GEOLOGICAL STUDIES IN THE HORSERANCH RANGE, NORTHERN BRITISH COLUMBIA (104P/07, 10)

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INTRODUCTION

This report presents the results of field study of a high-grade schist complex exposed in the Horseranch Range of northern British Columbia. Data from reconnaissance mapping (Gabrielse, 1963 and personal communication, 1985) and the regional antiformal structure of the range suggested that it may be a metamorphic core-complex. This project was undertaken to investigate the structure, metamorphism and age of the complex, to assess its mineral potential, and to contribute to the study of basement tectonics in the northern Cordillera.

LOCATION AND ACCESS

The area is located in the Cassiar Mountains approximately 65 kilometres southwest of Watson Lake, Yukon (Figure 1-24-1). It is within 1:50 000 map sheets 104P/07 and 104P/10. Mapping was carried out from fly-camps positioned and supplied by helicopter from Watson Lake during July and August 1987.

REGIONAL SETTING AND PREVIOUS WORK

The Horseranch Range lies in 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. The range is bounded to the east and west by the Deadwood and Horseranch faults (Gabrielse, 1985) (Figure 1-24-1). It is underlain by a thick sequence of schistose Proterozoic and/or lower Cambrian, shallow-water metasedimentary rocks, by orthogneiss, and by post-tectonic ultramafic and granitoid intrusions. The structure of the range is that of a northerly trending, doubly plunging anticlinorium. Contacts with younger platformal rocks to the west and east are drift covered or faulted.

Gabrielse (1963) reported mesoscopic tight folds in quartzite and gneiss, with axial planes forming an upward-converging fan centred on the main anticlinorial axis, crenulations in quartz-mica schist, and a-c joints related to the major anticline. At least 2 kilometres of vertical uplift is postulated along the Horseranch and Deadwood faults (Gabrielse, 1985). On the basis of regional correlations, the rocks were thought to be upper Proterozoic and/or Cambrian. Uranium-lead ages of detrital zircons from the schist complex suggest a source-rock age of 2.22 billion years (Erdmer and Baadsgaard, 1987), similar to source-rock ages elsewhere in the Cassiar terrane. The age of metamorphism(s) and uplift is unknown.

LITHOLOGY

The schist complex (Horseranch Group of Gabrielse, 1963) consists of interlayered pelitic to psammitic schist, quartzite, marble and minor amphibolite, intruded by granitic and mafic to ultramafic rocks. A moderately west-dipping mylonite zone is developed at the western boundary between the schist complex and lower grade, homogeneous quartzite. Chloritic phyllite, overlain by unmetamorphosed dolomitic limestone, overlies the quartzite at the western margin of the Horseranch Range. A fault separates the unmetamorphosed sedimentary rocks to the west and the phyllite and ultramafic to mafic intrusive rocks to the east (Figures 1-24-1 and 1-24-2).

METASEDIMENTARY AND SEDIMENTARY ROCKS

CENTRAL SCHIST COMPLEX

The central schist complex is the most extensive and structurally the lowest unit in the map area. It consists of interlayered, fine to medium-grained pelitic to psammitic schist, quartzite, marble, fine to medium-grained granitic to granodioritic orthogneiss and minor amphibolite. Compositional layering (defined by quartz-rich, carbonate-rich and mica-rich layers) approximately 5 centimetres to 20 metres thick is parallel to the main schistosity. Quartz and feldspar stretching lineations are locally developed in psammite, quartzite and orthogneiss. Centimetre to metre-scale concordant quartz veins, boudins and lenses are common in the schist. Locally, veins of quartz and aplite 0.1 to 0.5 centimetre thick are tightly to isoclinally folded with axial surfaces parallel to the main schistosity. The limbs of these folds and other veins of quartz and granitic rock are boudinaged. This suggests that at least some quartz veins and granitoid intrusions are syntectonic with respect to the schistosity. Quartz veins and granitoid intrusions also cut the foliation (*see* below).

