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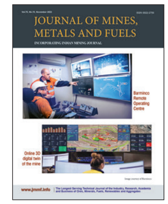

Structural Controls on Gold Mineralisation in Nagavi Area, Gadag Schist Belt, Karnataka, India

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Abstract

Minerals and metals play a very important role in the country's economic growth and as well as construction industries. Minerals also support automobile industries as they are required to manufacture steel and other products using various minerals. So, minerals and mining industries are the backbones of any country's Gross Domestic Product (GDP). In the study area, Banded Iron Formation (BIF) hosted auriferous sheared zones which are indicating very good gold and associated mineralisation. In the study area, different litho units occur like metabasalt, schist, shale and pyritiferous metabasalt. Banded Iron Formations (BIFs) are dominating in the study area along with quartz vein, Banded Fe-Mn Chert and BIFs float. Different rock chip samples show encouraging gold mineralisation zones. Auriferous shear zones on top of the hilltop in the reef. In the study area, Petrography and mineralogy have played a vital role in gold and associated mineralisation in the Nagavi area. Gold is closely associated with sulphides, mainly pyrite and pyrrhotite, and to a lesser extent, with bismuth tellurides and carbonate minerals. The gold content range in BIF's of the Nagavi area is from < 20 to <27 ppb. In the study area, geological structures like dips, strike, faults, folds, joints and unconformities support gold mineralisation. Majorly these structures control the gold and associated minerals.

Keywords: *Auriferous Shear Zones, Faults, Folds, Geological Structures, Gold Mineralisation*

1.0 Introduction

Dharwar Craton consists of Western and Eastern Dharwar Craton, each craton having different petrological and mineralogical variations. In the 1990's Gadag Schist Belt assisted in a greater understanding of the hydrothermal activity and geology activity in the schist bodies. There are three zones in the Gadag schist belt i.e. central zone, the east zone and the west zone which are hosted by Banded Iron Formations (BIFs). Gadag schist belt is very well-known in India as well as the rest of the world for ancient British gold mining activities. The Nagavi study area is located in the northern part of the central zone of the Gadag schist belt and the gold and associated mineralisation is controlled by BIFs-hosted rocks. The Nagavi area is somewhat unusual in that it represents a deposit formed during low-PT conditions and relatively brittle deformation Ugarkar, *et al.*,[1]; Napoleon, *et al*[2]. The Geological Survey of India has systematically explored all the gold and associated mineral-bearing tracts and also sulphide mineralisation in the western half of the Gadag schist belt between Nagavi in the north and Sangli mines

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in the south including Hosur and Yelisirur. The Hungund-Kushtagi schist belt is an extension of the Ramagiri - Penakacherla schist belt exposed in the adjacent state of Andhra Pradesh, which together with the Karnataka Craton is considered as Dharwar batholith[1,3-5].

2.0 Location and Accessibility

The study area Nagavi is located in the northern part of the Gadag Schist Belt (GSC) and about 6 km south of Gadag town in the taluk and district of the same name in northern Karnataka. The Survey of India toposheet is Numbered 48M/11 of 1:50000 scale and is bound by longitudes from 75° 35' 21.15" to 75° 38' 13.20" E and latitudes from 15° 20' 25.14" to 15° 24' 9.65" N. The total study area is about 13 sq. km. The Gadag district headquarters is about 350 km by road towards the northwest of Bangalore and is also well connected with the railway. The study area Nagavi is well served by all-weather roads, National Highway towards the south-west to Mulugunda and another National Highway towards the West to Hubli-Dharwar city and good tar roads towards Shirhatti taluk (Figure 1).

3.0 Objectives

The present work on structurally controlled Gold Mineralisation Nagavi area deals with the following objectives.

- To understand the geological structures of the area.
- To study the gold mineralisation controlled by geological structures.
- To understand the mineral variations in different places in the study area.
- Study of BIF-hosted structurally controlled gold mineralisation.

4.0 Geology of Nagavi Area

Nagavi area consists of different litho units, like, Metabasalt, Banded Iron Formation (BIFs), schist, shale, argillite, auriferous shear quartz veins, quartz veins, thin bands of carbonates and pyritiferous metabasalts. The gold and other associated mineralisation are localized in the reef at top of the hill at the regional anticline, which is well defined by the BIFs prominently forming the

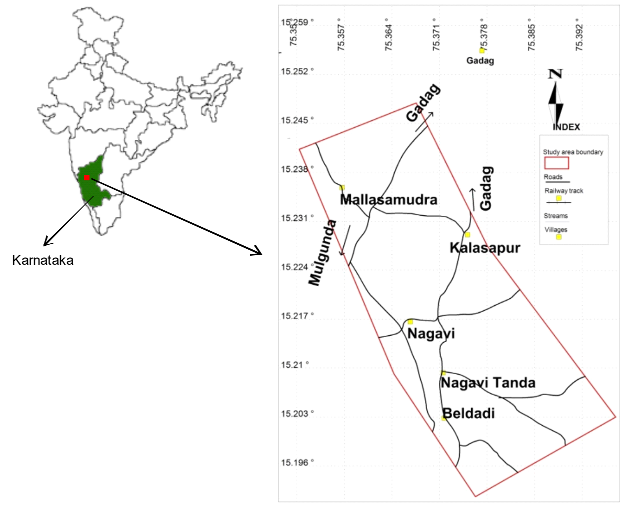

Figure 1. Location map of Nagavi area.

