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Geology of the Sturgeon Lake 02 kimberlite block, Saskatchewan

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Abstract — The diamondiferous Sturgeon Lake 02 body is the first documented glacially transported block of kimberlite. The block is between 50 m and 240 m in size and up to 21 m thick. During glacial transport, the kimberlite has been juxtaposed between shale blocks, probably of Cretaceous age. The kimberlite block comprises crater-facies kimberlite composed of thinly bedded to thinly laminated, normally graded, primary pyroclastic airfall, lapilli tuffs and coarse ash which appear to have undergone little or no reworking. More than one eruptive phase was involved in the formation of the observed kimberlite. This kimberlite contains vesicular lapilli and may have formed by a different style of subaerial eruption to many other kimberlites.

Introduction

At least two kimberlites have been discovered in the Sturgeon Lake area, 35 km to 40 km northwest of Prince Albert in Saskatchewan (Fig. 1A). These kimberlites occur near the northeastern edge of the Phanerozoic sedimentary rocks of the North American Interior Platform. The platform sediments overlie Archaean basement. The pre-glacial bedrock at Sturgeon Lake comprises Cretaceous marine shales of the Ashville Formation. The only other documented kimberlites in Saskatchewan, and the Prairies, occur at Fort à la Corne, 80 km east of Prince Albert. This province includes a large number of bodies (at least 18, possibly over 70) ranging in size up to 74 ha (Lehnert-Thiel et al. 1992), some of which are diamondiferous and contain crater-facies kimberlite.

Monopros Ltd. discovered the first kimberlite in Saskatchewan, Sturgeon Lake 01, in 1988. The second kimberlite, Sturgeon Lake 02, was discovered in 1989 by Corona Corporation and investigated further by Claude Resources Inc. and Cameco Corporation. Sturgeon Lake 02 is buried under approximately 50 m of glacial overburden and was discovered through an airborne magnetic anomaly. The western portion of the Sturgeon Lake 02 kimberlite was under license to Monopros Ltd.. This kimberlite contains diamonds (e.g., Mining Journal, July 14, 1989) but is not economic.

Five holes have been drilled into the Sturgeon Lake 02 kimberlite (Fig. 1B). In 1989, hole LK-1-89 was drilled by Corona Corporation and holes SL-12-89 and SL-13-89 were drilled by Monopros. In 1990, hole LK-2-90 was drilled by Claude Resources and SL-1-90 was drilled by Cameco Corporation. Holes SL-1-90 and SL-12-89 are located 140 m and 375 m, respectively, north of the road intersection shown in Figure 1A. All the drillholes were vertical except for LK-1-89 (Fig. 2). Holes SL-1-90, SL-12-89 and SL-13-90 produced only drill chips while the other two holes yielded drillcore.

This paper presents a summary of the megascopic features of each of the drillholes as supplied by Claude Resources and Monopros, as well as the results of a megascopic and macroscopic examination of a portion of the drillcore LK-2-90 (Fig. 3) and the petrographic examination of rock chips from holes SL-1-90, LK-1-90 and SL-13-89.

Megascopic Features

The megascopic features of the drillholes are summarized in Figure 2. The drilling shows that the Sturgeon Lake 02 kimberlite is a horizontal body which has a limited lateral (Fig. 1B) and vertical extent (Fig. 2). Figure 2A shows that the proven lateral extent of the kimberlite is 50 m. Presuming that the kimberlite is continuous between the two groups of drillholes shown in Figure 1B, the lateral extent of the kimberlite is greater than 240 m. The vertical thickness varies from 8 m to 21 m. Geophysical data also support the drilling evidence for limited vertical thicknesses and the lack of any underlying pipe (P. Gummer then of Claude Resources, pers. comm.).

The main part of all the drillholes consists of glacial overburden which occurs both above and below the kimberlite. According to information supplied by Claude Resources for drillhole LK-2-90, the overburden is considered to comprise mainly glaciofluvial material and minor glacial tills. In the Monopros holes the overburden comprises till, gravel and sand. The Cretaceous bedrock occurs at approximately 140 m below surface in drillhole SL-1-90 (Fig. 2A). In SL-12-89 black shale was intersected at 152.4 m until the end of the hole at 156.1 m and is also considered to be pre-glacial bedrock. The kimberlite does not incorporate any glacial material in any of the holes. Very minor shale occurs within the kimberlite (see Macroscopic Features below).

Up to 5 m of shale occurs both above and below the kimberlite in holes LK-1-89 and LK-2-90 (Fig. 2A). Shale

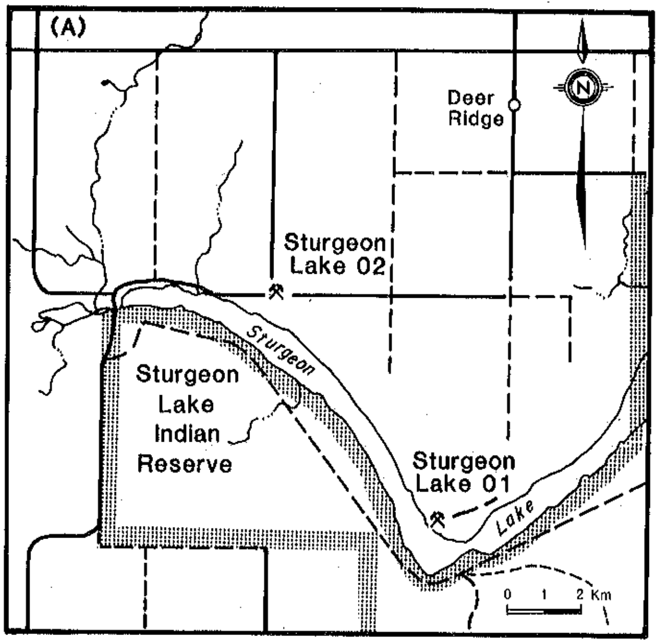

Fig. 1A. Location of the Sturgeon Lake 01 and 02 kimberlites. Sturgeon Lake occurs 35 km to 40 km northwest of Prince Albert.

