MAP NO.:
106 D 16

ASSESSMENT REPORT X
PROSPECTUS
CONFIDENTIAL X
OPEN FILE

DOCUMENT NO: 092852
MINING DISTRICT: Mayo
TYPE OF WORK: Geology, Geochemistry

REPORT FILED UNDER: Chevron Minerals Ltd.

DATE PERFORMED: May - August 1989

DATE FILED: April 1990

LOCATION: **LAT.:** 65° 50'N

AREA: Wernecke Mountains

LONG.: 134° 20'W

VALUE $: 8000.00

CLAIM NAME & NO.: STEEL 1-16 YB 03020 - YB 03035

WORK DONE BY: M. Hitzman

WORK DONE FOR: Chevron Minerals Ltd.

DATE TO GOOD STANDING:

REMARKS: #37 PAGISTEEL Work in 1989 consisted of re-logging and re-sampling of drill core in Whitehorse, and relogging of core on the property. Detailed mapping was conducted on the property and samples were analyzed for multiple elements including NAA for Rare Earths. The author concluded that Pagisteel and other Wernecke breccias are similar in mineralogy and alteration style to the Australian Olympic Dam deposit. An extensive program involving additional claims, geochemistry, detailed mapping and geophysical work was recommended.

indexed June 26/90
Summaryed April 19/91

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MAYO, Y.T.
I.A. & N.D.

ASSESSMENT REPORT
EXPLORATION ON THE STEEL CLAIMS (PAGISTEEL PROPERTY)
WERNECKE MOUNTAINS, YUKON

092852

Mayo Mining District
N.T.S. 106 D
Latitude: 65° 50'
Longitude: 134°20'

Owners: Chevron Minerals Ltd.
Operator: Chevron Minerals Ltd.

Author: M. W. Hitzman
April 1990

This report has been examined by the Geological Evaluation Unit under Section 53 (4) Yukon Quartz Mining Act and is allowed as representation work in the amount of $ 8000.00.

W LeBarge

for Regional Manager, Exploration and Geological Services for Commissioner of Yukon Territory.

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APPENDICES

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1.0) 1989 EXPLORATION PROGRAM - SUMMARY

During 1989 Chevron carried out a limited exploration program on the Pagisteel (Steel) property in the Wernecke Mountains, east-central Yukon Territory (Figure 1). The Pagisteel property covers the largest known example of an iron-rich breccia body in the Wernecke Mountains. These breccia bodies are characterized by iron, copper, uranium and rare earth element mineralization. This style of mineralization is similar to that in the giant Olympic Dam deposit in Australia.

The first stage of work involved re-logging and re-sampling of the drill core from the property stored at the H.S. Bostock core library in Whitehorse (DDH 4) in May 1989. Field work on the property was conducted between August 13-16, 1989. Two geologists (M. W. Hitzman and M. Dittrick) conducted mapping /sampling on Steel Claims 1-16 and relogging of diamond drill holes DDH- 1 and 5 (Appendix VI). Unfortunately the location of the drill holes on the property has not been recovered. No maps showing original drill hole locations have been found and although drill pads can be located on the ground, there is no indication as to which cores correspond with which pads. Detailed mapping was conducted in the area of the old hematite showing (hematite knob) and mapping traverses were completed in the Bear River valley and on the south side of the Bear River to delineate the extent of the breccia body. A number of surface samples of the breccia from the claim block were collected as well as samples of drill core from the core stored on site. These samples were submitted for multi-element geochemical analysis, including neutron activation analysis for rare earth elements. A number of these samples were also cut and examined petrographically by the author. Three samples were submitted to Dr. D. Beaty at Chevron Oil Field Research Company Laboratories for carbon and oxygen isotope analysis. An additional part of the 1989 program involved comparative studies of the Pagisteel breccias with other breccias in the Wernecke Mountains and similar systems elsewhere in North America and in Australia and northern Europe.

2.0) LOCATION AND CLAIM STATUS

The Pagisteel property is located on the Bear River in the Wernecke Mountains, Yukon (134°20', 65°50'; NTS 106D - Nash Creek). The claim block consists of 16 claims (Steel 1-16) staked by Archer Cathro & Associates on behalf of Chevron Minerals Ltd. on April 8, 1989 and recorded on April 12, 1989 (Figure 2). The property is located approximately 100 km

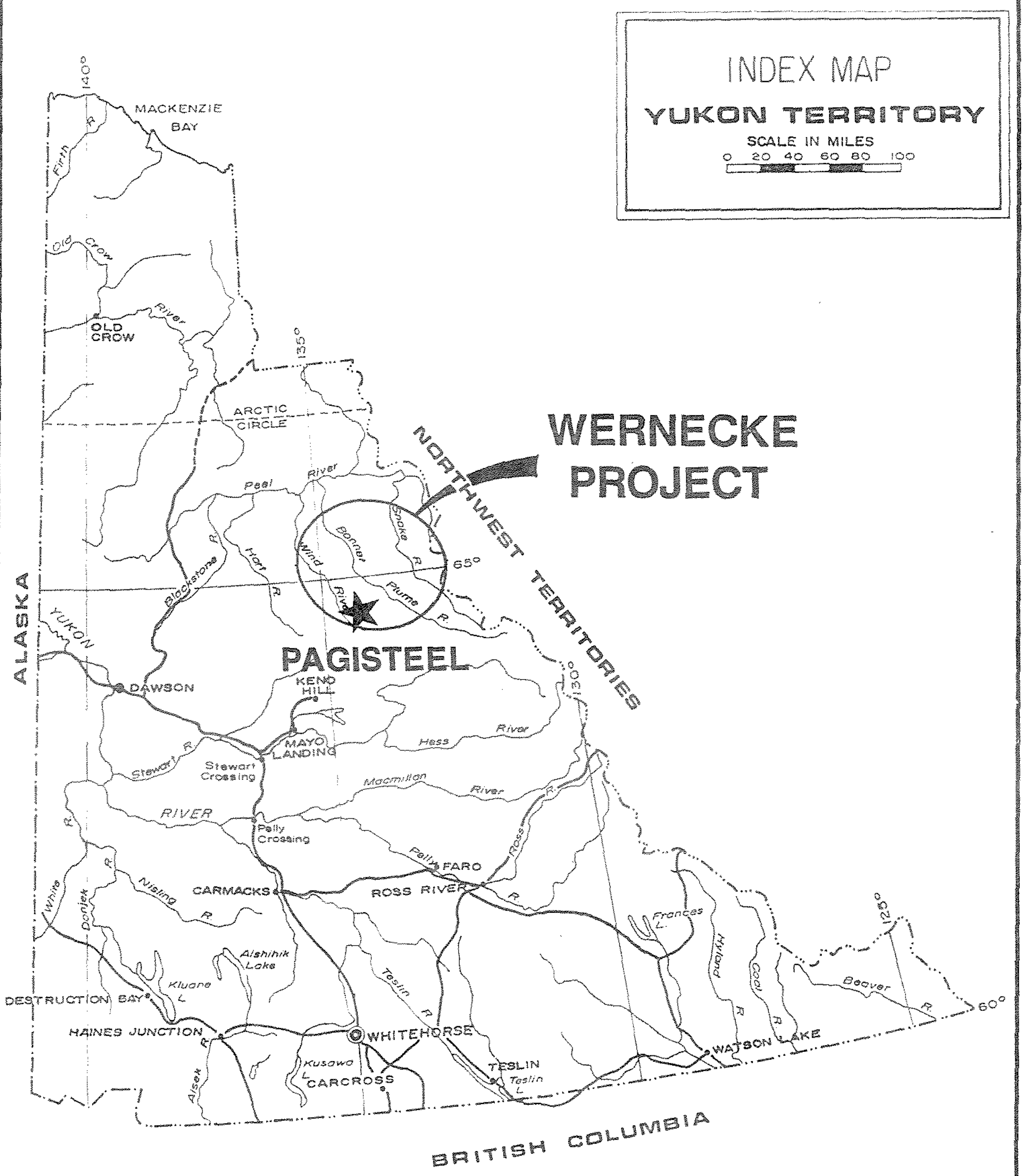
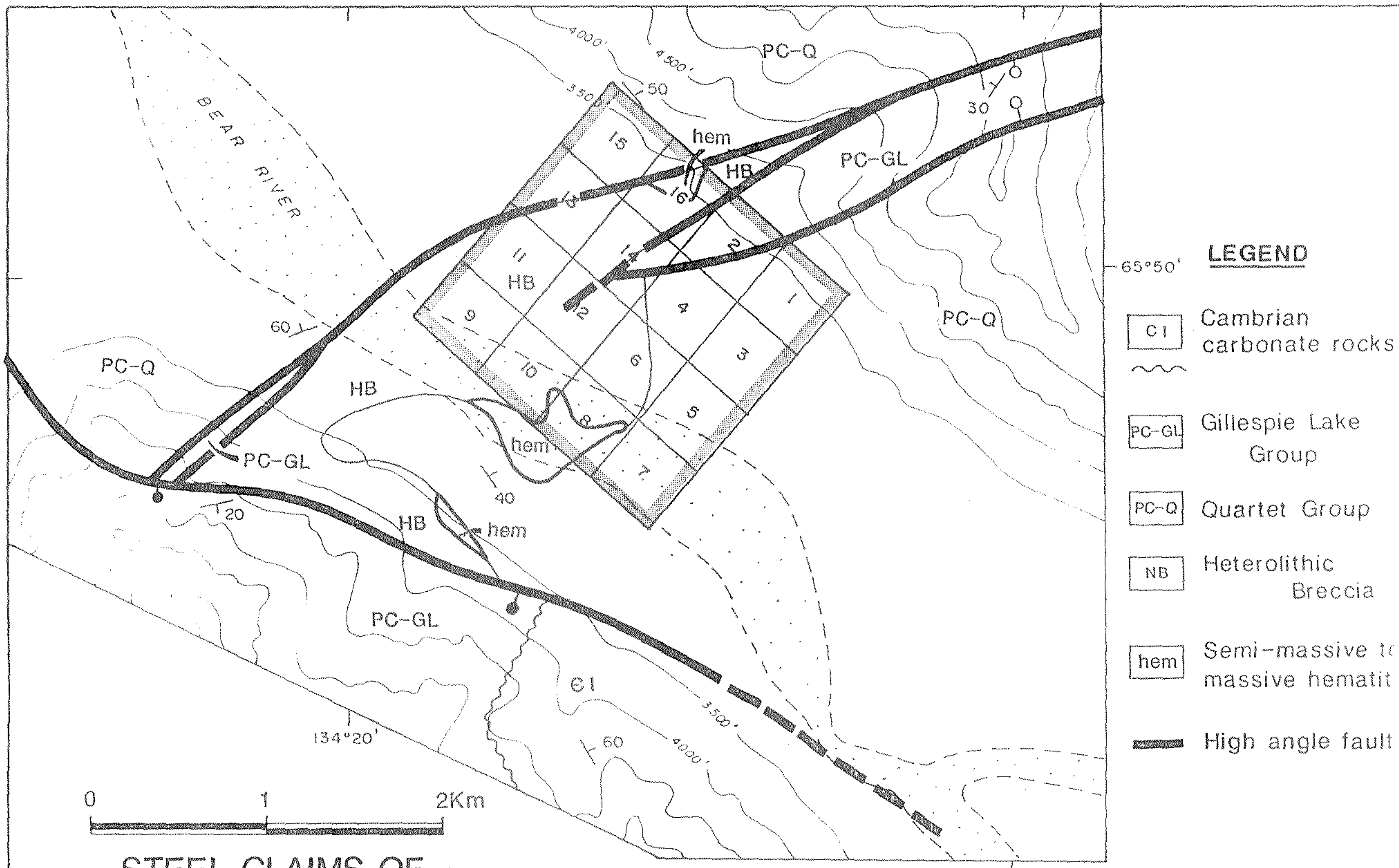


Fig.No.1

NTS.106/D



STEEL CLAIMS OF -

PAGISTEEL PROSPECT, WERNECKE MTNS, YUKON

NTS. 106

FIG.No.2

northwest of Keno Hill and is accessed by light aircraft to the Bear River strip adjacent to the property, heliocopter, or along the Wind River winter road which crosses the property.

3.0) PREVIOUS EXPLORATION

The original showing of massive hematite on the north bank of the Bear River on a small knob approximately 250 meters above the valley floor was staked by A. Jellinek and P. Runer of Pacific Giant Steel Ores Ltd. in 1962. Between 1962 and 1966 minor trenching and an airborne magnetic survey was conducted around the original showings. In April 1967 equipment was moved onto the property along the Wind River winter road and an airstrip was constructed approximately 3 kilometers from the showing. Ten diamond drill holes were completed around the original showing during the summer of 1967. Work on the property ceased following this drilling with the death of the managing director of Pacific Giant (Jellinek). Although the property was visited by a number of companies during the breccia-related, uranium "boom" of the 1970's, the lack of recognititon of pronounced radioactive anomalies within the Pagisteel breccia lead to a lack of interest on the part of the companies exploring in the area. The property lay dormant until it was staked by Chevron in 1989. Current interest centers on the hematitic breccia body which underlies much of the claim block as an Olympic Dam - type target with potential for significant copper, gold, light rare earth element (LREE) and uranium mineralization.

4.0) REGIONAL GEOLOGY

The central Wernecke Mountains are composed of a thick succession of weakly metamorphosed sediments of Middle Proterozoic age which have been termed the Wernecke Supergroup and subdivided by Delaney (1981) into three groups.

The oldest is the Fairchild Lake Group which is exposed along the Bonnet Plume RIver valley in a major northeast-trending, northeast -plunging antiform which contains numerous subsidiary, parallel open folds with moderate to steep dips. The Fairchild Lake Group consists of light-grey weathering, thin- bedded to laminated metamudstone, metasiltstone and quartzite. Most of the sediments may be classed as metasiltstones and consist of a granoblastic mosaic of fine (0.05 to 0.25 mm) grains of quartz and feldspar, oligoclase-andesine annd K-feldpsar, with scattered flakes of muscovite and minorbiotite. Minor carbonate beds are intercalated with the sequence, especially in the middle and upper portions of the unit. Carbonate-rich zones generally contain red, maroon and purple metachert and metasiltite beds. Stratigraphic thickness of the unit is not known with certainty as the base is not exposed. Delaney (1981) estimated at least 4 kilometers of section while Archer and Schmidt (1978) suggested a thickness of approximately 1500 meters from demonstrably unfaulted sections. Grossly, the unit appears to record a shallowing upward sequence with deeper water clastic sediments, containing rare carbonate sediments probably derived from an adjacent eastern carbonate shelf, overlain by shallow marine terrigeneous sediments and minor carbonate beds. The contact between the Fairchild Lake Group and the overlying Quartet Group appears to be conformable in most areas. However, the lower metamorphic grade of the overlying Quartet Group rocks and the indication of a dramatic change in facies from the shallow marine sediments of the uppermost Fairchild Lake Group to the anoxic, deep marine sediments at the base of the Quartet Group suggests the contact may be a disconformity.

The Quartet Group consists of a monotonous succession of dark grey to brown weathering sandstone, siltstone and mudstone with very minor silty dolomite. The basal several hundred meters of this group is comprised of dark grey to black weathering, thin bedded, silty carbonaceous mudstone and carbonaceous claystone. Diagenetic pyrite is a common consituent of these sediments. It is likely they accumulated in a sediment-starved, anoxic basin. These fine-grained mudstones grade upwardinto a thick sequence of grey to dark-grey or brown weathering siltstone and sandstone with lesser mudstone. Most rocks consist of subrounded grains of fine- to medium-grained (0.05 to 5 mm), undulatory quartz with minor feldspar surrounded by unoriented muscovite and sericite which contains abundant, disseminated opaque material. Several of the sandstones are arkosic. Bed thickness ranges from several centimeter to 2 meters. Sedimentary textures are commonly well preseved and include both asymmetrical and symmetrical ripple marks, flame structures, and ball and pillow load structures as well as minor desiccation, shrinkage cracks. The upper Quartet Group was believed by Delaney (1981) to be approximately 5 kilometers in thickness; more recent mapping (Bell, 1986 a,b) suggests it may only be 3000 meters thick. It appears that much of the upper Quartet Group was deposited in a shallow marine environment and thus represents, in gross form, a shallowing upwards sequence.

The Gillespie Lake Group conformably overlies the Quartet Group. The contact between the two units is gradational. The first occurrence of orange-weathering silty dolostone beds has been taken as the base of the Gillespie Lake Group. The lower portion of the unit consists of intermixed grey-weathering siltstones similar to those in the Quartet Group and orange-weathering silty dolostone beds. The Gillespie Lake Group also records a shallowing up sequence and the stratigraphically highest recognized portions of the unit consist of stomatolitic dolostone, oolitic dolostone and parallel-laminated to wavy bedded dolostone indicative of supratidal conditions. Delaney (1981) states that 4 kilometers of Gillespie Lake section are present but the present mapping suggests that the true thickness may be closer to 1,000 meters of section.

While there are no known volcanic rocks in the Wernecke Supergroup, there are a number of fine- to medium-grained gabbro or diorite dikes and sills which are generally chloritically altered. While most of these dikes are less than 10 meters in width there are several gabbro sills up to 50 meters thick cutting the Gillespie Lake Group in the southern Wernecke Mountains. The dikes appear to be most common in, and adjacent to, the discordant breccia bodies cutting the Fairchild Lake and Quartet Group rocks. The age of the dikes has not been established. Lamprophyre dikes are also present in Quartet Lake area. Biotite from two of these dikes gives K/Ar dates of 613 ± 15 and 552 ± 13 Ma (Stevens et al., 1982). Petrographically similar dikes cut the Hadrynian Rapitan Group (Yeo, 1981) in the Knorr Range.

