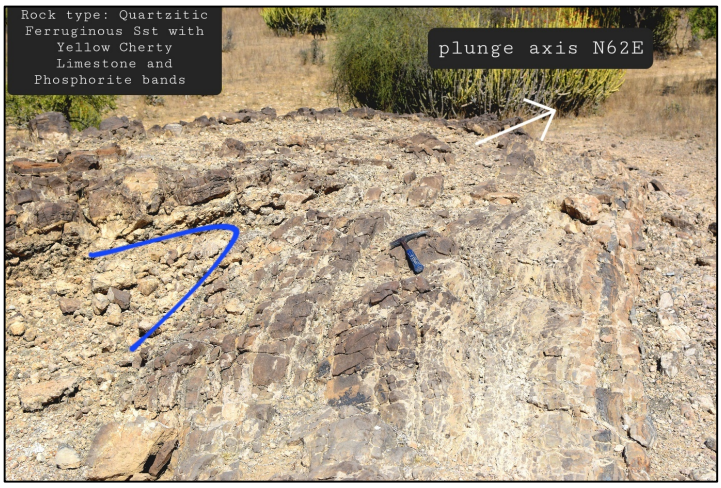
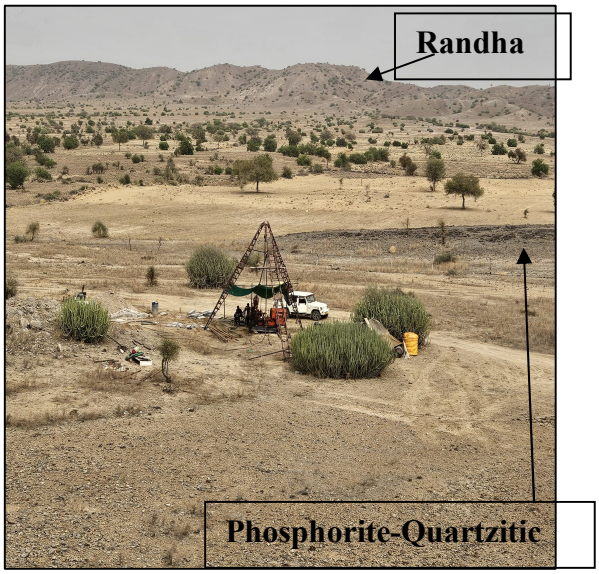
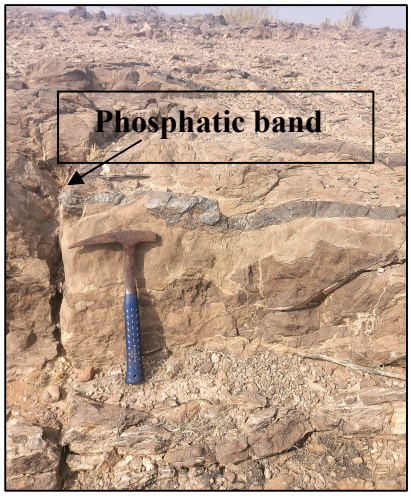
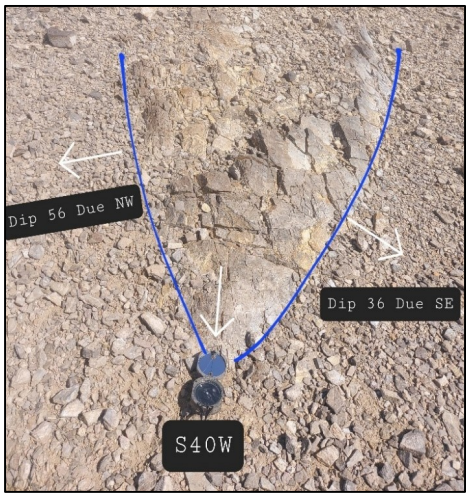
GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3) FOR ROCK PHOSPHATE IN NIMBLI BLOCK (2.7 Sq.km) DISTRICT: JAISALMER, RAJASTHAN

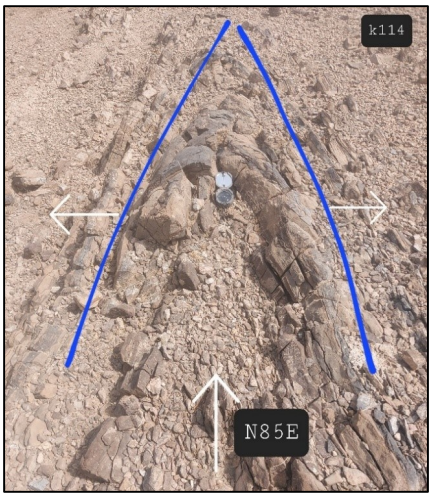
(TEXT ANNEXURE AND PLATES)











MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly known as Mineral Exploration Corporation Limited)

A Government of India Enterprise

CORPORATE OFFICE, NAGPUR-

February 2025

GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3) FOR ROCK PHOSPAHTE IN NIMBLI BLOCK, DISTRICT: JAISALMER, RAJASTHAN

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SALIENT FEATURES

S No	Work order No	F.No.23/400/2023-NMET/370 dated 12th December 2023
1	Name of the Exploration block	The Nimbli block for Rock Phosphate
2	Level of Investigation	G-3
3	Mineral/Ore	Rock Phosphate
4	Area	270 hectares
5	Location Tehsil District State	Survey of India Topo sheet 40J/16 Fatehgarh Jaisalmer Rajasthan
6	Topography	Elevation High 275 mRL Elevation Low 246 mRL
7	Strike length	2.5km NE-SW
8	Period of Exploration	29.01.2024 to 30.09.2024
9	Drilled meterage	2131.13 (m) (838.13m by GSI 1969-79) (1293.00 m by MECL 2023-24)
10	Number of Boreholes	56 (24 nos drilled by GSI 1969-79) (32 nos drilled by MECL 2023-24)
11	Phosphorite intersection& Thickness	Minimum Intersection depth 0.80m (B-46) and Maximum intersection depth 57.35 m (B-58) and thickness varies from 0.99 m (MNP-07) to 11.88 m (MNP-02)
12	Net Geological resources with Average grade Cross Sectional Method	2.59 million tonnes with average grade 11.32% P_2O_5 at >5% P_2O_5 cut-off 1.64 million tonnes with average grade 13.84% P_2O_5 at >10% P_2O_5 cut-off

कार्यकारी सारांश

भूवैज्ञानिक रिपोर्ट प्रारंभिक गवेषण (जी-3) निम्बली ब्लॉक, जिला: जैसलमेर, राजस्थान में रॉक फॉस्फेट के लिए पर

कार्यकारी सारांश

1.0.0 **परिचय**

1.1.0 रॉक फॉस्फेट या फॉस्फोराइट एक गैर-अपरदी अवसादीय चट्टान है जिसमें विभिन्न कैल्शियम फॉस्फेट का बारीक दाने वाला मिश्रण होता है, जिनमें सबसे महत्वपूर्ण हाइड्रॉक्सिल-एपेटाइट, कार्बोनेट-एपेटाइट, फ्लोरापेटाइट और उनके ठोस घोल होते हैं। दुनिया में लगभग 80% फॉस्फेट उत्पादन फॉस्फेट चट्टानों (फॉस्फोराइट) से प्राप्त होता है जिसमें एक या अधिक फॉस्फेटिक खनिज होते हैं, आमतौर पर पर्याप्त शुद्धता और मात्रा वाले कैल्शियम फॉस्फेट को वाणिज्यिक उत्पादों के निर्माण में सीधे या सांद्रण के बाद उपयोग करने की अनुमति होती है।

1.2.0 रॉक फॉस्फेट फॉस्फोरस का एक महत्वपूर्ण प्राकृतिक स्रोत है और इसका उपयोग रासायनिक फॉस्फेटिक उर्वरकों के उत्पादन के लिए कच्चे माल के रूप में किया जाता है। रॉक फॉस्फेट का सीधा उपयोग अम्लीय मिट्टी के लिए उपयुक्त पाया गया है क्योंकि निम्न पीएच रॉक फॉस्फेट को घुलनशील बनाने में मदद करता है और पौधों को फॉस्फोरस के उपलब्ध रूप को बढ़ाता है।

1.3.0 "रॉक फॉस्फेट" शब्द उस चट्टान पर लागू होता है जिसमें एक या एक से अधिक फॉस्फेट खनिज, आमतौर पर पर्याप्त ग्रेड और उपयुक्त संरचना के कैल्शियम फॉस्फेट मौजूद होते हैं जो वाणिज्यिक उत्पादों के निर्माण में सीधे या सांद्रता के बाद इसके उपयोग की अनुमति देते हैं। रॉक फॉस्फेट का रासायनिक विश्लेषण आमतौर पर P_2O_5 या ट्राई कैल्शियम फॉस्फेट $Ca_3 (PO_4)_2$ के प्रतिशत के रूप में रिपोर्ट किया जाता है।

1.4.0 कृषि में फास्फोरस का कोई विकल्प नहीं है। हमारे देश में सभी उर्वरक खनिजों की कमी है। भारत में रसायन और उर्वरक, ग्रेड एपेटाइट और रॉक फॉस्फेट के भंडार/संसाधन बहुत सीमित हैं। इसलिए, भारत में फॉस्फोराइट का गवेषण समय की मांग है। वास्तव में, भारत सरकार, राज्य सरकारें, जीएसआई, एमईसीएल आदि जैसी गवेषण एजेंसियां फॉस्फोराइट के गवेषण कार्यक्रम को बढ़ावा देने के लिए कई कदम उठा रही हैं।

1.5.0 भारत में एपेटाइट और रॉक फॉस्फेट की उपलब्धता कम है। एपेटाइट के मामले में, देश पूरी तरह से आयात पर निर्भर है, जबकि रॉक फॉस्फेट के भंडार भारत के प्रीकैम्ब्रियन से लेकर टर्सियरी संरचनाओं में हैं , जैसे कि राजस्थान, मध्य प्रदेश, उत्तर प्रदेश, बिहार, पश्चिम बंगाल और आंध्र प्रदेश, जबकि रॉक फॉस्फेट का उत्पादन केवल दो राज्यों राजस्थान और मध्य प्रदेश से होता है।

1.6.0 राजस्थान में रॉक फॉस्फेट के निक्षेप विभिन्न लिथोलॉजिकल संरचनाओं में पाए जाते हैं, जिनकी आयु प्रीकैम्ब्रियन से लेकर टर्सियरी तक भिन्न-भिन्न है, तथा ये उदयपुर, बांसवाड़ा, सीकर, जैसलमेर, जयपुर, अलवर और चित्तौड़गढ़ जिलों में पाए जाते हैं।

1.7.0 मिनरल एक्सप्लोरेशन एंड कंसल्टेंसी लिमिटेड (एमईसीएल) ने राजस्थान राज्य में रॉक फॉस्फेट के लिए डेस्कटॉप अध्ययन के बाद, राजस्थान के जैसलमेर जिले में आने वाले रॉक फॉस्फेट के लिए "निम्बली ब्लॉक" में जी-3 स्तर का गवेषण प्रस्ताव तैयार किया है।

1.8.0 28 और 29, नवंबर को आयोजित एनएमईटी की 59 वीं टीसीसी में निम्बली ब्लॉक में 2.7 वर्ग किलोमीटर क्षेत्र में रॉक फॉस्फेट के लिए प्रारंभिक गवेषण (जी-3) का प्रस्ताव प्रस्तुत किया गया था और समिति ने चरण I और II यानी चरण I भूवैज्ञानिक मानचित्रण और चरण- II गवेषणात्मक वेधन में गवेषण प्रस्ताव की सिफारिश निम्नलिखित सुझावों के साथ की थी;

(क) स्थलाकृतिक सर्वेक्षण सहित 1:2000 पैमाने पर विस्तृत भूवैज्ञानिक मानचित्रण

(ख) चरण II की गतिविधियों को पूरा करने के लिए दो महीने में (कार्य शुरू होने के बाद) भूवैज्ञानिक मानचित्रण डेटा की समीक्षा

1.9.0 6 दिसंबर, 2023 को आयोजित 32वीं कार्यकारी समिति (ईसी) की बैठक ने 12 दिसंबर, 2023 को जारी किए गए अनुमोदन आदेश के साथ परियोजना को मंजूरी दे दी, जिसमें 12 महीने की समय सीमा और एमईसीएल की अनुमोदित लागत ₹ 3,55,98,122/- थी।

1.10.0 एमईसीएल ने 29.01.2024 को भूवैज्ञानिक मानचित्रण, स्थलाकृतिक सर्वेक्षण सहित गवेषण कार्य शुरू किया और 05.03.2024 को पूरा किया। भूवैज्ञानिक मानचित्रण और स्थलाकृतिक सर्वेक्षण डेटा की समीक्षा 25, 29 और 30 अप्रैल, 2024 को (वीसी के माध्यम से) आयोजित 64वीं टीसीसी बैठक में की गई। भूवैज्ञानिक मानचित्रण डेटा की विस्तृत चर्चा और समीक्षा के बाद समिति ने राय व्यक्त की कि ब्लॉक की संरचना पर गहन समझ के साथ बोरहोल की योजना बनाने की आवश्यकता है और समिति ने ब्लॉक में झुके हुए और कुछ ऊर्ध्वाधर बोरहोल वेधन करने की सिफारिश की।

1.11.0 एमईसीएल ने 24.05.2024 को वेधन कार्य शुरू किया और 30.09.2024 को पूरा किया, कुल 32 बोरहोल में 1293.00 मीटर वेधन पूरी की गई, जिसे दो चरणों में ड्रिल किया गया (चरण-I में 15 बोरहोल, चरण-II में 17 बोरहोल)

1.12.0 संबद्ध क्षेत्र-कार्य डीजीपीएस सर्वेक्षण, नमूनाकरण आदि सहित सभी कार्य एक साथ पूरे किए गए। विश्लेषणात्मक/प्रयोगशाला अध्ययन एक साथ एमईसीएल एवं अन्य सरकारी/एनएबीएल मान्यता प्राप्त प्रयोगशालाओं में किए गए।

2.0.0 ब्लॉक स्थल और पहुंचने की सुविधा

2.1.0 निम्बली ब्लॉक क्षेत्र भारतीय सर्वेक्षण विभाग की टोपोशीट संख्या 40 जे/16 के अंतर्गत आता है तथा यह राजस्थान राज्य के जैसलमेर जिले की फतेहगढ़ तहसील के विरभानी , कोहरा और निम्बली गांवों के आसपास के 2.70 वर्ग किलोमीटर क्षेत्र को कवर करता है । ब्लॉक क्षेत्र के कॉर्नर बिंदुओं के निर्देशांक भूगणितीय (जियोडेटिक) और यूटीएम दोनों नीचे दी गई तालिका में दिए गए हैं।

निम्बली ब्लॉक, तहसील : फतेहगढ़, जिला : जैसलमेर के लिए कार्डिनल बिंदुओं के निर्देशांक।

ब्लॉक कार्डिनल बिंदुएं	यूटीएम जोन-42 (मी)	
	ईस्टिंग (मी)	नॉर्थिंग (मी)
ए	690363.4099	2900741.7710
बी	693116.3576	2902684.8000
सी	692331.9713	2903129.3150
डी	691118.5043	2900313.3370

2.2.0 निम्बली ब्लॉक उप-जिला मुख्यालय फतेहगढ़ (तहसीलदार कार्यालय) से अच्छी तरह से जुड़ा हुआ है, जो ब्लॉक से उत्तर-पूर्व दिशा में 55 किमी दूर स्थित है और एनएच 68 पर पड़ता है। जिला मुख्यालय जैसलमेर ब्लॉक से उत्तर दिशा में स्थित है, जो 1115 किमी की दूरी पर है, जहां कोहरा और जैसलमेर को जोड़ने वाले दो राष्ट्रीय रानिक्षेपर्गों अर्थात एनएच-11 और एनएच 68 द्वारा पहुंचा जा सकता है।

3.0.0 गवेषण के उद्देश्य

a. संरचनात्मक मानचित्रण के साथ 1:2000 पैमाने पर भूवैज्ञानिक मानचित्र को अद्यतन करना तथा खनिजीकरण के विस्तार को सिद्ध करने के लिए वेधन करना।
b. 1:2,000 पैमाने पर स्थलाकृतिक सर्वेक्षण, 2 मीटर समोच्च अंतराल के साथ
c. 2.5 किमी नतिलंब (एनएनई-एसएसडब्ल्यू) और गहराई निरंतरता स्थापित करने के लिए, चरण- । में 400 मीटर सेक्शन अंतराल पर बोरहोल वेधन किए जाएंगे और इसके बाद चरण-II में 200 मीटर सेक्शन अंतराल पर बोरहोल ड्रिल किए जाएंगे।
d. 2021 तक संशोधित यूएनएफसी मानदंडों के अनुसार फॉस्फोराइट संसाधनों का अनुमान 5% से अधिक कटऑफ (आईबीएम थ्रेशहोल्ड मान) पर लगाया जाना।
e. ब्लॉक की नीलामी के लिए राज्य सरकार को सुविधा प्रदान करना।

4.0.0 निम्बली ब्लॉक में किए गए कार्य की प्रकृति और मात्रा का विवरण

4.1.1 कार्यकारी समिति की मंजूरी के बाद, एमईसीएल ने गवेषण गतिविधियाँ जैसे भूवैज्ञानिक मानचित्रण, स्थलाकृतिक सर्वेक्षण, वेधन, नमूनाकरण और रासायनिक विश्लेषण किया है। प्रस्तावित कार्य की मात्रा और किए गए कार्य की मात्रा नीचे दी गई है।

निम्बली ब्लॉक क्षेत्र, जिला जैसलमेर, राजस्थान में किए गए गवेषण कार्य का विवरण

क्र. सं.	कार्यमद	इकाई	कार्य की अनुमोदित मात्रा	उपलब्धि
1	भूवैज्ञानिक मानचित्रण (1:2,000 पैमाने पर)	वर्ग किमी	2.70	2.70
	स्थलाकृतिक सर्वेक्षण (1:2,000 पैमाने पर)	वर्ग किमी	2.70	2.70
2	भू-रासायनिक नमूनाकरण	नग	50	42
	चैनल नमूनाकरण			
3	अन्वेषणात्मक वेधन (कोर वेधन)	मी	1700 मी (32 बीएचएस)	1293 मी (32 बीएचएस)
5	प्रयोगशाला अध्ययन			
	क. सतह के नमूने (बेडरॉक नमूनाकरण / चैनल नमूनाकरण)			
	i) रासायनिक विश्लेषण; 5 मूलकों अर्थात P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 और LOI के लिए प्राथमिक	नग	50	42
	ख. बोरहोल के लिए प्राथमिक नमूने			
	i) रासायनिक विश्लेषण; 5 मूलकों अर्थात P_2O_5 , SiO_2, Al_2O_3 , Fe_2O_3 और LOI के लिए XRF विधि द्वारा प्राथमिक विश्लेषण	नग	350	367
	5 मूलकों अर्थात P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 और LOI के विश्लेषण के लिए बाह्य जाँच नमूना (प्राथमिक नमूनों का 10%)	नग	35	35
	ग. 34 बोरहोल नमूनों के क्षेत्रों से समग्र नमूने पर तात्विक ट्रेस तत्व अध्ययन			
	34 मूलकों अर्थात V, Ba, Cr, Ga, Rb, Cs, Ca, U, Th, Eu, Hf, La, Lu, Sm, Tb, Yb, Ce, Dy, Er, Nd, Pr, Tm, Sc, Y, Zn, Cu, Pb, Ni, Co, Cd, Sc, Ag, Li, Mo के लिए सम्मिश्र नमूना को विश्लेषित किया जाएगा ।	नग	30	23
6	**भौतिक अध्ययन**			
8	एक्सआरडी अध्ययन	नग	10	10
9	संपूर्ण पेट्रोग्राफिक/अयस्क सूक्ष्म अध्ययन/ मिनरोग्राफिक अध्ययन	नग	20	20
11	विशिष्ट गुरुत्व निर्धारण	नग	10	10
12	रिपोर्ट तैयार करना (डिजिटल प्रारूप)	नग	1	1

5.0.0 भूविज्ञान और गवेषण के परिणाम

5.1.1 क्षेत्रीय रूप से अध्ययन क्षेत्र राजस्थान बेसिन का हिस्सा है जो सिंधु भू-समन्वय का पूर्वी किनारा बनाता है और इसमें अरावली के पश्चिम और उत्तर-पश्चिम में भारत-पाकिस्तान सीमा तक अवसादीय ट्रैक शामिल है। राजस्थान बेसिन को तीन उप-बेसिन में विभाजित किया गया है जो बेसमेंट रिज/फॉल्ट द्वारा एक दूसरे से अलग हैं। ये उप-

बेसिन हैं: जैसलमेर उप-बेसिन, बीकानेर- नागौर उप-बेसिन और बाड़मेर- सांचोर उप-बेसिन (डीजीएच, भारत के बाद)।

5.1.2 भू-संरचनात्मक दृष्टि से, जैसलमेर उप-बेसिन को उत्तर में किशनगढ़ अवदाब, पश्चिम में सिंक्लिनल शाहगढ़ शेल्फ, दक्षिण में मियाजलार अवदाब तथा मध्य भाग में जैसलमेर-मारी आर्क में विभाजित किया गया है, जैसा कि ओएनजीसी द्वारा किए गए भूभौतिकीय जांच में पता चला है (राघवेन्द्र राव, 1972)।

5.1.3 निम्बली ब्लॉक बिरमानिया बेसिन का हिस्सा है, बिरमैना फॉस्फोराइट बेसिन मियाजलर डिप्रेशन का हिस्सा है और निम्बली ब्लॉक क्षेत्र बिरमानिया फॉर्मेशन में स्थित है। प्रोटेरोज़ोइक-अर्ली पैलियोज़ोइक के अनुरूप अवसादन के पहले चक्र को बिरमानिया/ रंधा फॉर्मेशन के रूप में नामित किया गया है जो डीप वाटर के अवसादो का प्रतिनिधित्व करता है।

5.1.4 क्षेत्रीय रूप से यह क्षेत्र मियाजलर डिप्रेशन (जैसलमेर उप-बेसिन का हिस्सा) में आता है तथा बिरमानिया बेसिन से संबंधित है। पोखरण हाई बीकानेर- नागौर उप-बेसिन को जैसलमेर उप-बेसिन से अलग करता है, देवीकोट - नचना अपलिफ्ट जैसलमेर उप-बेसिन को बाड़मेर सांचोर उप-बेसिन से अलग करता है ।

5.1.5 निम्बली ब्लॉक क्षेत्र बिरमानिया बेसिन में आता है जो भारत के पश्चिमी राजस्थान के थार रेगिस्तान के मध्य में स्थित एक अंडाकार आकार का बेसिन है। यह मालानी आग्नेय चट्टानों से घिरा हुआ है जो प्री कैम्ब्रियन (डीजीएच के बाद) से संबंधित हैं।

5.1.6 बिरमानिया बेसिन में सिलिकिक्लास्टिक, कार्बोनेट और फॉस्फोराइट फेसीज़ की लगभग 900 मीटर मोटी अवसादीय श्रृंखला शामिल है। ये श्रृंखलाएँ बेसिन के उत्तरी भाग में जुरासिक युग के लाठी कंग्लोमरेट द्वारा असंगत रूप से ढकी हुई हैं।

बिरमानिया फॉस्फोराइट निक्षेप की सामान्यीकृत स्ट्रेटीग्राफी नीचे दी गई है

आयु	गठन	लिथोलॉजी	अधिकतम मोटाई
जुरासिक	लाठी	कांग्लोमेरेट्स, ग्रिट्स, बलुआ पत्थर और शेल	660 मी
असंगत			
कैंब्रियन	बिरमानिया	डोलोमाइटिक चूना पत्थर, चेर्टी चूना पत्थर, शेल, सिल्टस्टोन और बलुआ पत्थर	>90
		शैल सफेद भूरे से लेकर विविध रंग का, रेतीला से लेकर कार्बनयुक्त, सिल्टस्टोन और बलुआ पत्थर की पट्टियों के साथ	60
		फास्फोराइट	1 मीटर से कम से 9 मीटर से अधिक
		क्वार्टजाइट बलुआ पत्थर	1-4मी
		बफ रंग का बारीक दाने वाला, चूनायुक्त बलुआ पत्थर, गहरा भूरा चूनायुक्त और लौहयुक्त बलुआ पत्थर	50-270मी
		भूरा पीला या चेरी जैसा भूरा चूना पत्थर	>80मी
	असंगत		

आयु	गठन	लिथोलॉजी	अधिकतम मोटाई
	रेनडा	बलुआ पत्थर और अधीनस्थ कैंसरयुक्त चट्टानें और शेल्स	

5.1.7 फिल्ड सीजन : 1968-70 के दौरान भारतीय भूवैज्ञानिक सर्वेक्षण (जीएसआई) द्वारा बिरमानिया में फॉस्फोराइट के लिए गवेषणात्मक वेधन किया गया। निम्बली ब्लॉक में और उसके आसपास 68 बोरहोल में कुल 2053.89 मीटर की वेधन की गई और 1.5 से 40.0 मीटर की गहराई पर 55 बोरहोल में फॉस्फोराइट का पता लगाया गया। संसाधनों का अनुमान 10% P_2O_5 कट-ऑफ और न्यूनतम चौड़ाई 1.5 मीटर लगाया गया और औसत ग्रेड 12.91% के साथ 3.49 मिलियन टन की स्थापना की गई।

5.1.8 वर्तमान गवेषण कार्यक्रम के दौरान, निक्षेप के 2.5 किमी उत्तर-पश्चिम-दक्षिण-पूर्व नतिलंब की दिशा में वेधन की योजना बनाई गई थी, जिसके साथ उत्तर-पश्चिम-दक्षिण-पूर्व दिशा में चिह्नित 16 सेक्शन लाइनें लगभग 200 मीटर की दूरी पर रखी गई हैं। इन सेक्शन लाइनों पर कुल 32 बोरहोल्स में कुल 1293.00 मीटर वेधन (जी3 चरण) की गई, ताकि ब्लॉक क्षेत्र में फॉस्फोराइट अयस्क पिंड की नतिलंब और नति की निरंतरता की जांच की जा सके।

5.1.9 वेधन दो चरणों में पूरी की गई, चरण-I में कुल 15 बोरहोल (एमएनपी-01 से एमएनपी-15) जिसमें 541.00 मीटर वेधन शामिल है, पूरा हो गया है और चरण-II में कुल 17 बोरहोल (एमएनपी-16 से एमएनपी-32) जिसमें 752.00 मीटर वेधन शामिल है, पूरा हो गया है, इस प्रकार निम्बली ब्लॉक क्षेत्र में कुल 32 बोरहोल जिसमें 1293.00 मीटर वेधन शामिल है, पूरा हो गया है ।

5.1.10 जीएसआई द्वारा ड्रिल किए गए कुल 24 बोरहोल (बी-32 से बी35) को फॉस्फोराइट बेड के लिए सहसंबंध और संसाधन मूल्यांकन के लिए माना जाता है। 24.00 बोरहोल में कुल 838.13 मीटर की खुदाई पूरी हो गई है (1968-70 में, जीएसआई ने बिरमानिया में फॉस्फोराइट के लिए गवेषणात्मक वेधन की गई ।)

5.1.11 निम्बली ब्लॉक बिरमानिया बेसिन का हिस्सा है जिसमें असममित दोहरी ढलान वाला अनुदैर्ध्य शीर्ष तह शामिल है जो लगभग 5 किमी की नतिलंब लंबाई पर NE-SW दिशा में फैला हुआ है (चित्र क्षेत्रीय फोटो)। संरचनात्मक रूप से निम्बली ब्लॉक क्षेत्र में एक दोहरी ढलान वाला एंटीक्लाइन और एक दोहरी ढलान वाला सिंक्लिनल फोल्ड शामिल है जो NE-SW फॉस्फोराइट-सैंडस्टोन लिथो-एसोसिएशन के साथ बना है। तह असममित, अनुदैर्ध्य, तीक्ष्ण-शीर्ष, दोहरी ढलान वाले और साथ ही खुले फोल्ड की एक प्रणाली बनाती है जो निक्षेप की नतिलंब और लंब के साथ-साथ बनी हुई है।

5.1.12 क्षेत्र में सभी संरचनाएं जटिल रूप से मुड़ी हुई हैं, कुछ मीटर के भीतर मोड़ और मोड़ अक्ष के अनुरूप ढलान बदलती रहती है या तो उत्तर की ओर या दक्षिण की ओर, ढलान 5° से 35° तक होती है। पहले बताए गए बड़े तह 25° से 30° के कोण पर झुकते हैं, जब अक्ष के साथ पता लगाया जाता है तो ढलान अलग-अलग होती है।

5.1.13 प्राथमिक नमूना विश्लेषण की प्राप्ति पर जो 5 मूलकों अर्थात P_2O_5, Fe_2O_3 , Al_2O_3, SiO_2 , LOI के लिए किया गया था, क्षेत्र को >5% P_2O_5, कटऑफ (IBM दिशा-निर्देश) के आधार पर सीमांकित किया गया था। निम्बली ब्लॉक में ड्रिल किए गए 56 बोरहोल्स (MECL द्वारा 32 और GSI द्वारा 24) में से, फॉस्फोराइट ज़ोन B-46 में 0.80 मीटर

ऊर्ध्वाधर गहराई से लेकर B-58 में 57.35 मीटर ऊर्ध्वाधर गहराई तक और मोटाई 0.99 मीटर (MNP-07, P_2O_5 -5.55%) से 11.88 मीटर (MNP-02, P_2O_5 -7.56%) के बीच भिन्न होती है।

5.1.14 वर्तमान गवेषण के दौरान, बोरहोल लगभग 200 मीटर नतिलंब अंतराल पर किए गए थे। यूएनएफसी प्रणाली और खनिज (खनिज सामग्री के साक्ष्य) नियम-2015 के भाग III-I में दिए गए विनिर्देशों के अनुसार, ब्लॉक में खनिज संसाधन को अनुमानित श्रेणी (333) के रूप में वर्गीकृत किया गया है।

5.1.15 फॉस्फोराइट अयस्क संसाधन और ग्रेड का अनुमान "भूवैज्ञानिक क्रॉस-सेक्शन विधि " (मुख्य विधि के रूप में) और "लेवल प्लान विधि" (द्वितीयक विधि के रूप में) चेक विधि द्वारा लगाया गया है।

5.1.16 निम्बली ब्लॉक में 5% P_2O_5 कटऑफ पर भूवैज्ञानिक क्रॉस सेक्शन विधि द्वारा अनुमानित कुल फॉस्फोराइट अयस्क संसाधन सकल संसाधनों 3.24 मिलियन टन है, संसाधनों से 20% कटौती के बाद कुल नेट-इन-सीटू भूवैज्ञानिक संसाधन 2.59 मिलियन टन है, जिसमें **P_2O_5 का औसत ग्रेड 11.32%,** SiO_2 38.66%, Al_2O_3 12.13%, Fe_2O_3 4.97% और LOI 10.26% है। संसाधनों का अनुमान 2.5 वर्ग किलोमीटर की संचयी नतिलंब लंबाई पर लगाया गया है।

5.1.17 10%P_2O_5 कटऑफ पर निम्बली ब्लॉक में भूवैज्ञानिक क्रॉस सेक्शन विधि द्वारा अनुमानित कुल फॉस्फोराइट अयस्क संसाधन सकल 2.11 मिलियन टन है, संसाधनों से 20% कटौती के बाद कुल नेट-इन-सीटू भूवैज्ञानिक संसाधन 1.69 मिलियन टन है जिसमें **P_2O_5 का औसत ग्रेड 13.84%** , SiO_2 37.05%, Al_2O_3 10.08%, Fe_2O_3 5.18% और LOI 7.65% है।

5.1.18 संसाधनों की गणना लेवल प्लान विधि द्वारा 200mRL, 225mRL और 250mRL पर 25 मीटर ऊर्ध्वाधर अंतराल पर की गई है। लेवल प्लान विधि द्वारा कुल भूवैज्ञानिक संसाधन 3.12 मिलियन टन है, सकल संसाधनों से 20% कटौती के बाद , कुल नेट-इन-सीटू भूवैज्ञानिक संसाधन 2.49 मिलियन टन है , जिसमें **P_2O_5 का औसत ग्रेड 11.45%,** SiO_2 का 39.51%, Al_2O_3 का 12.13%, Fe_2O_3 का 4.71% और LOI का 7.85% है।

5.1.19 भूवैज्ञानिक क्रॉस सेक्शन विधि और लेवल प्लान विधि से संसाधनों के बीच अंतर 3.85% है और P_2O_5 का ग्रेड अंतर 0.14% है। दोनों विधियों द्वारा अनुमानित संसाधनों में भिन्नता सीमा के भीतर है, इसलिए भूवैज्ञानिक क्रॉस सेक्शन विधि द्वारा अनुमानित संसाधन की विश्वसनीयता सभी व्यावहारिक उद्देश्यों के लिए मानी जा सकती है।

6.0.0 सिफारिशों

6.1.0 निम्बली में गवेषण जी-3 स्तर पर किया जाता है; 2.5 किमी की नतिलंब लंबाई से लेकर 50 मीटर की ऊर्ध्वाधर गहराई तक संसाधनों की स्थापना की गई है। हालांकि, खदान खोलने से पहले अयस्क लाभकारी अध्ययन, व्यवहार्यता अध्ययन के साथ-साथ जी-2/जी-1 स्तर पर व्यवस्थित गवेषण करने की सिफारिश की जाती है। ब्लॉक को समग्र स्तर पर नीलाम किया जा सकता है।

GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3) FOR ROCK PHOSPHATE IN NIMBLI BLOCK, DISTRICT: JAISALMER, RAJASTHAN

EXECUTIVE SUMMARY

1.1.0 INTRODUCTION

1.1.1 Rock phosphates or phosphorite is a non-detrital sedimentary rock comprising fine grained mixture of various calcium phosphates, most important being hydroxyl-apatite, carbonate-apatite, fluorapatite and their solid solutions. About 80% phosphate production in the world is derived from phosphate rocks (phosphorite) containing one or more phosphatic minerals, usually calcium phosphate of sufficient purity and quantity permit its use directly or after concentration in manufacturing commercial products.