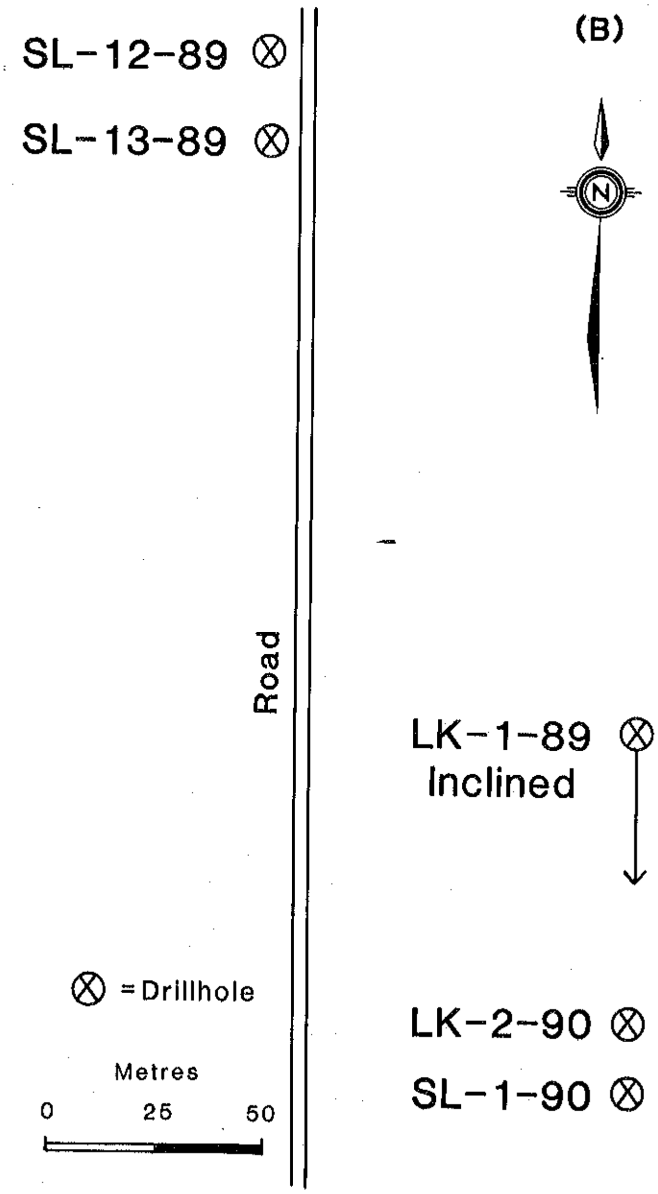

Fig. 1B. Location of the five holes drilled into the Sturgeon Lake 02 kimberlite. SL-1-90 is located 140 m north of the east-west road shown just to the south of the body in (A).

occurs only below the kimberlite in holes SL-1-90 and SL-13-89 (Figs. 2A and 2B), whereas no shale occurs adjacent to the kimberlite in hole SL-12-89 (Fig. 2B). An intersection of shale with no associated kimberlite occurs within the glacial sediments approximately 45 m below the kimberlite in LK-1-89 (Fig. 2A). Palynology of one sample shows that the marine shale from just below the kimberlite in drillhole SL-13-89 is Albian in age (98 Ma to 105 Ma), possibly late Albian (S. de Gasparis, Palynex, unpub. report).

Macroscopic Features

The macroscopic investigation included an examination of the full intersection of kimberlite but only very limited intersections of the adjacent shale in drillhole LK-2-90 (Figs. 2A and 3). Core recovery within the kimberlite was generally good. The main features of the core are summarized in Figure 3 and are described below with increasing depth.

The upper 60 cm of the investigated drillcore comprises a friable fragmental rock (Fig. 4A) composed of numerous small fragments of dark gray to black shale. The angular to rounded fragments are mostly less than 5 mm in size, but they range up to 10 mm. Some of the fragments contain a well developed lamination which is probably bedding. The relative orientation of the lamination between the fragments appears to be random. The occasional fragment of sandstone (up to 10 mm) and single grains of quartz also occur. One small (2 mm) piece of brown fibrous material, which is almost certainly wood, shows little sign of petrification. The rock is matrix supported. The matrix appears to be composed of finely comminuted material similar to the shale clasts. The rock is termed a matrix supported shale breccia. Some small angular light green fragments of kimberlite up to 15 mm in size are present in the breccia adjacent to its lower contact (Fig. 4B). The kimberlite fragments are similar to the main kimberlite which occurs below the contact. Abundant single plates of a greenish mica-like mineral occur in the same area of the breccia as the kimberlite fragments. These grains are similar to the secondary vermiform grains occurring in the kimberlite below. The abundance of these grains increases toward the contact. The contact of the shale breccia to the kimberlite below at 61 m is sharp, planar and dips at 60° (Figs. 3 and 4B).

Massive lithified hard, but altered, overall green colored kimberlite occurs between 61 m and 73 m. The degree of alteration varies within the kimberlite and, in parts, the primary features are completely masked (e.g., at 69 m to 70 m, Fig. 3). Primary features can be discerned in other parts of the core but they are most evident in the fresher intersection above 65.5 m. Much of the kimberlite has been

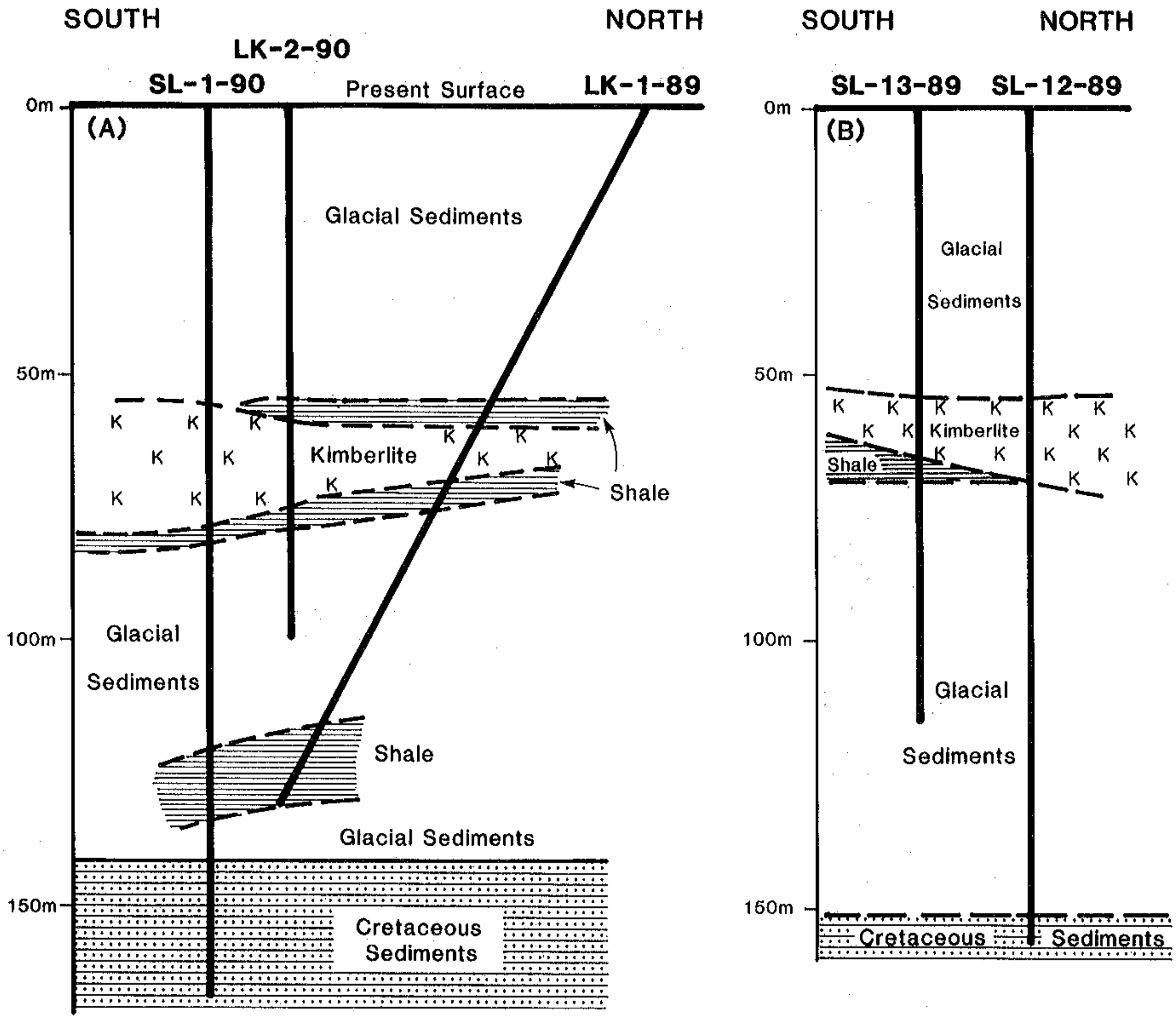

Fig. 2. Cross sections through the Sturgeon Lake 02 kimberlite summarizing the main geological features. (A) is based on information supplied by Claude Resources and (B) on information supplied by Monopros.