The age of the Wernecke Supergroup is poorly constrained. Monozite from the NOR breccia, cutting the Fairchild Lake Group, in the Richardson Range to the North of the Wernecke Mountains, yields a 1270 ± 40 Ma reversely discordant U-Pb age (Parrish and Bell, 1987). Minimum ages for the Quartet Group are given from dating minerals in the breccia bodies which cut the sediments. Phlogopite and biotite in breccia bodies cutting Quartet Group sediments in the Quartet Mountain area give K/Ar dates of 1510 and 1040 Ma respectively (Archer et al., 1977; Godwin et al., 1982). Pb-U ± Th isotope analysis of uraniferous samples from a number of breccia bodies cutting Quartet Group sediments from throughout the Wernecke Mountains gives a wide range of ages (Archer et al., 1986). The oldest date is 1194 Ma from the Igor breccia body and this may represent the time of mineralization or modification of the mineralization by later Proterozoic deformation. The Gillespie Lake Group sediments have been dated using galena from a stratiform, presumably syngenetic to syndiagenetic Pb-Zn-Cu occurrence in the Hart River area. This galena yields a model lead age of 1288 Ma (Morin, 1979). Galenas from lead deposits in the Gillespie Lake Group in the Coal Creek Dome of the Ogilvie Mountains, approximately 100 km to the west of the central Wernecke Mountains yields model lead ages of approximately 1440 Ma (Godwin et al., 1982).

The age of the Wernecke Supergroup is probably dominantly Helikian though portions of the Fairchild Lake Group may be Aphebian. Sedimentologic data points to an easterly source for the Fairchild Lake and Quartet Group sediments (Delaney, 1981). A late Aphebian continental collisional event postulated by Hoffman (1979) in the Coronation geosyncline, N.W.T. 700 kilometers east of the Wernecke Mountains may be the ultimate sediment source.

On the eastern side of the Wernecke Mountains an angular unconformity separates the Wernecke Supergroup from overlying Upper Proterozoic sediments. The lowermost of these units is the Pinguicula Group (Eisbacher, 1981) which consists of maroon and green siltstones and shales with several intercalated andesite flows. The Pinguicula contains weak red bed copper mineralization in the Wernecke Mountains. The Pinguicula Group is probably age equivalent to the Mackenzie Mountains Supergroup which hosts significant red bed copper mineralization in transgressive strata between continental red beds at Coates Lake, Northwest Terrtories, approximately 200 kilometers east of the Wernecke Mountains (Chartrand and Brown, 1985). The Rapitan Group of Hadrynian age overlies the Mackenzie Mountain Supergroup. Immediately east of the Wernecke Mountains, the Rapitan Group contains Superior-type iron formation including the major Crest iron deposit (Gross, 1965). On the western side of the Wernecke Mountains the Wernecke Supergroup is unconformably overlain by Cambrian through Orodovician carbonate rocks.

The unconformity at the top of the Wernecke Supergroup has been correlated with the mid to late Proterozoic Racklan orogeny by Gabrielse (1967). The occurrence of basal Paleozoic rocks resting on either Gillespie Lake or Quartet Group sediments in the Wernecke Mountains is evidence for latest Proterozoic to early Cambrian tectonism. The nearby thick clastic wedges in the Upper Proterozoic Windemere Group suggest syndepositional faulting (Eisbacher, 1976, 1977, 1978a, 1978b, 1981). To the south on the MacDonald Platform conglomerate wedges beneath the Early Cambrian carbonate platform indicate that syndepositional faulting continued into the Paleozoic (Archer et al., 1986). Proterozoic deformation resulted in block faulting as well as the formation of broad folds. Faulting appears to have been largely along north to northwest trends which parallel the trends in the Richardson Fault Array to the north.

The Wernecke Supergroup rocks commonly show a weak cleavage which becomes more pronounced with stratigraphic depth. Rocks in the Fairchild Lake Group are commonly phyllitic and display a lower greenschist mineralogy. The entire Wernecke Mountains area is within the Laramide fold and thrust belt and is characterized by numerous reverse and thrust faults. The combination of Proterozoic and Late Cretaceous through Eocene Laramide deformation has produced a complex structural mosaic. Mapping to date in the region is not sufficient to confidently unravel this structural overprint.

5.0) BRECCIA BODIES - DISTRIBUTION AND MORPHOLOGY

Approximately 90 separate breccia bodies have been recognized in the Wernecke Mountains (Archer and Schmidt, 1978). The breccia bodies account for approximately 2 percent of the exposed Wernecke Terrane. They cut Fairchild Lake and Quartet Group sediments. No well documented examples of breccias cutting Gillespie Lake Group rocks are known although breccia is in fault contact with Gillespie Lake Group sediments at several locations. Breccia bodies are more abundant in the Fairchild Lake Group. This may indicate that the breccias are more common at deeper stratigraphic levels. Alternatively, this concentration may reflect structural control of the breccias since the Fairchild Lake Group is primarily exposed as an uplifted block along the extension of the Richardson Fault array.

The breccia bodies occur as dike-like or sill-like zones ranging from a few meters to more than 100 meters wide. They also form generally elongate, pipe-like bodies from 100 meters to over 3 kilometers in diameter. The vast majority of breccia bodies in the Wernecke Mountains appear to have formed along anticlinal axes (Igor, Dolores Creek) and/or faults. Long axes of the breccia bodies tend to be oriented either north-northwest (Igor, Irene, Glacier Lake, NOR), parallel to the major faults in the Richardson Fault Array, or east-northeast (Dolores Creek, Pagisteel), in a conjugate orientation to the major structures.

Contacts between the breccia bodies and the wall rocks are variable and appear to be controlled largely by the type of wall rock. Contacts between breccia and sandstone and siltstone tend to be sharp with dragging of the wall rocks suggesting forceful emplacement. Contacts between breccia and mudstones or highly argillaceous siltstones are commonly gradiational with brecciation becoming less intense away from the body. In all rock types breccia bodies are surrounded by fractured and veined wall rocks. While most of the pipe-like bodies have well defined, regular boundaries, other breccia bodies have irregular boundaries and contain numerous sheet-like offshoots which can extend several hundred meters along individual stratigraphic horizons.

Breccia clasts are derived from the adjacent wall rock. No exotic clasts have been recorded. Laznicka (1977a, 1977b) has noted the presence of altered clasts of diorite dike material in the breccias at Dolores Creek which appear to have been derived from dikes cutting the adjacent sediments. Megascopically similar fragments in the Igor breccia (Laznika and Gabourty, 1988) are probably chloritized siltstone clasts. There appears to have been little displacement of rock types vertically within the breccia bodies. The maximum recorded displacement of breccia material is 150 meters upward (Archer and Schmidt, 1978), although Bell (1986 b) suggests significantly greater upward movement of clasts. No significant downward movement of clasts has been recognized.

Clast size ranges from more than 100 meters in diameter to finely comminuted particles. In most breccias, clasts tend to be less than a meter in diameter. Clast shape ranges from highly angular to rounded or embayed. Embayed clasts indicate modification, and/or formation, of breccia texture by hydrothermal alteration. Clast size and shape is lithologically controlled with competent siltstones and sandstones tending to form larger and more angular clasts. Argillaceous siltstones and mudstones generally form smaller, more rounded clasts. Much of the more argillaceous sediment appears to disarticulate upon brecciation into rock flour consisting of quartz grains and clay. The wide variety of breccia types is probably the result of both mechanical brecciation and hydrothermal replacement of clasts and is similar to the spectrum of textures described by Oreskes and Einaudi (1990) from the Olympic Dam deposit in South Australia.

Matrix composition in the breccias is variable between separate breccia bodies and within individual bodies. Most breccia appear to have a matrix dominated by quartz and clay (now sericite) derived from disarticulated sediment. However, in many breccia bodies this matrixappears to have been modified by hydrothermal alteration. Alteration was synchronous with, and postdated, brecciation.

Breccias generally display little internal texture and appear to be massive. However, several of the breccia bodies contain zones with pronounced lamination or banding and fluxion or fluidization textures. In nearly all cases this lamination appears to be steeply oriented relative to the edges of the breccia body. Rarely, this banded material appears to grade into distinct veins. The location of this type of breccia within bodies is variable. In the NOR breccia fluxion textured breccia comprises the central portion of the elongate pipe (Templeman-Kluit, 1981) while in the Irene breccia fluxion or fluidization textured breccia forms a discontinuous rim on the margin of the breccia body. Laminated breccia with fluidization textured veins occurs throughout the Igor breccia body but is restricted to a paragenetically late alteration event.

6.0) BRECCIA BODIES - ALTERATION

All breccia bodies display a halo of bleaching. This bleaching is the result of destruction of disseminated carbonaceous material and iron oxides in the sediments. The extent of this peripheral alteration varies between individual breccia bodies. In breccias cutting the Fairchild Lake Group, such as in the Dolores Creek area, bleaching extends several kilometers from the breccia contact (Laznika and Edwards, 1979). In breccia bodies in the middle to upper Quartet Group, such as Igor, bleaching extends tens to several hundreds of meters from the breccia contact. Distribution and intensity of bleaching appears to be controlled by porosity and permeability of the sedimentsas well as structurally-related porosity.

Alteration mineralogy and zoning appears to be a function of depth. Breccia bodies cutting Fairchild Lake Group rocks commonly display zones of intense sodium metasomatism characterized by albitization. In the Quartet Group, breccia bodies generally lack intense albitization, but contain zones of intense carbonate alteration as well as zones of extreme iron metasomatism.

6.1) Breccias cutting the Fairchild Lake Group

Alteration in breccia bodies cutting the Fairchild Lake Group sediments has been described at Dolores Creek and Glacier Lake (Bell, 1986b; Laznika, 1977a,b; Laznika and Edwards, 1979). At Dolores Creek the alteration zone extends several kilometers outside of the the elongate, generally north to northeast-trending breccia bodies which are up to 2.5 kilometers long. The breccia bodies in the south-central portion of the altered area display extreme sodium metasomatism. At the Porphyry prospect, extremely altered breccia has a light pink to grey color and a medium to coarse grained texture which is megascopically similar to an igneous intrusive rock. Albitite commonly contains magnetite, now largely converted to hematite. The albitite bodies are generally small, 50 by 150 m in plan view, and appear to form veins within the breccia parallel to the long axis of the breccia body.

Albitite is surrounded by a zone of less intense sodium metasomatic alteration containing albite - paragonite - sericite. Iron oxide is present in this alteration zone as hematite, though at least some is probably martite after magnetite. This type of sodium metasomatic alteration is present both in breccia and in adjacent Fairchild Lake sediments. Albite is best developed in quartz-rich quartzites and metasiltstones while paragonite is dominant in argillaceous metasiltstones and metamudstones. Limestone and dolostone lenses within the Fairchild Lake within this alteration zone locally contain calc-silicate minerals. Scapolite and chlorite are the most prominent alteration minerals; minor actinolite may also be present. Near the fringes of this alteration is a zone of potassium enrichment mineralogically characterized by abundant sericite and lesser biotite.

The sodium metasomatic alteration zone centered on the breccia bodies is enveloped in a phyllic alteration zone in the surrounding Fairchild Lake and Quartet Group sediments. Phyllic alteration is dominated by sericite and chlorite and gives way outwards to increasingly ferroan carbonate-rich alteration assemblages. The fringe of the alteration system is dominated by a ferroan carbonate - chlorite assemblage. Minor hematite is present in all these peripheral assemblages.

Albite veins cutting the albite - paragonite - sericite alteration assemblage, quartz - albite veins cutting the phyllic alteration assemblage, and quartz - sericite - chlorite - carbonate veins cutting the carbonate - chlorite assemblage suggest this alteration pattern is a prograde system with alteration fronts moving outward from the breccia bodies. This alteration pattern indicates that the breccia bodies themselves formed the locus of hydrothermal alteration and served as fluid conduits.

This prograde alteration event appears to have postdated or been roughly synchronous with brecciation. The majority of the breccia appears to have had a matrix and clast mineralogy of quartz - sericite - chlorite corresponding to the mineralogy of the phyllic alteration zone. This was overprinted by the sodium metasomatic alteration assemblages. However, Bell (1986b) has noted rare albitite clasts in breccia indicating multiple periods of brecciation or alteration or both.

The prograde alteration assemblages are cut by another assemblage of veins dominantly containing ferroan carbonate, chlorite, quartz and hematite. This assemblage is nearly identical to that of the apparent fringes of the prograde alteration system. It is probable that these late veins represent a retrograde collapse of the system, related to temperature decline.

Alteration in other breccia bodies cutting Fairchild Lake Group rocks such as NOR and Irene is less well known. At the NOR prospect, which appears to cut the uppermost Fairchild Lake Group, early alteration appears to have been dominated by the formation of albite with lesser potassium feldspar and sericite and minor biotite, actinolite and magnetite (Parrish and Bell, 1987; Templeman-Kluit, 1981; M.H. Sanguinetti, per. comm., 1989). Extreme alteration of this type resulted in the formation of medium-grained, feldspar-rich, igneous-apperaring rock. This alteration assemblage appears to have developed in discrete zones, or veins, in the center of the breccia body. Alteration of clasts and matrix in the breccia surrounding the albite-rich centers produced a quartz - sericite - chlorite assemblage. The albite-rich and quartz -sericite alteration assemblages were later largely converted to quartz - chlorite - carbonate - hematite assemblages. This retrograde alteration appears to dominantly effect breccia matrix. At the Irene breccia, as currently exposed, the breccia cuts the upper Fairchild Lake Group at the approximate stratigraphic level of a prominent limestone marker bed. Alteration assemblages in the breccia are dominated by calcite and quartz with minor albite. The preponderance of calcite may be due to the stratigraphic position of the breccia as exposed. Large alteration halos extending outside of the breccia bodies, as at Dolores Creek, are not present at the NOR and Irene bodies although discontinuous zones of chlorite and hematite alteration of surrounding Fairchild Lake Group sediments are present at both bodies.

6.2) Breccias cutting the Quartet Group

In breccia bodies cutting the Quartet Group alteration appears to be dominated by chlorite - carbonate and hematite. Alteration effects breccia matrix and some clasts; rarely does significant alteration extend into the surrounding host rocks. Of the breccia bodies in the Quartet Group, only the Igor breccia has been studied in detail. The Igor breccia, as exposed, cuts through inter-layered sandstones, siltstones and mudstones of the middle Quartet Group. The breccia body consists of a marginal zone of disrupted Quartet Group rocks. Within this zone more competent sandstone and siltstone beds have been fractured and boudinaged. Movement is taken up in the more incompetent mudstone layers which behave plastically. Alteration within this marginal zone consists of bleaching of the sediments and minor growth of carbonate. Alteration appears to initially effect mudstones and argillaceous siltstones.

With increasing brecciation and alteration the marginal disrupted facies grades into a breccia consisting of siltstone and sandstone fragments in a quartz-sericite matrix which is variably altered to chlorite, carbonate and quartz with minor magnetite and hematite. Carbonate minerals are dominated by dolomite with minor calcite. With increasing alteration clasts may be wholly or partially altered to a similar assemblage. Alteration of clasts is most intense on clast rims or along fractures or veins cutting the clasts and results in the rounding of originally angular clasts. However, even in zones of intense carbonate - chlorite alteration, the original breccia texture is preserved. Carbonate - chlorite matrix breccia is the dominant rock-type in the Igor body. It is probable that this style of alteration is roughly synchronous with breccia formation.

Extreme alteration of this type results in the formation of a carbonate - magnetite rock. Generally the zones consist of buff- to white-colored carbonate, almost entirely dolomite, with variable amounts of subhedral to euhedral magnetite. Original breccia texture is generally completely destroyed resulting in a massive appearing rock. Magnetite is generally disseminated and individual crystals ranges in size from several millimeters to over 2 centimeter in diameter. Skeletal crystals of magnetite in a carbonate-quartz matrix are common. Many carbonate - magnetite zones contain short intervals of semi-massive to massive magnetite. In addition to carbonate and magnetite these intesely altered zones contain quartz and minor barite, chlorite, sericite, albite, and fluorite. Occassionally chlorite or barite can form up to 70 % of the rock over a meter. Psuedomorphs of scapolite (?) replaced by quartz, carbonate, and albite as well as actinolite (?) replaced by chlorite and quartz are also observed.

Zones of carbonate - magnetite alteration form elongate vein-like structures parallel to the long axis of the breccia body. They are most common on the western edge of the breccia body along a structurally controlled axis. Most carbonate - magnetite zones are less than 2 meters in width and have a strike length of under 50 meters. However, one large zone on the northeast side of the body is up to 20 meters wide and 300 meters long.

Measurement of homogenization temperatures in fluid inclusions in carbonate minerals, quartz, and fluorite from the carbonate - chlorite and carbonate - magnetite assemblages yield temperatures ranging from 80 to 300° C. Homogenization temperatures of dolomite and calcite cluster around 140° C, while fluorite averages 190° C and quartz ranges from 130 to 300° C and averages approximately 200° C. Carbonate minerals and quartz in the carbonate - chlorite assemblage have homogenization temperatures which cluster around 130° C. Thus the carbonate - magnetite assemblage appears to have formed at generally higher temperatures.

The carbonate - chlorite and carbonate - magnetite assemblages are cut by hematite-rich breccias at Igor. These hematite breccias are elongate parallel to the trend of the carbonate - magnetite zones and are most prominent along the same structural axis that controls the location of the earlier carbonate - magnetite zones. Ground magnetic results and outcrop data suggests that the hematite breccia lenses may coalesce in the southern portion of the breccia to form a semi-circular body. The hematite breccia is characterized by replacement of magnetite in the earlier assemblages by hematite (martite) as well as the formation of abundant specular hematite. Carbonate (calcite and dolomite), quartz, and chlorite are also major constituents of the alteration assemblage and fluorite and minor to significant barite are also commonly present. While breccia textures are generally preserved, several small zones of massive hematite resulting from extreme iron metasomatism also occur.

