CHAPTER 1. INTRODUCTION

1.1 General

The calc-silicate rocks are medium to high grade metamorphic rocks consisting essentially of calc-silicate minerals and less than 5% volume of carbonate minerals i.e. calcite and/or aragonite and/or dolomite, as per the 'Subcommission on the Systematics of Metamorphic Rocks' (SCMR) classification scheme.

These rock types are reported to occur as small scattered outcrops or isolated lensoidal bodies amidst Precambrian rock formations. Examples from India include, the calc-silicate rocks of Koduru, Andhra Pradesh (Sivaprakash, 1981), Kondapalle, Eastern Ghats belt (Sengupta and Raith,2002),Surguja district, Chhatisgarh (Patel,2007),Khandia Formation, Champaner Group, Gujarat (Das et al.,2009) and Hammer-Head syncline, Southern Sandmata Complex, Rajasthan (Purohit et al.,2015) etc. Examples from other parts of the world incorporate, the calc-silicates of Prince Rupert, British Columbia, Canada (Crawford et al.,1979), Munchberg Gneiss complex, Bavaria, Germany (Klemd et al.,1994),Partridge Breast Lake, northern Manitoba, Canada (Owen and Dostal,1994), Oslo rift, southern Norway (Jamtveit et al.,1997), Alboran basement, western Mediterranean (Vizcaino and Soto,1999), Gebel Yelleq area, Northern Sinai, Egypt (El-Enen et al.,2004), Kokchetav massif, North Kazakhstan (Shatsky et al., 2006), Silgara Formation, Central Santander Masiff, Colombian Andes (Rios et al., 2008), Policka unit, Svratka unit and SE Moldanubian Zone, Bohemian massif, Czech Republic (Burianek and Pertoldova,2009), Igarra, southwestern Nigeria (Ikoro et al., 2012), Sawtooth Metamorphic Complex, Idaho, USA (Fukai,2013) and Southern Highland Complex of Sri Lanka (Sameera and Perera ,2015) etc.

Studies related to the petrogenesis of these rocks help to comprehend the paleo-geographic and tectonic reconstructions of a particular region along with regional and contact metamorphic processes or metasomatism of pre-existing rocks (Ferry, 1994; Rose, 1996; Ordonez-Calderon et al., 2008).Similarly, these rocks act as a good lithostratigraphic markers as their presence within lithostratigraphic sequence facilitates the determination of coherency within the complex of metamorphic rocks and associations with other nearby terrains (Burianek and Pertoldova, 2009).

The north-western part of the India is marked by a mountain range, known as the 'Aravalli Mountain Belt' (AMB) which traverses the states of Delhi, Haryana, Rajasthan and Gujarat for a distance of about 700 km in a NE-SW direction. Southernmost part of this belt is called as the 'Southern Aravalli Mountain Belt' (SAMB) which hosts the Lunavada Group, a second youngest Group of the Aravalli Supergroup. It comprises of six formations chronologically, viz., Kalinjara, Wagidora, Bhawanpura, Chandanwara, Bhukia and Kadana from oldest to youngest (Gupta et al., 1997). The 'Kadana Formation' is the only formation of Lunavada Group, which falls within the Gujarat state, atleast partially; while remaining formations completely fall in the Rajasthan state (Iqbaluddin, 1989).It is having Meso-proterozoic age. The calc-silicate rocks under investigation belong to the Kadana Formation and are geographically located at the NE part of the Gujarat state. Location of the study area is shown in (Fig.1.1).

