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Visible Gold Content and Lithology of Till from Overburden Drillholes, Beardmore-Geraldton Area, District of Thunder Bay, Northern Ontario

by

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Abstract

A Canada-Ontario Mineral Development Agreement program of glacial geological research is presently underway in the Beardmore-Geraldton area of northern Ontario. This study is meant to test the usefulness of and provide guidelines for till sampling as a mineral exploration method. Elsewhere, it has been shown that analysis of the geochemistry, mineralogy and visible gold content of till samples can lead to the recognition of mineralized bedrock which acted as the source of glacially dispersed debris.

In the vicinity of and northeast of Beardmore, samples from the uppermost metre of thin, discontinuous till contain numerous fine gold grains. This is a preliminary indication that surface till sampling is likely to be an efffective exploration tool in this area.

In the Wildgoose Lake-Geraldton area, however, thick till contains abundant Paleozoic limestone and Proterozoic metasediments, derived from the Hudson Bay Lowland 150 km to the northeast, which dilute and/or bury locally derived debris. In order to determine the stratigraphy and composition of this thick till fourteen rotasonic overburden boreholes were drilled by the Geological Survey of Canada, in cooperation with the Ontario Geological Survey, during September, 1987.

The first analytical results of this drilling program, visible gold grain counts, are presented here. More detailed geochemical,lithological and mineralogical data will be presented in future publications. Included will be analysis for gold which may reside in a fraction which would be overlooked in visible gold analysis, such as gold in sulphides or extremely fine grained gold. Other elements, which may serve as indicators of gold mineralization, are also being studied.

The Paleozoic carbonate (limestone) rich upper till which is present throughout the area and which is responsible for the great till thicknesses encountered in the study contains isolated single gold grains which are probably unrelated to local mineralization.

Low gold grain counts, accompanied by very abundant sulphides, were obtained from the lower till in two holes located in Colter Township, between Turkey and Scroll Lakes.

A high gold grain count and numerous sulphides were obtained in a lower till unit at a site located in central Lindsley Township. This hole was located on Highway 11 at a pipeline access road 0.3 km east of the Wildgoose Beach road. Neither the distance nor the direction of glacial dispersal for this till unit is known. Ice flow indicators such as striations and drumlins imply southwestward or south-southwestward dispersal. The possibility that this till is associated with an older west-southwestward ice flow should not, however, be discounted.

Introduction

The Canada- Ontario Mineral Development Agreement is a subsidiary agreement to the Economic and Regional Development Agreement signed by the governments of Ontario and Canada in November of 1984. The Beardmore-Geraldton area is one of several areas in which geological surveys meant to stimulate further growth in Ontario's mining industry have been initiated. Past gold production from this belt has been concentrated in areas of abundant outcrop. Excellent potential for further discoveries exists where glacial overburden conceals the rock. Increased recognition of the usefulness of till sampling as an exploration tool in such areas (Shilts,1984; DiLabio and Coker, 1987) has necessitated the acquisition of a more thorough knowledge of these sediments. This glacial geological research program in the Beardmore-Geraldton area (Figure 1) is a joint effort of the Geological Survey of Canada and the Ontario Geological Survey. The program is meant to address the stratigraphy, sedimentology, composition and source of glacial sediments, particularly till, in the vicinity of known and potential gold mineralization.

Precambrian Geology

The Precambrian geology and gold mineralization of the Beardmore-Geraldton area have recently been described by Mason and McConnell (1983) and Mason and White (1986). The Wabigoon Subprovince is subdivided in this area into two greenstone belts, the Onaman-Tashota Belt in the northwestern portion of the study area and the Beardmore-Geraldton Belt which parallels and flanks the highway linking the communities of Beardmore, Jellicoe, Geraldton and Longlac (Figure 1). The Onaman-Tashota Belt consists predominantly of intermediate to felsic volcanics intruded by felsic plutonic bodies. The Beardmore-Geraldton Belt is a predominantly metasedimentary sequence intercalated with mafic to intermediate metavolcanic rocks. Late Precambrian diabase dykes and, in the western portion of the study area, large tabular sills intrude the older rocks. Nineteen past-producing mines in the area yielded over four million ounces of gold and 300,000 ounces of silver (Mason and White, 1986). Copper, nickel, zinc, lead, molybdenum, tungsten and iron mineralization are also present (Pye et al., 1966).

Quaternary Geology

Prior to the present study, the Quaternary geology of the Beardmore-Geraldton area was examined by Zoltai (1965, 1967) and Sado (1975).

The bedrock surface in the area is, with the exception of the central portion of the study area, generally well exposed and displays abundant streamlined roches moutonees and whaleback forms. These features parallel the youngest set of striations, a radiating pattern ranging from about 250 degrees at Beardmore, 230 degrees at Geraldton, to 210 degrees at Longlac. Rare occurrences of preserved older striations indicate a former ice

flow direction of 210 degrees at Beardmore and 190 degrees at Geraldton (Kristjansson and Thorleifson, 1987). Veillette (1986) has reviewed evidence for an older west-southwestward ice flow which also may have influenced the Beardmore-Geraldton area.

Till forms an extensive to, in the central portion of the study area, continuous sheet which constitutes the most common surficial unit in the area. The most distinctive feature of this deposit is the abundance, particularly in areas of thick till, of granule and pebble-sized clasts of Paleozoic carbonates and Proterozoic clastic and chemical sediments derived from the Hudson Bay Lowland 150 km to the northeast. This far-travelled material has undergone surprisingly little dilution by more locally derived debris. This is attributed to a zone of vigorous ice flow emanating from Paleozoic terrane, to the high erodibility of Paleozoic carbonates combined with the low erodibility of Archean granites occurring between the greenstone belt and the Paleozoics, as well as to the short distance over which glacial ice flowed over greenstones prior to the deposition of till in the study area. Thin till in the area around and northeast of Beardmore as well as a relatively thin second till unit at the base of several drill holes lacks Paleozoic carbonate but is rich in angular Archean rock fragments of presumed nearby derivation. The drumlinized surface of the till, its massive and compact structure and the ubiquitous presence of faceted and striated clasts, including pavements, indicate that this deposit is a lodgement till deposited by actively sliding ice.

Numerous well developed eskers constitute belts of thick sand and gravel crossing the area. Extensive glaciolacustrine deposits obscuring underlying till and bedrock occur only as sand in low areas near Lake Nipigon in the western portion of the study area.

Field and analytical methods

The surficial geology of the southernmost three-quarters of the area depicted in Figure 1 was mapped in detail over the summers of 1986 and 1987.

Till samples have been collected in shallow excavations dug by hand as well as with the use of a backhoe. An area of thick and continuous till in the Wildgoose Lake area, between Jellicoe and Geraldton, was sampled during September 1987 using a rotasonic overburden drill. Although smaller samples were taken during the earliest phase of fieldwork, a standardized procedure in which a till sample of approximately 14 kg is collected has been established. Four subsamples are taken for: 1) analysis of fine grained sediment geochemistry, 2)grain size and matrix carbonate content, 3) supplementary analyses, and 4) an archive subsample. Samples are presently being prepared and analysed for precious metal and trace element geochemistry of the less than 63 micron (-230 mesh) silt plus clay fraction as well as trace element geochemistry only on the less than 2 micron clay fraction. The remaining sample of at least 10 kg has been

processed for lithologic analysis of the gravel fraction, the separation for mineralogic and geochemical analysis of the non-magnetic and magnetic heavy mineral concentrate with a specific gravity of greater than 3.3, as well as the identification and description of visible gold grains obtained on a shaker table and by panning. Chemical analysis and examination of the mineralogy of the heavy mineral concentrate has also been initiated.

