Kimberlite fields of Angola: structural control and diamond presence

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About one thousand kimberlite pipes have been discovered on the territory of Angola to date. This makes the country unique in the scale of manifestation of kimberlite magmatism. The pipes are combined into 11 regions and 36 fields (Figure 1). Macrodiamonds were discovered in kimberlites of seven fields. As a rule, each of them has a pipe-leader, characterized by higher grades and diamond reserves. Kimberlite magmatism on the territory of Angola is related to several periods of tectonic and magmatic activity: Proterozoic-Early-Paleozoic (?), Triassic and Early Cretaceous. Majority of kimberlite bodies, including diamond mines, are Cretaceous.

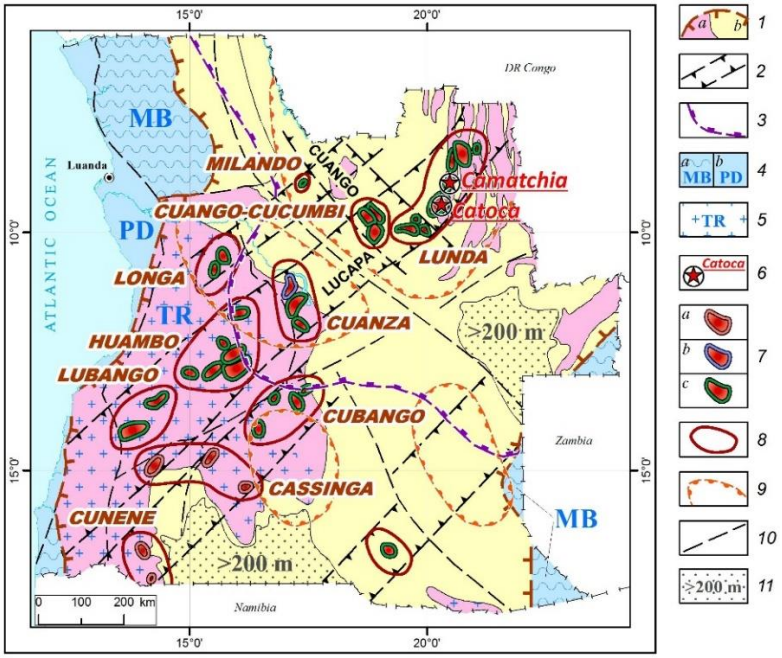

Figure 1: Kimberlite fields and regions in tectonic structure of Angola.

1-5 – main structural and tectonic factors of distribution of kimberlite fields: positive (*1* – Archean craton Congo (*a* – territories with exposed, *b* – buried kimberlites), *2* – zones of tectonic and magmatic activity, *3* – area of favourable deep structures), negative (*4* – mobile belts (*a*), pericontinental depression (*b*), *5* – areas of tectonic and thermal reworking); *6-9* – diamond presence: *6* – kimberlite diamond mines, *7* – kimberlite fields (*a* – Proterozoic-Early Paleozoic (?), *b* – Triassic, *c* – Early Cretaceous), *8* – kimberlite regions, *9* – areas of dispersion of diamonds in terrigenous rocks; *10* – major deep-seated faults; *11* – depressions with overburden of >200 m.

Kimberlite pipe sizes vary from 0,3 ha to 100 ha and 150 ha. Six most rich pipes with diamond grades of 0,5-1,0 carats per tonne (cts/t). were discovered in NE of Angola in Camatchia field (Camagico pipe) and five pipes in Catoca field (Catoca, Tchiuzo, CatE42, Luax071 and Luax072). The number of bodies with grades from 0,1 to 0,5 cts/t is around twenty. A typical diamond-bearing

kimberlite pipe in Angola consists of crater, diatreme and root channel zone. The thickness of crater formations reaches 270 m.

