HYDROGEOLOGY OF EASTERN PART OF JHARIA COALFIELD, INDIA

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ABSTRACT

The Jharia coal basin, the major source of metallurgical coal in India, is a part of East-West trending intracratonic basin in eastern India. Little is known about the hydrogeology of the ground water system around underground coal mines. This paper outlines the results of a research programme carried out during the period 1980-85 to develop the hydrogeological studies in the Jharia Coalfield. Water table in weathered zone aquifer is observed to fluctuate cyclically with seasons and suggest that shallow ground water flow system is unexpected in the mines 15m below the surface. Porosity and permeability are influenced by a number of petrological factors. The acquifer characteristics obtained by the pumping tests are very low and these formations are classified as poor aquifers. The relatively small volumes of water reported from the mines is directly related to poor hydraulic conductivity of the rocks associated with the coal. The locations of water leakages observed from the underground mines and the structural features are showing the same trend, which gives an evidence of the importance of the structural discontinuities in groundwater flow.

The compositions of water in the eastern part of Jharia Coalfield reflects the effects of chemical processes occuring between the minerals within the lithologic frame work. The pH is alkaline in the northern-edge and becomes slightly acidic towards the centre of the block, where the pH is alkaline, sulfate of water is low. The specific conductance of the water trend to reflect the sulfate concentration of the mine water. This is believed toresult from the sulfate bondeing more than the iron ions in an oxidising environment. Thus the sulfate ions remain in solution and is reflected in the specific conductance readings.

INTRODUCTION

Mines in the Jharia coalfield have been developed over a century before for the exploration of the coal resources occuring in the formations and consequently the geology, physico-chemical properties, rank characteristics and utilisation potentialities have been studied extensively but not the hydrogeology. The review of work indicates there remains ample scope for the systematic investigations and scientific research on the various hydrogeological and hydrogeochemical aspects of the coal mining in the Jharia coalfield, involving a number of problems including

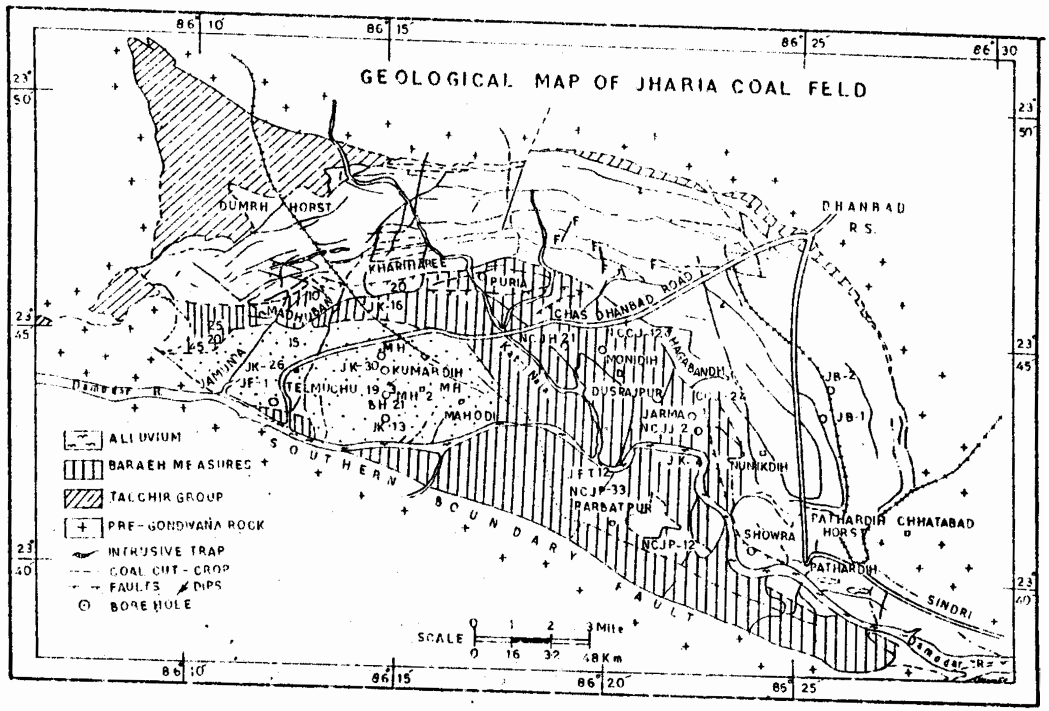
GEOLOGICAL MAP OF JHARIA COAL FELD
DUMRH HORST
KHARIHAREE
PURIA
MADHUBAN
CHAS DHANBAD ROAD
DHANBAD R.S.
MONIDIH
KUMARDIH
TELMUCHU
MAHODI
DUSRAJPUR
JARMA
NUNIKDIH
PARBATPUR
SHOWRA
PATHARDIH HORST
CHHATABAD
PATHARDIH
SINDRI
JAMUNIA
Damodar R.
SOUTHERN BOUNDARY FAULT
ALLUVIUM
BARAEH MEASURES
TALCHIR GROUP
PRE-GONDWANA ROCK
INTRUSIVE TRAP
COAL CUT-CROP
FAULTS
DIPS
BORE HOLE
SCALE
0 1 2 3 Mile
0 16 32 48 Km

