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LITHOLOGY OF KIMBERLITE PIPE ORIFICE OF CAMACHIA

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ЛІТОЛОГІЯ УСТЯ КІМБЕРЛІТОВОЇ ТРУБКИ КАМАЧІЯ

First diamonds were discovered in Angola in 1912. In the next 40 years, diamond mining was conducted from alluvial deposits. To date, the country are found about 700 kimberlite deposits. Camachia kimberlite pipe was put into operation in 2005. It is among the ten largest mines of the world and is located in the north-eastern part of Angola. Camachia tube is oval in shape with a diameter of about 650 m and an area of about 30 acres. The host rocks of kimberlite pipes are typically Archean gneisses, migmatites, which are covered volcanic-sedimentary rocks whose power in the crater of the tube is about 100 m. The total area of host rocks is about 1,2 millions m^3 and weighs is about 600 000 tons. Morphologically tube is complicated, double and consists of two tubes and craters, and east crater tube partially destroyed west crater tube. Lithological composition of the western crater is differed from the east crater. Diamondiferous pipes are different. The reason for this is probably under different conditions of their formation. The upper part of the deposit is represented mainly by river - alluvial deposits. Besides river alluvium are presented in varying amounts talus, proluvial and colluvial deposits, which are difficult to separate because of their multiple mixing. Currently, the diamonds are extracted from alluvial deposits, since the depth of pit is small, from 5 to 20 m. The rocks tube Camacho East are presented volcanic rocks hypabyssal magmatic phase (kimberlites) and post-magmatic rocks phases (autolytic kimberlite breccia xenoliths). The rocks of crater are presented by various volcanic-sedimentary rocks: tuff-siltstone, tuff-sedimentary breccia, tuff-sedimentary xenoliths.
Conducted research allowed identifying and describing medium link of kimberlite rock transformation from their crystalline rocks to the sediments and showing the possibility of determining of sludge capacity formation in the southern and northern latitudes. Also, this study allows determining the gradient of the primary alluvium rate of transfer to the secondary alluvial deposits and after that to offshore field. As a result, medium link, between kimberlite and offshore field can be divided to the smaller links in order to develop general method of searching alluvial deposits of diamonds.
Keywords: kimberlite pipe, crater, diamond mine, alluvial deposits, Camachia tube.

Вперше алмази були відкриті в Анголі в 1912 р. У наступні 40 років видобуток алмазів вівся з алювіальних відкладів. До теперішнього часу в країні виявлено близько 700 кімберлітових родовищ. Кімберлітова трубка Камачія введена в експлуатацію в 2005 році. Вона входить в десятку найбільших копалень світу і розташована в північно-східній частині Анголи. Трубка Камачія має овальну форму, діаметром близько 650 м і площею близько 30 акрів. Вміщуючі породи кимберлитової трубки є типові мігматито-гнейси архею, перекриті вулканогенно-осадочними породами, потужність яких в кратері трубки становить близько 100 м. Загальна площа вміщуючих порід складає 1,2 млн. $м^3$, а вага складає приблизно 600 тис. т. Морфологічно трубка складна, подвійна, складається з двох трубок і кратерів, причому кратер східної трубки частково зруйнував кратер західної трубки. Літологічний склад західного кратера відрізняється від східного. Алмазоносності трубок різна. Причина цього, ймовірно, у різних умовах їх утворення. Верхня частина родовища представлена, в основному, річковими - алювіальними відкладами. Крім річкового алювію присутні в різних обсягах делювіальні, пролювіальні і колювіальні відклади, які складно розділяти через їх багаторазове змішування. В даний час вся видобута руда в родовищі припадає на алювіальні відклади, оскільки глибина кар'єра невелика, від 5 до 20 м. Породи трубки Камачія-Схід представлені вулканогенними породами гіпабіссальної магматичної фази (кімберліти) і породами постмагматичних фаз (автолітичні кімберлітові брекчії, ксеноліти). Породи кратера представлені різними вулканогенно-осадочними породами: туфо-алевролітами, туфо-осадочними брекчиями, туфо-осадочними ксенолітами.
Проведені дослідження дозволили виділити та схематично описати проміжну ланку перетворення кімберлітових порід від кристалічного стану до осадового и показати можливість визначення градієнта формування потужності осаду в північних та південних широтах, а також градієнта швидкості перенесення первинного алювія, до вторинного, розсипного родовища, а після цього, до шельфового. В підсумку, проміжна ланка, між кімберлітом та шельфовим розсипом може бути розділена на менші ланки для розробки загальної методики пошуку розсипів алмазів.
Ключові слова: кімберлітова трубка, видобуток алмазів, алювіальних відклади, трубка Камачія.

