Rhyolitic Ignimbrites in the Region of Afyon (Central Anatolia) *

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Abstract

Occurrence and field relations of an extensive ignimbrite sheet near Afyon in Central Anatolia are described.

These rhyolitic ignimbrites are part of the important Neogene volcanic activity in Turkey and belong to the alignment of volcanic complexes along the inner border of the Taurian ranges.

In close stratigraphical connection and in the same tectonic position as the rhyolites there occurs an assemblage of high-potassic, intermediate to basic volcanic rocks (alkali trachytes, mela-trachytes, latites and leucite-bearing rocks).

Petrological and magmatological considerations led to the conclusion that the rhyolites and the potassic series, in spite of the close geological connection, are not related by processes of magmatic differentiation.

Arguments in favour of an anatectic origin of the rhyolitic melt are presented. The occurrence of garnet and allanite as accessory minerals and as inclusions in the salic minerals of the ignimbrite are interpreted as relictic witnesses of a sialic parent rock. However, the trace elements, especially high Rb connected with low Sr, Ba and Zr and K/Rb ratios below 100 give a pattern generally explained by strong fractionation processes.

Introduction

Anatolia is known as a region of very extensive ignimbrites since WESTERVELD (1956) explained the pumice tuffs and associated lava-like rocks of the Neogene formations in Cappadocia near Kayseri as typical ignimbritic rocks.

This author compared the areal extension of the ignimbrite sheets with the area occupied by such voluminous welded tuff formations as

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the North Island of New Zealand and Lake Toba in Sumatra. PASQUARE in his mapping of the Neogene Urgup-Goreme basin, traced individual ignimbrite units over an area of more than 5000 km^2.

We report here ignimbrites belonging to the volcanism around Afyon in the western part of Central Anatolia. The Afyon volcanism, as well as the volcanism of the Kayseri region, is a prominent part

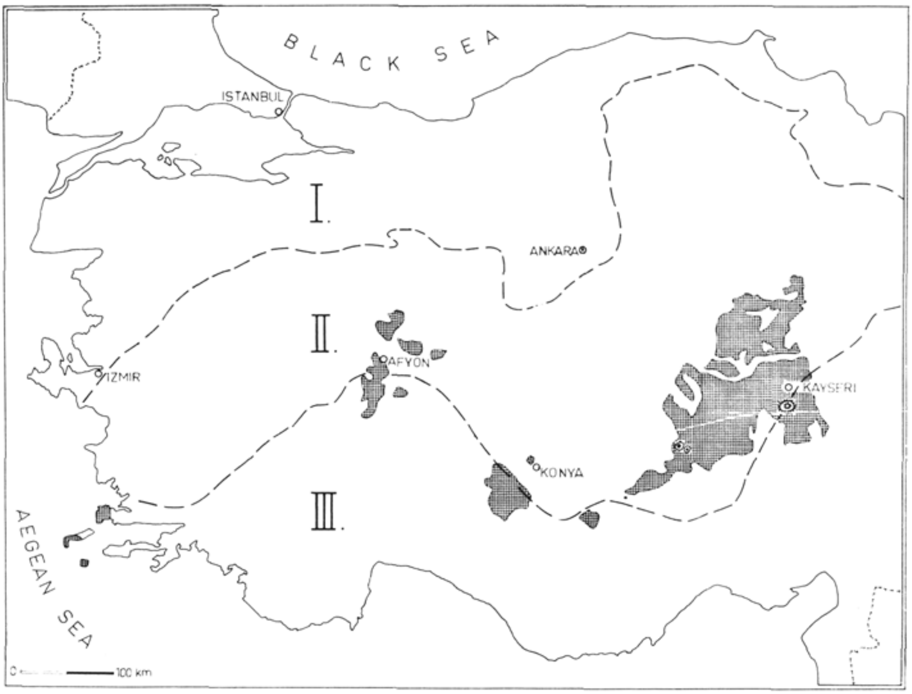

FIG. 1 - Distribution of the volcanic areas along the inner border of the Taurus in Western and Central Anatolia. Tectonic limits after KETIN (1966).

of the extended volcanic belt, which follows the inner border of the Taurus fold ranges towards the Anatolian median massifs.

This zone of Neogene volcanism reaches from the Mediterranean in the west up to Lake Van and Armenia in the East (Fig. 1).

It may be emphasized, that the inner border of the Taurus with its associated volcanism reaches the Aegean Sea in that zone, where the Hellenic arc arrives, which forms a volcanic island arc with a northward dipping Benioff-zone (NINKOVICH and HAYS). It is suspected that this Anatolian volcanism structurally forms the continuation of the Hellenic island arc, but in the continental area the processes of crustal underthrusting and overriding must be complex and geophysical data for the region are scarce. McKENZIE (1970) determined the different movements of an Aegean and a Turkish plate, both being underthrusted by the relative northwards moving African lithosphere plate.

