GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITE IN

AMBARA WEST BLOCK

(Area-143.15 Sq Km)

TEHSIL-LAKHPAT AND NAKHATARANA, DISTRICT- KACHCHH, GUJARAT

(Under NMEDT Programme)

Parts of Toposheet no. 41A/14 and 41 E/02

TEXT, ANNEXURE AND PLATES

MECL

MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly known as Mineral Exploration Corporation Limited)

A Government of India Enterprises

CORPORATE OFFICE, NAGPUR

APRIL 2026

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CHAPTER-1

EXECUTIVE SUMMARY

1.1.1 Glauconite, a potassium-rich green silicate mineral, occurs within the sandstone and shale horizons of the Kutch Supergroup in the Kachchh region and is considered an important resource due to its potential use as a natural fertilizer, soil conditioner, and alternative source of potash. Potassium is one of the three primary macronutrients essential for plant growth, along with nitrogen and phosphorus. It plays a critical role in several physiological processes in plants, including enzyme activation, water regulation, photosynthesis, and protein synthesis, thereby significantly influencing crop yield and quality. With the increasing importance of potassium in modern agriculture, the global potash industry has expanded steadily over the last century to meet the growing demand for potassium-based fertilizers.

1.1.2 According to the United States Geological Survey (Mineral Commodity Summaries, 2025), global potash production capacity was about 65.2 million tonnes of K_2O in 2024, which is projected to increase to approximately 76.0 million tonnes by 2028. Presently, most of the global potash supply is derived from marine evaporite deposits and potash-rich brine sources, where minerals such as sylvite, carnallite, kainite, and polyhalite are mined and processed to produce commonly used fertilizers like Muriate of Potash (MOP) and Sulphate of Potash (SOP). However, more than 90% of global potash production is concentrated in a few countries, including Canada, Russia, Belarus, China, Germany, Chile, Brazil, and the United States, creating supply dependency for potash-importing nations such as India. In this context, the exploration of alternative potassium-bearing minerals such as glauconite, feldspar, and mica has gained increasing attention as a potential pathway to enhance resource security and reduce import dependence, particularly in regions where conventional evaporite deposits are absent.

1.1.3 India is one of the world's largest consumers of potash fertilizers but lacks economically mineable evaporite potash deposits, resulting in heavy dependence on imports. To address this gap, exploration has increasingly focused on non-conventional potassium sources such as glauconitic sandstone, potash-rich shales, and feldspathoid-bearing rocks. Glauconitic sandstone, a marine sedimentary rock enriched in the mineral glauconite, forms under slow sedimentation conditions on continental shelves and is now recognized as a potential alternative source of potassium fertilizer. Geological studies indicate that India hosts more than 3,000 million tonnes of glauconitic sandstone resources with K_2O contents typically ranging from about 4–8%, reported from several states including Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Gujarat.

1.1.4 Recognizing its strategic importance, glauconite has been included under national initiatives aimed at strengthening domestic mineral supply. Policy support through the Mines and Minerals (Development and Regulation) Amendment Act, 2023, along with exploration programs and tranche-based auctions of critical mineral blocks, promotes the systematic development of resources such as glauconite. These initiatives encourage participation of agencies like MECL and the private sector to enhance fertilizer security, reduce import dependence, and support India's long-term resource and agricultural sustainability goals.

1.1.5 The Ambara West Block is situated in the northern part of the Kachchh Basin, Gujarat, which forms part of the extensive Kachchh Supergroup sedimentary sequence in north-western India. The basin comprises four major stratigraphic units: Pachcham, Chari, Katrol, and Umia (Bhuj) Formations, representing a Jurassic to Early Cretaceous marine depositional history. The Kachchh region, including the Rann of Kachchh and the Kachchh Peninsula, covers an area of about 45,600 Sq. Km and is characterized by hill ranges, coastal plains, tidal flats, deltaic plains, and other younger geomorphic units. These sedimentary sequences are well known for their mineral potential, including occurrences of glauconitic sandstone, which forms under marine shelf depositional conditions and is considered a potential source of potassium-bearing minerals (Biswas, 1977; GSI reports).

1.1.6 The Ambara West Block, covering approximately 143.15 Sq. Km, was taken up for Reconnaissance Survey (G-4 stage) by MECL based on recommendations from earlier investigations by the Geological Survey of India. The block falls within Survey of India Toposheet Nos. 41A/14 and 41E/02 and forms part of a regional glauconitic sandstone belt of Kachchh District. Previous studies by GSI around Guneri Village have reported glauconite-bearing shale and sandstone horizons within the Katrol and Bhuj (Umia) formations, indicating favourable geological conditions for potash mineralization and fertilizer mineral exploration in the region.

1.1.7 The Reconnaissance survey proposal for Glauconitic in Ambara West Block, Kachchh District, Gujarat was submitted in was recommended in 1st TCC-II Meeting of NMEDT in 26th to 27th September 2024 and was approved by 38th EC meeting of NMEDT on 29th November 2024. Sanction Order was issued on 13th December 2024. The program was scheduled for 12 months (up to 12th December 2025), later extended by three months (up to 31st March 2026).

1.1.8 The area of the exploration block is 143.15 Sq. Km, Field operation was initiated by MECL on 1st April 2025, carried out geological mapping on 1:12500 scale, pitting and subsequently carried out drilling. The Geological Report is being submitted in April 2026.

1.1.9 The Ambara West Block, located in Kachchh District, Gujarat, falls within Lakhpat and Nakhatrana Tehsils and is well connected by road through National Highway-754K, which passes approximately 1 Km from the block area along the Nakhatrana–Rawapar–Mata no Madh route. The district headquarters Bhuj is situated about 100 Km to the south-east, and serves as the nearest major transport hub, with both Bhuj Railway Station (Western Railway) and Bhuj Airport located at a similar distance. The block area exhibits gently undulating terrain, with elevations ranging from about 60 m to 224 m above mean sea level, and shows a regional slope towards the north and north-east. The Ambara West Block is contiguous with the Mudhan–Khatiya Block along its northern margin, while its eastern boundary is shared with the Ambara Maru Block. Drainage in the area is controlled by seasonal streams such as Bhukhi Nadi, Nara Nadi and Gajansar Nadi, forming predominantly dendritic drainage patterns with localized trellis development, which reflects the underlying sedimentary structure of the region.

1.1.10 Geologically, the block lies within the northern Kachchh Basin and is stratigraphically represented mainly by the Katrol Formation (Late Jurassic–Early Cretaceous) with regional association of the Bhuj (Umia) Formation. The Katrol Formation consists predominantly of sandstone, ferruginous and feldspathic sandstone, shale, conglomerate and fossiliferous horizons, within which glauconite mineralization occurs in discrete stratigraphically controlled layers. Glauconite occurs as green pellets and peloids disseminated within fine- to medium-grained sandstones and silty matrices, commonly associated with sedimentary structures such as parallel bedding, cross-bedding, ripple marks and laminations, indicating deposition in a shallow marine shelf to nearshore environment under low to moderate energy conditions. The development of glauconite reflects slow sedimentation and prolonged sediment–water interaction under sub-oxic marine conditions, typical of marine transgressive phases in the basin. Within the Ambara West Block, these glauconitic horizons show lateral continuity at the block scale, shows favourable conditions for occurrences of potash-bearing glauconitic sandstone resources.

1.1.11 Detailed field investigations carried out in the Ambara West Block involved systematic geological mapping, lithological observations, and measurement of structural elements at surface exposures. During field traverses, the sedimentary formations of the Katrol Formation, comprising glauconitic sandstone, shale, calcareous sandstone and associated lithounits, were examined with respect to lithology, stratigraphic continuity, and mineralisation characteristics. Bedding attitudes recorded in the field indicate generally gentle dips ranging from about 5° to 10°, with strikes varying from NE–SW to NW–SE, reflecting the regional structural grain of the basin. The formations are observed to be largely undisturbed, with no evidence of major folding or fault displacement within the block. Geological observations further indicate persistent lateral continuity of glauconite-bearing horizons, while minor variations in dip and lithological disposition are attributed mainly to weathering and local erosional effects rather than tectonic disturbance.

1.1.12 The Ambara West Block lies within a relatively stable inter-fault domain of the Kachchh Basin, where regional fault systems have influenced basin architecture and sedimentation but have not caused direct structural disruption within the block. Field and borehole data indicate gentle bedding dips and largely sub-horizontal strata at depth, suggesting minimal tectonic disturbance and good continuity of stratigraphic units, particularly the glauconitic sandstone horizons.

1.1.13 Geological and structural mapping on a 1:12,500 scale was carried out in the Ambara West Block to delineate glauconitic horizons and associated structural features, with the objective of identifying surface manifestations and understanding the lateral and vertical disposition of mineralized zones. During the course of exploration, extensive geochemical sampling was undertaken, including around 100 bedrock samples, 91 pit samples, and 214 borehole samples. In total, 405 primary samples and 41 external check surface samples were generated. All primary samples were analysed for eight chemical radicals, including K_2O, at the MECL Chemical Laboratory, Nagpur, while the external check samples were analysed at the Jawaharlal Nehru Aluminium

Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory, to ensure analytical quality control.

1.1.14 Drilling operations commenced on 02 January 2026 and were completed on 14 January 2026, during which 10 boreholes (MKAW-01 to MKAW-10) were drilled on an approximate 1600 m × 1600 m grid pattern, consistent with the Minerals (Evidence of Mineral Contents) Rules, 2015 requirements for G-4 (Reconnaissance) level exploration. MECL completed 273.00 m of vertical drilling across these boreholes, generating 214 primary drill core samples and 21 check samples for chemical analysis. The drilling results indicate that glauconite-bearing zones within the Katrol Formation, defined using a cut-off grade of >3% K_2O, were intersected in the boreholes, confirming the presence of glauconitic sandstone horizons within the block. Out of 10 boreholes, 8 boreholes intersected the glauconitic sandstone horizon and have been considered for resource estimation. The remaining two boreholes (MKAW-6 and MKAW-7) did not intersect the glauconitic sandstone; therefore, they are excluded from resource estimation.

1.1.15 Resource estimation for the Ambara West Block has been carried out using the Polygonal Method, with a 20% deduction applied to the gross in-situ resources to account for geological uncertainties such as cavities and structural irregularities, resulting in net in-situ resources. A total of 212.11 million tonnes of Reconnaissance Resources (UNFC 334) with an average grade of 4.30 % K_2O has been estimated over an area of 18.44 Sq. Km. The results indicate promising glauconite mineralisation, and the block is recommended for upgradation to a higher level of exploration in identified potential zones. The area may also be considered for auction under the critical and strategic mineral framework. Further studies such as SEM–EDS analysis and grain size characterization are recommended to confirm glauconite mineralogy and distinguish it from associated feldspar and mica phases.

CHAPTER-2

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

2.1.0 MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly Mineral Exploration Corporation Limited)

A Govt. of India Enterprise; A Miniratna-I CPSE

Ministry of Mines, Govt. of India

Dr. Babasaheb Ambedkar Bhawan, High Land Drive Road,

Seminary Hills, Nagpur-440006

Maharashtra, India

2.2.0 PERSONNEL ASSOCIATED WITH EXPLORATION

Exploration agency: Mineral Exploration and Consultancy Limited

Experience: 51 Years, Since 1972

Email: cmd@mecl.gov.in; gm-exploration@mecl.gov.in

Sl. No.	Name of the Person	Designation	Qualification	Experience
1	Shri Shrikant Sharma	HOD (Exploration)	M.Sc. Geology	23 Years
2	Shri P. Ravindran	GM (Exploration) Rtd.	M.Sc. Geology	35 Years
3	Shri Naveen Pala	Sr. Manager (Geology)	M.Sc. Geology	21 Years
4	Shri Bhuneshwar Kumar	Manager (Geology)	M.Sc. Geology	20 Years
5	Shri Rajeev Pandey	Geologist	M.Sc. Geology	01Years
6	Shri Shibasish Mohanty	Young Professional Geology	M.Sc., Geology	04 Years

CHAPTER-3

3.0.0 TITLE AND OWNERSHIP

3.1.0 Report Title: Geological Report on Reconnaissance Survey (G-4 Stage) For Glauconite in Ambara West Block (Area-143.15 Sq. Km), Tehsil-Lakhpat and Nakhatrana, District- Kachchh, Gujarat

Ownership: Government of Gujarat

Name of Prospector: MINERAL EXPLORATION AND CONSULTANCY LIMITED (Formerly Mineral Exploration Corporation Limited) A Govt. of India Enterprise; A Miniratna-I CPSE, Ministry of Mines, Govt. of India

Address of Prospector: Dr. Babasaheb Ambedkar Bhavan, High Land Drive Road, Seminary Hills, Nagpur, Pin- 440006, Maharashtra, India

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

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

3.2.0 DETAILS ABOUT PERIOD OF PROSPECTING

The exploration programme in the block commenced on 1st April 2025 with geological mapping at a 1:12,500 scale. This was followed by pitting and exploratory drilling, during which DGPS surveying and borehole core sampling were undertaken in parallel to support accurate documentation. Analytical and laboratory investigations were then carried out in MECL laboratories and other NABL-accredited laboratories to generate reliable geochemical and petrological data.

3.3.0 DETAILS OF EXPLORATION AGENCY, QUALIFICATION, AND EXPERIENCE OF ASSOCIATED TECHNICAL PERSONS ENGAGED IN EXPLORATION

3.3.1 **Exploration Agency:** Mineral Exploration and Consultancy Limited
(Formerly Mineral Exploration Corporation Limited)
A Govt. of India Enterprise-A Miniratna-ICPSE

3.3.2 Qualification : M.Sc. / M. Sc. Tech. (Geology)

3.3.3 Experience: Experience: Since 1972

CHAPTER-4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

4.1.1 The Ambara West Block is located in Lakhpat and Nakhatrana Taluka, Kachchh District, Gujarat, on the western part of the Kachchh mainland. It lies near the villages of Amiya, Meghpar, Junachay, Valka Nana, Valka Mota, Paneli, Gadani villages and falls on Survey of India Toposheet Nos. 41A/14 and 41E/02. The total area of the block is about 143.15 Sq. Km.

4.1.2 The Ambara West Block falls in parts of the Survey of India Toposheet No. 41A/14 and 41E/02 and it lies between 23° 30' 45.975"N to 23° 38' 24.470"N latitudes and 68° 57' 5.324"E to 69° 5' 35.282"E longitudes. The Location Map is given in Plate-I and Text Fig. 4.1. The co-ordinates of the corner points of the block area both in geodetic and in UTM are given in table No.- 4.1 and in Annexure IA.

4.1.3 The Ambara West Block has been delineated on the basis of geological continuity of glauconite-bearing horizons established through earlier investigations, supplemented by supporting geochemical (NGCM) evidence. The present reconnaissance block constitutes the southeastern extension of the G-4 investigation block of the Geological Survey of India (FSP 2014–15), reported in Detailed Investigation for Potash in Glauconite Bearing Shale and Sandstone around Guneri Village, Kachchh District, Gujarat, wherein glauconite-bearing shale and sandstone horizons of the Katrol and Bhuj Formations have been identified. The delineation of the block is further supported by National Geochemical Mapping (NGCM) data, wherein 34 stream sediment samples falling within the proposed block record K_2O values ranging from 0.84% to 3.05%, indicating glauconitic potential comparable with adjoining mineralised areas. In view of the persistence and lateral continuity of glauconitic sandstone observed in the adjoining GSI block, the present exploration block has been conceived to establish the southeastern continuity and extension of the mineralised horizon. The Ambara West Block shares a common boundary with the Mudhan–Khatiya Block along its northern boundary and with the Ambara Maru Block along its eastern boundary, both of which have also been explored by Mineral Exploration and Consultancy Limited (MECL), further substantiating regional continuity of the prospective glauconite-bearing tract.

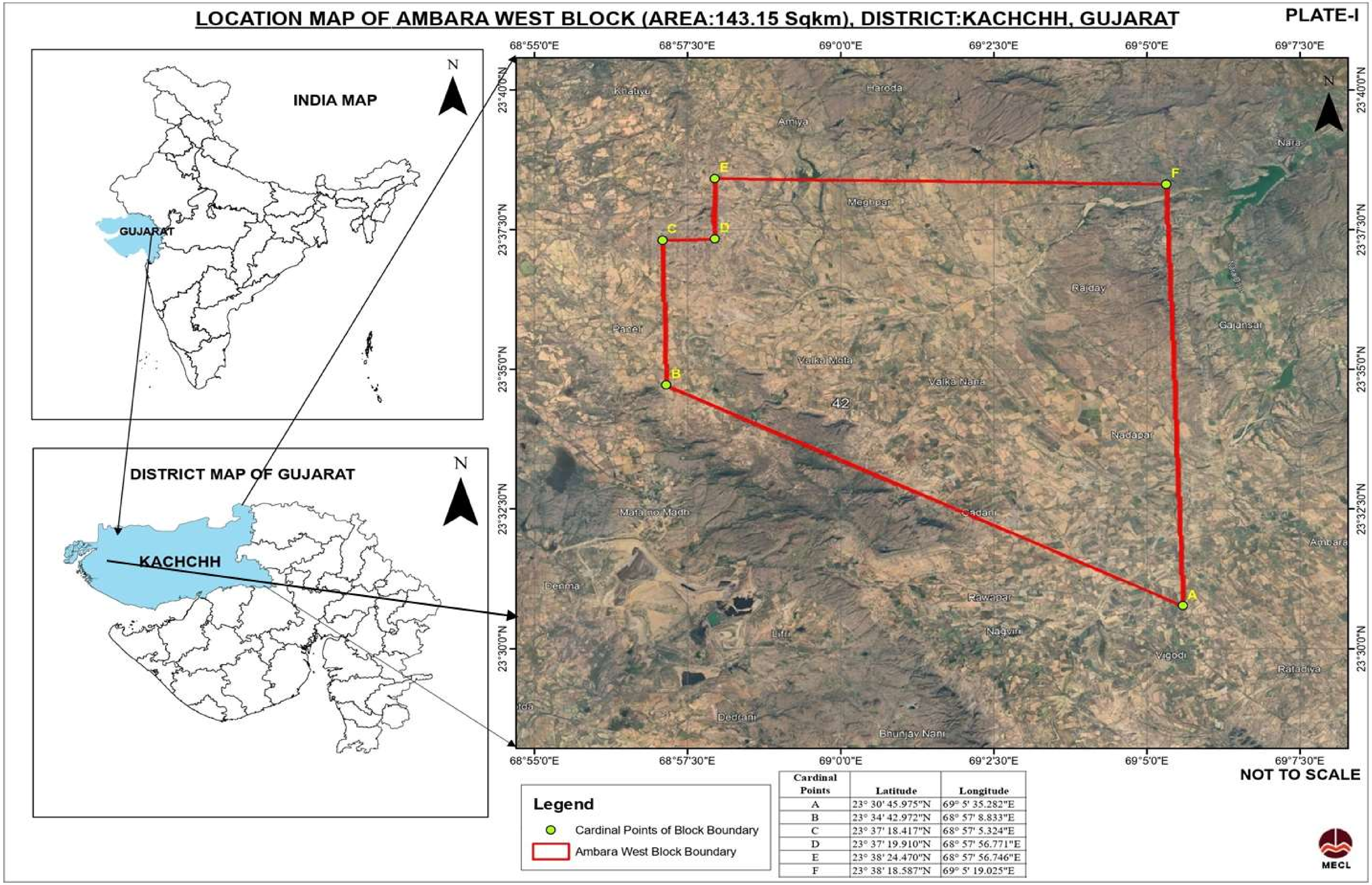
4.1.4 The block boundary is defined by six cardinal points (A–F) as listed in Table 4.1. The coordinates are derived from Survey of India toposheets 41A/14 and 41E/02 and have been validated through GIS-based geo-referencing, incorporating regional mineralisation data from the NGDR portal and Google Earth during boundary delineation.

Table No.-4.1

Co-ordinates of cardinal points of block boundary of Ambara West Block for Glauconite, District: Kachchh, Gujarat

Point	Latitude	Longitude
A	23° 30' 45.975"N	69° 5' 35.282"E
B	23° 34' 42.972"N	68° 57' 8.833"E
C	23° 37' 18.417"N	68° 57' 5.324"E
D	23° 37' 19.910"N	68° 57' 56.771"E
E	23° 38' 24.470"N	68° 57' 56.746"E
F	23° 38' 18.587"N	69° 5' 19.025"E

4.1.5 Ambara West Block is accessible from the district headquarters Bhuj via Nakhatrana – Rawapar – Mata No Madh Road, connecting through National Highway NH-754K. The NH-754K passes at an approximate distance of 1 km from the block area and provides metalled road connectivity via Rawapar village to Mata No Madh village. Lakhpat Tehsil, the administrative jurisdiction of the block, is located at a distance of about 40 km from the block area. The district headquarters Bhuj lies approximately 100 km towards the southeast of the block. The nearest railway station is Bhuj, situated at a distance of about 100 km in the southeast direction. Bhuj Railway Station is a Class-A station on the Western Railway (Western Line) network. The nearest airport is Bhuj Airport, located approximately 100 km southeast of the block area, providing regular air connectivity to major cities.



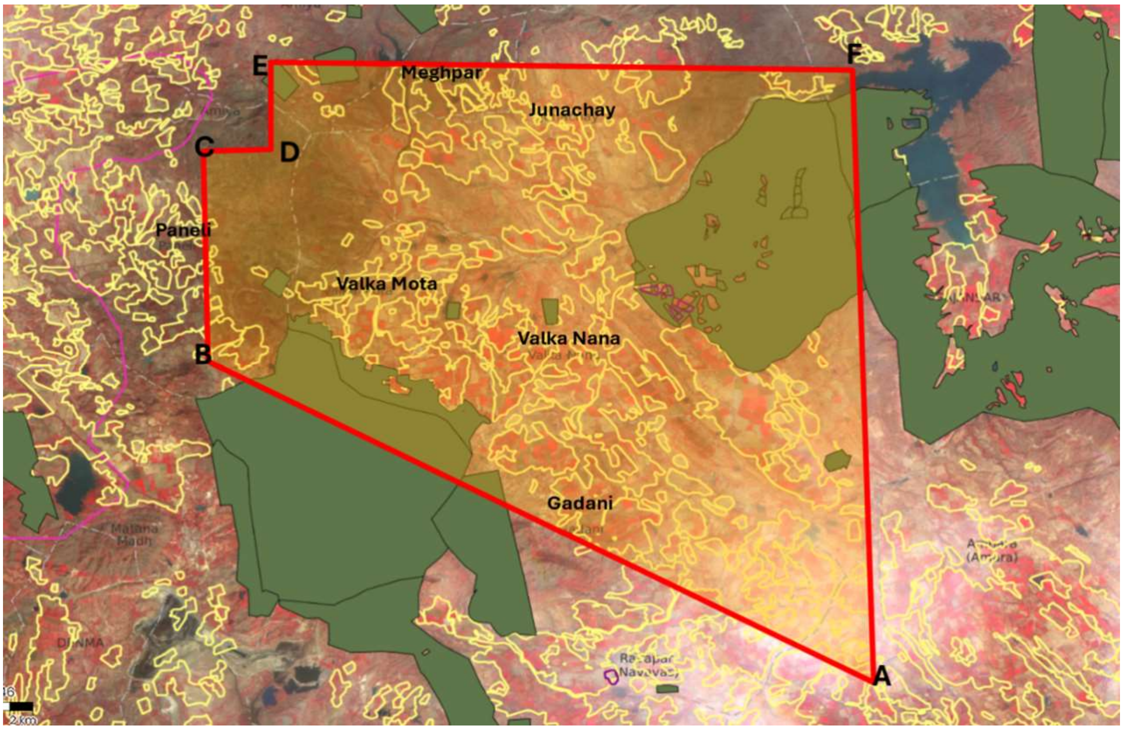
Cardinal Points	Latitude	Longitude
A	23° 30' 45.975"N	69° 5' 35.282"E
B	23° 34' 42.972"N	68° 57' 8.833"E
C	23° 37' 18.417"N	68° 57' 5.324"E
D	23° 37' 19.910"N	68° 57' 56.771"E
E	23° 38' 24.470"N	68° 57' 56.746"E
F	23° 38' 18.587"N	69° 5' 19.025"E

Text Figure-4.1: Location Map of Ambara West Block for Glauconite, District: Kachchh, Gujarat

4.2.0 DETAILS OF THE AREA WITH LAND USE

4.2.1 The land use pattern of the Ambara West Block comprises agricultural land, forest patches, grazing land and uncultivated terrain, with spatial variations controlled by topography, soil cover and geological conditions. Agricultural land is predominantly developed around Meghpar, Junachay, Valka Nana, Valka Mota and Gadani villages, whereas the Paneli sector and adjoining western parts show comparatively fragmented cultivation associated with larger stretches of grazing and uncultivated land.

4.2.2 Forest land occurs as discrete patches, more prominent in the central, southwestern and eastern sectors of the block, while the northern sector is relatively dominated by agricultural use. Grazing land and uncultivated scrub terrain occupy substantial inter-village areas, particularly in the western and southern parts, indicating overall predominance of agricultural land in the northern-central sectors and mixed grazing–uncultivated land use in the western-southern sectors.