The shape and surface morphology of the gold grains may be indicative of distance of transport by glacial processes (Averill and Zimmerman, 1986). Grains were assigned to one of three categories:

1. Grains classified as delicate are characterized by primary crystal faces, pitted leaf surfaces and intact ragged leaf edges.
2. Irregularly shaped gold grains are pitted, with the grains either retaining their gross primary shape or having become curled.
3. Abraded gold grains are considered primary leaves reduced to smaller flakes with polished surfaces.

Averill and Zimmerman (1986) found that if most of the grains in an anomalous sample conform to one class , hence discounting some exceptions, transport distances of less than than 100 m, 100 to 1000 m, and more than 1 km can be inferred for delicate, irregular and abraded gold grains, respectively.

Visible gold content of surface till samples

The occurrence of visible gold grains in till samples collected in the study area from the C horizon of soil profiles at a depth of 0.6 to 1.0 m has been reported by Thorleifson and Kristjansson (1987) and is summarized in Figure 1. Background values of one and two grains occur sporadically throughout the study area, including sites north of the mineralized belt. A lack of visible gold grains in till samples collected in the southeastern portion of the study area, down-ice flow from known gold mineralization in the Geraldton area may be related to the greater thickness of till in this area. While the upper metre of till generally lacks visible gold, lower portions of a compositionally stratified sequence may better reflect nearby mineralization. A stratification of this nature could have been produced by the gradual elimination of local debris sources as subglacial bedrock highs were buried by the accreting till. Alternatively, a completely homogenized till could yield negligible indications of local mineralization due to excessive dilution by far-travelled debris. Similar carbonate-rich till considered a hindrance to mineral exploration was reported by Karrow and Geddes (1987) and Hicock (1987) for the Hemlo area.

In contrast, visible gold grains in near-surface till samples occur frequently in the western and northwestern portions of the study area. Till is thinner and and bedrock outcrops are much more frequent in this area. Glacial ice flow would in this case have had a much greater opportunity to disperse locally

derived material into till now exposed at the surface. The lesser quantity of far-travelled debris in this area results in some combination of less burial of locally-derived till along with a lesser degree of dilution. This area was also judged to be favourable for surface till sampling by Closs and Sado (1981).

Stratigraphy in areas of thick till

In order to investigate the nature of the thick till sheet occurring between Jellicoe and Geraldton, 14 boreholes, labelled A to N in Figures 1 and 2, were drilled in September, 1987. Thick, massive and compact silty till, rich in Paleozoic granules and pebbles, was encountered in all but one hole (Figure 3). At five of these sites, a distinctly separate till unit of variable texture but with few Paleozoics and a high concentration of presumably locally derived angular Archean debris was encountered at the base of the sequence. These occurrences of a second till may or may not all be correlative. Furthermore, the composition of this till may be a reflection of a shorter distance of transport by the same ice flow which deposited the overlying till, or it may have been the product of an earlier, perhaps substantially different, ice flow direction. Elsewhere, Paleozoic carbonate-rich till extends to bedrock. At four sites, the uppermost sediments consist of graded diamictons, interpreted to have been deposited as sediment flows in a proglacial environment, interbedded with sand and gravel.

Visible gold content and lithology of subsurface till samples

Data regarding the visible gold content, gravel fraction lithology and colour of subsurface samples are presented in Table 1. Descriptions of bedrock intersected over one to two metres at the base of each hole are presented in Appendix 1.

Estimates of the lithology of the +10 mesh (1.7mm) gravel fraction of the till samples are visual approximations.

The thick upper till contains abundant Paleozoic carbonates (limestone) derived from the Hudson Bay Lowland. Occasional spikes of high granitic content in this till imply incorporation from granitic rocks whose contact with greenstones is located 10 km north of the drillsites. The sedimentary and volcanic fraction of carbonate-rich till is likely to be dominated by Proterozoic clastic and chemical sediments derived from the Hudson Bay Lowland.

The lower till is dominated by angular metasedimentary and metavolcanic rocks of presumed local derivation. Abundant sulphides were obtained from this till in holes D, E and I.

The colour of till and other diamictons is brownish (2.5Y) down to a depth of about 4 to 6 m. From this depth to bedrock, till colour is greyish, usually slightly yellowish (5.0Y) or neutral (N).

The carbonate-rich upper till contains isolated single gold grains ranging in size from 25 to 200 microns (1000 microns=1mm). Fifteen occurences of such grains were in every case classified as abraded. The source of these grains is unknown, but it is unlikely that they are related to local mineralization .

The uppermost samples in holes C an J yielded two and five gold grains, respectively. These sites were located on road, so surface contamination should be considered a possibility.

Holes K and N present examples of a compositional transition at the base of the upper till. In both cases, limestone content diminishes with depth while sedimentary and volcanic rocks increase. In hole N, one sample from this transition zone yielded one delicate gold grain.

A lower till unit was encountered in holes D, E, I, N and K. A greater proportion of samples containing visible gold were obtained from this unit, compared to the upper till. Occurrences of two-grain counts in holes D and E perhaps should be considered an indication of a backgound value of 1 to 2 grains, higher than the 0 to 1 grain background in the upper till. These background grains were described as abraded in every case. Abundant sulphides, mostly pyrite, were encountered in heavy mineral concentrates from this till, particularly in the cases of holes D and E.

Six samples were obtained from the lower till in Hole I. The third and fourth samples down from the upper contact yielded one irregular and one abraded gold grain, respectively. The lowest sample, which was separated from bedrock by 2.5m of silty very fine sand lacking gold grains, yielded 53 gold grains ranging from 25 to 325 microns. This total includes 31 abraded, 19 irregular and 3 delicate grains. Irregular and delicate grains are confined to grains finer than 100 microns.

Summary

An extensive and well exposed till sheet in the Beardmore-Geraldton area shows promise as a useful tool in mineral exploration. In areas of thin and discontinuous till, surface samples contain locally derived debris indicative of gold mineralization. In areas of thick till, surface samples lack a detectable local component, but samples obtained by drilling have indicated greater local derivation in portions of the upper till and have yielded elevated gold grain counts in a lower till unit. The distinction between a lower till and a zone of the upper till rich in locally derived material is likely to be crucial in deciphering dispersal direction. Thorough analysis of glacial sedimentological features and hence the use of non-destructive drilling techniques are therefore recommended.

