SUBSIDENCE PREDICTION REPORT
(THROUGH 3-D NUMERICAL MODEL)

DHIRAULI COAL BLOCK
SINGRAULI COALFIELD

STRATATECH MINERAL RESOURCE PRIVATE LIMITED
MADHYA PRADESH (INDIA)

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VARANASI 221 005
UP (INDIA)
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1.0 INTRODUCTION

The Dharauli Coal Block in Singrauli Coalfield, in the State of Madhya Pradesh has been allocated to M/s Stratatech Mineral Resource Private Limited (SMRPL) vide Letter No. NA-104/7/2020-NA dated 03.03.2021 by MoC, GoI.

Dharauli Coal Block is located in Singrauli Coalfield (Main Basin), village(s) Aamdand, Belwar, Dharauli, Jhalari, Phatpani, Amraikhoh, Bansibridha and Sirswah, Tehsil: Sarai,Singrauli district of Madhya Pradesh. The Dharauli coal block boundary coordinates inWGS84 datum as per CMDPA (Coal Mine Development & Production Agreement) is as follows:

List of Cardinal Points

P1: Latitude 23^{0}56'07" Longitude 82^{0}19'04";

P2: Latitude 23^{0}56'07" Longitude 82^{0}24'21";

P3: Latitude 24^{0}03'04" Longitude 82^{0}24'21"

P4: Latitude 24^{0}03'04" Longitude 82^{0}19'04"

The area is covered by Survey of India Toposheet no. 64 I/5-II The total area involved in this project is 2672 ha, out of which 1436.19 ha is forest land.

The block is located at about 70 km south-west of Singrauli township, whereas it is around 50 km south-west of Waidhan township, the District Headquarter of Singrauli District.

1.1 LOCATION & COMMUNICATION

Dharauli Coal Block is located in Singrauli Coalfield (Main Basin), village(s) Aamdand,Belwar, Dharauli, Jhalari, Phatpani, Amraikhoh, Bansibridha and Sirswah, Tehsil: Sarai,Singrauli district of Madhya Pradesh. The block is located at about 70 km south-west of Singrauli township, whereas, it is around 50 km south-west of Waidhan township, the

District Headquarter of Singrauli District. All blocks are well contacted with the tehsil and district headquarter through Major district road followed by NH-75 at 23 Km in N. A metalled road from Parsona to Mara is located further east of the block. An un-metaled road branching out of this at Rajmelan culminates at Sarai. From this road to the west of River Mahan, a north-south running road leads to Langadda via Bhalyatola, Suliyari &Jhalri. The block is also accessible by an all weathermetalled road from Singrauli as well as from Waidhan. The distance of Sarai-Gram, the nearest major railway bstation on Chopan-Singrauli-Katni line of central railway is about 18 km from the block. The nearest Airport is Varanasi which is at a distance of about 250 km from Waidhan. Shakti Nagar is an important industrial town in the vicinity of Singrauli and Waidhan townships. The other very important industrial township & railway station Renukoot is at a distance of 70 km from Waidhan on Chopan-Garwah Road section of eastern railway. Block is traversed by number of fair weathered and forest roads. The important villages in and around the block are Suliyari & Dharauli villages located within the block, while village Jhalri & Majhalipath are located outside, west of the block.

Table 1: Infrastructure Details of Near Project Area

Parameters	Description	Distance (km) from Lease Area	Direction from Lease Area
Nearest Railway Station	Sarai Gram	18	North-West
Nearest Airport	Varanasi	250	North East
Nearest Highway	Waidhan-Sidhi State Highway	20 Km	North
Nearest Major Settlement	8 villages within the mine	-	-
Nearest Water Body	Hurdul Nala	0.0	Flows from east to west

Source: (i) Satellite Imagery of Study Area; (ii) Open Series Map (SOI) Sheet No. 63 L/4, 63L/8, 64 I/1 & 64 I/5; (iii) Google Earth Inc

1.2 TOPOGRAPHY and DRAINAGE

Western part of Dharauli block is characterized by almost plain topography, while, north-eastern and south-central part are highly undulating and have rugged topography as evident from the topographical plan. The northeastern and south central part of the block have forest cover and is occupied by hillocks of elevation up to a maximum of 638 m above MSL. In general elevation of ground varies from 459.23m as observed near borehole MSD-102 to 603.45 m near borehole MDP-19 located in the south-western and south-eastern corner of the block respectively.

Drainage of the block is mainly controlled by westerly flowing Hurdul Nala which traverses the block and passes almost through central part of the block. Many small seasonal nallas originating from elevated topography of north eastern and south central part of the block drain its water into HurdulNala. The minor nallas and tributaries present in the block shows dendritic to sub-dendritic drainage pattern.

1.3 FOREST COVER AND LAND FORM

The administrative jurisdiction of proposed Dharauli coal mine comes under SingrauliForest Division. Out of the lease hold area of 2672 ha only 1436.19 ha is forest land.

Table2: Lease Hold Area

Type of Land	Area (ha)
Forest Land	1436.19
Non-Forest Land	1235.81
Total	**2672.001**

1.4 CLIMATE

Climate of the area is characterized by hot dry summer as welldistributed rainfall in the monsoon season. The summer season beginsfrom March and extends up to May with maximum temperature rising upto 48°C during the peak period. The monsoon period extends from Juneto September with an average rainfall of 1132.7 mm. The winter season commences in early November up to February with the mean daily temperature of 8.1°C.

2.0 GEOLOGY

The geology of the district reveals that the Occurrence of various works formation as old as granites of Achaean age to the Alluvium of Recent age. The other important formations Outcropping in the district are Deccan trap of cretaceous – Eocene, Gondwanas of Paleozoic to Mesozoic Sandstone and other ranks of Vindhayans and Phyllites. Quartzites, Schist Gneisses and Granites of Archeans age. The Geology of the district is shown in the Hydrogeogical Map. The general Stratigraphical Succession obtained in the district is given as under:

Table 3: Geology of the Area

Period	Series/Stage	Lithology	
Recent Pleistocene	Alluvium	Allvium and soil cap comprising clay, sand gravel etc.	
Cretaceous to Eocene	Deccan Trap	Basaltic Lava flows	
Permian to Carboniferous	Gondwanas	Upper Gondwana formation Ranging formation Talchir formation	Sandstone Shale eval conglomerate and glauconite
Cambrian	Vindhyans	Kaimur Series Semri Series	Porcellinite sandstone Orthoquartzite and conglometry
Pre-Cambrian	Archeans	Phyite, Quartzites, Granite, Schist, gneisses metabasic sedimentary and inhusives	

Geology of Singrauli Coal Field:

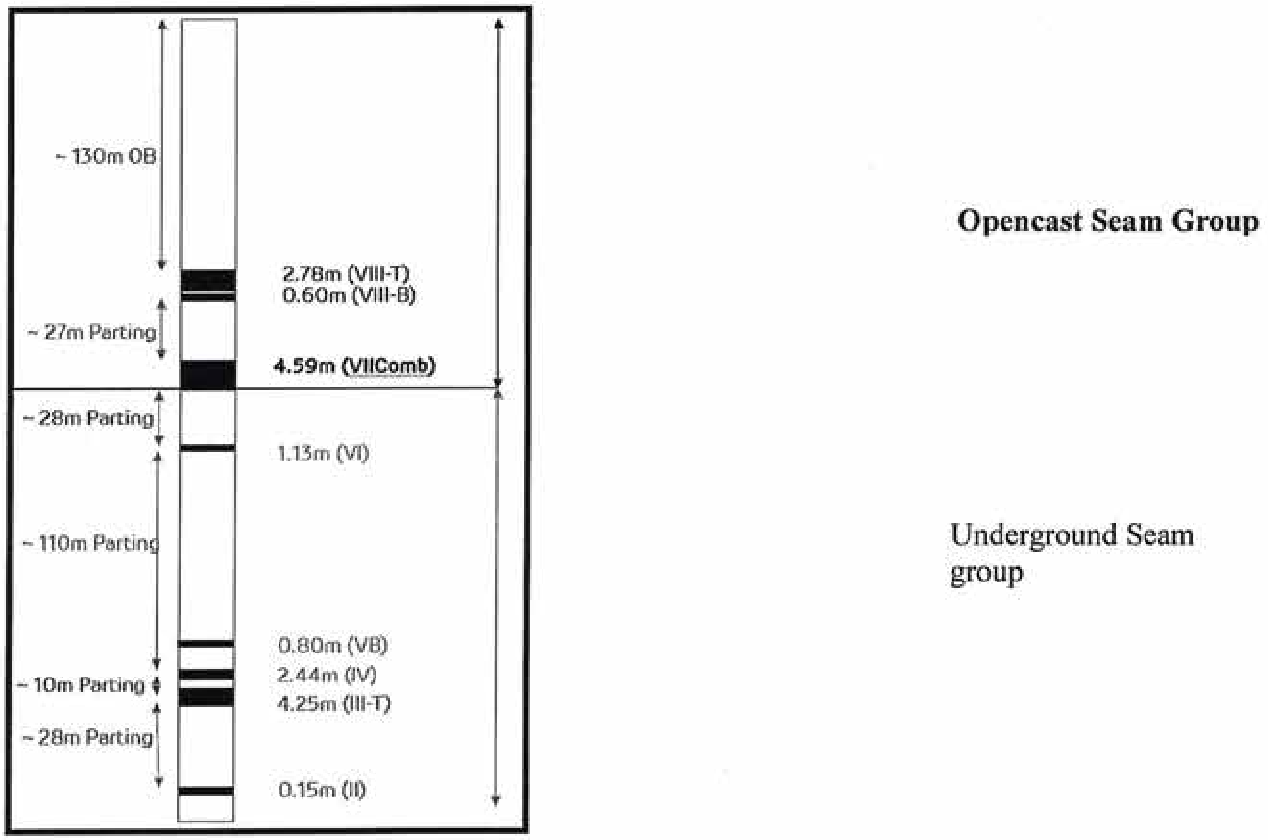
Singrauli coalfield forms the northern extremity of Son-Mahanadi master Gondwana basin, at the junction region of east-west trending Damodar-Koel-Tatapanigarben and the NW-SE trending Son-Mahanadi rift zone; thus, reflecting the lithological and structural characteristics of both Damodar and Son valley Gondwana basins. The northern limit of the Singrauli coalfield is defined by a major east-west trending northern boundary fault, which is parallel to the Narmada-Son lineament. High standing Mahadeva hills are defining the southern boundary. Talchir beds rest un-conformably over Precambrian rocks and the Precambrian themselves are forming the eastern boundary whereas the western boundary is formed by the contact of Precambrian and Supra Barakar sediments.

Geology of Dharauli Block:

The Dharauli block is traversed by 11 normal gravity faults designated as F1-F1 to F11-F11. There are two sets of faults - one trending NW-SE and the other trending NE-SW. The magnitude of these faults varies from 5 m to 85 m within the block. The faults have been deciphered based on the floor level difference observed on either side of the fault planes and on the basis of borehole intersections. It is pertinent to mention here that the numbers of minor slips are also observed in boreholes causing insignificant reduction of parting and seam thickness. It is seen that, out of 11 faults interpreted, 10 faults are of low magnitude having throw between 5 m to 35 m except fault F9-F9 which is having maximum 85 m of throw. In general, the strike varies from NW-SW in the entire area of the block to almost E-W in the southern part of the block with gentle dip of 2° to 4° north-easterly to north and south-westerly to south at places. The net geological and mineable reserves estimated for both open cast and underground mining is 558.01 Mt and 313.79 Mt respectively

3.0 METHOD OF WORKING

Considering the geo-mining characteristics of the block and for conservation of resource, it is proposed to extract the coal reserves within the block using combination of open cast mining (upto seam VII) and underground mining (below Seam VII to Seam II) method.



Opencast limit is planned upto seam VII floor due to thick parting and thin coal seams below seam VII.

Mine opening is planned from southwest corner of block (in-crop of seam VII) and further development is planned along strike of the seam. The opencast mine is planned up to 280 m depth

Underground mining

Mine Boundary

Limit of underground mining is defined by half of the pillar width (24m), all along the block boundary and workable thickness (1.5 m) of underground seams.

There will be four accesses to the seams in each sector – two shaft and two inclines. One incline will be for coal evacuation by a belt conveyor and will also be used as air intake for each sector. Second incline will be used for man and material transport and also as air intake for ventilation purpose each sector. Two shaft will be used as return air shaft equipped with main mechanical ventilator in each sector.

The main parameters of the sector wise openings are proposed in below table-

Sl. No.	Name	Purpose	Length / Depth (m)	Size of Entry	Type of Support
			Sector I		
1	Incline 1	Evacuating of coal by Belt conveyor, Intake	406	5.5m x 3.3m	Roof bolting. Wire mesh & W-straps and yielding access where necessary. Girders in interconnection
2	Incline 2	Haulage for material & traveling of Man, Intake	410	5.5m x 3.3m	Roof bolting. Wire mesh, W-straps & yielding access where necessary. Girders in interconnection
3	Air Shaft 1	Return Air	85	6.0m diameter	RCC/MCC lined through out
4	Air Shaft 2	Return Air	224	6.0m diameter	RCC/MCC lined through out
			Sector II		
1	Incline 3	Evacuating of coal by Belt conveyor, Intake	1168	5.5m x 3.3m	Roof bolting. Wire mesh & W-straps and yielding access where necessary. Girders in interconnection
2	Incline 4	Haulage for	1174	5.5m x	Roof bolting. Wire mesh,

		material & traveling of Man, Intake		3.3m	W-straps & yielding access where necessary. Girders in interconnection
3	Air Shaft 3	Return Air	215	6.0m diameter	RCC/MCC lined through out
4	Air Shaft 4	Return Air	367	6.0m diameter	RCC/MCC lined through out

Rated Capacity – Dharauli Coal Block underground mining has been planned for a rated capacity of 1.5 mtpy. This output is considered technically feasible because of seam thickness, seam occurrence (mostly patchy), geological disturbance (11 faults dip side), parallel opencast mining operation, limited strike length which is further divided into small sub sectors due to dip side faults.

Mining Scheme

The general orientation of the block is North-South (~9.9 x 2.7 km) and coal extraction by underground mining is proposed by two set of inclines seeing the dip rise length (9.9 km) of block. First set of inclines is planned to cover Northern Sector (~ 4 km length) and second set of inclines for Southern sector (~ 5.9 km length). Two Inclines and one air shaft are proposed at western side of block boundary and other air shaft will be driven separately for at eastern side of block.

The underground mining will be first start in the northern part of ML area with Incline No.3 and No.4. The dimensions of the inclines are 5.5 M x 3.3 m with gradient of 1 in 5. The entry of inclines are located on borehole No. MSD-65 at Surface RL 490m and are aligned towards borehole No. MSD-15. The Incline will reach the floor of seam II at 230 m FRL and will have a length of ~1174m crossing Seam VI to III Top and partings. Production from these inclines will start from the 3rd year of mine operation which includes two years of development work (Drivage of inclines and air shaft). The northern sector will be operational for 22 years (including ramp up and ramp down period) with peak production of 1.5 Mtpa.

Second set of Inclines named as incline no. 1 and 2 is proposed to access southern sector. The dimensions of the inclines are 5.5 M x 3.3 m with gradient of 1 in 5. The entry of Inclines are located on borehole No. MSD-107 at Surface RL 460m and are aligned towards borehole No. MSD-59. The Incline will reach the floor of seam III at 380 m FRL and will have a length of ~410m crossing Seam VI to III Top and partings. Seam II is not developed in this sector therefore the incline are not planned up to seam II. Production from the Southern inclines will start from the 12th year and will be operational up to 38 years (including ramp up and ramp down period) with peak production of 1.5 Mtpa. Southern side incline cannot be started early because of keeping lag of 300 m from opencast mine operation for safe Mine Operation

Support system

A. During Development:

1. All the development galleries will be supported as per the approved systematic support rules
2. All development galleries in coal are proposed to be supported by five non-retractable resin grouted roof bolts of 1.8m length for VI, IV, II and combined III Top Seams, in one row for Sector-I & II . The bolts will be made of 22mm diameter high tensile strength Tor Steel.
3. The distance between the rows of roof bolts as well as between two bolts in the same row shall be 1.2m. The roof bolts nearest to the pillar shall be kept 0.60m away from the edge of the pillars.

