EAST KOOTENAY GEOPHYSICAL SURVEY, SOUTHEASTERN BRITISH COLUMBIA (82F, G, K): SULLIVAN - NORTH STAR AREA

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INTRODUCTION

This paper summaries geophysical characteristics of the Sullivan-North Star area of southeastern British Columbia, based on a preliminary examination of new multiparameter airborne data acquired as part of the East Kootenay Geophysical Survey. It complements a paper summarizing regional results of the survey (Lowe *et al.*, 1997). The new geophysical data offer improved screening of exploration targets in the region.

The contracted, helicopter-based survey was funded by the Government of British Columbia and coordinated by the Geological Survey of Canada. It provides high-quality, public-domain geoscience data to assist mineral exploration and enhance understanding of the geology and known mineral deposits of the region. Electromagnetic (EM), total field magnetic, gamma ray spectrometric, and VLF data were acquired in three areas (Figure 1). The surveying was completed by Dighem I Power, a division of CGG Canada Ltd., of Mississauga, Ontario. Data were collected in the St. Mary and Findlay Creek areas in 1995 and in the Creston area in 1996.

The survey areas lie within the Purcell anticlinorium of southeastern British Columbia and are underlain primarily by the prospective Aldridge Formation (Figure 1). The St. Mary River area covers approximately 2000 km^2 and includes the Sullivan Mine, a world class sedimentary exhalative (SEDEX) deposit. The Findlay Creek area covers about 400 km^2 south of Findlay Creek, and west of Canal Flats and includes Rusty Ridge, a promising area near the lower-middle Aldridge Formation contact with fragmental units and tourmalinite alteration. The Creston area comprises about 600 km^2 and extends east from Creston to Yahk and south to the U.S. border.

This paper discusses some of the more obvious features that are presented on B.C. Ministry of Employment and Investment Open File 1996-23 hardcopy maps released July 11, 1996. This release includes total field aeromagnetics, conductivity, potassium, thorium/potassium, and ternary radioelement maps. A comprehensive digital data set for the survey area is available from the National Geophysical Data Centre in Ottawa ((613) 995-5326). The quality and high resolution of new data collected over prospective geology warrant additional industry analysis.

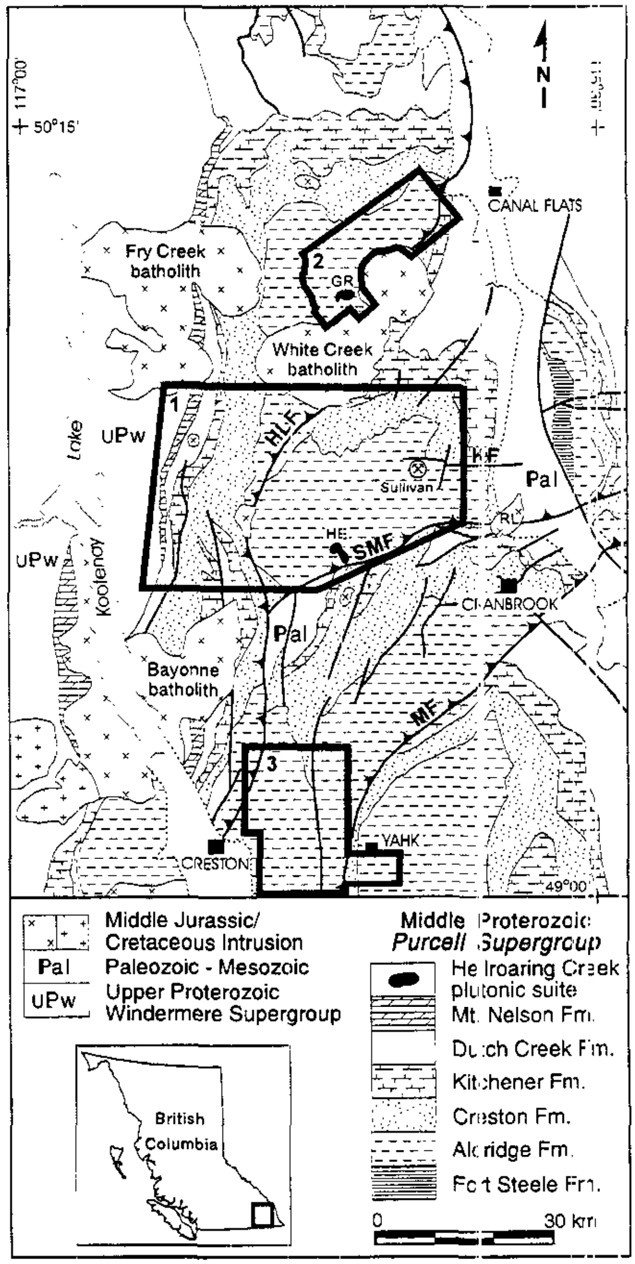

Figure 1. Regional geological setting of Purcell Supergroup showing the location of the three geophysical survey areas within the Purcell anticlinorium (modified from Höy *et al.*, 1995a). 1 = St. Mary River area; 2 = Findlay Creek area; 3 = Creston area. GR = Greenland Creek stock, HE = Hellroaring Creek stock, HLF = Hall Lake fault, KF = Kimberley fault, MF = Moyie fault, RL = Reade Lake pluton, SMF = St. Mary fault.

GEOLOGICAL SETTING

The survey areas lie within the Purcell anticlinorium, a broad north-plunging structural culmination cored by Middle Proterozoic (circa 1500 to 1350 Ma) Purcell Supergroup sedimentary rocks (Figure 1). The succession is more than 10 km thick and comprises syn-rift, deep water turbidites of the Aldridge Formation, and post-rift fill, shallow-water to locally subaerial clastic and carbonate rocks of younger units (Figure 2). Laterally extensive gabbroic sills ("Moyie sills") intrude the Aldridge sediments and provide a minimum age for the syn-rift package (1467 Ma; Anderson and Davis, 1996). Late Proterozoic conglomerate, siliciclastic and volcanic rocks of the Windermere Supergroup unconformably overlie Purcell Supergroup rocks along the margin of the anticlinorium.

Aldridge and overlying Creston Formation predominate in the survey areas. The Sullivan SEDEX deposit occurs near the transition from lower to middle Aldridge in the St. Mary River area. Faulted and structurally complex upper Purcell and Windermere Supergroup strata crop-out in the western third of the St. Mary area and Cambrian Cranbrook and Eager formations occur along the area's southern edge. Small pegmatitic plutonic rocks of middle Proterozoic age include Hellroaring Creek (4 km^2) and Greenland Creek plutons (1.6 km^2; Reesor, 1996). Large Cretaceous plutons, including parts of the White Creek and Fry Creek batholiths, and related smaller stocks plug many of the faults. More detailed maps and unit descriptions are presented in Carter and Höy (1987), Leech (1958), Höy (1984a, b; 1993), Höy and Diakow (1982), Reesor (1958, 1973, 1983, 1996), Rice (1937, 1941), and others (Figure 3).

MINERAL OCCURRENCES

There are 74 known mineral occurrences recorded in the MINFILE database for the survey areas; 63, including the Sullivan Mine, within St. Mary River area, and 11 within the Findlay Creek area. Sixty-five percent of these occurrences are hosted in the lower and middle Aldridge Formation and Sullivan-type SEDEX deposits are the most economically important. Past producers include the North Star, Stemwinder, Silver Hill, Rice, Park and Humbolt Mines. Vein and disseminated base metal sulphide deposits and occurrences are distributed throughout the stratigraphic section (Figure 2). Stratabound Cu-Ag occurrences analogous to the western Montana Copper Belt are potential targets in mud-cracked, wavy-bedded quartz arenites (shallow-water) of the Creston Formation. Locally Cretaceous stocks are related to gold mineralization and could represent the source of placer gold contained in several creeks (for example Sawmill, Lisbon and Perry creeks).