The beginning of the volcanism falls — where stratigraphical determinations were possible — in the Upper Miocene or Lowermost Pliocene (BECKER-PLATEN, 1970; BEHRING, 1971). This coincides with the period of tectonic uplift of the Anatolian mass and the subsidence of Neogene lacustrine basins all over the Anatolian region. The volcanism greatly developed during the Pliocene and persisted or rejuvenated in several areas until the Quaternary or even the postglacial time. As a whole, the volcanism along the inner border of the Taurus system is a late- to postorogene calc-alkaline province. Among the early products acid magmas predominate, whereas the final products are mainly andesites and basaltic andesites or high-alumina basalts.

Geological Situation of the Afyon Volcanism

Afyon is situated in the western part of Central Anatolia, where the Taurus range has a salient bow to the North. North and south of the Afyon plain, which is probably a young graben structure, large volcanic areas are exposed, the extension of which is approximately represented on the Geological Map of Turkey 1:500,000.

The main part of the volcanic area is underlain by low-grade metamorphic rocks attributed to the paleozoic (PAREJAS, 1943).

Only in the south, the carbonatic series of the Taurian Mesozoic form the substratum of the volcanic formations. Terrestrial and lacustrine Neogene sediments are alternating with the volcanic rocks.

In the volcanological and petrological character different parts of this Afyon volcanic complex exhibit differing main features (Fig. 2): Around Afyon and in the south of this town latitic to trachytic lavas form morphologically well preserved domes. They consist of hornblende and biotite bearing rocks often with very large sanidine phenocrysts (up to 5 cm ∅). Connected with the dome extrusions was the formation of immense masses of breccias, partly of nuée-origin, partly as friction breccias formed with the extrusion of the domes.

South of the line Sandikli-Suhut (Fig. 2), an explosive formation of peperino-like tuffs and tuff breccias has a great development. They carry blocks of leucitic lavas and are connected with flows of leucite-

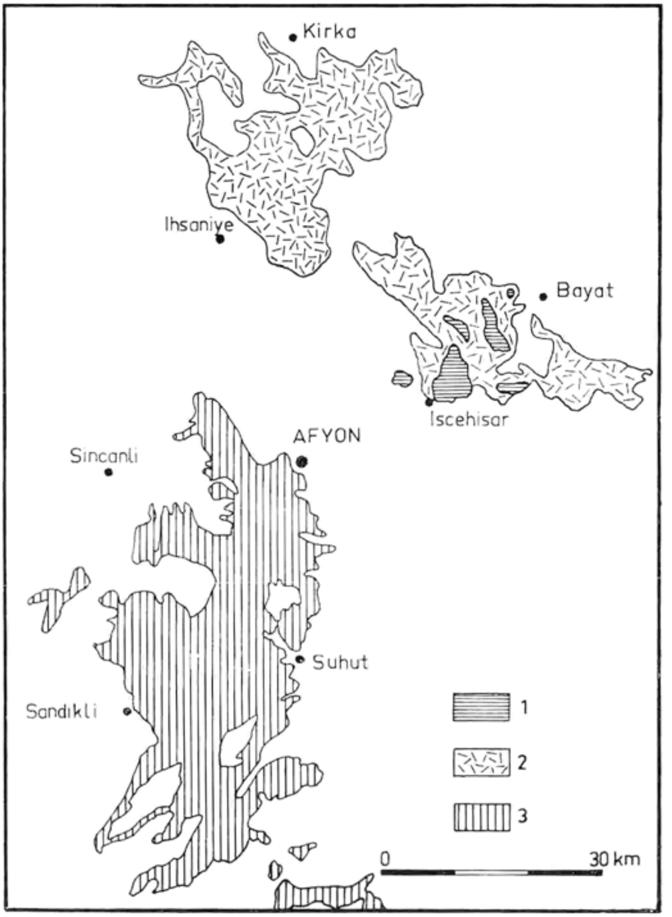

FIG. 2 - Sketch map of the volcanic areas near Afyon (Central Anatolia) 1 = Basic lavas capping the ignimbrites near Iscehisar; 2 = Rhyolitic ignimbrites; 3 = Latitic and trachytic domes, lavas and breccias of Afyon associated with leucite-bearing lavas and tuff-breccias.

tephritic and leucititic composition. But the leucitic rocks are still connected with domes of the latitic-trachytic type.

In the north of the Afyon plain, between the villages of Iscehisar, Bayat, Kirka and Ihsaniye, rhyolitic pumice tuffs and compact rhyolites form a large ignimbrite plateau. The ignimbrites are capped by basic lava flows, some of which carry leucite in the groundmass.

The main volcanic activity in the Afyon province developed at the Miocene/Pliocene boundary, the ignimbrites are of Pliocene age and the caping lavas belong to the Upper Pliocene or even lowermost Pleistocene.

