Yukon Engineering Services

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A Ground Probing Radar Survey of the Upper Indian River Placer Property

M.A. Power

Placer Leases PL7961, PL7962, PL7963, PL7964 (claim sheet 115 O10 e and f)

138° 41' W 63° 37' N

Work performed between January 15, 1989 and January 25, 1989 for RK Resources Ltd.

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Introduction

This report describes a ground probing radar (GPR) survey of the Upper Indian River placer property (figure 1 and 2) conducted between January 15, 1989 and January 25, 1989. Portions of the valley containing lower Australia and Wounded Moose Creeks were surveyed on lines perpendicular to the existing drainages to define the bedrock surface.

Conclusions and Recommendations

a. Conclusions

1. A reflector, tentatively identified as bedrock, occurs at a depth of approximately 10-20 feet on lines A-4, A-5, A-6 and A-7 immediately west of Australia Creek (figure 3). Some evidence of the same reflector east of Australia Creek occurs on line A-6.

2. Radar soundings of the remainder of the property indicate that clay-rich overburden is strongly attenuating the signal and obscuring deep reflectors.

3. The electromagnetic (EM) phase velocity of near surface material on the property is unknown and consequently depths can only be estimated. The depths given in this report could be in error by as much as ±25%.

4. Ground probing radar technology can be used to map the top 30 to 40 feet of overburden and/or bedrock in a placer deposit if little clay is present and if measures are taken to ensure good ground coupling and to minimize reverberations.

b. Recommendations

1. The area west of Australia Creek should be tested by drilling on lines A-4 through A-7 at the sites shown in figure 3.

2. Once depths to bedrock are determined, the GPR data should be recalibrated using a corrected velocity. The GPR data may then be used in a subsequent volume estimate and mine plan.

Property location and access

The Upper Indian River placer property is located 55 miles southeast of Dawson City, Yukon near the confluence of Australia and Wounded Moose Creeks with Indian River (NTS 115 O 10, figures 1 and 2). The property consists of placer leases PL 7961, PL 7962, PL 7963, and PL 7964 on claim sheets 115-O-10 (e and f) and these are held by RK Resources Ltd. The property consists of 2 creek leases and 2 first tier bench leases on the lower reaches of Australia and Wounded Moose Creeks. Year-round road access is available via the Hunker-Bonanza-Granville Road from Dawson City.

Geological Setting

Poor outcrop exposure near the property prevents a detailed description of the geology. Government mapping by Bostock (1942) and Debicki (1985) indicates that the property is underlain by Triassic foliated coarse-grained granodiorites and Triassic feldspar-quartz schist. These units outcrop at several locations along the Australia-Sulphur ditch above Australia Creek, and are expected to continue across the valley to Wounded Moose Creek. No data from the geophysical program suggests any major lithologic or structural changes in the study area.

During the Tertiary Period, massive amounts of alluvial gravel were transported down the Australia Creek valley, and remain as benches above the recent stream gravel depositions. Both creeks occupy the same valley in the lower 4 miles, and geomorphologic evidence suggests that they have meandered laterally across that broad alluvial plain. The valley escaped the pre-Reid, Reid and McConnell glacial advances and the "black muck"- a frozen organic layer typical of the region- overlies the gravel deposits.

As yet, recirculation drilling has not been conducted on the property and consequently the stratigraphy of the overburden and the bedrock cannot be described in any further detail.

The Ground Probing Radar

a. Theoretical basis

The adaptation of radar technology to geotechnical applications was first achieved by Geophysical Survey Systems Ltd. in 1971 with the development of the Subsurface Interface Radar (SIR) system. Instruments developed subsequently have essentally the same technology and improved digital data handling capabilities. The radar method consists of transmitting a high frequency wavelet into the earth and recording reflections from subsurface reflectors.

