Generating long-period and tremor-like seismicity without fluids in volcanic materials

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Background

Volcano seismicity is routinely used in the remote monitoring and forecasting of activity at volcanoes around the world. The nature of this seismicity varies, but long period (LP) seismicity is generally interpreted as an indicator of fluid migration, and as a potential precursor of increased activity at the surface. We employ acoustic-emission to monitor rock deformation experiments using weak volcaniclastic sediments at a range of strain rates, including simulating low strain-rate deformation typical of shallow conditions during volcanic unrest. These produce microseismic events which are spectrally indistinguishable from long-period and tremor seismicity observed in natural volcanic settings, with the effect most noticeable at low (visco-elastic creep) strain rates.

Method

Samples were analysed using a Sanchez servo-controlled triaxial deformation apparatus, combined with a 12 channel acoustic emission (AE) system recording at 10 MHz. The Neapolitan Yellow Tuff samples were prepared as a 40 mm diameter 100 mm long core, dried, and placed within a nitrile jacket which enables the attachment of the AE sensors. Confining pressure is provided by either oil using servo-controlled pumps, or a nitrogen gas supply. 1.5 MPa confining pressure was used, simulating ~ 100 - 150 m depth in high permeability volcaniclastic sediment.

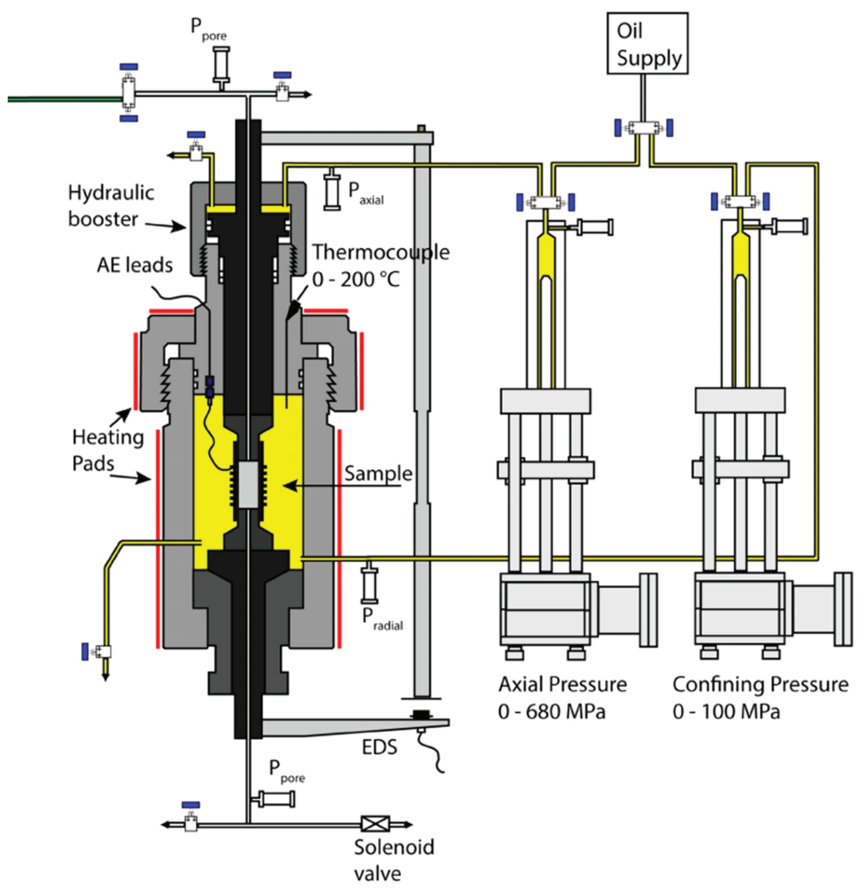


Figure 1 Triaxial cell used in this work, adapted from Fazio *et al.* 2019

Rapid axial deformation was generated at a constant 3.6 mm/hr, with failure genrally occurring between 30-40 minutes after the start of the experiment. Slow deformation experiments ran at 0.6 mm/hr and ran until similar total deformation had been achieved. This did not result in brittle failure of the material.