4. In geologically disturbed areas and in junctions the galleries should be additionally supported by roof bolts of 1.8m / 2.4m length with w-straps.

5. In extreme bad condition additional supporting with steel girders shall be provided.

6. Support system shall follow the DGMS approved Systematic Support Plan.

B. During Depillaring Stage:

1. During the extraction of pillars, additional supporting will be required at the goaf edges in the form of breaker line support in order to facilitate caving. The breaker line support roof bolts will be of 2.4m length with 0.8m grid pattern which will be placed during development of split galleries only. The first bolt in a row shall be 0.20m away from the edge of the pillar.

2. If need be, sides of the pillars are to be supported by two Fiber-glass/reinforced plastic (GPR) based rib bolts of 1.8m length. This support may be required where the height of extraction is more than 3m or areas where spalling of coal pillar is observed.

4.0 PERIOD OF PREDICTION

The time period for the prediction of subsidence required is 65 years as given by the company.

Stage-I	up to 20 years
Stage-II	20 to 30 years
Stage-III	30 to 40 years
Stage-IV	40 to 50 years (only development)
Stage-V	50 to 60 years
Stage-VI	60 to 70 years
Stage-VII	73 to 78 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 Dharauli Project 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 VI seam, IV seam, III seam and II seam. The simulated mine plan has a scale of 1:5000, same as that provided by the mining company.

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.

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

S.L. No.	Bore hole No.	X-Co-ordinate (m)	Y-Co-ordinate (m)
1	MDP-20	2963	6127
2	MDP-22	6749	2404
3	MSD-6	2092	6062
4	MSD-50	3258	1780
5	MSD-100	7716	374

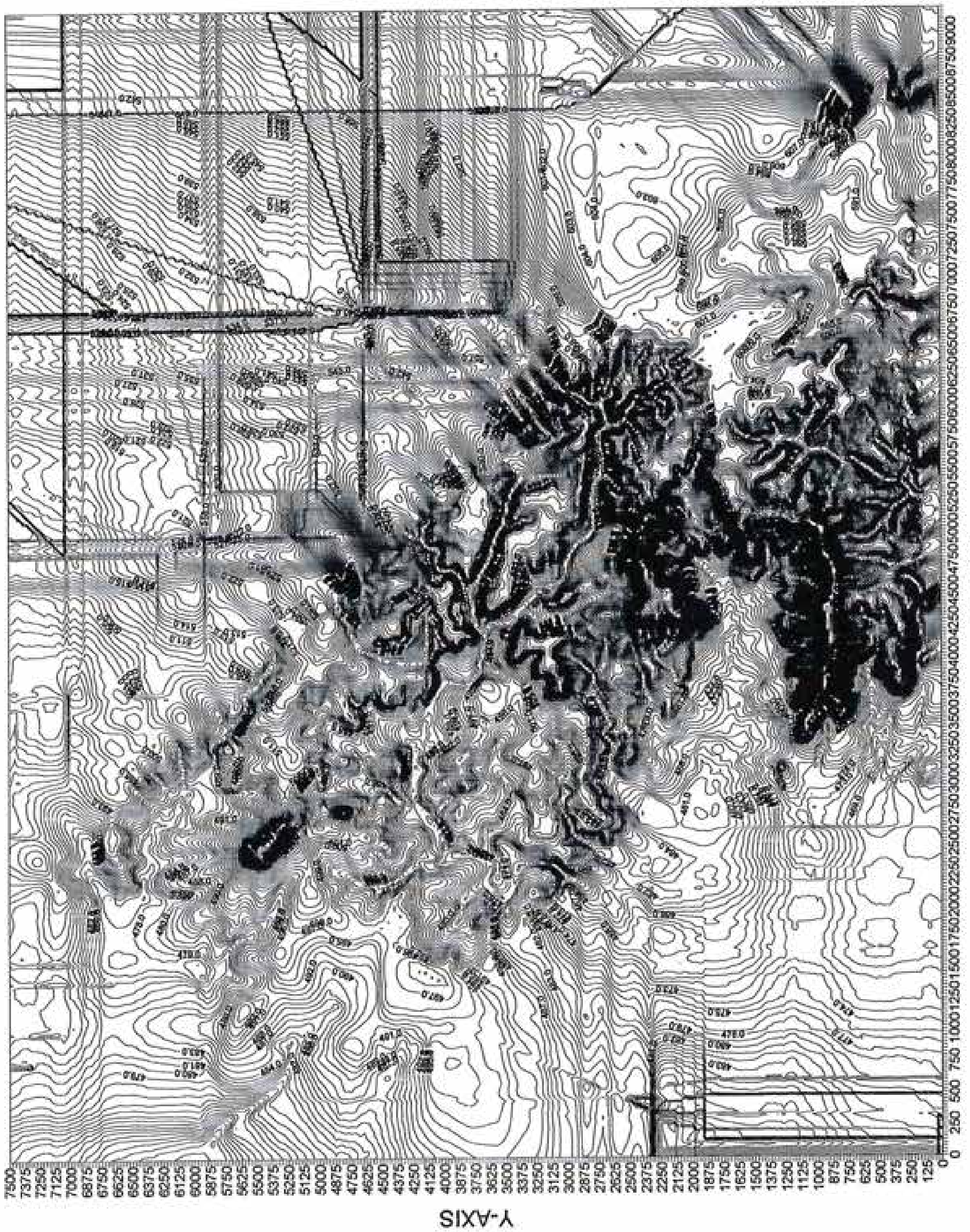


FIG.1 SURFACE CONTOURS BEFORE MINING (DHARAULI UG PROJECT)

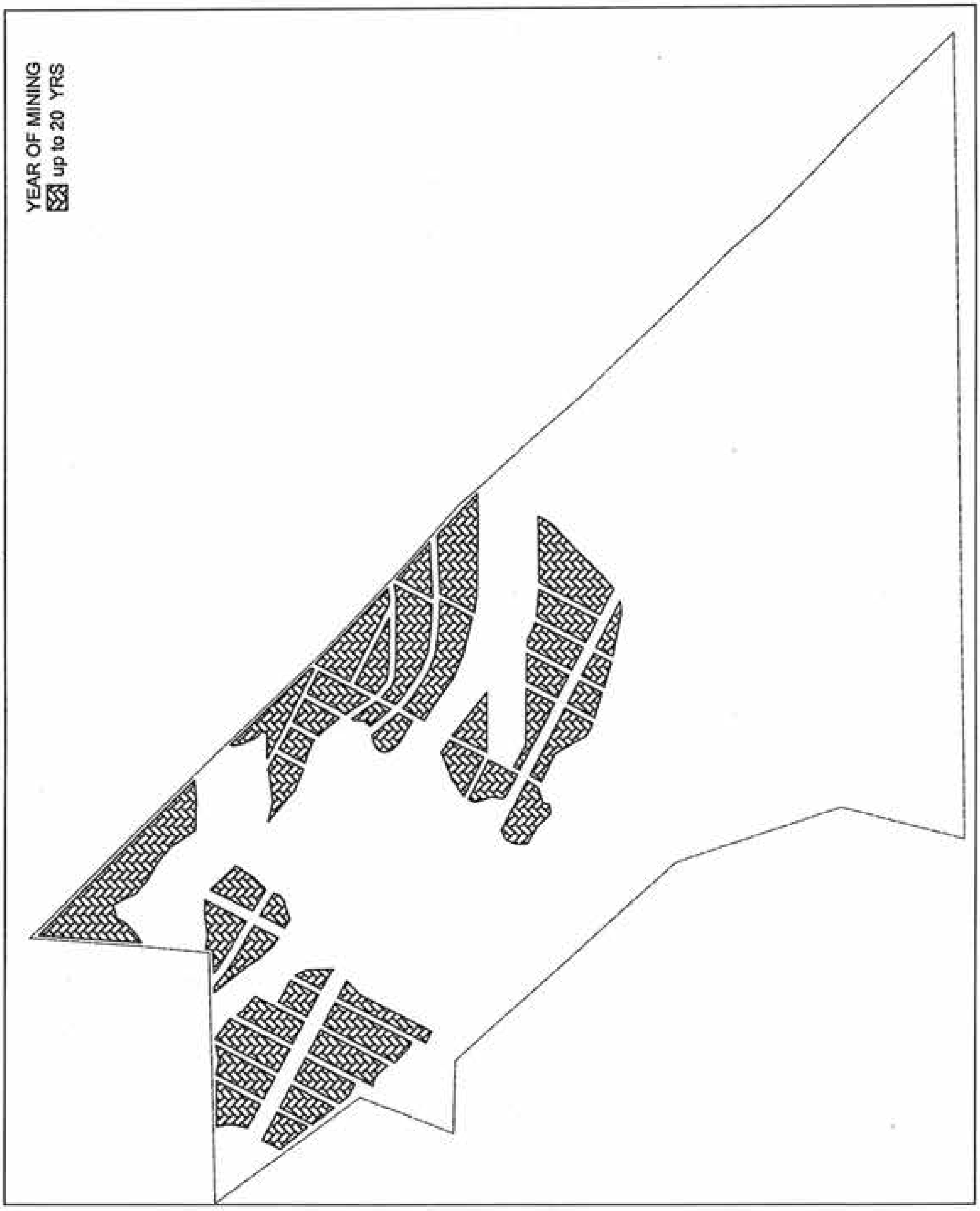


FIG.2 SIMULATED GRID MAP OF SEAM VI (DHARAULI UG PROJECT)

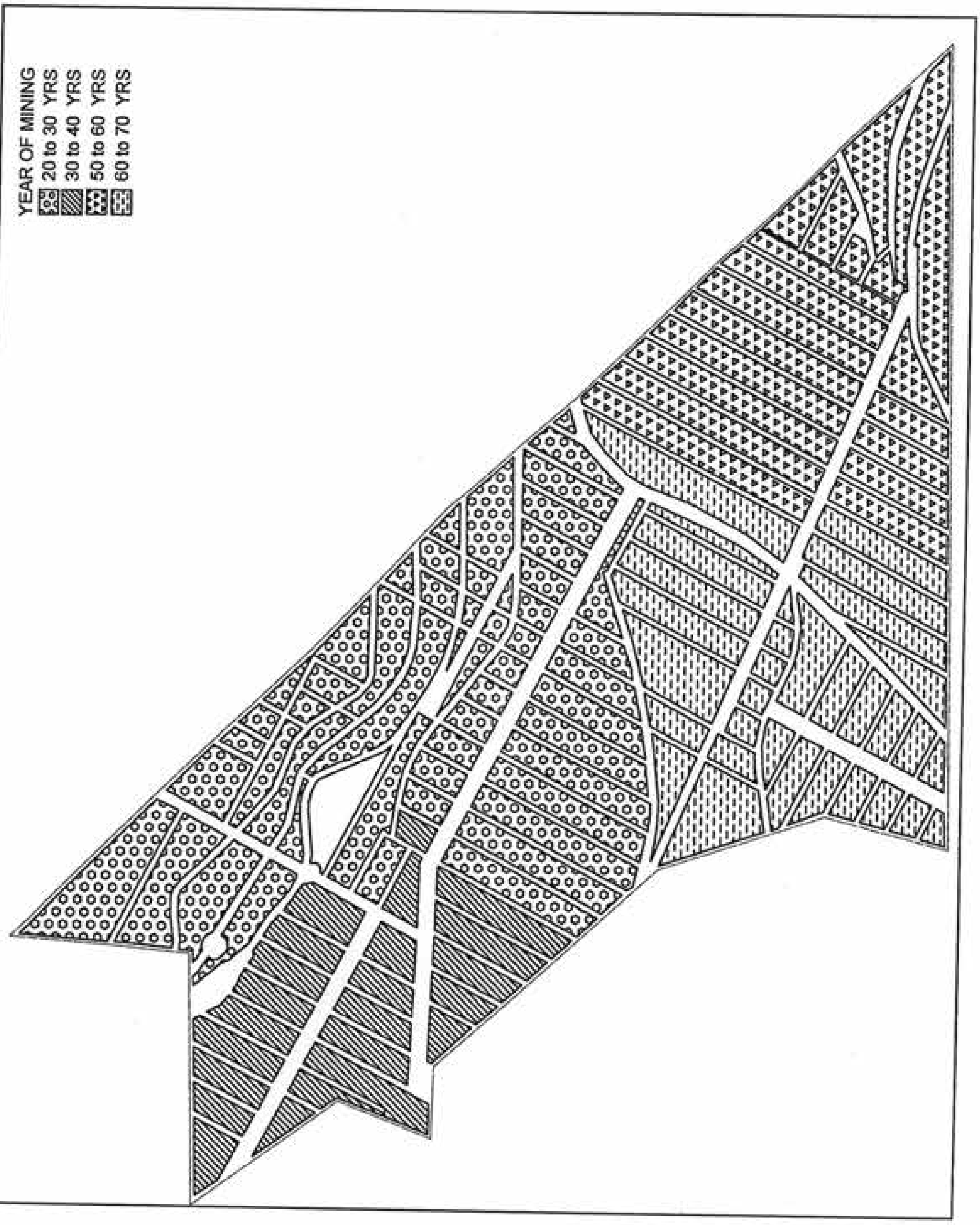


FIG.3 SIMULATED GRID MAP OF SEAM IV (DHARAULI UG PROJECT)

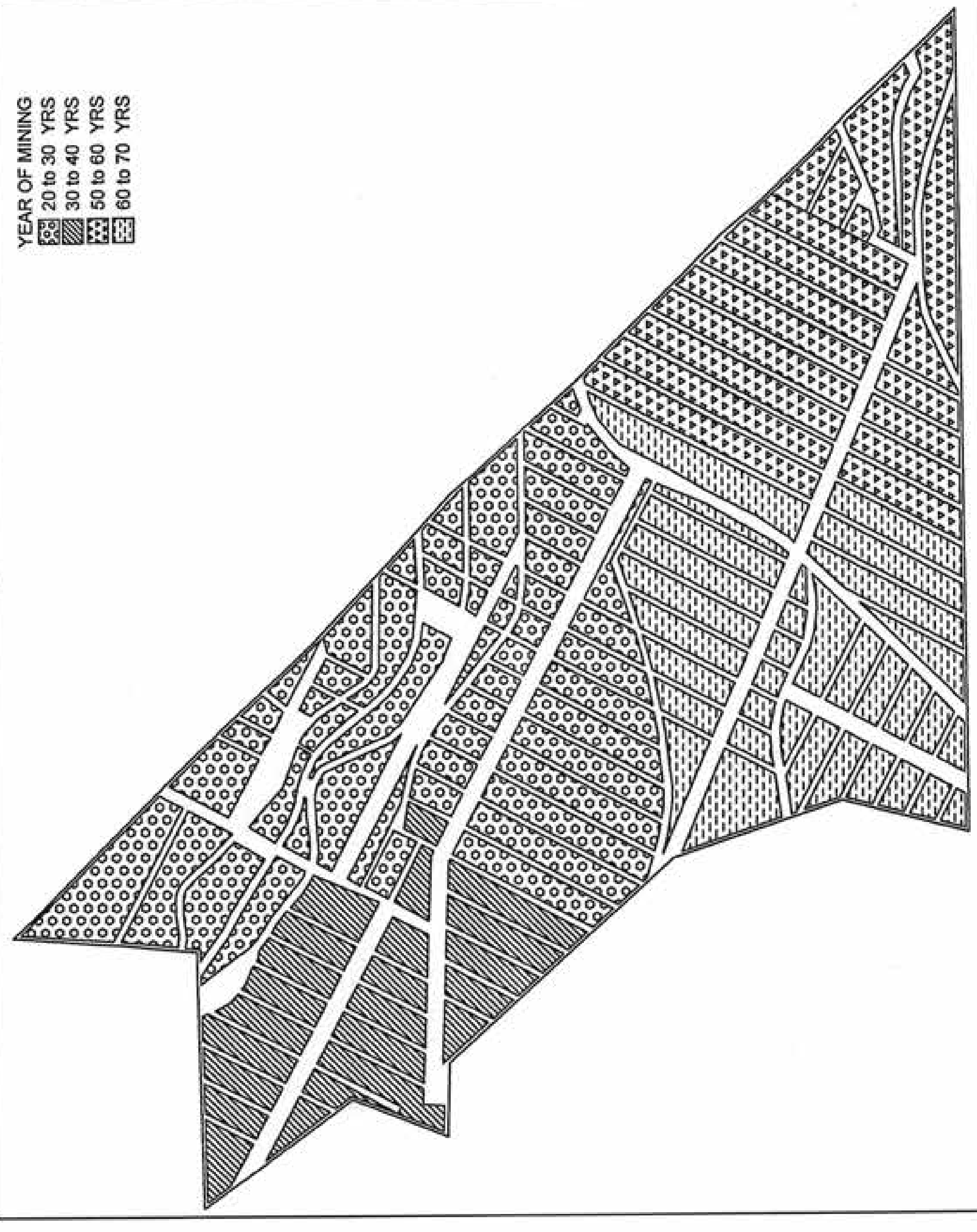


FIG.4 SIMULATED GRID MAP OF SEAM III (DHARAULI UG PROJECT)