Sullivan is a world class Pb-Zn-Ag SEDEX deposit formed in an intracratonic rift setting within deep water turbidites. It occurs close to the intersection of the Kimberley fault with the Sullivan-North Star corridor (see Figure 5a). The deposit and its regional setting have been the focus of a five year multidisciplinary study, the Sullivan-Aldridge Project (results in preparation for a Geological Survey of Canada Special Paper). Fragmental units, albite and tourmaline alteration as well as discordant Moyie gabbro are features found at Sullivan deposit and many other mineral occurrences in this region.

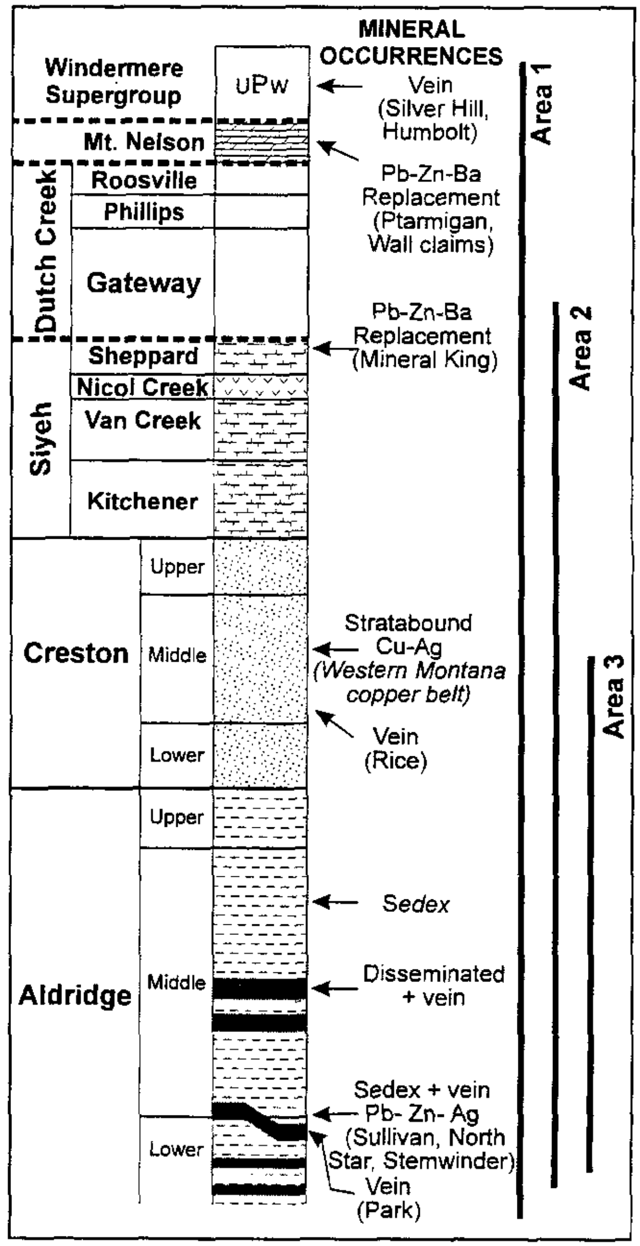

Figure 2. Stratigraphic column for the Purcell Supergroup which lies unconformably beneath the Windermere Supergroup (modified from T. Höy, written communication, 1996). Stratigraphic nomenclature along the eastern half of the Purcell anticlinorium is better defined than the west because of two important regional markers; Nicol Creek Formation lava and Phillips Formation sandstone. The stratigraphic position of several mineral occurrences are indicated. Thick vertical lines denote the range of stratigraphy exposed in each survey area.

STAKING - EXPLORATION ACTIVITY

The government's announcement of the geophysical survey and release of the new data resulted in about 200 km^2 of new staking in the St. Mary River survey area. This represents a 30% increase (about 850 km^2 of claims, Figure 4) over 1995 staking levels. New claims staked by Cominco Ltd., Eagle Plains Resources Ltd. and Miner River Resources Ltd. encompass conductive units and apparent bedrock conductors in the Dutch Creek Formation (LaFrance Creek Group of Reesor, 1996) north of Sawyer Creek, and in the Horsethief Creek Formation. Cominco also staked apparent bedrock conductors in the middle and upper Aldridge Formation in the Tower Creek area.

In the Findlay Creek area, about 105 km^2 of new claims were staked representing a 440% increase over 1995 staking levels. Staking occurred predominantly around Rusty Ridge and west of Doctor Creek. Grass-roots exploration is underway. In addition, coincident magnetic and EM anomalies were drilled jointly by Eagle Plains Resources Ltd. and Miner River Resources Ltd.

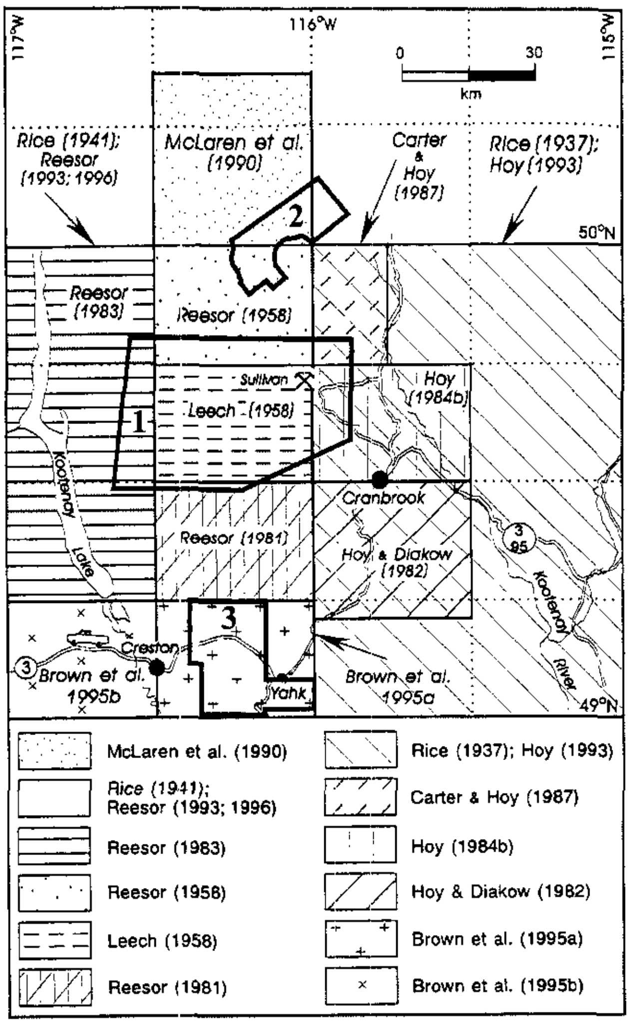

Figure 3. Regional geological mapping coverage adjacent to the geophysical survey areas: 1 = St. Mary River area, 2 = Findlay Creek area, and 3 = Creston area.

Data acquisition for the Creston area was completed in September, 1996 but results were not available to include in this report. Since announcement of the survey in this area there has been a 65% increase in staking and more is expected upon release of the data. Some of the new claims are related to Iron Range mineralization (Figure 4) and a newly recognized pluton south of Highway 3. Claims east of Yahk are part of a larger group acquired by Abitibi Mining Corp. and Sedex Mining Corp; extending beyond the surveyed area to the northeast.