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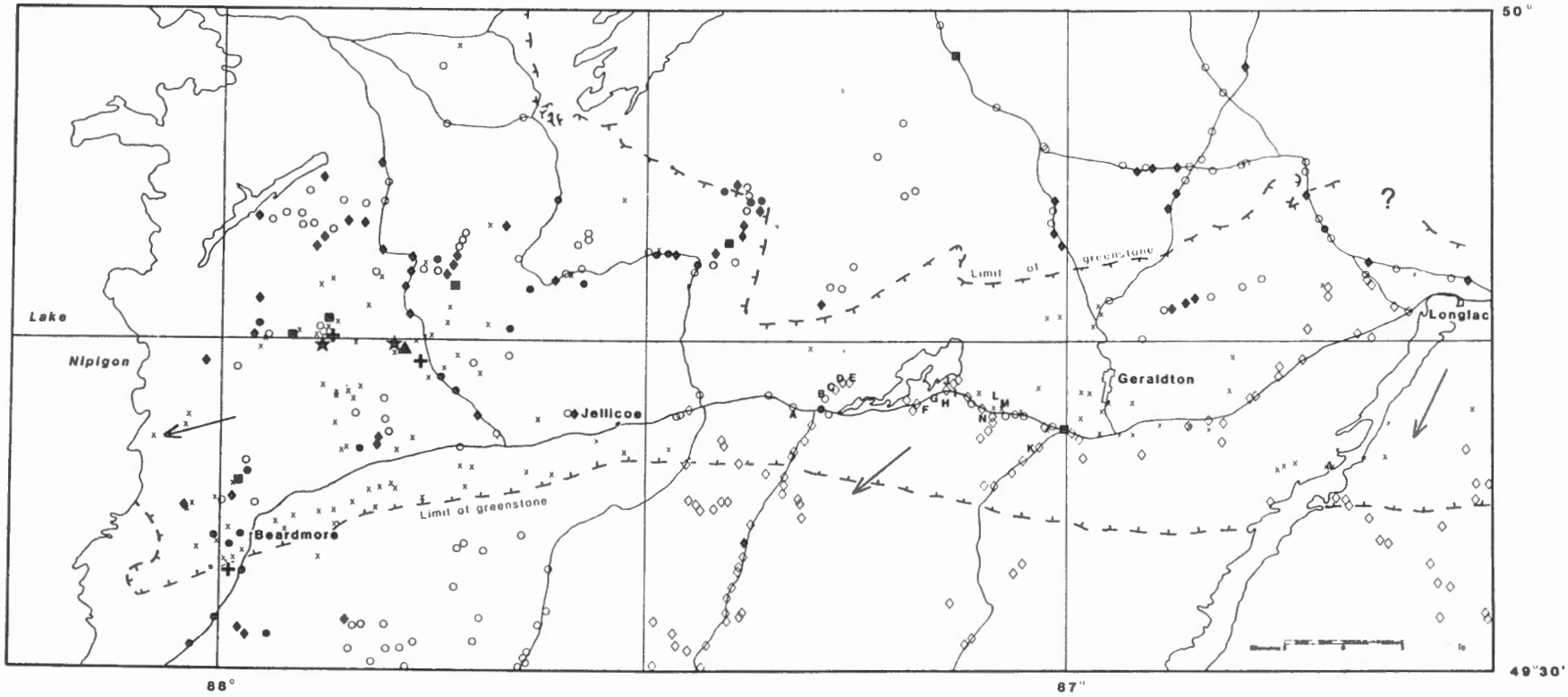

Figure 1. The distribution of visible gold grains in surface till samples. Symbols indicate, in 2 kg sample, no gold (open diamond), and, in a 10 kg sample, no gold (open circle), one gold grain (closed diamond) two to four grains (closed circle), five to ten grains (square), eleven to twenty grains (triangle), 21 to 50 grains (cross), and 51 to 100 grains (star). Known sites of gold mineralization (x) are taken from Pye et al. (1966). Arrows indicate the direction of the youngest ice flow.

