CHAPTER I

INTRODUCTION

General

Saurashtra peninsula is situated in the western parts of Gujarat State, India. It is bounded by Arabian Sea on the west and south and by the little Rann of Kutch on the north, while on the eastern side, it is bounded by alluvial track of Gujarat and the Gulf of Cambay.

Dhrangadhra Formation is the oldest rock formation exposed in the north eastern part of the Saurashtra peninsula. This formation has taken its name from the town Dhrangadhra where the type section is well exposed. It consists of predominantly horizontally bedded sandstone and intercalations of clays, carbonaceous shales

and thin bands of coal. Deposition of (Dhrangadhra Formation) commenced in Upper Jurassic and continued upto Lower Cretaceous to probably Middle Cretaceous.

Major production of fireclays of Gujarat is from Saurashtra region. Out of 66 opencast mines of fireclay in Gujarat, 29 are in Surendranagar District and 22 in Rajkot District. The estimated reserve of fireclay deposits in Gujarat is 0.98 million tonnes; (Indian Year Book, 1972). Gujarat was the leading producer of fireclay in the year 1970. Since then, Gujarat is the second largest producer of fireclay in India. In 1975 the annual production of fireclay in Gujarat was 3,99,733 tonnes worth of 19,17,000 rupees.

Fireclay is mostly used in the manufacture of heat resistant articles such as firebricks, blocks, retarts and various types of refractories. It is also used in ceramic products, stonewares and sanitarywares.

The total production of fireclay in India is (entirely) consumed by indigenous industries. Refractory and iron and steel industries account for 91% while ceramic and foundary industries account for 9% of the total utilization of fireclay.

TABLE I.1

Major Occurrences and Workable Deposits* of fireclay

(Saurashtra)

Sr. No.	District	Taluka	Villages
1	Surendranagar	Chotila	Amarapar, Bagagela*, Songadh*, Thangadh*, Hanuman, Hasanpur, Kandolia*, Kervali, Nalokhisaram, Khanpar*, Tarnetar*.
	- do -	Muli	Khakhrathal*, Sadala*, Gadhada*, Palasa*, Rampurda, Vagadia.
	- do -	Sayala	Ishwaria*.
2	Rajkot	Morvi	Udepur, Jambudia*, Makansar*, Jodhpur, Lakhdirnagar, Rafaleswar*, Adesar, Sajjampur, Dhunada, Paneli*.
	- do -	Wankaner	Panchasia, Vinaygadh*, Ratidevali*, Hasanpur, Saltanpur*, Matel*, Lunsar*.

The fireclay from these extensive fireclay deposits is used for the manufacture of pottery, refractory, roofing tile, glazed tile, stoneware, sanitaryware and electric insulating products by factories at Than, Morvi, Wankaner, Surendranagar, Rajkot and Dhrangadhra. Inferred reserves of fireclay in Surendrangar district are 0.14 million tonnes and that of Rajkot district is 0.02 million tonnes.

Fireclay deposits are also located in the Sabarkantha district at Himatnagar, Illol, Kadoli, Eklare, and Arsudia, and in Mehsana district at Pedhamli, Fudeda, and Mandhi. In Kutch district, fireclay deposits are associated with the Umia beds and are known to occur at Madhpur, Manuara Kalitapari, Adesar, Luda and Thikadi.

Location

The study area extends from latitude 22°30' to 22°50' North and longitude 70°50' to 71°25' East and covers a total area of about 5250 sq.km. It forms parts of one inch toposheets No. $\frac{N}{2 \& 6}$, $\frac{J}{13}$ and $\frac{J}{14}$.

(Fig. I.1)

Fireclay occurrences in Saurashtra are given in (Fig. I.2).