Event rates & core frequencies

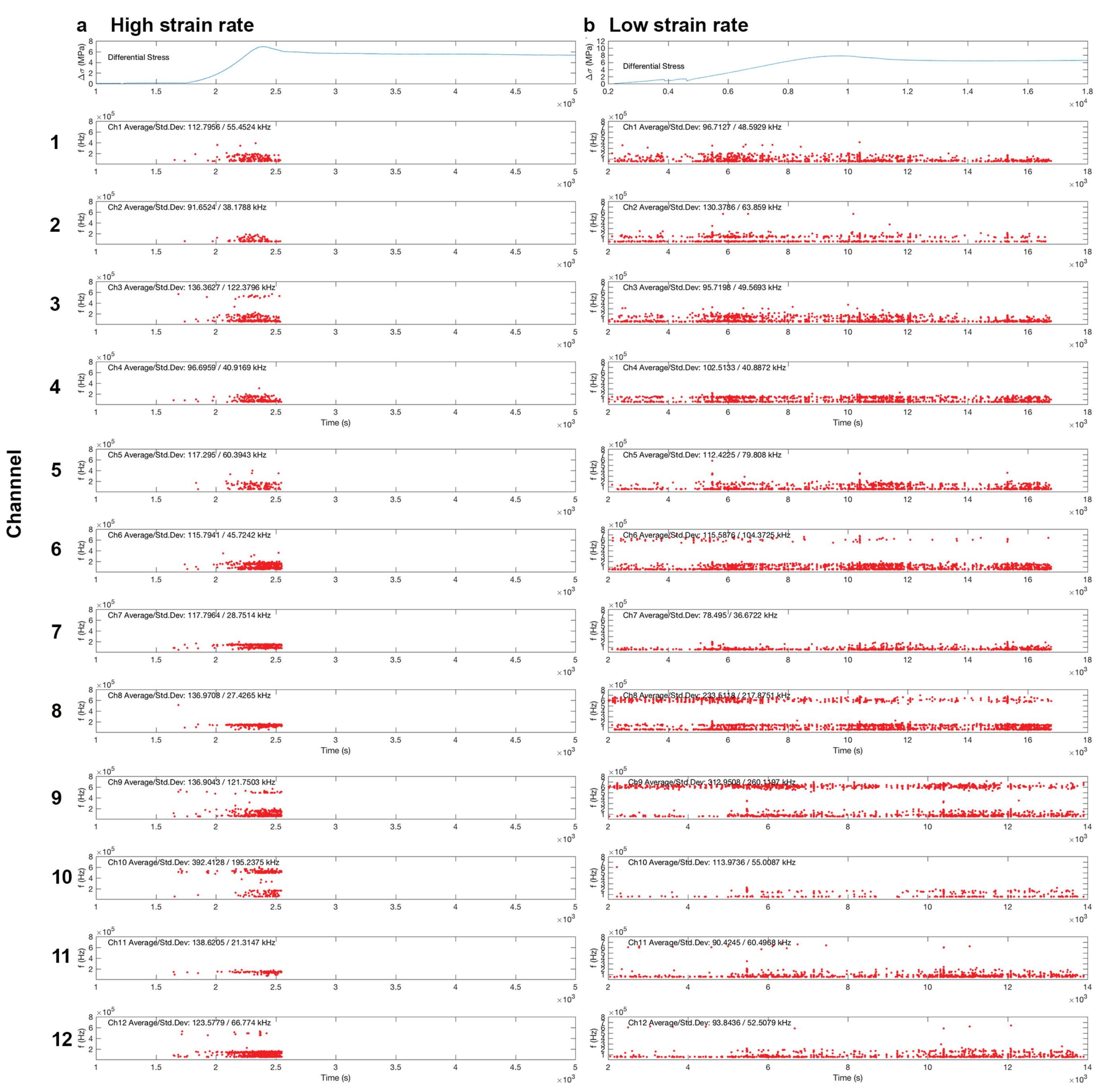