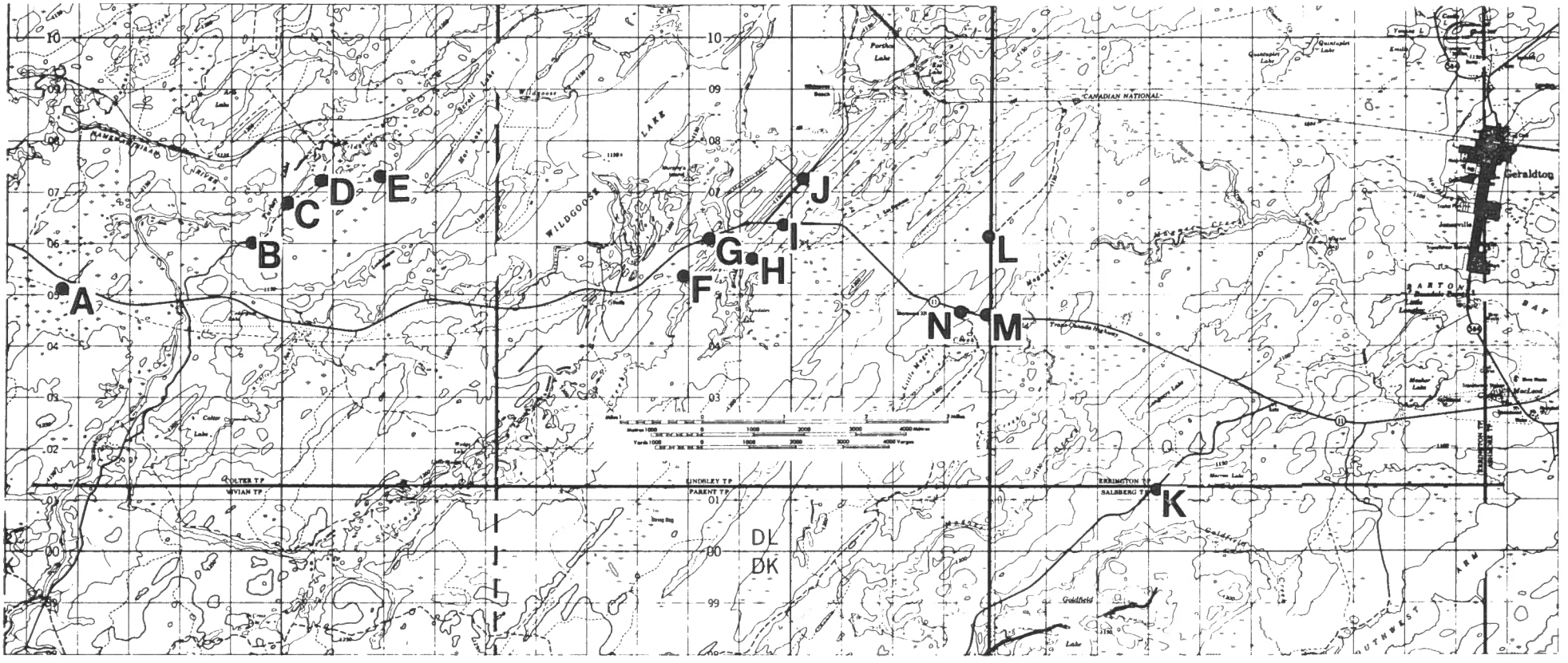

Figure 2. Rotasonic overburden drillhole locations

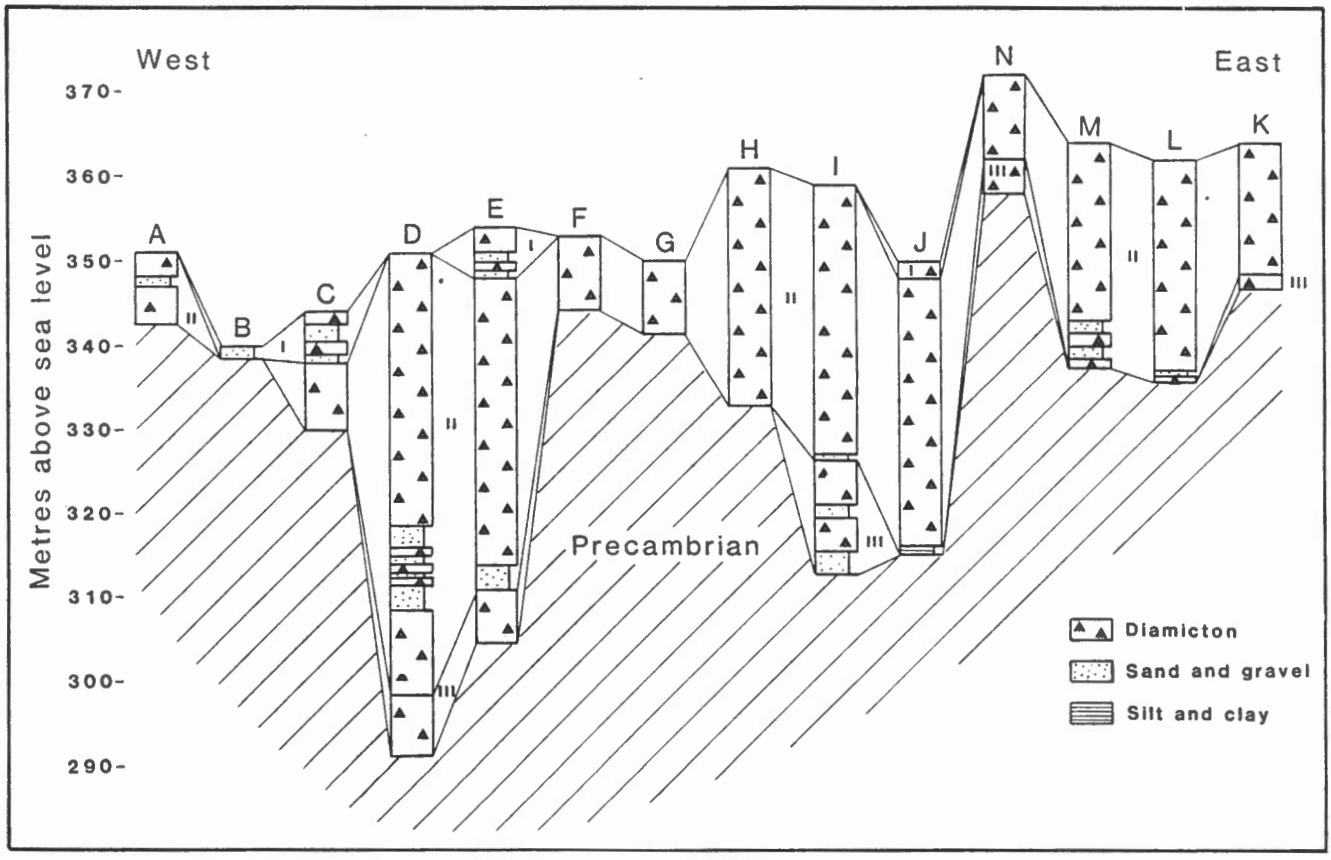

Figure 3. Stratigraphy of thick overburden from drillholes A to N between Jellicoe and Geraldton. A discontinuous cover of proglacial sand and sediment flows (Unit I) overlies a thick and extensive silty till rich in granules and pebbles of Paleozoic carbonate and Proterozoic metasediments derived from the Hudson Bay Lowland (Unit II). At five sites, a second till unit (Unit III) with few Paleozoic carbonates was encountered. Locations are given in Figures 1 and 2.

Table 1. Visible gold content, gravel fraction lithology, and colour of subsurface samples.

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
Number				302	302	302	302	302
Mean				12.2	37	24	39	0.3
Minimum				6.2	5	0	0	0.0
Maximum				16.3	100	70	80	53.0
Hole A								
87TCA1001	1.0	Diamicton	2.5Y 6/2	7.6	25	25	50	0
87TCA1002	2.1	Diamicton	2.5Y 6/2	14.3	30	20	50	0
87TCA1003	4.5	Diamicton	2.5Y 6/2	14.4	30	20	50	0
87TCA1004	5.5	Diamicton	2.5Y 6/2	12.9	20	5	75	0
87TCA1005	6.5	Diamicton	5.0Y 5/1	10.2	40	10	50	0
87TCA1006	7.5	Diamicton	5.0Y 5/1	10.3	30	5	65	0
Hole C								
87TCA1007	1.0	Diamicton	2.5Y 7/4	11.5	35	5	60	2
87TCA1008	4.3	Diamicton	2.5Y 6/2	11.1	30	10	60	0
87TCA1009	6.5	Diamicton	2.5Y 6/2	6.2	35	10	55	0
87TCA1010	7.8	Diamicton	5.0Y 5/1	13.4	25	25	50	0
87TCA1011	9.0	Diamicton	5.0Y 4/1	11.1	30	30	40	0
87TCA1012	10.0	Diamicton	5.0Y 4/1	11.6	30	40	30	0
87TCA1013	11.5	Diamicton	5.0Y 4/1	11.8	30	30	40	0
87TCA1014	12.5	Diamicton	5.0Y 4/1	10.9	30	30	40	0
87TCA1015	13.5	Diamicton	5.0Y 4/1	12.5	20	20	60	0
Hole D								
87TCA1016	1.0	Diamicton	2.5Y 6/2	10.7	25	15	60	0
87TCA1017	2.0	Diamicton	2.5Y 6/2	9.0	20	15	65	0
87TCA1018	3.0	Diamicton	2.5Y 6/2	9.4	35	15	50	0
87TCA1019	4.0	Diamicton	2.5Y 6/2	10.9	25	10	65	0
87TCA1020	5.0	Diamicton	2.5Y 6/2	12.1	30	15	55	0
87TCA1021	6.3	Diamicton	2.5Y 6/2	16.3	10	20	70	1
87TCA1022	7.5	Diamicton	5.0Y 5/1	9.0	5	15	80	0
87TCA1023	8.5	Diamicton	5.0Y 5/1	10.1	10	20	70	1
87TCA1024	9.5	Diamicton	5.0Y 5/1	11.4	10	15	75	0
87TCA1025	10.8	Diamicton	5.0Y 5/1	12.6	10	60	30	0
87TCA1026	12.0	Diamicton	5.0Y 4/1	12.4	20	40	40	0
87TCA1027	13.0	Diamicton	5.0Y 4/1	11.8	10	60	30	0
87TCA1028	14.0	Diamicton	5.0Y 4/1	8.7	20	60	20	0
87TCA1029	15.0	Diamicton	5.0Y 4/1	9.0	10	70	20	0
87TCA1030	16.0	Diamicton	5.0Y 4/1	15.4	20	70	10	0
87TCA1031	17.0	Diamicton	5.0Y 4/1	11.3	5	20	75	0
87TCA1032	18.0	Diamicton	5.0Y 4/1	11.3	10	35	55	0
87TCA1033	19.0	Diamicton	5.0Y 4/1	10.3	10	30	60	0
87TCA1034	20.0	Diamicton	5.0Y 4/1	11.7	10	25	65	0
87TCA1035	21.0	Diamicton	5.0Y 4/1	12.6	10	15	75	0
87TCA1036	22.0	Diamicton	5.0Y 4/1	12.3	10	30	60	0
87TCA1037	23.0	Diamicton	5.0Y 4/1	10.9	10	20	70	0
87TCA1038	24.0	Diamicton	5.0Y 4/1	11.7	20	15	65	0
87TCA1039	25.0	Diamicton	5.0Y 4/1	11.1	30	15	55	0