INTRODUCTION

Angola is located on the Atlantic coast of South Africa and borders with Namibia, Democratic Republic of the Congo and Zambia. Being one of Portuguese former colonies, Angola became independent in 1975, with the population nowadays of 12, 3 million people.

First diamonds were discovered in Angola in 1912. For the next 40 years, the industry had been based entirely on the diamond mining from alluvial deposits (such mining involves the extraction of diamonds from deposits of sand, gravel and clay, which are brought out in a natural way due to water erosion and were deposited along the banks of rivers, coastline or on the ocean floor).

Angola has extensive diamond reserves (estimated at 180 million carats or 900 tons), principally in the provinces of Lunda Norte and Lunda Sul in

the central and northeastern parts of the country. To date, approximately 700 kimberlites have been located in the country. Most of the diamond rich kimberlites are located along a north east - south west trend that extends in to neighbouring DRC.

Luo mine or grant area Lyo-SMCC, exploiting the kimberlite pipe of Camachia is a diamond mine, commissioned in 2005. It is considered to be one of the 10 largest mines in the world and is located in the north-eastern part of Angola, in the southern province of Lunda Norte. Concession area is 225 km^2. Luo mine is located 75 kilometers from Lucapa, the capital of the province of Lunda Norte and approximately 80 km to the north of the city of Saurimo, the capital of the province of Lunda Sul and 1300 km from Luanda, the capital of Angola, where the base of the company is situated.

The diamond area is geographically located in the north-east of Angola between 7° and 9° parallels to the south and between the meridians 20° and 21° to the east. This region is a part of the southern margin of the Congo Basin, representing a natural geomorphological area in Angola.

The concession area is located in the central part of the Lunde plateau where the rocks of crystal shelf are exposed only in the river valleys, and the rest of the area is covered with rocks of sedimentary cover. River valleys of Luashimu and Shikapa site some large groups of kimberlites. The explored part is located in the concession Luo, namely the Camachia pipe which is just near the river junction of Shikapa and Luo and the Camagico tube, located in the southern part of the river Luo.

Researches of kimberlite formation, its diamond potential, placer generation have conducted for decades. However, there are many unclear problems (Zinchuk, 2014; Afanasiev, Zinchuk, Pokhilenko, 2010; Vaganov, 2000; Grahanov, Shatalov, Styrov, 2007; Zinchuk, 2000). An analysis of the literature of different countries has shown that the main efforts were focused on the mineralogy studies, petrology, geochemistry and other parameters wich were applied to kimberlites and placers, giving almost all diamonds. An intermediate link in this list was not investigated enough. How placers are formed from initial kimberlite pipe body? The answer is seemed obvious - by destroying of kimberlite. More detailed information is difficult to find. According to the author, each link in the chain of formation of kimberlite is important for understanding the mechanisms of these transformations. The fact that this mechanism is not the only one can not be doubted, since the conditions of such transformations differ greatly. Most of the researches are focused on diamond potential issues such as the absence of diamonds in kimberlites, difficult, often impossible location placer sources, depth of formation, the difference of geochemical characteristics of magmatic melt and host rocks (Frolov, Lapin, Tolstov, 2005). Therefore, this publication is aimed mainly at studying exactly intermediate link, transition of kimberlites to the placers.

The object of the research is the diamondiferous minefields of LUO-Camachia-Kamajiku of Angolan plateau.

