THE FIRST FINDING OF CR-SR-LOPARITE-TYPE AND CR-CHEVKINITE-TYPE MINERALS IN DIAMONDS.

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Minerals with exotic composition containing up to 40% of rare eath elements and up to 11% of chrome were found as mineral inclusions in diamonds from the River Ranch kimberlite pipe (Limpopo Mobile Belt, SE Africa).

These exotic inclusions were found due to green haloes of radioactive damage in two diamonds, which belong to the type IaA. Both diamonds host numerous (4-15) brown to yellow opaque inclusions (50*30-80 mμ) with green haloes (100*150 mμ). The inclusions are flat-faced, elongated, of irregular shape. During this study we only analysed the inclusions situated far away from any fractures. Analyses were carried out on a fully automated Cameca/Camebax Microbeam electron microprobe with an accelerating voltage of 25 kV and an electron beam current of 40 nA. The raw data were treated with an on-line PAP correction program. Most elements were counted for 10 seconds except for Ce, Sr, Nd, Nb, Pr, Th which were counted for 30 seconds to increase precision.

The phases responsible for the radioactive damage were found to be a chrom-strontian-loparite-type mineral inclusion in specimen N413 and a chrom-chevkinite-type mineral inclusion in specimen N248. The chrom-strontian-loparite-type mineral contains 29.78-30.15% TiO_2, 0.61-0.7% Al_2O_3, 7.81-7.77% Cr_2O_3, 0.39-0.41% FeO, 1.81-2.03% CaO, 0.16-0.1% Na_2O, 4.46-4.44% K_2O, 19.95-19.72% SrO, 3.51-3.64% Nb_2O_5, 17.46-17.25% La_2O_3, 12.69-12.53% Ce_2O_3, 1.44-1.45% ThO_2. The chrom-chevkinite-type mineral inclusion has in its composition 18.73-20.54% SiO2, 8.93-8.54% TiO_2, 1.27-8.12% Al_2O_3, 11.54-11.14% Cr_2O_3, 1.04% FeO, 1.43% MgO, 0.58-0.6% CaO, 2.38-1.54% SrO, 2.64-1.68% Nb_2O_5, 11.76-12.03% La_2O_3, 28.33-25.10% Ce_2O_3, 1.32-1.38% ThO_2, 6.64-5.92% Nd_2O_3, 2.28-2.21% Pr_2O_3, 1% F. Sample N413 also contains rhoenite and an unidentified volatile-bearing silicate phase as alteration products for the loparite-type mineral, while additional mineral inclusions in N248 diamond are represented by a high-manganese spinel and an unidentified volatile-bearing silicate phase.

Both phases are isotropic, with very high index of refraction. Reflectance of the Cr-Sr-loparite-type inclusion closely resembles the reflectance of Sr-loparite (Haggerty and Mariano, 1983) and decreases from 18 to 16% with an increase of wave length. A reflectance of the Cr-chevkinite-type inclusion is 14-12% in short wave diapason , but equal to those of loparites at $\lambda \approx 600$ nm.

The position of the Cr-Sr-loparite-type mineral in the ternary system perovskite-loparite-tausonite (Mitchell and Vladykin, 1993) is shown in Fig.1a. The River Ranch rare-earth titanate is different in composition to all the reported perovskite-type minerals due to high contents of K and Cr (Fig.1b. and c). Another difference between the inclusions from the two diamonds and reported loparites is the La/Ce ratio. In all loparites investigated so far Ce prevails over La (La wt%/Ce wt%

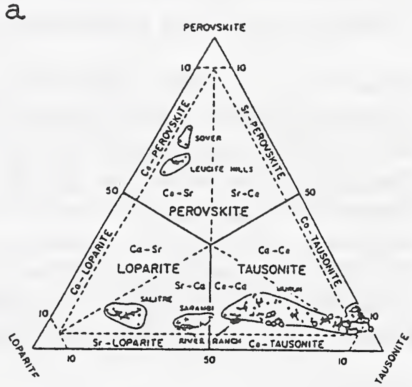
= 0.65-0.82), whilst our Cr-Sr mineral has the ratio of 1.36-1.39. The Cr-chevkinite-type mineral contains much chrome in contrast to chevkinites and perrierites and lower in iron content than these minerals.

The X-ray difraction study could only be carried out on the Cr-Sr-loparite-type grains (due to grain size restrains) using CuKa-radiation with a Ni filter (to obtain monochroomatic X-rays). An exposure time of 10 days in an evacuated Gandolfi camers was employed to collect the data. Only the strongest reflections are given in Table 2 due to the size of the crystal (<50 mμ) that could be mounted. The X-ray data is different to that of loparite and Sr-loparite. Therefore we conclude that the inclusion extracted from the N413 diamond is a new mineral.

