American Mineralogist
Vol. 57, pp. 932–940 (1972)

METASOMATIC ORIGIN OF SOME MICROGRAPHIC INTERGROWTHS

MARIN SECLAMAN AND EMIL CONSTANTINESCU, *Faculty of Geology and Geography, Bucharest University, Bucharest, Romania*

ABSTRACT

Some micrographic intergrowths in a small pegmatite dike from Sebeş Mountains and in alkali granites from Banat Province have formed by replacement of feldspar or other minerals by quartz. The main textural features of these intergrowths are 1) The graphic quartz is skeletal, and the same skeletal quartz is sometimes included in two or more crystal hosts; 2) Occasionally the feldspar host is obviously deformed, whereas intergrown graphic quartz is nondeformed; 3) Some graphic quartz tends to develop along interfaces between feldspar or other mineral crystals, as well as along cleavage planes, fractures, slips, and deformation bands of its feldspar host.

INTRODUCTION

According to Fersman (1952), Vogt (1928), and many others, graphic texture is a result of simultaneous crystallization of feldspar and quartz. On the contrary, Schaller (1926), Wahlstrom (1939), and Drescher-Kaden (1948), among others, believe that this texture can be formed by replacement of feldspar by quartz or *vice-versa*. In his recent treatise on migmatites and the origin of granitic rocks, Mehnert (1968, p. 194–199) has critically examined the two points of view on the origin of graphic textures and came to the conclusion that a simultaneous crystallization of quartz and feldspar seems to be the most probable assumption. However, in some cases, the textural features of graphic intergrowth undoubtedly show a metasomatic development of graphic quartz. In order to emphasize these features, two examples are presented here.

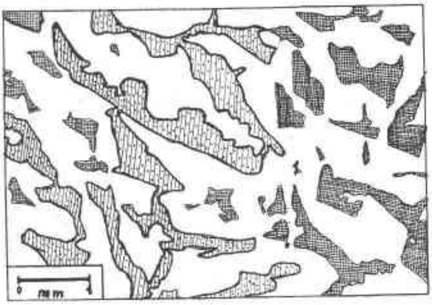
SEBES MOUNTAINS

In the northern part of the Sebes Mountains (Southern Carpathians, Romania) there are a few small granitic bodies of uncertain age. In one of these bodies, on the Sibisel Valley, there is a small pegmatite dike (about 3 m thick) formed of microcline, quartz, acid plagioclase (6–8% An), a little muscovite, and partially or totally chloritized biotite. The microcline and coexistent plagioclase occur either as pure crystals or in mutual perthitic intergrowth. The quartz also occurs either as "free" grains or in micrographic intergrowth with microcline, plagioclase, and even with muscovite or biotite. In the central part of the pegmatitic dike, where granulation is coarser, the graphic quartz is well developed, but near the walls, where there is a fine-grained zone, it seldom appears. In this external zone a lot of quartz and feldspar crystals have anomalous extinctions, fractures, and other deformation features indicating that the fine granulation of the external zone at least partly is due to shearing movements localized near the walls. Between the external and central zones there is a transition, with intermediate granulation, where a large part of the graphic intergrowths are broken and even completely destroyed. It is suggested, therefore, that the graphic intergrowth in the external zone has probably been destroyed by shearing movements.

In the graphic intergrowth the quartz usually occurs as "inclusions" in the feldspar, similar in aspect with the so-called "ichtyoglipts", "hieroglyphs", or "rods" described by Fersman (1952), Wahlstrom (1939), and others. The quartz inclusions generally look in thin section as if they were isolated, but many of them have the optical axis directed in the same way as shown by simultaneous extinction. This common optical orientation may be accounted for differently depending on the interpretation of the relations between inclusions. If we consider that they are actually isolated, the common optical orientation might be explained only by admitting that all the quartz inclusions have the same reticular orientation into the host feldspar, as assumed by Fersman. On the contrary, if we consider that quartz inclusions are only apparently isolated, due to the so-called "cut-effect", then all inclusions with the same optical orientation should be interpreted as parts of the same skeletal crystal. Fersman rejects the possibility of connection between quartz inclusion ("hicthyoglipts"), noting that when feldspar of macrographic samples is altered the detached quartz has no skeletal shape. However, Simpson (1962), has demonstrated the skeletal nature of his graphic quartz by series sectioning.