Banded and laminate textures, which appear to be the result of fluidization, are relatively common in hematite breccia, especially in or adjacent to zones of extreme iron metasomatism. These fluidization textures have steep dips and strike parallel to the long axis of the breccia body. Generally banded breccia forms millimeter to 3 meter thick veins cutting more masive, hematite-altered breccia. The veins contain clasts of hematite-altered, carbonate - chlorite breccia in a hematite-rich, specular hematite - quartz matrix.

Homogenization temperatures in fluid inclusions in carbonate and fluorite from hematite breccia range from 90 to 175° C. Carbonate averages 110° C while quartz averages approximately 145° C. A single quartz grain yielded a homogenization temperature of 295° C. It appears, from the limited data available, that the hematite breccia alteration represents a lower temperature, retrograde event in relation to the prograde carbonate - chlorite and carbonate - magnetite alteration event.

7.0) BRECCIA BODIES - MINERALIZATION

The Wernecke breccia bodies are characterized by iron, copper, uranium, gold, cobalt and rare earth element mineralization. While all the breccia bodies examined to date contain zones of iron enrichment, other styles of mineralization appear to be patchily developed. Thus far economic concentrations of breccia-hosted uranium, base or precious minerals have not discovered in the region.

Iron mineralization is ubuiquitous in the breccia bodies. Early, prograde alteration suites generally contain accessory magnetite. In the Igor breccia magnetite mineralization is significant with a number of 1 to 5 meter thick lenses of semi-massive magnetite. Hematite appears to occur as a distal accessory mineral in the early alteration suites but is most common in the later, retrograde alteration assemblage. The hematite occurs as martite after earlier formed magnetite and as primary specular hematite. Significant massive to semi-massive specular hematite replacing breccia occurs in the Igor, Pagisteel, NOR, Bond and Eaton breccias. At Pagisteel approximtely 1 million tonnes of hematite grading 29.3 % soluble iron have been outlined by drilling beneath an outcrop of massive to semi-massive hematite 300 m long by 180 meters wide (Archer and Schmidt, 1978). Iron is also present in the breccia bodies as pyrite and in iron-bearing carbonates such as ferroan dolomite and siderite.

Rare earth elements are generally weakly enriched (greater than 2 times background) in the Wernecke breccias. Geochemical analysis of breccia indicates that, in general, rare earth elements are progressively enriched in breccia throughout the alteration sequence with the light rare earth elements showing the most dramatic enrichment. However, the highest values obtained to date in individual samples from the breccias come from areas of intense prograde alteration; carbonate - magnetite rock at the Igor Prospect (537 ppm La and 689 ppm Ce) and albitized breccia at NOR (2.7% Ce and 3% La; Sanguinetti, 1989, per. comm.). The highest LREE values are found in samples with high P_2O_5 contents. At Igor the LREE host appears to be dominantly apatite while monozite contains elevated LREE at NOR (Parrish and Bell, 1987). Apatite and monozite are intergrown with the alteration minerals at both Igor and NOR suggesting that LREEs were precipitated during prograde alteration.

Copper mineralization occurs in nearly every breccia body examined to date. In breccia bodies cutting the Fairchild Lake Group metasediments two styles of copper mineralization are present. The Porphyry Prospect at Dolores Creek (Laznika and Edwards, 1979) and the NOR Prospect (Templeman-Kluit, 1981) contain disseminated chalcopyrite in the zone of intense albititzation. This chalcopyrite locally replaces magnetite and is intergrown with, or replaces, pyrite, magnetite, martite and specular hematite. At Dolores Creek and Irene copper is also found in quartz - iron carbonate - pyrite veins peripheral to the breccia bodies. At Irene the major vein is approximately 5 meters wide and trends nearly perpendicular to the strike of the breccia body; it has been traced for nearly 150 m. It consists of quartz with lesser iron carbonate and has a 3 to 5 meter envelope of bleached and silicified wallrock.

In breccia bodies hosted by the Quartet Group, copper mineralization consists of disseminated and veinlet-controlled chalcopyrite in carbonate-chlorite, carbonate - magnetite and hematite breccia. In carbonate - chlorite and carbonate - magnetite zones the chalcopyrite occurs either as replacements of magnetite or as disseminated grains between carbonate crystals. The chalcopyrite is commonly intergrown with a dull-reflecting pyrite. Both the chalcopyrite and dull-reflecting pyrite are commonly replaced by a bright euhedral pyrite. At the Igor Prospect, the highest concentrations of chalcopyrite occur in zones of massive to semi-massive magnetite or in carbonate-rich zones adjacent to magneitite-rich zones. Numerous intervals of up to 3% Cu over several meters have been discovered in such zones. Chalcopyrite and pyrite are also found in hematite breccia. While chalcopyrite in the hematite breccia can sometimes be observed to replace magnetite or martite in these zones, it commonly appears to be intergrown with specular hematite. Disseminated copper mineralization at Igor is associated with elevated levels of mercury.

Chalcopyrite and pyrite are also found in carbonate (quartz - barite) veins cutting all breccia and alteration types as well as host rocks immediately adjacent to the breccia bodies. These veins are commonly several millimeters to several centimeters in width and appear to be discontinuous along strike. They are characterized by elongate crystals of dolomite on vein-edges which are perpendicular to vein walls and vein centers of calcite. The sulfides typically occur with the dolomite or between the dolomite and the wall-rock.

Cross-cutting relationships between the copper and iron sulfides and the alteration minerals in the breccias both in the Fairchild Lake and Quartet Groups indicate that sulfide mineralization is late relative to sodium and iron metasomatism. However, the restriction of the highest grades of copper mineralization to zones of intense albitic alteration in the Fairchild Lake Group and intense carbonate alteration in the Quartet Group suggests that some of the copper mineralization was related to the prograde alteration event. It appears that copper and iron sulfides may have begun deposition at this time and continued through the period of retrograde alteration, including the intense iron metasomatism in the Quartet Group breccias.

Although minor chalcocite and copper carbonate minerals are found in near-surface weathering zones, it appears that primary copper mineralization is composed entirely of chalcopyrite. Tertiary enrichment zones are small, probably due to Pleistocene alpine glaciation of much of the region. To date, no supergene enrichment zones have been discovered in mineralized breccia beneath upper Proterozoic and basal Paleozoic unconformities though exploration for this style of mineralization has not been undertaken.

Minor cobalt is also present in copper-rich zones as evidenced by the presence of erythrite in weathering zones. Cobalt occurs in volumetrically minor cobaltite and as cobaltiferous pyrite. Preliminary microprobe investigation of cobalt distribution in pyrite suggest an apparently random distribution. Molybdenum is also geochemically anomalous in copper-rich zones. Although individual samples contain up to 1% Mo, no molybdenum mineral has been identified to date.

Weak uranium mineralization has been recognized in all the breccia bodies examined to date. The principal uranium mineral is brannerite which occurs as a hard, reistant, shiny black mineral containing 10 to 50% U_3O_8. Minor pitchblende has also been recognized at Dolores Creek (Pterd Prospect), Igor and Bond. Uranium mineralization is patchily developed and has been found in the complete spectrum of alteration types. The highest concentrations have been reported from albitized breccia in the NOR breccia body (Parrish and Bell, 1987) and from quartz veins peripheral to the breccia bodies (Archer and Schmidt, 1978). Supergene enrichment of uranium has not been reported from any of the breccia bodies.

Gold mineralization in the breccias is poorly understood. Gold distribution appears to be patichly developed with values of several hundred ppb common within the breccia. The highest gold values have been found peripheral to the breccias and commonly appear to be associated with uranium mineralization. Many of the brannerite-bearing veins peripheral to the breccias contain elevated gold values and at the Eaton prospect spectacular rosettes of free gold up to 2 millimeters in diameter are intergrown with coarse brannerite.

8.0) AGE OF THE BRECCIA BODIES

The breccias are restricted to the Wernecke Supergroup indicating that they formed during the Proterozoic prior to the deposition Upper Proterozoic Pinguicula Group sediments. There is no well documented example of breccia cutting the Gillespie Lake Group carbonate rocks suggesting that the breccias may have been emplaced during the later stages of Wernecke Supergroup deposition. Pb-U ± Th isotope analyses of uraniferous samples from the breccia bodies (Archer et al., 1986) yields a wide range of discordant ages. The data are difficult to interpret because of the effects of loss or gain of either U parent or Pb daughter isotopes. The oldest date is 1194 Ma from the Igor breccia. Monozite from the NOR breccia yields a 1270 ± 40 Ma reversely discordant age (Parrish and Bell, 1987). Phlogopite and biotite in breccia bodies cutting Quartet Group sediments in the Quartet Mountain area give K/Ar dates of 1510 and 1040 Ma respectively (Archer et al., 1977; Godwin et al., 1982). Based on the available evidence the best estimate for the age of the breccias is between 1500 and 1300 Ma.

9.0) CLASSIFICATION OF THE BRECCIA BODIES

The Wernecke breccias appear to be a member of a broad class of deposits (Oreskes et al., 1989; Hitzman et al., 1990) characterized by:

1) *Age* . The majority of known, large deposits are mid-Proterozoic (1100-1700 Ma) in age.
2) *Setting.* Cratonic or continental margin environments, typically within silic-intermediate igneous rocks of anorogenic type.
3) *Association with extension.* Spatial or temporal association with probable extensional tectonics; deposits are commonly located along major structural zones.
4) *Mineralogy.* Magnetite or hematite is a dominant mineral; CO_3, Ba, P, or F minerals are ubuiquitous and commonly abundant; Ti-rich phases are absent or rare.
5) *REEs.* Anomalous to potentially economic REEs.
6) *Alteration.* Extensive Fe-metasomatism.

Other deposits in this class include the Kiruna deposits in Sweden, the Olympic Dam deposit in South Australia, the iron deposits in southeastern Missouri, and the Bayan Obo deposit in China.

The Wernecke breccias share the majority of these characteristics with the significant exception that, besides minor basaltic dikes, they are not associated with volcanic or plutonic rocks. Unlike, many of the other deposits of this class they do not contain large zones of massive iron mineralization. However, iron mineralization is the volumetrically most abundant type of mineralization recognized to date in the breccia bodies. In terms of morphology the Wernecke breccias are most similar to the Olympic Dam breccia body (Oreskes and Einaudi, 1990).

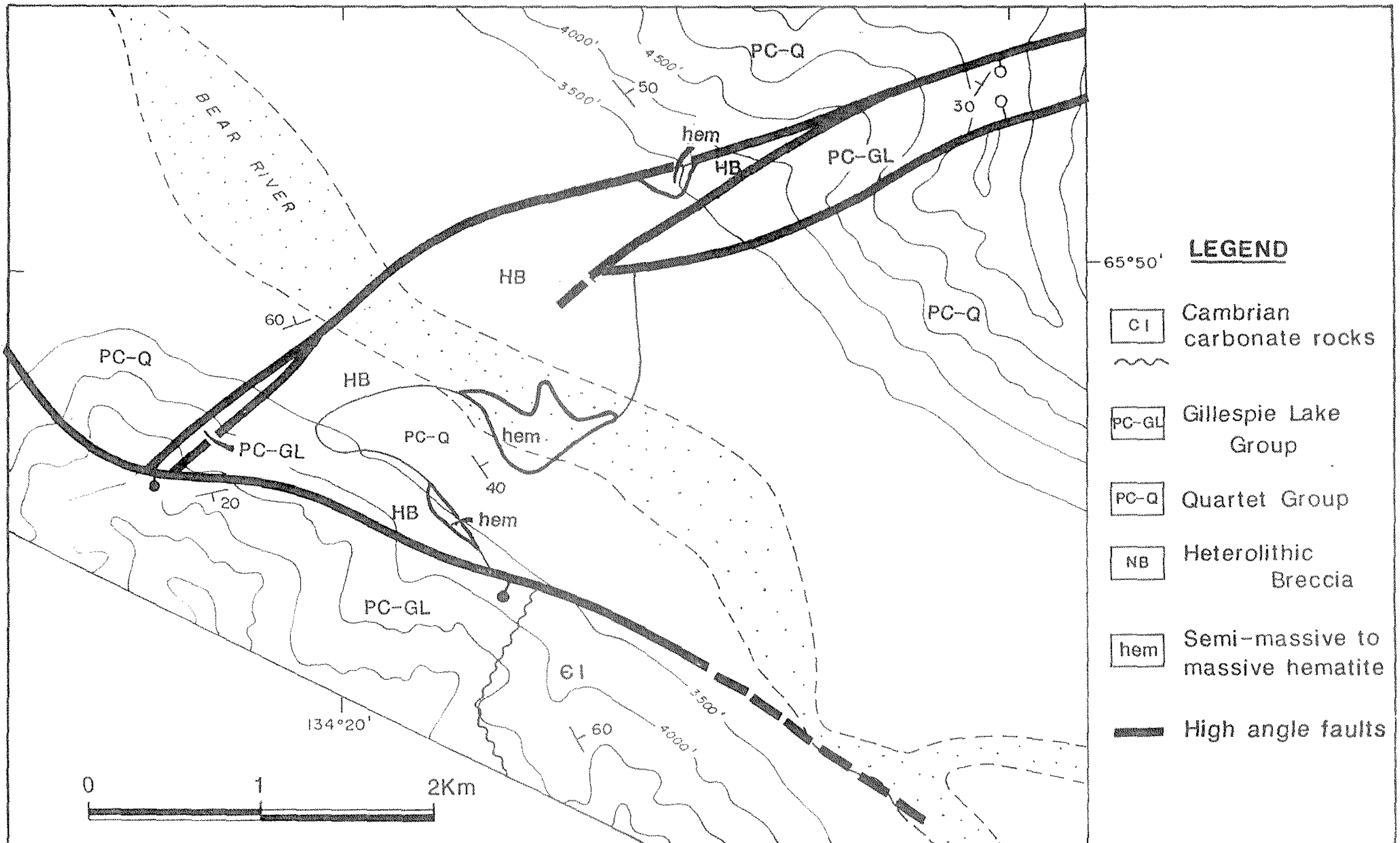
Kiruna-type magnetite - apatite - actinolite deposits in intermediate to felsic volcanic rocks of Aphebian age (1860 to 1790 Ma) have been recognized on the western and southern margins of the Slave Province in the Great Bear magmatic zone near Great Bear Lake

(Badham and Morton, 1976; Gandi, 1988, 1990; Gandi and Bell, 1989; Hilderbrand, 1986) and in the East Arm of Great Slave Lake (Badham, 1978). Several of these deposits, such as the Sue-Diane (8 million tonnes, 0.8% Cu with minor U and Au; Gandhi, 1989; Gandi and Bell, 1990), Mar and Damp Prospects (Cannuli et al., 1990; Sawiuk et al., 1990), conatin significant copper and uranium. Thus the Wernecke breccias form the youngest in a range of Kiruna-Olympic Dam - type deposits in Aphebian and Helikian age rocks in northwestern Canada.

10.0) GEOLOGY OF THE PAGISTEEL PROSPECT

The Pagisteel breccia body extends across the Bear River valley (Figure 3) and is the largest breccia body recognized to date in the Wernecke Mountains. The shape of the breccia body is poorly understood. In gross form the breccia body appears to be an elongate mass approximately 3 by 1 kilometers in diameter. The breccia appears to be fault bounded on three sides. Where the northern contact of the breccia is exposed in outcrops along the Bear River and immediately north of the hematite knob on the northeastern corner of the body it is a fault. The breccia is juxtaposed against Quartet Group sediments along this fault except on the extreme southwest edge where there is a sliver of Gillespie Lake Group carbonate rocks between the breccia and the Quartet Group sediments. The southwestern side of the breccia body is cut by a high-angle fault which separates it from carbonate rocks of the Gillespie Lake Group which are unconformably overlain by a basal Cambrian section to the southeast. To the northeast the breccia body appears to be juxtaposed with a narrow graben containing Gillespie Lake Group carbonate rocks bound to the north and south by Quartet Lake Group sediments. It is only along the southern edge of the breccia body that an apparently non-faulted contact with Quartet Group rocks is present. This contact is exposed in outcrops along the Bear River and more poorly exposed on the lower slopes of the mountains south of the Bear River. The mapped extent of the breccia body is based on exposures and interpretation of aeromagnetic data (Cohen, 1965). It appears to be highly irregular with a large bulbous protrusion of the breccia body to the south under the Bear River and another immediately adjacent to the fault on the southwest portion of the body.

Mapping to date of the sparse outcrops of the breccia is not sufficient to differentiate breccia types. However, from the available evidence it appears that, like the Igor breccia body, the Pagisteel body has a carapace of disrupted Quartet Group rocks consisting of broken sandstone and siltstone beds in a more plastic mudstone matrix which is gradiational into a true breccia with a quartz - sericite (mudstone) - chlorite - carbonate matrix. The



GEOLOGY OF THE -

PAGISTEEL PROSPECT, WERNECKE MTNS, YUKON

NTS. 106D

FIG. No. 3

carbonate consists of both calcite and dolomite. With increasing alteration the matrix is progressively enriched in chlorite and carbonate and hematite. In the southwestern portion of the breccia body on the slopes above the Bear River the breccia matrix is predominantly chlorite -rich. Only one small zone of massive carbonate alteration with associated magnetite mineralization, similar to those at the Igor prospect, has been identified to date at Pagisteel. This zone is located in the southeast corner of the breccia (sample IGM-06). Samples collected from Pagisteel have been separated into breccia types (carbonate - chlorite breccia, carbonate - magnetite rock, and hematite breccia) corresponding to the division recognized at the Igor prospect.

