CHAPTER I

INTRODUCTION

SECTION A: Introducing the area.

SECTION B: Introducing the work.
SECTION - A.

INTRODUCING THE AREA

Just a century back, in 1881, V. Ball unveiled the Singhbhum Precambrian geology and this Singhbhum Precambrian belt is now one of the most attractive terrains within the Indian Precambrian shield both from the point of view of mineral potentiality and academic interest. The Singhbhum Precambrian terrain offers an excellent opportunity to study the early history of crystal evolution as here is exposed a Proterozoic belt in juxtaposition with Archaean granitic platform (Bose and Chakraborti, 1981; Sarkar, 1982). The Dalma volcanic belt is a constituent of this Proterozoic belt developed around the platform largely comprising OMG tonalite gneiss and Older metamorphics (ca 3800 Ma) and Singhbhum granites (ca 3000 Ma) (Sarkar and Saha, 1977; Basu et. al., 1981).

Location and Accessibility

The arcuate belt (Fig. No. 1A. 1) of Dalma metavolcanics to the north of 'Copper Belt Thrust' (Dunn and Dey, 1942) extends from Bankura and Purulia districts of West Bengal in the east, to the Ranchi district of Bihar in the west with the major display in the Singhbhum district, Bihar. This belt shows an outcrop length of about 200 Km. from east to west. The body presents a much narrower outcrop width at its eastern extremity.
whereas to the west the outcrop splits into a host of sub-
parallel linear segments which together swing back into an
arcuate hinge. Within this extensive tract four separate
sectors were chosen for the present study only on the basis
of the best development of the volcanic members and distinct
relationship between the metavolcanics and the metasedimen-
taries. Inaccessibility also limits the continuity in litho-
logic mapping. The sectors studied from east to west, are
named after well known village in each sector e.g. Kunchia
(86° 28'; 22° 47' 12''), Chandil (86° 04'; 22° 57''), Khunti
(85° 59'; 22° 58') and Kanderkuti (85° 50'; 22° 52' 45'').
Short field studies were also carried out in other parts of
the volcanic belt to confirm regional distribution of rock
types studied in the four sectors. The investigated areas
fall in the Survey of India toposheet number (73 J/5, 73 J/1
and 73 F/13) with the above order. All the sectors, except
Kunchia (Purulia district, West Bengal), lie in the Singhbhum
district, Bihar. The areas were mapped in the scale of
1:31,680 separate geological maps of Kunchia sector (Fig.
1A. 2), Chandil sector (Fig. 1A. 3), Khunti sector (Fig. 1A. 4)
and Kunderkuti sector (Fig. 1A. 5) were prepared to show the
distribution of rock types.

For the first sector, Kunchia, (Fig. 1A. 1) the easiest
approach is from Galudih Railway Station. From Galudih Rly.
Station the village is about 10 Km. towards north which can
be covered by only bullock-cart. The second and third sectors (i.e., Chandil and Khunti) are connected by road with subdivisional Head quarters at Jamshedpur. The Chandil (junction) Railway Station is in the heart of second sector while in the third sector, Khunti, could be reached by bus from Chandil (junction) Railway Station. The fourth sector, Kunderkuti is a moderately large village to the south and is approachable from the Raj Kharswan Railway Station on S. E. Railway. This area is unapproachable in all the seasons except the winter. During this season only the jungle cutters go by truck within forests and that opens the only avenue to reach the area of study. Among these four sectors the eastern most (Kunchia) and the Western most (Kunderkuti) are covered by thick vegetation giving rise to almost dense forest constituted mainly by Sal trees and huge thick undergrowths. On the open ridges the vegetation closely confirms to that of a hot dry region while in the humid valleys dense bushy undergrowth of a moist region may be noted.

Topography

The panoramic view in this part of the country is pleasant, particularly in the hill tracts. Many fine ever-remembering views fully repay the trouble and energy require to reach the required vantage spots.
Dalma hillrange is the conspicuous topography within the Singbhum terrain and represents a residue of once prominent mountain range of Precambrian times. Some isolated peaks of Dalma range is the expression of resistant quartzites - residues of prolonged weathering. Within the Dalma volcanic terrain the topographic expression is variable. Mostly in all the sectors the physiography of this suite breaks the monotony of flat country on either flanks and forms isolated peaks, the highest being 643 mts. (Khunti Sector) above mean sea level. Such geomorphological break may suggest a relatively younger age of the metavolcanic belt compared to the enclosing metasediments.