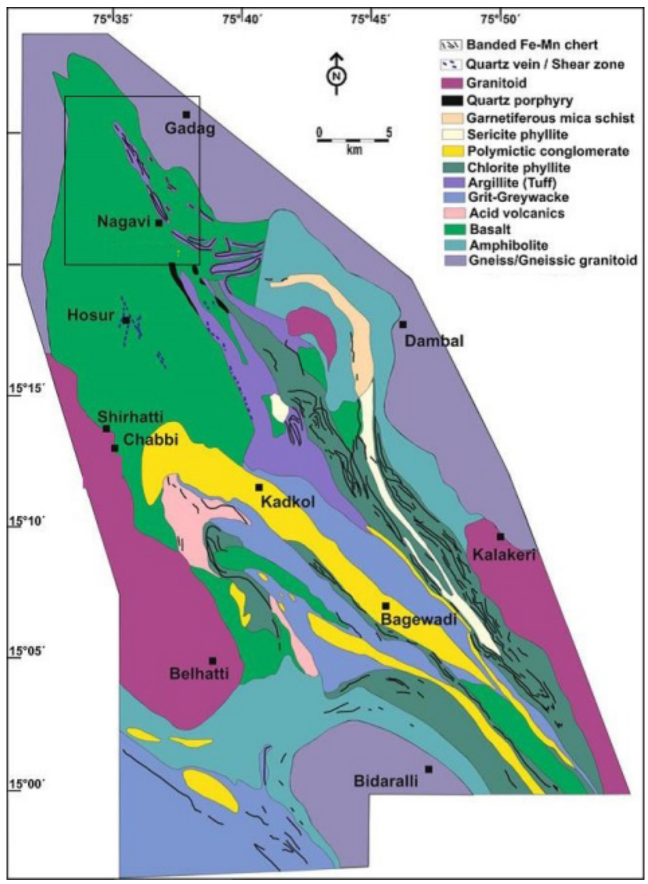

Figure 2. Geological map of Gadag Schist Belt.

ridges (Figure 2). BIFs are characterized by the presence of alternating iron and silica-rich layers[6,7]. This type of different layers is usually observed on several scales in the field outcrop from millimetre scale to meter scale

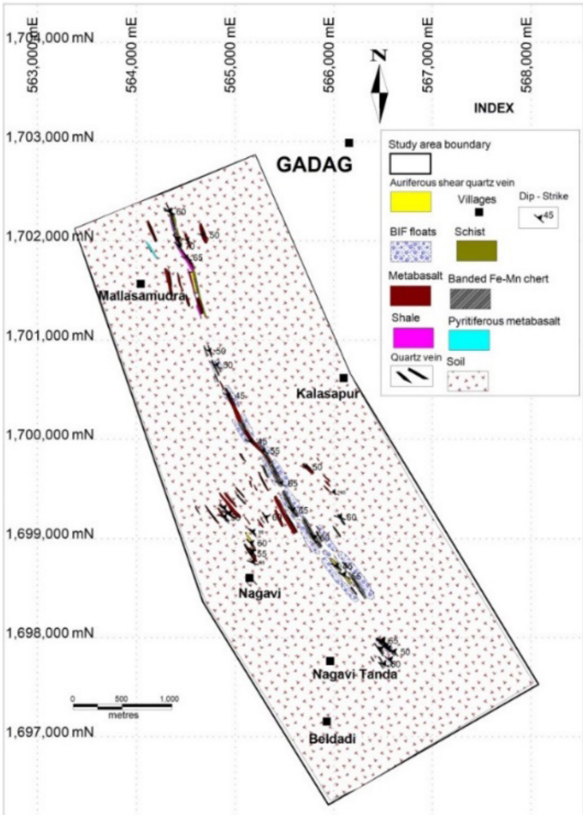

Figure 3. Geological map of Nagavi study area.

bands. The carbonate variation in a mineral phase like calcite and siderite may be present in the iron-rich layers. Hard-banded iron ore and flaky nature ore are located in the Nagavi area. The Gadag schist belt consists of a 2000 m thick pile of meta-volcanic and meta-sediments[8] (Chakrabarti, *et al.,* 1993) and a banded iron formation (Radhakrishna and Vaidyanadhan 1997). Hard-banded iron ore and flaky ore are located in the Nagavi area. The structural disposition of the belt is the result of an overall E-W compressional regime with uplift and diapirism of the sialic basement within which the N-S trending Archaean shear systems have caused buckling and refolding of earlier fold belts, making all the linear elements parallel to the direction of shear (Figure 3).

5.0 Methodology

5.1 Field Techniques and Sampling

The study area has been marked on the Survey of India toposheet no. 48M/11 and enlarged it to an A3 size scale for field reference. Geological mapping of the area has been carried out using a GPS (Garmin make Map 62S model with 3 to 4 meters accuracy and compass). All field data like litho-contacts, rock exposure, location coordinates, trends and descriptions were recorded during the geological traverses. The fresh quartz vein outcrop samples were collected from the Nagavi study area from different in-situ outcrops and packed in a sealed cover and submitted to PPOD Lab, GSI, and Bangalore for fluid inclusion studies.

5.2 Geological Mapping and Sampling

Detailed geological mapping was carried out by taking close-spaced traverses (200m) across the regional strike of the formations in the study area to identify the various litho-contacts and different rock types, structural settings, sheared mineralisation zones, sulphidation zones in the Nagavi area of Gadag schist belt. During geological mapping, rock-chip samples have been collected from BIF, shear quartz veins and metabasalt to analyse major and minor elements and also petrography study. The quartz vein samples were collected from different locations in the study area to analyse the fluid inclusion study. The different litho contacts of rock-chip samples were also collected for gold analyses.

5.3 Petrography and Mineralogy

Rockchip samples have been collected during fieldwork in different locations for petrography and mineralogy study. These studies were carried out at the PPOD Laboratory, Geological Survey of India (GSI), Bangalore. These tests were conducted under Carl Zeiss/Nikon binocular petrological microscope for the mineralogy, texture, alteration etc. and photomicrography is also carried out.

