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THE DIAMONDS OF SIBERIA

Almazy Sibiri, Leningrad 1957
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PREFACE

Diamonds are the hardest of all known minerals and artificial alloys. The unsurpassed durability of diamonds and their resistance to the action of chemical agents and to wear account for the wide-spread use of diamonds in technology. Diamonds are precious stones of extra fine quality and are used in the jewelry business.

It is hard to find a branch of industry in which diamonds are not used in one way or another. They are particularly popular in the metal industry, in stone cutting and in the branches of polishing and grinding industry. They are also used for the boring of hard rocks. The use of diamonds greatly accelerates production processes increasing the quality and the precision of production. For that reason, the demand for diamonds in industry increases every year despite great achievements in the field of producing hard and superhard alloys.

As a result of the increased demand for industrial diamonds the world output of diamonds exceeded 14.4 million carats toward the beginning of World War 11 (1940). During the war the output of diamonds dropped 9-11 million carats. However it attained its pre-war level in 1949. The output of diamonds has increased particularly in the past five years. In 1954, the world output of diamonds achieved 20.4 million carats of which 16.8 million caratas -- or about 82 per cent -- were used for industrial purposes.

The above figures testify to the tremendous demand for industrial diamonds in recent years. Our national industry experineces an acute shortage of diamonds. The low contents of diamonds in the deposits of the Ural Mountains does not allow a large scale development of diamond mining. Work launched in the deposits of the wester slopes of Central Ural Mountains from 1941 to 1944 has not been sufficiently developed to meet the demands for industrial diamonds on the home market. The import of diamonds from abroad is rather difficult in view of the obstacles put in our way by capitalist countries that control the world diamond market. As a result of this situation the use of industrial diamonds in the Soviet Union is limited. Many branches of our industry are unable to botain diamonds and have to work with substitutes. Substitutes are, for instance, used in all drilling works.

Preliminary estimates revealed that hundreds of millions of rubles could be saved yearly by the Ministry of Geology and the Protection of Mineral Resources USSR and the Ministry of Non-Ferrous Metallurgy USSR along, if diamonds were used in mining operations. An even greater saving would be achieved through the use of diamonds in metal works, machine tool construction, instrument construction and in the branches of the grinding and polishing industry.

As a result of the tremendous tasks of developing national economy and increasing the productivity of labor set by the XXth Party Congress within the framework of the Five-Year Plan the supply of domestic diamonds to industry has become a vital problem of nation-wide importance.

In the period from 1954 to 1955 rich original sources of diamonds and placer deposits similar to foreign diamond deposits including even the South African diamond fields were discovered in the Yakutsk ASSR.

The rich diamond deposits in the Siberian platform were discovered as a result of surveys made in recent years.and, particularly, in 1955-195[illegible]. These deposits will make it possible to organize a diamond mining industry in the Yakutsk ASSR that would fully meet the demands for industrial diamonds in the Soviet Unions.

The paper <u>The Diamonds of Siberia</u> was prepared by a team of geologists who participated in the Amakin expedition that was arranged by the department for Research in the Ural Mountains and in Siberia at the Ministry of Geology and the Protection of Mineral Resources USSR on the basis of the latest materials available on the study of diamond deposits on the Siberian platform. The paper also includes reports on the occurrence of diamond rocks discovered on the territory of the Yakutsk ASSR as well as detailed accounts of the petrography and mineralogy of kimberlites and the crystallography and mineralogy of diamonds. The paper deals with the properties of the diamond-bearing placer deposits of the Vilyui Basin and the methods of geological diamond prospecting under conditions of the Siberian platform.

In view of the abundance of its factual data and its novelty as well as the importance of the problem of supplying our national economy with domestic diamonds, this paper is of great interest to the broad circles of Soviet geologists despite inadequate references to the original sites of diamonds and an insufficient elaboration of individual problems.

K. Korshunov

I. ORIGINAL SOURCES OF DIAMONDS IN THE BASIN OF THE VILYUI RIVER

The Vilyui diamond-bearing region (Figure 1 and 2 - inset) is located in the northwest of the Yakutsk ASSR and expands to include the basin of the Vilyui River and its main tributaries, the rivers Markha, Tiung, Ygyatta, Akhtaranda and the Bolshaya and Malaya Batuobi.* The total area of the diamond-bearing deposits exceeds 300,000 square kilometers.

In recent times this region has been expanding toward the north. Industrial diamond deposits were discovered in the basins of the rivers Muna and Olenek.

Structurally, the Vilyui diamond-bearing basin is located in the central part of the Siberian platform at the site of the conjugation of several large structures of various ages: the Anabar Lower Paleozoic Anticline, the Angar-Lena Lower Paleozoic depression, the Upper Paleozoic Tungusak Syncline and the Mesozoic Vilyui Syncline.** This gives and idea of the location of the deposits of the Paleozoic and the Mesozoic in the above areas.

The entire north of the region as part of the southern slope of the Anarbar Anticline, is primarily formed of sedimentary deposits of the Upper Cambrian and the Lower Ordovician that

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* On the geological map (Figure 2) the names of the two last rivers are listed in the Yakutsk language: The Bolshaya Batuobiya-Ulakhan-Batuobiya River, the Malaya Batuobiya-Uchohuguyi-Batuobiya River

** Names of the structure quoted from N.S. Shatsky and N.S. Zaitsev (1954) that are highly inclined in the southwest toward the Tunguska Syncline where they are gradually replaced by deposits of the Middle and Upper Ordovician and Lower Silurian.

North of the above region, toward the center of the Anbar Mountain Range we found very old sedimentary rocks of the Middle and Lower Cambrian as well as reefs of the Upper Proterozoic.

These almost not dislocated sedimentary rocks data from the Lower Paleozoic and Upper Proterozoic. They are embedded with great shifts and angular unconformity on the folded rocks of the old pre-Cambrian that serves as the foundation of the platform. The overall thickness of the Upper Proterozoic and Lower Paleozoic deposits (ranging from reefs to Silurian formations inclusive) or -- and it amounts to the same -- the depth of the stratification of the crystal bed is determined by N.S. Zaitsev as varying from 1,500 to 2,000 meters.

In the south, the region of Lower Paleozoic rocks of the Anbar slope tapers off changing in the northeast into the Angaro-Lena Lower Paleozoic depression where a number of large positive and smaller negative structures and domal formations were noted.

In the north and northwest, this depression borders on the Tunguska Syncline which consists of thin sedimentary and tuff rocks of the Upper Paleozoic and Lower Mesozoic with intruding stratified and crossing traps. In eastern and southeastern direction the Lower Paleozoic rocks are gradually submerged under continental and marine sedimentation of the Lower Jurassic which form the border area of the Vilyui Syncline and the inclined superimposed Tunguska-Vilyui Mesozoic depression. The thickness of the Lower Jurassic sediments does not exceed 100 meters here. In the east, that is toward the center of the Vilyui Syncline, Lower Jurassic rocks alternate with increasingly younger Mesozoic deposits their width gradually increasing in that direction. The central part of the Vilyui Syncline is formed by Cretaceous deposits. According to recent reports the overall width of all Mesozoic deposits exceed three kilometers.

The basic igneous rocks of the trap complex gravitate toward the border of the Tunguska Syncline and are associated with the zone of deep fractures that stem from the areas of crustal movements on the borders of the Tunguska Syncline and the surrounding Lowbrr-Paleozoic structures. The basic phase of trap vulcanism dates back to the Triassic.

There is a geological analogy between Siberian traps and the dolerites of Carru in South Africa bearing down on the similarity between the geological development of these two important pre-Cambrian platforms and their diamond-bearing areas.

This similarity is emphasized by the occurence of peculiar alkaline basalt rocks on the Siberian platform similar to the basalts that are found along with South African kimberlites. This fact gave rise to certain prognoses.

It has been definitely established now that kimberlites occur on the Siberian platform. As far as their petrography and occurence is concerned they are absolutely analoguous to South African kimberlites.

These rocks are associated with local structures and run vertically into the depth. They are known as "explosvie pipes." Kimberlites that fill the pipes are the original sites of diamonds in South Africa as well as in Siberia.

Kimberlite pipes were discovered in two areas of the Vilyui diamond-bearing basin. These areas are located at a distance of a few hundred kilometers from each other: in the south, in the Malaya Batuobiya region, and in the north in the Daaldyn region. Both border on the Tunguska Syncline where Ordovician carbonaceous rocks predominate almost exclusively and are adjacent to the zone of the greatest occurence of traprocks.

Below is a description of the geological structure of the regions and the geology of kimberlite pipes.

GEOLOGICAL OUTLINE OF THE MALAYA BATUOBIYA BASIN

This territory is part of the Suntarskyi District of the Yakutsk ASSR.

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GEOLOGICAL OUTLINE OF THE MALAYA BATUOBIYA BASIN

This territory is part of the Suntarskyi District of the Yakutsk ASSR.

It is located in the basin of the Malaya Batuobiya River, an important tributary of the Vilyui River, within the boundaries of the flat Central Siberian elevation and on the border of the Lena-Vilyui lowland.

Tre Malaya Batuobiya Basin is located where two different structural areas contact each other: the Upper Paleozoic area of the Tunguska Syncline and the Mesozoic area of the Vilyui depression which accounts for the heterogeneity and complexity of the geological structure of this territory (Figure 3).

The bed is underlain by variegated gypseous marls of the Upper Lena formation orginating with the Upper Cambrian. They occur extremely rerely and it only emerges to the surface at a few points in the center of deep brachyanticline folds. The deposits of the upper Lena formation gradually change into a wide (up to 200 meters) series of carbonaceous sandstone and argillaceous and carbonaceous rocks. Most geologists classify them as part of the Ust Kut formation of the Lower Ordovician. These rocks are very common and fundamental in the geological formation of this area. The basement of the formation is characterized by an interstratification of heavy and platy dolomites and calcareous rocks with variegated marl. In the upper parts of the formation carbonaceous sandstones prevails. Sandstone that originates presumably with the Carboniferous Era is embedded on the eroded surface of Lower Paleozoic rocks and was identified only in one spot. There are also continental argillaceous sandstone deposits of the Lower Permian which are found in the form of small spots in the northwest. Their thickness does not exceed a few dozen meters. In some areas the rocks are interbedded with small (10 to 20 meters) tuff formations (tuff, sand and tuff conglomerates) of the Upper Permian and Lower Triassic. The nature of their contact with the Lower Permian deposits is not clear.

Deposits of the Lower and Middle Paleozoic are intruded by primary igenous trap rocks represented by uniform fine and medium-size crystals of olivine diabase. Most common are sills with a thickness of about 100 meters in the northwest. Their thickness decreases in the southeast; they disappear completely in the upstream area of the Malaya Batuobiya River. Dykes are the most frequently encountered cross layers here and, to a lesser extent, irregularly shaped intrusions. Dykes are common in the northwest which is characterized by the greatest concentration of traprocks as well as in other areas where they occur in Ordovician rocks. Apparently, the intrustion of the basic mass of diabase took place in the Triassic Era inasmuch as they intrude Lower Paleozoic rocks, as well as the productive (R_1) and the tuffogenic formation. (R_2-T).

Mesozoic deposits are found in the form of sandstones and conglomerates of the Upper Liassic (Ukugut formation) which are embedded on the eroded surface of all older sedimentary and igneous rocks described above. South of the area, Lower Jurassic deposits are most common. They fill a flat depression that runs in almost latitudinal direction from the Nizhaya Tunguska River toward the basin of the Vilyui River where it merges with the edge of the Vilyui depression. The thickness of the sandy congrolmerate deposits of the Ukugut formation gradually increases toward the axial part of the depression reaching 100 meters there. At the edge of tho depression Jurassic deposits are eroded and found only in the form of individual patches. Their thickness does not exceed 20 to 25 meters.

Littoral, marine and argillaceous clays as well as calcareous deposits of the Middle Liassic are conformably embedded on continental deposits of the Upper Liassic. These deposits are greatly eroded with the exception of a very small area. Their thickness reaches a maximum of ten to 12 meters.

Old alluvial deposits of sand, gravel, pebble and kaolinite clays presumably of Tertiary age belong to the Cenzoic (?). They were found in the basin of the midstream are of the Iireleekh River in 1955. They form small patches in a flat watershed of carbonaceous rocks of the Ust-Kut formation of the Ordovician. Further research will show wheter there deposits also occur in other areas.

Common are eluvial, deluvial, solifluctional and bog deposits of Quaternary age. They were transported from the upper part of rivers and watersheds. There are also young (river beds) and old (terraces) alluvialconglometates of sand and pebble from large river valleys.

Rocks of the Lower Paleozoic, Middle Paleozoic and Mesozoic along with magmatic traprock are unevenly distributed and are associated with certain northeastern areas and zones that are subordinate to the general expansion of the structures in this part of the Siberian platform.

The structure in the northwest of the Malay Batuobiya Basin is primarily compoesed of traps that intrude rocks of the Lower and Upper Paleozoic. Southeast from the zone of traps a predominance of rocks of the Ordovician was observed with individual sections unconformably overlain by younger deposits of the Lower Permian and Lower Jurassic. The entire south and southeast of the basin is formed of continental deposits of the Lower Jurassic with small zones covered by littoral-marine deposits of the Jurassic.

As a result of the tectonics of this areathe geological zonal structure is very distinct. It borders on three structures that expand in northeastern direction (figure 4):

1) the southeast edge of the Tunguska Syncline where rocks of the productive formation occur most commonly

2) the areas of the relatively upheaved stratification of rocks of the Lower Paleozoic at the edge of the Vilyui Syncline and the Tunguska-Vilyui Mesozoic depression, and

3) the Tunguska-Vilyui Mesozoic depression.

As a whole, the above structures correspond to three structural stages. The rocks of the Lower Paleozoic that form the lower structural stage are embedded almost horizontal and plunge gently in the east. Against the background of the general monoclinal dip of the rocks several flat anticlinal folds overburdened by emerging deposits of the oldest Upper Cambrian and deposits of the lower beds of the Ust Kut formation were encountered. It is very likely that these structures are connected with the tectonics of salt deposits. There are flat brachyfolds in the rocks of the Lower Paleozoic which may also be connected with it.

The rocks of the Upper Paleozoic that form the middle structural stage are horizontally embedded on the eroded surface of the deposits of the Lower Paleozoic.

In the south and in southeaster direction, the rocks of the Lower Paleozoic are submerged under deposits of the Lower Jurassic that belong to the upper structural stage that fills out the flat Mesozoic depression of the Tunguska-Vilyui area. The rather sharp plunge of the rocks of the Lower Paleozoic at the border of the depression is, evidently, of young tectonic shifts, such as, for instance, a relative subsidence of the central part of the depression while the border section is upheaved. These shifts may have caused the minor fissures, cracks and clefts that characterize this area and are visible on aerial photographies. They follow two sets of patterns: running southward and northeast. more or less along the present outlines of the Tunguska-Vilyui depression. Older deep fractures were filled with trapmagma during its intrusion and run south and northwest.

Faulting is common in the west of the above territory, in the midstream basin of the Bolshaya Batuobiya River where trap intrustions are most common. This area of intense discordances and block shits is, actually, the continuation of the zone of fractures in southeastern direction including the basin of the Akhtaranda River and the adjacent area of the Vilyui River Basin. In the east, in direction of the Malaya Batuobiya River, faulting becomes more conspicuous although individual fractures are still found even there which proves the drastic tectonic unconformity between the rocks of the Ust Kut formation and the younger rocks of the Lower Permian and Lower Jurassic. It also bears witness of the presence of individual trapdykes in the zone of sedimentary beds in the rocks of the Lower Paleozoic.

Before the original diamond-bearing deposits in the basin of the Malaya Batuobiya River had been discovered research revealed in 1954 the connection between the aureole of the dissemination of pyropes and consequently the region of the estimated distribution of kimberlite pipes, with a definite tectonic structure, that is with the area of relatively upheaved rocks of the Lower Paleozoic which borders directly in the southeast on the field where traps are most common.

This tectonically unstable zone on the border of the Mesozoic depression was considered as the most likely diamond-bearing source.

In the southeast, toward the Bolshaya Batuobiya River this unstable zone tapers out and the area of the maximum occurence of traprock borders on the Tunguska-Vilyui depression. This discovery led to the assumption that there is only little change of finding original sources of diamonds in the basin of the Bolshaya Batuobiya River.

Investigations conducted in 1955 by the surveying and prospecting teams of the Amakin expedition corraborated this assumption. The kimberlite pipe found in the basin of the Malaya Batuobiya River is located within the borders of the above structure. The fact that it is shot through with pyropes lead to the assumption that there must be other kimberlite pipes which are still to be traced in the future. Survey and prospecting teams established that west of this area in the basin of the Bolshaya Batuobiya River there was not much to expect in regard to original diamond deposits or placer deposits.

GEOLOGY OF THE KIMBERLITE PIPE "MIR"

In June 1955 team No. 132 of the Amakin expedition discovered the first kimberlite pipe in the basin of the Malaya Batuobiya River, This kimberlite pipe was named "Mir".

The geological structure of the area adjacent to the pipe "Mir" is rather simple (Figure 5x). The oldest rocks are carbonaceous and belong to the Ust Kut formation. They are mostly encountered in the form of heavy and fine dolomite platies or in the form calcareous dolomites interetratified with gray

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x Another kimberlite pipe was discovered in 1956 within the above structure. It was named "Kollektivnaya" pipe. In addition, several important magnetic anomalities were established in this area by geophysical research.

and less frequently with reddish marl. The deposits of the Ust Kut formation run almost horizontally but flat brachy folding occurs.

The greatly eroded rocks of the Ust Kut formation are overlain by continental sand and argillaceous sediments. Pollen analysis proved that they belong to the Lower Jurassic Era. The sediments in the above section are formed of small clastic carbonaceous facies that are rather unusual for the continental Lower Jurassic series. The foundation of the layer is formed by bedded, gray and yellow as well as mottled loose and solid clays, varied clays, thinly laminated banded argillaceous rocks and siltstones with vegitation sediments. They include disintegrated interstratifications and lenses of varbonaceous clays and brown coal with a thickness that varies from a few centimeters to 0.5 to 0.8 meters, or probably even more since minor mining operations did not strip the bottom layer of coal.

The foundation of the visible part of the bed contains light-gray arkosic sands and sandstones as well as rusty colored ferruginous solid sands with the grains varying in size.

The top levels of the Lower Jurassic deposits are formed of friable and heavy sands. They are medium and coarse-grained, yellow and grayish yellow and interstratified with pebbles and gravel sands. The lithology the top section is similar to common and characteristic Lower Jurassic continental deposits (Ukugut formation).

Directly northeast from the pipe "Mir" the widest occurence of Lower Jurassic deposits was found on a flat watershed where they form an irregular oval patch and are washed out northeastward and southeastward by the upper parts of small streams.

In the northeast, the Lower Jurassic deposits form a sharp tectonic unconformity with the rocks of the Ust Kut formation bordering on them along the line of an assumed fault that stretches in northeaster direction along the Khabardin River. The pipe "Mir" is located along the continued line of this fault.

In the east and southeast from the pipe, Lower Jurassic deposits are normally interbedded in the rocks of the Lower Paleozoic. Their contact lies at an absolute altitude of 330 to 340 meters and at a relative altitude of 60 to 70 meters.

It is quite possibel that the thickness of Lower Jurassic deposits--ranging from 1 to 3 and up to 15 meters -- increases toward the fault level at its northwest hanging wall.

East and south from the described section sand, gravel and pebble sedimentation of the Lower Jurassic directly covers carbonaceous Ordovician rocks. There are no coal facies.

The youngest formations (excluding the formations of the Quaternary) are evidently those detected in 1955 by team No. 200 in the form of peculiar clay, sand and gravel diamond-bearing deposits not affected by erosion in a very small zone (200 by 400 meters) only near the pipe "Mir". The characteristic peculiarity of these deposits, which differ drastically from the environment is the uniform coarse clastic matter represented pebbles and gravel of quartz, quartzite, fling and other indurated rocks with a small quantity of greatly eroded conglomerates of kaolinized rocks, the composition of which has not been established. Solid and heavy kaolinite bright and variegated clays (gray, bluish-gray, yellow, raspberry red, etc.) are interbedded in the foundation of the series.

The lithologic peculiarities of this series of rocks testify to its lake and alluvial origin and that they were products of the chemical weathering of the surrounding rocks when they were redeposited under the conditions of a slightly disintegrated relief.

This is a good explanation for the high concentration of diamonds in this series which exceeds the diamond content in the kimberlites. The thickness of the above deposits is not great at all ranging only by several times from one to five meters. In a very small area the thickness changes drastically. This may be due to the sink-holes in the carbonaceous basement rocks of the Paleozoic which preserved them from erosion.

The age of these deposits is commonly accepted as Pre-Quaternary, most likely Tertiary, for general reasons and because of the similarity to other regions of the Siberian platform where the kaolinite crust shows the effects of weathering on rocks of the Upper Cretaceous Period.

The correlation of the kimberlite pipe "Mir" with the above rocks of the Paleozoic, Mesozoic and Cenozoic is clearly shown on maps and profiles (Figure 5). The pipe tears through rocks of the Ust Kut formation. For the time being no direct contact with younger deposits has been observed. The pipe "Mir" looks like an irregular oval body stretching from northwest to southeast. Its size is 490 x 320 meters (Figure 6).

Mining operations penetrated into the top kimberlite layer destroyed by weathering at a depth of 3.5 to 4 meters and only in some sections hard and solid rocks were encountered. Despite the depth of erosion the upper part of the pipe is built as follows: x

A delluvial and eluvial stratum is formed of fine-grained sands and some varved clays or gravel kimberlite with scales of bluish-green chlorite, and grains of pyrope and ilmenite. It includes rare rubble of hard kimberlites as well as rounded and sharp angular fragments of surrounding rocks. Delluvial deposits are greenish-gray and greenish-yellow. Interstratification is occasionally observed in the direction of the dip. In the peripheral parts of the pipe the delluvial structure changes somewhat. Large fragments and carbonaceous blocks of the Ust Kut formation conspicuously predominate here, sometimes forming a continuous delluvial bed up to 1 to 1.5 meter thick which covers the eluvial kimberlite.

At a depth of two to three meters greatly weathered kimberlite was encountered. It is formed of friable rocks that disintegrate rarely into detritus and gravel. The rocks are

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x The description of the pipe is taken from the report of mining teams.

greenish-gray, yellowish-green, dark green and sometimes light-blue; they are rich in bluish-green chlorite and pyropes and, to a lesser degree, in ilmente. The size of the fragments increases with the depth. The rocks are marked by a pattern of thin (up to 0.5 centimers) apophyses filled out with calcite. In areas that were not as much affected by erosion a series of vertical cracks was observed which rarely are genlty inclined. Southeast (110 to 120 degrees) and southwest (210 to 230 degrees) cracks are in predominance. Along the cracks, iron lends the kimberlite an orange and rusty coloring. Deeper down the kimberlite becomes increasingly solid gradually turning into monolith rock. The cross-section of the kimberlite reveals that its structure is not homogenous. Two types of rocks can be recognized clearly: small clastic kimberlite tuff and coarse clastic kimberlite breccia.

Small clastic kimberlite tuff fills most of the pipe except its extreme southeastern part. Several varieties of tuff which differ in color and mineral composition should be discussed in more detail.

The first variety is a grayish-green massive rock formed of unevenly disseminated rounded grains of live-green and light-green serpentine which frequently consists of non-eroded pseudomorphs after olivine. It encloses individual flat crystals (five to seven millimeters large) of bluish-green chlorite and rounded winered and mayve grains of pyrope. The size of the mauve grains varies from one to five millimeters. The grains of pyrope are usually crumbling and easily split into small bits. They are surrounded by a thin greenish kelyphitic halo. The enclosure of small (up to 0.5 mentimeters) rounded, angular and irregular grains of ilumenite with a characteristic tar luster occurs less frequent. Numberous fragments of small-grained kimberlite ranging from 0.5 to three centimeters were observed in the rocks. Fragments of country rock are less frequent. Occasional banding caused by the interstratification of varities of coarse and fine-grained tuffs was noted.

The second variety is distinguished by the dark color of its basic mass and the brownish-green color of the serpentine. The rocks are shot through with extremely fine carbonaceous serpentine apophyses and minerals are enclosed in a halo of an aggregate of carbonaceous serpentine.

The two varieties of grayish-green and dark-green kimberlite form the whole central and northwestern section of the pipe which show deep erosion.

The third variety is a light greenish-yellow porous and blistered rock. Its structure bears great resemblance to that of the above varieties but its basic mass is lighter and the grains of olivine are smaller (pseudomorphs). In addition, an almost complete absence of bluish-green chlorite is conspicuous. The presence of a somewhat large number of fragments of country rock than in the above varieties should be noted. Individual clearly ferruginous sections of light kimberlite are yellowish-brown. On the map, this variety of kimberlite represents a semi-circle with a width of about 50 meters bordering on the pipe in the southeast at in its most uplifted part. It is most likely that the above-mentioned light kimberlite forms the altered upper part of the pipe which was affected by erosion in the center and in its northwestern part.

The second type of kimberlite -- the coarse tuffobreccia -- is represented by two varieties.

The first variety is encountered southeast of the pipe near the contact. The light gray greatly altered basic mass of the rock contains numberous irregularly disseminated grains and fragments of serpentinous olivine, laminae of bluish-green chlorites, and rounded grains of pyrope and ilmenite. The quantity of chlorite greatly exceeds the quantity contained in the first type of kimberlite. The presence of a great quantity (30 percent) of angular and rounded fragments of country rock is another characteristic property.

The second variety is encountered in the center of the pipe, near the upper part of the Khabardin River. The rocks are clearly marked by the presence of breccia, with patches showing the presence of quartz and even.of secondary quartzite.

In the kimberlites werfound inclusions of related ultrabasic rocks, crystalline schists (eclogites, eclogite-like rocks, and crystalline schists of the Pre-Cambrian), sedimentary rocks of the Lower Paleozoc and traps.

Among related inclusions which are, as a whole not very common in Siberian kimberlite (with the exception of kimberlite inclusions) lite peculiar greatly altered inclusions with porphyrite-like crystalline pyropes are found in individual sections of the pipe "Mir". Evidently they have formed from of the ultrabasic rocks (See Chapter II). The inclusions of eclogite-like rocks and crystalline schists of the Pre-Cambrian Ere which are very common in the kimberlite of the Daaldyn District are rarely found here.

Among foreign inclusions, carbonaceous rocks of the Ust Kut formation as well as diabases strongly predominate in this area. Inclusions of quartzite and other altered rock that cannot be identified under field conditions are rare. Their quantity is rather small and amounts to an average of about 5-10 percent in comparison with the surrounding kimberlite.

Sedimentary rocks are formed of dolomites and marls. Their fragments are usually rounded and, less often, angular. Their sizes vary from only a few millimeters to 10 to 16 centimeters. There are also slightly altered or almost unaltered sedimentary rocks their original structure having remained intact(fine oolitic, stromatolitic, etc. structure). Sometimes a fine bluish-green rim of metamorphic rock surrounds these fragments. In addition, there are differences in chert. However, actual contact cherts were not discovered by petrographic survey.

It is interesting that in the central section of the pipe inclusions of argillaceous rocks alternate with sharp angular argillite fragments, some of them washed down to clay and others very dense and with chert. These rocks bear a strong resemblance to deposits of the Lower Jurassic period which may be found directly in the vicinity of the pipe. The size of the visible part of the xenolith is 1.5 by 1.3 meters.

As a rule Diabase fragments have an aphanitic texture or other fine textures. They are angular and, occasionally, rounded. The size of the fragments reaches 20 to 25 centimeters in diameter. Large diabase rocks were encountered, their size reaching 1.5 by 0.35 meters. These rocks are almost not affected by kimberlite magma. The kimberlite is somewhat harder around the inclusions and seems to be "soldered" to the inclusions.

Foreign inclusions are distributed irregularly in the kimberlite mass. It should be pointed out that, as a whole, the greatest number of carbonaceous country rock was observed along the peripheral parts of the pipe. Accumulations of diabase fragments are encounted in the contact area and in the center of the pipe.

As already mentioned, the kimberlite pipe "Mir" tears through the sedimentary rocks of the Ust Kut formation formed by small oolitic argillaceous or sandy dolomites. The kimberlite contact with the country rocks is very conspicuous. The kimberlite reaches a thickness of three to five meters in the zone of contact where it turns into a porous clayey mass. Ferric oxide lends it an orange coloring. It is difficult to estimate the construction of this zone at greater depth since mining operations have penetrated into a depth of only two meters. Sedimentary rocks near the contact are slightly altered within a zone of two to three meters; they gradually turn greenish-yellow in the vicinity of the kimberlite and are conspicuously light near the contact. Dolomite oölites harden and their structure changes.

For the time being, "Mir" is the richest diamond-bearing pipe. During prospecting and surveying work diamonds were discovered directly in the primary rocks, i.e. in the kimberlite (Fig. 7 & 8).

The age of the "Mir" kimberlite pipe could not be determined if we based ourselves on the correlation between the kimberlite and the surrounding sedimentary rocks since we would only identify rocks of post Lower Ordovician age. However, the occurence of a great quantity of trap fragments in the kimberlite leads to the assumption that the pipe originates with the post Permian or even post Triassic period since the intrustion of traprock on this territory took place primarily in the Triassic -- inasmuch as they tear through the deposits of the productive (R_1) and and the tuff (P_2-T) formations.

It is impossible to determine the possible maximum age of the kimberlite pipe "Mir",since direct contacts with the Jurassic deposits cannot be traced. At the same time, it should be noted that the correlation of the rocks of the Lower Jurassic with the kimberlite pipe "Kollektivnaya", discovered in 1956 in the same district, seems to indicate that the kimberlites formed in before the Lower Jurassic Era.

It is interesting that the determination of the geological correlation between the Paleozoic and the Mesozoic rocks in the site of the pipe "Mir" leads to important conclusions as to the depth of erosion.

If we assumed that the kimberlite formed in the pre-Jurassic or post-Permian period, the effect of erosion would be very deep since the deposits of the productive and tuff formations at the edge of the southeast border of the Tunguska Syncline are not very thick and could not have 100 to 150 meters in pre-Jurassic times.

On the basis of data available we may state that the erosion affected the pipe "Mir" at a maximum depth of about one hundred meters and, probably, even less.

GEOLOGICAL OUTLINE OF THE DAALDYN REGION

The Daaldyn diamond-bearing region is located in the basin of the Daaldyn River, a left tributary of the Markha River, on the territory of the Olenek Administrative district of the Yakutsk ASSR.

Physico-geographically the area is located within the boundaries of the Central Siberian elevation. In the north it borders on the area of the Viluyi-Olenek watershed. The inclined ondulated relief with numerous small benches at the slopes of the mounds, due to the lithologic peculiarities of the rocks that form the basin of the Daaldyn River, is characteristic of the area. Only in the west in the basins of the rivers Sytykan and Alla-Urekh small truncated mesas of traprocks were observed.

Structurally, the Daaldyn district is located at the north northeastern edge of the Tunguska Syncline. It borders in the north on the southern slope of the Anabar Mountain Range and is associated with the Viluyi-Tunguska zone of fractures.

The geological structure of the Daaldyn diamond-bearing region is comparativel simple (Figure 9). Carbonaceous rocks of the Lower Paleozoic period are very common and actually occupy the entire territoyr. In several spots these deposits are marked by intrusions and trapdykes as well as by kimberlite pipes.

The Lower Paleozoic deposits dating from the Lower Ordovician are divided in three series.

Series of bituminous limestone: formed by brown and dark-gray thick and thin-bedded rocks with several layers of limestone conglomrates. In the center, a peculiar layer of clotted argillaceous limestone (marl) was found. In the underlying part of the series trilobite fauna was encountered. Somewhat further down there are patches of dark brown limestone with abundant trilobite fauna. The visible thickness of the deposits is about 40 meters.

The limestone conformably covers the underlying rocks and is very developed. Underlying interbedded yellowish and gray limestone, calcareous sands, conglomrates and oolite limestone occur commonly. Frequently, this layer is superseded by facies of mottled levels of red and rusty-colored fine argillaceous limestone, gray limestone sic and conglomrate.

Fine white and yellowish porous limestone occurs somewhat higher; it forms characteristic blocks that resemble tombstones on the surface of the slopes. Still hiher it turns into mottled limestone interbedded with coarse layers of limestone and light dolomite-like algael limestone. This is topped by two layers of mottled limestone, the lower containing rich trilobite fauna. The total thickness of the limestone series ranges from 150 to 160 meters.

The upper part of the layer of Lower Paleozoic deposits contains mostly dense fine-grained dolomites, greenish argillacous dolomite, fine-grained yellowish limestone and oolite dolomite limestone. These rocks form thin strat that are interbedded and include layers of interstratified conglomerates and algael dolomites. All these rocks are jointed in a series of dolomite and limestone. The thickness of this series varies from 30 to 110 meters.

The deposits of the Lower Paleozoic are typically littoral sediments and in some parts lagoon sediments that were transported to a shallow basin where they were exposed to differentiated oscillations; as a result of these oscillations the individual beds are thin and there is local faulting in the accumulation of sediments as well as alterations in the rock facies.

The traprocks are formed of medium and fine-grained aphanitic olivine diabase. They are most common in the southwest and west of the district in the basin of the Sytykan River and the upper parts of the Markha River. Blanket intrusionss predominate over dykes.

Blanket intrusions form three layers: at 360 meters above the sea level -- the thickness amounts to ten meters, at 380 to 490 meters above the sea level -- 120 meters and at 550 to 650 meters -- 80 to 100 meters. The outcrops of dyke traps are poor because of heavy overburden.

Trap intrusions are of Permian-Triassic age by analogy with other districts of the Siberian platform. It should, however, be emphasized that the site of the kimberlite pipes is is located beyond the strip of the maximum occurrence of traps.

Carbonaceous deposits of the Lower Paleozoic run usually almost horizontal with a slight inclination in the southwest toward the central part of the Tunguska Syncline.

A more detailed study of tectonics reveals that the entire lower series of bituminous limestone and the bottom of the calcaveous series of rocks is disrupted forming slight folds of a width varying from two to three and up to 150 to 200 meters. The inclination of the wall varies from two to five and up to 80 degrees. The axes of the folds are, as a rule, aligned toward the northwest and the north-northwest and less frequent in northeastern direction. In the upper part of the dolomite and calcareous series larger and greater inclined folds were observed which result from the outcropping of markers at various hypsometric levels.

A number of large tectonic fissures were encountered in the region, primarily in northwestern direction. Some kimberlite pipes ("Kroshka," "Leningradskaya," "Geophizicheskaya," and others) are connected with these fissures.

At several points in the watersheds a pattern of small clefts that run northeast and northwest were noted. They are, evidently, connected with young structures.

Geology of Kimberlite Pipes

Diamond-bearing kimberlites form tubular bodies (pipes) which tear through the carbonaceous series of rocks of the Lower Paleozoic. These rocks were found only in one area in 1954 (pipe "Zarnitsa").

In the summer of 1955 teams 167 and 204 of the Amakin Expedition as well as some members of the Eastern Geophysical Expedition discovered kimberlites in many parts and on a large territory of the Daaldyn District.

Structurally these kimberlite fields are probably associated with the deep fractures that mark a large zone in the northwest area of the Markha River where most faulting occurs and the effects of magma are visible. This zone borders on the right bank of the Daaldyn River next to a pattern of small fissures in the Ordovician series and lies within the boundaries of the kimberlite bodies found in this area. The fissures are visible on aerial photographies and have been discovered in the course of surveying and magnitometric works.

A total number of 22 kimberlite pipes was discovered in the Daaldyn region. Mining operations have not as yet penetrated into pipes found through magnetic surveys.

The study of the kimberlite pipes was being conducted during their discovery in the course of surveys. It goes without saying, therefore, that they have not been studied equally well. For the time being, the kimberlite pipe "Zarnitsa" has been investigated more or less thoroughly. Mining operations penetrated into a depth of ten to 12 meters. Some material was gathered on the pipes "Udachnaya," "Leningradskaya," "Molodezhynaya," "DolgOzhdannaya," and "Dalnaya," by a metwork of prospecting pits and trenches at a depth of 2.5 to three meters. The pipes "Poliarnaya," "Maliutka," "Sosednaya," "Osennaya," "Sytykam," "Zagadochnaya," and "Nevidimaya," have been hardly studied with only and individual mining operations that penetrated into a depth of one to two meters.

The above kimberlite pipes are located on a large territory (in an area of about 25 by 60 square kilometers) with well marked outlines of the kimberlite fields.

Kimberlite pipes vary in different sizes. Their diameters vary from 40 to 50 meters (pipe "Maliutka") and reach 600 meters (pipe "Zarnitsa"). The pipes are usually rounded or somewhat elongated, frequently the outlines are bizarre.

The pipes that have been discovered so far are located in watersheds, along slopes and in river beds. They are hardly visible. It is impossible to discover the pipe through aerial photography and only very rarely can their outlines be identified. Geophysical investigations conducted in 1955 in the Daaldyn diamond-bearing region have produced very favorable results in the discovery of kimberlite pipes.

Below is a short description of the kimberlite pipes located in the area.

Pipe "Zarnitsa"

"Zarnitsa" was the first pipe discovered in August 1954 in the Daaldyn region during prospect operations for pyropes. It is located on the flat turfy surface of a watershed between two small streams that flow into the Daaldyn River.

The size of the pipe is 573 by 532 meters. The kimberlite pipe has the shape of an isometric body (Figure 10). The relief of the pipe is invisible, it simply follows the elevated horizontal profile of the watershed.

As a result of harsh climatic conditions the surface of the kimberlites is hardly altered. No weathering zones of "yellow and blue soil" which are characteristic of South African pipes have been observed here.

The basic erosion was brought about by frosts that contributed to the disintegration of the dense material of the pipe. The eluvial zone is 4-5 meters thick. It covers hard, monolith kimberlite.

The eluvium shows a few markers under a cover of moss and soil with an admixture of loam, gravel and eluvial material of the kimberlite, there is a bed of loam and gravel half a meter thick. It is interbedded with gravel and detritus formations that are up to one meter thick. These formations are underlain by small and large eluvial conglomerates the size of individual units reaching half a meter. Gradually they change into monolith kimberlite. The eluvial material is firmly cemented by ice.

The kimberlite of the pipe "Zarnitsa" represents a rather hard greenish or bluish-gray carbonaceous rock. There are numerous external inclusions of different shapes and sizes which in certain areas amount to over 50 percent of the total volume of rocks so that the kimberlite resembles vulcanic tuffobreccia.

The kimberlite may be classified into five groups:
First: the predominat variety here is greatly weathered light greenish-gray and slightly ferrigenous kimberlite which contains

a maximum of 50 percent foreign fragments (Figure 11);

Second: this variety is very dense compact kimberlite with a great quantity of yellowish-green grains of pseudomorph of serpentine after olivine, shot through with grains of ilmenite and pyropes and micaceous laminae. The color of the kimberlite is greenish-gray. Fragments amount to about 60 percent.

Third: this variety is formed of hard, coarse breccia, a fresh fracture is deep dray, slightly carbonaceous kimberlite, the contents of fragments 60 to 70 percent.

Fourth: very hard, compact light blue or green kimberlite with small fragments (up to 30 percent) of other rocks.

Fifth: hard small fractured yellowish-brown kimberlite impregnated with ferric oxide.

The basic body of the pipe consists of the first and second variety of kimberlite. So far, no correlation has been established between the two. The third variety is associated with the outer borders of the pipe forming a semicircle that expands from the north, northeast to the southeast. The fourth variety is found in one section only at the eastern border of the pipe. The fifth variety of the kimberlite was encountered only at a depth of six to ten meters in Prospecting Pit No.15. It is a 30 centimeters thick vein-like body that cuts through the hard greenish-blue kimberlite of the fourth variety. The vein expands at 50 to 60 degrees in the northeast and dips at 80 degrees in the southeast.

The kimberlite body is characterized by coarse fracturing. It divides the monolith rock into large angular carbonaceous blocks. Two patterns of joints without any uniform direction were observed among fractures. One pattern of joints dips in the northwest at 320 to 328 degrees at an angle of 70 to 74 degrees; the other joints are less pronounced, they have a northeastern 70 degrees dip at an angle of about 50 degrees.

The slickensides are well developed along the fissures; they are accompanied by breccia and shale. Most frequently the slickensides are observed in the adjacent zones of the pipe as well as in the kimberlite and in carbonaceous surrounding rocks. Frequently, peculiar ball-like jointing characteristic of individual kimberlite varieties were observed. The diameter of these ball-shaped formations reaches one to one and a half meters; they easily fall apart into large pieces.

Microfracturing is characteristic of kimberlite so that this rock easily crumbles during the process of thawing.

Surveys revealed that evidently the essential fracturing which serves as an excellent feeder for hydrothermal solutions is connected with faulting in the pipe that is overburdened by slickensides.

Probably the deep alteration of kimberlite manifested in intense carbonization, complete serpentinization of olivine and, partially, of the basic mass, is connected with these solutions. In some areas small druses of crystalline calcite and accumulations of magnetite were encountered. Investigations of the contact of surrounding rocks revealed that in some sections the dip of the contact surface is directed toward the center of the pipe at an angle of 50 to 70 degrees; occasionally some upheaved stratum of the surrounding rocks are noticeable.

As a rule, the rock is greatly weathered in the zone of contact where the thickness of the greatly altered kimberlite reaches one to one and a half meter. Abundant deep-red formations of ferric oxide and intense carbonization of the kimberlite were perceived. Limestone and clay shale are somewhat harder at the contact with the kimberlite, and, are evidently, at least partially recrystallized.

Great quantities of xenoliths of sedimentary rocks formed by different kinds of limestone, dolomite and argillite are common in the kimberlite. The size of the inclusions varies from a fraction of a millimeter to 0.5 meters. It was established that the increase in the size of the xenolity of sedimentary rocks as well as their quantity is associated with the areas thar border on the pipe. The large inclusions of light-yellow and yellow limestone have a diameter of up to 1.5 meter ("floating reefs"). Limestone inclusions are, usually, rounded while dolomite and argillite is more frequently present in the form of flat angular fragments.

In the xenoliths of limestone and argillite rich fauna of brachiopods, gastropods, corals, trilobites, etc. is present (Figure 12). But the greatest quantity of fauna was found in light coffee-colored limestone and green argillite where entire sections consist of brachiopods. Rich fauna composed of brachiopods and gastropods filled the xenolity of deep-gray bituminous limestone. This fauna has been excellently preserved. It is interesting to note that among various species characteristic of the Ordovician, Llandoverian fauna was detedted. However, the deposits of this fauna were completely washed away on this particular territory.

Along with sedimentary rocks, xenoliths of metamorphic rocks commonly occur in the kimberlite of the pipe "Zarnitsa." As a rule, they have a smooth rounded surface and sometimes resemble rolled pebbles. The form of the xenoliths varies: they are flat, elongated, ball-shaped, etc. The size ranges from 1 to 1-15 centimeters. Usually, the xenoliths are surrounded by a dense deep-green chlorite serpentinous halo and can be easily "shelled," similar to nuts. Deep-green and light crystalline schists occur commonly. Also frequently present are garnet-like (pyrope-bearing) crystalline schists with excellently marked banding caused by the interbedding of layers bearing rich garnet. More frequent are light kaolinized eclogites and somewhat less common are darker very resistant eclogites.

Ilemite is the most common mineral in the kimberlite along with rounded grains of pyrope, their size reading one centimeter; less often are laminae of biotite up to one centimeter large and egg-shaped yellowish green entirely serpentinous olivine two to three millimeters large; chromium diopside is extremely rare.

Pipe "Nevidimka"

This pipe was discovered by magnetic survey in July 1955. The pipe is about 250 by 150 meters. It expands in southwestern direction and has uneven winding outlined. In an eluvial layer, at a depth of 2.5 meters, small fragments of kimberlite were discovered. Larger pieces were found in the bed of the Yaki River that has been washing away the pipe. Under the microscope the kimberlites of the pipe "Nevidimka" strongly resembles the rocks of the pipe "Zarnitsa". They are formed by light greenish-gray and highly carbonized kimberlite breccia. There are 40 to 60 per cent fragments.