The drainage of the whole area is collected by the Subarnarekha river which enters the district through the northern hill tract, north-west of Jamshedpur, cuts across the volcanic belt and then meanders south-east over the mica schist plains. Apart from this river many tributaries are present all of which take their avenue across the phyllite ranges to stream capture. Due to this good water logging the hills are covered with densely populated big Sal trees (Shorea robusta) and undergrowths. Low grounds are open and often form paddy fields.

The control of lithology on the topography of the area is evident. In general, the metabasalts occur in the low grounds. Only at places, near Kunchia and Kunderkuti, the rock makes up low mounds. The metasedimentaries, especially the
phyllite and quartzite, for the ridges and other elevated topographic features. This general feature helped in locating the boundary between the Dalmas and the enclosing metasedimentaries.
SECTION B

INTRODUCING THE WORK

Though extensive field and laboratory studies have been carried out on the granitic rocks of Singhbhum, detailed petrology and geochemistry of the Singhbhum metavolcanic belt lying to the north of granitic terrain have not been taken pp till only recently. The volcanics and volcanioclastics constitute a significant part of the metamorphic belt of Singhbhum lying between granite to the south and granulite - migmatite belt to the north (Fig. 1A. 1). Obviously a connected history of evolution of this precambrian terrain can not be understood unless the metavolcanics are studied with due emphasis and the tectonic setting of the belt is evaluated.

The present study has been oriented with this view. Precambrian volcanism offers a subject of topical research as it helps in a better and deeper understanding of the early crustal evolution as also the characteristics of ancient volcanism. One such characteristic as manifested in early Precambrian greenstone belts is the effusion of early ultramafic lavas (O’Nions and Pankhurst, 1978) compared to Phanerozoic volcanism. Again the tectonic setting for the Precambrian greenstone belts are now considered equivalent to that of the marginal basins situated in the back arc region (Burke et al., 1976; Tarney and Windley, 1981).
The Dalma volcanic assemblage in its low grade dress may be designated as a greenstone belt (Gupta et al., 1980). The volcanics within the metamorphic belt of Singhbhum offers an excellent opportunity to study the nature of Precambrian volcanism. The variation within the suite has been quantified with the help of both major and trace element data. These chemical data collected in course of present study have been used to bring out the compositional variation within the volcanic belt composed of basic, ultrabasic lavas and pyroclastic members as also to establish the palaeotectonic setting for this volcanic belt. Field and laboratory investigations across different sectors in different parts of the volcanic belt, though in a low grade metamorphic dress, reveal a large dominance of high magnesian volcanic members particularly towards the basal part (as pointed out above to be characteristic of greenstone belt) of this volcanic sequence followed upward by basaltic flows through a pyroclastic horizon. The Dalma basalts in their geochemical characters are distinctive from average 'all basalt' (Manson, 1967; Prinz, 1967) the most significant feature being their general depleted nature as brought out through present study. Geochemical characterisation of marginal basin basalts are yet not well defined and their field in discriminant diagrams used for identifying tectonic setting are not well delineated. The present study attempts to show new light on major and trace element chemistry of such basalts.
Previous Work

V. Ball (1881) appears to be the earliest worker who studied the Dalma volcanics, describing it as a 'Sill' and designated it a 'Trap'.

The first regional study of the Singhbhum Precambrian terrain was made by Dunn (1929), who had opined that Dalmas were altered basic lavas mixed with agglomerates and breccia. He also recognised the extrusive character of these rocks from the occurrence of amygdaloidal structure, agglomerates and breccia and a general fine grained appearance. According to him, a series of Subaerial lava flows took place over an erosional surface of the country rock. He suggested that the Dalmas occupied the core of an east-west trending narrow regional syncline and placed the Dalma volcanics at the top of the stratigraphic sequence.

In a later regional study, Dunn and Dey (1942) regarded the Dalma lavas as the top most member of the Iron-Ore series. (Chapter II). They suggested that the lavas were poured out under sub-aerial terrestrial conditions on a somewhat peneplained surface. The rocks had been subjected to slight folding in N-S direction. Thus the flows had been folded into a great synclinorium. They added that the greater part of the lavas was fine grained. But some coarser grained epidiorites also occur. Such types apparently represent an intrusive phase
within the flows.

