STRUCTURAL GEOLOGY OF THE PROUT PLATEAU REGION, ISKUT RIVER MAP AREA, BRITISH COLUMBIA (104B/9)

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INTRODUCTION

The Iskut River map area contains several important mineral deposits and has been the focus of numerous recent geological studies, including government sponsored regional surveys (Alldrick and Britton, 1988; Britton and Alldrick, 1988; Anderson, 1989; Alldrick *et al.*, 1989, 1990; Britton *et al.*, 1989b, 1990; Anderson and Thorkelson, 1990) and extensive property-scale mapping conducted by mining companies. Despite the large amount of exploration work within the area, its structural history is poorly understood and even the stratigraphic framework is only established at a basic level. A regional-scale structural and stratigraphic framework is essential to further evaluate the metallogeny of the area, and will be useful for designing strategies for future exploration programs.

A regional study of the structural evolution of the Iskut River area is one important aspect of the multifaceted Iskut River metallogeny project currently being conducted by the Mineral Deposit Research Unit at the University of British Columbia. This study began with geologic mapping in the Unuk River map area during the 1991 field season. Long-term objectives are to provide a regional structural and stratigraphic framework for the area, which will then be integrated with property-scale studies focusing on relationships between mineralization and deformation. These goals will be achieved through 1:20 000-scale geological mapping of key areas which feature well-exposed rocks and potentially significant structural and stratigraphic relationships. Deposit-scale mapping by other MDRU researchers, and property maps provided by MDRU industry members will

