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GEOLOGY OF THE QUESNEL TERRANE IN THE SPANISH LAKE AREA, CENTRAL BRITISH COLUMBIA* (93A/11)

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KEYWORDS: Regional geology, Quesnel terrane, Likely, Triassic black phyllites, structural geology, stratigraphy.

INTRODUCTION

The following paper summarizes the preliminary results of detailed mapping in the Spanish Lake area, Likely, central British Columbia. Fieldwork during the 1987 season was conducted in conjunction with mapping by A. Panteleyev and D.G. Bailey (this volume) to the south and west respectively. Regional mapping was initiated in 1986 (Panteleyev, 1987; Bloodgood, 1987b) to focus on the details of structure, stratigraphy and mineralization within the sedimentary and volcanic assemblages comprising the Quesnel belt within map sheet 93A. Fieldwork during the 1987 season extended mapping further to the north along the northwesterly trend of the Quesnel belt (Figure 1-12-1). The intent of this study is to elucidate the details of structure and stratigraphy within the Triassic metasedimentary sequence in the Spanish Lake area, and to determine possible controls on mineralization. The 1987 field studies focused on detailed structural and stratigraphic examination of the Triassic black phyllites. Regional correlations of the stratigraphic variations recognized within the black phyllite package were based upon previous work to the south, in the Eureka Peak area (Bloodgood, 1987a, 1987b), and recent work in the Quesnel Lake area by Struik (1983), Rees (1981) and Rees and Ferri (1983).

GEOLOGIC SETTING

The Spanish Lake area lies immediately east of Likely in central British Columbia. An area of approximately 400 square kilometres was examined, bounded to the south and west by the northern shore of Quesnel Lake; the eastern and northern map boundaries are defined by the trace of the Eureka thrust. The area lies within the Quesnel terrane (Struik, 1986) of the Intermontane Belt (Monger *et al.*, 1982) and is adjacent to the Omineca Belt–Intermontane Belt tectonic boundary (Figure 1-12-1). This tectonic boundary is believed to represent a convergent zone between the arc-related Quesnel terrane and the parautochthonous Barkerville terrane of the Omineca Belt to the east. The terrane boundary is defined by the Eureka thrust (Struik, 1986).

Underlying the area are middle Triassic to early Jurassic sedimentary and volcanic rocks, which historically have been correlated to the Quesnel River Group and Takla Group (Campbell, 1978; Rees, 1981; Tipper, 1978). More recently they have been informally correlated with the Nicola Group to the south, where rocks of equivalent age and lithology have been recognized within the Quesnel terrane. A mafic