Most geological materials are relatively low-loss media and EM phase velocities can be calculated from

$$V_p = \frac{c}{\sqrt{K}}$$

c - $3X10^8$ m/s (speed of light in vacuo)
K -relative dielectric constant

Representative velocities for geological materials commonly found in placer settings in Northern Canada are tabulated in Table I. The velocity of overburden materials may be measured in-situ in one of three ways: (1) By direct borehole velocity surveys (2) By using the common mid-point method commonly applied in refraction seismic work (Davis and Annan 1987) and (3) By calibrating a known reflector with a corresponding depth from a drillhole log.

The reflection observed on a radargram occurs when an incident EM wave strikes the boundary between two materials of different dielectric constant or conductivity. For normal incidence at a planar reflector in low-loss media, the amplitude of the reflection (R) is

$$R = \frac{K_1^{1/2} - K_2^{1/2}}{K_1^{1/2} + K_2^{1/2}}$$

where K_1 and K_2 are the relative dielectric constants of the material overlying and underlying the boundary. The amplitude of the reflection is reduced if the incidence is oblique, if the surface is rough and/or if the boundary is gradational (Annan and Davis 1977). EM radiation is attenuated in conductive media and in the placer setting, clay and brine may strongly attenuate the radar signal and limit penetration to a depth of 2-3 m (Annan and Davis 1976).

Commonly the transmitting and receiving antennas are one in the same or so close together relative to the depth of penetration that the depth to the first interface may be calculated from the first arrival at time t by

$$d = 2v_p t$$

Deeper interface depths may be determined using a layer-stripping technique similar to those used in seismic inversion (see Telford et al. 1977 for discussion). If the antennas are separated by a substantial distance relative to the depth of penetration (eg. > 0.5xd) corrections for the slanted ray path and refraction at interfaces may be necessary.

b. Field Procedure

The geophysical survey was conducted using an SIR-3 (model PR 8300) GPR manufactored by Geophysical Survey Systems Inc. of Hudson NH. This particular instrument was equipped with a 120 MHz transmitter/receiver antenna pair (model 3110) and operated at a pulse rate of 50 KHz. The instrument was placed in a Nodwell to keep it at or above the minimum operating temperature (0 C) and the antennas, spaced at 2 m, were towed in a specially constructed wooden sled to ensure good ground coupling and to minimize damage to the antenna housings (figure 4). The survey was conducted by towing the antennas at a constant speed of approximately 3 km/hr and recording a continuous profile.

Reverberations (multiples) were a serious source of noise and these were traced to two sources. A ubiquitous problem was reverberation between the transmitter and the Nodwell. This was partially solved by towing the antenna sled as far back from the Nodwell as possible (~40 m) thereby causing the reverberations to appear approximately 150 ns after pulse initiation. This left a sufficiently wide window in which to record subsurface reflections. A second set of multiples appeared whenever the antenna sled rode on any appreciable snow pack (> 0.5 m) and these were causes by strong repeated reflections at the ground surface. The survey lines were cleared down to ground level prior to the survey and snow pack reverberations are comparitively rare in the records.

Survey Control

A total of 4.7 line-km were surveyed and cleared with a D-6 CAT bulldozer for the main portion of the geophysical survey.

Another interval of approximately 5 line-km was surveyed with the GPR but the data was neither inverted nor is included with this report. Most of the GPR data collected off the main survey grid was strongly contaminated with multiples but a test section on the Australia Creek road did produce 3.2 line-km of good quality records. On the main survey grid, 82 control points were surveyed-in by a two-man crew using a Geodimeter 210 and the survey points are marked on the radargrams as numbered fiducials.

Results and Interpretation

The survey grid is shown in figure 3 and radargrams obtained on lines A-4, A-5, A-6 and A-7 are contained in the back pocket of this report. No evidence of a bedrock reflector on lines AT-1 and AT-2 was found and the data was neither processed nor included in this report. The radargrams taken on the crosslines show 1 or 2 weak subsurface reflectors in short intervals. Clay-rich organic muck limits radar penetration and obscures deeper reflectors in much of the survey area. In areas where 2 reflectors are visible, the uppermost, flat and shallow reflector seems to demarcate the base of the muck at around 4 feet.

