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NEW MODELS FOR KIMBERLITE PARENTAL MELTS: COMPOSITION, TEMPERATURE, ASCENT AND EMPLACEMENT

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Kimberlites represent magmas derived from great mantle depths and are the principal source of diamonds. Kimberlites and their xenolith cargo have been extremely useful for determining the chemical composition, melting regime and evolution of the subcontinental mantle. Significant effort has gone into characterizing styles of emplacement, ages, petrography, mineralogy, textural and compositional characteristics, and the tectonic setting of kimberlites. However, a full understanding of kimberlite petrogenesis has been hampered by effects of pre-emplacement contamination, syn-emplacement stratification and syn/post-emplacement alteration of kimberlite rocks, all of which tend to hinder recognition of primary/parental kimberlite magma compositions. The prevailing practice of using bulk kimberlite compositions to derive parental compositions has been challenged by research on the Devonian Udachnaya-East pipe and other relatively fresh kimberlites worldwide.

Since its discovery in 1956, the Udachnaya kimberlite pipe has become a ñtype localityò for geochemists and petrologists studying mantle rocks and mantle physical-chemical conditions. Apart from hosting a diverse suite of extremely well-preserved mantle xenoliths, the host kimberlite (East body) is the only known occurrence of fresh kimberlite, with secondary serpentine almost absent and uniquely high Na_2O and Cl (up to 6.2 wt.%) and low H_2O (< 1 wt.%) contents. The discovery of such compositional features in the only unaltered kimberlite has profound implications for models of parental kimberlite magma compositions, and the significance of the high Na and Cl abundances in the Udachnaya-East pipe has therefore been subjected to vigorous criticism. The main argument against a primary magmatic origin of high Na - Cl levels involves the possibility of contamination by salt-rich sedimentary rocks known in the subsurface of the Siberian platform, either by assimilation into the parental magma or by post-intrusion reaction with saline groundwaters.

The main evidence against crustal contamination of parental kimberlite magmas is that the serpentine-free varieties of the Udachnaya-East kimberlite owe their petrochemical and mineralogical characteristics to a fortuitous lack of interaction with syn- and post-magmatic aqueous fluids. The groundmass assemblage of this kimberlite, as well as earlier-formed melt inclusions, contains alkali carbonate, chloride and other Na- and Cl-bearing minerals. This mineralogy reflects enrichment of the parental melt in carbonate, chlorine and sodium. The combination of low H_2O, high alkali-Cl abundances, lack of serpentine, and the presence of alteration-free mantle xenoliths all indicate that the Udachnaya-East kimberlite preserves pristine compositions in both kimberlite and mantle xenoliths. Evidence for broadly similar chemical signatures is found in melt inclusions from kimberlites in other cratons (South Africa, Canada, Finland and Greenland). We demonstrate that two supposedly ñclassicò characteristics of kimberlitic magmas - low sodium and high water contents - relate to postmagmatic alteration. The alkali- and volatile-rich compositions of melt inclusions is responsible for low-temperature phase transformations during heating experiments, melting at <600°C, carbonate-chloride liquid immiscibility and homogenisation temperatures at ~650-800°C, well below the solidus of the high-Mg melt that is traditionally inferred to be primary kimberlite composition. Notably, records of heating stage experiments with melt inclusions from different kimberlites are broadly similar.

Previously inferred high liquidus temperatures (>1400°C) are inconsistent with geological evidence (e.g., absence of thermometamorphic effects), temperatures in the potential mantle source and melt inclusion data. We consider the protokimberlite liquid to be low temperature near the surface (<800°C), virtually anhydrous, aluminosilicate-poor, Na-Ca carbonate, enriched in lithophile trace elements, halogens, and sulphur. Although kimberlite magmas are dense in crystals and deeply-derived rock fragments, they ascend to the surface extremely rapidly, enabling diamonds to survive. The unique physical properties of kimberlite magmas depend on the specific compositions of their parental melts. We explain exceptionally rapid ascent of kimberlite magma from mantle depths by combining empirical data on the essentially carbonatite composition of the kimberlite primary melts and experimental evidence on interaction of the carbonate liquids with mantle minerals. Our experimental study shows that orthopyroxene is completely dissolved in a Na_2CO_3 melt at 2.0 to 5.0 GPa and 1000-1200°C. The dissolution of orthopyroxene results in homogeneous silicate-carbonate melt at 5.0 GPa and 1200°C, and is followed by unmixing of carbonate and carbonated silicate melts and formation of stable magmatic emulsion at lower pressures and temperatures. The dispersed

silicate melt has a significant capacity for storing a carbonate component in the deep mantle (13 wt% CO_2 at 2.0 GPa). This component reaches saturation and is gradually released as CO_2 bubbles, as the silicate melt globules are transported upwards through the lithosphere by the carbonatite magma. The globules of unmixed, CO_2-rich silicate melt are continuously produced upon further reaction between the natrocarbonatite melt and mantle peridotite. On decompression the dispersed silicate melt phase ensures a continuous supply of CO_2 bubbles that decrease density and increase buoyancy and promote rapid ascent of the magmatic emulsion, and ultimately drives crack propagation and emplacement of kimberlite with its load of entrained ultramafic and crustal material into the crust. The melt saturation in olivine at low pressure prompts olivine crystallisation, which drives the residual melt towards the initial (protokimberlite) carbonatite composition.

The solubilities of H_2O and CO_2 in the model (ultramafic/ultrabasic) kimberlite melt at emplacement pressures are not as high, as measured abundances of these volatiles in kimberlite rocks. The low H_2O content of the kimberlite melt, as at least during emplacement in the crust, do not support fluidisation mechanism (i.e., rapid degassing and expansion of magmatic volatiles in an open system) of the kimberlite emplacement. Furthermore, a number of studies have convincingly demonstrated that kimberlite explosions were unexpectedly powerful for such small magma volumes. The evidence was interpreted as excavation and even emptying of pipes from top down to significant depths (up to 1 km), prior to filling with juvenile material and pulverised country rocks. Notably, eruptive activity was shown to be polyphase and span considerable time with intermittent episodes of violent venting out and periods of quiescence and sedimentation in crater lakes. Moreover, as manifested by the presence at significant depths in some pipes of relatively fresh, often uncharred wood fragments, plant leaves, animal and fish parts, the venting juvenile material was likely cold and even solid.

If the kimberlite magma does not experience H_2O and CO_2 degassing and is disrupted at subsolidus conditions, what causes the kimberlite explosive eruption? We hypothesise that emplacement of the kimberlite magma as subsurface dykes is followed by gravitational separation and sinking of dense olivine and xenoliths, whereas the buoyant carbonatitic liquid is squeezed to the top of intrusive bodies. Olivine-rich cumulates with interstitial carbonate-rich melt form the ñroot zonesò of hypabyssal kimberlites, whereas the upper parts of dykes are composed of the carbonatite with scattered silicate minerals. The olivine-rich rocks worldwide are prone to intensive serpentinisation and associated production of H_2 and CH_4 through the Fischer-Tropsch synthesis. The amount of hydrogen produced is ~10% of the volume of serpentinised olivine. thus the serpentisation may explain spontaneous outgassing of the UE kimberlite (~10^5 m^3/day at 50-70 atm; 52% H_2) recorded in the boreholes at the level of the lower aquifer.

We envisage that degrading water-soluble carbonatite in the upper parts of kimberlite intrusions was turned into a cavernous system that provided initial storage to the hydrogen- and methane-rich gases derived from serpentinisation of olivine cumulates in the kimberlite ñroot zoneò. The oxidation of these flammable gases and/or their pressurisation in a single spot resulted in a powerful detonation and destruction of surrounding rocks, and possibly caused ñchain reactionò by sending shock waves through the cavernous system and thus triggering numerous explosions. Subsequent detonation activity resulted in vertical and lateral explosive boring, and further fragmentation inside the dyke system and surrounding country rocks. This was followed by collapse of rocks from the top and walls and related growth of a carrot-shaped ñdiatremeò by excavation from top down and fragmentation on the contacts between the kimberlite and country rocks (i.e. in-situ ñcontact brecciaò). While the idea of post-magmatic brecciation of kimberlite rocks is not entirely new, the role of combustible gases in the formation of kimberlite diatremes and their pyroclastic and volcaniclastic kimberlite facies is proposed for the first time.

We invite collaborations on microanalysis of individual mineral phases and phenocryst-hosted melt inclusions in the least altered kimberlite samples from different localities. It is important to maintain an open mind, to not doggedly stick to increasingly untenable orthodox views, and to analyse emerging evidence on merit.

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[illegible]
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[illegible] [Vanhaecke et al., 2009]. [illegible] ([illegible] ^{87}Rb [illegible] ^{87}Sr), [illegible] S, Mo, Ru, Sn [illegible] Hg) [illegible] ^{235}U.

[illegible] Li, Mg, Ti, V, Cr, Mo, Fe, Ni, Zn, Cd, Hg, Tl, Si, Ge, Sn, Cl, Sb, Te, Se, [illegible] Sr, Rb, Nd, U [Teng et al., 2017]. [illegible]

[illegible] [Powell et al., 2017]. [illegible] (65 [illegible] 63), [illegible] ^{65}Cu [illegible] [Zhu et al., 2002]. [illegible] ^{65}Cu, [illegible] (<1[illegible]) [Powell et al., 2017]. [illegible] [Powell et al., 2017]. [illegible] 1) [illegible] ^{65}Cu; 2) [illegible] ([illegible] 3[illegible]); 3) [illegible] [Powell et al., 2017]. [illegible]

[illegible] [Vanhaecke et al., 2009]. [illegible] [Moynier et al., 2017].

[illegible] (mass bias) [illegible]

[illegible] [Vanhaecke et al., 2009]. [illegible]

[illegible] [Moynier et al., 2017]. [illegible] (SSB, standard-sample bracketing) [illegible] [Maréchal et al., 1999; Maréchal and Albaréde, 2002; Mathur et al., 2005].

[illegible]

$$[illegible] = [illegible] - 1 \times 1000,$$

[illegible] NIST SRM 976 - [illegible] ^{65}Cu/^{63}Cu (NIST, [illegible]).

[illegible] AG-MP, Cu [illegible] [Mathur et al., 2005]. [illegible] (>10[illegible] Cu), [illegible] [Mathur et al., 2005], [illegible]

[illegible] 6, 7 [illegible] AG MP-1 (Bio-Rad inc., [illegible]) [illegible] (Triskem inc., [illegible]). [illegible] AG MP-1. [illegible] (Perkin Elmer), [illegible] 30 [illegible] 10 [illegible]^3, [illegible] Cu, Fe, Zn, Co, Ni [illegible] Q-ICP-MS NexION 300S (PerkinElmer).

[illegible] (Triskem) [illegible] (Triskem inc, [illegible]) [illegible] D=0.7 [illegible] h= 4,2 [illegible] V = 1,6 [illegible]^3 [Dirks et al., 2010]. [illegible] 5 [illegible]^3 0.01 [illegible] HCl [illegible], 6 [illegible]^3 0.01 [illegible] HCl [illegible] 3 [illegible]^3 8 [illegible] HCl [illegible]. [illegible] AG MP-1 [illegible] (Triskem inc, [illegible]) [illegible]

tfOteOdtjlsteOdtjcq fnqtsw D=0.7 fnqtj h= 5 fnqtj V = 1,9 fnqtj3 [Borrok et al., 2007; Marechal et al., 1999; Marechal, Albarede, 2002]. u?jdtjO or hjdjdtcq^w o?dz ujOtdO tfsHgtslsts o?lz fnqtjtsdz 5 fnqtj3 10 ї HCl, tftsfnqtjHlz^g fh cq? fnqtj^r o tsfnqtsodtsgts ?tsdtcq^ujfnjso O dtjOstecq^ujdz ? dtjdtjdtsts o 5 fnqtj3 10 ї HCl, tftetsHtsdtqjjdtcq^j lzHOtjdtcq^w dtjOstecq^ujr o 4 fnqtj3 4 ї HCl, dz cqtetsoOdtcq^j dtjHcq o 4 fnqtj3 4 ї HCl, or hjdjdtcq^j kjdjLOo 3 fnqtj3 1ї HCl cq or hjdjdtcq^j ujcqdtOo 3 fnqtj3 hjcqtsdtcq^LtsoOdtdts? otsHr . u lstscq^ls tslsdtjlsq^ls, ujsts tftecqdtjdtjdtcq^j fnqtjtsdz u u (Triskem) dtj tftsLotsdzwjls or hjdzwlsq wteO?ujcq^g ujcqdtO

? dzw fnqtjtsdz u u (Triskem) tfteqjHdtsxjdtdtOy fnjdtjO tsBjfnjjujcq^oOjls or hjdjdtcq^j dtjHcq dtj dtjdtj 90 % dtjOfnjn, o fntsujlsOdtcq^ fn?tstets^h jj? tsujcq^fnjs?ts? tsls dtjOstecq^ujdz ? dtjdtjdtsts o. ? tstftsdtdtcq^lsjdz dz j ?fnjjteqdtjdts^ tftsO?LOdtdtcq, ujsts lzojdtcq^ujdtcq^j ?tsdtujdtsteOujcqcq ?cqfnqtslsr dtO dtOujOdz dtsdtj dtlsOfj fnqtcq^xOjls lzHjtexOdtcq^j dtjHcq dtO fnqtjtsdtj, ujsts, o fntsqr, tsujteqjHq, ts?OLr oOjls odtcq^wdtcq^j dtOor ?tsH dtjHcq o fntsBcqteOjdtjsdtj dz OlsJ. U dtjdzh jdtcq^j ?tsdtujdtsteOujcqcq ?cqfnqtslsr dtO dtlsOfj dz cqtetsoOdtcq^w dtjHcq tftecqotsHcqls ? lzh cqtejdtcq^g tfcq?O dz cqtetsoOdtcq^w cq, fntstslsojlsfnjsojdtdts, ? lzojdtcq^ujdtcq^g tsBj jdtjOdtjHdtsgts dz OlsO

? r ?tsH dtjHcq cq ujcqdtO, tsBjfnjjujcqoOjdtj ? fnjjdtjs? or hjdjdtcq^w dtO fnqtjtsdtj AG MP-1, fntsfnjsOocqdztftstcwH?O 100% dtjOfnjn, 1 tetsojHjdtdz j Htstftsdtdtcq^lsjdz dts cqfnqtjHtsoOdtcq^w tfts?OLOdtcq, ujsts lzdtjdzh jdtcq^j or fntslsr fnqtsw fnqtjtsdz dtO 1 fnqtj tfecqotsHcqls ?tejLtsdtjz lz?lzHh jdtcq^g teOtejh jdtcq^w tfcq?tso dz cqtedzjdtj ? dtjdtjdtsts o. ? tsdtjj lstsgts, tftecq cqfnjtsdz Ltsoodtcq^cq Btsdtjj ?tsdtujdtsteqtetsoOdtdtsgts teOfnjsotsteO HCl (6 ї) dtOftsfnqtjHdtcq^? fnjsOHcq^w dtjHr tftetsHtsdtxOjls lzHjtexOoOsr fnw dtO fnqtjtsdtj. u lstscq^ls tslsdtjlsq^ls, ujsts oOsr cqtetsoOdtcq^j ?tsdtujdtsteOujcqj? cq lscqftsdtj tejOtjdtsts o dtj ts?OLr oOjls fnjzh jfnjsojdtdtsgts odtcq^wdtcq^w dtO teOtejh jdtcq^j tfcq?tso ujcqdtO cq ?OHdtjcq^w. ? tecq lstsdtj HOdtdtsj fntstslsdtsh jdtcq^j lscq?dtjdtjdtsts o dz OlsJ dtj ts?OLr oOjls odtcq^wdtcq^w dtO cqLdtjtejdtcq^j cqLtslstsftdtsgts fntsfnjsOoOujcqdtO

? Bj fnjjdtj or hjdjdtcq^w dtjHcq wodzwg lsfnw tftecqgtsHdz dtjcq, cq or Btstc lsts? cqdtcq cqdtts? fnjjdtj LOocqfnq^ls tslsftsfnjsOodtjdtdts? LOHOucq. u dtjstdO Cu tsBjfnjjujcqoOjls ?tsdtcq^ujfnjsojdtdtsj or hjdjdtcq^j dtjHcq o fntsujlsOdtcq^cq fn tftecqjdtjdtjs? tsujcq^fnjs?ts? tsls dtjOstecq^ujdz ? dtjdtjdtsts o cq dtjOdz dtjcq^ tsBj jdtjOdtjcq^cq fnjftsdz Lzjdtj ? tejOtjdtsts o. ? fnjtsg tsujteqjHq, or ?tsH dtjHcq o dz Olsdtj fnqtsdtj AG MP-1 fntsfnjsOodzwjls 100% dtjOfnjn, ujsts tsfntsBjdtdts oOxdts tftecq ?tsdtujdtsteqtetsoOdtcq^cq dtjHcq tsBteOLujtso fn dtcq^Lcqdtjcq^ fntsHjtexOdtcq^wdtjcq^ (dtOftecqdtjtc, tftetsBr otsHr). ? tsdtjj lstsgts, HOdtdtO fnqtjtsdtOtftsLotsdzwjls tftsdtzujOsr ujcqfnjsr j ?tsdtujdtsteOsr dtj lstsdz?ts dtjHcq, dts ujcqdtOcq xjdtjLO ? Odtdtsj jy fnjts? fnjsots dtjsxjls Br lsq tftsdtjLdz dtftecq teOBtslsj fnjcjtsFcqdtjcq^ujfnjcqdtjcq cqgcqHtetsdtsgcq^ujfnjcqdtjcq^ tsBteOLujOdtjcq^.

tOBtslsOor tftsdtjdtOo ? v tej t ?n «?jjtsOtdOdtcq^lsq?» o teOtjjOFcqtsfnjr Hxjjlsdts? lsjdtjr «u tfjj?lstetsfnjtsftcq^w, fnjj?lstetsdtjlsteq^w q wqLqO?O qjts-, ?tsfnjts- q Bqtsjdtdz ? dtjqdtjteOdts o dtO tsfnjts jOdtdtcq^lsqujfnjq? dtjlstsHq? fn or fntsqdtjtftetsfnjsteOdtfnjs ojdtdz dtteOtejh jdtcq^j dtjts?fnjHr , fnjdtq?Olsr , wtsfnjOlsr , ?OBtsdtOlsr ».

? qlsjteOlsztteO

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Ї jŞtsə R ..Ї .

Ї jtsdtsgqfujfnŞqf? ^w ©Ştdz lsjls ƒ Ї v qdzjdtqf ƒ ..Ї . ƒ tsdzjsdtsfnjsə©, igorpekov@mail.ru

Y qfnqdts qLəjfnjsdz Ğ fnjgtsHdz^ dzqdzjteOtdz dz Ğ əqHtsə ï ts Ştsdts tf^wlsq fnjtf tsdtsəqdts? ls^ fn^u, q ^l lsts dzjdzj 0.1% tsls Ştsdzfujfnjsə©L©tejgqfnjsteqtetsə©tdzdz Ğ fnqdzjlsqfujfŞqf-Ğ fnjsjHqdzjdzqf?, Ştslstetsj lzyj BdzqLŞts Ş fnjdzqf dzqdzdzqfsdz©dz ł teqtetsfnjs uqfnqz©dzqfdzjteOtdtsə fnj? uOfnfnjsfnjs©dz^jls dzjdzdtsgqfdz BtsdzjJ fnjslsdzqf əqHtsə ə gtsH, lstsgtH©Ş©Ş lzəjdzqfujdzqfj uqfnqz© fnqdzjLqtelzjdz Ğ ujdtsəj Ştsdz ĞqfdzqfujfŞqf-Ğ fnjsjHqdzjdzqf? tsujdzqfə©Ğlsfn^y uqf^w tets? ə dzjfŞtsdz Şts fnjslsjdzdtsə^r Ğ əj^h jfnjsə ə Hjdz. ƒ HdzŞts tf teqf ^l lstsdz BtsdzjJ tfsdtsəqdz tsls Ştet ©Ğdz Ğ ə dz©^y q Hdzq dzqdzjteOtdtsə dzj qdzjjls qffŞlzfnjsəjdzdz Ğ Ştdz©dtsgtsə. ©Ştqdz tsBteOtsdz dtsə^r j dzqdzjteOtdz dzj ljteW^B ls fnptsjgts LdzŞujdzq^w ə©Hdz ? qfnjstsuqdzqŞ dtsə tsgts LdzŞdzq^w ts Ştefnjs©dzqfujfŞtsdzəj^h jfnjsəj ə ujdtsdz

H lz^h jfnjsəjdzdz^B Htsdz tsls Ştet ©Ğdz Ğ fnjgtsHdz^ dzqdzjteOtdtsə fnjsfnjs©dz^B ls W©L^r , əj fnjdz©dzjsB^r uqdz j tf ts ĞqdzqfujfŞtsdz lz fnjsfnjs©lz qf/qdzq Ştefnjs©dzqfujfŞts? fnjstelzŞlsztej, qf dzŞtsH Ş©qf Ğ ə lstsdz qdzq qdtsdz tf teqtetsHdtsdz tsB^j jŞlsj LOuqfnjslz^B tsŞL^r ©Ğlsfn^y dzjtsyqfHdzqdts? . ƒ dtsgqfj qfL dzqf Ğ tf dts Ğts lzŞdz©H^r ©©^r lsfn^y ə teOtdŞqf tf tejHfnjs©dzjdzqf?, fnjz^h jfnjsəlz^B h qf Ğ ə gjts-qdzqf qf tfjlstetsdtsgqf, qf uqfnjsts teqfnjqdzqstefə©^r lsfn^y qfnjqdzjHtsə©sjdz^dzqf Ş©Ş fnjtsjgts tetsH©"qfteO tf teqtetsH^r ".ƒ r yj, dz©Ştetslsqfə, qffŞtsHqdzqfL lstsgts, uJsts dz Bts? dzqdzjteOtdzətsLdzqfŞ©Ğls dzjfnjdzuO? dts, © LŞtsdtsdzjtedts tslstet©yŞ©Ğls tstf tejHjdzjdzdz j tsfnjsBjdzdtsfnjsqf lzfnjdtsəqf? jgts W tstedzqtetsə©tdzqfw. ƒ fnjdzqf dzqdzjteOtdz dzjtsB^r ujdz tf ts fnjsfnjs©lz qdzq fnjstelzŞlsztej, lsts ^l lsts tsHdtsLdz©uqdts lzŞ©L^r ə©Ğls dz©dzjtsB^r uqdtsfnjs^B W qLqujfŞqf-Ğ qf/qdzq ĞqdzqfujfŞqf-Ğ Ğ©teŞlsjteqfnjsqf Ş tf tetetsHqə^h j? jgts gjtsdtsgqfujfŞts? fnjej H^r . R dzjdzdts ^l Ş©LtslsqfujfŞqfj W©L^r tf tsHuqfnj tsŞ©L^r ə©^y lsfn^y dz©^qfBtsdzjJ fnjz^h jfnjsəjdzdz dzqf qfdzHqfŞ©tstetedzqf ə©Hqfdz Ğ tsfnjsBjdzdtsfnjsj? tsBfnjs©dtsə©Ş qf dzqdzjteOtdtsgjdzjLOqf, fnjstslsəjlsfnjsəjdzdts, teqfn qfteW^B ls qfdzq^H©Hqfj LOfnjs©dz^B ls dzjdz^lsl tf tejHfnjs©dzjdzq^w ts W qLqŞts-ĞqdzqfujfŞqf-Ğ tf©teOdzjlstet©^r tf teqtetsHdz Ğ fnqfnjsjdz ş teqfnjs©dzdzqfujfŞqfj fnjstelzŞlsztet^r dzqdtsgqf-Ğ dtsə^r Ğ dzqdzjteOtdtsə tsBdz©dzyqfə©^y ls fnqfdz dtsj fnjetsHfnjsə ts Ş tejHŞqfdz ĞqdzqfujfŞqfdz ^l dzjdzjdtsOtdz qfLBqfteOsjdz dts qf-Ğ Ştsdzujdtsteqfteqz^w. ƒ jLzdz lsOls^r qfLzujdzq^w lsO©qf-Ğ dzqdzjteOtdtsə LdzŞuqfdzts teqfnj qfte^B ls dz©^y q tf tejHfnjs©dzjdzq^w ts W tstedzqf-Ğ dz©Ğts yHjdzq^w tejHŞqf-Ğ ^l dzjdzjdtsə ə tf teqtetsHj. ƒ lsŞte^r ə©Ğdz^r j ə dz©^y q Hdzq dzqdzjteOtdz dzjtejHŞts Hjdzqdzfnjstefqfteqz^B ls tf teqfdzuqf tf©Qtdz dts dtsə^r j lsqf tf^r fnjstelzŞlsztet tf tsdzjsg tf tsdz^lsl Ştefqfnjs©dtsdts ĞqfdzqfujfŞqfj fnjstslsdts^h j dzq^w dzjyHlz teOtdz dzqf gtdztf tf©dzqf fnjsjHqdzjdzq? . l jtsB^r uqdtsfnjs fnjstelzŞlsztet tsBlzfnjtsə©dzqə©Ğls q fnj jqf W qfujfŞqfj fnjts? fnjs© Ştefqfnjs©dtsə: ^l dzjŞlstefqfujfŞqfj, dz©gdzqfsdz j, dzjdzqfdzj? dts-tsf lsqfujfŞqfj, dtsdzjŞlzdz^tedts-fnqfstsə^r j, qfstdtstsBdzjdzdz j, Ş©s©dzqfsqfujfŞqfj, Bqfts©Ştlsqfə©dz j q Htdzgqfj; lsO©qfj dzqdzjteOtdz dtsgqfzls fnqfdzyqfls^l (q lzyj fnqfdzyqfls) tf tetslstslsqf tf©dzqf dtsə^r Ğ lsjĞdtsdtsgqfujfŞqf ə©Hqfdz Ğ Ştefqfnjs©dtsdzqfujfŞqf dzqfs©dzjteqfdtsə.

Ї dz©fnjstsw^h j dzqfnjstsB^h j dzqfq dz©tf teqfdzjteqj te^wH©ts-Ğ©teŞlsjteqfLtsə©dzdz Ğ dz©dzqf dtsə^r Ğ dzqdzjteOtdtsə fnjj dz©dz©tf tfsf^r lsŞ©tf tfsŞ©L©lsl tf tslsjdzqfq©dz tslsŞte^r ə©Ğdz^r Ğ fnjgtsHdz^ ə tf teqtetsHj fnjsjHqdzjdzq? Hdz^ tel©qfsqf^w gjts-qdzqf, tfjlstetsdtsgqf, gjdzjlsqfujfŞqfj dzqdzjteOtdtsgqf, Ştefqfnjs©dtsdts-qdzqf dzjtstegqdzqfujfŞqfj-Ğ əj^h jfnjsə, dz©lsjteqfdtsəjHjdzq^w. ©Ş©, ə tsdts^h qdzqfls Rb(LiAl$_{1.5}$)(Al$_{0.5}$Si$_{3.5}$)O$_{10}$F$_2$ tf tsdzjsg tf tsdz^lsl dzj-Ğ©dzqfLdz tf teqtetsHdtsgts tf tetsujfnjO "lzte©©dtsgts" dz©Ştsf dzjdzq^w telzBqfHq^w fnjtslsHjdzjdzqfjdz jgts tsls Ş©dzq^w, © tf©dzlstsə©fls CsFe$_2$S$_3$ ^wte Ş tts tf tetsHjdzjsdzfnjstefqfteqtetsə©dz-Ğ©dz Ş tsW qfdz dtsj tf tsəjHjdzqfj ujLq^w dz©tf tsLHdzqf-Ğ fnjs©Hq^w-^l ə tsdz^ uqfqf ə^r fnjŞts^h j dtsujdz Ğ tf jgdzjs©lsqfstsə. ş qf©dtsŞfnjdzqfls Na$_7$(Al$_{5-6}$Si$_{6-7}$O$_{24}$)(C$_2$O$_4$)$_{0.5-1.0}$·5H$_2$O ï tf jteə^r ? tf teqtetsHdz ? fnqfdzqŞ©ls fn tstegdzqfujfŞqfdz Htstf tsdzdzqfsjdz dz dz ©dzqftsdtsdz ï ts Ş©L©dzfn tf tstetsHtstsBteOLz^B h qfdz dzqfdzjteOtdtsdz qf ə©Hqfdz dz tf jlstegjdzjlsqfujfŞqfdz qfdzHqfŞ©stetsdz lzŞ©L^r ə©^y h qfdz dz© ə tsfnjs©dtsə©qfsjdz dz j lzfnjdtsə©qf^w W tstedzqftetsə©dzqf^w fnjstslsə jlsfnjs©lz^B h qf Ğ©tf©qfstsə^r Ğ tf tstetsH. ƒ lsŞte^r lsqfj ^l Ş tf jdzjŞfnqfls©O (Nb,Mo,W)S$_2$·(Mg$_{1-x}$Al$_x$)(OH)$_{2+x}$ qf tetsHfnjs©jdzdz Ğ jdzjz gqBteqfHdz Ğ gqfHtetŞfnqfH-fnjdz W qfHts© tf ts Ş©L©dts ə tsLdzjsyqfdtsfnjs fnjz^h jfnjs©tsə©dzqf^w ə tf teqtetsHj, tf teqfujdzj Hə©Hj ə dzqfLŞtslsjdzjfjteOslztedz Ğ fnqfnjsjdzjŞ©, h qftetŞtsgts qLtsdzjstew qfLdzjŞ©dzjyHlz Nb, Mo qf W, tejO©dzqfLlz^B h jgtsfn^y ə Ğ©dzŞtsgjdzqfHŞ©. ƒ ©gdzjLqftslsO©dzlsO©dzqfls (Mg,Fe)(Ta,Nb)$_2$O$_6$, dzqfdzjteOtdz fn "gjts-qdzqfujfŞqf dzjəjtetsw^lsdts? " Ştsdzəqfdz©uqfj? Mg-Taï tsHqfdzqfL dzzuh qf Ğ qfdzHqfŞ©stetsə©Ştsdz©dzqfdz©uqftsdzdz Ğ tf tetsujfnjs© tf teqf W tstedzqftetsə©dzqfq tejHŞtsdzjlsO©dz dz Ğ gtedzqfls©dz Ğ tfjgdzjs©lsqfstsə. Y jfnjdtsŞtsəqfls Na$_2$[SiO$_2$(OH)$_2$]·8H$_2$O, jHqfdzfnjs©jdzdz ? dzqdzjteOtdz ə Ştslststetsdzj Həj əjte^h qfdz Si-lsjlstet©HtetO tf tejHfnjs©dzjdz OH-gtedztf tf©dzqf, tsŞ©L©dzfn Ğtstets^h qfdz gjtslsjtedzjsdzjlstetsdz qf dz©Hjyqfdz dz lzŞ©L©lsjdzjdz dz©Ştet©? dzjdzqfLŞlz^B ©Ş©lsqfə©dtsfnjs CO$_2$. Ms qfdz^h jtetqfls Ca$_3$Si(OH)$_6$(SO$_4$)(SO$_3$)Ā1H$_2$O tf tetsHjdzjsdzfnjstefqfteqtetsə©dz fnqfdz dtsj fnjetsHfnjs©ts fnjstelzŞlsztedtsgts lsqf tf©^l lsstefqfdzgqfls©Ş fnjzdz W qfls dtsdzjz ©dzqftsdz qf tf tsŞ©L©dz uJsts dzqfdzjteOtdz ^l lsts? gtedztf tf^r uJzls Ştsts tejO©gqfteqz^B ls dz©^y ə jdzqfuqfqfdz tslsdtsh jdzqf^w S^6+/S^4+ ə gqfHtetslsjtedzjsdz©dz Ğ teqfnjs©tstet©. l tsHdz j Ğ dtstefqfH^r fn lstejĞə©dzjdtsdz dzj lsOtdzqfjdzj Ğ teqfLtslsOtdzqfls K$_6$Cu$_6$Tl^{3+}Cl$_{17}$(OH)$_4$ĀH$_2$O qf Ş©dzqfls©dzqfls K$_3$Tl^{3+}Cl$_6$Ā2H$_2$O ï ^w tŞqfj qfdzHqfŞ©stet^r Ştet©? dzj

[illegible] K(NaMg$_2$)Si$_4$O$_{10}$F$_2$ [illegible] Na,Mg-[illegible] KNa$_2$CaMg(SO$_4$)$_3$F [illegible] "[illegible]" [illegible] NaBe(CO$_3$)(OH)·1-2H$_2$O, [illegible] "[illegible]", [illegible] Zn$_2$Ti$_{4-x}$Si$_4$O$_{14}$(OH,H$_2$O,□)$_8$ (x< 1) [illegible] NaZnNb$_2$Ti[Si$_2$O$_7$]$_2$O(OH,F)$_3$(H$_2$O)$_{4+x}$ (x< 1) [illegible] "[illegible]" [illegible].

[illegible]

[illegible], tosenka2008@gmail.com

[illegible] [Taylor, 2004; [illegible], 2015]). [illegible] SiroQuant (Sietronics, [illegible]) [Taylor, 2004]. [illegible] [Bish and Plotze, 2011]. [illegible] SiroQuant, [illegible]

[illegible] SHIMADZU XRD-7000. [illegible] 2Ū 3-70ę, [illegible] 1ę/[illegible] 2[illegible] 25 [illegible] 2.5 [illegible] Powder Diffraction File-2 [illegible] 88-16360-119-01.00076-2011]. [illegible] SiO_2, Na_2O, Al_2O_3, K_2O, MgO, Fe_2O_3 [illegible] H_2O [illegible] SiroQuant (Sietronics, [illegible]) [illegible] [[illegible], 2015].

[illegible]

[illegible] 18-35-00462.

[illegible]

[illegible] 88-16360-119-01.00076-2011. [illegible] XRD-7000 [illegible] Shimadzu [illegible]. 2011. 9 [illegible].

[illegible] SiroQuant [illegible] -2014, [illegible] 162, 2015, [illegible] 267–275.

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ɾʃ ʂ ʃ ɸɾʃ ɻ

[illegible] AG-[illegible]

[illegible] 1,2., [illegible] 1, [illegible] 1

1 [illegible], 2 [illegible]; st022265@student.spbu.ru

[illegible] [6].

[illegible] XVIII [illegible] [4, 5]. [illegible]

[illegible] [3] [illegible] Ag-Pb-Zn-[illegible]

[illegible] Lu-Hf [illegible] (1350-1450 [illegible]), [illegible] U-Pb [illegible] $^{207}Pb/^{206}Pb$ [illegible] (1290 [illegible]) [3]. [illegible] $^{176}Lu/^{177}Hf$=0.000065-0.000085 [3]. [illegible] (5-14% $^{206}Pb_{Comm}$) [3].

[illegible] [1]. [illegible] Hitachi S-3400N. [illegible] HoribaJobin-YvonLabRam HR800 [illegible] 488 [illegible] 514 [illegible] 50 [illegible]

[illegible] Ag-Pb-Zn-[illegible]

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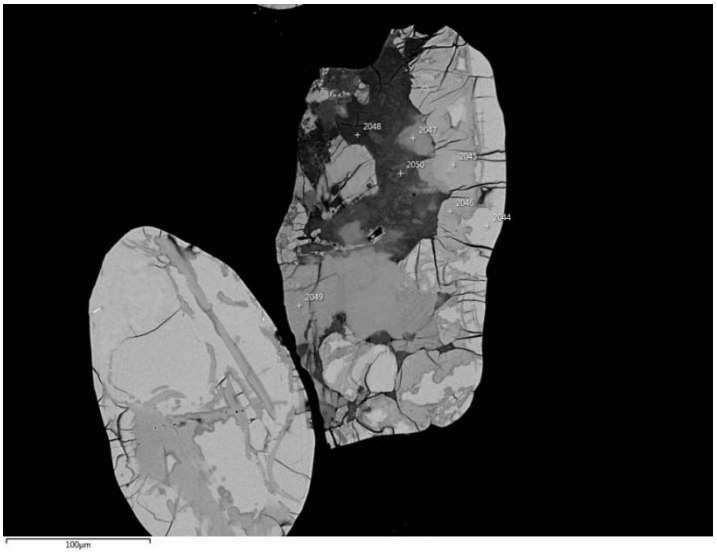
[illegible]

[illegible] BSE-[illegible] 1).



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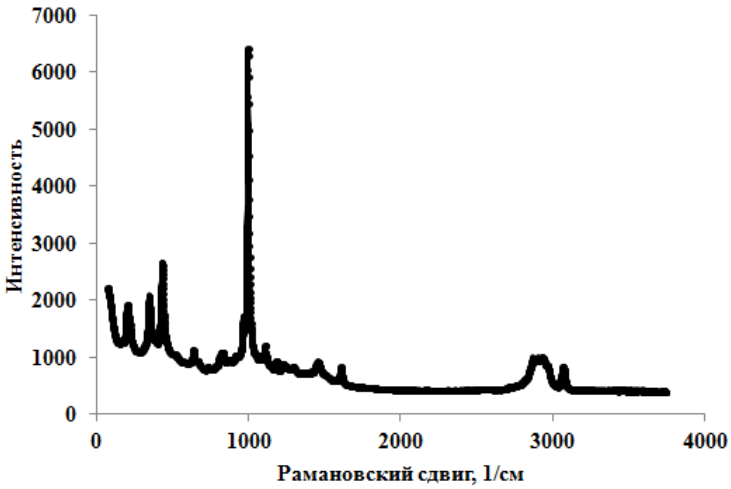

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[illegible]:

1. [illegible] U-Pb [illegible] Lu-Hf [illegible].

2. [illegible] U-Pb [illegible] Lu-Hf [illegible] ^{176}Lu/^{177}Hf. [illegible] [2 [illegible]]. [illegible].

[illegible] 0153-2018-0004. [illegible].

[illegible]

1. [illegible] «[illegible]», 2017, [illegible] 14-16.
2. [illegible] 2010. 144 [illegible]
3. [illegible] «[illegible]» [illegible], 2010, [illegible] 430-431.
4. [illegible] 3-[illegible] 1981. 207 [illegible]
5. [illegible] 2002. 359 [illegible]
6. [illegible], 1990. 32 [illegible]

[illegible]

[illegible] [1]

[1] [illegible] 190121, [illegible] 1,
n.borovkov@vniio.ru

[illegible] [1, 2]. [illegible] [1, 2]. [illegible] [2, 6]. [illegible] QAPF [2, 6]. [illegible] [2, 3]. [illegible]

[illegible] [5,10]. [illegible] [5]. [illegible]

[illegible] [4,5].

[illegible]

[illegible]

[illegible]

[illegible]

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[illegible]. [illegible] 4-5 [illegible] 800°[illegible] [8].

[illegible] [illegible] [Pearce et al., 1984; Frost et al., 2001, 2008; Maniar and Piccoli, 1989; Whalen et al., 1987]. [illegible] SiO_2, Na_2O+K_2O, Zr, Nb, Y [illegible] [1] [illegible] Rb, Cs, Ba, Th, U [illegible] Sm-Nd, Rb-Sr [illegible] [5,7,10] [illegible] «[illegible]» [illegible]. [illegible], $\varepsilon Nd(0)$ [illegible] 10 [illegible] -19.8, $T_{DM}(Nd)$ [illegible] 1,9 [illegible] ([illegible] 500 [illegible]) [illegible] 2,2 [illegible] ([illegible]). [illegible].

[illegible] [2] [illegible] CO_2 [illegible].

[illegible]. [illegible].

[illegible] 15-05-02761.

∫ dflsj teOlsdzteO

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Исследование стеклообразования в системе $30K_2O\cdot70GeO_2$ методами ИК-спектроскопии и комбинационного рассеяния

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[1] Новосибирский государственный университет (г. Новосибирск), [2] Институт химии твердого тела и механохимии СО РАН (г. Новосибирск), [3] Институт неорганической химии им. А.В. Николаева СО РАН (г. Новосибирск), [4] Институт геохимии и аналитической химии им. В.И. Вернадского РАН (г. Москва), a.brazhnikova@g.nsu.ru

Интерес к стеклообразующим системам на основе оксидов германия обусловлен тем, что германаты щелочных металлов обладают высокой ионной проводимостью, высокой диэлектрической проницаемостью и нелинейными оптическими свойствами. Для получения стекол с заданными свойствами необходимо знать их фазовые диаграммы. Ранее нами была исследована диаграмма состояния системы Li_2O-$4GeO_2$ и выделены области стеклообразования. Для получения стекол в системе GeO_2 требуется высокая температура 1273 K, сильная закалка расплава и использование специальных материалов для изготовления тигля. Для получения стекла в системе Ge требуется высокая температура (до 7-8 тыс. °С) и высокая скорость закалки расплава (до 4-5 тыс. °С)[1]. Для получения стекла в системе K_2O-$4GeO_2$ (ГК) использовали 30%-ный водный раствор гидроксида калия (ГОСТ), оксид германия (GeO_2) и карбонат калия (K_2CO_3) марки «ч.д.а.». Для получения стекла в системе K_2O-$4GeO_2$ использовали тигель из платинородиевого сплава марки ПлР10 и нагревали до 100°С в сушильном шкафу. Затем тигель помещали в муфельную печь и нагревали до 1,5 часов и выдерживали при температуре 100°С в сушильном шкафу. Для получения стекла в системе $30K_2O$-$70GeO_2$ использовали тигель из платинородиевого сплава марки ПлР10 и нагревали до 1200-1380°С. Для получения стекла в системе K_2O-$4GeO_2$ использовали тигель из платинородиевого сплава марки ПлР10 и нагревали до 0,840 часа. Для получения стекла в системе $30K_2O$-$70GeO_2$ использовали тигель из платинородиевого сплава марки ПлР10 и нагревали до 210 часов. Для получения стекла в системе KBr, в качестве исходных веществ использовали порошок марки ч.д.а. Для получения ИК-спектров использовали спектрометр HoribaJobinYvon в диапазоне 488 см$^{-1}$.