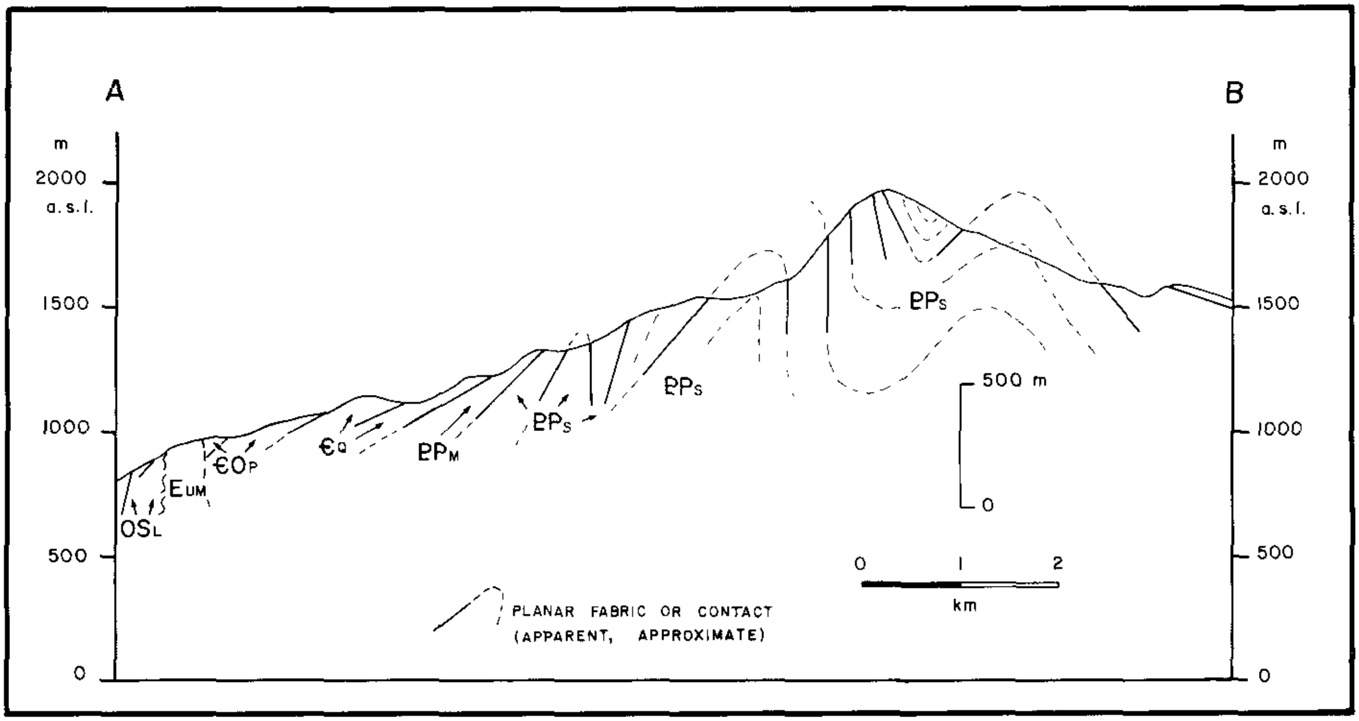

Figure 1-24-2. Structural cross-section through the Horseranch Range (*see* Figure 1-24-1 for section location).

Quartzite is fine to medium grained, and contains minor biotite and muscovite, and locally garnet. Quartzite adjacent to marble layers contains disseminated pyrite. Fine to medium-grained, white to buff marble characteristically contains layers of quartz, quartzite, chert and calc-silicate (diopside-garnet-rich) rock 0.5 to 5 centimetres thick, which are oriented parallel to the foliation and are locally boudinaged or pinch and swell. Specks of graphite(?) are commonly disseminated in marble.

Fine to medium-grained granitic to granodioritic orthogneiss locally forms layers 5 to 15 metres thick and concordant lenses within the central schist complex.

A pinching and swelling amphibolite layer is exposed in biotite schist on the eastern shore of Gale Force Lake (Figure 1-24-1). Relict ophitic texture is preserved in the centre of the layer. Its schistose margins indicate that the biotite schist and the amphibolite have been deformed together.

Mylonite Zone

Mylonite is developed in a zone 400 metres to 1 kilometre wide and at least 13 kilometres long between the central schist complex and overlying quartzite along the western margin of the Horseranch Range (Figure 1-24-2). The mylonite zone includes part of the central schist complex, dioritic rocks of unknown affinity and medium to coarse-grained granitoid rocks. Granitic, ultramafic and mafic rocks that intrude the mylonite are not deformed. No widespread retrogression is associated with the mylonite zone.

