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Authors' addresses

M. Sanborn-Barrie *(msanborn@nrcan.gc.ca)*
R. Berman *(rberman@nrcan.gc.ca)*
Geological Survey of Canada
615 Booth Street
Ottawa, Ontario K1A 0E9

T. Skulski *(tskulski@nrcan.gc.ca)*
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

H. Sandeman *(hsandema@nrcan.gc.ca)*
626 Tumiit Building
P.O. Box 2319
Iqaluit, Nunavut X0A 0H0

S. Johnstone *(johnstone_sandra@yahoo.com)*
Dept. of Earth Sciences
University of Waterloo
Waterloo, Ontario
N2L 3G1

T. MacHattie *(trevor@maildrop.srv.ualberta.ca)*
Department of Earth and Atmospheric Sciences
1-26 Earth Science Building
University of Alberta
Edmonton, Alberta
T6G 2E3

D. Hyde *(darrellhyde@hotmail.com)*
Department of Earth Sciences,
Memorial University of Newfoundland
St. John, Newfoundland
A1B 3X5

Structural and metamorphic geology of the Walker Lake–Arrowsmith River area, Committee Bay belt, Nunavut

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Continental Geoscience Division, Ottawa

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Abstract: The Walker Lake–Arrowsmith River area is characterized by two dominant lithotectonic styles. In the south, narrow, linear, northeast-striking, amphibolite-facies granite-greenstone belts and an adjacent batholith contain penetrative northeast-striking, $D_2 \pm D_1$ transposition fabrics and are cut by an east-striking dextral shear zone. In the north, upper amphibolite- to lower granulite-facies metasedimentary rocks, cut by peraluminous and metaluminous granite bodies, display variably oriented structures attributed to three deformational events. The two domains are separated by several 1–2 km wide, arcuate belts of high-strain rocks with moderately southward-dipping fabrics, down-dip to west-plunging lineations, and shear-sense indicators suggesting normal, southward-directed extensional displacement. These shear zones may have juxtaposed the granite-greenstone and paragneiss domains, or may reflect strain localization within a progressive regional metamorphic gradient. Preliminary interpretations of available data suggest regional tectonometamorphism at ca. 2.6–2.3 Ga, with a second tectonothermal event accompanying granite magmatism at ca. 1.8 Ga.

Résumé : Les régions cartographiques de Walker Lake et d'Arrowsmith River sont caractérisées par deux principaux styles lithotectoniques. Au sud, d'étroites bandes linéaires de granite et de roches vertes du faciès des amphibolites allongées dans une direction nord-est, ainsi qu'un batholite situé à proximité montrent des fabriques de transposition $D_2 \pm D_1$ bien marquées et sont recoupés par une zone de cisaillement dextre de direction est. Au nord, des roches métasédimentaires du faciès des amphibolites supérieur ou du faciès des granulites inférieur sont recoupées par des massifs de granite hyperalumineux et de granite métalumineux et présentent des structures d'orientations diverses attribuées à trois épisodes de déformation. Les deux domaines sont séparés par plusieurs bandes arquées de 1 à 2 km de largeur de roches intensément déformées qui présentent des fabriques modérement inclinées vers le sud, des linéations suivant le pendage ou plongeant vers l'ouest et des indicateurs du sens du cisaillement qui laissent croire à un déplacement normal en régime extensif dirigé vers le sud. Ces zones de cisaillement pourraient avoir entraîné la juxtaposition des domaines de granite et de roches vertes aux domaines de paragneiss ou refléter des zones de concentration de la déformation à l'intérieur d'un ensemble touché par un métamorphisme régional à gradient progressif. Les interprétations préliminaires des données disponibles suggèrent un tectonométamorphisme régional à 2,6-2,3 Ga environ suivi d'un deuxième épisode tectonothermique ayant accompagné un magmatisme granitique à 1,8 Ga environ.

INTRODUCTION

The Walker Lake–Arrowsmith River area of the Committee Bay belt, Nunavut, encompasses parts of two 1:250 000-scale map sheets (northern NTS 56 J and southern NTS 56-O), and represents an extension of 1:100 000-scale mapping carried out during the 2000 field season (Fig. 1; Sandeman et al. (2001a, b)). The map area (*see* Fig. 2 *in* Skulski et al., 2002) is dominated by three crustal domains: granite-greenstone belts dominate its central region, a granitic batholith occurs in the southeast, and high-grade metasedimentary rocks occur in the north (*see also* Skulski et al., 2002). These lithological domains have been variably affected by at least two penetrative deformation events, multiple metamorphic events, and localized shearing. Rocks within all domains display moderately to strongly developed strain fabrics and structures and preserve low-pressure, medium- to high-grade metamorphic mineral assemblages. Accordingly, an understanding of the polyphase tectonometamorphic history of these rocks is the first step toward deciphering the stratigraphy of the Prince Albert group, its tectono-magmatic setting, and the tectono-metamorphic evolution of the area in a regional context. The following overview presents preliminary observations and interpretations of fabrics, structures, and mineral assemblages from the Walker Lake–Arrowsmith River area of the Committee Bay belt.

GRANITE-GREENSTONE DOMAIN

The central part of the Walker Lake–Arrowsmith River area comprises narrow, linear, northeast-striking, amphibolite-facies greenstone belts with a komatiite-quartzite association which typifies supracrustal belts of the Rae domain from Saskatchewan (Murmac Bay group) to Baffin Island (Mary River belt), a discontinuously exposed strike length of about 2000 km (Fig. 1). The central granite-greenstone domain comprises four northeast-striking, komatiite-bearing belts (*see* Fig. 2 *in* Skulski et al., 2002). From south to north, these are: 1) the Three Bluffs belt, within which iron-formation-hosted gold exploration has been targeted; 2) the main 2–8 km wide Howling Wolf Lake belt, with a strike length of more than 100 km; 3) the discontinuous amphibolite-dominated central Hayes River belt; and 4) the metabasalt-dominated north Hayes River belt. The greenstone belts have been intruded by plutonic rocks of variable composition (early tonalite-granodiorite followed by granodiorite-monzogranite), strain state, and age that similarly have a northeast-trending belt-like geometry. The dominant structural fabric of this domain is a penetrative, northeast-striking, southeast-dipping fabric that appears to have formed at low-pressure, lower- to middle-amphibolite-facies conditions.

