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Caldera resurgence as a possible cause of slope failure in volcanic areas: the Ischia island case history

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Slope instability in active volcanic areas is a factor of major hazard to be considered. Due to their rapid growth and deformation, active volcanoes experience gravitational disequilibrium and periodical structural failures. Depending on the geodynamic framework of a volcano, nature, style of activity and climatic conditions, slope instability occurs at different scales, from relatively small-volume mass movements to huge lahars and debris avalanches. Moreover, volcanoes located in coastal areas or islands, may experience lateral collapses with the potential to generate large tsunamis. Although there is very little literature on the relationships among caldera resurgence, volcanism and slope instability, recently also the caldera resurgence has been suggested as a possible cause of slope failure, as for the southern flank of the island of Ischia in the Southern Tyrrhenian sea (Italy). Ischia island gives a good opportunity to investigate such phenomena and related effects, as it is the only documented example of resurgent caldera in which, during uplift, volcanism and generation of mass movements have been very active and linked to each other in a sort of cyclical behaviour.

The island of Ischia is one of the most impressive examples of resurgent calderas in the world. This caldera formed in response to a complex explosive eruption that, about 55 ka B.P., produced the Mt. Epomeo Green Tuff ignimbritic deposit. Starting from at least 30 ka B.P. the caldera floor has been uplifted of about 900 m, due to a resurgent phenomenon, which occurred through intermittent uplifting, likely triggered by the intrusion of new magma into the system, and tectonic quietness phases. During uplift, volcanism and generation of mass movements were very active. The resurgent area is composed of differentially displaced blocks and has a poligonal shape, resulting from reactivation of regional faults and activation of faults directly related to volcano-tectonism. The western sector is bordered by inward-dipping, high-angle reverse faults, cut by late outward-dipping normal faults due to gravitational readjustment of the slopes. The north-eastern and the south-western sides are bordered by vertical faults with right transtensive and left transpressive movements, respectively. The area located to the east of the most uplifted block is displaced by outward-dipping normal faults.

Some giant landslides and their relationships with volcano-tectonism have been recognized at Ischia. Their deposits are intercalated with primary volcanics and minor landslide deposits in the eastern sector of the island. Within the northern and western sectors, historical earthquake-triggered landslides are well exposed, also due to lack of recent volcanic rocks. The largest landslide bodies seem to have a submarine counterpart, as evidenced by the hummocky topography of the seafloor in the offshore of the island. The recognized landslides vary from small lahars to large debris-avalanche, whose detachment areas are clearly conditioned by the geometry of the same structures that drove resurgence and fed volcanism.

In conclusion, the results of a detailed stratigraphical, sedimentological and structural study carried out at Ischia, emphasize the intimate interplay among slope instability, resurgence dynamics, fault generation, seismicity and volcanism on the island.