PGE Mineralogy of the Hanumalapur Complex, Karnataka, India

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Introduction

The Archean Hanumalapur Complex (previously referred to as Channagiri layered complex) in Karnataka, India, contains a promising PGE-mineralization that was discovered in the early 1990's (Devaraju et al 1994, Alapieti et al 1994). It is one of several tectonically separated blocks, together spanning over 30 km in length with thicknesses ranging from about 0.2 to 1 km. These blocks belong to the Hegdale Gudda Formation and represent its mafic-ultramafic lithounits. The Hanumalapur block that hosts the stratiform PGE mineralizations is about 3 km long and 0.3 km wide. According to field relations, the complex is of Archean age and has been thoroughly metamorphosed (Devaraju 2000). Hence the list of the main rock-forming minerals is rather short comprising generally just amphibole, chlorite and magnetite along with the more confined occurrences of carbonate, epidote and talc. Exploratory drilling of this PGE mineralized block was carried out by the Department of Mines & Geology, Government of Karnataka, from 1998 to 2001. So far eight drill-cores ranging in length from about 150 meters to over 250 meters have been obtained and a large amount of mineralogical and whole rock PGE analytical data has been generated. The results have been rather encouraging as the best whole rock PGE values indicate several ppm's of Pt+Pd. This paper presents a synthesis of the large amount of mineralogical data gathered so far.

Samples and analytical techniques

All samples used in this study were taken from one drill core only (viz., DH-1). Continuous sampling has been applied to almost the entire drill core for lead fire-assay analysis of Pd, Pt and Au. Polished thin sections were then made from samples with anomalously high PGE concentrations for identifying and studying the PGM's with an optical microscope as well as a SEM/EDS system.

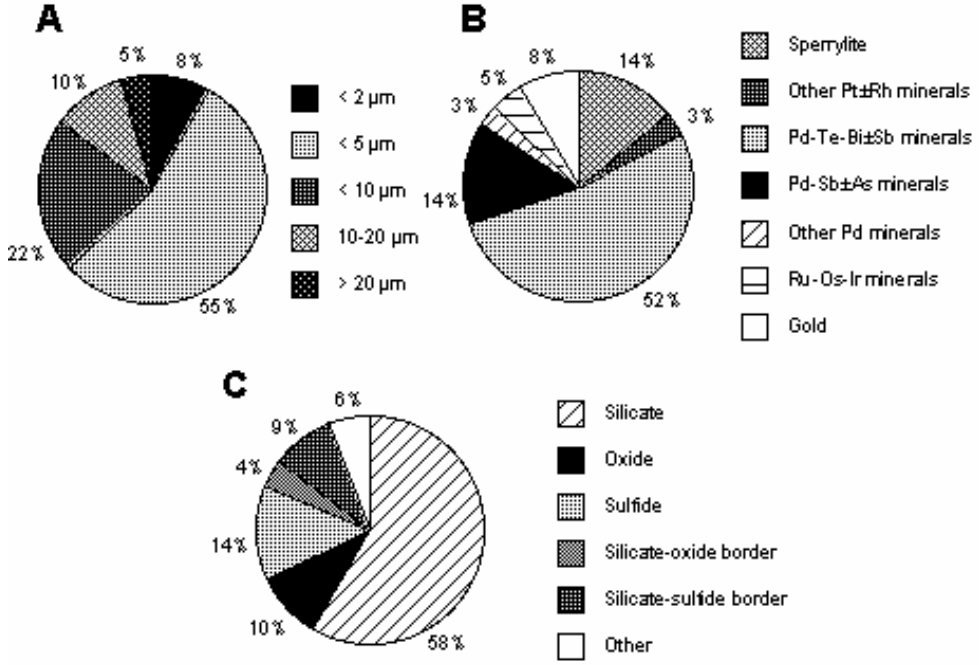

Figure 1. *Grain sizes (A), distribution (B) and hosts (C) of the PGM's in DH-1. The last section in (C) termed "Other" includes the association of PGM's with carbonates as well as three or more of the other groups at a time.*

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Due to the small grain size, which is commonly < 5 µm as shown in Fig. 1A and the limitations of the energy dispersive analytical method and hardware, the actual analyses are usually semi-quantitative and hence some interpretation is required to identify the mineral. Also the actual formulae of many PGM's are so close to each other that the differences often fall within reasonable analytical errors. Then there is also the probability of yet to be proven solid-solution series between several possible end-members. All these problems become very evident particularly when dealing with the various Pd-Sb and Pd-Te-Bi minerals.

So far over 650 PGM grains have been analyzed from DH-1 and they have been grouped as shown in Fig. 1B into sperrylite, other Pt±Rh minerals, Pd-Te-Bi minerals, Pd-Sb±As minerals, other Pd minerals and Ru-Os-Ir minerals. Gold grains have also been documented. This division is based on statistics, chemical affinities of PGE's and the association of certain minerals with some of the main rock-forming minerals. Fig. 1C gives a generalized representation of how the PGM's relate to other minerals.

Sperrylite ($PtAs_2$) is by far the most common Pt-bearing mineral in the analyzed samples. Sperrylite grains are often euhedral or subhedral and they are usually associated with silicates.

The group "other Pt±Rh minerals" includes moncheite ($PtTe_2$), cooperite (PtS), braggite ((Pt,Pd)S) and platarsite (PtAsS) and all of them tend to occur in silicates. Hollingworthite (RhAsS) is also presented in this group mainly for the sake of simplicity but also because it may contain significant amounts of Pt and/or Ir and hence fits reasonably well into this group.

