CHAPTER-1

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1-1 GENERAL

Evolution of continental crust during the early history of the earth has been receiving appreciable attention by many researchers (Taylor and McLennan, 1985; Fyfe, 1990). At present, it is commonly agreed that nearly 65% of the earth’s crust, in particular the continental crust was emplaced prior to 2500 Million years (Moorbath and Taylor, 1981). It is also estimated that 40% of the present continental volume was evolved in 3000 million years (Dia et.al, 1990). The Sm-Nd, Rb-Sr mass balance studies and their isotope ratios have proposed that the Archaean crust was composed of 70% felsic (granite) and 30% mafic (komatiite) materials.

The present continental crust with regard to its nature and genesis has remained a subject of intensive research during the past four decades (McLennan and Taylor, 1991). Major emphasis, however, has been attempted towards the understanding of the volcanic rocks, which are dominant in the crust (Drury et.al, 1983).
Anyhow some attention has also been paid towards the various kinds of sediments (Eriksson and Donaldson, 1986). The knowledge of volcanic constituents has brought to light the conditions and processes through which the volcanic and other magmatic rocks have been produced. The characters of sediments reveal information regarding the nature and intensity of exogenic processes operating at different times throughout geological history.

The vertical as well as lateral non-homogeneity of the mantle was demonstrated by Claesson et.al, (1984), from petrogenetic modeling of igneous rocks particularly using Sr and Nd isotope signatures. In fact, the total Nd isotope data has helped in establishing the compositional layering of the mantle. Between the two layers of the mantle identified, the upper layer is depleted in $^{143}$Nd (De Paolo, 1980; Allegre et.al, 1983), as it has actively taken part in the formation of the crust. Nearly partial melting and fractionation of the upper mantle and thus resulting depletion of $^{143}$Nd have produced the entire crust. A depleted mantle was left after the formation of the upper mantle, which has resulted in the upper crust. Heat transfer in the lower mantle takes place through conduction while mass transfer results through plume activity. In the upper mantle, which is depleted,
the heat and mass transfer take place by convection. This convection is believed to be responsible for adding new and younger portions of the crust as well as accretion of the early-formed continental crust.

The present continental crust incorporates granulite facies of rocks, which are very widespread and are found in all the shield areas of the world. Traditionally, the granulite formation is understood to have evolved in two main periods around 3100 and 2600 million years ago (McLennan and Taylor, 1991). In recent times it has been suggested that several Precambrian regions have had a multi-stage evolutionary history (Jacobsen, 1988). The above two concepts of granulite formation have equal currency in the contemporary understanding.

Petrogenesis of the granulites has remained a subject of controversy among the petrologists in the light of the concept of metamorphic facies. The granulite facies terrains have all along been considered by many to represent the barren residue left after partial melting during the course of deep-seated metamorphism (Weaver and Tarney, 1981). However some recent models identify the role of reduced water activity in stabilizing the dry mineral assemblages in granulites, and Newton et al., (1980) have proposed such definition
due to carbon metamorphism by CO$_2$ streaming. Gneisses extending over thousands of kilometers in the Precambrian terrain are the important associates of granulites. Many believe, that older sialic crust derives these Archaean gneisses, however, from the field characters it is difficult to accept this concept. The processes may include either partial or complete melting resulting in mobilization and reconstitution as an essentially new rock. On the other hand Moorbath (1975), using the isotopic data of Archaean gneisses, suggests that several Archaean and Proterozoic gneisses are predominantly juvenile additions to the pre-existing continental crust. Both the views pose several questions, which need to be tackled on the basis of further in-depth studies. These exploratory efforts, it needs to be mentioned here, have to tackle more often than not, the problem of mineralogical and petrologic changes that take place in the inexorable processes of metamorphism.

1.2 PROBLEM AND OBJECTIVES

It is now accepted that some processes involving an extraction of the sialic lithophile elements out of the mantle during geologic time have formed the continental crust. However many questions regarding this have remained unanswered as yet. To understand the
processes involved in changing the earth’s crust a thorough knowledge of the rock types that represent the Precambrian is necessary. In this context, the greenstone – granulite – granite terrain of the Indian shield is undoubtedly a promising area for an in-depth study.

The Precambrian suits of South India, consisting of greenstones, granulites, gneisses and granites, which form the part of upper continental crust, have been evolved due to multiple igneous, sedimentary and metamorphic activities, posing a lot of problems regarding their correlation and classification. Moreover, the problem of classifying these suits of rocks has become more complicated as they occur with varying stages of deformation.

A review of the research work and literature of the past few decades clearly show that the classification proposed by Fermor (1932) forms the basis for researches in the Precambrian shields of the world. According to him the Archaean rocks, especially from Indian shield, have been classified into (1) charnockitic and (2) non-charnockitic terrains. Some of the other significant contributions regarding the South Indian Precambrian shield include the broad two-fold division (Eastern Ghat Mobile Belt and Southern Cratonic
Granulite Terrain), proposed by Divakara Rao (1982) and, the
discovery of several east-west trending shear zones in Peninsular
India (Drury et al., 1984).

