writer has studied in detail the myrmekite in the granites and granodiorites of Mt. Abu batholith, Rajasthan, India, and has found plagioclase of myrmekites to be albitic in composition. "The association of quartz with internal vein perthite" as shown in Figure 1 (Hubbard 1966 p. 766) has been taken as an evidence of exsolution of quartz (as well as of vein perthite) from orthoclase microperthite. Alling (1938) always regarded the vein perthites to be of replacement origin. Moreover, silica could be introduced from without with albitic solution Moreover, if the quartz is of exsolution origin, it is difficult to understand why it has not formed characteristic myrmekitic intergrowth with vein perthite plagioclase also, as it does in other places.

Finally, according to Hubbard (1966 p. 771), "During the significant period in the history of charnockites, conditions were thus ideal for myrmekite formation by exsolution scheme of Schwantke. . . ." But the charnockites have been shown to be of diverse origin and there are many igneous charnockites in which no myrmekite has been found despite the "ideal conditions for the myrmekite formation."

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MYRMEKITE IN CHARNOCKITE FROM SOUTHWEST NIGERIA: A REPLY

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In his comments on my paper, Dr. Garg reinterprets my observations of the myrmekites of the S.W. Nigerian charnockites to conform with Shelley's (1964) hypothesis of myrmekite growth by incorporation of intergranular quartz in exsolving albite. For many reasons I found Shelley's proposals unacceptable for the myrmekites I studied. Perhaps the most striking feature opposed to Shelley's development scheme is the fixed proportionality of quartz to plagioclase found throughout the undeformed myrmekites in any one rock of my series (Hubbard 1966, p. 772). Continuing work on this feature serves to confirm this proportional relationship of components, controlled by the composition of the plagioclase component of the myrmekite. Dr. Garg singles out for reinterpretation the fine polyfurcated quartz zone at the myrmekite-alkali feldspar interface reported and illustrated in my article (Fig. 4 and 5). This remains, to my mind, one of the most compelling petrographic features indicative of coprecipitation of the plagioclase and quartz synchronous with the advance of the growth front into the source alkali feldspar (p. 772). Dr. Garg's contention that " . . . quartz away from the contact will have ample space to recrystallize . . . " pin-points, I feel, a difficulty in Shelley's interpretation of myrmekite growth; the problem of space availability.

Dr. Garg comments on the absence of quartz associated with internal perthite exsolution, not accepting the vein perthite-quartz associations as parallel features to myrmekite since myrmekitic morphology is not developed. Schwantke (1909) drew attention to this apparent anomaly in the paper in which he first proposed the concept of myrmekite as an exsolution product. Spencer's (1945) recognition of the association of quartz and vein perthite, though providing new impetus to the exsolution theory, still left unexplained the absence of quartz associated with film perthite. No satisfactory explanation of this anomaly has, to my knowledge, been published to date. My own view is that vein perthite and myrmekite development are allied processes separable from film perthite development in both time and mechanism. At the time of writing this reply I have completed an article (now being critically read prior to submission for publication) in which I detail my reasons for this belief. I consider vein perthite and myrmekite, on lattice defect/energetic grounds, to belong to the early stages of the exsolution history of the feldspars and to have a common nucleation and growth mechanism, along the lines proposed by Shelley (1964), which results in the production of both plagioclase and quartz. Film perthite exsolution, on the other hand, I interpret as belonging to a latter stage with a mechanism distinct from that of vein perthite and which is non-quartz producing. Such a separation in time of these two contrasted perthite types has already been suggested by Laves and Soldatus (1962) on structural grounds. It is hoped that the model proposed in my forthcoming paper provides an acceptable solution to this perennial and cogent criticism of the exsolution myrmekite theory as it now stands.

