Miocene and Pliocene Volcanic Rocks of the Addis Ababa-Debra Berhan Area (Ethiopia). Geo-petrographic and Radiometric Study *

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Abstract

North and south of the long basaltic range running from Addis Ababa to Debra Berhan (Ethiopia) there are large ignimbritic plateaux which are very similar both morphologically and lithologically, and which are considered to be stratigraphically equivalent by previous researchers. Accurate geological reconstructions and many radiometric age determinations have allowed these plateaux to be distinguished into two distinct ignimbritic formations. The first corresponds to the most recent rocks (Miocene) of the « Alaji Series », and the second to the Pliocene « Balchi Series ». The two formations are separated from one another by basalts attributable to the « Termaber » central-type volcanism taking place in the Addis Ababa-Debra Berhan area more recently than in other parts of the Ethiopian plateau.

Introduction

The area between Addis Ababa and the Debra Berhan zone (Fig. 1) at the boundary between the Ethiopian plateau and the escarpment sloping down to the Main Ethiopian Rift and to south-western Afar, has a very complex geological setting. From the morphological point of view, this area is formed by a series of reliefs stretching on a SW-NE direction and including the Entotto-Rufi-Ciolle-Caho mountains and, east of Shano, the Megherez-Ankober-

* This work was financed by Consiglio Nazionale delle Ricerche as part of the programme « Ricerche geologiche e petrografiche in Africa Orientale ».
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Woti and Termaber mountains. This long chain made up almost only of basalts separates two very large ignimbritic plateaux, extending one towards the Ethiopian plateau, and the other towards the Ethio-

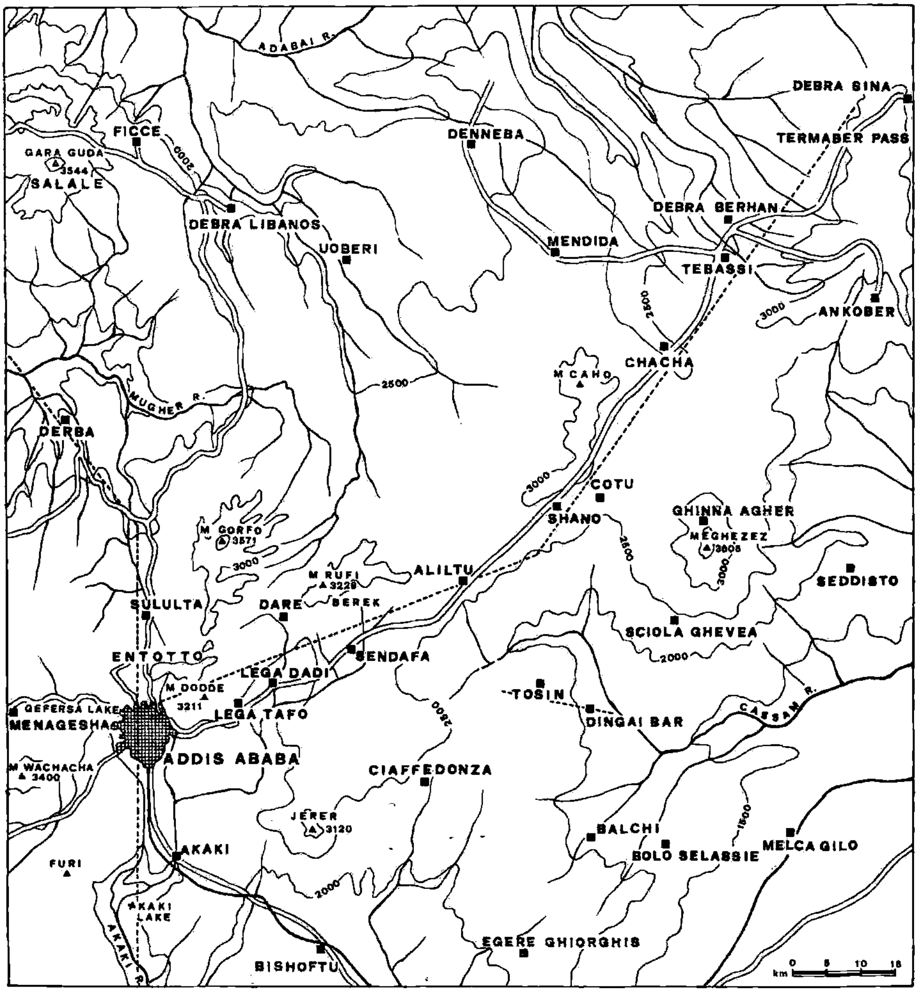

FIG. 1 - Topographical sketch map of the studied area.

pian rift. Both the plateaux have about the same elevation and are made up of acidic rocks (trachytes, trachyrhyolites, and alkali-rhyolites).