Text Figure-4.2 Map showing the Land-use for the Ambara West Block and surrounding area (Source: PM Gatishakti Portal)

4.3.0 MINERAL(S) UNDER INVESTIGATION

4.3.1 Block was explored for Glauconite.

CHAPTER-5

5.0.0 PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 RELIEF OF THE AREA WITH MINIMUM AND MAXIMUM ELEVATION, DRAINAGE PATTERN, NATURAL WATER COURSES, RESERVOIRS, ETC.

5.1.1 The Ambara West Block, covering an area of about 143.15 Sq. Km and falling in Lakhpat and Nakhatrana Taluka of Kachchh District, is situated in the western part of the Kachchh Mainland. The terrain is characterized by gently undulating surfaces with intervening rocky uplands and Quaternary plains, typical of the stable mainland uplift of Kachchh. Based on interpretation of regional satellite data, the area shows a general north to north-east-ward regional slope. Elevation within the block broadly varies from about 20 m to 155 m above mean sea level (amsl), with higher ground occurring towards the western part and relatively lower elevations towards the eastern part, reflecting moderate relief developed due to tectonic stability and prolonged Quaternary geomorphic processes.

5.1.2 The block and its surrounding areas are drained by Bhukhi Nadi, Nara Nadi, Gajansar Nadi, along with several second- and third-order streams developed in the region. The overall drainage pattern is predominantly dendritic to sub-dendritic, with localized development of trellis pattern, suggesting minor structural influence. Drainage is ephemeral in nature, with short seasonal nalas becoming active during the monsoon and remaining dry for most of the year, consistent with the semi-arid climatic conditions of the region.

5.1.3 Surface water resources within and around the block are limited. Natural water courses are discontinuous and seasonal, and perennial streams are absent. Surface water availability is mainly supported by village talavs, small check dams, and rain-fed ponds, developed for storage of monsoon runoff to meet domestic and livestock requirements.

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

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5.2.1 The Ambara West Block is accessible from the district headquarters Bhuj via Nakhatrana–Rawapar–Mata No Madh road through NH-754K. The National Highway-754K passes at an approximate distance of 1 km from the block boundary and provides all-weather connectivity to the area through metalled roads linking Rawapar village with Mata No Madh village. The internal and approach road network is adequate for movement of light and medium vehicles, making road transport the primary mode of access for personnel, equipment, and supplies to the block.

5.2.2 Rail connectivity in the region is available through the Bhuj–Naliya railway corridor, which lies outside the block area. Bhuj serves as the nearest major railhead, facilitating transport of materials and manpower to the region, from where road transport is used to access the block. At present, no rail infrastructure passes through the block area.

5.2.3 Electric power infrastructure in the region comprises medium- and high-voltage transmission lines running mainly along existing road alignments, supplying electricity to nearby villages and settlements. Telecommunication facilities, including mobile network coverage with 4G services, are available along major roads and inhabited areas; however, signal strength and reliability tend to reduce in sparsely populated interior tracts. Overall, the existing infrastructure provides adequate logistical support for exploration activities, though alignment and execution of field operations will require due consideration to avoid interference with existing utilities and local infrastructure.

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

5.3.1 The host population in and around the Ambara West Block comprises predominantly Maldhari pastoral communities, who represent the traditional rural and semi-nomadic population of the western Kachchh mainland. These communities are primarily engaged in livestock rearing, including cattle, buffalo, sheep, and goats, and practice seasonal or semi-nomadic grazing depending on rainfall and fodder availability. In addition to pastoral households, the host population includes agrarian communities practicing rainfed agriculture and artisan families involved in traditional crafts characteristic of the Kachchh region.

5.3.2 Socio-economic conditions of the host population reflect moderate to low literacy levels, generally ranging from about 33% to 65%, and a young age structure, with the 0–6 years age group constituting approximately 11% to 18% of the population in surrounding villages (Census 2011). Livelihoods are closely linked to common property resources, particularly grazing lands (gochar), village talavs, and seasonal nalas, making the population highly dependent on monsoon rainfall and seasonal water availability. These characteristics indicate a resource-dependent socio-economic setting, requiring careful planning of exploration activities to minimize disturbance to grazing areas and water sources.

5.3.3 The Ambara West Block is situated in a predominantly rural landscape characterized by dispersed human settlements. Villages located within and in the immediate vicinity of the block include Amiya, Meghpar, Valka Nana, Valka Mota, Paneli, Matana Madh, and Ravapar (Navavas). These villages range from small settlements with a few hundred inhabitants to larger villages such as Ravapar (Navavas) and Matana Madh, which function as local habitation and service centers.

5.3.4 Settlement distribution is largely influenced by road connectivity, availability of surface water sources, and traditional land-use practices. Population density is generally low to moderate, with sex ratios broadly ranging from about 890 to 1,000 females per 1,000 males, consistent with rural demographic trends of Kachchh. Workforce participation is mainly in livestock rearing, rainfed agriculture, and allied rural occupations, with a mix of main and marginal workers.

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 As per Census of India 2011, the Ambara West Block lies in a predominantly rural socio-demographic setting within Lakhpat and Nakhatrana Taluka of Kachchh District, characterized by dispersed settlements and low to moderate population density. Villages located within and in the immediate vicinity of the block include Amiya, Meghpar, Valka Nana, Valka Mota, Paneli, Matana Madh, and Ravapar (Navavas). Population size varies from a few hundred in smaller villages to several thousand in larger settlements such as Ravapar (Navavas) and Matana Madh. The overall sex ratio in these villages generally ranges between about 890 and 1,000 females per 1,000 males, consistent with rural demographic trends of western Kachchh. The habitation referred to locally as Junachay is understood as a small settlement/hamlet and is not enumerated as a separate census village in the 2011 records.

5.4.2 Literacy levels in the villages surrounding the block are low to moderate, broadly ranging from approximately 33% to 65%, with comparatively lower literacy observed in smaller and pastoral-dominated settlements. The 0–6 years age group constitutes about 11% to 18% of the total population, indicating a relatively young demographic profile. Workforce participation comprises a mix of main and marginal workers, with livelihoods predominantly based on livestock rearing, rainfed agriculture, and allied rural activities, typical of the socio-economic structure of the Kachchh mainland. Overall, the socio-demographic characteristics indicate a resource-dependent rural population, which is an important consideration for planning and execution of exploration activities in and around the Ambara West Block.

5.5.0 HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES OF WORSHIP, PUBLIC UTILITIES ETC.

5.5.1 The Ambara West Block lies within Lakhpat and Nakhatrana Taluka of Kachchh District, an area recognized for its cultural, archaeological, and religious heritage. Government records indicate the presence of several protected and notified heritage sites within the wider regional setting of these talukas. Important archaeological monuments include the Siyot Caves, located near Siyot village, comprising early rock-cut caves dated broadly to the 1st–2nd century AD, which were subsequently adapted for Hindu religious use and are protected by the Archaeological Survey of India (ASI). To the west, the Lakhpat Fort, an 18th-century fortification enclosing the historic town of Lakhpat, represents a major notified heritage structure with associated religious monuments. In addition, the Koteshwar Temple, situated near Narayan Sarovar, is an important pilgrimage centre forming part of the broader cultural landscape of western Kachchh. While these sites do not lie within the block boundary, they are significant cultural assets of the region and are relevant from a heritage-sensitivity perspective.

5.5.2 As per Census of India 2011, the Ambara West Block is situated in a predominantly rural socio-demographic setting. Villages located within and in the immediate vicinity of the block include Amiya, Meghpar, Valka Nana, Valka Mota, Paneli, Matana Madh, and Ravapar (Navavas). These settlements are small to medium-sized rural villages, with livelihoods primarily dependent on livestock rearing, rainfed agriculture, and allied activities. Religious practices in these villages are closely integrated with pastoral and agrarian life, with local temples, shrines, and community spaces forming important socio-cultural focal points.

5.5.3 Public utilities in the block area and surrounding villages are basic but functional, consistent with rural infrastructure patterns of the talukas. Local governance is provided through Gram Panchayats, while primary schools and anganwadi centres cater to elementary education and child welfare. Rural health sub-centres and community health workers provide primary healthcare services, with advanced medical facilities accessed at Bhuj, the district headquarters. Village talavs, check dams, and borewells constitute the principal sources of domestic and livestock water supply, particularly during post-monsoon periods. Electricity distribution lines and telecommunication services extend to most villages, ensuring basic connectivity and supporting routine socio-economic activities.

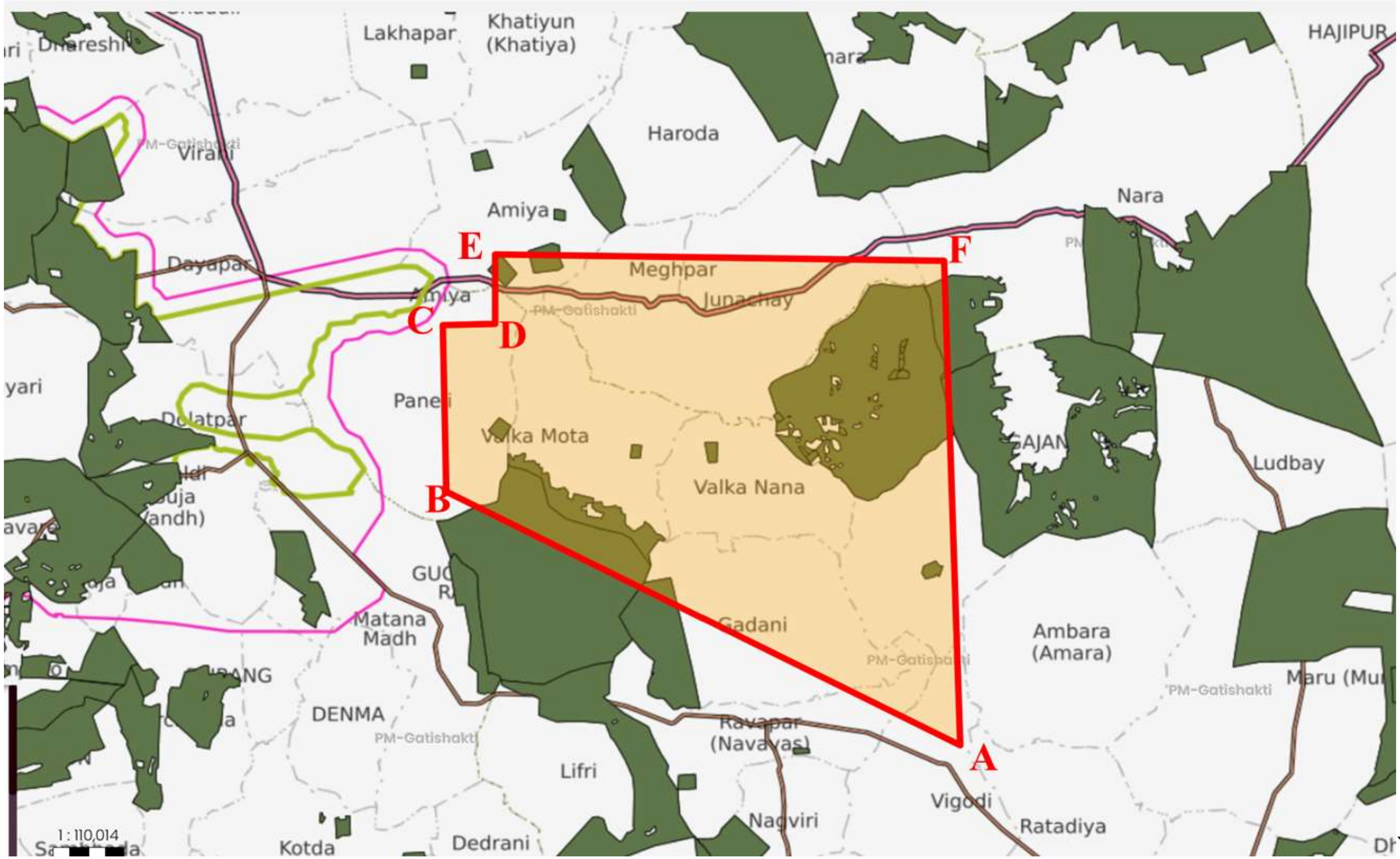
5.6.0 FORESTS, SANCTUARIES, NATIONAL PARK AND WILD LIFE SANCTUARIES ETC.

5.6.1 The Ambara West Block, located in Lakhpat and Nakhatrana Taluka of Kachchh District, Gujarat, is situated in a semi-arid ecological zone characterized by scrub forests, saline flats, and desert vegetation. According to the Gujarat Forest Department and Champion & Seth classification, the region falls under Type Desert Thorn Forests, with dominant species including Prosopis juliflora, Acacia senegal, Capparis decidua, and Salvadora persica. These forest patches are typically non-notified and scattered, but serve as critical ecological buffers and grazing habitats. The block lies in proximity to two major protected areas:

- **Narayan Sarovar Wildlife Sanctuary:** The Narayan Sarovar Wildlife Sanctuary, located to the southwest of the Ambara West Block, is a notified Protected Area under the Wildlife Protection Act and covers approximately 444 sq km. The sanctuary represents a typical arid–desert ecosystem with dominant vegetation comprising desert thorn scrub, Euphorbia scrub, and dry savannah communities. The principal flora includes species of Acacia (notably Acacia nilotica), Salvadora, Ziziphus, Capparis, various Euphorbia species, and scattered patches of Prosopis which has been recorded as invasive in parts of the sanctuary. The fauna is characteristic of the arid biome and includes Chinkara (Indian Gazelle), Blackbuck, Nilgai (Bluebull), Indian Fox, Desert Fox, Striped Hyena, Caracal, Indian Wolf, Indian Hare, Porcupine, Wild Boar, and small carnivores such as the Indian Grey Mongoose. The sanctuary also supports rich avifaunal diversity, with more than 160 species reported, including raptors, bustards, migratory waterbirds, and other desert-adapted bird species. Recent survey records (2020–2023) from the Gujarat Forest Department, ZSI, and regional checklists confirm continuing presence of these species' groups within the protected area.

- **Kachchh Desert Wildlife Sanctuary:** The Kutch Desert Wildlife Sanctuary is situated approximately 25–30 Km east of the Ambara West Block and forms India's largest protected saline wetland, spanning nearly 7,506 Sq. Km. The landscape comprises extensive seasonal wetlands, saline plains, mudflats, and desert scrub. Vegetation is dominated by halophytic and xerophytic species such as Prosopis (primarily P. juliflora), Commiphora wightii (Gugal), Euphorbia ("Thor"), Salvadora, Capparis decidua, and Dichrostachys/Senegalia ("Gorad"), representing a typical dry scrub–thorn ecosystem. The fauna includes desert ungulates and carnivores such as the Indian Gazelle, Nilgai, Desert/Indian Fox, Striped Hyena, and occasional Caracal sightings. The sanctuary is internationally known for its large congregations of migratory and resident waterbirds, including Greater and Lesser Flamingos, Pelicans, Cranes, Avocets, and numerous wader and gull species that utilize the seasonal wetland habitats; "Flamingo City" within the sanctuary continues to be a major breeding site during favourable years. Reptilian fauna such as the Spiny-tailed Lizard and other desert-adapted species are also well documented. The ecological influence of this protected wetland extends across the wider Lakhpat–Kutch desert landscape, even though it lies outside the immediate buffer zone of the Ambara West Block.

5.6.2 There is no Eco-Sensitive Zone (ESZ) within the block area. The nearest notified ESZ and Wildlife Sanctuary is the Narayan Sarovar Wildlife Sanctuary. Text Figure-5.1.



Text Figure-5.1 showing the status of nearby ESZ and National Park in the vicinity of the Ambara West Block (Source – PM Gatishakti Portal)

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

5.7.1 The Ambara West Block falls in a predominantly arid scrub–desert landscape where vegetation is sparse and dominated by hardy xerophytic species typical of western Kachchh. The area primarily supports Acacia/Babool, Prosopis juliflora, Salvadora spp., Euphorbia scrub, Capparis, scattered Ziziphus, and seasonal grasses/herbs that appear after rainfall. Wildlife within the block boundary is characteristic of open scrub and semi-desert terrain, with Chinkara (Indian gazelle), fox, hare, porcupine, small rodents, reptiles such as spiny-tailed lizard, and a mix of resident birds adapted to dry thorn-scrub habitat. No notified Eco-Sensitive Zone lies inside the block boundary, and no major protected-area species or critical habitats are recorded within the core prospecting area as per available official data.

5.7.2 In the surrounding region, two major notified wildlife habitats influence the ecological setting. To the southwest lies the Narayan Sarovar Wildlife Sanctuary (~444 Km^2), hosting desert-thorn forest with Acacia, Ziziphus, Salvadora, Euphorbia, gugal, and savannah scrub supporting Chinkara, Blue bull, Blackbuck, Caracal, Desert Fox, Striped Hyena, and over 180–200 bird species including desert bustards, harriers, and seasonal waterbirds. Around 25–30 Km east of the block lies the Kutch Desert Wildlife Sanctuary (~7,506 Km^2), characterised by saline wetlands, “bets,” and desert scrub with Prosopis, Euphorbia, Commiphora (gugal), Capparis, and halophytes, supporting large congregations of Greater/Lesser Flamingos, pelicans, cranes, waders, Chinkara, Blue-bull, foxes, hyenas and desert reptiles. These sanctuaries lie outside the block limits but form the nearest significant ecological receptors, representing sensitive arid-ecosystem biodiversity relevant for regional environmental assessment.

5.8.0 WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR, ETC., WITHIN OR NEARBY AND CLIMATIC CONDITIONS

5.8.1 The Ambara West Block and its surrounding areas are drained by Bhukhi Nadi, Nara Nadi, Gajansar Nadi, along with several second- and third-order streams developed in the region. The overall drainage pattern is predominantly dendritic to sub-dendritic, with localized development of trellis pattern, suggesting minor structural influence. Drainage is ephemeral in nature, with short seasonal nalas becoming active during the monsoon and remaining dry for most of the year, consistent with the semi-arid climatic conditions of the region.

5.8.2 Surface water resources within and around the block are limited. Natural water courses are discontinuous and seasonal, and perennial streams are absent. Surface water availability is mainly supported by village talavs, small check dams, and rain-fed ponds, developed for storage of monsoon runoff to meet domestic and livestock requirements.

5.8.3 The climate in the Ambara West Block region is arid to semi-arid, characteristic of the wider Kachchh district. According to long-term climatological data at Bhuj (nearest meteorological station), the annual mean temperature is approximately 26.4 °C. Summers are extremely hot, with peak temperatures reaching about 39–40 °C (sometimes higher), whereas winter temperatures may drop to around 10–12 °C during the coldest nights. Annual rainfall is low and erratic: long-term records suggest an average annual precipitation in the range of ~300–400 mm, with most rainfall concentrated during the southwest monsoon months (June to September). Humidity also shows wide seasonal variation: during pre-monsoon and peak summer the relative humidity may drop to ~25–30%, whereas during monsoon and early mornings it may climb to ~65–75%, leading to average/hypothetical annual humidity around 50–55%.

5.9.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTOR

5.9.1 The Ambara West Block in Lakhpat and Nakhatrana Taluka lies in a semi-arid zone with undulating terrain, calcrete crusts, and ephemeral drainage. Rainfall averages 300–400 mm annually (IMD), groundwater is often saline, and seasonal water scarcity poses operational challenges.

5.9.2 Socially, the Ambara West Block is surrounded by dispersed rural settlements. Villages located within and in the immediate vicinity of the block include Amiya, Meghpar, Valka Nana, Valka Mota, Paneli, Matana Madh, and Ravapar (Navavas). The surrounding administrative areas show significant rural populations: Lakhpat Taluka had a total population of 62,552 with an average literacy rate of about 62.1% as per Census 2011, which reflects predominantly rural demographics and low literacy levels relative to broader regional averages. Nakhatrana Taluka recorded a population of 146,367 with a literacy rate of approximately 71.1% in 2011, indicating relatively higher educational attainment in parts of the wider region.

5.9.3 The host population is predominantly composed of Maldhari pastoralists and agrarian households, who rely on gochar lands and grazing corridors for livestock rearing, alongside rainfed agriculture and traditional crafts. Disruption to grazing lands or village water sources due to exploration or related activities could adversely affect livelihoods and potentially trigger community resistance. Additionally, the area contains significant heritage and cultural assets, including Siyot Caves and Lakhpat Fort, as well as important places of worship such as Koteshwar Temple and Narayan Sarovar.

CHAPTER-6

6.0.0 INFRASTRUCTURE AND ENVIRONMENT

6.1.0 LOCAL INFRASTRUCTURE, HOST POPULATION, HISTORICAL SITES, FORESTS, SANCTUARIES, NATIONAL PARK AND ENVIRONMENTAL SETTING OF THE AREA.

6.1.1 The Ambara West Block, located in Lakhpat Taluka and Nakhatrana Taluka of Kachchh District, is reasonably well connected by a network of State Highways and Major District Roads, linking nearby villages such as Vigodi, Rawapar, Mata No Madh, Dolatpar, Siyot, Dayapar, and Ghaduli. The nearest major road access is through Dayapar, which provides onward connectivity to Bhuj and Gandhidham.

6.1.2 Rail connectivity in the region is provided by the Bhuj–Naliya railway line, with Bhuj Railway Station serving as the nearest major railhead, located approximately 100–105 Km southeast of the block. The station facilitates both passenger and limited freight movement within the district.

6.1.3 Port infrastructure is available at Kandla Port, situated at an approximate distance of 180 km southeast, and Mundra Port, about 160 Km southeast of the block. Both ports are major handling centres for bulk minerals, industrial raw materials, and exports, thereby enhancing logistical viability.

6.1.4 Block is well supported by infrastructure, with reliable electric power supply available through medium- and high-voltage transmission lines along district roads, supported by substations at Dayapar and Ghaduli. However, water availability is limited due to the semi-arid climate, and is mainly sourced from village talavs, check dams, and borewells, with additional supply transported during dry periods. The block does not fall within any Eco-Sensitive Zone (ESZ), and the nearest protected area is the Narayan Sarovar Wildlife Sanctuary.

6.1.5 The Kachchh region hosts several mineral-based industries, including cement, ceramics, fertilizer blending, and salt-based chemical industries, mainly around Gandhidham, Mundra, and Bhuj. Glauconite from the Ambara West Block has potential applications in fertilizer, soil conditioning, and ceramic industries, and the presence of nearby industrial clusters indicates good regional demand. Additionally, the proximity to Mundra and Kandla ports provides strong logistical advantages for transportation to domestic and international markets.

CHAPTER-7

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

7.1.1 Regionally, the Ambara West Block is situated in the northern part of the Kachchh Basin, a pericratonic rift basin of western India. Lithostratigraphically, the block forms part of the Katrol Formation, which belongs to the Late Jurassic–Early Cretaceous age. The Kachchh Peninsula and the adjoining Rann of Kachchh cover an area of approximately 45,612 Sq. Km, and are physiographically divided into hill ranges, dissected coastal erosional plains, gently sloping peripheral tracts, tidal flats, deltaic plains, and marginal accretionary zones.

7.1.2 The Kachchh Basin preserves a complete sedimentary sequence from Middle Jurassic to Holocene, with a major unconformity between the Mesozoic and Cenozoic rocks due to non-deposition, tectonism, and volcanism at the close of the Cretaceous. The Mesozoic succession includes marine sediments from Bathonian to Tithonian (Portlandian) and non-marine Cretaceous deposits, laid down in sub-littoral to deltaic environments during two major depositional cycles: a Middle Jurassic transgressive cycle and a Late Jurassic–Early Cretaceous regressive cycle (Biswas, 1981). These sediments rest on a Precambrian granitic basement, exposed only in the Nagar Parkar Hills of Pakistan.