Though a multitude of variations are present, the breccia is dominantly matrix supported. Though many breccias superficially appear to be heterolithic, most contain similar Quartet Group siltstone and quartzite clasts which display variable degrees of alteration. No exotic clasts have been identified in the Pagisteel breccia. Clast size varies from millimeters to 5 meters in diameter but the majority of clasts appear to be 5 centimeters or less in diameter.

In the vicintiy of the hematite knob in the northeastern corner of the body and on the slopes of the mountain to the south of Bear River between 4,500 and 4,000 feet elevation, the breccia contains numerous red-colored clasts ranging in size from millimeters to several meters in diameter. These clasts vary from pink colored siltstones to brick red rock with round to oval spots of chlorite up to 2 centimeters in diameter. The brick red clasts are superficially similar to vesicular, K-feldapar-rich rhyolite. However, on close inspection, all these red altered rocks can be seen to be siltstones and sandstones which have been variably recrystallized and contain minor albite and disseminated specular hematite. While most of the clasts are subrounded with sharp edges, some show highly irregular boundaries with chlorite and specularite forming veins and embayments into the clasts.

11.0) MINERALIZATION IN THE PAGISTEEL BRECCIA

Approximtely 1 million tonnes of hematite grading 29.3 % soluble iron have been outlined by drilling beneath an outcrop of massive to semi-massive hematite 300 m long by 180 meters wide on the north side of the Bear River (Archer and Schmidt, 1978). This zone of hematite is the largest concentration of semi-massive to massive iron oxide recognized to date in the Wernecke breccia bodies. Aeromagnetics suggests that a larger body of semi-massive to massive hematite is present on the southern edge of the breccia body directly under the Bear River (Figure 3). Massive iron oxide samples (such as samples PH-7 and PH-17, with up to 77% Fe $_2O_3$ - Appendix IV) examined to date appears to be a mixture of martite and specular hematite. In polished section minor remnants of magnetite are present in the martite. Texturally the massive hematite from the outcropping hematite mass in the northern portion of the Pagisteel breccia is nearly identical to hematite breccia from the Olympic Dam deposit in South Australia. Minor specular hematite is present in much of the breccia as a matrix consitituent but rarely exceeds 8 %.

Copper mineralization is evident throughout much of the breccia. Most of the copper mineralization examined to date consists of weak disseminations of chalcopyrite in hematite-rich matrix breccia. The most extensive area of weak mineralization occurs in breccia with abundant red colored clasts on the slopes of the mountains immediately south of the Bear River. Similar mineralization occurs in the drill core from the old Pagisteel showing. The best assay from the samples taken in 1989 was 0.28% Cu (sample Ph-20); however, no high-graded samples were submitted for assay.

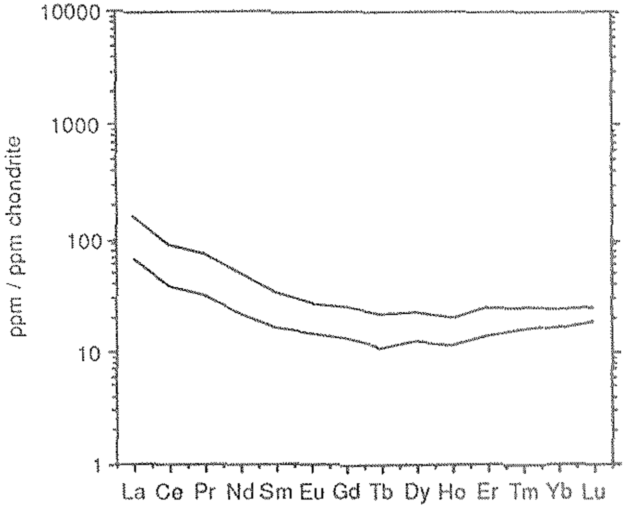
Rare earth elementmineralization is low in samples examined to date. The best assays are 267 ppm La and 226 ppm Ce (sample PH-12) and 246 ppm La and 268 ppm Ce (sample IGM-08). However, none of the samples analyized to date from Pagisteel contain high P_2O_5 (in apatite or other phospate minerals) which form the usual hosts for LRRE mineralization. Chondrite normalized rare earth element patterns for the different rock types at Pagisteel (Figure 4) show patterns similar to those at the Igor prospect. Quartet sediments have a relatively flat pattern. Carbonate -chlorite breccia, carbonate-rich breccia and hematite breccia show a progressive enrichment in LREEs relative to heavy REEs as well as a pronounced positive Europium anomaly.

To date, no areas of the breccia have been located which contain highly anomalous uranium. Early radiometric surveys in the area did not suggest near-surface enrichment of uranium. However, river gravels and glacial sediments in the floor of the Bear River valley may mask modest uranium concentrations and no ground radiometric surveys have been conducted.

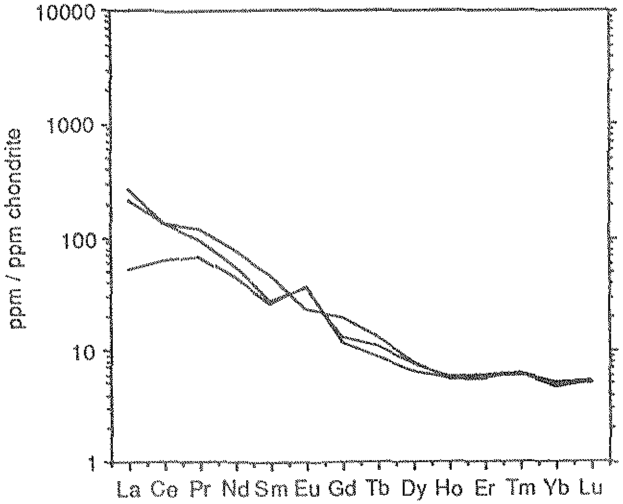
Barium is highly anomalous in many of the samples from Pagisteel. The single sample of carbonate-rich breccia (IGM-06) contains 25.8% BaO (Appendix IV) while several of the samples of carbonate - chlorite matrix breccia (IGM-07, 07A) and hematite breccia (PH-7) contain in excess of 1 % BaO.

Rare Earth Element (REE) Patterns
Pagisteel Prospect, Yukon

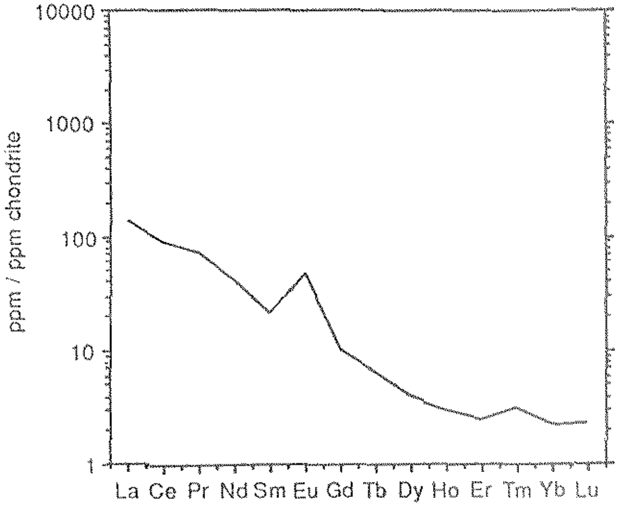
Disrupted Quartet sediments



Carbonate chlorite breccia



Carbonate magnetite



Hematite breccia

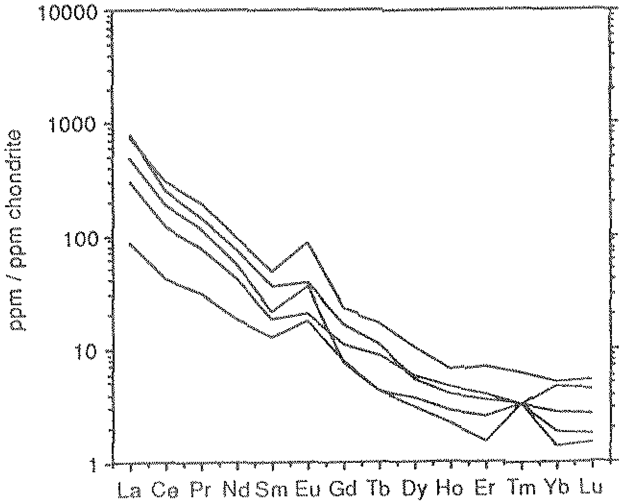


Fig No 4

12.0) STABLE ISOTOPE GEOCHEMISTRY OF THE PAGISTEEL BRECCIA

Three samples of the Pagisteel breccia (PH-21 carbonate-chlorite breccia, IGM-06 carbonate - magnetite rock, and Pag 4-48 hematite breccia) were submitted to Dr. D. W. Beaty at the Chevron Oil Field Research Company laboratory in La Habra, CA. for carbon and oxygen isotopic analysis (Appendix V). The samples formed part of a larger suite studied to characterize the stable isotope geochemistry of the Wernecke breccias. The samples from the Pagisteel breccia most closely resemble unaltered Wernecke Supergroup sediments in their stable isotope geochemistry. The isotopic data are permissive that the breccia contains carbonate derived from the surrounding country rocks rather than from a carbonatite intrusive at depth.

13.0) CONCLUSIONS AND RECOMMENDATIONS

Pagisteel, and the other Wernecke breccias, are similar in mineralogy and alteration style to the giant Olympic Dam deposit (450 million tonnes of 2.5% Cu). The Pagisteel breccia body is the largest single breccia body recognized to date in the Wernecke Mountains. It also contains the largest known concentration of hematite breccia in the district. The target for the prospect is a 100 million tonnes of 2.5% copper or copper equivalent.

Future work on the property should include detailed mapping of the breccia body to attempt to map distinctive breccia zones. Geochemical analysis of a number of samples should accompany this work as well as a soil geochemical survey. Sixteen additional claims should be located to the southwest of the existing block to cover extensions of the breccia. Because the majority of the breccia body is hidden under the Bear River, geophysical surveys should be conducted to determine the extent of the breccia and its mineralogy. A detailed ground magnetic survey combined with a gravity survey would constrain the location and extent of both hematite-rich bodies (gravity and magnetic anomalies) and magnetite bodies (high magnetic anomaly). In addition, wide dipole-dipole induced polarization surveys may be able to locate zones of sulfide enrichement which would form drilling targets. In addition, or in conjunction with specific target drilling, a northwest oriented fence of angle holes across the breccia body should be completed to determine the distribution of breccia types and associated mineralization. Both mapping and the geophysical surveys could be carried out from the old Pagisteel camp and would require minimal heliocopter support.

14.0) REFERENCES

Archer, A., Bell, R. T., and Godwin, C. I., 1977, Mineralogical breccias of Wernecke Mountains (abs): *in* Geol. Assoc. Canada 1977 Annual Meeting, Vancouver, B. C., Abstracts, p. 4.

Archer, A., Bell, R. T., and Thorpe, R. I., 1986, Age relationships from U-Th-Pb isotope studies of uranium mineralization in Wernecke breccias, Yukon Territory: Canada Geol. Survey of Paper 86-1A, p. 385-391.

Archer, A., and Schmidt, U., 1978, Mineralized breccias of early Proterozoic age, Bonnet Plume River district, Yukon Territory: Canadian Mining Metallurgy Bull., v. 71, no. 796, p. 53-58.

Badham, J. P. N., 1978, Magnetite-apatite-amphibole-uranium and silver-arsenide mineralizations in Lower Proterozoic igneous rocks, East Arm, Great Slave Lake, Canada: Econ. Geol., v. 73, p. 1474-1491.

Badham, J. P. N. and Morton, R. D., 1976, Magnetite-apatite intrusions and calc-alkali magmatism, Camsell River, N.W.T.: Canadian Jour. Earth Sci., v. 13, p. 348-354

Bell, R. T., 1986 a, Geological map of northeastern Wernecke Mountains, Yukon Territory: Canada Geol. Survey Open File 1207.

Bell, R. T., 1986 b, Megabreccias in northeastern Wernecke Mountains, Yukon Territory: Canada Geol. Survey Paper 86-1A, p.375-384.

Cannuli, M., Climie, J.A., and Sawiuk, M., 1990, Cu-Co-Au-U mineralization in magnetite-specularite matrix of rhyodacite breccia at Damp Prospect and its metallogenic significance to the Great Bear magmatic zone, *in* Enge, A. D. and Padgham, W. A., eds., Exploration Overview 1989 Northwest Territories, Mining, Exploration and Geological Investigations, March 1990, Canada Dept. Indian Affairs and Northern Devel., p. 30.

Chartrand, F. M., and Brown, A. C., 1985, The diagenetic origin of stratiform copper mineralization, Coates Lake, Redstone Copper Belt, N.W. T., Canada: Econ. Geol., v. 80, p. 325-343.

Cohen, H. H., 1965, Airborne Geophysical Survey, Bear River iron deposit, Yukon Territories, Canada: unpublished company report 65-103.

Delaney, G. D., 1981, The mid-Proterozoic Wernecke Supergroup, Wernecke Mountains, Yukon Territory, *in* Campbell,. F. H. A., ed., Proterozoic Basins of Canada, Canada Geol. Survey Paper 81-10, p. 1-23.

Eisbacher, G. H., 1976, Proterozoic Rapitan Group and related rocks, Redstone River area, District of Mackenzie: Canada Geol. Survey Paper 76-1A, p. 117-125.

Eisbacher, G. H., 1977, Tectono-stratigraphic framework of the Redstone copper belt, District of Mackenzie: Canada Geol. Survey Paper 77-1A, p. 229-234.

Eisbacher, G. H., 1978a, Redefinition and subdivision of the Rapitan Group, Mackenzie Mountains: Canada Geol. Survey Paper 77-35, 22p.

Eisbacher, G. H., 1978b, Two major Proterozoic unconformities, northern Cordillera: Canada Geol. Survey Paper 78-1A, p. 53-58.

Eisbacher, G. H., 1981, Sedimentary tectonics and glacial record in the Windermere Supergroup, Mackenzie Mountains, northwestern Canada: Canada Geol. Survey Paper 80-27, 40 p.

Gabrielse, H., 1967, Tectonic evolution of the northern Canadian Cordillera: Canadian Jour. Earth Sci., v. 4, p. 271-298.

Gandhi, S. S., 1988, Volcano-plutonic setting of U-Cu bearing magnetite veins of FAB claims, southern Great Bear magmatic zone, Northwest Territories: Canada Geol. Survey Paper 88-1C, P. 177-187.

Gandhi, S. S., 1989, Rhyodacite ignimbrites and breccias of the Sue-Dianne and Mar Cu-Fe-U deposits, southern Great Bear magmatic zone, Northwest Territories: Canada Geol. Survey Paper 89-1C, p. 263-273.

Gandhi, S. S., 1990 in press, Bi-Co-Cu-Au-As and U occurrences in the Snare Group metasediments and felsic volcanics of the southern Great Bear magmatic zone, Lou Lake, Northwest Territories: Canada Geol. Survey Paper 90-1C.

Gandhi, S. S. and Bell, R. T., 1989, Magnetite deposits of the Great Bear magmatic zone, Canada: *in* Geol. Soc. of America 1989 Annual Meeting, St. Louis, MO., Abstracts with Programs, p. A33.

Gandhi, S. S. and Bell, R. T., 1990, Potential for Olympic Dam - type Cu-Au-U-Fe deposits in the Great Bear magmatic zone, *in* Enge, A. D. and Padgham, W. A., eds., Exploration Overview 1989 Northwest Territories, Mining, Exploration and Geological Investigations, March 1990, Canada Dept. Indian Affairs and Northern Devel., p. 34.

Godwin, C. I., Sinclair, A. J., and Ryan, B. D., 1982, Lead isotope models for the genesis of carbonate-hosted Zn-Pb, shale-hosted Ba-Zn-Pb, and silver-rich deposits in the northern Canadian Cordillera: Econ. Geol., v. 77, p. 82-94.

Gross, C. M., 1965, Geology of iron ore deposits and iron-formations of Canada, in Report of Activities, Field 1964, Canada Geol. Survey Paper 65-1, p. 142-143.

Hilderbrand, R. S., 1986, Kiruna-type deposits: their origin and relationship to intermediate subvolcanic plutons in the Great Bear magmatic zone, northwest Canada: Econ. Geol., v. 81, p. 640-659.

Hitzman, M. W., Oreskes, N., and Einaudi, M. T., invited paper submitted, Geologic characteristics and tectonic setting of Proterozoic Fe-REE deposits: 8th IAGOD symposium, Ottawa, Canada, Aug. 1990.

Hoffman, P. F., 1979, Wopmay Orogen: continent - microcontinent - continent collision of Early Proterozoic age, Bear Province, Canadian Shield (abs): *in* Geol. Assoc. Canada Program with Abstracts, v. 4, p. 58.

Laznika, P., 1977a, Geology and mineralization in the Dolores Creek area, Bonnet Plume Range, Yukon: Canada Geol. Survey Paper 77-1A, p. 435-439.

Laznika, P., 1977b, Geology and mineralization in the Dolores Creek area, Yukon: Canada Dept. Indian Affairs and Northern Devel., Open File, May 1977, 87 p.

Laznika, P., and Edwards, R. J., 1979, Dolores Creek, Yukon - a disseminated copper mineralization in sodic metasomatites: Econ. Geol., v. 74, p. 1352-1370.

Laznika, P., and Gabourty, D., 1988, Wernecke breccias and Fe, Cu, U mineralizatiom: Quartet Mountain - Igor are (NTS 106E): in Abbott, G., ed., Yukon Geology, v. 2; Canada Dept. Indian Affairs and Northern Devel., p. 42-50.

