Microstructural Analysis of the Teslin Fault, Northwestern British Columbia

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INTRODUCTION

The Canadian Cordillera is host to numerous crustal-scale shear zones, including the Tintina and Denali faults (Gabrielse, 1985). Study of these faults is necessary in order to determine motions of allochthonous terranes subsequent to their accretion onto the west margin of ancestral North American. Accurate knowledge of past motions on crustal scale faults is critical these paleogeographic reconstructions.

The Teslin Fault is a crustal-scale fault located approximately midway between the Denali and Tintina faults (Wheeler and McFeely, 1991). It separates the Cache Creek and Yukon-Tanana Terranes in the Jennings River area (Figure 1; Mihalynuk *et al*., 2001). Only a single exposure of the

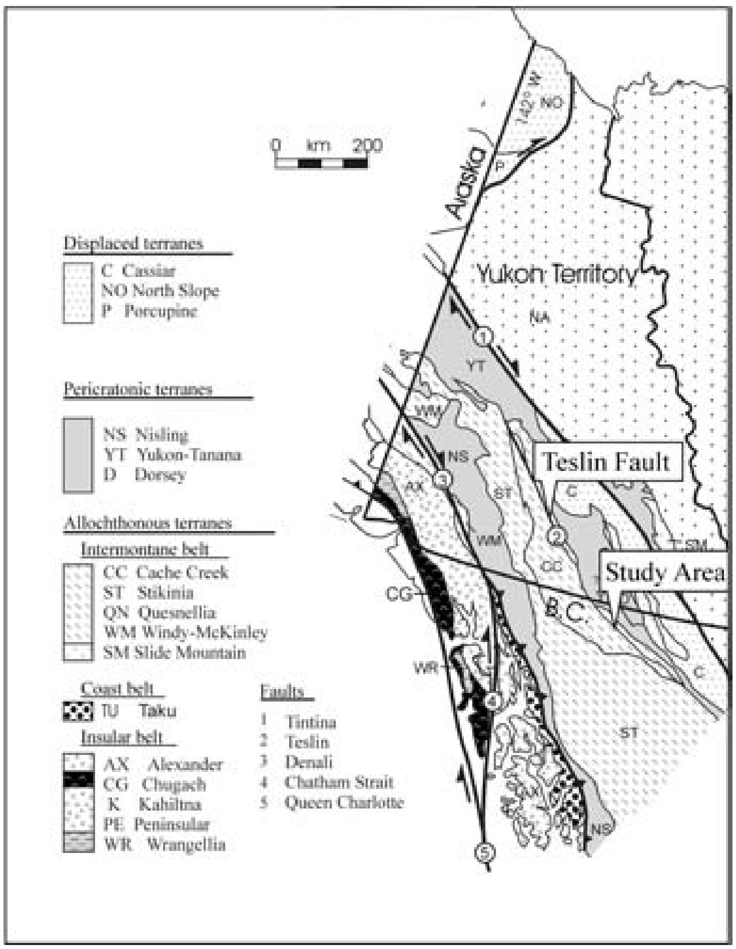

Figure 1. General overview of the Northern Cordillera depicting the relative position of the Teslin Fault, related terranes, and study area (modified from de Keijzer, 1995).

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Teslin Fault is known. It is located below high water along the Jennings River. A preliminary study of the fault at this locality by de Keijzer *et al.* (2000) showed the dominant ductile deformation to be sinistral. This report augments that of de Keijzer *et al.* (2000) by focusing on micro-structural analysis of mylonites collected from the Jennings River location.

MINERALOGY AND STRUCTURAL FABRICS

A greenschist facies metamorphic mineral assemblage is exhibited by the Jennings River mylonites. It consists of partially recrystallized quartz, muscovite, and epidote, with lesser amounts of chlorite, actinolite, and biotite. Some of the epidote replaces plagioclase (Photo1). Euhedral pyrite cubes modified by cataclasis are locally common, but account for less than 1 % of the rock.

Jennings River mylonites display a well-developed steeply plunging lineation within a pervasive, steeply east-dipping foliation. The ductile fabric is well developed in the Yukon-Tanana Terrane greenstone but not in the rocks of the adjacent Cache Creek Terrane (de Keijzer *et al.,* 2000). A later brittle-ductile shear fabric overprints the ductile fabric in the greenstone providing evidence for two distinct episodes of deformation along the fault zone.

DUCTILE SINISTRAL MICRO-FABRICS

Micro-structural shear sense indicators characteristic of ductile fabrics in the Yukon-Tanana Terrane greenstone are of dominantly sinistral sense. The most common shear indicator consists of quartz and minor calcite fiber trails that nucleated on rotating pyrite porphyroblasts (Figure 2). Undulose fiber extinction suggests deformation coeval with fiber growth, while the fiber geometry shows face-controlled displacement. Fiber geometry indicates

Photo 1. Plagioclase grain with epidote replacement. Field of view (across) is 1.2 mm.