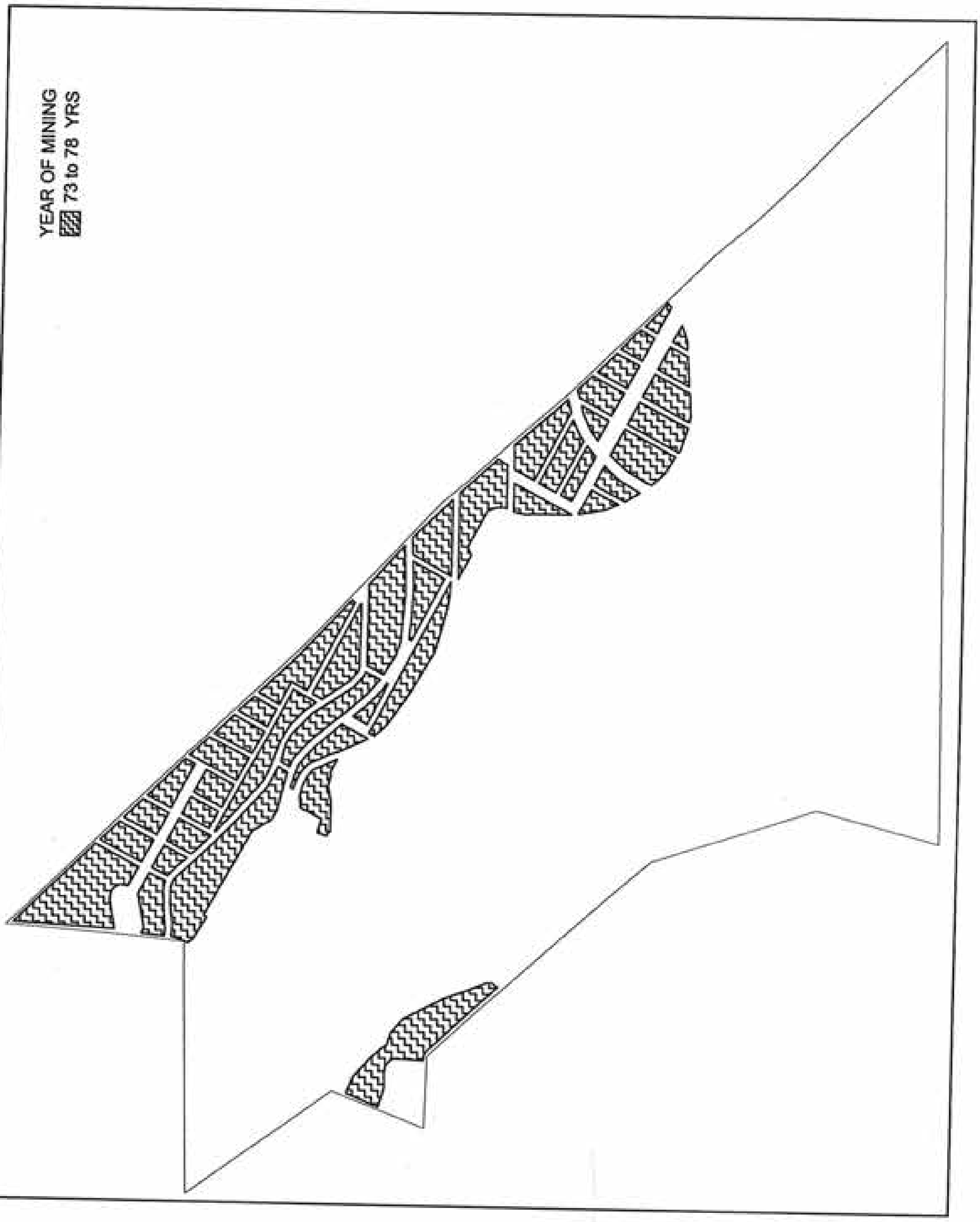


FIG.5 SIMULATED GRID MAP OF SEAM II (DHARAULI UG PROJECT)

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.

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 20 m grid on the surface having about 111000 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. 6 shows the subsidence contours after up to 20 years of mining. Similarly, Fig. 7, Fig. 8, Fig. 9, Fig. 10 and Fig. 11 give the subsidence contours at the end of 30 year, 40 year, 60 year, 70 year and 78 year 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, m
1.	up to 20	0.862
2.	20 to 30	2.384
3.	30 to 40	2.391
4.	50 to 60	2.391
5.	60 to 70	2.716
6.	73 to 78	2.716