Fig.1.

the collection of data and field observations and to cope up with this gigantic task of multidisciplinary approach, a part of Jharia coalfield was taken up particularly Mukunda and Bhagaband blocks in the eastern part for detailed investigations.

The present paper aims at an integrated study of the tectonic and hydrogeology deciphered from a large volume of surface and sub-surface data (CMPDIL,1980).

REGIONAL SETTING

The tectonic history of Jharia coal basin involves the initiation of the basin by general downwarping of the basin floor, its early differentiation into a number of sub-basins, later merging of these sub-basins into a single major narrow intra-basinal graben bounded by contemporaneous normal faulting, followed by post-depositional faulting and finally intrusion of dolerites and lamprophyres. (Ahmad and Ahmad 1979, Ghosh and Mukhopadhyay 1985).

[Fig.1]

The Damodar river is the principal controlling drainage of the area in an easterly direction and is a perennial river. The drainage of this field with tributory draining area for Damodar is defined by Chotkari Jore, emerging from the north of the area, and the Tisra Jore and Surunga Jore are two tributaries in the eastern part.

The coalfield is surrounded by metamorphic rocks represented by gneisses, quartzites, mica-schist and amphibolites. The basin has an oval outcrop and the overall dip of the strata (5 to 10°) is towards the basin centre. The broad structure is that of a large scale elongate doubly plunging open syncline or an elongate structural basin. There are number of smaller domes and basins within the larger structure. These are also very open and somewhat elongate and trending E-W parallel to the major basin (Fig.1).

MUKUNDA BLOCK

The Mukunda block area is entirely covered by the Barakars and is overlain by thin layers of sandy soil and clay. The rocks of the Barakar formation consists of pebbly sandstones, grits, fine to coarse grained sand stone, siltstones, fireclays, shales, carbonaceous shales and coal seams. The maximum thickness of the Barakar as encountered in the boreholeNo.LJ/2 has been found to be about 600m. The coal, non-coal strata ratio is 1:4.6 within the area (CEMPDIL Report 1980). The thickness of the soil and weathered zone together varies 1 to 10m. A generalised sequence of coal seams and the intervening parting and a general lithology is shown in Fig.2. A number of basic dykes are observed in the colliery workings of the area. The strike of the formation is generally NNW-SSE to N-S covering the major part of the block. The bedding dip 4 to 12° due to WSW-West and North respectively. The gradient of the seam is steeper nearly 40° because of the proximity of the area to the major faults.

[Fig.2]

The area traversed by 17 faults with throw varying up to 70 m including 5 underground faults with variable throw ranging up to 5 m. It will be observed from Fig.2 faults trending NW-SE ranging in throw from 5 to 15 m. belonging to this category. These faults are mostly located in the central part of the block. Two major faults trending EW and ranging in throw from 20 to 90 m are of this category. The occurence of these faults is characterised by steeply dipping beds in the near vicinity.