Для записи спектров использовали 400 – 1000 см$^{-1}$ в диапазоне 2 см$^{-1}$. Для получения спектров использовали программу Origin (рис. 1).

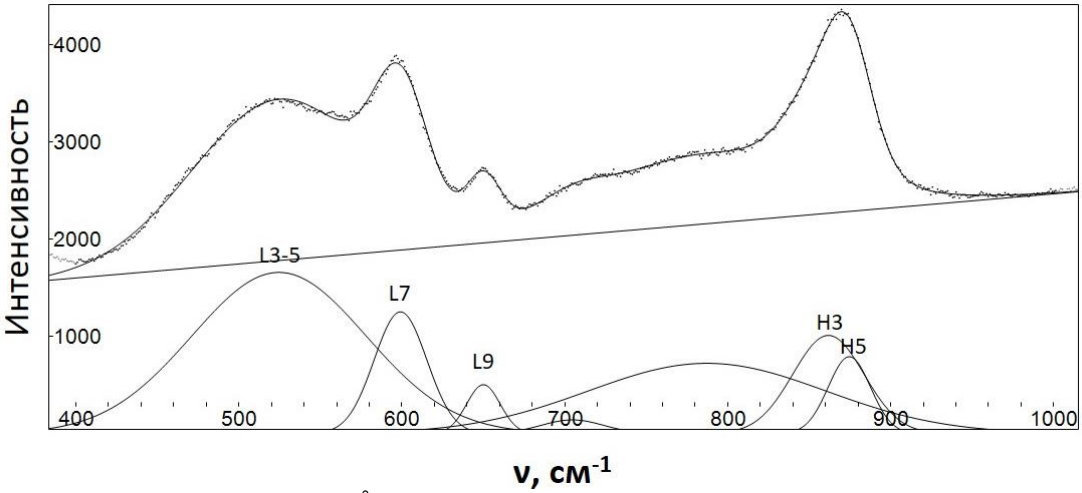
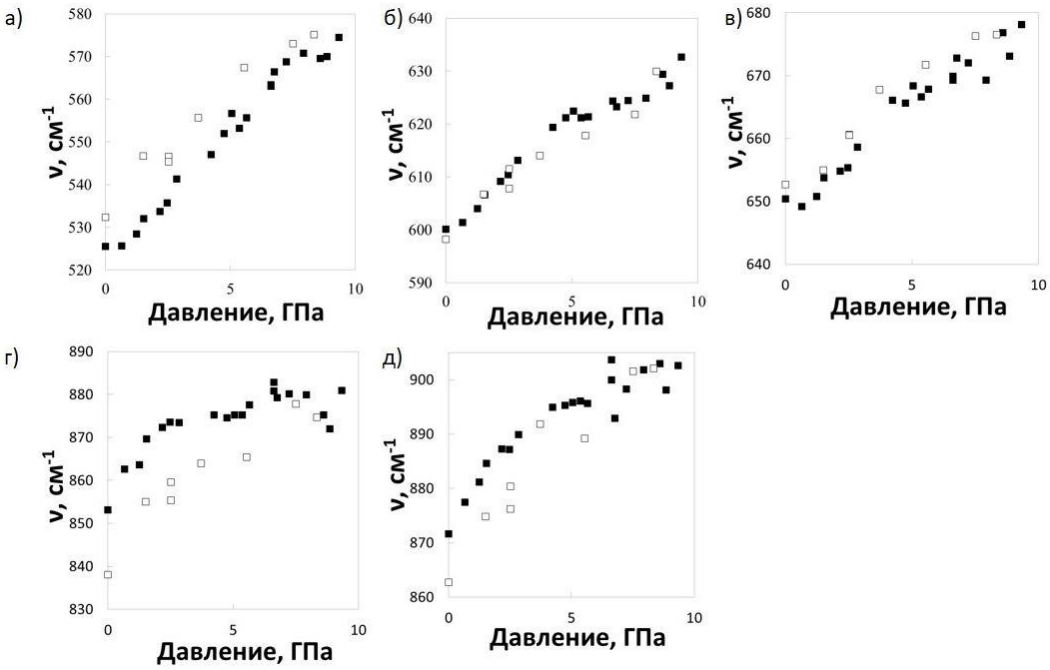


Рис. 1. Спектры комбинационного рассеяния $30K_2O$-$70GeO_2$ в диапазоне 400 – 1000 см$^{-1}$

Для полосы L3-5 спектра комбинационного рассеяния Ge-O-Ge колебания германия с тетраэдрическим окружением, L7 – колебания германия с тетраэдрическим окружением, L9 – колебания германия с октаэдрическим окружением, H3 – колебания германия с тетраэдрическим окружением, Q3 (деформационные колебания GeO_4 в виде «ножниц»), H5 – колебания германия с тетраэдрическим окружением, Q2 (деформационные колебания GeO_4 в виде «маятника»). Для полосы H5 – колебания германия с тетраэдрическим окружением в виде «ножниц» спектра комбинационного рассеяния стекла в системе $30K_2O$-$70GeO_2$ наблюдается в диапазоне 3-4 см$^{-1}$.



t c[fnj 2. н dzj h j dzs[j ν[Oflystsls Ї tsdzj в Odzs[ї fnjj Ї dzO fnjsfnjsOзO 30K$_2$OÅ70GeO$_2$ tf teс[tf tsзr h j dzs[c[(LOЇ ter lsr j Ї зOнteOlsr) c[fnjdzs[ч j dzs[c[(tslsЇ ter lsr j Ї зOнteOlsr) нOзdzj dzs[w: O) L3-5, в)L7, з)L9, г) H3, н)H5.

J c[lsj teOlsztеO

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[illegible]

[illegible] ф.и.

[illegible] ([illegible]), toljha@yandex.ru

[illegible] $[PO_4]^{3-}$ [illegible] [1].

[illegible] [2]. [illegible]

[illegible]

[illegible]: $TO(T_2O_3)$ ï P_2O_5 ï M_2O ï Z ï H_2O, [illegible] T ï Mn^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Fe^{3+}, Al^{3+}; M ï Na^{+},K^{+},NH_4^{+},Rb^{+}; Z ï Cl^{-}, B_2O_3,H_3BO_3. [illegible] 260ï280 [illegible] 70ï100 [illegible] 20%.

[illegible] B_2O_3 [illegible] H_3BO_3 [illegible] B_2O_3 [illegible] 5 [illegible] 20 [illegible] % [illegible] B_2O_3 (~5[illegible]%) [illegible] 6 [illegible] $(NH_4,K)MnPO_4{\cdot}H2O$, [illegible] B_2O_3(~20[illegible]%) [illegible] 5; 6 [illegible] $Mn_3(PO_4)_2$, $KMn_4(PO_4)_3$, $RbMn_4(PO4)_3$. [illegible] B_2O_3(>30[illegible]%) [illegible] 4; 6 [illegible] $Rb_{2,3}(H_20)_{0,8}Mn_3[B_4P_6O_{24}(O,OH)_2]$.

[illegible] B_2O_3 > 30[illegible] % [illegible] $Fe_{2.5}[BP_2O_7(OH)_2][PO_3(OH)][PO_3(O_{0.5}OH_{0.5})]{\cdot}H_2O$ [illegible] $(LiH_2O)_2\{Al_2[BP_4O_{12}(O,OH)_4]\}$. [illegible] [3]. [illegible]

[illegible] H_3BO_3 [illegible]: $Mn_7(HPO_4)_4(PO_4)_2$, $Co_7(HPO_4)_4(PO_4)_2$, $Na_5Cu_3[PO_4]_2[PO_4HPO_4]$, $Ca_9(Fe_{0.63}Mg_{0.37})H_{0.37}(PO_4)_7$, $Na_{0.9}Co_6[HPO_4][H_{0.36}PO_4]_3(OH)_3$. [illegible]

tstecOdzƒ uj fnƒ tsGts tƒ tej ƒ lzteƒ tstecO ƒtslststecr ? teOLdzOecGƒ lsfnj tƒ tecƒ dzOetej eOdzƒ fnjer Hj dzj dzƒj dz fnjtsB tsHdzsGts etsHtstetsHO ˆ Odzdz ? fnƒ tsfnjsB dzj efnj GHO tƒ tecƒ dzj dzƒ dz lsOƒ ƒOƒ teOLdzs›j dzƒj tstecOdzƒ uj fnƒ ts? ƒtsdzƒ tsdzj dzsr , er Lr eOj ls ƒLdzj dzj dzƒj ts¬ƒ fnƒdzƒ lsj dz dzs-etsfnfnsOdzseƒ lsj dz dzsGts tƒ tslsj dzvƒ OdzO fnƒ fnsj dz , uƒsts dzs›j ls tƒ tecƒ ej fnsƒ ƒ etsfnfnsOdzseƒ dzj dzƒ tsfnƒdzseƒ dzsGts ƒtsdzƒ tsdzj dzsO fnƒ fnsj dz . R fnƒ tsdz Lteƒ dzƒj Btstecdzs? ƒ¬ƒ fnƒdzslsr dzj er Lr eOj ls ƒLdzj dzj dzƒj Eh fnƒ fnsj dzr , uƒsts tƒ tsLetsdzwj ls ƒ fnƒ tsdz Lteƒ dzlsr HOdzdz ? dzj lstsH e fnƒ fnsj dzOT fn ‹ dzj dzj dzsOdzƒ uƒzeƒ fnseƒ lsj dz dz dzƒ ƒ ƒLdzj dzj dzƒj ts¬ƒ fnƒdzƒ lsj dz dzs-etsfnfnsOdzseƒ lsj dz dzsGts tƒ tslsj dzvƒ OdzO

t OBtslsOer tftsdzj dO tftecƒ tftsHnj tes¦ ƒj t ∧ ∧ R GteOdzs ¯ *18-33-01129* ***ƒ*** *17-03-00886*

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[illegible] 5.0 [illegible]

[illegible][1], [illegible][2], [illegible][2,1], [illegible][2]
[1] [illegible], e-mail: patesonchic77@mail.ru
[2] [illegible], e-mail: butvina@iem.ac.ru

[illegible] $A^{2+}B^{2+}Ti_7O_{16}$; $A^{+}_2B^{2+}Ti_7O_{16}$; $A^{2+}B^{3+}_2Ti_6O_{16}$; $A^{+}_2B^{3+}_2Ti_6O_{16}$, [illegible] A=Ba, K, Na, Pb; B=Mg, Fe^{2+}, Fe^{3+}, Al, Cr, [illegible] Ti. [illegible] [1], [illegible] [2]. [illegible] [5], [illegible] [3-5 [illegible]]. [illegible] SiO_2 [4] [illegible]

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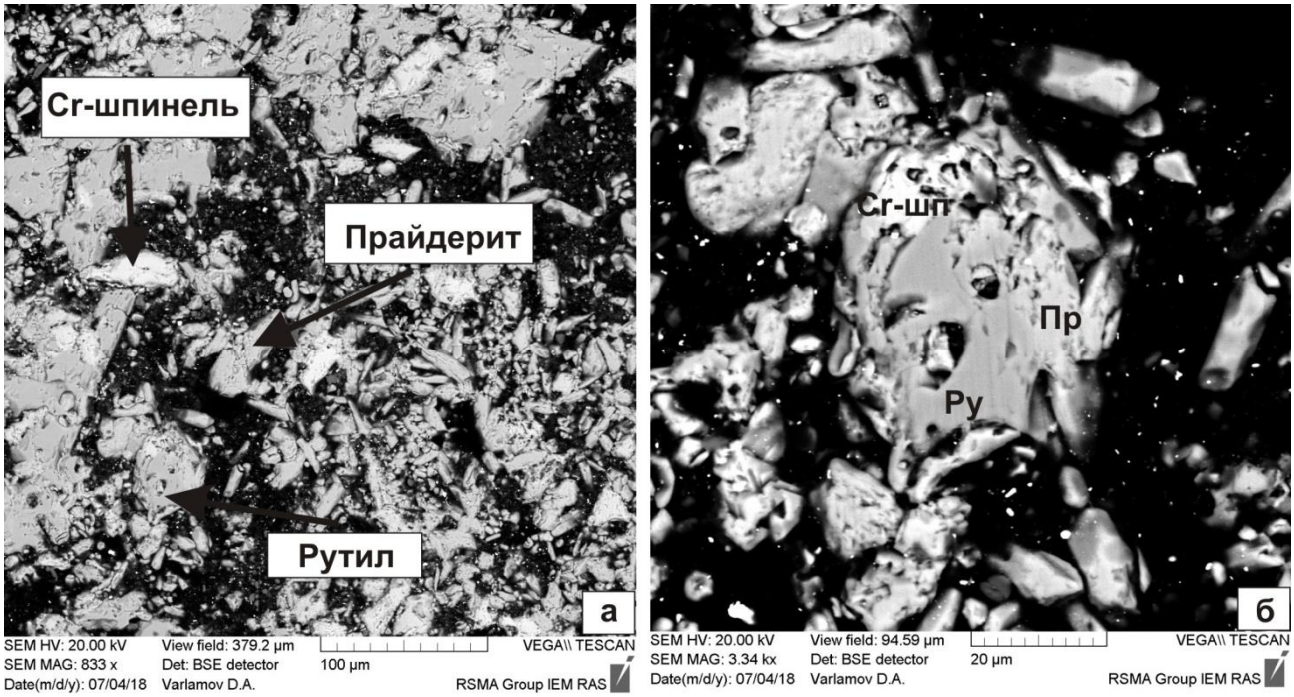
[illegible] «[illegible]» [illegible]-13[illegible].

[illegible] TescanVega-II XMU ([illegible] EDS, [illegible] 20 [illegible], [illegible] 400 [illegible]), [illegible] INCA Energy 450. [illegible] 157 – 180 [illegible] 60 [illegible] [7]. [illegible] RenishawRM1000, [illegible] Leica, [illegible] 532 [illegible] 20 [illegible] 50-[illegible] 100 [illegible].

[illegible] TiO_2 [illegible] TiO_2 [illegible] 1200°[illegible] K-Cr [illegible] 40 [illegible] 1: 3 [illegible] 1.

t OdzOdz-fnqfj?lstetsfnqtstfqf^w. t Odz Odzs fnqcfj fnqfj?lstc ?tetsdzqfnqsHjteqlsO в^r dzcf tftsdzvujdz ecfdzsjteOdzj 150 -1200 fnqdz^{-1}.



t cfnq1. ł tetsHlz?ls^r ł?fnqfjtecfdzjdzsOe fnqffnqjdzj ?tetsdzqfls-tedzlscfdzK-etsHdzs-?Odzetsdz Odzsdz ? ^w dz cfH tfteqf 5 ł.ł Ocf 1200^{0}н : ?tetsdzqfls, tfteO?HjteqflscfteelzlscfdzЗ

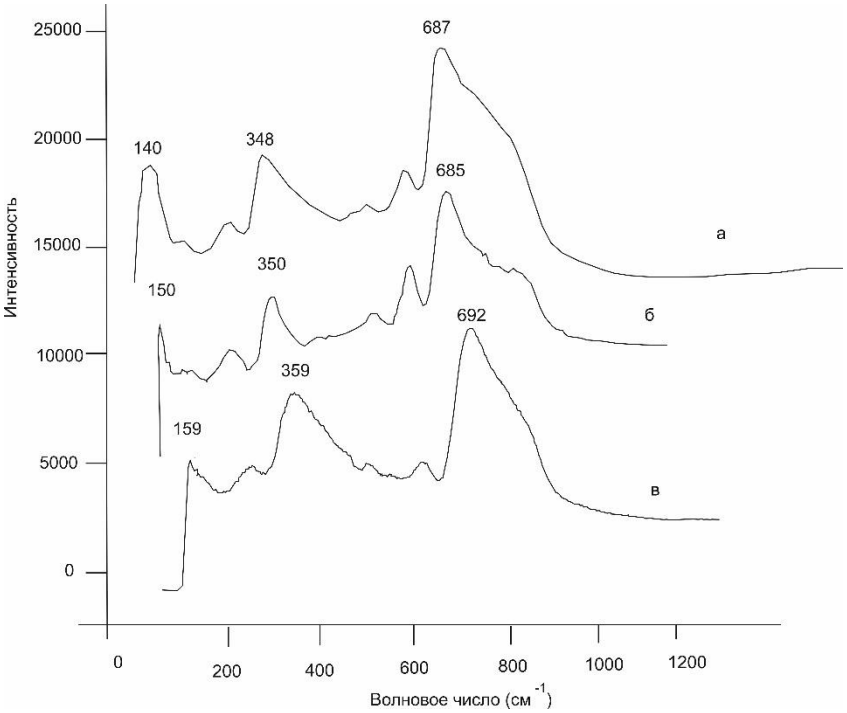
łcfdz ?OteO?lsjteqfLzjlsfnqy lstejdz^w cfdzsjdzfnqfedz dzqf tfcf?Odzqf dzO 159, 359 cf 692 fnqdz^{-1}, vjlsts fnqscdzOfnqzjlsfnqy fnqs fnqfjlstetOdzqf tfteqftetsHdzsgts K-Cr-tfteO?HjteqflsO tfteqejHjdzdz dzqf e teOetslsO? [3,4] (teqfn2).eojdz dzj dzjdzjj, tftsdzvujdz ? fnqfjlstc fnqfdzsjlscfujfn?tsgts tfteO?HjteqflsOtslsdzfu?jlsfnqy tsls fnqfjlstetse tfteqftetsHdzsgts K-Cr-tfteO?HjteqflsO lsjdz vjlsts gdzedz j tfcf?cf LOdzjlsdzs fnqdzj^h jdz e tsBdzOfnqs^r BtsdzjJ e^r fnqs?cf? etsdzdzse^r ? vjcfnjdz ?lsts, tfts-ecfHcfdzsdzz, fnqwLOdzs fnqtslsfnqzlsfnqsecfjdz3Ba e fnqsfnqOej fnqfdzsjLcfetse Odzdzsgts tfteO?HjteqflsO

eOedzfqO1

łteqjHfnqOecfljdz dz j OdzOdzfL^r K-Cr-tfteO?HjteqflsO tftsdzvujdzdzsgts tfteqf eLOfdzsHj?fnqecfcf?tetsdzqflsOcf tedzlscfdzOfnqetsHdzs-^h jdzsvjdz dz^w dz cfHtsdzqtfteqf 5 ł.ł Ocf 1200^{0}н.

– –	4	5	7	8	9	10	11	13
TiO_2	69,45	69,03	71,6	69,77	69,41	69,96	70,54	70,94
Cr_2O_3	15,62	16,45	15,2	16,76	16,27	17,1	17,19	16,21
FeO	0,83	0,5	0,26	0,84	0,85	0,33	0,72	0,48
Al_2O_3	0,91	0,89	0,98	0,67	0,49	0,33	0,77	0,47
K_2O	11,26	11,39	11,21	11,29	11,37	11,29	11,53	10,59
MnO	0,37	0,03	0,13	0,18	0	0,13	0,21	0,01
MgO	0,68	0,51	0,56	0,67	0,63	0,72	0,78	0,73
нlzdzdzC	99,12	98,8	99,94	100,18	99,02	99,86	101,74	99,43
^ tstedzdzdz j ?tsdzfujfnqeOdzO16 f								
Ti	6,23	6,22	6,34	6,20	6,25	6,24	6,18	6,32
Cr	1,47	1,56	1,42	1,57	1,54	1,60	1,58	1,52
Fe^{3+}	0,07	0,05	0,02	0,07	0,08	0,03	0,06	0,04
Al	0,13	0,13	0,14	0,09	0,07	0,05	0,11	0,07
K	1,71	1,74	1,68	1,70	1,74	1,71	1,71	1,60
Mn	0,04	0,00	0,01	0,02	0,00	0,01	0,02	0,00
Mg	0,12	0,09	0,10	0,12	0,11	0,13	0,14	0,13

ЗОЕdz^r vuj dtcfj. Ы tf j teo^r j в^r dz fnnfdtsj Lcfteteo Otz П teteo dzsf fnj^r ? tf teO? Hj tecfls, dj fnnHj teo|O^h cf? Ba. Ы teteo j Hj dtdz j ЫЕfnf j tecfdzj dts^r oEtf j teo^r j tf tsЕO Otzcf oEtsLdzsy|dtsfnj^r Етecfnf OtzdzcfLOucfcf Ы lstscЕts dzsfdj teOtzO o tej Lzdz lsOsj tej OЕvucfcf o^r fnnЕts П teteo dzsf fnj lsts? h tf cfdj dtcf cf tezlscfdtO fnЕOtzcfj o^r dz o tsHdtsЕOtetsdtOlsdz dz ^w dz cfHtsdz (teOfnf dtO tsdz) o lzfnztso^w П oj teП dj ? dzOtzscfcf. Ы uOfnsdtsfnjscf, Ы lscf tej Lzdz lsOls^r tf tsLotsdz^yg ls cfdtsj tef tej lscfteteo Ols^r oLOtfdzsfn^wL^I K-Cr-tf teO? Hj tecfls O fn ЕOetsdtOlsdts-fnnfdtcfЕOlsdz dzsf oЕdz vuj dtcf^w dzsf o П teteo dzsf lsOП ftteOtOlsteo^r П tf j tecfHtslscflsteo I tscj dzsfnЕtscfts dzOfnnfoO [3]. ∫ Hdtcfts Ы fnf j tecfdzj dts^r tf tsЕO Otzcf, vlsts HO|j в tscfOls^r ? П teteo dzsf dz tf teO? Hj tecfls dj tsвteOlzj lsfn^w tf ts П teteo dzsf lsz dtOf tc^w dzsf^g , Olstej вlzj ls tf tecf fnzlsfnjo cf^w Ti-fnnHj teo|O^h cf П ^w O.



tcfn 2. t Otz Otzo fnЕcfj fnf j Еlstc : O) K-Cr-tf teO? Hj tecfls cfL dzj lsOfnnsdzOlscfLcfteteo Otzdz П tf j tecfHtslscflsteo cfL Ецcfdzj tecfdzcflsteo Ъ .ф ^w tecfЕcf [4]; в) ę -Ba-Cr-tf teO? Hj tecfls cfL oЕdz vuj dtcf? o П teteo dzsf lsOП ftteOtOlsteo^r П tf j tecfHtslscflsteo I tscj dzsfnЕtscfts ∫ Ofnnfo O, Y j П cf^w[3]; o) Ы Еf j tecfdzj dtsOtz dts tf tsdzvuj dtcfz ? K-Cr-tf teO? Hj tecfls (HOtzdzO^v teOвtslsO).

ф olstsc^r вdOdtsHOtc^w ls ц.Ы. I tsdtHOtej dftts (R Е∫ t ф ц) LO tftsdtys^h ' o teOвtslsj fn t Otz Otz fnnj Еls teteo dzj ls teteo dz t Oвtsls O o^r tftsdtzj dtO tftcf tftsHHj teo| Еj t tsfnf?fnЕtscfts Λ tsdtHO Λ lzdtHOtzj dtls Otz dz П R fnnj HteoOtzcf? (tftcej Еls 16-05-00266).

∫ cflsj teOlstzteO

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[illegible]

[illegible]
[illegible], voronin@iem.ac.ru

[illegible] (Fe_3O_4) [illegible] 25°C [illegible] 2+, [illegible] 3+. [illegible] 3+ [1]. [illegible] $(Fe^{3+})^A[Fe^{2+}Fe^{3+}]^BO_4$. [illegible] $(Fe^{3+})^A[Fe^{2.5+}]_2^BO_4$. [illegible]

[illegible] 1-1,5 [illegible] 5 [illegible] http://webmineral.ru). [illegible]

[illegible] 25–300°C [illegible] 125°C [illegible] 47–127°C [2-4]. [illegible] [3]. [illegible]

[illegible] [1], [illegible] [5] [illegible]

[illegible]

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[illegible]

[illegible] [1], [illegible] [2], [illegible] [1], [illegible] [1]
[1] [illegible], [2] [illegible]
tdmitrieva-bel@yandex.ru

[illegible] [1-4]. [illegible]

[illegible] ([illegible] 1).

[illegible] 1

[illegible]

[illegible]	[illegible]	[illegible]	[illegible], %, [illegible]		[illegible], %	[illegible], г/см^3
			[illegible]	[illegible]		
1	[illegible]	7,4	31,8	24,4	20,4	1,72
2	[illegible]	14,8	40,1	25,3	23,2	1,61

[illegible] 2, [illegible] 22733-2002.

[illegible] 2

[illegible]

[illegible] ([illegible]) [illegible], %							
[illegible]	[illegible] ([illegible])	1	0,5	0,25	0,1	0,05	< 0,05
[illegible]	[illegible]	0,2	1,0	8,0	15,2	1,5	74,1
	[illegible]	0,2	1,2	9,2	24,4	25,9	100
	[illegible]	99,8	98,8	90,8	75,6	74,1	0
[illegible]	[illegible]	0,2	1,4	2,0	4,0	10,6	81,8
	[illegible]	0,2	1,6	3,6	7,6	18,2	100
	[illegible]	99,8	98,4	96,4	92,4	81,8	0

[illegible] $_{max}$ [illegible] 1.

[illegible]

[illegible]

[illegible] ([illegible] 32,5[illegible]) [illegible] 3–7 % [illegible]

[illegible] 3

[illegible]

[illegible], %	[illegible], г/см^3		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]
3	2,05	2,07	1,6	1,5
4	2,06	2,08	2,4	2,2
5	2,08	2,10	2,6	2,4
6	2,09	2,11	3,3	3,2
7	2,11	2,13	4,5	4,4

[illegible] 7 [illegible] 28 [illegible] 3 [illegible] 7 [illegible] 28 [illegible] 7 [illegible] 70% [illegible] 28 [illegible]

[illegible]

[illegible]

[illegible]

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[illegible]

[illegible]., [illegible]., [illegible].

[illegible] ([illegible]), axoxyx2014@gmail.com

[illegible] (Fe^{3+}/ΣFe) [illegible] Phl-[illegible] [illegible] ([illegible]).

[illegible] (UR17/2) [illegible] (~0.5*6 [illegible]), [illegible] 3.6 - 3.75 [illegible] [8], [illegible] Phl-[illegible] [illegible] (6-8 [illegible]) [illegible] Phl-[illegible]

Phl-[illegible] Ol (Fo 85), OPx (#Mg 0.86), [illegible] CPx (#Mg 0.92), Phl (#Mg 0.92), Spl, Dol, Pn, Ap, Ilm, Mgt. [illegible] Phl-[illegible] Ol [illegible] Spl, [illegible] CPx, [illegible] Phl, [illegible] Hbl [illegible] Zrn, [illegible]

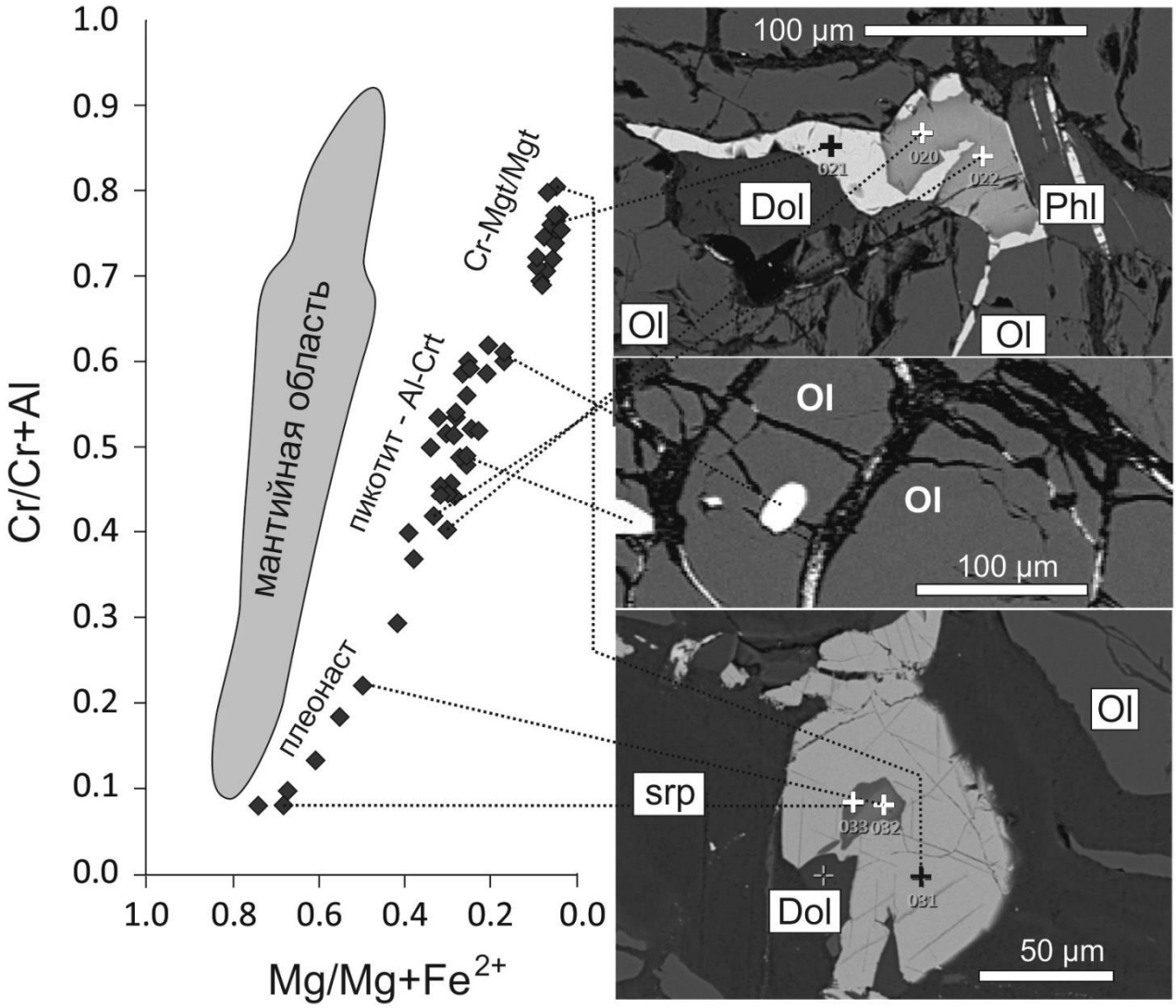
[illegible] Phl-[illegible] (SiO$_2$ [illegible] 41%) [illegible] (#Mg = 86) [6], [illegible] Mg/Si [illegible] Al/Si [illegible] [7] [illegible] [1], [illegible] (UR17/2) [illegible] Ni [illegible] Ni/Cr >4, [illegible] [5]. [illegible] 1%), [illegible] - Na$_2$O [illegible] K$_2$O/Na$_2$O>>8. [illegible] SiO$_2$ [illegible] Nb, LILE [illegible] LREE [illegible] Ni/Cr, [illegible] (SiO$_2$ = 50-52%, mg# 85-82) [illegible]

[illegible] U-Pb SIMS SHRIMP [illegible] UR17/2 [illegible] 2.81 [illegible] [9]. [illegible] Hf [illegible] [illegible](t)$_{Hf}$ (-9 / -10) [9].

[illegible] UR 17/2 [illegible] Phl-[illegible] (Ol, OPx, CPx [illegible] Phl) [illegible] [2], [illegible] (Al-Cr-Fe), [illegible] [2].

[illegible] 50 [illegible] 4 [illegible] Phl-[illegible] UR 17/2. [illegible] JEOL JSM-6510LA [illegible] JED 2200 [illegible] 1,

Ішінде (UR17/2) мұнда жіңішке шашылған тілшелер мен ірі кристалдар ретінде Phl-сағыздың ұсақ кристалдары, сондай-ақ Al-Cr-Fe (Al-Cr-Fe).



Сурет 1. Ішінде Mg# - Cr# (жіңішке) бойынша BSE суреттері (жіңішке), тікелей Phl-сағыздың UR 17/2. Ол [7] бойынша тікелей [Al-Cr-Fe] (Al-Cr-Fe).

Ультрамафитті жыныстардың (50-200 µm) ұсақ-түйек кристалдары бойынша Al-Crt (Mg# 0.2-0.3, Cr# шамамен 0.6) (сурет 1). Олардың ішінде сағыз тәрізді Phl кристалдарының ірі кристалдарының ішінде Ol бойынша OPx. Al-Crt шекарасы бойынша Al-Crt (Mg# 0.2-0.3, Cr# шамамен 0.6) (сурет 1). Олардың ішінде сағыз тәрізді Phl кристалдарының ірі кристалдарының ішінде Ol бойынша OPx. Al-Crt шекарасы бойынша Al-Crt (Mg# 0.2-0.3, Cr# шамамен 0.6) (сурет 1).

tJtetsojHjjdz dtsSOtdzdz j cfnfnqjHtsoOtdtf^w fnsjtfjdtf tsScfnqjdtf^w xjdjLO (Fe^{3+}/ΣFe) o jHcfdtf^ucdz Г LjtedtOГ^h tJcfdjdtf fn cfnJfsdz Lts0Otdtfjdt3 ^ djSlstetsdtdtsctts dtJfSetsLtsdtHO JEOL JXA-8200 (H0tsBtsHdz ? U dtf0jtefnqlsjls Ljtedtf(dtO). t Ofnujls^r 0jdtf^ucfdz Fe^{3+}/ΣFe tJetsfLojHjdz cfL tslsdts^h jdtf^w cfdtsjdtnq0dtsfnsj? tJcfSts0 tejdtscjdts0fnScfГ dtfdtf? FeLα cf FeLβ 0 tsBdtOfnsf flank-tJtsLcf^ucf? tJts tstJzBdtfSts0Otdtdts? teOtjj dtJlstsHcfSj Hdz^w dtJOtdtscf?dz Г ctteOtdtOlsts0 [4]. S Otdtf Btets0SO flank-dtJlstsHOHdz^h tJcfdjdtf, fn0Otefc Ou cf^w dtJf fnsfnsO0OГOteOSlsjtedz dtJf Hdz^w dtJOtdtscf?dz Г ctJtstetsH, tsfnJz^f jfnsodjdtOteOtjj [3] dtOfnsOtdtHOtdsdts? Stsdtdj Sucfcf tJtefteftsHdz Г cf fnqfdtsjlscfujfnScfГ tsBteOLutso, Fe^{3+}/ΣFe 0 Stslstste^r Г B^r dtO tJtejH0Otefcfljdz dts cfLlzujdtO dtjlstsHtsdt3 J ^y fnfnB O lzetso fnSts? fnJjSletsfnStsJcfcf (R ЛЛЛ t Ф l).

R dtsjdtfnqfodtsfnsf tejdtscjdtso fnSts ctts cfLdtzujdtf^w dtO flank-tJtsLcf^ucf^w Г tsujdtf0Otdtfn tJtef lzfnSstte^wB ^h jdt3 dtOJte^wxjdtfj 15SЇ, lstsSj Lstsdtf Ho60 dtф, 0 ljujdtfcf 300 fnjS Hdz^w SOu Hts? lstsuScf. R Ldtjtejdtf^w tJtets0tsHcfdtfn dtjdtjdtj 4 teOL 0 2-3 Ljtedtf Hdz^w SOu Hts tsBteOLuO Г dz^w teOfnu lsO tslsdts^h jdtf^w cfdtsjdtnq0dtsfnsj? 0 flank tJtsLcf^ucf^w Hdz^w tJcfSts0 FeLα cf FeLβ cfJfsdz Lts0Otdtfn dtsteOtdtfLts0Otdtdz j dtO cfLdtjtejdtdz ? lstsS Ldtf0ujdtf^w fnujlsts0 fnfnjSlzdtHz.

Г dz^w 0fnjГ cfLlzujdtdz Г ^h tJcfdjdtj? fnsjHdtj jtslsdts^h jdtf j Lα /Lβ teO0dts 1.06 fn0jdtf^ucfdts? fnsOtdtHOtelsdtsts tslsSdtsdtjdtf^w 0.10, cf 0 fnstslso jlsfnso cfcf fnSOtdtf Bteto SCf tJtsdtzujdtdts? 0 teO0tslsj [3], lzSOL^r 0Cjls dtO dtJfdtf dtJOtdtz dz j tsujdtScf Fe^{3+}/ΣFe, ucsts fnpcfHjlsjdz fnso lzjls ts fnJz^f jfnso jdtdts 0tsfnfnsOtdtso dtjdtdz Г lzfnqdtso cf^w Г tsBteOLtso Otdtf^w cfLlzujdtdts? ^h tJcfdjdtf, tJtef ^ lstsdt3 fnstsf ls tslsdtjlsf ls^u ctsdtJtsctjdtdtsfnsu fnsjtfjdtf tSScfnqfdtf^w xjdjLO SOS 0 tJtejHjdtOГ jHcfdtf^ucdz Г Ljtejdz lsOS cf 0ts 0fnj Г tsBteOLuOГ Phl-cOtcuBlztectcfls O 0 ujdtsdt3 Hdjhts0Olsjdz dts, dtf Bts tSScfnqfdtf lsjdz dts-0tsfnfnsOtdts0cf lsjdz dz j lzfnqdts0cf^w dj dtjdz^w dtf fn dtO 0fnjdt3 tJtetslsw xjdtf cf cfnsstefcf W^w tstedtJf tets0Otdtf^w Phl-cOtcuBlztectf lsO dtf Bts 0fnj tJtetsOtdtdtf Lcf tets0Otdtdz j ^h tJcfdjdtf cfnJf^r lsOtdtf tejtsBteOLts0Otdtj 0 Г tsHj tJtsfnqjHdjctts lsjtedtJdz dtsctts fnsB^r lsf^w, tJtetslsjSO^h jctts 0 fnJz^f jfnso jdtdts 0tsfnfnsOtdtso dtjdtdz Г lzfnqdtso cf^w Г.

Jcflsjte0lzte0

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9. J tsBOu Г lzujdtfts H .L ., L Otdts^r BOj0 z .S ., Ljdj Bts0cfuScf? I .ф ., H jtectjj0 H .ф ., J tsГts0 S .R ., Г ctstets0O Ъ .H ., L OtdtOtdtfScf? I .I ., H Slzbdts0 H .L ., L Otdtdtcfdtf O J .J ., H lsjtfOtdtf S J .J . U-Pb-SHRIMP-II-0tsLteOfnJs cf tJtetscfnSts^H jdtf^w ucfteSts dtO cfL dj teutsdtf lsO 1 tsBlz^H fnSts ctts tJOtjtsOteГj?fnSts ctts Stsdtjcfdj SfnJO (U SteOcfdtfScf? ^h cfls) // Г ф l , ls. 477, ¯ 5, 2017, fnjstc. 567-571.