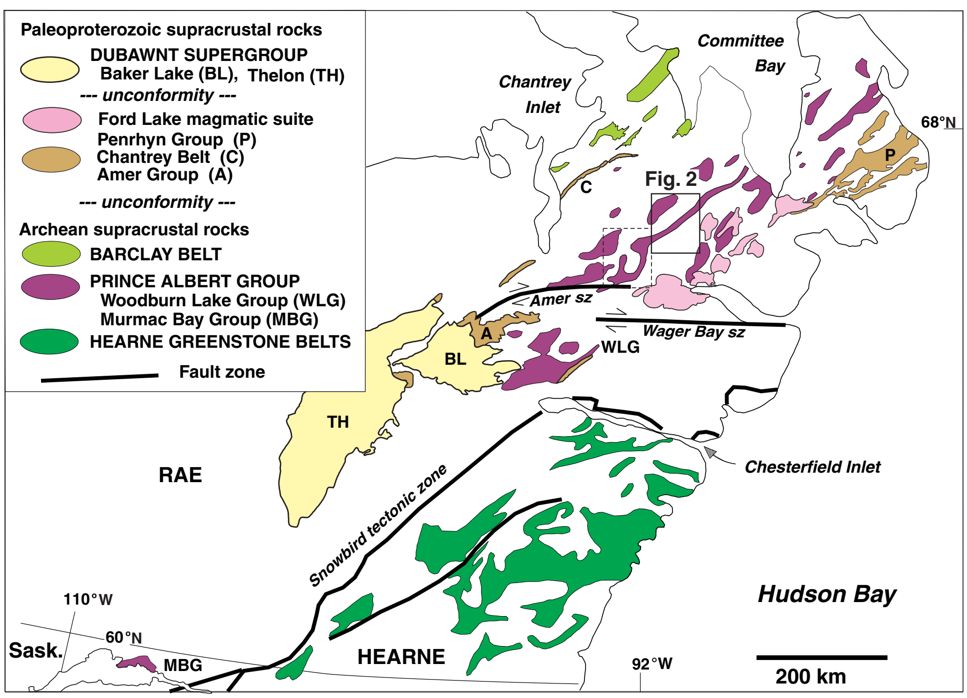

Figure 1. Regional geology of the north-central western Churchill Province; sz=shear zone

Primary structures (S_0)

Primary structures from the greenstone belt domain were mainly observed in komatiite and quartzite. In komatiitic rocks, weathering colour and textural variations between metre-thick, cumulate and spinifex-textured zones delineate the orientation of bedding. Textural variations within the upper parts of flows, such as the transition from coarse-grained, aligned platy spinifex upwards into fine-grained, randomly oriented microspinifex, locally provide an indication of younging (*see also* MacHattie, 2002). Overlying the komatiite, a major unit of quartzite, about 100 m thick, is typically medium- to thinly bedded and well sorted, such that grain size variations (grading) are only very rarely recognized. Metre-scale crossbedding was identified at two localites (Fig. 6 *in* Skulski et al. (2002)). Psammitic to pelitic rocks that both underlie and overlie the main quartzite unit are poorly bedded, well sorted rocks that are rarely graded. Locally, crosslaminations (<1 cm thick) and asymmetrical disposition of aluminosilicate minerals provided younging criteria in these rocks.

Younging was determined at eleven localities in the map area (Fig. 2). These directions, together with bedding orientation, the sequence of lithological units (stratigraphy where younging is known), and geometry of minor folds were used to identify major folds.

D_1 structures

In supracrustal rocks, planar tectonic fabrics that predate the regional northeast-striking foliation are rarely observed, and where recognized, occur almost exclusively in komatiitic rocks. This foliation, defined by aligned to schistose tremolite-serpentine-talc, is parallel to bedding and, based on overprinting fabric relationships, is interpreted as S_1. At widespread localities across the central domain, S_1 in komatiite strikes northwestward and dips shallowly northeast or moderately southwest. In plutonic rocks, S_1 is clearly recognized in the hinges of F_2 folds (described below) where it is defined by aligned biotite and parallel, elongate quartz at a high angle to S_2.

F_1 folds were inferred at two localities of superimposed folding. In the Three Bluffs area and at the western end of the central Hayes River belt, the trace of F_1 trends north to northwest.

D_2 structures

The dominant fabric thoughout the granite-greenstone domain is a moderate to strongly developed, northeast-striking foliation that affects virtually all supracrustal rocks and most plutonic rocks (Fig. 2). This fabric is axial planar to regionally developed, northeast-trending F_2 folds that fold an earlier S_1 foliation. In general, this regional foliation appears to represent a composite $S_2 \pm S_1$ fabric, as F_2 hinges commonly display two moderately to weakly developed oblique foliations, S_1 and S_2, whereas F_2 limbs generally contain a single foliation of higher strain intensity.

$S_2 \pm S_1$ foliation has a general southeastward dip, but shows variations in both dip direction and inclination. Within the supracrustal belts, S_2 planes dip moderately to steeply (65–85°) to the southeast (Fig. 2a). Intervening plutonic panels have more variable planar fabric attitudes. In the south, $S_2 \pm S_1$ varies from steeply southeast- to steeply northwest-dipping, whereas in the northern part of the granite-greenstone domain, $S_2 \pm S_1$ generally maintains a shallow (14–25°) to moderate (55–70°) southeastward dip. The $S_2 \pm S_1$ fabric is uniformly characterized by moderate (15–40°) east- to northeast-plunging lineations (Fig. 2b) defined most typically by an elongate quartz shape fabric. The shallower dip of $S_2 \pm S_1$ foliation in the northern part of the granite-greenstone domain results in generally shallower (5–15°) eastward-plunging lineations.

Numerous regional northeast-trending F_2 folds within plutonic rocks of the central domain are defined by dip variations of foliation and recognition of fold closures defined by S_1 (Fig. 2). These F_2 folds are upright to overturned (northwest-vergent), noncylindrical antiforms and synforms that tend to die out over a strike length of 4–12 km. On the basis of closure configuration, regional F_2 folds appear to plunge westward in the western half of the granite-greenstone domain, and eastward in the eastern half. Macroscopic folds typically show Z-asymmetry or are symmetrical, and show a general plunge reversal about a north-northwest trending (330°) axis depicted on Figure 2.

The configuration of folds affecting the distribution of greenstone belts is less certain, because of sparse younging direction data, discontinuous exposure, and the high proportion of plutonic rocks that intrude these belts. The main Howling Wolf Lake belt yielded the majority of younging data (Fig. 2) from which important constraints for Prince Albert group stratigraphy have been derived (Skulski et al., 2002). A reversal in younging has been determined along the length of the Howling Wolf belt, from southward younging at Kellett River and Howling Wolf Lake to northward younging at the main quartzite ridge in the Twin Peaks area. This can be interpreted in two ways. The belt may represent a south-facing homoclinal sequence that, through pervasive asymmetric Z-folding, has short-limb segments (i.e. Twin Peaks quartzite ridge) of north-younging strata (Fig. 3a). Alternatively, this belt may be folded about an overturned, northwest-vergent syncline, if northward-younging in the Twin Peaks area is laterally significant (Fig. 3b). In this scenario, the Twin Peaks quartzite would represent the southern, north-younging limb, whereas the Howling Wolf Lake and Kellett River sections would comprise the northern, south-younging limb. Pervasive development of structures with dextral vorticity characterizes the Kellett River, Howling Wolf Lake, and Twin Peaks areas (Fig. 4). This consistent sense of asymmetry supports the interpretation that these areas occur on the same limb of a fold. In the alternative model (Fig. 3b), pervasive Z-asymmetry on both limbs of a regional syncline would imply significant dextral transpression during, or subsequent to, D_2 folding.