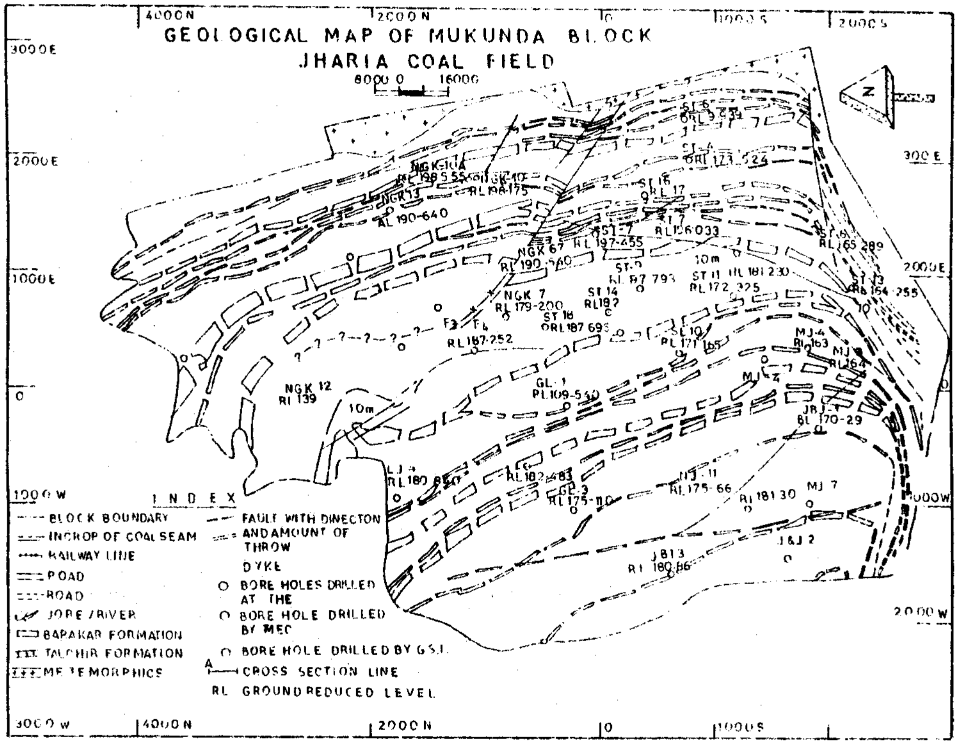
GEOLOGICAL MAP OF MUKUNDA BLOCK
JHARIA COAL FIELD
4000 N
2000 N
3000 E
2000 E
1000 E
300 E
2000 E
1000 W
2000 W
3000 w
INDEX
BLOCK BOUNDARY
INCROP OF COAL SEAM
RAILWAY LINE
ROAD
JORE / RIVER
BARAKAR FORMATION
TALCHIR FORMATION
FAULT WITH DIRECTON AND AMOUNT OF THROW
DYKE
BORE HOLES DRILLED AT THE
BORE HOLE DRILLED BY MEC
BORE HOLE DRILLED BY G.S.I.
CROSS SECTION LINE
RL GROUND REDUCED LEVEL

Fig.2.

