Silicate-Chromite Type PGE Mineralization in the Hanumalapur Complex, Karnataka State, India

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An unusually thick sulfide-poor mineralized zone enriched in platinum-group elements (PGE) is described in the Hanumalapur Complex in the Shimoga District, Karnataka State, India. This promising occurrence was discovered by the present authors (T.T.A. and T.C.D.) from outcrops upon re-evaluation of vanadium-bearing titaniferous magnetite deposits in the early 1990's. The PGE-enriched zone is traceable in outcrops for almost three kilometers in a north-south direction and was penetrated by eight drill holes, the distance between the northernmost and southernmost ones being about 1.8 kilometers. The mineralized zone is erratic in thickness and PGE distribution. The maximum thickness detected so far is some 60 m and the maximum Pt+Pd+Au concentrations just exceed 6 ppm.

Ever since the discovery of titaniferous magnetite deposits by Smeeth and Sampath Iyengar in 1916, most geological investigations in the area have been centered around either these or the small chromite deposits subsequently discovered in some of the ultramafic bodies to the east of the area. The State Department of Mines and Geology and the Geological Survey of India have repeatedly prospected for both V-Ti magnetite and chromite deposits in the area, but apart from exploratory mining of the Masanikere V-Ti magnetite, the investigations have not resulted in the opening of any mines. The find reported here represents the first potential PGE occurrence to be identified in India (Devaraju *et al.* 1994, Alapieti *et al.* 1994 and Radhakrishna 1996).

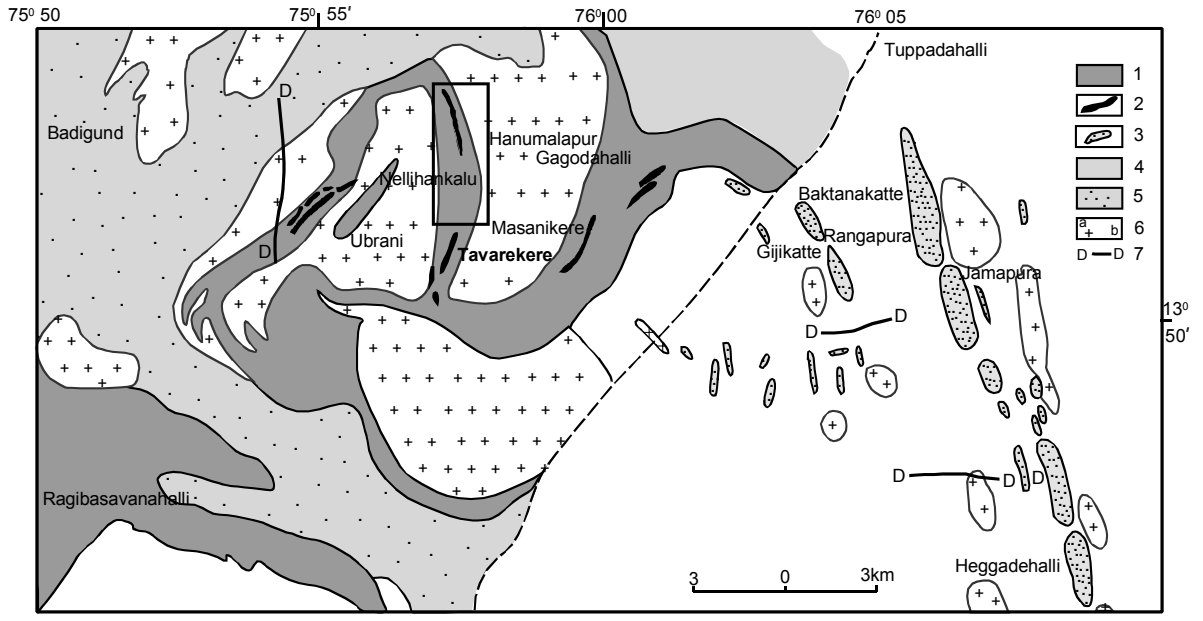

Figure 1. *Geologic map of the area around Tavarekere, South Channagiri, indicating the area studied here (partly adapted from Chadwick et al. 1988). 1. Hegdale Gudda Formation (HGF); 2. Magnetite bands and lenses; 3. Eastern ultramafic bodies; 4. Tuppahalli Formation; 5. Kur Gudda Formation; 6. Basement granitoids, a) Uniform-looking tonalite-granodiorite, b) Banded gneiss. 7. Mafic dyke.*

