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Ground Water Management in Jhamarkotra Mines

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Abstract :Mining by its nature is an activity where progress is made by adopting safe, economic and environment friendly path. This is possible only by understanding different natural phenomenon operating in and around the mining area. These phenomenons can be related either to stresses existing in the earth's crust or to behaviour of ground water regime. Mining operations planned and implemented on the basis of such studies make them safe, economic and environment friendly so that they benefit the mankind and posterity.

Jhamarkotra mine known for Phosphate mining is located 26 km southwest of Udaipur city in Aravali hills is made up of meta-sedimentary rocks. Mining activities in Jhamarkotra mine is facing problem due to presence of groundwater in phosphate bearing dolomitic limestone rock. In the present study, source and flow path of groundwater has been identified using multidisciplinary approach using hydrogeological investigations, remote sensing techniques, isotopic studies, and resistivity survey. To control groundwater in mining area, sites for new tube wells are suggested to withdraw groundwater and to lower the water level in mine area.

Keywords: Groundwater, Flow direction, Isotopes, Rock phosphate, Jhamarkotra mines

INTRODUCTION

With the advent of modern excavation technologies, the surface mining operation has increased both in physical size and efficiency. The availability of new and improved machinery has led to a vast increase in the economic depth of extraction possible. The extent to which this is occurring is exemplified by the fact that surface mining operations are frequently exploiting the near surface mineral deposits which were previously worked underground mining.

The increase in the possible economic working depth has resulted in surface mine workings extending well below the water table. Consequently, groundwater and, occasionally surface runoff have become factors for major concern. Surface mine excavations in India are generally quite shallow, but with new technologies the mining activity extends below the water table.

Where surface mines are excavated into aquifer materials, they clearly remove part of the aquifer, which in itself may represent a loss of resource (e.g. increased loss due to evaporation) or at least an increase in vulnerability for the surrounding aquifer.

Besides these obvious impacts, most other effects of surface mines on natural hydrogeology are rather subtle. A "halo" of increased permeability (e" 100 times greater than background values) can develop around open-pit walls, due to extensional fracturing induced by blasting and the reduction of lateral stresses.

The source of inflow to a surface mine may be (i) inflow from precipitation and percolation through the backfill which forms its own water table, (ii) inflow through geological / structural features, (iii) inflow from mineral beds and underground aquifers, (iv) transmission via disused / abandoned mine workings, and (v) inflow pit floor heave and/or piping (Ngah, 1984). Therefore, to design a dewater plan for an open cast mine, it is important to understand the source of water.

Jhamarkotra rock phosphate mine is the largest open cast mine in India and practically the only commercially exploitable deposit of rock phosphate in India. It has the greatest potential of the rock phosphate than any other mine in the India. Rajasthan State Mines and Minerals Limited (RSMML) are mining rock phosphate from this mine since 1968. The mine has an estimated reserve of 80 million tons of the rock phosphate. However, the deposit is highly disturbed by the folding and faulting of the beds during early Proterozoic origin called the Aravali-Delhi Origin (Roy et. al., 1980). Nevertheless, growing techniques of excavation are making it possible to continue the mining at present and also in future.

Earlier workers (Chaudhary, 2002; Kulkarni et al 1998) have tried to understand the problem of water ingress into mine from different point of views. The present study was focused to identify the source of groundwater, direction of flow and to suggest groundwater management plan for Jhamarkotra mines, so that mining activities can continue for excavation of precious mineral resource.

STUDYAREA

Jhamarkotra mine is located 26 km. southeast of Udaipur city and falls in the Girwa block of Udaipur district (Fig.1). The mine, covering a total area of about 18.44 km2, is divided into 11 blocks, namely A, A-extension, B, C, D, E, F, G, H, I and J (Ground Water Department Report, 1991). Topographically the area is comprised of highly undulating Aravali hills. Structurally, the area forms antiformal and synformal basins having rock phosphate deposits which have attained the heights of 480 to 600 m above MSL.

The area is drained by two major tributaries of Jhamari River which are ephemeral in nature. The rivers flow from NW to SE. The area can be divided into three sub basins developing to the extent of 4th order streams.

The area has a semi-arid type of climate with mean annual temperature of 25°C however the annual temperature varies from 15°C in January to 35°C in May. The normal monsoon rainfall for last 26 years is 548.10 mm and the average monsoon rainfall for last 5 years is 525 mm. The non monsoon rainfall is about 32.5 mm.

