

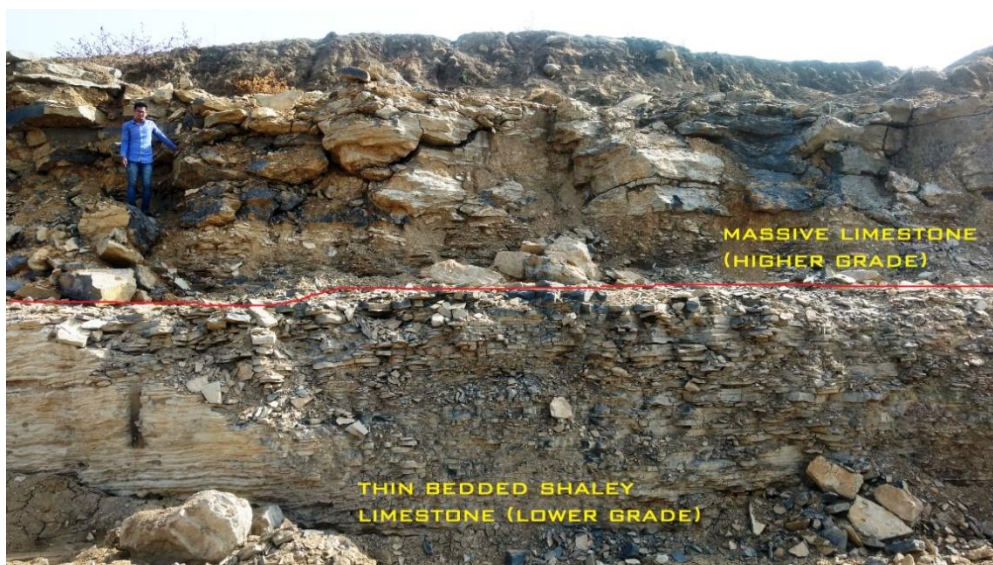
**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G2) FOR
LIMESTONE**

JAMODI-MAHANNA BLOCK

RAGHURAJNAGAR

DISTRICT : SATNA, MADHYA PRADESH

TEXT, ANNEXURE & PLATES



A MINI-RATNA COMPANY

MINERAL EXPLORATION CORPORATION LIMITED
(A Government of India Enterprise)
CORPORATE OFFICE, NAGPUR

MARCH - 2018

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, DISTRICT- SATNA, MADHYA PRADESH**

C O N T E N T S

PARA No.	D E S C R I P T I O N	PAGE NO.
	SALIENT FEATURES	i
CHAPTER-I		
1.0.0	INTRODUCTION	1-8
1.1.0	General	1-2
1.2.0	Background	2-3
1.3.0	Location and Accessibility	3
1.4.0	Physiography and Drainage	3-5
1.5.0	Previous Work	5
1.6.0	Objectives of Exploration	6
1.7.0	Present Work	6-8
1.8.0	Acknowledgement	8
CHAPTER-II		
2.0.0	GEOLOGY AND STRUCTURE	9-17
2.1.0	Regional Geology of the Area	9
2.2.0	Geology of the Area	9-11
2.3.0	Description of different Formations	11-12
2.4.0	Structure of the Block	12-13
2.5.0	Depositional Environment	13
CHAPTER-III		
3.0.0	EXPLORATION METHODOLOGY	18-32
3.1.0	Introduction	18
3.2.0	Scheme of Exploration	18
3.3.0	Limitations	18-19
3.4.0	Topographic Survey and Geological Mapping	19
3.5.0	Surface Drilling	19
3.6.0	Drill Core Logging and Sampling	19-20
3.7.0	Sampling and Analysis	20-21
3.8.0	Physical Analysis	21
3.9.0	Petrographic Studies	21
3.10.0	Specific Gravity Determination	21
3.11.0	Limestone Zones Intersected in MECL Boreholes	21-29
3.12.0	Utilisation Aspects and Mineability	29-32

PARA No.	DESCRIPTION	PAGE NO.
CHAPTER-IV		
4.0.0	EVALUATION OF EXPLORATION DATA	33-37
4.1.0	General	33
4.2.0	Aerial Extent	33
4.3.0	Thickness of Limestone	33-34
4.4.0	Grade of Limestone	34
4.5.0	Chemical Constituents	35
4.6.0	Overburden	36
4.7.0	Petrographic Studies	36
4.8.0	X-Ray Diffraction Studies	37
4.9.0	Minor and Trace elements	37
CHAPTER-V		
5.0.0	RESOURCES AND GRADES	38-48
5.1.0	General	38
5.2.0	Basic Assumptions	38-39
5.3.0	Methodology	39-42
5.4.0	Categorisation of Resources	42
5.5.0	Resources	42-47
5.6.0	Summary of Resources	48
CHAPTER-VI		
6.0.0	STATISTICAL EVALUATION AND RELIABILITY OF DATA	50-61
6.1.0	Introduction	50
6.2.0	Reliability of Chemical analysis	50-61
6.3.0	Comparison and Reliability of estimated Resources	61
CHAPTER-VII		
7.0.0	CONCLUSIONS AND RECOMMENDATIONS	62-64
7.1.0	Conclusions	62-63
7.2.0	Recommendations	64
	REFERENCE	65
	LIST OF PERSONNEL ASSOCIATED WITH EXPLORATION	66

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, DISTRICT- SATNA, MADHYA PRADESH
LIST OF ANNEXURE**

ANNEXURE NO.	T I T L E	PAGE NO.
I A	Statement Showing Co-ordinates (in WGS-84) and Reduced Levels of Triangulation Stations fixed by MECL (G4 & G3/G2), Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	IA/1-2
I B	Statement Showing Co-ordinates (in WGS-84), Reduced Levels and total Depth of boreholes (G4 & G3/G2) drilled by MECL, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	IB/1-5
I C	Co-ordinates of cardinal points (in WGS-84) of block boundary, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	IC/1
I D	Co-ordinates of cardinal points of Leasehold areas, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	ID/1-2
IIA	Statement Showing Run-wise lithologs of boreholes (G4) drilled by MECL, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	IIA/1-10
IIB	Statement Showing Run-wise lithologs of boreholes (G2 & G3) drilled by MECL, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	IIB/1-89
III A	Statement Showing Primary Analysis (for 6 radicals CaO, MgO, SiO ₂ , Al ₂ O ₃ Fe ₂ O ₃ & LOI) of borehole core samples generated by MECL, Jamodi-Mahanna Block (G4), Dist: Satna, Madhya Pradesh.	IIIA/1-5
III B	Statement Showing Primary Analysis (for 6 radicals CaO, MgO, SiO ₂ , Al ₂ O ₃ Fe ₂ O ₃ & LOI) of borehole core samples generated by MECL, Jamodi-Mahanna Block (G2 & G3), Dist: Satna, Madhya Pradesh.	IIIB/1-65
III C	Statement showing details of Composite Core sample Analysis (for 12 radicals CaO, MgO, SiO ₂ , Al ₂ O ₃ Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , TiO ₂ , Mn ₂ O ₃ , K ₂ O, Na ₂ O & LOI) of boreholes drilled by MECL, Jamodi-Mahanna Block (G4), Dist: Satna, Madhya Pradesh.	IIIC/1
III D	Statement showing details of Composite Core sample Analysis (for 12 radicals CaO, MgO, SiO ₂ , Al ₂ O ₃ Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , TiO ₂ , Mn ₂ O ₃ , K ₂ O, Na ₂ O & LOI) of boreholes drilled by MECL, Jamodi-Mahanna Block (G2 & G3), Dist: Satna, Madhya Pradesh.	IIID/1-6
III E	Statement Showing Primary Analysis (for 2 radicals SO ₃ & P ₂ O ₅) of core samples generated by MECL, Jamodi-Mahanna Block (G2&G3), Dist: Satna, Madhya Pradesh.	IIIE/1
III F	Statement Showing Primary Analysis (for 6 radicals CaO, MgO, SiO ₂ , Al ₂ O ₃ Fe ₂ O ₃ & LOI) of Outcrop samples collected by MECL, Jamodi-Mahanna Block (G4), Dist: Satna, Madhya Prades	IIIF/1

IV A	Statement showing borehole-wise intersections of Cement grade limestone in Boreholes drilled by MECL, Jamodi-Mahanna Block (G4 & G3/G2), Dist: Satna, Madhya Pradesh.	IVA/1-3
IV B	Statement showing borehole-wise intersections of Ungraded limestone in Boreholes drilled by MECL, Jamodi-Mahanna Block (G4 & G3/G2), Dist: Satna, Madhya Pradesh.	IVB/1-5
VA	Statement showing Primary Vs. Check analysis of core samples of boreholes drilled by MECL, Jamodi-Mahanna Block (G4 & G3/G2), Dist: Satna, Madhya Pradesh.	VA/1-7
VB	Statement showing Primary Vs. External Check analysis of core samples of boreholes drilled by MECL, Jamodi-Mahanna Block (G2&G3), Dist: Satna, Madhya Pradesh.	VB/1-3
VIA	Statement showing Emission Spectroscopic analytical results of Limestone samples, Jamodi-Mahanna Block (G4), Dist: Satna, Madhya Pradesh.	VIA/1
VIB	Statement showing Emission Spectroscopic analytical results of Limestone samples, Jamodi-Mahanna Block (G2&G3), Dist: Satna, Madhya Pradesh.	VIB/1
VII	Statement showing X-Ray Diffraction Analysis results of Limestone samples, Jamodi-Mahanna Block (G4 & G3/G2), Dist: Satna, Madhya Pradesh.	VII/1-2
VIIIA	Statement showing Petrographic Studies of Limestone samples, Jamodi-Mahanna Block (G4), Dist: Satna, Madhya Pradesh.	VIIIA/1-4
VIIIB	Statement showing Petrographic Studies of Limestone samples, Jamodi-Mahanna Block (G2&G3), Dist: Satna, Madhya Pradesh.	VIIIB/1-8
IX	Statement showing Specific Gravity of Limestone samples, Jamodi-Mahanna Block (G4 & G3/G2), Dist: Satna, Madhya Pradesh.	IX/1-2
X A	Statement showing Section wise, Borehole-wise Indicated and Inferred Category Resources of Limestone Zone I & II estimated by Cross Sectional method, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	XA/1-5
X B	Statement showing Thickness wise, Grade-wise Resources of Limestone Zone I, II & Ungraded limestone estimated by Iso-Chore method, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	XB/1-3
X I	Statement showing Administrative/ Financial sanction for G-4 and G2/G3 Level Exploration of Limestone in Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	XI/1-10
XII	Comments of Peer reviewer on the Geological Report on General Exploration (G-2) for Limestone, Jamodi-Mahanna Block, District- Satna, Madhya Pradesh	XII/1-2

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, DISTRICT- SATNA, MADHYA PRADESH**

LIST OF PLATES

PLATE NO	TITLE	R.F
I	Location Map, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	-
II	Topographical and Geological map of Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
IIIA	Geological Cross Section (S1, S2, S3, S4, S11, S12 &S13) along dip direction with quality data, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:4000
IIIB	Geological Cross Section (S5 to S10) along dip direction with quality data, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:4000
IV	Floor Contour Plan of bottom most limestone of Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VA	Iso-chore Map of Limestone Zone-I, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VB	Iso-chore Map of Limestone Zone-II, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VC	Iso-chore Map of Ungraded limestone, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VIA	Iso-Grade Map of Limestone Zone-I, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VIB	Iso-Grade Map of Limestone Zone-II, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:10000
VIIA	Graphic Lithologs of MECL Boreholes (MJRS-1 to 5) with Zone Details, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:500
VIIB	Graphic Lithologs of MECL Boreholes (MJRS-6 to 88) with Zone Details, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	1:500

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, DISTRICT- SATNA, MADHYA PRADESH
LIST OF TEXT FIGURES**

Text Figure No.	Description	Page No
1	Location Map of Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	4
2	Regional Geological map with location of Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	10
3	Geological Map with borehole & outcrop sample locations of Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	14
3A	Field Photographs (1, 2, 3 & 4)	13
3B	Field Photographs (1, 2, 3 & 4)	15-16
4	Floor contour plan	17
5A	Scatter Plot of Primary Vs. Check analysis of CaO % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	51
5B	Scatter Plot of Primary Vs. Check analysis of MgO % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	52
5C	Scatter Plot of Primary Vs. Check analysis of SiO ₂ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	53
5D	Scatter Plot of Primary Vs. Check analysis of Al ₂ O ₃ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	54
5E	Scatter Plot of Primary Vs. Check analysis of Fe ₂ O ₃ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	55
5F	Scatter Plot of Primary Vs. Check analysis of LOI % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	56
6A	Scatter Plot of Primary Vs. External Check analysis of CaO % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	58
6B	Scatter Plot of Primary Vs. External Check analysis of MgO % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	59
6C	Scatter Plot of Primary Vs. External Check analysis of SiO ₂ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	59
6D	Scatter Plot of Primary Vs. External Check analysis of Al ₂ O ₃ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	60
6E	Scatter Plot of Primary Vs. External Check analysis of Fe ₂ O ₃ % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	60
6F	Scatter Plot of Primary Vs. External Check analysis of LOI % Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	61
7	Geological Cross Section S13, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	41
8	Resource map, Jamodi-Mahanna Block, Dist: Satna, Madhya Pradesh.	49

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK , DISTRICT- SATNA, MADHYA PRADESH
LIST OF TABLES**

Table No.	Description	Page No
1.1	Quantum of work carried out by MECL in Jamodi-Mahanna Block (G4 level)	6-7
1.2	Quantum of work carried out by MECL in Jamodi-Mahanna Block (G3 & G2 level)	7
2.1	Regional stratigraphic succession of the area around Jamodi-Mahanna Block	11
3.1	Intersection of Cement grade limestone in boreholes drilled by MECL, Jamodi-Mahanna Block (G4, G2 & G3)	22-24
3.2	Intersection of Ungraded limestone in boreholes drilled by MECL, Jamodi-Mahanna Block (G4, G2 & G3)	25-28
3.3	Specifications for Cement, Iron & Steel and Chemical industry of limestone	32
5.1	Section wise, borehole wise indicated category (332) resources of Cement grade limestone (Zone-I) of Jamodi-Mahanna Block (Part-A) by cross sectional method	43
5.2	Section wise, borehole wise indicated category (332) resources of Cement grade limestone (Zone-II) of Jamodi-Mahanna Block (Part-A) by cross sectional method	44
5.3	Section wise, borehole wise inferred category (333) resources of Cement grade limestone (Zone-I) of Jamodi-Mahanna Block (Part-B) by cross sectional method	45
5.4	Section wise, borehole wise inferred category (333) resources of Cement grade limestone (Zone-II) of Jamodi-Mahanna Block (Part-B) by cross sectional method	45
5.5	Thickness wise resources of Cement grade limestone (Zone-I) of Jamodi-Mahanna Block (Part-B) by iso-chore method	46
5.6	Thickness wise resources of Cement grade limestone (Zone-II) of Jamodi-Mahanna Block (Part-B) by iso-chore method	46
5.7	Thickness wise resources of Ungraded limestone of Jamodi-Mahanna Block (Part-B) by iso-chore method	47

Table No.	Description	Page No
5.8	Summary of resources by cross sectional method	48
5.9	Summary of resources by Iso-chore method	48
6.1-6.6	Comparison of Primary vs Check for CaO, MgO, SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ and LOI respectively	51-56
6.7 C	Comparison of estimated resources of Jamdi-Mahanna block	61

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, RAGHURAJNAGAR
DISTRICT- SATNA, MADHYA PRADESH**

CHAPTER-I

1.0.0 INTRODUCTION

1.1.0 GENERAL

- 1.1.1 Since man has lived in houses, there are evidences all over the world of limestone being used for construction purposes from thousands and thousands of years ago. The Great Pyramids of Giza which are 4,575 years old, made completely out of limestone and as we all know, is still standing strong today. The use of limestone for manufacture of cement goes back to the time of Roman Empire. Romans discovered that quick lime added to the volcanic ash of Pozzuoli gave cement that set under water. In 1756 John Smeaton in England made "lime" by burning argillaceous limestone and discovered that it set under water. Thus, the advent of natural hydraulic cements there by augmented the search for limestone.
- 1.1.2 Limestone is a sedimentary rock which is made up mostly of calcium carbonate in the form of calcite. Generally, it is mostly formed in warm, clear and shallow marine environment making it a bio-chemical sedimentary rock. It's formed as a product of an accumulation of shells, corals, algal and other biogenic debris. Similarly, limestone can also be a chemical sedimentary rock which is formed by the precipitation of calcium carbonate from a lake or the ocean water. Limestone often containing magnesium carbonates either $\text{CaMg}(\text{CO}_3)_2$ or (MgCO_3) mixed with calcite is termed as dolomitic or magnesium limestone.
- 1.1.3 Cement, Iron & Steel industries are the major and bulk consumers of limestone. It is also consumed in chemical industries like calcium carbide, bleaching powder, soda-ash, precipitated calcium carbonate etc. Besides, it is used as fluxing material in ferro-alloys, pelletization plants, foundries and in the production of sponge from iron, as refining materials in the production of sugar, as an additive in glass industry; and as a coating material in fertilizer industry.
- 1.1.4 India has huge resources of limestone distributed over different parts of country and is comfortably occupied 2nd place in the world after China in annual capacity and production of cement. Cement grade limestone occurs in all the limestone bearing areas, while SMS, BF and chemical grade limestone occur in selective areas. Increase in steel production in the country has escalated the demand for SMS (Steel Melting Shop) and BF (Blast furnace) grade limestone. Concerted efforts to locate SMS & BF grade limestone along with cement grade limestone are imperative to meet the growing demand which in turn will reduce the imports of limestone that has increased to 17.18 million tonnes in 2015-16 from 13.94 million tonnes in 2014-15 (as per mineral year book-2016).

- 1.1.5 The total resources of limestone of all categories and grades as per UNFC system as on 01/04/2015 are estimated at 203,224 million tonnes of which 16,336 million tonnes (8%) are under reserves category and 186,888 million tonnes (92%) are under remaining resources category. Karnataka is the leading state heaving 27% of the total resource followed by Andhra Pradesh and Rajasthan (12% each), Gujarat (10%), Meghalaya (9%), Telangana (8%), Chhattisgarh and Madhya Pradesh (5% each) and remaining 12% by other states. Grade wise, cement grade has leading share of about 70% followed by unclassified grades (12%) and BF grade (7%). Remaining (11%) are others.
- 1.1.6 As per mineral year book-2016, the production of limestone in 2015-16 was about 303.80 million tonnes increased by 4% as compared to that of the previous year. About 97% of the total production of limestone during 2015-16 was of cement grade, 2% of iron and steel grade and the rest 1% consisted of chemical grades.
- 1.1.7 Rajasthan was the leading producing state accounting for (22%) of the total production of limestone, followed by Madhya Pradesh (12%), Andhra Pradesh (11%), Karnataka & Chhattisgarh(9% each),Gujarat & Telangana (8% each),Tamil Nadu(7%) , Himachal Pradesh & Maharashtra (4% each) and the remaining 6% was contributed by Meghalaya, Odisha, Uttar Pradesh, Jharkhand, Assam, Kerala, Bihar and Jammu & Kashmir.
- 1.1.8 In the year 2013-14, the total consumption of limestone and other calcareous minerals/materials, as reported by different industries was 307.35 million tonnes. Cement was the major consuming industry accounting for 94% consumption followed by iron & steel (4%) and chemical industry (2%).
- 1.1.9 India is second largest in cement production after China. There are 210 cement plants in the country with installed capacity of 410 million tonnes in 2015-16 in addition to that, 350 mini cement plants having estimated capacity of 11.10 million tonnes per annum. The total production of cement reached to 283.45 million tonnes in 2015-16 registering a growth of about 6.52% over the preceding year.

1.2.0 BACKGROUND

- 1.2.1 On enactment of MMDR Amendment Act 2015, Minerals (Evidence of Mineral Contents) Rule 2015 and Mineral Auction Rule 2015, Govt. of India directed State Governments to speed up exploration work for different Mineral Commodities i.e. especially the notified minerals, in the respective states. Accordingly Madhya Pradesh Government requested MECL to take up exploration work of Limestone in 3 Blocks in Satna Districts of Madhya Pradesh.
- 1.2.2. Representatives from Govt. of Madhya Pradesh and Mineral Exploration Corporation Ltd visited the proposed area to find out the possibilities of taking up of the exploration work in the area. The limestone exploration proposal of Jamodi-Mahanna Block Tehsil - Raghurajnagar, District-Satna, Madhya Pradesh submitted by MECL for G3 / G2 level was discussed in 1st meeting of Technical Committee of NMET held

on 01 & 02 April, 2016 at GSI Central Region, Nagpur. The Committee recommended Geological Mapping, surface/outcrop samples and five scout boreholes covering the entire block with an area of 31 Sq. Km to generate analytical data at G4 level. MECL accordingly modified the proposal and placed for approval in the 2nd meeting of Technical Committee held on 5th May 2016 at GSI, Training Institute, Hyderabad. On recommendations of Technical Committee the proposal was approved in the 2nd Executive Committee meeting held on 09-05-2016 at Ministry of Mines, New Delhi. During midterm review meeting, it was proposed by the Technical Committee of NMET to review the exploration data after receiving the results of G-4 level exploration. The proposal for upgrading level of G3/G2 was recommended & put to the Executive Committee for administrative approval. The executive committee in its fourth meeting held on 21.02.2017 has approved the proposal for upgrading to G2 & G3 level.

- 1.2.3 The administrative/ financial sanction for exploration for limestone in Jamodi-Mahanna block at an estimated cost of Rs. 545.34 lakhs was received from Ministry of Mines, Govt. of India, National Mineral Exploration Trust ,New Delhi vide F no 6/1/NMET-2015 dated 03.04.2017.

1.3.0 LOCATION AND ACCESSIBILITY

- 1.3.1 The Cement grade limestone deposit is located in the Jamodi- Mahanna, Khamriya, Pasiyan, Phutainaha, Phutondhi and Ramsthan areas of Tehsil- Raghurajnagar, District- Satna, Madhya Pradesh. The deposit falls within the Survey of India Toposheet No. 63 D/14 and 63 H/2. The block limits with Latitude and Longitude as following:

A	:	80°55' 59.8704"	-	24°37'31.7724"
B	:	80°57' 37.4112"	-	24°37'16.2204"
C	:	80°58'45.1812"	-	24°39'07.3045"
D	:	80°59' 30.8396"	-	24°38'50.7768"
E	:	80°58' 53.1408"	-	24°35'19.3260"
E	:	80°56' 53.1408"	-	24°35'19.3260"

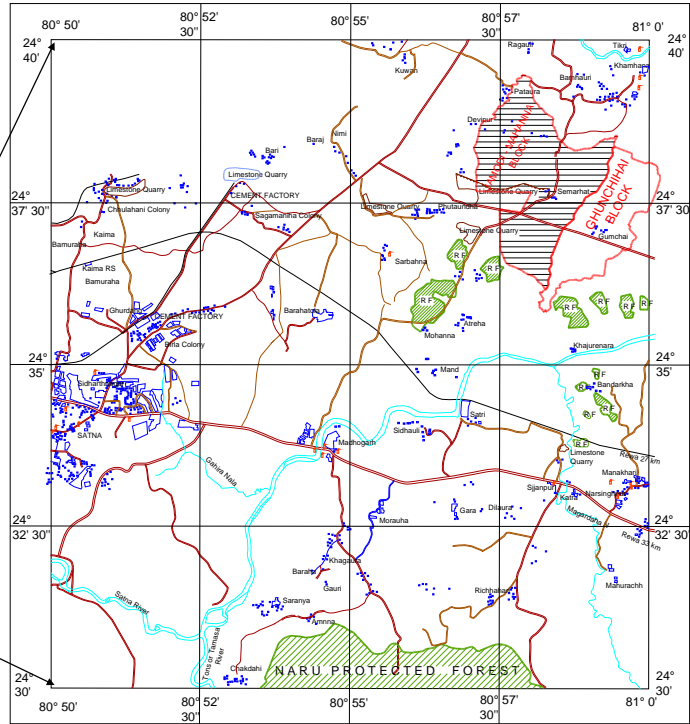
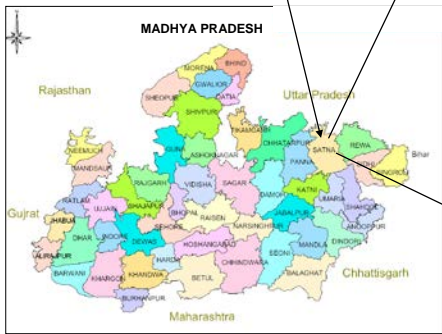
- 1.3.2 Jamodi-Mahanna block lies 25 km north of Satna town having facilities like banking, postal, communication. It is the nearest railhead on Bombay-Howrah main line, thus connecting area for fast communication and transportation. Satna, the district headquarter have most of the Infrastructure facilities like, police station, bank facility, workshop facility etc. A good network of motorable /metalled road is available in the area. Location map of Jamodi-Mahanna block is provided as Text Figure-1.

1.4.0. PHYSIOGRAPHY & DRAINAGE

- 1.4.1 Physiographically, Satna district forms a part of Vindhyaachal range. The back slope of Vindhyaachal leads to a broad plain with low ridges and valleys and rise gently to Bhandar Plateau in the south. The Bhandar Plateaus comprises Isolated mesasand buttes and is succeeded further south by Kaimur ridge reaching maximum elevation of 704 m. The Satna district is mainly drain by Son and Tons or Tamasa Rivers and their tributaries.



**LOCATION MAP OF JAMODI - MAHANNA BLOCK
DISTRICT SATNA, MADHYA PRADESH**



1.4.2 The block Jamodi-Mahanna forms a plane table land rising 300m above mean sea level. The block depicts plain with gentle slope towards South. The highest and lowest points in the block are 315m and 285 m respectively above MSL. The average rainfall in the area is 800 mm to 1100 mm. Wildlife in the area is scanty. This area is irrigated by two manmade canals situated in the northern and central part of the block. The east flowing Satna River controls the main drainage of the area which also forms the southern boundary of the block.

1.5.0 PREVIOUS WORK

1.5.1 Since the middle of the 19th Century, Vindhyan basin have been studied by the stalwarts like Medicott (1860), Mellet (1869), Oldhem (1851), Vredonbera (1906) and others. Oldhem suggested a threefold division of Upper Vindhyan into Kaimur, Rewa and Bhandar. Mellet (1869) have given a comprehensive geological account of the Vindhyan rocks and its equivalents. He also subdivided the Lower and Upper Vindhyan into various litho units. A comprehensive account of the work carried out on the limestone deposits in Rewa-Satna area is contained in the report on Investigation of Flux Grade Limestone in Rewa- Satna area by D.R.S.Mehta and P.K Raman, Geologist of Geological Survey of India. A vivid account of Nagod Limestone (Bhandar Limestone) is given by Rao et al.

1.5.2 The Directorate of Geology and Mining, Madhya Pradesh, in the regular programme of survey of various mineral deposits of the state had already undertaken and completed preliminary assessment of high grade limestone blocks of Nagod Limestone in the adjoining area.

1.5.3 Due to depleting deposits of SMS grade limestone in the property of MP state Mining Corporation Ltd. (A Government of Madhya Pradesh Undertaking) the Corporation's authorities approached DGM to locate area of SMS and higher grade limestone within economic distance of transport from the Satna railway siding of the corporation. Selection of detailed geological work and proving of high grade limestone deposit for the Madhya Pradesh State Mining Corporation was therefore based on the recommendations contained in the work carried out by S.S Mishra (1974-75), DGM, MP.

1.5.4 The geological investigation was taken up around Rampur and Ramasthan, Raghuraj Nagar Tehsil, Dist.-Satna included in the Survey of India Toposheet no 63 D/14. The work in the above area commenced in October-1975 and was closed in September-1976. An area of 200 Sq. km between Latitude 24°36' to 24°39' and Longitude 84°47' to 84°59' was mapped on scale 1:63360.

1.5.5 The rock formation belongs to Bhandar group of Vindhyan Super Group. The area is found to contain 8 m to 13.5 m thick dark grey limestone horizon of lower Nagod limestone of average grade corresponding to flux grade. A total of 17.05 million tonnes of flux and cement grade limestone have been proved in the Ramasthan block by DMG, Rajasthan. However, if mechanized mining is carried out, the grade may fall to the cement grade.

1.6.0 OBJECTIVES OF EXPLORATION

1.6.1 The present exploration was carried out with the following objectives.

- I. To demarcate the limestone occurrence in the study area by drilling boreholes at 400m X 400m grid interval covering part "A" (G2 Level) and 800m X 800m in Part "B" (G3 Level) to cover entire block area under G-2 & G3 level of exploration.
- II. To estimate the Indicated category (332) & Inferred category (333) of Resources as per UNFC guidelines and to assess quality and grade of limestone.
- III. To carry out exploration as per Mineral (Evidence of Mineral Contents) Rule-2015, Mineral Auction Rule-2015 and MMDR Acr-2015 in turn facilitate the State Government (MP) in Auctioning of the block.

1.7.0 PRESENT WORK

1.7.1 MECL commenced exploration work in Jamodi-Mahanna block on 08.02.2017 in an area of 31.00 sq km and completed geological mapping, topographic survey and 3731.00 m core drilling in 83 boreholes and other associated geological work in November 2017.

1.7.2 During the course of exploration the following quantum of work was carried out by MECL (G4 & G3 & G2 level). Table –1.1 & 1.2

Table No. - 1.1

QUANTUM OF WORK CARRIED OUT BY MECL IN JAMODI-MAHANNA BLOCK (G4 level), DISTRICT- SATNA, MADHYA PRADESH

Sl. No.	Item of Work	Unit	Quantum of work proposed	Achievement
1	Geological Mapping (on 1:10000 scale).	Sq. Km.	31.00 sq. km	31.00 sq. km
2	Surface / Out crop sampling	Nos.	20 numbers in an area of 31.00 Sq. Km	20 numbers
3	Drilling	m.	250m (5 Scout BHs)	274.00 (5verticalBHs)
4	Laboratory Studies			
	i) Chemical Analysis;(core samples) Primary + Check for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	120 Primary + 10 Check = 130	Primary -101 + Check-05 Total - 106
	ii)Chemical Analysis;(Surface samples) Primary for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI		20	20
	iii) External Check sample for analysis of 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	5	-

	iv) Composite Samples a) For 12 radicals (CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , LOI, MnO ₂ , K ₂ O, Na ₂ O and Cl.)	Nos.	15	11
5	Physical Studies			
	a) Spectroscopic Studies (10 elements)	Nos.	10	10
	b) XRD studies	Nos	10	10
6	Petrological Studies (Petrographic Studies)	Nos	10	10
7	Specific Gravity Determinations	Nos	20	20
8	Report Preparation (Digital format)	Nos.	1 No.	1 No.

