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The Geometry and Kinematic History of the Howard's Pass XY Deposits

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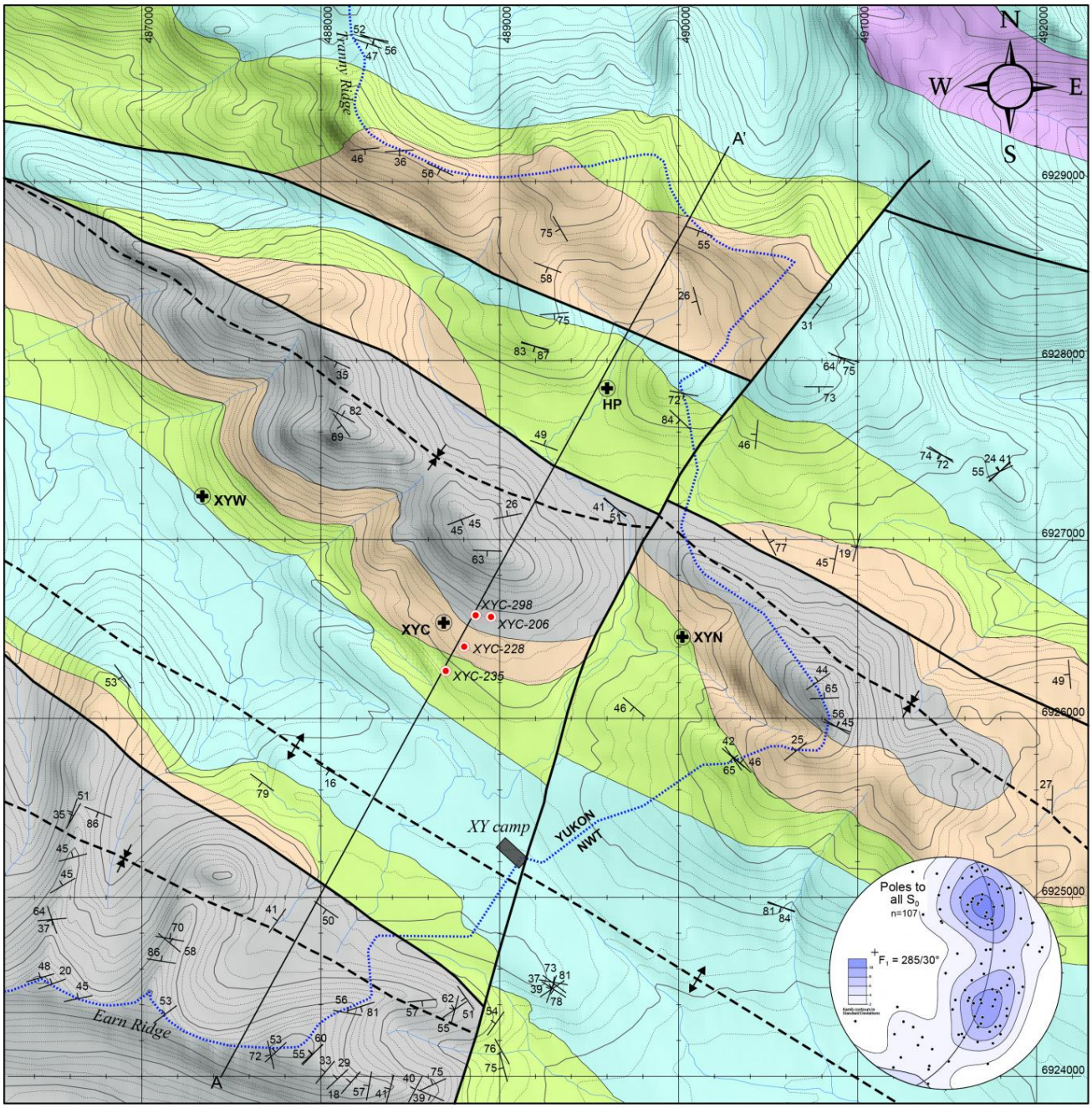
The shale-hosted massive sulfide deposits of Howard's Pass are home to the world's most well-endowed undeveloped Zn-Pb resources. Sulfide deposition occurred in the Silurian, and the deposit was deformed during the Cretaceous Cordilleran orogeny. The Zn-Pb deposits have been incorporated into a series of upright WNW-striking folds on a 40-km trend along the border of the Yukon and Northwest Territories. Owing to the structural complexity of the deposits, multiple structural models for their evolution have been proposed. These range from Silurian soft-sediment deformation to the proposal of a regional shear zone hosting the deposits. In the shear zone model, bedding is completely transposed and previously interpreted stratigraphic boundaries are tectonic in origin. This current study aims to test this model and is focused on the XY group of deposits at the eastern end of the Howard's Pass district. Lithostratigraphic mapping and structural observations indicate one main phase of folding, F_1, and the XY group of deposits is located on the southern limb of a macroscopic syncline. F_1 folds are upright and gently plunging to the WNW-NNW (Fig. 1). A regionally developed, steep NE-dipping cleavage, S_1, is axial planar to the F_1 folds across Howard's Pass. S_1 typically manifests as a slaty cleavage comprising pervasively developed dissolution seams. Within the mineralized sections at XY, located within the Duo Lake Formation, S_1 forms spaced sulfide-rich dissolution seams that were previously interpreted as dewatering structures. These seams are up to 0.5 cm wide and show coarser-grained sphalerite, galena, and pyrite than the laminae they cut across. S_1 is visible at both the mesoscopic and microscopic scale, and its position relative to compositional layering (S_0) is a function of its location within a fold; however, at the outcrop scale S_0 has an enveloping surface that is always oblique to S_1. It shows variable degrees of refraction across S_0 contacts, which is especially prevalent in the limbs of mesoscopic folds. A later kink fabric, S_k, is seen locally at a high angle to S_1 and may be genetically linked to movement on WNW- and NNE-striking faults that overprint the F_1 folds. Mapping constraints show that the faults exhibit normal dip-slip movement. Structural mapping shows that the geometry of the deposits is primarily controlled by folding and that contacts between units are stratigraphic in origin. S_1 and S_k are the only foliations mapped. No shear zone fabrics were identified and there is no evidence that bedding has been transposed.

