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Till Sampling in the Casa-Berardi Gold Area, Quebec: A Case History in Orientation and Discovery

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ABSTRACT

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Inco Limited discovered gold in northwestern Casa-Berardi township, Quebec, in April 1981. The discovery, named the Golden Pond Zone, is located under approximately 45 m of overburden.Diamond drilling at Golden Pond up to August 1983 indicated two main zones of Au mineralization on either side of a major east–west-trending graphitic fault zone. The mineralization consists of pyrite-arsenopyrite-native Au-bearing quartz-carbonate veins in carbonatized Archaen sediments and volcanics. A reverse-circulation overburden drilling program was undertaken in the vicinity of the Golden Pond zone in December 1983. The program, under the management of Overburden Drilling Management of Ottawa, was designed to test for glacial dispersal of the known mineralization and thereby to evaluate the effectiveness of till sampling as an Au exploration method in the Casa-Berardi area. Gold and As anomalies related to the Golden Pond zone are found mainly in heavy-mineral concentrates of the lower till that lines the bedrock depression which is spatially associated with bedrock mineralization. These anomalies occur south of the known mineralization and constitute an example of a glacial dispersal train. Most of the till gold grains are very fine (50–150 microns). The gold grains in the till 100 m south of the Golden Pond zone are delicate while the majority of those encountered 400 m to the south are either irregular or abraded, indicating transport over greater distances.

Following the success of orientation survey, till sampling was used as a screening tool to evaluate geophysical and/or stratigraphic targets east and west of the Golden Pond zone prior to diamond drilling. During the initial sampling program in early 1984, targets were commonly tested at intervals of either 300 m or 400 m along strike and 25–100 m down ice. Closer-spaced sampling was undertaken to further define anomalous dispersal trains prior to diamond drilling. Two reverse-circulation holes drilled 300 m apart in April 1984 to test the continuation of the Golden Pond geophysics encountered an anomalous gold-arsenopyrite dispersal train 2.5 km to the east. Follow-up till sampling in June 1984 further defined the anomalous train. The heavy-mineral concentrate from the bottom till sample of a hole 100 m east of the earlier anomalous hole contained approximately 700 very delicate gold grains, mostly in the 50–100 micron size range, and was concluded to be at source. Diamond drilling in July 1984 confirmed the existence of the Golden Pond East zone.

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INTRODUCTION

In April 1981, Inco Limited discovered Au mineralization under approximately 45 m of overburden by diamond drilling an electromagnetic anomaly in northwestern Casa-Berardi township, Quebec. The discovery, named the Golden Pond Zone, is accessible by an all-weather gravel logging road from La Sarre, 100 km to the south (Fig. 1). The Detour Lake gold mine is 50 km to the northwest in Ontario, the Selbaie base metal deposit is 30 km to the northeast, and Noranda is 160 km to the south.

Eight hundred and eighty-two (882) claims are held and cover a 42-km strike length extending from Bradette township, Ontario, through Dieppe, Casa-Berardi, Raymond, Puisseaux, and Estrees townships, Quebec (Fig. 2). Inco and Golden Knight Resources own 60% and 40%, respectively of 865 claims, and together own 60% of 17 Domex claims.

Diamond drilling in 17 holes at Golden Pond between April, 1981, and August, 1983, indicated two main zones of steeply south-dipping Au mineralization over a strike length of 400 m, lying both north and south of a major east–west-trending graphitic fault zone (Fig. 3). The mineralization consists of pyrite-arsenopyrite-native Au-bearing quartz-carbonate veins in carbonatized Archean sediments (sandstone, siltstone, graphitic mudstone) and volcanics (felsic agglomerate, lapilli tuff).

The main problem faced by Inco Exploration following the Golden Pond discovery was how to explore the extensively drift-covered property quickly and effectively. The favourable Golden Pond stratigraphy could be traced by geophysics (magnetics, electromagnetics, IP) for many kilometres east and west of Golden Pond but there was no unique or characteristic geophysical signature which was capable of differentiating mineralized from nonmineralized areas. It was decided that till sampling by reverse-circulation drilling offered the best chance of providing an effective tool to delineate diamond drill targets in areas of potentially favourable geology (Averill, 1978; Gray, 1983; Averill and Zimmerman, 1984).

GOLDEN POND ORIENTATION SURVEY

An eleven-hole (506 m) orientation reverse-circulation overburden drilling program was undertaken in the vicinity of the Golden Pond Zone in December, 1983. The program, under the management of Overburden Drilling Management (ODM) of Ottawa, was designed to test for glacial dispersal from the known mineralization and thereby evaluate the effectiveness of till sampling as an Au exploration method in the Casa-Berardi area. The eleven holes were drilled on three east–west profiles; one profile was drilled 100 m north of the Golden Pond Zone, while the other two profiles were drilled 100 m and 400 m south of the zone (Fig. 3). On each profile, a 200-m hole separation was used.

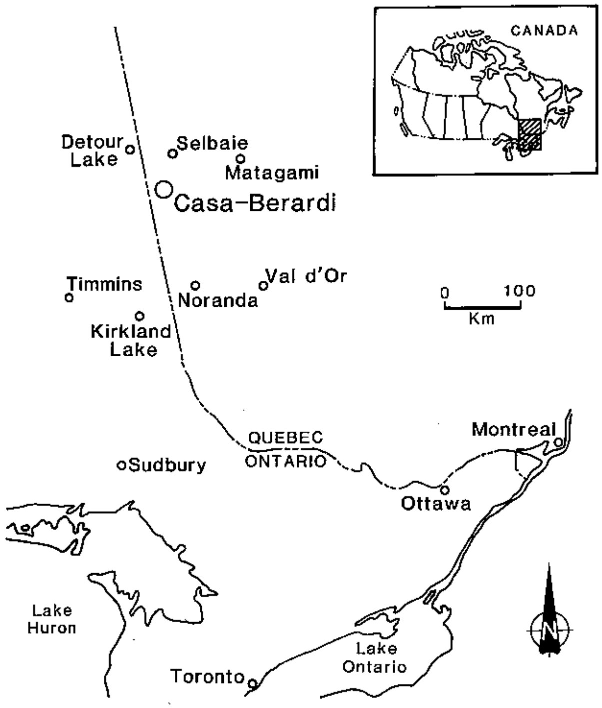

Fig. 1.Location of the Casa-Berardi area, Quebec.