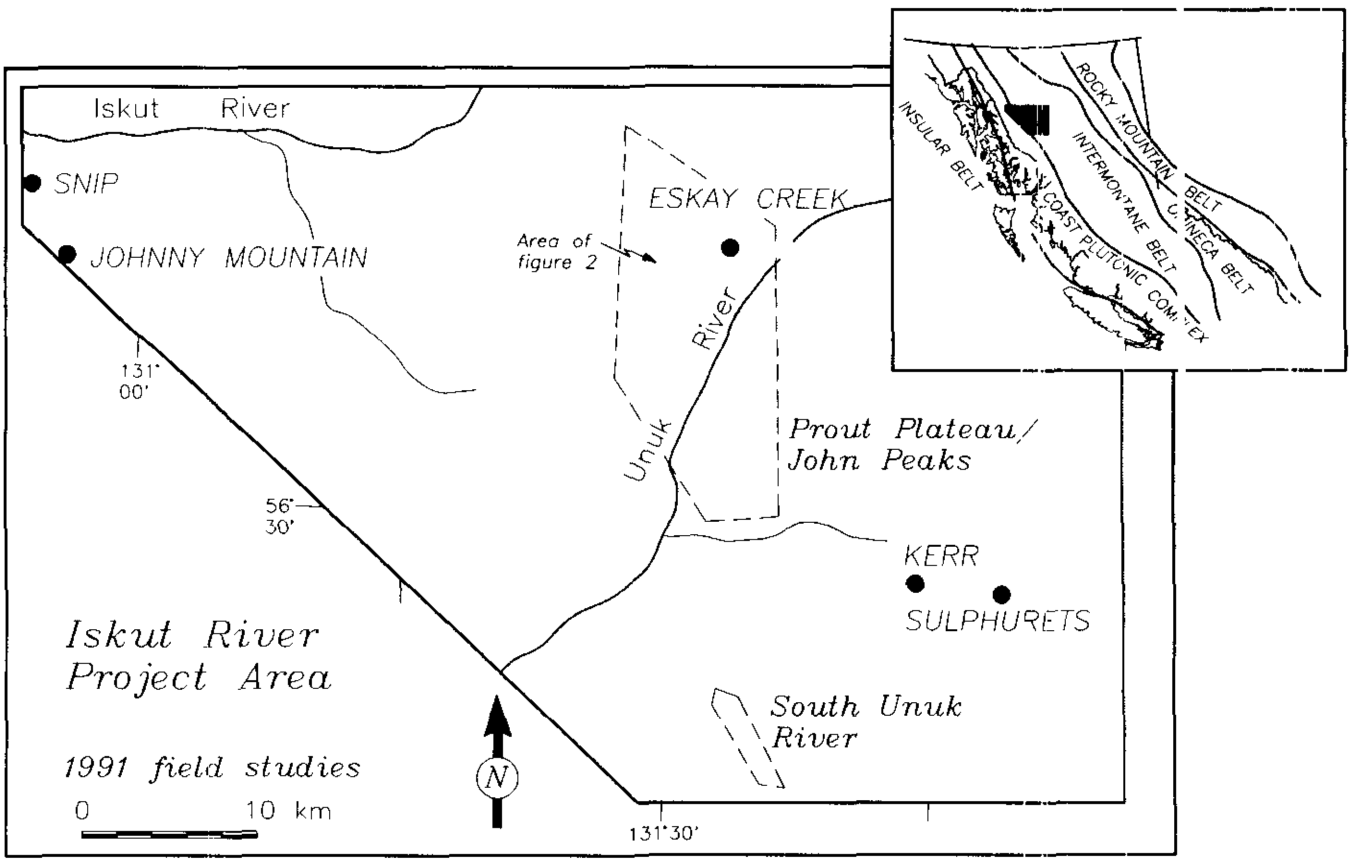

Figure 6-5-1. Location of the Iskut River map area within the five tectonic belts of the Canadian Cordillera, and locations of areas examined during the 1991 field season.

