# ON THE ALKALI SYENITES OF MUNDWARA SUITE, SIROHI DISTRICT, RAJASTHAN

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The Mundwara alkalic carbonatite complex in the Sirohi district, Rajasthan is manifested in three closely spaced plug like bodies viz., Tua, Mer and Musala each characterised by alkalic stamp. This magmatic suite includes rocks of syenite family comprising foid syenite and foid monzosyenite. The alkali syenites as developed in all the three bodies are essentially hypersolvus types and the alkali feldspar, the dominant constituent of the rocks, shows varying degrees of unmixing. The chief mafic constituent, pyroxene, shows progressive enrichment in sodium and iron. Brown amphibole is also common. Mineralogical and chemical data suggest that the syenite of Mundwara alkaline suite is the product of differentiation of an alkaline basic magma and shows progressive enrichment in alkalies from Tua to Musala through the Mer ring complex.

## INTRODUCTION

ALKALIC magmatism connected with Deccan volcanicity is manifested in many parts of western and northwestern India. Mundwara alkaline suite, developed near Mundwara village (24° 50′ N; 72° 33′ E) in the Sirohi district of Rajasthan, is one such locale of alkaline igneous activity. Apparently, the petrographic and mineralogical characters of the alkali syenites of Mundwara, though occurring within extensively developed Precambrian granites, are conspicuously different from those associated with the Precambrian belts of India. This alkaline complex was first brought to notice by Coulson (1933) but relatively little work was done by him on this complex. Sharma (1969) published an account of the petrology of the suite and commented on the possible trend of differentiation within it. Detailed studies on the mineralogy and chemical petrology of the complex are, however, still lacking and particularly, no systematic effort has been made to explore the possible genetic connection between the closely spaced plugs (viz., Tua, Mer and Musala). Bose and Dasgupta (1973) described the Mundwara syenites briefly, emphasizing on the chemical and mineralogical aspects of the Musala syenites only. Chakraborti (1974) carried out detailed petrological studies on the sub-volcanics of Tua, Mer and Musala intrusions. The aim of the present paper is to furnish a brief account of the petrology of the foid syenites and closely related rocks from the Mundwara alkaline suite, comprising all the three plug viz., Tua, Mer and Musala, to bring out their possible genetic relation and to emphasise that not only each plug has distinctive alkaline stamp but the degree of alkalinity increases from Tua to Musala.

## GEOLOGIC SETTING AND OCCURRENCE OF MUNDWARA SYENITES

The topographic expression of Mundwara igneous suite breaks the monotony of undulating Erinpura granite terrain. The three hills, Tua (436mt), Mer (584mt) and Musala (509mt) represent relatively young topography compared to the pene-plain underlying the ancient Precambrian granitic terrain (Chakraborti, 1974). The Mundwara suite is manifested in three discrete assemblages as developed in these plug like bodies viz., Tua, Mer and Musala, with a wide spectrum of compositional variants from ultrabasic and basic types, viz., feldspathic peridotite (picrites), pyroxe-nites, melteigites, olvine gabbro, through a group of alkaline basic rocks including theralite, shonkinite, essexite to feldspathoidal syenite, leucosyenite and carbonatite. It is remarkable that relative proportion of these members vary in three plugs, Tua being rich in ultrabasic and basic members whereas syenitic rocks are relatively abundant in Musala assemblage. Alkali syenites are also developed, though as minor bodies, in Mer and Tua assemblages. In Tua, the syenites occur as numer-ous veins of variable width within normal and layered gabbros. Syenites are associ-ated with pyroxenite and alkali gabbros in the central Mer. The Musala syenites occur at the hill top as distinctly individual unit, and are spatially associated with the alkaline basic differentiates.

