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# STRUCTURAL STUDY OF HIGHLY DEFORMED MEGUMA PHYLLITE AND GRANITE, VICINITY OF WHITE HEAD VILLAGE, S.E. NOVA SCOTIA: A REPLY TO HILL AND RAESIDE

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We thank Hill and Raeside for the comments on our paper (Mawer and Williams, 1986). We disagree with several of their conclusions and reinterpretations, however, and will discuss these in turn.

## TRANSPOSITION CYCLES

Hill and Raeside state that all structures we previously described belong to a discrete $D_2$ event. This is certainly incorrect. The complexity of the transposition process (e.g., Williams, 1983, 1985) in terranes of multiple deformation makes any subdivision into phases or events of deformation highly suspect. The most one can hope for in nearly all such cases is to be able to decipher local overprinting relationships. An important point apparently unappreciated by Hill and Raeside is that deformation in areas such as the eastern Meguma is highly heterogeneous in time and space at all scales. Apparent $D_2$ structures in one outcrop may be $D_3$ structures in an adjacent outcrop, and of relative $D_1$ age in a third. Small domains with just one tectonic foliation (which may be early, late, or somewhere in between) may lie next to domains with multiple foliations. The eastern Meguma Terrane is an excellent example of the ongoing and cyclically overprinting process of large-scale transposition (Williams, 1983; Mawer and Williams, 1986 and ongoing work), both of original stratigraphy and of successively-formed structures. The division of deformation into two distinct events ($D_1$ and $D_2$) and the further subdivision of these events into phases ($D_{1a}$, $D_{1b}$, $D_{2a}$, $D_{2b}$, $D_{2c}$), as attempted by Hill and Raeside, is misleading and obscures important information about the continuous nature of the deformation sequence. The very complexity of such a scheme, and the fact that structural correlation between closely-spaced areas is difficult (and commonly not possible) upholds one of our original conclusions, that it is impossible to determine the number of transposition cycles in this area. We concentrated on the latest transposition foliation in the metasedimentary rocks (be it a $D_1$- or $D_2$- or whatever-aged structure) in order to more fully understand the continuous nature of the transposition process. We agree that deformation producing folds, which can be recognised throughout the Meguma Terrane, probably predated development of the Cobequid - Chedabucto Fault System (see also Mawer and White, 1987). We do not, however, accept Hill and Raeside's microstructural evidence for this earlier deformation for the reasons outlined above.

## PORPHYROBLAST RELATIONS

Porphyroblast/matrix relations in multiply-deformed terrains are notoriously difficult to explain in an unambiguous manner (Vernon, 1978; Williams, 1985; Bell, 1986). Such relations are critically dependent on the strain environment in which the porphyroblasts grow, the scale and shifting patterns of deformation partitioning, and the absolute rates of porphyroblast growth. These factors are generally poorly known, if at all. Areas of continuous cyclic transposition (as in the eastern Meguma Terrane) will certainly preserve complex, perhaps undecipherable, relations. It is for this reason that we concentrated on the late syntectonic cordierite porphyroblasts which record a simple history. All cordierite porphyroblasts we have studied in thin section (over 50 thin sections with more than 400 cordierite porphyroblasts) show consistent simple dextral rotation about essentially vertical axes. Hill and Raeside's reinterpretation of our Fig. 2d is wrong - there is no hint of millipede structure in the figured thin section (see Fig. 1 of this reply). In any case, we fail to see how the presence of millipede structures in other porphyroblasts alters our conclusions in any way, given the facts of multiple transposition and heterogeneous deformation at all scales (as shown in Mawer and Williams, 1986). The most important property of the cordierite porphyroblasts we studied is that they invariably overgrow the latest transposition foliation, and are slightly rotated in a dextral sense. For this reason, the porphyroblasts are late syntectonic with respect to the development of this foliation.

## AGE DATING

All available age dating from this area of the Meguma Terrane refutes the statement in Hill and Raeside's conclusions that the granite plutons were emplaced relatively early in $D_2$ (for example, see Reynolds and Muecke, 1978; Dallmeyer and Keppie, 1984). $^{40}Ar$-$^{39}Ar$ mica dating indicates statistically-identical ages for granite plutons and nearby



