CHAPTER II

BACKGROUND INFORMATION

In order to provide a suitable background to the present study, the author has summarized in this chapter the salient features of the investigations carried out by the various previous workers on the Champaner Series.

Earlier workers like Blanford (1869), Fermor (1909, 1934, 1936), Beer (1918), Hobson (1926), Rama Rao (1931) and Gupta and Mukerjee (1938) investigated the Champaner Series in the course of their regional studies in Central and Western India. It was only during the last 15 years

that exclusive attention was paid to the Champaners by Roy (1958), Rasul (1963, 1964, 1965), Sathe (1963, 1965, 1967) and Sadashivaiah (1963, 1964, 1966).

Blanford (1869)

The name Champaner Series is due to Blanford (1869) whose is the earliest account of these rocks. One of the pioneers of Indian Geology, Blanford was the first to investigate the geology of the Western India. He classified the Azoic rocks of this part of the country into four series as under (Blanford, 1869, p.27):

4. Vindhyan Series
3. Bijawur Series
2. Champaneer Beds
1. Metamorphic Series.

As he was undecided about the relative positions of the four series, he included these under the name Azoic, solely to express the fact that all were unfossiliferous, leaving the question of their geological horizons quite open.

The 'Metamorphic Series' according to Blandford (1869, p.28) comprised the basement rocks including granite, syenite, gneiss, hornblende schist, quartzites

and other crystalline formations. His (p.35, 36), Bijawar Series "consisted chiefly of laminated siliceous limestone, jasper or hornstone breccia. Sandstone generally argillaceous and often brecciated, and slates and schists were also present". He (p.34) found Bijawars to be less crystalline than the basement rocks, but "much more metamorphosed than the Vindhyans and other stratified rocks of newer age".

The rocks of the study area and its neighbourhood, occurring at considerable distance from the Bijawars and Vindhyans, were considered by Blanford to represent an altogether different series, which he called as Champaner Beds, resting over the Metamorphic Series. He has described these rocks in considerable detail (1869, p.41-42).

The author found Blanford's account of Champaner beds quite useful as a suitable starting point and hence he has preferred to describe below the account of the Champaner rocks, as given by Blanford in his own words.

"The principal constituent rock of the Champaneer beds is quartzite or quartzite sandstone, very similar in character to rocks which occur both in the Bijawurs and the metamorphics. The other beds are mostly slates,

conglomerates, and limestones, ferruginous bands occasionally occurring. Some of the limestones are highly crystalline; in one place near Kudwal they were found to contain actinolite; in other places, as near Soorajpoor, they were quite unaltered. All the rocks susceptible of eleavage are highly cleaved, the planes striking about west 10° - 20° north in general. Some of the slate appears to be so fissible that it might probably be made available for roofing."

Regarding the sequence of beds, Blanford opined, "Very little can be ascertained of the sequence of the beds. The slates, limestones and quartzites of Soorajpoor are evidently high in the series; they appear to rest upon the conglomerates of Jhubban and these again upon the quartzites of Narookot and Dandiapoora. Judging from the extent of alteration too, the Soorajpoor beds are high in the group. But no base is seen, unless the quartzites of the southern patch rest upon granite about Manikpoor. These quartzites much resemble those of Narookot."

Blanford found conglomerates to be, "the most distinctive beds in the group." He writes, "They are well seen about Jhubban on the road between Soorajpoor

and Jumbooghora. The matrix is in general a coarse gritty sandstone, containing pebbles and boulders often a foot in diameter, and occasionally more (one was measured which amounted to 3 feet), and consisting of granite, quartzite, talcose slate, and crystalline limestone. The talcose slate of which some of the pebbles are composed is scarcely more metamorphosed than the Champaneer beds themselves. The quartzite boulders are the largest. The limestone pebbles are very numerous, and as they are dissolved away on the surface by exposure to the weather, the hollows which contained them remain empty, and give a peculiar vesicular appearance to the rock. Some of the limestones of the pebbles contain silicious laminae as in the limestones of the Bijawurs, but the rock in this case is more crystalline. It rather resembles the limestone in the metamorphics E of Kanas. The cleavage, which is characteristic of the Champaneer beds throughout, is frequently apparent in these pebbles, though it is but rarely distinguishable in the sandy matrix; none of the pebbles are typically Bijawur."