Rock phosphate occurs in cavernous dolomitic limestone and it is present as a thin bed dipping at an angle of 45° to 55° to the horizontal. The top surface level is about 600 m above MSL and mine working has gone to a depth of 190 m i.e. up to 410 m above MSL. Further, RSMML plans to excavate the deposit up to 350 m above MSL. Ground water level contours indicate that present water level in the mining area is about 405 m above MSL and the ground water flow direction is from NW to SE. As the water level is very near to the bottom of the mining pit, it is not possible to excavate to further depth unless the water table is lowered. Fractures and solution cavities provide paths for movements of ground water in the rock phosphate bearing dolomitic limestone and under the present condition of water level the mine is facing the threat of closure. Therefore, it is the need of the hour to lower the water table in the mine area in order to facilitate safe mining.

The major problem that mining activity is facing from time to time is the ingress of groundwater in the mining pit mainly in the 'D' and 'E' block. The geometry of the ore body (i.e. thin and steeply dipping) had resulted in long and narrow pits with great depth extension, which involves very high stripping ratio with high lead and lift for waste and mineral. It has been estimated that the aquifer in the mining area has a potential of 35 million cubic meter static water. So in order to keep working levels dry tube wells are installed around the periphery of the pit. However, the path of ingress of groundwater is under investigation.

The top surface level in the mine area was about 600 m above mean sea level (MSL) and mine working has gone to a depth of up to 405 m and 425 m above MSL in D & E block respectively. Further, RSMM Ltd. plans to excavate the deposit up to 320 m above MSL. Groundwater level