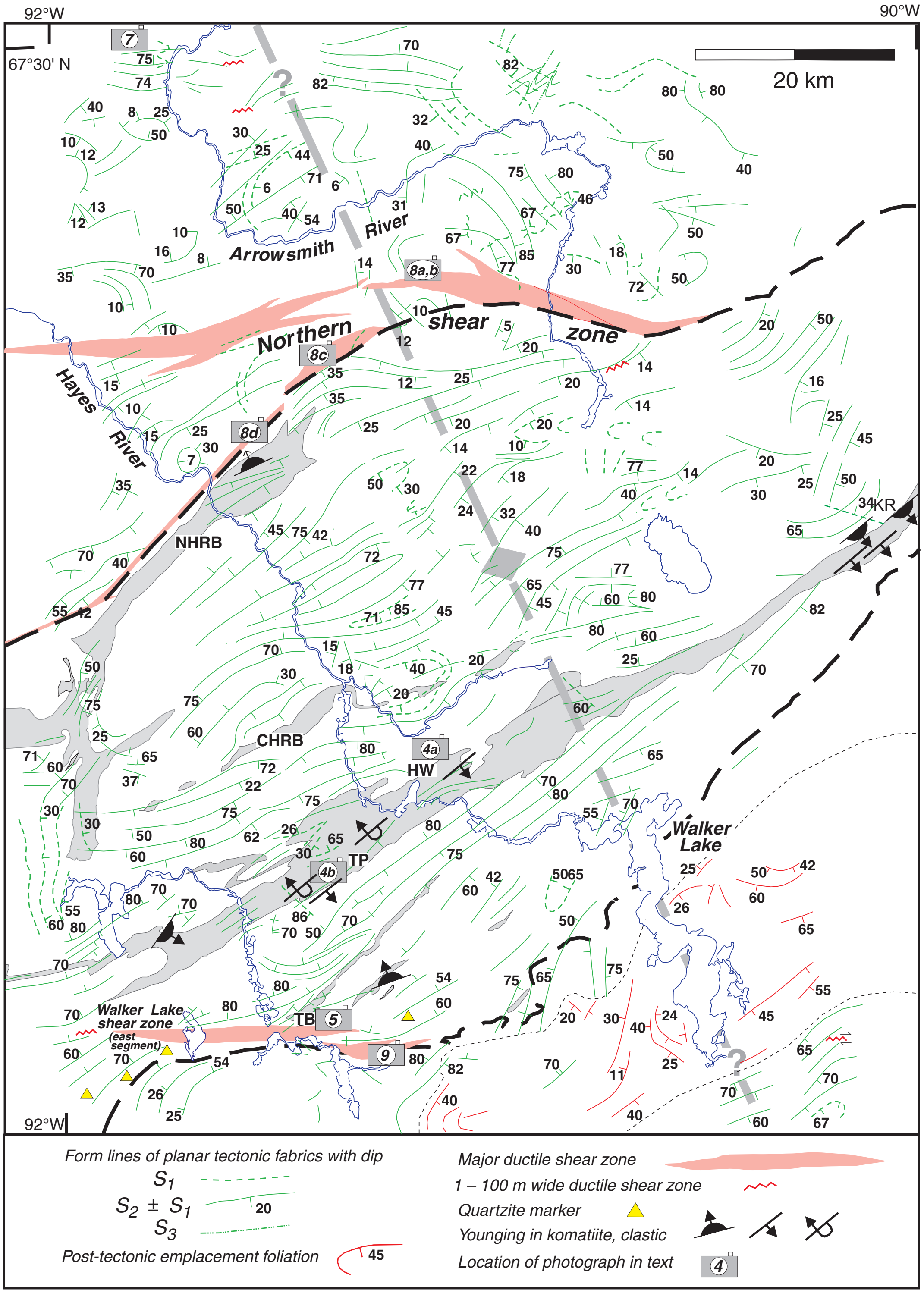

Figure 2. *Structural geology of the Walker Lake–Arrowsmith River area. Major crustal domains shown by thick dashed lines and supracrustal belts of the central domain shown by grey tone. Also shown are locations of photographs and place names referred to in text: Three Bluffs, TB; Twin Peaks, TP; Howling Wolf Lake, HW; Kellett River, KR; central Hayes River belt, CHRB; northern Hayes River belt, NHRB. Thick grey line transecting map area separates dominantly west- and east-plunging folds, discussed in text.* ***a)*** *Planar tectonic fabric data represented as form lines with average dip values, and major shear zones.*