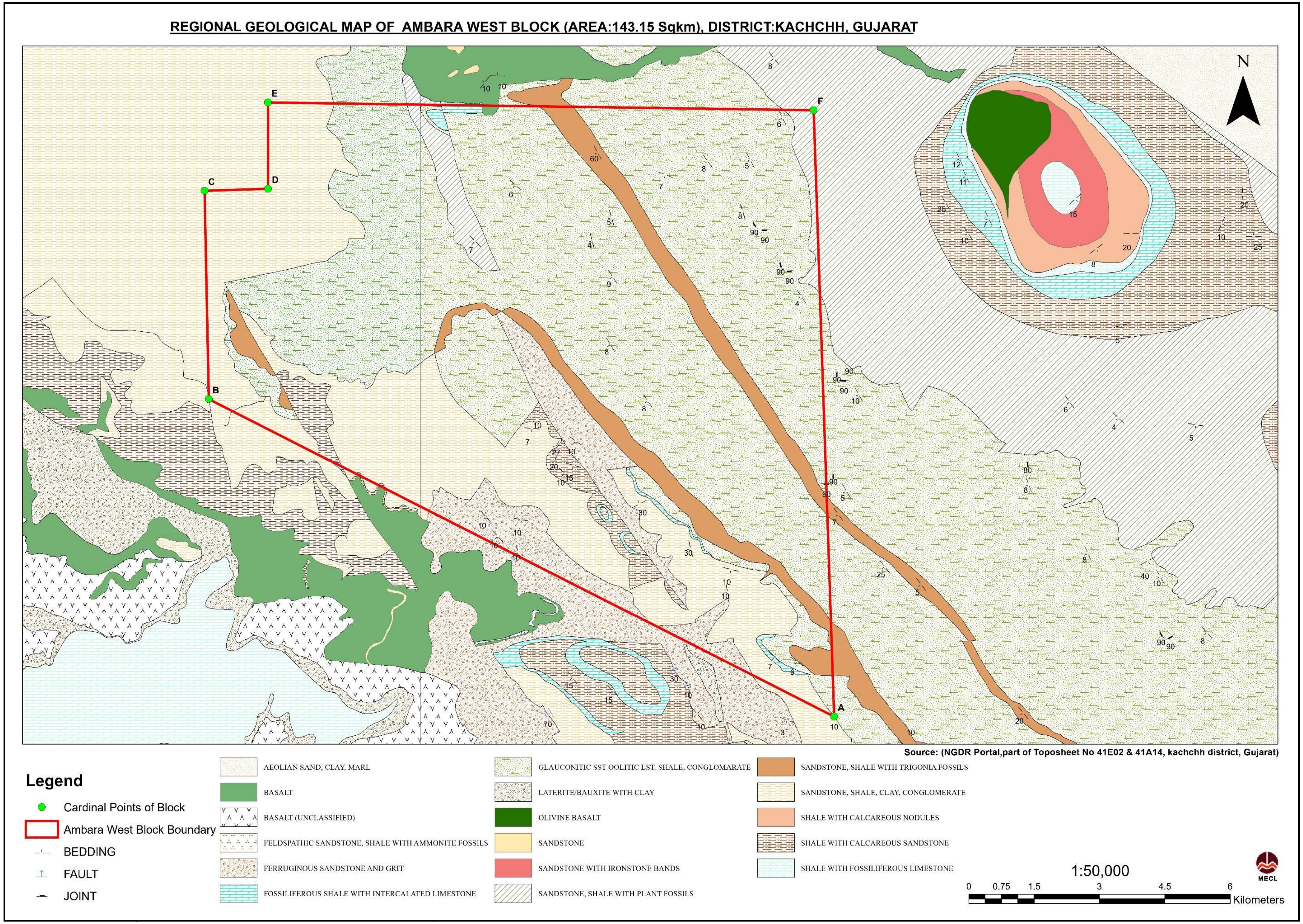
7.1.3 The stratigraphy of the basin is well established, comprising the Mesozoic Pachchham, Chari, Katrol and Umia Formations, as depicted in the regional geological map (Text Figure 7.1). The Katrol Formation, which hosts most of the Ambara West Block area, consists of red and brown sandstones, shales, glauconite-bearing horizons and marl, deposited under marginal marine conditions. The overlying Umia Formation comprises glauconitic sandstones and fossiliferous shales, while the underlying Chari and Pachchham Formations consist of oolitic limestones, marl and calcareous shales. The Deccan Traps of Late Cretaceous–Early Palaeocene age overlie the Mesozoic units in parts of the basin, though they are not exposed within the Ambara West Block, and are succeeded by Palaeogene and Neogene sediments occupying peripheral lows.

7.1.4 The Mesozoic sediments of Kachchh are represented by the Pachchham, Chari, Katrol and Umia Formations (after Krishnan, 1982). The classification of the Mesozoic succession of Kachchh, as proposed by Krishnan (1982), is presented in the table- 7.1.

Table-7.1

Regional Stratigraphic sequence of Litho units (after Krishnan, 1982)

Age	Unit	Sub-division	Lithology
Post-Aptian	UMIA (1000 m)	Bhuj beds (Umia Plant beds)	Sandstone and shale
Aptian		Ukra beds	Marine calcareous shale
Upper Neocomial		Umia beds	Barren sandstone and shale
Valanginian		Trigonia beds	Barren sandstone
Upper Tithonian		Umia ammonite beds	Shale and sandstone
Middle Tithonian	KATROL (300 m)	Upper Katrol Shales	Shale
Middle Tithonian		Gajansar beds	Shale
Lower Tithonian		Upper Katrol (Barren)	Sandstone
Middle Kimmeridgian		Middle Katrol	Red sandstone
Upper Oxfordian		Lower Katrol	Sandstone, shale, marl
Oxfordian	CHARI (360 m)	Dhosa Oolite	Green and brownoolitic limestone
U. Callovian		Athleta beds	Marl and gypseous shale
Middle Callovian		Anceps beds	Limestone and marl
Middle Callovian		Rehmani beds	Yellow limestone
Lower Callovian	PATCHAM (300 m)	Macrocephalus beds	Shales with calcareous bands and golden oolites
Lower Callovian		Coral bed	Shale and limestone
Lower Callovian to Bathonian		Patcham shell limestone Patcham basal beds (Kuar Bet beds)	Limestone, shale and marl



Text Figure 7.1: Regional Geological map showing the Ambara West Block.

7.2.0 REGIONAL STRUCTURE

7.2.1 The Ambara West Block lies within the Kachchh Basin, a pericratonic rift basin along the western continental margin of India, whose structural evolution is governed by basement-controlled extensional tectonics. The basin is dissected by a series of E–W to ENE–WSW and NW–SE trending deep-seated faults, resulting in a mosaic of uplifted structural highs and intervening subsiding depocentres. These basement lineaments exert a first-order control on sediment thickness, facies distribution, and depositional environments of the Mesozoic sedimentary succession.

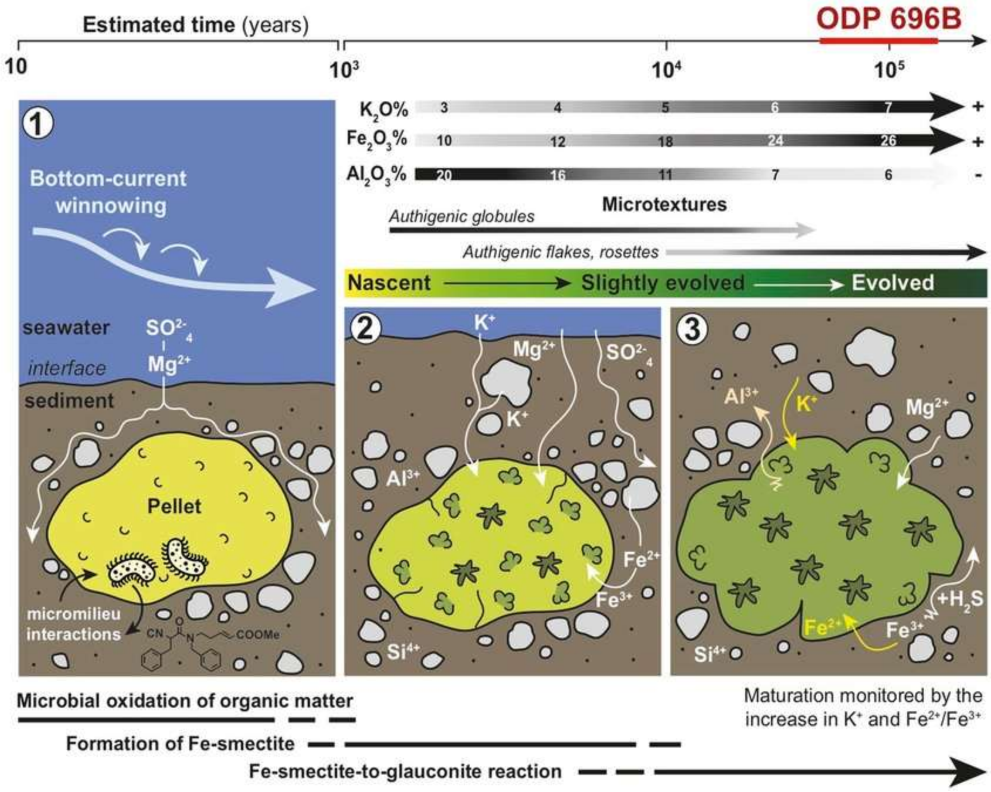
7.2.2 The Mesozoic sequence, including the Katrol Formation, is gently deformed and exhibits low-angle dips with broad open warps. Regional bedding strikes vary from NE–SW to E–W and NW–SE, reflecting the influence of basin-scale structural elements such as domes, flexures, and fault-controlled blocks. Faulting is predominantly normal to oblique-slip, with many faults interpreted as syn-sedimentary growth faults active during Jurassic–Early Cretaceous sedimentation. Post-Mesozoic tectonic events include emplacement of Deccan Trap volcanics during the Late Cretaceous–Early Palaeocene and mild Cenozoic reactivation of older structures, resulting in gentle warping without intense folding or structural disruption.

7.3.0 REGIONAL MINERALIZATION

7.3.1 The glauconite mineralisation in the Ambara West Block does not show any direct structural control, such as fault-hosted or structurally remobilised concentration. The mineralisation is stratabound and stratiform, occurring within well-defined glauconitic sandstone beds of the Katrol Formation. Regional geological structures have influenced mineralisation indirectly by controlling basin subsidence, sediment supply, and marine transgressive–regressive cycles, which governed the depositional environment of glauconite-bearing sediments (after Biswas, 1981; Krishnan, 1982).

7.3.2 The sedimentary sequence in the block is gently deformed, with only low-angle dips and broad open warps, and shows no evidence of major post-depositional faulting. This structural simplicity has helped preserve primary bedding features and resulted in good lateral continuity of glauconite-bearing horizons.

7.3.3 Glauconite formation in the Katrol Formation is interpreted to have occurred in shallow marine shelf environments under conditions of slow sedimentation or sediment starvation, typical of condensed sedimentary sequences, where prolonged interaction between seawater and iron-rich clay precursors promotes glauconitisation (after H. Odin & A. Matter, 1981) (Text Figure 7.2).



Text Figure 7.2: Schematic model of glauconite genesis and progressive maturation through Fe-smectite transformation under marine depositional conditions.

7.4.0 BLOCK GEOLOGY

7.4.1 The Ambara West Block is underlain by a sequence of Mesozoic sedimentary rocks belonging mainly to the Katrol Formation (Late Jurassic–Early Cretaceous), with subordinate exposures of the Bhuj Formation (Early Cretaceous). The Bhuj Formation represents a younger phase of siliciclastic sedimentation in the Kachchh Basin and is exposed mainly in the western part of the block area. Lithologically, the Bhuj Formation comprises medium- to coarse-grained sandstone, shale, clay, grit, and conglomerate, with locally developed fossiliferous horizons containing Trigonia. The sandstones are generally ferruginous to feldspathic in nature and indicate deposition in a nearshore to fluvio-deltaic environment, as documented in regional GSI studies.

7.4.2 The Deccan Trap volcanics of Late Cretaceous to Palaeocene age occur locally near the northern & southern boundary of the Ambara West Block. These volcanic rocks are represented mainly by basaltic lava flows, along with associated Dayapar intrusive bodies, which are well documented in western Kachchh. The basalts are typically massive to vesicular and represent a post-sedimentary volcanic phase that unconformably overlies the Mesozoic sedimentary succession. The Deccan Trap exposures are limited in areal extent within the block and do not host glauconite mineralization; however, they form an important regional stratigraphic marker.

7.4.3 The Katrol Formation, of Late Jurassic to Early Cretaceous age, occupies the major part of the study area and constitutes the principal geological unit of economic interest in the Ambara West Block. The formation represents a dominantly marine siliciclastic depositional system and is characterized by a heterogeneous assemblage of lithologies, including shale with calcareous sandstone, sandstone with Trigonia fossils, glauconitic sandstone, conglomerate and shale with plant fossil impressions.

7.4.4 Glauconitic sandstone horizons within the Katrol Formation occur as stratigraphically controlled beds, commonly interbedded with shale and sandstone. These horizons are interpreted to have formed under shallow marine shelf to nearshore conditions, associated with slow sedimentation rates during marine transgressive phases, as established in GSI regional stratigraphic frameworks for the Kachchh Basin.

7.4.5 Structurally, the sedimentary succession in the Ambara West Block is influenced by the regional tectonic framework of the Kachchh Basin. The regional strike of bedding planes is broadly parallel to the Guneri Dome, showing variations from NE–SW, E–W, to NW–SE directions. The rock beds are generally horizontal to gently dipping, with low-angle dips towards the southeast and southwest and lithological contacts are predominantly gradational, indicating continuous sedimentation without major structural breaks.

7.4.6 Contacts between successive Litho-units are predominantly gradational, indicating continuous sedimentation without major structural breaks. No major faults or folds have been identified within the block area at the reconnaissance scale; however, gentle warping related to basin-scale tectonism is evident. The tentative stratigraphic succession of lithounits exposed within the block area, as established by GSI, is presented in Table 7.2.

Table- 7.2:

Stratigraphic sequence of the Ambara West Block for Glauconite District: Kachchh, Gujarat (After GSI - Biswas, 1981; Krishnan, 1982).

Age	Formation	Lithology
Holocene	Rann Formation	Calcareous clay and silty marl
Late Cretaceous–Palaeocene	Deccan Volcanics	Basaltic lava flows with associated Dayapar intrusive bodies
Early Cretaceous	Bhuj Formation	Medium to coarse-grained sandstone with shale and clay; locally conglomerate and fossiliferous horizons containing Trigonia
Late Jurassic–Early Cretaceous	Katro l Formation	Shale with calcareous sandstone; interbedded sandstone and shale; sandstone and shale with Trigonia fossils; glauconitic sandstone, shale and conglomerate; sandstone and shale with plant fossil impressions
Middle–Late Jurassic	Chari Formation	Shale with fossiliferous limestone; shale with calcareous nodules; sandstone with ironstone bands

7.4.7 The stratigraphic succession of the area ranges from Late Jurassic–Early Cretaceous to Holocene and is predominantly composed of sedimentary formations. No volcanic units occur within the block boundary; however, a few basaltic boulders are observed near the south-western boundary, indicating the presence of volcanic rocks in the surrounding region. The Katrol Formation (Late Jurassic–Early Cretaceous) is the oldest unit exposed in the area and consists of shale, calcareous sandstone, interbedded sandstone and shale, conglomerate, and fossiliferous beds containing Trigonia. Glauconite mineralization in the Ambara West block is mainly associated with Katrol formation, particularly within alternating bands of glauconitic sandstone and shale horizons. These horizons are overlain by glauconitic sandstone and shale beds, which occur predominantly throughout the mineralized zone. The Katrol Formation is overlain by the Bhuj Formation (Early Cretaceous), which comprises medium- to coarse-grained sandstone interbedded with shale, clay, and occasional conglomerate. These sedimentary units are overlain by the Deccan Volcanics (Late Cretaceous–Palaeocene), represented by basaltic lava flows with associated Dayapar intrusive bodies. The youngest stratigraphic unit in the region is the Rann Formation (Holocene), consisting mainly of calcareous clay and silty marl.

7.4.8 Large-scale geological mapping of the Ambara West Block was carried out at a 1:12,500 scale over 143.15 Sq. Km to establish a robust geological framework for exploration and resource evaluation. Systematic field investigations facilitated the delineation of lithological units, stratigraphic contacts, geomorphological features, and structural elements. Based on these observations, the identified rock types/formations have been delineated and depicted in the interpreted geological map, presented as Text Fig. 7.3 and Plate–III.

7.5.0 DESCRIPTION OF ROCK TYPES PRESENT IN AMBARA WEST BLOCK

7.5.0.1 SOIL: The Ambara West Block is covered by a thin soil mantle composed mainly of sandy to clayey feldspathic material derived from weathering of the underlying Mesozoic sedimentary rocks of the Kachchh Basin. The soil generally shows light brown to brown colour, with occasional reddish patches indicating ferruginous enrichment, while greenish tints in some areas suggest the presence of glauconitic detrital material related to nearby glauconite-bearing sandstone horizons. The soil forms a laterally persistent regolith cover with an average thickness of about 1.0 m, although local variations range from 0.50 m to 3.00 m, controlled mainly by topography, drainage, weathering intensity, and sediment accumulation, resulting in thinner soil on elevated areas and thicker deposits in low-lying zones.

Field observations within the Ambara west block reveal the presence of lithological units belonging to the Rann formation, Bhuj Formation and Katrol Formation which are described below.

7.5.1 LITHOLOGIES BELONGING TO BHUJ FORMATION

7.5.1.1 Feldspathic Sandstone: - In the Ambara West Block, lithounits of the Bhuj Formation are exposed predominantly in the southern & eastern part of the area. The Bhuj Sandstone is characterized by medium- to coarse-grained, feldspathic sandstone, indicating derivation from a continental to cratonic provenance, as widely documented for the Bhuj Formation in the Kachchh Basin. The sandstone is moderately sorted, ferruginous at places, and displays well-developed cross-bedding, and current ripple marks, which are the dominant sedimentary structure observed in the field.

These cross-bedded units indicate deposition under moderate- to high-energy conditions, consistent with fluvio-deltaic to shallow marginal-marine environments reported in earlier studies. Structurally, the sandstone beds exhibit a general NW–SE strike with very gentle dips towards the southwest, reflecting the regional structural grain parallel to the Guneri structural high.

The gentle attitude of bedding, absence of deformation, and preservation of primary sedimentary structures suggest deposition in a relatively stable tectonic regime during Early

Cretaceous time. The feldspathic composition of the sandstone further supports rapid sediment supply from uplifted source areas with limited transport, a characteristic feature of the Bhuj Formation across western Kachchh.

The feldspathic sandstone exposures display well-developed Planar (Tabular) Cross-Bedding and Trough Cross-Bedding within fine- to medium-grained sandstone. These sedimentary structures are represented by inclined foreset laminae forming distinct cross-stratified sets produced by the migration of sandy bedforms under marine current activity.

Planar cross-bedding is characterized by straight, parallel foreset laminae bounded by relatively planar surfaces, indicating deposition by the migration of two-dimensional sand waves under relatively steady marine currents. Trough cross-bedding, on the other hand, is identified by curved, concave-upward foreset laminae forming trough-shaped cross-sets, which develop due to the migration of three-dimensional subaqueous dunes under variable current conditions.

The occurrence of both cross-bedding types indicates deposition in a shallow marine depositional environment, where sediments were transported and reworked by tidal currents, wave action, and longshore currents. Such sedimentary structures commonly develop in shoreface, tidal channel, and nearshore sand-bar settings, reflecting moderate- to high-energy marine hydrodynamic conditions.

The bedding-plane exposures show well-developed Ripple Marks preserved on fine- to medium-grained sandstone surfaces. The ripples occur as closely spaced, sub-parallel ridges and troughs with wavelengths of a few centimetres, as indicated by the geological hammer used for scale. The ripple crests are continuous and maintain a consistent orientation across the exposed bedding surface.

The ripple morphology is slightly asymmetrical, suggesting formation under the influence of current-driven sediment transport. The sandstone is moderately sorted and shows brown to dark ferruginous staining due to weathering and iron oxide enrichment.

The presence of well-preserved ripple marks indicates deposition in a shallow marine environment, where sediments were reworked by wave action and tidal currents. Such structures are typically developed in shoreface to nearshore sand-bar settings under moderate-energy hydrodynamic conditions.

Photo 7.1 Photograph showing Planar (tabular) cross-bedding near Paneli village.

Photo 7.2 Photograph showing trough cross-bedding near Valka mota village. (23°33'36.6"N 69°01'55.2"E)

Photo 7.3 Photograph showing Current Ripple Marks near Paneli village.
(23°35'47.1"N 68°58'10.8"E)

Photo 7.4 Photograph showing Current Ripple Marks near Paneli village.
(23°35'35.0"N 68°57'20.3"E)

7.5.1.2 Trigonia Fossil–Bearing Horizon: The block is marked by the occurrence of a distinct and laterally persistent fossiliferous horizon containing Trigonia, which serves as an important stratigraphic marker within the Mesozoic sequence. The interpreted geological map indicates that the Trigonia-bearing units occur as elongated belts within sandstone–shale interbedded strata, predominantly associated with the Bhuj Formation and Katrol Formation. These fossiliferous horizons exhibit notable lateral continuity across the block and are mainly composed of medium-grained sandstone interlayered with shale, occasionally showing calcareous characteristics. Such lithological associations indicate sedimentation under shallow marine to marginal marine conditions.

The widespread occurrence and abundance of Trigonia fossils suggest deposition within a well-oxygenated and moderately energetic marine setting, corresponding to regressive phases recorded during the Late Jurassic–Early Cretaceous period of the Kachchh Basin. Earlier investigations on the Mesozoic stratigraphy of the basin have identified Trigonia as a typical faunal component of nearshore marine environments, commonly associated with shoreline progradation. Within the Ambara West Block, the consistent occurrence of this fossil-bearing horizon, its stratigraphic confinement, and its close association with sandstone-dominated facies make it a valuable biostratigraphic and paleoenvironmental marker for stratigraphic correlation and interpretation of depositional environments across the area.

Photo 7.5 Photograph showing Trigonia fossil-bearing zone near Meghpar village.
(23°37'05.5"N 68°59'58.0"E)

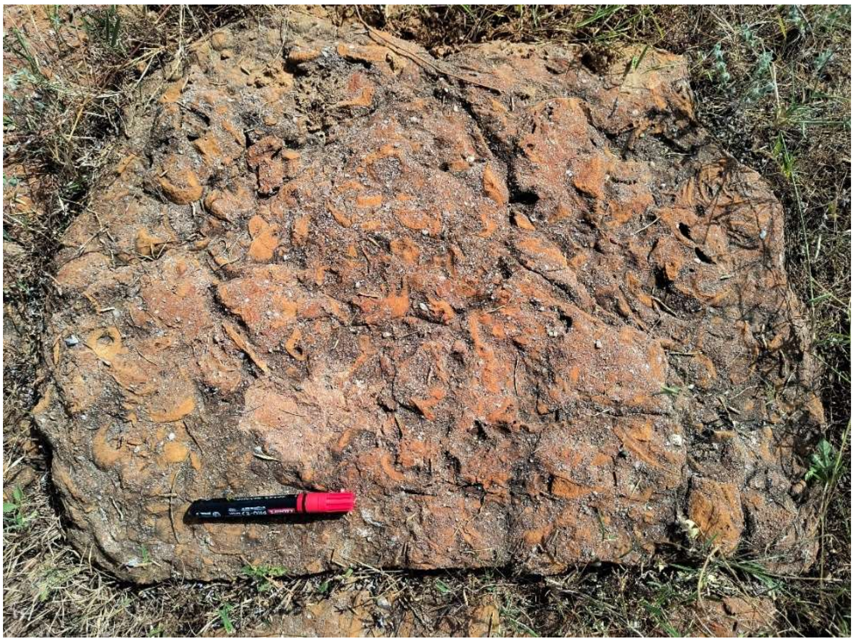


Photo 7.6 Photograph showing Trigonia fossil-bearing zone near Gadani village.
(23°33'22.3"N 69°03'25.3"E)

7.5.1.3 Intercalated Sandstone-Shale formation: Interbedded sandstone and shale constitute a significant lithological component of the Bhuj Formation within the Ambara West Block, particularly in the northern and north-western sectors. These units comprise medium- to coarse-grained feldspathic sandstone interlayered with shale horizons, reflecting periodic variations in depositional energy. The sandstone beds are generally moderately sorted and locally exhibit ferruginous staining, while the shale layers are fine-grained, compact, and comparatively less resistant to weathering.

The occurrence of alternating sandstone and shale beds, as delineated in the geological map, indicates sedimentation under fluvio-deltaic to marginal marine conditions, where fluctuations in current energy and sediment supply controlled facies development. Earlier studies on the Bhuj Formation have documented such intercalated sequences as typical of the Early Cretaceous regressive phase of the Kachchh Basin, representing transitions between relatively high-energy sandstone deposition in channels or nearshore settings and lower-energy shale accumulation in quieter water environments.

Photo 7.7 Photograph showing Sandstone with Shale intercalated
near Junachea village. (E- 23°38'00.8"N 69°05'12.2"E)

7.5.1.4 Ferruginous sandstone and Grit: Ferruginous sandstone constitutes a prominent lithological unit within the Ambara West Block and is predominantly exposed in the northern to north-western parts of the area. The unit forms part of the Bhuj Formation. In the field, the sandstone is medium- to coarse-grained, moderately sorted, and feldspathic in composition. It typically exhibits a reddish to brown colour due to the presence of iron oxide cement. The rock is generally compact to moderately indurated and displays well-preserved primary sedimentary structures such as cross-bedding and planar bedding, indicating deposition under moderate- to high-energy conditions.

The ferruginous character of the sandstone is interpreted to have developed through iron enrichment during early diagenesis, followed by oxidation under subaerial or near-surface conditions. This is evidenced by the pervasive iron staining observed along bedding planes, joints, and fracture surfaces. The preservation of primary sedimentary structures and the gentle attitude of bedding recorded in the field suggest sedimentation under fluvio-deltaic to marginal marine conditions, where depositional energy fluctuated periodically. The ferruginous sandstone represents a distinctive and easily recognizable lithounit within the Bhuj Formation and contributes significantly to the development of sandy, iron-rich soils across the block area.

Photo 7.8 Photograph showing Ferruginous Sandstone and Grit near Valka-nana village.

7.5.2 LITHOLOGIES BELONGING TO KATROL FORMATION

7.5.2.1 Glauconitic Sandstone: Glauconitic sandstone constitutes a significant lithological unit of the Katrol Formation within the Ambara west Block. In the field, the unit is typically fine-grained, friable, and exhibits a distinctive greenish, greyish green & whitish green colour attributed to the abundance of glauconite. The sandstone is generally poorly to moderately indurated and locally shows sandy to silty texture, disintegrating easily upon weathering. Structural observations indicate that the beds strike predominantly in a NW–SE direction with very gentle dips towards the southwest, suggesting a relatively undisturbed sedimentary sequence.