Morin, J., 1979, A preliminary report on Hart River - a Proterozoic massive sulfide deposit, Yukon Territory: *in* Mineral Industry Report, Dept. of Indian and Northern Affairs, 1979-9, p. 22-24.

Oreskes, N. and Einaudi, M. T. E., in press, Origin of REE-enriched hematite breccias at the Olympic Dam Cu-U-Au-Ag deposit, Roxby Downs, South Australia: Econ. Geol.

Oreskes, N., Einaudi, M. T., and Hitzman, M. W., 1989, Tectonic setting of Olympic Dam and relation to other Proterozoic Fe-REE deposits: 28th International Geol. Congress, Abstracts, Washington, D.C., June, 1989, p.

Parrish, R. R. and Bell, R. T., 1987, Age of the NOR breccia pipe, Wernecke Supergroup, Yukon Territory: Canada Geol. Survey Paper 87-2, p. 39-42.

Sawiuk, M., Cannuli, M., and Climie, J. A., 1990, The Damp Prospect: volcanic-hosted polymetallic (Cu-Fe-Co-U) breccia mineralization, *in* Enge, A. D. and Padgham, W. A., eds., Exploration Overview 1989 Northwest Territories, Mining, Exploration and Geological Investigations, March 1990, Canada Dept. Indian Affairs and Northern Devel., p. 51.

Stevens, R. D., Delabio, R. N., and Lachance, G. R., 1982, Age determinations and geologic studies, K-Ar isotopic ages, report 15: Canada Geol. Survey Paper 81-2, p. 16-17.

Templeman-Kluit, D. J., 1981, NOR, summary of assessment work and description of mineral properties: *in* Yukon, Geology and Exploration 1979-1980, Dept. of Indian and Northern Affairs, p.300-301.

Yeo, G. M., 1981, The Late Proterozoic Rapitan glaciation in the Northern Cordillera, *in* Campbell,. F. H. A., ed., Proterozoic Basins of Canada, Canada Geol. Survey Paper 81-10.

APPENDIX I

STATEMENT OF QUALIFICATIONS

STATEMENT OF QUALIFICATIONS

I, Murray W. Hitzman, hereby certify that:

1. I am presently employed as a geologist by Chevron Minerals Ltd. at 400 - 815 West Hastings Street, Vancouver, B.C.
2. I have studied geology at Dartmouth College (A.B. 1976), and have graduate degrees in geology from the University of Washington, Seattle (M.S. 1978), and from Stanford University, Stanford, California (Ph.D. 1983).
3. I have practiced within the geologic profession since 1975.
4. That I am a member in good standing of the Geological Association of Canada, the Geological Society of America, the Society of Economic Geologists and The Geological Society.
5. That the work outlined in this report was conducted under my supervision.

Dated the 6 day of April, 1990

Murray W. Hitzman

APPENDIX II

COST STATEMENT

STEEL CLAIMS 1989-90 COST STATEMENT

GEOLOGIST SALARIES

	Field	Office and core logging	Field dates	
M. Hitzman	3 days	25 days	August 11-13	$7,048.00
A. Archer		3 hours		165.00
W. D. Eaton		4 hours		160.00
M. Dittrick	4 days		August 10-13	840.00
K. Garus	1 day			160.00
			TOTAL	$8,409.00

DISBURSEMENTS

Airline flights		734.00
Car rental	4 days @ $50	200.00
Lodging		335.00
Heliocopter time& fuel (Trans North Air 8/11&12)		6,856.60
Telephone		80.89
Food, meals		143.40
Maps, copying		76.80
Geochemical analysis (X-Ray Labs)		1,493.25
Thin sections and petrographic reports		569.25
Drafting, reproduction		1,127.33

TOTAL COST **$20,025.52**

APPENDIX III

SAMPLE DESCRIPTIONS

SAMPLE DESCRIPTIONS - PAGISTEEL PROSPECT

PH-1	Gillespie Lake Group carbonate. Limestone cut by 5 cm wide vein containing rock fragments and coarse, iron-rich carbonate. No iron oxide or sulfides. Located in complex structural zone. Unclear if these are peripheral veins to Wernecke-type breccia in Gillespie Lake.
PH-2	Quartet Group siltite. Disrupted Quartet with siltstone clasts in a disaggregated siltstone matrix; trace pyrite in matrix. Sample as float in area of major fault intersections of breccia, Quartet and Gillespie Lake sediments. This breccia may be late tectonic.
PH-3	Hematite Breccia. Clasts of pink colored (altered) Quartet siltstone and massive specular hematite in a dark grey quartz-chlorite- hematite matrix. This breccia is located up hill from the hematite knob. (this sample plus PH-5 submitted for whole rock analysis as PH-5).
PH-4	Disrupted Quartet. A block of siltstone within the outer breccia cut by veins with filled with disaggregated Quartet sediments (quartz - sericite) and minor specular hematite. From the breccia up hill from the hematite knob. (thin section).
PH-5	Hematite breccia. Clasts of pink colored (altered) Quartet siltstone in a dark grey quartz- specular hematite matrix (similar to PH-3). Sample from the breccia immediately above the hematite knob. (submitted for whole rock analysis with PH-3).
PH-6	Hematite breccia. Pink and grey colored Quartet siltstone in a quartz - specular hematite- carbonate matrix. The brown weathering (iron-rich?) carbonate forms clots throughout the matrix. Sample located on the south side of the breccia hill above the hematite knob. (thin section).
PH-7	Hematite breccia. Semi-massive to massivehematite with minor pink colored Quartet siltstone clasts and clots of brown weathering carbonate. Hematite knob near old Pagisteel drill hole sites. (whole rock analysis).
PH-8	Gillespie Lake Group. Dolostone. Brown weathering with a light grey color on fresh surface. From thick bedded Gillespie Lake adjacent to breccia but separated by fault. The sample does not appear altered. (whole rock analysis; thin section; C&O isotope analysis).
PH-9	Quartet Group. Siltite. Dark green grey color. Sample from within the fault zone bounding the southern edge of the breccia body. The outcrop is sheared but not obviously brecciate. The outcrop is located in the stream to the southeast of the hematite knob.
PH-10	Disrupted Quartet. Pink, grey and dark grey siltstone clasts in a siltite flour matrix with minor disseminated hematite. The breccia is cut by iron carbonate veins. The sample is from the Bear River outcrop. It is the most heterolithic breccia observed in disrupted breccia along the river. (thin section, whole rock analysis with PH-14).
PH-11	Disrupted Quartet. Pink and purplish siltstone clasts in a purple phyllitic matrix composed of siltite flour with minor disseminated specular hematite. Trace chalcopyrite in matrix. The breccia is cut by discontinuos carbonate veins. The sample is from the Bear River outcrop. (thin section).

PH-12 Hematite breccia. Small red colored siltstone clasts in a dark grey, phyllitic matrix breccia with variable amounts of hematite - locally up to 25% hematite over 1 meter in the outcrop. The sample is from the Bear River soutcrop. (whole rock analysis).

PH-13 Disrupted Quartet. Sheared siltite and mudstone with "augen" of carbonate - quartz in a dark grey phyllitic matrix. Appears to be he outermost edge of the breccia or shearing is related to the adjacent fault. The sample is from the Bear River outcrop. (thin section).

PH-14 Quartet Group. Sheared medium to pale green mudstone now with a phyllitic texture. The sample is from the Bear River outcrop immediately adjacent to the fault bounding the breccia body. (thin section, whole rock analysis with PH-10).

PH-15 Quartet Group. Medium grey siltite showing bedding. The rock appears unaltered but is mildly sheared. The rock is from the Bear River outcrop to the north of the fault separating the breccia body from the Quartet Group. (thin section, whole rock analysis).

PH-16 Hematite breccia. Pink colored Quartet siltstone clasts in a massive, black matrix - weakly hematitic. Sample is from the southwest breccia body at approximately 4,000'.

PH-17 Hematite breccia. Massive hematite from a block or irregular zone within the southeast breccia body. (whole rock analysis).

PH-18 Hematite breccia. Clasts of brick red to pink colored Quartet siltstone. These clasts are up to 1 meter in diameter in the breccia. The clasts contain disseminated chalcopyrite (2 %) and specular hematite (3 %) and cut by discontinuous specular hematite veins. (polished thin section, whole rock analysis).

PH-19 Carbonate-chlorite breccia/ hematite breccia. Rounded to subangular red to pink colored siltstone clasts in a dark grey phyllitic matrix with carbonate-chlorite and minor hematite. The matrix contains minor disseminated chalcopyrite. (thin section).

PH-20 Disrupted Quartet/ Carbonate-chlorite breccia. Brown, grey and red colored Quartet siltstone clasts in a dense quartz-sericite - (carbonate-chlorite) matrix. The breccia contains approximately 1% disseminated chalcopyrite. (thin section, whole rock analysis).

PH-21 Carbonate-chlorite breccia. Large clasts of grey siltstone in a iron carbonate-quartz-(chlorite-specular hematite) matrix. Clasts range in size from several millimeters to 12 centimeters in diameter. Many of the smaller clasts are brick red colored. (thin section, whole rock analysis with PH-22, C&O isotope analysis).

PH-22 Carbonate-chlorite breccia. Irregular shaped clasts of grey siltstone in a massive, carbonate-rich matrix. (whole rock analysis with PH-21).

PH-23 Hematite breccia. Large pink colored siltstone clast with psuedo-amygdules and abundant small grey, tan, pink and red colored siltsone clasts in a dark grey phyllitic matrix with minor disseminated hematite. (thin section).

PH-24 Hematite breccia. Large red colored clast of siltstone cut by numerous crackle veinlets of specular hematite in a dark black, massive matrix. (thin section).

PH-25 Altered Quartet siltstone. Siltstone with individual beds boudinaged and showing red colored alteration. More argillaceous beds are black and probably contain disseminated hematite. (thin section).

PH-26 Altered Quartet siltstone. Red colored altered siltstone clast (from in hematite breccia) with psuedo-amygdules filled with hematite-carbonate-biotite?-amphibole?-(quartz) - (sulfides, py, cp). The clast is cut by gash veins filled with iron carbonate. (thin section, whole rock analysis).

PH-27 Basal Cambrian carbonate. Black banded carbonate from just above unconformity. Does not fizz with dilute hydrochloric acid - dolomite, siderite?

PH-28 Fairchild Lake Group. 28A - coarse white limestone - marker bed; 28B - grey, silty limestone. From ridge above Fairchild Lake - type section. (thin section, whole rock analysis, C&O isotope analysis).

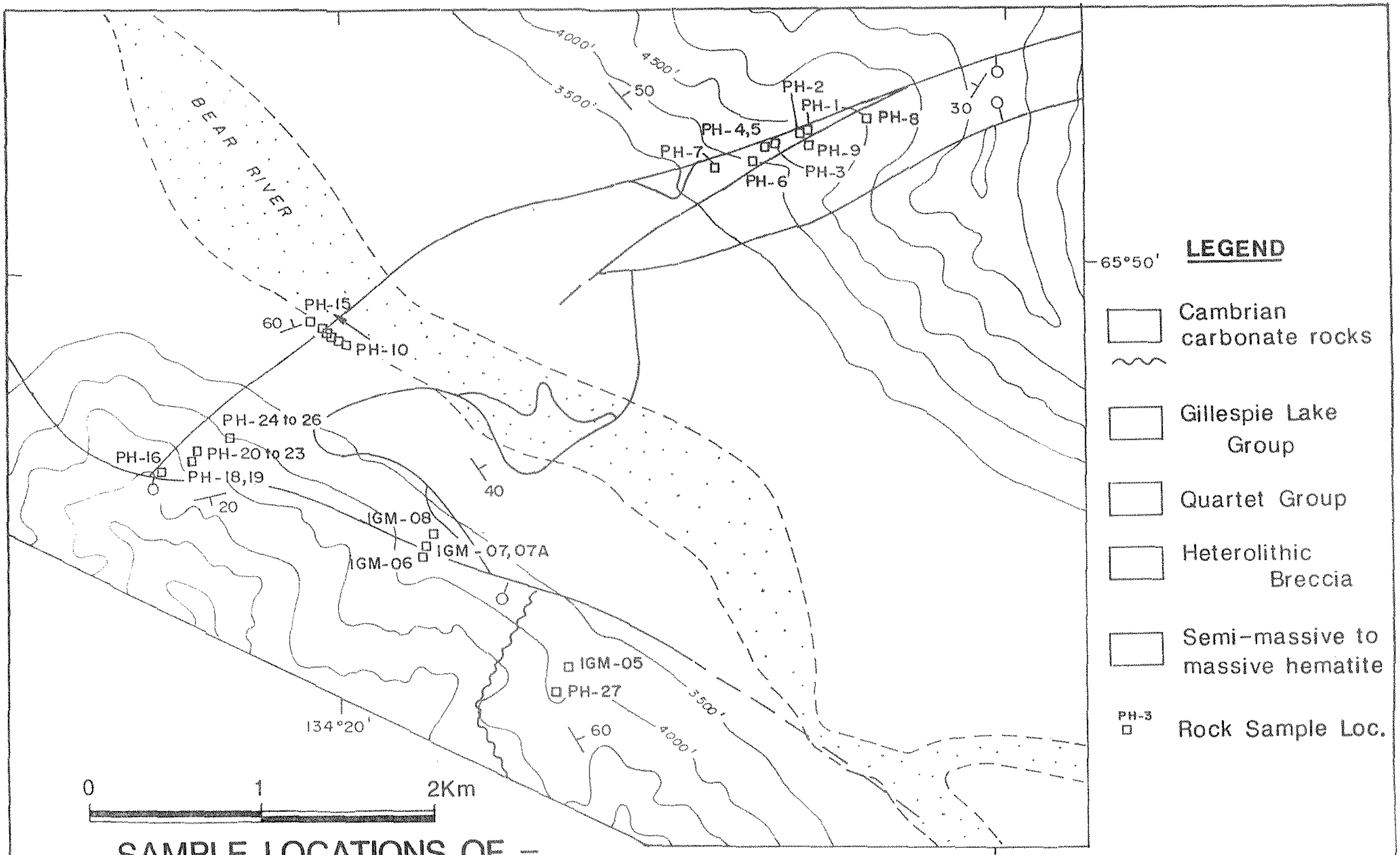
IGM-05 Basal Carbrian carbonate. Red bed, sabkha carbonate and shale.

IGM-06 Carbonate -magnetite rock. Banded carbonate - quartz - magnetite rock from the edge of the breccia body. This rock type forms a 1 meter wide band in carbonate-chlorite breccia. Magnetite forms coarse euhedral to subhedral crystals. Small zones in the rock contain up to 2% disseminated chalcopyrite. (thin section, whole rock analysis).

IGM-07 Carbonate-chlorite breccia. Siltite and minor siltstone clasts (many flattened) in a well foliated grey phyllitic matrix with a carbonate-rich matrix with trace hemtite and pyrite. (polished thin section, whole rock analysis).

IGM-07A Carbonate-chlorite breccia. Siltite and siltstone clasts in a foliated dark carbonate - sericite -quartz matrix with <1% pyrite and minor hematite. (polished thin section, whole rock analysis).

IGM-08 Hematite breccia. Clast deficient breccia in a dark brown carbonate-hematite-chlorite matrix with coarse carbonate crystals. Weakly foliated. Minor sulfides pyrite > chalcopyrite. (polished thin section, whole rock analysis).



SAMPLE LOCATIONS OF –

PAGISTEEL PROSPECT, WERNECKE MTNS, YUKON

NTS 106/D

FIG. No. 5

APPENDIX IV

GEOCHEMICAL DATA

XRAL

X-RAY ASSAY LABORATORIES
A DIVISION OF SGS SUPERVISION SERVICES INC.
1885 LESLIE STREET • DON MILLS, ONTARIO M3B 3J4 • CANADA
TEL: (416)445-5755 TELEX: 06-986947 FAX: (416)445-4152

CERTIFICATE OF ANALYSIS

REPORT 10033

TO: CHEVRON CANADA RESOURCES LIMITED
ATTN: MURRAY W. HITZMAN
1900-1055 WEST HASTINGS ST.
VANCOUVER, B.C.
V6E 2E9

CUSTOMER No. 561

DATE SUBMITTED
26-Sep-89

REF. FILE 5877-S5

Total Pages 8

45 ROCKS Proj. M718

	METHOD	DETECTION LIMIT		METHOD	DETECTION LIMIT
AU PPB	FADCP	1.	MO PPM	ICP	1.
LI PPM	ICP	1.	AG PPM	AA	0.5
BE PPM	DCP	1.	CD PPM	AA	0.2
B PPM	DCP	10.	IN PPM	AA	0.5
CO2 %	WET	0.01	SN PPM	XRF	2.
F PPM	WET	20.	SB PPM	NA	0.2
NA PPM	NA	10.	CS PPM	NA	1.
WRMAJ %	WR	0.01	LA PPM	ICPMS	0.1
P PPM	ICP	10.	CE PPM	ICPMS	0.1
S PPM	XRF	50.	PR PPM	ICPMS	0.1
K PPM	AA	10.	ND PPM	ICPMS	0.1
SC PPM	ICP	0.05	SM PPM	ICPMS	0.1
V PPM	DCP	2.	EU PPM	ICPMS	0.05
CR PPM	NA	2.	GD PPM	ICPMS	0.1
MN PPM	ICP	2.	TB PPM	ICPMS	0.1
FEO %	WET	0.1	DY PPM	ICPMS	0.1
CO PPM	ICP	1.	HO PPM	ICPMS	0.05
NI PPM	ICP	1.	ER PPM	ICPMS	0.1
CU PPM	ICP	0.5	TM PPM	ICPMS	0.1
CU %	XRF	0.01	YB PPM	ICPMS	0.1
ZN PPM	ICP	0.5	LU PPM	ICPMS	0.05
GA PPM	ICP	0.1	HF PPM	NA	0.5
GE PPM	DCP	10.	TA PPM	NA	1.
AS PPM	NA	0.1	W PPM	NA	1.
SE PPM	GFAA	0.5	HG PPB	WET	5.
RB PPM	XRF	2.	TL PPM	ICPMS	0.1
WRMIN PPM	WR	10.	PB PPM	ICP	2.
SR PPM	ICP	1.	BI PPM	ICPMS	0.1
Y PPM	ICP	1.	TH PPM	NA	0.5
ZR PPM	XRF	1.	U PPM	NA	0.1
NB PPM	XRF	2.			