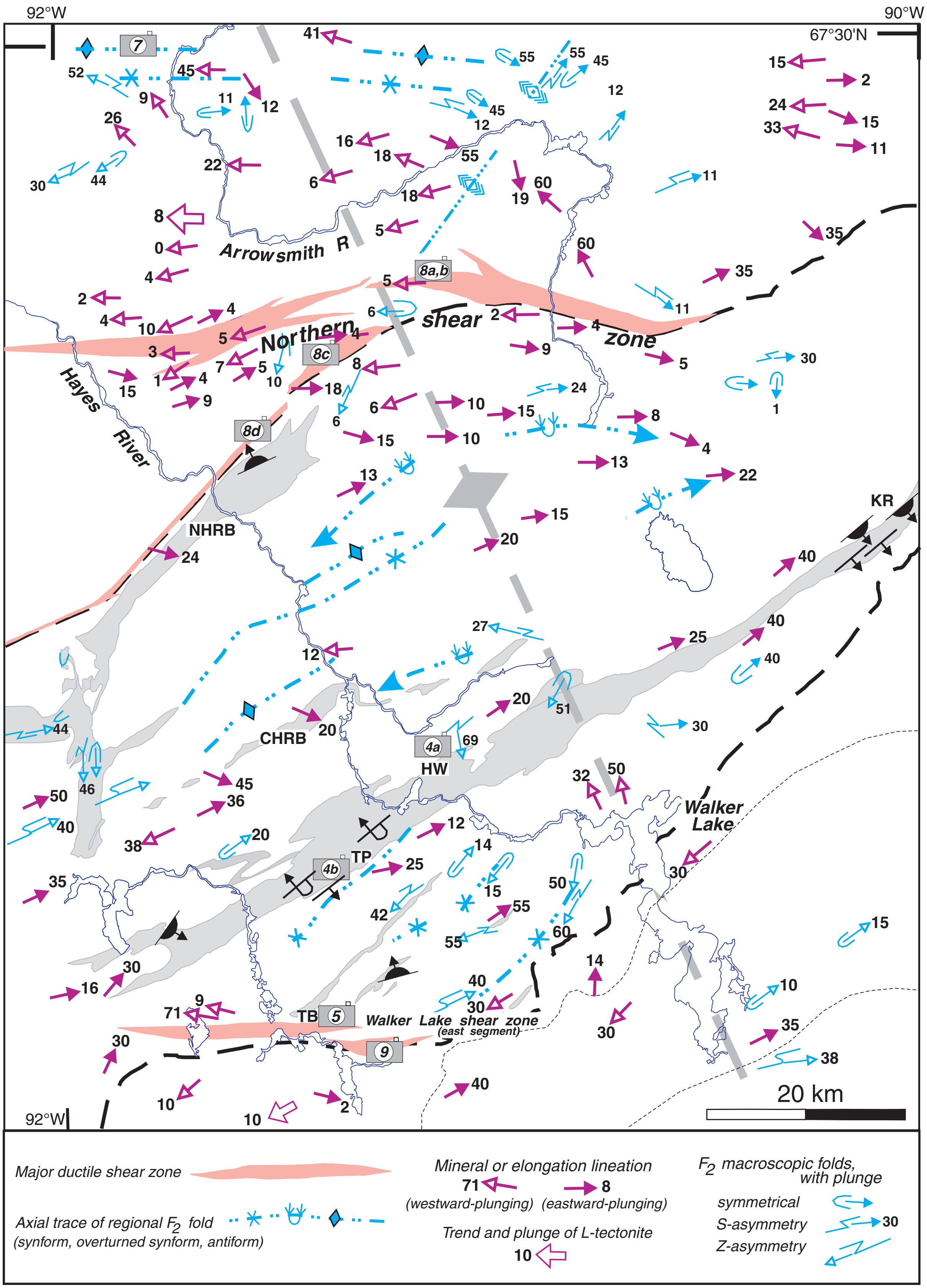

Figure 2. b) *Trend and plunge of linear structural elements, axial traces of major folds, and geometry of minor folds.*

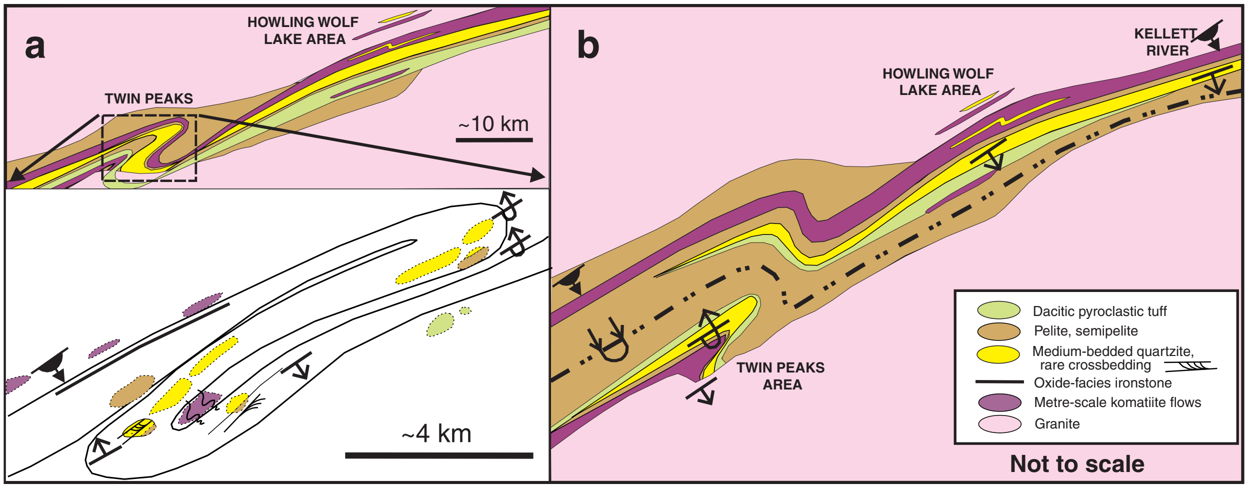

Figure 3. *Tectonostratigraphic relationships in the main komatiite-quartzite belt showing relationship of north-facing quartzite ridge at Twin Peaks to regional structure.* ***a)*** *Short limb of an asymmetric* F_2 *Z-fold. Note that* S_2 *is generally parallel to* S_0+S_1*, except in* F_2 *hinge where envelope of buckled* S_0+S_1 *is at high angle to* S_2*. Detail shows mapped outcrops only.* ***b)*** *North-younging south limb of a regional, overturned syncline centred on the main komatiite-quartzite belt, subsequently overprinted by pervasive Z-folds. Schematic plan represents about 100 km strike length*

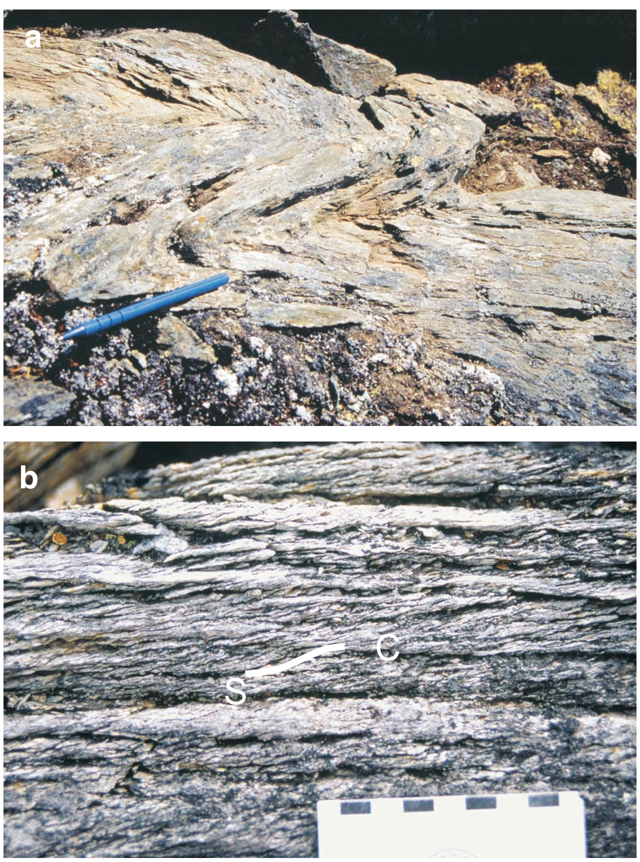

Figure 4. *Asymmetric structures reflecting dextral vorticity along the main komatiite-quartzite belt.* ***a)*** *South-plunging Z-folds in komatiite from Howling Wolf Lake area.* ***b)*** *Dextral S-C fabrics in muscovite±sillimanite-bearing interbeds within main quartzite unit at Twin Peaks. Photograph locations on Figure 2.*

Northward younging at one locality in the Three Bluffs and north Hayes River belts may be a manifestation of regional-scale folds involving these belts, but this is unclear given such sparse younging data. The degree to which thrust imbrication has affected these rocks is also under examination, although neither high-strain zones nor faults were generally observed to form boundaries to the greenstone belts.