The glauconitic sandstone commonly occurs in association with glauconitic shale and intercalated bands of grey shale, forming an alternating sequence of arenaceous and argillaceous lithologies. The glauconitic shale is fine-grained, fissile, and greenish-grey in colour, while the grey shale is comparatively compact and devoid of glauconite. Such lithological alternations reflect periodic variations in sediment supply and depositional conditions. Field mapping indicates that these glauconitic horizons are predominantly developed in the central part of the block, where they exhibit greater lateral continuity and thickness relative to the marginal areas.

The occurrence of glauconitic sandstone in association with glauconitic and grey shale within the Katrol Formation suggests sedimentation under a shallow marine shelf setting characterized by relatively low to moderate hydrodynamic energy conditions. The development of glauconite within the sandstone and shale horizons indicates slow rates of sediment accumulation, which allowed the authigenic formation and preservation of glauconite pellets within the sediment matrix. Such conditions are commonly associated with marine transgressive phases, where reduced clastic influx and prolonged residence time of sediments on the sea floor promote glauconitization.

The rhythmic alternation of arenaceous (sandstone) and argillaceous (shale) facies further reflects periodic fluctuations in sediment supply and depositional energy, possibly controlled by variations in shoreline position, marine currents, and episodic influx of clastic material from nearby landmasses. The fine-grained, fissile nature of the shale units suggests deposition in relatively quieter offshore or inner shelf conditions, whereas the glauconitic sandstone horizons represent slightly higher energy episodes involving the deposition of sand-sized sediments under marine current activity.

The consistent NW–SE strike and gentle southwesterly dips recorded in the field indicate that the strata remain structurally stable and only mildly disturbed, preserving the primary sedimentary architecture of the formation. The lateral continuity and stratabound nature of the glauconitic horizons across the block further support their deposition within a laterally extensive shallow marine depositional system, likely representing an inner to mid-shelf environment within the broader Kachchh Basin during the Mesozoic marine transgressive–regressive cycles.

Photo 7.9 Photograph showing Glauconite Horizons in river bed near Valka Village
(E- 23°35'19.8"N 68°57'26.8"E)

Photo 7.10 Photograph showing Glauconite Horizons near Paneli Village
(23°34'52.0"N 68°57'58.1"E)

Photo 7.11 Photograph showing Glauconite Horizons near Paneli Village.
(23°35'01.5"N 68°58'05.2"E)

Photo 7.12 Photograph showing Bedrock sample of glauconite AW-15 (6.03% K2O)
(23°35'16.0"N 68°57'49.2"E)

Photo 7.13 Photograph showing Bedrock sample of glauconite AW-04 (5.13% K2O) (23°37'04.8"N 68°59'20.1"E)

Photo 7.14 Photograph showing glauconite & Alternate band of glauconite horizons (Sandstone and Shale) in Borehole no- MKAW-04 (Depth-12.00m to 16.00m).

7.5.2.2 Glauconitic Shale: - Glauconitic shale forms an important lithological unit within the Katrol Formation of the Ambara west Block. It is typically fine-grained and exhibits a greenish-grey to dark green coloration. The shale is generally fissile in nature and commonly occurs interbedded with bands of glauconitic sandstone. These alternating beds impart a characteristic rhythmic lithological pattern to the sequence.

The unit is well developed in both surface exposures and borehole cores within the study area. In outcrops, it appears as compact to moderately friable shale with well-developed fissility. Borehole core samples reveal similar characteristics, showing shale enriched with disseminated glauconite grains. The presence of glauconite imparts the distinctive greenish colour to the rock.

The rhythmic interbedding of shale and glauconitic sandstone indicates periodic fluctuations in depositional energy and sediment supply. The sandstone layers likely represent short-lived higher-energy events (such as storms, tidal currents, or pulses of clastic input), whereas shale deposition reflects quieter background sedimentation.

Considering the presence of glauconite, fine-grained sediments, and periodic sandstone interbeds, the depositional environment is interpreted as a shallow marine shelf to inner–middle shelf setting, possibly influenced by episodic storm activity and variable clastic influx.

Photo 7.15 Photograph showing Glauconite Shale Horizons near Paneli Village (23°34'04.2"N 68°58'41.3"E)

7.5.3 RANN FORMATION

7.5.3.1 Calcareous Clay and Silty Marl Formation: Calcareous clay and silty marl represent the youngest lithological unit identified within the Ambara West Block. This unit was primarily encountered during Mapping & pitting operations conducted in the North-western and South-eastern parts of the area. In the field, it appears as a soft, light grey to buff coloured, fine-grained deposit composed mainly of calcareous clay mixed with silt-sized particles. The material is generally poorly consolidated and exhibits a plastic consistency when moist. It displays weak stratification or a massive structure, suggesting deposition under relatively low-energy conditions.

7.5.3.2 The calcareous nature of the deposit is indicated by its effervescence upon reaction with dilute acid and the presence of a carbonate-rich matrix. The association of silty marl with calcareous clay points to sedimentation in calm depositional settings where fine clastic material accumulated together with carbonate mud.

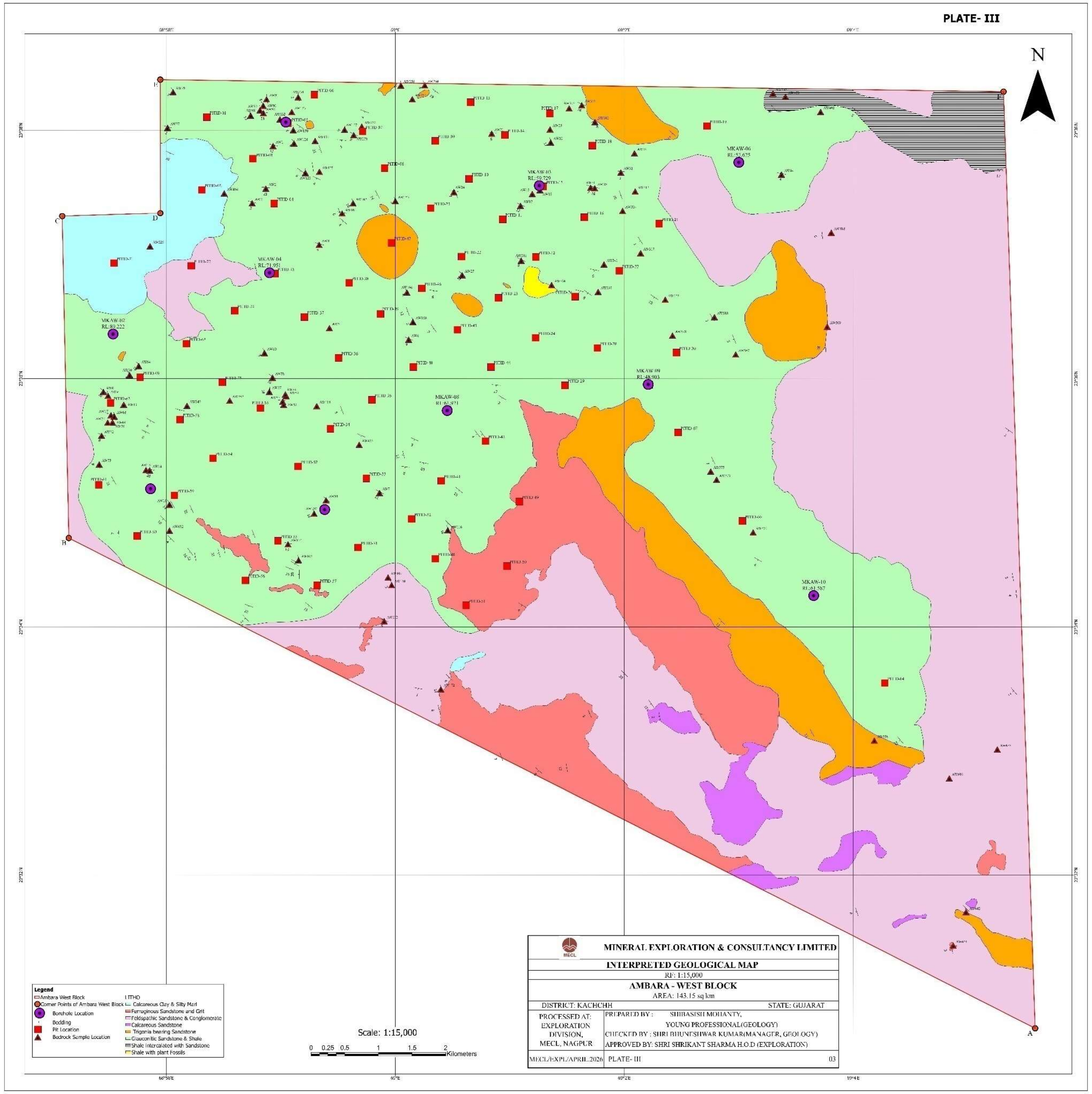
7.5.3.3 These sediments are interpreted to have formed in a quiet, shallow-water environment, such as a tidal flat or lagoonal setting, where both fine-grained clastic sediments and carbonate mud were deposited. The unit forms a thin surficial cover over the older Mesozoic formations and locally conceals the underlying bedrock, particularly in low-lying and gently sloping parts of the block.

Photo 7.16 Photograph showing Marl bands near Paneli Village

Photo 7.17 Photograph showing Calcareous Clay near Gadani Village

Photo 7.18 Photograph showing Marl bands near Valaka Village

7.5.4 The Interpreted Geological Map is presented in Text fig. 7.3 and Plate –III.



Text Figure.7.3 Interpreted Geological Map of Ambara West Block

7.6.0 STRUCTURAL DETAILS OF THE AREA SUCH AS DIP, STRIKE, FOLDS, FAULTS, ETC.

The Ambara West Block forms part of a relatively stable structural domain within the Kachchh Basin. Regional geological studies, however, indicate the presence of several major fault systems in the adjoining areas, as depicted in the regional geological map. These structures mainly comprise basin-bounding and intra-basinal normal faults trending predominantly NW–SE to NE–SW, reflecting the extensional tectonic setting associated with the evolution of the Kachchh rift basin.

7.6.1 No major fault planes are directly exposed or traceable within the Ambara West Block. Nevertheless, their regional influence is reflected in the overall structural grain of the area, subtle tilting of strata, and minor variations in lithological distribution. Field observations indicate that bedding planes of the exposed lithounits generally exhibit gentle dips ranging from about 5° to 10°.

7.6.2 Subsurface information derived from borehole data suggests that the strata are largely sub-horizontal at depth, indicating minimal structural disturbance. The variation in dip observed in surface exposures is therefore interpreted to result mainly from differential weathering, minor surface irregularities, and localized erosion rather than significant tectonic deformation.

7.6.3 The absence of observable fault displacement within the block suggests that the area represents a relatively stable fault block or inter-fault domain. While regional fault systems have influenced the structural configuration and sedimentation pattern of the basin, the Ambara West Block itself appears to be largely unaffected by direct faulting, thereby preserving the continuity of stratigraphic units, particularly the glauconitic sandstone horizons.

7.6.4 The Ambara West Block lies within a structurally stable segment of the Kachchh Basin, although major regional faults occur in the surrounding areas. These faults trend mainly NW–SE to NE–SW and reflect the extensional tectonic setting of the basin. No direct evidence of faulting has been observed within the block, suggesting that it represents a stable inter-fault domain with minimal tectonic disturbance. Field observations show gentle bedding dips of about 5°–10°, while borehole data indicate nearly horizontal strata at depth.

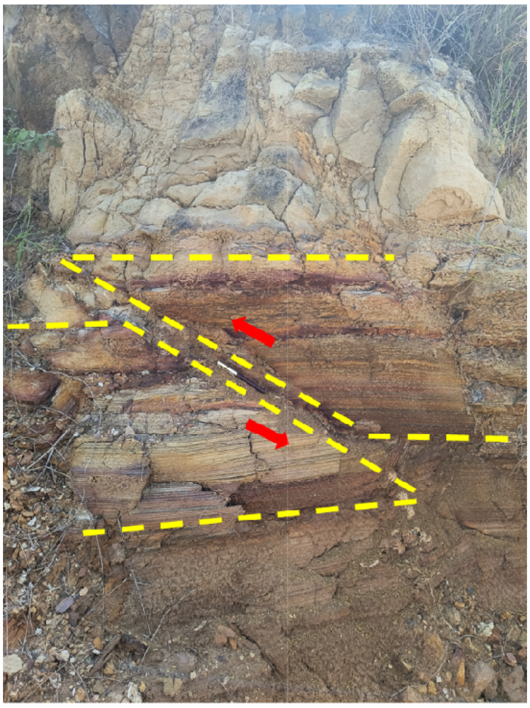


Photo 7.19 Photograph showing Minor Fault in Glauconitic Shale Bed observed near Paneli Village.

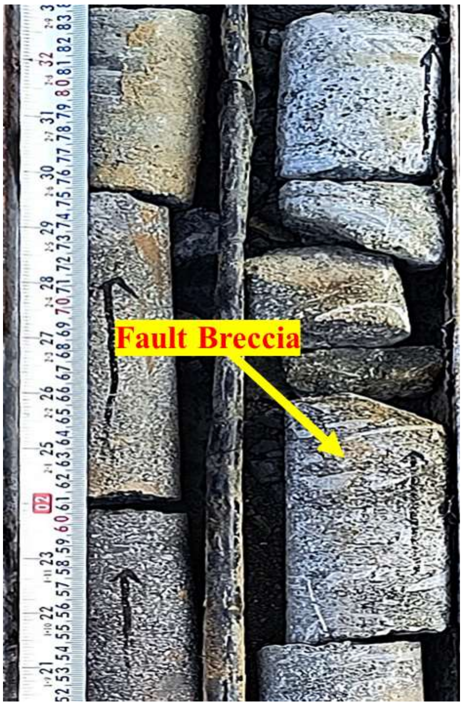


Photo 7.20 Photograph showing Fault Breccia in Borehole no- MKAW-05 (from 19.00m to 20.00m Depth).

7.7.0 MINERALIZATION IN THE BLOCK

The glauconite mineralisation in the Ambara West Block is stratabound and bedded in character, occurring within marine siliciclastic sedimentary sequences of the Katrol Formation. The mineralisation is laterally persistent and stratigraphically controlled, with no evidence of structural or hydrothermal control, indicating a syngenetic to early diagenetic sedimentary origin. On the basis of these characteristics, the deposit is classified as a sedimentary, stratiform glauconite deposit, formed under shallow-marine shelf to nearshore conditions during marine transgressive phases.

7.7.1 The bedrock samples show K_2O values ranging approximately from about 2.0% to 5.1%, with several samples such as AW-1, AW-3, AW-4 and AW-5 recording values above the 3% K_2O cut-off (As per IBM), which is commonly adopted for identifying glauconitic sandstone horizons in exploration studies. Pit samples collected from surface exposures show a wider range of K_2O values from about 1.4% to 5.8%, with representative samples such as AWPT-01, AWPT-04 and AWPT-05 indicating moderate to strong enrichment of potassium. These results confirm the presence of near-surface glauconitic sandstone layers within the block area.

7.7.2 Subsurface information from borehole samples further supports the continuity of glauconite mineralisation. The K_2O values in drill core samples range from about 0.3% to 6.0%, with several intersections exceeding the >3% K_2O threshold, indicating stratigraphically controlled glauconitic horizons within the Katrol Formation. Trace element analysis also shows enrichment of Ba, Rb and Sr in samples such as AW-231, AW-406, AW-980 and AW-1609, which is typical of glauconitic marine sediments where Rb substitutes for K in glauconite and Ba–Sr enrichment occurs during marine diagenesis. The combined geochemical and trace element signatures suggest that the glauconite mineralisation formed in a shallow marine shelf environment under slow sedimentation and sub-oxic conditions, which are favourable for authigenic glauconite formation.

7.7.3 The geochemical and petrographic characteristics indicate that glauconite mineralisation in the Ambara West Block developed during marine sedimentation within the Katrol Formation of the Kachchh Basin. The formation of glauconite is interpreted to have occurred under conditions of slow sedimentation rates and a sub-oxic marine environment, which allowed prolonged interaction between seawater and sediments. Such conditions facilitated the authigenic development of glauconite pellets within sandstone and shale horizons. These features are typical of continental shelf depositional settings, where glauconite commonly forms during marine transgressive phases characterized by low sediment supply and extended sediment–water interaction, leading to the enrichment of potassium-bearing glauconitic minerals within the sedimentary sequence.

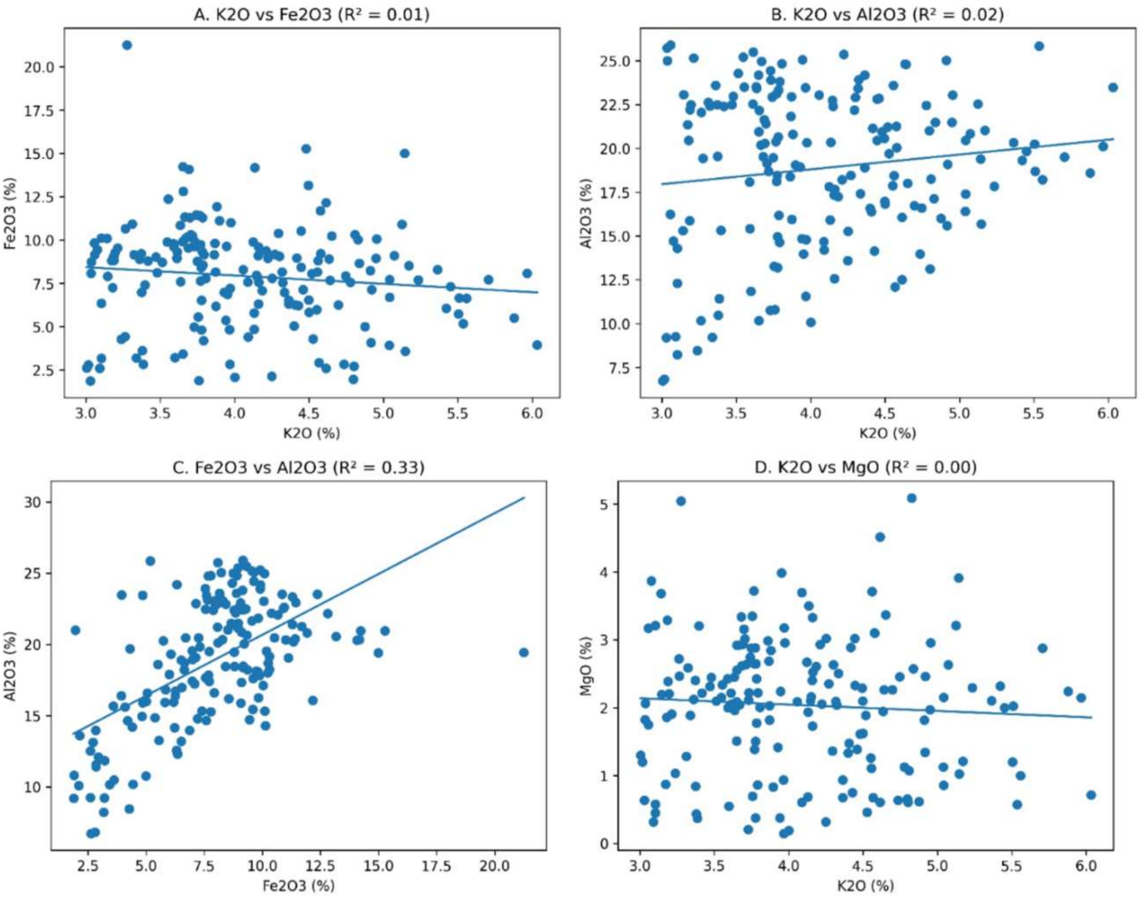
7.7.4 **Genesis of Glauconite Mineralization**

The genesis of glauconite mineralization in the Ambara West Block is interpreted as authigenic, controlled primarily by depositional environment and early diagenetic processes. The elevated K_2O and Fe_2O_3 contents in both pit and bedrock samples indicate progressive potassium fixation and iron enrichment within clay precursors during early burial. Localized enrichment of P_2O_5 in several samples suggests episodic phosphatic conditions associated with condensed sedimentation horizons, further supporting slow sedimentation rates. The chemical association of iron enrichment with low Na_2O and moderate MgO implies formation under sub-oxic to mildly reducing marine pore-water conditions, which are favourable for glauconite maturation. Variations in glauconite grade across the block reflect differential degrees of diagenetic evolution, quartz dilution, and carbonate influence rather than changes in genetic processes. The mineralization is therefore interpreted as autochthonous, formed in situ within marine sediments during early diagenesis, with subsequent chemical stabilization during burial.

The petrogenetic and mineralization characteristics identified for glauconite in the Ambara West Block, based on major oxide geochemistry, are consistent with authigenic, diagenetic glauconite formation under shallow marine shelf conditions, a model that aligns with widely documented glauconite occurrences in the Kachchh Basin of Gujarat.

7.7.5 Interpretation of Bivariate Plots

Bivariate plots of major oxides are useful for understanding glauconite maturation, mineral associations, and the source of potassium in glauconitic sediments.



(a) K_2O vs Fe_2O_3

The K_2O–Fe_2O_3 relationship is commonly used to assess the maturity of glauconite. Glauconite is an iron-rich potassium phyllosilicate, and therefore potassium enrichment is generally associated with increased iron content. In the Ambara West samples, a weak to moderate positive trend between K_2O and Fe_2O_3 suggests that potassium is partly associated with Fe-bearing glauconite pellets. The relatively scattered distribution and moderate R^2 value indicate that potassium distribution is also influenced by other minerals such as clay minerals and feldspar within the sandstone matrix. Overall, the observed K_2O range (~3–6 wt%) suggests the presence of nascent to slightly evolved glauconite.

(b) K_2O vs Al_2O_3

The K_2O–Al_2O_3 plot helps distinguish whether potassium is derived from glauconite or K-bearing detrital minerals such as K-feldspar or illite. A strong positive correlation between these oxides would typically indicate potassium derived from K-feldspar or illitic clay minerals, which contain significant aluminum. However, the weak correlation observed in the Ambara West dataset suggests that potassium is not dominantly associated with Al-rich minerals, indicating that glauconite is the primary host of potassium in these sediments.

(c) Fe_2O_3 vs Al_2O_3

The Fe_2O_3–Al_2O_3 relationship reflects the coexistence of iron-bearing minerals and aluminous clay components. The moderate positive clustering of samples indicates that Fe-rich glauconite pellets occur together with clay minerals within the sandstone matrix. This relationship suggests a mixed mineral assemblage consisting of glauconite, clay minerals, and quartz framework grains, which is typical of glauconitic sandstones deposited in shallow marine environments.

(d) K_2O vs MgO

The K_2O–MgO relationship is useful for evaluating glauconite evolution. During glauconite maturation, magnesium is gradually replaced by potassium through cation exchange processes in the mineral structure. Therefore, mature glauconite typically shows increasing K_2O and decreasing MgO values. The weak negative to scattered trend observed in the Ambara West samples indicates that glauconitization is at an early stage, suggesting the presence of nascent to slightly evolved glauconite formed during early diagenesis.

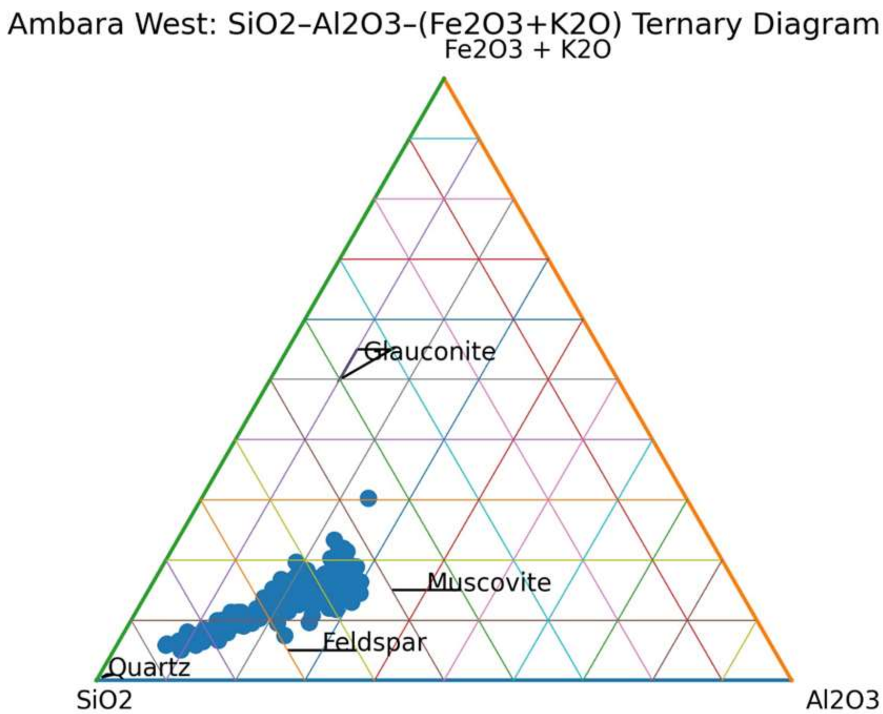
7.7.6 Statistical Characteristics (Skewness and Kurtosis)

The skewness–kurtosis analysis of the Ambara West Block dataset indicates that K_2O (+0.54) and SiO_2 (+1.08) are positively skewed, suggesting localized enrichment of potassium and quartz, whereas Al_2O_3 (-0.62) shows negative skewness, indicating a relatively uniform clay matrix. Fe_2O_3 (+0.33) and MgO (+0.17) exhibit near-symmetrical distributions. The kurtosis values indicate that Fe_2O_3 (+1.62) is leptokurtic, suggesting clustering of Fe-bearing phases, while K_2O,

Al_2O_3, and MgO are platykurtic, reflecting broader dispersion of these components. Overall, the dataset is non-normally distributed and controlled by heterogeneous mineralogical composition. The low R^2 values in most bivariate plots indicate that the system is controlled by multiple factors rather than a single linear relationship. Positive skewness of K_2O and SiO_2 suggests localized enrichment of glauconite and quartz, whereas negative skewness of Al_2O_3 reflects a relatively uniform clay matrix. The moderate correlation between Fe_2O_3 and Al_2O_3 indicates coexistence of glauconite and clay minerals. Overall, mineralisation is controlled by a combination of localized glauconite pellet distribution, clay matrix contribution, quartz dilution, and early diagenetic processes, rather than uniform chemical evolution.