The Potassic Suite

Within the general picture of a calc-alkaline province along the Taurian ranges, the Afyon volcanism exhibits a special petrological character: The bulk of the lavas emitted revealed to be alkaline with a pronounced potassic tendency. We give here a preliminary account of the presence of such high-potassic volcanic series in Central Ana-

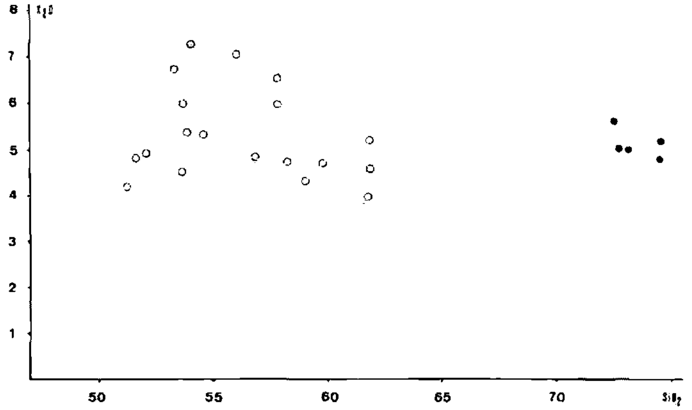

FIG. 3 - Potash-silica diagram for the analyzed rocks of the Afyon volcanism. Open circles = potassic suite; Solid circles = ignimbrites. Leucitite not plotted.

tolia. The K_2O/SiO_2-diagram of Fig. 3 demonstrates not only the high potash contents but equally the apparent lack of rocks with lower potash contents.

The apparently most primitive material are the capping lavas around Iscehisar and black lava flows from the southern flank of the Sincanli depression SW of Afyon. From analyses 1-5 in Table 2 it may be seen, that this material represents latites, mela-trachytes and alkali trachytes with potassic cheracter, high colour index and partly with silica undersaturation. The projection of these rocks in the classification double triangle of Streckeisen using the Rittmann norm is given in Fig. 4.

Two derivative evolutionary lines respectively yielded the saturated, normative quartz- bearing, again with potassic latites of the domes around Afyon (Anal. 7-9) and the leucite-bearing lavas and tuffs south

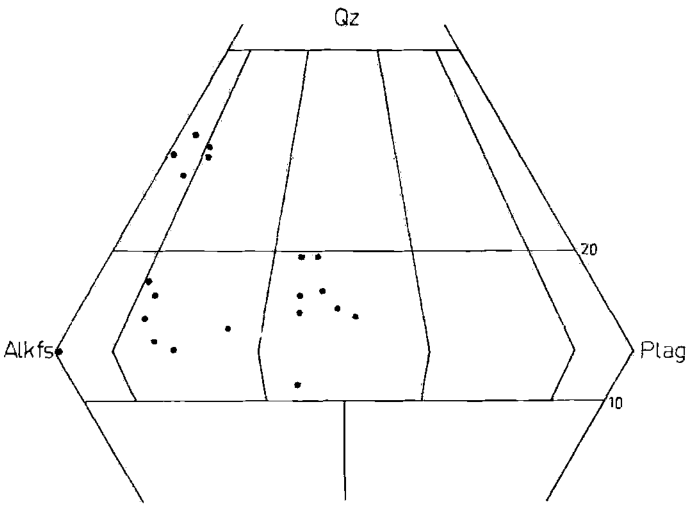

FIG. 4 - Double triangle representation for Streckeisen's classification. Leucitite not plotted.

of Sandikli and Suhut. The leucite-bearing rocks show different stages of silica undersaturation, the extreme types being leucitites mottled with leucite phenocrysts up to 2 cm in diameter. Analysis 10 in Table 1 is given to characterize such types.

From this it may be seen, that the area of Afyon represents a high-potassic province, as pronounced as the classical Roman and Campanian region in Italy.

The leucite rocks developed under the same *general* tectonic conditions, where calc-alkaline rocks equally occur (Fig. 1). DICKINSON & HATHERTON (1967) gave a possibility to explain the relationship of potassic rocks and the andesite series in island arcs and similar structures, relating the potash content of the magmas with the depth of the underlying Benioff-zone. The scarce knowledge of the deep structures of the area in consideration prevents, for the moment, the establishing of closer relation of the potash content of the Afyon rocks with tectonic processes.

The Afyon Ignimbrites

The ignimbrites north of Afyon (Fig. 2) cover an area of about 2000 km^2. They overlie a marked relief in paleozoic schists and marbles. Laterally they are intercalated with Neogene lacustrine sediments. Their stratigraphical position is Pliocene.

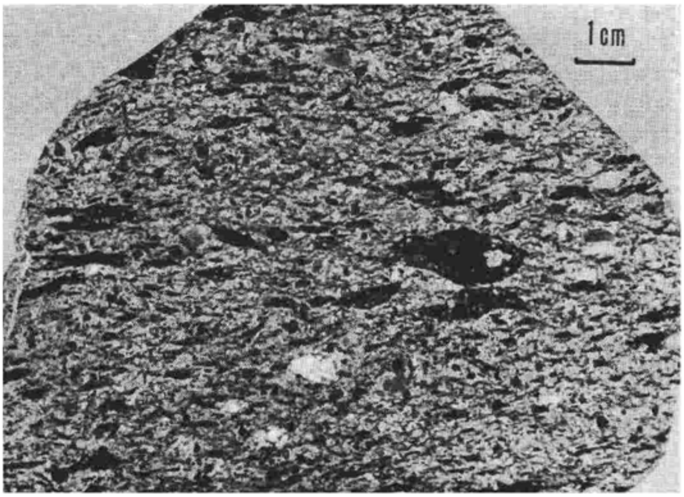

FIG. 5 - Specimen of the « fiamme-type » ignimbrites, Afyon.