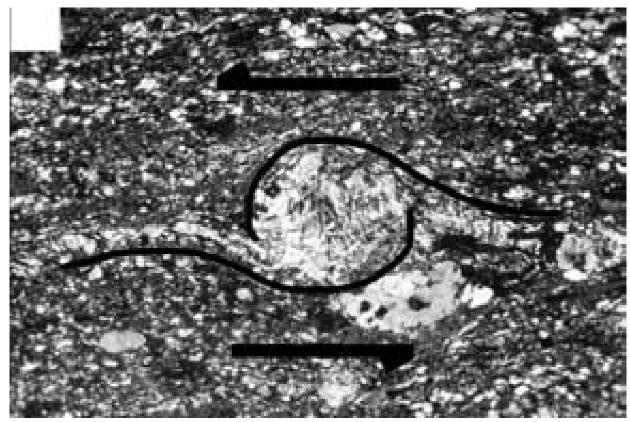

Photo 2. Delta-type porphyroclast showing sinistral shear. The porphyroclast and its tails are principally epidote. Field of view across is 1.6 mm.

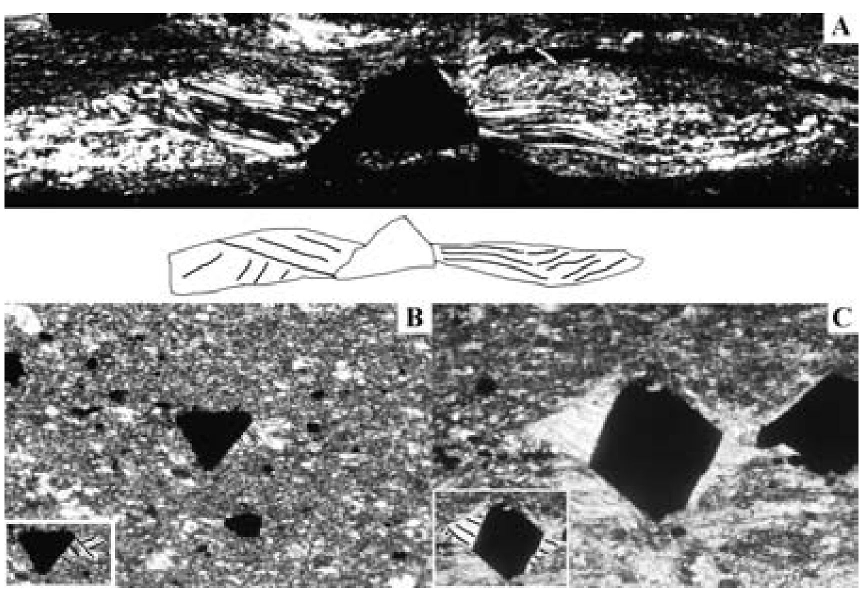

Figure 2. Quartz fibers on pyrite grains. Scale (a) 5 mm across (b) 1.2 mm across (c) across 0.6 mm.

counterclockwise vorticity and sinistral shearing during growth.

Sigma and delta-type porphyroclasts show a predominant sinistral shear sense, consistent with the mineral fibers. Tails emanating from delta porphyroclasts wrap down into the foliation plane indicating a counterclockwise rotation (Photo 2). The sigma-type porphyroclasts exhibit tangential tails that do not wrap down into a foliation plane, instead they originate directly from the edge of the porphyroblast with stair-step type geometry.

BRITTLE-DUCTILE DEXTRAL DEFORMATION

Evidence for dextral shearing is preserved in quasi-ductile micro-shears that cut across the earlier ductile fabrics (Photo 3). Little offset is apparent across these shears and most commonly, foliation planes bend into and out of the shear zone with minimal disturbance. This quasi-ductile shearing is not pervasive (with the exception of one sample within which the shearing is entirely penetrative), and probably represents much less displacement relative to the dominant sinistral fabric.

METAMORPHISM DURING DEFORMATION

The mylonitic greenschist mineral assemblage constrains the pressure and temperature range for these rocks to

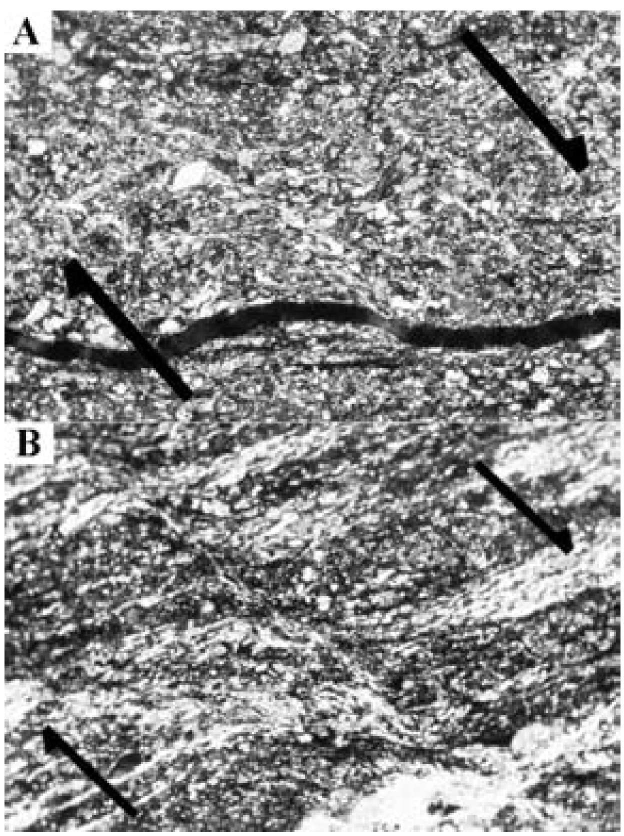

Photo 3. Dextral micro-faults clearly crosscutting ductile foliation planes. Field of view (a) across is 3 mm (b) across is 1.6 mm.

