COMMENT

TWO DISTINCT LATE PRECAMBRIAN (AVALONIAN) TERRANES IN SOUTHEASTERN NEW ENGLAND AND THEIR LATE PALEOZOIC JUXTAPOSITION

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O'Hara and Gromet (1985) present new isotopic data for some of the metaplutonic units of eastern Connecticut and Rhode Island which they interpret as showing that there are two distinct terranes in the Avalonian basement of Rhode Island, eastern Massachusetts, and eastern and southeastern Connecticut. They also present some new quartz c-axis orientations and a reinterpretation of structural data from published sources which they interpret as showing that a major, high-temperature shear zone separates the two terranes. They conclude that this has resulted from the oblique collision of their eastern basement terrane with the rest of New England resulting in the Permian Alleghanian orogeny. The isotopic results are a welcome addition to the data base for New England, and the structural and tectonic interpretations represent a new and unique view of the tectonics of southeastern New England. There are, however, several aspects of this study that can be interpreted in other ways. These concern, primarily, the interpretation of rock fabrics in southeastern New England. The evidence I will cite does not support the existence of O'Hara and Gromet's (1985) shear zone. I will also argue that the geological evidence does not support the hypothesis that an Alleghanian-aged collisional suture is present in southeastern New England.

The structural data O'Hara and Gromet (1985) cite in support of the existence of the proposed shear zone are as follows: sigmoidal curvature of mineral elongation lineations into and out of the shear zone, an increase in the intensity of foliation and/or lineation toward the center of the shear zone, and a consistent sense of obliquity in quartz c-axis orientations. The compilation of lineations O'Hara and Gromet (1985) interpret as having a sigmoidal pattern incorporates, in the western portion of their study area, northwest-trending lineations of the Lake Char-Honey Hill fault zone (fig. 1). This fault zone is characterized by a wide zone of mylonitization (Dixon and Lundgren, 1968) associated with Alleghanian low-angle normal displacement (Goldstein and Owens, 1985; Goldstein, 1982a,b). There are at least two possible interpretations of the lineation pattern: (1) the northwest-trending lineations and Lake Char mylonites on the west side of O'Hara and Gromet's (1985) shear zone are unrelated to the north-trending lineations to the east, in the center of the proposed shear zone. This is an interpretation I favor and which results in no sigmoidal pattern of lineations (fig. 1). (2) The northwest-trending lineations represent the western side of a large shear zone. This interpretation, presented by O'Hara and Gromet (1985), suffers because of the presence of mylonites along the western boundary of the proposed shear zone. Implicit in this model is that these mylonites result from very low strains