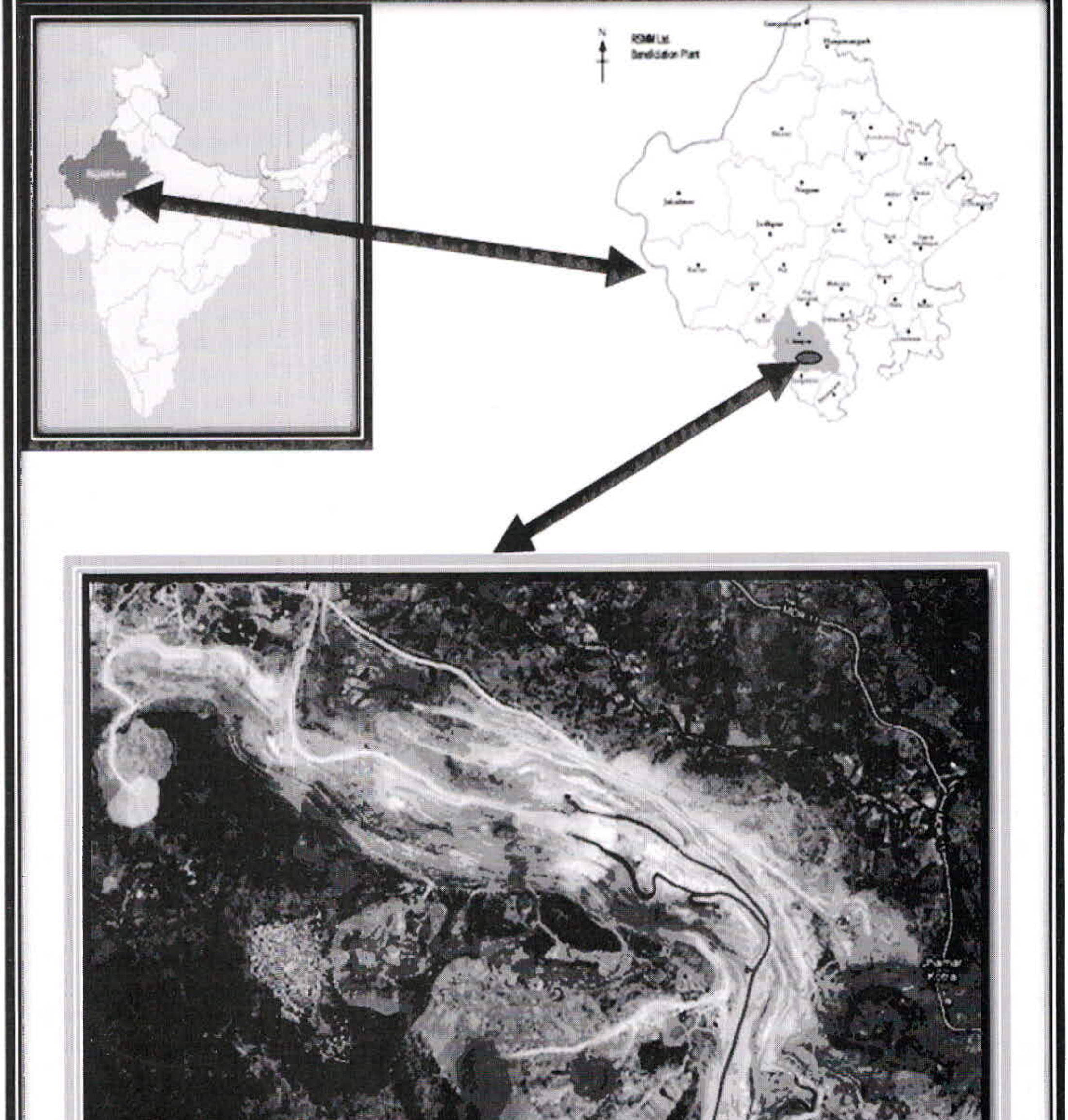

Fig.1. Location of the study area

contours indicate that present water level in the mining area is about 402 m and 421m above MSL (for D & E block respectively) and the groundwater flow direction is from NW to SE. As the water level is very near to the bottom of the mining pit, it is not possible to excavate to further depth unless the water table is lowered. The fractures and solution cavities within the dolomitic limestones provide paths for the movement of the groundwater and under the present condition of water level, the mine is facing the threat of closure.

In the area around Jhamarkotra mines, metasedimentary rocks belonging to the Aravalli Group lie unconformably over a basement of gneisses and granites (Heron, 1953). The rock phosphate horizon outcrops near the base of the Aravalli rocks. The banded gneisses are the oldest rock unit in the area (Fig.2).

