Diffusion in Crystals

Estimating geologic cooling rates from diffusion profiles in minerals

May 24 2023

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Overview

Write something about how diffusion rates vary for different cations and isotopes, crystal-chemical controls on diffusion rates, the temperature dependence of diffusion, and its application for recovering cooling rates of rock samples. Use Kohn et al. (2017) as your guide. For example, Figure 1 & Figure 2. Fake link.

Generally speaking, *geospeedometry* involves dozens, or even hundreds, of (sub)micrometer-scale measurements of major elements (e.g. Fe, Mg), trace elements (e.g. Zr, Ti), and/or isotopic compositions (e.g. $\delta^{18}O$, U-Th-Pb) across mineral grain boundaries, or from the centers (cores) of a mineral grains to their outer edges (rims). The individual spot measurements of *in situ* crystal chemistry are typically made on an Electron Probe Microanalyzer (EPMA), Laser-Ablation Inductively Coupled Plasma Mass Spectrometer (LA-ICP-MS), or Secondary Ion Mass Spectrometer (SIMS). These instruments have upsides & downsides in terms of their dollar cost, time commitment, accessibility, availability, reliability, capability, and analytical advantages & disadvantages (Table 1).

Table 1: Common instruments for micro-analyses of minerals

instrument		spot			sample	
	precision (%)	size (μ)	rate (spot/hr)	fee (USD/spot)	prep	cost (USD)
EPMA	1-2	1-3	10-100	2-5	C coat	30-50
LA-ICP-MS	1-2	10-50	100-600	1-2	none	30-50
SIMS	1-2	1-35	1-4	25	Au coat	30-50

Note: samples can be polished epoxy rounds or thin sections

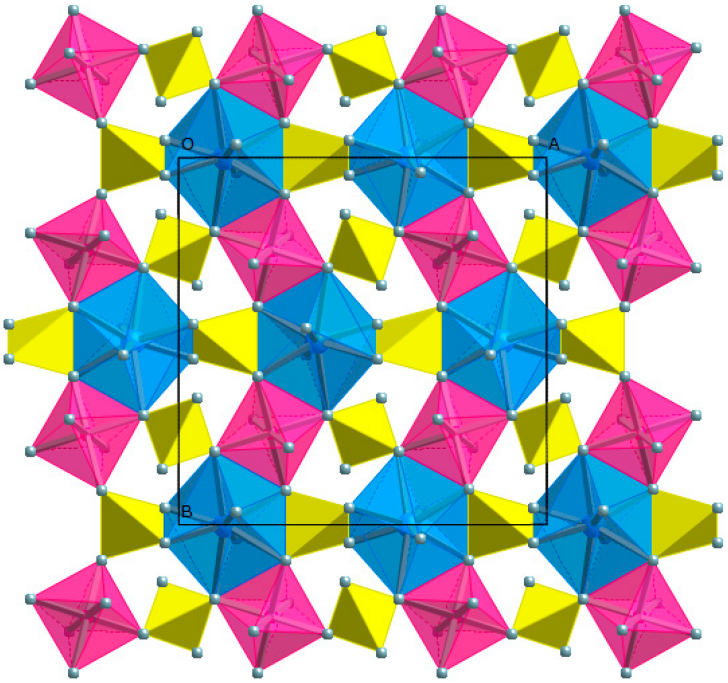

Figure 1: The garnet crystal structure showing dodecahedrally- (blue; Mg, Fe^{2+}, Mn, Ca), octahedrally- (pink; Al, Fe^{3+}), and tetrahedrally-coordinated (yellow; Si) lattice sites. Gray spheres are O atoms. Note the zig-zag arrangement of alternating pink octahedra and blue dodecahedra. From Antao (2021).