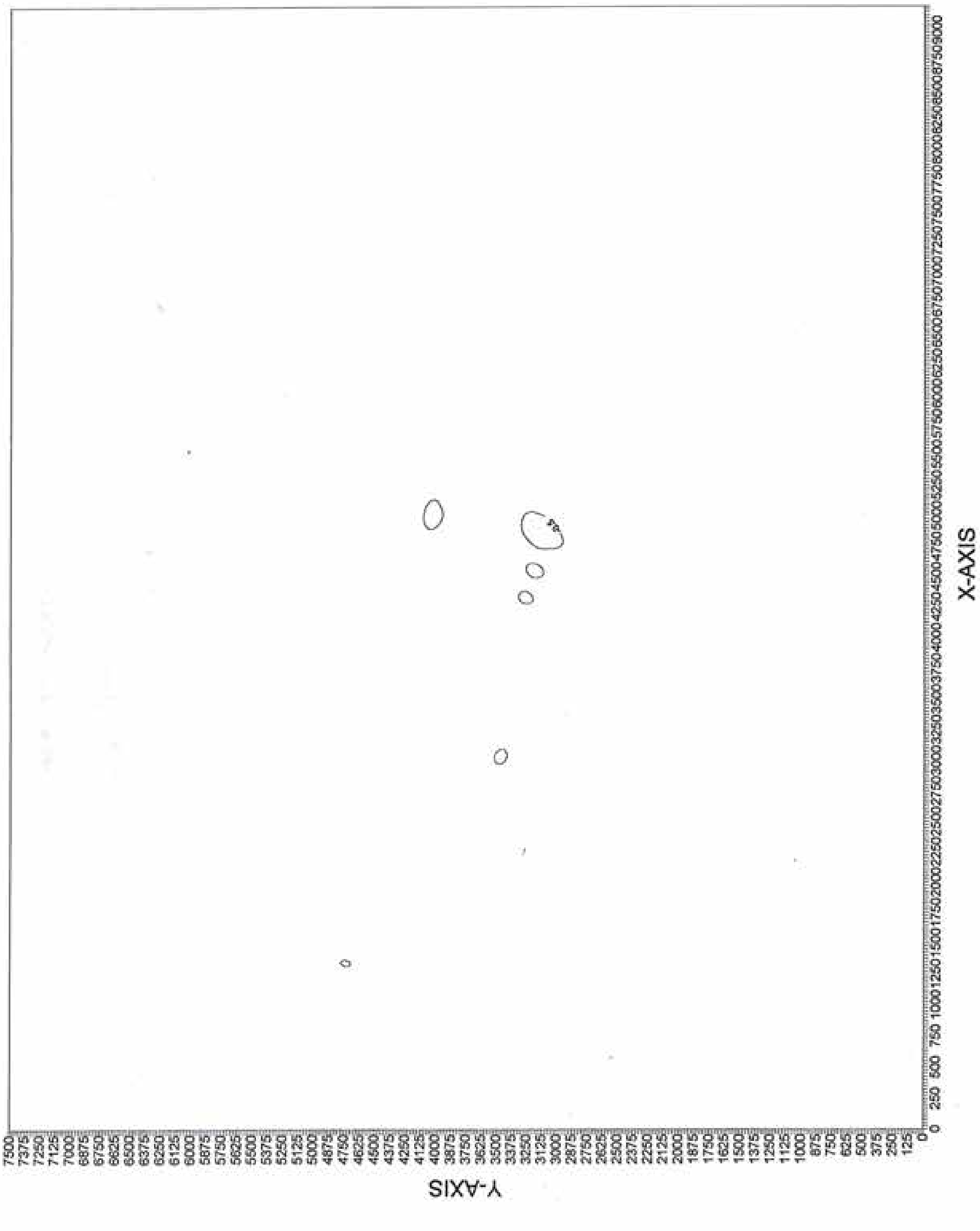


FIG.6 SUBSIDENCE CONTOURS UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

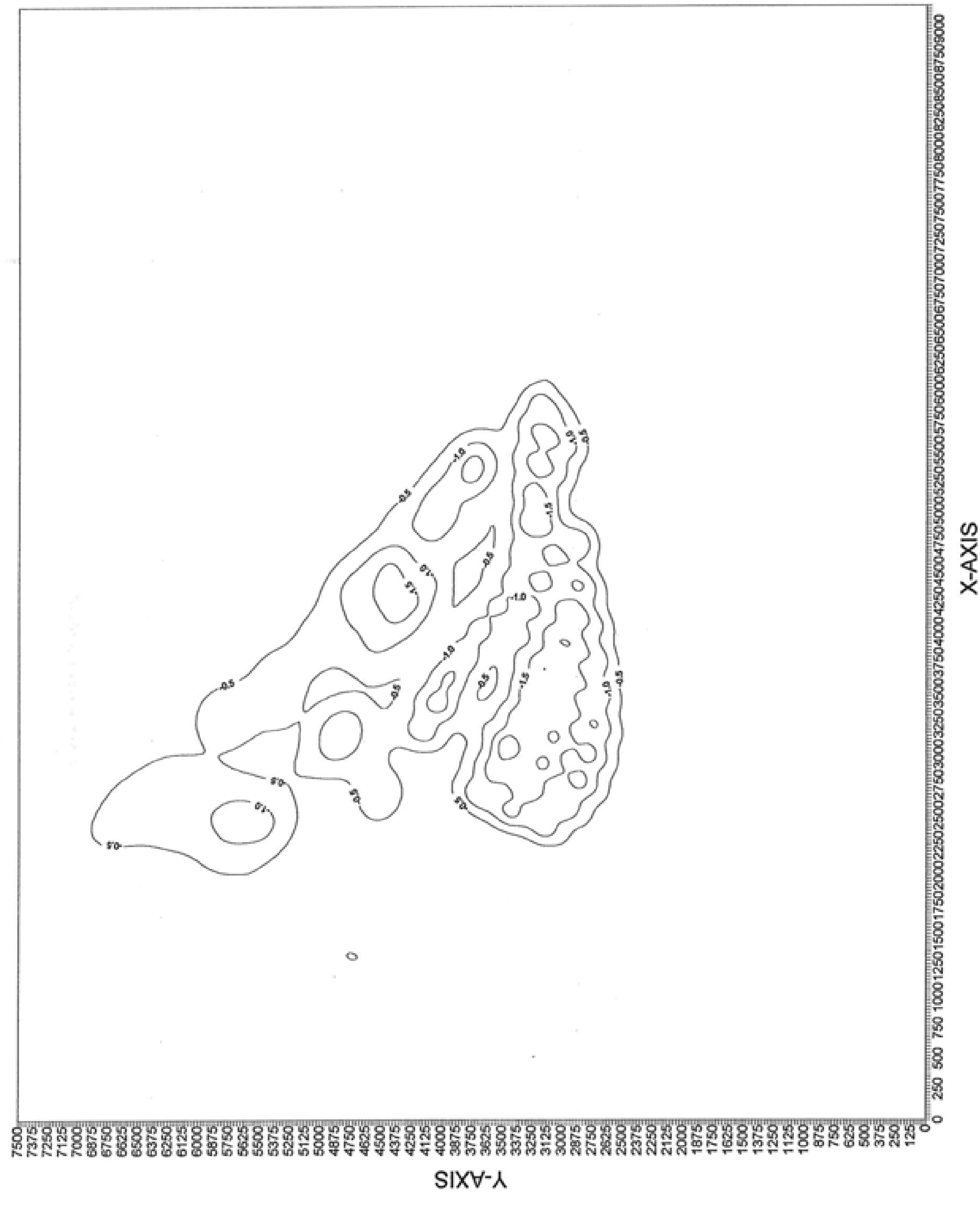


FIG.7 SUBSIDENCE CONTOURS AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

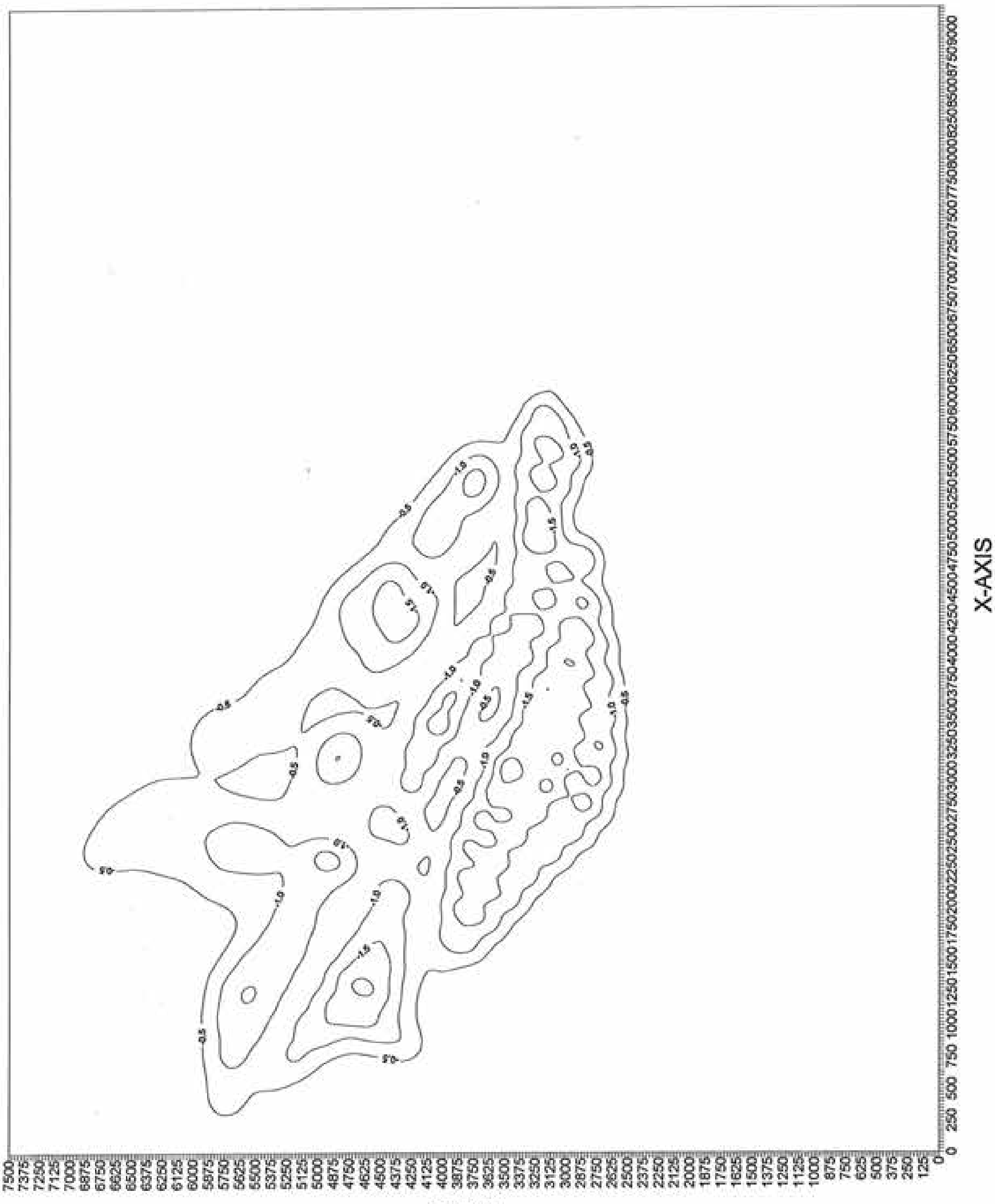


FIG.8 SUBSIDENCE CONTOURS AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

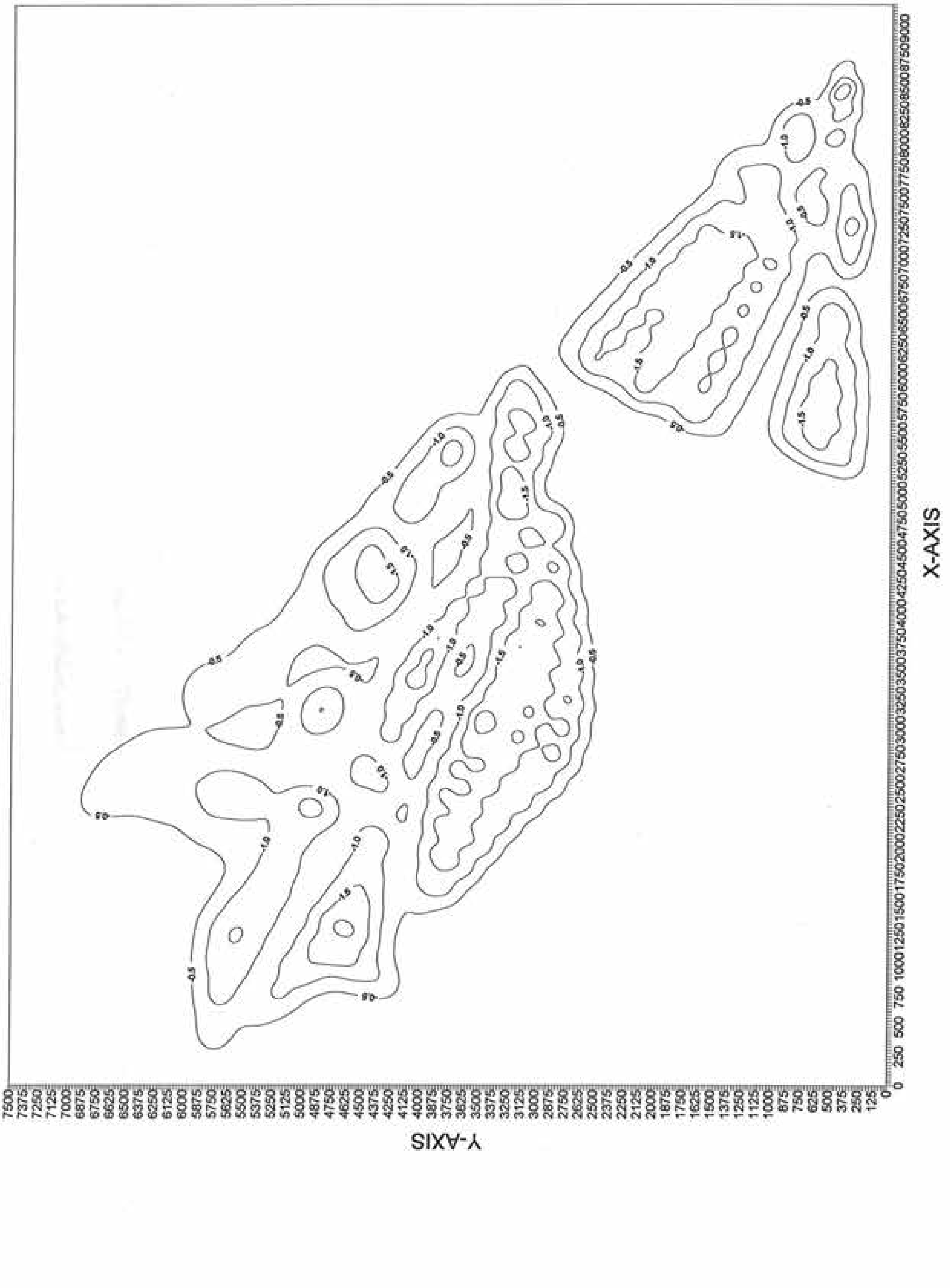


FIG.9 SUBSIDENCE CONTOURS AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

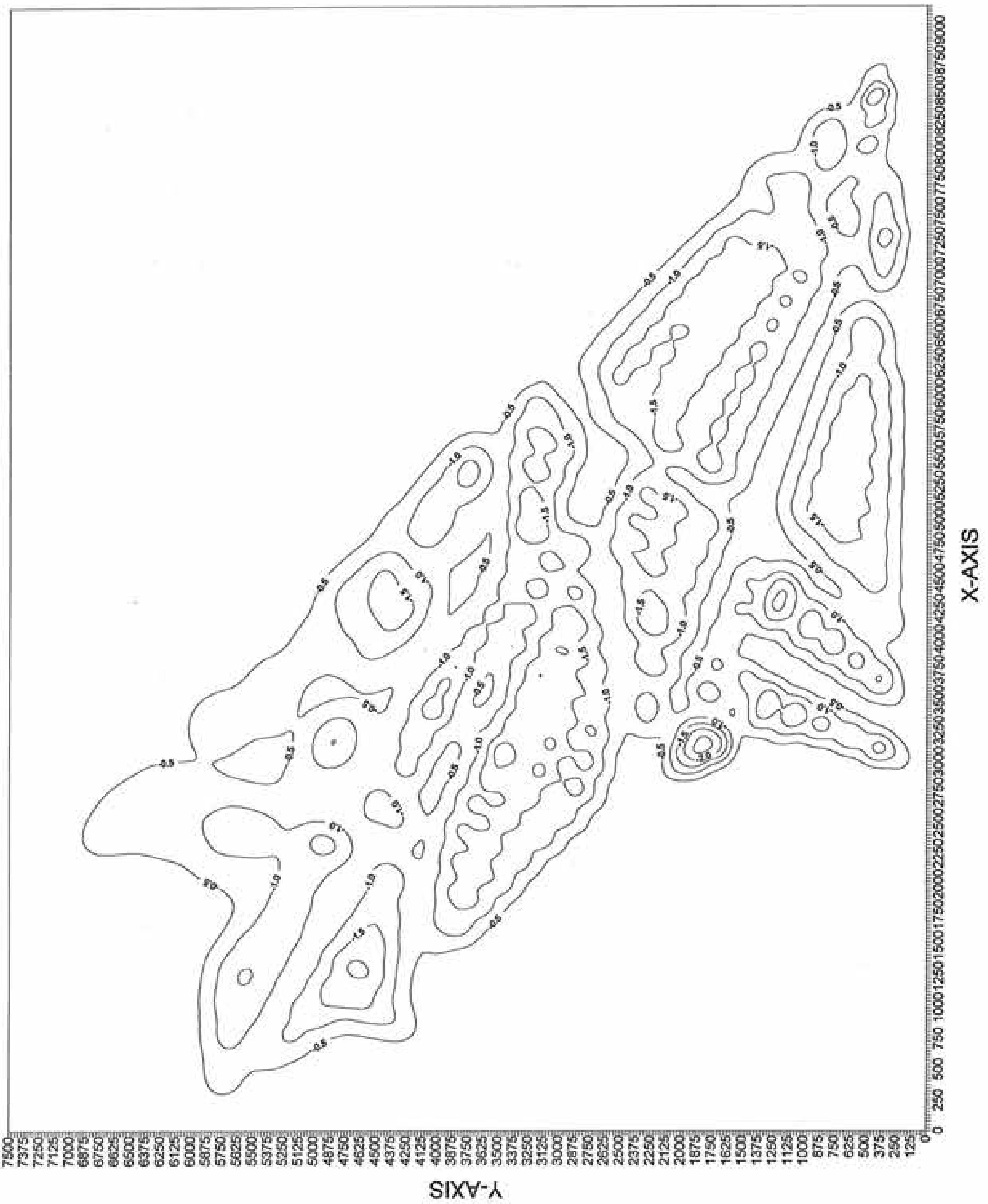


FIG.10 SUBSIDENCE CONTOURS AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

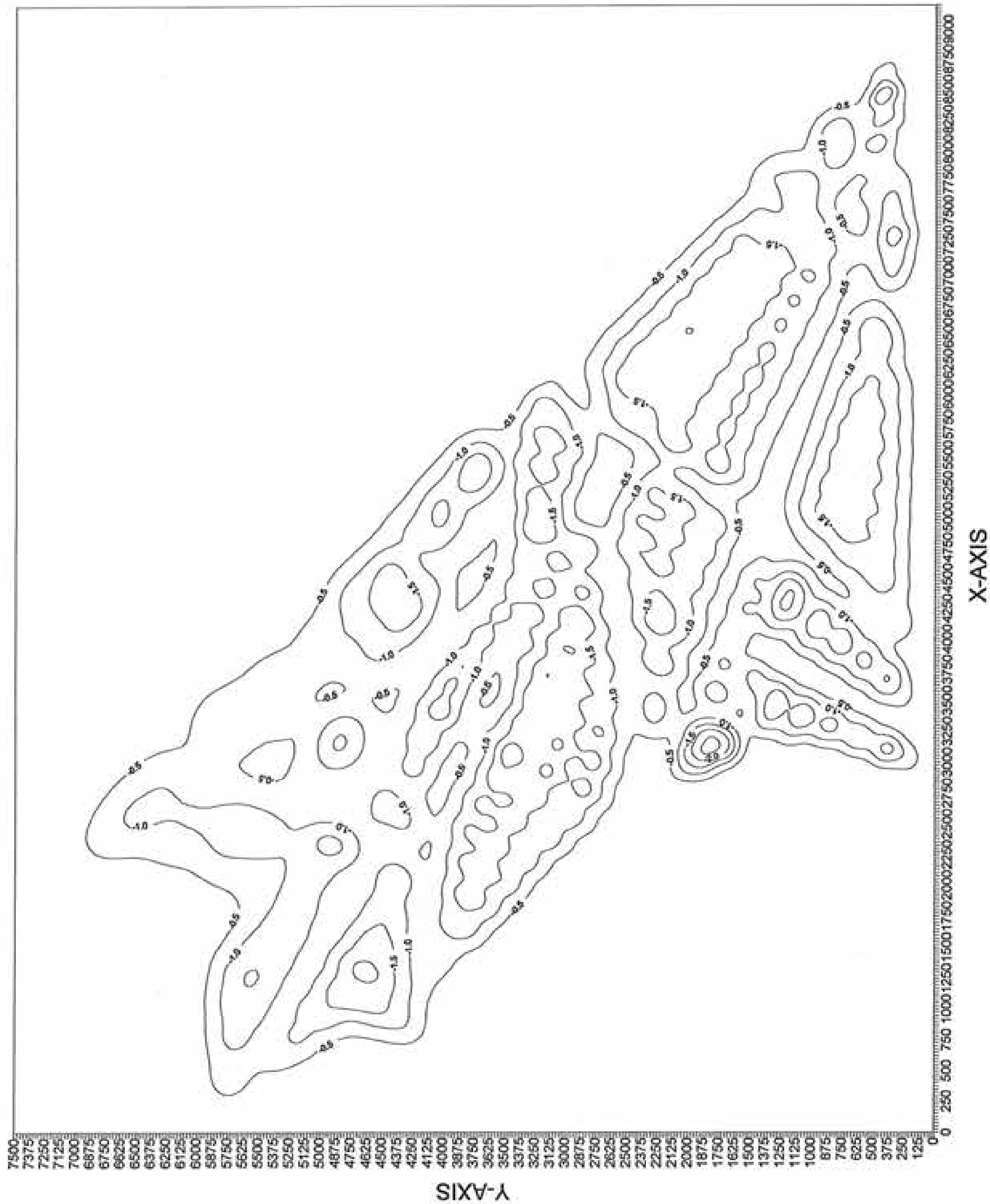


FIG.11 SUBSIDENCE CONTOURS AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

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. 12 through 17 give prediction of the subsidence at the end of 20 year, 30 year, 40 year, 60 year, 70 year and 78 year 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 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 12 through 17 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 20 times to have appreciable viewing impact.

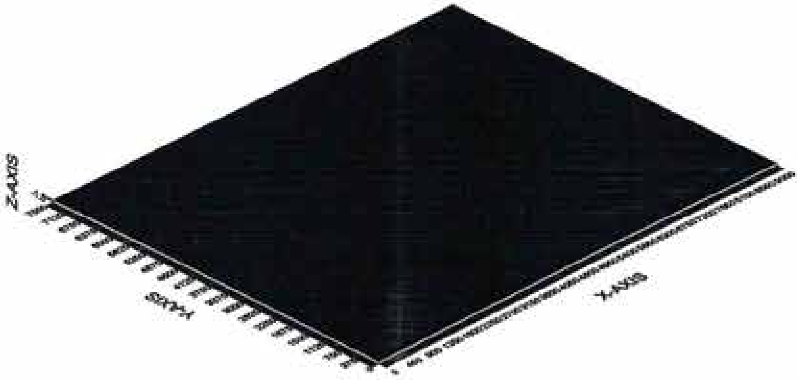


FIG.12a SUBSIDENCE PROFILE UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

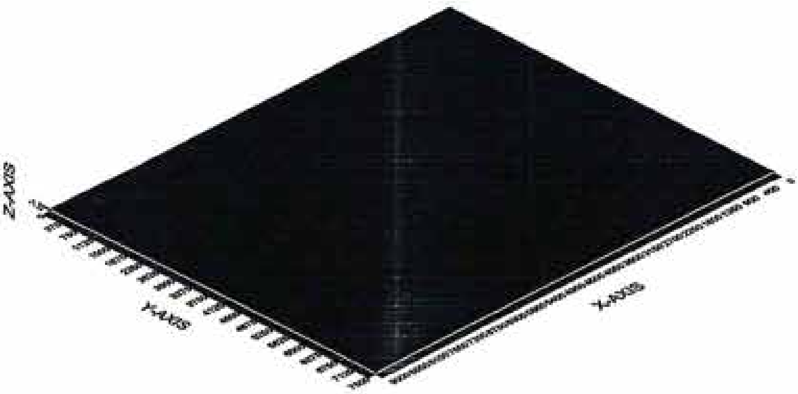


FIG.12b SUBSIDENCE PROFILE UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

FIG.13a SUBSIDENCE PROFILE AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

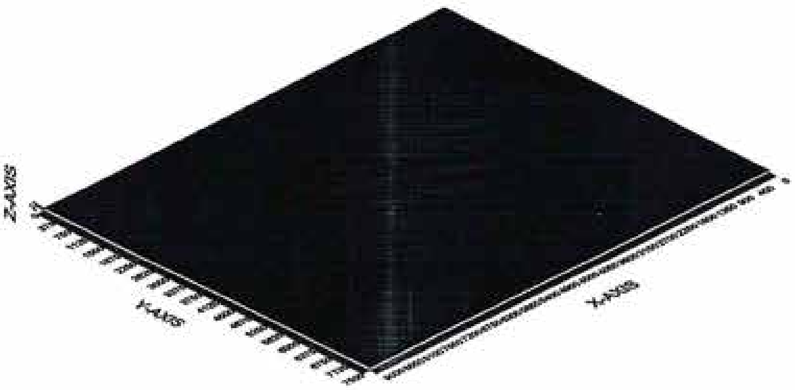


FIG.13b SUBSIDENCE PROFILE AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

FIG.14a SUBSIDENCE PROFILE AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

