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Cross correlation of chemical profiles in minerals: insights into the architecture of magmatic reservoirs

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Analysis of chemical zoning in minerals offers the opportunity to reconstruct the pre-eruptive conditions and the temporal evolution of magmatic reservoirs. The chemical composition of minerals is a function of the thermodynamic conditions of the reservoir from which they grow and therefore minerals record the evolution and variation of residual melt chemistry and intensive parameters within the magmatic system. A quantitative approach is required to determine if similar crystals actually shared a portion of their crystallisation history. These analyses are in many cases extremely time consuming and rather expensive. Therefore, it is not always possible to analyse a statically significant number of crystals, especially within their textural context in thin sections and that is the main reason to build automated methods. We are presenting a numerical cross-correlation method that compares the zonation pattern of minerals to identify if they share the totality or part of their growth history. We modified the method first developed by Wallace and Bergantz (2004) to compare profiles in minerals also from samples collected in different outcrops and that can be used for any dataset (i.e. geochemical proxies in stratigraphic sections).

The main purpose of this method is to objectively compare chemical profiles in minerals (collected by electron microprobe, LA-ICP-MS or cathodoluminescence images) and quantify their degree of similarity. For this purpose, we use a well-known mathematical tool: the cross correlation which is a way of quantifying the difference between two given signals at a given position. Once our program was built, we performed tests using a set of synthetic profiles, profiles acquired along different transects of the same mineral and also on different minerals.

Finally we applied our program to about 100 zircons from Kilgore Tuff, Heise Volcanic Field (USA) collected at different stratigraphic levels in two different outcrops. The correlation shows that two populations of zircons can be identified on the base of the variations of grey-scale intensity of catholuminescence of their outer rims. The relative proportion of zircons from the two population is different in the investigated sections, which are locate at two extreme of the Heise caldera. No correlation was found between the cores of these zircons. These results suggest, in agreement with recent zircon isotopic studies that several isolated pockets of eruptible magma merged just before the eruption (e.g. Wotzlaw et al., 2014).

References

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