5.4 Rockchip Sample Analysis For Gold

Samples have been collected from different areas i.e. shear zones, trial pits and sheared quartz veins with BIF contacts during fieldwork and these samples were analysed by GTA-AAS method in Geological Survey of India Laboratory (GSI), Southern Region, Bangalore.

6.0 Gadag and Nagavi Structures

In Gadag schist Belt the secondary structures are observed and which are in the deformational structures such as folds, faults, shear zones and thrust zones, which are induced by directional stresses. The study area forms a part of the regional fold whose anticlinal closure lies at the Nagavi area (Figure 4).

The geological structures were observed in different places in the study area, such as folds, faults, shear zones and thrust zones, these structures are induced by directional stresses (Figure 5). The Nagavi area is part of regional folding structures where anticlinal closure lies at the Nagavi area[9]. The folding structures are clearly defined with the hard compact rocks of BIF with the relatively softer rocks alternately[10]. The structure and tectonic aspects of the BIF were studied by Saha, *et al*[11]. The silicate facies of banded iron formations are also locally developed[12]. Studies on various aspects of BIFs and the resultant iron ores especially the high-grade hematite ores are attracting the attention of different researchers in recent times[13]. Different litho units like metabasalt, quartz veins, argillites, chlorite schists, quartz sericite phyllite and carbonates occur in the study area. In the study area, geological structures were observed especially ripple marks, bedding, faults, folds of oolitic and vesicular structures and sheared zones. These structures strongly support sulphide mineralisation in the Nagavi area.

In the Nagavi area, the secondary structures were observed during the field visit which is in the deformational structures such as faults, shear zones, folds, and sheared thrust zones. The regional fold whose anticlinal closure lies at the Nagavi area. The fold is indicated clearly by the hard compact rocks of BIF with the relatively softer rocks[10].

The structure and tectonic aspects of the BIF were studied by Saha, *et al.,*[11] most of these banded iron formation horizons belong to the oxide facies banded iron-formations as defined by Chakraborty, *et al.,*[14] but silicate facies banded iron-formations are also locally developed[12].

6.1 Ripple Marks

Ripple marks are waved shape structures which are formed by fluid movement over sediments and syndepositional modifications. Identified the ripple marks in the area at a few places and ripple marks indicate the shallow water deposition of these Banded Iron Formations (BIFs).

6.2 Bedding

The bedding plane represents the presence of beds more or less well separated. Especially BIF bedding plane

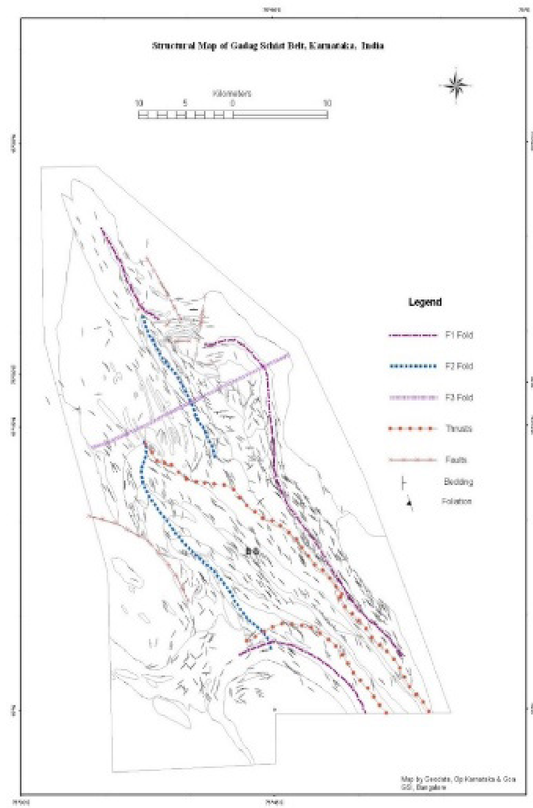

Figure 4. Structural map of Gadag schist field.

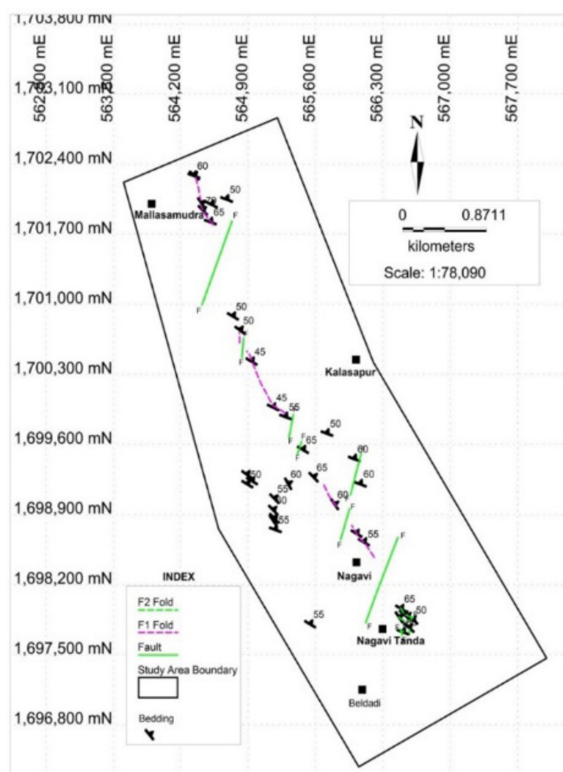

Figure 5. Structural setting map of Nagavi area.

is sharp and linear. These bedding planes can be traced at places with thicknesses varying from a few millimetres to centimetres observed in the Nagavi area (Figure 6).

6.3 Folds

The F1 folds and intersection lineation also define the F1 fold axis. It is prominently seen as grove lineations in BIFs. The F1 fold shows a northerly plunge of 40° to 45°. Several minor folds are seen at the anticlinal closure near Nagavi. Each minor fold is sheared and the corresponding quartz veins form auriferous lodes. These shear zones are confined only to the hinge portion of the F1 fold whereas the main axial shear continues further north of Mallasamudra. Near Mallasamudra village due to dilation of the shear zone and multiple faulting, auriferous quartz veins are emplaced (Figure 7 to Figure 11).

