HOW FAR WAS THE SEA FROM THE UMRER BASIN DURING SAKMARIAN TIME ?*

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ABSTRACT

The litho-succession of coal-bearing formation in Umrer area was treated statistically to find out the sedimentary facies model. For this purpose, first-order Markov chain analysis with probability tests were done. A lower plain deltaic model with inter-distributory bay was revealed which indicates a fair possibility of the site close to a sea of low energy environment. This is also supported by biostratigraphic and sedimentological studies done by other workers. Narmada Valley basins may also be looked into for further confirmation.

INTRODUCTION

Umrer Basin lying between latitudes 20°50′45″ to 20°52′50″ N and longitudes 79°16′0″ to 79°18′30″ E exhibits a semi-elliptical shape with truncated southern margin by vertical boundary fault trending almost east-west. The rock sequence comprises Precambrian basement (granites and older Metamorphics), Talchir, coal-bearing formation, Kamthi, Lameta and Deccan Trap Formations. The rock sequence is covered by blanket of black cotton soil and is only exposed in Umrer open-cast mine. Precambrian and Lameta rocks, however, crop out at places adjacent to the area and Deccan Trap is well-exposed to the northwestern and southern areas.

On the basis of lithological attributes, the coal-bearing formation has so far considered to be of Barakar age. BHARADWAJ AND ANAND-PRAKASH (1974), based on palynological findings established three biozones ranging from Lower Karharbari to Upper Karharbari Formation.

The object of the present study is to establish sedimentary environment of the coal-bearing formation with the help of statistical models. This is primarily done by probability tests through first-order Markov chain analysis. The Markov process is one in which the probability of the process being in a given state at a particular time may be deduced from the knowledge of the immediately preceding state (HARBOUGH & BONHAM-CARTER, 1970).

The first-order Markov chain depends on the relationship between a given bed and the bed immediately succeeding it in multistorey lithologies. Finally the stationary/non-stationary nature of the sequence can be derived from related statistical test (Probability diagram).

A fairly large amount of borehole data of the coal-bearing formation of Umrer Coalfield was available for study.

ANALYTICAL METHOD

To study the sedimentation pattern or history of the sedimentary sequence, the authors followed the general procedure for the first-order Markov chain analysis.

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Transition Count Matrix

It is the first step for the Markov chain analysis. It has a two dimensional array. The row or horizontal divisions are the number of couplet transitions of the lower bed and the upper bed. The transition count matrix is represented by 'f_{ij}' where i=row number and j=column number.

Two methods are followed to arrange the basic data in relation to the succession of the lithologies as the first step of the Markov chain analysis. The first method is by assuming that any lithological unit, suppose X, cannot pass upward to the same lithology, i.e., another X bed, so that successive beds of an area must be lithologically different. On the other hand, the second method is by assuming that the lithology of one type can pass upward into the same lithology so that the adjacent lithological units can be the same. This is done by recording the beds found at certain intervals. In the present case, the first method is followed.

Probability Matrix

There are two types of probability matrices :

(1) The transition probability matrix p_{ij} which reflects the actual probabilities of the given transition occurring in the given section. Thus

$$p_{ij} = f_{ij}/s_i$$

where s_i=sum of the f_{ij} for the i-th row of the f-matrix.

(2) Independent trials probability matrix r_{ij}, which gives the probability of the given transition of the interbedded different lithofacies occurring randomly. Thus

$$r_{ij} = s_j/(t-s_i)$$

where t=the total number of beds $= \sum_{ij}^{n} f_{ij}$, n=total number of rows and columns and s_j=the sum of f_{ij} for the j-th column of the f-matrix.

(3) There is also a difference matrix d_{ij}, found by subtraction of the independent trials probability matrix from the transition probability matrix.

$$d_{ij} = p_{ij} - r_{ij}$$

The positive values represent those transitions that occur more frequently than those occurring randomly. Thus the larger values give the stronger modes by which the Markov chain can be constructed.

Test of significance

To detect the presence or absence of random occurrence of the beds in succession, a test of significance to the result is necessary. Chi-square test is suitable for this purpose; the formula of which is

$$x^2 = \sum_{ij}^{n} (f_{ij} - s_i\, r_{ij})^2/s_i\, r_{ij}.$$

given by BILLINGSLEY (1961) and GINGERICH (1969).

The number of degrees of freedom is the number of non-zero entities in the r-matrix minus the rank of the matrix, i.e., n^2---2n. According to AGTERBERG (in MIALL, 1973), this equation may be used in the case where the transition count matrix exceeds 5. So an alternate test may be performed, recommended by ANDERSON AND GOODMAN (1957) and

HARBOUGH AND BONHAM-CARTER (1970), where the values of transition count matrix do not exceed 5. The equation is

$$x^2 = 2 \sum_{ij}^{n} f_{ij} \cdot \text{Log}_e (p_{ij}/p_j), \quad \text{where} \quad p_j = \sum_{i}^{n} {}_{ij} / \sum_{ij}^{n} f_{ij}.$$

Here the degrees of freedom is $(n-1)^2 - n$. The null hypothesis is that "the vertically upward sequence of the stratigraphic column was derived by random variation in the depositional mechanism."

SAMPLING METHOD

The authors followed the procedure by counting only the diagnostic litho-facies transitions in the sections under study. From the counting method, the change in the depositional process can be visualised.

Here, four lithofacies are considered—

A—Sandstone,
B—Siltstone,
C—Shale, and
D—Coal+carbonaceous shale.

