

## **Infrasonic Crackle from the 2011 Eruption of Nabro Volcano, Eritrea: Evidence for Supersonic Jet Noise**

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An understanding of volcanic jets is critical to determining eruption column dynamics and mitigating volcanic hazards. However, volcanic jets are inherently difficult to observe directly due to their violence, opacity, and complex multi-phase and multi-component flow features. Recent work has shown similarities between the sound produced from explosive volcanic jets and man-made jet engines and rockets [Matoza et al., 2009]. We show that infrasound generated by the eruption of Nabro Volcano, Eritrea has waveform features highly similar to waveforms associated with the crackle phenomenon uniquely produced by supersonic jet engines and rockets. Crackle is characterized by repeated asymmetric pressure pulses with higher-amplitude compressions than rarefactions and can be quantified by the skewness (a measure of the asymmetry of the waveform probability density function). The infrasonic crackle from Nabro reported here strongly indicates that infrasound from some volcanic eruptions is produced in similar ways to man-made jet noise from heated, supersonic jet engines and rockets. Noise sources and flow dynamics of jet engines and rockets are better characterized and understood than volcanic jets, suggesting volcanologists could utilize the modeling and physical understandings of man-made jets.

Nabro Volcano, Eritrea erupted explosively on 12 June 2011 and injected vast quantities of SO<sub>2</sub> into the upper troposphere and stratosphere, disrupted air traffic, and severely affected communities in this remote region. Significant infrasound was recorded by two infrasound arrays: IS19 (Djibouti, 264 km) and IS32 (Kenya, 1708 km). The IS19 infrasound array detected the eruption with high signal-to-noise and provides the most detailed eruption chronology available, including eruption onset, duration, and changes in intensity. As seen in numerous other studies [Fee and Matoza, 2013], sustained low-frequency infrasound from Nabro is coincident with high-altitude emissions. The unique, distinctive infrasonic crackle from Nabro highlights the potential to use infrasound to determine some volcanic jet characteristics and parameters such as velocity, mass eruption rate, temperature, etc. Additionally, we reiterate the potential to use infrasound as a real-time, remote means to detect hazardous emissions, particularly in remote and poorly monitored regions.

Fee, D. and Matoza, R.S., 2013. An overview of volcano infrasound: From hawaiian to plinian, local to global. *Journal of Volcanology and Geothermal Research*, 249: 123-139, doi: 10.1016/j.jvolgeores.2012.09.002.

Matoza, R.S., Fee, D., Garces, M.A., Seiner, J.M., Ramon, P.A. and Hedlin, M.A.H., 2009. Infrasonic jet noise from volcanic eruptions. *Geophys. Res. Lett.*, 36(L08303) doi:10.1029/2008GL036486.