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Geochemistry and petrogenesis of the Gallego Volcanic Field, Solomon Islands, SW Pacific and geotectonic implications

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ABSTRACT

The Upper Miocene to present day Gallego Volcanic Field (GVF) is located in northwest Guadalcanal, Solomon Islands, SW Pacific, and potentially includes the offshore Savo volcano. The GVF is a multi-centred complex covering an area of ~800 km^2 on Guadalcanal and a further ~30 km^2 on the island of Savo, north of west Guadalcanal. GVF volcanism is characterised by effusive eruptions of lava, intrusion of sub-volcanic plutons, as well as pyroclastic flow and fall deposits dominated by block and ash flow deposits. Geochemical analysis of a representative suite of samples from the GVF demonstrates that the GVF comprise largely a 'main suite' of basalts to andesites and minor trachyandesites. The predominant mineralogy of the GVF comprises plagioclase, amphibole, clinopyroxene and magnetite-ilmenite. Associated with the 'main suite' are cognate nodules composed of hornblendite, gabbros, and clinopyroxenite. Interpretation of major and trace element geochemistry and petrographic studies suggests that fractionation was dominated by early clinopyroxene, and later amphibole + clinopyroxene + minor plagioclase. Geochemical features such as the incompatibility of Sr suggest that plagioclase largely crystallised en-masse late in the fractionation sequence. The presence of amphibole and late fractionation of plagioclase is suggestive of derivation from initially water-rich magmas. The region is characterised by strong geographically-related geochemical variations as evidenced by the Woodlark (and Manus) basins: basalts become more arc-like within the ocean basins with decreasing distance to the subducting trench. The GVF-Savo volcanoes are spatially and geochemically affected by deep N-S fractures that show some evidence of sympathetic geochemical variations with distance from the trench (e.g. Sr/Y ratios). Comparison with a range of international data for Th/Nb vs Pb/Nb and Dy/Yb vs SiO_2 indicate that: amphibole was indeed a strong controlling phase on magmatic evolution; garnet had no obvious role; there was little sediment input into the source region; that relative Pb/Nb enrichments may be linked to similar enrichments within the subducting Woodlark basin (and by analogy with the Manus basin and its abundant hydrothermal Pb-rich sulphide deposits); and the predominant influence on the source region for GVF-Savo was from metasomatic fluids and/or melts from the slab subducting at the southern trench.

1. Introduction

The Solomon Islands have a relatively complex tectonic history and present day setting, with opposing subduction zones, ridge subduction, and oceanic plateau subduction all contributing to a range of complex and varied geology in terms of structure, age and geochemistry. This paper is a study of the Gallego Volcanic Field (GVF), an area of recent volcanism in northwest Guadalcanal.

The key objectives of the study are to: characterise the regional petrography and geochemistry of the GVF; compare and contrast the gross geochemical features and petrogenesis of the GVF with nearby Savo volcano and test the hypothesis that the latter represents the northernmost and most recently active extension of the GVF; examine possible geographical compositional variations; and to add new data of relevance to discussions about geo-tectonic dynamics within the central part of the Solomon arc.

1.1. Geotectonic setting of the Solomon Islands

The Solomon Islands volcanic arc consists of two parallel NW–SE trending island chains, that form a section of the Greater Melanesian Arc, which stretches from Papua New Guinea to Tonga, marking the collision zone between the Indo-Australian and Pacific tectonic plates (Fig. 1; Coleman, 1966; Petterson et al., 1999; Schuth et al., 2004). The islands form an upstanding topographic block measuring 1200 km by 250 km, surrounded by relatively deep ocean floor to the northeast and southwest (Petterson et al., 1999). The Solomon block is bounded by the Vitiaz trench (North Solomon Trench System; NSTS) to the northeast and the New Britain-San Cristobal trench (South Solomon Trench System; SSTS) to the southwest (Petterson et al., 1999).

