Chapter I
Introduction.
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INTRODUCTION

1.1: Preamble:

Peninsular India is covered predominantly by pre cambrian rocks extending through the entire range of Precambrian times from 3,800 Ma to the late Precambrian or early Palaeozoic. Much of the literature in Precambrian geology has centred around the presence of rocks of great diversity as regards their structure, tectonics, grade of metamorphism and petrogenesis. In general the term "high grade" refers to rocks belonging to the granulite facies and which includes the well-known Charnokites; while "Low grade" implies rocks of lower amphibolite facies and those belonging to the green schist facies. Based on the correlation of early to middle Proterozoic intracratonic sedimentary assemblages across a large part of the Peninsular shield, and also on the basis of major structural joins (sutures) between various Precambrian terrains, seven cratonic divisions of the Precambrians were proposed by Naqvi and Rogers, 1986, as (1) Western Dharwar, (2) Eastern Dharwar, (3) Granulite or Southern Granulite Terrain, (4) The Eastern Ghats, (5) Bhandara, (6) Singhbum and (7) Aravalli / Bundelkhand. Most of the joins are along thrust zones.
The Western Dharwar Craton is bounded by the Arabian Sea on the West, by the overlying Deccan basalts towards north and by transition into granulite-facies assemblages towards south. The eastern margin is more uncertain with a likely N-S shear separating it from the Eastern Dharwars.

Viswanatha and Ramakrishnan (1981) showed that kyanite bearing assemblages occur on the western side of the shear and cordierite bearing assemblages (Radhakrishna, 1954) lie on the eastern side. This difference implies a higher P-T metamorphic condition towards the East than to the West.

The principal structural trends in the Western Dharwar Craton follow approximately along North-South. These trends are marked by the orientation of the major schist belts; the orientation of the Closepet granite; small-scale structures such as the foliation in gneissose, schistose and other enclaves in the gneisses; cleavage and schistosity in the greenschist belts, etc. (Mukhopadhyay, 1986). Greenstone belts in the southern part of the craton tend to be small, engulfed in gneisses, and metamorphosed to amphibolite facies; while the schist belts to the north are larger and occur mostly as green-schist facies rocks. The northern belts, in general, also appear to be younger than the southern ones. As a first approximation, this distribution of schist belts may be due to exposure of deeper levels of the craton further south, with the deepest levels being represented by the granulite terrain.
The strata in this sequence into two series, the Lower series
Kalinga series after the town of Kalinga in north Karnataka.

Bruce Poole (1876) and named the sequence of rocks as
Rainu (1940). This sedimentary basin was first studied by
a total area of 5,400 sq. km was interpreted by Narayana
et al. (1987). However, with the help of aerial photographs
4,267 sq. km and they occupy an area of 5,100 sq. km (Jayaprakash,

The total measured thickness of these sedimentary is

Maharashtra State.

extends unto Mahabaleshwar and Alibaug in the Kolhapur district.
Sanawad along the southern boundary. In the west the basin
isolated outliers of quartzites occur around Karhunad, and
Sanawad. The Kolapur sub-group forms a substantial structure.
stripped towards the north. The northwesternmost outlier is seen
besides, they are also partly concealed under the Deccan
rocks of this group cover an area of about 8,300 sq. km.

Intertrappe of India as the Kalinga series (Poole 1876). This
suite has been referred in the early geological
interest in the Proterozoic suite of rocks in Peninsular India.

Maharashtra State, constituting one of the districts of
extending into parts of Kolhapur and Senni districts of
Karnataka.
consisting of deformed rocks and the upper series showing little or no signs of deformation. Krishnan (1964), and Pascoe (1968), have adopted a four-fold classification consisting of two cycles of sandstone, quartzite and conglomerate, followed by shale and limestone.

In 1966, Nautiyal divided the "Kaladgi series" into the lower Kaladgi series and the Upper Kaladgi series consisting of rocks of the Kaladgi and Badami Basins respectively, and correlating the latter with the "Bhima series" King (1872). Here the classification was chrono-stratigraphical with two major unconformities; the first between the Dharwars and the Kaladgis, and the second between the lower Kaladgis and the upper Kaladgis. Viswanathiah (1977), redesignated the Proterozoic sequences as the Kaladgi Group and the Badami Group which were further divided into a number of formations and members. The formations were named on the basis of their geographical localities and lithology.

