Solid Solution of Pt-Pd with Bi-Te-As elements and possibility of new phases discovery background on the Monchepluton PGE Paleoproterozoic study.

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INTRODUCTION.

Bi-Te-As phases of Pt-Pd alloys, occur in virtually all known PGE deposits in the world, also evidenced by their naming, which refers to particular deposits, let us use, for example, merenskite, stilwaterite, moncheite. These minerals are an important source both for platinum and palladium as well as for tellurium. These phases are accompanied by sulphides among which they are usually located. Most often they are pyrite, pyrrhotite, chalcopyrite, pentlandite and many others. They form massive sulphide ore or are admixtures in ultrabassic and alkaline rocks in novae complexes of rocks containing PGE deposits in the world. Analyzing the discussed alloys one can notice some regularities indicating that they can be part of a solid solution, which, depending on the conditions of crystallization, breaks down into individual phases. Careful observation of this process may shed light on the crystallization conditions of the discussed mineralization and indicate probable phases that should be tried or synthesized in the laboratory. This text is intended to indicate the anticipated phases and initiate their search among known deposits.

METHODS:

During the investigations in the micro-area of the scale samples containing PGE mineralization conducted in 2013-2018, the problem of identification and alignment of the Bi-Te-As phases arose from various deposits originating from N Europe and Canada, while the information was noticed when it was possible to look at this aspect. For this purpose, based on the known properties of the elements in question, we tried to model their combinations, the energy of these molecules and the conditions of crystallization. These results are presented below.

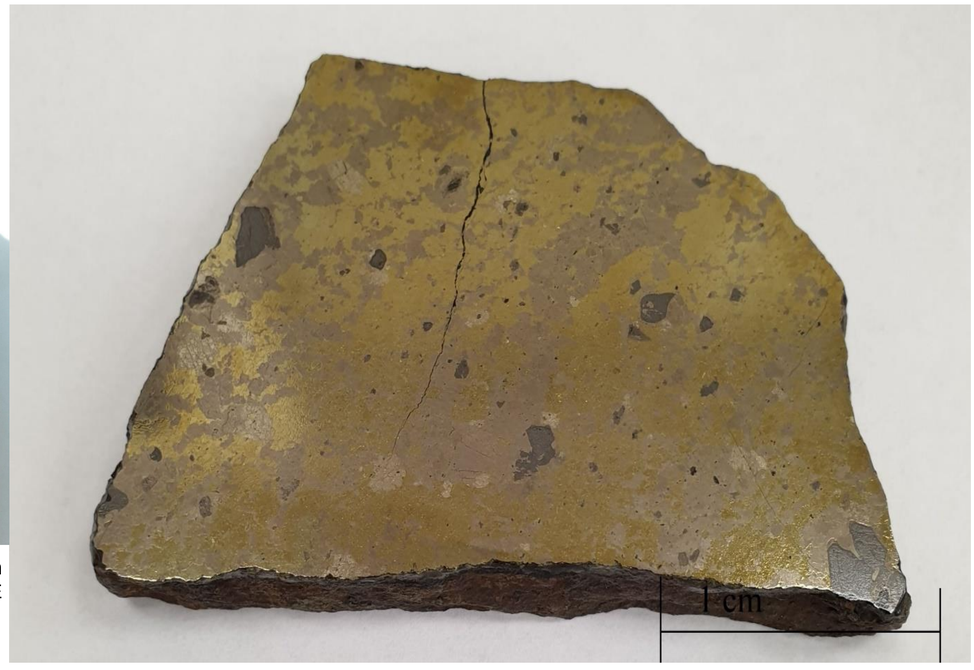

Fig 1. An example of breccia with sulphides and PGE minerals from Broken Hammer, Sudbury (in left), massive sulphide ore with PGE minerals from Monchepluton, Kola Peninsula (in center).

RESULTS:

Pt-Pd phases of Bi-Te-As alloys, occur in virtually all known PGE deposits in the world, also evidenced by their naming, which refers to particular deposits, let us use, for example, merenskite, stilwaterite, Moncheite (fig 1). These minerals are an important source both for platinum and palladium as well as for tellurium. These phases are accompanied by sulphides among which they are usually located. Most often they are pyrite, pyrrhotite, chalcopyrite, pentlandite and many others. They form massive sulphide ore or are admixtures in ultramafic and mafic rocks in novae complexes of rocks containing PGE deposits in the world. Authors was made about 20. thousands of microanalysis in samples from selected PGE deposits (e.g. Sudbury, Monchepluton, Imandra, Fedoro-Panski, Imandrovski etc.). Analyzing the discussed alloys one can notice some regularities indicating that they can be part of a solid solution, which, depending on the conditions of crystallization, breaks down into individual phases (fig 2-4, tab. 1). Careful observation of this process may shed light on the crystallization conditions of the discussed mineralization and indicate probable phases that should be tried or synthesized in the laboratory. This text is intended to indicate the anticipated phases and initiate their search among known deposits. The analysis of currently known minerals and their projection indicate that at least three extreme bismuth, tellurium, arsenide are possible in combination with platinum the more so that their counterparts exist in the case of palladium alloys and intermediate minerals such as merenskite and moncheite. It is possible that known minerals are the product of the breakdown of higher temperature and pressure phases as a result of reaction with the solution (Piela 2006, Kittel 1999, Subbotin et al 2017). The five-component system that is said solution is the key in understanding the method and conditions of the formation of alloys containing the present components. It is also possible that they are richer in other elements or allow a certain amount of "impurities" within the miscibility of alloys, contributing to the formation of atypical PGE mineralization also containing Pb, Ag and Se (Neradovski et al 2017). It is possible that these phases may have a cosmic character and become scattered and assimilated in terrestrial rocks during multiple processes of differentiation, gargoyle and anatexis accompanying intrusions of ultramafic rocks which disappeared into supracrustall rocks, which could contain such material. However, such conclusions are too early to write about it, although it cannot be ruled out that the study of Archaik rocks will shed light on this aspect as well.

