INDIAN AND NORTHERN AFFAIRS

NICKEL-COPPER SULPHIDE DEPOSITS
IN THE KLUANE RANGES,
YUKON TERRITORY

S.W. CAMPBELL

OPEN FILE REPORT
EGS 1976-10

INTRODUCTION

Permo-Triassic rocks of the Kluane Ranges west and northwest of Kluane Lake, Yukon Territory host a number of nickel-copper and copper occurrences, including the Wellgreen Mine which operated briefly during the period May 1972 to August 1973. However, little public information is available concerning these deposits. In 1974 and 1975 S.W. Campbell carried out field investigations during the summer related to these deposits and their host rocks, with partial support from the Department of Indian Affairs and Northern Development Geology Section in Whitehorse, Yukon. The preliminary results of this study are embodied in this open file report. The report is in two parts. The first concerns a general description of the nickel-copper occurrences and their geologic setting. The second is a more detailed description of the Quill Creek area which hosts the Wellgreen Mine. Miss Campbell is continuing her study of these deposits as part of a Ph.D. thesis at the University of British Columbia, Vancouver.

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ABSTRACT

A sequence of Permo-Triassic rocks within a 260 square kilometre part of the Kluane Ranges, southwestern Yukon, consists of Lower Permian volcaniclastic and sedimentary rocks, disconformably overlain by upper Triassic amygdaloidal volcanic rocks. Mafic to ultramafic rocks occur within the upper part of the Permian section and in the Triassic flows. Folding and faulting of this sequence is intense.

The ultramafic rocks are peridotite-dunite complexes in the form of sills. Some gabbroic bodies have intruded along sill boundaries, but most are separate sills or dykes. Nowhere have they been found cutting rocks younger than the upper Triassic volcanics.

Ni-Cu mineralization is spatially associated with the gabbros and peridotites. Dunite portions of ultramafic complexes are barren. Sulphide minerals include pyrrhotite, pentlandite, and chalcopyrite, locally with pyrite, sphalerite, and galena. Occurrences are classified as follows:

1. Massive to stringer within country rock adjacent to gabbro intruding peridotite.
2. Massive to heavily disseminated at the country rock contact of gabbro intruding peridotite.
3. a) Heavily disseminated to nearly massive within gabbro intruding peridotite.

   b) Disseminated within separate gabbroic bodies.
4. Very weakly disseminated within peridotite.

The mineralized gabbro-ultramafic intrusions are spatially related to the Triassic volcanic flows.

The mafic and ultramafic rocks, their Ni-Cu deposits, and volcanic flows are believed to be related genetically.

INTRODUCTION

A belt of Ni-Cu-bearing mafic and ultramafic rocks and spatially associated Cu-bearing volcanic flow rocks extends for approximately 190 kilometres from Slims River northwest to White River. This belt lies within the Kluane Ranges flanked on the southwest by the St. Elias Mountains and on the northeast by the Shakwak Trench. The areas included within the present study are shown in Figure 1.

Numerous mineral prospects exist in the area including past-producing Wellgreen Mine and showings at Arch Creek, Linda Creek, and Canalask on the White River. Minor showings occur southwest of Linda Creek, in Arch Creek canyon, and along Tatamagouche and Burwash Creeks.

GENERAL GEOLOGY

A 260 square kilometre section of the Kluane Ranges was mapped between Burwash Creek and Donjek River (Map a). Here a sequence of Permo-Triassic volcanic and sedimentary rocks is wedged between Duke River Fault to the southwest and Shakwak Fault to the northeast (Muller, 1967).

The oldest rocks are Lower Permian, medium-green andesitic volcanic breccia, thinly bedded to massive tuff, minor amounts chlorite schist, and locally, interbedded argillite and limestone. This unit reaches an estimated thickness of 1,200 metres and is overlain conformably by 900 metres of Lower Permian sedimentary rocks. The contact is gradational. Grey to black argillite, chert, and siltstone form the lower portion of this unit with an upward change to argillaceous limestone, buff-coloured massive limestone, and discontinuous beds of reddish-brown conglomerate and massive sandstone. Upper Triassic amygdaloidal basalts with minor thin, discontinuous limestone interbeds overlie the Permian strata disconformably. These volcanic rocks are dark green with black amygdules to reddish-purple with creamy-white vesicle fillings. Individual flows measure about 15 metres across. Total thickness of this Triassic unit is approximately 900 metres.

Mafic and ultramafic rocks occur within the upper part of the Permian volcaniclastic-sedimentary sequence and in the Triassic volcanics.

The entire Permo-Triassic section has been folded and faulted. Subparallel inclined synclines and anticlines have axial planes striking 100° and dipping 70°SW and axes plunging 30° to the west. Faulting has been intense with many of the lithological contacts acting as fault surfaces or shear zones. Near-vertical dip-slip faults are parallel to the fold axial traces and at a 30° angle to the Shakwak Fault. A younger group of strike-slip faults trends roughly perpendicular to the Shakwak Trench.