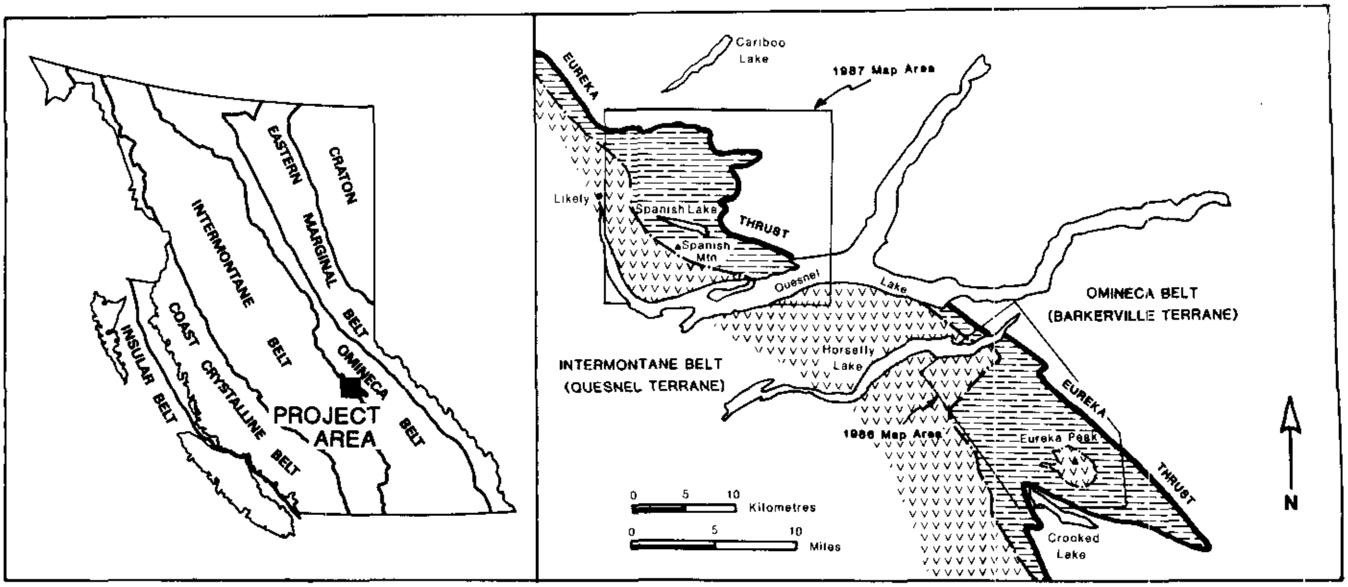

Figure 1-12-1. Location of the 1987 and 1986 map areas, with the configuration of the Omineca–Intermontane Belt tectonic boundary, defined by the Eureka thrust. The distribution of the Triassic metasediments is indicated by the stippled pattern; they are overlain by volcanics to the west.

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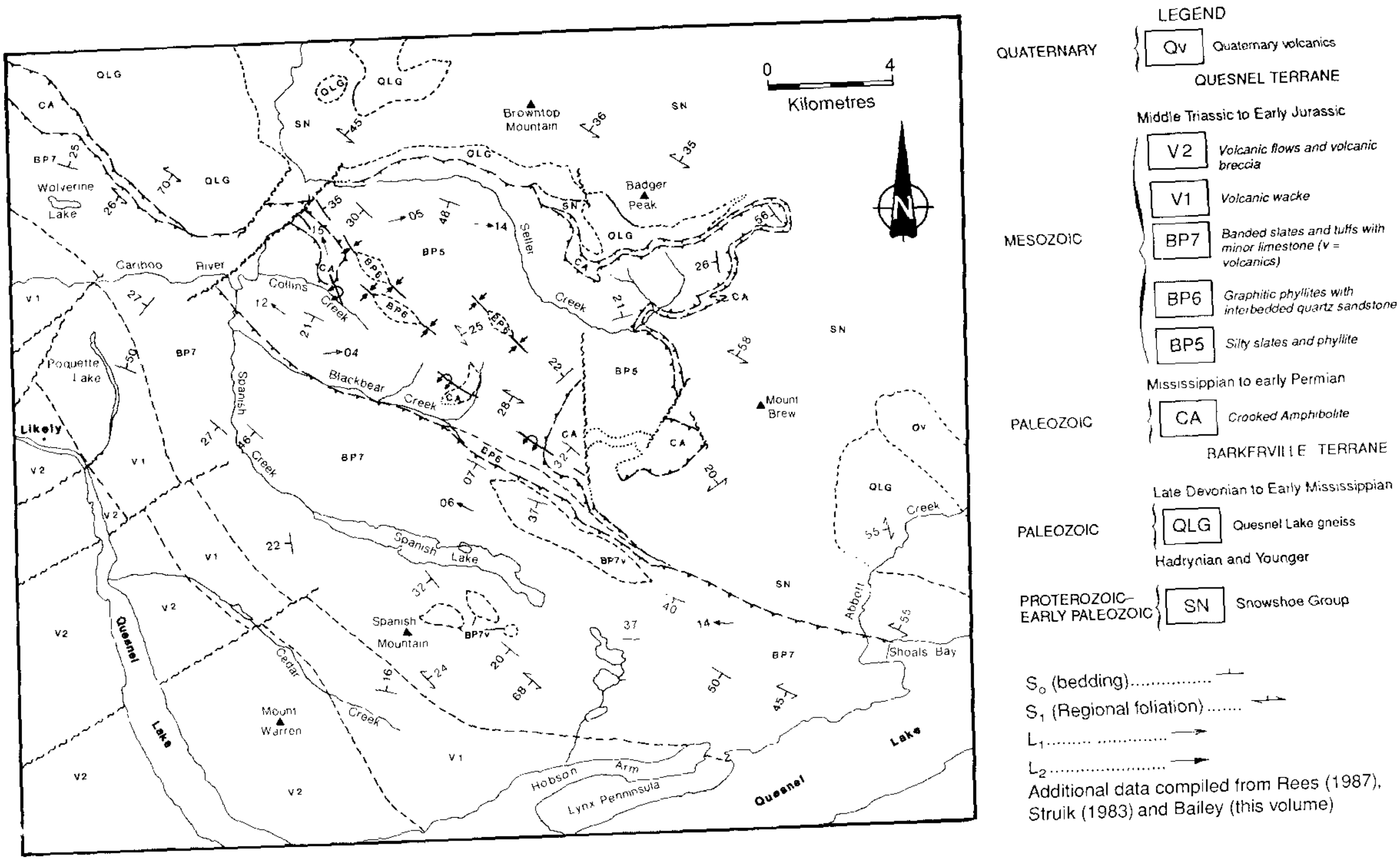

