TOPAZ: Long-term volcanic risk forecasting for deep geological repositories for radioactive waste

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The TOPAZ Project is an unusual application of volcanic event forecasting as it endeavours to look forward thousands of years into the future. The 2011 Tohoku earthquake highlighted the susceptibility of Japan to major disruptive tectonic events, but also the need to adopt risk-based approaches to quantifying specific hazards, in particular the location-specific likelihood of events exceeding given hazard levels. Japan intends to manage its higher activity radioactive wastes from nuclear power generation in deep geological repositories. Geological repositories might be susceptible to disruption by direct hit or closely adjacent events such as volcanic intrusion or major fault shear, as well as by slower processes, such as exhumation by uplift and erosion. The likelihood of specific impacts needs to be quantified for different timeframes, so that any consequent radiological risks can be estimated. For tectonic events, a risk-based approach combining specific event likelihood with consequences can be used to help decide on site suitability, the treatment of hazards from future volcanic events is more challenging. Since 2002, the Nuclear Waste Management Organisation of Japan has been developing methodologies for quantifying a range of tectonic hazards at potential sites. The avoidance of disruption over the first few thousands of years is of paramount importance in a safety case for waste disposal, as the intrinsic hazard potential of these wastes is high during this period. Although hazard potential decreases considerably after a few thousand years, regulatory requirements might entail estimating impact scenarios out to 1 Ma. One development of the project extends the 100 ka methodology for forecasting over longer periods by using expert elicitation to capture expert judgments on alternative modes of evolution of the tectonic system and associated volcanic events, and to characterize the related process uncertainties. This technique rationalizes the full range of expert knowledge and converts it into relative scenario weights to support probabilistic assessment for both tectonic and volcanic futures. For the latter, the approach developed by NUMO produces quantified hazard maps of impacts for use in site selection. These have been developed to show the probability of any event within 25 km2 blocks and the probability of explosive volcanic events of a specified magnitude (M5) or greater on the VOGRIPA scale. The maps provide information for quantitative radiological risk assessments and quantify project risk by identifying locations where uncertainties/risks are either acceptable or a credible safety case would be difficult to sustain. This paper briefly outlines the approach, provides examples of the hazard maps produced for different regions of Japan and discusses the uncertainties involved in this novel application of volcanic risk evaluation. Additional current work is extending the scope to include caldera-scale event likelihood.