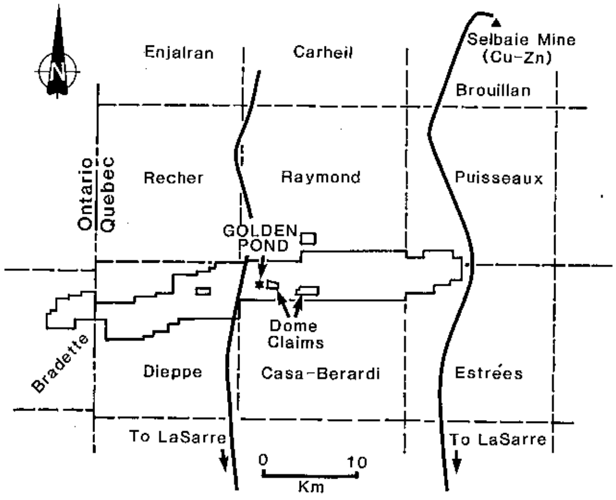

Fig. 2. Casa-Berardi area, Quebec, showing location of the Inco – Golden Knight Joint Venture claims and the Golden Pond discovery area.

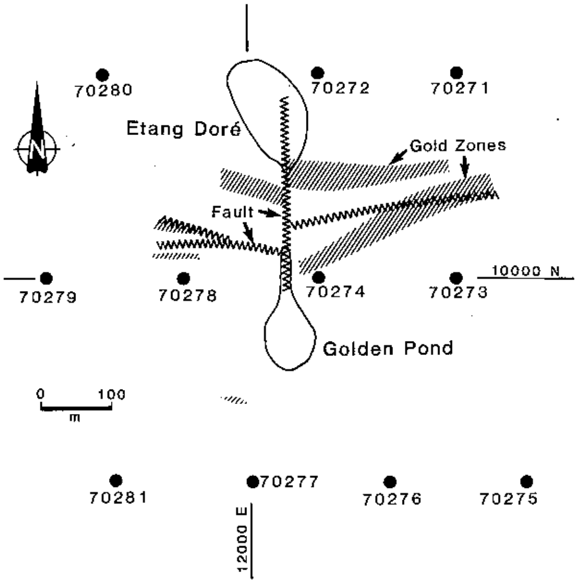

Fig. 3. Plan of the Golden Pond area as of December, 1983 showing Au-mineralized zones and locations of eleven reverse-circulation drill holes.

Continuous samples of all coarser clastic horizons (till, gravel, sand) were collected as well as bedrock chip samples. Gravels and sands were typically sampled at 3-m and 6-m intervals, respectively, while tills were sampled at 1.5-m intervals. Sample weights averaged 5–7 kg.

Sample processing

All samples of till, sand and gravel taken during the program were shipped to the ODM laboratory for processing which involved wet sieving (1700 microns), preconcentration on a shaking table, methylene iodide (SG 3.3) heavy-liquid separation, and magnetic separation.

Gold grains picked from the shaking table were examined under a binocular microscope, measured to determine their influence on the analysis of the concentrate, and classified as to degree of transport based on size and shape. Delicate gold grains indicate transport from source less than 100 m, irregular grains indicate transport of between 100 m and 1000 m and abraded grains indicate transport in excess of 1000 m. Examples of each class are presented in a later section.

Special additional processing was required for many of the samples because free Au is abundant and many of the grains are finer than the minimum size (125 microns) that separates cleanly from magnetite on the table. To obtain a reliable estimate of the total number of gold grains present, samples that produced multiple grains on the table were refined in a delicate panning operation and the pan concentrates were scanned under a binocular microscope.

Heavy-mineral concentrates were assayed for Au, As and S at the Inco Exploration Assay Laboratory in Sudbury.

Overburden stratigraphy

Quarternary units present in the Golden Pond area (Figs. 4, 5 and 6) comprise lower till, lower sediments, upper till, and upper sediments of both glaciofluvial and glaciolacustrine origin.

The lower till unit forms a semicontinuous blanket over the drilled area. On the southernmost section the lower till is very thin or absent, apparently as a result of a gradual rise in bedrock topography in this direction. The good preservation of this unoxidized local till is due to the fact that the entire drilled area is a bedrock depression.

The lower till has a fine silty sand matrix of grey colour. Cobble-sized clasts are common, and at least 80% of these appear to be of local origin. In some holes on the central and southern profiles, 90% of the clasts are sediments and volcanics similar to the Golden Pond sequence, while on the northern profile, clasts of biotitic greywacke from the units overlying the Golden Pond sequence predominate. The high percentage of local material, indicative of intense scouring of the bedrock surface, makes this an ideal sampling medium for exploration purposes.

A lens of till within the lower sediments of hole 70274 (Figs. 4, 5) is tentatively correlated with the lower till due to matrix and clast colour and composition.

The lower sediment unit is comprised variably of clay, silt, sand and gravel and is present in all but one hole. The varied nature of the sediments suggests a shallow glaciolacustrine environment with some intermittent glaciofluvial action.