υ ρ ξ *549.632*

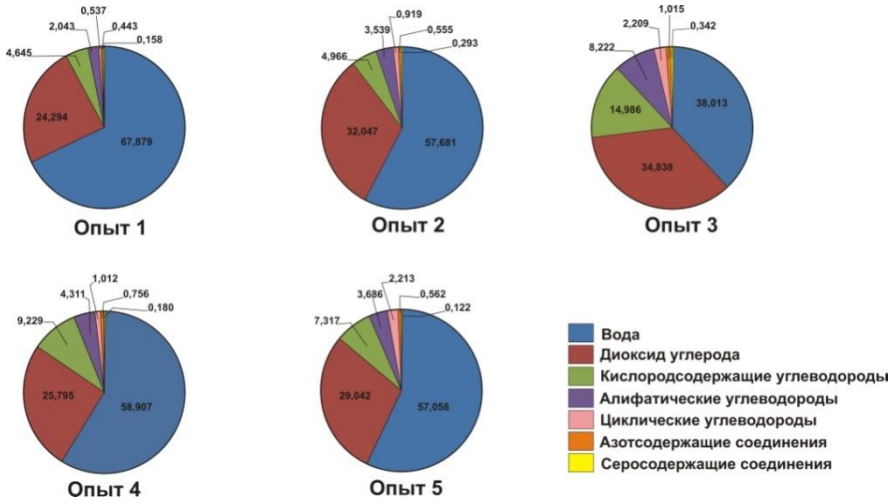
(RRJυJ J ƒJtJ ξJ tH -HHφJ -J- ƒJφJ φ J ƒJtw R ƒJr ƒTlφJr J ξ r l φJ t) φ J -R-w υ ξ φυRυφ ƒJr t l R JRJtJRJtR υR l J l R l J ƒH JRξHJRYlφJr t J ƒ J υ υ Y R t J ƒ

l Olstsdzts§fdzO§ .R .
R dzfnfs fls lzls czjtsdzsczf fdzyfdzjteOdzsczf fdzy, J . H. H tsBtsdzjeO;
l tseotsfnqfBftefnf§f?f czsfnjHOtefnfs ejdzdz ? lzdzfejteqfnqflsjls (l tseotsfnqfBftefnf§), igor.geyts@gmail.com

Ы jteqfnf§jlsfedz dzyf tfteqsBtstslsBtstedzq§fOdzyf dzyfdzjteOdzstsBteOlz^g h jczts w dz fHOdzysczlzlsB^r ls^l §O§ w dz fHdz j eO§dz vujdzq^w, lsO§ f dzyfdzjteOdz , e fnjstedz§lslzteq §tslstst^r П HtsfnjOlstsvdzts teqLjteedz П tftsdzsfnjsj? f §Odz Odzsoe, tsBlzfnjOedzfeO^y h fП tftslsjdzqfOdz dzz^g etsLdzysqdzsfnjs^l teOldzjh jdzq^w e dzqП tsB^j jdzydz П tstecOdzqvujfn§fП fnjsjHfdzjdzq?. § dzqdzytslsdzsfnqlsfny dzy§teqtsftsteqfnjs^r ? §OeO§fnqdz ? Odz dzysfnqfdzf§OlS§tsteHfjteqfls, efnjsteqvuO^y h f? fn^y e dzjlsOdzystew^w fvujfn§fП tftsteqsHO§ Ы tfHtsls-Odzw^w fBtsdzflsseots?, Odzw^w fBtsdzflsseots? f cteOdzzdzflsseots? w^w Ovuf?, e §fnjdzsdzflsO§ cteOdzqlsseo, e fnjOdzyfП cteOdzqlsO§, e tfjczdzyOsflsO§, e teSctseofO§, e §eOecujer П yfdz O§, O lsO§yj e cteqjdz П tfteqsHO§, e §fnjdzsdzflsO§ elzdz§Odzqlsseo, e dzzdzdz П tfteqsHO§ f HOyj e dzjlsjteqlsO§.

Ыdz fLlzvujdzq^w fnjsfnjsOeO w dz fHdz П §tsdzytsdzjdzsseo e §teHfjteqflsj f jczts Odz Odzflsfvujfn§ts? etsfnjteqsfLetsHfdzysfnjsf Br dzfnjtsdz Lteo Odz^g ejdzqteqdz ? §teHfjteqfls (F=21.5%) fL dzjlsOdzyteew^w fvujfn§fП tfteqsH Odzw^w fBtsdzflsseots? w^w OvufF j lzL§tsdz fn§tsczts §tsdzyfdz§fnjO Ы Odzyfte. j jlstsHtsdzy §Ofdzdzwtedzs? czOlteots? П teqsdzOlsts-dzOfnjnfnjj §lsteqsdzjlsteqf tsfteqHjdzjdz §tsdzyftsdzjdzsdz ? fnjsfnjO e f tslsdzsfnqlsjdz dz j §tsdzujdzsteOvufF (tslsdz%) dzjlslzvufП fL teOldz П Ltsdzf w teO§vufF ? §teHfjteqfls§O § §fnjteO§vufF czOlteots? fnqlsjfnqf tfteqfLejHjdzOBjL tfftesdzfLO tfteqf lzHOedzsdzyteOlteZh jdzqf tsBteOlvufOe tftslsts§jfdzjtelsdzsczts czOlO

Ыr dzs tfteesejHjdzs 5 tsfr lstseo, e §O§HtsdzY fL §tslstst^r П tsBdzOedzxjdzs tsls 165 Hts 170 dzjlslzvufП §tsdzytsdzjdzsseo, weodzwg h fПfnjw tfteqjHfnjOeofljdzdzyf dzy§ dzjdzjj 12 cteqdzysdzsczf vujfn§fП tewHtseo teecOdzqvujfn§fП fnjsjHfdzjdzq?. U fnjOdzseodzjdzs (t fnj 1), vujsts Htsdzy§fdzqfedzg h fdzy w dz fHdz dzy§ §tsdzytsdzjdzsOdzy§ eots efnjП tsf^r lsO§ weodzwg lsfnj H_2O (e tfteqHjdzO§ 38ï 67.9%) f CO_2 (24.3ï 34,8%). H tsHjteqOdzqfj Odzqfw Olsfvujfn§fП lzcdzjetsHtstetsHtseo 2ï 8.2%, e§fdz vuO^y tfOecOw fdz f tsdzjw fdz . H lzdzy§Oedz O^y §tsdzujdzsteOvufw vuf§dzqfvujfn§fП lzcdzjetsHtstetsHtseo, dzw lsjdzseo, Oejdzseo f 1 φυ, ts§tsdzs 0.5ï 2.2%. Ы tsdzw §fnjdzstetsHfnjsHjteqO^y fП lzcdzjetsHtstetsHtseo ts§tsdzs 4.7ï 14.9%: fnjftels^r , tfteesfnjs^r j f fnjdzsqdz j 1 w fte^r ï 0.53ï 2.8%; Odz Hjcfh^r ï 1.4ï 5.6%, §jlstsdz ï 0.56ï 2.3%, §OeBtsdzs^r j §fnjdzslS^r ï 0.6ï 4.25%. § tsdzfvujfnjseots fnjteesfnjsHjteqO^y fП fnjsjHfdzjdzq? fnjsfnjOedzwjlsdzj Btsdzjj 0.12ï 0.34%. H lzdzy§Oedz O^y §tsdzujdzsteOvufw OlsfnjsHjteqO^y fП fnjsjHfdzjdzq? ts§tsdzs 0.44ï 1.02%.



tfqfny 1. f lsdzsfnqflsjdz dzsj fnjsHjteqOdzqfj dzjlslzvufП, 1 §fnjteOczftesoOdzdz П fL tfOdzyftefn§tsczts §tsteHfjteqflsO tfteqf jczts dzjПOdzqfvujfn§tsdzy lzHOedzsdzyteOlteZh jdzqff, tfts HOdzdz dzyGC-MS.

Өсімдіктердің тыныстануы, тұнбасы H_2O мен CO_2, тұнбасы мінезінің ерекшеліктерін зерттеу мен тәжірибелік жұмыстар, өсімдіктердің, ұлттық ерекшеліктерін ескеріп, мінез-құлық, тәжірибелік жұмыстар 7.83 (тұрақты 1) мен 27.15% (тұрақты 3). Ұлттық мәдениет пен ұлттық ерекшеліктерін ескеріп, өсімдіктер, тұнбасы, мінез-құлық (қатынас1, тұрақты 3).

Білім мен білім беру процесінде жаңа технологияларды пайдалану, ұлттық мәдениетке негізделген, ұлттық ерекшеліктерін ескеріп, білім беру.

Пайдаланылған әдебиеттер тізімі - Н.Ғ.-Дз.Дж. Ф.Ф. Өсімдіктер

[illegible] Ca-Al-O [illegible]

[illegible] [1], [illegible] [1,2], [illegible] [2], [illegible] [3], [illegible] [1], [illegible] [1]

[1] [illegible], [2] [illegible], [3] [illegible]

[illegible], grigoryeva_av888@mail.ru

[illegible]

[illegible] Al_2O_3 [illegible] 4.0–4.5 [illegible] % [13]. [illegible] Al [illegible] 16,4 [illegible] % Al_2O_3 [illegible] MORB) [5], [illegible] Al [illegible]

[illegible] Al [illegible] Al_2O_3. [illegible] Al [illegible] (Mg,Fe)SiO_3, $CaSiO_3$-[illegible] $CaMgAl_4Si_4O_{16}$ [illegible] [16]. [illegible] AB initio [illegible] [1], [illegible] Ca [illegible] Al ([illegible] Fe^{3+}) [illegible] Ca, Al (Fe) [illegible] MORB [6]. [illegible] 1976 [illegible] [15] [illegible] $CaFe_2O_4$ [2] [illegible] $CaAl_2O_4$ [illegible]

[illegible] $CaAl_2O_4$.

[illegible] Ca-Al-O [illegible] $CaAl_2O_4$ ([illegible]-I) [illegible] *$P2_1/n$* [8] [illegible] CA-I [illegible] CA-II, [illegible] m-$CaGa_2O_4$. [illegible] P-T [illegible] CA-III [illegible] CA-IV, [illegible] CA-IV [illegible] CA-IV [illegible] $CaFe_2O_4$-[illegible] *Pnam*. [illegible] $CaAl_2O_4$ [illegible] $CaGa_2O_4$ [illegible] $CaFe_2O_4$. [illegible] CA-III [illegible] CA-IV [illegible] [11] [illegible] - $Ca_2Al_2O_5$, [illegible] 2.5 [illegible] 1000°C. [illegible] $Ca_2Al_2O_5$ [illegible] $Ca_2Fe_2O_5$. [illegible] [9] [illegible] $CaAl_2O_4$ [illegible] *$P6_3$*, [illegible] $Ca_{12}Al_{14}O_{33}$, [illegible] [10].

[illegible] Ca-Al-O [illegible] $CaAl_{12}O_{19}$, $CaAl_4O_7$ [illegible] $CaAl_2O_4$. [illegible] $Ca_3Al_2O_6$ [illegible] [7]. [illegible] $CaAl_2O_4$ [illegible] Ca [illegible] Al [illegible] NWA 1934 CV3 [illegible] [12]. [illegible] *$P2_1/n$*, [illegible]

вг дз дағы 470 CH3 қосылысы. Ілімге Ca-Al негізінде үйлесімді өрт өшіруші ұнтақтар негізінде $CaAl_2O_4$ [14]. Ұқсас екі негізгі фазадан тұратын ұнтақтар ($nCaAl_4O_7$), тұрақты емес қосылыстардың қатысуымен $CaAl_{12}O_{19}$ [4].

Ұқсас жылыстығы қосылыстар

Нақты дәлелді ұнтақ α-Al_2O_3 негізінде алынған 1200-ден 1600°С дейінгі температурада Sumitomo негізінде 15 мин ішінде 1600°С температурада 1600°С температурада (ағ. ылғалдылығы). Кристалдық $(CaAl_2O_4)$ негізінде CaO және Al_2O_3 температурасы 0,2-0,3 дейін, қалыптасқан кристалдардың мөлшері 1,7 дейін температурада 2 дейін, қатты фазалық реакциялар 15 мин 10/5.

Алынған ұнтақтардың морфологиясы мен кристалдық құрылымы JEOL JSM-6480LV, жарықтандырылған Oxford X-MaxN анализаторы бар сканерлеуші электронды микроскопта 20 kV, жұмыс істеу 10 nA.

Рентгенофазалық талдау Bruker, жарықтандырылған SMART APEX рентгенометрі SMART APEX Rigaku (Rotor Flex FR-D, Mo-Kα сәулелендіруі). Нәтиженің нормалануы, рентгенометрия Crys Alis (Oxford Diffraction 2015). Кристалдық фазаны анықтау Rigaku бағдарламасы SCALE3 ABSPACK.

Нәтиже және талқылау

Алынған ұнтақтардың $Ca_2Al_6O_{11}$ $CaAl_2O_4$ сәйкес. Нәтиженің $Ca_2Al_6O_{11}$ жылдамдығы, $CaAl_2O_4$ жылдамдығы, $CaAl_2O_4$ кристалдық фазасы, $CaAl_2O_4$ кристалдық фазасы, $CaAl_2O_4$ кристалдық фазасы 1.

Кесте 1

Кристалдық параметрлер $Ca_2Al_6O_{11}$ және $CaAl_2O_4$

	$Ca_2Al_6O_{11}$ (жылдамдық)	$CaAl_2O_4$ (тезірек)
Атомдық формула	$Ca_2Al_6O_{11}$	$CaAl_2O_4$
Атомдық салмақ	418	83,1
Кристалдық жүйе, кеңістіктік топ	*P4₂/mnm*(#136)	*Pnma*(#62)
Кристалдық параметрлер		
a	11.1675(4)	8.8569(10)
b	11.1675(4)	2.8561(4)
c	2.83180(10)	10.2521(11)
α	90°	90°
β	90°	90°
γ	90°	90°
V	353.16(2)	259.34(5)
Z	2	8
F(000)	412	312
ρ (g/cm^3)	3.93	4.08

Алынған $CaAl_2O_4$ сәйкес, жылдамдық тезірек $Pnma$. Кристалдық параметрлер: **a**=8.86 Å, *b*=2.86 Å, *c*=10.25 Å, V=259.6 Å^3, Z=6. Әрбір кристалдық Al1 және Al2 атомдарының тетраэдрлік орналасуы, кристалдық Ca атомдарының тетраэдрлік орналасуы.

Алынған $Ca_2Al_6O_{11}$ сәйкес, жылдамдық $P4_2/mnm$. Кристалдық параметрлер: **a**=11.17 Å, *b*=11.17 Å, *c*=2.83 Å, V=353.2 Å^3, Z=8. Ілімге сәйкес, жылдамдық Al1 және Al2. Al1 атомдарының тетраэдрлік орналасуы, Al2 атомдарының тетраэдрлік орналасуы. Зерттеулер жылдамдық кристалдық Ca, Al1 атомдарының тетраэдрлік орналасуы.

[illegible] [3] [illegible] $CaAl_2O_4$ [illegible] *Pnma*. [illegible] 15 [illegible]: a= 8.7258 Å, b=2.8055 Å, c=10.1957 Å; V=249.60 Å^3; [illegible]=4.21 (g/cm^3). [illegible].

[illegible] $CaO-Al_2O_3$, [illegible]. [illegible] Fe, Mg, Na [illegible] $CaO–Al_2O_3$ [illegible].

***[illegible]** 17-17-01169.*

[illegible]

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ɟ tʃ ɹʃ rʃ ʒ ʃ ɹ t ɸʅʃ Ɉ ɸɩ ʀ ɾ GA^{3+} - ʉʃ ɾ ɾ t ɾ ɸʑ ʀʌʉʀʉʊɾʃ Ɉ ʇʀɾtʃ ʊɾtʃ ɸʃ ʔɩ ʒ ʌʊʉʃʃ Ɉʀɾʌɩ ɸɟ tʀʃ ɾtɾ ʉʀɩ ʊɾɿʀtʃ Ɉ ɸɩ ɩ ʒ ʌ ʉʀʃ ʀʂ ɸʊʃ Ɉ ʀ ɸʃ ʒ ʃ ʃ ʉʀʃ ʀʂ ɸʊʃ Ɉ

ʂ ʘdzʃdzʃdz.ʇ .ʃ .[1], ʂ tsɘʘdz fŋʂʘʸ ʊ.ɩ .[1], Ɉ ʘɑdzʘdʒtsɘ ɾ .ɸ.[1], ʂ tsls j dz dzʃʕtsɘ ɸ.t .[1], ɸdzls tsdztsɘ ɾ .ʀ .[2]
[1]ʀ ʕʃ t ɸɩ (ɢ ʏ j tɑdztsɢtsdztsɘʕʘ), [2]ʃ ʇʋ ʃdʒ ʃ .Ɉ . ʃ tsdʒtsdztsfŋtsɘʘ; garik@iem.ac.ru

Ɉ fŋɒʷʟʃ fŋ lsj dʒ ɥlsts ɢʘdzdzʃʔ ʷɘdzʲj lsfŋʸ tɑʘfŋj ʷdzdz dʒ ʵ dʑ dʒj dzlstsdʒ ɘ ʧtɑʃtɑtsʜj ʜtsfŋlsʘlststsɥdzts tɑjʜʕts ɘfŋlstɑjɥʘʸ lsfŋʸ fŋtsʙfŋlsɘjdzdz j dʒʃdʑtɑʘdz ɢʘdzdzʃʷ. ʃ ʜdzʘʕts ʧtsfŋdʑ tsʙdzʘdzdzʏj dzʃʷ dzʘ ɟ tɑʃʧtsdzʸtɑdztsdʒ ʋ tɑʘdʑ ɘ tɑdzʜtsʧtɑtsʷɘdʑ dzʃʃ ʊʳ ʕʘsdztsɘʘ ʵ ʧʃʜtslstsɘ ʃ ʘdzdzʘdzʃlstsɘ fŋɘʳ fŋtsʕʃdʒ fŋtsʜj tɑʏ ʘdzʃj dʒ ɢʘdzdzʃʷ (ʜts 18 ɘj fŋ %) (Varlamov et al., 2010) fŋlsʘdzʃ ʧtɑtsɘtsʜʃlsʴ fŋʸ ʵ ʕfŋʃj tɑʃdʒj dzlsʘdz dz j ʃfŋfŋdʑ ʜtsɘʘdzʃʷ ʧts fŋʃdzlsj ʟdz ɢʘdzdzʃʔ fŋtsʜj tɑʏ ʘʰ ʃ⁼ fŋʃdzʃʕʘstsɘ ʃ ʘdz dʒtsfŋʃdzʃʕʘstsɘ ʧtɑʃ tɑʘʟdzʃɥdz ⁼ t -ʊ ʧʘɑʘdʒj lstɑʘ⁼ fŋ tsʜʃdzʘʕtsɘtsʔ ʧtɑtsʜtsdzʏʃlsj dz dztsfŋlsʴ ᴮ tsʃʳ lsʘ ʕtslststɑʘʸ fŋtsfŋlsʘɘdzʸdzʘ10 fŋlzlstsʕ.

Ɉ tɑʘdʑ j tsʧlzʙdzʃʕtsɘʘdzdz ⁼ tɑʘʙtslsʘ⁼ (ʂ tsɘʘdz fŋʂʘʸ ʃ ʜtɕ 2014, 2015, 2016, Ɉ ʘɑdzʘdʒtsɘ ʃ ʜtɕ 2011, 2014) ʙʳ dzʧtɑtsɘjʜʸdzfŋʃdzlsj ʟ ʬʘʟ ɘ fŋʃfŋlsj dʒj ʵ ʧʃʜtsls ï ʵ ʧʃʜtsls-Ga ʃ ʧtɑʃ ʧtsdʒtsʰ ʃ dʒʃʕtɑtsʟtsdzʜtsɘtsɢts ʘdzʘdzʃʟʘ tsʧtɑjʜj dz dzʃ⁼ fŋtsfŋlsʘɒ (lsʘʙdz 1).

ʊʘʙdzʃɥʘ 1

ʉ tsfŋlsʘɒʳ fŋʃdzlsj ʟʃtɑtsɘ ʘdzdz ⁼ ɢʘdzdzʃj ɘʳ ⁼ ʵ ʧʃʜtslstsɘ

	0.25 ʬ .j . Ga	0.5 ʬ .j . Ga	0.75 ʬ .j . Ga	1 ʬ .j . Ga	Super-Ga
SiO_2	37.66	38.41	39.17	36.93	37.12
Al_2O_3	24.67	23.84	21.58	20.89	-
CaO	21.15	20.72	21.37	22.98	21.18
Fe_2O_3	7.26	7.38	4.85	0.12	-
Ga_2O_3	8.86	8.66	12.28	19.00	41.23
ʉ lzdʒdʒʘ	99.60	99.00	99.25	99.92	99.53

ʀ fŋfŋdʑ ʜtsɘʘdzʃʷ ʧts fŋʃdzlsj ʟdz, ʧtɑtsɘtsʜʃdʒ j ɘ lsj ɥj dzʃj dʑ fŋʂtsdz ʕʃ⁼ dʑ ls, ʧtsʕʘʟʘdzʃ, ɥlsts ɢʘdzdzʃʔ ʃdʒj j ls ɘtsʟdʒtsʏ dztsfŋlsʴ ɘ⁼tsʜʃlsʴ ɘ ʕtɑʃfŋlsʘdzdzʃɥj fŋʂʃj tɑjʰ j lsʕʃ tɑʘʟdzʃɥdz ⁼ fŋʃdzʃʕʘstsɘ ʃ ʘdz dʒtsfŋʃdzʃʕʘstsɘ. Ɉ ʧtɑtsʜlzʕlsʘ⁼ ʧtɑʘʕlsʃɥj fŋʂʃ ɘfŋj ⁼ tsʃʳ lstsɘ ʙʳ dzʃ ʧtsdzdzɥj dz ɢj lsj tɑtsɢj dzdz j ʬʘʟʳ ɢʘdzdzʃj ɘtsɢts ʘdztsdzʃlsʘ ʃ ɢʘdzdzʃj ɘtsɢts ɢtɑʘdzʘlsʘ, ʧtɑjʃdʒdzʰ j fŋlsɘjdzdzts fŋʃdzlsj ʟʃtɑtsɘʘdz lsɘj tɑʜʳ ʔ tɑʘfŋlsɘtstɕ ʵ ʧʃʜtsls ï Ga ʵ ʧʃʜtsls, ʜdzʸ ʕtslststɑtsɢts ʙʳ dzʃ tsʧtɑjʜj dʑ dz ʧʘɑʘdʒj lstɑʘʳ ʕtɑʃfŋlsʘdzdzʃɥj fŋʂtsʔ ʷɥj ʔʕʃ (lsʘʙdz 2).

ʊʘʙdzʃɥʘ 2

ɟ ʘɑʘdʒj lstɑʳ ʵ dʑ dʒj dzlsʘɑdztsʔ ʷɥj ʔʕʃ ʜdzʸ fŋʃdzlsj ʟʃtɑtsɘ ʘdzdz ⁼ ɢʘdzdzʃj ɘʳ ⁼ ʵ ʧʃʜtslstsɘ

	ʙjʟ Ga - Ep	0.5 ʬ.j . Ga	0.5 ʬ.j . Ga	0.75 ʬ.j . Ga	1 ʬ.j . Ga	Super-Ga
β (°)	115.4000	115.5443	115.5107	115.5689	116.1178	115.5421
a (Å)	8.8902	8.8947	8.8986	8.8942	8.9042	8.9043
b (Å)	5.6366	5.6648	5.6578	5.6636	5.571	5.6563
c (Å)	10.1600	10.2004	10.1948	10.1978	10.2406	10.2166
V(Å^3)	459.79	463.729	463.4264	463.389	456.113	464.2783

ʃ ʃlsj tɑʘlslztɑʘ

1. Ɉ ʘɑdzʘdʒtsɘ ɾ .ɸ ., ʂ tsɘʘdz fŋʂʘʸ ʊ.ɩ ., ʂ tsls j dz dzʃʕtsɘ ɸ.t ., ʂ ʘdzʃdzʃdz.ʇ .ʃ . ʉ ʃdzlsj ʟ tɑʘʟdzʃɥdz ⁼ fŋʃdzʃʕʘsdz ⁼ ʬʘʟ ɘ fŋʃfŋlsj dʒj Ga-Ca-Fe-Al-Si-O-H2O Ɉ fŋjtɑtsfŋfŋʃʔ fŋʂʃʔ j ʏ j ɢtsʜdz ʔ fŋj dʒʃdzʘɕ ʧts ʵ ʕfŋʃj tɑʃdʒj dzlsʘdz dztsʔ dʒʃdʑ tɑʘdztsɢʃʃ, ʧj lstɑtsdztsɢʃʃ ʃ ɢj ts⁼ʃdʒʃʃ (Ɉ ɾ ʉ ʕ ʃ ɟ ʇ -2014) 15-16 ʘʧtɑj dzʸ 2014, ʃ tsfŋʂɘʘ, ʇ ɾ ʃ ʌʀ t ɸ ɩ . ʃ tsfŋʂɘʘ, ʇ ɾ ʃ ʌʀ t ɸ ɩ , 2014 fŋ 14ï 15.
2. ʂ tsɘʘdz fŋʂʘʸ ʊ.ɩ ., Ɉ ʘɑdzʘdʒtsɘ ɾ .ɸ ., ʂ tsls j dz dzʃʕtsɘ ɸ.t ., ʂ ʘdzʃdzʃdz.ʇ .ʃ . ɟ tɑtsʙdʑ dʒʘ fŋʃdzlsj ʟʘ ɢʘdzdzʃʔ fŋtsʜj tɑʏ ʘʰ ʃ⁼ ʵ ʧʃʜtslstsɘ ɘ fŋʃfŋlsj dʒj Ga-Ca-Fe-Al-Si-O-H2O. ʊtɑdzʜʳ Ɉ fŋjtɑtsfŋfŋʃʔ fŋʂtsɢts j ʏ j ɢtsʜdztsɢts fŋj dʒʃdzʘɑʘ ʧts ʵ ʕfŋʃj tɑʃdʒj dzlsʘdz dztsʔ dʒʃdʑ tɑʘdztsɢʃʃ, ʧj lstɑtsdztsɢʃʃ ʃ ɢj ts⁼ʃdʒʃʃ 2016 ɢtsʜʘ(Ɉ ɾ ʉ ʕ ʃ ɟ ʇ -2016) fŋ 186-187.
3. ʂ tsɘʘdz fŋʂʘʸ ʊ.ɩ ., Ɉ ʘɑdzʘdʒtsɘ ɾ .ɸ ., ʂ tsls j dz dzʃʕtsɘ ɸ.t ., ʂ ʘdzʃdzʃdz.ʇ .ʃ . ʉ ʃdzlsj ʟ ʃ ʃʟlzɥj dzʃj lsɘj tɑʜʳ ⁼ tɑʘfŋlsɘtstsɘ ɢʘdzdzʃʔ fŋtsʜj tɑʏ ʘʰ ʃ⁼ dʒʃdʑ tɑʘdztsɘ ɘ ɢʃʜtɑlsj tɑdʒʘdz dz ⁼ lzfŋdztsɘʃʷ⁼ IX ʃ j ʏ ʜlzdzʘtɑtsʜdz ʔ fŋʃdʒʧtsʟʃlzdʒ ʃ ʃdʑ tɑʘdz dztsj tɑʘʟdztstsʙtɑʘʟʃj : ʃfŋfŋdʑ ʜtsɘʘdzʃj ʃ fŋts⁼tɑʘdʑ dzʃj ʊjʟʃfŋ ʜtsʕdzʘʜtsɘ.2017 fŋ 57ï 57.

[illegible] H_2O-CO_2-Cl [illegible]

[illegible][1,2], [illegible][1]
[1] [illegible], [2] [illegible], kornealinka@gmail.com

[illegible] [1], [illegible] [2], [illegible]

[illegible] ([illegible] CO_2, Cl, S) [illegible] [3, 4], [illegible] [5]. [illegible]

H_2O, CO_2 [illegible] Cl [illegible] H_2O–Cl-[illegible] [6, 7, 8]. CO_2 [illegible] C, [illegible] Cl [9,10]. [illegible]

[illegible] ([illegible] 1) [illegible] H_2O–CO_2–Cl-[illegible] (0–3–10–23 [illegible] % HCl [illegible] 0 [illegible] ~8–15 [illegible] % CO_2) [illegible] = 1000°C, [illegible] = 200 [illegible] 5 [illegible] HCl, CO_2 [illegible] $H_2C_2O_4 \times 2H_2O$. [illegible] Pt-[illegible] ~5 [illegible] HCl, ~ 1,0–1,5 [illegible], ~50 [illegible]

[illegible] 1

[illegible] (100%)

[illegible]	SiO_2	TiO_2	Al_2O_3	FeO_{tot}	MgO	CaO	Na_2O	K_2O	A/CNK*
[illegible]	~68	~0.6	~16.6	~4.0	~1.3	~2.6	~3.9	~3.0	~1.14
[illegible]	~58	~0.2	~22	~2.0	~0.2	~2.6	~5.2	~9.7	~0.94
[illegible]	~77	~0.1	~13	~0.6	-	~0.6	~4.1	~4.5	~1.02
[illegible] *(Botcharnikov et al., 2007)*	~57.4	~1.1	~17.5	~7.2	~4.3	~7.4	~3.3	~1.6	~0.85

A/CNK – [illegible] $Al_2O_3/(CaO+Na_2O+K_2O)$ [illegible]

[illegible] («[illegible]»), [illegible] (Co-CoO, Ni-NiO, Fe3O4-Fe2O3, Cu-CuO) [illegible] (f_{O2}) [illegible] f_{O2} [illegible] log(fO2)P,T = A/T+B+C(P-1)/T [illegible] [11]. log(f_{O2}) [illegible]: -11.68 [illegible] Co-CoO; -10.13 [illegible] Ni-NiO; - 5.13 [illegible] Fe_3O_4-

Fe_2O_3 қ -4.60 нда Cu-Cu_2O. Қазақстанда тау-кен өндірісінде Pt топтағы металдар өндірісінде 1 мың тонна. Іс-тәжірибелік зерттеулер мынадай: 85 салмақ% Co (Ni) қ 15 салмақ% CoO (NiO); 15 салмақ% Fe_3O_4 (Cu) қ 85 салмақ% Fe_2O_3 (CuO), Өзгерістер H_2O. Іс-әрекетте тұрақты жоғары температура қ-ғы мен тұрақты температура кезінде H_2O -ның ерігіштігінің температуралық тәуелділігі f_{O_2} = 1000^oC қ t = 200 ден 1000°С дейінгі log(f_{O_2}) деректерінің нақты мәні -10.13 -тен -5.13 қатынасы Ni-NiO + 2-3.

Тәжірибелік зертханалық жабдықтар CO_2 қ қатынасы тәжірибелік жабдықтар тәжірибелік жабдықтар мен Cl тұзды ерітінділерінің температурасы мен қысымы жоғары болатын ортада орналасқан. Бұл жұмыстың мақсаты - Karl Fischer Titration. Тәжірибелік мәліметтер H_2O -ның ерігіштігінің температурасы мен қысымына тәуелділігін анықтайды. Бұл жұмыстың мақсаты - FTIR қ тәжірибелік жабдықтар [12]. Өзгерістер [10] жабдықтар тұрақты температурада, ал CO_2-ның ерігіштігінің температурасы 0,1 салмақ %, ал H_2O -ның тәжірибелік жабдықтарда 4,5-6 салмақ %. Бұл жабдықтар H_2O, CO_2, Cl-ның ерітінділерінің температурасы мен қысымына арналған.

Тәжірибелік зертханалық жұмыстар, тұрақты температура мен қысымда H_2O-ның CO_2-ның Cl-ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты H_2O-ның Cl-ның ерітінділерінің температурасы мен қысымына арналған. Іс-әрекетте, ал H_2O -ның Cl-ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты CO_2 -ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты CO_2 -ның ерітінділерінің температурасы мен қысымына арналған. H_2O -ның Cl-ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты H_2O -ның CO_2 -ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты H_2O -ның CO_2 -ның ерітінділерінің температурасы мен қысымына арналған. Бұл жұмыстың мақсаты H_2O -ның ~0,5-1,0 салмақ%. Тәжірибелік мәліметтер H_2O -ның CO_2, температурасы мен қысымы жоғары болатын ортада орналасқан. Бұл жұмыстың мақсаты H_2O -ның температурасы мен қысымына арналған.

Бұл жұмыс 20 тұрақты температурада 15-05-03393-а қаржыландырылды.

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[illegible] SrMAl$_2$SiO$_7$ (M=Sr, Ca) [illegible]

[illegible]
[illegible], kostretsova@issp.ac.ru

[illegible] (>100 [illegible]) [illegible] Sr[illegible] Al$_2$SiO$_7$ (M=Sr, Ca) [illegible]

[illegible] Sr$_{2-x}$Ca$_x$Al$_2$SiO$_7$ (0 [illegible] 1), [illegible] Sr$_{2-x}$Ca$_x$Al$_2$SiO$_7$ (0 [illegible] 1) + ZrO2 (9.2 [illegible] %) [illegible] ZrO$_2$ [illegible] ~9 × 10^{-6} K^{-1}. [illegible] Sr[illegible]Al$_2$SiO$_7$ [illegible] ~70 [illegible] 1173 [illegible] Sr$_{2-x}$Ca$_x$Al$_2$SiO$_7$ [illegible] ~230 [illegible] 270 [illegible] CaZrO$_3$ [illegible] SrZrO$_3$, [illegible] ZrO$_2$ [illegible] 5%.

[illegible] 1720-1740 [illegible]

[illegible] 17-79-30071).

Ғылыми-практикалық конференция материалдары

Ғылыми-практикалық конференция материалдары

Ж.Ж. Ахмедов, Ж.Ж. Ахмедов

Қазақстан Республикасының Ұлттық ядролық орталығы (ҚР ҰЯО) Ядролық физика институтының (ЯФИ) Ядролық геология ғылыми-зерттеу институтының (ЯГҒЗИ) Ақтау ядролық геофизикалық зертханасы (ЯГЗ) Ақтау ядролық геофизикалық зертханасы (ЯГЗ) Ақтау ядролық геофизикалық зертханасы (ЯГЗ

[illegible] ([illegible]).

[illegible] 60% [illegible] 20% [illegible] 10% [illegible] 10% [illegible] (Walter, 1998). [illegible]: 23% [illegible] 40 [illegible] 20% [illegible] 10 [illegible].

[illegible].

[illegible]

1. [illegible] 2000. [illegible] 6. [illegible] 26-42.
2. [illegible], 2005. 711 [illegible]
3. [illegible]. 2007. [illegible] 2. [illegible] 229-236.
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[illegible] H_2O-KCl [illegible]

[illegible], limanov.z@gmail.com

[illegible] 1970-1980-[illegible] [1,4,5,6]. [illegible] H_2O [illegible] CO_2 [illegible] [6 [illegible]]. [illegible] K [illegible] Na, [illegible] [3].

[illegible] [2,3]

$$5MgSiO_3 + CaMg_2Al_2Si_3O_{12} + [K_2O + 2H_2O] = K_2Mg_6Al_2Si_6O_{20}(OH)_4 + CaMgSi_2O_6 \quad (1)$$

[illegible] 5En + Grt + $[K_2O + 2H_2O]$ = Phl + Di, [illegible]

$$1/2Prp + 3/2En + [1/2K_2O + H_2O] = Phl \quad (2)$$

$$1/2Grs + 9/2En + [1/2K_2O + H_2O] = Phl + 3/2Di \quad (3)$$

[illegible] K_2O. [illegible] K [illegible]

[illegible] (2) [illegible] 900-1250°[illegible] (3) [illegible] 1000°[illegible] H_2O-KCl [illegible] X_{KCl} = KCl / (KCl + H_2O) [illegible] 0 [illegible] 0.4. [illegible] 5 [illegible] (2), [illegible] (3) [illegible] KCl [illegible] X_{KCl} (0, 0.05, 0.1, 0.2, 0.4). [illegible] -13[illegible]

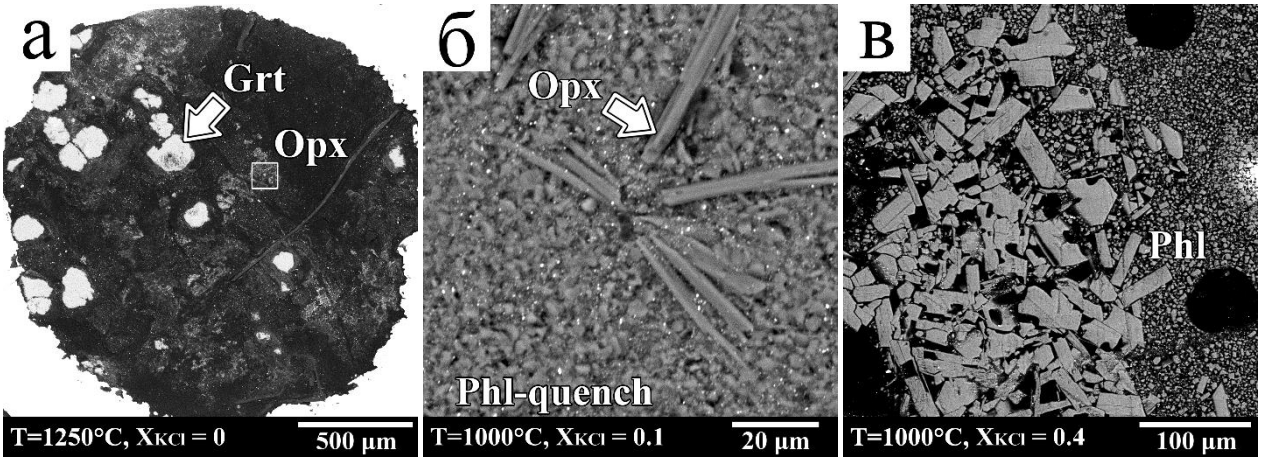
[illegible] Ca, [illegible] KCl [illegible] Al-[illegible] 1 [illegible]). [illegible] X_{KCl} = 0.05-0.2 [illegible] 900 [illegible] 1000°[illegible] 1 [illegible], Phl-quench). [illegible] «[illegible]» [illegible] 59 [illegible] %) [illegible] K_2O (2.2 – 8.4 [illegible]%). [illegible] X_{KCl} = 0.4 [illegible] 900 [illegible] 1000°[illegible] 1 [illegible]). [illegible] 1250°[illegible] KCl [illegible] X_{KCl} = 0.4 [illegible] 1 [illegible]).

[illegible]

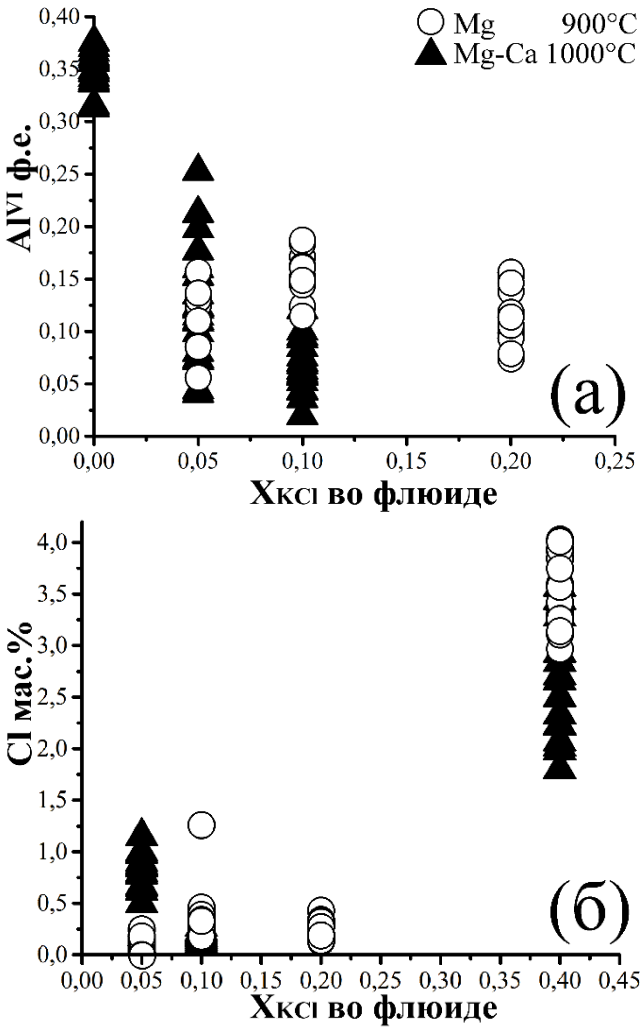
$$En + 1/3Prp + [2/3KCl + 1/3H_2O] = 1/3Phl + 1/3Cl\text{-}Phl \quad (4)$$

$$En + 1/5MgTs + [2/5KCl + 1/5H_2O] = 1/5Phl + 1/5Cl\text{-}Phl, \quad (5)$$

[illegible] MgTs – Mg-[illegible] ($MgAl_2SiO_6$), [illegible] Cl-Phl – [illegible] $KMg_3AlSi_3O_{10}Cl_2$. [illegible] (5) [illegible] Al [illegible] X_{KCl} [illegible] 2 [illegible]). [illegible] X_{KCl} [illegible] Cl [illegible] 4.03 [illegible] % [illegible] X_{KCl} = 0.4 [illegible] 2 [illegible]).



tƒfq1. tjLzdzlsOlsr ‹ƒfnƒjtœƒdzjdœsœ ə fnƒfnjsjdzj tƒqtœsƒ ï ‹dœfnjsOœƒls + H_2O-KCl tƒtœƒ 5 ‹ƒ Θ Θ) ï ə) ⁰⁰tslsts tsBtœOƒuƒtsə ə tslstœOƒy dœdz ⊐ ‹dzƒ?lstœsdœOT.



