In situ CO$_2$ quantification in apatite by FTIR: Opportunities and limitations

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CO$_2$ is a key agent for metamorphic and igneous processes, for example, driving metamorphic reactions, controlling mass transfer, and impacting the solidus. However, determining the CO$_2$ content in igneous and metamorphic systems is notoriously difficult due to the fugitive behavior of CO$_2$. While studying fluid inclusions can be a useful way to gain insights into fluid compositions, their complexity can be a limiting factor when interpreting fluid compositions in the crust. An alternative approach for determining crustal fluid compositions is the analysis of minerals that contain volatile fluid tracers. Although several minerals can incorporate the fluid tracers H$_2$O, Cl, and F, such as amphibole or biotite, the variety of minerals in silicic rocks that host CO$_2$ is limited. One exception is apatite. Apatite, a ubiquitously present mineral in crustal rocks, can incorporate CO$_2$ in its crystal structure via different (coupled) substitution (e.g., Pan and Fleet, 2002).

While it has been previously recognized that apatite can incorporate appreciable amounts of CO$_2$, its quantification on a micrometer-scale has remained difficult due to the lack of suitable techniques, challenging sample preparation methods, and the shortage of reliable standard reference material. Here we present preliminary data from our attempt to calibrate absolute CO$_2$ contents in apatite on a micro-meter scale using Fourier-Transform Infrared Spectroscopy (FTIR) using a microscope equipped with a Germanium-tip objective. This set up allows attenuated total reflectance measurements ofapatites in polished thin sections, without the need for doubly polished samples. The absorption of C-related bands is calibrated with a set of independently measured apatite standard reference materials via nuclear reaction analyses. Limitations of the technique and new opportunities to better quantify CO$_2$ contents in igneous and metamorphic systems will be discussed.