TRANSPRESSION AS THE MAIN DEFORMATIONAL EVENT IN AN ARCHEAN GREENSTONE BELT, NORTHEASTERN MINNESOTA; P.J. Hudleston and D. Schultz-Ela, Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN 55455; R.L. Bauer, Department of Geology, University of Missouri, Columbia, MO 65211; D.L. Southwick, Minnesota Geological Survey, 2642 University Ave., St. Paul, MN 55114.

Deformed and metamorphosed sedimentary and volcanic rocks of the Vermilion district constitute an Archean greenstone belt trending east-west between higher grade rocks of the Vermilion Granitic Complex to the north and the Giants Range batholith to the south. Metamorphic grade is low throughout, being lowest in the center of the belt (chlorite zone of the greenschist facies) (1). All the measured strain, a cleavage or schistosity, and a mineral lineation in this belt are attributed to the 'main' phase of deformation (D_2) (2) that followed an earlier nappe-forming event (D_1)(3, 4), which left little evidence of penetrative fabric (2).

Previous work assumed that the D_2 deformation resulted from north-south compression across the district, presumably related to diapiric intrusion of the batholithic bodies to the north and south (1). A number of lines of evidence now lead us to believe that a significant component of this deformation resulted from dextral shear across the whole region. Thus the Vermilion fault, a late-stage largely strike-slip structure (1) that bounds the Vermilion district to the north, may simply be the latest, most brittle expression of a shear regime that was much more widespread in space and time. Features that are indicative of shear include ductile shear zones with sigmoidal foliation patterns, highly schistose zones with the development of shear bands, feldspar clasts or pyrite cubes with asymmetric pressure shadows, and the fact that the asymmetry of the F_2 folds is predominantly Z for at least 15 km south of the Vermilion fault.

The presence of a large component of simple shear may help explain additional structural features in a simpler way than otherwise possible. Just south of the Vermilion fault the cleavage locally becomes folded and a new spaced cleavage develops in a similar orientation to the old cleavage away from the folds. Rather than interpreting this as evidence for an additional episode of deformation, we consider it to be due to a single process of continuous shear: a foliation develops and after a large strain local perturbations result in folding of the old foliation and the development of a new one axial planar to the folds.

The same type of perturbation can lead to the juxtaposition of ENE-trending zones of constrictional and flattening strains (5), a distinctive feature of the rocks of the Vermilion district otherwise hard to account for. The maximum extension directions (X) of all samples showing constrictional strain, plunge east at angles between 30 and 65°. X in samples showing flattening strain plunges east or west, but near the Vermilion fault all plunges are west or more steeply east than they are in constrictional samples. The maximum shortening direction (Z) plunges consistently less than 25° to the north or south.

The strain variations require a model which can satisfy compatibility constraints and space considerations. The area of consistent constrictional strains in the south may represent one regional component of the strain. Spatial correspondence of flattening strains with the Vermilion fault suggests that a simple shear component was added in that area. A modified model of transpression may explain how E-plunging X axes are reoriented to become W-plunging by a concomitant inhomogeneous progressive simple shear. Less than vertical plunge of the X axes may necessitate some component of oblique motion on the fault.

In a general way the strain patterns observed in the Vermilion district can be reasonably explained by a history of N-S shortening accompanied by inhomogeneous dextral simple shear. The variations of strain may be a consequence of variations in the relative intensities of shortening and shear, large perturbations of the shear, or the influences of other structures. There may be an analogy with the strain partitioning that occurs in small scale ductile shear zones at large strains.

For transpression to have occurred, the Vermilion district would have to have been a region of relatively soft crust caught beween two more rigid (either thicker or cooler) blocks to north and south. We do not yet know to what extent the high-grade terranes to north and south were also affected by transpression deformation and therefore the configuration of the more rigid block.

References

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