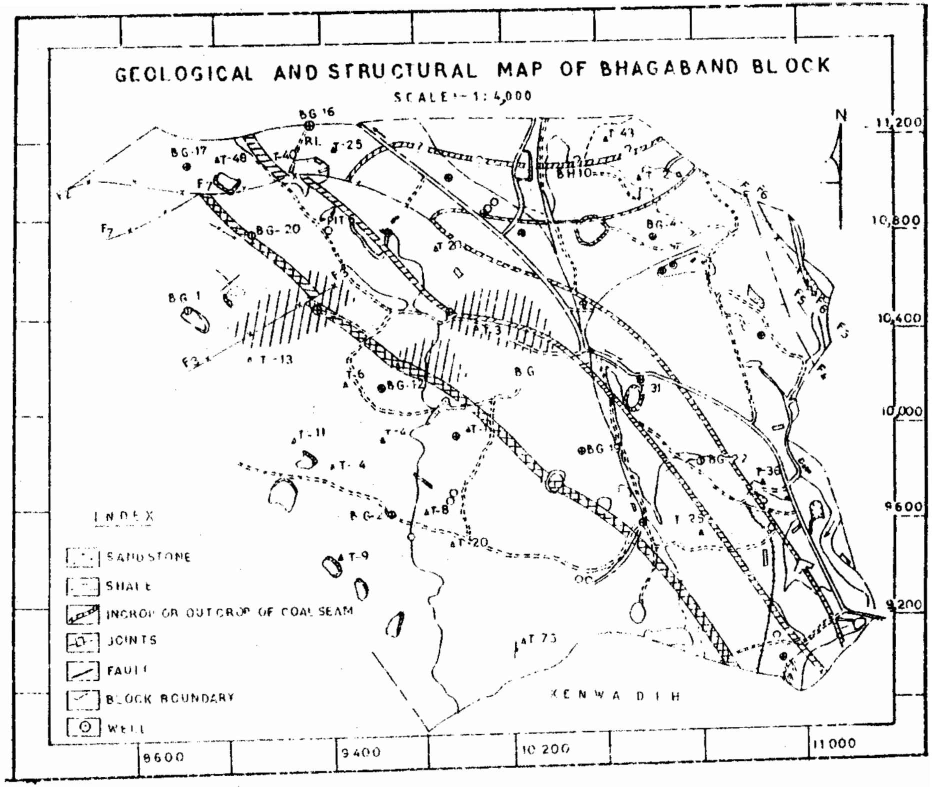
GEOLOGICAL AND STRUCTURAL MAP OF BHAGABAND BLOCK
SCALE :- 1: 4,000
N
INDEX
SANDSTONE
SHALE
INCROP OR OUTCROP OF COAL SEAM
JOINTS
FAULT
BLOCK BOUNDARY
WELL
KENWADIH
11,200
10,800
10,400
10,000
9600
9200
8600
9400
10 200
11000

Fig.3.

BHAGABAND BLOCK

The Bhagaband block is covered by 1.0-1.5 m thick alluvium and sandy soil. This is followed by a zone of weathered Barakars, down to a maximum of about 13 m. Subvertical jointing is seen and the dips 30-40° show reversal from northeasterly to southeasterly direction. The bore-hole data reveals the presence of faults with varying throws. There are eight faults having throw of more than 35m (Fig.3). It has not been possible to identify faults with small throws.

[Fig.3]

HYDROGEOLOGY

The information about the hydrogeology was obtained by conducting and observations during test borings and by examination of core samples and also by repeated measurements of water levels in the open dug wells in different seasons. The test bores made to the depth of the coal seam and the boring that encountered voids provided information on water conditions in the mines. Bore hole data collected from the various organisations such as Geological Survey of India, Mineral Exploration Corporation Ltd and Central Mine Planning & Design Institute have been of great help.

WATER LEVEL FLUCTUATIONS:

The mean annual rainfall in the Jharia coalfield is 1260 mm. It is estimated that 45% of the rainfall generate a run off of 5.2 million cubic meters per year. During the post monsoon season in October 1980, the streams have been found to be practically dry at the point of entry in the area showed that the 45% runoff from the mean annual rainfall i.e. 5.2 million cubic meters per year would enter the eastern part of Jharia coalfield. Water levels were measured for 48 dug wells in May and September months of 1981 and Dec 1980. The depth of the wells varies from 4 to 13 meters. Water table in this area is observed to fluctuate with seasons and suggest that the shallow ground water flow system is unexpected by the mining engineers 15 meters below the surface. Water level measurements were recorded month wise in the year 1981 for the well nos. 3,17,21.29 and 40 and the fluctuations are shown in Fig.4 representing the Lodna, Tisra and Bhulanbararee collieries. In general the water level fluctuations varies from 0.5 to 8.80 m. Water table contour maps are prepared for different seasons show the non-existance respond to underground mining. The field observations, suggest that wells situated in the fractured zone are dry.

[Fig.4]

AQUIFER PARAMETERS

Five bore holes drilled were subjected to a short period for pumping tests. These bore holes are located in Tisra Colliery (NGK 10 and10A) and Lodna colliery HMJ_1 and HMJ_2 and another bore hole at Bhalgora shaft. A summary of the maximum rate of pumping for each bore hole transmissivity, saturated aquifer thickness penetrated, permeability and storage coefficient is given in Table 1.

