Journal of Structural Geology 33 (2011) 192–202

Contents lists available at ScienceDirect

Journal of Structural Geology

journal homepage: www.elsevier.com/locate/jsg

Deformation partitioning in transpressional shear zones with an along-strike stretch component: An example from the Superior Boundary Zone, Manitoba, Canada

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ARTICLE INFO

Article history:
Received 5 February 2010
Received in revised form
27 June 2010
Accepted 4 July 2010
Available online 14 July 2010

Keywords:
High-strain zone
Strain partitioning
Triclinic flow
Orogen-parallel stretch
Lineation
Trans-Hudson orogen

ABSTRACT

The partitioning of triclinic flow into domains of apparent monoclinic and apparent orthorhombic flow is described and discussed, using the Aiken River shear zone (ARSZ) as an example. The ARSZ is a 1–1.5 km wide east–west trending, dextral, north-side-up, mylonite zone, within the northern part of the Superior Province in Manitoba. It displays a high along-strike stretch (∼10), which is most likely indicative of an escape-tectonic setting.

Although the central mylonite zone exhibits an apparent monoclinic fabric symmetry, the actual flow field was probably triclinic with a high simple shearing over pure shearing ratio, which resolves potential strain compatibility problems with neighbouring domains. The simple shearing-dominated zone is relatively narrow and has well-defined boundaries. An up to ∼20 km wide zone adjacent to the ARSZ shows an apparent orthorhombic fabric symmetry with shear zone boundary-parallel horizontal stretch and shear zone-orthogonal shortening. However, the actual flow may have been triclinic with a low simple shearing over pure shearing ratio. Either way, the pure shear component of the ARSZ is distributed over a much broader area than the simple shear component and has diffuse boundaries. This is consistent with simple shearing being a softening and pure shearing a hardening process.

1. Introduction

Shear zones may have monoclinic or triclinic symmetry. Monoclinic shear zones can be considered as special cases, where the shear direction is parallel to one of the principal axes of the pure shearing component (cf. Robin and Cruden, 1994; Jiang and Williams, 1998; Lin et al., 1998). Shear zones may be thinning (transpression), thickening (transtension) or not changing thickness. Triclinic transpression zones are most common, because most orogens, active convergent plate boundaries, and volcanic arcs are associated with oblique convergence between plates or blocks (Jiang et al., 2001; Jiang, 2007b, and references therein).

In transpression zones, the shear zone-parallel maximum stretch is usually assumed or interpreted as being vertical or down dip (Sanderson and Marchini, 1984; Tikoff and Greene, 1997; Lin et al., 1998) or oblique (Czeck and Hudleston, 2003). Shear zone boundary-parallel horizontal stretch in subvertical shear zones is not commonly reported. Similarly, orogen-parallel stretch is not common and existing estimates of finite orogen-parallel stretch are low. The two types of stretch are related, because crustal-scale subvertical shear zones are generally parallel to the trend of the orogen. It is commonly believed that a high shear zone boundary-parallel horizontal stretch or orogen-parallel stretch is not favourable, because it would cause space and strain compatibility problems in deformation. Furthermore, strain hardening would resist the shear zone- or orogen-orthogonal (pure shear) shortening that usually occurs at the same time.

In this paper, we present evidence for a high shear zone boundary-parallel horizontal stretch in the subvertical Aiken River shear zone (ARSZ) in the Superior Boundary Zone, northeast of Thompson, Manitoba, Canada (Fig. 1). The amount of horizontal stretch along the shear zone is estimated to be in the order of 10. We discuss the feasibility of such high shear zone-parallel stretches, for the ARSZ, as well as in general. A common tectonic

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0191-8141/$ – see front matter
doi:10.1016/j.jsg.2010.07.003