The best sequence may be seen between Afyon and Kirka, on the hill called Koroglukalesi Tepe. This point is where the direct road Afyon-Eskisehir crosses the main divide of the region. The ignimbrite sheet there has a maximum thickness of 300 m and consists of a basal main flow unit of about 200 m and 2-3 following minor flow units. The main part of the sheet offers the lava-like aspect of a quartz porphyry. This is the result of an intense devitrification and crystallization process, which obliterated everey shard outline or pyroclastic texture. It is easily understood why these rocks figure as rhyolitic lavas on the Geological Map of Turkey.

Only at the base of the main flow unit are the original textures preserved. A non-welded, 1-2 m thick chaotic tuff-breccia is followed by an about 10 m-thick vitrophyric zone, where no devitrification took place. Flattened lenses and shards of black obsidianic vitrophyre give the typical « fiamme »-texture of ignimbritic rocks (Fig. 5). Partly the welding of the lenses is strong enough to yield a homogenous black vitrophyre. Upwards, the vitrophyric and fiamme-rich base gradually passes into the main mass of nearly 200 m thickness, which is characterized by thorough devitrification and crystallization. Only in the narrow transition zone, ghost outlines of the originally vitric constituents are discernible.

Welding is — apart from lowermost basal meter — intense from the base to the top in the ignimbrites of Afyon. But laterally the ignimbrite sheet passes into non-welded and nearly loose chaotic pumice tuffs at the margins.

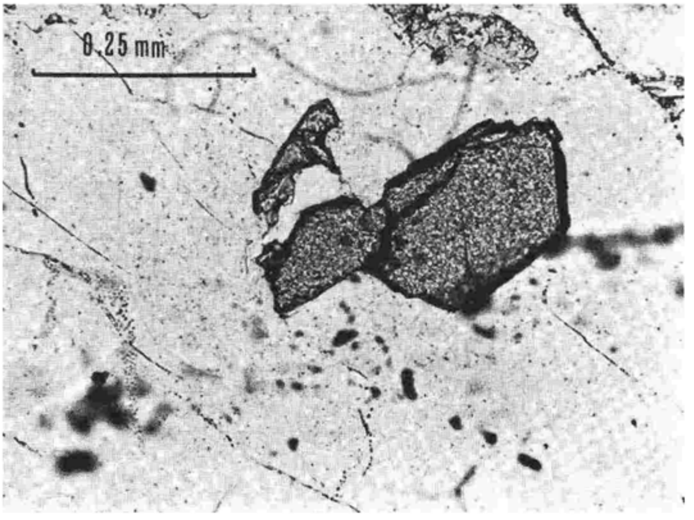

FIG. 6 - Ignimbrites of Afyon. Garnet inclusion in sanidine.

Petrography

The ignimbrite rocks are characterized by a high phenocryst content, which represents 30-35 vol % of the total rock. Salic constituents are represented by quartz, sanidine and plagioclase. The only mafic mineral is biotite, which amounts to about 1 vol %.

The minerals are always markedly fractured and often occur in fragments. Quartz phenocrysts are frequently corroded and embayed but exhibit also crystal faces of the hexagonal bipyramid. Due to its cleavage, biotite occurs very often as flakes, which show an elastic deformation during welding and compactoin of the ignimbrite. In the main unit the quartz content ranges between 33 and 45 vol % of the