Figure 1-12-2. Generalized geologic map of the Spanish Lake area.

volcanic unit, the Crooked amphibolite, is the basal unit of the Quesnel terrane (Struik, 1986). It occurs discontinuously along the terrane boundary, and may be correlative to the Slide Mountain terrane exposed further to the north.

The Quesnel terrane overlies Hadrynian to early Paleozoic metasediments of the Snowshoe Group, and locally is in direct contact with the Quesnel Lake gneiss. These two units comprise the Barkerville terrane within the area.

STRATIGRAPHY

Field studies during the 1987 season concentrated upon establishing the finer stratigraphic details within the black phyllites. For a unified understanding of the regional geology, all of the major map units will be briefly described, with more detailed descriptions of the units identified within the phyllites. Figure 1-12-2 depicts place names, and areal distribution of the lithologies and structures in the discussion that follows.

BARKERVILLE TERRANE

SNOWSHOE GROUP

Rocks of the Snowshoe Group comprise the oldest lithologies observed within the area. They are well exposed in the northern part of the map area, to the north of Seller Creek. The Snowshoe Group consists of interbedded, dark grey to olive, pelitic and semipelitic schist, laminated micaceous quartzite, siliceous dark grey phyllite and metasiltite, with subordinate dark micritic limestone, grit, wackestone and amphibolite. Detailed mapping by Struik (1983) has delineated finer subdivisions within this map unit.

QUESNEL LAKE GNEISS

The Quesnel Lake gneiss occurs as a large intrusive body within the Snowshoe Group metasediments. Megacrystic quartz-feldspar augen gneiss of granitic composition comprises the unit within the map area. The Quesnel Lake gneiss is well exposed north of the Cariboo River where it occurs as a large body adjacent to the tectonic boundary. Along this contact, the gneiss contains a mylonitic fabric and is mechanically intercalated with the Crooked amphibolite which structurally overlies it (Plate 1-12-1). To the north of Seller Creek, the gneiss appears to be structurally overlain by the Triassic metasediments of the Quesnel terrane. Unfortunately the contact between the two is not exposed. Uranium-lead dating of the Quesnel Lake orthogneiss further to the south has constrained the age of emplacement as Late Devonian to Middle Mississippian (Mortensen *et al.*, 1987).

Plate 1-12-1. Mechanical intercalation of Quesnel Lake gneiss and the Crooked amphibolite along the Eureka thrust.

QUESNEL TERRANE

CROOKED AMPHIBOLITE

The Crooked amphibolite defines the basal unit of the Quesnel terrane. It overlies both the Quesnel Lake gneiss and the Snowshoe Group. It is well exposed north and west of the Cariboo River, where it overlies the Quesnel Lake gneiss, and it occurs discontinuously along the eastern trace of the boundary. The base of the Crooked amphibolite defines the Eureka thrust along which mechanical intercalation of the amphibolite with adjacent units is observed everywhere that the contact is exposed.

Medium to dark green, well-foliated talc chlorite schist, amphibolite, serpentinite and ultramafic rocks comprise the Crooked amphibolite within the map area. Compositional layering within the chlorite schists and amphibolites is defined by alternating plagioclase and hornblende-rich layers, 2 to 5 centimetres thick. The ultramafics occur as large, rusty weathering, lensoid bodies of serpentinized harzburgite near the tectonic boundary, and as smaller lenses (up to 2 metres) within individual exposures.

TRIASSIC BLACK PHYLLITE

Four mappable units have been defined in the Spanish Lake area. Differentiation of each unit and correlation with units recognized in the Eureka Peak area are based solely upon field observations of lithologic variations.