replaced by a distinctive light to darker green glistening mineral which somewhat resembles a mica. This mineral occurs as elongate rectangular grains up to 3 mm to 4 mm in size which often have a vermiform habit. These grains have a well developed cleavage parallel to the short axis of each grain. The outer surfaces of the grains often have lineations or grooves parallel to the long axis of the grain. Nixon et al. (1993) suggest that this mineral is antigorite but a positive identification is yet to be made. Unlike many other secondary minerals which replace kimberlites, this mineral completely obliterates all the primary mineralogy and textures where it occurs. The grain size of this mineral appears to vary with the clast size of the host kimberlite (up to 5 mm). Other secondary minerals include serpentine, carbonate and clay minerals. Secondary magnetite is locally very abundant and it occurs in irregular patches (up to 20 mm) which tend to preferentially replace the interclast matrix. Some of these patches are concentrated along bedding planes. The abundance of the secondary magnetite varies in different parts of the kimberlite.

The main part of the investigated drillcore comprises massive light or milky to darker green (to whitish) rocks. At various places within the core it can be seen that the rocks are composed of three main constituents: (1) abundant single grains of pseudomorphed olivine (up to 3 mm) and less common single grains of phlogopite, ilmenite and garnet, (2) igneous fragments (up to 10 mm), and (3) some xenoliths. Clast supported textures are present. The igneous fragments are equant to ovoid in shape and have irregular, often curvilinear, shapes with re-entrant embayments (Fig. 5). These fragments are composed of two generations of olivine (up to 3 mm) and small spherical structures which strongly resemble vesicles set in a finer matrix (Fig. 5). The olivines include anhedral, often rounded, macrocrysts as well as smaller euhedral phenocrysts. The occasional grain of primary brown phlogopite (up to 2 mm) is present within

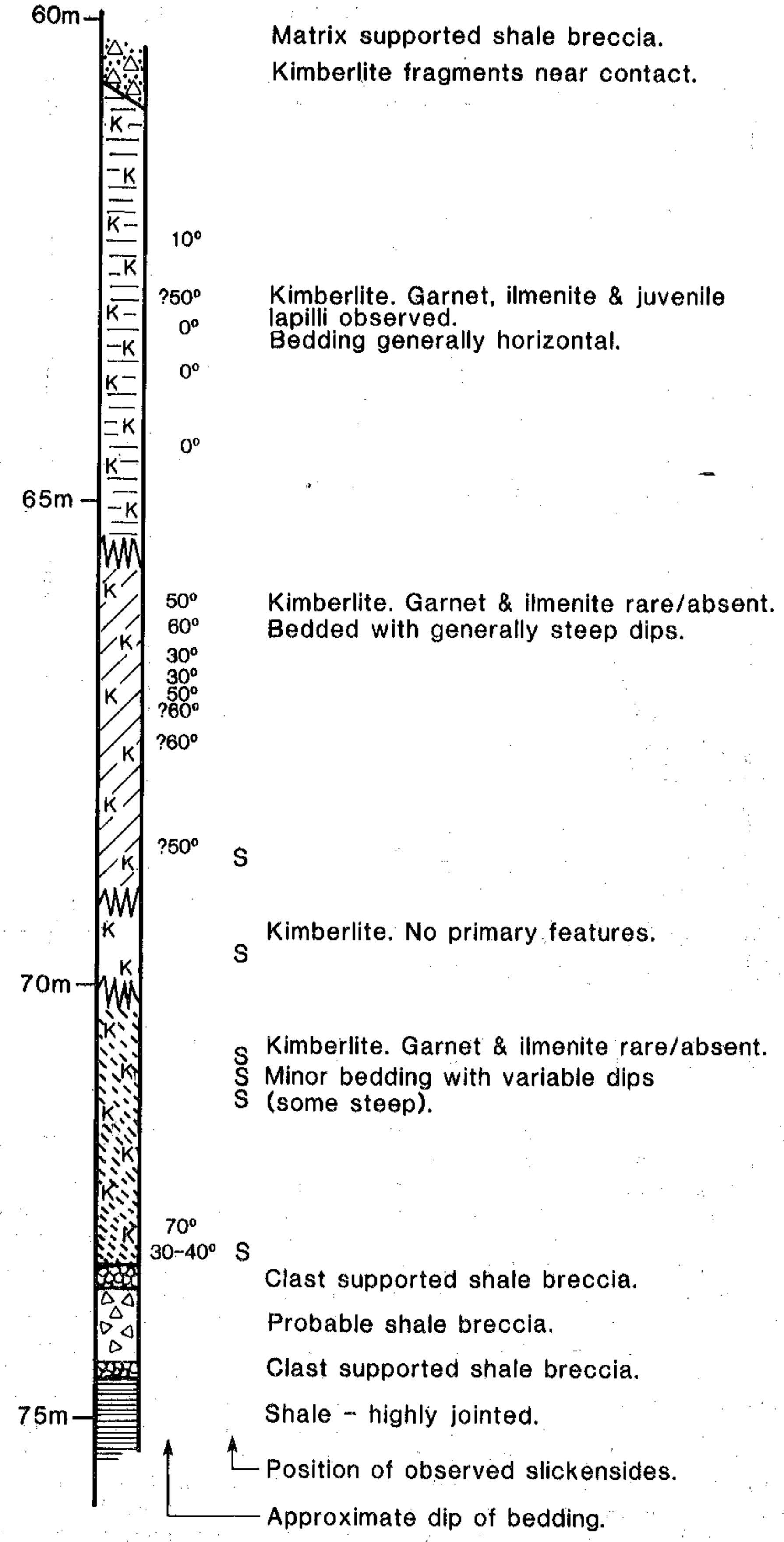

Fig. 3. Summary of the main megascopic and macroscopic features of the kimberlite and imme-tures of the kimberlite and immediately adjacent intersections within -90. drillcore from hole LK-2-90.

some fragments. Similar single phlogopite grains can be abundant, especially in the finer grained rocks (e.g., Fig. 6). The garnets range up to 9 mm in size and have variable colors including purple, red and orange. The single grains of olivine appear to be mainly anhedral. The olivine grains within and outside the igneous fragments have been replaced mainly by light green serpentine. The occasional xenoliths (mostly <20 mm) include quartzite, fine sediments and a pink garnet-bearing xenolith (13 mm in size) which may represent basement. Also present at 66.4 m is a very irregular 'patch' of dark gray to black shale which has delicate apophyses. Much smaller clasts of similar material occur along adjacent bedding planes. This material appears to represent plastically deformed poorly consolidated shale within the kimberlite. The relationship of this material to its host kimberlite is not clear.