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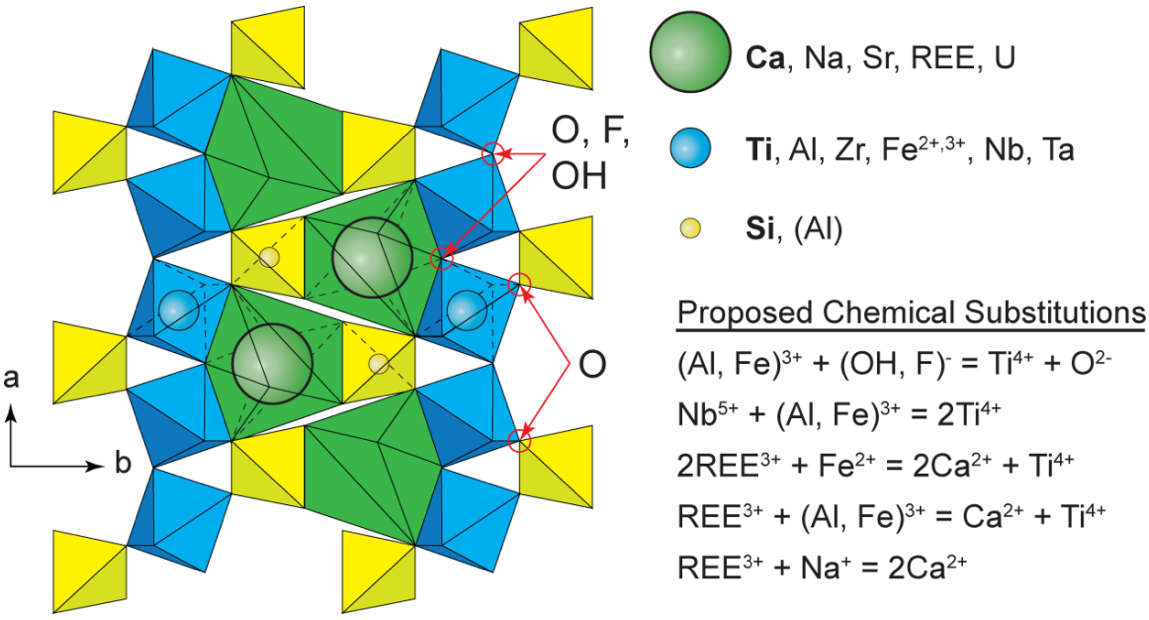

Figure 2: Crystal structure of titanite ($CaTiSiO_5$). From Kohn (2017).

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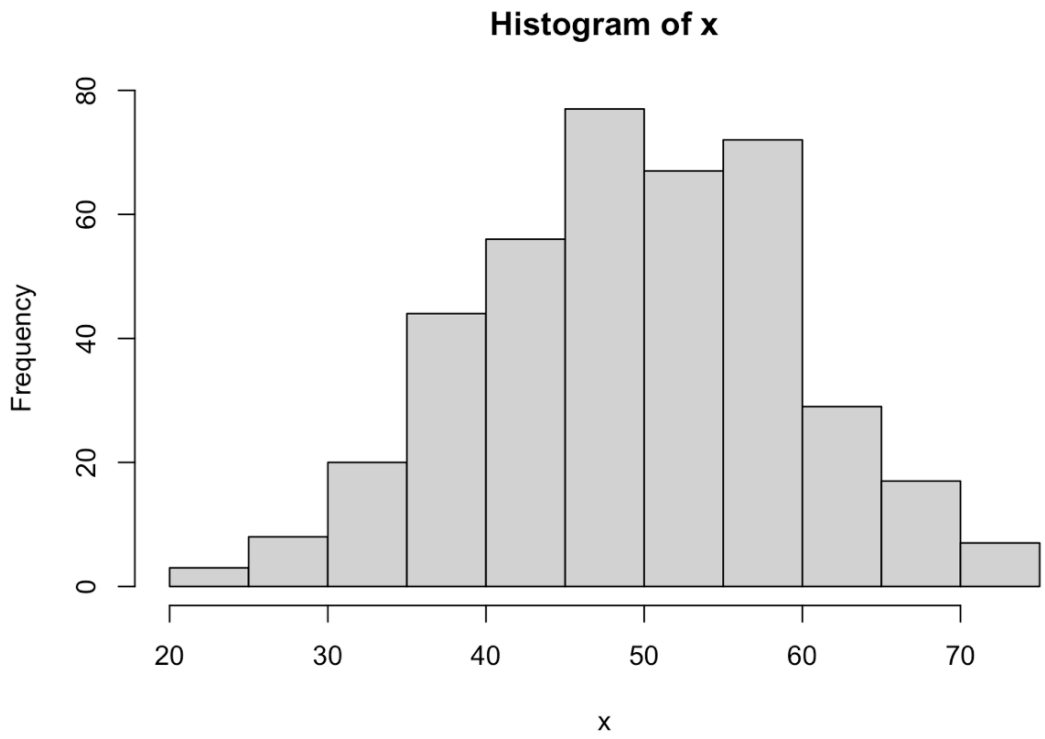
Code block

```
for i in {1..5}
do
  echo "Welcome $i times"
done
```

```
x <- rnorm(400, mean=50, sd=10)
hist(x)
```



References

Antao, S. M. (2021). Crystal structure of an anisotropic pyrope garnet that contains two cubic phases. *Minerals*, *11*(12), 1320.

Kohn, M. J. (2017). Titanite petrochronology. *Reviews in Mineralogy and Geochemistry*, *83*(1), 419–441.

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