SILTY SLATES AND PHYLLITES (UNIT 5)

The basal member of the sedimentary succession is presently correlated with "Unit 5" of the Eureka Peak area (Bloodgood, 1987a, 1987b), and consists of reddish brown-weathering, dark to medium grey phyllites. Bedding is defined by fine compositional laminations and grey siltstone beds, 1 to 10 centimetres thick. Rusty to sandy weathering schistose tuffs occur locally, with an average thickness of 1 metre. Cleavage is always well developed; the unit is characterized by a planar slaty to phyllitic foliation. Carbonaceous material is commonly concentrated on cleavage planes.

The unit is well exposed along the roadcuts immediately south of Seller Creek, and comprises the bulk of the metasediments exposed to the north of Blackbear Creek.

GREY PHYLLITES AND INTERBEDDED SANDSTONES (UNIT 6)

This unit outcrops less extensively than Unit 5, and is generally confined to the core region of small synformal folds north of Spanish Lake. The basal contact with Unit 5 is gradational over a distance of several metres. Bedding is defined by pale grey, parallel-laminated siltstone beds, generally less than 2 centimetres thick (Plate 1-12-2). The consistently well-bedded, thin, light-coloured siltstone beds are characteristic of this unit, and distinguish it from the monotonously grey silty phyllites of Unit 5. Based on lithologic similarities, this unit is correlated with "Unit 6" in the Eureka Peak area (Bloodgood, 1987a, 1987b).

TUFFS, SLATES AND PHYLLITES (UNIT 7)

Stratigraphically and structurally upsection, a package of mixed volcanics and sediments is recognized, and is in thrust contact with the underlying sequences along its entire strike length. It is well exposed south of Blackbear Creek, underlying the Spanish Lake and Spanish Mountain areas. It is lithologically distinguished from the underlying phyllitic sequence due to the incorporation of a distinct volcanic component in the sediments. Lithologically, it appears to be equivalent to "Unit 7" of the Eureka Peak area (Bloodgood, 1987a, 1987b).

Very black, rusty weathering, slaty to phyllitic metasediments comprise the sedimentary component of this unit. Individual finely laminated beds range from 3 to 50 centimetres thick. Minor pale silt and sand horizons are observed near the base of the unit and range in thickness from 1 to 4 centimetres. Colour laminations are common within the individual beds. Dark brown to black-weathering, grey limestones occur throughout the unit. Conodonts obtained from these limestones range in age from Anisian to Ladinian, and indicate possible imbrication within the unit (L.C. Struik, personal communication, 1987).

The volcanic component of the sequence increases progressively upsection, and consists of banded tuffs, volcanic conglomerate, flow breccias and local pillow lavas. Pale green, rusty weathering tuffs are interbedded with black slates and range in thickness from 2 centimetres to 1.5 metres. Locally, white-weathering, pale green tuffs dominate the succession. They are characteristically very siliceous and well banded; bedding varies from 2 to 5 centimetres thick. Despite the siliceous nature of this unit, a penetrative planar cleavage is usually well developed. Locally overlying the banded tuffs is a discontinuous volcanic conglomerate containing clasts of the underlying tuffs. Occurring as discontinuous lenses are volcanic flow breccias and pillow lavas which are well exposed on several prominent knobs east of Spanish Mountain. Compositionally and texturally, the flow breccias appear equivalent to the augite-bearing porphyritic flows which occur at the base of the volcanic sequence farther to the west (Bailey, this volume), and to the south in the Eureka Peak area (Bloodgood, 1987a). Dykes of the same composition occur locally, and are believed to represent feeders to the overlying volcanic sequence.

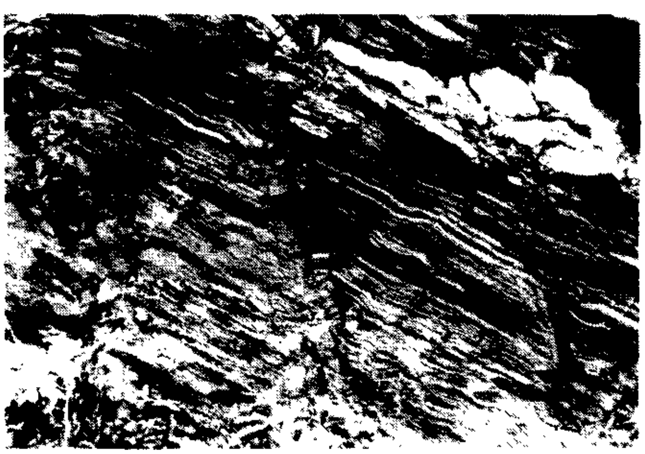

Plate 1-12-2. Thinly bedded, light-coloured siltstones characterize the bedding within "Unit 6". A barren quartz vein is observed shallowly truncating bedding in the upper right.