1.1.2 Rock phosphate is an important natural source of phosphorus and is used as raw material for the production of chemical phosphatic fertilizers. The direct application of rock phosphate has been found suitable for acidic soils as low pH helps to solubilize the rock phosphate and increases available form of Phosphorus to the plants.

1.1.3 The term "Rock phosphate" is applied to the rock in which one or more phosphate minerals, usually calcium phosphate of sufficient grade and suitable composition are present which permits its use directly or after concentration, in the manufacture of commercial products. The chemical analysis of rock phosphate is usually reported as percentage of P_2O_5 or a tri calcium phosphate $Ca_3 (PO_4)_2$.

1.1.4 There is no substitute for phosphorus in agriculture. Our country is deficient in all fertilizer minerals. The reserves/resources of chemical and fertilizer, grades apatite and rock phosphate in India are very limited. So, exploration of phosphorite is the need of the hour in India. In fact, Govt. of India, State Governments, Exploration Agencies like GSI, MECL etc are taking several steps to boost the exploration programme for phosphorites.

1.1.5 India is deficient in Apatite & Rock Phosphate availability. In case of apatite, the country is fully dependent upon imports, while the Rock Phosphate deposits are in the Precambrian to Tertiary formations of India, viz states in Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Andhra Pradesh while production of rock phosphate is only from two states namely, Rajasthan and Madhya Pradesh

1.1.6 Rock phosphate deposits in Rajasthan occur in various lithological formations varying in age from Precambrian to Tertiary, falling in districts Udaipur, Banswara, Sikar, Jaisalmer, Jaipur, Alwar and Chittorgarh.

1.1.7 Mineral Exploration and Consultancy Limited (MECL) after desktop study for rock phosphate in the state of Rajasthan, has formulated G-3 level of exploration proposal in "Nimbli block" for rock phosphate falling in the district Jaisalmer of Rajasthan.

1.1.8 Proposal for preliminary Exploration (G-3) for Rock phosphate in Nimbli block over an area of 2.7 sq.km was submitted in 59th TCC of NMET held on 28th & 29th Nov and committee recommended the exploration proposal in phases I & II i.e. Phase I Geological Mapping and Phase-II Exploratory drilling, with following suggestions;

(a) Detailed Geological Mapping on 1:2000 Scale including Topographic Survey

(b) Review of Geological Mapping data in two months (after commencement of work) for carrying out phase II activities

1.1.9 32nd Executive committee (EC) meeting held on 6th December 2023 approved the project with sanction order issued on 12th December 2023 with time line of 12 months and approved cost of MECL ₹ 3,55,98,122/-.

1.1.10 MECL commenced exploration work comprising of geological mapping, topographical survey on 29.01.2024 and completed on 05.03.2024. Geological mapping and topographical survey data was reviewed in the 64th TCC meeting held on 25th, 29th & 30th April 2024 (via VC), the committee after detailed deliberation and review of geological mapping data opined that planning of boreholes needs to be done with the diligent understanding on the structure of the block and committee recommended for inclined and a few vertical boreholes to be drilled in the block.

1.1.11 MECL commenced drilling operations on 24.05.2024 and completed on 30.09.2024, a total 1293.00 meters in 32 no of boreholes drilled in two phases (phase -I 15 no of boreholes, Phase -II 17 no of boreholes)

1.1.12 The allied field-work including DGPS survey, sampling etc. were completed simultaneously. The analytical/laboratory studies were carried out simultaneously in laboratories of MECL and other Govt. /NABL accredited laboratories.

2.0.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

2.1.0 The Nimbli Block area falls in part of Survey of India Toposheet No.40 J/16 and covers an area of 2.70 sq. km in and around villages Virbhani, Kohra & Nimbli in Fatehgarh Tehsil of district: Jaisalmer, state Rajasthan. The Co-ordinates of the corner points of the block area both geodetic and UTM are given in table below.

Co-ordinates of Cardinal Points for Nimbli Block, Tehsil: Fatehgarh, Dist: Jaisalmer.

Block Cardinal Points	UTM Zone-42 (m)	
	Easting (m)	Northing (m)
A	690363.4099	2900741.7710

Block Cardinal Points	UTM Zone-42 (m)	
	Easting (m)	Northing (m)
B	693116.3576	2902684.8000
C	692331.9713	2903129.3150
D	691118.5043	2900313.3370

2.1.2 Nimbli block is well connected with sub-district headquarter Fatehgarh (Tehsildar office) which is situated 55km away in northeastern direction from the block and falls on NH 68. District headquarter Jaisalmer is lying in northern direction from the block which at a distance of 1115 km, can be approached by two national highways connecting Kohra and Jaisalmer viz., NH-11 and NH68.

3.1.0 OBJECTIVES OF THE EXPLORATION

f. Updating of Geological map on 1:2000 scale with structural mapping and to carry out drilling to prove the extension of mineralization.

g. Topographical survey at 1:2,000 scale, with 2m contour interval

h. To establish the 2.5km strike (NNE-SSW) and depth continuity of the phosphorite ore body through subsurface drilling in two phases, Phase-I boreholes to be drilled on 400m section interval followed by 200m section interval in Phase-II.

i. To estimate Phosphorite resources as per UNFC norms at >5% cutoff (IBM threshold value) as per Minerals (Evidence of Mineral Contents) Rules 2015 amended upto 2021.

j. To facilitate the state govt. for auction of the block.

4.1.0 DETAILS OF NATURE AND QUANTUM OF WORK CARRIED OUT IN NIMBLI BLOCK

4.1.1 After the approval of Executive committee, MECL has carried out exploration activities i.e., geological mapping, topographical surveying, drilling, sampling and chemical analysis. The quantum of work proposed vis-à-vis quantum of work carried out is furnished below.

Details of Exploratory Work carried out by MECL in Nimbli block area, Dist Jaisalmer, Rajasthan

Sl. No.	Item of Work	Unit	Approved Quantum of work	Achieved
1	Geological Mapping (on 1:2,000 Scale)	sq km	2.70	2.70
	Topographical Survey (on 1:2,000Scale)	sq km	2.70	2.70
2	Geochemical Sampling	Nos.	50	42
	Channel sampling			
3	Exploratory Drilling (Core drilling)	m	1700 m (32 BHs)	1293 m (32 BHs)

Sl. No.	Item of Work	Unit	Approved Quantum of work	Achieved
5	Laboratory Studies			
	A. Surface samples (Bedrock sampling / channel sampling)			
	i) Chemical Analysis; Primary for 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI	Nos.	50	42
	B. **Primary samples for Borehole**			
	i) Chemical Analysis; Primary for 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI by XRF method	Nos.	350	367
	iii) External Check sample (10% of Primary samples) for analysis of 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI	Nos.	35	35
	C. 34 Elemental Trace Element Studies on Composite sample from zones of borehole samples			
	Composite samples will be analyzed for34 radicals i.e. V, Ba, Cr, Ga, Rb, Cs, Ca, U, Th, Eu, Hf, La, Lu, Sm, Tb, Yb, Ce, Dy, Er, Nd, Pr, Tm, Sc, Y, Zn, Cu, Pb, Ni, Co, Cd, Sc, Ag, Li, Mo	Nos	30	23
6	**Physical Studies**			
8	XRD studies	Nos	10	10
9	Complete Petrographic/ Ore microscopic study/ Minerographic Studies	Nos	20	20
11	Specific Gravity Determination	Nos	10	10
12	Report Preparation (Digital format)	Nos.	1	1

5.1.0 GEOLOGY AND OUTCOME OF THE EXPLORATION

5.1.1 Regionally the study area is part of Rajasthan basin which forms the eastern flank of Indus Geosyncline and comprises the sedimentary track to the west and north west of Aravalli up to Indo-Pakistan Border. Rajasthan basin has been divided into three sub-basins separated from each other by basement ridges/faults. These Sub-basins are: Jaisalmer Sub-basin, Bikaner – Nagaur Sub-basin and Barmer-Sanchor Sub-basin (after DGH, India).

5.1.2 Geotectonically, the Jaisalmer sub-basin has been distinguished into Kishangarh depression in the north, synclinal Shahgarh shelf in the west, Miajlar depression in the south and the Jaisalmer-Mari arch in the central part, as revealed in the geophysical investigations by ONGC (Raghavendra Rao, 1972).

5.1.3 Regionally area falls in Miajlar Depression (part of Jaisalmer sub-basin) and belongs to Birmania basin. Pokhran high separates the Bikaner-Nagaur sub-basin from Jaisalmer sub-basin, Devikot-Nachna uplift separated from Jaisalmer sub-basin from Barmer Sanchor sub-basin.

5.1.4 Nimbli block is part of Birmania basin, which is an oval shaped basin located in the heart of the Thar desert, western Rajasthan, India. Birmaina phosphorite basin is a part of Miajlar depression and Nimbli block exposes rocks of Birmania Formation. The first cycle of sedimentation corresponding to Proterozoic-Early Palaeozoic is designated as Birmania/Randha Formation representing deeper water sediments.

5.1.5 The Birmania basin comprises around 900-metre-thick sedimentary sequence of siliciclastic, carbonate and phosphorite facies. These sequences are unconformably overlain by Lathi conglomerate of Jurassic age in northern flank of the basin.

Generalized Stratigraphy of the Birmania phosphorite deposit is as below, after GSI

Age	Formation	Lithology	Max Thickness
Jurassic	Lathi	Conglomerates, grits, sandstone and shale	660 m
Unconformity			
Cambrian	Birmania	Dolomitic limestone, cherty limestone, shale, siltstone and sandstone	>90
		Shale white brown to variegated, arenaceous to carbonaceous with siltstone and sandstone bands	60
		Phosphorite	Less than 1m to over 9m
		Quartzite sandstone	1-4m
		Buff colour fine grained, calcareous sandstone, dark brown calcareous and ferruginous sandstone	50-270m
		Greyish yellow or cherty grey limestone	>80m
	Unconformity		
	Randa	Sandstones and subordinate calcareous rocks and shales	

5.1.6 GSI carried out Exploratory drilling for Phosphorite at Birmania during FS: 1968-70. A total 2053.89m of drilling was carried out in 68 no of boreholes in and around Nimbli block and phosphorite was intersected in 55 no of boreholes at depths varying from 1.5 to 40.0 m. Resources were estimated at 10% P_2O_5 cut-off and minimum width of 1.5m and established 3.49 million tonnes with average grade 12.91%.

5.1.7 During the present exploration program, drilling was planned along 2.5 km NW-SE strike of the deposit along which, 16 nos. of section lines marked in NW-SE direction placed approximately 200m apart. On these section lines a total 32 nos. of boreholes involving total 1293.00m drilling (G3 stage) carried out to check the strike and depth continuity of Phosphorite ore body in the block area.

5.1.8 Drilling was completed in two phases, in Phase-I a total 15 no of boreholes (MNP-01 to MNP-15) involving 541.00 m of drilling is completed and in Phase -II a total 17 (MNP-16 to MNP-32) no of boreholes involving 752.00m drilling is completed, thus a total 32 no of boreholes involving 1293.00m of drilling is done in Nimbli block area.

5.1.9 A total 24 nos. of boreholes drilled by GSI (1968-70) in Nimbli block are considered for correlation and resource evaluation for phosphorite beds. This involves 838.13m in 24.00 no of boreholes.

5.1.10 The siliciclastic, calcareous and phosphatic sediments of Nimbli block display asymmetric doubly plunging longitudinal apex fold which extends in NE-SW direction over a strike length of approx. 5km (fig. Regional Geological map). Structurally the Nimbli block area comprises one doubly plunging anticline and one doubly plunging synclinal fold traced along NE-SW phosphorite-sandstone litho-association. Folding forms a system of asymmetric, longitudinal, sharp-apex, doubly plunging as well as open folds which are traced all along strike and dip of deposit.

5.1.11 All the formations in the area are complexly folded, with dip is changing frequently, the fold axis either plunges either northwards or southwards, plunge ranging from 5º to 35º. The larger folds plunge at angles of 25º to 30º the plunge varying when traced along the axes.

5.1.12 On the receipt of primary sample analysis which was carried out for 5 radicals viz P_2O_5, Fe_2O_3, Al_2O_3, SiO_2, LOI, zone was demarcated on the basis of >5% P_2O_5, cutoff (IBM guidelines). Out of 56 nos. of boreholes (32 nos. by MECL and 24 nos. by GSI) drilled in Nimbli block, phosphorite zone is intersected at vertical depth ranging from 0.80 m in B-46 to 57.35 m in B-58 and thickness variying between 0.99 m (MNP-07, P_2O_5-5.55%) and 11.88 m (MNP-02, P_2O_5-7.56%).

5.1.13 During the present exploration, boreholes were spaced at approximately 200m strike interval. As per UNFC system and specifications given in Part: III-I of Minerals (evidence of Mineral content) Rule-2015, mineral resource in the block is categorised as inferred category (333).

5.1.14 The Phosphorite ore resource has been estimated by “Geological cross-section Method” (as principal method) and “Level Plan Method” as check method.

5.1.15 The total Phosphorite ore resources estimated by Geological Cross section method at 5% P_2O_5 **cutoff** in Nimbli block is **3.24 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.59 million tonnes** with an average grade of **11.32% P_2O_5,** 38.66% SiO_2, 12.13% Al_2O_3, 4.97% Fe_2O_3 and 10.26% LOI. The resources are estimated over a cumulative strike length of 2.5 sq. km.

5.1.16 At **10% P_2O_5 cutoff** the total Phosphorite ore resources estimated by Geological Cross section method in Nimbli block is **2.11 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **1.69 million tonnes** with an average grade of **13.84% P_2O_5**, 37.05% SiO_2, 10.08% Al_2O_3, 5.18% Fe_2O_3 and 7.65% LOI.

5.1.17 The Resources has been calculated by Level Plan Method at 200mRL, 225mRL and 250mRL at 25m vertical intervals. The total Geological resource by **Level Plan Method** is 3.12 million tonnes, after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.49 million tonnes** with an average grade of **11.45% P_2O_5**, 39.51 SiO_2%, 12.13% Al_2O_3, 4.71% Fe_2O_3 and 7.85% LOI.

5.1.18 The difference between the resources from Geological Cross section method and Level Plan Method is 3.85% and grade difference of P_2O_5 is 0.14%. The variation in resources estimated by both the methods are within acceptable limit and the reliability of resource estimated by Geological Cross section method may be considered for all practical purposes.

6.0.0 RECOMMENDATIONS

6.1.0 Exploration in Nimbli is carried out G-3 level; resources have been established over a strike length of 2.5km up to vertical depth of 50m. However, it is recommended to carryout systematic exploration in G-2/G-1 level along with ore beneficiation studies, feasibility studies before opening of mine. The block may be auctioned at composite level.

CHAPTER – II

2.0.0. DETAILS OF THE QUALIFIED PERSON(S) / EXPLORATION AGENCY

(To be provided separately for all the qualified persons signing off the report)

Table No 2.1

(a) Name:	**MINERAL EXPLORATION AND CONSULTANCY LIMITED** **(Formerly Mineral Exploration Corporation Limited)** (A Govt. of India Enterprise; A Miniratna-I PSE) (Ministry of Mines, Govt. of India)
(b) Address:	Dr. Babasaheb Ambedkar Bhawan, High Land Drive Road, Seminary Hills, Nagpur-440006.
(c) Contact Mobile No:	0712-2510289; 0712-2511829
(d) E-Mail id:	cmd@mecl.gov.in gm-exploration@mecl.gov.in
(e) Qualification:	Professionals with M.Sc / M.Tech (Geology) Qualification
(f) Experience:	Professionals with experience > 30 Years
(g) Affiliation to any organization/company, if yes, specify the name of the organization or company.	A Govt. of India Enterprise; A Miniratna-I PSE Ministry of Mines, Govt. of India

2.1.0 DETAILS OF QUALIFICATION AND PERSONNEL ASSOCIATED WITH VARIOUS ASPECTS OF EXPLORATION, ASSESSMENT OF RESOURCES AND RESERVES.

2.2.0 The details of personnel associated with the exploration in Nimbli block for Rock Phosphate in district - Jaisalmer, Rajasthan are given in following Table No 2.2

Table No 2.2

Details of personnel associated with Preliminary exploration (G-3) for Rock Phosphate in Nimbli block, Jaisalmer, Rajasthan

1	**Overall Planning, Co-ordination & Overall supervision**	:	Shri P. Ravindran, GM (Exploration / Non-Energy Minerals)
		:	Shri P. P Kulkarni, Dy. GM (Exploration) (Rtd) Shri Naveen Kumar Pala, Sr Manager Geology
2	**Proposal Preparation team**	:	Shri Naveen Kumar Pala, Sr Manager Geology
		:	Shri Peeyush Kumar, Asst Manager Geology
		:	Smt Moumita Gosh, Sr Geologist
3	**Project management & Field Operation**	:	Shri Khusiram, Manager (Drilling) / Project Manager
		:	Shri Peeyush Kumar, Asst Manager Geology
		:	Shri Mahipal Charan, Sr, Geologist

3	**Sampling**	:	Shri Shyam Nath Hazari, Sr. Tech (Sampling)
4	**Chemical Laboratory, MECL**	:	Shri P. Ravindran, GM (Exploration / Non-Energy Minerals)
		:	Shri Rohit Sharma, Manager (Chemistry)/Head (laboratory)
		:	Dr. (Mrs.) Deepti R. Rahangdale, Manager (Chemistry)
		:	Shri Bhojanna Wadekar, Assistant Manager (Chemistry)
5	**Petrological Laboratory, MECL**	:	Shri Sayantan Pal, Manager (Geology)
6	**Survey & Drawing**	:	Shri Jagdish Thakral, Survey & Map Officer
		:	Shri Durgesh Devarshee, STA (S & D)
		:	Shri P.S.Negi, ASMO
7	**Data Processing & Documentation**	:	Shri Naveen Kumar Pala, Sr Manager Geology
		:	Shri Peeyush Kumar, Asst Manager Geology
		:	Smt Moumita Gosh, Sr. Geologist
		:	Smt Soumya Anand, Sr Geologist
		:	Shri N.C.S.Reddy, Sr. Operator (Computer)
		:	Shri Uday A. Patil, Sr. Operator (Computer)
8	**Reprography & Printing**	:	Shri Jagdish Thakral, Sr. Survey & Map Officer
		:	Shri Durgesh Devarshee, STA (S & D)

CHAPTER - III

3.0.0 TITLE AND OWNERSHIP

3.1.0 TITLE: GEOLOGICAL REPORT ON "PRELIMINARY EXPLORATION(G-3) FOR ROCK PHOSPAHTE IN NIMBLI BLOCK, DISTRICT: JAISALMER, RAJASTHAN".

3.1.1 **Ownership:** Department of Mines and Geology, Government of Rajasthan

3.1.2 **Name of Prospector:** Mineral Exploration and Consultancy Limited (Formerly Mineral Exploration Corporation Limited)

3.1.3 **Address of Prospector:**

Mineral Exploration and Consultancy Limited (MECL),
Dr. Babasaheb Ambedkar Bhavan,
High Land Drive Road, Seminary Hills,
Nagpur, Maharashtra Pin- 440006

3.1.4 **E-mail of Prospector:** cmd@mecl.gov.in; gm-exploration@mecl.gov.in

3.1.5 **Telephone numbers of Prospector:** 0712-2510289; 0712-2511829

3.2.0 DETAILS OF PERIOD OF PROSPECTING

3.2.1 Proposal of preliminary Exploration (G-3) for Rock phosphate in Nimbli block over an area of 2.7 sq.km was submitted in 59th TCC of NMET held on 28th & 29th Nov 2023 and committee recommended the exploration proposal in two phases i.e. Phase I Geological Mapping and Phase-II Exploratory drilling, with following suggestions;

b. Detailed Geological Mapping on 1:2000 Scale including Topographical Survey
c. Review of Geological Mapping data in two months (after commencement of work) for carrying out phase II activities

3.2.2 32nd Executive committee (EC) meeting held on 6th December 2023 approved the project with sanction order no. F.No.23/400/2023-NMET/370 dated 12th December 2023 with time line of 12 months and approved cost of ₹ 3,55,98,122/-.

3.2.3 MECL commenced exploration work comprising of Geological mapping, Topographical survey on 29.01.2024 and completed on 05.03.2024. Geological Mapping and topographical survey data were reviewed in the 64th TCC meeting held on 25th, 29th & 30th April 2024 (via VC), the committee after detailed deliberation and review of Geological mapping data opined that planning of boreholes needs to be done with the diligent understanding on the structure of the block and committee recommended for inclined and a few vertical boreholes to be drilled in the block.

3.2.4 MECL commenced drilling operations on 24.05.2024 and completed on 30.09.2024, a total 1293.00 meters of drilling was completed in 32 no of boreholes which were drilled in two phases (phase -I 15 no of boreholes, Phase -II 17 no of boreholes)

3.2.5 The allied field-works including DGPS survey, sampling etc. were completed simultaneously. The analytical/laboratory studies were carried out simultaneously in laboratories of MECL and other Govt./NABL accredited laboratories.

CHAPTER - IV

4.0.0 DETAILS OF THE AREA UNDER STUDY

4.1.0 LOCATION OF THE BLOCK

4.1.1 The Nimbli block area falls in part of Survey of India Toposheet No.40 J/16 and covers an area of 2.70 sq. km in and around villages Beermani, Kohra & Dheerpura of Fatehgarh Tehsil, district: Jaisalmer, Rajasthan. The block location on topo-sheet is given text fig 4.1 and as PLATE-I. The Co-ordinates of the corner points of the block area in UTM are given in table below.

Table No – 4.1

Co-ordinates of Cardinal Points for Nimbli Block, Tehsil: Fatehgarh, Dist: Jaisalmer.

Block Cardinal Points	UTM Zone-42 (m)	
	Easting (m)	Northing (m)
A	690363.194	2900741.785
B	693116.292	2902685.019
C	692331.939	2903129.021
D	691118.576	2900313.265

4.2.0 CONNECTIVITY

4.2.1 Nimbli block is well connected with sub-district headquarter Fatehgarh (Tehsil office) which is situated 55km away in northeastern direction from the block. District headquarter Jaisalmer is lying in northern direction from the block at a distance of 115 km and can be approached by two national highways connecting Kohra and Jaisalmer i.e., NH-11 and NH68.

4.3.0 LAND USE PATTERN:

4.3.1 Most of the area under investigation is covered by aeolian sand of Great Thar Desert. The study area exposes NE-SW trending hillocks/mounds rising to elevation of 25m from surface. Southern part of the block is occupied by agriculture fields.

4.4.0 MINERAL(S) UNDER INVESTIGATION OR GRANTED UNDER LICENSE OR LEASE

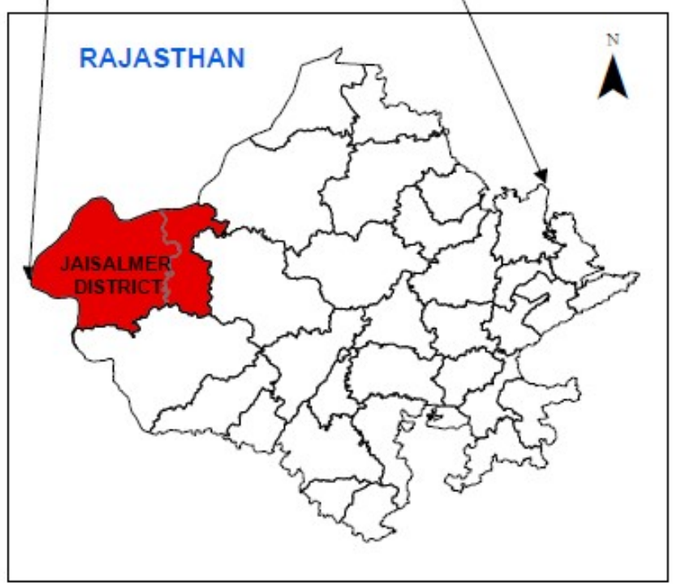
4.4.1 The Nimbli block has been explored for Rock Phosphate.

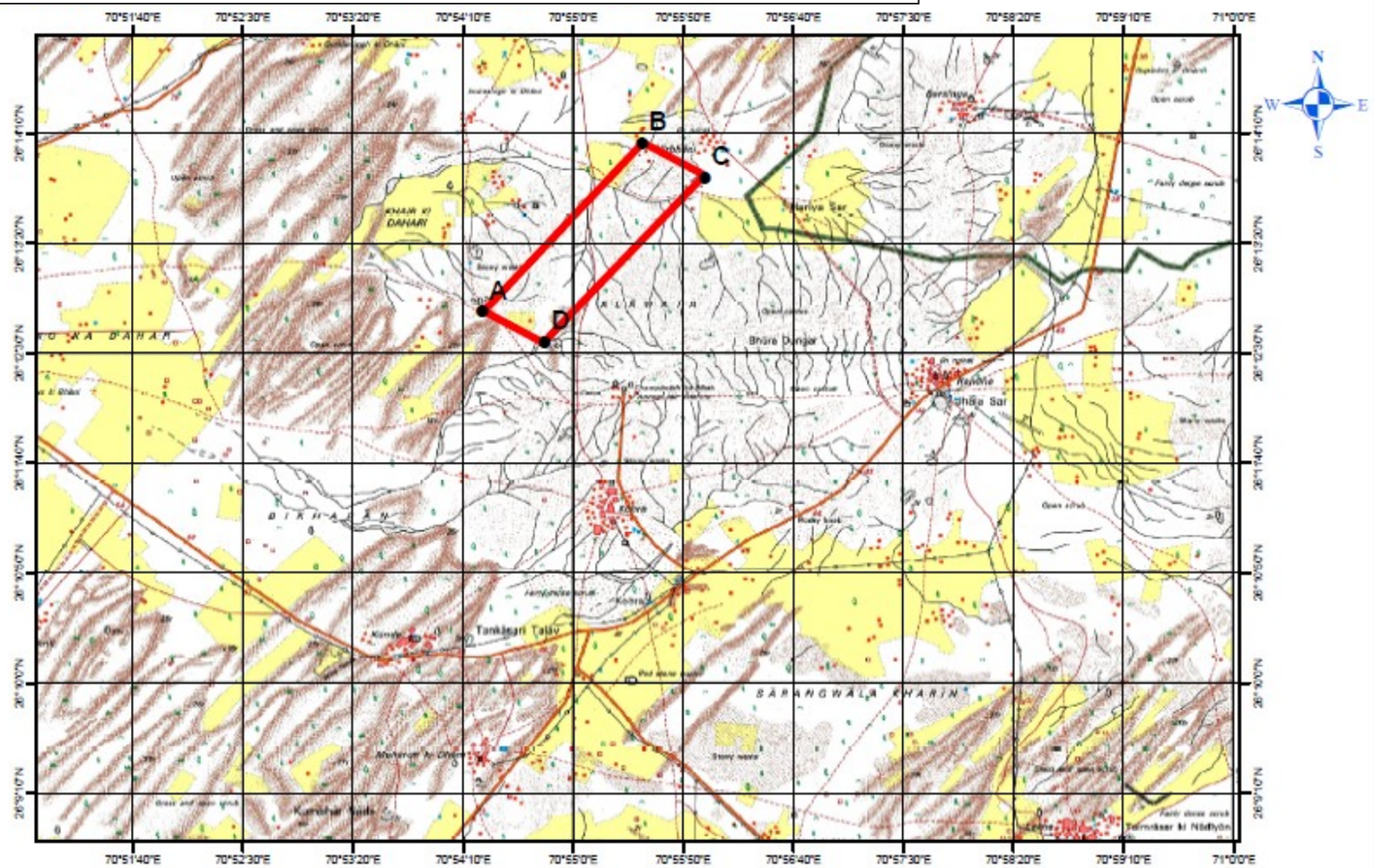
4.5.0 ACKNOWLEDGMENTS

4.5.1 Mineral Exploration and Consultancy Limited (MECL) places profound sincere thanks to TCC committee of NMET and the officials of State Government of Rajasthan for awarding the work of preliminary exploration in Nimbli block Rajasthan. MECL also expresses

sincere thanks to Village, District, Panchayat Authorities of Jaisalmer and Fatehgarh Tehsil, for their kindly support and kind cooperation while executing the exploratory work.

Location Map of Nimbli Block (2.70 sq. km.) G-3 Level Exploration for Phosphorite mineral, Tehsil Fatehgarh, District: Jaisalmer, State: Rajasthan (Part of Toposheet No: 40J/16)





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LEGEND

- Nimbli Block Corner Points
- Nimbli Block Boundary

TEXT FIGURE 4.1

MINERAL EXPLORATION AND CONSULTANCY LTD.
(Formerly Mineral Exploration Corporation Ltd.)
Ministry of Mines, Govt of India Enterprise, MINIRATNA-I CPSE
An ISO 9001:2015, 14001:2015 & 45001:2018 Certified Company

CHAPTER - V

5.0.0 PHYSIOGRAPHY AND ENVIRONMENT

5.0.0. PHYSIOGRAPHY

5.0.1 Study area falls in Jaisalmer district of Rajasthan, which is a part of Great Indian Thar Desert. Area is covered mostly by aeolian sand, widespread sand dunes morphology is broken by steeply rising isolated hills and flat rocky areas. The hill ridges of Randha and Birsingha are east-west trending and rise abruptly to about 150 meters from the ground level, these hill ranges are located in southeast direction from the block. The terrain south of these ridges is again flat and is occupied by rhyolites and granites which are seen as isolated outcrops. The area west of the Nimbli deposit is mostly occupied by sand dunes which are cut by streams and water courses

5.0.2 The sand cover in most of the terrain is migratory. Systematically arranged sand dunes, strike NE-SW, point towards constant directional winds. The thickness of the sand cover in the Nimbli area is not more than 12 meters.

5.0.3 Localized ephemeral streams and water courses are present in the Nimbli and adjacent areas, apart from local streams. Regionally the area is drained by Luni River which flows from Samdari, passes through Balotra. Luni river is also ephemeral, flowing only in response to heavy precipitation.

5.1.0. ROADS, RAILWAY TRACK, ELECTRIC TRANSMISSION LINE, TELEPHONE LINE, ETC.

5.1.1. Nimbli block is well connected with sub-district headquarter Fatehgarh (Tehsildar office) which is situated 55km away in northeastern direction from the block and falls on NH 68. District headquarter Jaisalmer is lying in northern direction from the block which at a distance of 115 km, can be approached by two national highways connecting Kohra and Jaisalmer i.e., NH-11 and NH68.

5.1.2. Inside the explored block there are no major electrical /telephone line.

5.2.0. HOST POPULATION (LOCAL TRIBES), HUMAN SETTLEMENTS WITHIN AND NEARBY THE AREA

5.2.1. The investigation area lies under administrative control of Fatehgarh Tehsil, Jaisalmer Dist, Rajasthan. As per provisional data released by Census India 2011, total area of Fatehgarh tehsil is 4,340 km². and has a population of 1,01,020 people with a population density of 23 inhabitants per square kilometre. There are about 17,795 houses in the sub-district.

5.2.2. When it comes to literacy, average literacy rate of Fatehgarh Tehsil in 2011 were 54.71% in which, male and female literacy were 71.01% and 35.28% respectively. Total literate in

Fatehgarh Tehsil were 44,127 of which male and female were 31,146 and 12,981 respectively. There are about 120 villages in Fatehgarh tehsil.

5.2.3. Beermani, Dheerpura & Kohra are the villages falling inside and in vicinity of the Nimbli block area viz., present phosphorite explored block.

5.3.0. **SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY**

5.3.1. The Sex Ratio of Fatehgarh Tehsil is 836. Thus, for every 1000 men there were 836 females. Schedule Caste (SC) constitutes 16% while Schedule Tribe (ST) were 6% of total population in Fatehgarh Tehsil.

5.3.2. Beermani (Virbhani) and Kohra are the villages that lie in the block which has a total population of 2540 nos with breakup of 1146 and 1394 in respective villages. Literacy rate is 77.54% in Beermani, 59.22% in Kohra

5.3.3. In Fatehgarh Tehsil out of total population, 42,337 were engaged in daily wages work (main work) activities. 51.7% of workers describe their work as Main work (Employment or Earning more than 6 Months) while 48.3% were involved in Marginal activity providing livelihood for less than 6 months. Of 42,337 workers engaged in Main Work, 11,072 were cultivators (owner or co-owner) while 2,598 were Agricultural labourers.

5.4.0. **HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES**

5.4.1. Jaisalmer situated at about 105km from the explored block is famous tourist destination with places like Amar singh and Gaddisar lake, Patwa and Nathmal haveli, Ludarwa and Kuldhara and Sam Sand dunes and Jaislamer golden fort.

