Short-term volcano-tectonic earthquake forecasts based on a moving mean recurrence time algorithm: the El Hierro seismo-volcanic crisis experience

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Under certain conditions volcano-tectonic (VT) earthquakes may pose significant hazards to people living in or near active volcanic regions, especially on volcanic islands; however, hazard arising from VT activity caused by localized volcanic sources is rarely addressed in the literature. The evolution of VT earthquakes resulting from magmatic intrusions shows some orderly behavior that may allow forecasting of the occurrence and magnitude of major events. Governmental decision-makers can thus be warned of the increased probability of larger-magnitude earthquakes in the short term time-scale. We present here a methodology to forecast the occurrence of large-magnitude VT events during a volcanic crises; it is based on a Mean Recurrence Time (MRT) algorithm that translates fluctuations of the Gutenberg-Richter distribution parameters into time-windows of increased probability of a major VT earthquake. The MRT forecasting algorithm was developed after recognizing repetitive patterns in the seismic swarm episodes occurring between July and November 2011 at El Hierro (Canary Islands). From then on, this methodology has been applied to consecutive seismic crises registered at El Hierro, achieving a high success rate in the real-time forecasting of volcano-tectonic earthquakes within 10-day time-windows. The MRT may be applied to other volcanoes provided that the observed seismicity corresponds to the same type of swarms: raising number of VT events with increasing magnitudes, followed by a mainshock, and a rapid decay of the seismicity. Then, the algorithm may be readily adapted to any real-time monitoring system. In addition, the concept of time-windows of increased likelihood of large-magnitude earthquakes should be easily understood and accepted by governmental decision-makers, making the management of risk more effective.