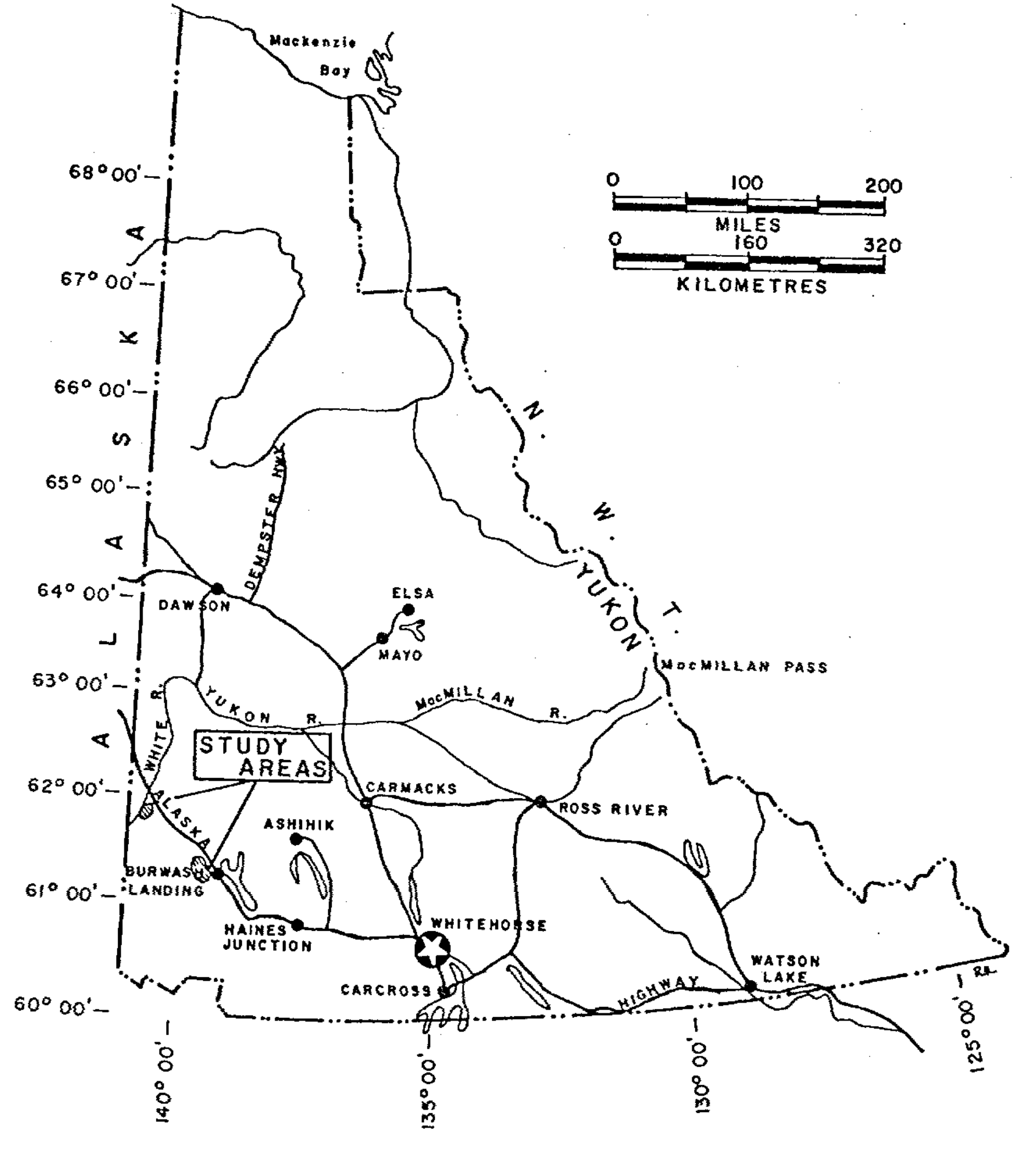

Figure 1. Location of st...

ULTRAMAFIC ROCKS

Dunite, harzburgite, minor lherzolite, and werhlite are the rock types found in the ultramafic complexes. Original mineral compositions are obscured by extensive serpentinization. The original dunite consisted of olivine with up to 5 per cent orthopyroxene and 2 per cent biotite. Harzburgite was composed of 60 to 70 per cent olivine, 25 per cent orthopyroxene, and minor biotite and sulphides. Lherzolite contained up to 55 per cent olivine, 15 per cent orthopyroxene, 25 per cent clinopyroxene, and some biotite and disseminated sulphides. Werhlite consisted of equal amounts of olivine and clinopyroxene, with minor biotite and sulphides. Alteration has converted all olivine to serpentine and magnetite. Minor orthopyroxene is left unaltered.

Dunite is medium-grained with serpentine retaining the euhedral pseudomorphic form of olivine that had a well developed cumulate texture. The peridotites are fine- to medium-grained.

The ultramafic complexes are layered with a thin basal section of dunite. Above this a thicker peridotite grades upwards from harzburgite to werhlite.

Many of the ultramafic/country rock contacts have been obliterated by shearing or faulting. Where preserved they are sharp with stringers of peridotite extending into the surrounding rocks. Terminations of the ultramafic bodies show stringers or fingers subparallel to the sedimentary layering. The ultramafites are generally concordant but locally are discordant.

GABBROIC ROCKS

Mafic intrusive rocks recognized in the region are either gabbros or olivine gabbros. Their original mineral composition consists of approximately equal amounts of plagioclase and clinopyroxene, up to 15 per cent olivine, and about 15 per cent orthopyroxene. Deuteric alteration has produced the following changes: olivine has been partially to completely serpentinized; plagioclase has been saussuritized; and the pyroxenes have been altered to uralite, carbonate, and chlorite along grain edges.

The gabbros are all medium-grained and massive with subhedral crystals.

These mafic bodies occur in three distinct settings:

1. Along the lower or upper contact of an ultramafic complex and concordant with it.
2. As concordant bodies near the Permo-Triassic disconformity.
3. As small discordant bodies within the Triassic volcanic flows.

Ni-Cu SULPHIDE DEPOSITS

General

Nickel-copper deposits are associated spatially with gabbroic and peridotitic rocks. Dunite portions of the ultramafic complexes are barren. Sulphide minerals include pyrrhotite, pentlandite, and chalcopyrite, locally with pyrite, sphalerite, and minor amounts of galena.