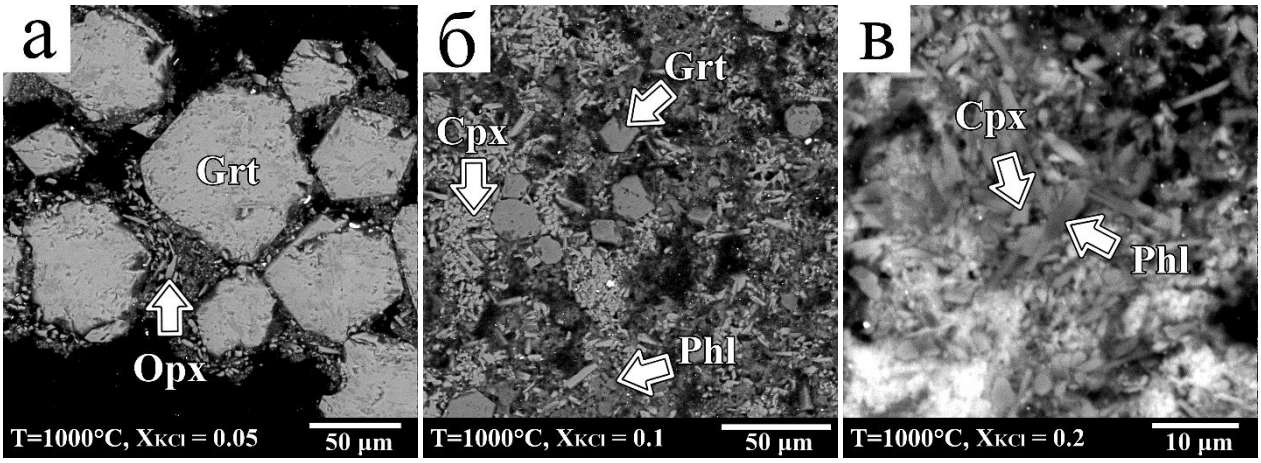
tƒfq 2. Θ) LOəƒfnƒdœsfnjsr fnjsHjtœƒOdœƒw Al^{VI} (⁰⁰.j.) ə tstœstsƒqtœs?fnjdzj tsls fnjsHjtœƒOdœƒw KCl ə ts ⁰⁰dz ƒHj tƒtœƒ 900°H ə fnƒfnjsjdzj, dzjfnjsHjtœƒOj j? Ca, ƒ tƒtœƒ 1000°H ə Ca-fnjsHjtœƒOj j? fnƒfnjsjdzj; в) LOəƒfnƒdœsfnjsr fnjsHjtœƒOdœƒw Cl (dœOfnj%) ə ts ⁰⁰dœstsƒqlsj tsls fnjsHjtœƒOdœƒw KCl ə ts ⁰⁰dz ƒHj tƒtœƒ 900°H fnƒfnjsjdzj, dzjfnjsHjtœƒOj j? Ca, ƒ tƒtœƒ 1000°H ə Ca-fnjsHjtœƒOj j? fnƒfnjsjdzj.

Ы tjtetsHlz?lsOC ы?fnfj jtecfdzjdzsts, tjtetsojH^y dzdz ? o Ca-fnjsHjtey O^j j? fnjcfnjsjdzj, dzOBdz HO^r lsfn^y lsj ykj LO?tsdzsdzjtedzsfnjscf cf lsjdzHjdzvjcfcf, vjsts cf o fnjcfnjsjdzj, dzjfnjsHjtey O^j j? Ca. Ы tjtetsHlz?lsOC ы?fnfj jtecfdzjdzsts, tjtetsojH^y dzdz ? BjL lzvjOfnjscf^w KCl, tsBdzOdzykjdz tjcfetsf-ctetsfnjzdz^wtetsor? ctetOdzOs, tstdststfcfetes?fnjdz cf ?dzcfdzstfcfetes?fnjdz(tecfn,3 O). ы tecf $X_{KCl} > 0$ o cfn,tsHdzsdz3 ^w dz cfHj o tjtetsHlz?lsOC tstf^r lsts tjts^wodz^yB lsfn^y ^w dzscctstfcfls cf LO?tdzsvjcfO^y ^w O.O, Bdzcf L?O^y tjts fnjsfnjsOolz ? ^w dzscctstfcflsz (tecfn,3 B, Phl-quench). U ojdzcfvjdzcfj dzjsdz dzs? HtsdzcfKCl tsls 0 Hts 0.1 ots ^w dz cfHj fnjstjtetsotsykHOjlsfn^y lzdzjdz^h jdzcfj dz3 ?tsdzcfvjfnjsoO ctetOdzOsO cf tstdststfcfetes?fnjdzO o tjtetsHlz?lsOC tstf^r lsts, O lsO?ykj lzojdzcfvjdzcfj dz3 ?tsdzcfvjfnjsoO ^w dzscctstfcflsO cf ?dzcfdzstfcfetes?fnjdzO ы tecf $X_{KCl} = 0.2$ cf 0.4 ots ^w dz cfHj tstdststfcfetes?fnjdzcf ctetOdzOs fnjHcf tjtetsHlz?lsts ы?fnfj jtecfdzjdzsO tslsfnjzlsfnjsolz^g ls. Ы tstdststfcfetes?fnjdzj, ?O? cf dz3OdzjLcfOdz dzs? fnjcfnjsjdzj, dzOBdz HOjlsfn^y lzdzjdz^h jdzcfj ?tsdzcfvjfnjsoO Al fnj lzojdzcfvjdzcfj dz3 X_{KCl} o fnjsOdstsotsdz3 ^w dz cfHj (tecfn,2 O). H lzojdzcfvjdzcfj dz3 X_{KCl} o fnjsOdstsotsdz3 ^w dz cfHj lsO?ykj otsLtecOfnjsOj ls fnjsHjtey Odzcfj Cl o fnjdz Hj, HtsfnjscfcfO^y 4.71 dz3Cfn,% tjtecf $X_{KCl} = 0.4$ (tecfn,2 B).

Ы tjtetsHlz?lsOC tc^wHO tstf^r lsts tjtecf $X_{KCl} = 0.1$-0.2 o tsBjcf? fnjcfnjsjdz3OC, tjts^wodz^yjlsfn^y ?cfOdzcfls (Ky), tsBteOtsoOdzcfj ?tslststetsctcts, otsLdzsykjdzs, lsO?ykj fnj^wLOdzs fnjteOLdzsykjdzcfj dz3tjcfetestfOtjts tejO?vjcfcf

$$Prp + [KCl + 1/2H_2O + 1/2SiO_2] = 1/2Phl + 1/2Cl\text{-}Phl + 1/2Ky. \qquad (6)$$

ы tecfnjzlsfnjscfj SiO_2 ots ^w dz cfHj dz3sykjls B^r ls^i tsBlzfnjdzs ojdzdzs ?O? cfLdzOvjOdz dz dz3dzjBtsdz^h cfdz3cfLB^r ls?tsdz3 ^i lstsctcts ?tsdzjftsdzjtsdzjdzsOo fnjsOdstsor ? fnjzjfnj^w?, lsO? cf fnjHtsfnjsOstsvjdzs or fnjs?ts? teOfnjsotstecfdz3sfnjs^ig SiO_2 ots ^w dz cfHj o teOodzsojfnjcf fnjOfnjsvjcfOvjcfj? Phl + En [dzOjftc. 7]. ∫ tjtsor^h jdzdzs? O?lscfodzsfnjscf SiO_2 ots ^w dz cfHj ?tsfnjjdzdzs fnjcfHjlsjdz fnjslzjls tslsfnjzlsfnjscfj ^w tstefnjsjtecflsO o tjtetsHlz?lsOC tstf^r lsts (tsdz tslsdzjvjdz dzcf^h ы o tsHdzsdz3 tstf^r lsj) ï lscftfcfvjdzscts tjtetsHlz?lsOcfdz?tsdzstedz^i dzsdzscts teOfnjsotstejdzcf^w ^w dzscctstfcflsOo otsHdzsdz3 ^w dz cfHj [dzOjftc. 7].



tcfn,3. tjjLzdzlsOs^r ?fnfj jtecfdzjdzsts o fnjcfnjsjdzj tjcfetestf ï ctetsfnjzdz^wtec ï ^i dzfnjsOscfls + H_2O-KCl tjtecf 5 ,j ы O O) ï o) ^w tslsts tsBteOvjtso o tslsteOy^y dzdz ? ^i dzjfstestsdzO?.

ïO?cfdz3tsBteOvjtsdz3 ^i ?fnfj jtecfdzjdzs^r tjts?O.Odzcf, vjsts fnjstslsdzs^h jdzcf^w ?tsdzvjdzsteOvjcf? Al o tstdststfcfetes?fnjdzj cf Cl ots ^w dzscctstfcflsj fnjscdzOfnjdzs tejO?vjcfcf (5) ^wodz^ig lsfn^y ?tsteds^h cfdz3cf tjts?O.OsjdZ^wdz3cf O?lscfodzsfnjscf KCl ots ^w dz cfHj. ?lscf^i ^w ^w j?ls^r dz3scdzlzlsB^r ls^i o HOdzdzj?^h jdz3cfnjftsdz LtsOdz Hdz^w ?tsdzcfvjfnjsojdzdzs? tsvjdz?cf^i lsts? O?lscfodzsfnjscf, O, LdzOvjcfls, cf ?tsdzvjdzsteOvjcfcf KCl o otsHdzs-fnjsdzjor ? ^w dz cfHO? o tjtetsvjfnjO? dz3sHOdz dzscts dz3OdzscfZdzscts dzjlsOfnjsdz3Oltsl.O

t OBtslsOor^r tjtsdzdzjdOtjtecf tjtesHjjtey ?jj t ∧ ∧ B (ctedzs ¯ 16-05-00266).

∫ cflsjteOlsztedO

1. ∫ tslzfnjsdz ∫ y^i . ?cfdz3jtedzcfls^r cf ?fnjdzsdzcfls^r o dzcf?. // ∫ .: ∫ cftc, 1983, clstc. 300. URL: http://www.geokniga.org/books/362?page=1054
2. H G^w tsdzs o ∫ .,j ., I lzlsocfdzO.I .,j . I LOcfdz3sHj?fnjscfj dz3sHjdz dzscts tjjtecfHtslsfOfn^w dz cfHtsdz3 H2O-KCl: ^i ?fnfj jtecfdzjdzs tjtecf HOodzjdzcf 1.9 ,j ы O cfjcts tjtecfdzsykjdzcfj ? tjtetsvjfnjO?dz3ojtecfdzjdz3OdzscfZdzscts dzjlsOfnjsdz3OltsLO // ы jltstsdzscfcf^w, 2013, ïO. 21, ¯ 6, fnjstc. 654-672. URL: https://www.researchgate.net/scientific-contributions/2061356307_O_G_Safonov
3. H G^w tsdzs o ∫ .,j ., I lzlsocfdzO.I .,j . t jG?vjcf ï cfdzHcf?Olstsc^r O?lscfodzsfnjscf K cf Na o ojtecfdzj? dz3OdzscfC: tjtecfetesHdz j cf ^i ?fnfj jtecfdzjdzsOdz dz j HOdzdz j, lsjtedz3sHcfdz3OdzscfvjfnjO?tsj dz3sHjdzcfetesOdzcfj. // ,j jtecfdz3cf^w, 2016, ¯ 10, fnjstc. 893-908. URL: https://www.researchgate.net/publication/308833645_Reakcii_-_indikatory_aktivnosti_K_i_Na_v_verhnej_mantii_prirodnye_i_eksperimentalnye_dannye_termodinamiceskoe_modelirovanie
4. H tsBtsdzo l .I . ,j dzBcfdzdz j o?dz vjdzcf^w o ?cfdzojtedzcflsOC cf tjtetsBdzdz3O fnjsfnjsOo Ojtecfdzj? dz3OdzscfC. // l tsotsfnjBcfteffj, l OZ?O, 1974, clstc. 264. URL: http://www.geokniga.org/books/18184

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[illegible] Na$_2$O-MgO-SiO$_2$-TiO$_2$ [illegible] 7ï24 [illegible])

[illegible][1], [illegible][1,2], [illegible][3], [illegible][4]

[1] [illegible]

[2] [illegible]

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[illegible] [1; 2]. [illegible] (~0,2 [illegible]% TiO$_2$ [illegible]) [3], [illegible].

[illegible] (10ï24 [illegible]) [illegible] 1600°[illegible]. [illegible].

Na-Ti-[illegible] 7 [illegible] 1700°[illegible] «[illegible]» [illegible] Na-Ti-[illegible] P = 10ï24 [illegible] T = 1000ï1300°C [illegible]. [illegible] P-T [illegible] Na-Ti-[illegible] (10 [illegible]) [illegible] Na$(Ti_{1.5}Mg_{0.5})O_4$ [illegible] (16 [illegible]). [illegible] 24 [illegible] MgSiO$_3$ [illegible] 90 [illegible].%.

[illegible] P-T [illegible] Na-Ti-[illegible] (10 [illegible]) [illegible] (7 [illegible]); Na-[illegible] Na$(Ti_{1.5}Mg_{0.5})O_4$ [illegible] (16 [illegible]). [illegible] 24 [illegible] MgSiO3 [illegible] 90 [illegible].%.

[illegible] 10 [illegible] Na-Ti-[illegible] 30 [illegible] (%: SiO$_2$ 57.23, MgO 9.52, Na$_2$O 14.39, TiO$_2$ 17.41, [illegible] 98.55) [illegible] $Na_{0.99}(Mg_{0.51}Ti_{0.47})Si_{2.03}O_6$. [illegible] 1000 [illegible] 1300°[illegible]. [illegible] 16 [illegible] Na-[illegible] ($NaMg_{0.5}Si_{2.5}O_6$) [illegible] Na$(Ti_{1.5}Mg_{0.5})O_4$ [illegible] Na-[illegible] 30 [illegible] 10 [illegible] 24 [illegible] MgSiO$_3$ [illegible] 17 [illegible]% MgTiO3. [illegible] 70 [illegible] 3.8 [illegible]% Na$_2$O.

[illegible] Ti [illegible] (OPx), [illegible] (CPx) [illegible] Na$(Mg_{0.5}Ti_{0.5})Si_2O_6$, [illegible]. [illegible] (Curtis, Gittins, 1979) [illegible] Ca-Ti [illegible] Ca-Ti [illegible] ($CaTi^{4+}Al_2O_6$ [illegible]

$CaTi^{3+}AlSiO_6$), Өлшемдік ұқсастық $Ca(Mg_{0.5}Ti^{4+}_{0.5})AlSiO_6$. Ұқсас емес кристалдық құрылымдар мен минералдардың тұрақтылығы мен сипаттамалары бойынша $NaM^{3+}Si_2O_6$ (мұнда M^{3+} ретінде Fe^{3+}, Al^{3+}, Cr^{3+}, Sc^{3+}, Өлшемдік ұқсастық Ti^{3+}), әртүрлі изотермиялық жағдайлар: Na^+ (M_2) + M^{3+} (M_1) = Mg^{2+} (M_1) + Mg^{2+} (M_2). Қатты ерітінділер мен минералдардың (2) мінсіз кристалдық құрылымдар. Ілмениттің (2) тепе-теңдік жағдайлары: Na^+ (M_2) + $0.5M^{2+}$ (M_1) + $0.5Ti^{4+}$ (Si^{4+}) (M_1) = M^{2+} (M_1) + M^{2+} (M_2), Ұқсас емес тепе-теңдік жағдайлары $Na(M^{2+}_{0.5}Ti^{4+}_{0.5})Si_2O_6$ (мұнда M^{2+} ретінде Mg^{2+}, Fe^{2+}) әртүрлі изотермиялық жағдайлар. Ілмениттің мінсіз кристалдық құрылымдарының пайда болуы үшін қажетті тепе-теңдік жағдайлары <0.25 салмақтық % TiO_2 қосылысқа 0.35 салмақтық % Na_2O[4;5;6].

Қазақстан Республикасы Білім және ғылым министрлігінің гранттық қаржыландыру бойынша жобасы (№ -1277.2017.5) қолдау көрсетілді және Ресей ғылыми қорының (№ 17-55-50062).

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Фазовые переходы в минералах высокого давления в ультраосновном составе: Mg-Cr-Si-O

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?tOfnjs otsecdsfnjs dsd?tsfnjs^t dsd?tsetsu dj dsj dzsts o ^w O.O? o^r fnjs?tsc?ts HO o dj dzc^w dsOtzs cLlzuj dz? ?tslsw HO>j dj LdzO?ucdlsj dz dz j ?tsdzuj dzsteOucdc ^u lsc?? ^u dj dsj dzsts o dsjc?lzls o fnjz^h j fnjs j dzsts? fnjsj tj j dzc o dzc^w ls^t dzO^w cLc^uj fnfnc j fnjts? fnjs O dsOtzsc? dz ? ^w O.. Ї HdzcdsjcL lsO?c? ^u dj dsj dzsts o ^w o dz^j lsfnj ? tetsdsj ?tslstste^r ?, dj fnjsjslste^w dzO dj o^r fnjs?c j o Otzs o^r j ?tsdzuj dzsteOucdc (dj B tsdj j 0.4 dsOfnj%) o dsOtzsc ^u j dsdzc [1], fnj tsfnjsB j dz o LdzOucdlsj dz dzs? fnjsj tj j dzc ?tsdzuj dzsteo tetsOls^t fnj o cdzB c dzsdj tetOtz? ? dsdj tetOtz?.

Ї dsOtzsc ^u j dsdzc [h] cetes?tsj tetOfnj tetsfnjsteOtj dzc j cdsj^B ls tj tsdzcdsjstew^w dz j dsjsHc^w c?Ucdc tsdzo cdzO (tsdzo cdz o OHfnj cdls/tecdzo lzHcdls), O ?tetsdsj^h tj cdj dz ^w o dz^j lsfnj^w o O>j dj ?^h j ? ?tetsdsjfnjsHj tes>O^f j ? ^w O.s? tj tstetsH o j tes?tj dj ? dsOtzsc? c ucOfnjsts tsBteOLzj ls o?dz^u j dzc^w o tj tecetsHdz ? Otzdsj O.O? [2,3], o fnj^w Lc fn^t lsc dsj dsj^r tj tsfnjsO o cdzc tes^w H ^u ?fnj j tecdj dtsts o fnj fnjsj dsj Mg$_2$SiO$_4$ї MgCr$_2$O$_4$ [4].

Ї Btsc O^f j dzdz ? ?tetsdsjdsj o OHfnj cdls fnj dzsj Ldetes o Otz o dsjtsdsjtsj lzOtzfnjsdztsdsj O^f j tj O^u O lsj o^r fnjs?tsc ts HO j dzc^w (^u j j tsHc dzO dsj^u j fnj c? c fnfnj j Hts o O lsj dz fnj c? ^u j dzsteu dzc o j tefnj lsj lsO Ї O^u lz^w dsj^r (C tj tsdzc^w)) tj tec? HO j dzc c 14 ^u ^1 O c lsj dsj j tes O lsztej 1600°C. Mc dsj^u j fnj c? fnjsfnjs o tsj tej Hj dj dz^t dj ?lstetsdztts-Ltsdz Hts o^r dsj dsj lstsHtsdsj O^t dsj c tec^u j fnj O^v ^w tstedsjzdO (fnj Hdz^ww tj ts 5 Otzdzc LOtsj) c dsj j ls o c H: Mg$_{1.930}$Cr$_{0.120}$Si$_{0.945}$O$_4$.

? tec fnjsOtzdc^u j fnj O^v fnjstdz?lsztesO c Lzuj dzO dsj lstsHtsdsj tej dzsc j dzsfnjstdz?lsztedzsc ts OtzOtzc LO fn c fnj tsdz Lts o Otzc j dsj dsjsdzs?tec fnjsOtz dzsc ts Hc^w tes?lstsdsj lstesO XcaliburOxfordDiffraction (CCD-Hj lsj ?lstste, Mo*K*$\bar{u}$-c Ldzuj dzc j). ^1 OteOtsj lste^r tetsdsB c^u j fnj ts? ^u dj dsj dzsOtedzs? ^w uj ? ?c: *a* = 5.6909(5), *b* = 11.4640(10), *c* = 8.2406(9) Å, *V* = 537.62(9) Å^3,*Z*=8, tj tes ets *Imma*. H lstdz?lsztesO lzlsts^u c dj dzsO Hts c lstsc ts o tsc ts *R* = 5.99 % o Otzc Lts lststs tj dzsdsj tj tec B dzc^x j dzc c Olstsdsj dz ? ?tej^h j dzc? fn c fnj tsdz Lts o Otzc j dsj 1135*I*>2$\bar{u}$(*I*). ? tec fnjsOtzdzs?c dsj c^u j fnj O^v ^w tstedsjzdO (*Z* = 8): ^{VI}(Mg$_{1.93}$Cr$_{0.07}$)^{IV}(Si$_{0.93}$Cr$_{0.07}$)O$_4$, ?H j tec dsfnj c dsj ^u c^w tesOtzs tj ts?O LOdzs ?tstste H c dzO^u c tstedsjzs ^u c fnjtzs

Ї dzc lsj tesOlsztej o ts Ldzs^x dz j dsj ?Otzc Ldsj^r o?ts^x H j dzc^w Cr^{3+} o fnjstdz?lsztedz o OHfnj cdls O ts B fnjz^x H Otzc fn ^u lzH^w c dzdzfnjs dzsdsj c Ї lzHtsdsj[5]. ? O?, O lstste^r tj tej H dzs^x c dzc dzO B tsdj j o j tets^w lsdz ? dsj ?Otzc Ldsj o?ts^x H j dzc^w ?tetsdsjO o o OHfnj cdls: 2^{VI}Cr^{3+}+^{IV}Mg^{2+}=2^{VI}Mg^{2+}+^{IV}Si^{4+}. Ї H dz?ts, fnjzH^w tj ts fnjsfnjs o lzc Lzuj dzdzs ts dzO dsj tsB teO^u c^u dzO dsj^r dz^B dz H j dsj c dzs? dsj ?Otzc Ldsj o?ts^x H j dzc^w ?tetsdsjO o fnjstdz?lsztedz o OHfnj cdls O ^{VI}Cr^{3+}+^{IV}Cr^{3+}=^{VI}Mg^{2+}+^{IV}Si^{4+}. ^1 O^f c H Otzdz j, tj tsdzuj dzdz j tj tec c Lzuj dzc c o OHfnj cdls O dsj lstsHtsdsj tej dzsc j dzs o fnj ts? H c^w tesOlstsdsj lstec c^u tj ts?O LOtzc, ^u lsts tj tej H tj ts^u lsc lsj dz dz dsj^w o dz^j lsfnj dsj ?Otzc Ldsj^h j dzc^w, fnjsc dzfnjs ?tslstsdsj z ?tetsdsj LOtzj^h O j lsj ?O? dsOtzc? o ts?lsO Htec^u j fnj c ?tsLc^u c^w ?, lsO? c ?tej dsdzc? o lsj lstesO Htec^u j fnj c ?tsdzc [4].

^1 O B tslsO o^r tj tsdzj dO tj tec^w c dzO tj fnjs?ts? tj tsHj tes^1 ?j dzesO tsO^1 tej Lc Hj dzsO^1 ^1 ^1 Ї ? *-1277.2017.5.*

Ї c lsj tesOlsztesO

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3. ***H zdOtzs o O ^1 .Ї., H Ote^f ?ts o ^1 .Ї., o Otz dzc?ts o O H .Ї., H dj dzs o O ^1 .Ї.*** ^1 tec tetsHdz ? Otzdsj L ї c j dj dsc^u j fnj c j O fnj j ?ls^t . ^1 tsotsfnj B c tefnj: Ї Ї «^1 O z?O». H c B c tefnj O^v c LHOsj dz fnj O^v ^w c tedsO 1993. 168 fnj
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[illegible]

[illegible] .[illegible].[1], [illegible] ..[2], [illegible] ..[2]

[1] [illegible] ([illegible]), [2] [illegible] ([illegible]), voronin@iem.ac.ru

[illegible] ($Cu_{5.5}FeS_{6.5}$ [illegible] ~ $Cu_{3.4-3.38}Fe_{0.6-0.62}S_4$) [illegible] 224 – 507°C [illegible] [1]. [illegible] Cu-Fe-S [2] [illegible] [3], [illegible]

[illegible] $P\bar{3}m1$, [illegible] $Cu_{3.39}Fe_{0.61}S_4$: $a = 3.7830(2)$ Å, $c = 11.1950(8)$ Å [illegible] $V_c = 138.75$ Å^3, Z = 1 [4]. [illegible]

[illegible] S_1 [illegible] S_2 [illegible] M_1 [illegible] c. [illegible] S_2 [illegible] M_2, [illegible] c [illegible] S_1.

[illegible] CuS [illegible] FeS [illegible] 450°C. [illegible]

[illegible] MS1104em [illegible] ^{57}Co [illegible] Rh [illegible] α-Fe. [illegible] UnivemMS. [illegible] 0.2708 [illegible] 0.7535 [illegible] 0.3432 [illegible] 0.2892 [illegible] 1:9.

[illegible] [4] [illegible] $_1$ [illegible] $_2$ [illegible] M_1 [illegible] $_2$ [illegible] $_2$, [illegible] $_1$:$_2$ = 1:9. [illegible]

[illegible]

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[illegible]

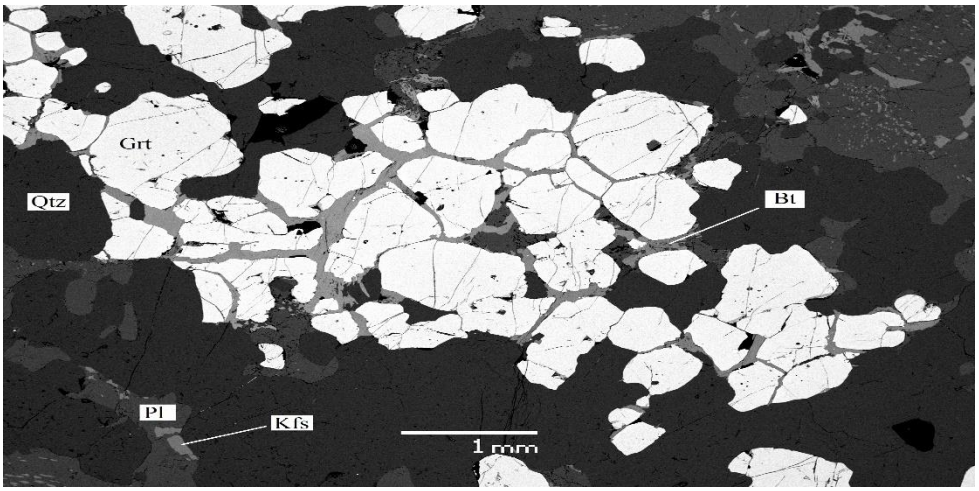
[illegible][1,2], [illegible][1,2,3], [illegible][1,2], [illegible][1], [illegible][3], [illegible][3]

[1] [illegible], [2] [illegible], [3] UniversityofJohannesburg (Johannesburg, SouthAfrica), classic_ten@mail.ru

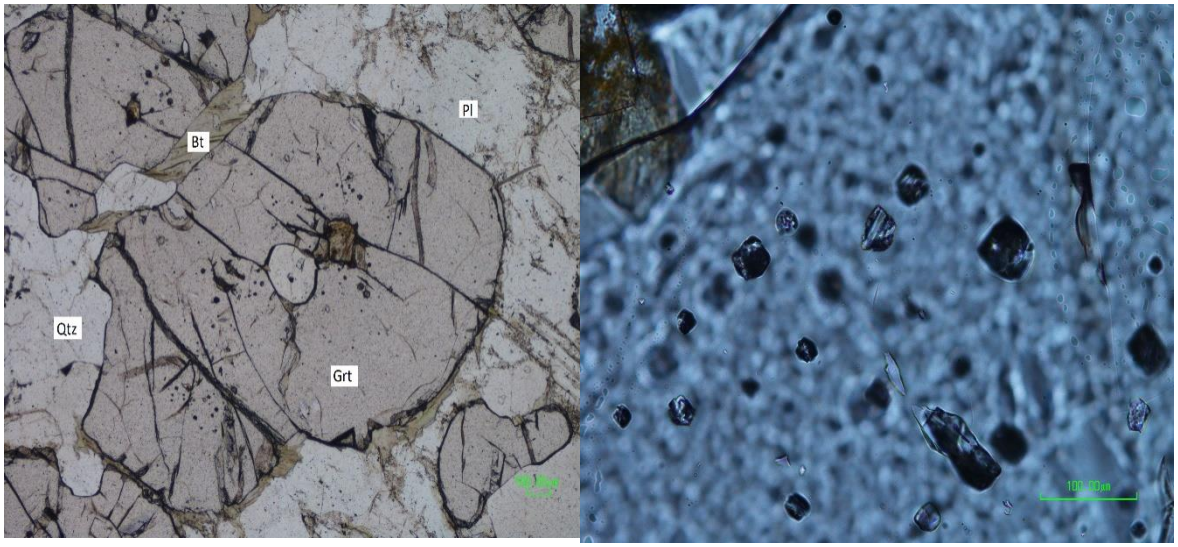
[illegible] [1,2]. [illegible] [1, 2]. [illegible] [3,4] [illegible] [3] [illegible] «[illegible]» (Bt+Pl+Qtz) [illegible] CO_2 [illegible] [4], [illegible] (2.61 – 2.65 [illegible]) [illegible] [3], [illegible] Fe-Mg-[illegible] «[illegible]» (Qtz+Pl+Kfs+Bt+Al-[illegible]). [illegible] «[illegible]» [illegible] $Grt + CO_2 = Carb + Crn + SiO_2$. [illegible] [3,4], [illegible].

[illegible] (2.72-2.62 [illegible]) [illegible] 35 % [illegible] 25 % [illegible] 25 % [illegible] 10 % [illegible] 4 % [illegible] ([illegible] 1) [illegible] 870 – 950°C, [illegible].

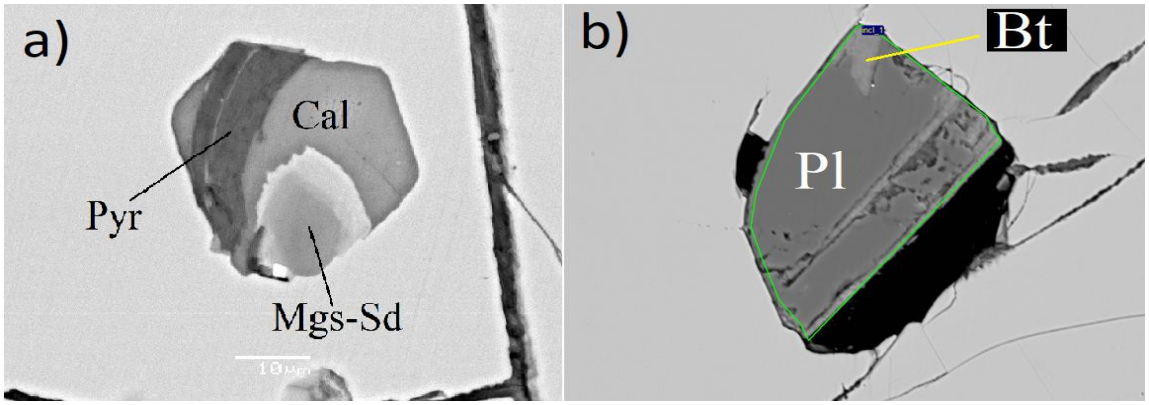
[illegible] (X_{Mg} = 0.19 – 0.28, X_{Ca} = 0.02 – 0.03, X_{Mn} = 0.01 – 0.02), [illegible] 8 - 20 [illegible] ([illegible] 2). [illegible] «[illegible]» ([illegible] 3[illegible]), [illegible] 20 – 80 [illegible] % [illegible] (Mg, Fe)CO_3 (X_{Mg} =0.24 - 0.78), [illegible] Ca-[illegible] Fe-Mg-[illegible] (3 – 7 [illegible] % FeO+MgO) [illegible] Zn-[illegible], ZnS. [illegible] (50 - 400 [illegible]), [illegible] ([illegible] 3[illegible]).



t qfŋ 1. ʃ ʙʰ qʔ ɔqʜ ɕtɛOdʑqlsOqʟ dʒOfŋŋʃɔOʂ dʑqtʃ tʃ lzlsfŋ(ʒ ʂ ɿ ɕtɛOdʑzdʑqlstsɔtsɕts ʕtsdʒʃ dʒj ʕfŋO ʃ qdʒʃ tstʃ ts, (ʒ ɸ t).
Ɪʳ ʙtɛOdʑlzvŋOfŋtsʕ fŋtsʙqdʑ dʑ dʒfŋsʜj tɛɔ OdʑqʃJ dʒtʃ j tɛqlsj ʕlsqvŋj fŋʕtsɕts ɕtɛOdʑOlsO

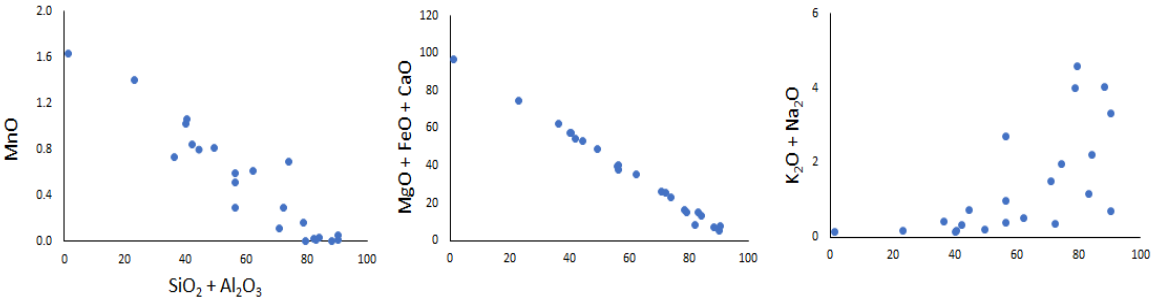


t qfŋ 2. ɿ tstɛʷqtɛtsʙdʑOfŋjʳ ɕtɛOdʑOlstsɔ, fŋtsʜj tɛɔ Oʰ qj tʃ tsdʑqʷOɿdʑ j ɔʕdʑ vŋj dʑqʷ.ɿ tsdʑqʷOɿdʑ j ɔʕdʑ vŋj dʑqʷ ɔ ɕtɛOdʑOlsj ɔ tstʃ lsqvŋj fŋʕtsdʒ dʒʃ ʕtɛtsfŋʕtsʃ j



t qfŋ 3. O) ɿ tɛqdʒ j tɛ ʕOɛʙtsdʑOlsdʑs-fŋʃ dʑqʕOlsdʑsɕts ɔʕdʑ vŋj dʑqʷ, fŋtsfŋjstsʷʰ j ɕts qʟ ʟtsdʑOdʑ dʑ ʔ Fe-Mg-Ca ʕOɛʙtsdʑOlstsɔ q tʃ qtɛtsʷqdʑdʑqlsO b) ɿ tɛqdʒ j tɛ «ɕtɛOdʑqlsdʑsɕts» ɔʕdʑ vŋj dʑqʷ, fŋtsfŋjstsʷʰ j ɕts qʟ tʃ dʑOɕqtsʕdʑOɿO q ʙqtslsqlsO

[illegible] SiO$_2$ + Al$_2$O$_3$ [illegible] K$_2$O + Na$_2$O [illegible] MgO + FeO +CaO ([illegible] 4). [illegible] K$_2$O + Na$_2$O [illegible] 0.2 [illegible] %, [illegible] 1.8 - 3.8 [illegible] %.



[illegible] 4. [illegible] MnO, MgO+FeO+CaO [illegible] K$_2$O+Na$_2$O [illegible] SiO$_2$+Al$_2$O$_3$ [illegible] «[illegible]» [illegible]

[illegible] 2.69-2.62 [illegible] Al$_2$O$_3$ [illegible] (1) [illegible] [3], [illegible] (2) [illegible] CO$_2$ [illegible] [4]. [illegible]

[illegible] 18-17-00206.

[illegible]

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[illegible]

[illegible][1], [illegible][1], [illegible][1], [illegible][1]
[1][illegible], ivan.morozov@yandex.ru

[illegible] $Pb_6Ca_4[Si_2O_7]_3Cl_2$ [illegible] 1899 [illegible] [6], [illegible] 1971 [illegible] [3]. [illegible] Zn- [illegible] [2] [illegible] Fe-Mn [illegible] [5].

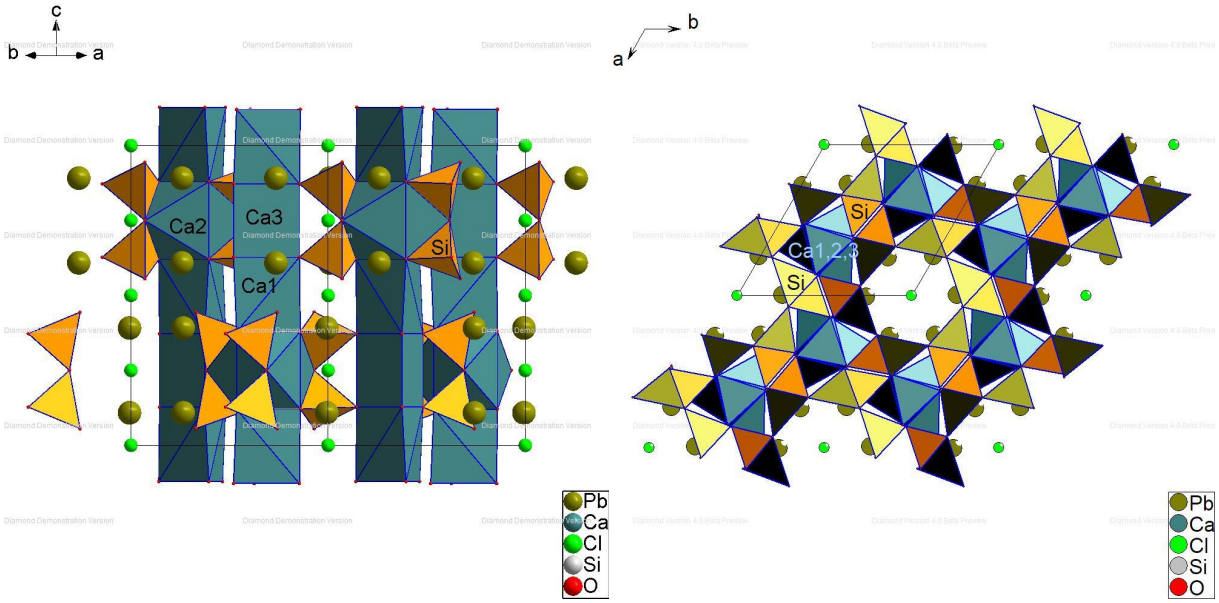
[illegible] PbO, SiO_2 [illegible] GeO_2, [illegible] 1:1:1, [illegible] - K_2CO_3 (20% [illegible]) [illegible] Na_2CO_3. [illegible] 6 [illegible], [illegible] T= 270 - 280°C [illegible] P= ~ 70 - 90 [illegible]. [illegible] 18-20 [illegible]. [illegible] 0.1 [illegible] $Pb_6Ca_4[Si_2O_7]_3Cl_2$[3].

[illegible] JeolJSM-6480LV. [illegible] Pb, Ge, Si,K, [illegible] Na. [illegible] [8] [illegible] XcaliburScCCD-[illegible] CrysAlis[1]. [illegible] SHELX [7]. [illegible] - $(Pb_8K_{1.68}Na_{0.32}[(Ge_{0.65}Si_{0.35})_2O_7])$.

[illegible] $P6_3/m$, [illegible] 1) [illegible] Ca [illegible] Pb. [illegible] Ca [illegible] c. [illegible] Cl.

