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Early Alpine Rift Volcanism in Continental Greece: the Case of Glykomilia Area (Koziakas Mountain)

Früher alpiner Rift-Vulkanismus im kontinentalen Griechenland: der Fall des Glykomilia-Gebietes (Koziakas Berge)

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With 7 figures

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Abstract

Petrographic, geochemical and mineral chemistry data are presented for the mid-Triassic volcanic rocks of Koziakas mountains, western Thessaly, Greece. These extrusive rocks are associated with pyroclastics, and underlain cherts, radiolarites and limestones of Carnican age. The textures of the volcanics are mainly porphyritic and glomeroporphyritic. Phenocrysts and microlites of zoned plagioclase, K-feldspar and clinopyroxene can be distinguished as principal primary phases. Pumpellyite, calcite, chlorite and albite are the predominant secondary phases formed during very low-grade metamorphism. The volcanics belong to the transitional alkaline – subalkaline series and are classified as trachyandesites. On the basis of major and trace element whole rock chemistry, clinopyroxene composition and stratigraphy, the lavas erupted in the pelagic – abyssal marine rift environment of Pindos basin and show certain subduction related characteristics, which, however, either originated from a back arc basin or they are inherited and the rift setting was of continental or mid-ocean type. Greater assimilation of crustal rocks by the parent magmas and more complicated magma chamber processes may have taken place in the Triassic volcanics of the eastern margin of Pindos basin, under which Koziakas volcanics were generated, than in the westernmost margin volcanics.

Zusammenfassung

Es werden die petrographischen, geochemischen und mineralchemischen Daten für die mitteltriasischen Vulkanite der Koziakasberge in West Thessalien, Griechenland, mitgeteilt. Diese extrusiven Gesteine bilden zusammen mit Pyroclastica, unterlagert von Cherts, Radiolariten und Kalksteinen, eine Abfolge triassischen Alters. Die Gefüge der Vulkanite sind überwiegend porphyrisch und glomerophyrisch. Phenokristalle und Mikrolithe von zonierten Plagioklasen, K-Feldspat und Klinopyroxen sind offensichtlich die primären Phasen. Pumpellit, Calcit, Chlorit und Albit überwiegen bei den sekundären Phasen, die sich während der niedriggradigen Metamorphose gebildet haben. Die Vulkanite gehören zu den Alkali-Subalkali-Übergangsserien und können als Trachyandesite bezeichnet werden. Nach den Haupt- und Spurenelementen der Gesamtgesteinschemie, der Zusammensetzung der Klinopyroxene und der Stratigraphie ergoß sich die Lava in die pelagische-abyssale Grabenregion des Pindosbeckens. Bestimmte Anzeichen von Subduktionseinflüssen lassen sich erkennen. Diese sind jedoch entweder von einer Rückensenke aus entstanden oder ererbt. Größere Beimengungen von Krustengesteinen in dem Ausgangsmagma und sehr komplizierte Prozesse in der Magmakammer beeinflußten während der Trias die Vulkanite in der östlichen Region des Pindos-Beckens, unter denen auch die Koziake Vulkanite als die westlichsten Randvulkanite gebildet wurden.

Introduction

The oldest volcanic rocks associated with the Alpine orogenesis of continental central Greece are of Palaeozoic to early Mesozoic age. They are distributed as small dispersed occurrences in a vast region of both external (Gavrovo-Tripolis and Pindos Units) and intermediate (Western Thessaly, Parnassos, Maliac and Eastern Greece Units) zones of Hellenides. These volcanics mainly occur in the areas of Tzoumerka, Lakmon, Vardoussia, Eratini, Kremasta, Northern Pindos, Othrys, Koziakas, Lokris, Evia and Attica (SIDERIS, 1967; CLEMENT, 1968; HYNES, 1974; FLEURY, 1976; ARDAENS, 1978; COURTIN, 1979; TERRY, 1979; PE-PIPER et al., 1981; FERRIERE, 1982; PE-PIPER, 1982, 1983; PE-PIPER and PANAGOS, 1989; PE-PIPER and MAVRONICHI, 1990) (Fig. 1). Triassic volcanics are also found in Peloponnese and Eastern Aegean Islands, as well as in ex-Yugoslavia domains (MARAKIS, 1972; BEBIEN et al., 1978; PE-PIPER, 1984).

The Triassic volcanics are usually found in close association with pyroclastic rocks and cover a wide spectrum of petrological types ranging from sub-alkaline basalts and picrites to alkaline trachytes and keratophyres. It is considered they became deposited in a continental rift environment or in back arc basins accompanied by subduction zones.

In this work, we present geochemical, petrological and mineral chemical data of volcanic rocks occurring in the northern part of Koziakas mountains (western Thessaly), near Glykomilia village. A comparison of the Triassic volcanism between the eastern and western margin of Pindos basin is also given.