The upper till is present in all but two holes. Areally, it is known to be much more extensive than the lower till and its absence from the two holes is due to the downcutting effect of the glacial stream responsible for the deposition of the upper (glaciofluvial) sediments.

The upper till has a silty sand matrix of grey-beige colour, a slightly lighter colour than that of the lower till. Clasts are of cobble size, but there is a higher proportion (minimum 30%) of "foreign" (i.e., intrusive) material as opposed to the high local clast component of the lower till. In cases where no intervening sediments separate the upper and lower tills, the distinction is based only on matrix colour and clast composition.

The upper sediment unit includes sediments of both glaciofluvial and glaciolacustrine origin. The glaciofluvial sediments comprise esker gravels and sands deposited in an in-ice conduit of the same ice sheet responsible for the

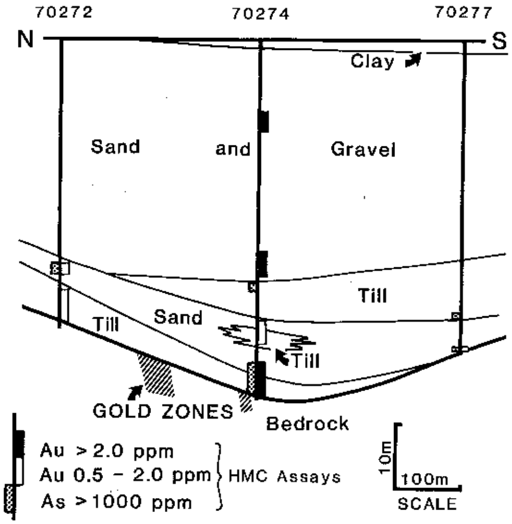

Fig. 4. 12100E Section at Golden Pond showing overburden stratigraphy and heavy-mineral concentrate (HMC) geochemistry approximately parallel to glacial direction.

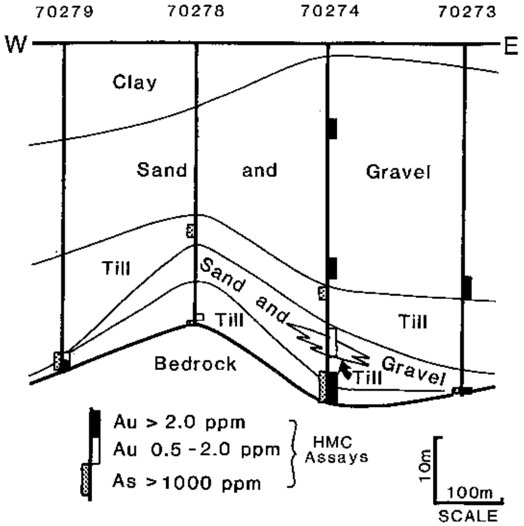

Fig. 5. 10000N Section at Golden Pond showing overburden stratigraphy and heavy-mineral concentrate (HMC) geochemistry approximately 100 m down-ice (south) of Au mineralization.

deposition of the upper till. The glaciolacustrine sediments represent the final Quaternary event in the area. The sediments range from fine sand and silt to gritty and nongritty clay.

Overburden geochemistry

Within the Golden Pond area, heavy-mineral Au and As anomalies in the overburden are present which define the known bedrock source as well as some

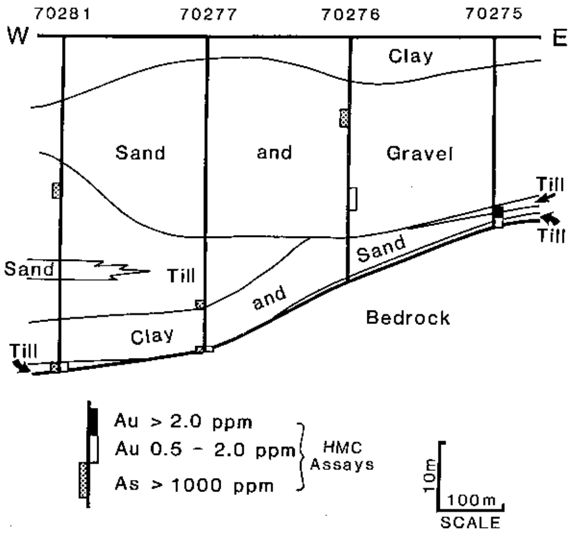

Fig. 6. 9700N Section at Golden Pond showing overburden stratigraphy and heavy-mineral concentrate (HMC) geochemistry approximately 400 m down-ice (south) of Au mineralization

which are considered erratic. The erratic anomalies are generally restricted to upper till and upper sediment sections, and are for As or Au alone, they are not considered significant. In most cases these Au anomalies are the result of the presence of a single abraded gold grain in small concentrates from gravels. Erratic As anomalies are concluded to result from arsenopyrite derived from an unknown source as they are commonly of a different variety than those at Golden Pond.

Anomalies related to the Golden Pond Zone are found mainly in the lower till that lines the bedrock depression which is spatially associated with bedrock mineralization. These anomalies occur only on the two southern drill profiles, and on this basis alone are assumed to be related to the known mineralization and constitute a glacial dispersal train. The following evidence supports this conclusion:

(1) Almost all of the till gold grains are within the same size range (50–150 microns).

(2) Gold grains in the till up to 100 m south of the Golden Pond zone are delicate while the majority of those encountered 400 m to the south are either irregular or abraded indicating transport over greater distances.

(3) The Au at Golden Pond is closely associated with pyrite and arsenopyrite, and the Au-bearing till concentrates show exceptional enrichment in these minerals. In fact, the lower till concentrates in hole 70274, immediately south of the Golden Pond zone, contain 100 times more pyrite than those from holes north of the zone, and as a result are very much oversized, weighing 100 g rather than the normal 5–15 g.