Plane parallel bedding with normal grading is present in some parts of the kimberlite (Fig. 6). Observed individual beds range in size from a few to 100 mm in thickness. Thicker beds may not have been recognized. For example, the upper part of the piece of core shown in Figure 6 probably comprises only part of a bed. The bedding results from sorting with the size variations being reflected by all of the main constituents, i.e., the igneous fragments, single grains and xenoliths. In the intersections with thinner and better defined bedding, a coarser bed may be composed mainly of olivine pseudomorphs up to 2 mm and small xenoliths up to 4 mm. Such material may be interbedded with finer material which is less than 0.5 mm in size (Fig. 6). The thickness of the beds often appears to vary with the grain size. Although some sorting has occurred throughout the kimberlite, most rocks contain a range of clast sizes and can be described as poorly sorted. A summary of the observed bedding dips are given in Figure 3. These dips are variable but they tend to be horizontal above 65.5 m while they tend to be steeper in the intersection from 65.5 m to 69.2 m. No actual cross bedding was observed. Elongate constituents, which comprise mainly primary mica and xenoliths, are typically oriented parallel to the bedding (Fig. 6). Occasional examples of undulating bedding planes were observed (e.g., 67.5 m). Some disturbance of the bedding by minor faulting was noted (Fig. 6). At 66.5 m a vertical throw of 33 mm was estimated for one such fault.

Different sub-types within the kimberlite have been recognized.

1. Above 65.5 m the kimberlite contains macrocrysts of garnet and ilmenite and displays well developed bedding which is mainly horizontal. In parts the ilmenite and garnet can be seen to be common to abundant. Secondary magnetite is also present in this intersection.
2. Between 65.5 m and 69.2 m the kimberlite is more altered but garnet and ilmenite appear to be rare or absent. In this intersection the bedding is steeper with dips ranging from 30° to 60°, some faulting was noted and secondary magnetite appears to be absent.
3. Below 71.6 m some minor variable but steeply dipping bedding was observed. Garnet and ilmenite again appear to be rare or absent. It is unclear whether or not this intersection is a continuation of the kimberlite sub-type between 65.5 m and 69.2 m. Slickensides transecting the lithified kimberlite were observed at various points within the core but only below 68.5 m, i.e., only within the 4.5 m of the lower contact of the kimberlite (Fig. 3).

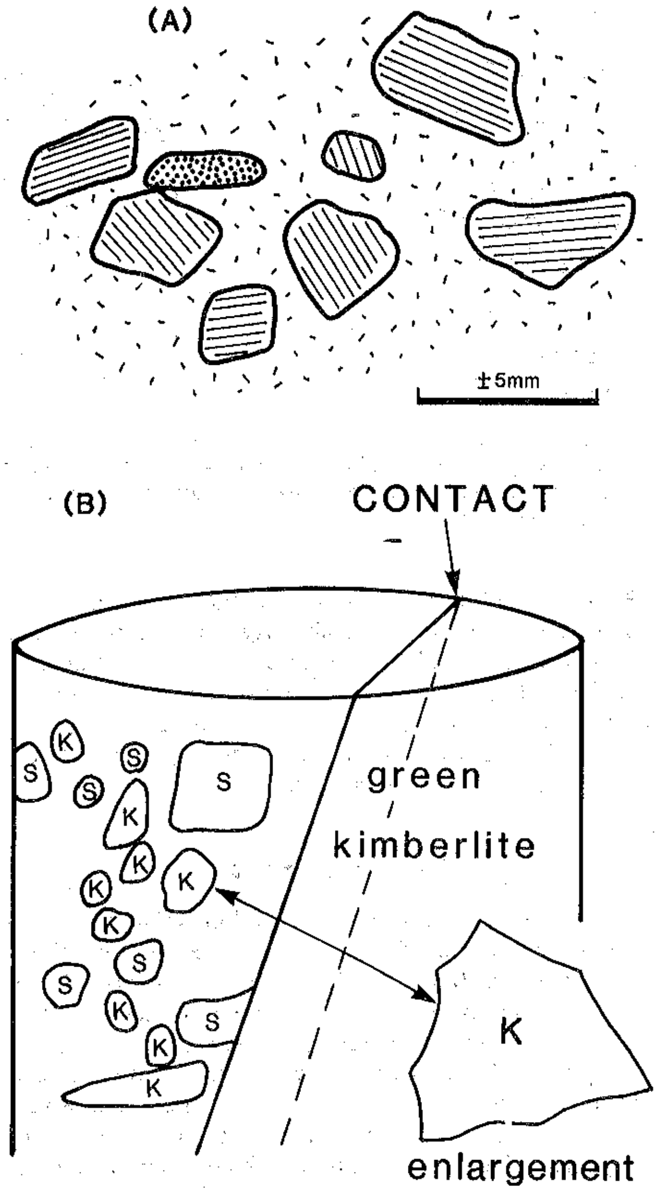

Fig. 4. (A) Macroscopic nature of the shale breccia at 60.7 m near the top of the drillcore shown in Figure 3. The drillcore is 4.5 cm in diameter. The clasts comprise mainly laminated shale (striped) with less common coarser sediments (stippled). Note the variation in orientation of the fabric within each clast. The matrix to the clasts comprises similar, but finer, material. (B) The steep sharp upper contact of the kimberlite (60.8 m to 60.9 m) as shown in Figure 3. Shale breccia similar to that shown in Figure 4A occurs above the contact. Here it contains not only clasts of shale and sandstone (S) but also angular fragments of green kimberlite (K). Only some clasts are shown in the sketch. Massive kimberlite occurs below the contact.

Unfortunately, the lower contact of the kimberlite is not well represented in the drillcore. Below the kimberlite, between 73 m and 74 m, the core comprises a clast supported shale breccia which has little or no discernible matrix (Fig.

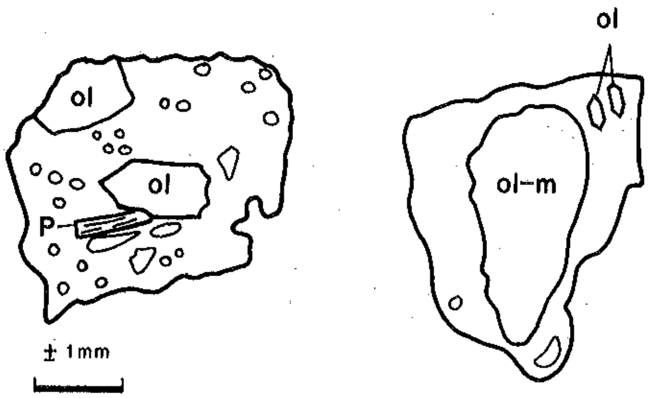

Fig. 5. The macroscopic nature of two juvenile fragments. They contain two generations of olivine (ol, ol-m is a macrocryst), a lath of phlogopite (p) and spherical vesicle-like structures which are set in a fine groundmass.

