# Mineralogical features of the China kimberlites - comparison with Arkhangelsk diamondiferous province

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Many kimberlitic pipes occur in the Hua Bei craton (North-Chinese platform), some of them contain economic-grade diamonds: Men In (Liaonin) and Fu Xian (Shandong), whereas others do not. Mineralogy of the Chinese kimberlites was investigated by Bao Yannan and Lu Fengxiang (1996). In addition to those work, we investigated special collection of diamonds, mantle xenoliths, garnets, olivines, flogophites, chromites and minerals of the kimberlitic groundmass from diamondiferous regions. We compared our results to diamonds and their accompanying minerals from the M.V. Lomonosov deposit (Zolotitskoye field), and from other pipes (V. Grib pipe, Verkhotinskoye and Kepinskoye fields) of the Arkhangelsk diamondiferous province.

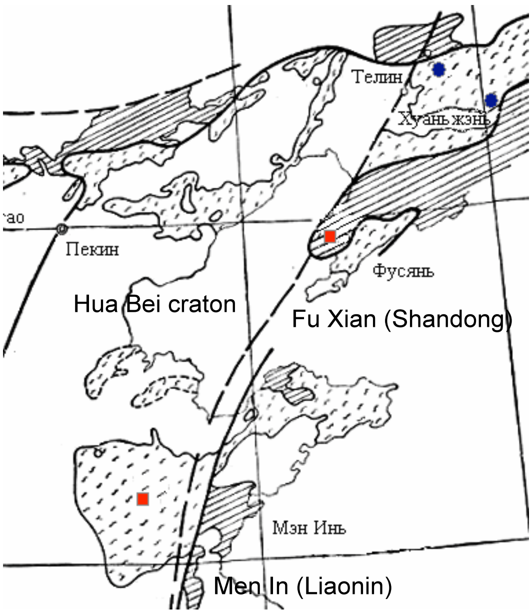



Fig.1. Location of kimberlites of the Hua Bei craton

## Samples studied and methods used

Diamonds (55), garnets (93), Cr-spinels (127) and olivines (25) from the kimberlitic pipes of the Hua Bei craton (North-Chinese platform) were investigated in our work. The Men In (Liaonin) and Fu Xian (Shandong) are the main diamondiferous provinces in China (fig.1). We investigated samples from 4 pipes: the Victory - 1 "Sheily", the Red flag № 6 in area Men In; pipe № 50 "Bihigh" and № 42 in area Fusjan. The following mineralogical peculiarities of the kimberlites were established: a low output of heavy fraction, absence of the Ilmenite.

Diamonds were investigated using a scanning electron microscope (SEM), IR – spectroscopy, photoluminescence and EPR instruments. We investigated polished sections of the kimberlites and chemical composition of the minerals by the thermal analysis (13), IR - spectroscopy (13), X-ray spectroscopy (11) and micro-probe analyses methods (71). The chemical compositions of the accompanying minerals were determined using a JSM-820 SEM with attached energy-dispersive detector. Statistical analysis of the data was performed according to a chemical-genetic mineral classification from kimberlites on the basis of a cluster and discriminate analysis procedure (Garanin et al. 1996, Garanin & Possoukhova 1998).

## Diamonds and mantle xenoliths

Among diamonds - octahedrons, dodecahedrons, O-Д polyhedrons with different type of a photoluminescence (blue, pink, yellow - green, zoned), physical type Ia and IaB1, dodecahedrons prevail (fig.2). The concentration of the nitrogen defects is high and A-form prevails. Crystals without the observably paramagnetic defects prevail. Ultrabasic inclusions prevail and sulphides were not established. According to Tailor's diagram diamonds were in the mantle not for a long time and not for a high temperature. The peculiarities of their morphology and spectral characteristics have shown the similarity with the diamonds of the M.V. Lomonosov deposit and differ from the V. Grib pipe (Kudryavtseva et al., 2005). Thus, diamonds of China and Arkhangelsk province had a differ history during and after their formation.


