W.A. No. ....

NAME JACK

SUBJECT REPORTS

PROPERTY FILE 82N088-07

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DIA MET MINERALS LTD. | ISLAND STAR RESOURCE CORP. | CHEVRON MINERALS LTD.

JACK CLAIMS

The Jack claims comprise eight blocks totalling 121 units in the Golden Mining District, British Columbia, 50 kilometers north of Golden. The claims cover a single kimberlite diatreme pipe, 54 acres in area, that intrudes sedimentary rocks of Paleozoic age. The Jack pipe and others in British Columbia were discovered by Geologist, Chuck Fipke of Dia Met Minerals, using his heavy mineral techniques in which specific indicator minerals unique to kimberlites were identified. Prior to 1982 there were no known kimberlites in British Columbia.

Detailed mineralogical and chemical analyses of the indicator minerals and geological considerations have shown that the Jack claims are an important geological target for the following reasons:

1. The chemical composition of the four most important indicator minerals, pyrope garnet, picroilmenite, chromite and chrome-diopside, equal or surpass the desired compositions of known diamond producing kimberlite pipes.

2. The areal extent of the Jack pipe, totalling some 54 acres, compares favourably in area with pipes found throughout the world that range in size from 1 to 360 acres and average about 30 acres. In general, the greater the size in area, the more productive is the pipe. The Jack pipe is the 10th largest kimberlite out of some 50 major diamond producers in the world.

3. An interpretation of seismic data by Price (1980) indicates the earth's crust above the Mohorovicic discontinuity to be between 50 and 55 km thick, northeast of Golden. Due to this inordinate thickness of crustal rocks, suitable conditions were available to permit diamond crystallization.

4. Processing of 29.5 kgs. of kimberlitic sample from the Jack pipe yielded a single micro-diamond that weighed 0.0004 gm or 0.002 carats or equal to a one point stone. For purpose of comparison, the diamond content of the average kimberlite now being mined is 0.25 carats per tonne or 0.0015 oz./tonne which is equal to 1 carat of diamond per 20 tonnes of kimberlitic ore processed.

From a statistical standpoint to have discovered a diamond in a test sample of this small size is either extremely fortuitous or indicative of a potentially diamond-rich kimberlite.

The property could become Canada's first diamond producer.

INTRODUCTION

Since 1976 a number of companies have explored the W. Cordillera of N. America for diamondiferous kimberlite and lamproite. These are not the only known hosts of diamond, but in the case of N. America they are probably the most important. In general, the exploration techniques used by each company are alike, however, in detail these techniques can be significantly dissimilar.

Most of the techniques are constructed in the anticipation that the diamond host will be a "typical" kimberlite, despite the fact that it is becoming increasingly difficult to satisfactorily define this rock type. An example of this problem is the recent recognition of diamondiferous lamproite in Arkansas that, for decades, was described as kimberlite and/or peridotite (Scott-Smith and Skinner, 1984, and Waldman et al, 1986)

Kimberlite most often contains a somewhat unique suite of silicates and oxides in concentrations that usually vary between about 0.5% and 10% of the rock by volume for each mineral. Each of these minerals is a member of the so-called heavy mineral suite, i.e. S.G. >2.9. The silicates also have very distinctive colors and the silicates and oxides have compositions that are, in general, restricted to occurrences in kimberlite. These characteristics have meant that these minerals lend themselves readily to discovery by heavy mineral geochemical exploration.

It is appropriate to note that the most diagnostic mineral that could be utilized in these programs is diamond, however, it occurs in concentrations in the host that are so low that its utility is severely restricted. It has been used very effectively in parts of Australia but this use is somewhat unique.

The following discussion will deal with kimberlite as the most common diamond host in the Cordillera. The recent recognition of lamproite as another important source rock has meant that the explorer need be aware that the differences from kimberlite are significant only to the extent that some of the kimberlitic minerals may not be as abundant in lamproite and that other non-"kimberlitic" minerals may be additionally useful in the exploration for diamondiferous lamproite.

This discussion will describe the results of geochemical programs carried out in three sub-areas in the Cordillera. In each case the geochemical techniques used for discovery were somewhat different as were the target kimberlites and the overall geological setting. Other factors such as climate, topography and drainage were also different and had a major impact on the design and execution of the subsequent exploration programs for each sub-area. The three areas to be discussed are in the foothills of the Colorado Rockies, the Main Ranges of the British Columbia Rockies and in the MacKenzie Mountains of the Northwest Territories. Refer to Fig. 1 for general locations of each of the areas.

SAMPLING TECHNIQUES

Common to all the areas that were explored is a topography of moderate to extreme relief produced by a well-developed drainage system of intermittent and perennial streams and rivers. Because of this, it was assumed that detritus from an eroding kimberlite would probably be transported from its source to the nearest drainage(s). This transport would be accomplished largely by mechanical agencies, principally soil creep and run-off accompanying rainfall and snow melt. The three case studies discussed here were therefore part of exploration programs that were designed assuming that discovery would be effected in large part by mineral anomalies in stream silts.

Although this assumption is self evident to most explorationists working in the Cordillera, this type of diamond exploration is significantly different from that practiced in other parts of the world. For example, much emphasis is placed on soil and loam sampling in southern Africa and South America because of the poorly developed drainage systems and/or a topography of little relief that does not promote effective dispersion of kimberlitic detritus.

Initially therefore, for all three areas, a "guesstimate" was made that a sample interval of about 1.5 km along all the major drainages would probably be sufficient to locate heavy mineral anomalies derived from kimberlites in the drainage basin. This sampling interval proved in most cases to be appropriate for discovery, although in many cases much follow-up sampling and reconnaissance mapping was necessary before such discovery was made.

