



## STRUCTURE AND METAMORPHISM IN THE HORSERANCH RANGE, NORTH-CENTRAL BRITISH COLUMBIA (104P/2,7,10)

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**KEYWORDS:** Regional geology, Horseranch Range, Cassiar terrane, Ingenika Group, schist complex, structural geology, metamorphism.

### INTRODUCTION

Detailed geological mapping of a Proterozoic and/or Cambrian high-grade schist complex in the Horseranch Range of north-central British Columbia was initiated to investigate its structure and metamorphic history, and to contribute to the understanding of basement tectonics in the northern Cordillera. This report presents the results of the second season of a 2-year field study. Several questions raised by the first field season's work (Plint and Erdmer, 1988) are addressed.

### LOCATION AND ACCESS

The area is located in the Cassiar Mountains, approximately 65 kilometres southeast of Watson Lake, Yukon Territory (Figure 1-36-1), and is covered by NTS map sheets 104P/2, 104P/7 and 104P/10. Mapping was conducted during June and July, 1988 from fly camps positioned and supplied by helicopter from Watson Lake.

### REGIONAL SETTING AND PREVIOUS WORK

The Horseranch Range lies within the Cassiar terrane (Monger and Berg, 1984), which comprises Upper Proterozoic and Paleozoic miogeoclinal and platformal strata that were displaced northwards by several hundred kilometres along the Tintina-Northern Rocky Mountain Trench fault system (Gabrielse, 1985).

Gabrielse (1963) documented the major rock types and the structure of the Horseranch Range, and correlated its geology with the Upper Proterozoic Windermere Supergroup and the Lower to Middle Paleozoic Atan, Kechika, Sylvester and Sandpile groups. The range is underlain by a thick sequence of metasedimentary schists, by orthogneiss, and by post-tectonic ultramafic, mafic, and felsic intrusions (Gabrielse, 1963; Plint and Erdmer, 1988). Proterozoic uranium-lead ages (2.2 Ga) for detrital zircon indicate that the schists have a Proterozoic provenance (Erdmer and Baadsgaard, 1987). The dominant structure of the range is that of a northerly trending, doubly plunging anticlinorium bounded to the east and west by the Horseranch and Deadwood faults respectively. At least 2 kilometres of vertical uplift is postulated along these faults (Gabrielse, 1985).

The central schist complex consists of interlayered pelitic to psammitic schist, quartzite, marble and minor amphibolite, intruded by granitic and mafic to ultramafic rocks. The eastern contact of the schist complex is drift-covered; to the west, the schists are separated from low-grade homogeneous quartzite by a moderately west-dipping mylonite zone. Kinematic indicators in the mylonite zone indicate top-down-to-the-northwest movement, suggesting the mylonite is related to tectonic denudation. Chloritic phyllite, overlain by unmetamorphosed dolomitic limestone, overlies quartzite at the western margin of the Horseranch Range. The Horseranch fault (Gabrielse, 1963, 1985) separates the dolomitic limestone from rocks to the east.

Three fold phases have been identified in the map area:  $F_1$  tight to isoclinal folds, commonly defined by quartz veins, with axial surfaces parallel to the schistosity in the schist complex;  $F_2$  passive folds in the mylonite which deform mylonitic layering; and  $F_3$  upright to steeply inclined, gently northwesterly or southeasterly plunging folds which re-fold  $F_1$  and  $F_2$  folds and are congruent with the overall antiformal structure of the Horseranch Range. In addition, tight to isoclinal, horizontal folds occur in fine-grained calcareous layers in the phyllite. These folds are northwesterly trending with moderately southwesterly dipping axial surfaces and are cut by an axial planar cleavage. This cleavage is deformed by west-southwesterly trending, gently westerly plunging kinks and chevron folds. Fine crenulation lineations, mineral stretching lineations defined by quartz and feldspar and locally by hornblende, and fine rodding in quartz veins and quartzites in the schist complex are parallel to the hinge lines of  $F_3$  folds. Rodding and stretching lineations in the mylonite are parallel to those in the schist complex (Plint and Erdmer, 1988).

### ROCK UNITS

No new rock types have been identified in the southern part of the schist complex. Staurolite is common in the southwestern and northern parts of the range, and kyanite is present in at least one outcrop on its eastern flank (Figure 1-36-1).

