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# Method for Separation and Detection of Gold Sulphide from Banded Magnetite Quartzite (BMQ) of Goa

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**ABSTRACT**

Gold (I) sulphide is the inorganic compound with the formula $Au_2S$. It is the principal sulphide of gold. It decomposes to gold metal and elemental sulphur, illustrating the nobility of gold. Recovering gold from sulphide refractory gold ore has been an important guarantee for the sustainable development of gold industry, while there are many challenges in the treatment of sulphide refractory gold ore, such as environmental pollution and low gold recovery. In this study we aimed at separating gold sulphide from Banded Magnetite Quartzite (BMQ) of Goa. The BMQ sample wasdried, powdered, concentrated by panning method and subjected to magnetic separation using neodymium magnet and sieved into different fractions with the sieve size of 250, 150, 106, 53 µm. Powdered sample was tested for presence of gold sulphide by ICP-AES, SEM-EDX, CHNOS Analysis methods.

***Key words:*** *Gold sulphides, Banded Magnetite Quartzite (BMQ), Goa, Biooxidation, Separation and detetction.*

## Introduction

Goa is situated in the northwestern part of the Western Dharwar Craton (WDC) which is Asia's major metallogenic province (Dessai, 2011). The iron ores of Goa are associated with greenstone and occurs as bands, reefs and lenses of BHQ and BMQ (Dessai, 2018). Various research findings show the presence of gold in the WDC and parts of the Konkan region. Occurrence of gold (0.06 to 0.16) ppm in laterite and powdery ore of the Keri and Kalne villages of Maharashtra and < 0.1 ppm gold in laterite and iron ores in the Sindhudurg district (Umathay, 1993). Occurrence of gold in sulphidic BIFs ranging from 0.7 to 3.2 g/t (Sawkar *et al.,* 1995). Lot of work has been done on biomineralization of gold and on biofilms on bacterioform gold (Reith *et al.,* 2007, 2009; Fairbrother *et al*., 2013). Gold(I) sulfide is the inorganic compound with the formula $Au_2S$ and principal sulphide of gold. It decomposes to gold metal and elemental sulphur, illustrating the nobility of gold. Recovering gold from sulphide refractory gold ore has been an important guarantee for the sustainable development of gold industry, while there are many challenges in the treatment of sulphide refractory gold ore, such as environmental pollution and low gold recovery.

In this study, A novel method for gold sulphide recovery from BMQ was proposed with the purpose of improving recovery efficiency of gold.

## Methodology

### Sample preparation

Collected samples were dried, powdered using mor-

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tal and pestle (Panda *et al.,* 2011). The recovered sample was concentrated by panning method (Southam *et al*., 2009) and subjected to magnetic separation using neodymium magnet (Oliveira and Larizzatti, 2006) and sieved into different fractions with the sieve size of 250, 150, 106, 53 µm.

**ICP-AES studies**

Inductively coupled plasma atomic emission spectroscopy (ICP-AES) is an analytical technique used for the detection of chemical elements. The coarse ferromagnetic material was removed first serial washing was then carried out with tap water to remove the lighter and soluble fraction and heavier insoluble fraction (I) was resubjected to magnetic separation to remove fine ferromagnetic particles which had escaped previous treatment. The heavier fraction (II) was then dried and tested for detection of Sulfur by Lassaigne's and lead acetate test. The intensity of this emission is indicative of the concentration of the element within the sample. Quantification of gold by ICP-AES method was carried out at the Cera Laboratories in Mumbai. 10 gram of completely dried sample at 105°C (Panda *et al.,* 2011) with 106 micron size sieved fraction of each sample was sent for the analysis as per the demand of the instrument and company.

**Scanning electron microscopy (SEM) study**

Gold sulphide particles were analyzed using SEM-EDX characterization by Carl-Zeiss Scanning Electron Microscope (SEM) (USIC, Goa University). The gold sulphide particles were mounted on a carbon tape and the images were obtained with operational conditions 15 to 35kV (Falconer *et al.*, 2009).

**CHNS/O Elemental Analysis**

Sulphur analysis was carried out using CHNS/O Elemental Analyzer Perkin Elmer PE 2400 series II which works on frontal chromatography technique for separation and estimation of C, H, N, S and O elements in a sample. It was carried out at Sophisticated Instrumentation Centre for Applied Research and Testing (SICART) at Vallabh Vidyanagar, Gujarat, India

## Results and Discussion

We were successful in obtaining the powdered, dried sieved fractions of the samples. The fractions 150, 106, 53 µm showed high concentration of gold and same fraction were thus used for the further studies. Similar finding has been reported in Brazalian mines (Oliveira and Larizzatti, 2006), Australian mines (Reith, 2013). The iron ore from the BIF of Goa has not been subjected to multi-elemental analysis (such as Au, Ag, Pt including REE). However, our studies have established that BMQ contains 8 ppm. Values of gold (0.98–4.72 ppm) has been reported from Gadag greenstone belt, Western Dharwar Craton, Peninsular India (Ugarkar *et al.,* 2016). Determination of gold (0.5 to 50 ppm) in low grade ores and concentrates by anion exchange separation followed by neutron activation has been