VOLCANIC WACKES

Coarse-grained, green volcanic sandstones and wackes comprise the uppermost unit of the sedimentary package. It is well exposed along the main road north of Likely, and to the south of Spanish Mountain. Interbedding of siltstones and sandstones and minor black argillaceous sediments defines bedding, which is generally obscure in this unit. Schistosity is poorly developed and is only present locally. No lithologically equivalent units are recognized in the Eureka Peak area.

VOLCANICS

Volcanic rocks of Triassic to Jurassic age immediately overlie the sediments described above. The contact between the sediments and volcanics is not exposed, but must occur in the Cedar Creek valley. The basal member of the volcanic sequence consists of augite-bearing flows and local pillow lavas. These are well exposed on Mount Warren, south of Cedar Creek. Equivalent lithologies are recognized in the Eureka Peak area, marking the base of the volcanic sequence. The remainder of the overlying volcanic sequence has been examined by Bailey (this volume).

STRUCTURE

FOLDING

Overprinting relationships of structural elements (bedding, cleavage, lineations) indicate that two phases of deformation involving folding have occurred.

PHASE 1 DEFORMATION

First phase structures (F_1) are recognized throughout the area and are represented by "mostly northeast-verging" folds of bedding (S_0). A penetrative slaty to phyllitic foliation (S_1), dipping shallowly to moderately to the southwest, is well developed axial planar to F_1 folds. The intersection of bedding and cleavage defines an intersection lineation parallel to the F_1 minor fold axes. A mineral elongation lineation is observed locally. First phase linear structures plunge gently to the northwest and southeast, in the azimuth range of 320 to 350 degrees.

First phase structures are developed at all scales throughout the area. Small-scale isoclinal folds of bedding are pervasively developed, and there is evidence for larger scale overturned to recumbent folds. The structural vergence observed on mesoscopic F_1 folds, and the map pattern outlined by the exposures of Crooked amphibolite south of the Cariboo River, indicate a large antiformal culmination in this area, which is interpreted as a large, easterly verging Phase 1 nappe structure.

Phase 2 Deformation

Phase 2 structures (F_2) overprint and refold F_1 structures throughout the area. Structural elements associated with F_2 are a well-developed nonpenetrative cleavage (S_2), manifest as a crenulation cleavage, or a spaced cleavage, or locally a fracture cleavage (Plate 1-12-3). A prominent lineation is defined by the intersection of S_0/S_2 or S_1/S_2. The intersection lineation is parallel to the fold axis of mesoscopic F_2 folds, and S_2 is developed axial planar to F_2 mesoscopic structures.

F_2 folds occur as open, buckle folds and conjugate kink-type folds. The axial surfaces of F_2 structures are present as conjugate sets dipping moderately to the northeast and southwest. Linear structures associated with F_2 are curvilinear along the trace of the F_2 hingeline (Plate 1-12-4), and plunge gently to the northwest and southeast. Within the hinge region of mesoscopic F_1 folds, the S_2 surface approaches into near parallelism with the S_1 surface. This geometric relationship characterizes the area north of Spanish Lake where an F_1 nappe is postulated.

The overprinting of F_1 structures by F_2 deformation, at a slightly oblique angle, is responsible for the development of a series of antiformal culminations and synformal depressions recognized throughout the area. This fold interference geometry is further enhanced by the doubly plunging nature of both the F_1 and F_2 fold axes. The map pattern of "Unit 6", which is restricted to lozenge-shaped synformal depressions, is attributed to this geometric relationship. This structural geometry, characterized by an arching in the hinge region, has resulted in the exposure of deeper structural levels within the core region of the F_1 structure.