Certain aspects of the Lunavada Group have been worked out by previous workers, viz. lithology of the southern most parts of the Rajasthan and northern parts of the Gujarat was studied by Gupta and Mukherjee (1938).They prepared an excellent geological map of this area.A detailed account of stratigraphic, sedimentational, deformational and metamorphic history of the Proterozoic sequence exposed in the Kadana reservoir and adjacent areas has been given by Iqbaluddin (1989). Structural aspects with respect to fold history, deformational mechanisms along with related metamorphic aspects have been studied by Mamtani (1998). Although the investigators like Iqbaluddin(1989) and Mamtani (1998) have mentioned the occurrence of calc-silicate rocks present within study area, a lucid understanding of the origin and the metamorphic history of the rocks, which is vital for a possible interpretation of a geotectonic model of the evolution of these rocks is still lacking. Thus it is a least understood crustal sector in terms of this aspect.

Hence the present author has attempted to resolve the problem, i.e. tectono-metamorphic evolution of calc-silicate rocks of the study area through her work.

The focus of the present study is to provide detailed petrological, mineral chemistry and geochemical data of these rocks. In view of the recent developments of Precambrian Geology, it was deemed necessary to obtain more information on the type of protolith of these calc-silicates, depositional environment as well as provenance of that protolith and physicochemical conditions of metamorphism, thus amplifying the knowledge of the calc-silicate rocks of Lunavada area in particular.

To achieve this goal, an extensive data set on the mineralogy and the bulk compositions of rocks had been acquired and by applying modern concepts, interpretations

were done. Thermo-barometry and phase petrology studies is simplified more with the help of PERPLEX software thus revealing the metamorphic facies of these rocks.

Findings of the above study will help in understanding the crustal evolution of the Precambrian shield exposed in the study area by resolving the complexities involved in it. This kind of work would be unique for this area and will add up to the existing knowledge.

