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PHELPS DODGE – METDIST MINING INDIA PVT. LTD.

EXPLORATION REPORT

ON THE

LALGARH RECONNAISSANCE PERMIT

DAUSA DISTRICT, RAJASTHAN

INDIA

Author: Arun Kalra

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I. INTRODUCTION

1.1 BACKGROUND

During a field visit by Phelps Dodge Exploration geologists to examine the conglomerate horizon around Lalgarh, about 30 km southeast of Jaipur, several copper-rich quartzite clasts were noticed. With the objective to discover the source of this copper mineralization, Phelps Dodge Exploration India Pvt. Ltd. applied for a Reconnaissance Permit (RP) around Lalgarh, Dausa district, Rajasthan and was granted an area of 683.72 sq.km. on 21 April, 2001. This was subsequently transferred to the joint venture company, Phelps Dodge-Metdist Mining India Pvt. Ltd. on 24 December, 2001.

Phelps-Dodge Metdist Mining India Pvt. Ltd is a Joint Venture company promoted by Phelps Dodge Exploration Corporation, USA and Metdist Ltd. of UK, with Phelps Dodge as operator of the JV. Phelps Dodge Corporation is the world's largest publicly traded copper producer and a world leader in continuous-cast copper rod and molybdenum production. Metdist operates a copper wire rod plant in Malaysia with an annual capacity of 100,000 tones.

1.2 EXPENDITURE

The expenditure commitment was Rs.7.50 lakhs for the first year, Rs.10.0 lakhs for the second year and Rs.20.0 lakhs for the third year. However, the entire RP area was relinquished before the end of the second year. Thus, against an expenditure commitment of Rs.17.50 lakhs for the first two years, the actual expenditure has been Rs.21.83 lakhs.

II. LOCATION AND GEOLOGY

2.1 LOCATION AND ACCESS

The Lalgarh Reconnaissance Permit area, which is located in the Dausa district, of Rajasthan State, falls in Survey of India toposheet No.54B (Figure 1). The area is about 30 km southeast of Jaipur and is easily accessed via National Highway Eleven, (NH-11) which connects Jaipur and Agra. Dausa, the District headquarters, which is located at the northeast edge of the RP area, is also connected by NH-11 and by rail (Western Railway) to Jaipur.

2.2 TOPOGRAPHY AND DRAINAGE

The topography in general is flat with most of the area being covered by aeolian sands. The only prominent topography is a NW-SE trending ridge from Lalgarh to Garh, low hills near Banskho and a small isolated hill at Madhogarh.

The prospect is cut by small streams draining southwards into the Kharli Nadi, which flows into the Morel river, south of the survey area. However, the streams and rivers in the area are dry for most of the year.

2.3 REGIONAL GEOLOGY

The mid-Proterozoic Delhi Basin extends over a strike length of more than 700 km in a NE-SW direction and has a maximum width of 120 km in northeastern Rajasthan. In its northeastern part, the Delhi Basin consists of several fault bounded sub-basins which contain 3 to 10 km thick volcanic and sedimentary infill sequences belonging to the Delhi Supergroup (Singh, 1995). The depo-centres, from east to west, include the Bayana-Lalsot, the Alwar and Khetri sub-basins. The Alwar sub-basin is the largest and is separated from both, the Khetri and the Bayana-Lalsot sub-basins, by prominent faults or lineaments (Sinha Roy et. al., 1998). The Alwar sub-basin is comprised of smaller scale horst and graben (ie. "third-order" structures), margined by faults that were apparently syn depositionally active (Singh, 1984 a, b, 1988 ; Deb & Sarkar, 1990). The Lalgarh RP area encompasses the third-order Lalgarh graben, the margin being delineated by the Lalgarh East Fault (Figure 2).

2.4 GEOLOGY OF THE LALGARH AREA

The Lalgarh RP covers the majority of the Lalgarh graben, one of three mid-Proterozoic Alwar Group grabens developed upon Proterozoic Raialo Group metasediments and Archaean-early Proterozoic basement rocks in the Jaipur-Alwar region (Singh, 1984a, b, 1998).

The Lalgarh graben appears to be bounded by a north-trending fault zone on its eastern edge; a portion of this fault zone is exposed in a ridge at Madhogarh where highly sheared mafic-ultramafic volcanics and intercalated, highly transposed quartzites are found. The western edge of the graben is uncertain and may be marked by more of a gradational break forming the hinge of a half-graben. The southern edge of the graben is marked by the sudden transition from the low hills of shallow-dipping boulder conglomerates to a steeply-dipping, east-southeast striking ridge of Raialo Group marble, quartzite and basalt.

The sedimentary fill of the Lalgarh graben generally strikes east-southeast and dips shallowly to the north (Fig. 3). These sediments consist of a monoclinal sequence of conglomerate, pebbly sandstone and sandstone that fines to the north. Singh 1984a,b; 1988) has divided the basin fill into four major facies: Facies A – Boulder conglomerates, Facies B - Red Conglomerates, Facies C - Conglomerates and Sandstones, and Facies D - Sandstones. Facies A to C comprise the Rajgarh Formation, while Facies D constitutes the Kankwarhi Formation.

2.5 RAIALO GROUP

Strata of the Raialo Group, across the project area, are preserved in two distinct structural settings:

(i) As isolated outcrops, comprised predominantly of light weathered quartzite, situated west and due south of the Facies A (lower Alwar Group) outcrop belt (Figure 3). An isolated outcrop of probable Raialo Group quartzite and schist was also encountered at Madhogarh located 4 km east of Garh.

(ii) As an up to ~100 m thick sequence underlying the west-northwest – to northwest – striking outcrop belt of Facies A conglomerates adjacent to the margin of Lalgarh Graben. (Figure 3).