TABLE I

Selected heavy-mineral concentrate assays – Golden Pond orientation

Sample #	From (m)	To (m)	Interval (m)	Log	Au (ppm)	As (ppm)	S (%)
RC Hole 70274							
20	48.3	49.8	1.5	Sand	2.7	3,060	11.3
21	49.8	51.3	1.5	Till	4.5	20,600	24.1
22	51.3	52.8	1.5	Till	4.0	17,600	25.9
23	52.8	53.4	0.6	Till	5.3	28,100	21.3
24	53.4	54.6	1.2	Rock			
RC Hole 70275							
4	22.8	25.5	2.7	Sand	0.08	98	2.0
5	25.5	26.6	1.1	Till	9.1	107	5.2
6	26.6	27.6	1.0	Clay, Till	1.2	580	7.8
7	27.6	28.8	1.2	Rock			

The strength of the Au-As anomaly is well illustrated by the results from hole 70274 presented in Table 1. The assays of the heavy-mineral concentrates from the bottom four samples over a total interval of 5.1 m range from 2.7 to 5.3 ppm Au and from 3060 to 28,100 ppm As, with the highest values in both elements being from the basal sample.

Approximately 40 gold grains in the 50–150 micron size range were noted when the bottom two samples (#22 and #23) of lower till from hole 70274 were panned. The majority of the grains are delicate (Fig. 7) and reflect a short distance of transport. Pyrite and arsenopyrite constituted 60–70% and 25–30% of the heavy-mineral concentrate, respectively. The arsenopyrite grains that accompany the Au are of a short columnar variety with distinct rhombic cross-sections (Fig. 8). Gold grains from the overlying sample #21 (Fig. 9) are of the irregular class due to the greater distance of transport from the northern Golden Pond mineralized zone located 150 m up-ice from the hole, and/or because of reworking of the till.

ODM (S.A. Averill, pers. commun., 1984) has established that, as a mineralized source is approached, the grade of methylene iodide till concentrates becomes similar to the grade of the source. In hole 70274, concentrate grades in the range of 3–5 ppm Au are equivalent to average grades over wide sections of Golden Pond mineralization.

On the southern profile (Fig. 6), the critical lower till horizon is either absent or is reworked and very thin. Still, high background to anomalous Au anomalies were obtained, and fine gold grains of the Golden Pond type are present. In hole 70275 (Table 1), where the lower till is separated from the upper till by only a few cm of protective lower sediments, recycling of Au into the upper till is evident. Gold occurs mainly in the two bottom samples of hole 70275; two of

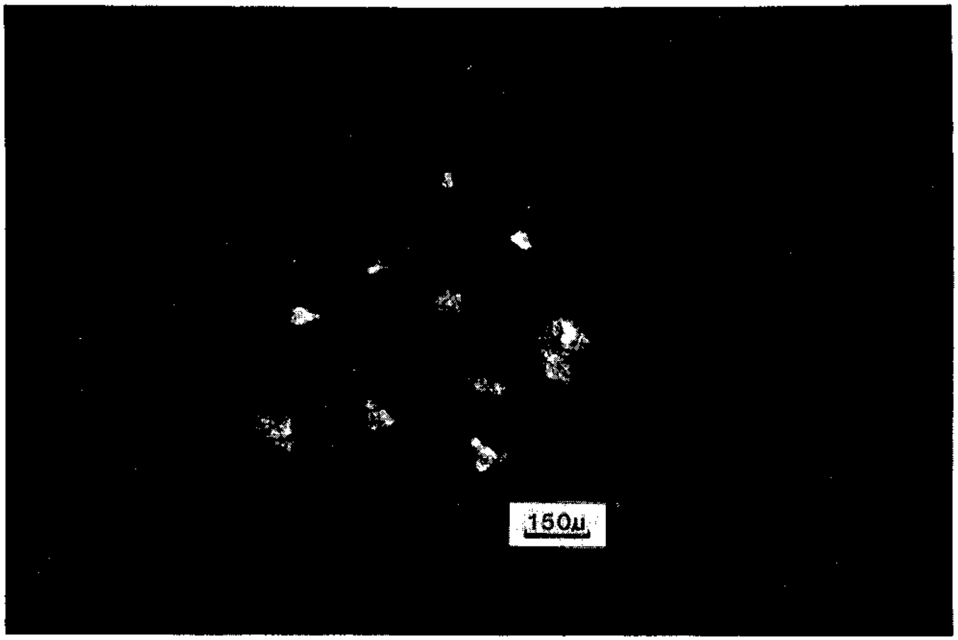

Fig. 7. Photograph of delicate gold grains from Sample #23 in RC hole 70274.