Naha and Ghosh (1960) suggested that the rock types of the Dalmas could be considered as island arc but no petrological or chemical support was furnished. Bhattacharyya (1960) published a note on sill-like appearance of the Dalmas in Sonapet valley section. Sarkar and Saha (1962), while reviewing the Singhbhum stratigraphy, suggested that the Dalma lavas and the underlying Singhbhum series of rocks were folded into an E-W trending southward overturned fold forming the Singhbhum anticlinorium and the Dalma synclinerium. De. (1964) reported distinct unconformity between the mildly warped basaltic flows and the underlying highly folded pelitic schists in the eastern extremity of the belt in Midnapur district of West Bengal. De et al. (1963) suggested that the Dalma metabasalts are plateau basalts. Bhattacharyya et al. (1970) concluded from geophysical observations near Chandiil (Bihar) that the Dalmas, instead of occupying the core of a syncline, form a sheet-like structure in the folded Precambrian sequence. According to them, the lack of evidence of angular unconformity or any conglomerate horizon between the Dalmas and the metasedimentary strongly support the view that the Dalmas represent concordant lava outpourings without any break in sedimentation and that the phyllites and mica schists in the north are younger than the Dalmas which, in turn, are younger than the phyllites and mica schists in the south. Gupta et al. (1977) studied on the
nature of pyroclasts just west of Chandil. They reported that a tuffaceous horizon with impersistent "pyroclastic conglomerate" horizons marks a prominent disconformity between the underlying carbonphyllite - tuff sequence and the overlying massive meta-basalts. In the central sector of the Dalma volcanic ranges. They also mentioned that the pyroclastic conglomerate and boulder represents distinctly reworked unit derived through short distance transportation. The later basaltic flows represents a violent eruptive phase and distinct change in depositional environment. The main bulk of the basaltic lava of the Dalma suite was poured out subsequent to the reworking of the pyroclastics. Based on the geochemical affinities Yellur (1977) opined that the Precambrian Dalma amphibolites represent an oceanic basalt of tholeiitic composition, and these were erupted at diverging plate margins and indicate "faster spreading of the ocean floor". He also included some samples of Dhanjori lavas in his compilation work and tectonic interpretation. Dhanjori lavas are quite disturbed from Dalmas in geologic setting (Dunn and Dey, 1969; Sarkar and Saha, 1977). Sarkar and Bhattacharyya (1978) furnished a detailed structural account related to superposed deformations in Hesadith - Tebo area, western Singhbhum, Hihar. According to them there are three generations of folds as \( F_1 \), \( F_2 \) and \( F_3 \). Gupta and Basu (1979) reported the occurrence of pillow lava in the Dalmas near Khunti in Singhbhum.
district, Bihar and ultimately ruled out the possibility of
sub-aerial eruption, as suggested by Dunn (1929). Bhattacharyya
and Dasgupta (1979) studied the basic fragments which are
embedded in the metabasalts from this (without siting
locations) terrain. They consider these coarser fragments
of the pyroclastic rocks as ultramafic clots preserved by some
unknown mechanism and engulfed in the effusive phase of magma
which now constitutes the groundmass material. Chakraborti
and Bose (1980) furnished a brief report on the high
magnesian character of the Dalma and emphasized on the nature of the
coarser clasts in the volcanic agglomerates, which are very
akin to Komatiites. Recently Gupta et al. (1980) furnished
a detailed report on the Proterozoic ultramafic and mafic lavas
and tuffs of the Dalmas. They opined that the initial igneous
activity is represented by mafic and ultramafic intrusives and
lava of tholeiitic, alkaline and komatiitic affinities. They
showed that the pillow lavas are characterised by high iron
and low potassium content with prominent ocean floor affinities.
A detailed chemical study of the pyroclastic member of the
Dalma volcanic pile, by Chakraborti (1980), reveals the coarse
fragmental components to bear a Komatiitic impress where as
the groundmass material is somewhat variable in character.
He considers that the chemical compositions of the volcanic
clasts and the corresponding matrices attest to changing
chemistry of the magma in course of evolution of the volcanic
belt and emphasizes combined role of volcanism and sedimentation in evolution of the terrain.

Bose and Chakraborti (1981) identified for the first time a fossil marginal basin in this terrain. According to them a sedimentary basin with a remarkable BIF horizon towards its base developed on the flank of Singhbhum granite platform. The Dalma volcanic belt developed as a miniature rift zone along the median part of the basin. Recently Bhattacharyya and Daagupta (1982) opined, on the basis of different groups of mineralogical assemblages ranging from low green schist to high amphibolite facies, that the P-T conditions increases from east to west within the belt. Sarkar (1982) from a review of available geological data proposed a model based on converging microplates for the evolution of Dalma mobile belt.

Considering the areal extent of the huge Dalma volcanics the work done so far is negligible. Present investigation includes both structural and petrological account of the parts of Dalma volcanics emphasising mainly on the detailed petrology and geochemistry of the Dalma volcanics. Present study also includes the trace element distributions of the Dalma members which was not studied by any other worker in detail. On the basis of this trace element chemistry an attempt has been taken to decipher the paleotectonic setting for the Dalma volcanic belt.
Determinative and analytical procedures.