To the extent that it was possible, i.e. dictated by the sample site and/or the medium being sampled, approximately 10 to 15 kg of minus 6 mesh sample was gathered at each site. Samples were invariably taken at those sites that were judged most likely to have concentrated the heavy fraction of the stream load. All samples were sent to the C.F. Minerals laboratory in Kelowna, British Columbia for initial processing, that is, the recovery and classification of the heavy mineral fraction.

This processing consists of three main stages: washing, screening and drying; heavy liquid separation (TBE and methylene iodide); and classification of the "heavies" into four categories using Frantz isomagnetic separators. These latter categories provide separates for each of the most easily recognizable kimberlitic minerals, viz., pyrope, chrome diopside, ilmenite and diamond.

Subsequent examination of the magnetic separates was usually carried out at the project offices or at a laboratory in Superior Oil Company's Tucson office. The objective of this examination was to label and describe the anomalous samples and extract from them a representative selection of the kimberlitic population for mounting prior to microprobe analysis.

Microprobe analysis was carried out at Superior's Geoscience Lab in Houston, Texas, or at the probe facility of the University of Cape Town's Geology Department. The importance of microprobe/SEM analysis will be discussed as a separate part of this paper. It is relevant to note here that it significantly contributes to the explorer's ability to rank anomalous drainages and, in so doing, shorten the time between anomaly recognition and diamond discovery.

COLORADO

The Sloan Kimberlites

This group of at least six Siluro-Devonian kimberlite pipes and an unknown number of dikes are located in Larimer County in north-central Colorado about 65 kms northwest of Ft. Collins (Fig. 1). They are included in a larger group informally known as the "State-line pipes" because the other pipes in the group define an area which straddles the state boundary shared by Colorado and Wyoming. All of the subsequent discussion will describe the geochemical exploration associated with the pipes and will refer to the dikes only where necessary.

The topography in the vicinity of the pipes consists of rolling hills with a relief of about 185 meters. The two principal drainages, Rabbit Creek and Meadow Creek are perennial, while their tributaries flow after heavy rains or during the spring thaw.

The hillsides and upland plateaus are covered by mixed aspen and coniferous forest while the valleys are predominantly grassland. It is important to note that the kimberlites are also usually covered by grasses for the most part. This phenomenon has not been studied in detail but it appears to be due to an aversion of the arboreal species to clay-rich soils in this part of Colorado and Wyoming.

The Sloan pipes are hosted by Precambrian crystalline and metamorphic rocks (Silver Plume Granite and its equivalents). Each pipe is quite different in shape, size and the nature of the various kimberlite intrusions that occupy the respective diatremes (Table 1). All of these bodies, including Sloan 1 and 2, are small compared to pipes that are commonly mined and which have surface areas that are typically larger than ±12 hectares.

TABLE 1

Physical Characteristics of the Sloan Kimberlites

Pipe #	Pipe Shape	Pipe Area (Ha)	Elevation (m amsl)	# of kimberlites within diatreme
1	Elongate	7	2200	8
2	Dike-like	3	2200	3
3	Irregular	<1	2300	?1
4	Irregular	1	2200	?1
5	Irregular	3	2300	3
6	Oval	2	2300	3

Sloan 1 and 2 are in fact parts of the same highly irregular-shaped diatreme. The eastern part of this diatreme, a 30 meter wide, dike-like extension, is known as Sloan 2. Sloan 1 is also rather complex in that it contains at least eight discrete kimberlite intrusions while Sloan 2 probably contains no more than three. Although Sloan 5 and 6 occur very close to each other, they are not known to be contiguous.

A limited number of absolute age dates have been reported for the pipes in the Colorado Rockies. Most recently, Smith (1983), obtained two ages from Iron Mountain in Wyoming, 308 ± 32 Ma and 395 ± 15 Ma, and one age from the Estes Park dike, 394 ± 45 Ma. The last two of these dates support a fission track age of 380 Ma reported by Naeser and McCallum (1977) from an unidentified pipe in the State-line group.

At the outset of exploration in Colorado, it was decided to sample all perennial and intermittent drainages at a three kilometer spacing. This distance was somewhat arbitrarily selected and the spacing was intended to be modified if circumstances dictated. In the case of Rabbit Creek a spacing of about a 0.8 km was initially selected because the presence of a number of kimberlites was suspected. In the case of Meadow Creek, the initial spacing of three kilometers was shortened to 0.8 km after the anomalous nature of the drainage had been established.

The geochemical dispersion patterns associated with the Sloan pipes is very much a reflection of their primary mineralogies. Sloan 1 and 2, for example, contain some kimberlites that are rich in pyrope and chrome diopside, i.e. these two minerals occur in concentrations of up to 5% by volume of the rock. At least two of the major phases at Sloan 1 do not, however, contain mesoscopic chrome diopside and pyrope. Much of the Sloan 2 diatreme is occupied by a single intrusion that contains megacrystic pyrope, chrome diopside and ilmenite and it is possibly this phase that dominates the kimberlitic detritus downstream from that pipe as well as Sloan 1.

The diamond population at Sloan 1 and 2 contains a spectrum of shapes from those are are well preserved octahedra to types that are highly resorbed tetrahexahedra. Colors range from those that are near D or E to some that are very dark brown - yellow stones are very rare. A typical selection of gem diamond shapes is shown in Figure 3.