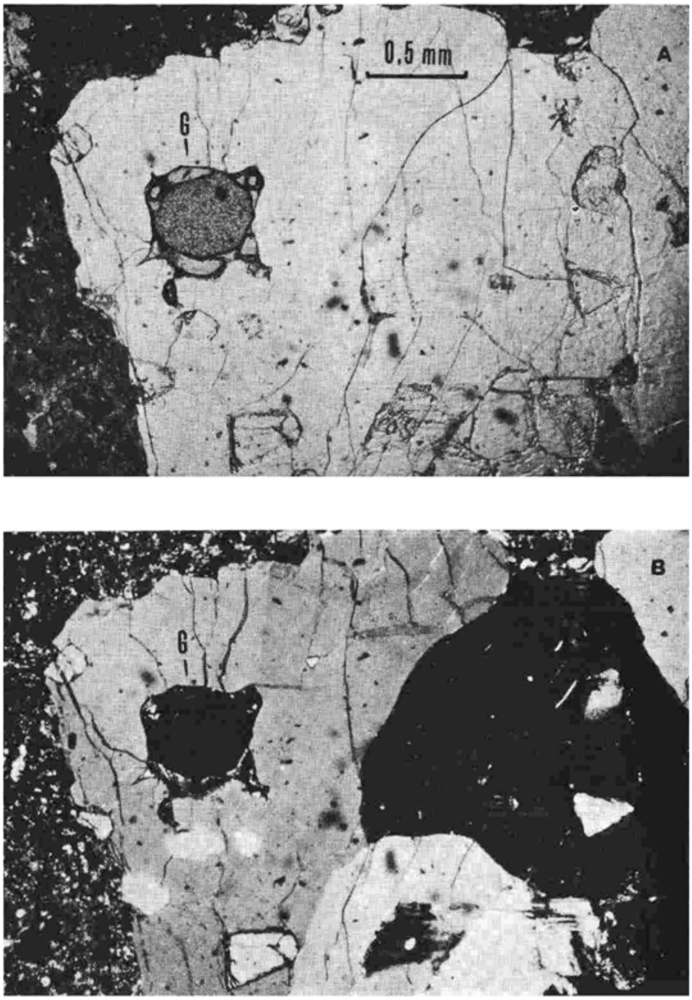

FIG. 7 - Ignimbrites of Afyon. Garnet inclusion (G) in an aggregate of quartz and feldspars. Parallel (A) and crossed (B) nicols.

total phenocrysts, sanidine reaches 34-50 vol % and plagioclase 12-18 vol %. Average plagioclase compositions vary from An_{23} to An_{32}, sanidine shows an Ab content around 18-20 mol %.

As accessory minerals, zircone, apatite, garnet (of almandine affinity) and allanite (orthite) are present. Garnet and allanite are frequently included in quartz and feldspar phenocrysts and in granophyric aggregates of the salic minerals (Figs. 6-7). The accessory constituents are generally less than 0.1 wt % of the total rock.

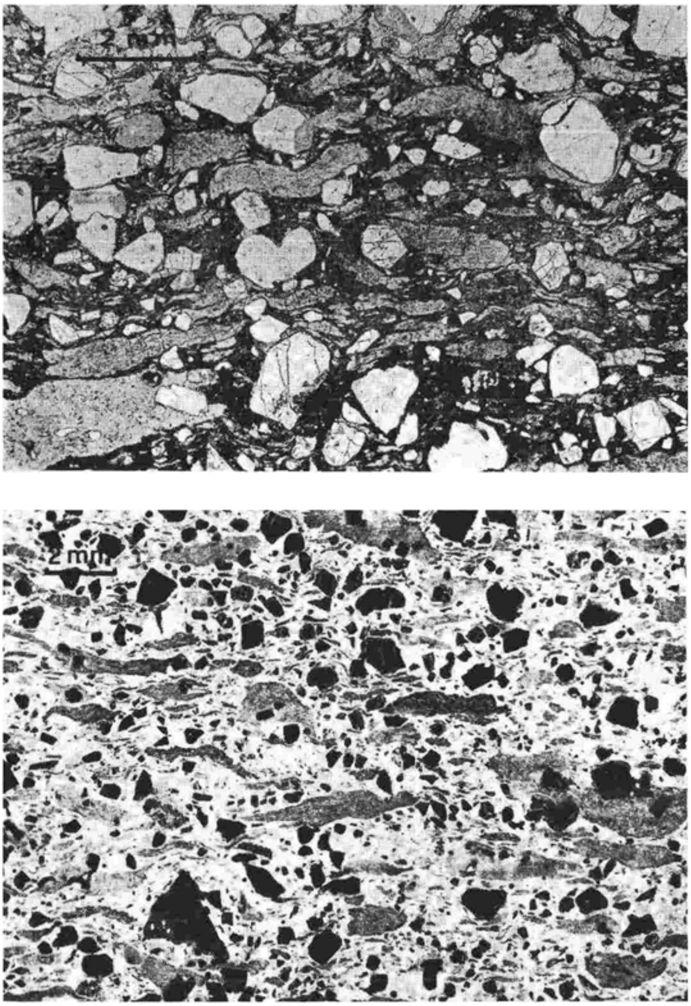

FIG. 8 - Microscopical textures of the vitrophiric base of the Afyon ignimbrites.

Minor flow units of limited extension occur in places on top of the main ignimbrite. Some of those have been sampled at Koroglukalesi Tepe. Mineralogy, textures and crystallisation patterns are essentially the same as in the main mass. The only noticeable variation can be found in the An content of the plagioclase, which ranges between An_{22} and An_{24}. The lower An content in the minor flow units seems to be connected with a lower modal plagioclase content. In the minor units plagioclase does not exceed 11 vol % of the phenocrysts.

The textures are characterized in the less devitrified facies by the flattened glass shreds and collapsed pumice fragments as shown in

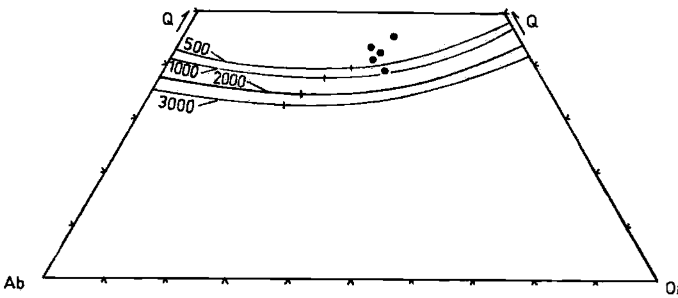

FIG. 9 - Normative Qz-Ab-Or diagram for different pressures (after TUTTLE and BOWEN) for the rhyolitic ignimbrites of Afyon.

