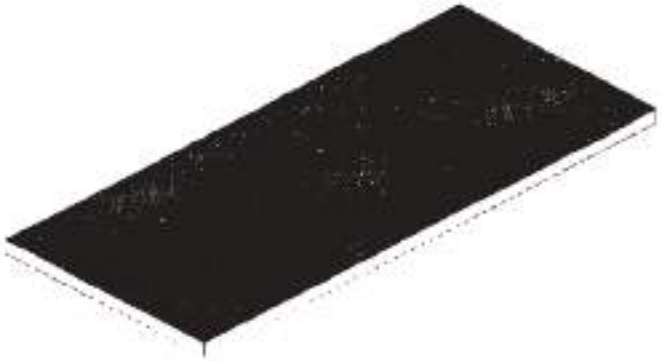
STUDY ON SUBSIDENCE AND MEASURES FOR MITIGATION/PREVENTION OF SUBSIDENCE



SHAHPUR EAST COAL BLOCK

NATIONAL MINERAL DEVELPOMENT CORPORATION
SHAHDOL, MADHYA PRADESH (INDIA)

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1.0 INTRODUCTION

Shahpur East coal block of NMDC is located in Sohagpur Coalfield, in the northern belt of Son-Mahanadi basin. It is located in Shahdol and Umaria districts of Madhya Pradesh. It is proposed to excavate coal by underground mining method of bord and pillar system of mining.

1.1 LOCATION

Shahpur East Block area falls under administrative control of Shahdol and Umaria districts in Madhya Pradesh state. It lies in the north Eastern part of Sohagpur coalfield, about 12 Km. South-East of Shahdol town, the district headquarter. The block is located at a distance of 75 Km. from Umaria town. The block covers an area of about 693 Ha falling in

Latitude (N) : 23°14'21" to 23°15'37" and

Longitude (E) : 81°18'48" to 81°20'28"

in the Survey of India Toposheet Nos. 64 E/7 and 64 E/8 (R.F.1:50,000).

The block boundary limits of Shahpur East Block are given below:

North : Shahpur Block explored by GSI & East of Shahdol Block.

East: Bicharpur block explored by GSI.

South: Block boundary supplied by NMDC. Promotional exploration is in progress by CMPDIL / GSI in the South.

West : Shahpur West Block,

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1.2 COMMUNICATION

The block is well connected by road and rail. The Sohagpur and Shahdol townships are close to the area connected through metalled road. The Shahdol town located on National Highway No. 78 is only 12 KM from the site. The nearest railway station is Shahdol (4 km aerial and 12km by road) connected from Jabalpur and Bilaspur in South Eastern Railway.

The Bilaspur–Katni section of the South Eastern railway traverses the Eastern part of the Sohagpur Coalfield through the important mining centres of Burhar-Amlai & Dhanpuri. The eastern part of the field is served by the Anuppur-Chirmiri branch line which passes through Kotma, Bhadra, Yamuna & Bijuri Collieries. Jabalpur is the nearest Airport located about 300 KM well connected by air route to New Delhi.

1.3 CLIMATE

The area experiences three seasons during the year. The summer is from March to June when the day temperature varies from 25°C to 46°C and at night, it is between 18°C to 24°C. Mid June to September is the rainy season and from October, the winter sets in and continues upto February. During winter season, the maximum day temperature varies from 26°C to 31°C while the minimum night temperature shows variation from 7°C to 15°C.

The average rainfall in the area varies from 1000 mm to 1700 mm annually. A very small part in Shahpur East Block, is covered by private eucalyptus plantation. The rest of area covered by cultivated land where paddy is the main annual crop of the area.

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1.4 DRAINAGE

The land form in Sohagpur Coalfield is controlled by the lithological set up of the different formations. The Talchirs have formed low-lying plains with average altitude of 450 m to 500 m above MSL. The area to the north rises to an elevation of over 1000 m with successive escarpments. The Barakar strata with their undulatory to low dips have given rise to a feature of less rolling topography. However, the Barakar sandstones stand out prominently against the surrounding plains, wherever they are capped by basic sills-dyke. To the east of Singara, one such prominent ridge is noted. The dolerite, a common feature of this coalfield, forms a rugged to hilly topography. In contrast to the featureless topography of the areas where Lower Gondwana strata occurs, the Upper Gondwana rocks form prominent ridges. They constitute the prominent plateau to the north. This plateau joins with the Sonhat plateau in the east.

The Son river (17.23 km on NE side) with a north-Easterly flow is the main drainage channel of Sohagpur coalfield. Several streams originate in the high trappean region in the south and join the Son. These north flowing streams include Nargara, Sarpa, Bagiha, Bakan, Suthna, Tipon etc. The Kewai river originating in the Supra Barakar plateau of the Sonhat coalfield, forms the main drainage in the eastern part of the coalfield. The eastern most part of the coalfield is also drained by the Jhiria and Kulharia nalas, which ultimately discharge into the Hasdo river, which flows close by.

In Shahpur East Block, the maximum elevation is around 490 m. Observed in the south-East part near Bh No. MSSE-4 and minimum elevation is 470 m. as ..... observed in the north-east corner of the block for Bh No. MSSE-. The Shahpur East Block is marked by dendritic pattern of drainage system formed by north-ward flowing nala namely Ghinachunia, This is the only drainage system available within the block. A number of small ponds are found within the block.

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1.5 FOREST COVER

The Shahpur East block does not have forest cover on the surface.

2.0 GEOLOGY

The Shahpur East Block falls in the North Eastern part of Sohagpur Coalfield. The area explored is mostly covered by sandy soil as few scanty exposures of Barren Measure sandstones are marked along the nala. Dolerite outcrops are observed at two places.

Geological succession

The stratigraphic sequence in the block is given below in Table 4.4 and the surface geological features based on subsurface data are furnished in Plate VII.

Table – 2.1

Geological Succession of Shahpur East Block

Age	Formation	Lithology
Recent	Soil	Soil & Alluvium
Mid. Permian	Barren Measures	Pink, buff, red sandstone, red shale etc.
Lw. Permian	Barakar	Coarse to medium grained sand-stone subordinate shales and coal seams
Lw. Permian to Up. Carboniferous	Talchir	Greenish sandstone & siltstones with pebbles of Granite.
---------- Unconformity ----------		
Pre-Cambrian	Metamorphics	Porphyritic granite gneisses

The thickness range of each formation within the block as intersected in the boreholes are given in Table 2.2.

Table No.: 2.2

Thickness Range of Different Geological Formations

Formation	Thickness Range (m)		Remarks
	Minimum	Maximum	
Soil / Alluvium	1.00 (MSSE-3, 18, 44, 46, 53)	8.75 (SSH-20)	
Weathered Mantle	4.66 (MSSE-9)	30.25 (MSSE-2)	
Barren Measures	3.00 (MSSE-37)	64.70 (SSH -8)	
Barakars	121.03 (MSSE -53)	243.35 (SSH-20)	Full Column intersected in three Bhs. of GSI
Talchirs	2.49 (SSH-24)	20.05 (SSH-21)	Talchir intersected in 3 Boreholes of GSI
Metamorphics	Not drilled upto basement		

Table – 2.3

SEQUENCE OF COAL SEAMS, SHAHPUR EAST BLOCK

Sequence of Seam / Parting	Range of Seam Thickness (m)		Range of Parting (m)	
	Minimum	Maximum	Minimum	Maximum
IV	0.03 (MSSE-46)	2.85 (MSSE-15)		
Parting			33.95 (MSSE-27)	57.00 (MSSE-39)
L2	0.02 (MSSE-18)	2.28 (SSH-14)		
Parting			5.42 (SSH-14)	26.53 (MSSE-15)

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III A	0.30 (MSSE-30)	5.49 (MSSE-13)		
Parting			0.34 (MSSE-53)	3.60 (SSH-8)
III B	0.42 (MSSE-10)	4.76 (MSSE-31)		
Parting			0.77 (MSSE-37)	4.17 (MSSE-53)
III L	0.50 (MSSE-11)	1.05 (MSSE-14)		
Parting			14.07 (MSSE-15)	22.12 (SSH-8)
II	0.15 (MSSE-25)	4.55 (MSSE-31)		
Parting			16.30 (SSH-13)	45.10 (MSSE-39)
I	0.05 (MSSE-5)	0.60 (MSSE-29)		
Parting			16.88 (MSSE-19)	38.70 (MSSE-5)
L1	0.05 (MSSE-3)	0.90 (SSH-25)		

3.0 METHOD OF WORKING

Conventional bord and pillar system of mining will be adopted for excavating coal from Shahpur East Block. Only seams 1V, L2, IIIA and II will be worked.

4.0 PERIOD OF PREDICTION

The time period for the prediction of subsidence required is 33 years as given by the company.

Stage-I	15 years
Stage-II	20 years
Stage-III	25 years
Stage-IV	30 years

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Stage-V 33 years

4.1 SIMULATION FOR PREDICTION

The natural mining has to be simulated before it can lend itself to the numerical modeling. As the first step, Fig. 1 is a simulated grid map of the proposed mining area of Shahpur East Block in terms of contours of the surface profile. Fig. 2, Fig. 3, Fig. 4 and Fig. 5 is the simulated grid map of the workings of the IV, L2, IIIA and II seams. The simulated mine plan has a scale of 1:5000, same as that provided by the mining company.