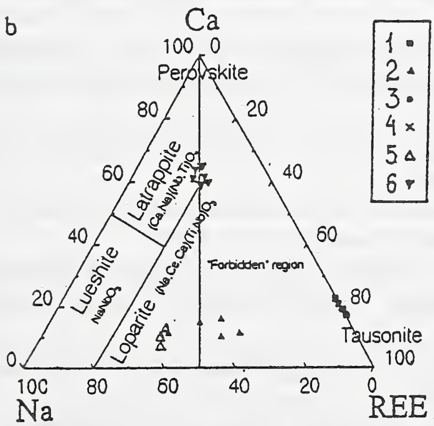
Table. X-ray diffraction data for Cr-Sr loparite and the perovskite-type minerals

N413 inclusion		Rel. loparite 20-272		Sr-loparite 35-618		Tausonite	
dA	Int	dA	Int	dA	Int	dA	Int
		3.90	10	3.85	1		
3.00	10	3.50	10				
2.78	100	2.75	100	2.74	100		
						2.76	100
2.46	50						
2.27	10	2.24	20	2.24	20		
2.15	10						
1.96	10	1.93	65	1.94	40	1.95	50
		1.74	10				
		1.58	55	1.58	50	1.59	30

a



b



c

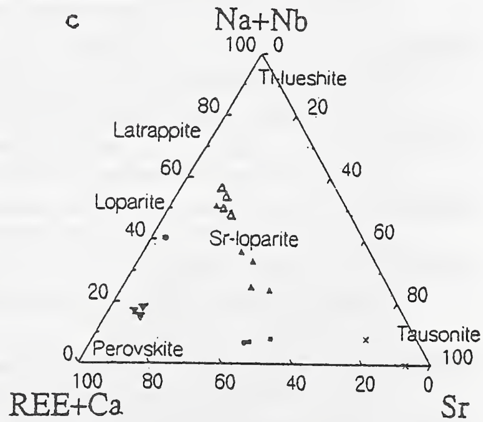


Fig.1a-c. a. Compositions (mol% end-member molecules) of tausonites from Little Murun and other Sr-bearing perovskites in the ternary system perovskite-loparite-tausonite (Mitchell and Vladykin, 1993).Solid field corresponds to Cr-Sr-perovskite in assumption that loparite end member does not contain K; striped field - in assumption that loparite end member contains K. b. Plot of Na-Ca-REE for loparites and tausonites with delineated A-cite classification of perovskite minerals ABO_3 (Nickel and McAdam, 1963). 1- Cr-Sr-loparite-type mineral; 2- Sr-loparite (Haggerty and Mariano, 1983); 3- loparite (Vlasov, 1966); 4- tausonite (Vorobiev et al., 1984); 5-

Sr-Ce-perovskite (Mitchell and Steele, 1992); 6- REE-tausonite (Mitchell and Vladykin, 1993) c. Plot of REE+Ca-Na+Nb-Sr for loparites and tausonites.

We share the common point of view on the origin of titanates and minerals containing REE and LIL-elements in the mantle due to metasomatism (works by Haggerty and Erlank) with the non-CO_2 fluid enriched with K and F.

The green colouration of haloes around radioactive inclusions was shown (Vance and Milledge, 1972) to become brown above 600°C. Therefore our diamonds resided in the upper mantle at a depth where temperature didn't exceed 600°. Mineral phases in the River Ranch diamonds are equilibrated at a 50 mW/m^2 geotherm, which reaches the temperature of 600° approximately at P=24 kb (80 km) (Kopylova et al., 1995). Similar parameters of origin (P=20-30 kb and T=1000-1100°C) for mantle rare earth titanates were published by Haggerty et al. (1983a)

Diamonds are not stable at the 600°C temperature and a pressure less than 34 kb. Thus, the investigated inclusions are not epitaxial. We attribute a presence of REE titanates in non-fractured diamonds either to metastable growth of the diamonds or to metasomatising agent penetrating diamonds via healed fractures. *In both* cases our phases are typical for metasomatism predating kimberlite formation, rather than for an unaltered mantle. A non-epitaxial origin of the exotic REE titanates is confirmed by a coexistence of a low-pressure high-manganese spinel and the presence of K (rather than sodium, usually occuring in the loparite) in the loparite-type mineral. Concentrations of the highly inert elements Ti and Cr in studied radioactive phases seem to be inherited from a pre-metasomatic mantle peridotite.

References:

Haggerty, S.E., and Mariano, A.N., 1983. Strontian-loparite and strontio-chevkinite: two new minerals in rheomorphic fenites from the Parana Basin carbonatites, South America. Contrib. Mineral. Petrol.,84: 365-381.

Haggerty, S.E., Smyth, J.R., Erlank, A.J., Rickard, R.S. and Danchin, R.V., 1983a. Lindsleyite (Ba) and mathiasite (K): two new chromium-titanates in the chrichtonite series from the upper mantle. Amer.Mineral., 68: 494-505.

Kopylova, M.G., Gurney, J.J., and Daniels, L.R.M., 1995. Mineral inclusions in diamonds from the River Ranch kimberlite. Ext.Abs., this volume

Mitchell, R.H., and Steele, I., 1992. Zirconium and potassium silicates and strontium perovskite in lamproites from the leucite hills, Wyoming. Canad.Miner., 30: 1153-1159

Mitchell, R.H., and Vladykin, N.V., 1993. Rare-earth element - bearing tausonite and potassium bearing titanates from the Little Murun potassic alkaline complex, Yakutia, Russia. Miner.Mag., 57: 651-664

Nickel E.H., McAdam, R.C., 1963. Niobian perovskite from Oka, Quebeec: a new classification of the perovskite group. Can. Mineral, 7: 683-697.

Vance, E.R., and Milledge, H.J., 1972. Natural and laboratory alpha-particle irradiation of diamond. Miner.Mag., 38: 878-881

Vlasov, K.A., 1966. Geochemistry and mineralogy of rare elements and genetic types of then deposits. II. Mineralogy of Rare Elements. Israel Prog. for Sci. Translations: Jerusalum, 688p.

Vorob'ev, E.I., Konev, A.A., Malyshonok Y.A., Afonina G.G., and Sapozhnikov, A.N., 1984. Tausonite $SrTiO_3$ - a new mineral from the perovskite group. Zapiski Vsesoyuznogo Mineralogich. Obzh., 113, N1: 86-89.