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SOURCE OF SEEPAGE IN THE SUDAMDIH MINE AREA USING ENVIRONMENTAL ISOTOPES, BIHAR, INDIA

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ABSTRACT

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The Sudamdih mine area situated in the Jharia coal fields of Bihar, India, has several old workings that have been abandoned due to waterlogging. During the development of several horizons in recent years heavy seepage of water was noted. An attempt has been made to find out the hydraulic link of the seepage water with one or more of the nearby water bodies, i.e. the Damodar River, a surface pond, groundwater etc. Preliminary study based on environmental isotopes, of tritium and oxygen-18, shows that most of the seepage water is probably derived from local groundwater.

INTRODUCTION

The origin of water occurring in mines is of interest to mining hydrology for both safety and economic aspects. The main aim of the present work was to determine the hydraulic connections in the case of the Sudamdih mine area in India where several workings have already been abandoned due to waterlogging. The investigations were performed with the aid of environmental isotopes.

DESCRIPTION OF THE AREA

The Sudamdih mine area is situated in the southeastern part of the Jharia coal field, about 25 km from Dhanbad town in Bihar (India). The Jharia coal field has an elliptical shape with an area of about 450 km^2 (about 38 km east–west and 20 km north–south) and contains 18 coal seams of the Barakar Stage. Sudamdih is one of the most difficult mines in this coal field because of its peculiar coal geology. The area is bordered by the great Patherdih horst to the north and lies close to a great fault running along the southern side of the Damodar River. The mining area extends about 1 km from the northern bank of the Damodar River. The average surface gradient is slightly steeper on the northern side of the river than the southern side. Topographic elevation is about 245 m near the railway station of Dhanbad. The average annual rainfall in this area is about 1260 mm.

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The mining area is pitted with many abandoned old workings, which are presently waterlogged. Even among many mineable coal seams in several horizons there is a persistent problem of water percolation. At certain places the percolation is noted to be seasonal. The present study was undertaken to delineate the source of this heavy percolation from among several possibilities, such as the Damodar River, groundwater, surface pond, or even the waterlogged old mines.

The Jharia coal field consists of two predominant rock formations: the basement Archaean gneisses; and Permo-Carboniferous and lower Mesozoic sediments, comprising the Gondwana system. There is a great stratigraphic unconformity between them (Fox, 1930). The lower Gondwanas consist of the Talchir, Damuda and Panchet series. The Damuda series is further subdivided into the Barakar stage, barren measures and the Ranigunj stages. The present study area is underlain by the Damuda series and Barakar stages.

The post-Gondwana earth movements are manifested in the field by the presence of a large number of vertical, subvertical and cross faults with EWE, WE and NE–SW trends in the lower Gondwana Formation (Fig. 1).

The Sudamdih study area occurs in the Barakar stage, having 18 coal seams. Roman numerals designate the seams in ascending order from bottom to top. The present study includes coal beds V–XVIII; strike is east–west and dip is about 25° towards south (Fig. 1). At present coal is being extracted from three seams: VIII-A, IX/X and XI/XII; from horizons at 200, 300 and 400 m depth.

Groundwater in this area occurs under unconfined conditions in weathered, jointed and fractured zones. The saturated rock masses are usually tapped by open wells. The depth of the water table varies from 1.3 to as much as 20 m below ground level and generally conforms to the topography with the groundwater flow following the general slope of the land surface (Dutt and Mukherjee, 1977). However, the number of observation wells is rather small and the available data are too sparse to give a distinct picture of the postmonsoon rise of the water table in different parts of the area. All the perennial streams in the area are effluent in character (Bhattacharya, 1984).

The present problem in the Sudamdih active mine area in the VIII-A and XI/XII seams of the east lateral is heavy percolation of water. During 1984 the rate of percolation increased by factors of two to three, during September to November at certain locations, resulting in total stoppage of mining activity. If the source of the seepage water could be identified, attempts to stop the percolation could perhaps be made. Therefore, isotopic investigations were undertaken to trace the percolation water to one or more of the nearby bodies, namely, abandoned workings, the Damodar River, surface pond or groundwater bodies.