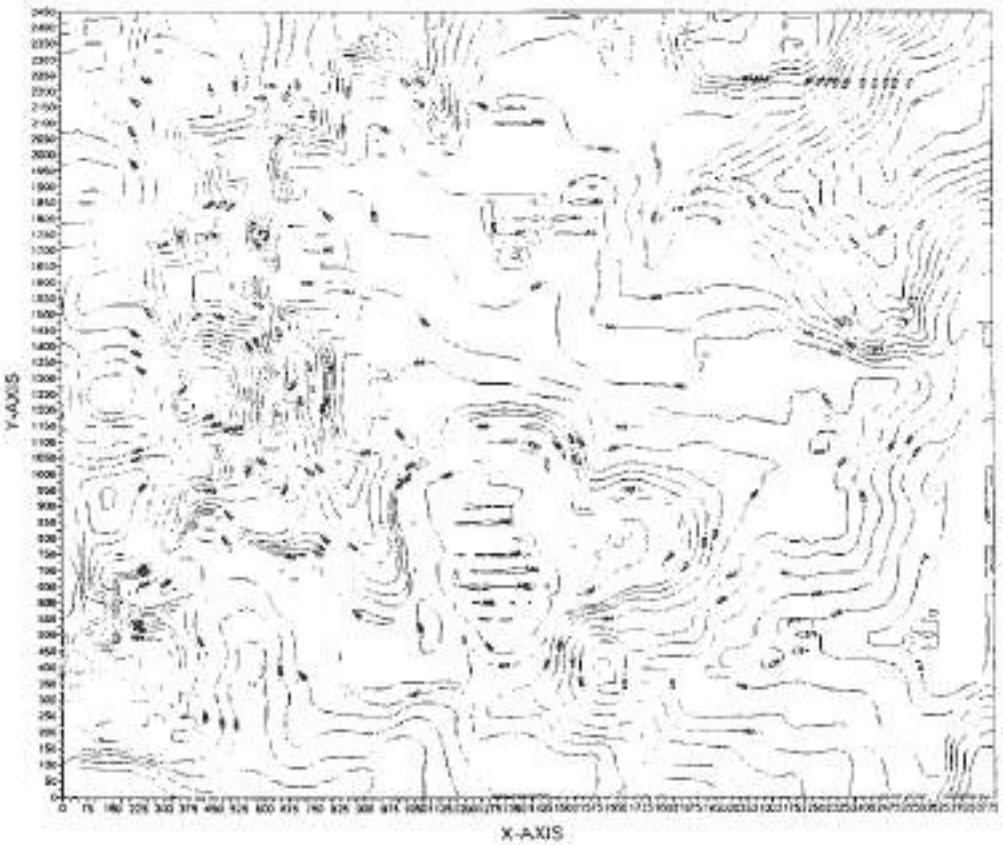

FIG.1 SURFACE CONTOURS BEFORE MINING (SHAHPUR EAST BLOCK)

FIG. 2 SIMULATED GRID MAP OF SEAM IV (SHAHPUR EAST BLOCK)

FIG 3 SIMULATED GRID MAP OF SEAM L2 (SHAHPUR EAST BLOCK)

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FIG.4 SIMULATED GRID MAP OF SEAM III-A (SHAHPUR EAST BLOCK)

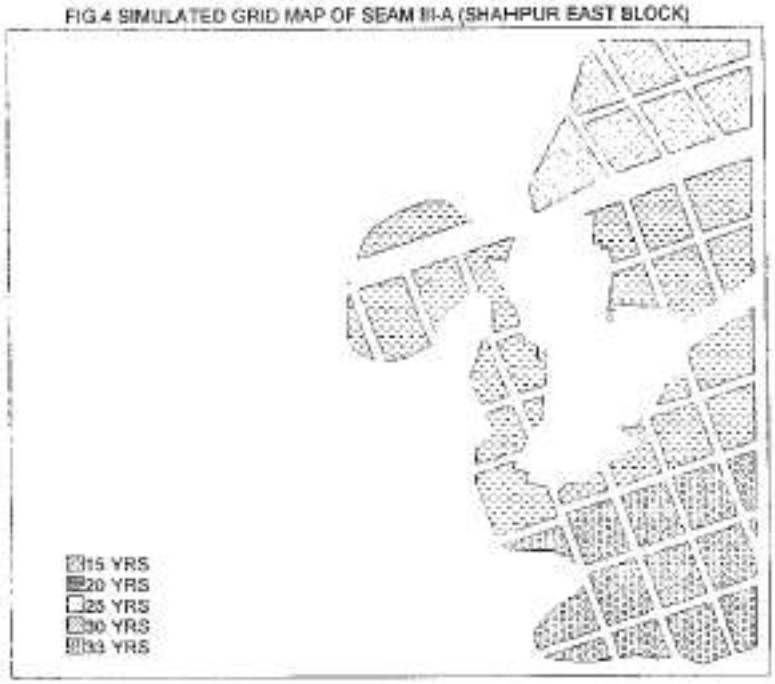

FIG.5 SIMULATED GRID MAP OF SEAM II (SHAHPUR EAST BLOCK)

Table 4.1 gives the co-ordinates of few boreholes on the simulated grid maps, which can be used for the studying, and analyzing of all the maps provided by us.

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Table 4.1: Co-ordinates of some boreholes on the simulated grid map.

S.L. No.	Bore hole No.	X-Co-ordinate	Y-Co-ordinate
1	MSSE-14	2185	1800
2	MSSE-23	2235	585
3	MSSE-24	990	1405
4	MSSE-4	125	335
5	MSSE-5	535	2060

4.2 REQUISITE GEOTECHNICAL PARAMETERS FOR THE PREDICTION

The numerical prediction of subsidence requires following basic data:

1) Geotechnical parameters of the seam and surrounding rock mass upto the surface,

2) Mathematical model and computer programs (software)

3) Major structural features of the strata,

4) Details of the mine excavation

5) Sequence of extraction and size of panels, and

6) Important features on the surface.

The information on the above mentioned parameters were provided by the company. The company also provided the data for the physico-mechanical properties used in the simulation. The above properties were taken for various panels as per their proximity to the above boreholes in the block. The boreholes nearest to the panels were considered to be representative one and hence selected for the simulation.

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4.3 PREDICTION TECHNIQUE

The computer-simulated model was developed for the prediction of subsidence and alterations in the resulting profile of the surface, keeping in mind the total area, the mining sequence and geo-technical properties and above all, depth of each mining panel, which varies significantly from panel to panel. The grid map for simulation is based on 25 m grid on the surface having about 20000 points for calculation process using finite element method (FEM) – a numerical simulation technique. The computation for prediction of subsidence of the area is based on the grid pattern. The 3-D mathematical model, thus simulated was subjected to the finite element analysis. The model also takes care of the non-linear behaviour of the rock mass (if any), bed separation and its recontact.

5.0 RESULT

5.1 PREDICTED SUBSIDENCE CONTOURS

Fig. 4 shows the subsidence contours after 5 years of mining. Similarly, Fig. 6, Fig. 7, Fig. 8, Fig 9 and Fig. 10 gives the subsidence contours at the end of 5, 10, 15, 20 and 25 years of mining, respectively. The maximum values of the subsidence predicted at the end of each time blocks are given in Table 5.1.

Table 5.1: **Maximum values of predicted subsidence at the end of mining.**

Sl. No.	Year	Subsidence values, (in m)
1.	15	- 0.886
2.	20	- 1.187
3.	25	- 1.188

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4.	30	-1.302
5.	33	-1.321

To illustrate an overall picture, a few subsidence values along with coordinates on the simulated grid maps have also been …..???

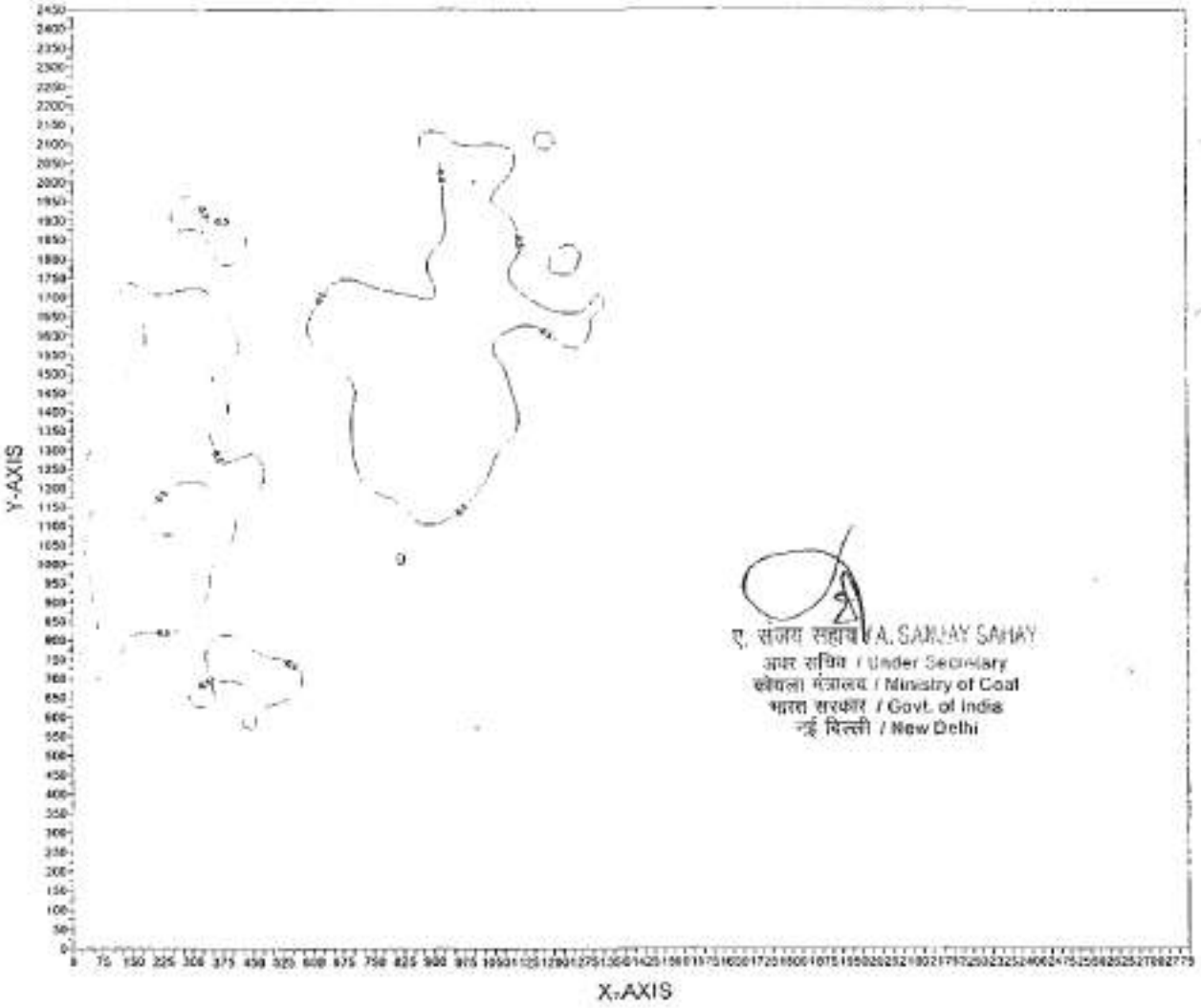

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FIG.6 SUBSIDENCE CONTOURS AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