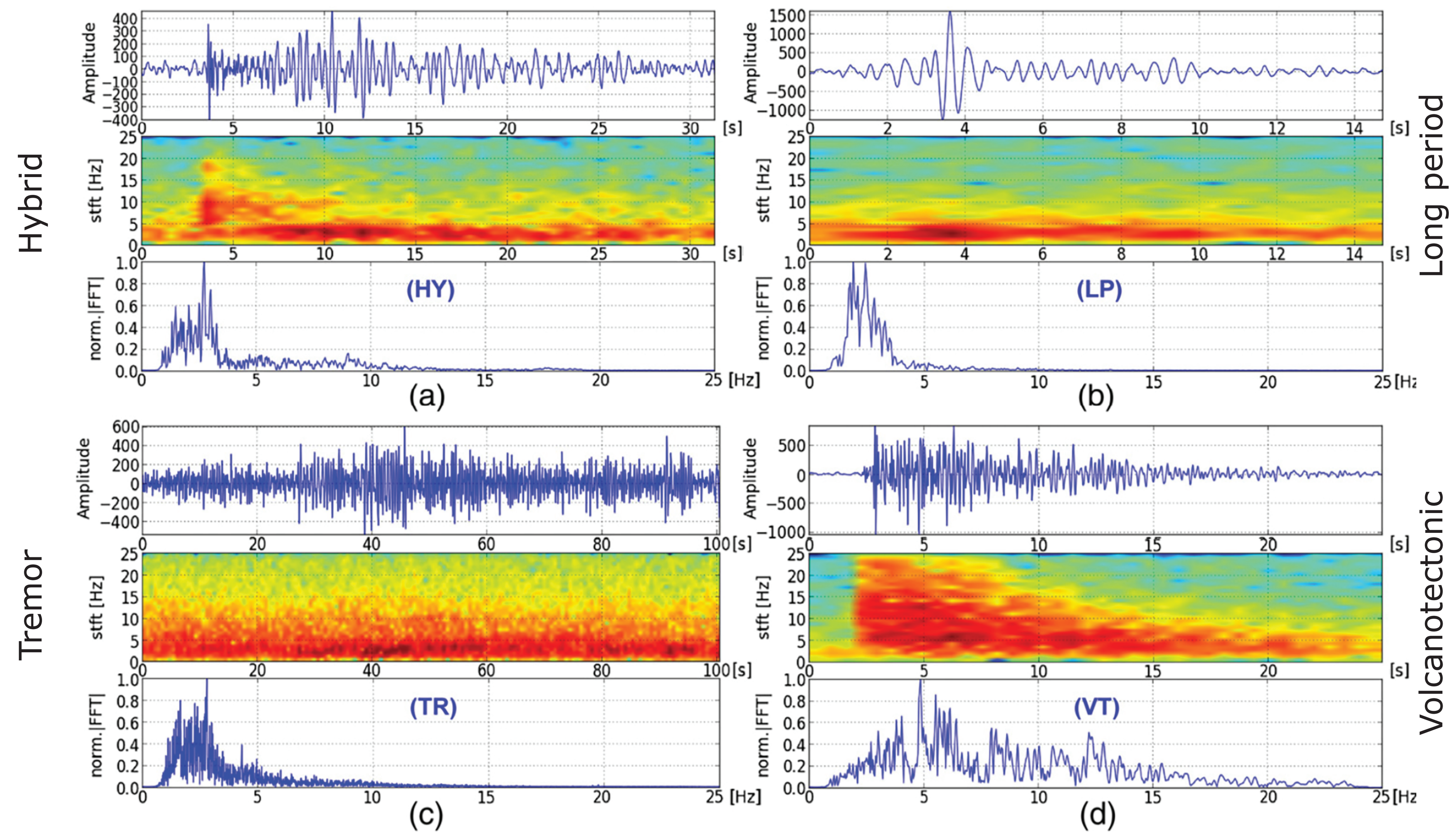