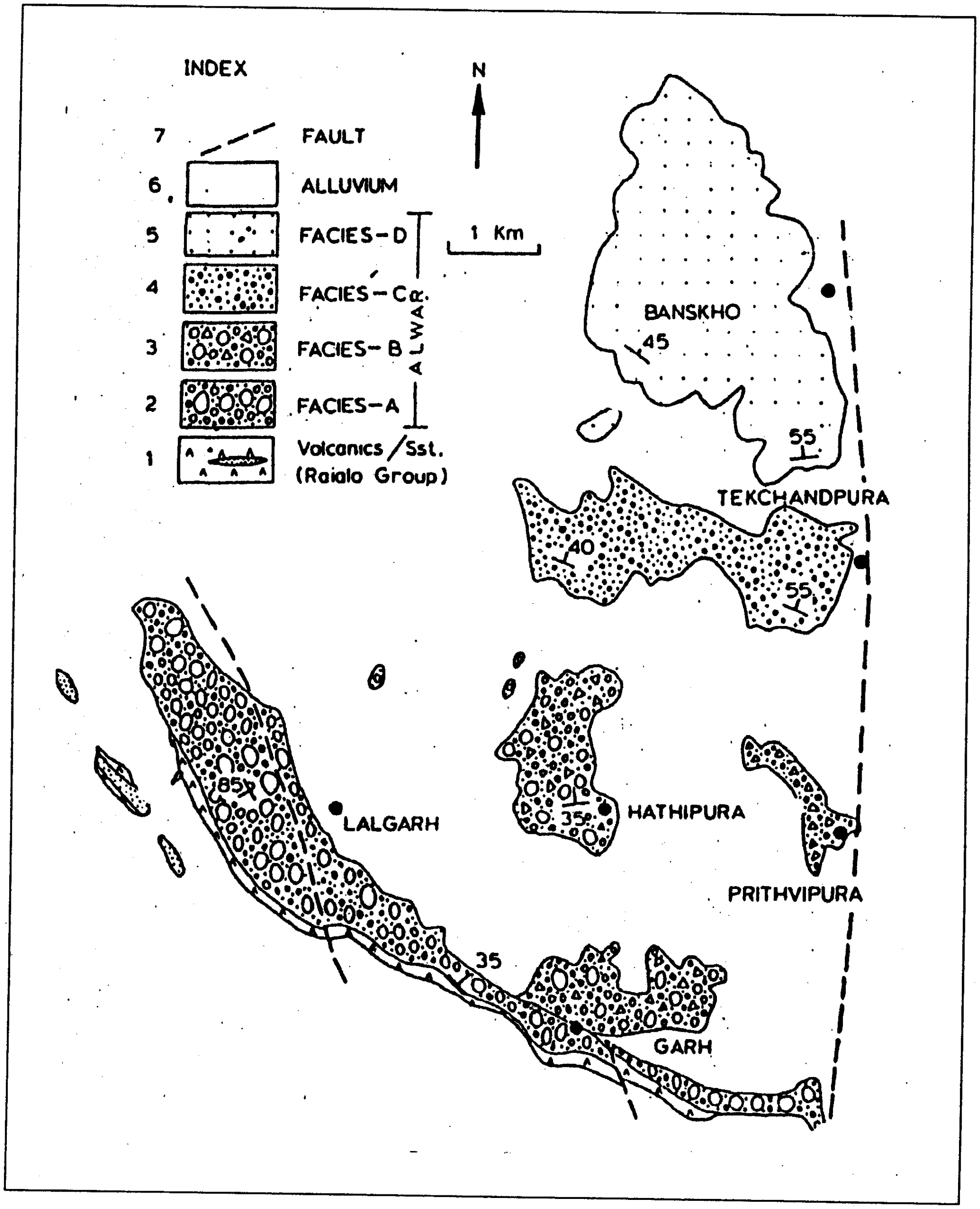


Figure-3 Sedimentary Facies of Lalgarh Graben (after Singh, 1984a)

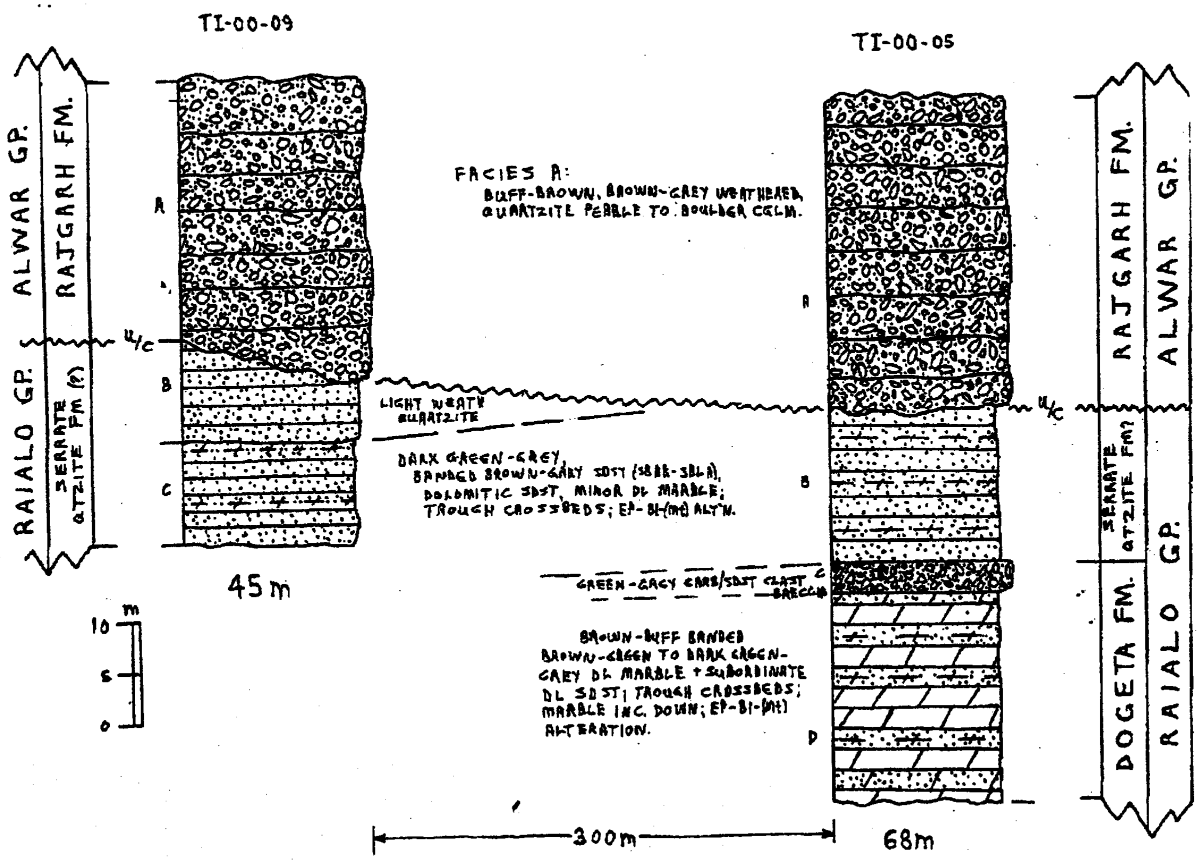
This outcrop belt of Raialo comprises of altered dark green to gray weathered intermixed dolomitic marble and trough crossbedded sandstone (Figure 4 & 5; Plate III A, B and IV A). The sequence is unconformably overlain by Facies-A conglomerates of the lower Alwar Group (Plate IV A, V A).

The isolated Raialo Group outcrops form prominent northwest – trending ridges, up to 50 m wide, that consist of resistant buff-brown-pink banded purple-gray to buff-white weathered, fine to medium-grained quartzite (quartzarenite to subarkose). The quartzites are thinly bedded, with micaceous partings and locally contain abundant trough crossbeds, cross-laminations and wave to current ripple marks. The beds are also, in part, arranged into small scale thinning or shallow upward cycles up to 3 m in thickness. These arrangements represent probable shallow marine tidal bar cycles and comprise trough crossbedded, up into very thin bedded quartzarenite. Locally, small outcrops of medium-crystalline, green-gray metadiabase (up to 10 m x 15 m in size) occur along the base of the quartzite ridges. In the area due south of Gumanpura, the light weathering, resistant quartzites are locally extensively limonite stained but are unmineralized.

The outcrop at Madhogarh consists of alternating bands of recessive, dark weathering quartz-feldspar-muscovite schist (up to 60 m wide) and resistant, light weathering, fine-grained planar to trough crossbedded quartzite up to 20 m wide (Figure 6; Plate IV B).

Preserved Raialo Group strata, outcropping beneath Facies A conglomerates along the southwest margin of Lalgarh Graben, comprise an up to ~ 100 m thick succession of altered, dark weathering dolomitic marble and dolomitic sandstone (with sandstone content increasing up-section), which is overlain by up to 10 m of light weathering, planar- to trough-crossbedded quartzite (Figure 4 and 5; Plate III A, B). The strata probably represent portions of the Dogeta and Serrate Quartzite Formations. The succession comprises dark green-gray banded buff-green, fine crystalline thin to medium bedded dolomitic marble that is intermixed with dark gray to brown-green-gray, thin bedded to trough crossbedded, fine to medium grained dolomitic sandstone (subarkose to sublitharenite) and minor green-brown tremolitic calc-silicate. The sandstone content increases up-section, the upward

Figure 4: Log of the Raialo – Alwar Group stratigraphic section in the area 1 km west of Garh (Stations TI-00-05 and 09; after Iannelli ,T. R., 2001)