The distribution and mode of the anomalous samples in Rabbit Creek is shown in Figure 2 at fourteen sites. This diagram details only the results for mineral abundances in the -60 to +120 mesh fraction. Chrome diopside at each of the sample sites usually occurs as angular to subangular grains because it seems to disintegrate readily into progressively smaller pieces as a function of a very well developed cleavage and distance from source. Pyrope on the other hand, is commonly rounded to subrounded, although angular grains are present in some of the samples.

The number of mineral grains occurring at each site exhibits a general decrease with increasing distance from the source kimberlites. However, there are a number of sites at which there is a significant increase in the number of minerals relative to the site immediately on the upstream side. This phenomenon is true for both minerals sampled. Once it was established that this was not due to the ingress of "new" kimberlitic detritus from an additional source, it was concluded that the site(s) probably represented more favorable conditions for the concentration of heavy minerals.

The dispersion of kimberlitic minerals from Sloan 5 and 6 in Meadow Creek is also shown in Figure 2. Notice that the stream load does not contain chrome diopside because most of the source kimberlites, like some of those at Sloan 1, are chrome diopside poor. These kimberlites do, however, contain pyrope but the dispersion pattern for this mineral is unusual in that its relative abundance shows an increase with distance from source. In the case of this particular creek it is unlikely that this is phenomenon is an artifact of site specific concentrating conditions. Alternatively, it could be due to a progressive change in the gradient of the stream, which becomes flatter towards its point of entry into Halligan Reservoir. This would imply that as the gradient flattened, more and more of the sediment load would be deposited.

BRITISH COLUMBIA

Jack Diatreme

The Jack is the larger of at least two diatremes in a group that occurs about 35 kms northwest of Golden in east-central British Columbia (Fig. 4). These two pipes are at the northwestern end of a kimberlitic province that is approximately 50 kms long (NW-SE) and 8 kms wide and is parallel to the regional tectonic fabric.

Topography in the area of the diatreme is extreme - relief is on the order of 1800 meters. The drainage pattern is dominated by a number of small creeks with high gradients that are the tributaries of streams that occupy the bottoms of large glaciated valleys. During the winter the smaller tributaries are frozen over, as are parts of the larger streams, however, during the spring thaw flow in all these drainages is torrential. Mechanical dispersion of detritus under these fluvial conditions is therefore very efficient.

The diatreme is hosted by Late Cambrian to Ordovician and ?Silurian carbonates which form part of the east dipping limb of the Cockscomb anticline, which in turn is thrust easterly over the U. Devonian on the west dipping Mons fault (Northcote, 1983, and Wheeler, 1962).

The age of emplacement of this diatreme has not yet been determined. Structurally, it may pre-date Laramide deformation which, in this part of the Rockies, was dominated by folding and major imbrication. Because the diatreme rocks exhibit a very weak foliation the pre-Laramide, or even late syn-Laramide, age is suggested. This latter age is very different from the 241 ± Ma age obtained by Smith (1983) for the Cross pipe, which is about 250 kms to the southeast. It is also very different from the 408 ± 15 Ma date obtained by Wanless et al (1965) from a small pipe about 30 kms to the south of the Jack.

The dimensions of the Jack can best be approximated by outcrops of kimberlitic marl and tuff occurring along a ridge which strikes southeast from Lens Mountain and separates the Lyell icefield from a smaller icefield to the southwest (Fig. 5). One large outcrop of marl is located within the smaller icefield. Together, these limited outcrops define a pipe that measures at least 1.20 kms by 0.50 kms for an aggregate surface area of about 58 hectares, making this one of the larger kimberlitic pipes in the world. The marls that make up at least 75% of the outcrop are epiclastic, i.e. they accumulated as back-wash sediments in the crater created by the explosive emplacement of the diatreme.

The dispersion pattern for kimberlitic detritus from the Jack is shown in Figure 5. During initial sample investigation only the -60 to +120 mesh fraction was examined. Of all the samples examined, only one (L113) contained a single grain of chrome diopside. Subsequent examination of the -120 mesh fraction of these same samples yielded a number of samples containing both chrome diopside <u>and</u> pyrope. Furthermore, the results of the sampling indicated that there are at least two sources of kimberlitic detritus in the headwaters of the drainage sampled by sample L113.

Sample G87 contains detritus that is probably derived from the Jack, while sample G88 probably contains detritus from another kimberlite. This interpretation is possible because the character of the two samples is so different; whereas G87 is pyrope-rich and contains no chrome diopside, G88 is chrome diopside-rich but contains subordinate pyrope. It is possible, though, that this difference in the make-up of the two samples is an artifact of the sampling procedure. Downstream from these two sites the drainage contains minerals derived from both sources.

NORTHWEST TERRITORIES

The Mountain Diatreme

This large diatreme is one of a small group, numbering perhaps three or four, that occur in the Sayunei Range of the western NWT. The Sayunei Range is part of the northern Mackenzie Mountains. The diatreme is about 195 kms southwest of Norman Wells, a settlement on the Mackenzie River.

Topography in the area consists of mountains that are commonly between 1980 and 2100 meters high, incised by broad valleys that have elevations between 1200 and 1500 meters. The valleys are occupied by streams and rivers that flow only during the short summer season. Dispersion of kimberlite detritus has been very efficient as in the case of the Jack.

The Mountain has been emplaced into unnamed Early Cambrian to Middle Ordovician carbonates and Early Ordovician to Early Silurian Mt. Kindle carbonates. The Mountain, as well as some of the satellite diatremes, occurs at or near the edge of the carbonate platform of the Mackenzie Mountains (Godwin and Price, 1986). The same authors report radiometric dating (K-Ar and Rb-Sr on phlogopite) that has yielded two Silurian ages for emplacement, i.e. 445 ± 17 Ma and 427 Ma.