METHODS AND SAMPLES

The isotope concentration of tritium (radioactive isotope of hydrogen) and oxygen-18 (stable) were measured in water samples taken from the abandoned

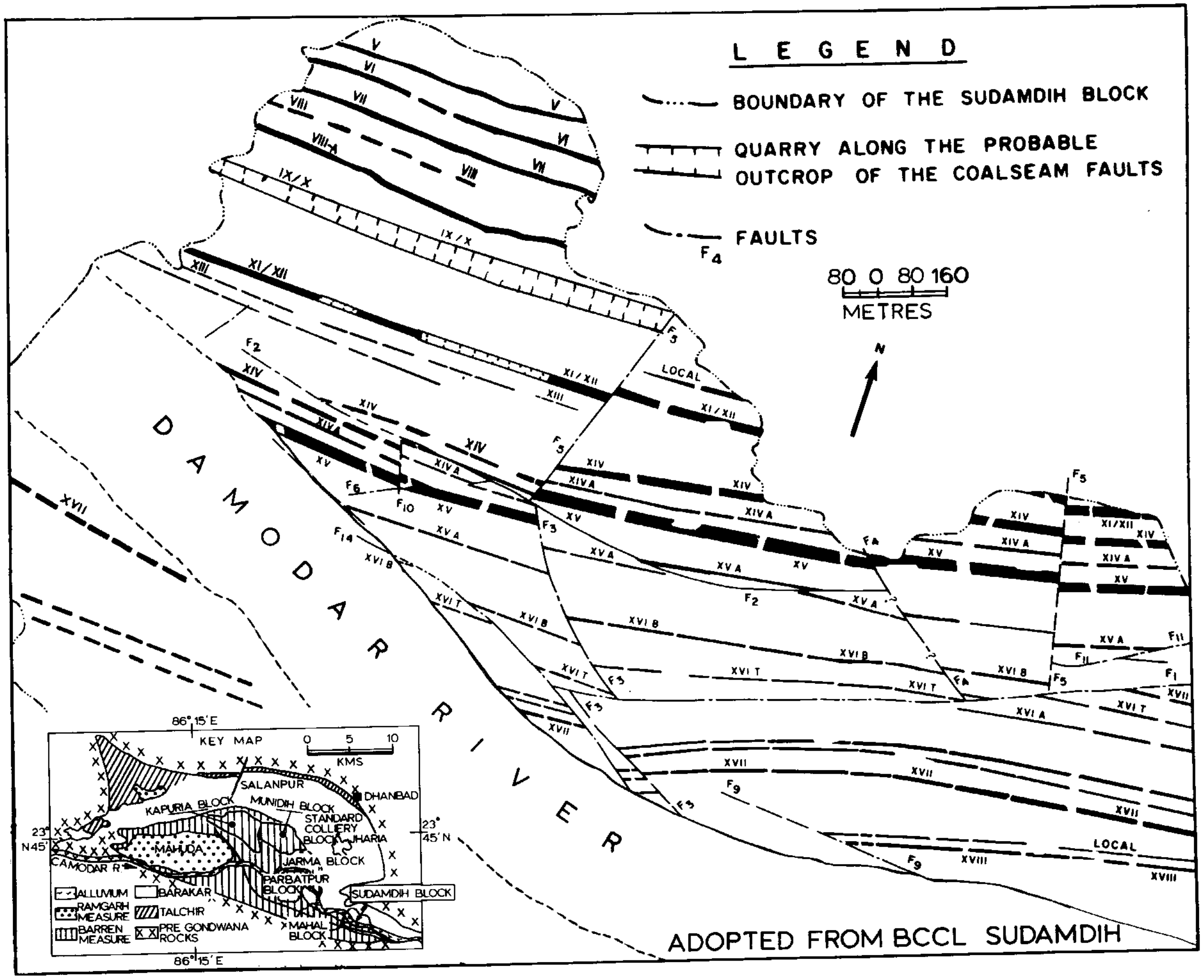

Fig. 1. Plan showing probable outcrops of coal seams and faults, Sudamdih area, Jharia coal field.

mines, a surface pond, the Damodar River and groundwater. Attempts were made to correlate these sources with isotope concentrations of seepage water in active mines.

Tritium concentration in present day precipitation is of the order of 20–30 TU (one tritium unit equals one atom of tritium (^3H) per 10^{18} atoms of hydrogen (^1H). Depending upon the turnover time, or the "age", tritium concentration of mine water is lowered by an appropriate amount. Rapid connection, if any, between the possible sources and seepage areas will be indicated by almost identical tritium concentration in both. In the case of oxygen-18, each of the possible surface water sources is characterised by its own oxygen-18 content and similarity of the oxygen-18 content can be used to infer possible hydraulic linkage.