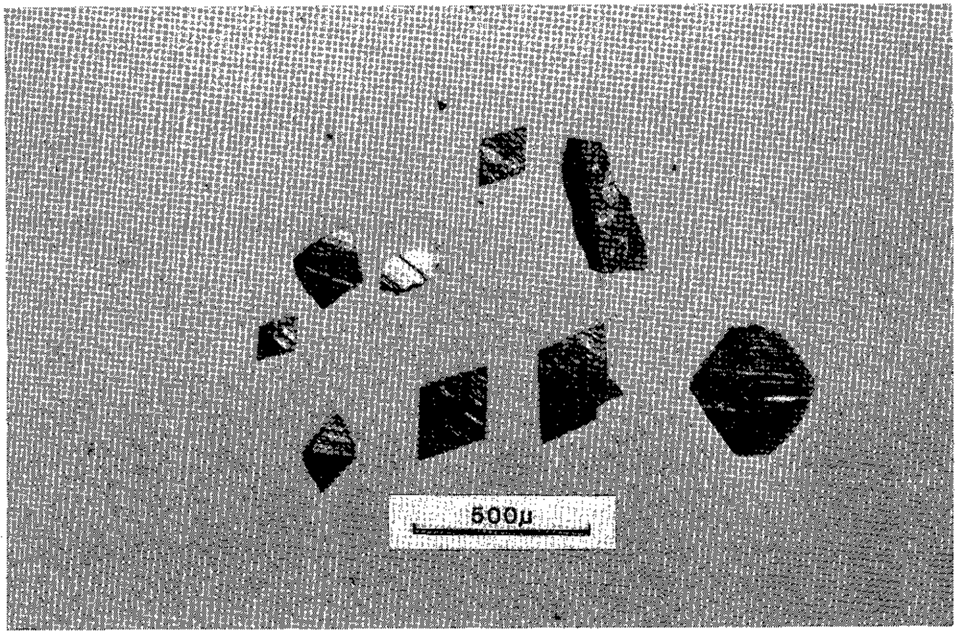

Fig. 8. Photograph of arsenopyrite grains from Sample #23 in RC hole 70274.

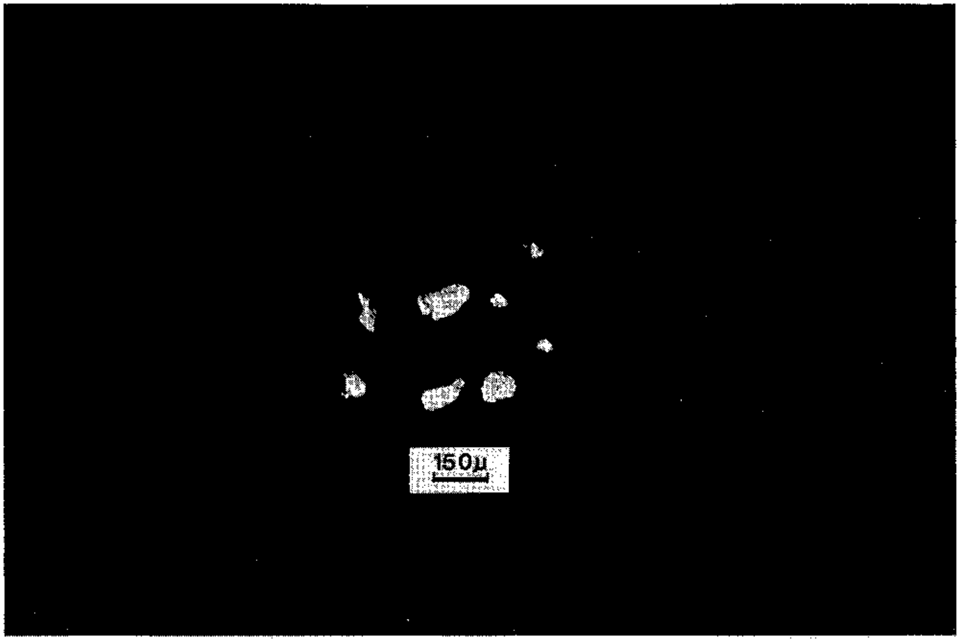

Fig. 9. Photograph of irregular gold grains from Sample #21 in RC hole 70274.

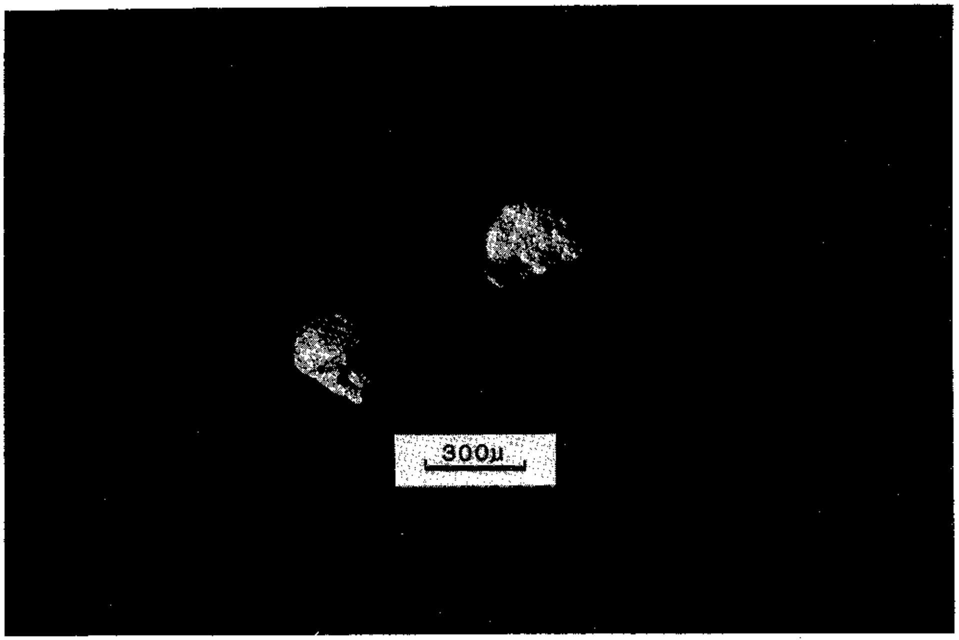

Fig. 10. Photograph of abraded gold grains from Sample #5 in RC hole 70275.

the nine grains in Sample 5 are irregular while the remaining seven are abraded (Fig. 10). This probably reflects the fact that the Au has been recycled into the upper till as 400 m of ice transport would be expected to reduce the gold grains only to the irregular class.