A tan-weathering, biotite-bearing, grey to white marble is exposed at the north end of the range, structurally overlying the schist complex. Resistant siliceous layers 1 to 5 centimetres thick are commonly parallel to a biotite-defined foliation. Minor white quartzite and mica schist are locally interlayered with the marble. Structurally overlying the marble is a muscovite-chlorite-garnet schist, locally containing layers of hornblende-garnet calc-silicate schist, two-mica

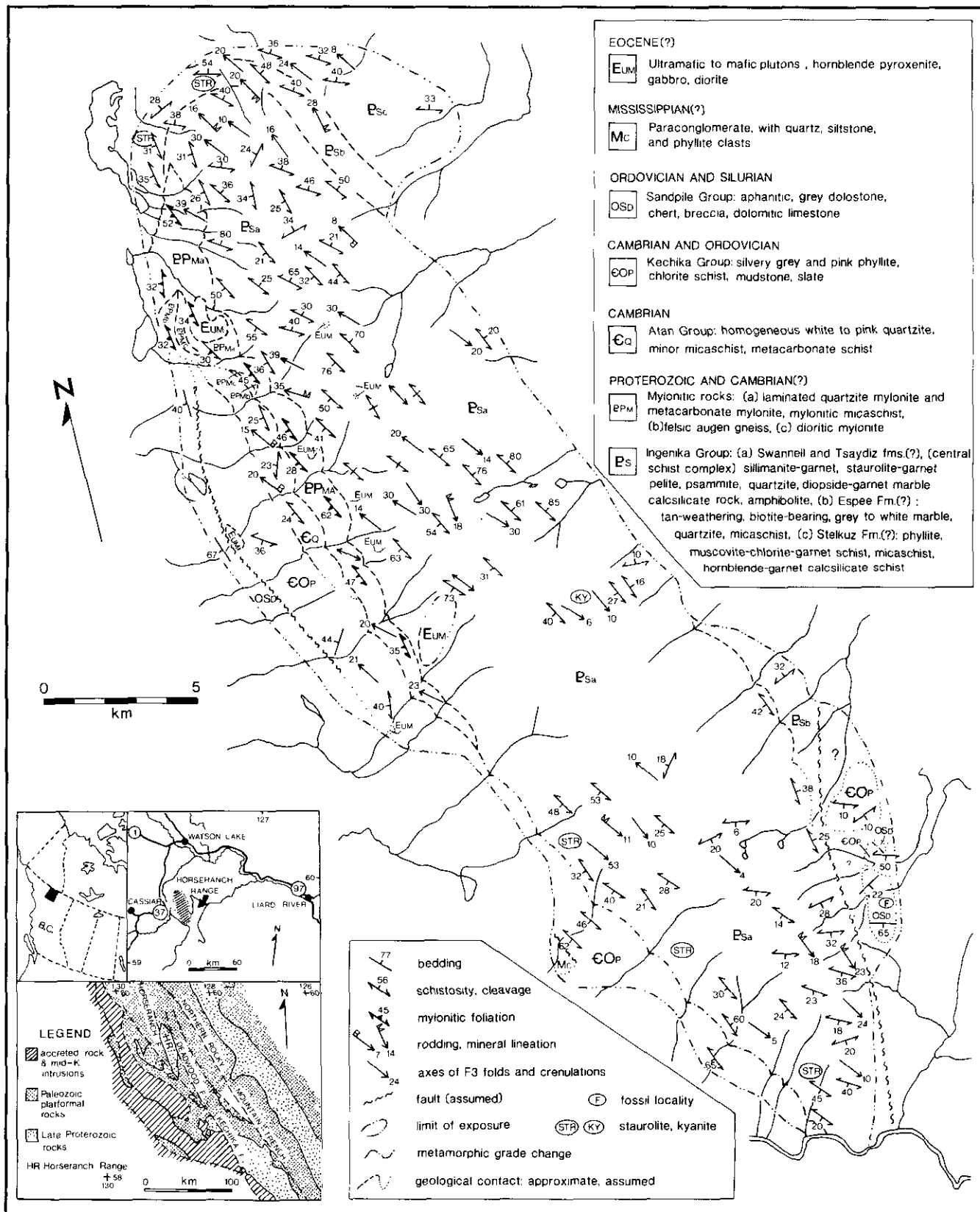


Figure 1-36-1: Geology of the Horseranch Range. Inset shows index map and regional geology.



Plate 1-36-1: Isoclinal  $F_2$  fold in mylonitic metacarbonate schist deforms the mylonitic foliation and is refolded by tight,  $F_3$  folds.

semipelitic to psammitic schist, grey to white quartzite, and grey marble 1 to 5 metres thick. Along the northwestern side of the range, these units are deformed in a mylonite zone and are more highly metamorphosed.

The "phyllite unit" (Plint and Erdmer, 1988) is expanded here to include silvery grey calcareous phyllite, pink to white siliceous phyllite, silvery green-grey chloritic phyllite, chloritic schist, grey, locally fossiliferous mudstone, and calcareous black slate. Minor paraconglomerate containing clasts of quartz, phyllite and siltstone exposed west of the phyllite may be of Mississippian age (Gabrielse, 1963).