Table No. - 1.2

**QUANTUM OF WORK CARRIED OUT BY MECL IN JAMODI-MAHANNA
BLOCK (G3 & G2 level), DISTRICT- SATNA, MADHYA PRADESH**

Sl. No.	Item of Work	Unit	Quantum of work proposed	Achievement
1	Geological Mapping (on 1:10000 scale).	Sq. Km.	31.00 sq. km	31.00 sq. km
2	Drilling	m.	4255m (107 BHs)	3731.00 (83 BHs)
4	Laboratory Studies			
5	i) Chemical Analysis (Primary + Check)for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	2000 Primary + 200 Check = 2200	Primary 1641 + Check-164 Total = 1805
	ii) Chemical Analysis Primary for 2 radicals i.e. SO ₃ & P ₂ O ₅	Nos.	50	55
	iii) External Check sample for analysis of 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	100	86
	iv) Composite Samples For 12 radicals (CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , LOI, MnO ₂ , K ₂ O, Na ₂ O and Cl.)	Nos.	650	159
	b) Physical Studies			
6	c) Spectroscopic Studies (10 elements)	Nos.	20	20
	d) XRD studies	Nos	25	20
	e) Petrological Studies (Petrographic Studies)	Nos	25	25
7	Specific Gravity Determinations	Nos	30	29
8	Report Preparation (Digital format)	Nos.	1 No.	1 No.

1.7.3 This report incorporates the surface & subsurface data generated by MECL during G4 and G3 & G2 level explorations within the block.

1.8.0 ACKNOWLEDGEMENT

1.8.1 Mineral Exploration Corporation Limited (MECL) expresses its sincere gratitude to the Ministry of Mines, Technical Committee of NMET, National Mineral Exploration Trust (NMET), Govt. of India, Geological Survey of India (GSI) and Directorate of Geology and Mining (DGM) Madhya Pradesh at whose behest the exploration work in Jamodi-Mahanna Block has been executed. The local administration / authorities at Satna district, Madhya Pradesh also deserves a special mention with thanks for extending all necessary help and guidance in completing the exploration work successfully.

CHAPTER-II

2.0.0 GEOLOGY AND STRUCTURE

2.1.0 REGIONAL GEOLOGY OF THE AREA

The rock types of the region, District- Satna, ranges in age from Archaean to Cainozoic. The Archaean rocks comprise of granites & gneisses and are exposed only in northern part of the Satna district. The rocks of Vindhyan Supergroup comprised of Semri, Kaimur, Rewa & Bhandar groups. The Semri Group of rocks is represented by an alternating sequence of Sandstone and shale along with porcellanite and limestone. The Semri Group of rocks mainly exposed in the southern and northern part of the district. The Rohtas Limestone of Semri Group is light to grey in colour, fine grained compact and well bedded. The Kaimur Group comprising mainly sandstone which is fine grained; massive and thick bedded is exposed in the northern and southern part. The Rewa Group of rocks comprises mainly of sandstone, shale and conglomerate. The Bhandar Group of rocks exposed as a broad band and comprises mainly Shale, Nagod limestone and upper Bhandar sandstone. Nagod limestone is fine grained, hard, compact thinly bedded to massive with some stromatolitic bands. The upper Bhandar Sandstone forms the cliffs of the Bhandar plateau and is composed of purple to reddish brown, fine to medium grained, flaggy to massive and well sorted sandstone inter-bedded and splintery shale and siltstone. Lameta Formation comprising sandstone and shale range in thickness from 15-80m and occurs in the form of clusters on the hillocks of upper Rewa Sandstone. Laterite occurs as capping on the Bhandar Group of rocks and on the upper Rewa Sandstone. It has a maximum thickness of 60m. Regional geological map is provided as Text Figure-2.

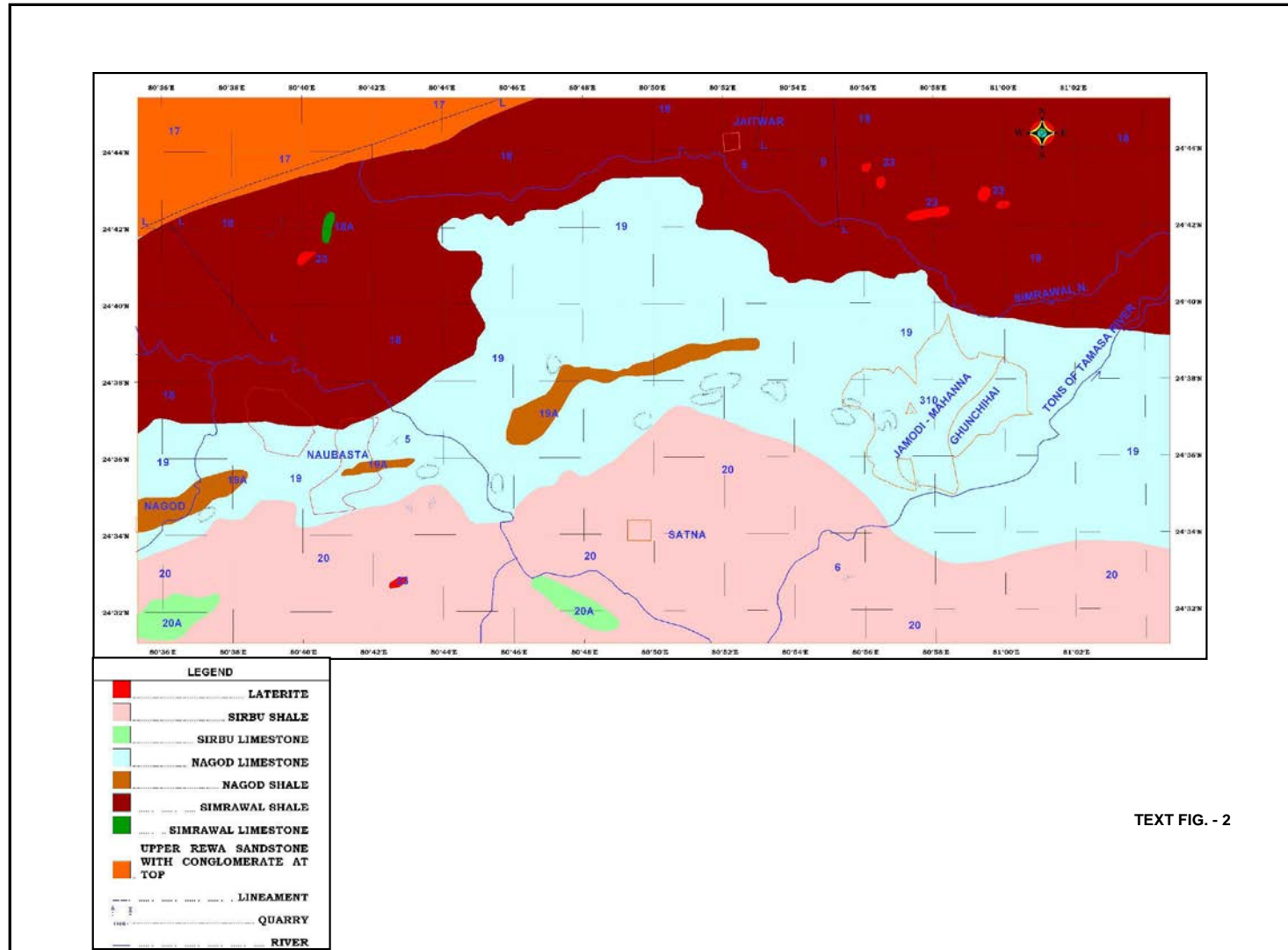
2.2.0 GEOLOGY OF THE AREA

2.2.1 Most of the area within the explored block is covered by cultivable lands and soil. The limestone outcrops are exposed in form of patches in the central region of the block and in the mine sections. Geology of the block has been deduced tentatively on the basis of surface geological traverses along the profile lines and with the help of sub-surface exploratory borehole data.

2.2.2 The rock formation occurring in the study area comprises sandstone, shale and limestone, all belonging to the Bhandar Group of Upper Vindhyan. These rock formations are horizontal having south-easterly dips varying from 1° to 3°. The geological map with borehole locations is given as Text Figure-3.

The general stratigraphic succession of the study area is as below:

**REGIONAL GEOLOGICAL MAP OF NAGOD-SATNA-JAITWAR AREA
DIST : SATNA, MADHYA PRADESH**



TEXT FIG. - 2

Table-2.1
The Regional stratigraphic succession of the area around
Jamodi-Mahanna Block

Super group	Group	Formation
Recent	-	Laterite
Upper Vindhyan	Bhander Group	Upper Bhander Sandstone
		Sirbu Shale
		Lower Bhander Sandstone
		Bhander (Nagod) Limestone
		Ganurgarh/Simrawal Shales

2.3.0 DESCRIPTION OF DIFFERENT FORMATIONS

2.3.1 GANURGARH SHALE

It is the oldest formation of the Bhander Group also known as Simrawal shales, overlies the Govindgarh Sandstone (Upper Rewa Sandstone) and underlies the Bhander Limestone with conformable relationship. It is made up of reddish-brown coloured shale, calcareous siltstone and fine-grained sandstone. In petrographic studies it is observed that clay/mica minerals present as fine flaky aggregates showing alignment. Gypsum is present as fine prismatic grains segregating into parallel bands.

2.3.2 BHANDER (NAGOD) LIMESTONE

The limestone are well bedded, fine to medium grained and grey to dark grey in colour. They are traversed by two sets of joints which are parallel to their strike and dip directions. Columnar Stromatolites are abundantly developed. It is widely mined for cement and metallurgical industry.

The limestone deposits are horizontally bedded with dips varying from 0° to 3° towards south to south-east. The upper part of the Bhander Limestone is made up of greyish to yellowish brown, micritic limestone, oolitic limestone, and stromatolitic limestone with thin bands of grey shale. The lower part of the Bhander Limestone is made up of light brown to grayish green coloured limestone intercalated with thin to thick brown to greenish shale layers. Stromatolitic feature is also seen in this part. These two parts of bhander (Nagod) limestone is separated by a thick layer of lower grade shaley limestone, calcareous shale and green shale.

Further, the Bhander limestone show fairly considerable variations in quality and thickness, both laterally as well as vertically. Again, in several localities the rich quality limestone beds are overlain and also inter-layered with limestone which is of inferior grade.

2.3.3 LOWER BHANDER SANDSTONE – (Impure Siliceous Limestone)

The rock occurs almost as a persistent capping over the Bhander Limestone deposits in the area east and also west of Satna, right up to Nagod in the West, with occasional breaks. The rock varies in colour from greyish white to pale grey and pale brown, often cherty in nature and well bedded with thin argillaceous intercalations. The rock is hard, compact, and comes out in slabs.

This rock has perhaps been responsible for the preservation of a large tract of limestone strata underneath, protecting it from sub aerial erosion.

2.3.4. SIRBU SHALES.

It is made up of light yellow, grey to greyish green shales and siltstones interbedded with grey to brownish grey sandstones. The shales are thinly bedded and places directly overlie the limestone horizon. Very prominent exposures of Sirbu Shales are seen in the northern part of the block, at the canal sections.

2.3.5 UPPER BHANDER SANDSTONE

These sandstones, also known as Maihar Sandstone, makes the distinct hillocks, situated away from the limestone area were not examined in the investigation and accordingly not described.

2.4.0 STRUCTURE OF THE BLOCK

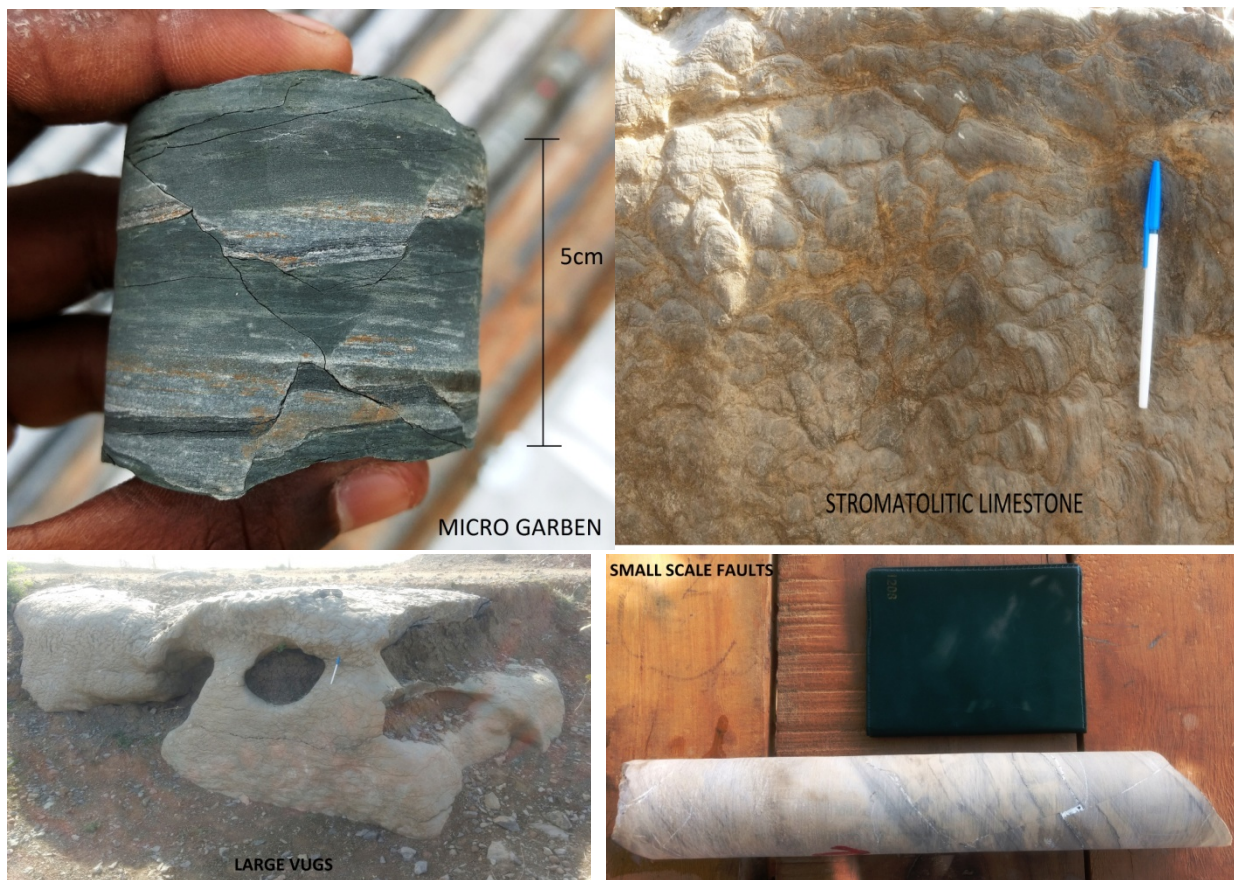
2.4.1 The uniform horizontal disposition of the sedimentary sequence in the area of investigation indicates that the area has not undergone any major tectonic disturbance. Dip and strike data of Bhander Limestone has been recorded from the outcrops as well as from the mine / quarry sections. The dip varies from horizontal (0°) to 3° with dip direction towards south to south-east.

2.4.2 To study the basin configuration about deposition of limestone beds, a Floor Contour Plan is prepared on 1:10000 scale (Plate no. IV and Text Figure-4). The floor of Bhander (Nagod) Limestone (Cement grade Zone-II) is considered for drawing Floor Contours at 2m interval. The generalised strike of the strata within the block is E-W and Dip of 1 to 3 degree towards south. It is confirmed from Geological Cross Sections drawn within the block. As established in the adjacent Ghunchihai Block, strike is NE-SW which become almost E-W in Jamadi-Mahanna block. Surface and subsurface data is incorporated for finalization of structure of the block.

2.4.3 Among the primary sedimentary structures, bedding planes and laminations are very common within shale-sandstone unit but not so prominent within limestone. The secondary structures observed in the area are joints and stylolites. The limestone beds are traversed by two sets of joints which are parallel to their strike and dip directions. A

distinct and marker horizon of shale with soft sedimentary deformation structure, like small scale flame structure, is seen in drill cores. It is found at the gradational contact between the Bhandar limestone and Ganurgarh shale.

- 2.4.4 Porous structure with vugs filled with secondary calcite and dolomite is very common in Bhandar limestone. These can be of small 2-5 cm scale to as big as 1m in size, seen in the quarry sections (Text Figure-3A/3).
- 2.4.5 Small scale faults are also seen in core (Text Figure-3A/4). In Bhandar limestone formation, shale lamellae are displaced by micro garben (Text Figure-3A/1). In limestone, secondary carbonate veins are seen to be displaced occasionally.

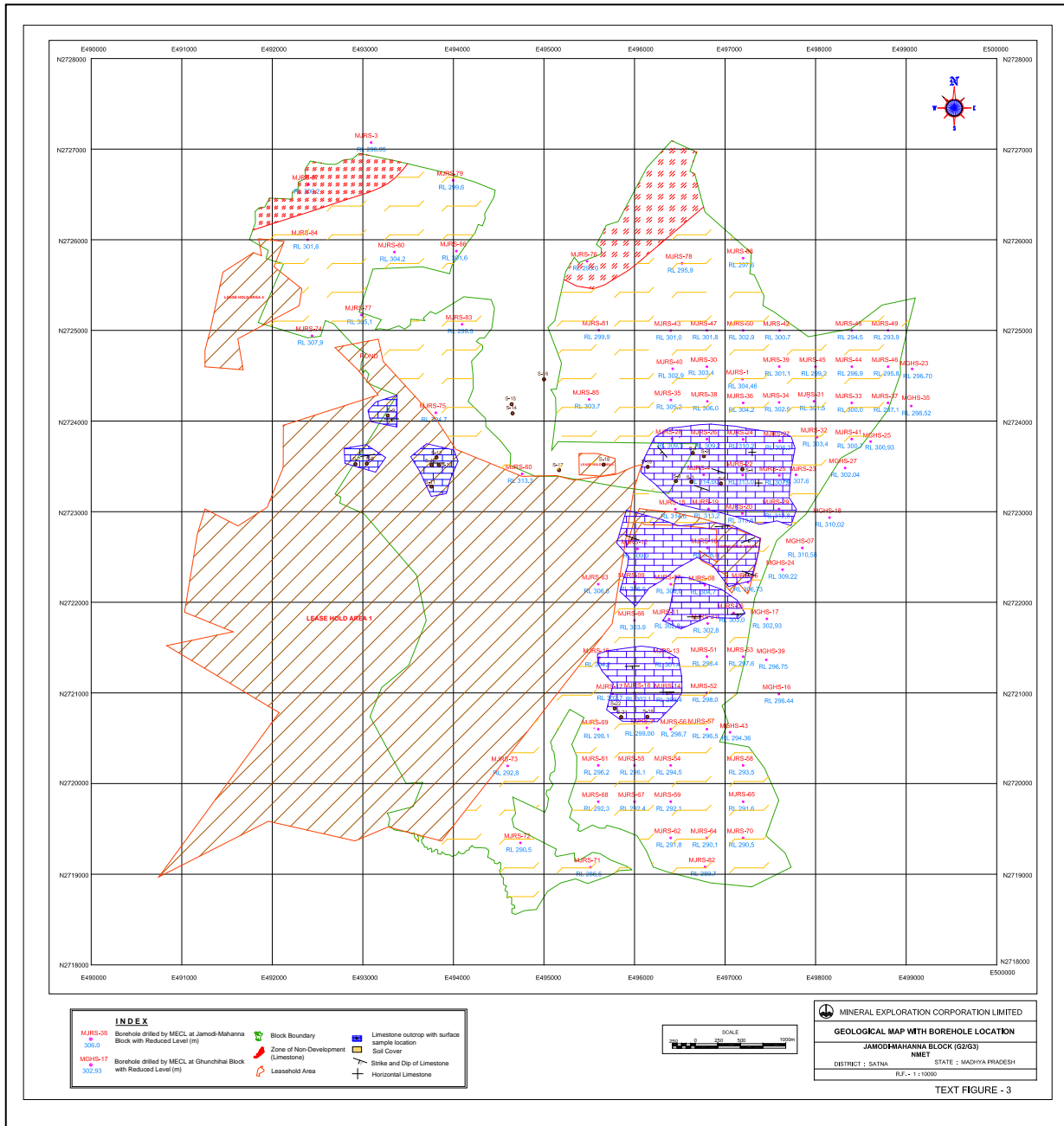


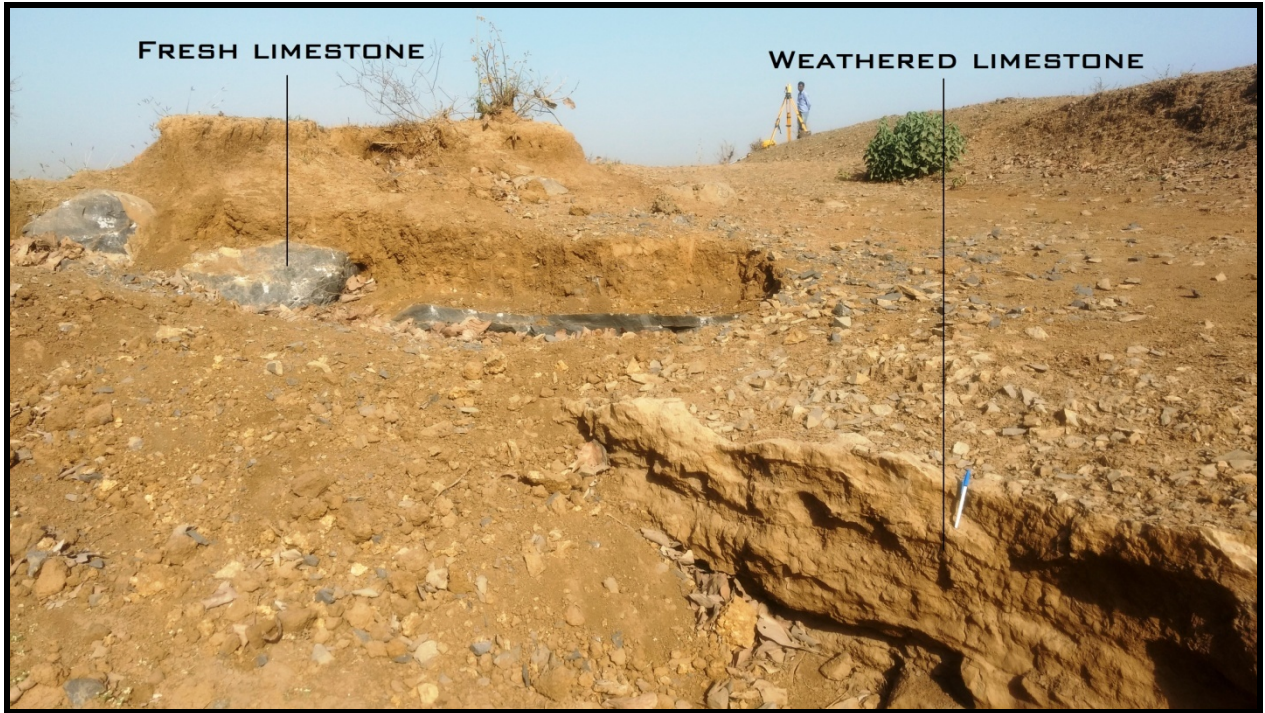
Text Figure-3A: 1. Small scale microgarben 2. Columnar stromatolitic limestone (section)
3. Large vugs in limestone 4. Small scale faults

2.5.0 DEPOSITIONAL ENVIRONMENT

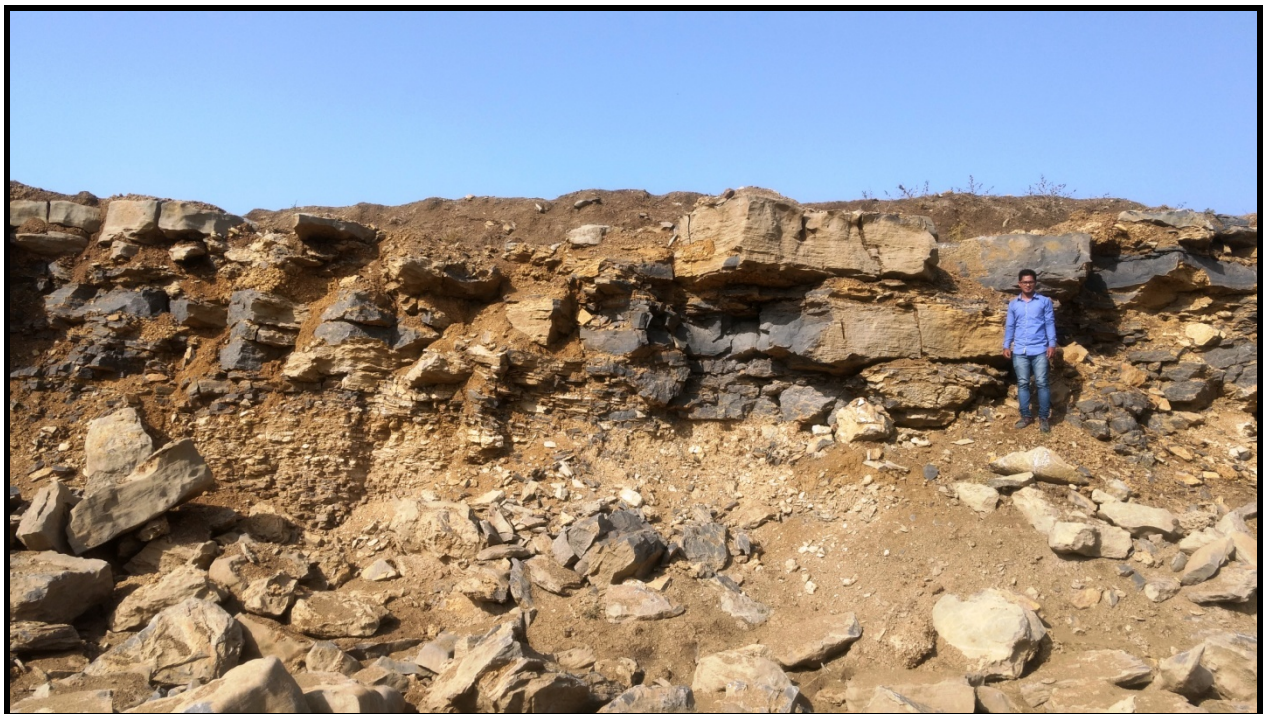
- 2.5.1 The gypsum bands of the Ganurgarh shale depict a lagoonal environment of deposition. The Bhandar limestone with intercalated thin shale laminations can be formed in a shallow marine tidal environment with a phase of transgression that forms the thick shale formation in between the upper and lower Bhandar limestone.