Gortani and Bianchi (1941; 1973) considered the whole sequence of acidic and basic rocks outcropping on the area as belonging to the Oligocenic « Magdala Series ».

Miller and Mohr (1966) were the first to give the radiometric age (4.5 m.y.) of a rhyolite from the Addis Ababa zone (summit of Wachacha volcano). On the basis of this dating Mohr (1967) considers as Pliocenic not only the acidic rocks of the Addis Ababa plain, but also the « rhyolites » outcropping on the north along the Afar margin from Meghezez to as far as Dessie and Woldia. That is, he considers all these « rhyolites » more recent than the « Shield Group Basalts ».

Brock, Gibson and Gach (1970) on the basis of a 250 m thick sequence of basic and acidic rocks exposed in a canyon of the upper basin of the Cassam river in the Aliltu region, consider the volcanic sequences of the Ethiopian plateau as « a single complex stratigraphic unit » whose lowest rhyolitic member gave a radiometric age of 21 m.y. and the upper (youngest) member, at the top of the sequence, gave an age of 9 m.y. B.P.

According to Zanettin and Justin-Visentin (1973), the acidic rocks (interbedded with greater or lesser amounts of stratiform basalts) of the central-eastern Ethiopian plateau form a large and continuous cover extending from Amba Alaji to the Debra Berhan and Mugher areas. These acidic rocks lie on the « Aiba Flood Basalts » and are overlaid by the « Termaber Basalts » which are the products of a central-type volcanism.

In spite of the lithologic, morphological and topographical similarities with the « Alaji Rhyolites », the acidic rocks forming the plateau on the south of the Addis Ababa-Sendafa road belong to a more recent volcanic series, which has been called the « Balchi Series » (Zanettin and Justin-Visentin, 1974).

Geological Setting and Radiometric Age Determinations

The areas surveyed for this study are the following:

i) the territory crossed by the Debra Berhan-Addis Ababa road from *a*) Debra Berhan to Shano, and *b*) from Shano to the eastern slopes of Entotto Mts.;

ii) the territory around Addis Ababa; and

iii) the Cassam Canyon.

TABLE 1 - K/Ar ages of the acidic volcanic rocks of the Addis Ababa-Debra Berhan area (Ethiopia).

Sample	*Locality*	$\frac{^{40}Ar.\ Rad.\ cc.\ S.T.P.}{g} \cdot 10^{-6}$	$^{40}Ar.$ *Rad.* %	*K* %	*Na* %	$t \pm \varepsilon$ *m.y.*
Et_{72} - 89	Debra Berhan-Termaber road (2900 m)	2.6328	84.08	4.28	3.45	15.4 ± 0.3
Et_{71} - 117	Near Mendida	2.2541	77.00	3.62	3.31	15.8 ± 0.5
Et_{72} - 125	Near Shano	1.3925	53.40	4.46	—	7.8 ± 0.25
Et_{73} - 17	Near Shano	1.8078	74.13	4.06	3.62	11.3 ± 0.3
Et_{71} - 114	Debra Berhan	1.4631	33.16	3.32	—	11.0 ± 0.3
Et_{73} - 3	Alíltu	1.5146	43.52	4.90	—	7.7 ± 0.25
Et_{72} - 4	Caffa river (Lega Dadí)	0.9079	45.16	4.57	4.97	5.0 ± 0.16
Et_{72} - 13 a	Mt. Dodde	8.8084	81.63	9.94	0.56	22.1 ± 0.4
Et_{72} - 10	Mugher canyon	2.3613	82.23	2.38	—	25.1 ± 0.5
Et_{72} - 18	Near Sululta	0.8705	34.34	4.10	4.50	5.3 ± 0.25
Et_{72} - 28	Gefersa lake	0.8374	50.09	4.68	4.21	4.5 ± 0.12
Et_{72} - 135	Akaki gorge	0.8797	56.92	4.30	—	5.2 ± 0.16
Et_{72} - 39	Cassam canyon (1860 m)	2.5905	69.81	2.76	6.42	23.4 ± 0.4
Et_{73} - 13	Cassam canyon (2200 m)	2.2031	75.81	3.51	—	15.6 ± 0.3
Et_{72} - 45	Cassam canyon (2370 m)	1.9302	78.01	3.63	5.63	13.1 ± 0.3

A brief description of their geology and the radiometric ages of the analysed samples are hereafter reported.