3). Individual fragments appear to be angular and they range in size up to 10 mm, occasionally larger. Some different small white fragments within this rock do not appear to be kimberlite. Although core recovery in this intersection was poor, below 74 m (to 78.5 m) the core comprises dark gray-black shale which is well jointed (steeply dipping) but does not appear to have been fragmented.

Microscopic Features

Thin sections of nine samples of kimberlite, each comprising several rock chips, were examined. These samples derive from depths between 60 m to 73 m in drillhole SL-1-90 and 54.5 m in SL-13-89 and unknown depths within LK-1-90. The nature of each rock chip is different but they all appear to be related and represent variations on a single theme. The degree and style of alteration of the chips is variable. The samples are now composed mainly of serpentine, the unidentified secondary mineral with the distinctive vermiform habit described previously, probable secondary carbonate and secondary opaque magnetite. Each of these constituents occurs in varying proportions in different parts of the rocks. As noted previously, the vermiform mineral (up to 3 mm in size) replaces all constituents where it occurs and, therefore, no remnant features remain wherever it is abundant. This mineral is pleochroic pale green to pale brown and has a well developed cleavage parallel to the short axis of the grains. These features do not seem to be consistent with the suggestion that this material is antigorite by Nixon et al. (1993).

Primary features can be discerned in some chips. These samples are fragmental rocks which are composed mainly of single grains of olivine and less common mica together with some igneous fragments (Fig. 7A). The olivine has been totally replaced mainly by serpentine and carbonate. Most of the single grains appear to be anhedral macrocrysts (up to 2.5 mm) although some smaller euhedral grains probably do represent phenocrysts. In some chips the olivines are all finer grained, for example < 1 mm in size, and then they include both anhedral grains belonging to the macrocryst suite as well as phenocrysts. Fragmentation of the single olivines has not occurred. Macrocrysts of probable ilmenite and less common garnet similar in size to the olivine macrocrysts are present in some parts.

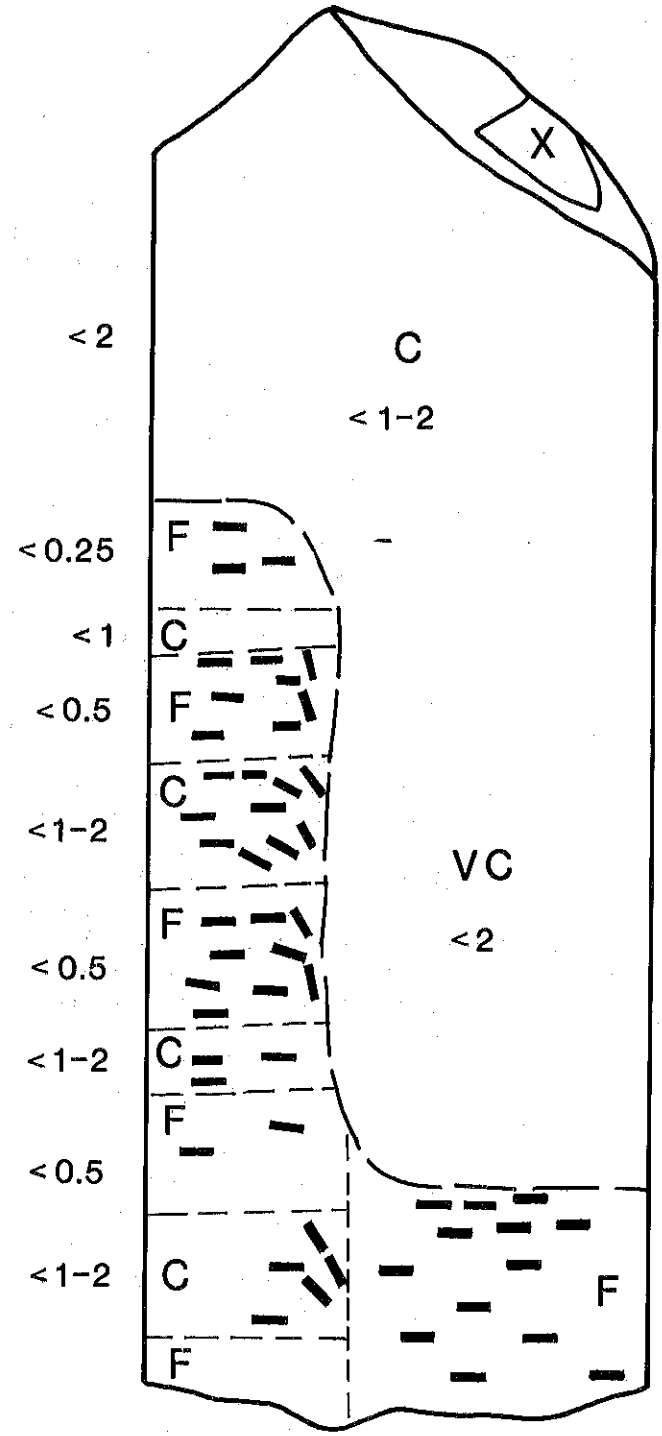

Fig. 6. A probable minor fault within laminated kimberlite at 64.6 m to 64.7 m. VC = very coarse, C = coarse, F = fine kimberlite. The numbers give an overall indication of the clast size in millimeters in the different areas. The lath-shaped grains are oriented micas. X = xenolith. The core is 4.5 cm in diameter.

The igneous fragments (up to 2 mm) are a consistent, and important, constituent (Fig. 7A) and appear to be a cognate primary part of the rocks. These fragments are mainly small and turbid. They often have irregular outlines which may be curvilinear with re-entrant embayments (Figs. 7A to B). These fragments are composed of olivine pseudomorphs and phlogopite set in a fine-grained groundmass (Fig. 7B). The laths of phlogopite, whether within a fragment or not, are often pleochroic to an orange brown color and display typical mica cleavage (Fig. 7B). The primary phlogopite, therefore, can easily be distinguished from the vermiform secondary mineral. The vermiform material does not preferentially replace the primary mica. Some of the phlogopite grains are distorted by the invasion of secondary material (Fig. 7A). Groundmass minerals include serpentine, carbonate, fine spinel and apatite (<0.05 mm in size). The spinel occurs as subhedral to euhedral opaque grains. The apatite occurs as lath-like grains. Some fragments have a base dominated by serpentine which may have a fine dusting of opaque material throughout giving it a gray color. Probable primary carbonate occurs in the groundmass of other fragments. As is often the case, it is difficult to establish whether the carbonate is primary or secondary. Both types of groundmass or base (serpentine or carbonate), although not similar to true glass, appear to be quenched. Spherical vesicle-like structures are present in some of the fragments (Fig. 7B). Some fragments are composed of abundant spherical vesicles set in a clearer base which is composed of either isotropic serpentine-like material or extremely fine grained to cryptocrystalline carbonate (Fig. 7C). More irregularly shaped vesicle-like structures are also present. These fragments, especially those similar to the example shown in Figure 7C, resemble vesicular juvenile lapilli. Other variations of glassy looking igneous clasts are present including some finer inconspicuous fragments which could be ash. No composite fragments were observed. Xenoliths are present but not common. The interclast matrix is composed mainly of serpentine although some carbonate is present (Fig. 7B). The carbonate sometimes rims the olivines.

