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Submarine explosive activity and ocean noise generation at Monowai Volcano, Kermadec Arc: constraints from hydroacoustic T-waves

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Submarine volcanic activity is difficult to detect, because eruptions at depth are strongly attenuated by seawater. With increasing depth the ambient water pressure increases and limits the expansion of gas and steam such that volcanic eruptions tend to be less violent and less explosive with depth. Furthermore, the thermal conductivity and heat capacity of water causes rapid cooling of ejected products and hence erupted magma cools much more quickly than during subaerial eruptions. Therefore, reports on submarine volcanism are restricted to those sites where erupted products – like the presence of pumice rafts, gas bubbling on the sea surface, and local seawater colour changes - reach the sea surface. However, eruptions cause sound waves that travel over far distances through the Sound-Fixing-And-Ranging (SOFAR) channel, so called T-waves. Seismic networks in French Polynesia recorded T-waves since the 1980's that originated at Monowai Volcano, Kermadec Arc, and were attributed to episodic growth and collapse events. Repeated swath-mapping campaigns conducted between 1998 and 2011 confirm that Monowai volcano is a highly dynamic volcano.

In July of 2007 a network of ocean-bottom-seismometers (OBS) and hydrophones was deployed and recovered at the end of January 2008. The instruments were located just to the east of Monowai between latitude 25°45'S and 27°30'S. The 23 OBS were placed over the fore-arc and on the incoming subducting plate to obtain local seismicity associated with plate bending and coupling of the subduction megathrust. However, we recognized additional non-seismic sleuths in the recordings. Events were best seen in 1 Hz high-pass filtered hydrophone records and were identified as T-waves. The term T-wave is generally used for waves travelling through the SOFAR channel over large distances. In our case, however, they were also detected on station down to ∼8000 m, suggesting that waves on the sea-bed station were direct waves caused by explosive activity at Monowai volcano. Source-receiver distances were in the order of 70 km to 250 km. However, several events recorded on the local network were also detected at distances of several thousands of kilometres (up to ∼ 16.000 km away) from the source, clearly indicating T-waves. We used the local network to automatically detect and locate T-wave bursts. Detecting and triggering was most effective when correcting the time of each OBS for a predicted travel time defined by the source-receiver distance. Using this approach we obtained appropriate data for automatic onset detection using long-term/short-term averages (LTA/STA). Out of the ∼3500 events we could clearly associate more than 2000 events with Monowai. Eruptive activity at Monowai, however, was not evenly distributed in time but was highly clustered, indicating 13 to 15 major eruptive sequences. The sequences lasted from several hours to about 2 days. Periods of no detectable activity range from ∼1 day to 70 days. The same approach was used to search the global database for the same time interval. Two Global Seismic Network (GSN) seismic stations and two hydroacoustic monitoring stations of the CTBTO provided T-waves from Monowai. We were able to record the same sequences, but the number of detected events was several times lower.