Some observations on the rocks of the Elchuru Alkaline Pluton, Prakasam District, Andhra Pradesh

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Abstract

The rocks of the Elchuru alkaline pluton are broadly classified into (a) mafic-rich alkaline rocks and (b) leucocratic alkaline rocks. Field and petrographic observations suggest that these alkaline rocks constitute a differentiated series which conformably intruded the pre-existing gneisses. The occurrence of mafic-rich alkaline rocks points to a magmatic origin of the pluton and its abyssal source.

Introduction

Undersaturated rocks of plutonic aspect occur around Elchuru village (16°04'48"N and 79°55'42"E) in Prakasam district of Andhra Pradesh (Leelanandam *et al*,, 1972a). This alkaline pluton is oval in outline (Fig. 1) covering an area of about 16 km^2. It is enveloped conformably by a group of Precambrian gneisses that are frequently intercalated with black streaky amphibolites. The contact between the alkaline body and its surrounding country rocks is fairly well defined and a noteworthy feature here is the total absence of contact effects around the pluton.

Field set-up

The Elchuru pluton is composed of nepheline syenites and their mafic variants (Leelanandam *et al.*, 1972b); however, in terms of relative abundance, the nepheline syenites constitute the bulk of the pluton. The sparsely distributed mafic-rich alkaline rocks occur as lenticular or elongated outcrops within the nepheline syenites. At several places the mafic-rich alkaline rocks are traversed by veins and bands of nepheline syenite. The observed field evidences clearly indicate that the nepheline syenites are younger to the mafic-rich alkaline rocks in the Elchuru pluton.

Based on the colour index, the alkaline rocks of Elchuru are broadly classified into two groups, namely (1) mafic-rich alkaline rocks (95–30 vol % mafics) and (2) leucocratic alkaline rocks (< 30 vol % mafics). Again taking the variation in mineral assemblage into consideration, the mafic-rich alkaline rocks are further subdivided into (a) melanocratic alkaline rocks (95–65 vol % mafics) and (b) mesocratic alkaline rocks (65–30 vol % mafics). In mineral assemblage the mafic-rich alkaline rocks are broadly comparable to that of shonkinite-malignite group of rocks (cf. Johannsen, 1938). Modes of the typical specimens, each representing a particular group are given in Table I. It is significant to notice that all the major rock units of the Elchuru alkaline pluton are nepheline bearing, but nowhere the mineral is seen to exceed 35 vol%. Consequently the rocks of ijolite-urtite series (nepheline-rich and feldspar-poor rocks) are not encountered in the Elchuru pluton

In the field all the rocks show close spatial and temporal relationship with one another. Where melanocratic and mesocratic rocks occur together it is difficult to demarcate a sharp boundary between them. A more or less similar contact relationship is seen to exist between the mesocratic and leucocratic alkaline rocks also. In the pluton, a well defined boundary can, however, be seen wherever the leucocratic rocks come into direct contact with the melanocratic rocks.

Petrography

Melanocratic alkaline rocks: These dark-looking rocks are coarse grained massive and homogeneous. The essential constituents are pyroxene (salite) and biotite, the glistening flakes of the latter mineral impart a crumbly appearance. Other minerals which are less prominent include plagioclase, orthoclase, nepheline, sphene, apatite and opaque mineral.

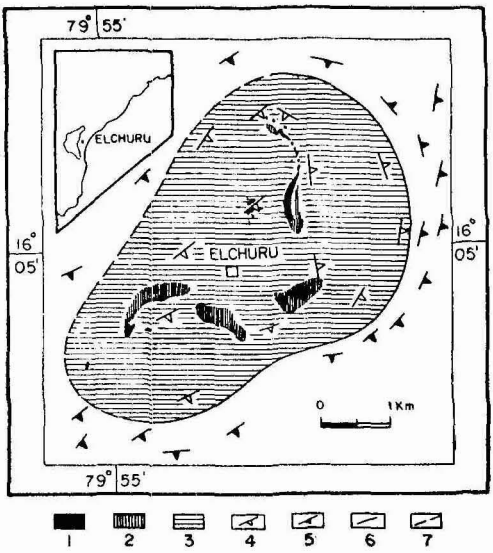

Figure 1. Geological map of the Elchuru alkaline pluton. Inset map shows part of peninsular India indicating the location of Elchuru. 1–Melanocratic alkaline rocks, 2–Mesocratic alkaline rocks, 3–Leucocratic alkaline rocks, 4–Strike and dip direction of the alkaline rocks, 5–Strike and dip direction of the country rocks, 6–Observed boundary, 7–Inferred boundary.