Geological Outlines

The Koziakas mountain range is an independent geographical unit of particular geological importance and occupies a key position on Hellenides and the Hellenic Arc in general. It is made up the Western Thessaly Unit (PAPANIKOLAOU and SIDERIS, 1979; PAPANIKOLAOU and LEKKAS, 1979; LEKKAS, 1988), which corresponds to the Ultrapindic Zone of AUBOUIN (1959) and represents a missing link between the external and internal (e.g. Pelagonian Unit) geotectonic zones (Fig. 1) in the area of central Greece. This is pointed out, among others, by its complex lithostratigraphy and tectonic structure. The Western Thessaly Unit has been considered as a separate geotectonic unit in the Hellenic Alpine system due to its continuous sedimentation from Ladinian to Middle – Upper Eocene (LEKKAS, 1988) and a number of specific stratigraphical characteristics, such as:

- neritic sedimentation during Jurassic, evolving laterally to deep sea environment because of obvious pelagic sedimentation,

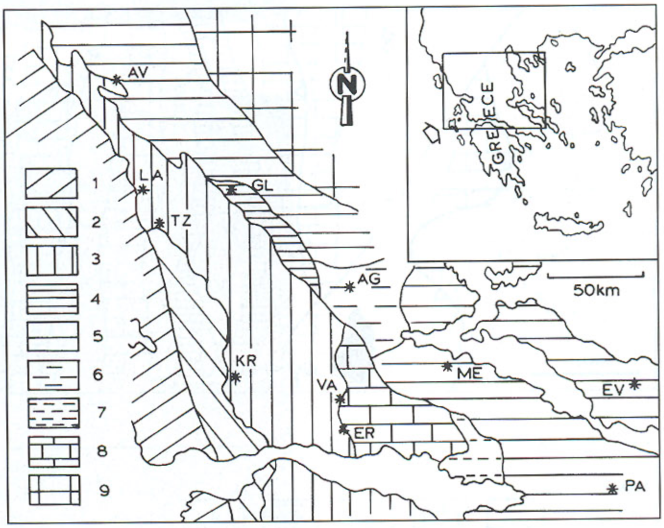

Fig. 1. Geotectonic Units in the area of central Greece (1 – lonian Unit, 2 – Gavrovo-Tripolis Unit, 3 – Pindos Unit, 4 – Western Thessaly Unit, 5 – Eastern Greece Unit, 6 – Maliac Unit, 7 – Biotic Unit, 8 – Parnassos Unit, 9 – Pelagonian Unit). The main Triassic volcanic occurrences are shown with an asterisk. TZ – Tzoumerka, LA – Lakmon, AV – Avdella (Northern Pindos), GL – Glykomilia (Koziakas), AG – Agrilia (Othrys), KR – Kremasta, ER – Eratini, VA – Vardoussia, ME – Melidoni (Lokris), EV – Evia, PA – Parnis (Attica).

- absence of unique representative stratigraphic column for all outcrops at Koziakas mountains,
- marked differences in lithology and deformation from one plase to another,
- presence of peculiar lithofacies,
- presence of ophiolitic blocks, which maintain their original stratigraphic contacts with the sedimentary rocks of the unit.

The lower part of the Wester Thessaly Unit can be directly related with the respective part of the Pindos Unit (LEKKAS 1988). It is partly, overthrusted westwards onto the latter, while common horizons between the two units indicate local lateral transitions (PAPANIKOLAOU and LEKKAS, 1979).

Detailed field investigation including geologic mapping in the study area (Fig. 2) revealed that the following formations are present:

- flysch of Tertiary age, which is composed of mudrocks alternating with sandstones,
- oolitic, microbrecciated limestone, 20–40 m in thickness, containing *Protopeneroplis striata* WEYNSCHENK of Dogger – Malm age and packed between "radiolarites – pelites",
- "radiolarites – pelites", involving intercalations of radiolarites, pelites and sandstones with cherts and few microbrecciated limestone horizons,
- "radiolarites with silex", approximately 40 m in overall thickness, containing pyroclastic fragments and limestone intercalations and locally underling "radiolarites –

