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Autor(en): **Marmo, Vladi / Mikkola, Toini**

Objekttyp: **Article**

Zeitschrift: **Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie**

Band (Jahr): **35 (1955)**

Heft 2

PDF erstellt am: **17.05.2024**

Persistenter Link: https://doi.org/10.5169/seals-27851

On the Microcline of the Granitic Rocks of Central Sierra Leone
II.

By *Vladi Marmo* (Freetown, Sierra Leone) and *Toini Mikkola* (Helsinki)

Abstract

The microcline of granites of Central Sierra Leone has been examined on the Universal stage and it was thereby observed, that its $2V_\alpha$ varies roughly between 76° and 86°, but particularly so, that the majority of the examined microclines have $2V_\alpha = 76°$ or $= 85—86°$, the minority $= 82°—84°$ and practically none between the values of 78° and 81°. In addition, the values around 76° seem to be characteristic of the microcline of pegmatites and porphyroblasts, while the values around 86° are characteristic of other granites and especially of those in which the microcline is accompanied by the formation of myrmekite. The present paper is to continue the study on microcline, published earlier in this journal (Marmo, 1955c).

Introduction

In Central Sierra Leone the Kangari Hills and the Sula Mountains form a schist-belt about 200 km long in north-south direction. The southern part of this schist-belt — the Kangari Hills — consists of serpentine together with an amphibolite zone in the east and of amphibolite in the west, the central parts being composed of different varieties of quartzites and related metasediments including a minor zone occupied by banded ironstone. The Sula Mountains are of a similar composition except for the serpentines, which are less widely distributed there and for the banded ironstone, which in the Sula Mountains forms huge ore reserves.

Synkinematic granites embrace the whole schist-belt and in its northern part some minor areas of late-kinematic granite occur.

The formation is very old Pre-Cambrian, and according to so far unpublished age determinations, its age is definitely more than 2×10^9 years, and may be even more than 2.5×10^9 years, but is obviously less than 3×10^9 years.

During the study of the embracing granites, special attention was paid to their content of potash feldspar, which appeared to be exclusively microcline in all the varieties of granites met with in Central Sierra Leone. However, microscopic study has revealed that the microcline may vary not only in its mode of occurrence, as described before (MARMO 1955 c), but also in optical properties. Not only does the microcline from different granites differ, but in the same granite the microcline filling the interstitial spaces may be distinctly different, for instance, from the microcline forming porphyroblasts.

GOLDSMITH and LAVES (1954 a, b) have shown that variations occur in the Al-Si order—disorder in the lattice of microcline resulting in a deviation from 90° of α and γ.

This deviation was called a new conception (GOLDSMITH and LAVES, 1954 a) of triclinicity. For convenience of description triclinicity is set from 0 to 1. 0 represents the triclinicity of monoclinic potash feldspar and the value 1 stands for "maximum" microcline.

Five samples of microcline from the country near the Sula Mountains and Kangari Hills, all from different pegmatites and porphyroblasts, were sent to Dr. JULIAN R. GOLDSMITH of Chicago University, for determination of triclinicity. He found that they were all typical highly triclinic microclines with almost maximum triclinicity. He also found that according to his determinations by X-rays, the content of albite in solid solution was very low in these microclines, which are typical of highly triclinic microclines. Unfortunately similar determinations could not be made regarding the triclinicity of the interstitial and replacing microclines of the granitic rocks which display a marked deviation in their optical properties to be discussed below.

For the present study most of the determinations on the U-stage were carried out by Mrs. TOINI MIKKOLA, Geological Survey of Finland, Helsinki. Dr. VLADI MARMO, Geological Survey Dept. of Sierra Leone, Freetown, is responsible for the other parts of the present paper.

On the Microcline of Granites

As MARMO described in the first part of the present study (MARMO, 1955 c), the most striking difference in the microclines from different places shows in the intensity of their cross-hatching. In different microclines double twinning is developed to a different degree. The best developed cross-hatching usually appears in the microcline filling the interstices of other minerals, but it also may be rather well developed in the microcline replacing the plagioclase. It is less well developed in certain migmatites, in coarse granites, and in porphyroblasts and may be entirely lacking in the microcline of pegmatites, which, however, according to GOLDSMITH's determinations (see above) still display the highest triclinicity.

