# ON THE ORIGIN OF THE CHARNOCKITES

*By N Jayaraman*

There is still difference of opinion regarding the origin of the charnockites Some hold that the charnockites are a huge plutonic complex intruding into the gneisses and schists of the peninsula, while others suggest a metamorphic origin involving complete re-crystallisation of the original rock The characteristics associated with charnockites do indicate some metamorphism, but not however, of the type required to result in complete liquifaction and recrystallisation of the original rock for the formation of the charnockite series, whose extent is very large The great uniformity in many of the characteristics of the charnockites throughout its entire area is in favour of a magmatic origin The evidences of metamorphism commonly met with in these rocks appear to be due mostly to general metamorphic movements in the plutonic zone brought about during the consolidation of the charnockite magma

After a detailed examination of the various characteristics of the charnockite series, Holland[1] comes to the following conclusion "Deformation has occurred whilst the magma was still in a plastic condition, and one accompaniment of such deformation would, in all probability, be the production of a granulitic structure in which groups of granules would represent the break up of larger individuals of the same species" But, at the same time, Holland could not exclude the possibility that a severe type of metamorphism of the solid rock might have resulted in the formation of charnockites

A detailed study of the acicular inclusions in the charnockite quartz has been carried out recently by the author[2] and the results obtained appear to throw some light on this interesting problem

When a thin section of the charnockite quartz is examined under the microscope it shows an enormous number of inclusions which can be classified under two heads, viz , (a) regularly arranged acicular inclusions, (b) the more or less irregular drop-like and dust-like inclusions showing much variation in size. When sections cut perpendicular to

the C axis are examined between crossed nicols, the acicular inclusions exhibit high birefringence, while the other inclusions are almost isotropic, a few of them being weakly birefringent. When the quartz grains which appear to be homogeneous shapeless crystals are examined under the microscope between crossed nicols, they are found to be made up of many crystals grains in different orientations, that is, the whole specimen looks like a mosaic crystal. This definitely shows that the quartz has undergone granulation or fragmentation as the case may be. But the uniformity of the grain size, the perfect optical unity of grain to grain inspite of different optical orientation and the absence of definite mortar structure exclude the assumption that the granulation has resulted from a metamorphism of a solid rock involving a good deal of grinding and crushing. They show, on the other hand, that the original magma, from which the charnockites have originated, must have been subjected to a slow and general movement without any particular directional effect. The plasticity of the magma continued to be present even after the cessation of the general tectonic movements, which produced the granulation effect by splitting a main centre of crystallisation into many centres and rotating them through various angles. The strain shadows exhibited by the quartz grains can also be explained in the same manner.

Often the acicular inclusions were found to extend through adjacent fragments of the quartz in unbroken continuity indicating thereby either a secondary origin or a secondary arrangement due to molecular diffusion. The secondary arrangement could not be due to cracks produced by orographic movements as stated by Johannsen[1] because, in the charnockite quartz the needles are found to follow definite crystallographic directions. If the cracks are assumed to be of orographic ones, they must have been produced by tensional effects which would give them spindle-like appearance. But actually it was found that the needles are always of uniform thickness and never show thinning at the ends. The smooth contact of the needles with the quartz and the rod-like appearance of the needles cannot go hand in hand with the idea of tensional cracks. Thus, now the acicular inclusions of rutile show that they originated only after the stoppage of the

metamorphic movements But it appears that even at the time when the rutile needles were being formed, the magma was still in a plastic condition because, neither a secondary origin nor a secondary arrangement of these needles, which involve bodily molecular movement, could have taken place in a perfectly solid medium So the metamorphic movements which are of earlier origin than the needles must have been of the plutonic type As proofs of a very severe type of metamorphism involving high temperature and pressure to produce this state of semi-solid or pasty condition of the rock mass are lacking, the view of Holland that deformation occurred during the process of consolidation of the original magma seems to be acceptable although not conclusive

The origin of the acicular inclusions themselves can be traced to the final stages of the consolidation of the charnockite magma due to a general infiltration of a titanium solution which partly crystallised in the quartz as fine rutile needles and partly remained dispersed as colloidal particles of a titanium compound Prabably, the crystallisation of the rutile needles took place along lines of "chemical weakness" in the quartz grains due to slow diffusion of the titanium material It is, perhaps, due to this phenomenon that the rutile needles are always found only along definite directions in the quartz and are not distributed allthrough In cases where the needles extend into the adjacent grains of quartz, these lines of chemical weakness in those quartz grains must have been brought in contiguity in such positions as to give rise to continuous lines of weakness along which the titanium later on crystallised as rutile needles These continuous lines of chemical weakness, when passing from grain to grain, form either straight or bent lines as the case may be.

It can, therefore, be concluded that the charnockites are of magmatic origin and that they suffered a slight metamorphism during the later stages of the consolidation of the magma They are mainly crystalline intrusives intruded into the peninsular gneiss

The author proposes to deal with this problem in greater detail after a detailed petrographic and chemical examination of charnockite samples from various regions It is also proposed to carry out helium

determinations in the charnockites and associated rocks with a view to calculating their age

It is interesting to note that Groves[4] recently proposed a plutonic metamorphic origin to the charnockites of Uganda

The author wishes to express his grateful thanks to Dr K R Krishnaswami for his kind and helpful criticisms in preparing this paper

REFERENCES

1 Holland, T H, *Mem Geol Surv Ind* Vol 28, Part 2, p 140 (1900)

2 Jayaraman, N, *Current Science*, Vol VI, No 8, p 381 (1938), *Ind Acad Sci*, Vol IX, No 3, Sec A (1939)

3 Johannsen, A, *A Descriptive Petrography of the Igneous Rocks*, Vol II, p 135, (1932)

4 Groves, A W, *Q J G S*, No 362, (1930)

*Department of Pure & Applied Chemistry,*
*Indian Institute of Science,*
*Bangalore.*