GEOLOGICAL MAP WITH BOREHOLE AND OUTCROP SAMPLE LOCATIONS JAMODI-MAHANNA BLOCK, DIST: SATNA, MADHYA PRADESH





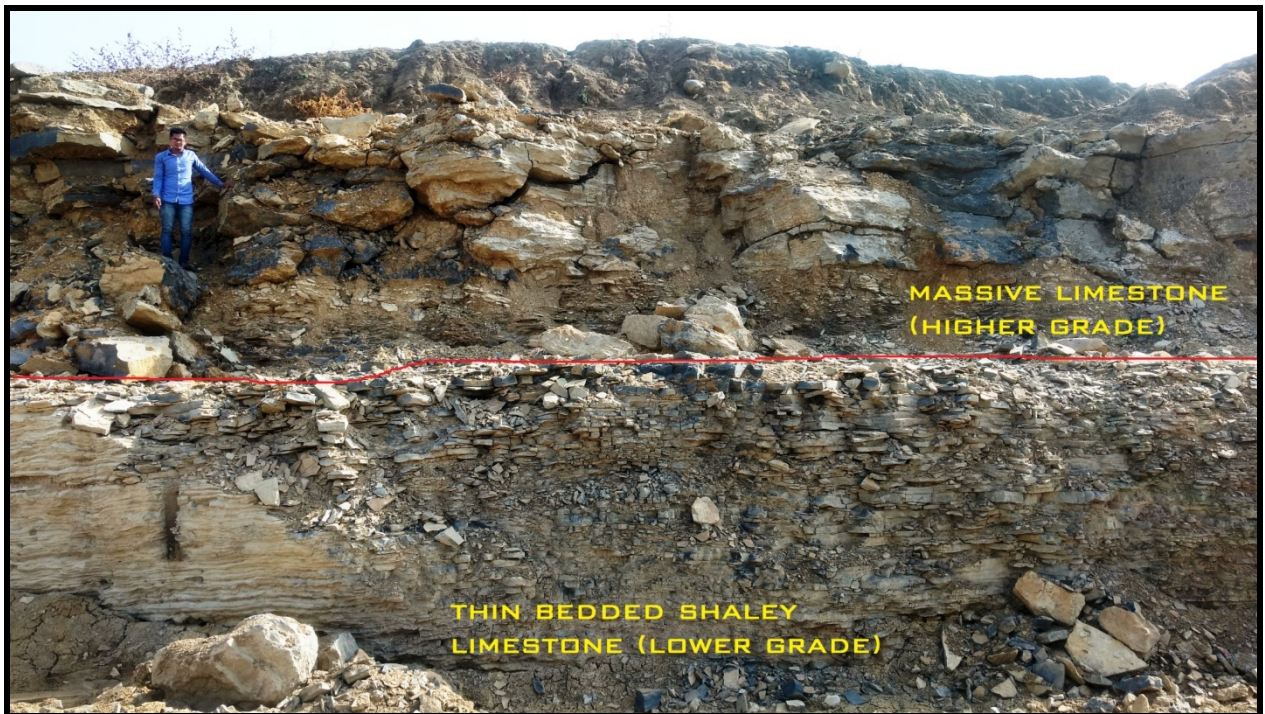
Text Figure-3B.1- Juxtaposition of fresh and weathered limestone



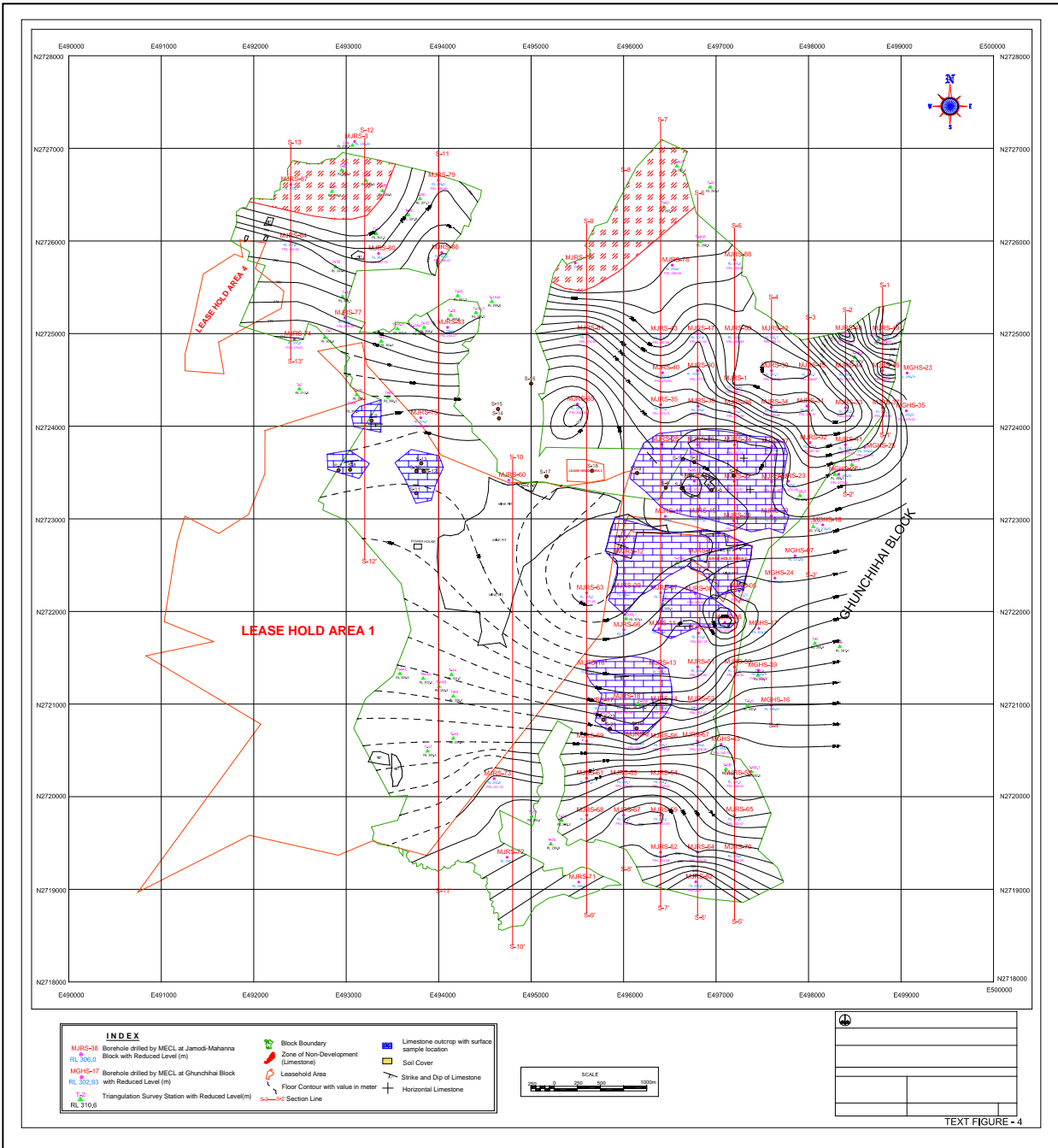
Text Figure-3B.2- Limestone in mine section



Text Figure-3B.3- Bedded limestone in mine section



Text Figure-3B.4- Thin bedded shaley limestone overlain by massive limestone in quarry section



CHAPTER-III

3.0.0 EXPLORATION METHODOLOGY

3.1.0 INTRODUCTION

3.1.1 Based on the outcome of five scout boreholes of the G-4 exploration stage, a total of 297.317 million tonnes of Cement grade net in-situ resources of “**Reconnaissance (334) category**” have been estimated in Jamodi-Mahanna Block. The recommendation of further exploration was taken into consideration and exploration at G2&G3 stage with closer grid spacing has been carried out to delineate the shape, size and geometry of cement grade limestone deposit and increase the confidence level of resource estimation of earlier exploration.

3.2.0 SCHEME OF EXPLORATION

3.2.1 To achieve the objectives, exploratory drilling was carried out with associated survey, sampling and laboratory studies for assessment of the available resources. Details of all the exploration activities are given in the following paras.

3.3.0 LIMITATIONS

3.3.1 The entire assessment of deposit is based on surface and subsurface data obtained from geological mapping, drilling & sampling. Thus limitations as regards to logical interpretation of these data are as follows. The leasehold boundary within the block has been provided by DGM, MP.

3.3.2 Out of proposed 107 boreholes, 83 boreholes have been drilled in G3/G2 stage. The 24 proposed boreholes, that could not be taken up as 12 of them are located within leasehold area and rest of them were not accessible either due to rainy season or agricultural activity or due to borehole located within forest area in the block. Thus, the entire assessment has been done based on the data collected from 88 boreholes (83 G2 & G3 level and 5 G4 level).

3.3.3 Out of these 88 drilled boreholes, 72 were drilled in 400X400m grid (G2 level) and rest 16 in 800X800m grid (G3 level). The line of separation of G2 (Part A) and G3 (Part B) category boreholes have been shown in Text Figure-8.

3.3.4 The entire interpretations of the exploration data is based on the assumptions of gradual change between the points of observations.

3.3.5 The core loss whenever occurred is generally attributable to the solution cavities / cavernous/ and occasionally due to the weathered, oxidized and fractured nature of the formations generally below the soil cover. In these cases, extrapolation of thickness was done on proportionate basis of physical characteristics of the lithology and other logical factors.

3.3.6 Out of the total 31 sq. Km block area, cumulative 9.12 sq. Km within the block is leasehold area. Thus, all the geological interpretations along with estimated resources are limited within the lease free area only.

3.4.0 TOPOGRAPHIC SURVEY AND GEOLOGICAL MAPPING

3.4.1 Triangulation network have been laid down in the proposed study area with the help of DGPS. Boreholes have been fixed on the ground as approved by NMET. RL's and co-ordinates of survey stations and borehole points have been determined and the same is furnished as Annexure No I-A and I-B respectively.

3.4.2 The geological mapping on 1:10000 scale was carried out in 31.00 sq. km. area by taking traverses with the help of DGPS. About 50% of the area of the block is covered with soil/alluvium. The exposures of Bhandar/Nagod limestone in the central part of the block were mapped and surveyed where ever available and plotted on the geological map along with strike & Dip. Northern and southern part of the block is completely covered with soil/alluvium. All the geological features wherever possible have been recorded, plotted and furnished in the Topographical and Geological Map as Plate II.

3.4.3 22 nos of outcrop samples were collected from outcrops/exposures of Limestone during G4 level exploration. These locations were plotted on the plan (Plate II). Analytical results for 6 radicals are presented as Annexure-III F.

3.5.0 SURFACE DRILLING

3.5.1 After review of data generated at G4 level, Technical Committee of NMET recommended 107 boreholes covering the entire area of the block in G2/G3 stage. Out of which 83 boreholes have been drilled in this block. The drilling in the block commenced on 08.02.2017 and completed on 24.11.2017. Thus the total meterage of 4005.00 m have been drilled in 88 vertical boreholes in the block during G4 & G-3/G-2 levels of exploration.

3.5.2 The entire core drilling has been done by wire line method in NQ borehole size using diamond bits. Bentonite mud was used as drilling fluid to flush out the cuttings and to stabilize the borehole wall. The drilling fluid also works as a coolant to avoid burning of drilling bits. Core recovery of more than 90% was maintained in limestone, however, in case of weathered, loose & fractured formation and in solution cavities filled with clay the core recovery was low.

3.6.0 DRILL CORE LOGGING AND SAMPLING

3.6.1 The entire core recovered by drilling was logged systematically in detail describing different lithological units. The details of lithology, its grain size, colour, structural features etc. were recorded. In limestone the density of fossil content, presence of intercalations, stylolite structure and cavities have been recorded. Due to poor core recovery at places, extrapolations of various drilled depth were done on proportionate

basis considering the physical characteristics of individual units recovered. All the cores were kept and preserved properly in the core boxes following 'Book pattern'. The duplicate half core was preserved in core boxes and handed over to DGM, MP.

- 3.6.2 The run-wise lithologs of boreholes MJRS-1 to 88 drilled by MECL are given as Annexure-IIA & IIB and its graphic lithologs with zone details has been given as Plate-VII.

3.7.0 SAMPLING AND ANALYSIS

- 3.7.1 Since the estimation of quality and quantity of the limestone deposit is based on the primary analytical data, hence sampling was given the utmost importance in the entire scheme of exploration. The detailed account of the different sampling technique adopted is summarized below:

- 3.7.2 **PRIMARY AND CHECK SAMPLES:** Considering the uniform nature of limestone over considerable thickness in all the boreholes and after critical study of lithological data generated during the present exploration, an optimum sample length of 2 m is justifiable in evaluating the grade of limestone. Hence the length of primary sample was kept at 2 m during sampling of MECL borehole cores depending on the Lithology, fossil content etc. However the samples of shorter or larger lengths were also prepared wherever felt necessary depending on the variations in the lithology and fossil contents etc.

- 3.7.3 The drill core samples of the limestone were split into two equal halves by using core splitter for preparation of primary samples. One half was powdered to -100 mesh and the other half was kept for further studies (Petrological studies etc.). By mixing, coning and quartering of the sieved powder desired representative samples were drawn. Out of these representative samples, 100 gm samples were sent to MECL Chemical Laboratory for primary analysis and remaining samples were preserved as duplicate samples. A total of 1742 (G2 & G3-1641 and G4-101) primary core samples have been prepared and sent to MECL laboratory for analysis of 6 radicals i.e. CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃ & LOI. These are the basic and most essential chemical constituents to specify the grade of limestone in view of its utilization aspects such as cement manufacturing, Iron & Steel industry, Chemical industry, Fertilizer and Glass industry. A total of 55 samples, drawn from the vugs and porous limestone zones, have been prepared and sent to MECL laboratory, for analysis of SO₃ & P₂O₅. In addition to 1742 primary samples 169 numbers primary samples (around 10% of primary samples) have been analyzed for CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃ & LOI as check samples to examine the quality of sampling and 86 nos primary samples have been analyzed for the same as external sample, to check the reliability data.

- 3.7.4 The results of primary analysis of borehole core samples for both 6 radicals (G2/G3 & G4) and 2 radicals are furnished as Annexure-IIIA, IIIB and IIIE respectively. Analytical results of primary samples versus internal and external check samples are given as Annexure-VA & VB respectively.

3.7.5 **COMPOSITE SAMPLE ANALYSIS:** Composite samples have been prepared borehole wise and length wise (maximum 6 m) by taking powdered material (-) 100 mesh of each primary samples in volume proportion and thoroughly mixing, followed by coning and quartering. The details of 159 Nos. composite samples in G2/G3 level and 11 Nos. in G4 level and its analysis for 12 radicals (CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, SO₃, P₂O₅, TiO₂, Mn₂O₃, K₂O, Na₂O and LOI) has been furnished as Annexure-III C & IID respectively.

3.8.0 PHYSICAL ANALYSIS

3.8.1 **Spectroscopic Studies:** 20 composite samples from G2 & G3 level and 10 from G4 level of selected zones from boreholes were subjected to spectroscopic analysis for minor and trace elements (10 radicals) at Physical Laboratory of JNARDDC, Nagpur and the results are furnished as Annexure-VIA & VIB respectively.

3.8.2 **X-Ray Diffraction Studies:** The 20 composite samples from G2 & G3 level and 10 from G4 level of selected zones from the boreholes were subjected to X-ray diffraction studies at Physical Laboratory of MECL to determine the individual composition and to identify major and minor constituents in the limestone. The results of these studies are given as Annexure-VII.

3.9.0 PETROGRAPHIC STUDIES

3.9.1 25 nos. of specimens of Limestone from G2 & G3 level and 10 from G4 level boreholes cores were subjected to petrographic studies at Petrology Laboratory, MECL, Nagpur. The results of these petrographic studies are presented as Annexure-VIIIA & VIIIB respectively.

3.10.0 SPECIFIC GRAVITY DETERMINATION

3.10.1 30 nos. and 20 nos. limestone core samples, at G2/G3 and G4 level respectively, from MECL boreholes were subjected to specific gravity determination at Petrology Laboratory, MECL Nagpur. The average specific gravity of these 50 samples has been calculated as 2.64 and considered for calculation of resources. The results of specific gravity determination are presented as Annexure-IX.

3.11.0 LIMESTONE ZONES INTERSECTED IN MECL BOREHOLES

3.11.1 Cement grade limestone zones have been identified on the basis of assay values that satisfy the criteria of CaO \geq 42%, MgO $<$ 4% and SiO₂ $<$ 16%. Two distinct cement grade limestone zones have been identified. From top to bottom these zones have been named as Zone-I and Zone-II respectively. At some instances splitting of these zones have occurred and named as Zone-IA, Zone-IB, Zone-IIA, Zone-IIB & Zone-IIC. The splitting has been named also in order of their occurrences from top to bottom. The thickness of cement grade limestone Zone-I varies from 1.00m (MJRS-05) to 16.00m (MJRS-60) whereas the same for Zone-II varies from 1.00m (MJRS-81) to 13.60m (MJRS-52). The grade variation of CaO for Zone-I is minimum 42.25%

(MJRS-10) to maximum 49.25% (MJRS-05) and for Zone-II is minimum 42.08% (MJRS-12) to maximum 48.88% (MJRS-46). The cement grade limestone is sandwiched between ungraded limestone zones assessed on the basis of the threshold value given by IBM i.e. 34% CaO. Borehole wise cement grade and ungraded zones are presented as Table-3.1 and 3.2 and also given as Annexure – IVA and IVB respectively.

Table-3.1
Intersection of Cement grade limestone in boreholes drilled by MECL
Jamodi-Mahanna block (G4 & G3/G2), Dist: Satna, Madhya Pradesh
Zone based on $\geq 42\%$ CaO, $< 4\%$ MgO and $< 16\%$ SiO₂ cut-off

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade	Zone
	From	To		%	%	%	%	%	%		
MJRS-1	11.35	14.85	3.50	47.23	1.31	8.02	1.81	1.33	39.38	Cement	II
MJRS-2	1.00	4.67	3.67	44.45	1.32	10.71	2.02	1.27	36.56	Cement	I
	35.73	41.23	5.50	44.17	1.60	12.17	2.59	1.60	36.25	Cement	II
MJRS-4	1.60	4.30	2.70	47.06	1.33	9.21	1.86	1.18	38.33	Cement	IA
	7.58	9.21	1.63	44.90	1.55	11.13	2.27	1.55	36.10	Cement	IB
	36.70	37.90	1.20	45.22	1.43	10.31	2.53	1.44	37.20	Cement	IIA
	39.50	41.10	1.60	44.32	1.78	11.79	2.36	1.41	36.30	Cement	IIB
MJRS-5	1.00	2.00	1.00	49.25	0.93	6.45	1.37	1.10	38.80	Cement	IA
	3.00	4.34	1.34	44.30	1.24	11.78	2.29	1.75	35.90	Cement	IB
	31.15	44.50	13.35	43.84	3.17	10.08	2.03	1.54	36.78	Cement	II
MRS-07	4.00	15.70	11.70	43.93	3.37	4.76	1.89	1.50	37.99	Cement	I
	39.20	43.00	3.80	45.51	1.56	4.94	2.05	1.49	37.20	Cement	II
MJRS-08	0.00	6.50	6.50	45.09	2.54	5.47	1.31	1.82	37.97	Cement	I
	31.50	35.50	4.00	42.80	1.67	6.31	1.85	2.51	35.41	Cement	II
MJRS-09	2.00	9.00	7.00	42.42	3.11	4.71	2.24	1.62	36.73	Cement	I
MJRS-10	5.00	7.00	2.00	42.80	3.71	10.26	2.24	1.68	37.82	Cement	IA
	11.00	12.30	1.30	42.25	2.07	12.79	2.52	1.95	35.01	Cement	IB
	37.00	39.00	2.00	42.57	1.64	12.77	2.64	1.93	35.87	Cement	II
MJRS-11	43.50	45.50	2.00	42.47	3.95	8.40	1.33	1.59	38.22	Cement	II
MJRS-12	0.10	15.10	15.00	45.67	2.40	4.40	1.68	1.29	38.53	Cement	I
	37.00	39.10	2.10	42.08	1.72	13.47	2.77	1.72	35.84	Cement	IIA
	42.60	44.00	1.40	47.81	1.45	7.15	1.57	1.18	39.08	Cement	IIB
MJRS-13	1.50	4.00	2.50	47.47	1.98	7.01	1.40	1.04	39.10	Cement	I
	35.75	43.00	7.25	44.30	1.56	6.09	2.19	1.59	37.01	Cement	II
MJRS-14	0.00	3.96	3.96	49.17	1.02	2.91	1.16	1.10	40.11	Cement	I
	30.50	34.50	4.00	43.88	1.63	10.98	2.32	1.67	37.04	Cement	IIA
	39.90	43.50	3.60	43.86	3.35	9.26	1.79	1.36	38.57	Cement	IIB
MJRS-15	1.50	8.00	6.50	42.92	2.38	5.51	2.14	1.43	36.52	Cement	I
	38.50	44.50	6.00	44.33	1.50	10.72	2.22	1.68	36.76	Cement	II
MJRS-16	0.40	14.05	13.65	46.34	2.04	8.10	1.59	1.33	38.79	Cement	I
	44.00	46.00	2.00	47.66	1.20	7.15	1.54	1.44	38.76	Cement	II
MJRS-17	8.65	12.50	3.85	43.06	1.53	6.42	2.13	1.59	35.61	Cement	I
	43.50	45.00	1.50	42.34	1.58	13.50	2.47	2.08	36.07	Cement	II
MJRS-18	35.50	38.50	3.00	44.82	1.50	9.96	2.17	1.85	37.22	Cement	II
MJRS-19	0.00	9.60	9.60	42.92	2.84	11.62	2.09	1.50	36.87	Cement	I
	39.00	45.00	6.00	44.93	1.42	10.44	2.14	1.53	37.43	Cement	II
MJRS-20	0.00	4.00	4.00	47.62	1.73	7.39	1.38	1.05	39.67	Cement	I
MJRS-21	0.80	2.50	1.70	44.53	1.23	11.02	2.13	1.74	37.24	Cement	I
	29.65	31.30	1.65	47.55	1.36	7.46	1.72	1.24	39.16	Cement	II

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade	Zone
	From	To		%	%	%	%	%	%		
MJRS-22	2.20	8.80	6.60	42.40	2.11	12.42	2.43	1.93	35.94	Cement	I
	35.35	37.05	1.70	46.36	1.26	8.65	1.78	1.48	37.02	Cement	II
MJRS-23	18.40	27.80	9.40	44.60	1.73	5.68	2.20	1.60	37.83	Cement	II
MJRS-24	0.00	2.00	2.00	42.41	1.27	14.29	2.14	1.59	35.33	Cement	I
	32.50	34.25	1.75	42.46	1.79	13.53	2.72	1.61	36.10	Cement	IIA
	39.55	41.30	1.75	45.46	3.11	7.81	1.56	1.41	39.44	Cement	IIB
MJRS-26	3.50	6.00	2.50	42.47	1.46	13.48	2.43	2.09	35.76	Cement	I
	38.10	41.25	3.15	43.34	3.80	5.95	1.81	1.38	38.42	Cement	II
MJRS-27	20.20	21.76	1.56	44.58	1.62	10.58	2.41	1.56	37.55	Cement	IIA
	26.48	28.08	1.60	43.32	1.53	12.79	2.48	1.60	36.18	Cement	IIB
	32.50	34.00	1.50	44.95	3.85	8.01	1.44	1.08	40.05	Cement	IIC
MJRS-28	9.66	11.22	1.56	46.06	1.31	8.93	1.74	1.41	38.79	Cement	I
	31.00	32.50	1.50	42.93	1.66	12.63	2.71	1.72	36.55	Cement	II
MJRS-29	2.00	4.75	2.75	45.59	1.12	9.77	1.72	1.27	36.52	Cement	I
	33.00	36.00	3.00	45.45	1.74	9.21	1.97	1.42	37.86	Cement	II
MJRS-30	12.00	16.80	4.80	44.11	2.52	10.60	2.03	1.42	38.07	Cement	II
MJRS-34	5.00	13.00	8.00	44.46	1.45	11.38	2.29	1.53	36.57	Cement	IIA
	17.50	19.00	1.50	43.72	3.63	9.81	1.79	1.54	37.75	Cement	IIB
MJRS-35	17.00	25.00	8.00	42.73	2.10	12.61	2.44	1.67	34.43	Cement	II
MJRS-36	14.00	22.00	8.00	42.14	1.89	13.60	2.71	1.73	35.25	Cement	II
MJRS-38	18.50	26.90	8.40	42.95	1.60	12.45	2.54	1.91	36.03	Cement	IIA
	31.80	33.40	1.60	43.88	3.79	8.71	1.61	1.28	38.42	Cement	IIB
MJRS-39	3.00	6.40	3.40	43.53	2.81	10.61	1.79	1.43	37.60	Cement	IIA
	9.60	11.00	1.40	44.54	3.32	9.13	1.68	1.31	38.81	Cement	IIB
MJRS-40	13.00	18.50	5.50	45.90	2.18	8.94	1.63	1.35	38.78	Cement	II
MJRS-41	8.00	9.95	1.95	47.45	1.09	8.04	1.68	1.22	39.29	Cement	IIA
	11.90	13.82	1.92	44.17	1.94	11.86	1.75	1.35	37.30	Cement	IIB
	17.66	19.58	1.92	44.10	3.86	9.13	1.53	1.14	38.88	Cement	IIC
MJRS-43	4.00	5.83	1.83	47.00	2.28	7.81	1.33	1.26	39.24	Cement	II
MJRS-45	0.80	5.68	4.88	44.81	2.52	10.23	1.76	1.43	38.66	Cement	II
MJRS-46	13.00	19.85	6.85	48.88	2.03	5.98	1.07	0.97	40.32	Cement	II
MJRS-47	8.00	10.13	2.13	46.51	2.56	8.07	1.35	1.25	39.35	Cement	II
MJRS-48	6.70	13.00	6.30	42.71	2.49	12.58	2.44	1.60	37.09	Cement	II
MJRS-50	5.00	9.30	4.30	46.19	3.22	7.38	1.34	1.15	39.82	Cement	II
MJRS-51	23.10	25.00	1.90	48.31	1.29	6.30	1.39	1.53	39.11	Cement	II
MJRS-52	25.50	39.10	13.60	43.63	2.63	10.73	2.00	1.47	37.56	Cement	II
MJRS-53	22.99	32.62	9.63	42.44	3.91	11.31	1.97	1.50	37.45	Cement	II
MJRS-54	2.00	10.00	8.00	45.69	1.67	9.70	1.80	1.57	37.70	Cement	I
	40.00	47.90	7.90	45.22	1.67	10.07	2.07	1.40	37.91	Cement	II
MJRS-55	1.00	16.50	15.50	46.39	2.57	7.52	1.51	1.25	39.23	Cement	I
	40.18	46.10	5.92	45.96	1.64	9.22	1.92	1.36	38.53	Cement	II
MJRS-56	3.00	5.30	2.30	42.77	1.59	13.18	2.13	1.46	35.45	Cement	I
	33.10	41.50	8.40	45.21	1.45	10.37	2.07	1.59	37.66	Cement	II
MJRS-57	2.00	5.85	3.85	42.44	1.87	12.89	2.35	1.83	35.93	Cement	IA
	9.40	11.20	1.80	44.89	1.75	10.65	1.77	1.63	37.92	Cement	IB
	30.41	38.87	8.46	44.71	1.50	10.86	2.19	1.51	37.30	Cement	II
MJRS-58	3.00	6.20	3.20	43.95	1.22	11.57	1.97	1.45	36.39	Cement	I
	32.20	36.60	4.40	44.25	1.47	11.00	2.24	1.56	36.87	Cement	II
MJRS-59	7.40	20.16	12.76	44.20	2.31	10.30	1.88	1.41	36.87	Cement	I
	47.10	53.14	6.04	45.31	1.93	9.67	1.89	1.39	38.27	Cement	II
MJRS-60	2.00	18.00	16.00	46.38	2.15	7.32	1.51	1.72	38.65	Cement	I
MJRS-61	6.00	16.00	10.00	44.45	2.27	10.04	1.90	1.38	37.63	Cement	I
	44.46	48.00	3.54	43.54	1.60	11.60	2.45	1.72	36.60	Cement	II
MJRS-62	8.11	9.98	1.87	44.01	3.89	7.70	1.37	1.56	37.87	Cement	IA
	13.72	23.80	10.08	43.67	2.89	10.32	2.03	1.60	37.24	Cement	IB
	49.50	55.50	6.00	45.28	1.47	10.16	2.00	1.34	37.25	Cement	II

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade	Zone
	From	To		%	%	%	%	%	%		
MJRS-63	6.00	16.66	10.66	43.23	2.81	10.69	2.00	1.67	37.02	Cement	I
MJRS-64	1.50	13.70	12.20	43.14	2.82	11.06	2.02	1.50	37.22	Cement	I
	43.00	46.06	3.06	43.19	1.71	12.15	2.37	1.69	36.58	Cement	IIA
MJRS-65	48.90	50.26	1.36	42.34	2.27	12.77	2.24	1.70	36.11	Cement	IIB
	4.70	6.54	1.84	44.80	2.00	10.23	1.92	1.32	37.62	Cement	I
MJRS-66	33.60	38.05	4.45	45.89	1.47	9.20	1.99	1.40	38.41	Cement	II
	7.93	23.89	15.96	44.49	2.78	9.83	1.92	1.44	37.97	Cement	I
MJRS-67	7.96	18.10	10.14	42.72	3.19	10.22	1.95	1.53	36.64	Cement	I
	47.00	54.80	7.80	44.11	1.66	11.22	2.29	1.63	37.19	Cement	II
MJRS-68	13.50	19.50	6.00	47.93	1.77	6.44	1.35	1.15	39.49	Cement	I
MJRS-69	7.30	20.30	13.00	44.22	2.27	10.58	1.98	1.47	37.23	Cement	I
MJRS-70	3.00	12.60	9.60	44.61	1.36	11.18	1.99	1.48	34.91	Cement	I
	38.40	44.50	6.10	42.88	1.74	13.09	2.56	1.70	36.65	Cement	II
MJRS-71	8.25	17.13	8.88	43.00	3.02	10.83	2.03	1.46	36.91	Cement	I
MJRS-72	15.52	25.58	10.06	45.34	2.46	8.28	1.66	1.29	38.13	Cement	I
MJRS-73	4.60	12.70	8.10	44.01	3.06	9.74	1.91	1.37	37.55	Cement	I
	42.00	51.10	9.10	44.83	1.62	10.43	2.09	1.52	37.54	Cement	II
MJRS-74	18.20	25.00	6.80	44.80	1.47	10.69	2.17	1.48	37.62	Cement	IA
	31.00	32.50	1.50	46.05	2.71	7.40	1.47	1.18	39.76	Cement	IB
MJRS-75	4.00	7.00	3.00	47.48	1.36	7.32	1.54	1.25	38.97	Cement	I
	26.60	28.30	1.70	45.40	1.56	9.90	2.03	1.41	38.02	Cement	IIA
	36.40	38.00	1.60	43.19	3.72	9.79	1.85	1.37	38.44	Cement	IIB
MJRS-77	8.50	16.06	7.56	47.43	1.47	7.71	1.57	1.21	39.50	Cement	II
MJRS-79	9.66	13.00	3.34	46.10	2.19	11.30	1.36	1.57	36.58	Cement	II
MJRS-80	2.00	5.80	3.80	48.14	1.14	7.69	1.45	1.09	39.47	Cement	II
MJRS-81	6.00	7.00	1.00	43.26	1.56	12.65	2.50	1.92	36.98	Cement	IIA
	13.40	18.80	5.40	43.75	3.65	9.47	1.70	1.26	38.73	Cement	IIB
MJRS-82	15.80	19.60	3.80	42.28	3.50	11.21	2.24	1.65	37.20	Cement	I
	51.70	55.10	3.40	47.18	1.45	8.24	1.79	1.40	38.69	Cement	II
MJRS-83	5.35	8.95	3.60	44.21	1.21	11.71	2.56	1.83	37.30	Cement	IIA
	14.35	16.25	1.90	43.43	3.92	9.47	1.80	1.42	38.72	Cement	IIB
MJRS-84	5.90	7.45	1.55	43.59	1.68	10.81	2.27	1.87	36.57	Cement	II
MJRS-85	22.90	24.80	1.90	47.91	1.31	6.96	1.68	1.46	38.38	Cement	II
MJRS-88	4.70	6.40	1.70	45.54	2.22	8.77	1.98	1.84	39.08	Cement	II

Table-3.2
Intersection of Ungraded limestone in boreholes drilled by MECL
Jamodi-Mahanna block (G4 & G3/G2), Dist: Satna, Madhya Pradesh
Zone based on 34%≤CaO<42% cut-off