The main constituents of these rocks generally have a clast supported texture although the degree of packing is variable (Fig. 7A). One of the rock chips examined incorporated a planar change in clast size (Plate 7D) which must represent one of the bedding planes observed macroscopically and discussed above. Plate 7D shows that the change in rock type is not sharp. Single grains of mica are locally common and, as can be seen in Figure 7D, they tend to be concentrated with the finer clasts and oriented parallel to the bedding.

Discussion

Rock-type Classification

Primary features observed in these altered rocks include anhedral macrocrysts and smaller euhedral phenocrysts of pseudomorphed olivine which resemble the two generations of olivine that are characteristic of kimberlites. Other macrocrysts include ilmenite and less common garnet. Phlogopite macrocrysts and phenocrysts are also present. Observed primary groundmass minerals include serpentine, spinel, apatite and probably carbonate. The quenched or glassy nature of the igneous fragments results in a paucity of groundmass minerals. This precludes a strict petrological classification of this body. All the observed features are characteristic of, but not exclusive to, kimberlites (cf. Mitchell, 1986). Although the presence of vesicular fragments is atypical, it is not sufficient to preclude the classification of these rocks as kimberlites. No other features were observed that would exclude these rocks from being kimberlites. This body, therefore, is considered to be a kimberlite (archetype or Group 1; Woolley et al., in press). It is not possible to classify these rocks mineralogically because of the lack of crystallization of the groundmass.

Textural Classification

This kimberlite is composed of clast supported single grains of olivine, mica, ilmenite and garnet which occur together with small igneous fragments and some xenoliths (Fig. 7A). These rocks can, therefore, be termed volcaniclastic kimberlites. The igneous fragments are often glassy, vesicular and have irregular curvilinear outlines (Figs. 5, 7A to 7C). The nature of the fragments shows that they are neither globular segregations, pelletal lapilli nor autoliths which occur in different facies of kimberlites (cf. Clement and Skinner, 1985; Mitchell, 1986) but are rather extrusively formed juvenile lapilli of pyroclastic origin (Figs. 5, 7B and 7C). This conclusion, together with the presence of common grading and bedding (Figs. 3, 6 and 7D), shows that texturally these rocks are classified as crater-facies kimberlites (cf. Clement and Skinner, 1985). It must be noted that kimberlites classified as crater-facies need not be confined to within a volcanic crater although this is where they are most likely to survive erosion and be preserved in the geological record.

Mode of Formation

It has been suggested above that the fragments forming these rocks were formed by pyroclastic processes. It is difficult to comment on whether reworking of these clastic deposits was significant. The lack of abrasion and breakage of often fragile clasts including a possible poorly consolidated shale xenolith, the paucity of extraneous material and very fine material, the presence of plane parallel bedding and the identification of at least two kimberlite sub-types are all features which would strongly suggest that reworking has not been important in their formation. The investigated part of the kimberlite is most likely to comprise material which has been formed and deposited by primary pyroclastic airfall processes. These rocks can, therefore, be termed lapilli tuffs and coarse ash.

Two generations of olivine that are typical of kimberlites are present. However, when compared to classic kimberlites, the macrocrysts at Sturgeon Lake 02 are finer grained (<3 mm) and the phenocrysts much less abundant. This feature is likely to result from pyroclastic sorting. It is not understood why the grain size of the secondary vermiform mineral follows the clast size of the host kimberlite. Vesicular lapilli have not been reported from kimberlites

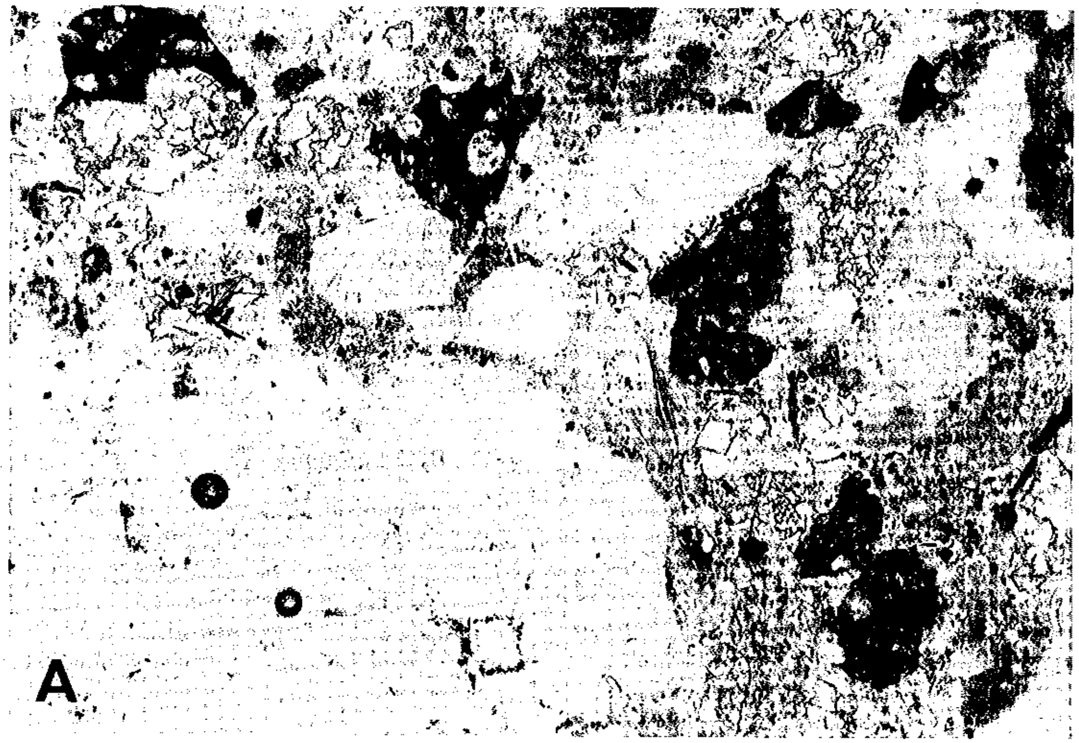

Fig. 7A. Field of view = 1.6 mm. Primary features in this rock include common small dark turbid igneous fragments, some olivine pseudomorphs and a distorted lath of phlogopite. Also present are common grains of the secondary vermiform mineral (v). The interclast matrix is composed of pale green serpentine and high relief carbonate.