5.4.2. Millions of years ago an ocean submerged Jaisalmer, the discovery of seashell here emphasizes this belief.

5.4.3. Wood Fossil Park a national Geological Monument is at Akal village (17 km off the city on the Jaisalmer-Barmer Road)

5.5.0. FORESTS, SANCTUARIES, NATIONAL PARK AND WILD LIFE SANCTUARIES ETC.

5.5.1. Nimbli block area does not fall within 10km radius of any protected areas such as National parks, Wild life sanctuaries etc. The nearest protected area and important Great Indian Bustard area is Dessert National Park located at about 65km in southern direction from the block.

5.6.0. FLORA AND FAUNA WITHIN AND NEARBY

5.6.1. Natural fauna and flora are scarce, the former consisting mostly of small reptiles, rodents and insects. The vegetation is very sparse and consist of mostly xerophytic shrubs and grass. Trees are very uncommon and are seen only near water wells and in old stream courses

marked by alluvium. The main crop of the area is millet and Jeera, agriculture is entirely dependent on rainfall. There is no lift-irrigation system in this region.

5.7.0. WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR, ETC

5.7.1. Regionally area is drained by Luni River which flows from Samdari, passes through Balotra. Luni river is also ephemeral, flowing only in response to heavy precipitation.

5.7.2. Ground water and Indira Gandhi Nahar Project (IGNP) canal are the only source of irrigation in the district. IGNP, Government of Rajasthan aims to irrigate the desert land of Western Rajasthan with Himalaya's water and provide drinking water to core of inhabitants. The canal originates from Harike barrage situated in Punjab. IGNP canal enters Jaisalmer district near village Nachana and flows towards western direction. It has a command area falling to the north of the canal.

5.8.0. CLIMATIC CONDITIONS

5.8.1. The district experiences arid type of climate. Normal rainfall in the district during the period 1951-2000 is 181mm. Mean annual rainfall during the period 2001 – 2011 has been higher than the normal rainfall. Average annual rainfall for the period 2001-2011for Fatehgarh tehsil is 280.14mm. Almost 90% of the total annual rainfall is received during the southwest monsoon, which enters the district in the first week of July and withdraws in the mid of September. As the district lies in the desert area, extremes of heat in summer and cold in winter are the characteristic of the desert. Both day and night temperatures increase gradually and reach their maximum in May and June. The temperature varies from 48° C in summer to 2° C in winter. Atmosphere is generally dry except during the monsoon period. The humidity is highest in August with mean daily relative humidity of 43%. The annual maximum potential evapotranspiration in the district is 1850 mm and it is highest in the month of June and lowest in the month of December.

CHAPTER - VI

6.0.0 INFRASTRUCTURE

6.1.1 LOCAL INFRASTRUCTURE CONNECTIVITY AND FACILITIES

The district has no medium or largescale industrial venture. Rajasthan Mines and Mineral Limited is promoting mining and crushing of limestone project. District has good road connectivity. Public utilities like Banks, colleges, Health care Services and Public transport services are available at Fatehgarh Tehsil town. Jaisalmer being tourist town has all major public infrastructure.

CHAPTER - VII

7.0.0. GEOLOGY

7.1.0 REGIONAL GEOLOGY

7.1.1 Regionally the area is part of Rajasthan basin which forms the eastern flank of Indus Geosyncline and comprises of the sedimentary track to the west and north west of Aravalli up to Indo-Pakistan border.

7.1.2 The tectonic evolution of Rajasthan basin took place in four distinct phases corresponding to - Precambrian - Triassic plate movement - Breaking of Indian plate from southern continent during Jurassic - Collision of Indian plate with the Eurasian plate from Eocene onwards - Uplift of Sind-Baluchistan fold belt resulting in filling up of the Indus shelf.

7.1.3 Rajasthan basin has been divided into three sub-basins separated from each other by basement ridges/faults. These Sub-basins are: Jaisalmer Sub-basin, Bikaner – Nagaur Sub-basin and Barmer-Sanchor Sub-basin (after DGH, India).

7.1.4 Geotectonically, the Jaisalmer sub-basin has been distinguished into Kishangarh depression in the north, synclinal Shahgarh shelf in the west, Miajlar depression in the south and the Jaisalmer-Mari arch in the central part, as revealed in the geophysical investigations by ONGC (Raghavendra Rao, 1972). The structural trends in the basin are mainly NNW-SSE or NW-SE corresponding to Dharwarian trend along with NE-SW trending Aravalli ranges (Singh, 2006). The basin has a long and well-established sedimentation history ranging from Upper Paleozoic to Quaternary interspersed with tectonic events at the end of Early Paleozoic, Mesozoic and Tertiary with well-marked transgressive- regressive cycles.

7.1.5 Birmaina basin is a part of Miajlar Depression and Nimbli block area lies in Birmania basin. The first cycle of sedimentation corresponding to Proterozoic-Early Palaeozoic is designated as Birmania/Randha Formation representing deeper water sediments.

7.1.6 Pokhran high separate the Bikaner-Nagaur sub-basin from Jaisalmer sub-basin, Devikot-Nachna uplift separates from Jaisalmer sub-basin from Barmer Sanchor sub-basin

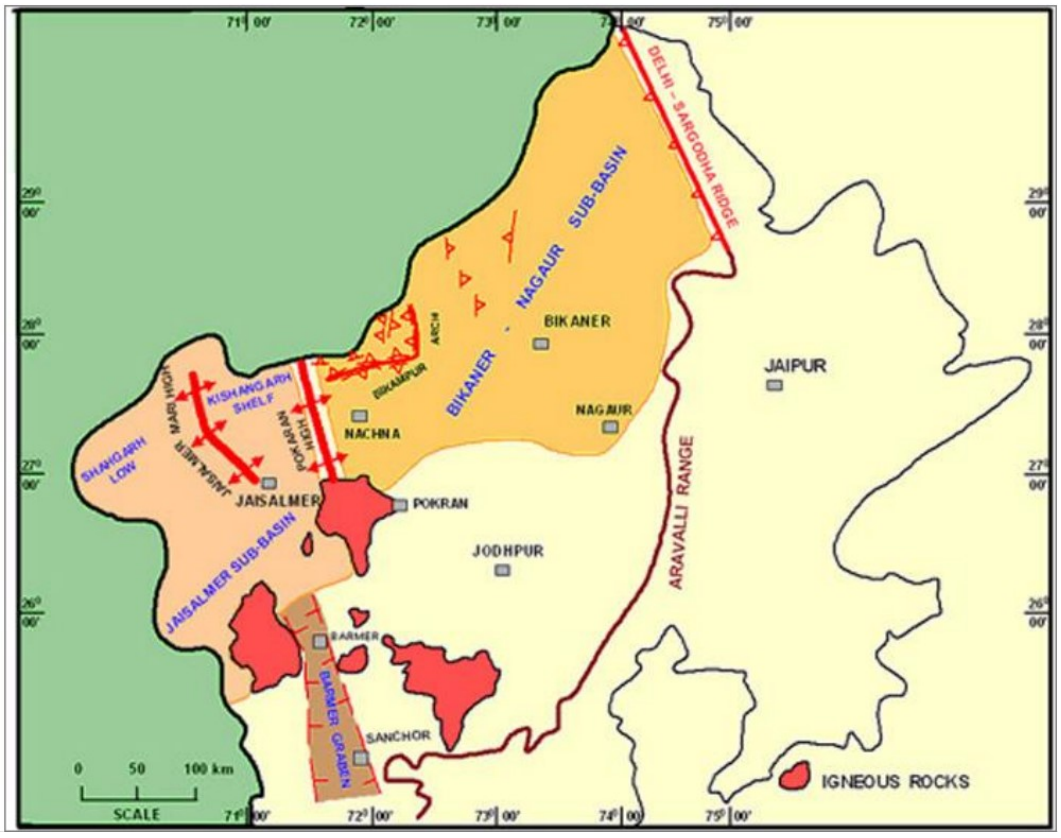
7.1.7 Regional Geological Map is enclosed at Text plate 7.1, 7.2 and as Plate -II, generalized stratigraphy of Jaisalmer sub-basin is given below table

Table no 7.1

Generalized Stratigraphy of Jaisalmer sub-basin (After DGH, India)

Age	Formation	Lithology	Max Thickness
Quaternary	Shumars	Laterised Ferruginous sandstones	660m
Unconformity			
Eocene	Bandha Khuiala	Chalky limestone, fossiliferous limestone and silt stone Gypseous shales and marls, fossiliferous hard	470 m

Age	Formation	Lithology	Max Thickness
		limestone	
Unconformity			
Palaeocene	Sanu	Sandstone	200 m
Unconformity			
Cretaceous	Parh Goru/abur Parihar	Sandstone Arenaceous limestone, fragmental and fossiliferous limestone and quartzitic sandstone Feldspathic sandstones with occasional hard calcareous grits and ferruginous sandstone	1000 m
Unconformity			
Jurassic	Bedesar Baisakhi Jaisalmer Lathi	Hard ferruginous and calcareous grits with inter-calatory sandstone Soft shales, sandy shales, silts, sandstone and quarzitic sandstone Conchoidal limestone and sandstone Sandstones, grits and shales	2000 m
Unconformity			
Triassic	Shumarwali	Sandstone	700 m
Unconformity			
Permian	Karampur	Sandstone, Shale, Clay	500 m
Unconformity			
Cambrian	Birmania Randha		900 m
Unconformity			
Pre-Cambrian	Malani Igneous suite	Granites (Jalore-Siwana), Rhyolites, Porphyries, metamorphics	



Text fig 7.1 Regional Geological Map showing basins and separation in Rajasthan state source DGH

7.2.0 DESCRIPTION OF FORMATIONS

7.2.1 **Malani Igneous Suite:** This formation comprises of granite, rhyolites, porphyries, metamorphics and Jalore-Siwana granite. In the district rhyolite is exposed towards east of Dangri village, which belongs to the Malani Igneous Suite and comprise mostly glassy to porphyritic varieties varying from pink, green to black and chocolate in colour. In the porphyritic varieties phenocrysts of orthoclase are seen in a slightly devitrified glassy matrix. The granites usually contain hornblende and are intrusive in to the rhyolites. It is considered to be equivalent to the Siwana and Jalor Granites.

7.2.2 **Randha–Birmania** sequence is exposed at the centre of the Thar Desert (western Rajasthan). It is the western most Precambrian sequence in India, with very limited exposures. Randha-Birmania sequence is part of Birmania basin which is oval shaped, roughly trending north–south and is considered as an isolated remnant of the Marwar Basin (Maheshwari et al. 2002, 2007). Underlain by Malani suite of igneous rocks (780–680 Ma) and unconformably overlain by the Lathi Formation (Jurassic), it comprises about 900 m thick sequence of siliciclastic, carbonate and phosphorite facies. The basin is divided into older Randha and younger Birmania formations. The Randha Formation, considered to be Ediacaran in age, is a sequence of mainly medium to coarse-grained siliciclastic rocks. The exposures occur as numerous hillocks around Randha Village, after which this formation has been named. Most workers consider that the Randha Formation unconformably overlies the Malani Igneous Suite. A faulted contact between the two units has also been suggested by Pareek (1984). The contact between Randha and Birmania formations is considered unconformable by some workers.

7.2.3 The **Birmania Formation** is essentially calcareous; the lower part is dominated by carbonates with some layers of thin, interbedded siltstones. The upper part consists of carbonates associated with phosphorite. Thickness of the Birmania Formation is estimated to be about 536m. The upper boundary of this formation is unconformable with Lathi Formation (Singh 2006). The lithological association and occurrence of phosphorite indicate towards a marine setting. Foetid limestone is characteristic of reducing and restricted depositional environment (Singh 2006). This is indicative of quiet water or shallow tidal environment of deposition.

The occurrence of the multicellular algal fossil Wengania exquisita in phosphatic chert of the Birmania Formation suggest that it was deposited during the Ediacaran. Detrital zircon age distributions contain prominent populations of 1.7-1.9 Ga grains, with subordinate younger grains that range from 650-980 Ma.Paul Myrow (2015, Precambrian Research).

7.2.4 Lathi Formation: The Lathi beds are well exposed at the base of the ENE-WSW trending ridge, 8 km south of Fatehgarh. At places, sandstone is arenitic and haematite occurs as pellet. A middle Jurassic age has been assigned to this formation on the basis of leaf impressions of Ptyllophyllum and fossil wood.

7.2.5 Jaisalmer Formation: The Jaisalmer Formation comprising yellowish to buff coloured highly fossiliferous limestone conformably overlies the Lathi Formation. A well-defined contact between the two is seen 1.6 km N45°W of Rividi. Abundant fossils of Rhynchonellids, Terebratulids, Trigonia, Pecten, Natica, Nautilus and a host of others have been obtained from this formation. On the basis of the fossils an upper Jurassic age has been assigned to this formation.

7.2.6 Baisakhi Formation: This formation of late Jurassic age and consists of four lithostratigraphic members. The rocks are exposed along an arc, approximately 8–10 km wide, stretching from the Kanoi Fault in the southwest to the area northeast of Kanod

7.2.7 Bhadesar Formation, overlies the Baisakhi Formation, and is represented by fossiliferous limestone followed by ferruginous sandstone with thin intercalation of clay beds, and is of Tithonian to possible Lower Cretaceous age. Bhadesar Formation is overlain by Parihar, Gor/Abur and Parh formation.

7.2.8 Parihar, Gor/Abar and Parh formation are represented by feldspathic sandstone with occasional grit and ferruginous sandstone to arenaceous limestone and quartzitic sandstone.

7.2.9 Sanu formation overlies Par, Gor/abur, Parihar Formation which consists of unconsolidated highly current bedded reddish glauconitic sandstone and silty sandstone Sanu formation is overlain by Khuiala and Bandha formation:

7.2.10 Khuiala and Bandha Formation: This formation represents regression of sea but the upper part of Sanu and subsequent Khuiala and bandha formation represent third marine transgression. This forms the closure of sedimentary cycle in Jaisalmer basin

7.2.11 Most of the area in the region is covered with Quaternary aeolian sand

7.3.0 REGIONAL STRUCTURE OF THE BLOCK

7.3.1 Nimbli block forms part of Birmania formation where all lithologies are highly folded and thrown into asymmetric doubly plunging longitudinal fold which extends in NE-SW direction over a strike length of approx. 5km.

7.3.2 Based on structure, Birmania phosphorite deposit has been divided into three major blocks by GSI, i.e., (i) Birmania, (ii) Ladu Singh, and (iii) Kohra; Birmania block is having two doubly plunging anticline and two doubly plunging syncline where as in Ladu Singh block there is doubly plunging anticline and in Kohra block

there is one anticline and one syncline. These anticlines and synclinal folds which are plunging northwards or southwards are connected by smaller folds.

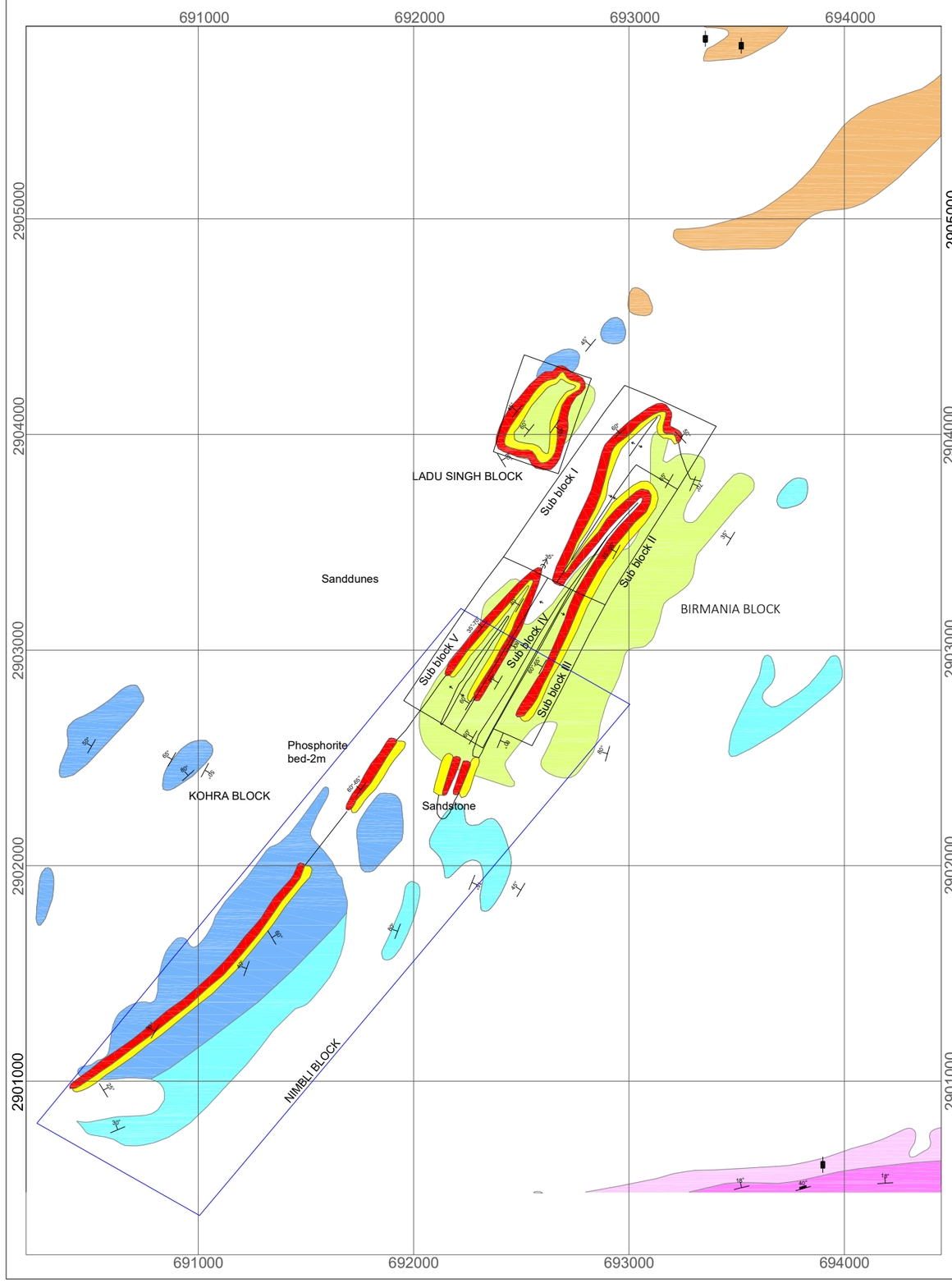
7.3.3 General trend of the phosphorite beds is NE-SW. Strike length of the folds is more than the width of the longitudinal part of the folds. Strike length of the phosphorite is about 5 km, while width is approximately 100m in birmania area 50m in Kohra/nimbli and Ladu Singh block area (Ref: Regional Geological map). Dip of the beds varies between 35° to 80° with rolling dips towards eastwards and westwards.

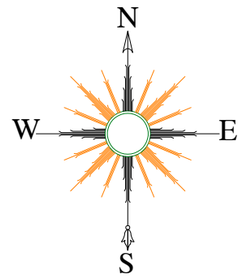
7.3.4 Most of the area is covered by sand and structural data cannot be measured owing to this cover. However, structural data of intense folding was measured wherever outcrops were mapped. Strike slip and oblique faults (as displacement of beds) are present near axial plane and near apex/crest of folding, numerous minor folds are observed with frequent breaks.

7.3.5 Due to complexity of folding owing to system of asymmetric, longitudinal, sharp-apex, doubly plunging folds which makes difficult to measure the exact thickness of phosphorite bands. The most conspicuous feature of the area is the quartzitic sandstone-phosphorite sequence which can be used as a marker horizon for establishing the structures and stratigraphic succession. The members show facies change when traced along and across the strike. This is best exemplified by the phosphorite horizon. In the southern part of the Kohra block the phosphatic limestone is immediately overlying the quartzitic sandstone. When traced northwards, the phosphatic limestone becomes thinner and is absent for a strike length of about 400 metres where cherty limestone lies directly on the quartzitic sandstone. Traced northwards from this point the phosphorite changes over to a sandy shale with chert, which is the most common rock type in the Birmania block.

7.3.6 The study area is a part of Birmania and Kohra blocks which is represented in Regional Geological Map as text Fig. 7.2 and Plate no.II.

REGIONAL GEOLOGICAL MAP WITH NIMBLI BLOCK, FATEHGARH-TAHSIL, JAISALMER-DISTRICT, RAJASTHAN.





SCALE 1:20,000

LEGEND

- PHOSPHORITE BEDS
- SAND STONE
- PHOSPHORITE BEARING SANDY LIMESTONE
- CALC/FERUGINOUS/QUARTZITIC SANDSTONE, CHERTY LIMESTONE
- CHERTY, DOLOMITIC LIMESTONE, SHALY SST, SILTSTONE
- GRITTY, PEBBLY/FERRUGINOUS SST, CONGLOMERATE, SILTSTONE, CLAY
- FERRUGINOUS, QUARTZITIC SANDSTONE AND SHALE
- CALCAREOUS, QUARTZITIC SANDSTONE WITH GRITTY BANDS
- FINE AEOLIAN SAND AND SILT WITH OCCASSIONAL KANKAR

INDEX

- NIMBLI BLOCK BOUNDARY
- 25° BEDDING
- 40° INCLINED JOINT
- VERTICAL JOINT
- 30° FOLD AXIS
- KEY MAP FOR SUB BLOCKS AS MARKED BY GSI

TOPOSHEET: 40J/15,16

PLATE-II

SOURCE:
1. SKETCH MAP OF SANDSTONE-PHOSPHORITE BASIN AREA (PART OF BIRMANIA BASIN), JAISALMER DISTRICT (Based on planetable map of the area on 1:500 Scale) Scale 1cm=200 metre(Approx) by G.S.I (RAJ) D.O.No-48/66
2. BHUKOSH, GSI

TEXT FIGURE-7.2

7.4.0 BLOCK GEOLOGY

7.4.1 The Nimbli phosphorite block falls in the oval shaped Birmania Basin located in Thar desert of western Rajasthan, India. It is underlain by Malani Igneous Suite of rocks which belong to Precambrian (After DGH). The Birmania Basin comprises around 900-metre-thick sedimentary sequence of siliciclastic, carbonate and phosphorite facies.

7.4.2 All the rock formations described by the geologists of the Oil and Natural Gas Commission are not present in the area. The only two formations occurring are the Birmania and the Lathi formations. The stratigraphic succession in the Birmania area built up on the basis of structure and sedimentary features is as follows

7.4.3 Generalized Stratigraphy of the Birmania phosphorite deposit (Nimbli Block) is as below, after GSI

Table 7.2

Age	Formation	Lithology	Max Thickness
Jurassic	Lathi	Conglomerates, grits, sandstone and shale	660 m
Unconformity			
Cambrian	Birmania	Dolomitic limestone, cherty limestone, shale, siltstone and sandstone	>90
		Shale white brown to variegated, arenaceous to carbonaceous with siltstone and sandstone bands	60
		Phosphorite	Less than 1m to over 9m
		Quartzite sandstone	1-4m
		Buff colour fine grained, calcareous sandstone, dark brown calcareous and ferruginous sandstone	50-270m
		Greyish yellow or cherty grey limestone	>80m
	Unconformity		
	Randha	Sandstones and subordinate calcareous rocks and shales	

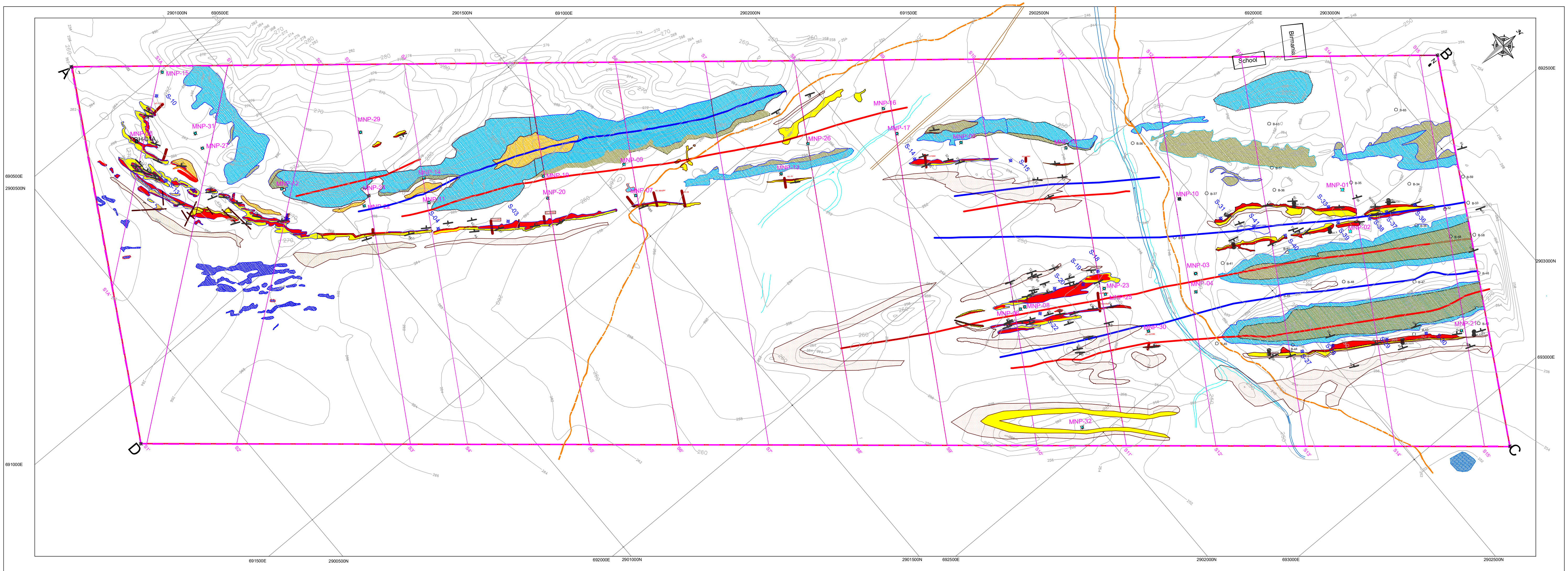
7.4.4 The oldest member exposed in the area is cherty limestone near Kohra village, the base of the Birmania Formation is probably below the sand covered ground between this exposure and the Randha ridge. The contact between the Randha and the Birmania formations is not exposed anywhere. The youngest exposed member (the calcareous chert or its equivalent dolomitic limestone or sandstone) is overlain by the conglomeratic sandstone and grit of Lathi Formation (Jurassic).

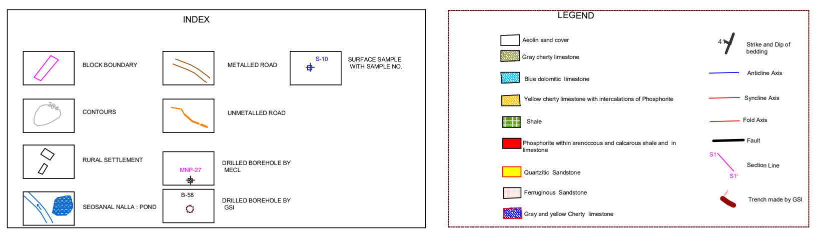
7.4.5 The general strike of the formations is NE-SW with complex folding. The individual members of the formation show considerable variation in thickness when traced along and across the

strike. The complex folding accompanied by doubly plunging, minor folds make it difficult to measure the exact thickness. The most conspicuous feature of the area is the quartzitic sandstone-phosphorite sequence which can be used as a marker horizon for establishing the structures and stratigraphic succession. The members show facies change when traced along and across the strike. This is best exemplified by the phosphorite horizon in the southern part of the Nimbli block where the phosphatic limestone is immediately overlying the quartzitic sandstone whereas in the northern area of the block shaly phosphatic horizon lies directly over the quartzitic sandstone. Another feature which reflects this gradational change is an increase in the ferruginous content in the calcareous sandstone from north to south. The calcareous and ferruginous sandstones cannot be marked separately in the Nimbli block (in the southern part of the area) owing to their intercalatory relationship.

7.4.6 GSI has prepared the Geological map of Birmania phosphorite deposit in 1:2000 scale with plane table survey during the field season of 1968-1969 & 1969-70, in which the data was hazy, hence MECL further has carried out the geological mapping of Nimbli block in 1:2000 scale.

7.4.7 The Topographical and Geological plan is presented as Text fig 7.3 and Plate no.III





Block Cardinal	UTMZone-42(m)	
	Easting(m)	Northing(m)
A	690363.4099	2900741.771
B	692331.9713	2903129.315
C	693116.3576	2902684.8
D	691118.5043	2900313.337

TEXT FIGURE 7.3

7.5.0 DESCRIPTION OF ROCK TYPES

7.5.1 The detail description of rock types as mapped by MECL during exploration is given in following paragraphs:

7.5.2 CHERTY LIMESTONE:

7.5.2.1 The cherty limestone forms the oldest rocks member in the area mapped and is exposed in the southern part of the Nimbli block. It is greyish-yellow or grey in colour, hard, feebly jointed and thick bedded (up to 1m), breaking with a sub-conchoidal fracture. It is crystalline to micro crystalline and mainly composed of calcite, dolomite and chert, the last making about 20 % volume of the rock. Thin calcite, veins of secondary origin are also seen traversing at places.

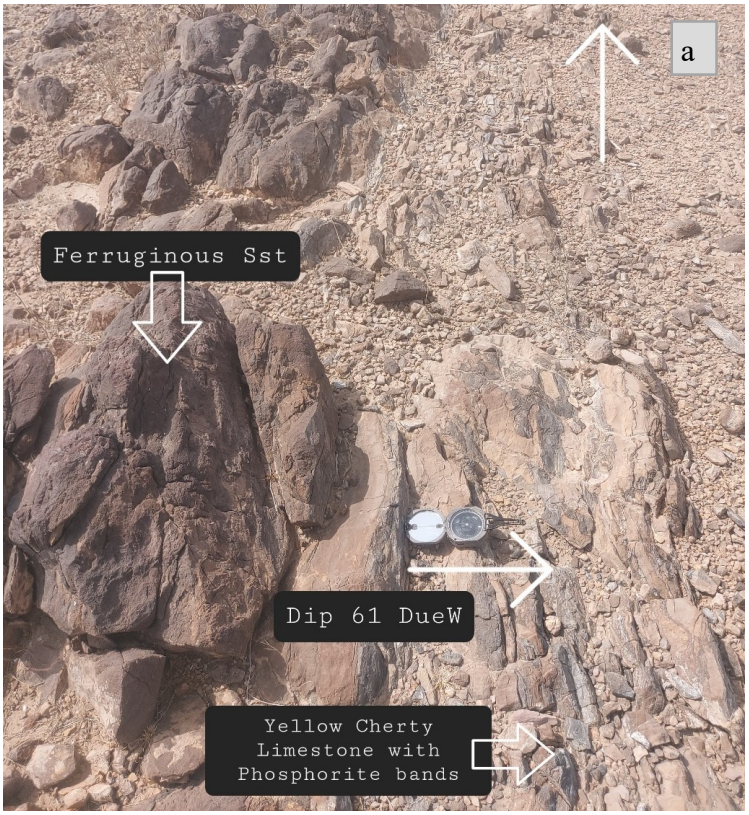
7.5.3 FERRUGINOUS CALCAREOUS SANDSTONE AND VARIEGATED SHALE

7.5.3.1 The ferruginous calcareous sandstone is a medium grained, dark chocolate-brown coloured rock that often has thin bedding, well-developed bedding cleavage in fine grained variety. The ferruginous nature of sandstone is observed by leaching of iron oxide which is intermixed with calcareous matter which shows intercalatory nature.

7.5.3.2 Microscopic studies reveal the presence of hematite as medium to moderately coarse patches, patchy fillings and as very fine grains, the sub-rounded quartz grains of the non-ferruginous variant shows a mosaic-like structure.

7.5.3.3 In the northern part the sandstone is more calcareous in nature which is generally fine to medium grained, thick bedded, buff coloured rock which shows wavy to lenticular bedding and small-scale cross bedding at places. It is mainly composed of rounded to sub rounded or sub angular grains of quartz with some calcite. In the northern part, yellowish to light grey and purplish-red coloured shale horizon overlies calcareous sandstone (Fig.7.4, 7.5)

Fig 7.4(a), (b) Out crop of calcareous sandstone in contact with variegated shale and in (7b) borehole no MNP 18 from 34.00 to 39.00m respectively.



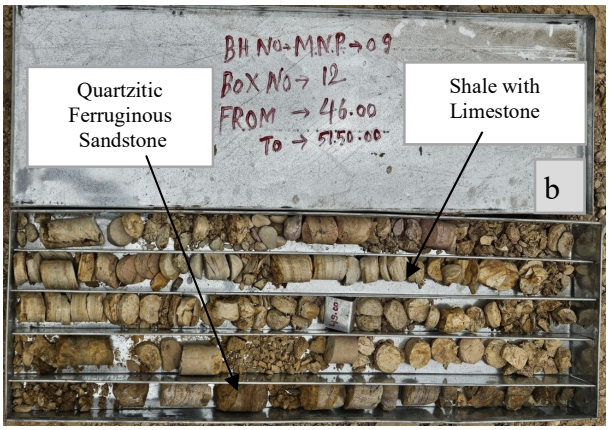


Fig 7.5 (a) Ferruginous Sandstone in contact with phosphatic limestone exposed along section line S3-S3'

Fig 7.5 (b) MNP-09: drill cores of Quartzitic ferruginous sandstone overlain by Shale and Limestone bands

7.5.3.4 The intercalatory nature between the calcareous and ferruginous sandstones, which may be distinguished as two distinct rock types in the northern portion of the block, the same cannot be identified individually in the southern portion of the block. The maximum thickness of ferruginous calcareous sandstone intersected is in borehole no MNP-28 of 17.00m

7.5.3.5 In the central and southern part of the block the rock type is overlain by variegated shale and yellowish brown to grey coloured limestone containing phosphorite bands. (Fig.7.5)

7.5.4 QUARTZITIC SANDSTONE

7.5.4.1 This formation is pale brownish to fawn in colour, fine to medium grained, hard compact, well bedded showing cross-bedding at places. The upper horizon is intercalated with shale and phosphate bands and this contact of overlying phosphorite and quartzitic sandstone act as a marker horizon throughout the block. The thickness of the quartzitic sandstone intersected in boreholes varies from minimum 1.00m (MNP-07) to maximum 6.00 m (MNP-03). The rock type overlies red to purple coloured variegated and sandy shale.

