GEOLOGY OF THE WEST MARGIN OF THE SHUSWAP TERRANE NEAR SICAMOUS IMPLICATIONS FOR TERTIARY EXTENSIONAL TECTONICS (82L, M)

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INTRODUCTION

Recent field and geochronological investigations, in conjunction with LITHOPROBE seismic surveys, have led to the recognition of crustal-scale, low to moderate-angle, Eocene extensional faults and shear zones in the southern Omineca Belt. The present study focuses on documentation of the Eagle River fault, an extensional shear zone that delineates the western boundary of the Shuswap metamorphic terrane (Figure 1-6-1). The geometry and the tectonic history of the Eagle river fault place important constraints on crustal cross-sections through the southern Omineca Belt.

The Shuswap terrane consists of polydeformed rocks that have been metamorphosed in the sillimanite zone of the amphibolite facies. The western margin of the Shuswap terrane is a sharp metamorphic discontinuity, for which various interpretations have been offered. Jones (1959) mapped the boundary as a high-angle fault. Campbell (1971) documented closely spaced isograds, but no fault. Okulitch (1979) showed the boundary between rocks of contrasting metamorphic grade to be cut locally by high-angle faults. Fyson (1970) suggested that the high-grade rocks of the Shuswap terrane formed as a hot metamorphic infrastructure, separated from cold, brittly deformed upper-crustal rocks by a steep geothermal gradient. A detailed study of the structure and metamorphism in the Mara Lake area by Nielsen (1978, 1982) seemed to support the hypothesis of a steep metamorphic gradient with no major structural break.

These studies were completed before the concept of crustal-scale, low-angle normal faults, for example, Wernicke (1981), had gained much attention. More recently, low-angle normal faults have been documented in the Columbia River valley (Read and Brown, 1981; Lane, 1984), the Okanagan Valley (Bardoux, 1985; Parkinson, 1985a, 1985b; Parrish et al., 1985; Templeman-Kluit and Parkinson, 1986), and on both east and west flanks of the Valhalla Complex (Parrish, 1984; Carr, 1986; Carr et al., 1987) (Figure 1-6-1).

Uranium-lead zircon ages of synkinematic granites (Solberg, 1976; Carr et al., 1987; Parrish et al., 1988) have established Eocene histories of ductile shearing and subsequent brittle deformation in each of these fault zones. Potassium-argon mineral dates consistently record an early Tertiary thermal history in the high-grade footwall rocks, whereas the low-grade, brittly deformed hangingwall rocks preserve Mesozoic cooling ages (see Parrish et al., 1988, for a summary).

The present investigation was prompted by reconnaissance mapping by Journeay and Brown (1986) which led to the discovery of mylonites in the Eagle River valley near Sicamous.
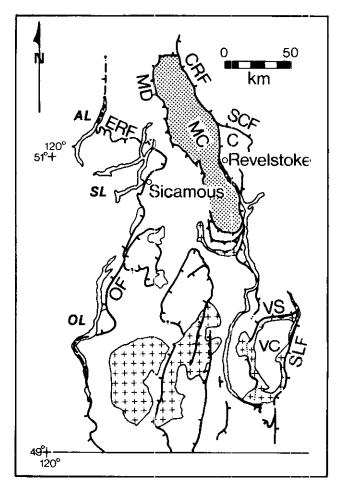

Figure 1-6-1. Tectonic map of the southern Omineca Belt, modified after Parrish et al. (1988). C: Clachnacuddain allochthon; CRF: Columbia River fault; ERF: Eagle River fault; MC: Monashee Complex; MD: Monashee décollement; OF: Okanagan fault; SCF: Standfast Creek fault; SLF: Slocan Lake fault; VC: Valhalla Complex; VS: Valkyr shear zone; AL: Adams Lake; OL: Okanagan Lake; SL: Shuswap Lake.