The Material Investigated

Care was taken that the samples for the present study should show all the possible modes of occurrence of microcline and especially the microcline of pegmatites, of aplitic granites, of more or less massive synkinematic granites, of gneisses and of migmatites, all belonging to the same area of synkinematic granites and some late-kinematic granites, were included in the study. In the thin sections containing different generations of microcline, those were determined separately.

The plagioclase of the synkinematic granites of Central Sierra Leone contains anorthite to the extent of 25 to 34%, while in most cases the average is 26%; the plagioclase of late-kinematic ones show an average 10% or less. For some samples, examined for microcline, the $2V_\gamma$ angle of the plagioclase was also determined. In the following all samples investigated will be described in brief.

Microcline of Pegmatites

VM 535: A coarse tourmaline-biotite pegmatite. Bumbuna. The microcline forms large crystals up to 15 cm in diameter which are creamy white in colour and in most cases no twin-hatching can be observed under the microscope. According to GOLDSMITH (p. 288), its triclinicity almost reaches the maximum. The large microcline grains may contain patches of plagioclase ($2V_\gamma = 76°$; albite). In addition, cross-hatched minute grains of microcline sometimes occur in the mass of fine-grained quartz or in interstices. Each variety of microcline was examined, and in each case $2V_\alpha = 76°$ was obtained for the microcline.

VM 2647: Coarse pegmatite containing both microcline and plagioclase, the former appears to be replacing the latter. Near Jagbwema. The cross-hatching is distinct but not very sharp. $2V_\alpha = 76°$.

VM 2635: Pegmatitic portion of "Ader gneiss". Near Kowama. The microcline is white, and according to GOLDSMITH (p. 288) has almost the highest triclinicity. Contains both coarse microcline and small grains in a mixture with quartz. $2V_\alpha$ in the former is 76°, in the latter 85°.

VM 45: Potassic pegmatite-granite. Near Keimadugu. The sample contains a little dark brown biotite and many large scales of muscovite. The microcline is fresh and coarse (up to 2 cm across). In addition there is a little interstitial microcline. $2V_\alpha = 76°$ in both instances.

VM 3123: Microcline-pegmatite. North-west of Mamuri. The microcline is pink and according to GOLDSMITH (p. 288) of nearly the highest triclinicity. The microcline is mostly unhatched and contains only spots of cross-hatched areas. Along its fissures albite occurs. The microcline is often associated with myrmekite, the rims of which may be lacking or, on the other hand, very well developed. $2V_\alpha = 84°$.

VM 2630: Simple pegmatite. Makoni. Contains large (up to 3 cm across) grains of microcline in a mass consisting mainly of quartz. No micas. Cross twinning is mostly rather distinct, but in places hardly observable. In both cases $2V_\alpha = 75$ to 78°.

Microcline of Synkinematic Rocks

VM 2739: Veined gneiss. Makoni. Feldspars are white, mostly plagioclase, the microcline being sparse, but the plagioclase is often antiperthitic. Interstitial microcline has $2V_\alpha = 84°$, an isolated grain 82°.

VM 256: Granodiorite. Kamaron. Contains epidote. Plagioclase is rather abundant ($2V_\gamma = 77°$, andesine). Sphene is present in a moderate amount with a little apatite. Microcline amounts to about one third of the plagioclase and mainly occurs filling the interstices or replacing the plagioclase, which is often strongly affected by sericitisation. The interstitial microcline has $2V_\alpha = 82°$, the one replacing the plagioclase has 76°.

VM 250: Granodiorite. Kamaron. Microcline is very sparse and occurs filling the interstices. $2V_\alpha = 76°$.

VM 2605: Gneiss rich in quartz. East of the Kangari Hills. The microcline is well cross-hatched but the lamellae are often bent. $2V_\alpha = 84°$.

VM 1325: Granite. Near Makong. Microcline rather abundant and well cross twinned. Mostly interstitial. Both micas are sparse and occur in equal amounts. $2V_\alpha = 82$ to 83°.

Microcline Accompanied by Myrmekitisation

VM 370: Gneiss granite. West of the Sula Mountains. The microcline is well twinned, mostly interstitial, and around the plagioclase grains myrmekite is abundant. $2V_\alpha = 85°$.