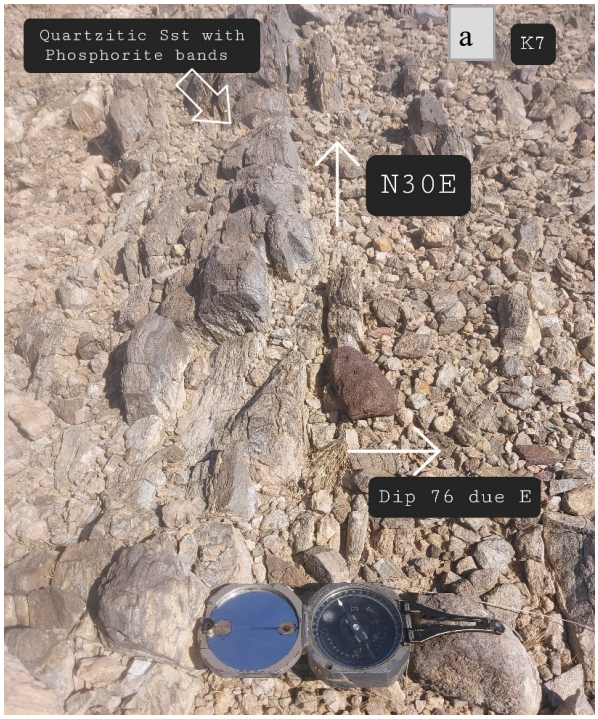


Fig7.6: Quartzitic Sandstone with phosphorite bands along section S11-S11'

7.5.5 PHOSPHORITE

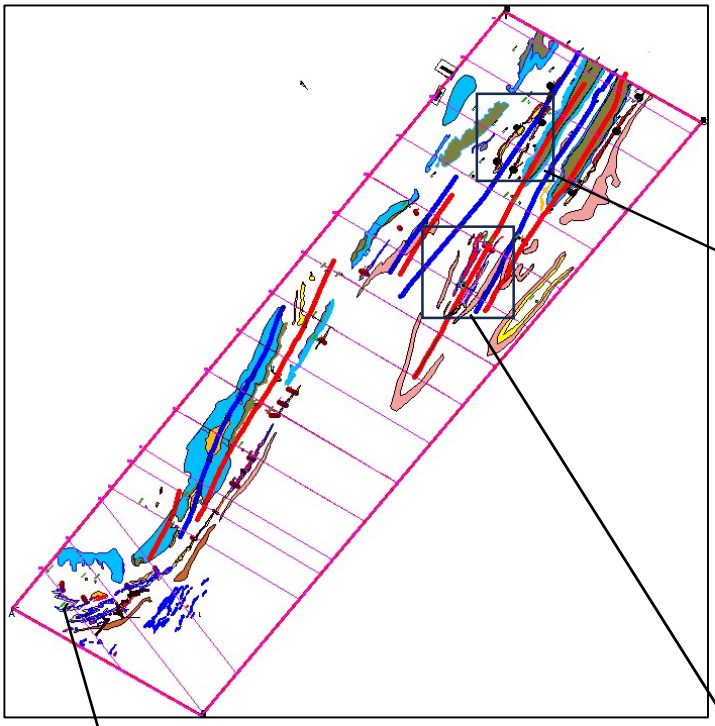
7.5.5.1 The phosphate rock is associated with calcareous shaly sandstone and banded limestone as thin (1.0cm) to massive (2.0m) bedding, which also shows interbedded relation with overlying shale. In hand specimen the phosphate is fine grained, light brown coloured, shows fissile, banded nature within shale, while occur as thin dark bands in limestone. The phosphorite rock unit has NE-SW strike, dip 35^{o}-80^{o} due westwards/eastward due to folding. The rock unit is overlying the quartzitic sandstone which acts as a clear distinction and contact acts as a marker horizon for identification of phosphorite deposition. All the lithologies exposed are complexly folded which show repetitive folding, with a series of anticline and synclines.

7.5.5.2 Phosphorite and quarzitic sandstone horizon forming a plunging anticline is exposed over a 500m strike length with maximum width across the section of 90m between, section lines S12 and S15 and limbs further folded eastward forming consecutive anticlinal and synclinal structure which is clearly marked in the geological map and Text fig 7.7 and 7.7 (a).

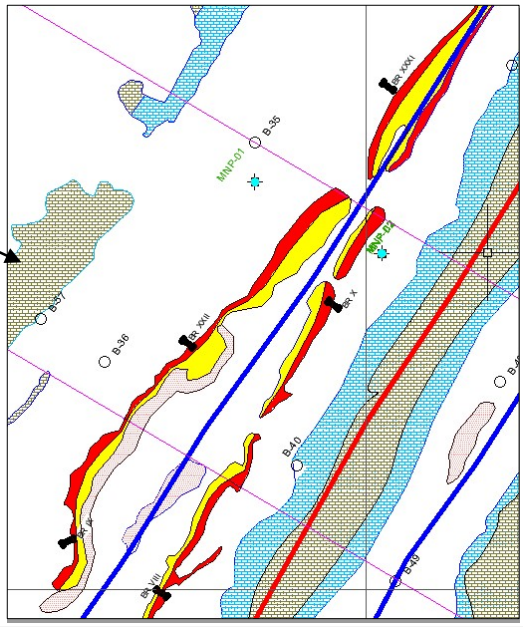
7.5.5.3 Further the rock unit is exposed over a strike length of 430m with cumulative width of 80m, between section line S9-S9' and S12-S12' forming a plunging syncline, where phosphate is associated with limestone and shale horizon. (Text fig 7.7b).

7.5.5.4 Further north-west of this exposure beyond aeolian cover the phosphorite-quartzitic sandstone unit is exposed as thin bands of 2-3m width and 200m length along NE-SW strike dipping towards west between section S9-S9' and S10-10'.

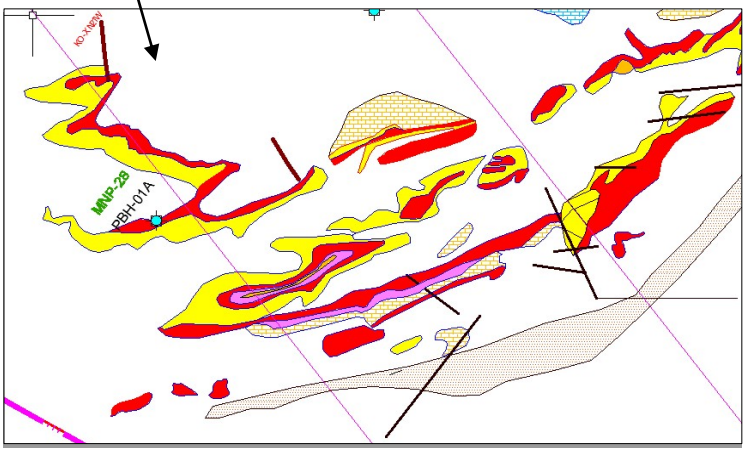
7.5.5.5 Between Section lines S6-S6' and S1A-S1A' the phosphorite-quartzitic sandstone unit is exposed over a NE-SW strike length of 1104m dipping westward, whereas the strike changes to almost E-W between section S1A-S1A' and S2-S2'(Text fig 7.7 (c)). The repetitive folding pattern in limestone associated with phosphorite bands exposed across the strike in width span of about 200m along section line S1A.



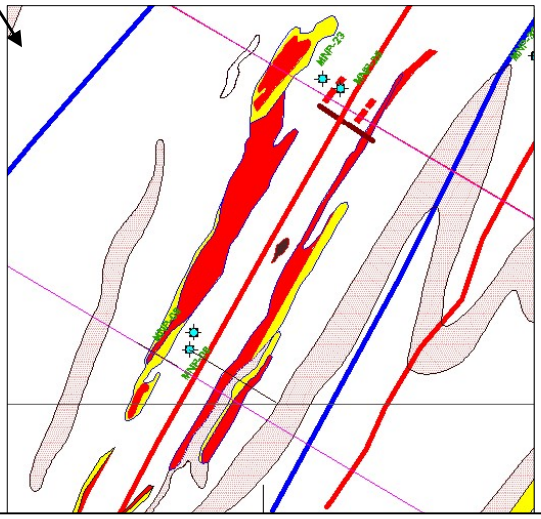
Text Fig 7.7. Geological Map of Nimbli Block



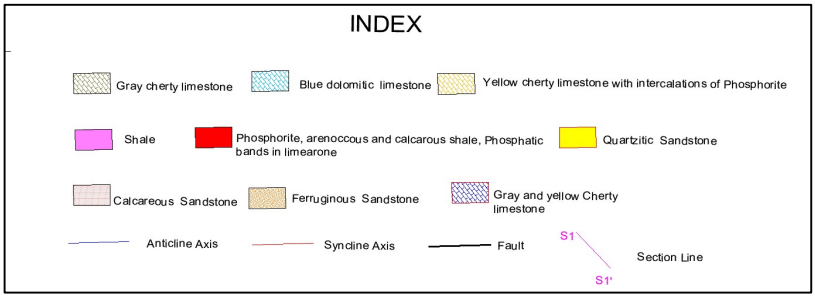
Text Fig. 7.7 (a) Phosphorite-quarzitic sandstone horizon forming Plunging anticline between Section S12-S12' and S15-S15'



Text Fig.7.7 (c) Complex small scale, repetitive folding in



Text Fig. 7.7 (b) Phosphorite-quarzitic sandstone horizon forming Plunging Syncline between Section S9-S9' and S12-S12'



7.5.5.6 Petrographic study has been conducted on 15 nos. of drill core samples collected from phosphatic horizon which reveals that quartz occurs as fine to medium subrounded grains floating over very fine micritic matrix, dahllite is seen present as fine subrounded patches, clay minerals are also seen present as thin sub-parallel laminations comprising of very fine flaky aggregates and associating very fine silt sized quartz grains with it, calcite has also intruded as fine fillings and patches, collophane is noted as very fine amorphous aggregates, fine pisolites and as fine patchy relics within calcite matrix, tourmaline occurs as very fine to fine prismatic grains in accessories, sericite is noted as very fine flakes in accessories and reddish ferruginous fillings and stains are seen associated with opaques (Fig.7.8 a, 7.8 b)

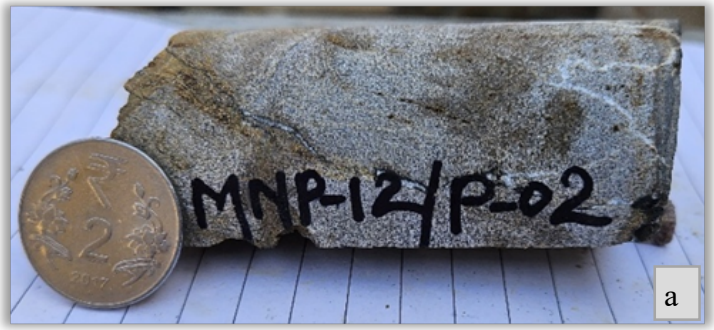


Fig. 7.8 (a) Drill core photograph (MNP-12) of phosphorite association in calcareous shaly sandstone.

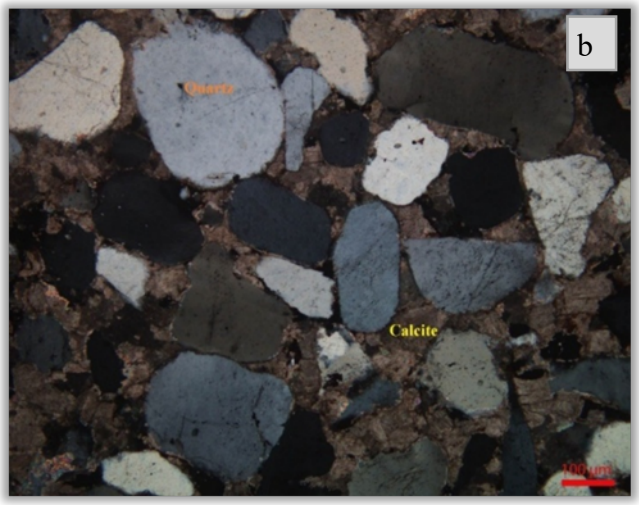


Fig. 7.8 (b) Photomicrograph showing fine subrounded to subangular quartz grains floating over micritic matrix in quartz wacke as seen under crossed nicols.

Specimen No.: MNP12/ P-02, Magnification: 100X

Fig. 7.9 (a) Drill core photograph of Phosphorite in association with sandstone.

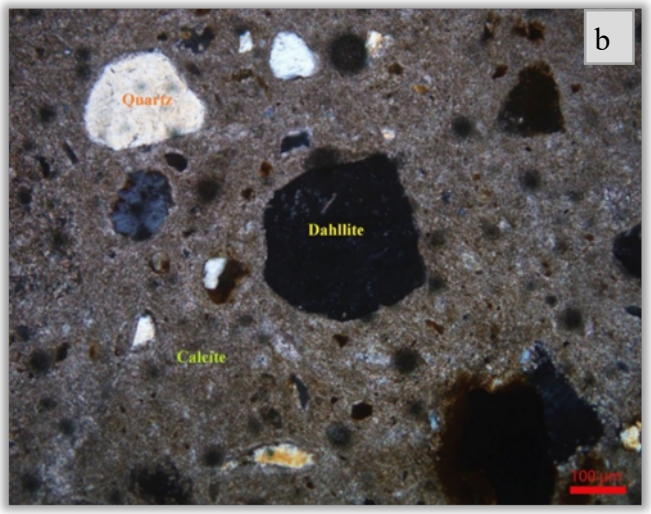
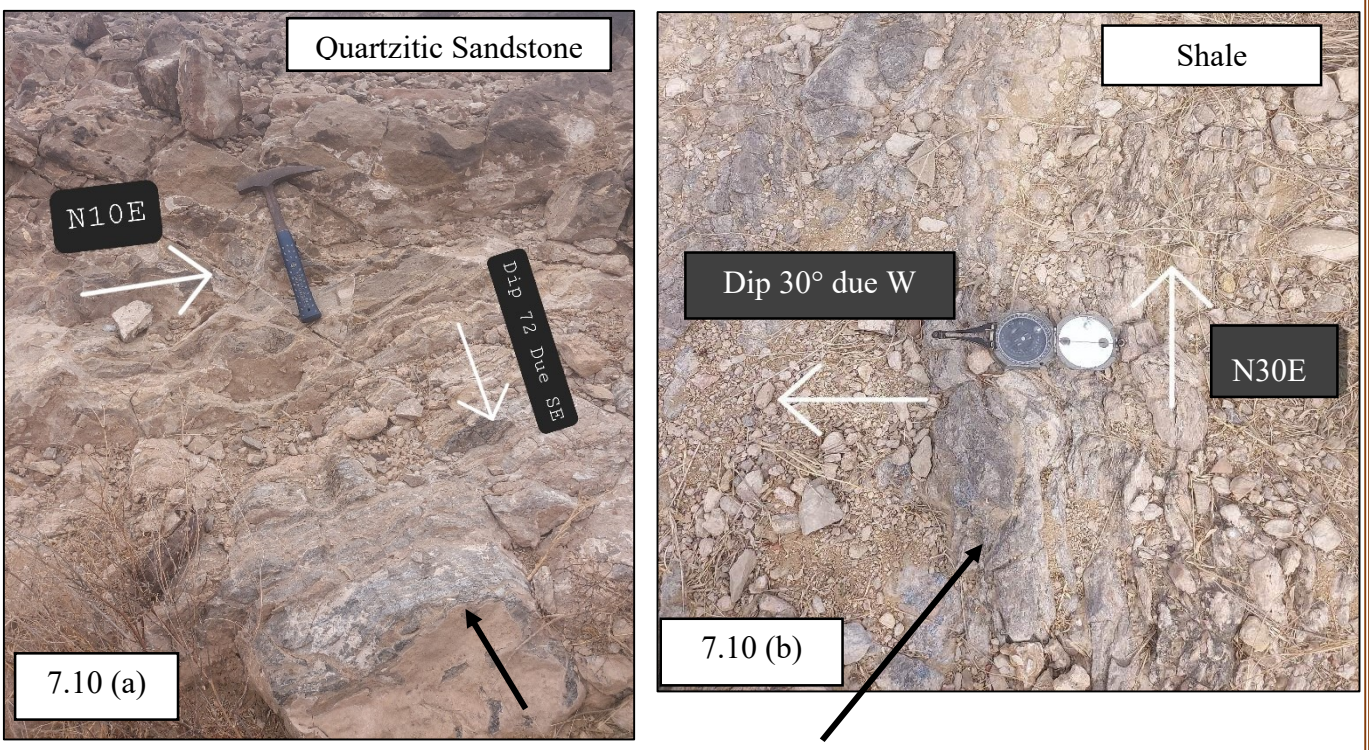


Fig 7.9 (b) Photomicrograph showing subrounded Dahllite patch within quartz wacke as seen under crossed nicols.

Specimen No.: MNP01/ P-01; Magnification: 100X

7.5.5.7 Between section line S12-S12' and S15-S15', phosphorite is associated with calcareous shaly sandstone, with alternating layers of white to blue argillaceous sandstone and chert which also forms important phosphatic formation (fig.7.10 (a, b, c)). The individual phosphatic and shale bands vary in thickness from few centimetres to about 30 cm in core samples.



Phosphatic bands in calcareous shaly sandstone

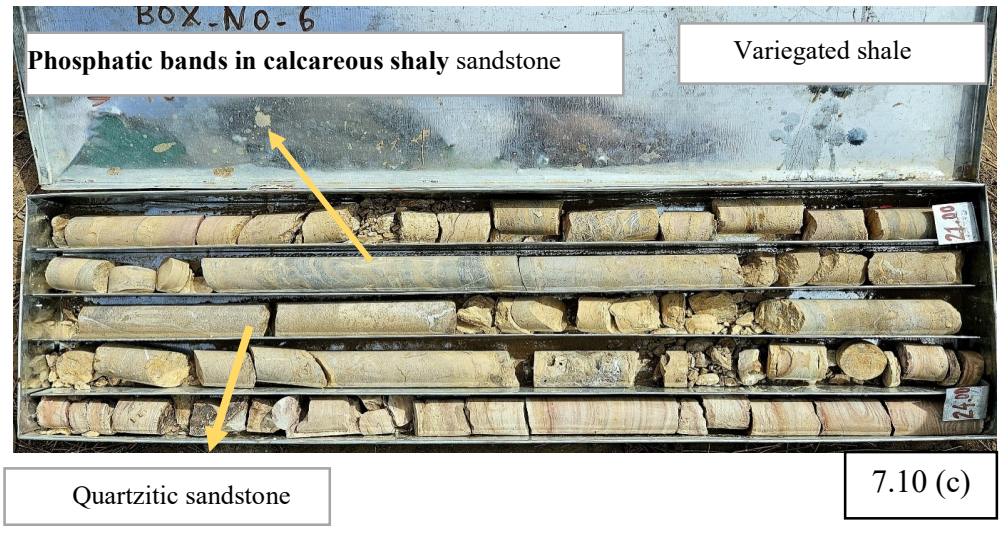


Fig. 7.10 Phosphorite exposure in calcareous shaly sandstone along section S13-13' (a) in contact with quartzitic sandstone along the eastward dipping limb of anticlinal fold (b) in contact with shale along the westward dipping limb of anticlinal (c) Phosphorite bands in calcareous shaly sandstone from BH MNP 12 from 20.00 to 25.00m.

7.5.5.8 Between Section lines S1A-S1A' and S12-A12', the banded phosphorite is associated with fine-grained, yellowish brown to grey limestone unlike in northern part where phosphate beds intermixed with shale. Dark phosphorite bands that are 4 to 10 cm thick alternate with the limestone in certain locations and drill cores (Fig.7.11).

Fig. 7.11. Banded phosphatic limestone in BH MNP15 from 17.00 to 22.00m.

7.5.5.9 Out of 56 nos. of boreholes (32 nos. by MECL and 24 nos. by GSI) drilled in Nimbli block, phosphorite zone (demarcated at 5% P_2O_5 cutoff) is intersected at depth ranging from 0.80 m vertical depth in B-46 to 57.35 m vertical depth in B-58 and thickness varying between 0.99 m (MNP-07, P_2O_5-5.55%) and 11.88 m (MNP-02, P_2O_5-7.56%).

7.5.5.10 A mixed solution of Ammonium Molybdate, Vanadate regent and Nitric acid (Shapiro Solution – After Leonarda Shhapiro, United States Geological Survey) is used for identification of phosphatic rock. When solution is dropped upon the specimen, presence of phosphorus is indicated by a yellow - coloured stain or a crust of yellow phospho-ammonium molybdate (Fig.7.12). Thus, by scanning with Shaprio solution undesired sampling and analyzing of non-phosphatic rock could be eliminated.

Fig. 7.12: Yellow effervescence on reaction of Shapiro solution in contact of phosphorite.

7.5.6 VARIEGATED SHALES AND YELLOW CHERTY LIMESTONE

7.5.6.1 In Northern part of block, invariably overlying the phosphorite are shales, varying in colours from light grey-yellowish to dull white and purplish red. This banded shale is intersected immediately above the phosphate horizon in boreholes drilled between section lines S12-S12' and S15-S15'. One sample MNP21/ P-13 studied under microscope reveals that ferruginous matter is present as reddish amorphous aggregates and patches, seen segregating into zones. In boreholes the shale horizons vary in thickness from 10m to 20m. The lower portion of this horizon is associated with thin calcareous phosphatic bands.

7.5.6.2 Variegated shale found in association with siliceous yellow cherty limestone between section line S1A-S1A' to S10-S10'overlying the phosphatic horizon and also shows intercalatory relation at some places while the yellow cherty limestone rests directly on the phosphatic horizon elsewhere. In boreholes drilled between these sections it is clearly evident that variegated shale / yellow limestone intercepting above phosphorite (fig7.13).

7.5.6.3 The yellow cherty limestone is a brownish-yellow fine-grained rock in which sub spherical and flattened oval shaped pebbles of clayey limestone are seen. Its lower beds in contact with phosphorite shows fissile nature. This unit which varies in thickness from 5 to about 20 m in boreholes (fig7.14 (a) & (b)).

Fig. 7.13 Variegated shale intercepted in borehole MNP30- 14.00 to 18.00m.

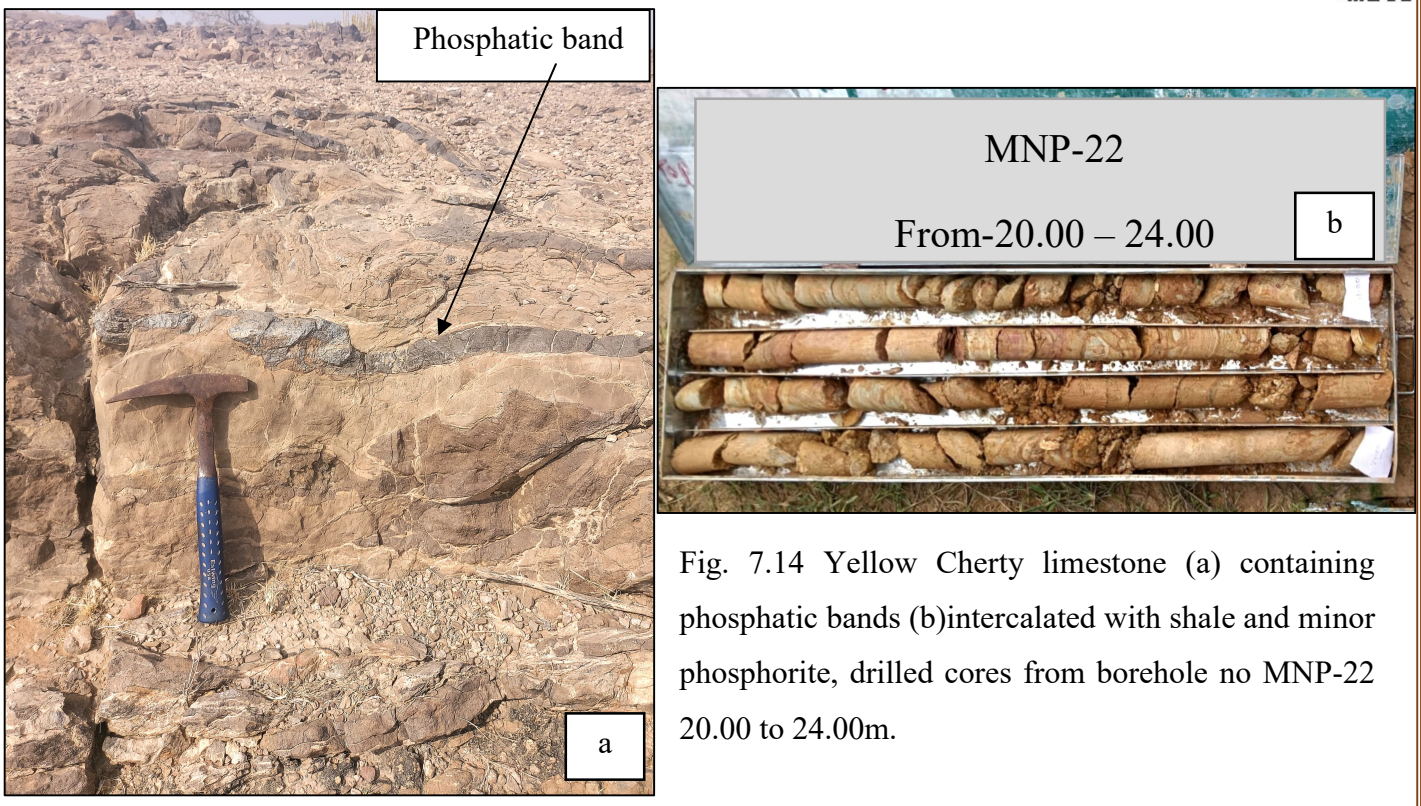


Fig. 7.14 Yellow Cherty limestone (a) containing phosphatic bands (b)intercalated with shale and minor phosphorite, drilled cores from borehole no MNP-22 20.00 to 24.00m.

7.5.7 DOLOMITIC LIMESTONE

7.5.7.1 The dolomitic limestone is a fine grained, dense, hard, bluish-grey thick bedded rock, with individual beds being 2 to 20 m thick. The rock type is the youngest member of the Birmania Formation. It shows typical 'elephant skin' weathering surface. The prominent feature of this formation can be traced along NE-SW trending mounds which are rising up to height of 25 m from the surface along multiple synclinal axes of folding.

7.5.7.2 Calcareous cherty limestone overlies dolomitic limestone on the surface. Thin veins of calcite and rarely chert of secondary origin along with ferruginous matter is seen traversing the rock. Vertical thickness of 35.40m up to 59.40m intersected in MNP-26 in which the rock type overlain by the black shale.

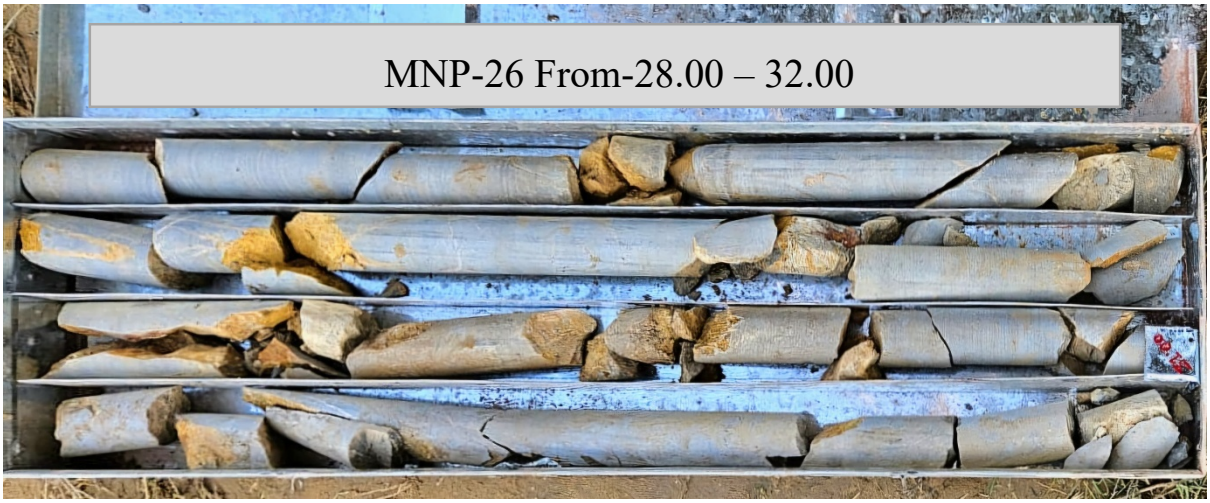


Fig. 7.15 Dolomitic limestone intercepted in borehole no MNP-26 28.00 to 32.00m.

7.5.8 AEOLIAN SOIL/SAND

7.5.8.1 Most of the area in the block is covered with aeolian sand with an average thickness of 5m, however in boreholes the thickness ranges from 0.50m to 1.00m. The sand is light brown to brown in colour, associated with kankar (fig. 7.16).

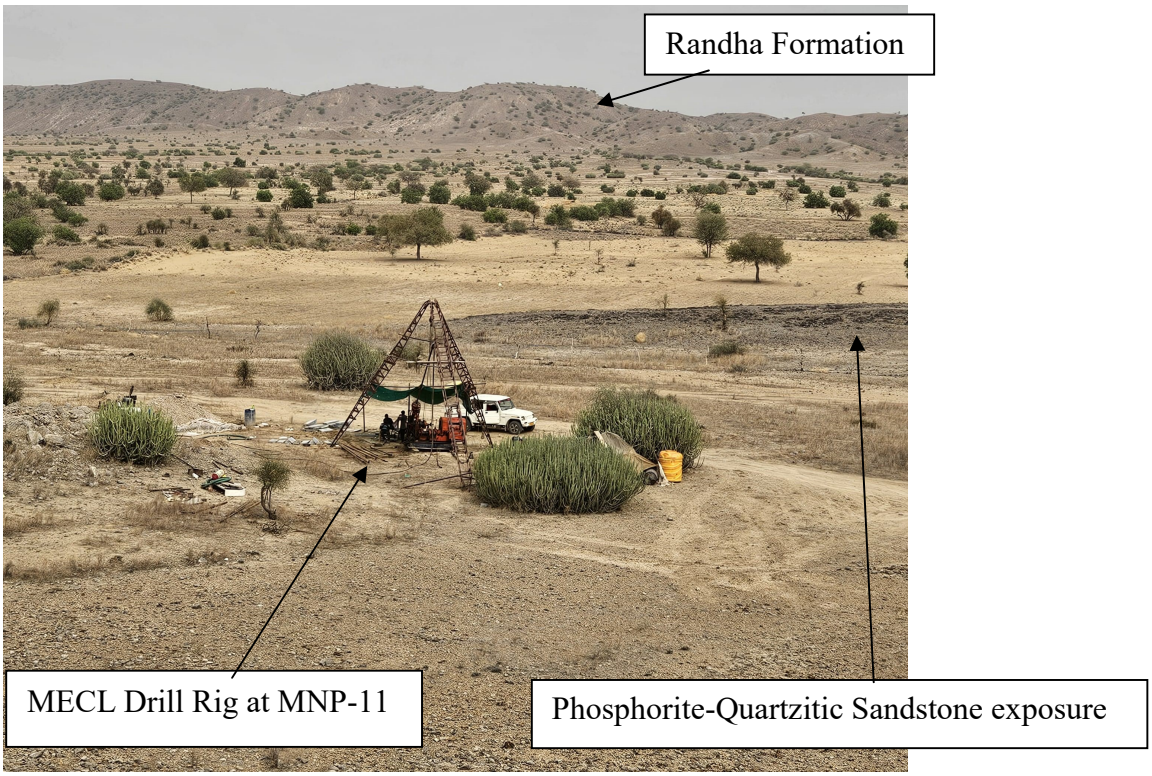


Fig. 7.16 Field Photograph of Aeolian sand cover

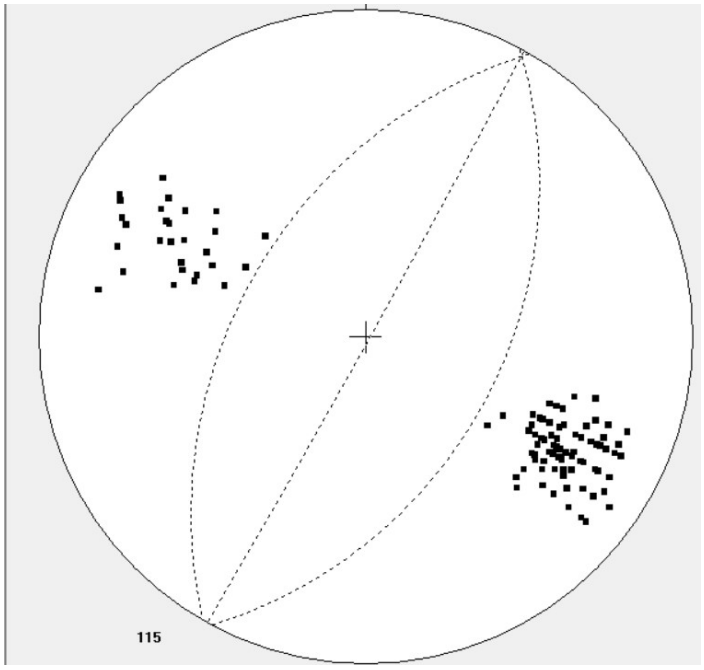
7.6.0 STRUCTURE WITHIN THE BLOCK

7.6.1 Nimbli block is part of the Birmania basin which comprises of asymmetric doubly plunging longitudinal apex fold which extends in NE-SW direction over a strike length of approx. 5km (Regional Map Plate II, Text fig 7.2).