About twentyfive water samples were collected for tritium and oxygen-18 measurements (Fig. 2). Three samples from old abandoned mines representing XIV-A, XIV and XV seams and one sample each from a nearby pond, groundwater (shallow well and a deep "old shaft" well) and the Damodar River were taken twice during 1984 and 1986. Two rainwater samples were also collected during 1986. Ten samples from underground active mines were collected, representing the VIII-A, IX/X and XI/XII seams, at the 200, 300 and 400 m horizons. Three samples were collected from the Patherdih colliery located near the study area. 500 and 100 ml water samples for tritium and oxygen-18 analysis, respectively, were collected and stored in glass bottles with double-lid sealing.

For tritium measurements, water samples were converted to methane, purified and measured (Athavale et al., 1967) by gas proportional counters at NGRI, Hyderabad. Oxygen-18 measurements were carried out at PRL, Ahmedabad by a modified version of the standard Epstein–Mayeda technique (Bhattacharya et al., 1985) using a VG Micromass 602D CO_2 machine.

RESULTS AND DISCUSSION

Table 1 shows the results of tritium and oxygen-18 measurements. Two of the abandoned mines (samples 11, 13) have high tritium concentrations (19 and 48 TU) which are close to the values expected in the last few years' precipitation. Similarly, tritium concentrations in surface pond water, and river water range between 15 and 26 TU. Shallow groundwater has a tritium concentration of 25 TU (sample 16.1), whereas deep groundwater (sample 16.2, old shaft about 100 m deep) has a tritium content of about 5 TU. However, almost all the samples in seepage waters from active mines have negligible tritium, which indicates that the turnover time of the waters is at least of the order of three decades. Therefore, the high contrast between the tritium values of the seepage water and the other suspected source water rules out the possibility of fast connection between the two.

The oxygen-18 concentrations (expressed as ‰ deviation from standard mean ocean water) in the abandoned mine water samples cluster around −7.5

