Comments on draft policy Assessment Work - Types

Re: Grass Roots Prospecting

Undiscovered outcrops of mineralised rock are now considered to be very uncommon in Ontario, especially after 100+ years of countless prospectors searching for valuable deposits. The reality is that most often 'float' is found, which the prospector/exploration company then followed up by travelling a short distance up-ice (as in glaciation – "glacial transport is generally less than 2/3 of a mile" (reference OGS MDC 17 Abstract)) & digging a hole or trench to look for buried float, and repeated until (hopefully) the source is found. *See OGS-Mineral Deposit Circular 17 – Ontario Occurrences of Float, Placer Gold, and Other Heavy Minerals, 1978, page 1 '*Introduction*', & pages 4-7 regarding *Glacial Transport, Boulder Tracing,* and *Indicator (mineral) Trains*, notably gold grains and Kimberlite Indicator Minerals (KIMs).

This basically defines 'Grass Root Prospecting'. Pages 191-193 of OGS MDC-17 specifically relates to initial (as in grass roots) prospecting for diamond 'outcrops' by locating kimberlite indicator minerals in soil samples, as in sediments or soils collected by hand shovel and/or hand auger. It would seem the search for & assays for KIMs should be allowed grass roots credits as it is for gold/base metals, etc., as noted on in "Assessment Work Costs" page 6, first and second paragraphs. The reason I bring this up is that I have recently been disallowed grass roots credits for these very activities in my 'first boots on the ground' traverses and till sampling to look for indicator minerals. It appears that diamond prospecting at this grass roots level may not be well understood, and it would be helpful/instructive to more clearly define/elaborate upon in the policy description of grass roots prospecting.

Similar to KIMs in diamond prospecting, the same technique is used when searching for metamorphic/magmatic massive sulphide indicator mineral (MMSIM) grains. Companies check for these grains in till samples when looking for massive sulphide Ni-Cu deposits. (See page 38 of *Gao, C. 2012. Results of regional till sampling in the Cobalt–New Liskeard–Englehart areas, northern Ontario; Ontario Geological Survey, Open File Report 6259, 87p.*) In the search for high grade chromite (Ring of Fire), anomalous chromite in drift (i.e., till samples) is a good indicator mineral.

Comments on draft policy Assessment Work - Costs

Separately, at the moment in Kirkland Lake, there are essentially no experienced field workers available at any cost (they've pretty much retired or now work in local mines for double the wage plus benefits), and you expect $350/day, the maximum for assessment work, will bring them back?

- $350/day = $43.75/hour

- Speaking of contractors, my mechanic now charges $110/hour for his labour; Furnace contractors are $140/hour/man, including their time travelling to and from a job; other trades are similar in cost.
- 11 years ago I was working for Frank Basa (Gold Bullion Development Corp and Castle Resources, now Canada Silver Cobalt Works) doing similar work to my own ventures in diamond exploration. I was earning $500/day + mileage, all expenses, plus a cabin with meals at the Auld Reekie Lodge in Gowganda.
- As a self-employed drywall contractor in the 1970s-1992, I was earning $60/hour doing piece work. Now at recent prices I would be earning more than double that.

*I'm including the relevant pages from OGS-MDC 17 (Ferguson, Freeman 1978) for ease of reference.

http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/MDC017//MDC017.pdf

and page 38 from (Gao, C. 2012). Results of regional till sampling in the Cobalt–New Liskeard–Englehart areas, northern Ontario; Ontario Geological Survey, Open File Report 6259

http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/imaging/ofr6259//OFR6259.pdf

(Page 1, Ferguson, Freeman 1978)