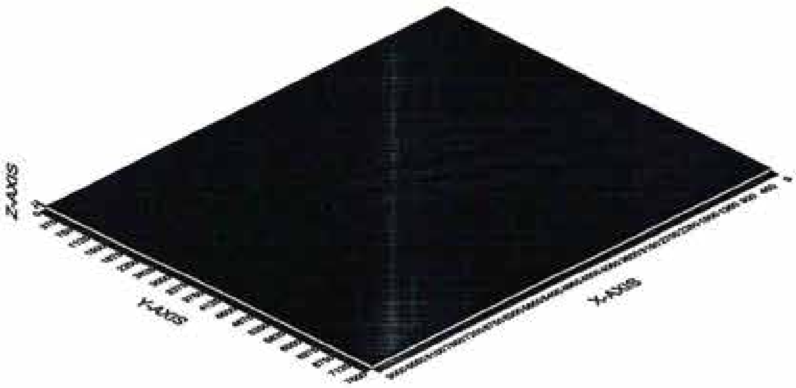


FIG.14b SUBSIDENCE PROFILE AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

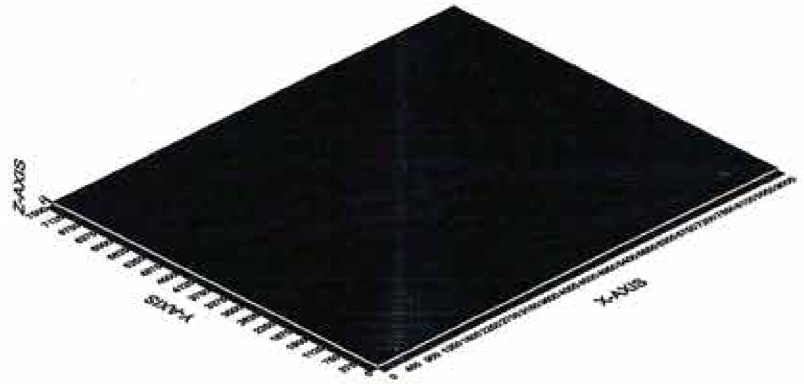


FIG.15a SUBSIDENCE PROFILE AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

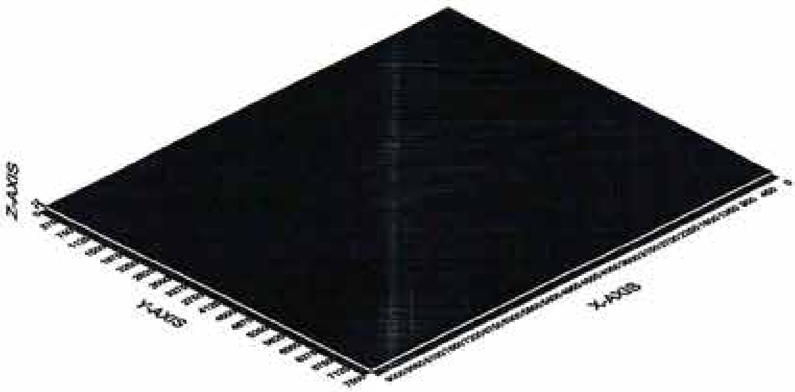


FIG.15b SUBSIDENCE PROFILE AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

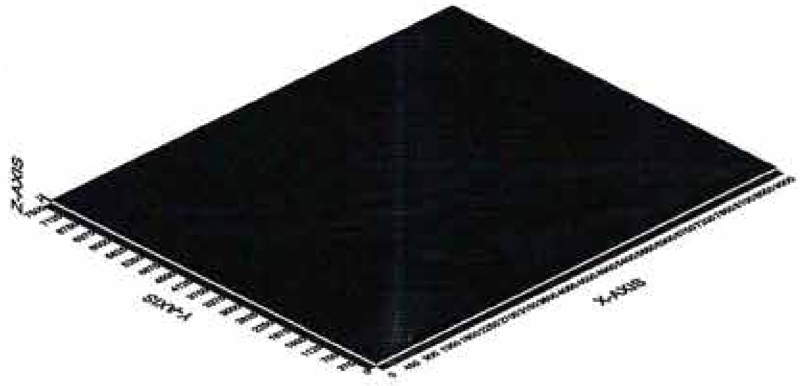


FIG.16a SUBSIDENCE PROFILE AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

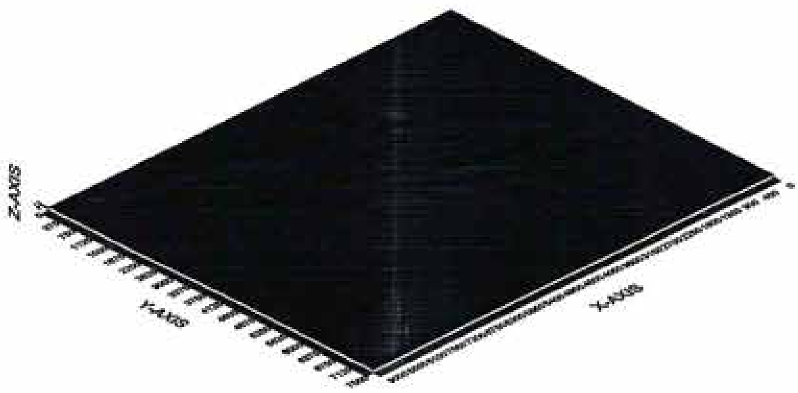


FIG.16b SUBSIDENCE PROFILE AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

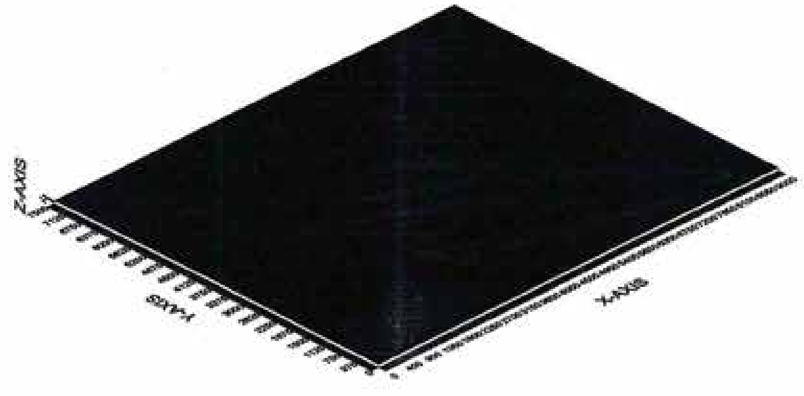


FIG.17a SUBSIDENCE PROFILE AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

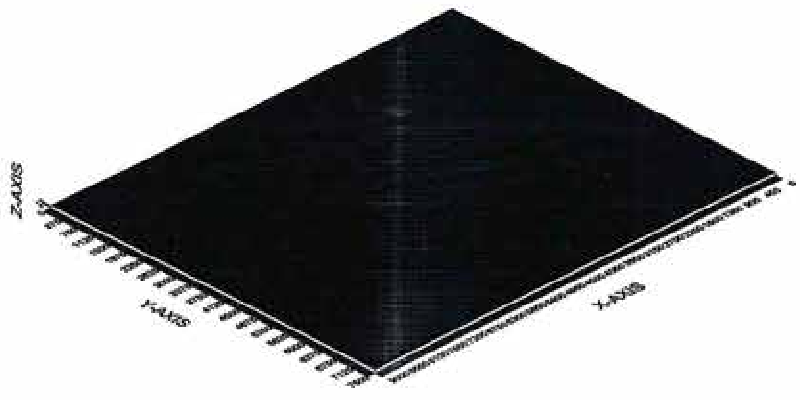


FIG.17b SUBSIDENCE PROFILE AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

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 up to 20 year, 30 year, 40 year, 60 year, 70 year and 78 year of mining have been predicted and are shown in Fig. 18 through Fig. 23.

Fig. 24 shows the 3-dimensional prediction of surface profile before mining for the Dharauli Project. Figs. 25 through 30 give the 3-dimensional prediction of surface profile at the end of each mining sequence (the 'Z' axis has been exaggerated to 10 times for having better visual appearance of the impact of subsidence).

