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On the Origin of Gneissic Banding

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RÉSUMÉ

C'est sans doute dans le jeu subtil entre déformation et recristallisation que prend naissance le rubanement gneissique. On propose ici un mécanisme génétique qui fait intervenir un contrôle étroit de la déformation isoclinale, si répandue dans les tectogènes, sur un métasomatisme préférentiel et différentiel.

ABSTRACT

It is doubtless the interplay between deformation and recrystallisation that leads to the formation of gneissic banding. A genetic mechanism is here proposed that depends essentially on the control by isoclinal deformation, a very common feature in tectogenic belts, of preferential and differential metasomatism.

The origin of banding in gneisses and migmatites has long been a source of perplexity, debate and speculation. Various hypotheses have been proposed, none of which appear to cover the multiple aspects of the phenomenon. The difficulty of this complex problem is probably related to the fact that, once again, convergence is involved: there are surely different types of gneissic banding, corresponding to different modes of origin, but all ending up in the production of a rock in which alternations of light and dark bands constitute this structure. Another difficulty resides in the delicate evaluation of the respective rôles of those two foremost factors in the creation of metamorphic rocks: recrystallisation and deformation.

The following mechanisms could possibly, and sometimes certainly do, lead to the formation of banded gneisses:

1) mimetic recrystallisation of an already banded rock; the new bands are at least parallel to the old ones, with which they may in fact coincide.

2) introduction of quartzo-feldspathic material along axial plane structures. This represents a form of migmatisation, which could either be synkinematic or late-kinematic (even post-kinematic) in relation to the folds in which these axial plane veins occur. Very good examples of this relationship have been shown to us by J. G. RAMSAY in the folds of the Moine Series near Loch Monar, Scotland (cf. Fig. 7–87 in RAMSAY, 1967, for instance). It is not clear though whether this mechanism can lead to complete reorientation of the rock's structure.

3) transition from agmatite to banded gneiss, through increasing or progressive deformation. This is again remarkably well illustrated in Scottish rocks, i.e. the Lewi-

sian amphibolitic agmatites near Glenelg. Still, while this occurrence is of great interest, it would probably be erroneous to think of it in terms of widespread development. Moreover, the actual process of redistribution of material into parallel planes or bands through deformation has not yet been clearly elucidated (here, folds are possibly, if not probably formed—if they are, this occurrence may in fact be related to the following considerations). Banded mylonites may be formed in a similar manner.

These instances do not represent the most common situation in banded gneisses. They probably cannot explain the vast majority of cases of gneissic banding.

Yet another model may be envisaged, which tries to take into account the general parallelism between gneissic foliation, and the older layered structure (if it existed), such as sedimentary bedding, on which the metamorphic banding is superimposed. This relationship has been noted by geologists for many years, some attributing it to mimetic recrystallisation, others just leaving it at that.

The following proposition is based on the observation that banded gneisses have always been deformed (and generally more than once!), and that isoclinal deformation always appears to turn up at some point during the history of a banded gneiss.

Now, it is a well known fact that isoclinal deformation is the prime factor which brings into parallel relationship bedding and cleavage, for instance. One suspects that the same holds true in the case of gneissic banding.

The other source of inspiration—and in fact, all that follows is but extrapolation—is the highly interesting work conducted by P. Misch (cf. Misch, 1969), R. L. Gresens (cf. Gresens, 1966), and J. R. Carpenter (cf. Carpenter, 1968). The latter has demonstrated that pressure gradients due to folding during regional metamorphism may bring about "the migration of water to low pressure fold crests". This in turn may lead to different metamorphic assemblages in crest and limbs of a fold. Misch, in his more recent paper, again suggests the possibility of formation of a new axial plane structure during folding. Another stimulating contribution by D. M. Carmichael (1969) confirms the importance of small-scale metasomatic activity during recrystallisation.

