Comment on “190Pt-186Os geochronometer reveals open system behaviour of 190Pt-4He isotope system” by Luguet et al. (2019)

O.V. Yakubovich1-2*, A.G. Mochalov2, V.M. Savatenkov1-2, F.M. Stuart3

Accurate and precise chronology of ore forming processes is critical for the development of genetic models for ore formation. New methods (190Pt-186Os and 190Pt-4He) have been developed recently for determining the timing and complexity of platinum group metal (PGM) mineralisation (e.g., Coggon et al., 2012; Shukolyukov et al., 2012a, Yakubovich et al., 2015). Although these methods are fraternal, both based on the alpha particle decay of 190Pt, the geochemical behaviour of the daughter products (186Os and 4He) contrasts significantly. The combination of these isotope systems for dating single ore mineral phases offers a great opportunity to resolve the timing of ore formation.

The first combined study of 190Pt-186Os and 190Pt-4He systems in Pt mineralisation - the Kondyor zoned ultramafic complex in the Aldan shield, Russia – has generated a controversial result. Mochalov et al. (2016) obtained 190Pt-4He ages of multiple individual Pt alloy grains to be 112–129 Ma, that was consistent with regional geology, sequence of mineral formation and independent age estimations. Subsequently Luguet et al. (2019) reported a 190Pt-186Os isochron age of 240–250 Ma. This age discrepancy led Luguet et al. (2019) to conclude that the 190Pt-4He ages of the Pt grains reflected “open system” behaviour, essentially arguing that the radiogenic 4He generated by Pt decay had diffused out of the grains since their formation. This explanation is extremely difficult to reconcile with the experimental low diffusion rate of radiogenic 4He in Pt-Fe alloys (Shukolyukov et al., 2012a,b), the retention of extremely high concentrations of cosmogenic 4He by Pt-Fe alloys (Yakubovich et al., 2019) and with the theory of helium behaviour in metals in general (Trinkaus and Singh, 2003). Herein we provide an alternative point of view on the discrepancy between 190Pt-4He and 190Pt-186Os systems in Pt alloys of the Kondyor alkaline-ultramafic complex.

There is abundant independent radiometric geochronological evidence that the Kondyor ultramafic massif and the associated PGM mineralisation has an Early Cretaceous age; Sm-Nd, Rb-Sr, 40Ar-39Ar, baddeleyite U-Pb ages are in the range 120–132 Ma (Table S-1). These ages are essentially consistent within measurement uncertainty. These isotope systems have closure temperatures that range from ~300 °C (biotite Ar-Ar; Harrison et al., 1985) to over 1150 °C (clinopyroxene Sm-Nd; Van Orman et al., 2001), implying that Pt mineralisation was simultaneous with intrusion, and that post-intrusion cooling of the complex was instantaneous, within our ability to resolve it.

Luguet et al. (2019) have ignored the evidence for the Cretaceous age of alkaline magmatic complexes, and associated ore deposits, in the Aldan shield region (Varmolyuk et al., 2019 and references therein). In support of the Early Triassic age of the Kondyor ultramafic complex they remark on the similarity with detrital zircon grains from the Lena river and Mobe-Upper Amur basin. These rivers are 800–1500 km from the Kondyor ultramafic massif, and the detrital zircons are generally accepted to originate in the Angaro-Vitim batholiths and the China craton (Wang et al., 2011; Miller et al., 2013; Guo et al., 2017) rather than the Aldan shield.

The Luguet et al. (2019) study failed to put the study material into context. The formation of platinum mineralisation within the Kondyor massif was polycyclic (Mochalov, 2019). Cumulate dunites, the earliest rocks of the massif, underwent syn-magmatic recrystallisation and metasomatic transformation under the influence of ultramafic, mafic, alkaline, and granitoid intrusions. This resulted in the formation of five genetically distinct types of PGMs. The Pt alloys analysed by Luguet et al. (2019) belong to the later generations of PGM that were formed due to the recrystallisation and remobilisation of earlier PGM at temperatures not higher than 650–850 °C (see Supplementary Information; Table S-2). This indicates that the PGE chemistry of fluids that were responsible for the formation of these Pt alloys evolved with time. It also indicates that the age of Pt alloys is coeval with the emplacement of Kondyor massif. Thus, there is no evidence for the crystallisation of these Pt alloys in a root of an Early Triassic volcano that was exhumated in Early Cretaceous time, as proposed by Luguet et al. (2019).

Figure 1 shows the Pt-Os data sample 1265 obtained by Luguet et al. (2019; Table S-2, part 2). There is significant variation in 186Os/188Os and 186Os/188Os ratios. Based on 186Os/188Os ratio the samples studied by Luguet et al. (2019) fall into several mineral types; native osmium (Os, Os+), aggregates and cryptaggregates of native osmium with isoferrplatinum (Pt+Os) and isoferrplatinum (Pt+Pt+) (Fig. 1b). The regression line in 190Pt/188Os and 186Os/188Os space for each of these mineral types have different and distinct slopes (Fig 1a). Ontogeny of the minerals show that native osmium crystallised before the Pt alloys

1. Institute of the Earth Sciences, Saint-Petersburg University, Universitetskaya emb. 7/9, Saint-Petersburg, Russia
2. Institute of Precambrian Geology and Geochronology RAS, Makarova emb. 2, Saint-Petersburg, Russia
3. Scottish Universities Environmental Research Centre, Rankine Avenue, East Kilbride, UK

*Corresponding author (email: oyv.yakubovich@gmail.com)

Received 15 June 2021 | Accepted 5 December 2021 | Published 17 January 2022

https://doi.org/10.7185/geochemlet.2201
eralogy of the PGE and geochemistry of HSE in general. will surely provide a number of significant additions to the min-
in the other ultramafic massifs (mantle, island arc, shield) they
grains. If such phenomena are present in other ore occurrences
able features of the behaviour of the Pt and Os isotopes in PGM
ance of 187Re–187Os isotope system within the same grains
and therefore provides no age information. The obvious disturb-
all the data (Fig. 2b in Luguet et al. 2019) is not an isochron,
and therefore provides no age information. The obvious disturb-
ance of 187Re–187Os isotope system within the same grains
(Fig. 2a in Luguet et al. 2019) directly confirms this.

In summary, the data provided by Luguet et al. (2019) do not show any evidence for open 190Pt–4He system behaviour. Nor does it provide any support for an Early Triassic age of the Kondyor massif. The discrepancy between 190Pt–4He and 190Pt–360Os ages of the Pt alloys of the Kondyor massif reflect contrasting geochemical behaviour of daughter isotopes during the polycyclic formation of platinum mineralisation. 190Pt–4He age reflects the age of mineral formation itself, while the 190Pt–360Os isotope system fingerprints earlier redistribution of PGE. Luguet et al. (2019) have established a number of remarkable features of the behaviour of the Pt and Os isotopes in PGM grains. If such phenomena are present in other ore occurrences in the other ultramafic massifs (mantle, island arc, shield) they will surely provide a number of significant additions to the mineralogy of the PGE and geochemistry of HSE in general.

Acknowledgements

The authors are grateful to A.V. Ivanov and A.B. Kotov for valuable discussion. This research was supported by RTD of IPGG RAS (FMUW-2022-0004; FMUW-2022-0003) and SUERC.

Editor: Cin-Ty Lee

Additional Information

Supplementary Information accompanies this letter at https://www.geochemicalperspectivesletters.org/article2201.


