GEOL 4740

SELKIRK PROJECT: GEOLOGICAL AND GEOPHYSICAL BACKGROUND OF THE GOLDEN BOY PROJECT

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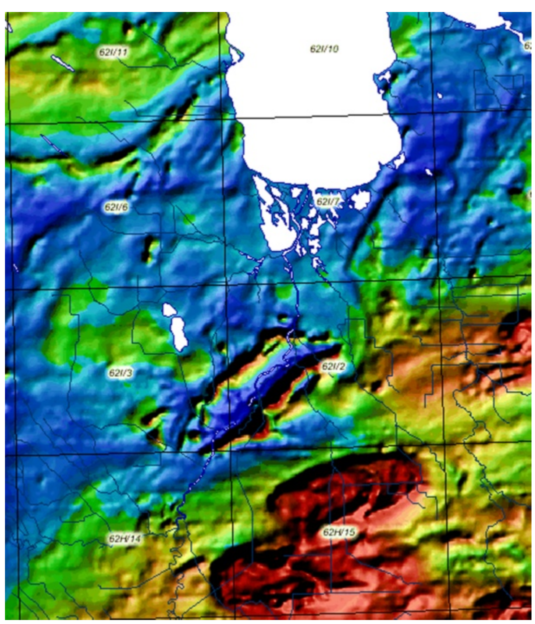

Colour shaded relief magnetic map of Golden Boy anomaly

SELKIRK PROJECT: GEOLOGY AND GEOPHYSICAL BACKGROUND OF THE GOLDEN BOY PROJECT

1. INTRDOUCTION

This document will provide you with familiarization with the geological and geophysical background of the Selkirk Golden Boy Project. The Golden Boy Project is associated with major geophysical anomalies located to the south of Selkirk, Manitoba. The gravity and magnetic anomalies associated with the project are two of the strongest isolated potential field anomalies in southern Manitoba, the gravity anomaly is ~500 GU and the magnetic anomaly is 2,500 nT. The anomaly is interpreted to be caused by mafic rocks and mineralization within an Archean greenstone belt located beneath several hundred metres of Phanerozoic rocks. The prospect has been examined by ProAm Explorations Corporation.

In the Geophysical Field School Selkirk Project you will make gravity and magnetic measurements on the northwestern lobe of the elliptically shaped anomaly. You will also examine a geological core (DDH2 or *98-gb-2*) taken in the area of the measurements. Analysis will involve extensive modelling and inversion of the potential field data collected during the project as well as larger-scale data from elsewhere in the anomaly. An important aim of the work is to provide a geologically-constrained model of the geophysical anomalies.

2. LOCATION

Figure 1 shows the location of the anomaly. The elliptically-shaped anomaly extends is about 24 km long and 12 km wide and runs in a southwest direction from Selkirk, Manitoba. The corresponding Precambrian structure has been referred to as the Selkirk Greenstone Belt (Gowan et al. 2009). Figure 2 shows an aerial image of the study area. The study area extends approximately 6 km along the southeast end of Highway 67. Some surveys may also take place on the roads running parallel to Highway 67 to the southwest and northeast.

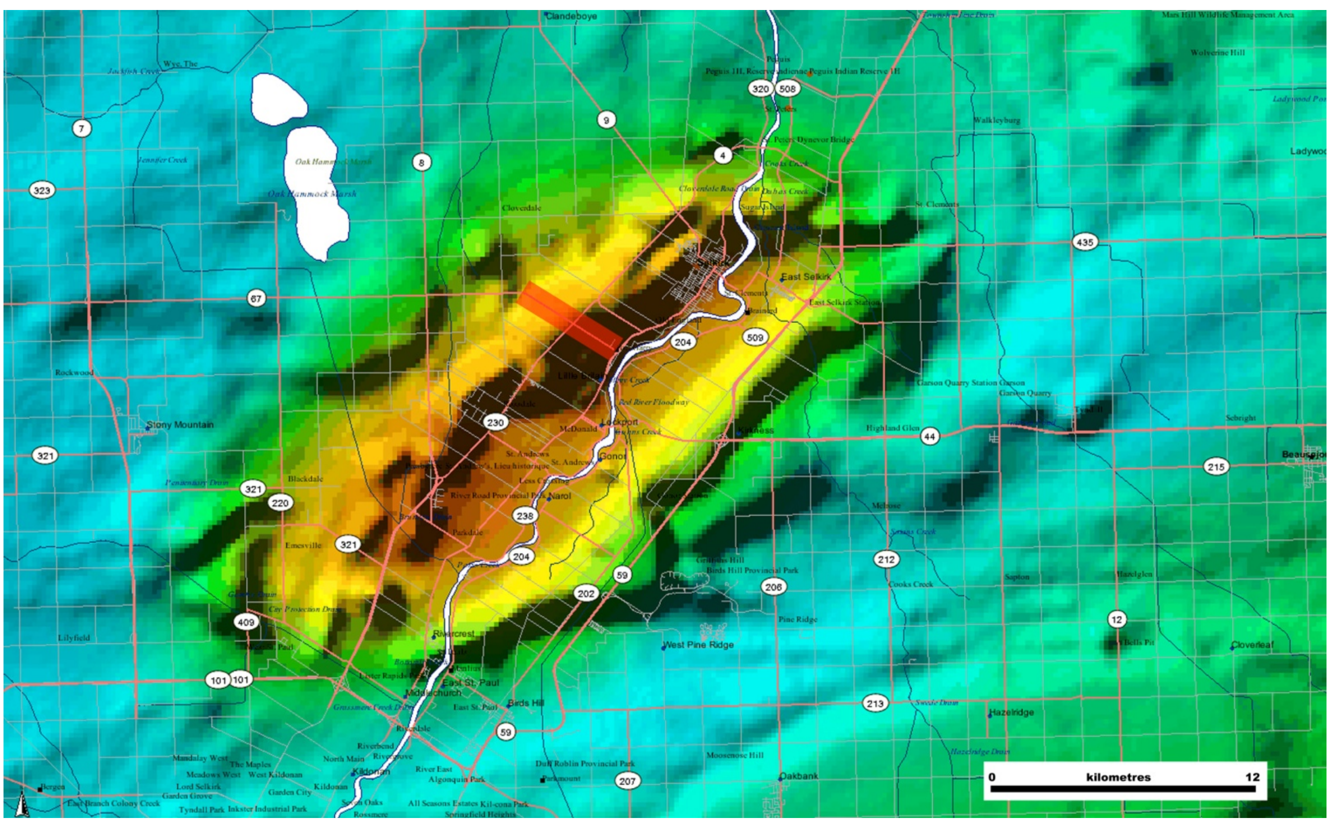

Figure 1. Location of Golden Boy anomaly and field school study area. Map shows colour gravity and shaded relief magnetic responses. Orange box shows the location of the study area which is located about 6 km southwest of Selkirk, Manitoba. Taken from Manitoba Geological Survey GIS Map Gallery.