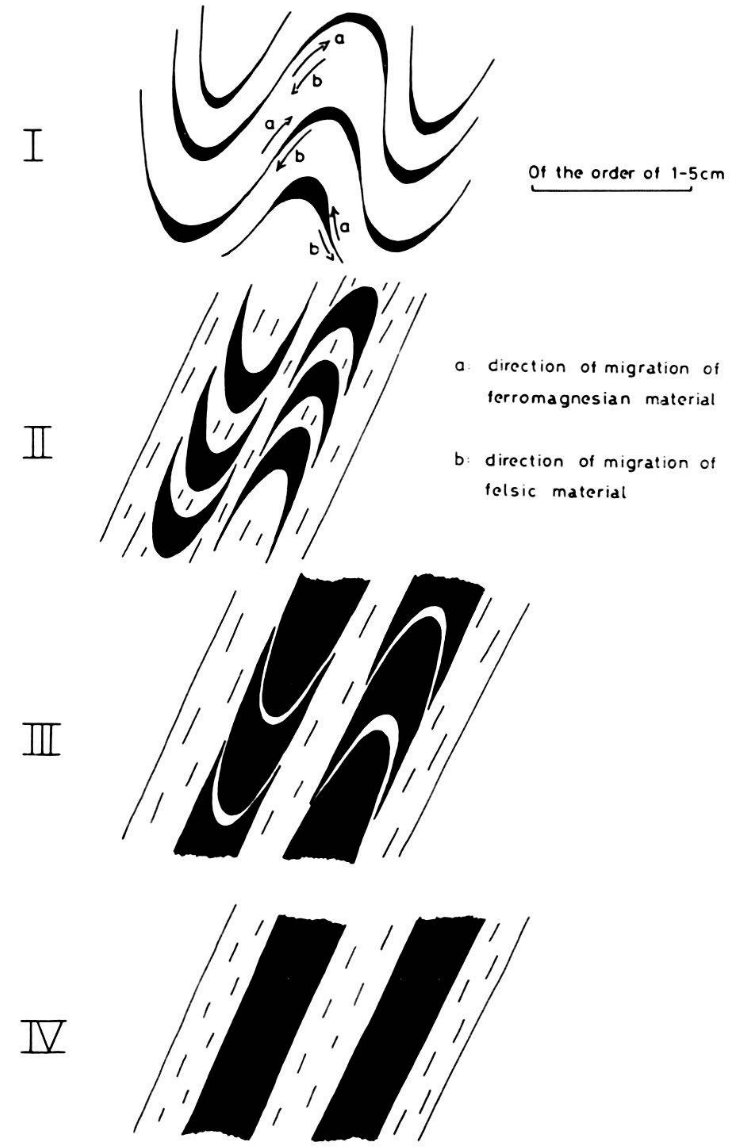
The envisaged mechanism has been divided into four stages in the Figure — they are, of course, but steps in a transitional sequence.

Stage I. – Incipient folding in graywacke or semi-pelite in anatectic conditions. Hydrated ferromagnesian material (mainly biotite and amphibole) begins to concentrate in crestal zones.

Stage II. – Continuation of the formation of hydrated ferromagnesian assemblages in low pressure crestal zones, with concomitant migration of feldspathic material to the limbs. Deformation has increased, and the folds are tighter.

Stage III. – Differentiation is almost complete—a few quartzo-feldspathic veins still record the closures (a not uncommon situation).

Stage IV. – Final stage. Production of "simple" banded gneiss. Of course, the leucocratic layers still contain some ferromagnesian material, and vice-versa.



Progressive development of gneissic banding through isoclinal deformation and concomitant metasomatic recrystallisation.

The discussion of such a model may lead to the following conclusions:

a) to begin with, isoclinal deformation probably plays an essential rôle in the production of most banded gneisses.

b) in this model, each dark band represents a hinge zone, from which the periodicity of the folds may be deduced.

c) "simple" folds which show deformation of the banded structure (in other words, the bands turn round the hinge) may actually be double structures (especially if mineral orientation follows the banding).

d) the wedging-out of individual layers in gneissic banding may represent the junction of axial planes.

e) the type of deformation mechanism involved in this model may be a complex combination of buckling and shear. In any case, the development and persistance of low pressure zones in the crests of folds demands an explanation. The recognition and situation of pressure-dependent assemblages may afford useful information on fold mechanisms in rock where recrystallisation has occurred.

f) another point is a possible explanation for so-called "intrafolial" folds. They may represent stages in this sequence (see stage II).

In this hypothesis, which corresponds to gneisses with hydrated ferromagnesian assemblages (mainly biotite and amphibole), the redistribution of material is related to the mobility of water (or at least hydroxyl groups). In pyroxene-bearing gneisses etc., different types of activity will have to be envisaged, but the fundamental principle may possibly remain the same.

The above represents yet another attempt in explaining adequately gneissic banding. It may not be valid. Nevertheless, it is in the subtle interplay between deformation and recrystallisation that the answer is to be found.

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