*Petrography of the Mundwara Syenites*

The alkali syenites of Tua plug may be classified into two types on the basis of their petrographic characters, namely Aegirine augite syenite and Brown hornblende syenite. Both are characterised by presence of nepheline (average 7% by volume). Megascopically, the aegirine augite syenites are medium to coarse grained leucocratic, hypidiomorphic granular rocks, characterised by subhedral laths of alkali feldspar and clots of pyroxene alongwith small nepheline grains. Under the microscope, the alkali feldspar, appears to be altered and shows numerous fine opaque inclusions, variable in shape and size, slightly strained and intimately associated with nepheline and sodalite. Aegirine augite, the chief mafic constituent occurs as subhedral or tabular crystals with haphazard orientation. The other constituents such as brown amphibole, sphene, apatite, opaques occur as accessary minerals (Table-I).

Megascopically, the brown hornblende syenite is coarse grained, leucocratic to somewhat mesocratic, with dull dark clots of brown hornblende in a white felsic groundmass. In thin section, the alkali feldspar is dirty with some minute opaque inclusions, most grains are simple twinned and some exhibit cryptoperthitic intergrowth. Nepheline grains are clear in appearance and intimately associated with feldspars. The chief mafic constituent is the brown hornblende. Carbonates, clinopyroxene, sphene, apatite, opaques, sodalite are accessories (Table-I).

Syenites and related rocks of Mer can be grouped into three petrographic types on the basis of foid percentage and colour index.

(1) Foid bearing melamonzosyenite
—( Foid < 10%, Average colour index 43),

(2) Foid bearing monzosyenite
— (Foid < 10%, Average colour index 34)

and 3) Foid bearing syenite.
— (Foid < 10%, Average colour index 11).

TABLE I

*Modal analyses of foid syenites of Mundwara (Vol. per cent)*

| Sl. No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Sp. No. | TL/34s | T/37 | M/WF10 | M/11 | M/WT12 | V/1H | V/1G | Mu/11T |
| Alkali feldspar | 67.1 | 40.8 | 44.6 | 55.1 | 79.0 | 47.6 | 64.7 | 73.8 |
| Plagioclase | — | — | 13.2 | 5.2 | — | 5.2 | — | — |
| Brown amphibole | 2.5 | 18.4 | 4.2 | — | 2.3 | 1.0 | — | — |
| Biotite | — | — | 10.1 | 9.5 | 2.1 | 7.9 | 0.1 | 0.3 |
| Aegirine | 14.0 | 3.8 | 9.7 | 14.9 | 3.2 | — | 4.5 | 6.3 |
| Titanaugite | — | 0.8 | 4.9 | — | — | 5.8 | — | — |
| Nepheline | 6.4 | 7.6 | 3.5 | 4.6 | 7.6 | 8.5 | 19.9 | 9.4 |
| Sodalite | 0.9 | 2.4 | 1.7 | 1.6 | 1.8 | 11.9 | 9.8 | 1.1 |
| Carbonates | — | 2.5 | — | — | 1.5 | — | — | 5.6 |
| Apatite | 0.7 | 1.2 | 3.0 | 3.0 | 0.3 | 1.9 | 0.1 | — |
| Sphene | 0.4 | 12.1 | — | 1.7 | — | — | 0.1 | 1.7 |
| Olivine | — | — | 0.8 | — | 0.9 | 2.8 | — | — |
| Opaques | 7.9 | 10.5 | 4.4 | 4.5 | 1.4 | 5.1 | 0.9 | 1.7 |
| Total | 99.9 | 100.1 | 100.1 | 100.1 | 100.1 | 100.0 | 100.1 | 99.9 |

1. Aegirine augite syenite of Tua.
2. Brown hornblende syenite of Tua.
3. Foid bearing melamonzosyenite of Mer.
4. Foid bearing monzosyenite of Mer.
5. Foid bearing syenite of Mer.
6. Foid monzosyenite of Musala.
7. Foid syenite of Musala.
8. Foid bearing syenite of Musala.