Optical studies: Under the optical studies the determination of refractive index (R. I.) was done by liquid immersion method in white light. Each matching liquid was checked before and after used by Abbe and Jolly refractometers. Extinction angle ($\Delta C$ or $\angle C$) was determined from mineral grain showing highest interference colour. A number of determinations were carried out in order to avoid any inaccuracy. Optic axial angle was determined on four axes universal stage.

Mineral separation: Particularly fresh samples were chosen and crushed to a definite size range (-80 to + 100 mesh). Amphibole grains were separated by isodynamic separator and from the leuco fraction plagioclase grains were separated through repeated feeding of sample with step wise increase in field intensity.

X-ray techniques: The mineral grains were ground in agate mortar with alcohol. X-ray powder diagrams were taken in Rigaku focussing camera (internal diameter is 11.46 cm.). Samples were x-rayed with Cu K$_{\alpha}$ radiation.

Chemical analyses: For this study proper sampling is very much important. Keeping this view in mind sampling was done from different levels of each member and each samples was collected from deeper part of exposures (by digging 2 to 2½' with shovel) to get fresh representative samples. For each sample
about 500 grams of bulk rock (in case of homogeneous types and
1000 grams for inhomogeneous types) was crushed by jaw crusher
and then powdered to a definite size (-120 mesh) by diamond mor-
tar avoiding any contamination and loss at all stages. From this
sample powder particular amount of sample was taken by coning
and quartering method and was finely agated in a mechanical agate
mortar. To determine major element proportions, each rock sample
(agated) was made into two solutions viz., solution A and
solution B by following methods of rapid chemical analysis as
recommended by Sharpiro and Brannock (1955). Solution A is used
to determine the SiO₂ and Al₂O₃ percentages with the help of
colorimeter. CaO and MgO was determined by titration of the
solution B. Alkalies were determined by flame photometric
technique using standard solutions with adequate background
(of Na₂O and K₂O) according to the alkali contents of the samples
treated. Total iron, MnO, TiO₂ and P₂O₅ were determined by
colorimeter from the solution B. FeO was determined by titra-
tion (against 1(N) solution of KMnO₄) directly from the sample
powder after dissolving it in hot hydroflouric acid soluṭi)n.
Various U S G S rock standards (Flanagan, 1973) viz., POC - 1,
AGV-1 and BCR-1, were analysed. As a check on the precision
and accuracy the U S G S standards were used as unknowns and
it is found that the accuracy is upto a limit of ± 1% for major
elements and ± 0.05% for the minor elements. Most of the
samples were analysed at the Department of Geology, Presidency
College, Calcutta. Few samples were analysed at Chemical Laboratory of Geological Survey of India at Calcutta for checking the results.

For the trace element concentrations of the Dalma rocks, the analyses were carried out by the author at the Bhaba Atomic Research Centre, Trombay by the technique of emission spectroscopy. Firstly, the sample was mixed with internal standard graphite mixture in the ratio 1:5 by weight and then excited at 15 Aamps. D. C. for a period of 60 seconds. Jarrell Ash grating spectrograph (Ebert mount) is used to photograph the emitted spectra in the region 2265 - 3515 Å. Palladium, Tin and Silicon were used as internal standards. The analytical lines in the photographic plate were read and matched with standard lines of different elements by Densitometer. Different detection limits have been fixed for different elements and the accuracy, was found to vary between 2 - 20%, was assessed by analysing international rock standards (BCR-1, JB-1 etc.) as unknowns. A few samples were analysed at Geological Survey of India laboratories at Calcutta. The element Rb for few samples were analysed by following Neutron Activation method at Mineralogisches Institut, University of Freiburg, West Germany through the courtesy of Dr. W. Czygan.

Rare Earth Elements for a few samples were determined at the Department of Geology, Bedford College, London, through the courtesy of Dr. A. D. Saunders. The analyses were done following the Neutron Activation method.
FIG. 1A. LOCATION MAP SHOWING THE EXTENSION OF THE DALMA VOLCANIC BELT, SINGHBHUM DISTRICT, BIHAR (AFTER DUNN & DEY, 1942).

LOCATIONS: A. KUNCHIA  B. CHANDIL  C. KHUNTI  D. KANDERKUTI  E. SONAPET VALLEY  F. HESSAIH  G. BANO.

1. GAILIC PLATFORM  2. DALMA VOLCANIC BELT  3. MARGINAL BASIN FILLED WITH VOLCANICLASTICS, CLASTICS AND VOLCANICS. INSET SHOWS LOCATION OF AREA INVESTIGATED.