He further recorded that at one place near Anandpoor the matrix of the conglomerates appeared, "to be a perfect breccia, a mixture of angular fragments of black slaty siliceous rock and coarse sandstone, both containing pebbles. This was near the junction of the conglomerate with slaty beds, the latter apparently the newer." For the nature of this breccia, he observed that the rocks appeared "to have been much crushed; they look as if angular fragments of slate had become mixed with sandstone, and then all reconsolidated. The granite and quartzite pebbles, however, exhibit no signs of any violence."

"The area occupied by these beds extends for about 20 miles to the east from Pavagarh hill, and for 7 or 8 miles to the south from Champaneer, at the north-east base of the hill. To the north they stretch for a considerable distance, but have not been examined. There is also a small tract of hilly country a few miles further south, which appears to consist of them. As it does not appear at all certain whether they can be referred to any one of the systems of rocks hitherto described as intervening between the metamorphics and the Vindhyans in Central India,

it appears best to give them a temporary and local name, and that of the old town of Champaneer, the former capital of the Mahommedan Kingdom of Guzerat, appears best suited for the purpose."

Fermor (1909)

Fermor visited the Champaner area in 1905 in connection with his investigations of manganese deposits of India. He found that the rocks of Champaner Series were lithologically similar to the rocks of Dharwar age exposed in Central and South India. Consequently he correlated the rocks of Champaner Series with those of Dharwar facies (1909, p.281, 282).

According to the mode of occurrence and origin, Fermor (1909, p.297) classified the Dharwarian manganese ores into following three categories:

(A) manganese ores associated with the less metamorphosed type of Dharwars,

(B) ores associated with more metamorphosed type of Dharwars, and

(C) ores in laterite resting over Dharwars.

He further divided category (A) into 'primary ores' and 'Outcrop secondary ores' (lateritoid ores); and category

(B) into 'primary ores', 'outcrop secondary ores' and 'deep secondary ores' (including gondite series). Accordingly, he classified the manganese ores of Champaner also. He grouped ores of Shivrajpur with 'primary' and 'outcrop secondary' ores of less metamorphosed types of Dharwars. The ores at Goldungra (Jothawad hill, Narukot) were grouped with the 'deep secondary' ores (associated with the Gondite Series) of the more metamorphosed types of Dharwars.

Fermor described the manganese ores of Champaner Series as composed essentially of pyrolusite and psilomenlane with small amounts of braunite.

He observed that at Narukot (Jothwad), the interaction between manganese bearing host rocks and the intrusive granite and pegmatite has resulted into development of various interesting manganese bearing minerals, like manganese pyroxenes (schefferite, blanfordite, rhodonite), manganese amphibole (winchite), manganese epidote (piemontite), manganese-garnet (spessartite), manganesian biotite (manganophyllite) and manganesian sphene (greenovite).

Beer (1918)

Beer (cf. Hobson, 1926, p.341) described the country of Champaner Series as the "Retort-shaped hilly area which lies south-west of Pavagarh Hill, the delivery pipe of the retort constituting the hill range south of Kadwal in the north-western corner of Chhota Udepur State."

Hobson (1926)

The eastern part of the Champaner Series has been described by Hobson (1926), who investigated the metamorphic rocks and intrusive granite of Chhota Udepur (to the E and NE of the present area). Giving a detailed account of Champaner rocks around Pani Mines, Hobson (1926, p.345-348) recorded the following sequence of rock types as encountered by him southwards from the plains of Kadwal:

Phyllites or clay slates with intercalated quartzites in Kadwal plain.

Highly siliceous calc-granulite of Jhari, Kalikui and Bhabar.

Mica-schists, phyllites and manganese horizon.

Quartzite forming main ridge "1400".

Thin conglomerate (sedimentary).

Phyllites.

Dark grey calc-granulite with tremolite and/or actinolite.

Phyllites and schists.

Gneiss with bluish quartz, muscovite, biotite and tourmaline.

He (p.347) noted that these beds, "have an approximately east and west strike and dip at a very high angle, being in fact practically vertical."

Regarding the granitic rocks, Hobson (p.343) mentions, "granite or granitoid gneiss covers the whole area with the exception of the north-western corner and certain isolated patches of crystalline schists or gneiss, limestone and quartzite and a few intrusive dykes of trap. The whole of the granite is remarkably constant in composition, the chief variation being in its texture." Hobson was of the opinion, "that this granite or granitoid gneiss is intrusive into the Champaner beds and therefore post Dharwar in age."(p.343)

Rama Rao (1931)

The northern extension of the Champaner Series in the former Bariya State was surveyed by Rama Rao. He (1931, p.61) classified the Champaner Series in different groups as under:

Champaner Series	Rajgad Shales,
	Dharia limestone,
	Bariya quartzites,
	Poyelli felspathic quartzite
	----------Conglomerate---------(?)
	Poyelli limestone, argillite, etc.
	Micaceous gneiss of Dhanpur (?)
	----------(?)
	Archaean crystalline schists and gneisses.