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade
	From	To		%	%	%	%	%	%	
MJRS-1	9.00	11.35	2.35	37.57	1.49	20.32	3.69	2.30	33.02	UNGRADED
	14.85	18.35	3.50	36.50	1.99	20.83	4.05	2.24	32.53	UNGRADED
MJRS-2	4.67	11.54	6.87	36.34	1.54	25.37	3.40	2.02	29.77	UNGRADED
	41.23	45.00	3.77	39.09	3.89	15.75	3.00	1.89	34.93	UNGRADED
MJRS-4	4.30	5.94	1.64	35.93	1.59	22.95	3.97	2.14	30.30	UNGRADED
	14.10	16.60	2.50	37.50	2.13	20.48	3.88	2.39	32.65	UNGRADED
	33.20	41.10	7.90	39.87	2.01	16.72	3.41	1.92	28.32	UNGRADED
MJRS-5	4.34	7.02	2.68	35.02	1.80	26.05	3.92	2.42	24.90	UNGRADED
	11.00	13.00	2.00	39.01	1.88	17.89	3.14	2.35	33.30	UNGRADED
	27.00	28.38	1.38	34.10	2.39	23.15	4.23	3.03	30.30	UNGRADED
MJRS-6	0.00	3.00	3.00	39.62	1.11	17.23	2.88	2.00	32.35	UNGRADED
	27.00	30.50	3.50	37.75	4.21	8.59	3.00	1.97	34.13	UNGRADED
MJRS-7	2.00	4.00	2.00	40.40	3.84	13.99	2.68	1.84	35.88	UNGRADED
	43.00	47.00	4.00	35.15	4.52	9.52	3.32	2.23	32.53	UNGRADED
MJRS-8	11.50	15.00	3.50	39.04	2.69	9.28	2.15	2.82	33.63	UNGRADED
	35.50	39.50	4.00	38.81	2.09	8.76	1.96	3.31	33.10	UNGRADED
	43.50	45.50	2.00	42.03	6.47	7.39	1.17	1.44	34.85	UNGRADED
MJRS-9	11.00	15.00	4.00	36.56	2.95	9.19	3.62	2.30	32.50	UNGRADED
	42.50	44.50	2.00	40.72	1.64	14.75	3.09	1.98	33.71	UNGRADED
MJRS-10	3.00	5.00	2.00	41.20	3.31	13.07	2.46	1.74	35.66	UNGRADED
	7.00	11.00	4.00	39.99	3.86	12.97	2.58	2.07	35.59	UNGRADED
	12.30	14.00	1.70	35.65	3.08	19.96	3.29	2.31	30.80	UNGRADED
	39.00	41.00	2.00	39.85	1.93	16.26	3.23	1.87	34.78	UNGRADED
	43.00	45.00	2.00	38.34	5.91	13.15	2.23	1.75	37.34	UNGRADED
MJRS-11	0.00	6.00	6.00	39.78	1.38	16.82	2.97	1.86	33.39	UNGRADED
	34.50	43.50	9.00	35.70	2.98	18.28	2.40	3.91	31.96	UNGRADED
MJRS-12	15.10	19.10	4.00	41.27	2.28	13.53	2.34	1.89	35.17	UNGRADED
	39.10	42.60	3.50	40.22	1.94	8.73	3.02	1.96	34.46	UNGRADED
MJRS-13	0.00	1.50	1.50	41.36	2.99	13.15	2.42	1.60	35.88	UNGRADED
	10.00	11.50	1.50	37.64	1.77	18.83	3.15	2.10	31.66	UNGRADED
	43.00	45.00	2.00	37.25	7.87	12.57	2.05	1.60	38.12	UNGRADED
MJRS-14	3.96	5.92	1.96	35.68	1.18	21.83	3.48	2.18	29.54	UNGRADED
	7.88	9.84	1.96	36.74	1.69	20.61	3.34	2.50	31.60	UNGRADED
	28.50	30.50	2.00	38.92	2.02	16.87	3.28	2.24	34.36	UNGRADED
	36.30	39.90	3.60	39.64	5.14	12.85	2.37	1.81	37.22	UNGRADED
MJRS-15	8.00	10.50	2.50	36.81	1.99	19.87	3.15	1.98	30.70	UNGRADED
	44.50	46.50	2.00	38.11	1.86	18.41	3.39	2.06	32.64	UNGRADED
MJRS-16	14.05	16.00	1.95	38.81	4.13	14.51	3.07	2.19	35.03	UNGRADED
	17.85	19.70	1.85	35.93	2.46	19.83	3.23	2.20	31.42	UNGRADED
MJRS-17	2.25	8.65	6.40	39.80	2.59	7.20	2.84	1.86	34.51	UNGRADED
	39.76	43.50	3.74	36.60	1.98	10.34	3.85	2.47	31.85	UNGRADED

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade
	From	To		%	%	%	%	%	%	
MJRS-18	2.00	11.41	9.41	37.27	2.74	7.79	3.11	2.32	32.27	UNGRADED
	40.00	45.50	5.50	36.92	5.18	9.05	2.92	1.94	34.97	UNGRADED
MJRS-19	9.60	15.25	5.65	36.94	2.16	9.91	3.13	2.15	32.13	UNGRADED
	19.70	23.00	3.30	40.55	1.66	15.68	2.66	2.08	34.33	UNGRADED
	37.00	39.00	2.00	35.26	2.13	21.74	3.72	2.43	30.74	UNGRADED
	45.00	47.00	2.00	35.24	1.93	21.79	3.66	2.19	30.77	UNGRADED
MJRS-20	4.00	7.50	3.50	40.91	1.17	15.47	2.74	1.83	34.99	UNGRADED
	38.50	42.50	4.00	40.11	1.95	15.80	2.82	1.97	34.26	UNGRADED
MJRS-21	2.50	4.25	1.75	39.61	1.89	15.51	3.03	2.20	34.37	UNGRADED
	28.00	29.65	1.65	36.60	1.96	19.60	3.76	2.34	31.68	UNGRADED
	33.00	34.50	1.50	37.56	2.61	18.59	3.03	2.10	32.82	UNGRADED
	36.00	41.00	5.00	38.48	6.12	7.32	2.26	1.62	37.07	UNGRADED
MJRS-22	8.80	11.00	2.20	36.89	2.59	17.85	3.44	2.32	31.77	UNGRADED
	12.85	14.75	1.90	40.24	2.95	14.90	2.61	1.73	34.55	UNGRADED
	33.65	35.35	1.70	36.04	1.98	20.27	4.31	2.46	31.08	UNGRADED
	40.45	44.05	3.60	40.12	3.64	8.13	2.45	1.85	34.64	UNGRADED
MJRS-23	16.50	18.40	1.90	34.43	1.74	22.91	4.31	3.07	30.80	UNGRADED
	27.80	33.30	5.50	40.93	5.03	6.27	2.00	1.47	37.74	UNGRADED
MJRS-24	27.25	29.00	1.75	35.45	2.13	21.54	3.90	2.49	30.65	UNGRADED
	36.00	39.55	3.55	38.98	4.52	8.10	2.69	1.85	35.99	UNGRADED
	41.30	43.00	1.70	37.12	2.98	18.32	3.37	2.12	33.56	UNGRADED
	27.80	29.60	1.80	35.95	1.62	21.11	3.98	2.65	30.41	UNGRADED
MJRS-25	33.20	39.00	5.80	38.93	7.01	6.21	2.08	1.59	37.94	UNGRADED
	1.00	3.50	2.50	39.74	2.18	16.08	2.95	1.97	34.43	UNGRADED
	28.80	30.40	1.60	40.83	1.60	14.85	2.88	1.91	34.87	UNGRADED
MJRS-26	36.55	38.10	1.55	35.26	6.92	15.90	2.81	2.02	35.64	UNGRADED
	19.00	20.20	1.20	36.14	2.76	20.12	3.96	2.60	33.44	UNGRADED
	29.70	32.50	2.80	40.60	4.74	8.46	2.30	1.64	37.48	UNGRADED
	36.10	38.20	2.10	39.12	1.80	17.88	3.48	2.10	34.88	UNGRADED
MJRS-27	0.00	2.70	2.70	38.04	1.78	18.04	3.41	2.18	32.48	UNGRADED
	29.50	31.00	1.50	41.21	1.55	14.15	2.96	1.96	34.94	UNGRADED
	32.50	34.00	1.50	36.74	2.18	19.87	3.88	1.93	32.92	UNGRADED
	43.00	45.00	2.00	38.54	3.71	15.21	2.62	1.87	34.68	UNGRADED
MJRS-28	4.75	7.50	2.75	38.02	1.78	18.49	3.25	2.18	32.53	UNGRADED
	10.65	13.20	2.55	40.42	3.62	13.25	2.21	1.67	35.88	UNGRADED
	31.50	33.00	1.50	40.31	2.11	14.47	3.01	1.87	34.72	UNGRADED
	36.00	46.50	10.50	37.88	4.37	15.57	2.84	1.92	34.85	UNGRADED
MJRS-29	16.80	26.40	9.60	39.48	7.08	10.63	1.74	1.37	38.50	UNGRADED
MJRS-30	13.00	19.00	6.00	38.52	3.48	17.68	2.63	1.70	34.34	UNGRADED
MJRS-31	6.50	22.10	15.60	38.26	5.21	14.22	2.50	1.77	35.32	UNGRADED
MJRS-32	8.50	13.50	5.00	36.96	8.48	12.24	1.92	1.50	37.52	UNGRADED
MJRS-33	3.00	5.00	2.00	35.01	1.72	22.23	4.34	2.75	30.27	UNGRADED
	13.00	17.50	4.50	41.36	4.37	12.39	2.07	1.64	36.31	UNGRADED

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade
	From	To		%	%	%	%	%	%	
MJRS-35	15.65	17.00	1.35	39.83	2.76	14.98	2.71	2.49	34.18	UNGRADED
	25.00	30.50	5.50	37.62	6.81	12.89	2.31	1.73	36.34	UNGRADED
MJRS-36	22.00	23.20	1.20	36.74	5.95	16.56	2.68	1.81	35.00	UNGRADED
	24.40	28.82	4.42	38.86	7.57	10.60	1.85	1.53	37.99	UNGRADED
MJRS-37	6.00	17.00	11.00	40.93	5.04	12.32	1.95	1.43	37.46	UNGRADED
	17.70	18.95	1.25	34.57	6.76	19.09	1.98	1.70	34.38	UNGRADED
MJRS-38	28.50	31.80	3.30	38.97	5.73	12.37	2.61	1.77	37.10	UNGRADED
MJRS-39	6.40	9.60	3.20	40.40	5.89	11.94	1.80	1.46	37.70	UNGRADED
	11.00	12.40	1.40	41.96	5.33	9.51	1.68	1.37	38.64	UNGRADED
MJRS-40	20.00	24.00	4.00	40.66	6.21	9.89	1.69	1.34	39.32	UNGRADED
MJRS-41	6.00	8.00	2.00	40.73	1.78	15.62	2.86	1.92	35.43	UNGRADED
	13.82	17.66	3.84	40.20	7.41	10.00	1.63	1.33	38.62	UNGRADED
	19.58	21.50	1.92	36.43	4.34	18.82	3.00	1.91	33.01	UNGRADED
MJRS-42	2.00	10.28	8.28	38.43	5.84	14.54	2.11	1.60	36.45	UNGRADED
	13.60	15.60	2.00	35.43	10.11	15.52	1.76	1.69	35.01	UNGRADED
MJRS-43	7.66	13.15	5.49	39.51	7.76	10.51	1.62	1.35	38.47	UNGRADED
MJRS-44	6.00	18.10	12.10	38.34	8.51	11.97	1.51	1.46	37.60	UNGRADED
MJRS-45	5.68	10.56	4.88	37.45	5.29	17.55	2.12	1.74	35.20	UNGRADED
MJRS-46	19.85	26.00	6.15	40.69	7.00	9.92	1.52	1.28	38.99	UNGRADED
	30.10	32.20	2.10	35.19	10.04	15.93	2.01	1.55	35.08	UNGRADED
MJRS-47	12.26	20.80	8.54	38.32	6.04	13.84	2.20	1.61	36.63	UNGRADED
MJRS-48	3.00	6.00	3.00	37.25	1.42	20.56	3.96	2.43	32.64	UNGRADED
	17.00	19.00	2.00	40.23	6.74	10.42	1.91	1.36	39.07	UNGRADED
	21.00	23.00	2.00	37.55	5.14	16.09	2.65	1.75	35.56	UNGRADED
	29.00	31.00	2.00	40.73	8.91	8.70	1.12	1.10	39.09	UNGRADED
MJRS-49	8.00	14.70	6.70	40.98	4.11	13.65	1.84	1.33	36.97	UNGRADED
MJRS-50	9.30	17.00	7.70	39.19	7.36	11.80	1.71	1.40	37.63	UNGRADED
MJRS-51	25.00	34.50	9.50	39.80	5.04	12.76	2.07	1.55	37.04	UNGRADED
MJRS-52	19.50	21.80	2.30	34.11	1.58	23.59	4.31	3.04	30.30	UNGRADED
	24.20	25.50	1.30	39.13	1.96	17.13	3.32	2.13	33.89	UNGRADED
	39.10	40.50	1.40	40.62	4.03	13.53	2.01	1.54	36.77	UNGRADED
MJRS-53	20.25	22.99	2.74	38.22	2.69	17.68	3.33	2.06	34.04	UNGRADED
	32.62	41.30	8.68	35.63	5.46	19.36	2.62	1.79	33.38	UNGRADED
MJRS-54	51.06	54.22	3.16	37.13	10.23	9.88	1.54	1.28	38.97	UNGRADED
	62.86	64.32	1.46	38.13	6.91	11.57	1.94	1.71	37.20	UNGRADED
MJRS-55	16.50	17.95	1.45	39.87	2.20	15.40	2.37	1.68	32.80	UNGRADED
	46.10	49.06	2.96	40.24	1.85	16.21	2.95	1.83	34.09	UNGRADED
	53.50	56.46	2.96	37.78	8.28	11.13	1.92	1.42	38.77	UNGRADED
MJRS-56	9.90	14.50	4.60	39.00	1.63	18.30	3.06	2.23	33.29	UNGRADED
	41.50	49.12	7.62	40.48	5.84	11.15	1.88	1.47	38.22	UNGRADED
MJRS-57	25.80	30.41	4.61	36.41	2.19	20.22	3.68	2.58	32.04	UNGRADED
	38.87	48.10	9.23	38.67	6.72	11.88	1.93	1.40	37.30	UNGRADED
MJRS-58	37.90	47.50	9.60	38.68	5.41	13.67	2.31	1.67	36.53	UNGRADED

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade
	From	To		%	%	%	%	%	%	
MJRS-59	5.60	7.40	1.80	38.20	5.84	13.77	2.06	1.73	36.22	UNGRADED
	20.16	22.00	1.84	35.98	2.35	19.43	3.11	2.03	31.09	UNGRADED
	45.72	47.10	1.38	39.16	1.83	16.41	3.32	2.00	33.75	UNGRADED
	54.65	60.70	6.05	39.15	7.15	10.14	1.74	1.38	38.64	UNGRADED
MJRS-60	22.00	23.50	1.50	39.16	1.88	17.83	2.99	2.25	33.60	UNGRADED
MJRS-61	4.00	6.00	2.00	40.56	5.17	11.54	1.84	1.73	37.22	UNGRADED
	16.00	17.45	1.45	35.13	3.76	18.15	3.50	2.46	31.83	UNGRADED
	24.70	26.34	1.64	36.78	1.99	20.49	3.24	2.28	31.35	UNGRADED
	41.16	44.46	3.30	36.38	2.27	19.87	3.67	2.48	32.14	UNGRADED
MJRS-62	9.98	13.72	3.74	39.48	4.59	13.63	2.44	1.73	35.96	UNGRADED
	23.80	25.10	1.30	39.04	2.08	16.80	2.65	1.93	32.30	UNGRADED
	47.96	49.50	1.54	36.87	2.12	19.49	3.61	2.40	32.51	UNGRADED
	55.50	58.50	3.00	39.30	4.84	13.80	2.40	1.87	36.32	UNGRADED
MJRS-63	16.66	19.50	2.84	36.64	2.64	19.33	3.36	2.10	31.36	UNGRADED
	27.00	28.90	1.90	36.39	2.19	20.58	3.55	2.48	32.38	UNGRADED
	34.00	34.95	0.95	39.00	2.69	15.89	2.92	2.04	33.81	UNGRADED
MJRS-64	13.70	16.80	3.10	38.07	2.56	17.16	3.24	2.20	33.58	UNGRADED
	50.26	56.00	5.74	39.17	6.62	11.46	1.93	1.56	38.06	UNGRADED
MJRS-65	6.54	8.38	1.84	36.37	1.47	21.73	3.01	2.35	30.25	UNGRADED
	13.92	15.77	1.85	36.03	1.55	22.16	3.51	2.67	31.48	UNGRADED
	38.05	39.55	1.50	35.01	2.27	21.47	4.24	2.63	31.58	UNGRADED
	40.90	42.25	1.35	38.05	4.89	16.63	2.64	1.90	35.28	UNGRADED
	43.60	49.00	5.40	38.73	7.90	10.46	1.75	1.40	39.09	UNGRADED
MJRS-66	6.60	7.93	1.33	40.74	3.45	14.20	2.65	1.66	36.25	UNGRADED
	23.89	26.55	2.66	36.74	2.86	19.17	2.93	2.12	31.76	UNGRADED
	30.00	31.00	1.00	40.66	1.89	15.96	2.64	2.15	34.53	UNGRADED
MJRS-67	18.10	19.55	1.45	36.64	2.67	18.95	3.28	2.16	31.80	UNGRADED
	27.40	29.00	1.60	37.51	6.51	14.31	2.37	1.65	37.24	UNGRADED
	42.90	44.26	1.36	35.91	2.42	20.61	3.39	2.61	32.16	UNGRADED
	45.63	47.00	1.37	35.64	2.31	20.78	3.94	2.65	32.47	UNGRADED
	56.10	62.00	5.90	43.50	4.86	7.56	1.52	1.26	39.49	UNGRADED
MJRS-68	9.00	12.00	3.00	44.72	4.33	7.29	1.41	1.44	39.17	UNGRADED
	19.50	21.00	1.50	39.66	2.14	16.31	2.57	1.70	33.60	UNGRADED
	22.50	25.50	3.00	35.88	2.35	20.58	3.25	2.12	31.11	UNGRADED
MJRS-70	12.60	15.80	3.20	37.39	1.48	20.49	3.00	1.97	30.93	UNGRADED
	44.50	46.00	1.50	40.34	3.06	15.59	2.72	1.80	35.52	UNGRADED
	48.70	56.25	7.55	36.78	8.45	12.88	2.10	1.57	36.61	UNGRADED
MJRS-71	17.13	24.59	7.46	37.81	2.95	16.66	3.00	2.06	32.70	UNGRADED
MJRS-72	12.68	15.52	2.84	36.69	7.08	13.20	2.17	1.86	36.24	UNGRADED
	25.58	28.50	2.92	37.08	2.59	18.09	3.03	1.92	31.36	UNGRADED

BH.NO	Depth (m)		Thick. (m)	CaO	MgO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	LOI	Grade
	From	To		%	%	%	%	%	%	
MJRS-73	3.00	4.60	1.60	38.08	5.83	13.72	2.08	1.65	35.37	UNGRADED
	12.70	15.50	2.80	36.33	2.77	19.11	3.31	2.16	30.81	UNGRADED
	23.65	24.80	1.15	37.40	1.97	19.43	3.34	2.38	32.58	UNGRADED
	51.10	53.00	1.90	37.23	10.05	9.90	1.82	1.54	38.57	UNGRADED
MJRS-74	16.56	18.20	1.64	37.39	2.02	19.50	3.48	2.22	33.30	UNGRADED
	25.00	31.00	6.00	39.39	6.16	12.13	1.92	1.46	37.88	UNGRADED
	32.50	34.00	1.50	38.46	5.24	14.29	2.34	1.67	36.62	UNGRADED
MJRS-75	2.70	4.00	1.30	35.02	1.85	22.36	3.68	2.46	30.58	UNGRADED
	23.20	24.90	1.70	39.85	1.79	15.50	3.25	1.97	34.80	UNGRADED
	28.30	30.00	1.70	39.56	1.99	16.59	3.13	2.06	34.32	UNGRADED
	31.60	36.40	4.80	40.61	6.13	10.01	1.85	1.44	39.01	UNGRADED
MJRS-77	6.00	8.50	2.50	35.47	2.04	21.45	3.75	2.54	31.58	UNGRADED
	16.06	26.00	9.94	40.20	5.31	12.40	2.06	1.50	37.53	UNGRADED
MJRS-78	4.20	6.40	2.20	36.90	6.00	19.27	2.41	1.92	33.03	UNGRADED
MJRS-79	6.33	9.66	3.33	35.01	9.35	19.48	1.23	1.25	33.02	UNGRADED
MJRS-80	5.80	13.50	7.70	42.44	4.80	10.50	1.69	1.31	38.50	UNGRADED
	14.50	16.50	2.00	38.56	7.09	14.91	1.23	1.32	36.14	UNGRADED
MJRS-81	3.00	6.00	3.00	38.61	1.62	17.93	3.55	2.54	33.41	UNGRADED
	9.80	13.40	3.60	41.09	5.06	10.29	1.70	1.43	38.35	UNGRADED
	18.80	20.30	1.50	39.78	3.58	16.40	2.17	1.46	35.71	UNGRADED
	22.15	24.00	1.85	38.36	10.49	11.11	1.47	1.26	36.73	UNGRADED
MJRS-82	8.40	15.80	7.40	38.74	77.11	31.03	21.83	2.87	38.15	UNGRADED
	19.60	21.50	1.90	39.55	2.49	12.16	2.53	2.55	37.99	UNGRADED
	48.30	51.70	3.40	36.70	2.01	19.08	3.97	2.50	33.02	UNGRADED
	55.10	57.00	1.90	35.12	2.29	22.40	4.29	2.46	31.03	UNGRADED
	61.50	66.00	4.50	37.25	6.32	13.60	2.54	1.92	36.25	UNGRADED
	67.50	69.00	1.50	36.36	8.08	16.01	1.80	1.80	33.30	UNGRADED
MJRS-83	8.95	14.35	5.40	37.38	5.73	15.44	2.87	2.10	35.98	UNGRADED
MJRS-84	15.75	17.50	1.75	40.51	3.72	18.32	2.00	1.32	33.35	UNGRADED
MJRS-85	19.50	21.00	1.50	40.78	1.68	14.91	3.26	2.16	34.83	UNGRADED
	24.80	28.60	3.80	38.52	1.97	17.56	3.55	2.13	32.96	UNGRADED
	32.00	36.00	4.00	36.88	9.58	10.83	1.77	1.43	39.04	UNGRADED
	39.75	41.50	1.75	37.42	8.24	11.05	2.35	1.77	38.20	UNGRADED
MJRS-86	5.30	10.40	5.10	38.44	4.16	15.57	2.90	2.11	35.19	UNGRADED
	19.50	21.00	1.50	37.73	5.57	17.74	2.33	1.59	34.58	UNGRADED
MJRS-88	6.40	8.00	1.60	39.77	2.07	16.19	3.16	2.28	34.72	UNGRADED
	36.00	42.00	6.00	38.58	2.17	16.94	3.54	2.24	32.53	UNGRADED

3.12.0 UTILISATION ASPECTS AND MINEABILITY

The specifications of limestone for various industrial uses are as follows:

1. Cement Industry

CaO	:	42% (minimum) to 46%
MgO	:	4% (max.)
Silica	:	16% (max.)
Al ₂ O ₃	:	2 (max.)
Fe ₂ O ₃	:	2% (max.)
SO ₃	:	1.75% (max.)

a) Lime Saturation factor: 0.66 to 1.02

$$\text{Silica Modules} = \frac{\text{SiO}_2}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3} = 1.2 \text{ to } 4.0$$

$$\text{Iron Modules} = \frac{\text{CaO}}{\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3} = 1.7 \text{ to } 2.4$$

$$\text{Hydraulic Modules} = \frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3} = 0.65 \text{ (min.)}$$

B. I. S. (Bureau of Indian Standards) Specification

CaO	:	42% (Min)
MgO	:	2.5% (Max.)
SiO ₂	:	15% (Max.)
P ₂ O ₅	:	1.5 % (Max.)
FeS ₂	:	2% (Max.)

2. Iron & Steel Industry

Elements	BF Grade	SMS Grade	LD Grade
CaO	42% (Min.)	48% (Min.)	52% (Min.)
MgO	4% (Max.)	3% (Max.)	2% (Max.)
SiO ₂	9% (Max.)	4% (Max.)	1% (Max.)
SiO ₂ + Al ₂ O ₃	11.5% (Max.)	-	-
Total Insoluble	12%	-	-
Acid Insoluble	-	6.5% (Max.)	-

3. Chemical Industry

BIS Specifications (1S:3204-1978, Reaffirmed-2003)

Characteristics	Requirement in percent by mass for			
	Calcium carbide	Bleaching Powder	Caustic soda	Sugar
CaO (Min.)	54.0	54.0	53.0	50.0
MgO (Max.)	0.8	2.0	1.0	1.0
SiO ₂ (Max.)	1.0	0.75	-	2.0
Fe ₂ O ₃ (Max.)	0.25	0.15	-	-
Mn ₂ O ₃ (Min.)	-	0.06	-	-

CO ₂ (Min.)	42.00	42.00	42.00	41.00
Loss on Ignition (LOI)	46.00	46.00	46.00	44.00
S (Max.)	0.10	-	-	-
P (Max.)	0.01	-	-	-
Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	0.50	-	-	1.5
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	-	-	3.0	-

4. Fertilizer Industry

CaCO₃+ MgCO₃ : 85% (Min)
SiO₂ : 5% (Max.)

5. Glass Industry

CaCO₃ : 94.5 %
CaCO₃ + MgCO₃ : 97.5 %
Fe₂O₃ : 0.20 % (Max.)

BIS Specifications (1S:997-1973, Reaffirmed-1998)

CaO : 53.0 %
SiO₂ : 2.5 %
Fe₂O₃ : 0.10 %
CaO + MgO : 54.50 %

6. Foundry Industry

BIS Specifications (1S:4149-1978, Reaffirmed-2008)

Characteristics	Grade-1	Grade-2	Grade-3
CaO (Min.)	52 %	50 %	45 %
SiO ₂ (Max)	1.5 %	3 %	5 %
R ₂ O ₃ (Al ₂ O ₃ + Fe ₂ O ₃) Max.	1 %	1 %	2 %
MgO	2 %	3 %	5 %
Insoluble matter	0.5	1	2
Sulphur & Phosphorus	Traces	Traces	Traces

Table 3.3

**Table Showing Specifications for Cement, Iron & Steel and
Chemical Industry of Limestone**

Constituents	Cement Industry (Specification)	Iron & Steel Industry (Specification)			Chemical Industry BIS Specifications (IS:3204-1978, Reaffirmed-2003)				
						Requirement in percent by mass for			
		<i>BF Grade</i>	<i>SMS Grade</i>	<i>LD Grade</i>	<i>Calcium carbide</i>	<i>Bleaching Powder</i>	<i>Caustic soda</i>	<i>Sugar</i>	
CaO (Min.)	42% (Min.) to 46%	42% (Min.)	48% (Min.)	52% (Min.)	54.0	54.0	53.0	50.0	
MgO (Max.)	4% (Max.)	4% (Max.)	3% (Max.)	2% (Max.)	0.8	2.0	1.0	1.0	
SiO ₂ (Max.)	16% Max.)	9% (Max.)	4% (Max.)	1% (Max.)	1.0	0.75	-	2.0	
Fe ₂ O ₃ (Max.)	2% (Max.)				0.25	0.15	-	-	
Mn ₂ O ₃ (Min.)	--	--	--	--	-	0.06	-	-	
CO ₂ (Min.)	--	--	--	--	42.00	42.00	42.00	41.00	
Loss on Ignition (LOI)	--	--	--	--	46.00	46.00	46.00	44.00	
S (Max.)	--	--	--	--	0.10	-	-	-	
P (Max.)	--				0.01	-	-	-	
Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	--				0.50	-	-	1.5	
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	--	11.5% (Max.)			-	-	3.0	-	
Acid Insoluble			6.5% (Max.)						

CHAPTER –IV

4.0.0 EVALUATION OF EXPLORATION DATA

4.1.0 GENERAL

4.1.1 The investigation carried out by way of drilling with associated geological and laboratory studies have generated the exploration data to establish the shape, size and geometry of the deposit. This formed the basis for evaluation of various deposit parameters in this block. The salient features of the evaluation are discussed below.

4.2.0 AERIAL EXTENT

4.2.1 The areas of detailed exploration are mostly under active cultivation, though few quarries and exposures of limestone occur. However, the subsurface data coupled with geological mapping are vital in deciphering and demarcate the approximate dimensions of limestone bearing horizons. Cardinal points of the block boundary as provided by DGM, MP is given in Annexure-IC.

4.2.2 The area given was considered for the evaluation and estimation of in-situ geological reserves of cement grade limestone. Out of 31 sq.km of total block area, cumulative 9.12 sq. Km area within the block is demarcated as leasehold area. The details have been given as Annexure-ID.

4.2.3 Floor contour plan of limestone in this block (Plate No. IV) revealed that floor of the cement grade Zone-II (bottom zone) dipping in the South direction which confirmed the thickening of limestone column. The general strike of the limestone formation is E-W with gentle dip (1° to 3°) towards South to South-East. However, towards the Northern boundary of the mineralized area, the strike becomes NW-SE and at some places the dip becomes 0° .

4.2.4 No limestone formation has been intersected in the boreholes MJRS-87, MJRS-03 and MJRS-76. A Zone of Non-development of Bhandar Limestone (Plate-IV) has been demarcated by a line around these negative intersecting boreholes, by connecting midway points of the surrounding positive intersecting boreholes. This limits the aerial extent of the limestone deposit. No limestone, whether graded or ungraded, is intersected in this zone.

4.3.0 THICKNESS OF LIMESTONE

4.3.1 Thickness of Bhandar limestone, irrespective of any grade, within this block varies between 2.20m (MJRS-78) to 29.62m (MJRS-67). The borehole with minimum intersection thickness of limestone (MJRS-78) is located at the northern boundary of the block and the borehole with maximum intersection thickness of limestone

(MJRS-67) is at the southern boundary. It also confirms that the limestone formation is dipping towards south and thickness is increasing towards dip direction.

- 4.3.2 When the thickness of cement grade limestone zones is concerned, it varies throughout the block. It is so because of the chemical criteria ($\text{CaO} \geq 42\%$, $\text{MgO} < 4\%$ and $\text{SiO}_2 < 16\%$) that has been set to differentiate cement grade limestone out of the Bhandar limestone. The thickness of cement grade limestone Zone-I varies from 1.00m (MJRS-05) to 16.00m (MJRS-60) whereas the same for Zone-II varies from 1.00m (MJRS-81) to 13.60m (MJRS-52). Thickness of Ungraded limestone varies from 1.50m (MJRS-60) to 20.60m (MJRS-82).
- 4.3.3 Iso-chore plans for cement grade (Zone-I and II) and ungraded limestone have been prepared (Plate 5A, 5B & 5C respectively) to show the distribution of thickness of different limestone horizons zone wise and for calculation of resources of Cement and Ungraded Limestone. The Iso-Chore contour line with value Zero (0) of Cement grade Zone-I is considered to be the line that bounds the "Zone of Non-development of Cement grade limestone Zone-I". No cement grade limestone zone-I has been intersected within this zone by any borehole.