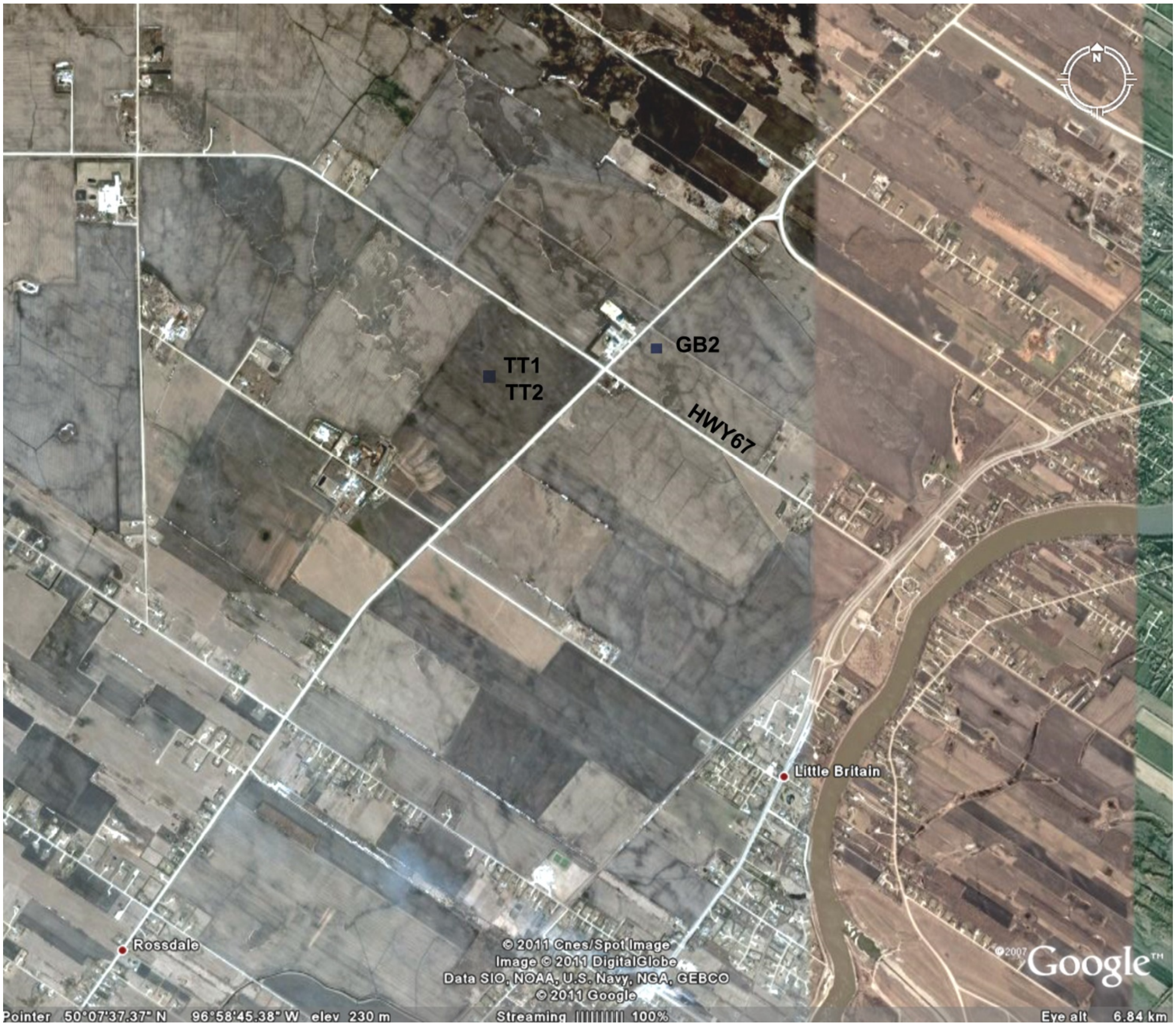

Figure 2. Aerial image of survey area. The survey extends along the straight portion (southeastern end) of Highway 67. Also shows are the location of Golden Boy 2 drill-hole and the Terra test 1 and 2 drill-holes.

3. POTENTIAL FIELD ANOMALIES

3.1 Large-scale response Figure 3 shows the Bouguer gravity anomaly map of Manitoba. The Golden Boy anomaly is clearly visible even at this scale. It forms an elliptically-shaped high. There is a similar anomaly about 50 km farther to the west. Figure 4 shows the magnetic map for Manitoba. The Golden Boy anomaly is clearly visible although the anomaly is not as prominent as the gravity anomaly. It consists of approximately parallel magnetic highs that are coincident with the side of the elliptical-shaped gravity high. There are also magnetic features associated with the gravity high 50 km to the west.

3.2 Anomaly-scale response Figure 5 and 6 show the Golden Boy gravity and aeromagnetic anomalies. The gravity anomaly consists of a ~+500 GU anomaly relative to background values of ~-500 GU. The magnetic anomaly consists of two limbs in which the magnetic field reaches peak values of ~1,000 nT relative to background areas.

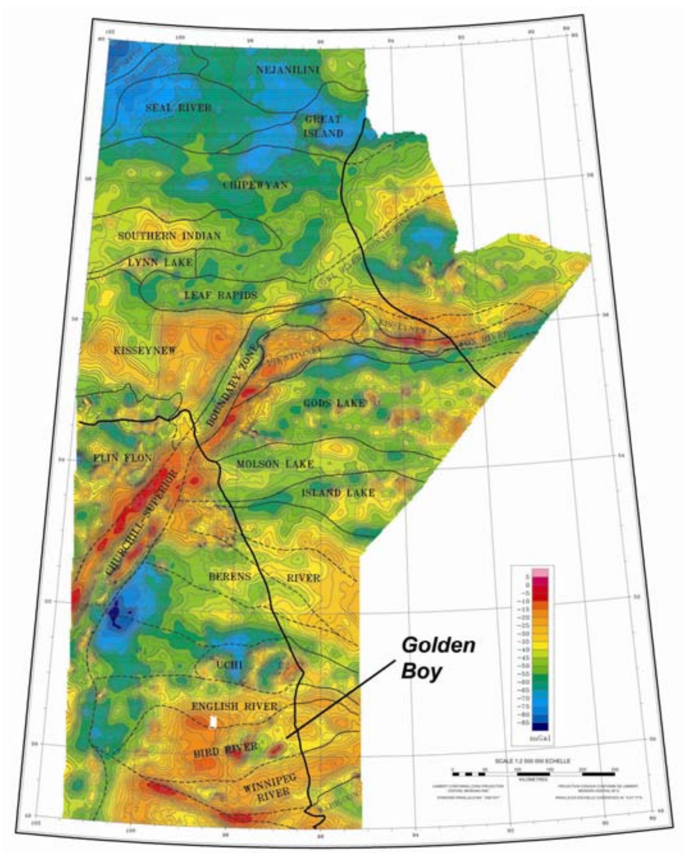

Figure 3. Gravity map of Manitoba showing the Golden Boy gravity anomaly.