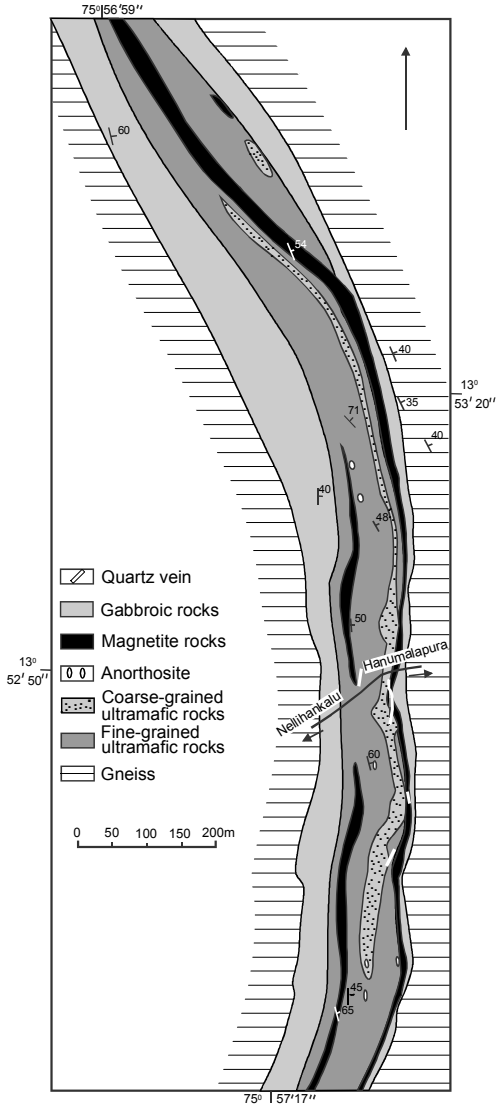

Figure 2. *Geologic map of the PGE mineralized Hanumalapur Complex.*

The Hanumalapur Complex is one of several mafic-ultramafic complexes located in the western Dharwar Craton between latitude13°45' - 13°55' N and longitude 75°50' - 76°10' E (Fig. 1). The western part of the area is composed of a portion of the southeastern part of the late Archean Dharwar Super Group (3000-2500 Ma) of the Shimoga basin, and the eastern part is occupied predominantly by a granite-gneiss terrain (~3000 Ma). These are separated by a northeasterly trending fault plane, designated by Chadwick *et al.* (1988) as the Main Eastern Boundary Fault.

Ten occurrences of mafic-ultramafic complexes lying within the area (Fig. 1) have been investigated by the present workers, with the specific aim of discovering evidence of PGE mineralization. These complexes comprise bodies exposed near Ubrani, Tavarekere, Masanikere and Hanumalapur in the western part of the area, and belong to the Hegdale Gudda Formation (HGF), while the Shivani, Gijikatte, Baktanakatte, Basavapura, Burudekatte and Rangapura occurrences, which are mostly ultramafic in composition, occur enclosed in the basement gneiss in the eastern part of the area (Fig. 1). The present quite comprehensive study has indicated that, among the bodies examined here, only the Hanumalapur offshoot of the HGF has provided evidence of a potential ore-level PGE occurrence so far. Whether the eastern bodies are of the same age as those representing the HGF is not clear from the available data, but the observed field relationships suggest that these are younger than the surrounding gneiss. Contacts between the bodies and gneisses are usually sheared and the ultramafic bodies themselves are highly altered and no chilled contacts have been preserved. A distinctive feature of the eastern ultramafic bodies, as opposed to the westernmost ones, is the absence of titanomagnetite seams, while instead they commonly host chromitite bands. By contrast, no chromitite bands have been encountered within the HGF, which is characterized by prominent magnetitite bands and lenses, mainly composed of titaniferous magnetite and chlorite. Disseminated chromite has been encountered in the Hanumalapur Complex, however.

