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The geometrical relationship between the stretching lineation and the movement direction of shear zones: Reply

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IN OUR paper (Lin & Williams 1992), we established a simple technique of using the orientation of the stretching lineation and the *S*-foliation to determine the attitude of a shear zone and tentatively applied the technique to the D_1 structures in the Cadillac tectonic zone (D_1 CTZ) as reported by Robert (1989). Because we are not familiar with the regional geology around the CTZ, our purpose was not to challenge the interpretation of Robert (1989) but to use his data to demonstrate how our technique could be applied to natural shear zones. In his Discussion, Robert agrees with us that the D_1 CTZ can be better interpreted in terms of a dominant dip-slip movement rather than by the transpression model of Sanderson & Marchini (1984) (referred to as the Transpression Model, later) which he supported in his paper. After modifying his own interpretation, he questions the applicability of our technique to the D_1 CTZ and thus questions our interpretation of the dip of the D_1 CTZ. His interpretation of the dip was based on the observed dip of the 'bounding shear zones' of the CTZ or the lithological contacts. Accordingly, this Reply addresses three main points: (1) why the D_1 CTZ can be better interpreted in terms of a dominant dip-slip movement; (2) whether our technique is applicable to the D_1 CTZ; and (3) whether the dip of the observed 'bounding shear zones' is the dip of the D_1 CTZ.

The Transpression Model involves a shear-zone-bounded deformation zone that experiences transcurrent shear accompanied by horizontal shortening across the zone and resulting vertical lengthening along the zone. This model is able to explain vertical stretching lineations in a zone of transcurrent shearing; stretching lineations in this model can be either horizontal or vertical. Because the vertical stretching lineation in the model is the result of pure shear deformation, there should not be evidence of significant non-coaxial deformation parallel to it. However, in the CTZ, F_1 intrafolial folds range from non-cylindrical, shallowly plunging folds to steeply plunging sheath folds (Robert 1989) and thus indicate a significant component of non-coaxial deformation parallel to the subvertical L_1 stretching lineation. This led us to conclude that the D_1 CTZ can be better interpreted in terms of a dominantly dip-slip movement rather than by the Transpression Model, and thus led us to apply our technique to the D_1 CTZ.

The applicability of our technique to the D_1 CTZ also partly depends on the interpretation of Robert (1989). By favouring the Transpression Model, Robert (1989) clearly preferred to interpret the obliquity of the S_1 foliation to the CTZ strike as the result of D_1 deformation. In his discussion, Robert modifies his interpretation and now prefers to attribute this obliquity to the effect of D_2, and thus suggests that S_1 was significantly reoriented during D_2. If this new interpretation is correct, our technique should not be applied to the D_1 CTZ.

The parallelism of foliation to the local boundary of the CTZ at two exposures of the boundary (Robert's Discussion) can be interpreted in two ways. (1) The foliation is S_1 and was parallel to the shear zone boundary prior to D_2. During D_2, *both the foliation and the shear zone boundary were folded.* In this case, the observed dip of the CTZ would be that of the D_1 CTZ. This interpretation is preferred in Robert's discussion. However, this interpretation implies that D_2 is more likely to be a regional folding, rather than a shear zone deformation as interpreted by Robert (1989). (2) D_2 is a product of shear zone deformation and the foliation is S_2. The foliation is parallel to the shear zone boundary because of the strong deformation in the 'bounding shear zones'. Whether the 'bounding shear zones' are D_1 or D_2 is discussed below.

The Transpression Model requires bounding shear zones with dip-slip movement. Robert (1989) did point out the existence of such shear zones, but the kinematics of the shear zones was not clearly presented. Now that the D_1 CTZ does not form part of the Transpression Model, the bounding shear zones are not a kinematic requirement of the D_1 movement picture. Thus, the relationships between the 'bounding shear zones' and the D_1 deformation have to be demonstrated rather than assumed. The highly strained talc–chlorite–carbonate schists, which Robert suggested represent the southern bounding shear zone, were also suggested to represent the locus of concentrated transcurrent shearing (Robert 1989, p.2673). If the latter is true, the shear zone is more likely due to D_2 deformation, which is characterized by

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dextral transcurrent shearing (Robert 1989). The asymmetric features such as S-shaped conglomerate pebbles and bookshelf texture are only observed in plan view, not in cross-section (Robert's Discussion). Although these may not be reliable shear-sense indicators (*ibid.*), they indicate significant subhorizontal non-coaxial deformation, which suggests that they are also more compatible with the D_2 rather than the D_1 deformation. (Note that the S-shape of the conglomerate pebble in fig. 4C of Robert 1989 is associated with a later NW–SE-striking foliation that overprints the E–W-striking S_1.) Consequently, the observed steep northerly dip of the shear zone does not necessarily mean that the D_1 deformation zone has the same dip. On the other hand, this implies that the D_1 structures have been strongly modified during D_2, and the technique of Lin & Williams (1992) should be used with caution. Consequently, we agree that our interpretation of the D_1 CTZ as dipping 60° to the south is not necessarily correct. However, the 'coincidence' of our interpreted shear sense with the only observed F_1 fold vergence supports, but does not prove, our interpretation.

To summarize, we thank Robert for his discussions and agree with him that the technique proposed by Lin & Williams (1992) should be applied with caution to shear zones with complex deformation histories (we never doubted this). We are glad that Robert agrees with us that the D_1 CTZ can be better interpreted in terms of a dominantly dip-slip movement picture rather than as part of the Transpression Model. To prove or disprove the interpretation of the dip of the D_1 CTZ, it is important to determine the effect of D_2 and to further investigate the kinematic histories of the 'bounding shear zones'.

REFERENCES

Lin, S. & Williams, P. F. 1992. The geometrical relationship between the stretching lineation and the movement direction of shear zones. *J. Struct. Geol.* **14**, 491–497.

Robert, F. 1989. Internal structure of the Cadillac tectonic zone southeast of Val d'Or, Abitibi greenstone belt, Quebec. *Can. J. Earth Sci.* **26**, 2661–2675.

Sanderson, D. J. & Marchini, W. R. D. 1984. Transpression. *J. Struct. Geol.* **6**, 449–458.