Chapter 8

SUMMARY AND CONCLUSIONS
8.1 Summary

Banded iron formation hosted gold deposits have gained more importance 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. Gold has been under great demand for exploration and exploitation in all parts of the world ever since the dawn of civilization, more intense during last two centuries. As a result of intense research, many scientific concepts and methodologies have evolved thereby enriching the science and also in providing impetus and inputs into several sub disciplines of science such as modern chemistry, metallurgy, exploration and geology etc., Thus intense exploration for gold carried out in all the countries in the last few decades has brought to light several world class gold deposits in Canada, U.S.A, Africa, U.S.S.R, Brazil, Western Australia etc.

With the closure of world class gold mine of KGF, there is an urgent need of identifying potential gold deposits so as to augment domestic production which now forms only a small part of the huge domestic consumption. It is known that, all greenstone belts in Dharwar Craton are evidenced with numerous ancient/old workings, some of which date back to 24B.C. A thorough exploration of these old occurrences might lead to the discovery of mineable gold deposits. With this objective, research work on “A study on Banded Iron Formation (BIFs) of Nagavi area, Gadag schist belt with special reference to sulphide mineralisation through GIS and Remote Sensing technology” has been carried out by adopting conventional methods like geological mapping, geochemical sampling, geochemical analysis, petrological, mineralogical, fluid inclusions and structural studies supported by GIS and RS techniques.

Nagavi area consists of different lithounits like Banded Iron Formations (BIFs), schists, metabasalt, shale, argillite, sheared quartz veins and thin bands of carbonates. BIFs occur as dissected bodies occupying the ridge part of the mound and their thickness varies from 1 to 20m. BIFs extend to a length of more than 5 kilometers in study area. Hematite and magnetite lead the iron-rich layers, often accompanied by other metal oxides and sulphides 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. Metabasalts occur on both sides of the mound
which are cut across by quartz veins at places. Pyritiferous metabasalt occur near Mallasamudra village. Greyish green medium gained chlorite schist is occurring in an old working pit near Mallasamudra village. Schistocity is well developed in these schists.

In the Nagavi area the general trend of lithounits is N 50°-55° W to S 50°-55° E and dipping towards North East. The BIF bands are folded into synform and antiform adjacent to the shale. At places quartz veins are intruded into the BIFs and Metabasalts. The primary and secondary structures are observed in the deformational structures such as and folds, faults, shear zones, thrust zones, oolitic and vesicular structures, which are induced by directional stresses. The fold is defined clearly by the hard compact rocks of BIF with the relatively softer rocks.

The massive banded hematite quartzite with intrusion of fractured quartz veins were indicating the solid solution entering into BIF with mineralization. The BIF sample has been examined under the microscope and it is composed of alternate bands of quart-rich and opaque-rich bands. The rock is compact and greyish brown color. In microscopic examination, the quartz-rich bands consist of highly recrystallized equigranular (~40-50 μm) quartz grains subordinate amount of opaque. These bands are 0.4-1.5 mm thick and contain up to 10% ~ 10 μm sized opaques. Few quartz grains are elongated parallel to the banding. Opaque-rich bands are up to 50 -500 μm thick and consist of euhedral to subhedral, square to rectangular shaped opaque. Opaques are rimmed by goethite indicating that most of the opaques are iron-oxides.

Under microscope, the metabasalt shows fine to medium grained glassy texture. Pyroxene and plagioclase are the main constituent minerals with magnetite and pyrite in the accessory phase. Most of the pyroxenes are altered to epidote and chlorite. The carbonated sheared anorthosite rock exposure near Mallasamudra and the rock sample and sample has been examined under megascopic and it shows compact and light greenish grey in colour. The rock is very fine to medium grained and inequigranular. It consists of simple to polysynthetically twinned subhedral (100-200 by 400-600 μm) laths (~40-45%) set in a groundmass of irregular anhedral grains of secondary carbonate (~35-40%), chlorite (~8-10%), opaque (~5-7%) and accessory epidote and quartz.
Representative samples have been collected and analysed for major and trace elements. Based on the analytical results of BIF samples (Wt %) of SiO$_2$, Al$_2$O$_3$ and Fe$_2$O$_3$ content, the samples were analysed and grouped as Banded Hematite Quartzite, Banded Hematite Chert and Banded Magnetite Quartzite. The samples show the mixtures of SiO$_2$, Fe$_2$O$_3$ and SiO$_2$ varying from 50.01 to 71.97% and Fe$_2$O$_3$ varying from 23.00 to 48.31%. CaO is varying from 0.02 to 0.29% justifying the BIF association with carbonates. Al$_2$O$_3$ lies between 0.03 and 1.83% and these samples clearly indicating the shaly BIF. The MgO varies from 0.03 % to 0.45%. The correlation of Al$_2$O$_3$ and CaO and alkalies suggests little input of feldspar in the BIF.

