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Post-subduction remobilization of metals triggered by microplate rotation – a case study from the Bismarck Archipelago, Papua New Guinea

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Arc volcanism related to subduction is known to release large amounts of volatiles. Among them, S and Cl have the capability to transport metals from the Earth's interior to the upper crust where they may be concentrated in ore deposits. Metal fluxes, even in single volcanic systems, are high enough to form giant ore deposits within ∼50 ka. The fact that such deposits are rare but concentrated in few, well-endowed regions must reflect unique magmatic and tectonic processes that control metal concentration and migration. Among the processes thought to be responsible for metal enrichment are crustal recycling, melting of metasomatized mantle, and microplate interactions that create pathways for mantle melts through the crust.

The region of Papua New Guinea in the Western Pacific is particularly well-endowed in Cu and Au. Here, complex plate tectonic processes including subduction reversals, microplate formation and reorientations, and large-scale lithospheric extension have led to the formation of a number of world-class Cu and Au deposits. The major Cu deposits are associated with continent collision in the Miocene. The Au deposits are Pliocene and younger and are more closely linked to recent microplate tectonics. One of those is the giant Ladolam porphyry-epithermal Au deposit on the island of Lihir in easternmost Papua New Guinea. Lihir belongs to one of four island groups in the Tabar-to-Feni volcanic island chain that has emerged in the last 3.6 Ma from the New Ireland Basin, a much older sedimentary forearc basin relative to subduction along the stalled Manus-Kilinailau Trench.

Here, we present a new interpretation of the regional geodynamic framework combining onshore and offshore data that extends the known geological framework of the area by a factor of 5-10 compared to the land cover alone. The distribution of onshore and offshore lithotectonic assemblages shows that magmatism in the Tabar-to-Feni island chain is not migrating along the chain, as previously suggested, but crosses the chain at a high angle to the Manus Kilinailau Trench, in accordance with a model of Pacific slab breakoff resulting from the stalled subduction. In the model, the general emergence of post-subduction high-K magmatism is closely related to slab breakoff, whereas the focusing of melts into distinct volcanic systems is controlled by regional crustal structure. Following post-Miocene adjustments of the North and South Bismarck microplates, the New Ireland Basin has been undergoing major lithospheric extension. Offshore seismic profiles image large normal faults between the individual island groups. These structures are genetically linked to rifting of New Ireland and extension in the eastern Manus Basin. The geometry of the crustal blocks in the basin indicate that Lihir is located at the point of maximum extension of the rift, thus explaining the anomalous magmatic and hydrothermal activity.