Wellgreen Mine

The Wellgreen Mine (Map b) is at the northwest extremity of an elongate ultramafic body, which extends for 7,500 metres, has a width of 600 metres, and is situated on the southwest limb of a major syncline. The intrusion is a layered complex of 52 metres of dunite at the base and 396 metres of peridotite. Olivine gabbro intrudes along the upper contact of the Quill Creek ultramafic complex. It is semi-continuous for 1,500 metres and averages 9 metres in width.

Discontinuous, narrow alteration zones border the layered body. These zones represent quartz-carbonate alteration of Permian volcaniclastic rocks and are possibly related to serpentinization of the ultramafite.

There are four types of Ni-Cu sulphide occurrences in the Wellgreen Mine area:

1. Stringer to disseminated sulphides in fractured cherty argillite country rocks. (Grades reach 1 to 2 per cent Ni and 2 to 3 per cent Cu).
2. Massive, 3 to 18 metre wide bodies with sharp contacts, which sit at the gabbro/country rock contact. Underground studies show them to be erratic and discontinuous bodies that swell and pinch out along the contact (Vincent, 1972). These swells plunge at a small angle to the west. (Grades reach a maximum of 6 per cent Ni and 2 to 3 per cent Cu).
3. Very heavily disseminated sulphides are contained in the gabbro. (Grades reach 1 to 2 per cent Ni and 2 to 3 per cent Cu).
4. Weakly disseminated sulphide minerals occur in the peridotite.

Arch Creek

The 900 metre by 90 metre peridotite at the Arch Creek property (Map d) appears to be a dismembered portion of the large Quill Creek body which fingers out near the Wellgreen Mine. A 0.6 to 1 metre wide gabbroic body of unknown length intrudes the ultramafite along its northeast contact with cherty argillite.

Ni-Cu sulphide occurrences are similar to those at Wellgreen, but on a much smaller scale. Maximum grades in the massive sulphides are 3 per cent Ni and 1 per cent Cu.

Linda Creek

The large Quill Creek ultramafic body trends across the Linda Creek property (Map c) and has numerous inclusions of volcaniclastic rocks. Minor elongate 9 metre wide gabbroic bodies have intruded both the peridotite and its inclusions.

Sulphide occurrences include:

1. Stringer zones within volcaniclastic inclusions intruded by gabbro.
2. Massive to heavily disseminated sulphides at the gabbro/volcaniclastic contact. (Grades reach a maximum of 3.5 per cent Ni and 2 per cent Cu).
3. Disseminated sulphide minerals within the small gabbroic intrusions.

Another type of sulphide occurrence includes stringers containing at least one of, pyrite, chalcopyrite, sphalerite, and galena, in 5 to 8 centimetre wide carbonate veins cutting the volcanic tuff and interbedded cherts and argillites. This occurrence is a short distance southwest of the peridotite body.

Canalask Property

At the Canalask property, White River (Map e), an ultramafic complex of undetermined length and 250 metres in width intrudes the upper part of the Permian volcaniclastic unit on the northeast side of a possible syncline. The intrusion consists primarily of dunite with discontinuous peridotite. A 60 metre wide gabbroic body intrudes along the basal contact of the dunite.

Ni-Cu sulphide occurrences include:

1. Massive bodies and stringers within cherty argillite and banded chert. Pyrite and sphalerite are also present. At the main showing Ni values average 0.18 per cent and Cu 0.040 to 0.58 per cent.
2. Weakly disseminated sulphide minerals occur within the moderately unaltered peridotite. Both the dunite and gabbro are essentially barren.

Showings

Minor showings of Ni-Cu mineralization are present at four locations within the Quill Creek area.

1. At Arch Canyon a small (900 metre by 60 metre) peridotite body with minor gabbro occurs at the Permo-Triassic contact. Pyrrhotite and chalcopyrite are disseminated throughout the gabbro and peridotite.
2. Along Tatamagouche Creek a 4,500 metre by 300 metre gabbroic body occurs at a fault contact between Permian sedimentary rocks and Triassic volcanic flows. The gabbro contains disseminated pyrrhotite and chalcopyrite.
3. A gabbro measuring 250 metres across is exposed on Burwash Creek. It sits within a thick Permian sedimentary sequence. The mineralization is disseminated.
4. A 270 metre wide peridotite-gabbro complex is situated upstream of the above gabbro along Burwash Creek. Disseminated and stringer sulphides occur in fractures in cherty argillite country rock. Moderately heavy disseminated pyrrhotite and chalcopyrite exist at the gabbro/argillite contact and minor disseminations are present within the gabbro.
5. Southwest of Linda Creek property a 3,900 metre by 20 metre gabbroic body conformably intrudes near the Permian-Triassic contact. Local disseminations of pyrrhotite and chalcopyrite are found in the gabbro.

SUMMARY

There are four principal types of Ni-Cu sulphide occurrences in the study areas.

1. Massive, stringer to disseminated within cherty argillite country rock.
   a) adjacent to gabbro intruding peridotite.
      Wellgreen Mine, Arch Creek, Linda Creek, and Upper Burwash Creek
   b) adjacent to peridotite.
      Canalask Property
2. Massive to heavily disseminated at the country rock contact of gabbro intruding peridotite.
      Wellgreen Mine, Arch Creek, Linda Creek, and Upper Burwash Creek
3. a) Heavily disseminated within gabbro intruding peridotite.
      Wellgreen Mine, Arch Creek, Linda Creek, Arch Canyon, and Upper Burwash Creek
   b) Disseminated within separate gabbroic bodies.
      Tatamagouche Creek, Burwash Creek, and SW of Linda Creek
4. Very weakly disseminated within peridotite.
      Wellgreen Mine, Arch Creek, Linda Creek, Canalask Property, Upper Burwash Creek, and SW of Linda Creek

TRIASSIC VOLCANIC ROCKS

Triassic volcanic flow rocks within the Kluane Ranges are equivalent to Nikolai volcanics in Alaska. Mineral composition includes plagioclase, clinopyroxene, and magnetite. The amygdules contain chlorite, epidote, pumpellyite, and calcite. Native copper, chalcocite, and malachite are also present locally in the basalt. Amygdules commonly account for 10 to 25 per cent by volume of the rock.