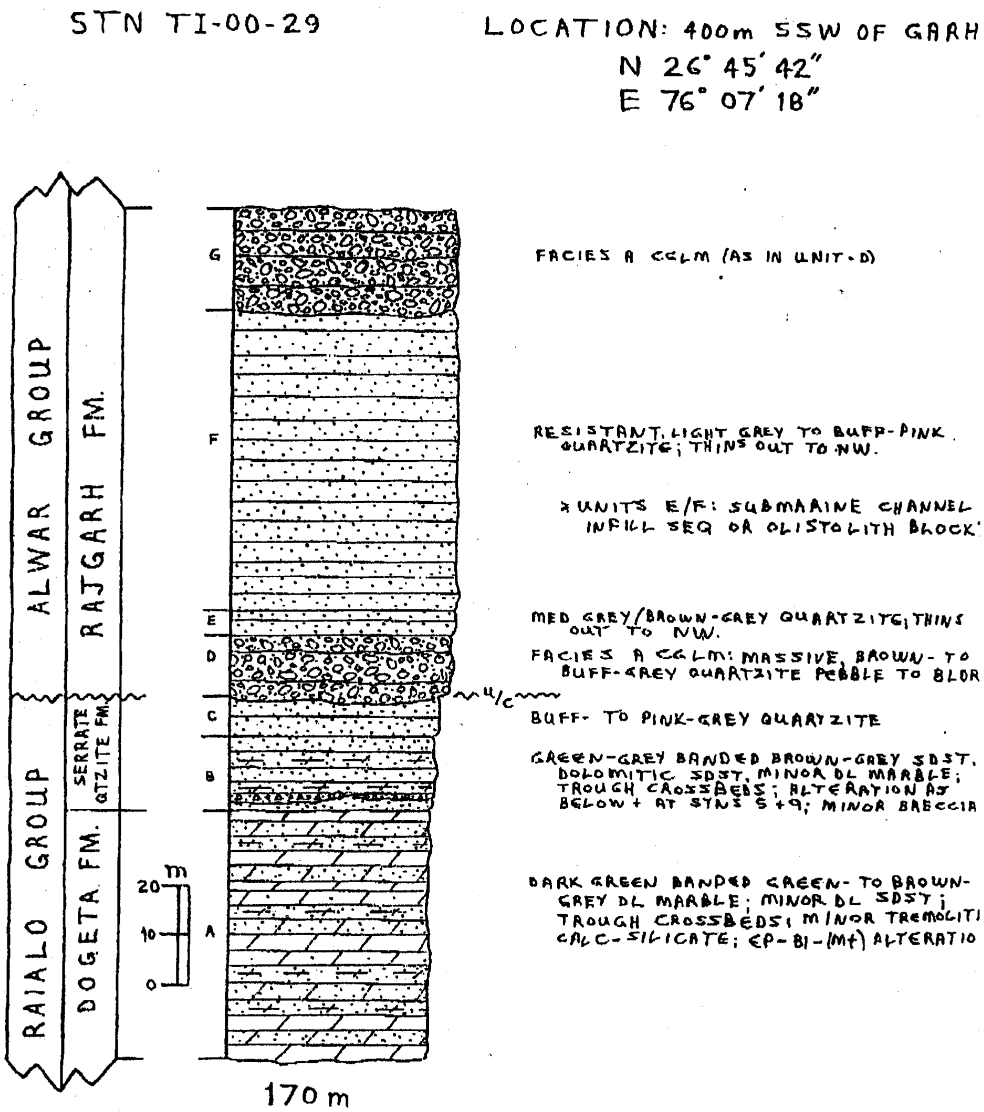


Figure 5: Log of the Raialo – Alwar Group stratigraphic section in the area ~400 m south-southwest of Garh (Station TI-00-29 ; after Iannelli ,T. R., 2001)

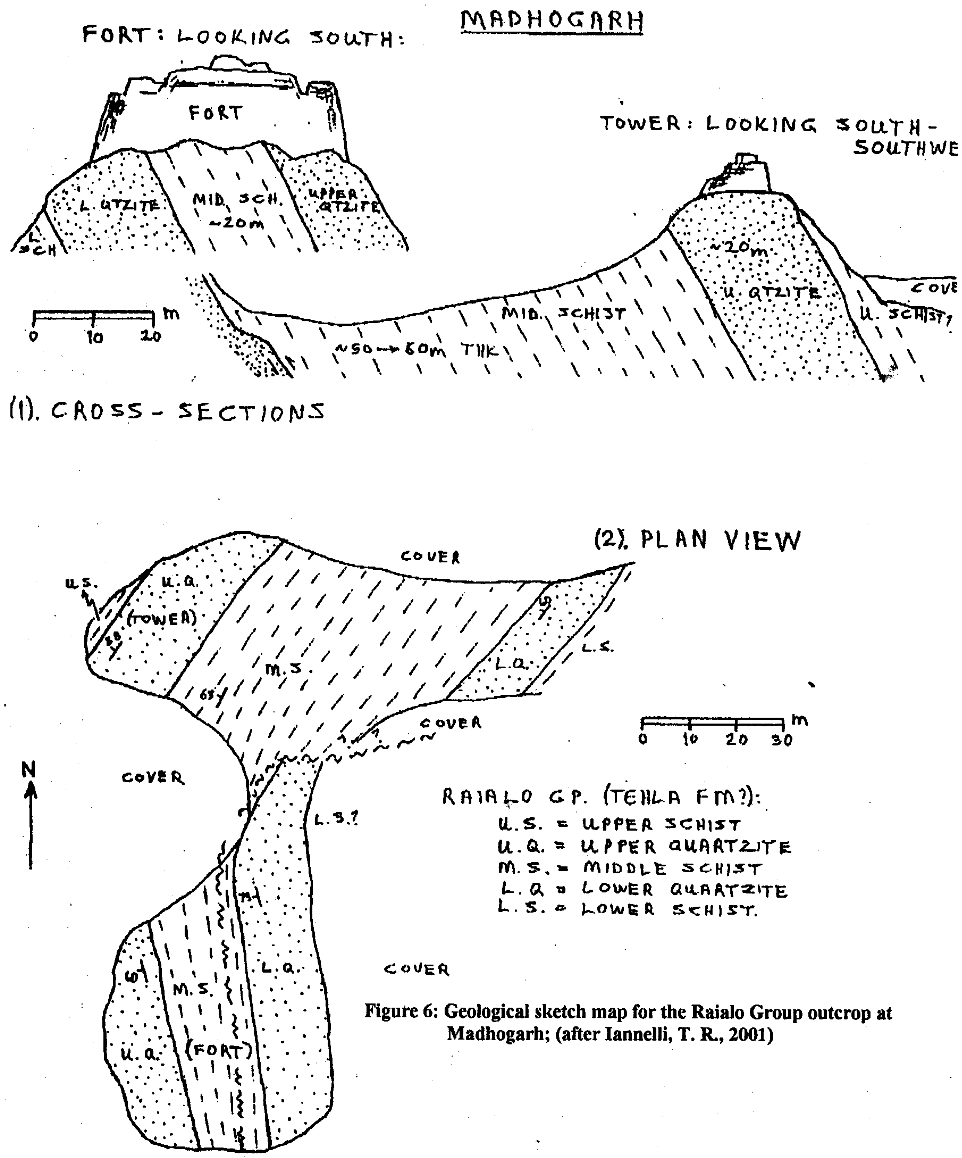


Figure 6: Geological sketch map for the Raialo Group outcrop at Madhogarh; (after Iannelli, T. R., 2001)

change marking the transition from the Dogeta Formation into the Serrate Quartzite Formation. Sedimentary structures include cross-laminations, soft sediment folding and load casts. The intermixed carbonate + sandstone beds are further characterized by the occurrence of bedding subparallel and cross-cutting networks of bright green epidote+biotite+/- magnetite alteration. The stratigraphic succession locally contains up to 3 m thick breccia unit comprised of angular dolomitic marble and dolomitic sandstone intraclasts set within an altered, epidote-bearing matrix (Figure 4).

The dark weathering carbonate + sandstone sequence is overlain by resistant, buff-to pink-gray weathered quartzite (subarkose). This unit resembles quartzite sequences observed in the isolated outcrop ridges exposed south of the Lalgarh Graben. The unit is tentatively assigned to the Serrate Quartzite Formation (Figure 4 & 5,Plate III B, IV A & V A). This quartzite unit is unconformably overlain by Facies A boulder conglomerates (Alwar Group) and is locally missing from the Raialo Group succession. The absence of this unit can be most easily explained by a process in which the Raialo Group succession has been exhumed and eroded down-sequence to varying degrees during Alwar depositional time. The eroded material was subsequently incorporated into the overlying Rajgarh Formation sediment pile.