In addition to inclusions of sedimentary rocks many rounded xenoliths of crystalline shale are encountered including pyrope-bearing xenoliths. A great quantity of grains of pyrope and ilmenite was found as well as brown micaceous laminae. The cementing mass of the rock amounts to 40 - 60 percent and is composed of strongly carbonized green and gray serpentine material. The heavy fraction of the schlich basically consists of ilmenite and pyrope with the grains varying in color and size.

Considering the similarity between the kimberlite of these pipes and their location we may assume that they are linked deep within the earth by a common channel.

Pipe "Maliutka"

This pipe was discovered in Mat 1955 in the process of searching for pyropes. The discovery was confirmed eventually by magnetic surveys. The size of the pipe is about 50 by 70 meters. It is somewhat elongated with even slightly winding outlines. The pipe is submerged under deluvial deposits of carbonaceous rocks of the Ordovician. The thickness of these rocks reaches 1.5 meters.

The kimberlite of the pipe "Maliutka" consists of extremely close-grained light blue and greenish greatly calcarous rock including a great quantity of rather large (from one to 10 centimeters) fragments of various sedimentary rocks (limestone, argillite, etc.).

Xenoliths amount to about 30 to 40 per cent of the total rock with 60 to 70 per cent composed of a light blue and green serpentinous cementing of chlorite mass. The heavy fraction of schlich is primarily formed of small grains of pyrope, ilmenite and magnetite. There are few signs that chromium diopside is present.

Pipe "Sosednaya"

This pipe is located southwest of the pipe "Maliutka". It was found in September 1955 by magnetic survey. The size of the pipe is 120 by 80 meters.

On the surface the pipe is overlain by argillaceous deluvium of carbonaceous rocks of the Paleozoic. It is two meters thick. The kimberlites that fill out the pipe consist of very close grained, small, deep gray and comparatively weakly carbonated breccia shot through with small grains of pyrope and ilmenite, light micaceous laminae as well as with large flat crystals of chlorite. Xenoliths amount to about 60 per cent. Present are rounded fragments of close-grained limestone, black micaceous slate and pyrope-bearing rocks (in a cube test of the eluvium one diamond crystal was discovered).

Pipe "Dolgozhannaya"

The pipe was discovered through geophysical research in August 1955. Its sizes: 220 by 220 meters. It is rounded and somewhat elongated at its northeast side. The pipe is located on the slope of a mound and is overlian by a deluvial coat of carbonaceous rocks that form a watershed. The thickness of the delivium varies from 0.5 to 12. meter. The kimberlite eluvium is formed by kimberlite fragments of a different size ranging from quick loam and gravel and including fragments of 0.5 meter.

Under the microscope the kimberlites that fill out the pipe consist of close-grained grayish-brown or greenish-gray strongly carbonated small fragments of tuff and breccia. Various xenoliths amout to 70 per cent of the total volume of the rock and the brownish or greenish-gray cementing carbaceous serpentinous mass amounts to a mere 30 per cent. Sedimentary rocks of gray, deep gray and greenish limestone, calcareous conglomerate, slate and other rocks predominate among a great variety of inclusions. The quantity of the xenoliths of sedimentary rocks increase markedly near the contacts. An almost unchanged fauna of trilobites was discovered in the form of an inclusion directly in the kimberlite.

In addition to inclusions of sedimentar rocks there are large (up to ten centimeters) inclusions of various green and black crystal schists found in the kimberlites (although they are not very common)as well as minor inclusions of greatly weathered pyrope-bearing metamorphic rock. All these xenoliths are 0.3 to 30 - 40 centimeters large; they are rounded, with a smooth surface.

In addition to xenoliths of different rocks perfectly rounded grains of pyrope are disseminated throughout the kimberlite. They are usually bloody red or violet. There are also small fragments of ilmenite which appear to be "welded".

The mass of schlich of the kimberlite eluvium consists primarily of large grains of pyrope (up to three millimeters). ilmenite and magnetite. Less common are chromite, green pyroxene, small grains of olivine and other minerals.

In the contact zones between the kimberlite and the surrounding rocks ferruginous deposits are found. In some parts the kimberlite is highly carbenaceous. Excellent slickensides are observed on kimberlites and sedimentary rocks. Hydrothermal phenomena are only slightly pronounced in the kimberlites. As a rule, magnetite fills the hollows and cracks. It is found here in the form of crystals or an unbroken reniform mass while calcite is present in the form of crystals and variegated sinters.

Pipe "Leningradskaya"

This pipe was discovered through geophysical survey in August 1955. On the surface the pipe is overlain by a blanket of argillaceous deluvial sedimentation composed of fragments of carbenaceous rock of the Ordovician with a thickness of 1.5 to slate and other rocks predominate among a great variety of inclusions. The quantity of the xenoliths of sedimentary rocks increase markedly near the contacts. An almost unchanged fauna of trilobites was discovered in the form of an inclusion directly in the kimberlite.

In addition to inclusions of sedimentar rocks there are large (up to ten centimeters) inclusions of various green and black crystal schists found in the kimberlites (although they are not very common)as well as minor inclusions of greatly weathered pyrope-bearing metamorphic rock. All these xenoliths are 0.3 to 30 - 40 centimeters large; they are rounded, with a smooth surface.

In addition to xenoliths of different rocks perfectly rounded grains of pyrope are disseminated throughout the kimberlite. They are usually bloody red or violet. There are also small fragments of ilmenite which appear to be "welded".

The mass of schlich of the kimberlite eluvium consists primarily of large grains of pyrope (up to three millimeters). ilmenite and magnetite. Less common are chromite, green pyroxene, small grains of olivine and other minerals.

In the contact zones between the kimberlite and the surrounding rocks ferruginous deposits are found. In some parts the kimberlite is highly carbonaceous. Excellent slickensides are observed on kimberlites and sedimentary rocks. Hydrothermal phenomena are only slightly pronounced in the kimberlites. As a rule, magnetite fills the hollows and cracks. It is found here in the form of crystals or an unbroken reniform mass while calcite is present in the form of crystals and variegated sinters.

Pipe "Leningradskaya"

This pipe was discovered through geophysical survey in August 1955. On the surface the pipe is overlain by a blanket of argillaceous deluvial sedimentation composed of fragments of carbonaceous rock of the Ordovician with a thickness of 1.5 to

1.7 meter. Magnetic survey shows that the pipe is somewhat elongated expanding from west to east. Size 520 by 350 meters.

Presumably, the kimberlite pipe tears through a rather thick diabase dyke that runs northeast intruding rocks of the Lower Paleozoic. Unfortunately, it has not been possible so far to establish the contact zone between the kimberlite and the diabase.

The kimberlite that fills out the pipe is formed by dense highly carbonaceous rock in the form of small tuff-like violet and brown fragments. The fragments in the rock amount to 80 to 90 per cent and only ten per cent consists of cemented carbon and serpentine. The size of the fragments is usually one to one and a half centimeters and less frequent two to five centimeters. The basic mass of inclusions is formed of sedimentary rocks of various limestones dolomites clay shales etc. Brachiopod fauna is present in the xenoliths of gray bituminous limestone. The xenoliths of sedimentary rock are depressed and, occasionally, perfectly rounded xenoliths are encountered.

Xenoliths of dark crystal shale are considerably less frequent in the kimberlite breccia. Also rare are small xenoliths of pyrope-bearing rock and xenoliths of dense deep-gray diabase formed of medium grains.

The cementing mass of the rock contains yellowish-green serpentine pseudomorph after olivine, rounded grains of ilmenite, that are up to one centimeter large and different-colored grains of pyrope as well as rare crystals pf phlogopite. In the vicinity of the contacts hydrothermal magnetite deposits were observed and differently shaped varigated crystals of calcite were found in hollows and cracks. The massive group of schlich composed of small kimberlite eluvium contains mostly ilemite and some pyrope and magnetite. Individual grains of bright green chromium diopside are present.

Pipe "Molodezhnaya"

It is located at a distance of one kilometer from the pipe "Leningradskaya." It was found by magnetic survey simultaneously with the pipe "Leningradskaya."

Its size is 160 by 180 meters. It is elongated in the west and has even but occasionally broken outlines. Under a blanket of argillaceous deluvium of rocks of the Paleozoic kimberlite eluvium was detected at a depth of 0.3 to 1 meter. An oxidized contact zone of kimberlite and limestone surrounding the pipe was discovered.

In regard to form and composition the kimberlite is very similar to the kimberlite of the pipe "Leningradskaya." Generally it is present in the form of dense small fragments of dark greenish-gray kimberlite tuff. Various xenoliths amout to 60 per cent of the total volume of the rock. The difference between the kimberlite of the two pipes is that the kimberlite of "Molodezhnaya" contains much less crystal schists, and hardly any pyrope. However, very common here is large ilmenite with a size of up to four centimeters. As a whole, the rocks are highly carbonaceous. Excellent deposits of calcite crystals are found frequently in cracks and hollows. Occasionally, pronounced mineralization takes place as a result of the segregation of a uniform mass of magnetite.

The above mentioned pipes "Dolgozhdannaya," "Leningradskaya," and "Molodezhnaya" are located on the same level, in almost latitudinal direction.

Pipe "Dalnaya"

It was encountered during schlich testing for pyropes. According to the magnetic survey it is an isometric body with slightly winding outlines. The size of the pipe is 300 by 340 meters. Under a blanket of deluvial sedimentation of 1.5 to two meters greenish-brown fine-grained kimberlite eluvium was encountered with a large quantity of fragments of eclogite-like rock, crystal schists, sedimentary rock and many large rounded fragments of ilmenite (from two to three centimeters) as well as variegated pyrope.[x] The kimberlite is formed of a very dense greenish-brown (oxidized) highly calcareous variety and contains up to 60 per cent xenoliths of various rocks and minerals.

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[x] Crystals of light green unchanged olivine are common in alluvium.

Pipe "Udachnaya"

It was encountered in Jüne 1955 during schlich tests for pyropes.

The pipe "Udachnaya" is located on the left bank of the Daaldyn River in a field of sedimentary rocks of the Lower Paleozoic. It is shown on the map as an oval body with a bulge in the western part. The size of the pipe is 750 by 300 meters. The pipe is inclined in the southwest and is traced by bores which reach a depth of 200 meters under the surface. Bituminous limestone and dolomite with stratifications of silststone constitute the surrounding rocks.

The kimberlite that fills out the pipe "Udachnaya" is formed of two varietiesL 1) kimberlite breccia, light-gray and greenish-gray; 2) basalt-like deep green kimberlite with some breccia.

The western part of the pipe is formed of kimberlite breccia. It is characterized by a great quantity of fragments essentially consisting of various kinds of limestone; common are xenoliths of metamorphic rock of Pre-Cambrian age (biotite and fedlspar anorthosite-like rock, pyroxene-feldspar and garnet gneiss, micaceous slate, granelite and eclogite). The cementing mass of breccia contains great quantities of clastic ilmenite, garnet, magnetite, phlogopite, chromium diopside and changed olivine.

The eastern part of the pipe is formed of basalt-like kimberlite. It is a dark gray-green rock with a small quantity of clastic material and breccia. The cementing mass is characterized by the predominace of chlorite and serpentine over carbonate; grains of olivine are only partially serpentinous; less pyrope is present here than in breccia.

The central part of the pipe "Udachnaya" is composed of a great quantity of breccia and weathered kimberlite that form a strip of a width that varies from 100 to 140 meters. This strip divides the above mentioned kimberlite varieties. In the kimberlite of this zone a great number of slicken-sides were observed as well as highly ferrugious patches. The zone of the eroded kimberlite, resembles the contact zone in the way the character of the rocks has changed since in the contact zone the kimberlite is also formed of highly brecciated, carbonaceous and ferruginous deposits.

The above peculiarities in the construction of the pipe "Udachnaya" indicate that the pipe has been filled out at least in two different ways. This assumption is corroborated by the difference between the content of diamonds in the kimberlite breccia and in the basaltoid kimberlite.

The upper bed of the pipe is composed of rubble and kimberlite conglomerate cemented by ice. The rubble and conglomerate bed is overlain by eluvial and deluvial formations their thickness reaching up to two and a half meters. These formations consist of argillaceous soil with gravel and kimberlite rubble as well as a great number of apophyses and ice lenses.

The pipe "Udachnaya" is the richest diamond-bearing pipe of the Daaldyn District.

Pipe "Sytykanskaya"

Discovered in August 1955 during schlich tests for pyropes. The size of the pipe is 150 by 100 meters. It tears through carbonaceous rock of the Lower Paleozoic and is located at a distance of ten meters from the borders of a sill of olivine diabase. The greatest part of the pipe is overlain by deluvial argillaceous limestone and large diabase conglomerate. It was established through mining that the pipe does not border on diabase.

The kimberlite breccia that fills out the pipe is greatly weathered. It consists of highly carbonaceous rock. Its cementing mass contains a great number of phlogopite phenocrysts; their size reaches up to one and a half centimeters. Only the quantity of pseudomorphs after olivine exceeds that of phenocrysts of mica. There is a considerable quantity of ilmenite and variegated rounded grains of pyrope. There is almost no calcite, so characteristic of Daaldyn kimberlite. There is an insignificant quantity of foreign inclusions, primarily formed of limestone, argillites and calcareous sinters. A rounded xenolith of yellow quartzite was encountered. It reminds of quartzite in conglo -

merates of approximately Permian age that are common in the Sytykan-Markha watershed. As a rule, rounded fragments of micaceous slate and eclogite form other xenoliths here. One xenolity of deep gray diabase was discovered.

Even rather superficial research revealted that, evidently, the pipe "Sytykanskaya" belongs to the group of pipes in this district that are rich in diamonds.

Pipe "Zagadochnaya"

Discovered in August 1955 by schlich tests for pyropes. Field research established two spot-like areas (contours) -- the presumed location of the pipe. These areas reveal that kimberlite eluvium is present. They are located at a distance of 140 to 150 meters from each other, the size of one of them is 40 by 50 meters, of the other 50 by 70 meters. In the top layers the the eluvium of this pipe consists of "green soil" -- a product created by considerable fragmentation of kimberlite that distinguishes this pipe from the others in this district where the zone of "green" or "blue" soil cannot be identified among the basic loam and gravel top layer of fragmental kimberlite.

The "green soil" of this pipe is, actually heavy light-green loam that includes rounded grains of pyrope which can be easily detected by the unaided eye and a great quantity of large (up to half a centimeter) grains of chromium diopside which is another characteristic feature of this particular pipe in the Daaldyn region. There is a visible quantity of scale of brown and individual fragments of limestone, micaceous slate and other rock. Slightly rounded fragments of surrounding limestone of the Lower Ordovician are present.

Under the "green soil" there is an eluvium layer of kimberlite gravel and rubble. The kimberlite of the pipe "Zagadochnaya" is a dense light green rock. Its xenoliths are formed by numerous light gray, gray and yellowish limestones in which frachopoid fauna is rather common while trilobites are encountered only occasionally. The fragments are usually rounded, their size varies from one to five centimeter.

Metamorphic rock is common. Its fragments are rounded and do not exceed five to six centimeters in diameter. Mostly they consist of almost black crystal schists, biotite, garnet slate and pyrope which can be easily detected by the unaided eye and a great quantity of large (up to half a centimeter) grains of chromium diopside which is another characteristic feature of this particular pipe in the Daaldyn region. There is a visible quantity of scales of brown mica and individual fragments of limestone, micaceous slate and other rock. Slightly rounded fragments of surrounding limestone of the Lower Ordovician are present.

Under the "green soil" there is an eluvium layer of kimberlite gravel and rubble. The kimberlite of the pipe "Zagadochnaya" is a dense light green rock. Its xenoliths are formed by numerous light gray, gray and yellowish limestones in which brachopoid fauna is rather common while trilobites are encountered only occasionally. The fragments areusually rounded, their size varies from one to five centimeters and rarely reach twenty centimeter.

Metamorphic rock is common. Its fragments are rounded and do not exceed five to six centimeters in diameter. Mostly they consist of almost black crystal schists, biotite, garnet slate and pyrope-bearing rock. Xenoliths of diabase were observed among magma rock. Most inclusions are "clad" in a green chlorite "coat", its thickness ranging from one to three millimeters.

Pipe "Osenniaya"

Discovered in September 1955 in the course of magnitometric research. The size of the pipe is 120 by 80 meters. It is isometric with bizarrely winding outlines. The pipe is overlain by a deluvium coat of Paleozoic deposits. Their thickness reaches up to 1 to 1.5 meter. The alluvium of the pipe is formed by markedly ferruginous greenish-gray kimberlite with inclusions of rounded dark and light fragmental pyrope-bearing rock, micaceous slate and a great number of various sedimentary rocks. The massive part of eluvium schlich is primarily formed of pyrope and ilmenite.

Pipe "Poliarnaya"

Discovered in July 1955 by magnetic survey. The size of the pipe is 100 by 100 meters. Its shape is almost isometric. The kimberlite is embedded almost directly under a bed of moss. It is formed of very light, slightly grayish and occasionally brown completely carbonaceous rock in which the cementing material amounts to 95 per cent of the total volume of the rock. As a rule, the small fragments of sedimentary rock do not exceed five per cent of the total volume. The massive part of the schlich contains very few small-grained ilmenites, and, rarely, grains of pyrope. These minerals are not visible to the eye in the rock.

X X

X

Summing up the results of field research conducted on the kimberlite varieties that fill out the pipes of the Daaldyn region it may be concluded that they differ in color, texture and size as well as in the composition and quantity of xenoliths and the degree of carbonatization of the cementing mass and the fragments. The mineralogical composition of the massive part of schlich from the eluvium of the different pipes also varies.

The kimberlite of the pipe "Mir" in the region of the Malaya Batuobiya River differs greatly from the kimberlite of the Daaldyn region. First of all, the kimberlite of the pipe "Mir" is much darker. This is caused by the presence of chlorite and serpentine and the slight carbonization as well as by an almost complete absence of crystal schists. There are also some mineralogical differences such as the considerable occurrence of chlorite in the kimberlite of the Malaya Batuobiya area, a greater uniformity in the colors of garnet, a low content of ilmenite, etc. But these differences are only obvious by way of comparing the kimberlite of the pipe "Mir" with that of the pipe "Zarnitsa."

In most pipes olivine is completely serpentinous. However, in the pipe "Dalnaya" a great number of unchanged olivine has been encountered in the duvium of the kimberlite. This shows that the zone of serpentinization ends at a depth that varies for each pipe. Geophysical data on the low specific gravity of the kimberlite of several pipes testify to the fact that the zone of serpentization is rather deep.

As already noted the kimberlites of the Daaldyn region tears through the sedimentary rock of the Lower Paleozoic and through traprock (pipe "Leningradskaya"). This, it may be assumed safely that the kimberlites of the Daaldyn region are also of post-Permian age similar to those of the Malaya Batuobiya region. The age of the kimberlites can be indisputably established only after their correlation with the Jurassic rocks of the Malay Batuobiya District will be clarified since these deposits are not present in the Daaldyn region.

Figures 13 and 14 show the shapes and sizes of the kimberlites that fill out the pipes of the Vilyui Basin as compared with African kimberlite.

II. PETROGRAPHY OF SIBERIAN KIMBERLITES[x]

Just like the kimberlites of Africa. Siberian kimberlites consist of vulcanic breccia in the form of characteristic pipe-like bodies. Along with kimberlite this breccia is formed of different inclusions of igneous, metamorphic and sedimentary rocks of varying origin (N. N. Sarsadskikh and L. A. Popugayeva, 1955). For that reason the petrographic report deals not only with the kimberlites but also with the inclusions that have been encountered in these kimberlites.

Chapter one, dealt with the kimberlites of the Daaldyn (pipe "Zarnitsa," "Udachyana," "Maliutka," and "Polidarnaya,") and the Malaya Batuobiya (pipe "Mir") Districts.

The petrographic and mineral study of kimberlites is rather difficult in view of the considerable changes in the rocks. These changes were brought about by the internal and external processes and the foreign intrusions of mineral which can often hardly be distinguished from the components of the kimberlite (V.S. Sobolev, 1959). The main rock-forming mineral is olivine of which the kimberlite phenocrysts are composed (samples were taken primarily from top beds). It is completely serpentinous so that only the outlines of the pseudomorphs can be traced. The basic mass of rocks was even more affected (serpentinization and carbonatization) making it, occasionally, very dificult to determine the character of the cement -- wheter it is always pyroclastic or sometimes magmatic as may be assumed from the study of individual fragments of kimberlite in the kimberlite rock. Regardless of these changes, however, a detailed study leads to a number of interesting discoveries in regard to mineralogical and structural properties which are described below.

The following rock-forming minerals were found by investigating the kimberlites: olivine (mostly in the form of pseudomorphs), phlogopite, augite (in the form of pseudomorphs), ilmenite,

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[x] The material concerned with the petrography and mineralogy of of kimberlites was elaborated with V.S. Sobolev's advice.

perovskite and apatite.

In addition to minerals that are characteristic of the kimberlites many mineral fragments are related xenoliths and eclogite-like rocks (also those originally connected with the formation of kimberlite magma) are present, such as: garnet-pyrope, monocline pyroxene of the cromium diopside type and, evidently, omphacite, enstatite (as a rule only in pseudomorphs), spinel, chromite, disthene, corundum, rutile and various minerals contained in foreign inclusions. Among secondary minerals most common are: serpentine, calcite, dolomite, chalcedony and zeolite (?).

Furthermore, chapter two reports on the petrography of xenoliths in kimberlite pipes. To being with, the so-called relative xenoliths of ultrabasic rocks (porphyritic peridotites) are described. They are not characteristic of Siberian kimberlite and have been found in the pipe "Mir" only where they are formed of rocks that have undergone such major alterations that their identification is unreliable. Furthermore, the chapter dwells on the numerous and interesting xenoliths of crystalline schists. Also discussed are inclusions of eclogite-lie rocks and rich pyrope-bearing eclogites not known to have been present in the formations of the Pre-Cambrian, as well as typical crystalline schists of the Pre-Cambrian, primarily those known as charnockite schists with rhomboid pyroxene.

Since eclogites and eclogite-like rocks are very common in kimberlites throughout the world it may be assumed that their genesis is linked with the origin of either the kimberlites or their magma. At the same time, there is no doubt that these rocks are crystalline schists.

Investigations of Siberian kimberlites led to interesting discoveries revealing how hypersthens crystalline schists of the Pre-Cambrian were gradually transformed into eclogite rocks. This transformation is known as the "garnetization" (eclogization) of crystalline schists.

The paper contains a short petrographic review of diabase xenoliths (Siberian traps) and the xenoliths of sedimentary rocks. Reference is made to the characteristics of the changes that have taken place in the contact zone.

The chapter closes with a relatively short petrographic report on Siberian kimberlites as compared to similar rocks in South Africa.

I. PETROGRAPHY OF KIMBERLITES

Kimberlites of the Daaldyn District

The material available on the pipe "Zarnitsa" serves as the basis for the petrographic description of the kimberlites in the Daaldyn District.

The pipe "Zarnitsa" is formed of breccia kimberlite 90 per cent of which consists of fragments and minerals and 10 per cent of a cementing carbonaceous serpentine mass (Figure 15). The texture of the rocks is fragmental and strongly resembles crystalloclastic texture since neither the fragments nor the cementing mass reveal any traces of cataclastic processes.

The fragments consist of the following: a completely altered rock of the picrite porphyrite type which is natural kimberlite, extremely fine and medium-grained limestones, serpentine-chlorite and chlorite carbonaceous shales as well as numberous and different crystalline schists.

There is a great quantity of fragmental serpentinous crystalline olivines and a few rounded grains of pyrope, pitch-black ilmenite, emerald-green chromium di pside, magnetite, phlogopite, perovskite, and chlorite.

The basic cementing mass of kimberlite breccia is composed of a fine-grained mixture of serpentine and carbonate.

The sizes of the fragments vary from 0.1 millimeters to one centimeter, they are, usually, ore or less rounded or oval. Uneven fractures have smooth surfaces. The fragments of altered kimberlite (magma) are small (from 0.1 to 0.2 to 2.5 to 3 millimeters) and are found in large quantities than other fragments, but form only 35 to 40 per cent of the fragmental mass and less often 45 to 50 per cent.

Picrite porphyrite (natural kimberlite) found in breccia is completely altered. Basically it consists of carbonate, serpentine, secondary magnetite, and accessory mineralss (ilmenite and pervoskite), It can only be identified by the primary relict texture of the rocks.

Porphyitic texture microlith texture of the basic mass, and fluid and ataxite structures are recognizable in the kimberlite. The altered kimberlite is formed by two varieties, one with and the other without phlogopite. The latter predominates. This variety is characterized by the porphyritic texture and consists of large pseudomorphs of serpentine after olivine (phenocrysts), and a basic mass of excessively fine-grained carbonate, serpentine and pulverulent magnetite.

Pseudomorphs of serpentine after olivine form 20 to 35 per cent of the rock, the basic mass 65 to 80 per cent, but these figures fluctuate. The size of the pseudomorphs after olivine varies from 0.5 to 1.2 to 1.5 millimeters.

The pseudomorphs after olivine are characterized by well preserved crystallographic forms. They are composed of serpentine (80 per cent), secondary magnetite (15 to 18 per cent) and carbonate (five to seven per cent). These figures are, however, arbitrarily accepted but they are not precise since occasionally, fragments of altered kimberlite are found with carbonate as the main inherent part of the pseudomorphs after olivine.

There are a few pseudomorphs composed of carbonates with an octahedral cleavage that are, evidently, formed after pyroxene.

The pseudomorphs of serpentine are light-yellow with a very low birefringence and sometimes no interval can be detected in the corssing Nicol's prisms which leads to the assumption that the texture is amorphous.

The central serpentineus peripheric part of the pseudomorph is composed of secondary magnetite sometimes in association with carbonate.

The basic mass is formed of 85 - 90 per cent carbonate, five to ten per cent pulverized magnetite and about five per cent serpentine. The green and greenish-gray kimberlite breccia in the basic mass of the fragmental apokimberlite contains a considerable amount of light-green chlorite.

Occasionally, fragments of altered kimberlite are identified. The basic mass reveals excellently preserved relict fluid structures. This is due to the fact that small pseudomorphs of carbonate are formed after prismatic microlith pyroxene.

Ilmenite and perovskite are frequently observed in the altered kimberlite. Perovskite is present in the form of fine (0.05 - 0.8 millimeters) grains of square cleavage surrounded by an opaque rim. Often, it develops in the form of small crystals around grains of ilmenite.

Altered kimberlite with phlogopite is found somewhat less often in the fragments. It is a rock that strongly resembles the above rock with the difference, however, that phlogopite is present, both in phenocrysts as well as in the basic mass (Figure 16). Phlogopite-bearing kimberlite is, as a rule, characterized by a fluid structure which is manifested in the formation of pseudomorphs after olivine, microlith phlogopite and pseudomorphs of carbonate after microlith pyroxene that seems to be "streamlined" along original phenocrysts of olivine.

Schist-bearing kimberlites with amygdules are rare. Amygdules are present in great quantities. They are oval, elongated and sometimes very bizarrely shaped (Figure 17).

Amygdaloidal kimberlite contains pseudomorphs of distinctly double-refracting serpentine after xenocrysts of a mineral, the presence of which is testified by the wide reactive rim that is filled out with serpentine but has a different texture (Figure 18).

Characteristic of the kimberlite is the presence of sharply angular fragments of serpentine with an extremely low birefringence which can be distinguished from the serpentine that forms the small pseudomorphs after olivine. Some of these fragments still show crystallographic outlines which are characteristic of olivine (Figure 19). These outlines lead to the conclusion that the fragments used to be large phenocrysts of altered olivine that had formed at the first stage of the crystallization process of magma and that they had been homogenous inclusions. Mostly, fragments of serpentine are found without any trace of crystallographic form. Large (up to five millimeters and more) fragments of altered kimberlite, the central part of which is composed of kimberlite without schist while in the peripheral part a considerable amount of phlogopite is recognizable, are of great interest. The variety of which the central section consists changes gradually to the rock developed on the outside of the fragments, with the number and size of schist laminae decreasing toward the center while the basic mass is entriched by pulverized magnetite.

The fluid relict structure is primarily found on the outside of the fragments and is manifested in a more or less orderly dissemination of the pseudomorph of serpentine after the phenocrysts of olivine, pseudomorphs of carbonate after microlith pyroxene and phlogopite laiminae. The pseudomorphs run parallel to the edges of the fragment. Thus, we may assume that the fragments were set free during the plastic flow and the subsequent crystallization has apparently been accomplished either in the process of movement or probably even while the fragments turned since they are mostly rounded or oval. However, after the rock hardened the fragments were evidently, still on the move since in some areas along the edges of the fragments cut pseudomorphs after olivine could be identified.

This formation was probably a result of the characteristic properties of the crystallization process. However, it should be emphasized that no set pattern was observed in the formation of many fragments. In the above mentioned fragments, for instance, pseudomorphs after phenocrystalline olivine, and microlith pyroxene were often found primarily on the outside. Another fragment, however, has porphyritic texture and fluid which is more pronounced in its center. Sometimes the texture in the center is analagous to that on the outside in a fragment of altered magma.

Fragments of kimberlite of ataxitic appearance were found; the rock contains irregularly shaped sections (or bands) which are similar in composition but differ drastically in texture.

There are, for instance, the following three intermittent sections in the rock:

1. Composed essentially of pseudomorphs of serpentine after phenocrysts of olivine (up to 55 - 60 per cent) and of the basic mass (40 per cent) in which microlith phlogopites and pseudomorphs of carbonate after microlith of pyroxene are easily recognizable.

2. Composed of small and rare psoudomorphs of serpentine after olivine (25 per cent), large fragments of limestone (30 per cent) and a disintegrated basic mass without phlogopite and microlite (45 per cent). It is possible that the growth of phenocrysts and microlity pyroxene has impeded inclusions of numerous limestones.

3. This section is characterized by a small number of pseudomorphs after olivine (15 to 20 per cent), an absence of microxenoliths of foreign rocks and a less crystallized, disintegrated, ligher basic mass.

The sections change gradually, but occasionally, boundaries are well marked. Larger fragments show that altered kimberlite sometimes contains a great quantity of microxenoliths of foreign rocks (limestone, chlorite-serpentine-calcareous microschists) and fragments of younger rocks with porphyric texture but with a slightly different composition and texture of the basic mass.

Figure 20, for instance, shows that the fragment is included in second generation altered kimberlite that was only occasionally preserved in the form of a halo. This halo is also inherent part of the fragment.

First generation altered kimberlite which includes fragments of limestone and serpentinous olivine, is composed of pseudomorphs after olivine and a basic mass that is formed by an aggregate of carbonate and serpentine. A considerable quantity of serpentine is present amounting to 30 - 35 per cent of the basic mass. This is actually one of the differences that distinguish it from second generation kimberlite. The basic mass contains a few small grains of perovskite surrounded by a dark rim.

There is no evidence of a relict microlith texture of fluid structre in altered first generation kimberlitesslight brown schists is present, evidently, phlogopite; the microlith texture of the basic mass has remained intact.

In this variety, pseudomorphs after phenocrysts of olivine, micaceous laminae with even crystallographic contous and small pseudomorphs of carbonate after microlith pyroxene can easily be identified. The prismatic form and the fluid distribution of microlite are perfectly well preserved.

Small angular intervals between microlites are filled with carbonate, extremely impure pulverized mineral. By way of accessory minerals there is perovskite in the form of small grains around ilmenite in this kimberlite as well as in the first generation kimberlite.

Thus, the fact that fragments of altered kimberlite with a brecciated texture and inclusions of other rocks are present in the fianlly transformed kimberlite breccia, leads to the assumption that the formation of breccia has taken place at different stages.

Very common in breccia are fragments of altered kimberlite with inclusions of limestone. The contact of both rocks is clearly marked. The surrounding altered magmarocks frequently contain less and smaller phenocrysts -- pseudomorph of olivine and microlites -- pseudomorph of pyroxene. They run in the direction of the parallel contact. At some places there are traces of magmatic rock that filled the cracks of the limestone and at the contact microscopic loose limestone fragments were found submerged under the disintegrated surrounding mass of magmatic rock.

Sometimes, the breccia contains small fragments predominantly formed of phlogopites. Phlogopite laminae have no uniform direction. The space between them is filled by magnetite and carbonate. Phlogopite pleochroism ranges from light-yellow, occasionally brown-yellow for Ng to colorless for Np; Ng-Np = 0.030; 2 V is extremely small and negative.

In addition, small fragments of bright-green chlorite are found. They have a pronounced pleochroism ranging from a bright green for Ng to colorless for Np. Chlorite analyses conducted with a blowpipe revealed the presence of chromium which, evidently, accounts for the color of this mineral.

As already mentioned the large fragments of kimberlite are rare, there are sections of breccia composed only of pseudomorphs of serpentine and magnetite after crystalline olivine surrounded by an insignificant quantity of altered basic mass in the form of rims (Figure 21). As a rule, these fragments (size: 0.3 to 0.5 millimeter) are rounded or oval and are adjacent although they do not always touch closely upon each other. They differ from each other in the composition or texture of the basic mass. The basic mass of one of the fragments, for instance, shows a predominance of amorphous microscopic grains of carbonate with an insignifican content of pulverized magnetite, while magnotite predominates greatly in another fragment and still is another phlogopites are present in the basic mass. There are also fragments with a distinctly fluid structre, etc. This proves that they are not part of the primary rocks but stem from different areas.

The angular space between fragments is filled with serpentine. Serpentine accretes in the form of thin concentric crystal fragments. The characteristic property of this serpentine is a distinct birefringence, columnar texture and negative elongation.

Non-birefringent, evidently amorphous serpentine was observed in the central part between the planes of separation. Sometimes, only crusts of columnar serpentine was observed around the intervals while the intervals appear to be hollow. For that reason the specific gravity of the altered kimberlite is greatly decreased.

In addition to kimberlite fragments, the following minerals were encountered in the breccia fragments by microscopic research: garnet, rutile, perovskite, ilmenite, magnetite,and,less,often, chromium diopside.

The garnet is of a light pink color and sometimes colorless or a light violet pink. Garnet that appeared green in daylight and pink under electric light was found. Figure 22 shows an interesting fragment of a garnet in altered kimberlite. The crystal part is destroyed and submerged under a serpentinous cementing mass of breccia. Another part is enclosed in the primary surrounding kimberlite and is surrounded by a reactive rim of fine columnar brown serpentine. The width of the rim is 0.15 millimeters. In one spot rutile was found in association with garnet.

Perovskite is present in the form of fine grains with a square cleavage in the basic mass of kimberlite and in the form of small fragments in the cement of breccia. Its grains are surrounded by a black opaque rim.

The cementing mass of breccia is formed of serpentine and carbonate. However, it is impossible to establish the content of these two minerals although the predominance ofserpentine is obvious. The serpentine in the cementing mass is similar to the serpentine of which the fragments in the breccia are formed.

Kimberlites of the Malaya-Batuobiya District

The kimberlites of this district were studied on the basis of the pipe "Mir".

The microscopic kimberlites of the pipe are represented by two varieties:

1. Small fragmental rocks which are frequently clearly stratified and remind of typical tuff;

2. Large compact fragmental rocks, with a great quantity of quartz in some areas, very similar to vulcanic tuffo-breccia.

The kimberlites are of various deep-green shades, their color is much darker than that of the kimberlites of the Daaldyn District.

The first variety of rocks is characterized by a texture of fine crystalloclastic fragments. The rocks are formed by large and small fragments of olivine phenocrysts (completely substituted by serpentine and carbonate) that amount to 70 - 80 per cent of the mass, fragments of garnet-pyrope (up to 2- 3 per cent) and a brown cementing mass (20 to 25 per cent) formed of a carbonate and serpentine aggregate (Figure 23). Brown biotite schists and blue-green chlorites are frequently encountered as well as magnetites. Ilmenite, pervoskite, spinel and diopside are not common here.

Among fragments of foreign matter the following are most common: limestone, serpentine-chlorite and carbonaceous schists, quartzites and diabases constituting 3 - 5 per cent and sometimes even 10 per cent of the rocks. There are numberous fragments of altered kimberlite of porphyritic texture.

The unusually large number of fragments of crystalline olivine (pseudomorphs of serpentine after olivine) allows to classify this rock as kimberlite crystal loclastic tuff. The size of the fragments of olivine crystals (pseudomorphs after olivine) vary from 0.5 to 1-5 millimeters. The fragments are usually rounded, oval and irregular in shape.

The pseumorphs are often meshed with the meshs formed by polarized fine columnar serpentine while the nuclei of the meshs are filled with carbonate. The larged pseudomorphs after olivine are surrounded by rims of carbonate. These rims do not surround the pseudomorphs after olivine completely. Usually they are found along the fracturing. Small pseudomorphs after olivine have, as a rule, crystallographic outlines and are predominantly composed of serpentine and less frequent of carbonate.

It should be emphasized that secondary magnetite is substituted for olivine. It is abundant in pseudomorphs of olivine in the kimberlites of the Daaldyn District but has not been found here.

Garnet is rather common in the form of large (2.5 to 5 millimeters) and fine (0.1 to 5 millimeters) grains. Along with grains that have a kelyphite rim, garnets without any rim (Figure 24) are also found.

The kelyphitic rim that is sometimes up to 0.5 millimeters wide (for large grains) consists of a fine columnar mineral, the finest columns of this mineral often run perpendicular to the walls of the grains. A rim of minute laminae of chromium-bearing chlorite was encountered around a kelyphilic rim.

Fragments of grains of garnet surrounded by a keliphitic rim on one side only, are present which clearly testifies that they are dislocated. Occasionally chlorite is substituted for garnet. The refraction of the garnet varies from 1.738 to 1.754 which indicates that it can be classified into the pyrope series. It is interesting that there are no acicular inclusions in the garnet which are very characteristic of garnets in the kimberlites of the Daaldyn District.

In the Malay Batuobiya region only violet and red varieties of pyrope are found. A fragment of crystalline diopside with NG = 40° is partly (around the edges) replaced by a rim of carbonate. Individual areas of the kimberlite are rich in bluish-green chlirite that replaces brown mica. Micaceous laminae are frequently greatly deformed and even torn into pieces. Occasionally, the chlorite is so much laminated that large laminae form a cluster of columns saturated with calcite. Occasionally, chlorite replaces biotite only partially, as a rule along the edges in the form of narrow bands and along cleavage cracks. The refraction of chlorite: Nm = 1.583. The bluish-green color of chlorite is caused by the presence of chromium (according to spectrum analysis).

There are fragments of reddish-brown spinel, picotite, ilmenite and perovskite by way of accessory components; perovskite is rare, very fine grains of it sometimes for a rim around the grains of ilmenite.

The cementing mass of the rocks is formed of a fine-grained aggregate of carbonate and serpentine. Rather often a sharp predominace of serpentine over carbonate is observed. Occasionally, there is a reversed relation between these two components. Small pseudomorphs of serpentine after olivine are disseminated in the cementing mass. The pseudomorphs often contain idiomorphic primary olivine so that the rock appears effusive.

The secondary variety is very typical of tuffobrecciated rocks. They are distinguised from the above-mentioned rocks by the presence of large fragments and a typical breccia structure. It should be pointed out that occasionally kimberlite breccia is strongly marked by the presence of quartzite so that even secondary quartzite is encountered (Figure 25).

The rocks are characterized by amygdaloidal and crustified texture caused by large and small pores that are either partially or fully filled with quartz and quartzite. The crustification of the texture is caused by the accretion of quartz in the form of a rim around the grains of serpentinous olivine. The elongated grains of quartz run perpendicularly to the edges of the olivine grains.

The amygdules are also very peculiarly shaped and characterized by complex multizonal concentric formation on the outside, a rim of fine crystalline carbonate develops while a rim of quartz that appears to be crustified (with distinct zones of growth for the individual grains of quartz) is followed by a zone of collomorphous structure presumably composed of chalcedony or quartzine; there is a rim of carbonate and, finally, the center is formed again of quartz.

A casing of quartz and carbonaceous type-veins marks the development of idiomorphic crystals of pyrite.

The greatly disintegrated fragments of kimberlite are saturated with brown ferric oxide and cemented by greatly oxidized fine-grained quartz. In some areas the quartz aggregates have a spherulite texture. The rock is cut by a pattern of cavities filled with quartz and calcite.

We shall now compare briefly the kimberlites of the Malaya Batuobiya District with analoguous rocks of the Daaldyn District.

In respect to petrography the kimberlites of the Daaldyn District are distinguished from the kimberlites of the Malaya Batuobiya region by the variety and richness of their inclusions of related and foreign rocks. The kimberlite that fills out the pipe "Mir", for instance, reveals a predominace of inclusions of sedimentary rocks (limestone, schist) and diabases with rare xenoliths of eclogite-like rocks whereas the Daaldyn kimberlite that fills out the pipe "Zarnitsa" is rich in rocks of the eclogite facies as well as in inclusions of sedimentary rocks.

The essential difference of rocks is evident from a comparison between the rate of foreign inclusions (in percent) and the cementing mass that plays a subordinate role in the kimberlites of the Malaya Batuobiya and the Daaldyn Districts. The basic mass of inclusions (up to 90 percent) in the kimberlites of the Daaldyn District is formed of sedimentary and crystalline rocks. In the kimberlites of the Malaya Batuobiya region fragments of serpentinous olivine predominate; their content reaches up to 70-80 per cent.

The kimberlites of the Daaldyn District are characterized by fragments of kimberlite magma(of the picrite porphirite type) with and without schist while the rocks of the Malaya Batuobiya region contain only few of these fragments.

The kimberlites of the two districts have a completely different mineralogical composition: the Daaldyn kimberlites contain chlorite and rarely biotite. The former are rich in pyrope and ilmenite, perovskite is also present. The latter contain only pyrope, while ilmenite and pervoskite are rare. Furtheron, there are orange-colored violet and red pyropes in the Daaldyn rocks while this variety has never been known to exist in the kimberlite of Malay Batuobiya.

Apparently, the kimberlite of the pipe "Mir" has been affected by tectonics after its formation. This is evident from the breccia that has marked the rocks consupcuously and as a result quartz has formed. This process has not taken place in the kimberlites of the daaldyn region.

Table 1

Test No. COMPOSITION	Kimberlite pipes						
	"Zrnitsa":		"Boliarnaya"				"Udachnaya"
	1-a	3-a	1	2	3	4	14/1
	Analysts						
	M.Stukalova		M.Chuyenko	K.Baklanova	V.Koviasina	V.Koviasina	M.Chuyenko
SiO_2	26.85	26.51	25.66	29.72	27.20	30.58	27.60
TiO_2	1.40	1.60	2.77	0.21	2.51	2.10	2.29
AlO_3	2.34	2.35	2.61	6.51	4.98	1.20	1.42
Cr_2O_3	0.14	0.11	0.20	0.19	0.04	0.08	0.16
FeO_3	4.77	7.08	9.23	10.19	11.34	7.66	7.63
FeO	2.34	1.80	1.71	2.58	2.00	1.71	1.64
MnO	0.12	0.10	0.20	0.14	0.21	0.14	0.18
MgO	22.82	25.32	25.49	29.80	27.08	32.21	26.67
CaO	17.37	14.60	13.28	6.00	8.80	7.80	12.40
NaO) K_2O)	0.24	0.26	0.07	0.30			0.10
BaO			0.26	Traces	0.05	0.08	0.22
NiO	0.07	0.08	0.13	0.08	0.12	0.18	0.12
P_2O_5	0.16	0.30	0.35	0.32	0.12	0.20	0.46
S	Not Found	Not Found	0.03	Traces	0.05	0.04	0.15
CO_2	13.80	11.60	10.20	2.69	6.03	5.31	9.74
H_2O	1.35	1.17	0.40	0.68	1.56	1.26	1.20
Indissoluble Products	6.40	7.40	7.60	10.50	8.31	9.82	8.52
	100.17	100.28	100.19	100.16	100.40	100.35	100.50

The chemical composition of Siberian kimberlites can be determined by chemical analyses of samples taken from the pipes of the Daaldyn region. The results of such analyses are shown in Table 1. They show that in chemical composition Siberian kimberlites correspond to disintegrated ultra-basic rocks, in general, and to African kimberlites, in particular, Petrochemical comparisons can only be made after less altered rocks have been tested.