Radiometric age determinations (Table 1, Fig. 2) were carried out at the Institute of Geochemistry of the University of Rome according to the following procedure. Concentrates of anorthoclase (in a single case, of sanidine) obtained using normal enrichment

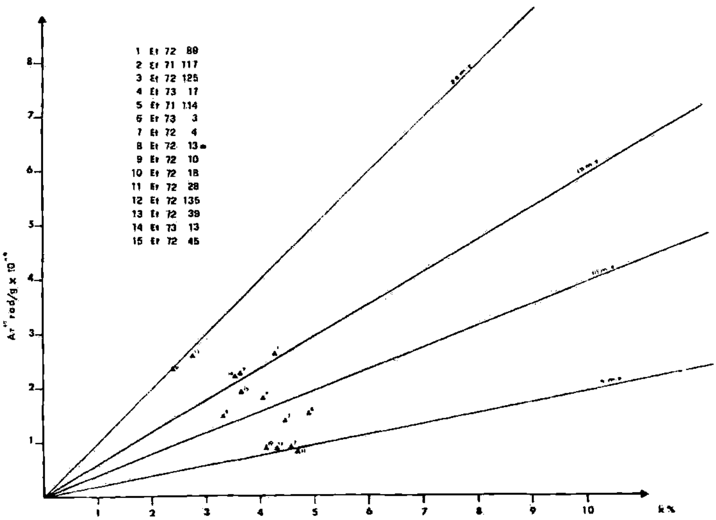

FIG. 2 - K/Ar dating of the rocks of the Debra Berhan-Addis Ababa area: Isochronal representation of the experimental results.
Symbols of rock samples as in Table 1.

methods have been used. Argon was determined by isotopic dilution with ^{38}Ar as an internal standard using an A.E.I. M S 10 spectrometer ([1]). The extraction line reduced to a very small volume allowed rapid and efficient purifications to be made. K was determined using an Optica C.F. 4 flame spectrophotometer. Age measurements on a P207 muscovite standard gave a value of 80.2 ± 2 m.y. which is in very good agreement with the proposed value of 80.1 ± 1 m.y.

As a preliminary information it is to be pointed out that the long mountain range running from the Gorfo and Rufi mountains to the Ankober and Termaber mountains is made up of « Termaber Basalts » and lies over the « Alaji Rhyolites » outcropping on the

([1]) This spectrometer is particularly versatile owing to the reproducibility and rapidity of measurements, and to an almost complete non-existence of effects of memory and fractioning (when the work is done at very low pressures, $< 10^{-5}$ mm Hg).

Ethiopian plateau between Debra Berhan and the Mugher river area (ZANETTIN and JUSTIN-VISENTIN, 1973). Only the Entotto hills are formed of « rhyolites ».

Territory Crossed by the Debra Berhan-Addis Ababa Road

a) From Debra Berhan to Shano:

The ignimbrites of the Debra Berhan area probably formed a large flat plain, now deeply eroded by the tributaries of the Adabai river. Along the road to the Termaber pass these ignimbrites are covered by « Termaber Basalts » (Fig. 3).

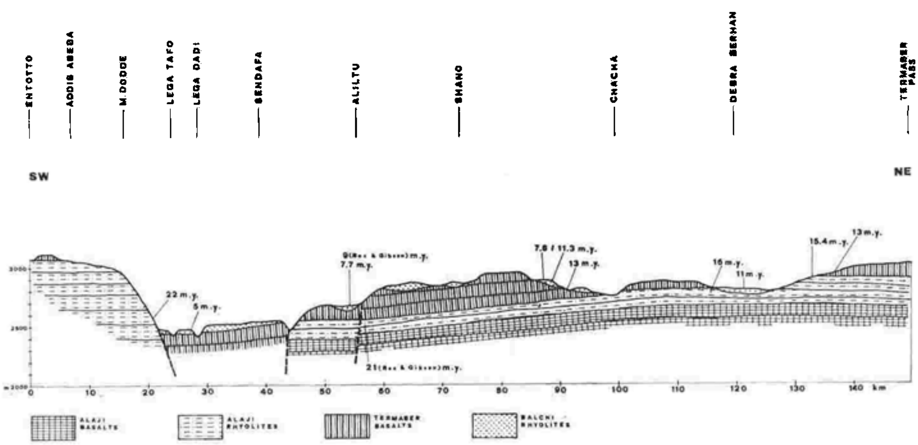

FIG. - 3 Geologic cross section from Debra Berhan to Addis Ababa.