2.6 ALWAR GROUP

Strata of the Alwar Group are preserved in the Lalgarh, Jaipur – Dogeta, Bayana and Lalsot grabens and attain a maximum thickness of 2500 m to 3300 m. The Alwar Group unconformably overlies the Raialo Group in central parts and along the margins of component graben of the Alwar sub-basin, and overlies pre-Delhi Supergroup rocks along the flanks of the graben (Singh, 1984a, 1988, 1995). The conglomerate-sandstone-siltstone association of the Alwar Group is unconformably overlain by carbonate and siliciclastic strata of the Ajabgarh Group. The group is subdivided into the Rajgarh, Kankwarhi and Pratabgarh Formations in the Alwar sub-basin. The Rajgarh – Kankwarhi succession occurs throughout the sub-basin where it is characterized by considerable variations in overall thickness (i.e. thickness ranges from 10 m to 2800 m).

In Lalgarh Graben the Alwar Group is represented by the Rajgarh and Kankwarhi Formations. The former is subdivided into three "members", each being characterized by a distinct sedimentary facies – Facies A to C (Figure 3 to 5), which outcrop across the middle and southern parts of the graben. Facies D strata comprise the Kankwarhi Formation, and outcrop across the northern portion of Lalgarh Graben (Figure 3; Singh, 1984 a).

2.6.1 Facies A: Boulder Conglomerates

This succession, which ranges up to 1000 m in thickness (Singh, 1984a), was examined in outcrops in the vicinity of Garh and due west of Lalgarh (Figure 3). Facies A boulder conglomerates lie unconformibly over light weathered quartzite of the Serrate Quartzite Formation or upon variably intermixed dark weathering dolomitic sandstone and marble of the Dogeta Formation (Figure 4 & 5; Plate IV A, V A). The contact is an angular disconformity, resulting from down-cutting during deposition of Facies A boulder conglomerates into the underlying Raialo Group sediment pile. The amount of down cutting, as implied from field observations, is on the order of several 10's of metres.

Facies A comprises semi-resistant, buff-brown to pink-gray weathered, oligomictic conglomerate (Plate V A, B). The conglomerate is generally massive, locally crudely stratified and predominantly matrix supported. The clast consists of subrounded to rounded, spheroidal to ovoidal, buff- to pink-gray quartzite pebbles to boulders. The clasts resemble, light weathered quartzites of the Raialo Group (see previous section). They may be largely derived from cannibalization of the upper part of the Raialo succession. The quartzite clasts contain primary bedding and trough crossbeds, range up to 0.6 m x 1.5 m in size, and have long axes oriented sub parallel to the palaeoflow direction. The only other prevalent clast type consists of brown-gray weathered quartzite pebble conglomerate cobbles and boulders (<5%). The matrix ranges from micaceous subarkose to siliceous phyllite. Previous interpretive work concluded that Facies A boulder conglomerates accumulated as thick basin margin alluvial fan and proximal braid plain deposits in a syndepositionally active trough ("Lalgarh graben"; Singh, 1984a, 1995). This initial infill material was derived, in part, from the upper Raialo Group succession that had been uplifted along synsedimentary faults and remobilized into the Lalgarh graben (Singh, 1988, 1995).

Light-weathering quartzite units locally occur within the Facies A succession and appear enveloped by boulder conglomerate (Plate IV A). These resistant, brown- to pink-gray weathered quartzite bodies are up to 60 m in thickness have thin partings and interlenses of Facies A conglomerate and pinch out along strike into the conglomerate. Their origin is not clear and may represent:

(i) Submarine channels deposited during progradation of marginal fans, or

(ii) Olistolith blocks broken off en-masse from the palaeo fault escarpment and dumped into the marginal sediment pile.

The field setting comprises supermature, shallow marine quartzite bodies that are enveloped within immature alluvial fanglomerates. This juxtaposition of incompatible palaeoenvironmental settings would suggest that interpretation # ii is more plausible.

2.6.2 <u>Facies B: Red Conglomerates</u>

Conglomerates of Facies B, which are estimated to exceed 1200 m in thickness (Singh, 1984a), were examined in the vicinity of Garh, Hathipura and Pirthvipura (Figure 3; Plate VI & VII). Facies B strata consist of massive, resistant, unsorted and largely unstratified polymictic pebble to boulder conglomerate. The clast population changes dramatically in both a lateral and vertical sense. Hence, the conglomerate is dominated by different clast suites across the project area. Facies B outcrops comprise resistant dark gray, dark brown to red-gray weathered, clast supported polymictic pebble to boulder conglomerate. Matrix ranges from 5% to 20% in amount and consists of very coarse-grained to granular litharenite. Subordinate lenses or thin beds of very coarse-grained to pebbly arkose to litharenite occur locally. The sandstones comprise <5% of Facies B sequences, are typically < 1 m in thickness, and locally contain small to medium scale trough crossbeds.

The clast population is characterized by the following lithologies:

1. Quartzite: Quartzite clasts are sub-spheroidal to ovoidal in shape, with long axes that range from <5 cm to >40cm in length. They typically weather dark gray, brown- to red-gray, maroon and buff to light-gray, and have a fine-grained to (locally) cherty texture. Quartzite clasts are prevalent in the vicinity of Garh and Pirthvipura (Plate VII). The **mineralized clasts**, found in the Garh area, consist of malachite +chalcocite bearing gray, light gray to red-gray fine-grained quartzite. The mineralized quartzite clasts range from 5 cm x 4 cm up to 25 cm x 50 cm in size (Plate VI B, VII B). Some of the mineralized clasts contain abundant fine-crystalline chalcocite and malachite. However, the distribution of the copper rich clasts is tightly confined to an area 0.5 km x 1 km in size, centered 1 km east-northeast of Garh (Figure 3 and the rock assays are given at Annexure VII).

2. Granite: Granite clasts are coarse-crystalline to porphyritic, spheroidal in shape and up to 0.6 m x 1 m in size. The subrounded to rounded clasts weather pink and buff - to pale-pink in colour. They comprise an important part of the conglomerate clast population in the Garh area (Plate III A). However, porphyritic granite pebbles to boulders dominate in the Hathipura area where they form up to 80% of the clast population (Plate VI A).

3. Carbonate + Dolomitic Sandstone: Carbonate and dolomitic sandstone clasts are semi-recessive, brown to buff-brown weathered, ovoidal to discoidal in shape, and up to 0.4 m x 0.55 m in size (Plate VII A). They comprise dolomitic subarkose to sublitharenite, and sandy dolostone to fine-crystalline dolomitic marble. Carbonate and sandstone pebbles to cobbles form an important part of the clast population at Garh and Hathipura. These clasts are stratigraphically distinctive and most likely have been derived from erosion of the Dogeta Formation of the mid to lower Raialo Group. The Dogeta Formation would have been the youngest carbonate-bearing succession, beneath the Alwar Group, to be remobilized into the Lalgarh Graben.

4. Chert And Banded Iron Formation: Magnetite + chert to hematite + chert banded iron formation, and red to dark-gray weathered chert pebbles to cobbles form a minor but important component of the clast population over most of the facies B outcrop area. Locally however, they occur in appreciable amounts and form a significant portion of the clast population in Rajgarh Formation conglomerate outcrops at Pirthvipura (Plate VII B).

5. Minor Clast Types: Subordinate clast lithologies include:

(i) Brown-gray weathered, tremolitic calc-silicate (Garh area).

(ii) Green-gray weathered, fine-crystalline metadiabase (locally up to 5% in amount in the Garh area).

(iii) Discoidal buff-brown weathered, micaceous siltstone clasts, which occur in notable amounts only in the Pirthvipura area (Plate VII B).

