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Remarks on a paper by V. Marmo "On the Microcline of the Granitic Rocks of Sierra Leone"

By *F. Laves* (Zurich)

In an interesting paper "On the Microcline of the Granitic Rocks of Central Sierra Leone" V. MARMO (1955) develops some ideas "on the origin of microcline". These ideas are opposed to the conclusions published by the present writer (1950, 1952) and by J. R. GOLDSMITH and the writer (1954 a and b).

The importance of the question of microcline formation for geological and petrological problems may, therefore, justify the following remarks.

On the basis of logical interpretation of crystallographic facts the following statement can be made (LAVES, 1950 and 1952):

> If microcline appears cross-hatched in such a way that the twin plane of those lamellæ which follow the albite law is perpendicular to the twin axis of those lamellæ which follow the pericline law, such microcline has previously been a monoclinic potash-feldspar modification (sanidine).

Numerous cross-hatched microclines have been investigated by single crystal X-ray methods. All have been found to be twinned this way. Thus, it appears rather safe to suspect that all cross-hatched microclines developed from a potash-feldspar phase that crystallized originally as a monoclinic one. It should be noted that from a purely crystallographic point of view nothing can be said about the formation of such microcline that is untwinned, or twinned only after the albite law or the pericline law. However, GOLDSMITH and LAVES (1954a, b) collected a large number of experimental facts which enabled them to assume that in most of these cases also, and inasmuch as magmatic, migmatic, or metamorphic rocks are concerned, the microcline is formed by diffusive transformation from a pre-existing monoclinic potash-feldspar phase. Special care was taken to discuss the formation of microcline "single crystals", as opinions expressed in the literature (MACKENZIE, 1954) indicated some reluctance by petrographers to accept the conclusions[1]) of the present writer (1950, 1952).

[1]) A short comment may help to avoid further misunderstandings. MACKENZIE (1954) — after discussing the writer's conclusions based on the occurrence of the combination of albite *and* pericline laws with the mutual relations stated above — writes (p. 354): "There seems no firm reason, however, to extend the hypothesis to

GOLDSMITH and LAVES (1954b) investigated some of the so-called microcline "single crystals". The fact that these "single crystals" usually show small areas of cross-hatched material indicates that at least these small areas have been monoclinic before. Furthermore, the fact that these cross-hatched areas are in structural continuity — as far as can be judged by optical examination — with those parts which appear to be a "single crystal" indicates that a sort of oriented (Sammel-) recrystallisation favoured *one* of the four microcline twinning positions (which have originally equal probability) in order to facilitate the formation of an untwinned crystal. Such a tendency is to be expected from general principles of thermodynamics, as the removal of twin boundaries leads to a lower state of energy. This process requires Al/Si exchange movements that are known to be very sluggish at low temperatures. As it appears that the discussed "microcline single crystals" are confined in their occurrence to old rocks, the suggested process is in agreement with geological observations.

It is interesting to note that careful reading of MARMO's paper reveals the possibility of a similar explanation of the formation of those microcline "single crystals" he reported finding in the African rocks. He writes (p. 164): "Finally, also concretionary pegmatites may contain microcline *without any* cross-hatching (fig. 7)", and two sentences later: "In such microcline there are *always* narrow patches, in which also cross-hatching occurs (fig. 7)". (Italics by the writer.)