7.6.2 Nimbli block (2.5km NE-SW strike) is carved along 5km strike of the phosphorite deposition and structurally the Nimbli block can be divided into three areas i.e., Northern, Central and Southern. Northern area comprises of one doubly plunging anticline and one doubly plunging synclinal fold traced along NE-SW phosphorite-sandstone litho-association. In central area only one limb which is phosphorite-sandstone strike NE-SW along 1100m and southern area comprises of EW to NW-SE trending phosphorite-sandstone litho-association. In the entire block folding forms, a system of asymmetric, longitudinal, sharp-apex, doubly plunging as well as open folds which are traced all along strike and dip of deposit.

7.6.3 To understand the structure of the block, bedding data from all the formations has been collected and plotted on stereo net, which inferred two limbs, out of which the westerly dipping limb strike N30°E dipping at 58°

due NW and one easterly dipping limp striking N28°E with 56° dip due SE. The plunge of the fold is trending N29°E with the axial plane is dipping at 89°due SE.



1: Westerly dipping Limb: N30°E/58° due 300
2: Easterly Dipping Limb: N28°E/56° due 118
3: Axial Plane: N29°E/89° due 119

No. of Data = 115
Mean Principal Orientation = 69/299
Mean Resultant dir'n = 41-302
Mean Resultant length = 0.67
(Variance = 0.33)
Calculated. girdle: 88/208
Calculated beta axis: 2-028
Girdle1: 58/300 [axis: 32-120]
Girdle2: 56/118 [axis: 34-298]
Girdle3: 89/119 [axis: 1-299]

Fig 7.17 Stereo Net Plot of Primary Bedding Planes

7.6.4 The general strike of beds and the fold axis is NNE-SSW though local variations in response to minor folding are common. The dip of bedding ranges from 35º to 80º westwards or eastwards, due to folding. Along the limbs of the folds, the dips are usually steeper, giving rise to the progressive asymmetry noticed across the strike. The axial planes of folds are nearly vertical or dip at angles of more than 80º. A number of micro to large folds are seen in the area along with one main doubly plunging anticline and one doubly plunging syncline.

7.6.5 In the southern part of the block the general strike of the beds turns to nearly east-west and the strike of the folds to north-south. All along the strike of formation there are numerous small scale strike slip and dip slip faults. One strike slip fault has been mapped striking N25ºW causing repetition of the phosphate beds as seen on ground.

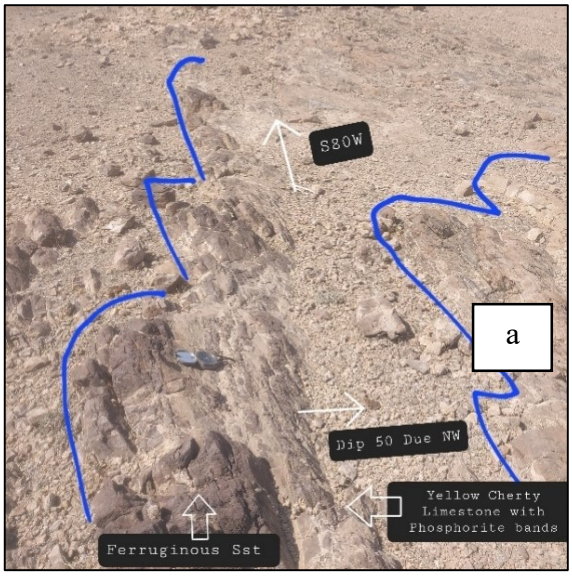


Fig 7.18 (a) Repetition of folding in phosphatic limestone southern margin of block.

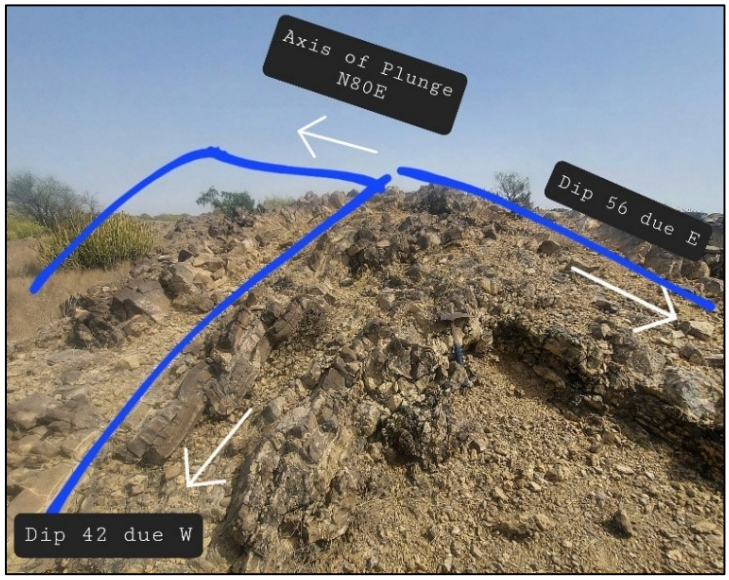


Fig 7.18 (b) Folding of ferruginous sandstone and phosphatic limestone plunging N80°E

7.6.6 All the formations in the area are complexly folded, within few meters dip changing corresponding to the fold and fold axis plunging either northwards or southwards (fig 7.19), plunge ranging between 5º to 35º. The larger folds plunge at angles of 25º to 30º with the plunge varying when traced along the axes.

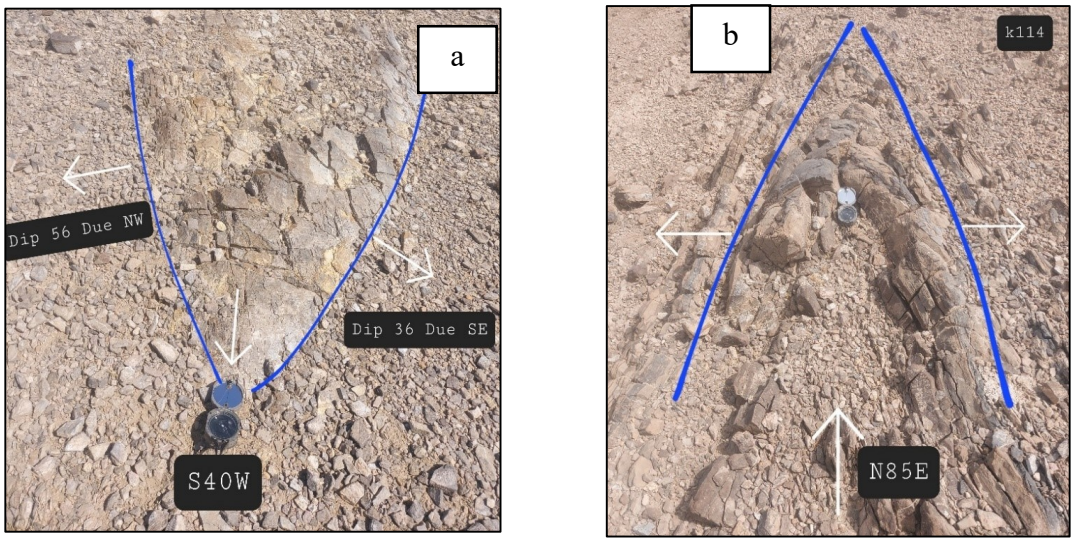


Fig 7.19 (a) fold plunging SW in Calcareous sandstone (b) Plunging NE in Phosphatic limestone

7.6.7 Only one limb over a strike length of 1500m is exposed between sections S2-S2' and S10-S10' and remaining area being sand covered.

7.6.8 Folding in the area comprises of open folds, chevron folds, recumbent folds and micro scale folding owing to the regional fold (fig7.20, 7.21, 7.22).

Fig 7.20, 7.21 : Intense folding of Phosphorite and shale bands as seen in excavated Pit along the ore body in adjacent area (Outside Nimbli block)

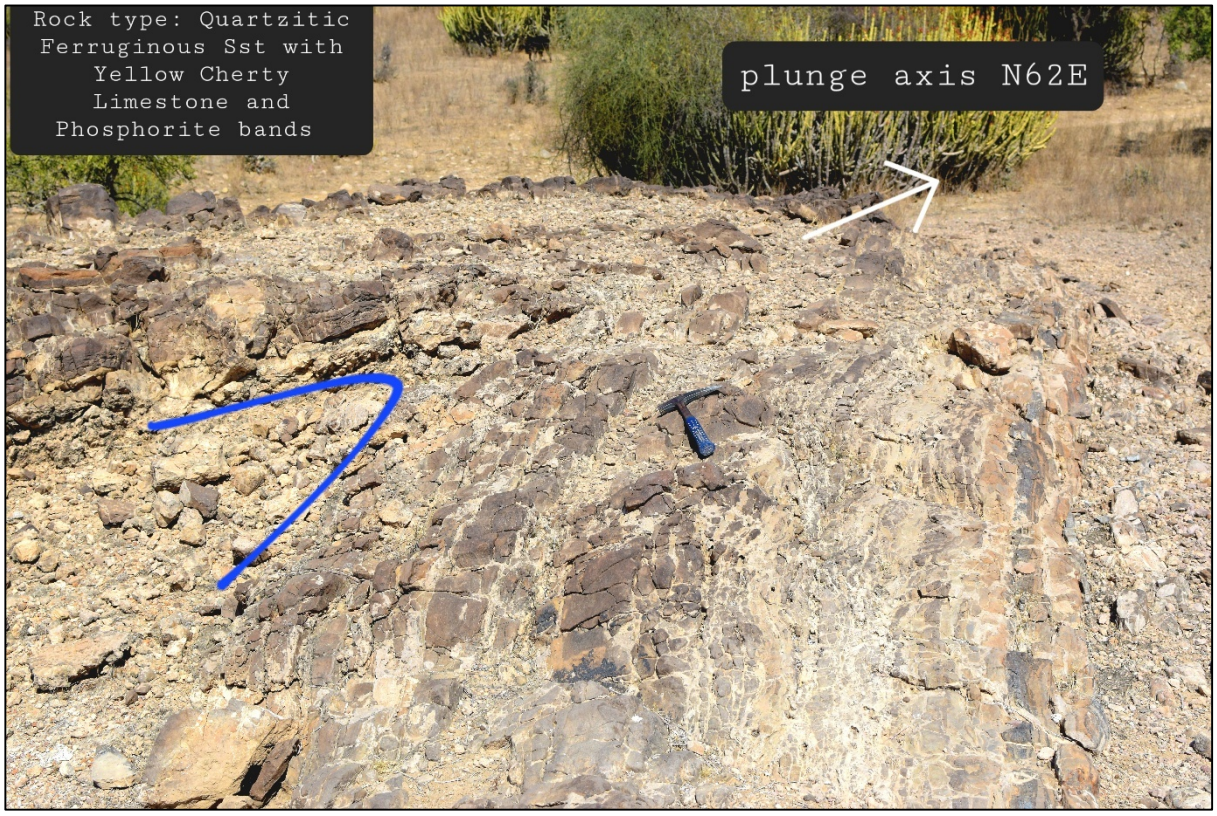


Fig 7.22 folding along Section S1A-S1A' in Quartzitic sandstone and yellow cherty limestone (with dark phosphorite bands)

7.6.9 Joints are associated with the bedding plane and observed in the younger formation i.e limestone/dolomitc limestone.

7.6.10 The sharp apex longitudinal nature of the folds, the absence of axial plane cleavage of foliation, general asymmetry, irregular pattern and discontinuity of folds suggest that the folds are superficial and not deep seated and confined to bimania phosphorite deposition.

7.6.11 The folds in the phosphate bands are often asymmetric and discontinuous, which is consistent with deformation caused by tectonic compressional forces. The presence of doubly plunging folds is a classic indicator of tectonic folding. These features arise when compressional forces act obliquely or variably, causing folds to have a plunging hinge on both ends. The Birmania formation, has undergone multiple phases of tectonic activity, particularly during the Mesozoic and later periods. The tectonic stresses during these events likely caused the deformation of the phosphate bands.

7.7.0 PHOSPHATE MINERALISATION

Genesis of phosphate mainly known as phosphogenesis occur in various kinds of deposit, which are described below:-

(i) Igneous Phosphate deposits,

(ii) Biogenic (Guano bird or Island) deposits&

(iii) Marine Sedimentary deposits

7.7.1 Approximately 75% of world phosphate production comes from marine sedimentary deposits followed by Igneous phosphate deposits (15%).

7.7.2 Most of the world's phosphate production comes from marine phosphorites. The richest and largest of these deposits form at low latitudes in areas of upwelling associated with divergence, chiefly along the west coasts of the continents or, in large Mediterranean seas, along the equatorial side of the basin. Lesser but significant concentrations form along the west sides of poleward-moving warm currents along the eastern coasts of continent.

7.7.3 The majority of marine sedimentary phosphates are the result of interaction between complex biogeochemical processes that occur under particular environmental conditions (Diagram given below). Continental margins and epeiric seas seem to be the most favourable locations for the accumulation of phosphate deposits. They occur at depths varying between 100 and 500 m, with a limited supply of terrigenous and carbonate detritus, which corresponds to a phosphogenic window. In these environments, upwelling currents play an essential role in lifting phosphorus-rich deep water to the surface, triggering significant biological productivity. A shift from suboxic to sulfidic conditions seems to coincide with the highest rate of apatite precipitation.

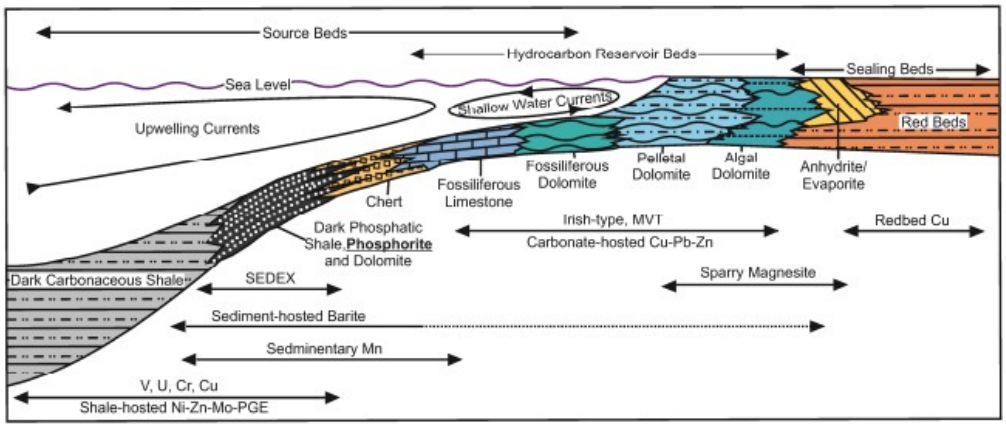


Fig 7.23 Schematic pattern of sedimentation, currents, petroleum generation, and metal accumulation in the Phosphoria sea (modified from Sheldon, 1963)

7.7.4 Phosphate-bearing rocks are generally stratiform; bed thicknesses range from less than 1 metre to tens of metres and may extend for distances up to several hundreds of kilometres in their longest dimension. The thickest deposits are amalgamated/condensed beds (tabular units) reflecting variations in upwelling intensity and storm frequency through time. Individual phosphorite deposits delimited by drilling may measure from a few hundreds of meters to tens of kilometres in their longest dimension. Phosphorite deposits commonly occur in belts.

7.7.5 Generally, Phosphorite deposits are associated with sedimentary rocks including marl, black shale, chert, limestone, dolostone, and in some cases lava flows, tuffs and diatomite-bearing rock.

7.7.6 Earth crust contains of about 0.27% of P_2O_5 and about 200 minerals are known that contain 1% or more of P_2O_5. Apatite is the primary mineral but a number others are common in deposits formed during weathering of phosphate rock and guano examples are brushite ($HCaPO_4v_2H_2O$),Monetite($HCaPO_4$),Whitlockite($HCa_3(PO_4)_2$),Crandallite($Ca_3Al_3(PO_4)_2)(OH)_5$ .H_2O),Wavelite($Al_3(OH)_3(PO_4).5H_2O$), Taranakite (K_2Al6 $(PO_4)_6$ $(OH)_2.18H_2O$), Millisite (Na,K) CaAl6(PO_4)4 $(OH)_9.3H_2O$), Variscite ($AlPO_42H_2O$) and Strengite ($FePO_4.2H_2O$).

7.8.0 PHOSPHATE MINERALOGY IN NIMBLI BLOCK

7.8.1 The lithological association i.e. shale, limestone, sandstone and phosphate indicate shallow marine setting.

7.8.2 In the Nimbli block, the phosphate rock occurs as thin to massive bed in calcareous shaly sandstone and banded limestone. Phosphatic deposition shows interbedded relation with overlying shale.

7.8.3 Petrography/Mineragraphy/XRD studies has been carried out on 20 nos. of drill core samples. Out of which 15 samples has been analysed under petrographic studies and 05 no. of samples analysed for mineragrphic studies, details of which are given below:

7.8.4 Petrographic studies - Petrographic studies on phosphorite samples reveals that quartz and Calcite forms the major mineral assemblage. Collophane, illite, ferruginous matter, chlorite, dahllite forms the minor mineral assemblage. Tourmaline, zircon, sericite and opaques occur as accessory minerals.

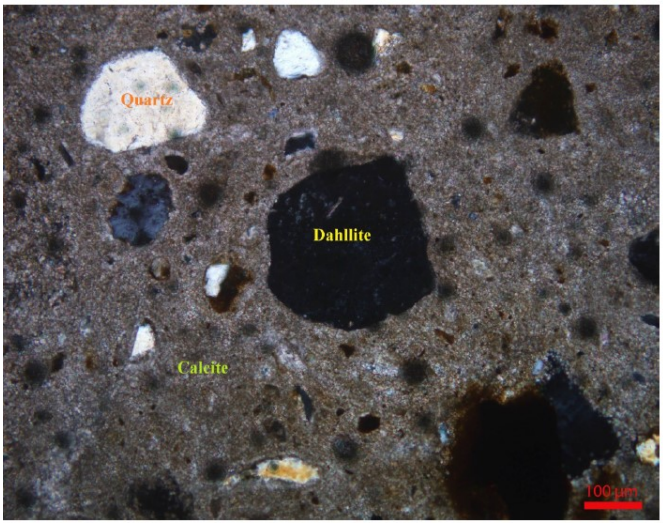


Fig 7.24. Photomicrograph showing subrounded dahllite patch within quartz wacke as seen under cross nicolst. Specimen No.: MNP01/P-01 Magnification: 100X

Quartz occurs as fine to medium subrounded grains floating over very fine micritic matrix (fig. 7.9 b). Framework grain to matrix ratio is almost equal. Collophane occurs as fine pisolites, patches and as very fine amorphous aggregates in association with calcite. Ferruginous matter is present as reddish patches and fillings, mostly within quartz rich laminations and also seen over calcitic aggregates. Clay minerals occur as very fine flaky aggregates within quartz rich laminations. Illite occurs as very fine flaky aggregates in segregated zones. Sericite is present as very fine disseminated flakes. Tourmaline and zircon are noted as very fine prismatic grains in accessories.

7.8.5 Mineragraphic studies: Mineragraphic studies on phosphorite samples reveals that goethite, hematite, limonite and rutile/anatase forms the major mineral assemblage. Magnetite and Ilmenite forms the minor mineral assemblage and pyrite found as accessory minerals. Goethite and hematite together occur as intermixed patches and patchy fillings showing compositional zoning, where hematite is seen being replaced by goethite (Fig7.24.). Hematite is also noted as very fine disseminated specks associating very fine specks and blades of rutile/ anatase. Limonite occurs as reddish patches, fillings and amorphous aggregates, especially along pores and cavities. Magnetite/ ilmenite are noted as fine subhedral grains. Pyrite is noted as very fine specks in accessories.

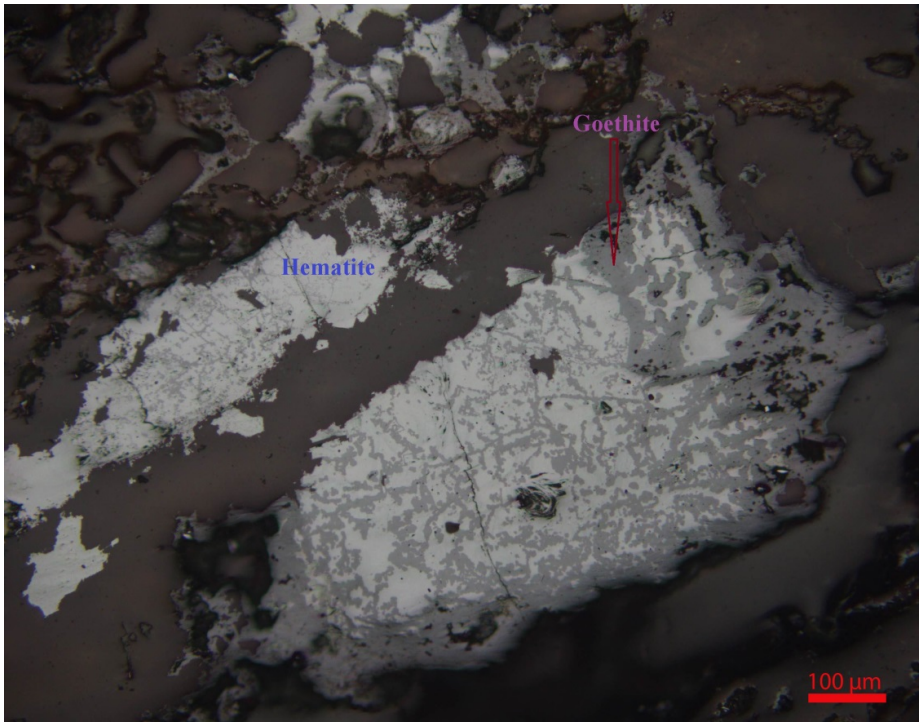


Fig7.25. Photomicrograph showing hematite patches being replaced by goethite fillings as seen under reflected light. Specimen No.: MNP32/M-05 Magnification: 100X

7.8.6 Collophane is the main phosphorite mineral present in the Nimbli block, occurring as amorphous aggregates, patches and pisolites within different rock types viz. quartz wacke, limestone and shale. Mostly it is present in minor level of concentration, i.e., in the range of 1-5% in the bulk. It is often seen being replaced by calcite. Dahllite/ apatite/ well crystalline phosphorite mineral concentration are rarely found in areas; may be due to higher diagenetic level to lower level of metamorphism

7.8.7 **XRD Studies:** A total of 10 nos. of samples have been submitted to Chemical Lab, MECL, Nagpur. The samples details are tabulated in table below

Sl. No.	Sample Name	Major (≥ 5 %)	Minor (≤ 5 % to ≥ 1 %)	Trace, Faint Trace (≤ 1 %)
1	MNP/XRD-01	Quartz, Apatite, Muscovite	Kaolinite, Calcite	Langite
2	MNP/XRD-02	Quartz, Apatite, Calcite, Muscovite-Paragonite	Kaolinite, Illite	Phlogopite, Hollandite, Biotite
3	MNP/XRD-03	Quartz, Apatite, Calcite	Illite	Kaolinite, Magnetite, Langite, Barite
4	MNP/XRD-04	Quartz, Apatite, Crandallite, Muscovite, Calcite	Phengite	Goethite, Biotite
5	MNP/XRD-05	Quartz, Apatite, Muscovite, Calcite, Phengite, Crandallite	Illite	Phlogopite, Kaolintie, Magnesite
6	MNP/XRD-06	Calcite, Quartz, Apatite	Carlinite, Goethite	Birnessite, Jacobsite, Zeolite, Illite
7	MNP/XRD-07	Quartz, Calcite, Muscovite	Apatite	Biotite, Goethite, Tourmaline, Langite

Sl. No.	Sample Name	Major (≥ 5 %)	Minor (≤ 5 % to ≥ 1 %)	Trace, Faint Trace (≤ 1 %)
8	MNP/XRD-08	Apatite, Quartz, Calcite, Muscovite	Langite, Biotite	Kaolinite, Sericite
9	MNP/XRD-09	Quartz, Calcite, Muscovite, Apatite	Sericite, Goethite, Biotite, Dickite	Phengite, Phlogopite, Hollandite
10	MNP/XRD-10	Quartz, Calcite, Muscovite, Apatite, Illite	Biotite	Kaolinite, Phengite, Brucite

7.8.8 Maximum thickness of phosphorite bands (11.88m in MNP-02) is found in northern region of the block whereas thickness along with grade decrease while traversing southwards.

7.8.9 On the primary sample analysis which was carried out for 5 radicals viz P_2O_5, Fe_2O_3, Al_2O_3, SiO_2, LOI, zone was demarcated on the basis of 5% P_2O_5 cutoff (IBM guidelines). The maximum P_2O_5 analysed is 18.92% (B-48, 4.40m) and minimum P_2O_5 analysed is 5.59% (MNP-12, 1m).

CHAPTER - VIII

8.0.0. PREVIOUS EXPLORATION

8.1.0 Geological Survey of India (GSI) – W.T.Blanford (1877), C.A. Hacket (1881 & 1887) were the first stalwarts who have studied this region, followed by R.D. Oldham (1866 & 1893), T.D. LaTouche (1911) and A.M. Heron (1932) and by Swaminath (1960-62).

8.2.0 General account of the geology is given by A.M. Heron and E.W. Pascoe. Detailed geological mapping was carried out by Narayanan, J.S. Mishra, V.S.Depura, B.P. Srivastava and S.Srivasan of the Oil and Natural Gas Commission between 1959 and 1962.

8.3.0 GSI in the year 1966 carried out geology and preliminary assessment of the Birmania phosphorite deposit, Jaisalmer district, Rajasthan. Assessment was carried out by Shri B.Srikantan, V.N.Sant, S.B.Sharma and associated workers

8.4.0 Shri B.Srikantan et al. 1968-70, have divided the Birmania and Kohra area into 5 sub blocks each and Ladu-Singh area into four sub blocks and accordingly carried out geological mapping, trenching and sampling. They have given the account for complex folding, change in nature and thickness of phosphorite beds and estimated a probable resource of 4.34 million tonnes with average grade of 9.95% P_2O_5. Out of estimated probable resource, Birmania block which has 5 sub-blocks accounts for 3.64 million tonnes with average 10.22% P_2O_5., Kohra which also has 5 sub blocks accounts for 0.55 million tonnes with average 8.86%P_2O_5., and Ladu-Singh block accounts for 0.15 million tonnes with average 9.72% P_2O_5.

8.4.1 Shri B.Srikantan et al. have Recommended the block to be taken up for exploratory drilling.

8.5.0 FS: 1968-70, GSI carried out exploratory drilling for phosphorite at Birmania, under Shri G.P.Deshmukh.

8.5.1 Birmania phosphate area (approx. area 4 sq.km) was divided into three major blocks i.e., (i) Birmania, (ii) Ladu Singh, and (iii) Kohra

8.5.2 Birmania block was selected for exploratory drilling owing to strike persistence of phosphorite over a strike length 2.2 km, dividing the Birmania area into 5 sub blocks as per 1966 exploration report.

8.5.3 A total 2053.89m of drilling was carried out in 68 no of boreholes and phosphorite was intersected in 55 no of boreholes at depths varying from 1.5 to 40.0 m

8.5.4 Resources were estimated at 10% P_2O_5 cut-off and minimum width of 1.5m and established 3.49 million tonnes with average grade 12.91%.

8.5.5 Ore beneficiation studies were carried out at Indian Bureau of Mines (IBM) during the same year and IBM opined that by both "Air and Flotation type test the ore is not amenable for beneficiation on account of high percentage of lime and intimate association with amorphous collophane (phosphate mineral). It is also observed that sample does not produce any concentration due to uniform distribution of phosphate from coarse to fine.

8.5.6 GSI did not recommend the block for further work, stating that the deposit is not economically viable as in the year 1970.

8.6.0 In the year 2022, MECL has carried out G-2 level exploration in Notified Mining Lease area (about 4 sq.km) of FCI Aravali Gypsum and Minerals India Limited (FAGMIL) (PSE, Ministry of Chemical and Fertilizers),which is part of Birmania phosphorite deposit. A total 3752.00m of drilling was carried out in 69 no of boreholes and phosphorite was intersected in 34 no of boreholes at depths varying from 0.5 to 64.0m with average thickness of 5.733m at 5% cut off. A total 4.54 million tonnes of net in-situ resources of phosphorite with average grade of 10.04 % P_2O_5 have been established along 1.4km strike length of Birmania Sector (1.78 sq km) and 0.09 million tonnes of net in-situ resources of phosphorite with average grade of 6.15 % P_2O_5 have been established along 0.4km strike length of Ladu Singh Sector (0.58 sq km). A total of 4.63 million tonnes resource of phosphorite in both Birmania and Ladu Singh Sector are estimated by MECL.

CHAPTER - IX

9.0.0. AERIAL OR GROUND GEOPHYSICAL OR GEOCHEMICAL DATA

9.1.0. Details of aerial, ground geophysical and geochemical survey

9.1.1 Aerial or Ground geophysical survey had not been carried out in the Nimbli block area.

CHAPTER - X

10.0.0. EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 **INTRODUCTION:**

10.1.1 On approval of EC, NMET, the following scheme of exploration has been formulated. The objectives are given below:

The exploration proposed by MECL with the following objectives:

a. Updating of Geological map on 1:2000 scale with structural mapping and to carryout drilling to prove the extension of mineralization.

b. Topographical survey at 1:2,000 scale, with 2m contour interval.

c. To establish the 2.5km strike (NNE-SSW) and depth continuity of the phosphorite ore body through subsurface drilling in two phases, phase-I boreholes will be drilled on 400m section interval and followed by 200m section interval in phase-II.

d. To estimate phosphorite resources as per UNFC norms at > 5% cutoff (IBM threshold value) as per Minerals (Evidence of Mineral Contents) Rules 2015 amended upto 2021.

e. To facilitate the state govt. for auction of the block.

10.1.2 MECL commenced exploration work comprising of geological mapping, topographical survey on 29.01.2024 and completed on 05.03.2024. Geological mapping and topographical survey data was reviewed in the 64th TCC held on 25th, 29th & 30th April 2024, the committee after deliberation and the review of exploration data opined that planning of boreholes needs to be done with the diligent understanding on the structure of the block and committee deliberated on the matter and recommended for inclined boreholes to be drilled in the block.

10.1.3 MECL commenced drilling operations on 24.05.2024 and completed on 30.09.2024, a total 1293.00 meters of drilling was completed in 32 no of borehole which were drilled in two phases (phase -I 15 no of boreholes, Phase -II 17 no of boreholes)

10.1.4 The allied field-work including DGPS survey, sampling etc. were completed simultaneously. The analytical/laboratory studies were carried out simultaneously in laboratories of MECL and other Govt. /NABL accredited laboratories.

10.1.5 The quantum of work proposed vis-à-vis quantum of work carried out is furnished in Table no 10.1.

Table No 10.1
Details of Exploratory Work carried out by MECL in Nimbli block area, Dist Jaisalmer, Rajasthan

Sl. No.	Item of Work	Unit	Approved Quantum of work	Achieved
1	Geological Mapping (on 1:2,000 Scale)	sq km	2.70	2.70
	Topographical Survey (on 1:2,000Scale)	sq km	2.70	2.70
2	Geochemical Sampling	Nos.	50	42
	Channel sampling			
3	Exploratory Drilling (Core drilling)	m	1700 m (32 BHs)	1293 m (32 BHs)
5	Laboratory Studies			
	A. Surface samples (Bedrock sampling / channel sampling)			
	i) Chemical Analysis; Primary for 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI	Nos.	50	42
	B. **Primary samples for Borehole**			
	i) Chemical Analysis; Primary for 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI by XRF method	Nos.	350	367
	iii) External Check sample (10% of Primary samples) for analysis of 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI	Nos.	35	35
	C. 34 Elemental Trace Element Studies on Composite sample from zones of borehole samples			
	Composite samples will be analyzed for34 radicals i.e. V, Ba, Cr, Ga, Rb, Cs, Ca, U, Th, Eu, Hf, La, Lu, Sm, Tb, Yb, Ce, Dy, Er, Nd, Pr, Tm, Sc, Y, Zn, Cu, Pb, Ni, Co, Cd, Sc, Ag, Li, Mo	Nos	30	23
6	**Physical Studies**			
8	XRD studies	Nos	10	10
9	Complete Petrographic/ Ore microscopic study/ Minerographic Studies	Nos	20	20
11	Specific Gravity Determination	Nos	10	10
12	Report Preparation (Digital format)	Nos.	1	1

10.2.0 **DETAILS OF PITTING, TRENCHING, DRILLING AND ITS DISTRIBUTION:**

10.2.1 Pitting and trenching activities have not been carried out in the block area.

10.2.2 The approved scheme of Preliminary Exploration (G-3) work in Nimbli Block includes Geological mapping, exploratory drilling, core logging, core sampling and associated laboratory studies.