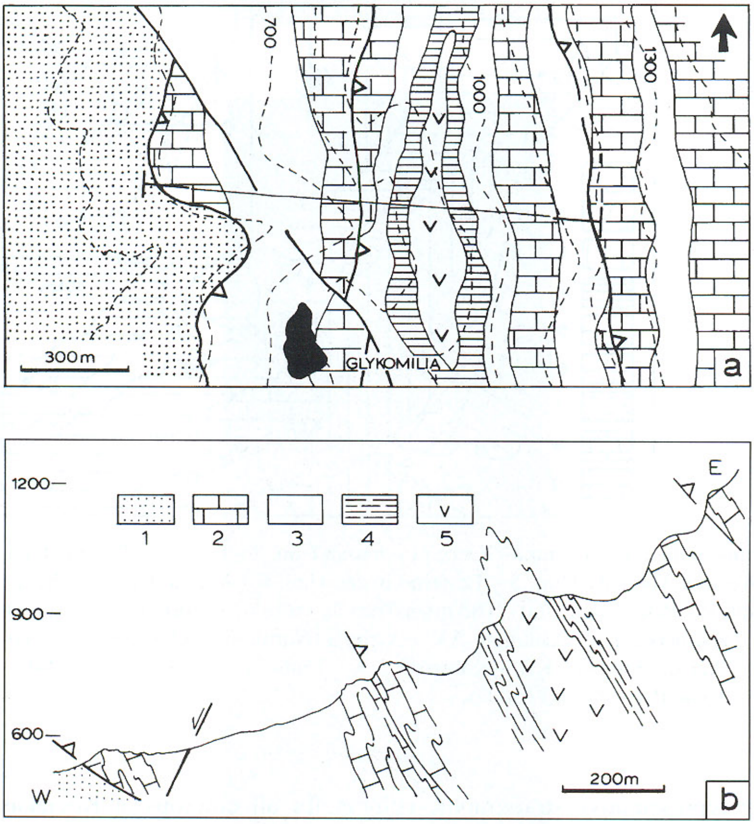

Fig. 2. Geological sketch map (a) and cross section (b) in the Glykomilia, Koziakas area. 1 – Flysch of Western Thessaly Unit, 2 – Oolitic microbrecciated limestones, 3 – Radiolarites, pelites and sandstone intercalations, 4 – Cherts and radiolarites intercalations, 5 – Volcanics.

pelites". In a limestone horizon conodonts (*Prioniodina venustra* HUCKRIEDE and *Prioniodina excavata* MOSHER) of Carnian age were identified,

- volcanic rocks, in the form of small lava flows, about 50 m in thickness, concordantly underlie the previous formation, since radiolarites follow all their anomalies, i.e. the radiolarites were deposited in the lava flows.

Hemispherical projections (not shown) in radiolarites with silex reveal asymmetry of folds indicating the presence of a dome around the volcanic rocks. Hence, the volcanic rocks are of Carnian or possibly mid-Triassic (Ladinian) age.

Petrography

The volcanics are generally without large varieties in their macroscopic and microscopic features. Their colour is light brown to grey-beige, while in fractured areas, due to oxidation, it is dark brown to black. They show porphyric structure with well observed phenocrysts of primary feldspars and pyroxenes, with a size of 2–3 mm and rarely up to 1 cm. Local accumulation of feldspars and pyroxenes phenocrysts creates a glomeroporphyric structure. The feldspars are weakly altered and consist mainly of plagioclase, whereas in smaller amounts K-feldspars occur. Twinning and zoning are common in all feldspars. Pyroxenes are of quadrilateral type and present alteration or replacement signs by secondary minerals. Moreover, other primary minerals consist of some quartz crystals, opaque minerals, apatite and zircon, which is often enclosed in plagioclase phenocrysts. The groundmass consists mainly of microlith of feldspars, clinopyroxenes, ore minerals and interstitial devitrified isotropic material.

Secondary minerals due to low grade metamorphism are occasionally found: calcite, albite, pumpellyite, Fe-oxides, chalcedonic quartz, chlorite and rarely epidote and white mica. Pumpellyite is present in veinlets or small accumulations of radiated yellow-brown crystals, and along with chlorite replaces partly or totally phenocrysts of pyroxenes and feldspars.

Microscopic investigation of the green cherty rock material with white – spots that closely accompany the volcanics reveal that it is composed of fine grained quartz, which sometimes shows layering. Lithoclasts and peloids of calcite, albite and quartz surrounded by magnetite are also observed. Veinlets of chlorite, calcite, and chalcedonic quartz cross cut the rock. The above characteristics fit to an epiclastic pyroclastic rock enriched in silica.

Mineral Chemistry

The microprobe mineral analyses were undertaken using the energy dispersive spectrometer – Cambridge Microscan 5 of the University of Athens, using 15 kV accelerating voltage, specimen current 3.3 nA on cobalt metal and livetime 50 sec. For calibration of the instrument and matrix effect corrections natural and synthetic materials were used as standards. Representative chemical analyses of the preserved primary minerals are given in Table 1.

In terms of the conventional pyroxene quadrilateral the analysed clinopyroxene crystals are classified as ferrous-magnesian augites. Their relatively high TiO_2 content, which ranges between 0.47% wt. and 0.90% wt., may reflect respective concentrations of the parent magma. The low Cr amount and the high Ti/Al_{tot} ratio reveal an orogenic (volcanic arc) calcalkali character of the volcanic host rock (Fig. 3).