The aim of the research is to conduct lithological analysis of kimberlite formations and compare their geological positions in diamondiferous area.

The Camachia tube was discovered in the early 60-ies of the last century. It is located at the bottom of the river valley Shikapa, an area which suffers from the effects of erosion in its river-bed. About 50% of the kimberlite body is covered with alluvial and eluvial deposits from the Kalahari Desert. The enclosing rocks of kimberlite pipe are common Archean migmatite gneisses, overlaid with volcanic-sedimentary rocks, the power of which is about 100 m in the crater of the tube.

The Camachia tube has a roughly circular shape with a diameter of about 650 m and an area of about 30 acres. The tube consists of hypabyssal and igneous rocks, represented by two main genetic facies. Morphologically the tube is composite and doubled, consists of two tubes and craters, except that one crater demolished some part of the second one. The first or the eastern crater represents phyric kimberlites and autolytic explosion breccia, and the second or the western one, is represented by sedimentary formations of volcanic origin with inclusions of kimberlite material and consisting of tuffites, tuff-clay rocks, tuff-conglomerates, breccia, and tuff-sedimentary deposits of various structures.

Thus, a volume of volcanic rocks is about 1.2 million m^3 and a weight is about 600 000 tonnes. These rocks are not presented by crystalline rocks. They are represented by crystalline-amorphous, and they have more amorphous component particularly in that part which is closer to the surface.

Previous studies have shown that in two designated bodies or tubes there are two different magmatic eruption craters. The analysis showed the distinction in rocks and kimberlite minerals of these two pipes. Ore minerals are formed under different conditions. Camachia-East and Camachia-

West are characterized by their own genesis and their own mineralogical set at the different stages of rock formation.

Thus, the Camachia deposits are a symbiosis of two kimberlite bodies, conventionally called Camachia-East and Camachia-West. Their relative positions are reflected in the geological sections and are not considered here. An important point is the fact that the body of Camachia-West does not come out to the surface and is deposited at the depth of 120 m. In addition, the body of Camachia-West is quite underestimated, the actual drilling there involves only three wells of small diameter (112 mm) and traced to the depth of 400 m. Therefore, the basic data in the research paper founds on the results of exploration of Camachia-East body.

RESULTS OF RESEARCHES AND THEIR ANALYSIS.

The study area refers to the flat part, and savanna, having sandstone as the basis.

The deposits are located in the bottomed land and river-bed of Shikapa river, therefore it was necessary to deflect the stream (change the direction) in order to explore and exploit the minefield. Thus, the upper part of the deposit is represented mainly by fluvial and alluvial deposits. In addition to the riverine alluvium various amounts of deluvial, proluvial and colluvial deposits are found, which are difficult to separate taking into account their multimixing. The Fig. 1 shows the abovementioned rocks with an admixture of iron hydroxides, which dye the rock brown.

Alluvial deposits are represented by unconsolidated sediments of permanent water flows and include rubbles of different level of roundness and size (boulder, pebbles, gravel, sand, loam, clay). Currently, all the mined ore in the minefield accounts for these deposits, as far as the open-pit mine is of a shallow depth, from 5 to 20 m. Deluvial, colluvial and proluvial deposits barely differ from one another. Deluvial is relatively widespread and is formed by the transfer of host rocks and ore rain flows (so-called sheedflood water). The critical part plays the force of gravity.

Moreover, flushing colluvium effuses from colluvial sediments.

Figure 2 shows the deepest part of the deposit (up to 40-50 m), which formes the quarry benches. Volcanic and sedimentary rocks are clearly visible on the rock outcrops, tuff-breccia, sand, clay with impurities of iron hydroxides.

The following types of ores and rocks exist: PK - porphyre kimberlite; AKB - autolytic kimberlite breccia; TCB - tuff-kimberlite breccia; TSB - tuff-sedimentary breccia; AAT - aleurolite-argillic tuffs. Host rocks, mainly gneisses.

