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# Volcanic edifice weakening via thermal reactions

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Edifice instability, that can result in catastrophic flank collapse, is a fundamental volcanic hazard. The sub-volcanic basement can encourage such instability, especially if it is susceptible to reactions generating thermal decomposition near magmatic temperatures. For this reason, understanding how the physical and chemical properties of sub-volcanic lithologies deteriorate at high temperatures is potentially highly relevant for volcanic hazard mitigation. This is particularly true for sedimentary rock, commonly found underlying volcanic edifices worldwide, that undergo rapid deterioration even under modest temperatures. Here we present the first experimental study of thermo-chemical reactions, induced by magmatic temperatures, on a range of sedimentary rocks from a sub-volcanic basement.

Here we present the results of an experimental study on three different limestones found within the subvolcanic basement at Mt. Etna, Italy. The three limestones are (1) Thala limestone (19% porosity, 73-22 calcite-dolomite ratio), (2) Mt. Climiti limestone (32% porosity, 100% calcite) and (3) a marly limestone (6.5% porosity, 75% calcite, 15% quartz and 10% kaolinite). Our study demonstrates that, at temperatures of 800˚C, the carbonate in the samples is completely dissociated, resulting in a loss of about 45% mass (for the two purer limestones) and about 35% for the marly limestone. Secondary phases, such as portlandite, lime and periclase, form at these high temperatures. These debilitating chemical changes have a dramatic influence on the physical properties of the investigated limestones. Porosity, dynamic Poisson's ratio and the$V_p/V_s$ ratio all show a substantial increase, whilst P- and S-wave velocities and dynamic Young's modulus all show a substantial decrease. Although total changes in physical properties are less for the marly limestone, likely to be the result of its lower carbonate content, it shows greater physical property degradation at lower temperatures, due to the dehydroxylation of kaolinite.

We suggest that these changes in physical properties can help explain (1) the increased edifice instability seen to follow magmatic events, (2) the anomalously low seismic velocity zone present within the sub-volcanic sedimentary basement, (3) the anomalously high $CO_2$ degassing and the conflict between the calculated magma volume at depth (using $CO_2$ emissions) and the volume of erupted magma, and (4) the anomalously high $V_p/V_s$ ratios and the rapid migration of fluids. The data also suggest that care must be taken when selecting elastic parameters (1) to model ground deformation at an edifice, (2) for the calibration of damage mechanics criteria, and (3) when applying simple failure criteria to studies of volcano flank stability.