The diatreme measures approximately 850 meters by 450 meters and has a surface area of about 9 hectares. It is geologically simple in that it is occupied by only two major kimberlitic phases, a central green breccia and a marginal rusty weathering breccia. Godwin and Price (1986) have mapped three other phases that are volumetrically minor. One of these phases, the epiclastic reworked tuff, is important because it indicates that the diatreme is exposed very near its original surface of emplacement and has undergone minimal erosion since that time. This is analogous to the level of exposure of the Jack. Unlike the Jack however, the Mountain Diatreme was preserved by deposition of younger sediments very soon after its emplacement and it is only recently that it has been exhumed (post-Eocene).

This exploration example affords a good illustration of the necessity of adapting geochemical techniques to a very specific target. The detritus downstream from the diatreme is dominated by kimberlitic zircon and kimberlitic chromite, whereas chrome diopside, pyrope and picroilmenite are very minor constituents.

Dispersion of this detritus is illustrated in Figure 6 for results from the -60 to +120 mesh fractions. The mineral train is considerable, i.e. at least 10 kms and to some extent this is a function of geography. Because of the high latitude, oxidation of kimberlitic rocks is minimal and has resulted in the unusual occurrence of large (± 1 meter diam.), ice-rafted boulders of the diatreme rocks at least 5 kms downstream from their source. In addition many smaller kimberlitic boulders have been transported downstream for at least 3 kms by run-off. Both of these phenomena mean that there are sources for detritus, that are a considerable distance from the diatreme and which contribute to the drainage being sampled. It is very rare to find kimberlitic rocks as part of the boulder train at lower latitudes, e.g. in Colorado.

The behavior of the geochemical anomalies is also unusual inasmuch as zircon exhibits a pattern of decreasing abundance with distance from source, whereas the pattern for chromite is just the opposite. Admittedly, this conclusion is based on a small number of sample points, nonetheless it is difficult to explain this phenomenon as it relates to two minerals with similar densities.

MICROPROBE GEOCHEMISTRY

The compositions of some members of the pyrope family have made it possible to devise a target-ranking technique that significantly improves the explorer's ability to discover diamond-bearing kimberlite. The technique described below refers, thus far, only to pyrope derived from diamondiferous, peridotitic kimberlite. At least two other ultrabasic rocks contain diamond, namely eclogitic kimberlite and lamproite. The basis for the technique is the hypothesis that mantle peridotite contains an assemblage of minerals, especially diamond and pyrope, that become part of a kimberlite melt by disaggregation of such entrained peridotite as the melt rises to the earth's surface.

The pyropes, Group 10 of Dawson and Stephens (1976), that are so useful in this respect have been described and discussed by Sobolev et al., (1973), Boyd and Gurney (1982) and Gurney (1984). Shown in Figure 7 are binary plots of pyrope compositions from the matrices of a number of kimberlites, from those that are barren or very low-grade to two pipes that are currently being mined. These plots are a modification of those as used by Sobolev (1974). Note: these "Sobolev diagrams" are not, by implication, a more useful way of illustrating the data than those used by Gurney (1984).

The plots are derived from SEM analyses carried out at Superior Oil's Geoscience Lab in Houston and/or at the probe facility of the Geology Department at the University of Cape Town. Also included are some data from the literature, although these comprise less than 10% of the points shown. Each of the plots is subdivided into four rectangular areas. The most important of these is in the lower left corner and defines the field of compositions similar to pyropes that are most typically found as diamond inclusions. The upper right area usually includes the majority of pyrope compositions for peridotitic kimberlite that correspond to Group 9 of Dawson and Stephens (1976).

The first two plots shown include no compositions in the "diamond inclusion" (DI) field and are representative of pipes that are very low grade or barren, i.e. Jack and Lovedale. The Lovedale pipe referred to here is in the Cape Province of South Africa and should not be confused with the diamondiferous pipe of the same name referred to by Wagner (1914) that is in the Orange Free State. The data from the Sloan pipe include very few compositions in the DI field indicative of low average grades, which is indeed the case. The data for the high grade Mir (USSR) and Finsch (South Africa) pipes contain many pyrope compositions in the DI field.

Somewhat predictably, the data set shown leaves the impression that interpretations of probe data are likely to be relatively simple and straightforward as they apply to this particular group of kimberlites and their pyropes. It is well to remember that during the operation of an exploration program the character (peridotitic, eclogitic or lamproitic) of the target will not be known until much exploration data has been generated - it is at that time that interpretations as outlined above can properly be made.

Qualifications that should and can be imposed on the data interpretation are illustrated by the Jack example. At first glance the data from this pipe are, as indicated above, suggestive of very few diamonds in the host. However, this particular data set is small compared to that from the other sites. There are also no exposures of kimberlitic breccias, instead the data are from minerals in rocks that include a very dilute (<5%) kimberlitic component. It is possible therefore, that the Jack interpretation will change as more data are generated and the underlying kimberlites are sampled. In the case of Sloan, there is also the added possibility that much of the diamond population has been derived from disaggregated eclogite, not only peridotite.

In practice therefore, definitive conclusions about the significance of the pyrope compositions require a large data base to serve as a filter to properly label those samples that contain pyropes with a high probability of diamond paragenesis. The diagrams shown above are thus intended to serve as an introduction to the methodology and should be integrated into diamond exploration programs with appropriate caution.

CONCLUSIONS

It is indeed possible to discover diamondiferous kimberlite in the N. American Cordillera using comparatively uncomplicated geochemical exploration techniques. Demonstrably, the most effective of these is heavy mineral sampling of stream sediment. This is because the physical characteristics of kimberlitic minerals (color, surface texture and density) enhance their respective abilities to be concentrated in stream silts as well as facilitate their subsequent recovery and recognition.