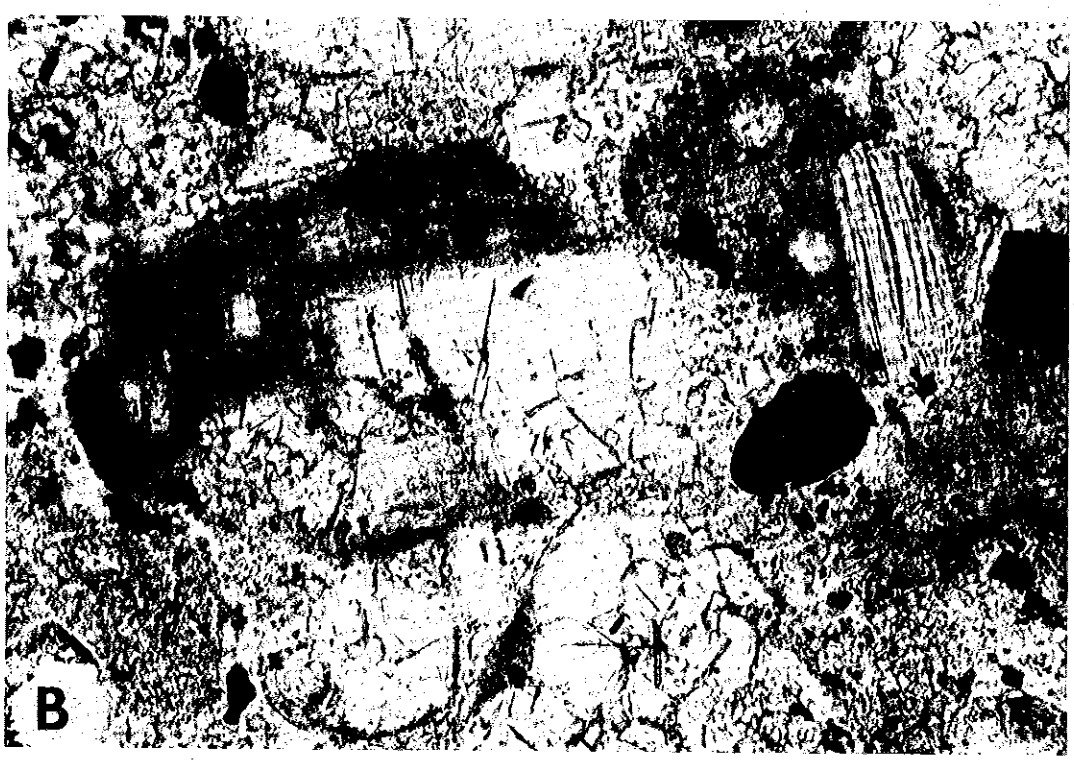

Fig. 7B. Field of view = 0.6 mm. This plate illustrates the nature of the small turbid igneous fragments. This fragment is composed of a colorless carbonatized olivine phenocryst and a lath-like microphenocryst of phlogopite set in a fine-grained groundmass. The groundmass contains fine, often euhedral, opaque grains of spinel and spherical vesicle-like structures. One larger rounded opaque probable ilmenite macrocryst is also present. Note the curvilinear outline to this clast.

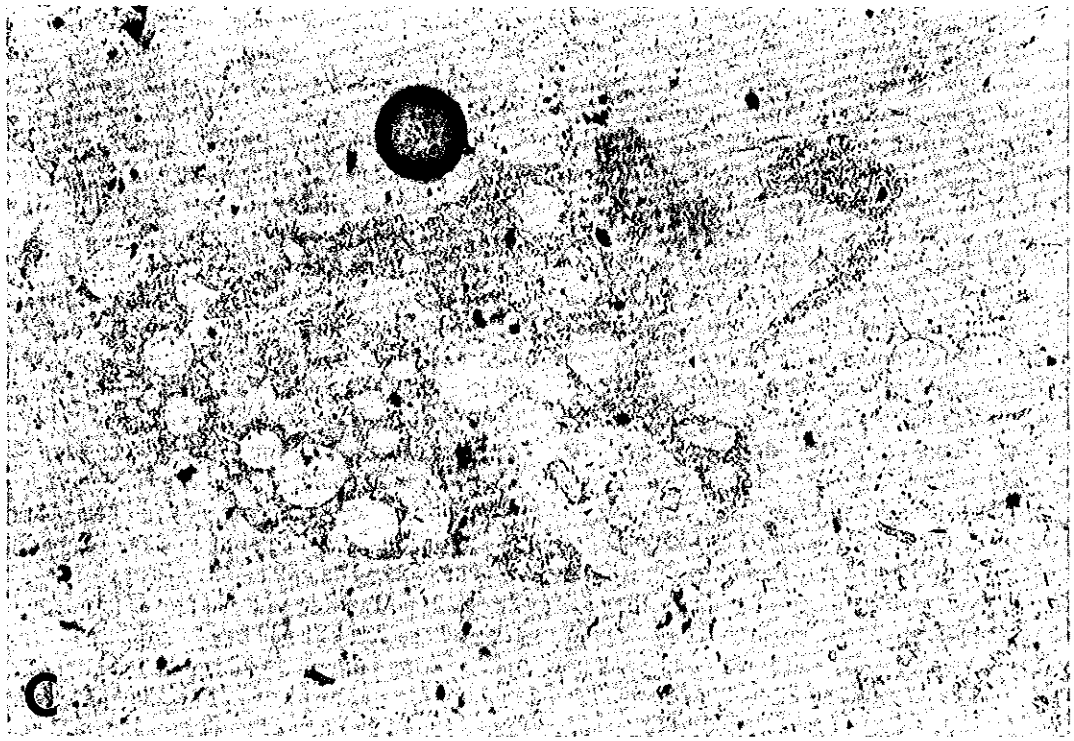

Fig. 7C. This photomicrograph illustrates the second type of igneous fragment. Olivine pseudomorphs together with numerous spherical vesicle-like structures are set in a very fine-grained base. This fragment strongly resembles a vesicular juvenile lapillus.