Fig. 8. In the main mass typical ignimbritic textures are macroscopically obliterated by devitrification; spherulitic, fibrous and mosaic devitrification textures prevail. Although these rocks are crystallized, shreds and fiamme-outlines are still visible under the microscope. The intensity of welding and compaction is indicated by the penetration of large broken phenocrysts into pumice and glassy shards.

Chemical Data

Chemical analyses of the Afyon ignimbrites are presented in Table 1; they show that the composition of the entire cooling-unit varies in a narrow range. The Afyon ignimbrites are alkali-rhyolites to rhyolites and there is only a little difference between the vitric (Af 121a) and the devitrified facies (Af 130). Secondary changes of the bulk composition therefore are probably of minor importance, but they exist as testified for instance by variations in normative cordierite content.

The normative Qz+Ab+Or amounts to ca. 90 %. If plotted in the normative Q—Ab—Or triangle of Tuttle and Bowen (Fig. 9) the ignimbrites lie on the quartz side of the thermic minimum for 2 kb.

TABLE 1 - Chemical Analyses of Afyon Ignimbrite.

	Af 25(1)	*Af 29*(1)	*Af 130*	*Af 121a*	*Afs 1*
SiO_2	74.52	73.07	74.54	73.15	73.55
Al_2O_3	12.22	11.91	13.02	12.91	12.69
Fe_2O_3	0.74	1.96	1.02	0.88	0.92
FeO	0.14	0.14	0.14	0.20	0.25
MnO	0.02	0.02	0.01	0.09	0.04
MgO	0.55	0.30	0.40	N.D.	0.25
CaO	0.70	1.05	0.85	0.76	0.95
Na_2O	2.12	2.74	2.60	2.70	2.50
K_2O	5.16	4.96	4.80	5.64	5.00
P_2O_5	0.07	0.46	0.04	0.03	0.03
TiO_2	0.28	0.12	0.04	0.03	0.04
H_2O	3.24	2.96	2.10	2.87	3.30
Total	99.76	99.69	99.58	99.26	99.55
		C.I.P.W. Norm			
ap	0.17	1.09	0.09	0.07	0.07
il	0.35	0.24	0.07	0.06	0.07
mt	—	0.17	0.37	0.85	0.82
hm	0.74	1.84	0.77	0.29	0.35
or	30.49	29.30	28.18	33.32	29.54
ab	17.93	23.17	21.99	22.83	21.14
an	3.02	2.21	4.01	3.58	4.51
cor	2.04	1.23	2.12	1.06	1.51
q	40.33	36.77	38.84	34.34	37.56
hy	1.37	0.77	1.02	—	0.62
ru	0.11	—	—	—	—
		Rittmann's Norm (Vol. %)			
Qz	39.53	36.56	37.26	33.69	36.59
San	50.16	55.39	49.19	58.40	51.16
Plg	3.02	1.09	6.34	4.16	6.91
Biot	1.14	2.53	1.06	0.51	0.04
Cord	5.64	3.25	5.87	2.97	4.92
Mt	0.08	0.30	0.16	0.18	0.17
Il	0.29	—	0.04	0.03	0.03
Ap	0.13	0.88	0.08	0.06	0.08

(1) Analyst: M. CARÀ, I.I.V., Catania (Italy).
Af 25 - Alkali-rhyolite, minor flow-unit at Koröglukalesi Tepe.
Af 29 - Alkali-rhyolite, main flow-unit at Koröglukalesi Tepe (devitrified part).
Af 130 - Ahyolite, main flow-unit (devitrified part).
Af 121a - Alkali-rhyolite, glassy « fiamme » in the main flow-unit.
Afs 1 - Rhyolite, main flow-unit (vitrophiryc part).

It must be noted, that the Na_2O/K_2O ratio, equal to 0.40-0.55 is lower than in comparable rock series.

Table 2 presents the trace element distribution in the ignimbrites of Afyon. The principal chemical features that emerge from Table 2 are the high Rb content and the low concentration of Sr and Ba. The K/Rb ratio is considerably low and ranges between 80 and 101.

TABLE 2 - Trace Elements Distribution in Afyon Ignimbrite *.

	Af 121a	*Afs 1*	*Af 130*
Rb	495	516	391
Sr	N.D.	34	15
K/Rb	94	80	101
Ba	N.D.	N.D.	38
Zr	45	46	61
Y	118	101	73
Ce	65	57	54
La	21	20	8
Zn	37	37	52
Cu	22	24	22
Ni	2	4	6
Cr	17	68	19
Co	N.D.	1	9

* Concentration in ppm.
Af 121a - Glassy « fiamme » of Afyon ignimbrite.
Afs 1 - Main ignimbritic unit: vitrophiryc part.
Af 130 - Main ignimbritic unit: devitrified part.