K/Ar age determinations gave values of 15.4 ± 0.3 m.y. for the upper member of the ignimbritic sequence; and of 13 ± 0.6 m.y. for the overlying basaltic flow (Teledyne Isotopes). Similarly near Mendida on the road to Giurru the K/Ar age of a rhyolite underlying the « Termaber Basalts » is 15.8 ± 0.5 m.y. These values are consistent with a 15-16 m.y. B.P. age for the latest emissions of « Alaji Rhyolites ».

The Addis Ababa-Debra Berhan road crosses the basaltic range near Shano linking the northern ignimbritic plateau with the southern one. Near Shano (ca. 2,800 m a.s.l.), an ignimbritic cover has given ages of 11.3 ± 0.3 m.y. and 7.8 ± 0.25 m.y. and has been attributed to the

« Balchi Series » (ZANETTIN and JUSTIN-VISENTIN, 1974). Such ignimbritic cover overlies the basalts with large plagioclase phenocrysts from the volcano Meghezez (3,603 m a.s.l.) which are 13 ± 0.6 m.y. old and belong to the « Termaber Series ». Southwards, the ignimbritic cover is thicker and more continuous while northwards it becomes thinner and, from a certain point onwards, it is fragmented due to an erosion process — SW of the road between Shano and the Chacha bridge and towards Debra Berhan rounded remainders of this ignimbritic cover are very often found over the basalts. In such cases, it is quite obvious that these are « post-Termaber » « rhyolites ». When the « rhyolites » lie directly over the « Alaji Rhyolites » it is practically impossible to distinguish the « Alaji » from the « Balchi » « rhyolites » on the field. *E.g.*, in the Debra Berhan zone, a « rhyolite » sample taken in the town gave an age of 11.0 ± 0.3 m.y. which is rather lower than the age of the surrounding acidic rocks (15-16 m.y.) and of the « Termaber Basalts » (13 m.y.), whereas it is close to the age of a « Balchi Rhyolite » collected near Shano.

b) From Shano to the eastern slopes of Entotto Mts.

Aliltu, Sendafa and Lega Dadi (Fig. 3) are situated at the northern boundary of the large ignimbritic plateau extending from Addis Ababa to the Cassam Canyon. The ignimbrites overlay the « Termaber Basalts », as it can be seen in many valleys — near the dam of the Lega Dadi river; on the Caffa river, near the village of Lega Dadi; near Lega Tafo. The stratiform acidic rocks are thus to be referred to the « Balchi Rhyolites », as shown also by K/Ar age determinations (7.73 ± 0.25 m.y. and 5.0 ± 0.16 m.y. for two samples collected near the village of Aliltu and along the Caffa river, respectively). Therefore, the « Balchi » « rhyolitic » cover would extend, to the north, as far as the Bereck and Rufi basaltic mountains.

On the west of Lega Tafo where the « Termaber Basalts » are covered by the « Balchi Rhyolites » it rises up Mt. Dodde forming the eastern part of the Entotto hills. There, thick, compact, massive rhyolitic lavas, pink to milky-white in colour, outcrop cut sharpy by faults. A K/Ar age of 22.1 ± 0.4 m.y. indicates that these lavas belong to the « Alaji Rhyolites ». These lavas make up a thick pile of flows accumulated along E-W fissures and uplifted northward (ZANETTIN and JUSTIN-VISENTIN, 1974).

Territory around Addis Ababa

Addis Ababa is located at the southern foot of Mt. Entotto. Between Mt. Dodde — on the road to Debra Berhan — and Lake Gefarsa — on the road to Ambo — the hills are composed of thick acidic lava flows belonging to the « Alaji Rhyolites », whereas at the Entotto pass highly pumiceous tuffs and glassy lavas outcrop which are difficult to be attributed to this series. Near the Entotto church, about 3,100 m a.s.l., a layer of fine-grained basalts overlies the rhyolites.