ONTARIO OCCURRENCES OF FLOAT, PLACER GOLD AND OTHER HEAVY MINERALS

INTRODUCTION Mineral exploration has long been an active pursuit of both individuals and mining companies in Ontario. In recent years there has been a resurgence of interest in prospecting by individuals as a full-time occupation, but more especially as "weekend prospectors". Accordingly, it was thought appropriate to collect together the reported instances of mineralized fragments dislodged from their bedrock source so that the techniques of tracing such fragments to their source as well as the locations of known fragments would be available to those interested in mineral exploration. Loose pieces of rock or vein materials that have been separated from the bedrock by weathering and erosion are called 'float' and if the material has been transported and deposited by glacial action the float boulders generally occur in 'till' of 'glacial drift'. Glacial erosion of ore deposits that in most cases have been deeply weathered by a long, previous erosion cycle produces a train of fragments ranging in size from boulders to clay-sized particles. An age-old method of prospecting, that has been used since mining first began, has been tracing mineralized float, in order to locate the bedrock source of the mineralization. Recently the concept has been expanded to include all size fractions and to include geochemical determinations of the content of metal ions adsorbed to the surfaces of silt and clay particles. This broadening of the exploration technique has resulted in a renewed interest in float boulders as the possible starting point of an exploration program. Also, as the number of new finds decreases from prospecting outcrop areas, we must turn our attention to the drift covered areas. Professor A. Dreimanis of the University of Western Ontario has published two papers on tracing float. The first paper was called "Steep Rock Iron Ore Boulder Train" (Dreimanis 1956) and the second paper was "Tracing Ore Boulders as a Prospecting Method in Canada" (Dreimanis 1958). A review of boulder tracing case histories in Sweden is given by Grip (Grip 1953). A more recent collection of papers is called "Prospecting in Areas of Glacial Terrain", edited by M.J. Jones (Jones 1973, p.138; 1975, p.154). Some years ago, the writers began a compilation of float and placer gold occurrences as part of a lecture "Tracing Float and Mineral Fragments", delivered to Mineral Education classes (Ferguson and Freeman 1973, p.43-60). E.G. Bright (1973) formerly Regional Geologist at Timmins, compiled a map (Figure 1) showing mineralized float and heavy mineral occurrences in the Timmins area and stated that he knew the locations of eighty-two pieces of mineralized float. All the known occurrences of float, placer gold and indicator minerals for kimberlite were first compiled as open file report 5104 by S.A. Ferguson and released in May 1974. The present publication stems from OFR 5104 and is issued to provide easy access to as wide an audience as possible of the information contained herein.

(Page 4, Ferguson, Freeman 1978)

Glacial Deposits and the Occurrence of Float and Indicator Minerals

GLACIAL HISTORY Ontario has been exposed to winter's ice and snows for thousands of years. Every so often, however, ice has accumulated sufficiently to move over the landscape as large continental glaciers. Fortunately, at present, the glaciers have melted northward, and we are able to enjoy summer as a time to vacation, rockhound, and prospect. Glacial ice forms from the yearly accumulations of snow that have not melted during the summers. Eventually the snow granules are compressed to form ice granules and when sufficient ice has accumulated, glaciers begin to flow down hill into valleys and basins. At the Earth's polar regions, glaciers started expanding some 10,000,000 years ago, however, at the mid-latitudes large scale spreading of glaciers began somewhat more than 1,000,000 years ago. Evidence suggests at least four major ice advances have moved over the Ontario landscape; the most recent advance being termed the *Wisconsinan*, from the terminal deposits left in the State of Wisconsin about 18,000 years ago. Several advances and melt-backs (recessions) occurred during the Wisconsinan Glacial Stage overriding and altering the earlier glacially created landforms. Glaciers scoured and polished exposed rock surfaces creating scratched or striated rock surfaces (glacial striae). Glaciers also smoothed and elongated surface bedrock to create stream lined rock knobs (roche moutonnees) which indicate the direction of glacial movement. Drumlins are streamlined hills similar to roche moutonnees but composed of glacial debris with or without a bedrock core. Glaciers have left their scoured rock powder (rock flour) along with rock and soil debris (properly called till) in deposits called moraines. A terminal moraine is the ridge of debris, or till, along the front of a glacier marking the farthest advance of the ice. A recessional moraine is a similar ridge of till formed behind the terminal moraine during the melting back of the glacier. These moraines are roughly parallel and trend approximately at right angles to the glacial movement. During the melting or recession of the glaciers much meltwater was produced which redistributed the till into a number of features. Melt water drainage cut large river channels (called meltwater channels) and also cut spillways into the land at the point where glacial lakes drained. Today, with the land higher than when it was depressed by the weight of the glacier and with less water available, these glacial water courses are dried out or contain undersized "misfit" streams along their former courses. Some meltwater also flowed through constricted ice tunnels within or beneath glaciers depositing loads of sediment along their bottoms. When the ice receded long ridges of sand and gravel called eskers were left on the land. Glacial meltwater also flooded areas to form glacial lakes in which clay and silt settled out as glacial lacustrine deposits. Wave action within these lakes formed beaches and shorelines which may be seen in a few places along hillsides today. The major glacial features described above may be seen on the published maps indicated in Figure 2.

