Occurrence of Platinum Group of Elements (PGE) in Odisha and their Importance

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ABSTRACT

Wafted by the breeze of Bay of Bengal, Odisha stands at eastern coast of India being ninth largest state by area. The state is endowed with wide gamut of mineral resources like Iron ore, Bauxite, coal, limestone, manganese ore, gemstones, fireclays, nickel ore and platinum group of minerals etc. The state has got a lion's share of the Country's mineral reserves. Several mineral based industries have already come up in the state with many others are in pipeline. The dynamic State Government of Odisha has left no stone unturned in cashing in on the attention it has been getting from different business houses in recent times. The huge mineral resources of the state, 480 km long coastal stretch, the liberalised economic policy of Govt. of India, Industrial Policy 2007 and availability of infrastructural support make the state an investors' paradise. Exploration for Platinum group of elements (PGE) has been undertaken in many prospective areas of India based on the well-established genetic concepts of PGE mineralization in space and time. At present Odisha is the only state of India where there is presence of significant resource for Platinum group of elements (PGE) is proved after drilling by Geological Survey of India in collaboration with BRGM (France) at Baula-Nuasahi ultramafic complex. Apart from this there are many other locations found to be presence of the PGE but yet to be quantified.

1. INTRODUCTION

Platinum is popularly known in the society as Rich Man's Gold. It is basically bright white and precious metal which has got wide application to industry. Platinum Group of Elements comprises of a family of six greyish to silver white metals Platinum (Pt), Palladium (Pd), Rhodium (Rh), Ruthenium (Ru), Osmium (Os) and Iridium (Ir) are the rarest of precious metals in the earth's crust. Because of the similar physical and chemical properties, they tend to occur naturally together in the same mineral deposits. These are often associated with gold and silver and are classically known as Noble Metals. They all have commonality of extreme rarity in occurrence on the surface of the earth and attractive appearance with noncorrosive qualities even with long use and normal exposure to the ambience and the environment. Their crustal abundance are very low (less than sub-ppb level to maximum 10 ppb) and the PGE deposits are too few in number compared to other metalliferous or more specifically other precious metal deposits of the world. Exploration techniques in this field aimed at detecting subtle indications of PGE mineralization and assessing the economic potential of a geological environment have, however, yet to be developed and field tested. Success will depend on the formulation of practical sets of guidelines for implementing a programme of PGE exploration.

A concept oriented approach supplemented by appropriate field techniques is necessary to identify PGE targets. In view of the fine size of the PGM in the host rock, occurrence over narrow thickness and lack of clear-cut contact for easy discernability, field identification of zones of enrichment is rendered difficult.

2. OCCURRENCE IN ODISHA

Tony Naldratt of Canada, called the father of platinum group element (PGE), has mentioned in the editorial columns of the Journal of Geological Society of India that Bastar Craton and Cuddapah basin are two potential areas in India, where one should look for PGE mineralization. Based on geological criteria such as rock association, age, tectonic setting, depositional environment, geochemical association and abundances, the principal terrains for identification and delineation of Platinum group of elements are explored at certain targets areas in Odisha: 1. Baula-Nuasahi, Keonjhar District 2. Sukinda area, Jajpur District, 3. Singhbhum-Odisha Craton and 4.Amjori Hill, Keonjhar District (Mukherjee, 1998). However in addition to above four targets, the incidence of this platinum group of mineralization found to be reported at two other localities of Odisha. One being Bastar Craton located at western Odisha and another at Eastern Ghat Granulite belt located at southern part of Odisha. All the six locations are shown in *Figure-1*. In India, only a minor amount of Palladium is recovered as a byproduct from Singhbhum Copper belt, Jharkhand. Besides, no other Platinum Group Elements mine production is known in India as on date.