GEOPHYSICAL DATA ACQUISITION

Electromagnetic, magnetic, gamma ray spectrometric, and VLF-EM data were acquired using a helicopter flown at a mean terrain clearance of 60 m. Flight lines were 400 m apart with control lines approximately 5 km apart. The system configuration for the survey is illustrated in Plate 1. Instrumentation and coil configurations are detailed in British Columbia Ministry of Employment and Investment Open File 1996-23 and Lowe et. al (1997).

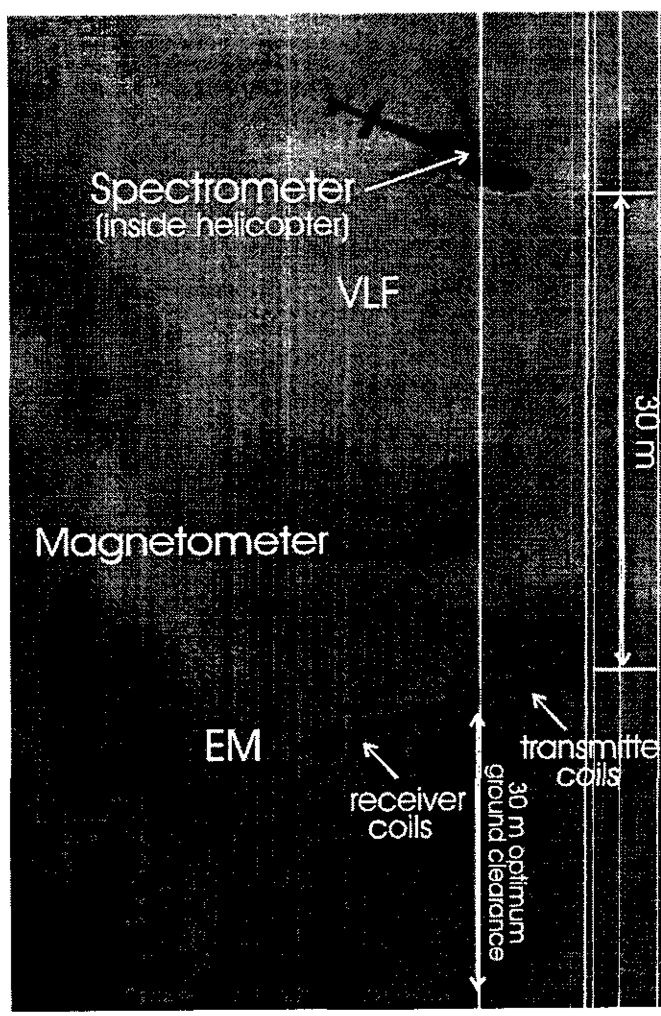

Plate 1. Bird configuration for the East Kootenay Geophysical Survey. The EM bird contains three transmitter and receiver coils. The spectrometer is housed inside the helicopter.

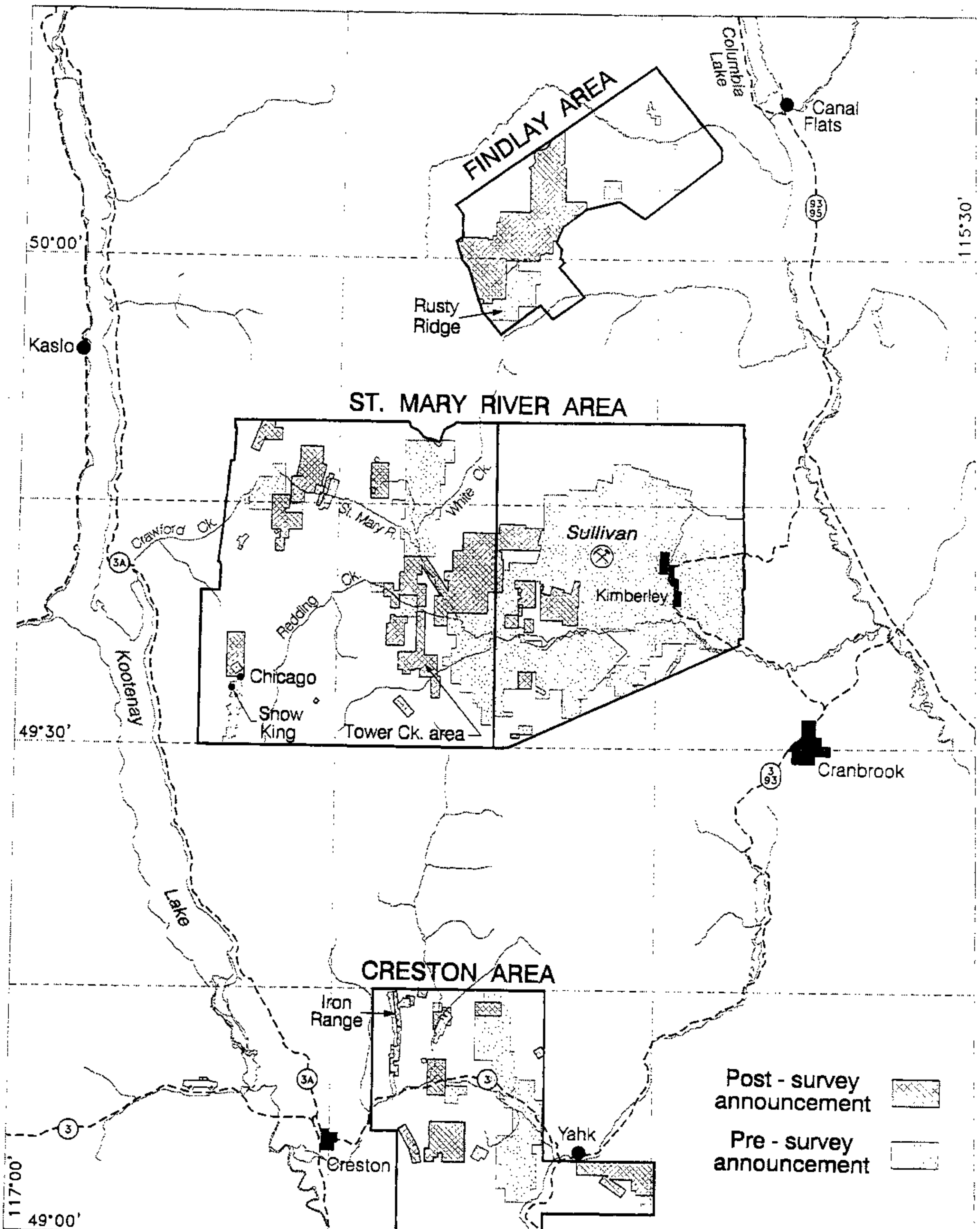

Figure 4. Simplified representation of claim staking pre- and post-announcement of the geophysical survey. Increases were 30%, 440% and 65% for the St. Mary River, Findlay Creek and Creston areas, respectively.

SULLIVAN-NORTH STAR CORRIDOR

The Sullivan-North Star corridor is a 6 km by 1.5 km, north-trending zone of fragmental and disrupted sedimentary rocks that are intensely altered and locally mineralized (Hagen, 1983; Höy, 1984a). The corridor hosts Sullivan, North Star and Stemwinder deposits (Figure 5). It is truncated by the Kimberley fault to the north and pinches-out to the south due to deeper stratigraphic levels and thicker Quaternary cover. The North Star and Stemwinder stratiform and vein deposits were mined up to 1929 and contained about 100,000 tonnes of ore. The corridor is interpreted to be a rift-related hydrothermal field (Turner *et al.*, 1995).