4.4.0 GRADE OF LIMESTONE

- 4.4.1 The grades of the limestone intersected in the boreholes drilled in Jamodi-Mahanna block has been assessed into Cement / BF grade on the basis of compositional variations of main chemical constituent's viz. CaO, MgO, SiO_2 , Al_2O_3 , Fe_2O_3 and LOI of primary chemical analysis. The cut-off limit for compositional variations of main chemical constituents fixed for different grades of limestone as enumerated in table no 3.3 have been adopted by MECL with marginal variations. The above grade wise compositional variation holds good in best way with the specification of limestone utilized in different industries after considering the reliability of chemical analysis.
- 4.4.2 The grade variation of CaO for Zone-I is minimum 42.25% (MJRS-10) to maximum 49.25% (MJRS-05) and for Zone-II is minimum 42.08% (MJRS-12) to maximum 48.88% (MJRS-46). The cement grade limestone is sandwiched between ungraded limestone zones assessed on the basis of the threshold value given by IBM i.e. 34% CaO. Borehole wise cement grade and ungraded zones are presented as Annexure – IVA and IVB respectively.
- 4.4.3 Iso-Grade plan for cement grade limestone Zone-I & II have been prepared (Plate 6A & 6B respectively) to show the distribution of CaO% of different limestone horizons throughout the block. Borehole nos. MJRS-25, 31, 32, 33, 37, 42, 44, 49, 78 and 86 have only intersected ungraded limestone. No cement grade limestone zones have been intersected in these boreholes. Thus a line has been drawn to demarcate an "Zone of Ungraded limestone" by connecting midway points of each surrounding boreholes, where any of the cement grade limestone has been encountered, to these above boreholes.

4.5.0 CHEMICAL CONSTITUENTS

4.5.1 Major Constituents

As mentioned earlier, Limestone is classified to different grades on the basis of three major chemical constituents i.e. CaO, MgO and SiO₂. The other major constituents of limestone are Al₂O₃, Fe₂O₃ and LOI. The range of major constituents pertaining to Cement grade Limestone of Jamodi-Mahanna block is appended in the following table:

Cement grade	CaO %		MgO %		SiO ₂ %		Al ₂ O ₃ %		Fe ₂ O ₃ %		LOI%	
	Mini.	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.	Maxi.
Zone-I	42.25	49.25	0.93	3.89	2.91	14.29	1.16	2.52	1.04	2.09	34.91	40.11
Zone-II	42.08	48.88	1.09	3.95	4.94	13.60	1.07	2.77	0.97	2.51	34.43	40.32

4.5.2 Deleterious Constituents

The most deleterious constituent of cement is MgO as it affects the soundness of set cement. It mostly enters through limestone. The Indian manufactures consider 4% as a safe limit. Another harmful impurity in limestone for cement making is Sulphur. The SO₃ content in limestone should not exceed 1.75% because it forms sulpho-aluminate which has a marked swelling property. The minimum and maximum SO₃ content in limestone of this block is 0.08 and 1.06 respectively, which is well within safe limit.

4.5.3 Minor Constituents

Besides the above broad chemical specifications, cement grade limestone bound to have some limitations in the content of minor elements and constituents. Although these minor constituents do not have direct significance in assessing the suitability of a limestone, their presence beyond certain limits is undesirable as it may affect the manufacturing process or the quality of cement adversely.

- Phosphorous content (as P₂O₅) should not exceed 1% as excess phosphorous inhibits clinker minerals formation and reduces the strength of cement appreciably. Here P₂O₅ content limits between 0.002% to .028%.
- Titanium content (as TiO₂) should not exceed 1% as excess Titanium lowers the strength of cement appreciably. In this block TiO₂ content ranges between 0.02% to 0.14%.
- Manganese should not exceed 3% (Mn₂O₃) as it has similar adverse effect on the quality of cement. Limestone of this block satisfies this criterion.
- Chloride content (as Cl) should not exceed 0.015% as it would otherwise cause corrosion and other process difficulties especially in dry process of cement manufacture. Here, Cl content limits between 0.06% to 0.16%.

4.6.0 OVERBURDEN

The limestone column in Limestone block is generally overlain by soil, kankar with calcite, clay and oxidized, leached limestone. The thickness of overburden is of primary importance in planning and economics of an opencast mine. Normally with the increasing thickness of overburden, more mechanization is bound to be introduced as large quantity of overburden is required to be handled for the same production of limestone. The range of overburden thickness in Jamodi-Mahanna limestone block is given below:

Mininum	Maximum
0.10	19.00
(Bh.No.MJRS-12)	(Bh.no. MJRS-31)

Average overburden thickness is 3.78m

4.7.0 PETROGRAPHIC STUDIES

- 4.7.1 A total of 25 nos. of Petrological samples from drill cores of the block has been subjected to petrographic studies. Limestone samples of Jamodi-Mahanna block shows that the major minerals (>30%) in the rocks is calcite but gypsum and quartz also constitute a major minerals in some other specimens. Calcite in the rocks occurs as finely crystalline to microcrystalline, micritic/massive aggregates or grains segregating in thin parallel layers or as recrystallized coarser grains at places. The minor minerals (>1% to <5%) are opaque, clayey material, quartz, dolomite, albite, sericite & muscovite. Whereas accessory minerals (<1%) are ferruginous materials, opaque, quartz, albite, muscovite, biotite, sericite, celestite, halite etc. Opaques occur as fine euhedral to anhedral grains, veins and fillings. Clayey material is present in the fractures and as dull patches and very fine dispersed matter intermixed with calcite at places. Quartz occurs as fine anhedral grains floating in calcite mosaic. Dolomite occurs as medium subhedral to euhedral aggregates. Muscovite, sericite and biotite is seen present as fine to very fine flakes mostly segregated in clayey bands. Albite occurs as fine anhedral to prismatic grains. Calcite and dolomite at some places occur as intruding veins comprising medium to coarse subhedral grains. Gypsum occurs as fine to medium prismatic, bladed and fibrous aggregates segregated in thin bands. Fine calcite grains are seen replacing gypsum along its cleavage traces at places. Celestite and halite are present as fine grains associated with gypsum. Stromatolitic traces are present in some of the specimens occurring as sinuous-undulating sub-parallel thin clayey layers interbedded with micritic layers.
- 4.7.2 The different limestone specimen studied for petrographical studies under microscope has been identified as massive limestone, impure limestone, thinly laminated impure limestone, limestone with alternate clay bands, thinly laminated limestone with alternate clay bands and Gypsum interbanded with clayey micrite etc.

4.8.0 X-RAY DIFFRACTION STUDIES

4.8.1 X-ray diffraction studies of 20 composite samples of limestone have revealed the presence of calcite, Dolomite and Quartz as major constituent ($\geq 5\%$) and Quartz Dolomite & muscovite as minor minerals ($\leq 5\%$ to $\geq 1\%$). Gypsum, Illite, Pyrite, ankerite, muscovite, magnetite, spinel, apatite, siderite, muscovite, rutile and amesite (clay) occur as accessory or trace minerals ($\leq 1\%$).

4.9.0 MINOR AND TRACE ELEMENTS

4.9.1 The emission spectroscopic studies on 10 and 20 samples of limestone have been carried out at G4 and G2/G3 level respectively. The results are presented as Annexure-VIA and VIB respectively.

The observations on these studies are:

- Lead (Pb) is present and ranges from 3.4 ppm to 30.0 ppm.
- Nickel (Ni) is present and ranges from 2.50 ppm to 5.7 ppm.
- Cobalt (Co) is present and ranges from 0.9 ppm to 2.7 ppm.
- Zinc (Zn) is present and ranges from 8.6 ppm to 49.3 ppm.
- Molybdenum (Mo) is present and ranges from 0.20 ppm to 1.7 ppm.
- Manganese (Mn) is present and ranges from 201.5 ppm to 443.8 ppm.

CHAPTER –V

5.0.0 RESOURCES AND GRADE

5.1.0 GENERAL

5.1.1 MECL carried out G-3/G-2 level exploration to establish strike and depth continuity and thickness of limestone horizon in Jamodi-Mahanna block by drilling 83 vertical scout boreholes in an area of 31 sq. km. with the objective to make systematic assessment of grades of limestone and to estimate reconnaissance (332/333) category resources.

Previously, MECL had drilled five (05) scout boreholes in this block at G-4 level. The data of those 5 boreholes are also incorporated for Resource and Grade calculation at present level.

5.1.2 In Jamodi-Mahanna block, the Bhandar / Nagod limestone with two Cement grade limestone zones were intersected in the 40 boreholes out of 88 boreholes drilled in the area. The grey colour massive/stromatolitic limestone in the upper and lower part of the 40 boreholes corresponds to the upper and lower cement grade limestone zones i.e. Zone-I & Zone-II respectively. Apart from these 40 boreholes, there are 30 boreholes in the block in which only the lower cement grade Zone-II have been intersected. Similarly, there are such 5 boreholes where only the upper cement grade Zone-I have been intersected. In 3 boreholes (MJRS-3, 76 and 87), no limestone has been intersected and in 10 boreholes, only ungraded limestone has been encountered. Borehole wise graphic lithologs with zone details (grade and thickness variation) of MECL boreholes is furnished as Plate-VII.

5.2.0 BASIC ASSUMPTIONS

5.2.1 For estimating the resources and grades of limestone following parameters have been considered.

- i) Limestone zones for cement grade have been prepared based cut-off i.e. minimum 42% CaO, 4% MgO (Max.) and 16% SiO₂ (Max.) cut-off. Limestone zones have also been prepared for 34% to less than 42% CaO.
- ii) The zones of different grades have been demarcated from the primary analysis values as per the cut-off limits for CaO, MgO and SiO₂ as detailed in para 3.12.0 of Chapter III.
- iii) Limestone resources have been estimated for the zones demarcated based on the cut-off given above for Cement grade. The exploration is restricted to Bhandar/Nagod Limestone only and all the boreholes were closed in the Nagod/ Ganurgarh shales. The minimum thickness

of 1.00m of Graded/ungraded zone has been considered for resource estimation by both the methods.

- iv) The thin and impersistent /localized zone intersected in the boreholes established on the basis of primary analyses which could not be correlated thus were merged with the thick /most persistent zones within which they were occurring and average composite analyses have been calculated for these merged zones.
- v) The resources and grade have been estimated by Cross Sectional method. Resources have been calculated by Iso-chore method also to check the reliability of calculated resource by cross-sectional method.
- vi) A total of 9 nos. of Cross Sections have been drawn along dip direction at 400 m spacing in Part A and 4 nos. of Cross Sections have been drawn along dip direction at 800 mts in Part B spacing by joining maximum boreholes on section lines to show the behavior of limestone zone. The boreholes which were not falling on section lines have been projected on the nearest section line.
- vii) The strike and dip continuity of limestone which is a bedded sedimentary deposit of regular habit has been established in the entire block based on the intersection and correlation of different lithological units in the boreholes drilled. A total of 88 boreholes (Phase I- 5 BHs & Phase II- 83 BHs) have been drilled at grid spacing of boreholes is around 400m (G2) and 800m (G3). A line has been drawn to separate G2 and G3 category resources and shown on Text Figure-8. This line divides the block in to two parts namely **Part-A** (G2 level exploration, Eastern Part) and **Part-B** (G3 level exploration, Western Part). Thus, the limestone resources in Part-A have been kept under Indicated (G2) category (332) and Part-B (333) have been kept under Inferred (G3) category as per exploration norms for limestone enumerated in the Minerals (Evidence of Mineral Content) Rule 2015.
- viii) The lease hold area within the block has been excluded from the total area of the block while computation of resources.
- ix) The average specific gravity of limestone has been taken as 2.64 arrived from mean of specific gravity determined for 50 limestone samples at MECL Laboratory.
- x) A deduction of 20% from Gross in-situ resources has been made to arrive at Net in situ resources by Cross sectional method as well as by Isochore method for unseen geological factors i.e. slope factor and cavities/caverns etc.

5.3.0 METHODOLOGY

5.3.1 The resources of limestone have been estimated by Cross Sectional method as well as Iso-Chore method. The methodology adopted, keeping the above assumptions in view, for resource estimation is as follows:

5.3.2 **Cross Sectional Method:**

A total of 9 nos. of parallel cross section lines at 400m interval(Part A)and 4 nos. of parallel cross section lines at 800m interval(Part B) drawn across the strike in N-S direction from N1 to N13 throughout the block as shown in plate III. Efforts were made to pass these sections through drilled borehole locations wherever possible. The borehole which were not falling on section lines have been projected on the nearest section line. Since the beds are generally horizontal with very low dip of 2 to 5 degree and boreholes drilled are all vertical, hence true thickness will be the same as thickness intersected in the boreholes. Geological cross sections are generated by GDM software. Cross sectional area on each section has been measured with the help of Auto CAD map 2016 software and recorded systematically. Influence between two section lines having 400m spacing has been taken half way i.e. 200m and for 800m spacing the influence has been taken 400m. Each of these areas has been multiplied with sectional influence/strike influence of the section lines to give volume. The volume is then multiplied with average Sp. Gravity to calculate gross resources.

$$R = Sv \times T \times Avg \text{ Sp. gravity}$$

Where R = Resources / Tonnage

Sv = Sectional area of limestone

T = Influence of half way (200m/400m) between successive section lines

Sp. gr. = Specific gravity of limestone

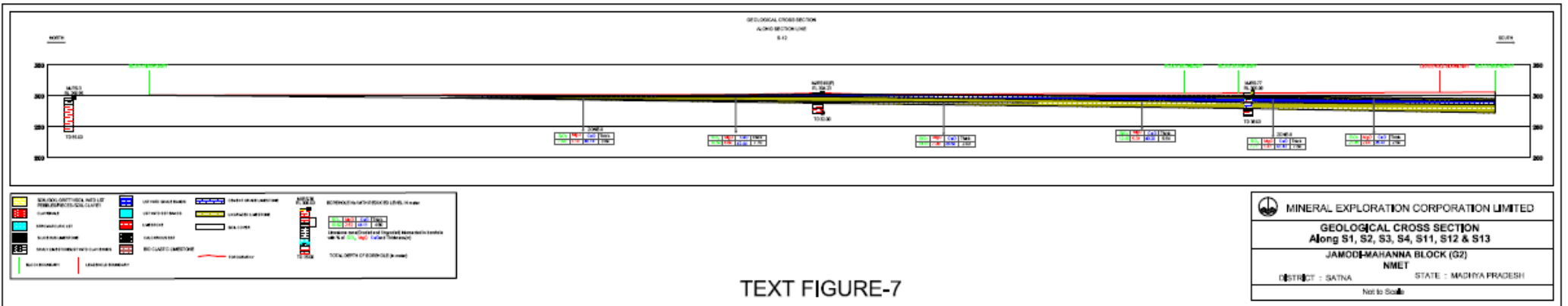
Efforts were made to calculate the average grade for 6 radicals CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃ and LOI section by section. Thus average grade of the block is calculated.

5.3.2 **Iso-chore Method:** In this method of resource estimation, zone wise total thickness of limestone zone intersected in each borehole below overburden has been computed and marked on the respective Iso-chore plan (Plate-5A, 5B & 5C). The isochors at 1 m interval were drawn for different thickness range by law of gradual change. Total data of 88 boreholes of MJRS series are considered for drawing Iso-chores. The zone of Non-development limestone and UG limestone have been marked on the Iso-chore plan. The data of peripheral boreholes of MGHS series of Ghunchihai block are considered while drawing Iso-chores. The thickness-wise area between two successive iso-chores has been measured with the help of AutoCAD Map-2016 software and recorded systematically. Each of these areas is multiplied by average value of vertical thickness ranges in that area to get the volume. Since the borehole grid spacing is 400m in Part A & is 800 m in Part B, resources have been kept as Indicated category (332) in Part A and Inferred category (333) in Part B. The formula for resources estimation is as follows:

$$R = Av \times T \times Sp. gr.$$

Where

R	=	Resources / Tonnage
Av	=	Area between the contours
T	=	Average vertical Thickness
Sp. gr.	=	Specific gravity of limestone



5.3.3 To arrive at net in-situ a resource of limestone by Cross sectional & Iso-Chore method, 20% deduction was made from gross in-situ resources towards unseen geological factors i.e. slope factor and void/cavity etc.

5.4.0 CATEGORISATION OF RESOURCES

5.4.1 Resources of limestone have been categorized under Indicated category (332) in Part-A of the block and Inferred Category (333) in Part-B of the block as per the United Nations Framework Classification (UNFC). The parameters & assumptions for resources estimation have already been defined in Para 5.2.1.

5.5.0 RESOURCES

5.5.1 The resources of limestone have been estimated section wise, category-wise & grade-wise as per specifications for different grades as given in Para 3.12.0 and basic assumptions enumerated Para No. 5.2.0, by Cross sectional & Iso-chore method and have been furnished as Annexure-XA & XB respectively.

5.5.2 Resources are estimated by Cross sectional and Iso-chore Method. The details of the resources estimated by Cross sectional and Iso-chore Method are given in the Table-V-1 to V-7.

Table-5.1

**SECTION WISE AND BOREHOLE WISE INDICATED CATEGORY (332) RESOURCES
OF CEMENT GRADE LIMESTONE (ZONE-I) OF JAMODI-MAHANNA BLOCK (PART-A)
(CROSS SECTIONAL METHOD)**

SECTION LINE	BH. NO.	SECTIONAL AREA (m ²)	STRIKE INFLUENCE (m)	VOLUME (Cu. M)	GROSS IN-SITU RESOURCE (Tonnes)	NET IN-SITU RESOURCE (Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
S4	MJRS-29	1116.7734	400.00	446709.3600	1179312.7104	943450.1683	45.59	1.12	9.77	1.72	1.27	36.52
	MJRS-24	846.5513	400.00	338620.5200	893958.1728	715166.5382	42.41	1.27	14.29	2.14	1.59	35.33
	MJRS-22	2334.8588	400.00	933943.5200	2465610.8928	1972488.7142	42.40	2.11	12.42	2.43	1.93	35.94
	MJRS-20	1725.7138	400.00	690285.5200	1822353.7728	1457883.0182	47.62	1.73	7.39	1.38	1.05	39.67
	MJRS-05	184.8415	400.00	73936.6000	195192.6240	156154.0992	46.42	1.11	9.50	1.90	1.47	37.14
	MJRS-58	864.5550	400.00	345822.0000	912970.0800	730376.0640	43.95	1.22	11.57	1.97	1.45	36.39
	MJRS-65	1169.0775	400.00	467631.0000	1234545.8400	987636.6720	44.80	2.00	10.23	1.92	1.32	37.62
	MJRS-70	5660.4187	400.00	2264167.4800	5977402.1472	4781921.7178	44.61	1.36	11.18	1.99	1.48	34.91
	MJRS-26	1046.4525	400.00	418581.0000	1105053.8400	884043.0720	42.47	1.46	13.48	2.43	2.09	35.76
	MJRS-04	2513.4593	400.00	1005383.7200	2654213.0208	2123370.4166	46.25	1.41	9.93	2.01	1.32	37.49
	MJRS-19	2863.8889	400.00	1145555.5600	3024266.6784	2419413.3427	42.92	2.84	11.62	2.09	1.50	36.87
	MJRS-10	1746.9024	300.00	524070.7200	1383546.7008	1106837.3606	42.58	3.06	11.26	2.35	1.79	36.71
	MJRS-08	2507.9288	400.00	1003171.5200	2648372.8128	2118698.2502	45.09	2.54	5.47	1.31	1.82	37.97
	MJRS-21	738.6002	400.00	295440.0800	779961.8112	623969.4490	44.53	1.23	11.02	2.13	1.74	37.24
	MJRS-57	5343.7960	400.00	2137518.4000	5643048.5760	4514438.8608	43.22	1.83	12.18	2.16	1.77	36.57
	MJRS-64	8571.4321	400.00	3428572.8400	9051432.2976	7241145.8381	43.14	2.82	11.06	2.02	1.50	37.22
	MJRS-82	1750.1518	400.00	700060.7200	1848160.3008	1478528.2406	42.28	3.50	11.21	2.24	1.65	37.20
	MJRS-28	233.2358	400.00	93294.3200	246297.0048	197037.6038	46.06	1.31	8.93	1.74	1.41	38.79
	MJRS-15	3605.7366	400.00	1442294.6400	3807657.8496	3046126.2797	42.92	2.38	5.51	2.14	1.43	36.52
	MJRS-07	6277.8038	400.00	2511121.5200	6629360.8128	5303488.6502	43.93	3.37	4.76	1.89	1.50	37.99
	MJRS-13	1050.9075	400.00	420363.0000	1109758.3200	887806.6560	47.47	1.98	7.01	1.40	1.04	39.10
	MJRS-14	1372.9950	400.00	549198.0000	1449882.7200	1159906.1760	49.17	1.02	2.91	1.16	1.10	40.11
	MJRS-56	1228.3875	400.00	491355.0000	1297177.2000	1037741.7600	42.77	1.59	13.18	2.13	1.46	35.45
	MJRS-54	3178.2150	400.00	1271286.0000	3356195.0400	2684956.0320	45.69	1.67	9.70	1.80	1.57	37.70
	MJRS-59	5051.7000	400.00	2020680.0000	5334595.2000	4267676.1600	44.20	2.31	10.30	1.88	1.41	36.87
	MJRS-62	6876.8622	400.00	2750744.8800	7261966.4832	5809573.1866	43.73	3.05	9.91	1.93	1.60	37.34
	MJRS-12	5475.1054	313.00	1713707.9902	4524189.0941	3619351.2753	44.37	2.40	4.40	1.68	1.29	38.53
	MJRS-09	3569.6700	400.00	1427868.0000	3769571.5200	3015657.2160	42.42	3.11	4.71	2.24	1.62	36.73
	MJRS-66	8571.0375	400.00	3428415.0000	9051015.6000	7240812.4800	44.49	2.78	9.83	1.92	1.44	37.97
	MJRS-02	2320.3687	400.00	928147.4800	2450309.3472	1960247.4778	44.17	1.32	10.71	2.02	1.27	36.56
	MJRS-55	5373.1012	400.00	2149240.4800	5673994.8672	4539195.8938	45.96	2.57	7.52	1.51	1.25	39.23
	MJRS-67	6223.8503	400.00	2489540.1200	6572385.9168	5257908.7334	44.11	3.19	10.22	1.95	1.53	36.64
	MJRS-16	4655.6926	342.00	1592246.8692	4203531.7347	3362825.3878	46.34	2.04	8.10	1.59	1.33	38.79
	MJRS-17	2467.1675	400.00	986867.0000	2605328.8800	2084263.1040	43.06	1.53	6.42	2.13	1.59	35.61
	MJRS-69	4520.2950	400.00	1808118.0000	4773431.5200	3818745.2160	44.22	2.27	10.58	1.98	1.47	37.23
	MJRS-61	3912.4237	400.00	1564969.4800	4131519.4272	3305215.5418	44.45	2.27	10.04	1.90	1.38	37.63
	MJRS-68	3235.9650	400.00	1294386.0000	3417179.0400	2733743.2320	47.93	1.77	6.44	1.35	1.15	39.49
	MJRS-71	2332.7762	400.00	933110.4800	2463411.6672	1970729.3338	43.00	3.02	10.83	2.03	1.46	36.91
TOTAL				48086424.8194	126948161.5232	101558529.2186	44.03	2.37	9.16	1.91	1.47	37.34

Table-5.2

**SECTION WISE AND BOREHOLE WISE INDICATED CATEGORY (332) RESOURCES
OF CEMENT GRADE LIMESTONE (ZONE-II) OF JAMODI-MAHANNA BLOCK (PART-A)
(CROSS SECTIONAL METHOD)**

SECTION LINE	BH. NO.	SECTIONAL AREA (m ²)	STRIKE INFLUENCE (m)	VOLUME (Cu. M)	GROSS IN-SITU RESOURCE (Tonnes)	NET IN-SITU RESOURCE (Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
S1	MJRS-46	1379.1375	336.00	463390.2000	1223350.1280	978680.1024	48.88	2.03	5.98	1.07	0.97	40.32
S2	MJRS-48	741.2433	400.00	296497.3200	782752.9248	626202.3398	42.71	2.49	12.58	2.44	1.60	37.09
	MJRS-41	1624.7432	400.00	649897.2800	1715728.8192	1372583.0554	45.25	2.29	9.67	1.65	1.24	38.49
S3	MJRS-45	1746.5657	400.00	698626.2800	1844373.3792	1475498.7034	44.81	2.52	10.23	1.76	1.43	38.66
	MJRS-23	2940.5868	368.00	1082135.9424	2856838.8879	2285471.1103	44.60	1.73	5.68	2.20	1.60	37.83
S4	MJRS-39	1583.8538	400.00	633541.5200	1672549.6128	1338039.6902	43.82	2.96	10.18	1.76	1.40	37.95
	MJRS-34	3682.5374	400.00	1473014.9600	3888759.4944	3111007.5955	44.34	1.80	11.13	2.21	1.53	36.76
	MJRS-27	2112.6335	400.00	845053.4000	2230940.9760	1784752.7808	44.27	2.94	13.38	2.70	1.81	48.23
S5	MJRS-29	840.3979	400.00	336159.1600	887460.1824	709968.1459	45.45	1.74	9.21	1.97	1.42	37.86
	MJRS-88	1167.6742	350.00	408685.9700	1078930.9608	863144.7686	45.54	2.22	8.77	1.98	1.84	39.08
	MJRS-50	2673.6413	400.00	1069456.5200	2823365.2128	2258692.1702	46.19	3.22	7.38	1.34	1.15	39.82
	MJRS-01	1636.2563	400.00	654502.5200	1727886.6528	1382309.3222	47.23	1.31	8.02	1.81	1.33	39.38
	MJRS-36	2490.0975	400.00	996039.0000	2629542.9600	2103634.3680	42.14	1.89	13.60	2.71	1.73	35.25
	MJRS-24	1631.0578	400.00	652423.1200	1722397.0368	1377917.6294	43.96	2.45	10.67	2.14	1.51	37.77
	MJRS-22	454.7250	400.00	181890.0000	480189.6000	384151.6800	46.36	1.26	8.65	1.78	1.48	37.02
	MJRS-05	1115.4660	400.00	446186.4000	1177932.0960	942345.6768	43.84	3.17	10.08	2.03	1.54	36.78
	MJRS-53	3133.5960	325.00	1018418.7000	2688625.3680	2150900.2944	42.44	3.91	11.31	1.97	1.50	37.45
	MJRS-58	2223.1592	400.00	889263.6800	2347656.1152	1878124.8922	44.25	1.47	11.00	2.24	1.56	36.87
	MJRS-65	1873.1813	400.00	749272.5200	1978079.4528	1582463.5622	45.89	1.47	9.20	1.99	1.40	38.41
	MJRS-70	4839.5278	400.00	1935811.1200	5110541.3568	4088433.0854	42.88	1.74	13.09	2.56	1.70	36.65
S6	MJRS-47	1215.9450	400.00	486378.0000	1284037.9200	1027230.3360	46.51	2.56	8.07	1.35	1.25	39.35
	MJRS-30	1915.1550	400.00	766062.0000	2022403.6800	1617922.9440	44.11	2.52	10.60	2.03	1.42	38.07
	MJRS-38	3287.9526	400.00	1315181.0400	3472077.9456	2777662.3565	43.10	1.95	11.85	2.39	1.81	36.41
	MJRS-26	1652.8541	400.00	661141.6400	1745413.9296	1396331.1437	43.34	3.80	5.95	1.81	1.38	38.42
	MJRS-04	1438.5084	400.00	575403.3600	1519064.8704	1215251.8963	44.71	1.63	11.16	2.43	1.42	36.69
	MJRS-19	1747.7971	400.00	699118.8400	1845673.7376	1476538.9901	44.93	1.42	10.44	2.14	1.53	37.43
	MJRS-10	951.3147	300.00	285394.4100	753441.2424	602752.9939	42.57	1.64	12.77	2.64	1.93	35.87
	MJRS-08	1497.5100	400.00	599004.0000	1581370.5600	1265096.4480	42.80	1.67	6.31	1.85	2.51	35.41
	MJRS-21	747.2588	400.00	298903.5200	789105.2928	631284.2342	47.55	1.36	7.46	1.72	1.24	39.16
	MJRS-51	1260.4387	400.00	504175.4800	1331023.2672	1064818.6138	48.31	1.29	6.30	1.39	1.53	39.11
	MJRS-52	4557.0262	400.00	1822810.4800	4812219.6672	3849775.7338	43.63	2.63	10.73	2.00	1.47	37.56
	MJRS-57	6788.2050	400.00	2715282.0000	7168344.4800	5734675.5840	44.71	1.50	10.86	2.19	1.51	37.30
	MJRS-64	4469.5763	400.00	1787830.5200	4719872.5728	3775898.0582	42.93	1.88	12.34	2.33	1.69	36.44
	MJRS-82	1090.4438	400.00	436177.5200	1151508.6528	921206.9222	47.18	1.45	8.24	1.79	1.40	38.69
S7	MJRS-43	901.1250	400.00	360450.0000	951588.0000	761270.4000	47.00	2.28	7.81	1.33	1.26	39.24
	MJRS-40	1993.3763	400.00	797350.5200	2105005.3728	1684004.2982	45.90	2.18	8.94	1.63	1.35	38.78
	MJRS-35	2657.4188	400.00	1062967.5200	2806234.2528	2244987.4022	42.73	2.10	12.61	2.44	1.67	34.43
	MJRS-28	756.8719	400.00	302748.7600	799256.7264	639405.3811	42.93	1.66	12.63	2.71	1.72	36.55
	MJRS-15	2712.4319	400.00	1084972.7600	2864328.0864	2291462.4691	44.33	1.50	10.72	2.22	1.68	36.76
	MJRS-07	2489.7037	400.00	995881.4800	2629127.1072	2103301.6858	45.51	1.56	4.94	2.05	1.49	37.20
	MJRS-11	1209.9937	400.00	483997.4800	1277753.3472	1022202.6778	42.47	3.95	8.40	1.33	1.59	38.22
	MJRS-13	2938.8037	400.00	1175521.4800	3103376.7072	2482701.3658	44.30	1.56	6.09	2.19	1.59	37.01
	MJRS-14	3515.0513	400.00	1406020.5200	3711894.1728	2969515.3382	43.87	2.44	10.16	2.07	1.52	37.77
	MJRS-56	3550.0162	400.00	1420006.4800	3748817.1072	2999053.6858	45.21	1.45	10.37	2.07	1.59	37.66
	MJRS-54	3058.0425	400.00	1223217.0000	3229292.8800	2583434.3040	45.22	1.67	10.07	2.07	1.40	37.91
	MJRS-59	2450.2692	400.00	980107.6800	2587484.2752	2069987.4202	45.31	1.93	9.67	1.89	1.39	38.27
S8	MJRS-62	2953.3083	400.00	1181323.3200	3118693.5648	2494954.8518	45.28	1.47	10.16	2.00	1.34	37.25
	MJRS-12	1062.4164	313.00	332536.3332	877895.9196	702316.7357	44.37	1.61	10.94	2.29	1.51	37.13
	MJRS-18	1390.9995	400.00	556399.8000	1468895.4720	1175116.3776	44.82	1.50	9.96	2.17	1.85	37.22
	MJRS-02	2074.6125	400.00	829845.0000	2190790.8000	1752632.6400	44.17	1.60	12.17	2.59	1.60	36.25
	MJRS-55	2504.0475	400.00	1001619.0000	2644274.1600	2115419.3280	45.96	1.64	9.22	1.92	1.36	38.53
S9	MJRS-67	4215.3715	400.00	1686148.6000	4451432.3040	3561145.8432	44.11	1.66	11.22	2.29	1.63	37.19
	MJRS-16	595.3754	342.00	203618.3868	537552.5412	430042.0329	47.66	1.20	7.15	1.54	1.44	38.76
	MJRS-17	458.7525	400.00	183501.0000	484442.6400	387554.1120	42.34	1.58	13.50	2.47	2.08	36.07
	MJRS-61	719.5500	400.00	287820.0000	759844.8000	607875.8400	43.54	1.60	11.60	2.45	1.72	36.60
TOTAL				45989181.5424	121411439.2719	97129151.4175	44.46	1.99	10.12	2.09	1.54	37.65