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Tab. 1 List of solid solution Pd, Pt; Te, Bi, As phases.

Group	Phases					
Bi	A	Froodite $PdBi_2$	B	Platiniumpalladiumbismuthite* Pt_3PdBi_4	C	Platiniumbismuthite* Pt_3Bi_2
BiTe	D	Sobolevskite Pd(BiTe) Kotulskite Pd(TeBi)	E	Merenskite $PtPd(BiTe)_2$ Moncheite $PtPd(TeBi)_2$	F	Maslovite PtBiTe
Te	G	Telluropalladynite Pd_9Te_4	H	Telluroplatiniumpalladynite** $PtPd_2Te_6$ and $Pt_2Pd_2Te_5$***	I	Mitrofanovite Pt_3Te_4
TeAs	J	Törnroosite $Pd_{11}(AsTe)_2$	K	Platiniumtörnoosite* $Pt_2Pd_1As_4Te_2$***	L	Tellurosperylite** Pt_5AsTe_4***
As	M	Palladoarsenide Pd_2As Stillwaterite Pd_8As_3	N	Palladosperylite* $PtPd_2As_3$	O	Sperrylite $PtAs_2$
AsBi	P	Palladobismutharsenide Pd(As,Bi)	Q	Palladobismuthosperylite* $Pt_2Pd(As,Bi)_2$	R	Platiniumarsenidobismuthite* $Pt_2(As,Bi)$
AsBiTe			S	Arsenidomerenskite* $Pt_2Pd_3Bi_2Te_2As_3$		

*-phases non exist yet (proposed name), **phases founded by author using microanalysis method, *** measured in origin samples.

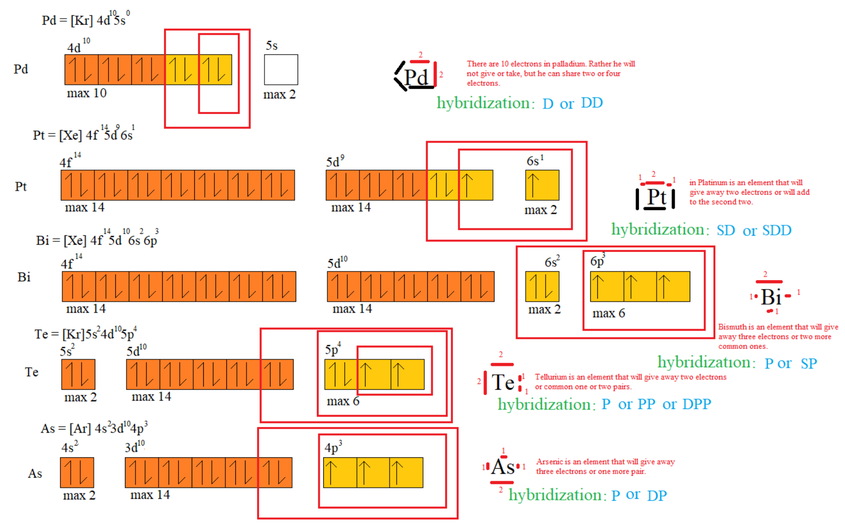

Fig 2.Valence electron configuration in Pd, Pt, Bi, Te, As elements.

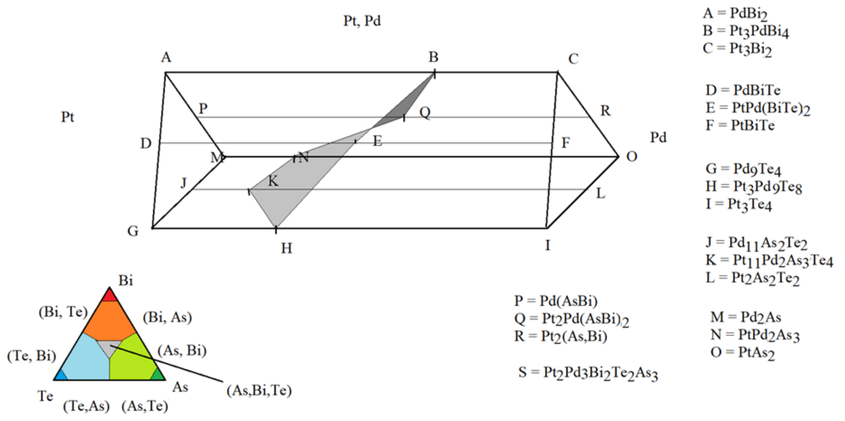

Fig 3. Projection of the Pd-Pt, As-Te-Bi phases.