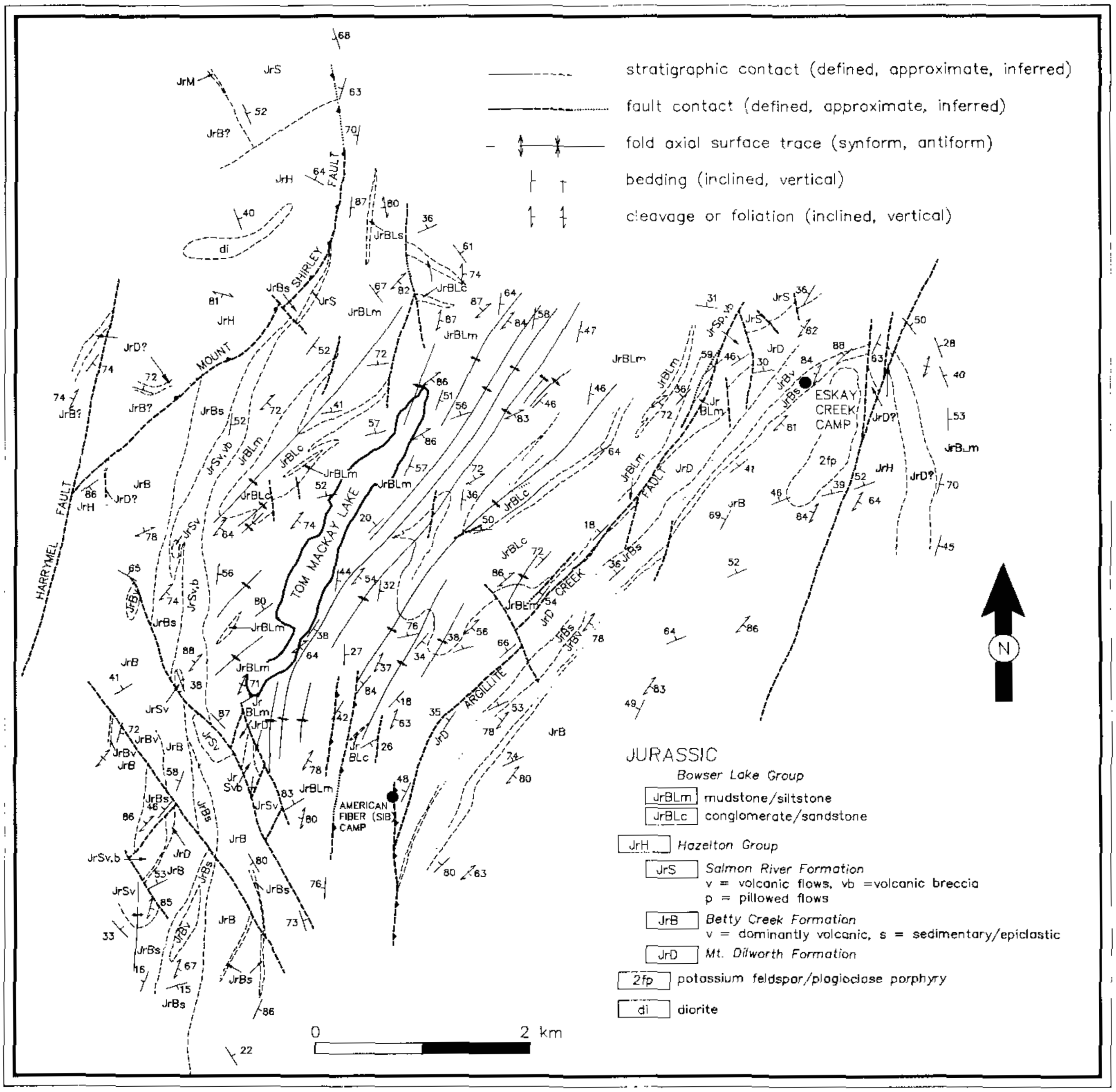

Figure 6-5-2. Simplified geologic map of the Prout Plateau area, based on 1991 fieldwork.

be combined with the new regional mapping to provide the most up-to-date geologic compilation of the Iskut River area.

Mapping during the 1991 field season concentrated on the John Peaks and Prout Plateau areas and exposures of the South Unuk River fault (Figure 6-5-1). Preliminary results from the Prout Plateau area are discussed in this paper; other work will be presented in future reports.

GENERAL GEOLOGY

The Prout Plateau is underlain by rocks of two major stratigraphic divisions. Rocks of the lower division belong to a regionally extensive sequence of Lower Jurassic volcanic and epiclastic rocks of the Hazelton Group more than 2 kilometres thick. Hazelton Group rocks are conformably overlain by argillites, sandstones and conglomerates of the Middle and Upper Jurassic Bowser Lake Group. Intrusive rocks are volumetrically minor, and include potassium feldspar-plagioclase-hornblende porphyritic dikes and stocks (Premier porphyry) and scattered aphyric dikes of varied composition. The stratigraphy and alteration history of Hazelton and Bowser Lake rocks in the Prout Plateau area is the subject of R. Bartsch's M.Sc. thesis at The University of British Columbia, and preliminary results from his study appear elsewhere in this volume (Bartsch, 1992).

Rocks of the Bowser Lake Group form the lowest overlap assemblage within the Bowser Basin, which occupies much of the northern Intermontane Belt. The Prout Plateau area contains some of the most westerly exposures of this important rock package, and geological relationships with older rocks there will probably be critical to unravelling the tectonic history of the Bowser Basin. The plateau also lies near the boundary between the Skeena fold belt to the east (Evenchick, 1991) and the Coast Plutonic Complex to the west, and mapping here will contribute to understanding of the transition between these major tectonic features.

Existing geological maps (Grove, 1986; Alldrick *et al.*, 1989) show the structural geology of the plateau area as dominated by a major north to northeast-trending syncline-anticline-syncline fold sequence. Faults mapped or inferred in the area, although continuous for several kilometres, do not offset stratigraphic contacts appreciably. One notable exception is the Unuk-Harrymel fault, which skirts the western edge of the Unuk River map area and has inferred east-side-down displacement (Britton *et al.*, 1989b). The Hazelton Group – Bowser Lake Group contact is exposed for several tens of kilometres along the limbs of the fold triplet sequence, making the area ideal for examining transitions in structural style between the two units. The Early to Middle Jurassic age range of the units also provides the opportunity to evaluate the regional affects of a proposed Early Jurassic deformation event in the Iskut River area (Bevier and Anderson, 1991).