Facies B conglomerates were deposited in marginal alluvial fan to proximal braidplain palaeo-environmental settings, in a deeply subsiding, tectonically active graben (Singh, 1984a, 1988, 1995). The latero-vertical variation in clast size and population provides insight into the following aspects of the depositional history of Rajgarh Formation conglomerates:

1) Stratigraphic Source of Mineralized Clasts: The mineralized quartzite clasts occur associated with appreciable amounts of distinctive buff-brown to brown weathered dolomitic marble, calc-silicate and dolomitic sandstone pebbles to boulders. The carbonate + sandstone clast assemblage has most likely been derived via erosion of the Dogeta Formation. Hence by association, the mineralized quartzite clasts must also have been originally derived from a similar stratigraphic setting (i.e. from siliciclastic sequences in the middle to lower portion of the Raialo Group).

2) Nature of the Mineralized Clast Source Area: The large size of some of the mineralized boulders would imply derivation from a relatively close source area (i.e. a clast source most likely within a few kilometers of the depositional margin of the Lalgarh Graben).

The tight distribution of the mineralized clasts implies:

i) That the original stratigraphic source was of limited extent and there was not a large volume of material to erode into the depositional basin, or

ii) That the source area of the mineralized clasts was of a large scale, but may have been exposed to erosion for only a short period before being buried by an onlap succession of alluvial fanglomerates.

3) Mineralized Quartzite Clasts: The occurrence of mineralized clasts in a sediment pile comprised of remobilized Raialo Group material most likely implies that the mineralization was originally syngenetic or early epigenetic in origin. This conclusion is plausible since the host material was "rapidly" eroded into a tectonically active graben.

4) Latero-vertical Clast Distribution: The latero-vertical distribution of clasts, in conglomerates of Facies A and B, records the gradual exhumation of a considerable portion of the Raialo Group succession and exposure and subsequent reworking of syntectonic granite bodies. The gradual transition in clast type distribution, from Facies A into Facies B conglomerates, records the progressive down section reworking of the Raialo Group.

2.6.3 Facies C: Interbedded Conglomerate And Sandstone

This facies association, which is about 600 m thick and comprises the upper portion of the Rajgarh Formation (Singh, 1984a), was examined in outcrops located northwest and west-southwest of Tekchandpura (Figure 3). The lithologic assemblage consists of light-gray to brown-gray weathered, semi-resistant, massive to poorly stratified polymictic para- to ortho-conglomerate, with subordinate layers and lenses of sandstone ((Plate VIII A).). The sandstone component increases up section from <20%, near the base, to >40% at the top of the Rajgarh Formation succession. T he s andstones consist of planar, thin- to medium-bedded, to trough crossbedded, medium-grained to pebbly arkose + sublitharenite. Facies C strata grade upwards, through a gradual decrease in the conglomerate content, into sandstone-dominated sequences of the Kankwarhi Formation.

The conglomerate clast population is dominated by the occurrence of subrounded to rounded pebbles to cobbles of white quartz (60% to 70%; maximum clast size: 15 cm x 23 cm). Quartz clasts are followed, in order of abundance, by pink feldspar (~10% to 15%), buff- to pink-brown-gray quartzite (~10% to 15%) and a variety of miscellaneous rock types such as granite and basic meta-igneous pebbles (<5%). The clasts are set in a matrix of coarse-grained to granular arkose + litharenite (20% to 60%).

Facies C sequences are typically arranged into conglomerate – sandstone fining-upward cycles (Plate VIII A).). The cycles generally range in thickness from 1-4 m, and consist of massive to poorly stratified, unsorted conglomerate up into intermixed conglomerate + sandstone, which is overlain by planar-bedded to trough-crossbedded sandstone. Cycle bases are characterized by the presence of scouring, while sandstone units contain graded beds and reactivation surfaces. The cycles are superimposed on an overall fining-upward trend in Facies C successions (and in the

Rajgarh Formation in general). The intermixed conglomerate + sandstone facies assemblage accumulated in a proximal to distal braidplain setting, during the waning stages of synsedimentary tectonism in the Lalgarh graben.

2.6.4 Facies D: Sandstones

Facies D strata, which are estimated to exceed 400 m in thickness, were observed in the area ~1.5 km south-southwest of Banskho (Figure 3). They comprise the Kankwarhi Formation (Singh, 1984a). The lowermost part of the formation consists of semi-resistant, brown-pink-gray banded buff-gray weathered, medium- to very coarse-grained subarkose with subordinate, variably intermixed dark gray to pink-brown, quartz + feldspar pebble conglomerate (10% to 15%; conglomerate beds are up to 1 m thick. The pebble component decreases rapidly upwards and the bulk of the upper two-thirds of the formation consists of sandstone. The latter comprises resistant buff-white to pink-gray weathered, subarkose + quartzarenite with subordinate very fine-grained quartzarenite + siltstone. Trough crossbeds (locally up to 1 m thick) are common; sedimentary structures also include cross-laminations, scours, and lenticular bedding. Facies D sequences also contain 1 m to 3 m thick thinning- or shallowing-upward cycles, comprised of trough crossbedded into planar thin bedded to thick laminated sandstone.

Strata of the Kankwarhi Formation ("Facies D") were deposited in an intertidal to shallow subtidal palaeo-environmental setting, during the siliciclastic platform expansion phase in the evolution of Lalgarh graben (Singh S.P 1984a; Iannelli T. R 2001).

2.7 PALAEOCURRENT TRENDS

Palaeocurrent information was recovered from well-exposed trough crossbeds in dolomitic sandstones of the Raialo Group (Plate III B), and in coarse-grained to pebbly litharenite + arkose lenses and layers intermixed with conglomerates of facies B and C of the Alwar Group (Plate VIII A). The long axis orientation of quartzite cobbles and boulders, in the conglomerates of Facies A at stations 5 and 9 also provided useful information (Plate V B). The Palaeocurrent rose diagrams are given at Annexure – II.

Raialo Group – Serrate Quartzite Formation (Garh area; Station TI-00-05): The plotting of trough axes and foreset dip azimuths, of trough crossbeds in dolomitic sandstone, indicated a predominant northwest-directed palaeocurrent trend (i.e. and a southeastern source area).

Alwar Group – Basal Facies A Conglomerate (Garh area; Stations TI-00-05) (N 26° 45' 40.9" E 76° 07' 10"), TI-00-09 (N 26° 45' 48", E 76° 07' 00"): Palaeocurrent information, derived from long axis trends of ovoidal cobbles and boulders, indicated a predominant northeast-directed palaeocurrent trend (i.e. and a southwestern source area).

Alwar Group – Facies B Conglomerate (Hathipura area; Stations TI-00-04 (N 26° 46' 48" E 76° ° 07' 09"), TI-00-17 (N 26° 46' 54" E 76° 07' 12"): Plotting of foreset dip azimuths, of trough crossbeds in litharenite, indicated a northwest- through north-northeast – directed palaeocurrent trend (i.e. and south-eastern to south-southwestern source area).

Alwar Group – Facies C Conglomerate and Sandstone (Tekchandpura area; stations TI-00-24 (N 26° 48' 11" E 76° 09' 13") and TI-00- 25(N 26° 48' 30" E76° 09' 1 9"):Plotting o f t rough a xes a nd f oreset d ip azimuths, of trough crossbeds in arkose + litharenite, indicated a predominant west- and northwest – directed palaeocurrent trend (i.e. and a south to southeast source area).

Conclusion

A synthesis of the above palaeocurrent results (Annexure I), and those of previous work in the project area (Singh, 1984a, 1988), implies that the main sediment source areas for the Rajgarh Formation were located to the east, southeast and south of the preserved outcrops and postulated synsedimentary fault margins of the Lalgarh graben (Figures 2 and 3).

2.8 RIFTING HISTORY

The shortening history of the Aravalli mountains has resulted in large crustal blocks being faulted, folded and tilted on end, offering a unique view deep into rift structures, making it possible to examine the original extensional architecture and stratal geometries of basin sequences. The Lalgarh area is an extremely valuable locality, in that it provides an excellent exposure of the regional unconformity between the Raialo Group and the overlying Alwar Group and allows the rifting history of this sequence boundary to be reconstructed.