6.4 Faults

A minor fault strike direction in the NNW-SSE direction has affected the western limb of the syncline. The various types of faults zone identified in the area like major and minor faults (Figure 12 and Figure 12a). The faulting confined to a stratum lying between undeformed bands is called an intraformational fault.

6.5 Sheared Zones

Identified the mineralized shear zones which are trending in N20°W- S20°E direction for nearly 450m to 500 m near old working mines in the Nagavi area. In the Mallasamudra area, several N-S trending shear zones (parallel to F1) are noticed. Syntectonic auriferous sheared quartz veins were emplaced into the BIFs in F1 axial direction (Figure 13).

6.6 Vesicular and Oolitic Structures

Vesicular and oolitic structures were observed in the study area and oolitic structures were observed within the quartz vein (Figures 14 and 15). The oolitic is commonly found in large current bedding structures that resemble sand dunes. In extrusive rock, the textures contain voids left by gas bubbles that escape as lava solidified.

7.0 Gold Mineralisation Model

The gold and associated mineralization in the Nagavi study area, with a deformed iron formation hosted in a polydeformed paragenesis sequence[15]. The mineralization is characterized by very strong sulphide mineralization, silica and auriferous quartz veins developed within a sulphidic chert unit (Figure 16). The gold mineralization

Figure 6. Ripple marks in BIF (Hill top area near to old Adit of Nagavi Area).

Figure 7. Bedding plane with synclinal fold in BIF (Hill top area near Nagavi).

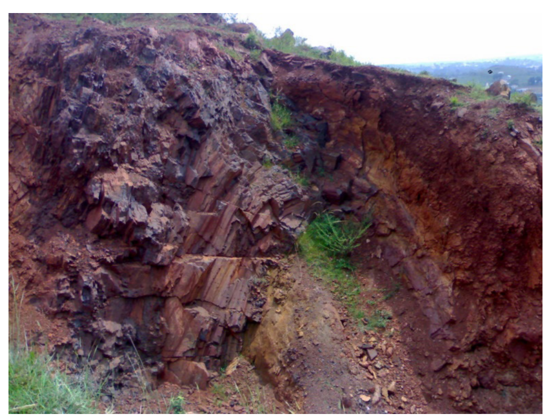

Figure 8. Anticlinal fold in the contact between Phyllite and laminated BIF (Nagavi south).

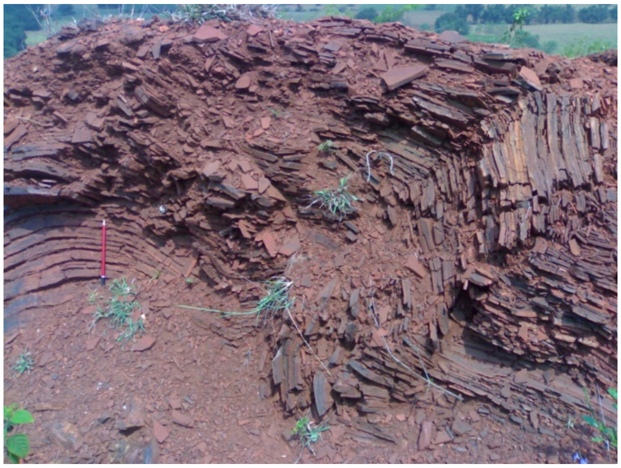

Figure 9. Anticlinal Fold in Flaky BIF (Nagavi south).

Figure 10. Asymmetrical fold in the metabasalt exposure (Near Nagavi).

Figure 11. Large recumbent fold (Near Nagavi).

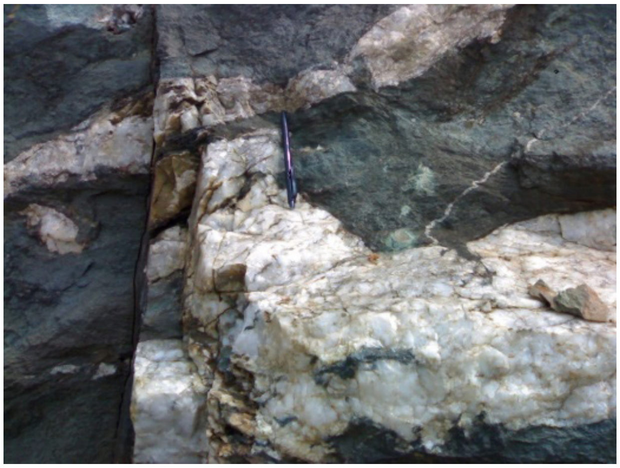

Figure 12. Faults across and along the strike in metabasalt.

Figure 12(a). Sugary white fracture quartz veins.

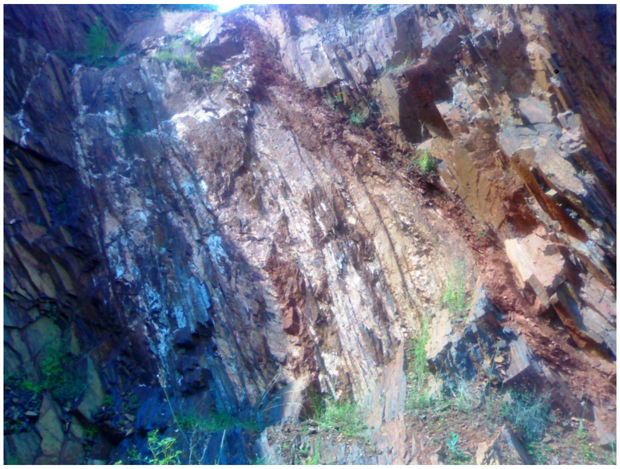

Figure 13. Shear quartz vein in BIF contact.