These rocks are not much different in megascopic look except the variation of colour index. All the representatives of this broad group show crustified appearance on the weathered surface. In the melamonzosyenite, potash-feldspar is slightly altered but few fresh tablets of potash-feldspars of light buff colour, occur in foid bearing monzosyenite and foid bearing syenite. Appearance of plagioclase is characteristic in foid bearing melamonzosyenite while it is totally absent in foid bearing syenite. In the foid bearing syenite, nepheline is quite distinguishable by its greasy lustre. Sodalite characteristically occurs in the foid bearing syenite as clear glassy or translucent ink blue grains. Pyroxene and biotite are present as chief mafic constituents in the foid bearing syenites. In general, the rocks are coarse grained and hypidiomorphic granular. Under the microscope, potash-feldspars are found to be somewhat altered. Cryptoperthitic intergrowth is common in foid bearing syenites. Lamellar twinned plagioclase crystal mantled by potash feldspar, is well demonstrated by the foid bearing melamonzosyenites where discrete plagioclase grains are also common. Nepheline and sodalite occur as interstitial to feldspars in foid bearing syenites where nepheline sometimes encloses perthites, biotites and hornblende. Pyroxene varies from titanium rich augite in melamonzosyenites and monzosyenites to aegirine augite in foid bearing syenites. Aegirine also forms as rims around titanaugite in melamonzosyenites suggesting a later soda enrichment in pyroxene crystallisation trend. Carbonates, apatite, chlorite, opaques are the accessories (Table I).

Syenites and related mela rocks of Musala are broadly of two groups occuring in close association, viz., syenites and monzosyenites and melasyenites and mela-monzosyenites of which the later group grades to alkaline basic rocks and so such rocks are not included in present discussion. The first group viz., syenites and monzosyenites, is again subdivided as :—

(*a*) Foid monzosyenite (Presence of Foid $> 10\%$, plagioclase; colour index 26).
(*b*) Foid syenite (Foid $> 10\%$; colour index 23).
(*c*) Foid bearing syenite (Foid $< 10\%$; colour index 16).

Megascopically in all the rocks, alkali-feldspar is slightly altered while plagioclase when present, in foid monzosyenites, is fresh but is absent in the other two types of syenites. Haphazard arrangement of feldspathoids and fine laths or clots of mafics are characteristic. In thin section, the rocks are hypidiomorphic granular, coarse grained, show perthitic intergrowth of alkali-feldspar. Plagioclase showing zoning of hourglass pattern and mantled character is only common in foid monzosyenites. The chief mafic constituent is aegirine augite, widely occurring in foid syenites and foid bearing syenites while in foid monzosyenites aegirine augite occurs as sodic rims around augites. Apatite, biotite, sphene, hornblende, opaques are accessories (Table—I).

*Mineralogy*

*Plagioclase* in the foid monzosyenite of Mer is found to be mantled by a rim of alkali feldspar reflecting an alkali enrichment in the later stage of crystallization. Lamellar twinning is common in plagioclase grains but the individual lamellae, having variable width, are not at all continuous. The composition is estimated as oligoclase ($An_{30}$) from the $2V_x = 83°$ and $X'$ V 010 = 80°. The composition of plagioclase from the mantled core in the foid monzosyenite of Musala is estimated as oligoclase ($An_{37}$) from the optic axial angle $2V_x=88°$ and $X'$ V 010=20°.

*Alkali feldspar*, the ubiquitous mineral in all the varieties of syenite and related rocks as described earlier, is identified as Orthoclase from the unresolved $131/1\bar{3}1$ reflections in X-ray powder diagram and $2V_x = 78°$. In all petrographic types the feldspar is perthitic, showing a variable degree of unmixing. Perthitic intergrowth is developed both along trace of 010 and 001 as seen in the aegirine augite syenite of the Tua assemblage while a randomness is encountered in case of brown hornblende syenite of the same plug. In the Mer syenites the perthitic intergrowths are very fine and more or less their regular arrangement is maintained while they are extremely irregular in Musala syenites in all respects viz., shape, size and arrangement which indicates an advanced degree of unmixing. Simple twinning on carlsbad law is common. Partial chemical analysis ($K_2O = 4.72\%$, $Na_2O = 9.71\%$, $CaO = 1.60\%$) of a feldspar from Mer syenite reveals the feldspar to be close to soda orthoclase with the composition $Or_{23.5}\,Ab_{69.7}\,An_{6.8}$. Bose and Dasgupta (1973) reported the composition of feldspar from Musala syenite to be $Or_{48.7}\,Ab_{51.0}\,An_{0.3}$.

