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A New Model for Gas Transport and Storage in a Permeable Volcanic Edifice

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There is a marked contrast between the behaviour of a volcano in an open system compared to one which is closed. It is therefore essential to understand degassing, to appreciate how much gas is lost and where. Previous studies by a variety of scientists have led to the accumulation of data via field evidence from both active and fossil volcanoes (Stasiuk et al., 1996), laboratory experiments (Moore et al., 1994) and conceptual modelling, in which Darcy's Law has become increasingly applicable (Eichelberger et al., 1986; Edmonds et al., 2003). Of particular interest for this study, is the effect different permeabilities and pressure gradients (atmospheric, lithostatic, hydrostatic) have on the degree and pattern of the gas flux.

A new method has been devised to investigate gas transport and storage in a permeable volcanic edifice. The continuity equation and Darcy's law are amalgamated to derive a partial differential equation which is solved using a finite element method to obtain the gas pressure. The associated pressure gradient is then used within Darcy's law to calculate the gas flux. The properties of the gas are described by the ideal gas law. The strength of this method is that it allows the modelling of two and three dimensional structures both in stationary equilibrium and as a time dependent progression. A geometry is created and the pressure and permeabilites incorporated into the model as boundary and domain conditions respectively. The aim of the model is to investigate how variable permeability and pressure gradients influence the gas flux, for example highly permeable cracks in the dome, or impermeable layers within the volcanic structure.

We also use this gas model to complement the model of Neuberg et al. (2006) in which brittle failure of the conduit-wall boundary is used as a trigger mechanism of low-frequency earthquakes. The associated behaviour of the gas in response to the brittle failure is simulated in our model by increasing the permeability through a narrow zone at the boundary between the conduit and country rock.

Our model is highly versatile and has the potential to be integral to the understanding of gas transport and storage within a permeable volcanic edifice.