The Camachia-East rock types correspond to the volcanic rocks of hypabyssal magmatic phase (kimberlites) and post-magmatic rock phases (autolytic kimberlite breccia, xenoliths). Crater rocks

Fig. 1. Alluvial-diluvial-proluvial-colluvial complex of rocks at the Camachia tube orifice.

Fig. 2. The deepest part of the Camachia mine where volcanic and sedimentary rocks are visible on the outcrops.

represented various volcanic and sedimentary rocks: tuff-siltstones, tuff-sedimentary breccia, tuff-sedimentary xenoliths.

The Camachia-West rock types correspond to volcanic and sedimentary rocks in the crater, xenoliths, magmatic rocks of hypabyssal phase, autolytic kimberlite breccia (Fig. 3).

The main ore types of Camachia-East deposit are: porphyre kimberlite, autolytic kimberlite breccia, tuff-kimberlite breccia, tuff-sedimentary breccia. The first two types of ore deposits are igneous facies, cement breccias based on tuff-kimberlite represent crater facies.

These facies are covered with clastic sedimentary rocks of all known types: eluvium, deluvium, proluvium, colluvium, alluvium and aeolian sediments which are repeatedly mixed. If we divide intermediate link according to the time (from kimberlite to the formation of placers) we will obtain the following subunits which are specific for the field. On kimberlite pipe body lie combustion products - fragments of crystalline rocks. Above the section lie tuff-kimberlite and tuff-sedimentary breccias (crumbling rocks), which are covered with sediments above mentioned species (broken or amorphous rocks). Precipitations are formed all the time, from the moment of the explosion, until today. Degree of deposits processing depends from the time and conditions. How these results are applicable to existing conditions in Angola, we will judge after a relative comparison of the mean precipitation capacity for a certain period of time. For this the gradient of the formation of sediment power in northern and southern latitudes will be calculated. Also, the gradient of the primary alluvium speed transfer (on the site of the tube) to the secondary, alluvial placer deposits, and after that, till the sea (ocean) or shelf deposits will be calculated. As a result, medium link, between kimberlite and offshore field can be divided to the smaller links in order to develop general method of searching alluvial deposits of diamonds.

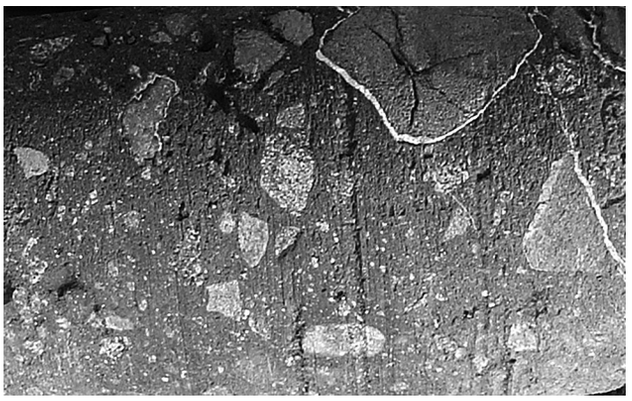

Fig. 3. Autolytic kimberlite breccia drill sample.

CONCLUSION.

The kimberlite deposits of Camachia represent a dual pipe, where the eastern crater partially destroyed the west crater of the tube. The kimberlite rocks and craters have certain dissemblance, indicating the time difference of their formation. Their diamondiferousness is not the same, which is probably due to the different conditions of their formation.

Currently the volcano-sedimentary rocks of the upper part of the Camachia-East crater are exploited, overlaying the Camachia-West crater deposits. A detailed research the formation conditions of these tubes can help to identify the diversity in their diamondiferousness that is both of scientific and practical value.

Conducted research allowed identifying and describing medium link of kimberlite rock transformation from their crystalline rocks to the sediments and showing the possibility of determining of sludge capacity formation in the southern and northern latitudes. Also, this study allows determining the gradient of the primary alluvium rate of transfer to the secondary alluvial deposits and after that to offshore field. As a result, medium link, between kimberlite and offshore field can be divided to the smaller links in order to develop general method of searching alluvial deposits of diamonds.

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