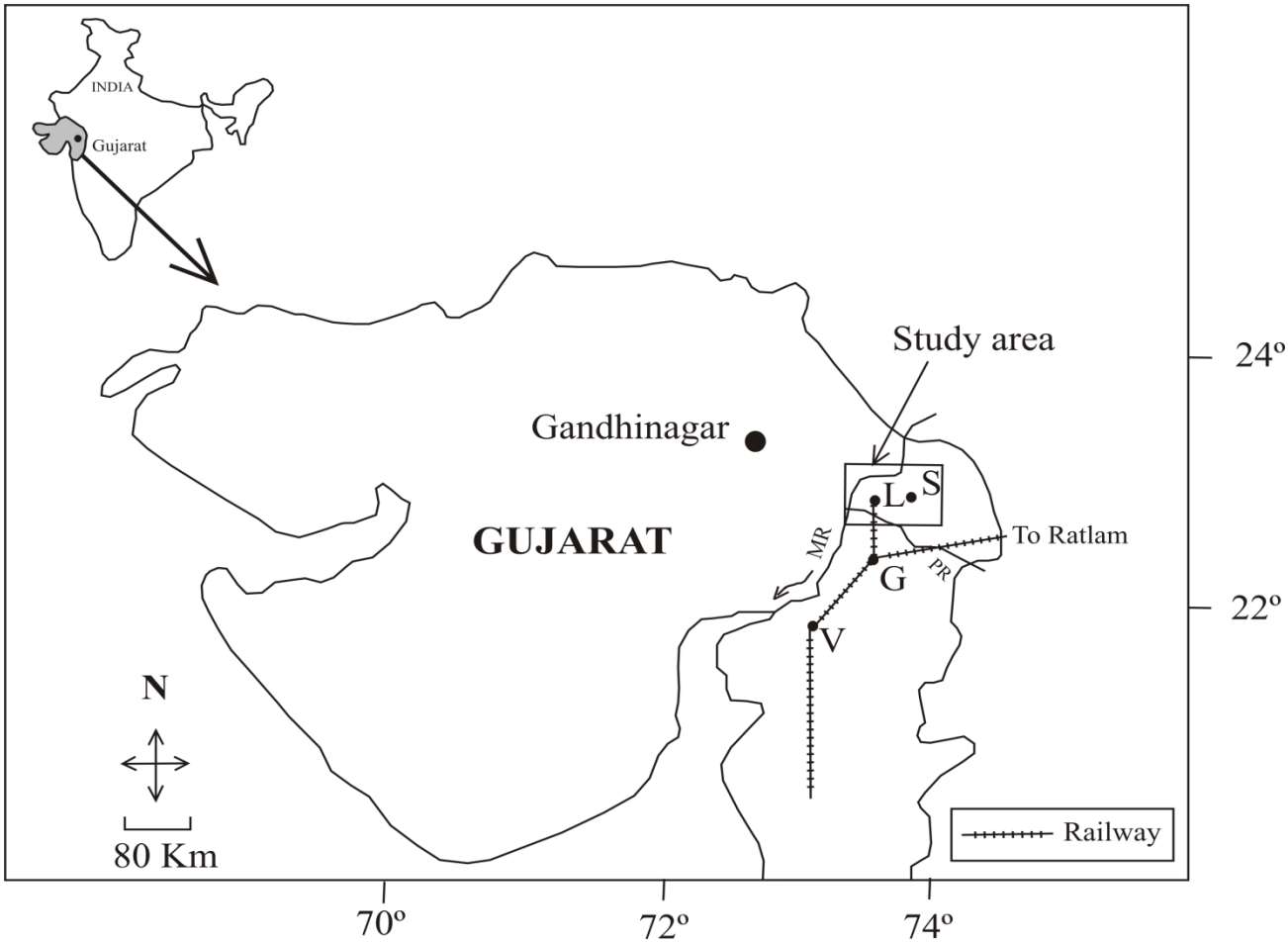

Figure 1.1: Location map of the study area. L-Lunavada, S-Santrampur, G-Godhra, V-Vadodara, M.R.- Mahi River, P.R.- Panam River.

1.2 Topography

The study area is the southern extension of the Aravalli Mountain Belt (AMB) that extends from the southern Rajasthan in the north to the Mainland Gujarat in the south. Here, topographical variation can be seen which is a direct reflection of the lithological differences of the constituent rocks. This region comprises of gently rolling plains and valleys which are occupied mainly by softer rocks like chlorite and mica schists, phyllites and meta-siltstone, prone to rapid erosion thus covered by a thin veneer of soil. Similarly, it is punctuated by

some linear, monotonous hogbacks as sub-vertical monoliths formed of Aravalli quartzites thus forming a diversified terrain which can be very well percieved through the 'Shuttle Radar Topography Mission'(SRTM) derived shaded relief map of the study area (Fig.1.2).

The quartzites associated with the mica schists and chlorite schists withstand the weathering better because of their superior hardness and thus form steep narrow ridges. The highest ridge in the study area is 281 m which lies 8 km S of Santrampur. The plateau land made up of basaltic lava flows located at the SE part of the area and the floodplains produced by Panam river and its tributaries are some secondary topographic features seen in and around the study area.

1.3 Drainage

The study area is commanded by the 'Mahi drainage basin', popularly known as the 'Mahisagar River' which is a largest river in this area and serves as an essential source of irrigation. It originates from the Malwa hills (NE of the study area) and thereafter crossing the Rajasthan State it enters the Gujarat state and flows through the Santrampur, the Lunavada and the Godhra talukas of the Panchmahal district in the Gujarat and then following south-westerly regional slope ultimately debouches into the Gulf of Khambhat. Panam, Khatlaer, Sukhi and Chibota are the important tributaries and subtributaries of the Mahi and are mostly ephemeral.

The Panam river originates from the Devgadh Baria taluka of Dahod district and enters the Panchmahal district of the Gujarat. It flows largely through forests and hilly tracts and merges into the Mahi river. The stream Chibota originates from Surpur village of Santrampur taluka and flows through the Surpur, Pichhoda, Umber and Santrampur villages and meets the Khatlaer river near Santrampur town. The Suki river starts from the village Vansia of the Jhalod taluka and meets the Khatlaer at Santrampur after flowing through the hamlets nearby. The Khatlaer river originates at the confluence of Suki and Chibota in Santrampur and meets the Mahi river.