Individual flows were recognized locally within the volcanic sequence. These flows measure up to 50 feet thick and show colour variation from dark green at the base to red at the top. There is no apparent upward increase in proportion of amygdules within individual flows.

Chalcocite and malachite occur within carbonate stringers and veins in the amydgaloidal basalts. Native copper appears in thin, discontinuous dendritic veins.

INTERPRETATION

The gabbro and ultramafic intrusions are related spatially to the Triassic volcanic flows, such that they occur in, immediately adjacent to, or within 900 metres stratigraphically of the basalt. Nowhere do gabbroic bodies intrude rocks younger than these volcanics.

A model is proposed that incorporates genetic relationships among mafic and ultramafic intrusive rocks, Ni-Cu sulphide deposits and Triassic volcanic flows. The more mafic members of the suite were intruded prior to volcanism as peridotite magmas that differentiated in place to form layered sills. Then gabbros intruded along sill contacts, as individual sills, or as dykes with some of the dykes acting as feeders for the Triassic basaltic flows. Field, petrographic, mineralographic, chemical, and age data are being collected to test this model.

Recognition of the ultramafic complexes as sills is supported by the following field and petrographic evidence:

1. The ultramafites are localized stratigraphically near the Permian volcaniclastic/sedimentary contact.
2. They are elongate in shape and dominantly concordant to sedimentary layering.
3. Dunite and peridotite portions of the complexes are layered.
4. Modal variations of serpentine pseudomorphs after olivine and both clino- and ortho-pyroxene are compatible with layering in ultramafic complexes.
5. Dunite portions of the complex have a well developed cumulate texture.

Gabbroic rocks have intruded the ultramafic complexes. This is supported by contact relations between the gabbro and peridotite. Contacts are sharp with stringers of gabbro intruding peridotite.

Massive sulphide bodies intruded along the gabbro/cherty argillite contact. This is supported by:

1. Sharp contacts of the massive sulphide bodies and stringers of sulphides running into fractures in the cherty argillite.
2. Inclusions of cherty argillite in the massive sulphide bodies.
3. Abrupt change in the grade of nickel between disseminations in the gabbro and sulphides in the massive bodies.

Textural features of the Ni-Cu deposits suggest a magmatic origin. Massive ore contains exsolution flames of pentlandite in pyrrhotite and silicate inclusions are found within sulphide minerals. Disseminations in gabbro consist of blebs of pyrrhotite-chalcopyrite, indicative of sulphide immiscibility. Some petrographic sections show small sulphide blebs along cleavages in pyroxene crystals. Disseminated ore at Canalask Property shows irregular, scattered patches of sulphide minerals, indicating possible remobilization. This agrees with Campbell's (1960) suggestion that Canalask sulphide minerals may be partly hydrothermal in origin.

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GEOLOGY OF THE QUILL CREEK AREA, KLUANE RANGES, YUKON TERRITORY

S.W. CAMPBELL

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Location and Access

Quill Creek map area is 29 kilometres northwest of Burwash Landing in a section of the Kluane Ranges bounded on the northeast by the Shakwak Trench, on the southeast by Burwash Creek, and on the west by Donjek River. A 13 kilometre, all-weather, gravel road trending west-southwest from the Alaska Highway Mile Post 1111 provides good access to the area.

Mineral Exploration

Massive sulphides were discovered in June, 1952, by W.B. Green and C.A. Aird along a gully that is situated northwest of the junction of Nickel Creek and a major tributary (Map b). Claims staked by them were optioned by Hudson Bay Mining and Smelting Company who formed a subsidiary, Hudson-Yukon Mining Company Limited, to direct an exploration program on what became known as the Wellgreen Property (Craig and Laporte, 1972). Development on the property during the period 1953 to 1956 included surface geological work, 4,270 metres of underground workings, and 19,825 metres of surface and underground diamond drilling. Underground workings involved an adit driven westerly for 1,220 metres at elevation 1,296 metres, that was connected by winzes and raises to working levels 1,363 metres, 1,235 metres, and 1,113 metres. The work indicated an estimated 669,365 metric tons of ore, containing 2.05 per cent Ni, 1.42 per cent Cu, 0.073 per cent Co, 0.157 grams Au/metric ton, 1.188 grams Pt/metric ton, and 0.844 grams Pd/metric ton (Green, 1968; Findlay 1969).

The property was inactive from 1956 to 1968 with the claims being held in good standing. Re-evaluation of the property began in 1968, when ground geophysical surveys were conducted over the main showings. These outlined several anomalous areas, which prompted 762 metres of diamond drilling from June to November, 1969, to investigate the possibility of disseminated sulphide zones (Craig and Laporte, 1972). A powerhouse and mine dry were built at the portal in 1970 and a mill and townsite were started at Mile 1111 of the Alaska Highway.

Production from the Wellgreen Property began in May, 1972, at a rate of 564 metric tons/day, but this decreased to 419 metric tons/day and finally to 303 metric tons/day until shut-down in August, 1973 (Mines and Minerals Activities 1973). A total of 96,221 metric tons of ore were milled and the concentrate shipped to Haines, Alaska by road for trans-shipping by deep sea vessel.

Regional Geologic Setting

A sequence of Permo-Triassic volcanic and sedimentary rocks with spatially related mafic to ultramafic bodies of the Kluane Ranges are wedged between the Shakwak Fault to the northeast and the Duke River Fault to the southwest. These rocks are folded about subhorizontal, northwest-trending fold axes. The stratigraphy is complicated by numerous northwest-trending faults, which commonly form contacts between units. Both primary layering and foliation dip steeply either to the northeast or southwest.