Figure 14. Vesicular texture and thin bands of BIF in metabasalt.

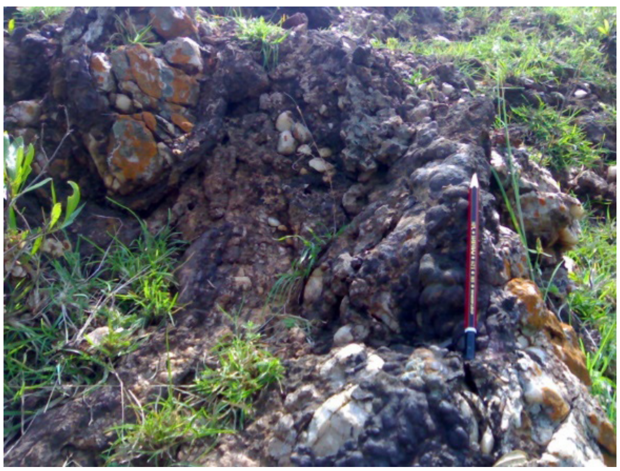

Figure 15. Oolitic structures within Quartz vein and BIF contact (Nagavi South).

is epigenetic in nature but strata bound because it is confined to the cherty iron formation[1].

The sulphide oxide replacement textures are observed in the ore zones, the occurrence of gold mineralisation. The gold values vary from <20 ppb to <27 ppb. All samples were analysed for Au by GTA - AAS method. The BIF samples were collected from different locations over a width of 0.2 to 0.3 m with the intrusion of a shear quartz vein. NNB 19 and NNB 12 samples were collected from auriferous shear quartz veins with BIF contact and sheared quartz vein on top of hill[16]. This vein quartz emplacement is showing a brownish colour due to oxidation of sulphides, the quartz vein shows prominent pinching and swelling structures. These samples are showing very good gold values of <22 and < 26. The Samples NNB 20 and NNB 22 were collected from auriferous sheared zone trail Pit No.2 and ancient working trench number 2 and encouraging analysis results were received <20 and <27 ppb. Sample numbers 28 and 26 were collected from ancient working trench 4 and Shear auriferous zone (trail Pit No.1), these samples are showing results of <20 and <27 values (Table 1). BIF-hosted gold mineralisation forms an integral part

Table 1. Analytical results of BIF-hosted shear zone samples from the Nagavi study area

	Sample No.	* Au by GTA-AAS (in ppb)	Sample description
1	NNB 19	<22	Auriferous sheared quartz vein zone with BIF contact
2	NNB 12	<26	Sheared quartz vein on top of a hill
3	NNB 20	<21	Auriferous sheared zone (trail Pit No.2)
4	NNB 22	<27	Ancient working trench 2
5	NNB 28	<20	Ancient working trench 4
6	NSB 26	<27	Shear auriferous zone (trail Pit No.1)

*GTA-AAS testing carried out by GSI Lab, Chemical Division, Bangalore

of many Archaean greenstone belts in countries such as Australia[17,18], and South Africa[19].

The source of iron in BIF could be due to submarine volcanism and associated hydrothermal circulation by the exhaling model proposed by Gross[20,21]. The gold has a close association with pyrrhotite suggesting that mineralisation occurs under conditions of relatively low sulphur activity. Gold is associated with sulphide and commonly occurs as inclusions in pyrite grains along boundaries of pyrrhotite and gangue minerals as micro-crack fillings in pyrite or as discrete grains.

7.1 Megascopic Study

In the Megascopic study the rock consists of compact and grey to brown (Figure 17 field photograph and Figure 18 microscopic study) whereas, in the microscopic examination, the rock is composed of alternate bands of quartz-rich and opaque–rich bands. The quartz-rich bands consist of highly recrystallised equigranular (~100

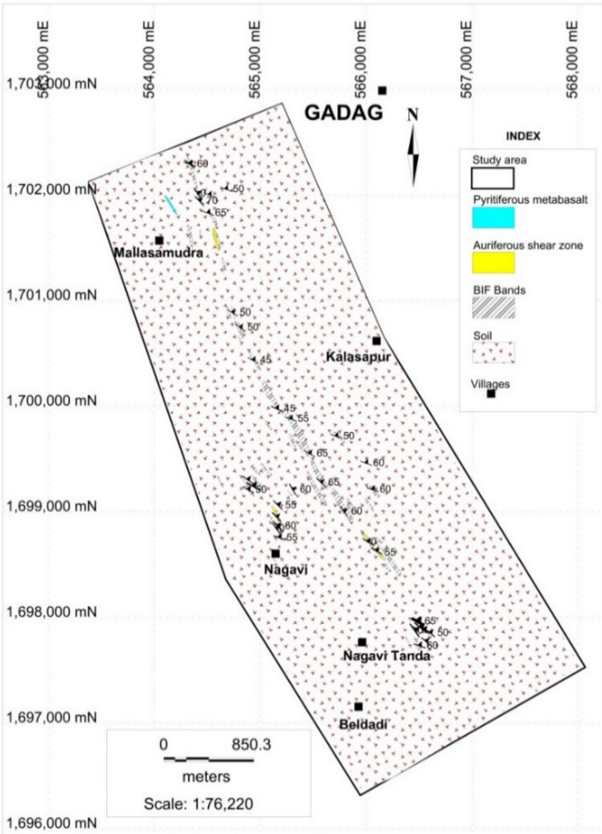

Figure 16. Auriferous gold-bearing shear zones.