Later works by Newton et al., (1990) proposes Carbonic
metasomatism for the formation of granulites and charnockites.
Several contributors have also made fluid inclusion studies to infer the
processes involved in the making of these rocks.

The study area, Tiruchirapalli forms a part of the Proterozoic
southern granulite terrain and occurs as a suture zone between the
stable cratonic granulite zone and eastern-ghat mobile belt. A
thorough study of the geology and geochemistry of this area has not
been carried out by any one in the past.

The major objectives of the present attempt are to:

1. Document and characterize the geology of the area,
2. Conduct detailed geochemical studies of the rocks, and
3. Describe the processes of evolution of these rocks.

1.2.1 METHODOLOGY

To achieve the above objectives the following activities have
been carried out systematically utilising the limited facilities
available.
1. A base map of 1:50,000 scale was prepared using the details available in the Survey of India topographic sheets 58 J/9, J/10, J/13 and J/14.

2. A detailed geological map showing the various litho units was prepared.

3. From the data collected in field, like the trends of various outcrops and other structural details, a structural interpretation was made.

4. Representative rock samples were collected systematically from outcrops and well cuttings for carrying out optical and geochemical studies.

5. More than 150 micro sections were prepared and examined for making detailed petrographic, mineralogical and textural studies.

6. Significant rock types in the area were chemically analysed for their major oxide, trace element and, REE contents using standard procedures.

7. Based on the above data the petrogenesis of the study area was postulated.

1.2.2 ORGANISATION OF THE THESIS

The thesis consists of eight chapters and has been organized in the following order.
The first chapter provides a general discussion on the evolution of the continental crust. The second chapter gives the lithology and structure of Tamil Nadu. The problem, aims and methodologies are described at the end of this chapter along with a brief review of the previous work in adjacent areas and elsewhere.

The third chapter offers a brief discussion on the geology and structure of the study area. The important rock types including meta-sedimentaries such as quartzite and calc gneiss, enclaves like basic granulite and amphibolite, charnockites, and variety of granitic gneisses and pegmatites, have been elaborately described.

Regional fold systems with coaxially co-folded sub systems have been identified and described. The area is also dissected with a few non-parallel shear zones. Petrofabric elements are quantified and discussed. Detailed Geological map of the study area with a few structural informations are appended in this chapter.

In the forth chapter, petrographic information has been culled-out from about 150 micro slides. Some of the important textural features have been micro-photographed and presented.

The descriptions of analytical procedures adopted for determining the chemical compositions are given in chapter five.
Major oxide, trace elements and REE data for the rocks of the study area and, similar geochemical outputs from different terrains have been tabulated.

The inferences deduced by integrating the chemical data through various plots and variation diagrams are presented in the sixth chapter.

In the seventh chapter, the results of various studies carried out in the study area have been integrated, interpreted and discussed. Based on the discussions the possible successive geological events, which took place in the study area, are visualized.

The findings are summed-up in the eighth chapter. A conceptual petrogenetic model for the study area has also been formulated. The references cited are listed at the end.

1.2.3 LOCATION OF THE STUDY AREA

An area of about 450 square kilometers, around Tiruchirapalli city and encompassing parts of Tiruchirapalli taluk has been selected for this research work. The area lies between latitudes 10° 42' and 10° 50'E and longitudes 78° 32' and 78° 50'N. It forms part of Survey of India top sheets 58 J/9, J/10, J/13 and J/14. The study area is well
connected through a network of roads, railways and airway. The location map of the study area is presented as figure 1-1.

1.2.4 PHYSICAL FEATURES

The study area lies close to the flood plains of the river Cauvery and Coleroon, which flow, in the northern part of the study area. A few monadnocks of resistant rocks are exposed at Rock Fort, Golden Rock and Tiruverambur in the central and eastern part of the study area. In the southern part two small rivers Koraiyur and Uyankondan River and Ariyar dissects the area, flowing generally towards east, northeast. A contour canal called Katalai canal caters to the irrigation needs of this area.

It is a thickly populated residential area with a few isolated hills such as Rettaimalai, Kuttimalai, etc., which are extensively quarried for building stones and road metal. Many small villages like Manikandam, Enamkulathur, and Sannasipatti dot the south and southeastern part of the study area.

1.2.5 PREVIOUS WORK

King and Foote (1889) have contributed much to the early literature on geology of Tiruchirapalli. Gowrishankar (1959), Narayanaswamy and Purnalakshmi (1967), Raghunathan (1976),
Ramachandran (1987) and Subramanian (1992) have mapped parts of the study area for petrological studies and mineral exploration. Most of the investigations were carried out in this area on behalf of the Geological Survey of India and the State Department of Geology and Mining. Singh and Rajamani (2001) have investigated the REE patterns of river sediments of the Cauvery River flowing along the northern periphery of the study area.