7.7.7 Interpretation of the Ternary Diagram (SiO_2 – Al_2O_3 – (Fe_2O_3 + K_2O))

The SiO_2–Al_2O_3–(Fe_2O_3 + K_2O) ternary diagram is useful for evaluating the relative contributions of quartz, clay/feldspar minerals, and glauconite components in sedimentary rocks.



In this diagram:

- SiO_2 apex represents quartz-rich sediments.
- Al_2O_3 apex represents clay minerals and feldspar components.
- Fe_2O_3 + K_2O apex represents the glauconite component.

The Ambara West samples cluster predominantly toward the SiO_2 apex, indicating that the sediments are quartz-rich sandstones. A slight shift toward the Al_2O_3

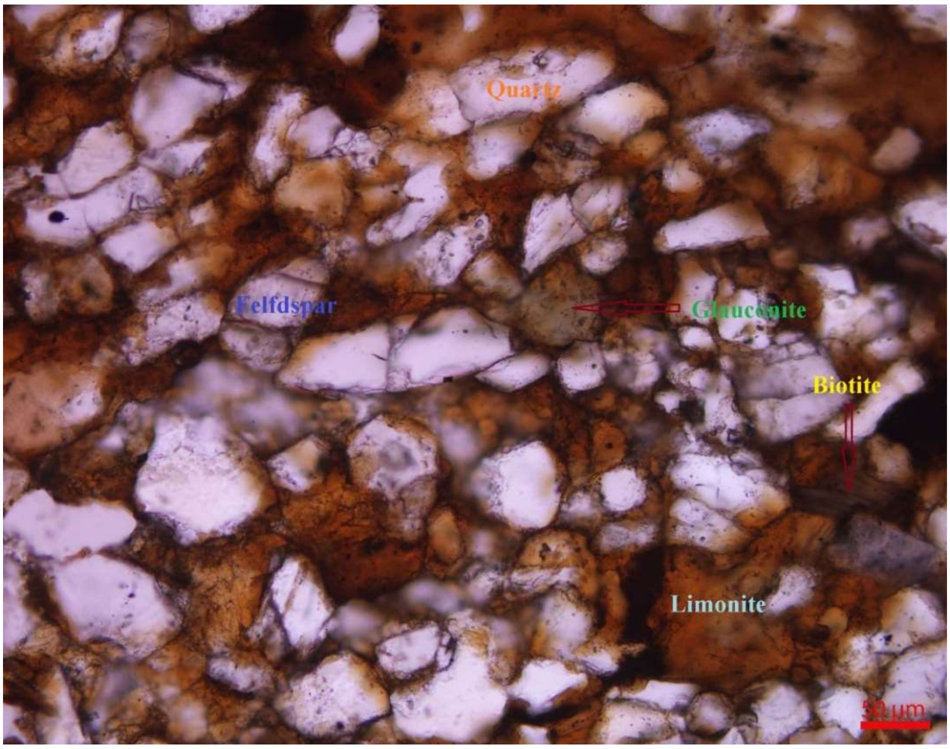
direction reflects the presence of clay minerals and feldspar within the matrix. However, the samples plot relatively far from the $Fe_2O_3 + K_2O$ apex, indicating that although glauconite is present, it does not dominate the bulk composition of the rock. Distribution shows that the studied rocks represent quartz-rich glauconitic sandstones containing dispersed glauconite pellets within a clay–feldspar matrix. Such compositions are typical of marine shelf depositional environments characterized by slow sedimentation rates that favor glauconite formation.

7.8.0 PETROLOGICAL STUDIES.

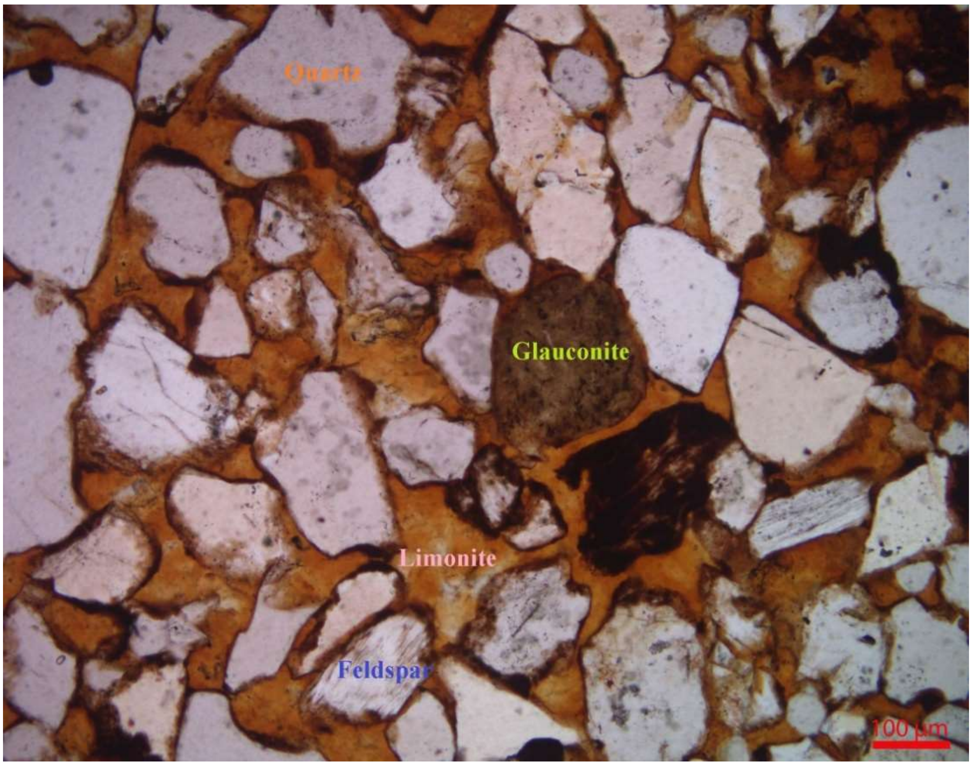
Petrological studies were carried out on the major lithological units encountered in the Ambara West Block. A total of ten representative samples from different lithological types were selected for petrographic analysis and examined at the MECL Laboratory, Nagpur.

Petrographic examination of representative samples from the Ambara West Block indicates that the rocks are predominantly composed of fine- to very fine-grained siliciclastic sediments, mainly represented by biotite-rich shale and arkosic wacke. The major mineral constituents include quartz, feldspar, biotite, and calcite, while limonite, opaques, ferruginous matter, and chlorite occur as minor constituents. Accessory minerals identified in the thin sections include glauconite, muscovite/sericite, zircon, tourmaline, monazite, kaolinite, and lithic fragments. The quartz and feldspar grains are generally subrounded to subangular and silt-sized, floating within a fine-grained matrix composed of limonitic, ferruginous, or micritic material, indicating deposition in a low-energy sedimentary environment.

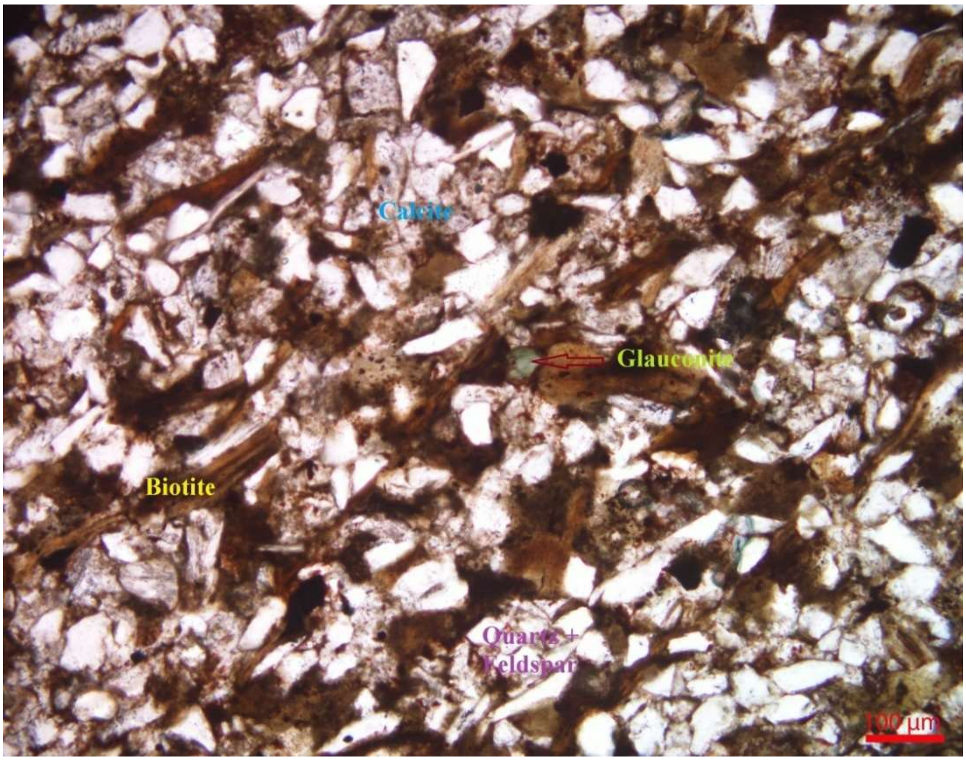
The occurrence of glauconite as fine subrounded pellets and relict patches, locally replaced by limonite, confirms the presence of glauconite-bearing horizons within the sedimentary sequence. Biotite, muscovite/sericite, and chlorite occur as very fine flakes showing parallel alignment, suggesting depositional lamination and subsequent diagenetic modification. Accessory heavy minerals such as zircon, tourmaline, and monazite indicate a detrital provenance derived from continental sources. The presence of sedimentary textures such as lamination, granular framework, ferruginous matrix, and alteration of feldspar to clay minerals (kaolinite) reflects deposition under shallow marine conditions followed by diagenetic alteration.



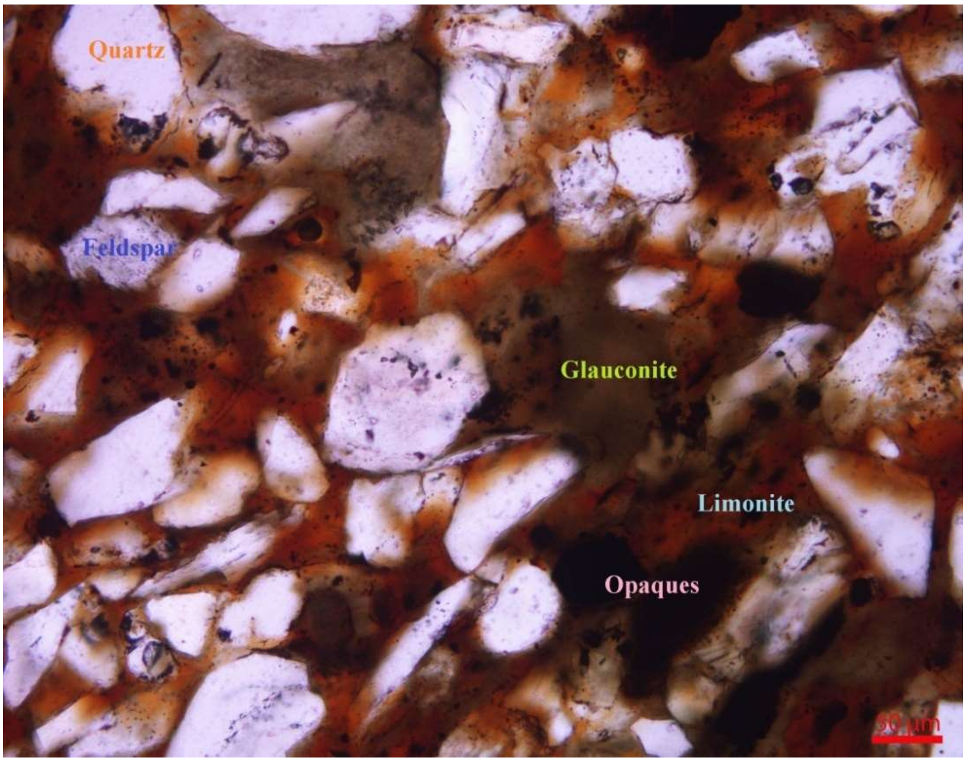
Pmg – 1: Photomicrograph showing presence of glauconite relicts in biotite rich shale as seen under plane polarized light. **Specimen No. : AW-235, Magnification : 200X**



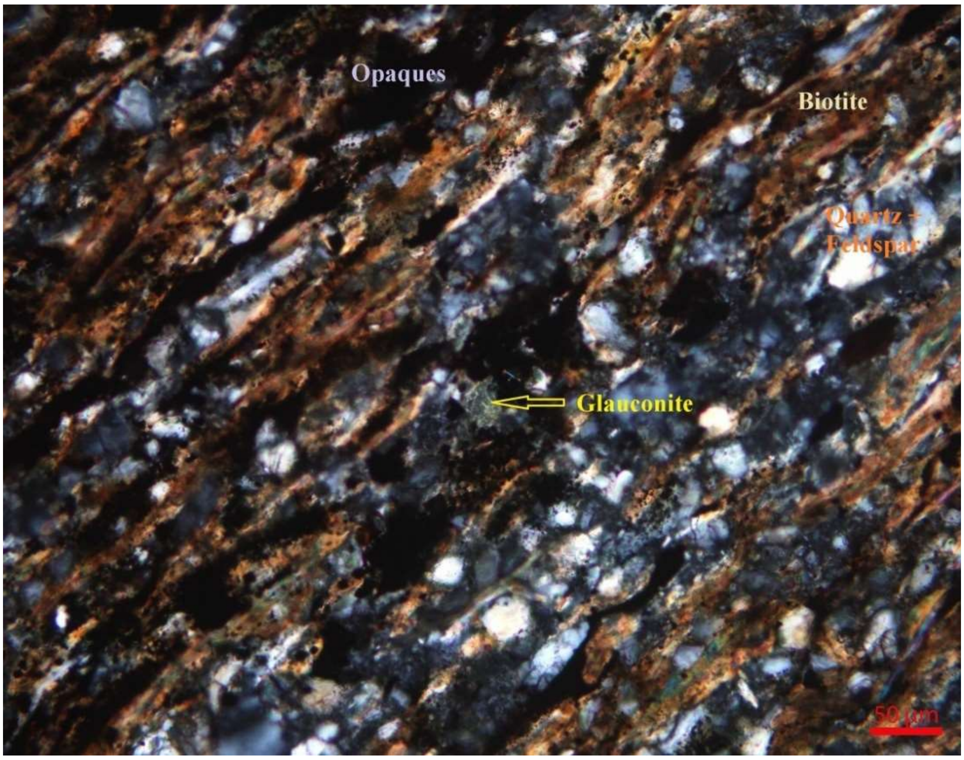
Pmg – 2: Photomicrograph showing presence of glauconite in arkosic wacke as seen under plane polarized light. **Specimen No.: AW-337, Magnification: 100X**



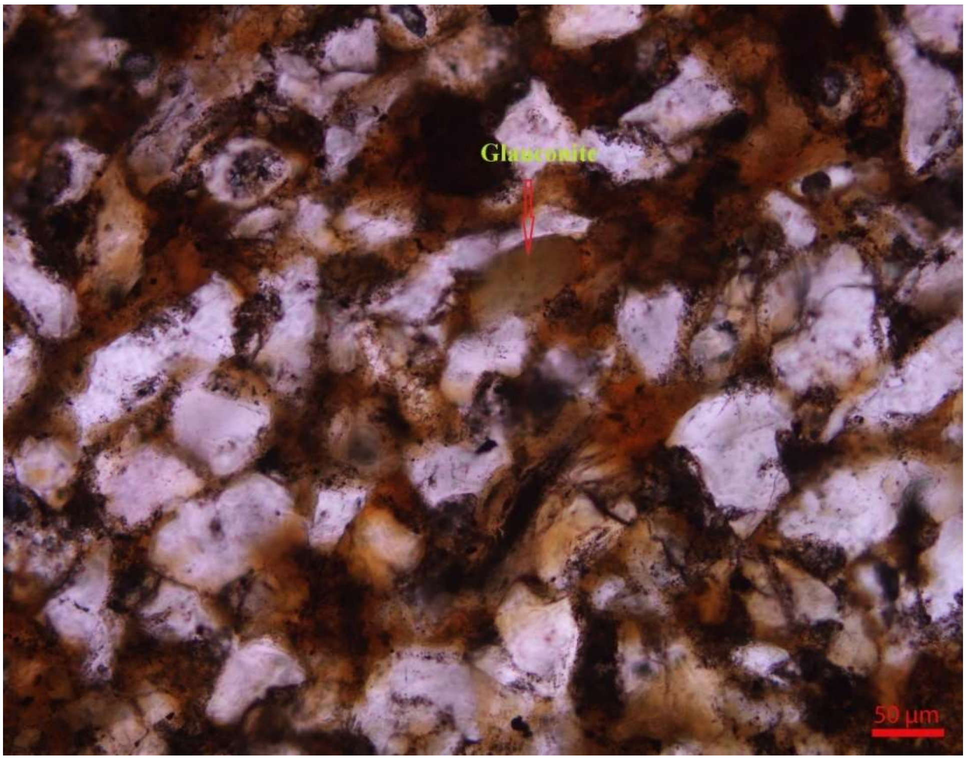
Pmg – 3: Photomicrograph showing presence of glauconite in biotite rich shale as seen under plane polarized light. **Specimen No.: AW-633, Magnification: 100X**



Pmg – 4: Photomicrograph showing glauconite relicts within limonitic patches in biotite rich shale as seen under plane polarized light. **Specimen No. : AW-972, Magnification : 200X**



Pmg – 5: Photomicrograph showing presence of glauconite in biotite rich shale as seen under crossed nicols., **Specimen No.: MKAW-03P1, Magnification: 200X**



Pmg – 6: Photomicrograph showing glauconite relicts within limonitic patches in biotite rich shaly sandstone as seen under plane polarized light.
Specimen No.: MKAW-09P1 (MKAW-09BD1), Magnification: 200X

7.9.0 EXTENT OF MINERALIZATION

7.9.1 The Ambara West Block, encompassing an area of 143.15 Sq. Km and situated in Lakhpat and Nakhatrana Talukas of Kachchh District, occupies the western part of the Kachchh Mainland. During the Reconnaissance Stage (G-4) exploration, systematic investigations were undertaken, comprising detailed geological mapping at 1:12,500 scale, collection of 100 bedrock samples, excavation of approximately 150 cubic metres of exploratory pits with 91 pit samples, and exploratory drilling of 10 boreholes aggregating 273 metres.

7.9.2 Integration of lithological mapping, surface sampling, pitting, and subsurface borehole data establishes the presence of stratiform, stratabound glauconite mineralisation hosted within marine siliciclastic units of the Katrol Formation. All boreholes intersected K_2O-bearing horizons, with cumulative mineralised thicknesses ranging from approximately 1.0 m (MKAW-08) to 17.5 m (MKAW-04), indicating persistence of mineralisation in the subsurface. The mineralised horizons are encountered at shallow sub-surface levels, with the upper contact occurring close to the surface and extending downwards to depths corresponding to the maximum borehole penetration.

7.9.3 Based on the correlation of surface and subsurface data, and considering the bedded nature, lateral continuity, and stratigraphic control of the glauconitic horizons, an area of approximately 18.44 Sq. Km has been interpreted as mineralised at the present reconnaissance level of confidence. The glauconite-bearing horizons show strike continuity in a NW–SE direction, broadly aligned with the regional structural trend of the Kachchh Basin.

Table No 7.3

Borehole-wise, Cumulative Mineralised Zone Details in Ambara West Block, Kachchh District, Gujarat

Polygon No	Borehole No.	Polygon Area (m^2)	Zone Thickness (m)
P1	MKAW-01	2231388	8.20
P2	MKAW-02	1826493	3.90
P3	MKAW-03	2560000	5.00
P4	MKAW-04	2337232	17.50
P5	MKAW-05	2544810	8.50
P6	MKAW-08	2560000	1.00
P7	MKAW-09	2146141	2.00
P8	MKAW-10	2235545	13.00
Total		**18441608 m^2**	**59.10 m**
		18.44 Km^2	

CHAPTER-8

8.0.0 PREVIOUS WORK

8.1.0 DETAILS OF PREVIOUS EXPLORATION CARRIED OUT BY OTHER AGENCIES/PARTIES

8.1.1 The Geological Survey of India (GSI) has carried out various geological, mineral investigation, and reconnaissance studies in different parts of the Kachchh Basin, including areas proximal to the Ambara West Block. The salient contributions relevant to glauconite and associated minerals are listed below.

8.1.2 Early regional investigations by GSI focused on industrial and fertilizer minerals in Kachchh District. Z. G. Ghevariya carried out investigations for bentonite deposits in Kachchh District during FS 1978–80, covering Survey of India Toposheet Nos. 41R/10, 41R/11, 41R/14, and 41R/15, and documented the geological framework of sedimentary formations hosting industrial minerals.

8.1.3 Occurrences of glauconite in the Mesozoic and Tertiary formations of the Kachchh Basin were reported by several workers, including Kulkarni and Agarwal (1963–64), Kulkarni and Desikan (1965–66), Vijaya Sarthi and Sable (1984–85), Ghevariya (1980–81), and Ghevariya and Srikarni (1990–91). These studies established the widespread presence of glauconite within sandstone and shale units of the basin.

8.1.4 Jain, R. L. (1994–95) carried out investigations for potash in glauconite-bearing shale and sandstone over an area of about 100 Sq. Km on 1:25,000 scale in Kachchh District, Gujarat. Based on a glauconite-bearing band with a cumulative thickness of ~1.5 m, strike continuity of 3–4 km, and exploration up to 2 m depth, a tentative reserve of 0.02 million tonnes of glauconite with an average K_2O content of 5.33% was estimated.

8.1.5 Sarkar and Banerjee (2011) suggested an authigenic origin for glauconite occurring in the Naredi Formation. Rathore, S. S. et al. (1999) carried out K–Ar dating of glauconite from the Ukra Member, and reported ages of approximately 105.2 ± 1.3 Ma, indicating glauconite formation during Early Cretaceous time.

8.1.6 Ajaya Kumar Sahu, Dhananjai Verma, et al. (FS 2016–17) conducted a G-4 Reconnaissance Survey for lateritic bauxite and lithomargic clay around Umarsar and Guneri areas (Toposheet No. 41A/13), Western Kachchh. The study estimated a reconnaissance mineral resource of 3.04 million tonnes of bauxite at 30% Al_2O_3 cut-off, with an average grade of 38.40% Al_2O_3, and 101,840.92 tonnes of lithomargic clay with an average 36.62% Al_2O_3. During this investigation, two glauconite samples were also analysed, reporting K_2O values ranging from 5.07% to 7.27%, indicating the presence of potassic glauconite in the region.