The plagioclase phenocrysts and microphenocrysts are labradorite (An_{54-57}). The major part of albitic plagioclase (Ab_{70-100}, Or_{0-19}, An_{0-11}) are interpreted to result from secondary subsolidus processes, as replacement phases of more calcic plagioclase or K-feldspars. Two distinct populations of K-feldspar phenocrysts were determined, one with Or_{42-58} and the other is more potassic with Or_{70-88}. The presence of K-feldspars has also been confirmed in Triassic shoshonitic rocks of the Lakmon mountain in Pindos Unit (PE-PIPER, 1983).

The analysed opaque minerals are mainly titaniferous magnetite, with TiO_2 ranging from 15.93 to 16.73% wt. (Table 1).

It proved impossible to obtain satisfactory analyses of most secondary crystals due to their small size and mutual intergrowths with other mineral phases. Thus, only chlorite

Table 1. Representative microprobe analyses of minerals from the mid-Triassic Koziakas volcanics. Chemical formula recalculation is based on 6 (O) for clinopyroxene (= cpx), 8 (O) for plagioclase (= plag), albite and K = feldspar (= K-fsp), 3 (O) for Ti-magnetite (= Ti-mgt), 28 (O) for chlorite (= chl) and 8 (O) for alteration product (= alt prd).

Mineral Analysis	cpx 28	cpx 30	cpx 32	cpx 39	plag 5	albite 33	K-fsp 35	K-fsp 34	Ti-mgt 37	chl 16	alt prd 9
SiO_2	51.04	51.09	51.14	51.26	52.97	67.92	63.17	64.57	0.94	32.75	76.90
TiO_2	0.90	0.62	0.47	0.57	–	–	0.64	–	16.73	–	–
Al_2O_3	2.27	1.56	0.30	1.47	28.63	20.07	18.23	18.91	2.41	13.02	12.17
FeO	10.56	10.47	11.29	11.29	0.70	0.42	0.45	0.15	72.26	21.63	0.77
Cr_2O_3	0.15	–	0.44	0.12	–	–	–	–	0.28	0.13	–
MnO	0.37	0.15	0.31	0.41	–	–	0.10	–	0.83	0.20	–
MgO	14.96	14.79	14.5	14.28	0.31	–	–	–	1.98	16.39	0.20
CaO	20.25	19.68	19.2	19.33	11.18	0.24	0.68	0.23	–	0.89	0.28
Na_2O	0.45	0.58	0.62	0.31	4.36	10.28	0.90	4.89	0.46	0.61	2.57
K_2O	0.03	0.21	0.05	0.14	0.36	0.06	14.78	8.79	0.12	0.49	6.73
Total	100.98	99.15	99.32	99.18	98.51	98.99	98.95	97.54	96.01	86.11	99.62
Si	1.88	1.91	1.92	1.93	2.43	2.99	2.95	2.98	0.03	6.88	3.35
$Al^{(IV)}$	0.10	0.07	0.06	0.06	1.55	1.04	1.05	1.02	0.09	1.12	0.63
$Fe^{3+(IV)}$	0.02	0.02	0.02	0.00	–	–	–	–	–	–	–
$Al^{(VI)}$	0.00	0.00	0.00	0.00	–	–	–	–	–	2.10	–
Ti	0.02	0.02	0.01	0.02	–	–	0.02	–	0.39	–	–
Fe^{3+}	0.10	0.10	0.09	0.06	–	–	–	–	–	–	–
Cr	0.01	0.00	0.01	0.00	–	–	–	–	0.01	0.02	–
Mg	0.82	0.83	0.81	0.80	0.02	–	–	–	0.09	5.14	0.01
Fe^{2+}	0.21	0.21	0.24	0.29	0.03	0.02	0.02	0.01	*1.88	3.80	0.03
Mn	0.01	0.01	0.01	0.01	–	–	–	–	0.02	0.04	–
Ca	0.80	0.79	0.77	0.78	0.55	0.01	0.03	0.01	–	0.20	0.01
Na	0.03	0.04	0.04	0.02	0.39	0.88	0.08	0.44	0.03	0.24	0.22
K	0.00	0.01	0.00	0.01	0.02	0.00	0.88	0.52	0.01	0.13	0.37
sum cat	4.00	4.01	3.98	3.98	4.99	4.94	5.03	4.98	2.55	19.67	4.62