µm) quartz grains with triple-point junctions and a subordinate amount of opaque. Opaque-rich bands are up to 4 mm thick and consist of euhedral to subhedral, and square to rectangular shaped opaque. Opaque is rimmed by goethite indicating that most of the opaque is iron-oxides. A few needles of goethite and opaque are also present. A few parallel to sub-parallel quartz veins cutting the banding at approximately 45° angle are also present. Quartz in these veins is also recrystallised with the development of triple-point junctions. The rock is identified as banded magnetite/hematite chert/quartzite. The field photographs indicate that the auriferous sheared quartz vein zones are associated with banded iron formation and it occurs in most of the places in the study area.

In Figure 19 field photograph and Figure 20 microscopic study, the yellow colour pics indicate pyrite with a cubic shape. It indicates the sulphide mineralisation took place in the study area. Microscopic study of the polished specimens of sulphides bearing carbonated sheared an orthosite samples show sulfide assemblages of pyrite and arsenopyrite. They show mutual boundary, replacement, inclusion, panidiomorphic and exsolution textures. Some grains show a dotted appearance due to exsolved blebs of chalcopyrite. Chalcopyrite shows a brass-yellow colour and occurs as blebs in sphalerite and as growth crystals in arsenopyrite and as a replacement in pyrrhotite.

Pyrite is the dominant mineral and it occurs as individual or aggregates of subhedral to all allotriomorphic grains. It is fine to medium-grained and creamy to whitish yellow-coloured. It also occurs as an inclusion in the pyrite grains. It shows strong yellowish to greyish anisotropic and brownish cream to reddish brown bi-reflectance. Pyrite occurs as perfect cubes (panidiomorphic) with slightly corroded margins and as aggregates. It shows yellowish-white reflectance. It also occurs as fine to coarse-grained, euhedral to subhedral crystals and as fracture fillings along with pyrrhotite and arsenopyrite. Thus, pyrrhotite (FeS) is the first sulfide

Figure 17. Field Photo: BIF with sheared quartz vein.

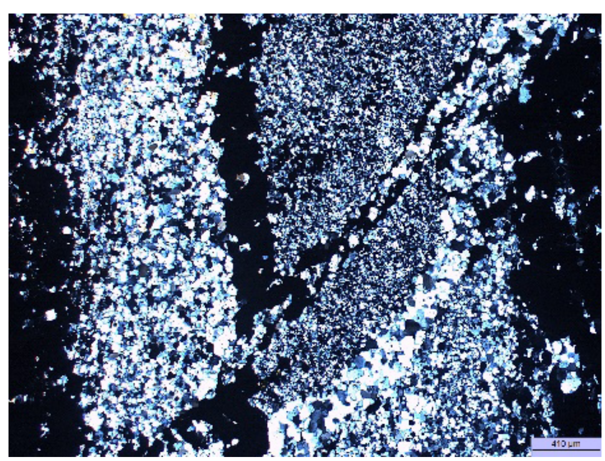

Figure 18. Thin section showing BIF with sheared quartz vein.

Figure 19. Field Photograph showing pyritiferous metabasalt.

Figure 20. Microphotograph exhibiting secondary carbonates with Pyrites.

to appear from which other sulfides-pyrite (FeS2) and arsenopyrite (AsFeS) are formed.

8.0 Wall Rock Alterations and Sulphidation

The prominent wall rock alterations were observed in the study area. The chloritisation and sericitisation occur at places near Nagavi and Mallasamudra area and carbonization and silicification is also observed. Based on the field observations of petrography and analytical data, the gold mineralization in the Nagavi area is of BIFs-hosted auriferous shear zones. Gold mineralization appears to be closely associated with BIFs. The intensity of mineralization is not strong enough to consider this a commercial gold mineralisation. However, a further detailed study is essential to identify the auriferous mineralized shear zones' characteristics. Chloritisation, sericitisation, carbonisation and silicification suggests that the hydrothermal alterations in the ancient workings as seen in the pit. A good amount of sulfides in the form of pyrite are seen as metabasalt. The auriferous shear zones are clearly showing gold mineralisation.

The Banded Iron Formation (BIFs) hosted gold mineralisation with quartz vein permeations which contain sulfides such as pyrite, pyrrhotite and arsenopyrite. The concentration of sulfides is more pronounced at the contact between BIF and quartz veins and also in the interfragmentary spaces which indicate that the sulfides have formed as a result of fluid permeation consequent to the intrusion of quartz veins. The quartz veins are also fractured and fragmented suggesting that they are syntectonic. The original BIF is of oxide facies and it shows sulfides. Thus, the fluids accompanying the quartz veins have interacted with the iron-rich BIF resulting in the formation of iron sulfides due to 'sulphidation'.

9.0 Ancient Workings in Auriferous Shear Zones at Nagavi Area

There are old exploratory trenches in the Nagavi area and these trenches are made across the auriferous shear zone on top of the hill near Nagavi. All the trenches have intersected BIFs and fractured quartz veins. The weathered zone is restricted to the top 0.2m to 0.5m. The average length of the trench is about 6 to 8m, the width is 1m and the depth is 1m. The exploratory trenches were made to confirm the width of the auriferous shear zone. Figure 21 and Figure 22 show the exploratory trenches for gold exploration. Figure 23 shows that the trial pits were made in contact with BIF and metabasalts where the auriferous sheared zones were found. The ancient old Adit was found in the reef and it indicates the sheared zones are at top of the hill also in the form of BIF-hosted gold mineralisation (Figure 24).

There are exploratory pits in auriferous shear zones in the western part of the hill which contain metabasalt and BIF contacts. These pits trend NW-SE direction. The distance between the two pits is about 15m. The average length of the pit is 3 to 4m, the width is about 1 to 2m and the depth is 2 to 3m. There are two mineralised zones delineated in this area (gold values < 20 ppb to 27 ppb). One shear zone is observed at the reef and another one is found at the NW part of the hill in the contact of BIF and

Figure 21. Photograph showing old working trench.