Phase 3 Deformation

Phase 3 deformation is ubiquitous throughout the area as a spaced cleavage and fracture set. The fractures dip steeply to the north and south. Fracture spacing varies according to

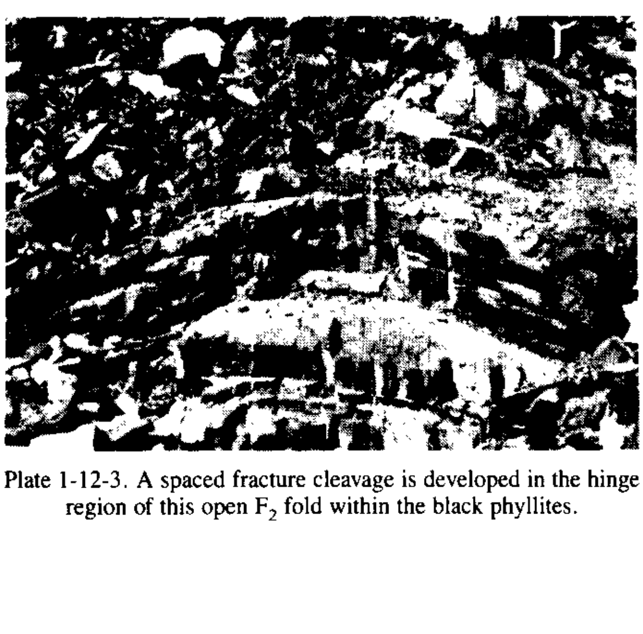

Plate 1-12-3. A spaced fracture cleavage is developed in the hinge region of this open F_2 fold within the black phyllites.

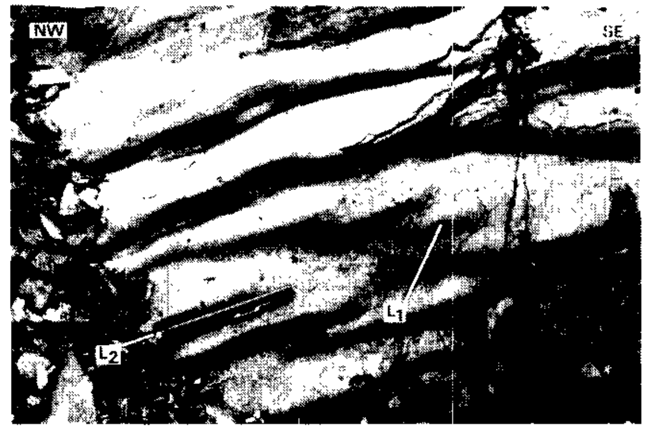

Plate 1-12-4. Plan view of a slaty cleavage (S_1) surface which has been folded by F_2. The plunge of the F_2 fold axis changes along the trace of the F_2 hingeline (parallel to the eraser), giving rise to doubly plunging structures. The first phase lineation (L_1) defined by the intersection of bedding (S_0) on the slaty cleavage surface (S_1) can be seen in the lower right.

lithology, and ranges from about 1 centimetre to 1 metre. No macroscopic folds are associated with this structural event which overprints all previously developed fold forms.

FAULTING

Thrust Faults

Three major thrust faults are recognized in the area: the Eureka thrust; a thrust at the base of the metasedimentary package; and a thrust at the base of the tuff-phyllite unit.

Thrust faults are believed to be synchronous to F_1 deformation and are overprinted and deformed by F_2 structures.

The Eureka thrust is a low-angle, southwesterly dipping fault at the base of the Quesnel terrane. The Crooked amphibolite occurs discontinuously along the terrane boundary, and where it is absent, the Triassic metasediments immediately overlie the fault. Mechanical intercalation of the Crooked amphibolite with Quesnel Lake gneiss is well exposed on the large, logged knobs north of the Cariboo River.

A second thrust occurs at the base of the metasedimentary package. Near Collins Creek, imbrication of Crooked amphibolite with the overlying phyllites is well exposed. Plate 1-12-5 illustrates the faulted contact between these two units and also shows a well-developed S_2 fabric overprinting the fault zone. This fault is inferred from topographic features and confirmed by stratigraphic correlations to the Eureka Peak area, which indicate that the lower portion of the sedimentary stratigraphy recognized in that area is absent in the Spanish Lake area. It is believed that thrusting along the tectonic boundary affected higher structural levels, resulting in the removal of lower stratigraphic units.

A thrust contact is observed at the base of Unit 7 which discordantly overlies the Crooked amphibolite north of Cariboo Lake. In this area, mechanical intercalation resulting from thrusting is evident along the contact. North of Spanish Lake, Unit 7 directly overlies Units 5 and 6 of the black phyllite stratigraphy and, further to the east, metasediments and volcanics of Unit 7 overlie the Snowshoe Group. Ages of

Plate 1-12-5. Imbrication along the contact between the Crooked amphibolite and the Triassic metasediments. An imbricate slice of Triassic sediments lies in the hangingwall of this fault. Quartz-filled fractures are prominent close to the fault zone, which is overprinted by F_2 southwesterly dipping crenulations.

conodonts obtained from this unit indicate that it may also be internally imbricated (L.C. Struik, personal communication, 1987).

