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Fluid ascent and magma storage beneath Gunung Merapi

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Gunung Merapi in Central Java belongs to the most active volcanoes in the world. Central Java is part of the Sunda Arc, a 5.000 km long subduction zone between the Eurasian and the Indo-Australian Plate with a convergence rate at the Java trench of 67 mm/year. The subduction process causes natural hazards like earthquakes and volcano eruptions. Merapi's dominant type of volcanism is andesitic and explosive and its frequent eruptions threaten its densely populated surrounding with pyroclastic flows mainly. Since decades researchers investigate this volcano to understand this dynamic magmatic system and to discover its supposed magma chamber regarding to an improved risk assessment.

The ascent of the fluids and the formation of partial melts as well as their distribution in the crust can be detected by seismic and seismological methods, and imaged with seismic tomography indicating these areas by reduced seismic velocities and enforced attenuation of seismic waves as proven at many continental margins. Therefore, seismic experiments were carried out at Merapi to explore the 3D velocity structure of the volcano edifice, and the crust and mantle wedge above the subducting slab beneath Central Java. As a result a 3D structural image of the lithosphere above the Wadati Benioff plane was obtained. Local earthquakes trace the subducted slab as a 30 km thick double layer in a depth range of 80 km to 150 km. At a distance of up to 150 km from the trench the slab is near-horizontal. Between 150 km and 250 km distance, the dip increases to 45 degrees and steepens to 70 degrees down to 600 km depth.
Beneath Central Java we identified a large low velocity body in the crust which extends down to the upper mantle. Shear wave signals recorded above this anomaly are strongly attenuated compared to neighboring areas. Active volcanoes like Merapi, Sumbing, and Lawu are located at the edge of this anomaly between high and low velocity regions. The anomalous body has a volume of >50.000 km3 with a decrease in P and S velocities up to 30%. Even the resulting Vp/Vs ratio of up to 1.9 is unusually high for the lower crust. Additionally, an ascending path of fluids and partial melts could be detected. This anomaly is directed to the slap at 100 km depth, and inclined by 45 degrees. At around 100 km depth, the seismicity is increased too. This may imply that dehydration of the slap leads to fluid ascend from the down-going slab and chemically causing a decrease of the melting temperature of the penetrated material. The high velocity reduction values combined with high Vp/Vs ratio implies that the region is subject to an increase in temperature, reduced shear strength, and an estimated volume content of fluids/partial melts of 13% up to 25%. These results will be discussed with recent findings from other structural investigations at Lake Toba, and parts of the Andes.