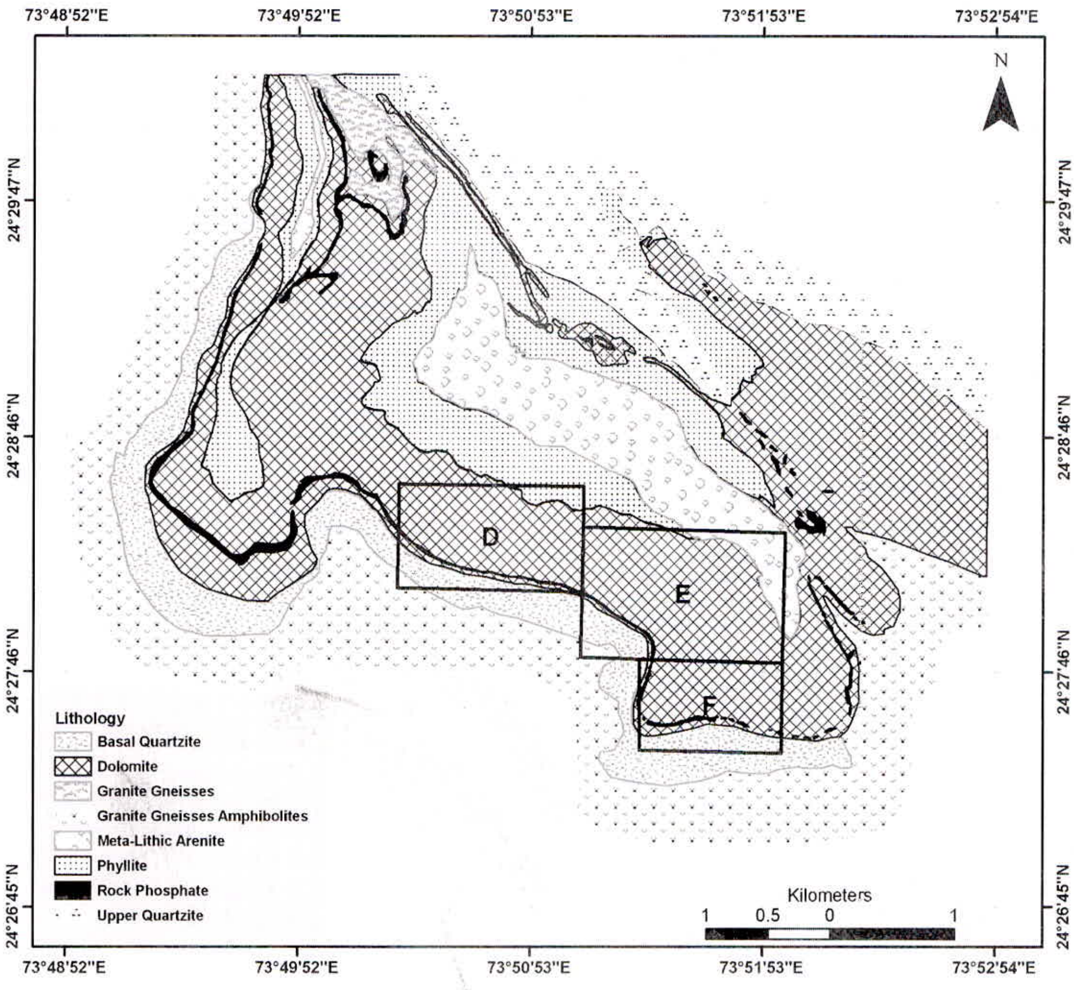

Fig.2. Geological map of Jhamarkotra Mines

METHODOLOGY

A multi disciplinary approach has been adopted for the study which includes Geological, Geophysical, Remote Sensing and GIS and Isotopic Approach. The study and extraction of mining area has been done by remote sensing and GIS approach. Isotopic characteristics (age of groundwater and their source at different locations) of surface and groundwater were determined to demarcate the recharge and discharge characteristics. The groundwater flow direction in and around mine area was ascertained using groundwater contours and resistivity survey.

RESULTS AND DISCUSSION

Groundwater condition in Mine area

Inside and around the mine area, groundwater occurs under confined to semi confined conditions in dolomitic limestone, the main aquifer that is characterized by the presence of solution cavities of varying dimensions at various depths and is fresh in quality. Groundwater flow direction in the mines was observed to be from North-West to South-East. The water level in the D-block used to be higher than the E-block. Now, the water level in the E-block is observed to be higher than in the D-block (Fig.3).

Identification of source of water

Groundwater in any area can be due to recharge from rainfall or any surface water body or it may be the paleowater which might have been recharged in the past. The source of groundwater can be ascertained using properties of the atoms and their isotopes that constitute the molecule of water, i.e., oxygen and hydrogen. The source of groundwater in the mine has been determined by analyzing the stable isotope of oxygen and hydrogen in the waters of the area.