These 207 square kilometres of the Kluane Ranges contain four major map units, corresponding to units 10 to 13 of Muller (1967). Permian pale to medium green volcanic breccia, thinly bedded to massive tuff, and minor quantities of chlorite schist (resulting from intense shearing corresponding to Muller's map unit 10, have an estimated thickness of 1,220 metres and are overlain conformably by a Permian sedimentary sequence. Pale to dark grey argillite, siltstone, and local black, slaty argillite (Muller's map unit 11) have an apparent thickness of 915 metres. Other sedimentary rock types within this sequence include discontinuous beds of reddish-brown conglomerate, greyish-brown massive sandstone, and buff-coloured massive limestone and argillaceous limestone. Younger Triassic amygdaloidal basalts (Muller's map unit 13) unconformably overlie the Permian strata. These volcanics are dark green with black amygdule fillings to reddish-purple with white to cream-coloured fillings. The basalt is massive throughout an estimated thickness of 915 metres. Thin, discontinuous layers of limestone, conglomerate, and argillite are interbedded with the amygdaloidal basalt. Dark green to black mafic to ultramafic bodies, 100 to 500 metres wide and 2 to 9 kilometres long, appear concordant with the Permian units. Locally they are discordant and appear within the amygdaloidal basalt. These ultramafites do not appear to cut through rocks younger than the basalt (J.W.H. Monger, personal communication).

Local Geology

Approximately 3.5 square kilometres surrounding the Wellgreen Mine were mapped at a scale of 1 centimetre to 24 metres.

Oldest known rocks in the area are Permian volcanic tuff and breccia of andesitic composition with minor amounts of interbedded sedimentary rocks (Map b, map unit 1). This unit has an apparent thickness of 1,200 metres. The breccia consists of pale green angular to subrounded fragments (measuring 0.5 to 1.5 centimetres) set in a darker green, fine-grained matrix. Fine-grained, thinly bedded (2.5 to 7.5 centimetres) to medium-grained, massive volcanic tuff is more widespread than the breccia. Discontinuous, thin sedimentary units are interbedded with volcanic tuff. Interbedded argillite and limy argillite are abundant in the northwest section of the map area and a thin limestone unit, sandwiched between massive volcanic tuff, occurs in the northwest corner. Local shearing of this volcanic unit has produced chlorite lenses arranged subparallel to the foliation, which serve as a distinct feature of unit 1a.

Permian sedimentary rocks (Map b, map unit 2) overlie the andesitic tuffs to the northeast. Black slaty argillite, medium grey massive argillite, limy argillite, and minor pebbly sandstone constitute the portion of unit 2 present in the Quill Creek map area. Bedding in the argillite is visible locally with beds ranging from 0.2 to 0.7 centimetres in thickness. Colour varies slightly from bed to bed. The black argillite has a well-defined slaty cleavage near shear zones.

Triassic, dark green to reddish-purple, amygdaloidal basalt (Map b, map unit 4) is in fault contact with volcanic tuff in the southwest half of the map area. This unit forms massive outcrops and only locally has developed a foliation. The amygdules are filled with white to cream-coloured calcite and zeolites and pale green epidote. Epidote is also abundant as stringers throughout the basalt.

Intensely sheared, serpentinized, dark green to greenish-black peridotite and pale green dunite form a large ultramafic body (Map b, map unit 3) which is locally discordant with the Permian volcanic and sedimentary units. Medium-grained, greenish-grey, massive gabbro is localized near No. 1 Showing and pinches out into peridotite. The ultramafic body separates into three fingers at its northwest extremity, probably as a result of shearing. Numerous shear directions have affected the ultramafic body and it is impossible to discern the amount of relative movement. The ultramafite appears to be poorly differentiated. Scarcity of outcrop and overprint of serpentinization (approaching 100 per cent alteration in some outcrops) combine to mask details of the crystallization history of the ultramafic body. Shears are common along the ultramafic content, however, some outcrops show a sharp contact with stringers of ultramafite pervading the Permian rocks. Inclusions of Permian rocks are present where the ultramafite begins to finger.

Discontinuous, narrow alteration zones are located at the ultramafic contact. These zones represent carbonatized unit 1 and reach a maximum thickness of 60 metres. The original volcanic tuff and interbedded argillite have been almost totally replaced by carbonate minerals.

Small, fine- to medium-grained, hypidiomorphic to porphyritic, felsic dykes (Map b, map unit 7) cross cut all previously described map units. Their composition ranges from granitic to granodioritic.

Structural Geology

The map units represent the southwest arm of a northwest trending syncline (Muller, 1967). The units dip steeply southwest, although dips are locally to the northeast at approximately 80°, suggesting tilting of the axial plane.

Foliation is roughly parallel to the sedimentary layering. Shears are numerous: the ultramafite is riddled with shears with slickenside plunges ranging from near horizontal to vertical.

Unit 4 is in fault contact on both its northeast and southwest sides with unit 1. Sedimentary rocks of unit 2 conformably overlie volcanic tuff and breccia, although shearing and lack of outcrop obliterate most of the contact zone.

The ultramafic body trends northwest and dips steeply to the southwest. It is predominantly discordant in the Quill Creek map area, although on a broader scale the elongated body is conformable.

Economic Geology

Nickel-copper sulphides are present at three locations in the map area. The dominantly pyrrhotite, pentlandite, and chalcopyrite association varies from weakly disseminated throughout the ultramafite, to heavily disseminated and stringer sulphides, and finally to massive sulphides. All sulphide concentrations are spatially close to the gabbro or peridotite. Local alteration, including amphibolitization, chloritization, and carbonatization, occurs near the sulphide mineralization.