*Nepheline* is also present in all the varieties of syenite in varying amounts. It appears to be colourless to dirty with greasy lustre in the hand specimen. Under the microscope, the nepheline grains are found to be interstitial between feldspars indicating it to have developed as a late phase.

*Sodalite* appears to be glassy light ink blue with conchoidal fracture in the hand specimen while under microscope it is colourless with numerous fluid inclusions arranged in a line or in an arcuate fashion. Several rows of inclusions of varying size and shape may be present in individual grain.

*Pyroxene* is the principal mafic constituent in the investigated syenites and shows compositional variation from titanium rich augite on the one hand to aegirine augite on the other — the latter being the dominant type (Table—I). Titanaugite is conspicuous in melamonzosyenites and monzosyenites of Mer and Musala respectively. Musala syenites are highly crowded with aegirine augite (Table II). The mineral appears as homogeneous discrete grains in the syenites of Musala but not in Tua and Mer syenites, suggesting an extreme soda enrichment in syenite fraction of Musala in comparison to the other two assemblages viz., Tua and Mer. Grains with colourless core and bright grass green margin, reveals progressive soda enrichment in course of crystallisation.

The next abundant mafic constituent is the brown amphibole which is found in all the three occurrences of syenites and related rocks in varying amounts. The pleochroism and absorption (Table III) suggest the amphibole, in most cases to be a sodicalcic type. The optical properties (Table III) and the chemical data (Bose & Dasgupta, 1973) of amphibole from nepheline syenite of Musala hill, suggest the amphibole to be a member of the kaersutite-barkevikite series (Bose, 1963).

TABLE II

*Optical data of pyroxene from the Mundwara syenites*

| Sl. No.<br>Sp. No. | 1<br>TL/34s | 2<br>T/37 | 3<br>M/WF10 | 4<br>M/11 | 5<br>M/WT12 | 6<br>V/1G | 7<br>V/1H |
|---|---|---|---|---|---|---|---|
| $X$ | Olive green | Deepgreen | Green | Deepgrass green | Olive green | Deepgrass green | Pink |
| $Y$ | Green | lightgreen | pale green | grassgreen | palegreen | green | faint pink |
| $Z$ | Yellowish green | palegreen | yellowish green | brownish green | Pale yellowish green | Colourless to pale green | Pale pink |
| Absorption | $X>Y>Z$ | $X>Y\geqslant Z$ | $X>Y>Z$ | $X>Y>Z$ | $X>Y\geqslant Z$ | $X>Y>Z$ | $X>Z\geqslant Y$ |
| $2V_z$ | 88° | high | 60° | 74° | high | 74° | 65° |
| $X\wedge C$ | 33° | 34° | 47° | 39° | 33° | 43° | 51° |
| $N_x$ | 1.716 | 1.718 | 1.713 | 1.712 | | 1.712 | 1.702 |
| $N_z$ | 1.742 | 1.743 | 1.739 | 1.737 | N.D | 1.737 | 1.722 |
| $N_z—N_x$ | 0.026 | 0.025 | 0.026 | 0.025 | | 0.025 | 0.020 |

1. Aegirine augite from aegirine augite syenite of Tua.
2. Aegirine augite from brownhornblende syenite of Tua.
3. Aegirine augite from foid bearing melamonzosyenite of Mer.
4. Aegirine augite from foid bearing monzosyenite of Mer.
5. Aegirine augite from foid bearingsyenite of Mer.
6. Aegirine augite from foid syenite of Musala.
7. Titan augite from foid monzosyenite of Musala.

