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The basaltic to trachydacitic upper Diliman Tuff in Manila: Petrogenesis and comparison with deposits from Taal and Laguna Calderas

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ABSTRACT

The basaltic to trachydacitic (50–65 wt.% SiO_2) upper Diliman Tuff is the youngest deposit of a sequence of tuffaceous deposits in Metro Manila. The deposit is located north of Taal Caldera and northwest of Laguna Caldera, which are both within the Southwest Luzon Volcanic Field. Chemical variations in the pumice fragments within the upper Diliman Tuff include medium-K basalt to basaltic andesite, high-K basaltic andesite to andesite and trachyandesite to trachydacite. Magma mixing/mingling is ubiquitous and is shown by banding textures in some pumice fragments, considerable range in groundmass glass composition (54 to 65 wt.% SiO_2) in a single pumice fragment, and zoning in plagioclase phenocrysts. Simple binary mixing modeling and polytopic vector analysis were used to further evaluate magma mixing. Trace-element variations are inconsistent with the medium-K and high-K magmas being related by crystal fractionation. The medium-K basalts represent hotter intrusions, which induced small degrees of partial melting in older crystallized medium-K basaltic material within the crust to produce the high-K magmas. All melts likely differentiated in the crust but the emplaced and new basaltic intrusions originated from the mantle wedge and were generated by subduction zone processes. The volcanic source vent for the upper Diliman Tuff has not been identified. In comparisons with the deposits from adjacent Taal and Laguna Calderas it is chemically distinct with respect to both major- and trace-element concentrations.

1. Introduction

The Diliman Tuff refers to primary and reworked volcaniclastic deposits of uncertain origin that underlie the Metropolitan Manila area. This deposit is 10 km north of the Southwest Luzon Volcanic Field (Fig. 1A), which is a 7 km^2 region consisting of strato-volcanoes, monogenetic centers and calderas (Oles et al., 1995). Southwest Luzon Volcanic Field is related to the eastward subduction in the Manila Trench and extension in the Macolod Corridor (Knittel et al., 1988; Defant et al., 1988; Forster et al., 1990) (Fig. 1A). The uncertainties with regards to the volcanic source of the Diliman Tuff are due to factors such as: proximity to several possible source centers; complicated volcano-tectonic setting and modification of landscape from urban development. This study will focus on the petrology and geochemistry of one unit, the upper Diliman Tuff, the youngest pyroclastic flow deposit in the volcaniclastic sequence. The chemical variations within this unit will be compared to those exhibited by similar pyroclastic deposits from Taal (60 km south) and Laguna (40 km southeast) calderas (Fig. 1B) to constrain the source of the unit and determine possible hazard implications on Metro Manila. Geologic mapping of Metro Manila was reviewed from 1997 to 1999 as part of the study on Laguna Caldera (Catane and Arpa, 1998; Arpa et al., 1999). In 2002, as a component for the seismic hazard study of Metro Manila, well distributed core samples were collected to better constrain the stratigraphy of the area. These previous projects provided background data to study the petrology of the Diliman Tuff with the objective of determining its origin.

This study also evaluates the chemical variations within the upper Diliman Tuff unit in terms of magma differentiation processes that can produce compositions that range from basalt to trachydacite. Several models can explain the compositional variation, particularly production of silicic magmas, in island arcs. For example, processes such as melting of underplated subduction related magmas was proposed to explain felsic volcanism in the Kermadec Arc (Smith et al., 2003) and the Costa Rican Arc (Hannah et al., 2002; Vogel et al., 2006a,b). In this model, partial melting of the crust is caused by heat transfer from the crystallizing basaltic intrusions, causing the production of a wide range of melt compositions simultaneously (Annen and Sparks, 2002; Vogel et al., 2004). In subduction settings, the basaltic magma is widely believed to result from partial melting of the mantle wedge fluxed by fluids dehydrated from subducting crust and sediments or down-dragged hydrated mantle peridotite (Tatsumi, 1989; Peacock,