Homogeneous Quartzite and Phyllite

Homogeneous, white to pink, fine to medium-grained quartzite structurally overlies the mylonite zone. The quartzite is well jointed and finely rodded, and commonly contains pyrite as stringers and disseminated blebs. Locally, irregular discordant pods of low-grade metacarbonate rock and concordant continuous layers of crenulated biotite schist are exposed within the quartzite. This compositional variation may reflect original sedimentary layering. The quartzite unit is distinguished from quartzite layers in the central schist complex by its greater areal extent and homogeneity.

Structurally (and stratigraphically ?) overlying the quartzite is a zone of chloritic, fissile, aphanitic, silvery green-grey phyllite locally interlayered with chlorite schist (possibly metatuff). It characteristically contains cherty layers 1 to 15 centimetres thick which are commonly boudinaged or tightly folded and are cut by a phyllitic cleavage which is axial planar to tight folds.

Dolomitic Limestone

Unmetamorphosed, fractured and locally brecciated, aphanitic, dark grey dolomitic limestone is exposed west of the phyllite. The limestone is commonly cut by a fine network of chert veinlets and is brecciated near the inferred contact with metamorphic and plutonic rocks to the east, suggesting the presence of a fault zone (Horseranch fault of Gabrielse, 1963, 1985).

REGIONAL CORRELATIONS

Gabrielse (1963 and personal communication, 1985) suggested a correlation of some of the rocks structurally beneath the mylonite with the lower quartzite of the Cambrian Atan Group. However, the homogeneous quartzite that overlies the mylonite is lithologically more similar to the Atan quartzite than is quartzite beneath the mylonite. Exposure at the contact between the overlying quartzite and phyllite is poor, and no limestone which would correlate with the upper limestone division of the Atan Group is exposed, which makes any interpretation tentative. However, assuming that the apparently condensed section results from a local hiatus, the homogeneous quartzite is correlated here with the Atan Group. The question of whether any part of the central schist complex correlates with the Atan Group will require testing by radiometric age determinations.

The phyllite has been correlated with the Devono-Mississippian Sylvester Group, a sequence of greenstone and clastic metasedimentary rocks (Gabrielse, 1963). However, as metavolcanic rocks are a minor component of the phyllite in the study area, and as the unit is lithologically more similar to phyllite of the Cambro-Ordovician Kechika Group in adjacent areas, it is correlated here with the Kechika Group (Figure 1-24-1). Confirmation of this correlation will require fossil age determinations. The dolomitic limestone along the western margin of the map area has been demonstrated, on the basis of fossil ages, to correlate with the Ordovician-Silurian Sandpile Group (Gabrielse, 1963).

INTRUSIVE ROCKS

MAFIC AND ULTRAMAFIC ROCKS

Dark green to black, medium to coarse-grained, massive diorite, gabbro and hornblende pyroxenite intrude the central schist complex, the mylonite, the homogeneous quartzite and the phyllite. The intrusions commonly form small plugs 6 to 10 metres across. A large, irregularly shaped body of coarse-grained, massive hornblende pyroxenite, approximately 1.5 square kilometres in area, crops out in the northeastern part of the map area (Figure 1-24-1). This body contains inclusions of fine-grained tourmaline and garnet-bearing felsic rocks, and of quartzite of unknown affinity. No contact metamorphic effects are associated with the mafic to ultramafic intrusions.

GRANITOID ROCKS

Granitic dykes and sills are widespread in the central schist complex, and generally postdate penetrative fabrics in all units, and F_3 folds (*see* below). Their composition ranges from two-mica granodiorite to granite. Grain size is variable and commonly less than 1 centimetre. Large alkali or perthitic feldspar phenocrysts are common in medium to fine-grained phases. Tourmaline, developed locally as radiating sprays up to 4 centimetres long, and euhedral garnets 1 to 5 millimetres across are common accessories. Quartz veins cut and are cut by the granitoid intrusions.

Injection migmatite is locally developed between late syn to post-tectonic granitoid dykes and sills and semipelitic schist of the central schist complex.

STRUCTURAL GEOLOGY

PLANAR FABRICS

No unequivocal primary sedimentary structures are preserved in the central schist complex. Local F_1(?) folds and sheared quartz veins and granitic dykes suggest some transposition of primary fabric (Plate 1-24-1), and local compositional layering is interpreted as tectonically modified bedding.