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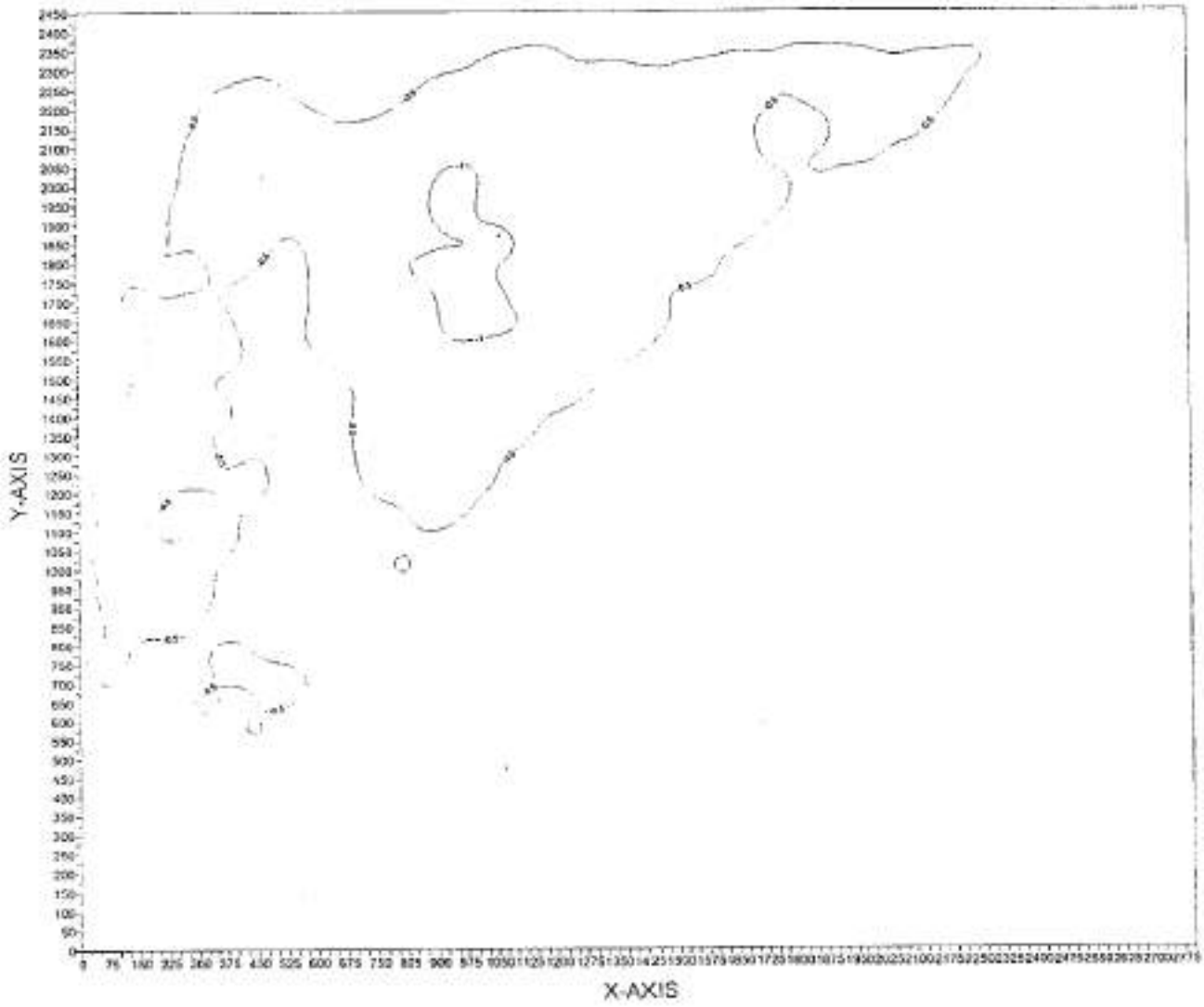

FIG.7 SUBSIDENCE CONTOURS AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

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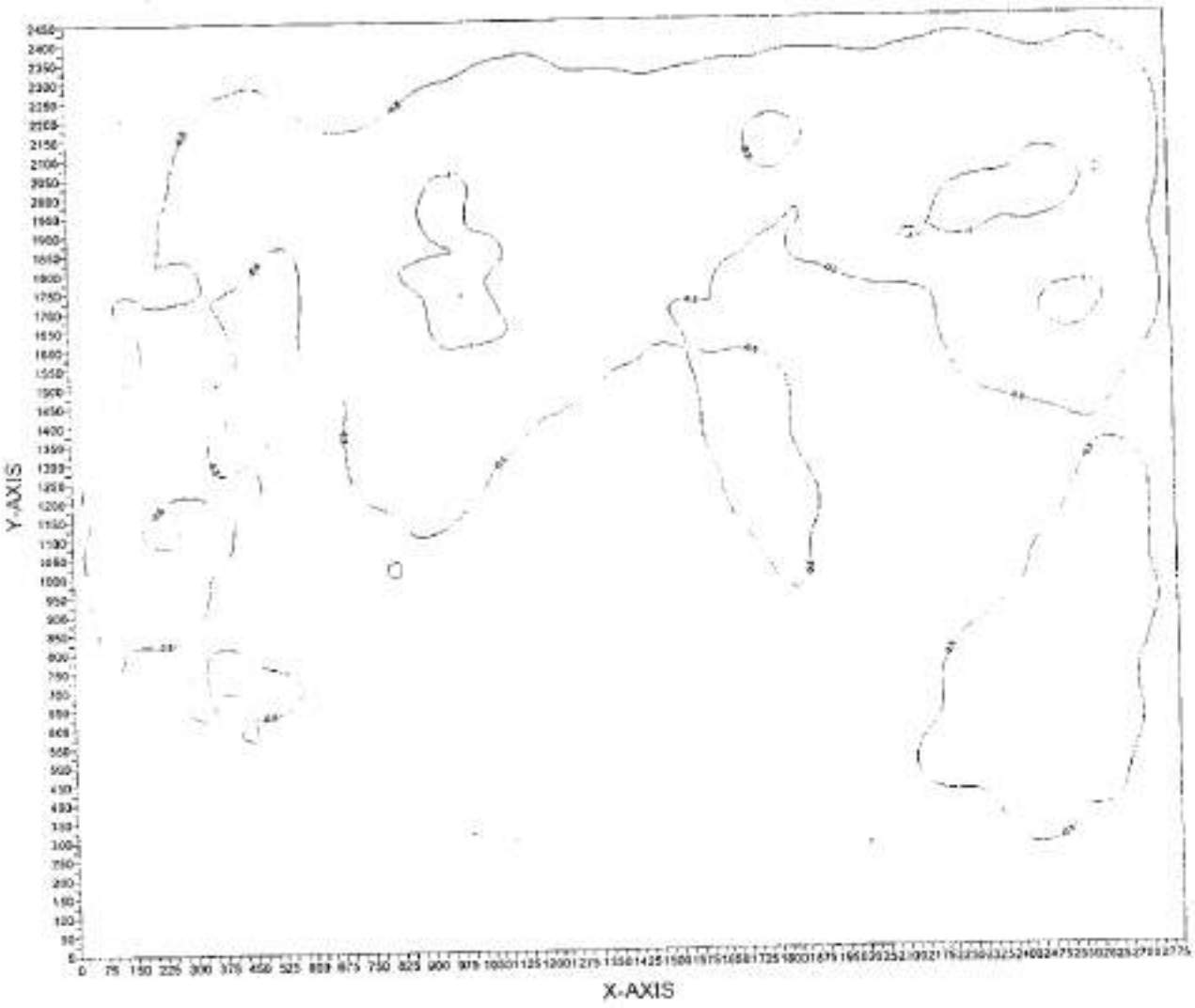

FIG.8 SUBSIDENCE CONTOURS AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

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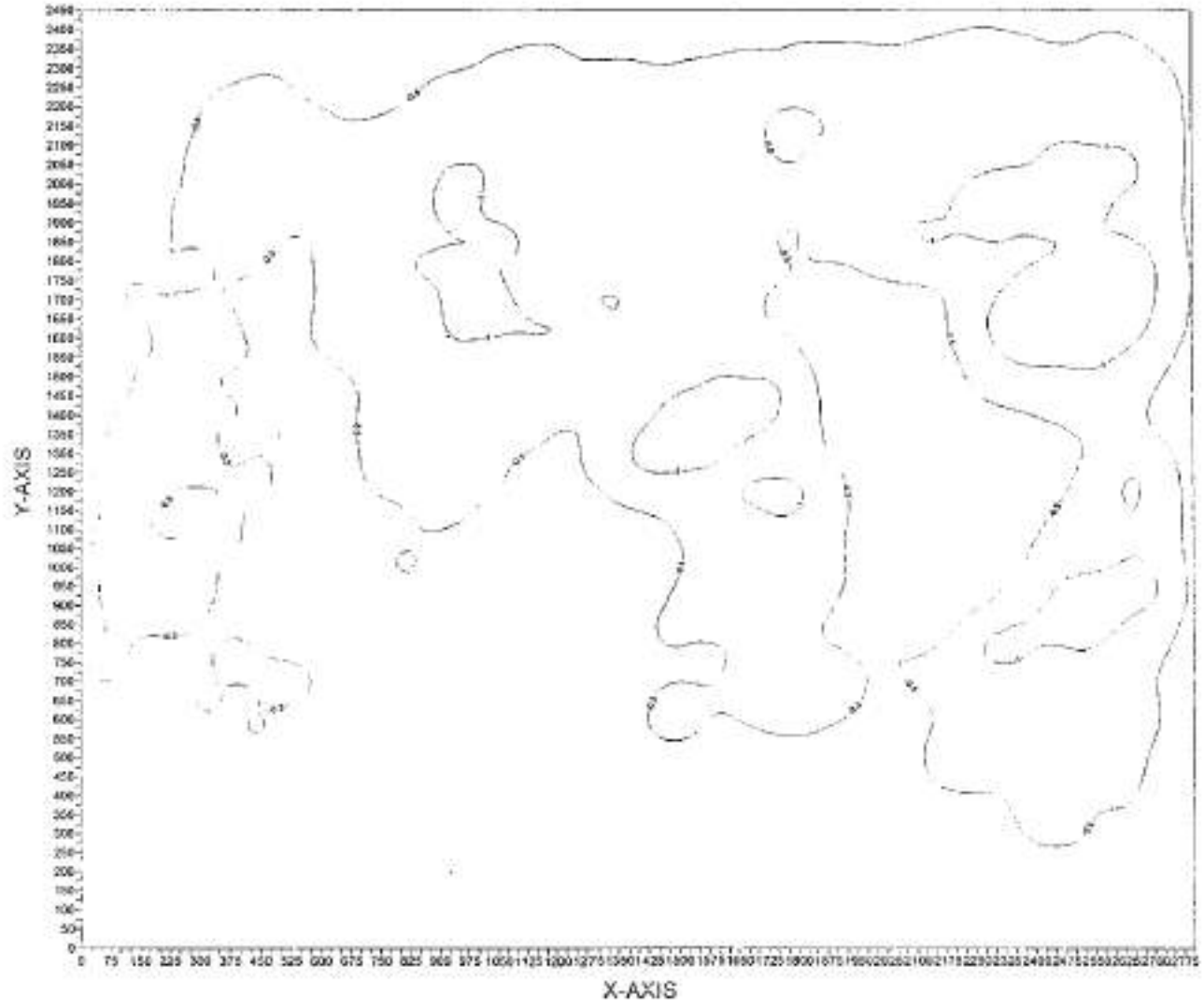