The Sullivan deposit has been in continuous production since 1900 and is one of the world's largest stratiform, sediment-hosted massive sulphide deposits. It has produced over 140 MT of ore containing 9 million kg silver, 8 billion kg lead and 7.4 billion kg zinc. The total resource was estimated to be more than 160 Mt grading 6.5% Pb, 5.6% Zn, 25.9% Fe and 67 g/t Ag (Ransom *et al.*, 1985). The mine is projected to close in 2001. It has been extensively documented by geological studies including Hamilton *et al.* (1983), Hamilton (1984), Ransom *et al.* (1985), Höy *et al.* (1995b) and Turner *et al.* (1993, 1995). The deposit comprises a discordant western vent zone (Leitch and Turner, 1992) and an eastern stratiform zone of bedded ores close to the lower-middle Aldridge contact. Deposit characteristics include footwall chaotic breccia, intraformational conglomerate, tourmalinite alteration pipe, muscovite and albite-biotite-chlorite-alteration, manganiferous garnet-rich beds, a gabbro arch, and gently east-dipping stratiform massive and laminated sulphides. The orebody comprises massive pyrrhotite and banded pyrrhotite-galena and sphalerite. Its maximum thickness is about 100 m and it thins rapidly to the east. The dimensions of the vertical projection of the deposit to surface are about 2.0 km by 1.6 km (Figure 5a).

The following is a description of the geophysical responses around the Sullivan Mine and Sullivan - North Star corridor near Kimberley. Despite extraction of over 140 MT of ore from the Sullivan Mine, the remaining portions still produce significant but subdued magnetic and conductivity responses. In addition, accumulations of altered, barren to weakly mineralized waste rock on the surface around the deposit correspond with pronounced magnetic and EM anomalies as well as with distinctive radioelement concentrations.

Electromagnetics

At the Sullivan Mine, non-cultural EM conductors are coincident with the surface projection of the sulphide-rich Sullivan horizon, especially where it is cut by the Sullivan fault along the west side of the deposit, and along the south side of the open pit (Figure 5). The Sullivan fault zone contains pyrrhotite at depth (R.J.W. Turner, personal communication, 1996) and this is most likely the source of the conductors on the west side of the deposit. The undisturbed pyrrhotite replacement body as well as other unmined massive sulphide ore may also contribute to the high conductivity values observed here. The finite conductors are quite broad, less than 15 m deep, with in-phase and quadrature values generally larger than 15 ppm. They also have large conductance (conductivity times thickness) values, as calculated from the 900 Hz coaxial data assuming a two-dimensional vertical conductor in free space. Curiously, the collapse zone of the deposit, where mining has been closest to surface, does not correspond to a conductivity anomaly.

There are also a number of EM conductors related to cultural features including mine buildings, heavy equipment, and powerlines lines immediately east and south of the Sullivan open pit (Plate 2). In general, the deeper a given conductor is buried the lower the absolute values of both the in-phase and quadrature components. However, the ratio of the in-phase and quadrature components is only slightly affected by burial depth. This ratio is an important indicator of conductivity; the larger the ratio the better the conductor (see Figures 5 and 6).

The most prominent and concentrated cluster of EM anomalies for the entire survey area occurs in the vicinity of the North Star-Stemwinder Mines, over an area 1.0 km by 1.2 km. The cluster is comprised of shallow conductors with larger conductance values than those at Sullivan. These conductors result from north-trending sulphide deposits including those in the abandoned mine areas and sulphide filled fractures. The associated conductivity anomaly dies-out where the Stemwinder vein pinches-out north of Mark Creek, in an area of thick Quaternary cover and deep weathering. This deep weathering zone comprises oxidized and friable bedrock up to 146 m below surface and probably represents a preserved zone of Tertiary weathering (P. Ransom, personal communication, 1996).

A broad, east-trending zone of moderate to high conductivity (900Hz coaxial) with numerous apparent conductors east of Kimberley along highway 95A corresponds to powerlines and transformers, homes and possibly wet, clay-rich surficial material.

Magnetics

Within the Sullivan-North Star corridor there is an irregularly-shaped (4.5 km by 3.2 km), moderately positive magnetic anomaly with localized zones of high anomaly values over the Sullivan and North Star deposits (Figure 5b). The anomaly is truncated to the north by the east-trending Kimberley fault. The western and southern boundaries are less well defined. To the east the anomaly abruptly terminates at a narrow (< 500 m wide), south-trending magnetic linear that extends from the St. Mary River valley to the Kimberley fault.

The localized zones of maximum magnetic anomaly values at Sullivan and North Star (peak amplitudes are approximately 90 and 60 nT, respectively), correspond to the shallowest portions of the mineralized zones and at Sullivan occur along the trace of the Sullivan fault (Figure 5b). The Sullivan "high" is due in part to the massive pyrrhotite replacement body (up to 50 m thick and 500 m long, P. Ransom, personal communication, 1996) and to the network of pyrrhotite-quartz-carbonate veins beneath the western portion of the orebody. Most of this pyrrhotite must be weakly magnetic otherwise a stronger anomaly would be produced. Although the eastern portion of the orebody includes stratiform beds of magnetite (cumulative thickness of less than 1 metre), this material is volumetrically minor and much of it has been mined, accounting for the lower magnetic amplitudes observed in this region.

The North Star "high" is situated between the North Star and Stemwinder Mines, where abundant disseminated and fracture-filled pyrrhotite occurs. As within the Sullivan Mine the magnitude of the anomalies suggests that a considerable proportion of the pyrrhotite must be in the ideally antiferromagnetic form (i.e. troilite). North of the Stemwinder Mine lower magnetic amplitudes correspond to the zone of thick Quaternary cover and deep bedrock weathering discussed above.

Gamma Ray Spectrometry

In the Sullivan Mine area, elevated radioelement concentrations (K- potassium, eU - equivalent uranium, and eTh - equivalent thorium) are associated with the open pit, collapse zone and waste dumps (Figure 5b and Plate 2). Although these anomalies are enhanced by the increased exposure and better drained material resulting from mining, ground spectrometry confirms that elevated concentrations are present. Subtle eTh/K ratio lows are apparent over the eastern and southern waste dumps, but are not associated with the open pit or collapse area. This suggests that the transported waste rock contains relatively more potassium than that exposed near or at surface in bedrock and surficial materials. Elevated K, eU and eTh patterns extend northward from the pit area, across the Kimberley fault, over argillaceous units of the upper Aldridge Formation on Sullivan Hill. This trend is lithologic, but unrelated to the mineralization and sericite alteration that characterize the Sullivan-North Star corridor.

Patterns over the North Star deposit show similar increases in all three radioelements, and the airborne eTh/K lows in this area and in situ spectrometry on bedrock and talus indicates that relative enrichment of potassium does occur. The enrichment corresponds closely to exposed sericite alteration within the sub-

