15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. **7** Ext. Abs. GSG2019-120

Mineralogical, Petrological and Geochemical Study of the Agios Ioannis Lavas, at Kamena Vourla Area, Greece

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The volcanic center of Lichades is located in the Northern Euboean Gulf and consists of a complex of volcanic islands and lava outcrops named Agios Ioannis and Vromolimni at the Kamena Vourla area, in mainland (Georgalas, 1938). Different theories have been proposed about Lichades volcanic center geological setting. Innocenti et al. (2010) based on Sr–Nd–Pb isotopic data, related this volcanic center with the large volcanic belt that developed north of the Pelagonian–Attic–Cycladic–Menderes massifs, encompassing a 35 Ma timespan which is widespread over a large area from NW Greece–Macedonia to the Aegean–western Anatolia. According to the above authors, the Euboea-Kamena Vourla volcanic products are orogenic in character and partially contemporaneous with the south Aegean active volcanic arc, but with different geochemical features, related to distinct magma sources. The volcanic center of Lichades are located along the major tectonic structures in the area (Kranis, 1999). Karastathis et al. (2011) showed that there is a magma chamber under the North Euboean Gulf area using low seismic P-wave velocity values and high Poisson ratios at depths below 8 km, also coincident with a Curie surface estimated at 7-8 km depth. Kanellopoulos et al. (2017a, 2017b) suggested that the volcanic center of Lichades and the associated magmatic chamber is the heating source and contributes with a portion of deep magmatic fluid to the geothermal fluid of Euboea-Sperchios system, alongside with seawater and only limited meteoric water contribution.

Figure 1. Agios Ioannis lava outcrop at Kamena Vourla area.

Detailed petrographic analysis of volcanic rock samples collected from Agios Ioannis was conducted in thin sections, using polarized optical microscope (OM). Mineral composition has been determined by Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS) and powder X-ray powder diffraction (XRPD). The volcanic rocks are characterized by vitrophyric texture. Their matrix is dominated by glass, numerous, randomly oriented microlites of plagioclase and minor sanidine, clinopyroxene and amphibole (Fig, 2a, b). Phenocrysts are commonly plagioclase, olivine, quartz, clinopyroxene and amphibole. Plagioclase occur as large euhedral to subhedral grains, displaying patchy or concentric zonation. At places, plagioclase phenocrysts are rimmed by a thin rind of K-rich feldspar (sanidine, Fig. 2c), which can rarely be found as phenocryst as well. Olivine is usually found as large, euhedral to subhedral grains or they can form glomerophyric aggregates along with clinopyroxene crystals. Sometimes, zoning and the existence of embayments in the crystals may indicate reactions with the host melt, as the crystallization was evolving through time. Amphiboles, mostly hornblende, is usually forming euhedral grains with characteristic zoning. Locally, replacement by opaque phases suggest minor opacitization processes. Resorbed quartz phenocrysts are uncommon, but they are always rimmed by clinopyroxene crystals. Vesicles are abundant and, in some cases, amygdules filled with euhedral clinopyroxene may occur. Clinopyroxene is also present as euhedral phenocrysts or even as glomerophyric aggregates. Sphene may occur as a rare accessory mineral. Finally, opaque phases, commonly spinel, magnetite and rutile are quite abundant, scattered in the vitreous matrix.