On the basis of LANDSAT imagery Nair and Raju (1984), distinguished the sedimentaries into the (Lower) Kaladgi and the (Upper) Badami Groups. The Kaladgi formations could be seen on the Imagery forming linear doubly plunging folds in a general WNW-ESE direction. The gently inclined Badami formations are easily identifiable on the imagery as lighter toned patches extending in a general E-W direction.
The Precambrian rocks of India display a great deal of structural and tectonic complexities. The active tectonic events, which they have witnessed during the long span of geological time of 3.5 Ga since the formation of the original solid crust, have direct effect on the deformational activities. The Indian Peninsula encompasses a number of tectonic centers, giving rise to the formation of more or less well marked cratonic blocks. These Tectonic centers not only influenced the formations close to them, but also the more distant and younger formations, to a lesser extent.

The different thermotectonic episodes affecting the Precambrians of the World are also discernable in the Precambrian rocks of India. These episodes of deformation, have left behind them rich material for structural studies. The traces of kinematics, dynamics and tectonics of deformation provide ample material for a thorough study of the structural evolution of the rocks. A better understanding of these aspects can be achieved by detailed microstructural study of the rocks involved, on the basis of their deformed constituents. The objective of microscopic analysis thus is to corroborate, modify and amplify. The inferences drawn from the study of mesoscopic bodies, and to obtain additional information that is accessible only through the microscopic domains.
The occurrence of different, discrete litho-units in an area with different deformational rate furnish us the opportunity of following a multidimensional approach to the study of the highly deformed units and the lowly deformed units. The dynamic tectonism of the older rocks and its continued effect on the younger rocks with common constituent quartz, in both the units provide a wide view of the impact of microstructural development on the deformational history. Obviously, since the area has undergone a long span of tectonism, the deformation has reached an intense level and the work of structural analysis is an immense task. The complexity of structures and the different rates of deformations would necessitate a careful and detailed study. The microstructural study of this area would provide a natural case history and will be complementary to the work of Jadaav (1987) carried out in the main Kaladgi basin. Such a kind of approach may give a fresh view about the tectonic history of the area.

1.3 : Area of Investigation :

The microstructural analysis of the Precambrian rocks was carried out around Ajra town (about 120 km SW of Kolhapur), Kolhapur district, Maharashtra State. The Toposheet Nos. 47 L/3, 47 L/4 and 47 L/8 include the study area which lies between the latitudes 16° 00′ to 16° 30′ N; and the
longitudes 74° 30' E (Fig.1). The area between 16° 15' to 16° 30' N and 74° 15' to 74° 30' E is mostly occupied by the Deccan Trap volcanics and is excluded from the present work. The total area measures about 1040 sq. km. Although the whole area was covered during the preliminary studies, greater emphasis was laid on the area around Ajra (16° 13' N and 74° 14' E), as the surrounding area exposes different types of Precambrians (namely, metamorphosed Archaeans and the Proterozoic Sedimentaries) which are in close contact with each other. Ajra town is located on Deccan Traps on the south bank of the river Hiranyakeshi at a height of about 2,100 feet above sea level. The geological sequence recorded by Sahasrabudhe (1958) in the G.S.I. Records is as under.

Soil and Alluvium ---------- Recent and Sub recent
Deccan Traps -------------- Lower Eocene
Lower Kaladgi Series --------- Cuddapah
Granite-gneiss with basic ------- Archaeans
inclusions; schistose group

The Deccan Trap lava flows overlie the irregularities in the denuded land surfaces of the schistose rocks, granite gneisses, and sandstones and quartzites of the Kaladgis. The lava flows attain an enormous thickness towards west and south. The erosive activities of the Ghataprabha and Hiranyakeshi rivers expose the underlying Precambrian formations. Laterite caps the summit of the Deccan Trap hills at a number of localities.
FIG. 1: LOCATION MAP.
Physiographically, the Kaladgi hills are joined together in an E-W direction to the main basin. From the SW to NE the area is dissected by the rivers Ghataprabha and Hiranyakeshi which flow in a meandering pattern.