Each of the studies cited above has readily detectable geochemical signatures that are similar to the extent that the anomalies are made up of one or more members of the kimberlite family. The examples are different in respect of how each member has behaved in the fluviodynamic sense, i.e. it is not yet possible to explain nor predict how effectively one particular mineral will be transported or concentrated in streams and rivers in the Cordillera.

Successful exploration programs are therefore those that have maximized similarity of sample treatment from site to site. Specifically, this has meant no pre-concentration in the field (i.e. hand-panning) and, to the extent possible, exactly the same laboratory treatment of all samples over an extended period of time. Given such control it is possible to assign to each kimberlitic mineral anomaly a probability of diamond association and, in so doing, significantly minimize both time and money commitments to the discovery of "ore".

ACKNOWLEDGEMENTS

We owe a very special debt to our colleagues, the management, geologists, mineralogists, samplers and lab technicians of the Superior Oil Company, Falconbridge Nickel Company of Canada and C.F. Minerals Research, for their essential contribution to the design and execution of a number of very effective and exciting diamond exploration programs. Dr John Gurney of the University of Cape Town was a very enthusiastic and instructive consultant to all the above programs. The authors would also like to thank Mobil Corporation and Long Lac Minerals (USA) for permission to include data from the Sloan district in this paper.

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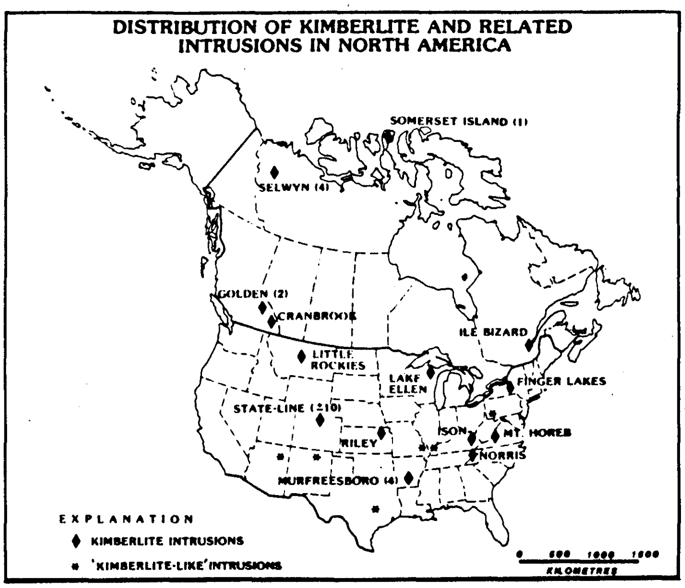


Figure 1. Locations of the important kimberlite provinces in North America. Numbers in parentheses after the district name are for the number of known diamondiferous pipes in the district. The Sloan pipe is part of the State-line group, Jack is part of the Golden group, and the Mountain Diatreme is part of the Selwyn group.

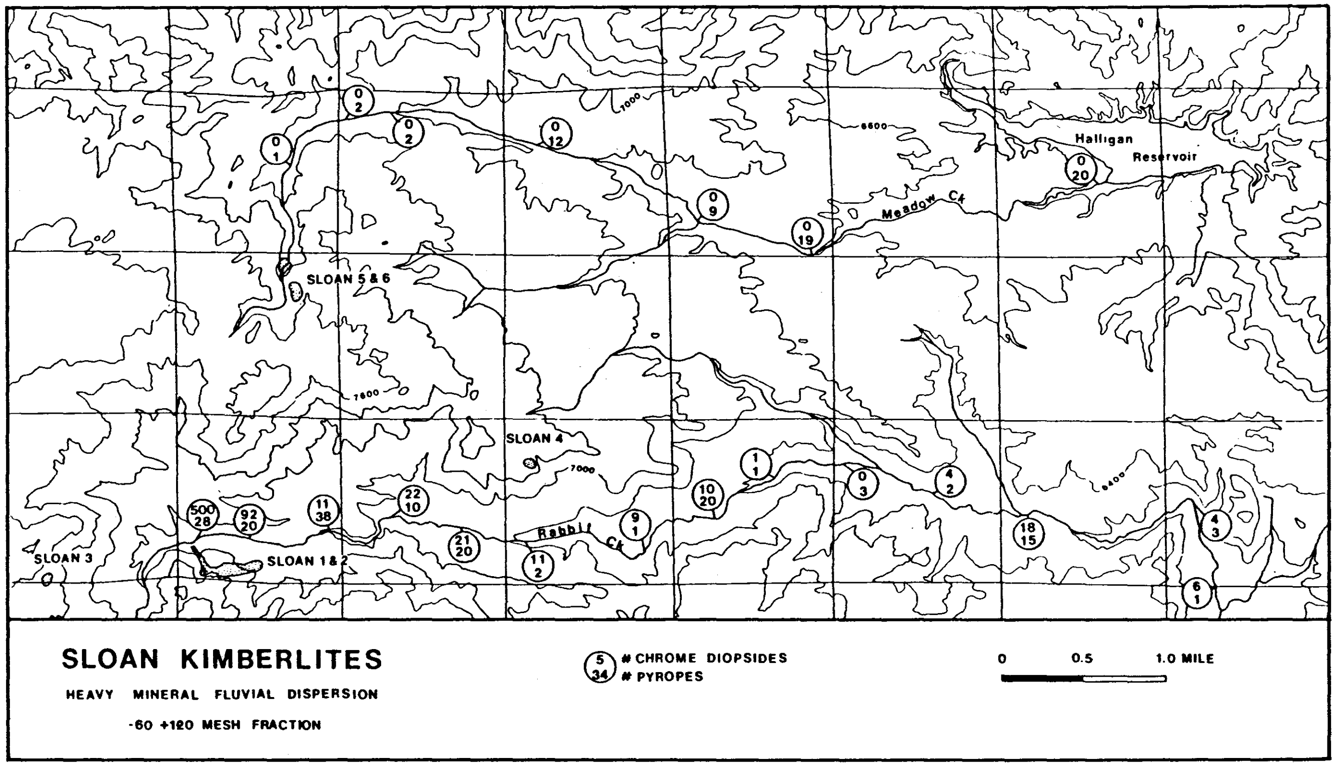
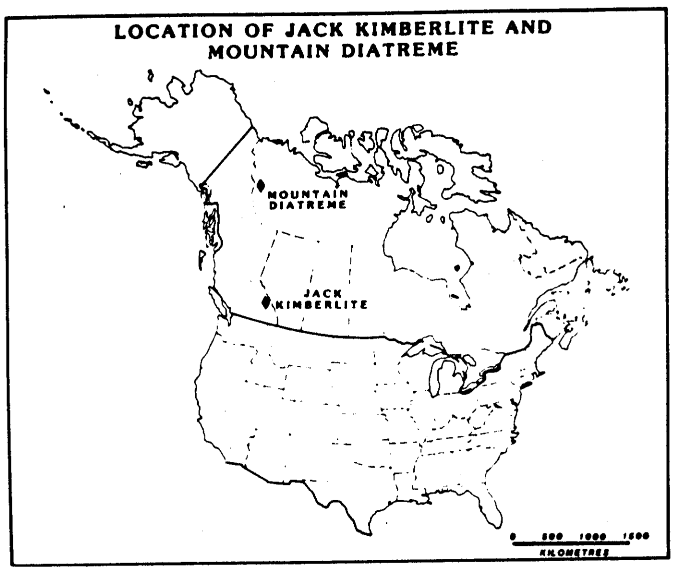