Zr is relatively low and Ce is high, when compared *e.g.* with the dates of EWART *et al.* (1968). Yttrium is strongly enriched with about 100 ppm.

Ten chemical analyses of lavas from the Afyon volcanic complex are shown in Table 3. Their composition varies from alkali trachytes to latites; they belong to a well defined potassic suite. Trachytes and alkali trachytes have been observed directly overlying the ignimbrite sheet, but no transitional terms are present.

Origin of the Ignimbritic Magma

The large volumina of rhyolitic ignimbrites makes it difficult to explain the magma as a product of a differentiating basaltic melt. This argument weighs in Afyon even heavier than elsewhere, because

TABLE 3 - Chemical Analyses of Afyon Lavas.

	Af 45(1)	*Af 17*(1)	*Af 10*(1)	*Af 134*	*Af 40*(1)	*Af 59*(1)	*Af 13*(1)	*Af 32a*(1)	*Af 117*	*Af 114*(1)
SiO_2	51.20	53.62	53.07	53.83	56.05	58.18	59.75	61.85	54.06	49.78
Al_2O_3	14.32	13.95	10.83	13.77	14.02	15.54	16.02	16.18	14.02	16.78
Fe_2O_3	2.69	5.31	2.23	3.82	3.60	4.23	5.33	4.06	4.22	5.30
FeO	4.66	2.08	4.59	3.00	1.65	1.72	0.36	0.21	1.50	1.86
MnO	0.17	0.14	0.18	0.11	0.14	0.15	0.14	0.14	0.07	0.22
MgO	7.05	8.16	8.97	6.38	6.25	3.93	2.62	2.62	5.14	1.51
CaO	7.99	6.45	5.75	7.60	5.04	5.88	4.20	3.64	7.17	5.46
Na_2O	3.00	2.95	2.30	1.72	2.30	3.40	4.10	3.50	1.28	2.68
K_2O	4.20	4.46	6.00	5.42	7.08	4.20	4.70	5.20	7.30	11.12
P_2O_5	0.82	0.68	1.08	0.59	0.71	0.70	0.55	0.52	0.79	0.58
TiO_2	1.32	1.38	1.55	1.29	1.35	0.85	1.20	0.87	1.27	1.55
H_2O	2.32	1.10	3.54	1.57	2.03	1.59	1.27	1.03	2.48	2.81
Total	100.25	100.51	100.59	99.43	100.40	100.37	100.27	99.82	99.63	99.65

C.I.P.W. Norm

	Af 45	*Af 17*	*Af 10*	*Af 134*	*Af 40*	*Af 59*	*Af 13*	*Af 32a*	*Af 117*	*Af 114*
ap	1.94	1.62	2.56	1.40	1.68	1.66	1.30	1.23	1.87	1.37*
il	2.51	2.62	2.94	2.45	2.56	1.61	1.06	0.74	2.41	2.94
mt	3.90	3.16	3.23	5.54	1.86	3.57	—	—	1.38	2.22
hm	—	3.13	—	—	2.32	1.77	5.33	4.06	3.27	3.77
or	24.81	26.35	35.45	32.02	41.83	24.81	27.77	30.72	44.07	40.52
ab	22.96	24.95	19.45	14.54	19.45	28.75	34.68	29.60	10.82	—
an	13.21	11.65	1.51	13.85	7.03	14.74	11.43	13.09	10.49	0.92
q	—	—	—	3.10	0.37	8.00	7.84	11.71	1.59	—
di	16.79	12.38	15.84	15.61	10.38	7.67	2.78	—	15.51	8.11
hy	—	10.52	6.66	9.05	10.75	6.23	5.23	6.52	5.61	—
ol	10.04	2.84	9.06	—	—	—	—	—	—	—
ne	1.31	—	—	—	—	—	—	—	—	12.28
lc	—	—	—	—	—	—	—	—	—	19.75
tn	—	—	—	—	—	—	1.57	1.11	—	—

* wo present in norm Af 114 as 4.99.

Rittmann's Norm (Vol. %)

	Af 45	*Af 17*	*Af 10*	*Af 134*	*Af 40*	*Af 59*	*Af 13*	*Af 32a*	*Af 117*	*Af 114*
Qz	—	—	—	2.90	7.24	5.72	10.89	15.85	1.41	—**
San	37.21	48.82	62.57	47.16	49.20	42.96	40.25	39.70	60.19	20.34
Plg	26.60	20.81	—	19.11	7.57	30.62	28.69	27.13	11.65	—
Ne	—	—	—	—	—	—	—	—	—	—
Lc	4.50	—	—	—	—	—	—	—	—	57.17
Cpx	17.63	14.98	20.06	11.87	11.87	17.60	5.13	1.84	21.60	14.02
Ol	10.01	11.73	12.29	—	—	—	—	—	—	—
Biot	—	—	—	—	21.71	—	12.44	13.82	—	0.64
Mt	1.06	1.00	1.01	2.05	0.73	0.85	0.81	0.59	1.78	2.05
Il	1.23	1.32	1.78	0.58	0.23	0.85	0.69	0.33	0.72	—
Ap	1.73	1.43	2.28	2.70	1.43	1.41	1.08	0.70	2.64	1.16

** Melanite present in Rittmann's Norm Af 114 as 3.04.

(1) Analyst: M. CARÀ, I.I.V., Catania.