Radioactive Pulps will be
DISCARDED ON ________

DATE 31-OCT-89

CERTIFIED BY
Jean H.L. Opdebeeck, Vice President Operations

XRAL 31-OCT-89 REPORT 10033 REF.FILE 5877-S5 PAGE 1 OF 8

SAMPLE	AU PPB	LI PPM	BE PPM	B PPM	CO2 %	F PPM	NA PPM	P PPM	S PPM	K PPM
PH-5	13	28	4	20	4.09	1100	600	--	432	--
PH-7	5	6	9	60	0.10	300	190	--	10845	--
PH-12	10	13	6	10	2.23	490	250	--	<50	--
PH-17	12	11	5	<10	0.15	640	200	--	<50	--
PH-20	25	12	2	<10	1.98	520	960	--	1067	--
PH 21,22	2	52	4	130	8.03	2200	530	--	<50	--
PH 26	11	6	2	<10	3.53	510	980	--	156	--
IGM-06	1	14	5	90	1.64	710	200	--	57150	--
IGM-07	6	86	5	90	4.59	2100	280	--	18300	--
IGM-07A	20	106	7	260	3.86	3300	530	--	6000	--
IGM-08	35	91	5	100	3.16	3200	170	--	2940	--

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SAMPLE	SC PPM	V PPM	CR PPM	MN PPM	FEO %	CO PPM	NI PPM	CU PPM	CU %	ZN PPM
PH-5	5.61	84	100	--	1.1	10	55	422.	--	12.4
PH-7	<0.05	50	64	47	0.1	2	38	12.9	--	15.2
PH-12	1.96	100	79	--	0.3	6	15	85.1	--	15.2
PH-17	1.27	130	90	43	0.3	<1	7	35.1	--	17.5
PH-20	8.23	170	85	--	0.9	6	29	2780.	--	23.6
PH 21,22	9.49	90	94	--	1.0	9	28	33.9	--	8.8
PH 26	5.14	88	84	--	0.4	13	23	480.	--	12.1
IGM-06	0.50	34	26	--	7.0	13	25	<0.5	--	41.4
IGM-07	4.00	70	83	--	2.5	24	27	1.2	--	41.4
IGM-07A	5.77	130	86	--	4.3	53	39	1.2	--	31.6
IGM-08	4.71	76	97	--	1.9	25	49	31.2	--	25.6

SAMPLE	GA PPM	GE PPM	AS PPM	SE PPM	RB PPM	SR PPM	Y PPM	ZR PPM	NB PPM	MO PPM
PH-5	19.0	<10	17.0	<0.5	162	30	8	104	--	7
PH-7	18.6	<10	36.0	<0.5	29	--	3	<1	--	6
PH-12	20.4	<10	23.0	<0.5	114	9	5	53	27	2
PH-17	24.7	<10	12.0	<0.5	84	6	4	51	14	<1
PH-20	14.9	<10	9.8	1.9	168	13	21	303	--	21
PH 21,22	22.6	<10	3.5	<0.5	224	15	9	114	23	<1
PH 26	22.8	<10	5.1	<0.5	152	12	37	386	--	<1
IGM-06	33.2	<10	2.1	<0.5	81	--	5	<1	8	2
IGM-07	23.6	10	6.6	<0.5	140	--	9	<1	21	12
IGM-07A	25.8	10	22.0	1.1	206	--	9	9	24	11
IGM-08	25.1	<10	18.0	<0.5	156	--	10	23	24	16

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SAMPLE	AG PPM	CD PPM	IN PPM	SN PPM	SB PPM	CS PPM	LA PPM	CE PPM	PR PPM	ND PPM
PH-5	<0.5	<0.2	<0.5	9	4.1	2	100.	106.	9.2	26.1
PH-7	<0.5	<0.2	<0.5	<2	18.0	1	163.	168.	13.6	34.8
PH-12	<0.5	<0.2	<0.5	<2	7.1	1	267.	226.	17.4	46.3
PH-17	<0.5	<0.2	<0.5	<2	3.0	1	28.5	36.8	3.6	11.6
PH-20	<0.5	<0.2	<0.5	11	1.9	1	22.3	34.1	3.8	14.0
PH 21,22	<0.5	<0.2	<0.5	35	1.3	2	72.7	122.	14.2	48.0
PH 26	<0.5	<0.2	<0.5	27	1.7	1	55.2	84.1	9.1	32.5
IGM-06	<0.5	<0.2	<0.5	<2	3.2	7	47.4	81.2	8.6	25.6
IGM-07	<0.5	<0.2	<0.5	<2	7.7	7	17.8	56.7	8.1	27.8
IGM-07A	<0.5	<0.2	<0.5	<2	8.3	13	90.5	119.	11.4	34.7
IGM-08	<0.5	<0.2	<0.5	<2	8.9	5	246.	268.	22.8	61.4

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SAMPLE	SM PPM	EU PPM	GD PPM	TB PPM	DY PPM	HO PPM	ER PPM	TM PPM	YB PPM	LU PPM
PH-5	3.5	1.47	2.8	0.4	1.7	0.36	0.8	0.1	1.0	0.15
PH-7	4.1	2.57	1.9	0.2	0.9	0.17	0.3	<0.1	0.3	<0.05
PH-12	6.8	2.79	4.2	0.5	1.6	0.31	0.7	<0.1	0.6	0.09
PH-17	2.4	1.27	2.0	0.2	1.1	0.22	0.5	<0.1	0.4	0.06
PH-20	3.1	1.04	3.3	0.5	3.7	0.88	2.8	0.5	3.7	0.64
PH 21,22	8.7	1.66	5.1	0.6	2.3	0.43	1.1	0.2	1.0	0.17
PH 26	6.5	2.00	6.6	1.0	6.6	1.54	5.0	0.8	5.3	0.84
IGM-06	4.1	3.38	2.6	0.3	1.2	0.24	0.5	<0.1	0.5	0.08
IGM-07	4.8	2.66	3.0	0.4	1.9	0.43	1.1	0.2	1.1	0.18
IGM-07A	5.3	2.51	3.3	0.5	2.2	0.44	1.2	0.2	1.1	0.17
IGM-08	9.1	6.13	5.9	0.8	3.1	0.52	1.4	0.2	1.1	0.18

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SAMPLE	HF PPM	TA PPM	W PPM	HG PPB	TL PPM	PB PPM	BI PPM	TH PPM	U PPM
PH-5	3.4	<1	33	42	0.4	<2	0.2	12.0	3.6
PH-7	INF	<1	59	720	<0.1	<2	0.4	3.4	8.9
PH-12	1.4	<1	31	7	0.1	<2	0.2	9.9	7.0
PH-17	1.7	<1	12	32	0.1	<2	0.1	5.3	3.3
PH-20	9.8	2	11	14	0.3	<2	0.4	32.0	14.8
PH 21,22	3.7	1	5	13	0.3	<2	<0.1	16.0	2.6
PH 26	12.0	3	11	18	0.3	<2	0.2	42.0	15.2
IGM-06	INF	<1	25	420	0.2	<2	0.3	3.3	3.8
IGM-07	2.8	<1	34	430	0.4	<2	0.1	8.0	4.7
IGM-07A	3.2	1	45	860	0.6	<2	1.4	12.0	7.3
IGM-08	2.1	<1	35	1000	0.3	<2	0.6	8.8	7.9

XRAL

XRF - WHOLE ROCK ANALYSIS 31-OCT-89 REPORT 10033 REFERENCE FILE 5877 PAGE 8 of 8

SAMPLE \ PPM	SR	Y	NB	BA
PH-5	---	---	73	---
PH-7	89	---	55	---
PH-12	---	---	---	---
PH-17	---	---	---	---
PH-20	---	---	57	---
PH 21,22	---	---	---	---
PH 26	---	---	58	---
IGM-06	2270	---	---	---
IGM-07	827	---	---	---
IGM-07A	283	---	---	---
IGM-08	74	---	---	---

XRAL

XRF - WHOLE ROCK ANALYSIS 31-OCT-89 REPORT 10033 REFERENCE FILE 5877 PAGE 7 of 8

SAMPLE \ %	SIO2	AL2O3	CAO	MGO	NA2O	K2O	FE2O3	MNO	TIO2	P2O5	BAO	LOI	SUM
PH-5	47.0	10.8	3.03	2.05	---	6.98	23.7	0.16	0.47	0.24	0.30	5.00	99.7
PH-7	13.9	0.65	0.10	0.58	---	0.23	77.8	---	0.18	0.14	2.46	0.39	96.4
PH-12	27.3	4.87	1.83	1.41	---	2.67	58.8	0.07	0.27	0.26	0.04	2.54	100.1
PH-17	15.7	3.12	0.51	0.89	---	1.64	75.9	---	0.37	0.47	0.03	0.77	99.4
PH-20	52.5	15.1	1.92	1.08	---	11.9	12.6	0.05	1.51	0.59	0.19	2.47	99.9
PH 21,22	51.0	13.3	5.47	4.38	---	6.37	9.52	0.14	0.57	0.17	0.08	9.00	100.0
PH 26	53.6	15.3	2.98	1.53	---	12.1	8.84	0.09	1.28	0.60	0.16	3.54	100.0
IGM-06	12.8	3.13	1.15	0.51	---	1.01	35.2	0.35	0.31	0.21	25.8	2.00	82.7
IGM-07	32.6	7.42	4.29	2.49	---	2.18	38.1	0.41	0.46	0.21	6.20	5.00	99.5
IGM-07A	38.3	10.0	1.29	2.42	---	3.53	34.0	0.38	0.53	0.46	2.50	5.77	99.2
IGM-08	28.2	7.23	2.61	2.48	---	2.68	49.9	0.21	0.36	0.43	1.26	4.62	100.0

Chemex Labs Ltd.
Analytical Chemists * Geochemists * Registered Assayers
212 BROOKSBANK AVE., NORTH VANCOUVER,
BRITISH COLUMBIA, CANADA V7J-2C1
PHONE (604) 984-0221

To : CHEVRON CANADA RESOURCES LTD.
MINERALS STAFF
1900 - 1055 W. HASTINGS ST.
VANCOUVER, B.C.
V6E 2E9

Project : M718
Comments: ATTN: MS MAUREEN HENRY CC: M.W. HITZMAN

Page No. : 1
Tot. Pages: 1
Date : 3-OCT-89
Invoice # : I-8926393
P.O. # : 30667

CERTIFICATE OF ANALYSIS A8926393

SAMPLE DESCRIPTION	PREP CODE	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	TiO_2 %	P_2O_5 %	MnO %	BaO %	LOI %	TOTAL %	Cu %	CO_2 % inorg	S % (Leco)	FeO %	$+H_2O$ %	$-H_2O$ %
116418 PH8	248 200	34.19	5.59	3.36	10.90	16.35	0.22	2.51	0.22	< 0.01	0.25	0.06	25.96	99.64	———	25.6	0.003	2.64	0.60	0.05
116419 PH10+14	248 200	45.32	12.22	15.61	4.26	5.86	0.23	6.01	0.51	0.17	0.17	0.07	9.74	100.15	< 0.01	8.1	< 0.001	1.84	1.56	0.12
116420 PH14	248 200	67.11	13.59	7.55	3.54	0.81	0.22	2.86	0.51	0.14	0.03	0.05	3.82	100.25	———	0.7	0.060	5.42	3.32	0.10
116421 PH15	248 200	64.79	17.37	7.24	1.80	0.46	1.00	3.15	0.74	0.26	0.05	0.07	3.19	100.10	———	< 0.2	< 0.001	5.83	3.21	0.12
116422 PH18	248 200	50.86	14.16	8.92	2.67	4.23	0.27	11.20	1.45	0.53	0.11	0.15	5.75	100.25	0.26	5.4	0.090	1.49	0.48	0.11
116423 PH28B	248 200	59.61	7.12	1.72	3.65	11.13	0.53	2.32	0.22	0.10	0.20	0.02	13.41	100.05	———	11.9	0.176	0.70	0.84	0.07

APPENDIX V

PRELIMINARY REPORT ON STABLE ISOTOPE GEOCHEMISTRY OF CARBONATE BRECCIAS, WERNECKE MTNS., YUKON

D.W. Beaty

Chevron

Chevron Oil Field Research Company

La Habra, CA
December 14, 1989

PRELIMINARY REPORT ON STABLE
ISOTOPE GEOCHEMISTRY OF
CARBONATE BRECCIAS,
WERNECKE MTNS., YUKON

To: M.L. HITZMAN
Chevron Resources, Vancouver

As per your letter of September 17, 1989, I have studied the stable isotope properties of 21 samples from Kiruna, Sweden and the Wernecke Mtns., Yukon. As discussed below, I have also made some preliminary studies on a few samples from Olympic Dam, and have received samples from Southeast Missouri but have not had a chance to study them. As you requested, I am wrapping up my work on these samples at this time in order to provide you with preliminary data and interpretations by Dec. 19.

Analytic procedure

With two exceptions, the carbonate in each of the samples was analyzed for $\delta^{18}O$ and $\delta^{13}C$ (Table 1; I am also enclosing our laboratory listing which contains CRC sample numbers and laboratory index numbers for future reference). The two exceptions are samples K7 (from Kiruna) and IGH-4 (from the Igor Breccia), which do not contain enough carbonate to analyze. One sample (IGH-14, from the Igor Breccia) was diverse enough that three isotopic determinations were made. The matrix and clasts from one piece of breccia (IGH-14a) were analyzed separately, and a second, unbrecciated rock from the sample bag was analyzed as well (IGH-14b). If you remember, IGH-14a is the sample you helped me drill out.

Analytic accuracy, precision

Two of the 21 samples were duplicated (IGH-15 and S-16), and the data were reproduced to within 0.02 permil in $\delta^{13}C$ and to within 0.14 permil in $\delta^{18}O$. The standard deviation on analyses of the calcite standard (Harding Iceland Spar) that was run with these samples is 0.06 in $\delta^{13}C$ and 0.03 in $\delta^{18}O$. The mean value of the standard was found to differ from the accepted value by 0.07 in $\delta^{13}C$, and by 0.24 in $\delta^{18}O$. Within the limits of analytic precision this suggests a small systematic error in $\delta^{18}O$. I will check these results and correct them if necessary within the next few weeks.

Mineralogy

X-ray diffraction analysis was carried out on all of the samples to determine the carbonate mineralogy prior to isotopic analysis. The Kiruna samples were all found to be calcite-bearing and dolomite-free, as were those from the Irene breccia. The Pagisteel and Igor breccias contain both calcite and dolomite. With one exception, however, each of our samples contains only one of these two carbonate minerals. The three samples of unaltered host rocks contain both calcite and dolomite. One sample contains calcite only (PH-28A), one sample contains dolomite only (PH-8), and one sample (PH-28B) contains both. For the samples with mixed mineralogy (IGH-15 and PH-28B), the extraction procedure combined the CO_2 evolved from both minerals. Because of the interest you expressed in the x-ray data, I am including copies of the diffraction patterns.

Isotopic results

Unaltered host rocks. The unaltered host rocks from the Wernecke Mtns. have $\delta^{18}O$ of +18 to +19 and $\delta^{13}C$ of +0.7 to -2.3. I am not familiar with much data on carbonates of this age. One possibly relevant study was done on the 1.2 b.y. Mescal Limestone in central Arizona by Beeunas and Knauth (1985: Bull. G.S.A., v. 96, p. 737-745). They found $\delta^{18}O$-values ranging from +14 to +25, and most $\delta^{13}C$-values between +1 and +3. Although our data from the Werneckes are close to this range, we obviously have too little data to interpret diagenetic and alteration processes in our rocks.

Wernecke Breccias. The samples from the Pagisteel Breccia most closely resemble the unaltered host rocks. The isotopic data are certainly permissive that the Pagisteel Breccia contains carbonate derived from the surrounding country rocks. The Igor and Irene Breccias have distinctly lower $\delta^{18}O$. This indicates either that these breccias formed from a different carbonate reservoir, or that the carbonate exchanged with a hydrothermal fluid. The Igor samples show a wide range of $\delta^{13}C$ values, but the Irene samples are uniformly low in $\delta^{13}C$. Note that the calcite in the lamprophyre dike cutting the Irene Breccia (IRH-5) is isotopically indistinguishable from the calcite in the breccia.

Kiruna. The two limestone samples you submitted from Kiruna ($\delta^{18}O$ = +10 to +11) are isotopically quite different than 'normal' sedimentary rocks, and are indistinguishable from two samples of Kiruna ore (skarn and Hauki-type hematite beds). This group of samples has isotope values within a relatively restricted range of $\delta^{18}O$ = +10 to +14 and $\delta^{13}C$ = -3 to -5, and considering how different these rocks are, the isotopic similarity is noteworthy. This suggests that these limestone beds were recrystallized as part of the mineralization process, thereby exchanging isotopes. Sample S-12, which is banded magnetite-apatite-calcite rock immediately underlying one of the orebodies is significantly higher in $\delta^{18}O$ (+20) than the other Kiruna samples. That calcite must have formed at either lower temperature or from a fluid with higher $\delta^{18}O$.

