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Petrogenesis of trachyte and rhyolite magmas on Ponza Island (Italy) and its relationship to the Campanian magmatism

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ABSTRACT

Magmatism on Ponza island (Italy) has been reviewed, considering both new and literature data, and compared with the Campanian Volcanic District (CVD) rocks. Different origins have been inferred for the two main rock types (trachyte and rhyolite). The trachytes were formed by fractional crystallization (FC) processes coupled with minor upper crustal contamination from magmas similar to the least evolved magma erupted into CVD. The rhyolites formed by partial melting of a lower crust component. The two lithotypes evolved through intra-suite FC, and they are correlated with the volcanic rocks of the CVD by major element, trace element and isotope data, extending the Campanian compositional spectrum. To explain the FC and the melting processes, a tectonic model is developed in which most of the FC for the CVD occurred in the lower-intermediate crust where magma rises from the upper mantle and is stored in a process of magma accumulation and fractionation. These processes have produced enough heat to melt the crust and cause several rhyolite episodes in Ponza Island. A subduction-related setting must be inferred to explain the origin of the Ponza trachytes and rhyolites and the rest of the CVD volcanism.

1. Introduction

Ponza Island is part of the Pontine Archipelago (comprising four main islands: Ponza, Palmarola, Zannone and Ventotene) on the margin of the continental shelf in the Tyrrhenian Sea, north of Ischia and south of Gaeta (Fig. 1). Ponza is in a tectonically complex area and is particularly interesting because it is situated near the 41° parallel discontinuity in a convergent arc system (Serri et al., 1993; Argnani and Savelli, 1999; Savelli, 2000). The 41° parallel discontinuity is a dextral transcurrent fault system at the boundary between the northern and southern Tyrrhenian Basin (Savelli and Wezel, 1979). The area has also experienced moderate extension, in which the lithosphere and crust of the southern Tyrrhenian Basin have been subjected to significant thinning since the Tortonian (Morelli, 1984; Zitellini et al., 1984; Serri et al., 1993). Magma origins involve both crustal and mantle end-members (the heat flow ranges between 100 and 150 mW m^2; Della Vedova et al., 1984, 1991), and crustal thickness is approximately 20–25 km (Morelli, 1984). Barberi et al. (1967), Alessio et al. (1974), Savelli (1987), Metrich et al. (1988) and Conte and Savelli (1994) have contributed to a better understanding of some geological, petrographical and petrological features of the Pontine Islands, also indicating the similarity with HKCA (High-K Calca-alkaline) rocks. Trachytic and rhyolitic magmatism similar to the Ponza island is found in the Roman and Tuscan provinces of mainland Italy where high silica HKCA rocks (rhyolites) are found as product of the early magmatic activity at Monte Cimino volcano (e.g., Perini et al., 2003) at Vico volcano (e.g., Perini and Conticelli, 2002; Perini et al., 2004), and at Sabatini–Manziana (Conticelli et al., 1997). Additionally, rhyolites and granites that were formed by partial melting of continental crust are also found in the Tuscan Province for rocks of various ages, from Pliocene to recent (e.g., Poli et al., 1984; Innocenti et al., 1997; Poli et al., 2003).

Using new and existing geochemical data on the Pontine Islands volcanic rocks (e.g., Metrich et al., 1988; Conte and Dolfi, 2002; Fedele et al., 2003; Cadoux et al., 2005), the principal aim of this study is to develop a clear petrological and geochemical evolutionary picture of the Ponza magmatic suite and to place the magmatic activity in the context of the Mediterranean tectonic system (e.g., Doglioni et al., 1999; Marani et al., 2004). Of particular interest is the genesis of trachyte and rhyolite in the same magmatic suite and the relationship between Ponza magmatism and the Campanian Volcanic District (CVD, Paone, 2004). The CVD belongs to the Roman Comagmatic Province in terms of petrological provinciality as defined by Washington (1906). This study presents a geochemical and petrological evaluation of the Ponza magmatism, it relates the Ponza magmatism to the CVD, and proposes a model for the latter.

2. General overview of the geology of Ponza Island

Volcanic products of Ponza Island (Fig. 1) have been extensively studied (e.g., Bellucci et al., 1999a, 1999b; Conte and Dolfi, 2002; Fedele et al., 2003; Cadoux et al., 2005). Bellucci et al. (1999a) defined the mineralogy and the stratigraphy of the island and showed (with a