2. PETROGRAPHY OF XENOLITHS

Xenoliths inclusions can be classified into following groups according to their genesis:

1. Xenoliths of ultra-basic rocks (porphyric peridotites);
2. Xenoliths of crystalline schists;
3. Xenoliths of basic rocks (Siberian traps);
4. Xenoliths of sedimentary rocks.

Below is a petrographic report of these groups and a short outline of some problems concerned with their origin.

The Xenoliths of Ultra-Basic Rocks

The xenoliths of ultra-basic rocks which are, as a rule, characteristic of kimberlites have so far not been encountered in the pipes of the Daaldyn District. It should, however, be taken into account that as a result a very low resistance the xenoliths may have been completely altered in greatly altered kimberlites and could easily be mistaken for altered xenoliths of other rocks. In the pipe "Mir" xenoliths of porphyric peridotites with garnet were identified but they were changed so much that even the identification of the rocks is not quite reliable.

Macroscopically the xenoliths of porphyric peridotites are formed of deep-gray, very dense rocks with large (up to one centimeter) phenocrysts of rasperry-red pyrope surrounded by wide kilyphite rims. Along with garnets pseudomorphs of a yellowish green mineral after some columnar femic mineral are visible. The aphanitic deep gray mass of rocks clearly shows small crystals of an ore mineral (pyrite?).

The texture of the rocks is either porphyritic or porphyritic-like. The texture of the basic mass can only be identified without intersecting nicols since the primary texture is completely masked by a considerable degree of alteration. There are reasons to assume that the basic mass was composed of extremely fine idiomorphic grains of olivine which were probably overlain by glassy mesostasis. As a result of post-magmatic processes the olivine and the mesostasis were completely transformed into an aggregate of serpentine, quartz and carbonate.

The basic mass of the rocks is intensly mineralized. Porphyric phenocrysts are formed of dichroic garnet and pseudomorphs of serpentine, chlorite and carbonate after large crystals of femic minerals that must have been present in the past.

Garnet is present in the form of rounded and oval porphyric phenocrysts usually surrounded by a brownish-green rim of a reactive origin. The rim is saturated with brown ferric oxides and mineral dust. The index of refraction for the garnet varies from 1.738 to 1.754 which is characteristic for pyrope series. The grains of the garnet are greatly fissured and secondary schists-like minerals develop along the fissures.

In addition to garnet, pseudomorphs of serpentine and carbonate as well as chlorite and carbonate after large porphyric phenocrysts and, apparently, femic minerals (olivine, enstatite?) were found.

The discovery of the above xenoliths sheds some light on the origin of garnets in the kimberlite of the pipe "Mir" where inclusions of eclogites and eclogite-like rocks are extremely rare. It is very likely that some of the violet and red pyropes with a lower index of refraction in the pipes of the Daaldyn District also stem from similar disintegrated ultra-basic rocks. However, the origin of pyrope in ultra-basic rocks has not been determined; the kelyphite halo around its grain is quite remarkable and evidently testifies to either its xenogenic origin or to early crystallization.

Xenoliths of Crystalline Schists

As already mentioned two very different genetic groups are recognizable among the xenoliths of crystalline schists that are very abundant in the kimberlites of the Daaldyn District and, apparently, completely missing in the pipe "Mir":

1) The group of eclogites and eclogite-like rocks and 2) the group of so-called crystalline schists of the Pre-Cambrian complex.

Garnetized crystalline schists, to be discussed separately, lie between these two basic groups. The mineralogy and texture of the rocks in the second group is completely analogous to the crystalline schists of the Pre-Cambrian in the Aldan Shield and the Anabar Mountain Range. There is a predominance of hypersthene crystalline schists that change into amphibolite and leucocratic crystalline schists. The crystalline schists that are rich in alumina and common in the Aldan shield but rather rare in the Anabar Mountain Range are not present. Evidently, the xenoliths were filled with kimberlite magma at the depth of Pre-Cambrian beds. The fact that these xenoliths are common in the Daaldyn District is due to its vicinity to the Anabar Mountain

Range and, consequently to the deposits of the pre-Cambriant that were not very deeply bedded and where explosions had taken place.

Eclogites and eclogite-like rocks of the first group have so far not been discovered among the crystalline schists of the Pre-Cambrian deposits in East Siberia; they belong to a completely different metamorphic facies (Escola, 1920). The paragenesis of monoclinal pyroxene -- a mineral that is rather rich in calcium and not accompanied by aluminum -- as well as garnet of the pyrope-almandite series which is usually rich in a pyrope component, that is a mineral saturated with alumina and in which aluminum is not accompanied by alkali and calcium, is a characteristic feature of these rocks.

The fact that magnesium-rich garnet has formed instead of cordierite speaks agains the presence of charnockite crystalline schists of the Pre-Cambrian (Korzhinsky, 1936). In regard to the redistribution of oxides it is, as already mentioned, only characteristic of eclogites which differe from the usual igneous or metamorphic rocks which a similar chemical composition by their considerably higher specific gravity indicating a formation under much higher pressure.

Eclogite inclusions are characteristic of the kimberlites of South Africa where they are, however, not found in the crystalline schists of the Pre-Cambrian. Their origin there has not been determined but it is assumed that it may have some connection with the formation of kimberlite magma and maybe even of diamonds.

There is not sufficient material available as yet to study thoroughly the problems of the formation of eclogite xenolith in the kimberlite but interesting observations have already been made which will undoubtedly contribute to such study. Peculiar intermittent rocks (the so-called garnetized crystalline schists) were encountered with the remainder of minerals of pre-Cambrian gneiss, particularly hypersthene; however, garnet is already present in considerable quantities and its ultimate formation is quite certain. The coexistence of garnets with different indices of refaction was also established, that is with varying iron content which shows a complete lack of balance in this rock.

As there is no possibility of dwelling in greater detail on these intricate problems we shall confine ourselves to describing the rocks.

Xenoliths of Eclogites and Eclogite-Like Rocks

Eclogites

Eclogites without feldspar composed of pyrope and monoclinal pyroxene are the most typical but rare representatives of eclogite rocks.

The texture of the rocks is granoblastic, coarsegrained and porphyroblastic.

The mineralogical composition is simple; monoclinal pyroxene and garnet-pyrope. Sometimes there is an admixture of biotite, rutile, ilmenite and apatite.

Most common among secondary minerals are chlorite, serpentine (?), carbonate and ferric oxides (Figure 26).

The garnet is represented by pyrope with an index of refraction that varies between 1.738 and 1.754. More common is pyrope with N = 1.738. Large, usually rounded and oval, greatly split porphyro-blastic garnets are typical. Along the cracks a development of a greenish-brown cholorite-like mineral with a slightly raised birefringence was observed. As a result of this decomposition the garnet along the pattern of cracks if frequently split into numerous polyhedral grains.

Frequently, porphyroblastic garnet in the altered kimberlites is surrounded by a wide greenish-brown kelyphite halo with fine aphanitic texture and increased birefringence.

Sometimes kelphite halos are encountered that follow the idiomorphic outlines of the grains of garnet from the outside while inside the sharp edges are rounded out by decomposition so that the grains are ball-like or oval and irregular.

The basic mass of the rock is composed of pyroxene. As a rule, it is found in light-green irregular grains.

The following results were obtained by measruing the optic constant of pyroxene in a Fedorov devide: 2V from $+63^\circ$ to $+66^\circ$; $cNg = 44-45^\circ$; $Ng' = 1.712 - 1.714$; $Np' = 1.680 - 1.690$; $Ng' - Np' = 0.022 - 0.024$. This data shows that monoclinal pyroxene belongs to the hedenbergite diopside series according to its composition. It contains 25 to 35 percent ferric component with slightly increased Ng, which is, evidently, due to the presence of Fe_oO_3 and Al_2O_3 although the latter does not exert an essential influence upon optic constants. 2V is also increased which may be due to the presence of a jadeite component in decreased cNg. The question as to whether pyroxene belongs to omphacite can only be solved by determining the alkali content, but so far no pyroxene analysis has been made.

Replacement of monoclinal pyroxene by carbonate was frequently noted. Along the issures a greenish-brown chlorite-like or kaolin mineral develops. The almost opaque decomposition products are frequently highly saturated with ferric oxide.

Rutile is not common and is found in the form of irregular grains. Their size varies from 0.1 to 0.2 millimeters. They are usually of an amber color,rarely red. Apatite is present in the form of small oval and irregularly shaped grains.

Biotite is rarely present in the above varieties of eclogite. It is found, as a rule, in the form of large scales and is less often accumulated. The biotite is of light orange coloring with a clearly marked pleochroism that ranges from orange(reddish) in Ng. to light yellow (almost colorless) in Np, along the axis of Nm it is orange (brownish). The scheme of absorption is: $Ng > Nm > Np$. The index of refraction is Nm - 1.621. Small scales and laminae of red-brown biotite are sometimes developed in an aggregate of a greenish-brown chlorite-like mineral along with carbonate. Biotite is, evidently, secondary.

Eclogite-like Rocks

(Plagioclastic crystalline pyroxene schists with garnet)

Crystalline schists with garnet-pyrope, monoclinal pyroxene and secondary plagioclase form a large part of the inclusions. These rocks also form under conditions of eclogite facies since they are a variety of eclogites and should even be separately classified.

The following varieties should be pointed out:
a) rocks, poor in plagioclase and most similar to eclogites;
b) rocks, rich in plagioclase; c) rocks with disthene;
d) rocks rich in hornblende.

Rocks that are poor in plagioclase contain 10 to 15 per cent of it. Their texture usually ranges from granoblastic to porphyroblastic and is formed of large grains of garnet. Sometimes lamineted and banded structures are observed. Mineral content: Plagioclase, pyrope garnet, monoclinal pyroxene; accessory minerals: apatite, ore mineral; secondary mineral: colorless amphibole, chlorite, brown ferric oxide. Monoclinal pyroxene is in predominance here. Its color is light green, pleochroism is absent. Along the fissures undetermined greenish-brown products of decomposition develop. Frequently, pyroxene is partially or fully replaced by colorless amphibole. In one microsection monoclinal pyroxene revealed 2V = plus 66°, cNg = 45°, in another 2V = plus 68°, cNg = 45°.

Plagioclase is usually represented by antipertite. Individual grains have narrow polysynthetic twins. A partial replacement by sericite is noted as well as by a brownish-green kaolin mineral. The measuring of the grains of plagioclase in the Fedorov device produced andesine No. 32 - 42.

Garnet is found in the form of irregular rounded and oval grains. They are up to 1-2 millimeters large. Quite often, it is found in the form of angular fragments 0.1 to 0.2 millimeters large. Strong fissuring was noted, along the fissures the development of a greenish-brown aggregate of a secondary mineral (kaolin?) was observed.

The index of refraction of the garnet is $N < 1.767$. The rock contains pseudomorphs of serpentine after xenomorphic grains of a mineral that had been present earlier.

Rocks rich in plagioclase are encountered primarily in eclogite-like inclusions. Under the microscope they are light gray with bands enriched by a dark mineral and pyrope. The presence of woll-preserved plagioclase with a glassy luster account for the gray color.

The texture is, as a rule, granoid and porphyroblastic. When hornblende is present the texture is nematogranoblastic and poikilitoblastic, but the latter is not very frequent. Usually the grains are coars. Many xenoliths have a distinct schist structure,sometimes they are banded.

The mineral content is very versatile. Along with plagioclase, garnet and monoclincal pyroxene, hornblende and scapolite are found sometimes replacing plagioclase. Kaolin represents the basic mass of secondary minerals. Among accessory minerals zircon, apatite, rutile and ore mineral are present. Also serpentine, chlorite and undetermined products of the decomposition of pyroxene.

Usally plagioclase has irregular outlines and is often found in the form of antipertite. Along with albites pericline twins are rather common. Plagioclase is partially replaced by clay minerals of the kaolin type. As a rule, decomposition starts on the outside of the grains proceeding toward the pattern of fissures. One microsection revealed the presence of serpentinous plagioclase. Seven samples of plagioclase grains were tested. The tests showed that its composition corresponds primarily to andesine (No. 38 - 42), varying from oligoclase (No.25) to acid labradorite (No. 59). Along with plagioclase a smaller quantity of scapolite is also present which clearly replaces plagioclases in some areas. Scapolite is an intermediate mineral with an index of refaction Ng = 1.582, Np = 1.561 showing that the content of a meionite component reaches 55 percent. In some xenoliths potash felspar with perthitic texture along with plagioclase is present.

A green variety of monoclinal pyroxene is found, usually in coarse xenomorphic grains and less often in elongated columns. Small grains of rutile and hornblende are present in pyroxene inclusions. A greenish-brown chlorite-like or clayey mineral often develops along the pyroxene and, occasionally, brown ferric oxides and brown biotite. Seven samples, tested for optical constants showed: 2V from plus 60° to plus 66°, cNg from 40° to 44°. The indices of refraction were: Ng' from 1.702 to 1.712, Np' from 1.680 to 1.690; Ng'-Np' from 0.022 to 0.026. Thus this pyroxene is analogous in form and optical constants to the pyroxene of eclogites.

Plagioclase pyroxene schist differs inasmuch as it contains brown-green horblende with a pleochroism ranging from brown-green in Ng to light brown-green in Np; along the axis of Nm it is brown-orange. 2V = -80°, cNg = 22°, Ng' = 1.676, Np' = 1.652. One microsection showed a hornblende of 2V = -76°, cNg = 22°. The scheme of absorption and the color of the mineral are analogous to the preceding one.

The rock contains light brown biotite with a pleochroism that includes colorless biotite in Np and a normal scheme of absorption. Biotite is, evidently, secondary and develops from garnet and ore mineral. Tests clearly reveal that hornblende is replaced by orange-brown biotite.

Garnet is found in the form of pyrope in large irregular porphyroblasts and less often in the form of idiomorphic crystals. Intense fissuring and chlorite developments along the fissures was observed.

Some samples produced the following indices of refactrion:

$1.754 > N > 1.737$ and $1.767 > N > 1.754$
$1.754 > N > 1.740$ and 1.737
$1.754 < N < 1.767$
$1.767 > N$
$1.767 > N > 1.754$

Judged by its indices of refraction and color the garnet belongs to the pyrope almandine variety with a content of approximately 30 to 40 percent almandine. It is a rather interesting fact that these xenoliths are characterized by garnets for which the indices of refraction are not the lowest and which are redeposited in the kimberlite originating, evidently, with othe rocks -- maybe ultrabasic rocks of the type described above. Chemical analyses revealed that the garnets from eluvium (Figure 72) contain calcium and chromium. However, the content of chromium is rather low in garnets that resemble the garnets in eclogites. The presence of andradite (up to ten percent) raises the index of refraction so that the almandine content is considerably lower than shown by the Winchell diagram (20 percent).

Accessory minerals such as apatite, rutile and ore mineral are rare and are, usually, included in the basic minerals of the rocks. In the kimberlite of the pipe "Udac'naya" a fissure in the garnet is filled out with a fine prismatic actinolite variety (Figure 27). The peripheric parts of the fissures in the garnet are filled out by extremely fine prisms of actinolite that accrete perpendecularly to the walls of the tissures. The pleochroism of the actinolite ranges from light-green in Ng to light yellow in Np, cNg is about 20°.

Many xenoliths are marked by peculiar acicular inclusions of a mineral in the garnet. These inclusions are located under an angle of 60° in relation to each other (Figure 28). Sometimes this pattern is changed. A long and fine prismatic acicular form can be recognized when the mineral greatly magnified, In larger units a greenish-yellow pleochroism can be detected. The mineral has a positive elongation. The index of refraction is clearly higher than in garnet.

The high colors of the interference up to the second series should be noted as well as the extreme thinnes of the crystal which testifies to birefringence. This characteristic as well as the acicular form of the crystals and the occasional lattice-like pattern lend this mineral the appearance of rutile. However, in the aciculae the extinction is oblique its angle reaching 25-26 degrees so that there is no question of rutile. For that reason, the mineral should be investigated nore thoroughly.

Rocks with Disthene: This rock belongs to the group that is rather rich in plagioclase but differs because it contains disthene. The texture of the rock is granoblastic porphyroblastic, in some sections nematoblastic and even fibroblastic.

The rock is formed of garnet, monoclinal pyroxene, plagioclase, disthene, scapolite and individual grains of apatite and ore mineral. Considerable quantities of pyrope garnet are present with N = 1.738 - 1.754 - 1.767. Usually they are found in the form of large irregular porphyroblasts. Less often they are idiomorphic. The surface of the garnet is smooth and lustrous.

Kelyphite rims are characteristic of most grains of garnet. It is an interesting fact that the clusters of disthene usually abut against the kelyphite halo without penetrating into the garnet. The grains of garnet, without a kelyphite rim are intruded by disthene like the other minerals. (Figure 29).

Second in quantity is plagioclase in the form of irregular blades which are often fractured. Scapolite that replaces plagioclase is greatly developed. Clayey minerals often develop along the fracturers.

Plagioclase is twinned, and narrow polysyntnetic twins occur commonly. Everywhere the grains of plagioclase are penetrated by clusters of disthene aciculae. The inclusions often contain grains of monoclinal pyrocene, garent and apatite. Two tests with grains of plagioclase included on the Fedorov device produced No. 50, that is acid labradorite.

Disthene characterizes the rock. It develops in the form of fine aphanitic xyloid aggregates, conic clusters as well as divergent "suns" (Figure 30) so that the identification of the mineral is uncertain. Disthene primarily associated with grains and accumulations of garnet. Disthene frequently forms the outside rim around them (the inside rim is kelyphitic). The disthene aciculae are characterized by cleavage of (100) with a normal that almost coincides with the axis of Np.

The measuring of the disthene aciculae through the Fedorov device produced 2V from plus 80° to plus 89° which distinguishes it from typical disthenes.

Diablastic texture was notices where disthene along with monoclinal pyroxene have penetrated disintegrated texture.

Monoclinal pyroxene is encounted in considerable quantities in xenomorphic grains with a good parallel cleagave 2V = plus 63°, cNg = 40 - 41°.

Apatitie in the form of small irregular grains and ore mineral is present as an accessory minerals.

<u>Rocks rich in hornblende:</u> along with pyrope and monoclinal pyroxene hornblende and sometimes biotite play an essential role in these rocks. The texture is nematogranoblastic and in some areas lepidogranoblastic. Monoclinal pyroxene is occasionally found as well as small quantities of biotite, pseudomorphs of a kaolin mineral after plagioclase, clacite, apatite and ore mineral.

Pale-green hornblende with slight pleochroism in ligher shades is in predominance. The angle of optical axes is 2V = minus 73°, cNg = 20°. Indices of refraction: Ng' = 1.684, Np' = 1.664; Ng' - Np' = 0.020, which corresponds to 45 percent iron component.

Biotite is present in the form of large scales, its pleochroism ranging from a brownish-orange in (Ng) to a slightly yellow (almost colorless) in Np. Gratly deformed and even split scales have been found. Inclusions of ore mineral and sometimes of grains of apatite, rutile and pseudomorphs of serpentine after a mineral are occasionally present. The index of refraction of the biotite: Nm = 1.615 which proves its low iron content.

Monoclinal pyroxene is found in the form of fine light green xenomorphic grains with pronounced parallel cleavage. The angle of the optic axial angle: 2V = plus 64°; cNg = 44-45°; Ng' = 1.712; Np' = 1.690; Ng' - Np' = 0.022.

Along the fractures individual grains of pyroxene are replaced by a greenish-brown chlorite-like mineral sometimes together with calcite.

Garnet is encountered in individual fine grains and shapeless segregations. Along the pattern of fine fractures that branch out light-brown secondary biotite develops. The index of refraction for the garnet varies between 1.738 and 1.754 which classifies it as a pyrope with 30 to 40 percent almandine component. At one place, colorless pargasite hornblende was encountered (Figure 31).

Here are the optic constants: 2V = 65 - plus 66°; cNg = 25-26°; Ng' = 1.658; Nm' = 1.645; Np' = 1.638. These data confirm the definition.

A somewhat different variety of rocks was encountered although it resembled the above-mentioned rocks. Partially decomposed plagioclase and pertite is common in this rock along with hornblende, monoclinal pyroxene and pyrope garnet. Plagioclase and potash feldspar are common in irregular grains which are either partially or completely replaced by argillaceous products of weathering. The measuring of the plagioclase grains produced andesine No. 34.

The constants of monclinal pyroxene usual for these rocks: 2V = plus 66°; cNg = 44°; Ng' = 1.722, Np' = 1.7000; Ng' - Np' = 0.022.

Hornblende is distinguished by its deep green-brown color with pronounced pleochroism from deep green or brown in Ng to light green and brown in Np. The optic axial angle is 2V = 72°; cNg = 18-20°. Partially, hornblende is replaced by secondary orange-colored biotite.

The indices of refraction for various grains of garnet are: $N \sim 1.738$; $N \sim 1.738$; $N \sim = 1.754$; $N > 1.754$, but < 1.767.

One sample showed an interesting inclusion: a contact between hornblende-garnet crystalline schist and plagioclase potash feldspare rock with hornblende. Hornblende crystalline schist consists of hornblende, pyroxene, pyrope-garnet and kaolin pseudomorph after plagioclase (?). Hornblende is analogous to the preceding one with a pleochroism from brownish green in Ng to light brown in Np. Optic constants: 2V = -72-74°; cNg = 18-20°.

The contact with the feldspar rock is not very pronounced. The grains and the segregation of hornblende grains form a streaky structure in the leucocratic rocks.

Plagioclase is encountered in the form of more or less uniform grains with narrow polysynthetic twins, stomotimes of an antiperthite texture. Two samples of plagioclase measured with the Dedorov device produced andosine No. 35-40.

Pertites are easily detected and are characterized by banded frequently parallel penetrations of plagioclase into potash feldspar. Sometimes, the form of plagiclase deposits resembles typical ichtyoglyptic formations and a complete analogy with the graphic texture of pegmatites can be established. Occasionally greatly fractured xenomorphic grains of quartz are found.

Hornblende and monoclinal pyroxene are common in individual grains and show complete similarity with the corresponding minerals of the above-mentioned melanocratic rocks.

It has already been mentioned, that in many xenoliths of eclogites and eclogite-like rocks intense secondary alterations have taken place. Plagioclase is replaced by a kaolin-like mineral and pyroxene by undetermined clay-and chlorite-like products. In some cases this alteration is so conspicuous that both, pyroxene and plagioclase are fully replaced by secondary minerals which provides only a vague idea about the character of the rock judged by relict garnet and other resistant minerals (rutile) as well as by the gradual transformation into less altered rocks (Figures 32, 33).

Pseudomorphs of secondary minerals after pyroxene are usually dark and are sometimes concentric. Along the edges of the pseudomorphs a darker rim is found while carbonate is present in the central part. Sometimes the carbonate surrounds relict pyroxene. Some pseudomorphs after plagioclase also reveal zonary structure. (Figure 34).

Garnet is usually the most resistant mineral (of the main minerals) found among secondary minerals in the form of round porphyroblasts; the fractures of these porphyroblasts are also filled with secondary minerals.

The altered xenoliths rocks are rather varied; a special study of the secondary products as well as of the texture of these rocks has still to be made. There is no doubt, that along with eclogite rocks other types of greatly altered crystalline schists commonly occur. The fact that biotite is relatively well preserved is very characteristic. In some cases secondary products resemble serpentine and it is very likely that among the altered xenoliths of this group ultra-basic rocks (peridotites with garnet) will eventually be identified similar to the rocks in the pipe "Mir".

Xenoliths of Garnetized Crystalline Schists

This group includes peculiar crystalline schists which belong to the eclogite facies according to the paragenesis of garnet with monoclinal pyroxene. At the same time they contain a paragenesis of rhombic pyroxene with plagioclase which speaks against their membership in the eclogite group. In some places a young formation of garnet is clearly visible along with the relict character of hypersthene so that there is no doubt that eclogization of hypersthene and hypersthene hornblende of Pre-Cambrian crystalline schists has taken place.

Below, an account of two typical representatives of the xenoliths of this group of rocks. The texture is granoid and coarse-grained. The structure is foiliated. Garnet, rhombic pyroxene, monoclinal pyroxene, plagioclase, hornblende in small quantities and biotite occur commonly in the rocks. Of accessory minerals apatite and ore mineral are present. Secondary minerals: chlorite, iddingsite and biotite (Figure 35).

Plagioclase constitutes an essential part of the rock (about 50 percent). Rather common are antipertite penetrations of potash feldspar into the plagioclase. The twins are narrow, polysynthetic and sometimes periclinal. In some grains kaolin is developed along the fractures. Four tests of plagioclase grains produced andesine No. 40-45.

Occasionally, scapolitization of plagioclase is recognized and quite often plagioclase is replaced by kaolin mineral. In antipertites, decomposition has only affected plagioclase while bands and strips of potash feldspar remain completely intact.

Rhombic pyroxene occurs rather commonly in the form of large irregular grains, with a sometimes clearly marked cleavage. On the outside and along cleavage fractures red-brown iddingsite often replaces individual grains. Usually, fine grains of garnet surround the hypersthene like a wreath. A cluster of grains of hypersthene and garnet was noted. The pleochroism of rhombic pyroxene ranges from various shades of green in Ng to pink in Np. Three tests produced the following optic constants: 2V from minus 68° to minus 69°, $Ng' = 1.686$; $Np' = 1.674$. Optic data reveal that the composition of rhombic pyroxene is close to bronzite and is characterized by a rather low content of $FeSiO_3$ (up to 16-19 percent) (Sobolev, 1949).

As a rule, garnet is found in the form of coarse porphyroblasts which are often greatly fractured. The grains are not idiomorphic. Grains of garnets are often clustered with monoclinal pyroxene as well as with rhombic pryoxene. In the contact zone between ore mineral and feldspar younger irregular grains are clearly visible as well as jointed grains of garnet. Along with grains of pyrope with $N > 1.738$, but < 1.754, grains of garnet with $N = 1.767$ and $N > 1.780$ occur. It may be assumed that the latter index of refraction applies to the garnet that develops around the ore mineral.

In a typical eclogite rock the presence of garnet with different indices of refraction was noted. This applies to an even greater extent to the rocks which are described here, i.e. the balance is established only in individual points and sections while from a physico-chemical point of view the whole rock does not represent a balanced system.

Monoclinal pyroxene is rather common. It is light-green and partially replaced with chlorite and hornblende. Pleochroism is not very well marked in the lighter shades. At some areas hornblende is replaced by brownish-orange biotitle and by a fine-grained garnet aggregate that forms vein-like patterns and branches out into coarse-grained hornblende. The axial optic angle varies from 74 to 84 degrees.

Along with coarse scales of biotite the rock is marked by fine orange-brown laminae and scales which are usually observed at the contact with ore grains. The coarse scales vary in pleochroism from orange-brown in Ng and light-brown (almost colorless) in Np. The basic mass of secondary biotite develops as a result of the presence of hornblende and hypersthene. Nm = 1.628.

Apatite in the form of shapeless fine grains as well as ore mineral is rather common among accessory minerals.

Crystalline schists that contain both kinds of pyroxene with garnet in which femic minerals are characterized by a higher iron content belong to the same group. The tecture is granoblastic and porphyroblastic.

The rock is formed of plagioclase, hypersthene, garnet which is rather rich in an almandine component, hornblende, and biotite. Less common is monoclinal pyroxene and individual grains of quartz. Accessory minerals: apatite, rutile, and ore mineral. The following secondary minerals are very developed: chlorite, iddingsite, carbonate, scapolite and, less often, serpentine, kaoline, and brown ferric oxides.

Considerable quantities of plagioclase are present in the form of wide laminae and irregular grains with polysynthetic twins. Scapolite is often substituted for plagioclase. Individual grains of plagioclase are opaque or semi-opaque. Sometimes plagioclases is replaced by greenish chlorite. Five tests of the plagioclase with the help of the Federov device produced oligoclase andesine No. 26 - 35.

There is not too much hypersthene, often it is present in the form of individual grains which are either partially or fully replaced by iddingsite and saturated with ore dust (Figure 36). Four tests to determine the optical constants with the help of the Fedorov device produced the following results: 2V from -66° to -74°; Ng' = 1.710; Np' = 1.696 - 1.698; Ng' - Np' = 0.014 - 0.012.

According to the indices of refraction the content of $FeSiO_3$ has been established to be about 37 percent (molecular percent).

A predominance of monoclinal pyroxene among femic minerals is obvious. The grains are well preserved, chloritization and partial carbonization is only observed along fractures. Four tests to establish the optical constants with the Fedorov device produced the following results: 2V from +61° to +64°; cNg = 42-43°; Ng' = 1.712 - 1.714; Np' = 1.690.

Small quantities of hornblende with a pleochroism from greenish-brown for Ng to light-brown for Np were found in some samples. The optical constants (four tests) are as follows: 2V from -72° to -80°; cNg = 18-22°; Ng' = 1.684; Np' = 1.664-1.665. Judged by the optical constants there are 50 percent ferric component in the hornblende.

The garnet forms large fractured porphyroblasts and is sometimes shot through by fine irregular grains. The inxed of refraction varies from 1.767 to 1.780 and up testifying to the almandine nature of the garnet.

Small scales of secondary orange-brown biotite which usually develop by the presence of hornblende are rather common in the rock.

Pseudomorphs of serpentine after xenomorphic grains of mineral that must have been present in the past and grains of hornblende were encountered.

As an exception apatite and rutile are found only in the form of inclusions in basic minerals.

Xenoliths of Crystalline Schists in Pre-Cambrian Rocks

The mineral composition of crystalline schists in Pre-Cambrian rocks varies but mostly these schists belong to the group of crystalline schists that contain hypersthene along with different quantities of monoclinal pyroxene, hornblende and biotite.

The texture of the rock is either granoblastic or nematogranoblastic and, occasionally, poikiloblastic.

The following basic minerals are present: plagioclase, hypersthene, hornblende and small quantities of monoclinal pyroxene, biotite and sometimes perthitic potash feldspar as well as quartz. There are the following accessory minerals: apatite, zircon, spinel, (pleonasts), and ore mineral. Secondary minerals are represented by chlorite, carbonate, iddingsite, biotite and clayey minerals along with ferric oxides. Plagioclase occurs rather commonly. The grains are most irregular. Wide, broken laminae with more or less irregular outlines occur less frequently. Twins are narrow, polysynthetic and often irregular. Rather frequently, non-twinned compounds were encountered. Antiperthites were found very often.

Clayey products of weathering, evidently, of the kaolin group develop in the grains along fractures. The grains are very cloudy appearing almost opaque in daylight, They are grayish. Fine grains of hornblende, ore mineral and sometimes of zircon and apatite are present in inclusions.

Plagioclase is often replaced by light-green chlorite and calcite, sericitization is noted. Eight tests conducted with plagioclase grains in the Fedorov device revealed fluctuations ranging from No. 41 to No. 58, i.e. variations from andesine to labradorite.

Hornblende is in predominance among dark minerals. It is found in the form of a deep-brown variety. Its pleochroism ranges from light brown in Np and brownish-orange along the Nm axis. The scheme of absorption is normal. Grains of monoclinal pyroxene, feldspar, apatite and ore mineral occur commonly in inclusions. Hornblende is partially replaced by chlorite, brown biotite and calcite (Figure 37). Six tests to determine the optic constants with the Fedorov device produced: 2V from -71° to -74°; $cNg = 18 - 22^\circ$; $Ng' = 1.684 - 1.692$; $Np' = 1.664 - 1.672$.

Pyroxenes are encountered together with hypersthene, the latter being frequently in subordinate quantities and occasionally in the form of individual grains.

Hypersthene forms irregular grains that are conspicuously marked by corrosion from iddingsite. Decomposition affected the grains from outside developing along the pattern of small fractures. Sometimes all that remains of the large grains of hypersthene are small relict sections. There is no pleochroism. Seven tests to establish the optic constants with the Fedorov device produced: 2V from -63° to -74°; Ng' = 1.706 - 1.718; Np' = 1.694 - 1.706.

The indices of refraction show that $FeSiO_3$ is present as follows: 34 percent $FeSiO_3$ with Ng' = 1.706; 45 percent $FeSiO_3$ with Ng' = 1.718. Rhombic pyroxene contains considerable quantities of iron.

Monoclinal pyroxene is found in the form of large xenomorphic grains. Polysynthetic twins were noted. The grains of monoclinal pyroxene are replsed by a brownish-green chlorite-like material with a somewhat higher birefringence and sometimes by calcite along the fractures. The optic axial angle ranges from $+60$ to $+62^\circ$, cNg does not exceed 40°.

Biotite occurs in the form of coarse, elongated scales and small irregular laminae along hornblende. The former have a clear pleochroism that ranges from reddish-brown in Ng to light yellow in Np. It is obvious that biotite is more idimorphic than the grains of hornblende (Figure 38).

Apatitie predominates among accessoyr minerals. Frequently it is irregular or rounded and oval, the grains being included in basic minerals. Grains of zircon are extremely rare, but ore mineral is abundant. Sometimes it is associated with greenish spinel known as pleonaste.

Along with hypersthene hornblende schists, inclusions without hypersthene were encountered. These inclusions contain considerable quantities of monoclianl pyroxene and hornblende. Monoclinal pyroxene has 2V = 60-62°; cNg = 40-42° and close by resembles diopside. A replacement of the grains of pyroxene by chlorite and calcite was noted. The hornblende is similar to the variety mentioned in connection with hypersthene hornblende schists. Plagioclase equals andesine No. 38 - 45. A partial replacement of plagioclase by a fine aggregate of a colorless mineral -- presumably kaolin -- was recognized. The rocks contain some elongated scales of deep-brown biotite. Its pleochroism is of light-brown shades and the diagram of absorption is normal. Rutile predominates among accessory minerals. An unusual rock with bluish-green monoclinal pyroxene of the aegirite-augite type was discovered in a xenolith.

The texture of the rock is granoid and coarse-grained. The structure is of micro-cleavage and banded type. Basic minerals: plagioclase, monoclinal pyroxene; accessory minerals: apatite and magnetite. Plagioclase is mostly replaced by an isotropic brownish clayey mineral.

Tests with the Fedorov device produced plagioclase-labradorite No. 62 - 65.

Monoclinal pyroxene is predominant in the form of a bluish-green variety with an optic axial angle of $2V = +58^\circ - 60^\circ$ and $cNg = 47^\circ$ which proves its similarity to aegirite augite. The pleochroism is pronounced -- it varies from bluish-green in Ng to yellowish-green in Np. The indices of refraction are: $Ng' = 1.724$, $Np' = 1.696$, $Ng' - Np' = 0.028$.

Apatite and ore mineral is usually included in plagioclase and monoclinal pyroxene, It is of minor importance.

Two inclusions in the kimberlite of "Zarnitsa" are formed of feldspar schists with hornblende.

Along with plagioclase, porthitic potash feldspar and hornblende is present as well as the accessory minerals zircon and apatite. Secondary minerals: chlorite, serpentine, biotite, calcite, and clay-like minerals of the halloysite group. A grain of monoclinal pyroxene was identified in one section.

The basic part of the rock is formed of plagioclase in the form of irregularly shaped grains which are usually replaced by clay-like minerals. A partial carbonization of plagioclase is under way. Tests of the grains of plagioclase with the Fedorov device produced andesine No. 38. Along with plagioclase banded perthites are very common. Individual grains of potash felspar are partially decomposed so that they acquire characteristic brownish color. Individual grains of brownish-green hornblende were found: $2V = 172^\circ$ and $cNg = 18-19^\circ$.

Along with secondary laminae of red-brown biotite that replaces hornblende, well formed elongated scales were identified. The pleochroism ranges from brownish-orange in Ng to light brown (almost colorless) in Np. Apatite grains are found in the form of inclusions in plagioclase.

A xenolith composed of biotite and hornblende with altered plagioclase was also recognized. It has a lepidolite nematorgranoblasic texture.

Xenolith of Basic Rocks

The xenoliths of basic rocks are formed of greatly altered gabbroid diabase and diabase. They are abundant in the pipe "Mir" as well as in some pipes of the Daaldyn District.

The rocks have a poikilitic or ophitic texture. Idiomorphic plagioclase is always very conspicuous.

Main minerals: plagioclase and monoclinal pyroxene. Sometimes pseudomorphs after olivine are present. Accessory minerals: titano-magnetite and apatite.

Plagioclase is encountered in the form of narrow idiomorphic laminae of different sizes. Occasionally the rock is shot through with large porphyric-like laminae. Tests (six) of the plagioclase with the Fedorov device showed that the component fluctuates between No. 60 and 77, i.e. that it is labradorite-bytownite.

Monoclinal pyroxene usually occurs in the form of large grains cut through by plagioclase. The optic constants of the pyroxene (one test) produced the following results: $2V = +50^\circ$; $Ng' - 1.717$, $Np' -1.697$.

Titano-magnetite occurs in characteristic xenomorphic grains, while apatite is present in the form of fine aciculae.

In texture and mineral composition the above rocks are analagous to Siberian traps (Sobolev, 1936). However the difference consists in the common occurrence of various secondary minerals. Among secondary minerals green, occasionally isotropic or anisotropic, clinoclases or foliated chlorophaite is present. It replaces mesostasys, partially pyroxene and, presumably, olivine. It is also found in ordinary traps.

Other secondary minerals that are not characteristic of traps are common along with chlorophaites in xenoliths. Occasionally instead of dark chlorophaite light-green magnesian chlorophaite develops. Sometimes it has a perfectly divergent aggregate which is sometimes replaced not only by mesostasys but also by plagioclase.

Other undetermined secondary minerals also develop. Plagioclase is replaced by a kaolin and hydromicaceous mineral aggregate, pyroxene by a clay-like nontronite mineral. These minerals resemble secondary products in the altered xenoliths of crystalline schists and sometimes they almost completely replace primary minerals.

The above secondary alterations of the xenoliths in traps are associated with the general alteration of kimberlites, evidently under the action of the solutions that rise and circulate in the pipes after their formation.

Xenoliths of Sedimentary Rocks

Fragments of a fine crystalline carbonaceous rock, obviously limestone, predominate among the xenoliths of sedimenary rocks. Along with large fragments, which are visible in the course of field research, fine fragments that reach a maximum size of one centimeter are extremely common. In some areas a considerable part of breccia fragments is composed of these fine fragments. Sometimes it is difficult to distinguish between these fragments and the secondary carbonate of the cementing mass. The fragments are often rounded or oval. Along the edge of the fragments a fringe of more cryptocrystalline carbonate and a fringe of dust-like or uniform magnetite is often discovered. The presence of these fringes accounts for the concentric formation of these fragments.

Sometimes fragments of limestone are observed. They are impure since they contain 70 to 80 percent magnetite and are easily mistaken for carbonaceous shale under the microscope.

In addition, great quantities of purer limestone without magnetite is present in the breccia.

The study of numerous samples revealed that the fragments of limestone surrounded by a magnetite rim or concentric as a result of the dissemination of dust-like magnetite are, actually, microxenoliths (Figure 39).

It should, however, be emphasized that microxenoliths of limestone without a magnetite rim are often included in altered kimberlite.

In most cases the limestone found in breccia fragments has a micro-texture and is sometimes cryptocrystalline.

Rather common are fragments of limestone with organogenic texture. Organic residues in the samples resemble rounded formations of fine-grained carbonates and oval concentric formations. Sometimes the fauna is better preserved. The samples clearly show formations that appear to be the microlimbs of crinoids and fragments of brachiopod shells (Figure 40).

In addition to fragments of organogenic limestone included in breccia, fragments of carbonaceous rock with an extremely unusual clastic spherulite texture were identified. The rock is composed of spherulite and semi-spherulite carbonaceous formations, their size ranging from 0.5 to 0.8 millimeters in diameter and is cemented by calcite.

Sometimes pseudoolitic limestone fragments are recognized. They are composed of rounded formations of darker microcrystalline carbonate submerged in calcite cement (Figure 41). The size of the pseudoolitic fragments reaches one millimeter in diameter. These formations are classified as pseudoolites because the concentric or divergent formation is either not clearly marked or missing altogether.

Movreover, a fragment of a carbonaceous rock was discovered with an unusual texture that resembled crustified texture and consisted of a foliated carbonate. These tectures also bear a resemblance to organogenic coral textures, but the rock is clearly of a veinstone variety since microxenoliths of kimberlite breccia (Figure 42) are present.

Fragments of serpentinous chlorite and chlorite-lime micro-schists are rather common. The rock is characterized by cleavage structure and microlepidoblastic texture. It consists of serpentine and chlorite or only chlorite in the form of uniformly oriented minute laminae with an insifnigicant admixture of carbonate.

In daylight the rock is green. Most chlorite laminae have the same optic constant; pleochroism varies according to the aggregate so that the color of the rock changes at the turn of the microscope.

Alterations of Xenoliths Along the Contacts

Xenoliths in fragments of magmatic kimberlite are frequently distinctly marked by small grains of apatite and ore mineral of the effect of magma. It is reflected in the formation of secondary biotita in the contacts (Figure 43).

Occasionally small scales of phlogopite in the contact of limestone and magmatic rock were also identified.

Frequently, the zone along the contact of a xenolity is greatly saturated with brown ferric oxides revealed as a narrow continuous rim. Sometimes chlorite develops instead of biotite in the contact with surrounding kimberlite. This chlorite is saturated with ore dust and brown ferric oxides.

In the contacts of the fragments of breccia nothing indicates that the cement has a clastic instead of a magmatic character.

3. COMPARISON BETWEEN KIMBERLITES OF SIBERIAL & SOUTH AFRICA

In the geological description the similarity between the kimberlites of the pipes of the Vyliyui region and those of South Africa has already been emphasized. Let us briefly compare natural kimberlites with xenoliths.

Despite the tremendously altered components and textures of the rock it may be affirmed that magmatic rock is a typical kimberlite. Evidently, kimberlites without mica or poor in mica are in predominance. However, varieties of micaceous kimberlites are also encountered. The similarity is further emphasized by the presence of a very characteristic secondary mineral. This mineral is perovskite that has so far been encountered in Siberian kimberlites in considerably smaller quantities and in the form of extremely fine crystals.

Another similarity consists in the common occurrence and genesis of minerals characteristic of kimberlite, namely pyrope and picroilmenite. These minerals behaved like xenogenic minerals in kimberlite magma; they reacted to magmaby forming characteristic kelyphite fringes around the pyrope and thin-bladed crystals of perovskite around ilmenite.

Not only the composition and texture of the magmatic rock bears a striking similarity to African kimberlites but also the fragmental and often brecciated structure of the mass that fills out the pipe which is characteristic of most pipes of explosion. (Wagner A., 1909). It would be premature to discuss the details of the formation of these pipes but it should be emphasized that several generations of magmatic kimberlite fragments can be identified in the breccia just as in pipe of South Africa. This fact testifies to the complexity of the process.

Another feature that is common between Siberian and African kimberlites is the drastic alteration of the rocks that has advanced so far in Siberian kimberlites that unaltered olivine has been recognized only in two pipes. However, by analogy with South Africa it may be assumed that alteration gradually decreases with depth where less altered kimberlites will presumably be found considerably complicating the methods of enrichement.

Despite the similarity between the secondary alterations, which are evidently of an endogenous character, Siberian kimberlites are distinguished by the absence of a thick exogenous zone known as "yellow and blue soil" and characteristic of the pipes of South Africa.

As in African kimberlite, breccia fragments of other rocks are also abundant in Siberian kimberlite breccia. The abundance of "nodules" of eclogite-like rocks in the kimberlites of the Daaldyn region should be noted. Similar to South African kimberlite their quantity in different pipes varies and sometimes they are present in insignificant quantities as, for instance, in the pipe "Mir" of the Malaya Batuobiya region.

At the same time, there is an essential difference between the Siberian and the South African pipes. While real eclogites without plagioclase predominate in South Africa eclogite-like rocks are occur mostly in Siberian kimberlites. These rocks are rich in intermediant plagioclase and it is recommended to give them a special name. Feldspar-bearing eclogites were found in the Katanga tubes of Africa (Belgian Congo) but they are marked by more basic plagioclase (Verhoogen J., 1940).

Similar to the kimberlites of Africa, xenoliths of crystallein schists along with eclogite-like rocks from the underlying Pre-Cambrian bed occur commonly in Siberia. At the same time, this stage of research has already shown interesting transformations of these crystalline schists to eclogite rocks which will, undoubtedly, plan an important role in a more detailed study of the genesis of these rocks.