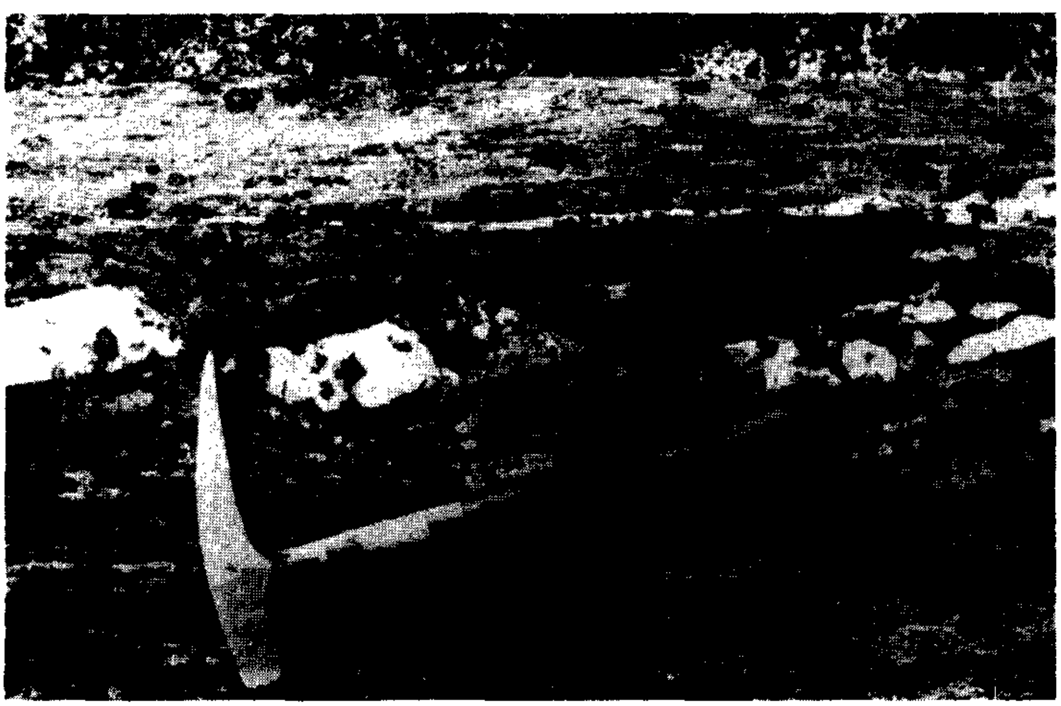

Plate 1-24-1. Type 2B asymmetrical pull-aparts in a quartz vein in the central schist complex, indicating sinistral shear along a nearly vertical foliation surface (terminology after Hanmer, 1986). Note normal, extensional shears at the pinches.

The parallel alignment of micas and tabular quartz and feldspar grains defines the main schistosity in the central schist complex. In the mylonite, foliation is defined by fine colour banding in quartzite, strung-out quartz and feldspar aggregates in psammite and granitoid rocks, and ductile flow banding in metacarbonate rocks. The contact between the central schist complex and the mylonite zone is placed at the first appearance of highly strained marble, calc-silicate rock, or finely banded quartzite. On the basis of minimum covered intervals between outcrops of mylonite and nonmylonitic schist, the contact zone is approximately 5 to 10 metres wide. Foliation in the mylonite is concordant with the schistosity in the underlying schist and with the foliation in the overlying quartzite.

LINEATIONS

A northwesterly trending (320°), horizontal to gently northerly plunging quartz and feldspar stretching lineation is common in quartzite and psammite of the central schist complex. A local rodding in concordant quartz veins and in fine-grained quartzite is parallel to the stretching lineation.

In the mylonite, quartz rodding and quartz and feldspar stretching lineations trend northwesterly (300 to 330°) with moderate plunge (12 to 33°).

FOLDS

Distinction of fold phases is hindered by the paucity of refolded folds. However, on the basis of the planar fabrics they deform, and of the units in which they are developed, three phases of folding are recognized in the central schist complex, mylonite zone, and quartzite sequence, and two in the phyllite.

The earliest folds (F_1) in the schist complex are tight to isoclinal, locally transposed, centimetre-scale folds with axial planes parallel to the foliation. They deform quartz and aplite veins 1 to 5 millimetres wide which also cut the foliation, indicating that F_1 folds may result from local flattening during foliation development.

F_2 folds deform the foliation in the mylonite. They range from folds with axial surfaces parallel to the mylonitic foliation, to west-northwesterly trending, moderately plunging folds with steeply dipping west-southwesterly striking axial surfaces (Plate 1-24-2). Differential weathering between carbonate-rich layers and resistant quartz-rich layers highlights F_2 structures in mylonitic metacarbonate rocks. Fold limbs in competent layers are commonly attenuated or boudinaged; boudins are dextrally, and locally sinistrally, rotated and exhibit well-developed tails (Plate 1-24-3).