FIG.9 SUBSIDENCE CONTOURS AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

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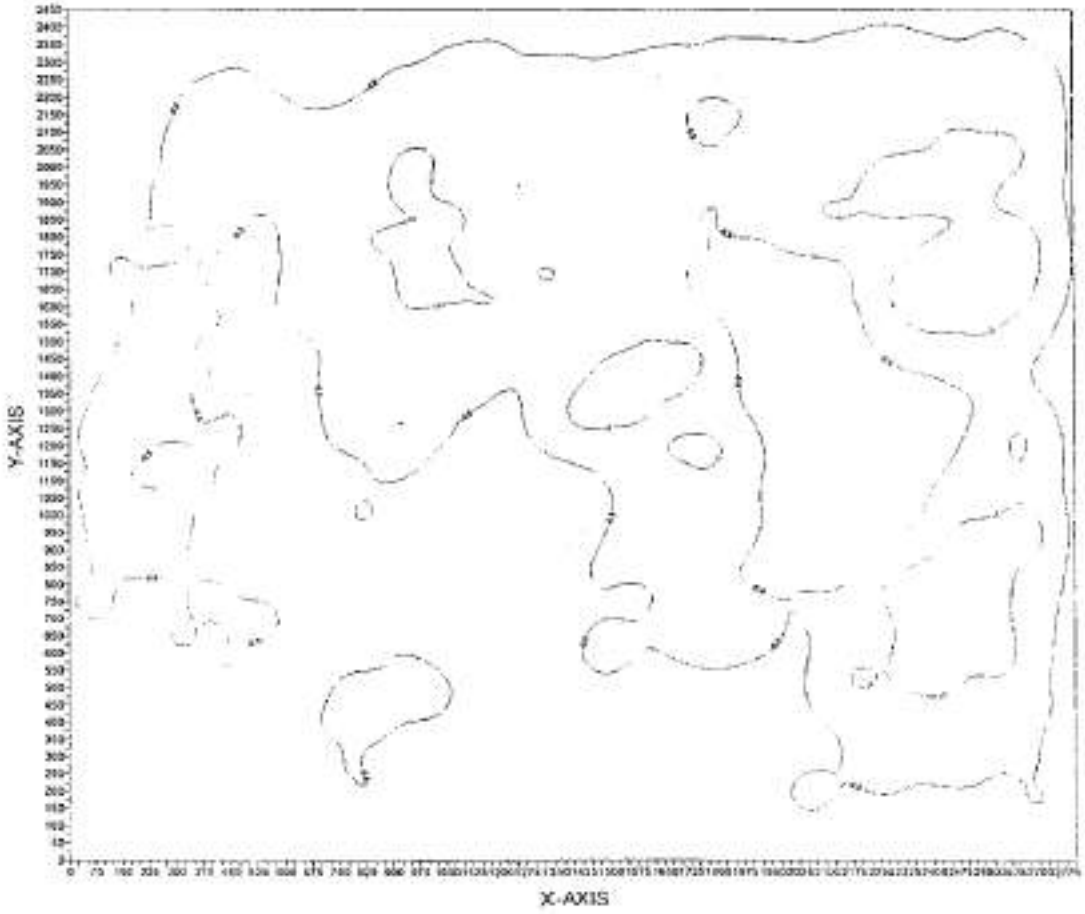

FIG.10 SUBSIDENCE CONTOURS AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

5.2 THREE DIMENSIONAL PROJECTIONS OF SUBSIDENCE

To give a 3-dimensional impact of the subsidence, the predicted subsidence has been projected on the surface for each of the mining period based on X and Y coordinate defining the horizontal plane and 'Z' coordinate, the depth of the surface. It may be noted that the 'Z' coordinate has been exaggerated (20 times) to have a better visual appreciation of the impact of subsidence.

Figs. 11 through 15 give prediction of the subsidence at the end of 15, 20, 25, 30 and 33 years of mining respectively, considering the surface to be horizontal, before mining. These figures give a real feel of the impact of subsidence as a result of the

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progression of mining with time. Two sets of subsidence figures are provided for each stage. These are having opposite viewing directions, *i.e.* 45° and 225°. It may be pointed out at this stage that the 3-dimensional projections shown in the figures 11 through 15 should not be used to pin point the maximum subsidence area because all the points may not be visible on the map. However, these drawings provide fairly accurate idea about ground behavior after mining.

It is worth noting that the troughs shown in the figures should be viewed in the proper perspective as the scale in 'Z' direction has been enlarged to 10 times to have appreciable viewing impact.

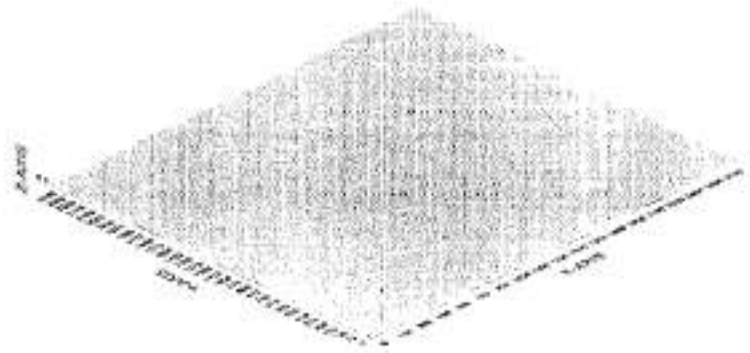

FIG.11a SUBSIDENCE PROFILE AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

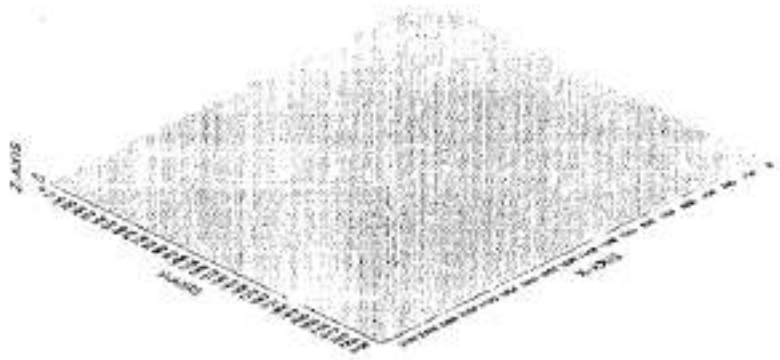

FIG.11b SUBSIDENCE PROFILE AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

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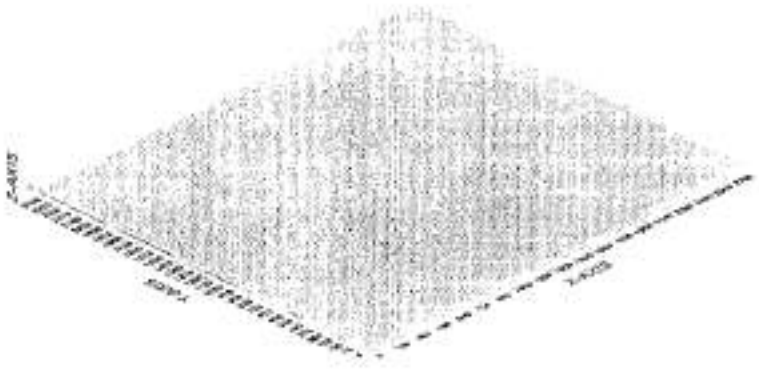

FIG 12a SUBSIDENCE PROFILE AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

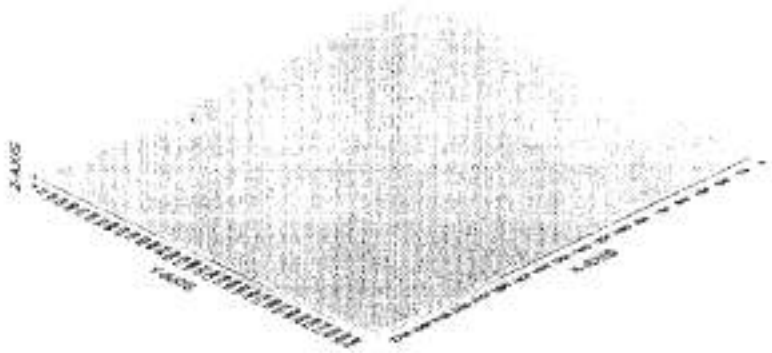

FIG.12b SUBSIDENCE PROFILE AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

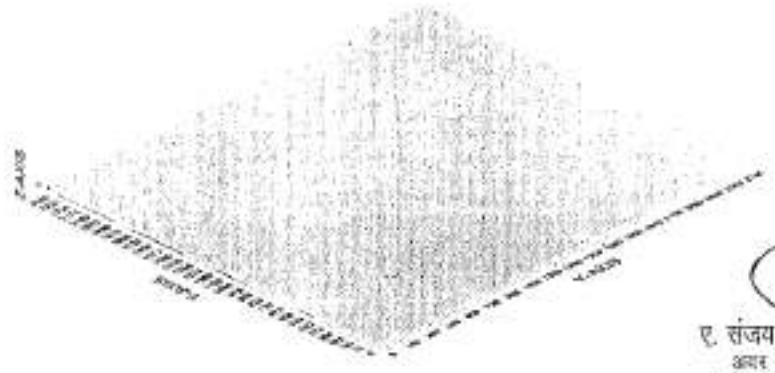

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FIG.13a SUBSIDENCE PROFILE AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