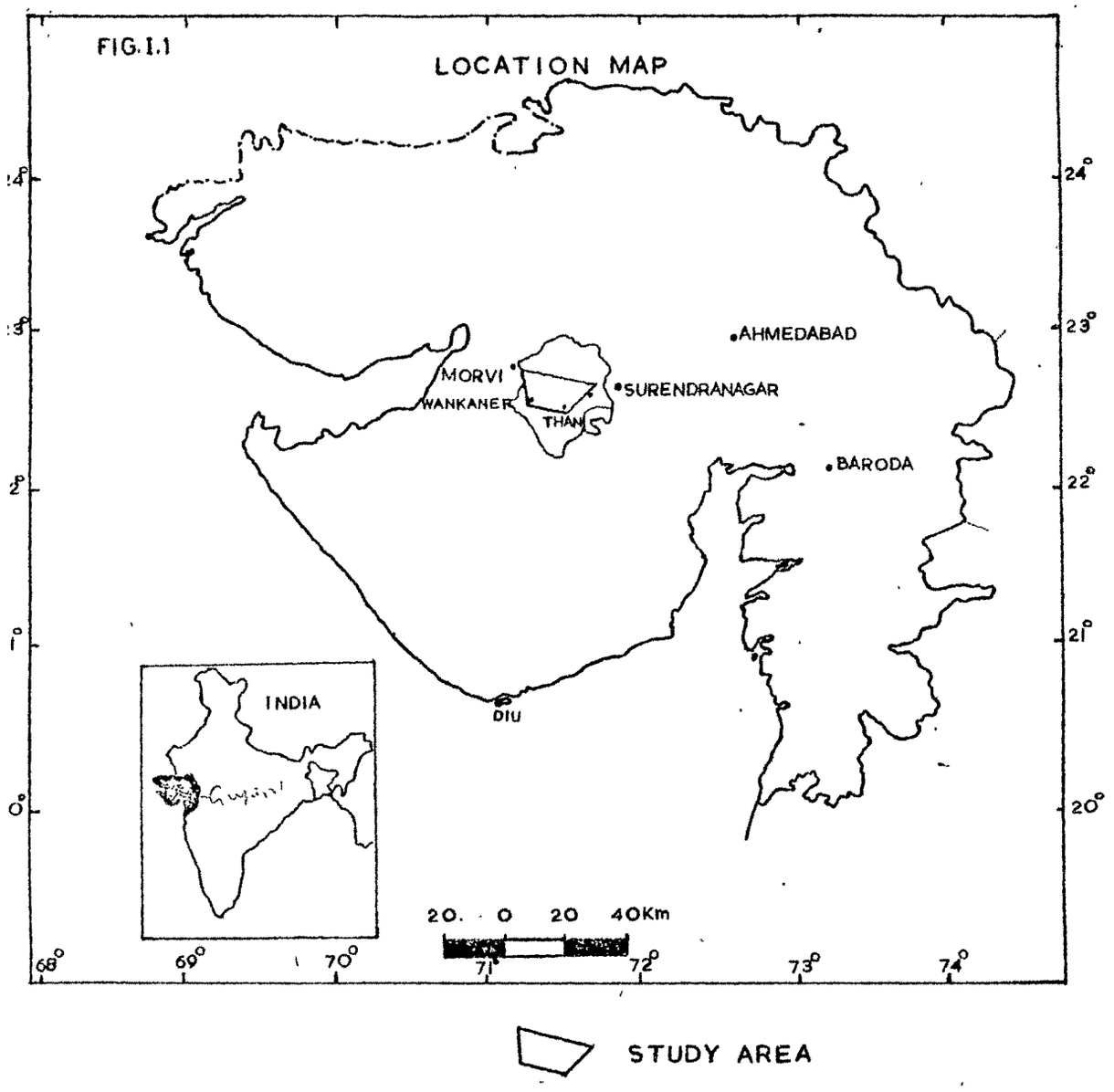
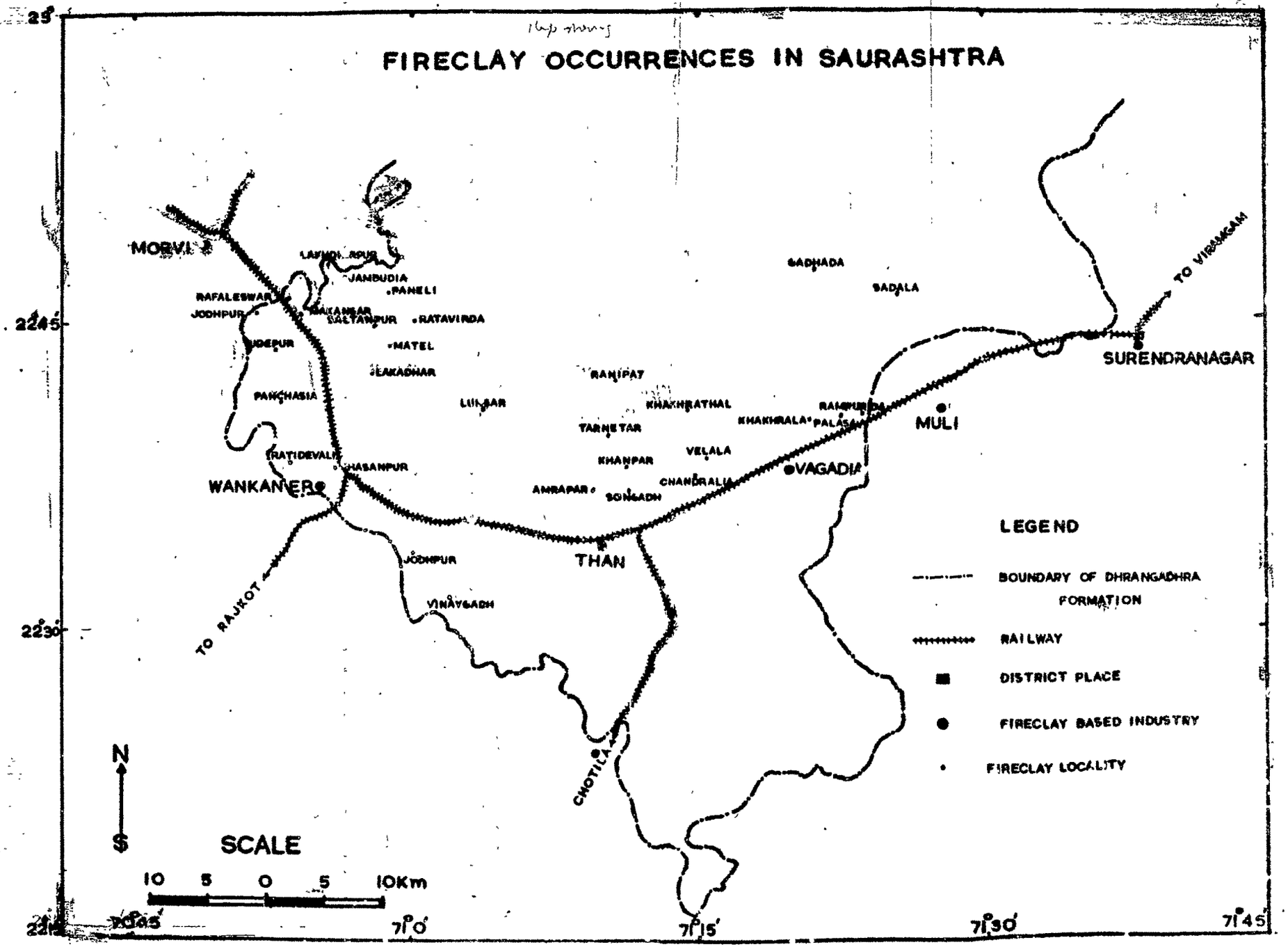