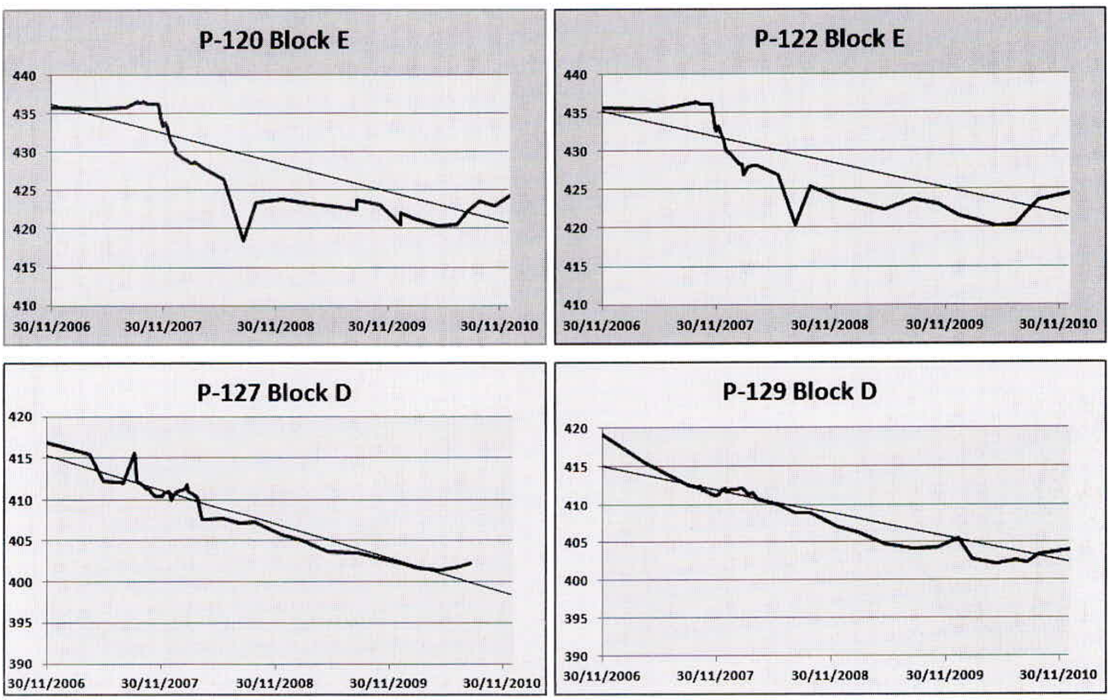

Fig.3. GW table trends in Jhamarkotra mines

Kulkarni et al. (1998) carried out isotopic investigations to determine the source of water to the mining pit and concluded that the nearby lakes may not be source of groundwater.

Groundwater samples were collected from the mine and the surrounding areas during the months of Feb'10, Aug'10 and Jan'11. The precipitation samples were also collected from the study area during that period. The samples were analysed for δD and $\delta^{18}O$, and plot of δD v/s $\delta^{18}O$ is shown below in figure 4:

To find the source of groundwater in the pumped water from the mines, the isotopic signatures of precipitation, surface water bodies and groundwater were plotted. The isotopic signatures of the precipitation almost follow the Global Meteoric Water Line (GMWL). The groundwater samples also lie very close to GMWL, indicating its origin from the precipitation. The surface water samples lie away from the line indicating evaporation effect.

Groundwater Flow Direction

To find out the groundwater flow direction in the Jhamarkotra mines, resistivity survey has been conducted using ABEM Terrameter SAS 4000.

The resistivity survey that has been carried out in the 'D' and 'E' block of the mines during June