TABLE III

*Optical data of brown amphibole from the Mundwara syenites*

| Sl. No. | 1 | 2 | 3 |
|---|---|---|---|
| Sp. No. | T/37 | M/WF10 | Mu/1 |
| $X$ | Greenish brown | Cream yellow | Golden yellow |
| $Y$ | Greenish yellow | Deep reddish brown | Deep brown |
| $Z$ | Brownish green | Dark clove brown | Deep brown |
| Absorption | $Z = Y > X$ | $X < Y < Z$ | $Z = Y > X$ |
| $2V_x$ | Very high | 77° | 82° |
| $Z \wedge C$ | 17° | 19° | 20° |
| $N_x$ | 1.661 | 1.652 | |
| $N_z$ | 1.688 | 1.677 | N.D. |
| $N_z - N_x$ | 0.027 | 0.025 | |

1. Brown hornblende from brown hornblende syenite of Tua.
2. Brown hornblende from foid bearing melamonzosyenite of Mer.
3. Brown hornblende from foid monsozyenite of Musala.

Strongly pleochroic variety of biotite is found in the nepheline syenite with the absorption scheme $Z = Y =$ dark brown, $X =$ golden yellow, $Z = Y > X$, with β being 1.651 in Mer syenites while it is 1.673 in the Musala syenites. Biotite from Musala syenites (Bose & Dasgupta, 1973) showing $\beta = 1.683$, high birefringence, the dÅ (060) spacing of 1.5450 (Å) — all these suggest it is an intermediate member of the annite-phlogopite series.

*Calcite, sphene, apatite and opaque Fe- Ti oxides* are the accessory minerals within the syenites. Frequent occurrence of sphene indicates the rocks to be rich in lime and titania. The Fe—Ti oxides in nepheline sodalite syenite appears as homogeneous magnetite with discrete ilmenite along with pyrrhotite, pyrite and minor hamatite while ilmenomagnetite with martitization is common in microsyenites of Musala (Bose & Dasgupta, 1973).

## DISCUSSION

The foid syenites of Mundwara are essentially hypersolvus types. The feldspar in the Mundwara syenite is an Orthoclase crypto/microperthites showing a limited Al/Si order and unmixing. These may imply a relatively rapid subsolidus cooling in subvolcanic conditions. The feldspar in Musala syenite, however, shows relatively advanced stage of unmixing possibly in a more wet environment.

In the syenites and related rocks low proportions of volatile bearing phases like apatite and calcite point to a relatively dry environment of crystallization except that the presence of brown hornblende in some foid syenite, attesting to a mildly hydrous nature of the magma.

Presence of calcic pyroxene, sodicalcic amphibole, sphene and apatite in syenite of Tua, all attest to a relatively lime rich syenitic fraction which came out as a late liquid from fractional crystallization of basic magma within Tua vent. Syenite liquids developed in Mer and Musala plugs are progressively enriched in alkalies. This is evident from the fall of normative An content compared to increase of D. I. from

