"Submarine volcanism and hydrothermalism in the western Pacific"

Richard J. ARCULUS
Professor, Research School of Earth Sciences
The Australian National University

In the past 25 years, multinational and multidisciplinary efforts using multibeam sonar mapping, drilling/dredging/coring campaigns, hydrothermal vent surveys, and mineral exploration, involving ships, submersibles, and various remotely controlled and autonomous underwater vehicles, have revolutionized our understanding of the volcanic and hydrothermal activity of the submarine portion of the "Ring of Fire" in the western Pacific. The discoveries include: 1. A very large increase in the number of known volcanoes in both arc and backarc settings. In the case of the Tonga-Kermadec (TK) system for example, there are now 70 known volcanoes in ~2000km of arc strike length, of which about 30% are hydrothermally active. Zones of widespread active volcanic activity and hydrothermal venting are occurring in all of the currently extending backarc basins; 2. The particularly metal- and magmatic gas-rich hydrothermal fluids associated with this activity have generated volcanogenic sulfide deposits of low tonnage but very high-grade and potential exploitability, and constitute a significant fraction of the global hydrothermal inputs into the Pacific Ocean. A number of commercial companies currently hold exploration leases for much of the arc-back systems of the western Pacific, and a mining license has been issued for an area in the Bismarck Sea (eastern Manus backarc basin); 3. New magma types have been identified among the extrusives of the backarc basins tapped from a remarkable range of mantle protoliths, spanning ultra-depleted to enriched sources. For example, alkali-rich, continental rift-like basalts lacking the characteristic high field strength element depletions associated with arc-proximal backarc basin basalts, are being erupted in the Nifonea Ridge of the Vate Trough of Vanuatu. In contrast, basalts of the Central Lau Spreading Centre are among the most depleted basalt types known in the spectrum of global backarc and mid-ocean ridge basalts. Currently active boninite volcanism has been identified at the Tongan volcanic front and reararc. Boninites are generated most commonly only in subduction zone settings involving the hydrous fluxed melting of refractory (e.g., clinopyroxene-poor lherzolite and harzburgite) lithologies. Boninite was a widely erupted magma type closely following subduction zone inception in the Izu-Bonin-Mariana (IBM) arc, but is demonstrably involved as a mixing component of active magmatism in both the TK and IBM arcs; 4. Clear links have been established between backarc ridge/rift morphologies, dissolved volatile loads in magmas, and rates of spreading; 5. Iron isotope studies have demonstrated the more depleted (i.e., prior melt loss) character of the mantle sources involved in backarc and arc magma generation than those associated with mid-ocean ridges; 6. Remarkably fresh examples of mantle wedge-derived peridotites (harzburgite-dunite) likely representative of these mantle sources have been recovered from two locations in Papua New Guinea. These peridotites are strongly depleted and include highly magnesian olivine and Cr-rich spinel, correlative with considerable loss of melt. In addition however, their orthopyroxene-rich nature relative to intraplate spinel peridotites reflects enrichment in silica-rich, subducted slab-derived fluids prior to or concurrent with melting in the mantle wedge; 7. Ingress of the Samoan (hot-spot) plume into the northern Lau Basin, has been identified primarily by noble gas (He, Ne, Xe) analysis. It appears the primary component of the invading plume comprises the "FOZO" type rather than the EM1-EM2-HIMU flavours also identified along the Samoan chain. Tracking of the geochemically distinctive Samoan plume is significant in terms of both toroidal and poloidal mantle flow patterns in the Tongan mantle wedge. Discoveries continue to be made, and research opportunities abound.