Fig. 3. Geologic map of the 2020 XY region field area. Stereonet of all bedding data collected in mapping area is shown in the lower right (lower hemisphere projection, equal area). From Kamal and Hickey (2020).



Legend

0 1,000 Metre

Devonian

Earn Group
Undifferentiated mudstone and sandstone. Dark to light grey finely laminated mudstone with <5 mm grey-black silty layers. Weathered outcrops show distinct maroon bands. Interbedded with cherty lenses 1-20 cm and silty limestone up to 1 m. Often forms shale when breaking along dense cleavage planes. Mudstone is variably calcareous. Sandstone is fine-grained with small, rounded chert and quartz granules. Matrix is beige-yellow with orange weathering and consists of subrounded chert clasts and lithic fragments. Seen as piles of rubble and not *in situ*. Massive sandstone blocks are cut by large quartz veins. Poorly sorted conglomerate is seen just outside of the field area.

Silurian to Early Devonian

Steel Formation
Medium to dark grey mudstone with strong orange weathering strongly expressed in outcrop and in talus. Small, <1 cm dark grey silty layers show "wispy" texture that does not weather as strongly. Associated with weathered pyrite cubes with quartz-calcite pressure shadows. Contains coarse, crystalline limestone concretions ranging from 1 cm up to 2 m. Concretions exhibit a strong, fetid odor when a fresh surface is exposed.

Early Ordovician to Silurian

Duo Lake Formation
Dark grey to black, recessively weathering, mudstone. Fine-grained, carbonaceous and locally calcareous. Interbedded with thin <1 cm dark grey silty bands, chert lenses up to 1 m and limestone beds from 1 cm to 2 m. Contains 1 cm blue bands of phosphate. Very fissile and forms pencil cleavage in outcrop. Locally graptolitic towards the top. Mineralization is hosted within the "Active Member" and sulphides (sphalerite, galena, pyrite) are seen in sedimentary beds and in spaced, sulphide rich dissolution seams that are axial planar to folds.

Cambrian to Early Ordovician

Rabbitkettle Formation
Dominantly fine-grained, crystalline light grey limestone layers up to 5 cm with a "wavy" texture interbedded in a rusty orange silty, argillaceous matrix with visible quartz and feldspar. Matrix is variably dolomitic. Different varieties show much thinner layers with laminae thickness <1 cm and no dolomite. Local layers of massive crystalline limestone with no internal textures.

Cambrian

Vampire Formation
Recessive weathering, dark grey to brown, mudstone, siltstone and interbedded sandstone. Not mapped as part of this study, but compiled from Gordey and Anderson, (1993)

XYC Pb-Zn deposit

XYC-228 Drillhole

84 Bedding, S_0

Contact

Fault

Trace of S_1 axial plane cleavage (cross section)

F_1 synform

F_1 antiform

AM Active member of Duo Lake (on cross section)

Universal Transverse Mercator Projection, Zone 9N. North American Datum 1983.