* Total Fe as Fe^{2+}

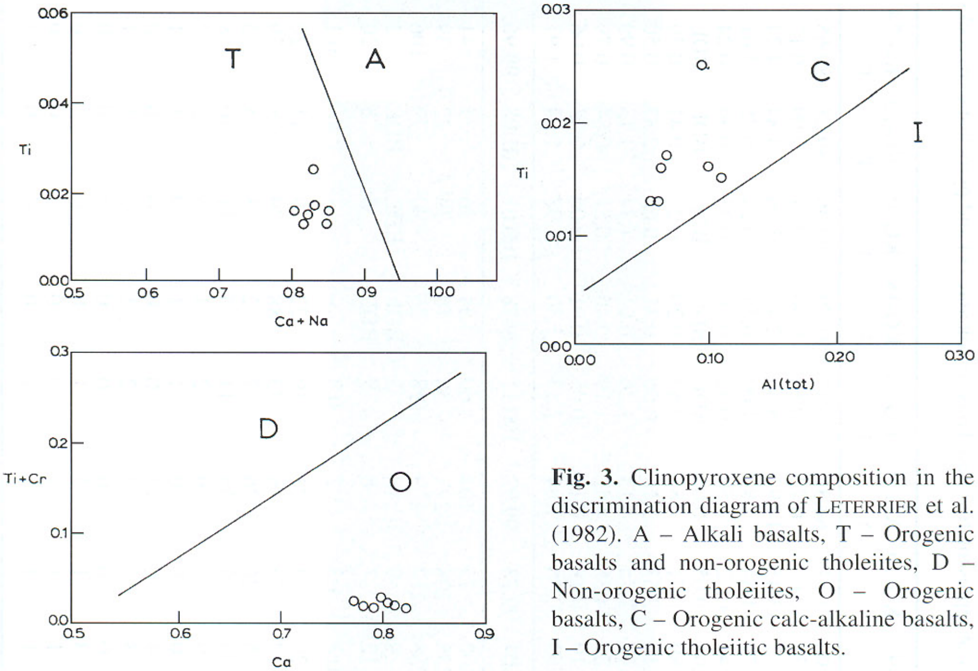

Fig. 3. Clinopyroxene composition in the discrimination diagram of LETERRIER et al. (1982). A – Alkali basalts, T – Orogenic basalts and non-orogenic tholeiites, D – Non-orogenic tholeiites, O – Orogenic basalts, C – Orogenic calc-alkaline basalts, I – Orogenic tholeiitic basalts.

analyses were taken, showing diabantite composition and X_{Mg} about 0.42. Silica rich alteration products, probably from breakdown of K-feldspars, were also determined (Table 1).

Geochemistry

In 10 representative samples of volcanics and in 5 samples of green pyroclastic rocks chemical analyses of major elements and certain trace elements were performed by XRF in the laboratories of University of Pisa (Italy) (Table 2).

The samples analysed present relatively small ranges in most measured elements as well as low LOI content. However, as evidenced by the development of several secondary mineral phases, mobilisation may have taken place in at least some chemical elements. In the sample KG-10, which is veined by chalcedonic quartz, SiO_2 increased by about 7% wt. (Table 2). Besides, the alteration seems to have slightly affected the potassium concentration, which shows, in comparison with many other elements, a wider range from 3.89% wt. up to 4.85% wt. Thus, in order to constrain on the petrogenesis of the volcanics, we based our investigation mostly on the immobile elements.

Applying the diagram Nb/Y vs. Zr/TiO_2 of WINCHESTER and FLOYD (1977), which uses immobile elements only, the volcanics plot in the field of trachyandesite (Fig. 4). Nevertheless, with the TAS diagram, which is constructed by mobile alkali elements and silica, the volcanics fall in the trachyte field and belong to the transitional (between alkaline and sub-alkaline) series (Fig. 5). The transitional character is also revealed consid-

Table 2. Whole rock major and trace element chemical analyses and CIPW norms of representative mid Triassic volcanic (v) and pyroclastic (p) rocks from Koziakas mountain BDL = Below detection limit.