Legend

MOUNT FOWLER ORTHOGNEISS

EAGLE BAY ASSEMBLAGE

SICAMOUS FORMATION

TSALKOM FORMATION

SILVER CREEK FORMATION

SHUSWAP TERRANE

Garnet–biotite–hornblende–quartz–feldspar Gneiss

Calc-silicate, Marble, Amphibolite, Semipelite

Amphibolite, Semipelite

Biotite–hornblende Granodiorite Gneiss

Semipelitic to Pelitic Sillimanite–garnet–biotite Schist, Feldspathic Psammite, Amphibolite Boudins

Foliation

Lineation in (west-directed, east-directed) Mylonite

Normal fault

Line of cross section

0   10 km

Map labels

119° 45' 118°30'

B 46
M 46

NORTH
QUEEST MTN.

QUEEST
MTN.

SHUSWAP

B 49
M 52

B 48
H 92

Malakwa

MT.
GRIFFIN

Three Valley
Gap

Sicamous

MT.
MARA

Grindrod

Mara

HUNTERS RANGE

EAGLE

LARCH HILLS

RANGE

FAULT

Eagle River

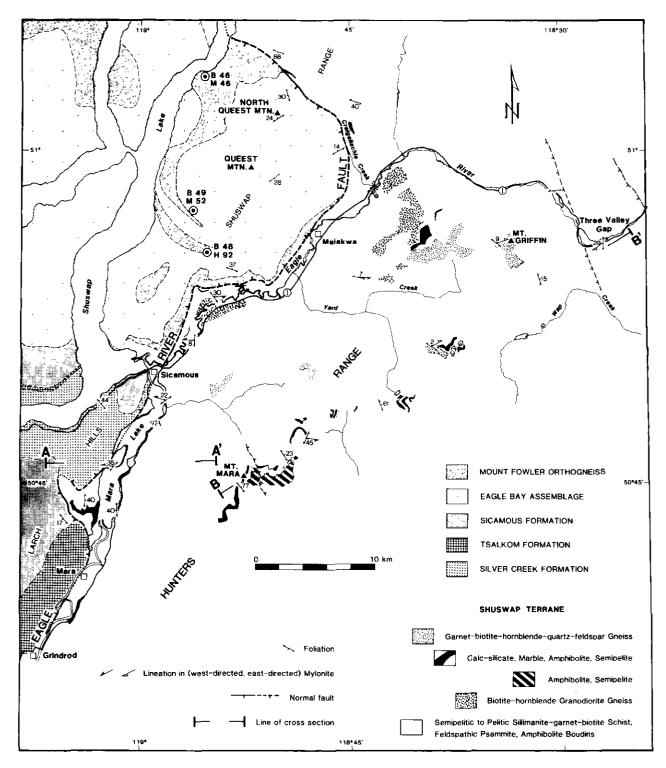Shuswap Lake

Mara Lake

51°

50°45'

Figure 1-6-2. Geological map of the eastern Shuswap Highland near Sicamous. Geology in hangingwall of Eagle River fault in part from Okulitch (1979) and Jones (1959). Potassium-argon mineral dates (in Ma; **B** = Biotite, **M** = muscovite, **H** = hornblende) from Okulitch (1979) and Wanless *et al.* (1978)

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EAGLE RIVER FAULT

The Eagle River fault (Journeay and Brown, 1986) is a ductile-brittle normal fault that juxtaposes low to medium-grade metamorphic rocks of the Mount Ida Group (Jones, 1959) against migmatitic paragneiss of the Shuswap terrane (Figure 1-6-2). Mylonites in the immediate footwall exhibit C/S fabrics, rotated feldspar porphyroclasts with asymmetric recrystallized tails, and shear bands that consistently indicate relative westward movement of the upper plate.

Shear fabrics in mylonites near Sicamous and along the east side of Mara Lake are defined by garnet-biotite-sillimanite-potassium-feldspar assemblages. Sillimanite and quartz-feldspar aggregates define a strong west-trending stretching lineation. Some discrete shears contain retrograde chlorite after biotite, and local cataclastic zones display slickensides with west-directed chlorite fibre lineations subparallel to the stretching lineation. About 150 metres beneath the projected position of the brittle detachment on the west side of Mara Lake, retrograded west-verging mylonites exhibit slickensided shear planes, spaced about 2 millimetres apart, defined by chlorite and relict sillimanite.