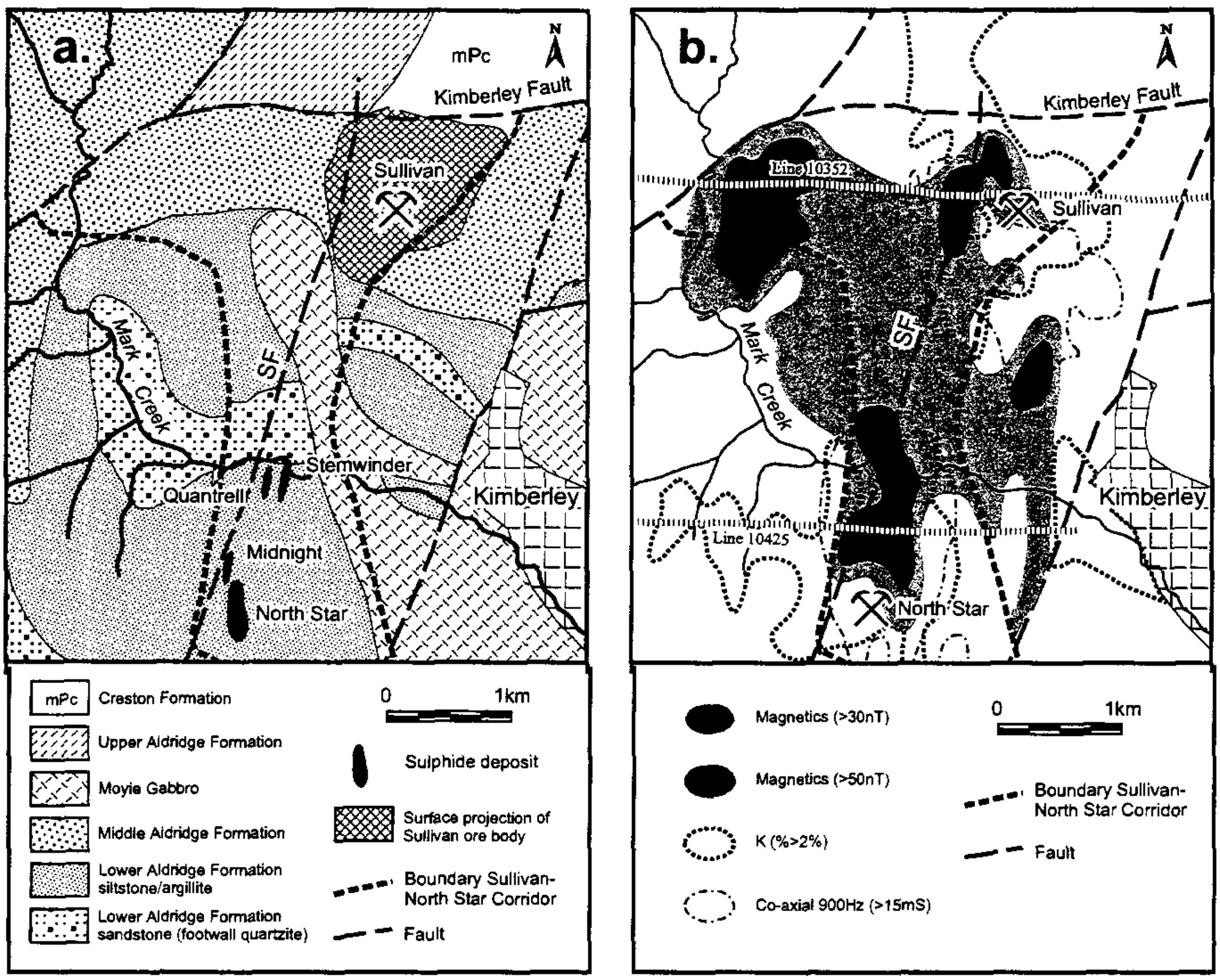

Figure 5. a) Geological map of the Sullivan-North Star corridor (modified from Hagen, 1985; Höy, 1993); b) Simplified magnetic, EM (900Hz coaxial) and K anomalies for the region shown in (a). SF = Sullivan fault.

vertical root zone of the Sullivan-North Star corridor. This includes the narrow, north-trending high K, low eTh/K ratio pattern which extends 2.0 km to the south. These patterns are enhanced by increased bedrock exposure related to old mine workings (ex. North Star Mine area), trenches, cleared ski runs or talus, however, they still reflect the primary north-trending alteration system.

Lower amplitude K highs with coincident eTh/K lows occur west and northwest of North Star Hill, in steeply sloping or bowl shaped areas covered with a very thick clay-rich till. While these anomalies accurately reflect the relatively K rich chemistry of the till, the corresponding low magnetic total field response suggests that the radioelement anomalies do not represent exploration targets as characterized by those known within the Sullivan-North Star corridor. The combination of radiometric and magnetic/electromagnetic patterns may provide useful exploration vectors for these SEDEX deposits. This combination has been clearly demonstrated over many other deposit types, such as alkalic and calc-alkalic porphyry-Cu-Au+/-Mo deposits and volcanic-hosted massive sulphide deposits elsewhere (Shives *et al.*, 1995).

Borehole geophysical logs and tables for Sullivan Mine stratigraphy drilled east of Kimberley are presented in Killeen *et al.* (1995) distal (about 5 km southeast) from the altered core zone that constitutes the Sullivan-North Star corridor. These logs show that massive sulphide encountered in the hole produces intensely positive conductivity and magnetic susceptibility anomalies but no significant radiometric signature. From this point of view the massive sulphide in this hole must be unusual as nowhere else in the region do such strong responses occur. However, most subunits of the Aldridge are weakly magnetic and resistive. This illustrates the challenge faced by explorationists in SEDEX camps because alteration zonation can be restricted or absent on the fringe of a deposit.