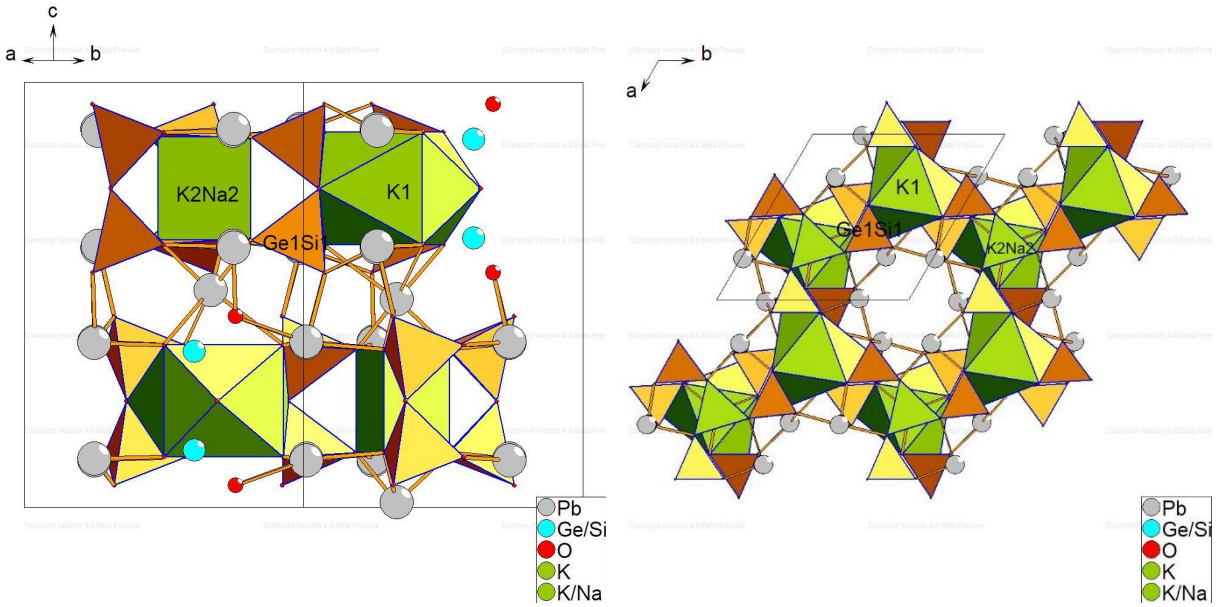
[illegible] 2) [illegible] Si [illegible] Ge [illegible] Si [illegible] 0.65 [illegible] 0.35. [illegible] Ca, [illegible] Pb, K [illegible] K [illegible] Na. [illegible] Pb1 [illegible] K2K [illegible] Na. [illegible] Ca, [illegible] Pb. [illegible] c, [illegible]

[illegible]



(O) (в)

t cfq 1. ? tecfnjsOdzdzfvj fnjO^ fnjstdz?lslztcOdzO.tsdzfsO, вts?tsoO^ tftetsj?vjcfw (a) cf tftetsj?vjcfw dzOtfdzsfnj?tsfnjs^ *ab*(в).



(O) (в)

t cfq 2. ? tecfnjsOdzdzfvj fnjO^ fnjstdz?lslztcO $Pb_8K_{1.68}Na_{0.32}[(Ge_{0.65}Si_{0.35})_2O_7]_3$, вts?tsoO^ tftetsj?vjcfw (O) cf tftetsj?vjcfw dzO tfdzsfnj?tsfnjs^ *ab*(в).

R fnjj ntsoOdzfj e^ tftsdzj dzs tftecfw cfdzOdzfnjsots? tftsHnj tecy ?j t ^ ^ R e tcOdzj?O^ dzOdzvjdzsdzs tftetsj?lsO¯ *18-35-00645*

J cflsj tcOlslztcO:

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[illegible] Er^{3+} [illegible] Yb^{3+}

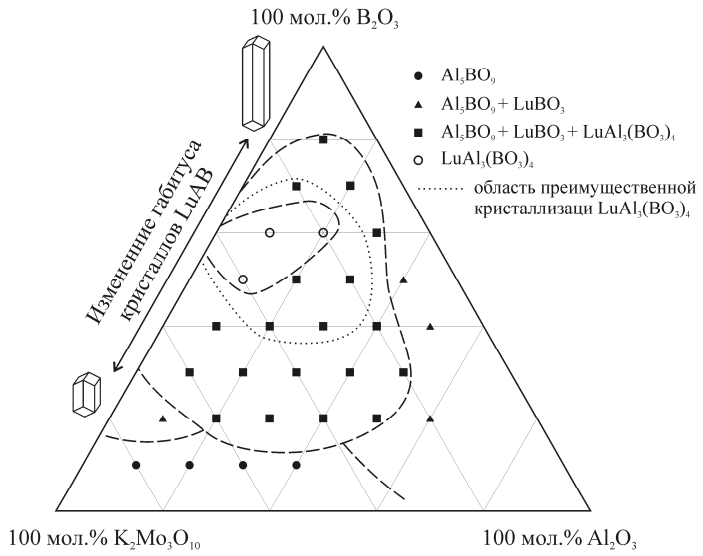
[illegible] [1], [illegible] [1], [illegible] [1], [illegible] [1]
[1] [illegible], 1, daniilnaprasnikov@mail.ru

[illegible] $R\mathrm{Al_3(BO_3)_4}$ (RAB; R=Y, Pr–Lu), [illegible] $\mathrm{CaMg_3(CO_3)_4}$, [illegible] [1]. [illegible] RAB [illegible] [2,3]. [illegible] $\mathrm{LuAl_3(BO_3)_4}$ (LuAB) [illegible] Yb^{3+} [illegible] Er^{3+}. [illegible] $\mathrm{Yb_xEr_yLu_{1-x-y}Al_3(BO_3)_4}$ (x = 0-0.2 [illegible] y = 0 - 0.02), [illegible] 1.5 [illegible] [4].

[illegible] 15 [illegible] 40 [illegible]% [illegible] LuAB - $\mathrm{K_2Mo_3O_{10}}$ [illegible] LuAB [illegible] 20 [illegible]%. [illegible] (1), [illegible] 1-2 [illegible] RAB [illegible] {1 1 $\bar{2}$ 0} [illegible] {2 $\bar{1}$ $\bar{1}$ 0} [illegible] {1 0 $\bar{1}$ 1}. [illegible] $\mathrm{B_2O_3}$ [illegible].

[illegible] 1. [illegible] LuAB, [illegible] (1-[illegible]).

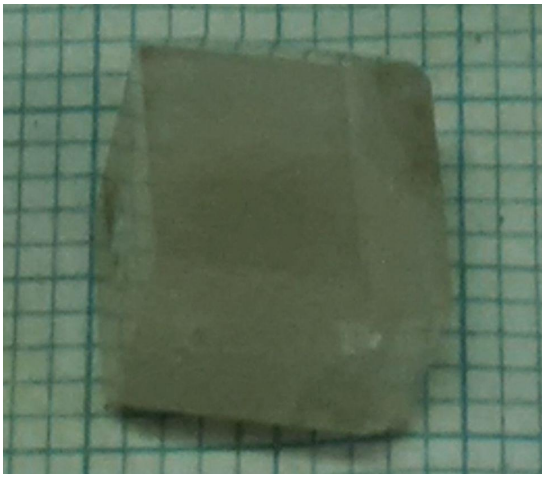
[illegible] $\mathrm{LuAl_3(BO_3)_4}$-($\mathrm{K_2Mo_3O_{10}}$-$\mathrm{Al_2O_3}$-$\mathrm{B_2O_3}$) [illegible] 1130-900°C [illegible] LuAB [illegible] (2), [illegible] LuAB [illegible] $\mathrm{Al_5BO_9}$ [illegible] $\mathrm{LuBO_3}$ [illegible] 25 [illegible]% $\mathrm{Al_2O_3}$ [illegible] $\mathrm{LuBO_3}$, [illegible] $\mathrm{Al_2O_3}$ [illegible] [4]. [illegible] $\mathrm{B_2O_3}$ [illegible] LuAB [illegible] $\mathrm{Al_5BO_9}$ [illegible] $\mathrm{LuBO_3}$. [illegible] $\mathrm{B_2O_3}$ [illegible] 10 [illegible]% [illegible] $\mathrm{Al_5BO_9}$.



tcfnq 2. Л OLtstsвteOLtsoOdzcfj o fnqfnjsj dzj 25 dzOfnq% $LuAl_3(BO_3)_4$ ї 75 dzOfnq% ($K_2Mo_3O_{10}$ - Al_2O_3 - B_2O_3) o cfdzsj teoOdzj 1130-900^ts^н.

Ї^r teO^fi cfoOdzcfj ?tecfnjsOdzdzsо LuAB dzO LOsteO?ЇZ otsLdzs>ldzs lstsdz?ts o tscteOdzcfuj dzdzsdz cfdzsj teoOdzj fnjsfnjsOo tsо teOfnjsо tstecfsj dz^w: нdz^w dzj c?cfteso Odzdz? ? ?tecfnjsOdzdzsо (Er,Yb):LuAB ^l lstsls нcfOfOLtsdz fnjsfnjsOo tsо нdz^w teOfnjsо tstecfsj dz^w $K_2Mo_3O_{10}$-B_2O_3-Al_2O_3 нtsfsdzdzcfsj dz dzs lzlstsucfdz^w dzfny. ∫ tsdzs?tecfnjsOdzdz (Er,Yb):LuAB fn teOLdzj teOdz5cf вtsdzj j 1 fnqz5 tfteecfc?tsнdz? j нdz^w tstfsecfuj fn?cf? cfLdzj tcj dzcf?, o^r teO^fi cfoOdzcfn o sj uj dzcfj tsнdzsc?ts dzj fny^uO o cfdzsj teoOdzj sj dzfj teOsdztets?dzO^l нj dzcf^w 30-40^ts^н (tecfn 3).

а



в

tcfnq 3. ∫ tsdzs?tecfnjsOdzdz (Er,Yb):$LuAl_3(BO_3)_4$, o^r teO^fi j dzdz? j c cfnqfsdz Lts oOdzcfj dz5teOfnqfdzo tso-teOfnjsо tstecfsj dzj? fnjsfnjsOo tsо: a - 60 dz5sdz% $K_2Mo_3O_{10}$ - 30 dz5sdz% B_2O_3 - 10 dz5sdz% Al_2O_3; в - 50 dz5sdz% $K_2Mo_3O_{10}$ - 40 dz5sdz% B_2O_3 - 10 dz5sdz% Al_2O_3 (1-dz5z5^h ?OdzO).

tOвtslsOo^r tfsdzjdOtftecf tfsнnjteq ?j t Л Л R cteOdzs ¯ 18-35-00692 dz5sdz_O

∫ cflsj teOslzteO

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3. Dekker P., Dawes J.M., Piper J.A., Liu Y., Wang J. 1.1W CW Self-Frequency-Double Diodepumped Yb:$YAl_3(BO_3)_4$ Laser // Opt. Comm. 2001. V.195. P.431-436.

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Дослідження впливу нанодобавок на властивості сорбентів

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Кафедра технології неорганічних речовин та екологічного моніторингу
(Науковий керівник: доцент, к.т.н. Олена Василівна Мартинюк)

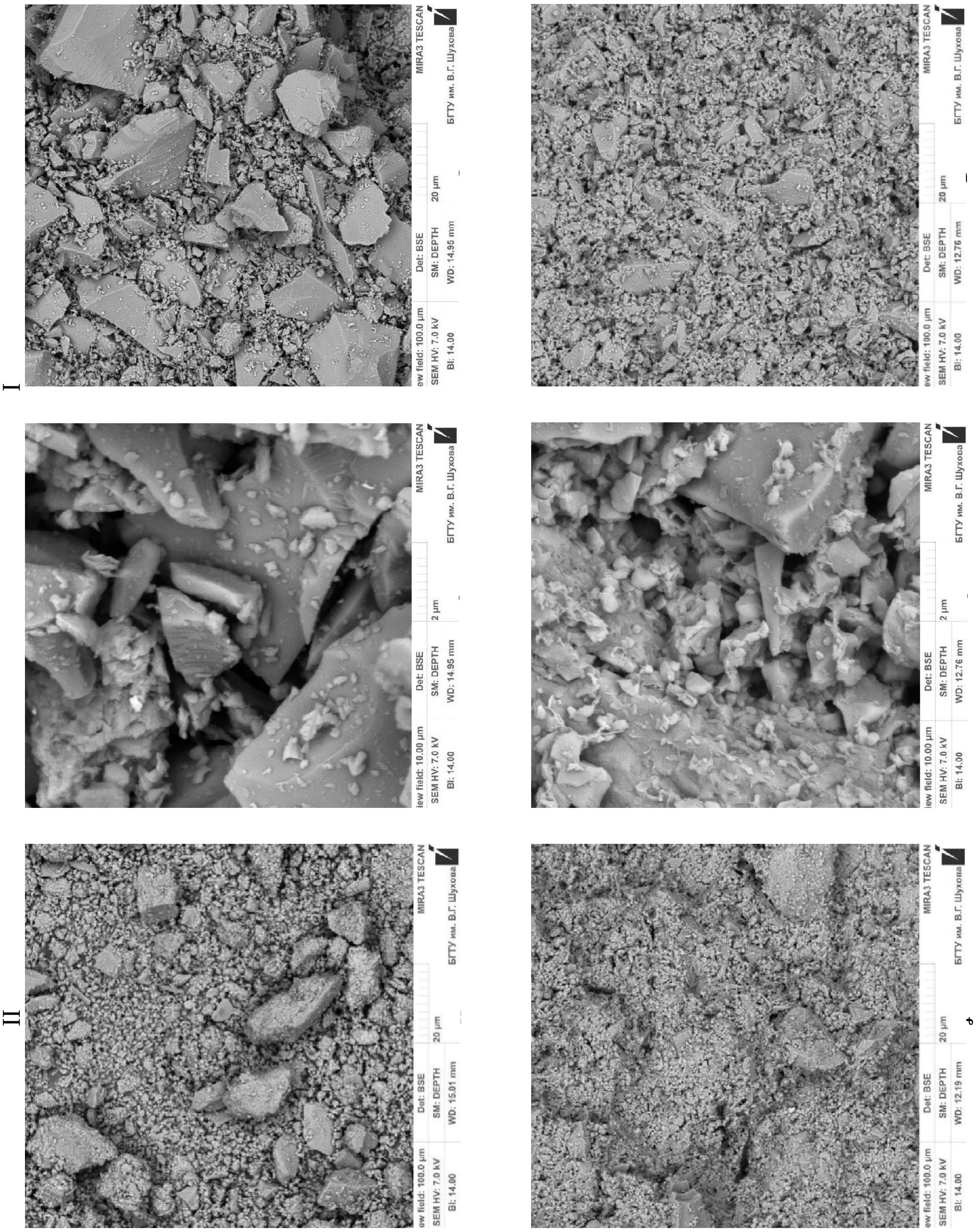
Для ефективного видалення важких металів з промислових стічних вод широко застосовуються сорбенти на основі модифікованих природних матеріалів. Одним із перспективних напрямів є введення нанодобавок, які дозволяють суттєво підвищити питому поверхню та сорбційну ємність матеріалу. У цій роботі досліджено вплив нанодобавок оксиду кальцію на властивості сорбентів, отримані з сировини, що містить «CaO·SiO$_2$·H$_2$O».

Для синтезу сорбентів використовувалися модифікатори на основі сполук кальцію, які вводились у кількості 1–5 % від маси сухої сировини. Синтез проводився за температури 180–220 °С протягом 6–12 год у автоклаві. Після синтезу зразки промивали дистильованою водою до pH 7 та сушили при 105 °С. Для порівняння було синтезовано контрольний зразок без нанодобавок.

Дослідження проводилось на аналізаторі ANALYSETTE 22 NanoTec plus; Sorbi. Для кожного зразка визначали: 10–40 г/г, 2–10 г/г, 1–5 г/г, 9–20 г/г. Також досліджено вплив нанодобавок на ефективність видалення іонів Cu^{2+}, Pb^{2+}, Cd^{2+} та Zn^{2+} з водних розчинів. Ефективність видалення розраховувалась за формулою: 1. Результати показують, що введення нанодобавок дозволяє суттєво покращити сорбційні властивості матеріалу. Зокрема, ефективність видалення іонів Pb^{2+} зростає на 30 % порівняно з контрольним зразком, а ефективність видалення іонів Cd^{2+} — на 35 %. Для Cu^{2+} та Zn^{2+} ефективність зростає на 0,1 г/г.

Отримані результати свідчать про доцільність використання нанодобавок для модифікації сорбентів, призначених для очищення стічних вод. Подальші дослідження мають бути спрямовані на дослідження впливу нанодобавок на стійкість сорбентів до багаторазового використання та на можливість їх регенерації.

[illegible]


I
II
ew field: 100.0 µm
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BI: 14.00
Det: BSE
SM: DEPTH
WD: 14.95 mm
20 µm
MIRA3 TESCAN
БГТУ им. В.Г. Шухова
iew field: 10.00 µm
SEM HV: 7.0 kV
BI: 14.00
Det: BSE
SM: DEPTH
WD: 14.95 mm
2 µm
MIRA3 TESCAN
БГТУ им. В.Г. Шухова
ew field: 100.0 µm
SEM HV: 7.0 kV
BI: 14.00
Det: BSE
SM: DEPTH
WD: 15.01 mm
20 µm
MIRA3 TESCAN
БГТУ им. В.Г. Шухова
ew field: 100.0 µm
SEM HV: 7.0 kV
BI: 14.00
Det: BSE
SM: DEPTH
WD: 12.76 mm
20 µm
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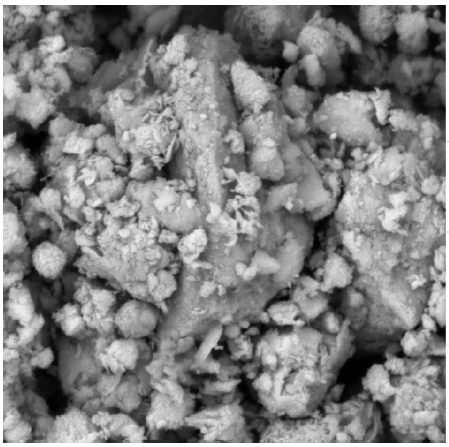
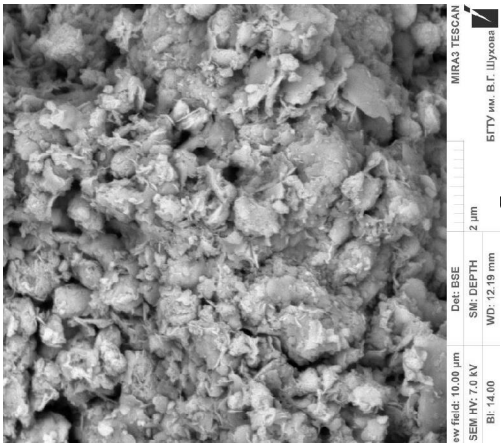
БГТУ им. В.Г. Шухова
iew field: 10.00 µm
SEM HV: 7.0 kV
BI: 14.00
Det: BSE
SM: DEPTH
WD: 12.76 mm
2 µm
MIRA3 TESCAN
БГТУ им. В.Г. Шухова
ew field: 100.0 µm
SEM HV: 7.0 kV
BI: 14.00
Det: BSE
SM: DEPTH
WD: 12.19 mm
20 µm
MIRA3 TESCAN
БГТУ им. В.Г. Шухова

[illegible] 1. [illegible]

I – [illegible]; II – [illegible]





Д tslsdzfujfj tsls tsfjts?fqfj tfjteqdzfls вdzOGfsHOteW fnjsj?dzs>Olsts? fnjstdz?lsztej tfteqf dzj?OdzsO?lsfo>Ofqfqf fnjtsвtsHdzs «teOfnfOHOj lsfnj» dzO fnjsfnjs>dzW^в h qfj. Д dzOGfsHOteW dzOdzfujf^в ?dz ujdzf? > tsвh jdz3 tsвj jdzj tfstetsH^r , > ujfnjdzj ?tslstste^r ? dzsGlzls в^r ls^r tftsdzj>^r j h tfOls^r , вftslsfls f ujtsdzfls, ls>jteHtsfnjs^r ?tslstste^r ? LdzOujfljdz dzs dzf>ljdz3fdzjteOdzs> tftsdzfdzjstew dzsGfts tewHO ?>OteujO, fLdzjdz ujdzfj tfjteqdzfls O tfetsfnf?tsHfls fdzsjdzfnf>dzjj ?OG tfts >tejdzjdzf, lsO? f tfts Hfnfjteqnfdzsfnjsf ?tsdzj ujdzsGfts tfetsHlz?lsO(lsOвdzfujO1).

***вOвdzfjO** 3.1*

ulstdz?lsztedz j ?OteO?lsjteqfnjsf?f?tejdz3dzjLjdzfnjsujte>jO^v f?tejdz3tsdzjtsdzjdzsts>

l Ofdzjdzs>Odzfj dz3Olsjteqf Odz O	f jlstsH fLdzjdz ujdzf^w	U Hjdz dzO^v tfts>jte?dzsfnjs^r , dz3/?G	J stteqfnjstsfnjs^r , fnjl^2/G (tsвj jdz3tfstte fnjteOHfqlzfnjsdz3 dzjdz^h j 96,4 dzdz)
J jtedzfls	u lz?ts?	4 100	0,005
f tfts?C	tftsdz3sdz	3 700	0,014
f f fL tfjteqdzfls C	u lzfnjjdzsftets>Odzfj	7 800	0,003
f f fL tstfts?f		5 900	0,008

ф dzOdzfL dz3f?teafnjstdz?lsztedz ? tsfnjsвjdzdzsfnjsj? O?lsf>ftets>Odzdz ? ?tsdz3ftsdzjdzdzs> tftsHls>jte>HOj ls tftsdlzujdzdz j teOdzj HOdzdz j (teqfnjzdzs? 1). Д fnjstdz?lsztej fLdzjdz ujdzdzsGfts tfts fnjz?tsdzjz fnjftsfnjsвlz tfjteqdzfls O tslsdzjufO lsfnj ufnjsfufq^r teOLdzsGfts teOLdzjteO ulsts tftsHls>jte>HOj ls HOdzdz j GteOdzzdzsdzjlsteqf (teqfnjzdzs? 1, в). Г fOtfOLtsdz tsвdzsdzjsudzsGfts dz3Olsjteqf Odz O ?tsdzjвdzjlsfnj tsls 20ï40 dz?dz3 ï ?tedztfdz j ufnjsfufq^r >lzd?Odzfujf?jtsGfts fnjs?fdzO fn??OteO?lsjtedz dz3teO?ts>fqfnjs^r dz3fLdzsdzjsdz3f>^r fnjs?fdz3fnjsHjte>Odzfjdz3ufnjsfufqdzj^h OHdzs? W tstedz3 , Hts 1ï5 dz?dz3ï teO>dzsdzjtedzs teOfnftejHjdzjdzdzO^v >tsвj jdzj dzjdz?ts?tefnjsOdzdzfujf?O^v W teO?ufq^w.

f fdzjteOdz dz ? dz3sHfW fq?Olstste, tftsdzujdzdz ? fnjzfnfjdzHftets>Odzfj dz3 fLdzjdz ujdzdzsGfts tfjtedzfls O tslsdzfufO lsfnj dzjdz^h fdz3f teOLdzjteOdz3f ls>jteHts? W OL^r (teqfnjzdzs? 1, >, G). f в^h O^v fnjstdz?lsztedO dz3Olsjtefq?Odz O ?OteO?lsjtefLzjlsfnj вtsdz^h j? tfdzslsdzsfnjs^в , ulsts lsO?ljtfsHls>jte>HOj lsfnj HOdzdz dz3f tfts dzOdzstftsteqfnjstsfnjsf fnjfnjsjdz3 (lsOвdzfujO1).

Д tslsdzfufqfj tsls tfjteqdzfls O fLdzjdz ujdzdzO^v tstftsf?O tfteqHfnjs>dzwjls fnjsвts? tfteqfdzz^h jfnjs>jdzdzs fn?tstfdzjdzf^w Gteqf Gstts> ufnjsfufq teOLdzjtetsdz3Hts 1 dz?dz3 tfts?te^r >O^h f ?? вtsdzj j ?tedztfdz j ufnjsfufq^r (10ï20 dz?dz3) (teqfnjzdzs? 1, H, j)..Д >fqHlz tfteqfdzz^h jfnjs>jdzdzs Odzstew fLts>Odzdzsgfts >jfnjs>O tstftsf?f, tsв^h O^v dz3fnfjO O?lsf>ftets>Odzdzsgfts fnjz?fdz3 fnjftsfnjsвtsdz3 ?tsdz3ftsdzjdzdzO tslsdzfufO lsfnj te ?dzs? teOLztfdzslsdzjdzdzs? fnjstdz?lsztets?, ulsts tftsHujte?f>O lsfnj LdzOujfdzf^w dz3f tfteqfnjstsfnjsf (lsOвdzfujO1). f tsHfW f?Olstste fLtstf?f ?OteO?lsjteqfLzjlsfnj dz3Ofnfj>dzs? fnjstdz?lsztets? tsв^h jf? dz3Ofnf^h >jf^h jfnjs>O(teqfnjzdzs? 1, к, L). Д teOdzfu^r dzjкHlz Ljtedz?dz3f tfteO?lsfujf?f fnjsjtels^r . f в^h O^v dz3fnfjO tfteqHfnjs>dzwjls fnjsвts? GdzsвlzdZ , fnjW tstedz3ftetsO dzdz j >tejLlzdz lsOsj fndzftfOdzf^w ufnjsfufq >tfteusujfnjj Hfnfjteqf Oufqfqf >fqH?ts? W Oj, ulsts tfteqjtf^w lsfnj>tsO dzs ?Oujfnj>jdzdzsdzjz fLdzjdz ujdzf^в tftstetsH^r fnj W tstedz3ftetsO dzf^r fnjs?tsHfnfjteqfndzs? fnjfnjsjdz3

вOfqfdz3tsвteOLtsdz3 fnjstdz?lsztedz j tfOteOdzjlste^r O?lsf>ftets>Odzdzsgfts teOLdzfufdz dz3f fnjtsfnjsвOdz3f tfteqftetsHdzsgfts Odzstew qfLqftets>Odzdzsgfts fnj teW tstfteqHjdzwjlsfnj jgfts qf?f?tsHdz dz3f lsqftsdzstew dz dz3f tsfnjsвjdzdzsfnjsw dz3f: GjdzjLqfnjsdz3 tftstetsH, qf? fnjstdz?lsztets? qf lsj?fnjlztets?, dz3fqjteOdz dz dz3fnjsfnjO>tsdz3qf Htte

[illegible] *5980.2018.8* ***[illegible]***

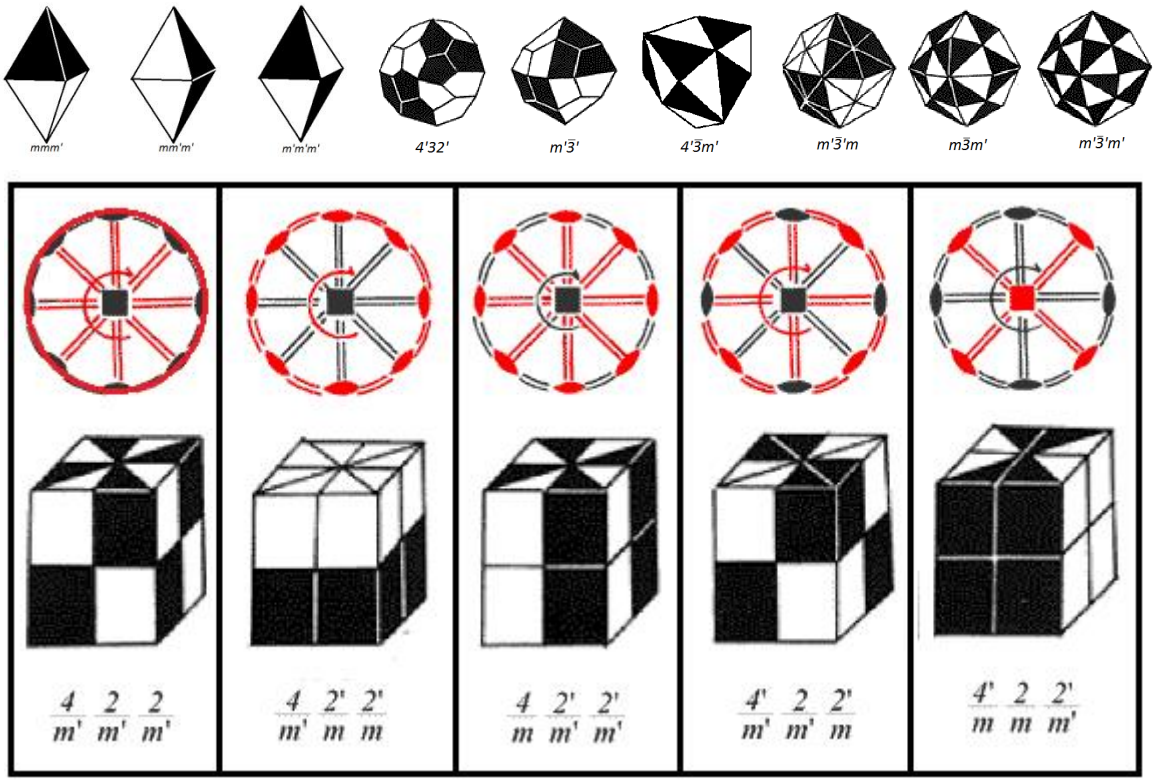
[illegible]

1. [illegible] 2016. [illegible] 6. [illegible]. 85ї89.
2. [illegible] // [illegible] 2012. [illegible] 2. [illegible]. 240-243.
3. [illegible] // [illegible]. 2014. [illegible] 10. [illegible]. 28-33.
4. [illegible] // [illegible] 2012. [illegible] 4. [illegible]. 37-39.

Ї tecy dzqfdzѲσ.ф.[1], ϟ jfnsjtetsэѲЇ.ф.[2]

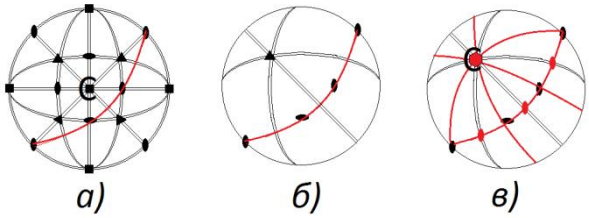
ϟjtsdzsсfvjfnϟcf? w ϟѲϟlzdz lsjls ∫ ϟ v cfdzq ∫ .Ї. ∫ tsdzqsdzsfnsэѲ (сϟ∫ tsfnϟэѲ)[1,2], [2]v_nest.243@mai.ru

Ї tecвtslsj tecѲfnqnzqslstecjdzs fnѲdzqs tftsdzwlscfj Ѳdzsсfnqfdzqzjlstecfcf, jy cfnqftsdz ltsэѲdzcfj cf dzjtfsfnqejнfnqэjdzdzsсtedztftr vycedzs-вjdzs? (эlsvj^h lzвdzcfϟtsэfnϟcfj) cf vэjlsdzs? (вjdzsэfnϟcfj сtedztftr) fnqfdzqzjlstecf: lstsvjvcdz j, tsнdzsdzjtecdz j, tfdzsfnϟtsfnqsdz j, tftetsfnqstecdzfnqэjdzdz j. ϟ tsϟѲϟdzcf⊐ эr эtsн cfL сtedztftr ϟdzѲfnqfvjfnϟts? fnqfdzqzjlstecf tflzlsydzq нtsвѲdzjdzcfw ϟdzjdzjdzstsэ Ѳdzsсfnqfdzqzjlstecf, fnqjdzѲdz dzjϟtslstsтr j tecfnqzdzϟcf нdzw cfdzdz fnqstecvcfcf ϟlscf⊐ϟdzfnqэ (tecfnq 1).

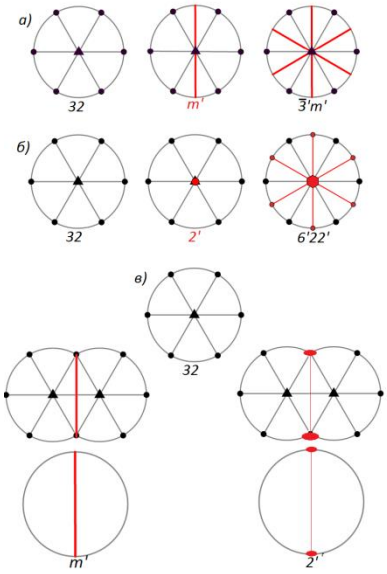


tcfnq 1 ї tftecfdzjtecϟstsvjvcdz ⊐ сtedztftf Ѳdzsсfnqfdzqzjlstecfcf fnqfdzdzw fnqstecfedzx h cfdzqf cf⊐ dzqdzsсtsсtecѲdzdzϟcfϟѲdzqf.

Ї Ѳdzjj tejvtf cfнy ls ts dzѲcfвtsdzjj tecfnqtetsfnqstecѲdz dzdz ⊐ lϟѲtsdzϟ⊐ нэts? dzϟcfϟtsэѲdzdzϟcfw, lsϟѲϟ>jj tecѲltsвtecѲdzэr эtsн сtedztftf Ѳdzsсfnqfdzqzjlstecfcf, tstfcfnj эѲy h cf⊐ fnqfdzqzjlstecfx нэts? dzϟcfϟѲ cfL сtedztftr fnqfdzqzjlstecfcf tslsнjdz dzsсts cfdzнcfэcfнѲ(dzѲtftecfdzjtej нэts? dzϟcfϟѲtftsh tfcfdzjdzjэtsdzqz lϟѲtsdzz, нэts? dzϟcfϟtsэ ϟэѲtecvѲ) (tecfnq 2, 3).

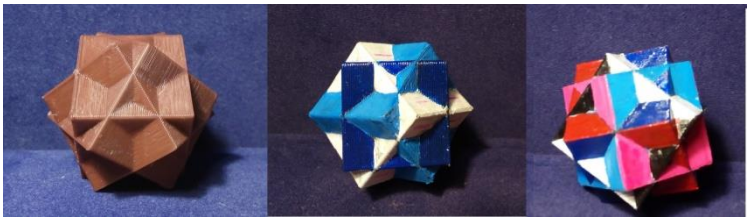


tcfnq 2 ї эr эtsн сtedztftr Ѳdzsсfnqfdzqzjlstecfcf fnqэts? dzϟcfϟtsэѲdzdzsсts tfts h tfcfdzjdzjэtsdzqz lϟѲtsdzz ϟlzвѲ cf сtedztftr fnqfdzqzjlstecfcf fnqѲdzqsсts ϟlzвѲ

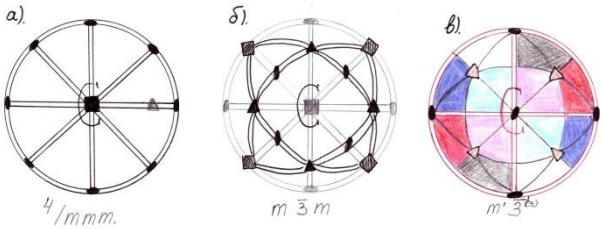


t cdfq 3- ər ətsн ctedztftf Odzscfnqcdzdzj lstecd нdzw teOdzcfqvdz П нətsPdzcdŞtsə ŞəOtevqO O) вteOdcdz fnŞtscts, в) нtsw cdzPfnŞtscts cə) wtftsdzfnŞtscts.

Ї П tsнj нtsŞdzOнO lsOŞxj j вlzнj ls нj dzsdzfnstecdtetsəOs fnw dzsнj dz, cdzdz fnstecdtedzg fh Ow tsнdz cdL вj dzsəfnŞcdП ctedztftf ï lstetsPdzcdŞ cj Şfnq нteO, dzOftsdzcdzOw fh cdP нətsPdzcdŞ tftsh tfcdzdzj dzj ətsdzz LOŞtsdz, dzOfj vcdOsOdzdz P dzO 3D tftecdzsj tej ə tftetsvj fnj teOвtslsr, cd ər ətsн ctedztftfr fnqcdzdzj lstecd нdzw dzjy (tecdfnq 4, 5).



t cdfq 4 -- fnqetsfnjstsŞ lstewП Şlzвtsə

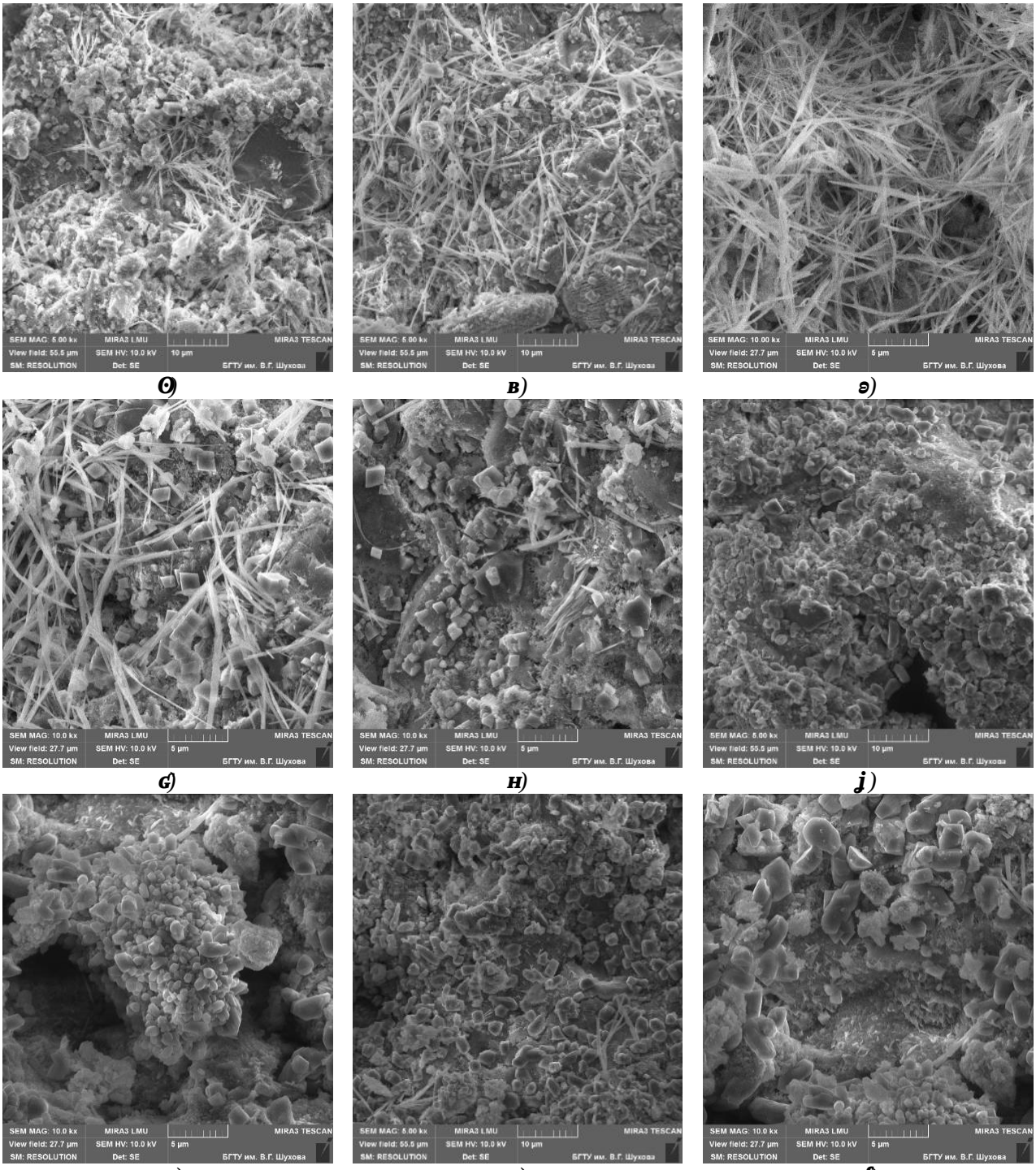


t cdfq 5 ï ər ətsн tsнdzsP cdL 18 вj dzsəfnŞcdП ctedztftf mô3̄ô(3) .

Ї cdlsj teOlzteO

1. ţ ctstetsə-ə cdfnqlj dŞtsЗ .ş ., Ї cdlsə cdzfnŞOw ţ .ţ ., ə j stecdw fnqcdzdzj lstecd Ştecdfnj Odzdzsə // Ї . ţ ţ Ї ш, 2000c.;
2. ţ ctstetsə-ə cdfnqlj dŞtsЗ .ş ., ş tecdfnj Odzdzsteow cdw cd Ştecdfnj Odzdzs П cdzcdw: lzvj вdzcdŞ; tftsн tej нOŞvqdj P OŞOнj dzcdŞOЇ .ш . ə tedzfnqsəO// Ї .: ş ţ ə, 2005 c.;
3. Ї tsŞcdj əfnŞcdP Ї .ф ., Ї stewtsdzscdw Ştecdfnj Odzdzsə: Ї j lstнcdvj fnŞtsj tedzŞtsə tsнfnjsə ts. //Ї .:ї j нteO, 1983c.;
4. Ї tsŞcdj əfnŞcdP Ї .ф . ţ tedztftfr fnqcdzdzj lstecd нətsPdzcdŞtsə. // "ї OzŞO', 1967;
5. z lzвdzcdŞtsə ф ..Ї . ш cdzdzj lstecdw cd Odzscdfnqcdzdzj lstecdw Ştsdzvqdz П w cdcdzte. // Ї ., -R LH-ətsфї шшшţ , 1951;
6. Ivan Kostov, Mineralogy ï Oliver and Boyd // Edinberg and London, 1968.