Fig. 2. Diamond crystal from the Liaonin region

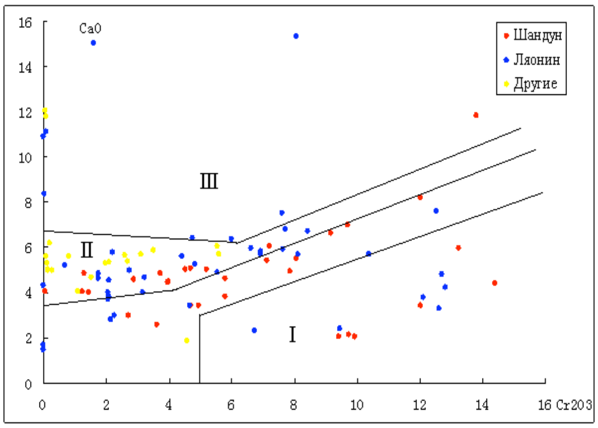
We investigated mantle xenoliths (dunite and lhersolite) from the Men In kimberlites. Relicts of primary minerals were analyzed. Garnets were not established. Olivine corresponded to highly – Fe-forsterite from Mg-Fe peridotites (7 group). Chromites have low content of $Cr_2O_3$, high content of $Al_2O_3$ and Fe and do not correspond() to diamondiferous criteria (Sobolev, 1974). Phlogopite is similar to phlogopite from the groups II of the Arkhangelsk province (Bogatikov et al., 1999) and high titanium phlogopites were established similar to ones from lamproites. Sulfides - millerite and pyrite. They differ from sulfides of the Yakutia (Garanin et al.1991) and have more Ni and Co. Xenoliths in Chinese kimberlites are rare and they are strongly changed. Therefore, it is possible to assume: during formation of kimberlites the mantle rocks were melted and their fragments were not kept, as well as in M.V. Lomonosov deposit. Another situation we have in the V. Grib pipe. The xenoliths in this pipe are abundant and they are fresh.

**Table 1. Chemical composition of the sulphides**

| | S | Ni | Co | Fe | Cu | Sum |
|---|---|---|---|---|---|---|
| 1 | 35.29 | 60.71 | 3.84 | 0.51 | 0.08 | 100.45 |
| 2 | 34.28 | 59.08 | 4.22 | 0.83 | 0.05 | 98.52 |
| 3 | 35.07 | 60.88 | 3.74 | 0.67 | 0.00 | 100.43 |
| 4 | 34.05 | 62.34 | 3.79 | 1.02 | 0.00 | 101.22 |
| 6 | 53.23 | 0.14 | 0.08 | 46.45 | 0.00 | 99.92 |
| 8 | 53.94 | 0.36 | 0.12 | 44.99 | 0.00 | 99.49 |
| 9 | 54.64 | 0.02 | 0.03 | 45.40 | 0.00 | 100.11 |
| 10 | 54.29 | 0.00 | 0.02 | 45.75 | 0.00 | 100.11 |
| 11 | 53.08 | 0.17 | 0.05 | 45.28 | 0.10 | 98.72 |
| 12 | 54.00 | 0.11 | 0.05 | 45.28 | 0.00 | 99.45 |

**Indicator minerals**

Garnets, chromites and olivines were investigated and connection between their composition and contents of diamonds in kimberlites (fig 3) is confirmed. In *high diamondiferous Shandong* kimberlites there are a lot of high-Cr-garnets from high diamondiferous dunites and harzburghites (1group) and equigranular lherzolites (3 group). There are a lot of chromites from high diamondiferous dunites and harzburghites (1 group) and high-Cr spinels from lherzolites (3 group). There are found a lot of low- Fe-olivines from inclusions in diamond and diamondiferous Mg-peridotites (1&2 groups) and middle-Fe-olivines from inclusions in diamond and diamondiferous Mg-peridotites (3&4 groups). In *middle diamondiferous Liaoning* kimberlites found less spinels from groups 1&3, a lot of middle-Cr-spinels from lherzolites (4 group) and a lot of low- and middle-Cr-garnets from diamondiferous equigranular lherzolites (5 group), less olivines from groups 3&4. In *barren Hua Bei kimberlites* there are a lot of low-Cr-garnets from lherzolites and websterites (9 group) and garnets from diamondiferous Mg-Fe eclogites (19 group); spinels from groups 1&2 are not present and there are a lot of low-Cr-spinels from lherzolites (5 group). There are found a lot of high-Fe olivine from Mg- and Fe-peridotites with ilmenite (groups 4&5). Thus, Shandong is similar to M.V. Lomonosov deposit; Liaoning - to Verkhotinskoe field and barren kimberlites from Hua Bei - to Kepinskoe field. There are no analogues of a V.Grib pipe. Olivines are replaced with serpentine, as against of Arkhangelsk province where there is established saponite together with serpentine.



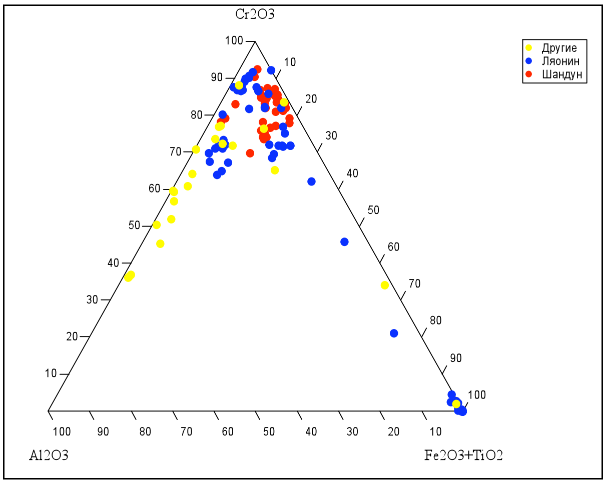




Fig. 3. Chemical composition of the garnets and Cr-spinels of the Chinese kimberlites: red - Fu Xian (Shandong); blue - Men In (Liaonin); yellow – barren kimberlites. I – diamondiferous dunites and harzburghites; II – lherzolites, III – verlites & websterites according to N.V. Sobolev, 1974