Table-5.3

**SECTION WISE AND BOREHOLE WISE INFERRED CATEGORY (333) RESOURCES OF
CEMENT GRADE LIMESTONE (ZONE-I) OF JAMODI-MAHANNA BLOCK (PART-B)
CROSS SECTIONAL METHOD**

SECTION LINE	BH. NO.	SECTIONAL AREA (m ²)	STRIKE INFLUENCE (m)	VOLUME (Cu. M)	GROSS IN-SITU RESOURCE (Tonnes)	NET IN-SITU RESOURCE (Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
S7	MJRS-28	233.2358	200.00	46647.1600	123148.5024	98518.8019	46.06	1.31	8.93	1.74	1.41	38.79
	MJRS-15	1955.1923	200.00	391038.4600	1032341.5344	825873.2275	42.92	2.38	5.51	2.14	1.43	36.52
S9	MJRS-17	2467.1675	200.00	493433.5000	1302664.4400	1042131.5520	43.06	1.53	6.42	2.13	1.59	35.61
	MJRS-69	4520.2950	30.00	135608.8500	358007.3640	286405.8912	44.22	2.27	10.58	1.98	1.47	37.23
	MJRS-61	3912.4237	40.00	156496.9480	413151.9427	330521.5542	44.45	2.27	10.04	1.90	1.38	37.63
	MJRS-68	3235.9650	129.00	417439.4850	1102040.2404	881632.1923	47.93	1.77	6.44	1.35	1.15	39.49
	MJRS-71	2332.7762	200.00	466555.2400	1231705.8336	985364.6669	43.00	3.02	10.83	2.03	1.46	36.91
S10	MJRS-60	715.1185	284.00	203093.6540	536167.2466	428933.7972	46.38	2.15	7.32	1.51	1.72	38.65
	MJRS-73	6572.4408	740.00	4863606.1920	12839920.3469	10271936.2775	44.01	3.06	9.74	1.91	1.37	37.55
	MJRS-72	9017.8140	655.00	5906668.1700	15593603.9688	12474883.1750	45.34	2.46	8.28	1.66	1.29	38.13
S11	MJRS-75	2406.6990	662.00	1593234.7380	4206139.7083	3364911.7667	47.48	1.36	7.32	1.54	1.25	38.97
S13	MJRS-74	2412.4505	360.00	868482.1800	2292792.9552	1834234.3642	45.03	1.70	10.10	2.04	1.43	38.00
TOTAL				15542304.5770	41031684.0833	32825347.2666	44.98	2.45	8.67	1.78	1.34	37.90

Table-5.4

**SECTION WISE AND BOREHOLE WISE INFERRED CATEGORY (333) RESOURCES OF
CEMENT GRADE LIMESTONE (ZONE-II) OF JAMODI-MAHANNA BLOCK (PART-B)
CROSS SECTIONAL METHOD**

SECTION LINE	BH. NO.	SECTIONAL AREA (m ²)	STRIKE INFLUENCE (m)	VOLUME (Cu. M)	GROSS IN-SITU RESOURCE (Tonnes)	NET IN-SITU RESOURCE (Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
S7	MJRS-43	901.1250	200.00	180225.0000	475794.0000	380635.2000	47.00	2.28	7.81	1.33	1.26	39.24
	MJRS-40	1993.3763	200.00	398675.2600	1052502.6864	842002.1491	45.90	2.18	8.94	1.63	1.35	38.78
	MJRS-35	2657.4188	200.00	531483.7600	1403117.1264	1122493.7011	42.73	2.10	12.61	2.44	1.67	34.43
	MJRS-28	756.8719	200.00	151374.3800	399628.3632	319702.6906	42.93	1.66	12.63	2.71	1.72	36.55
S9	MJRS-15	1955.1923	200.00	391038.4600	1032341.5344	825873.2275	44.33	1.50	10.72	2.22	1.68	36.76
	MJRS-17	458.7525	200.00	91750.5000	242221.3200	193777.0560	42.34	1.58	13.50	2.47	2.08	36.07
S10	MJRS-61	719.5500	40.00	28782.0000	75984.4800	60787.5840	43.54	1.60	11.60	2.45	1.72	36.60
	MJRS-73	4921.1222	740.00	3641630.4280	9613904.3299	7691123.4639	44.83	1.62	10.43	2.09	1.52	37.54
S11	MJRS-79	827.5575	800.00	662046.0000	1747801.4400	1398241.1520	46.10	2.19	11.30	1.36	1.57	36.58
	MJRS-83	3257.1051	800.00	2605684.0800	6879005.9712	5503204.7770	43.94	2.15	10.93	2.30	1.69	37.79
	MJRS-75	2722.3393	662.00	1802188.6166	4757777.9478	3806222.3583	44.33	2.61	9.84	1.94	1.39	38.22
S12	MJRS-80	2674.0462	800.00	2139236.9600	5647585.5744	4518068.4595	48.14	1.14	7.69	1.45	1.09	39.47
	MJRS-77	3755.7095	400.00	1502283.8000	3966029.2320	3172823.3856	47.43	1.47	7.71	1.57	1.21	39.50
S13	MJRS-84	1812.6900	800.00	1450152.0000	3828401.2800	3062721.0240	43.59	1.68	10.81	2.27	1.87	36.57
TOTAL				15576551.2446	41122095.2857	32897676.2286	45.19	1.81	9.93	1.96	1.49	37.89

Table – 5.5
THICKNESS WISE RESOURCES OF CEMENT GRADE LIMESTONE (ZONE-I) OF
JAMODI-MAHANNA BLOCK (ISO-CHORE METHOD)

THICKNESS RANGE	AVERAGE THICKNESS (m)	AREA (m ²)	VOLUME (Cu m.)	Gross In-situ Resource (Tonnes)	Net In-situ Resource (Tonnes)
<2.00	1.00	1085666.5674	1085666.5674	2866159.7379	2292927.7903
2.00 - 3.00	2.50	836619.8387	2091549.5968	5521690.9354	4417352.7483
3.00 - 4.00	3.50	705239.4670	2468338.1345	6516412.6751	5213130.1401
4.00 - 5.00	4.50	526233.0343	2368048.6544	6251648.4475	5001318.7580
5.00 - 6.00	5.50	581155.6590	3196356.1245	8438380.1687	6750704.1349
6.00 - 7.00	6.50	561140.8432	3647415.4808	9629176.8693	7703341.4954
7.00 - 8.00	7.50	510678.0855	3830085.6413	10111426.0929	8089140.8743
8.00 - 9.00	8.50	1059174.9047	9002986.6900	23767884.8615	19014307.8892
9.00 - 10.00	9.50	1393370.5940	13237020.6430	34945734.4975	27956587.5980
10.00 - 11.00	10.50	691415.2379	7259859.9980	19166030.3946	15332824.3157
11.00 - 12.00	11.50	708585.1401	8148729.1112	21512644.8534	17210115.8827
12.00 - 13.00	12.50	357410.5548	4467631.9350	11794548.3084	9435638.6467
13.00 - 14.00	13.50	225931.8213	3050079.5876	8052210.1111	6441768.0889
14.00 - 15.00	14.50	129914.3085	1883757.4733	4973119.7294	3978495.7835
15.00 - 16.00	15.50	58383.6996	904947.3438	2389060.9876	1911248.7901
Non Development Zone-I	-	12451453.7905	-	-	-
LEASEHOLD AREA WITHIN BLOCK	-	9125873.7556	-	-	-
TOTAL		31008247.3021	66642472.9812	175936128.6704	140748902.9363

Table – 5.6
THICKNESS WISE RESOURCES OF CEMENT GRADE LIMESTONE (ZONE-II) OF
JAMODI-MAHANNA BLOCK (ISO-CHORE METHOD)

THICKNESS RANGE	AVERAGE THICKNESS (m)	AREA (m ²)	VOLUME (Cu m.)	Gross In-situ Resource (Tonnes)	Net In-situ Resource (Tonnes)
<2.00	1.00	3422591.6458	3422591.6458	9035641.9449	7228513.5559
2.00 - 3.00	2.50	2267897.8613	5669744.6533	14968125.8846	11974500.7077
3.00 - 4.00	3.50	2361516.3668	8265307.2838	21820411.2292	17456328.9834
4.00 - 5.00	4.50	2596604.2983	11684719.3424	30847659.0638	24678127.2510
5.00-6.00	5.50	2059392.3114	11326657.7127	29902376.3615	23921901.0892
6.00 - 7.00	6.50	1457491.6507	9473695.7296	25010556.7260	20008445.3808
7.00 - 8.00	7.50	964630.4953	7234728.7148	19099683.8069	15279747.0456
8.00 - 9.00	8.50	428982.4811	3646351.0894	9626366.8759	7701093.5007
9.00 - 10.00	9.50	194342.0153	1846249.1454	4874097.7437	3899278.1950
10.00 - 11.00	10.50	105534.0247	1108107.2594	2925403.1647	2340322.5317
11.00 - 12.00	11.50	70234.4088	807695.7012	2132316.6512	1705853.3209
12.00 - 13.00	12.50	26255.2256	328190.3200	866422.4448	693137.9558
13.00 - 14.00	13.50	8154.2586	110082.4911	290617.7765	232494.2212
Non Development Zone-II	-	5918746.5028	-	-	-
LEASEHOLD AREA WITHIN BLOCK	-	9125873.7556	-	-	-
TOTAL		31008247.3021	64924121.0886	171399679.6738	137119743.7390

Table – 5.7
THICKNESS WISE RESOURCES OF UNGRADED LIMESTONE OF
JAMODI-MAHANNA BLOCK (ISO-CHORE METHOD)

THICKNESS RANGE	AVERAGE THICKNESS (m)	AREA (m²)	VOLUME (Cu m.)	GROSS IN-SITU RESOURCE (Tonnes)	NET IN-SITU RESOURCE (Tonnes)
<2.00	1.00	1079182.7116	1079182.7116	2849042.3586	2279233.8869
2.00 - 3.00	2.50	562866.3641	1407165.9103	3714918.0031	2971934.4024
3.00 - 4.00	3.50	569798.1434	1994293.5019	5264934.8450	4211947.8760
4.00 - 5.00	4.50	883242.4437	3974590.9967	10492920.2312	8394336.1849
5.00-6.00	5.50	2195287.4902	12074081.1961	31875574.3577	25500459.4862
6.00 - 7.00	6.50	3047208.9871	19806858.4162	52290106.2186	41832084.9749
7.00 - 8.00	7.50	3243037.5952	24322781.9640	64212144.3850	51369715.5080
8.00 - 9.00	8.50	2548066.6137	21658566.2165	57178614.8114	45742891.8491
9.00 - 10.00	9.50	2581924.4546	24528282.3187	64754665.3214	51803732.2571
10.00 - 11.00	10.50	1748322.3920	18357385.1160	48463496.7062	38770797.3650
11.00 - 12.00	11.50	898225.5915	10329594.3023	27270128.9579	21816103.1664
12.00 - 13.00	12.50	766968.3718	9587104.6475	25309956.2694	20247965.0155
13.00 - 14.00	13.50	326557.8270	4408530.6645	11638520.9543	9310816.7634
14.00 - 15.00	14.50	130514.9911	1892467.3710	4996113.8593	3996891.0874
15.00 - 16.00	15.50	66858.4049	1036305.2760	2735845.9285	2188676.7428
16.00 - 17.00	16.50	44605.6794	735993.7101	1943023.3947	1554418.7157
17.00 - 18.00	17.50	26992.4272	472367.4760	1247050.1366	997640.1093
18.00 - 19.00	18.50	22543.3691	417052.3284	1101018.1468	880814.5175
19.00 - 20.00	19.50	23726.0807	462658.5737	1221418.6344	977134.9075
20.00 - 21.00	20.50	28881.9329	592079.6245	1563090.2085	1250472.1668
Non Development of Limestone	-	1087561.6755	-	-	-
LEASEHOLD AREA WITHIN BLOCK	-	9125873.7556	-	-	-
TOTAL		31008247.3023	159137342.3215	420122583.7288	336098066.9830

5.6.0 SUMMARY OF RESOURCES

5.6.1 The summary of resources by Cross Sectional method is given in Table-5.8

Table 5.8
Summary of Cement grade Limestone Resources of Jamodi-Mahanna Block
by Cross Sectional method

CEMENT GRADE LIMESTONE	INDICATED							INFERRED							TOTAL						
	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
ZONE-I	101.5585	44.03	2.37	9.16	1.91	1.47	37.34	32.8253	44.98	2.45	8.67	1.78	1.34	37.90	134.3838	44.31	2.39	9.04	1.88	1.44	37.48
ZONE-II	97.1291	44.46	1.99	10.12	2.09	1.54	37.65	32.8976	45.19	1.81	9.93	1.96	1.49	37.89	130.0267	44.59	1.94	10.07	2.06	1.53	37.71
TOTAL RESOURCES (Million Tonnes)	198.6876	44.24	2.19	9.63	2.00	1.51	37.49	65.7229	45.09	2.13	9.30	1.87	1.41	37.90	264.4105	44.45	2.17	9.55	1.97	1.48	37.59

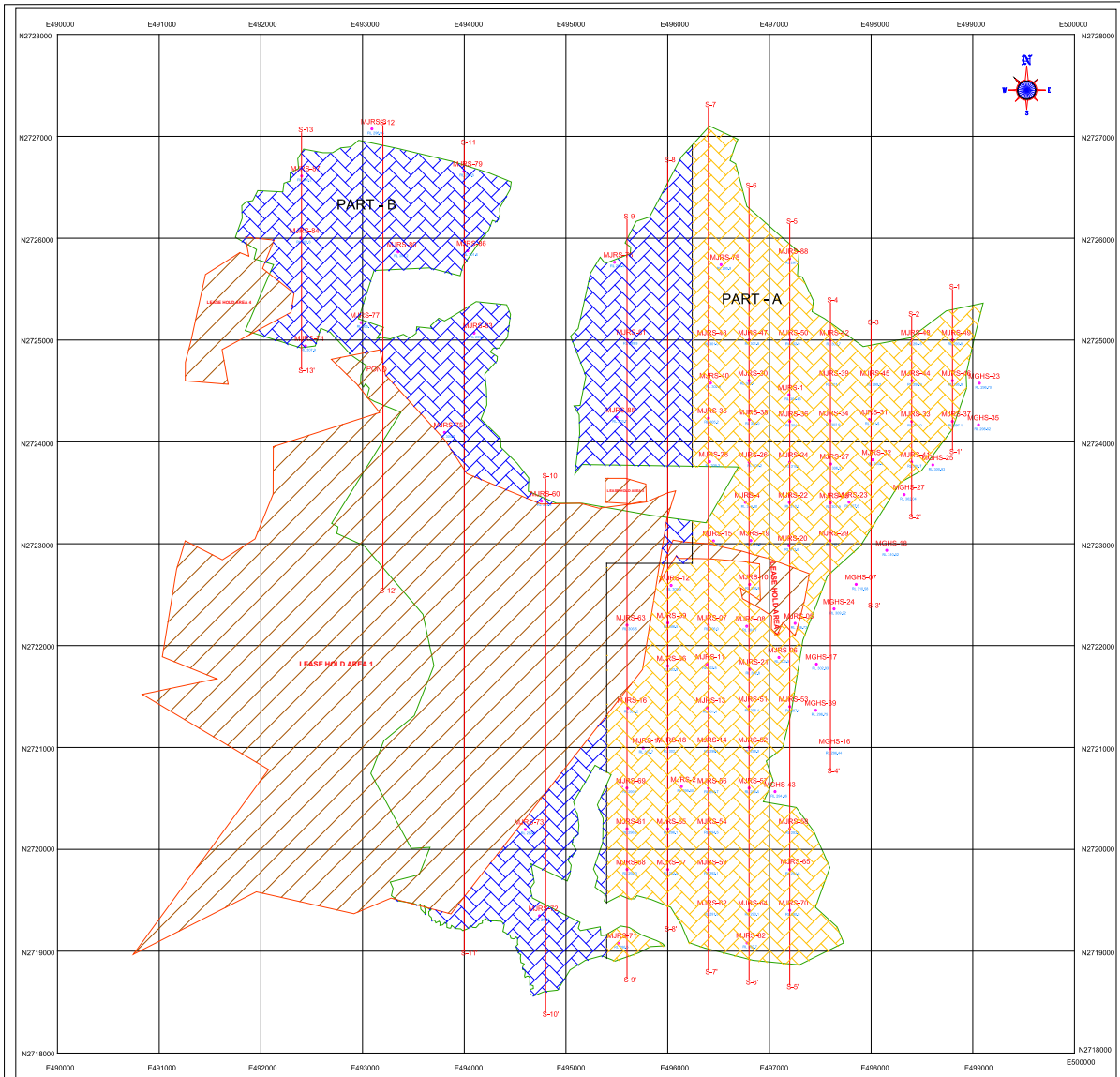
5.6.2 A total of **264.4051 million tonnes** net in-situ limestone resources with an average grade of 44.46% CaO, 2.17% MgO, 9.55% SiO₂, 1.97% Al₂O₃, 1.48% Fe₂O₃ & 37.59% LOI i.e. Cement grade have been estimated in the block. To the total Net in situ resources, Cement grade Zone-I and Zone-II contributes 50.82% and 49.18% respectively. The total resource has been categorized under Indicated (332) and Inferred (333) category. Indicated resources corresponds to the Part-A of the block whereas Inferred category corresponds to Part-B of the block. 75.14% of the total resource is estimated and reported as Indicated Category (332) and the rest 24.86% is estimated and reported as Inferred (333) category, as per United Nations Framework Classification (UNFC).

5.6.3 The summary of resources by Iso-chore method is given in Table-5.9

Table 5.9
Summary of Cement grade and Ungraded Limestone Resources
Of Jamodi-Mahanna Block, by Iso-Chore method

CEMENT GRADE LIMESTONE	GROSS RESOURCES (Million Tonnes)	NET RESOURCES (Million Tonnes)
ZONE-I	175.9361	140.7489
ZONE-II	171.3996	137.1197
TOTAL	347.3357	277.8686
UNGRADED LIMESTONE	420.1225	336.0908

5.6.4 A total of **277.8686 million tonnes** net in-situ Cement grade limestone resources have been estimated in the block. To the total Net in situ resources, Cement grade Zone-I and Zone-II contributes 50.65% and 49.35% respectively. The resource of ungraded limestone has been calculated by Iso-Chore method only and estimates 336.0908 million tonnes Net in-situ resources.



INDEX	
MURS-38	Borehole drilled by MECL at Jamodi Mahanna Block with Reduced Level (m)
RL 306.0	
MGH-17	Borehole drilled by MECL at Ghunchihai Block with Reduced Level (m)
RL 302.90	
	Block Boundary
	Line separating Indicated and Inferred Category Resource Area
	Leasehold Area
	Inferred Category (333) Resource Area
	Indicated Category (332) Resource Area



MINERAL EXPLORATION CORPORATION LIMITED

RESOURCE MAP WITH BOREHOLE LOCATION

JAMODIMAHANNA BLOCK (G2/G3)

NMET

DISTRICT : SATNA STATE : MADHYA PRADESH

R.F. : 1:10000

CHAPTER –VI

6.0.0 STATISTICAL EVALUATION AND RELIABILITY OF DATA

6.1.0 INTRODUCTION

6.1.1 Reliability in statistics is the overall consistency of a measure. A measure is said to have a high reliability if it produces similar results under consistent conditions. It is the characteristic of a set of test scores that relates to the amount of random error from the measurement process that might be embedded in the scores. Scores that are highly reliable are accurate, reproducible and consistent from one testing occasion to another. That is, if the testing process were repeated with a group of test takers, essentially the same results would be obtained.

6.2.0 RELIABILITY OF CHEMICAL ANALYSIS

6.2.1 A total number of 164 internal check samples from boreholes MJRS-6 to 88 of Jamodi-Mahanna Block have been analyzed in MECL Chemical Laboratory, Nagpur to check the reliability of chemical analysis. The Primary analysis data v/s Check analysis data and variation in the percentage of CaO, SiO₂, MgO, Al₂O₃, Fe₂O₃& LOI are given in Annexures- VA along with scatter plots (Text Figure-5A to 5F). The average variation in percentage of CaO, SiO₂, MgO, Al₂O₃, Fe₂O₃& LOI are given in the following table:

Percentage Variation	No of Samples CaO	No of Samples SiO ₂	No of Samples MgO	No of Samples Al ₂ O ₃	No of Samples Fe ₂ O ₃	No of Samples LOI
<0.5%	150	146	163	159	162	143
0.5-1%	9	10	Nil	2	Nil	15
1-1.5%	2	4	1	2	2	1
1.5-2%	Nil	1	Nil	Nil	Nil	1
2-2.5%	2	Nil	Nil	Nil	Nil	2
2.5-3%	Nil	1	Nil	1	Nil	Nil
3-3.5%	Nil	1	Nil	Nil	Nil	1
Total	163	163	164	164	164	163

(Note: Only one value difference of SiO₂%, CaO% and LOI% is 21.14, 16.14 & 11.69 respectively which is exceptional)

6.2.2 Thus it is obvious from the above table that the variation in both CaO and SiO₂ content is less than 0.50% in 92% & 90% of the samples respectively. The variation in MgO, Fe₂O₃, Al₂O₃ and LOI is less than 0.50% in 98% of the samples whereas variation in LOI content is less than 0.50% in 88% of the samples.

6.2.3 Scatter plot of Primary vs Check samples for various radicals are provided in the Text Figure 5A to 5F. The details of all the statistical parameters pertaining to radicals CaO, SiO₂, Al₂O₃, Fe₂O₃, MgO & LOI & Na₂O are provided in the Table 6.1 to 6.6 respectively.

Table 6.1
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	CaO	
	Primary	Check
No. of Sample Pairs	164	
Arithmetic Mean	41.208	40.964
Standard Deviation	3.296	3.625
Std. Error of Mean	0.257	0.283
Variance	10.861	13.143
Mean of Deviation	0.244	
Standard Deviation (Error)	1.329	
Correlation Coefficient	0.931	
Mean Absolute Error	0.332	
Mean Relative Random Error	0.805%	
Paired T value	2.36	
F-Test	0.826	

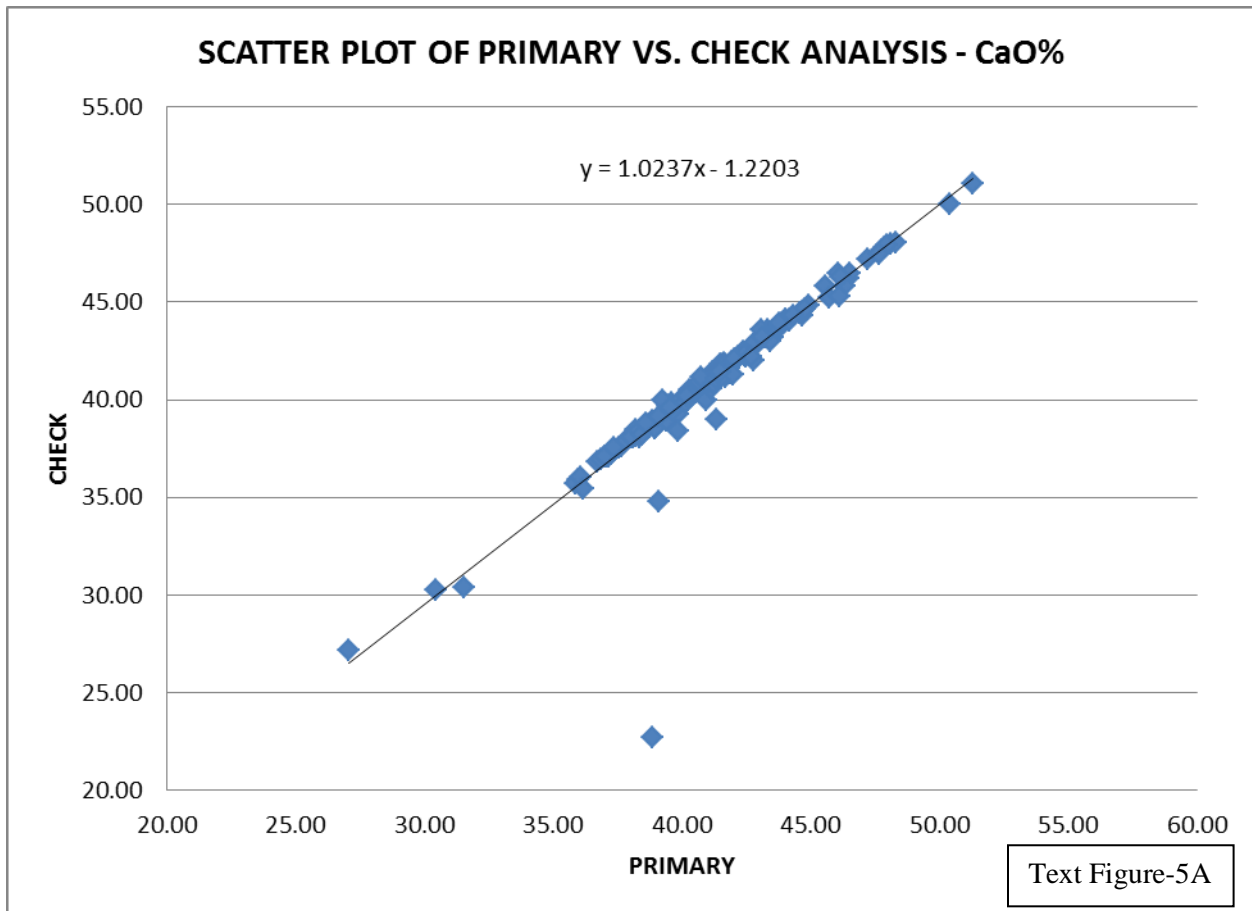


Table 6.2
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	MgO	
	Primary	Check
No. of Sample Pairs	164	
Arithmetic Mean	3.148	3.129
Standard Deviation	1.658	1.668
Std. Error of Mean	0.129	0.13
Variance	2.748	2.782
Mean of Deviation		0.019
Standard Deviation (Error)		0.134
Correlation Coefficient		0.997
Mean Absolute Error		0.063
Mean Relative Random Error		2.005%
Paired T value		1.72
F-Test		0.98

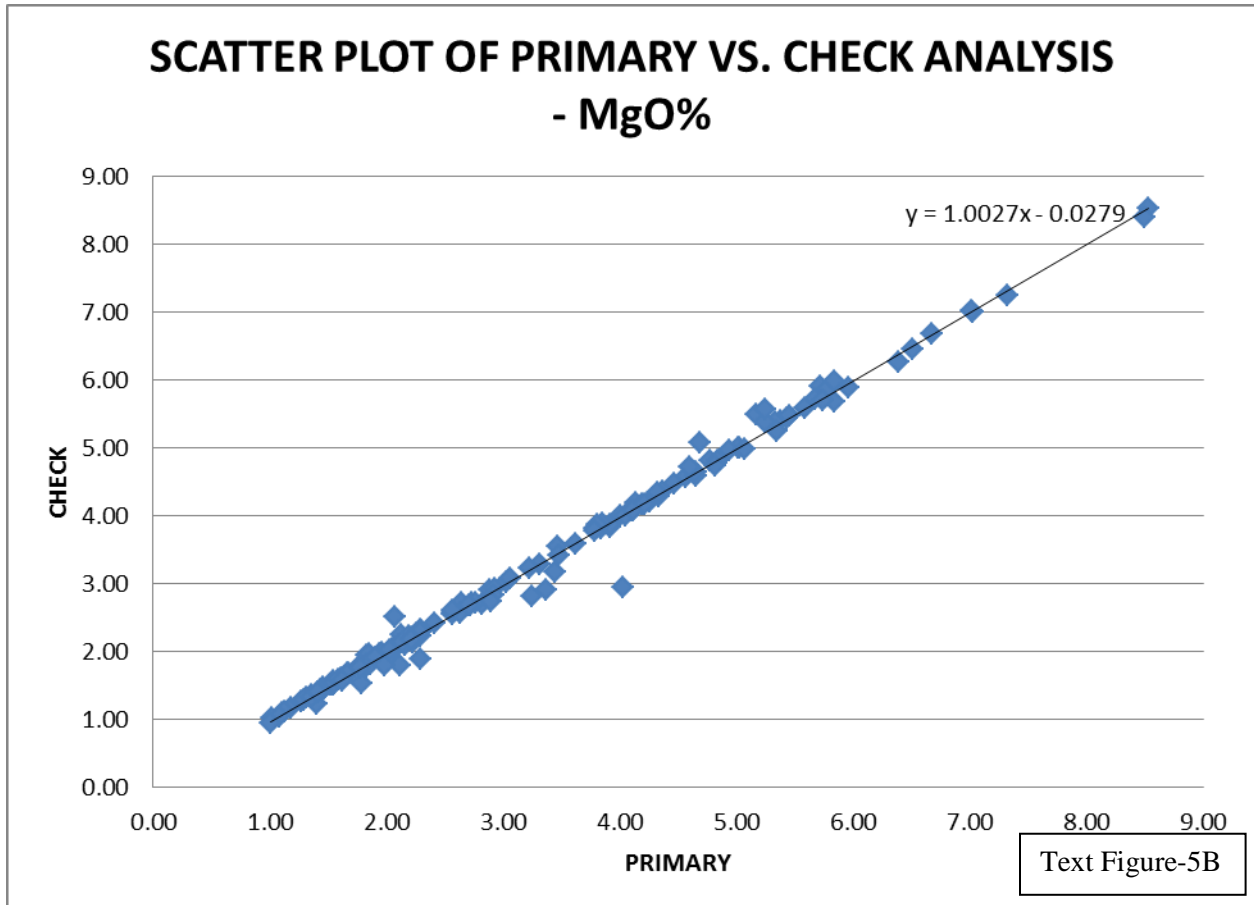


Table 6.3
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	SiO ₂	
	Primary	Check
No. of Sample Pairs	164	
Arithmetic Mean	13.132	13.495
Standard Deviation	3.877	4.311
Std. Error of Mean	0.303	0.337
Variance	15.027	18.583
Mean of Deviation		-0.362
Standard Deviation (Error)		1.736
Correlation Coefficient		0.916
Mean Absolute Error		0.428
Mean Relative Random Error		3.256%
Paired T value		2.67
F- Test		0.808