Comparison: Kiruna vs. Wernecke*s*. I presume because of the metal content that the Wernecke Mtns. breccia pipes formed by some sort of hydrothermal process. If so, the isotopic composition of the water that precipitated the calcite can be calculated given the temperature. Tommy Thompson reports that the fluid inclusions in carbonate from these samples homogenize at 100-120°C, and that fluid inclusions in quartz and fluorite homogenize at about 300°C. The isotopic fractionation between dolomite and calcite in sample IGH-14a corresponds to a temperature of 250°C. In Table 1 I have listed the isotopic composition of the water in equilibrium with these samples at these temperatures. If the hydrothermal temperature was near 300°C (as seems likely), then these rocks were subjected to a flow of high-^{18}O water of some sort (perhaps magmatic water?). If the temperature was low, then the hydrothermal fluid must have had a high component of meteoric water.

As we have discussed in the past, I think it is too simplistic to interpret the low carbon isotope values as the mixing of carbon from two different reservoirs. Water/rock exchange can also affect $\delta^{13}C$ in hydrothermal systems. The $\delta^{13}C$-values of -3 to -5 may or may not represent igneous carbon. Perhaps we can discuss this at more length in the future.

Olympic Dam

Five samples from Olympic Dam were processes by the same method as those from Kiruna and the Wernecke Mtns. The five samples had extremely low CO_2-contents. The first sample gave a peculiar mass spectrometer run, so a mass scan was run on the gas from the second one. The mass scan showed a significant amount of nitrous oxides mixed with the carbon dioxide (specifically NO and NO_2). Because NO_2 has a mass of 46, as does $C^{16}O^{18}O$, there is major interference in measuring $\delta^{18}O$. The nitrous oxides could be removed and the analysis repeated if the data are important enough to us. There is no interference at mass 45, which is used to determine $\delta^{13}C$, and the first sample (256-3) had a $\delta^{13}C$-value of -4.94. Because of the interference problems and the small sample size, the rest of the samples were discarded.

Have you seen any indication for anomalous nitrogen in the Olympic Dam deposit? Perhaps the problem here is that we are working with samples of such low CO_2 content that trace nitrogen becomes a serious consideration. Naomi Orestes presented carbon and oxygen isotope data on siderite from Olympic Dam, and her data are very similar to ours from Kiruna.

Southeast Missouri

On December 11 I received a box of 14 pulp samples from Rick Eisenberg. My understanding is that these samples represent both SE Missouri and Olympic Dam, although no documentation was included. It is too late for me to analyze these samples in time to meet your Dec. 19 deadline, so I will wait until we can discuss this after the holidays.

CONCLUSIONS

1). In your Sept. 17 letter you posed a specific question about carbonate origin in the Wernecke breccias. My best interpretation is that the Pagisteel Breccia contains a significant component of mechanically admixed country rock, and that Igor and Irene contain hydrothermal (or hydrothermally exchanged) carbonate. Proving this interpretation would require more work, which may not be justified given current priorities.

2). The ore deposits at Kiruna show more complexity than we can interpret with five isotope analyses (not surprising!).

3). The Irene Breccia, and to a lesser extent the Igor Breccia, are isotopically quite similar to Kiruna.

Dave Beaty
D. W. BEATY
COFRC

xc w. all attachments except x-ray patterns:
Rick Eisenberg (Chevron Resources, Minneapolis)
W.S. Hallager
M. Schoell
C.R. Sykes
W.D. Wiggins

File-1+1 of ea (except x-ray patterns)

Table 1. Isotopic analyses of Wernecke Mtns. samples

		--Carbonate--		calculated fluid ----$\delta^{18}O$ at T(oC)----		
Sample #	Mineral	$\delta^{13}C$	$\delta^{18}O$	100	120	300
Samples of unaltered host rocks						
PH-8	Dolomite	-0.87	17.78		Unaltered	
PH28 a	Calcite	0.73	19.20		Unaltered	
PH28 b	Cal./Dolo.	-2.35	18.21		Unaltered	
Pagisteel Breccia						
IGM-06	Dolomite	-4.16	15.28	-6	-4	7
Pag4-48	Dolomite	-2.07	19.24	-2	0	11
PH-21	Calcite	-0.62	15.73	-1	1	10
Irene Breccia						
IR-6	Calcite	-3.76	13.23	-4	-2	8
IR-8	Calcite	-2.32	11.87	-5	-3	6
IRH-2	Calcite	-2.39	11.97	-5	-3	6
IRH-5	Calcite	-3.20	14.27	-3	-1	9
Igor Breccia						
IGH-12	Dolomite	-2.83	9.93	-12	-9	2
IGH-14a, matrix	Dolomite	-2.11	14.93	-7	-4	7
IGH-14a, clast	Calcite	-0.38	13.13	-4	-2	8
IGH-14b	Dolomite	1.83	13.67	-8	-6	5
IGH-15	Cal./Dolo.	0.03	15.21	-2	0	10
		0.04	15.35	-2	0	10
IGH-7	Dolomite	-2.38	14.59	-7	-5	6
Kiruna District						
K-6	Calcite	-4.70	14.05	-3	-1	8
S-12	Calcite	-2.43	19.87	3	5	14
S-16	Calcite	-2.94	10.73	-6	-4	5
		-2.92	10.81	-6	-4	5
S-31	Calcite	-3.27	9.84	-7	-5	4
V-7	Calcite	-5.10	9.86	-7	-5	4
Standards analyzed with the samples						
COFRC Marble #1	Calcite	1.69	21.78			
NBS-23	Strontianite	-34.83	1.14			
H.I.S	Calcite	-4.74	11.97			
H.I.S.	Calcite	-4.65	12.04			
H.I.S. (50C)	Calcite	-4.80	12.03			
Mean (H.I.S.)		-4.73	12.02			
Deviation (H.I.S.)		0.06	0.03			
Accepted value (H.I.S.)		-4.80	11.78			

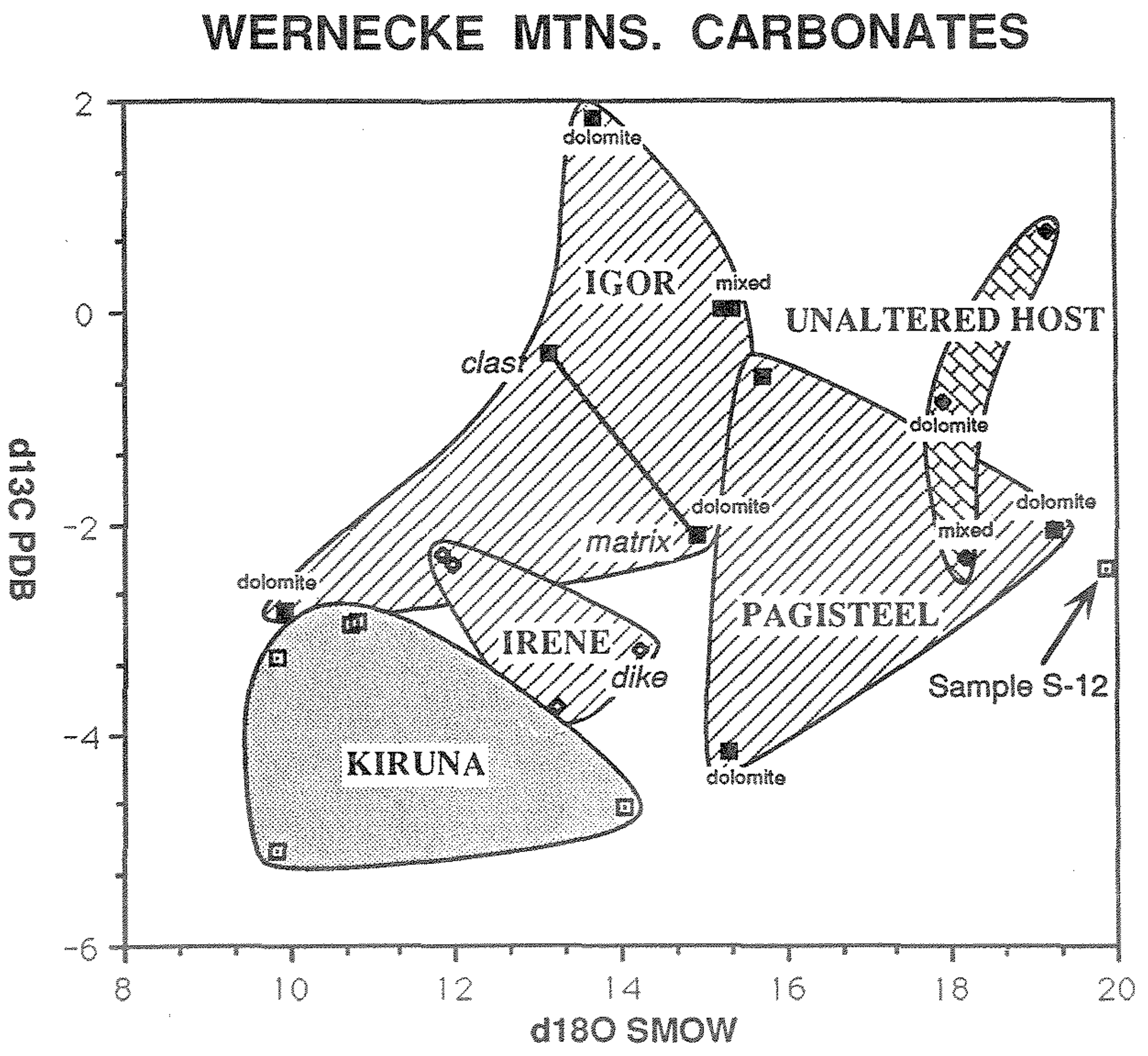


Figure 1. $\delta^{13}C$ and $\delta^{18}O$ relationships in carbonate from the Wernecke Mountains, Yukon and from Kiruna, Sweden. The Wernecke samples are from three breccia pipes (Igor, Irene, and Pagisteel) and from the unaltered country rocks. Analytic uncertainty is approximately the size of the data symbols. Samples consisted of dolomite (labelled), mixed dolomite/calcite (labelled), or calcite (unlabelled). The breccia matrix and clast from sample IGH-14a were sampled approximately 1 cm apart.

COFRC STABLE ISOTOPE LABORATORY

Project: Wernecke Mtns.

---Mass	spec---					----Extraction----					$\delta^{13}C$	$\delta^{18}O$	$\delta^{18}O$
#	date	Sample ID	Component	CRC #	Mineral	Number	date	Standard	Raw45	Raw46	‰ PDB	‰ PDB	SMOW
3.149	11/7/89	1089-CO2-2						CHV #1	-24.477	10.851	-30.126	-7.728	22.894
3.040	10/18/89	CHV #2						CHV #1	-32.942	-21.458	-38.068	-39.905	-10.276
3.148	11/7/89	CHV #2						CHV #1	-32.829	-21.281	-37.954	-39.737	-10.103
3.156	11/7/89	COFRC Marble #			Calcite	B250-8	11/7/89	CHV #1	5.273	9.806	1.690	-8.809	21.779
3.140	11/2/89	H.I.S			Calcite	B248-6	11/1/89	CHV #1	-1.045	.264	-4.736	-18.326	11.968
3.032	10/17/89	H.I.S.			Calcite	B245-8	10/17/89	CHV #1	-.966	.339	-4.653	-18.253	12.044
3.188	11/16/89	H.I.S. (50°C)			Calcite	B257-3	11/16/89	CHV #1	-1.135	-.680	-4.800	-18.263	12.033
3.151	11/7/89	IGH-12		49641-13	Dolomite	B250-2	11/7/89	CHV #1	.704	-.904	-2.827	-20.303	9.930
3.152	11/7/89	IGH-14a	matrix	49641-14	Dolomite	B250-3	11/7/89	CHV #1	1.526	3.950	-2.114	-15.449	14.934
3.047	10/18/89	IGH-14a	Bxa clast	49641-014	Calcite	B246-7	10/17/89	CHV #1	3.068	1.394	-.381	-17.196	13.133
3.153	11/7/89	IGH-14b	Bxa clast	49641-14	Dolomite	B250-4	11/7/89	CHV #1	5.177	2.719	1.827	-16.674	13.671
3.142	11/2/89	IGH-15		49641-015	Calcite	B248-9	11/1/89	CHV #1	3.516	3.421	.030	-15.178	15.214
3.186	11/16/89	IGH-15		49641-015	Calcite	B257-2	11/16/89	CHV #1	3.496	2.554	.038	-15.043	15.353
3.192	11/28/89	IGH-7		49641-12	Dolomite	B258-1	11/28/89	CHV #1	1.238	2.618	-2.375	-15.795	14.578
3.154	11/7/89	IGM-06		49641-4	Dolomite	B250-5	11/7/89	CHV #1	-.375	4.289	-4.157	-15.113	15.281
3.026	10/17/89	IR-6		49641-007	Calcite	B245-2	10/17/89	CHV #1	-.090	1.491	-3.756	-17.100	13.232
3.027	10/17/89	IR-8		49641-008	Calcite	B245-3	10/17/89	CHV #1	1.216	.179	-2.317	-18.422	11.869
3.028	10/17/89	IRH-2		49641-009	Calcite	B245-4	10/17/89	CHV #1	1.150	.276	-2.390	-18.326	11.968
3.029	10/17/89	IRH-5		49641-010	Calcite	B245-5	10/17/89	CHV #1	.462	2.519	-3.201	-16.091	14.272
3.025	10/17/89	K-6		49642-002	Calcite	B245-1	10/17/89	CHV #1	-.945	2.296	-4.697	-16.307	14.050
3.157	11/7/89	NBS-23			Strontianite	B250-9	11/7/89	CHV #1	-29.550	-10.341	-34.826	-28.827	1.143
3.155	11/7/89	Pag4-48		49641-5	Dolomite	B250-6	11/7/89	CHV #1	1.698	8.161	-2.073	-11.268	19.244
3.189	11/16/89	PH-21			Calcite	B257-1	11/16/89	CHV #1	2.897	2.916	-.615	-14.682	15.725
3.141	11/2/89	PH-8		49641-001	Dolomite	B248-8	11/1/89	CHV #1	2.783	6.718	-.865	-12.686	17.783
3.090	10/26/89	PH28 a		49641-002	Calcite	B247-2	10/25/89	CHV #1	4.298	7.314	.733	-11.309	19.202
3.089	10/26/89	PH28 b		49641-002	Calcite	B247-1	10/25/89	CHV #1	1.386	6.337	-2.345	-12.270	18.211
3.030	10/17/89	S-12		49642-004	Calcite	B245-6	10/17/89	CHV #1	1.355	7.953	-2.432	-10.660	19.871
3.031	10/17/89	S-16		49642-005	Calcite	B245-7	10/17/89	CHV #1	.595	-.929	-2.942	-19.527	10.730
3.033	10/17/89	S-16		49642-005	Calcite	B245-9	10/17/89	CHV #1	.614	-.862	-2.924	-19.455	10.805
3.042	10/18/89	S-31		49642-006	Calcite	B246-2	10/17/89	CHV #1	.265	-1.803	-3.265	-20.392	9.839
3.041	10/18/89	V-7		49642-001	Calcite	B246-1	10/17/89	CHV #1	-1.448	-1.776	-5.097	-20.368	9.863

APPENDIX VI

DRILL LOGS

SCALE ________ DEPTH ________ NOTES BY ________ LOCATION ________
COLLAR COORD. N. ________ E. ________

DEPTH	% REC.	ASSAYS						DETAIL	MINERALIZATION	ROCK TYPE
								[illegible] < 1% [illegible]	[illegible]	[illegible]
									X SAMPLE	
								Q [illegible] [illegible] C.A.		
								[illegible]	X [illegible]	[illegible]

SCALE ______ DEPTH [illegible] NOTES BY [illegible] LOCATION [illegible]
COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS	DETAIL	MINERALIZATION	ROCK TYPE
100			[illegible] 152.5' [illegible] Pr[illegible] Red patches (Siltstone?) [illegible] disseminated [illegible] hematite (to ~5-7%) Quartz veinlets more numerous than above unit (up to 5%) with orientations ~40-60° to core axis. Rare disseminations of pyrite & possible chalcopyrite, occasional dissem. to small blebs of bright green malachite. Limonite on some fracture surfaces & as disseminations (infilling pits).		
110					
120'			123.3-146' Box. Missing		
130'					
140'			146.0-152.5' As described above		
150'			152.5-195.2' Hematite Rich Zone, Faint Breccia Texture in places, medium grey, fine grained hematite matrix (& possibly some argillite?) with blebs, disseminations & clasts of red hematite, specular hematite occurs a dissem., blebs, & patches. Contains more red hem. than first massive hem. unit. [illegible] & limonite on [illegible] fracture surfaces. Rare veinlets of quartz [illegible] no preferred orientation [illegible] blebs	Pervasive Hematite - grey fine grained, patchy specular, & blebby to disseminated red hematite. Occasional pyrite disseminations (seem more common in upper unit)	Hematite Breccia?
160'					
170'					
180'					
190'					
			195.[illegible] B[illegible]		
200'					

SCALE ______ DEPTH ______ NOTES BY ______ LOCATION ______
COLLAR COORD. N. ______ E. ______

DEPTH	% REC	ASSAYS						DETAIL	MINERALIZATION	ROCK TYPE

[illegible]

Gray-green [illegible] white clasts [illegible] quartz [illegible] mineral [illegible] to [illegible] dissemination [illegible] unit grades [illegible] more [illegible] section

[illegible] 220' [illegible]

[illegible] Agl Brx

Matrix is more fine grained [illegible] than above. also seems to be slightly finer clasts from above

[illegible]