RESULTS OF THE 1991 FIELDWORK

STRATIGRAPHY

An analysis of Hazelton Group stratigraphy in the Prout Plateau area is presently being conducted by R. Bartsch (Bartsch, 1992) and only a brief summary is presented here. The Lower to Middle Jurassic Hazelton Group in the Iskut River area is conventionally divided, in ascending order, into the Unuk River, Betty Creek, Mount Dilworth and Salmon River formations (Anderson, 1989). Existing maps show that the upper three of these units are exposed in the Prout Plateau area. However, lithofacies within these formations are very variable and laterally discontinuous, leading to correlation difficulties. In general, the lowest rocks exposed consist of epiclastic and volcanic strata which have historically been correlated with the Betty Creek Formation. In the Eskay Creek area (Figure 6-5-2), four units are mappable within this sequence: a lower volcanic and epiclastic unit of intermediate composition, an overlying package of epiclastic sandstone, siltstone, conglomerate and local fossiliferous carbonate, an upper intermediate to felsic volcanic unit ("footwall dacite" at Eskay Creek, Britton *et al.*, 1989a), and a thin, laterally discontinuous mudstone-siltstone package. These four map units can be traced the length of the Eskay Creek and SIB properties with only minor fault offsets (Figure 6-5-2), but are not individually mappable in the Mount Shirley area to the west. Felsic fragmental and massive volcanic flows and pyroclastic rocks, presently correlated with the Mount Dilworth Formation, overlie the epiclastic and volcanic succession in most, but not all locations. Uppermost Hazelton Group rocks consist of basaltic to andesitic flows of the Salmon River Formation. These rocks include pillowed flows, volcanic breccias and massive flows, and contain variable amounts of interbedded mudstone. On the north slope of Mount Shirley, extensive areas of pillowed flows, tentatively assigned to the Salmon River Formation, contain thinly bedded felsic tuffaceous intervals. Lithologies of the Salmon River Formation grade in a north to south direction from pillowed flows, to broken pillow breccias and volcanic breccias, to massive flows.

The base of the Bowser Lake Group is mapped at the top of the highest occurrence of volcanic rocks within the Salmon River Formation. Although this boundary is easily mapped on the Prout Plateau, in surrounding regions where the Salmon River Formation consists entirely of fine-grained sedimentary rocks, it can be a difficult distinction to make, and some workers advocate placing the Hazelton Group – Bowser Lake Group boundary below the Salmon River Formation (Kirkham *et al.*, in preparation). At Prout Plateau, the Bowser Lake Group is distinguished by thick sequences of rhythmically bedded mudstone and siltstone, which enclose laterally discontinuous sandstone and chert-pebble conglomerate layers. Thickest accumulations of coarse clastic rocks occur adjacent to the Eskay Creek area. Although these units are several hundred metres thick near Eskay Creek, they pinch out completely a few kilometres to the west.

STRUCTURAL GEOLOGY

BOWSER LAKE GROUP

The present structural geometry of the Prout Plateau area reflects folding and faulting associated with significant amounts of east-west shortening in both Bowser Lake Group and Hazelton Group strata. Bowser Lake Group rocks are best exposed in a major north-plunging syncline which encloses the Tom Mackay Lake area (Figure 6-5-2). Lithologies here are dominated by thick sequences of thinly bedded siltstone and mudstone, with lesser conglomerate and sandstone layers.

In general, intensity of deformation and amounts of shortening increase southward toward the pinch-out of Bowser Lake strata in the hinge of the syncline. At Tom Mackay Lake and northwards, second order folds within the major syncline are symmetric, have wavelengths of 400 to 800 metres, and have rounded to subangular hinges with interlimb angles of about 90°. Faults in this area have only minor offset, but some unrecognized layer-parallel slip is likely. Simple estimates of the amount of shortening based on fold geometry, indicate a minimum of approximately 40 per cent east-west shortening; total shortening will also include a component of penetrative strain leading to cleavage formation, and this estimate therefore represents a minimum value.

The contact between the Hazelton Group and the Bowser Lake Group near Tom Mackay Lake is either faulted or conformable, depending on the locality. Bedding truncations, missing stratigraphy and localized tectonism in Bowser Lake Group rocks along the east side of Mount Shirley indicate that the west side of the syncline is cut by a

A.

B.

C.