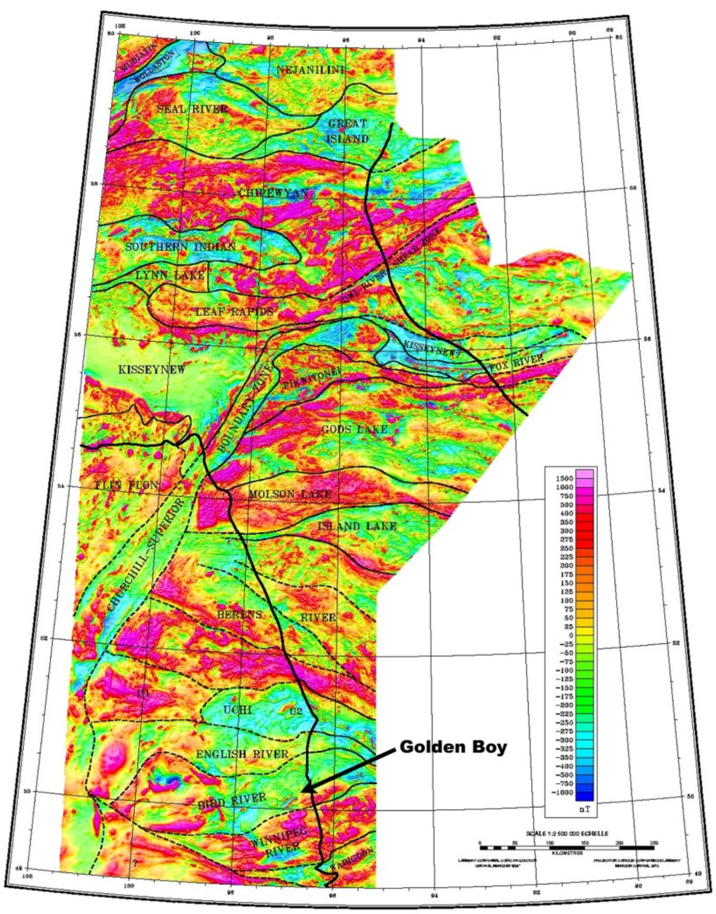

Figure 4. Magnetic map of Manitoba showing the Golden Boy gravity anomaly.

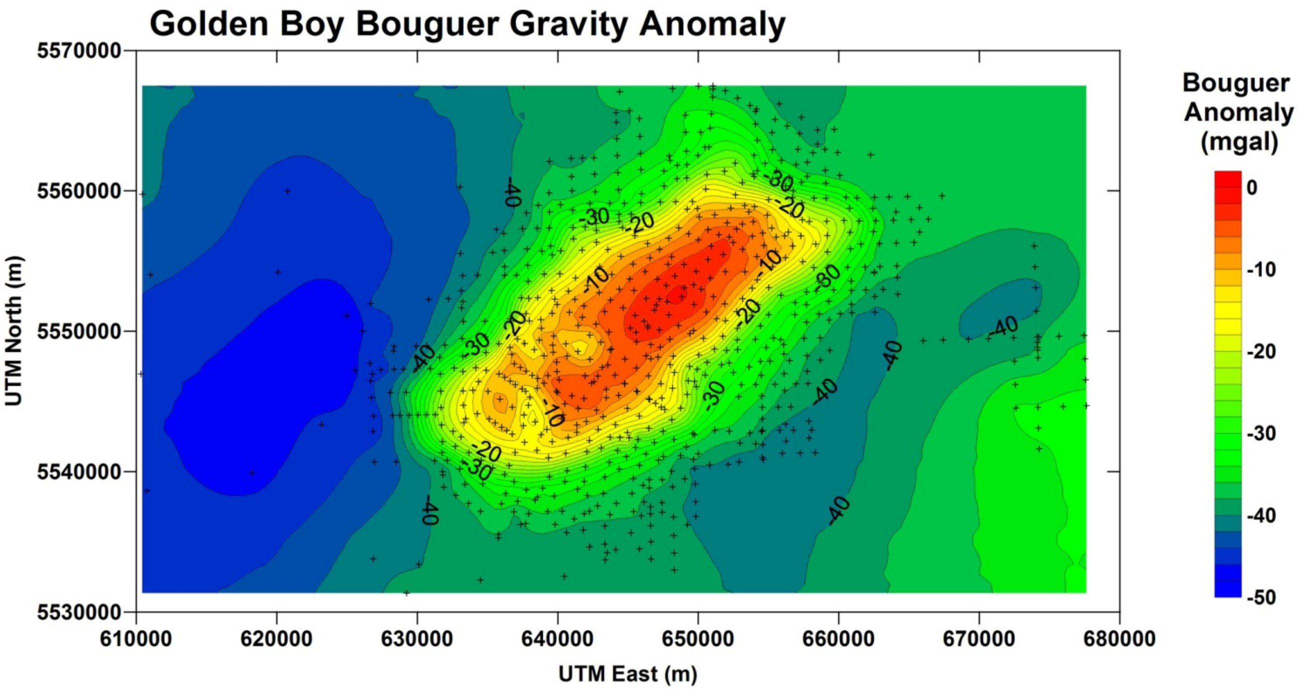

Figure 5. Golden Boy Bouguer gravity anomaly. Crosses show data locations used to produce map. Regional anomaly has not been removed.

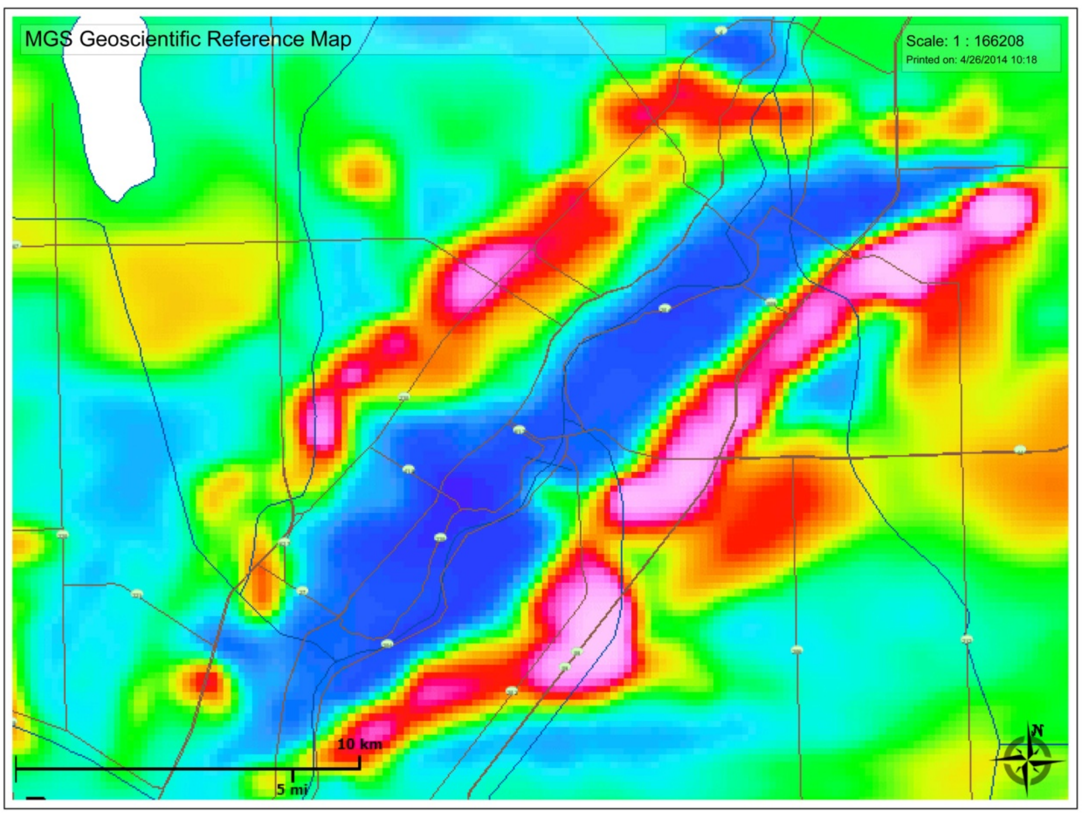

Figure 6. Golden Boy residual total field magnetic anomaly (Manitoba Geological Survey GIS Map gallery, 26th April 2014).