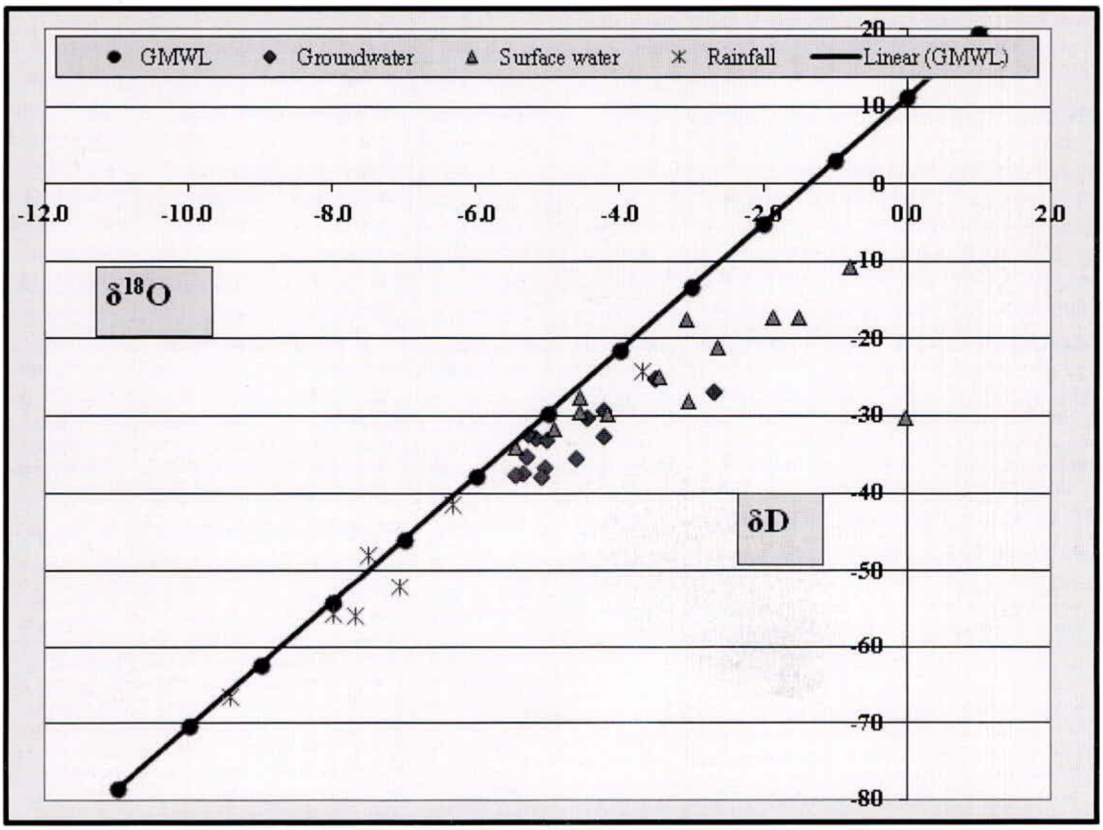

Fig.4. δD v/s $\delta^{18}O$ of groundwater Jhamarkotra Mines

2011 has revealed that ground water ingress at the current depth in the mining pit is due to the presence of faults and fractures at the junction of these two blocks. The location of the points is given in figure 5.

The overall result of the field survey shows that the ingress of the groundwater to the 'D' block is from ENE direction to WSW direction at depth of 2 to 13m from 430 m MSL. However the overall flow direction is from NW to SE in the Jhamarkotra area. This local flow may be because of unloading of overburden or blasting activity or both. So under consideration of the resistivity data, for effective dewatering of the ground water it is suggested to install tube wells at locations 1,2,3 and 4 in the north eastern part around the periphery of the pit. The resistivity points and the preferred locations for the installation of new three tube wells are shown in the figure 6 and 7.

CONCLUSION

The present study has been carried out with the objective of identification of source of groundwater in blocks D and E of Jhamarkotra

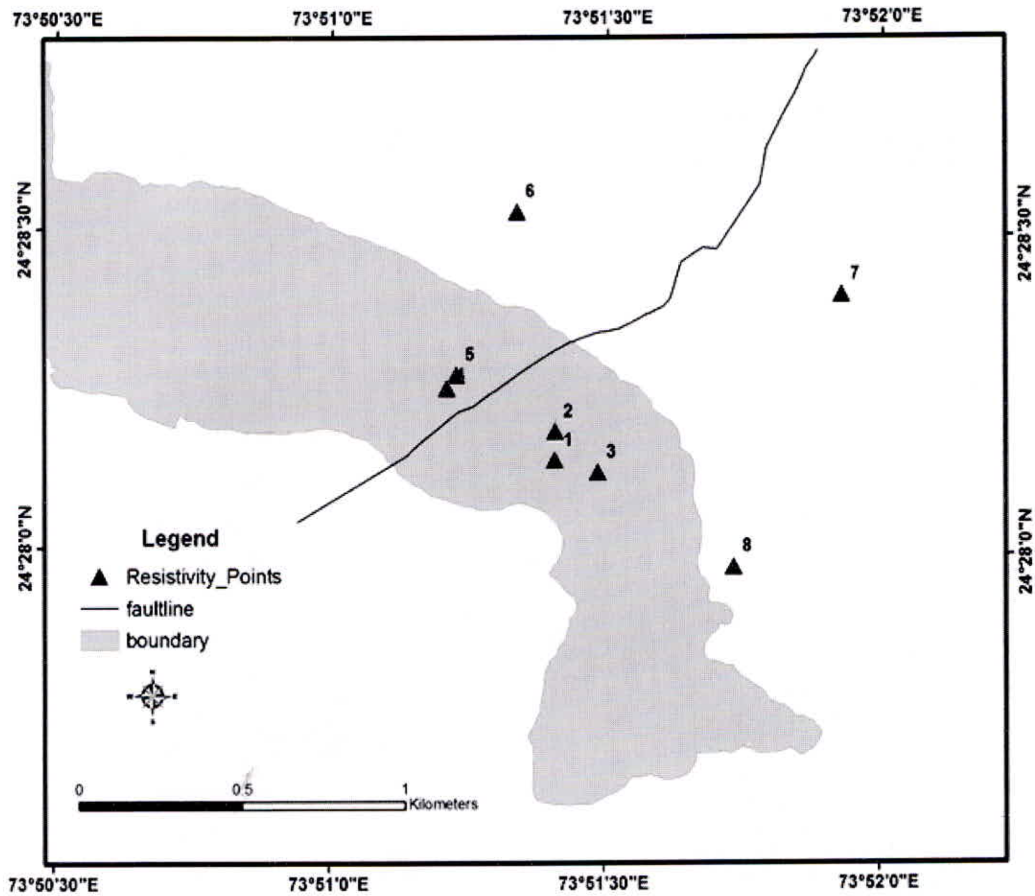

Fig.5. Location of the points (Resistivity survey)