Walker Lake shear zone

The moderately to strongly developed regional northeast-striking $S_2 \pm S_1$ foliation typical of the granite-greenstone domain progressively changes its character and intensity in the southwest part of the map area (Fig. 2a; *see also* Johnstone et al. (2002)). Here, a progressive change in planar fabric orientation from northeast striking, moderately northwest dipping (60–80°) to west striking, steeply north dipping occurs. Mineral lineations progressively decrease in pitch with proximity to the west-striking zone, which contains near-horizontally lineated rocks. Accompanying this change in attitude is a change in strain state from moderate L<S fabrics to high-strain L≥S tectonite. In plutonic rocks, high strain is reflected by strong biotite±amphibole alignment, quartzofeldspathic segregation, quartz-ribbon structure, and grain-size reduction of matrix minerals resulting in a high proportion of porphyroclastic units. High-strain metasedimentary rocks are schistose and contain pervasive microfolds (Fig. 5). Collectively, these changes are interpreted to define a steeply north-dipping, west-striking, high-strain zone, the east segment of the Walker Lake shear zone (Dufrense and Williamson, 1997; Johnstone et al., 2002). Dextral strike-slip displacement on the Walker Lake shear zone is supported by deflection of regional strain fabrics and regional aeromagnetic anomalies into the zone, the presence of asymmetrical

Figure 5. *Metasedimentary rocks of the Three Bluffs belt affected by the dextral strike-slip Walker Lake shear zone.* ***a)*** *Psammitic to semipelitic rocks with back-rotated quartz boudins. Extensional shear bands between boudins, though subtle, can be observed to offset the upper thin quartz vein.* ***b)*** *Magnetite-chert ironstone with pervasive millimetre- to centimetre-scale Z- and/or M-folds on a metre-scale Z-fold. Relationship of field of view to macroscopic Z-fold shown in small inset figure.*

structures consistent with dextral shear sense (Fig. 5), and lineation attitudes interpreted to reflect subhorizontal, maximum finite extension. An estimate of the magnitude of displacement is provided by right lateral offset of about 20 km on a potentially correlative quartzite unit exposed north and south of the shear zone (triangle symbols *in* Fig. 2a).

Metamorphic character of the granite-greenstone domain

Metamorphic grade varies from lower-amphibolite facies in the southeast to middle-amphibolite facies in the eastern and northern portions of the granite-greenstone domain. Diagnostic subassemblages at lower grade include staurolite-muscovite-garnet, cordierite-andalusite-muscovite, and cordierite-garnet-biotite in metapelitic rocks; andalusite-sillimanite in impure quartzite; and hornblende-plagioclase in metavolcanic rocks (Fig. 6). Most porphyroblasts appear to be pre- to synkinematic with respect to the dominant ($S_2 \pm S_1$) foliation, with the exception of some garnet which also occurs postkinematically. Higher grade semipelitic rocks contain sillimanite-garnet-muscovite-biotite, with pre- to synkinematic sillimanite porphyroblasts retrograded to fibrolitic mats rimmed by coarse muscovite.

SOUTHEASTERN PLUTONIC DOMAIN

The southeastern part of the Walker Lake area is underlain by a suite of granitic rocks that represent part of a regional northeast-striking batholithic complex (Skulski et al., 2002). These plutonic rocks are intrusive into the granite-greenstone belt domain, as evidenced by screens of supracrustal rocks, including quartzite and komatiite, exposed southeast of Walker Lake (*see* Fig. 2 *in* Skulski et al., 2002) and an intrusive relationship with tonalite in the southeast corner of the map area. Within the map area, this plutonic domain consists mainly of foliated K-feldspar megacrystic granite and weakly foliated to massive equigranular monzogranite. Both phases are magnetite bearing, which results in uniformly high aeromagnetic values that are diagnostic of this domain.

K-feldspar megacrystic monzogranite generally possesses a northeast-striking, southeast-dipping foliation defined by weak to moderate alignment of biotite. A weak preferred shape fabric defined by quartz plunges moderately to shallowly to the northeast. These L/S fabrics parallel S_2/L_2 fabrics within the granite-greenstone domain. In contrast, equigranular monzogranite is typically massive or weakly foliated with a moderately to shallowly dipping foliation of variable strike (Fig. 2a) that is interpreted to be a post-tectonic primary emplacement fabric.

NORTHERN METASEDIMENTARY DOMAIN

The northern domain is dominated by metasedimentary rocks and paragneiss, cut by peraluminous and metaluminous plutonic rocks. In contrast to the relatively straight transposition fabric of the granite-greenstone domain, the northern metasedimentary domain displays variably oriented structures attributed to at least three deformational events. Low-pressure, upper amphibolite- to lower granulite-facies metamorphism is indicated by metamorphic mineral assemblages in rocks of pelitic to semipelitic composition. Associated peraluminous leucogranite bodies produced via partial melting of metasedimentary rocks appear to have locally formed in situ, but in general are suspected to have been mobilized from a proximal source region.

Primary structures

Compositional layering clearly attributed to primary bedding is rarely observed in the northern metasedimentary domain. At one locality, well preserved compositional and textural variations define bedding and northward younging (Fig. 2), although the significance of this data in the folded

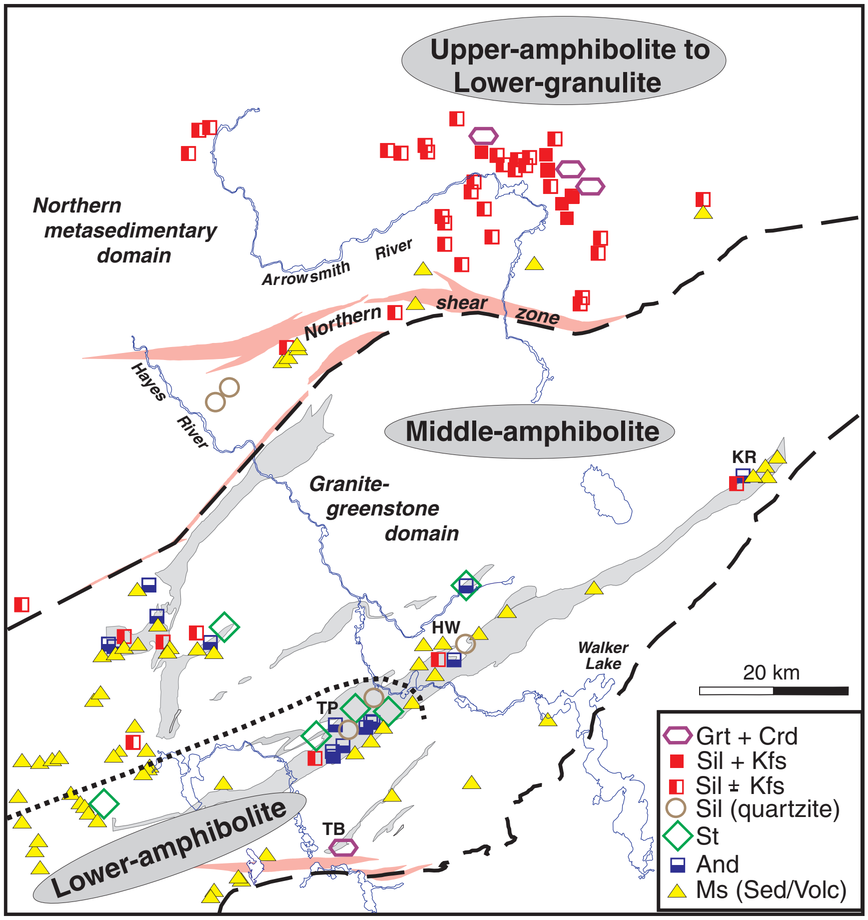

***Figure 6.** Distribution of key metamorphic minerals in the Walker Lake–Arrowsmith River area. Major shear zones and major lithological contacts shown for reference. Heavy dotted line shows approximate boundary between lower- and middle-amphibolite-facies. Grt=garnet, Crd=cordierite, Sil=sillimanite, Kfs=K-feldspar, St=staurolite, And=andalusite, Ms=muscovite, Sed/Volc=sedimentary and/or volcanic rocks, KR=Kellett River, HW=Howling Wolf Lake, TP=Twin Peaks, TB=Three Bluffs*

high-grade terrain is unclear. Compositional variations from aluminosilicate-bearing (pelitic) to aluminosilicate-absent (psammitic) layers locally provided some indication of bedding orientation within these rocks.