In composition Siberian pipes differ from African pipes by the care occurrence of xenoliths of ultra-basic rocks(disregarding fragments of kimberlites in the kimberlite, of course) which have so far only been discovered in the pipe "Mir" where they are, however, completely altered. It is nevertheless, quite possible that this complete alteration leads to a certain masking of such xenoliths and that in the future great quantities will be discovered.

Finally, it should be emphasized that similar to African pipes Siberian pipes contain a great number of xenoliths of sedimentary rocks torn through by the pipes not only from underlying but also from overlapping eroded beds.

Thus, despite certain differences in the substantial composition of rocks and xenoliths in the Vilyui diamond-bearing region, Siberian rocks are typical kimberlites analogous to the classic kimberlites of South Africat in regard to occurrence and substantial composition.

III. MINERALOGY OF SIBERIAN KIMBERLITES

The study of the mineralogy of Siberian kimberlites as presented in this chapter[x] is based on the results of a preliminary investigation of pulverized samples, concentrates of enrichment and grains obtained during prospecting of the two

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[x] The results of the microscopic study of rock-forming minerals as well as of Siberian kimberlites and the xenoliths of other rocks are quted in the petrographic report.

kimberlite pipes "Mir" and "Zarnitsa". Some of the samples were obtained from the recently discovered kimberlite pipes "Zagadochnaya" and "Dalnaya". The samples used in the study were taken from a maximum depth of three to four meters, and consequently, are only characteristic of the top layers of the kimberlite pipes including eluvium.

The first brief report on the minerals in the pipe "Zarnitsa" was compiled by N.N. Sarsadskikh and L.A. Popugayeva. At the same time, a team of geologist (M.A. Gnevushev, G.O. Gomom, M.P. Metelkina and A.P. Chernenko) identified such minerals as pyrope and ilmenite which are the main companions of diamonds. A considerable part of the data is included in this book. It is based on the study of concentrates washed out from diamond-bearing placer deposits near the kimberlite pipes.[x]

The minerals discovered during the study of samples are subdivided into primary minerals (directly connected with the formation of the kimberlite) and secondary minerals (formed as a result of subsequent alterations of the kimberlite). Primary minerals are, in turn, divided into two groups: kimberlite minerals (including a certain part of xenogenic minerals) and minerals that form the xenoliths:

	Primary	Secondary
Kimberlite minerals	Xenoliths minerals	
Diamond	Pyrope	Serpentine
Ilmenite	Almandine	Calcite
Pyrope	Grossularite	Quartz
Chromdiopside	Hypersthene	Calciostrontianite
Diopside	Turmalin	Celestine
Olivine	Chrodiopside	Phlogopite
Phlogopite	Diopside	Chlorite
Magnetite	Zircon	Hydromica
	Apatite	Magnetite
	Feldspar	Pyrite
	Quartz	Limonite

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[x] While this paper was bing published, rich material on petrographic and mineralogic characteristics of kimberlites became available. It will be published in special journals and articles. We shall merely note at this point that for the time being the petrography of little altered kimberlites with young olivine is being studied as well as includions in kimberlite that turned out to be much more versatile. A fascinating type of inclusions was, for instance, discovered where along with disthene that has been verified through chemical analysis a peculiar "grossurlate" was found with a total content of 35 percent almandine and pyrope components. Among new interesting minerals moissanite was discovered.

Research showed that the mineralogical composition of the kimberlites is more or less stable. There are, however, some differences in the quantitative ratio of individual minerals in various kimberlite pipes. In the kimberlites of the pipes "Mir" and "Zarnitsa" a sharp predominace of ilmenite over other minerals was observed while in the kimberlites of the pipe "Zagadochnaya" ilmenite is only found in the form of rare grains. On the other hand, there is an abundance of chromdiopside in the eluvium of the kimberlite pipe "Zagadochnaya" while only occasional grains are found in the pipes "Mir" and "Zarnitsa."

Table 2 shows the mineral content in different kimberlite pipes:

Name of Pipe	Primary Minerals		Secondary Minerals	
	Common Occurrence	Rare Occurrence	Common Occurrence	Rare Occurrence
"Zarnitsa"	Ilmenite	Alamandine	Calcite	Calciostrontianite
	Pyrope	Diopside	Serpentine	Celestine
		Chromdiopside	Magnetite	Chlorite
		Feldspar	Limonite	Phlogopite
		Phlogopite		Quartz
		Olivine		
		Zircon		
		Apatite		
		Quartz		
"Mir"	Ilmenite	Grossularite	Serpentine	Hydromica
	Pyrope	Chromdiopside	Magnetite	Quartz
	Magnetite	Zircon	Chlorite	
		Turmalin	Calcite	
		Quartz	Limonite	
"Zagadochnaya"	Pyrope	Ilmenite	Calcite	
			Serpentine	
	Chromdiopside	Chromite	Hydromica	
			Limonite	

Below is a description of all these minerals with the exception of diamonds. A special chapter is devoted to them. The most characteristic companions of diamonds -- pyropes and ilmenites -- are described in great detail.

Pyrope

Pyrope occurs commonly in all kimberlite pipes that have been investigated. As a rule, it is found in the form of somewhat flattened grains with rounded outlines (Figure 44), but is frequently present in grains with canchoidal fractures. The surface of the grains is usually rough, with numberous small cracks filled out by secondary minerals that lend the pyrope a dirty grayish-red coloring. An intricate pattern develops on some grains resembling the patterns found on some diamonds greatly corroded.

Pyropes found in kimberlites are, as a rule, rounded. This is caused by their partial resorption in the process of rock formation. There are no traces of crystalline planes on the grains of pyrope.

Some grains of pyrope are covered by a grayish-white or greenish-black kelyphite halo (Figure 45). These kilyphite halos are most frequently found on pyropes in the kimberlites of the Malaya Batuobia River and the Allaroo-Choohurdakh River while they arevvery rare in the Daaldyn region.

According to M. Yu Fishkin's research (Chair of Mineralogy of Lvov State University) the kelyphite halos on the grains of pyrope consist of the following minerals:

1. Bright green chlorite with Nm = 1.622 and Np = 1.609 with blue anomalous colors of interference;

2. Biotite with light-brown pleochroism Ng ≅ Nm = 1.630 and Np' = 1.609.

3. Calcite with Ng = 1.656, in some grains dolomite with Ng = 1.682.

4. Columnar amphibole in association with chlorite, Ng = 1.643 and Np = 1.620. Clearly biaxial negative mineral with a wide angle 2V, presumably actinolite.

5. Hydromica (?); in fine micaceous aggregates (Ng = 1.532), which often form a white or grayish-while kelyphite halo.

6. Hyperathene (?) in individual grains, with a pleochroism in greenish-yellow shades, Ng = 1.711 and Np' = 1.698.

7. Plagioclase in individual grains Ng = 1.558 and Np' = 1.550.

The size of the pyrope grains varies from 0.1 millimeter to 1.0 centimeter in diameter. The average size of the most common grains is 0.5 to 2.00 millimeters. The color of the pyropes varies greatly. There are deep red (Figure 46), red (Figure 47), violet (Figure 48), pink (Figure 49), orange (Figure 50) and almost colorless pyropes. Within the same range of colors different shades were recognized due to the various degrees of richness of the color. It was established that a certain color was characteristic of each deposit. In the kimberlites of "Zarnitsa", for instance, red and deep-red pyropes predominate, in "Mir" violet pyropes and in "Zagadochnaya" orange pyropes. A few grains of pyrope were found (in the pipes "Mir" and "Zarnitsa") to posses the property of changing color under a different light. The change of coliring according to the light was clearly recognized in immersion compounds under the microscope. In daylight the pyrope appeared green while it was red under electric light. This change in color is also characteristic of in alexandrites and is, evidently, of the same nature (Grum-Grzhimailo, 1947). The coloring of the grains of pyrope changes gradually. The richest color is a deep-orange and a bright violet. Between these two extreme shades there is color scheme that ranges from reddish-orange, orange-red, and blood-red to violet-red and often violet. According to the results of the spectrum analysis (Table 3 and 4) this large color scheme is a result of the different quantities of chromium in the pyropes. In order to verify the correlation between the color of the pyropes and the content of chromium, several grains of differently colored pyropes were subjected to a smei-qualitative spectrum analysis (each grain separately). The chrome content was determined according to the intensity of line 2843.3A° on a pentavalent scale (Table 3) that has been chosen arbitrarily.

Table 3

Number of Pyropes	Color of Grain	Intensity of line 2843.3A° on arbitrary scale (Cr)
1	Orange with yellowish tone	1
2	Pale yellow-orange	1
3	Light-orange	1
4	Rich-orange	1-2
5	Light-red	2
6	Light intense red	3
7	Light bright-red	3
8	Bright red with violet tone	3

Table 3 - Cont'd.

Number of Pyropes	Color of Grain	Intensity of line 2843.3A° on arbitrary scale (Cr)
9	Violet-red	4
10	Deep violet-red	4+
11	Deep red-violet	4++
12	Very deep red-violet	4+

The correlation between the color of the pyropes and the content of chromium is rather obvious. The content of Cr_2O_3 is orange pyrope exceeds by many times that of violet pyrope.

To ascertain that the color of the pyropes was actually determined by the chromium ion, the line of absorption in the in the visible section of the spectrum was recorded for several differently colored grains of pyrope. It was established that for all red and violet pyropes and for one orange pyrope the line of absorption was identical. It is characterized by two highest quantities: 410 - 420 millimeters and 565 - 570 millimeters. We know that these two highest quantities are characteristic of minerals colored by the ion Cr_2O_3.

Two samples of orange pyrope produced a different line of absorption with a rahter low indistinct maximum ranging from 400 to 450 millimeters and two additional minor maxima on the right and on the left. Evidently, chromium did not affect the color of these particular samples.

On hand of an artifical ruby (died by an isomorphic admixture of Cr_2O_3) S.V. Grum-Grzhimailo and Ye. P. Utina (1953) proved that the intensity of the color may be determined by the high maxima of spectrum absorption which shows a linear dependency with the content of chromium.

To verify whether this dependency also applies to pyropes the content of chromium was established by spectrum analysis (simultaneously with Mn and Ti) in samples of pyrope for which the lines of absorption had been previously recorded.* The data

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* Spectrum analyses carried out in the laboratory of the Central Expedition of Union Trust No. 2 by Ya. M. Kravtsov.

of the analyses of red and violet varieties were compared to the maximum on the lines of absorption with $\lambda = 420$ mu, being most stable. This highest quantity was deducted from the ordinate that corresponds to the absorption coefficient with $\lambda = 650$ mu, since from there on the line of absorption is actually straight.

The table shows that the linear correlation between the content of chromium and the maximum of absorption can be established rather clearly. Further study is required to establish the effect of other possible chromosphores on the lines of absorption in the spectrum. The dependence of the height of the maximum of absorption on the content of chromium in the pyrope is shown in Table 4:

Table 4

Number of Sample	Color of Samples	Content of Cr in %	Height of Maximum of Absorption in $\lambda = 420$ mu in units of scale K
6	Light reddish-violet	1.10	1.24
8	Light ink-colored violet	1.18	1.20
10	Deep violet	1.25	1.52
3	Red	1.33	2.08
7	Rich violet	1.55	2.28
11	Red violet	1.58	2.36
9	Rich violet	1.60	2.44
1	Bright violet	1.78	3.52

In some grains of pyrope inclusions of other minerals were identified. They are particularly common in the pyrope of the kimberlite that fills out pipe "Mir" while the pipe "Zarnitsa" inclusions are rare and occur almost exclusively in orange-colored grains of pyrope.

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* (continued from page 85).....

The lines of absorption were recorded in the Laboratory of the Central Expedition of Union Trust No. 2 by G.O. Gomon on spectrophotometer Sf-4.

The quantitative spectrum analysis of samples was made by A.I. Chernenko in the laboratory of the East Siberian Branch of the Institute of Geology of the Academy of Sciences USSR.

Inclusions are formed of idiomorphic grains with chromium spinel that reveals well developed octahedral planes (Figure 51). Sometimes they are acicular (Figure 52) and sometimes lamellarx (Figure 53). In come grains of pyrope rather large (up to 1.5 millimeter) inclusions of emerald-green chromiopside (Figure 54) were discovered.

Table 5 shows the data obtained through chemical analysis and some physical properties of eight samples of pyrope taken from kimberlite pipe "Zarnitsa". By way of comparison data that apply to South African kimberlite are quoted along with data on garnets that resemble almandine of the Pre-Cambrian gneiss in the Aldan Shield and Anabar Mountain Range.

Samples for the analysis were selected according to the color of the garnets and index of refraction with an accuracy of ±0.005.

Below, crystallo chemical formulae for garnets. Their chemical composition is shown in Tabbe 5.

1. $(Mg_{2.16} \cdot Fe^{\cdot\cdot}_{0.34} \cdot Mn_{0.01} \cdot Ca_{0.36})_{2.87}(Al_{1.66} \cdot Fe^{\cdot\cdot\cdot}_{0.12} \cdot Cr_{0.14} \cdot Ti_{0.02})_{1.94}$
   $(Si_3O_{12}) \not- 0.09\ SiO_2$
2. $(Mg_{2.26} \cdot Fe^{\cdot\cdot}_{0.43} \cdot Mn_{0.01} \cdot Ca_{0.40})_{3.10}(Al_{1.60} \cdot Fe^{\cdot\cdot\cdot}_{0.03} \cdot Cr_{0.22} Ti_{0.01})_{1.86}$
   $(Si_3O_{12}) \not- 0.03\ SiO_2$
3. $(Mg_{2.23} \cdot Fe^{\cdot\cdot}_{0.35} \cdot Mn_{0.02} \cdot Ca_{0.51})_{3.11}(Al_{1.80} \cdot Fe^{\cdot\cdot\cdot}_{0.12} \cdot Cr_{0.22})_{2.14}$
   $(Si_{2.81} Ti_{0.02} O_{12})$
4. $(Mg_{2.24} \cdot Fe^{\cdot\cdot}_{0.43} \cdot Mn_{0.001} Ca_{0.38})_{3.06}(Al_{1.73} \cdot Fe^{\cdot\cdot\cdot}_{0.08} \cdot Cr_{0.10} Ti_{0.02})_{1.93}$
   $(Si_3O_{12}) \not- 0.01\ SiO_2$
5. $(Mg_{2.06} \cdot Fe^{\cdot\cdot}_{0.46} \cdot Mn_{0.01} \cdot Ca_{0.53})_{3.06}(Al_{1.64} \cdot Fe^{\cdot\cdot\cdot}_{0.18} \cdot Cr_{0.08} Ti_{0.84})$
   $1.94\ (Si_3O_{12})$
6. $(Mg_{2.17} \cdot Fe^{\cdot\cdot}_{0.49} \cdot Mn_{1.02} \cdot Ca_{0.38})_{3.06}(Al_{1.64} Fe^{\cdot\cdot\cdot}_{0.16} Cr_{0.03} \cdot Ti_{0.05})$
   $1.88\ (Si_3O_{12}) \not- \not- 0.04\ SiO_2$
7. $(Mg_{2.08} Fe^{\cdot\cdot}_{0.56} \cdot Ca_{0.37})_{3.01}(Al_{1.84} \cdot Fe^{\cdot\cdot\cdot}_{0.02} \cdot Cr_{0.02})_{1.98}\ (Si_{2.97}$
   $Ti_{0.03} O_{12})$
8. $(Mg_{2.27} \cdot Fe^{\cdot\cdot}_{0.40} \cdot Ca_{0.31})_{2.98}(Al_{1.88} \cdot Fe^{\cdot\cdot\cdot}_{0.03} \cdot Cr_{0.03} \cdot Ti_{0.02})_{1.98}$
   $(Si_3O_{12}) \not- 0.01\ SiO_2$
9. $(Mg_{1.74} \cdot Fe^{\cdot\cdot}_{0.73} \cdot Ca_{0.40} \cdot Mn_{0.02})_{2.89}(Al_{1.93} \cdot Cr_{0.17})_{2.10}(Si_{2.98}O_{12})$
10. $(Mg_{1.79} \cdot Fe^{\cdot\cdot}_{0.81} \cdot Ca_{0.37})_{2.97}(Al_{1.96} \cdot Cr_{0.08})_{2.04}(Si_{2.99}O_{12})$
11. $(Mg_{2.06} \cdot Fe^{\cdot\cdot}_{0.55} \cdot Ca_{0.38} \cdot Mn_{0.02})_{3.01}(Al_{1.86} \cdot Fe^{\cdot\cdot}_{0.09} \cdot Cr_{20.3})_{2.04}$
    $(Si_{2.96}O_{12})$

12. $(Mg_{2.14}\cdot Fe^{\cdot\cdot}_{0.47}\cdot Ca_{0.40}\cdot Mn_{0.02})_{3.03}(Al_{1.83}\cdot Fe^{\cdot\cdot\cdot}_{1.83}\cdot Ce_{2.06})_{2.10}$
    $(Si_{2.98}O_{12})$
13. $(Fe^{\cdot\cdot}_{1.73}\cdot Mg_{0.89}Ca_{0.14}\cdot Mn_{0.05})_{2.81}(Al_{2.00}Fe^{\cdot\cdot\cdot}_{0.08})_{2.08}(Si_{3.03}O_{12})$
14. $(Fe^{\cdot\cdot}_{1.90}\cdot Mg_{0.47}\cdot Ca_{0.30}\cdot Mn_{0.12})_{2.79}(Al_{2.00}Fe^{\cdot\cdot\cdot}_{0.05})_{2.05}(Si_{3.07}O_{12})$
15. $(Fe_{1.96}\cdot Mg_{0.47}\cdot Ca_{0.30}\cdot Mn_{0.12})_{2.79}(Al_{2.00}Fe^{\cdot\cdot\cdot}_{0.05})_{2.85}$
    $(Al_{2.10}\cdot Fe^{\cdot\cdot\cdot}_{0.08})_{2.18}\ (Si_{2.95}O_{12})$
16. $(Fe_{1.59}\cdot Mg_{0.86}\cdot Ca_{0.13}\cdot Mn_{0.05})_{2.69}(Al_{2.03}\cdot Fe^{\cdot\cdot\cdot}_{0.17})_{2.20}(Si_{3.01}O_{12})$
17. $(Fe_{1.52}\cdot Mg_{0.20}\cdot Mn_{0.02}\cdot Ca_{0.77})_{2.51}(Al_{2.10}Fe^{\cdot\cdot\cdot}_{0.24})_{2.34}\cdot Si_{2.99}O_{12}$

Based on these formulae the content of individual components in these garnets was determined (Table 6).

Table 5

No. of Pyrope	1	2	3	4	5	6	7
Color	Violet Red	Deep Violet	Deep Violet	Orange Red	Orange Red	Red Orange	Orange
Index of Refraction	1.749	1.754	1.759	1.744	1.749	1.754	1.754
Specific Gravity	3.68	3.75	3.72	3.73	3.65	3.77	3.74
Size of Edge of Elementary Nucleus	Undetermined	11.534	11.522	11.509	11.527	11.532	Undetermined
Analyst Composition	V. Koviazina	S. Boyarshinova	V. Koviazina	S. Boyarshinova	K. A. Baklanova	K. Koviazina	M. Stukalova
SiO_2	43.26	41.98	38.80	41.70	41.20	41.93	41.20
TiO_2	0.50	0.32	0.38	0.45	0.76	1.04	0.60
Al_2O_3	19.72	18.91	21.00	20.42	19.24	19.20	21.75
Fe_2O_3	2.24	0.62	2.25	1.46	3.22	3.00	2.21
Cr_2O_3	2.70	4.02	3.82	1.91	1.56	0.65	0.33
FeO	5.61	7.18	5.70	7.27	7.40	8.08	9.31
MnO	0.20	0.24	0.44	0.21	0.22	0.33	-
MgO	20.27	20.98	20.60	20.86	18.70	20.03	19.32
CaO	4.73	5.21	6.72	4.95	6.83	4.93	4.74
Na_2O	-	-	-	-	-	-	-
H_2O	-	-	-	-	-	-	0.10
Indissoluble Products	1.16	1.00	0.66	1.19	1.12	1.23	1.00
P_2O_5	-	-	-	-	-	-	-
Total	100.39	100.46	100.37	100.38	100.25	100.42	100.56

Table 5 - Cont'd,

No. of Pyrope	8	9	10	11	12	13	14
Color	Raspberry Pink	Rich Wine Red	Hyacinth Red	Bloody Red	Brownish Yellow	-	-
Index of Refraction	1.744	-	-	-	-	-	-
Specific Gravity	3.76	-	-	3.78	3.737	-	-
Size of Edge of Elementary Nucleus	-	-	-	-	-	-	-
Analyst Composition	M. Stukalonova	According to P.A. Wagner	After P.A. Wagner	After P.A. Wagner	After P.A. Wagner	After Ye.N. Lavrenko	After Ye.N. Lavrenko
SiO_2	42.83	41.34	40.90	40.47	39.42	39.42	37.84
TiO_2	0.40	-	-	-	-	-	-

Table 5 - Cont'd.

No. of Pyrope	8	9	10	11	12	13	14
Al_2O_3	22.30	22.75	22.81	21.56	22.00	22.00	22.82
Fe_2O_3	1.03	-	-	3.83	1.50	1.50	1.31
Cr_2O_3	0.70	2.96	1.48	1.15	-	-	-
FeO	6.72	12.12	13.34	7.84	27.00	27.00	30.17
MnO	-	0.36	-	0.27	0.78	0.78	0.93
MgO	21.30	16.20	16.43	19.92	7.95	7.95	6.70
CaO	4.05	5.17	4.70	5.09	1.70	1.70	0.60
Na_2O	-	-	-	-	-	-	-
H_2O	0.10	-	-	-	-	-	-
Indissoluble Products	0.95	-	-	-	-	-	-
P_2O_5	-	-	-	-	-	-	-
Total	100.39	100. 0	99.85	100.13	100.35	100.35	100.37

Table 5 - Cont'd.

No. of Pyrope	15	16	17
Color	-	-	-
Index of Refraction	-	-	-
Specific Gravity	-	-	-
Size of Edge of Elementary Nucleus	-	-	-
Analyst Composition	after Ye.N. Lavrenko	after M.Ya. Apostalov	after M.N. Rabkin
SiO_2	30.98	39.04	39.88
TiO_2			-
Fe_2O_3	0.91	2.92	4.02
Cr_2O_3	-	-	
FeO	28.68	24.65	22.43
MnO	1.80	1.37	0.28
MgO	3.99	7.49	1.60
CaO	3.57	1.87	8.87
Na_2O	-	-	0.27
H_2O	-	-	-
Indussoluble Products	-	0.38	0.72
P_2O_5	-	-	0.12
Total	99.45	100.13	100.05

Footnote: No. 1 - 8 pyropes from the eluvium of kimberlite pipe "Zarnitsa." No. 9-12 pyropes from South African kimber-

The data shown in Table 6 reveal that the content of the pyrope component in the garnets of Siberian kimberlites fluctuates between 69 percent and 76 percent, so that these garnets may actually be classified as pyropes (Figure 55). Second comes almandine with a content from 10 percent to 18.6 percent. These components amount to a total of 79 to 94 percent. As already mentioned the content of chromium in all pyropes is very characteristic. In all red varieties of pyrope the content is noticeably higher. The admixture of uvarovite fluctuates accordingly between 1.5 and 11.8 percent.

Table 6

COMPONENTS	Number of samples								
	1	2	3	4	5	6	7	8	9
Pyrope	75.3	72.9	71.7	73.2	70.8	70.9	69.2	76.2	60.2
Almandine	10.0	12.9	10.8	14.1	13.4	13.1	18.6	13.4	25.25
Spessartine	0.3	0.3	0.7	0.3	0.3	0.3	-	0.7	0.7
Grossularite	-	-	-	2.0	-	-	5.3	5.4	5.75
Andradite	4.3	0.6	5.1	4.1	6.9	8.1	5.9	2.5	-
Uvarovite	7.2	11.8	11.3	5.2	4.1	1.6	1.0	1.5	8.1
Ca-Ti - Garnet	1.0	0.5	-	1.1	2.1	2.7	-	1.0	-
Skiagite	1.9	1.0	0.4	-	2.4	0.3	-	-	-
Total	100.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6 - Cont'd.

Components	10	11	12	13	14	15	16	17
Pyrope	60.25	61.4	70.6	31.6	16.8	27.3	31.9	8.0
Almandine	61.4	18.3	15.5	61.6	68.1	66.9	59.3	60.6
Spessartine	18.3	0.7	0.7	1.8	4.3	2.1	2.1	0.8
Grossularite	0.7	3.8	0.35	0.7	8.3	-	-	20.3
Andradite	3.8	4.4	10.0	4.3	2.5	1.7	5.5	10.3
Uvarovite	4.4	4.4	2.85	-	-	-	-	-
Ca-Ti Garnet	4.4	-	-	-	-	-	-	-
Skiagite	-	-	-	-	-	2.0	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Footnote:

Numbering of samples same as in Table 5.

Footnote: (Cont'd. From Page 88).....
lite. Almandines No. 13 - 16 from Pre-Cambrian gneiss of the Aldan Shield No. 17 -- Almandine from the garhet micaceous gneiss of the Anabar Mountain Range.

Andradite and grossularite are always present in rather small but fluctuating quantities whereas spessartine occurs in insignificant quantities (the content of MnO in the analysed garnets is completely insignificant).

This, chemicall red and violet garnets in the kimberlite are pyropes with a noticeable content of chromium and calcium (and a corresponding quantity of uvarovite and andradite). In regard to the content of the main componemts and the characteristic admixture of uvarovite and andradite they are bear a strong similarity to the pyropes in the diamond-bearing kimberlites of Africa.

In the garnets of old (pre-Cambrian) crystalline schists found in the mountain areas around the Siberian platform there is a sharp predominance of almandine over pyrope while chromium is not present, as a rule, or is present in very small quantities. However, the content of manganese is almost always higher than in pyrope. To illustrate this situation we quote results of the quantitative spectrum analysis in Table 7 in addition to data shown in table 5. Analysis was made of sixteen samples of almandine garnet from the rocks around the Siberian platform and from various areas in the basin of the Viluyi River where almandine garnet is eventually redeposited as a result of the deterioration of these rocks.* The table shows that the content of chromium in these garnets usually does not exceed 0.01 percent and only rarely amounts to 0.05 percent while the content of manganese amounts to one percent in most samples.

The above data show that the investigated garnets are very characteristic of the Siberian platform. If pyropes in the kimberlites were considered as introduced minerals their original source should not be assumed to be the usual metamorphic schists of the crystalline foundation of the platform but rocks of different genesis.

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* The fact that the samples are classified as almandine has been verified by the determination of the index of refraction through immersion.

The indices of the refraction of pyropes (Table 5 and 8) fluctuate within a rather wide range.*

The index of refraction increases with a heightened intensity of color approximately to the same degree as in all three basic colors of pyrope -- orange, red and violet it varies from 1.733 - 1.735 to 1.764 - 1.767. The overlapping of the indices of refraction for differently colored pyropes is also mentioned by N.N. Sarsadskikh and L.A. Popugayeva. The index of refraction - 1.767 is established only for rich deep-red grains of pyrope from the kimberlite pipe "Zarnitsa." Evidently, these grains have the highest content of almandine although there is no doubt that the increased index of refraction is also influenced by the content of chromium.

Fifteen tests have been donducted with pyropes taken from the diamond-bearing kimberlites of the basin of the Daaldyn and Malaya Batuobiya Rivers to establish the size of the edge of the elementary mesh (a). The results of the X-ray analysis are shown in Table 9.***

Table 7

Number of Sample	Area where sample was taken(River)	Color of Garnet	Content in % Mn	Ti	Cr
94	Vitim	Pink	>1	0.83	0.1
64	Dzhida	Pinkish-yellow	>1	0.34	<0.01
64-2	Dzhida	Pink with yellow tone	>1	0.20	<0.01
64-3	Dzhida	Pale Pink	>1	0.17	<0.01
49	Angara	Salmon red	0.63	0.06	0.01
50	Angara	Flesh colored	0.95	0.06	0.01
96	Vilyui	Light pink	>1	0.43	<0.01
73	Tunguska	Pink	0.76	0.04	0.01
97	Vilyui	Flesh colored	-	-	<0.01
74	Tunguska	Flesh colored	>1	0.02	<0.01
29	Vilyui	Pink	0.81	0.07	<0.01
85	Markha	Pink	>1	0.15	0.02

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* indices of refraction were determined at the Faculty of Crystallography of Leningrad State University by T.G.Petrov under V.G. Tatarsky's guidance through the method of immersion in white light according to the system of colored strips, with an accuracy of ±0.001 (liquids have been checked preliminery on a refractometer with possible errors not exceeding ±0.0005).

** X-ray analyses were conducted by V.I. Mikheyev at the X-Ray Laboratory of Leningrad Mining Institute.

Table 7 - Cont'd.

Number of Sample	Area where sample was taken (River)	Color of Garnet	Content in % Mn	Ti	Cr
85a	Markha	Brownish-red	1	0.15	0.01
85b	Markha	Flesh colored	1	0.58	0.06
98	Tiung	Pink	0.57	0.19	0.08
99	Tiung	Flesh-colored-pinkish	1	0.26	0.01

Footnote: Sample No. 94 was taken from gneiss; samples No. 96, 97 from Jurassic conglromerates, samples No. 64, 64-2, 64-3, 49, 50, 73, 74, 29, 85, 85b, 98, 99 were selected from ore slime.

For samples No. 1, 2. 9, 10, 11 (Table 9) chemical analyses are available (corresponding to No. 2, 3, 4, 5, 6, on Table 6).

It should be emphasized that value in the investigated garnets does not only exceed the computed data for garnets of the pyrope-almendine series but frequently even exceeds a of pur almandine (a = 11.49) which is, undoubtedly, related to the considerable quantity of calcium that is characteristic feature of kimberlite garnets.

Table 9

Number of Pyrope	Color of Samples	Number ±0.002	a
1	Deep violet red	1.754	11.534
2	Deep violet red	1.759	11.522
3	Deep violet red	1.764	11.543
4	Deep violet red	1.769	11.554
5	Deep violet red	1.774	11.571
6	Mauve 1.744	1.744	11.515
7	Mauve	1.754	11.527
8	Mauve	1.759	11.530
9	Orange-red	1.744	11.509
10	Deep orange-red	1.754	11.532
12	Orange	1.739	11.496
13	Orange	1.749	11.514
14	Orange	1.759	11.532
15	Colorless	1.744	11.528

Ilmenite

As already mentioned ilmenite occurs commonly in kimberlite pipe "Zarnitsa." It is not quite as common in pipe "Mir" and found in only very small quantities in pipe "Zagadochnaya."

The sizes of the grains of ilmenite vary just as much as those of the grains of pyrope. It should, however, be pointed out that in pipe "Zarnitsa" this mineral is encountered in the form of large grains. Individual grains of ilmenite occasionally exceed ten millimeters in size. The largest indivisible ilmenite grains -- called "nodules" -- are sometimes the size of a nut.

Usually, ilmenite is observed in the form of angular fragments (Figure 56) or a cluster of them (Figure 57). Laminated crystals and, generally, grains with either traces of faces or clearly marked faces are extremely rare. Only in samples* taken from pipe "Mir" three grains of ilmenite (one to 1.5 millimeter) crystals showed a clean-cut cleavage.

The surface of the grains of ilmenite is usually covered with a fine gray film of leucoxene. The leucoxene rim is 1 - 1.5 millimeter wide (Figure 58). A fresh ilmenite fracture is pitch-black and has a metallic luster.

In pipe "Zarnitsa" grains of ilmenite are surrounded by minute (less than 0.1 millimeter) crystals of perovskite (Figure 59).

One grain of ilmenite was found shot through by very fine grains of violet red pyrope. However, inclusions of ilmenite grains were also discovered in a laminae prepared from red pyrope to obtain the lines of absorption.

Table 10 shows data obtained by analysing the ilmenite of Siberian kimberlites and, b way of comparison, the results of analyses made of the kimberlite of other countries along with data of two analyses of ilmenites from basic rock of Siberia and Greenland. There is also one analysis of ilmenite taken from old Siberian conglomerates.*

Grains of ilmenite without magnetic propertie were used for analysis 3 and 6. Magnetic grains of ilmenite were tested in analyses 4, 5 and 7.

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* The samples of ilmenite for chemical analysis were selected in the same manner as the samples of pyrope, i.e. they were taken from the kimberlites and concentrates in the deposits directly connected with the kimberlite pipes.

The above data revel that ilmenite found with Siberian diamonds differs from the usual kind inasmuch as it contains considerable amounts of ferric oxide and magnesium. In this respect it is identical with ilmenites found in the kimberlites of Africa and America.

Ilmenite from differentiated Siberian traps differs considerably from ilmenite from kimberlite that is poor in magnesium. This characteristic accounts for the striking similarity to the ilmenite in gabbros of Greenland.

It is common knowledge that ordinary ilmenite (closely related to crichtonite in composition -- $FeTiO_3$) is only slightly magnetic. Part of the grains of ilmenite in kimberlite reacts to an ordinary magnet forming little chains like magnetite. The rest does not react quite as well and only individual grains are drawn. Some grains do not react at all to an ordinary magnet. It is impossible to determine the magnetic properties of the grains by their appearance. The highly magnetic grains have the same appearance as the non-magnetic variety. However, they differ sharply from the opaque grains of magnetite with a lusterliess surface that are also present in the rock. This, despite an identical appearance the magnetic properties of ilmenite vary greatly. As shown below this is caused by the peculiarities of the chemical composition.

Table 11 shows the results of chemical analyses in terms of individual componencts. Data for such components as, for instance, hematite, rutile etc. are arbitrary since there is no evidence as to the state of the surplus of corresponding oxides in the ilmenite.

The table shows that the geikielite component amounds to about 1/3 in the ilmenites of Siberian (with the exception of the highly magnetic variety) South African and North American kimberlites. On the other hand, the geikielite content does not exceed 6-8 percent in ilmenite bound to gabbroic magma. Essentially, this kind of ilmenite is almost pure crichtonite ($FeTiO_3$). All ilmenites that stem from kimberlites (with the exception of No. 5 and 7 of ilmenite that are endowed with very different magnetic properties and in which the content of geikielite is low) are similar.

Table 10

	Ilmenite from the kimberlites and placer deposits of the Vilyui River Basin				
			Ilmenite from concentrates Daaldyn River		
	Ilmenite from Alluvium "Zarnitsa"	Ilmenite from Aluvium tube "Mir"	Non-Magnetic	Slight Magnetic	Highly Magnetic
Number of Samples	1	2	3		5
Components					
SiO_2	0.40	0.10	0.40	0.96-	0.92
TiO_2	47.95	46.33	47.06	33.58	32.80
Fe_2O_3	13.15	17.96	15.25	32.54	37.95
Cr_2O_3	0.75	0.41			
FeO	28.00	26.29	28.02	22.99	25.14
MnO	-	-	0.14	0.24	0.24
MgO	9.00	8160	9.22	9.28	2.64
CaO					
V_2O_5	0.20	0.20	Undetermined	Undetermined	Undetermined
Nb_2O_5	0.13	-	"	"	"
H_2O +105°	-	-	0.20	0.24	0.20
Total	99.58	99.89	100.29	99.83	100.06
Specific Gravity	4.58	4.61	-	-	-
Analysts	K.A. Baklonova	K.A. Baklonova	V.D. Bugrova	V.D. Burgrova	V.D. Bugrova

Table 10-Cont'd.

	Ilmenite from ore slime Iirelukh River		African and North American		
	Non-Magnetic	Magnetic	Ilmenite in Mükerab (S.W. Africa) after P.A. Wagner	Ilmenite in Kimberlie (S. Africa) after P.A. Wagner	Ilmenite from kimberlite pipe "Zafu" (Belgian-Congo) after J. Verhoegab
Number of Samples	6	7	8	9	10
Components					
SiO_2	0.33	-	-	-	-
TiO_2	48.96	36.20	49.27	53.79	53.21
Fe_2O_3	16.24	36.95	11.27	7.05	11.90
Cr_2O_3			0.63	-	-
FeO	25.91	20.83	29.34	27.05	27.99
MnO	0.20	0.15	0.29	-	-
MgO	8.22	4.65	8.87	12.10	7.20
CaO			0.13	-	-
V_2O_5	Undetermined	Undetermined	-	-	-
Nb_2O_5	"	"	-	-	-
$H_2O + 105^{\circ}$	0.20	0.20	-	-	-
Total	99.98	99.80	99.99	100.30	96.29
Specific Gravity	4.570	4.749	-	-	-
Analysts	V.D. Burgova	V.D. Burgova	-	-	Elpisberg

Table 10-Cont'd.

	African & N.Americans	Ilmenite from basic rock		Ilmenite from old
	Ilmenite from Elliott(Kentucky)U.S.A. after P.A. Wagner	Ilmenite from Alamzhakh intrusion traps (Velyui River)	Ilmenite from gabbro of E. Greenland, after E.A. Vincent	Conglomerates on watershed between Markha & Tiung River after M.I. Plotnekova
Number of Samples	11	12	13	14
Components				
SiO_2	-	-	0.14	0.20
TiO_2	49.32	49.50	49.89	52.80
Fe_2O_3	9.13	2.81	6.26	9.96
Cr_2O_3	0.74	-	-	-
FeO	27.81	44.64	40.39	33.84
MnO	0.20	-	0.41	0.28
MgO	8.86	1.56	2.27	1.04
CaO	0.23		0.34	1.84
V_2O_5	-	Undetermined	-	-
Nb_2O_5	-	"	-	--
H_2O+105°	-	-	-	-
Total	98.50	98.50	99.99	100.14
Specific Gravity	-	-	-	-
Analyst	-	K.A. Baklonova	E.A. Vincent	V.O. Bugrova

Table 11

Numbers	Ilmenites from the kimberlites and placer depositsin the basin of the Vilyui River						
	1	2	3	4	5	6	7
Components							
Chrichtonite	58.4	57.3	54.7	31.8	64.0	56.2	53.0
Geikielite	34.6	33.4	35.0	39.1	12.4	31.8	21.0
Pyrophanite	-	-	0.4	0.5	0.6	0.4	0.4
Ruile	-	0.2	-	-	-	3.6	4.3
Perovskite	-	-	-	-	-	-	-
Magnetite	2.1	-	5.1	22.6	1.6	-	-
Crhomite	0.5	8.9	4.8	6.0	21.4	8.0	21.3
Hematite	4.4	0.2	-	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 11-Cont'd.

Numbers Numbers	Ilmenite from the kimberlites of Africa and USA				Ilmenite from basic rock		Ilmenite from conglomerates in the watershed between Markha and Tiung Rivers
	8	9	10	11	12	13	14
Chrichtonite	59.5	51.5	59.5	60.4	89.5	87.5	75.1
Geikielite	33.3	41.3	2715	34.2	6.0	8.6	4.1
Pyrophanite	0.6	-	-	0.5	-	0.9	0.6
Rutile	-	-	7.4	0.5	-	-	10.1
Perovskite	-	-	-	-	-	-	5.1
Magnetite	23.9	4.9	-	-	2.8	-	-
Chromite	4.3	2.5	5.6	4.4	-	3.0	5.0
Hemanite	-	-	-	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Footnote: The samples are numbered as in table 10.

The chemical composition of ilmenite from the gravel of watershed resembles ilmenite from traprocks.

The magnetic varieties of ilmenite as seen in table 10 are characterized by a very considerable contents of ferric oxide (up to 38 percent) which, evidently, accounts for their magnetic property and for a higher specific gravity.

The interrelation between the specific gravity and the magnetic properties of the ilmenite is clearly shown in Figure 60, where specific gravities are indicated along the axis of the abscissa. The specific magnetic susceptibility of ilmenite with different degrees of magnetizability of the ilmenite fraction is s shown along the axis of the ordinate. To obtain these fractions a sample of the ilmenite was taken from the eluvium of the kimberlite pipe "Mir". The sample was divided in an electromagnetic separator and the current changed from 0.1 to 1.1a (table 12).

Table 12

Number of Fraction	Current divided into x in separator	Contents of fraction in the sample, in %, according to weight	Specific Gravity of Fraction	Specific magnetic susceptibility $x \cdot 10^{-6}$ CgSuO
1	0.4	5.3	4.680	960
2	0.5	10.5	4.636	321
3	0.6	15.6	4.625	241
4	0.7	22.0	4.608	175
5	0.8	21.9	4.590	143
6	0.9	14.4	4.580	113
7	1.0	7.8	4.575	83
8	1.1	2.5	4.570	87

The specific gravities of the fraction were determined by V.K. Konopleva with an accuracy of ±0.002. The value of magnetic susceptibility was determined by I.Ya. Bedeker with the help of an induction device at the magnetic station of the Geologorazvedka Plant (Geological Research Plant) in Leningrad with an accuracy of one to two percent.

It is commonly assumed that ilmenite can retain only small quantities of ferric oxides in a state of solid solution. Further research is needed to determine the state of ferric oxides in the tested ilmenite samples. Grains of magnetic ilmenites seen under the microscope in the form of polished microsections (without an etching test showed that in the overwhelming majority of cases they had a homogenous structure that could not be distinguished from the structure of non-magnetic or very slightly magnetic grains (only two grains from among several dozen split into two phases).

It is not impossible that this great quantity of ferric oxide is preserved in the ilmenite without decomposition of the solid solution as a result of its quick cooling during the process of hardening.

In addition to a high content of magnesium and ferric oxides that ilmenites from the diamond-bearing kimberlites are characterized by presence of chromium, although it is found in insignificant quantities. Evidently, it is not characteristic for ilmenite in traprocks. Table 13 shows the results of a semi-quantitative spectrum analysis of the six samples (no. 1, 2, 3, 4, 5 and 6) of ilmenite from the kimberlites of diamond-bearing placer deposits (their chemical composition is shown in table 10, the corresponding numbers are 1, 2, 3, 4, 5, 6 and 7) and, by way of comparison, a sample of ilmenite from the differentiated traps of the Alamdzhaka intrustion (No. 12, table 10)*.

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* - Spectrum analyses were conducted by Ya. M. Kravtsov in the Laboratory of the Central Expedition of Union Trust No. 2.

Table 13

Elements	Number of Samples 1	2	3	4	5	6	7
Si	0.1-1.0	0.1-1.0	0.1-1.0	0.1-1.0	0.1-1.0	0.1-1.0	0.1-1.0
Ti	≽10	≥10	≫ 10	≫ 10	≫10	≫10	≫ 10
Al	0.1-0.3	0.1-0.3	0.1-1.0	0.1-0.3	0.1-1.0	0.1-0.3	0.1-1.0
Mg	≫ 10	≫10	1.0-1.0	10	1.0-1.0	3.0-6.0	1.0-3.0
Mn	0.01-0.03	0.01-0.03	0.6-1.0	0.6-1.0	0.06-0.1	1.0-3.0	0.06-0.1
Cr	0.6-1.0	0.1-0.3	0.01-0.03	0.03-0.06	0.03-0.06	0.01-0.03	Not Found
Nb	≍0.01	-	-	-	-	-	-
Ni	0.03-0.03	0.01-0.03	0.1-0.3	0.1-0.3	0.1-0.3	0.6-0.1	0.06-0.1
Fe	> 10	>10	≫ 10	≫10	≫10	≫10	≫10
V	0.06-0.1	0.03-0.06	0.1-0.3	0.06-0.01	0.1-0.3	0.1-0.3	Not Found
Co	-	-	~0.001	~0.001	~0.001	~0.01	0.1

Figure 61 shows the graphic results of the spectrum analysis of these samples.

As shown in the table, chromium and vanadium are present in all the samples of ilmenite from kimberlites but were not found in ilmenite taken from traps. The presence of Nb in ilmenite taken from the pipe "Zarnitsa" is also confirmed by chemical analysis (see table 10).

The rather high content of magnesium and the presence of chromium in ilmenite is, obviously, a common geochemical peculiarity inherent in the complex of minerals of ultra-basic diamond-bearing rocks of the Siberian platform, as distinguished from minerals in trap formations (these ilmenites are not characteristic of them) and from corresponding minerals in the rocks of the crystalline foundation of the platform.

Magnetite

Magnetite occurs rather commonly in the minerals of kimberlites. Magnetite could be classified into two genetic groups:

1) magnetite formed simultaneously with the rock;

2) magnetite formed in the process of serpentinization.