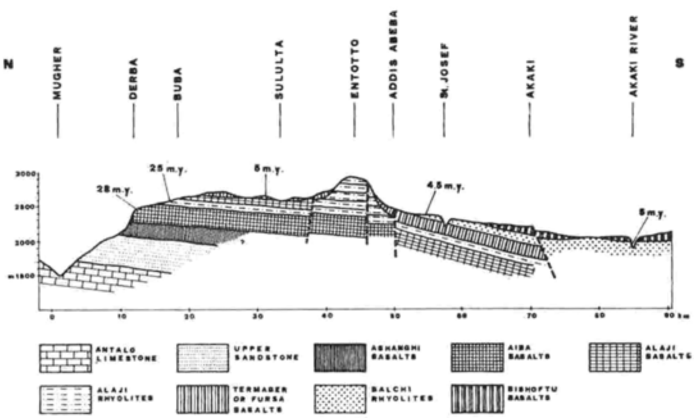

FIG. - 4 Geologic cross section from Mugher River to Akaki River.

On both sides of the Entotto hills, thick lateritic palaeosoils separate Miocene holocrystalline rhyolitic lavas from compact very fine-grained and spheroidally fissured basalts (Fig. 4).

On the northern ignimbritic plateau, the same sequence: ignimbrites-red laterites-compact fine-grained basalts can again be found. This suggests that these ignimbrites also belong to the « Alaji Series », as a radiometric age of 25.1 ± 0.5 m.y. would confirm [2]. The compact basalts covering the ignimbrites with flows of variable thick-

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[2] Determined on a sample collected 7 km from Derba along a track leading to the canyon floor.

nesses, belong to the « Alaji Series ». They often underlie huge masses of « Termaber Basalts » — *e.g.*, Mt. Gorfo — but sometimes form wide structural plains.

Near Sululta, on the plateau, there are small patches of ignimbrites whose K/Ar age is 5.3 ± 0.25 m.y. They are therefore « Balchi Rhyolites » probably emitted by the volcano Wachacha.

At the foot of the Addis Ababa hills, the « Balchi Rhyolites » — which in this area can clearly be attributed to the activity of the volcano Wachacha — overlie the above mentioned Miocene lateritized rhyolites, or the basalts which cover these rhyolites locally (Fig. 4). A K/Ar age determination for a sample from near Lake Gefarsa gave a value of 4.5 ± 0.12 m.y. which is in good agreement with the age of a lava flow at the summit of Wachacha (4.5 m.y.) (MILLER and MOHR, 1966).

The ignimbritic plateau dipping southwards disappears near Akaki under the « Bishoftu Basalts » (ZANETTIN and JUSTIN-VISENTIN, 1973) and reappears in the canyon of the Akaki river (Fig. 4). A sample collected in that zone gave a K/Ar age of 5.2 ± 0.16 m.y.

Cassam Canyon

The rock sequence of the Cassam canyon, between the village of Tosi (2,620 m a.s.l.) and the canyon floor (ca. 1,600 m a.s.l.) is made up of interbedded basalts and « rhyolites » (Fig. 5). The lowest not very thick acidic layer is found at 1,860 m a.s.l. and gave a K/Ar age of 23.4 ± 0.4 m.y. It overlies the « Alaji Basalts » which are at the canyon bottom. A trachytic layer outcropping between 2,100 and 2,200 m a.s.l., and forming the small plain on which the village of Dingai Bar is located, gave instead a K/Ar age of 15.6 ± 0.3 m.y. Another thin « rhyolitic » layer at 2,370 m a.s.l. has an age of 13.1 ± 0.3 m.y. Such ages are consistent with the ages of the « Alaji Series » suggesting that the « rhyolites »-basalts sequence of the Cassam canyon belongs to this series.

On the contrary, the « rhyolites » which close the sequence and which form the large plateau extending towards Addis Ababa, are to be attributed to the « Balchi Rhyolites ». This conclusion is corroborated by the unconformity between the « Alaji » and the « Balchi » Series (ZANETTIN and JUSTIN-VISENTIN, 1974) downstream of the above described Cassam canyon exposure.

The Cassam sequence can be compared with the rock sequence described by REX, GIBSON and DAKIN (1970) for the northern slope of the same canyon. These authors give an age of 21 m.y. to a layer near the bottom of the sequence, and an age of 9 m.y. to a layer at the summit of the sequence. If our values are compared with these