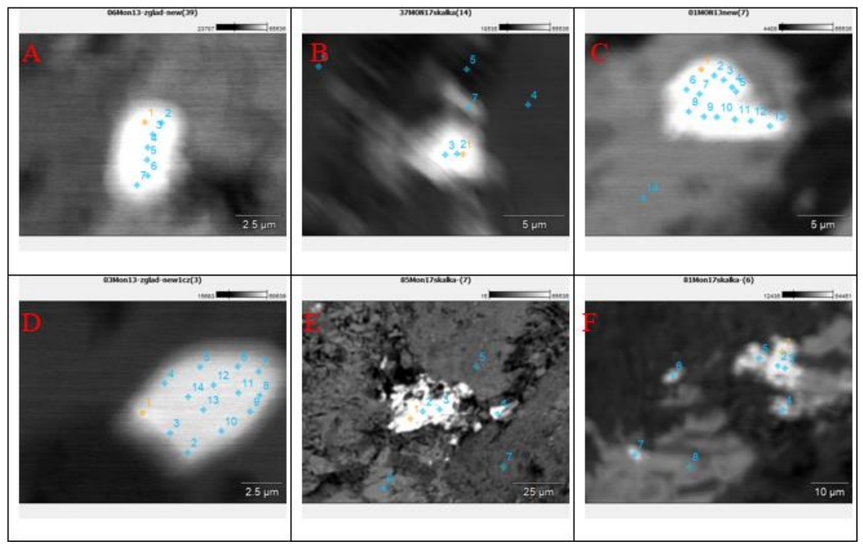

Fig 4. Exemplary BSE microphotographs of the new phases: A. Telluroplatiniumpalladynite (Phase3); B. bright center are Pb-Kotulskite (phase 2b), point -7 Pb-mitrofanovite (phase 2a); C. Platiniumtörnoosite (phase 6b); D. Ag-Telluropalladynite (phase 1b); E. Ag-Maslovite (phase 1); F. bright center are Ag-Kotulskite (phase 1a).

CONCLUSION

The Pd-Pt and Te, Bi, As alloy solution is an important element in the exploration and processing industry of the Te, PGE (tab. 1). The analysis of currently known minerals and their projection indicate that at least three extreme bismuth, tellurium arsenite and bismuth arsents are possible in combination with platinum, the more so that their counterparts exist in the case of palladium alloys and intermediate minerals such as merenskite and moncheite. It is possible that known minerals are the product of the breakdown of higher temperature and pressure phases as a result of reaction with the solution. The five-component system that is said solution is the key in understanding the method and conditions of the formation of alloys containing the present components. It is also possible that they are richer in other elements or allow a certain amount of "impurities" within the miscibility of alloys, contributing to the formation of atypical PGE mineralization also containing Pb, ag and Se. It is possible that these phases may have a cosmic character and become scattered and assimilated in terrestrial rocks during multiple processes of differentiation, gargoyle and anatexis accompanying intrusions of ultrabassic rocks which disappeared into supracrustal rocks, which could contain such material. However, such conclusions are too early to write about it, although it cannot be ruled out that the study of Archaik rocks will shed light on this aspect as well.

References

1. Arzamastsev A.A. 1994. Unique Paleozoic Intrusions of the Kola Peninsula.,pp. 79. Apatity, Russian Academy of Science Publ.
2. Bayanova T.B., Pozhylienko V.I., Smolkin V.F., Kudryshov N.M., Kaulina T.V., Vetrin V.R., 2002; Katalogue of the geochronology data of N-E part of the Baltic Shield, Apatity, pp. 53 (RUS)
3. Boruckiy B.E. 1989; Rock-forming minerals of the high-alkaline complexes. Nauka Publ., pp214 (RUS).
4. Britvin S.N.., Ivanov G.Yu., Yakuvenchuk V.N., 1995; Mineralogical accessory on Kola Peninsula, World of stones, 5-6 (RUS)
5. Fanasev B.V., 2011; Mineral resourses of the alkaline –ultrabasic massifs of the Kola Peninsula, Apatity, pp151. (RUS)
6. Huber 2014; Mineralogical and petrographic characterization of selected alkaline massifs of the Kola Peninsula, northern part of the Baltic Shield, TMKarpinski Publisher, pp. 183. (POL).
7. Huber 2017; Ultrabassic -Alkaline Intrussion in Africanda (N Rosja) petrology –geochemistry analysis. Sciences Publisher pp. 87 (POL).
8. Kramm U, Kogarko LN, Kononova VA, Vartiainen H. 1993; The Kola alkaline province of the CIS and Finland: precise Rb–Sr ages define 380–360 Ma age range for all magmatism. Lithos, 30: 33-44.
9. Pozhylienko W.I., Gavrilienko B.V., Zhirov D.V., Zhabin S.V., 2002; Geology of the ore regions in Murmańsk District, Apatity, pp. 360.