Sample	KG-1	KG-3	KG-4	KG-5	KG-6	KG-7	KG-8	KG-9	KG-10	KG-11	KG-13	KG-18	KG-19	KG-23	KG-24
	v	v	v	v	v	v	v	v	v	v	p	p	p	p	p
SiO_2	64.67	64.80	64.79	64.84	64.66	64.66	64.62	65.00	71.81	64.31	86.97	93.70	90.36	89.28	89.65
TiO_2	0.72	0.75	0.72	0.73	0.72	0.74	0.73	0.74	0.67	0.72	0.16	0.06	0.11	0.09	0.12
Al_2O_3	14.95	14.80	14.73	14.83	14.66	14.90	14.82	14.77	13.45	14.93	5.35	2.48	3.76	4.84	4.24
Fe_2O_3	2.87	3.63	3.11	2.77	3.30	2.94	2.36	2.79	1.84	2.84	1.09	0.55	0.24	0.75	1.01
FeO	1.38	1.12	1.42	1.32	1.40	1.35	1.10	1.44	0.72	1.50	0.32	0.16	0.73	0.30	0.24
MnO	0.05	0.06	0.07	0.06	0.05	0.06	0.09	0.05	0.05	0.06	BDL	BDL	BDL	BDL	BDL
MgO	1.84	2.05	2.09	1.72	2.11	1.95	1.23	1.89	0.71	1.82	0.63	0.20	0.27	0.41	0.39
CaO	2.86	3.26	3.26	2.61	3.06	3.34	4.15	3.10	2.63	3.16	0.56	0.31	0.65	2.37	0.50
Na_2O	4.01	3.94	3.98	4.08	4.03	4.06	4.14	4.17	2.75	4.13	1.26	0.61	1.34	1.13	0.99
K_2O	4.73	4.10	3.95	4.85	3.89	4.27	4.53	4.27	4.35	4.42	1.19	0.40	0.51	0.84	0.79
P_2O_5	0.20	0.20	0.18	0.19	0.20	0.19	0.19	0.19	0.19	0.19	0.05	0.01	0.06	0.03	0.06
LOI	1.55	1.35	1.95	2.01	1.31	1.33	1.74	2.63	0.56	1.84	2.53	1.30	1.98	1.04	1.97
Total	99.83	100.06	100.25	100.01	99.39	99.79	99.70	101.04	99.73	99.92	100.11	99.78	100.01	101.08	99.96
Rb	114	102	97	114	98	107	110	100	75	104	60	34	36	37	41
Sr	224	254	254	210	238	252	232	238	208	227	38	18	39	22	39
Zr	240	238	236	240	238	251	247	238	217	239	128	56	90	79	106
Nb	8	10	9	9	8	11	10	9	9	10	3	BDL	BDL	BDL	2
Y	8	8	12	11	10	8	9	12	7	8	9	BDL	5	8	20
Nb/Y	1.0	1.2	0.75	0.8	0.08	1.4	1.1	0.8	1.3	1.2	0.3	–	–	–	0.1
An	21	24	24	18	23	22	19	20	33	21	19	22	19	15	20
Q	16	18	18	16	18	16	15	17	33	16	73	88	79	78	79
Or	28	24	23	29	23	25	27	25	26	26	7	2	3	5	5
Ab	34	33	34	35	34	34	35	35	23	35	11	5	11	10	8
An	9	11	11	8	10	10	8	9	12	9	2	1	3	2	2
C	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
Di	3	3	3	3	3	4	7	4	0	4	0	0	0	0	0
Hy	3	4	4	3	4	3	0	3	2	3	2	1	2	1	1
Wo	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Mt	3	2	3	2	3	2	2	3	1	3	1	0	0	1	0
Il	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Hem	1	3	1	1	2	1	1	1	1	1	1	0	0	0	1

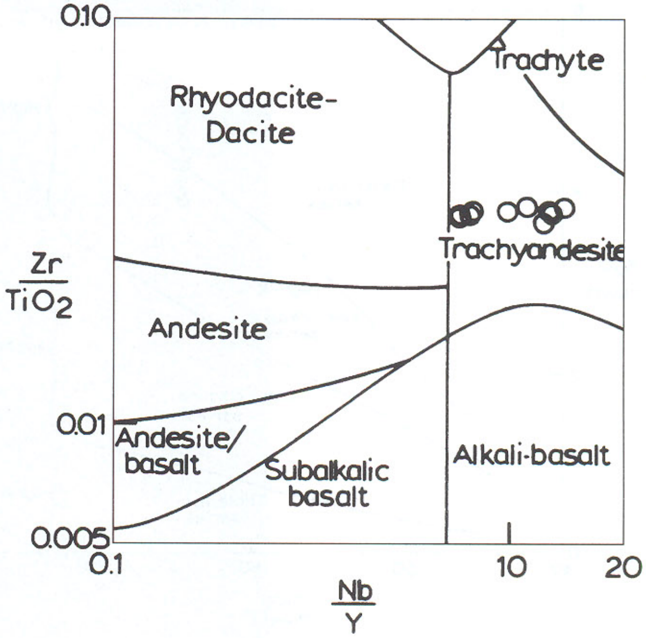

Fig. 4. Zr/TiO_2 vs. Nb/Y plot of WINCHESTER and FLOYD (1977) for the Koziakas volcanics classification.