Figure 2 - Time series of core frequencies for each recorded event across the 12 sensors during (a) a high strain rate and (b) a low strain rate experiment, including stress-strain curve in the upper panel. These results show that while both high and low strain rate experiments show low frequency events, although the very lowest frequency signals (<100 kHz) are more common in the lower strain rate conditions, and that the bulk of seismicity in the lower strain rate conditions is occurring after the material reaches peak strength, ulike the high strain rate experiments where seismicity accelerates as peak strength is approached and then ceases. Event rates in high strain rate experiments are higher, but total number of events is

Event spectra

a) Volcanoseismic signals



b) Experimental signals

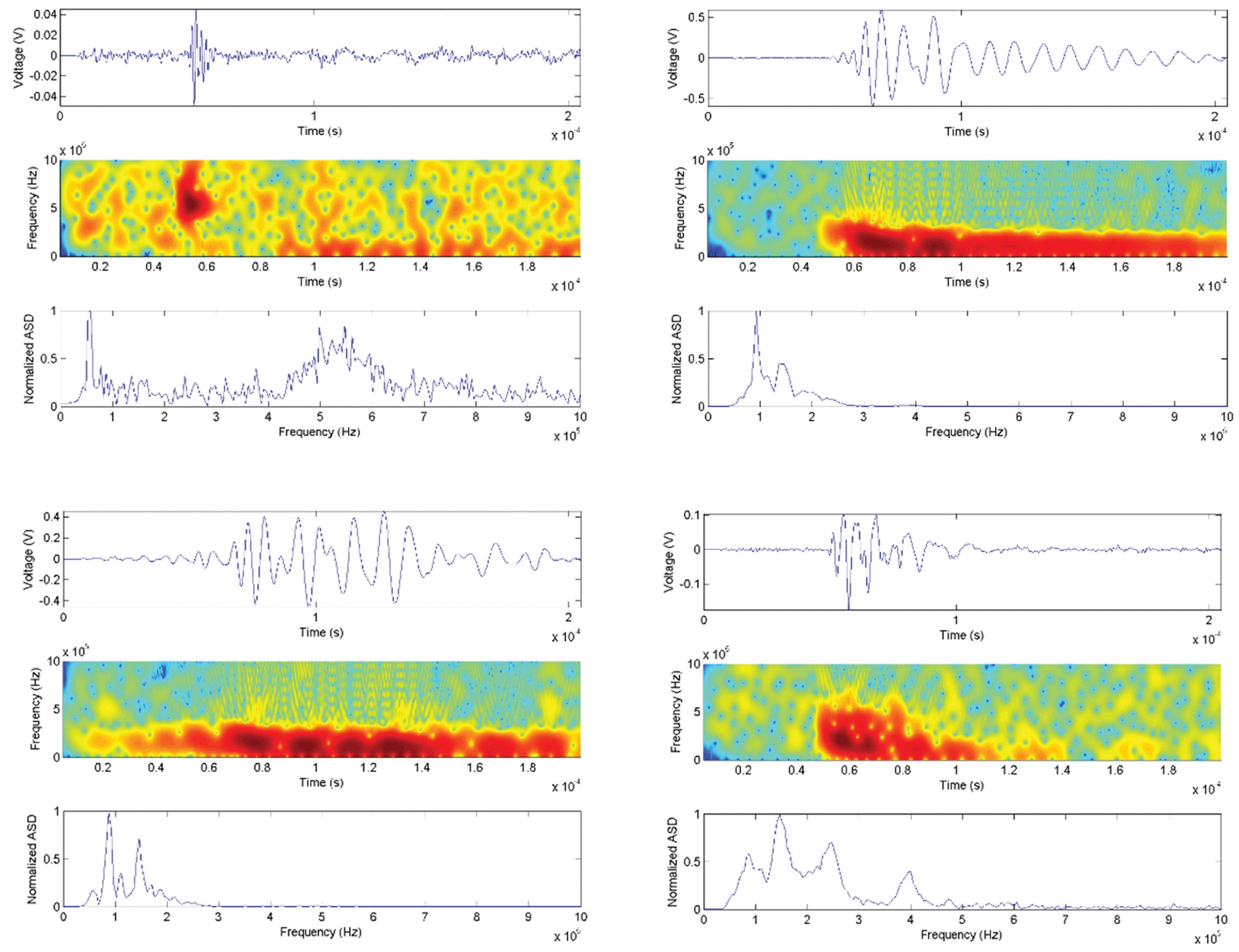


Figure 3 (a) typical events representing the four main classes of volcanoseismicity, recorded at Deception Volcano, adapted from Cortes et al 2014, and (b) experimental signals recorded during low strain rate experiments which have similar character. In the experimental data transducer voltage is proportional to the magnitude of compression. Note 10^6 dimension-frequency scaling, e.g. Benson et al. 2008

Summary

Low frequency long duration seismic activity (LP and tremor) has been associated with fluid movement in forecasting volcanic activity (e.g. Aki et al., 1977).

Low strain-rate experiments of Neapolitan Yellow Tuff - typical of low-cohesion volcanic materials - **simulating shallow surface deformation** of an edifice **generates LP and Tremor-like events with no fluid migration required.**

Volcanic tremor and long period seismicity may not always mean what we think they do.

References

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