WATER FLOW THROUGH FRACTURES, JOINTS, FAULTS,SHEAR ZONES AND DYKES

A variety of structural features have been mapped which have a profound influence on stability and waterflux. Structural features mapped include joints, faults, dykes and related features. The vertical joints or steeply dipping fractures show no indication of movement. They are present every where in the Barakar

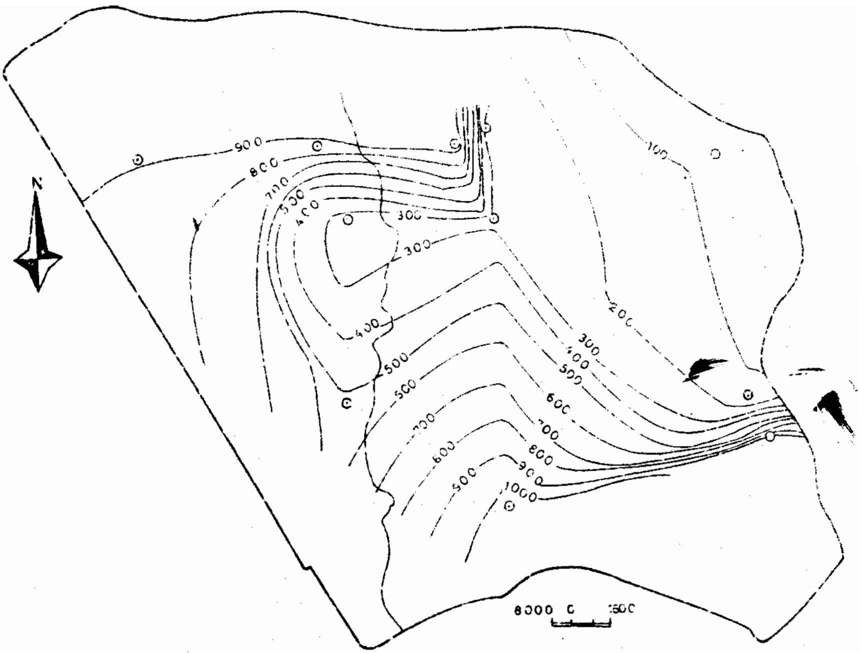

FIG.4a ISO SPECIFIC CONDUCTANCE MAP - CONCENTRATION INTERVAL 100 ppm BHAGABAND BLOCK.

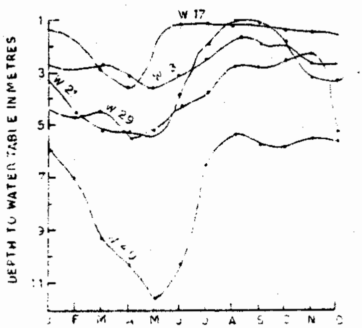

FIG.4b WATER LEVEL FLUCTUATIONS FOR WELLS 3, 17, 21, 29 AND 40

FIG.4

sand stone and shale and are locally very prominent in the Bhagaband Block and Tisra Collieries. Fault and shear zones are promising locations and are indicated by alignment of drainage courses and by other geological features. According to Larson (1972) rocks that are involved in tectonic deformation the open mass of the fractures can, in most cases be related to tension or shear phenomena. The tension fractures may be more open and hence may be more suitable for water leakages than shear fractures. Moreover in multilayered rocks, the more competent beds may be severely fractured, as is evident along the dykes, where the water seepage occurs.

Open joints which occur in the mine roof are probably the result of mining activity. There are vertical fractures with a narrow opening in the coal and roof rock. Small faults also occur in various areas throughout the mines. Unlike ordinary joints, the intensity and spacing of open joints and faults are uneffected by roof rock type. They are very prominent in the sandstone. Their occurence is quite localised. Water flows into the mine along some open joints and faults are clearly seen in the field investigations.