GOLDEN POND DISPERSAL TRAIN

In summary, the Au-As dispersal train resulting from the Golden Pond mineralization is characterized by the following properties:
(1) It is stratabound at the base of the locally derived lower till unit.
(2) It is at least 2 m thick and therefore is evident in two or more consecutive 1.5-m samples.
(3) It has a minimum width of 200 m measured perpendicular to the direction of ice advance.
(4) It has an abundant concentration of gold grains in the 50–150 micron size range.

The precise orientation of the dispersal train cannot be determined because the drilled area is small relative to the Golden Pond source, and also because the host lower till horizon becomes thin and discontinuous to the south resulting in a train with a known maximum length of up to 400 m. However, the distribution of the train with respect to bedrock mineralization is consistent with the southwestward to southward direction of lower till transport that has been established for the surrounding region (Shilts, 1980; Baker et al., 1984; S.A. Averill, pers. commun., 1984). It is interesting to note that ODM speculated that if the lower till was transported in a southwestward direction, the presence of Au in the till in hole 70275 suggested that the Golden Pond mineralization extends further to the east than shown in Fig. 3. This indeed proved to be the case as diamond drilling in December 1983 and January 1984 extended the Golden Pond zone another 400 m to the east.

GOLDEN POND EAST ZONE DISCOVERY

Following the success of the orientation survey, reverse-circulation till sampling was used as a screening tool to evaluate geophysical and/or stratigraphic targets east and west of the Golden Pond zone prior to diamond drilling. During the initial sampling program in January, 1984, and a second phase in March–April, 1984, (Fig. 11), targets were tested at intervals of either 300 m or 400 m along strike and 25–100 m down-ice. This resulted in the identification of at least two anomalous dispersal trains, one located 1 km west of Golden Pond and the other 2.5 km east of Golden Pond. The remainder of this section will refer exclusively to Golden Pond East.

The Au-As dispersal train at Golden Pond East was evident in two reverse-circulation holes drilled 300 m apart in April 1984 (Fig. 12, holes 71432 and

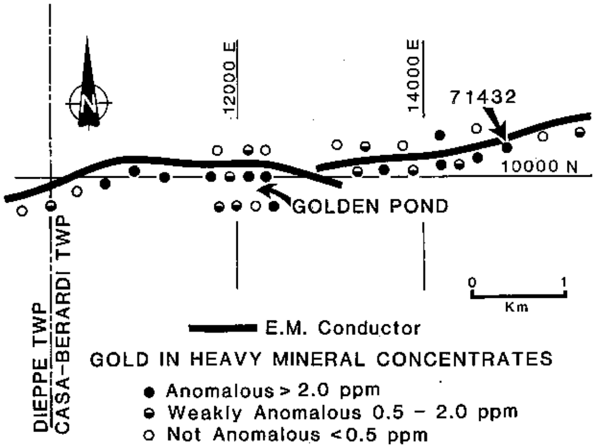

Fig. 11. Plan showing results of reverse-circulation drilling from the Golden Pond orientation survey and exploration follow-up east and west of Golden Pond. Anomaly classification is based on the highest heavy mineral concentrate (HMC) gold assay from the bottom three samples.

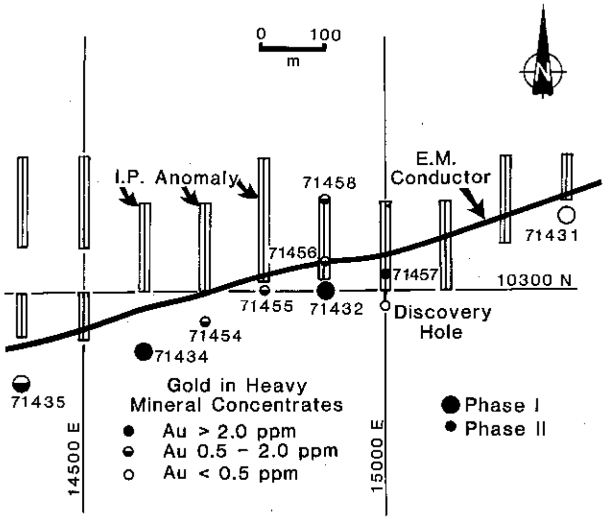

Fig. 12. Plan showing the results of the initial and follow-up phases of reverse-circulation drilling at Golden Pond East.

71434). The most anomalous hole was 71432 on Section 14900E. As shown in Table 2, the heavy-mineral concentrates from the bottom two till samples are strongly anomalous in both Au and As. The value of 57 ppm Au from the bottom sample was the highest gold assay returned from the reverse-circulation drill program up to that time. Twelve sharply delicate gold grains 50–150 microns in size were identified when the sample was panned (Fig. 13). It was concluded that the source was within 50–100 m and that most of the Au mineralization could be of the invisible type.

Fig. 13. Photograph of delicate gold grains from Sample #12 in RC hole 71432.