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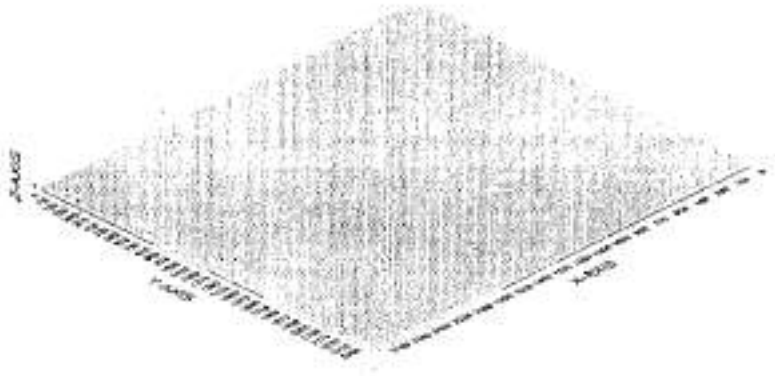

FIG.13b SUBSIDENCE PROFILE AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

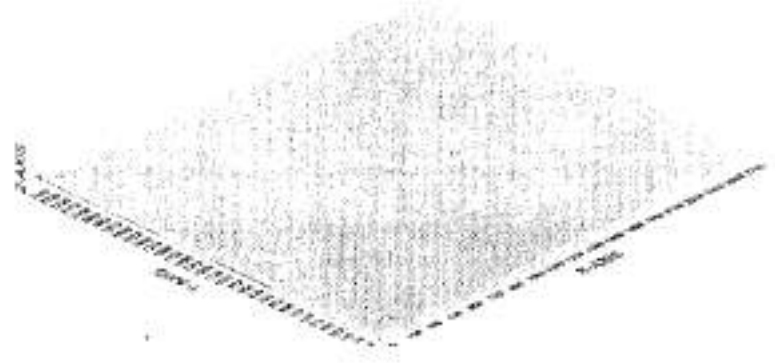

FIG.14a SUBSIDENCE PROFILE AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

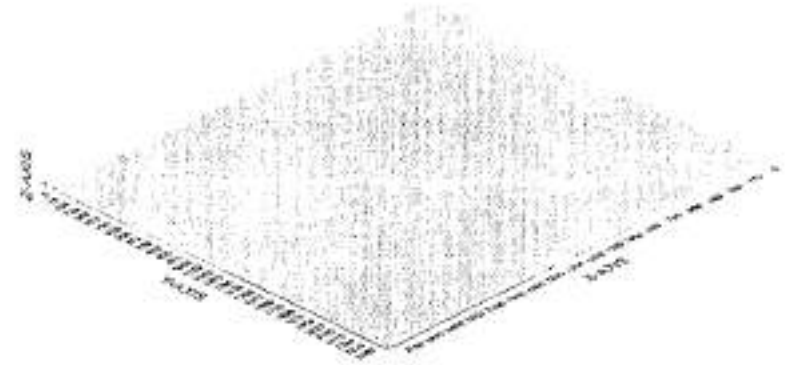

FIG.14b SUBSIDENCE PROFILE AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

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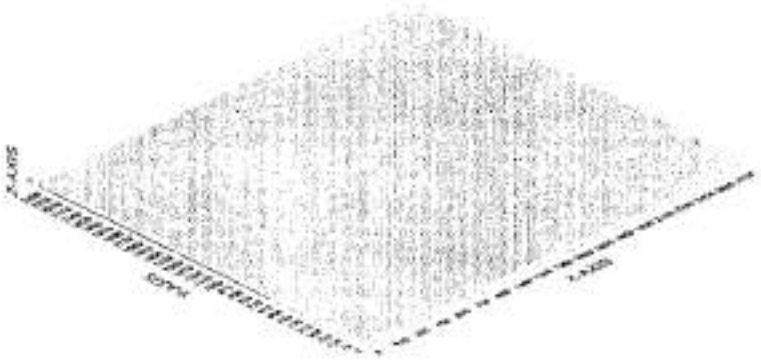

FIG.15a SUBSIDENCE PROFILE AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

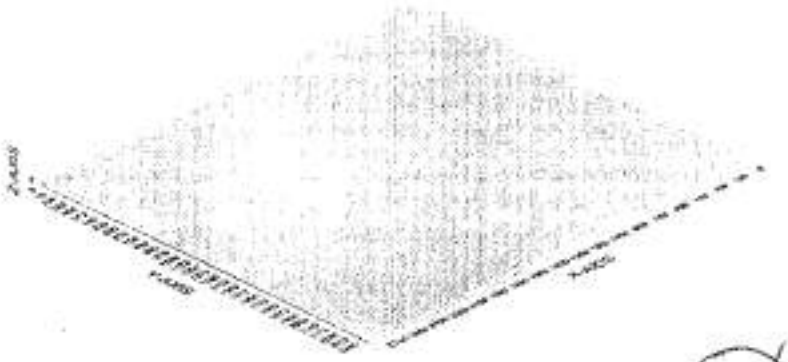

FIG.15b SUBSIDENCE PROFILE AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

5.3 SURFACE PROFILE

The surface profiles of the mining block after each stage of mining have also been predicted. These profiles have been obtained by superimposing subsidence with pre-mining surface profile after each mining sequence for different time blocks. Fig. 1 gives the surface profile of the mining block before mining. The contour maps which would finally emerge as a result of mining after 15, 20, 25, 30 and 33 years have been predicted and are shown in Figs. 16 through 20.

Fig. 21 shows the 3-dimensional prediction of surface profile before mining for the Shahpur East Block. Figs. 22 through 26 give the 3-dimensional prediction of surface profile at the end of each mining sequence after 15, 20, 25, 30 and 33 years of mining respectively (the 'Z' axis has been exaggerated to 10 times for having better visual appearance of the impact of subsidence). A set of figures showing surface subsidence and surface profile at the end of each stage of mining is also being provided in larger sizes at a scale of 1:5000. The surface contours along with the panels of the seam are also being provided in larger sizes *i.e.*, at a scale of 1:5000.

