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3D and 4D tomography for volcanic and magmatic materials: recent successes & future directions

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Recent advances in laboratory and synchrotron X-ray tomography now mean we can produce images with high spatial and phase resolution faster than ever before. This allows us to use in situ apparatus to perform in situ observations under realistic conditions. Here we present a series of case studies that provide overview of the latest high speed real-time x-ray tomography methods, where acquisition rates can now reach 20 3D frames per second at spatial resolutions of a few microns. When these frame acquisition rates are applied to volcanic and magmatic processes, we can capture the phase interactions in magma flows: from bubble growth and coalescence to crystal network formation and disruption, and the extraction of melts from crystal mushes. We will showcase the latest apparatus for in situ analysis of the rheological properties of magmatic, and the interaction processes that occur during 3-phase deformation. This can be used for multi scale imaging on any synchrotron beamline. We will also discuss some of the other recent laboratory and synchrotron techniques, and those under development (correlative microscopy, helical scanning, hyperspectral imaging, XRD tomography etc.) and how these may transform our understanding of volcanic and magmatic processes.