Figure 22. Photograph showing old working trench.

Figure 23. Photograph showing exploratory trail pits in auriferous shear zones (Pit 1 and Pit 2) in the western side hill.

Figure 24. Photograph showing ancient Adit on top of the hill.

metabasalt where ancient working pits are made in shear zones. Another shear zone occurs near Mallasamudra. The pyritiferous metabasalts were found near Mallasamudra.

BIF is restricted to later structures (quartz veins / shear zones) in vein-type gold mineralisation or iron sulphide-rich zones adjacent to such Geological structures. Structurally controlled BIF-hosted gold mineralisation is characterized by the following factors:

- A close association between gold and iron sulfide minerals.
- The presence of gold-bearing quartz veins and/or shear zones along faulted sheared quartz vein
- The structural complexity of the host area
- The paucity of lead and zinc in the two principal verities of BIF-hosted gold mineralisation can be defined can be based on the dominant style of gold distribution (Kerswill, 1986, 1993, Mac Donald, 1990): Stratiform and non-strati-form or vein type.

10.0 Stages of Fluid Channelization and Mineralisation

As the shearing progressed in the deformation zones in the high strain zones in the hinge portion (closure portion) of the anticlinal fold at Nagavi north, the mineralizing fluids accompanying the quartz vein emplacement got focused and channelized along the shear zones in stages. Quartz and carbonates were deposited in the shear zone at an early stage. During this stage, fluid-wall rock alteration took place resulting in silicification and carbonisation in the enclosing rocks. Simple sulphides such as pyrrhotite and pyrite also formed at this stage.

The second stage was marked by episodic shearing and fracturing as a result of which, the earlier intruded quartz and carbonate veins got fractured resulting in increased permeability for the ascending ore-bearing solutions. At this stage, additional silica and metals were deposited in the altered and structurally prepared shear zone and crushed wall rock zones and finally resulting in the formation of arsenopyrite, chalcopyrite and pyrite with the availability of As, Cu, Zn and Pb. The third stage is marked by renewed fracturing /fragmentation resulting in the breakup of early-formed sulfides and alterations of early-formed sulfides such as pyrrhotite to arsenopyrite and pyrrhotite to chalcopyrite. Gold seems to have been occluded in the sulfide minerals (as micro grains or as invisible gold in the lattice) during the second and third stages rather than the first stage. This observation confirms the three-stage model of auriferous metallogenesis in shear zones (Bonnemaison and Marcouz, 1990).

11.0 Summary

In Nagavi are structurally controlled Banded Iron Formation (BIF's) hosted gold and associated mineralisation have gained more prominence in the last few decades mainly due to the modern methods of mining and extraction of gold with the help of which 'large tonnage low-grade deposits could be exploited profitably. Currently, gold has been under great demand for exploration and exploitation all over the world, more intense during the last two centuries. As a result of intense methodologies, and research, many scientific concepts and methodologies have evolved thereby enriching the science and also providing impetus and inputs into several sub-disciplines of science such as modern exploration techniques, metallurgy, chemistry, geology etc.,

A strong positive correlation exists between gold and arsenic. The gold is uniformly disseminated in thin but laterally extensive units of cherty, pyrrhotite-rich iron formation that are conformably interlayered with sulfide and oxide-poor formation. In the mineralisation area, the sulfide is rich in iron formation that is associated with carbonate facies and black carbonaceous shale relatively close to volcanic centres. In hydrothermal systems in the earth's crust, mineral solution equilibria give rise to ore-forming fluids which are characterized by low oxidation potentials (Seward, 1984; Henley, *et al.,* 1984) such that the dominant oxidation state of dissolved gold.

With the closure of the world-class gold mine of KGF, there is an urgent need of discovering potential new gold deposits so as to enhance domestic production which now forms only a small part of the huge domestic consumption. A thorough exploration of these old occurrences might likely lead to the discovery of mineable gold deposits. This study has been carried out by adopting conventional methods like geological mapping, and petrological and mineralogical studies supported by gold analysis results.

The study area comprises different litho units like sheared quartz veins, schists, Banded Iron Formations (BIFs), and metabasalt. The length of the BIFs extends up to a 5 km strike length in the study area. Hematite and magnetite lead is often accompanied by other metal sulphides and oxides such as pyrite and carbonates. The varying amounts of carbonate mineral phases, such as calcite and siderite may or may not be present in both iron-rich and chert-rich layers. In the study area, metabasalts occur on both sides of the mound which are cut across by quartz veins at a few places. Near the Mallasamudra area, pyritiferous metabasalt indicates sulphidation. The contact of BIFs bands and shale which are folded into synform and antiform system. At places, quartz veins are intruded into the BIFs and metabasalts. In the Nagavi area, the general trend of litho units is N 50°-55° W to S 50°-55°E and dipping towards north east.

The gold mineralisation seems to be epigenetic indicating the replacement of primary magnetite by pyrite. The zone of deformed rock is associated with a large regional shear-zone structure and also intense fracturing with discordant quartz sulphide veins. The sheared gold-bearing veins crosscut the ferruginous quartzite which is interpreted as Banded Iron Formations (BIFs). Field data and petrographic observations were used to characterize the mineralizing fluids of gold-bearing quartz veins, which are spatially associated with BIFs in the Nagavi area. Pyrite is the dominant mineral. It occurs as individual or aggregates of subhedral to all orthomorphic grains. It is fine to medium-grained and creamy to whitish-yellow coloured. The localization of auriferous fluids along the axial shear zones defined the structural control of the deposit. Thus, the shear-controlled quartz-carbonate venation sulphide assemblage and their textural relationship.