The Lalgarh region is characterized by a prominent ridge of E-W striking, N-dipping highly deformed Raialo Group strata, which are overlain by a wedge of poorly stratified, texturally immature polymictic conglomeratic strata of the Alwar Group. Conglomeratic strata thicken abruptly towards the east, against the inferred N-S striking Lalgarh East Fault.

Plate I: Lalgarh area: In the foreground is the uplifted edge of the tilted half graben ; in the background (towards east) is the regional unconformity between the Raialo Group and the overlying Alwar Group-white capping on ridge (after O'Dea, Mark, 2002).

The Lalgarh East Fault is interpreted to be a west-dipping rift fault that was active during the deposition of the conglomerate. Displacement on this fault uplifted Raialo Group footwall rocks to the east and created wedge-shaped accommodation space in its hangingwall to the west.

From south to north the conglomerate undergoes pronounced changes in its fragment composition reflecting the progressive uplift and erosion of different pre-rift footwall source rocks. The southernmost Stage-1 conglomerate package (Facies A: Boulder Conglomerate) consists predominantly of quartzite clasts, as described above. This is overlain to the north by the Stage-2 (Facies B: Red Conglomerate) consisting of fragments of quartzite, carbonate + dolomitic sandstone and banded iron formation. Included in this Stage–2 conglomerate package are the mineralized quartzite clasts.

Stage-3 conglomerates overly this sequence to the north and consist predominantly of granitic clasts, as exposed near Hathipura. While this is stratigraphically the youngest conglomeratic sequence in the Lalgarh area, it must have been derived from the deepest and presumably oldest part of the pre-rift sequence. Thus, there is an inverse relationship between syn-rift stratigraphy and pre-rift stratigraphy, wherein the youngest syn-rift sequence is derived from the oldest pre-rift sequence as the beds are right-way up, as evidenced by cross bedding features.

Plate II: Stage-2 conglomerate (Facies-B, red conglomerate) from the Lalgarh area. Note the predominance of poorly sorted, texturally immature calcareous clasts at this locality. (after O'Dea, Mark, 2002)

The depositional history of the Alwar conglomerate was characterized by a protracted period of rift-related tilting, footwall uplift and erosion and is summarized in Figure .7 in the form of schematic E-W cross-sections. As depicted in this figure, an important geometrical and mechanical consequence of normal faulting in extensional basins is the uplift of the footwall due to tilting of the fault block. When elevated above sea level the uplifted footwall region undergoes erosion leading to the exposure of pre-rift and syn-rift rocks below an angular unconformity.

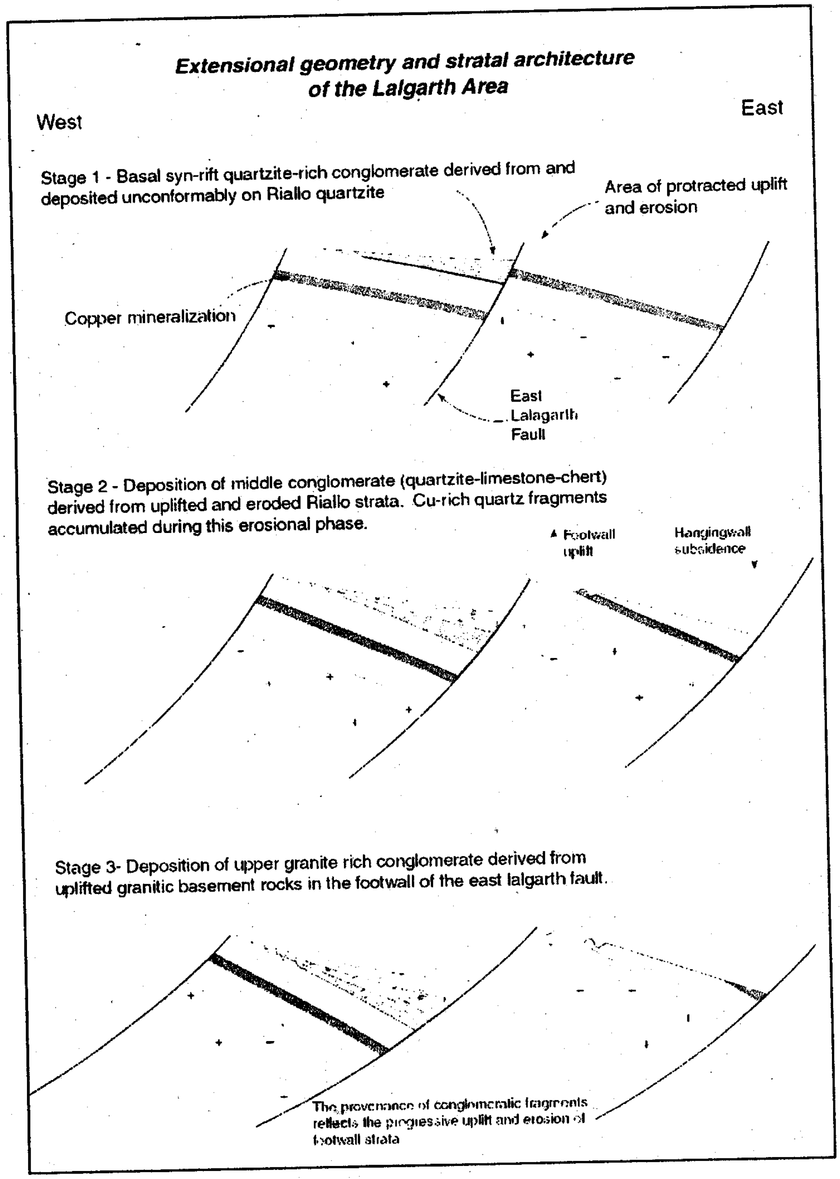


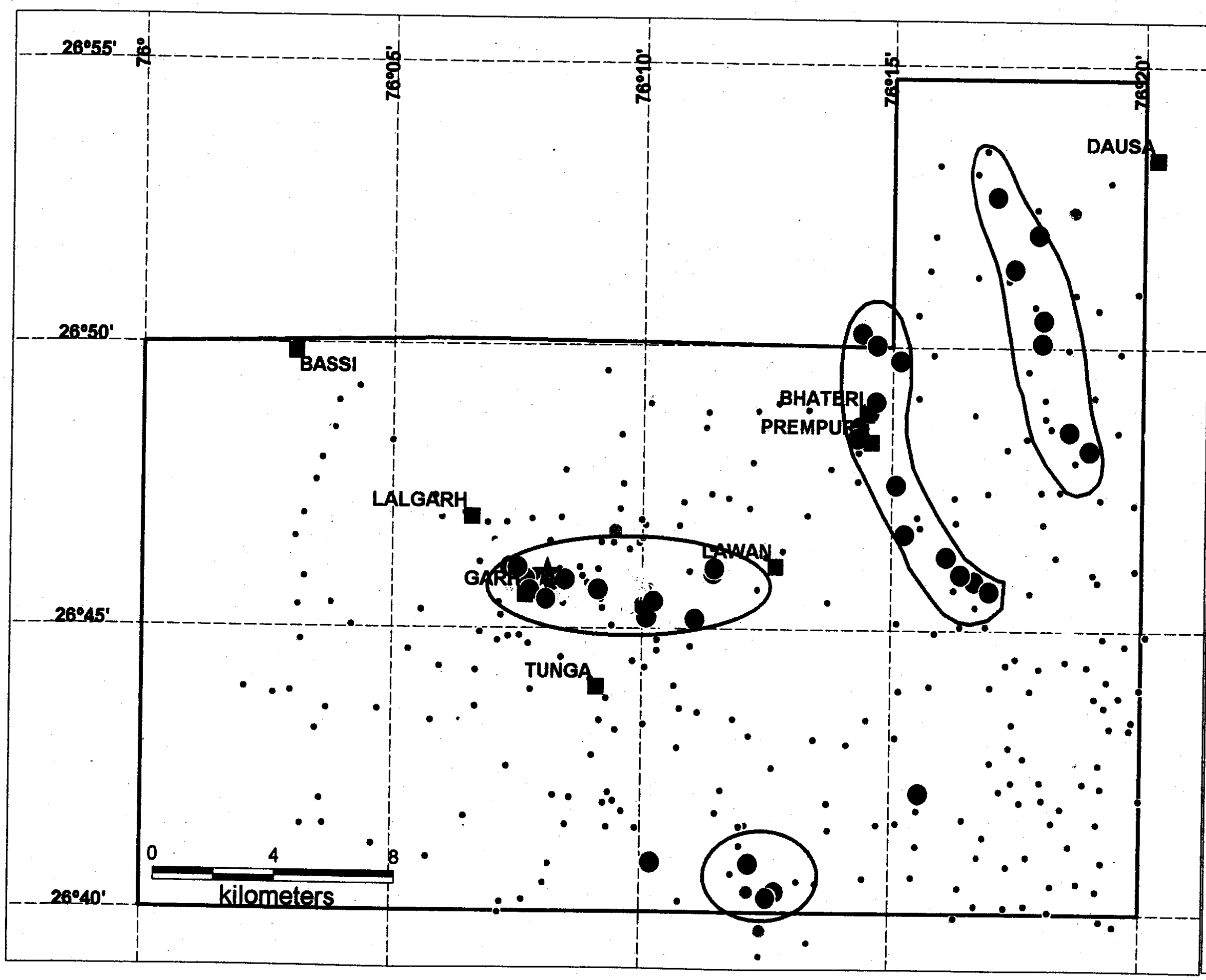
Figure 7 Schematic E-W cross sections across the Lalgarh area depicting the tilt block geometry and accumulation of syn-rift conglomeratic sequences in the hangingwall of the Lalgarh East Fault, (after O'Dea, Mark, 2002).