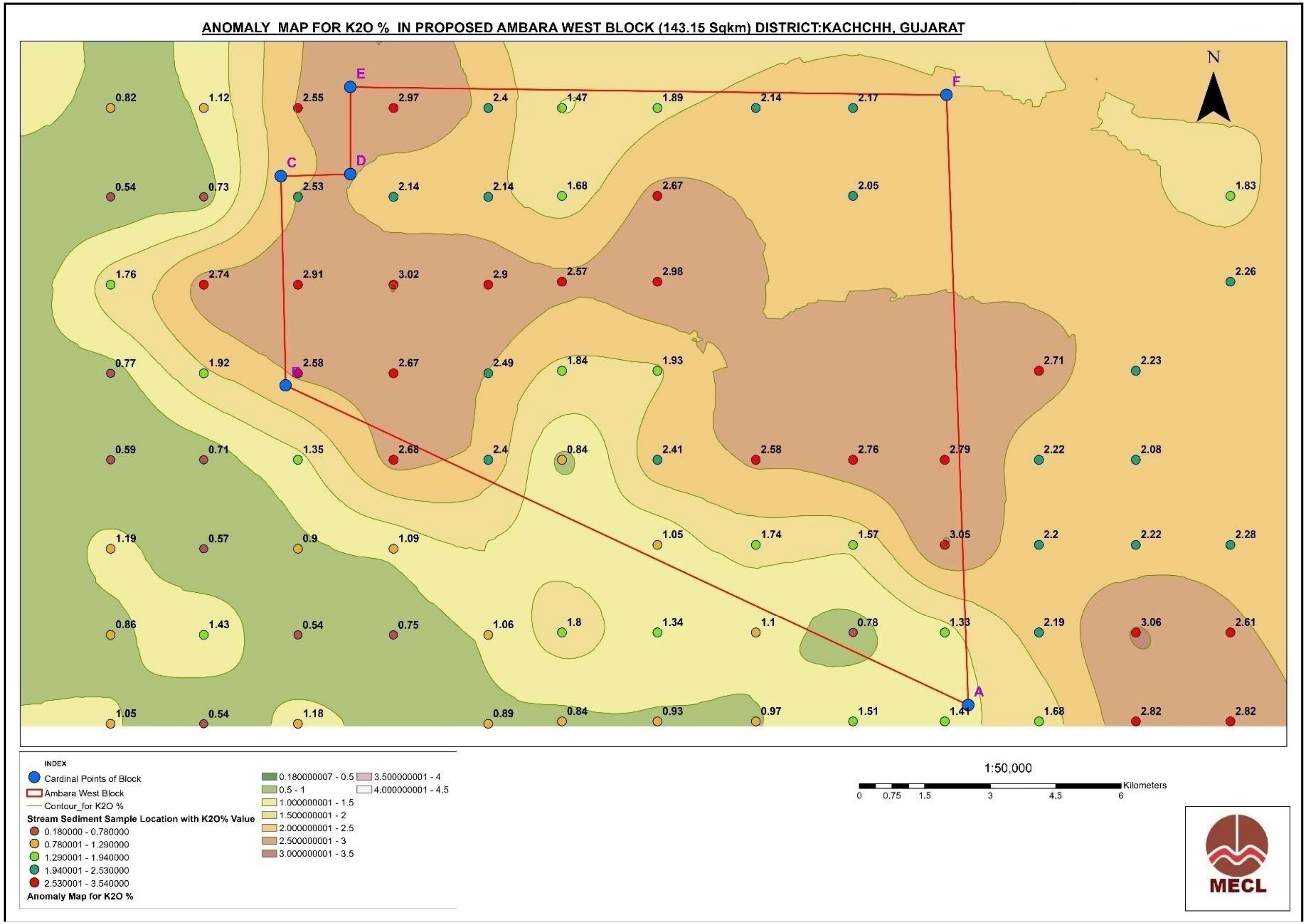
8.1.7 Basheer, H. K. and Kumar, A. (FS 2014–15) carried out detailed investigations for potash in glauconite-bearing shale and sandstone around Guneri village, Kachchh District. The study estimated glauconite resources in different grade brackets, with K_2O contents ranging from <2% to >4%, and based on the exploration results, the Guneri block was placed on the auction platform.

8.1.8 The present Reconnaissance Survey for glauconite in the Ambara West Block has been proposed in the south-eastern extension of GSI's explored Guneri Block (FS 2014–15). The extension area is inferred to host glauconite-bearing sandstone and shale units of the Katrol Formation, as established by regional stratigraphic continuity. As per GSI records, the Bhuj (Umia) Formation in the region comprises ferruginous sandstone, glauconitic sandstone (hard, compact, intercalated, sandy to clayey), and feldspathic sandstone, supporting the regional prospectivity for glauconite-hosted fertilizer minerals.

8.1.9 As part of the Geological Survey of India's National Geochemical Mapping Programme (NGCM), systematic stream sediment sampling was carried out in and around the Ambara West Block on a 2 Km × 2 Km grid pattern, following standard NGCM protocols. The objective of this regional geochemical survey was to identify elemental dispersion patterns and delineate areas favourable for mineralisation.

8.1.10 A total of 34 stream sediment samples were collected from the drainage network within the study area and analysed for major and trace elements. The analytical results indicate K_2O values ranging from 0.84% to 3.05%. Based on NGCM regional background levels for sedimentary terrains of the Kachchh Basin, K_2O values exceeding ~1.5% are considered anomalous and indicative of enrichment in potassium-bearing minerals. Several samples from the block area record values above this threshold, suggesting geochemical anomalies related to glauconite-bearing lithologies in the source areas. (Text Figure 8.1)

8.1.11 Comparable ranges of elevated K_2O values have also been reported from adjacent areas to the north of the block, where glauconitic sandstone occurrences have been delineated by GSI, indicating regional geochemical continuity. The NGCM data thus provide independent geochemical evidence supporting the presence and lateral persistence of glauconite mineralisation within the Ambara West Block and corroborate the geological and exploration findings of the present investigation.



Text Figure 8.1: K_2O Anomaly Map with Proposed Ambara West Block, Lakhpat and Nakhatrana Taluka, Kachchh District, Gujarat

CHAPTER-9

9.1.0 AREAL OR GROUND GEOPHYSICAL OR GEO-CHEMICAL DATA

9.1.1 The present exploration has been carried out for Glauconite in Ambara West Block (Area-143.15 Sq. Km), Tehsil-Lakhpat and Nakhatrana, District- Kachchh, Gujarat for which Areal or geophysical survey has not been carried out.

CHAPTER-10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 INTRODUCTION

10.1.1 The Reconnaissance survey proposal for Glauconitic in Ambara West Block, Kachchh District, Gujarat was submitted in was recommended in 1st TCC-II Meeting of NMEDT in 26th to 27th September 2024 and was approved by 38th EC meeting of NMEDT on 29th November 2024. Sanction Order was issued on 13th December 2024. The program was scheduled for 12 months (up to 12th December 2025), later extended by three months (up to 31st March 2026).

10.1.2 The Ambara West Exploration Block, covering an area of 143.15 Sq. Km, is located within the Kachchh Basin, a region of regional geological significance characterized by diverse lithological units and known mineral occurrences. Field operations were initiated by Mineral Exploration & Consultancy Limited (MECL) on 1st April 2025 and comprised systematic geological mapping on 1:12,500 scale, followed by pitting and exploratory drilling. Detailed core logging, systematic sampling, and laboratory-based analytical studies were carried out to assess the lithological characteristics and mineral potential of the block. The block is well connected by a network of approach roads and lies in close proximity to Bhuj Railway Station, ensuring effective accessibility for exploration activities and logistical support. The present Geological Report is being submitted in March 2026.

10.1.3 The present investigation was undertaken to evaluate the glauconite potential within the block area. Considering the strategic importance of glauconite in agricultural and industrial applications, the exploration programme was designed to delineate glauconite-bearing horizons through integrated geological mapping, exploratory drilling, core logging, sampling, and laboratory investigations. This stage of investigation has generated baseline geological and exploratory data essential for preliminary resource assessment and for establishing the economic significance of glauconitic mineralisation in the Ambara West Block, thereby forming a technical basis for future stages of exploration and development planning.

10.1.4 **OBJECTIVES OF INVESTIGATION** On approval of EC, NMEDT, the exploration programme in Ambara Block has been formulated to fulfil the following objectives:

a. To carry out systematic geological and structural mapping on 1:12,500 scale for delineation of glauconitic horizons, including associated structural features, and to establish the surface expressions as well as lateral and vertical disposition of mineralised zones.
b. To evaluate the surface quality and grade characteristics of glauconitic horizons through collection of surface samples comprising bedrock, channel, and pit samples, thereby guiding the subsequent stages of exploration.
c. To establish the surface continuity of glauconite mineralisation concealed beneath soil and overburden cover through systematic pitting.
d. Based on the outcomes of geological mapping, sampling, and pitting, to undertake systematic exploratory drilling in a grid pattern to establish the vertical and lateral continuity of mineralisation, along with its qualitative and quantitative attributes.
e. To estimate glauconite resources in accordance with UNFC norms and the Minerals (Evidence of Mineral Contents) Amendment Rules, 2021.
f. To generate adequate geological and exploratory data to facilitate upgradation of the block to a higher level of exploration.

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 Ambara West Block, Kachchh District, Gujarat

Sl. No.	Item of Work	Unit	Approved Quantum	Achievement
1	Geological Mapping (1:12500 scale)	Sq. Km	143.15	143.15
2	Surface Geochemical sampling (Bed Rock)	Nos.	100	100
3	Exploratory Mining (Pitting)	Cu M.	150	150.30
4	DGPS Survey for Borehole fixation	Nos	10	10
5	Drilling (Core)	m.	300	273.00
6	Surface samples (Bedrock/Channel/Pit/ BH Samples)			
	i) Primary samples for 8 radicals	Nos.	414	405

	(K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3 & Fe_2O_3)			
	ii) 10% External check samples for 8 radicals (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3 & Fe_2O_3)	Nos.	41	41
	iii) Trace Element (34 element)	Nos.	30	30
7	Petrological Studies (10 samples)	Nos	10	10
8	XRD Study	Nos.	15	15
9	Modal Analysis	Nos	10	Nil
10	Determination of Bulk Density	Nos.	5	5
11	Geological Report preparation	Nos.	1	1

10.2.0 DETAILS OF EXPLORATION ACTIVITIES TAKEN UP

10.2.1 LARGE SCALE GEOLOGICAL MAPPING:

Large-scale geological mapping of the Ambara West Block was carried out on a 1:12,500 scale, covering the entire 143.15 Sq. Km block area. The mapping was undertaken to establish a reliable geological framework for exploration and resource evaluation. During field investigations, lithological units, stratigraphic contacts, and structural features were systematically identified and recorded. Based on these observations, a detailed geological map was prepared at the same scale, incorporating updated field data and structural interpretations to accurately represent the geological setting of the block.

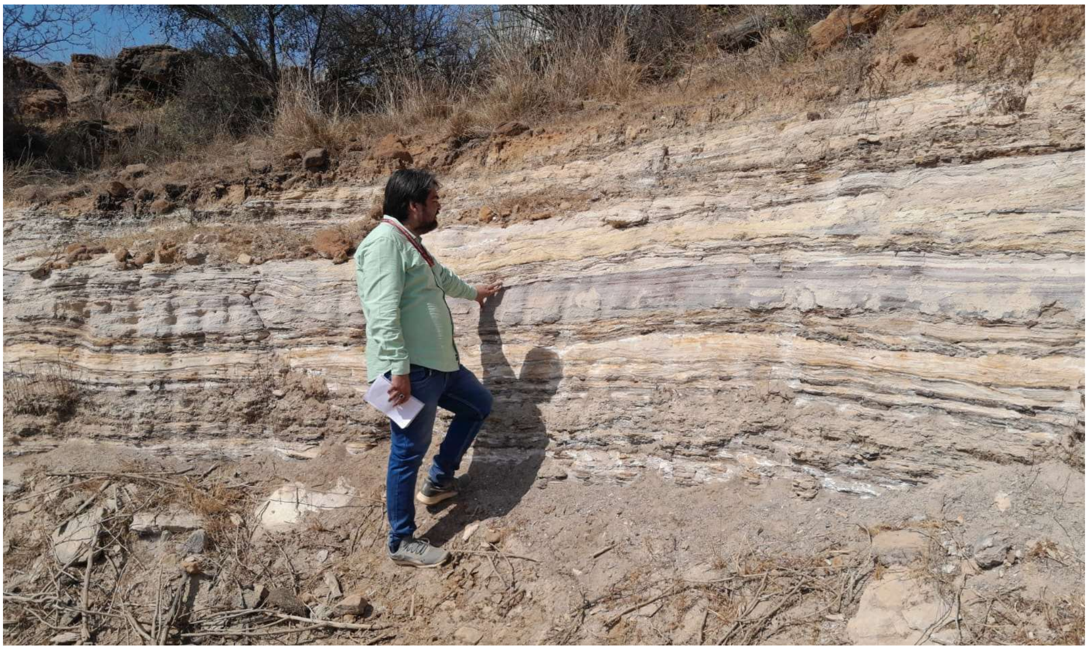


Photo. 10.1 Photograph showing geologist involved in geological mapping in the block

10.2.2 Exploration activities in the Ambara West Block commenced on 01 April 2025 and were completed on 14 January 2026. As part of the exploration programme, the geological mapping helped delineate lithological variations, structural trends, and potential mineralized horizons, particularly within the sedimentary sequence of the area. The geological map prepared from this work provides a comprehensive regional base for further exploration, sampling, drilling, and evaluation of glauconitic sandstone resources in the block.

10.2.3 The mapping program involved methodical field observations, including the documentation of lithological contacts, stratigraphic boundaries, geomorphological expressions, and structural elements. Major lithological units were carefully identified and mapped, comprising ferruginous sandstone, feldspathic sandstone, glauconitic sandstone, sandstone with Trigonia fossils, fossiliferous limestone, and basalt. These units were differentiated based on their field characteristics, fossil content, and mineralogical composition.

10.2.4 Lithological boundaries and contacts were established with the aid of handheld GPS instruments, ensuring spatial precision in plotting and reducing positional errors. Structural data, including the attitude of bedding planes, cross bedding patterns, were systematically recorded using a Brunton Compass, enabling a clear understanding of the overall structural disposition of the block.

10.2.5 The general strike of the litho-units was observed to be NE–SW, with sub-horizontal dips ranging between 5° and 10° towards the southeast. This structural orientation provides insights into the tectonic regime and depositional environment of the area. The integration of lithological and structural data allowed for the preparation of a comprehensive geological map (Plate–III), which represents the up-to-date field observations and interpretations.

10.2.6 This geological map serves as a reliable baseline for subsurface correlation, stratigraphic reconstruction, and mineral resource evaluation. It provides a scientifically robust framework for guiding exploratory drilling and future development activities within the Ambara West Block.

10.2.7 Large-scale geological mapping of the Ambara West Block was carried out to document lithological variations, stratigraphic relationships, and structural features, with particular emphasis on the delineation of glauconite-bearing horizons. The mapped area is underlain predominantly by Late Jurassic to Early Cretaceous sedimentary sequences belonging mainly to the Katrol Formation, with limited and discontinuous exposures of the Bhuj Formation of Early Cretaceous age. Lithounits of the Bhuj Formation were observed mainly in the western part of the block area and comprise sandstone, shale, clay, grit, and conglomerate, with localized fossiliferous horizons containing Trigonia.

10.2.8 The Katrol Formation occupies the major part of the block area and forms the principal stratigraphic unit exposed during large-scale mapping. It is represented by shale with calcareous sandstone, sandstone, shale with Trigonia fossils, glauconitic sandstone, oolitic limestone, conglomerate, and shale with plant fossil impressions. Glauconitic sandstone horizons were mapped as distinct and laterally traceable beds, commonly interbedded with shale and calcareous sandstone.

10.2.9 Local exposures of Deccan Trap volcanics of Late Cretaceous–Palaeocene age were recorded in the south-western part of the block. These consist of basaltic lava flows with associated Dayapar intrusive bodies, resting unconformably over the sedimentary succession.

10.2.10 Structurally, large-scale mapping indicates that the strike direction of bedding planes in the Ambara West Block is predominantly NE–SW. This orientation is consistent with the regional structural grain of the Kachchh Basin and the alignment of the Guneri Dome, reflecting basin-scale tectonic control. The sedimentary beds are generally horizontal to gently dipping, with low-angle dips towards the southeast and southwest, and contacts between successive lithounits are predominantly gradational, suggesting uninterrupted sedimentation without major structural disturbances at the mapping scale.

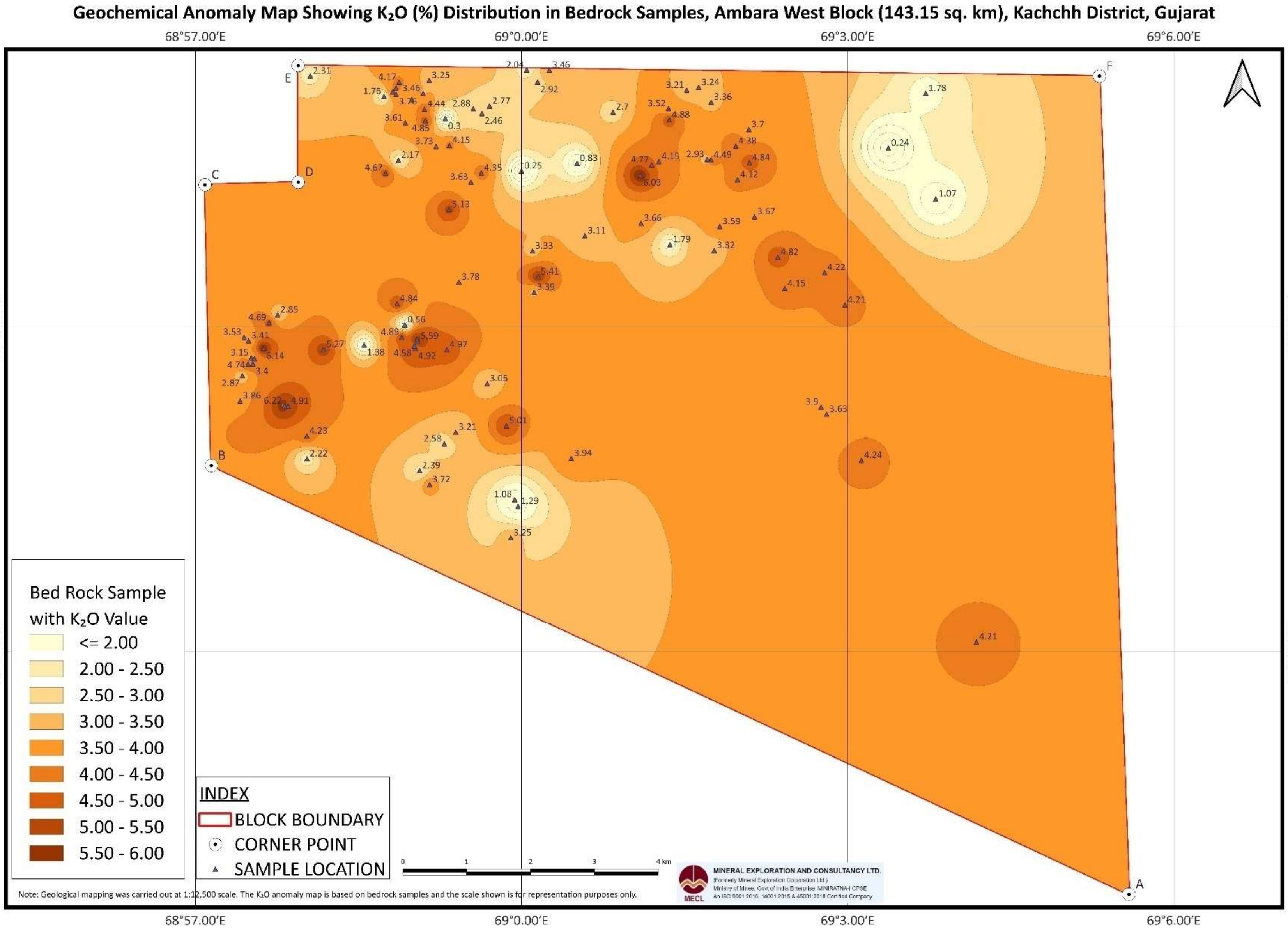
10.2.11 **Bedrock sampling:** During systematic geological traverses in the Ambara West Block, glauconite-bearing horizons were carefully delineated and representative bedrock samples were collected to characterize the nature and extent of mineralisation. Sampling was carried out by chipping fresh, unweathered material from exposed glauconitic sandstone and associated shale and clay units, ensuring adequate representation of the mineralized horizons. A total of 100 bedrock samples were collected and analysed for 8 major oxides (radicals) and 17 no of samples were analysed using ICPMS for 34 trace elements at the MECL Laboratory.

10.2.12 Prior to sample collection, weathered and altered surfaces were removed using a geological hammer to expose fresh glauconitic bands, typically exhibiting greenish to olive-grey coloration. Sample chips were collected along the strike of the exposures and across the width of the mineralized bands to minimize localized bias and to capture lithological and textural variations within the horizons.

This systematic and uniform sampling methodology ensured that the collected samples are representative of the average glauconite content, textural characteristics, and mineralogical distribution of the bedrock. In total, 100 bedrock samples were collected from the block area. The samples constitute a reliable dataset for subsequent petrographic studies, geochemical analysis, and grade evaluation, and form the basis for assessing the glauconite resource potential of the Ambara West Block. Geochemical Anomaly map showing (K2O) distribution in bed rock samples in Ambara West Block (Text Figure 10.1).

10.2.13 **Pitting:** A total of 75 pits, involving a cumulative excavation volume of about 150.30 m^3, were excavated in the Ambara West Block to assess the distribution, thickness, and grade of near-surface glauconitic mineralisation. Pitting was undertaken in glauconitic sandstone and glauconitic shale/clay horizons, based on the results of prior bedrock sampling and reconnaissance-scale geological mapping. Pit locations were selected systematically in areas showing surface glauconite indications, with additional infill pits excavated in anomalous zones to refine the understanding of lateral continuity and enrichment patterns. The locations of all pits were recorded using GPS, and each pit was excavated to expose fresh, un-weathered bedrock. The detailed statement showing pit details and logging is provided in Annexure-IIIB.

10.2.14 The pits were generally 1.0 m × 1.0 m in plan dimensions and were excavated to depths ranging from 1.00 m to 2.80 m, depending on lithological conditions and depth to competent bedrock. All pit locations have been plotted on the geological map (Plate–III) for spatial reference. From the excavated pits, a total of 97 samples were Collected. From which, 91 pit samples were analysed for major oxide constituents, namely K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 (Annexure–IIB) and 6 no of Samples were analysed using ICPMS for 34 trace elements. Analytical results for major oxide constituents indicate that 52 out of 91 samples contain more than 3% K_2O, confirming moderate to high glauconite enrichment in several parts of the block. The K_2O values



Text Figure 10.1: Geochemical Anomaly map showing (K_2O) distribution in bed rock samples in Ambara West Block.

10.2.15 Range from 3.02% to 6.19%, with Pit Sample No. AWPT-73 recording the highest grade of 6.19% K_2O.

 Photo. 10.2 Photograph showing the layout marking and north orientation of Pit No- 42 near Valka Nana village, prior to excavation.	 Photo. 10.3 Photograph showing excavation in progress at Pit No. 07 near Meghpar Village.
 Photo. 10.4 Photograph showing the involvement of a geologist during logging at Pit No- 40 near Valka Nana Village.	 Photo. 10.5 Photograph showing sampling in progress at Pit No- 37 near Meghpar village.

10.2.16 The enriched horizons identified through pitting are interpreted to represent primary glauconite concentrations within relatively less-weathered sandstone units, and constitute priority targets for further evaluation of glauconite resources in the Ambara West Block.