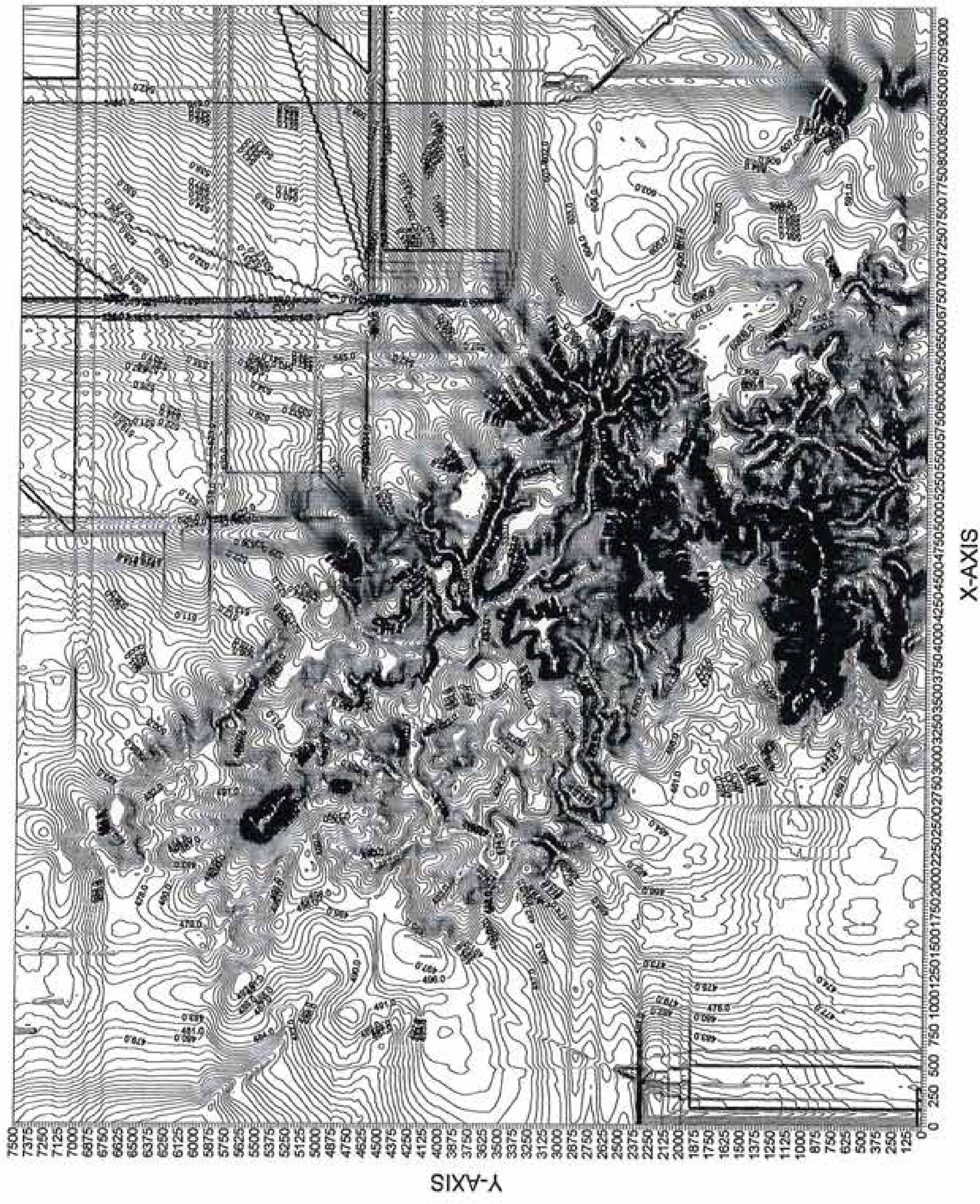


FIG.18 SURFACE CONTOURS UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

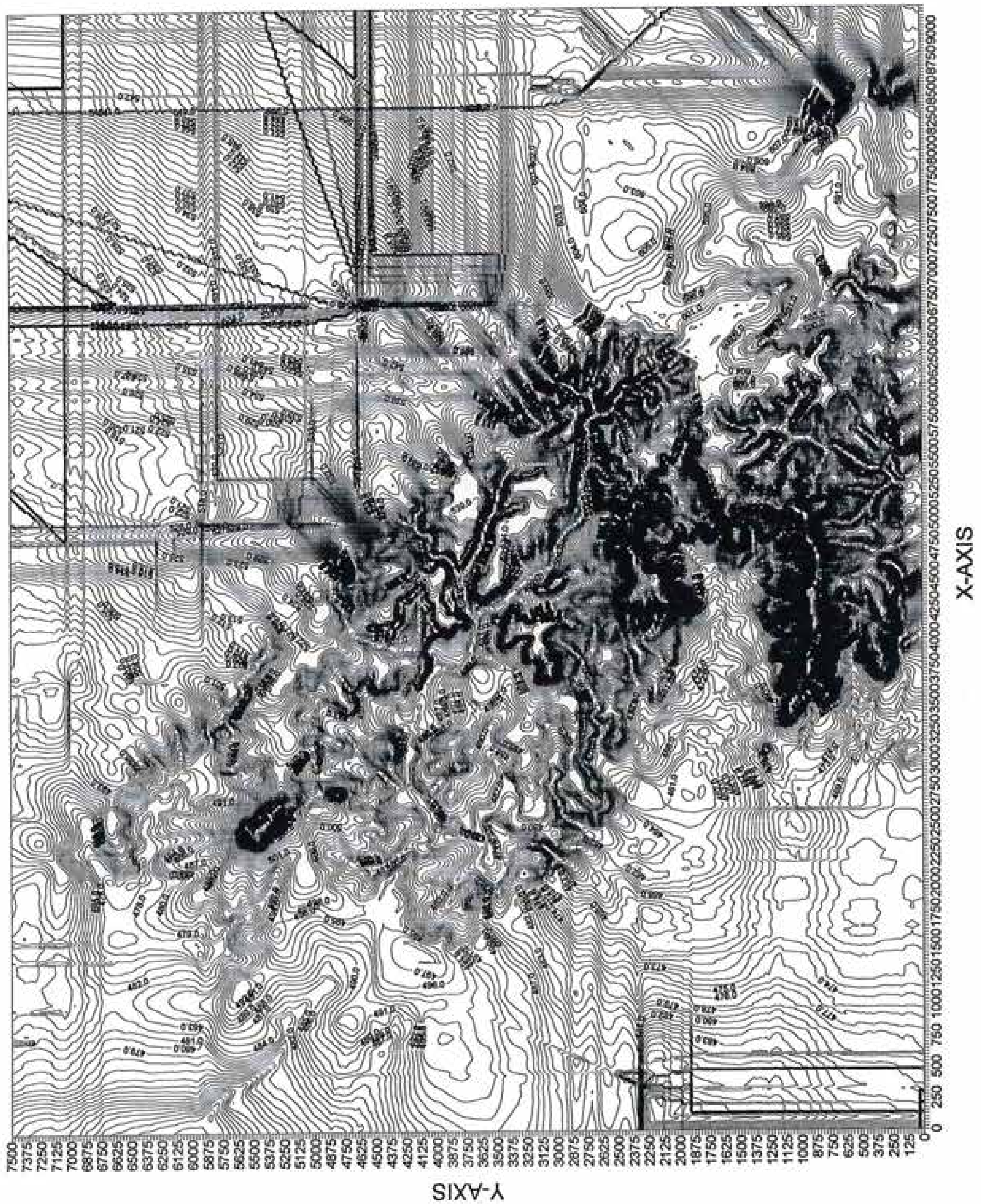


FIG.19 SURFACE CONTOURS AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

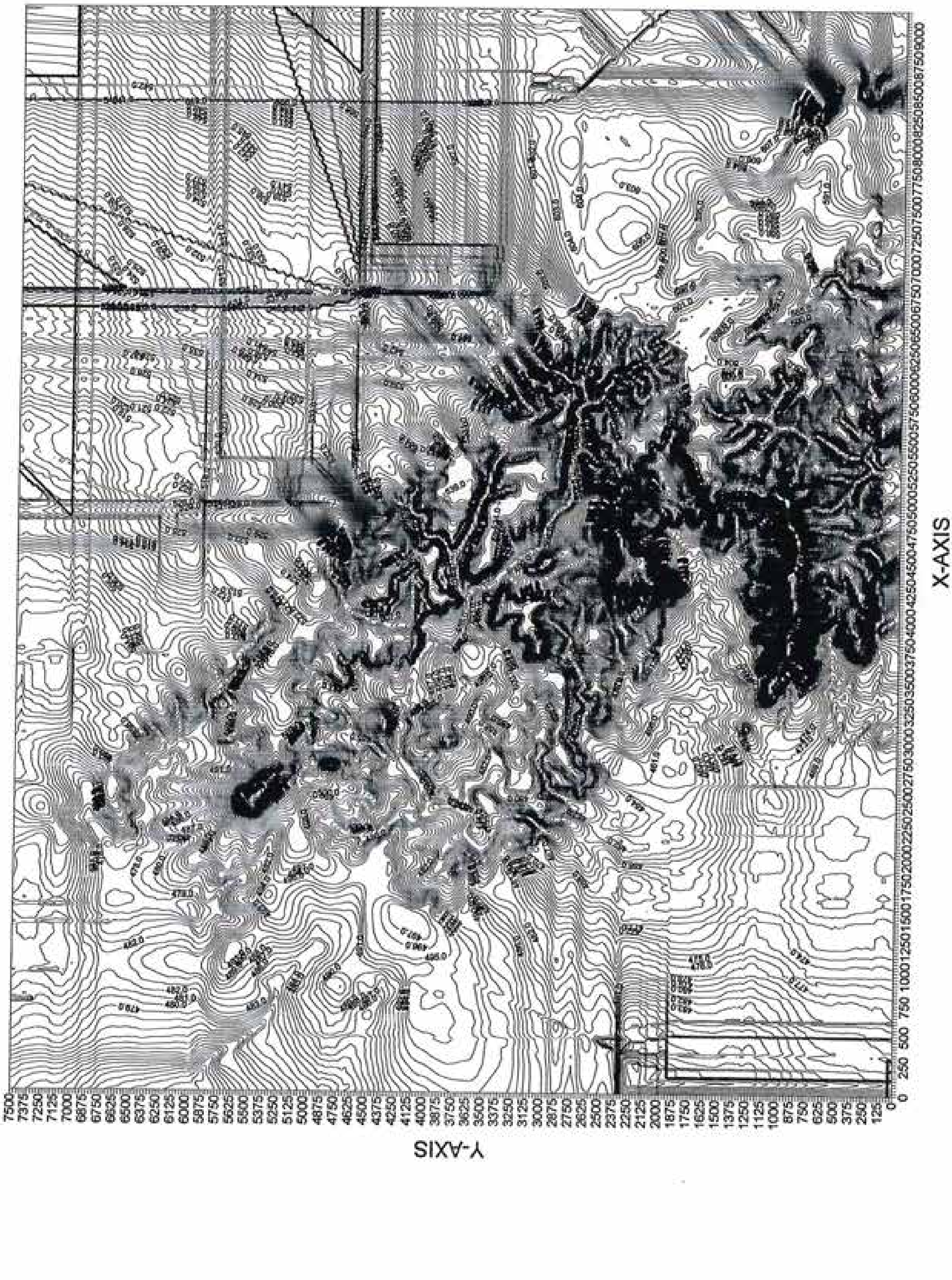


FIG.20 SURFACE CONTOURS AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

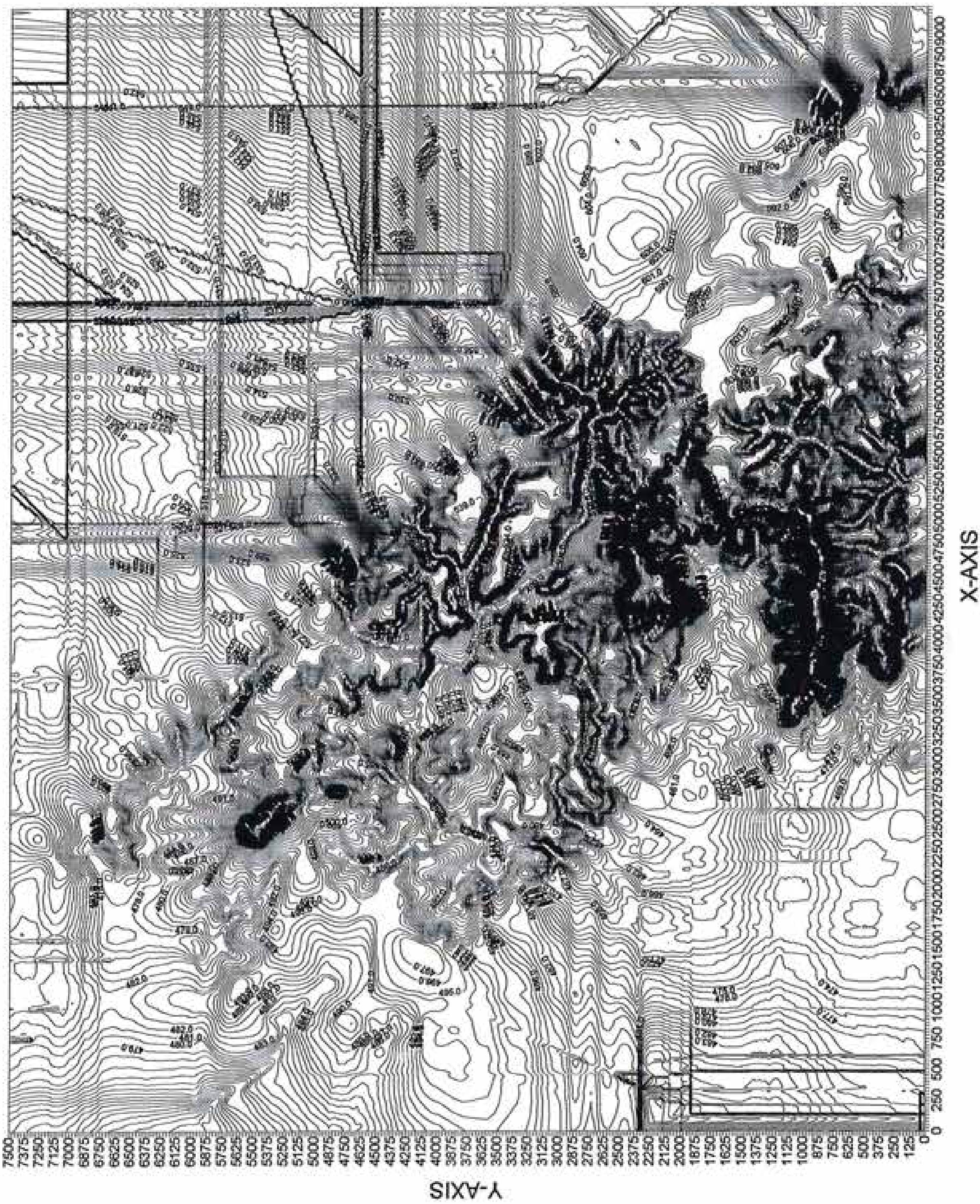


FIG.21 SURFACE CONTOURS AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

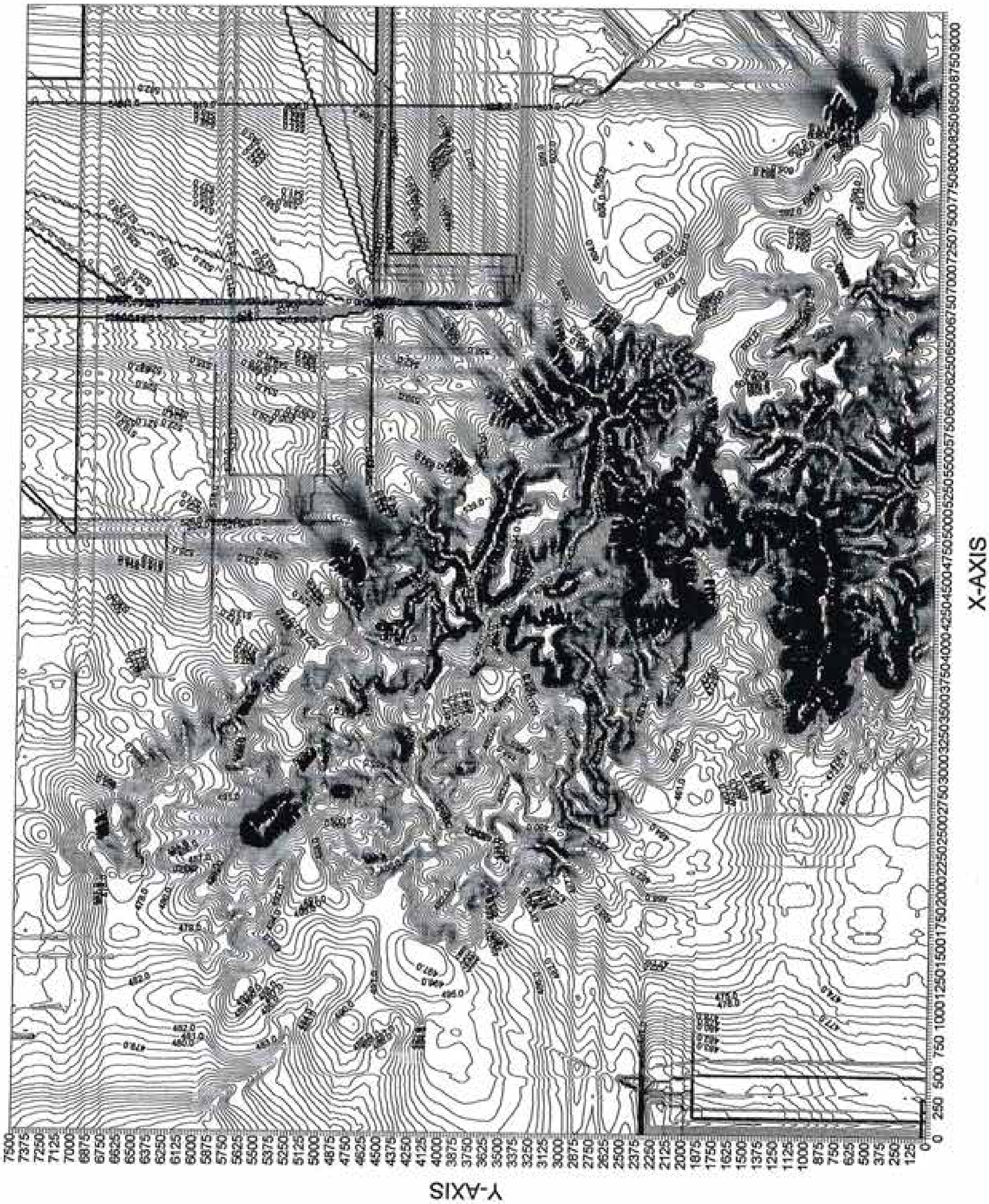


FIG.22 SURFACE CONTOURS AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

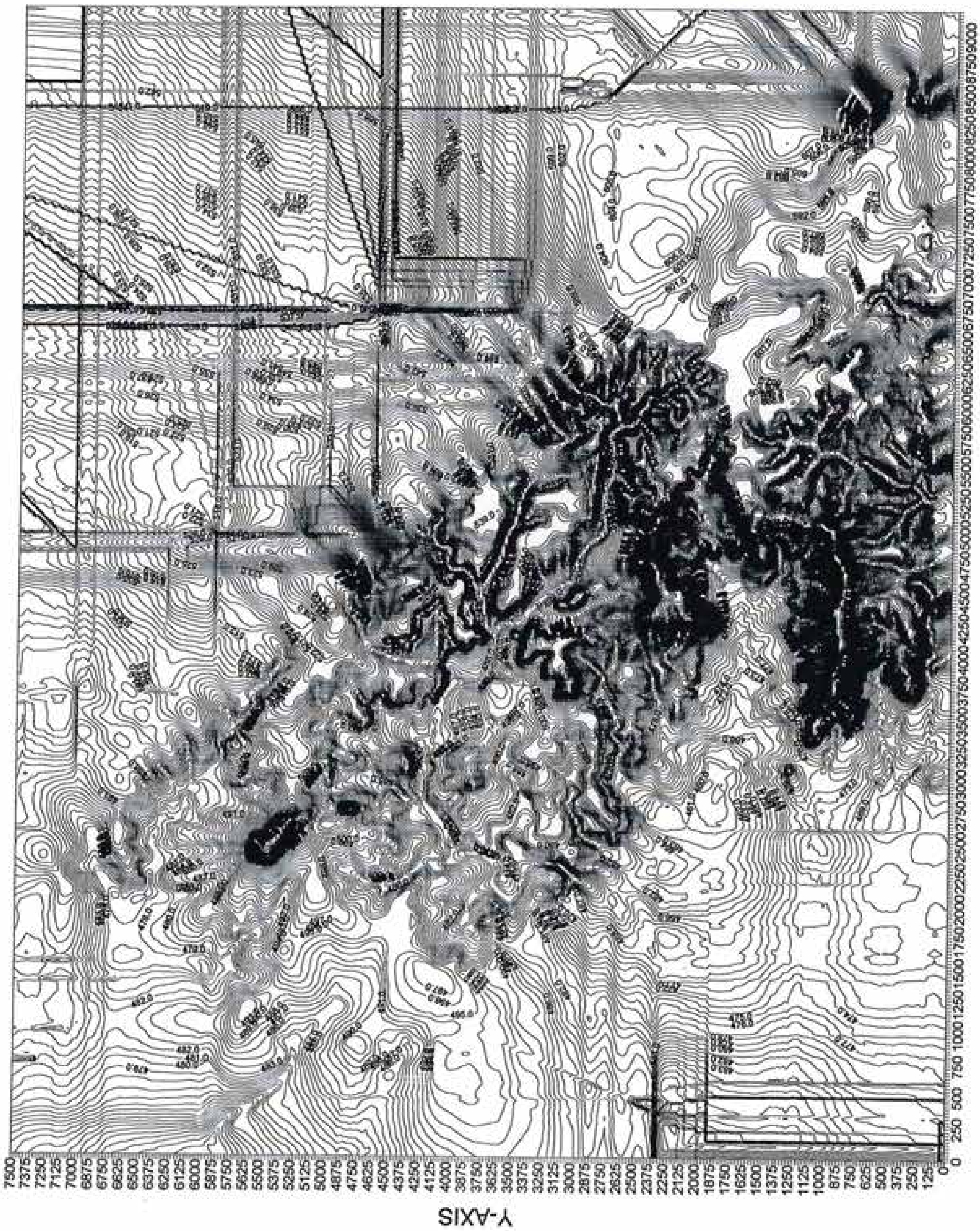


FIG.23 SURFACE CONTOURS AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

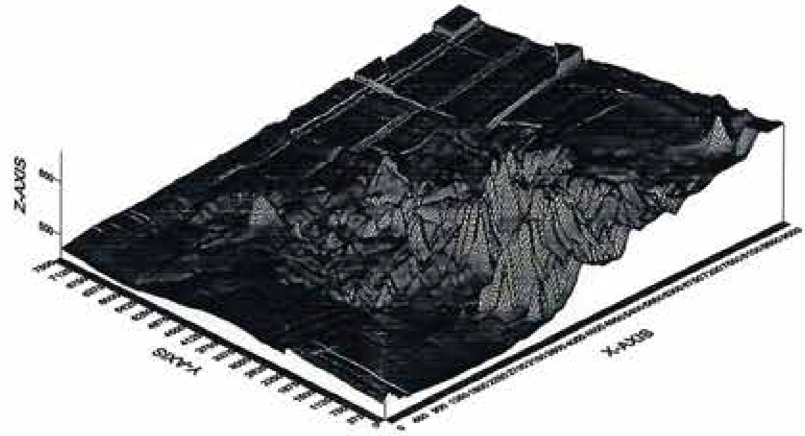


FIG.24a SURFACE PROFILE BEFORE MINING (DHARAULI UG PROJECT)