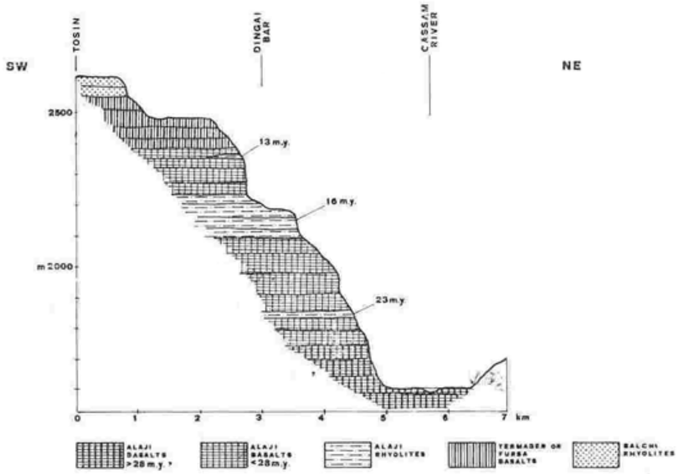

FIG. - 5 Geologic cross section of the Cassam Canyon.

latter values, the 21 m.y. old layer can be attributed to the « Alaji Rhyolites » and the 9 m.y. old layer can be put in relation with the rhyolites outcropping near Alíltu which have an age of 7.7 ± 0.25 m.y.

Petrographic Outlines

The rocks composing the two ignimbritic plateaux in the surveyed area have been attributed chiefly to the « Alaji » and to the « Balchi » Series (ZANETTIN and JUSTIN-VISENTIN, 1973; 1974 ZANETTIN *et al.*, 1973). Their petrographic features and main differences are hereafter briefly described.

« *Alaji Rhyolites* »

These rocks can be subdivided into two groups: *i*) volcanic rocks forming very extensive covers of constant thickness; and *ii*) volcanic rocks forming large relief — *e.g.*, Mt. Entotto.

i) Acidic Covers: These are in general made up of scarcely compact rocks varying in colour from white to red. Macroscopically, the rocks have a porphyritic texture and are formed of rounded grains of quartz and euhedral phenocrysts of feldspars cemented in a micro- to cryptocrystalline groundmass. Fragments of lens-shaped basalts are quite common (normally not larger than 2×0.5 cm). Small glassy lenses are also recognizable, together with pumices which are sometimes squeezed between the phenocrysts. Axiolites occur frequently, while spherulites are rarer. In some cases, streams of vesicles are very clear. Sometimes the groundmass is red coloured due to microgranules of iron oxides. The phenocrysts may be very large and are more or less irregular in shape.

Quartz occurs as both corroded and euhedral or anhedral crystals. Sanidine and/or anorthoclase were found in all the rocks ($2V_{\gamma}$: 15°-52°), and are generally twinned according to the Carlsbad law and to the albite and pericline laws, respectively. Plagioclase (15-25 % An) is rarer and sometimes may lack completely. It is fresh, weakly zoned, and normally twinned according to the albite, albite-Carlsbad and pericline laws. Dark minerals are generally very scarce; an amphibole in perfectly fresh euhedral crystals (pleochroism from yellow to reddish-brown, $Z\Lambda\gamma = 15$-18°) has been defined as oxyhornblende. Aegirineaugite (pleochroism in green; $Z\Lambda\gamma = 65$-70°) was also found though rarely. In some cases very abundant crystallites were noticed, whose optical characteristics could not well be determined even though they can probably be attributed to aegirine or aegirinaugite. Such crystallites are distributed in the matrix forming spots, tuft-like and comb-like aggregates. Magnetite, ilmenite, apatite, zircon and rutile are accessories.

ii) Volcanic Rocks Forming Large Reliefs: These are prevalently compact rocks deep to pale pink, brown or off-white in colour, which break up conchoidally or in sharply angular fragments. Irregular trains of minute pale granules often form small recumbent folds giving the rock a flow structure. Vacuoles and a very characteristic fissuring due perhaps to a differential alteration can quite often be noted.

Most of these rocks are holocrystalline with more or less abundant euhedral phenocrysts mostly of feldspars. The groundmass is made up of an intergrowth of microlites of feldspars, quartz and opaque minerals. These latter are distributed irregularly clustering in dark-red spots.

Sanidine and/or anorthoclase phenocrysts ($2V_{\alpha} = 7\text{-}50^{\circ}$) display their typical twinnings and in places are somewhat cloudy due to an incipient alteration into kaolin. Plagioclase (20-26 % An) is very scarce, and sometimes may lack. It is twinned and unzoned. Its core is often altered. Sometimes plagioclase crystals made up of alternatively altered and fresh concentric zones are present. In other cases the alteration is limited as usually to fractures, cleavages or composition faces of the twins. In all cases the altered zones are characterized by the constant occurrence of fine-grained iron oxides. Quartz phenocrysts are in general absent and, when present, they are even rarer than the plagioclases. Ferromagnesian minerals are absent or rare. Occasional relics of small prismatic crystals probably of biotite or of a brown amphibole have been noticed. Patches of zeolites, serpentine and rare accessories, such as apatite, zircon and rutile, also occur.