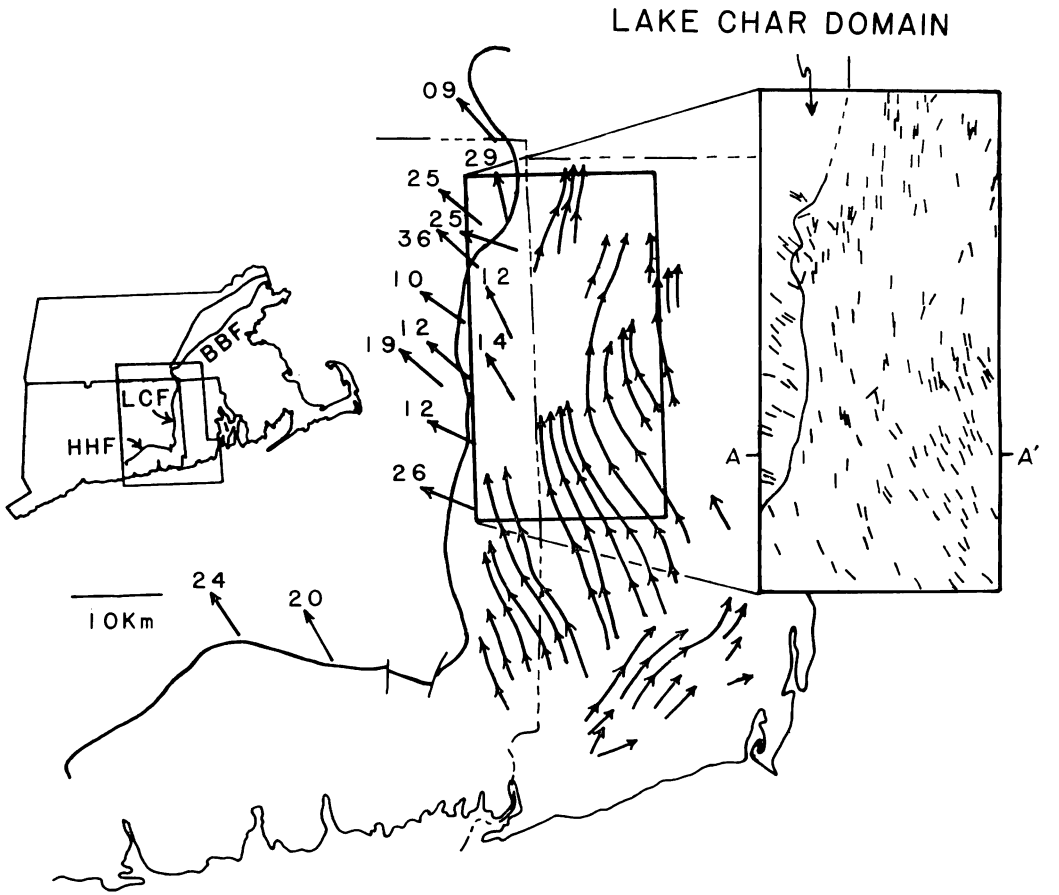

Fig. 1. Lineation summary for southeastern New England. Arrows with labeled plunges represent the vector means of field measurements of mineral elongation lineations in mylonites of the Lake Char-Honey Hill fault zone. Long lines with multiple arrowheads are the lineation summary of Day et al. (1980), and the box on the right side of the figure is the lineation summary of O'Hara and Gromet (1985). The solid line added to O'Hara and Gromet's lineation summary shows a western domain of northwest-trending lineations in Lake Char mylonites.

(O'Hara and Gromet, 1985, fig. 8). The strong grainsize reduction in mylonites is almost universally accepted as a strain softening mechanism that allows large strains to be concentrated in reasonably narrow zones. Although there are no strain data for Lake Char mylonites, magnetic susceptibility anisotropy data suggest large strains in those rocks (Goldstein, 1980). Certainly, the shear strain in the mylonites must be larger than zero which is what O'Hara and Gromet (1985, fig. 8) have calculated.

Additional observations argue against the interpretation that the lineation pattern in eastern Connecticut and Rhode Island is related to a major shear zone: (1) foliation is constant across the proposed shear zone with only the elongation lineation changing orientation; (2) sigmoidal

patterns are not evident except in a small segment of the southern part of O'Hara and Gromet's (1985) study area (fig. 1); (3) the strong development of lineation in the center of the shear zone and the near absence of foliation are suggestive of apparent finite constriction, a strain state not predicted by theoretical considerations (Ramsay and Graham, 1970) and inconsistent with a shear zone origin; (4) mylonites of the Lake Char fault zone show evidence of motion during a period of cooling and uplift (Goldstein and Owens, 1985) whereas the rocks in the center of the proposed shear zone were only deformed at high temperature (O'Hara and Gromet, 1985).

The observations cited above suggest that the sigmoidal pattern of lineations either does not exist or is not consistent with the interpretation of a major shear zone. Additional evidence cited by O'Hara and Gromet (1985) in favor of a major shear zone is the increase in intensity of rock fabrics toward the center of the shear zone and a consistent sense of quartz c-axis obliquity in the deformed metaplutonic units of eastern Connecticut and Rhode Island. Fabrics do seem to intensify from east to west across Rhode Island, but this may be related to a westward increase in deformation as one moves from the margin of the orogen toward its center. The fabrics do not decrease westward from the center of the proposed shear zone. O'Hara and Gromet (1985) assume that the fabrics that increase westward are all Alleghanian, at least in their eastern domain. However, both Dreier (1984) and Nelson (1976) have documented pre-Alleghanian deformations in rocks of the eastern domain. Presumably, the Ponagansett gneiss was also deformed prior to the Alleghanian orogeny. The fabrics in these metaplutonic rocks are the result of finite strain, and, although an Alleghanian overprint is nearly a certainty, so is a pre-Alleghanian component. The parallelism of metamorphic isograds with the hypothetical shear zone is cited as evidence that the Alleghanian metamorphism is intimately related to the proposed fault. The locations of these isograds are highly speculative, especially considering the dominance of granitic rocks in this region.