10.2.17 The details of pit samples sample values for K_2O% are tabulated below in Table 10.2.

Table 10.2
Details of pit sample values for K_2O % in Ambara West Block, Kachchh District, Gujarat

Sl. No.	Pit No.	Primary Sample ID	Easting (m)	Northing (m)	RL (m)	K_2O (%)
1	PITID-01	AWPT-01	2613828	497200	97	3.26
2	PITID-02	AWPT-02	2612747	497125	98	1.89
3	PITID-03	AWPT-03	2613211	497882	101	1.37
4	PITID-03	AWPT-03-A	2613211	497882	101	4.84
5	PITID-04	AWPT-04	2612545	498199	96	4.07
6	PITID-05	AWPT-05	2613738	498406	90	4.18
7	PITID-06	AWPT-06	2614161	498797	92	4.57
8	PITID-06	AWPT-06-A	2614161	498797	92	4.33
9	PITID-06	AWPT-06-B	2614161	498797	92	4.78
10	PITID-07	AWPT-07	2613617	499514	72	3.97
11	PITID-08	AWPT-08	2613072	499841	65	3.72
12	PITID-09	AWPT-09	2613475	500594	72	2.88
13	PITID-10	AWPT-10	2612912	501096	67	3.60
14	PITID-11	AWPT-11	2612306	501597	68	2.67
15	PITID-12	AWPT-12	2611746	502088	64	3.44
16	PITID-13	AWPT-13	2614049	501118	74	4.78
17	PITID-14	AWPT-14	2613562	501629	64	4.32
18	PITID-15	AWPT-15	2612798	502198	57	3.46
19	PITID-16	AWPT-16	2612336	502809	48	1.80
20	PITID-17	AWPT-17	2613882	502296	77	1.51
21	PITID-18	AWPT-18	2613406	502928	58	2.69
22	PITID-18	AWPT-18-A	2613406	502928	58	4.66
23	PITID-19	AWPT-19	2613696	504633	64	2.77
24	PITID-20	AWPT-20	2613152	505102	78	2.97
25	PITID-21	AWPT-21	2612240	503920	71	3.02
26	PITID-22	AWPT-22	2611753	500985	56	3.38
27	PITID-22	AWPT-22-A	2611753	500985	56	2.46
28	PITID-23	AWPT-23	2611141	501533	60	1.38
29	PITID-23	AWPT-23-A	2611141	501533	60	3.45
30	PITID-24	AWPT-24	2610549	502086	57	0.90
31	PITID-25	AWPT-25	2612476	500526	69	3.50
32	PITID-25	AWPT-25-A	2612476	500526	69	3.59
33	PITID-26	AWPT-26	2611160	502672	79	3.73

Sl. No.	Pit No.	Primary Sample ID	Easting (m)	Northing (m)	RL (m)	K_2O (%)
34	PITID-27	AWPT-27	2611543	503329	50	2.39
35	PITID-28	AWPT-28	2610397	503003	56	2.78
36	PITID-29	AWPT-29	2609843	502520	46	1.96
37	PITID-29	AWPT-29-A	2609843	502520	46	2.55
38	PITID-30	AWPT-30	2610328	504177	47	5.03
39	PITID-30	AWPT-30-A	2610328	504177	47	5.41
40	PITID-31	AWPT-31	2607434	499448	81	3.47
41	PITID-32	AWPT-32	2607857	500241	97	2.27
42	PITID-33	AWPT-33	2608459	499570	80	4.99
43	PITID-34	AWPT-34	2609199	499035	79	5.91
44	PITID-35	AWPT-35	2609628	499654	85	3.70
45	PITID-36	AWPT-36	2610250	499157	79	3.72
46	PITID-36	AWPT-36-A	2610250	499157	79	3.87
47	PITID-37	AWPT-37	2610856	498650	71	4.12
48	PITID-37	AWPT-37-A	2610856	498650	71	4.69
49	PITID-38	AWPT-38	2611363	499314	61	2.55
50	PITID-39	AWPT-39	2610901	499780	66	2.97
51	PITID-40	AWPT-40	2610115	500269	73	4.38
52	PITID-41	AWPT-41	2608422	500682	72	3.19
53	PITID-42	AWPT-42	2609012	501340	71	3.04
54	PITID-42	AWPT-42-A	2609012	501340	71	2.99
55	PITID-43	AWPT-43	2609480	500778	66	4.28
56	PITID-43	AWPT-43-A	2609480	500778	66	4.97
57	PITID-44	AWPT-44	2610115	501423	63	3.56
58	PITID-45	AWPT-45	2610667	500923	76	3.51
59	PITID-46	AWPT-46	2611282	500395	73	0.74
60	PITID-46	AWPT-46-A	2611282	500395	73	0.39
61	PITID-47	AWPT-47	2611957	499943	107	0.44
62	PITID-48	AWPT-48	2607267	500596	92	2.14
63	PITID-49	AWPT-49	2608114	501842	77	3.54
64	PITID-49	AWPT-49-A	2608114	501842	77	2.10
65	PITID-50	AWPT-50	2607157	501659	94	1.97
66	PITID-51	AWPT-51	2606575	501051	97	0.87
67	PITID-52	AWPT-52	2608636	498556	76	3.38
68	PITID-53	AWPT-53	2609506	497994	72	2.79
69	PITID-54	AWPT-54	2608757	497290	75	3.42
70	PITID-55	AWPT-55	2607532	498256	77	4.26
71	PITID-56	AWPT-56	2606946	497772	83	3.81
72	PITID-57	AWPT-57	2606872	498838	94	2.51
73	PITID-58	AWPT-58	2609336	496800	79	2.32
74	PITID-59	AWPT-59	2608207	496718	103	4.79
75	PITID-60	AWPT-60	2607603	496163	87	3.55

Sl. No.	Pit No.	Primary Sample ID	Easting (m)	Northing (m)	RL (m)	K_2O (%)
76	PITID-61	AWPT-61	2608364	495593	82	5.08
77	PITID-62	AWPT-62	2609583	495770	88	4.57
78	PITID-63	AWPT-63	2610461	496895	75	2.66
79	PITID-64	AWPT-64	2605418	507273	64	3.14
80	PITID-65	AWPT-65	2606719	506215	58	2.83
81	PITID-65	AWPT-65-A	2606719	506215	58	1.16
82	PITID-66	AWPT-66	2607826	505157	87	2.47
83	PITID-67	AWPT-67	2609142	504201	54	3.87
84	PITID-68	AWPT-68	2609852	503772	54	5.63
85	PITID-69	AWPT-69	2609961	496208	88	1.47
86	PITID-70	AWPT-70	2610605	495812	105	4.08
87	PITID-71	AWPT-71	2611657	495819	100	0.85
88	PITID-72	AWPT-72	2611616	496968	93	2.95
89	PITID-73	AWPT-73	2611499	498211	75	6.19
90	PITID-74	AWPT-74	2610949	497615	83	2.91
91	PITID-75	AWPT-75	2609888	497430	76	2.53

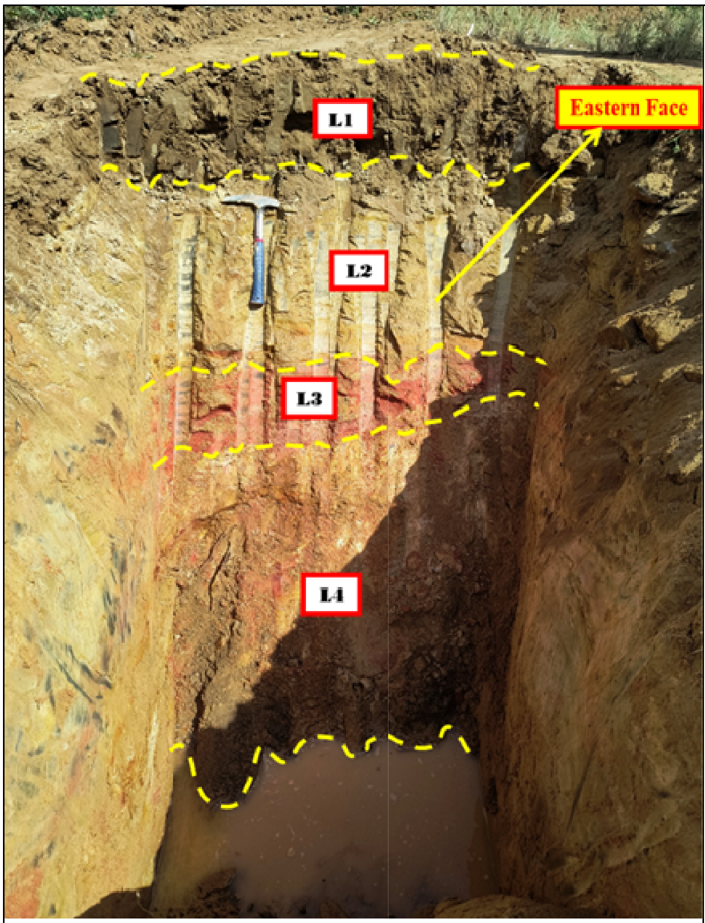


Photo 10.6 Photograph showing eastern face of Pit no: P-15 near village Junachay (K2O Average of (L2) & (L4)-3.46%).

Pit exposure showing lithological sequence in PIT-15 of the Ambara West Block. The section comprises brown sandy soil from 0.00–0.40 m(L1), underlain by whitish green glauconitic sandstone from 0.40–1.00 m(L2), followed by a thin ferruginous sandstone horizon (maroon coloured) between 1.00–1.20 m(L3), and further underlain by whiteish green glauconitic sandstone extending up to 2.00 m depth (L4).

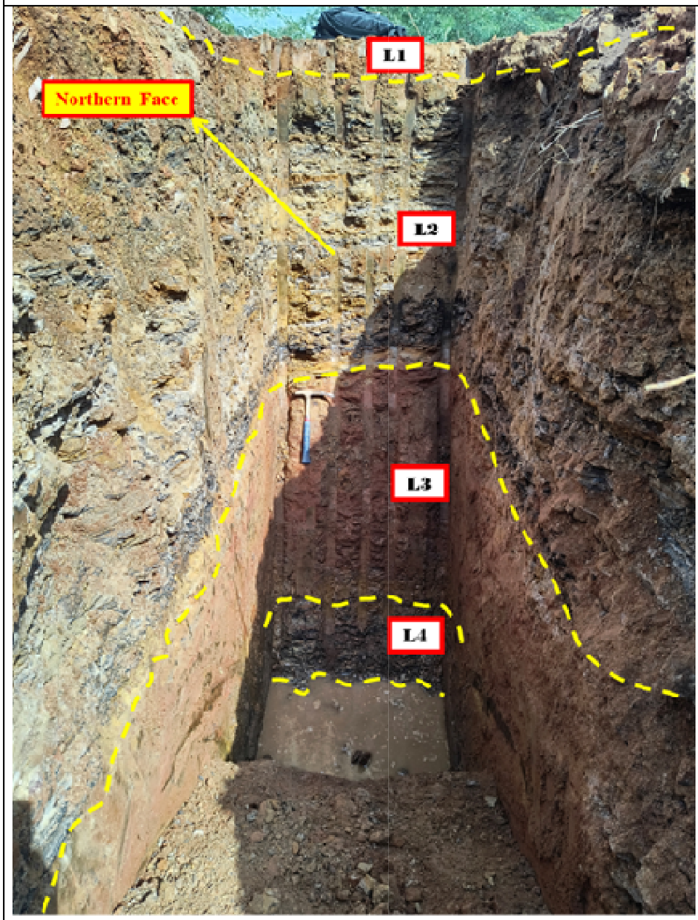


Photo 10.7 Photograph showing northern face of Pit no: P-43 near village Valka Nana (K2O of (L2) - 4.28%, K2O of (L4) -4.97%).

Pit exposure showing lithological sequence in PIT-43 of the Ambara West Block. The section comprises brownish red topsoil from 0.00–0.20 m (L1), underlain by alternating bands of glauconitic sandstone and grey shale from 0.20–1.40 m (L2), followed by weathered FGSST between 1.40–2.40 m (L3), and further underlain by alternating bands of glauconitic sandstone and grey shale extending up to 2.80 m depth (L4).

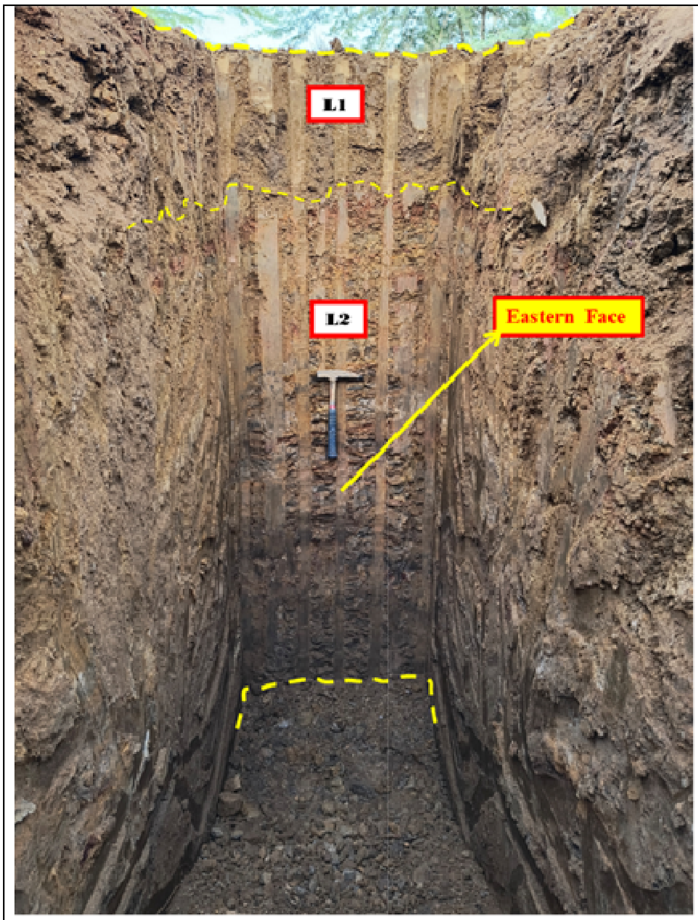


Photo 10.8 Photograph showing eastern face of Pit no: P-40 near village Valka Mota (K2O of (L2)-4.28%).

Pit exposure showing lithological sequence in PIT-40 of the Ambara West Block. The section comprises yellowish green topsoil from 0.00–0.50 m (L1), underlain by alternating bands of glauconitic sandstone and grey shale from 0.50–2.40 m (L2).

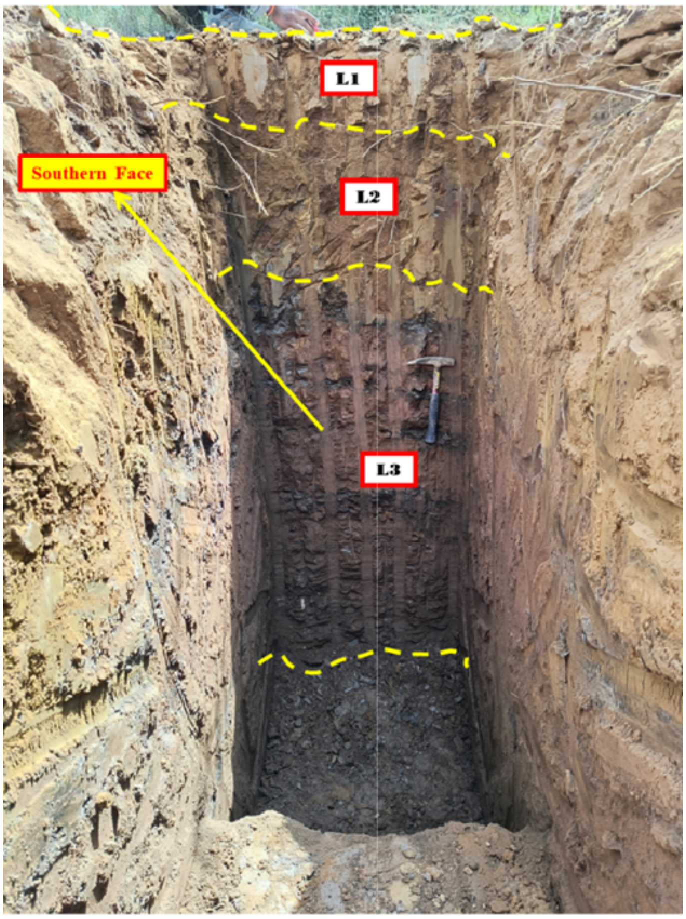


Photo 10.9 Photograph showing southern face of Pit no: P-37 near village Meghpar (K2O of (L2)-4.12% & K2O of (L3) -4.69%).

Pit exposure showing lithological sequence in PIT-37 of the Ambara West Block. The section comprises yellowish brown sandy soil from 0.00–0.30 m (L1), underlain by yellowish green sandstone (glauconitic sandstone) from 0.30–0.70 m (L2), followed by alternating bands of glauconitic sandstone, grey shale, and FGSST extending from 0.70 m to 2.10 m depth (L3).

10.2.18 **Exploratory Drilling:**

10.2.18.1 As part of the present exploration programme, exploratory core drilling was undertaken in the Ambara West Block at the G-4 (Reconnaissance) level to evaluate the lateral continuity and depth persistence of glauconite mineralization. A total of 10 boreholes were planned and executed on approximately 1600 m × 1600 m grid pattern, in conformity with the provisions of the Minerals Evidence of Mineral Content Rules, 2015.

10.2.18.2 Drilling operations commenced on 02 January 2026 and were completed on 14 January 2026, achieving a cumulative drilled meterage of 273 m. The boreholes were designated MKAW-01 to MKAW-10.

10.2.18.3 The coordinates and Reduced Levels (RLs) of all boreholes were determined using Differential Global Positioning System (DGPS) under the WGS-84 datum, ensuring accurate and consistent positioning. The borehole locations, have been plotted on the geological map of the block (Plate–III) for spatial reference.

Table- 10.3

Details of Boreholes in Ambara West Block for Glauconite in Tehsil-Lakhpat and Nakhatrana, District- Kachchh, Gujarat

Sl. No.	BH. No.	RL (m)	Northing (m)	Easting (m)	Date of Commencement	Date of Closure	Total Depth(m)
1	MKAW-01	498372.7810	2613753.8550	83.053	02.01.2026	05.01.2026	30.00
2	MKAW-02	495806.0190	2610604.1810	89.222	04.01.2026	10.01.2026	23.00
3	MKAW-03	502140.1090	2612810.8880	59.729	04.01.2026	06.01.2026	30.00
4	MKAW-04	498130.6610	2611513.0960	71.951	06.01.2026	08.01.2026	30.00
5	MKAW-05	496362.7800	2608304.4850	85.249	07.01.2026	14.01.2026	30.00
6	MKAW-06	505104.4680	2613156.6800	53.625	08.01.2026	09.01.2026	15.00
7	MKAW-07	498950.6490	2607996.1670	79.44	09.01.2026	10.01.2026	25.00
8	MKAW-08	500771.3710	2609469.6960	61.921	11.01.2026	11.01.2026	30.00
9	MKAW-09	503758.1560	2609856.7880	48.903	12.01.2026	13.01.2026	30.00
10	MKAW-10	506217.2230	2606720.2270	61.587	13.01.2026	14.01.2026	30.00
Total Drilling Depth							**273.00**

10.2.19 Detailed geological logging of all borehole cores was carried out, incorporating systematic observations on structural features, lithological variations, and mineralogical characteristics (Annexure-II). Core sampling was undertaken majorly at 1.0 m intervals, with minor adjustments where lithological changes warranted closer control. In nearly all boreholes, horizons of glauconitic sandstone and glauconitic shale/clay were encountered, confirming the widespread occurrence of glauconite-bearing strata within the block. A total of 214 borehole core samples were collected and analysed for 8 major oxides (radicals), and 7 samples were analysed for 34 trace elements at the MECL Laboratory.

Photo 10.10 Photograph showing the location of Borehole Site (MKAW-01).

10.2.20 Associated laboratory investigations were conducted in parallel with core logging, and the results of chemical analyses of borehole samples are presented in Annexure -IVC. These analyses provide quantitative data on oxide composition, particularly K_2O enrichment, which is critical for glauconite resource evaluation.

10.2.21 Table 10.4 summarises the delineated enriched K_2O zones identified within the Ambara West Block, Kachchh District, Gujarat, based on subsurface exploration through boreholes. The table records the depth intervals of glauconitic horizons, together with the average K_2O grades calculated for each mineralised zone. This dataset offers a concise overview of the spatial distribution, thickness, and grade characteristics of glauconite-bearing horizons, forming a reliable basis for subsurface correlation, grade estimation, and resource categorisation.

10.2.22 Most boreholes display several mineralized intervals at varying depths, indicating a consistent presence of potash mineralization across the area.

Table- 10.4

Table showing mineralisation zone and average grade for K2O encountered in boreholes, in Ambara West Block for Glauconite in Tehsil-Lakhpat and Nakhatrana, District- Kachchh, Gujarat

From (m)	To (m)	Thickness (m)	K_2O %	SiO_2 %	MgO %	CaO %	Na_2O %	P_2O_5 %	Al_2O_3 %	Fe_2O_3 %
BH No-MKAW-01										
0.00	2.00	2.00	3.95	43.58	3.61	3.79	0.48	0.19	20.37	12.79
8.80	12.00	3.20	5.23	61.52	2.71	0.22	0.17	0.08	17.32	6.33
15.00	18.00	3.00	4.82	67.62	1.28	0.46	0.17	0.06	15.89	4.64
BH No-MKAW-02										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	2.00	2.00	3.50	62.84	0.70	0.86	0.20	0.07	15.68	8.74
11.10	12.00	0.90	4.25	76.00	0.32	0.15	0.22	0.05	13.60	2.14
13.50	14.50	1.00	4.80	62.25	0.66	0.28	0.12	0.04	21.01	1.96
BH No-MKAW-03										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	4.00	4.00	3.30	78.50	0.98	0.59	0.16	0.04	9.21	3.77
9.00	10.00	1.00	4.50	61.36	1.62	2.28	0.16	0.07	16.82	5.84
BH No-MKAW-04										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	2.00	2.00	3.24	79.36	0.44	0.25	0.18	0.06	9.35	3.40
4.00	13.50	9.50	5.07	54.94	2.47	0.47	0.25	0.09	18.64	9.89
22.00	23.00	1.00	3.26	72.69	2.72	0.65	0.12	0.50	10.17	4.43
25.00	30.00	5.00	4.56	71.74	1.24	0.34	0.16	0.19	13.27	3.73
BH No-MKAW-05										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	2.00	2.00	5.07	53.04	2.13	3.20	0.91	0.37	18.28	6.79
5.50	8.00	2.50	3.87	48.44	3.73	7.65	0.21	0.08	13.69	6.34
25.00	27.00	2.00	3.13	47.73	3.58	5.32	0.56	0.36	15.29	9.26
28.00	30.00	2.00	3.38	49.83	3.09	2.69	0.48	0.10	17.70	10.07

BH No-MKAW-08										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
5.30	6.30	1.00	4.81	55.89	1.07	0.24	0.74	0.09	18.25	10.31
BH No-MKAW-09										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	2.00	2.00	4.90	54.76	2.01	3.21	0.84	0.06	16.74	7.21
BH No-MKAW-10										
From (m)	**To (m)**	**Thickness (m)**	**K_2O %**	**SiO_2 %**	**MgO %**	**CaO %**	**Na_2O %**	**P_2O_5 %**	**Al_2O_3 %**	**Fe_2O_3 %**
0.00	1.00	1.00	3.37	59.78	0.84	0.69	0.25	0.09	19.54	6.99
13.00	24.00	11.00	4.18	57.53	2.16	2.24	0.39	0.11	17.22	7.02
27.00	28.00	1.00	4.75	59.95	2.46	1.09	0.45	0.05	16.61	7.92

10.3.0 Data spacing for reporting of exploration results:

10.3.1 The boreholes were spaced at an interval of approximately 1600 m, which is considered adequate for establishing glauconite resources at the G-4 stage (Reconnaissance Exploration) in accordance with the provisions of the Minerals (Evidence of Mineral Content) Rules, 2015. Based on the present level of exploration and the available geological data, the estimated resources of the Ambara West Block may be classified under the Reconnaissance Mineral Resource (UNFC Code: 334) category.

CHAPTER-11

11.0.0 LOCATION OF DATA POINTS

11.1.0 ACCURACY AND QUALITY OF SURVEY

11.1.1 The survey of boreholes drilled in the block has been carried out by the DGPS. (Annexure-IB). The photograph of instrument is given in Photo-11.1.

Photo-11.1: DGPS survey in the block using DGPS at Borehole no- MKAW-01

11.1.2 The SOI base station was utilized for fixing the borehole positions on the ground as well as for obtaining the reduced levels of the boreholes. The base station used from the SOI India CORS network. The coordinates of the SOI base station are provided in Table-11.1.

Table-11.1

Coordinates of the SOI CORS Base Point for DGPS Survey of Ambara West Block for Glauconite in Tehsil-Lakhpat and Nakhatrana, District- Kachchh, Gujarat

Base Station	Latitude	Longitude	Easting (m)	Northing (m)	RL (m)
Survey Of India (Dayapar)	N23°37'55.26554"	E68°54'06.38488"	489981.079 m	2613490.249 m	103.834 m

11.1.3 Technical Specifications of DGPS

Make: Trimble GNSS

Model: DA-2 Catalyst

Year: 2025

a) Measurement Accuracy:

Static Mode

- Horizontal: 10 mm + 0.1 ppm or better
- Vertical: 20 mm + 0.4 ppm or better

b) Baseline Processing Results

Total 4 boreholes were drilled in the block by MECL as part of present G4 stage exploration have been fixed by DGPS survey instrument. Borehole locational co-ordinates & Reduced level (RL) of the borehole are given in Annexure-IB and also shown in Plate-III.

11.2.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

The survey work has been carried out with the help of DGPS(GNSS) for higher level measurement accuracy. A point list was then generated as .csv file for topographical points and summary was attached along with report. The baseline processing results are also enclosed with this report. Survey work carried out by the experienced qualified surveyor as per the prevailing standard procedures.

CHAPTER-12

12.0.0 SAMPLING TECHNIQUE

12.1.0 NATURE AND QUALITY OF SAMPLING AND MEASURES TAKEN TO ENSURE SAMPLE REPRESENTATIVITY

12.1.1 Drill core samples were collected systematically from glauconite-bearing zones intersected in boreholes. Care was taken to avoid weathered or altered portions, and only fresh, unoxidised core segments were sampled. Each core was split lengthwise into two halves using a core splitter: one half was preserved for record, while the other half was used for sampling. Individual samples weighed about 1.0–1.5 kg and were placed in clean cotton bags, securely tied and labelled to ensure proper identification and traceability.

12.1.2 Sample preparation followed standard geological protocols to maintain accuracy. The collected core samples were first crushed, then ground in a pulveriser, and finally homogenised with mortar and pestle to achieve a fine powder of -200 mesh size. After each sample, all equipment—including crusher, pulveriser, trays, and tools—was thoroughly cleaned to prevent contamination.

12.1.3 Representative portions were obtained using the coning and quartering method. The powdered sample was heaped, flattened, and divided into four quadrants; two opposite quadrants were retained and the process repeated until the required weight was achieved. About 300 g of homogenised powder was prepared and split into three packets of 100 g each: one for primary analysis, one for check analysis, and one for laboratory reference. Remaining material was stored in sealed, labelled containers under controlled conditions.

12.1.4 These procedures ensured that the samples were representative of the glauconite-bearing zones. Avoidance of altered material preserved geological integrity, systematic splitting maintained archival record, fine grinding ensured uniform particle size, and coning and quartering provided statistical representativity. Triplicate division of samples supported analytical reliability, while strict cleaning and secure packaging eliminated risks of contamination and ensured traceability.