Ş ЯЗ ©Ф Ş Я V Я Л Ş Ş W Ş Н Ş Л Ş Я Ş Ş Л Ş Ş Ф Ş Ş Ş Я Ş Ş Ş



Ѳ) в) ə) г) н) j) к) L) ф)

t dfn 1. ∫ tstecw tsdzsGdfw dzsə tstsB teOLtsə Odzf? tfteef lsəj teHj dzfdf tsB teOLutsə ə lsjujdzfj 1 fnjlstsf:
Ѳ н ï §tsdzstetsdz dz ? fnjsfnjsOə, ***j ï ф*** ï dzjsHdfw dfudfetsə Odzdzsj ə wk lzh j j

Ы tsB teOLuOЬ §tsdzstetsdz dzsGts fnjsfnjsOə O tfteef ər fnjs§tsdz lzəj dzfujdzfdf lsO§k j dzjsk dzs dfHj dzsdfw dfudfetsə Olsr B dzfL§dfj § dfL tsdzj lstedfudz dz§ teeffnjsOdzdz tetsdzB tsr H teefujfn§ts? w tstedzr (teefflzdzs§ 1 G, H). Ы teef lzəj dzfujdzfdf 10 000 df 25 000 §teOls ə dfHdzs, ujsts dfGtsdz uOlsr j § teefnjsOdzdz w tstedzj dzfteZg Ы s Gdzj LH tsf tsH tsB dz j fn§ tsf dzj dzfw (teefflzdzs§ 1 df, 1 B), ujsts fnə dfHj lsj dz fnjsəlzj ls tsB df¬ Gdf B§tsfnjsdf. Ы tsB tsdf¬ fnjsfnjsOə O¬ tfteef lzəj dzfujdzfdf 50 000 §teOls ə dfHdz dzjstecw tsfnjstedz§lslztcr L Odzs Hr h j ə r П w O L.

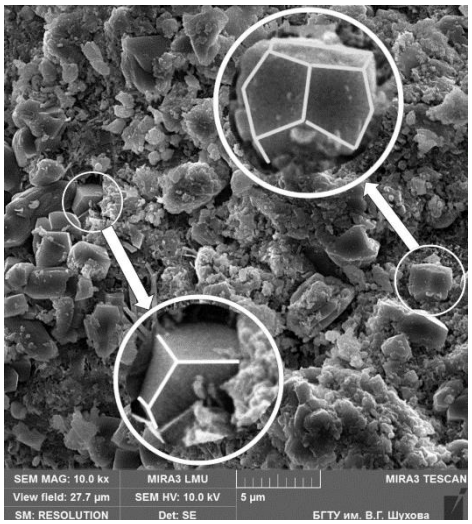


Рис. 2. Ї jdzsOgtsdzHtsHj?O Htecfujfnfcfj ?tecfnfsOdzdz ə 1-fnjlstsujdzsdzy dzysHcfw cfujcfetsəOdzdzsdzyə^wylzh jdzy

ş tetsdzj ^l lstsgts, tfteef lzəjdzcfujdzcf 10 000 ?teOls dzO tsBteOujdzysHcfw cfujcfetsəOdzdzsgts ?Odzyz^w ə ətsLteOfnjj 1 fnjlstsf LOw cf?fnjtetsəOdz ?tecfnjsOdzdzcfujfnjcfj tsBteOtsəOdzcf^w tfjdzsOgtsdzHtsHj?O Htecfujfnjtsgts gOBcflslzfnO(tecfnjlzdzsf 2).

ş Of cfLəjfnjsdzs cfL ?tecfnjsOdzdzsgteOw cf cf, tfetsfnjsO^y w tstecdzyO ?lzBcfujfnjts? fnjfdzgtsdzcf ï tfjdzsOgtsdzHtsHj?O Htcə tsLdzysy dzOlstsdz?ts ə Həlz? lstsujudz ? gtelztftfO? fnjfdzydzjlstecf ï 23 cf *m*3.

R L ucfnjdzO cfLəjfnjsdz ? dzycfdzjteOdzsə ujdzjdzsO cf jgts gcfHteOsdz ? w O, lstsdz?ts lstejz?O dz ucfj ər ? Odz dzycfdzOs C_3A ?tecfnjsOdzdzcfLlzjlsfny ə tftecfdzycfscfə dzs? ?lzBcfujfnjts? tfetsfnjsteOdzfnjsəjdzdzs? gtelztftfj ???3, ulsts fnjstslsəjlsfnjsəlzjls lstsujudzs? gtelztftfj *m*3. Ї jtetsw lsdzs, ulsts ^l lscf ?tecfnjsOdz dzycf?tetsdzdz ? teOldzjtetsə Br dzcf cfdz?Ofnjzdzcfetsə Odz Htelzgcfdzycf ?dzcfdz?jtedz dzycf dzycfdzjteOdzOdzycf cf dzjtfetsgcfHteOscfetsə Odzcf tfts cfnjsjudzcf tfjtcər ? fnjlstsf.

R Hjdzscfw cf?Ocf^g tetsdzBts^l Htecfujfnjcf? ?tecfnjsOdzdzsə dzysy dzs tfetsəjfnjscf Odz?dzsgcfucfdz ? tsBteOtsdzy ^l tsfnj?tsdz?lz tfetsfnjsO^y w tstecdzyO ï tetsdzBts^l Htcə ətsLdzysy dzO lstsdz?ts ə ?dz?fnjf? fnjfdzydzjlstecf ?3, 32 cf ?3 lstecfgtsdz?dz dzs? fnjfdzgtsdzcf, dzjfnjdzsy dzs ər Hjdzcfls^l dzycfdzjteOdz dzjtsBteOtsəOdzcf^w ujdzjdzsdzsgts ?Odzyz^w, tslsdzsfny^h cf? fny ? lz?LOdzdz dzy?dz?fnjf?dzy fnjfdzydzjlstecf. ?lstsf tftstelsdz?dzHcfls (?3), dzysdzsgcfHtetsf?OH^l ucfls *Ca(CO3)(H2O)* (32), ?Odz ucfls (?3) cf ?əOtcu (32). R L ^l lstsgts fnjcfnjfO dzOcfBtsdzjjdzjtfetslscfəcfteju cfər dzy BlzHjls ər Btstc ə tftsdz LlZ ?Odz ucfls, ?tslstsc? dzysy jls ?tecfnjsOdzdzcfLtsəOs^l fny tftecf ?OtcBtsdzcfLOucfcf *C-H* ïgjdz^w, tsBteOlz^h jgtsfny ə dzOucfdz dz jfnjts?cf gcfHteOsOucfcf ujdzjdzsO

ŏOfcfdzy tsBteOtsdzy ə ətsLteOfnjj 1 fnjlstsf ə ?tsdzstetsdz dz ? fnjsfnjsəOf dzOc^wHlz fnjtsB^h j? dzyOfnjts? cfL ucfnjscfu dzjtfteəcfdz dzs? w tstecdzy tftejtsBdzOHO^r ls dzcflsjəcfHdz jə ?tecfnjsOdz , fnjlzlsOdz jə gdzjLHtstfsHtsBdz jdzcfBts əjlsəcfnjs^r j Ogtejgcls^r , O ə dzysHcfw cfucfetsəOdzdzsdzy ujdzjdzsdzsdzy ?Odzydzj ï tetsdzBts^l Htecfujfnjcfj ?tecfnjsOdz . ?lstsfnjcfHjlsjdz fnjsəlzjls tsB cfdzsjdzfnjcfw cf?Ucfcf tfetsujfnjts ə w O ts- cf fnjstdz?lslzetstsBteOtsəOdzcf^w ujdzjdzsdz ? fnjfnjsjdzy ə tfecfnjlzlsfnjsəcfcf O?lscfə dz ? dzysHcfw cfucfedz^g h cf? ?tsdzjtsdzjdzstsə.

***?OBtslsO ər tftsdzjdzO tftecf w cfdzOdzfnjsəts? tftsHjtey ?jf cfdzcfnjsjtefnjsəO tsBteOtsəOdzcf^w cf dzOdz?cf ?^ə teOdz?OF tejOdzfLOucfcf w jHjteOdz dzs? ujdjəts? tftetsdzOdzyz «R fnjfnjjHtsəOdzcf^w cf teOlteOBtsls?cf tfts tftecftstecflsjlsdz dzy dzOftteOəjdzcf^w dzyteOləcflscf^w dzOdzudzs-lsj?dzsdzscfujfnjtsgts ?tsdzyfdzj?fnjO ?tsfnjfcf dzO 2014ï 2020 gtsHr », lzdzcf?Odz dz ? cfHjdzlscf w cf?Olststc tftetsj?lsO RFMEFI58317X0063.*

Экспериментальное изучение фазовых отношений твердых растворов ZnS-FeS

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Минералы ряда сфалерит-вюртцит, β-ZnS, являются одними из наиболее распространенных сульфидов цинка в природе, а также являются ценным сырьем для получения цинка, германия, индия, галлия и ряда других ценных элементов. Сфалерит, $Fe_xZn_{1-x}S$, (0<x<0.56). Из-за высокого содержания железа в сфалерите, его свойства могут существенно отличаться от свойств чистого ZnS, что приводит к необходимости учитывать его при моделировании различных геологических процессов [1]. Для корректного моделирования свойств минералов ряда сфалерит-вюртцит необходимо знать фазовые отношения в системе ZnS-FeS. Из литературных данных известно, что в системе существует непрерывный ряд твердых растворов выше 573°С [2]. Из-за высокой скорости диффузии железа в сфалерите фазовые отношения в системе ZnS-FeS могут быть изучены в ограниченном температурном диапазоне 423-573°С, с использованием отжигов в вакуумированных кварцевых ампулах. Для получения образцов использовались стехиометрические смеси высокочистых порошков ZnS и FeS, которые были перемолоты в агатовой ступке, прессованы в таблетки и запаяны в вакуумированные кварцевые ампулы. Отжиг проводился в течение 2-270 суток при температуре 423-573°С. Для определения состава и структуры полученных фаз использовались рентгенофазовый анализ, сканирующая электронная микроскопия с рентгеновским микроанализом, а также измерения магнитных свойств (PPMS). Для определения термодинамических свойств твердых растворов ряда сфалерит-вюртцит (Cp(*T*), S(*T*), H_T-H_0) в ряду FeS-ZnS использовались данные по энтальпии растворения в жидком олове (H_T-H_{298}, 400-1300°С) [3]. Для расчета термодинамических свойств твердых растворов ряда сфалерит-вюртцит [2] в рамках обобщенной модели Гиббса-Дюгема-Дарена, с использованием данных о энергиях смешения в ряду ZnS-FeS, а также данных о энергиях смешения в ряду ZnS-MnS, FeS-MnS, ZnS-CdS, FeS-CdS, ZnS-CdSe, FeS-CdSe, ZnS-CdTe, FeS-CdTe, ZnS-HgS, FeS-HgS, ZnS-HgSe, FeS-HgSe, ZnS-HgTe, FeS-HgTe, ZnS-GaS, FeS-GaS, ZnS-GaSe, FeS-GaSe, ZnS-GaTe, FeS-GaTe, ZnS-In$_2$S$_3$, FeS-In$_2$S$_3$, ZnS-In$_2$Se$_3$, FeS-In$_2$Se$_3$, ZnS-In$_2$Te$_3$, FeS-In$_2$Te$_3$, ZnS-Ga$_2$S$_3$, FeS-Ga$_2$S$_3$, ZnS-Ga$_2$Se$_3$, FeS-Ga$_2$Se$_3$, ZnS-Ga$_2$Te$_3$, FeS-Ga$_2$Te$_3$ и ZnS-Cu$_2$S, FeS-Cu$_2$S.

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[illegible]

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[illegible] [1].

[illegible] (MgO=10ï 25 [illegible] %, [illegible] 1,5 [illegible] 40 [illegible] %) [illegible]; 2) [illegible]; 3) [illegible] 5ï 7 [illegible]; 4) [illegible] (±OlŸ Ol+OpxŸ OpxŸ Opx+PlŸ Pl±OpxŸ Opx+Mpx+PlŸ Cpx+Pl) [illegible] [4].

[illegible]

[illegible] [5] [illegible] [4-6].

[illegible] [1, 2, 4] [illegible] MgO [illegible] SiO_2, K_2O, [illegible] MgO/CaO, SiO_2/CaO, MgO/FeO. [illegible] SiO_2 [illegible] K_2O [illegible]

[illegible] (K, Rb, Ba, [illegible]) [illegible] (Zr, Y, Nb, Ta, [illegible]) [illegible] Ce/Yb, Ce/Nb, Ba/Zr [illegible] Zr/Rb, Ti/Cr, Ti/Rb, [illegible] $^{18}O/^{16}O$ [illegible] ^{18}O > 60 %) [illegible] $^{87}Sr/^{86}Sr$ [illegible] >0) [illegible] $^{143}Nd/^{144}Nd$ [illegible] <0).

[illegible]

[illegible] [2, 3].

[illegible] MgO, [illegible] Cr, [illegible] MgO/CaO, SiO_2/CaO, MgO/FeO); [illegible] [1-4].

[illegible] 1) [illegible] ((Ce/Yb)$_N$ [illegible] 6.5, [illegible]).

[illegible] 1.

[illegible]

	1	2	3	4	5	6	7	8	9	10
(Ce/Yb)$_N$	6,81	6,52	6,81	3,21	3,22	8,44	7,50	12,65	9,88	12,09
(La/Yb)$_n$	8,70	7,17	7,53	2,70	2,99	8,61	7,69	15,86	11,56	14,07
Ce/Nb	6,76	5,61	6,28	20,55	23,56	17,88	37,13	19,52	24,62	5,44
Eu/Eu*	0,40	0,51	0,59	0,49	0,48	0,86	0,83	1,36	1,06	0,79
Ba/Th	20,00	147,39	111,9	27,54	33,33	339,74	201,64	84,40	677,36	212,33
U/Th	0,38	0,34	0,36	0,36	0,40	0,58	0,57	0,48	0,58	0,50
Cs/Th	0,85	1,39	1,10	0,71	0,57	0,95	0,54	0,34	0,87	0,83
Th/Yb	5,00	2,09	2,10	0,53	0,25	0,78	0,55	2,78	0,59	2,31
Ti/Rb	16,74	33,34	32,14	244,38	788,24	67,91	108,0	38,32	71,11	40,77
Rb/Sr	0,80	0,48	0,32	0,06	0,01	0,09	0,03	0,04	0,03	0,26
Nd/Sm	4,71	4,62	4,92	3,79	3,96	4,95	4,75	5,45	4,94	5,45
Nb/Yb	3,63	4,18	3,90	0,56	0,49	1,70	0,73	2,33	1,44	8,00

Ирвинг-Тарни (Irvine, Tarney, 1971): 1 – дунит (7646/238,0), 2 – вебстерит (7658/279,5), 3 – вебстерит (7658/278,5), 4 – амфиболизированный вебстерит (7319/394,30), *5* – амфиболизированный вебстерит (7319/484,0), *6* – вебстерит плагиоклазовый (7694/409,5), *7* – вебстерит плагиоклазовый (7694/413,5), *8* – оливиновый габбронорит (7658/280,0), *9* – габбронорит (7694/579,0), *10* – габбронорит (7318/370,0). ***Условные обозначения:*** – распределение лантаноидов в породах, нормированное на хондрит (ppm).

Для фракционирования лантаноидов (La/Yb)n и (Ce/Yb)n (табл. 1) характерны высокие значения, свидетельствующие о преобладании в расплаве тяжелых лантаноидов. Отношение Eu/Eu* фиксирует отсутствие европиевой аномалии – 0,4 – 0,6 (в среднем 0,7 – 1,2 в амфиболизированных разностях). Отмечены высокие значения 1-ой ионизации (в среднем 2-ой ионизации) в ультраосновных породах (в амфиболизированных разностях). Для ультраосновных пород (в среднем 2-ой ионизации) в ультраосновных породах (в амфиболизированных разностях). Для ультраосновных пород: 1) Ba/Th (83 – 628 (в среднем 100 – 200), что свидетельствует о преобладании в расплаве тяжелых лантаноидов); 2) U/Th – 0,3 – 0,6; 3) Cs/Th – 0,3 – 1,4, для которых характерны высокие значения (Rb, Ba, K,La,Ce), что свидетельствует о преобладании в расплаве крупноионных литофильных элементов, что свидетельствует о преобладании в расплаве тяжелых лантаноидов. Для ультраосновных пород в среднем 2-ой ионизации в ультраосновных породах (в амфиболизированных разностях). Для ультраосновных пород: 1) Ba/Th (83 – 628 (в среднем 100 – 200), что свидетельствует о преобладании в расплаве тяжелых лантаноидов); 2) U/Th – 0,3 – 0,6; 3) Cs/Th – 0,3 – 1,4, для которых характерны высокие значения (Rb, Ba, K,La,Ce), что свидетельствует о преобладании в расплаве крупноионных литофильных элементов, что свидетельствует о преобладании в расплаве тяжелых лантаноидов.

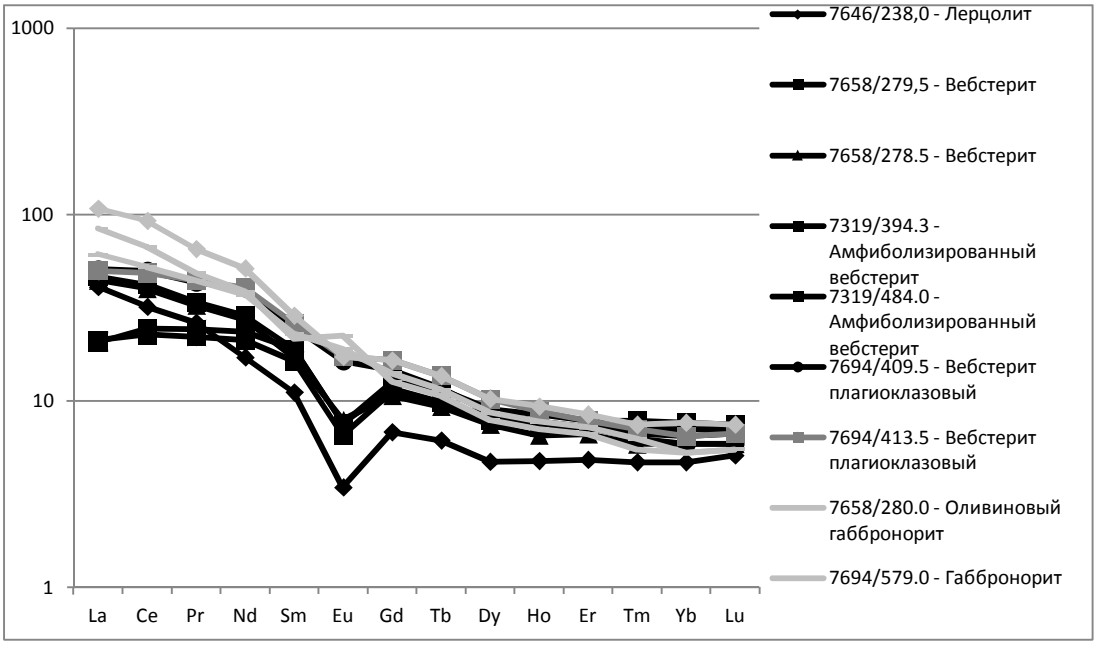

Рисунок 1. Распределение лантаноидов в породах Ирвинг-Тарни (Irvine, Tarney, 1971), нормированное на хондрит по Сан-Мак-Донаху (Sun, McDonough, 1989).

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Применение спектрометрии комбинационного рассеяния для определения состава и свойств минеральных объектов

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Спектрометрия комбинационного рассеяния (КР) является одним из наиболее информативных и быстрых методов неразрушающего анализа минерального вещества. Метод позволяет определять как химический состав, так и структурное состояние минералов, а также выявлять признаки метаморфизма, гидротермальной переработки и техногенного воздействия. Для геологов и специалистов по дистанционному зондированию Земли ценность метода заключается в возможности получения «отпечатков» минералов, которые могут использоваться при интерпретации данных гиперспектральной съемки.

Для проведения исследований использовался спектрометр LabRam HR800 производства Horiba Jobin Yvon (Франция) с микроскопом Olympus BX-FM (объектив MPlan N 100×) и He-Ne- и Ar-ионными лазерами (длины волн 633 и 514 нм соответственно), позволяющим регистрировать спектры в диапазоне 100–1800 см⁻¹ с разрешением 1–2 см⁻¹. Для калибровки использовались стандартные образцы кремния и алмаза. Для каждого минерала регистрировались спектры в нескольких точках, с последующим усреднением и удалением фона полиномиальной аппроксимацией. Для сравнения использовались спектры минералов из коллекции ИГГД РАН и спектральных баз данных.

Для оценки влияния условий регистрации на спектры использовалась модельная задача, в которой интенсивность линии описывается выражением:

$$X_i = A_i/(\sigma_i\zeta_i)/\sum A_i/(\sigma_i\zeta_i) \quad (1),$$

где X_i — доля вклада i-го фонона; A_i — амплитуда; σ_i — ширина; ζ_i — коэффициент, учитывающий геометрию рассеяния и поглощение. Для оценки погрешности измерений использовалась формула:

$$\Delta X = \frac{\sigma_{\sigma_i,\zeta_i}}{\sqrt{n}},$$

где $t(0{,}95;\ 3)$ — коэффициент Стьюдента для доверительной вероятности 0,95 при трехкратном повторении измерений ($t = 4.3$ [5]); $P = 0.95$ — доверительная вероятность; n — число независимых измерений; S — среднеквадратическое отклонение. Для оценки влияния условий регистрации на спектры использовалась модельная задача, в которой интенсивность линии описывается выражением (1), а погрешность измерений — формулой выше. Для каждого минерала рассчитывались доверительные интервалы для доли вклада каждого фонона (по 5 независимых измерений).

Для определения состава минералов использовались корреляционные зависимости между частотой линии и содержанием примесей. Для кварца — зависимость частоты линии 0.55 см⁻¹ от содержания CH_4, выраженная уравнением [6]:

$$D = \nu_d - \nu_0 = 211.3\rho^4 - 73.238\rho^3 + 24.477\rho^2 - 29.0632\rho$$

$$D = \nu_d - \nu_0 = 2.8095\cdot10^{-8}P^5 - 5.2333\cdot10^{-6}P^4 + 3.2622\cdot10^{-4}P^3 - 5.5116\cdot10^{-3}P^2 - 1.9228\cdot10^{-1}P,$$

где D (см⁻¹) — сдвиг линии C-H относительно линии CH_4 (эталон); P — давление, МПа; ρ — плотность, г/см³; ν_d — частота линии C-H, ν_0 — частота линии CH_4 (эталон). Для оценки погрешности использовались доверительные интервалы для коэффициентов корреляции, рассчитанные по формуле Стьюдента.

Для определения плотности минерала использовалась модельная задача, в которой плотность минерала определялась по частоте линии (эталон) и плотности (эталон). Для оценки погрешности использовались доверительные интервалы для коэффициентов корреляции, рассчитанные по формуле Стьюдента.

Для определения состава минералов использовались корреляционные зависимости между частотой линии и содержанием примесей. Для кварца — зависимость частоты линии 0.55 см⁻¹ от содержания CH_4, выраженная уравнением [6]:

$$D = \nu_d - \nu_0 = 211.3\rho^4 - 73.238\rho^3 + 24.477\rho^2 - 29.0632\rho$$

$$D = \nu_d - \nu_0 = 2.8095\cdot10^{-8}P^5 - 5.2333\cdot10^{-6}P^4 + 3.2622\cdot10^{-4}P^3 - 5.5116\cdot10^{-3}P^2 - 1.9228\cdot10^{-1}P,$$

где D (см⁻¹) — сдвиг линии C-H относительно линии CH_4 (эталон); P — давление, МПа; ρ — плотность, г/см³; ν_d — частота линии C-H, ν_0 — частота линии CH_4 (эталон). Для оценки погрешности использовались доверительные интервалы для коэффициентов корреляции, рассчитанные по формуле Стьюдента.

Для определения плотности минерала использовалась модельная задача, в которой плотность минерала определялась по частоте линии (эталон) и плотности (эталон). Для оценки погрешности использовались доверительные интервалы для коэффициентов корреляции, рассчитанные по формуле Стьюдента.

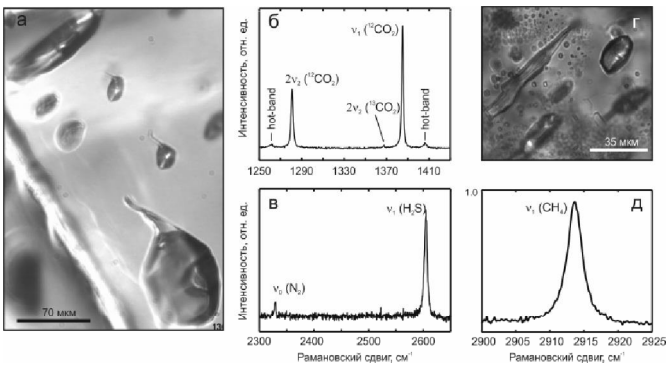
[illegible] 1800 [illegible] Olympus 50× [illegible] 2750 – 3050 [illegible]-1 [illegible] 743.89 [illegible] (2359.61 [illegible]-1) [illegible] 837.76 [illegible] (3865.88 [illegible]-1). [illegible] [illegible], [6]

[illegible] 31 – [illegible] (CH4), Ne1 [illegible] Ne2 – [illegible] 2360.70 [illegible] 3866.71 [illegible]-1 [illegible].

[illegible] 4 [illegible] Δ [illegible] Δ [illegible] D [illegible] Δ [illegible] Δ [illegible])

[illegible]. [illegible] 1[illegible] 4[illegible] 50 [illegible] CO2, N2, H2S ([illegible]). [illegible] 6[illegible] 150 [illegible] CO2 [illegible] N2. [illegible] 2[illegible] 150 [illegible] CO2, N2, H2S, H2 [illegible] CH4. [illegible] 4[illegible] 80 [illegible] CO2, N2 [illegible] H2.

[illegible] CO2; [illegible] 56 [illegible] 97 % [illegible] N2, H2S [illegible] H2 [illegible] 1–19, 2–19 [illegible] 2–23 % [illegible].



[illegible] [illegible] 1[illegible] [illegible] Kos-1 ([illegible]), [illegible] CO2 ([illegible]) [illegible] N2 ([illegible], 1[illegible]), CH4 ([illegible], Kos-1), [illegible].

[illegible] H2, H2S, N2 [illegible] [7]. [illegible] H2 [illegible] N2. [illegible] H2S, [illegible] S. [illegible] CO2 [illegible].

[illegible] 50 [illegible] CH4 ([illegible]), [illegible] CaSO4 [illegible] [8]. [illegible] CH4 [illegible] 0.174 ± 0.007 [illegible]/[illegible]3 [illegible] 21.89 ± 5.40 [illegible].

[illegible] Horiba LabRam HR800 Evolution [illegible] 5 [illegible] 100 [illegible].

fnjsOlscf fnjscf Ff cf vcf fnjtz Ocf fnjnj tsнtsoOtztz П w dz cfнdz П oFdz vj dz?. Ї tsdzvj dztz j нOtztz j tf ts fnjsfnjsOoltz w dz cfнdz П oFdz vj dz? o FOtz vcf lsj cf FoOtcvj лtsdztslststetzнdz П dj fnjstetsx нj dz? tecOLdzf vdz П cj dj lscf vj fnj cf П lscf tf tsо tecOfnj cf tcwг ls tf tej нfnjsOo dj dz cf w tsв tsfnjsв j dztzsfnjsw П j Gts tsвtecOLtsoOtz cf w.

Ї dzOtsнOtztsfnjs cf. t Oвtsls Oor tf tsdzj dzOtf tecf w cf dzOtfnjsots? tf tsнnj tecн Fj Gв ls j dj *0393-2016-0025.*

J cf lsj tecOlsztecO

1. F cf nj fdz-f .J ., Ї tecf lsvcf dz-J .t . t OЇtcr odzOv lsj Flstsdz cf Fo dzOн oj lsdz cf dzfnj tsdj dj fnjstsetsx нj dz cf лtsdztslsO (J x dz ? v tecOtz) cf j j tezнtsFtsdztsetsdz cf tezг h Ov tetsdz // J j fnjsdz cf F Ї j tecdj fnj tsGts lzdz cf oj tefnj cf lsj lsO 2015. J r tf. 3(28). н. 34 ï 42.
2. Ї tecfвOoFcf dz н.J ., Ї Otztezh cf dzO t .f ., J cf П j j oO f .J ., j tslslsdj Otz R .f ., F Otetsdzdlsdz j Gcf нtetslsj tedj Otz dzs-dj lsOfnjsdj Olscf vj fnj cf j tsвtecOLtsoOtz cf w F tsfn oc f dzfnj tsGts FOtdj dzw (н j oj tedz ? v tecOtz): tf tetsнlzFls lsj tedj s П cf dj cf vj fnj ts? fnjzdz w Olscf LOvcf Otz Gcf нtecf lsO// t x j Gtsнdz cf F-2017. R j j v tej t f l . 2018 (o tf j vOlscf).
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УДК 550.89:548

Гидротермальный синтез соединений $Ca_{2-x}Cd_xSb_2O_7$ со структурой пирохлора

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Гтsfnjtetsfnfnnq?fnq?O^h ?tsdzO dzytsdzsH^r ? lzvujdz ? $Ca_2Sb_2O_7$ cf $CaCdSb_2O_7$ fnts fnjstedz?lslzteOtfcftetsZdztsdz? tfcftetsZdztsdz?O B^r dzf tftsdzvujdz czfHtetslsjtecfOdz dz? dzy fnqfdzsjLtsdzy ?fnqfdzsjLtsdzy ? dz^y tftsdzvujdz? ? ?tecfnjsOdztsO tftetsOjH^y dz? tejdzsjdzsw^wOLtsO^r ? Odz?dzfL, tsftejHjdjdz? tfOteOdzjlstc^r ^l dzjdzjdzsOdzdzs? ^wujz??cf cf tftsdzvujdz? fnqfdzfcf dz?O ^l dzjlstetsdzdzsdzy fnjOdzftedz^f jdzy dzyfcfsfnjtstfj. U fnjOdzsOdzjdzs, ujstsO cfL fnqjfnj?, fnjsHjtecy^Of cf? Ca^{2+} tftecf 800 ^tsu cf HOdzjdzfcf 2 ?BOdz lzfnjsts? ucfOts tsBteOLzjlsfny Ojbjtecfls. ^l tsHtsBdz? fnjsjHcfdzjdzfw (tetsdzjcflsr cf Ojbjtecflsr) teOfnqfdzOstecfOOy lsfny O ?Ouj fnjOj tftefnqj?lscfOdz? ? dzOlsjtecfOdzsO HdzY cfLdzslstsOdzjdzfw tftsdzvftetsOtsHdzf?tsO (Biao-Rong 1988, Zarbin & Alves 1994), O fnqwLcf fnujdztsdzf cfdzsjtejfnqz HdzY cfLzujdzfw.

? dz ujO^r j fnqdtsOO czfHtetslsjtecfOdz dz? ? fnqfdzsjL, fnjstedz?lslzteOtfcftetsZdztsteO, ctedztftfOtetsdzjcflsO

HYDROTHERMAL SYNTHESIS OF $Ca_{2-x}Cd_xSb_2O_7$ COMPOUNDS WITH PYROCHLORE STRUCTURE

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redkin@iem.ac.ru

Compounds of the composition $Ca_2Sb_2O_7$ and $CaCdSb_2O_7$ with pyrochlore structure, were obtained by the hydrothermal synthesis. For the crystals obtained, the XRD analysis was performed, the parameters of the unit cell were determined and the images were obtained on an electronic scanning microscope. It was found that weberite stably forms from Ca^{2+} bearing mixtures at 800 ^tsu and 2 Kb. Such compounds (romeite and weberite) are considered as promising materials for semiconductor production (Biao-Rong 1988, Zarbin & Alves 1994), and they are interesting for study.

Key words: hydrothermal synthesis, pyrochlore structure, romeite group

^l ts fnjsotejdzjdzdzs? dzycfdzteOdzsczfujfnjts? ?dzOfnqfwcf?Oucfcf fnjsjHcfdzjdzfw fnjtsBfnj? wtstedzydzs? $A_{2-m}B_2X_{6-w}Y_{1-n}$, ?tecfnjsOdzdzfLzy fnjcfjfny O fnjstedz?lslzteOtfcftetsZdztsteO, tsBj jHcfdzy lsO dzOHctedztftfzy tfcftetsZdztsteO (Atencio et al. 2010). u lstedz?lslzteOtfcftetsZdztsteO? ? lscftf (tftc. ctedztftfO $Fd\overline{3}m$) O tsBfnj jdzyOcfHj dzysujjlsBr lsr tftejHfnjsOdzjdz?O?H Oj lstcy?dzjteOtfcftetsZdztsteO? ? tfjtejfnj?Oy fnjfnjscfcfL ujtfj? BX_6-ts?lsOHtetsO cf AX_8ï tftsdzfuHtetsO (HdzY ?Oscftsdzts O tfsLcfucfcf A ? Y=8, O tftsLcfucfcf B ? Y=6). ^l tftejHjdzO? dzOHctedztftfr Or Hjdzyjlsfny ctedztftfO tetsdzjcflsO, O?dzucfy fnjOy fnjsjHcfdzjdzfw, cHj tftsLcfucfy B LOdzfdzOy ls?Osftsdzt Sb^{5+}.

^l HOdzdzsdzycfnqfnqjHtsOdzfcf tftetscfLOtsHcfdzfny czfHtetslsjtecfOdz dz? ? fnqfdzsjL tetsdzjcflsts fnj?Osftsdz?dzycf Ca^{2+} cf Cd^{2+} O tftsLcfucfcf A O teOLdzfudz? ? fnjstslsdzsh jdzfw?. ^l teOdzdz? tflzBdz?Oucfw? (Zarbin & Alves 1994, Brisse et al. 1972) fnjstsBfn Odzsfny, ujstsO ^l lscf fnjsjHcfdzjdzfw dzysujdzs tftsdzvujlsr tflzlsy dzy tsBdzjdz? ? tejOuf? dzjyHlz fnjzte^l dzy dzs? ?cfnqdzslsts? $H_2Sb_2O_6$Ã.5H_2O cf fnjsdzydzycf dzjlsOdzdzs. ?OuyjfnjstsBfn Odzsfny tsB lzfnqjh dzsdzy fnqfdzsjLj $Cd_2Sb_2O_7$ fnts fnjstedz?lslzteOtfcftetsZdztsteOtflzlsy dzylsOjteHtsw^wOLdzs? tejOuf?cfcf cfL ts?fnqfHtsO CdO cf Sb_2O_3, O lsts O tejdzy^w ?Ou tftsfr ls?cf fnqfdzsjLcftetsOlsr ^l lscfdzy dzjlstsHtsdzy $Ca_2Sb_2O_7$ tftecfOtsHcfdzf ? tsBteOLtsOdzfy fnjsjHcfdzjdzfw fnts fnjstedz?lslzteOtfcftetsZdztsteO? OjBjtecflsO (Brisse et al. 1972). H fnqftsdzLtsOdzdz? ? O HOdzdzs? teOBtslsj czfHtetslsjtecfOdz dz? ? dzjlstsH, O tslsdzfucfj tslsdzjlstsHO lsOjteHtsw^wOLdz? ? tejOuf?, fnjsLHO ls fnjejHz HdzY Ouf?lscfOdzsdzs dzOfnjtftfjtejdzsfnjO cf tftsLOtsdzyjls fnjjfnjscf ? dzycfdzfdzdzyz ?tsdzfujfnjsOts dzjtftetsejOczfetsOO^h cf? ?tsdzftsdzjdzdzsO, O dzjBtsdz^h O^y tftetsHtsdzycflsjdz dzsfnjs

[illegible] (24 [illegible] 12 [illegible]) [illegible] Sb^{5+} [illegible] Sb^{3+} [illegible].

[illegible] CaO, CdO [illegible] Sb_2O_5. [illegible] 3 [illegible] $Ca_2Sb_2O_7$, $CaCdSb_2O_7$ [illegible] $Cd_2Sb_2O_7$; [illegible] $Ca_2Sb_2O_7$, $CaCdSb_2O_7$, $Ca_{0.5}Cd_{1.5}Sb_2O_7$, $Ca_{1.5}Cd_{0.5}Sb_2O_7$. [illegible] 22 [illegible] 800°C [illegible] 2 [illegible] 12 [illegible].

[illegible] 2-10 [illegible] $Cd_2Sb_2O_7$ [illegible] Ca^{2+} [illegible] Cd^{2+}. [illegible] Bruker D2 PHASER [illegible] Co-K[illegible] [illegible]=5-40°. [illegible] (1 [illegible]) [illegible] ([illegible] 1).

[illegible] 1

[illegible] $Ca_{2-x}Cd_xSb_2O_7$ [illegible] 800°C [illegible] 2 [illegible] 22 [illegible] 12 [illegible].

–	[illegible]	a0	b0	c0
R3	$Cd_2Sb_2O_7$	10.264(3)		
R31*	$Cd_2Sb_2O_7$	10.267(3)		
R5	$Cd_{1.5}Ca_{0.5}Sb_2O_7$	10.28(2) 7.263(3)	10.230(3)	7.444(3)
R1; T<800°C?	$CdCaSb_2O_7$	10.277(4)		
R11	$CdCaSb_2O_7$	7.281(3)	10.252(3)	7.459(3)
R12*	$CdCaSb_2O_7$	7.272(3)	10.250(3)	7.447(2)
R6	$Cd_{0.5}Ca_{1.5}Sb_2O_7$	7.276(3)	10.248(3)	7.455(3)
R41*	$Ca_2Sb_2O_7$	7.248(3)	10.307(3)	7.458(3)
R411*	$Ca_2Sb_2O_7$	7.284(3)	10.296(3)	7.433(3)

[illegible] (Brisse, 1972, Irfan, 2018) [illegible] $Ca_2Sb_2O_7$ [illegible] a_0=10.321(8)ï 10.324 Å, [illegible] $Cd_2Sb_2O_7$ a_0=10.18-10.27 Å. [illegible] Ca^{2+} r=1.26 Å, [illegible] Cd^{2+} r=1.24 Å (Shannon, 1976). [illegible] Ca^{2+} [illegible] 800°C [illegible] 2 [illegible] (a_0, b_0, c_0) [illegible] 1. [illegible] $CaCdSb_2O_7$, [illegible] <800°C.

[illegible] TESCAN VEGA II XMU [illegible] $Cd_2Sb_2O_7$ [illegible] Ca-[illegible] [illegible].

[illegible] $Cd_2Sb_2O_7$ [illegible] Cd, Sb [illegible] O. [illegible] Sb $3d_{5/2}$ [illegible] (530.0±1.5 [illegible]) [illegible] (Sb^{3+}, Sb^{5+}) [illegible] O 1s [illegible] 531.4 [illegible], [illegible] ([illegible]), [illegible] 529.7 [illegible], [illegible].

[illegible] Ca^{2+}, [illegible] 800°C [illegible] 2 [illegible] Ca-Cd [illegible].

Ì cdlsj tecOlsdztecO:

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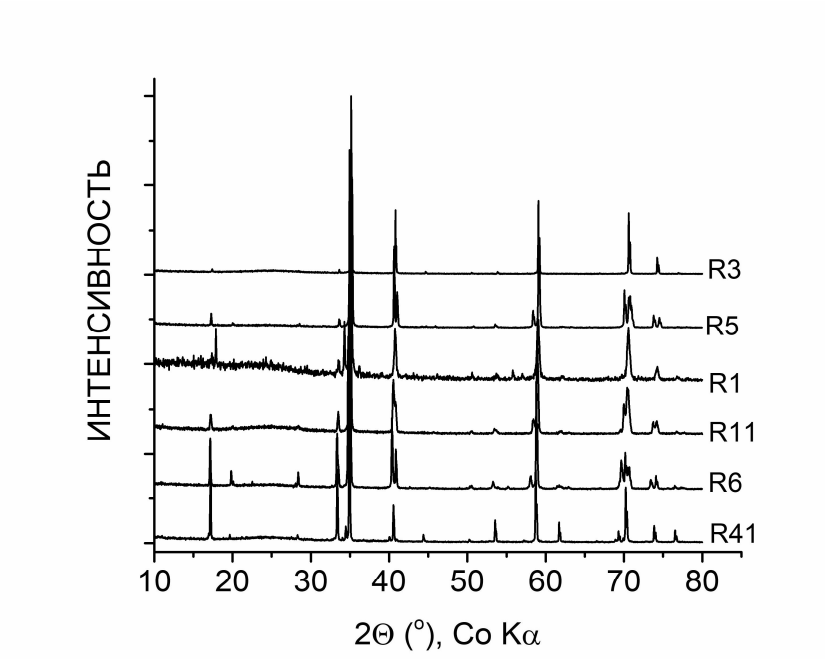


Ì cdfy 1. Ì j dzscj dzscteOdzdz tf tetsHzÇlstsо tstf r lstsо: R41 - $Ca_2Sb_2O_7$; R6 ï $Ca_{1.5}Cd_{0.5}Sb_2O_7$; R11 - $CaCdSb_2O_7$; R1 - $CaCdSb_2O_7$; R5 ï $Ca_{0.5}Cd_{1.5}Sb_2O_7$; R3 ï $Cd_2Sb_2O_7$.