The acceptance of these four lithofacies is granted as some worker (MIALL, 1973) have cautioned regarding the selection of correct lithofacies which should be fully representative for meaningful way.

RESULT AND DISCUSSION

From the above study, four different lithofacies (ignoring the minor differences within each other) have been identified for the purpose of Markov analysis. Different tally matrices and facies relationships have been derived (Table-1 and the probability diagram).

Chi-square test yields a value of 31.14 which is well above the limiting value 20.09 at 99% confidence level and 15.51 at 95% confidence level for 8 degrees of freedom. Thus the null hypothesis, i.e., "the stratigraphic succession is a product of random variation in nature" is rejected. This can be concluded that the probability matrix has the Markov property and there is less than 1 in a 100 chances of such a distribution of probabilities arising from successive events that are independent.

Table 1

(A) Transition Count Matrix (f_{ij})

	A	B	C	D	Total
A	0	23	61	26	110
B	13	0	25	26	64
C	49	17	0	107	173
D	49	27	82	0	158
Total	111	67	168	159	505

(B) Transition Probability Matrix (p_{ij})

	A	B	C	D
A	0.00	0.21	0.56	0.24
B	0.20	0.00	0.39	0.41
C	0.28	0.10	0.00	0.62
D	0.31	0.17	0.52	0. 0

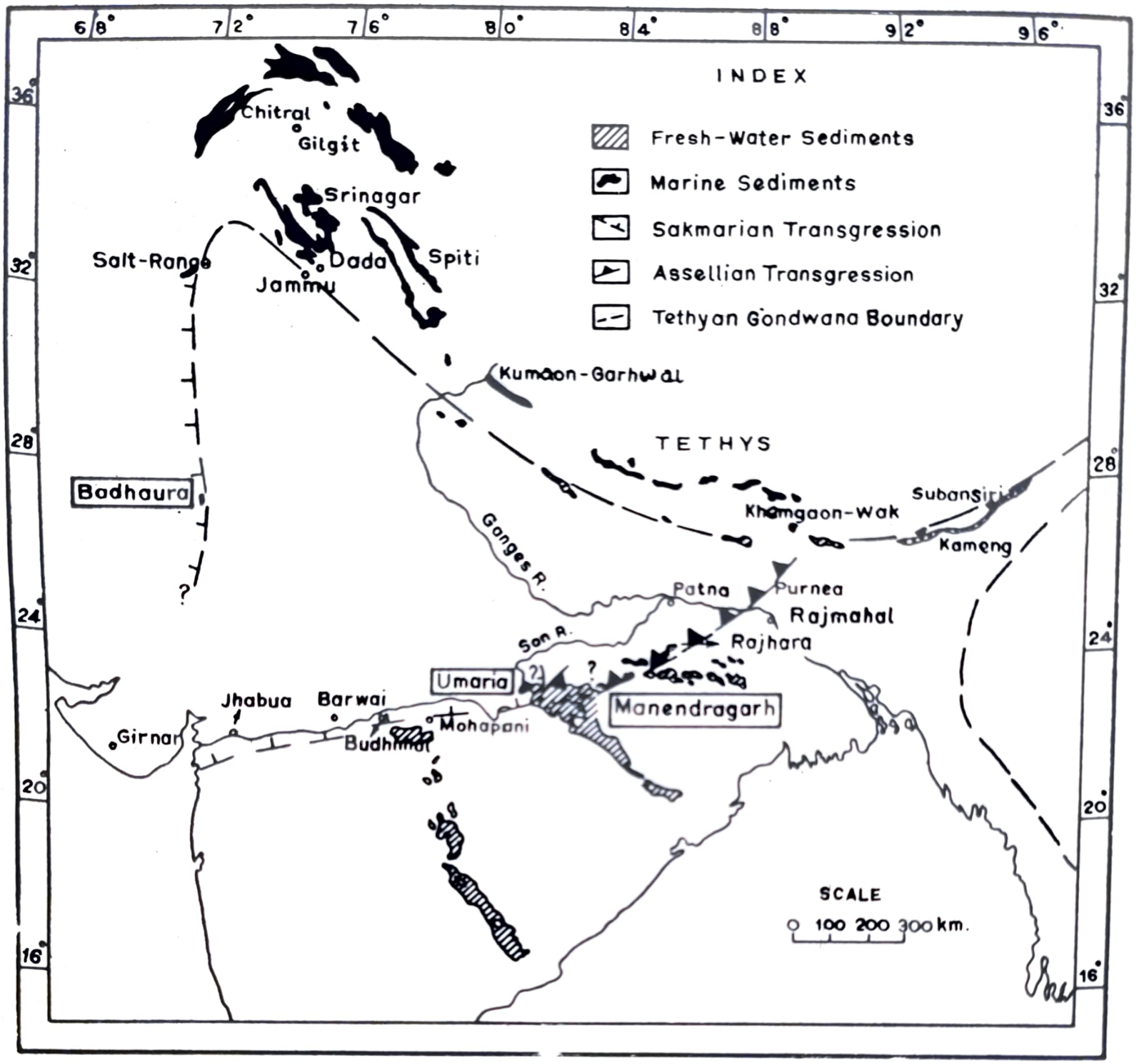

Fig. 2. Early Permian marine transsgression in Peninsular India (After Shah & Sastry, 1975)

AND SASTRY (1975) and BHARADWAJ *et al.* (1978) in the adjoining areas. Similar studies should be taken up in the isochronous formations of Narmada Valley coalfields for further confirmation.

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