DISTANCE OF GLACIAL TRANSPORT A few glacial erratics have been transported long distances from their source areas. For example, a distinctive jasper pebble conglomerate from the North Shore of Lake Huron was transported about 620 miles (1,000 km) southwestwards to the vicinity of Columbia, Missouri, U.S.A. At one time this was assumed to be the general case and it certainly appears to be true for boulders of iron ore. However, more detailed studies have shown that the over lying glacial soils and rock fragments are generally representative of the underlying bedrock. In 1957 D.F. Hewitt (Geological Branch, personal communication) made pebble counts from gravel pits in southern Ontario and found that the largest percentage of pebbles were local in origin. Grid sampling of the till and outwash to the southeast of the mines at Kirkland Lake showed that at a distance of 2,000 feet (610 m) from the source the gold content ranged from l to 10 particles, but at a distance of 10,000 feet (3050 m) gold was generally absent (Lee 1963, p.26). "Airborne radiometric measurements give an average analysis over a large area, including outcrop and overburden, but it is generally true that overburden radioactivity relates closely to that of the underlying rock". (Darnley et al. 1971, p.36). This observation is additional evidence that the overburden itself is essentially local in nature.

(Page 6-7, Ferguson, Freeman 1978)

BOULDER TRACING Boulder tracing has long been an established technique which begins as a visual scrutiny of clasts exposed on or near the surface. Roads and railway cuts, gravel pits, areas burnt over or cleared for farming are easiest to investigate. Boulders of interest are broken with the hammer and examined with the hand lens. Rusty, stained or weathered boulders, are of major interest to prospectors, especially if the rusty appearance is due to the weathering of sulphide minerals. It should be remembered that rusty stains may also be owing to the weathering of iron carbonate minerals. Boulders of particular rock types which may be associated with economic mineralization should be recorded, as well as boulders of distinctive rock types which may assist in following the train, particularly if the mineralized clasts of interest are not abundant. Additional field observations can be made using a magnet, or a small electromagnetic unit such as a mine detector for sulphide minerals and magnetite, or a geiger counter or scintillometer for radioactive boulders. In a detailed survey, the ground is prospected very thoroughly until all clasts of interest have been located and are plotted on a map in order to assist in systematically following the train. Records should be kept of the dimensions of the clasts, the roundness, surface features, minerals present and reaction with geophysical instruments.

INDICATOR TRAINS The following description of indicator trains is taken from Shilts (1975, p.80):

"Indicator trains are finger or ribbon shaped in plan view and vary in size and intensity according to the interactions of a number of factors, the most important of which are (1) type of fraction analysed, (2) degree of weathering of samples, (3) uniqueness of the component traced with respect to background bedrock, (4) size of the source, (5) resistance of the component to abrasion (mineralogy), (6) roughness of topography in the dispersal area and (7) topographic position of the source, whether protected or exposed to glacial scour".