Plate 6-5-1. Examples of mesoscopic structural fabrics in the Prout Plateau region: (a) slaty cleavage in thinly bedded mudstone and siltstone of the Bowser Lake Group; (b) sharply refracted penetrative cleavage in tuffaceous sediments of the Betty Creek Formation; (c) clast-flattening fabric perpendicular to cleavage surfaces in volcanic conglomerate of the Betty Creek Formation.

steeply west-dipping fault in that area. Southward, this fault joins, or is cut by, the Harrymel fault, and the two rock packages are conformable. On the eastern limb of the western syncline, the contact between the Bowser Lake and Hazelton groups is the Argillite Creek fault. Both the faulted contact and stratification within these units dip steeply to the northwest. Speculation that the contact is an unconformity is not supported, given the lack of a basal shallow-water deposit in the younger sequence, the apparent truncation and tectonism in overlying units and the rapid thickening of the rhythmically bedded siltstone-mudstone package southward (Figure 6-5-2).

South of Tom Mackay Lake, toward the syncline closure, Bowser Lake Group strata are more strongly deformed, but the poorer exposure at lower elevations makes mapping of continuous structures difficult. At the south end of the lake, fold axial surfaces are more closely spaced than farther north, and fold limbs are locally overturned. In this same area, folds with a strong westerly asymmetry are cut by westerly directed thrust faults, and axial surfaces swing to a more northerly orientation. Shortening amounts are difficult to estimate due to uncertainty in determining fault cut-off locations, but fold geometry alone requires in excess of 50 per cent east-west shortening. Contacts with Hazelton Group rocks are different from those found farther north as well: on the west syncline limb, steeply dipping faults striking 150° truncate folds in the Bowser Lake Group and juxtapose the sedimentary strata against lower parts of the Hazelton Group to the west. These faults are not usually exposed in outcrop, but are easily recognized by structural or stratigraphic truncation and topographic expression. The simplest interpretation of movement history involves hundreds of metres of east-side-down displacement. On the eastern limb, the contact is faulted along Coulter Creek where the contact between the two units dips gently to moderately eastward. The geometry here is consistent with a west-vergent thrust fault contact placing Hazelton Group rocks over Bowser Lake Group strata.

The Bowser Lake Group has not been mapped in detail southward through the syncline closure, but projection of structural styles south down Coulter Creek suggests a strongly tectonized, fault-bounded package of sediments within the fold core, an inference corroborated by reconnaissance examinations (R. Bartsch, personal communication, 1991). The faulted fold-closure probably lies near the confluence of Coulter Creek and the Unuk River, where the bounding faults merge.

HAZELTON GROUP

Hazelton Group rocks are best exposed in the anticline core east of Tom Mackay Lake and on the western edge of the Prout Plateau, south of Mount Shirley. In general, they are more massive and stratigraphic markers are less continuous than in the overlying Bowser Lake Group; consequently mappable structures are more difficult to define. Hazelton Group units are broadly folded and are cut by several generations of steeply dipping faults. South of Mount Shirley, two sets of faults are common: earlier faults are subvertical, strike 030° to 050°, and expose older strata on their northwest sides. More regionally continuous, steeply dipping faults striking 145° to 155° truncate the older faults, and generally expose older strata on their southwest sides. In places these younger faults separate the Bowser Lake Group from the Hazelton Group. Slip-direction indicators are lacking for both sets of faults. Broad, north to northwest-trending folds in the Hazelton Group are cut and offset by the northwest-striking faults, resulting in locally complex contact distribution patterns along the ridge south of Mount Shirley. Mapping along the flanks of this ridge in the Harrymel and Coulter Creek valleys by R. Bartsch (personal communication, 1991) suggests that the ridge forms the core of a regional antiform and that Hazelton strata form dip slopes along the flanks.

East of the Tom Mackay syncline, a monoclinal section of northwest-dipping Hazelton Group strata extends across the Eskay Creek and SIB properties. Stratigraphic markers can be traced continuously across both claim groups, with only minor apparent left-lateral offsets along northerly striking faults. There is probably some faulting parallel to stratigraphic layering, but it is not mappable at 1 20 000 scale. Regional maps show this northwest-dipping panel forming the west limb of a major northwest-trending anticline. This interpretation is supported by the occurrence of southeast-facing Bowser Lake Group argillites and mudstones along the lower reaches of Eskay Creek and in the Unuk River valley. The transition from west-facing to east-facing beds, however, occurs within a structurally complex, poorly exposed area and coincides with a major northeast-striking fault. This fault obscures the fold hinge and has undetermined offset. The apparent lack of continuity of Hazelton Group felsic volcanic rocks across the hinge (Figure 6-5-2; Alldrick *et al.*, 1989) is probably related to this faulting.