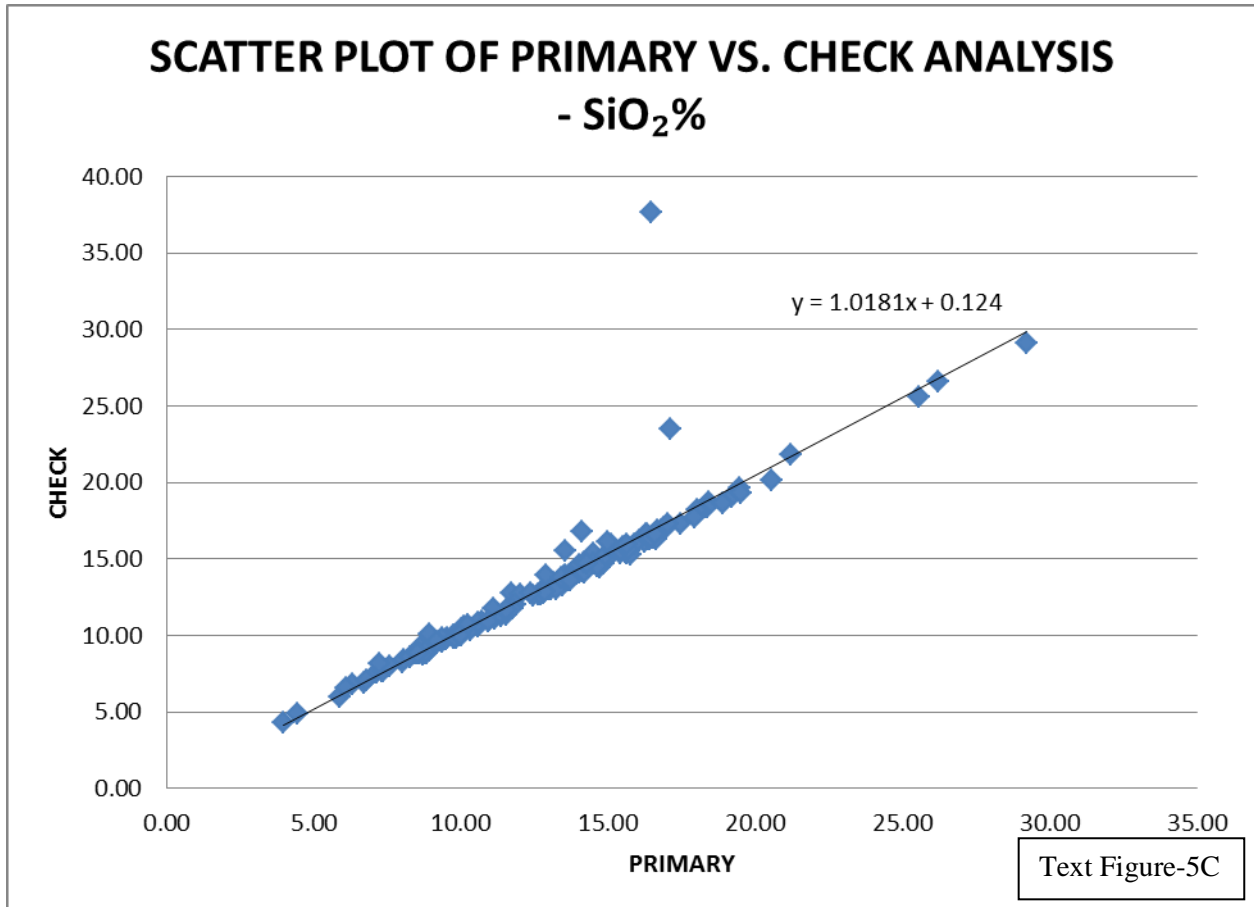


Table 6.4
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Al ₂ O ₃	
	Primary	Check
No. of Sample Pairs	164	
Arithmetic Mean	2.405	2.476
Standard Deviation	0.712	0.779
Std. Error of Mean	0.056	0.061
Variance	0.507	0.607
Mean of Deviation		-0.071
Standard Deviation (Error)		0.275
Correlation Coefficient		0.936
Mean Absolute Error		0.093
Mean Relative Random Error		3.854%
Paired T value		3.30
F- Test		0.835

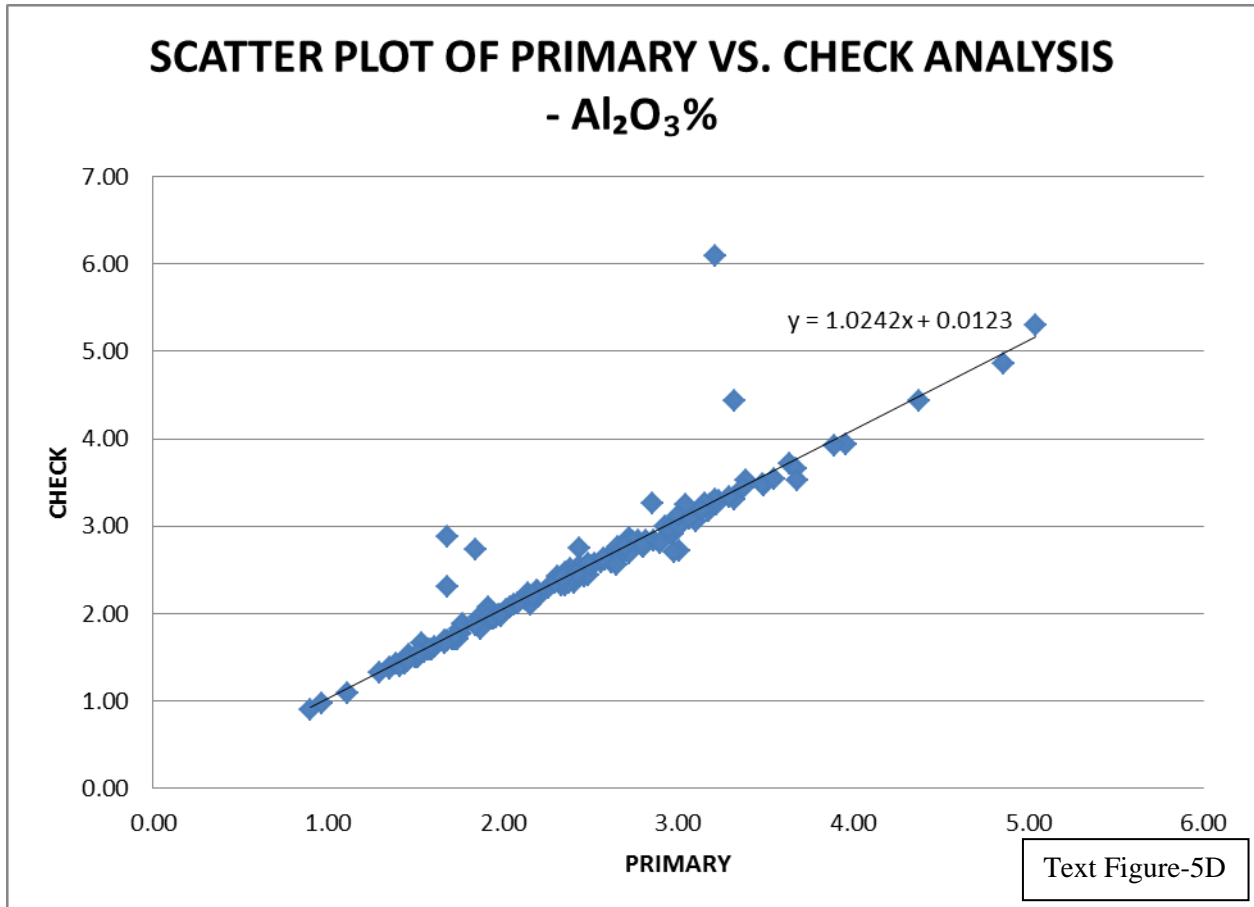


Table 6.5
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	Fe2O3	
	Primary	Check
No. of Sample Pairs	164	
Arithmetic Mean	1.732	1.747
Standard Deviation	0.378	0.393
Std. Error of Mean	0.03	0.031
Variance	0.143	0.154
Mean of Deviation	-0.014	
Standard Deviation (Error)	0.179	
Correlation Coefficient	0.892	
Mean Absolute Error	0.056	
Mean Relative Random Error	3.241%	
Paired T value	1.00	
F- Test	0.927	

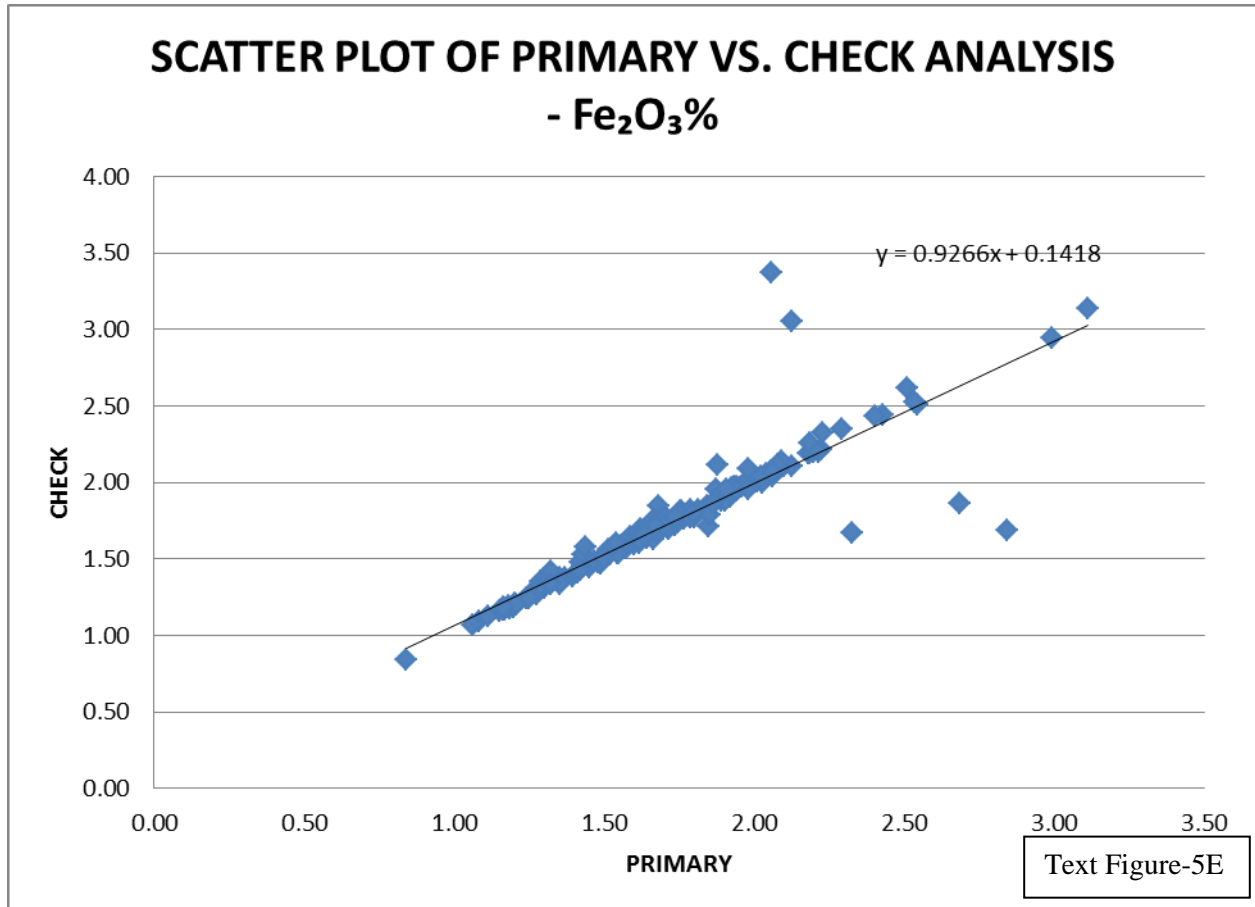
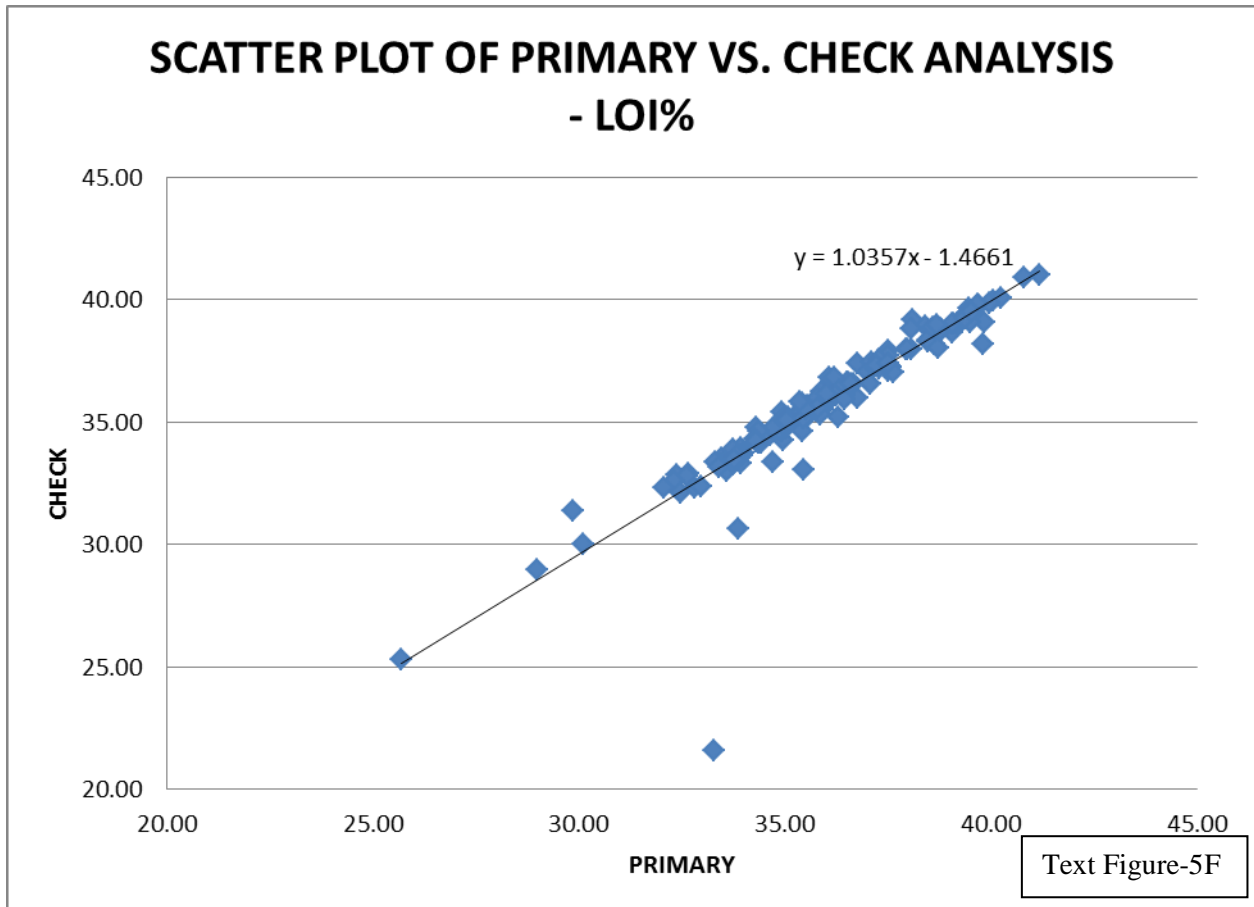


Table 6.6
COMPARISON OF PRIMARY Vs. INTERNAL CHECK ANALYSIS

COMPARISON INDEX	LOI	
	Primary	Check
No. of Sample Pairs		164
Arithmetic Mean	36.071	35.891
Standard Deviation	2.398	2.683
Std. Error of Mean	0.187	0.21
Variance	5.749	7.199
Mean of Deviation		0.18
Standard Deviation (Error)		1.02
Correlation Coefficient		0.925
Mean Absolute Error		0.361
Mean Relative Random Error		1.002%
Paired T value		2.25
F- Test		0.798



Statistical Parameters	CaO	MgO	SiO₂	Al₂O₃	Fe₂O₃	LOI
Mean of deviation	0.244	0.019	-0.362	-0.071	-0.014	0.18
Paired T-value	2.36	1.72	2.67	3.30	1.00	2.25
Table T-value (at 99.95% confidence level)	3.357	3.357	3.357	3.357	3.357	3.357
Standard deviation of error	1.329	0.0134	1.736	0.275	0.179	1.02
Correlation Co-efficient	0.931	0.997	0.916	0.936	0.892	0.925
F-value	0.826	0.98	0.808	0.835	0.927	0.798

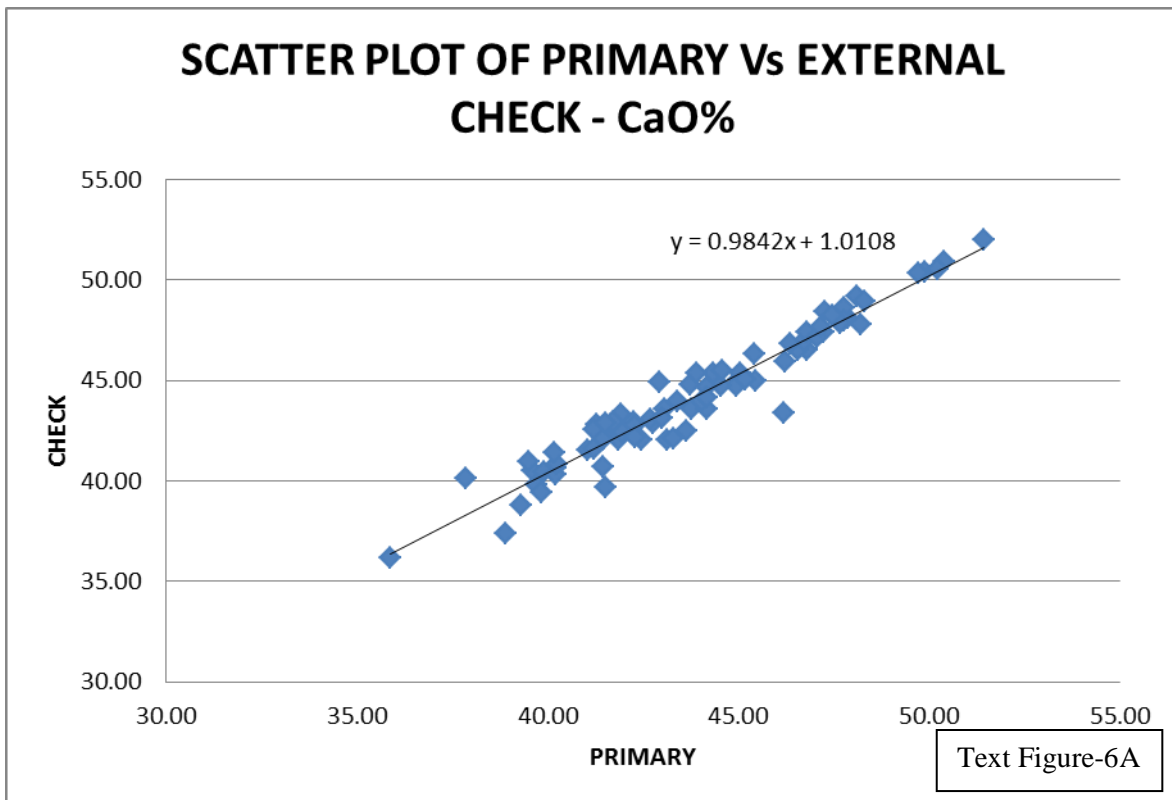
The data set for intra-laboratory Primary Vs. Check analysis comprises 164 pairs of samples. The above table shows that the differences in arithmetic mean, manifested by low “mean of deviation” for all the 6 major constituents, are insignificant. The calculated paired-T value is less than t-table value, which again proves that the difference in mean is insignificant. Standard deviation of error is also very less showing good reliability of analyzed data. Correlation coefficient ranges between 0.892 to 0.997, which is also confirmed by Primary vs Check scatter plot (Text Figure 5A to 5F). It shows the good correlation between primary and check analysis. As the F-test value for all 6 major constituents is approaching 1, it also advocates about good correlation among two set of sample analysis. All these statistical data certify the good quality of sample preparation as well as chemical analysis.

- 6.2.2 A total of 86 samples from boreholes of Jamodi-Mahanna Block have been analyzed as external check sample at JNARDDC, Nagpur to check the reliability of chemical analysis. The Primary analysis data v/s External Check analysis data of CaO, SiO₂, MgO, Al₂O₃, Fe₂O₃& LOI are given in Annexures-VB along with scatter plots (Text Figure-6A to 6F).

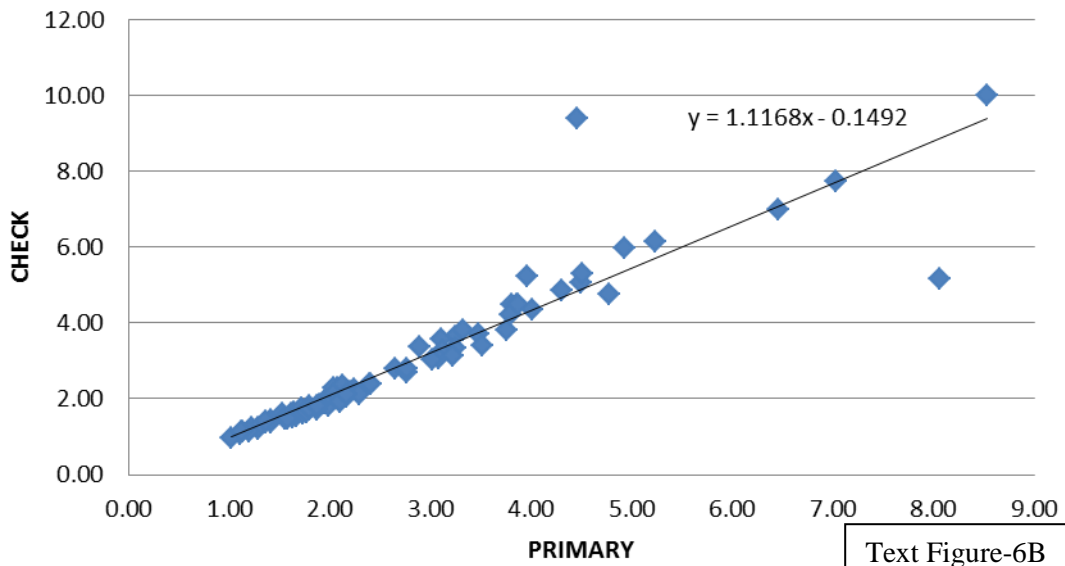
Statistical Parameters	CaO	MgO	SiO₂	Al₂O₃	Fe₂O₃	LOI
Mean of deviation	-0.32	-0.17	-1.02	0.04	0.57	0.26
Paired T-value	-3.4	-2.07	-8.8	1.92	46.29	2.38
Table T-value (at 99.95% confidence level)	3.402	3.402	3.402	3.402	3.402	3.402
Standard deviation of error	0.81	0.71	1.03	0.19	0.11	0.98
Correlation Co-efficient	0.968	0.890	0.926	0.905	0.896	0.906
F-value	1.032	1.45	1.08	1.33	1.61	1.09

The data set for intra-laboratory Primary Vs. Check analysis comprises 86 pairs of samples. Out of these 86 pairs, about 6% of samples having anomalous difference (greater than $\pm 2\%$) in CaO% values. Considering it as outlier, these 6% of external check samples have not been taken up for statistical evaluation. The above table shows that the differences in arithmetic mean, manifested by

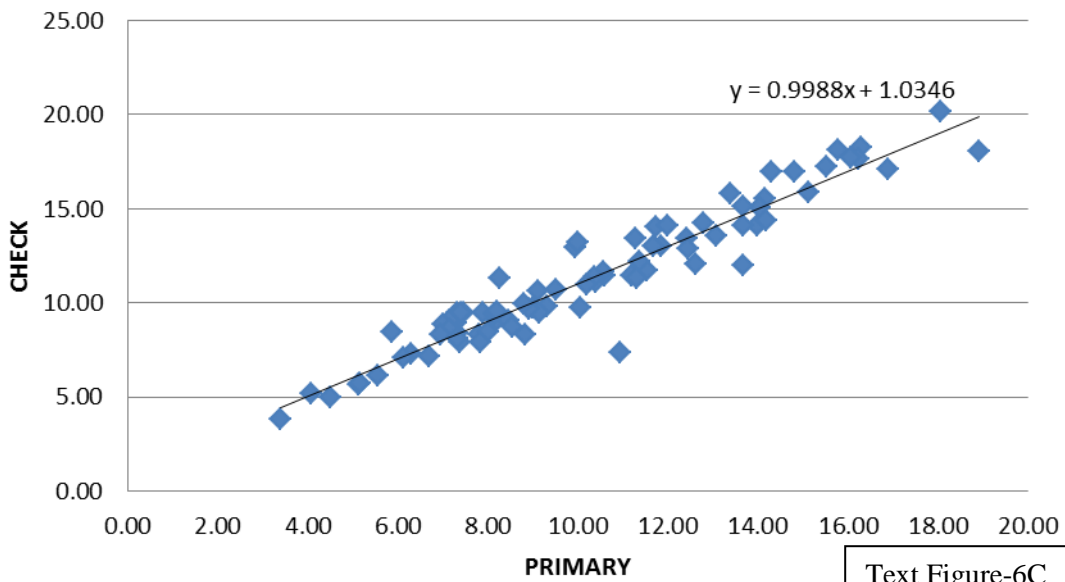
low “mean of deviation” for Cao, MgO, Al₂O₃& LOI, are insignificant. For SiO₂ and Fe₂O₃, the “mean of deviation” is high. This is also reflected in their paired T-values. The calculated paired t-value is less than t-table value for Cao, MgO, Al₂O₃& LOI, which again proves that the difference in mean is insignificant. But for SiO₂ and Fe₂O₃, the calculated paired T-value is higher than T-table value. It depicts that the difference in mean for SiO₂ and Fe₂O₃, is significant and the values of external check for the same cannot be reproducible. Standard deviation of error is very less showing good reliability of analyzed data. Correlation coefficient ranges between 0.840 to 0.926, which is also confirmed by Primary vs Check scatter plot (Text Figure-6A to 6F). It shows the good correlation between primary and check analysis. As the F-test value for all 6 major constituents is approaching 1, it also advocates about good correlation among two set of sample analysis. All these statistical data certify the good quality of sample preparation as well as chemical analysis.