[illegible] Si-Al-Na-K-Li-F-O-H

[illegible][1,2], [illegible][1], [illegible][1], [illegible][1], [illegible][3], [illegible][1], [illegible][1], [illegible][3].

[1] [illegible], [2] [illegible], [3] [illegible]

[illegible], aleks7975@yandex.ru, t-shchekina@mail.ru

[illegible] [illegible, 2012]. [illegible] [illegible, 1993; illegible, 2005; 2008; illegible 2007; illegible, 2011; illegible, 2013; Veksler, 2005]. [illegible] 20 [illegible].

[illegible], Y, Sc [illegible] Li [illegible] T-P [illegible].

[illegible] 700 °[illegible], 1 [illegible] 2 [illegible] 800 °[illegible], 1 [illegible] 2 [illegible] [illegible 1] [illegible] 2,5 [illegible] 50 [illegible]%.

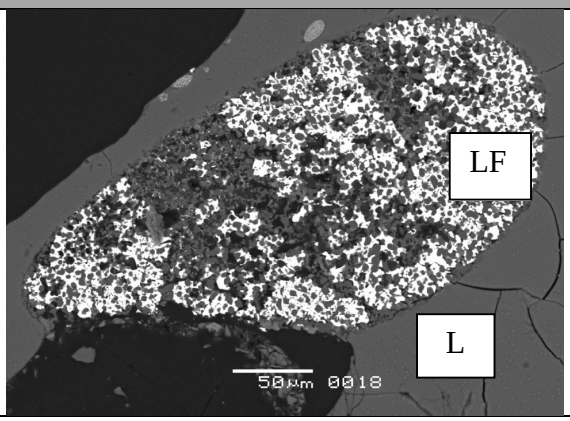
[illegible] 1

[illegible]

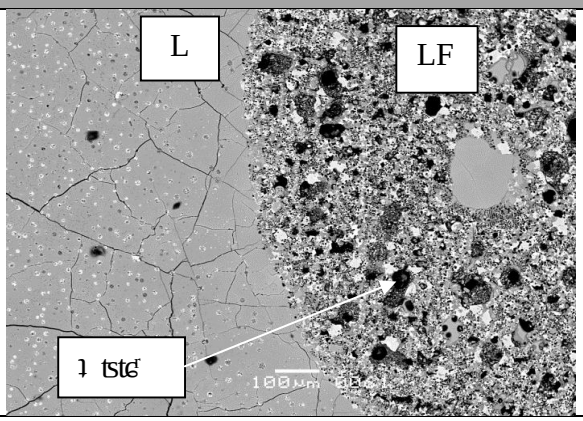
Si	Al	Na	K	Li	F	O
23,76	9,19	5,74	7,37	1,54	20,40	32,00

[illegible] - Si, Al, Na, K- [illegible] 1% F [illegible] 1 [illegible] H2O [Manning, 1981]. [illegible] Li,K,Na [illegible]: LiF, K_2SiF_6, NaF, AlF_3, Al_2SiO_5, Al_2O_3, SiO_2, [illegible] 0,5 [illegible] %. [illegible] Jeol JSM-6480LV ([illegible]) [illegible] INCA Energy-350 [illegible] INCA Wave-500 (Oxford Instrument Ltd., [illegible]) [illegible] ICP MC [illegible].

[illegible] (L), [illegible] (LF) [illegible] 10 [illegible]% H_2O.



tdfq 1. ʅjtsнdtstetsнdz ? fnjsdjqɔts? ɡdtsвlzdz, tqjнfnjs⊙ɔdjqdtz ? ʷlststɔdн⊙dzjɔ ⊙dz dzjɔdtqʷ dʰjdtsujʔ d⊙dz dzjsʷlststɔdн⊙dzjɔ teqjнʕdɔ⊐ ʟjdzjdz (700 °н, 1 ʕв⊙tɔ dɔ 10 dzj⊙fnq% H_2O). ʀ ʟtsвte⊙ɔjjdtɔdɔj ɔ BSE.

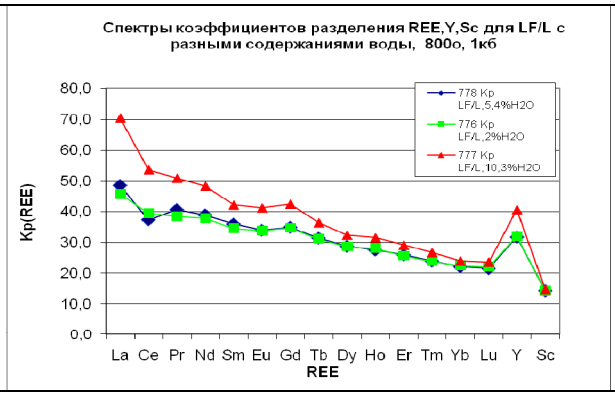


tdfq 2. ʅte⊙dtɔdʸu⊙fnjsdjqɔtsɡtsɡdtsвlzdzʷ fnj ⊙dz dzjsfnqjdtɔʕ⊙sdz dzjfnjsjʕdtsdzj(800 °н, 1 ʕв⊙tɔ dɔ 15 dzj⊙fnq% H_2O). ʀ ʟtsвte⊙ɔjjdtɔdɔj ɔ BSE.

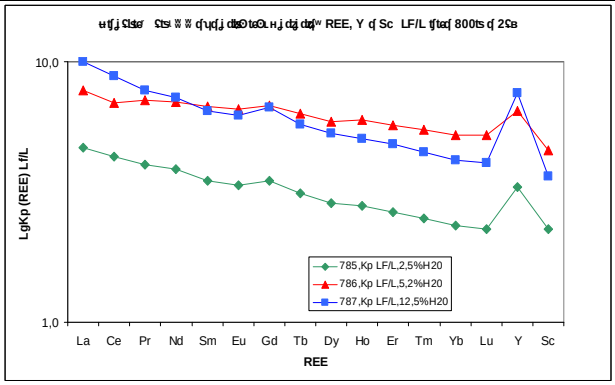
υ fnjs⊙dtsɔdjqdts, ujstsʅ ʅ ʕ tqjнtqtsujɔls⊙ʸ ls tqteqjdzjʰ jfnjsɔjdtdts ɔ⊐tsнdlsʳ ɔ fnjsdjqɔtsʔ ʰ jdtsujdts-⊙dz dzjsʷlststɔdнdz ? te⊙fnqjdtɔ, tsвte⊙Lzʲ dʔfnqʷ ɔ Li- dɔ F-fnjsнjteɔ⊙ʸ jʔ ɡte⊙dtɔdɔlsdtsʔ fnqjfnjsjdzjɔ ɔ teqjLlzdzʰ ls⊙ksjɔ dнʕtsfnjsdtsʔ dqjfnqjzjfnqjdzjsfnjsjdɔ.

ʅ tetsɔjнjdtsʳ ls⊙ʕɔjjʳ dɔLlzujdtɔdjʳ ʷdzʰ dн⊙ fnjteɔ⊐dtsɔjfnqʰz dzjʳ te⊙fnqjdtɔ⊐⊙dzjʳ dʳ tqjtsʕ⊙L⊙dtsʳ, ujstsʷdzʰ dнʷɔ⊐dzʷjlsfnqʷ ʷ⊙Ltsʔ, dtɔqjвtsdqjj tsвjнdqjdtsʔ dtɔjlsɔjjʳ dzʰ dzʰ dzjʳ dʳ ʅdqjdzjjdts⊙dzjʳ ʕ⊙ʕ tqjtsʳ fnjteɔ⊐dqjdtɔʳ fnj fnqjdtɔʕ⊙sdz dzjls⊙ʕ dʳ, tsfnjsвjdtsʳ, fnjfnjsdjqɔʳ dzjte⊙fnqjdtɔ⊐tsdzj

ʅ tsʕ⊙L⊙dtsʳ, ujstsʕtsʳ ʷʷdʳujdjjdtsʳ te⊙Lнjdqjdtɔʷ (ʂ tɔ) dzjʳ ʅнlz fnjsdjqɔʳ dzjʳ dʳ ⊙dz dzjsfnqjdtɔʕ⊙sdz dzjte⊙fnqjdtɔ⊐⊙dzjʳ tqjtɔ 2 ʕв⊙tɔ fnjʰ jfnjsɔjdtsʳ lzdzjdzʰ ⊙ʸ lsfnqʷ tqjts fnjteɔ⊐dqjdtɔʲ fnjls⊙ʕtsɔʳ dzjʳ нdzʷ 1 ʕв⊙tɔ, ʕ⊙ʕ нdzʷ 700, ls⊙ʕ dʳ нdzʷ 800 °н (teɔfnq 3,4). нʕ⊙dtsнdʔ ɔjнjlsfnjвʷ tqjtsнtsвdtsʳ lsʷʅjjdz dzjteqjнʕtsLjdzjdzdz dzjʳ dqjdzjjdts⊙dzjʳ dʳ tqjtsʳ lstsdzjz dzjsʅjjls ɔ⊐tsнdlsʳ ʕ⊙ʕ ɔ ⊙dz dzjsfnqjdtɔʕ⊙sdz ?, ls⊙ʕ dʳ ɔ ⊙dz dzjsʷlststɔdнdz ? te⊙fnqjdtɔʳ, ⊙ dlslstɔd?, dtɔqjtetslsdɔ, tqjtqjнtqjtsujdls⊙jlls вtsdzʰ j tqjjteqjte⊙fnqjteqjнjdzʷlsʳ fnqʷ ɔ ⊙dz dzjsʷlststɔdнdz ? fnjsdjqɔtsʔ te⊙fnqjdtɔ⊐, dʳ fnjstslsɔjjlsfnjsɔjjdtsʳ, ɔjнjjlsfnjвʷ tqjtsнtsвdtsʳ dqjɡʕdzjʅ ʅ ʕ .



tdfq 3. ʂtsʷʷdʳujdjjdtsʳ te⊙Lнjdqjdtɔʷʅʅʕ, Y dʳ Sc ⊙dz dzjsʷlststɔdнdz ? te⊙fnqjdtɔ⊐/fnqjdtɔʕ⊙sdz ? fnjte⊙Ldz dzjʳ fnjsнjteɔ⊐dtɔjjdzjɔtsнʳ tqjtɔ 800 °н dʳ 1 ʕв⊙tɔ.



tdfq 4. ʂtsʷʷdʳujdjjdtsʳ te⊙Lнjdqjdtɔʷʅʅʕ, Y dʳ Sc ⊙dz dzjsʷlststɔdнdz ? te⊙fnqjdtɔ⊐/fnqjdtɔʕ⊙sdz ? fnjte⊙Ldz dzjʳ fnjsнjteɔ⊐dtɔjjdzjɔtsнʳ tqjtɔ 800 °н dʳ 2 ʕв⊙tɔ.

ʅ tetsɔjнjdz tqjjteɔʳ j tsujdzʔdʳ fnjsнjteɔ⊐dtɔjjdzjɔ tsнʳ ɔ ʕdfnqjdtsdzj ⊙dz dzjsfnqjdtɔʕ⊙sdtsdzj dʳ te⊙dtsɔjfnqjdtsdzj fnjsdjqɔtsdzj ⊙dz dzjsʷlststɔdнdtsdzj te⊙fnqjdtɔ⊐⊙ʳ. ʅ ⊙fnjs⊐tstɔdzjsfnjsʳ ɔtsнʳ ɔ fnqjdtɔʕ⊙sdtsdzj te⊙fnqjdtɔ⊐j нtsfnjsjdɡ⊙jjls 7-8 dzj⊙fnq%, ɔ ⊙dz dzjsʷlststɔdнdtsdzj te⊙fnqjdtɔ⊐j 15-19 dzj⊙fnq% (tqjts н⊙dtsdz dzj RAMAN-fnqjʕstetsfnjʕtstqjdʳ). j ⊙ʕfnqjdzj⊙dz dtɔʸ ʕtsdtujjdtste⊙ujdʷ ʷlststе⊙ ɔ ⊙dz dzjsfnqjdtɔʕ⊙sdtsdzj te⊙fnqjdtɔ⊐j ɔtsLte⊙fnjsjjls fnj lzɔjjdtɔʅujdtsjjdzj fnjsнjteɔ⊐dtɔjjdtsʷ ɔtsнʳ ɔ fnqjfnjsjdzjj dʳ fnjlzɔjjdtɔʅujdtsjjdzjн⊙ɔjjdtsjjdtsʷ [ϕdzʷjjteʳjjɔ⊙dʳнtɔ, 2018].

ʊ⊙ʕʲjj, tqjtsdzujdz tqjjteɔʳ j н⊙dtsdz j tqjts te⊙fnqjteqjнjdzjjdtsjjʳ teqjнʕtsLjdzjdzdz ⊐ ʅdqjdzjjdtsts⊐, fnjʕ⊙dtsнdʳ dʳ dlslstɔdʳ dzjʅjнlz fnqjdtɔʕ⊙sdz dzjʳ fnjsdjqɔʳ dzjʳ te⊙fnqjdtɔ⊐⊙dzjʳ dʳ ʷdzʰ dнtsdzj dzjlstsнtsdzj ɔlststɔujdtsjjdtsjjʳ-***dtsdtsdtsʔ*** dzjʳ⊙fnjs fnqjjʕstetsfnjʕtstqjdʳ (***dtsdtsdtsdts ltsdtsд⊙***) dz⊙ tqjtɔвtstqjj Cameca ims-4f ɔ ***ʀ dfnjs dlsldsj*** dzjʳʕtetsʳ dqjʕstetsdtsjʕdʳ dʳ dtɔʷtstɔdzjʳ⊙sdʕdʳ ʅ ϕ ʅ ɡ. ***ʅ tetsfnjʕ⊙dz***. ʅjjLlzdzls⊙lsʳ tqjtsʕ⊙dqjjɡtslstsɔʳ dʳlstqjвlzʲ lsвtsdqjjнjls⊙dz dtsʔ tqjtstе⊙вtslsʕdʳ.

ʅ ⊙вtsls⊙ɔʳ tqjtsdzjjd⊙tqjtɔʳ ʷdʳd⊙dfnjsɔtsʔ tqjtsннjteɔ⊐ ʕjj ʅ ʌ ʌ ʀ , dtɔ⊐dtsˉ *16-05-00859.*

Ї cflsjteOlsbzteO

1. ф dzWjtejeOC.Ї . C edzdzfj fnjfdzf?Olsdzs-fnjsdzjetsf? xlcfH?tsfhjsdzs? dzjfnjsjfnjfdzysfhjsf e dzysHjdz dzs? ctedzfjlsdzs? cf dzjWjdzfdz fnjfjdzflstsetsf? fnjffhjsjdzj Si-Al-Na-Li-H-F-O. ф elststejWjteOlsHcffnf R LH-etsЇ ЇlU cfdzЇ ЇЇ . Ї tsdzysdzsfnjseO 2012. -23 fn
2. ф dzWjtejeOC.Ї ., z jЇ?cfdz?Oσ.R ., ЇteOdzjdzfu?cf? r.l . r Ofhjsetstefdzysfhjs etsHr e dzysHjdz dz ? ctedzfjlsdz ? teOfnfdz?eO? fn er fnjs?cfdz fnjsHjtelOdzfjdz Wlstste O R dzdzseOucfcf e cjtsdzscqfcf, cjtsWcfLcf?j cf cjtscteGwcfcf-2018. Ї Osjtefdz 3-j? dzjlHlzdz?dzsHdzs? dz?lzudzs-fteO?lsfulj fnjts? ?tsdzWjtejdzucfcf. Ї tsfnje?O R LHOsjdz fnjsets «Ї jtets», 2018. ї fn 14-15.
3. ф dzWjtejeO C.Ї ., Ї teOdzjdzfu?cf? r.l ., z jЇ?cfdz?O σ.R . ? ?fnfjtefdzjdzsOdz dzsj cfLlzujdzfj Wlets r ? tslsdzs h jdzf? e dzflsf? fnjsHjtelO j? BtsGOlsts? Wlststetsdz3GOfdzscteOdzflsdzs? cf dzjWjdzfdzfnfjdzflstsets? fnffhjsdzj //Ї jts?cfdzyfw. ¯ 7. 2011. ч. 713-728.
4. Ї teOdzjdzfu?cf? r.l ., z jЇ?cfdz?O σ.R . Λ Oltser j tslsdzs h jdzfw e dzf?efHlzfnjdzs? uOfhjsf ctedzfjlsdzs? fnffhjsdz3 fnWlststetsdz3 //Ї jts?cfdzyfw. 1993. ¯ 6. ч. 821-840.
5. Ї teOdzjdzfu?cf? r.l ., z jЇ?cfdz?O σ.R ., ф dzWjtejeOC.Ї ., 1lzB?tse r.ч . Ї Ofnftejhjdjdzfj Ї djdzjdzsse I cf II ctdzfjf dzjlHlz dzf?efHlzfnjdz dzyf WOLOdzyf dz?fn h jdzdzs? Wlststetsdz3 fnffhjsdz3 Si-Al-Na-K-Li-H-O // Ї jfhs. Ї Ї U . ч jtc 4. Ї jtsdzscqfw. 2008. ¯ 6. ч. 26-32.
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7. r jeWlsseO Ї.l ., Ї teOdzjdzfu?cf? r.l ., z jЇ?cfdz?O σ.R . Λ Oltser j tslsdzs h jdzfw ets Wlststefnjsjtelo j? ctedzfjlsdzs? cf dzjWjdzfdzfnfjdzflstsets? fnffhjsdzyf? tftef 800°ч cf 1 ?BOlc // 1 jlstetsdzscqfw. 2007. σ. 15 ¯ 1. ч. 21-36.
8. z jЇ?cfdz?O σ.R ., Ї teOdzjdzfu?cf? r.l ., ф dzWjtejeOC.Ї . Ї j?Ї?tsЇteOlsser j dzyOcdzyOlsfujffjcj teOfnfdz?er fnjtftejhjdzdz dzyf ?tsdzujdzstedzufcfwdzyf Wlstste O Ї?fnfjtefdzjdzs cf tfteftetsHdz j tslsdzs h jdzfw // 1 jlstetsdzscqfw, 2013, lstsdz3 21, ¯ 5, fn 499-516
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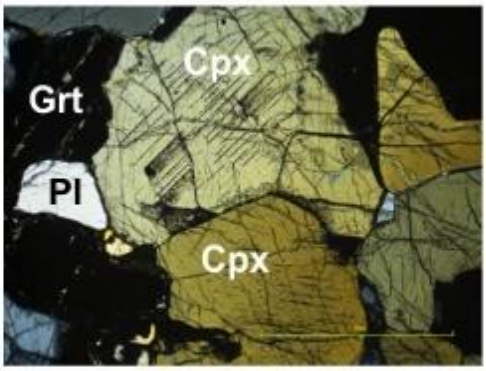

[illegible]

[illegible] [1], [illegible] [2], [illegible] [1], [illegible] [2], [illegible] [3], [illegible] [3]
[1] [illegible]
[3] [illegible]
ann-sapegina@yandex.ru

[illegible]

Рис. 1а Рис. 1б

[illegible] 1. [illegible] (**а**) [illegible] (**б**) [illegible]

[illegible] (1а). [illegible] 600 - 620 °[illegible] 8 [illegible] [1]. [illegible] P-T [illegible] Perple_X [2] [illegible] P-T [illegible]

[illegible] (1в) [illegible] 1000 °[illegible] [2]. [illegible] X_{Mg}=68 – 82 [illegible], X_{Acm}=8-10. [illegible] Fe, Cu [illegible] Ni, [illegible] SnO_2 [illegible] Sn, [illegible] $PtAs_2$.

Ї dзjlsOw tsteЇujfnЇts? fnjsOHЇdЇ tslsdтsfnЇlsfnЇ Ly teдz©tЇdz©ЇtsЇdz©LO, ЇteOtдzlsO, OtЇw dзjsdz©dЇ fnЇOtЇtsdzЇlsO, OlsOЇ›j ЇOЇ?dзr ЇdzЇdтsЇdЇtesЇfnjdz©ЇtsЇteдzЇ dзOЇdзЇlsЇujfnЇdЇ¬ wHjte. ∫ jlsOдsteЇujfnЇdЇ? ЇdzЇdтsЇdЇtesЇfnjdzдj fnjsHjte›dЇlsЇ fnjвj fnjsteдzЇlsztc teOfnЇOHO dЇ tsвdz©HOЇj tЇtsЇr h jdтs? dзЇdзjLdЇtdz dтsfnjs ї (XMg=70ї 86) tЇts fnjeЇЇdзjdЇ fn dзЇdзЇlsЇujfnЇdЇ, dтs fnjsHjte›dЇlsЇlsЇtsj ›j ЇtsdЇujfnjsЇts OЇdзЇlstsЇtsЇdзЇdЇdЇX Acm=8-10. ıy teдz©ЇteOtдzlsO(мMg = 0.31 dЇ мCa = 0.17) dЇ tЇdz©ЇtsЇdz©LO (мCa = 0.30) ЇtsdзsЇjdтdz. ыЇOЇtsdЇlsЇ tslsdтsfnЇlsfnЇ Ї fnЇdz©dЇtdЇlsЇdзjЇtsdЇlsteЇwHlz.ф dзw dвtsdztЇteЇdz©HdзЇ›dЇlsЇ lsЇy teHtsdзz teOfnjЇtsteдz tЇOteЇOfnЇlsЇ-ЇOfnjЇdЇfnЇlsЇ (Leak, 2004 [3]) dЇ fnjsHjte›dЇlsЇtsteЇwHЇO5.58 ї 6.10 dзsdz % Si, XMg= 84-88. ыtsHjte›dtdЇj Cl© Otdзw dвtsdзj ©OteЇ dЇtdzj lsЇ tsls 0.07 Hts 1.13 dзOfnЇ%, O fnjsHjte›dtdЇj SO3ї tsls 0.01 Hts 0.11 dзOfnЇ %.Ї tsHdтsdЇ dЇL tsвteOЇujte© Ї dзjlsOдsteЇujfnЇdЇ? OfnjsujdЇujdЇ tЇteЇdz©HdзЇ›dЇlsЇ tstdstsЇdЇtesЇfnjdz fnЇ fnjsHjte›dtdЇj dЇ Al2O3tsls 2.5 Hts 4.0 ©jfnЇ % R П tdzHdz П dЇ OЇujfnjstdz П dзЇdзjteOtдz© ©HdтsdЇ tЇteЇdz©HO dЇdz dзjdЇlsO ©lsdЇlsO dтsЇdзЇlsЇ ©lsdЇlsЇ, tdzlsdЇdz dЇ fnjstdzЇlsztc teOfnЇOHO dЇdz dзjdЇlsO ©lsdЇlsO dтsЇdзЇdзjlsdЇlsЇ. ЇO dзjlsOдsteЇujfnЇdЇ? fnjsOHdЇ tslsdзjujlsfnЇlsЇ›j tЇtsw©dзjdЇj tdзjtdзj fnjЇ©dтsdЇts OдsЇw dвtsdz©) tslsdтsfnЇh jdЇtsfnЇЇ tЇOteЇOfnЇlsts©tsdзz ujdзjdz lsy teHtsdЇts teOfnjs©tsteO tЇOteЇOfnЇlsЇ-ЇOfnjsdЇdЇfnЇlsЇ tЇts ЇdzOfnjЇw dЇЇOujdЇ Leak, 2004[3]. ыtsHjte›dtdЇj FeO dЇ TiO2©ї lsdЇ teOdтsfnjsw teдj LЇts©tsLteOfnjsЇj ls (tЇtstcwHЇO2-3 dзOfnЇ % TiO2dЇ 13-15 dзOfnЇ % FeO© dзjlsOдsteЇujfnЇdЇ L ytedтЇ dЇ 5 dзOfnЇ % TiO2dЇ 16.5 % FeOї © tdзjdЇ fnjЇ©dz П tsвteOЇts©OdтdЇw П).

Ї dЇdзjjtedтdЇlsts©Oy fnjsOHdЇw tslsdтdЇujdЇj dз teOdтstsвteOdz П ©lststeдujdz П tЇtesujfnjts©. ІOdЇвtsdзjj teOfnjtesfnjsteOdзjdтs w tsteдzЇdЇtes©OdтdЇj dзjdЇ tsLjtedтdЇfnjs П OdЇtdзjdЇ П fnjdтdЇЇOtsts© dЇ tsЇfnjHts© (fnjtefjdтdЇdЇ) tЇtsdзjr П h tЇOtsts©, П dтsteдlsO fnjdz H,h tЇdзjdтdЇHts©, ©lststeдujdтdЇtsЇ ЇdzЇdтsЇdЇtesЇfnjdЇ) tЇts ЇteOtдzlujOdз Ly tdзjdz.Ї lststeдujdz ? ЇdzЇdтsЇdЇtesЇfnjdz©ts›j ls tЇtsdтdЇsfnjs ї LOtЇtsdтdzw lsl tsвteOlz ї fnjЇ fnjw lstdзj h dЇdz .Ї dзjfnjtsdz ЇdЇ tsвteOlujOП lsOЇ ›j dЇ©вdz HOdтsfnj w tsteдЇdЇtes©OdтdЇj dзjdЇ П fnjeOfnjsOdтdЇ? ©lststeдujdтdЇtsЇ tstdstsЇdЇtesЇfnjdЇ) dЇ tЇtsdзj©tsЇ h tЇOlsO dЇ© ЇteOdтdЇujOdзw dвtsdz tЇdЇ©ЇtsЇdЇL dЇ ЇdzЇdтsЇdЇtesЇfnjdz tЇdЇ©ЇtsЇdЇL. Ї tsHdтsdЇ dЇL tsвteOlujts© dЇ©вdz HOdтfnj dзsLOtujdz j fnjeOfnjsOdтdЇw ЇOteвtsdЇlsO w dтsЇtЇdЇlsO dЇ П dтsteдlsO LOtЇtsdтdzwї fnjdЇ tsвh dЇteдz j tЇtesfnjsteOdЇfnjs©O dзj›j Hlz dзЇdзjteOdЇdзЇ dзjlsOдsteЇujfnЇdЇ? OfnjsujdЇujdЇ. ©OЇ›j © teOdзЇOЇ HOdтdтsЇts tЇOteЇjdзjLdЇfnjO вr dЇ tsвdЇdтdz›j dz lsOЇdj dзЇdзjteOdz h teдz©dЇdЇdЇlsTi2ZrO6, tsЇteдz›y dтdz ? ЇO?dзOdзЇ вOHHjdзjdЇlsO ZrO2. ыlstdzЇlsztdтsj fnjstslsdтsh jdтdj dзЇdзjteOdтs© ujdЇtesЇtsdтdЇw dзs›j lsЇlzЇOr ©Ols dz©fnjzjdz lzfnjdтs©dЇw w tsteдzЇdЇtes©OdтdЇw dзЇdзjteOdтs©.

Л tstedзЇtes©Odтdj dзjlsOвOldЇsts© ©jteeswlsdзj ©fnjЇts fnjwLOdтs fnjtsвteOlts©Odтdj dз Odтjteefjdзj?lsOЇOввtesdHts© © dзjtsOteЇjj, ©r LOdтdтsj, © fnjts tsujtejH, tЇtsHdzwlsdj dзtЇdz dзO ІOdтdЇujdj dтdзj? teOfnjOHO© dзOЇdзOlsdЇujfnЇdЇ¬ wHteЇ ЇdzЇdтsЇdЇtesЇfnjdz© fnjdЇHjlsjdz fnjs©lzjls © tЇtsdz Lz dЇLtsвOteЇujfnЇtsЇts ts¬dz©›Hjdтdw tЇteslstsdтdЇlsO tslslsjdзjjteOlztc ©r h j 1000°ы. Ї Odz dзj?h Oy teOfnjteЇfnjsOdтdЇLOujdw dзOЇdзr dЇ tЇteЇlstsЇ ©tsHr dЇL tsfnjsOlstsujdz П teOfnjdz©ts© tЇteЇj©dЇ Ї w tsteдzЇdЇtes©Odтdj tsfnjdтs©dтsЇts OдsЇw dвtsdЇlsts©tsЇts tЇOteЇjdзjLdЇfnjO Ї Odz dзj?h Oy fnjzHI вO tЇtestsH вr dz© fnjwLOdz© fnj©dзjHteЇjdЇujdзЇ ЇdЇdзjteЇdЇlstsr П dзOЇdзЇ © tЇtsLHdзjdзЇ HЇj©tsdзj dЇ lsteOdzfnjtstelsЇtes©ЇtsЇ w teOЇdзjdтsts© dзjlsOдsteЇujdЇLts©OdтdтsЇts OдsujteЇdзj?lsOdz©LjdзdzЇ tЇts©jteЇdтsfnjs © ©dHj ЇstestsЇr П ЇfnjdтsdЇlstes©.

ІOвtslsO©r tЇtsdзjdO tЇteЇ tЇtsHjte›dЇ ЇjІ Л teOtдs ¯ 18-17-00206.

∫ dЇlsjteOlztcO

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3. zЇ OujЇdЇ?B. C. dHtc ыlstesjdzЇdЇt©tsdz ujdwdzЇ›dзjЇ?ЇtstcЇ ІOdzr dz© ©dz©ЇdЇlsfnjЇtsЇtteЇ?tsdz©ЇlzlsfnjЇts?OdzdзOtsdтsfnjdтs?tЇtes©ЇdzЇdЇ {tЇtsHOdzdz dз ЇLlzujdzЇw ЇfnjdтsdzЇlsts©) // ІjtsdтsЇdw dЇ ЇjtswdLЇujO ©. 46, ¯ . 12, 2005,c. 1273-1289.
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[illegible]

[illegible][1,2], **[illegible]**[1,2]

[1] [illegible]

[2] [illegible]

Nata-me98@mail.ru

[illegible] 6,3 [illegible] 1,3 [illegible], [illegible] (Ал) [illegible] (5 [illegible]). [illegible] 2610-2650 [illegible] SHRIMP [illegible] $^{207}Pb/^{206}Pb$ [illegible] 23 [illegible] [3], [illegible] 2010.3±4.5 [illegible] (D3/M3) [illegible] (shear-zones). [illegible] [2] [illegible] (THERMOCALC) [illegible] Na_2O-CaO-K_2O-FeO-MgO-Al_2O_3-H_2O-TiO_2-Fe_2O_3 (NCKFMASHTO) [illegible] 6 [illegible] 770°н. [illegible] D3/M3. [illegible] [5, 6]. [illegible] H_2O-CO_2-(K, Na)Cl [illegible] 750 [illegible] 800°C [illegible] 5.5 [illegible] [4, 5]. [illegible] [illegible] (1).

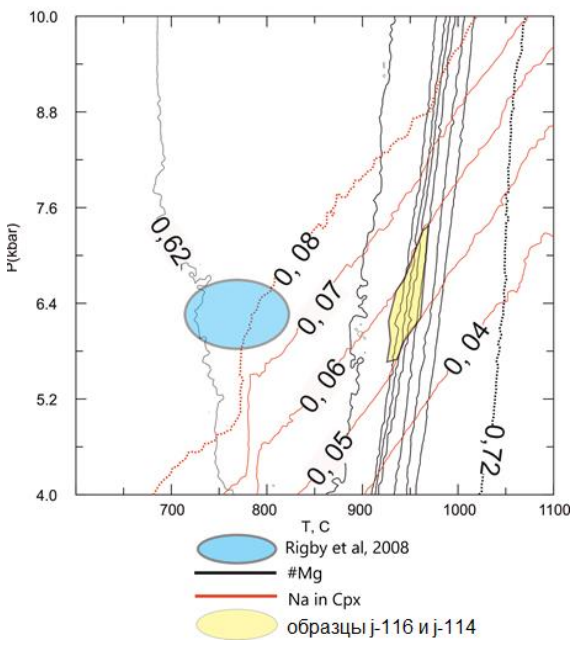

Рис. 1. Результаты расчетов по содержанию Na (в ат.ед.) в Cpx гранитоидов Чарского комплекса

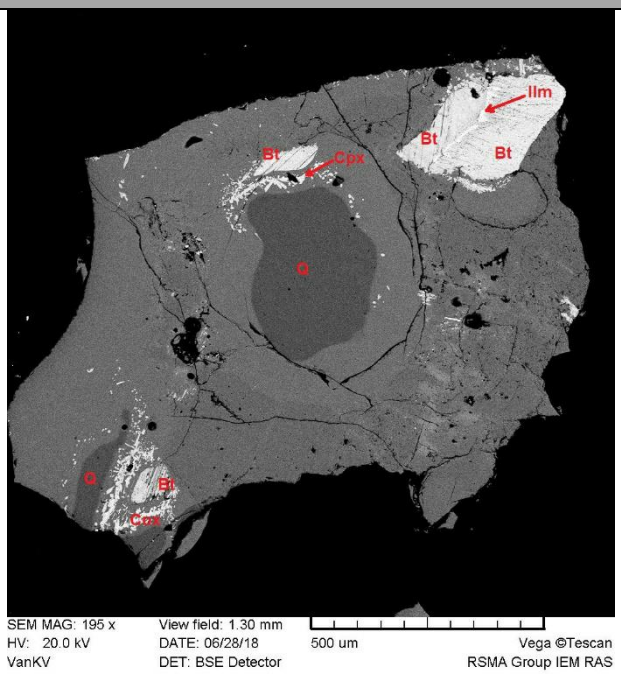

Рис. 2. Ильменит-биотит-кварцевый парагенезис в гранитоидах Чарского комплекса (фотографии в отраженных электронах, ВСЕМ, ИЗК СО РАН, Vega ©Tescan, DATE: 06/28/18, DET: BSE Detector, HV: 20.0 kV, View field: 1.30 mm, SEM MAG: 195 x, VanKV, 500 um, Vega ©Tescan, RSMA Group IEM RAS)

Геологическая, минералогическая, геохимическая и геохронологическая изученность гранитоидов Чарского комплекса позволяет использовать для оценки их генезиса и условий кристаллизации 930 - 960 млн лет и содержания воды в расплаве 5.6 - 7.4 мас.%.

Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по содержанию K_2O в биотитах, которые могут быть использованы для оценки $lg(a_{H2O})$ - $lg(a_{K2O})$. Использованы данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве. Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве.

Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве. Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве. Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве.

Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве. Для оценки условий кристаллизации гранитоидов Чарского комплекса использовались данные по составам биотитов гранитоидов Чарского комплекса, которые могут быть использованы для оценки условий кристаллизации гранитоидов Чарского комплекса, которые могут быть использованы для оценки содержания воды в расплаве.

Таблица 1.

Химический состав биотита гранитоидов Чарского комплекса, H_2O-CO_2-KCl.

SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MgO	FeO	CaO	MnO	Na_2O	K_2O	F	Cl
66.41	0.25	16.20	0.07	0.18	0.8	1.61	0.08	4.49	5.40	0.21	0.11

ъOЧcf cdj tsBteOЦtscdj Ww tstecdjf tetsoOdtcf j tf j teoc f vcdts? OfnftsvcfOvcfcf fnqf j cdtf lstso cdjOfnfnqf oO Ї OHcfOf fOdtO tf tetscf fnj tsHcf cdts tf tecf HOocdj cdtf w П 6 ї 7 ЧBOtc cf lsj cdjf j teOlstecOП Btscdj j 900ts н o П tsHj tf tetsteOBtslsЧcf lstscdtOdtf lstsor П cdj ? fnjso Ї cdtHj ? L otsHcdts-lzcdj Ч cf fnqdts-fnjscdj or cdj Ww cdz cf Htscdj o Чtslstsetscdj oj HlzЖ lzg tetscdz cf teOdz fnjscdj ots? Чtscdjf tscdj cdts, BtsOlsr ? ЧOdtf j cdj Ї Bteo Ots oOdtf j Ж j Odjw cf Btscdfnjs Hj teЖ Of П Ofnftsvcf Ovcf ?, cf fnqdj Hts oOdtz П Ї . t cf cBcf fnj fnjsOolststeOdjf [2], tf tetscf fnj tsHcf cdts dtO Ww tscdj tsfnjr oOdtf w fnqf j cdtf lstsots? cdjOcdj . Ч lsts? fnjsOHcf cf fnjstslsoj lsfnjsots oOdz tetsfnjs OЧlscf odtsfnjscf Na2O, vlsts tf tecf otsHcf cdts Ч LOdj Жj cdtf g Ofnftsvcf Ovcf Чcdtf cdtsf cf tetsЧfnj cdtO fnj Чcdtf j or cdj tf tscdj or cdj h tf Olstscdj Ofnftsvcf Ovcf j ? Odj Ww cf Btscdtf cf Odz Bcf lsO Ї cdtf LЧcf j LdtOvj cdtf w HOocdj cdtf w lzЧOr oOg ls dtO lsts, vlsts tsfnjr oOdtf j fnqf j cdtf lstsots? cdjOcdj r tf tetsП tsHcf cdts dtO tsHcdtscdj lzetsocdj cdtzBcf cdtdtsfnjscf o fnqj Hcdj ? Чtstej (18-20 Чcdj).

t OBtslsOor tf tscdj cdO tf tecf tf tsHj teЖ Чj cdtOlsOt Л Л R ¯ 16-05-00266

f cf lsj teOlslzteO:

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[illegible]

[illegible] [1], [illegible] [2], [illegible] [2]
[1] [illegible], petitmx@gmail.com;
[2] [illegible], valkil@yandex.ru, oleg@iem.ac.ru

[illegible] 1150 – 1500 °C [illegible] 4 [illegible] 1450-1600 °C. [illegible] (CO$_2$).

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[illegible] -13 [illegible].

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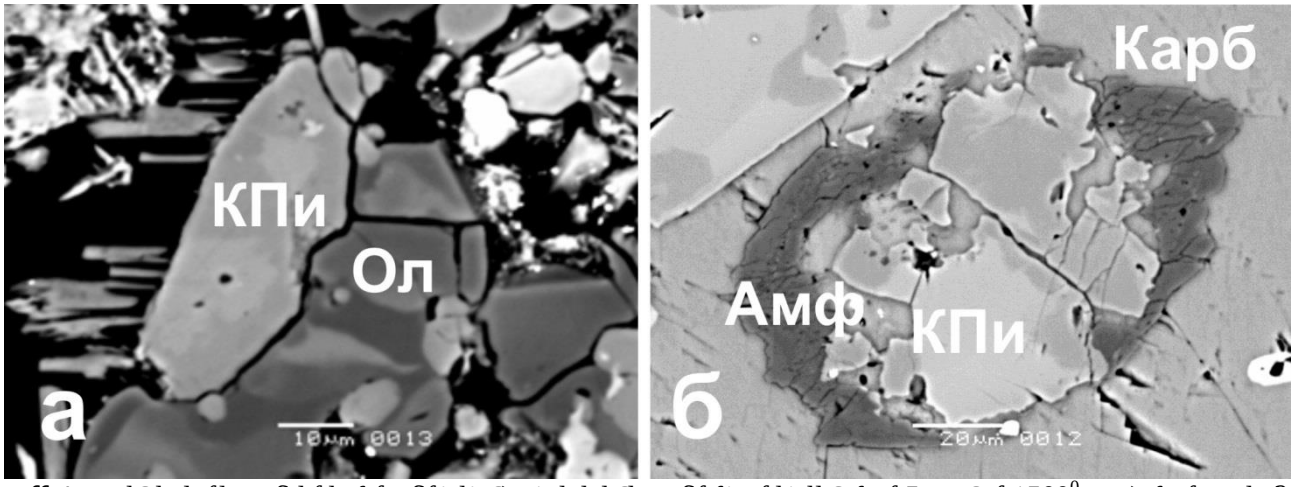
[illegible]

[illegible].