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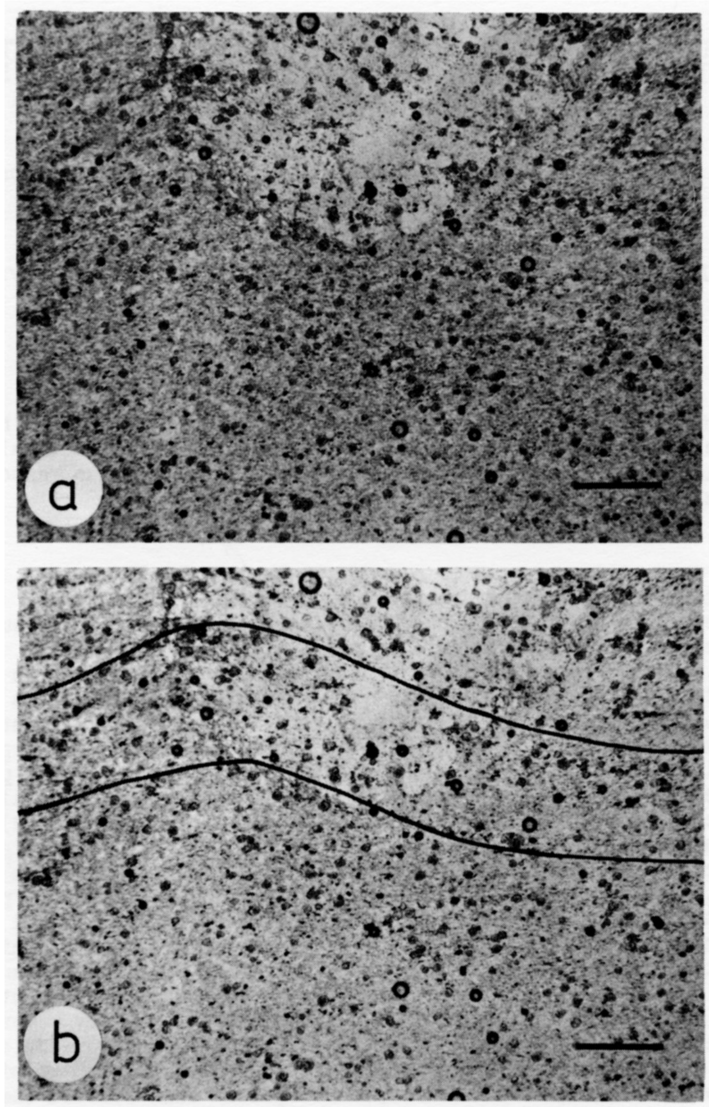


Fig. 1. Photomicrograph of half of cordierite porphyroblast and adjacent matrix shown in Fig. 2d of Mawer and Williams, 1986 (a - plane polarised light view; b - superimposed trend lines of $S_i$ and $S_e$). Note that $S_i$ and $S_e$ are continuous, there is no hint of millipede microstructure, and porphyroblast shows simple dextral rotation. Horizontal section, scale bar - 0.5 mm.

slates and phyllites. Also, Rb-Sr granite whole rock dates of Dallmeyer and Keppie (1984) and U-Pb monazite dates of T. Krogh (reported in Hill and Raeside's discussion) are statistically identical to these mica dates. This undoubtedly means that the country rock ages have been reset by granite intrusion late in their history. Small-scale structural analysis, as discussed in our original paper and below, further shows that the granites are late syntectonic with respect to the latest transposition foliation.

## RELATIVE TIMING OF GRANITES, FOLIATIONS AND PORPHYROBLASTS

We have shown (Mawer and Williams, 1986 and work in preparation) that the dominant foliation in metasediments of the present area is the final product of multiple cyclic transposition. We have further shown that the cordierite porphyroblasts in these rocks have overgrown this latest transposition foliation and are rotated with respect to it. The style of deformation we reported for the granite at White Head (mesoscopically undeformed core with intensity of deformation progressively increasing towards the margin) is seen in several other plutons of the area (see also Mawer and White, 1987). There is indeed late shearing concentrated at the pluton margin, as evidenced by the development of S-C textures there, but we would argue that this is simply one more consequence of the progressive dextral shearing which caused the transposition of the country rocks. The latest transposition foliation in the metasediments is continuous with and of the same orientation as the C (shearing) foliation in the granites. Further, shear strains recorded in the granites are small (gammas of about 1), whereas shear strains in the transposed country rocks are considerably larger (Mawer and White, 1987; Mawer and Williams, 1986 and work in preparation). These points taken together are difficult to explain if granites were intruded early in the deformation, and rather indicate that the granites of this area intruded late syntectonically with respect to the latest transposition foliation, as concluded in our original paper. An identical conclusion has been reached by J.R. Henderson (written communication, 1984) for the Liscomb granite south of the present area, based on detailed meso- and microscopic structural analysis.

## CONCLUSIONS

We appreciate the comments and interest of Hill and Raeside, but we disagree with several of their conclusions. Specifically, we feel that: a) the number of transposition cycles in the eastern Meguma Terrane is indeterminate, and will vary from domain to domain because of the heterogeneous nature of the deformation at all scales in time and in space; b) the cordierite porphyroblasts we described are late syntectonic with respect to development of the latest transposition foliation, and show small amounts of simple dextral rotation about vertical axes; c) present age dating in the area indicates a late resetting of metasediment ages due to granite intrusion, resulting in statistically identical metasediment and granite ages (this holds for $^{40}$Ar-$^{39}$Ar metasediment and granite mica ages, U-Pb granite monazite ages, and Rb-Sr granite whole-rock ages); and d) granites were intruded late syntectonically with respect to the latest transposition foliation, not early.


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