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
87TCA1040	26.0	Diamicton	5.0Y 4/1	9.4	35	15	50	0
87TCA1041	27.0	Diamicton	5.0Y 4/1	13.5	45	25	30	0
87TCA1042	28.0	Diamicton	5.0Y 4/1	14.0	50	40	10	1
87TCA1043	29.0	Diamicton	5.0Y 5/1	14.1	65	30	5	0
87TCA1044	30.0	Diamicton	5.0Y 5/1	11.5	50	20	30	0
87TCA1045	31.0	Diamicton	2.5Y 6/2	9.8	60	25	15	0
87TCA1046	32.0	Diamicton	5.0Y 5/1	9.2	60	20	20	0
87TCA1047	35.5	Diamicton	5.0Y 6/1	12.3	60	25	15	0
87TCA1048	39.0	Diamicton	5.0Y 6/1	13.0	50	25	25	0
87TCA1049	43.5	Diamicton	5.0Y 6/1	14.5	40	30	30	0
87TCA1050	45.0	Diamicton	5.0Y 5/1	13.0	50	30	20	1
87TCA1051	46.0	Diamicton	5.0Y 5/1	10.6	50	25	25	0
87TCA1052	47.0	Diamicton	5.0Y 6/2	12.8	35	35	30	0
87TCA1053	48.0	Diamicton	5.0Y 7/1	10.6	25	35	40	0
87TCA1054	49.0	Diamicton	5.0Y 7/1	11.8	20	40	40	0
87TCA1055	50.0	Diamicton	5.0Y 6/1	12.9	25	35	40	0
87TCA1056	51.0	Diamicton	5.0Y 6/1	12.2	25	35	40	0
87TCA1057	52.0	Diamicton	5.0Y 6/1	12.3	25	35	40	0
Lower till:								
87TCA1058	53.5	Diamicton	N 4/0	13.7	70	20	10	2
87TCA1059	55.0	Diamicton	5.0Y 5/1	15.8	60	10	30	1
87TCA1060	56.0	Diamicton	5.0Y 5/1	15.6	65	10	25	0
87TCA1061	59.5	Diamicton	5.0Y 5/1	12.4	75	15	10	1
Hole E								
87TCA1062	0.5	Diamicton	2.5Y 6/2	9.8	35	15	50	0
87TCA1063	2.0	Diamicton	2.5Y 6/2	10.1	30	20	50	0
87TCA1064	5.3	Diamicton	2.5Y 6/2	12.2	35	20	45	0
87TCA1065	6.8	Diamicton	5.0Y 5/1	12.9	40	20	40	0
87TCA1066	8.0	Diamicton	5.0Y 5/1	10.5	35	25	40	0
87TCA1067	9.0	Diamicton	5.0Y 5/1	12.9	40	20	40	0
87TCA1068	10.0	Diamicton	5.0Y 5/1	11.1	40	20	40	0
87TCA1069	11.0	Diamicton	5.0Y 5/1	12.4	35	40	25	0
87TCA1070	12.0	Diamicton	5.0Y 5/1	13.0	40	20	40	0
87TCA1071	13.0	Diamicton	5.0Y 5/1	12.5	40	30	30	0
87TCA1072	14.0	Diamicton	5.0Y 5/1	11.5	50	35	15	0
87TCA1073	15.0	Diamicton	5.0Y 5/1	11.9	40	30	30	0
87TCA1074	16.0	Diamicton	5.0Y 4/1	12.6	40	40	20	1
87TCA1075	17.0	Diamicton	5.0Y 4/1	12.3	50	35	15	0
87TCA1076	19.0	Diamicton	5.0Y 5/1	13.5	50	20	30	0
87TCA1077	20.0	Diamicton	5.0Y 4/1	12.0	45	25	30	1
87TCA1078	21.0	Diamicton	5.0Y 4/1	12.7	40	25	35	0
87TCA1079	22.0	Diamicton	5.0Y 4/1	12.8	35	25	40	0
87TCA1080	23.0	Diamicton	5.0Y 4/1	12.5	30	30	40	0
87TCA1081	24.0	Diamicton	5.0Y 4/1	12.0	30	30	40	0
87TCA1082	25.0	Diamicton	5.0Y 5/1	13.7	35	20	45	0
87TCA1083	26.0	Diamicton	5.0Y 4/1	14.9	30	25	45	0
87TCA1084	27.0	Diamicton	5.0Y 4/1	13.8	40	25	35	0
87TCA1085	28.0	Diamicton	5.0Y 4/1	13.7	25	15	60	1
87TCA1086	29.0	Diamicton	5.0Y 4/1	11.9	20	10	70	0

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
87TCA1087	30.0	Diamicton	5.0Y 4/1	14.0	20	20	60	1
87TCA1088	31.0	Diamicton	5.0Y 4/1	13.5	50	20	30	0
87TCA1089	32.0	Diamicton	5.0Y 5/1	13.5	25	25	50	0
87TCA1090	33.0	Diamicton	5.0Y 5/1	11.9	20	20	60	0
87TCA1091	34.0	Diamicton	5.0Y 5/1	12.5	25	35	40	0
87TCA1092	35.0	Diamicton	5.0Y 4/1	12.0	20	40	40	1
87TCA1093	36.0	Diamicton	5.0Y 4/1	12.9	40	40	20	0
87TCA1094	37.5	Diamicton	5.0Y 4/1	12.3	30	40	30	0
87TCA1095	38.5	Diamicton	5.0Y 4/1	12.2	35	35	30	0
87TCA1096	39.5	Diamicton	5.0Y 4/1	12.9	30	35	35	0
Lower till:								
87TCA1097	43.5	Diamicton	5.0Y 5/1	12.8	90	10	0	0
87TCA1098	44.5	Diamicton	5.0Y 5/1	12.8	90	10	0	2
87TCA1099	46.3	Diamicton	5.0Y 5/1	15.3	90	10	0	2
87TCA1100	48.5	Diamicton	N 6/0	13.5	85	10	5	0
Hole F								
87TCA1101	0.5	Diamicton	2.5Y 6/2	10.9	30	35	35	0
87TCA1102	1.5	Diamicton	2.5Y 6/2	11.3	20	50	30	0
87TCA1103	2.5	Diamicton	2.5Y 6/2	12.3	30	40	30	0
87TCA1104	3.5	Diamicton	2.5Y 6/4	12.3	30	30	40	0
87TCA1105	4.5	Diamicton	5.0Y 4/2	11.1	40	40	20	0
87TCA1106	5.5	Diamicton	5.0Y 4/1	11.3	40	20	40	0
87TCA1107	6.5	Diamicton	5.0Y 4/1	12.8	30	20	50	0
87TCA1108	7.3	Diamicton	5.0Y 4/1	10.7	20	20	60	0
87TCA1109	8.0	Diamicton	5.0Y 4/1	9.4	20	15	65	0
87TCA1110	8.8	Diamicton	5.0Y 4/1	9.7	40	10	50	0
Hole G								
87TCA1111	0.5	Diamicton	2.5Y 6/2	11.6	25	20	55	0
87TCA1112	1.5	Diamicton	2.5Y 6/2	12.6	40	30	30	0
87TCA1113	2.5	Diamicton	2.5Y 6/2	14.1	25	35	40	0
87TCA1114	3.5	Diamicton	2.5Y 6/4	13.8	35	35	30	0
87TCA1115	4.5	Diamicton	5.0Y 4/1	12.9	35	15	50	0
87TCA1116	5.5	Diamicton	5.0Y 4/1	11.8	40	15	45	0
87TCA1117	6.5	Diamicton	5.0Y 4/1	11.4	30	10	60	0
87TCA1118	7.5	Diamicton	5.0Y 4/1	11.8	25	25	50	0
87TCA1119	8.3	Diamicton	5.0Y 4/1	13.0	20	20	60	0
Hole H								
87TCA1120	1.0	Diamicton	2.5Y 6/2	12.8	10	20	70	0
87TCA1121	2.5	Diamicton	2.5Y 5/2	13.2	30	10	60	0
87TCA1122	3.5	Diamicton	2.5Y 5/2	13.3	30	20	50	0
87TCA1123	4.5	Diamicton	5.0Y 5/2	12.4	30	30	40	0
87TCA1124	5.5	Diamicton	5.0Y 5/1	12.2	55	25	20	0
87TCA1125	6.5	Diamicton	5.0Y 4/1	12.4	40	20	40	0
87TCA1126	7.5	Diamicton	5.0Y 4/1	12.9	30	50	20	0
87TCA1127	8.5	Diamicton	5.0Y 4/1	14.1	40	30	30	0
87TCA1128	9.5	Diamicton	5.0Y 4/1	12.5	60	25	15	0
87TCA1129	10.5	Diamicton	5.0Y 4/1	13.2	40	25	35	0
87TCA1130	11.5	Diamicton	5.0Y 4/1	12.4	45	20	35	0
87TCA1131	12.5	Diamicton	5.0Y 4/1	12.4	45	20	35	0