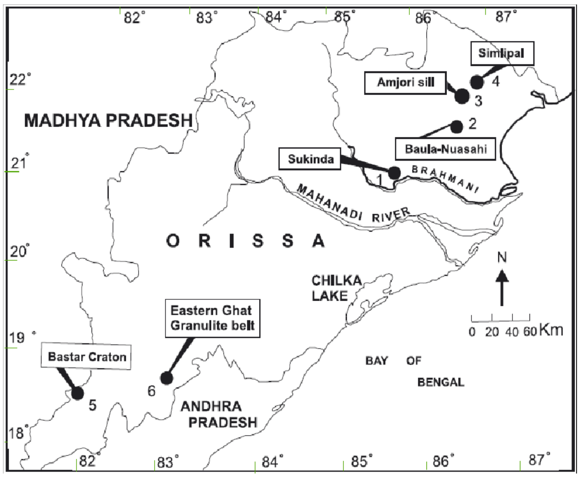

Figure-1 Location of Platinum bearing areas in Odisha

2.1 PGE AT BAULA – NUASAHI

Baula Nuasahi ultramafic complex of Keonjhar district is located at around 170 Km NNE from the state capital Bhubaneswar. It is NW SE trending and around 3 km long arcuate belt. Auge and Lerouge (2004) documented magmatic and hydrothermal PGE mineralization, both associated with chromites in the Baula-Nuasahi ultramafic complex, Odisha. The magmatic variety is a 'contact-type' mineralization that occurs at the contact of the Bangur gabbro and the ultramafics, and is characterized by high Pt/Pd ratio (~8 to 9). The hydrothermal type is restricted to the breccia apophysis of the Bangur gabbro, associated with an intense hydrothermal alteration and comprises relatively low Pt/Pd ratio. Within the Baula ultramafic complex, the interface between the ultramafic and the mafic unit (gabbro) in its eastern border, is marked by a prominent magmatic breccia zone ranging in width between 1 m to 40m and with a strike length of >2 km. Although incidence of platinum group elements (PGE) in the belt was recorded by Banerjee (1966), Roy (1970) and Chakraborty (1972), PGE rich zones containing more than 1 ppm (Pt+Pd) was reported by the AMSE wing of the Geological Survey of India (Thiagarajan *et al.* 1989). Subsequently the mineralized units confined to the brecciated Ganga Shankar chromite lode were identified (Nanda et *al*. 1996, Patra & Mukherjee 1996). A collaborative programme undertaken by BRGM, France and Geological Survey of India (1996 99) confirmed the PGE potential of the Baula sector (Augé *et al*. 1999). Two types of mineralization, viz. magmatic and hydrothermal origin, both linked to the intrusion of a gabbro into the ultramafic complex are reported (*Figure-2*). Confined within the gabbro, the ultramafic complex contains an orthopyroxenite band (50m wide and ~2 km long) in the west followed by other ultramafic members. The chromiferous dunite/ peridotite and chromitite with an estimated thickness of 120–150 m, constitute the core of the ultramafic complex. It hosts three major lodes of chromitite namely; Durga (av. 5 6m wide) in the west followed along dip by Lakshmi (2 3m) wide in the center and Ganga– Shankar (mainly dismembered) in the east (Mukherjee & Haldar 1975). The top of the ultramafic sequence is marked by a pyroxene rich unit whose contact with the easternmost gabbro is obscure. On the eastern and northeastern part, the gabbro with its variants is associated with bands of vanadiferrous magnetite. In the southern part of the exposed ultramafic complex, a coarse to very coarse grained gabbronorite, with large euhedral cumulus plagioclase and pyroxene crystals (up to 1 cm across) contains xenoliths of dunite, peridotite (sepentinite) and chromitite of variable size. This unit named as Bangur Gabbro intrudes all the litho units of the ultramafic complex including the gabbro unit. Confined to a restricted zone in the Baula (FACOR and IMFA mines) sector, the easternmost Shankar Ganga chromite lodes occur as bigger clasts within the gabbro matrix. Here chromite is generally being mined from the breccia zone. Within the matrix, base metal sulphide (chalcopyrite, pyrite, pentlandite and pyrrhotite) occur frequently both as stringers, veinlets and cluster. *Figure-3* shows the microscopic view of the existence of PGE in pyrrhotite. The southern extension of the complex, mostly concealed under

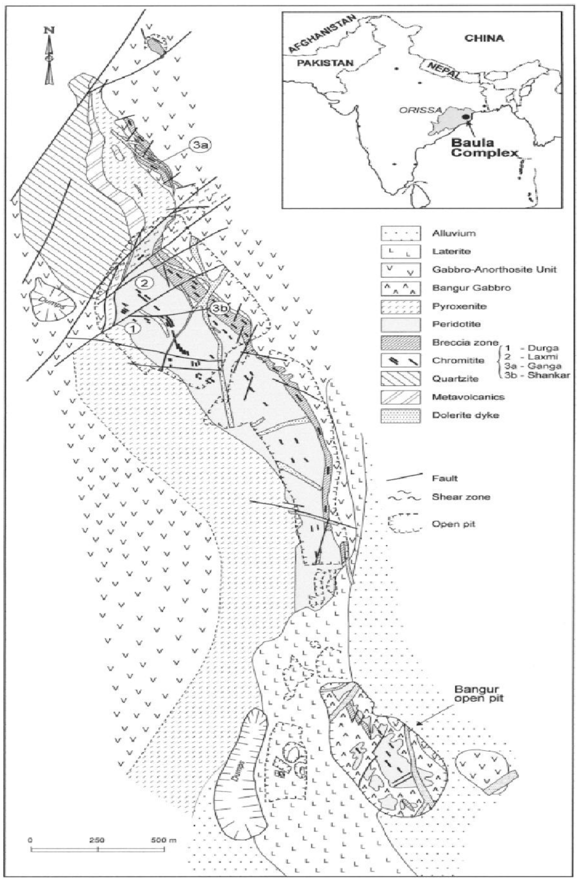

Figure-2 Geological map of Baula ultramafic complex, Keonjhar district, Orissa (GSI BRGM)

