



## **Character and timing of recent eruptions of the Tatun Volcanic Group, Northern Taiwan**

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The quaternary dominantly andesitic Tatun Volcanic Group (TVG) occupies 400 km<sup>2</sup> in the northern part of Taiwan Island. The group has more than 20 well-preserved volcanic edifices, multiple hot springs and fumaroles as hot as 120°C with magmatic isotopic signatures. Local seismic network has registered shallow volcano-tectonic earthquakes in the area. The TVG is surrounded by densely populated areas, the largest of which is Taipei City (7 million people), as well as by multiple industrial factories and two nuclear power plants. Therefore, the question about timing and styles of the most recent TVG eruptions is important.

We report results of our investigations of TVG physical volcanology, with focus on pyroclastic stratigraphy and eruption dynamics. For the most recent TVG eruptions were common long-term extrusions of crystal-rich, viscous lava. The eruptions formed dominantly monogenetic plug domes, coulees, and lava flows. The domes have heights of 150-400 m, base diameters of 0.5-2 km, and volumes of 0.05-0.3 km<sup>3</sup>. The nine best-preserved TVG lava flows have thicknesses of 80-150 m, lengths of 1-5.6 km, and volumes of 0.07-0.6 km<sup>3</sup>. Based on morphology of the largest lava flow we estimated an effusion rate of 6.4 m<sup>3</sup>/s, eruption duration of 1100 days, lava front speed of 2-3 m/hour. The only pyroclastic edifice of the Tatun group is a tephra ring ~500 m in diameter and 40 m high formed by plinian eruption. Apart from that, few non-reworked pyroclastic deposits are currently preserved at TVG. The available data have shown that the explosive activity of TVG was weak-to-mild, but rather diverse with deposition of fallout tephra, base surges, and pyroclastic flows. Fallout deposits are represented mostly by well-sorted, crystal-rich ash layers (Md 1.0-3.4 phi, sorting 0.9-2.4 phi) left by Vulcanian-type activity. Deposits of pumice fallout (Md -4-(-2.5) phi, sorting 1.2-2.4 phi) from Plinian eruptions are less common. Many of the eruptions show evidence of water/magma interaction: poor sorting, wide span of vesicularity of juvenile material, abundant xenoliths of country rocks, associated base surges, as well as ballistics of bread-crust and cauliflower type. Deposits of block-and-ash pyroclastic flows are lithic-rich and probably were formed mostly by collapses of growing domes and advancing lava flows (Merapi type).

The weakly explosive character of TVG volcanism can be explained by syneruptive non-explosive degassing of magma. In the case of the TVG, loss of volatiles probably occurred through country rocks, which were initially extensively fractured by the very active tectonic processes operating in Taiwan. A large number of hot and cold springs in the area point to a high permeability of these basement rocks. For the same reason, many explosive eruptions of the TVG may have been phreatomagmatic: through fractured conduit walls ground water had easy access to the ascending magma.

This study presents the first radiocarbon dates of various volcanoclastic deposits of the TVG, which indicate that Cising, Siaoquanyin, and possibly Huangzuei volcanoes had magmatic eruptions in the period 13,000-23,000 years ago. In addition, Mt. Cising had a phreatic eruption 6000 years ago, and possibly a magmatic extrusive eruption just before that. Our data have shown that TVG volcanoes should be considered as active. The results form the basis for reassessment of volcanic hazards of the area.