The gold mineralisation seems to be epigenetic because 1) it occurs in a zone of deformed rock associated with a large regional shear-zone structure, 2) it is restricted to zones of intense fracturing with discordant quartz sulphide veins, 3) textural evidence indicates that replacement of primary magnetite by pyrite. The Au bearing veins crosscut ferruginous quartzite which is interpreted as banded iron formations (BIFs). Field data, petrographic observations and fluid inclusion data 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 otriomorphic 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 veination sulphide assemblage and their textural relationship.

The P-T plots and Th-Salinity have been plotted by using the PVTX modeling software for fluid inclusions (version 2.01). The P-T estimates made from the total homogenisation of the aqueous-carbonic inclusions define a P-T path of evolution and in the present case the Isochores for mixed H$_2$O-CO$_2$ fluids are considered. The Carbonic inclusions are mainly dominated by CO$_2$ with some variable amounts of other gases such as CH$_4$, N$_2$ and H$_2$S?. Carbonic fluid inclusions appear to have contain only one or two carbonic phases at room temperature, theoretically they must contain aqueous phase. The melting temperature of CO$_2$ range from -56.2$^\circ$C to -62$^\circ$C (Table-1) indicating that the fluid is dominated by CO$_2$ and the maximum
Depression of melting temperature of CO$_2$ has -62$^\circ$C indicating the fluid contains a some amount of CH$_4$ in addition to CO$_2$.

The GIS and remote sensing technology is used for identifying lineaments, auriferous sheared zone and data integration. The satellite imageries like Landsat ETM, LISS III and Cartosat DEM have been used for data correlation and integration. The Landuse Landcover map has been prepared through ERDAS software. The Geographical Information System (GIS) techniques are useful in research work. The MapInfo, ArcGIS and ERDAS software are used to prepare geology map, lineament map, structural geology map, auriferous shear zones map and contour map.

### 8.2 Conclusions

Based on the research work with the available literature survey, geological mapping, sampling, interpretation with remote sensing and GIS techniques, it is concluded that Nagavi auriferous zone is comparable with quartz carbonate vein type deposits of Canada, South Africa and Australia. The auriferous metallogeny is regional one rather than local.

The development of the Gadag gold fields in the 1990s has assisted in a greater understanding of the geology and hydrothermal activity in the Central, East and West zones, which are hosted by Banded Iron Formations (BIFs) amongst others. BIF hosted gold mineralisation in the Nagavi area, which forms northern part of the Central zone of the Gadag Schist Belt and it has been reported by numerous researchers. This study concentrates on the geochemistry of BIFs of the Nagavi area which have been reported to be important carriers of gold.

In the Nagavi area, some samples shows that the Microscopic study of the polished specimens of sulphides-bearing carbonated sheared anorthosite samples shows that the sulfide assemblages of Pyrite and also mutual boundary, replacement, inclusion, panidiomorphic and exsolution textures.

The Major geochemistry presented here is suggested that the variations as a consequence of alteration, gold mineralisation with crystal fractionation having great influence. Mineralisation occurred within a uniform stress regime, as demonstrated by similar structural orientation of the vein types related to gold mineralisation.
In the Nagavi area, fluid inclusion studies clearly indicates that the fluid interaction with host rock along with fluid conduits clearly resulted in selective replacement of iron oxides and iron silicate mineral by sulphide and carbonate minerals. The fluids played the key role in the formation of gold bearing quartz bodies. The fluid inclusion indicates that the fluid responsible for the gold mineralization was a carbonic fluid of mixed metamorphic origin. With these results, it is confirmed that the possibility of gold mineralisation is coming from great depth. The regional exploration is essential to identify this sulphide mineralisation zone to prove an economically viable deposit.

It is quite clear that all these methods are quite efficient to delineate auriferous shear zones and hydrothermal alteration in the Nagavi area.

The findings of this research work are helpful in fulfilling the objectives of the research work in the study area and in understanding the sulphide mineralization in different environments.