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
87TCA1132	13.5	Diamicton	5.0Y 4/1	12.0	40	30	30	0
87TCA1133	14.5	Diamicton	5.0Y 5/1	12.2	30	20	50	0
87TCA1134	15.5	Diamicton	5.0Y 5/1	12.1	25	15	60	0
87TCA1135	16.5	Diamicton	5.0Y 4/1	10.6	30	25	45	0
87TCA1136	17.5	Diamicton	5.0Y 4/1	11.8	50	30	20	0
87TCA1137	18.5	Diamicton	5.0Y 4/1	12.6	40	25	35	0
87TCA1138	19.5	Diamicton	5.0Y 4/1	12.5	50	20	30	0
87TCA1139	20.5	Diamicton	5.0Y 4/1	12.7	40	25	35	0
87TCA1140	21.5	Diamicton	5.0Y 4/1	11.6	30	40	30	0
87TCA1141	22.5	Diamicton	5.0Y 4/1	12.7	30	40	30	0
87TCA1142	23.5	Diamicton	5.0Y 4/1	12.6	40	30	30	0
87TCA1143	24.5	Diamicton	5.0Y 4/1	13.7	35	30	35	0
87TCA1144	25.5	Diamicton	5.0Y 4/1	12.2	40	30	30	0
87TCA1145	26.5	Diamicton	5.0Y 4/1	11.7	50	20	30	0
87TCA1146	27.5	Diamicton	5.0Y 4/1	12.4	50	15	35	0
Hole I								
87TCA1147	0.5	Diamicton	2.5Y 6/2	11.2	40	30	30	0
87TCA1148	1.5	Diamicton	2.5Y 5/2	13.1	40	20	40	0
87TCA1149	2.5	Diamicton	2.5Y 5/2	12.5	40	20	40	0
87TCA1150	3.5	Diamicton	2.5Y 5/2	12.2	45	15	40	0
87TCA1151	4.5	Diamicton	5.0Y 4/1	12.3	50	20	30	0
87TCA1152	5.5	Diamicton	5.0Y 5/1	12.7	50	30	20	0
87TCA1153	6.5	Diamicton	5.0Y 4/1	12.9	45	25	30	1
87TCA1154	7.5	Diamicton	5.0Y 5/1	12.4	50	20	30	0
87TCA1155	8.5	Diamicton	5.0Y 5/1	12.6	45	25	30	0
87TCA1156	9.5	Diamicton	5.0Y 5/1	11.2	50	20	30	0
87TCA1157	10.5	Diamicton	5.0Y 5/1	11.3	35	25	40	0
87TCA1158	11.5	Diamicton	5.0Y 4/1	11.6	50	20	30	0
87TCA1159	12.5	Diamicton	5.0Y 4/1	11.7	50	20	30	0
87TCA1160	13.5	Diamicton	5.0Y 4/1	11.7	40	35	25	0
87TCA1161	14.5	Diamicton	5.0Y 4/1	12.3	50	15	35	0
87TCA1162	15.5	Diamicton	5.0Y 4/1	12.2	40	30	30	0
87TCA1163	16.5	Diamicton	5.0Y 4/1	12.4	40	30	30	0
87TCA1164	17.5	Diamicton	5.0Y 4/1	12.4	50	30	20	0
87TCA1165	18.5	Diamicton	5.0Y 4/1	11.9	40	50	10	0
87TCA1166	19.5	Diamicton	5.0Y 4/1	12.9	40	40	20	0
87TCA1167	20.5	Diamicton	5.0Y 4/1	10.9	35	25	40	0
87TCA1168	21.5	Diamicton	5.0Y 4/1	11.9	50	20	30	0
87TCA1169	22.5	Diamicton	5.0Y 4/1	12.4	40	10	50	0
87TCA1170	23.5	Diamicton	5.0Y 4/1	11.5	40	20	40	0
87TCA1171	24.5	Diamicton	5.0Y 4/1	12.3	40	20	40	0
87TCA1172	25.5	Diamicton	5.0Y 4/1	12.5	30	20	50	0
87TCA1173	26.5	Diamicton	5.0Y 4/1	11.2	50	20	30	0
87TCA1174	27.5	Diamicton	5.0Y 4/1	13.0	40	30	30	0
87TCA1175	28.5	Diamicton	5.0Y 4/1	11.7	30	20	50	0
87TCA1176	29.5	Diamicton	5.0Y 4/1	12.0	40	20	40	0
87TCA1177	30.5	Diamicton	5.0Y 4/1	12.7	40	10	50	0
87TCA1178	31.5	Diamicton	5.0Y 4/1	10.2	15	15	70	0
87TCA1179	33.0	Diamicton	5.0Y 4/1	9.9	15	15	70	0