About one third of all PGM grains found from DH-1 so far are kotulskite (PdTe) and a vast majority (over 80 %) of them are hosted by silicates. Also in the case of kotulskite it can best be seen that as the occurrence of a mineral gets more frequent its average grain size also increases. Although a large portion of kotulskite grains still fall within the 2-5 µm range the occurrence of much larger grains does indeed become more frequent. Kotulskites in DH-1 usually contain several percent of both Sb and Bi.

Merenskyite ($PdTe_2$) and michenerite (PdTeBi) are also common but with them the association with sulfides is more apparent for they are often found either inside of base metal sulfides or at the border between a sulfide grain and some other mineral (silicate, carbonate or oxide). In addition to these the group "Pd-Te-Bi minerals" contains a few grains of keithconnite ($Pd_{3-x}Te$), testibiopalladinite (Pd(Sb,Bi)Te) and some apparently unnamed phases.

The most common Pd-Sb±As minerals in DH-1 are mertieite-II (Pd_8Sb_3), stibiopalladinite (Pd_5Sb_2) and mertieite-I ($Pd_5(Sb,As)_2$) and they are most often found to occur as inclusions in silicates. Other minerals in the group "Pd-Sb±As minerals" include sudburyite (PdSb) isomertieite ($(Pd,Cu)_{11}(Sb,As)_4$), and some presumably unnamed phases. The small group of "other Pd-minerals" comprises temagamite (Pd_3HgTe_3), paolovite (Pd_2Sn), sopcheite ($Ag_4Pd_3Te_4$) and some unnamed phases.

In DH-1, minerals containing Ru and/or Os and/or Ir are generally closely associated with oxide minerals, namely chromite or Cr-rich magnetite. The minerals in this group are laurite (RuS_2), anduoite ($RuAs_2$), ruarsite (RuAsS), erlichmanite (OsS_2), osarsite (OsAsS) and irarsite (IrAsS).

The highest gold values from DH-1 are a few hundred ppb. Gold forms alloys with silver and the metal ratios vary a lot from nearly pure gold to about 90% silver. The grain sizes are usually very small. Gold grains are most often associated with base metal sulfides, but they do occur also in magnetite and in silicates. Often when gold is associated with silicates it forms composite grains with some PGM's.

Figures 1A-C present cumulative data, i.e. all different types of mineralizations combined. Figures 2A-F display the associations and distributions of PGM's within different types of mineralizations. This data is from the most important respective sections of DH-1 only. The silicate-hosted Pt-mineralization is not represented because the respective thin sections were virtually devoid of PGM grains even though the lead fire-assay analysis yielded more than 4.3 ppm of Pt and over 0.6 ppm of Pd. That can also be considered as evidence that the PGE's are not evenly distributed in the rock. Figures 2A-B represent the silicate-hosted Pd-mineralization, 2C-D the oxide-hosted PGE-mineralization and 2E-F the sulfide-hosted Pd-mineralization.

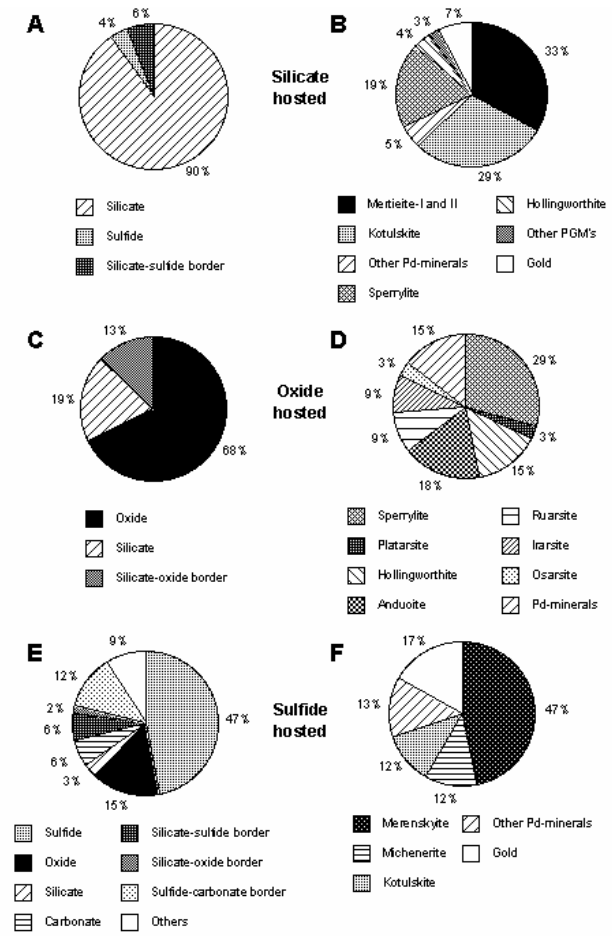

Figure 2. *Association (A) and distribution (B) of PGM's in silicate-hosted Pd-mineralization. (C) and (D) present the same for the oxide-hosted PGE-mineralization, respectively. (E) and (F) display the corresponding information for the sulfide-hosted Pd-mineralization, respectively.*

Conclusions

The lead fire-assay Pd+Pt analyses from the drill hole DH-1 of the Hanumalapur Complex indicate that there may actually be several different PGE mineralizations within the intrusion at different stratigraphic levels. When combined with the mineralogical data, this information leads us to distinguish four different types of PGE mineralization. They are in a descending order of PGE content 1) silicate-hosted Pd-mineralization, 2) silicate-hosted Pt-mineralization, 3) sulfide-hosted Pd-mineralization and 4) oxide-hosted PGE-mineralization. Preliminary studies of other drill cores support this conclusion.

References

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