Magnetite is usually encountered in the form of angular grains that are fragments of crystals. Frequently, these grains and the rock are interpenetrated. Some larger magnetite aggregates have a divergent formation (Figure 62). It is also present in the form of reinform sinters (See Figure 65) and sometimes in the form of fine druses or individual fine octahedron crystals. (Figure 63, 64).

Below are the results of semi-quantative specrum (Figure 14) and chemical (table 15) analyses of magnetite from kimberlite pipes "Zarnitsa" and "Mir".

Table 14

Origin	Si	Al	Mg	Ca	Fe	Mn	Cu	Ni	Cr
"Mir"	0.1-1.0	~ 0.1	0.1-0.3	0.01	$\gtrsim 10$	~ 0.01	~ 0.001	~ 0.001	< 0.10
"Zarnitsa"	0.1-1.0	-	0.1-0.1	0.01	$\gg 10$	0.03-0.06	-	-	-

Table 15

Oxides	Origin "Mir"	 "Zarnitsa"
SiO_2	1.56	0.20
TiO_2	0.40	0.80
FeO	25.20	27.93
Fe_2O_3	72.10	69.30
MnO	-	0.23
MgO	-	0.90
Total	99.26	99.36
Specific Gravity with $t=22^{\circ}$	4.67	4.82

Olivine

As already noted, the olivine in kimberlites is usually almost entirely replaced by serpentine and other secondary minerals.

A few grains of uhaltered olivine were found in the concentrates of the kimberlite pipe "Zarnitsa." The grains are small (from two to four millimeters), colorless (Figure 66), semi-transparent and with a dull surface. The color varies from an almost colorless shade to olive green. Mostly it is a light greenish0 yellow.

Table 16

Composition	Gravimetric %	Molecular Quantity	Atomic quantity of oxygen	Atomic quantities of oxygen in Serpentine (mg,al)$_3$ /Oh/$_4$/Si$_2$O$_5$	Diopside CaMg(Si$_2$O$_8$	Ferric hydro-oxides
SiO$_2$	40.82	679	1358	12	26	-
TiO$_2$	traces	-	-	-	-	-
Al$_2$O$_3$	0.09	1	3	3	-	-
Fe$_2$O$_3$	1.14	7	21	-	-	21
FeO	8.06	112	112	-	--	-
MnO	0.06	-	-	-	-	-
MgO	49.10	1218	1218	15	13	-
CaO	0.70	13	13	-	13	-
H$_2$O	0.27	14	14	-	-	14
Indissoluble Products	0.44	24	24	24	-	-
Total	100.41		2763	54	52	35

Table 16-Cont'd.

Composition	Atomic quantit.etc: Olivine (Mg,Fe)$_2$ SiO$_4$	Number of Atmos of oxygen in olivine	Number of cations in olivine
SiO$_2$	1320	2.01	1.00
TiO$_2$	-	-	-
Al$_2$O$_3$	-	-	-
Be$_2$O$_3$	-	-	-
FeO	112	0.17	0.17
MnO	-	-	-
MgO	1190	1.82	1.82
CaO	-	-	-
H$_2$O	-	-	-
Indissoluble Prod.	-35	4.00	-
Total	2622	4.00	-

Common multiple 4:2622 = 0.0015

Crystallochemical formula of olivine:

$$(Mg_{1.82}, Fe_{0.17})(SiO_4) + 0.08\ (Mg.Al)_3\ (OH)_4\ [Si_2O_5]\} + 0.07\ \{CaMg\ [Si_2O_6]\} + 0.05\ \{Fe_2O_3 \cdot nH_2O\}$$

A considerable quantity of olivine was found in the eluvium of kimberlite pipe "Dalnaya." the indices of refraction of this olivine are as follows: $Ng' = 1.652$, chemical composition and conversion data are shown in Table 16 (analyst B. D. Bugrova). The results of chemical analysis shown that olivine contains only about 9 percent fayalite component, i.e. the olivine has a high content of magnesium which is characteristic of serpentine in ultra-basic rocks.

Diopside and Chromdiopside

Diopside was rare in the grains of all deposits under study. These grains are composed of angular fragments. Their color ranges from almost colorless to bottle green. The size of the grains varies between two and five millimeters. The grains are semi-transparent and transparent. The surface of the grains in uneven, (Figure 67). Fresh fractures have a glassy luster.

The optic constants of the bottle green diopside from the kimberlite pipe "Zarnitsa" are as follows:

$$Ng = 1.712; \quad Np = 1.690; \quad Ng\text{-}Np = 0.022; \quad 2V = +62^\circ$$

No chemical analysis is available of pyroxene and the name has been chosen arbitarily.

Chromdiopside is also very rare in the kimberlites of pipes "Mir" and "Zarnitsa". The size of the grains, their form and surface are similar to the grains of diopside (Figure 68). The color of chromdiopside varies from dull to emerald green. As already mentioned above chromdiopside is found in the eluvium of the kimberlite pipe "Zagadochnaya" in great quantities, but usually its grains are decomposed, and lined with numerous cracks that are filled with grayish-pink products of decomposition. The color of this chromdiopside is a pale grayish green.

The optic constants of the emerald-green chromdiopside from the kimberlite pipe "Zarnitsa" are as follows: $Ng = 1.706$; $Np = 1.680$; $Ng\text{-}Np = 0.026$; $2V = +63^\circ$. Thepleochroism in Ng is a grass-green color; in Np yellowish-green. The indices of refraction of chromdiopside were measured for pipes "Mir" and "Zagadochnaya" with the following results; $Ng' = 1.696$. $Np' = 1.676$.

Table 17 shows the results of chemical analysis (Analyst V. Koviasin) and the conversion data of chromdiopside from the pipe "Zagadochnaya".

Table 17

Composition	Gravimetric %	Molecular Quantity	No.of oxygen atoms in		Number of atoms of oxygen in chromdiopside	Number of cations in crhomdiopside
			Serpentine	Chromdiopside		
SiO_2	54.25	903	28	1778	3.75	1.87
TiO_2	1.07	14	-	28	0.06	0.03
Al_2O_3	1.40	14	-	42	0109	0.06
Fe_2O_3	1.50	9	-	27	0.06	0.04
Cr_2O_3	1.82	13	-	36	0.08	0.05
FeO	1.34	18	-	18	0.04	0.04
MnO	0.10	-	-	1	-	-
MgO	16.70	414	42	378	0.79	0.79
CaO	21.60	536	-	536	1.13	1.13
K_2O)) Na_2O)		-	-	-	-	-
H_2O	0.05	3	3	-	-	-
Indissoluble Products	0.50	28	28	-	-	-
Total	100.33	1952	101	2844	6.00	-

Common denominator 6:2844 = 0.0021

Specific gravity = 3.05

Crystallochemical formula of chromdiopside:

$$\text{Ca}_{1.13}\,\text{Mg}_{0.79}\,\text{Fe}^{\cdot\cdot}_{0.04}\,(\text{Cr}_{0.05}\cdot\,\text{Fe}^{\cdot\cdot\cdot}_{0.04})\,\overline{\left[\text{Si}_{1.87}\,\text{Ti}_{0.03}\,\text{Al}_{0.06}\,\text{O}_6\right]}$$

$$+\ 0.02\left\{\text{Mg}_3\,(\text{OH})_4\,\boxed{\text{Si}_2\text{O}_5}\right\}\,0.006\ \text{H}_2\text{O}$$

Perovskite

Table 18 shows the quantitative spectrum analysis of perovskite from the pipe "Zarnitsa" where it is found in the form of extremely fine (less than 0.1 millimeter) cubic crystals (or fragments) which frequently form crusts on the surface of the grains of ilmenite

Table 18

Elements	Si	Al	Mg	Ca	Fe	Mn	Ti	Nb
		Traces			Traces	Traces		

Chromite

Chromite is very rare. It is found in the form of small (1.5 to 2 millimeters) black grains. Fresh fractures are pitch black.

Fine laminae have a brownish-red transluscence. The grains are represented either by small crystals, crystalline fragments or crystal clusters.

Octahedral faces on the crystals are rather common, but sometimes combinations of cubes and octahedrons are found. Frequently, the edges of the faces are rounded, which lends the crystals of chromite a typical somewhat elongated appearance.

Phlogopite

In the eluvium of the kimberlites phlogopite is usually represented by rounded greenish-brown blades. It occurs rather rarely. Considerable quantities of phlogopite were observed in the kimberlites of the pipe "Zagadochnaya" (Figure 69).

In the pipe "Zarnitsa"(Figure 70) chloropite develops instead of chlorite.

In one of the grains of pyrope taken from the pipe "Zagadochnaya" phlogopite laminae developed a long cracks which testifies to secondary its formation. (Figure 71). Secondary phlogopite was also identified in the limestone xenoliths of other rocks.

An optical investigation of several samples of mica from the eluvium of the kimberlite pipe "Zagadochnaya" was conducted by M. Fishkin (Faculty of Mineralogy, Lvov State University) with the following results: sample No. 1 - brown mica (turns silvery white and expands when warmed up), Nm = 1.564 ≈ Ng, Np = 1.637; sample No. 2 yellowish-green mica (turns silvery white and expands when heated); Ng = 1.566, Nm = 1.564, Np = 1.535.

According to optic data these two samples contain vermiculite - a micaceous phlogopite.

Chlorite

Great quantities of chlorite were observed in the eluvium of the kimberlites of the Malaya Batuobiya River. Together with serpentine they form a light grainy matetal.

Chlorite is encountered in the form of fine grayish-green laminae with a bluish tint (figure 72). White calcite

(Ng = 1.666)and dolomite (Ng = 1.682) was frequently observed in the grains of chlorite between laminae.

Table 19

Composition	Gravimetric %	Molecular Quantity	Atomic Quantity of Oxygen	Number of oxygen atoms	Number of Cations
SiO_2	30.48	507	1014	3.42	1.71
TiO_2	0.32	4	8	0.02	0.01
Al_2O_3	8.42	82	246	0.82	0.54
Fe_2O_3	7.31	46	138	0.46	0.30
Cr_2O_3-	0.26	1	3	0.01	-
FeO	6.81	95	95	0.31	0.31
MnO	0.06	1	1	-	-
NiO	0.13	1	1	-	-
MgO	25.18	624	624(581)	1.95	1.95
CaO	3.79	66	66(-)	-	-
K_2O)) Na_2O)	0.30	3	3	0.01	0.02
H_2O-))	1.24	69	69))598	)200	4.00
H_2O+)	11.13	619	619)	)	
CO_2	4.83	109	218	-	-
P_2O_5	Traces	-	-	-	-
Total	100.17		3105	9.00	

$$\begin{array}{r} 3105 \\ \underline{-327(Ca,Mg)CO_3} \\ 2778 \\ \underline{-90} \\ 2688 \end{array}$$

$$X = \frac{2mC-KA}{2m-K} = \frac{2.9\ 688 - 4.2778}{2.9 - 4} = 90$$

C - X = 688 - 90 = 598

Common denominator 2 688:9= 299

Crystallochemical formula of chlorite:

$$K_{0.02}\,(Mg_{1.95},\ Fe^{\cdot\cdot}_{0.31}\}\ \{Al_{0.32}\}\ \{Fe^{\cdot\cdot\cdot}_{0.30}\}\ [Si_{1.71}\ Ti_{0.01}\ Al_{0.22}\ O_5]$$

—0.3H_2O ++0.3 (Ca, Mg) CO_3

Table 19 shows the results of the chemical analysis of chlorite (analyst: K.A. Baklanova) taken from the pipe "Mir" and its conversion*. The quantity of calcium and magnesium was not included in the conversion. This chlorite has the following data: Nm = 1.595; specific gravity = 2.62 - 2.67.

The chemical analysis shows that the chlorite contains some Ni and Cr which evidently account for the unusual color of the chlorite.

The differential thermic curve of chlorite is shown in Figure 73.** The first endothermic effect within temperature

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*-The conversion of the chemical analysis to obtain the crystallo-chemical formula was done after V.S. Sobolev (1949).

ranges of 110 - 190° was caused by the absorption of water (confirmed by chemical analysis as shown on table 19). The second and third endothermic effect within the temperature ranges of 525-700° and 710-820° is a result of the isolation of chemically combined water which is caused by the different character of the bonds of this water in chlorite. The characteristic exothermic effect at a temperature of 860° is not very pronounced in view of the emergence of an additional endoeffect at a temperature of 830 to 840°. It has been brought about by the dissociation of calcium which had not been fully eliminated when the material was selected for testing.

V.I. Mikheyev conducted an X-ray analysis of the chlorite and the calculations of the Debye crystallogram are shown in table 20.

Table 20

Number of Lines	I	$\frac{d\alpha}{h}$	$\frac{dB}{h}$	I	$\frac{d\alpha}{h}$	hkl	Q
1	1	8.88	8.05				
2	3	(7.97)	7.23			002	14.26
3	7	7.14	6.47	10	7.1	002	14.28
4	1	5.00	4.71	4	5.2		
5	8	4.77	4.32	10	4.72	003	14.21
6	1	4.56	4.13				
7	3	(3.94)	3.57	5	3.93	004	14.28
8	10	3.58	3.24	10	3.54	004	14.32
9	4	3.35	3.03	Quartz Line			
10	4	(3.18)	2.886	1	3.12	005	14.430
11	1	3.01	2.727				
12	10	2.883	2.613	7	2.83	005	14.415
13	2	2.660	2.411	1	2.69		
14	6	2.570	2.330	5	2.55		
15	2	2.456	2.226	5	2.44		
16	6P	2.403	2.178	3	2.39	006	14.418
17	3	2.277	2.064	3	2.26		
18	4	2.195	1.990	2	2.22		
19	8	2.018	1.829	8	2.01		

Table 20 - Cont'd.

Number of Lines	1	$\frac{d\alpha}{h}$	$\frac{dB}{h}$	1	$\frac{d\alpha}{h}$	hkl	[illegible]
20	1	1.897	1.719	4	1.88		
21	3	1.805	1.636	4	1.83		
2	1	1.737	1.574	1	1.73	060	9.246
23	3	1.662	1.506	3	1.66		
25	3	1.569	1.422	7	1.563		
26	10	1.542	1.398	8	1.540	060	9.252
27	4	1.511	1.369	3	1.505		
28	3	1.466	1.328	1	1.460		
29	2	1.415	1.282	2	1.334	0.0.10	14.150
30	5	1.325	1.201	3w	1.323	400	5.300
31	5	1.297	1.175	2	1.294		
32	1	1.267	1.148	1	1.283		
33	2	1.227	1.112	4	1.220		
34	1	1.195	1.084	1	1.192		
35	1	1.179	1.067	2	1.176	0.0.12	14.124
36	1	1.149	1.042	1	1.148		
37	1	1.132	1.026	4	1.132		
38	2	1.109	1.005				
39	1	1.098	0.990		1.095		
40	1p	1.080	0.979				
41	2p	1.046	0.948		1.043		

Judged by the distribution of the lines and their relative intensitites chlorize is densitified in the test as shown in the same table by comparison with the data of a standard test of prochlorite.

A bright line with a plane-to-plane distance of 1.535 to 1.552 and a series of bright reflections of basic pinacoid are characteristic of Debye crystallograms of chlorite and of bedded silicate.

A Debye crystallogram made of the sample shows a bright line of 1.542 and a series of multiple reflections.

The leading lines of the Debye crystallogram of the tested sample are easily identified and the symbols of the

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** Thermic analyses conducted in the Thermic Lab of VSEGEI under guidance of V.P. Ivanova.

Table 20 - Cont'd.

Number of Lines	1	$\frac{d\alpha}{h}$	$\frac{dB}{h}$	1	$\frac{d\alpha}{h}$	hkl	Q
20	1	1.897	1.719	4	1.88		
21	3	1.805	1.636	4	1.83		
22	1	1.737	1.574	1	1.73	060	9.246
23	3	1.662	1.506	3	1.66		
25	3	1.569	1.422	7	1.563		
26	10	1.542	1.398	8	1.540	060	9.252
27	4	1.511	1.369	3	1.505		
28	3	1.466	1.328	1	1.460		
29	2	1.415	1.282	2	1.334	0.0.10	14.150
30	5	1.325	1.201	3w	1.323	400	5.300
31	5	1.297	1.175	2	1.294		
32	1	1.267	1.148	1	1.283		
33	2	1.227	1.112	4	1.220		
34	1	1.195	1.084	1	1.192		
35	1	1.179	1.067	2	1.176	0.0.12	14.124
36	1	1.149	1.042	1	1.148		
37	1	1.132	1.026	4	1.132		
38	2	1.109	1.005				
39	1	1.098	0.990		1.095		
40	1p	1.080	0.979				
41	2p	1.046	0.948		1.043		

Judged by the distribution of the lines and their relative intensitites chlorize is densitified in the test as shown in the same table by comparison with the data of a standard test of prochlorite.

A bright line with a plane-to-plane distance of 1.535 to 1.552 and a series of bright reflections of basic pinacoid are characteristic of Debye crystallograms of chlorite and of bedded silicate.

A Debye crystallogram made of the sample shows a bright line of 1.542 and a series of multiple reflections.

The leading lines of the Debye crystallogram of the tested sample are easily identified and the symbols of the

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** Thermic analyses conducted in the Thermic Lab of VSEGEI under guidance of V.P. Ivanova.

reflected surface grids are shown in table 20.

The table shows seven sequences of reflection from the plane of the pinacoid: 002; 003; 004; 005; 006; 0.0.10; 0.0.12. The value c-sin ≅ 14.2 is easily determined with their help. The tenth sequence of reflection is most reliable so that 14.150 is obtained for c.sin.

The bright line 060 with a plane-to-plane distance of 1.542 allows to determine the length of axis b of the elementary nucleus of the chlorite (b = 9.252 kx). Finally, reflection 400 (a line with a plane-to-plane distance 1.325) allows to determine that d·sin B= 5.300 kx. The results of all these calculations are shown in the last column (Q) of the table.

Thus, the elementary nucleus of the tested chlorite is rather accurately determined.

Serpentine

Serpentine is very common in the eluvium of the kimberlites in the Daaldyn and Malaya Batuobiya regions where it forms the basic mass of a light fraction of grainy material.

It is represented by grayish-white pale green, dark green, yellowish brown and brown rounded grains. Frequently, pseudomorphs after crystalline olivine are encountered. The faces are so clearly marked that the angles between them can be measured with the help of a gonimeters. The size of the grains varies from 1 to 3-4 millimeters, with the average size amounting to 1.5 to 2 millimeters.

The goniometric research of the pseudomorphs of serpentine after crystalline olivine was conducted by M. M. Slivko (Faculty of Mineralogy, Lvov State University) on a one-disk goniometer with the minimum division on the nonius of 30."

Pseudomorphs of light green-gray serpentine. The size of the crystals varies from 0.5 to 2.5 millimters. The faces of the crystals are, as a rule, uneven, ondulated with rounded edges. Under a binocular magnifier the crystals are heterogenous and have a mesh texture.

The following simple forms were established on the above crystals with the help of a goniometer: (110), (120), (021), (101), pinacoids (010) and (001), dipyramid (111).

The habit of the crystals is columnar, but the crystals are frequently depressed along the edge of the second pinacoid (010) which lends them a flattened appearance. The pinacoid (001) is slightly developed and only rarely absent.

Along with flattened forms, crystals with isometric profiles are found, perpendecular to (001). These crystals are usually elongated ratio 1;h reaches 2.5 : 1).

Pseudmorphs of light green and brownish serpentine.

The size of the crystals reaches 0.7 millimeters. They are more regular in form than the above variety. The same simple forms, however, are discovered on the crystals. Contrary to the light-green and gray varieties these crystals have shorter columns and are rarely flattened.

Figure 74 and 75 shows an orthogonal picture (axis z and axis g_2 which coincide are perpendecular to the diagram) of first and second crystalline pseudomorphs. The side of the faces as well as the elements of symmetry of those crystals and the angles between the normals and the planes mark these pseudomorphs as members of the rhombo-dipyramidal group of the rhombic syngomy, i.e. the symmetry of olivine crystals. However, the angles between the normals and the faces of the crystals deviate somewhat from those of olivine (table 21.) This is evidently due to the process of decomposition that accounts for distortion ofthe angles.

Here are the results of the optic tests of serpentine:

Sample No. 4_c Serpophite ("Zarnitsa") N= 1.566 - 1.549. Slightly birefringent.

Sample 5_c . Serpentine ("Zarnitsa") Ng= 1.558; Np= 1.548. Columnar. Dolomite with Ng= 1.680 is present and calicite and insignificant quantity of calcite with Ng = 1.662.

Sample No. 2_c. Serpentine (pipe "Mir"). Analogous to preceding sample No. 5_c.

Sample No. 3c. Serpentine (Pipe ("Mir"). Columnar. Ng = 1.558 - 1.560; Np = 1.546 - 1.548. Great quantities of dolomite with Ng = 1.678 - 1.680. Calcite was not encountered.

Samples No. 4c and 5c were subjected to thermic tests (Figure 76, 77).

Sample No. 4c is a serpophite. It is characterized by two endopeaks which correspond to the isolation of the water of absorption and constitution and by two exopeaks (at 300° and 810°) the nature of which has not been established. Sample No. 5 is analogous to the preceeding one. Endopeaks at 770° and 810° form one endopeak torn by an exopeak. Dolomite with Nm-1.680 was found optically in the grains but since the peak of dissociation of the magnesia component coincides with the endothermic stop of serpentine it appears (from the curves) as if only calcite were present in the serpentine. The temperature of the dissociation of $CaCO_3$ shows a tendency to drop which is typical for the decomposition of calcium when admixtures are present.

Table 22 shows the results of the chemical analysis of the samples as well as the crystallochemical formulas. The corresponding quantities of Ca and Mg were not included into the calculations.

Table 22

Composition	Samples			
	No.5c	No.4c	No.2c	No.3c
SiO_2	34.84	41.02	33.80	38.11
TiO_2	0.21	0.06	0.08	
Al_2O_3	0.50		0.57	
Fe_2O_3	0.68	1.49	3.22	3.85
Cr_2O_3	0.05		0.05	0.05
FeO	2.66	0.13	2.77	2.28
MnO	0.06		0.08	0.08
NiO	0.21	0.24	0.21	0.20
CaO	7.72	0.28	6.80	4.00
MgO	31.2	41.05	31.53	33.30
KO Na_2O	0.10			
H_2O	1.66	1.04	2.36	1.92

Table 22 - Cont'd.

Composition	Samples			
	No.5c	No.4c	No.26	No.3c
Indissoluble Products	10.14	14.00	9.79	10.59
CO_2	9.87	0.96	9.28	5.85
P_2O_5	0.053	0.013		0.22
Total	99.97	100.28	100.54	100.45
Specific Gravity	-	2.43	2.49	-
Analysts	K.S. Baklanova	V.Koviazina	M. Stukalova	

Crystallochemical formulas of serpentine:

$$(Mg_{2.51}\,Fe^{\cdot\cdot}_{0.14})\,(Al_{0.04}\,Fe^{\cdot\cdot\cdot}_{0.14})(OH)_4\,[Si_2O_5]\cdot 0.43\,H_2O + 0.04\,SiO_2 + 0.76\,(Ca,Mg)\,CO_3$$

$$(Mg_{2,51}\,Fe^{\cdot\cdot}_{0.10})\,Fe^{\cdot\cdot\cdot}_{0.15}\,(OH)_4\,[Si_2O_5]\,0.27\,H_2O + 0.08\,SiO_2 + 0.43\,(Ca,Mg)CO_3$$

$$Mg_{2.93}\,Fe^{\cdot\cdot\cdot}_{0.04}\,(OH)_4\,Si_2O_5\cdot 0.42\,H_2O\;\;0.06\,(Mg,Ca)CO_3$$

$$(Mg_{2.51}\,Fe^{\cdot\cdot}_{0.13})(Al_{0.03}\,Fe^{\cdot\cdot\cdot}_{0.02})\,(OH)_4\,\boxed{Si_{1.99}\,Ti_{0.01}\,O_5)}\cdot 0.39\,H_2O + 0.81\,(Ca,Mg)\,CO_3 + 0.13SiO_2$$

Calciostrontianite

Calciostrontianite was found only in the eluvium of kimberlite pipe "Zarnitsa" where it is almost the sole member of the heavy non-magnetic group. It occurs in the form of closely joined divergent aggregates of snow-white aciculae that are occasionally begine or yellowish-brown through the presence of ferric hydroxides. These aggregates are frequently completed by reniform sinters. They are colorless, semi-opaque or pinkish and brownish through the presence of ferric hydroxides (Figure 78).

The material is biaxial and negative with Ng = 1.674. The size of the aggregates of calciostrontianite reaches up to 0.6 to 0.7 centimeters.

Table 23 shows the results of a chemical analysis of calciostrontianite conducted by K. A. Baklonova and converted into crystalochemical formula.

Table 23

Composition	Gravometric %	Conversion of carbonate by 100%	Molecular quantity	$SrCO_3$	$CaCO_3$	$MgCO_3$
SiO_2	0.14	--	-	-	-	-
CaO	6.88	6.90	123	-	123	-
SrO	61.00	61.19	591	591	-	-
BaO	Tracds	-	-	-	-	-
MgO	0.29	0.29	7	-	-	7
CO_2	31.52	31.62	718	591	123	4
Total	99.03	100.00				

Crystallochemical formula of calciostrontiante:

$$(Sr_{0.823}\,Ca_{0.171}\,Mg_{0.009})\,CO_3$$

According to V.P. Ivanova's data the temperature of reversible polymorphous conversion is greatly reduced in comparison with pure strontianite which is, presumably, a result of the isomorphous admisture of calcium. However, the content of calcium in strontianite is lower than shown in the above formula since a loss in weight is observed during heating which corresponds to the decomposition of a certain part of calcium carbonate, presumably the admisture of calcite.

Calcite

Calcite occurs commonly in all deposits. Usually, it is found in the forms of transparent or semi-transparent crystalline cleavage fragments. Less often it is observed in the form of tiny scalenohedrons (Figure 79). Sometimes calcite is beige or brownish which testifies to ferric hydroxides. Rather often the crystal's and the grains of calcite are saturated with dark opaque inclusions. The index of refraction of calcite crystals is Ng = 1.666. Table 24 shows the results of a chemical analysis of calcite from the eluvium of pipe "Mir". It is converted into a crystallochemical formula (specific gravity 2.73).

Table 24

Composition	Gravometric %	Conversion of carbonate 100%	$CaCO_3$	$MgCO_3$	$SrCO_3$	$FeCO_3$
SiO_2	2.56	-	-	-	-	-
Al_2O_3	0.51	-	-	-	-	-
Fe_2O_3	0.07	-	-	-	-	-
FeO	0.14	0.14	2	-	-	2
MgO	0.78	0.80	20	20	-	-
CaO	52.84	54.59	974	-	-	-
SrO	0.43	0.44	4	-	4	-
CO_2	42.62	44.03	1001	20	4	2
Total	99.95	100.0				

Crystallochemical formula of calcite:

$(Ca_{0.974}, Mg_{0.020}, Sr_{0.004}, Fe_{0.002})\ CO_3$

The differential thermal curve for calcium (Figure 80) shows the characteristic endothermal effect at a temperature of 956° which testifies to the dissociation of calcite.*

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*-Research was conducted in the Thermic Laboratory of the all Union Scientific and Research Geological Institute of the Ministry of Geology (VSEGEI) under V.P. Ivanova's guidance.

QUARTZ

Quartz is found in most deposits in rather small quantities. There are two groups of quartz:

a) quartz from xenoliths, usually found in the form of small turbid rounded grains;

b) quartz connected with superposed hydrothermal processes, i.e. secondary quartz. It is often observed in well formed small (up to 2.5 millimeters) crystals with prismatic and rhombohedral well marked planes. However, it is even more frequently found in the form of spindle-shaped crystal clusters usually topped by several individual rhombohedral caps.

The grains and crystals of quartz are usually as transparent as water but also frequently of a beautiful yellowish-orange shade or of various shades of brown showing that they contain ferric hydroxides.

Pyrite

Pyrite was found in very small quantities in the eluvium of thepipe "mir". It is formed either of crystalline cubes and fractures or of ball shaped small (up to two millimeters) divergent aggregates. (Figure81).

Frequently, both the grains and the crystals of pyrite contain ferric oxides and are, therefore, reddish brown.

Disthene

Rare disthene was found in the pipes "Zarnitsa" and "Zagadochnaya". The size of the grains varies frm two to four millimeters. The grains are blade-like, transparent, light blue or blue. They have a glassy luster. Ng = 1.729, Np = 1.710.

Grossularite

Small (from 0.1 to 0.3 and from 1.5 to 2 millimeters) grains of grossularite are occasionally found in the grainy material of the eluvium of kimberlite pipe "mir". Most grains of grossularite are characterized by zonal coloring: in the center they are a deep brown and sometimes black with a predominance of brownish-yellow or greenish-brown toward the periphery. (Figure 82). Most of the grains are semi-octane, but often well-formed rhombododecahhedrons are encountered. Step-like pockets with polyhedral outlines mark some grains of grossularite. This is, the result of theprocess of growth.

Tourmaline

One rounded muddy-green grain of tourmaline was identified in the eluvium of the kimberlite pipe "Mir". Under the miscroscope a pleochroism was visible; greenish-brown in Nm to brownish yellow in Np, $Ng = Nm = 1.656$, $Np = 1.633$.

Apatite

Apatite in the form of white grains with $Ng = 1.634$ and $Np = 1.631$ was found in artificial concentrates from an eclogite-like rock (kimberlite of the pipe "Zarnitsa") in addition to pyrope, almandine and plagioclase.

Plagioclase

The light fraction of artificial concentrates from the xenolith of an eclogite-like rock ("Zarnitsa")is almost entirely composed of plagioclase present in the form of angular white blades. $Ng = 1.548$ and $Np = 1.539$. This corresponds to plagioclase No. 25.

Zircon

In concentrates from the eluvium of kimberlite pipe "Zarnitsa" several small (0.5 to 1.5 millimeters) sharp angular transparent pale pink grains of highly lustrous zircon were recognized. $Ng \leqslant 1.781$.

Brown Iron Ore

Occurs commonly in all deposits that have been examined. It is the final product of the decomposition of minerals.

There are ocherous brown, yellow and red-brown varieties. Solid varieties are brown and deep-brown; they are formed of rounded flat grains with a glossy surface. Grains were also found where light ocherous ferric hydroxides are interbedded with solid, dark -- usually brown -- ferric hydroxides. As already mentioned, brown iron ore forms pseudomorphs after grains and crystals of pyrite.

Despite their incompleteness, the above mineralogical data reveal the striking similarity between the main minerals in Siberian and in African kimberlites.

Garnet and ilmenite that accompany diamonds show the most conspicuous similarity. They are used to trace diamonds in primary deposits. At the same time, the data reveal some characteristic properties of Siberian kimberlites and, particularly the rare occurrence of perovskite. Further detailed study of the mineralogy of unaltered kimberlites would provide newmaterial allowing to determine the origin of these interesting rocks, in general, andthat of the diamonds, in particular.

IV. MINERALOGY OF DIAMONDS FOUND IN THE BASIN OF THE VILYUI RIVER

A systematic study of Vilyui diamonds was launched in 1952 under the guidance of the mineralogist and crystallographer N. A. Bobkov whose untimely death occurred during field work.

For various reasons and, primarily, as a result of the rich material that had become available through research and investigation on the tremendous terrritory of theVilyui River Basin and in view of the requirements of practical work, the study of Vilyui diamonds has so far been reduced to morphological reports on diamonds from various diamond-bearing areas. Such improtant practical problems as the occurrence of Siberian diamonds in primary deposits, their location in placer deposits estimates beased on the kimberlite of these deposits, etc. were successfully solved.

At the same time, questions pertaining to the physical properties of diamonds and their inclusion, etc. still need to be investigated.

The chapter on the mineralogy of Siberian diamonds represents merely a morphological report on their properties and is designed to provide readers only with a general idea on Vilyui diamonds.

1. General Information on Vilyui Diamonds

Size of Diamonds

The size of the diamonds found in primary and placer deposits in the basin of theVilyui River vary greatly ranging from tiny diamonds that weigh 0.1 to 0.2 milligrams to comparatively large (large for a mineral like the diamond) crystals of several carats.[x] Along with amorphous fragments whole perfectly formed fine crystals are found among the small varieties. The largest of the known Vilyui diamonds weighs 32.5 carats. It was found in the fall of 1956 in pipe "Mir."

The predominance of extremely fine crystals and crystalline fragments in primary rocks and placer deposits is a characteristic property of Vilyui diamonds. Ofter, over half of the diamonds in different placer deposits weigh less thatn ten milligrams while 70 to 90 percent of the diamonds weigh up to 20 milligrams. Large diamonds (arbitrarily, we include grains that weigh over half a carat -- 100 milligrams) occur throughout the area but in small quantities.

The curve that characterizes placer deposits, shows the dissemination of diamonds according to weight (Figure 83) (placer deposit "Ogonek" in the midstream area of the River Vilyui.) The curve shows that the maxium quantity of diamonds found in theplacer despoit weights under ten milligrams while the average weight is 13 milligrams since rather large diamonds occur. This discrepancy between the average weight and the weight of individual crystals marks all placer deposits. It is a result of the accumulation of the grains of diamonds in the stream of water according to hydraulic size andnot to their weight. Figure 84 shows the curve of the dissemination of diamonds in the same place deposit ("Ogonek") according to the radii of equivalent balls, which actually means that the radius of the ball-shaped particle that settles in the water at the same rate as the given diamond was determined. According to the diagram the curve of dissemination comes close to the well known standard Gauss dissemination which means that the alluvium

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[x] One metric carat equals 200 milligrams.

particles, deposited within a small area of the bed through the turbulence of the current, must be disseminated according to their size under statistically similar average conditions.

Thus, the dissemination of diamonds according to size in small areas as, for instance, in beds of rivers conforms entirely to the general laws applicable to all eluvium particles.

The dissemination of diamonds according to weight in the two primary rock deposits that have so far been investigated also reflects a drastic inconsistency since small diamonds predominate while large ones are found as an exception. (Figure 86 and 85). Thus thepeculiar way in which the diamonds are disseminated according to size is inherent in theprimary deposits while the diamonds are transformed to one degree or another in theprocess of transportation in the eluvium without, however, undergoing any essential changes.

If the data upon which the curves on Figures 85 and 86 are based were converted into the radii of equivalent balls, the dissemination would come close to normal. This is only natural since theprocessof crystallization is a static process and the size of the crystal in formation does not vary too much reflecting the average conditions of crystallization.

In this case, however, it is not the weight but the size of the individual crystals in formation that is decisive.

The average weight of the diamonds in theplacer deposits decreases rather regularly along with the current of diamond bearing rivers in the direction of the established (or presumed) primary sources. In the downstream area of the Vilyui River the average weight decreases from 27 to 8-9 milligrams (Figure87) and in the midstream area of the Markha River (Figure 88) it decreases from 20 to 7 milligrams.x The rate at which the average weight of diamonds decreases in placer deposits in the midstream areas of therivers Vilyui andMarkha amound to about three to four milligrams per 100 kilometers. The line showing the decrease of the average weight in these areas is, in fact, straight. As shown in Figure 87 the curve is pronounced near

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x The diagrams were prepared with a veiw to possible errors in the determination of the average weight.

the primary source. The same is noted on the curve for the midstream area of the Markha River in the area of the placer deposits of Ustrichnaya - Beregovaya which leads to the assumption that a primary source that has not been discovered as yet, must be located in the vicinity. Moreover, the diagram reveals that immediately below the pipe "Mir" the size of the diamonds in the placer deposits is much larger thatn in the primary bed. This is caused by the fact that directly below the pipe great quantities of fine diamonds are freed through the steep longitudinal profile of a small river so that the placer deposit in the bed of the river is enriched by some large size diamonds.

Forms of Crystals

All diamonds found in the Vilyui area are either octahedrons, rhombododechahedrons, or of a transitional habit shapes ranging from octahedrons to rhombododecahedrons. There are very few exceptions (Figure 89). Cubes are extremely rare.

Obviously laminar formation (layers) (Figure 89,90,91) is very characteristic of most Vilyui diamonds. Research revealed that in theprocess of laminar growth (in layers) of octahedrons and sometimes at relatively earlier stages of crystallization trigonal or ditrigonal layers which underlay every octahedral plane begin subsequently to decrease. Each newly formed layer does not reach the edge of the preceding one and is consequently smaller than the octahedral plane. As a result the edges of the octahedron are replaced by faces formed of individual "phases of growth" (of the protruding end faces of the layers of growth) while the flat, even faces of octahedrons decrease in size.

The overwhelming majority of diamond octahedrons does not have sharp straight cleavage edges which are common in many crystals of other minerals. Speaking of the "edges" of octahedrons we almost never refer to the line of contact on the cleavage planes but to a step-like or streaked surface that has come to replace the edge (Figure 92). Even on flat-faced octahedrons, a certain widening of the edges of the octahedron toward the top can always be observed.

The step-like and streaked surfaces that form on the site of the edges correspond generally to the edges of the rhombododecahedron. Depending on the stage of their development a gradual transition from an octahedron diamond to a rhombododecahedron habit takes place.

Even though individual heavy layers of growth (the layers that form the "stages of growth") are trigonal with sharp edges and vertical ends surfaces with rhombic outlines form a small trigonal terrace like pyramid (usually with a turncabed top composed of sets of parallel layers. Evidently such a crystal would procude octahedral signals on the gonimeter. In most cases the different stages of growth" of such crystals are rounded and even coarsely laminated formations produce rhombododecahedral signals on the goniometer in the form of blurred luminous triangles characteristic of so-called rounded diamonds.

These crystals are composed of ditrigonal layers of growth and the striated surfaces that replace the edges of the octahedron -- "the edges of the rhombododecahedron" -- are cut by a seam that runs approximately in the direction of the short diagonal of the rhombus (Figure 93). Gradual transitions are observed ranging from crystals with distinct schistose stratification and corresponding coarse and clearly marked striae along the "edges of the rhombododecahedron" on the one hand, to perfectly rounded crystals of diamonds that show almost no traces of laminar formation, on the other. (see Figure 94, 95, 96).

Two diametrically opposed viewpoints still prevail in the crystallography of diamonds on the formation of forms with curved edges (rounded rhombododecahedrons). The advocates of one viewpoint explain the origin of rounded rhombododecahedrons by dissolving processes that affect octahedrons (I. I. Shafranovskyi, 1948, A.A. Kukharenko, 1955). According ot others, the formation of forms with curved edges is caused by peculiarities connected with their growth (O.M. Ansheles, 1954, 1955).

Twins and Clusters

Twins and clusters are not very numberous among Vilyui diamonds although they are found throughout the entire are and are rather common.

In regard to the nature of twinning these diamonds do not differ from diamonds found in other parts of the world. Cluster twins, formed according to the "spinel law" predominate. The face serves as the plane of clustering. Octahedrons are most common among twinned crystals. This variety of twins is almost alwasy greatly depressed towards the triad axes that run perpendicular to the plane of twinning.

As a result, peculiar "triad" diamonds (Figure 97, 98) are fromed ranging from finest lamine (Figure 99) to almost isometric twins. Sometimes rounded diamonds (Figure 100) are twinned according to the same law.

Individual twins vary in size (Figure 101). They do not always grow together so as to form an equilateral triangle (Figure 102, 103, 104). Figure 105 shows a spinel twin taken at a sharp angle in relation to the depression axis. On Figures 106 and 107 the same crystal is represented in perpendicular and parallel positions respectively, in relation to the depression axis. Both crystals clearly have the flattened form of an octahedron. The photographs also show the angle of incidenco and the direction of the twinning seam where the striation of both twins are jointed represented the traces of diminishing trigonal laminae of the crystal.

In more isometric twins the line of the twinning seam is often irregular. It forms cracks and small hollows (Figure 108). Occasionally triangular hollows are encountered along the twinning seam (Figure 109).

Parallel clusters of isometrically shaped diamonds (Figure 110) are also encountered among depressed twins of the Vilyui diamonds formed according to the spinel law.

Figure 111 pictures a cluster of three crystals. Two large octahedrons have a parallel intergrowth. The small third crystal is intergrown according to the "spinel law." Sometimes two, three or more crystals cluster in a parallel manner or irregularly. (Figure 112, 113).

In the placer deposits as well as in original sites diamonds of the Vilyui River Basin clusters composed of a considerable number of extremely fine crystals (from ten to 30 or more) are occasionally found. Sometimes these indivisible clusters are made up of well-formed crystals. The habit and details of these crystals are clearly visible (Figure 114). In other samples indivisible clusters are not clearly outlined and represent an indistinct dense grainy mass (Figure 115) or an aggregate of amorphous particles.

In most cases, all crystals of such polycrystalline clusters are members of the same morphological group.

On hand of fractures of these clusters their inner structure can be determined. As a rule, the indivisible clusters are concentric around the center, that is formed of one or several irregular black grains of diamond. The early layers of either the crystals or the grains grown around such a center are usually dark (brownish-black or densely smoky). From the center outward the richness of the color usually decreases.

The polycrystalline clusters are, usually, aggregates of extremely fine and distinctly concentric diamonds. They are either spherical or depressed (flat). They resemble the variety of diamonds known as"ballas" (concentrically formed diamonds) or "bort" in the special meaning lent to this term by some foreign scholars (see I. I. Shafranovskyi, [illegible] Hmallovskyi, 1952).

A peculiar greasy luster, a lilac-brown, yellow-brown or densely smoky color and a great quantity of graphite inclusions in the form of fine dust-like flakes which occasionally overfill the crystals are characteristic of these clusters.

Peculiarities in the Formation of Faces

Forms of the layers of growth and striation on the faces of rhombododecahedrons:

It has already been mentioned that the outlines of the layers of growth and the laminae that form in the process of growth of an octahedral diamonds may be either trigonal or ditrigonal.

The ditrigonal variety has frequently rounded angles and the outlines of octahedral faces acquire a shield-shaped form. Depending on the form of the layers of growth on the "faces of rhombododecahedrons", either parallel or sheaf-like striae form, the latter intersected by a seam.

The followers of the "theory of dissolving" explain the formation of sheaf-like striation by processes of dissolving that affect the crystal from the top to the center of the edge and from the edge toward the center of the octahedral planes. The seam is considered to be a peculiar kind of "waterline" that shows the minimum rate at which dissolving takes place from the top of the octahedron downward. The frequent zigzagging and shifts(which often are very conspicuous) of this line in the direction of one of the tops (A.A. Kukharenko, 1955) is also explained by this theory.

Contrary to this school of thought, O.M. Ansheles (1952) explains the formation of distrigonal layers in the process of growth by the peculiar properties of their texture.

Parallel and sheaf-like striation is extremely common and marks most crystals of the Vilyui diamonds at one stage of development or another.

Inversely Parallel Triangular Hollows on Octahedral Faces

Triangular hollows that are either inversely parallel or grow inversely in relation to the octahedral face (with the vertexes directed toward the edges and the edges toward the vertexes of the faces) were frequently observed on octahedral faces of diamonds. At times, they represent a rather large growth that occupies an essential part of the face while they also occur in the form of extremely fine formations that look like a rash on the plane surface and are only visible under the microscope.

The common triangular hollows are usually depressed (Figure 116) but there are also large, deep hollows with terrace walls (Figure 117).

Very often a series of small triangular hollows develops on the face of the octahedron along the cracks of the octahedral faces forming a characteristic pattern of intersecting lines (Figure 118). Occasionally, the plane surfaces of the octahedron are densely covered by trigonal patterns of such hollows.

Inversely parallel triangular hollows are extremely common on diamonds throughout the world and are well known in literature.

Nevertheless, there is still no unanimous opinion as to their origin. Some scholars are convinced that they are connected with the growth of crystals. Others belive that most of these formations are associated with the different forms of corrosion (A.A. Kukharenko, 1954).

When these hollows start to form while the faces are growing as individual laminated small pyramids from the vertex of the octahedron (Figure 119), or when one side of the hollow remains open (Figure 120) during the growth originating with two vertexes, their formation in the process of the growth of the crystal is beyond any doubt. As regards the formation of numerous triangular hollows that sometimes cover the face of the crystal, we know that the faces of real crystals are not perfectly regular. In several points on the plane surface they are uneven, have hollows, protrustions and other defects. It is most likely that some of these points (because of dihedral and trihedral angles) are energetically best suited to receive the particles of the solution or fusion. It is these points that the sedimentation of the matter that is subjected to the symmetry of the plane sets in, i.e. on the plane surface of the diamond octahedron equilateral traingles develop from each of these points.