Af 45 - Latite, dike in Neogene sediments.
Af 17 - Mela-trachyte, lava-sheet overlying the ignimbrites near Iscehisar.
Af 10 - Alkali mela-trachyte, lava-boulders near Pasaköykorusu.
Af 134 - Mela-trachyte, lava-sheet at Agindag.
Af 40 - Mela-trachyte, lavas of Egerli-Dag at the contact with the underlying ignimbrites.
Af 59 - Latite, lava dome at Koca Tepe, south of Afyon.
Af 13 - Latite, dome near Kayadibi.
Af 32a - Latite, dome near Afyon.
Af 117 - Trachyte, lava-sheet near Kinik.
Af 114 - Phonolitic leucitite, volcanic vent at Cicektepe Köy.

here the rhyolites are accompanied only by extremely K-rich rocks, which differentiate towards leucitic rocks. A broad gap, that cannot be bridged, exists in several important petrological characteristics between the acid rocks and the potassic suite. This gap is evident for example in the K_2O-SiO_2-diagram of Fig. 3. The K/Rb versus K^+ plot of Fig. 10 shows that the ignimbrites are not connected to the correlation trend of the geologically related potassic suite. We there-

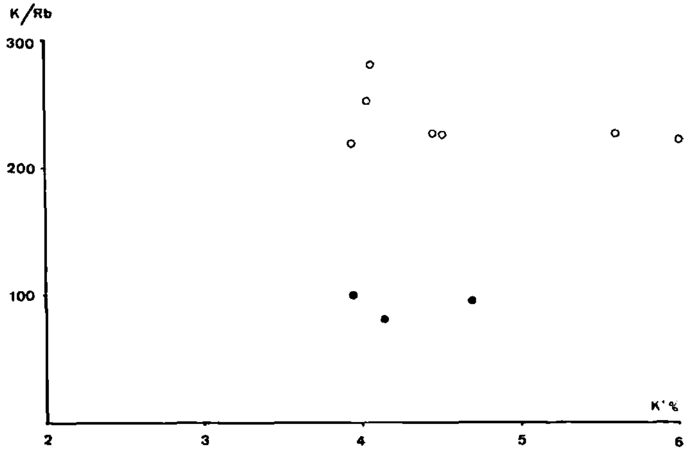

FIG. 10 - K/Rb versus K^+ plot for the Afyon ignimbrites (solid circles) and for the potassic suite (open circles). Leucitites are not plotted.

fore conclude, that the anatectic fusion of sialic crustal rocks supplied the magma for the ignimbrites. Neither fractional crystallisation nor assimilation of sialic material can be assumed for derivation of the rhyolitic melt from such potassic magmas.

Arguments in favour of an anatectic origin are the accessory minerals garnet and allanite. They are present in low amounts but with great regularity throughout the whole ignimbrite formation. The appearance of the garnet and its association with allanite is inconsistent with a primary crystallization as proved by GREEN and RINGWOOD (1968) for certain garnet phenocrysts in calc-alkaline rocks.

The presence as inclusions in salic phenocrysts and in coarse-crystalline aggregates of quartz and feldspars could suggest that garnet, allanite and at least part of the phenocrysts are relictic xenocrysts and witnesses of an original sialic rock which underwent anatectic fusion.

Trace elements show some peculiar features: the high level of Rb and Y for instance could be called a sialic or crustal rock feature. But the extremely low values for Ba, and Sr, relatively low Zr and consequently the low ratios of K/Rb and Ba/Rb are generally interpreted as typical indicators of strong fractionation processes (TAYLOR, 1965; TAYLOR *et al.*, 1968).

In Fig. 9 it has been shown that the plot for the ignimbrite composition lies in the quartz field in the Q—Ab—Or triangle for 2 kb. From the high content in modal quartz and sanidine it follows, that the figurative plotting point for the vitric phase of the ignimbrite alone would be shifted towards the Ab corner. If we assume, as a model, that this vitric phase approximately represents the early melting composition of an anatectic process, it is qualitatively indicative for higher pressures than would be the case taking the bulk composition as an anatectic liquid. Anatexis under high pressure can be expected, when crustal material is buried downwards with the descending slab of a lithosphere plate or overridden by another crustal segment.

If anatectic fusion is maintained as explanation for the origin of the rhyolitic rocks, a way to explain the fractionated pattern of the trace elements has to be discussed.

Possibly the original sialic material itself has a complex history involving important fractionation processes. On the other hand, little is known about the fractionation of the trace elements during partial anatexis. So it seems that for the moment the trace element behaviour cannot be used as a strong argument in favour or against an anatectic origin of the rhyolitic rocks under consideration.

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