FIG.I.1
LOCATION MAP
AHMEDABAD
MORVI
WANKANER
SURENDRANAGAR
THAN
BARODA
DIU
INDIA
20. 0 20 40Km
24°
23°
22°
21°
20°
68°
69°
70°
71°
72°
73°
74°
STUDY AREA

FIG. I·2


FIRECLAY OCCURRENCES IN SAURASHTRA
MORVI
LAVADIPUR
JANBUDIA
PANELI
RAFALESWAR
JODHPUR
SALTANPUR
RATAVINDA
MATEL
PANCHASIA
LUNSAR
RANIPAT
KHAKHRATHAL
TARNETAR
KHAKHRALA
PALASA
RAIPURDA
MULI
SADHADA
SADALA
TO VIRAMGAM
SURENDRANAGAR
RATIDEVALI
HASANPUR
WANKANER
KHANPAR
VELALA
VAGADIA
CHANDRALIA
ANRAPAR
SONGADH
THAN
JODHPUR
VINAVGADH
TO RAJKOT
CHOTILA
LEGEND
BOUNDARY OF DHRANGADHRA FORMATION
RAILWAY
DISTRICT PLACE
FIRECLAY BASED INDUSTRY
FIRECLAY LOCALITY
N
S
SCALE
10 5 0 5 10Km
22°45'
22°30'
22°15'
70°45'
71°0'
71°15'
71°30'
71°45'

Physiography

The area under study is undulated. Scattered hillocks range in height from 75 to 150 meters. In the western parts of the area, more or less continuous elongated flat topped hillocks are sloping due north or northwest, whereas the eastern part of the region is plain or dotted with isolated hillocks.

The maximum elevation in the western part of the area is about 165 meters near Matel and Saltanpur villages north-east of Wankaner and minimum elevation is 85 meters near the village Vadusar NNW of Than. In the eastern part of the area maximum elevation of about 185 meters is near Gugaliana Village and the lowest elevation is about 91 meters near Digsar village NE of Muli.

Drainage

The rivers in the study area viz. Bhogavo and Machhu originate from Chotila hillocks and are seasonal. Bhogavo river flows towards east and meets the sea in the Gulf of Cambay. Machhu river flows towards North-West and disappears in the Little Rann of Kutch. The tributaries viz. Kharodia, Lavario and Machhurio meet Machhu river

South of Bokadthamba village while tributary Maha merges into Machhu river near Wankaner. The rivers of Saurashtra exhibit radial drainage.