The location of these points of growth will be accidental in relation to the face of the octahedron and in relation to each other, since any defect on the plane surface at one point or another has also formed accidentally (Statistically speaking). Evidently, whenever there are three or more "points of crystallization" on one plane surface and for one reason or another the layers do not cover the entire plane the space between the triangles of growth will inevitably form inverse triangular hollows.

We should like to emphasize that the numberous experiments designed to bring about a corrosion of the faces (to which the advocates of the formation of inversely parallel triangular hollows usually refer) inevitably produce the same results: in the process of dissolving the faces are covered by triangular hollows which gradually acquire rounded outlines. This is brought about by the fact that dissolving or fusion starts at the defective point of a face and is subjected to its symmetry. A.A. Kukharenko's claim

(1954) that triangular hollows are always observed on octahedrons with "dissolved" edges is erroneous. It is easily recognized from the microphotographs in this book taken of crystals that revel no traces of dissolving. However, directly parallel triangles of depressions were observed only simultaneously with other traces of corrosion on the diamonds (M.A. Gnevushev, 1955). Thus, inversely parallel triangular hollows definitely form in the process of crystallization.

Tetragonal Figures and Patterns at the Vertex of Octahedrons

Tetragonal figures and patterns were observed at the vertex of octahedrons on many thin-bladed crystals of octahedral habit. The included microphotographs (Figure 121, 122) show how these tetragonal hollows form as a result of the overgrowth of laminae that decrease in size on the faces of octahedrons. These laminae do not reach the vertex of the octahedron and form step-like surfaces on its edges (Figure 123).

As a result of this peculiar growth plane surfaces marked by tetragonal patterns emerge at the outcome of the tetragonal symmetry axis corresponding to the faces of a cube in regard to its site. Sometime individual large and deep tetragonal hollows form at the outcome of the tetragonal (Figure 124).

The sides of such tetragonal hollows are always arranged along the diagonal face of a cube, i.e. run parallel to the edge of the octahedron. When a diamond is artifically dissolved these hollows acquire an inverse orientation (A.A. Kukharenko, 1955).

Columnar Sculpture[x]

Some Siberian diamdons of rhombodolecahedral habit are marked by a peculiar pattern. On Figure 125 the character of this pattern can easily be recognized. The faces of such crystals are formed of individual laminae or scales which overlap toward the triad axis of symmetry. The length of the scales that seem to protrude from under each other emerging to the plane surface is uneven and they are always considerably smaller than the plane. The scales are cut of the rhombododecahedron. As a result, a pattern of parts

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[x] This term is borrowed from A.A. Kukharenko (1955).

of the scales or "columns" that protrude along the long axis emerge on the face running parallel to the long diagonal of the face.

A.A. Kukharenko made a thorough study of the columnar form and the closely related "tiled" form of Ural diamonds. No study has been made of these sculptures on the Siberian variety of diamonds, therefore we shall not dwell on them.

It goes without saying that the above examples do not represent a complete picutre of the many different patterns that mark on the faces of Vilyui diamonds. Some of the("block sculputures") will be mentioned in the chapter on the characteristic properties of diamonds in different morphological groups. Others (small drop-like elevations, "shagreens," etc.) have not been studied adequately so that there is no point in discussing them.

Corrosion of Faces

The above properties of the structure of diamond faces are conditioned by the process of crystallization. Moreover, the faces of Vilyui diamonds are marked by traces of the reversed process -- although these traces are very rare-- the corrosion of the plane surface.

The most common sculpture is the so-called "structural matting". This structural matting develops to different degrees. Sometimes it is found as an extremely fine tarnish on the diamond which resembles the "sweat" on glass and metal when they are brought from outside into a warm room (Figure 126). The crystals are, usually unevenly matted so that the transparent substance of the diamond is visible in some sections. Frequently, the matting is rather dense but the individual patterns of the structure of the diamond (Figure 127) can usually be identified. It also happens that the matting affects the surface of the crystal in the form of unevenly disseminated spots (Figure 128).

Closely matted diamonds are milky-white (Figure 129, 1930). The surface of the diamond is rough to the touch and words can be written on it with a steel needle as if it were a pencil and a sheet of paper. Structural matting develops not only on whole crystals but also on fractures (Figure 131). When greatly developed it forms a distinct pattern of small elevations and hollows (Figure 132).

affecting the entire surface of the crystal through corrosion. The edges of highly corroded rhombododecahedrons are rounded (Figures 133, 1134, 135) while the surface is closely meshed. Not always is the entire surface of a diamond corrosed. Sometimes individual cavities form on an otherwise smooth surface. These cavities are caused by corrosion and are usually rounded (Figure 136). Not only whole crystals but also amorphous sharply angular fractures (Figure 137) are found among both, matted and corroded diamonds.

The fact that there are gradual changes ranging from a fine film of matting and including coarse corrosion testifies to the common nature of these phenomenon.

It is characteristic of structural matting that, as a rule, it covers the entire diamond including all the hollows. This feature distinguishes it essentially from mechanical matting. On hand of experiments (A.A. Kukharenko and V.M. Titova) it was proved that this matting forms under the action of gas. Our above observations fully corroborate the results of these tests. Structural matting and corrosion were brought about by highly mobile solvent that affected all points of the surface of the diamonds more or less to the same degree and freely penetrated into all hollows on the crystal. It may be assumed, therefore, that under natural conditions gas acts as this solvent agent.

Structural matting is observed on differently shaped diamonds: octahedrons, rhombododecahedrons, rounded diamonds and fractures.

Evidently, the corroding reagent affected diamonds after the process of crystallization. Only a very insignificant part of the diamonds is affected by the corroding action of the gas. This fact indicates that in the history of the formation of diamonds the action of the gas agent has only been of short duration and of an accidental nature so that only a few individual diamonds were affected by it.[x]

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[x] If this view were correct we should assume that the corrosion of diamond drystals did not take place at their present site and that diamonds with a different history of formation can coexist.--Editor.

So far it has not been possible to establish any association of traces of corrosion and certain diamond-bearing areas or deposits, particularly in view of the fact that corroded diamonds are very rare.

In one of his recent papers on rounded diamonds crystals A.A. Kukharenko (1954) refers to corroded sculptures on the plane surfaces of diamonds as one of the facts that testify to the origin of these forms as a result of the process of solution. But the above account reveals that these sculputures that form either after the process of crystallization or, probably, at the last stages of the formation of primary diamond-bearing rocks cannot be considered in the light of such evidence.

Specific Gravity

The specific gravity of Vilyui diamonds in correlation with other characteristics has not been specially studied. According to available data the figures range from 3.52 to 3.56 with an average 3.54. It is quite possible that these figures are somewhat too high.

Color

The overwhelming majority of Vilyui diamonds is colorless. Highly colored diamonds are extremely rare. Yellow crystals are of different shades ranging from a rather deep orange-yellow to a very light lemon-yellow. The nature of this coloring has not been studied but according to A.A. Kukharenko (1955) the yellow color in Ural yellow diamonds is due to the presence of a solid solution of chromium and titanium in the crystal. Among Vilyui diamonds the yellow coloring occurs most frequently in octahedrons including twins that are depressed according to the spinel law. Curiously enough, as a rule, these octahedrons and twins are covered by a dense pattern of inversely parallel triangular hollows of growth. Such a pattern has almost never been observed on colorless octahedrons. In this case, there is a connection between the sculpture of the faces and the coloring, i.e. the influence of the color pigment upon the growth of the crystal is established beyond any doubt.

Pale-aquamarine, light blue or greenish crystals are extremely rare among the diamonds of the Vilyui River Basin.

Individual green (sometimes even tabacco-brown) spots, known as "pigmentation spots" are more common on diamonds of this area. They are also known to exist on diamonds of other areas (Africa, the Ural Mountains). The richness of the color vaires for these spots but a deep grass-green is most characteristic. These spots which disappear from polishing are disseminated directly under the plane surface of the crystal.

Different views prevail on the origin "pigmentation spots". Now, this coloring can be produced easily in diamonds by bombarding the surface of the crystal with radioactive particles in tye cyclotron. As a rule, diamonds of such a natural coloring, encountered in older deposits for instance, the green diamonds of the Witwatersrand area of Pre-Cambrian Age (in South Africa). For that reason we are inclined to accept the view that pigmentation spots formed under natural conditions result from slight radioactive radiation that must have beeneffective for a considerable length of time (geologically).

A.A. Kukharenko's statement (1955) that such diamonds are not radioactive while artifically colored varieties possess highly radioactive properties is hardly correct. Diamonds that have been extracted from a cyclotrone and diamonds that remained in the soil for millions of years and may have lost their slight radioactivity a long time ago should not be compared.

In addition to more or less clearly colored diamonds which are extremely rare, crystals of various smokey shades and sometimes brownish or almost black are more common among Vilyui diamonds. This coloring is, evidently, produced by innumerable minute particles (flakes) of graphite in the diamond. It is particularly characteristic of polycrystal diamond clusters.

At first glance many Vilyui diamonds seem to be of various shades of yellow and sometimes red. A closer investigation reveals that this is caused by a penetration of ferric oxides into the finest cracks in the crystal and, consequently, does not affect the inner coloring of the diamond.

Luminescence

Almost without exception all Vilyui diamonds luminesce under X-rays, cathode rays and ultra-violet rays. The luminescence of diamonds is an intricate phenomenon and is not associated with any other property. At present, the study of luminescence with the help of precise methods is still at an initial stage. For that reason, we confine ourselves to statistical data on the photoluminescence of Vilyui diamonds under the action of ultraviolet rays. These data were obtained through visual observations of their luminescence in apparatus LYuM-1 with bulb PRK-4 and light filer UFS-3. Work was conducted at three to four ampere.

All Vilyui diamonds may be classified into four basic groups according to the character of their luminescence:

1. Diamonds with bluish luminescence;
2. Diamonds with yellow luminescence;
3. Diamonds with slight luminescence

Individual samples were red and green and some with zonal luminescence in addition to the more common blue and yellow luminescence. This, however, is very unusual.

The quantity of diamonds with different kinds of luminescence varies in each diamond-bearing area. In the placer deposits of the midstream area of the Vilyui River 36 percent diamonds have a bluish luminescence, 32 percent yellow, 10 percent luminesce only slightly and the color is indistinct while 22 percent reveal no visible luminescence. In the placer deposits of the midstream area of the Markha River the quantity of diamonds with blue luminescence is twice as large as in the Vilyui River area (60 percent) while diamonds with yellow luminescence are less common (23 percent). Only five and ten percent respectively reveal a very slight luminescence or none at all.

We may assume that there is a certain connection between the habit of a crystal and the color of its luminescence. The number of diamonds with bluish luminescence (various shades) increases gradually as one goes from octahedral varieties via transional varieties to rhombododecahedrons. On the other hand, diamonds with yellow luminescence decrease in number as crystals approach the rhombododecahdral habit.

Inadequate data are available on the correlation of luminescence and such properties of a diamond as its translucence and perfection of form. As a rule, 95 percent diamonds of "the first water" luminesce in various shades of blue while yellow luminescence prevails among smokey-colored and yellowish diamonds. At the same time diamonds of the "first water" with bluish luminescen are almost always found in the form of regular, isometric crystals.

It should be noted that luminescence in various shades of blue is most characteristic of rounded diamonds -- 90 percent of them posses this property -- and to a lesser extent of polycrystal clusters (27 percent diamonds with bluish luminescence).

Inclusions

Inclusions of different minerals in the diamonds of the Vilyui area have not been adequately studied as yet so that the following data should only be considered in the light of preliminary information.

First of all, it should be indicated that inclusions in diamonds are very commonly. A miscroscopic investigation shows that most diamonds have one or several inclusions. These inclusions have not been properly examined. They can be classified into the following groups according to the properties visible with the unaided eye:

Graphite inclusions: this group is most common. Inclusions of graphite are present in the form of fine laminae, scales and amorphous black and gray flakes that are disseminated both in the depth of the crystal as well as under its surface. The size varies from rather large inclusions that occupy a considerable part of the crystal face to extremely fine dust-like particles. There are two types of inclusions.

One type is found along the inner cracks of the diamond forming flat rounded blades (Figure 138) or rosettes (Figure 139) composed of several blades located on different levels but intertwined in the center. This center is always represented by either a crystal or a grain of a translucent mineral without a regular face included into a diamond (Figure 140). According to

A.A. Kukharenko (1955) graphite is an epigenetic inclusion that emerges after the formation of the diamond crystal on the walls of the cracks "as a result of the polymorphous transformation from diamond to graphite (cliftonite) apparently in connection with the drastic change in pressure during the formation of cracks." Inner cracks are evidently, the result of the difference that exists between the coefficient of linear expansion of the diamond and the translucent or ore mineral included in this diamond and representing the center of the rosette of graphite and, at the same time a syngenetic inclusion.

Another type of inclusions is found in the form of fine and minute flakes and particles of graphite disseminated in the diamond without any apparent pattern. This variety of inclusions is rather characteristic of smoke-colored diamonds and polycrystal diamond clusters where they actually invade the entire crystal accounting for its gray or even black color (in the center of polycrystal clusters).

It should be noted that rosettes and large blades of graphite were never found together with small flakes of graphite which clearly indicates the difference in their origin.

Inclusions of Translucent Minerals: As a rule they are rather fine (Figure 141, 142) crystals with well marked planes (Figure 143). Sometimes they are present in the form of grains broke at one end (Figure 144) or deformed and elongated with traces of faces (145). Most of them are completely colorless and transparent but sometimes richly raspberry and violet colored crystals are encountered. In the mass of the diamond all these inclusions are very conspicuous which bears wittness of an essential difference in the indices of refraction. There is no doubt that some of these inclusions belong to the olivine group. Yu. L. Orlov (Central Expedition of Union Trust No. 2) determined the following data for inclusions of a transparent greenish mineral in a diamond taken from the placer deposit of the Upper Kokun: $Ng = 1.690$, $Np \approx 1.650-1.652$, $2V \approx 90$. Through spectrum analysis Yu. L. Orlov established the presence of Si, Al, Mg, Fe, Ni and traces of Cr in another similar inclusion in a diamond from the placer deposit of Kolkhoznaya.

A.A. Kukharenko (1955) reported on inclusions of crystalline zircon found in Ural diamonds. However, Yu. L. Orlov's latest research showed that what has been taken for inclusions of zircon in Ural diamonds by A.A. Kukharenko was identified frequently either as olivine or garnet after a thorough study (Figure 146).

O.sic L.Orlov determined for one of these inclusion - an isotropic clear violet ghade grain -- N 1.768 and detected Si, Mg and Fe through spectrum analysis. Thus, the most common inclusions in diamonds are the same minerals that accompany it in kimberlite, i.e. olivine and pyrope.

As already pointed out the transparent inclusions are often surrounded by rosettes of graphite that develop along the inner cracks which run from the inclusions outward. This applies to colorless inclusions. We did not observe such rosettes around colored - (raspberry and violet) inclusions.

<u>Inclusions of ore minerals:</u> This group includes pitch-black crystals and irregular grains with a strong metallic luster (Figure 147). Both are found rather frequently in diamonds. They are present individually or in groups.

Contrary to blade inclusions of graphite these inclusions are clearly volumetric. Infrequently, some of them are surrounded by the above-mentioned rosettes of graphite. Whenever such grains are found in the form of regularly shaped octahedrons (Figure 148), usually with slightly rounded edges, we may assume that they are inclusions of chromium spinellide. Inclusions of ilmenite and magnetite may also be present.

<u>Inclusions of diamonds:</u> Diamond inclusions in diamonds are relatively rare. Usually, they are observed in the form of flat faced laminated octahedrons which are sometimes rather large by comparison to the surrounding crystal. This kind of inclusions may be distinguished with the unaided eye from other transparent and colorless minerals by the absence of surrounding cracks (with and without graphite). Moreover, their outlines are hardly visible; the inclusions seem to be submerged in the mass of the surrounding crystal and in this respect resemble phantom-crystals. These characteristics that distinguish them from other inclusions are brought about

by the fact that the coefficient of linear expansion and the indices of refraction of are the same for both, the inclusions and the surrounding crystal.

In addition to the above mentioned inclusions, inclusions of other minerals are present in Vilyui diamonds. However, they have not been identified and studied.

In some diamonds, for instance, fine irregular or elongated transparent yellowish-brown grains were encountered that may or may not be classified as brookiete and rutile. It is also possible that the elongated columnar black, almost opaque prismatic grains surrounded by a pattern of graphite cracks and found in one sample belong to the same group of minerals.

In two diamond cr stals rather large laminated emerald-green inclusions were identified and tentatively classified as chromdiopside.

It is interesting that there are inclusions with inclusions. In an elongated, colorless transperent crystal, for instance, included in a diamond and estimated to be a member of the olivine group numerous (over 10) inclusions in the form of rounded evenly disseminated spots were recognized.

There is no doubt that future detailed study of inclusions in Vilyui diamonds backed by the application of methods of mineralogical research will considerably amplify and complete the above classifications providing a key to the better understanding of the physicochemical conditions under which the formation of diamonds takes place.

State of Crystals and Traces of Mechanical Deterioration

A considerable part of Vilyui diamonds found in placer deposits consists of fractures. Usually, the average weight of the fractures differs only slightly from the average weight of whole crystals found in the same placer deposit which is caused by more or less similar conditions under which fractures and whole crystals are released and redeposited.

Fresh sharp angular fractures from vertexes, edges and, less frequently faces of the crystal have a glossy surface and show the greatest mechanical damages as a result of being transported by rivers from their original sites to placer deposits (some fractures are also found in kimberlite pipes). It goes without saying, that the degrees of these damages vary greatly ranging from tiny chippings on the edges of the crystals and including sharp angular spliners surrounded by cleavage planes (Figure 149, 150, 151, 152, 153, 154).

Usually, no traces of deterioration were observed on the surfaces of such fractures and on the well-preserved parts of crystals. Only their sharp and thin edges were broken and friable.

In the overwhelming majority of cases fractures in the crystal follow the directions of octahedral faces. The surfaces of the fractures have a terrace-like appearance. (Figure 155). But breaks with curved lines occur so that the surface of such breaks is conchoidal (Figure 156, 157).

A great number of damaged diamond crystals were found in the placer deposits of the Vilyui River Basin. About half of the total quantity of crystals that occurs there is damaged. Downstream, the number of fractures and splinters gradually increases. In the midstream area of the Markha River, for instance, it increases from 40 percent (in the placer deposits of the Ustrichnaya) to 60 - 70 percent (in the placer deposits of Nizhnaya and Ozernaya).

In addition to very common fresh fractures, crystals with traces of damages on faces and edges are very rare. This kind of damage proves that the action of water was protracted and intense so that the breaks were not brought about by single strong blows. It marks the faces by a coarse mechanical matting that fills numerous cracks, hollows and dents on the edges and at the vertex of the crystal (Figure 158).

When edges get continuously rounder vertexes more and more truncated it may end in the formation of completely rounded ball-shaped and ellipsoid grains with a dull surface. So far ball-like diamonds have not been found in the Vilyui River area but they are known to exist in the Ural Mountains.

Contrary to matting on the texture mechanical matting (at least at the early stages) does not affect the hollows on the surface plans of the crystal. It always entails fine cracks and dents formed on the edges and perpendicularly to them. The matting marks the faces with a closely intertwined chaotic pattern of extremely fine scratches and "dots" caused by blows.

Since diamonds with the marks of the above mechanical deterioration are extremely rare it is superfluous to classify them into a special genetic group as done, for instance, by A.A. Kukharenko for the Ural Mountains where this variety of crystals occurs commonly. It should be remembered that there are many dams (formed by the outcrop of traprocks) along the Vilyui and Markha Rivers where this variety was discovered, particularly in the upstream area of the Vilyui River. Many "pot holes" mark the dams. In such a "pot hole" a diamond would rather quickly show the baove traces of deterioration under the action of erosion in such natural "ball mill".

Diamonds found in the original sites as well as in placer deposits of the Vilyui River are of a rather poor quality since they are small with a considerable quantity of fractures and splinters, particularly diamonds in placer deposits. Diamond suitable for use in the jewelry trade are rather rare and the Vilyui varities are, essentially, for industrial purposes.

2. Basic Morphological Types of Vilyui Diamonds

A comparative study of many thousands of diamonds found in the placer deposits and in original sources of the Vilyui River Basin revealed that some of the characteristic properties were interlinked, i.e. occur simultaneously in the same types of crystals. Regular octahedrons, for instance, are almost always transparent, have a strong luster, do not contain numerous fine dust-like inclusions of graphite and mostly luminesce in bluish shades under the effect of ultraviolet rays. Diamonds with "splintery" striation are often muddy and contain numerous fine inclusions or either graphite or ore mineral; their luster is much weaker than that of well-formed octahedrons. Rounded diamonds belong to the group known as "first water" stones, they contain no inclusions and their luminescence is bluish, etc.

This fact allows for the identification of certain morphological types of crystals among the great variety of diamonds. Diamonds of the same morphological type and related through certain characteristic properties that occur simultaneously must have formed under similar conditions.

The following morphological classification of Vilyui diamonds is chosen arbitrarily. The manner in which the layers grow on the crystal and the characteristic properties of the layers of growth have been chosen as the basic indication inasmuch as both are directly associated with the conditions of crystallization.

The following morphological types of diamonds occur most commonly in the Vilyui River Basin including the basins of the Markha and Tiung Rivers:

Octahedrons with Flat Faces

This group comprises primarily perfect octahedrons with even lustrous planar surfaces, sharp straight edges and sharp vertexes. These crystals are not very common but in some deposits they are not a rarity. The above-mentioned octahedrons with traces of laminar (layer) formation manifested in a certain truncation of the edges as a result of the decreased growth of the layers toward the center of the plane, i.e. a gradual diminishing of their size, are members of the same group. Inasmuch as the overwhelming majority of the layers of growth is ditrigonal the laminar structure of the crystal is shown by a certain expansion of the edges toward the vertexes and by sheaf-like striation. Parallel striation is observed less often and on trigonal laminae (Figure 159).

All crystals of this morphological type have not only the form but also some other properties in common. As a rule, they are colorless diamonds of the highest quality (first water), very transparent, of a pure diamond luster that is accompanied by iridescence. Colored, dull or smokey crystals are not found in this group.

These diamonds rarely have any inclusions. As a rule, they are present in the form of individual relatively large diamond grains (sometimes surrounded by graphite rosettes), colorless, pink and violet crystals of transparent minerals (olixine or garnet?), large grains or crystal of ore mineral. Fine dust-like inclusions of ore minerals and fine numerous flakes of graphite are not characteristic of such diamonds.

Only the above-mentioned inversely paralle, triangular concavities of growth occur very commonly among the sculptures on the plance surfaces.

The average weight of octahedrons with smooth flat plane surfaces differs for diamonds from different deposits and diamond-bearing areas although the other common feature remain unchanged.

Crystals formed of Trigonal Layers of Growth

This group includes crystals with surfaces of the thick layers of growth that are visibly diminishing as the surface plane grows. Most diamonds of this type are octahedrous. Crystals of transitional habit (Figure 160) are less common. Crystals of rhombododecahedral habit are only found in exceptional cases. Small flat octahedral faces always remain where the triad axis of symmetry emerges.

This type of crystals bears a similarity to the above-mentioned octahedrons with traces of laminar structure. However, there is an essential difference between the planar and the profile form of the layers of growth. On the surface the layers of growth have very straight trigonal contours. The diminishing surfaces of the layers of growth that form eventually -- so-called "terraces of growth"-- have sets of vertical end planes and sharp edges instead of tapering down to nothing as in the preceding type.

Most crystals of the above-mentioned type are thinly laminated. A pattern of even parallel dash lines replace the edge of an octahedron with no traces of a cleavage seam are very characteristic of these crystals.

Almost no perfect diamonds are found in this group. But smoke-colored crystals and crystals with a great number of dust-like inclusions of ore mineral and flake-like inclusions of graphite are very common here.

Inversely parallel triangular concavities growth on this type of crystals have almost never been encountered.

It is an interesting fact that in most original sources of diamonds as well as in placer deposits small quantites of variety are present among the smallest diamonds.

Crystals with Polycentric Faces

Protruding and laminated triangular formations on the faces of the octahedron that are arranged parallely to its were discussed in the chapter on the general morphological characteristic of Vilyui diamonds. Diamonds of peculiar appearance classified into a special morphological group are a result of the unusual development of these growths.

Diamonds of octahedral habit belong to this group and less frequently diamonds of a transitional form with numerous protruding and clearly laminated ditrigonal (much rarer trigonal) formations on the faces of the octahedron (Figure 161, 162, 163). This structure of the crystal testifies to an extremely pronounced growth of the face of the octahedron at different points simultaneously or almost simultaneously. Evidently, the morphology of such crystals indicates that crystallization took place under some special conditions which may be determined by rapid drops in temperature and pressure, i.e. conditions of tremendous super saturation.

Particularly characteristic of this group are crystals with overlapping faces that are distributed in several rows in the form of comparatively flat, thinly laminated triangular formations (Figure 164). Irregularly developed crystals are frequently found among them. When such octahedron with a polycentric aley growing face is also elongated in the direction of one of the secondary axes of symmetry the triangles of the growth that protrude toward linear expansion of the vertex of the octahedron lend the diamond a "comb-like" appearance (Figure 165, 166).

The overwhelming part of this type of crystals is extremely transparent and colorless, although "first water" stones are not very common. Smokey crystals are ver rare and not all all characteristic of this group.

Inclusions are also rather rare. They are almost exclusively represented by large rosettes of graphite and large (in comparison to the diamond) individual grains (frequently well surrounded by minute crystals) of diamond, olivine and garnet (?).

The average weight of diamonds in this morphological group varies for different deposits.

Crystals compesed of Distrigonal Layers of Growth

We included into this group finely laminated octahedral, transitional or rhombododecahedral crystals composed of distrigonal or shield-like layers of growth in which the edges of the octahedron are replaced to one degree or another by surface which correspond as far as their location is concerned to the planes of a rhombododecahedron. Figure 167, and 168 represent the microphotographs of these crystals.

A distinct and often coarse pattern of sheaf-like lines on the surface is their characteristic property corresponding to the planes of a rhomobododecahedron (where the ribs of the octahedron are). It is usually intersected by several winding planary seams. This pattern is formed of the ends of the laminae of growth. As a rule, the edges of these laminae are rounded and not sharp as, for instance, in crystals composed of diminishing trigonal layers of growth. Sometimes this pattern of lines forms whatlooks like folds -- "crimping."

Most crystals in this group are colorless and transparent but smokey diamonds are not a rarity. Occasionally diamonds of "first water" are found. Mostly, they are formed of shield-like laminae, i.e. the obtuse angles of the ditrigonal laminae that make up these diamonds are rounded.

Rather common among the sculptures on the surface of the octahedral faces are inversely parallel triangular hollows of growth. Inclusions are mostly represented by fine flake-like formations of graphite. The average weight of diamonds in this group vaires for different diamond-bearing areas.

Crystals with a "Splintery" Pattern of Lines

These diamonds resemble diamonds in the preceding group. This group also includes finely laminated crystals of octahedral (Figure 159) transitional (Figure 170) and rhombododecahedral habit (Figure 171) formed of ditrigonal layers of growth.

They differ from the members of the preceding groups by the pattern of "lines on the edges of the rhombododecahedron." Evidently, the protruding ends of the individual layers of growth that were dislocated as a result of crystallization and form the pattern of lines do not follow a continuous line "along the faces of the rhombododecahedron" but are distrupted and replace each other echelon-like. The result is a peculiar "splintery" pattern of lines. As a result, the protruding ends of the layers of growth have rounded edges (as on crystals made up of ditrigonal layers of growth) and are often thicker where the lamina ends so that the latter appears to be emerging to the surface "at an angle".

Octahedral crystals of this type and generally crystals with well-preserved sections of octahedral faces can be recognized the the striking combination of a pattern of "splintery" lines as found on the faces of a rhombododecahedron on the even lustrous faces of an octahedron. The flat sections of the face of the octahedron are often marked by relatively large, individual inversely parallel triangular hollows of growth or sets of them which sometimes are found in the center of theplane. This type of crystals is frequently smoke-colored.

Diamonds of first water are rare. Inclusions are not characteristic of this group. When inclusions are present they consist of fine flake-like particles of graphite and ore minerals.

The average weight of diamonds in this group varies somewhat in the different original sites and various diamond-bearing placer deposits.

Crystals with Rounded Step-like Faces

Most crystals in this group have an octahedral or transitional appearance. A combination of the flat sections of the faces on an octahedron with step-like surfaces planes that correspond to the planes of a rhombododecahedron are found on these crystals.

This group of crystals is distinguished by individual steps formed on the edges of preceding thick layers of growth with a rounded profile (Figures 172, 173, 174, 175, and 176). Each of these layers has an outer edge that forms the end of a rounded step and is made up of numerous thin layers of growth. These layers, in turn, gradually diminish in size, they reced from the border, i.e. from the basis in direction of the tope of the step. This process explains why the steps have a characteristic rounded form. However, the steps are not always perfectly regular. They vary in height and their arrangement is not necessarily parallel.

Frequently, they run close to each other, taper out, replace each other in sets parallel to the edges of the octahedron.

If we assumed that the formation of crystal layers proceeds in a rhythmic manner, the existence of this type of crystals evidently shows that there are greater rhythms (thich rounded steps) that affect a series of smaller rhythms so that the formation of numerous individual fine layers of growth is explained.

Diamonds with rounded "step-like" faces are, as a rule, composed of distrigonal laminae which usually look like a shield. When the seam is clearly marked it can be traced throughout all the steps.

Thick laminae of growth are occasionally dislocated but they are always shifted toward the vertex and not toward the vertex and the edges as observed on crystals with faces that develop simultaneously at different points.

Diamonds with rounded step-like faces are usually colorless and transparent. Perfect stones (first water) are rather rare in this group. So far no inclusions were observed in this group.

The average weight of these diamonds is rather high in most deposits.

Crystals with Block Sculpture[x]

These diamonds (Figure 177) are usually represented by rhombododecahedrons (Figure 178) and less often by octahedrons which are frequently deformed. The faces of the diamonds are formed of individual closed curvilinear plane surfaces interlined with regularly bent lenses. Thus, the crystal appears to consist of individual sections (blocks) with different forms of perimeter and a differently curved surface, either convex or concave.

Triangular hollows and other accessories of growth characteristic of other groups of crystals are not typical for crystals with block sculpture.

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[x] This type of sculpture was identified and described by A.A. Kukharenko (1955) for the crystals of Ural diamonds.

Extremen transparence and a strong luster are inherent in members of this morphological group. Crystals are either completely colorless or are very slightly bluish. Inclusions are rare and consist of crystals and grains of diamond, zircon (?), graphite (rosettes) or ore mineral.

Most high-grade Vilyui diamonds with a very strong diamond luster are members of this group. The combination of numerous surfaces with various degrees of curvature produces an extremely strong natural iridescence.

A sharp predominance of bluish luminescence under the effect of ultraviolet rays is very characteristic of diamonds with block sculpture.

Diamonds in this group are of average size. Their average weight is more or less similar in all original sites of occurrence (from ten to 15 milligrams).

Rounded Crystals

This group includes rounded rhombododecahedrons with convex faces that are intersected by seams approximately along the short diagonal of the rhombus (octahedroids and dodecahedroids). This type of crystals are rather rare in the Vilyui area and in Siberia, in general, but they are in predominance in he placer deposits of the Central Ural Mountains. Rounded diamonds from the Ural Mountains have been thoroughly investigated and studied by A.A. Kukharenko (1955) and I.I. Shafranovskyi (1948).

Samples of rounded Siberian diamonds found in the placer deposits of the Vilyui River Basin are shown on Figures 179, 180, 181 and 182. We believe that rounded Siberian diamonds are produced by a series of gradual transitions that starts with ordinary laminar pseudorhombododecahedrons and proceeds to laminar crystals of octahedral habit.

Regardless of whether we assumed that rounded diamonds are the finished product of dissolved flat-faced octahedrons, or crystals with an extremely slow development, the growth of the latter being stunted periodically by partial dissolving, they must have formed in the process of slow crystallization deep within the earth.

Let us indicate some characteristic properties of rounded Siberian diamonds. Frequently, they are very transparent and many stones of first water are found among them. At the same time, this group comprises the basic mass of colored (yellow, light blue, green) diamonds which are extremely rare in Siberia. As a whole, inclusions do not occur commonly in these diamonds.

The faces of diamonds in this group are frequently marked by "tiled" sculpture (Figure 180). Peculiar patterns such as, for instance, a fine pattern of rhombic cracks (Figure 181) is found almost exclusively in members of this group.

The socalled "caverns of corrosion" are almost always associated with rounded diamonds (Figure 182).

Matted rounded rhombododecahedrons are included in this group. The matting of the texture affects sometimes the faces in the form of individual spots. However, this kind of matting affects diamonds of all morphological groups. But the conspicuous connection between some of the above-mentioned sculptures and rounded diamonds obviously reflects some characteristic properties of diamonds that are associated with either their origin or the form and, consequently, with the symmetry of the faces.

In regard to luminescence rounded diamonds differ essentially from members of other morphological groups. As a rule, 80 to 100 percent rounded diamonds from placer deposits of different areas luminesce in bluish shades under the effect of ultraviolet rays. It should be emphasized that the intensity of photoluminescence of rounded diamonds is considerably higher than in diamonds of other morphological groups.

Among rounded diamonds distored forms (Figure 183) occur rather frequently. They are either elongated or unilaterally pointed. This kind is widely found in the placer deposits of the Tiung River Basin (Figures 184 and 185).

Crystals of Cubic Habit

Crystals of cubic habit are extremely rare among Vilyui diamonds and single units are found among thousands of other forms (Figure 186). The cubic faces on these crystals are always uneven.

They are covered by a pattern of tetragonal truncated small pyramids (Figure 187 and 188); the bases of these pyramids follow the diagonal of the face. Octahedral faces usually develop on top and along the edges of the dube. As a result the vertexes of the cube are truncated by trigonal small pyramids that grow on it while a peculiar "ladder" forms along the edges (Figures 187, 189, 190). In most cases cubic crystals are isometric but sometimes expansion along a tetrad axis is observed (Figure 188).

The formation of such crystals is undoubtedly, caused by peculiarities of the process of crystallization. We know, for instance, (G. Bakli, 1954) that alum crystals cultivated in alkaline solution form cubes that develop as octahedrons after transfer to a neutral solution.

Crystals of cubic habit are formed with octahedral faces, on the edges and vertexes. They strongly resembling diamonds of cubic habit (Figure 191). Probably the altered composition of the medium of crystallization plays a decisive role in the formation of these crystals.

2. OCCURRENCE OF DIAMONDS OF DIFFERENT MORPHOLOGICAL GROUPS IN ORIGINAL SITES AND PLACER DEPOSITS

Diamonds in Original Sites

For the time being a rather considerable quantity of diamonds has been found only in the two kimberlite pipes "Mir" and "Zarnitsa."[x] For that reason, we shall confine our selves to reporting on these two pipes.

First of all we should like to note that the morpholigical composition of the diamonds within one and the same site of occurrence varies considerably as assumed on the basis of research in diamond-bearing placer deposits of various areas.

Members of most (with rare exceptions) above-mentioned morphological categories are found in original sites of occurrence as well as in placer deposits. In each of them two or three morphological types sharply predominate (mostly the largest ones) while others occur in much smaller quantities or as single units.

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[x] In 1956 a great quantity of diamond crystals was obtained from the pipe "Udachnaya."

Table 25 shows the occurrence of diamonds of different morphological groups according to number and weight (in percent) in the kimberlite pipes of the Vilyui River Basin.

Table 25

Number	Morphological groups of crystals	"Mir" diamond content in %	"Mir" average weight in mg	"Mir" content in % weight	"Zarnitsa" diamond content in %	"Zarnitsa" average weight in mg	"Zarnitsa" content according to weight in %
1	2	3	4	5	6	7	8
1	Octahedrons with smooth and flat faces	15.7	20	16.2	5.0	5.2	1.1
2	Diamonds with polycentrically growing faces	36.5	24	45.3	7.0	4.0	4.3
3	Diamonds composed of trigonal laminae	1.0	6.5	0.4	7.0	1.5	2.1
4	Diamonds composed of ditrigonal laminae	9.2	14.7	8.1	7.0	-	-
5	Diamonds with a pettern of "splintery" lines	27.8	13.4	19.3	41.0	7.2	45.1
6	Diamonds with rounded faces	4	19.6	4.1	2.0	13.0	5.6
7	Diamonds with block sculpture	7.2	18.0	6.6	17.0	10.9	38.1
8	Rounded diamonds	-	-	-	4.0	2.6	1.5
9	Other groups of diamonds	-	-	-	10.0	-	2.2

In the pipe "Mir" diamonds with polycentrically growing faces are in sharp predominace (36.5 percent), followed by striated diamonds (with a "splintery" pattern) (27.8 percent) and octahedrons with flat and even faces (15.7 percent). Almost 80 percent of all diamonds in the "Mir" belongs to one of these three morpholigical groups. The quantity of diamonds of other groups is insignificant and no rounded diamonds have so far been encountered.

In the kimberlite pipe "Zarnitsa" diamonds with "splintery" striation predominate (41 percent), second come diamonds with block sculpture (17 percent). Diamonds with polycentrically growing faces that predominate in the pipe "Mir" make up only 7 percent of the total of diamonds in the pipe "Zarnitsa", while octahedrons with planar and smooth faces amount to 5 percent.

There is a correlation between the average weight of diamonds in different morpholigical groups and their occurrence in these two original deposits. Diamonds with polycentrically growing faces are, for instance, common in and characteristic of the pipe "Mir"; they are also larges in size (average weight 24 milligrams). At the same time, the average weight of these diamonds in the kimberlite pipe "Zarnitsa" amounts to a mere five milligrams, i.e. they are five times smaller and occur five times less often than in the pipe "Mir" while diamonds with "splintery" striation and block sculpture are most common in "Zarnitsa" and are, at the same time, the largest.

Thus, the difference in the morphology of diamonds from various kimberlite pipes is very obvious. It is even more conspicuous if we considered the member of each morphological group in terms of weight (and not in quantitative units) as compared to the total mass of diamonds of a given original site of occurrence. These figures (obtained by multiplying the average weight of the diamonds in a given morphological group by their contents in percentage and converted into 100) are shown in columns 5 and 8 of table 25. These data prove that 81.8 percent diamonds (according to weight) in the pipe "Mir" have polycentrically growing faces of "splintery" striation or are octahedrons with flat and even faces

The total of other groups amounts to a mere 19 percent. However, the content of none individually exceeds ten percent.

Diamonds with "splintery" striation and block sculpture amount to a total of 83 percent (according to weight) in the kimberlite pipe "Zarnitsa."

We see that the basic mass of diamonds of one original site of occurrence or another contains only few morphological groups of crystals which were formed, evidently, under different physico-chemical conditions of crystallization in either different kimberlite pipes or within vaster limits (kimberlite fields).

The question may arise as to how permanent the morphology size of diamonds is within the kimberlite body and in its various sections. The study and exploitation of South African original diamond-bearing deposits shows that the structure of kimberlite pipes is often very intricate. They are formed of several "columns" of kimberlite with a different composition and texture and diamond-bearing to different degrees. The diamonds vary in size and shape.

Geophysical works conducted on the pipe "Zarnitsa" also revealed that the composition of kimberlite was not homogenous.

It was established through mining operations in six different sections of the pipe "Mir" that the morphological composition of the diamonds was identical and that their average weight and their dissemination was very similar.

Thus, the diamonds in the entire kimberlite body of the pipe "Mir" are morphologically homogenous, similar in size, and more or less evenly disseminated. It goes without saying, that this is only one example so that more complicated cases are likely to exist.

The above data testify to the fact that the morphology of Vilyui diamonds is rather versatile. Naturally, we wonder what has caused these crystals to acquiere such different forms and what where the conditions under which their faces have developed. What were the reasons for the formation of octahedrons with regular flat faces and sharp edges along with rounded rhombododecahedrons, and along with crystals of transitional habit and "splintery" striation on the "ribs of the rhombododecahedron"?

It is common knowledge that two different factors determine the forms of the crystal the peculiarities of the inner texture (thin texture) and the external conditions of growth. The inner texture determines only the basic morphological properties of the crystal. Apparently, it also influences to a certain degree the concrete form (geometrical form) of the morphological changes that are produced externally. However, these morphological changes or their absence, the degree of their development, etc. depend only on external factors.

There is a considerable number of such external factors which may influence the growing crystal simultaneously. V.A. Mokievsky (1955) for instance emphasizes the following factors: 1) supercooling of the fusion; 2) temperature at which crystallization takes place; 3) pressure; 4) concentration (conventional) fluxes; 5) direction in which the entire liquid mass (fusion) moves; 6) admixture in the fusion; 7) viscosity of the crystallization agent; 8) state of the dissolved substance; 9) electric and magnetic fields; 10) radioactive rays and other rays.

This enumeration how intricate the above question is. It becomes more complex when in relation to diamonds since their formation under natural conditions cannot be directly observed while they have been only recently developed synthetically in the laboratory. There are only the most general assumptions on the causes of the versatile morphology of diamonds. We believe, for instance, that thinly laminated and regularly formed diamond crystals develop in the process of delayed growth while crystals with a coarsely laminated texture have undergone rapid crystallization.

A.A. Kukharenko has recently proposed a genetic classification for natural forms of diamonds. This classification is to be based on the degree to which saturation affects the growth and the solution of diamond crystals. In the light of this classification we may consider the formation of diamonds with polycentrically growing faces as a result of rapid crystallization from solutions supersaturated with carbon and the formation of octahedrons with flat and even faces as forms grown under conditions of lesser supersaturation, etc. This theory, however, does not shed any light on the finer morphological distinction. There is still no explanation as to why diamonds with rounded step-like faces form in some cases and crystals with block sculpture is others etc.

It should be emphasized that the morphological types of diamonds as discussed in this paper are not actually a specific feature of diamonds found in the Siberian platform. The occur commonly in other diamond-bearing areas throughout the world (see A. Ye. Fersman, 1955; A.A. Kukharenko, 1955). Thus, these morphological types are not an accidental phenomenou but a common feature of all diamond deposits and are, undoubtedly, produced by the action of some external factors in the process of growth.

We should like to point out one of these external factors which has so far been almost overlooked by researchers. It concerns the possible influence of admixtures in the crystallization medium on the morphology of the crystals.

The influence of admixtures on the habit of crystals has been established a long time ago. Abundant literature is available on the subject which deals exclusively with experiments with easily crystallizing salts. The following established facts are of great interest:

1. Admixtures in the solution influence not only the degree of development of one simple form or another, but also the construction of the plane surface. The formation of "laminae" striation (G. Bakli, 1954, page 251) dull and imperfect faces (V.A. Mokievskyi, 1955) was particularly noted in this connection.

2. Even an insignificant quantity of admixtures may produce visible changes in the habit of the crystal (G. Bakli, 1954, V.A. Mokievskyi, 1955).

The above facts indicate that the characteristic forms of the crystals and the structure of the planes may sometimes develop under the influence of admixtures on the growth of the crystal. Even insignificant quantities of secondary components of the crystallization medium may act as such admixtures (this does not exclude the influence of the main components of the crystallization medium on the appearance of the crystals). The process of growth may sometimes be slowlin small diamonds under the influence of a greqt quantity of admixtures in the solution.

The question arises: do any factual data testify to the influence of admixtures on the morphology of Vilyui diamonds? In the preceding text we have repeatedly born down on the essential difference between the morphology of the diamonds found in the pipe "Mir" and the morphology of those in "Zarnitsa." There are, however other differences between these two original sites of occurrence in addition to the morphology and the average size of the diamond inclusions. The quantity and, partially, the composition of some minerals differ essentially in the two pipes.

We know that the kimberlite pipe "Zarnitsa" abounds in grains of magnesian ilmenite encountered in tremendous quantities. Actually, "Zarnitsa" represents a large industrial deposit of this mineral. The presence of magnetite, and secondar magnetite, also marks the pipe "Zarnitsa." In the pipe "Mir" the contents of ilmenite is much lower than in the pipe "Zarnitsa." Magnetite is also found in much smaller quantities.