VM 472: Granite. West of the Sula Mountains. The microcline is rather abundant, very clearly cross-grated and mostly interstitial. Myrmekite rims around the grains of sericitised plagioclase are well developed. $2V_\alpha = 86°$.

VM 1329: Coarse granite. The Matamo Stream. Microcline and myrmekite are rather abundant, plagioclase mostly turbid, and often it is entirely sericitised in its centre. $2V_\alpha = 86°$.

VM 2264: Coarse biotite granite. Between Semabu and Djaru. The microcline is interstitial, but also occurs replacing the plagioclase. Myrmekite rims around sericitised plagioclase are frequent. $2V_\alpha = 86°$.

Microcline of Porphyroblastic Granites

VM 1770: Porphyroblastic granite. North of Petema (West of the Kangari Hills). The porphyroblasts are up to 3 cm across and consist of microcline, oligoclase, and quartz. The plagioclase porphyroblasts are sometimes surrounded by a myrmekite rim. The matrix is rather granodioritic in composition and contains comparatively little interstitial or replacing microcline. $2V_\alpha$ was determined both for the microcline of the porphyroblasts and for that of the matrix. For the former $2V_\alpha$ was 76°, for the latter 86°. According to GOLDSMITH (p. 288) the microcline of the porphyroblasts is almost of maximum triclinicity.

VM 2664: Porphyroblastic migmatite gneiss. South of Kowama. Large microcline porphyroblasts (up to 4 cm in diameter) scattered around gneiss of evidently migmatitic origin and of granitic composition. The microcline of the matrix is mostly interstitial. Porphyroblasts have $2V_\alpha = 78°$, the enclosing gneiss 86°. Myrmekite is frequent.

VM 1330: Porphyroblastic granite. The Matamo Stream. Very much like sample VM 1770. The microcline of the porphyroblasts has $2V_\alpha = 76°$, the microcline of the matrix 85°.

VM 653A: Porphyroblastic granite. 3 km north of Bumbuna. According to GOLDSMITH (p. 288) the microcline of the porphyroblasts is of nearly perfect triclinicity, and it is either well or only slightly grated. $2V_\alpha$: of the microcline of porphyroblasts 76°, of the matrix 84°.

VM 914: Porphyroblastic granite. East of Bumban (Gbengbe Hills). Similar to VM 653 A, but the porphyroblasts are coarser and the matrix a little richer in microcline, $2V_\alpha$: of the microcline of porphyroblasts 75 to 77°, of the matrix 85°.

Microcline of some Granitised Rocks

VM 2198: Granitised amphibolite. South end of the Kangari Hills. The rock represents a biotite-hornblende-pyroxene-epidote amphibolite affected by potassium metasomatism (granitisation), which, presumably also led to the formation of biotite at the expense of hornblende. The minute grains of well cross-hatched microcline occur in interstices and usually are enclosed by plagioclase grains. $2V_\alpha = 82°$.

VM 2637: Granitised amphibolite. Near Kowama. Similar to VM 2198 except for the lack of pyroxene and a slightly greater content of microcline. $2V_\alpha = 84°$.

J 723: Granitised arkosic quartzite. Near Victoria. The rock consists mainly of equigranular plagioclase and predominant quartz. In addition there are few flakes of dark biotite and a little sericite. The sparse microcline is interstitial. $2V_\alpha = 86°$.

Microcline of some Late-kinematic Granites

VM 404: Aplitic, fine-grained late-kinematic granite. The Wankatana River. Sparse muscovite is the only mica. Plagioclase is a little more abundant than the microcline, which has $2V_\alpha = 86°$.

VM 444: Aplitic late-kinematic granite. The Wankatana River. It is associated with varieties containing molybdenite, but otherwise similar to VM 404; this sample contains many narrow rims of myrmekite around the grains of plagioclase. $2V_\alpha = 86°$.

VM 795: Aplitic, late-kinematic biotite-muscovite granite. The Tenene Hills. Microcline is a little more abundant than plagioclase, it is very well cross-hatched and has $2V_\alpha = 83°$.