TABLE I. Modes of the Elchuru alkaline rocks.

Serial No.	1	2	3	4
Specimen No.	130A	6	M6	G1
K-feldspar perthite	3.0	32.7	68.0	53.0
Plagioclase	1.0	—	—	28.8
Nepheline	2.6	5.0	9.7	4.4
Clinopyroxene	44.6	1.0	3.0	—
Amphibole	—	49.0	12.6	8.5
Biotite	45.1	5.0	2.2	2.3
Apatite	2.4	3.2	1.1	0.8
Sphene	0.3	2.1	0.1	1.3
Calcite	—	0.7	1.2	0.9
Zircon	—	0.8	—	—
Opaque mineral	0.6	0.5	2.1	—
Colour Index	90.6	58.4	20.0	12.1

1 =Ultrabasic alkaline rock
2 =Basic alkaline rock
3 =Leucocratic alkaline rock (Hypersolvus)
4 =Leucocratic alkaline rock (Subsolvus).

Under the microscope these rocks prominently exhibit an equigranular hypidiomorphic texture; sometimes they also show a glomero-porphyritic texture wherein clusters of coarse pyroxene crystals are seen surrounded by medium sized pyroxene and biotite. Preferred alignment of the constituent minerals is generally absent. The pyroxene in these rocks is always fresh with subhedral outline. It is pale greenish brown in colour; pleochroism is either absent or extremely feeble. The mineral has $2V_Z = 62°$, Z : c = 42°, $N_X = 1.694$, $N_Z = 1.723$. Biotite occurs as large flakes often showing crenulation. It is pleochroic in bright straw yellow (X) and deep reddish brown (Y & Z) colours. Inclusions of apatite and sphene are abundant. Anhedra of nepheline are invariably interstitial in habit and are closely associated with K-feldspar and plagioclase. K-feldspar is a non-perthitic or poorly perthitic orthoclase. It has $2V_X = 48°$, Z : b = 0. Plagioclase is usually found as small laths often twinned on albite law. The composition of plagioclase, as deduced from its RI values, ranges from An_{17} to An_{24}.

Mesocratic alkaline rocks: These rocks are coarse-grained, probably the result of increased activity of fugitive constituents: K-feldspar, perthite and amphibole (hastingsite); nepheline and biotite are ubiquitous. Clinopyroxene (acmitic diopside),

is found in trace amounts. Minor accessories include apatite, zircon, sphene, calcite and opaque minerals. In thin section, these rocks exhibit an equigranular hypidiomorphic texture.

The K-feldspar is a faintly perthitic orthoclase in which the intergrown sodic phase shows string and vein patterns. It has $2V_X = 53°$ and $Z : b = 0$. The mineral rarely develops simple twin on manebach law. Small apatite rods and zircon granules are the usual inclusions within the perthite crystals. Nepheline is usually found as anhedral grains with its characteristic freshness. Amphibole, which is the predominant mafic mineral, occurs as coarse subhedral plates. It is very strongly pleochroic with X = deep yellow, Y = deep brown and Z = brownish yellow colours. The mineral has $2V_X = 60°$, $Z : c = 17°$ and $N_X = 1.684$. The amphibole occasionally shows parallel growth texture with biotite, thereby indicating the simultaneous crystallization of these two hydrous minerals. Clinopyroxene is always found as anhedral grains. The presence of clinopyroxene patches (remnants) within amphibole crystals suggests that the former mineral preceded the later in the crystallization sequence. The pyroxene is moderately pleochroic in light shades of green (X), greenish yellow (Y) and yellow (Z). It has $2V_Z = 67°$, $Z : c = 46°$, $N_X = 1.701$ and $N_Z = 1.731$. Biotite occurs as broad blades of straw yellow (X) and reddish brown (Y & Z). Inclusions of apatite, sphene and opaque minerals are often found in biotite.