In the above-mentioned pegmatite dike, the reticular connection of graphic quartz inclusions is sometimes obvious even in thin section (Figure 1A). In many cases, however, the connection between inclusions is not obvious, but it can nevertheless be easily deduced. For instance, the quartz inclusions with the same optical orientation in Figures 1B and 1 C, are included in several hosts differently oriented, indicating that graphic quartz does not display any reticular orientation with respect to its host. In this case, the common optical orientation of quartz inclusions undoubtedly shows their reticular connection.

It is significant that feldspar from graphic texture often shows obvious signs of deformation, *e.g.*, changes of the cleavage directions,



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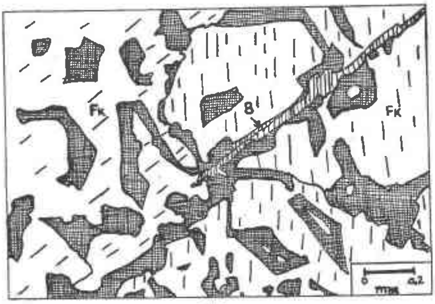

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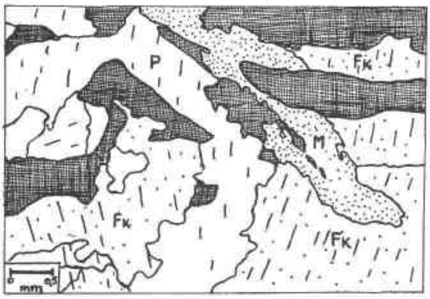

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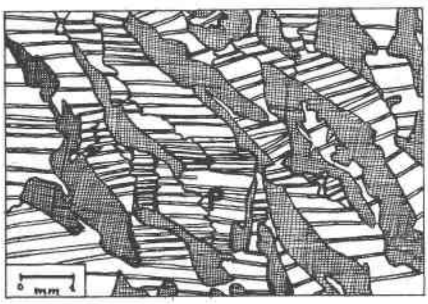

(d)

fractures, or even deformation bands resembling to a certain extent those noticed by Siefert (1965). However, the intergrown graphic quartz has most often almost a perfect uniform extinction, showing that it is not deformed (Figure 1D). This absence of quartz deformation in contrast with that of intergrown feldspar might be accounted for by three assumptions:

1. The present state of intergrowths is a consequence of a selective deformation. For instance, it might be assumed that under a relatively slight mechanical strain only the feldspar has been deformed while the intergrown graphic quartz has not been deformed. This explanation seems unlikely, because skeletal quartz is much more easily destroyed than its host feldspar, a fact which has been noticed by one of the present authors (Seclaman, 1971), in the case of macrographic intergrowths from some pegmatite bodies. Seclaman noticed that skeltal crystals of graphic quartz are broken even in the cases when intergrowth feldspar deforms only plastically. Plastic deformation of feldspar is frequently materialized only as translations along cleavage planes which do not disturb very much its optical and reticular continuity, whereas intergrown graphic quartz is so much destroyed that instead of a single quartz rod, optically continuous, there result tens or hundreds of crystal fragments with different optical orientation. This mechanical disturbance of the optical continuity of graphic quartz might explain the fact that sometimes in one and the same quartz rod many quartz crystals are differently oriented (Wahlstrom, 1939; Simpson, 1962).

2. The present state of the intergrowth is the result of two con-

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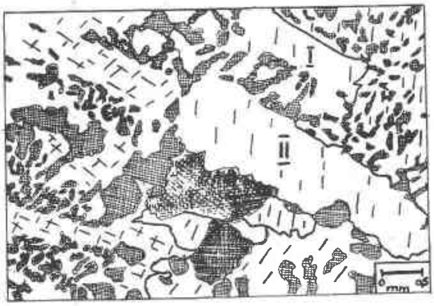
FIG. 1. Micrographic intergrowths from pegmatitic dike (Sibişel Valley) Q = quartz; F_K = K-feldspar; P = plagioclase; B = biotite; M = muscovite. (A) Quartz-microcline intergrowth in a thin section of about 0.05 mm thickness. Note the connection between dotted "hieroglyphs" and skeletal feature of graphic quartz. All quartz inclusions in the figure were connected when the thin section was about 0.1 mm thick. Crossed polars. (B) Alkali feldspar—quartz intergrowth. All quartz inclusions have the same optical orientation, although their hosts are differently oriented. Crossed polars. (C) The graphic quartz rods (black), which have the same optical orientation, are included not only in microcline, but even in plagioclase and muscovite. Crossed polars. (D) Plagioclase-quartz intergrowth. The plagioclase is obviously deformed, while the intergrown quartz is not deformed. Note the tendency of graphic quartz to develop along some fractures in plagioclase host. Crossed polars.