He correlated the Champaner beds with the rocks of Delhi System (1931, p.66). According to him (p.70), "The various subgroups into which the Champaner Series have been sub-divided in Baria, correspond both in their lithological characters and their order of superposition to the sub-divisions of the Delhi system as classified by Dr. Heron in 1917."

Fermor (1934, 1936)

In his subsequent investigations Fermor (1934,p.25-26) observed that the Champaners, the Aravallis, the Chilpighat Series, and the Dharwars of Mysore were roughly contemporaneous. Accordingly, he suggested that since the Champaners were found to be continuous with the typical Aravallis of Rajputana, the local term Champaner should be discarded in

favour of Aravalli.

In his classic work on the correlation of ancient schistose formations of peninsular India, Fermor (1936, p.42, Table 2) included the rocks of Champaner Series in the Archaean Province No.5 (comprising Rajputana and Gujarat), and he grouped them with the Manganese ore of the Marble Province of his non-charnockitic Region.

Gupta and Mukerjee (1938)

Citing previous observers, Gupta and Mukerjee (1938, p.180) considered the Champaners to be equivalent to the Aravallis. They regarded the granite and gneisses associated with the Champaners, as post-Aravalli but pre-Delhi, while the granitic rocks to the N, in the vicinity of Godhra, were thought to be equivalent to Erinpura granite.

More recent work on the Champaner Series is that of Roy, Rasul, Sathe, and Sadashivaiah. Roy and Rasul mapped this Series more with a view to know about the manganese deposits while Sathe and Sadashivaiah confined their studies to the mineralogy of those manganese bearing beds of Champaners which have been involved in the contact metamorphism of the invading granites.

Roy (1958)

Roy (1958) stated that the ores of Shivrajpur were composed of pyrolusite, psilomelane and some wad, and he also noticed minute shining specks of braunite in the ores occurring in the highly folded phyllites and quartzites.

Rasul (1963, 1964, 1965)

About the manganese deposits of the Champaner Series in Pani Mines area, Rasul and Sharma (1963,p.51) reported, "The manganese ores were found in association with phyllites and quartzites of the Aravalli System, and it seems that they have largely been formed as a result of secondary processes of concentration and replacement. The ores are composed mostly of Pyrolusite, Cryptomelane, and Manganite of secondary origin and a very minor amount of fragmentary Braunite, probably of primary and metamorphic origin."

On the basis of chemical composition, Rasul (1963, p.357) suggested that the phyllites of Shivrajpur were derived from pre-existing meta-sediments and that even after metamorphism the rocks did not suffer change in bulk composition except loss of water.

Rasul (1964, p.617-618) found the presence of manganese tabloids and boundinages in the phyllites of Bamankua and Shivrajpur, and he suggested that they were originally laid down as nodules and thin laminations of manganese oxides along with the pelitic sediments and that they were stretched into tabloids and rod-like boundins on account of the metamorphism of phyllites.

The stratigraphic sequence of Champaner rocks around Shivrajpur was also established by Rasul. While classifying these rocks he made particular reference of the conglomerates occurring around Richhbar and Jaban. In his own words (1964), "The conglomerate, having its structural character more or less concordant with those of the underlying and overlying formations probably does not indicate a stratigraphic break in the succession of the series....." Accordingly Rasul suggested that it was not possible to sub-divide the Champaners, in spite of their having a distinct horizon of conglomerate. Further he could not see the basement of the Series, in any part of the area surveyed. The stratigraphic sequence of Champaners as worked out by Rasul is given below:

Recent and Sub-Recent alluvium

Archaean	Post-Aravalli (Intrusive)	Kalsar granite and granitoid gneiss	
	Aravalli (Champaner Series)	6. Bamankua impure limestone often with pyrite	Unknown
		5. Shivrajpur phyllite with manganese ores	1000'-1050'
		4. Bhat quartzites ..	400'- 500'
		3. Richhbar grit and conglomerates	70'- 90'
		2. Jaban slate	600'- 650'
		1. Narukot quartzite..	Unknown
		?	
		(Original basement unknown)	

In a subsequent paper, Rasul (1965) presented results of the ore-microscopic studies on the mineralogical composition, textures, microstructures and paragenesis of the manganese ores of Shivrajpur. He has written that the bulk of the ores occurs as nodular, kidney-shaped, botryoidal, pisolitic and mamillated forms - all characteristics of colloidal origin. The ores are mostly composed of pyrolusite, cryptomelane and polianite with subordinate

amount of manganite. Braunite is associated only with non-colloform and massive variety of ores. This braunite with a small amount of pyrolusite, is of primary (metamorphic) origin, whereas other minerals mentioned above are formed as a result of deep secondary processes of ore deposition.