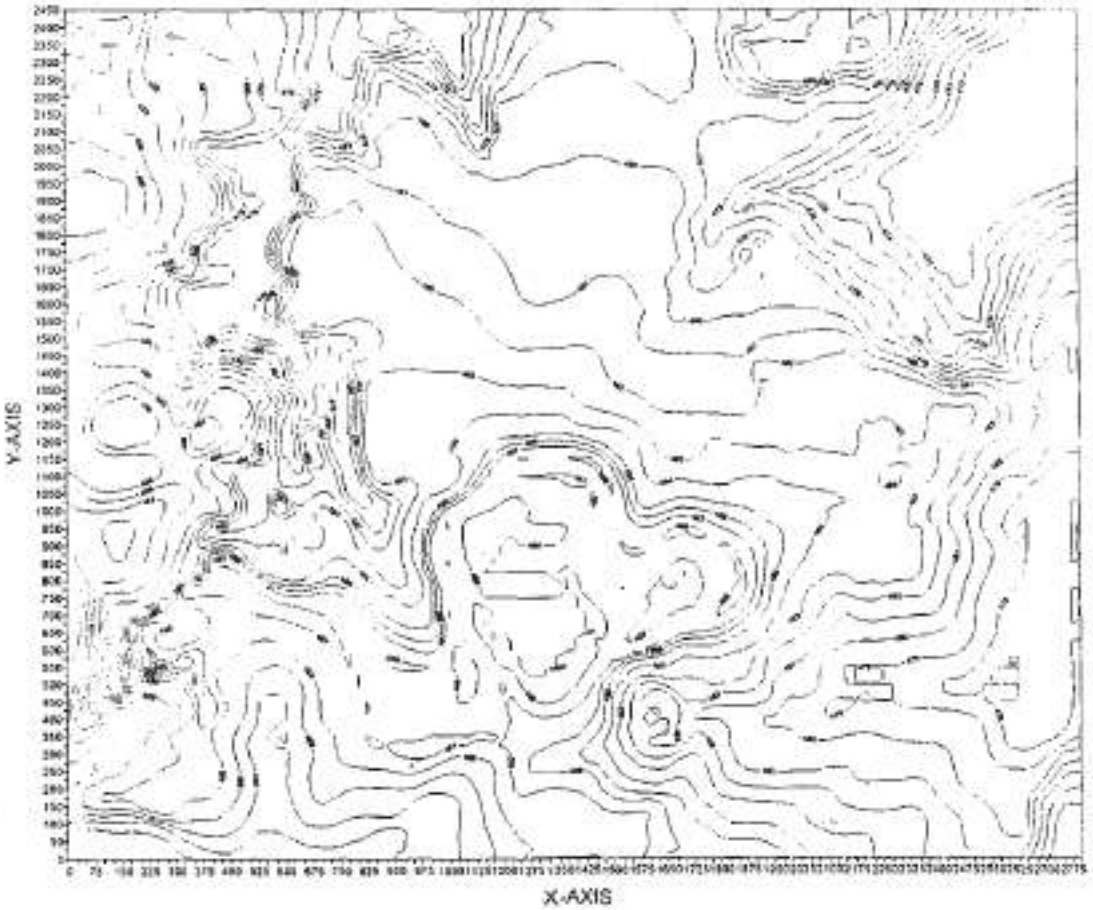

FIG.16 SURFACE CONTOURS AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

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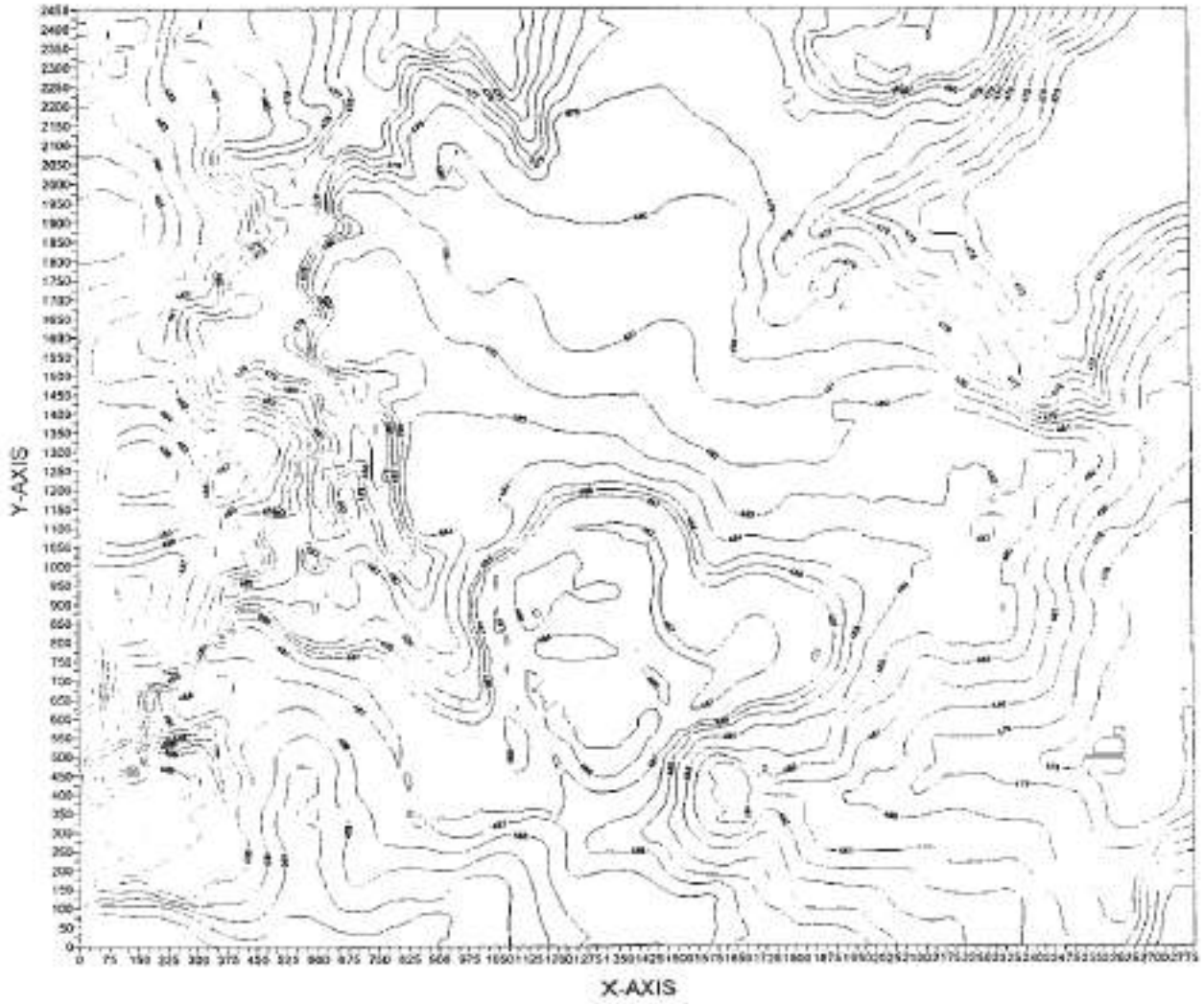

FIG.17 SURFACE CONTOURS AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

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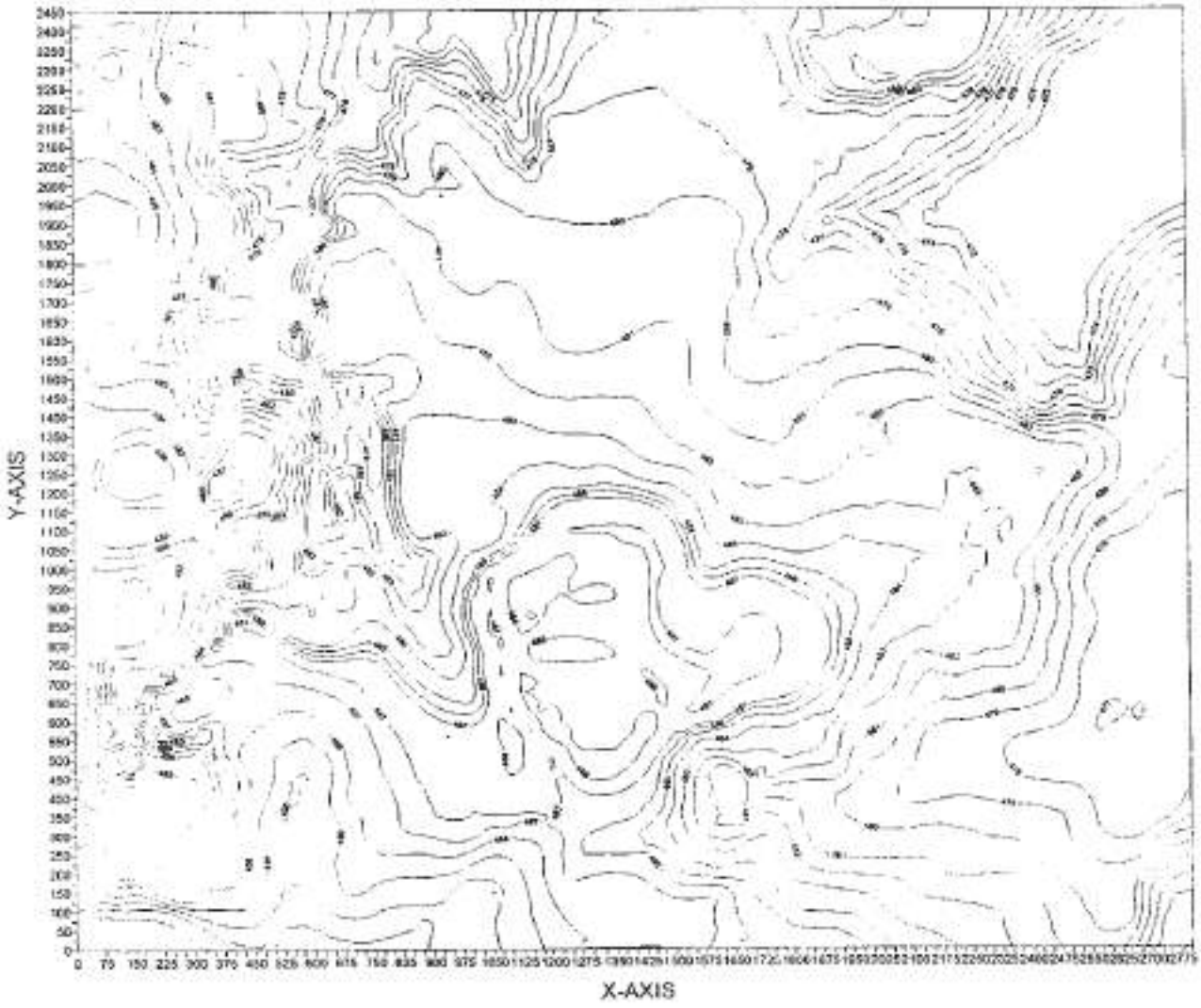

FIG.18 SURFACE CONTOURS AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

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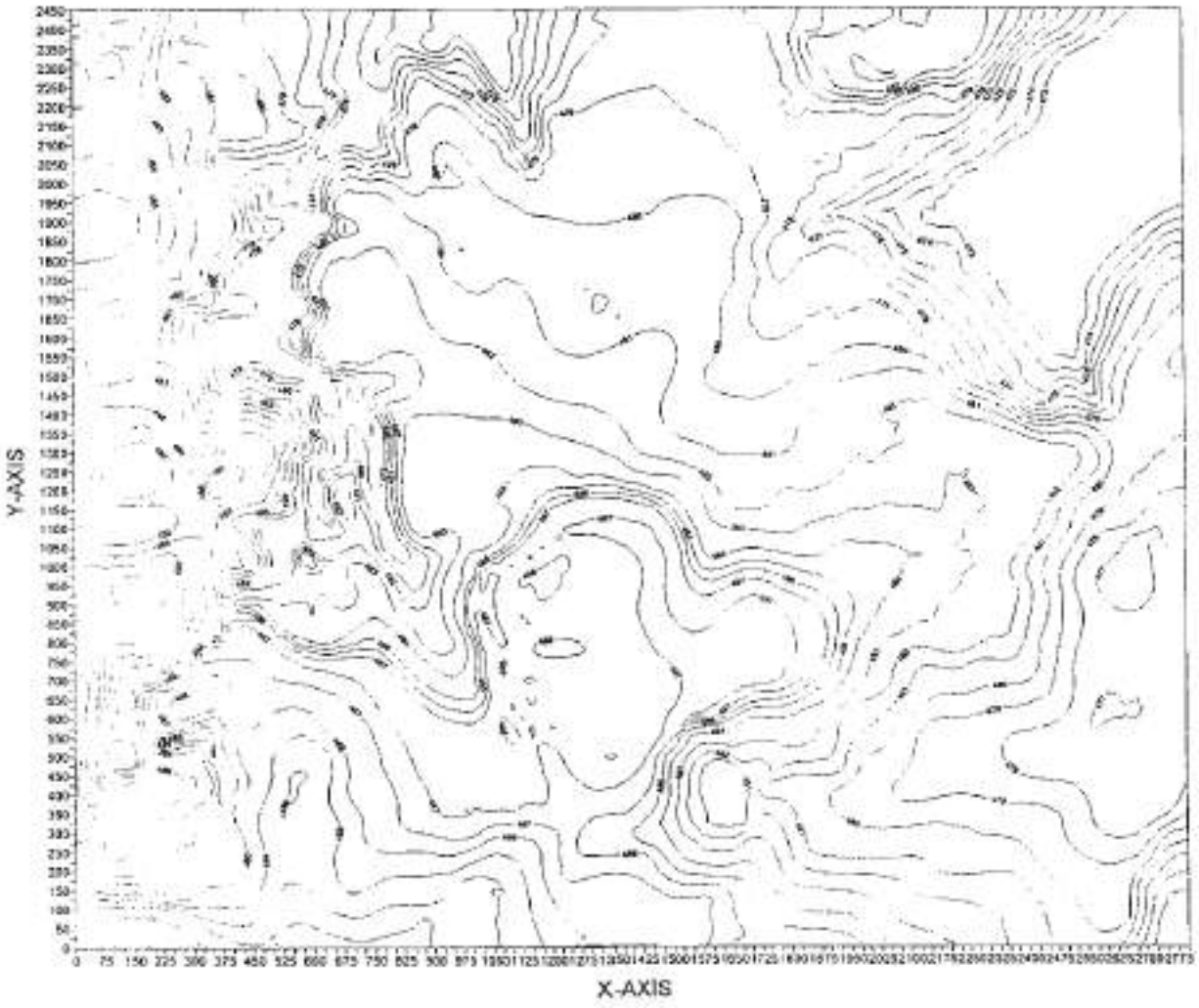

