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Spectral analysis and cross-correlation of very large seismic data-sets at the persistently restless Telica Volcano, Nicaragua.

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Telica Volcano, Nicaragua, is a persistently restless volcano (PRV) with daily seismicity rates that can vary from less than ten events per day to over a thousand events per day. Seismicity rates show little clear correlation with eruptive episodes. This presents a challenge for volcano monitoring and highlights the need for a greater understanding of the patterns of seismicity surrounding eruptive activity at Telica and other PRVs. Multi-parameter seismic investigations, including spectral and multiplet analysis, may provide important precursory information, but are challenging given such high rates of seismicity. We present a program 'peakmatch' that can effectively handle the cross-correlation of hundreds of thousands of events and identify multiplets. In addition, frequency ratios, basic spectral information, and amplitudes can be rapidly calculated for very large seismic data sets. An investigation of the seismic characteristics surrounding the 2011 phreatic eruption at Telica shows an unusual pattern of seismicity. Rather than a precursory increase in seismicity, as is observed prior to many volcanic eruptions, we observe a decrease in seismicity many months before the eruption. Spectral analysis indicates that during periods with high seismicity there are events with a broad range of frequencies, and that during periods of low seismicity there is a progressive loss of events with lower frequency energy (< 3 Hz). Multiplet analysis indicates that during periods with high seismicity there is a high degree of waveform correlation, and that during periods with low seismicity there is a low degree of waveform correlation. We suggest that these patterns of seismicity relate to a cyclic transition between open-system and closed-system degassing. Open-system degassing is observed seismically as periods with high event rates, a broad range of frequency content and high waveform correlation. A transition to closed-system degassing could be via sealing of fluid pathways in the magmatic and/or hydrothermal system, and periods of closed-system degassing are observed seismically as low event rates, higher frequency content and low waveform correlation. The eruption may then represent a transition back from closed-system degassing to open-system degassing.