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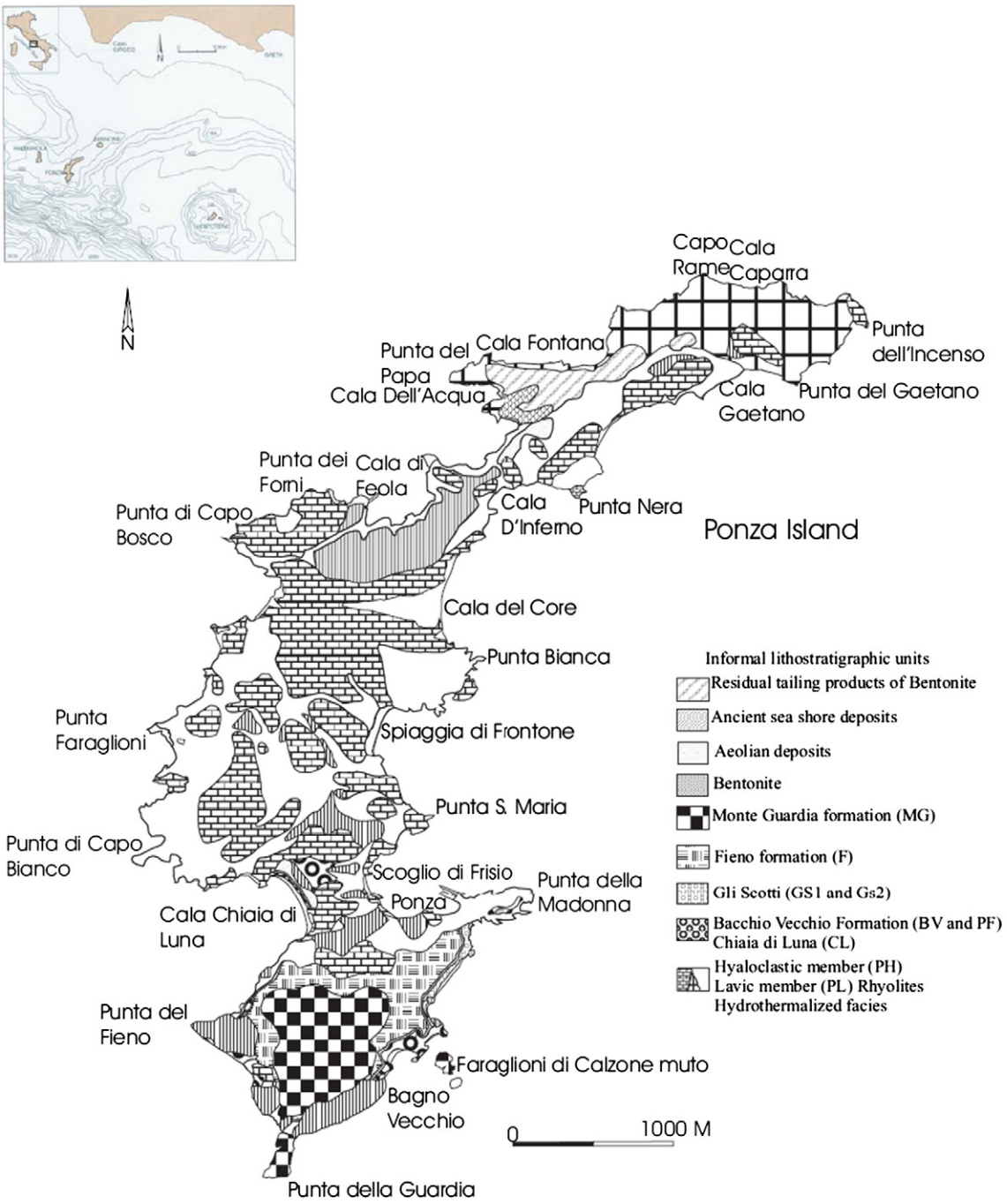

Fig. 1. Map of the western coast of Italy showing the Pontine Islands. Simplified geologic map of Ponza Island. Modified after Bellucci et al. (1999a, 1999b) with a stratigraphic legend.

K/Ar method) that the end of the volcanic activity is represented by *Le Formiche* unit (Monte Guardia formation, trachytes constituting a volcanic neck; 0.93 Ma). Conte and Dolfi (2002) presented the most recent geochemical data on the volcanic products of Ponza Island of the Pliocene submarine rhyolite and the Pleistocene subaerial trachyte and comendite and defined two evolutionary magmatic processes, distinguishing the Pliocene rhyolite rocks from the Pleistocene trachytic rocks. In their model, the two rock types were both produced by crystal fractionation processes in which the rhyolite was also affected by crustal contamination. Melt inclusion data (Fedele et al., 2003) suggest that the least evolved rocks from nearby Ventotene Island (VNT-3, trachybasalt, Table 2; 0.81 Ma; Bellucci et al., 1999A) are connected to the Pleistocene Ponza trachytes by fractional crystallization processes. Cadoux et al. (2005) redefined the chronology of the rhyolitic flow with several volcanic events occurring specifically at 4.2 Ma, 3.7 to 3.2 Ma and 2.9 to 1.0 Ma. They also produce K/Ar data for the Palmarola rhyolites and these data cluster at 1.7–1.6 Ma confirming the early data of Barberi et al. (1967). For the Ponza rhyolite, Scutter et al. (1998) estimated an erupted volume higher than 7 km^3 and that the material was extruded from at least three vents.

Table 1 shows the stratigraphy of Ponza Island with the formations, sample names and sample locations, rock types and the ages, respectively (from Bellucci et al., 1999a), and a summary of the phenocrysts and groundmass mineral assemblages from Belkin et al. (1996), Bellucci