Igneous dykes and peridotite dykes often intercept rock formations associated with heavily watered horizons. Saturated cavities and consequently feeders of water may be encountered, if the mining operations are carried out in their proximity. This has been observed along the dykes where the draining of water is more into the mine. (Lodna, Jayarampur and Bhagaband Collieries).

WATER QUALITY

48 water samples were collected from the open wells, 13 samples were collected from the underground mine sumps and goaf areas in Mukunda block and 11 samples were collected from the open wells in the Bhagaband block. The chemical analysis data of Mukunda and Bhagaband blocks was plotted on trilinear piper diagram, (Hem 1959) both for open wells and mine water. The well water in Mukunda block have been classified into (1) Alkaline earths exceed alkalies, (2) Alkalies exceed alkaline earths, (3) weak acids exceed strong acids, (4) strong acids exceed weak acids, (5) non-carbonate hardness exceed 50 percent, (6) no one of the cation and anion pairs exceed 50 percent. The mine waters are classified (1) carbonate hardness or secondary alkalinity of the water exceed 50% (2) non-carbonate hardness exceed 50 percent, (3) strong acids exceed weak acids (4) alkalies exceed alkaline earths. Whereas in the Bhagaband block, the well waters are showing similarity of the Mukunda block well water.

The iso concentration maps for well waters in Mukunda and Bhagaband blocks represented in Fig.4-6 and provides an interesting aspect of the water chemistry in the area. The pH is alkaline in the northern part and becomes slightly acidic towards the centre of the block, where the pH is alkaline and sulfate content of water is low. As the pH drops from neutral to acidic the elemental concentration in the water increases. The specific conductance of the water tends to reflect the sulfate concentration of the mine water. This is believed to result from the sulfate ion being more stable than the iron ions in an oxidising environment, where the pH ranges from 6 to 8. Thus the sulfate ions remain in solution and are reflected in the specific conductance reading.

[Fig.5]

Both the surface and mine water samples analysed in the Mukunda block have similar composition except their Na, Ca, Mg ratios may differ. Using this parameter we have two groups of samples, one group contains surface waters from northern portion and southern portion of the area which is enriched in Na. This group has also a higher TDS than other. An exploration of this enrichment

Table 1 Aquifer Parameters

Sl. No.	Test location	Lithology of the aquifer zone tested	Horiz[...] Depth ra[...]ge in m
1	North Tisra Borehole No NGKIO	Coarse Medium grained sst in between Seams III and IVB	13.34 to 43.04 wi[...] shale intercalation
2	North Tisra Borehole No NGKIOA	Coarse Medium grained sst in between Seams III and IVB	13.2 to 42.0 with shale and carbonaceus shale intercala tion
3	Lodna Near Borehole No GI9 Borehole No HMJ2	Medium to fine grained sst between seams VIII & IX/X	136-142
4	Lodna Near Borehole No	Medium to corse grai-	20.3-205.[...]

FIG.5.b WATER TABLE [illegible]
MUKUNDA BLOCK.

FIG. 5

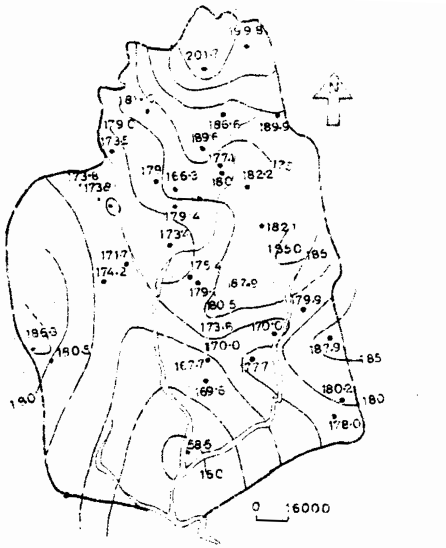

FIG.5.a WATER TABLE CONTOUR IN DECEMBER 1980 MUKUNDA BLOCK.