TABLE IV

*Chemical analyses, normative compositions and some chemical parameters of foid syenites of Mundwara*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 55.86 | 45.32 | 42.66 | 56.90 | 52.68 | 49.88 | 52.20 | 53.34 |
| $TiO_2$ | 1.00 | 2.08 | 1.60 | 0.29 | 1.10 | 2.54 | 0.95 | 0.83 |
| $Al_2O_3$ | 18.72 | 16.27 | 20.46 | 23.40 | 21.25 | 17.95 | 24.54 | 20.10 |
| $Fe_2O_3$ | 1.72 | 4.07 | 2.05 | 1.10 | 2.29 | 2.42 | 1.35 | 3.58 |
| FeO | 2.24 | 6.52 | 8.75 | 2.61 | 2.02 | 5.33 | 2.73 | 2.34 |
| MnO | 0.09 | 0.26 | 0.15 | 0.01 | 0.23 | 0.24 | 0.06 | 0.23 |
| MgO | 3.20 | 4.42 | 3.91 | 0.52 | 0.28 | 2.37 | 0.88 | 0.78 |
| CaO | 3.30 | 5.66 | 6.14 | 1.12 | 2.47 | 4.14 | 2.43 | 2.40 |
| $Na_2O$ | 6.30 | 7.00 | 5.67 | 8.15 | 9.08 | 8.47 | 9.97 | 8.46 |
| $K_2O$ | 5.72 | 4.27 | 3.83 | 4.58 | 6.38 | 4.55 | 3.81 | 5.77 |
| $P_2O_5$ | 0.82 | 2.57 | 1.74 | 0.02 | 0.27 | 1.24 | 0.58 | 0.25 |
| Cl | — | — | — | — | 0.07 | — | 0.81 | — |
| $CO_2$ | — | — | — | — | 0.04 | — | — | — |
| $H_2O$ | 1.20 | 1.20 | 2.18 | 0.42 | 1.49 | 0.80 | 0.17 | 1.22 |
| Total | 100.17 | 99.64 | 99.69 | 98.93 | 99.65 | 99.93 | 100.48 | 99.30 |
| Or | 33.92 | 25.02 | 22.80 | 27.24 | 37.81 | 26.69 | 22.80 | 34.13 |
| Ab | 32.49 | 15.62 | 5.76 | 40.87 | 16.24 | 17.29 | 34.58 | 25.42 |
| An | 5.84 | 0.56 | 19.18 | 5.56 | — | — | 8.62 | 0.30 |
| Ne | 11.36 | 23.63 | 22.72 | 15.05 | 30.96 | 26.98 | 20.45 | 24.45 |
| C | — | — | — | 2.96 | — | — | 3.16 | — |
| Ac | — | — | — | — | 1.85 | 4.16 | — | — |
| Di | 3.96 | 8.77 | 1.40 | 4.60 | 3.25 | 10.76 | — | 4.24 |
| Wo | — | — | — | — | 2.67 | — | — | — |
| Hy | — | — | — | — | — | — | — | — |
| Ol | 5.09 | 9.18 | 15.56 | — | — | 4.28 | 3.58 | — |
| Mt | 2.55 | 5.80 | 3.02 | 1.62 | 2.32 | 1.39 | 1.86 | 4.34 |
| He | — | — | — | — | — | — | — | — |
| Il | 1.98 | 3.95 | 3.04 | 0.61 | 2.13 | 4.86 | 1.82 | 1.58 |
| Ap | 2.02 | 6.05 | 4.03 | — | 0.67 | 3.02 | 1.34 | 0.59 |
| Ct | — | — | — | — | 0.10 | — | — | Others |
| Ht | — | — | — | — | 0.12 | — | 1.35 | 1.87 |
| Differentiation Index | 77.77 | 64.27 | 51.28 | 83.16 | 85.01 | 70.96 | 77.83 | 84.0 |
| $\frac{Na_2O \times 100}{Na_2 + K_2O}$ | 52.4 | 62.1 | 59.8 | 64.0 | 58.7 | 65.1 | 72.4 | 59.5 |
| $\frac{An \times 100}{Or + Ab + An}$ | 8.1 | 1.3 | 40.2 | 7.5 | 0 | 0 | 13.1 | 0.5 |

1. Foid bearing syenite from Tua assemblage (Sample No. T/37) of Mundwara. Analyst : Dr. S. N. Varma.
2. Foid bearing syenite from Mer assemblage (Sample No. S/7) of Mundwara. Analyst : Dr. S. N. Varma.
3. Foid monzosyenite from Musala assemblage (Sample No. VI/H) of Mundwara. Analyst : M. K. Chakraborti (Chakraborti, 1974).
4. Foid syenite from Musala assemblage (Sample No. VI G) of Mundwara. Analyst : M. K. Chakraborti, (Chakraborti, 1974).
5. Foid syenite/Nepheline-sodalite syenite from Musala Assemblage (sample No. 61/6) of Mundwara. Analyst : B. P. Gupta (Bose & Dasgupta, 1973).
6. Sodalite syenite from Musala assemblage of Mundwara. Analyst : F. Raoult (Coulson, 1933).
7. Nepheline syenite from Musala assemblage of Mundwara. Analysts : S. C. Gupta & T. R. Sharma (Sharma, 1969).
8. Average Nepheline syenite (Gerasimovsky, 1963)

Tua syenite to Musala syenite (Table IV). Further the occurrence of discrete grain of aegirine augite in Musala syenite in contrast to zoned augite in Tua and Mer syenitic rocks attest to increasing sodium enrichment in syenite magma of Musala.