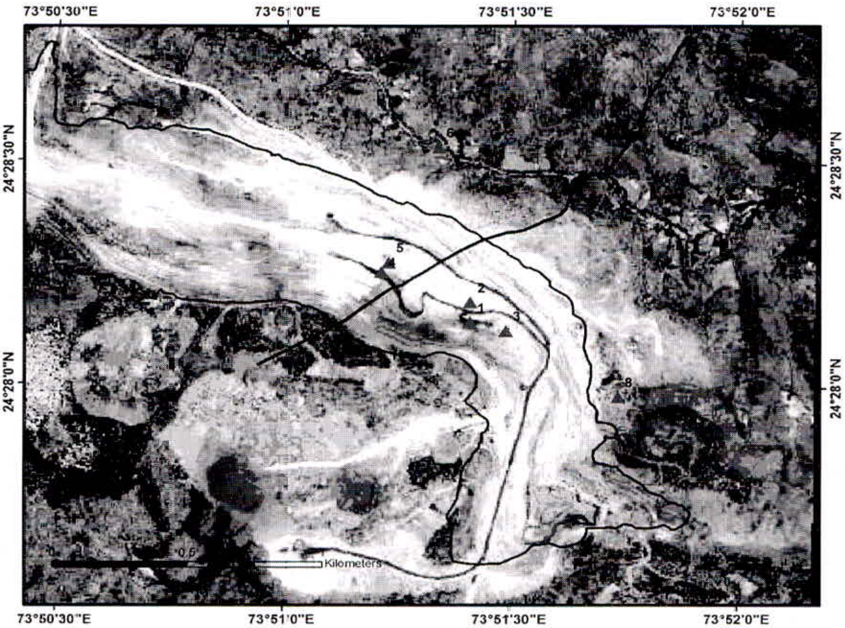

Fig.6. Resistivity survey points and possible flow direction

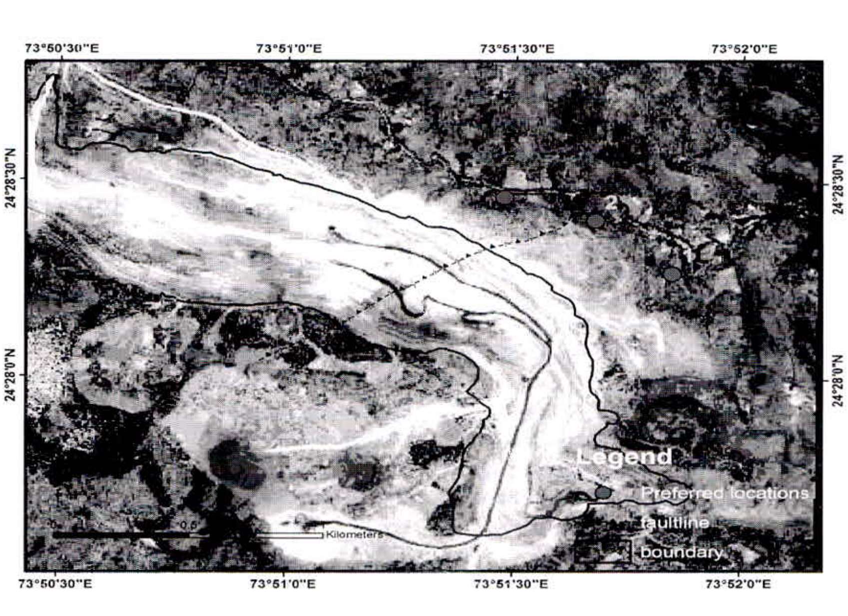

Fig.7. Preferred Locations of four new tube wells

mines and the complete future dewatering scheme to achieve a desirable drawdown. Also the study is aimed at suggesting measures for protection of groundwater quality in nearby wells. The characteristics of groundwater samples collected from mine area were close to GMWL, indicates its origin from the precipitation. As the ingress of groundwater to the D block is from ENE direction to the WSW direction, it is suggested to install 3 tube wells in the north eastern part around the periphery of the pit for effective dewatering.

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