D_1 structures

The earliest planar tectonic fabric recognized in the northern domain is defined by millimetre- to centimetre-scale segregation of quartzofeldspathic and micaceous layers resulting in an irregular S_1 migmatitic layering (Fig. 7). This gneissic foliation is generally defined by aligned biotite±red garnet (possibly almandine) and coarse-grained leucocratic veinlets suggesting incipient anatexis accompanied D_1. S_1 is variable in orientation at the outcrop- and map-scale, due to subsequent modification by folding. In general, however, the S_1 gneissosity enveloping surface has a northerly to northwesterly strike, and moderate to shallow dip to the east and west. F_1 folds are not identified in the northern domain.

D_2 structures

In areas with composite fabrics, S_2 is readily identified as being axial planar to folds that modify the orientation of S_1. Although variable in orientation, S_2 is typically a northeast- to east-striking schistosity that is defined by biotite+sillimanite+lavender garnet(likely pyrope)±cordierite±melt. In contrast to S_1, S_2 is typically steeply dipping (>70°) with northward dips appearing to dominate over southward dips. At the southward bend in the Arrowsmith River, S_2 planes define an arcuate northwest-striking pattern that is axial planar to folds of northeast-striking S_1.

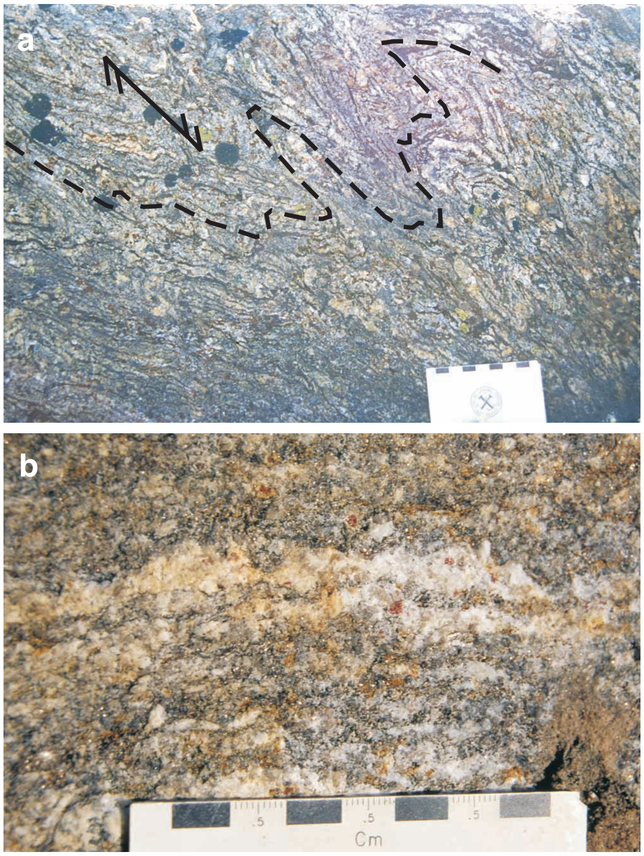

***Figure 7.** Paragneiss from the northern domain. **a)** Folded migmatitic S_1 gneissosity with fold envelope, highlighted by dashed line, oriented 354/47. Axial-planar cleavage to F_2 folds, indicated by symbol, oriented 090/78. **b)** Detail of 'a' showing migmatitic character of S_1 gneissosity defined by biotite-sillimanite-garnet±cordierite±K-feldspar±melt.*

In the northern metasedimentary domain, S_2 is commonly the dominant planar fabric at the scale of the outcrop, with S_1 migmatitic layering preserved in metre-scale panels. In bedrock exposures that display a single planar foliation, the eastward orientation and diagnostic steep dip of S_2, in contrast to the northerly strike and shallow dip of S_1, may be used to infer fabric generation. Linear elements associated with S_2 are generally defined by elongation of quartz and alignment of sillimanite. In the western part of the area L_2 plunges westward, whereas in the eastern part L_2 plunges eastward. Macroscopic F_2 folds show a similar plunge reversal. In the west, asymmetric Z- and symmetric folds plunge dominantly west (10–35°) whereas in the east, asymmetric S- and symmetric folds plunge to the southeast at 10–50°.

D_3 structures

Penetrative D_3 strain is locally observed to overprint D_2 structures but, in general, is interpreted by variations in the orientation of D_2 structures consistent with widely spaced, northeast-trending F_3 folds (Fig. 2). Observed D_3 structures include northeast-trending F_3 folds and S_3 fabrics that overprint and tightly fold S_2 at one locality in the north-central region. In addition, a set of metre-scale conjugate shear zones deflect and rework D_2 structures. Anomalous orientations of S_2 and S_1 structures at the southward bend in the Arrowsmith River may be due to an open northeast-trending F_3 fold in this area. In the adjacent map area to the southwest, widely spaced F_3 cross folds are interpreted to have affected D_2 structures, although in this region, F_3 folds are reported to trend northwesterly (Sandeman et al., 2001b).

Metamorphic character of the northern paragneiss domain

The northern domain consists dominantly of upper-amphibolite- to lower-granulite-facies rocks, with migmatitic paragneissic rocks exhibiting the assemblages garnet-sillimanite-biotite-potassium feldspar-quartz and garnet-cordierite-sillimanite-biotite-quartz±potassium feldspar±melt, respectively (Fig. 6). Two generations of garnet are apparent. Inclusion-rich subhedral, partially embayed, pre- to syntectonic porphyroblasts are enveloped by the main biotite-sillimanite defined foliation ($S_1 \pm S_2$). In contrast, smaller, subhedral to euhedral, post-tectonic garnet porphyroblasts overgrow the main foliation and commonly contain inclusions of aligned sillimanite. Whereas early garnet may be rimmed by cordierite, post-tectonic garnet appears to be in textural equilibrium with cordierite. These relations suggest that latest metamorphism probably occurred at higher grade, with the breakdown of biotite-sillimanite-quartz to garnet-cordierite-potassium feldspar-fluid/melt, and that heat outlasted strain in the northern domain.