MESOSCOPIC STRUCTURAL FEATURES

The most prominent mesoscopic structural features in Bowser Lake Group and Hazelton Group strata are well-developed, steeply dipping, north to northeast-striking cleavage fabrics. These cleavages are parallel to axial surfaces of macroscopic folds and the few mesoscopic folds scattered through the area. The form and visual appearance of cleavage correlates strongly with host lithology. A strong slaty cleavage is present at highest structural levels in bedded mudstone and siltstone of the Bowser Lake Group (Plate 6-5-1a). Coarse sandstone and conglomerate layers within this unit contain weakly to moderately developed spaced cleavage, best developed in fold hinges. Dissolution of clasts along cleavage surfaces is apparent in some exposures and is indicative of a pressure solution mechanism of cleavage formation in these areas.

Lithologically variable Hazelton Group rocks contain a wide variety of structural fabrics. At highest levels, volcanic breccias and pillowed flows of the Salmon River Formation contain no visible penetrative fabrics, and pillow shapes appear unstrained. However, interlayered mudstones are disharmonically folded and locally are strongly tectonized. Lower in the section, felsic volcanic flows contain a weak to moderate anastomosing foliation at Eskay Creek. Epiclastic sedimentary rocks contain weak to strong penetrative cleavage which refracts sharply across lithologic interfaces (Plate 6-5-1b). Coarse volcanic conglomerates contain strongly oblate clasts, with shortest dimensions perpendicular to cleavage planes (Plate 6-5-1c). Axial ratios in these clasts range up to 3:3:1. Clast elongation is rare and, where it occurs, is in a down-dip orientation.

Mesoscopic folds occur in scattered locations throughout the Prout Plateau area, and are usually north to northeast-plunging structures coaxial to the macroscopic folds. Minor fold asymmetry is variable and consistent with that expected for folds which are second order to the major structures. Fault drag folds are common along some of the major faults (*e.g.*, Argillite Creek fault, Mount Shirley fault) where their geometry is probably controlled by movement on adjacent structures.

DISCUSSION

Structures in the Prout Plateau area developed during a period of east-west contraction, during which approximately 50 per cent shortening was accommodated by rocks of the Hazelton and Bowser Lake groups. The cuspate syncline and lobate anticline structural form of the Bowser Lake Group - Hazelton Group contact is typical of folded multilayers with high competence contrasts. An arcuate swing in structural trend from northeasterly (north of Tom Mackay Lake) to northerly (south of Tom Mackay Lake) reflects either a reorientation of originally rectilinear features, or a variation in fold orientation during initial deformation. The latter interpretation is favoured because of the lack of overprinting mesoscopic features in outcrop; original arcuate trends may have been caused locally by emplacement of the structurally competent block formed by Mount Shirley against the northern part of the Prout Plateau syncline. North of Mount Shirley, where the Mount Shirley fault loses definition, structural trends are again more northerly (Read *et al.*, 1989), supporting this interpretation. However, maps of areas to the east suggest this swing to northeasterly structural trends may be part of a more regional northeast-trending fold set along the western edge of the Skeena fold belt.

Timing of deformation is only approximately constrained by the initial mapping. Major folds in the Prout Plateau area occur in rocks of both the Hazelton and the Bowser Lake groups. The wide age range of these packages, from Early to Late Jurassic, suggests that major Early to Middle Jurassic deformation documented elsewhere in the Cordillera did not have a strong impact on structural development of the Iskut River area. Evidence for Middle Jurassic deformation is limited to an intra-Hazelton Group unconformity around John Peaks (unpublished mapping, this study; Henderson *et al.*, 1992) and a Toarcian unconformity, to the north, on Troy Ridge (R.G. Anderson, personal communication, 1991). Most regional folding apparently followed deposition of the Bowser Lake Group sedimentary sequence, in latest Jurassic time or later. This timing is consistent with Cretaceous to Early Tertiary shortening to the east within the Skeena fold belt (Evenchick, 1991) and the folds in the Prout Plateau area can reasonably be considered to be the westernmost manifestation of this fold belt.

