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Structural evolution of a transpression zone in north central Newfoundland: Reply

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IN HIS discussion, Blewett raises important questions concerning (1) the nature and origin of the Boones Point Complex and (2) the overprinting relationship between F_2 and F_3 folds. Blewett also proposes that F_2 folds with the geometry of transected folds have formed synchronously with the transecting cleavage. These points will be briefly addressed, but the reply focuses on the last question raised by Blewett which is of more general interest: should folds with the geometry of transected folds be considered as overprints?

Blewett and other workers interpret the Boones Point Complex as a tectonized belt of débris flows related to an early thrusting event. The Boones Point Complex consists of several disrupted, incompetent horizons or mélanges surrounding more competent rock units. The deformation structures seen in the mélanges are 'hard rock' structures (see Lafrance 1989 for more details); there is no convincing evidence of unlithified sediment deformation. The mélanges occur in shear zones which in certain cases clearly transpose the regional S_3 foliation indicating that they developed late in the tectonic history of the region. The Boones Point Complex therefore consists of tectonized mélanges some of which are definitely late in origin, since they overprint the regional cleavage. There is, however, some justification for Blewett's and other workers' interpretations since, in a well dated sequence on eastern New World Island, a younger olistostromal unit lies between two older units (Jacobi & Schweikert 1976, van der Pluijm 1986). I would therefore like to reinforce a statement made in the original paper (Lafrance 1989, p. 711): "There may have been in the Boones Point Complex disrupted horizons related to an early thrusting event, but the late overprinting shearing would make them indistinguishable from shear zone mélanges".

Blewett questions the interpretation concerning the overprinting of F_2 folds by a large-scale F_3 fold on Swan Island (Lafrance 1989, fig. 3). He suggests that the girdle defined by the distribution of F_2 fold axes represents the axial surface of the folds about which the mesoscopic axes pitch, rather than a large-scale fold. Since F_2 folds retain the same vergence on both limbs of the large-scale fold, they may be interpreted, on the basis of the distribution of their axes alone, to overprint the large-scale fold (as proposed by Blewett) or to be overprinted by the large-scale fold.

As mentioned in the original paper, F_2 fold axial planes are folded around the large-scale fold; outcrop exposure is continuous along the coastline and this interpretation is based not only on equal-area projec-

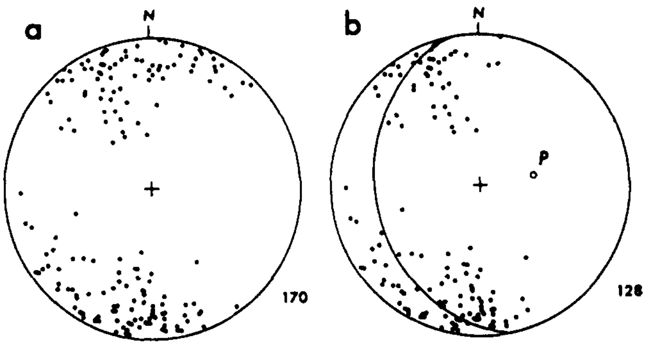

Fig. 1. (a) & (b) Equal-area, lower-hemisphere projections of poles to the axial planes of F_2 folds on Swan Island. P is the pole to the great circle defined by the poles to F_2 axial planes.

tions but also on direct field observation. One can walk from one limb, around the fold hinge, to the other limb of the fold. The orientation of poles to F_2 axial planes is shown in Fig. 1(a). The dispersion of the data is partly due to overturning which occurred late in the deformation history. The poles to overturned axial planes are removed in Fig. 1(b) which reveals the distribution of the remaining poles along a girdle. The broad concentration in the NW quadrant of the figure represents the average orientation of F_2 axial planes on the eastern limb of the fold, while the data in the SE and SW quadrants represent the orientation of axial planes in the hinge and west limb of the fold. Although there is still a certain degree of scatter, F_2 axial planes clearly do not cut across the large-scale fold but rather change in orientation from one limb of the fold to the other. This relationship can only be explained in terms of overprinting of the F_2 folds by a large-scale fold. Furthermore, as discussed in the original paper, the fold–cleavage geometry (see Lafrance 1989, figs. 4 and 5b), where a cleavage cuts obliquely across both limbs and the axial planes of F_2 folds, can only be explained in terms of overprinting. This cleavage is not folded by the large-scale fold (Lafrance 1989, fig. 3), contains both the poles to the girdles of bedding and F_2 axial planes (pole P in Fig. 1b), and is approximately axial planar to the large-scale fold and to mesoscopic folds on the south coast of the island with similar orientations to the large-scale fold. The interpretation therefore stands as it is.

Blewett presents examples where the cleavage transects fold axes in argillaceous beds while the cleavage is approximately axial planar to folds in competent psammitic beds, and concludes that since the cleavage must have formed synchronously with folding of the competent layers, the transection must also have occurred during folding. Although not referred to in Blewett's discussion, this interpretation fits remarkably well with the model proposed by Treagus (1988) who accounts for this type of geometry by refraction of three-dimensional strain associated with folding of oblique layers. A similar cleavage geometry, however, would be produced if extension, compression or oblique flattening across the folds occurred after the formation of the folds. In polydeformed areas such as north central Newfoundland, this is a distinct possibility. Furthermore, if the cleavage–bedding intersection in the competent layers is not parallel to the cleavage–bedding intersection in the incompetent layers, there is no reason to assume the cleavages in the competent and incompetent beds to be equivalent. As discussed in the paper, the axial-planar cleavage in the argillaceous beds could have been completely obliterated by an overprinting cleavage.

In his last comment, Blewett proposes that the chronology of deformation would be simplified if the overprinting of F_2 folds by S_3 cleavage were considered in terms of transection. Transected folds are, by definition, folds associated with a cleavage which is oblique to their hinges and formed synchronously or 'more or less' synchronously with the transecting cleavage. F_2 folds in north central Newfoundland, however, clearly formed prior to, and are cut by, the cleavage.

Structural mapping involves determining the succession of deformation phases; it should be model independent since it provides the data on which interpretations and models are based. To assume a genetic model on the basis of geometry alone (e.g. to assume folds formed synchronously with a transecting cleavage) at the onset of mapping would bias the data collected. It is therefore particularly important to separate structural data from interpretation in areas with polyphase deformation histories, such as Notre Dame Bay, since a transecting geometry may result from superposing structures from two separate deformation events or phases.

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