The No. 1 Showing consists of massive to stringer and heavily disseminated sulphides at the gabbro contact with volcanic tuff and minor amounts of argillite. The ore contact is sheared or talus-covered in most places, but is sharp where observable. Structural control of mineralization is suggested by the increased intensity of shears in the massive sulphide zone (Campbell, 1960). Major shears do not appear to offset the massive sulphides.

The No. 2 Showing has disseminated sulphides at the contact between serpentinized peridotite and volcanic tuff and argillite. Again the intesity of shearing is increased near the mineralized area.

No.3 Showing sits within locally altered unit 1 volcanic tuff and consists of two small outcrops of heavily disseminated pyrrhotite, pentlandite, and chalcopyrite. The mineralized zone is within 61 metres of peridotite. Amphibole and chlorite formed by alteration are abundant at this showing.

The heavily disseminated to massive sulphide mineralization is later than the ultramafite intrusion, but the presence of disseminated sulphides throughout the body, the sharp contacts of the ore zones, the close spatial relationship between showings and ultramafite, and the similar pyrrhotite-pentlandite-chalcopyrite association of the massive and sparsely disseminated sulphides suggests a late magmatic origin for the mineralization, with shearing being a possible structural control.

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GEOLOGIC LEGEND

(to accompany geological maps EGS 1976-10a,b,c,d,e by S.W. Campbell)

Cenozoic

- Tertiary
  - Paleocene
    - [7] Porphyritic latite, trachyte, rhyolite

Mesozoic

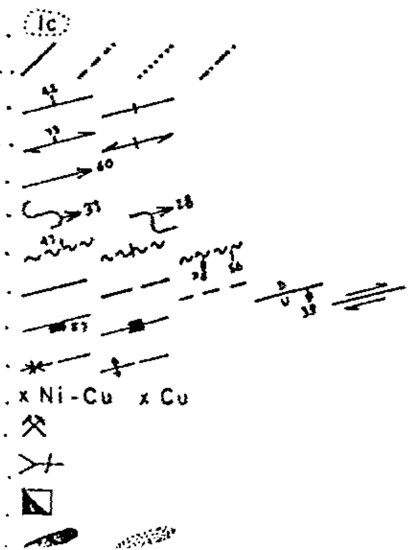
- Cretaceous (and earlier?)
  - [6] Kluane Range hornblende biotite granodiorite
- Upper Triassic
  - [5] Chitistone limestone
  - [4] Nikolai volcanic rocks
    - [4a] Amygdaloidal volcanic flows
    - [4b] Interbedded limestone
- Permo-Triassic
  - [3] Mafic and ultramafic rocks
    - [3a] Gabbro, olivine gabbro
    - [3b] Peridotite
    - [3c] Dunite
    - [3d] Quartz-carbonate alteration

