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Neogene subduction beneath Java, Indonesia: Slab tearing and changes in magmatism

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Java is a Neogene calc-alkaline volcanic island arc formed by the northwards subduction of the Indo-Australian Plate beneath Sundaland, the continental core of SE Asia. The island has a complex history of volcanism and displays unusual subduction characteristics. These characteristics are consistent with the subduction of a hole in the down going slab that was formed by the arrival of a buoyant oceanic plateau at the trench.

Subduction beneath Java began in the Eocene. However, the position and character of the calc-alkaline arc has changed over time. An older Paleogene arc ceased activity in the Early Miocene. Volcanic activity resumed in the Late Miocene producing a younger arc to the north of the older arc, and continues to the present day. An episode of Late Miocene thrusting at about 7 Ma is observed throughout Java and appears to be linked to northward movement of the arc. Arc rocks display typical calc-alkaline characteristics and reflect melting of the mantle wedge and subducted sediments associated with high fluid fluxes.

Between West Java and Bali the present arc-trench gap is unusually wide at about 300 km. Seismicity identifies subducted Indian Ocean lithosphere that dips north at about 20° between the trench and the arc and then dips more steeply at about 60-70° from 100 to 600 km depth. In East Java there is gap in seismicity between about 250 and 500 km. Seismic tomography shows that this gap is not an aseismic section of the subduction zone but a hole in the slab. East Java is also unusual in the presence of K-rich volcanoes, now inactive, to the north of the calc-alkaline volcanoes of the active arc. In contrast to the calc-alkaline volcanism of the main arc, these K-rich melts imply lower fluid fluxes and a different mantle source.

We suggest that all these observations can be explained by the tearing of the subducting slab when a buoyant oceanic plateau arrived at the trench south of East Java at about 8 Ma. With the slab unable to subduct, continued convergence caused contractional deformation and thrusting in Java. The slab then broke in front of the plateau. The trench stepped back to the south by about 150 km and subduction resumed behind the plateau, causing a hole to develop in the subducting slab. As the hole passed beneath the arc, and fluid flux declined, normal calc-alkaline volcanism ceased. With the mantle wedge melt component ‘switched off’ K-rich melts, produced from a deeper mantle component that remained undiluted, dominated arc volcanism. As the hole got deeper K-rich volcanism ceased. Normal, calc-alkaline, arc activity resumed when the untorn slab following the hole was subducted.