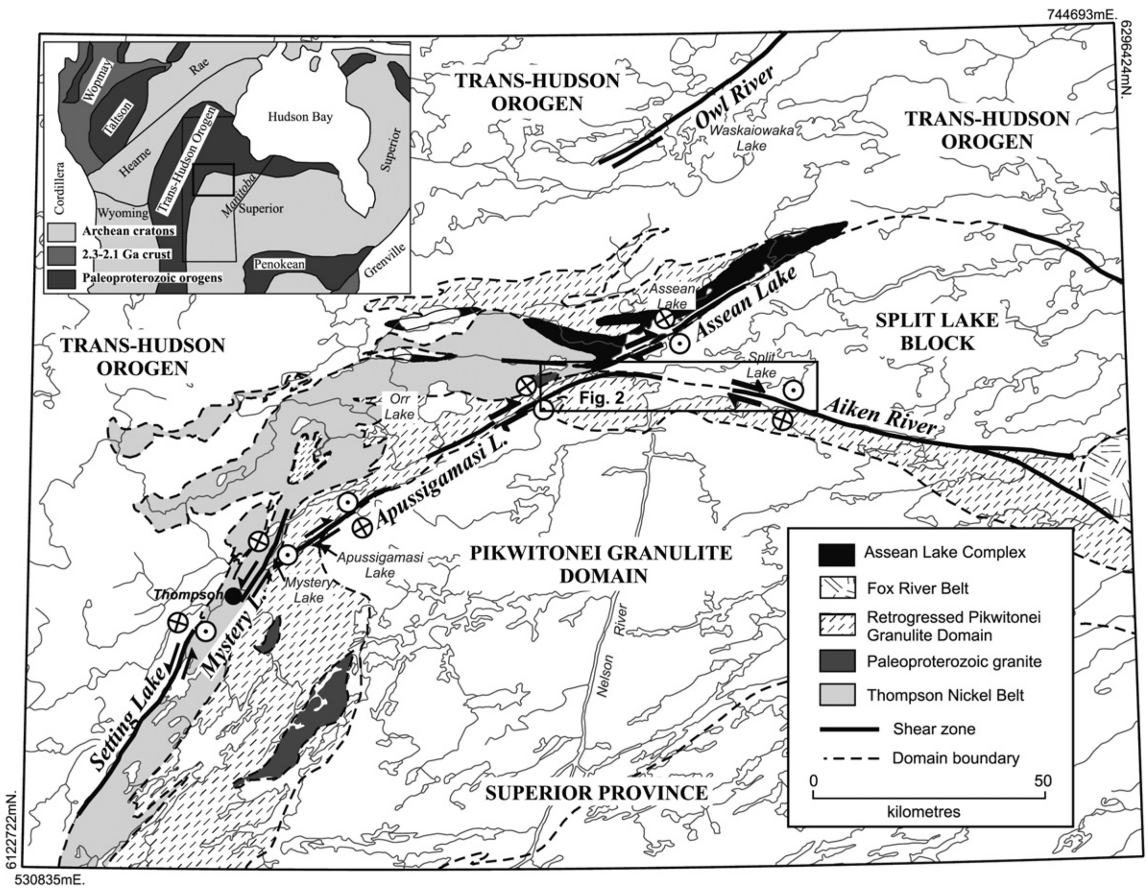

Fig. 1. Simplified geologic map of the northwestern Superior Boundary Zone (after Böhm et al., 2007). Shear zones and their senses of movement are indicated. Insert: simplified geological map of part of North America, showing Archean provinces and Paleoproterozoic belts.

setting for such shear zones may be lateral extrusion zones in escape-tectonic settings.

We also discuss strain partitioning in shear zones, using the ARSZ as an example. Transpression along this shear zone is partitioned into zones with a high and a low simple shearing over pure shearing ($\dot{\gamma}/\dot{\varepsilon}$) ratio, where 'simple shearing' and 'pure shearing' indicate rates of simple shear and pure shear, respectively (Means, 1990). The pure shear component is consistently distributed over a wider area than the simple shear component (cf. Lin et al., 1998), as is indicated by rotation patterns of lineations and fold hinge lines along the ARSZ, as well as by rotation or shear zone-orthogonal shortening or map scale structures along other shear zones in the Superior Boundary Zone (cf. Kuiper et al., 2009). Furthermore, triclinic flow along the ARSZ is partitioned into apparent monoclinic and apparent orthorhombic domains. The nature of these domains, and whether flow fields in these domains were truly monoclinic and orthorhombic, or triclinic with apparent monoclinic and orthorhombic symmetries, is discussed. It is argued that the domain with apparent monoclinic fabric symmetry is in fact a region of triclinic flow, based on strain compatibility arguments with adjacent domains. The apparent monoclinic fabric symmetry is a result of a high $\dot{\gamma}/\dot{\varepsilon}$ ratio and low finite strain. The domain with apparent orthorhombic fabric may be truly orthorhombic, or triclinic with a low $\dot{\gamma}/\dot{\varepsilon}$ ratio.

2. Geological background

The Superior Boundary Zone exists between the Archean Superior Province to the southeast and the Paleoproterozoic Trans-Hudson Orogen to the northwest. The Trans-Hudson Orogen is an amphibolite grade Paleoproterozoic belt that consists of Paleoproterozoic volcanic arc and passive margin sedimentary rocks, which record Paleoproterozoic continent collision and orogenesis (Machado, 1990; Ansdell, 2005; Corrigan et al., 2005). The Superior Province consists of Eoarchean to Neoarchean terranes that were amalgamated in the Neoarchean (Percival, 2007). The Pikwitonei Granulite Domain represents a mid- to deep crustal segment of the Superior Province. It consists of predominantly tonalitic and granodioritic gneisses that underwent granulite facies metamorphism and retrograde amphibolite grade metamorphism in the Neoarchean (Mezger et al., 1990; Böhm et al., 1999, 2007). The Split Lake Block consists of >2708 Ma gneisses and can be correlated with the Pikwitonei Granulite Domain (Corkery, 1985; Böhm et al., 1999; Kuiper et al., 2003, 2004a,b). It is bounded by the Assean Lake and Aiken River shear zones (Fig. 1). It consists of predominantly tonalitic and granodioritic gneisses with lower volumes of anorthosite, gabbroic and granitic gneisses, mafic granulite, layered amphibolite and pelitic schist and gneiss (Haugh, 1969; Corkery, 1985; Hartlaub et al., 2004). The Split Lake Block underwent granulite facies metamorphism and later amphibolite facies metamorphism, both in the Neoarchean (Corkery, 1985; Böhm et al., 1999, 2007; Downey et al., 2009).

The Assean Lake Complex (Fig. 1) consists of granitic and tonalitic gneiss, metasedimentary rocks and layered amphibolite that are older than 3.0 Ga material (Böhm et al., 2000, 2003, 2007; Hartlaub et al., 2006). The peak of metamorphism reached amphibolite facies. The Assean Lake Complex was deformed and metamorphosed during the Paleoproterozoic Trans-Hudson orogeny, but evidence for earlier events in the Late Archean and earliest Paleoproterozoic exist (Böhm et al., 1999, 2003). The Thompson Nickel Belt (Fig. 1)