Photo 4. Type III calcite twins indicating a temperature of >200°C. Field of view across is 0.6 mm.

between 250-420 C° and 2 -10 kbars pressure (Klein and Hurlbut, 1999). Type III calcite twins in the greenstone rocks (Photo 4) require temperatures of >200 C° (Ferril, 1998; Passchier and Trouw, 1998) during shearing which is consistent with the greenschist metamorphism indicated by the authigenic mineral assemblage.

DISCUSSION

Timing of motion on the Teslin Fault is poorly constrained. Three plutons, the 57 Ma Charlie Cole stock, the 196 Ma Coconino tonalite and unnamed 184 Ma syenites all lie within 10 km of the projected fault trace. The Charlie Cole and Coconino intrusions are strongly foliated, while the 184 Ma syenites are largely undeformed. The differential deformation suggests that strain subsequent to the crystallization of the deformed 57 Ma Charlie Cole stock was partitioned such that the 184 Ma syenites escaped shearing or the syenites had cooled sufficiently to act as a rigid body.

General plate motion models (Engebrertson *et al.*, 1985) may help constrain the timing of translation on the Teslin Fault. Oblique sinistral convergence between the Pacific and North American plates took place between the Early Jurassic and mid-Cretaceous. Sinistral ductile shear along the Teslin Fault may have occurred during this interval. Brittle-ductile dextral shearing of the older ductile fabric may be attributable to oblique dextral convergence and coupling of plates in the late Cretaceous and Tertiary times.

Futher data suggests another dextral transpression event peaking between 174 Ma and 172 Ma (Mihalynuk et al., 1999). However, the 184 Ma syenites associated with the Teslin Fault are undeformed providing no direct evidence for Middle Jurassic deformation. More geochronologic control is required to test these speculations and constrain the motion history of the Teslin Fault.

CONCLUSIONS

An early ductile sinistral shearing event is preserved in the gross foliation of the rocks, fibrous crystal growth on pyrite crystals, and delta and sigma-type porphyroclasts. This ductile deformation is crosscut by later, more localized, dextral and quasi-ductile shear characterized by micro-faults offsetting foliation. This data is important to developing a motion history on the Teslin fault; however, more geochronologic data are needed to provide accurate fault motion and timing data.

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REFERENCES CITED

de Keijzer, M. (1995): Tectonic evolution of the Teslin Zone and the Western Cassiar Terrane, Northern Canadian Cordillera; unpublished Ph. D. thesis, *Univeristy of New Brunswick*, 391 pages.

de Keijzer, M., Mihalynuk, M.G. and Johnston, S.T. (2000): Structural Investigation of an Exposure of the Tintina Fault; *in* Current Research, *Geological Survey of Canada*, Paper 2000-A5, 10 pages.

Engebretson, D.C., Cox, A. and Gordon, R. G. (1985): Relative motions between oceanic and continental plates in the pacific basin; *Geological Society of America*, Special Paper, 206, 59 pages.

Ferril, D.A. (1998): Critical re-evaluation of differential stress estimates from calcite twins in coarse grained limestone; *Tectonophysics*, Volume 285, pages 77-86.

Gabrielse, H. (1985): Major dextral transcurrent displacements along the Northern Rocky Mountain Trench and related lineaments in north-central British Columbia; *Geological Society of America Bulletin*, Volume 96, pages 1-14.

Hurlbut, C. S. Jr. and Klein, C. (1977): *Manual of Mineralogy*, 19th edition, John Wiley and Sons, New York, 681 pages.

Mihalynuk, M.G., Nelson, J.L., de Keijzer, M., Friedman, R.M., Roots, C.F. and Gleeson, T.P. (2001): Geology of Goodwin Creek (104N/9E); *BC Ministry of Energy and Mines*, Open File 2001-5, 1:50 000 scale.

Mihalynuk, M.G., Erdmer, P., Ghent, E.D., Archibald, D.A., Friedman, R.M., Cordey, F., Johannson, G.G. and Beanish, J. (1999): Age constraints for emplacement of the Northern Cache Creek Terrane and implications of blueschist metamorphism; *in* Geological Fieldwork 1998, *BC Ministry of Energy and Mines*, Paper 1999-1, pages 127-141.

Passchier, C.W. and Trouw, R.A.J. (1998): *Microtectonics*; Springer – Verlag, Berlin, 281 pages.

Wheeler, J.O. and McFeely, P. (1991): Tectonic assemblage map of the Canadian Cordillera and adjacent portions of the United States of America, *Geological Survey of Canada,* Open File, 1712A, scale 1:2 000 000.