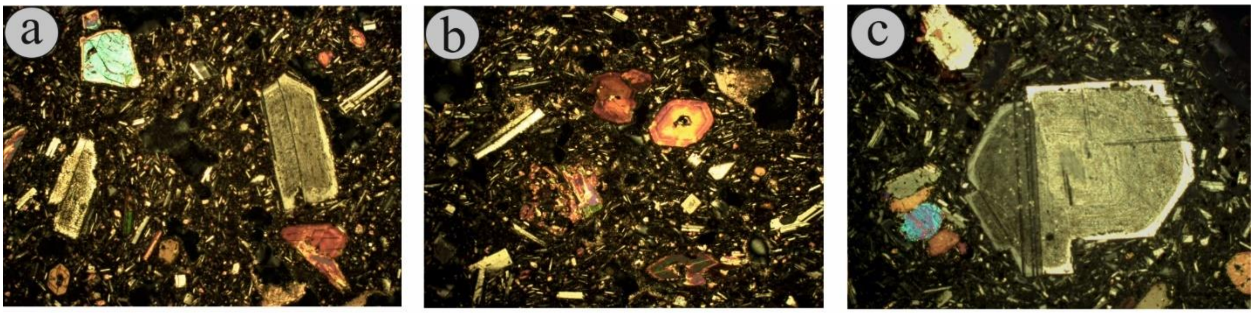

Figure 2. Photomicrographs of the studied volcanic rocks, taken under crossed nicols (a and b) Their matrix is dominated by glass, numerous, randomly oriented microlites of plagioclase and minor sanidine , clinopyroxene, amphibole grains and (c) Plagioclase appears as phenocrysts and commonly are rimmed by a thin rind of K-rich feldspar (sanidine).

A study of the bulk geochemical composition of selected samples was conducted by X-ray Fluorescence (XRF) and Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS). Major elements in the studied samples show a limited range of variation such as SiO_2 (57.3-58.8 wt%), TiO_2 (0.7 wt%) and Al_2O_3 (17– 17.5 wt%), MgO (3.1–3.4 wt%) and CaO (5.8–6.1 wt%). The volcanic rocks from Agios Ioannis plot in the fields of trachyandesites on the total alkali-silica (TAS) diagram. In the K_2O vs SiO_2 classification diagram, the studied samples plot in the field of high-K calc-alkaline series. Their trace-element patterns show relatively high Th and Ta contents, pronounced negative P anomaly and significant negative Rb, K, Ti and Y anomalies.

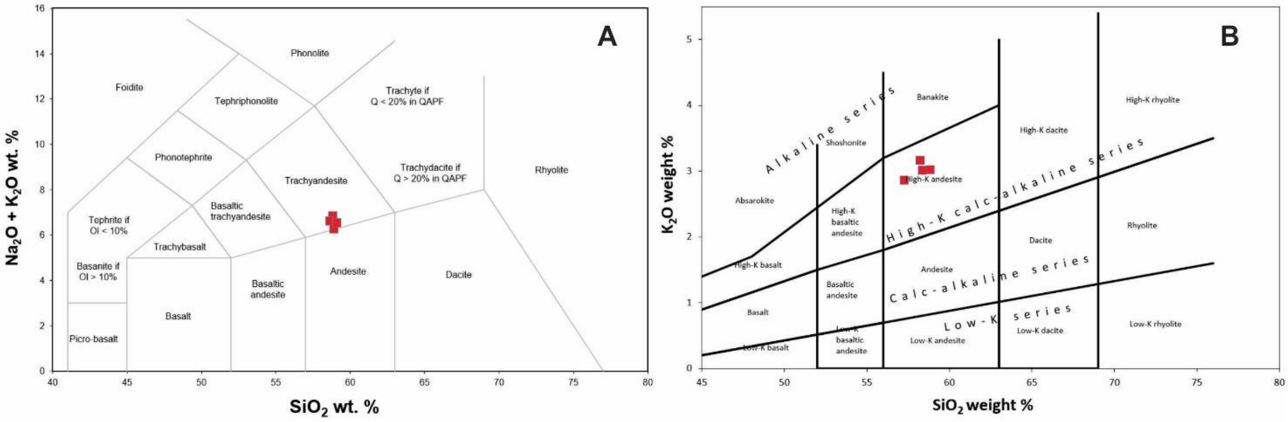

Figure 3. Classification diagrams (A) Total alkalis–silica (TAS) and (B) K_2O vs SiO_2.

The petrographic characterization and the geochemical signature of the Aghios Ioannis volcanics let us draw some preliminary conclusions of their petrological affinities, helping us to make some first inferences about their geotectonic evolution and their emplacement regime. The studied features are similar to geochemical characteristics of subduction-related rocks, with high normalized abundances of LIL elements and troughs in the normalized trace element plots at Nb, Sr, P and Ti. The small size of the volcanic centre of the studied area and the strong enrichment in incompatible elements suggest that the magmas resulted from small degrees of partial melting of an enriched subcontinental lithospheric mantle.

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