These field relationships are consistent with models for mid-crustal extensional simple shear zones, for example, Davis, 1983; Davis et al., 1986), which predict that footwall mylonites quenched at high metamorphic grade are overprinted by lower grade metamorphism, and eventually brittle shears, during uplift through the brittle-ductile transition zone in the crust.

Calc-silicate and amphibolite rocks in the Larch Hills near the southwest end of Mara Lake were inferred to be correlative with similar rocks on the east side of the lake by Nielsen (1978). These rocks are probably part of the footwall of the Eagle River fault, exposed in a small antiformal culmination. South of the Mara Lake, the fault trace follows the Shuswap River beyond Grindrod, and probably merges with the Okanagan Valley fault as suggested by Journeay and Brown (1986).

Northeast of Sicamous, the fault trace parallels the Eagle River valley as far as Craigellachie Creek, where it turns northwestward. On a logging road near North Queest Mountain, fractured and weathered sillimanite-biotite-muscovite schist of the footwall is separated from hangingwall granitoid gneiss of the Mount Fowler batholith by 50 metres of cataclasite and clay gouge. Unfoliated to weakly foliated pegmatite intrudes both the footwall and hangingwall, and is intensely fractured and weathered within the fault zone. The fault zone and foliation in the footwall rocks dip about 55 degrees southwest.

Continuity of the Eagle River fault between Craigellachie Creek and Adams Lake is inferred on the basis of the close spacing of garnet and sillimanite isograds mapped by Campbell (1971). Its position is approximated in Figure 1-6-1 by the margin of the Shuswap terrane as mapped by Okulitch (1979), modified slightly to agree with new mapping. Near the east shore of Adams Lake, chloritic phyllites of the Eagle Bay assemblage are exposed within 200 metres of coarse-grained biotite-muscovite schists, which are crossed by the sillimanite isograd about 5 kilometres away. Retrograded sillimanite migmatites near the mouth of Momich River, 8 kilometres from the north end of Adams Lake, display intense west-directed C/S fabrics and westerly rotated feldspar porphyroclasts.

Potassium-argon geochronolocal studies of biotite from Devonian and Cretaceous plutons in the hangingwall west of Adams Lake indicate Cretaceous cooling ages (Wanless et al., 1966; Campbell and Tipper, 1971; Belik, 1974; Okulitch, 1979; Jung, 1986). In hangingwall plutons west of Craigellachie Creek, biotite and muscovite potassium-argon dates are mid-Eocene (Wanless et al., 1978; Okulitch, 1979), whereas Mount Fowler orthogeniss southwest of Queest Mountain has yielded a Cretaceous hornblende date (Okulitch, 1979) (Figure 1-6-2). The mica dates suggest the hangingwall of the Eagle River fault near Craigellachie Creek did not cool below 280 to 350°C until the mid-Eocene, based on closure temperatures of radiogenic argon in biotite (Harrison et al., 1985) and muscovite (Purdy and Jäger, 1976; Wagner et al., 1977). West of Adams Lake, these systems must have closed in the Cretaceous.

FOOTWALL GEOLOGY

STRATIGRAPHY

The structural panel between the Eagle River fault and the Monashee décollement (Figure 1-6-1) consists mainly of quartzofeldspathic gneiss and leucopegmatite. The pegmatite forms condordant sheets and undeformed, discordant dykes; although its age has yet to be determined, much of it is probably related to the Eocene Ladybird suite (see Parrish et al., 1988). For the most part, exposure is sparse and stratigraphic control is poor, although stratigraphic successions have been mapped on the highest ridges of the Hunters Range, south of the Trans-Canada Highway (Figure 1-6-2). Similarity between successions on different ridges has enabled tentative correlation of a kilometre-thick section of metasedimentary and metavolcanic strata to be made across the Hunters Range. These correlations are compatible with the available structural data. If they are correct, then the rocks along the Trans-Canada Highway between Three Valley Gap and Sicamous constitute a mildly folded succession no more than 2 kilometres thick, within which there are no major structural breaks (Figure 1-6-3).