I have suggested (Hubbard, 1966, pp. 772–3) that: "The greater development and more regular morphology of myrmekite at alkali feldspar-plagioclase than alkali feldspar-alkali feldspar interfaces . . . may be interpreted as reflecting the decreasing degree of suitability of growth foundation found by the exsolving phases at these interfacial types. . . . " The internal sites of vein perthite exsolution may be considered as a special type of alkali feldspar-alkali feldspar interface. At such loci (lattice microcracks?) formation of the characteristic double row of blebs of normal alkali feldspar-alkali feldspar interfaces would probably be precluded since the lattice orientations of adjoining nucleations would be so similar, this being so for their possible respective foundations. The inferior foundation conditions and the lack of the directional control of growth characteristic of myrmekite development may explain the irregularity of morphology found for vein perthite-quartz aggregations.

If myrmekite grows by advance of plagioclase from its foundation interface into the source alkali feldspar, the development of a plug form by such a growth is predictable on energetic grounds. A hemispheric interface morphology allows the minimum possible interfacial energy between the myrmekite and the alkali feldspar. There will always exist lattice disarray and strain energy but this form reduces the surface energy to the minimum. Since sufficient energy is unlikely to be available for further nucleation at such interfaces, development of this shape probably marks the terminal stage of myrmekite growth.

My observation of myrmekite quartz paralleling the myrmekite to plagioclase contact is apparently not accepted by Dr. Garg since " . . . It is neither a commonly reported observation nor is brought out in Figure 4 of Hubbard's paper (1966)." An examination of my figure (p. 768) clearly shows the tendency to an L-shaped form demarcating the contact for a number of the quartz rods.

Dr. Garg states in his comments: " . . . The exsolved plagioclase from K-feldspar is always more sodic in composition contrary to the claim of Hubbard." If Dr. Garg means more sodic than the primary plagioclase a reading of my Table 1 (p. 765) will show I make no claim to the contrary. What I wished to convey by my statement " . . . The relatively high content of calcium in the exsolved plagioclase . . . " is that there is sufficient anorthite in the plagioclase to allow that the quartz component of the myrmekite might have been produced by the exsolution as proposed by Schwantke (1909).

Alling (1938) certainly concluded that vein perthite is of replacement origin, as Dr. Garg remarks, but many workers have since attributed an exsolution origin to at least some vein perthite (*e.g.* Spencer 1945, Laves and Soldatus 1962, Phillips, 1964). Dr. Garg infers that the vein perthite-quartz associations described in my paper are due to the introduction of "albite" and quartz. Such a conclusion makes it difficult to interpret the aureole free from film perthite around the vein perthite illustrated in my Figure 1 (Hubbard 1966). Dr. Garg himself points out, following Tuttle and Bowen (1958), that the deficiency of film perthite marginal to myrmekite " . . . Is explained by the migration of exsolved plagioclase to the margin of the orthoclase host."

Finally, Dr. Garg takes to task my statement that charnockitic crystallization conditions are ideal for exsolution myrmekite growth on the grounds that " . . . Charnockites have been shown to be of diverse origin . . . " and " . . . There are many igneous charnockites in which no myrmekite has been found. . . . " To my knowledge, there is little present controversy over the environmental conditions prevailing during the charnockite crystallization period. I quote from the conclusions in Howie's recent excellent review of the charnockite question (1964, p. 460); "Rocks of the charnockite series have crystallized or recrystallized under granulite facies conditions. The rocks reached this state regardless of their mode of origin as sediments, as igneous rocks or as pre-existing metamorphic rocks. . . . " The implications intended by my statement are detailed on p. 771 of my article. I made no claim that the S.W. Nigerian charnockites are of igneous origin, my data on this question being inconclusive, and I indicate (p. 763) that myrmekite will only form when the crystallizing charnockites are of suitable composition.

The object of my paper was to interpret as fully as possible my observations of the petrography and mineralogy of the myrmekite of the S.W. Nigerian charnockites. This I consider best achieved on the basis of an exsolution origin for both components for the reasons given in my article. I look forward to the publication of the results of Dr. Garg's detailed study of the myrmekite of Mt. Abu batholith in the hope that they shed some fresh light on the as yet still controversial problem of myrmekite genesis.

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