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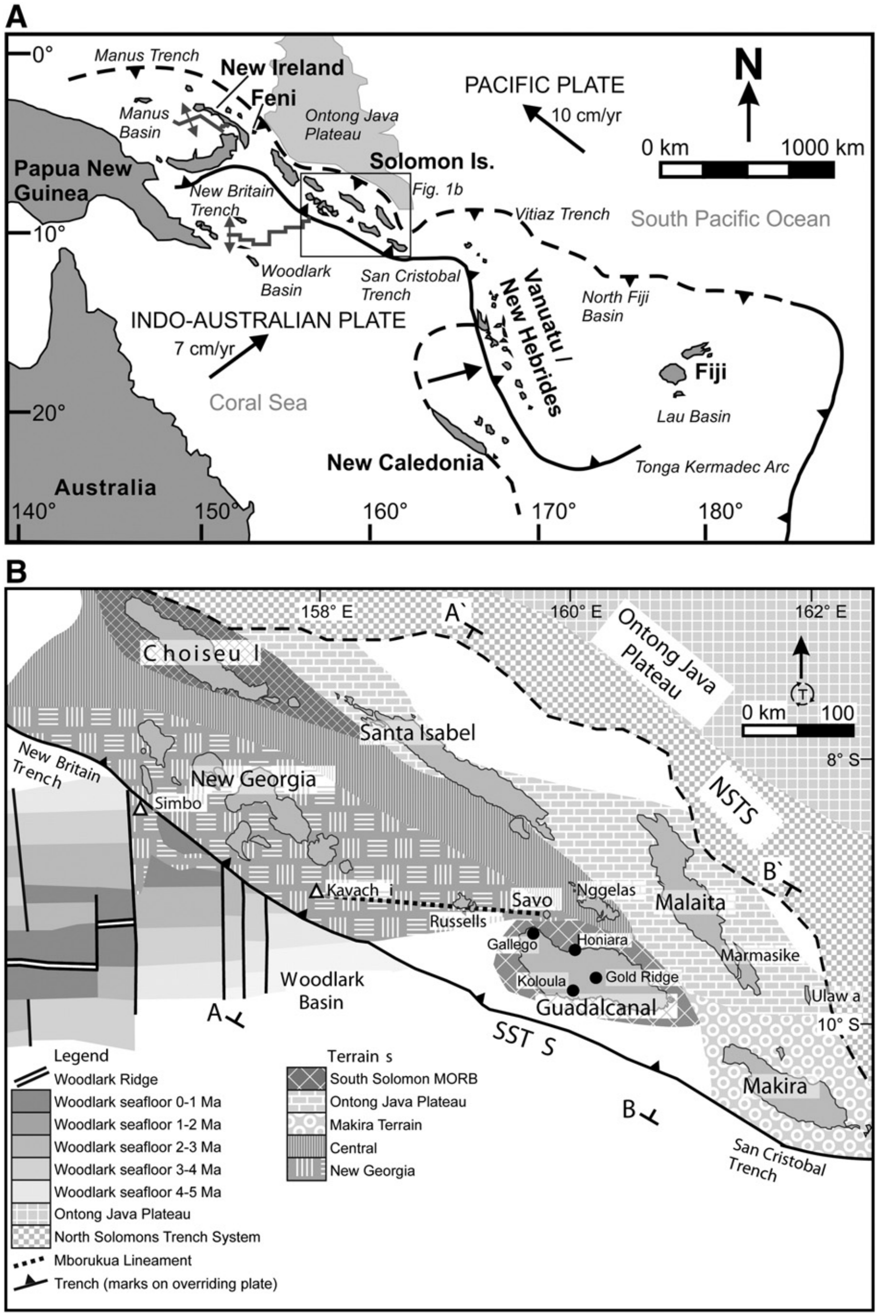

Fig. 1. (A) Map of the southwest Pacific and Greater Melanesian Arc. Active arcs shown with solid lines (arrow marks on the overriding plate). Inactive/intermittently active arcs shown as dashed lines. Arrows show relative plate motions. The Solomon arc is bounded by the northern (Vitiaz) trench and the Ontong Java Plateau and the southern New Britain–San Cristobal trenches (collectively the SSTS). Note the highly oblique convergence regime between the Pacific and Indo-Australian plates. (B) Map of the Solomon Islands showing major tectonic features and geological terrains (after Petterson et al., 1999). Ages for Woodlark Basin seafloor are based on magnetic lineations from Taylor (1987). SSTS = South Solomon Trench System, NSTS = North Solomon Trench System.

Initial southward-directed subduction of the Pacific Plate at the NSTS began in the Palaeocene and resulted in the earliest (first stage of magmatism) arc activity at 62–46 Ma (Petterson et al., 1999; Schuth et al., 2009). At 25–20 Ma the Cretaceous Ontong Java Plateau (OJP) reached the subduction zone, where its thickened crust (estimated to be 35 km thick; Mann and Taira, 2004) blocked the trench and resulted in a hiatus of magmatism, the deformation of the northern islands, and a reversal of subduction polarity during the Neogene (e.g. Petterson et al., 1999, 1997; Schuth et al., 2009). Geophysical models (e.g. Mann and Taira, 2004) suggest that the lower parts of the OJP continue to subduct beneath the island arc along a thrust detachment. The subducted Pacific slab may also be a source of metasomatic fluids and melts to the sub-arc mantle (König et al., 2007; Schuth et al., 2009; Smith et al., 2009).

The Indo-Australian Plate began its northward subduction at the SSTS around 5–8 Ma (Mann and Taira, 2004; Petterson et al., 1999) resulting in a second stage of arc magmatism (which continues today) and the formation of the younger, southern Solomon island chain (Schuth et al., 2009; Smith et al., 2009).

The young, hot, oceanic lithosphere of the Woodlark Basin and its recently active spreading centre, which form part of the Indo-Australian Plate, are currently being subducted at the SSTS, forming a trench-trench-transform triple margin (Chadwick et al., 2009; Petterson et al., 1999). The subduction of this spreading ridge has led