4. GEOLOGICAL SETTING

4.1 Precambrian geological setting The Precambrian rocks in southeastern Manitoba are Archean aged (>2500 million years) rocks of the Superior Province. They have been subdivided into a series of subprovinces based on their geology and physical properties. The four types are: volcano-plutonic belts, which contain greenstone belts; metasedimentary belts dominated by metamorphosed sedimentary rocks; plutonic belts dominated by granitoid rocks; and granulite belts, which are interpreted to represent deeper levels of the other subprovinces (e.g., Card and Ciesielski 1986). The subprovinces are useful for characterizing the properties of the physical rocks including the resistivity. Greenstone belts form relatively narrow (often 10 km or less) elongate zones throughout the Precambrian Shield. The belts contain volcanic and sedimentary rocks that were deposited in shallow ocean environments and are now metamorphosed and deformed. They host important volcanogenic metal deposits.

The subprovinces in the western Superior Province trend in an east-west direction (Figure 3,4). The Golden Boy anomaly is near the southern margin of the Bird River subprovince, a volcano-plutonic belt. The Bird River subprovince is characterized by the presence of greenstone belts containing volcanic rocks, and in some locations, strongly magnetic iron-rich rocks. The Golden Boy anomaly has been interpreted to be associated with a small greenstone belt which has also been called the Selkirk Greenstone Belt (Gowan et al. 2009).

4.2 Paleozoic geological setting In the area of the Golden Boy anomaly, the Archean rocks are overlain by about 180 m of Ordovician sedimentary rocks (Figure 7). The site lies in the easternmost part of the Williston Basin, a sub-basin of the Western Canada Sedimentary Basin. The Ordovician rocks include a basal unit consisting of ~30 m thick section of the Winnipeg Formation. This formation consists of basal quartzose sandstone and overlying shale. The Winnipeg Formation is overlain by a ~150 m section of the Red River Formation. This formation consists of mottled dolomitic limestone and shale.

The sedimentary rocks contain important aquifers (e.g., Render 1970). The Upper Carbonate aquifer occurs in the top 15 m to 30 m of the Red River Formation in the Winnipeg area (Figure 8). A minor aquifer called the Lower Carbonate Aquifer occurs in the lower part of the Red River Formation. The Winnipeg Formation contains a 6 to 12 m thick Upper Sandstone Aquifer and a 3 m thick Lower Sandstone Aquifer.

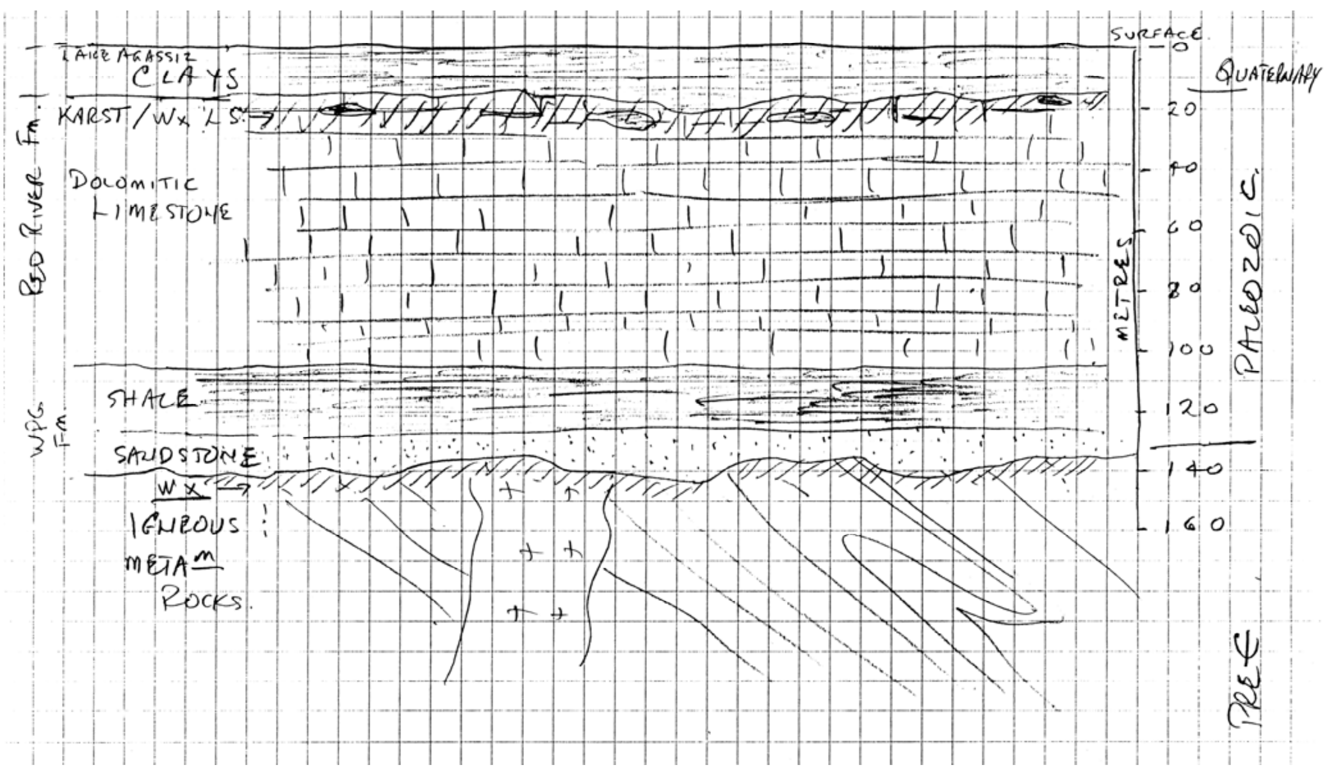

Figure 7. Sketch by W.C. Brisbin of the geological cross-section in the vicinity of the Golden Boy anomaly.

