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Geochemical Evidence for two Subducting Plates beneath North Sulawesi (Indonesia)

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This study reports geochemical data for four active volcanoes (Awu, Karangetang, Lokon, Ruang) from the Sangihe Arc and Colo volcano. The Sangihe Arc is located on the northern arm of Sulawesi and the islands between Sulawesi and Mindanao forms the western part of an arc-arc collision zone. The small isolated volcano Colo is located on the island of Una, which is situated 200 km south-west of the active Sangihe Arc. The tectonic setting of Colo is unclear. Three hypothesis have been postulated to explain its existence. It may be: (1) an isolated volcano related to a large fault, (2) part of the Sanghi Arc system, or (3) related to the extinct volcanism on the northern arm of Sulawesi. The purpose of this study is to: (1) establish the effects of collision on the geochemical characteristics of the volcanics and (2) assess the affinity of Colo.

The volcanics of Awu, Karangetang, Ruang and Lokon are basalts and andesites with normalised trace element abundance patterns typical of island arc basalts. The eruption products belong to the medium-K series, based on SiO_2-K_2O relationships. In contrast, the volcanics of Colo are classified as high-K dacites with a limited SiO_2 range of 62-65 wt.% and contain a plagioclase-biotite-amphibole phenocryst assemblage. Notable trace-element characteristics include the high Ba (>1000 ppm), depleted HREE and Sr/Y ratios of 170±14. Therefore, the Colo volcanics have many characteristics of adakites.

Sr and Nd isotopic ratios in the Sanghi Arc display limited variation. The values of $^{87}Sr/^{86}Sr$ (0.7037-0.7041) and $^{143}Nd/^{144}Nd$ (0.51230-0.51298) overlap those of the Halmahera Arc and are in the range of oceanic island arcs. Colo is on the other hand characterised by high $^{87}Sr/^{86}Sr$ (~0.7061) and low $^{143}Nd/^{144}Nd$ (~0.51260).

The trace element abundances and Sr - Nd isotopes of the Sangihe Arc volcanics suggest that subducted sediments did not play a major role during magma genesis, despite the presence of large quantities of sediment in front of the arc. This could be explained by the fact that the sediments have not yet reached the magma generation zone, or that the subducted sediments are mainly volcaniclastic in nature. The adakites of Colo can be best explained by melting of both the subducted oceanic crust and sediments. These contrasting geochemical signatures support the conclusion that Colo belongs to the southward subducting Celebes Sea plate, consistent with tomographic evidence for a structural separation with the westward dipping Molucca sea plate below the Sangihe Arc volcanoes.