Follow-up reverse-circulation till sampling, denoted by the smaller circles on Fig. 12, was undertaken on 100-m centres in June 1984 to further define the anomalous dispersal train. The collar positions of both the initial and follow-

TABLE 2

Selected heavy-mineral concentrate assays – Golden Pond East

Sample #	From (m)	To (m)	Interval (m)	Log	Au (ppm)	As (ppm)	S (%)
RC Hole 71432							
9	28.5	29.5	1.0	Till	0.02	14	0.2
10	29.5	30.5	1.0	Till	0.01	14	0.1
11	30.5	31.5	1.0	Till	32.1	16,000	7.9
12	31.5	32.1	0.6	Till	57.0	19,000	14.0
13	32.1	36.3	4.2	Rock			
RC Hole 71457							
9	22.5	24.0	1.5	Till	0.3	390	2.4
10	24.0	25.5	1.5	Till	0.3	1,000	3.2
11	25.5	27.0	1.5	Till	0.3	390	1.3
12	27.0	27.4	0.4	Till	106.0	140,000	21.0
13	27.4	29.0	1.6	Rock			

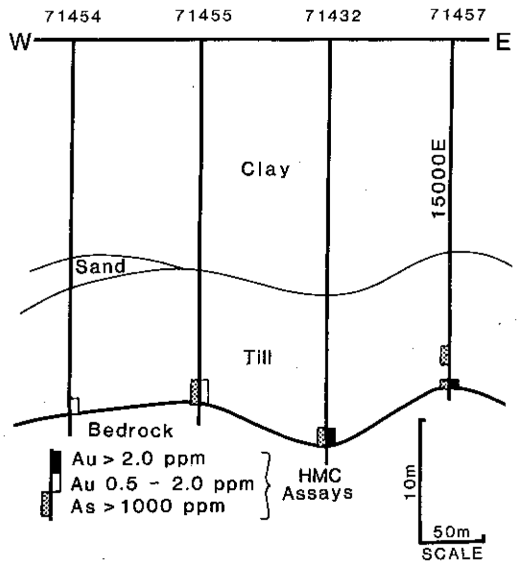

Fig. 14. 10300N Section at Golden Pond East showing overburden stratigraphy and heavy mineral concentrate (HMC) geochemistry immediately down-ice (0–30 m) from Au mineralization.

up phases of reverse-circulation drilling in relation to the electromagnetic conductor and IP anomaly are outlined in Fig. 12, as is the position of the eventual diamond drill discovery hole on Section 15000E.

The glacial stratigraphy at Golden Pond East as shown on Section 10300N (Fig. 14) over a distance of 300 m is simpler than that at Golden Pond. It consists of till overlain by fine and gritty clays. Most of the till is upper till similar to that at Golden Pond with approximately 70% local clasts. A thin veneer of lower till, with up to 80% local clasts, is present locally at the base of the till section. However, because of the absence of the lower sediment unit, it is difficult to distinguish it from the upper till. Overburden depths in the area average 25 m.

The heavy-mineral concentrate from the bottom till sample of hole 71457 drilled on Section 15000E contained approximately 700 sharply delicate gold grains mostly in the 50–100 micron size range (Fig. 15) and assayed 106 ppm Au and 140,000 ppm As. The anomaly is confined to the bottom sample and the conclusion by ODM early in July that the sample was effectively at source was confirmed a few days later by assays of up to 8.8 ppm Au from bedrock chip samples of pyritic quartz carbonate vein material.

Limonite spots are evident in the surface pits of some gold grains from Sample 12 in hole 71457 (Fig. 15) and probably record pre-Pleistocene weathering of the top of the Golden Pond East zone. Most of the arsenopyrite occurs as twinned prisms (Fig. 16) rather than columnar prisms as at Golden Pond.

The discovery diamond drill hole of the Golden Pond East zone was drilled

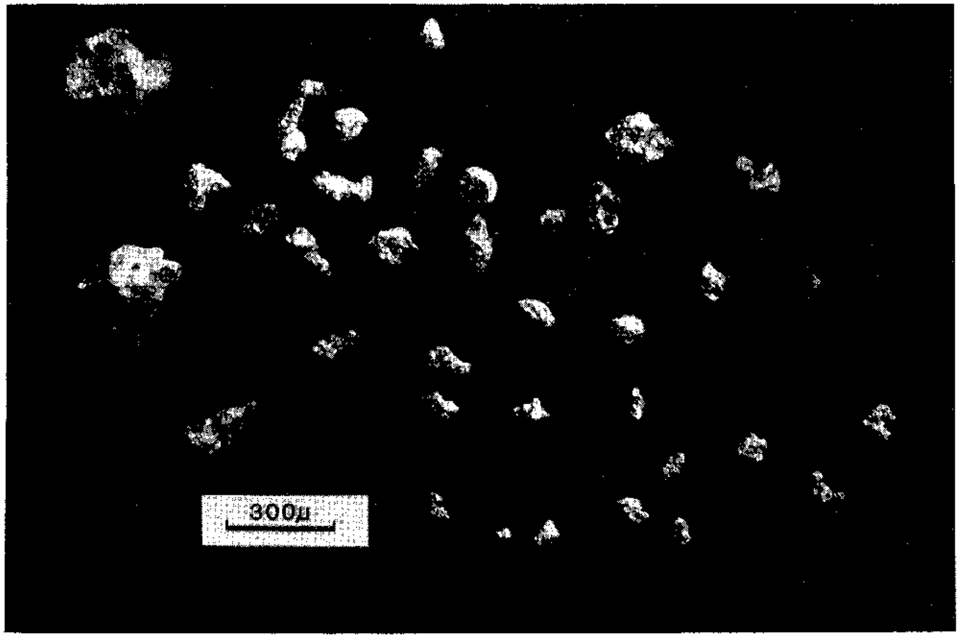

Fig. 15. Photograph of abundant delicate gold grains from Sample #12 in RC hole 71457