It is quite possible that the different content of chromium in the kimberlite and garnet of the pipes also exerts a certain influence. However, there are, no definite data available on the subject as yet.

Evidently, the difference in the morphology of the diamonds goes along with an essential difference in the mineralogical composition, i.e. in the chemical composition of the kimberlite. This is no coincidence. It is too early to decide whether the above-mentioned elements directly produce the morphological changes or whether these changes are brought about by accessory admixtures of other elements that are not as common in the kimberlite. But the adduced facts prove that the admixture may exert an influence on the morphology of the diamonds (together with other factors). This question deserves a careful study and its further elaboration will obviously provide a key to the correlation between the geochemical properties of the kimberlites and the properties of diamonds included in these kimberlites.

We should like to emphasize that preliminary morphological classification should not be applied to all characteristic properties of Vilyui diamonds in further research work.

Diamond-bearing Placer Deposits

The conspicuous predominance of a few morphological groups of diamonds in original sources is, of course, not as pronounced in placer deposits. Most of the diamond-bearing placer deposits are located in those sections of the valley above which rivers still have an adequate basin of supply. Inasmuch as there is no doubt that there are many original diamond sources of placer deposits of large streams are studied by analysing a mixture of diamonds from different original sites of occurrence. This mixture provides specific "spectra" of the type of diamonds for each area and may indicate a sharp predominance of diamonds from a primary source as well as some regional characteristics in original sources of diamonds in various diamond-bearing areas of the Siberian platform.

Evidently, the composition of diamonds in placer deposits is less versatile, becoming more uniform and more homogenous as the area of supply tapers down in the vicinity of a certain limited group of original sites.

Table 26 shows the contents of diamonds (in percentage) in different morphological groups in the placer deposits of the Vilyui River Basin. Let us quote a few examples.

The placer deposits of the pipe "Mir" in the bed of the river contain diamonds very similar to those present in the kimberlites of the pipe "Mir" as far as the quantative correlation of the individual morphological types is concrented. A rather conspicuous difference was only noted for diamonds with "splintery" striation and diamonds with round step-like faces. This similarity is only natural since particles are redeposited in the bed of the river as a result of the washout of the pipe "Mir."

Table 26

Diamond-Bearing Regions & Placer Deposits	Flat-faced octehedrons	Crystals with polycentric faces	Crystals composed of triagonal strata of growth	Crystals composed of distrigolan strata of growth	Crystals with "splintery" striation
Placer deposits in the bed of the river around pipe "Mir"	17.4	35.1	0.	8.9	17.5
Old pebble deposits near "Mir"	7.7	33.1	-	11.2	35.6
Placer deposits in midstream section of Malaya Batuobiya River	9.7	31.1	-	12.7	33.6
Placer Deposits in the downstream section of Malaya Batuobiya River	7.3	29.5	-	11.8	37.6
Midstream section of Vilyui River	[illegible]	23.9	1.5	15.8	17.0
Midstream section of Markha River	[illegible]	[illegible]	[illegible]	20.3	30.7
Placer deposits of the Tiung River Basin	2.3	8.5	4.5	[illegible]	[illegible]

Placer deposits in the midstream section of the Vilyui River (from Viuldiukar settlement to Rybachyi settlement) also bear a strong similarity to the pipe "Mir" and to the above placer deposits in regard to the morpholigical content of diamonds inasmuch as the basic mass of diamonds gets transported from these sources and redeposited in the placer deposits. Nevertheless, other original sources of diamonds with a different composition in the basin of the Vilyui River and above the estuary of the Malaye Batuobiya River obviously influence the placer deposits in the midstream section of the Vilyui River. Rounded diamonds, for instance, are present in small but noticeable quantities whereas they are absent in the pipe "Mir".

Table 26 - Cont'd.

Diamond-Bearing Regions & Placer Deposits	Crystals with rounded step-like faces	Crystal with block sculputre	Rounded Crystals	Crystals of Cubic Habit
Placer deposit in the bed of the river around pipe "Mir"	15.5	2.4	-	2.0
Old pebble deposits near "Mir"	1.0	5.4	-	4.8
Placer deposits in midstream section of Malaya Batuobiya River	-	5.8	-	4.9
Placer deposits in the downstream section of Malaya Batuobiya River	1.0	8.7	-	2.6
Midstream section of Vilyui River	8.5	6.7	4.8	6.2
Midstream section of Markha River	5.1	16.2	5.2	6.5
Placer deposits of the Tiung River Basin	7.4	11.9	53.6	-

Old pebble deposits near the pipe "Mir" contained diamonds of great morphological similarity with the diamonds in the pipe "Mir" as well as with these in placer deposits of the midstream and downstream sections of the Malaya Batuobiya River which are located some distance from the pipe "Mir."

A slight decrease in the number of octahedrons with flat and even faces as well as in the number of diamonds with polycentrically grouwing faces was observed while diamonds with "splintery" striation were found in greater quantities. It is probably due to the fact that the members of the two above groups (particularly those with polycentrically growning planes) are much less resistance because of their form than diamonds with "splintery" striation and usually of transitional or rhombododecahedral habits. These diamonds turn to amorphous fractures much quicker and do not fall into any group. Thus, we have a group of placer deposits redoposited rather closely to one original source of diamonds.

Placer deposits in the midstream section of the Markha River are marked by the predominance of diamonds that belong to three morphological groups, namely stones with a pattern of "splintery" lines, stones composed of ditrigonal layers of growth and stones with block structure. There are twice as many of the two latter varities than in the pipe "Mir". There are about ten times less diamonds with polycentrically growing cleavage planes and the average weight is three times smaller. At the same time theplacer deposits of the midstream section of the Markha River differ essentially from the morphological contents of diamonds in the placer deposits an in original sources in the upstream section of the Markha River. There is a considerable number of diamonds composed of ditrigonal layers of growth. In the midstream sections of the Markha River the content of this type of diamonds exceeds that in the kimberlite of the pipe "Zarnitsa" by three lines. All these facts together with data on the dessimination of diamonds according to size lead to the conclusion that independent original sources of diamonds exist in the midstream section of the Markha River.

In regard to the morphology of diamonds placer deposits in the basin of the Tiung River are in a very special category. The sharp predominance of rounded diamonds that exceed ten to 20 times the occurrence of diamonds in other regions (according to weight) leads to the assumption that original sourees must exist in the vicinity which, presumably differ from the kimberlite pipes of the Siberian platofrm. In addition to the practical significance the search for these basic sources is of tremendous scientific value since their discovery would provide a key to the real nature of rounded diamonds that has so far not been clarified despite the incredible amount of time and effort spent in trying to determine their genesis.

The comparative study of the morphology of diamonds in placer deposits and original sites of occurrence is of essential practical value inasmuch as the direction of the research work may open the path to the location of the original sources which will have to be discovered on the basis of the study of diamonds in placer deposits.

V. PLACER DEPOSITS OF DIAMONDS IN THE BASIN OF THE VILYUI RIVER

For the time being we assume that the occurrence of diamonds in the basin of the Vilyui River is a result of the presence of original sources of diamonds, i.e. kimberlite pipes. Through erosion original sources of diamonds supply material for the formation of diamond-bearing placer deposits: eluvium, deluvium and alluvium.

As the entire area of mellow soil in the Vilyui River Basin is seeded with crystals, placer deposits with a high concentration of diamonds are rare while rich diamond-bearing placer deposits are extremely rare. The first diamond-bearing deposits in the basin of the Vilyui River were discovered in 1949.

Placer deposits of Pre-Quaternary and Quaternary Age occur most commonly in the Vilyui River Basin.

Pre-Quaternary Diamond-Bearing Placer Deposits

Peculiar agrillaceous and sandy gravel diamond-bearing deposits discovered in the basin of the Malaya Batuoblya River near the pipe "Mir" belong to Pre-Quaternary placer deposits of the Vilyui diamond-bearing basin.

The fragmental material is uniformly represented by pebbles and gravel of quartz, quartzite, flint and other minerals which are only slightly affected by weathering, with some greatly deteriorated pebble of kaolinized rocks. The diamond-bearing deposits are underlain by light blue, bluish-gray, yellow, raspberry red and multi-colored dense and heavy clays. These deposits were discovered on a very small territory (150 by 300 meters) associated with the top carbonaceous basement rock that has karst topography. The thickness of the deposits is extremely variable ranging from one to 45 meters. Considerable quantities of pyrope and diamonds in the clayey and sandy gravel deposits were detected in preliminary tests.

The origin of diamond-bearing deposits has not been determined. Evidently, they have formed by the erosion and redeposition of the products of chemical weathering. They are the products of the surrounding Permian and Jurassic deposits as well as the traprocks and kimberlite with a rather blurred profile.

The occurrence of diamonds in the deposits is, evidently, connected with the neighboring kimberlite pipe "Mir.". It is quite possible that the diamonds have been set free by other pipes yet to be discovered.

Despite the lack of an apparent connection between the above deposits and the terrace and bed formations of the Malaya Batuobiya and Ireleekh rivers we may affirm that there are intermediate diamond collectors in the Malaya Batuobiya region representing a link between original sources of diamonds and alluvial placer deposits of the Quaternary Age.

Arbitrarily these deposits are considered to be of Pre-Quaternary Age, most likely of the Tertiary period. This, however, based on very general assumptions and by analogy with other regions of the Siberian platofrm where a kaoline crust, formed by weathering, was identified on rocks of the Upper Cretaceous. In this region the deposits could not be of earlier age since in the terrigenous formations of Permian and Jurassic Age in their immediate vicinity neither diamonds nor its paragenetic accessories have been discovered.

For the time being it is not possible to state anything more definite about the intermediary diamond collectors in other regions of the Vilyui diamond-bearing basin. At this point, however, we should like to note sections of sandy and gravel deposits were encountered in the basins of the Markha and Tiung Rivers where tests showed the presence of pyrope, chromdiopside and magnesian ilmenite -- the accessory minerals of diamonds -- which leads to the assumption that these deposits are very likely to be diamond collectors. Sections of gravel and pebble deposits enriched by the paragenetic accessories of diamonds and bearing diamonds are associated with the areas of development of the Euxenite Formations and so-called "watershed conglomerates" that occur commonly in the area between the Markha and the Tiung rivers.

New data have become available now testifying to the presence of older intermediary diamond collectors than the above-mentioned. The scholars of the Scientific Research Institute of the Mining Industry identified conglomerates in the upstream section of the Markha River that may have originated in the Permian Period and that contained diamond and pyrope.

Quaternary Diamond-Bearing Placer Deposits

Among placer deposits of Quaternary age eluvial, deluvial and alluvial placer deposits as well as placer deposits in short, gentle valleys should be discussed here.

1. Eluvial Placer Deposits are connected with diamond-bearing kimberlites and represent their products of weathering. The size of the eluvial diamond-bearing placer deposits depends on the size of the kimberlite pipes varying from 40 to 560 meters in diameter. The shape of the placer deposits reflects the shape of the kimberlite pipes.

The thickness of eluvial deposits is not constant even within the limits of one pipe fluctuationg between one to four meters and more. In the upper part of the layer the eluvium deposits are represented by a clay-like yellowish and greenish-gray mass which is enriched with gravel, rubble and kimberlite fragments; the latter predominate in the bottom of the layer.

2. Deluvial Placer Deposits have not yet been investigated and there is very little information available.

This type of territorial placer deposits are associated with eluvial deposits repr senting their deluvial fans on the slopes of water currents that have washed out or are still washing out the original sources of diamonds. They are usually encountered in the form of clayey or sandy and subargillaceous formations with a varying contents of rubble from local original rocks - primarily rocks of the Lower Paleozoic.

Kimberlite material weathered down to gravel, sand and fine particles of soil was found in the immediate vic nity of the kimberlite pipes.

Microscopic examination revealed that the paragentic compaions of diamonds -- pyrope, magnesian ilmenite and chromdiopside -- play a substantial role in the constituency of the deluvial placer deposits. Diamonds were found in the neighborhhod of some pipes (pipe "Zarnitsa," "Udachnaya," et al).

Deluvial placer deposits were found near all kimberlite pipes but their industrial value has not been established as yet. These placer deposits may lead the way to original sources of diamonds in regions where kimberlites have not been affected by erosion at the time being.

3. Placer Deposits in Short Gentle Ravines have not been studied adequately. There are closely liked with deluvial deposits. They are present in the basin of the rivers Malaya and in the basin of the rivers Makyn, Mlumileme, Tiung and Chenidikon. The loose deposits of which the water-collecting depression of the valleys that wash out the pipe "Mir" is composed represent a layer of turf, plant and subsandy and subargil aceous sedimentation underlain by sand and gravel deposits as well as rubble and boulder material of Lower Paleozoic carbonaceous rock. Below the pipe "Mir" great quantities of pyrope and ilmenite were identified in the sandy and gravel material and diamonds were recognized by the unaided eye. In the section where the water collecting depression passes the marshy mouth of a stream that has once existed here this material is somewhat rewashed forming a transitional material between deluvium and aluvium.

4. Aluvium Placer Deposits occur very commonly in the basin of the Vilyui River and its tributaries. Terrace and valley deposits are conspicuous in this area (Figure 192). Terrace placer deposits are associated with alluvial accumulations of pebbles at terraces one, two, three, four and five.

Diamonds were discovered in all terrace formations along the larger streams in the area where diamond-bearing placer deposits are developed in the valley. However, with few exceptions, the concentrations are insignificant.

Research work along the rivers Vilyui and Markha showed that the concentration of diamonds decreases regularly from the upper to the lower terraces. The concentrations are greatest in the placer deposits of the first and second terrace; but even they do not represent any great value in view of the low contents of diamonds particularly in relation to the total mountain area.

The terrace deposits in the Malaya Batuobiya regions have not been studied adequately. However, it is quite obvious that in the deposits of the first terrace as well as around the mouths of the stream the diamond contents in some spots exceeds by many times that of the rivers Markha and Vilyul.

The placer deposits in the valley fall into the following categories:

a) flood plains;
b) placer deposits in shoal, banks and beaches;
c) placer deposits in the fans of washed out mesas;
d) placer deposits on alluvial islands, sand bars and banks;
e) placer deposits in the river beds.

All the above types of valley deposits are interlined by mutual transitions so that the above classification is arbitrarily chosen.

Placer deposits in flood land occur commonly in the valley of the Malaya Batuobiya River. In the downstream section of the river they are traced along the outside of the meander. As a rule, the content of diamonds there is somewhat lower than in the actual river beds of alluvium islands, sand bars and banks and in the placer deposits of shoals, banks and beaches.

No kimberlite fragments were found in the constituency of the boulder, pebble and rubble material of alluvial placer deposits. They were merely identified in the form of individual rather small fragments in the water-collecting depression of the ravine that washes out the kimberlite of the pipe "Mir" and along the tributaries of the Daaldyn River in the immediate neighborhood of kimberlite pipes.

The fragments of local rocks are disseminated within an area that does not exceed a few dozen kilomers, pebbles of exotic rocks were encountered in the alluvium at a distance of 100 to 200 kilometers and more from the zone where they enter into the river bed.

The size of the fragments in the placer deposits vary greatly: it ranges from one to 12 centimeters (usually pebbles with a diameter of tow to five centimeters) including boulders and detritus of 0.5 meters in diameter. Traps and quartzites are in predominance. The size of the fragments of local rocks decreases conspicuously with the distance from the zone where they enter the river bed. Most pebbles are either round or perfectly ellipsoid. Flat pebbles are rare and is characteristic of rocks of the Lower Paleozoic.

The mineralogical composition of the hard formation of all alluvial diamond-bearing placer deposits is quite homogenous. The presence of pyroxene, ilmenite, magnetite (titanomagnetite), garnet, zircon and limonite is characteristic. The quantitative correlation between minerals (primarily between pyroxene and ilmenite) varies in the placer deposits and depends on the rocks that are washed out by the river. Most placer deposits show a visible predominance of pyroxene which is caused by the common occurrence of traprock. Usually, there are smaller quantities of ilmenite, zircon, chromite, almandine and other minerals of terrigenous formations of the Permian or the Lower Jurassic.

The presence of the paragenetic companions of diamonds -- pyrope, magnesian ilmenite, chromdiopside and pervoskite -- is a characteristic feature of the richest placer deposits. Individual units of pyrope and other paragenetic accessories of diamonds are known to be present in the placer deposits of the rivers Vilyui, Markha and Tiung. In the placer deposits of the Malaya Batuobiya and Daldyn Rivers pyrope and magnesian ilmenite are encountered in considerable quantites. The fact that the deposits contain great quantities of paragenetic accessories of diamonds leads to the assumption that there are rich placer deposits as well as original sources of diamonds.

In addition to diamonds, the placer deposits contain other valuable minerals, such as gold, platinum, osmiridium, and ilmenite. Valuable metals are usually found in the form of minute laminae. There is much ilmenite but its content usually does not exceed 0.7 kilograms per cubic meter. A simultaneous extraction of ilmenite from the placer deposits as well as from original sites should be considered in terms of reprocessing concentrates that are enriched by hard fractions.

The content of diamonds in placer deposits in valleys is greater than that in terraces. It was established that the content decreases the terraces get older. It was also noted that the content of diamonds in valley deposits increases in areas where terrace deposits are richer in diamonds.

The richest diamond-bearing placer deposits are found in the direct vicinity of original sources of diamonds or of rich intermediary diamond collectors. The content of diamonds decreases rather rapidly with the current and rich placer deposits change into poor ones. With the decrease in the content of diamonds average weight of the crystals also decreases and greater deterioration is noted.

IV. METHODS OF PROSPECTING FOR DIAMONDS

Pyrope, picroilmenite and chromdiopside are the most reliable paragenetic accessories of diamonds in original sources (kimberlite pipes). In the process of deterioration that affects the kimberlites these minerals are set free and are redeposited together with the diamonds in eluvial and deluvial formations. Eventually, they are carried away from the original source by the activity of the stream. Since the degree of resistance to deterioration varies, the diamond and its paragenetic accessories are transported at different distances. In order of succession, they resist deterioration as follows: diamond, picroilmenite, pyrope and chromdiopside.

Diamonds and the above paragentic accessories belong to minerals of the heavy fraction and are concentrated in loose deposits under very similar conditions so that these accessory are reliable in signalizing the presence of diamonds.

Examinations showed the correlation between the content of diamonds and that of the accessory minerals in placer deposits.

Diamonds are rare minerals and only small quantities are found in loose deposits. It is often difficult to identify them and x-ray tests have to be conducted. The accessory minerals are in conspicous predominance over the diamonds and can be recognized by their characteristic properties.

In the past great quantities of sand had to be reprocessed to establish the occurrence of diamonds on the Siberian platform as the method of finding diamonds through their paragentic accessories was unknow. Now, launder analyses of the accessory minerals indicates the presence of diamonds in the same deposits. The increasing concentration of pyrope, picroilmenite and chromdiopside in launder tests allows the detection of rich diamond-bearing placer deposits and original sources of diamonds through schlieren photography.

Pyrope is recognized most easily in the field among all accessory minerals.

Pyrope is found in loose deposits usually in the form of sharp angular conchoidal fractures and less often in the form of rounded grains with a corroded surface. Its coloring includes various shades of red, violet and oragne. The size of the grains ranges from extremely fine species to grains of four to five millimeters in diameter. There are rarely any larger grains. Pyrope is most easily recognized when it is encountered in grains of -2 plus 1 millimeters.

In view of its coloring, the identification of pyrope in the field is very simple. It is somewhat more difficult to recognize pink or very light pyropes which are easily confused with almandine. Laboratory tests have to be made on those varieties to determine optic and physical properties that are characteristic of pyrope. First of all, the index of refraction should be established precisely. For pyropes it must not be under 1.767. With the help of various immersion liquids light pyropes can also be detected in the field. However, pink and light pyropes are rather rare and usually dark pyropes occur commonly. This variety is easily recognized by the unaided eye.

It is suggested to conduct experimental work to achieve a separation of pyrope from alamdine with the help of magnetic separation inasmuch as the magnetic susceptibility increases in accordance to the content of iron. The construction of an extremely simple magnetic device to be used in field work would facilitate the identification of pyrope to a great extent.

Picroilmenite is a magnesian ilmenite characteristic of kimberlite pipes. It posses several characteristic properties that distinguish it from ilmenite in traps which occur most commonly in the loose deposits of this region. In the field picroilmenite is not as easily recognized as pyrope. Picroilmenite is pitch-black, has a metalic luster and a rough corroded surface. Sometimes minute crystals of perovskite surround grains of ilmenite. The size of the grains ranges from a fraction of a millimeter to one centimeter and more. The fine grains are usually angular while the large ones are rounded.

Contrary to trap ilmenite, picroilmenite posses magnetic properties -- most of its grains are attracted by an ordinary magnet. At the same time its appearance differs greatly from that of magnetite which is usually represented by dull grains with a tarnished surface. Fine splinters of picroilmenite are transparent and pleochroism can be noticed under the microscope. Through laboratory tests it is easily identified by its chemical composition and, primarily by the considerable content of MgO (from 10 to 17 percent).

Chromdiopside is easily spotted in the field by its emerald-green coloring. Grains that are greatly affected by deterioration are pale green or grayish-green. The grains have an irregular shape and the size varies from a fraction of a millimeter up to 1-2 millimeters sometimes even attaining a size of four to five millimeters and more. Chromdiopside is easily found with the help of chemical and spectrum analyses as well as through the microscope by its optic characteristics.

Diamonds are set free together with their accessory minerals in the kimberlite pipe in the process of deterioration of their original sites of occurrence, gradually losing the other minerals on their way. Least resistant and therefore the first one to disappear is chromdiopside; its largest grains are completely destroyed during transportation by the stream and disappear within the initial ten kilometers.

Pyrope is another fragile mineral and easily splits after entering a stream until it falls apart into tiny splinters disappearing after chromdiopside; it is rarely found at distances over 150 to 200 kilometers from the original source.

Picroilmenite can be transported much further but on the way it usually intermingles with trap ilmenite so that it is identified with great difficulties when found in the form of small grains and at considerable distances from the original source in the field.

The diamond endures transportation best of all minerals and may travel many hundred kilometers from its original site of occurrence. In the course of transportation it loses its paragenetic companions acquiring new accessory mineral on its way. The latter are, however, not associated with kimberlite rocks. In the process of transportation diamonds are disseminated in the mass of alluvial deposits. In the Vilyui Basin they do not form industrial placer deposits at a considerable distance from their original site of occurrence.

The following has to be taken into account in the course of prospecting of diamonds in the Vilyui Basin of the Siberian platform.

1. Valley placer deposits occur most commonly. Since diamonds are seeded almost in all loose deposits, there are but few placer deposits with a more or less high concentrations of diamonds while placer deposits that are rich in diamonds are extremely rare.

2. As a rule, terrace deposits are much poorer in diamonds than valley deposits. This applies particularly to placer deposits that are associated with the valleys of large rivers.

3. Rich diamond-bearing placer deposits are, as a rule, encountered at close distance from original sources. As the distance increases the content of diamonds in alluvial deposits falls rather rapidly.

4. In the overwhelming majority of cases kimberlite pipes are located in watersheds are are usually washed out by small tributaries. It is possible that kimberlite pipes are also present in the valleys of large streams but so far none have been found there.

The preliminary work consists in studying the samples of a given area and selecting the concentrates on a territory here a state survey has been conducted (1 : 1,000,000). The tests of the samples reveal the presence of paragenetic companions of diamonds primarily pyrope and picroilmenite.

If a geoligical survey (on a scale 1 : 200,000) were conducted in that region the concentrates collected during such survey would also have to be checked for paragenetic companions of diamonds. Their presence in the concentrates provides a guide for the geological search for diamonds.

If samples were not preserved or a check failed to reveal the presence the presence of pyrope and picroilmenite (it should be remembered that pyropes may have been washed out in the field during the selection of concentrates) the areas of geological prospecting for diamonds should be determined on the basis of general geological factors. The geological structure of an area, tectonics, stratigraphy, the characteristic properties of magnetic and gravity fields, etc. must be taken into consideration. The problem on favorable geological conditions requires thorough discussion and may be solved only after a detailed study of the kimberlite pipes and the depth of entire cross-section. However, from the very beginning it should be remembered that both regions were kimberlites occur occupy a definite geological position along the edge of the Tunguska Syncline and are located beyond the territory where maximum trap intrustions are found. Kimberlite pipes only tear through the Lower Paleozoic where it is relatively upheaved. A certain connection between the kimberlite pipes and the fractures in the Daaldyn and possibly in the Malaya Batuobiya regions is rather likely.

Geological research on diamonds in new areas is usually launched by field geological and geomorphological investigations with a thorough testing of the concentrates. In the course of the tests (survey) particular stress is laid on the identification of paragenetic accessories of the diamond.

Field investigations in the course of prospecting for diamonds has been started in the valleys of large streams but special attention is devoted to their tributaries, along which diamonds and their paragenetic companions could have been transported.

The scale on which investigations are carried on determines the extent to which the concentrates are being tested. Usually, field research is conducted on a scale 1 : 200,000 in any new region. After the discovery of pyropes and other accessories of diamonds more detailed field investigations are conducted (up to 1 : 50,000). After reducing the area from which the samples are taken by way of elimination the source of pyropes may be identified (or of other paragenetic accessories) and the path of their transporation traced.

In sampling concentrates it is important to consider the quantity of pyropes or chromdiopside in launder tests.

For launder test usually 20 lot (one lot - half an ounce -- translator)are used. The launder test sample is dispersed under a jet of water on sieves with meshes two and one millimeters large. To avoid a loss of particles that are one millimeter large the testing is done over ha basin. Gray concentrates wash out from among material under one millimeter in size. In the process of washing out the concentrates it is important not to wash out garnets.

From among the grains under two and over one millimeters 0.5 to one lot of samples is selected. On the basis of this amount the quantity of pyropes may be estimated (or chromdiopside). The remaining grains (under two and over one millimeters) are dried, packed and dispatched for X-ray tests. Material that is over two millimeters is used to study the content of the substances in the samples.

As a result of the above specialized sampling of concentrates the areas where the paragenetic accessories of diamonds occur are established and section can be outlined where they occur in greater quantities.

In areas where large concentrations of paragenetic accessories are established detailed investigation is launched to determine the presence of diamonds and its approximate rate of occurrence in a given region. Depending on the rate of occurrence, two to five samples are taken from each section where paragenetic accessories have been encountered. The volume of detailed testing amounts to one cubic meter of basic sands. The samples are dispersed under a jet of water on a suspension and screen equipped with two sieves. The size of the meshes is two and one millimeters. The material which is under two and over one millimeter (this material is found to contain the lighest quantity of diamonds) is dried, packed and dispatched for X-ray tests to the nearest laboratory.

Geological research teams should be equipped with portable light jigs which can easily be transported. With such devices material that is under two and over one millimeter large could be processed on the spot. With such equipment not only this material could be processed but also material under four and over two millimeters in size which would contribute greatly to the accuracey of the tests designed to discover diamonds.

The above method of sampling the concentrates allows to establish the regions where prospecting for diamonds should be undertaken in the course of field work. It also leads to the discovery of rich diamond-bearing placer deposits as well as original sites of diamonds.

However, not all the original sources of diamonds contain large quantities of pyrope that is always easily identified in the field. Such accessories of the diamond as picroilmenite are difficult to spot. For that reason, final conclusions on the results of tests should only be made after processing the material.

IV. GEOPHYSICAL METHODS OF DISCOVERING ORIGINAL SOURCES OF DIAMONDS

Simultaneously the geological research in the Vilyui diamond-bearing basin geophysical work is being conducted. The purpose of this work is to find new geophysical methods to discover original sources of diamonds. Geophysical surveys and tests of the pipe "Zarnitsa" have greatly contributed to this work. As a result of the various degrees of magnetic susceptibility of kimberlites and of its surrounding sedimentary rocks the method of magnetic investigation was found to be very valuable.

The magnetic susceptibility of kimberlite (pipe "Zarnitsa") is determined by values 2533 $\cdot 10^{-6}$ CGS units, it equals zero for the surrounding rocks. Furtheron, the geological conditions are extremely simple and are characterized by the development of uniform beds of horizontal carbonaceous rocks.

This, the extremely favorable physical factors in addition to excellent geological conditions have contributed to the high efficiency of geophysical works which led to the discovery of thirteen new kimberlite bodies.

As a rule, sections that have already been investigated by geophysical research (through the testing of concentrates for pyropes) are selected for geophysical survey. Kimberlite pipes were discovered rather quickly on such tested areas by applying magnitometry.

Magnetic survey was conducted with magnectic cariometers M-2 (a device that measures the vertical component of the magnetic field), their susceptibility set as 25 - 30_y per division.

General research was conducted on a territory 250 by 50 meters. Anomalies that resembled pipes were subjected to detailed studies. Large kimberlite bodies were studied within areas of of 25 by 20 meters, small bodies within ten by ten and even ten by five meters. Detailed as well as general surveys were conducted on the basis of auxiliary investigations. The preciseness of the research was determined by a cubic error of $\frac{\text{plus}}{\text{minus}}$ 15 y.

Kimberlite bodies clearly protrude in the form of positive anomalies against the background of a static magnetic field formed by a thick layer of sedimentary rocks of the Ordovician. It should be noted that the intensity of the anomalous magentic field created by the kimberlites is not the same for different pipes. Maximum magnetizing force was observed in the pipes of the Daaldyn region ("Zarnitsa," "Mallutka," etc.) reaching in individual sections $3,000_y$: the average for the above pipes amounts to about $1,000_y$ and even between 200 and 400 for individual pipes such as, for instance, "Mir," "Kroshka," and "Zagadochnaya."

All these data apply to kimberlite bodies that either emerge to the surface or are sumerged under an eluvial or deluvial blanket the thickness of which rarely exceeds one to one and a half meters in thickness. The difference in the magnetic force of individual pipes is, evidently, basically due to the different amounts of ferromagnetic minerals in the pipes. A comparison between the pipes "Mir" and "Zarnitsa" revealed that the former is less magnetic than the latter. This is due to the fact that kimberlite pipe "Zarnitsa" contains greater quantities of secondary magnetite while kimberlite pipe "Mir" had none. Similar observations were made on other pipes.

The heterogenousness of the magnetic field is also revealed in the sites of the pipes. This phenomenon is particularly conspicious in pipe "Zarnitsa" (Figure 193). The general background that characterizes the anomaly produces a megnetic force that ranges from 800 to $1,000_y$. In the north and northeast of the contact a zone of weak magnetic strength was observed producing 300_y and less. Individual sections of lower intensity are observed in the central parts of thepipe that is marked by maximum magnetic force. One point with a negative anomaly of the magnetic field was established. This heterogenousness in the structure of the magnetic field within one pipe is, evidently, the result of the different components in the individual sections of the kimberlite body. The comparatively low intensity may be caused by the presence of large xenoliths of sedimentary rock known as "floating reefs" and frequently encountered in the pipes of South Africa. Negative anomalies evidently correspond to zones with trap xenoliths. A detailed investigation of kimberlite pipes will contribute finding a more definite answer to a series of questions. Referring to the nature of the magnetic fields of other kimberlite bodies we should like to emphasize that many of them do not reveal such striking differentation.

Mostly a differentiation is observed but it is less pronunced than in the pipe "Zarnitsa." The pipe "Nevidimka" varies slightly: the intensity of its magnetic field is lowered to 400y as a result of the screening effect of the blanket of loose deposits (up to five meter thick) and the increased distance from the kimberlite body at which observations could be made. Therefore, the outlines of the anomaly appeared somewhat smoother in comparison to those of the pipe decreasing the field gradients on the plane of observation.

The decisive part in discovering kimberlite bodies covered by a blanket of sedimentary rock of a maximum thichness wll be played by the substantial composition of the kimberlites, the size of the bodies and their development under the soil. The conversion of the magnetic anomaly in pipe "Zarnitsa" to a horizon of plus 100 meters showed that the intensity of the anomaly decreases at an average rate of two amounting to 700y.

In the case of kimberlite body overlain by thin strata the location of the contacts, the size and shape of the pipe and, possibly, some of the elements of occurrence (angle of dip and azimuth, depth of penetration of the body) can be determined accurately by magnetic survey.

The basic criterion for the determination of the angle and the azimuth of the dip of a pipe is the characteristic of its surrounding magnetic field. Zones of negative anomalies along with positive anomalies in a kimberlite body under conditions of direct magnetizing testifies that the pipe is inclined. The depth of a kimberlite body can only be estimated when the kimberlite pipes are located in an area of regional magnetic anomalies.

If we assumed that regional anomaly is caused by the structure of the crystal bed we would figure out the depth to which it penetrates with an accuracy of 20 to 25 percent. When a kimberlite pipe is represented by a columnar body the depth to which the roof of the crystal foundation penetrates would correspond to the distance at which the pipe expands (into the depth) in the layer of sedimentary fromations.

The question as to whether kimberlite pipes are associated with certain intrusive structures of the crystal foundation is extremely interesting inasmuch as it allows to estimate the extent to which a basin is diamond-bearing and deserving, therefore, the most serious attention. The association of a group of kimberlite pipes in the Daaldyn River Basin with a system of trap veins is an interesting fact.

The question of the territorial connection of kimberlite fields with the plutonic structures of the platform is hard to answer since the territory has not been adequately studied from a geological viewpoint and almost no data are available as to its plutonic structure and the composition of the crystal foundation.

Along with direct search for kimberlite bodies geophysical methods of research should occupy a leading role in solving an important group of questions concerning the problem of diamond occurrence on the Siberian platform.

CONCLUSIONS

Important geological and research work conducted for a number of years by the Amakin Expedition in collaboration with other organization led to the discovery of original sources of diamonds in 1954-1955.

The original sites of diamonds turned out to be typical kimberlites in mineralogical composition, structure and texture as well as in their manner of occurrence. They form characteristic "explosion pipes" filled out by great altered breccia-like rock which consists of effusive appearance with some specific petrographic properties (presence of pervoskite, appearance of phlogopite, strikingly low iron content in all femic minerals, etc.) -- and the xenoliths of other rocks. Thre are, for instance, fragments of torn sedimentary rocks, pre-Cambrian crystalline schists, rocks of special origin such as eclogites which are unknown in stratigraphic cross-section and, very rarely, porphyrite-like peridotities with pyropes. The presence of early xenogenic minerals, pyrope and pikroilmenite that reacts to magma is also a charcteristic property.

For the time being a vast field of kimberlite pipes has been identified. It expands to include the basin of the Daaldyn River and adjoining regions. One pipe was discovered in the basin of the Malaya Batuobiya River.

The Malaya Batuobiya region is located at the meeting point of two important structural areas of different age: The Upper Paleozoic Tunguska Syncline and the Mesozoic Vilyui Syncline. The Daaldyn region is located on the north northeast border of the Tunguska Syncline bodering in the north on the southern slope of the Anabar Mountain Range. Both areas border on the outside on a zone that is marked by a mass occurrence of trap intrusions.

The kimberlites only tear through deposits of the Lower Paleozoic. According to the presence of trap fragments the age of the kimberlites is recognized at least as post-Permian. The maximum age limit is still undetermined since the correlation between the kimberlites and the deposits of the Jurassic has not been clarified as yet. However, geological investigations conducted in the region of the pipe "Kollektivanya" gives rise to the assumption that the kimberlites are most likely of pre-Lower Jurassic age. Although the kimberlites of the above areas reveal great similarity there are also differences primarily in the composition of the xenoliths. The great quantity of crystalline schists in the pipes of the Daaldyn region testify to the fact that explosions have taken place in pre-Cambrian strata that do not occur very deeply in this particular area.

In the Daaldyn region 22 pipes have been discovered eight of which are diamond-bearing. The size of the pipes -- which are predominantly oval-shaped -- vary from 45 meters to 600 meters and more along the longitudinal axis. However, the depth of the pipes has notnbeen studied. Their contacts are very steep, usually the body shows an inclination toward the inward.

Tests have shown that the pipe "Mir" in the Malay Batuobiya region is richer in diamonds that the pipes of the Daaldyn region.

Intensive post-magmatic alterations of the kimberlites that led to a complete serpentinization of olivine on upper levels facilitate the extraction of diamonds from the rock since it contains a relatively small quanity of heavy fraction with a specific gravity over 3.0 and is rather easily destroyed.

It is quite possible that along with the production of diamonds the extraction of ilmenite will be profitable from some pipes since the basic mass of concentrates in the Daaldyn region consists of this mineral.

The preliminary identification of pyrope and pikroilmenite in the alluvium led to the discovery of kimberlite pipes, The discovery of these minerals in the area of the Markha and Tiung Rivers leads to the assumption that individual kimberlite fields or pipes exist there. The occurrence of independent original sources of diamonds in the above regions may be assumed on hand of the quantitative dissemination of diamonds and, particularly, the detailed statistical study of the types of diamonds in placer deposits thatvary in accordance with their original site.

Placer deposits of the Vilyui Basin are, as a rule, rather poor in diamonds..Rather rich placer deposits were discovered only in the basin of the Malaya Batuobiya River.

In the same region a field of old conglomerates -- most likely of Pre-Tertiary Age -- was found in a rather small area. They have through the deterioration of the old crust of weathering and contain many diamonds.

We may affirm that an extremely large diamond-bearing region is located in the Western part of the Yakutska ASSR comparable only to South-African diamond-bearing regions. According to available data the basic reserves of diamonds in the Vilyui basin may be traced back to original sites and to a lesser degree to placer deposits. There is a rather limited number of rich placer deposits.

The investigation of kimberlite pipes through mining operations will reveal the change in the size of the kimberlite bodies under the surface and the content of diamonds in the different layers. The Character andthe degree of the changes that take place under the soil is an extremely important factor since the presence of considerable quantities of unaltered olivine in the rock that has been noted in various pipes may greatly affect the technology of enriching and extracting diamonds from kimberlites.

The geological petrographic and mineralogical data that have become available in the course of research conducted in the original sources of diamonds must be subjected to thorough scientific study which may solve the intricate problem of the origin of diamonds allowing for a more rational method of conducting the search for and surveys of original sources of diamonds.

Particular attention should be focused on determining the age of the kimberlites with greater accuracy by applying methods that would allow to establish the absolute age of the rocks and study deposits of the Jurassic and their correlation with the kimberlites,

The method of tracing the paragenetic companions of diamonds in the kimberlites -- pyrope, pikroilmenite and, partially, chromdiopside, -- should be widely used. To distinguish pyrope from almandine under field conditions these minerals should be verified through optic methods. Much simpler methods should be elaborated to isolate pyrope from almandine under field conditions.

To identify kimberlite pipes the method of magnitometric land survey should prove of great value since it has produced good results during theinitial experimental work. Aeromagnetic survey and aerial photography on special films should be made in the course of prospecting.

Along with the search of original sources of diamonds great attention should be devoted yo the search for rich diamond-bearing placer deposits, in general, and old placer deposits, in particular. The latter should be subjected to a most thorough and detailed investigation. In connection with the study of the genesis of placer deposits it is necessary to devote special attention to the study of the old and young crust of weathering.

The study of the original sources and placer deposits of diamonds has to be continued and expanded. It will contribute essentially solve the problem of their origin and distribution.

A versatile geological study of the region will lead to conclusions about the occurrence of diamonds in the Vilyui region.

The data contained in this paper as well as the results of tests made in the courseof further research may be used in work conducted in certain regions of the siberian platform.

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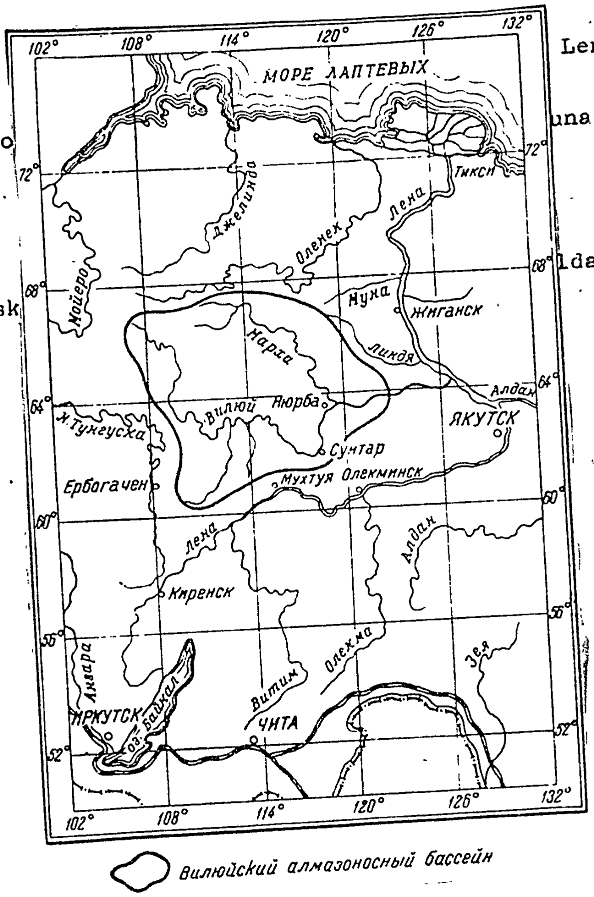


Vilyui Diamond-Bearing Basin

Figure 1: Map of the Central Part of the Yakutsk AssR

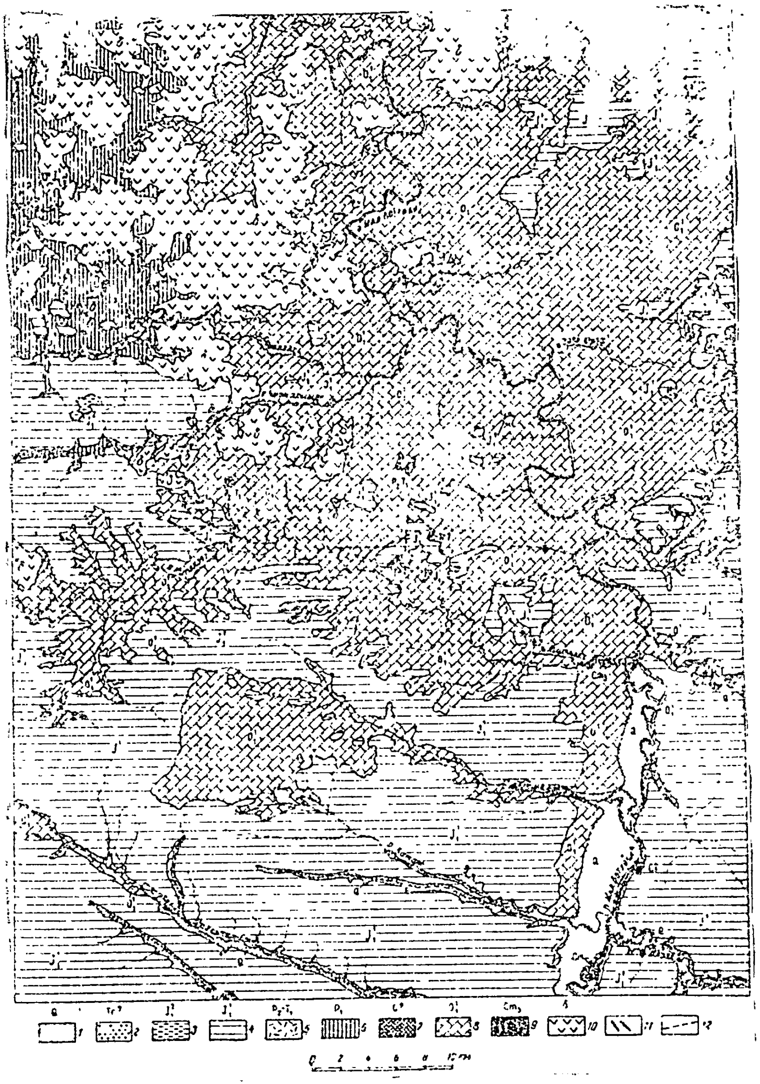


Figure 3: Geological Map of the Basin of the Midstream Area of Malaya Betubiya River. Compiled by N.V. Kind, M.P. Metelkina, Yu, I. Khabardin et al.