NORTHERN SHEAR ZONE

An arcuate corridor of annealed porphyroclastic mylonitic rocks, designated the Northern shear zone, separates the central granite-greenstone and northern metasedimentary domains (Fig. 2). This structure appears to encompass two major arcuate strands of very strongly foliated to mylonitic plutonic rocks (Fig. 8). A northernmost, east-trending, flat-lying high-strain corridor, with an exposed thickness of 1–3 km, extends about 40 km across the map area. Within this corridor, shallow (<15°) south-dipping mylonitic rocks (Fig. 8a, b) are characterized by very strong rodding lineations, defined by quartz and feldspar. At the local scale of observation, lineations are commonly oblique (i.e. 2–10° pitch on 0–15° dipping shear planes), whereas at the regional scale they are near parallel to the trend of the main high-strain corridor (Fig. 2b). In the west, lineations generally plunge shallowly westward (<10°), whereas east of the Arrowsmith

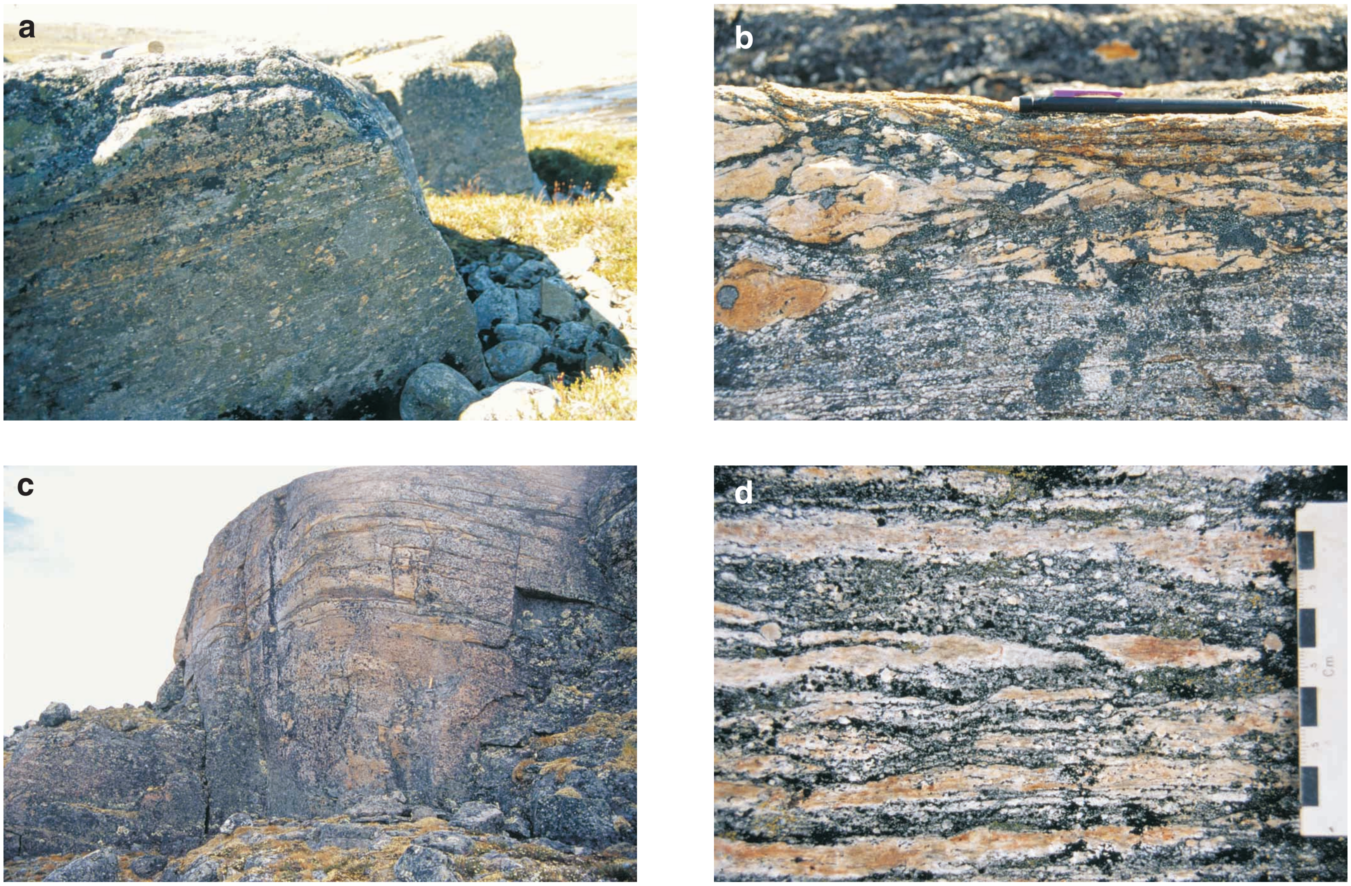

Figure 8. *High-strain plutonic rocks from the Northern shear zone.* ***a)*** *Flat-lying mylonite from the northern strand.* ***b)*** *Detail of 'a'.* ***c)*** *Flat-lying mylonitic rocks from the northeast-striking strand.* ***d)*** *Detail of high-strain plutonic rocks within the northeast-striking strand of the Northern shear zone. Photograph locations on Figure 2.*

River they generally plunge eastward (Fig. 2b). Asymmetrical structures, represented mainly by sigma-type winged porphyroclasts (Hanmer and Passchier, 1991), observed on horizontal exposures (oblique to the YZ plane) have been interpreted to reflect dextral shear sense for tectonites with shallow west-plunging mineral lineations, and sinistral shear sense for those with east-plunging mineral lineations. It is presently not clear the degree to which the northern strand accommodated strike-slip displacement relative to oblique-slip displacement, nor whether the reported change in shear sense and plunge reversals is due to very open (possibly synshear) folding of this structure.

An adjacent northeast-striking high-strain zone is similar in strain intensity, fabric development and protolith to that of the northern strand (Fig. 8c, d). The northeast-striking strand is a moderately shallow, southeast-dipping (35–15°) structure with strong rodding lineations that plunge to the east to southeast (25–20°). Sigma- and delta-type winged porphyroclasts and asymmetrical extensional shear bands are widespread in planes parallel to the lineation and perpendicular to foliation (XZ) and show top-down-to-the-southeast, extensional movement.

PRELIMINARY MONAZITE CHEMICAL AGES

Preliminary monazite chemical ages have been obtained using the electron microprobe facility at Carleton University (R. Berman, unpub. data, 2001). Although the data, collected from two samples from both the northern and central domains, are sparse at this stage, a reasonable degree of confidence derives from the overall consistency among these samples and also with chemical monazite ages obtained for several rocks from an adjacent map area (Sandeman et al., 2001a, b, c). In the northern domain, distinct cores and rims are exhibited by monazite grains that occur in the matrix and as inclusions inside pre- to syntectonic ($S_1 \pm S_2$) garnet. Monazite cores range from ca. 2.5–2.1 Ga; rims yield ca. 1.8 Ga, the same age as monazite inclusions in post-tectonic garnet. While more work is needed to understand fully these relationships, the data point to a significant thermal event at ca. 1.8 Ga, and a likely late Neoarchean or early Paleoproterozoic event. Within the greenstone belt, ca. 1.8 Ga monazite inclusions occur within synkinematic cordierite and crenulated matrix biotite at Three Bluffs (Fig. 6), and occur within foliated matrix biotite at Kellett River (Fig. 6). These results suggest that a component of young ca. 1.8 Ga deformation may penetratively affect the greenstone belt domain.