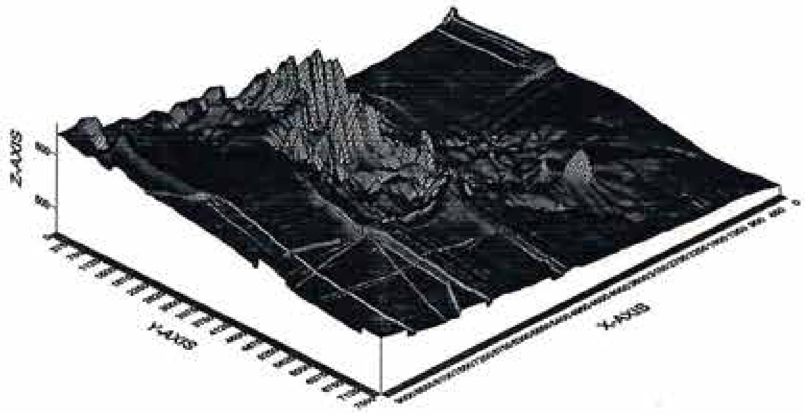


FIG.24b SURFACE PROFILE BEFORE MINING (DHÁRAULI UG PROJECT)

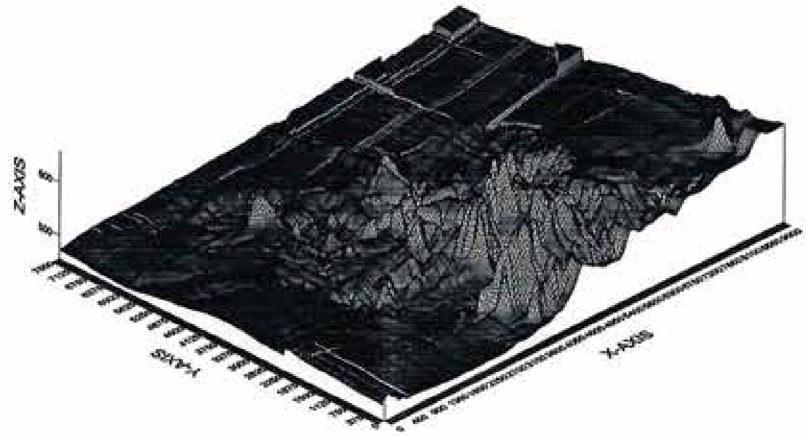


FIG.25a SURFACE PROFILE UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

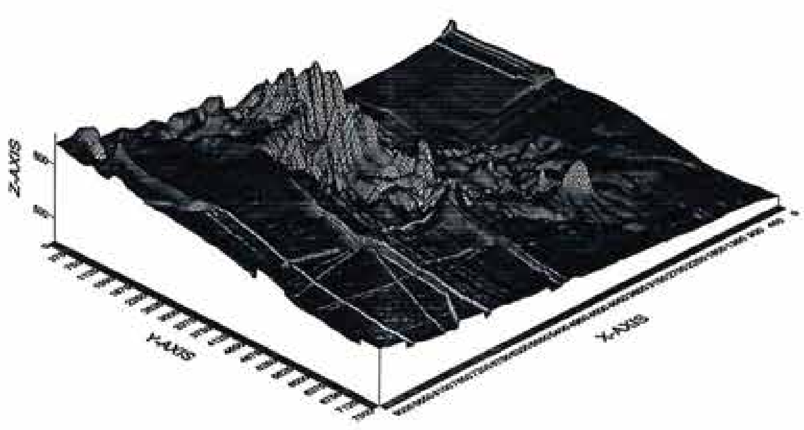


FIG.25b SURFACE PROFILE UP TO 20TH YRS OF MINING (DHARAULI UG PROJECT)

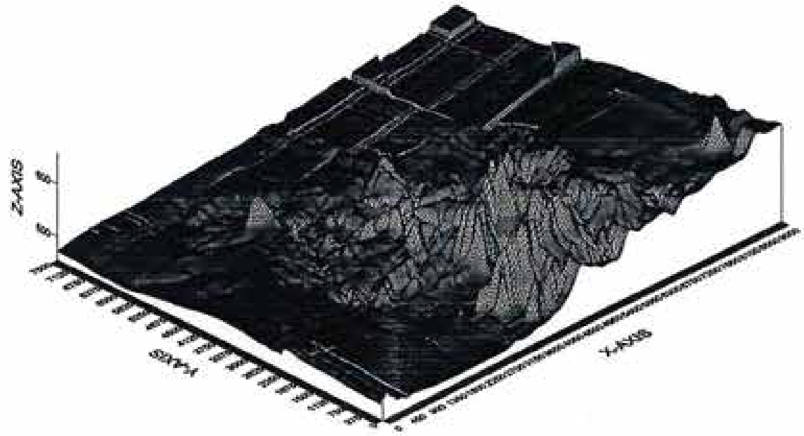


FIG.26a SURFACE PROFILE AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

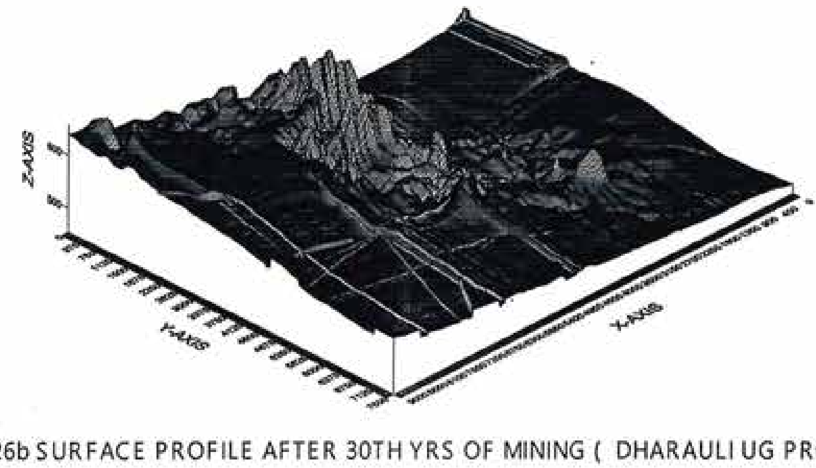


FIG.26b SURFACE PROFILE AFTER 30TH YRS OF MINING (DHARAULI UG PROJECT)

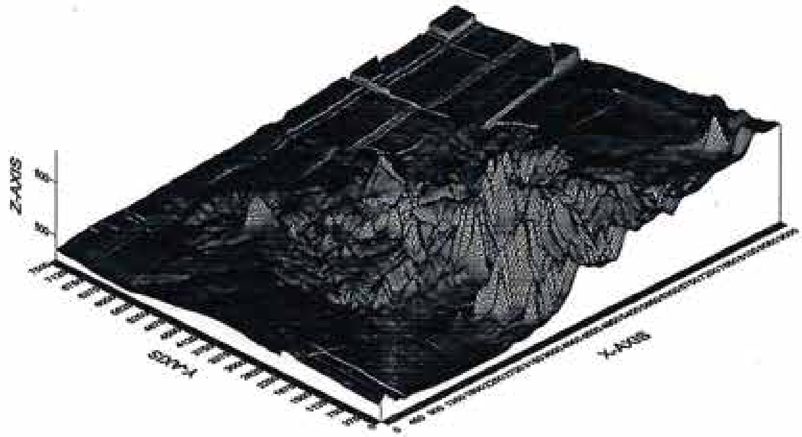


FIG.27a SURFACE PROFILE AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

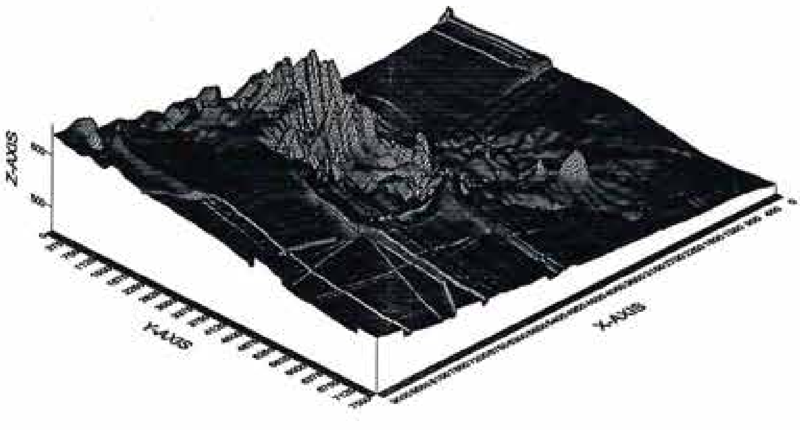


FIG.27b SURFACE PROFILE AFTER 40TH YRS OF MINING (DHARAULI UG PROJECT)

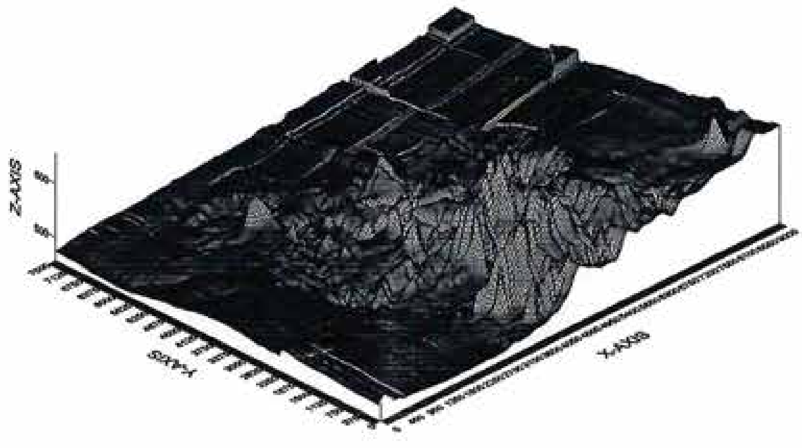


FIG.28a SURFACE PROFILE AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

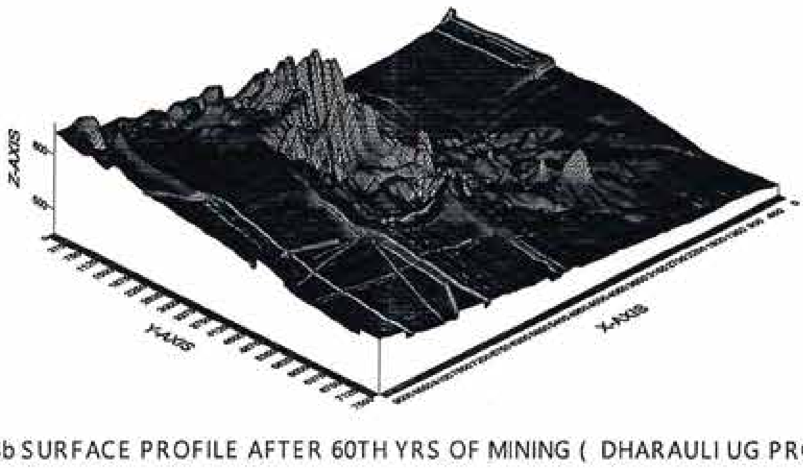


FIG.28b SURFACE PROFILE AFTER 60TH YRS OF MINING (DHARAULI UG PROJECT)

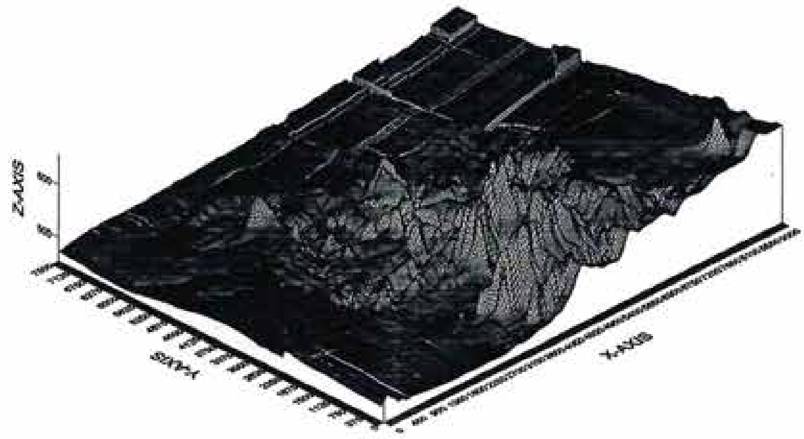


FIG.29a SURFACE PROFILE AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

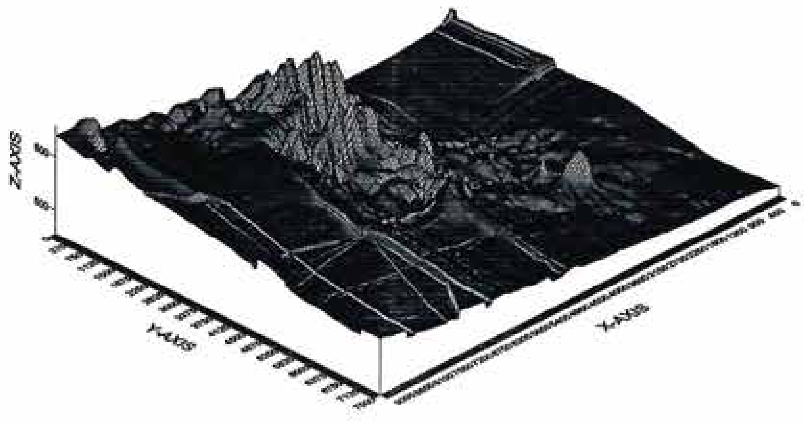


FIG.29b SURFACE PROFILE AFTER 70TH YRS OF MINING (DHARAULI UG PROJECT)

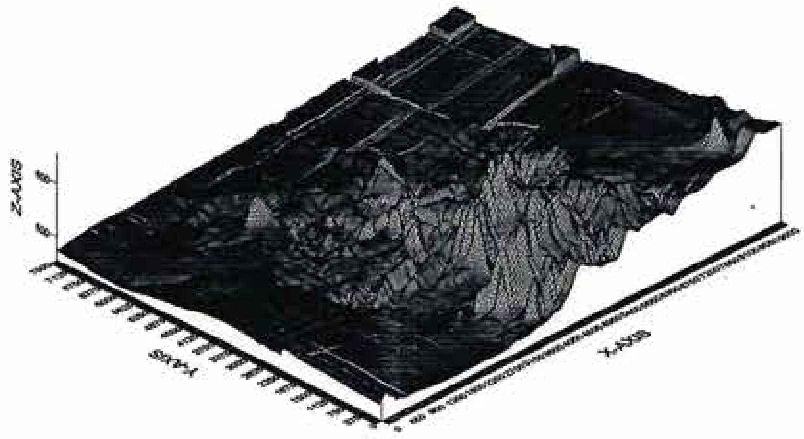


FIG.30a SURFACE PROFILE AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

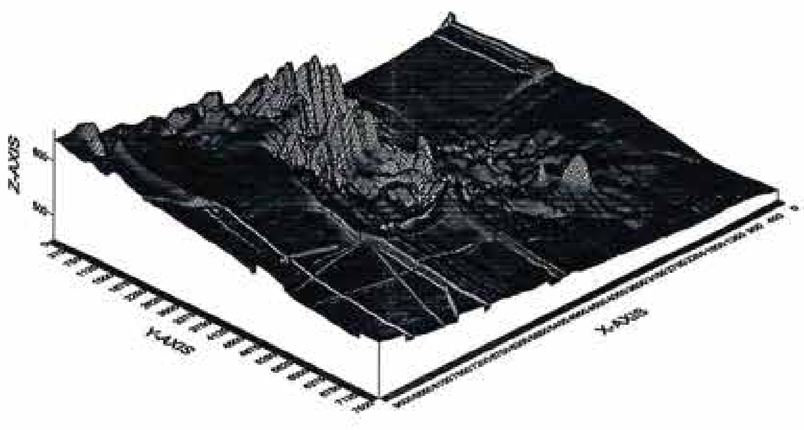


FIG.30b SURFACE PROFILE AFTER 78TH YRS OF MINING (DHARAULI UG PROJECT)

6.0 TENSILE STRAIN AND CRACK WIDTH

6.1 MAXIMUM TENSILE STRAIN

The maximum predicted tensile strain for Dharauli Project for various time blocks has been given below in table 6.1.

Table 6.1: Predicted maximum tensile strain for Dharauli Project at various time blocks

l. No.	At the end of mining in years	Tensile Strain (mm/m)
1.	up to 20	4.95
2.	20 to 30	13.90
3.	30 to 40	17.47
4.	50 to 60	17.47
5.	60 to 70	17.47
6.	73 to 78	17.47

The maximum predicted tensile strain has been predicted for each time block separately and is 17.47 mm/m at the end of mining.

