MSc by Research (*Volcanology*)

Welding under pressure: an experimental study of ignimbrite formation

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Background:

Sintering describes the process in which hot, fragmented volcanic particles (ash, pumice) adhere and fuse, either through viscous flow (melting and coalescence) or solid-state diffusion (atomic movement), forming denser, stronger volcanic rocks such as ignimbrites or lava domes (Figure 1), thereby reducing porosity and permeability [1]. Sintering is one of the most essential processes during ignimbrite formation, as evidenced by the transition from loose, dispersed Pyroclasts to a welded, compact ignimbrite. Within this wide textural spectrum, ignimbrites are often characterized by heterogeneous layers with varying degrees of sintering. The degree of sintering and its precise influence on the physical properties (porosity, permeability…) of materials are difficult to constrain, as they depend on several parameters, such as the pressure applied on the material. This type of constraint is believed to drive deformation localization and sintering heterogeneity.

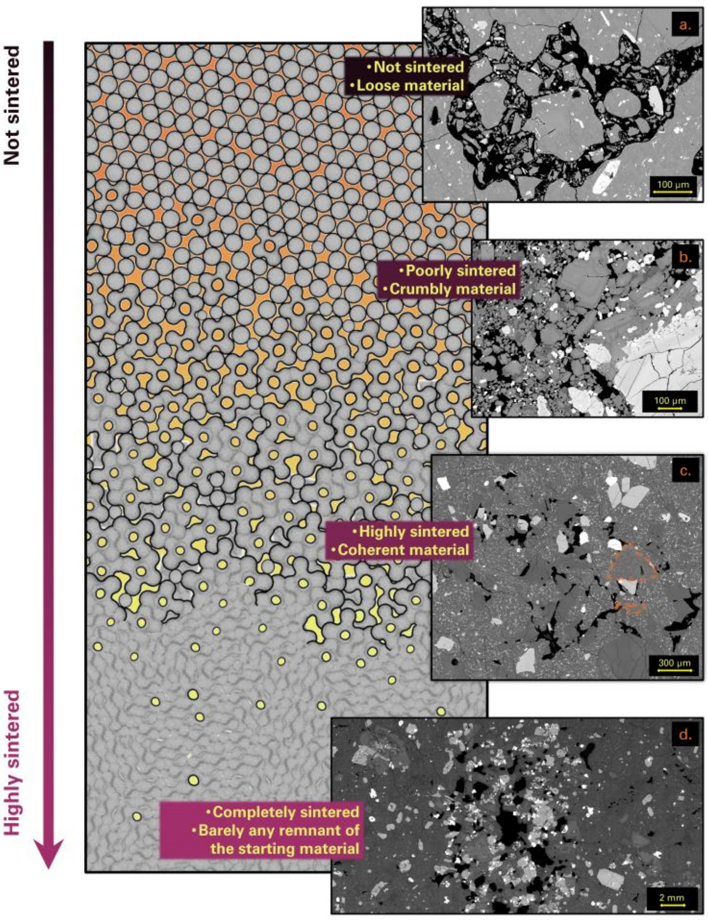

Figure 1: Schematic of particle sintering, from not sintered (top) to highly sintered (bottom). The inserts on the left are SEM images of (a.) Santiaguito Volcano, (b.) Colima Volcano, (c.) Ceboruco Volcano and (d.) Soufriere Hills Volcano.

These heterogeneous textures, generally associated with explosive eruptions [2], have also recently been observed in dome rocks, characteristic of effusive behaviour. To address this paradox, a recent conceptual eruption model [3] proposes that pyroclast sintering can also occur in shallower conduits, thereby triggering lava-like eruptions. This hypothesis demands the redefinition of the explosive and effusive eruptive styles and challenges previously established boundaries between these behaviours.

- *What is the influence of Uniaxial stress on Volcanic sintering?*
- *How do the experimental textures compare with the natural samples?*
- *Is sintering also responsible for effusive eruptions?*

Project Aims and Methods:

This project aims to constrain the influence of external uniaxial stress on sintering.
After 2D and 3D analyses of the different starting materials (to constrain the properties of the synthetic glass used), the candidate will conduct sintering experiments in a high-temperature oven at various timescales and under varying vertical loads.
The samples will be analysed both quantitatively to constrain their porosity and permeability and qualitatively by examining their textures. The candidate will also characterize a larger conceptual model of sintering with respect to several parameters such as timescale for rounding and coalescence of glass particles, surface tensions and capillary forces.

The aim is to observe and describe differences in sintering with/without external vertical pressure, and to compare these samples with natural ignimbrite and dome rock samples.
The outcomes of these experiments and models would apply to real-world volcanism, with the aim of improving our understanding of dynamic sintering in volcanic conduits and, to an extent, its influence on eruptive transitions.

Training and skills development:

- Sample preparation
- Microscopy and SEM imaging
- Experimental protocol and use of HT devices
- Writing of Scientific experimental reports

Pre-requisites:

The successful candidate will have:

- Good knowledge of Volcanology, with special interests in explosive behaviour and eruptive transitions,
- Good knowledge of Petrology and physical geology.

References and further reading

[1] Vasseur, J., Wadsworth, F. B., Lavallée, Y., Hess, K. U., & Dingwell, D. B. (2013). Volcanic sintering: Timescales of viscous densification and strength recovery. *Geophysical Research Letters*, doi:10.1002/2013GL058105

[2] J. C. Eichelberger, C. R. Carrigan, H. R. Westrich, and R. H. Price (1986). Non-explosive silicic volcanism, *Nature*, doi: 10.1038/323598a0.

[3] F. B. Wadsworth, E. W. Llewellin, J. Vasseur, J. E. Gardner, and H. Tuffen (2020). Explosive-effusive volcanic eruption transitions caused by sintering, *Sci. Adv*, doi: 10.1126/sciadv.aba7940.

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