1 - Alluvial deposits of Quaternary Age; 2 - Sand, Gravel and pebble deposits and kaolin clays presumably of Tertiary Age; 3 - Marine clays and limestone deposits with fauna of the Middle Liassic; 4 - continental sand and conglomerates deposits of the Lower Liassic (Ukugut Formation); 5 - tuff deposits of the Upper Permian and Lower Triassic age (tuff formation); 6 - continental sand and clay deposits of Lower Permian Age (productive formation) 7 - sand deposits presumably of Carboniferous Age (Emiaksin Formation) 8 - sand and carbonaceous as well as clay and carbonaceous deposits of the Lower Ordovician (Ustkut Formation); 9 - red and variaged gypiferous deposits of the Upper Cambrian (Upper Lena formation); 10 - blanket intrusions of traprock; 11 - tray dykes; 12 - tectonic lines

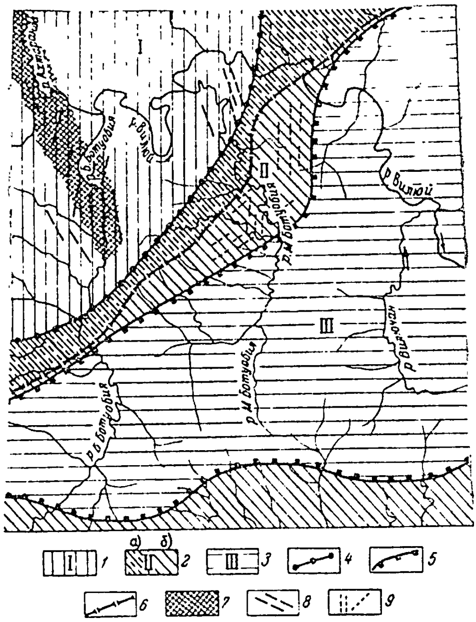


Figure 4 : Tectonic chart of the right bank of the Vilyui River between the Akharanda and Vilyuichan rivers. Compiled by N.V. Kind.

1 -southeast border of Tunguska Syncline; it coincides with the maximum occurrence of rocks of the productive formation of the Lower Permian (1); 2 - area of the relatively upheaved occurrence of the Lower Paleozoic on the border of the Vilyui Syncline and the Tunguska-Vilyui Mesozoic depression (II); a) torn by numerous traprock intrustions; b) almost without traprock intrustions; 3 - Tunguska - Vilyui Mesozoic depression and border area of Vilyui Syncline (I-I); 4 - border of Tunguska Syncline in the Upper Paleozoic; 5 - young borders of the Vilyui Syncline and the Tunguska-Vilyui Mesozoic depression coinciding with the borders of a relatively steep submersion of the Lower Paleozoic; 6 - outside border of the maximum occurrence of traps; 7 - areas of a maximum concentration of intrusive diabases with intense manifestations of post-magmatic mineralization (continuation of the zone of plutonic fissures that extends along the border of the Tunguska Syncline); 8 - very old (Upper Paleozoic) plutonic fissures that served as the basic channeks for the intrustion of traps; 9 - line of younger (predominantly Mesozoic and Cenozoic) small fissures, ditches and cracks caused by faulting and precipitation.

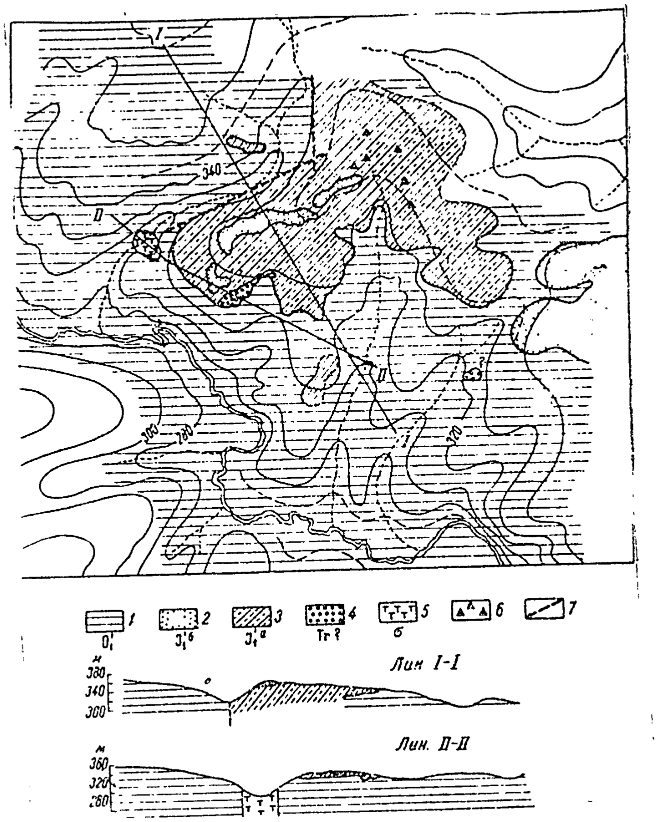


Figure 5: Rough geological map of the left bank area of the Iireleekh River in the region of the pipe "Mir". Compiled by N.V. Kind, P.F. Potapov and Ye. N. Yelagina according to the materials of team No. 1 32 and 200.

1 -dolomites, limestones, and marls - of the Lower Ordovician (ust Kut Formation); 2 - clays, clayey sands, siltstones and carbons of the lower Jurassic (upper bed of the Ukugut Formation); 4 - sand, gravel and pebble deposits, kaolin clays presumably of Tertiary Age; 5 - kimberlites; 6 - carbons in deposits of the Lower Jurassic stripped by mining operations; 7 - presumed lines of faulting.

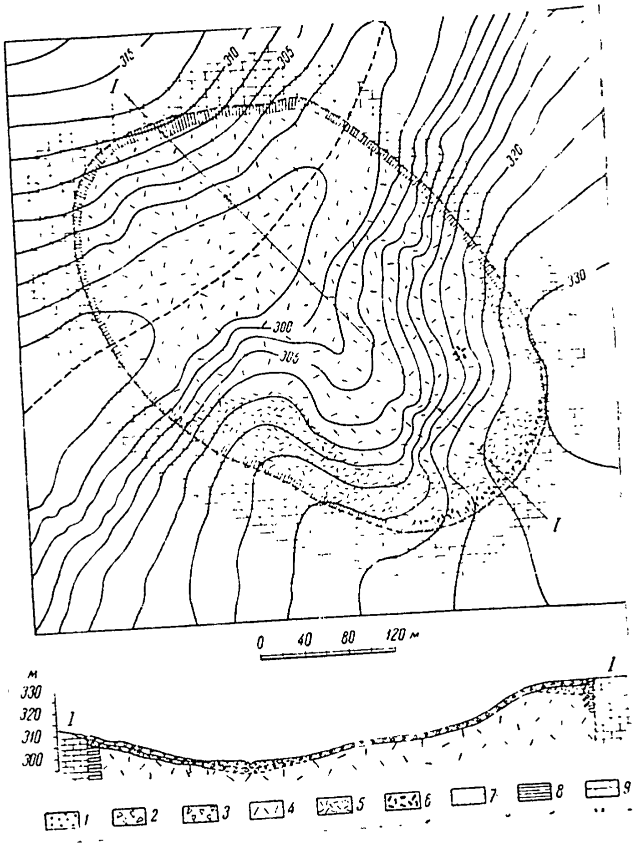


Figure 6: Rough geological map of kimberlite pipe "Mir". Compiled by N.V. Kind, M.P. Metelkina and Yu, I. Khabardin according to materials of the Amakin Expedition.

1 - Alluvial cones; 2 - detritus and block deluvium of surrounding varbonaceous rock; 3 - deluvial and eluvial deposits of kimberlites; 4 - small fragments of kimberlite tuff, grayish-green and deep green; 5 - altered small fragments of light yellow kimberlite tuff; 6 - coarse fragments of kimberlite breccia; 7 - coarse fragments of kimberlite breccia with quartz; orange colored kimberlite altered in contact areas; 9 - carbonaceous rocks of the Ust-Kut formation of the Lower Ordovicina. Overlain kimberlites of Tertiary formation are shown in the cross-section.

Figure 7: Diamond in the kimberlite of pipe "Mir". x10

Figure 8: Diamond in the kimberlite of pipe "Mir". x6

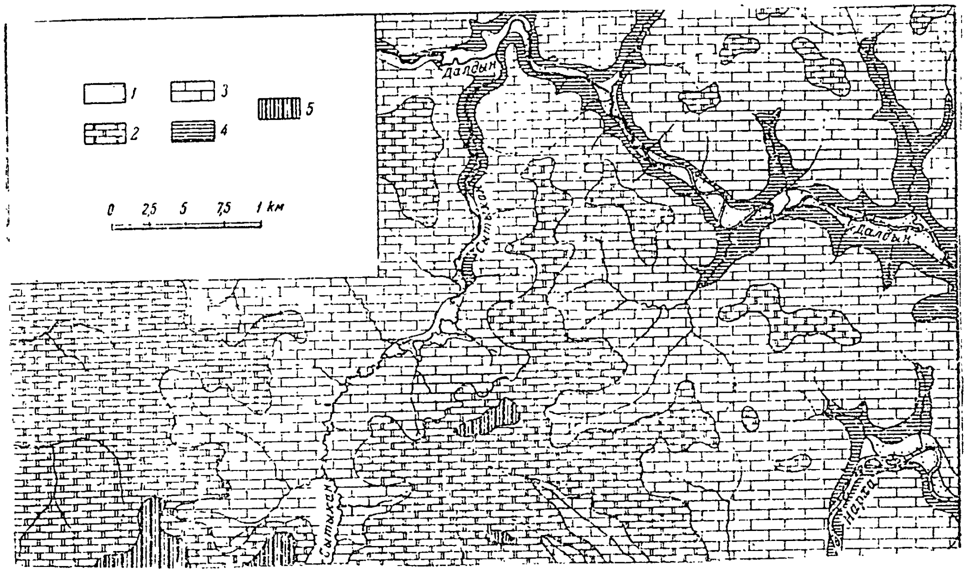


Figure 9: Geological Map of the Daaldyn Diamond-bearing region Compiled by M.N. Vasilieva, F.F. Ilyin, V.N. Shchunkin et al.

1 - Deposits of the Quarternary; 2 - limestone and dolomite layer; 3 - limestone layer; 4 - layer of bituminous linestone; 5 - blanket intrusion of traprock.

Cross
the Li

Scale

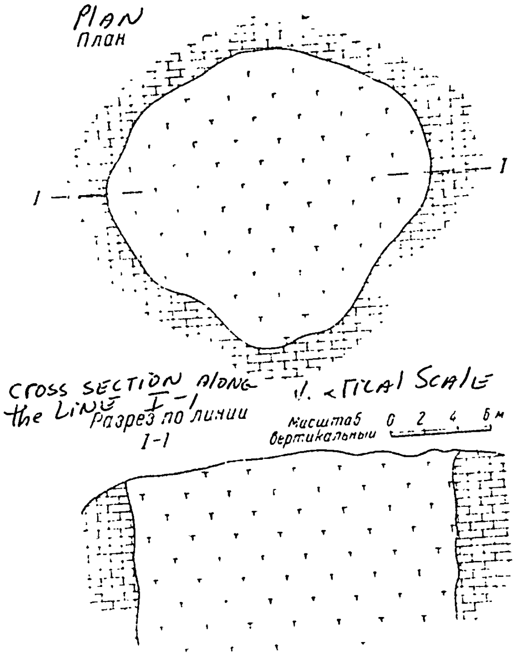


Figure 10: Outline of Kimberlite Pipe "Zarnitsa".

Figure 11: Greenish-gray kimberlite from pipe "Zarnitsa".

Figure 12: Linestone Xenolity with Coral Fauna from pipe "Zarnitsa".

Talala

Katipa

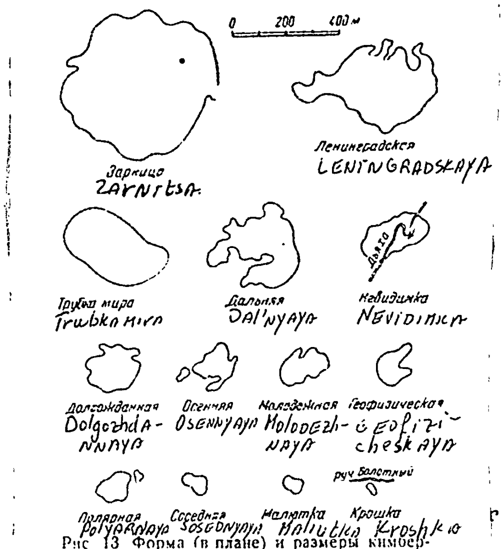
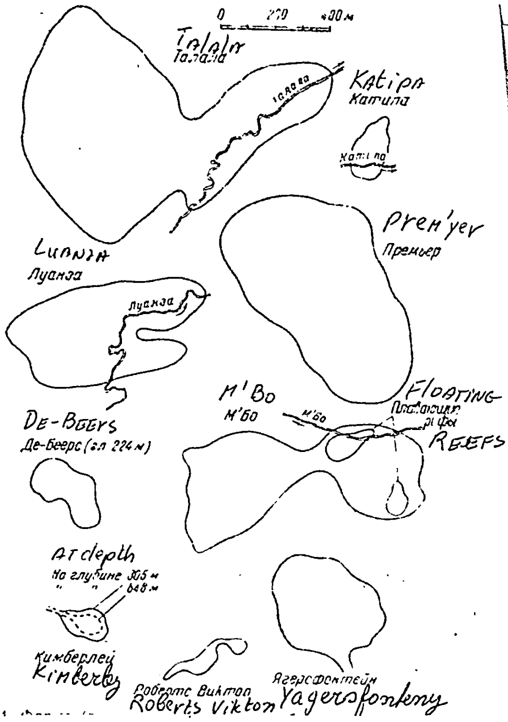


Рис 13 Форма (в плане) и размеры кимберлитовых трубок Вилюйского бассейна

Figure 13: Shape and Size of
Kimberlite Pipes
in the Vilyui Basin



Yagersfonteny

Figure 14: Shape and size of
kimberlite pipe of
Africa.

Figure 15: Microscopic View of Kimberlite Breccia

A - large fragment of altered kimberlite; B - small fragments of altered kimberlite and scraps of pseudomorphs of serpentine after olivine; B- fragments composed of serpentine; C- fragments of serpentine-chlorite schists; D- fragments of serpentine-carbonaceous rock. x10 times.

Figure 16: Altered Kimberlite with phlogopite.

A - pseudomorphs after olivine consisting of serpentine, secondary magnetite and carbonate; B - light brown schists; C - basic mass of altered kimberlite represented by carbonate. x22

Figure 17: Amygdaloid altered schist kimberlite from a breccia fragment.

A - amygdules filled out by serpentine and carbonate; B-pseudomorphs of serpentine and magnetite after olivine; C-scales of phologopite; D- decomposed basic mass. x18

Figure 18: Altered kimberlite from a breccia fragment.

A rounded formation in the center reminds of a xenocrystal of an outside mineral replaced by serpentine and surroundedby a reaction rim also filled out by serpentine. x15

Figure 19: Fragment of altered kimberlite in breccia
Fragments of serpentinous olivine crystals (first generation) are visible in the kimberlite. x20

Figure 20: Kimberlite fragment in breccia.
Well-preserved pseudomprphs of serpentine and carbonate after phenocrystals of olivine and pseudomoprhos of carbonate after microlites of pyroxene are clearly visible. x75.

Figure 21: Small fragments of kimberlite breccia.

A - minute fragments consist of pseudomorph of serpentine and magnetite after phenocrystals of olivine and a basic mass replaced by carbonate; B - limestone fragments; C - fragments of serpentine; D - cementing mass of breccia represented by serpentine. x22.

Figure 22: Fragment of garnet crystal in altered kimberlite. Crystalline garnet - A, to the left is a dar kimberlite rim - B, that included this crystal in the past. x40

Figure 23: Fine fragments of kimberlite tuff (breccia). Irr-gular grains of serpentinous olivine and fragments of limestone in the cementing mass: to the left is a grain of ilmenite. x70

Figure 24: Fine fragments of kimberlite tuff (breccia) Fragments of olivine crystals fully replaced by serpentine; violet pyrope split by cracks without a keliphite rim; to the left scales of chlorite. x70

Figure 25: Kimberlite Breccia.
Micrograined quartz (light), relict sections of slightly kimberlite with quartz (dark). x35.

Figure 26: Eclogite with Biotite.
Grains of Fissured pyrope and omphacite with cleavage are visible, below are large scales of biotite with inclusions of ore grains. x75.

Figure 27: Plagioclase pyroxene crystalline schist with garnet.
A grain of garnet, cracked, the crack filled out by actionolite. x70.

Figure 28: Plagioclase-pyroxene crystalline schist with garnet.
Garnet with two patterns of acicular inclusions. x70

Figure 29: Plagioclase Pyroxene crystalline schist with garnet and disthene.
Top: garnet grain without keliphite halo, below, it is interpenetrated by a claster of disthene crystals just like the plagioclase.

Figure 30: Plagioclase pyroxene crystalline schists.
Cluster-like agregates of disthene that penetrates into garnet. x80.

Figure 31: Plagioclase pyroxene crystalline schist with garnet and hornblende.
In the center is a more or less idomorphic grain of paragasite. x40.

Figure 32: Altered Rock
In the center: relict plagioclase almost completely replaced by kaolin products. x80

Figure 33: Altered Rock
Relicts of a grain of monoclinal pyroxene replaced by carbonate and partly by a chlorite-like mineral. x80

Figure 34: Altered Rock
Pseudomorphs of secondary minerals producting agregates of zonal formation similar to collomorphous texture. x75

Figure 35: Garnetized Rock
Grains of monoclinal and rhombic pyroxene garnets, to the right--xenomorphic grains of hornblende with cross cleavage. x75.

Figure 36: Pyroxene crystalline schist with garnet.
Rieght-large grains of hypersthene almost completely replaced by brown iddingsite: - grains of garnet. x75

Figure 37: Hyperstehen amphiobolic schists.
In the center-grains of hornblende, right - relicts of hyperstehene. Replaced by iddingsite: light grains are plagioclase. x75

Figure 38: Hyperstehene amphibolic schist. Elongated scales of biotite together with hornblende and ore mineral. x75

Figure 39: Rim of altered kimberlite around microxenolity. Enrichment with magnetite is noticeable in the peripheric section, of the fragment. x15

Figure 40: Remainders of fauna in a limestone xenolith of kimberlite breccia. x69

Figure 41: Pseudoolite limestone. Xenolith from kimberlite breccia. x25

Figure 42: Microxenolity of kimberlite in carbonaceous veinstone.x20

Figure 43: Contact between fieldspar pyroxene rock and surrounding kimberlite.
Development of scales of biotite and very intense ferric oxidation along the contact is visible. x50

Figure 44: Grains of pyrope in kimberlite pipe "Zarnitsa".

Figure 45: Grains of Pyrope in keliphite halo of pipe "Zagadochnays". x4

Figure 46: Grains of deep red pyrope in kimberlite pipe "Zarnitsa." x20

Figure 47: Grains of red pyrope in kimberlite pipe "Zarnitsa." x20

Figure 48: Violet pyrope from kimberlite pipe "Mir". x30

Figure 49: Orange pyrope from kimberlite pipe "Zarnitsa." x20

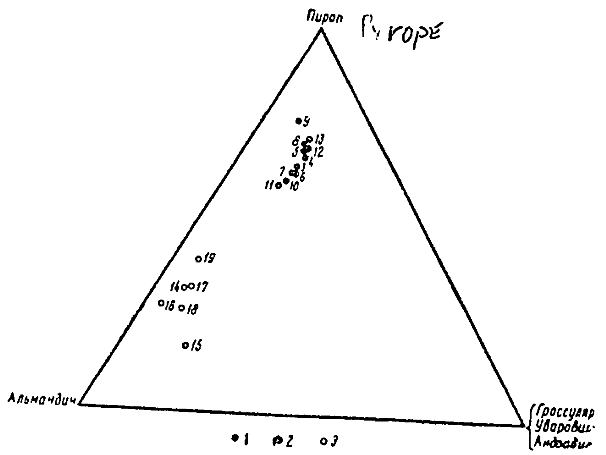
Figure 50: Grains of pale pink pyrope from kimberlite pipe "Mir." x20

Figure 51: Inclusions of crystals of chromium spinelide in red-violete pyrope of kimberlite pipe "Mir" x30

Figure 52: Elongated acicular inclusion in orange pyrope of pipe "Mir" x30

Figure 53: Laminar inclusion in orange-red of kimberlite pipe "Mir" x30

Figure 54: Inclusions of chromdiopside in pyrope taken from kimberlite pipe "Zagadochnaya." x40



Almandine

Grossularite
Varovite
Andradite

Figure 55: Content of main components in samples of pyropes of different origin.

1 - Pyrope from diamond-bearing kimberlites and pacer deposits of the Vilyui River Basin; 2 - pyrope from diamond-bearing kimberlites of South Africa; 3 - almandine from very old metamorphic schists of the Aldan Shield and Anabar Mountain Range.

Fiugre 56: Ilmenite from kimberlite pipe "Mir". x20

Figure 57: Cluster of ilmenite crystals from kimberlite pipe "Zarnitsa." x20

Figure 58: Leucoxene fringe of ilmenite from kimberlite pipe "Mir." x15

Figure 59: Pervoskite on grains of ilmenite in kimberlite pipe "Zarnitsa." x20

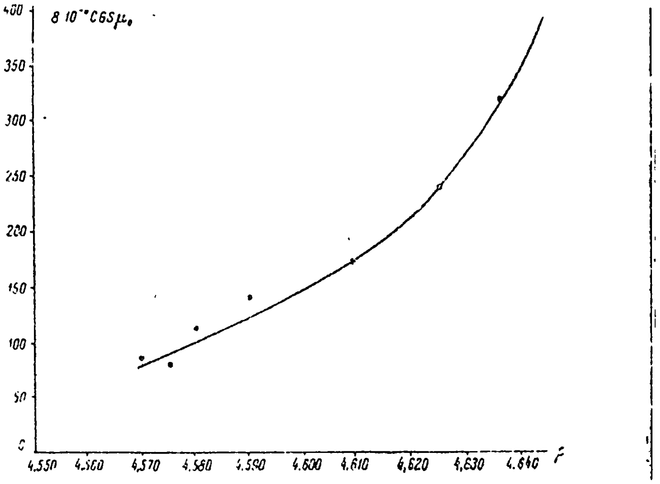


Figure 60: Correlation between specific (P) and magnetic susceptibility (x).

Element
No. of sample

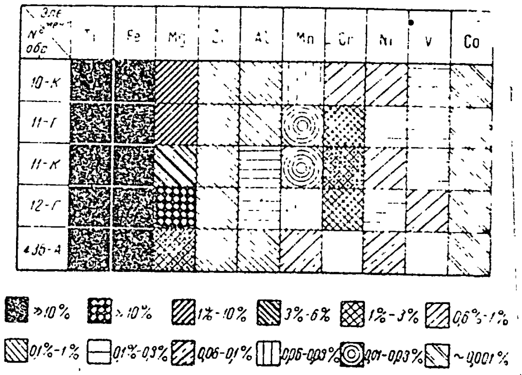


Figure 61: Diagram of the chemical composition of samples of ilmenite according to spectrum analysis.

Figure 62: Magnetite of divergent columnar structure from kimberlite pipe "Zarnitsa." x5

Figure 63: Druse of crystals magnetite from kimberlite pipe "Zarnitsa."

Figure 64: Cluster of Octahedral crystals of magnetic from kimberlite pipe "Zarnitsa." x1-

Figure 65: Reinform formation of magnetite from kimberlite pipe "Zarnitsa". x1.5

Figure 66: Grains of olivine from kimberlite pipe "Zarnitsa". x20

Figure 67: Grains of diopside from kimberlite pipe "Zarnitsa." x20

Figure 68: Grains of chromdiopside from kimberlite pipe "Zarnitsa." x20

Figure 69: Schist from kimberlite pipe "Zagadochnya." x5.5

Figure 70: Schist from kimberlite pipe "Zarnitsa." x20

Figure 71: Development of scales of phogopite along cracks in a grains of pyrope from kimberlite pipe. "Zagadochnaya." x30

Figure 72: Chlorite from kimberlite pipe "Mir." x25

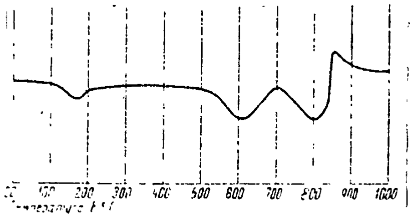


Figure 73: Differential thermic curve of chlorite

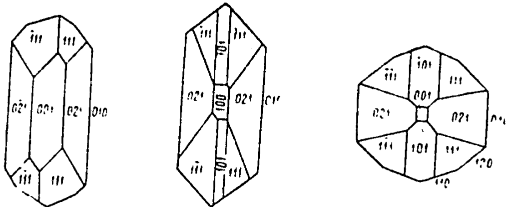


Figure 74: Pseudomorphs of serpentine after olivine

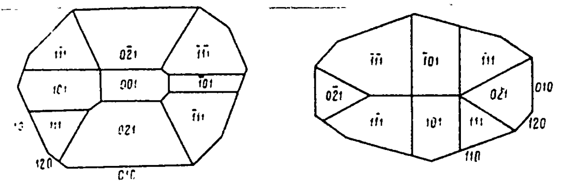


Figure 75: Pseudomorphs of serpentine after olivine

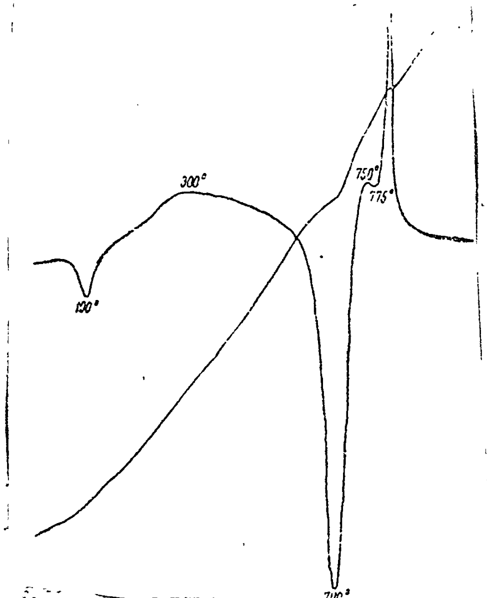


Figure 76: Differential thermic curve of serpentine. Sample No. 4a

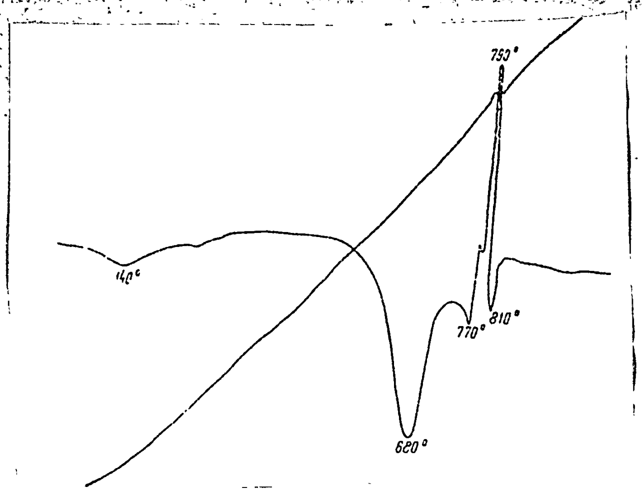


Figure 77: Defferential thermic curve of serpentine. Sample No.5c

Figure 78: Calciostronciante from kimberlite pipe "Zarnitsa." x15

Figure 79: Crystals of calcium from kimberlite pipe "Mir". x15

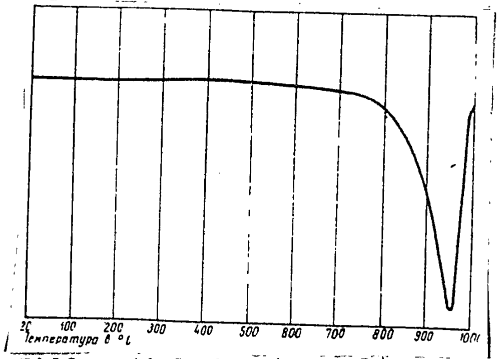


Figure 80: Differential thermic curve of calcite

Figure 81: Pirite from kimberlite pipe "Mir" x20

Figure 82: Grains of Grossularite (eluvium from kimberlite pipe "Mir") x20

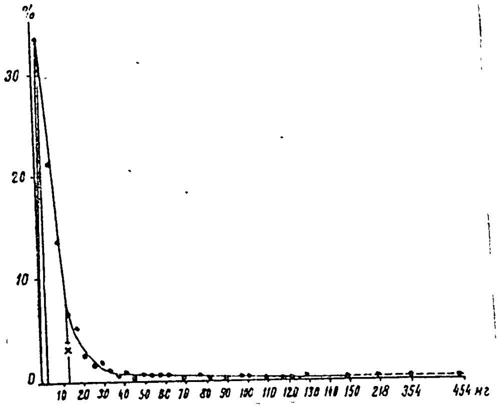


Figure 83: Curve showing dissemination of diamonds according to weight. Placer deposit "Ogonek."

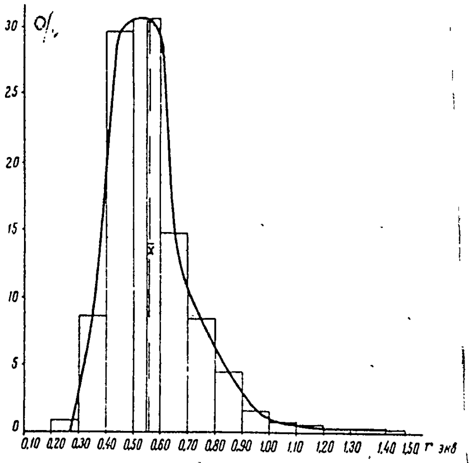


Figure 84: Histogram of the dissemination of diamonds according to radii of equivalent balls. Placer deposit "Ogonek."

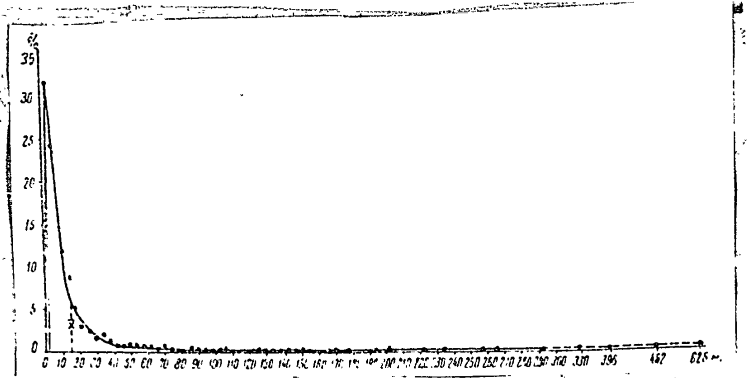


Figure 85: Curve showing distribution of diamonds in kimberlite pipe "Mir" according to weight.

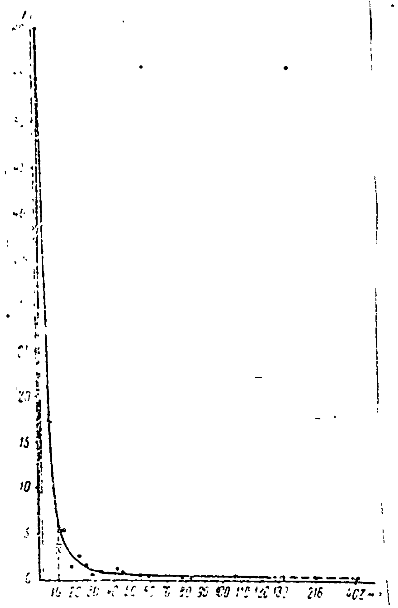


Figure 86: 'Curve showing dissemination of diamonds according to weight in kimberlite pipe "Zernitsa."

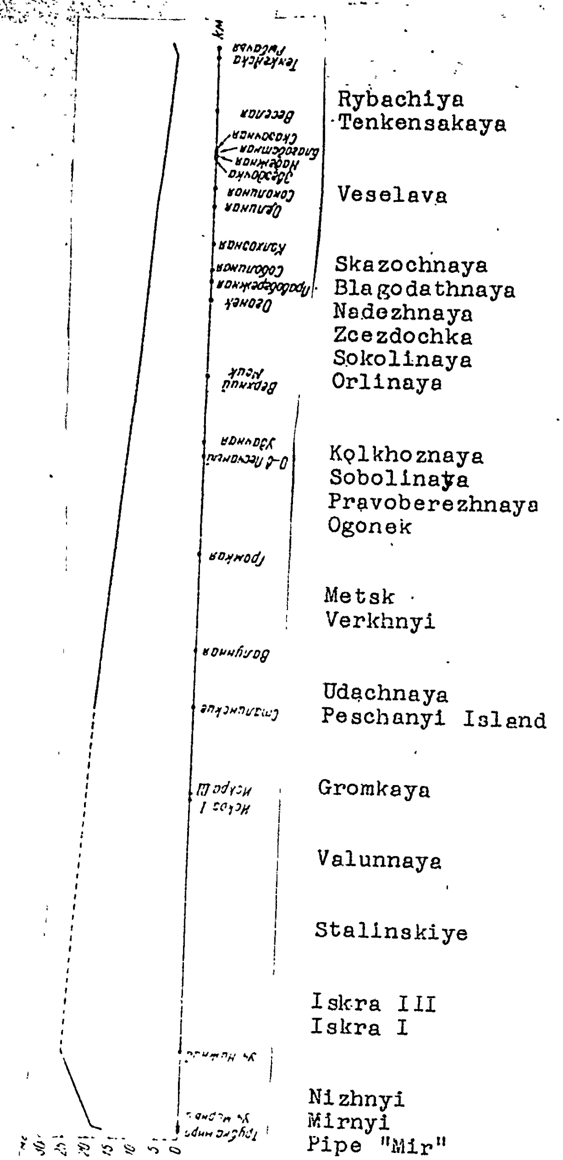


Figure 87: Diagram showing changes of average weight of diamonds in placer deposits of the Vilyui River. (accuracy of determination taken into account).

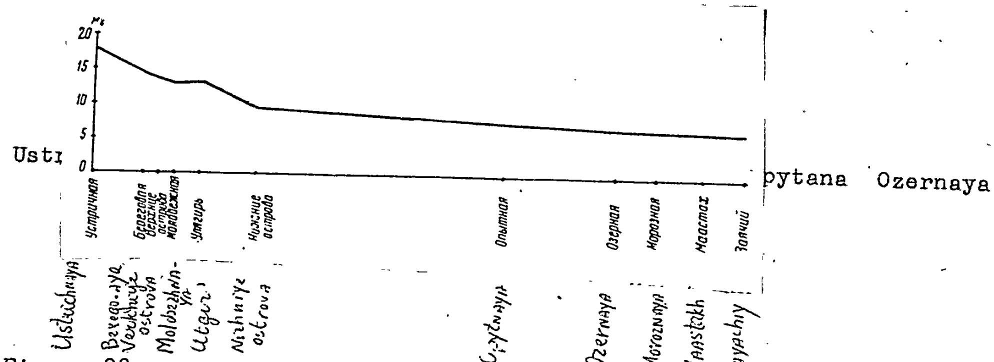


Figure 88: Diagram showing changes in the average weight of diamonds in placer deposits of the Markha River (under consideration of the accuracy of determination)

Figure 89: Blade-like diamond
crystal of transition
habit between octahedral
and rhombododecahedral.
x24

Figure 90: Coarse laminar
octahedral diamond
x13

Figure 91: Finely laminated
diamond crystal of
transitional habit

Figure 92: Diamonds octahedron
with striatiation
on surfaces in lieu
of edges.

Figure 93: Diamond crystal of
rhombododecahedral
habit of composed of
ditrigonal laminael
The left face reveals
winding line of face
seam. x15

Figure 94: Diamond crystal of
rhombododecahedral
habit composed of
ditrigonal laminae.
x20

Figure 95: Rhombododecahedron
with striation on faces
formed of protruding ends
of the layers of growth.
Left, pyramide of growth
at the outcrop of the triad
axis of symmetry. x15

Figure 96: Rounded diamond
rhombododecahedron
with traces of laminar
structure in the form
of winding cluster-
like striation. x22

Figure 97: Diamonds-spinel twins

Figure 98: Spinel twin of octahedral diamond, flattened along the triad symmetry axis. x15

Figure 99: Extreme degree of flattening of a spinel diamond twin.

Figure 100: Spinel twin of two rounded diamonds. x14

Figure 101: Flattened diamond octahedron with trigonal overgrowth in the position of a spinel twin. x26

Figure 102: Two flattened octahedrons grown together according to spinel law. x20

Figure 103: Isometric (upper) and flattened(lower) octahedrons grown together according to spinel law x19.

Figure 104: Flattened spinel twin of laminar octahedrons of diamonds.

Figure 105: Flattened spinel twin of a diamond octahedron, taken at a sharp angle twoard the axis of depression.

Figure 106: Depressed spinel diamond twin. Taken along axis of depression. x8

Figure 107: Same as on figure 106 Taken under straight angle in relation to axis of depression. x8

Figure 108: Fragment of spinel diamond twin with winding line of twin seam. x20

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Figure 130: Irregularly developed crystal of an octahedral daimond with a pattern of inversely parallel trigonal hollows on the face of the octahedron. The crystal is covered by striation of the texture.

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Figure 138: Inclusion of a rounded lamina of graphite on the surface of an irregularly developed rhombododecahedral diamond crystal. x9

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Figure 142: Small inclusion of transparent mineral(zircon?) in an octahedral diamond (top of photograph).x18

Figure 143: Inclusion of trans-olivine crystal in a diamond. x80

Figure 144: Fractured prismatic zircon (?) included in a diamond

Figure 145: Group of inclusions of olivine (?) crystals in a diamond

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Figure 147: Inclusion of a chromium spinelide (?) crystal.x80

Figure 148: Inclusion of an octahedral chromium spinelide crystal in a laminated diamond octahedron

Figure 149: Diamond octahedron with a small break on the face (at the edge) x7

Figure 150: Diamond octahedron with truncated top and cavities on the face. x17

Figure 151: Diamond octahedron with partly broken tops and faces; condoidal fracture is visible on face. x18

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Figure 153: Shapless fragment of a diamond crystal with fine winding cracks on the surface of the break. x18

Figure 154: Shapless fragment of a diamond crystal. x25

Figure 155: Irregularly developed crystal of a diamond with step-like surface of the fracture. x17

Figure 156: Parallelepiped fragment with conchoidal surface of the fracture. x15

Figure 157: Diamond twin depressed along the triad axis of symmetry with a pattern of conchoidal fractures on the broken face of an octahedron. x7

Figure 158: Irregularly shaped diamond crystal with traces of mechanical weathering on the edges and tops.

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Figure 160: Diamond crystal of transition habit composed of trigonal layers of growth. x25.

Figure 161: Diamond crystals with polycentrically growing faces.

Figure162: Fractured cathedral diamond with overlapping trigonal formations on the faces. x20

Figure 163: Diamond with polycentrically growing faces on the side of the exit. x21

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Figure 165: Irregularly developed (elongated along g_2) "comb-shaped" diamond octahedron. x12.

Figure 166: Same as on Figure 165. x21.

Figure 167: Diamond octahedron formed of shield-shaped layers of growth. On the site of the edges of an octahedron cluster-like striation is visible. x15

Figure 168: Diamond crystal of rhombododecahedral habit with a shield-like form of the layers of growth. x1.2

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Figure 170: Diamond crystal of a transition habit with "splintery" striation on the faces of the rhombododecahedron. x25.

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Figure 173: Irregularly developed diamond octahedron with rounded step-like faces. x28

Figure 174: Same as on Figure 173. x15

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Figure 177: Diamond with block sculpture

Figure 178: Rhombododecahedral diamond with block sculpture on the faces. x14.

Figure 179: Rounded rhombodedecahedral diamond. x14.

Figure 180: Rounded rhombododecahedral diamond with "tiled" sculpture on the faces. At the outcome of one of the tetrad axes of symmetry a large tetragonal hollow.

Figure 181: An octahedral diamond with a pattern of rhombic factures. x15.

Figure 182: Caverns of corrosion on a rounded rhombododecahedron. x12

Figure 183: Rounded deformed diamonds.

Figure 184: Rounded rhombododecahedron, slightly elongated along one of triad axes of symmetry. x14.

Figure 185: Rounded rhombododecahedron elongated along the tetrad axis of symmetryl x33

Figure 186: Cubic diamond. x25

Figure 187: Cubic diamonds with a development of octahedral faces on the edges and tops and with tetrahedral hollows on cubic faces. x30

Figure 188: Cubic diamond elongated along the tetrad axis of symmetry with truncated edges and tetrahedral depression on cubic faces. x40

Figure 189: Cubic diamonds with developed octahedral faces on edges and tops. x20

Figure 190: Same diamond as on Figure 189 taken from the side of the edge. x15.

Figure 191: Alumopotassic alum crystal (according to G. Bakli).

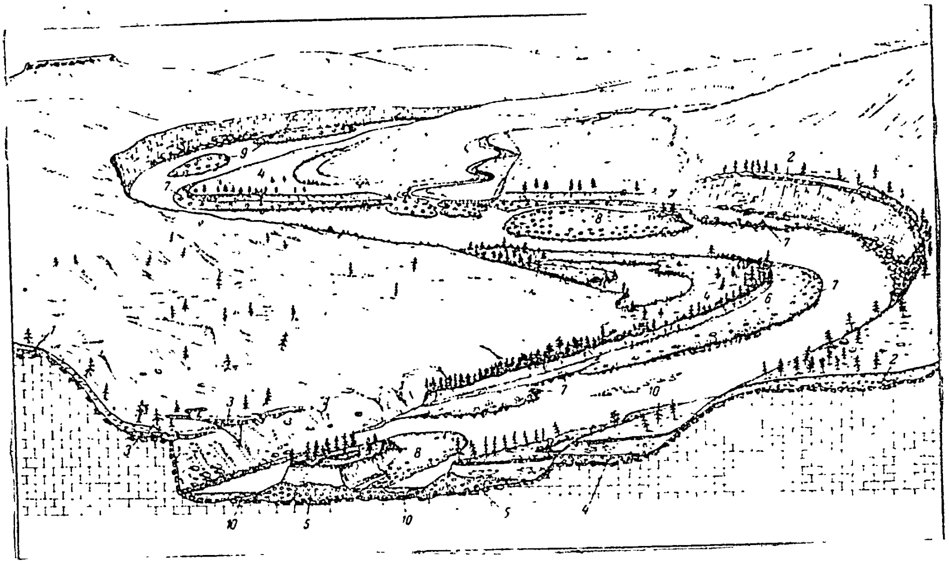

Fig 192 Geomorphological outline of the Markha River valley in the area of the placer deposits Verkhniye Islands.

Terrace deposits: 1 - 5th terrace; 2 - 4th terrace; 3 - 3rd terrace; 4 - 2nd terrace; 5 - 1st terrace. Valley deposits: 6 - flood deposits; 7 - Shoal waters, embankments; 8 - alluvial fans of residual terraces; 9 - spits, islands and banks; 10 - acutal river beds.

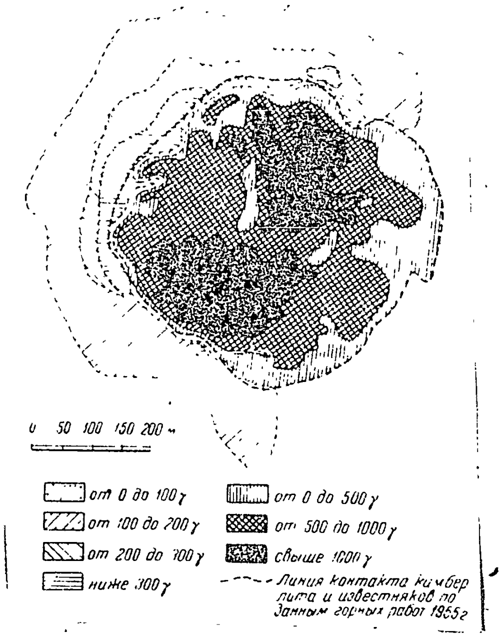

Fig. 193: Map of magnetic anomalies in the pipe "Zarnitsa"

Line of contact between kimberlite and limestone according to data available through mining operations in 1955.