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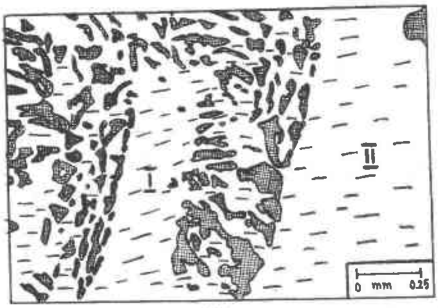

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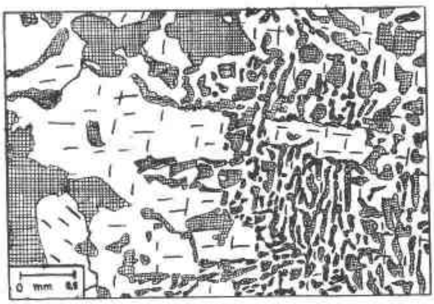

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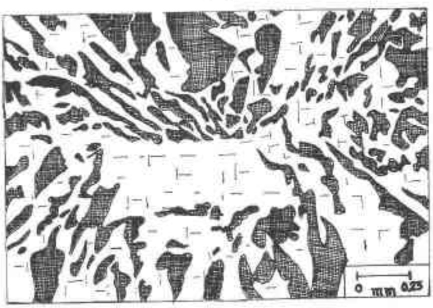

(d)

secutive processes: a) a deformation of both feldspar and intergrown quartz; b) a later recrystallization exclusively of the graphic quartz. As a consequence of this selective recrystallization, the graphic quartz lost its deformation state while the feldspar, which was not recrystallized, remained with its previously deformed appearance. However, it is difficult to explain why the quartz recrystallized skeletally and not as ordinary grains. Also exclusive recrystallization of graphic quartz is improbable. The quartz recrystallization requires some spatial redistribution not only of quartz, but even of the intergrown feldspar, and therefore recrystallization of graphic quartz necessarily should induce the recrystallization of the graphic feldspar itself.

3. The graphic quartz developed subsequently by partial replacement of the previous deformed feldspar.

This last hypothesis is the only one to fit with the textural peculiarities of the graphic intergrowths described above, namely: a) The tendency of graphic quartz to develop along the fractures of the feldspar host (Figure 1D); b) The development of the same skeletal crystal of graphic quartz in two or several adjacent feldspar or other mineral crystals (Figures 1B and 1C), as well as the tendency of

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FIG. 2. Micrographic intergrowths from alkali granite (Sasca Montană). (A) Alkali feldspar-quartz intergrowth. Note the idiomorphic "phenocrysts" of alkali feldspar surrounded by micrographic intergrowth. The graphic quartz inclusions have the same optical orientation, although their hosts are differently oriented. Crossed polars. (B) Detail within Figure 2A. Note the deformation bands in feldspar crystal. The graphic quartz has developed metasomatically especially in deformation bands. Some relatively undeformed portions between bands (I and II) have not been replaced by quartz, and they have remainded as relics, representing the very "idiomorphic phenocrysts". Crossed polars. (C) False idiomorphic feldspar phenocrysts surrounded by micrographic intergrowth. The "phenocrysts" and intergrown feldspar belong to the same alkali-feldspar crystal, but non-uniformly deformed. The "phenocrysts" represents the less deformed parts of feldspar crystals, whereas the intergrown feldspar represents the relatively deformed parts that have been subjected to a selective replacement by quartz along cleavage planes. The alkali feldspar is sectioned nearly parallel to (100). Crossed polars. (D) False idiomorphic feldspar phenocryst surrounded by micrographic intergrowth. The feldspar within graphic texture is not an overgrowth on "phenocryst", but a more deformed part of a bigger and previous feldspar crystal which has been selectively replaced by quartz along fractures and slips oblique to cleavages. The alkali feldspar is sectioned nearly parallel to (100). Crossed polars.

graphic quartz to develop along some interfaces between different feldspar crystals, a fact that also has been noticed. It is practically impossible to account for these peculiarities by simultaneous crystallization of graphic quartz and its host. From the metasomatic point of view, however, all these textural features can be explained adequately, because the same quartz crystal could grow by replacement along interfaces or along various fractures and "weakness zones" in one or several neighbouring minerals.