Ubiquitous, gentle to tight, northwesterly trending F_3 crenulations and mesoscopic folds (wavelengths of 0.1 to 2.0 metres, amplitudes of 0.1 to 0.5 metre) are prominent structures in the schist complex and are congruent with the Horseranch anticlinorial structure. These folds are commonly upright or steeply inclined and plunge gently northwest. In the south, F_3 folds vary from upright to recumbent, with hinge lines from horizontal to gently southeasterly plunging. This variation probably reflects the proximity of the central inflection of the anticlinorium outlined by Gabrielse (1963).

Northwesterly trending, gently plunging mesoscopic folds and crenulations locally deform the mylonitic foliation and mica schist layers in the homogeneous quartzite, demonstrating that F_3 folds postdate mylonitization.

Parallelism between F_3 fold axes, mineral stretching lineations and quartz rodding, and the presence of a-c joints

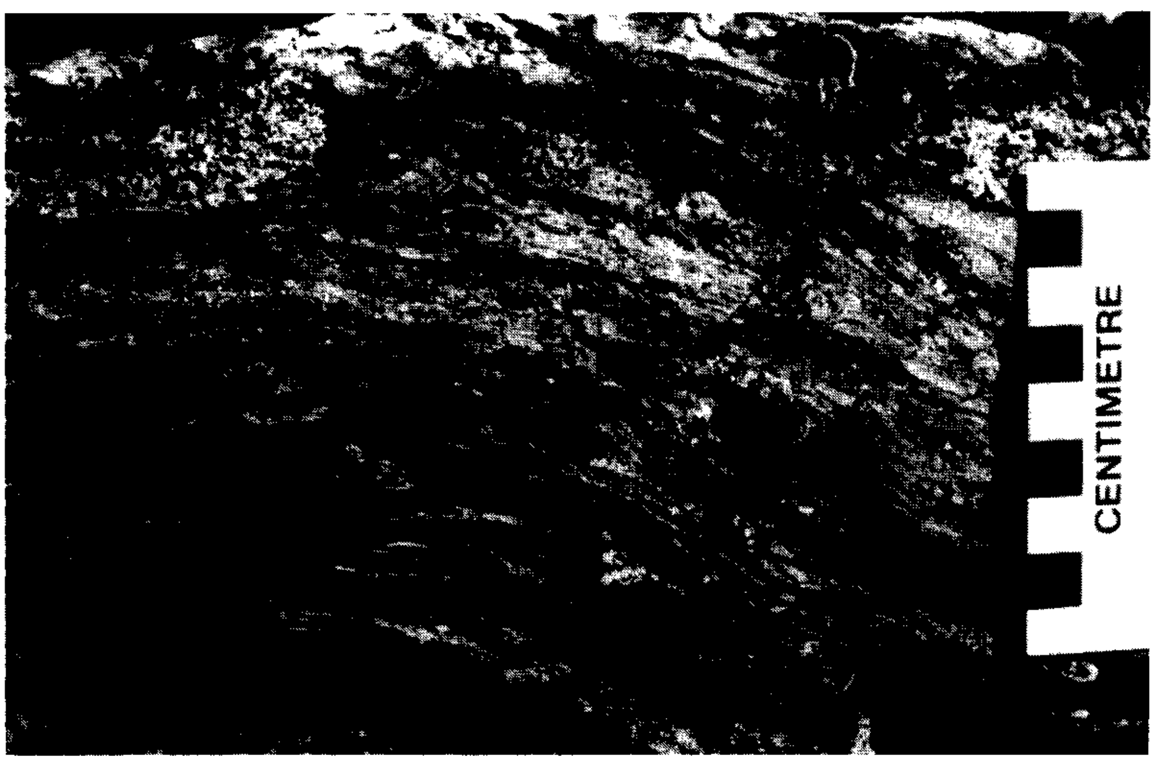

Plate 1-24-2. Tight to isoclinal folds (F_2) in mylonitic metacarbonate.

Plate 1-24-3. δ-type porphyroclast systems (Passchier and Simpson, 1986) of calc-silicate rock in a metacarbonate mylonite, viewed looking southwest, indicate top-to-the-northwest shear.

normal to F_3 axes, suggest that the latest strain was extension parallel to F_3 axes.