a thick laterite profile (>10m) is only exposed in the opencast mine of Odisha Mining Ltd. at Bangur. All the three chromite lodes (Durga, Laxmi and Shankar) of Baula have been brecciated and occur as clasts, thus losing their entity. These chromitite clasts are mined by OMC Ltd both by opencast and underground methods. In course of exploration work undertaken by OMC Ltd during 2004 05, encouraging values of Pt & Pd was reported from the breccia zone through ICP MS analysis carried out at NGRI Laboratory, Hyderabad. A detailed PGE investigation programme in Bangur is being carried out by GSI as a sponsored item of OMC Ltd. It is observed that in spite of the complex nature of gabbro at Bangur, a NW SE trending breccia zones rich in chromitite clasts is broadly decipherable, whose depth continuity is confirmed in underground mines occurring either as clusters or single grains within clinopyroxene and these are mainly associated with base metal sulphides. Concentration of Pt and Pd in the sulphide bearing chromitites is very distinct in the Nuasahi complex. There is clear variation in Ni/Cu ratios between the platinum bearing chromite lodes and adjacent gabbroic rocks. In the chromite lodes with platinum, the ratio is invariably higher. There is distinct positive correlation between silver and palladium indicating a possible geochemical linkage.

Geological Survey of India completed exploration including drilling to prove the depth continuity of the mineralized zone down to 300m. Shankar-Ganga lode is investigated in detail by GSI for two years in collaboration with BRGM (France). On completion of this project the indicated and inferred resources of PGE ore from the Baula area has been estimated as 14.2 million tonnes at a grade varying from 1.38 g/t to 1.55 g/t of Pt+Pd (Tejale, 2007). From this area IBM reported 2.33 ppm Pt, 1.99ppm of Pd, 1.54 ppm Ir, 2.46 ppm Rh and 0.71 ppm Ru. Odisha Mining Corporation from their lease area of 1900 hectares of Boula-Nuasahi complex from 65 samples analyzed by ICP-MS reported up to 18.59 ppm Pt as highest value (Nayak and Ray, 2007).

2.2 PGE AT SUKINDA

Since the discovery of Chromite in Sukinda area by TISCO people in late sixties, the exploration and mining activities related to chromite have intensified by many mining companies. The principal chromite deposits of the country are located in Odisha along a 2-5 km wide and 20 km long belt of ultramafic rocks in Jajpur-Dhenkanal districts well reported as Sukinda Ultramafic Belt. This Sukinda ultramafic belt is located at around 140 km north of Bhubaneswar, the state capital. This belt is found to be in the east-west trending valley around Damsal, a tributary to Brahmani river. It is flanked by Daitari hill ranges in the north and Mahagiri hill ranges in the south. The main chromite bearing areas are restricted to 3 km in width and 20 km in length. Sukinda chromite is relatively rich in chromium, Cr2O3 widely varying between 15 to 60% with MgO content around 11%. Cr/Fe ratio is more than 2. Southerly flowing Damsal Nala is the main drainage channel in the valley draining through the east-west aligned hill ranges locally called as Hunda Parbat of Daitari Ranges as well as Mahagiri, respectively forming as water divides of the Sukinda Valley. The entire complex covers an overall area of about 60 sq km. Geological set-up and geochemistry of Sukinda ultramafic complex has been well studied and described by several research persons.

The chrome and nickel bearing areas around Sukinda warrant exploration for PGE. Das Sarma et al (1966) reported 5 to 8 ppb of Platinum in the chromite and 5 to 11 ppb in the overlain laterite cover, from Sukinda chromite belt of Odisha. Chromitite and low grade oliviniferous chromite analyzed anomalous platinum values ranging from 2 to 400 ppb and palladium 1 to 500 ppb. In certain zones laterite and altered products like limonite capping on the ultramafic bodies analyzed 40 to 290 ppb Pt. Pyrite and chalcopyrite specks and disseminations are found in all the rock types in the area indicating the concentration of sulphides. The rocks which have analyzed from 0.5 to 1% sulphide are considered as the possible carrier of platinum minerals. In Kathpal chromite deposit located in the western most part of Sukinda complex incidence of platinum minerals have been reported. PGE are present as native alloys of Os-Ir- ru, metallic solid solutions or Ir-Pt and sulfides of Os-Ir-Ru and laurite-erlichmanite (Mohanty and Sen, 2007). Based on general geological set up, geochemical configuration, stratiform disposition, Sukinda complex chromite ore is considered comparable with platinum bearing Great Dyke of Zimbabwe where as the Baula-Nuasahi chrome ore shows similarities with that of Bushveld complex of South Africa. The information regarding the PGE was ignorant by the people at time of initial discovery of chromite in this area. Later on with discovery of the PGE in the ultramafic complex of the area, many international exploration companies started approaching to the area.