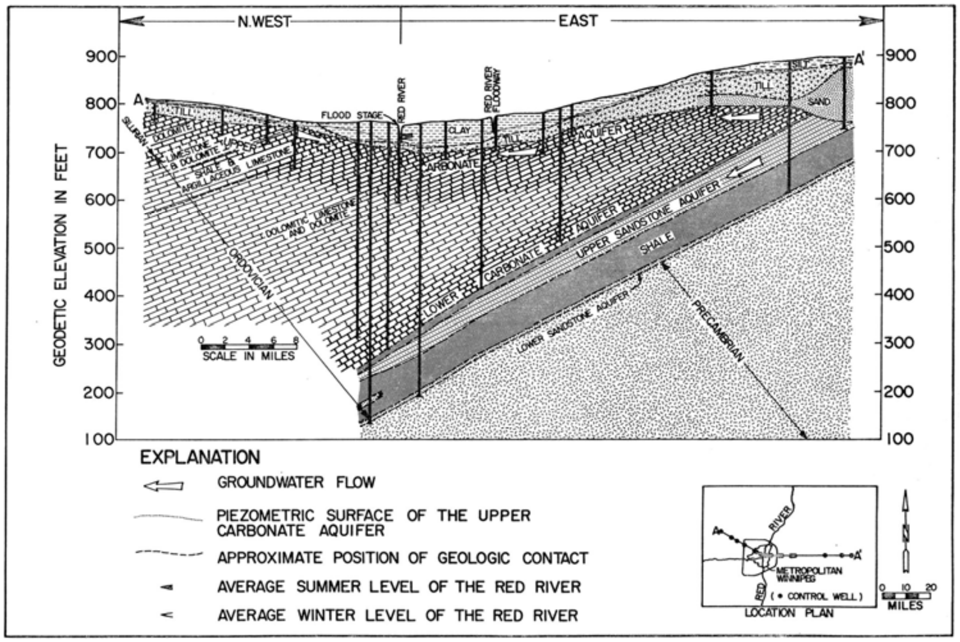

Figure 8. Geological cross-section of the Winnipeg region (Baracos & Render 1984).

3.3 Quaternary geological setting Figure 9 shows the surficial geology in the Winnipeg area. The area is dominated by clay-rich offshore glaciolacustrine deposits (with thickness varying from 1 to 20 m thick). In the Winnipeg area these deposits overlie a basal till units that is typically 2 to 4 m thick. The clay units are overlain by a layer of interbedded silt and silty clay that is typically 0.5 to 4.5 m thick.

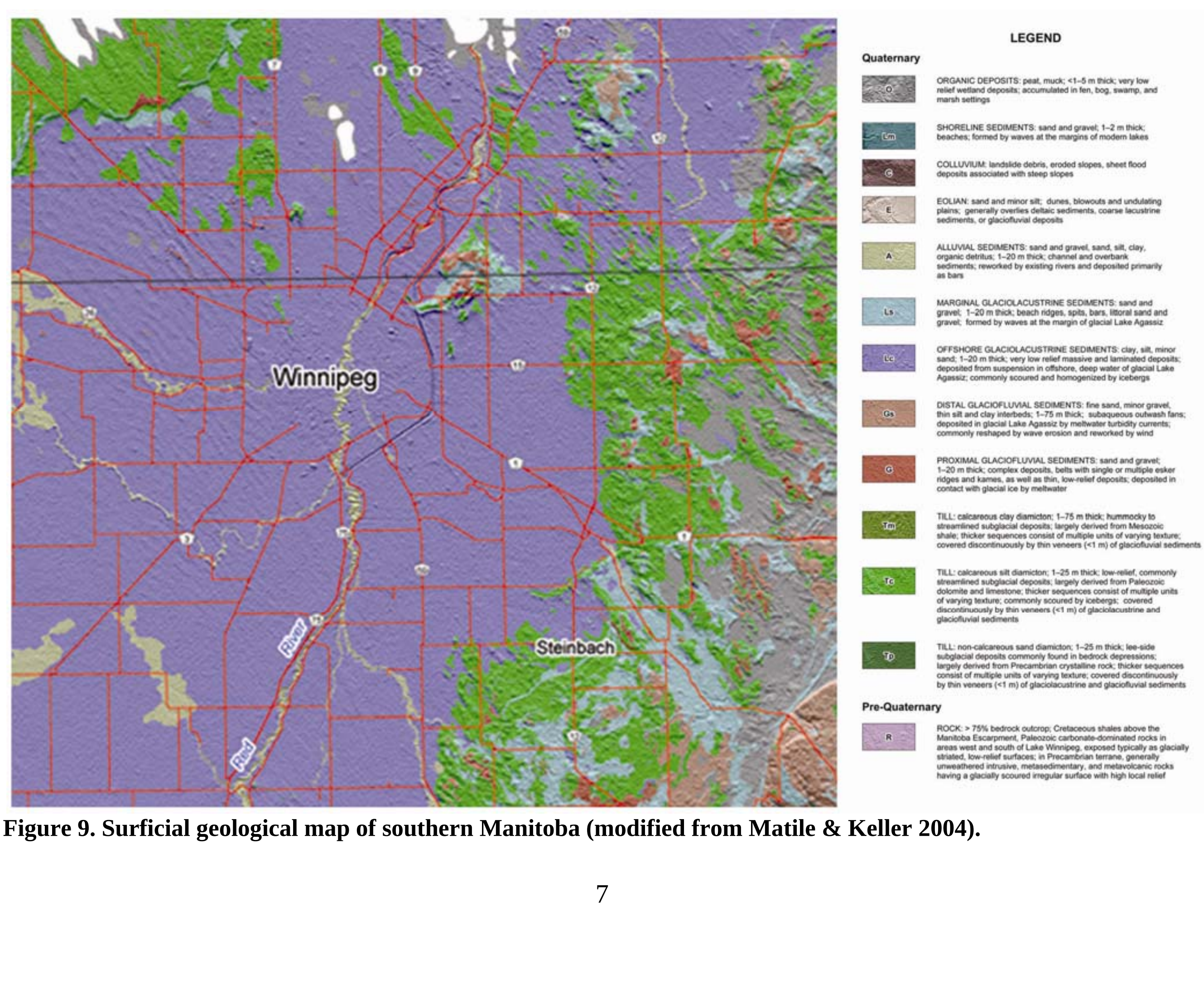

Figure 9. Surficial geological map of southern Manitoba (modified from Matile & Keller 2004).

4. EXPLORATION ACTIVITY

This information is taken in part verbatim from Emujakporue (2011)

In the 1950s, a magnetic survey in the Selkirk region showed significant anomalies, which were interpreted to be Precambrian (Russell, 1959; Hood, 1998). In 1958 two mineral exploration drill holes were completed into the Precambrian strata. The Terratest #1 and Terratest #3 holes shared a collar location near the Geophysical Field School survey location (Figure 2). The holes intersected gabbro, mafic volcanic rocks and interflow sediments and iron formation (Figure 10).