Banat Province

In Banat Province[1] there are many rocks with well-developed micrographic textures. Usually, these rocks are granodioritic but sometimes they can be even alkali granites devoid of plagioclase. These alkali granites occur in the proximity of Sasca Montana (Banat, Romania), and they are made up mainly of alkali feldspar with perthitic texture and quartz. Quartz occurs usually in micrographic intergrowth with perthite crystals and only seldom as isolated crystals. In micrographic intergrowth the quartz inclusions with the same optical orientation are often included in hosts with different orientations showing that the graphic quartz is here also skeletal. At first sight, this micrographic intergrowth (Fig. 2A) shows a resemblance to the products of artificial eutectic crystallization and thus it might lead to the belief that the intergrowth was due to simultaneous crystallization of alkali feldspar and quartz. As Figure 2A shows, the alkali feldspar is not entirely intergrown with quartz. Some idiomorphic feldspar "phenocrysts" are surrounded by micrographic groundmass. Usually, these "phenocrysts" are interpreted as a previously developed stage of feldspar that grew alone and free in a homogeneous melt, while intergrown feldspar represents a later generation corresponding to the simultaneous crystallization of feldspar and quartz. A careful examination, however, reveals that these feldspar "phenocrysts" are not genuine phenocrysts like those in igneous rocks of porphyritic texture. For instance, the detail of Figure 2B reveals that "phenocrysts" I and II are parts of a bigger alkali feldspar crystal that is non-uniformly deformed. In this big crystal there are some parallel deformation bands, and in many deformation bands there exist numerous inclusions of graphic quartz. The relatively undeformed portions between the bands do not contain graphic quartz, and they represent the very "idiomorphic phenocrysts" mentioned

[1] Banat Province includes all intrusive and effusive rocks of Senonian-Lower Eocene age of Western Romania, associated with Laramide tectogenesis.

above. Further, in some portions all quartz inclusions have a perfect optical continuity, pointing out that graphic quartz has not been deformed, though its host feldspar presents deformation bands and curved cleavage planes. The relative absence of deformation of graphic quartz as well as its tendency to develop along deformation bands of the feldspar substantiate the subsequent and metasomatic development of graphic quartz. Therefore, those "phenocrysts" should be interpreted as non-corroded relics of a bigger feldspar crystal, and not as growth during a previous generation of feldspar.

Some of these relics resembling authentic phenocrysts from volcanic rocks are shown in Figures 2C and 2D. They are sectioned perpendicularly to the *a* axis of feldspar and their plane edges are parallel to the cleavages. Most quartz inclusions appear like "rods" elongated both parallel to cleavages (Figure 2C) and obliquely (Figure 2D). At first sight, the impression is of a radial distribution of graphic quartz around the "phenocryst". Uspenski (1943) and others deduce from such a distribution that graphic quartz develops along directions of feldspar growth. However, these idiomorphic "phenocrysts" are relics and not growth centers of feldspar. In this case the distribution of quartz rods is a consequence of selective replacement of feldspar by quartz along some "weakness zones" which occurred in feldspar crystals during their deformation. These "weakness zones" are sometimes the very cleavage planes (Figure 2C), but in other cases they correspond to some glides oblique to cleavages (Figure 2D).

In short, the textural peculiarities of the above described quartz-feldspar intergrowths, may be satisfactorily explained only if we admit two consecutive stages in their genesis. The first was a non-homogeneous deformation of pre-existent feldspar crystals which were not yet intergrown with quartz. The non-homogenous character of deformation consists in the fact that some of the portions of feldspar crystals, of regular or irregular shapes, have been less affected by deformation, while others have been the site of development of reticular fractures, slips, and deformation bands, representing "weakness" or reticularly labilized zones. The second stage is a selective replacement of feldspar by quartz along "weakness zones". As a result, the quartz takes a complicated shape, imposed by the shape of "weakness zones". Skeletal quartz is thus generated.

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Manuscript received, June 3, 1971; accepted for publication, November 15, 1971.