The deepest extensive reflector in the radargrams is assumed to be bedrock. The appearance of this reflector is similar to that of a similar continuous reflector observed on the Australia Creek road at a depth close to that of bedrock in nearby drillholes. The precise EM phase velocity of the overburden cannot be determined and a representative value of 0.4 ft/ns is assumed. This figure may be in error by as much as ±25% depending on clay and ice content. All of the data collected in this survey were inverted using the above overburden velocity and the assumption of receiver/transmitter coincidence and vertical ray incidence. The lack of any reliable velocity model prevents a more rigorous approach. Consequently, the depth to bedrock may be in error by as much as ±25% as a result of uncertainty in the overburden EM phase velocity.

To interpret the data, the radargrams were digitized and reflections transferred to time sections. Depths were obtained at selected points on the time sections (eg. at either end, the midpoint, deepest or shallowest point on a reflector) using the assumptions cited above. The depths were merged with the topographic survey data to produce the cross-sections in figure 4. using the EMXS software package (Millar 1986). The intervals within these sections where estimates of depth based on geophysical data were made are indicated in black. Interpolated values outside of these areas should be viewed with even greater caution.

The data shows that the area immediately west of Australia creek is not blanketed by an extensive muck layer and contains a 10-20 foot thick gravel section. This appears to be the most favourable area to begin testing this deposit.

MPower

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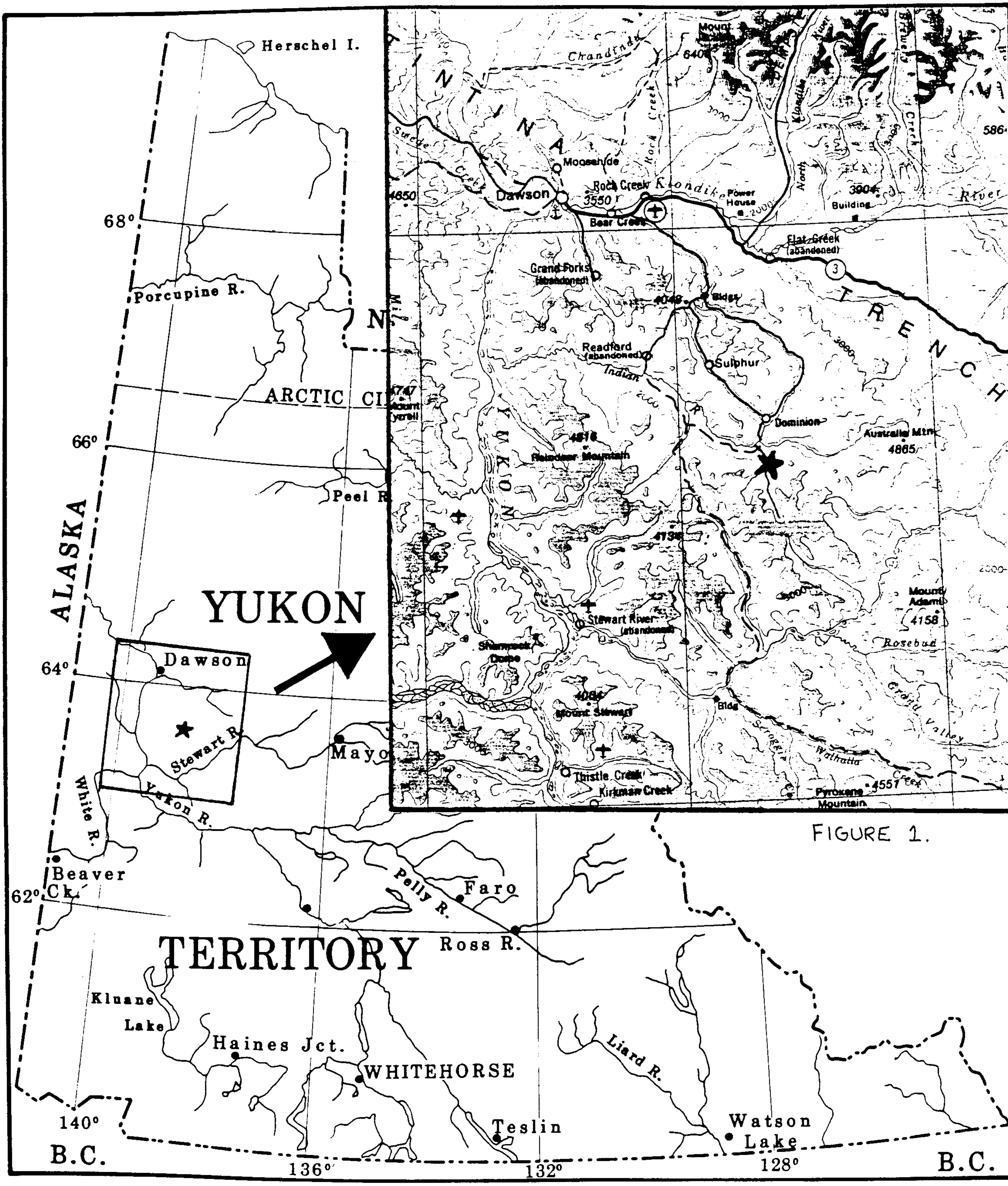
Table I. Electromagnetic phase velocities of geological materials commonly found in placer settings.