Some of the factors affecting indicator trains are also described by Shilts (1975, p.76-78) as follows:

"(1) If the lithological, mineralogical or chemical properties of the source of an indicator train are very different from those of the bedrock in the dispersal area, the indicator train will be distinct for a longer distance. For example, ultrabasic sources are usually easy to detect and have long, well-developed trains of nickel, chromium, cobalt and magnetite, components that are much less concentrated in the surrounding bedrock. . . " (76)

"(2) The size of the source, its orientation with respect to glacial flow and its topographic position influence the size of its dispersal train. If the source is in a protected hollow or on the "lee" (down-ice) side of a ridge, it was not so available to glacial erosion as if it formed a ridge or occurred in an exposed position". (76)

"(3) The roughness of the topography in the dispersal area controls the shape of indicator trains and the distance to which they can be traced. Debris that was

carried near the base of a glacier was often blocked or diverted by hills or ridges in the dispersal area". (76)

"(4) The mineralogy of the source affects both the strength and size of the dispersal train. Rocks com posed of soft minerals such, as serpentinized peridotites, are easily ground up, producing particles from clay to boulder size. Thus, serpentine is a common component of all textural classes of till from the source to the limits of detection of a train. Sulphides, being harder and more difficult to crush, are found predominantly in the sand sizes throughout the train, as are hard minerals such as chromite and magnetite. In the case of these latter three minerals, the mineralogy has an important influence on how the minerals, dispersed in a train by glaciers, have behaved under weathering conditions. Stable minerals (magnetite) are unaffected by weathering, but unstable minerals (sulphides) are broken down in weathered deposits". (78)

"Once a method of sampling and analysis has been established as effective, maps are drawn showing the dispersal of mineral fragments or of the cations re leased by their weathering. It is useful, if time and geological information permit, to map a dispersal train of some distinctive rock or mineral to serve as a model for the interpretation of less well-defined trains of economically interesting components . . . . The finger-or ribbon-shaped plans and long distance of transport are typical of most glacial dispersal trains studied in Canada. The "fan" shapes depicted on many published dispersal maps usually apply to boulder-sized erratics and outline the total area of dispersal, not the zones of maximum concentration".

(Page 191-194, Ferguson, Freeman 1978)

INDICATOR MINERALS An indicator mineral or pathfinder mineral is any mineral that aids in the discovery of an associated economic mineral. The indicator mineral may be more abundant, or may be easier to identify, or may enlarge the target area as part of a suite of associated minerals. Boyle (1974, p.1,3) has pointed out that associations of particular minerals are not fortuitous but are related to intrinsic chemical properties, and the conditions that prevailed at the time of deposition and in the subsequent weathering process. Indicator minerals may be identified directly, or by geochemical means which will determine the metallic or cation component of the mineral.

Indicator Minerals for Gold A heavy mineral study was carried out in the Klondike Area, Yukon Territory by the Geological Survey of Canada. From this study Gleason (1970, p.55-56) made the following observations:

"Pseudomorphs of goethite, limonite, and less commonly hematite, after pyrite are found in quantity in the creek gravels and eluvium over and near de posits of lode gold. Also associated with these depo sits are small amounts of galena, and in some places chalcopyrite and sphalerite. In addition, barite, muscovite (sericite), magnetite, chlorite, and apatite are common heavy minerals associated with one or more of the four types of lode gold deposits. The best pathfinder heavy mineral for gold in the area is gold itself. . . . Indicators are that geochemical prospecting using soil analyses would be a more useful, cheaper, and a faster method for outlining gold-bearing structures than heavy mineral work. Zinc, lead, and possibly copper are the pathfinder elements for gold."

The geochemical association of arsenic, mercury, antimony, and tungsten was known to exist at several gold mines in north-central Nevada. A geochemical survey carried out by Erickson et al. (1966) of the United States Geological Survey located an area that was anomalously high in arsenic, antimony, and tungsten, and it was assumed that the area should also be anomalously high in mercury and gold. This assumption proved to be correct and resulted in the discovery of the Cortez gold deposit containing 3.4 million tons (3.45 million tonnes) with an average gold content of 0.29 ounces per ton (Wells et al. 1969, p.526- 527; and Figure 7, this report).