Sathe (1963, 1965,1967)

Sathe's work in this area mainly pertains to a few stray mineralogical studies. In one paper, he (1963, p.9-11) pointed out that the green, shining pyroxene, found in the calc-gonditic gneisses and crystalline limestones of Jothwad manganese pit, is ferriferous and not manganiferous as might have been presumed due to its association with the manganese ore bands. He, (p.11) identified this pyroxene as 'Salite' of the diopside - hedenbergite series and he thought it to have been produced on account of interaction between the calc magnesian and calc arenaceous sediments (containing ferruginous matter) and the available silica in the rock.

In a subsequent paper, Sathe (1965,p.59-60) described the contaminated diorite fringes associated with the calc-pelitic xenoliths in Kalsar granite and

concluded that the diorite were genetically related to the granite and had been derived from it by contamination of the calcareous material of the country rocks.

Sathe and Choudhary (1967,p.616-618), also, reported stellate wollastonite from calc-silicate skarns of Jothwad hill. They (p.618) explained the concentration of stellate wollastonite (restricted to the outer margin of the wollastonite zone) as due to low temperature and consequent fall in the supply of introduced silica with increasing distance from the magmatic source.

Sadashivaiah (1963,1964,1966)

Sadashivaiah (1963) has given a classic account of calc-silicate skarns in the granite and gneiss at Jothwad. He (p.304) found that "the crystalline limestone situated at the contact of the granites and gneisses grades into calc-silicate assemblages containing abundant wollastonite. In the deeply cut portion of the central part of the quarry occurs calc-silicate skarns containing little or no wollastonite, abundant diopside, epidote, phlogopite and scapolite. Calc-silicate minerals often occur as bands along the bedding planes of the limestone." He also noticed variation in the distribution of skarn

minerals and accordingly, he grouped them into two main petrological types viz. (1) wollastonite-bearing rocks and (2) diopside-garnet-epidote-phlogopite skarns. He has given a detailed account of these rocks and minerals and has also discussed their origin. According to him (p.312), "The formation of the skarn minerals and the various associated features have been brought about by the temperature pressure gradients and diffusion of volatiles and silica during the metamorphism of the lime-stone due to the granitic intrusion."

In his subsequent papers Sadashivaiah (with his associates) has dealt at length the occurrences of winchite and piemontite at Jothwad hill.

Jointly with Naganna, he (Sadashivaiah and Naganna, 1964) described the mineralogy of winchite in a greater detail. He found winchite occurring "as segregations and patches at contact of pegmatites and manganese ore in a granite quarry at Jothwad hill (22°30':73°44') where inliers of gondites, calc-silicate skarns and manganese ore bodies are acutely folded within the granites and gneisses and cut by pegmatites and tongues of granitic rocks." He (p.360), concluded that the winchite from

Jothwad is a richterite with an affinity to arfvedsonite.

In another paper, Sadashivaiah and Tenginakai (1966) described the occurrence of piemontite in these skarns. They (p.64,65) have shown that the piemontite bearing calc-silicate rocks occur associated with the calc-silicate skarns, winchite - rich rocks, manganophyllite granulite and gondites, at the contact of the pegmatites, granites and gneisses and the manganese ore bands. It is concluded by them, ".....that the mineral assemblage of the calc-silicate rocks of Jothwad is intimately associated with kinetics of the metamorphic reactions taking place in the solid state at the energy level sufficient to cause recrystallisation aided by the influx of silica, soda and potash under metasomatic conditions into the impure limestones during the formation of the granites and gneisses of the area. The formation of tremolite and diopside bearing assemblages are connected with the rise of temperature aided by the diffusion of silica. Alkali and lime metasomatism have aided the formation of calcite and epidote. The development of scapolite, almandine garnet and piemontite is attributed to the presence of abundant volatiles and the interaction of the manganese of the manganese ore band during the metamorphism of the limestones."