Along the west and southeast flanks of the Horseranch Range a unit of tan to grey-weathering dolostone, locally with chert beds 1 to 3 centimetres thick, dolostone breccia and dolomitic limestone structurally overlies the phyllite unit. Calcite veins, 1 millimetre to 10 centimetres thick, commonly cut this unit. Fossils of rugose coral occur in the dolostone on the southeast flank of the range (Figure 1-36-1). Identification of these fossils is in progress.

## REGIONAL CORRELATIONS

We have previously correlated the homogeneous quartzite unit structurally above the mylonite with the Boya Formation (Atan Group) and suggested that the absence of overlying

Rosella Formation may result from a local hiatus. In keeping with this correlation and the local stratigraphy, mylonitic rocks, tan-weathering marble, chlorite-muscovite-garnet schist, and the central schist complex are correlated with the Proterozoic Ingenika Group (compare Mansy and Gabrielse, 1978). On the basis of descriptions of the Ingenika Group (Mansy and Gabrielse, 1978; Evenchick, 1985; Ferri and Melville, 1988), the tan-weathering resistant marble unit and muscovite-chlorite-garnet schist are correlated with the Espee and Stelkuz formations respectively. Therefore, the central schist complex may correlate with the Swannell and Tsaydiz formations. The phyllite and dolostone-dominated units are correlated with the Cambro-Ordovician Kechika Group and Ordovician-Silurian Sandpile Group respectively (compare Gabrielse, 1963; Plint and Erdmer, 1988).

## STRUCTURE

Data collected this season allow comment on the regional extent of the mylonite zone, the relative timing of mylonitization and of late upright folding, and the relationship of strain in the low-grade Paleozoic units to the central schist complex.

Figure 1-36-1 shows that the mylonite zone thins rapidly towards the northern and southern ends of the range. In the

north, northwesterly trending stretching lineations in the mylonite zone plunge moderately northwestward and kinematic indicators reflect top-down-to-the-northwest shear. Near the central part of the range, along its western flank, stretching lineations in the mylonite zone are horizontal, and C-S planes developed in granitoid rocks indicate dextral shear such that rocks structurally overlying the shear zone have moved north relative to those beneath it. An abrupt change in metamorphic grade from amphibolite facies (sillimanite zone) to greenschist facies (biotite zone) occurs across the mylonite zone (over approximately 100 to 600 metres horizontal distance) suggesting that tectonic thinning has occurred (compare Plint and Erdmer, 1988). East-west transects farther south reveal a similar change in metamorphic grade across approximately 200 metres (horizontal distance), in which biotite phyllite and fine-grained biotite schist are juxtaposed against staurolite-garnet schist. However, no mylonite is exposed in this area, suggesting the mylonite zone probably pinches out southwards. No change in fabric attitude or rock type accompanies the abrupt transition in metamorphic grade.

Mesoscopic mylonitic  $F_2$  folds are refolded by upright  $F_3$  folds (Plate 1-36-1). On a regional scale, therefore, the mylonite zone should be exposed on the eastern side of the range and at its northern and southern ends. The absence of mylonite on the east flank may be a function of poor exposure. The absence of mylonite at the southern end of the range may result from the lack of exposure or from truncation by the Horseranch and Deadwood faults. However, its absence from the northern end of the range is problematic.

Northwesterly trending folds in the Kechika Group may be coeval with  $F_3$  structures in the central schist complex. The later, west-southwesterly trending, gently westerly plunging kinks and chevron folds in this unit have no apparent equivalent in the schist complex.

## METAMORPHISM

Diagnostic metamorphic minerals in the schist complex include sillimanite (commonly as fibrolite), kyanite, or staurolite in pelitic and semipelitic schist, and diopside, grossular, and locally, hornblende or tremolite in marble. The widespread partial replacement of muscovite by potassium-feldspar and sillimanite in pelitic schist suggests that peak metamorphic temperature exceeded that of the muscovite-out equilibrium (650 to 700°C) in most of the schist complex. The presence of staurolite and kyanite in some of the schists places a lower pressure-temperature limit on metamorphism of approximately 500°C and 400 megapascals (4 kilobars). Assuming that pressures corresponding to peak metamorphic temperatures in sillimanite schist were higher than those in the structurally overlying staurolite and kyanite schists, a minimum pressure of 500 to 700 megapascals (5 to 7 kilobars) is plausible for the sillimanite schist.

Sillimanite, kyanite, and staurolite overprint the foliation or are randomly oriented on schistosity surfaces in the schist complex. This indicates that metamorphism outlasted foliation development. In the mylonite zone, sillimanite is folded by mylonitic ( $F_2$ ) folds, and diopside commonly occurs as porphyroclasts. Retrogression is minor and is characterized

by minor chlorite after biotite, white mica after feldspars, hornblende after diopside and chlorite, and biotite after igneous hornblende. Mylonitization, therefore, postdated peak regional metamorphism, and took place at high temperatures and/or under dry conditions.