1.4 Climate

The region falls within the semi-arid zone of western India. The winter lasts from November to March, when the atmosphere remains clear and mostly dry. From April to June, till the onset of the monsoon it remains hot and dry and is largely swept by the westerly winds. The rainy season lasts from July to October. The annual rainfall varies from 90 cm to 100 cm. Climatically,the area is included in the monsoon belt of India.

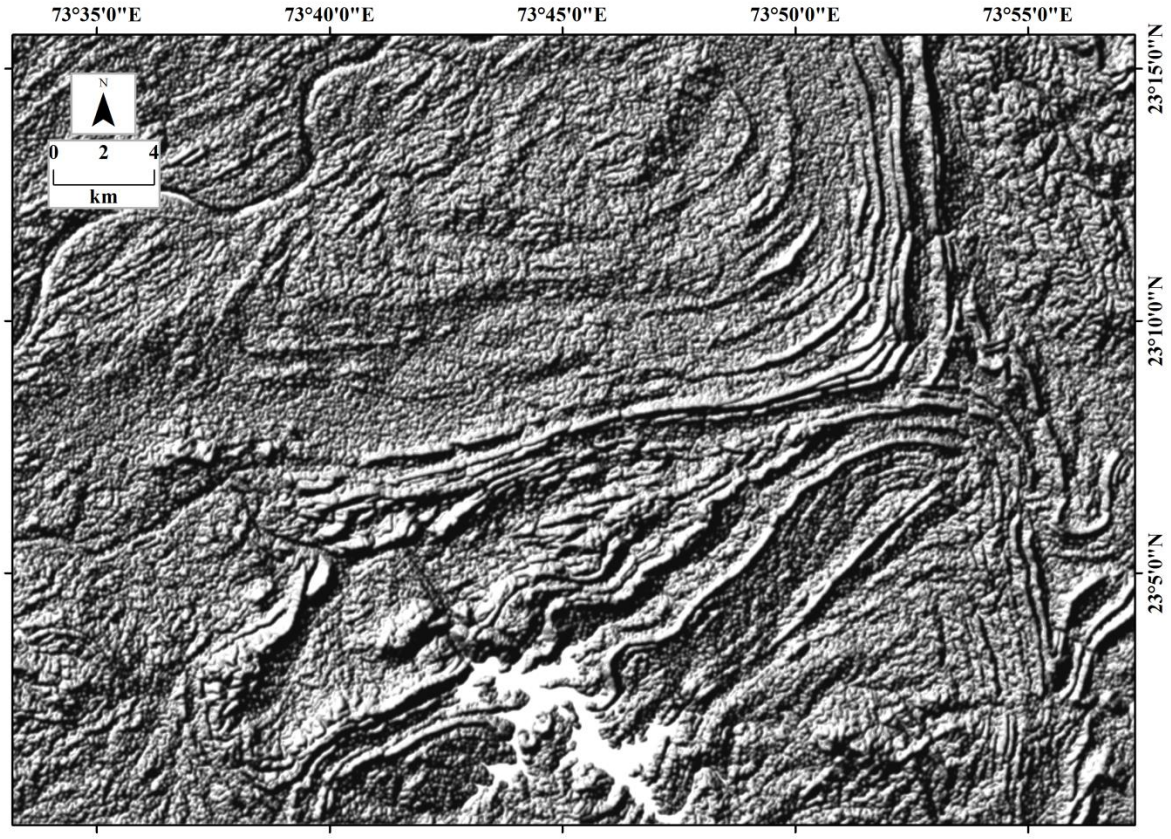

Figure 1.2: Shuttle Radar Topography Mission (SRTM) derived shaded relief map of the area lying towards the southeast of the Lunavada town. Study area is located within the prominent quartzitic fold which has occupied the southern part of the image. Source: USGS Earth-explorer.