Ice	0.28 ft/ns
Fresh water	0.06 ft/ns
Permafrost (clay/gravel)	0.25 ft/ns
Clay	0.16 ft/ns
Bedrock (viz. granite)	0.18 ft/ns

(source: GSSI SIR-3 documentation)


Herschel I.
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ARCTIC CI
Peel R
ALASKA
YUKON
TERRITORY
Dawson
Stewart R.
Mayo
White R.
Yukon R.
Beaver Ck.
Pelly R.
Faro
Ross R.
Kluane Lake
Haines Jct.
WHITEHORSE
Teslin
Liard R.
Watson Lake
B.C.
B.C.
68°
66°
64°
62°
140°
136°
132°
128°
Moosehide
Dawson
Rock Creek
Klondike
Bear Creek
Power House
Building
Flat Creek (abandoned)
Grand Forks (abandoned)
Readford (abandoned)
Indian
Sulphur
Dominion
Australia Mtn
4865
Reindeer Mountain
Stewart River (abandoned)
Mount Adams
4158
Rosebud
Mount Stewart
Thistle Creek
Kirkman Creek
Pyroxene Mountain
4551
TRENCH
YUKON
FIGURE 1.

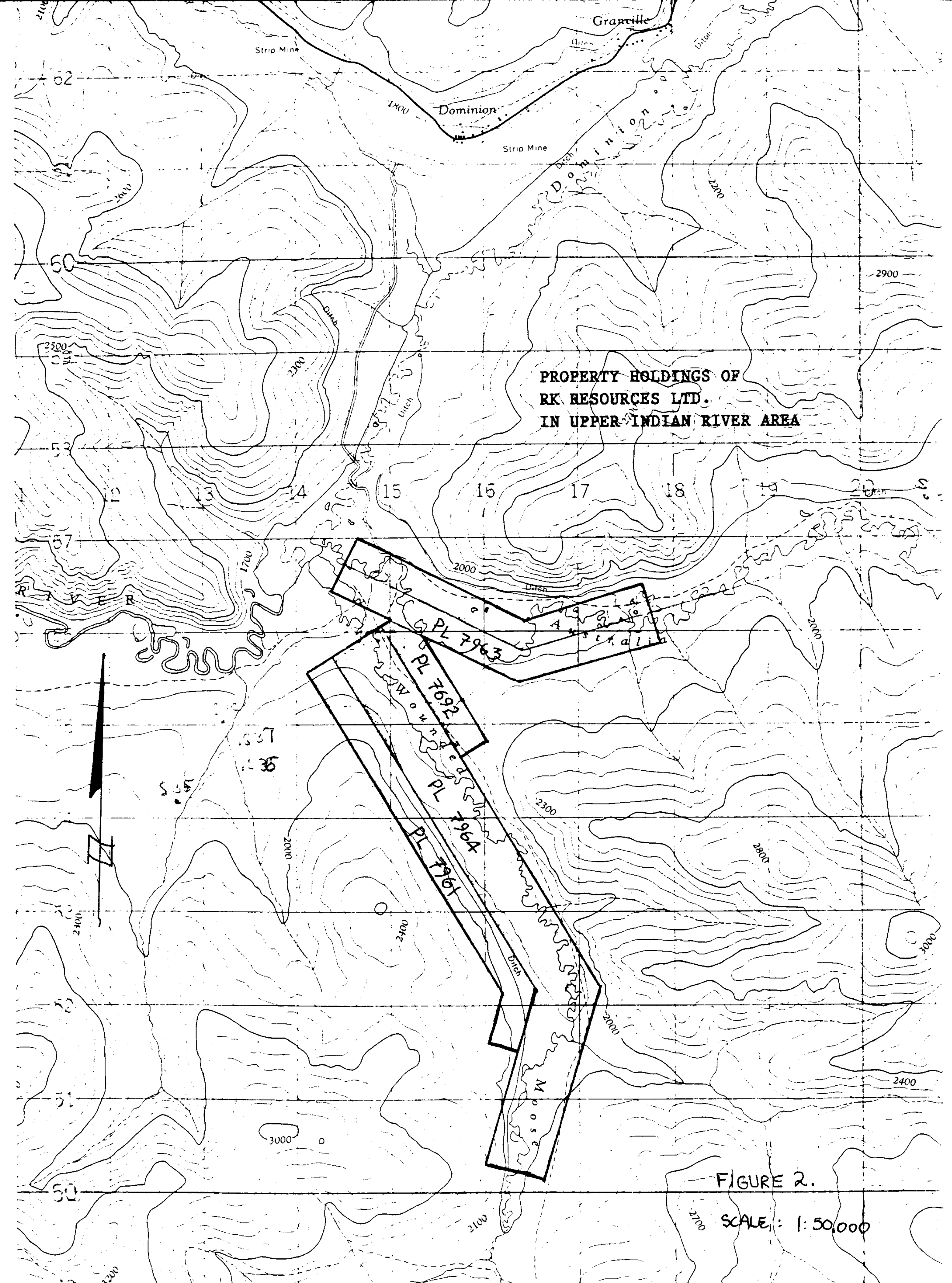


FIGURE 2.

SCALE: 1:50,000

Figure 5. Ground probing radar in operation at the Upper Indian River placer property. Antennas are towed in the sled while the instrument is operated from within the Nodwell.

Figure 3. Plan diagram of GPR survey grid. Filled circles designate recommended first priority drillhole locations; open circles indicate second priority drillhole locations. Scale 1:10,000.