« Balchi Rhyolites »

These silicic rocks are quite young, and are found in the southern part of the examined area. Macroscopically they are scarcely compact rocks, whitish or pale-green in colour. Locally, there are slightly indurated fine-grained tuffs, giving a characteristic morphology to the landscape. Compact and glassy lavas are locally present which are normally pale-green, although yellowish or orange types also occur.

All the rocks have a glassy groundmass with more or less devitrified spots or veins. Extremely fine-grained mesostases occur quite frequently, sometimes with eutaxitic and pseudo-fluidal structure easily recognizable for the curving of the « fiammae » near the phenocrysts. The « fiammae » vary in colour from dark brown to pale yellow. « Fiammae » of all these shades can even be found in a single sample. Basaltic and « rhyolitic » xenoliths are present. Among these, fragments of « Alaji Rhyolites » (which make up the reliefs, like Mt. Entotto) can be found. These fragments have not only been found in the immediate proximity of the reliefs but also at 2-3 km away, suggesting the presence of « Entotto-type rhyolites » below the recent « Balchi Rhyolites » cover.

The phenocrysts of the « Balchi Rhyolites » are mainly feldspars (sanidine and/or anorthoclase, $2V\alpha = 20\text{-}53^{\circ}$) and subordinate quartz and plagioclase (17-25 % An). They are euhedral often fractured almost always unaltered and sometimes deeply corroded and embayed crystals. Dark minerals are in general scarce and occasionally they are absent. A brown fresh amphibole, identified as oxyhornblende ($Z \Lambda \gamma = 15\text{-}20°$; $2V_{\alpha} = 72°$) occurs locally. Moreover, minute emerald-green crystals of pyroxenes — aegirine and, more rarely aegirine-augite ($Z \Lambda \alpha = 25°$; $2V_{\alpha} = 87°$) — are present. Iron oxides and zeolites are abundant; rutile, zircon and apatite are less common.

In conclusion, the rocks forming the two ignimbritic plateaux of the Addis Ababa and Debra Berhan areas — that is, the « Balchi Rhyolites » and the « Alaji Rhyolites » — are difficult to be distinguished from one another both on the field and under the microscope. From the microscopic point of view the only difference is a relatively greater amount of alkaline pyroxene in the « Balchi Rhyolites » than in the « Alaji Rhyolites », as shown on a statistical basis. The lava accumulations of the « Alaji Series » making up the Entotto and Dodde mountains are however clearly distinguishable for their macro- and microscopic features as previously described.

Preliminary Chemical Comparison

A chemical comparison between the rocks of the « Alaji » and « Balchi » Series may be of some difficulty in that in the surveyed area the « Alaji Rhyolites » outcrop only around Debra Berhan where the « Balchi Rhyolites » lie directly over them and therefore it is often impossible to ascribe the rock samples for certain to one or the other series. Thus, the chemical analyses of the « Alaji Rhyolites » outcropping slightly to the east of the surveyed area, in the Afar margin, have been used for a comparison with those of the rocks of the two series with SiO_2 between 68 and 71 % corresponding to the most frequent SiO_2 contents measured up to now for the « Balchi Rhyolites ».

	« Alaji Rhyolites »		*« Balchi Rhyolites »*
		SiO_2 68-71 %	
Al_2O_3	13-14 %		10-12 %
$Fe_2O_3 + FeO$	3-4 %		4.5-6.5 %
MgO	0.4-0.8 %		0.3-0.4 %
CaO	0.5-1.5 %		0.4-1 %
Na_2O	4-6 %		4-5 %
K_2O	4-6 %		4-5.5 %

The difference in chemical composition is too slight to cause a different mineralogical composition between the rocks of the two series. The higher Fe contents in the « Balchi Rhyolites » account for their being relatively rich in soda pyroxene.

If we compare the chemical composition of the Miocenic lavas making up the Entotto and Dodde reliefs (SiO_2 71-74 %) with that of the contemporary « rhyolitic » cover with an equal silica content (see below), we note that the very little amount of Mg and Ca in the Entotto rhyolites accounts for the absence of mafic silicates and for the rare or absent plagioclases in these rocks. This fact, together with their textures, allow these lavas and the other acidic rocks occurring in the studied area to be surely distinguished from one another.