1.5 Flora and Fauna

The vegetation in the area is rather poor and shrubby. Major parts of the forests occupy flat and gently undulating areas along the lower slopes of the hills, at the foothills and in the valleys. Sadad (*Terminalia tomentosa),* Shisham (*Dalbergia latifolia),* Khair (*Acacia cutechu),* Banyan *(Ficus bengalensis),* Nim (*Azadhirachta indica),* Mahuda (*Bassia latifolia),* Dhavdo *(Angeissus latifolia),* Bili *(Aegle marmelos)* and Bor (*Zizyphus mauritiana)* can be found along with some bushes of Kado *(Holarrhena antidysentrica) and* Awal (*Cassia auriculata).* Bamboo *(Dendrocalamus stiictus)* is also present. Besides these, some medicinal plants like *Bombusa vulgaris, Tectona grandis, Daedalacanthus roseus* and *Erythina indica* are common around Lunavada and Santrampur.

Oxen, cows, buffaloes, donkeys, horses, goats, sheep and camels are the most common domestic animals of the region and the carnivorous animals like panther- *Panthera*

pardus (Linnaeus) (*Dipdo*), jackal-Canis *aureus* (Linnaeus) *(Shial),* small Indian mongoose-*Herpestes auropunctatus* (Hodgson) *(Noliyo)* and herbivorous animals like hares-Indian Hare-*Lepus nigricollis* (F.Cuiver) *(Saslu),* blue Bull-*Boselaphus tragocamenlus* (Pallas) *(Nilgai),* Indian porcupine-Hysfnx *Indica* (Kerr) *(Shahudi),* and chital or spotted deer -*Axis axis* (Erxleben) (*Haran),* similarly, poisonous as well as non-poisonous varieties of snakes are some of the common wild animals reported from the region. Apart from this birds like pigeon, peacock, crow, dove, crane and partridge are found in this area.

1.6 Agriculture

Cultivation of various crops in all seasons is carried out with canal irrigation. Rice, wheat, jowar, bajri, maize, ragi, barley, tur, gram, fruits like, lemon, banana and papaya, mangoes, chiku, sugarcane and vegetables like potatoes, tomatoes, brinjals, chillies, onion, guwar, papdi, parwal along with ground-nuts, cotton, tobacco, sesame, castor-seed, udad, mag, peas and spices like cumin seeds, fennel seeds, chilly, hara dhania, garlic, ginger and turmeric are the important agricultural crops of the area.

1.7 Communication

The area is accessible by the road as well as by railways. Highway from Delhi to Mumbai passing through the Lunavada is the easiest way to approach the study area. Besides, the region can also be reached with the railway network Mumbai Central-Vadodara-Godhra-Delhi (broad gauge) and Godhra-Lunavada (narrow gauge).

1.8 Research objectives

1. To determine the protolith of the calc-silicate rocks of the study area.
2. To interpret the evolutionary history of these rocks by understanding their petrogenesis.
3. To perform the comparative petrological studies of calc-silicate rocks from other parts of the Southern Aravalli Mountain Belt (SAMB).

1.9 Methodology

1. Geological mapping of the bands of calc-silicate rocks was carried out and a detailed geological map was prepared.
2. Detailed sampling of the calc-silicate rocks was carried out for bulk/whole rock

geochemistry.

3. Thin sections were prepared to carry out petrographic analyses.
4. Polished thin sections with carbon coating, suitable for EPMA studies were prepared to determine the chemical composition of various minerals in these rocks.
5. Bulk rock geochemistry (major oxides, trace and rare earth elements data) was obtained by XRF, HR-ICP-MS instrument.
6. Determination of temperature and pressure conditions at peak metamorphism of these rocks was done through conventional geothermobarometry using mineral chemistry data.
7. Phase diagrams were computed using major oxide compositional data.
8. Metamorphic facies of the calc-silicate rocks was determined.
9. Geotectonic model depicting the evolution of Lunavada basin was constructed.

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