The metasedimentary/metavolcanic succession consists of semipelitic units separated by distinctive amphibolite, calc-silicate and hornblende gneiss (Figure 1-6-2). The semipelitic units include interlayered garnet-biotite semipelite and psammite, pelitic garnet-biotite-sillimanite schist, and a few layers of quartzite up to 50 centimetres thick. Boudins of amphibolite and hornblende gneiss up to 15 metres across are spectacularly exposed in semipelite along the Trans-Canada Highway at Three Valley Gap and on ridges near Mount Mara. The semipelitic units commonly contain over 50 per cent pegmatite by volume.

A distinctive amphibolite unit is about 100 metres thick at Mount Mara. The amphibolite is composed of alternate layers of biotite-hornblende ± garnet and diopside-plagioclase, and is interlayered with semipelites. Semipelite above the amphibolite unit is in turn structurally overlain by a succession, up to 50 metres thick, of diopsidic calc-silicate gneiss diopside-plagioclase-hornblende amphibolite, marble
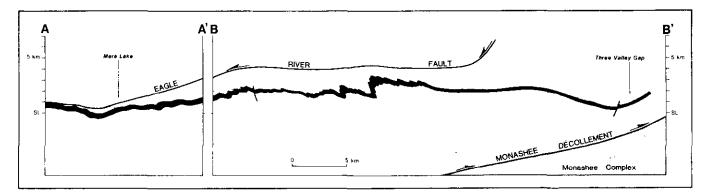
Figure 1-6-3. Composite structural cross-section through the Hunters Range between Sicamous and Three Valley Gap. Top of heavy black line beneath Eagle River fault represents top of calc-silicate unit described in text.

and semipelite. another semipelite unit separates the calc-silicate unit from garnet-biotite-hornblende-quartz-feldspar gneiss which caps Mount Griffin and ridges north and south of Yard Creek. This gneiss forms the structurally highest unit, contrary to a previous report that it lay structurally beneath rocks south of Yard Creek and at Mount Mara (Johnson, 1988). Biotite-hornblende granodiorite gneiss, containing rare interlayered paragneiss, is exposed on the northwestern slopes of Mount Griffin and along the Trans-Canada Highway southwest of Craigellachie.

Ages and stratigraphic facing of footwall rocks are unknown, but the semipelitic units with amphibolite boudins are probably correlative with monotonous semipelite-amphibolite successions of the Late Proterozoic Horsethief Creek Goup in the Kootenay Arc.

STRUCTURE

Compositional layering and subparallel penetrative foliation are deformed on mesoscopic scales by tight to isoclinal, generally southward-verging folds (F_2). Hinges of these folds are nearly parallel to an east-northeast-trending stretching lineation defined by aligned inequant minerals and mineral aggregates. A younger set of upright to overturned, west-verging inclined folds (F_3) deforms the early folds and the stretching lineation. These folds typically are open, although minor folds in pelites are close to tight and are chevron shaped. Discrete west-directed shears locally cut F_3 folds, and hence the folds may be as young as Eocene.

Mylonitic pegmatites in the northeastern part of the Hunters Range exhibit asymmetric feldspar porphyroclasts and shear bands indicative of east-directed shear. These fabrics are presumably older than the non-annealed, chlorite-grade, west-directed sheares of probable Tertiary age that cut pelitic rocks in the same area. The east-directed mylonites and F_2 folds are inferred to be Mesozoic (or Paleocene) compressional structures. East-northeast-trending stretching lineations may be analogous to similarly oriented lineations of compressional origin associated with the Monashee décollement (Journeay, 1986; Journeay and Brown, 1986). Stretching lineations that are clearly related to west-directed ductile shearing in the Eagle River fault zone have more easterly trends (Figure 1-6-2). Both sets of lineations formed in the sillimanite zone.