		« Alaji Rhyolites »	
	« Rhyolitic » Covers		*Entotto Lavas*
SiO_2		71-74 %	
Al_2O_3	11.5-12.5 %		13.5-14.5 %
Fe_2O_3 + FeO	2.5-3.5 %		1.5-2 %
MgO	0.1-0.6 %		0.03-0.04 %
CaO	0.2-0.8 %		0.05-0.1 %
Na_2O	3.5-5 %		5-5.5 %
K_2O	4-6 %		4.5-5 %

These conclusions must be considered as preliminary, and other comparisons based on a large number of chemical analyses of all the rock types in each of the two volcanic series are necessary. These data will shortly be published in a work on the « Alaji » and « Balchi » Rhyolites of the vast territory included between Amba Alaji and the Somali plateau.

We would emphasize, however, that a comparison between the rocks of the « Alaji Series » and those of the « Balchi Series » may be of little significance unless radiometric data are used.

Conclusive Remarks

On the basis of field observations and of radiometric age determinations some new results from the stratigraphic, chronologic and tectonic points of view have been reached for this part of Ethiopia. These can be summarized as follows:

i) The large structural plateaux on the north and south of the « Termaber » basaltic range are made up of stratiform « rhyolites » belonging to two volcanic series which are stratigraphically and chronologically quite distinct: the « Alaji » and the « Balchi » rhyolitic series. The two plateaux had been considered by previous authors as belonging to the same series; some authors (GORTANI and BIANCHI, 1941; 1973) attributing them to the older (« Alaji ») series; and others to the more recent (« Balchi ») series (MOHR, 1967).

ii) The upper members of the « Alaji Rhyolites » outcropping in this area are about 15 m.y. old. This age is not only based on K/Ar age determinations on the rhyolites (Table 1) but it is confirmed by the K/Ar age of the immediately overlying « Termaber Basalts » ([3]). The older members outcropping near Derba (Mugher canyon) and in the Cassam canyon are 25.1 and 23.4 m.y. old, respectively. The acidic lavas making up the Entotto hills are slightly younger — 22.1 m.y. old. These age values point therefore to a Miocenic age for the « Alaji Rhyolites » of this area.

iii) The central « Termaber » volcanism — in the Termaber-Meghezez area — seems to have taken place within a relatively short period of time: from 15 m.y. (the most recent age measured up to now for the upper members of the « Alaji Rhyolites ») to 11 m.y. ago (the age of the oldest members dated up to now for the « Balchi Rhyolites »). The K/Ar age for two basalts is 13 m.y. Since these basalt samples were taken from flows emitted by scarcely known volcanoes, it is impossible to say whether they represent the initial or the final products of the « Termaber » volcanism.

It is worth noting the remarkable difference in age between the basic central volcanism of the Ankober-Meghezez area and the central volcanism of the Kombolcha-Eloa area; in fact in the latter area the volcanism took place in the time interval from 28 to 18 m.y. B.P. (JUSTIN-VISENTIN and ZANETTIN, 1974) according to radiometric data given in MEGRUE *et al.*, 1972.

([3]) A preliminary chronological information reported in ZANETTIN and JUSTIN-VISENTIN (1973) on a purely indicative point of view must thus be corrected. However, it was clearly stated in that work that the conclusions were based upon a few preliminary radiometric data obtained for basalts sampled just in the Debra Berhan area.

iv) The « Balchi » silicic volcanism, mainly Pliocenic in age, first began in the Debra Berhan and Shano zones, *i.e.* north of the Cassam Canyon. In fact, in this area there are the oldest post-Termaber rhyolites (K/Ar age : ca. 11 m.y.). To the south and west in the areas of Lega Dadi, Addis Ababa and Akaki Canyon, the rhyolites are younger dating back to about 5 m.y. Still more recent age values are evidently related to products emitted by the volcanoes rising on the Pliocene ignimbritic plateau.

v) Petrochemical investigations show that the « Alaji » and the « Balchi » stratiform rhyolites are very similar and difficult to be distinguished from one another unless particularly favourable stratigraphical sequences are exposed. In the other cases the two series can be differentiated only by means of radiometric age determinations.

Acknowledgements

The Authors are indebted to Prof. M. Fornaseri, Director, Institute of Geochemistry, University of Rome for having offered them laboratory facilities for the radiometric age determinations. Mr. O. Fogú and Mr. L. Bettio are acknowledged for their kind collaboration during the work.

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Manuscript received March, 1974
Revised Ms. June 1974