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LARGE IGNEOUS PROVINCES THROUGH EARTH HISTORY: MANTLE PLUMES, SUPERCONTINENTS, CLIMATE CHANGE, METALLOGENY AND OIL-GAS, PLANETARY ANALOGUES (LIP – 2019)

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КРУПНЫЕ ИЗВЕРЖЕННЫЕ ПРОВИНЦИИ В ИСТОРИИ ЗЕМЛИ: МАНТИЙНЫЕ ПЛЮМЫ, СУПЕРКОНТИНЕНТЫ, КЛИМАТИЧЕСКИЕ ИЗМЕНЕНИЯ, МЕТАЛЛОГЕНИЯ, ФОРМИРОВАНИЕ НЕФТИ И ГАЗА, ПЛАНЕТЫ ЗЕМНОЙ ГРУППЫ (КИП – 2019)

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PLATINUM-BEARING PLACERS OF THE SIBERIAN PLATFORM AND THEIR POTENTIAL LINKS WITH LARGE IGNEOUS PROVINCES

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Introduction

Placer deposits in the Siberian platform are closely associated with well-known platiniferous intrusions (Kondyor, Inagli, Noril'sk, Chiney, and Guli) (Genkin, 1968; Krivenko et al., 1996; Lichachev et al., 1987 etc) but there are also numerous PGM placers of large areal extent in the river basins of Siberia (Vilyui, Lena, Aldan, Anabar, and Olenek) for which the primary sources are still unknown. Comparison of the Pt-bearing placers and correlation between the Re-Os and ^{190}Pt-^{4}He isotope ages of the PGM and with ages of major magmatic events in the Siberian craton showed that the potential sources for some of the placers are buried Precambrian mafic-ultramafic intrusions of Large Igneous Provinces (LIP). The approach of this paper can be applied to other cratonic areas with alluvial PGM of unknown origin.

Results

PGM placers in the Vilyui, Lena, Aldan, Anabar, and Olenek river basins belong to following mineralogical-geochemical types: rich-Rh ferroan platinum (Vilyui type); Rh-Ir-ferroanplatinum (Anabar type); Ir-ferroan platinum (mid-Lena type); and platinum-sperrylite association in placers of the Aldan shield. In the northeastern part of the platform (Anabar, and Olenek river basins) there are also compound gold-platinum-diamond placers from which not only diamonds and noble metals are recovered, but also rare-metal minerals (Okrugin, 1998; Okrugin et al., 2019; Shpunt, 1970); in these cases also, the sources are unknown.

Extensive Pt-bearing placers are likely eroded from buried mafic-ultramafic massifs. PGM as well as gold were supplied into recent placers from buried intermediate depth reservoirs as a result of repeated recycling of Proterozoic and Phanerozoic basal conglomerates. The fine fraction (less than 0.5-1 mm) of thin-platy "floating" PGM and gold migrated over great distances forming extensive dispersion haloes, potentially far from the primary sources.

In an attempt to establish potential source rocks for the placer platinum we compared mineralogical and geochemical characteristics of PGM with known ultramafic complexes and also correlated the ages of PGM (Okrugin et al. 2006, 2019; Yakubovich et al., 2018) dated by the Re-Os and ^{190}Pt-^{4}He methods with ages of major intraplate magmatic events (including some thought to belong to LIPs) that occurred in the Siberian craton (Ernst et al., 2016). In addition to the earlier determined Re-Os model ages (Okrugin et al., 2006) of Ru-Ir-Os minerals, we dated Fe-Pt alloys and sperrylite from some placers using a ^{190}Pt-^{4}He isotope method (Shukolyukov et al., 2012). The high stability of radiogenic He in the naturally occurring metallic (isoferroplatinum, ferroan platinum) and a non-metallic platinum compound (sperrylite) permits their use as a ^{190}Pt-^{4}He geochronometer (Yakubovich et al., 2015).

U-Pb dating of dolerite dykes and sills in South Siberia and North Laurentia revealed nine Proterozoic LIPs (Ernst et al., 2016), and 3 Phanerozoic LIPs, the 252 Ma Siberian Traps LIP, the 370-360 Ma Yakutsk-Vilyui LIP, and the 135 Ma High Arctic LIP (HALIP) (Ernst, 2014), and their ages in part match (within uncertainties) the alluvial PGM ages, which is suggestive of their genetic association in the period 1.9-0.15 Ga (Figure). These correlations allow us to make a step forward to identify specific (likely buried) bedrock intrusive sources for extensive platinum placers of the Siberian platform.