III. GEOCHEMICAL SURVEY

3.1 WATER WELL SAMPLING

There are only limited outcrops in the Lalgarh RP area, most of the area being covered by alluvium/ sand. However, there are numerous wells, both tubewells and open/ dug wells throughout the area. In the absence of outcrops, in order to try to broadly delineate areas/ zones with elevated copper, the copper content of water in the wells was tested. This was done with the help of portable field test kits.

The water well sampling was done at a reconnaissance distribution level 400-500 m spacing covering almost the entire RP area (Figure: 8). The details of water well sampling and copper values are given at Annexure – II. The survey delineated three areas with anomalous copper values (>1000 ppb) in water. One area is centered around the copper-bearing clasts near Garh, whereas the other two are east of it, around Prempura/ Bhateri (Figure: 8).



PHELPS DODGE-METDIST

LALGARH RP

Figure 8: WATER WELL SAMPLE LOCATION MAP

Cu in Well Water (ppb)

- 990-5000
- 550-990
- 180-550
- 0-180
- Copper bearing clasts
- Geochem Anomaly

IV. GEOPHYSICAL SURVEY

4.1 GROUND MAGNETIC SURVEY

A limited ground magnetic survey was carried out over the geochemical anomaly zone at Prempura. Three lines, Lines 1, 2, and 3 were surveyed in E-W direction. No appreciable anomaly was noted in this area (Annexure – III).

4.2 INDUCED POLARISATION SURVEY

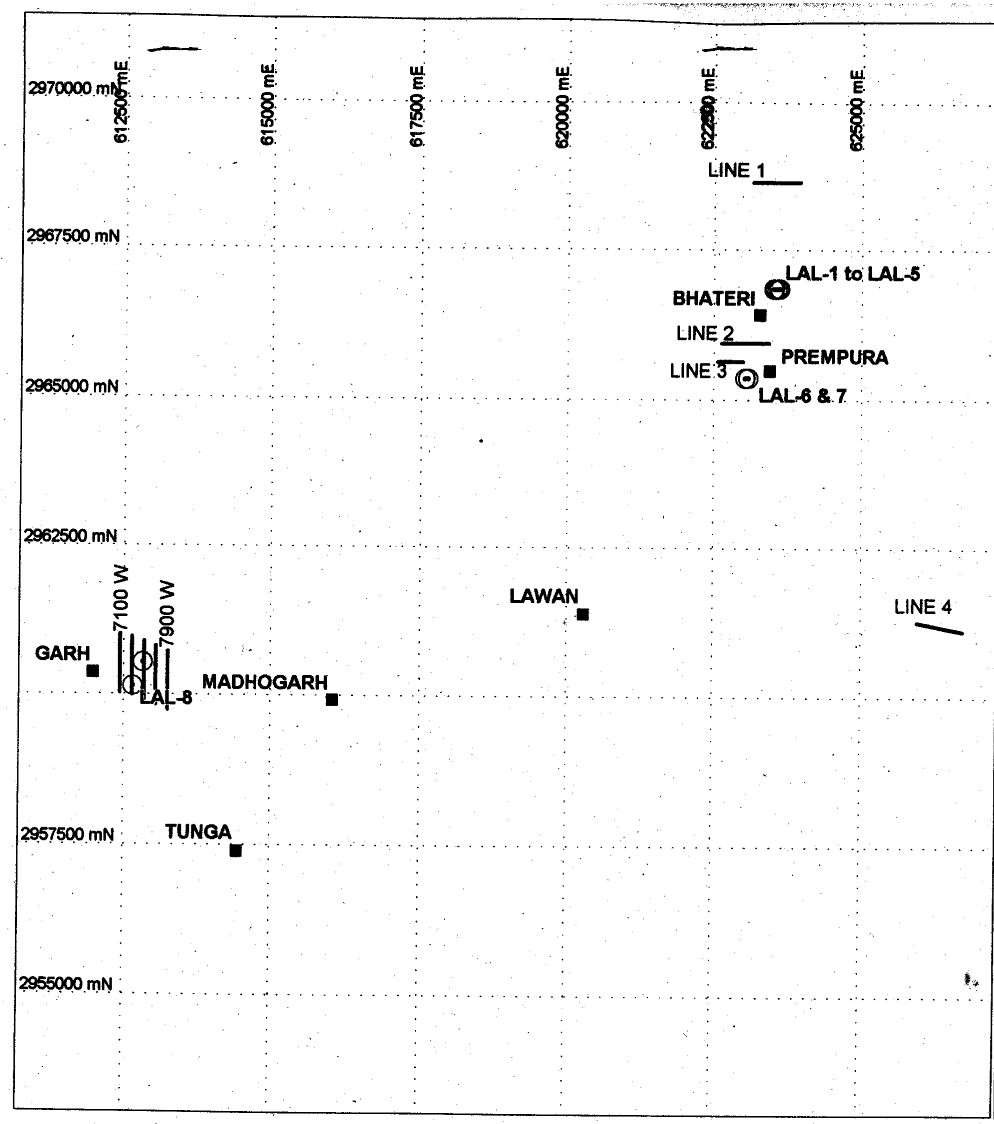
IP survey was carried out over the geochemical anomaly zones at Prempura and Garh, covering a total of 8.0 Line Kms (Table I: and Figure : 9). While the IP survey at Prempura was carried out by Indigeo Consultants, the survey in the Garh area was conducted by Elliott Geophysics International.

4.2.1 Equipment And Survey Configuration

The equipment used for the IP survey was hired from M/S Associated Cement Companies. It is a Zonge system consisting of a GGT-10 (10 KW) multi-purpose transmitter with a 7.5 KW generator set and a Zonge GDP32 multi-purpose receiver. The receiver and transmitter can be synchronised through 5 MHz crystals installed in the GDP32 receiver and the XMT 16 transmitter controller. A Zonge VR1B voltage regulator was used to regulate the 115 V voltage level coming from the generator set. The voltage supply (115 V) is provided as 3 phase 400 Hz AC. A specialised generator set therefore, has to be used with the transmitter to provide this type of power supply.