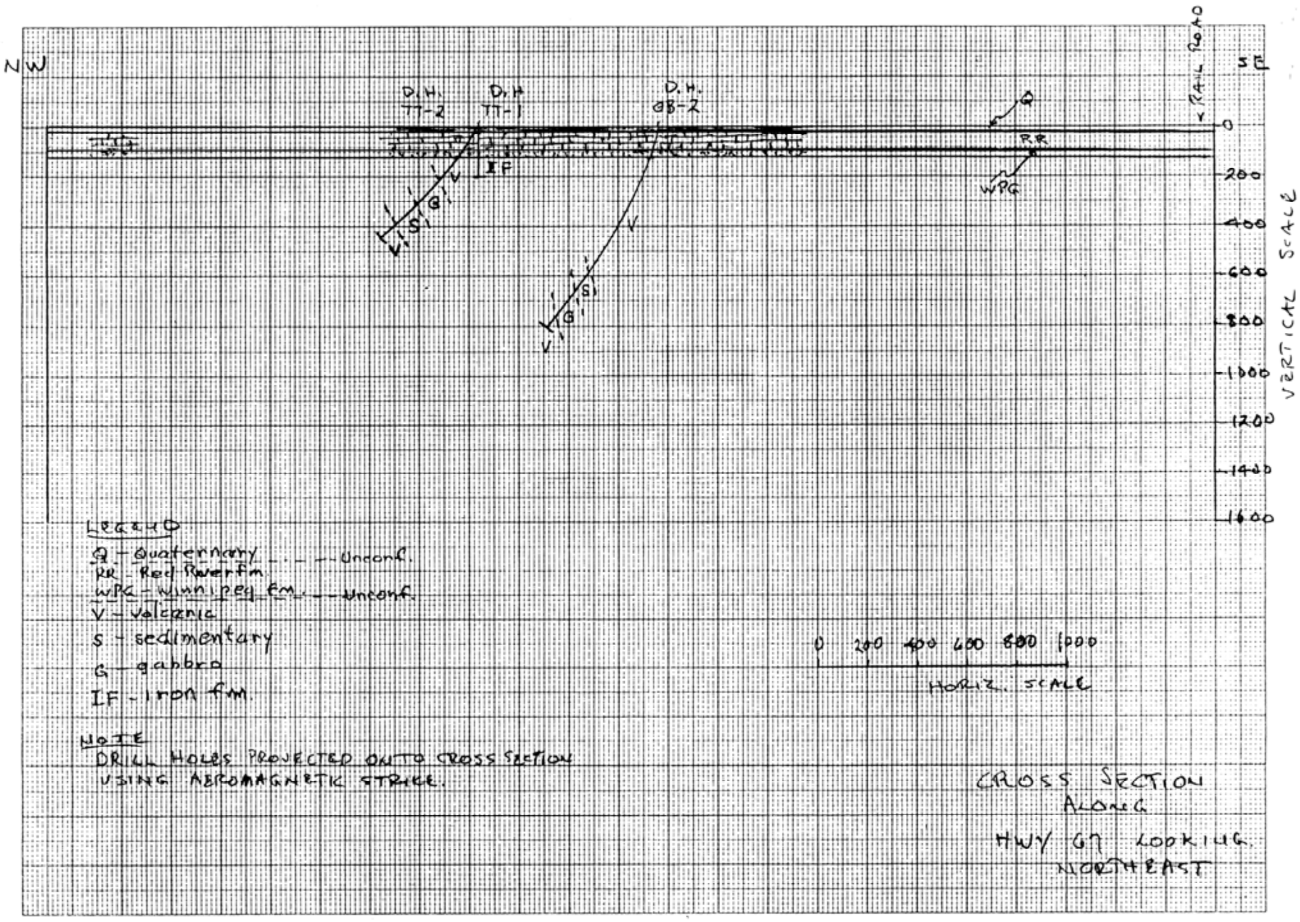

Figure 10. Sketch by W.C. Brisbin of the drill-hole intersections in the vicinity of the Geophysics Field School survey.

Several holes have been drilled into the structure to the east of the Red River. In 1960, about one kilometre east of the intersection of Provincial Highway 59 and Colville Road (P.R. 212), a vertical drill hole to a depth of 449.5 m was completed by R. Schaller, intersecting iron formation and gabbro within Precambrian rocks below 102.1 m (Schaller, 1960; Hood, 1998). In 1997, Manitoba Department of Energy and Mines completed two drill holes, intersecting iron formation and sediments within Precambrian rocks at depth of about 98.5 to 112.7 m (Bezys and Bamburak, 1997; Hood, 1998).

During the mid 1990's Red River Powder & Supply Co. Ltd. (RRPS) reviewed old records and core and examined more recent gravity and magnetic data. They interpreted the responses in terms of a Sudbury type intrusion with the potential for Ni-Cu (PGE) sulphides. In 1996, RRPS made an application for all crown land in the area and optioned the property to ProAm Exploration Corporation who completed surface gravity and a new aeromagnetic survey. The results of the airborne magnetic survey showed significant anomalies, and therefore allowed for a preliminary interpretation of the lithologies of the region (Hood, 1997, 1998). In order to test the hypothesis that the anomaly in the region has potential for nickel and other metals, and to locate the contact of a gabbro-pyroxenite intrusion that had been intersected in the 1960 drill hole program, ProAm completed two drill holes to test these anomalies (Figure 11): DDH1 had a total depth of 480.79 m, entering the Precambrian rocks at 170.11 m, and DDH2 had a total depth of 940.31 m, entering the Precambrian rocks at 154.68 m (Hood, 1998). DDH2 is also located near the Geophysical Field School survey area (Figure 2).

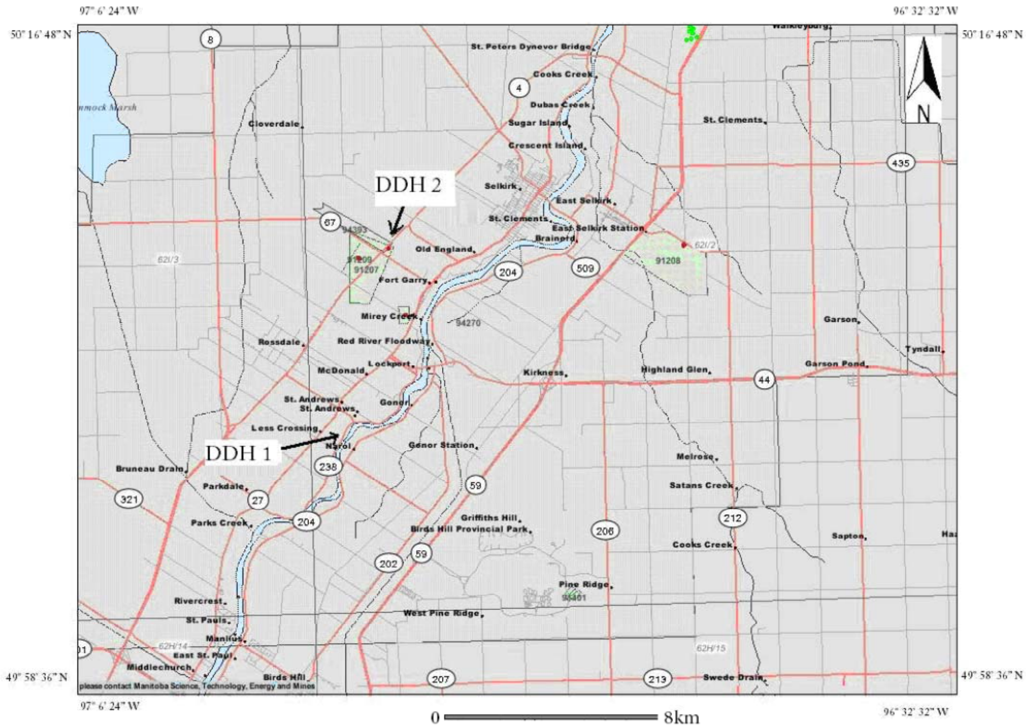

Figure 11. Location of ProAm drill-holes (Emujakporue 2011).

