

The rise of Atauro Island, Banda Arc, East Timor

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SUMMARY

Cessation of magmatism in the Banda Arc north of Timor about 3 million years ago has been followed by a period rapid continuing uplift, most dramatically evidenced by the presence of Quaternary coral at ~700 m above sea level on the island of Atauro. In order to understand how these processes constrain slab dynamics during the early stage of continental–arc collision (Timor – Banda Arc) we have mapped the island of Atauro in detail. The basic features of Atauro geology are described, and it is demonstrated how they may relate to slab processes deep beneath.

Key words: Atauro, Banda Arc, continental–arc collision

INTRODUCTION

The Timor region of the Banda Arc is an example of the early stage of a continental–arc collision. The end of volcanism and subsequent uplift of the island of Atauro, north of Timor reflects slab processes occurring below the arc. For the first time the geology of Atauro, part of the extinct segment of the Banda Arc, has been investigated and mapped in detail. Volcanic rocks of diverse chemistry and texture, uplift of coral reef terraces and evidence of large scale gravitational collapse combine to make Atauro an intriguing place to investigate the processes and effects of arc-continent collision.

GEOLOGY

The volcanic stratigraphy of Atauro comprises a varied succession of subaqueous lavas and sedimentary deposits, locally intruded by dykes and sills. Brecciated lavas of dacite composition dominate the sequence over most of the island, along with thick sedimentary deposits of similar composition. The south western part of the island is comprised of a distinctly different set of basaltic andesite lavas, however eruption of the different magma types appears to be contemporaneous.

Dacite

Dacite is widespread across the northern and eastern parts of Atauro. Coherent lava flows have been observed, however this unit most commonly occurs as an in situ hyaloclastite breccia of angular to sub-angular clasts up to 50 cm within a

matrix comprising 10–40% of the rock. The dacite is plagioclase- and occasionally clinopyroxene-phyric, with a fine-grained to glassy groundmass.

Resedimented dacite

The dominant unit of southern Atauro, thick southwest dipping sequences of tuffaceous material with dacite clasts outcrop spectacularly in coastal cliffs. Subangular andesite clasts up to 50 cm are typically supported in a matrix consisting of finer lithic fragments, broken crystals, scoria and volcanic ash. Bedding thickness is highly variable, from less than one centimetre to several metres, and may feature normal or reverse grading. Channels, ripples, crossbedding and flame structures are observed throughout the sequence.

Clinopyroxene-phyric basaltic andesite

Observed only in the southwest of the island, this distinctive unit features 1 cm clinopyroxene phenocrysts, along with smaller plagioclase and olivine phenocrysts in a fine-grained, crystalline groundmass. This basaltic andesite occurs as massive lava flows, and less commonly as angular, in situ breccia. Topography, combined with measured flow directions, support the presence of a single volcanic centre in the vicinity of the high ridge formed by Mt Berau and Mt Tutonairana, at around 800 m above sea level.

Other volcanic rock variants

Numerous other volcanic rock types, mostly dykes and sills of fairly limited outcrop extent, have been described. In the northeast, 1 metre wide clinopyroxene-phyric basaltic andesite dykes with narrow chilled margins intrude brecciated andesite. Hornblende-bearing rhyolite dykes and sills represent the most felsic lithology of the island. These pale grey, fine-grained rocks occur mainly in northern inland regions and extend over several hundred metres. Plagioclase- and clinopyroxene-phenocrystic andesite sills intrude dacitic breccia and sediments, most commonly in the southeast. These massive sills are up to 100 metres thick and feature columnar jointing and narrow chilled margins. Other minor variants include clinopyroxene-phyric andesite and hornblende-phyric andesite sills.

GEOCHEMISTRY

The volcanic rocks of Atauro exhibit two distinct chemical trends. Much of the island is composed of dacite; the less common rock variants range along a continuous trend to rhyolitic compositions. These rocks exhibit similar major element trends to other islands in the region. The

composition of the clinopyroxene-phyric basaltic andesite of the southwest is far removed from the dacites and rhyolites, with much lower SiO₂ (53%) and high CaO (13–15%) and MgO (8–10%). These rocks do not fit regional trends.

EVOLUTION OF ATAURO

Detailed mapping indicates provenance of the Atauro volcanic succession from two major volcanic centres. The widespread distribution of the dacite units, and consistent southwest dip of resedimented parts of the sequence, strongly suggests the former presence of a major volcanic centre to the northeast of the island. A series of prominent normal faults support collapse of the northeast part of the island. The overlapping contact between dacite and basaltic andesite of the south western centre suggests contemporaneous bimodal volcanism. Field investigation of the volcanic centres suggested by Abbott & Chamalaun (1981) does not support the existence of their proposed southeast and northern centres, however confirms the presence of the south western centre.

Geological mapping of Atauro has revealed that limestone is exposed over two thirds of the island's surface. A succession of terraces comprising coral reef sequences occur up to 700 m above sea level, reflecting the interplay between continuous uplift and eustatic sea level change. Dating of the lower terraces indicates an uplift rate for Atauro of 0.47 m/1000 years (Chappell & Veeh, 1978). No observations have been made of interbedded limestone and volcanic rocks, indicating that eruption occurred at a water depth below the coral growth zone.

A series of large scale, arcuate normal faults can be traced along the northern half of Atauro. The faults are expressed as scarps up to 4 km long, spaced around 500 m apart. Flat bottomed valleys are bounded by the scarps, which form steep slopes 80–130 metres high, and often include cliff sections up to 20 m high at or near the top of the slope. The limestone terraces are cut by these faults, indicating that uplift occurred prior to, or at the same time, as gravitational collapse to the east. The timing of this collapse has not been constrained absolutely, however preservation of landscape features such as raised valleys indicates that the normal faults are relatively young structures that may even be still active.

SLAB DYNAMICS

The cessation of active volcanism on Atauro and neighbouring islands around 3 Ma has been linked to continental-arc collision, and the resultant end of subduction (Abbott & Chamalaun, 1981). Early collisional processes in older orogens can only be speculated upon; the best opportunity to understand these processes is within the youngest orogens.

While there is a spatial and temporal link between collision of the Australian continent and the ending of volcanism in this region of the Banda Arc, the mechanisms and timing are not clear. Tearing of the subducting slab has been implied from the presence of aseismic zones; the unusual geochemistry of what may be the last magmas to erupt may shed light on this process. Discrimination between local and regional features of the uplift history of Atauro provides insight into both the deep seated slab processes and shallower, fault related processes that have occurred.

ACKNOWLEDGMENTS

KSE would like to acknowledge the support of a CSIRO Postgraduate Award.

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