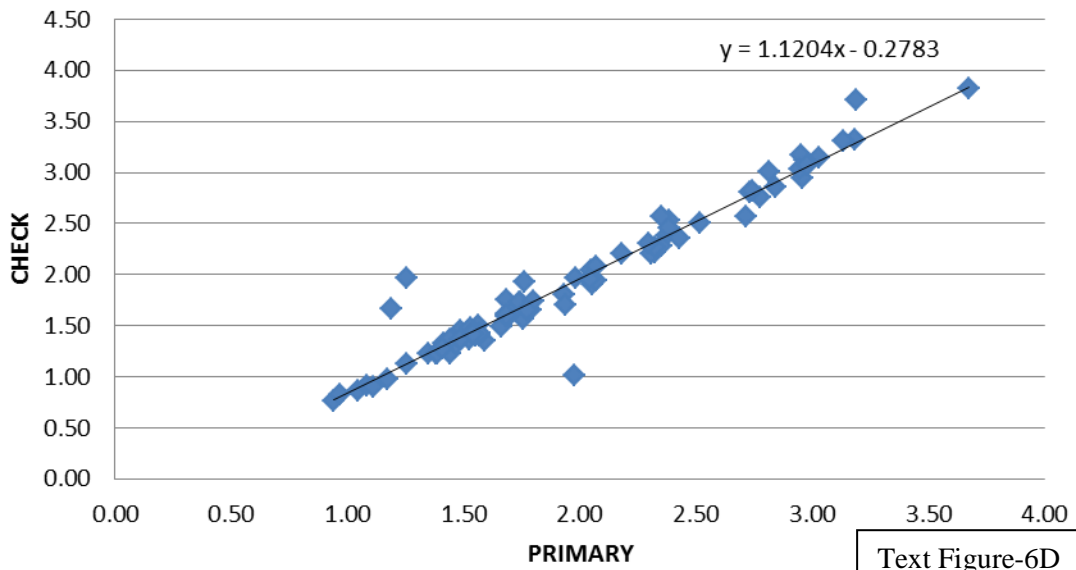
SCATTER PLOT OF PRIMARY Vs EXTERNAL CHECK - MgO%



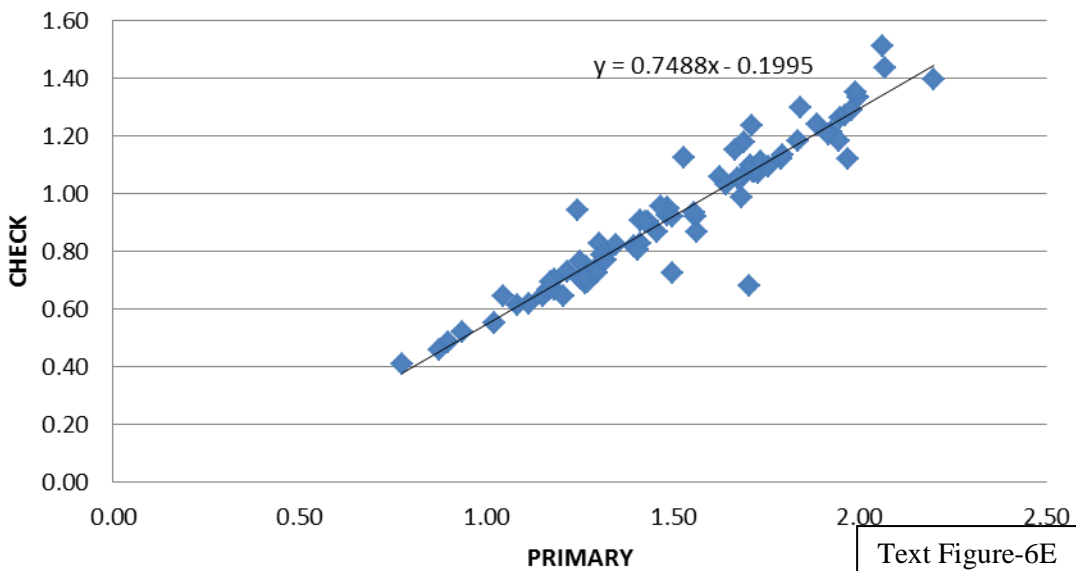
SCATTER PLOT OF PRIMARY Vs EXTERNAL CHECK - SiO₂%

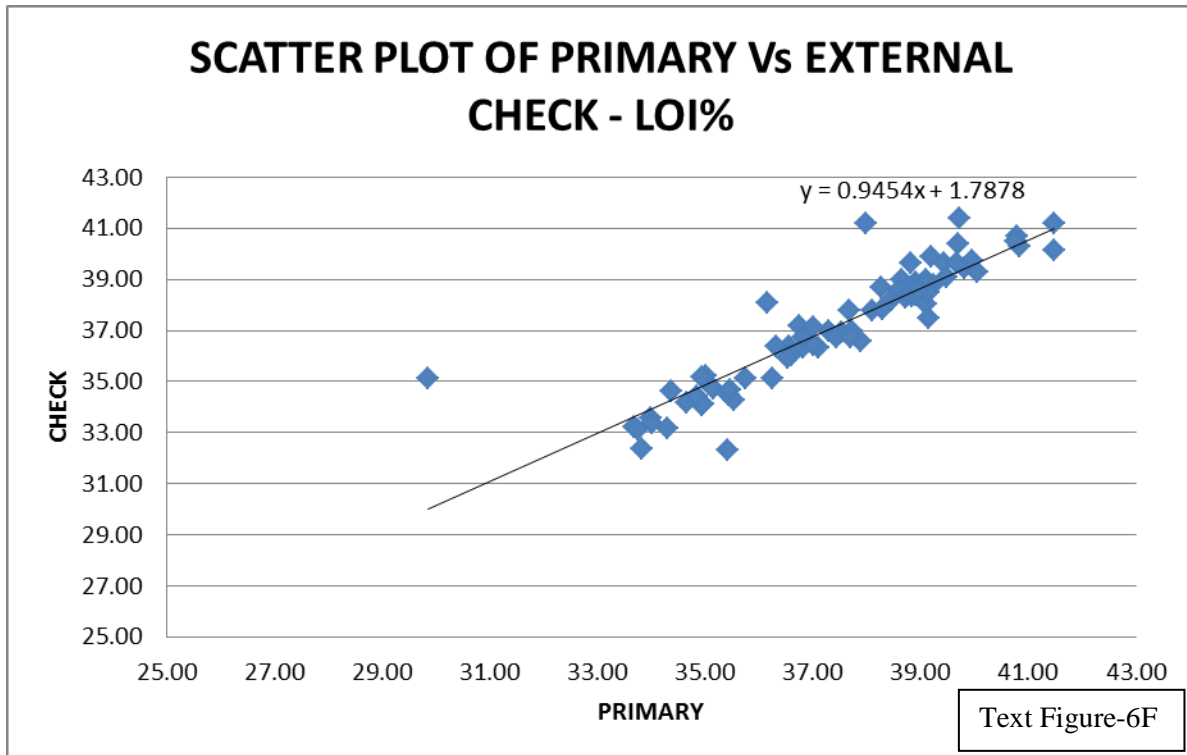


SCATTER PLOT OF PRIMARY Vs EXTERNAL CHECK - Al₂O₃%



SCATTER PLOT OF PRIMARY Vs EXTERNAL CHECK - Fe₂O₃%





6.3.0 COMPARISON AND RELIABILITY OF ESTIMATED RESOURCES

6.3.1 Resources of Jamodi-Mahanna Block have been estimated by Cross Sectional method in Indicated and Inferred category. To check the reliability of this estimation, resource has been calculated by Iso-Chore method also. By Iso-Chore method, categorization of resources in to Indicated and Inferred category is not possible. Thus, comparison has been done zone wise with respect to total Net In-situ resources and depicted as Table-6.7.

Table-6.7

Comparison of estimated resources of Jamodi-Mahanna Block

METHOD OF ESTIMATION	NET IN-SITU RESOURCES (in Million Tonnes)		
	ZONE-I	ZONE-II	TOTAL
CROSS SECTIONAL METHOD	134.3838	130.0267	264.4105
ISO-CHORE METHOD	140.7489	137.1197	277.8686
DIFFERENCE	6.3651	7.0930	13.4581

6.3.2 The above table shows that the resource calculated for cement grade Zone-I, Zone-II and total Net in-situ by Cross sectional method is 4.52%, 5.17% and 4.84% lower than that of by Iso-Chore method respectively. The degree of variation is within 10% tolerance limit. This difference is way below the maximum 10% limit, thus estimation of resources is highly reliable.

CHAPTER-VII

7.0.0 CONCLUSIONS AND RECOMMENDATIONS

7.1.0 CONCLUSIONS

- 7.1.1 On enactment of MMDR Amendment Act 2015, Minerals (Evidence of Mineral Contents) Rule 2015 and Mineral Auction Rule 2015, Govt. of India directed State Governments to speed up exploration work for different Mineral Commodities i.e. especially the notified minerals, in the respective states. Accordingly Madhya Pradesh Government requested MECL to take up exploration work of Limestone in 3 Blocks in Satna Districts of Madhya Pradesh.
- 7.1.2 Representatives from Govt. of Madhya Pradesh and Mineral Exploration Corporation Ltd visited the proposed area to find out the possibilities of taking up of the exploration work in the area. The limestone exploration proposal of Jamodi-Mahanna Block Tehsil-Raghuraj Nagar, District-Satna, Madhya Pradesh submitted by MECL for G3 / G2 level was discussed in 1st meeting of Technical Committee of NMET held on 01 & 02 April, 2016 at GSI Central Region, Nagpur. The Committee recommended Geological Mapping, surface/outcrop samples and five scout boreholes covering the entire block with an area of 31 Sq.Km to generate analytical data at G4 level. MECL accordingly modified the proposal and placed for approval in the 2nd meeting of Technical Committee held on 5th May 2016 at GSI, Training Institute, Hyderabad. On recommendations of Technical Committee the proposal was approved in the 2nd Executive Committee meeting held on 09-05-2016 at Ministry of Mines, New Delhi. During midterm review meeting, it was proposed by the Technical Committee of NMET to review the exploration data after receiving the results of G-4 level exploration. The proposal for upgrading level of G3/G2 was recommended & put to the Executive Committee for administrative approval. The executive committee in its fourth meeting held on 21.02.2017 has approved the proposal for upgrading to G2 & G3 level.
- 7.1.3 The administrative/ financial sanction for exploration for limestone in Jamodi-Mahanna block at an estimated cost of Rs. 545.34 lakhs was received from Ministry of Mines, Govt. of India, National Mineral Exploration Trust, New Delhi vide F no 6/1/NMET-2015 dated 03.04.2017.
- 7.1.4 MECL commenced exploration work in Jamodi-Mahanna block on 08.02.2017 in an area of 31.00 sq km and completed geological mapping, topographic survey and 3731.00 m core drilling in 83 boreholes and other associated geological work in November 2017.
- 7.1.5 The rock formation occurring in the study area comprises sandstone, shale and limestone, all belonging to the Bhandar Group of Upper Vindhyan. These rock formations are almost sub-horizontal having south-easterly dips varying from 1° to 3°.

Stratigraphically, the limestone belongs to Bhandar/Nagod Group. The limestone is well bedded, fine to medium grained, grey to dark grey colour deposit. The thickness of the limestone based on sub-surface data; vary from 2.20 m to 29.62 m. It is underlain by Nagod shales/Ganurgarh shales. The Bhandar/Nagod Limestone is covered by an overburden ranging in thickness from 0.10 m to 19.00 m. Outcrops of Bhandar/Nagod Limestone are observed in the central part of the Block and in rest of the area are concealed under soil/alluvium.

- 7.1.6 The G-3&G-2 level exploration was carried out in 31.00 sq. km. area by drilling 3731.00 m in 83 boreholes, analyzing 1805 primary samples (including 164 no check samples) for 6 radicals (CaO, MgO, Al₂O₃, Fe₂O₃, SiO₂& LOI), 159 composite samples for 12 radicals (CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, SO₃, P₂O₅, TiO₂, Mn₂O₃, K₂O, Na₂O and LOI), 25 samples for petrographic study, 20 samples each for X-ray diffraction and spectroscopic studies and 30 samples for specific gravity determination.
- 7.1.7 The thickness of limestone (including ungraded limestone bands) as intersected in boreholes drilled by MECL varies from 2.20 m (MJRS-78) to 29.62 m (MJRS-67). Two distinct cement grade limestone zones have been identified. From top to bottom these zones have been named as Zone-I and Zone-II respectively. The upper cement grade limestone Zone-I has attained a thickness which varies from 1.00m (MJRS-05) to 16.00m (MJRS-60). The lower cement grade limestone Zone-II thickness varying from 1.00m (MJRS-81) to 13.60m (MJRS-52). Borehole no MJRS-3, MJRS-76 and MJRS-87 has not intersected any limestone zone.
- 7.1.8 X-ray diffraction studies of 20 composite samples of limestone have revealed the presence of calcite, Dolomite and Quartz as major constituent (≥5 %) and Quartz Dolomite & muscovite as minor minerals (≤5 to ≥1%). Gypsum, Illite, Pyrite, ankerite, muscovite, magnetite, spinel, aapatite, siderite, muscovite, rutile and amesite (clay) occur as accessory or trace minerals (≤1 %).
- 7.1.9 Based on the outcome of 83 G3/G2 level boreholes and 5 G4 level boreholes, a total of **264.4105 million tonnes of Cement grade net in-situ** resources have been estimated, out of which **198.6876 million tonnes is of “Indicated (332) category” and 65.7229 million tonnes is of “Inferred (333) Category”**,by **Cross Section method** after deducting **20%** of the total resources towards unseen geological factors i.e. slope factor and cavities/caverns etc.
- 7.1.10 The average grade of **264.4105 million tonnes of Cement grade net in-situ** resources of have been assessed as 44.46% Cao, 2.17% MgO, 9.55% SiO₂, 1.97% Al₂O₃, 1.48% Fe₂O₃ & 37.59% LOI i.e. Cement grade.

7.2.0 RECOMMENDATIONS

- 7.2.1 In Part-A of Jamodi-Mahanna Block, boreholes have been drilled in 400X400m grid (G2 level) and the resources are estimated under Indicated (332) category of UNFC. The exploration is carried out as per Mineral (Evidence of Mineral Contents) Rule-2015, Mineral Auction Rule-2015 and MMDR Act-2015. This level of exploration will facilitate the State Government (Madhya Pradesh) for auctioning of Part-A of the block under ML.
- 7.2.2 In Part-B of Jamodi-Mahanna Block, boreholes were drilled in 800X800m grid (G3 level) and the resources are estimated under Inferred (333) category of UNFC. This Part-B requires further exploration on close grid (400X400m) in the block to bring resources of entire block under **332 Category** of UNFC.

**GEOLOGICAL REPORT ON GENERAL EXPLORATION (G-2) FOR LIMESTONE
JAMODI-MAHANNA BLOCK, RAGHURAJNAGAR
DISTRICT- SATNA, MADHYA PRADESH**

EXECUTIVE SUMMARY

1.0.0 INTRODUCTION

1.1.0 GENERAL

- 1.1.1 Limestone is a sedimentary rock which is made up mostly of calcium carbonate in the form of calcite. Generally, it is mostly formed in warm, clear and shallow marine environment making it a bio-chemical sedimentary rock. Cement, Iron & Steel industries are the major and bulk consumers of limestone. It is also consumed in chemical industries like calcium carbide, bleaching powder, soda-ash, precipitated calcium carbonate etc.
- 1.1.2 India has huge resources of limestone distributed over different parts of country and is comfortably occupied 2nd place in the world after China in annual capacity and production of cement.
- 1.1.3 On enactment of MMDR Amendment Act 2015, Minerals (Evidence of Mineral Contents) Rule 2015 and Mineral Auction Rule 2015, Madhya Pradesh Government requested MECL to take up exploration work of Limestone in 3 Blocks in Satna District of Madhya Pradesh.
- 1.1.4 On recommendations of Technical Committee the proposal for G-4 level exploration was approved in the 2nd Executive Committee meeting held on 09-05-2016 at Ministry of Mines, New Delhi. During midterm review meeting, it was proposed by the Technical Committee of NMET to review the exploration data after receiving the results of G-4 level exploration. The proposal for upgrading level of G3/G2 was recommended & put to the Executive Committee for administrative approval. The executive committee in its fourth meeting held on 21.02.2017 has approved the proposal for upgrading to G2 & G3 level.
- 1.1.5 The administrative/ financial sanction for exploration for limestone in Jamodi-Mahanna block at an estimated cost of Rs. 545.34 lakhs was received from Ministry of Mines, Govt. of India, National Mineral Exploration Trust, New Delhi vide F no 6/1/NMET-2015 dated 03.04.2017.

1.2.0 LOCATION AND ACCESSIBILITY

- 1.2.1 The Cement grade limestone deposit is located in the Jamodi- Mahanna, Khamriya, Pasiyan, Phutainaha, Phutondhi and Ramsthan areas of Tehsil- Raghurajnagar, District- Satna, Madhya Pradesh. The deposit falls within the Survey of India Toposheet No. 63 D/14 and 63 H/2. The block limits with Latitude and Longitude as following:

A	:	80°55' 59.8704"	-	24°37' 31.7724"
B	:	80°57' 37.4112"	-	24°37' 16.2204"
C	:	80°58' 45.1812"	-	24°39' 07.3045"
D	:	80°59' 30.8396"	-	24°38' 50.7768"
E	:	80°58' 53.1408"	-	24°35' 19.3260"
F	:	80°56' 53.1408"	-	24°35' 19.3260"

1.2.2 Jamodi-Mahanna block lies 25 km north of Satna town having facilities like banking, postal, communication. Satna, the district headquarter have most of the Infrastructure facilities like, police station, bank facility, workshop facility etc. A good network of motorable /metalled road is available in the area.

1.3.0 OBJECTIVES OF EXPLORATION

1.3.1 The present exploration was carried out with the following objectives.

- I. To demarcate the limestone occurrence in the study area by drilling boreholes at 400m X 400m grid interval covering part “A” (G2 Level) and 800m X 800m in Part “B” (G3 Level) to cover entire block area under G-2 & G3 level of exploration.
- II. To estimate the Indicated category (332) & Inferred category (333) of Resources as per UNFC guidelines and to assess quality and grade of limestone.
- III. To carry out exploration as per Mineral (Evidence of Mineral Contents) Rule-2015, Mineral Auction Rule-2015 and MMDR Acr-2015 in turn facilitate the State Government (MP) in Auctioning of the block.

1.4.0 PRESENT WORK

1.4.1 MECL commenced exploration work in Jamodi-Mahanna block on 08.02.2017 in an area of 31.00 sq km and completed geological mapping, topographic survey and 3731.00 m core drilling in 83 boreholes and other associated geological work in November 2017.

Table No. - 1.2
QUANTUM OF WORK CARRIED OUT BY MECL IN
JAMODI-MAHANNA BLOCK (G3 & G2), DISTRICT- SATNA, MADHYA PRADESH

Sl.	Item of Work	Unit	Quantum of work proposed	Achievement
1	Geological Mapping (on 1:10000 scale).	Sq.Km.	31.00 sq. km	31.00 sq. km
2	Drilling	m.	4255m (107 BHs)	3731.00 (83 BHs)
4	Laboratory Studies			
5	i) Chemical Analysis (Primary + Check)for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	2000 Primary + 200 Check = 2200	Primary 1641 + Check-164 Total = 1805
	ii)Chemical Analysis Primary for 2 radicals i.e. SO ₃ & P ₂ O ₅	Nos.	50	55
	iii) External Check sample for analysis of 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	100	86
	iv) Composite Samples For 12 radicals (CaO, MgO, Al ₂ O ₃ , SiO ₂ ,	Nos.	650	159

	Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , LOI, MnO ₂ , K ₂ O, Na ₂ O and Cl.)			
	a) Physical Studies			
6	a) Spectroscopic Studies (10 elements)	Nos.	20	20
	b) XRD studies	Nos	25	20
	c) Petrological Studies (Petrographic Studies)	Nos	25	25
7	Specific Gravity Determinations	Nos	30	29
8	Report Preparation (Digital format)	Nos.	1 No.	1 No.

2.0.0 GEOLOGY AND STRUCTURE

2.1.0 GEOLOGY

2.1.1 The rock formation occurring in the study area comprises sandstone, shale and limestone, all belonging to the Bhandar Group of Upper Vindhyan. These rock formations are almost sub-horizontal having south-easterly dips varying from 1° to 3°.

2.1.2 The general stratigraphic succession of the study area is as below:

Table-2.1
The Regional stratigraphic succession of the area around
Jamodi-Mahanna Block

Super group	Group	Formation
Recent	-	Laterite
Upper Vindhyan	Bhandar Group	Upper Bhandar Sandstone
		Sirbu Shale
		Lower Bhandar Sandstone
		Bhandar (Nagod) Limestone
		Ganurgarh Shales

2.2.0 STRUCTURE

2.2.1 The uniform sub-horizontal disposition of the sedimentary sequence in the area of investigation indicates that the area has not undergone any major tectonic disturbance. Dip and strike data of Bhandar Limestone has been recorded from the outcrops as well as from the mine / quarry sections. The dip varies from horizontal (0°) to 3° with dip direction towards south to south-east.

2.2.2 Among the primary sedimentary structures, bedding planes and laminations are very common within shale-sandstone unit but not so prominent within limestone. The secondary structures observed in the area are joints and stylolites. The limestone beds are traversed by two sets of joints which are parallel to their strike and dip directions.

3.0.0 EXPLORATION METHODOLOGY

3.1.0 SURVEYING, SURFACE GEOLOGICAL MAPPING AND EXPLORATORY DRILLING

- 3.1.1 Triangulation network have been laid down in the proposed study area with the help of DGPS. Boreholes have been fixed on the ground as approved by NMET. RL's and co-ordinates of survey stations and borehole points have been determined. The geological mapping on 1:10000 scale was carried out in 31.00 sq. km. area by taking traverses with the help of DGPS. About 50% of the area of the block is covered with soil/alluvium.
- 3.1.2 The exposures of Bhandar/Nagod limestone in the central part of the block were mapped and surveyed where ever available and plotted on the geological map along with strike & Dip. Northern and southern part of the block is completely covered with soil/alluvium.
- 3.1.3 After review of data generated at G4 level, Technical Committee of NMET recommended 107 boreholes covering the entire area of the block in G2/G3 stage. Out of which 83 boreholes have been drilled in this block. The drilling in the block commenced on 08.02.2017 and completed on 24.11.2017. Thus the total meterage of 4005.00 m have been drilled in 88 vertical boreholes in the block during G4 & G-3/G-2 levels of exploration. The entire core drilling has been done by wire line method in NQ borehole size using diamond bits. Core recovery of more than 90% was maintained in limestone, however, in case of weathered, loose & fractured formation and in solution cavities filled with clay the core recovery was low.

4.0.0 EVALUATION OF EXPLORATION DATA

4.1.0 THICKNESS AND GRADE OF LIMESTONE

- 4.1.1 When the thickness of cement grade lime stone zones is concerned, it varies throughout the block. It is so because of the chemical criteria ($\text{CaO} \geq 42\%$, $\text{MgO} < 4\%$ and $\text{SiO}_2 < 16\%$) that has been set to differentiate cement grade limestone out of the Bhandar limestone. The thickness of cement grade limestone Zone-I varies from 1.00m (MJRS-05) to 16.00m (MJRS-60) whereas the same for Zone-II varies from 1.00m (MJRS-81) to 13.60m (MJRS-52). Thickness of Ungraded limestone varies from 1.50m (MJRS-60) to 20.60m (MJRS-82).
- 4.1.2 The grade variation of CaO for Zone-I is minimum 42.25% (MJRS-10) to maximum 49.25% (MJRS-05) and for Zone-II is minimum 42.08% (MJRS-12) to maximum 48.88% (MJRS-46). The cement grade limestone is sandwiched between ungraded limestone zones assessed on the basis of the threshold value given by IBM i.e. 34% CaO.

5.0.0 SAMPLING, ANALYSIS AND ITS RELIABILITY

- 5.1.0 A total of 1742 (G2 & G3-1641 and G4-101) primary core samples have been prepared and sent to MECL laboratory for analysis of 6 radicals i.e. CaO, MgO, Al_2O_3 , SiO_2 , Fe_2O_3 & LOI. These are the basic and most essential chemical constituents to specify the grade of limestone in view of its utilization aspects such as cement manufacturing, Iron & Steel industry, Chemical industry, Fertilizer and Glass industry. A total of 55 samples, drawn from the vugs and porous limestone zones, have been prepared and sent to MECL laboratory, for analysis of SO_3 & P_2O_5 . In addition to 1742 primary samples 169 numbers primary samples (around 10% of primary samples) have been analyzed for CaO, MgO, Al_2O_3 , SiO_2 , Fe_2O_3 & LOI as check samples to examine the quality of sampling and 86 nos primary samples have been analyzed for the same as external sample, to check the reliability data.
- 5.2.0 Composite samples have been prepared borehole wise and length wise (maximum 6 m) by taking powdered material (-) 100 mesh of each primary samples in volume proportion and thoroughly mixing, followed by coning and quartering.

5.3.0 The data set for intra-laboratory Primary Vs. Check analysis comprises 164 pairs of samples. The table below shows that the differences in arithmetic mean, manifested by low “mean of deviation” for all the 6 major constituents, are insignificant. The calculated paired-T value is less than t-table value, which again proves that the difference in mean is insignificant. Standard deviation of error is also very less showing good reliability of analyzed data. Correlation coefficient ranges between 0.892 to 0.997, which is also confirmed by Primary vs Check scatter plot. It shows the good correlation between primary and check analysis. As the F-test value for all 6 major constituents is approaching 1, it also advocates about good correlation among two set of sample analysis. All these statistical data certify the good quality of sample preparation as well as chemical analysis.

Statistical Parameters	CaO	MgO	SiO₂	Al₂O₃	Fe₂O₃	LOI
Mean of deviation	0.244	0.019	-0.362	-0.071	-0.014	0.18
Paired T-value	2.36	1.72	2.67	3.30	1.00	2.25
Table T-value (at 99.95% confidence level)	3.357	3.357	3.357	3.357	3.357	3.357
Standard deviation of error	1.329	0.0134	1.736	0.275	0.179	1.02
Correlation Co-efficient	0.931	0.997	0.916	0.936	0.892	0.925
F-value	0.826	0.98	0.808	0.835	0.927	0.798

6.0.0 RESOURCE AND GRADE

6.1.0 BASIC ASSUMPTIONS

6.1.1 For estimating the resources and grades of limestone following parameters have been considered.

- i) Limestone zones for cement grade have been prepared based cut-off i.e. minimum 42% CaO, 4% MgO (Max.) and 16% SiO₂ (Max.) cut-off. Limestone zones have also been prepared for 34% to less than 42% CaO.
- ii) The zones of different grades have been demarcated from the primary analysis values as per the cut-off limits for CaO, MgO and SiO₂ as detailed in Geological Report, para 3.12.0 of Chapter III.
- iii) Limestone resources have been estimated for the zones demarcated based on the cut-off given above for Cement grade. The exploration is restricted to Bhandar/Nagod Limestone only and all the boreholes were closed in the Nagod/Ganurgarh shales. The minimum thickness of 1.00m of Graded/ungraded zone has been considered for resource estimation by both the methods.
- iv) The thin and impersistent /localized zone intersected in the boreholes established on the basis of primary analyses which could not be correlated thus were merged with the thick /most persistent zones within which they were occurring and average composite analyses have been calculated for these merged zones.
- v) The resources and grade have been estimated by Cross Sectional method. Resources have been calculated by Iso-chore method also to check the reliability of calculated resource by cross-sectional method.

- vi) A total of 9 nos. of Cross Sections have been drawn along dip direction at 400 m spacing in Part A and 4 nos. of Cross Sections have been drawn along dip direction at 800 mts in Part B spacing by joining maximum boreholes on section lines to show the behavior of limestone zone. The boreholes which were not falling on section lines have been projected on the nearest section line.
- vii) The strike and dip continuity of limestone which is a bedded sedimentary deposit of regular habit has been established in the entire block based on the intersection and correlation of different lithological units in the boreholes drilled. A total of 88 boreholes (Phase I- 5 BHs & Phase II- 83 BHs) have been drilled at grid spacing of boreholes is around 400m (G2) and 800m (G3). A line has been drawn to separate G2 and G3 category resources and shown on Text Figure-8. This line divides the block in to two parts namely **Part-A** (G2 level exploration, Eastern Part) and **Part-B** (G3 level exploration, Western Part). Thus, the limestone resources in Part-A have been kept under Indicated (G2) category (332) and Part-B (333) have been kept under Inferred (G3) category as per exploration norms for limestone enumerated in the Minerals (Evidence of Mineral Content) Rule 2015.
- viii) The lease hold area within the block has been excluded from the total area of the block while computation of resources.
- ix) The average specific gravity of limestone has been taken as 2.64 arrived from mean of specific gravity determined for 50 limestone samples at MECL Laboratory.
- x) A deduction of 20% from Gross in-situ resources has been made to arrive at Net in situ resources by Cross sectional method as well as by Isochore method for unseen geological factors i.e. slope factor and cavities/caverns etc.

6.2.0 SUMMARY OF RESOURCES

6.2.1 The summary of resources by Cross Sectional method is given in the table below:

Summary of Cement grade Limestone Resources of Jamodi-Mahanna Block
by Cross Sectional method

CEMENT GRADE LIMESTONE	INDICATED							INFERRED							TOTAL						
	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%	RESOURCES (Million Tonnes)	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	LOI%
ZONE-I	101.5585	44.03	2.37	9.16	1.91	1.47	37.34	32.8253	44.98	2.45	8.67	1.78	1.34	37.90	134.3838	44.31	2.39	9.04	1.88	1.44	37.48
ZONE-II	97.1291	44.46	1.99	10.12	2.09	1.54	37.65	32.8976	45.19	1.81	9.93	1.96	1.49	37.89	130.0267	44.59	1.94	10.07	2.06	1.53	37.71
TOTAL RESOURCES (Million Tonnes)	198.6876	44.24	2.19	9.63	2.00	1.51	37.49	65.7229	45.09	2.13	9.30	1.87	1.41	37.90	264.4105	44.45	2.17	9.55	1.97	1.48	37.59

6.2.2 A total of **264.4051 million tonnes** net in-situ limestone resources with an average grade of 44.46% Cao, 2.17% MgO, 9.55% SiO₂, 1.97% Al₂O₃, 1.48% Fe₂O₃& 37.59% LOI i.e. Cement grade have been estimated in the block. To the total Net in situ resources, Cement grade Zone-I and Zone-II contributes 50.82% and 49.18% respectively. The total resource has been categorized under Indicated (332) and Inferred (333) category. Indicated resources corresponds

to the Part-A of the block whereas Inferred category corresponds to Part-B of the block. 75.14% of the total resource is estimated and reported as Indicated Category (332) and the rest 24.86% is estimated and reported as Inferred (333) category, as per United Nations Framework Classification (UNFC).

6.2.3 The summary of resources by Iso-chore method is given in the table below:

Summary of Cement grade and Ungraded Limestone Resources
Of Jamodi-Mahanna Block, by Iso-Chore method

CEMENT GRADE LIMESTONE	GROSS RESOURCES (Million Tonnes)	NET RESOURCES (Million Tonnes)
ZONE-I	175.9361	140.7489
ZONE-II	171.3996	137.1197
TOTAL	347.3357	277.8686
UNGRADED LIMESTONE	420.1225	336.0908

6.2.4 A total of **277.8686 million tonnes** net in-situ Cement grade limestone resources have been estimated in the block. To the total Net in situ resources, Cement grade Zone-I and Zone-II contributes 50.65% and 49.35% respectively. The resource of ungraded limestone has been calculated by Iso-Chore method only and estimates 336.0908 million tonnes Net in-situ resources.

7.0.0 RECOMMENDATIONS

7.1.0 In Part-A of Jamodi-Mahanna Block, boreholes have been drilled in 400X400m grid (G2 level) and the resources are estimated under Indicated (332) category of UNFC. The exploration is carried out as per Mineral (Evidence of Mineral Contents) Rule-2015, Mineral Auction Rule-2015 and MMDR Act-2015. This level of exploration will facilitate the State Government (Madhya Pradesh) for auctioning of Part-A of the block under ML.

7.2.0 In Part-B of Jamodi-Mahanna Block, boreholes were drilled in 800X800m grid (G3 level) and the resources are estimated under Inferred (333) category of UNFC. This Part-B requires further exploration on close grid (400X400m) in the block to bring resources of entire block under 332 Category of UNFC.