Conclusions

One must keep in mind that all the U-stage determinations given above should be considered as values $\pm 2°$. Therefore, regarding the records listed above, one hardly can divide the values of $2V_\alpha$ into more than two groups, and these two are definite: 1. the microclines having $2V_\alpha \geqq 76°$, and 2. those having $2V_\alpha \leqq 86°$. The former seems to be characteristic of the microcline of pegmatites and of the porphyroblasts of porphyroblastic granites. The higher values are typical of all the other granitic rocks (including the late-kinematic granites), of the matrix of porphyroblastic granites, and of the microcline of granitised amphibolites and quartzite.

With regard to those microclines having the higher value for $2V_\alpha$, there seems to be a questionable tendency of microcline accompanied by the formation of myrmekite to attain the value deviating the least from the straight angle.

The remarkable exceptions found during these investigations are: pegmatite VM 3123, in which, however, the formation of myrmekite has been observed, and sample VM 250, a granodiorite with interstitial microcline having $2V_\alpha = 76°$, which therefore is of the kind observed as typical for pegmatites.

In the opinion of the present authors, it is difficult to make generalisations because of the amount of recorded thin sections being rather limited. On the other hand, the material investigated comes from an area about 200 km in length consisting of granites that embrace the same geosynclinal schist-belt, and the specimens investigated were picked at haphazard all over the area, with the object of collecting specimens illustrating the different ways of occurrence of microcline. Hence, at least within the particular area under discussion the results obtained are of a certain significance and the fact that in its optical properties the microcline of pegmatites differs markedly from the microcline of other granitic rocks is of particular importance.

This fact, obtained from the examination of microclines on the universal stage, favours the assumption that the properties of microcline depend upon the conditions of formation. There is no doubt that the properties of the microcline of pegmatites are dissimilar to those of synkinematic granites and gneisses, due — in the opinion of many of modern granite petrologists — to a large extent to synkinematic granitisation. These conditions are also different from those of the formation of late-kinematic granites, considered by different authors to have originated either through granitisation or by intrusions of magma.

Large insets of microcline frequently occur in granitic rocks. Previously they were considered almost unanimously to be phenocrysts, nowadays, however, the majority of petrologists are of opinion that at least in most cases they are porphyroblasts, an opinion shared also by one of the present authors (Marmo, 1955 a, b). Adjacent pegmatites have been said to have influenced the formation of these porphyroblasts as well (Salli, 1953), and, indicating the similarity of the microclines of pegmatites to the porphyroblastic granites, the present results may give support to that theory (p. 289 and 291), and so do the measurements of the triclinicity of representatives of both groups carried out by Goldsmith (p. 288) and recorded by him to be almost of maximum value.

The present authors, however, would not like to ascribe the formation of porphyroblasts directly to the influence of pegmatites, but only wish to state that there may be some essential similarities in the mechanisms of the formation of the microcline of pegmatites and of the microcline of porphyroblasts.

The variations in the $2V_\alpha$ of microcline in granitic rocks other than already discussed may also be of importance. There a variation from 82° to 86° occurs which is slightly more than the possible error of the measurements, if the accuracy shows $\pm 2°$, as suspected. The microclines accompanied by the formation of myrmekite seem to have a questionable tendency towards developing a slightly larger axial angle than the interstitial microcline and replacing or "eating" the plagioclase. This, however, is a matter of further investigations. It is the aim of the present paper to draw the attention of petrologists interested in the study of granitic rocks to the optical variations of the microcline in the mentioned rocks. The variations seem to portrait the different conditions of formation of the particular microclines, and this fact may be of importance as leading to a better understanding of the formation of granitic rocks in general.

If we tentatively consider the smaller axial angles to reflect the lower triclinicity, and, on the other hand, suppose (Goldsmith and Laves, 1954) that increasing triclinicity means either a decrease in temperature during the formation or an increase in time. The results of the present study would support the idea that the temperature of formation must have been somewhat higher for the microcline of pegmatites than it was for other granitic rocks considered in the present paper. The results will support the assumption too that myrmekitisation corresponds to the lower end of the temperature range for granitisation (Marmo and Hyvärinen, 1953).

At the present stage of our knowledge about microcline, such conclusions must, however, still remain a sort of tentative hypothesis.

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Received: August 19th 1955.