Depth of water level in open wells in the study area is 3 to 15 m from the surface in dry season.

Climate and Rainfall

Saurashtra receives rainfall during June to September from the south-west monsoon. The amount of rainfall is decreasing from south to north. The average annual rainfall varies between 200 to 2000 mm. The temperature is increasing from south to north. The maximum and minimum temperatures are 45°C and 10°C respectively. Climate of coastal area is moist while that of inland is dry. Natural vegetation is restricted to the agriculturally unproductive areas having adequate rainfall.

The area under investigation receives rainfall only during the monsoon period. The average rainfall for the past ten years for Rajkot district is 552.2 mm while that for Surendranagar district is 445.6 mm.

In general, the climate of study area is semi-arid type having low rainfall and great variation in temperature.

Title ?

TABLE I.2

Data Based on Year-wise Rainfall of Past Ten Years

	Rainy Days			Rainfall in mm		
	Mini-mum	Maxi-mum	Ave-rage	Mini-mum	Maxi-mum	Ave-rage
Rajkot district	19	87	36	236.0	1151.8	555.2
Surendra-nagar district	12	38	23	261.1	641.5	445.6

TABLE I.3

Title ?

(Data Based on Year-wise Temperature of Past Ten Years)

Temperature	Rajkot district °C	Surendra-nagar district °C
Average Mean Maximum	34.02	34.71
Average Mean Minimum	19.58	21.16
Average Highest	43.20	43.17
Average Lowest	5.59	7.00
Average of Highest and Lowest	24.35	25.87

Vegetation

The natural vegetation of the area is mostly thorny type. Acacia leucophyla, Prosopis specigeria and Salvedora oleoids are common trees. Euphorbia nerifolia Caparis aphylla are common shrubs. Cassia auriculata is a common herb. The above mentioned natural vegetation of this area has stunted growth and is characteristic of semi-arid climate and sandy to loamy soils. The natural vegetation grows more on the plain ground with soil cover. Minor forest is observed west of Ranipat.

Communication and Transport

Chotila, Wankaner and Morvi are well connected by National Highway which extends further to Kandla seaport. Muli, Wankaner, Than and Morvi are connected by meter-gauge railway to Rajkot and Surendranagar district head-quarters. This meter-gauge is upto Viramgam which further connects Ahmedabad, Baroda and Bombay by broad gauge. Than is located 50 and 71 kms and Wankaner is located 70 and 51 kms from Surendranagar and Rajkot respectively. Morvi, Wankaner and Rajkot are connected to the fireclay mining centres of Rajkot district and and Than, Muli and Surendranagar are connected to the

fireclay mining centres of Surendranagar district by motorable roads. Most of the open cast mines of fireclay are located to the north of the railway line between Muli and Wankaner and to the east of the railway line between Wankaner and Morvi.

Rajkot is the nearest airport which is connected by air to Bombay via Ahmedabad Jamnagar. The near about seaports are Navlakhi and Kandla.

Purpose and Scope of Investigation

The main purpose in undertaking the present investigation is to study the occurrence and origin of the fireclay deposits and to assess the quality of fireclay for its industrial use. Sampling of fireclay and associated rocks was carried out using one inch toposheets (41 $\frac{N}{2 \& 6}$, $\frac{J}{13}$, and $\frac{J}{14}$) as base map. Field observations including occurrence and stratigraphy of fireclay and associated rocks, sedimentary structures and mining methods followed by miners in this area were studied in detail. Accordingly fireclays have been classified into Plastic clays, Semi-flint and Flint clays, and Nodular clays. Evaluation of the suitability

of these fireclays for their industrial applications has been done by studying their characteristics in raw state, Green and Drying properties, Fire properties, Pyrometric cone equivalents and Atterberg limits. Hydrometer analysis was utilized to determine the size of the clay particles. Ion exchange capacity and pH were determined to throw some light on environment of deposition. Through chemical analysis percentages of silica, alumina and harmful constituents of fireclay have been found out, and the mineral make up and ionic formula have been calculated. To identify minerals in fireclays, and to determine degree of disorder in disordered kaolinite, Differential Thermal Analysis was carried out. Thermogravimetric Analysis was done to study the dehydration and phase change on heating fireclays. Through the process of X-ray Diffraction analysis, minerals in fireclays, and crystal structure of kaolinite were determined. Vertical mineralogical variation was studied from different horizons of fireclay bed by X-ray Diffraction analysis. Fireclay samples were studied under Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM) to determine the morphology and type of clay minerals. Identification

of Gibbsite, Coal and Illite were carried out with the help of prob unit. (X-ray micro-probe) attached to SEM. The depositional environment of fireclay bearing formation has been established by the grain-size analysis of the associated sandstone.