The DDH1 and DDH2 drill holes generally intersected mainly basalt, and some porphyritic andesite and dacite dykes (Hood, 1998). Table 1 presents core descriptions from ProAm DDH2 and Figure 10 illustrates the results. Sections beneath the Precambrian unconformity in DDH2 were mainly massive and pillowed flow basalt, including some interflow sediment/iron formation and rare felsic dikes (Hood, 1998). The basaltic flow contains quartz-carbonate veins, mineralized with pyrrhotite, magnetite, pyrite and chalcopyrite (Hood, 1998). A vein at 574.9-577.7 m contained over 50 % pyrrhotite and a 0.8 m sample of this vein returned 0.73% Cu. From 663.58 to 751.64 m, greywacke sediments flanked top and bottom by iron formation was intersected, and the greywacke unit consists of poorly bedded wacke and pelite; the iron formation was found to be anomalous in zinc, grading up to 375 ppm Zn (Hood, 1998). Above the greywacke, between 751.64 m and 798.14 m, is pillowed and massive basalt flows capped by a unit of iron formation and cherty siltstone, within this unit, zinc values graded up to 495 ppm (Hood, 1998). The bottom of the drill hole between 798.14 m and 940.30 m consist of gabbro which is likely to be synvolcanic (Hood, 1998). The combination of extensive hydrothermal veining, alteration within the underlying volcanic rocks and anomalous zinc suggests the potential for volcanogenic massive sulphide mineralization within the 663.58 to751.64 m and 751.64 m to 798.14 sections (Hood, 1998).

DDH2 confirmed that the magnetic anomaly in the area is due to a combination of magnetite and pyrrhotite occurring in hydrothermal vein systems and in interflow sediment horizons within sections of mafic volcanic rocks and greywacke (Hood, 1998). The combined results from the multiple drill-holes also allows for an interpretation of the larger scale structures in the Precambrian (Figure 12). The results indicate a subaqueous environment for extrusion of the lavas with the clastic sedimentary rocks indicating distal conditions (away from the continental margin). The volcanic and sedimentary rocks show signs of hydraulic fracturing, hydrothermal activity, carbonate alteration and movement of metallic oxides and sulphides indicating possible environments for volcanic massive sulphide (VMS) deposits. The results suggest some folding and overturning of the stratigraphy to produce repeated geophysical anomalies.

Table 1. Description of core from DDH2 (Emujakporue 2011 based on Hood 1998)

Formation	Rock Type	Depth (m)	General Description
Overburden	Top soil, clay, glacial till	0.00-17.98	-
Red River Formation	Dolomite/dolomitic limestone	17.98-121.31	Varies from beige to yellowish brown to grey dolomite and dolomitic limestone; frequent coral fragments, minor white devitrified chert nodule fragments, rare quartz fragments throughout; rare to minor pyrite, euhedral crystals and irregular fragments throughout
Winnipeg Formation	Shale	121.31-148.20	Very fine-grained, commonly fine-laminated bedding; varies from brownish-grey to greenish-grey to dark grey; soft, fossile, minor black shell fragments up to 5 mm, shell fragments are generally less than 1 mm thick and are occasionally curved and have growth lines; minor sandstone interbeds
	Sandstone	148.20-154.68	White to beige to brown, poorly layered with local brown irregular shaley partings roughly defining bedding orientation; fine-grained rounded quartz grains; poor; cemented with carbonate cement
Precambrian unconformity			
Bird River greenstone belt	Weathered/ altered basalt	154.68-159.95	Highly altered (probably weathered) basalt; generally dark grey to black greenish-black, fine-grained, brecciated texture with frequent irregular quartz-carbonate veinlet patches and black alteration enhanced along fracture planes; commonly serpentinitic along shears and fracture planes; local rounded concentric black rings from progressive alteration of breccia fragments; minor narrow shears
	Basalt, pillow flows	159.95-313.40	Fine-grained, grey, massive to locally sheared; frequent irregular quartz carbonate veinlets and patches often flanked by bleached light green-grey chlorite zones; frequent patches/zones of light grey vesicle fillings

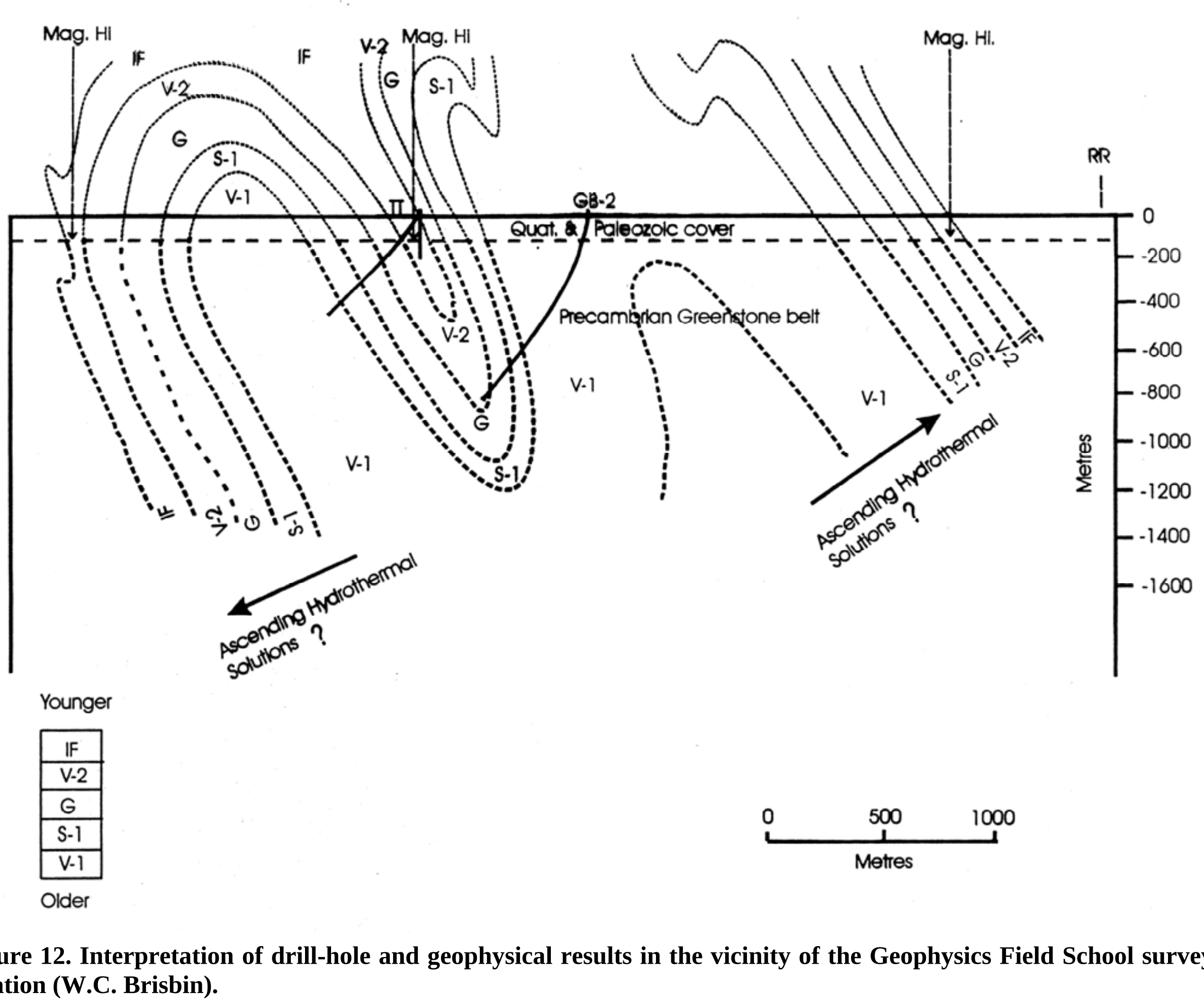

Figure 12. Interpretation of drill-hole and geophysical results in the vicinity of the Geophysics Field School survey location (W.C. Brisbin).