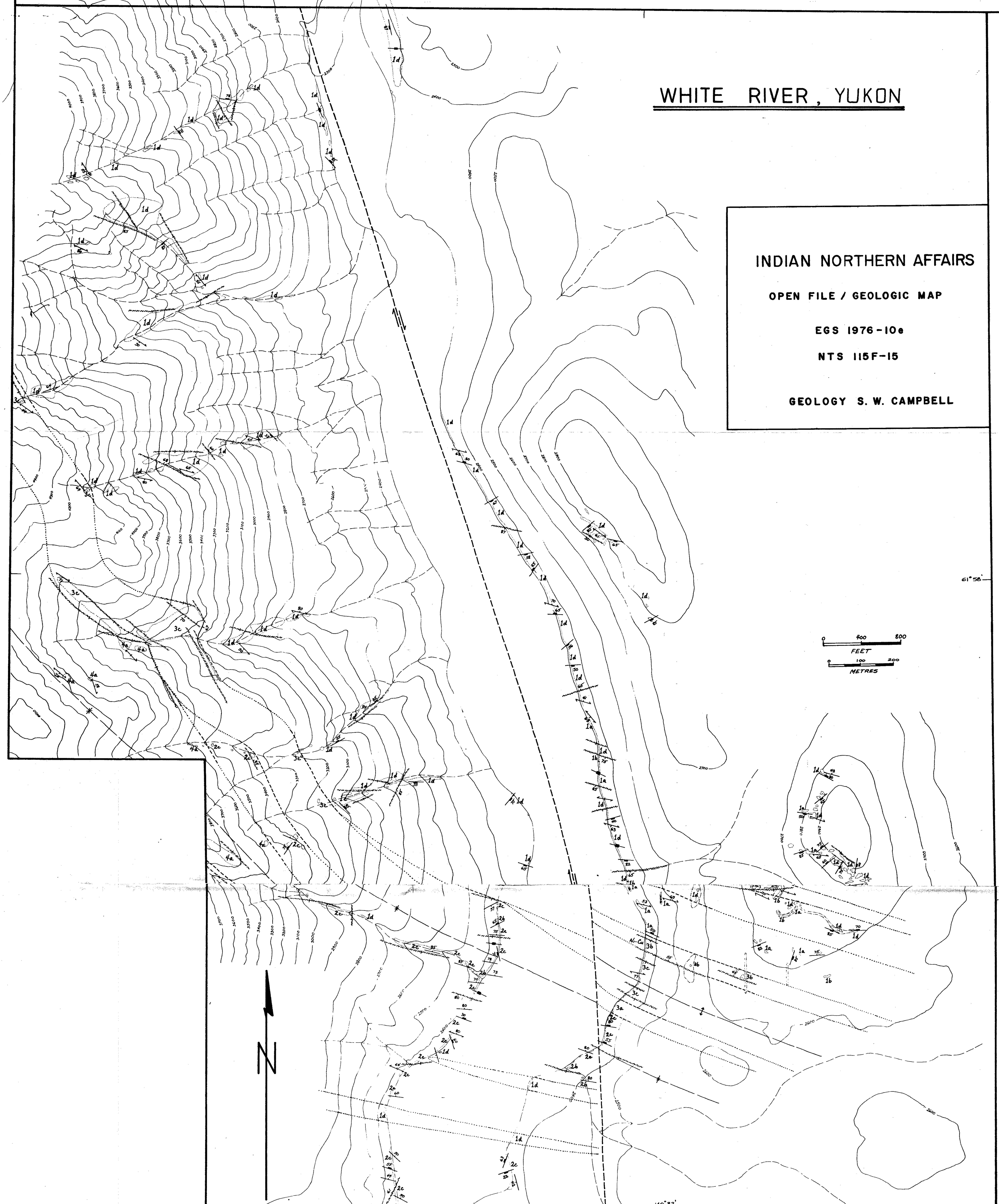
Paleozoic

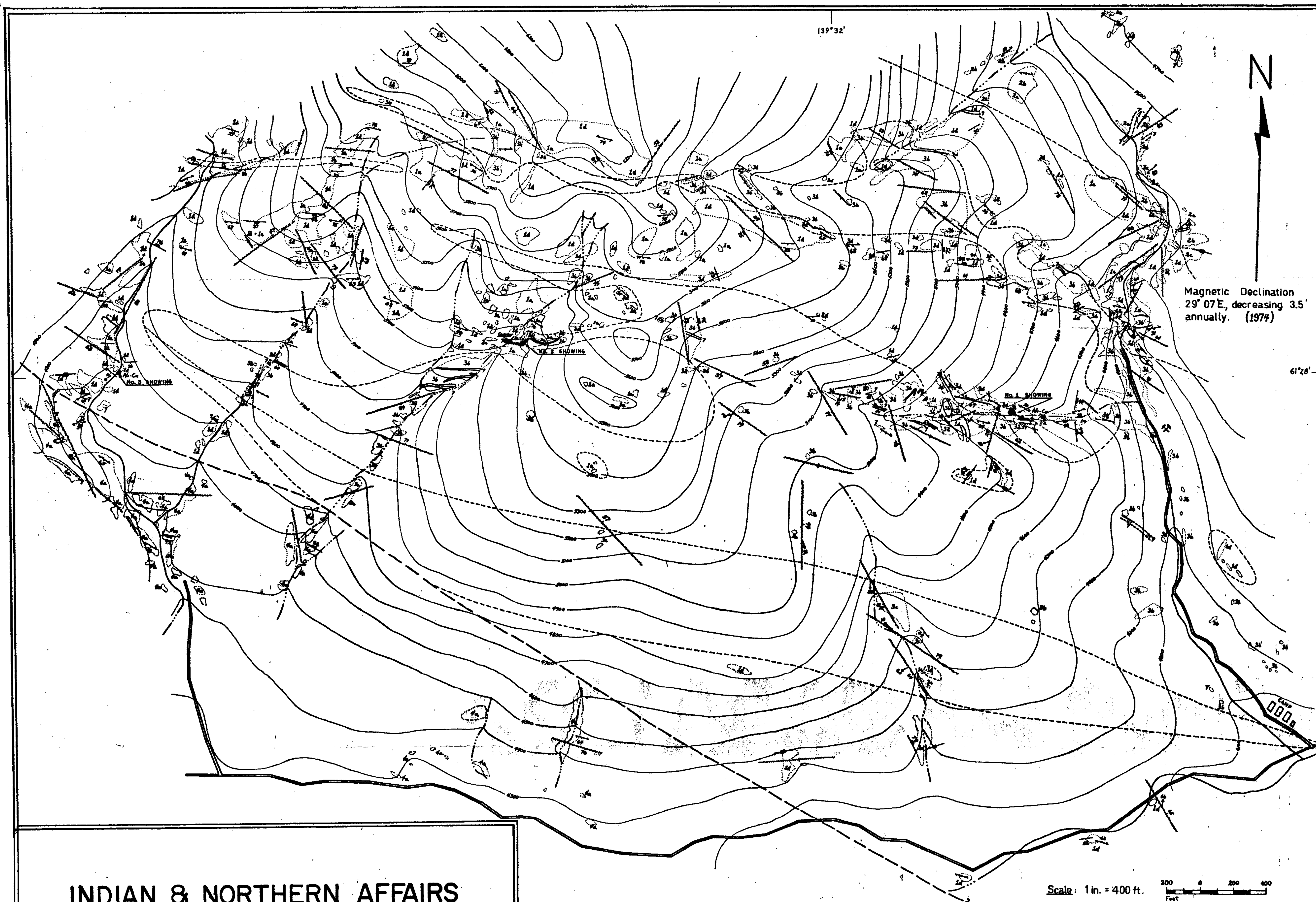
- Lower Permian
  - Skolai group
  - [2] Sedimentary sequence (Hasen Creek Formation*)
    - [2a] Limestone
    - [2b] Sandstone, greywacke, pebbly argillite, conglomerate
    - [2c] Shaly, limy, cherty argillite and chert
- Pennsylvanian to lower Permian
  - Skolai group
  - [1] Volcaniclastic sequence (Station Creek Formation*)
    - [1a] Shaly, limy and cherty argillite
    - [1b] Limestone
    - [1c] Volcanic breccia
    - [1d] Volcanic tuff

* U.S.G.S. equivalent

Rock outcrop area ....
Geologic boundary (defined, approx, assumed, gradational) ....
Bedding (inclined, vertical) ....
Schistosity (inclined, vertical) ....
Lineation ....
Minor fold (S,Z) with axis ....
Shear zone (inclined, vertical, with slickensides) ....
Fault (defined, approx, assumed, dip-slip, strike-slip) ....
Fractures (inclined, vertical) ....
Fold (trace of axial plane-syncline, anticline) ....
Mineral prospect ....
Mine (abandoned) ....
Adit (boarded up) ....
Shaft ....
Sulphide showings (massive, heavily disseminated) ....