Little or no new mineral growth is present in the axial surface region of late  $F_3$  folds. This suggests that  $F_3$  folding postdates regional metamorphism. A similar relationship has been documented in the Ingenika Group in the Deserters and Sifton ranges (Evenchick, 1985) and in the Wolverine complex (Parrish, 1976; Ferri and Melville, 1988). If  $F_3$  folds postdate regional metamorphism, isograds should be folded. The distribution of staurolite in outcrop suggests the staurolite isograd is folded. However, field occurrences of staurolite, kyanite and sillimanite are too few to allow delineation of isograds in the absence of detailed petrographic data.

## DISCUSSION AND CONCLUSIONS

The schist complex of the Horseranch Range has been metamorphosed to amphibolite facies (650 to 700°C, 500 to 700 megapascals) and subsequently mylonitized along its western margin. Tectonic thinning across the mylonite zone is reflected in an abrupt metamorphic transition. The northern part of the range exposes a deeper section of the schist complex than the southern part. This is reflected by the juxtaposition of biotite phyllite and fine-grained biotite schist against sillimanite-garnet schist across the mylonite zone in the north, and against staurolite-garnet schist in the south. Therefore, tectonic thinning and displacement across the mylonite zone decreases southward. The regional tectonic significance of the mylonite zone is still unclear. The absence of mylonite at the northern end of the range (around which all other units can be traced) is problematic. The continuity of the other units precludes the offset of the mylonite zone by a fault. Therefore, the zone must thin severely or pinch out entirely.

The absolute timing of regional metamorphism is unknown. However, on the basis of estimates of the age of metamorphism in the Sifton Range and the Wolverine complex (Evenchick, 1985; Parrish, 1976), metamorphism may be as young as Cretaceous. Regional metamorphism and mylonitization were followed by folding about an upright, northwesterly trending regional axis parallel to mesoscopic  $F_3$  folds. Uplift along the Horseranch and Deadwood faults postdates  $F_3$  folds.

Continuing work, including petrography, geothermobarometry, macroscopic and microscopic structural analysis, and uranium-lead and  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  isotopic dating, will address the following:

- The pressure and temperature conditions of metamorphism;
- The "absolute" timing of regional metamorphism and metamorphic cooling;
- The regional tectonic significance and "absolute" timing of mylonitization;
- The rate and mechanism(s) of uplift.

## ACKNOWLEDGMENTS

This study forms part of the senior author's Ph.D. research at the University of Alberta. Financial support by the British Columbia Ministry of Energy, Mines and Petroleum Resources and Natural Sciences and Engineering Research Council is gratefully acknowledged. Field assistance provided by K. Krey is sincerely appreciated.

## REFERENCES

- Erdmer, P. and Baadsgaard, H. (1987): 2.2 Ga Age of Zircons in Three Occurrences of Upper Proterozoic Clastic Rocks of the Northern Cassiar Terrane, Yukon and British Columbia, *Canadian Journal of Earth Sciences*, Volume 24, pages 1919-1924.
- Evenchick, C. (1985): Stratigraphy, Metamorphism, Structure, and Their Tectonic Implications in the Sifton and Desserters Ranges, Cassiar and Northern Rocky Mountains, Northern British Columbia, Unpublished Ph.D. Thesis, *Queen's University*, 191 pages.
- Ferri, F. and Melville, D.M. (1988): Manson Creek Mapping Project (93N/09), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 169-180.
- Gabrielse, H. (1963): McDame Map-area, Cassiar District, British Columbia, *Geological Survey of Canada*, Memoir 319, 139 pages.
- (1985). Major Dextral Transcurrent Displacements along the Northern Rocky Mountain Trench and Related Lineaments in North-central British Columbia, *Geological Survey of America*, Bulletin, Volume 96, pages 1-14.
- Parrish, R.R. (1976): Structure, Metamorphism, and Geochronology of the Northern Wolverine Complex near Chase Mountain, Aiken Lake Map-area, British Columbia, Unpublished M.Sc. Thesis, *The University of British Columbia*, 89 pages.
- Plint, H.E. and Erdmer, P. (1988): Geological Studies in the Horseranch Range (104P/7, 10), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 254-260.
- Mansy, J.L. and Gabrielse, H. (1978): Stratigraphy, Terminology and Correlation of Upper Proterozoic Rocks in Omineca and Cassiar Mountains, North-central British Columbia, *Geological Survey of Canada*, Paper 77-19, 17 pages.
- Monger, J.W.H. and Berg, H.C. (1984): Lithotectonic Terrane Map of Western Canada and Southeastern Alaska, Part B, in Lithotectonic Terrane Maps of the North American Cordillera, N.J. Siberling and D.L. Jones, Editors, *United States Geological Survey*, Open File Report 584-523, 104 pages.

# NOTES