mg·l$^{-1}$, with the highest value measured in the *jökulhlaups* during the first day of the eruption. The Si isotope composition ($\delta^{30}$Si) in the natural waters ranged from -0.45 to 1.38 ‰. Prior to the first flood, the Si isotope composition of the river (Y) was 0.84 ‰, very close to other surface waters in Iceland [1]. The lightest $\delta^{30}$Si ratios were found in X. In contrast, waters from Y were isotopically heavier (0.35 – 1.17 ‰). The heaviest Si isotope signatures were measured in Z (0.51 to 1.38 ‰).

The ash experiments were conducted on single cell plug, with fixed flow rate of DI water. The experiment was run at ambient T/P. The pH in the collected leachates went up to 10.3 the first day, dropping to pH 9.2 after 1 week. The results showed higher release rates of most elements during dissolution of salt coatings found on the ash-grain surface [2]. The total Si release rate, normalized to the measured BET surface area, went from $10^{-7.6}$ mole Si /m$^2$/sec. at the beginning, reaching steady state at $10^{-8.6}$ mole Si /m$^2$/sec. The $\delta^{30}$Si ratio measured was 0.28 ‰ in the first sample (after 13 min.) and then dropped down to -1.40 ‰ during dissolution of the salt coatings. It stabilazed at -0.60 ‰, closer to the isotope ratios of basalt [1].

These results show dramatic changes in the $\delta^{30}$Si ratios of the surface waters and floods during the eruption. The waters directly linked to the erupting crater and pristine ash, had significally lighter ratios than recorded in waters accompanying basalt weathering [1]. The flooded rivers recovered quickly, within 11 days the Si isotopic composition was found to be similar to that prior to the eruption.

[1] Georg et. al. (2007) *Earth Planet. Sci. Lett.* **261**, 476-490. [2] Alfredsson et. al. (2011) *Min. Mag.* **75(3)**, 423.