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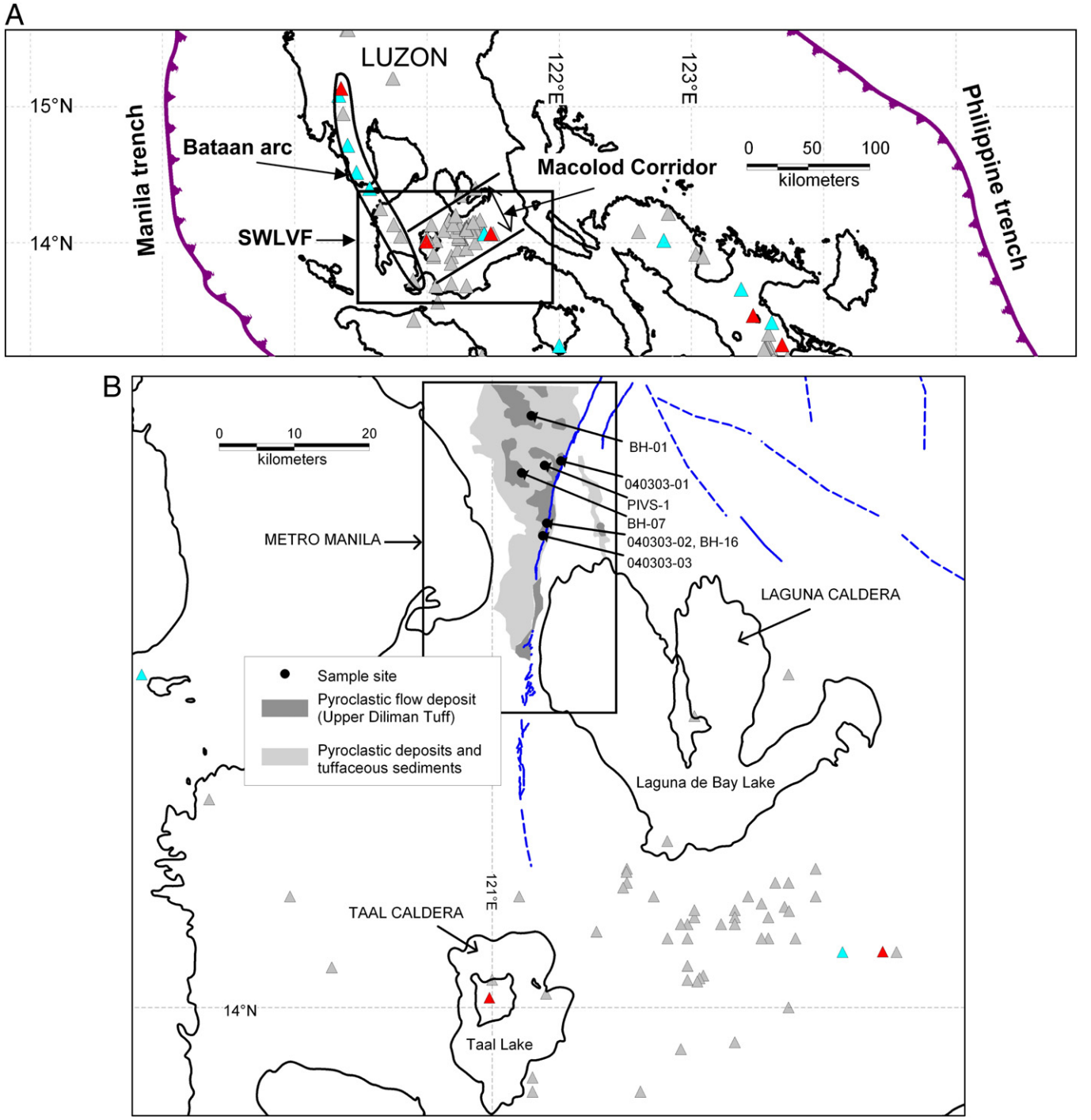

Fig. 1. A.) Map of the west-facing volcanic arc (Bataan Arc), the location of the Macolod corridor, Southwest Luzon Volcanic Field (SWLVF) and Manila and Philippine trenches. The symbols (triangles) represent volcanoes. B.) Map of Taal and Laguna Calderas and the enclosed area covering the extent of the surface geologic map of Metro Manila (revised after PHIVOLCS–NDCC geologic map of Metro Manila). Sample location sites and labels are indicated. Dashed and solid lines are active faults (inactive faults are not shown) (PHIVOLCS 2000 edition active faults map).

1990; Giggenbach, 1992; Grove et al., 2003). Particularly for volcanoes in Luzon, related to the subduction in the Manila Trench, the source materials have been enriched in large ion lithophile elements (LILE) and radiogenic Sr as a result of dehydration of the subducted crust and terrigenous sediments from Eurasia (Knittel et al., 1988; Defant et al., 1988; Mukasa et al., 1994; Castillo and Newhall, 2004). These models will be considered in our analyses of the volcanic setting and source magma differentiation for the upper Diliman Tuff unit.

2. Geologic setting of Southwest Luzon

The Philippines is bounded by subduction zones to the east and west. Subduction on the west margin, of Luzon, is along the Manila Trench (Fig. 1A). The main volcanic arc associated with this subduction occurs at about 100 km above the Wadati-Benioff zone (Cardwell et al., 1980) and is termed the Bataan Arc. There are many volcanoes in southwest Luzon located east of the Bataan Arc and more than 100 km