Normal Faults

Numerous steeply dipping, northeast-trending normal faults have been recognized within the volcanic sequences to the west of the study area (Bailey, this volume). These faults post-date the regional folding. High-angle faults are recognized in the metasediments and may be related to the Phase 3 spaced fractures which are well developed in the mapped area. Recognition of major throughgoing faults within the sediments is hindered by the subtlety of the stratigraphic variations.

MINERALIZATION

Gold mineralization within the metasedimentary sequences throughout the Quesnel gold belt is intimately associated with quartz-filled fractures. A detailed study was undertaken as part of this project, in order to document the association of mineralization with vein geometry, mineralogy, stratigraphic interval and structural position. It suggests mineralization may be related to the migration of fluids along major detachment surfaces recognized within the Quesnel terrane.

Veins are observed on all scales within the Spanish Lake area. Extension fractures are generally filled by quartz, or less commonly quartz-carbonate. The fibrous nature of the quartz filling is often evident in smaller fractures; larger fractures are characterized by a much blockier quartz filling. The veins range in size from small incipient quartz-filled veinlets which outline rootless isoclines (Plate 1-12-6) to much larger veins, up to 2 metres in thickness. Deformed and undeformed quartz veins occur on all scales, along the limbs of mesoscopic folds and localized in the hinge region of mesoscopic folds. This geometric relationship of the filled fractures to the mesoscopic structures indicates that fracturing began early, and continued throughout the deformational history, resulting in some fractures which are intensely deformed, while others remain unaffected by deformation.

Plate 1-12-6. Small quartz-filled fractures outlining rootless isoclines. The penetrative slaty cleavage is axial planar to these small folds which developed early in the deformational history.

In the Eureka Peak area, mineralization occurring as gold-pyrite-quartz veins is most prominent in the hinge region of second phase folds at a specific stratigraphic horizon. In contrast, preliminary observations in the Spanish Lake area suggest that gold mineralization may be concentrated near the intersection of merging fault zones. More detailed analysis of the data collected during the summer will be needed to substantiate this hypothesis.

CONCLUSIONS

(1) The stratigraphy within the metasedimentary sequence has been documented within the Spanish Lake area, and can be correlated with that defined in the Eureka Peak area, farther to the south. Correlation of units of similar lithology suggests that a large section of the basal portion of the stratigraphy is absent in the Spanish Lake area.

(2) Correlation of the morphological characteristics of structural elements associated with the major deformational events indicates that they are equivalent to

those documented in the Eureka Peak area. The geometry of the two major fold phases differs between the areas, and probably reflects differences in strain geometry and magnitude along the terrane boundary during and following initial plate convergence between terranes. The recognition of a regional F_1 structure contrasts with the Eureka Peak area, where no F_1 structures of regional extent have been identified (Ross *et al.*, 1985).

(3) Formation of thrust faults, that are frequently controlled by bedding contacts, occurred early in the deformational history. Both the Eureka thrust and the thrust at the base of Unit 7 are recognizable in both the Spanish Lake and Eureka Peak areas. These faults are overprinted by F_2 folds. Thrusting along bedding surfaces probably occurred in response to accumulated strain along contacts between rocks of differing composition and thus rheology. Internal imbrication of Unit 7 has been suggested by Struik (personal communication, 1987) based on ages obtained from conodonts extracted from this unit.

(4) Stratigraphic and structural evidence indicates a deformational history involving the development of regional easterly verging fold structures accompanied by easterly directed thrusting during the initial stages of accretion of the Quesnel terrane to North America. Due to the strong evidence supporting deformation by thrusting within the area, it is possible to interpret the geology in terms of an F_1 eastward verging nappe, which formed during Phase 1 deformation. With progressive deformation, detachment surfaces developed along zones of higher strain, resulting in the shearing out of the lower limb of the nappe. Only the upper limb is preserved, and hence, only the upper portion of the metasedimentary stratigraphy. North of the Cariboo River, only Unit 7 is preserved along the boundary. This same relationship is observed farther north in the Dragon Lake area (Struik, 1984). It is believed that internal imbrication within the Quesnel terrane resulted in the preservation of progressively higher stratigraphic "slices" of the metasedimentary package from south to north, as observed along the terrane boundary.

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