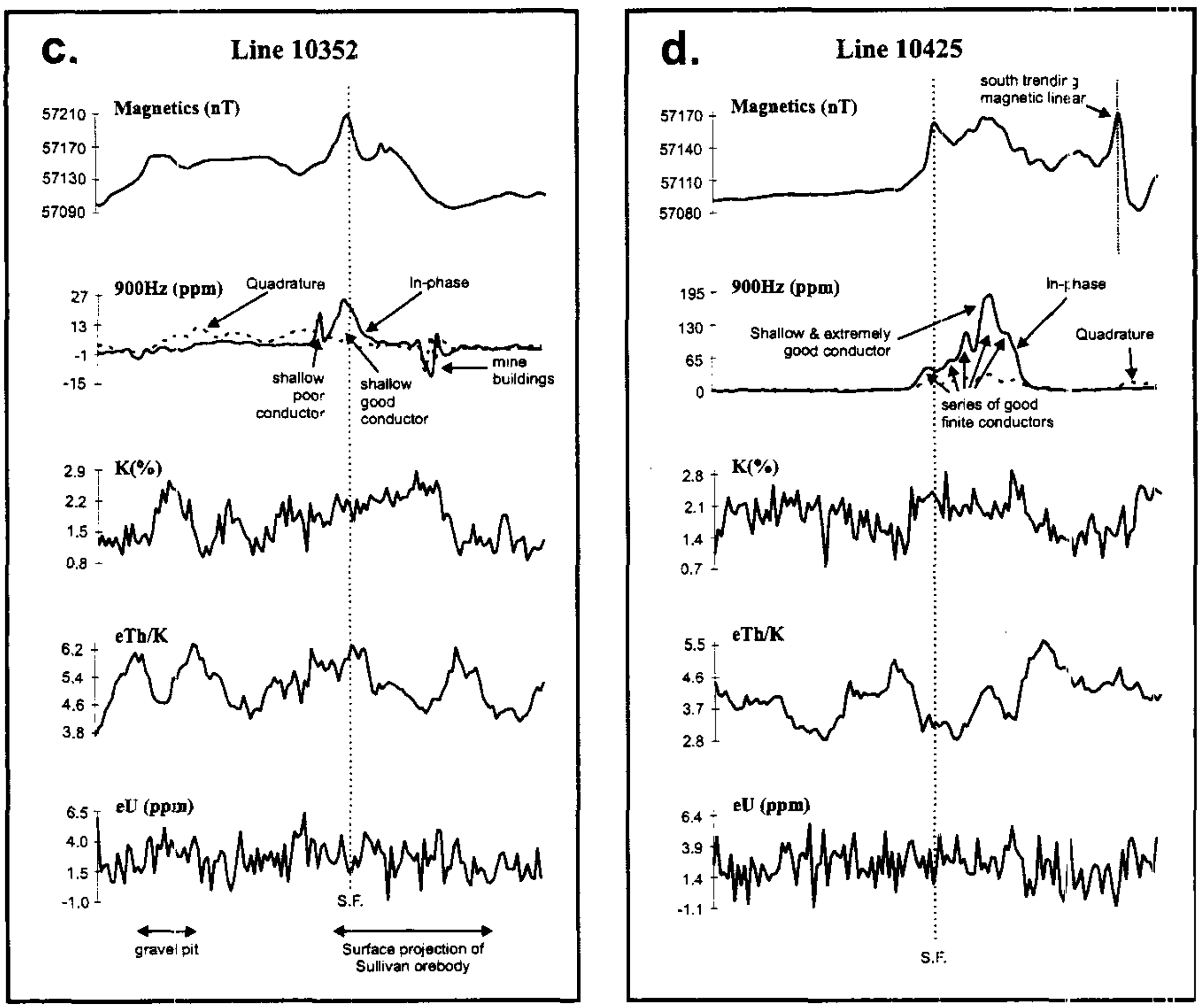

Figure 5. c and d) stacked profiles of magnetic, conductivity, K, eTh, and eU along the east-trending flight lines 10352 and 10425 over the Sullivan and Stemwinder deposits, respectively. SF = Sullivan fault.

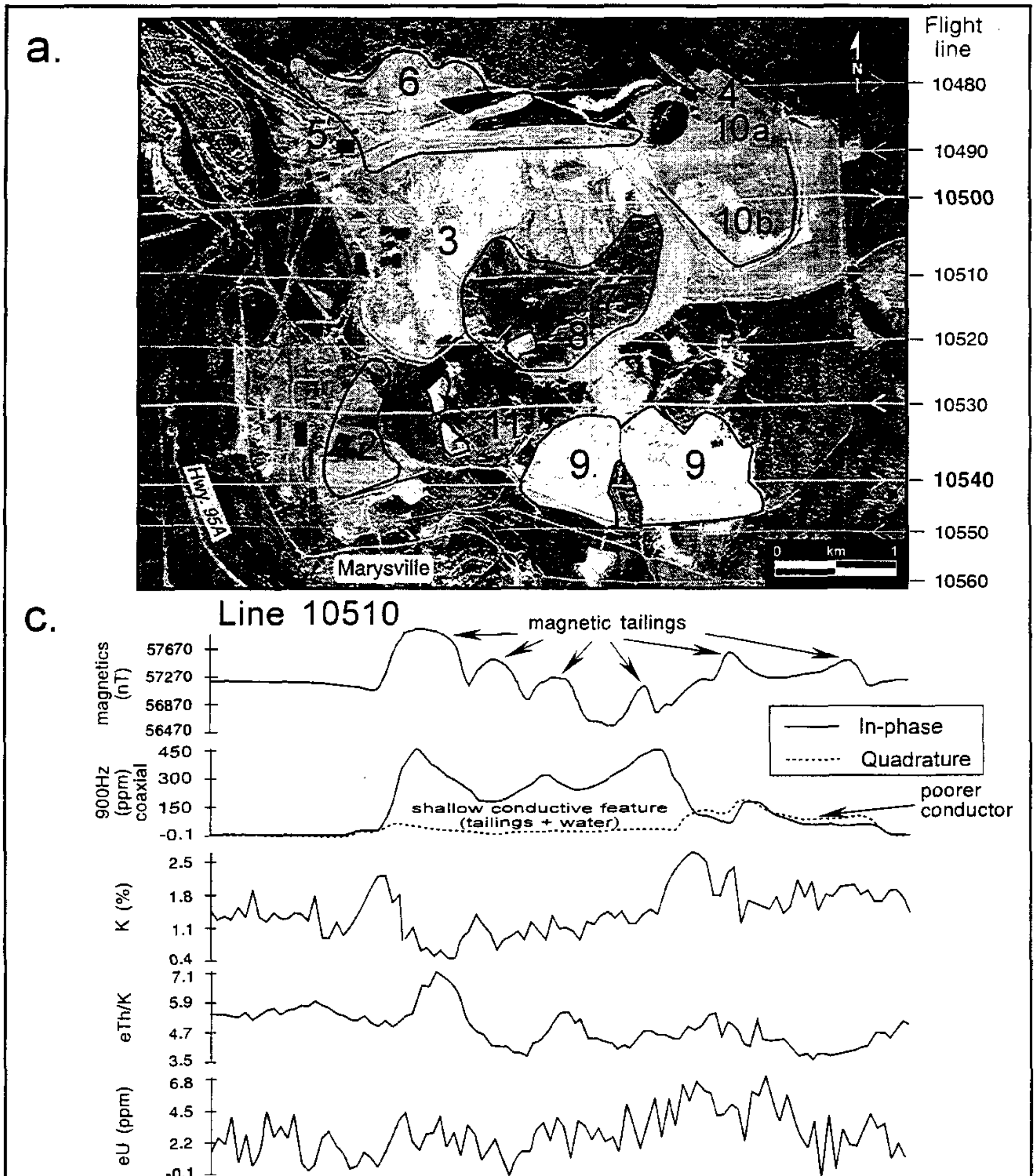

Figure 6. a) Surface features of the Sullivan tailings area, airphotograph supplied by Cominco Ltd. (photo FFC94016-29, August 10, 1994). 1 = fertilizer plant buildings (demolished); 2 = calcine tailings; 3 and 4 = old iron tailings (pyrrhotite concentrate; 40 years); 5 = mill buildings; 6 = float/waste rock; 7 = active tailings (post 1987) deposited over old iron tailings; 8 = water; 9 = gypsum tailings; 10a = siliceous tailings covered by float rock and glacial till and revegetated; 10b = siliceous tailings partially covered by float rock; 11 = thin layer of gypsum with minor water (old cooling ponds for gypsum plant. Arrows on flight lines indicate direction of helicopter during data acquisition; and c) stacked profile of magnetic, conductivity, K, eTh, and eU along flight line 10510.