Initial mapping in the area surrounding John Peaks has revealed structural styles consistent with those described for the Prout Plateau area. This area is dominated by a major west-vergent thrust fault within the Hazelton Group, which places an overturned folded sequence of Mount Dilworth Formation and older rocks onto an upright sequence of Salmon River Formation argillites and pillowed flows. Subsequent work will involve tracing regional structures between the two areas, and extending mapping to the south and east into the Sulphurets area.

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REFERENCES

Alldrick, D.J. and Britton, J.M. (1988): Geology and Mineral Deposits of the Sulphurets Area (104A/5, 104A/12, 104B/8, 104B/9); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-4.

Alldrick, D.J., Britton, J.M., MacLean, M.E., Hancock, K.D., Fletcher, B.A. and Hiebert, S.N. (1990): Geology and Mineral Deposits of the Snippaker Area, (104B/6E, 7W, 10W, 11E); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-16.

Alldrick, D.J., Britton, J.M., Webster, I.C.L. and Russell, C.W.P. (1989): Geology and Mineral Deposits of the Unuk Map Area, (104B/7E, 8W, 9W, 10E); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-10.

Anderson, R.G. (1989): A Stratigraphic, Plutonic, and Structural Framework for the Iskut River Map Area, Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada*, Paper 89-1E, pages, 145-154.

Anderson, R.G. and Thorkelson, D.J. (1990): Mesozoic Stratigraphy and Setting for Some Mineral Deposits in Iskut River Map Area, Northwestern British Columbia; *in* Current Research, Part E, *Geological Survey of Canada*, Paper 90-1E, pages 131-139.

Bartsch, R.M. (1992): Eskay Creek Area, Stratigraphy Update; *in* Geological Fieldwork 1990, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1992-1, this volume.

Bevier, M.L. and Anderson, R.G. (1991): Jurassic Geochronometry in Northwest Stikinia (56-57° N), British Columbia; *in* Program with Abstracts, *Geological Society of America*, Annual Meeting, San Diego.

Britton, J.M. and Alldrick, D.J. (1988): Sulphurets Map Area (104A/5W, 12W, 104B/8E, 9E); *in* Geological Fieldwork, 1987, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1988-1, pages 199-209.

Britton, J.M., Blackwell, J.D. and Schroeter, T.G. (1989a): Eskay Creek (104B 008); *in* Exploration in British Columbia 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, pages 197-223.

Britton, J.M., Fletcher, B.A., and Alldrick, D.J. (1990): Snippaker Map Area (104B/6E, 7W, 10W, 11E); *in* Geological Fieldwork 1989, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 115-125.

Britton, J.M., Webster, I.C.L. and Alldrick, D.J. (1989b): Unuk Map Area (104B/7E, 8W, 9W, 10E); *in* Geological Fieldwork 1988, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1989-1, pages 241-250.

Evenchick, C.A. (1991): Structural Relations of the Skeena Fold Belt West of the Bowser Basin, Northwest British Columbia; *Canadian Journal of Earth Sciences*, Volume 28, Number 6, pages 973-983.

Grove, E.W. (1986): Geology and Mineral Deposits of the Unuk River - Salmon River - Anyox Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 63, 152 pages.

Henderson, J.R., Kirkham, R.V., Henderson, M.N., Payne, J.G., Wright, T.O. and Wright, R.L. (1992): Stratigraphy and Structure of the Sulphurets Area, British Columbia (104B/8, 9); *in* Current Research, Part A, *Geological Survey of Canada*, Paper 92-1A, in press.

Kirkham, R.V., Ballantyne, S.B. and Harris, D.C. (in preparation): Sulphurets Area, British Columbia -- Preliminary Geology, Geochemistry and Mineralogy of a Deformed Copper, Molybdenum, Precious Metal System.

Read, P.B., Brown, R.L., Psutka, J.F., Moore, J.M., Journeay, M., Lane, L.S. and Orchard, M.J. (1989): Geology, More and Forrest Kerr Creeks (Parts of 104B/10, 15, 16 and 104C/1, 2); *Geological Survey of Canada*, Open File 2094.

NOTES