5. ADDITIONAL GEOPHYSICS

Table 2 lists magnetic susceptibility measurements made on the DDH1 and DDH2 cores. Additional measurements have been made on the DDH2 core during various Geophysical Field School projects. Table 3 shows specific gravity values measured on samples from DDH1.

Table 2. Magnetic susceptibility of geological units in DDH1 and DDH2 drill-holes (Emujakporue 2011 based on Hood 1998)

Drill core 1			Drill core 2		
Lithology	**Depth (m)**	**Corrected reading (SI)**	**Lithology**	**Depth (m)**	**Corrected reading (SI)**
Winnipeg Formation			**Winnipeg Formation**		
Shale	144.0	0.02	Shale	137.70	0.13
Shale	161.0	0.15	Shale	145.20	0.24
Sandstone	163.5	0.02	Sandstone	151.60	0.02
Precambrian			**Precambrian**		
Altered basalt	174.5	0.65	Altered basalt	156.50	0.83
Basalt	196.0	1.27	Basalt (PF)	196.00	1.79
Basalt	241.0	1.10	Basalt (PF)	251.00	1.37
Andesite dike	281.5	0.52	Basalt (PF)	300.00	1.44
Basalt	341.0	1.16	Basalt (MF)	330.00	1.68
Basalt	416.0	1.06	Dacite dike	345.00	0.14
Basalt	468.0	1.08	Basalt (MF)	376.00	1.71
			Basalt (PF)	423.00	2.45
			Basalt (MF)	451.00	1.98

Note: (MF) = Massive Flow
(PF) = Pillowed Flow

Magnetic susceptibility readings continued to 940.31 m for drill core 2 in original reference.

Note. Final values are in units of SI x 10^3.

Table 3. Density values for of geological units in DDH1 and DDH2 dril-holes (Hood 1998)

GB 97/98-1: SPECIFIC GRAVITIES

Calculated from dry and submersed weights of core samples ranging from 363.8g to 622.7g on a Mettler Toledo PB1501 balance.

Sample (meters)	Lithology	Specific Gravity (g/cc)
173.9	Altered Basalt	2.04
178.3	Partly Altered Basalt	2.49
209.4	Basalt	3.03
250.2	Basalt	3.01
282.1	Porphyritic Andesite	2.88
326.8	Basalt	3.04
392.2	Basalt	3.05
435.3	Basalt	3.05
477.3	Basalt	2.94

Electromagnetic surveys of the Golden Boy potential field anomalies have also been conducted. Woods (1998) as reported in Hood (1998) describes a borehole transient electromagnetic (TEM) survey in GB-97-1, east of the Red River conducted for ProAm Exploration Corporation. The survey used a Crone borehole Pulse Electromagnetic system. The responses were dominated by a very large near-surface response interpreted to be associated with the brine saturated aquifers in the Winnipeg Formation.

Lafortune and Langridge (1998) as reported in Hood (1998) describe a UTEM survey conducted by Lamontage Geophysics for ProAm Exploration Corporation. The survey used two transmitter loops, one in the Floodway adjacent to Birds Hill provincial park and one in Jehle's farm. This loop was centred on the location of ProAm DDH2 (Figure 2). One profile of data collected with this loop (1512 N) showed a cross-over in the response at ~5150 W (Figure 2). This cross-over had a broad flat appearance typical of a steeply-dipping deeper conductor. However, an analysis of this same feature by D. Woods using a CRONE pulse EM system suggested that the source was located at a depth of less than 80 m.

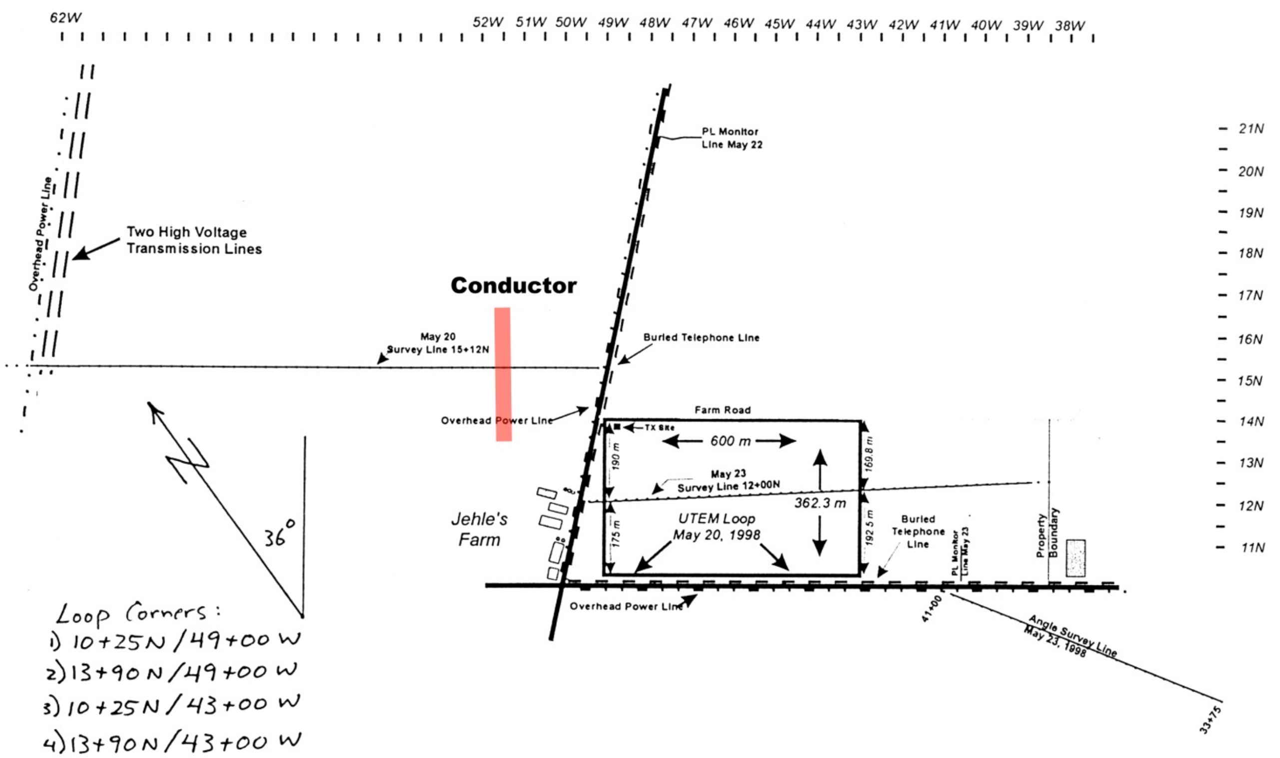

Figure 13. Location of UTEm transmitter loop for Jehle's farm profile (from D. Woods .

The University of Manitoba Geophysics Field School has been collecting magnetic and gravity data over the Golden Boy anomaly for a number of years. In 2011, Ogagaoghene Emujakporue completed a University of Manitoba GEOL 4920 technical report involving collection and modelling of ground magnetic data from the eastern limb of the anomaly.

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