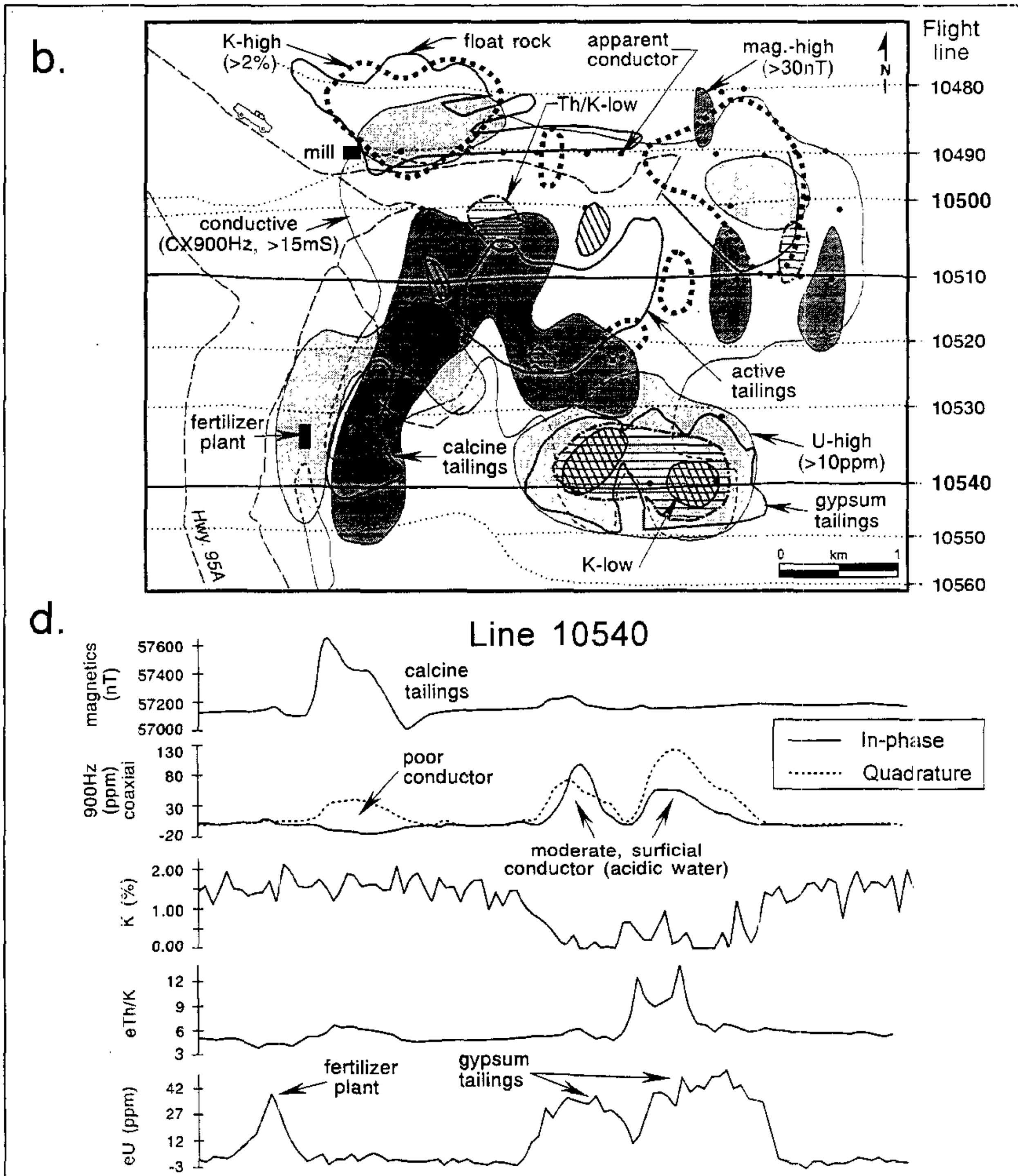

Figure 6. b) Corresponding simplified magnetic, EM (900Hz coaxial), K, eTh/K and eU anomalies for the region shown in (a); and d) stacked profile of magnetic, conductivity, K, eTh, and eU along flight line 10540.

SULLIVAN TAILINGS AREA

There are prominent geophysical anomalies in a 12 km^2 area over the Sullivan tailings (Figure 6). These anomalies result from base-metal extraction and fertilizer production. The northern tailings areas are dominated by waste material acquired from different parts of the Sullivan Mine and deposited over a 90 year interval.

The southern part of the tailings area includes the demolished fertilizer plant that operated from 1953 to 1987 and its associated two gypsum ponds. The phosphate rock was mined in Montana and processed into fertilizer: sulphate mixed with sulphuric acid formed gypsum and phosphoric acid (ammonia phosphate fertilizer). The gypsum by-product is now contained in two tailings ponds that have a unique gamma ray response which is described below.

Electromagnetics

The entire tailings area, including the gypsum tailings, form a broad zone of high conductivity, probably

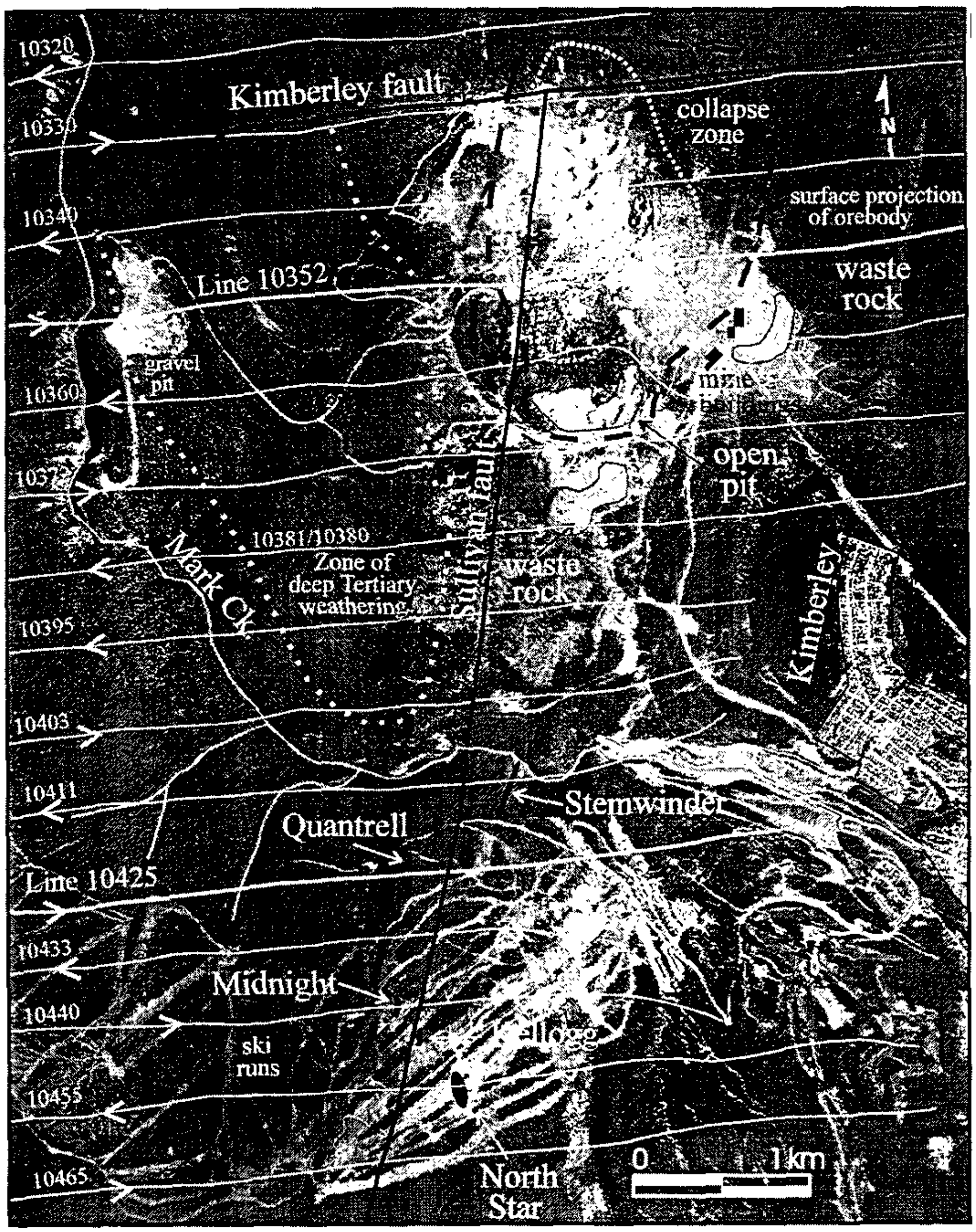

Plate 2. Surface features around the Sullivan-North Star corridor. Airphotograph supplied by Cominco Ltd. (photo FFC94016-19, August 10, 1994). Arrows on flight lines indicate direction of helicopter during data acquisition. The extent of the deep Tertiary weathering zone is courtesy of P. Ransom (written communication, 1996).

resulting from metal-rich acidic pore water. The pH and sulphate content of the tailings is variable, in part due to mixing of alkaline groundwater that seeps into the area from the north. In the gypsum tailings, residual sulphuric and phosphoric acid, and dissolved sulphate produce the low pH water (<2) that also has a high content of dissolved iron. Such a solution would be conductive. This high conductivity zone is equal in extent to the combined Sullivan and North Star conductivity anomalies, but is related to acidic pore water rather than bedrock.