FIG.19 SURFACE CONTOURS AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

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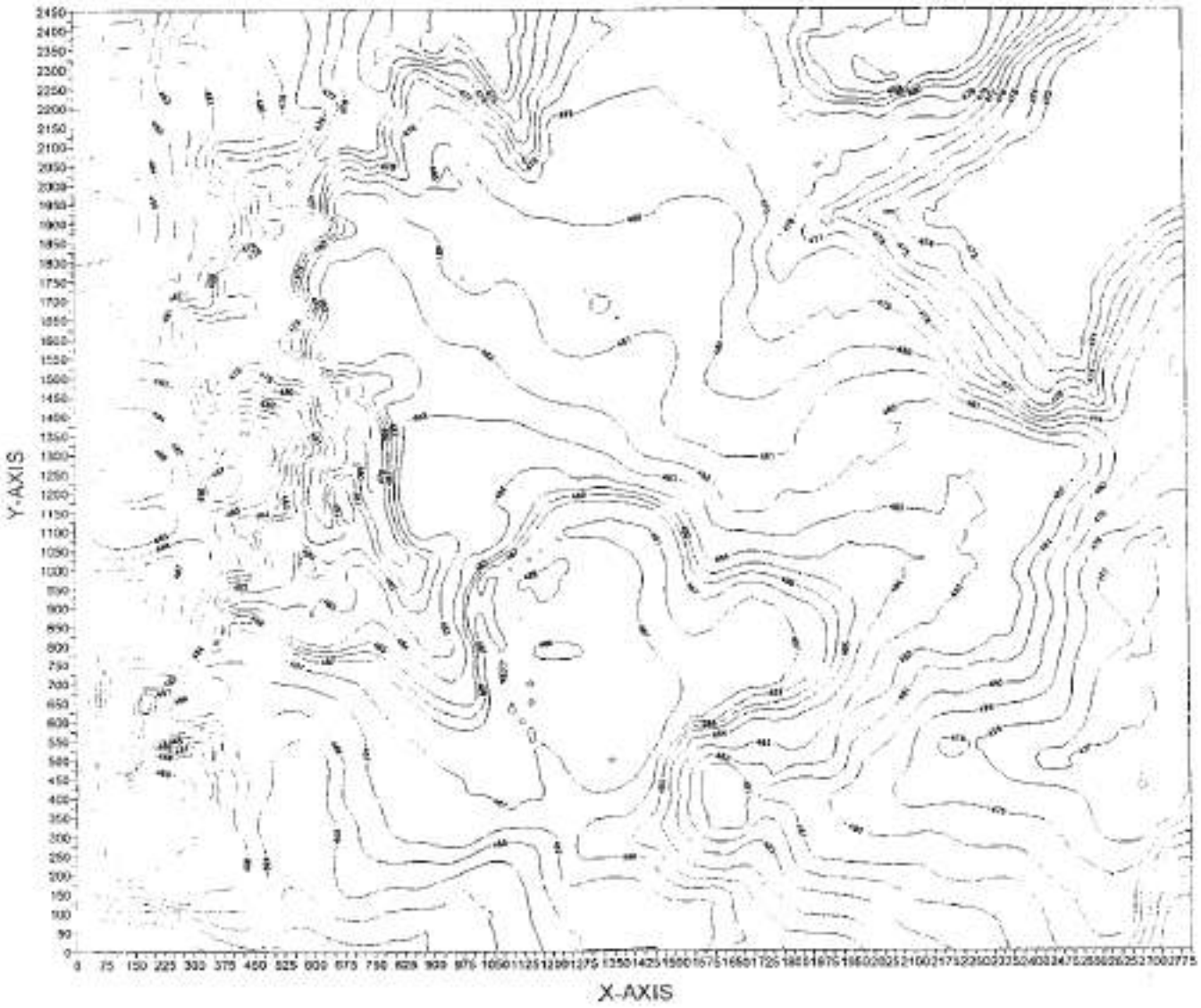

FIG.20 SURFACE CONTOURS AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

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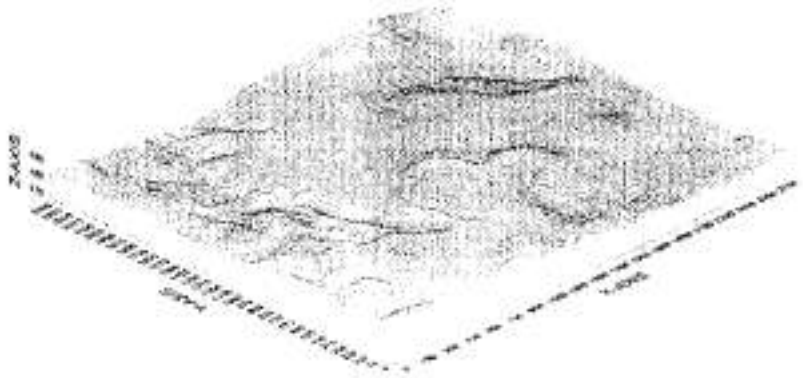

FIG 21a SURFACE POFILE BEFORE MINING (SHAHPUR EAST BLOCK)

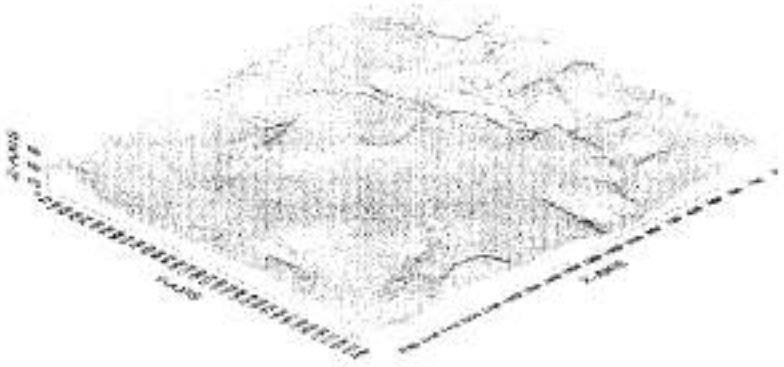

FIG.21b SURFACE POFILE BEFORE MINING (SHAHPUR EAST BLOCK)

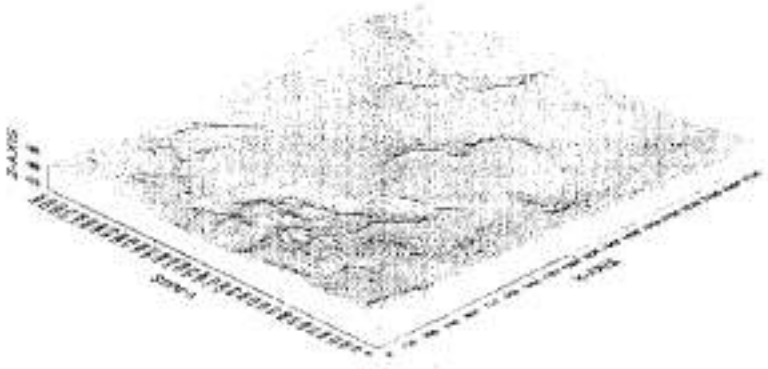

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FIG.22a SURFACE POFILE AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

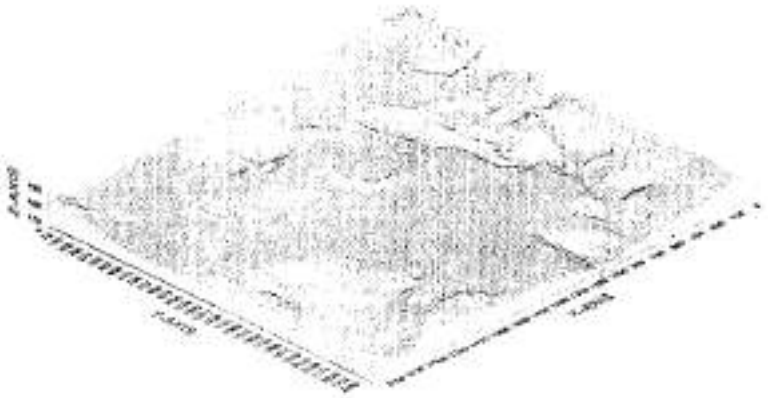

FIG 22b SURFACE POFILE AFTER 15 YRS OF MINING (SHAHPUR EAST BLOCK)

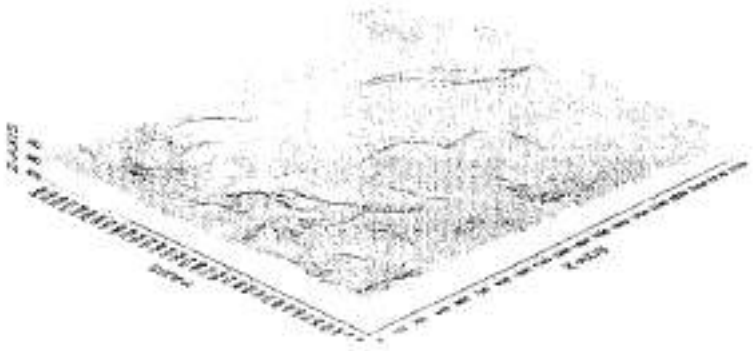

FIG 23a SURFACE POFILE AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

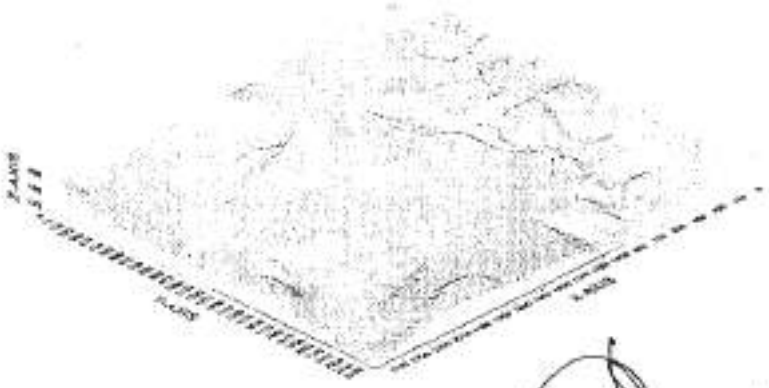

FIG 23b SURFACE POFILE AFTER 20 YRS OF MINING (SHAHPUR EAST BLOCK)

