EGU21-10053
https://doi.org/10.5194/egusphere-egu21-10053
EGU General Assembly 2021

Crystal zoning patterns: competition between crystal growth and elements diffusion

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Magma reservoirs represent areas of large variation in the physico-chemical properties of magmas and are directly associated with volcanic activity. Understanding the processes acting at inaccessible depths is of crucial importance to interpret monitoring signals and to develop quantitative models to forecast volcanic activity. Minerals are witnesses of the temporal evolution of the physico-chemical conditions within magma reservoirs recording variations of intensive parameters as chemical signals. However, the competition between crystal growth and elements diffusion in the melt phase can also modulate the chemical zoning of minerals, therefore complicating the interpretation of chemical zoning patterns. To disentangle this complexity, chemically zoned minerals are synthetically grown at the Petro-Volcanology Research Group of the University of Perugia, under controlled conditions. For these experiments tephra from 2002-03 Mt. Etna eruption is used as starting material. The zonation in minerals is been forced inside a high-temperature furnace by oscillating the temperature with three different setups: static conditions, using a controlled deformation gradient (Concentric Cylinder Apparatus) and using a chaotic mixing regime (Chaotic Magma Mixing Device). The zoned crystals are analysed for major and trace elements by Electron Probe Micro Analyzer (EPMA) and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), respectively. High spatial resolution elemental maps (0.5 micrometres) are also collected to characterise the zoning of selected crystals. The data are analysed using a series of custom-built machine learning algorithms to disentangle zoning related to variations of the thermodynamic conditions of crystal growth from the effects of the competition between diffusion and growth. The main target of this project is to provide quantitative tools to distinguish between chemical zoning forced by thermodynamic conditions of growth and chemical zoning produced by competition between crystal growth and element diffusion.