At the surface, the Hanumalapur Complex forms a north-south trending body about 5 km long which ranges in width from 200 m to 1 km, dipping 40^{o}-70^{0} to the east, and being sandwiched between the homogeneous late Archean tonalitic-granodioritic rocks (Fig. 1-2). The Complex has experienced metamorphism from upper greenschist to lower amphibolite facies accompanied by corresponding deformation, processes which have destroyed the original cumulus textures and primary minerals. The eastern contact of the body is almost vertical and highly sheared, while the western one is not exposed. The body itself is also sandwich-like, the western and eastern sides being composed of gabbroic rocks followed inward by magnetite-rich layers (magnetitites), while the central part is mainly composed of ultramafic rocks, the chief constituent minerals of which are aluminium-rich chlorite, amphibole and iron-chromium oxide. The last-mentioned mineral is at present chromium-rich magnetite, although it was originally chromite, relicts of which are encountered in the cores of the grains in places, thus indicating that this rock originally contained disseminated chromites.

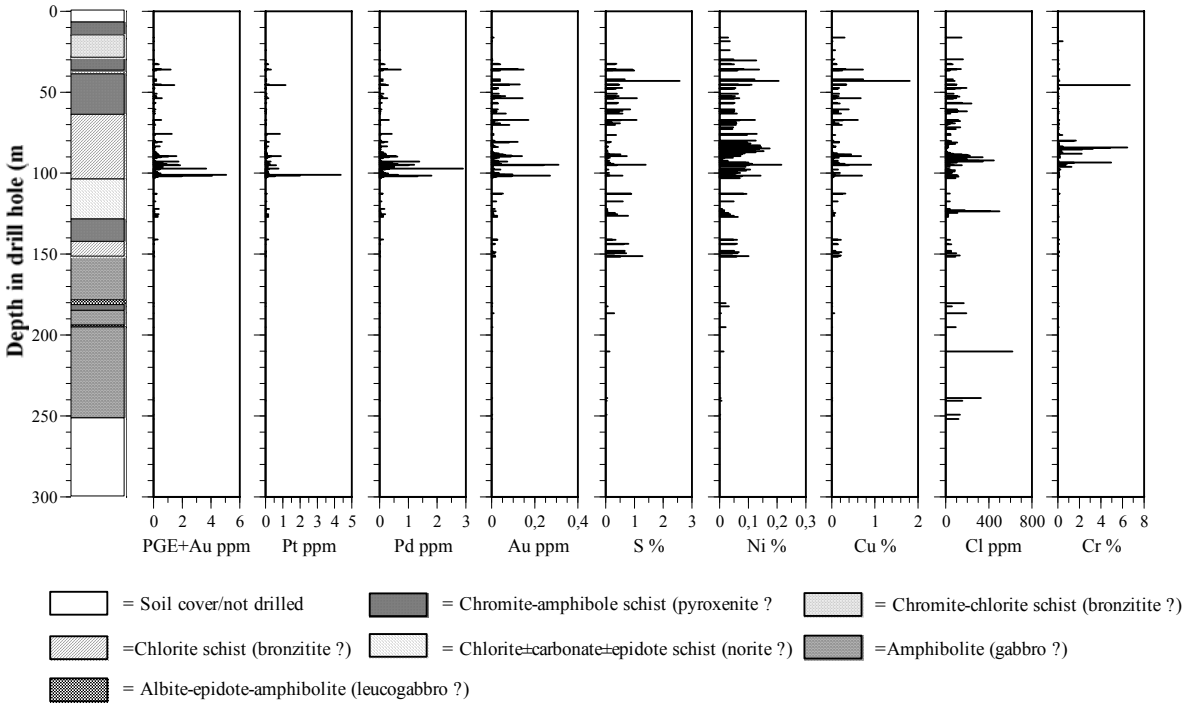

Figure 3. *Whole rock concentrations of PGE+Au, S, Ni, Cu, Cl, Cr in drill hole-1. The thickness of each bar represents the average sample length which is about 30 cm.*