10.3.0 **Exploratory Drilling:** During the present exploration program, drilling was planned along 2.5 km NE-SW strike of the deposit along which, 16 nos. of section lines marked in NW-SE

direction placed approximately 200m apart. On these section lines a total 32 nos. of boreholes involving total 1293.00m drilling was carried out to check the grade, thickness, strike and depth continuity of Phosphorite ore body in the block area.

10.3.1 Drilling was completed in two phases, Phase-I a total 15 no of boreholes (MNP-01 to MNP-15) involving 541.00 m of drilling and Phase -II a total 17 (MNP-16 to MNP-32) no of boreholes involving 752.00m drilling, thus overall in 32 no of boreholes 1293.00m of drilling was done in Nimbli block.

10.3.2 Intersection data of 24 nos. of boreholes drilled by GSI (B-32 to B-65) are considered for correlation and resource evaluation for phosphorite beds. A total 838.13m was completed in 24 no of boreholes (1968-70, GSI carried out Exploratory drilling for Phosphorite at Birmania).

10.3.3 In 1968-69 Geological report, Geological map and drilling data was compiled in local co-ordinate system and MECL during topographical survey identified few boreholes on ground which are drilled by GSI and accordingly transformation of maps is done to present coordinate system (UTM). Accordingly, GSI data set is used to construct the geological controls in the section along with MECL boreholes and making mineralized zone correlation etc.

10.3.4 Details of boreholes drilled by MECL (2023-24) and previously drilled boreholes by GSI (1968-70) with total depth are summarised in below given table 10.2 and 10.3 and submitted as Annexure No. IB and IC respectively.

Table-10.2
Details of Boreholes drilled by MECL in Nimbli block area, Dist. Jaisalmer, Rajasthan

Sl. No	Borehole No.	Reduced Level (m)	Northing (m)	Easting (m)	Dip of Borehole	Azimuth of Borehole	Date of Comme-ncement	Date of closure	Depth of Borehole (m)
1	MNP-01	254.106	2902768.15	692427.09	60°	115°	24.05.3024	30.05.2024	35.00
2	MNP-02	259.176	2902721.17	692510.66	57°	305°	31.05.2024	06.06.2024	32.00
3	MNP-03	249.465	2902391.53	692358.91	57°	300°	06.06.2024	11.06.2024	31.00
4	MNP-04	249.271	2902365.44	692390.86	58°	120°	08.06.2024	13.06.2024	30.00
5	MNP-05	252.076	2902175.3	691789.86	60°	120°	13.06.2024	18.06.2024	30.00
6	MNP-06	254.006	2902035.56	692165.52	57°	120°	15.06.2024	18.06.2024	27.00
7	MNP-07	258.346	2901533.83	691408.09	55°	120°	19.06.2024	23.06.2024	27.00
8	MNP-08	254.401	2902046.7	692167.88	55°	300°	20.06.2024	23.06.2024	25.00
9	MNP-09	260.069	2901558.55	691337.16	90°	0°	25.06.2024	07.07.2024	60.00
10	MNP-10	248.214	2902471.9	692205.54	55°	120°	25.06.2024	30.06.2024	28.00
11	MNP-11	267.959	2901164.9	691119.01	55°	120°	01.07.2024	07.07.2024	40.00
12	MNP-12	266.913	2900929.25	690881.46	55°	130°	08.07.2024	14.07.2024	40.00
13	MNP-13	252.995	2901817.57	691581.95	55°	115°	09.07.2024	13.07.2024	25.00
14	MNP-14	271.09	2901191.67	691069.07	50°	300°	16.07.2024	28.07.2024	75.00

Sl. No	Borehole No.	Reduced Level (m)	Northing (m)	Easting (m)	Dip of Borehole	Azimuth of Borehole	Date of Comme-ncement	Date of closure	Depth of Borehole (m)
15	MNP-15	258.544	2900891.62	690504.73	60°	155°	16.07.2024	21.07.2024	36.00
16	MNP-16	250.002	2902090.29	691617.51	55°	260°	25.07.2024	03.08.2024	60.00
17	MNP-17	249.692	2902076.93	691680.86	55°	110°	29.07.2024	06.08.2024	50.00
18	MNP-18	247.993	2902347.72	691951.47	55°	120°	05.08.2024	11.08.2024	50.00
19	MNP-19	263.648	2901401.9	691239.88	55°	300°	08.08.2024	15.08.2024	70.00
20	MNP-20	261.831	2901377.28	691284.54	55°	120°	13.08.2024	22.08.2024	50.00
21	MNP-21	261.501	2902769.92	692844.82	90°	0°	17.08.2024	22.08.2024	44.00
22	MNP-22	266.254	2901052.22	691054.54	55°	120°	24.08.2024	27.08.2024	35.00
23	MNP-23	250.469	2902204.21	692262.85	55°	120°	24.08.2024	28.08.2024	40.00
24	MNP-24	266.939	2901047.78	691030.86	55°	300°	29.08.2024	04.09.2024	40.00
25	MNP-25	250.366	2902210.93	692251.64	55°	290°	29.08.2024	03.09.2024	40.00
26	MNP-26	253.513	2901907.77	691569.16	90°	0°	05.09.2024	12.09.2024	65.00
27	MNP-27	262.61	2900850.64	690695.2	55°	190°	05.09.2024	09.09.2024	35.00
28	MNP-28	266.25	2900746.11	690587.83	90°	0°	11.09.2024	15.09.2024	30.00
29	MNP-29	268.903	2901148.2	690897.45	55°	145°	14.09.2024	19.09.2024	35.00
30	MNP-30	249.272	2902225.65	692390.06	55°	120°	17.09.2024	22.09.2024	40.00
31	MNP-31	261.644	2900860.07	690659.06	55°	10°	20.09.2024	28.09.2024	40.00
32	MNP-32	257.623	2901970.66	692460.46	90°	0°	24.09.2024	30.09.2024	28.00

Table-10.3

Details of Borehole drilled by GSI in Nimbli block, District Jaisalmer, Rajasthan
(Co-ordinates are arrived after georeferencing the original map with field identification of two GSI boreholes)

Sl No	Borehole No.	Reduced Level (m)	Northing (m)	Easting (m)	Dip of the Borehole	Date of Comm-encement	Date of closure	Depth of the Borehole
1	B-32	258.35	2902914.71	692601.751	90	22.08.69	13.10.69	24.25
2	B-33	258.3	2902970.009	692634.504	90	31.08.69	06.09.69	27.30
3	B-34	256.65	2902894.917	692516.148	90	07.09.69	13.09.69	31.30
4	B-35	254.43	2902768.278	692426.656	90	14.09.69	17.09.69	25.50
5	B-36	252.07	2902651.71	692330.221	90	18.09.69	19.09.69	17.00
6	B-37	249.26	2902529.492	692237.351	90	20.09.69	22.09.69	20.40
7	B-38	259.89	2902848.221	692597.547	90	22.09.70	3.10.70	39.41
8	B-40	259.08	2902583.324	692457.232	90	-	-	47.00
9	B-42	261.91	2902813.374	692859.175	90	05.11.69	08.11.69	16.22
10	B-43	263.75	2902684.983	692784.093	90	07.11.69	14.11.69	19.10
11	B-44	255.87	2902428.386	692608.814	90	10.11.69	15.11.69	27.50
12	B-45	249.04	2902329.062	692513.322	90	15.11.69	23.11.69	31.60
13	B-46	266.18	2902885.896	692771.584	90	03.12.69	13.12.69	23.50

Sl No	Borehole No.	Reduced Level (m)	Northing (m)	Easting (m)	Dip of the Borehole	Date of Comm-encement	Date of closure	Depth of the Borehole
14	B-47	264.12	2902760.995	692693.085	90	14.12.69	31.12.69	25.50
15	B-48	257.98	2902639.408	692590.202	90	01.01.70	03.01.70	10.90
16	B-49	254.35	2902508.057	692521.687	90	-	-	12.25
17	B-54	248.79	2902410.096	692267.435	90	11.03.70	20.03.70	46.50
18	B-56	246.43	2902473.84	692042.308	90	11.01.70	30.01.70	54.90
19	B-57	252.86	2902680.719	692288.057	90	31.01.70	10.02.70	50.30
20	B-58	262.99	2902926.732	692706.806	90	11.02.70	26.02.70	58.10
21	B-59	258.1	2902998.481	692581.151	90	27.02.70	08.03.70	29.95
22	B-62	247.63	2902438.847	692171.306	90	22.03.70	24.03.70	9.50
23	B-63	252.33	2902739.156	692206.781	90	-	-	91.65
24	B-65	252.25	2902979.863	692367.285	90	22.03.70	24.03.70	91.80

10.4.0 DATA SPACING FOR REPORTING OF EXPLORATION RESULTS

10.4.1 The boreholes (GSI & MECL) were spaced at 200m interval approximately, however few boreholes placed at less than 200m owing to folded nature of the deposit, which is sufficient to establish rock phosphate ore resources at G-3 stage (preliminary exploration) as per the exploration norms of Minerals (Evidence of Mineral Content) Rule-2015, The estimated resources in the block area may be placed under Inferred Mineral Resource (333) category as per UNFC code.

CHAPTER - XI

11.0.0 LOCATION OF DATA POINT

11.1.0 ACCURACY AND QUALITY OF SURVEY

11.1.1 The entire survey work has been carried out with the help of DGPS instrument for surveying and determination of block boundary cardinal points, borehole coordinates and Reduced level (RL). Initial ground control survey station (T-1) and temporary benchmarks were fixed on ground by Survey team at (A to L).

Table No: 11.1

Details of the Survey Station coordinates of survey station in Nimbli block, District: Jaisalmer, Rajasthan

Station	Easting	Northing	Reduced Level
Base Station (T-1)	2904134.662	692549.486	253.922
A	2902750.452	692742.525	279.08
B	2902655.5	692533.423	265.21
C	2902746.155	692771.498	279.031
D	2902752.956	692144.707	258.306
E	2902826.457	692192.193	260.697
F	2902182.026	691889.078	260.445
G	2902093.048	691792.905	256.447
H	2901980.146	691513.335	255.428
I	2901855.411	691392.111	266.067
J	2902057.519	692308.95	261.362
K	2902011.298	692440.154	262.022
L	2902959.913	692473.956	264.278

11.1.2 Technical specification of DGPS

(a) Make : Trimble DGPS
(b) Model R8-S (2017)

11.1.3 Measurement accuracy

(a) PPK mode (Static)
(b) Horizontal -3mm +0.1 mm or better
(c) Vertical -3.5 mm + 0.4 mm or better

11.1.4 During the survey, surface features i.e., roads, village area, habitation etc has been picked up and the same has been depicted in the topographical and geological map of the block and given as plate-III. Contouring has been carried out 1:2000 scale at 2m contour interval. A total 32 no of boreholes are drilled, whose position on ground is fixed by DGPS instrument. Borehole location co-ordinates and reduced level (RL) and total depth of drilling is given Table 10.2.

11.1.5 Prominent feature of this block is outcrops which are exposed as series of NE-SW trending mounds of limestone rising up to a maximum height of 25 meters from surface level.

11.2.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

11.2.1 The survey work has been carried out with the help of DGPS (Make-Trimble GNSS System, Model-R8s) and Electronic Total Station (M3) for higher level measurement accuracy. In order to have control on survey work, one base station T-1 and total twelve number of control stations A to L were established in the block. Survey work carried out by the experienced qualified surveyor as per the prevailing standard procedures.

CHAPTER - XII

12.0.0 SAMPLING TECHNIQUE

12.1.0 SURFACE SAMPLING

During geological mapping 42 no of geochemical samples were collected and analysed for 5 radicals i.e., P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI by XRF method. Each surface bedrock samples collected in the form of chips and the sample is pounded to a fine powder to enable it to pass through -200 mesh size. By mixing, coning and quartering of the sieved powder desired representative sample was drawn and sent to MECL Lab. for primary analysis. The results of surface geochemical sample analysis are furnished in Annexure-VA.

12.2.0 COMPOSITE SAMPLES:

12.2.1 Composite samples have been prepared borehole wise & zone/band wise at greater than 3% P_2O_5 cut off by taking powdered material (-200 mesh) of each primary samples in volume proportion and thoroughly mixing, followed by coning and quartering. The composite sample were analysed for 34 elemental analyses by ICPMS method in Chemical Lab, MECL. The results of these petrographic studies are presented in Annexure-VII.

12.3.0 X-RAY DIFFRACTION STUDIES

12.3.1 All the 10 no of composite samples of boreholes from phosphorite zones/bands were subjected to X-Ray Diffraction Studies at Physical Laboratory of MECL to determine the individual composition and to identify major and minor constituents present in the ore. The results of these XRD studies are presented in Annexure-XI.

12.4.0 PETROGRAPHIC STUDIES

15 no of core specimen of various lithology from boreholes are subjected to petrographic studies at Petrology Lab., MECL. The results of these petrographic studies are presented in Annexure-IX.

12.5.0 MINERAGRAPHIC STUDY

To study the ore mineral composition and minerals present in the ore, a total 05 no of core samples from boreholes were subjected to minerographic studies at Petrology Lab., MECL, Nagpur. The results of minerographic studies are presented in Annexure-X.

12.6.0 SPECIFIC GRAVITY DETERMINATION

12.6.1 Phosphorite bearing rock samples from boreholes were subjected for specific gravity determination at Petrology Lab., MECL. The specific gravity was determined by Walker steel yard method. The average specific gravity for these 10 samples has been calculated as 2.40 and

considered for resource calculation. The results of specific gravity determination are presented in Annexure-XII.

CHAPTER - XIII

13.0.0 DRILLING TECHNIQUE AND DRILL SAMPLING EMPLOYED

13.1.0 DRILL TYPE AND DETAILS

13.1.1 During the present investigation, MECL drilled a total 32no of boreholes with 1293.00m and carried out other associated geological and analytical work. The details of boreholes drilled by MECL are given in Annexure-IB.

13.1.2 Core drilling was carried out by two conventional wire line drill rigs viz. RD-60 (MEC-349) & RD-100 (MEC-358). Rotary wash type of wireline drilling method was undertaken. Diamond impregnated NQ bit (outer diameter 75.7 mm and inner diameter 47.6 mm) and TC bit had been used during drilling operation. At the initial depths, all the boreholes have been used with HW and NW casing to control falling of soil cover and loose friable weathered formation. All the precautions had been taken to maintain quality of drilling and to achieve maximum core recovery.

13.2.0 EXPLORATORY DRILLING

13.2.1 Owing to the folded nature of the deposit and to understand the structure, drilling was executed across the 2.5km NE-SW strike of the deposit. Along this strike a total 15 no of sections namely S1A-S1A' to S15-S15'were laid on 200m interval. Out of 32 no of boreholes 27 no of boreholes were inclined and 05 borehole drilled vertically.

13.3.0 WHETHER CORE AND CHIP SAMPLE RECOVERIES HAVE BEEN PROPERLY RECORDED AND RESULTS ASSAYED.

13.3.1 The drill cores have been logged in detail, viz., lithology, grain size, colour, nature and type of mineralisation along with structural details viz. foliation, fracture, fracture fillings and rock quality designation. Major lithology intersected in the boreholes are shale, limestone, cherty dolomite, phosphorite, quartzitic sandstone and calcareous sandstone. Phosphorite is mainly associated with shale/limestone.

13.3.2 The detailed run wise litholog and summarized litholog for boreholes drilled by GSI (Extracted from 1969-70 Field season report) and MECL are given in Annexure- III A, IIIB and Annexure- IV A, IV B respectively.

13.3.3 Samples were marked based on visual confirmation with Shapiro solution test. In general, the sample length has been kept at 1.00 m which varied in some instances because of variation in lithology and type and concentration of mineralisation. The details of analysis of primary core samples are given in Annexure-VB & VC.

13.4.0 MEASURES TAKEN TO MAXIMIZE SAMPLE RECOVERY AND ENSURE REPRESENTATIVE NATURE OF THE SAMPLES.

13.4.1 The core recovery varies from minimum 70.57% (MNP-08) and maximum 100% (MNP-28) with an average core recovery being 94.53%.

13.4.2 The short runs were drilled as per necessity so that optimum core recovery is maintained. The core recovery in the mineralized zones is about 93.88% which is satisfactory. Whenever core recovery is less, the grade of the recovered portion has been extrapolated over the non-recovered section. The quality of drilling was ensured during the operation.

13.4.3 The quality of drilling was ensured during the operation. After closure, all the boreholes have been properly sealed with cement.

13.5.0 ROCK QUALITY DESIGNATION (RQD)

13.5.1 Rock Quality Designation (RQD) is a modified measure of the degree of jointing and the fracture in a rock mass, measured as a percentage of drill core in lengths if 10cm or more. D.U. Deere in 1963 define the RQD as the ratio of the sum of the total length of the core pieces of length 10cm and length recovered from drilling of one run (3.0 m) drilling.

RQD percentage	Designated Rock Quality
90-100%	**Excellent**
75-90%	**Good**
50-75%	Fair
25-50%	Poor
0-25%	Very poor

13.5.2 RQD (%) = (Total length of the core in pieces of 10cm or more) / Length of the run) X100 During the detailed geological logging of the core samples, RQD have been measured over entire column of the core and mineralized zone. RQD data is in incorporated in the run-wise lithology.

13.5.3 The average RQD of all boreholes is less than 50% owing to the folding nature of the formation, hence all the formation falls in low quality rock category.

13.6.0 BOREHOLE CORE SAMPLING

13.6.1 A total 367 no of primary samples are generated from borehole core obtained after drilling by MECL. Samples were marked considering variation of phosphorite zone as well as lithology. In general, the sample length has been kept at 1.00 m which varied in some instances because of

variation in lithology and type and concentration of mineralisation. Hence, the overall sample length is varying with minimum 0.50 m to maximum 1.00 m.

13.6.2 Samples are demarcated during core logging, based on visual basis and on confirmation with Shapiro solution. Once the samples are marked, sample has been prepared by splitting of core into two equal halves by using core splitter one half is crushed to 100mesh and remaining half split core is stored in core box for future reference. The crushed 100 mesh sample were further grounded to fine powder and were passed through -200 mesh size sieve. Powdered material was mixed thoroughly and about 100 grams of samples taken for chemical analysis by successive coning and quartering as primary samples and rest of the material (-200 mesh size) kept as duplicate half for future reference.

CHAPTER - XIV

14.0.0 SUB-SAMPLING TECHNIQUES AND SAMPLE PREPARATION

14.1.0 WHETHER CUT OR DRAWN AND WHETHER QUARTER, HALF OR ALL CORE TAKEN

14.1.1 The drill core samples collected from the phosphorite zone demarcated on visual basis and confirmation of Shapiro's Solution, details of sampling procedure are described in Para 13.6.2, during the sample preparation the core sample has been split longitudinally into two equal halves with the help of hydraulic core splitter. One half has been preserved and the other has been crushed for the preparation of primary samples at -200 mesh size. Sample has been homogenized by proper mixing and coning quartering as per the standard sampling procedure.

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF SAMPLE PREPARATION TECHNIQUE.

14.2.1 Quality control procedures have been adopted during sampling. The samples have been prepared under the supervision of geologist and qualified sampling technician. Half split lines were marked properly and then the one half of split samples were crushed and pounded. Further measures have been taken during sieving and pounding/grinding of samples. The sieve and containers have been cleaned after processing of each sample to avoid contamination and measures have also been taken to avoid loss of powder in air.

14.3.0 QUALITY CONTROL PROCEDURES

14.3.1 It is very important to submit the representative sample of collected material for geochemical analyses. Therefore, each step has been performed meticulously. The crushing, grinding of sample and passing it through (-) 200 mesh sieves for core/surface samples, quantity of the samples has been reduced to 500 g by coning and quartering method after thoroughly mixing to maintain the homogeneity of the samples. Hence it can be assumed that the samples remain representative in nature of in situ material collected.

14.3.2 All the powdered samples were packed properly in the polythene sample bag with proper tag. Then the entire samples were transported to central chemical laboratory located in Nagpur. It has been thoroughly checked that none of the sample bags were damaged during the transportation, then the chemical analysis has been taken up.

14.4.0 MEASURES TAKEN TO ENSURE THAT THE SAMPLING IS REPRESENTATIVE OF THE IN-SITU MATERIAL COLLECTED.

14.4.1 Borehole cores have been sampled systematically as described in the earlier paragraphs. However, proper marking of primary samples from drilled cores following standard procedure

for primary and composite sample preparation shows the representative samples have been collected from the in-situ materials.

14.5.0 APPROPRIATENESS OF THE GRAIN SIZE

14.5.1 In accordance with the standard sampling procedures, it has also been observed that smaller the particle size, higher the homogeneity of the sample as well as higher the dissolvability during the chemical analysis. As a result, 0.50 m to 1.00 m length core samples having diameter of NQ size have been reduced to -200 mesh size to homogenize the sample and its true representation during sample analysis.

CHAPTER – XV

QUALITY OF ASSAY DATA AND LABORATORY TESTS

15.0.0 CHEMICAL ANALYSIS

15.1.0 GENERAL

15.1.1 A total 367 nos. of primary core samples and 42 no of surface geo chemical samples have been generated & all the samples were analysed for 5 radicals i.e. P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI. The samples were analysed through WD-XRF instrument. The detail of primary analysis has been furnished in Annexure V-A & V-C.

15.1.2 Further, on receipt of chemical analysis of primary core samples, 23 nos. of composite samples from the Phosphorite zone demarcated at >3% P_2O_5 cutoff were prepared and analysed for 34 elemental analysis by IC-PMS method, V, Ba, Cr, Ga, Rb, Cs, Ca, U, Th, Eu, Hf, La, Lu, Sm, Tb, Yb, Ce, Dy, Er, Nd, Pr, Tm, Sc, Y, Zn, Cu, Pb, Ni, Co, Cd, Sc, Ag, Li, Mo.

15.2.0 METHODOLOGY OF CHEMICAL ANALYSES BY XRF

15.2.1 Chemical Laboratory, MECL, Nagpur have RIGAKU make ZSX PRIMUS IV XRF instrument for analyses of major oxides. First pellets of the powdered samples are prepared using hydraulic press. Then the XRF instrument is calibrated using suitable matrix matching CRMs (Certified Referenced Materials). After calibration of the instrument the samples are analysed and the values of the P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 are obtained from the software. The Loss on Ignition has been determined by calculating the loss in weight of the sample after igniting the sample taken in a Pt crucible at 1000^oC in a muffle furnace.

15.2.2 CRM used for phosphorite analysis SARM32 (Produced by South Africa bureau of standards)

15.2.3 The following Precautions were followed in the laboratory while doing chemical analysis.

- PPEs were used to avoid any contamination to the samples.
- Label all containers to identify their contents.
- Avoid touching hot objects. Be careful when using hot objects. Use suitable tongs to remove hot containers from the furnace.
- Properly dispose of waste chemicals.

15.3.0 QUALITY CONTROL PROCEDURE

15.3.1 The standard operating procedure of quality control has been adopted during the chemical analysis in Chemical laboratory, MECL, Nagpur which includes

(i) Analysis of Certified reference materials/measurement standards

(ii) Analysis of blind samples

(iii) Use of QC samples and control charts

(iv) Analysis of blank samples

(v) Analysis of spiked samples

(vi) Analysis in duplicate samples.

15.3.2 Moreover 35 nos. of External check samples have been submitted for analysis of P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI to NABL Accredited lab (JNARDDC, Nagpur) and compared with its primary results.

15.3.3 STATISTICS OF CHECK SAMPLE

15.3.4 The statistical analysis of primary and external check analysis data has been carried out on P_2O_5, SiO_2, Al_2O_3, Fe_2O_3 and LOI. It has been observed from the correlation coefficient which is the measure of strength of a linear relationship between two data set. The correlation coefficient for P_2O_5 is 0.882. This indicates that the Primary and Check assays are co-relatable with each other. Further the Scatter plot of the primary Vs check assay in respect of seven radical (Text Fig No 15.1 to 15.5) shows scatter of values are closely following the bisector. The arithmetic mean of the primary and check data set are close to each other. Thus, it can be opined that the chemical analysis of the samples shows the repeatability and reliability of the analysis and also prove that the homogeneity of the samples.

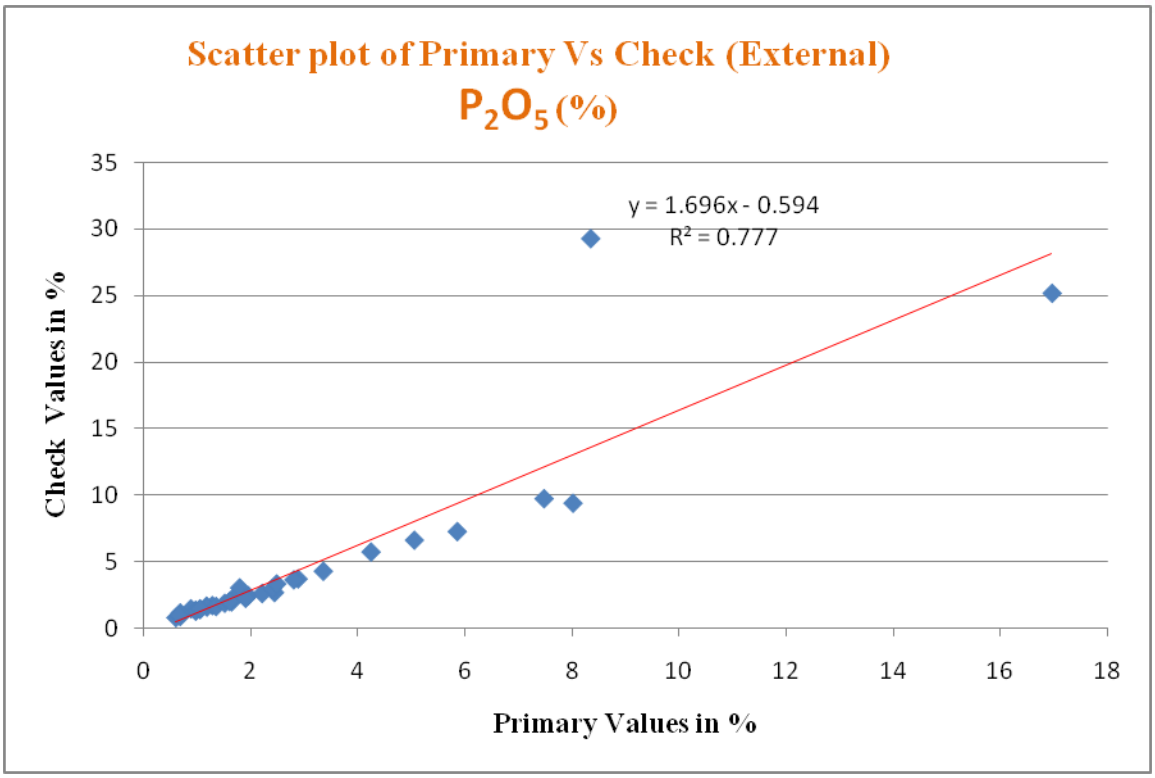


Table no 15.1

COMPARISON OF PRIMARY Vs.EXTERNAL CHECK ANALYSIS

COMPARISON INDEX	P_2O_5 %	
	Primary	Check
No. of Sample Pairs	35	
Arithmetic Mean	2.884	4.299
Standard Deviation	3.166	6.09
Std. Error of Mean	0.535	1.029
Variance	10.023	37.087
Mean of Deviation	-1.415	
Standard Deviation (Error)	3.619	
Correlation Coefficient	0.882	
Mean Absolute Error	1.415	
Mean Relative Random Error	49.044%	
Paired T value	-2.312	
F - test value	0.27	

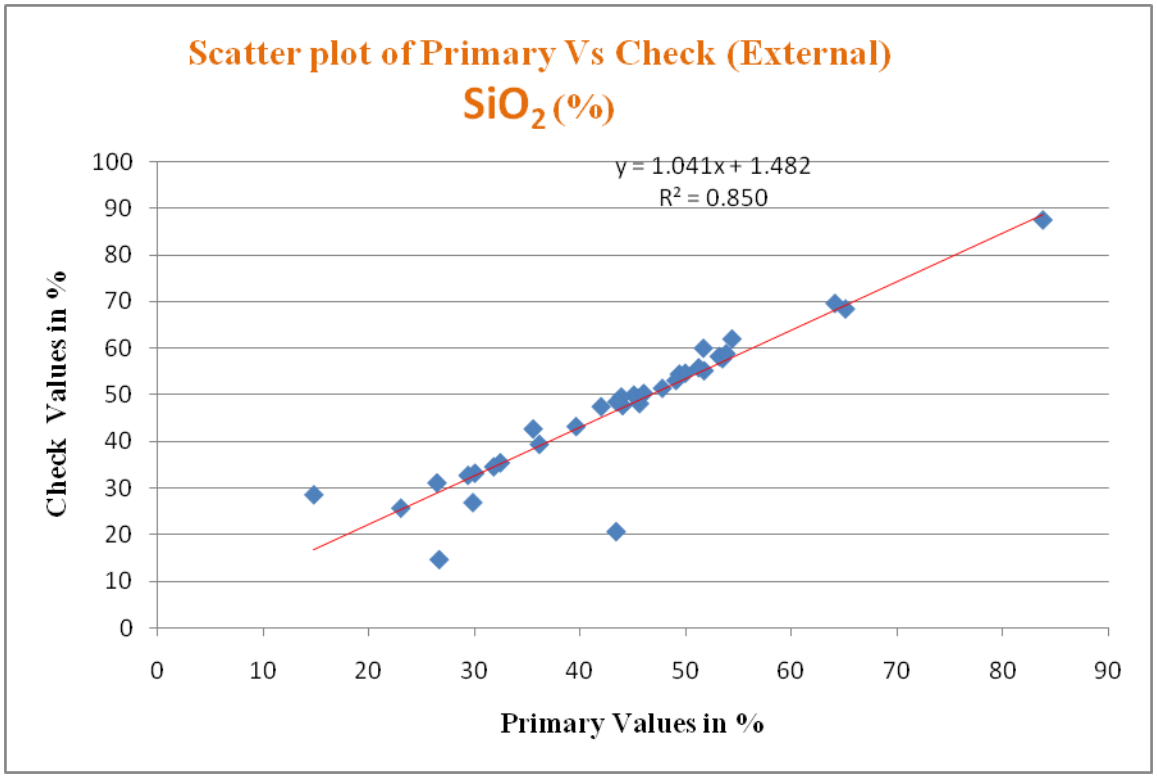


Table no 15.2

COMPARISON OF PRIMARY Vs.EXTERNAL CHECK ANALYSIS

COMPARISON INDEX	SiO_2 %	
	Primary	Check
No. of Sample Pairs	35	
Arithmetic Mean	43.781	47.07
Standard Deviation	13.155	14.851
Std. Error of Mean	2.224	2.51
Variance	173.063	220.55
Mean of Deviation	-3.289	
Standard Deviation (Error)	5.762	
Correlation Coefficient	0.922	
Mean Absolute Error	5.437	
Mean Relative Random Error	12.418%	
Paired T value	-3.377	
F - test value	0.785	

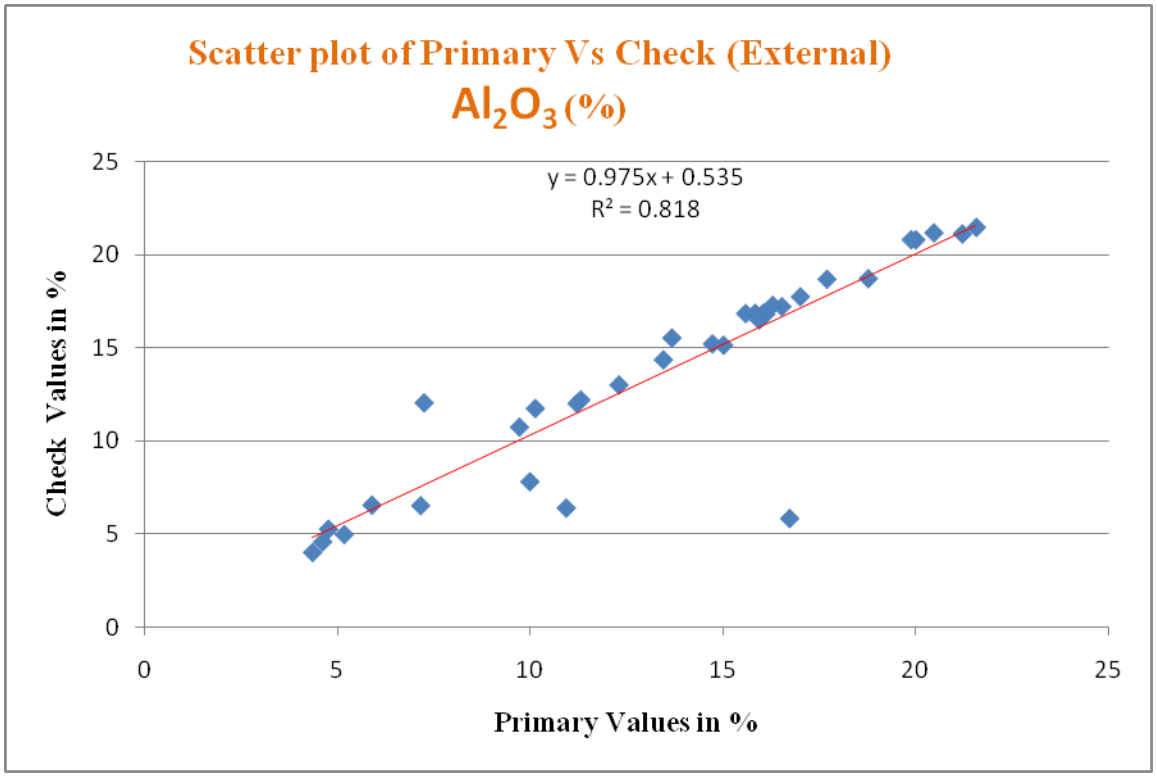


Table no 15.3

COMPARISON OF PRIMARY Vs.EXTERNAL CHECK ANALYSIS

COMPARISON INDEX	Al_2O_3 %	
	Primary	Check
No. of Sample Pairs	35	
Arithmetic Mean	13.511	13.716
Standard Deviation	5.014	5.407
Std. Error of Mean	0.848	0.914
Variance	25.143	29.233
Mean of Deviation	-0.205	
Standard Deviation (Error)	2.307	
Correlation Coefficient	0.905	
Mean Absolute Error	1.277	
Mean Relative Random Error	9.451%	
Paired T value	-0.525	
F - test value	0.86	