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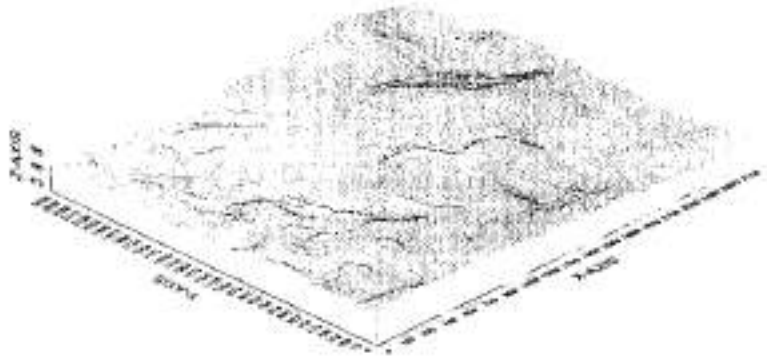

FIG.24a SURFACE POFILE AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

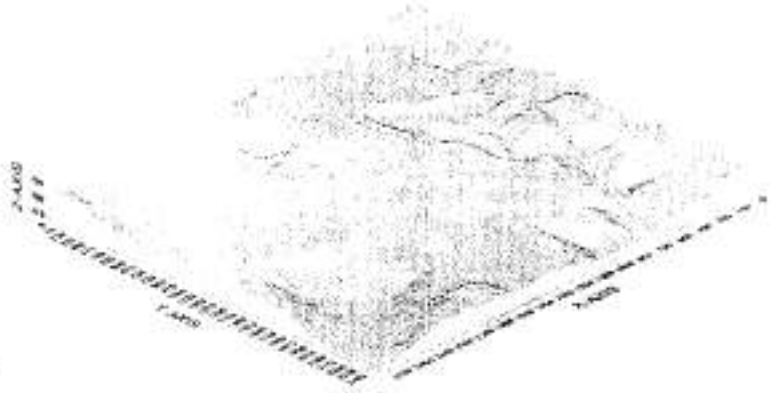

FIG.24b SURFACE POFILE AFTER 25 YRS OF MINING (SHAHPUR EAST BLOCK)

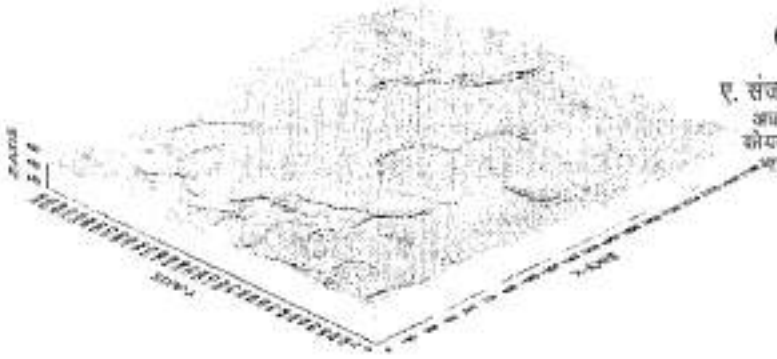

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FIG.25a SURFACE POFILE AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

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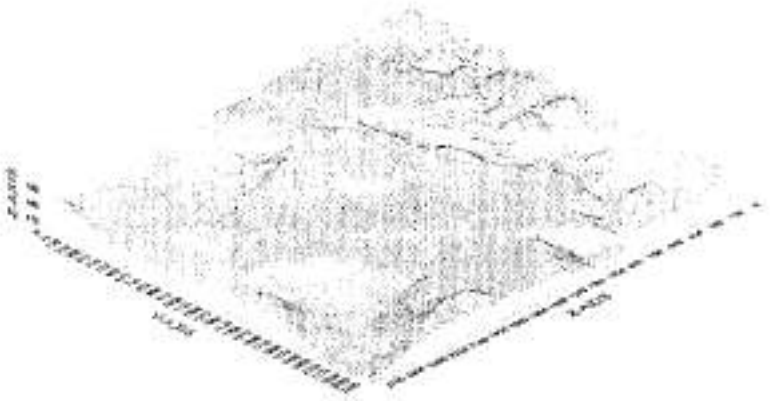

FIG.25b SURFACE POFILE AFTER 30 YRS OF MINING (SHAHPUR EAST BLOCK)

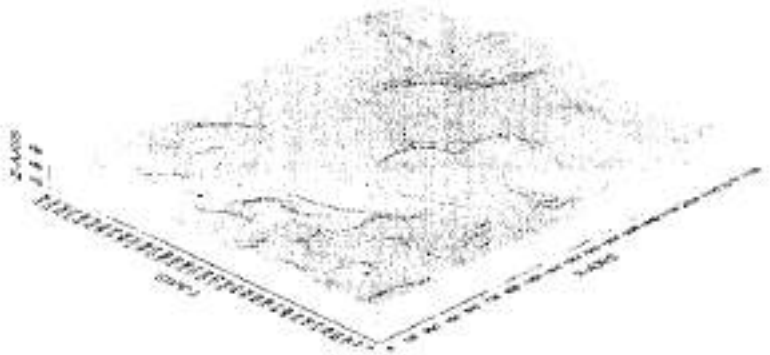

FIG.26a SURFACE POFILE AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

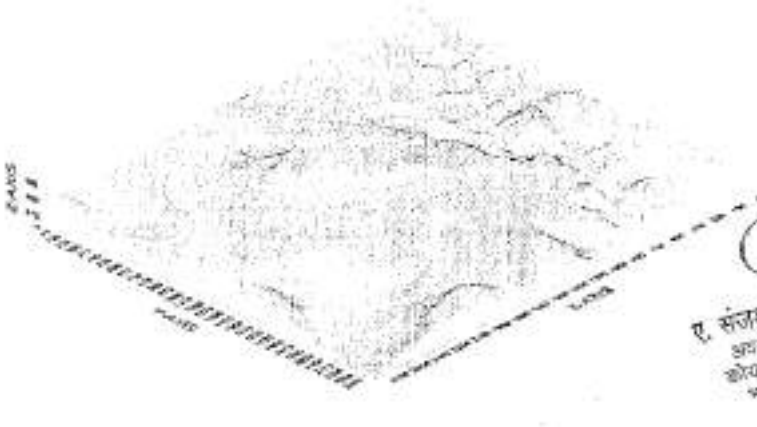

FIG.26b SURFACE POFILE AFTER 33 YRS OF MINING (SHAHPUR EAST BLOCK)

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6.0 TENSILE STRAIN AND CRACK WIDTH

6.1 MAXIMUM TENSILE STRAIN

The maximum predicted tensile strain for Shahpur East Block for various time blocks has been given below in table 6.1.

Table 6.1: Predicted maximum tensile strain for Shahpur East Block at various time blocks

Sl. No.	Time Block (in years)	Tensile Strain (mm/m)
1.	15	7.5
2.	20	8.7
3.	25	8.7
4.	30	9.2
5.	33	9.6

The maximum predicted tensile strain has been predicted for each time block separately and is 7.5 mm/m at the end of 15 years of mining. It remains constant, by and large, till the end of mining.

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6.2 CRACK

It is well established from the field experience that the cracks may occur under the condition of high tension and weak rock. The prediction of cracks width is associated with high degree of uncertainty. Zones of possible cracks will be in the vicinity of weak rocks and near fault planes under high tensile strain. To have accurate prediction, the strain maps should be superimposed over the detailed geological plan

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with geotechnical data. Cracks (more than 200 mm/m) are not likely to be formed due to extraction of the panels.

7.0 DISCUSSION

Fig. 6 through 10 shows the subsidence troughs formed at the end of each time block of 5 years of mining. The Maximum predicted subsidence at the end of 15 years of mining is 0.886 m. The maximum predicted horizontal tensile strain is 7.5 mm/m. The subsidence troughs spread in area and depth at the end of 20 years of mining (1.187). However the maximum predicted horizontal tensile strain increases slightly to 8.7 mm/m. The predicted maximum subsidence and horizontal strain remain constant at the end of 25 years of mining (1.188 m, and 8.7 mm/m). However, the subsidence troughs spread and cover more area. The predicted maximum subsidence at end of 30 years and 33 years of mining are 1.302 m and 1.321 m respectively. The predicted horizontal tensile strain remains, by and large, constant.

Effect of subsidence on surface structures present on the surface need careful examination. There are some villages, a road and a nala passing over the surface.

VILLAGES:- There are habitations of 3 villages (Chunia, Kathotia and Sinduri) lying within the block boundaries. protection pillar of sufficient size has been left below the above mentioned villages. There will not be any effect of subsidence on villages on the surface. Therefore, no subsidence management plan is required for villages.

GHINACHUNIA NALA:- The Ghinachunia nala flowing almost along the western boundary of the block enters the block from its south west corner and exits from the northern boundary and passes through the western part of the block. Protection pillar of sufficient size has been left below the above mentioned Nala. There will not be any effect of subsidence on the Nala. Therefore, no subsidence management plan is required for Ghogra Nala.

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ROAD:- A road passing through the south eastern part of the block which connects Shahdol on north east and Khameria in south west. Protection pillar of sufficient size has been left below the above mentioned Road. There will not be any effect of subsidence on the Road. Therefore, no subsidence management plan is required for the road.

8.0 SUBSIDENCE MANAGEMENT PLAN

Protection pillar of sufficient size has been left below habitations of 3 villages (Chunia, Kathotia and Sinduri), a road passing through the block and a nala over the surface. The formation of subsidence troughs are gentle in nature and predicted horizontal tesile strain is less than 10 mm/m. No damage is likely to occur to the surface structures on the surface.

Therefore, no subsidence management plan has been proposed for this block.

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9.0 CONCLUSION

Shahpur East Coal Block is proposed to be developed and depillared by Bord and Pillar system of mining. The life of the mine is proposed as 33 years. The depillaring operations will start from 10th year of mining.

The analysis shows that the peak subsidence predicted at the end of 15 years, 20 years, 25 years, 30 years and 33 years of mining are 0.886 m, 1.187m, 1.188 m, 1.302 m and 1.302 m respectively. The predicted peak tensile strain for above time blocks are 7.5 mm/m, 8.7 mm/m, 8.7 mm/m, 9.2 mm/m and 9.7 mm/m respectively. The subsidence troughs formed at the surface are gentle in nature and predicted peak horizontal tensile strain is always less than 10 mm/m.

There are many important surface structures on the surface of Shahpur East coal block such as habitations of 3 villages (Chunia, Kathotia and Sinduri Ghinachunia nala,

A road pasing through the south eastern part of the block which connects Shahdol on north east and Khameria in south west. There is no protected forest on the surface.

No damage is likely to occur to the surface structures on the surface. Therefore, no subsidence management plan has been proposed for this block.

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