In the phyllite, tight to isoclinal horizontal folds in fine-grained calcareous layers (2 to 15 centimetres wide) have northwesterly trending axes and moderately southwest-dipping axial surfaces. These folds are cut by an axial planar phyllitic cleavage. West-southwesterly trending, gently westerly plunging kinks and mesoscopic chevron folds deform this cleavage.

KINEMATIC INDICATORS

Kinematic indicators in the mylonite include: (1) asymmetrically folded or rotated boudins of chert, quartz and calc-silicate rock in marble (Plate 1-24-3); (2) tight to isoclinal asymmetric folds in banded quartzite; (3) granitic pull-apart "fish" and rotated quartz boudins derived from originally continuous veins, sills and dykes; and (4) C-S planes in orthogneiss and schist (Plate 1-24-4).

Plate 1-24-4. C-S planes in oriented, slabbed sample of mylonitic orthogneiss, viewed looking southwest, indicate top-to-the-northwest shear. Type σ_b-porphyroclast systems are feldspar.

Most observations indicate that lineation in the mylonite (and in the central schist complex) is approximately parallel to a principal extension axis. The lineation, together with C-S planes, pull-apart fish and asymmetrical folds, indicates an overall top-to-the-northwest shearing. Boudins of chert, quartz, and calc-silicate rock locally have well-developed tails defining both σ_b-type and δ-type porphyroclast systems (Passchier and Simpson, 1986). In almost all cases these porphyroclast systems indicate top-to-the-northwest shearing. Notwithstanding a few σ_a-type systems and sheared quartz veins indicating top-to-the-southeast shear, the overall displacement recorded in the mylonite zone is top-down-to-the-northwest or right-normal.

METAMORPHISM

Diagnostic metamorphic mineral assemblages include sillimanite and garnet in pelitic schist, and diopside and grossular in marble. Evidence of partial melting is not visible. Quartzofeldspathic layers lack mafic selvages, and many can be traced into late granitoid intrusions. Sillimanite and muscovite are stable in pelitic schist and potassium feldspar is absent, indicating amphibolite facies pressure-temperature conditions of approximately 550 to 650°C at assumed pressures of 200 to 500 kilopascals (2 to 5 kilobars). Locally well-developed sillimanite porphyroblasts cut across the schistosity in the central schist complex, indicating that metamorphism postdates the development of foliation in these rocks.

The metamorphic grade decreases outwards away from the core structure. An abrupt change from amphibolite grade (sillimanite zone) to greenschist grade (biotite zone) across the mylonite zone is interpreted as the result of tectonic thinning. In addition, the absence of pervasive retrogression in the mylonite suggests that deformation occurred at elevated temperatures.

MINERALIZATION

Mineralization in economic quantities was not observed in the map area. Disseminated pyrite is present in the ultramafic to mafic intrusions and in quartzite. Jarosite(?) and iron-oxide gossan is observed locally in pelitic schist and is related to minor disseminated sulphides. Beryl reported in pegmatite south of the map area (Gabrielse, 1963) was not observed in this study.

DISCUSSION AND CONCLUSIONS

The Proterozoic(?) schist complex of the Horseranch Range has been metamorphosed to amphibolite grade and subsequently mylonitized along its contact with lower grade Cambrian(?) rocks. The absence of extensive retrogression in the mylonite zone suggests mylonitization at elevated temperatures. Kinematic indicators reflect top-to-the-northwest, partly down-dip movement in the west-dipping mylonite zone (that is, extensional strain). Although the regional tectonic significance of this strain is still unclear, the sense of displacement in the mylonite zone suggests large-scale tectonic denudation.

Folding about an upright, northwest-trending regional axis parallel to the latest mesoscopic folds (F_3) apparently postdates the mylonitization, but additional data from the northern and eastern parts of the range are required to confirm this interpretation. The Horseranch fault postdates F_3 folds. The relationship of strain in the phyllite to that in the schist complex is unknown.

Future work, including detailed mapping, petrography, macro and microscopic structural analysis, and uranium-lead and ^{40}Ar-^{39}Ar isotopic dating will address the following:

(1) Depositional and metamorphic age of the schist complex.

(2) Structural relationships between the phyllite, the quartzite and the schist complex.

(3) Timing, rate and mechanism(s) of uplift of the Horseranch Range.

(4) Regional extent and tectonic significance of the mylonite zone and the absolute timing of mylonitization.

(5) Origin of the ultramafic to mafic and granitic rocks.

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