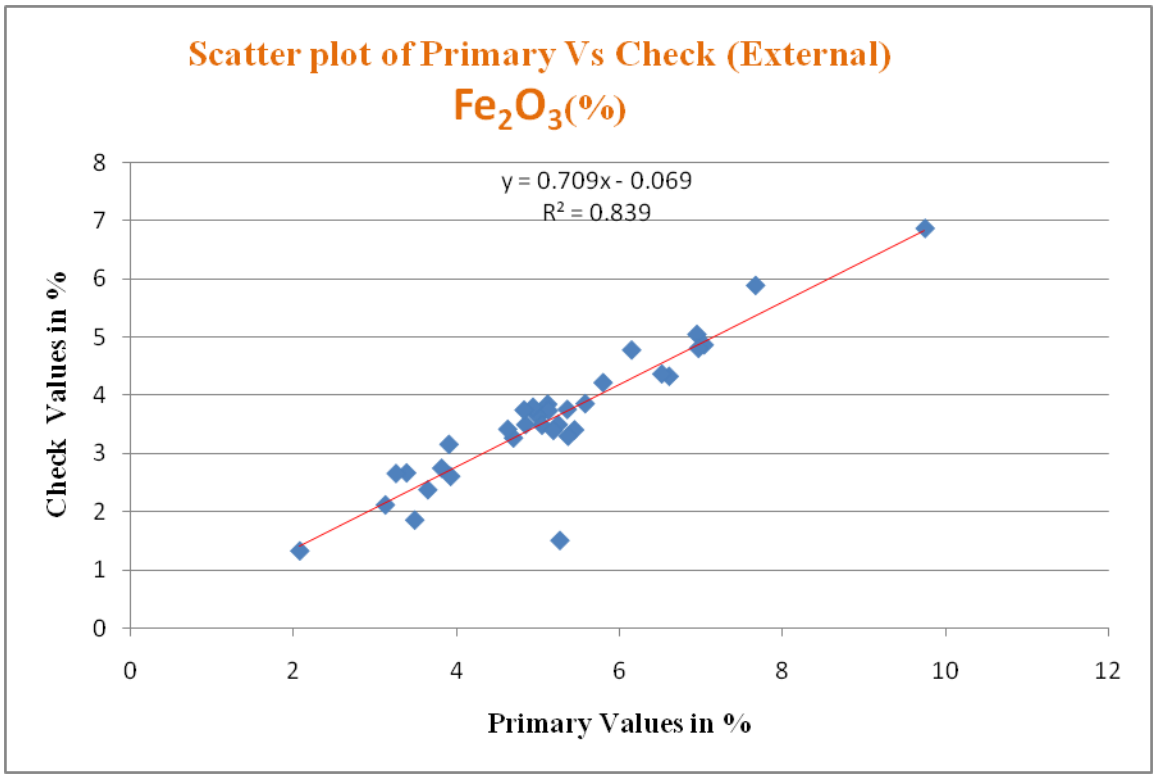


Table no 15.4

COMPARISON OF PRIMARY Vs.EXTERNAL CHECK ANALYSIS

COMPARISON INDEX	Fe_2O_3 %	
	Primary	Check
No. of Sample Pairs	35	
Arithmetic Mean	5.157	3.589
Standard Deviation	1.456	1.127
Std. Error of Mean	0.246	0.191
Variance	2.12	1.271
Mean of Deviation	1.568	
Standard Deviation (Error)	0.619	
Correlation Coefficient	0.916	
Mean Absolute Error	1.568	
Mean Relative Random Error	30.41%	
Paired T value	14.994	
F - test value	1.668	

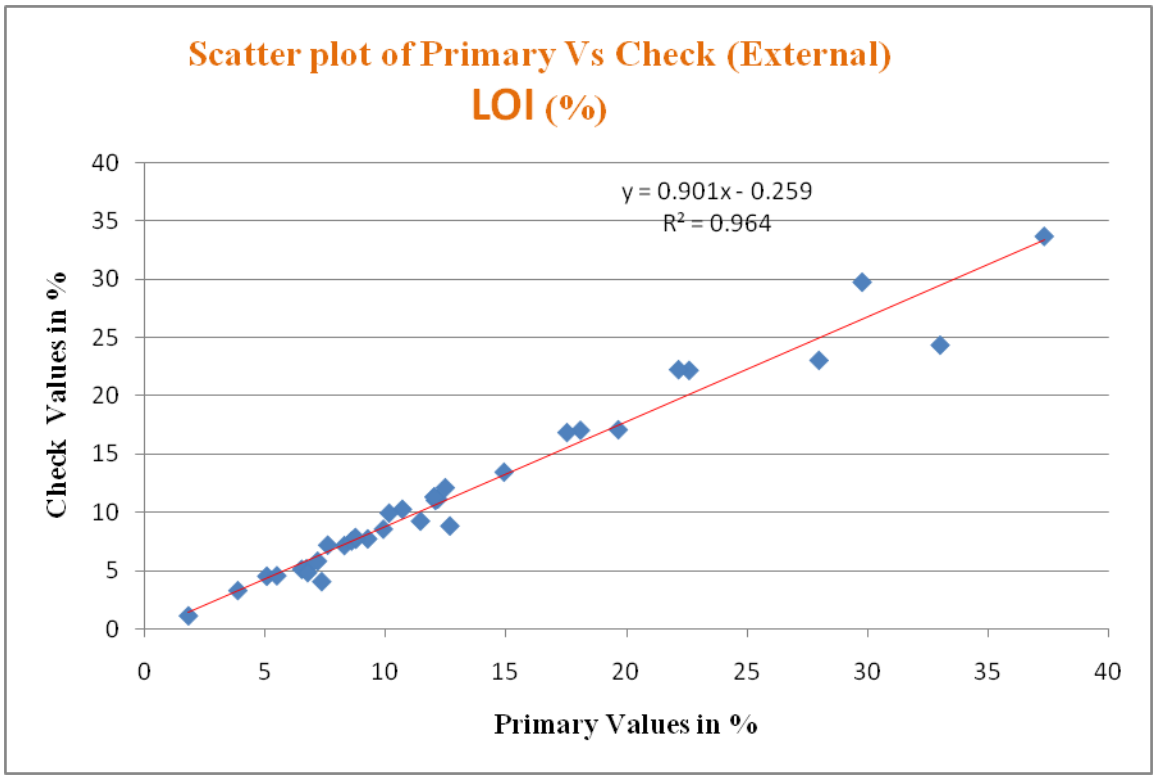


Table no 15.5

COMPARISON OF PRIMARY Vs.EXTERNAL CHECK ANALYSIS

COMPARISON INDEX	LOI %	
	Primary	Check
No. of Sample Pairs	35	
Arithmetic Mean	13.155	11.603
Standard Deviation	8.337	7.654
Std. Error of Mean	1.409	1.294
Variance	69.505	58.577
Mean of Deviation	1.553	
Standard Deviation (Error)	1.656	
Correlation Coefficient	0.982	
Mean Absolute Error	1.556	
Mean Relative Random Error	11.83%	
Paired T value	5.548	
F - test value	1.187	

15.4.0 SECURITY AND CHAIN OF CONTROL OF SAMPLES

15.4.1 The samples have been prepared at centralized mechanized sampling unit with proper labelling and tag and sent to chemical laboratory, Nagpur. All samples were prepared under supervision of qualified sampling technician where the necessary standard procedure and precautionary measures have been taken to avoid the contamination.

CHAPTER - XVI

16.0.0 MOISTURE

16.1.0 Method of determination of the moisture content.

16.1.1 All the analysis for phosphorite samples has been carried out in natural moisture.

CHAPTER - XVII

17.0.0 SPECIFIC GRAVITY

17.1.0 METHOD OF SPECIFIC GRAVITY DETERMINATION AND RESULT

17.1.1 Specific gravity determination has been carried out on 10 nos. of borehole core samples from phosphorite zones selected on visual basis and confirmation with Shapiro solution and study was carried out by Walker's steel yard balance method at MECL's Petrology Laboratory. The results of specific gravity study are presented in Annexure –XII.

17.1.3 Specific Gravity is varying from 1.90 to 2.71. Thus, the average specific gravity of the mineralized zones in the block is calculated as 2.40g/cc.

CHAPTER – XVIII

BENEFICIATION STUDIES

18.0.0 BENEFICIATION STUDIES AS MAY BE REQUIRED

18.1.1 Beneficiation studies has not been carried out in the present exploration as it was not in the scope of the approved quantum of work.

18.1.2 To enhance the quality of the phosphorite, it is recommended for Beneficiation studies during G-2 & G-1 level exploration.

CHAPTER - XIX

19.0.0. RESOURCE ESTIMATION TECHNIQUES

19.1.0 DISCUSSION ON SUFFICIENT DATA DENSITY TO ASSURE CONTINUITY OF MINERALISATION AND SYNTHESIS ADEQUATE FOR ESTIMATION PROCEDURE USED

19.1.1 Drill holes are spaced at approximately 200m intervals consistent with the industry standards for stratiform and lensoidal phosphorite deposit. The drill hole density is sufficient to provide reliable grade estimation for inferred resources under G3 stage of investigation. Continuity of mineralization is well constrained by stratigraphic units though in discontinuous lens, over a strike length of 2.5km. the geological mapping has brought out the disposition of phosphorite zones marking folded nature of the ore zones. The current data density and continuity analysis demonstrate sufficient confidence for resource estimation in the nimbli block..

19.1.2 Structurally the Nimbli block comprises of one doubly plunging anticline and one doubly plunging synclinal fold traced along NE-SW phosphorite-sandstone litho-association. Folding forms a system of asymmetric, longitudinal, sharp-apex, doubly plunging as well as open folds which are traced all along strike and dip of deposit. The general strike of beds and the fold axis is NNE-SSW though local variations in response to minor folding are common. The dip of bedding ranges from 35º to 80º westwards or eastwards, due to folding. The inclined boreholes are drilled perpendicular to the limb of phosphorite body and vertical boreholes are drilled along the synclinal axis**.**

19.1.3 During the Field season program of GSI (1969-70), total 2053.89m of drilling was carried out in 68 no of boreholes in and around Nimbli block area, out of which 24 nos. of vertically drilled boreholes are falling under the Nimbli block. In these boreholes the phosphorite zone (demarcated >5% P_2O_5 cutoff) is intersected at depth ranging from 0.80 m depth in B-46 to 57.35 m depth in B-58.

19.1.4 MECL carried out a total 1293.00 meters of drilling in 32 nos. of borehole (27 inclined and 05 vertical boreholes) which are spaced in 200m interval. In these boreholes the phosphorite zone (demarcated at >5% P2O5 cutoff) is intersected at depth ranging from 1.00 m depth in MNP-21 to 32.00 m depth in MNP-02 and thickness varies between 0.99 m (MNP-07, P_2O_5-5.55%) and 11.88 m (MNP-02, P_2O_5-7.56%).

19.1.5 For estimation of resources the geological mapping data, drilling data of GSI and MECL are considered.

19.2.0 WHETHER PREVIOUS EXPLORATION DATA HAS BEEN USED AND INTEGRATED WITH CURRENT EXPLORATION DATA FOR ASSESSMENT OF UPDATED RESOURCE

19.2.1 Previously drilled GSI (1967-69) borehole data involving 838.13m in 24 boreholes has been considered for geological interpretation, correlation and resource estimation. Details of GSI Boreholes. and Chemical

Analysis of samples is given as Annexure No. I-C and V-B respectively. As per MEMC Rules, boreholes with core recovery >70% in mineralized zone, are considered in resource estimation. Due to non-availability of borehole survey details and likely error of positioning of boreholes etc, MECL geo referenced the available maps along with field conformation of drilled boreholes and the same was integrated with the drill hole data of MECL in current exploration.

19.3.0 THE NATURE AND APPROPRIATENESS OF THE ESTIMATION TECHNIQUE(S), APPLIED AND KEY ASSUMPTIONS INCLUDING TREATMENT OF EXTREM GRADE VALUE DOMAINING, INTERPOLATION PARAMETERS, MAXIMUM DISTANCE OF EXTRAPOLATION FROM DATA POINT

19.3.1 For moderate to steep dipping ore bodies cross sectional, Longitudinal and Vertical section method and Level Plan methods are considered to be appropriate resource estimation methods. Hence MECL has estimated Phosphorite resources in Nimbli Block using Cross section method as principal method and Level Plan method as check method.

19.3.2 The estimation techniques applied in this geological study have been chosen based on the nature of the mineralization and the spatial distribution of assay data. The methodology incorporates robust grade interpolation while maintaining geological continuity. No extreme values have been encountered requiring capping techniques. Domain boundaries have been established based on lithological and structural controls to constrain grade estimation within geologically meaningful zones. The maximum extrapolation distance has been limited to a defined range beyond the nearest data points.

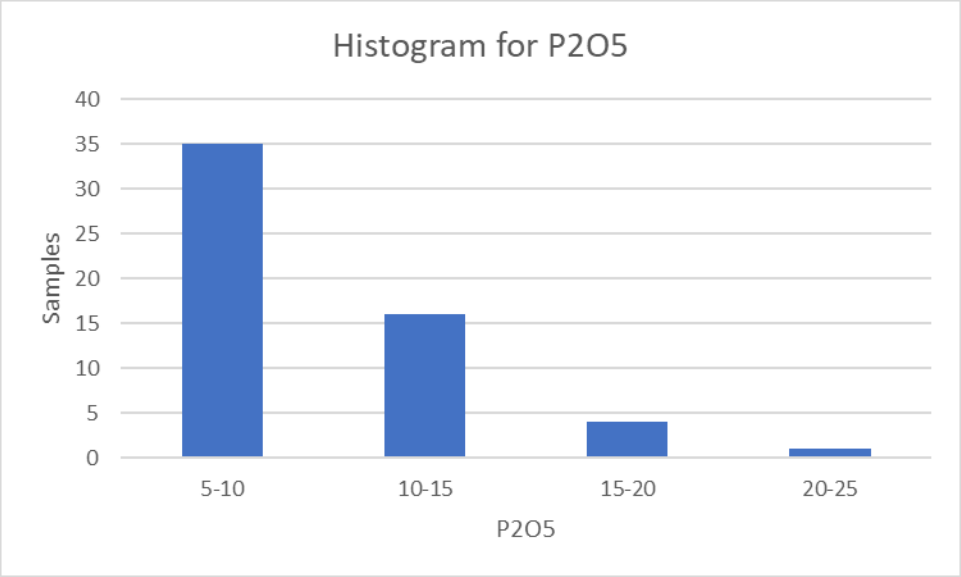
19.3.3 **ORE BODY CORRELATION**

19.3.3.1 As per IBM notification no. C284/3/CMG/2017 dated 25 April 2018 the threshold value of P_2O_5 in apatite and rock phosphate is given as P_2O_5 at 5%(min). Based on the assay value of P_2O_5% the ore has been classified into three categories, which has been mentioned in the following table:

Table No 19.1
End User Grade Classification of Phosphorite Ore

Sr No	Ore Classification	Range of P2O5%
1	Sub-Grade Ore (SGO)	≥5% P_2O_5% to <10%P_2O_5%
2	Low-Grade Ore (LGO)	≥10% P_2O_5% to <25%P_2O_5%
3	High Grade Ore (HGO)	≥25% P_2O_5%

19.3.3.2 To understand the behaviour of P_2O_5 in phosphatic zone, samples falling within this zone are studied by generating histogram which revels P_2O_5 content range between 5% and 25%, however 85% of the samples fall under 5% to 15% P_2O_5 category.



Text Fig No 19.1: Histogram of P_2O_5% of the borehole samples within the phosphatic zone

19.3.3.3 With reference to the end user classification of ore the Nimbli deposit fall under the Sub-Grade Ore (SGO) to Low-Grade Ore (LGO) category.

19.4.0 THE BASIS FOR CLASSIFICATION OF THE MINERAL RESOURCES

19.4.1 The present exploration was done under G3 stage and boreholes were spaced at approximately 200m strike interval. As per UNFC system and specifications given in Part: III-I of Minerals (evidence of Mineral content) Rule-2015, mineral resource in the block is categorised as inferred category (333).

19.5.0 THE ASSUMPTIONS MADE REGARDING RECOVERY OF BY PRODUCTS

19.5.1 Total 23 nos. of composite samples have been prepared from the delineated mineralized zones at 5% P_2O_5 cutoff for determining presence of any economically recoverable associated elements, table submitted below gives range of Maximum and Minimum values of element wise. The samples were analysed at MECL Laboratory, Nagpur.

Table 19.2
Range of maximum and minimum in composite samples analysed in Nimbli block

Element	Li	V	Cr	Co	Ni	Cu	Pb	Zn	Ga	Se
	Values in PPM									
Maximum	33.52	92.95	327.01	28.19	80.69	105.98	26.36	161.92	22.8	1.51
Minimum	10.46	28.06	90.18	6.59	19.13	28.65	12.54	40.26	5.14	0.31

Element	Rb	Mo	Ag	Cd	Cs	Ba	TREE	Th	U	Ca
	Values in PPM									
Maximum	158.05	17.05	0.25	0.58	8.42	806.16	562.04	24.46	21.61	24.81
Minimum	27.16	1.77	0.06	0.15	0.95	0.001	134.43	6.96	6.07	6.37

19.6.0 DETAILED DESCRIPTION OF THE METHOD USED AND THE ASSUMPTIONS MADE TO ESTIMATE TONNAGE AND GRADES

19.6.1 The Phosphorite ore resource and grade has been estimated by "Geological Cross-Section Method" (as principal method) and "Level Plan Method" as check method. The estimated resources placed under inferred (333) category of UNFC considering the following parameters and assumptions.

19.6.2 The axiomatic assumptions inherently involved in estimation of overall grade and resource of the deposit, which are given below

1. The rule of gradual change or law of linear function has been applied (Constantine C. Popoff, 1966) along with the rule of nearest points for application of influence of half way between successive boreholes.
2. The boreholes which are not intersecting any mineralisation have been considered as negative boreholes and completely eliminated from resource estimation. However, zones of > 2% P_2O_5 are considered for correlation purpose.
3. The thickness and grade of each mineralized zone intersected in the borehole have been considered as it is for the entire influence area of the borehole.
4. All the boreholes were placed at 200m strike interval, Hence, strike influence for all the sections has been considered up to the midpoint (half of the distance) of the next section on correlation and along the down dip and up dip, 50m has been considered from the phosphorite intersection.
5. Cut-off Grade: For the purpose of estimation of grade vis-à-vis resource of the phosphorite, it is necessary to arrive at a 'planning' cut-off grade. Hence, the overall average grade of the mineralized zones with >5% P_2O_5 cutoff grade has been considered for resource estimation.
6. True thickness of the zone has been considered for estimation of resources.
7. Specific Gravity: The average specific gravity of the mineralized zones is determined as 2.40. This value is considered for calculation of resources.
8. In general, boreholes spaced at approximately 200 m strike interval. Hence, strike influence for all the sections has been considered up to the midpoint (half of the distance) of the next section on correlation based on strike and dip data in outcrop/boreholes.
9. The Phosphorite zone has been projected to 50m from intersection towards down dip or up dip direction as the case may be where the adjacent borehole has no mineralization. For the borehole with continuous mineralization in adjacent boreholes, half way influence has been considered. Accordingly, the sectional area has been calculated. The

grade of the phosphorite zone intersected in the borehole has been assigned to its influence zones. An overall deduction of 20% is applied to the total gross tonnage to arrive at the net in situ geological resource of Phosphorite to account for geological reasons i.e., data gaps, core recovery, irregular nature of deposit and abrupt change in zone thickness.

19.6.3 **PHOSPHORITE ORE ZONE:**

19.6.4 Out of 56 no of boreholes (GSI 24 nos. and MECL 32 nos.) Phosphorite zone is intercepted in 33 no of boreholes (GSI 20ns, MECL-13nos).

19.6.5 Phosphorite zone details as intercepted in boreholes of GSI and MECL are given in Table no. 19.2 (Annexure VI-A) and 19.3 (Annexure VI-B & VI-C) respectively.

Table No 19.3

Summarised Phosphorite zone (>5% P_2O_5) details in boreholes drilled by GSI (1968-69) in the Nimbli block, Dist. Jaisalmer, Rajasthan

Bore hole Id	From (m)	To (m)	True Thickness (m)	P_2O_5 %
B-32	15.35	23.75	4.21	16.87
B-33	16.60	26.50	1.56	18.47
B-34	28.3	29.85	1.09	14.30
B-35	22.70	24.28	1.48	11.01
B-36	10.95	15.60	3.10	11.19
B-37	18.55	20.00	1.11	16.58
B-38	35.78	38.47	1.66	15.06
B-40	38.10	46.20	1.71	14.56
B-42	9.65	15.29	4.73	16.58
B-43	12.95	16.95	2.38	15.32
B-44	18.05	26.00	1.52	15.13
B-45	24.40	30.15	1.58	15.41
B-46	0.80	19.40	1.52	12.86
B-47	4.00	24.85	3.40	16.28
B-48	4.05	10.28	4.04	18.92
B-49	8.55	9.94	5.07	17.00
B-56	49.55	54.25	1.69	9.80
B-57	24.10	49.50	3.05	11.34
B-58	51.10	57.35	2.14	11.73
B-59	23.85	29.95	0.96	11.51

Table No 19.4

Summarised Phosphorite zone (>5% P_2O_5) details in boreholes drilled by MECL (2023-2024) in the Nimbli block, Dist. Jaisalmer, Rajasthan

S No	Borehole	From	To	Thickness	True Thickness	P_2O_5	SiO_2	Al_2O_3	Fe_2O_3	LOI
		in meters				in %				
1	MNP-01	12.00	14.00	2.00	1.94	**6.62**	33.88	11.17	5.02	13.16
2	MNP-02	20.00	32.00	12.00	11.88	**7.56**	44.31	13.44	4.30	6.88
3	MNP-03	18.00	26.00	8.00	8.00	**7.91**	39.98	11.08	4.62	9.51
4	MNP-04	6.00	13.00	7.00	7.00	**7.90**	36.30	8.44	3.41	12.84
5	MNP-06	10.00	19.00	9.00	8.95	**8.56**	42.94	16.72	4.50	7.52
6	MNP-07	9.00	10.00	1.00	0.99	**5.55**	42.09	13.08	4.53	9.91
7	MNP-08	7.00	13.00	6.00	5.49	**7.99**	40.81	15.02	5.89	8.35
8	MNP-10	8.00	14.00	6.00	5.52	**8.47**	28.33	5.61	8.24	14.96
9	MNP-12	21.00	22.00	1.00	0.99	**5.59**	24.09	7.46	3.59	22.13
10	MNP-13	7.00	8.00	1.00	0.98	**9.56**	25.10	4.66	5.01	15.89
11	MNP-16	50.00	51.00	1.00	0.99	**6.87**	54.81	13.60	4.37	3.48
12	MNP-21	1.00	10.60	9.60	6.17	**9.83**	38.01	11.64	3.35	9.51
13	MNP-22	25.50	26.50	1.00	0.52	**6.08**	27.88	8.02	10.87	15.47
14	MNP-23	21.00	25.00	4.00	3.82	**9.26**	40.61	15.26	4.88	6.36
15	MNP-25	22.00	25.00	3.00	2.99	**10.00**	45.52	13.41	6.13	4.25

19.7.0 METHODOLOGY ADOPTED IN CROSS-SECTION METHOD OF RESOURCE ESTIMATION

19.7.1 Following methodology has been adopted while computation of phosphorite ore resource by Geological Cross-Section Method.

1. A total of 15 Nos. Geological Cross Sections serially numbered as S1A-S1A′ to S15-S15′ and were drawn perpendicular to general strike of the mineralised zones spaced at 200m interval.
2. Geological Map along with topographical survey data and boreholes header data has been considered for preparation of profiles, the path of the inclined boreholes has been plotted along the profile by considering the azimuth with the help of GDM software.
3. The cross-sections have been prepared and correlated on the profile by marking the surface and subsurface geological data i.e., litho-units intersected in the borehole and its attitude i.e., Dip of the bedding, etc., ore zone along with nomenclature, thickness and qualitative data and the borehole data (lithology, nomenclature, thickness and analytical data of phosphorite ore).
4. The Phosphorite zone has been projected to 50m from intersection towards down dip or up dip direction as the case may be where the adjacent borehole has no mineralization. For the borehole with

continuous mineralization in adjacent boreholes, half way influence has been considered. Accordingly, the sectional area has been calculated.

5. In general, boreholes spaced at approximately 200 m strike interval. Hence, strike influence for all the sections has been considered up to the midpoint (half of the distance) of the next section on correlation based on strike and dip data in outcrop/boreholes.
6. The measurements have been made with the help of computer aided Auto- CAD Map 2025 software.
7. The sectional area obtained has been multiplied by cross sectional influence (strike influence) to obtain the sectional volume.
8. The sectional volume has been multiplied by the average specific gravity (2.40) to arrive at the resource tonnage.
9. The sum of Section-wise cross-sectional resource is the total geological gross/net in-situ resource.

19.8.0 METHODOLOGY ADOPTED IN LEVEL PLAN METHOD OF RESOURCE ESTIMATION:

19.8.1 To validate the resources by cross sectional method, Level Plan Method has also been carried out as check method.

19.8.2 A "geological resource estimation by level plan method" refers to a method where the quantity of a mineral deposit is calculated by generating horizontal cross-sections (level plans) at different levels within the deposit, essentially creating a 2D representation of the mineralization on each level to estimate the total volume and grade of the resource based on geological interpretations.

1. Three level plans have been generated which are separated at 25m vertical intervals, i.e. 1st level at 250mRL, 2nd level at 225 mRL and 3rd level at 200mRL. The level plan has been prepared for phosphorite zone (>5% P_2O_5) based on surface and sub-surface intersection and correlation.
2. Thickness of various zones intersected at respective mRL projected at particular section line on geological map and thickness of this zone correlated with boreholes of adjoining sections and extended up to the middle of section line on both sides**.**
3. Vertical influence has been considered up to the half influence of next above and below level i.e. 12.5m as per the mineralisation intersected in levels, otherwise the maximum vertical extent has been considered.
4. Different nomenclature for phosphorite zone has been assigned for each level for resource estimation purpose only. The marked phosphorite zone area at each level has been calculated with the help of computer aided AutoCAD Map 2025 software.
5. The phosphorite area calculated at each level is multiplied with the vertical influence as given in para 3. Thus, the volume and average grade is calculated.

6. The volume of the ore body with average grade is multiplied by the average specific gravity (2.40g/cc) to arrive at gross geological in-situ resource for each section by adding the tonnage of same level intersection.
7. Sum of tonnage calculated section wise for each level is the total gross geological in-situ resource.

19.9.0 GEOSTATISTICAL METHODS DETAILS

19.9.1 The resource has been estimated by Geological Cross Section and Level Plan method. Geostatistical method is not used for resource estimation in the block area.

19.10.0 DATA VERIFICATION AND/OR VALIDATION PROCEDURES USED

19.10.1 MECL undertakes data verification as a part of ongoing exploration programme. Checks carried out include validation of tabulated data, including collar, coordinate, sampling data, assay and lithological data, uses of blanks CRM, duplicate samples inserted routinely in to each batch submitted to the lab etc. strict QA-QC measures have been implemented to monitor assay quality in the chemical lab. In general, the standards indicate a satisfactory level of accuracy of the labs of both the primary and check analysis. The correlation pattern displayed by primary and check assay indicate acceptable level of accuracy of data that is being considered for grade and resource estimation. Site visits by supervisory officers ensure that all relevant data are collected faithfully by field team during geological mapping, surveying, enabling preparation of a geological map and geological report. The final output, passes through at least two stages of scrutiny internally and finally peer reviewed by a competent peer reviewer. The final report incorporated the suggestions recommended by the peer reviewer.

CHAPTER - XX

20.0.0. REPORTING OF RESOURCES

20.1.0 **RESOURCE AND GRADE**

20.1.1 Considering the structure and geology of Nimbli deposit the resources has been estimated by Cross Section method and to validate the estimated resources, Level Plan method is used as check method.

20.1.2 The Resources have been estimated Section wise and borehole wise in Cross-Section method and level plan method for phosphorite zone >5% P_2O_5 cutoff.

20.1.3 As per the standard practice, the gross geological resource has been reduced to 80% which is an empirical figure to arrive for Net In-situ geological resource owing to complex folded nature of the body, recovery loss during the drilling operation and any unforeseen conditions.

20.1.4 The total phosphorite ore resources estimated over a cumulative strike length of 2.5 sq. km by Geological Cross Section method at **5%P_2O_5 cutoff** in Nimbli block is **3.24 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.59 million tonnes** with an average grade of **11.32% P_2O_5,** 38.66% SiO_2, 12.13% Al_2O_3, 4.97% Fe_2O_3 and 10.26% LOI. The resources are estimated over a cumulative strike length of 2.5 sq. km (Annexure- XIII).

20.1.5 At **>10%P_2O_5 cutoff** the total phosphorite ore resources estimated by Geological Cross Section method in Nimbli block are **2.11 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **1.69 million tonnes** with an average grade of **13.84% P_2O_5**, 37.05% SiO_2, 10.08% Al_2O_3, 5.18% Fe_2O_3 and 7.65% LOI (Annexure- XIV).

20.1.6 The summarised, borehole wise, section wise Cross-Sectional resources at 5%P_2O_5 and 10% P_2O_5 cut-off in Nimbli block area (2.7sq km) are given in table 20.1 and 20.2.

20.1.7 The Resources has been calculated at 200mRL, 225mRL and 250mRL i.e at 25m vertical interval by Level plan method. The total Geological resource by **Level Plan Method** is 3.12 million tonnes, after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.49 million tonnes** with an average grade of **11.45% P_2O_5**, 39.51 SiO_2%, 12.13% Al_2O_3, 4.71% Fe_2O_3 and 7.85% LOI (Annexure-XV).

20.1.8 The summarised, zone wise, section wise Level Plan resources at 5%P_2O_5 cutoff in Nimbli block area (2.7sq km) are given in table 20.3.