INDICATOR MINERALS FOR KIMBERLITE Indicator minerals for kimberlite are pyrope garnet, magnesian ilmentite, olivine, and chrome diopside. The presence of any of these minerals is of interest but higher concentrations, larger and more angular fragments, or two or more of the minerals occurring together increases the probability that the source is not far distant.

Pyrope Garnets within eclogite inclusions in kimberlite, basalts, and layers in ultramafic rocks con sist of more than 55 percent pyrope. Similar inclusions in migmatite, gneissic terrain contain from 30 to 55 percent pyrope in the garnets (Coleman et al. 1965, p.483). Wright (1938, p.441) gave the average proportion of pyrope molecule in garnets in particular rock types as: kimberlite 72.3 percent; ecologites 37.4 percent; other basic rocks such as gabbros, anorthosites, and basalts 20.7 percent; amphibolite schist 20.3 percent; and biotite schist 13.8 percent. The presence of pyrope in association with magnesian ilmenite and chrome diopside suggest a kimberlite source. Most of the garnets in the heavy mineral concentrates from the James Bay Lowland collected by Wolfe et al. (1975, p.52-54) were angular and of no particular shape. The pyrope garnets were few in number and generally smaller than the other garnets with an average diameter of l mm (0.4 in.). Of the 20 pyrope grains identified 19 were approximately spherical and 1 grain was angular. The colour of the pyrope garnets varies from pale pink or pale red with a touch of purple, to pinkish-red-purple, to an intense reddish purple. The index of refraction is 1.76 or less and electron probe analyses of 10 grains showed the pyrope molecule to range from 66.8 to 73.7 percent. Well rounded pyrope grains having the appearance of highly abraided material is generally interpreted as evidence of transport and abrasion over a long distance. However, pyrope garnets in kimberlite occur as spherical nodules and the sphericity cannot be confidently related to rounding due to weathering and sedimentary processes.

The following excerpt is from Satterly (1971, p.21):

"Turskiy describes the use of Timofeyev's capillary tube (2-4 mm (0.8-1.6 in.) diameter rod with a 3-5 mm (1.2-2 in.) deep cup at one end) and heavy liquids for the identification of pyrope and magnesian ilmenite in prospecting for diamond deposits. Pyrope with a specific gravity of 3.70-3.75 is most common in kimberlites, and can be separated from almandine of a similar colour by using a liquid of gravity 3.8 in which a grain of pyrope floats and almandine sinks."

Magnesian Ilmenite Magnesian ilmenite or picroilmenite contains from 8 to 16 percent MgO. Wolfe et al. (1974, p.57) performed analyses on 14 grains suspected of being magnesian ilmenite all of which were black in colour, somewhat rounded, and with a subvitreous lustre. Analyses were performed for MgO, TiO_2, and FeO and only one grain was found to have a high enough magnesia content to be classed as magnesian ilmenite and five other grains were ilmenite with a low percentage of magnesia. Two grains were rutile and six were not ilmenite. Tremblay (1963) reported 2 grains of ilmenite as of probably kimberlitic origin in samples T55-62 and T69-62. **Chrome Diopside** Chrome diopside should contain more than l percent chromium (Dana and Ford, 1932, p.558). In the James Bay Lowland Wolfe et al. (1974, p.29 and Table 5) were unable to identify any chrome diopside. Fifteen grains were selected as possible diopside of which three were diopside without chrome and light grains were chrome-bearing diopside with the chrome content ranging from 0.09 to 0.57 per cent. Four of the eight grains displayed some cleavage and all the grains varied from light to dark green and olive, and one grain displayed some internal reflection. Sample T392-62 was reported by Tremblay (1963) as containing one grain of chrome diopside.