Diamond-bearing rocks are characterized by similar compositions of kimberlite indicator minerals (KIMs). Picroilmenites and garnets prevail in all pipes. Comparative analysis of diamonds in kimberlite bodies with different grades showed that stones are characterized by an individual morphogenetic features. The higher diamond grades, the higher the contents of laminar octahedrons. For example, diamonds of Catoca pipe (0,8 cts/t) in the comparison to other bodies are characterized by a relatively high content of octahedrons (up to 40 %) and 40 % of round crystals. Diamonds of Tchiuzo pipe (0,4 cts/t), are represented by round diamonds (85 %) and less amount of octahedrons (7 %). This is evidence of unfavorable physical and chemical conditions of diamond preservation which resulted in dissolution of stones in Tchiuzo pipe. In general, the content of octahedrons in pipes is relatively low: 5-45 %. In all the known pipes rounded crystals (dodecahedroids) prevail.

The conclusion about dissolution of diamonds in kimberlite melts can be supported by analysis of chemical composition of pyropes. For the majority of the pipes the number of pyropes of diamond association and G10 has a direct correlation with diamond presence and the amount of garnets, formed within a diamond window with temperatures from 900 to 1100 °C and pressures around 40-50 kbar (Figure 2). Another group of kimberlite pipes (Txicoa is an example) contains rather high (up to 5 % and more) content of pyropes of diamond association and G10, but does not contain diamonds. One can see on diagram that no one pyrope is in area of diamond window. This indicates sharp changes of temperature conditions in mantle reservoir and shows dissolution of diamonds. This is one of the reasons why many pipes in Angola do not contain diamonds.

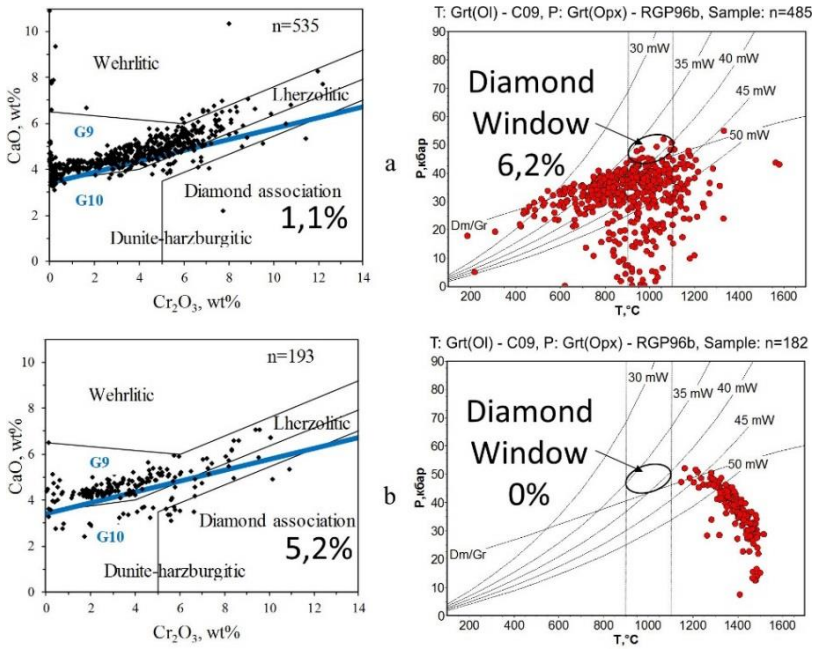

Figure 2: CaO-Cr_2O_3 diagrams of pyropes (fields by N.V. Sobolev, 1974, J.J. Gurney, 1973) in diamondiferous Catoca pipe, 0,8 cts/t (a) and non diamondiferous Txicoa pipe (b) and P-T conditions of garnets formation.

Analysis of conditions of formation of mantle melts (depth of formation, temperature, pressure), morphology of pipes, the number of bodies, diamond potential and other features of 90 % of the pipes shows that the territory of Angola can be divided into four types of the areas (Figure 3). The depth of kimberlite magmatism and diamond potential of pipes increase from the Atlantic coast (SW part) into the continent in the north-eastern direction. Their values have direct correlation with tectonic position of kimberlites and deep structure of the territory.