A strong positive correlation exists between gold and arsenic. The gold is uniformly disseminated in thin but laterally extensive units of cherty, pyrrhotite-rich iron formation that are conformably interlayered with sulfide and oxide-poor formation. In the mineralisation area, the sulfide is rich in iron formation that is associated with carbonate facies and black carbonaceous shale relatively close to volcanic centres.

12.0 References

1. Ugarkar AG, Panaskar DB, Ranganath Gowda G. Geochemistry, petrogenesis and tectonic setting of metavolcanics and their implications for gold mineralisation in Gadag Gold Field, Southern India. Gondwana Res. 2000; 3:371-384. https://doi.org/10.1016/S1342-937X(05)70295-1
2. Napoleon Q. Hammond, John M. Moore. Archaean lode gold mineralisation in banded iron formation at the Kalahari Goldridge deposit, Kraaipan Greenstone Belt, South Africa. Miner Deposita N. 2006; 41:483-503. https://doi.org/10.1007/s00126-006-0074-6
3. Chadwick B, Vasudev VN, Nazeer Ahmed. The Sandur Schist Belt and its adjacent plutonic rocks: Implications for Late Archean Crustal Evolution in Karnataka. Jour. Geol. Soc. India. 1996; 47:37-57.
4. Naqvi SM. Comment on "The Sandur Schist Belt and its adjacent plutonic rocks: Implications of Late Archean Crustal Evolution in Karnataka". Jour. Geol. Soc. India. 1997; 49(4):459-460.
5. Ram Mohan M, Sarma DS, Charan SN, Balaram V, Rajasekhar VB, Ahmad T. Geochemistry and petrogenesis of Amphibolites from the Southern part of Gadag greenstone belt, Karnataka. J Geol. Soc. India. 2008; 72:484-494.
6. Chandrashekharappa Agasnalli, M Basavanna, TK Lakkundi. Textural and Fluid Inclusions' Studies on Banded Iron Formations (BIFs) hosted Gold Mineralisation in the Nagavi area, Gadag Schist Belt, Dharwar Craton. 2014; 7(4):1593-1600. ISSN 0974-5904.
7. Chandrashekharappa Agasnalli M Basavanna, TK Lakkundi. Geochemistry of Banded Iron Formations and Associated Gold Mineralization of Nagavi, Gadag Schist Belt, Karnataka. 2015; 8(4):1880-188. ISSN 0974-5904.
8. Chakabarti S, Ugarkar, Devraju. Sedimentary structures in the Archaean sediments of Gadag schist belt, Karnataka. J. Geol. Soc. India. 1994; 41:523-528.
9. Chandrashekharappa Agasnalli, Kantharaja D Chandrappa, TK Lakkundi. A Study of primary sedimentary structures in Banded Iron Formation of Nagavi area, Gadag Schist Belt, Karnataka, India. 2021.
10. SC Puranik. Primary Sedimentary Structures in Banded Iron Formations from Gadag Schist Belt, Karnataka, India. International Journal of Earth Science and Engineering 2011; 4(2spl issue):111-121. ISSN 0974.
11. Saha AK, Ghosh S, Dasgupta D, Mukhopadhyay K, Ray SL. Studies on crustal evolution of the Singhbhum Orissa Iron Ore Craton. Monograph on Crustal Evolution; Indian Soc. Earth Sci. 1984; 1-74.
12. Bhattacharya HN, Chakraborty I, Ghosh KK. Geochemistry of some banded iron formations of the Archean Supracrustals, Jharkhand–Orissa region, India. *J. Earth Syst. Sci.* 2007; 116(3):245-259. https://doi.org/10.1007/s12040-007-0024-4
13. Govindaraju, Govindaiah S, Srikantappa C. Petrology, Geochemistry and P-T conditions of metamorphism of Supracrustals rocks of Nellore mica belt of Andhra Pradesh, India. 2003; 36(2), 2002; 37(1):62-75.
14. Chakraborty KL, Majumder T. Some important aspects of the banded iron formation (BIF) of eastern Indian shield (Jharkhand and Orissa). *Indian J. Geol.* 2002; 74(1–4):37–47.
15. Somesha G, Govindaraju, Vinaya M, Govindaiah S. Petrochemistry and P-T condition of amphibolites associated with Pegmatites of Holenarasipura and Karighatta schist belts of western Dharwar craton, Karnataka, India, International Journal of Scientific and Technology Research. 2019; 8:570-580.
16. Chandrashekharappa Agasnalli, MS Deepak, TK Lakkundi, VG Ajey Kumar. An Integrated study of Landsat ETM and Cartosat DEM Data in identification of Banded Iron Formations (BIFs) associated with sulphide mineralization. 2022; 19(1):(205), 35–44. https://doi.org/10.13168/AGG.2021.0041
17. Vielreicher RM, Groves DI, Ridley NJ, McNaughton NJ. A replacement origin for the BIF-hosted gold deposit at Mt. Morgans, Yilgarn Block, W.A. Ore Geol Rev. 1994; 9:325-347. https://doi.org/10.1016/0169-1368(94)90003-5
18. Lhotka PG, Nesbitt BE. Geology of un-mineralized and gold bearing iron formation, Contwoyto Lake Point Lake region, Northwest Territories, Canada. Can J Earth Sci. 1989; 26:46-64. https://doi.org/10.1139/e89-005
19. Pretorius AI, van Reenen DD, Barton JM Jr. BIF-hosted gold mineralization at the Fumani Mine, Sutherland greenstone belt, South Africa. S Afr. J Geol. 1988; 91:429-438.
20. Gross GA. 'Geology of Iron Deposits in Canada. General Geology and Evaluation of Iron Deposits'. Geological Survey of Canada Economic Report. 1965; 1:22. https://doi.org/10.4095/102455
21. Gross GA. 'Tectonic systems and the deposition of iron-formation'. Precambrian Research. 1983; 20:171-187. https://doi.org/10.1016/0301-9268(83)90072-4