**Mineral composition of the groundmass**

Mineral composition of the kimberlitic groundmass from different pipes was investigated: in pipe N50 (the Victory 1) and in pipe N42 serpentine prevail and a lot of dolomite was established in pipe N50. Separate phases of the eruption are differ. Carbonates established in early phase, and minerals containing $H_2O$ prevail in finished phases. The analysis of microcrystalline oxides from kimberlites of China testifies for a long and complex evolution. Picrochromites were established in pipe № 50 in the first phase, and it is point to significant depth of their origin (– вот эта фраза не совсем понятна.) Zone grains of Cr-spinels are more widely submitted in the subsequent phases. First phase in pipe № 42 contains secondary magnetite, developing on silicates. In the second phase Cr-spinels have irregular boundaries, there are sulfides and specific luminescent minerals. In the third phase - only relicts of chromites are safe and the basic minerals - rutile, perovskite, Ti-magnetite and Mg-magnetite. In the Victory 1 pipe are revealed microcrystalline oxides, formed at replacement of silicates; well faceted grains of square form and irregular-shaped grains. Perovskite prevails, there are a lot of sulfides. Then, in chromites Fe increases and Cr decreases. Thus, in all bodies picroilmenite is absent and from the first phase of introduction to the third phase the oxidizing potential and alkaline conditions accrues.

**Conclusion**

On the basis of complex comparative mineralogical researches similarity between Shandong kimberlites and kimberlites of the Zolotitskoe field, between Liaoning kimberlites and pipes of the Verkhotinskoe field, between barren kimberlites oh the Hua Bei kimberlites and Kepinskoe field in Arkhangelsk province is established. No analogues among investigated Chinese kimberlites and V. Grib pipe were found .

The study established the heterogeneity of the mantle substratum under Hua Bei craton. High diamond-bearing Shandong kimberlites were formed from high diamond-bearing dunites and harzburghites, diamond-bearing equigranular lherzolites and others diamond-bearing Mg-peridotites with high-Cr garnets and Cr-spinels. Average diamond-bearing Liaoning kimberlites were formed from equigranular lherzolites with low&middle-Cr garnets and spinels. Low diamond-bearing Hua Bei kimberlites were formed from lherzolites, websterites, ilmenite-rutile Mg-Fe eclogites, Mg- and ilmenitic peridotites with low-Cr spinels, high-Fe olivines and low-Cr garnets

Chemical and phase structure of minerals from the kimberlitic groundmass point out to long and complex evolution of the Hua Bei kimberlites which was individual in each pipe and established that the oxidizing potential and potashing environment accures from the first phase of eruption to the last one. In early phases there are established picrochromites - a parameter of significant depth of origin and high diamond-bearing potential of magma. In the second phase microcrystalline chromites have irregular form with irregular edges and ash value: content of $Fe^{3+}$ is increased. Last phase contain magnetite, a lot of perovskite and sulfides, and the minerals containing $H_2O$.

The following mineralogical peculiarities of the Chinese kimberlites were established: a low output of heavy fraction, absence of the ilmenite, a low share of eclogitic associations, a high content of round dodecahedral diamonds with a various photoluminescence (blue, yellow-green, pink, zone) and special spectral characteristics (without the paramagnetic centres, a lot of nitrogen in A-form, absence Ni) and mineral inclusions (sulfides were not established). It is possible to explain such peculiarities with special conditions of their formation. Kimberlites were generated on the ultrabasic mantle substratum which was substantially melted.

REFERENCES


1. Bogatikov O.A. et al. Arkhangelsk diamondiferous province (geology, petrology, geochemistry and mineralogy). - Moscow State University, 1999, 524 p. in Russia
2. Kudrjavtseva G.P. et al. The Atlas of morphogenese of diamond and minerals - satellites in kimberlites and related rocks of the Arkhangelsk kimberlitic provinces. - Moscow.: the Polar circle, 2005, 624p.- in Russia
3. Possoukhova T.V., Kudryavtseva G.P., Garanin V.K., Tikhova M., Verichev E.M. Two types of the diamondiferous kimberlites from the Arkhangelsk Province (Russia). In "Mineral Deposits at the Beginning of the 21-th Century", Balkema, Rotterdam, 2001, p.
4. Possoukhova T.V., Kudryavtseva G.P., Garanin V.K. Diamonds and accompanying minerals from Arkhangelsk kimberlites. In "Mineral Deposits: Processes to Processing", Balkema, Rotterdam, 1999, v. 1. P. 667-670
5. Sobolev N.V. Deep of inclusion in kimberlites and a problem of structure of the mantle. - Novosibirsk: the Science, 1974, 263p.