Without attempting to disprove the logic of our conclusions published in the papers mentioned above, MARMO suggests that the microcline of the granitic rocks of Central Sierra Leone — even when thoroughly cross-hatched — *grew* as triclinic potash feldspar. It should be stressed, however, that his suggestions are predominantly based on belief, as shown by the following sentences as examples (p. 166): "One can for instance hardly

untwinned microclines." The meaning of this sentence is rather unclear because MACKENZIE fails to define what he means by the word "hypothesis". If he means the writer's hypothesis as expressed by the above statement, MACKENZIE's sentence here quoted does not make sense; because it is not logical to extend an *hypothesis that holds only for twinned material* to *un*twinned material. If he means an hypothesis which might be formulated as "All microcline originated by a transformation from a monoclinic potash feldspar" he should have mentioned who proposed such an hypothesis. At the place in which it appears, the sentence seems to imply that the present writer proposed it. Of course, I never proposed such an hypothesis. — In short: The writer's (1950, 1952) *hypothesis* is: All cross-hatched material exhibiting the *microcline combination twinning law* has been formed from material that was monoclinic originally. GOLDSMITH's and the writer's (1954a, b) *suggestions* are: Probably most of the microclines in magmatic, migmatic and metamorphic rocks have previously been monoclinic potash feldspar.

belive that the microcline replacing plagioclase (fig. 1) should primarily have been orthoclase", or "In the case of the replacement the introduction of potassium into the lattice of plagioclase evidently must surmount certain frictional and structural resisting powers causing the grating from the very beginning of the formation of the microcline as also in cases of formation of interstitial microcline", or (p. 159) "It is noteworthy that in such cases the microcline is always intensively cross-hatched, hence it seems that the formation of replacing microcline was immediately accompanied by the twinning of growing microcline".

Furthermore, believing the potash feldspar to have *grown* in the triclinic state and using some data reported by GOLDSMITH and the writer (1954a), without discussing the applicability of these data to the problem he is concerned with, MARMO offers several suggestions with respect to the formation and stability of microcline and orthoclase. For example (p. 165): "Hence it seems that under hydrothermal conditions microcline is not stable at a temperature over the experimentally found transition point, but that orthoclase is stable at any temperature." Statements like this cannot be accepted without some reservations.

Also his suggestion (Abstract) "that the formation of microcline is possible under hydrothermal condition below 525° C, and if the accumulation takes place during a time long enough" is open to criticism, if this statement is intended to have a significant bearing on the question of temperature at which the rocks described may have been formed.

These critical remarks, however, do not in any way invalidate MARMO's very valuable description of the interesting features that can be observed in microclines of granitic rocks.

References

GOLDSMITH, J. R. and LAVES, F. (1954, a): The microcline-sanidine stability relations. — Geochim. et Cosmochim. Acta *5*, pp. 1—19.

— (1954, b): Potassium feldspars structurally intermediate between microcline and sanidine. — Geochim. et Cosmochim. Acta *6*, pp. 100—118.

LAVES, F. (1950): The lattic and twinning of microcline and other potash feldspars. — J. Geol. *58*, pp. 548—571.

— (1952): Phase relations of the alcali feldspars. — J. Geol. *60*, pp. 436—450 and 549—574.

MACKENZIE, W. S. (1954): The orthoclase-microcline inversion. — Min. Mag. *30*, pp. 354—366.

MARMO, V. (1955): On the microcline of the granitic rocks of Central Sierra Leone I. — Schweiz. Min. Petr. Mitt. *35*, pp. 155—167.

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Reply to the Remarks of Prof. F. Laves

I have not made any attempts to disprove the logic of the conclusions of GOLDSMITH and LAVES who, on crystallographic basis, suggest that "probably most of the microcline in magmatic, migmatic and metamorphic rocks have previously been monoclinic potash feldspar". In my opinion this logic can not be disproved. But, despite that, there seem to be difficulties in reaching an agreement with respect to this statement and the petrological evidences when ordinary old-Pre-Cambrian granites of Sierra Leone (or of Finland) are concerned. If, on the other hand, the granulites are discussed, the suggestions of LAVES will find there an excellent proof, but there both microcline and orthoclase may occur side-by-side.

In the syn- and latekinematic granites of Central Sierra Leone and of Central Finland orthoclase does not exist. In spite of a very careful search after orthoclase in these rocks by many petrologists, the monoclinic potash feldspar has not been found there, and if reported (in older literature), re-examination has always proved it to be an unhatched microcline.