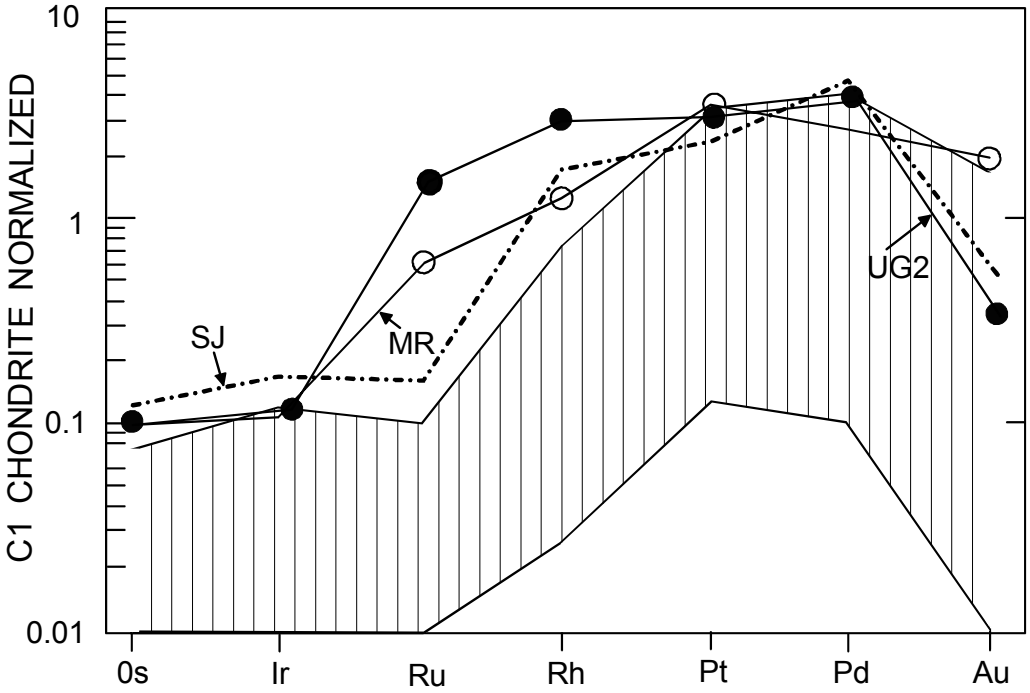

Figure 4. *Chondrite-normalized PGE and Au data for the Hanumalapur Complex (23 samples), compared with data for UG2 (from Naldrett and Cabri, 1976) and the Merensky Reef (MR, from Naldrett and Cabri, 1976) and the base metal sulfide type of the SJ Reef in the Penikat Intrusion (SJ, from Alapieti and Lahtinen, 2002).*

The platinum-group minerals (PGM) are concentrated in the last-mentioned chlorite-amphibole-magnetite/chromite rocks. The PGE-bearing zone includes platinum and palladium-rich reefs, the latter dominating over the former. PGE concentrations within the reefs commonly occur in association with chromite disseminations, although the PGM in certain reefs are found to be concentrated in pure silicate rocks (Fig. 3). On the other hand, the base metal sulfide-bearing rocks would seem to be devoid of PGE. The PGE-enriched zone can therefore been divided into a chromite type and a silicate type, the highest values in outcrops detected so far representing the former type and those in the drill holes the latter type.

Chondrite-normalized distribution patterns for the PGE-enriched zone in the Hanumalapur Complex are presented in Fig. 4, together with data from the UG2 chromitite, Merensky Reef and the base metal sulfide type of the SJ Reef in the Penikat Intrusion. The distribution pattern of the Hanumalapur Complex correlates well with that of the SJ Reef, even possessing a similar peculiar negative ruthenium anomaly (cf. Alapieti and Lahtinen, 2002). In addition, the SJ Reef is mostly sulfide-pure and commonly contains similar aluminium-rich chlorite, as mentioned above, thus forming a close counterpart to the Hanumalapur Complex.

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