Figure 2. Dispersion of pyrope and chrome diopside in the Sloan district drainages.

Figure 3. A selection of gem diamonds from Sloan 1 and 2. The stones each weigh about 0.10 carats and also show the range in shape from well preserved octahedron to resorbed tetrahexahedron.



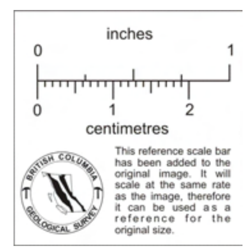


Figure 4. Location of the Jack kimberlite and the Mountain Diatreme.

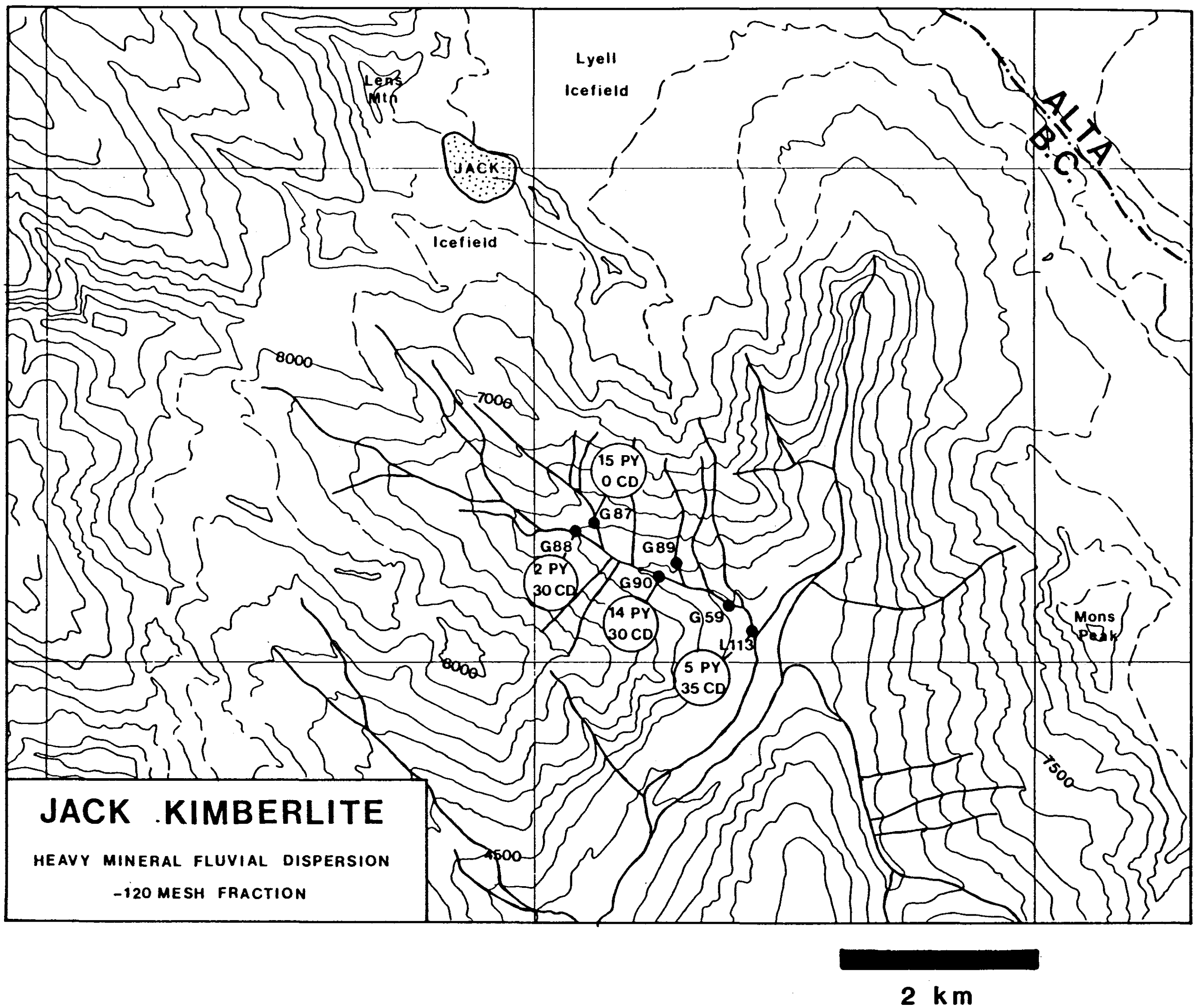


Figure 5. Fluvial dispersion of pyrope and chrome diopside from the Jack kimberlite.

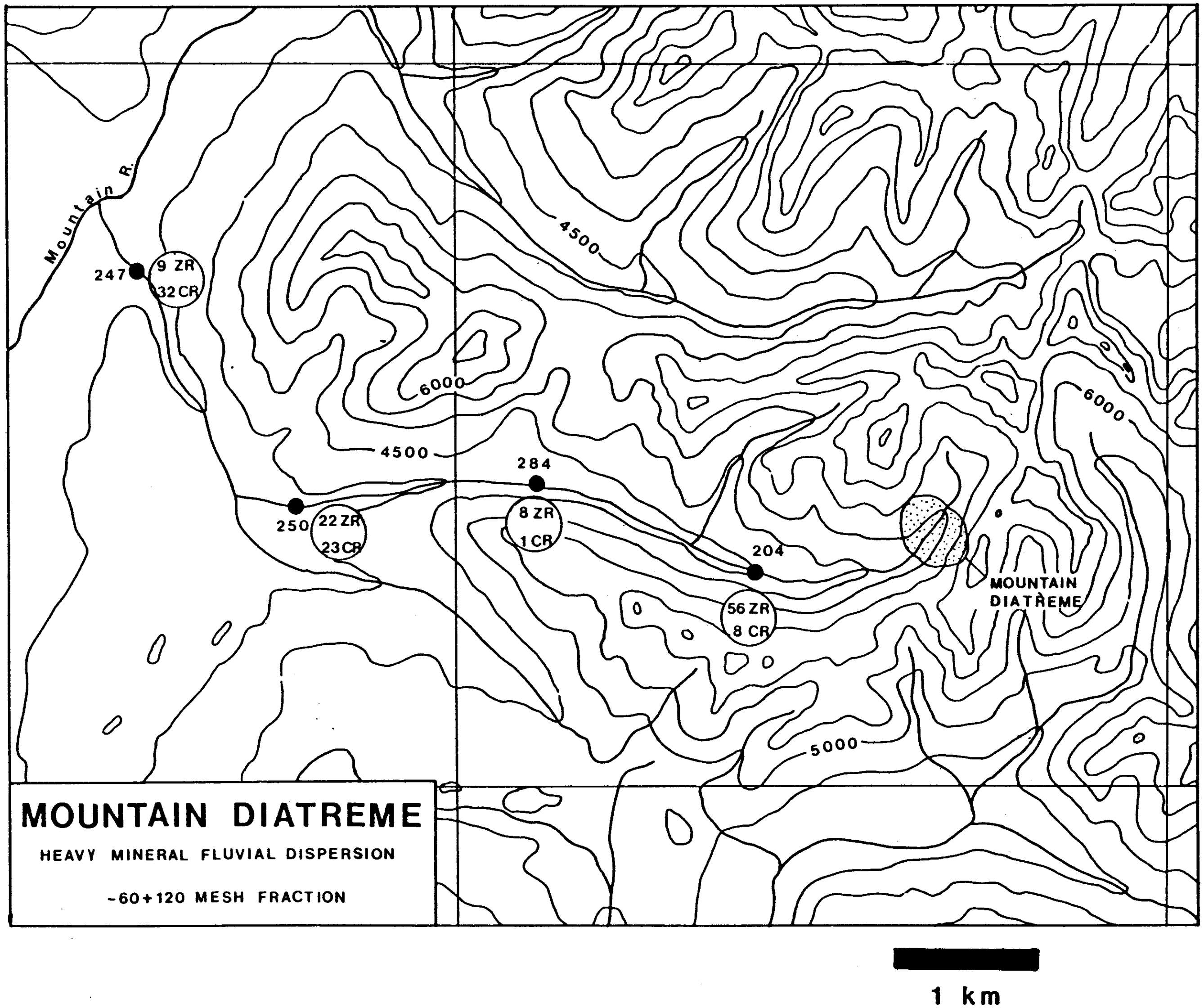
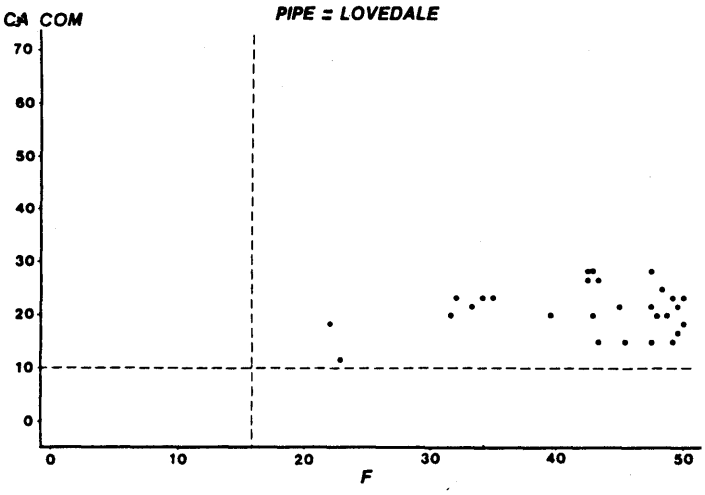


Figure 6. Dispersion of kimberlitic zircon and kimberlitic chromite from the Mountain Diatreme.