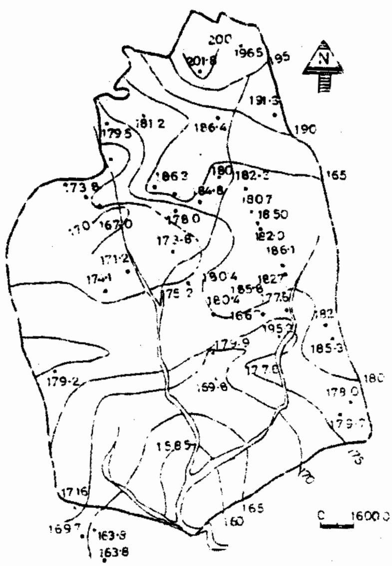

FIG.5.b WATER TABLE CONTOUR MAY 1981 MUKUNDA BLOCK.

FIG. 5

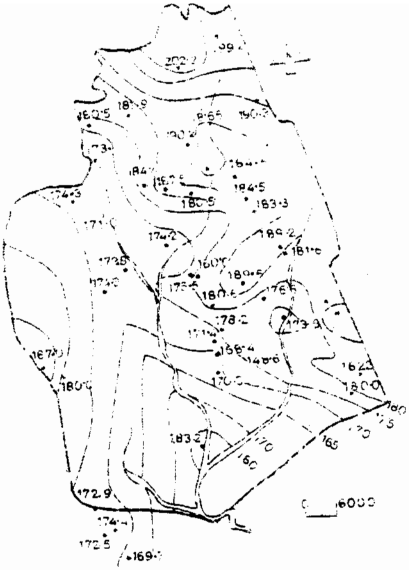

FIG.6.a WATER TABLE CONTOUR IN SEPTEMBER 1981
MUKUNDA BLOCK.

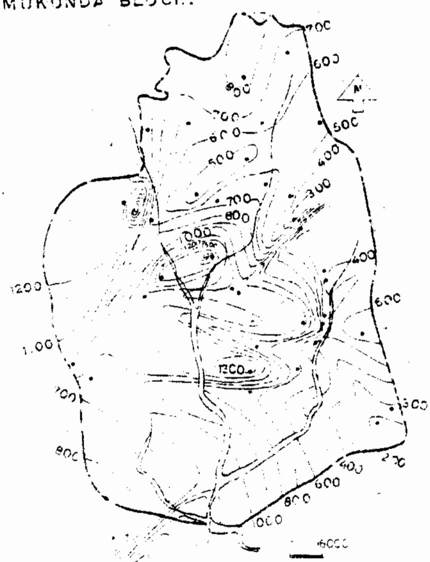

FIG.6.b ISO-SPECIFIC CONDUCTANCE MAP CONCENTRATION
INTERVAL 100 µ MHOS /Cms MUKUNDA BLOCK

FIG. 6

is based on the relative solubilities of sodium sulfates. The second group of water in which Mg is greater than Ca include both surface and ground waters from the other parts of the mine area, which are very similar in composition to spoil water. Thus the ground water has reached a composition similar to spoil water by surface infiltration and percolation through a representative section of overburden prior to mining. Consequently, admixture of this unconfined ground water with spoil water will result in minor and negligible changes (Sankaranarayana, I. 1986) (Fig.6).

CONCLUSIONS

The steeply dipping overburden includes several sandstone aquifers separated by aquitardal layers that limit vertical ground water flow. Season wise water level observations and water table maps show the shallow ground water aquifer (weathered zone aquifer) are not affected by underground mining. The water levels in the shallow aquifer are disturbed only in the vicinity of fractures and fault zones. Inthis aquifer, water levels are responsed to seasonal precipitation. The main hydraulic connection between a deep underground mine and shallow aquifer is through fractures, joints and fault zones. This is evidenced by the huge amount of water discharged from the underground mine sumps and goaf areas filled with water. Water seepage in the eastern part is mainly through tension fractures and in the more competent beds through severely fractured and mainly along the dykes. Increased water danger is apparent where mine workings approach or encounter faults parallel to the face line or faults which had old workings and also faults of considerable throw.

Water samples analysed from both surface and underground mines areas have similar composition except their Na, Ca and Mg ratios. By using this parameter two groups of samples result, one group contains surface waters from northern portion and southern portion of the area which is enriched in sodium. The second group of water in which Mg is greater than Ca includes both surface and ground waters from the other parts of the mine area.

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