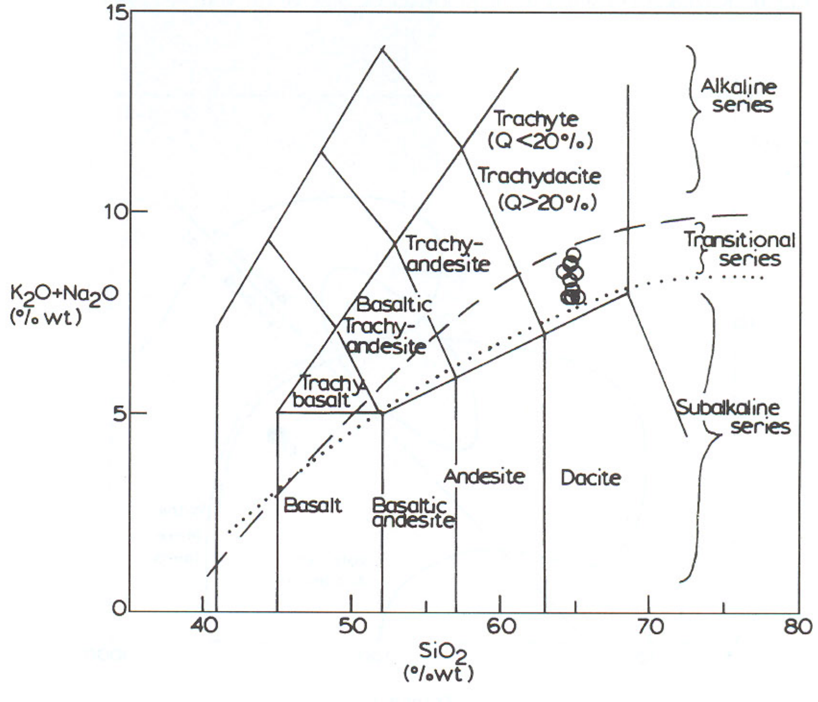

Fig. 5. Koziakas Triassic volcanics classification in the TAS (total alkali – silica) diagram of LE MAITRE (1989). Dashed line from IRVING and BARAGAR (1971), dotted line from KUNO (1966). Q – normative quartz.

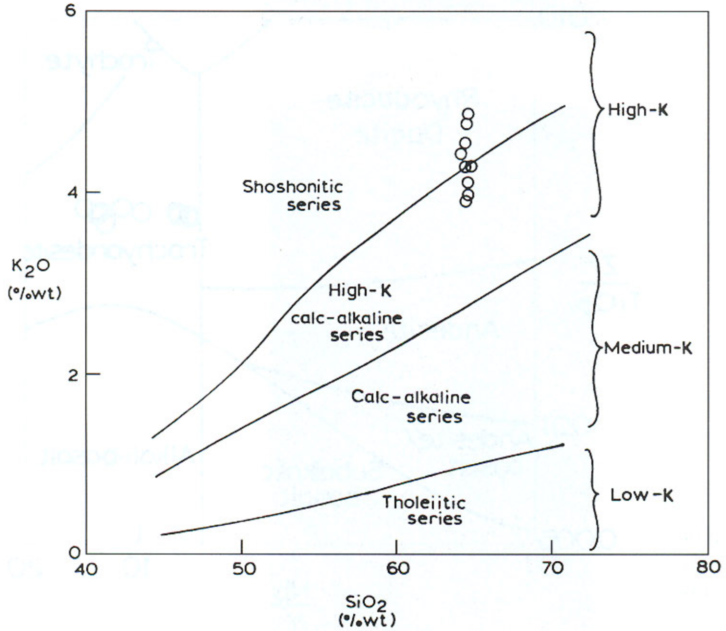

Fig. 6. Koziakas volcanics in the plot K_2O vs. SiO_2 of LE MAITRE (1989).

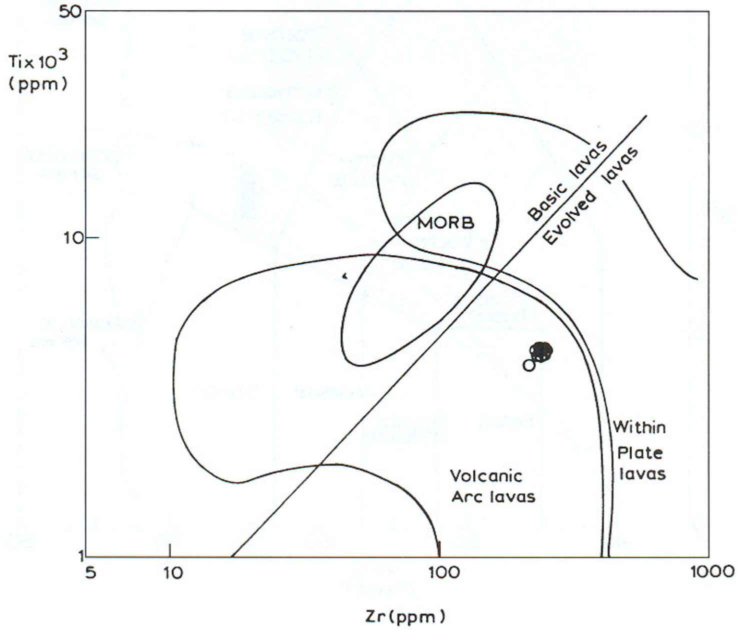

Fig. 7. Distribution of Koziakas Triassic volcanics in the discrimination diagram Ti vs. Zr of PEARCE (1982).

ering the ratio Nb/Y, which is high enough and ranges between 0.75 and 1.30 (cf. PEARCE, 1982). In the diagram K_2O vs. SiO_2 (LE MAITRE, 1989) (Fig. 6) the studied rocks clearly belong to high-K type volcanics. However, it cannot be further determined, whether the rocks are high-K calc-alkaline or shoshonitic. Finally the volcanics seem to have been derived from a subduction-related magma, as shown in the plot Ti vs. Zr of PEARCE (1982) (Fig. 7).