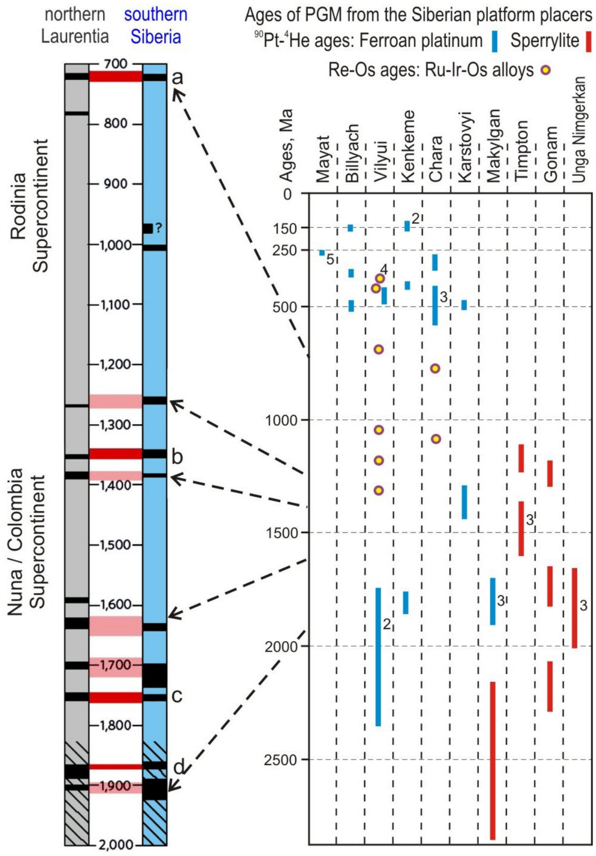

Figure. Correlation between the time of LIPs in the southern Siberian and the northern Canadian (Laurentia) cratons [Ernst et al. 2016] and the ages of Pt-group minerals from the Siberian platform placers

Thus, the variety of mineralogical-geochemical types of PGM assemblages in the Siberian platform placers may be explained by the presence of source rocks of several distinct types: from highly refractory cumulates of ultramafic rocks with chromite ores (Ru-Ir-Os minerals) to late-magmatic derivatives of differentiated intrusions of mafic rocks with sulfide ores containing Pt-Pd-rich phases.

Paleomagnetic, isotope-chronological, and geochemical studies of mafic rocks in the Siberian and North American (Laurentia) cratons (Ernst et al., 2016) revealed nine LIP events in the period 1.9-0.7 Ga (see left column of Figure). This indicates that the cratons were in close contact for more than 1.2 Ga. They jointly survived all tectonic/magmatic events during the formation and breakup of two supercontinents: Nuna (1.7-1.3 Ga) and Rodinia (1.1-0.7 Ga). The right side of the Figure presents Re-Os and ^{190}Pt-^{4}He isotope ages of PGM from the studied placers of the Siberian platform (Okrugin et al., 2006, 2019; Yakubovich et al., 2018). If the age was determined by the isochron method, then next to the lines of ranges is the number corresponding to the number of samples on which the isochron was obtained.

Next we consider whether the source of the Siberian platform PGM could be mafic-ultramafic intrusions belonging to large intraplate magmatic events (i.e. LIPs); We test these correlations on the basis of Re-Os and ^{190}Pt-^{4}He dating of the PGM in comparison with well-dated LIPs of the Siberian platform. For comparison we have a record of nine Proterozoic LIPs present in the Siberian craton (Figure) and two large Phanerozoic LIPs. However, given many regional mafic dyke swarms and other intrusive units that have not been dated, it is expected that additional LIPs remain to be discovered, of both Phanerozoic and Proterozoic age.

Conclusions

The data presented here on the chemical compositions and ages of PGM from Pt-bearing placers of the Siberian platform indicate a relationship between the placers and repeated episodes of Precambrian mafic-ultramafic magmatism within the platform. Ophiolites are not likely to be the potential source PGM given the geology and river flow patterns of the Siberian platform, leaving intraplate magmatism as a more likely source. Many of the PGM deposits were formed as a result of the basic and alkali-ultramafic intrusions associated with the Siberian Traps LIP at 252 Ma. We can link some placers of Anabar and Vilyui rivers to the 370-360 Ma Yakutsk-Vilyui LIP. There is also a PGM age match to the c. 500 Ma Kharaulakh LIP. We also see c. 1700-1800 Ma ages of ferroan platinum PGM that could be linked to either the 1750 Ma Timpton LIP or the 1870 Ma Kalar-Nimnur LIP.

Tectonic activation in the southern margin of the Siberian platform caused by Mesozoic subduction forming the Mongol-Okhotsk belt (Parfenov et al., 1999) was accompanied by subalkaline and alkaline magmatism including the Aldanian-type Pt-bearing concentrically-zoned massifs – Kondyor, Inagli, Chad, and others. So, some of the PGM could also be from these sources.

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