The IP survey method used was a dipole-dipole IP array (Figure:10). The array employed 100m dipoles for the receiver and transmitter electrodes. The effective sample interval is therefore around 50m at different n-spacings. Readings were taken for n=1 to 6.

A time domain Pulse (2 sec on/2 sec off) was used to provide broadband information. Thirteen time windows were recorded, from 50ms to 1950ms as well as a composite time period referred to as the Newmont normalisation. The composite window is integrated over a time period of 500ms to 1100ms.



PHELPS DODGE-METDIST

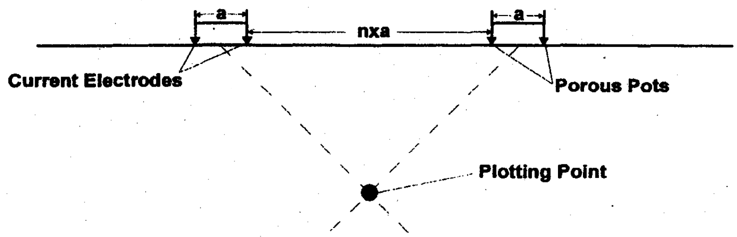
LALGARH RP

Figure 9: LOCATION OF IP-LINES AND PERCUSSION DRILLHOLES

INDEX

IP Line

LAL-1 Percussion Holes



Construction of IP Pseudo-section

Apparent Resistivity= $2 \times \pi \times dV/I \times n(n+1)(n+2)$

n = n-spacing
dV = measured voltage between pots
I = measured current between transmitter electrodes

Figure 10: DIPOLE-DIPOLE IP SURVEY CONFIGURATION

4.2.2 IP Survey in Prempura Area

The IP survey in Prempura/ Bhateri area was conducted along four lines, Line 1 to Line 4 (Figure 9) to test the geochemical anomaly. While Lines 1 to 3 are in the East-West direction, Line-4 is almost East-West. The apparent resistivity and apparent chargeability plots are shown at Figures Annexure–III and the results are summarised in Table I. Due to conductive overburden in the area, no obvious IP anomaly was detected.

4.2.3 IP Survey in Garh Area

The survey in Garh area was planned as a grid based survey, with five north-south lines of 1 Km each, at 200m spacing from 7100W to 7700W (Figure : 9). The survey was designed to locate a possible source to copper rich conglomerate clasts outcropping at the surface, near the northern ends of the survey lines. The IP pseudo-sections are presented at Annexure – IV.

TABLE I: SUMMARY OF I P SURVEY IN LALGARH RP

PREMPURA/ BHATERI AREA

Line	Electrode Spacing	Northing	Easting Start	Easting End	Length (Line Km)	Bearing	Comments
Line - 1	100 m dipole	2968640	623140	623940	0.8	E-W	Horizontal layering in resistivity pseudosection Indicating conductive overburden.
Line - 1	50 m dipole	2968640	623540	623740	0.2	E-W	
Line - 2	100 m dipole	2965940	622630	623430	0.8	E-W	Major cultural effects between 9700 E and 9900 E. Powerlines (running parallel to line), transformer and electric water pumps in this area. Conductive overburden evident at eastern end of line.
Line - 3	100 m dipole	2965635	622558	622958	0.4	E-W	Similar conductive overburden response to other lines.
Line - 4	100 m dipole	2961121	625944	626744	0.8	E-W	Obvious wind blown sand in the western extremity of line. Resistivities increase at the western extremity. The remainder of the line showing similar character to the other lines; cultural effects (Road/pipelines) centred at ~9970 E, characteris-ed by subtle "pantlegs" resistivity anomaly.
				Total :	3.0 Line Kms		

GARH AREA

Line	Electrode Spacing	Easting	Northing Start	Northing End	Length (Line Km)	Bearing	Comments
7100 W	100 m dipole	612445	2960020	2961020	1	N-S	The dominating feature on each of the sections is a deep resistive (>1000 ohm-m) and weakly chargeable (<20 msec) zone about the centre of each line.
7300 W	100 m dipole	612645	2959980	2960980	1	N-S	
7500 W	100 m dipole	612845	2959905	2960905	1	N-S	
7700 W	100 m dipole	613045	2959825	2960825	1	N-S	
7900 W	100 m dipole	613245	2959738	2960735	1	N-S	
				Total :	5.0 Line Kms		

The dominating feature on each of the section is a deep resistive (>1000 ohm-m) and weakly chargeable (>20 msec) zone about the centre of each line. The centre line for this grid, line 7500W, was modelled to try to estimate the thickness of alluvial sediments overlying weakly chargeable bedrock. The model section (Annexure–IV, Page 64), displays two IP features at southern (36 msec) and northern (14 msec) ends of the line, that extends down to weakly chargeable bedrock (<17 msec). The alluvial sediment thickness, estimated from the model, is approximately 150m. The IP response of the bottom layer suggests weakly chargeable bedrock as being the main source at depth. The anomaly at the southern end of the line is the strongest.

V. DRILLING

5.1 PERCUSSION DRILLING

Percussion drilling, by employing local water well drill rigs, was carried out to test the geochem + weak IP anomaly at Garh and the geochemical anomaly at Prempura/ Bhateri. A total of 9 vertical Percussion Holes, aggregating 679m drilling was carried out, as summarised in the Table II below:

Table II: Summary of Percussion Drilling at Lalgarh

PREMPURA AREA			
Drill Hole No.	**Location (WGS 84)**		**Depth (Metre)**
	Northing	Easting	
LG - 1	2966832	623595	64.00
LG - 2	2966832	623620	68.60
LG - 3	2966832	623570	64.00
LG - 4	2966832	623545	62.50
LG - 5	2966832	623520	61.00
LG - 6	2965351	623042	70.75
LG - 7	2965351	623093	68.60
GARH AREA			
LG - 8	2959985	612748	150.91
LG - 9	2960260	612918	68.60
			Total: 678.96m

5.2 DRILLING IN THE PREMPURA AREA

7 vertical percussion holes, LG-1 to LG-7 were drilled in the Prempura/ Bhateri area. Holes LG-1 to LG-5 near Bhateri were drilled along a east-west line at 25m to 75m spacing across the geochemical anomaly zone. Holes LG-6 and LG-7 were drilled near Prempura at 50m spacing to test the geochemical anomaly zone. Quartz-biotite±muscovite-amphibolite schist was encountered in all the holes and the assays returned insignificant copper values (Annexure –V)

5.3 DRILLING IN THE GARH AREA

As the IP survey indicated two features, one each at the southern and northern ends, two vertical percussion holes, LG-8 and LG-9 were drilled to test the same. While LG-8 was closed in quartzite, LG-9 was closed in limestone with marble bands. The summarised lithologs are given at Annexure –VI. As no copper mineralisation was intersected in these holes, no further drilling was undertaken in the area.

CONCLUSIONS

A study of the palaeocurrent trends in the project area supports that of previous workers (Singh, S.P.1984a, 1988). It implies that the main sediment source areas for the Rajgarh Formation were located to the east, southeast and south of the preserved outcrops and postulated synsedimentary fault margins of the Lalgarh graben.

The water well geochem sampling delineated three anomalous areas, one centered around the copper bearing clasts near Garh and the other two about 8 km. east of it, around Prempura/Bhateri. The IP Survey at Prempura/Bhateri indicates that the target area is overlain by surficial conductors, either wet clays or perhaps salty groundwater, due to which this method was not effective. However, IP survey in the Garh area indicated a weak chargeability zone.

Detailed reconnaissance studies, including percussion drilling, have failed to locate the palaeosource for the observed copper bearing clasts in the red conglomerates near Garh. It may be concluded that either the original stratigraphic source was of limited extent and there was not a large volume of material to erode into the depositional basin or that the source area of the mineralized clasts was of a large scale but may have been exposed for only a short period before being buried by an onlap succession of alluvial fanglomerates.