**Table 1.** Gold sulphides found elsewhere and their distribution and concentration in auriferous ores

| Types | Occurrence | Country | Reference |
|---|---|---|---|
| Primary gold–sulphide deposits | carboniferous strata of the Arctic zone | Russia | Aleksandrova *et al.,* 2020 |
| arsenical gold sulphide | | Greece | Komnitsas, C., and Pooley, F.D. 1990. |
| refractory gold sulfide | | Argentina | Marchevsky *et al.,* 2017 |
| Primary gold sulphide deposit | Migori granite-greenstone complex- Archean rocks | Migori gold belt, Kenya. | Ogola *et al.,* 2002 |
| Au, pyrite, and arsenopyrite | Birimian greenstone belt of Boromo–Goren (lower Proterozoic) | West Africa | Bamba *et al.,* 2002 |
| Au, pyrite, and arsenopyrite | Granite greenstone belts | Barberton Greenstone Belt (BGB) of the Kaapvaal Craton, South Africa | Pretorius *et al.,* 1988 |
| Primary gold deposit | Barberton Greenstone Belt (BGB) | South Africa | Altigani 2021 |

reported (Iyer and Krishnamoorthy, 1976). Chemical oxidation is performed at elevated temperatures with either dry (roasters) or wet (autoclaves) ore. For bio-oxidation the ore is mixed with water and microorganisms in highly aerated continuous stirred tank reactors (CSTR's).

As shown in Figure 1(a-b), typological classification of gold sulphide. Figure 1a and 1b show the irregular particles with the irregular BFG with rough surface. These grains ranged from 0.1 to 1mm in diameter coarse, sub-angular to angular with no mechanical damage. The presence of the elemental gold and sulphur is seen in the spectra presented in Figure 2.

The sodium fusion test or Lassaigne's test used to carry out elemental analysis for the qualitative determination of the presence of foreign elements, sulphur in an organic compound. The appearance of violet colour indicates the presence of sulphur.Lead acetate test was also positive which was indicated by the formation of a brownish-black precipitate which is formed due to sulfide ions which react with lead (II) acetate. Sulphur analysis was carried out using CHNS/O Elemental Analyzer which showed the presence of 0.6% of sulphur corresponding to approximately 9% (w/w) gold sulphide in heavy fraction of BMQ.

## Conclusion

We were successful in detection and seperation of

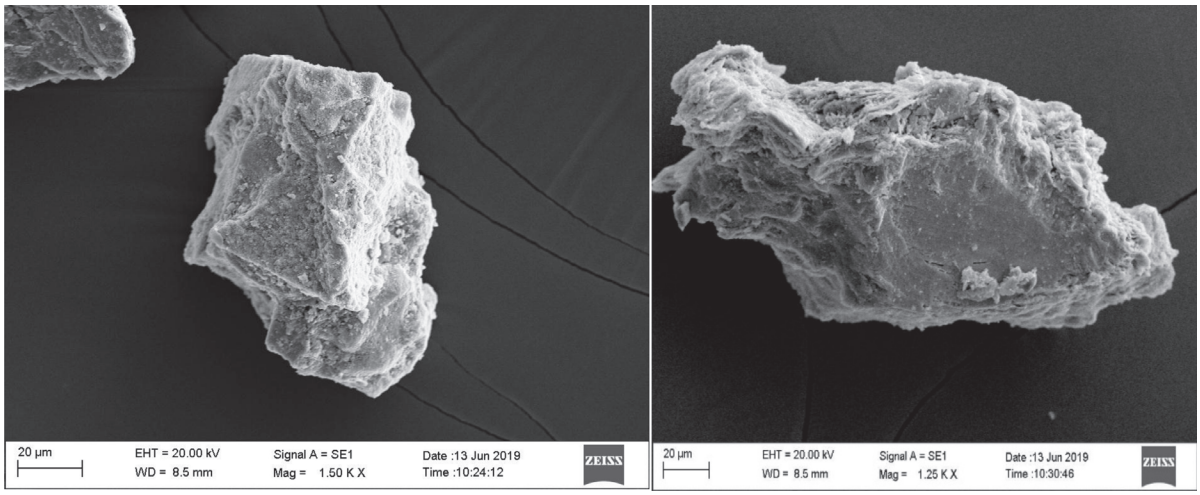


**Fig. 1(a-b).** SEM based typological classification of gold sulphide grains; a,b-Irregular with rough surface.

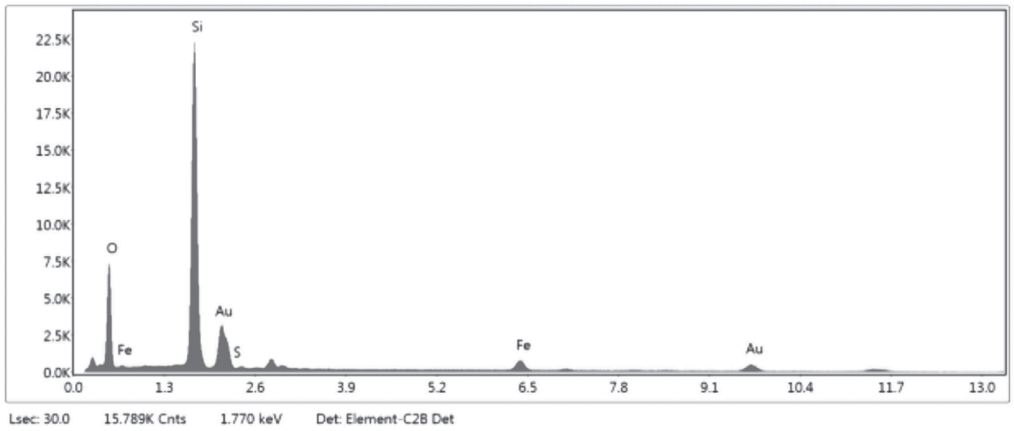


**Fig. 2.** SEM-EDX characterization of gold sulphide grains. The presence of the elemental gold can be seen in the spectra presented by the EDX analysis.

gold sulphide from the BMQ sample for the first time in Goa. The presence of gold sulphide in the sample provide opportunity to carry out the biooxidation using the bacterial cultures. Thus can be useful in biomining of gold.

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