TIMING AND TECTONIC SIGNIFICANCE OF TECTONO-METAMORPHIC EVENTS AFFECTING THE WALKER LAKE–ARROWSMITH RIVER AREA

The character of structures generated during polyphase deformation of the Walker Lake–Arrowsmith River area varies across the map area due to changes in rock type and metamorphic grade. Preliminary correlation of structures, suggested below, is based on the relative chronology of structures, their general geometrical aspects, and preliminary geochronological data.

D_1 event

D_1 is poorly constrained in the central granite-greenstone domain, but appears to have involved bedding-parallel fabric development, possibly during folding. At a number of widespread localities in komatiite, penetrative S_1 has a northwesterly strike and moderate to shallow dip. Rare F_1 folds trend northwestward. In the northern domain, S_1 migmatitic layering (Fig. 7) typically has a northwesterly strike and moderate to shallow dip. On the basis of geometrical considerations, middle-amphibolite-facies S_1 schistosity in the central domain may correlate with upper-amphibolite-facies S_1 migmatitic gneissosity in the northern domain.

Adjacent komatiite-quartzite belts in the map area to the southwest are interpreted to be folded into isoclinal north-trending F_1 folds (*see* Johnstone et al., 2002; MacHattie, 2002). The maximum age of D_1 is constrained by a preliminary U-Pb age of ca. 2.73 Ga for felsic volcanic rocks interpreted to core an F_1 syncline (H. Sandeman and T. Skulski, unpub. data, 2001). In the northern metasedimentary domain, preliminary chemical dating of monazite inclusions in garnet suggests that D_1 tectonometamorphism may be a Neoarchean (to early Paleoproterozoic) event.

Penetrative D_2 strain

D_2 structures may correlate between the central and northern domains, and may also be represented by the main fabric that affects the southeastern plutonic domain. Throughout the map area, structures attributed to a regional D_2 strain event are northeast to east striking, and are predominantly southeast dipping. F_2 folds are commonly overturned, northwest-vergent structures. A map-scale plunge reversal appears to be reflected in regional and macroscopic F_2 fold orientations within the central and northern domains, and in the L_2 plunge reversal in the northern domain. This may be caused by a map-scale, in-plane perturbation during D_2 strain, or by post-D_2 north-northwest-trending cross folding, as reported in the adjacent map area (Sandeman et al., 2001b). A model to explain these structural aspects must reconcile the fact that traces of planar elements, such as lithological contacts and foliation, are not deflected across the axis about which the folds change plunge, and the orientation of mineral lineations across the central domain does not vary.

The dominant regional northeast-striking, northwest-vergent structures of the Walker Lake–Arrowsmith River area of the Committee Bay belt appear to formed at least in part at ca. 1.8 Ga (*see* 'Preliminary monazite chemical ages', above), and are geometrically similar to regional structures identified to the southwest and northeast. To the southwest, D_2 structures affecting the Woodburn Lake group include a set of southeast-dipping, northwest-vergent folds and thrusts (Zaleski et al., 2001a, b). These structures are interpreted to have a maximum age of ca. 2.0 Ga, the age of the youngest detrital zircon from the Whitehills Lake conglomerate that carries a penetrative S_2 foliation. Northeast-striking, southeast-dipping overturned structures similarly affect rocks of the Amer Group (Patterson, 1986) and their equivalents in the Chantrey belt (Frisch et al., 1985), for which deformation is inferred to be bracketed between ca. 1.95 Ga and 1.85 Ga (B. Davis, pers comm., 2001). We speculate that the regional distribution of geometrically similar structures across the north-central western Churchill Province may reflect penetrative Paleoproterozoic strain (cf. Patterson, 1986) in the hinterland to the ca. 1.83 Ga Trans-Hudson Orogen (Lucas et al., 1996).

Northern shear zone

The Northern shear zone is a kilometre-scale shear zone with a footwall consisting dominantly of upper-amphibolite- to lower-granulite-facies paragneissic rocks that locally appear to have undergone in situ partial melting. The hanging wall comprises middle- to lower-amphibolite-facies rocks, with muscovite-bearing assemblages in sedimentary rocks. From the present distribution of assemblage data (Fig. 6), it is not

Figure 9. *Tonalite intruded by sheeted monzogranite veins within the steeply dipping, dextral strike-slip Walker Lake shear zone.*

clear the extent to which the Northern shear zone has influenced the metamorphic gradient in this region. Work is ongoing to test the possibility of a discontinuity in the regional metamorphic gradient across this structure, as well as its age.

Walker Lake shear zone

The east segment of the Walker Lake shear zone (Johnstone et al., 2002) is a steeply dipping, dextral, strike-slip shear zone some 25 km long. The absence of shear fabrics extending farther east than defined in Figure 2 is likely due the presence of voluminous post-tectonic granite (Fig. 2a; *see also* Fig. 2 *in* Skulski et al., 2002). Its western termination appears to coincide with a southwestward bend in the supracrustal-plutonic domain boundary. Strain related to the east segment of the Walker Lake shear zone is mainly observed in plutonic rocks, rather than localized within the northeast-striking Three Bluffs supracrustal rocks. A rheological control may have been important in localizing strain, if syntectonic intrusive dykes, or sheets, were preferentially emplaced into colder, more competent tonalitic wall rocks, thus providing heat for thermal softening. The sheeted character of younger granitic rocks into tonalite within the Walker Lake shear zone (Fig. 9) is consistent with a magmatically induced thermal mechanism to localize shear strain.

On a regional scale, the Walker Lake shear zone shares attributes common to regional Paleoproterozoic faults that transect the north-central part of the western Churchill Province. The Amer and Wager Bay shear zones (Fig. 1; Tella and Heywood (1978); Henderson and Broome, 1990) are east-striking, steeply dipping, dextral strike-slip structures that are delineated by pronounced aeromagnetic lineaments. The Amer mylonite zone is interpreted to have had an early ductile history between ca. 1.85 Ga and 1.83 Ga, with subsequent brittle reworking after ca. 1.75 Ga (Tella et al., 2001). The Wager Bay shear zone cuts 1808 ± 2 Ma granite, providing a maximum age of ductile, dextral strike-slip shear (Henderson and Roddick, 1990). Preliminary U-Pb data (S. Johnstone and J. Ketchum, unpub. data, 2001) bracket penetrative ductile movement on the Walker Lake shear zone to between ca. 2.6 Ga, the preliminary age of mylonitized tonalite, and ca. 1.83 Ga, the age of a weakly foliated pegmatite, interpreted to be late-tectonic with repect to dextral shearing. Preliminary chemical dating of monazite inclusions from matrix and porphyroblast phases (cordierite) from crenulated pelitic schist proximal to the Walker Lake shear zone in the Three Bluffs area provides an indication of Paleoproterozoic tectonometamorphism within this area, with deformation outlasting ca. 1.8 Ga metamorphism (R. Berman, unpub. data, 2001). Accordingly, the Walker Lake shear zone, like the Amer and Wager Bay shear zones, may represent an accommodation structure activated at a late stage of northwest-directed shortening across the north-central part of the western Churchill Province.

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