Abundance and Grain Size of Indicator Minerals The following description is abstracted from Satterly (1971, p.21,23). In the USSR studies were made on the grain sizes of indicator minerals downstream from the kimberlite pipes, which were supplemented by laboratory studies. The quantities of pyrope and magnesian ilmenite decrease little for l mile (1.6 km) from the pipe but the grain size decreases to a fraction of a millimeter, and laboratory tests on these minerals indicated that over a distance of 96 miles (154 km) they would be decreased to 10 percent of the original content. Olivine persists down stream for 3 to 3Vz miles (4.8-5.6 km) and chrome diopside persists for little more than few hundred yards. USSR experience shows that streams draining kimberlitic bodies contain anomalously high quantities of metals particularly zinc.

(Page 38, Gao, C. 2012)

Metamorphic/Magmatic Massive Sulphide Indicator Minerals

Metamorphic/magmatic massive sulphide indicator minerals (MMSIM®) are a group of stable heavy minerals typically derived, as Averill (1999) suggests, from volcanogenic massive sulphide (VMS) and magmatic Ni-Cu sulphide deposits, as well as from skarn and greisen rocks (Table 10). Common MMSIM® grains associated with VMS deposits include gahnite, chalcopyrite, red-rutile, staurolite, spinel, kyanite, Mn-epidote, orthopyroxene and sillimanite, whereas those with magmatic Ni-Cu deposits include Cr-rich phases such as Cr-diopside, chromite and Cr-rutile. It is noteworthy that anomalous counts of chromite in the drift material may indicate potential high-grade chromite mineralization in mafic and ultramafic igneous rocks as in the case of the McFaulds Lake ("Ring of Fire") area in the James Bay Lowland (Crabtree 2003). The metamorphic/magmatic massive sulphide indicator minerals occur in nonmineralized rocks; non-kimberlitic olivine, chromite and diopside derived from mafic to ultramafic rocks are also common in drift material sampled in northern Ontario (Averill 1999; Crabtree 2003). These minerals become significant only if other diagnostic minerals such as sulphides of the ore phases co-exist with them. However, sulphide heavy minerals are easily weathered and, with exception of chalcopyrite and, to a lesser degree, sphalerite, they are uncommonly preserved in the till and stream sediments (Barnett and Averill 2010). This often renders the use of MMSIM® for assessment of potential mineralization difficult. Gahnite is often enriched in zinc deposits during ore formation and stable in the subsequent secondary environment (Averill 1999; Crabtree 2003). Its coexistence with other MMSIM® in drift sediments may be linked to significant volcanogenic massive sulphide (VMS) type mineralization. The counts of MMSIM® are listed in Appendix 10. The counts of low-Cr diopside grains in this table differ slightly from those in the KIM data set where they are classified as MMSIM® or pseudo KIMs (see Appendix 6). As well, some picked ilmenite and chromite grains were reclassified as rutile and spinel on the basis of the microprobe data (see Table 7). For this reason, the number of low-Cr diopside grains from the KIM data set was used instead and the MMSIM® data set was adjusted to include the reclassified rutile and spinel grains. Also, chromite data from the KIM data set (see Appendix 9) was included here as part of the MMSIM® data set (see Figure 16). Although some low-Cr diopside grains are of kimberlitic origin, most of them likely come from non-kimberlitic sources such as ultramafic to mafic rocks (see Figure 21). Such mineral grains are abundant in the Precambrian bedrock terrain in the northern and southwestern parts of the study area. It was unexpected to find large concentrations of low-Cr diopside grains in the lake Timiskaming graben basin (Figure 40). This feature is probably related to glacial dispersion from mafic and ultramafic rocks situated in the Precambrian bedrock terrain north and northeast of the basin. Abundance of low-Cr diopside grains may indicate significant magmatic Ni-Cu mineralization in such igneous terrains (Averill 1999). Future work in this region is recommended.