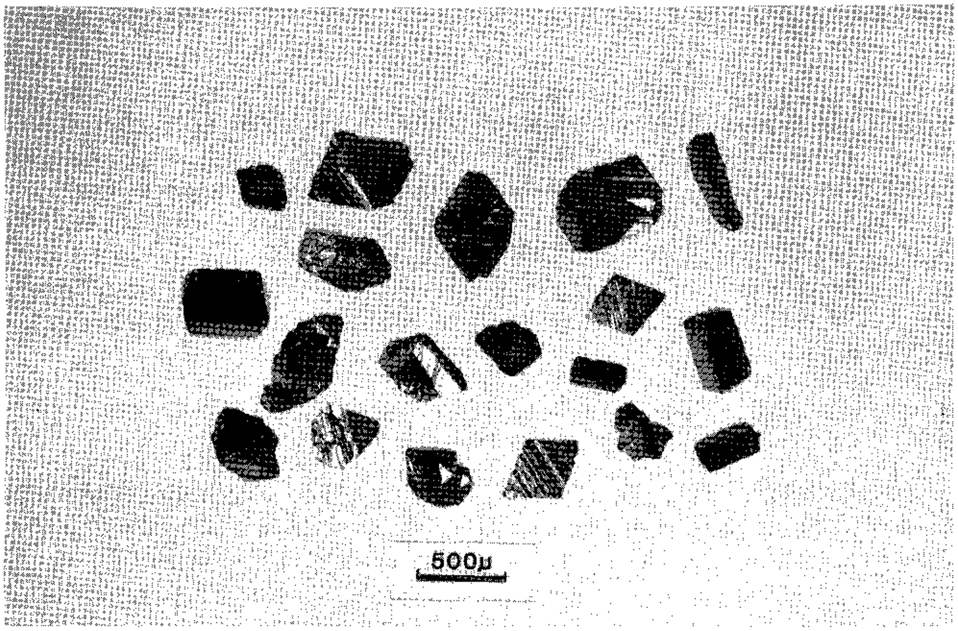

Fig. 16. Photograph of arsenopyrite grains from Sample #12 in RC hole 71457.

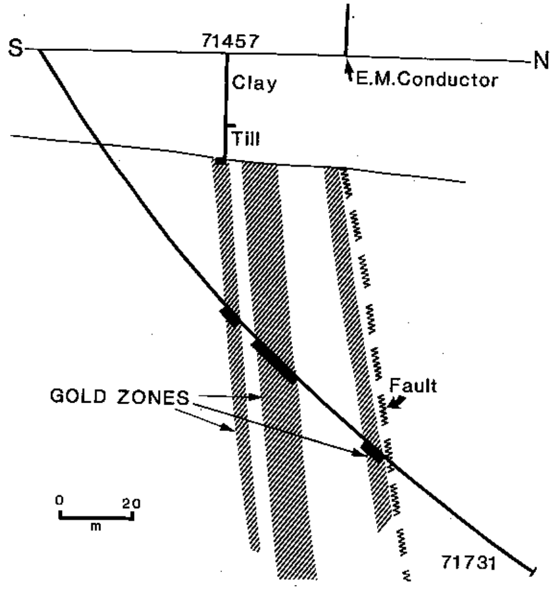

Fig. 17. 15000E Section showing the Golden Pond East mineralized zones and their spatial relationship to the discovery borehole and reverse-circulation hole as well as the E.M. conductor and major fault zone.

in July 1984. Figure 17 depicts the position of the Golden Pond East mineralized zones with respect to the strongly graphitic fault zone on Section 15000E. The reverse-circulation hole which actually intersected one of the mineralized lenses of the East zone was drilled 30 m south of the eletromagnetic conductor which traces the fault. Mineralization is similar in character to that at the Golden Pond zone and consists of pyrite-arsenopyrite-native Au-bearing quartz-carbonate veins up to 10 m thick in an intercalated sequence of carbonatized sediments and volcanics. The significance of the discovery of the Golden Pond East zone is evident from the preliminary undiluted drill indicated mineral resource estimate of 3.0 million tonnes grading 9.9 g/t Au (Northern Miner, March 14, 1985). This includes a higher-grade lens of 1.0 million tonnes grading 14.3 g/t Au.

OVERBURDEN SAMPLING COSTS

Between December, 1983, and July, 1984, a total of 2861 m of reverse-circulation drilling was undertaken in 91 holes on the Casa-Berardi property. This includes the orientation survey as well as all exploration and follow-up programs. The total cost of the program was $248,000 or $86.70 per metre and is broken down as follows: $130,000 for contract reverse-circulation drilling, $52,000 for consulting services, sample preparation and assays, $46,000 for salaries and overhead and $20,000 for road construction. The cost of overburden sampling using the reverse-circulation drilling and heavy mineral separation methods is essentially equivalent to the cost per metre of diamond drilling.

CONCLUSIONS

The Golden Pond orientation survey in December, 1983, was successful in identifying a strong Au-arsenopyrite-pyrite dispersal train within the lower till horizon. The till mineralization matches the mineralization in the Golden Pond zone and occurs only on the southern down-ice side of the zone. Clearly, the till mineralization is derived from the Golden Pond zone and constitutes an example of a glacial dispersal train. Thus, the orientation survey demonstrated that the reverse-circulation heavy-mineral exploration method could be used effectively to explore for similar deposits elsewhere in the Casa-Berardi area.

Follow-up overburden sampling in early 1984 encountered an anomalous Au-arsenopyrite-pyrite train 2.5 km east of Golden Pond. Closer-spaced reverse-circulation drilling in June 1984 to better define the dispersal train led to the diamond drill discovery of the Golden Pond East zone in July 1984.

Although the total cost per metre ($86.70) of overburden sampling by reverse-circulation drilling is essentially equivalent to that of diamond drilling, Inco's experience in the Casa-Berardi area has shown that the method is capable of defining prime drill targets quickly and reliably. The fact that the time between the orientation survey at the Golden Pond zone and the discovery of the Golden Pond East zone 2.5 km to the east totalled only seven months represents an impressive success for overburden geochemistry as well as for Inco and ODM.

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