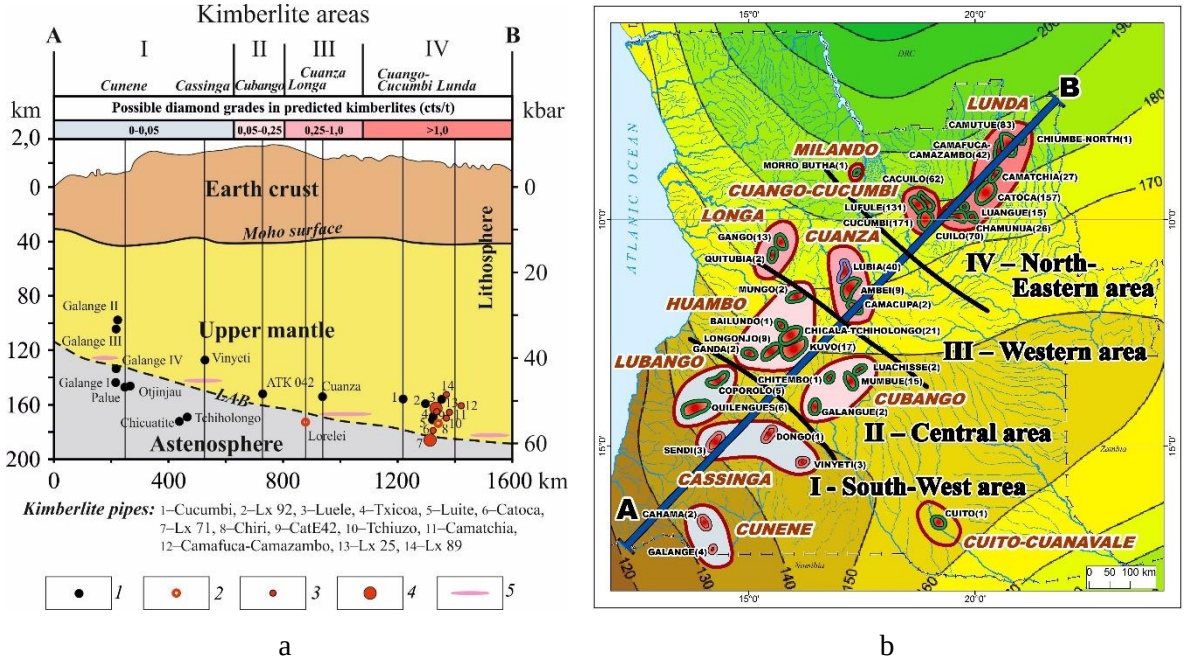

Figure 3: The depth of formation of kimberlitic melts in the section AB of the upper mantle (a) and kimberlite areas on the map of thickness of lithosphere (b).

1-4 – diamond grades in known pipes (cts/t): *1* – 0-0,05; *2* – 0,05-0,25; *3* – 0,25-1,0; *4* – >1,0; *5* – eclogitic lenses.

Structural and tectonic factors of controlling distribution of the known kimberlite fields in Angola were revealed (see Figure 1). The main ones are: 1) confinement to the blocks of Archean stabilization – cratons and within their territories to the areas without tectonic and thermal reworking in Peleoproterozoic (Eburnean) time; 2) connection with paleo-elevations in crystalline basement; 3) presence of positive structures (elevations) in Platform sedimentary cover; 4) confinement to trans-block linear zones of tectonic and magmatic activities. The most important diamond controlling structure of Angola is Lunda zone. The most favorable features of the deep structure for distribution of the known kimberlite fields of Angola are: 1) a significant thickness of the lithosphere (more than 150 km); 2) depressions and its slopes in relief of the Moho surface; 3) areas of decompaction of the Earth's crust; 4) areas of high velocities of seismic waves; and 5) low heat flow.

Based on a comprehensive analysis of kimberlite pipes of Angola (tectonic position, deep structure, morphology, age, conditions of formation of mantle melts, mineralogical and petrographic features at al.) the territories with different diamond potential were distinguished.