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
Lower till:								
87TCA1180	36.5	Diamicton	5.0Y 5/1	8.5	50	45	5	0
87TCA1181	37.5	Diamicton	5.0Y 5/1	11.4	49	49	2	0
87TCA1182	40.0	Diamicton	5.0Y 5/1	13.9	75	20	5	1
87TCA1183	41.0	Diamicton	5.0Y 5/1	14.9	85	10	5	1
87TCA1184	42.0	Diamicton	5.0Y 5/1	15.4	85	10	5	0
87TCA1185	43.0	Diamicton	5.0Y 5/1	13.7	90	5	5	53
87TCA1186	44.0	Sand	5.0Y 5/1	11.9	95	4	1	0
87TCA1187	45.0	Sand	5.0Y 5/1	11.0	95	4	1	0
87TCA1188	46.0	Sand	5.0Y 5/1	12.0	95	4	1	0
Hole J								
87TCA1189	1.3	Diamicton	2.5Y 6/2	12.6	30	20	50	5
87TCA1190	2.5	Diamicton	2.5Y 5/2	12.4	15	5	80	0
87TCA1191	3.3	Diamicton	2.5Y 5/2	8.9	15	20	65	0
87TCA1192	4.0	Diamicton	5.0Y 4/1	13.0	20	20	60	0
87TCA1193	5.0	Diamicton	5.0Y 4/1	11.9	20	10	70	0
87TCA1194	6.0	Diamicton	5.0Y 4/1	12.8	25	15	60	0
87TCA1195	7.0	Diamicton	5.0Y 4/1	12.3	15	15	70	0
87TCA1196	8.0	Diamicton	5.0Y 4/1	13.0	25	15	60	1
87TCA1197	9.0	Diamicton	5.0Y 4/1	12.6	25	25	50	0
87TCA1198	10.0	Diamicton	5.0Y 4/1	13.0	40	20	40	0
87TCA1199	11.0	Diamicton	5.0Y 4/1	12.3	50	30	20	0
87TCA1200	12.0	Diamicton	5.0Y 4/1	13.6	5	15	80	0
87TCA1201	13.0	Diamicton	5.0Y 4/1	13.5	35	40	25	0
87TCA1202	14.0	Diamicton	5.0Y 4/1	12.3	30	50	20	0
87TCA1203	15.0	Diamicton	5.0Y 4/1	12.4	60	20	20	1
87TCA1204	16.0	Diamicton	5.0Y 4/1	12.7	70	15	15	0
87TCA1205	17.0	Diamicton	5.0Y 4/1	13.9	35	35	30	0
87TCA1206	18.0	Diamicton	5.0Y 4/1	13.0	40	50	10	0
87TCA1207	19.0	Diamicton	5.0Y 4/1	12.0	40	40	20	0
87TCA1208	20.0	Diamicton	5.0Y 4/1	12.4	50	30	20	0
87TCA1209	21.0	Diamicton	5.0Y 4/1	11.8	40	30	30	0
87TCA1210	22.0	Diamicton	5.0Y 4/1	12.1	20	50	30	0
87TCA1211	23.0	Diamicton	5.0Y 4/1	13.2	30	40	30	0
87TCA1212	24.0	Diamicton	5.0Y 4/1	13.3	30	40	30	0
87TCA1213	25.0	Diamicton	5.0Y 4/1	13.5	30	40	30	0
87TCA1214	26.0	Diamicton	5.0Y 4/1	13.6	40	30	30	0
87TCA1215	27.0	Diamicton	5.0Y 4/1	11.6	30	40	30	0
87TCA1216	28.0	Diamicton	5.0Y 4/1	12.9	40	25	35	0
87TCA1217	29.0	Diamicton	5.0Y 4/1	14.5	50	25	25	0
87TCA1218	30.0	Diamicton	5.0Y 4/1	12.4	40	40	20	0
87TCA1219	31.0	Diamicton	5.0Y 4/1	13.7	50	20	30	0
87TCA1220	32.0	Diamicton	5.0Y 5/1	12.3	25	55	20	0
87TCA1221	33.0	Diamicton	5.0Y 5/1	11.4	40	30	30	0
87TCA1222	34.0	Diamicton	5.0Y 5/1	12.3	45	15	40	0
87TCA1223	34.5	Diamicton	5.0Y 5/1	11.9	50	20	30	0
Hole K								
87TCA1224	1.0	Diamicton	2.5Y 5/2	11.0	45	5	50	0
87TCA1225	2.0	Diamicton	2.5Y 6/2	11.9	30	30	40	1

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
87TCA1226	3.0	Diamicton	5.0Y 4/1	12.0	40	30	30	0
87TCA1227	4.0	Diamicton	5.0Y 4/1	12.2	40	20	40	0
87TCA1228	5.0	Diamicton	5.0Y 4/1	12.4	60	15	25	0
87TCA1229	6.0	Diamicton	5.0Y 4/1	12.9	45	40	15	0
87TCA1230	7.0	Diamicton	5.0Y 4/1	11.6	55	20	25	0
87TCA1231	8.0	Diamicton	5.0Y 4/1	11.9	55	35	10	0
87TCA1232	9.0	Diamicton	5.0Y 4/1	12.3	40	30	30	0
87TCA1233	10.0	Diamicton	5.0Y 4/1	12.1	70	20	10	0
87TCA1234	11.0	Diamicton	5.0Y 4/1	11.8	70	20	10	0
87TCA1235	12.0	Diamicton	5.0Y 4/1	12.8	70	20	10	0
87TCA1236	13.0	Diamicton	5.0Y 4/1	12.4	65	15	20	0
87TCA1237	14.0	Diamicton	5.0Y 4/1	12.4	80	15	5	0
87TCA1238	15.0	Diamicton	5.0Y 4/1	11.2	80	10	10	0
Lower till:								
87TCA1239	16.5	Diamicton	5.0Y 4/1	12.7	80	15	5	0
Hole L								
87TCA1240	0.5	Diamicton	2.5Y 6/2	11.4	50	20	30	0
87TCA1241	1.5	Diamicton	2.5Y 5/2	12.2	50	20	30	0
87TCA1242	2.5	Diamicton	2.5Y 5/2	12.5	60	20	20	0
87TCA1243	3.5	Diamicton	2.5Y 5/2	12.8	60	20	20	0
87TCA1244	4.5	Diamicton	5.0Y 5/2	12.9	50	20	30	0
87TCA1245	5.5	Diamicton	5.0Y 5/1	11.8	40	20	40	0
87TCA1246	6.5	Diamicton	5.0Y 4/1	11.9	30	20	50	0
87TCA1247	7.5	Diamicton	5.0Y 4/1	12.6	40	20	40	0
87TCA1248	8.5	Diamicton	5.0Y 4/1	12.1	40	20	40	0
87TCA1249	9.5	Diamicton	5.0Y 5/1	11.7	40	20	40	1
87TCA1250	10.5	Diamicton	5.0Y 4/1	12.6	30	10	60	0
87TCA1251	11.5	Diamicton	5.0Y 4/1	12.9	40	10	50	0
87TCA1252	12.5	Diamicton	5.0Y 4/1	13.0	30	20	50	0
87TCA1253	13.5	Diamicton	5.0Y 4/1	12.6	30	20	50	0
87TCA1254	14.5	Diamicton	5.0Y 4/1	13.7	30	10	60	0
87TCA1255	15.5	Diamicton	5.0Y 4/1	14.0	30	20	50	0
87TCA1256	16.5	Diamicton	5.0Y 4/1	13.0	20	25	55	0
87TCA1257	17.5	Diamicton	5.0Y 4/1	13.9	30	20	50	0
87TCA1258	18.5	Diamicton	5.0Y 4/1	12.1	15	65	20	0
87TCA1259	19.5	Diamicton	5.0Y 4/1	12.2	10	30	60	1
87TCA1260	20.5	Diamicton	5.0Y 4/1	11.7	10	30	60	0
87TCA1261	21.5	Diamicton	5.0Y 4/1	12.3	30	50	20	0
87TCA1262	22.5	Diamicton	5.0Y 4/1	11.6	30	40	30	0
87TCA1263	23.5	Diamicton	5.0Y 4/1	13.4	20	50	30	0
87TCA1264	24.5	Diamicton	5.0Y 4/1	12.3	50	25	25	0
87TCA1265	25.5	Diamicton	5.0Y 4/1	12.9	40	30	30	0
Hole M								
87TCA1266	0.5	Diamicton	2.5Y 5/2	12.0	15	5	80	0
87TCA1267	1.5	Diamicton	2.5Y 5/2	11.5	20	20	60	0
87TCA1268	2.5	Diamicton	5.0Y 4/1	11.8	25	30	45	0
87TCA1269	3.5	Diamicton	5.0Y 4/1	12.5	20	20	60	0
87TCA1270	4.5	Diamicton	5.0Y 4/1	12.5	40	20	40	0
87TCA1271	5.5	Diamicton	5.0Y 4/1	12.4	30	40	30	0