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 with geotechnical data. Cracks of width more than 150 mm/m are likely to be formed due to extraction of the panels in this project. However, opencast workings will be carried out for upper seam and the surface will be covered with overburden dump. The final surface RL will be approximately 90m higher than the original surface. Hence, it could be safely concluded that no surface crack of significant width will be observed on the surface.

7.0 DISCUSSION

The prediction of mine subsidence, horizontal tensile strain and crack width has been predicated on original ground surface. The mining plan envisages that upper seams will be extracted by opencast mining and then the area will be back filled with overburden dump material.

In some areas overburden dump will be pit on original surface before undertaking underground mining. There is no important surface structure on the surface and only over burden dump has been put before undertaking underground mining. Therefore, no surface structure will get damaged due to underground mining and subsidence.

It has also been predicted that original surface would have expected maximum horizontal tensile strain up to 17 mm/m. Therefore, crack upto width of 150 mm/m might be observed on the original surface (considering only underground mining and no surface mining). The dump put on the surface will lead to further heightening of the surface from the original surface. Moreover, the dump material is weak and some cracks of smaller width are likely to appear on the surface. Therefore, it is being suggested that the regular inspection of surface should be cavies out in the area marked (where underground mining is being carried out beneath it) to detect any surface crack appearing on the surface. They should be regularly filled up so that underground mining does not breath air and water does not go to underground working.

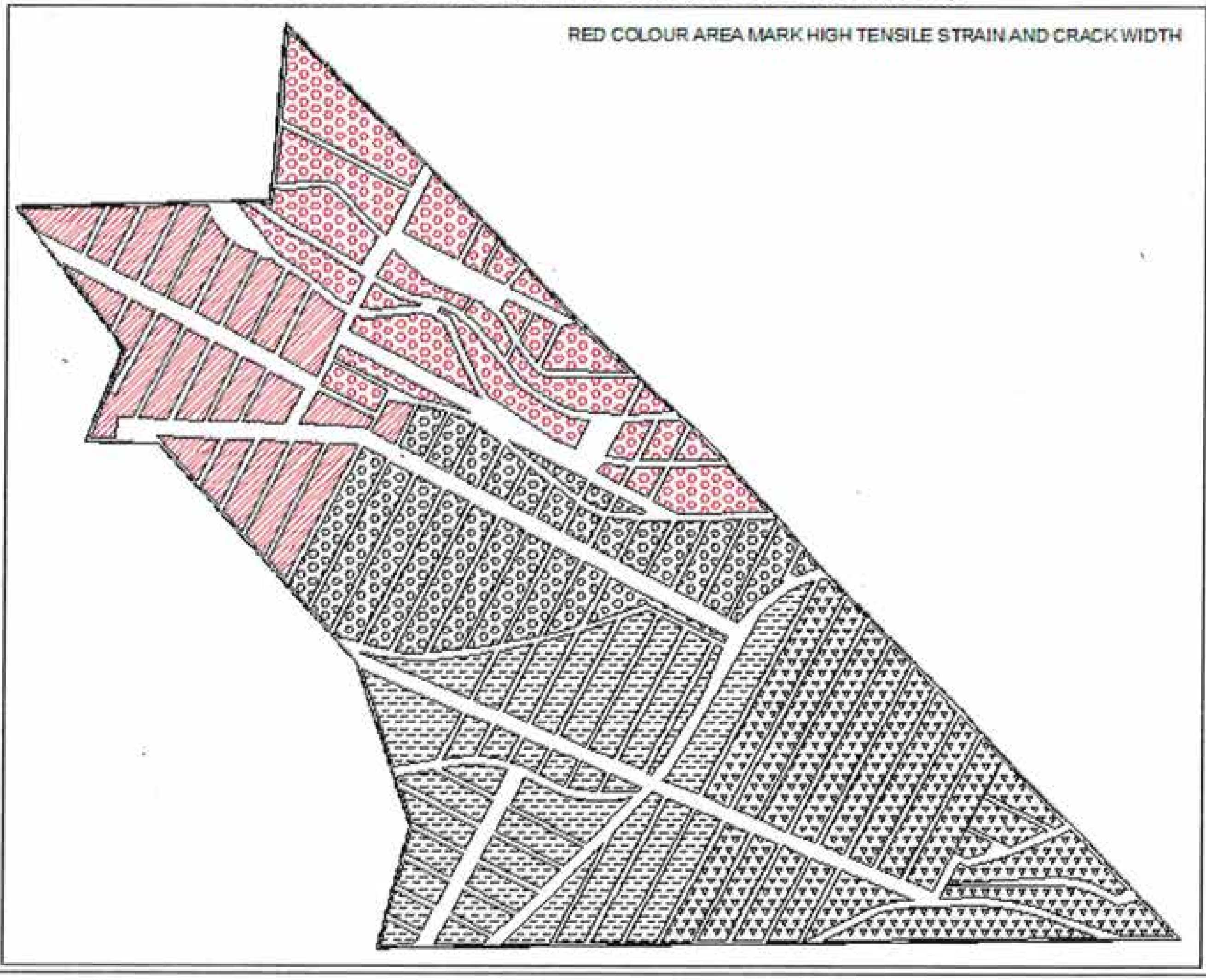
8.0 SUBSIDENCE MANAGEMENT PLAN

During the first 20 years, the working will be in the northern sector. The subsidence and resulting horizontal tensile strain will be within the permissible limit (maximum subsidence 0.862 m and maximum horizontal tensile strain 4.9 mm/m). there will not be any damage on the surface structures.

The over burden dumping over the quarry surface area which is marked for underground mining between 20 to 40 years will start. It will be gradual and done in phased manner.

It is being suggested that area marked in red colour in Fig 31 Should be regularly inspected at regular interval of 15 days to observe the cracks likely to occur on the surface in the time block of 20 to 40 years. The cracks should be properly filled up till such time the opencast workings extend to this area. No other subsidence management plan is being suggested.

FIG.51 Area to be marked crack width 150mm (DHARAULI UG PROJECT)



9.0 CONCLUSION

The depillaring operation will be carried out from 5th year of underground mining and it will continue upto 87 years of mining.

Predection of subsidenace has been carried out by 3D-numerical modelling based on FEM. The subsidence along with peak horizontal tensile strain has been predicated at the end of 20 years, 30 years, 40 years, 60 years, 70 years and 87 years (end of mining) of mining.

The peak predicated subsidence is 0.862 m at end of 20 years of mining, 2.384 m at end of 30 years, 2.391m at end of 40 years, 2.391m at end of 60 years and 2.716 m at end of 87 years of mining respectively .

The predicted peak horizontal tensile strain is 4.95 mm/m at the end of 20 years of mining, 13.90 mm/m at the end of 30 years of mining and 17.47 mm/m at end of 87 years of mining.

No surface feature is likely to get damaged as there is no important surface stracture on surface except the overburden dump.

An area has been marked on Fig. 31 where crack width up to 150 mm is likely to occur between 20 to 40 years of mining. It is being suggested that regular inspection should be carried out on the surface for identifying the crackes that are likely to be formed due to undergourd mining. The inspection should preferably be carried out at every 15 days. The cracks should be regularly filled up.

No other subsidnece management plan is being suggested.

(B.K. SHRIVASTVA)
Professor of Mining Engineering
PRINCIPAL CONSULTANT

APPENDIX

TABLE-I

Subsidence values (above 2.0 m) alongwith coordinates after end of mining

x-coordinate	y-coordinate	subsidence (predicted)
4350.000	1150.000	-2.008
4375.000	1150.000	-2.008
4275.000	1175.000	-2.032
4300.000	1175.000	-2.057
4325.000	1175.000	-2.067
4350.000	1175.000	-2.062
4375.000	1175.000	-2.046
4400.000	1175.000	-2.003
4250.000	1200.000	-2.052
4275.000	1200.000	-2.101
4300.000	1200.000	-2.110
4325.000	1200.000	-2.094
4350.000	1200.000	-2.063
4375.000	1200.000	-2.023
4250.000	1225.000	-2.058
4275.000	1225.000	-2.105
4300.000	1225.000	-2.101
4325.000	1225.000	-2.066
4350.000	1225.000	-2.010
4275.000	1250.000	-2.036
4300.000	1250.000	-2.029
3125.000	1675.000	-2.017
3150.000	1675.000	-2.036
3100.000	1700.000	-2.143
3125.000	1700.000	-2.232
3150.000	1700.000	-2.246
3175.000	1700.000	-2.201
3200.000	1700.000	-2.099
3075.000	1725.000	-2.115
3100.000	1725.000	-2.300
3125.000	1725.000	-2.386
3150.000	1725.000	-2.395
3175.000	1725.000	-2.348
3200.000	1725.000	-2.252
3225.000	1725.000	-2.094
3075.000	1750.000	-2.226
3100.000	1750.000	-2.417
3125.000	1750.000	-2.502
3150.000	1750.000	-2.509
3175.000	1750.000	-2.464
3200.000	1750.000	-2.373
3225.000	1750.000	-2.222
3250.000	1750.000	-2.002
3050.000	1775.000	-2.053
3075.000	1775.000	-2.330
3100.000	1775.000	-2.518
3125.000	1775.000	-2.604
3150.000	1775.000	-2.607
3175.000	1775.000	-2.561
3200.000	1775.000	-2.472
3225.000	1775.000	-2.325
3250.000	1775.000	-2.107
3050.000	1800.000	-2.172
3075.000	1800.000	-2.431
3100.000	1800.000	-2.606
3125.000	1800.000	-2.683
3150.000	1800.000	-2.681
3175.000	1800.000	-2.627
3200.000	1800.000	-2.534
3225.000	1800.000	-2.389
3250.000	1800.000	-2.174
3025.000	1825.000	-2.013
3050.000	1825.000	-2.291
3075.000	1825.000	-2.518
3100.000	1825.000	-2.664
3125.000	1825.000	-2.716
3150.000	1825.000	-2.699
3175.000	1825.000	-2.634
3200.000	1825.000	-2.537
3225.000	1825.000	-2.393
3250.000	1825.000	-2.189
3025.000	1850.000	-2.123
3050.000	1850.000	-2.368
3075.000	1850.000	-2.557
3100.000	1850.000	-2.664
3125.000	1850.000	-2.683
3150.000	1850.000	-2.640
3175.000	1850.000	-2.563
3200.000	1850.000	-2.468
3225.000	1850.000	-2.337
3250.000	1850.000	-2.150
3025.000	1875.000	-2.157
3050.000	1875.000	-2.369
3075.000	1875.000	-2.526
3100.000	1875.000	-2.600
3125.000	1875.000	-2.589
3150.000	1875.000	-2.522
3175.000	1875.000	-2.435
3200.000	1875.000	-2.343
3225.000	1875.000	-2.230
3250.000	1875.000	-2.067
3025.000	1900.000	-2.105
3050.000	1900.000	-2.294
3075.000	1900.000	-2.432
3100.000	1900.000	-2.488
3125.000	1900.000	-2.458
3150.000	1900.000	-2.379
3175.000	1900.000	-2.287
3200.000	1900.000	-2.196
3225.000	1900.000	-2.094
3025.000	1925.000	-2.001
3050.000	1925.000	-2.171

x-coordinate	y-coordinate	subsidence (predicted)	x-coordinate	y-coordinate	subsidence (predicted)
3075.000	1925.000	-2.297	3100.000	3425.000	-2.296
3100.000	1925.000	-2.345	3125.000	3425.000	-2.188
3125.000	1925.000	-2.312	3150.000	3425.000	-2.049
3150.000	1925.000	-2.229	2975.000	3450.000	-2.040
3175.000	1925.000	-2.134	3000.000	3450.000	-2.176
3200.000	1925.000	-2.041	3025.000	3450.000	-2.298
3050.000	1950.000	-2.029	3050.000	3450.000	-2.374
3075.000	1950.000	-2.139	3075.000	3450.000	-2.391
3100.000	1950.000	-2.181	3100.000	3450.000	-2.334
3125.000	1950.000	-2.146	3125.000	3450.000	-2.218
3150.000	1950.000	-2.066	3150.000	3450.000	-2.058
3900.000	2950.000	-2.026	2975.000	3475.000	-2.054
3925.000	2950.000	-2.006	3000.000	3475.000	-2.170
3900.000	2975.000	-2.023	3025.000	3475.000	-2.271
3925.000	2975.000	-2.026	3050.000	3475.000	-2.338
3900.000	3000.000	-2.001	3075.000	3475.000	-2.348
3925.000	3000.000	-2.024	3100.000	3475.000	-2.289
3125.000	3050.000	-2.053	3125.000	3475.000	-2.168
3150.000	3050.000	-2.078	3150.000	3475.000	-2.005
3175.000	3050.000	-2.047	2975.000	3500.000	-2.027
3125.000	3075.000	-2.068	3000.000	3500.000	-2.106
3150.000	3075.000	-2.095	3025.000	3500.000	-2.179
3175.000	3075.000	-2.067	3050.000	3500.000	-2.226
3125.000	3100.000	-2.025	3075.000	3500.000	-2.223
3150.000	3100.000	-2.051	3100.000	3500.000	-2.162
3175.000	3100.000	-2.028	3125.000	3500.000	-2.048
2900.000	3125.000	-2.013	3025.000	3525.000	-2.031
2925.000	3125.000	-2.057	3050.000	3525.000	-2.052
2950.000	3125.000	-2.046	3075.000	3525.000	-2.040
2900.000	3150.000	-2.071	1250.000	4550.000	-2.017
2925.000	3150.000	-2.117	1275.000	4550.000	-2.044
2950.000	3150.000	-2.107	1300.000	4550.000	-2.048
2975.000	3150.000	-2.043	1325.000	4550.000	-2.025
3700.000	3150.000	-2.006	1250.000	4575.000	-2.051
2900.000	3175.000	-2.066	1275.000	4575.000	-2.089
2925.000	3175.000	-2.114	1300.000	4575.000	-2.097
2950.000	3175.000	-2.104	1325.000	4575.000	-2.078
2975.000	3175.000	-2.038	1350.000	4575.000	-2.037
2900.000	3200.000	-2.005	1225.000	4600.000	-2.007
2925.000	3200.000	-2.050	1250.000	4600.000	-2.065
2950.000	3200.000	-2.043	1275.000	4600.000	-2.107
3025.000	3375.000	-2.068	1300.000	4600.000	-2.125
3050.000	3375.000	-2.109	1325.000	4600.000	-2.109
3075.000	3375.000	-2.101	1350.000	4600.000	-2.073
3100.000	3375.000	-2.050	1375.000	4600.000	-2.023
3000.000	3400.000	-2.068	1225.000	4625.000	-2.007
3025.000	3400.000	-2.172	1250.000	4625.000	-2.063
3050.000	3400.000	-2.236	1275.000	4625.000	-2.107
3075.000	3400.000	-2.240	1300.000	4625.000	-2.130
3100.000	3400.000	-2.191	1325.000	4625.000	-2.126
3125.000	3400.000	-2.098	1350.000	4625.000	-2.093
3000.000	3425.000	-2.137	1375.000	4625.000	-2.042
3025.000	3425.000	-2.258	1250.000	4650.000	-2.045
3050.000	3425.000	-2.333	1275.000	4650.000	-2.095
3075.000	3425.000	-2.349	1300.000	4650.000	-2.124

x-coordinate	y-coordinate	subsidence (predicted)	x-coordinate	y-coordinate	subsidence (predicted)
1325.000	4650.000	-2.128			
1350.000	4650.000	-2.102			
1375.000	4650.000	-2.051			
1250.000	4675.000	-2.025			
1275.000	4675.000	-2.070			
1300.000	4675.000	-2.104			
1325.000	4675.000	-2.113			
1350.000	4675.000	-2.093			
1375.000	4675.000	-2.044			
1275.000	4700.000	-2.033			
1300.000	4700.000	-2.065			
1325.000	4700.000	-2.079			
1350.000	4700.000	-2.064			
1375.000	4700.000	-2.017			
1300.000	4725.000	-2.009			
1325.000	4725.000	-2.024			
1350.000	4725.000	-2.008			