The analysed green pyroclastics present high silica concentration (greater than 86.97% wt.). Alumina (2.48–5.35% wt.), iron oxides, magnesia, alkalies and trace element contents are suggestive of volcanic-derived epiclastic material.

Discussion

In the region of continental central Greece, during mid-Triassioc times, the Pindos oceanic realm had just been developed between the Apulian foreland and Pelagonian microcontinent, accumulating mainly volcanic products, carbonates, sandstones and radiolarites. The mid-Triassic volcanics of Koziakas, which possess trachytic composition and are of transitional type, represent a small outbreak of the dispersed Triassic volcanism in a wide area of Pindos basin.

This central Hellenides Triassic volcanism is predominantly manifested as small occurrences at both the western margin of the Pindos zone, e.g. in the areas of Lakmon, Tzoumerka and Kremasta, and its eastern margin, e.g. in the localities of Avdella (North-eastern Pindos), Agrilia (Othrys), Vardoussia and Eratini (Fig. 1). The volcanics of all these sites show several common stratigraphical, petrographical and geochemical features (ROCCI et al., 1980; BEBIEN et al., 1980; PE-PIPER, 1982; SIDERIS and SKOUNAKIS, 1985). Remarkable similarities in stratigraphic setting, lithology and chemistry can also be drawn and with the Koziakas studied rocks erupted on the eastern margin of the Pindos basin. As common features among Koziakas and the other Pindos Triassic volcanics can be referred: the small thickness of the lavas (usually less than 50 m), their conformable covering by Upper Triassic carbonates or radiolarites, the close spatial and temporal association of lavas with volcanoclastic rocks, their restricted and dispersed exposition and the absence of significant magmatic differentiation within individual occurrences, and finally the type of primary minerals and metamorphic assemblages. However, as the Koziakas volcanics are products of high grade differentiation, they are closer resembling with transitional alkaline lavas found solely in formations and geotectonic units, which have been interpreted as representing the eastern oceanic margin of the Pindos basin. Trachytic rocks are also reported in Othrys (Agrilia) and Vardoussia mountains (ARDAENS, 1978; COURTIN, 1979; FERRIERE; 1982). The presence of evolved rocks (trachytes, trachyandesites, dacites, keratophyres), exclusively along the eastern margin, probably reflects different geodynamic evolution between the two sides of the Pindos basin during mid-Triassic times. The magmatic differentiation in both sources of parent magmas and magma chambers regions of the eastern part might be more complicated. At first a greater assimilation of crustal rocks in the parent magmas and secondly more extensive fractional crystallisation or magma mixing in many eastern magmatic centres can be suggested (cf. WYERS and BARTON 1986; WILSON, 1989).

Although there is a general agreement that the Triassic volcanism in Hellenides developed in a rifting environment only, a dispute has been raised, whether this setting shows or does not show subduction characteristics, that is, if it was a marginal back arc or continental rift or even mid-ocean basing. The dominance of andesites and the presence of shoshonites and high Th – strong Nb and Ta depleted basalts call for a descending slab activity (DERCOURT, 1980, ROCCI et al., 1980; PE-PIPER and PANAGOS, 1989). On the other hand, several authors believe that for subduction in the Triassic Pindos basin there is only little independent regional evidence (HYNES, 1974; BEBIEN et al., 1980; DUNCAN, 1987; ROBERTSON et al., 1990). They consider the geochemically determined subduction features are very weak, suggesting they may have originated either from lithosphere contamination or from an inherited older metasomatized mantle.

The trachytic extrusives of Koziakas were probably erupted in a deep rift marine basin during a relatively short period, as indicated by their transitional type chemistry, as well as by their small thickness and close association with silica rich pyroclastics and cherts. Even though they occupy a small volume only and are not accompanied by more basic or acid differentiates, subduction imprints are clearly observed in their trace element geochemistry and clinopyroxene composition. However, in order to be definite, whether these subduction characteristics could be ascribed to a back arc basin setting or if they are inherited and the rift was of pure continental or mid-ocean type, much more evidence is needed. A study of the REE and isotope geochemistry is anticipated for the near future.

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