If all this microcline previously was a monoclinic potash feldspar, the transformation must have been very complete indeed. As LAVES writes in his remarks, however, the Al/Si exchange movements required by the mentioned transformation process are very sluggish at low temperatures; at elevated temperatures they take place towards the formation of monoclinic orthoclase.

In all thin sections examined by the writer (about 600), the potash feldspar of the synkinematic granodiorites and granites of Central Sierra Leone is undoubtedly the youngest constituent of the rock (excepting secondary quartz), and it is definitely younger than most of the plagioclase. There are well known evidences which have led many petrologists to suggest that the microcline of synkinematic granites is exclusively of metasomatic origin (granitization). These evidences also clearly indicate, that the deposition of microcline was in most cases likewise a very sluggish process, as was also the introduction of potassium causing for instance the muscovitization of plagioclase.

Particularly in the porphyroblastic granites there are large microcline porphyroblasts (well cross-hatched), grown across the fractures of the rock.

Under such circumstances, if all potash feldspar grew as monoclinic orthoclase and then was transformed into triclinic microcline, one should expect that some traces of orthoclase have still survived, and particularly so because both the transformation of orthoclase into microcline and the introduction of potassium are very sluggish processes. In granulites the orthoclase occurs together with microcline, and yet these rocks may not be so very

much younger than the synkinematic granites, enclosed by which they may occur; they also are definitely older than the aplitic veins which may cut the granulites and contain the microcline as the sole potash feldspar.

With regard to the microcline replacing the plagioclase, the writer is of opinion that if in this connection the orthoclase were formed first, this replacement must have stopped before the transformation of orthoclase into microcline could begin, for otherwise also instances of plagioclase replaced by orthoclase would appear; such a replacement, however, is entirely unknown in the rocks here considered. In the granodiorites and granites of Central Sierra Leone, two groups of microcline exist that differ by the amount of 2V, but values deviating from those belonging to the mentioned groups are exceptional. Both the transformation of orthoclase and the introduction of potassium being sluggish processes, such a grouping could not be expected if all the microcline there should have originated from orthoclase, without all the intermediate values of 2V appearing as well.

The arguments of GOLDSMITH and LAVES, however, are very strong indeed, but it should be possible to reach an agreement with respect to the difference of opinion as it results from the diverging — either cristallographic or petrological — point of view. One could ask to what extent the orthoclase must form to make possible a transformation into microcline with a twinning where the twin plane of the albite lamellae is perpendicular to the twin axis of the pericline lamellæ? If the formation of a single molecular cell already produces the necessary conditions for the formation of such twinning, then the agreement will be reached, because under such circumstances, the microcline practically grows, the transformation taking place at a very initial stage of the growth.

From the petrological point of view this question is extremely important, because if the orthoclase is the first to grow in the rock, it is obvious that the conditions of rock formation essentially differ from those under which microcline is growing — even if its very initial stage is monoclinic.

I mentioned in my paper that under hydrothermal conditions microcline transforms into orthoclase at a temperature of 525° C. This value was published by GOLDSMITH and LAVES. This supposition of temperature, however, is supported by certain petrological authors as well. As mentioned above, the microcline of the rocks here under consideration is the product of granitization. According to KULLERUD and NEUMANN (1953, "The temperature of granitization in the Rendalsvik Area, Northern Norway". Norsk Geol. Tidskr., Bd. 32, pp. 148–155), as concluded from the solid solution of FeS in the sphalerite, the temperature of granitization is less than 500° C and the same conclusion the present writer drew from the ex-solutions in the sulphide minerals of granitized rocks.

Among the predominant granite petrologists there are several supporters of the idea that granitization takes place under hydrothermal conditions.

I wish to express my sincere thanks to Professor F. LAVES for his valuable critical remarks, which animated the present discussion.

Received: December 31st 1955. *V. Marmo.*