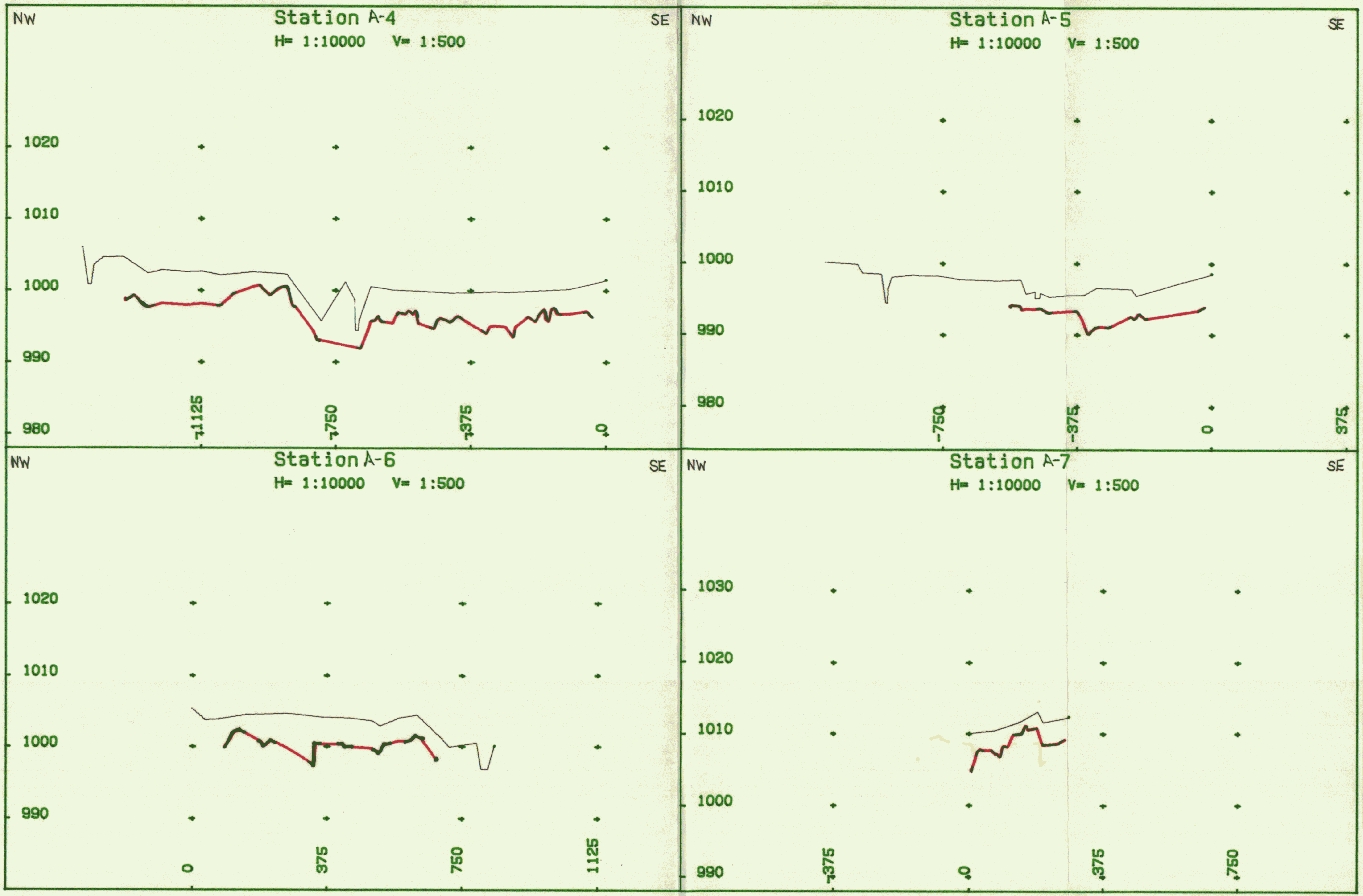


Figure 4. Depth section along lines A-4 through A-7. The topography is shown in black and the bedrock is in red. Where located by GPR, the bedrock reflector is shown in black.

Appendix A. Statement of Qualifications

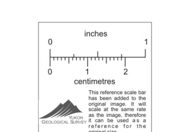
Michael Allan Power received a BSc. with first class honors in Geology in May 1986 and an MSc. in Geophysics in November 1988, both from the University of Alberta. He has worked in the mining exploration industry and in geophysical research since 1984.

Radargram 10
Line A-6
Gain: Shallow 4/10
Centre 7/10
Deep 6/10
Transmit rate: 50 KHz
High pass: 10 Hz
Low pass: 50 Hz

Radargram 11
Line A-7

Gain: Shallow 4/10
Centre 7/10
Deep 6/10
Transmit rate: 50 KHz
High pass: 10 Hz
Low pass: 50 Hz

Radargram 8
Line A-5
Gain: Shallow 4/10
Centre 6/10
Deep 5/10
Transmit rate: 50 KHz
High pass: 10 Hz
Low pass: 50 Hz



120102

Radargram 6
Line A-4

Gain: Shallow 4/10
Centre 6/10
Deep 6/10

Transmit rate: 50 KHz
High pass: 10 Hz
Low pass: 50 Hz