Table 20.1

Statement Showing Section Wise, Borehole Wise Estimation of Resource at 5% P_2O_5 Cut-off by Cross Section Method for Section S1A-S1A' to S15-S15' in Nimbli Block, District -Jaisalmer, Rajasthan

Specific Gravity 2.4 gm/cc

S1. No	Section Line No.	Borehole No.	Thickness (m)	Sectional Area (sq. m)	Strike Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
								Average Grade				
1	S2-S2'	MNP-12	0.99	105.94	188.67	47970.48	0.05	5.59	24.09	7.46	3.59	22.13
Sub Total of Resource and Grade for S2-S2' Section						**47970.48**	**0.05**	**5.59**	**24.09**	**7.46**	**3.59**	**22.13**
2	S3-S3'	MNP-22	0.52	41.75	117.59	11782.49	0.01	6.08	27.88	8.02	10.87	15.47
Sub Total of Resource and Grade for S3-S3' Section						**11782.49**	**0.01**	**6.08**	**27.88**	**8.02**	**10.87**	**15.47**
4	S6-S6'	MNP-07	0.99	56.51	199.69	27082.76	0.03	5.55	42.09	13.08	4.53	9.91
Sub Total of Resource and Grade for S6-S6' Section						**27082.76**	**0.03**	**5.55**	**42.09**	**13.08**	**4.53**	**9.91**
5	S8-S8'	MNP-13	0.98	56.49	200.25	27149.09	0.03	9.56	25.10	4.66	5.01	15.89
Sub Total of Resource and Grade for S8-S8' Section						**27149.09**	**0.03**	**9.56**	**25.10**	**4.66**	**5.01**	**15.89**
6	S9-S9'	MNP-16	0.99	102.32	200.00	49113.60	0.05	6.87	54.81	13.60	4.37	3.48
Sub Total of Resource and Grade for S9-S9' Section						**49113.60**	**0.05**	**6.87**	**54.81**	**13.60**	**4.37**	**3.48**
7	S10-S10'	MNP-06	8.95	326.91	199.67	156657.89	0.16	8.56	42.94	16.72	4.50	7.52
8	S10-S10'	MNP-08	5.49	133.92	199.65	64169.11	0.06	7.99	40.81	15.02	5.89	8.35
Sub Total of Resource and Grade for S10-S10' Section						**220826.99**	**0.22**	**8.39**	**42.32**	**16.22**	**4.91**	**7.76**
9	S11-S11'	MNP-23	3.82	173.17	200	83121.60	0.08	9.29	40.61	15.26	4.88	6.36
10	S11-S11'	MNP-25	2.99	105.82	200	50793.60	0.05	10.00	45.52	13.41	6.13	4.25
Sub Total of Resource and Grade for S11-S11' Section						**133915.20**	**0.13**	**9.56**	**42.47**	**14.56**	**5.36**	**5.56**
11	S12-S12'	B-45	1.58	151.13	200	72542.40	0.07	15.41	NOT ANALYSED			
12	S12-S12'	MNP-04	7.00	274.92	200.00	131961.60	0.13	7.90	36.30	8.44	3.41	12.84
13	S12-S12'	MNP-03	8.00	430.71	200.00	206740.80	0.21	7.91	39.98	11.08	4.62	9.51

S1. No	Section Line No.	Borehole No.	Thickness (m)	Sectional Area (sq. m)	Strike Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
								Average Grade				
14	S12-S12'	MNP-10	5.52	399.48	200.00	191750.40	0.19	8.89	24.09	5.62	7.60	16.56
15	S12-S12'	B-56	1.69	252.28	200.00	121094.40	0.12	9.80	NOT ANALYSED			
Sub Total of Resource and Grade for S12-S12' Section						**724089.60**	**0.72**	**9.24**	**33.32**	**8.45**	**5.40**	**12.89**
16	S13-S13'	B-44	1.52	166.51	200.00	79924.80	0.08	15.13	Not Analysed			
17	S13-S13'	B-49	5.07	503.84	200.00	241843.20	0.24	17.00				
18	S13-S13'	B-40	1.71	191.45	200.00	91896.00	0.09	14.56				
19	S13-S13'	B-36	3.10	220.34	200.00	105763.20	0.11	11.19				
20	S13-S13'	B-57	3.05	231.49	200.00	111115.20	0.11	11.34				
Sub Total of Resource and Grade for S13-S13' Section						**630542.40**	**0.63**	**14.44**				
21	S14-S14'	B-43	2.38	457.36	200.00	219532.80	0.22	15.32	Not Analysed			
22	S14-S14'	B-48	4.40	392.32	200.00	188313.60	0.19	18.92				
23	S14-S14'	MNP-02	11.88	796.93	200.00	382526.40	0.38	7.56	44.31	13.44	4.30	6.88
24	S14-S14'	MNP-01	1.94	103.64	200.00	49747.20	0.05	6.62	33.88	11.17	5.02	13.16
25	S14-S14'	B-35	1.48	69.87	200.00	33537.60	0.03	11.01	NOT ANALYSED			
Sub Total of Resource and Grade for S14-S14' Section						**873657.60**	**0.87**	**12.04**	**43.11**	**13.18**	**4.39**	**7.61**
26	S15-S15'	MNP-21	6.17	450.10	151.39	163537.53	0.16	9.83	38.01	11.64	3.35	9.51
27	S15-S15'	B-46	1.52	337.96	149.62	121357.38	0.12	12.86	Not Analysed			
28	S15-S15'	B-58	2.14	188.94	147.79	67016.26	0.07	11.73				
29	S15-S15'	B-32	4.21	294.13	146.48	103399.87	0.10	16.87				
30	S15-S15'	B-59	0.96	114.91	144.24	39779.08	0.04	11.51				
Sub Total of Resource and Grade for S15-S15' Section						**495090.13**	**0.50**	**12.44**	38.01	11.64	3.35	9.51
Gross Total Resource and Grade						**3241220.35**	**3.24**	**11.32**	**38.66**	**12.13**	**4.97**	**10.26**
Net Total in Situ Resource and Grade (20% reduction for unforeseen geological condition)						**2592976.28**	**2.59**	**11.32**	**38.66**	**12.13**	**4.97**	**10.26**

Table 20.2

Statement Showing Section Wise, Borehole Wise Estimation of Resource at >10%P_2O_5 Cut-off by Cross Section Method for Section S1A-S1A' to S15-S15' in Nimbli Block, District -Jaisalmer, Rajasthan

Specific Gravity 2.4 gm/cc

S. No	Section Line No.	Borehole No.	Thickness (m)	Sectional Area (sq. m)	Strike Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
								Average Grade				
1	S10-S10'	MNP-06	2.98	108.85	199.67	52161.79	0.05	13.63	35.73	14.32	4.16	6.61
2	S10-S10'	MNP-08	1.83	44.64	199.65	21389.70	0.02	11.82	35.01	13.68	9.10	6.35
Sub Total of Resource and Grade for S10-S10' Section						**73551.49**	**0.07**	**13.10**	**35.52**	**14.14**	**5.60**	**6.53**
3	S11-S11'	MNP-23	1.91	91.55	200	43944.00	0.04	10.00	37.86	14.40	4.18	7.14
4	S11-S11'	MNP-25	2.99	105.82	200	50793.60	0.05	10.00	45.52	13.41	6.13	4.25
Sub Total of Resource and Grade for S11-S11' Section						**94737.60**	**0.09**	**10.00**	**41.97**	**13.87**	**5.22**	**5.59**
5	S12-S12'	B-45	1.58	151.13	200	72542.40	0.07	15.41	Not analysed			
6	S12-S12'	MNP-04	3.00	117.82	200.00	56553.60	0.06	10.12	47.41	6.87	2.71	6.54
7	S12-S12'	MNP-03	2.00	107.67	200.00	51681.60	0.05	13.88	47.13	6.34	4.37	2.70
8	S12-S12'	MNP-10	3.68	245.93	200.00	118046.40	0.12	10.20	30.88	4.34	8.70	12.26
Sub Total of Resource and Grade for S12-S12' Section						**298824.00**	**0.30**	**12.09**	**38.72**	**5.43**	**6.22**	**8.65**
9	S13-S13'	B-44	1.52	166.51	200.00	79924.80	0.08	15.13	Not analysed			
10	S13-S13'	B-49	5.07	503.84	200.00	241843.20	0.24	17.00				
11	S13-S13'	B-40	1.71	191.45	200.00	91896.00	0.09	14.56				
12	S13-S13'	B-36	3.10	220.34	200.00	105763.20	0.11	11.19				
13	S13-S13'	B-57	3.05	231.49	200.00	111115.20	0.11	11.34				
Sub Total of Resource and Grade for S13-S13' Section						**630542.40**	**0.63**	**14.44**				
14	S14-S14'	B-43	2.38	457.36	200.00	219532.80	0.22	15.32	Not analysed			
15	S14-S14'	B-48	4.40	392.32	200.00	188313.60	0.19	18.92				
16	S14-S14'	MNP-02	3.96	260.57	200.00	125073.60	0.13	11.83	36.83	12.15	4.48	5.43
17	S14-S14'	B-35	1.48	69.87	200.00	33537.60	0.03	11.01	NOT ANALYSED			

S. No	Section Line No.	Borehole No.	Thickness (m)	Sectional Area (sq. m)	Strike Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
								Average Grade				
Sub Total of Resource and Grade for S14-S14' Section						**566457.60**	**0.57**	**15.49**	**36.83**	**12.15**	**4.48**	**5.43**
18	S15-S15'	MNP-21	4.50	324.65	151.39	117957.03	0.12	11.04	31.08	11.22	3.66	10.43
19	S15-S15'	B-46	1.52	337.96	149.62	121357.38	0.12	12.86	Not analysed			
20	S15-S15'	B-58	2.14	188.94	147.79	67016.26	0.07	11.73				
21	S15-S15'	B-32	4.21	294.13	146.48	103399.87	0.10	16.87				
22	S15-S15'	B-59	0.96	114.91	144.24	39779.08	0.04	11.51				
Sub Total of Resource and Grade for S15-S15' Section						**449509.63**	**0.45**	**13.02**	**31.08**	**11.22**	**3.66**	**10.43**
Gross Total Resource and Grade						**2113622.72**	**2.11**	**13.84**	**37.05**	**10.08**	**5.18**	**7.65**
Net Total in Situ Resource and Grade (20% reduction for unforeseen geological condition)						**1690898.18**	**1.69**	**13.84**	**37.05**	**10.08**	**5.18**	**7.65**

Table 20.3 (a)

Particulars of Section Wise, Zone Wise Resource estimated by Level-Plan method >5% P_2O_5 from Section S1A-S1A to S15-S15' for at 200mRL in Nimbli Block, Tehsil- Fatehgarh, District -Jaisalmer, Rajasthan

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
							Average Grade				
200	S14-S14'	1B	1344.1858	19.95	64359.6161	0.064	12.68	NOT ANALYSED			
		1C	1505.1793	19.95	72067.98488	0.072	18.92				
Sub Total of Resource and Grade for S14-S14' at 200 mRL					**136427.60**	**0.136**	**15.98**				
200	S13-S13'	1A	1087.92	21.95	57311.63	0.06	11.34				
Sub Total of Resource and Grade for S13-S13' at 200 mRL					**57311.63**	**0.06**	**11.34**				
200	S12-S12'	1A	1594.00	29.63	113352.53	0.11	9.80				
Sub Total of Resource and Grade for S12-S12' at 200 mRL					**113352.53**	**0.11**	**9.80**				
200	S9-S9'	1Z	414.00	32.32	32113.15	0.03	**6.87**	54.81	13.60	4.37	3.48
Sub Total of Resource and Grade for S9-S9' at 200 mRL					**32113.15**	**0.03**	**6.87**	54.81	13.60	4.37	3.48
Gross Total Resource and Grade					**339204.91**	**0.34**	**12.27**	**54.81**	**13.60**	**4.37**	**3.48**
Net Total in Situ Resource and Grade (20% reduction for unforeseen geological condition)					**271363.93**	**0.27**	**12.27**	**54.81**	**13.60**	**4.37**	**3.48**

Table 20.3 (b)

Particulars of Section Wise, Zone Wise Resource estimated by Level-Plan method >5% P_2O_5 from Section S1A-S1A to S15-S15' for at 225mRL in Nimbli Block, Tehsil- Fatehgarh, District -Jaisalmer, Rajasthan

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
							Average Grade				
225	S15-S15'	1A	367.03	25.50	22462.27	0.02	11.51	NOT ANALYSED			
		1B	1055.835	31.50	79821.13	0.08	16.87				
		1C	535.2472	31.50	40464.69	0.04	11.83				
		1D	627.0212	28.30	42587.28	0.04	12.86				
		1E	1206.0817	28.30	81917.07	0.08	9.83	38.01	11.64	3.35	9.51
Sub Total of Resource and Grade for S15-S15' at 225 mRL					**267252.43**	**0.27**	**12.86**	**38.01**	**11.64**	**3.35**	**9.51**
225	S14-S14'	1A	635.3	32.00	48791.04	0.05	11.01	NOT ANALYSED			
		1B	1621.9099	25.00	97314.59	0.10	12.68				
		1C	1042.7005	25.00	62562.03	0.06	18.92				
		1E	1107.7682	32.11	85369.05	0.09	11.01				
Sub Total of Resource and Grade for S14-S14' at 225 mRL					**294036.71**	**0.29**	**13.25**				
225	S13-S13'	1A	1763.57	25.00	105814.27	0.11	11.34	NOT ANALYSED			
		1B	987.89	36.86	87393.04	0.09	14.56				
		1C	1050.08	36.86	92894.20	0.09	17.00				
		1D	989.38	35.64	84628.03	0.08	17.00				
		1E	512.41	35.64	43829.79	0.04	15.12				
Sub Total of Resource and Grade for S13-S13' at 225 mRL					**414559.32**	**0.41**	**14.84**				
225	S12-S12'	1A	2638.65	32.80	207714.53	0.21	8.47	28.33	5.61	8.24	14.96
		1B	2135.57	33.85	173493.53	0.17	7.91	39.98	11.08	4.62	9.51
		1C	1846.42	33.85	150003.53	0.15	7.90	36.30	8.44	3.41	12.84
		1D	455.03	34.32	37480.23	0.04	15.41	NOT ANALYSED			
		1E	320.08	34.32	26363.99	0.03	15.41				

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
							Average Grade				
Sub Total of Resource and Grade for S12-S12' at 225 mRL					**595055.81**	**0.60**	**8.91**	**34.39**	**8.20**	**5.69**	**12.58**
225	S11-S11'	1B	2142.49	12.50	64274.64	0.06	9.29	40.61	15.26	4.88	6.36
Sub Total of Resource and Grade for S11-S11' at 225 mRL					64274.64	**0.06**	9.29	**40.61**	**15.26**	**4.88**	**6.36**
225	S9-S9'	1Z	404.49	18.20	17668.12	0.02	6.87	54.81	13.60	4.37	3.48
Sub Total of Resource and Grade for S9-S9' at 225 mRL					17668.12	**0.02**	**6.87**	**54.81**	**13.60**	**4.37**	**3.48**
225	S8-S8'	1A	317.81	30.54	23293.86	0.02	9.56	25.10	4.66	5.01	15.89
Sub Total of Resource and Grade for S8-S8' at 225 mRL					**23293.86**	**0.02**	**9.56**	**25.10**	**4.66**	**5.01**	**15.89**
Gross Total Resource and Grade					**1676140.89**	**1.68**	**11.77**	**36.78**	**9.93**	**5.00**	**11.36**
NetTotal in Situ Resource and Grade (20% reduction for unforseen geological condition)					**1340912.71**	**1.34**	**11.77**	**36.78**	**9.93**	**5.00**	**11.36**

Table 20.3 (c)

Particulars of Section Wise, Zone Wise Resource estimated by Level-Plan method at >5% P_2O_5 from Section S1A-S1A to S15-S15' for at 250mRL in Nimbli Block, Tehsil- Fatehgarh, District -Jaisalmer, Rajasthan

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
							Average Grade				
250	S15-S15'	1A & 1B	2937.77	14.87	104843.01	0.105	16.87	NOT ANALYSED			
		1C	473.44	27.7	31473.98	0.031	12.86				
		1D	320.98	27.7	21338.48	0.021	12.86				
		1E	1184.99	23	65411.27	0.065	9.83	38.01	11.64	3.35	9.51
Sub Total of Resource and Grade for S15-S15' at 250 mRL					**223066.75**	**0.223**	**13.86**	**38.01**	**11.64**	**3.35**	**9.51**
250	S14-S14'	1A	1739.3462	18.4	76809.53	0.077	6.62	33.88	11.17	5.02	13.16
		1B	2992.2918	19.5	140039.26	0.140	7.56	44.31	13.44	4.30	6.88
		1C	1105.3861	23.85	63272.30	0.063	18.92	NOT ANALYSED			
		1E	1045.8236	24.83	62322.72	0.062	11.01				
Sub Total of Resource and Grade for S14-S14' at 250 mRL					**342443.80**	**0.342**	**10.08**	**40.61**	**12.64**	**4.56**	**9.11**
250	S13-S13'	1A	1592.87	16.2	61930.96	0.062	11.19	NOT ANALYSED			
		1B	966.76	18.9	43852.22	0.044	14.56				
		1C & 1D	1548.38	13.47	50056.13	0.050	17				
		1E	364.72	16.5	14443.03	0.014	15.13				
Sub Total of Resource and Grade for S13-S13' at 250 mRL					**170282.33**	**0.170**	**14.10**				
250	S11-S11'	1B	1005.59	14.5	34994.53	0.035	10.00	45.52	13.41	6.13	4.25
		1C	1688.31	14.5	58753.34	0.059	9.29	40.61	15.26	4.88	6.36
Sub Total of Resource and Grade for S11-S11' at 250 mRL					**93747.87**	**0.094**	**9.55**	**42.44**	**14.57**	**5.35**	**5.57**
250	S10-S10'	1B	1592.87	23.73	90717.38	0.091	7.99	40.81	15.02	5.89	8.35
		1C	966.76	26.23	60859.46	0.061	8.56	42.94	16.72	4.50	7.52
Sub Total of Resource and Grade for S10-S10' at 250 mRL					**151576.85**	**0.152**	**8.22**	**41.67**	**15.70**	**5.34**	**8.01**
250	S8-S8'	1C	237.06	17.2	9785.99	0.010	9.56	25.10	4.66	5.01	15.89

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
							Average Grade				
Sub Total of Resource and Grade for S8-S8' at 250 mRL					**9785.99**	**0.010**	**9.56**	**25.10**	**4.66**	**5.01**	**15.89**
250	S6-S6'	1C	470.77	31.55	35646.65	0.036	5.55	42.09	13.08	4.53	9.91
Sub Total of Resource and Grade for S6-S6' at 250 mRL					**35646.65**	**0.036**	**5.55**	**42.09**	**13.08**	**4.53**	**9.91**
250	S3-S3'	1Aa	326.221	11.59	9074.17	0.009	6.08	27.88	8.02	10.87	15.47
		1Ab	305.890	10.47	7686.41	0.008	6.08	27.88	8.02	10.87	15.47
		1Ac	163.977	23.05	9071.21	0.009	6.08	27.88	8.02	10.87	15.47
Sub Total of Resource and Grade for S3-S3' at 250 mRL					**25831.79**	**0.026**	**6.08**	**27.88**	**8.02**	**10.87**	**15.47**
250	S2-S2'	1C	500.521	40.52	48674.71	0.049	5.59	24.09	7.46	3.59	22.13
Sub Total of Resource and Grade for S2-S2' at 250 mRL					**48674.71**	**0.049**	**5.59**	**24.09**	**7.46**	**3.59**	**22.13**
Gross Total Resource and Grade					**1101056.74**	**1.10**	**10.72**	**38.96**	**12.86**	**4.92**	**9.76**
NetTotal in Situ Resource and Grade (20% reduction for unforseen geological condition)					**880845.39**	**0.88**	**10.72**	**38.96**	**12.86**	**4.92**	**9.76**

Table 20.3 (d)

Summation of Section Wise, Zone Wise Resource estimated by Level-Plan method at >5% P_2O_5 from Section S1A-S1A to S15-S15' for at 200, 225, 250mRL in Nimbli Block, Tehsil- Fatehgarh, District -Jaisalmer, Rajasthan

mRL	Section Line	Zone	Area (sq.m)	Vertical Influence (m)	Resource (Tonnes)	Resource (Million Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
Gross Resource and Grade by Level Plan Method at >5% P_2O_5 (For 200, 225, 250mRL)					**3116402.54**	**3.12**	**11.45**	**39.51**	**12.13**	**4.71**	**7.85**
Net in Situ Resource and Grade by Level Plan Method (20% reduction for unforseen geological condition)					**2493122.03**	**2.49**	**11.45**	**39.51**	**12.13**	**4.71**	**7.85**

20.2.0 COMPUTATION OF AVERAGE GRADE

20.2.1 All calculations for grade estimation for phosphorite ore are made by weighted average method. Since the sample interval was uniformly maintained along with different litho-units, the length of the sample was mostly maintained at 1.00m interval with the exception of litho-unit variations, and any structural implications. The, weighted average has been calculated by following formula:

$$\text{Weighted average grade} = \frac{V1 \times G1+V2 \times G2+V3 \times G3+.....+ Vn \times Gn}{V1+V2+V3+.....+Vn}$$

Here `V' = Volume of phosphorite ore in individual borehole

`G'= Grade of the respective phosphorite ore in the corresponding borehole

20.3.0 COMPARISON OF ORE RESOURCE BY GEOLOGICAL CROSS SECTION AND LEVEL PLAN METHOD

20.3.1 The total phosphorite resources estimated by Coss Section and Level Plan method at 5% P_2O_5 cutoff have been compared for reliability of estimated resources. The comparison of resources is given below table.

Table no 20.4

Comparison of Cross Sectional and Level Plan resources, Nimbli block, Tehsil-Fatehgarh, District -Jaisalmer, Rajasthan

Method of Resource Estimation	Gross Resource (tonnes)	Net in situ Resource (Tonnes)	P_2O_5 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	LOI %
Geological Cross Section	3241220.35	2592976.28	11.32	38.66	12.13	4.97	10.26
Level Plan	3116402.54	2493122.03	11.45	39.51	12.13	4.71	7.85
Difference	437647.75	350118.20	0.14	0.85	0.00	0.26	2.41
Difference (%)		**3.85**					

20.3.2 From the above table it is inferred that the difference between the resources from Geological Cross section and Level Plan Method is 3.85% and grade difference of P_2O_5 is 0.14%, the variation in resources estimated by both the methods is within acceptable limit, hence the reliability of resource estimated by Geological Cross section method may be considered for all practical purposes.

20.4.0 CATEGORY OF RESOURCES

20.4.1 The present exploration for phosphorite in Nimbli block is carried out at G-3 level of Exploration where the boreholes are placed at 200m strike interval. The phosphorite zone is occurring as bedded homogenous deposit with significant folding comprising of long apex anticlinal and synclinal fold. The average phosphorite thickness in the block is 4.91m at >5%P_2O_5. Considering the nature and style of mineralization, borehole density and geological cross section interval which fulfil the criteria of G-3 stage exploration as per UNFC system and specifications given in Part: III-I of Minerals (evidence of Mineral content) Rule-2015, mineral resource in the **Nimbli block** is categorised as **inferred category (333)**.

CHAPTER - XXI

21.0.0. SUMMARY AND RECOMMENDATIONS

21.1.0 **SUMMARY**

21.1.1 The Nimbli block area falls in part of Survey of India Toposheet No.40 J/16 and covers an area of 2.70 sq. km in and around villages Beermani, Kohra & Dheerpura of Fatehgarh Tehsil, district: Jaisalmer, Rajasthan.

21.1.2 Preliminary Exploration (G-3) for rock phosphate in Nimbli block was carried out on approval of project in 32nd Executive committee (EC) meeting held on 6th December 2023, with sanction order no. F.No.23/400/2023-NMET/370 dated 12th December 2023 with time line of 12 months and approved cost of ₹ 3,55,98,122/-.

21.1.3 MECL commenced exploration comprising geological mapping, topographical survey on 29.01.2024 and completed on 05.03.2024 and the corresponding data has been reviewed in the 64th TCC meeting held on 25th, 29th & 30th April 2024 (via VC).

21.1.4 MECL commenced drilling operations on 24.05.2024 and completed on 30.09.2024. A total 1293.00 meters of drilling was done in 32 no of boreholes drilled in two phases (phase -I 15 no of boreholes, Phase -II 17 no of boreholes)

21.1.5 Regionally the area falls in Miajlar depression (part of Jaisalmer sub-basin) and belongs to Birmania basin. Pokhran high separates the Bikaner-Nagaur sub-basin from Jaisalmer sub-basin, Devikot-Nachna uplift separates Jaisalmer sub-basin from Barmer Sanchor sub-basin.

21.1.6 Nimbli block area falls in the Birmania basin which is an oval shaped basin located in the heart of the Thar desert, western Rajasthan, India. It is underlain by Malani Igneous Suite of rocks which belong to Late Proterozoic

21.1.7 The Birmania basin comprises of 900-metre-thick sedimentary sequence of siliciclastic, carbonate and phosphorite facies. The sequences is unconformably overlain by Lathi conglomerate of Jurassic age in northern flank of the basin.

Generalized Stratigraphy of the Birmania phosphorite deposit is as below, after GSI

Formation	Lithology	Max Thickness
Lathi	Conglomerates, grits, sandstone and shale	660 m
Birmania	Dolomitic limestone, cherty limestone, shale, siltstone and sandstone Shale white brown to variegated, arenaceous to carbonaceous with siltstone and sandstone bands Phosphorite	>90 60 Less than 1m to

Formation	Lithology	Max Thickness
	Quartzite sandstone Buff colour fine grained, calcareous sandstone, dark brown calcareous and ferruginous sandstone Greyish yellow or cherty grey limestone	over 9m 1-4m 50-270m >80m
Unconformity		
Randha	Sandstones and subordinate calcareous rocks and shales	

21.1.8 GSI carried out exploratory drilling for phosphorite at Birmania during FS: 1968-70. A total 2053.89m of drilling was carried out in 68 no of boreholes in and around Nimbli block and phosphorite was intersected in 55 no of boreholes at depths varying from 1.5 to 40.0 m. Resources were estimated at 10% P_2O_5 cut-off and minimum width of 1.5m and established 3.49 million tonnes with average grade 12.91%.

21.1.9 During the present exploration program, drilling was planned along 2.5 km NE-SW strike of the deposit along which, 16 nos. of section lines marked in NW-SE direction are placed approximately 200m apart. On these section lines in a total 32 nos. of boreholes involving total 1293.00m drilling (G3 stage) was carried out to determine the strike and depth continuity of phosphorite ore body in the block area.

21.1.10 Drilling was completed in two phases, in Phase-I a total 15 no of boreholes (MNP-01 to MNP-15) involving 541.00 m of drilling and in Phase -II a total 17 (MNP-16 to MNP-32) no of boreholes involving 752.00m drilling, thus a total 32 no of boreholes involving 1293.00m of drilling is done in Nimbli block area.

21.1.11 A total 24 nos. of boreholes drilled by GSI (B-32 to B35) are considered for correlation and resource evaluation for phosphorite beds. A total 838.13m was completed in 24.00 no of boreholes (1968-70, GSI).

21.1.12 The rocks of Nimbli block are folded into an asymmetric doubly plunging longitudinal tight hinged fold which extends in NE-SW direction over a strike length of approx. 5km. The Nimbli block comprises a doubly plunging anticline and a complementary doubly plunging syncline traced along NE-SW trending phosphorite-sandstone litho association. The folding pattern consists of a system of asymmetric, longitudinal, sharp-apex, doubly plunging and open folds, which are consistently observed along both strike and dip of the deposit.

21.1.13 All the formations in the area are complexly folded, with dip changing significantly within a few meters in response to folding. The fold axis plunge either northwards or southwards with dip angles

ranging from 5º to 35º. The larger folds exhibit plunge angles of 25º-30º though the plunge varies along their axes when traced in the field.

21.1.14 Phosphorite zones were demarcated on the basis of 5% P_2O_5, cutoff as per IBM guidelines. Out of 56 nos. of boreholes (32 nos. by MECL and 24 nos. by GSI) drilled in Nimbli block, phosphorite zone is intersected at vertical depth ranging from 0.80 m in B-46 to 57.35 m in B-58 and thickness varying between 0.99 m (MNP-07, P_2O_5-5.55%) and 11.88 m (MNP-02, P_2O_5-7.56%).

21.1.15 During the present exploration, boreholes were spaced at approximately 200m strike interval. As per UNFC system and specifications given in Part: III-I of Minerals (evidence of Mineral content) Rule-2015, mineral resource in the block is categorised as inferred category (333).

21.1.16 The phosphorite ore resource and grade has been estimated by "Geological Cross-Section Method" (as principal method) and "Level Plan Method" (as secondary method) as check method.

21.1.17 The total Phosphorite ore resources estimated by Geological Cross section method at 5%P_2O_5 **cutoff** in Nimbli block is **3.24 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.59 million tonnes** with an average grade of **11.32% P_2O_5,** 38.66% SiO_2, 12.13% Al_2O_3, 4.97% Fe_2O_3 and 10.26% LOI. The resources are estimated over a cumulative strike length of 2.5 km.

21.1.18 At **10%P_2O_5 cutoff** the total Phosphorite ore resources estimated by Geological Cross section method in Nimbli block is **2.11 million tonnes** after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **1.69 million tonnes** with an average grade of **13.84% P_2O_5**, 37.05% SiO_2, 10.08% Al_2O_3, 5.18% Fe_2O_3 and 7.65% LOI.

21.1.19 The Resources has been calculated by Level Plan Method at 200mRL, 225mRL and 250mRL at 25m vertical intervals. The total Geological resource by **Level Plan Method** is 3.12 million tonnes, after applying **20% deduction** from gross resources, the **Net-in-situ geological resource** is **2.49 million tonnes** with an average grade of **11.45% P_2O_5**, 39.51 SiO_2%, 12.13% Al_2O_3, 4.71% Fe_2O_3 and 7.85% LOI.

21.1.20 The difference between the resources from Geological Cross section method and Level Plan Method is 3.85% and grade difference of P_2O_5 is 0.14%. The variation in resources estimated by both the methods is which is within acceptable limit, hence the reliability of

resource estimated by Geological Cross section method may be considered for all practical purposes.

21.2.0 RECOMMENDATION

21.2.1 Exploration in Nimbli is carried out G-3 level; resources have been established over a strike length of 2.5km and vertical depth of 50m. However, it is recommended to carryout systematic exploration in G-2/G-1 level along with ore beneficiation studies, feasibility studies before opening of mine. The block may be auctioned at composite level.

CHAPTER - XXII

22.0.0. PLATES AND MAPS

Plates No.	Description	Scale
I	Location Map of Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	Not to Scale
II	Regional Geological Plan Birmania Basin (Source: GSI)	1:20,000
III	Topographical and Geological Plan (1:2000 scale), Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	1:2000
IV	Geological Cross Sections (S1A-S1A' to S15-S15'), Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	1:2000
V-A	Level plan Generated for Phosphorite zone >5% P_2O_5 at 200 mRL for resource estimation in Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	1:2000
V-B	Level plan Generated for Phosphorite zone >5% P_2O_5 at 225 mRL for resource estimation in Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	1:2000
V-C	Level plan Generated for Phosphorite zone >5% P_2O_5 at 250 mRL for resource estimation in Nimbli block, Tehsil- Fatehgarh, District – Jaisalmer, Rajasthan	1:2000

CHAPTER - XXIII

23.0.0. ANNEXURES OR ENCLOSURES TO THE REPORT

23.1.0 The report includes all the relevant annexure and maps/plans, sections photographs and photomicrographs etc.

CHAPTER - XXIV

24.0.0. ANY OTHER INFORMATION

24.1.1 PEER REVIEW OF GEOLOGICAL REPORT

24.2.1 Geological report has been peer reviewed by Dr P.R.Golani, Dy Director General, GSI (Rtd) Suggested peer review comments have been attended (Annexure No. XVII) and incorporated in the present Final Geological Report. Final review of the project was presented in 6th TCC committee II meeting held on 27th February 2025 and committee advised to submit the Final Geological Report.

CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that geological report has been prepared on preliminary exploration (G-3) for rock phosphate in Nimbli Block (2.7 Sq.km), District: Jaisalmer, Rajasthan by Mineral Exploration and Consultancy Limited (MECL) on behalf of National Mineral Exploration Trust. The report has been prepared in accordance with the Minerals (Evidence of Mineral Contents) Rule 2015 specified under Mineral Auction Rule, 2015 and amended up to 2021.

NAME: **P. RAVINDRAN**

DESIGNATION: **GENERAL MANAGER (EXPLORATION)**

DATE: 28.02.2025

LOCALITY INDEX

Locality	Latitude (DMS)	Longitude (DMS)
Birmania	26º14'15"	70º56'
Kohra	26º12'	70º45'
Ladu Singh Dhani	26º14'45"	70º56'
Jhinhindali	26º13'	70º49
Jaisalmer	26º54'	70º55'
Fatehgarh	26º50'	70º12'

REFERENCES

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ii) Report on the Exploratory Drilling for Phosphorite at Birmania, District Jaisalmer, Rajasthan (Field Season GSI 1968-69 & 1969-70)

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iv) Deere, D. U. and Deere, D. W., "The Rock Quality Designation (RQD) Index in Practice,"

v) Pareek H S 1984 Pre-Quaternary geology and mineral resources of northwestern Rajasthan; Geological Survey of India, Kolkata.

vi) Maheshwari A, Sial A N and Mathur S C 2002 Carbon isotope Cuctuations through the Neoproterozoic-lower Cambrian Birmania Basin, Rajasthan, India;

vii) Singh N P 2006 Mesozoic lithostratigraphy of the Jaisalmer Basin, Rajasthan;

viii) Age and implications of the phosphatic Birmania Formation, Rajasthan, India, Ma. Paul Myrow (2015, Precambrian Research).

ix) General Exploration (G-2 Level) For Rock Phosphate In Birmania Block Notified By Government of India In Favor Of FAGMIL by MECL (2023)

x) Geology of Jaisalmer basin studied from DGH, India website

xi) Jaisalmer District information from official website of Rajasthan government.

ABBREVIATIONS USED

SL. No.	Abbreviation	Full form
1	M / m	Meter
2	Cu m	Cubic Meter
3	RL	Reduced Level in metre
4	M.S. L	Mean sea level
5	IBM	Indian Bureau of Mines
6	GSI	Geological Survey of India
7	NMET	National Mineral Exploration Trust
8	EC	Executive Committee
9	TCC	Technical cum Cost Committee
10	MMDR	Mines and Minerals (Development and Regulation)
11	MECL	Mineral Exploration and Consultancy Limited
12	MEMC	Minerals (Evidence of Mineral Contents)
13	NABL	National Accreditation Board for Testing and Calibration laboratories
14	QA/QC	Quality Assessment/ Quality Checks
15	WGS-84	World Geodetic System-84
16	DMS	Degree Minute Second
17	UTM	Universal Transverse Mercator
18	F.S.P.	Field Season Program
19	DGPS	Differential Global Positioning System
20	XRF	X-ray Fluorescence
21	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
22	BDL	Below Detection Limit
23	MT	Million Tonnes