Figure 7. Plots of pyrope compositions from Lovedale, Jack, Sloan, Mir and Finsch.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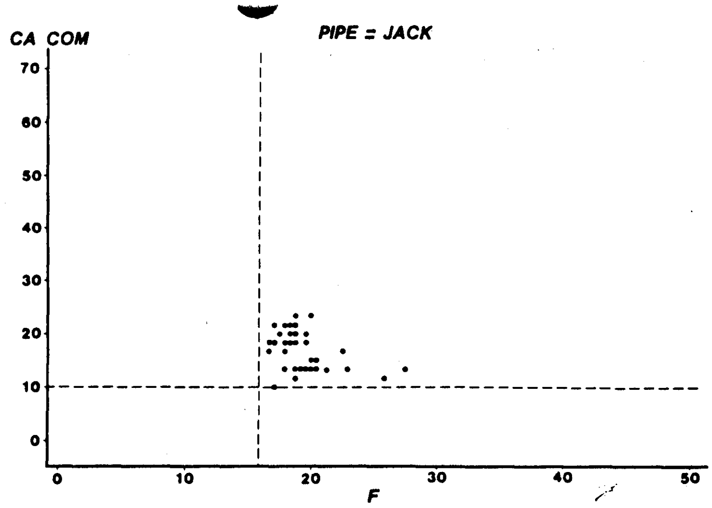
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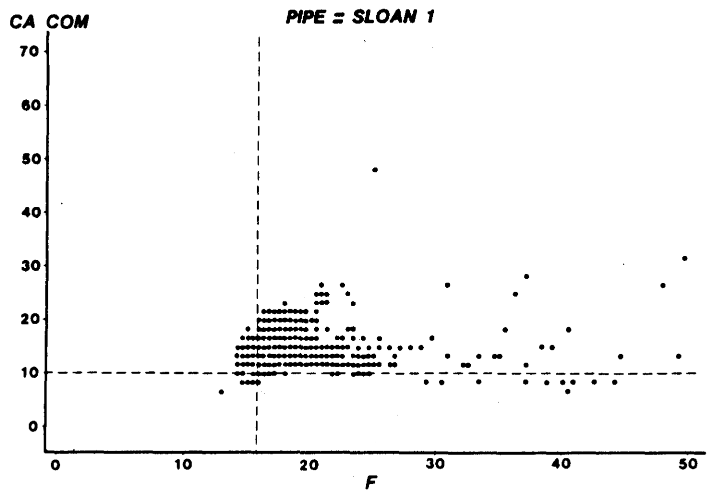
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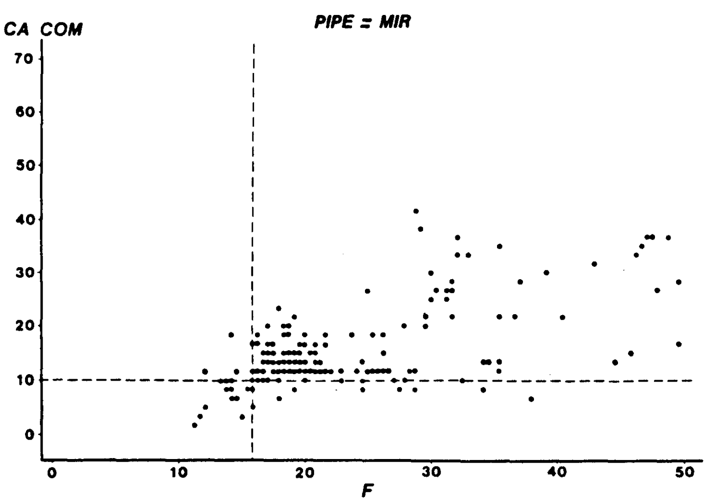
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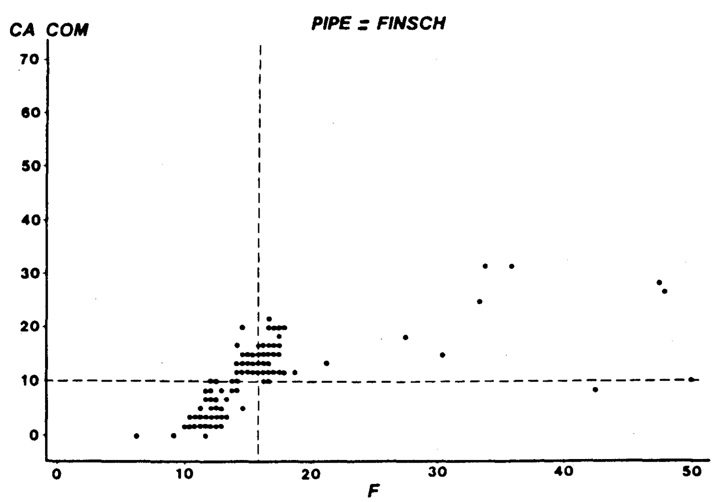
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