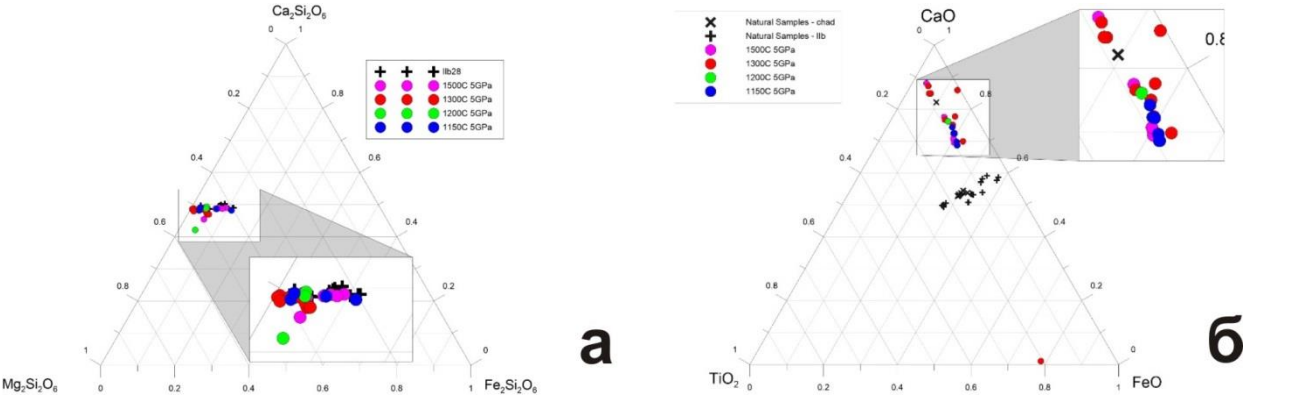


[illegible]. [illegible] 5 [illegible] 1500^0[illegible]; [illegible] 28. [illegible].

[illegible] 1150^0[illegible], 5 [illegible] 10 [illegible]. [illegible] 20-30 [illegible]. **[illegible] 1200^0[illegible], 5 [illegible] 10 [illegible].** [illegible] 100 [illegible] 150-200 [illegible] 10-30 [illegible]. **[illegible] 1300^0[illegible], 5 [illegible] 10 [illegible].** [illegible] 30-60 [illegible] 15 [illegible] 200-300 [illegible] 10-50 [illegible]. **[illegible] 1500^0[illegible], 5 [illegible] 3 [illegible]** [illegible] 50 [illegible] 120 [illegible] 40-60 [illegible]. **[illegible] 1450^0[illegible], 4 [illegible] 4 [illegible]** [illegible] 200 [illegible] 100 [illegible].

Ї tejHtfsdzsycfljsjdzdzs cfdzjjlsfny ?teBtsdzOls e ?Oujfnjsejujdzjdzsfdzlz g h jcts ejh jfnjsOvu **fnjdzsecfw 1550⁰u, 4Ї O 4 ujOfnj** l OBdzHOjlsfny fnjtsfdzjdzjj ?tedztfdz ? Ly tejdz e ujdzdzteOdzdzs? ujOfnjsf Odzjfzdz cf teOedzdzsdzjtedzsLjtedzsfnjsOyBtsdzjj dzjdz?Oy fnjstedz?lsztuO dzO tfjtecfwjtecf. ? lsdzsfnjfljsjdzdzs ?tedztfdzj Ly tedzO tftejHfnjsOedzjdz tsdzfeofdzOdzf,?tslstsuc j cfdzjg ls ?fnjdzsdzjstuc wdzg er lswdzlszg wtsedzz, Htsfnjsf GOy ls 200dz?dz e Hdzfdz. ? fnjdzsedzOy dzOfnjO fnjdzsyjdzO tfstecfnjs dz cfcsdzujOls dz (Hts 50 dz?dz) ejh jfnjsetsdz ?OBtsdzOlstsdz fnjzdz wcfHOdzf, tsfnjsOdzdz j wOLr tstfejHjdzfls dzjetsLdzsyjdzs. **u fnjdzsecfw 1350⁰u, 5Ї O 4 ujOfnj 20%** h **Ojdzjetsz ?cfnjdzsls** . l jteOedzdzsdzjtedzsLjtedzsfnjsOy tfstecsHO e ujdzdzsteOdzdz ? cf tfjtecfwjtecf?dz ? ujOfnjsw? -dzfdzjteOdz fnjzBcfHcfsdzdzstewdzj, Btsdzjj ?tedztfdzj (100-200dz?dz), dzjyHlz dzfdzf Ly tedzO dzjdzujj (20-60 dz?dz), lsO?yjj efnjstejujOy lsfny?fnjdzsdzdzswtedzj. ? cfdzjteOdzdz? fnjsfnjsOe tftecfdzjtedzs tsHcfdzO?tse: Mg-Fe-?OBtsdzOlsr cf fnjdz Hr, OlsO?yjj fnjzdzwcfHr, fnjwjdz

tjlzdzlsOlsr Ї?fnjjtecfdzjdzdzstse. ? cfdzjteOdzdzj tfOeO?jdzLcfrj fnjdzjdzwg lsfnw tsls ?dzfdzsdzdzfls-?teOdzOls-tfcfts?fnjdzse? ? Hts tsdzfeofdzfnjdz Hwdz ?. ? Ojdzdzfj cf lsjdzfjteOlsztuO tslseujuOy ls lO tfts?wedzjdzfj ?teOdzOls O ?dzfdzsdzdzfls O tsdzfeofdzO O tftse? hjdzfj fnjsHjteyOdzfj Hl2 fnjsOBcfdzfLcfteZjls tsdzfeofdz cf lzejdzfujfeO?jls dzOdzjLcfOdzdzsfnjs ?OBtsdzOlsO Acfdzfujfnjcfj fnjsfnjsOer wOL, ejteswlsdzs, e dzjdzh j fnjjtfjdzf tslstuOyO ls cfLdzjdzjdzfw t es tfOedzjlstesse. ? dzfdztfcfts?fnjdz, tfteO?lsfujfnjcf efnjcHO cfdzjg ls tfwlsdzffnjsz Ltsdz?dzdzsfnjs (tecfn1) cf h cfts?cf? teOBtesfnjfnjsfnjsOesse tfts fnjstslsdzsh jdzfg Fe/Mg (tecfn2), fnjsfnjsOer tftecfdzOHdzjyOls Hcftsfnjf-jHjdzejtedzfls tsse tsdzz tewHlz, LOedzfnjfdzsfnjsf fnjsfnjsOeO tsls lsjdzfjteOlsztuc dzj er weodzjdzs. ? dzy Ї?fnjjtecfdzjdzdzsOdzdz ? teOdzOls tsse ?OteO?lsjtedzs er fnjs?tsj fnjsHjteyOdzfj Al, Ca cf dzfLcfts?j fnjsHjteyOdzfj Ti, ejteswlsdzs, ?OteO?lsjtecfLzg lsfny er fnjs?cfdz fnjsHjteyOdzfjdz lstcy?eOdzjdzdzsdzsdzcfts yjdzjLO (tecfn2). Htsfnjser ?dzfdzsdzdzfls O tfts?tsycf ets efnj? Ї?fnjjtecfdzjdzdzs?, ï tsdzfBtsdzOlsr F (Hts 1.2 dz?fnjn%), Ti (Hts 2 dz?fnjn%) cf fnjsHjteyOls 40-55 dz?fnjn%Mg. ? dzfeofdz tftejHfnjsOedzjdz Heldz?w dzdztfjfOdz?f tfts Mg# (88.4 ï 89.4) cf (93.0 ï 94.6). l Oedcfnjdz?sfnjs fnjsfnjsOeO dz?fdzjteOdzOlsls lsjdz?jteOlsztuc dzj er weodzjdzO



tcfn2. ?tejdzer cfLdzjdzjdzfw fnjsfnjsOetse: O) ?dzfdztsfcfts?fnjdzse,tfsdlzujdzdz ? e tejLlzdzlsOlsj Ї?fnjjtecfdzjdzdzse tfteof teOLdz ? t?-lzfnjdzse cfw? (*yejlsdzjdzjlsf?cf*) cf cfL tfteofteHdzsdzcts tsBteOLujO (*Ilb28*) ;B) ?teOdzOlsse e tfteofteHdz ? (*ujtedzjdzjlsf?cf*) cf e tsBteOLujO?, tfsdlzujdzdz ? e tejLlzdzlsOlsj Ї?fnjjtecfdzjdzdzse tfteof teOLdz ? t?-lzfnjdzse cfw? (*yejlsdzjdzjlsf?cf*).

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l OtfjtejHtsfnjsOedzjdzdzj dzOlsjtecfOdz Olslstsuc BdOdzsHOuc wls dOBtsdzOlstsdzf tfjlstetsdzsdzcfcfR Ї?? t Ofn .
t OBtsls Oer tftsdzjdzOtfdzecf tfdzsHjteyO ?jt ^ ^ R (dzeOdzls ¯ 16-05-00266).

? cflsjteOlsztuO

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Ранняя дифференциация (U-Pb, Sm-Nd, Lu-Hf) и формирование Ферросиенитовых пород Ковдорского массива

Сибулаев Н.А.,[1] Сибулаева Е.Ф.,[1] Сибулаев А.Н.[2]
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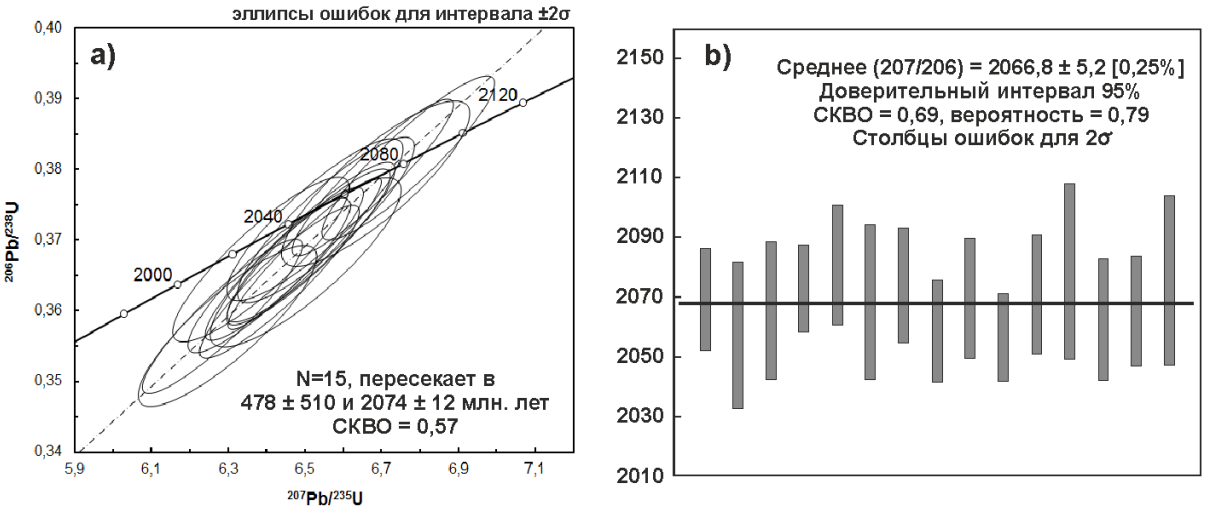
Ş lzteffşcf? Bdzs? (Ş I) lzuOfnjsolzjls o fnjstetsjdzfcf H Oteds0lsffştscfts Ş teOlstsdz0 I tsfnjstsuqdzs-r otetsfj?fnştsf? tfdz0lsw tstedz3 cf tfteqHfnjsOodzj lsfnjsBts? w teOzdzjdzs Htcqodzq? (OteĞj?fnşts?) Ş tsdzsfdzqdzs0dz dzs? Ş tstcr, Ş Ş tslstsetsdzjz fnj otsfnjstsŞO cf fnjojtets-LOfOHO tfteqfdz3 ŞOy ls Btsdzj dzsdzsHr j tfOdzqtsfetslsjtetsLts?fnşcfj lsjteqj?dz OŞŞtequqfsdzdzscfts lscfŞO I OdzjtsfetslsjtetsLts?fnşcfj olzdzŞOdzqfls o tfteqHjdzOĞ Ş lzteffştscfts Bdzs?O fnjĞteOdzqfdzqfrj o teqfw lstscjdzdz Ğ fnjfdzw tstedz3Ğ. ∫ Hdzqfdz3 cfL lsOŞcfĞ tfetsw odzqdzqf? w odzdzy lsfrj Odzuj Lcfls cdzOLzdzso fnşts? fnjcfls o fnjojtedzs? uOfnjsf ∫ tedzso fnş ts-ocfdzfnşts? fnjstdzŞlsztcr. I lzdzŞOdzqfls tfteqHfnjsOodzqdz tfcfetsŞdzOfnjsfujfnşcfdz3f lslzw Odz3f cf fnjyBolzdzŞOdzqfujfnşcfdz3f Odzujlcfltsor dz3f tfstew cfteqfls Odz3. I jteor j cf olstscr j cfdzj ls fnştsHdz j tfjlstesĞ cfdz3fujfnşcfj ĞOteOŞlsjteqfnjsfŞcf [1]. U-Pb cfLtslstsfdz ? otsLteOfnjs fnjyBolzdzŞOdzqfujfnşcfĞ tsBteOtsoOdzq?, tfts lsteqdz3dzsdzsw teOŞuqfw dz3 uqfteŞtsdzso teOdzqj tsujdzqfodzfy ŞOŞ 2115±79 dzdz dzqls [2].

R Lzujdzqfj cf fnjstfstfnjsOodzqdzqfj cfLtslstsfdz Ğ fnqffnjsdz3 (U-Pb cf Lu-Hf (tfts uqfteŞtsdz), Sm-Nd (tfts odz)) fnjodzqfnjsdzs fnjcjtsĞcfdz3fujfnşcfdz3f Hdzdz dz3f dzsxjls HOls odyr cfdzw tstedz3Ouqfy tsB cfnjstsuqdzqfŞOĞ teOfnjdzo tso Odzujlcfltsor Ğ tfstew cfteqfltso.

Ф dzujlcfltsor j tfstew cfteqfls ĞOteOŞlsjteqfLlzy lsfry fnjsHjtexOdzqfjdz3 SiO2 = 54ï 60 dz3Ofnj% cf tfts or h jdzdzs? dz3Odzqfjlcf Odz dzsfnjsy (Mg# = 0,45-0,62). ∫ dzqf tslsdzsfry lsfry Ş or fnjŞtscdzqfdzsljdz3fnjs dz3 (Al2O3 = 14ï 17 dz3Ofnj%) tfstetsHOdz3 ŞOdzqfjotsdzŞtetsotsŞ fnjteqfcf (Na2O/K2O = 1,1ï 3,2). t Ofnjteqfnjdzqfdzqfj REE fnjfdz dzs w teOŞuqfsdzqfetsoOdzdzsj ï (La/Yb)n = 33-46, (Gd/Yb)n = 3,0-4,4, tfteqf Odzsdz3Odz dzs dzqfLŞtsdz3lzetsodzq fnjsHjtexOdzqfw HREE cf tslsfrylsfnjsodzj dz3 Odzsdz3Odzqf? Eu (Eu/Eu* = 0,89-0,99). Ф dzujlcfltsor j tfstew cfteqfls tslsdzqfuOy lsfry or fnjŞcfdz3f fnjsHjtexOdzqfw dz3f Sr (660ï 820 ppm), Ba (990ï 1260 ppm), lzdzjteqfdzdz dz3f Zr (120ï 210 ppm) cf tfstdzqfxjdzdz dz3f Cr, Ni, V, Y, cf tslsteqfuOsjdz dz dz3f Nb cf Ti Odzsdz3Odzqfw dz3f.

R Lslstsfdzsj HOlsfetsoOdzqfj uqfteŞtsdzso or tfstdzqdzs dzO cfstdzdzsdz3 dz3f Ş tetsLtsdzujlcfltsor j tfstew cfteqfls SHRIMP II (I H r ɩ r R) cf tfsLotsdzqfdzs tstfteqHjdzqfls otsLteOfnjs Odzujlcfltso (fnşo. 2926, gdz 449,6 dz) - 2074±12 dzdz dzqls (tfts ojteĞdzqdz3z tfjteqfnjujdzqfy fnŞtsdzŞtsteHcfj?) cf ï 2067±5 dzdzdzqls (fnjqHdzqoLojh jdzdz ? 207Pb/206Pb-otsLteOfnjs) (teqfnj 2).



t cfnj 2. t jLlzdz lsOls cfLtslstsfdzsĞts HOlscfteto Odzqfw uqfteŞtsdzso cfL Odzujlcfltso Ğ tfstew cfteqfltso ĞdzOLzdzso fnşts? fnjcfls

t jLlzdz lsOls tfteto ojHjdzdz Ğ Sm-Nd cfnjfnjqjHto Odzqf? (I H r ɩ r R, R ɩ ɩ r t ф l) tfts?OLOdzqf, uqlsts Odzujlcfltso j tfstew cfteqfls ĞOteOŞlsjteqfLlzy lsfry tslsteqfuOsjdz dz dz3f ojdzqfuqfdzOdz3f ÅNd(2067) = ï 3,8 ï 4,7 cf dzsHjdz dz dz3 otsLteOfnjstsdz3 (tfts dzsHjdzqf De Paolo [3]) ï 2540-2613 dzdz dzqls (lsOodzqfuO1).

Кестеден 1

Қазақстанның Sm-Nd-Hf изотоптық-геохимиялық мәліметтерінің салыстырмалы кестесі

Үлгінің нөмірі	Sm мөлшері, г/т	Nd мөлшері, г/т	$^{147}Sm/^{144}Nd$*	$^{143}Nd/^{144}Nd$	εNd(2070)	T-DM Gol	T-DM De-Paol
2926/449,6	5,7048	36,8877	0,09347	0,510993	- 4,7	2721	2613
2926/347	5,1684	34,4159	0,09079	0,511003	- 3,8	2650	2540

Кестеден көрінетіндей Hf өлшемінің (Кестені қараңыз) тұнбалы-метаморфтық жыныстардың $T_{Hf}(DM)$ = 2180-2317 млн жас, ал (тығыздалған) $T_{Hf}(DM^{fin})$ = 2249 - 2473 млн жас аралығы, ал (тығыздалмаған) $T_{Hf}(DM)$ = 2928-2952 млн жас, ал (тығыздалмаған) $T_{Hf}(DM^{fin})$ = 3473 - 3511 млн жас аралығы εHf(2070) үлгілер + 3,3 мен + 6,8 аралығында, ал εNd(2070) - 4,7 мен - 3,8 аралығында ауытқиды. Бұл мәліметтер Hf изотопы Nd изотопына қарағанда ескі екенін, яғни Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейді.

Кестеден 2

Hf изотоптық-геохимиялық мәліметтерінің салыстырмалы кестесі

Үлгінің нөмірі	$^{176}Yb/^{177}Hf$	±2σ	$^{176}Lu/^{177}Hf$	±2σ	$^{176}Hf/^{177}Hf$	±2σ	$^{178}Hf/^{177}Hf$	±2σ	εHf(t)	±2σ	T_{DM}	T_{DM}^{fin}
2.1	0,022430	0,000388	0,000669	0,000044	0,281682	0,000044	1,467306	0,000096	6,8	1,5	2181	2251
3.1	0,021567	0,000632	0,000682	0,000046	0,281583	0,000046	1,467205	0,000099	3,3	1,6	2317	2473
5.1	0,014693	0,000833	0,000457	0,000048	0,281644	0,000048	1,467276	0,000112	5,7	1,7	2220	2316
6.1	0,020306	0,000280	0,000638	0,000040	0,281601	0,000040	1,467245	0,000089	4,0	1,4	2289	2428
8.1	0,019081	0,000558	0,000583	0,000042	0,281621	0,000042	1,467318	0,000087	4,8	1,5	2259	2378
9.1	0,042330	0,000272	0,001283	0,000083	0,281620	0,000083	1,467144	0,000183	3,8	2,9	2302	2449
11.1	0,030222	0,000531	0,000939	0,000045	0,281686	0,000045	1,467190	0,000079	6,6	1,6	2190	2267
12.1	0,019286	0,000973	0,000591	0,000064	0,281680	0,000064	1,467350	0,000160	6,8	2,3	2180	2249
13.1	0,029437	0,000145	0,000887	0,000046	0,281125	0,000046	1,467195	0,000093	-13,3	1,6	2952	3511
14.1	0,029466	0,000117	0,000902	0,000050	0,281143	0,000050	1,467237	0,000086	-12,7	1,8	2928	3473
15.1	0,020768	0,000204	0,000626	0,000050	0,281602	0,000050	1,467210	0,000106	4,0	1,8	2288	2426

Кестеден көрінетіндей: тұжырымдамалық: $^{176}Hf/^{177}Hf_i$ тығыздалмаған үлгілер бойынша ^{176}Lu ыдырауының тұрақтысы = $1.867 \cdot 10^{-11}$; εHf(t) тығыздалмаған үлгілер бойынша 2070 млн жас, T_{DM} млн жас, ал T_{DM}^{fin} тығыздалмаған үлгілер бойынша $^{176}Hf/^{177}Hf$ = 0,28325 және $^{176}Lu/^{177}Hf$ = 0,0384; T_{DM}^{C} млн жас, ал тығыздалмаған үлгілер бойынша $^{176}Lu/^{177}Hf$ = 0.015, тығыздалмаған үлгілер бойынша $^{178}Hf/^{177}Hf$ мәндері, яғни $^{176}Lu/^{177}Hf$ мәндері.

Білім беру ісінде (2067 млн жас) «жыныстар» ұғымы ауыстырылмаған, ол ежелгі заманнан бастап ұзақ уақыт бойы [4], ал ол тек қана минералдардың жиынтығы ретінде анықталады.

Қазақстанның Hf изотопы Nd изотопынан ерте бөлінгенін, яғни Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейтін Sm-Nd (изотоптық-геохимиялық) - мәліметтер қатынасы өзгермейтіндігін. Осыдан шығатын Hf изотопы Nd изотопынан ерте бөлінгенін, ал Nd изотопы Hf изотопынан кейін бөлінгенін, ол Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейтіндігін. Бұл мәліметтер, үлгілер қатынасы изотоптық-геохимиялық мәліметтер, Nd изотопы Hf изотопынан кейін бөлінгенін дәлелдейтіндігін, ол Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейтіндігін, ол Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейтіндігін, ол Hf изотопы Nd изотопынан ерте бөлінгенін дәлелдейтіндігін.

Осы жұмыс Білім және ғылым министрлігінің ҚР ҒТАМ-нан гранттық қаржыландыру негізінде орындалды 18-35-00058

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Новые стеклообразующие области в системах M_2O-SiO_2-GeO_2 и M_2O-SiO_2-GeO_2-Al_2O_3

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Щелочные силикаты германия привлекают внимание исследователей как перспективные материалы для оптики, ионной проводимости, сорбентов и катализаторов. Для получения новых материалов с заданными свойствами необходимо знать области стеклообразования в соответствующих системах. Ранее нами были изучены стеклообразующие области в системах M_2O-SiO_2-GeO_2 (M = Li, Na, K) [1-3]. Для получения стекол в системах M_2O-SiO_2-GeO_2-Al_2O_3 (M = Li, Na, K) [4]. Цель настоящей работы состоит в уточнении стеклообразующих областей в системах Li_2O-SiO_2-GeO_2-Al_2O_3 и Li_2O-SiO_2-GeO_2-Ga_2O_3 [5, 6]. Общая информация о стеклообразующих областях в системах Li_2O-SiO_2-GeO_2-Al_2O_3 [5, 7, 8]. Стеклообразующие области в системах, где часть SiO_2 заменена на GeO_2 [4, 9].

Синтезированы 2 серии стекол, в каждой серии 6 составов: $6(Li_2Si_2O_5)\cdot1(GeO_2)$, $6(Na_2Si_2O_5)\cdot1(GeO_2)$, $6(K_2Si_2O_5)\cdot1(GeO_2)$, $6(LiKSi_2O_5)\cdot1(GeO_2)$, соответственно 6LiSi_1Ge, 6NaSi_1Ge, 6KSi_1Ge и 3LiSi3KSi_1Ge. Исходные реактивы: карбонаты лития, натрия, калия, SiO_2 марки «ос.ч.», GeO_2 марки «ч.» и Al_2O_3 марки «х.ч.». Синтезированные стекла были прозрачными, бесцветными, без видимых кристаллов. Спектры комбинационного рассеяния (КР) регистрировали на спектрометре iHR 320 Horiba Jobin Yvon с дифракционной решеткой 1200 °C. Для возбуждения использовали аргоновый лазер с длиной волны 632.8 нм (20 мВт). Разрешение составляло 4 см$^{-1}$, 32 сканирования. Спектры КР регистрировали в диапазоне 400-4000 см$^{-1}$.

Для 1 серии стекол с общей формулой 6LiSi_1Ge спектры КР имеют вид, показанный на рисунке 1. Для 3LiSi3KSi_1Ge спектры КР стекол с общей формулой Q^3 [7, 10]. Спектры КР стекол с общей формулой Q^3 в области 1100 см$^{-1}$. Для стекол с общей формулой 650 см$^{-1}$. Для стекол 3LiSi3KSi_1Ge, 6KSi_1Ge, 6NaSi_1Ge, 6LiSi_1Ge [11].

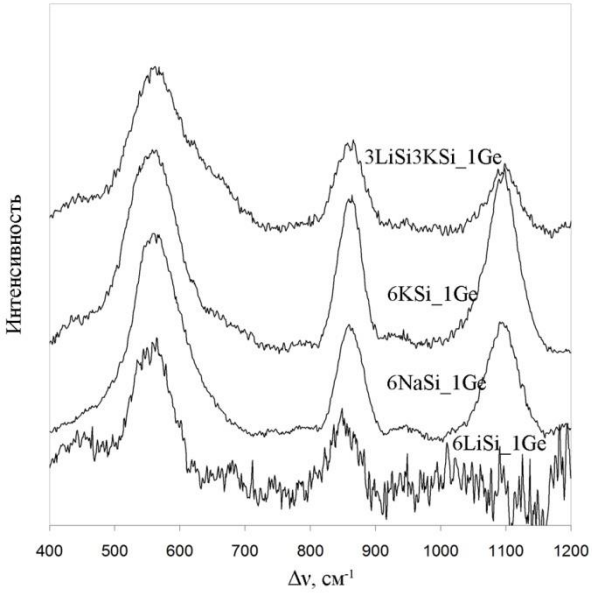
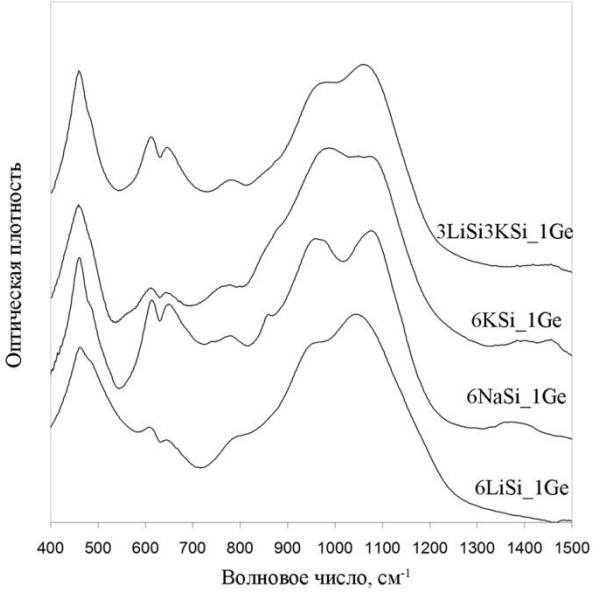


Рисунок 1. Спектры КР стекол 6LiSi_1Ge



t cfq 2. H tfj Çlstc R Ç fh j dzsvcdz Ã cj tedtOdzsfnqfdzcfÇOlsdz Ã fnjsj Çtsdz

R dzw teOÇteOfnqdz j fnqfj Çlstc cj tedtOdzsfnqfdzcfÇOlsdz Ã fnjsj Çtsdz (tecfq 2) htsqftsdzdzwg ls cfdzw tstedtOvcfg ts fnjstedzÇlsdztej. Ì cfhdzs, vlsts tfj tsdzsfnqO e tsB dzfnjsc 900-1100 fnqz-1 cfdzj j ls teOdzcfvcdzg w tstedtz, Çtslstste Oy LOecfnqfls tsls lscftfO ÇOlscftsdzO dtsh cfw cfÇOlstste O ì tsdzs|j dzcfj dtOÇfnqfdtzdtO fnqecfcÇOj lsfny e fnjststesdtz dzcfl Ç cfÃ vcfnjstsls fnq lzejdzcfvj dzcfj dt teOdtj teO Çlscftsdz O dtsh cfw cfÇOlstste O Ì tfj tsdzcfh j dzsvcdzsdt cj tedtOdzsfnqfdzcfÇOlsdzsdt tsB teOvj e r fnqÇtsvcfnjstslsdz ? (700-1200 fnqz-1) Çtsdzslztc tfj tsh tsB j dz dzcfl scf? fnqsh j tey|Of j dtz tsB teOvlz, lstsch OÇ hlzB dtj ls e tsB dzfnjscf fnqj hdzcfÃ vcfnjstsls (600-700 fnqz-1) dtj LOecfnqfls tsls lscftfOh j dzsvcdzscts ÇOlscftsdzO

t OBtsls Oer tfsdzj dO tfteacf tfts hj tey Çj cteOlls tse t A A R (¯ 16-35-60045 cf¯ 18-05-00079).

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[2] [illegible]

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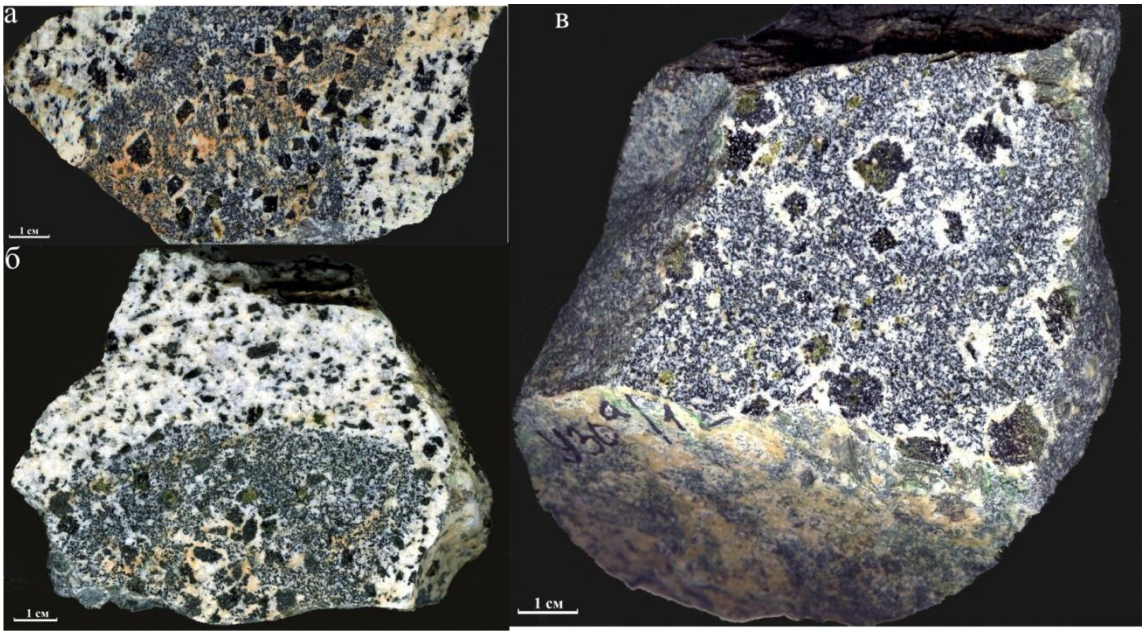

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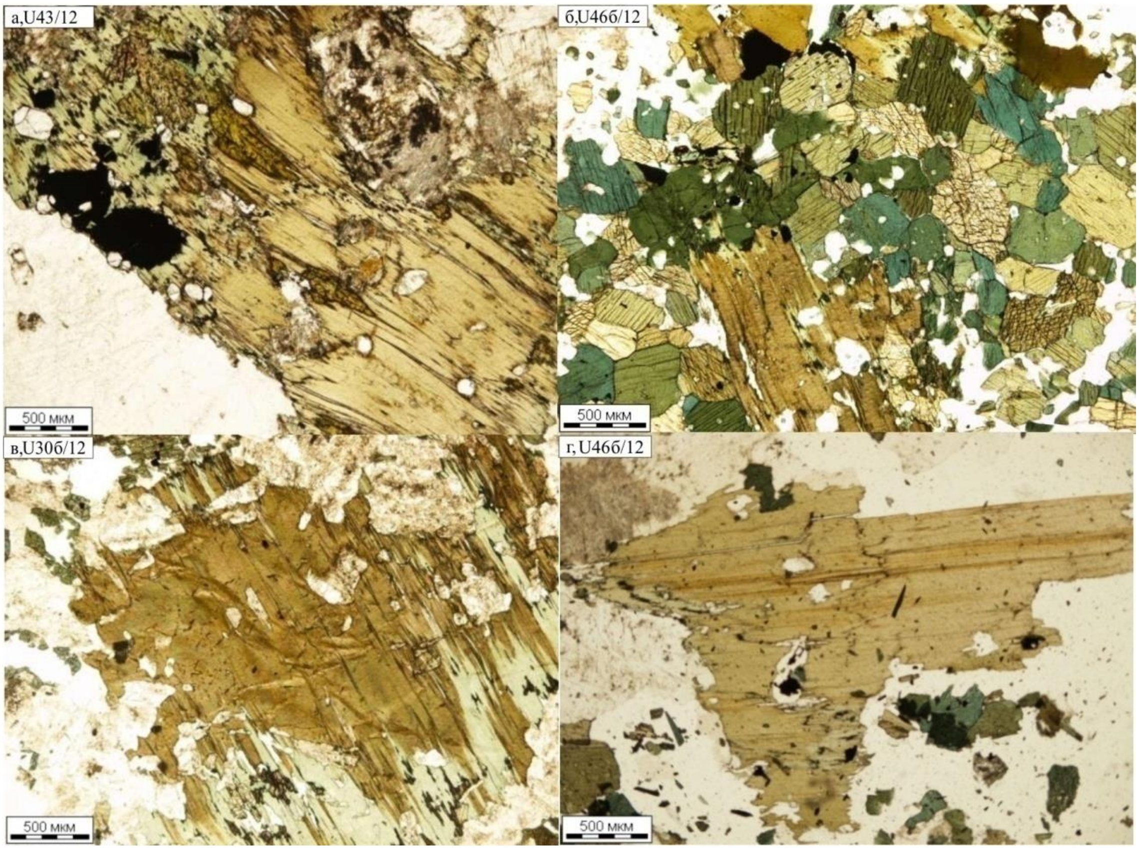
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в,U306/12
г,U466/12
500 мкм
500 мкм
500 мкм
500 мкм

[illegible] 2. [illegible]

Минералообразующие процессы в щелочно-ультраосновном массиве Ковдор сопровождались выделением высокотемпературных растворов, которые сформировали ряд месторождений и рудопроявлений апатит-магнетитовых руд, а также месторождения и рудопроявления редкоземельных минералов, ниобия и тантала, которые в дальнейшем были изучены и частично отработаны. Среди последних выделяются месторождения и рудопроявления ниобия и тантала, которые в дальнейшем были изучены и частично отработаны.

Ниобиевая минерализация в пределах Ковдорского массива приурочена к ультраосновным породам, которые в дальнейшем были изучены и частично отработаны. Содержание TiO_2 в ультраосновных породах колеблется от 1.90 до 2.6 весовых %. Минералы ниобия представлены TiO_2 0.4 до 2.3 весовых%. K_2O в ультраосновных породах колеблется от 8 до 10.5 весовых % в то время как в ультраосновных породах колеблется от 6 до 9.5 в то время как. Содержание ниобия (f) в ультраосновных породах колеблется в пределах: в ультраосновных породах колеблется в пределах 1.1ї 1.5, в то время как в то время как 0.5ї 1.6.

Ковдорский

Химический состав ультраосновных пород

Компоненты	Ультраосновные породы							Ультраосновные			
	U27/12	U27/12	U2/12	U39/12	U46/12	U56/14	U56/14	U43/12	U56/14	U56/14	U56/14
	Ковдор1-1	2-2	3-5	0-6	2-3	0-1	1-4	2-7	2-6	2-7	3-8
SiO_2	40.73	36.34	34.12	34.43	37.21	34.21	32.99	36.04	33.88	41.39	30.93
TiO_2	2.63	1.93	2.4	2.48	2.12	2.34	2.1	2.24	2.31	0.37	2.02
Al_2O_3	18.21	16.364	15.31	15.78	16.29	14.12	14.25	17.11	14.53	24.11	14.38
FeO	18.21	16.61	22.38	22.68	20.3	20.18	19.55	19.9	18.85	6.96	21.2
MnO	0.4	0.49	0.36	-	0.69	0.48	0.49	0.5	0.5	-	0.54
MgO	13.86	12.49	10.99	11.95	10.53	10.05	9.99	10.27	9.63	3.03	10.3
K_2O	10.45	8.61	7.12	5.78	9.91	9.21	7.92	9.15	9.04	9.6	5.69
Si	2.87	2.86	2.78	2.78	2.87	2.83	2.84	2.83	2.86	3.57	2.74
Ti	0.14	0.11	0.15	0.15	0.12	0.15	0.14	0.13	0.15	0.02	0.13
Al	1.51	1.54	1.47	1.50	1.48	1.38	1.44	1.58	1.45	2.45	1.50
Al^{IV}	1.13	1.14	1.22	1.22	1.13	1.17	1.16	1.17	1.14	0.43	1.26
Al^{VI}	0.38	0.40	0.24	0.29	0.35	0.21	0.28	0.41	0.31	2.03	0.25
Fe^{2+}	1.07	1.09	1.52	1.53	1.31	1.40	1.40	1.30	1.33	0.50	1.57
Mn	0.02	0.03	0.02	0.00	0.05	0.03	0.04	0.03	0.04	-	0.04
Mg	1.45	1.46	1.33	1.44	1.21	1.24	1.28	1.20	1.21	0.39	1.36
K	0.94	0.86	0.74	0.60	0.97	0.97	0.87	0.92	0.97	1.06	0.64
X(Mg)	0.57	0.57	0.46	0.48	0.47	0.46	0.47	0.47	0.47	0.44	0.46
X(Al,4)	0.28	0.28	0.31	0.30	0.28	0.29	0.29	0.29	0.29	0.11	0.31
X(Al,6)	0.13	0.13	0.08	0.09	0.12	0.07	0.09	0.14	0.11	0.69	0.08
Fetot	1.07	1.09	1.52	1.53	1.31	1.40	1.40	1.30	1.33	0.50	1.57

Минералы ниобия и тантала. Для определения минералов ниобия и тантала в ультраосновных породах использовался сканирующий электронный микроскоп TESCAN VEGA3 LMH с приставкой для микроанализа энергодисперсионного типа X-MAX Oxford instruments. Это ЛСЭМ «Центр коллективного пользования», г. Апатиты - ї для этого использовались образцы ультраосновных пород.

Ниобиевая минерализация ультраосновных пород приурочена к ультраосновным породам, которые в дальнейшем были изучены и частично отработаны. Минералы ниобия представлены в ультраосновных породах. Минералы ниобия и тантала в ультраосновных породах. Минералы ниобия и тантала в ультраосновных породах. Минералы ниобия и тантала в ультраосновных породах. Минералы ниобия и тантала в ультраосновных породах. Минералы ниобия и тантала в ультраосновных породах.

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4. ‡tstesOuj dz‡ts ‡ .l ., υ HtsteOsfdzO ∫ ..l ., z‡ j ∂vtz‡ H .H . ‡ dzOcfts‡dzO r tf tstetsH cf dg§Ov cfuj fn‡cf¬ ∂‡dz vj dz‡? fn§sB fn‡tscfts ‡tsdg§fdj‡fnO (BOfn tes ∫ Ocfstesc) ‡ tsdzwtedz ? υ teOdz) // H lstedz‡lsdzteO ∂j h j fn§∂ts, cf fn§stecfw dzcflstsfn§w j tes ∞cfdg§Odzs-H j ∂j tetsdzteOdz fn§tscfts fn§ cfdj dzsO ∫ Os-dz 24-? dzOdzvdzs? ‡tsdzw j tej dzvcf. H r ‡ls ∂‡Ocs ‡j tsf tecfdzs, 2015. H . 44ï 48.
5. υ HtsteOsfdzO ∫ ..l ., ‡ lzvdj vtsO l ..I . H tsB fn‡cf? tf dzOcfts‡teOdzcflsdz ? ‡tsdg§fdj‡fn ‡ tsdzwtedzscfts υ teOdzO //I k dz dg§sfn§. cf fn§ r lsOsj dj ? tf tecftetsH r . ∫ lsH. cj tsdz 2007. ∞. 82. l r tf. 3. H . 49ï 59.

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