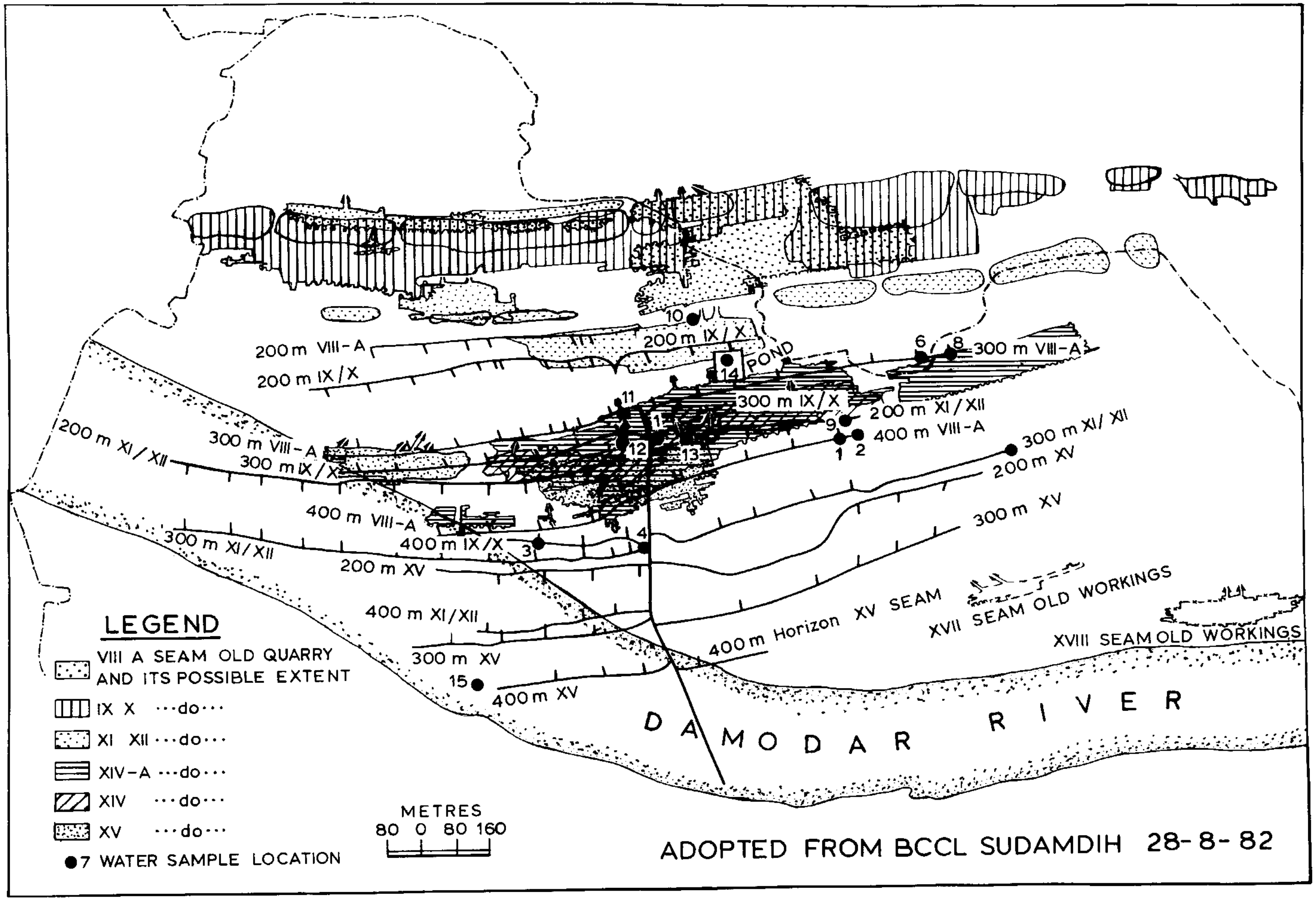

Fig. 2. Sample location map for environmental isotope study in the Sudamdih shaft mine area.

TABLE 1

Tritium (TU) and ^{18}O contents in water samples

Sample No.	Description	Date of collection	TU units	^{18}O (‰)
1	400 m horizon, VII-A, east, 5th rise	14.12.84	1 ± 3	−5.9
2	400 m horizon, VII-A, east 200 m away from sample I	14.12.84	2 ± 3	−5.9
3	400 m horizon, IX/X, west, inside	14.12.84	0 ± 3	−4.2
4	400 m horizon, IX/X, east, inside stopping	14.12.84	0 ± 3	−5.9
5	300 m horizon, IX/X, east, stopping	14.12.84	0 ± 3	−5.9
6	300 m horizon, VIII-A, east, 8th rise	14.12.84	0 ± 3	−5.6
7	300 m horizon, XI/XII, east	14.12.84	5 ± 3	−5.6
8	300 m horizon, VIII-A, east	14.12.84	3 ± 3	−5.6
9	200 m horizon, XI/XII, east	14.12.84	7 ± 3	−5.4
10	200 m horizon, VIII-A, east	14.12.84	0 ± 3	−6.3
11	Old mine, XIV seam	15.12.84	19 ± 3	−7.6
12	Old mine, XIV-A seam	15.12.84	4 ± 3	−7.8
13	Old mine, XV seam	15.12.84	48 ± 3	−7.5
14.1	Pond water	15.12.84	16 ± 3	+1.3
14.2	Pond water	11.1.86	15 ± 3	−0.5
15.1	Damodar River water	15.12.84	26 ± 3	−4.8
15.2	Damodar River water	11.1.86	15 ± 3	−7.3
15.3	Damodar River water	4.8.86	-	−7.3
16.1	Well water (shallow well)	15.12.84	25 ± 3	−5.2
16.2	Well water (deep well, old shaft)	16.1.86	5 ± 3	−5.3
17	Patherdih Colliery, VIII seam, main dip	16.12.84	30 ± 3	−6.2
18	Patherdih Colliery, VI seam, 10th lateral west	16.12.84	17 ± 3	−3.7
19	Patherdih Colliery, VII seam, 11th lateral east	16.12.84	13 ± 3	−5.1
20.1	Rain water, Sudamdih	15.1.86	-	−14.5
20.2	Rain water, Sudamdih	3.8.86	-	−10.8

^{18}O Represents ‰ deviation from Standard Mean Ocean Water (SMOW).

to −7.8‰, originating from the mixture of rainwaters having varying oxygen-18 contents such as that of −10.8‰ (August, 1986) and −14.5‰ (January, 1986) (Table 1), with mine seepage in difficult seams of the 300 and 400 m horizons having oxygen-18 contents ranging from −5.6 to −5.9‰ (except one of −4.2‰). The oxygen-18 of the surface pond water was positive indicative of nonequilibrium evaporation and that of the river shows variation from −4.8 (one value) to −7.3‰ (two values). Though mine water sample (3) having an oxygen-18 content −4.2‰ is close to the river water sample during December, 1984, later samples did not exhibit this closeness. Therefore, it is difficult to ascribe the source of seepage to the river.

However, the samples from the Patherdih collieries suggest mixtures of waters of different origin.

CONCLUSIONS

Analysis of the environmental isotopes of tritium and oxygen-18 in Sudamdih mine waters suggests that most of the seepage water resembles the local groundwater in oxygen-18 content, and low tritium contents inturn indicate longer residence time than that of the shallow well waters. However, further detailed study using seasonal sampling of precipitation and river water, and of additional groundwater would be needed to confirm the above preliminary findings.

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