The means of communication to the area is only by road. The easiest way to approach is by bus from Kolhapur. The town enjoys a very pleasant winter and tolerable summer, and is surrounded by thick tropical forests which were once full of Bamboos.

1.4 : Method of Work:

The present work was mainly carried out in following phases

(i) Preliminary survey of the area,
(ii) Mapping and sample collection, and
(iii) Laboratory Analysis.

The area was initially surveyed on a scale 1:60,000 to select the most suitable sites for undertaking the microstructural analysis of the Precambrians. After scanning the whole area which comes under the toposheets Nos. 47 L/3, 47 L/4 and 47 L/8, a smaller area around Ajra was selected for detailed study on the scale 1:6,000. Here, three distinct litho units, viz. (i) the metasediments of the Archaean, (ii) the Proterozoic sediments of the Kaladgi
Super Group, and (iii) the basaltic lava flows of the Deccan Traps occur together. The Archaeans and the Proterozoics were studied in detail in which the main structural data and the sample collections were done. The orientation of the samples was marked following the field procedure outlined by Turner and Weiss (1963) and these along with other samples, were subjected to laboratory analysis of oriented micro-sections. In order to obtain the order of deformation path (Kinematic), and the system of forces that acted on the rocks (dynamics) the thin sections were studied under a petrological microscope fitted with the 'Leitz' Universal Stage. The major mineral constituents and their mutual relationships were recorded. The most suitable constituent quartz, was studied in detail. The preferred direction of the crystallographic c-axis of quartz was marked as a linear fabric element which helps to deduce the major directions of the forces, and the kinematic markers such as recrystallization, recovery, lamination, undulose extinction, etc. To get a better indication of the process of deformation, the procedure was not only applied to the Archaean metasediments and amphibolites but also to the orthoquartzites of the Kaladgis.

Another technique employed here, providing a detailed visual picture of the deformation of quartz, is the Axial Distribution Analysis (A.V.A.) as suggested by Sander (1970).
A quicker method of counting of the structural data a new technique was employed as suggested by Phadke (personal communication). The data was plotted on conventional equal area Projection Net (Schmidt, 1925).

To obtain the path of strain in rocks the technique of strain analysis $R_f/\theta$ adopted by Lisle (1985), has been used. In addition, the methods suggested by Ramsay and Hubber (1983); and Elliot (1970); Wheeler (1984), etc. were also followed. The details of the different methods and techniques are discussed in the appropriate chapters of this thesis.

The results of the work are compared with the published natural case histories and available experimental data.

From the times of Bruce Foote (1876), up to the present day many research papers have been contributed to the Archaean and the Kaladgi sedimentaries. However, not enough has been done on the structural deformation undergone by the these rocks especially with respect to their micro-structural features in details. The regional study of Precambrian rocks under reference gives some insight into the tectonic aspects.

Since the study area falls somewhat remotely in the western most corner of the Kaladgi basin, it is quite likely
that the earlier workers concentrated on the main part of the Kaladgi Basin. The latest reference to the area around Ajra is to be found only in the work of Sahasrabudhe (1958). A detailed review of the previous geological literature on the Archaean of The Western Dharwar Craton and the Proterozoic Kaladgis is incorporated in the Chapter II to provide its significance in relation to the Precambrians of Ajra.

1.5 : Objectives of the Work:

Besides the routine lithological and structural mapping and collection of oriented samples for the fabric analysis and strain analysis, the present work was undertaken with following objectives dealing with microstructural investigations of the Precambrian rocks of the study area:

1) Evaluation of morphological changes in quartz porphyroclasts under the conditions of varying strain environment,

2) Evaluation of the mechanism of orientation and the controlling factors in case of c-axis patterns of quartz porphyroclasts.

3) Correlation of microfabric with regional structure.

4) Establishing the relationship between the major structural elements of the older and the younger Precambrian Units.