HANGINGWALL GEOLOGY

STRATIGRAPHY

The hangingwall of the Eagle River fault contains low to medium-grade metasedimentary and metavolcanic strata of the Mount Ida Group (Jones, 1959), which is represented by four stratigraphic packages. The most completely studied of these packages is the Eagle Bay assemblage, which comprises micaceous quartzite, mica schist, graphitic and chloritic phyllite, marble and metavolcanic rocks. Archaeocyathids indicate a Cambrian age for the marble, and other rocks of the assemblage have been dated as Devono-Mississippian, making correlation with the Badshot Formation and Lardeau Group of the Kootenay Arc likely (Schiarizza and Preto, 1987). Quartz-muscovite schist and quartzite of the Silver Creek Formation are presumably of Cambro-Ordovician age and may be equivalent to part of either the Lardeau Goup (Okulitch, 1979) or the Hamill Goup. The Tsalkom Formation consists of discontinuous greenstones of unknown age. It is overlain by phyllitic marble and calcareous phyllite of the Sicamous Formation. Campbell and Okulitch (1973) inferred the Sicamous Formation to be of Triassic age but the rocks closely resemble marble and phyllite of the Eagle Bay assemblage and are probably early Paleozoic (Preto and Schiarizza, 1985; A.V. Okulitch, personal communication, 1986). The Silver Creek, Tsalkom and Sicamous formations each have lithological equivalents within the Eagle Bay assemblage and therefore probably all are correlative with Kootenay Arc strata.

The Mount Ida Group is intruded by Devonian orthogneiss of the Mount Fowler batholith and by the Cretaceous Baldy and Raft batholiths. Eocene volcanic rocks unconformably overlie the older rocks.

STRUCTURE AND METAMORPHISM

All rocks of the Mount Ida Goup exhibit a strong foliation, which is deformed by early north to east-northeast-trending folds (Okulitch, 1979). Later northwest-trending folds and crenulations with steeply dipping axial planes formed in conjunction with southeast-directed thrusting and metamorphism in the Late Jurassic and Early Cretaceous

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(Schiarizza and Preto, 1987). Metamorphic grade ranges between the chlorite and (near North Queest Mountain) staurolite zones.

STRUCTURAL CROSS-SECTION

Figure 1-6-3 shows a cross-section through the Hunters Range between Three Valley Gap and Mara Lake. Precambrian basement gneisses and mantling metasedimentary strata of the Monashee Complex (Read and Brown, 1981) form the lowermost of three tectonic panels, separated from the overlying Shuswap terrane by the Monashee décollement. The Monashee décollement, an exhumed mid-crustal shear zone, was the locus of Middle Jurassic compressional shearing and large-scale east-directed overthrusting culminating in the Late Cretaceous or Paleocene (Journeay, 1986; Brown and Journeay, 1987). The position of the décollement in the section is based on Brown and Journeay (1987).

The Shuswap terrane forms the middle panel, between the Monashee décollement and the Eagle River fault. The heavy black line near the topographic surface is a first-order approximation of the form surface defined by the stratigraphic sucession described earlier. The top of this line corresponds to the calc-silicate unit and is constrained by down-plunge projections. The thickness of the line is partly schematic, but it corresponds to the base of the thick amphibolite unit where it can be constrained. The position of the Eagle River fault, which forms the "lid" to this middle panel, is estimated from apparent dips of the fault in the Eagle River valley, north of the section.

Relationships that are readily apparent from Figure 1-6-3 are: (1) the panel of Shuswap terrane between the Monashee décollement and the Eagle River fault is weakly to mildly folded, and apparently contains no major structural breaks; (2) the Monashee décollement ramps upward in the direction of transport, cutting up-section in its hangingwall; (3) the Eagle River fault cuts down-section in its footwall. The geometry of the Eagle River fault bears a striking similarity to the arched profile of a mature detachment terrane that has rebounded isostatically in response to denudation (see Wernicke, 1985, Figure 3d). The validity of this section awaits testing by the LITHOPROBE project.

ACKNOWLEDGMENTS

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