2.3 AMJORI SILL

Amjori sill is located in Keonjhar district of Odisha. It is about one km thick covering an area of about 130 sq.km which is another example of layered intrusion complex consisting of dunite, peridotite, gabbro and diorite sequence emplaced into the volcano-sedimentary suite of rocks of Early Proterozoic Cover sediments. Anomalous PGE values have been reported from a few localities from Amjori sill. Mukherjee (1998) reported up to 200 ppb of Pt and 60 ppb of Pd from pyroxenite from this area. Chromite bearing ultramafic bodies in the area need to be investigated in detail. Anorthosite-gabbro zones with V-Ti enriched magnetite bands considered as potential areas and have to be explored for possible concentrated zones of platinum mineralization. The sulphide bearing zones associated with chromite bands also deserve to be investigated for platinum group of elements.

3. INDUSTRIAL USE OF PGE ELEMENTS

With the burgeoning stage of the modern technologies at various industries, the application of the platinum group of elements increased many folds due to the chemical inertness and refractory properties of these metals are conducive for electrical, electronics, dental and medical fields. Platinum and palladium are primarily used as catalyst in controlling the toxicity of emissions from automobile, chemical and petroleum refining plants. Nearly half the total platinum used worldwide is as catalysts in catalytic convertors in automobiles. These metals are also used as catalyst in various chemical processes, viz, in organic synthesis in hydrogenation, dehydrogenation and isomerisation, production of nitric acid as also in fabrication of laboratory equipment. Platinum, palladium and a variety of complex gold-silver-copper alloys are used as dental restorative materials. The unique properties of platinum find varied applications in the medical field. Platinum's excellent compatibility with living tissue, as it does not get affected by the oxidizing reaction of blood, enables its utility in pacemakers. The primary usage of PGM in medical science is in chemotherapy for treatment of cancer. It has the ability to prevent division of certain living cells, a remarkable characteristic which find profound application in treatment of cancer. Besides, platinum-iridium alloys are extensively used in prosthetics and biomedical devices. Platinum's excellent conductivity lends itself for use in the electrodes of phosphoric acid fuel cells for generating electricity. Another significant use of platinum and its alloys in cast or wrought form are in jewellery. Platinum-iridium alloys find major application in making crucibles for growing crystals and in data storage disks of computers. Glass made with platinum and rhodium is used in housing construction, flat screen televisions, computer monitors, display panels, automobile displays, factory monitoring equipment, etc. Platinum is used to enhance storage capacity of devices, such as, computer hard discs, cell phones, digital cameras and personal music players. Recently, palladium silver resistors have been used in secondary lightening surge protection devices.

Significant quantities of the three light platinum group metals Ruthenium, Rhodium and Palladium are formed as fission products in nuclear reactors. Palladium has been of special interest due to its less complex behaviour when compared to rhodium and ruthenium. The demand of palladium is expected to rise as it is increasingly substituted for platinum as catalyst for petrol engines and to certain extent even in diesel engines.

4. CONCLUSION

Due to the diversified application of the PGE in various industries, the demand for PGE in the world is increasing at a faster rate and as per recent estimate by RENO, an Ottawa based Mineral Economics Firm, the growth expected for supply from South Africa, the biggest producer is expected to be around 7.5%. The demand for platinum will continue to rise with tighter emission controls, robust growth of automotive sector and electronics and emerging Indian market for platinum jewellery. There is a need for application of state-of-the-art technology and integrated multidisciplinary approach for exploration in the state. Also the prices of Platinum group of metals are on ascending trend. The presence of the precious noble PGE metals at couple of places inside the state of Odisha highlighted its importance over the world and already many external agencies/investors showed their interest and started approaching to have exploration and extraction operations as joint venture. There is tremendous scope for development of PGE deposits in both brown field and green field areas in the state. High value and precious byproducts have to be given proper weightage for evaluation. Those target locations of PGE are to be explored intensely to prove the reserve with the grade of elements based on which mining can be done and suitable modern hi-tech extraction techniques are to be implemented for the economic metal extraction. With the effective utilization of these PGE deposits, undoubtedly Odisha will be leading producer for the Platinum group of elements in world.

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