	Depth m	Sediment	Colour (Munsell)	Weight kg	Estimated: Sed&Volc +10mesh	Granitics +10mesh	Limestone +10mesh	Gold Grains
87TCA1272	6.5	Diamicton	5.0Y 4/1	14.1	25	30	45	0
87TCA1273	7.5	Diamicton	5.0Y 4/1	12.2	30	40	30	0
87TCA1274	8.5	Diamicton	5.0Y 4/1	12.7	20	20	60	0
87TCA1275	9.5	Diamicton	5.0Y 4/1	12.6	35	25	40	0
87TCA1276	10.5	Diamicton	5.0Y 4/1	12.9	15	5	80	0
87TCA1277	11.5	Diamicton	5.0Y 4/1	12.5	40	20	40	0
87TCA1278	12.5	Diamicton	5.0Y 4/1	12.3	70	10	20	0
87TCA1279	13.5	Diamicton	5.0Y 4/1	12.0	35	20	45	0
87TCA1280	14.5	Diamicton	5.0Y 4/1	12.3	25	10	65	0
87TCA1281	15.5	Diamicton	5.0Y 4/1	12.8	30	10	60	0
87TCA1282	16.5	Diamicton	5.0Y 4/1	12.4	20	15	65	0
87TCA1283	17.5	Diamicton	5.0Y 4/1	11.8	20	10	70	0
87TCA1284	18.5	Diamicton	5.0Y 4/1	12.6	40	10	50	0
87TCA1285	19.5	Diamicton	5.0Y 4/1	11.9	20	10	70	0
87TCA1286	20.5	Diamicton	5.0Y 4/1	12.5	30	10	60	0
87TCA1287	23.0	Diamicton	5.0Y 4/1	12.9	30	20	50	0
87TCA1288	26.0	Diamicton	5.0Y 4/1	13.3	30	20	50	0
Hole N								
87TCA1289	0.5	Diamicton	2.5Y 6/4	12.1	20	5	75	0
87TCA1290	1.5	Diamicton	2.5Y 6/2	11.7	20	5	75	0
87TCA1291	2.5	Diamicton	2.5Y 5/2	11.1	15	5	80	0
87TCA1292	3.5	Diamicton	2.5Y 5/2	10.0	20	5	75	0
87TCA1293	4.5	Diamicton	5.0Y 4/1	11.9	20	10	70	1
87TCA1294	5.5	Diamicton	5.0Y 4/1	11.7	15	5	80	0
87TCA1295	6.5	Diamicton	5.0Y 4/1	12.7	20	5	75	0
87TCA1296	7.5	Diamicton	5.0Y 4/1	12.4	20	5	75	0
87TCA1297	8.5	Diamicton	5.0Y 4/1	11.4	15	10	75	0
87TCA1298	9.5	Diamicton	5.0Y 4/1	13.6	35	15	50	0
87TCA1299	10.5	Diamicton	5.0Y 4/1	11.5	35	15	50	1
87TCA1300	11.5	Diamicton	5.0Y 4/1	12.8	30	20	50	0
Lower till:								
87TCA1301	12.5	Diamicton	5.0Y 4/1	9.5	99	0	1	0
87TCA1302	13.5	Diamicton	5.0Y 4/1	8.9	100	0	0	0

Appendix 1. Description of bedrock core (8 cm diameter, 1-2 m length) .

Hole A: Greywacke, brownish black, coarse grained, massive to weakly foliated, very minor quartz/carbonate veins up to 0.5 cm thick, very minor fracture coating sulphide (pyrite).

Hole B: Greywacke, dark greenish grey, moderately foliated, quartz veins with minor carbonate up to 1 cm thick, rusty staining on fractures, very minor sulphide (pyrite) along veins and fractures, occasional disseminated sulphide grains.

Hole C: Greywacke, greenish black, moderately foliated, abundant quartz/carbonate veins 0.1 to 1.0 cm thick, rare sulphide (pyrite) as fracture coatings and isolated grains, chlorite alteration along several veins.

Hole D: Greywacke, greenish grey, well foliated, sericitized, disseminated sulphide (pyrite, arsenopyrite?), sulphide on carbonate vein surfaces.

Hole E: Quartz sericite schist, sheared felsic intrusion?, light greenish grey, extremely well foliated, chloritic laminae, quartz chlorite veins, some crosscutting and deformed, disseminated fine grained pyrite throughout.

Hole F: Greywacke, black, weakly foliated, carbonate/quartz veins up to 1 cm, with sharp zig-zags, very rare fine pyrite in quartz vein.

Hole G: Greywacke, black, moderately foliated, deformed quartz/carbonate veins with minor sulphide, abundant sulphide (pyrite, pyrrhotite, chalcopyrite) on cross-cutting fracture surface.

Hole H: Greywacke, greenish grey with 1-5 cm lighter coloured irregular zones, moderately foliated, sericite alteration along quartz/carbonate veins, very minor sulphide (pyrite, arsenopyrite) along fractures crosscutting foliation.

Hole I: Greywacke, dark grey, laminated, strongly foliated, extensively deformed, offset laminae, variably chloritic, abundant stringers of quartz/carbonate with abundant sulphide (pyrite) parallel to foliation, fractures with sulphide at high angle to foliation.

Hole J: Greywacke, greenish black, chloritic, foliated,with fine crenulation, two orientations of quartz/carbonate veins with fine-grained pyrite.

Hole K: Greywacke, black, weakly foliated, bedded, minor quartz/carbonate veining, rare fracture-confined pyrite.

Hole L: Greywacke, greenish black, well foliated, fine crenulation, narrow chloritic zones, sericite zones, 2 cm

thick quartz/carbonate vein, irregularly distributed carbonate veinlets, disseminated fine-grained pyrite lacking association with veins, 1-3 mm bands of abundant 0.5-1.0 mm pyrite cubes associated with chlorite.

Hole M: Deformed pebble conglomerate, dark greenish grey, variably foliated, a few clearly defined 1-10 cm clasts including rounded granitic and fine-grained felsic volcanic?, fine-grained matrix, possible vein quartz, sericite patches (stretched fragments?), variable pyrite unevenly distributed.

Hole N: Feldspar porphyritic intrusive, greyish green with white phenocrysts, moderately to well foliated, minor carbonate and quartz veining up to 0.5 cm, disseminated pyrite up to 8 mm.