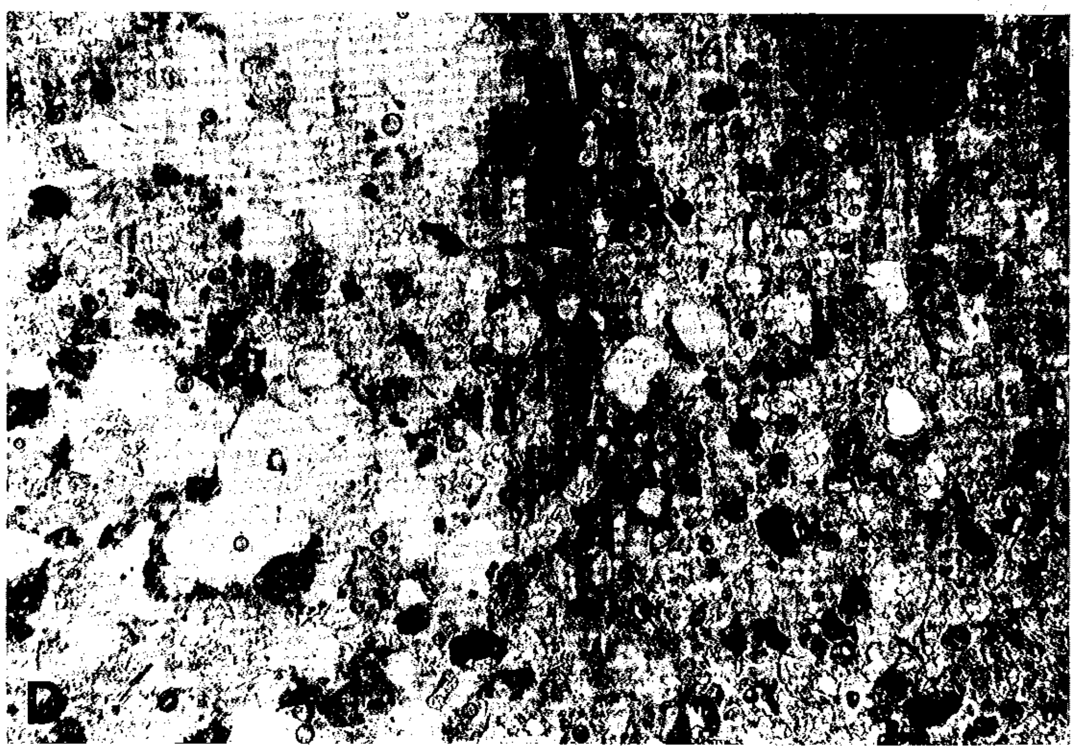

Fig. 7D. A darker clayey band separates two different beds. On the left hand side the rock contains fine clasts many of which are single carbonatized olivines. The laths of mica are oriented parallel to the clayey band or bedding plane. On the right hand side the rock is dominated by the secondary vermiform mineral but a coarser clast size can be observed.

(*sensu stricto*) previously. Modern published investigations of crater-facies kimberlites are not available. This author has examined many crater-facies kimberlites from Southern Africa, Russia, North and South America in which the majority of kimberlite fragments are spherical in shape. No vesicular examples have been noted. Similar observations have been made by other workers (Roger Mitchell, Matthew Field, pers. comm.; Field has examined in detail the geology of Orapa and Jwaneng and many other crater-facies kimberlites in southern Africa). The presence and nature of the vesicular lapilli at Sturgeon Lake 02, therefore, suggests that a different style of eruption may be involved in their formation, perhaps deviating from the kimberlite model (cf. Mitchell, 1986). In this respect it is interesting to note that xenoliths are not common in this kimberlite. Also the presence of vesicular lapilli probably suggests that at least some of the pyroclastic activity was subaerial. The presence of at least two types of juvenile lapilli (Figs. 7B and 7C) strongly suggests that the observed material derives from at least two different styles and/or phases of eruption. The formation of this kimberlite must have involved repetitive eruptions. Each bed or set of beds must represent separate eruptive pulses. The identification of different kimberlite subtypes within the core (above and below 65.5 m; Fig. 3) suggests that this core comprises at least two phases of eruption involving different erupting kimberlite magmas.

Mode of Emplacement

From the drilling information presented in Figure 2, it is not immediately apparent whether the kimberlite was deposited "in situ", and, therefore, is very young, or whether it has been displaced. Given that these rocks are classified as extrusive crater-facies kimberlites of pyroclastic origin, it is possible that such material could be deposited within the glacial sediments either by primary pyroclastic or secondary resedimentation processes. Many features, however, suggest that the kimberlite was not formed in its present position. In this respect it is important to note that no glacial material was found within the kimberlite. Both the kimberlite and the adjacent shale are lithified while the glacial sediments in which they occur are not. Also one area of marine shale subjacent to the subaerial kimberlite is Cretaceous in age. Below the kimberlite in LK-2-90 the shale breccia grades into unbrecciated shale suggesting that the fragmentation process only affected the margins of the shale against the kimberlite. Adjacent to the upper kimberlite contact in this hole, the shale breccia contains fragments similar to the lithified kimberlite below as well as single grains of the vermiform mineral which is a common secondary constituent in the kimberlite below. The vermiform mineral has replaced all the primary kimberlite constituents wherever it occurs, including both the clasts and the interclast matrix. This replacement must have occurred after the cementation or lithification of these volcaniclastic kimberlite deposits. The kimberlite to shale contacts, therefore, must be post-lithification tectonic, rather than pre-lithification depositional, features. The age of this kimberlite is not known but the Fort à la Corne kimberlites which occur some 80 km east of Prince Albert have been dated at 96 Ma (Lehnert-Theil et al., 1992) a little younger than one area of 98 Ma to 105 Ma shale occurring adjacent to the Sturgeon Lake 02 kimberlite.

All the geological features together show that the kimberlite and shale were not formed at their present location. The shale and kimberlite, therefore, must have been displaced. They must have been transported to their present locations by the same glacial processes that formed the adjacent glacial sediments. The brecciation at the observed kimberlite to shale contacts must have formed during glacial transport. It is interesting to note that the observed post-lithification slickensides within the kimberlite are concentrated toward the base of the block (Fig. 3). This could reflect basal shearing during transport. Slickensides, however, can be produced through other processes. There is no evidence of additional tectonic contacts within the kimberlite intersection in LK-2-90 suggesting that the kimberlite represents a single block. The brecciation within the shale suggests that the shale both above and below the kimberlite in LK-2-90 represent separate glacial blocks. Apparently this kimberlite block forms part of a blanket of material which includes mixed shale and weathered kimberlite that occurs within the same glacial horizon over about 100 km^2 (P. Gummer, then of Claude Resources, pers. comm., 1990). The shale found near the bottom of holes SL-1-90 and LK-1-89 (Fig. 2A) must comprise another glacial block which occurs at a different horizon within the glacial sediments. It seems most likely that the shale blocks are derived from the Cretaceous bedrock which occurs over large areas of this part of Saskatchewan. This in turn suggests that the kimberlite is Cretaceous in age.

Conclusions

The Sturgeon Lake 02 body is a glacially transported block of crater-facies kimberlite. The kimberlite block is at least 50 m, and probably 240 m, in maximum lateral dimension with observed vertical thicknesses varying from 8 m to 21 m. The kimberlite block occurs near the center of approximately 140 m of glacial sediments which overlie the Cretaceous bedrock. This body appears to be the first documented example of a glacial mega-block of kimberlite. Small kimberlite boulders are known to occur in glacial tills here and elsewhere in Canada. Blocks of shale are juxtaposed both above and below the kimberlite. The kimberlite-shale contacts have been brecciated during glacial transport. Another shale block occurs deeper within the glacial sediments. The shale blocks are most likely to be derived from the extensive Cretaceous bedrock which occurs in this area of Saskatchewan. The kimberlite is likely to be Cretaceous in age. The kimberlite is composed of a thinly laminated to thinly (and perhaps thicker) bedded sequence of primary pyroclastic airfall coarse ash and lapilli tuffs which probably have undergone little or no reworking. More than one phase of eruption was involved in the formation of the observed kimberlite. These rocks contain vesicular lapilli which have not been observed in kimberlites elsewhere and may reflect a different style of eruption to many other kimberlites. The presence of vesicular lapilli suggests that at least some of the eruptions forming this kimberlite were subaerial.

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