Weak apparent conductors are observed within the tailings area also. Those in the south and west are mainly cultural (power lines, metal buildings, etc.) in origin. The remainder lie within the tailings area proper (Figure 6b) and are of variable strength. Several broad, moderate strength conductors have unknown origin. Conductors imaged along flight line 10490 may be related to the tailings slurry carried in a PVC pipe.

Magnetics

The magnetic patterns do not follow present day surface features as more recent, less magnetic waste covers the sulphide-rich tailings. However, three strongly positive magnetic anomalies correspond to areas where pyrrhotite- and magnetite-rich tailings have been deposited (Figure 6). The magnitude of the anomalies reflects differing concentrations of magnetic minerals present in the tailings, as well as their depth of burial. Prior to 1987 tailings were separated into "siliceous" and "iron" varieties with 10% and 25-30% sulphur, respectively. Since then, one type of tailings has been deposited with about 18% sulphur (Bob Gardiner, personal communication, 1996). Field checking also suggests that the top layer of the sulphide-rich tailings (one metre or so depending on the level of the water table) is highly oxidized (limonitic) and less magnetic (magnetic susceptibility (MS) = 1.5×10^{-3} SI) than deeper, less oxidized tailings below this cap (MS = 6.0×10^{-3} SI).

The southwestern prong of the prominent, inverted V-shaped magnetic anomaly includes the iron-oxide pond (calcine; Figure 6b). Calcine is a by-product derived from roasting pyrrhotite concentrate to produce sulphuric acid (used in fertilizer production). The roasting process drove off sulphur and replaced it with oxygen, thus converting pyrrhotite to hematite. However, as much of the calcine is exceptionally magnetic (MS = 250×10^{-3} SI), it is inferred that much of the pyrrhotite was converted into ferromagnetic hematite (maghemite, gamma-Fe_2O_3).

The three smaller positive anomalies in the northeastern part of the tailings area occur where iron-rich material (pyrrhotite) is buried beneath siliceous waste rock.

Gamma Ray Spectrometry

As expected, radioelement patterns in the tailings area correlate closely with surficial material. The exposed float rock is characterized by elevated K, eU and eTh values, and depressed magnetic amplitudes. As observed in the Sullivan Mine area, this barren but altered material yields strong eTh/K lows which reflect the increased hydrothermal sericite content. Therefore, the two largest zones of elevated K correspond closely to areas of "float" rock and "siliceous" tailings (Figure 6). Three small K-lows reflect wetter or water covered portions of the tailings. The strongest eU concentrations correspond to the gypsum tailings and float/waste rock. Elevated eU in the Sullivan deposit could be related to allanite (C.H.B. Leitch, personal communication, 1996), an epidote mineral commonly with minor Th and U.

The two anhydrite tailings have unique, high eU and very low eTh and K signatures (Figure 6). The eU anomaly can be traced along the haulage way to the fertilizer plant. These tailings have recently (post airborne survey) been covered by silicic waste rock from the Sullivan Mine.

DISCUSSION

The analysis of the geophysical responses observed in the Sullivan-North Star corridor area provides baseline data that can be applied to mineral exploration elsewhere in the Purcell Basin.

High magnetic anomaly values, high electrical conductance, and low eTh/K ratios are characteristic of mineralization and sericitic bedrock alteration in the Sullivan-North Star corridor. This combination of geophysical responses is clear even in the vicinity of the Sullivan deposit, where up to 90% of the mineralization has been removed. On average, the depth of penetration of airborne EM system is about 100 metres and the radiometric system essentially samples only the top 20 to 30 centimetres; these limitations must be borne in mind when studying the new data.

The broad, moderate magnetic anomaly over the Sullivan-North Star corridor is distinct from local intense anomalies related to altered Moyie sills (cf. Lowe *et al.*, 1997). Another similar low amplitude, broad magnetic anomaly lies 8 km west of Sullivan in the lower Aldridge Formation near Matthew Creek. Although this anomaly lacks associated EM anomalies it warrants further analysis and follow-up investigation. Much of the Aldridge surveyed is characterized by low magnetic anomaly values implying that if present, undiscovered magnetic, massive sulphide deposits must be more deeply buried than the near surface portions of the Sullivan and North Star Mines.

The new data are a useful tool for other types of exploration. The spatial association of Cretaceous stocks to lode gold mineralization and placer deposits (for example Sawmill, Lisbon and Perry creeks) suggests a genetic link between the intrusions and gold. Preliminary analyses show that many of these plutons and/or magnetite-hematite breccias and stringer zones in nearby associated fault zones produce positive magnetic anomalies and distinct radioelement signatures. Therefore, a more thorough assessment of the new data may provide valuable information. Indeed, Lowe *et al.* (1997) demonstrate the utility of the data for refining the spatial distribution of the Reade Lake stock and for mapping distinctive phases within several of the other Cretaceous granitoids, including the White Creek batholith.

Another example where the new data provide complementary information for mineral exploration is illustrated in the southwest corner of the St. Mary River area. Here, deformed stratabound and vein mineralization includes disseminated galena, sphalerite, pyrite and tetrahedrite hosted within carbonate of the Dutch Creek or Mount Nelson formation. This rift-cover succession with alternating carbonate, argillite and quartzite hosts a number of stratabound Pb-Zn-Ba occurrences. These units are exposed in trenches and adits at the Chicago and Snow King, past producers near the headwaters of Redding Creek (Wall-Dave claims; Slingsby, 1980, 1981; Callan, 1990). A schistose mafic sill crops out on the east side of a sulphide vein at one of the Chicago trenches. The sill produces a strong magnetic high on the aeromagnetic map. Ground measurements across 2 metres of the sill indicate that the magnetic susceptibility increases from 0.68 to 30 x 10^{-3} SI units toward the mineralization, although there are no visible signs of alteration. Therefore, the identification of other magnetic sills and the direction of increasing magnetization may vector toward new zones of sulphide-rich veins.

Outside the survey area similar stratabound mineralization hosted by the same stratigraphic units include the past producing Mineral King Mine and Leg prospect (cf. Pope, 1989; Brown and Klewchuk, 1995).

Numerous other geophysical features within the survey areas require follow-up. A surprisingly large number of geophysical anomalies occur in the northwest part of the St. Mary River survey block. The upper Purcell Supergroup geology, including the Dutch Creek and Mount Nelson formations here is less well known but a recent map by Reesor (1996) provides a better base than that provided on the geophysical maps in British Columbia Employment and Investment Open File 1996-23. Analysis of these geophysical anomalies will undoubtedly provide a new perspective for explorationists working here.

CONCLUSIONS

In summary, the new and detailed geophysical data can be used to characterize and target several types of mineralization. In the case of sediment-hosted massive sulphides at Sullivan, analysis shows coincident high magnetic values, moderate to strong bedrock conductors, elevated K, low eTh/K are characteristic. This signature, with even stronger conductors, is also apparent around the North Star and Stemwinder Mines. Stratabound replacement occurrences are locally associated with magnetic sills and therefore careful follow-up of high magnetic values in the Dutch Creek and Mount Nelson part of the stratigraphy could lead to future mineral discoveries. Magnetic and radioelement patterns detail lithologic variations of Cretaceous plutons. Some of these bodies have potential to host or be related to gold mineralization. In addition, with the aid of the geophysical patterns current geological maps could be refined and sub-units distinguished. This could lead to new models and mineral targets.

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