SCALE ______ DEPTH [illegible] NOTES BY [illegible] LOCATION [illegible]
COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS						DETAIL	MINERALIZATION	ROCK TYPE
300'								continued chloritic on occasional fracture surfaces Occasional breccia zones (<1ft) which have pyrite & chalcopyr incorporated with the quartz which infills between the orangey-brown clasts → non-rotated – more like a crackle breccia due to veining. Py & CP (<1-2%) in these zones	Chalcopyrite & pyrite as disseminations within qtz veins in crackle breccia zones 308 311.5 ← Sample crackle breccia 313.0 ← Sample 3[illegible] ← Sample [illegible] veined quartz	Hematitic [illegible]
310'										
320'										
329'								329.0 END OF HOLE		

SCALE 1" = 10' STARTED ______ COMPLETED ______ PROPERTY Pa[illegible] HOLE No. [illegible]4-4

DEPTH ______ NOTES BY M[illegible] LOCATION Weirecke Mtns. 106

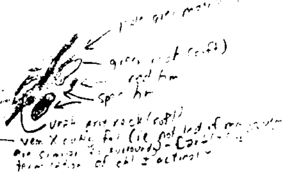
COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS					Stry
0					Pag 1:5 ⊗ ~5'		
	23%						
10	Hx A		hm rich vein		Pag 4-11 + assay	⊗ 35	
	30%					65°	
20	16%						
	40%				Pag 4-30	⊗ 70	
30	40%				Pag 4-33	⊗ 30	
box 1	40%		carb rich ep		Pag 4-35 (assay)	⊗	
	93%						
40	65%				Pag 4-47	⊗	
					Pag 4-48	⊗	
50	60%					65°	
	42%		dull hm zone		Pag 4-57 (assay)	⊗	
box 2							
60							
70			boxes missing				
80							
					Pag 4-85 (assay)	⊗	
	90%				Pag 4-85.2	⊗	
					Pag 4-93	⊗	
	90%				Pag 4-100		

DETAIL

there appears to be no foliated or [illegible] [illegible] 55° [illegible] be poor foliation [illegible] of [illegible] [illegible] [illegible] of [illegible] [illegible] distinct rock

Sky
1) soft grey rock
2) grey hm
3) red hm
4) spec hm vein
5) carb veins [illegible]



vein X cuts fol (ie not [illegible] of [illegible]) are similar to surrounds – Carb [illegible] [illegible] of [illegible] [illegible]

[illegible] of carb banding

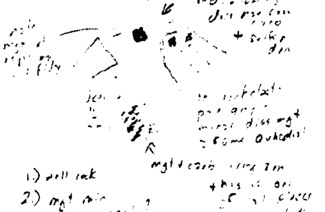
note flat ∠ of red hm zone

note straight edged carb veins (some w/ cp)

appears relatively well foliated

poorly developed foliation

@ 93.5' (Sample 93)



1.) [illegible] rock
2) mgt min
3) mgt + carb ?
4) hm + carb + [illegible]
5) hm
6) [illegible]

this is [illegible] [illegible] [illegible] what appears to be [illegible] [illegible] [illegible] rock.

[illegible] [illegible] developed by banding [illegible] [illegible] [illegible] [illegible] distinct carb [illegible] + [illegible] [illegible] [illegible] [illegible] cp.

@ ~9[illegible] several euhedral [illegible] <20% [illegible] ~2cm alb? [illegible] [illegible] [illegible] [illegible] [illegible]

MINERALIZATION

hm [illegible] metallic mineral >10% 2 [illegible] Trace cp as [illegible] [illegible] carbonate [illegible] [illegible] [illegible] [illegible] [illegible] throughout in areas [illegible] [illegible] specular hm – esp [illegible] [illegible] specular hm [illegible] mgt [illegible] magnetic [illegible] [illegible] mgt) w/ no sulfides

minor "wormy" specular hm, tr cp [illegible] [illegible] type hm 10-50% hm

[illegible] cp

appears to be definite correlation between [illegible] [illegible] zones & mgt rocks [illegible]

massive [illegible]

av approx 45-60% hm
tr cp but low

increase cp & mgt as get more carbonate – most cp as clots in [illegible] carb, up to 3% cp over [illegible] sections. Most mgt w/ carb (Pag4-30) also apparently frags of massive mgt

cp + py clots w/ massive hm

dom hm >50%. tr. cp in odd qtz-chl veinlets – esp where cut red hm patches & tr. diss cp. tot <1%

this a vein [illegible] [illegible]

increased cp, tr. mgt w/ carb-rich band

dom hm. up to 25% ? [illegible] mgt (or mag [illegible]) [illegible] w/ carb clots.

[illegible] py – [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] of [illegible] (mgt?) [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] appears [illegible] This is also where sulfide [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

mgt [illegible] [illegible] [illegible] [illegible]

ROCK TYPE and ALTERATION

dull grey rock [illegible] [illegible] when scratched [illegible] [illegible] [illegible] soft [illegible] [illegible] diss hm [illegible] altered (to clay) siltstone? [illegible] depends on % hm – most darker & % [illegible] as [illegible] [illegible] ([illegible] [illegible]) – [illegible] brownish

↓@ least [illegible] of massive grey hm [illegible] fol [illegible] [illegible] of reddish hm (Pag4-11) [illegible] [illegible] in [illegible]

↓grad. down to [illegible] w/ [illegible] [illegible] rock matrix + [illegible] [illegible] hm red hm as [illegible] [illegible] minor [illegible]

again [illegible] [illegible] into more or [illegible] dull grey [illegible] (or mgt) [illegible] [illegible] [illegible] [illegible] [illegible] of spec hm [illegible] soft clasts [illegible] Two "red" [illegible] [illegible] soft [illegible] [illegible] bands & [illegible] w/ no hm [illegible] [illegible] around hm [illegible]

more "br" appearing rock [illegible] dull grey, spec hm stringers [illegible] some angular [illegible] hm – soft rock clasts patchy carbonate

↓gradational into more massive rock – [illegible] to no bx text but w/ bands of white carb [illegible] – anhedral – like porphyroblasts or [illegible]

this (<5cm wide) zone [illegible] red hm & dk hm matrix

dull grey rock dominant (>50% @ top) – commonly well fol. to locally banded. in gen carb where present appears to cut as veins but minor [illegible] clasts also red hm as bands & @ 39' as [illegible] or clasts. [illegible] carb-rich band

dull med-dk grey rock, pink [illegible] hm, occasionally red hm bands & clasts. also minor fol & areas of [illegible] – usually accomp by some carbonate

3cm coarse carb vein w/ hm-mgt-cp – fluorite cuts the dull grey rock

loot like red hm frags

this rock clasts from above
↓
dk grey to black [illegible] relatively [illegible] [illegible] [illegible] [illegible] reddish [illegible] w/ tr. cp. [illegible] [illegible] & hm. [illegible] 20% [illegible] [illegible] 85-[illegible] more [illegible] hm [illegible] [illegible] fol [illegible] reddish frags ([illegible] clasts) [illegible] [illegible] [illegible] material [illegible] [illegible] rock type [illegible] [illegible] but more commonly as [illegible] clasts – [illegible] [illegible] [illegible] veins [illegible] [illegible] [illegible] [illegible] banded [illegible] [illegible] red hm [illegible] [illegible] country rock clasts [illegible]

↓change into [illegible] bx w/ frags of pale grey [illegible] [illegible] in slightly darker matrix ([illegible] hm) + reddish frags & carb rich frags – could be [illegible] [illegible] but [illegible]

SCALE 1" = 10'
STARTED
DEPTH
COMPLETED
NOTES BY MWH
PROPERTY Pegisteel
LOCATION Wernecke 106D
HOLE No. D04-4
COLLAR COORD. N. E.

DEPTH	REC. %	ASSAYS	DETAIL	MINERALIZATION	ROCK TYPE and ALTERATION
110	90% 30%	Pag4-103 assay Pag4-104 Pag4-109 assay	poorly developed foliation vary from 50-80°	dom hm prob 20% diff colors/varieties specks & veins of py. minor mgt-dom w/ chl-carb	containing veins w/ clasts weakly alt. siltstone in distilled hm matrix & red hm clasts. Also chl-carb-mgt clasts as clasts. Med. grey siltstone - no obvious bedding cut by irreg clots carb & chl. ~~[illegible]~~ minor hm - this country rock. - frag (clast) or in place???
box 3 110					
120			box Missing		
		Pag4-130		the carb veins - discont. are erratic	dk grey siltstone w/ discont "clasts" all zone of bonded carb (no mgt) look discont by in cont. apparent siltstone
130	55%	Pag4-132	siltstone also cut by stockwork carb vein-lets foliation locally developed. esp. near 60° base rock has porky appearance - late shearing?? whole zone cut by later brittle carb fracts	% hm unknown - looks hi but poor streak 15-20% & unit contains buckshot py throughout max 2% note apparent absence of mgt	dull grey hm appearing rock but weak red streak - dk shale? w/ some hm. locally bx'd & diss & good fol. text. contains dull red hm as patches-clasts is this vein or shale bed?
140			fol. of hm veinlet contains [illegible] as carb veins 65°-85°	hm prob. 15% diss py & cp throughout & as veinlets	dominantly a grey rock w/ bx to fol com. text. looks like siltstone cut by numerous fine hm veinlets. some red zo[illegible] like or clasts - one group extended laths - could be a repl. plag. only minor carb - could be a[illegible] same as above but orig not dk shale
	48%		in general this in situ bx is poorly foliated & no bedding apparent 55°	hm dominant (no mgt obvious) - as specular & prob diss in red clasts etc. Sulfides py & cp w/ cp app. dom in & adj to carb veins. cp can grow outside of carb veins. - Ruby Creek text	dk brown to nearly black fine gr. rock (siltstone?) cut by spec. hm veins. An in-situ bx w/ brownish rock & red rock locally pale brown & more hm matrix
150		Pag4-150 multiclast bx	rock cut throughout by carb veins - most hairline & discont or up to 1cm thick		pale grey brown siltstone clasts "clasts" of reddish hm siltstone
		Pag4-154	scapolite?? alb?	total hm 15-20%?	carbonate in gen [illegible] At 153.5' have some white xls - scapolite?
	75%		60° "pisolites" of red hm	darker rock & "scap" →	Most striking feature are red "clasts" in darker matrix ← note hm "pis. like"
box 4 160		Pag4-160	huge ovoid red hm 60°	slight decrease in % veins. little py appears. Also less hm <10%	clasts dominantly red but @ base some paler ones (greenish) - red all clasts? matrix varies irreg. from pale grey sericitic "siltstone" to more specular hm rich (just replaced seri. silt)
	63%		50° hm banding @ contact		relatively abrupt change to brownish rock w/ mild red streak but hard. scratch [illegible]. Almost ironstone - original siltstone remnant
		Pag4-168 assay	xls like "scap" above - some of these could be carb, but is not quite right 55°	mgt & carbs tr cp & py in hairline carb veins	← brown rock cut by paler carb & mgt
170	37%	Pag5-174 bedded? siltstone	40° bedding? yes	← no mgt	abundant carb - No mgt
	93%		100°		
180	50%				bx cons. of silt, red silt, hm, carb frag in siltstone-like matrix - "swirly" text
box 5			carb veins continue	hm prob 10% avg - goes up >50% in spec hm veins & bx	← crackle bx - in situ broken rock - probably dominantly in situ bx dom. dk brown rock hm siltstone - ironstone [illegible] or disrupted red [illegible] of red ironst. [illegible] of hm & "clasts" of [illegible] rich material Where most bed has specular hm matrix - this appears to grade into dk hm siltstone - complex replacement by strong
190	66%		55° disrupted bed of red silt?	difficult to tell replacement relationship w/ carb veins both appear present largest frag size ~3cm - most frags [illegible]	
	80%		45° foliation hm		

SCALE 1" = 40 STARTED ____ DEPTH ____ COMPLETED ____ NOTES BY MWR

PROPERTY Pegusleel HOLE No. DDH - 4

LOCATION Wernecke Mtns 106D

COLLAR COORD. N. ____ E. ____

DEPTH	REC %	ASSAYS	DETAIL	MINERALIZATION	ROCK TYPE and ALTERATION
200	50%		switch around 200' in that carb veins now [illegible] dk qz [illegible] or edges [illegible] ed? bedding not obvious [illegible] good to [illegible]	hm occurs as [illegible] massive veins (specularite? [illegible]) Tot 10% - tr py as buckshot thread. Minor cp [illegible]	same rock type as before - mag - bx w/ [illegible] [illegible] but gets pale grey matrix [illegible] - also appears to be more [illegible] here clasts remain similar: 1) red & brown 2) brown siltst 3) pale green silt[illegible] 4) rare greenish [illegible] clasts 5) carb clasts
box 6	50%		? rock poorly take fault		
210		Pag 4-211 ⊗ Pag 4-211.5 ⊗	Carb veins becoming much less prominent - don't see good veins in frags - ie as clasts [illegible] relatively	tot hm increasing up to 15-20% sulfides rare - tr py present	Continuing bx in general matrix gen. paler grey (more sericite? this doesn't look like conglomerate but true bx matrix sericite?) & hm w/ some spec hm bands or veins banded carb clasts or veins most prominent in red brown rock rare greenish frags
	40%				
220		Pag 4-220 ⊗			
	45%				
230	50%	Pag4-233 ⊗	note: in some sericitic frags have elongate xls (some preserved) most reddened & sigmoidal w/ spec hm [illegible] between frags	specular hm 20%. buckshot py in dk & light frags	dominantly pale grey sericitic rock (to almost green) cut by specular hm. orig. shaly rock? patches of carb present. still bx text locally as well. fewer red frags
	63%				
240 box 7		Pag4-241 ⊗			
			EOH? - end of boxes		
250					
260					

summary (going back over core)

0-95 grey siltstone, locally hematized & cut by several near massive hm veins @ - see log also carbonatized

95-110 bx spec hm matrix clast supported

110-130 missing

130-160 dk grey [illegible] as [illegible]

160-168 rd silt. bx - orig. red silt. bed?

168-176 dk. brown siltstone

186-232 bx, dom clast supported w/ local veins of matrix supp spec. hm

232-242 alt grey siltstone

this log assumes rocks largely in place. - seems reasonable assumption. However much of grey "siltstone" show odd flowing text - could be pipe material. Need more holes & mapping. There appears @ this scale to be little evidence of multiple bx. - ie do not see clear bx frags in bx. there appears to be bed // replacement by hm. Unclear if massive replacement in OD style. Some of red frags may be total replacement - ie pisoliths. But little massive hm in this hole (it was considered a barren hole).

seq. of events still unclear but prob.:

1.) A) bx (in situ) + hm (grey) as veinlets + mgt in siltstone
B) (concurrent?) massive dull & red hm veins
C) hm of red siltst.

2) specular hm veins & recrystz of other hm

3) (concurrent?) carb + mgt + sulf ↗ buckshot py earlier?

4.) late sulfides

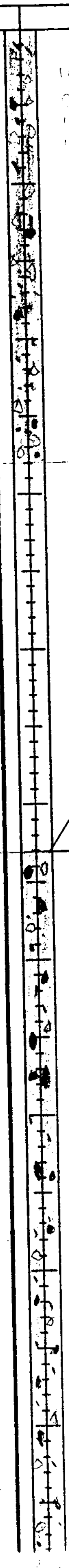
5.) Carb veins + cp

6.) latest barren carb veins

SCALE 1 [illegible] DEPTH NOTES BY [illegible] LOCATION [illegible]
COLLAR COORD. N. E.

DEPTH	% REC.	ASSAYS	DETAIL	MINERALIZATION	ROCK TYPE
0 – 28'			0– *Massive hematite* Grey to Specular [illegible] [illegible] and hematite. [illegible] breccia texture [illegible] [illegible], Fairly orange limonite stain [illegible] [illegible], fracture [illegible] Minor quartz [illegible] [illegible] [illegible] [illegible] interval * All the [illegible] are [illegible] the core in Box [illegible] mixed up [illegible] all [illegible]	[illegible] [illegible] [illegible] Spec	Massive [illegible] Breccia
28' – 53'			28' BOX MISSING		
53' –			53' Massive hematite Breccia [illegible]		Massive hematite Breccia
~90'			[illegible]	[illegible] hematite	[illegible]

10'
20'
30'
40'
50'
60'
70'
80'
90'
100'



SCALE ______ DEPTH ______ NOTES BY ______ LOCATION ______
COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS						DETAIL	MINERALIZATION	ROCK TYPE
								[illegible]		[illegible]
[illegible]								[illegible]	[illegible]	[illegible]

SCALE [illegible] DEPTH ______ NOTES BY [illegible] LOCATION ______ HOLE NO. ______

COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS						DETAIL	MINERALIZATION	ROCK TYPE
200'								as above	as above	Hematitic / [illegible] [illegible] Breccia [illegible]
210'										
220'										
230'										
240'										
250'										
260'										
270'										
280'										
290'										
300'										

SCALE ______ DEPTH ______ NOTES BY [illegible] LOCATION [illegible]
COLLAR COORD. N. ______ E. ______

DEPTH	% REC.	ASSAYS	DETAIL	MINERALIZATION	ROCK TYPE
300'			[illegible] are [illegible] [illegible] dome [illegible]		[illegible] 300' [illegible]
310'			[illegible] clasts [illegible] & certain [illegible] hematite [illegible] quartz [illegible] In a gray [illegible] matrix. Clasts [illegible] quartz [illegible] [illegible] but are not as [illegible] as [illegible] quartzite clasts (possibly [illegible] for classification)		
320'					
330'					
340'					
350'			? Clasts of [illegible], quartzite, quartz & minor [illegible] in a [illegible] [illegible] magnetite	Hematite (Spec) & Pyrite Dissem (< 1%) Rare Chalcopyrite dissems	? Chlorite [illegible] Breccia
360'		Contact somewhere Between here			
370'					
375			375' END OF [illegible]		