WHITE RIVER, YUKON
INDIAN NORTHERN AFFAIRS
OPEN FILE / GEOLOGIC MAP
EGS 1976-10e
NTS 115F-15
GEOLOGY S. W. CAMPBELL
0 400 800
FEET
0 100 200
METRES
61°58'
140°32'
N



Scale: 1 in. = 400 ft.

Scale: 1cm. = 48 m.

INDIAN & NORTHERN AFFAIRS

OPEN FILE GEOLOGIC MAP

EGS 1976-10b

NTS 115G-5

GEOLOGY OF THE WELLGREEN AREA, KLUANE RANGES, YUKON TERRITORY. (GEOLOGY BY S.W. CAMPBELL).

INDIAN & NORTHERN AFFAIRS

OPEN F:LE GEOLOGIC MAP

EGS 1976-10c

NTS 115G-6

GEOLOGY BY S. W. CAMPBELL

0 200 400
FEET

0 50 100
METRES

LINDA CREEK, YUKON

ARCH CREEK, YUKON

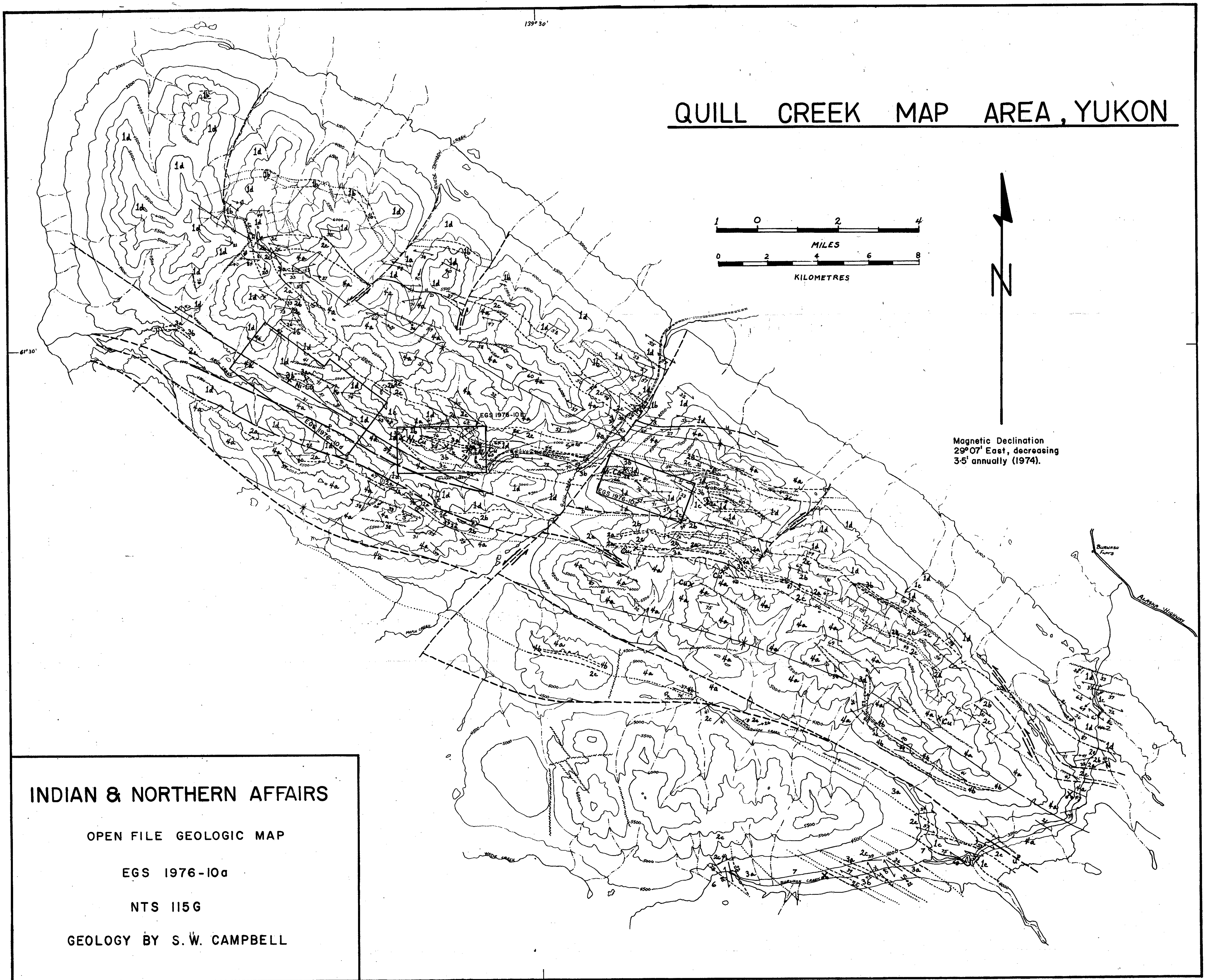
INDIAN & NORTHERN AFFAIRS

OPEN FILE GEOLOGIC MAP

EGS 1976-10d

NTS 115G-5

GEOLOGY BY S. W. CAMPBELL



QUILL CREEK MAP AREA, YUKON
MILES
KILOMETRES
Magnetic Declination 29°07' East, decreasing 3·5' annually (1974).
139°30'
61°30'
EGS 1976-10a
EGS 1976-10b
EGS 1976-10c
ALASKA HIGHWAY
BURWASH CREEK
INDIAN & NORTHERN AFFAIRS
OPEN FILE GEOLOGIC MAP
EGS 1976-10a
NTS 115G
GEOLOGY BY S. W. CAMPBELL