The oblique quartz c-axis data presented by O'Hara and Gromet (1985) do not demand the presence of a shear zone but are reflective of a component of simple shear. Such a situation is to be expected not only for shear zones but also for folds. It is probably very uncommon for exclusively pure shear to occur, and Mertz and Siddans (1985) have recently interpreted fabrics very similar to those shown by O'Hara and Gromet (1985) as associated with folding and not deformation in a shear zone. Thus, the c-axis data are as consistent with an origin involving folding as with an origin involving a shear zone.

The observations noted above shed doubt on the existence of O'Hara and Gromet's (1985) shear zone and, thus, their tectonic model. However, there are other reasons to reject the tectonic model. As the authors note, there is no evidence of an ocean basin that would have occupied the suture between the two terranes. There are no ultramafic or mafic igneous rocks or any sedimentary or metasedimentary material along the contact. There also is no evidence of any intrusive or extrusive igneous material

that may have resulted from subduction of an ocean basin between the terranes. The authors note that motion of the Esmond-Dedham terrane must have involved motion on strike-slip faults. Despite this they continue to refer to oblique collision of this distinct terrane with New England. The authors should be clear about this point. Was their Esmond-Dedham terrane *accreted* to North America during the Alleghanian orogeny (that is, separated from North America by an ocean basin prior to the Alleghanian orogeny) or accreted to North America prior to the Alleghanian orogeny in some location north of its present position and transported southward during the Alleghanian orogeny? The evidence may be consistent with the latter interpretation but is inconsistent with the former as admitted by the authors.

The evidence O'Hara and Gromet (1985) cite for remoteness of their Esmond-Dedham terrane from North America is the presence of alkalic intrusive rocks exclusively in their eastern terrane. There are two groups of these plutons, one with ages of approx 450 Ma and another with ages of approx 370 Ma (Hermes and Zartman, 1984). Zartman and Naylor (1984) have also cited these data as suggestive of a post-Acadian accretion of the southeastern New England basement. In light of the fact that no tectonic model has been proposed for the genesis of these alkalic magmas, and, in general, the chemical data necessary for such models are lacking, it is probably premature to use the presence or absence of these intrusives as evidence for any tectonic model.

One of the more significant reasons why the proposed Hope Valley shear zone cannot represent a major fault is the lack of either a northward or southward continuation. O'Hara and Gromet (1985) have noted this, and they suggest that the Bloody Bluff fault represents the northward continuation. The new Bedrock Geologic Map of Massachusetts (Zen, 1983) shows the contact between the two proposed terranes (the Ponagansett gneiss and the Serling plutonic group) as complexly folded. In addition, the Bloody Bluff fault represents a thrust fault with a left-lateral component (Goldstein, 1986), a motion sense incompatible with the proposal by O'Hara and Gromet (1985) which requires that the Bloody Bluff fault has normal motions with a right-lateral component. The age of the thrust motion may well be pre-Alleghanian (Goldstein, 1986; Nelson, 1976). O'Hara and Gromet (1985, p. 674) also claim that the Bloody Bluff fault separates rocks metamorphosed during the Acadian orogeny (west) from those that were not (east). However, Hatch and others (1984) note that rocks west of the Bloody Bluff fault did not experience an Acadian metamorphism. It appears that the Bloody Bluff fault does not fit the criteria for a northward continuation of the proposed shear zone.