The coprecipitation of plagioclase and potash feldspar is encountered in foid monzosyenites but when the residual magma descended on to the 'Petrogeny's Residua system' the alkali feldspar separated in profusion giving rise to the formation of syenitic rocks and ultimately with decreasing value of Si/Al ratio the residual liquid was pushed towards the field of nepheline crystallization which favours the formation of foid syenites (Fig. 1). All these features are tied to the trend of differentiation of an alkaline basaltic magma destined to an alkalic and carbonatitic magma with a gradual decrease of Si/Na + K ratio and the lime content.

The foid syenites belonging to Mundwara suite apparently show miaskitic stamp in having agpaicity 0.54 and association with carbonatite (Chakraborti & Bose, 1978). The chemical analyses of all the syenites along with that of an average nepheline syenite (Gerasimovsky, 1963), are furnished in the Table IV and it is clear that the chemical nature of foid syenites of Mer and Musala show a very close resemblance to that of average nepheline syenite (Gerasimovsky, 1963). The analyses are plotted in the $NaAlSiO_4$—$KAlSiO_4$—$SiO_2$—$H_2O$ system at $PH_2O$ = 1,000 $Kg/cm^2$ (Fig. 1), and it depicts that most of the Musala syenites are plotted within 820° and 850° isotherms in the under saturated field which suggest such liquid to be derived through ultimate fractionation process. Some syenite compositions fall slightly within the nepheline field which is likely to be due to abundant development of sodalite in such rocks.

The syenites of Mer have tendency to fall near the feldspar join and the Tua syenite, in the potash feldspar field. Monzosyenites are not on the plane of the system $Na_2O/Na_2O + K_2O$ ratios for the syenites (Table IV) indicate that the

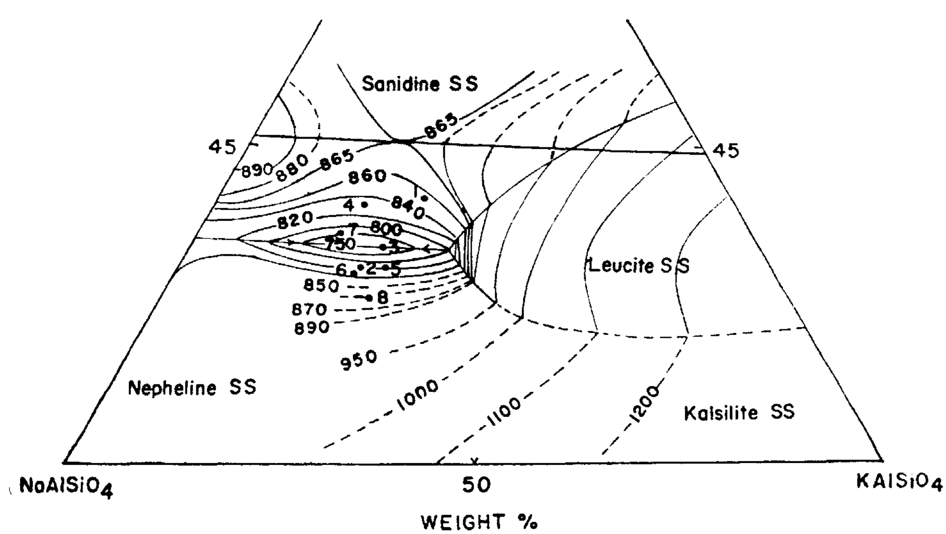


FIG. 1. Plots for nepheline syenites and related rocks of Mundwara suite in Qz-Ne-Ks-$H_2O$ system at $PH_2O$=1000 $Kg/cm^2$ (after Hamilton & Mackenzie, 1965). The numbers correspond to the rock types shown in Table IV. (For discussion see text).

syenite magma from Tua to Musala becomes particularly enriched in sodium relative to potassium.

This trend of alkali enrichment from Tua to Musala rock assemblages is indicated also by the bulk compositions of basic rocks in these plugs. The basic/ultrabasic rocks of Tua are apparently calcalkalic while the alkali gabbros are dominant in Musala.

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