Leucocratic alkaline rocks: These rocks are coarse to medium in grain size and are characterised by abundance of K-feldspar followed by nepheline. The mafic silicates viz., amphibole (ferrohastingsite), biotite and pyroxene (aegirin-augite) fluctuate in their relative amounts. Although these rocks are massive with no visible mineral alignment, some exhibit faint to perfect foliation. K-feldspar ($2V_X = 62°$, $Z : b = 0$) in these rocks is a finely perthitic orthoclase in which the intergrown plagioclase is arranged closely to form mesoperthites. String, vein and braid patterns are common. Occasionally the perthites are mantled by a continuous to discontinuous rim of albitic composition. The surrounding albite mantle maintains optical continuity with the intergrown material in the perthite crystal. Depending on the absence or presence of plagioclase as a discrete phase in addition to K-feldspar, two prominent varieties of nepheline syenite are recognized—hypersolvus and subsolvus nepheline syenites. In the hypersolvus rocks, plagioclase (An_{12}) is not found as a discrete mineral, whereas in the subsolvus ones it is found as independent grains along with K-feldspar. It is interesting to note that the structural state of the K-feldspar also differs conspicuously in these two rock varieties. In the hypersolvus rocks the K-feldspar has a monoclinic symmetry but in the subsolvus types the mineral shows a significant departure from monoclinic symmetry in various degrees. The extinction angle (Z : b) of K-feldspars in the subsolvus nepheline syenites show a range from 4 – 16°. Nepheline occurs as shapeless crystals often containing sharp and fine acicular crystals of aegirine-augite. These slender needles which are oriented parallel and diagonal to the 'c' crystallographic axis of the nepheline crystals, are supposed to have formed by an unmixing process involving nepheline and aegirine-augite compositional mixture (Madhavan, 1976; see also Tilley and Gittins, 1961; Ferguson, 1970; and Bailey, 1974). Amphibole occurs as subhedral plates. It is pleochroic with X = bright straw yellow, Y = brownish green and Z = bright green colours. It has $2V_X = 28°$, $Z : c = 14°$, and $N_X = 1.696$. The clinopyroxene in these rocks is strongly pleochroic with X = bright grass green, Y = yellowish green and Z = deep lemon yellow colours; the strong pleochroism is obviously due to the high concentration of acmite molecule in the pyroxene. The mineral has $2V_Z = 80 – 88°$, $Z : c = 58 – 67°$, $N_X = 1.720 – 1.726$ and $N_Z = 1.752 – 1.758$. The pyroxenes very

commonly exhibit compositional zoning. Flakes of biotite occur in close association with amphibole rather than pyroxene. The mineral exhibits strong pleochroism in straw yellow (X) and deep brown (Y & Z) colours. Calcite in these rocks is found in two distinct habits: (a) as dust like inclusions within nepheline and (b) as large discrete plates usually surrounding nepheline and K-feldspar crystals. Small crystals of sphene are found as inclusions in biotite and amphibole. Tiny rods of apatite occur as inclusions in the mafic as well as felsic silicates.

Conclusions

Detailed geochemical investigations carried out recently on these rocks (Madhavan, 1976), have proved that the Elchuru alkaline rocks constitute a differentiated series resulting from the fractional crystallization of a basic alkaline magma.

The occurrence of melanocratic alkaline rocks in the pluton is considered to be highly significant and of great petrogenetic value. The very presence of this rock type lends a strong evidence not only for the magmatic origin of the pluton but also for its abyssal source.

The presence of modal nepheline in every rock unit of the pluton is worth noting. This would indicate that the magma during its crystallization remained critically undersaturated with respect to silica. In this context it is pertinent to quote MacDonald (1974), who observed; 'The demonstration of Coombs (1963) that the degree of undersaturation of a salic alkaline magma varies closely with that of the associated basic rocks is strong evidence that fractional crystallization has played a major role in the origin of the alkaline salic rocks'.

The contact of the Elchuru alkaline pluton with the surrounding silicate gneisses is fairly well defined. The absence of chilled contacts testifies to the concept that the rocks near the border zone of the pluton intruded as a 'nearly completely crystalline mush'. The lack of exo- or endo-contact effects around the pluton may also be best understood when viewed in this context.

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