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The attenuation of interface waves: implications for low-frequency volcanic earthquakes.

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Volcanoes possess a wide variety of potential seismic sources and as such are capable of producing a large range of seismic signals. One category of volcanic seismic signal has, however, been recognised as having immense forecasting potential (Chouet, 1996), yet has also proved one of the most challenging to understand. These are low-frequency or long-period volcanic earthquakes, which are considered a key part of volcanic monitoring as they are one of the few available tools that can link surface observations directly to internal volcanic processes. Our model for their generation on the Soufrière Hills Volcano, Montserrat, is brittle fracturing of the magma at the conduit walls, which provides the seismic trigger mechanism, followed by conduit resonance.

In this study we first revisit an old debate over the nature of the resonating source body and discuss what role attenuation can play in discriminating between different models. We explain the origin of the attenuation of low-frequency signals, and describe how the amplitude loss can be decomposed into constituent parts. We also review previous research on the attenuation of low-frequency signals and discuss some of the limitations of these studies, highlighting where we feel our approach to be different.

To study in detail the relationship between the components of attenuation we use a forward modelling approach, including the intrinsic attenuation through viscoelasticity - parameterising the magma as an array of Standard Linear Solids. We demonstrate that the simple relationship between the components of the attenuation of Aki (1984) does not hold. We show that the two components of the observed attenuation do not contribute equally and that, in our models, interface waves do not experience the same level of attenuation as acoustic P-waves propagating in the fluid.

We then use an analytical approach, drawing on the work of Korneev (2008) who, following Ferrazzini & Aki (1987), derived an analytical expression for the interface wave phase velocity for a viscous fluid layer embedded between two elastic solids. We apply the equations of Korneev (2008) to a volcanic setting, and verify the results of our modelling: that the attenuation of the interface waves in such a layer is lower than for acoustic waves, given certain choices for magma viscosity.

Finally we summarise our findings and discuss the implications of these results. Our results lend support to the ‘conduit resonance’ model for low-frequency events, countering criticism that the intrinsic attenuation of the magma would be too high to support resonance.

References

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