In summary, the sigmoidal pattern of lineations, the intensity of rock fabrics, and the quartz c-axis asymmetries in eastern Connecticut and Rhode Island can be interpreted as unrelated to a shear zone. There are also no geological data that suggest that an ocean basin occupied the suture between the two proposed terranes, and the evidence for remoteness of the terranes prior to the Alleghanian orogeny is speculative. Consider-

ing that there appear to be no northward or southward continuations of the proposed shear zone, I favor an interpretation in which O'Hara and Gromet's (1985) proposed Hope Valley shear zone either does not exist or experienced only minor motions.

References

Day, H. W., Brown, M. V., and Abraham, K., 1980, Precambrian (?) crystallization and Permian (?) metamorphism of hypersolvus granite in the Avalonian Terrane of Rhode Island: Geol. Soc. America Bull., v. 93, p. 1118-1130.

Dixon, H. R., and Lundgren, L., 1968, The structure of eastern Connecticut, *in* Zen, E-An and others, eds., Studies in Appalachian Geology, Northern and Maritime: New York, Wiley Intersci., p. 219-229.

Dreier, R., 1984, The Blackstone Series: Evidence for Alleghanian deformation in an Avalonian terrane [abs.]: Geol. Soc. America, Abs. with Programs, v. 16, p. 13.

Goldstein, Arthur, 1980, Magnetic susceptibility anisotropy of mylonites from the Lake Char mylonite zone, southeastern New England: Tectonophysics, v. 66, p. 197-211.

———— 1982a, Geometry and kinematics of ductile faulting in a portion of the Lake Char mylonite zone, Massachusetts and Connecticut: Am. Jour. Sci., v. 282, p. 1378-1405.

———— 1982b, Lake Char fault in the Webster, Massachusetts area: Evidence for west-down motion, *in* Joesten, R. and Quarrier, S., eds., Guidebook for Field Trips in Connecticut and Southcentral Massachusetts, 74th Ann. Meeting, N.E.I.G.C.: p. 375-390.

———— 1986, A summary of fault motion histories for eastern Massachusetts and Connecticut [abs.]: Geol. Soc. America, Abs. with Programs, v. 18, p. 19.

Goldstein, Arthur, and Owens, J., 1985, Mesoscopic and microscopic structure of the Lake Char-Honey Hill mylonite zone, *in* Tracy, R. J., ed., Guidebook for Field Trips in Connecticut and adjacent New York and Rhode Island, Guidebook No. 6 (77th N.E.I.G.C.): Conn. Dept. Environmental Protection, p. 159-183.

Hatch, N. L., Jr., Zen, E-An, Goldsmith, R., Ratcliffe, N. M., Robinson, D., Stanley, R., and Wones, D. R., 1984, Lithotectonic assemblages as portrayed on the new Bedrock Geologic Map of Massachusetts: Am. Jour. Sci., v. 284, p. 1026-1034.

Hermes, O. D., and Zartman, R. E., 1985, Late Precambrian and Devonian plutonic terrane within the Avalon Zone of Rhode Island: Geol. Soc. America Bull., v. 96, p. 272-282.

Mertz, J. D., and Siddans, A. W. B., 1985, Finite strain states, quartz textures and the significance of lineation in Permo-Carboniferous metasediments of the Dora Maira Massif, Val Germanasca, Italy: Tectonophysics, v. 118, p. 61-73.

Nelson, A. E., 1976, Structural elements and deformational history of rocks in eastern Massachusetts: Geol. Soc. America Bull., v. 87, p. 1377-1383.

O'Hara, K. D., and Gromet, L. P., 1985, Two distinct late Precambrian (Avalonian) terranes in southeastern New England and their late Paleozoic juxtaposition: Am. Jour. Sci., p. 673-709.

Ramsay, J. G., and Graham, R. H., 1970, Strain variation in shear belts: Canadian Jour. Earth Sci., v. 7, p. 786-813.

Zartman, R. E., and Naylor, R. S., 1984, Structural implications of some radiometric ages of igneous rocks in southeastern New England: Geol. Soc. America Bull., v. 95, p. 522-539.

Zen, E-An, ed., 1983, Bedrock geologic map of Massachusetts: U.S. Geol. Survey and Commonwealth of Massachusetts.