Photo-12.1 Photograph showing sample sample crusher used in sample processing

Photo-12.2: Photograph showing pulveriser used in sample processing

Photo-12.3: Photograph showing coning-qurtering equipment used in sample processing

12.2.0 PRIMARY AND CHECK SAMPLE STUDIES

12.2.1 During the exploration work, a total of 273.00 m of core drilling was carried out targeting the glauconitic zones. A total of 214 nos. of borehole samples, 100 nos. of bedrock samples, and 91 nos. of pit samples were collected and analyzed for eight major oxides, namely K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 (Annexure-IVA, B, C). Further, 41 nos. of external check samples were prepared from borehole samples and analyzed for quality assurance. In addition to 405 nos of samples, 30 nos of primary samples have been analysed for 34 trace elements. The primary samples were analyzed at the Chemical Laboratory, MECL, Nagpur, while the external check samples were analyzed at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. The analytical results of the primary borehole samples and the external check borehole samples are presented in Annexure-IVA, B, C, D and Annexure-IVE, respectively. Analysis report of external check samples is awaited.

12.2.2 A total of 15 glauconite samples were subjected to X-ray diffraction (XRD) analysis at the MECL Laboratory for the identification and confirmation of constituent mineral phases. Analysis of the same is awaited.

MECL

CHAPTER-13

13.0.0 DRILLING TECHNIQUES AND DRILL SAMPLING EMPLOYED

13.1.0 DRILLING TYPES AND DETAILS

13.1.1 During the present investigation, MECL drilled a total of 10 boreholes aggregating to 273 m of core drilling and carried out other associated geological and laboratory analytical works in the study area. The exploration programme was executed to evaluate the lithological characteristics, mineralization pattern, and subsurface continuity of the targeted horizons. Detailed information on the boreholes drilled by MECL, including their locations, depths, coordinates, and drilling particulars, is provided in Annexure-IA. A consolidated summary of the borehole data, highlighting key parameters and drilling outcomes, is presented in Table-10.2.

13.1.2 Core drilling was carried out by two conventional wire line drill rigs viz. RD-100 (MEC-364 and MEC-349) & one hydrostatic drill rig KDR-600 (MEC-395). All the boreholes in the block were drilled in NQ size with single barrel /wire line, wet core drilling method. 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. The polymer was used as drilling fluid to flush out the cuttings and stabilize the borehole wall. The drilling fluid also works as a coolant to avoid burning of drill bits. All the precautions had been taken to maintain quality of drilling and to achieve maximum core recovery. The core recovery varies from minimum 86.60% (MKAW-07) and maximum 96.07% (MKAW-04) with an average core recovery is about 92.79%.

13.1.3 The recovery in the mineralized zone is about 94.27% which is satisfactory. The quality of drilling was ensured during the operation. After closure, all the boreholes have been properly sealed with cement pillars.

13.2.0 EXPLORATORY DRILLING

Owing to the bedded nature of the deposit, the drilling programme was planned with vertical boreholes. Accordingly, 10 boreholes were laid out on approximately 1600 m × 1600 m grid pattern spaced at 800m to 1600 intervals, to evaluate the lateral continuity, depth persistence, and thickness of the mineralized horizons.

Photo-13.1: Photograph showing Drilling Rig No- MEC-395 (KDR-600).

Photo-13.2: Photograph showing Drilling Rig No- - MEC-364 (RD-100).

13.2.1 This drilling pattern was designed to systematically assess the extent and depth of mineralization, establish stratigraphic continuity, and generate subsurface geological data essential for resource evaluation and future exploration planning.

13.2.2 Details of boreholes drilled by MECL in Ambara West Block are given in table no 10.2 in chapter 10.

13.3.0 DEVIATION SURVEY IN DRILLING

13.3.1 All the exploratory boreholes drilled within the block are vertical, with depths ranging from 15.00 m to 30.00 m. Owing to the shallow depth and vertical nature of these boreholes, no deviation was observed during drilling. Accordingly, deviation surveys were not carried out for the boreholes in the block.

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

13.4.1 The drill cores obtained from the Ambara West Block have been logged in detail, covering lithology, grain size, colour, nature and type of mineralisation, as well as structural attributes including foliation, fractures and fracture fillings. The major lithologies intersected in the boreholes comprise shale, ferruginous sandstone, feldspathic sandstone, limestone, and glauconitic sandstone. Detailed run-wise lithologs and summarized lithologs for all 10 boreholes drilled by MECL are presented in Annexure–II.

13.4.2 Core recovery in the glauconitic sandstone zones has been recorded at 94.27%, which is considered satisfactory. The recovery data were systematically documented during drilling and logging, ensuring accurate representation of the subsurface lithologies. Samples were delineated primarily on the basis of glauconitic zones identified visually. In general, the sampling interval was maintained at 1.00 m; however, variations were introduced where lithological changes, mineralisation type, or concentration warranted adjustment to capture representative material. Borehole-wise mineralised zones core recovery summary is mentioned below-

BH. No.	Core Recovery%
MKAW-01	95.92
MKAW-02	87.58
MKAW-03	93.40

BH. No.	Core Recovery%
MKAW-04	96.07
MKAW-05	94.36
MKAW-06	94.00
MKAW-07	86.60
MKAW-08	96.30
MKAW-09	89.77
MKAW-10	93.90
Average	**92.79**

Photo-13.3: Photograph showing recording of core recoveries by geologist of Ambara West Block.

13.4.3 The primary core samples collected from these zones have been subjected to detailed chemical analysis, with results presented in Annexure–IIIA. The analytical programme was designed to ensure reliability and reproducibility, with representative samples assayed to establish the grade and distribution of glauconite mineralisation. The systematic recording of core recoveries, coupled with the assay of primary samples, confirms that both recovery and analytical data have been properly documented and are suitable for resource evaluation.

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

13.5.1 Drilling operations were carried out with due care to maintain optimum core recovery, particularly within mineralised zones. Short drill runs were adopted wherever necessary to minimise core loss and ensure that the recovered material was representative of the in-situ lithology. The overall core recovery in the mineralised glauconitic horizons is about 92.36%, which is considered satisfactory for reliable geological and grade interpretation.

13.5.2 In instances where core recovery was less than complete, the grade of the recovered portion was extrapolated over the non-recovered section, following standard geological practice. This approach ensured that the analytical dataset remained representative of the mineralised interval while accounting for unavoidable gaps in recovery.

Photo-13.4 Photograph showing the recovered cores of Borehole No-MKAW-01 of Ambara West Block

13.5.3 The quality of drilling was closely monitored throughout the programme. Proper drilling techniques, use of suitable drilling fluids, and careful handling of cores were employed to minimise disturbance and maximise recovery. Continuous supervision and adherence to best practices ensured that the samples collected were both representative and suitable for subsequent geological and geochemical evaluation.

13.6.0 BOREHOLE CORE SAMPLING

13.6.1 A total of 214 primary samples were generated from borehole cores obtained during drilling operations carried out by MECL. The samples were demarcated considering both the variation in glauconitic sandstone zones and the associated lithological changes. In general, the sampling interval was maintained at 1.00 m; however, in certain instances, the interval was adjusted between 0.50 m and 1.60 m depending on lithological variation, mineralisation type, and concentration, to ensure representative coverage of the mineralised horizons.

13.6.2 Sample demarcation was carried out during core logging by the geologist, based on visual identification of glauconitic zones and lithological boundaries. Once marked, the cores were split into two equal halves using a core splitter. One half was retained in the core box for permanent record and future reference, while the other half was processed for analysis.

Photo-13.5 Photograph showing the half spitted cores of Borehole No-MKAW-01 of Ambara West Block

13.6.3 The analytical half was first crushed to approximately 100 mesh size, followed by further grinding to fine powder and sieving through -200 mesh to achieve uniform particle size. The powdered material was thoroughly homogenised to eliminate bias. From this homogenised lot, about 100 g of representative sample was obtained by successive coning and quartering and designated as the primary sample for chemical analysis. The remaining portion of the -200-mesh material was securely stored as duplicate reference material for future checks and validation.

13.6.4 This systematic approach ensured that the borehole core samples were representative of the glauconitic mineralised zones, with proper archival record maintained, and reliable analytical samples prepared for geochemical evaluation.

CHAPTER-14

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 Core sampling and analytical work were undertaken across the entire mineralised zones intersected in the boreholes to ensure complete and representative coverage of glauconite-bearing horizons. Each sample was carefully marked on the core during logging, with depth intervals clearly indicated prior to extraction. Special emphasis was placed on glauconitic sandstones and associated shale units, covering both high-grade and marginal mineralised sections to evaluate vertical and lateral grade variations. This approach ensured that all significant lithological variations within the mineralised sequence were represented in the analytical dataset.

14.1.2 The mineralised cores were split into two equal halves using a core splitter (Photo 14.1), thereby maintaining uniform distribution of ore minerals in both portions. One half of the split core was retained in the core box for permanent record and future reference, while the other half was processed for analysis. The analytical half was first crushed and pulverised to (-) 200 mesh size, and a representative ~500 g sample was obtained by the coning and quartering method (Photos 12.2 and 12.3). From this homogenised lot, two 100 g samples were prepared: one was sent to the MECL Chemical Laboratory, Nagpur, for primary chemical analysis, and the other was retained for check analysis. The remaining ~300 g of powdered material was preserved under controlled conditions for future studies.

14.1.3 During the present exploration programme, a total of 405 primary samples and 41 external check samples were prepared for chemical analysis. All primary samples were analysed for major oxides (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3) at the MECL Chemical Laboratory, Nagpur, following standard procedures. In addition, 30 primary samples were analysed for 34 trace elements at the same laboratory. The 41 external check samples were analysed at JNARDDC, Nagpur (NABL-accredited) to validate the analytical results and ensure the accuracy and reliability of the dataset.

Photo-14.1 Photograph showing core splitter used to split borehole cores

14.1.4 The detailed analytical results of the primary samples and the external check samples are presented in Annexure-IVA, B, C, D.

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

14.2.1 The sampling procedure for primary borehole core samples, as detailed in Para 14.1.0, was carried out under strict QA/QC protocols to maintain the quality and integrity of the samples. All equipment used in crushing, sieving, splitting, and homogenisation was thoroughly cleaned before and after processing each sample to eliminate the risk of contamination. In addition, regular maintenance of crushers, pulverisers, and sieves was undertaken to ensure consistent performance and reliability of the preparation process.

14.2.2 Samples were reduced to the required size fraction using standardised crushing and sieving techniques. The homogenised material was further subjected to the coning-and-quartering method to obtain representative splits. This procedure ensured that the prepared samples were statistically representative of the in-situ mineralised zones.

14.2.3 All preparation work was performed by trained and experienced personnel, following established geological protocols. The systematic application of proper technique and procedural discipline ensured that the samples were homogeneous, unbiased, and suitable for chemical analysis. As a result, the prepared samples accurately reflected the mineralised horizons intersected in drilling, thereby enhancing the reliability and reproducibility of the analytical dataset generated for the Ambara West Block.

14.3.0 QUALITY CONTROL PROCEDURES ADOPTED

14.3.1 Primary core samples were collected from the entire mineralised zones intersected in the boreholes and subsequently prepared at the centralised mechanised sampling unit at MECL Nagpur. Standardised sampling protocols were strictly followed to ensure that the samples were representative of the in-situ mineralisation. Each stage of sampling and preparation was carried out under the direct supervision of qualified sampling technicians, thereby maintaining consistency and reliability in the dataset.

14.3.2 External check samples were also prepared at the same facility, following identical procedures and under the same level of supervision. This ensured uniformity in preparation and eliminated procedural bias between primary and check samples. All equipment used for crushing, pulverising, sieving, and homogenisation was regularly cleaned and maintained to prevent contamination and to guarantee reproducibility of results.

14.3.3 The adoption of these QA/QC measures ensured that both primary and external check samples were of high quality, representative of the mineralised horizons, and suitable for chemical analysis. The systematic application of controlled procedures enhanced the reliability of the analytical results and provided confidence in the geochemical dataset generated for the Ambara West Block.

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

14.4.1 Primary samples were systematically marked and prepared from mineralised cores, with intervals carefully selected during detailed core logging to capture lithological and mineralisation variations. Sampling followed the standardised procedure outlined in Para 14.1.0, including core splitting, crushing, pulverising, and homogenisation to (-)200 mesh. Strict QA/QC protocols ensured uniformity and eliminated bias. The combination of accurate core marking and disciplined preparation techniques produced samples that are truly representative of the in-situ mineralised horizons, providing a reliable analytical dataset for resource evaluation.

14.5.0 WHETHER SAMPLE SIZES ARE APPROPRIATE TO THE GRAINSIZE OF THE MATERIAL BEING SAMPLED

14.5.1 For the determination of major oxides (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3) using X-ray fluorescence (XRF) and for the analysis of trace elements by ICP-MS, the samples were pulverized to a particle size of –200 mesh. This level of fine pulverization was adopted to ensure complete homogenization of mineral phases, minimize analytical bias, and achieve high reproducibility and accuracy of the analytical results.

14.5.2 Reduction to (–)200 mesh size is appropriate to the grain size of the glauconitic sandstone and associated lithologies, as it eliminates particle-size related bias and minimises analytical errors. The uniform fine powder facilitates thorough mixing of mineral phases and enhances the precision of XRF measurements.

14.5.3 The prepared powders were homogenised prior to pellet or fused bead preparation, following standard analytical protocols. This ensured that the elemental concentrations obtained were accurate, representative, and consistent with the in-situ mineralised material intersected in drilling.

CHAPTER-15

15.0.0 QUALITY OF ASSAY DATA AND LABORATORY TESTS

15.1.0 THE NATURE, QUALITY AND APPROPRIATENESS OF THE ASSAYING AND LABORATORY PROCEDURES

15.1.1 The Reconnaissance Survey (G-4 Stage) for glauconite in the Ambara West Block (Area: 143.15 sq. km), Tehsil Lakhpat and Nakhatrana, District Kachchh, Gujarat, included comprehensive laboratory analyses based on systematic geochemical sampling. A total of 100 bedrock samples, 91 pit samples, and 214 borehole core samples were collected during the programme. From these, 405 primary samples and 41 external check surface samples were prepared for chemical analysis.

405 nos of samples were analysed for eight major oxides (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3) using wavelength dispersive X-ray fluorescence (WD-XRF) and 30 nos for the analysis of trace elements by ICP-MS. (Annexure-IV A, B, C, D). This technique was selected for its high precision, reproducibility, and suitability for multi-element analysis of glauconitic sandstones and associated lithologies. The fine pulverisation of samples to (–)200 mesh ensured homogeneity and minimised analytical bias due to particle-size variation.

15.1.2 Primary samples were analysed at the MECL Chemical Laboratory, Nagpur, following established internal protocols, while external check samples were analysed at NABL-accredited laboratories to validate results and maintain QA/QC standards. The adoption of WD-XRF, combined with duplicate and external check analyses, ensured that the dataset generated is both reliable and representative of the mineralised horizons. A total of 15 glauconite samples were subjected to X-ray diffraction (XRD) analysis at the MECL Laboratory for the identification and confirmation of constituent mineral phases (Annexure–V).

15.1.3 Detailed descriptions of the analytical methods, including sample preparation, homogenisation, and QA/QC procedures, are provided in the subsequent sections of this report. These measures confirm that the assaying and laboratory procedures adopted during the survey were appropriate to the nature of the material and of sufficient quality to support resource evaluation in the Ambara West Block.

15.2.0 ANALYSIS OF GLAUCONITE BEARING SAMPLES BY XRF

15.2.1 WD XRF (Wavelength Dispersive X-ray Fluorescence)

The glauconite-bearing core samples collected during the exploration programme were analysed using Wavelength Dispersive X-ray Fluorescence (WD-XRF), a non-destructive analytical technique widely employed for the determination of major oxides in geological materials. This method was selected for its ability to provide high precision and accuracy in elemental quantification while preserving the integrity of the original sample.

In the present study, WD-XRF was utilised to determine eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 — which are critical for evaluating the chemical composition and grade of glauconitic sandstones. The analyses were carried out using a RIGAKU ZSX Primus IV XRF instrument, following standard laboratory protocols to ensure reproducibility and reliability of results.

The adoption of WD-XRF ensured that the analytical dataset generated was both accurate and representative of the mineralised horizons intersected in drilling. The precision of this technique, combined with rigorous sample preparation and QA/QC measures, provides confidence in the geochemical results used for resource evaluation in the Ambara West Block.

Photo 15.1 Photograph showing WD-XRF instrument (Rigaku, Japan) at Chemical Lab, MECL, Nagpur

15.2.2 PROCEDURE OF ANALYSIS BY WD XRF

Powdered samples were pelletised using a hydraulic press prior to analysis. The WD-XRF instrument (RIGAKU ZSX Primus IV) was calibrated using matrix-matched Certified Reference Materials (CRMs) to ensure accuracy and precision. After calibration, samples were analysed for eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 with oxide concentrations computed using the ZSX software. Loss on Ignition (LOI) was determined separately by heating the samples at 1000 °C in a muffle furnace and recording the weight loss.

Analytical Procedure:

1. Calibrate the WD-XRF instrument using selected representative samples and CRMs.
2. Verify that the instrument is set up according to standard operating guidelines.
3. Place the prepared pellet securely in the sample holder.
4. Ensure correct positioning of the sample cup within the instrument.
5. Initiate the WD-XRF analysis through the ZSX software.
6. Allow the instrument to scan the sample, during which incident X-rays excite atoms in the sample, causing emission of characteristic fluorescence.
7. Record and tabulate results, including oxide concentrations and relevant analytical parameters.

15.3.0 CHECK ANALYSIS FROM THIRD PARTY NABL ACCREDITED LABORATORY

15.3.1 To ensure the reliability and accuracy of analytical results, third-party check analyses were carried out at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. During the present exploration programme, a total of 41 external check samples derived from the block were submitted for independent analysis.

15.3.2 These external check samples were analysed for eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 — using standard laboratory protocols. The adoption of NABL-accredited facilities for check analysis provided an independent validation of the primary laboratory results, thereby strengthening the QA/QC framework of the exploration programme.

15.3.3 The detailed analytical results of these external check samples are presented in Annexure–IVE confirming that the procedures adopted were appropriate, reliable, and consistent with best practices for geochemical evaluation of glauconite-bearing formations in the Ambara West Block.

15.4.0 SECURITY AND CHAIN OF CONTROL OF SAMPLES SHOULD BE CLEARLY MENTIONED

15.4.1 The security and chain of custody of all samples — from collection in the field to preparation at the sampling unit and subsequent dispatch to the chemical laboratory — were maintained through a systematic and well-organised process. All samples were prepared at the centralised mechanised sampling unit under the direct supervision of qualified sampling technicians, ensuring procedural discipline and accountability at every stage.

15.4.2 Each sample was carefully labelled, tagged, and recorded prior to dispatch. Samples were transported to the chemical laboratory in securely sealed bags, with the integrity of the seals verified at the sampling unit before opening. This procedure ensured that the identity and traceability of each sample were preserved throughout the transfer process.

15.4.3 Strict adherence to standard operating procedures and precautionary measures eliminated the possibility of contamination. The sampling unit functioned independently from the chemical laboratory, thereby preventing any risk of cross-contamination between preparation and analysis. Remaining portions of the samples were properly preserved, securely stored, and clearly labelled for future reference, ensuring a complete and traceable chain of custody under company control.

15.5.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

15.5.1 To ensure the accuracy and reliability of analytical results, NCSDC-16006 Certified Reference Material (CRM) was employed as part of the quality control framework. The CRM was processed under identical conditions as the borehole core samples and analysed after every batch of 20 samples. This procedure provided a consistent benchmark for validating analytical precision and detecting any instrumental or procedural deviations.

15.5.2 In addition to internal QA/QC checks, a total of 41 external check samples sent at the JNARDDC Chemical Laboratory, Nagpur, which is NABL-accredited. Comparative results of primary and external check borehole samples are furnished in Annexure–IVE, providing independent validation of the analytical dataset. External check sample analysis report is awaited from the Lab.

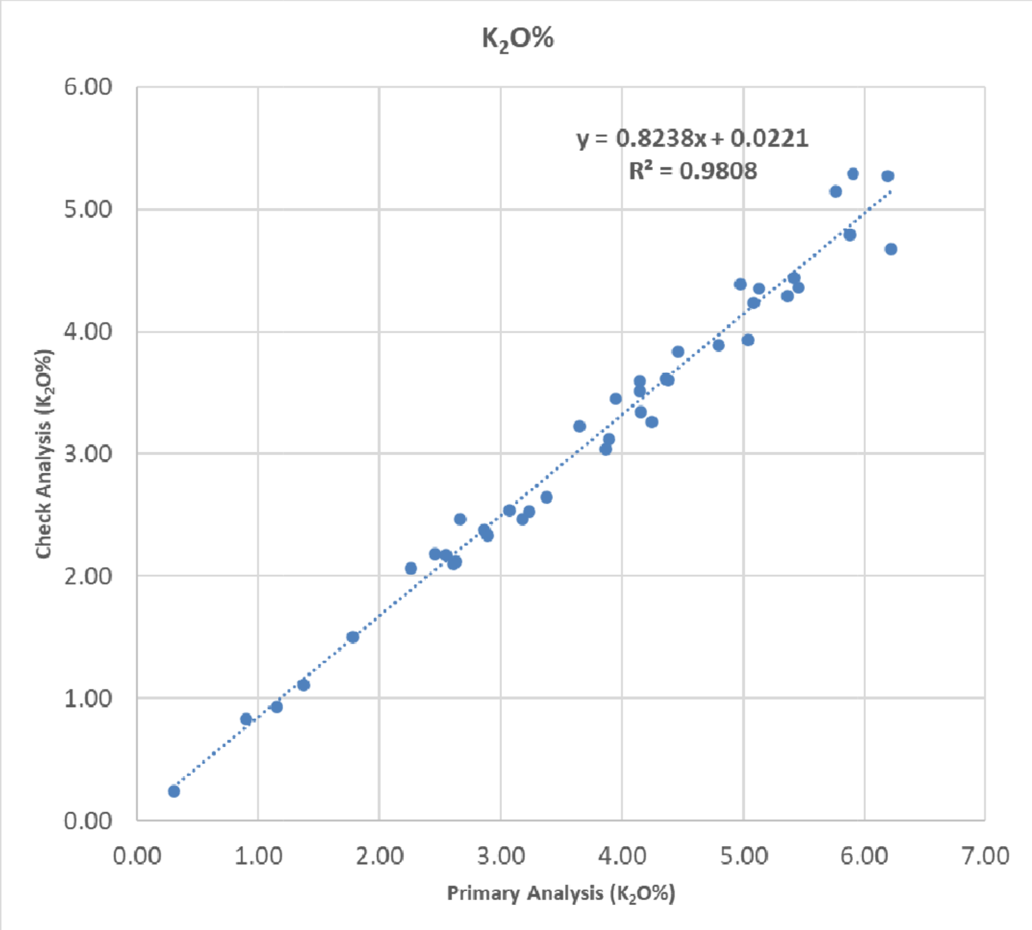
15.5.3 A statistical comparison between the Primary and External Check analytical results for K_2O (%) was carried out using 41 paired samples collected from bedrock, pit, and borehole samples of the Ambara West Block to evaluate the analytical precision, reproducibility, and reliability of the geochemical database. The results of the statistical analysis are presented in Table-15.1.

15.5.4 The Primary analyses yielded a mean K_2O value of 3.8007%, whereas the External Check analyses recorded a comparatively lower mean value of 3.1532%, indicating a positive analytical bias of 0.6475% in the Primary dataset. The high correlation coefficient (r = 0.9903) demonstrates excellent agreement and reproducibility between the two analytical datasets (Table-15.1).

15.5.5 The standard deviation values of 1.5125 and 1.2581 for the Primary and External Check datasets respectively indicate moderate dispersion in K_2O values. The corresponding variances of 2.2876 and 1.5829 suggest slightly higher variability in the Primary analyses. However, the low standard error values confirm that the mean concentrations are statistically reliable and representative.

15.5.6 The mean relative random error of 18.57% indicates moderate analytical variability between paired samples, which may be attributed to sample heterogeneity and analytical uncertainties. The paired t-value of 13.0193 indicates that the difference between the Primary and External Check means is statistically significant, suggesting the presence of a systematic positive bias in the Primary analyses. The F-test value of 1.4452 indicates comparable variance between the two datasets, reflecting similar analytical precision.

15.5.7 Overall, the statistical comparison indicates strong correlation and acceptable reproducibility between the Primary and External Check analyses for K_2O, thereby confirming the reliability of the analytical data generated for the Ambara West Block (Table-15.1).



Text Figure 15.1: Scatter Plot of Primary vs Check (External) sample analysis for K_2O (%)

Table-15.1

Statistical comparison of Primary and External Check sample analysis for K2O (samples)

Comparison Index	**Value**	
	Primary	**Check**
No. of sample pairs	41	
Arithmetic mean	3.8007	3.1532
Standard Deviation	1.5125	1.2581
Standard error of mean	0.2362	0.1965
Variance	2.2876	1.5829
Mean of deviation	0.6475	
Standard Deviation (Error)	0.3185	
Correlation Co-efficient	0.9903	
Mean absolute error	0.6475	
Mean relative random error (%)	18.57	
Paired T-value	13.0193	
F-test value	1.4452	

CHAPTER-16

16.0.0 MOISTURE

16.1.0 All the analysis has been carried out with natural moisture. However, Moisture analysis has not been done at this stage. Hence, no information can be provided.

CHAPTER-17

17.0.0 BULK DENSITY

17.1.0 BULK DENSITY ANALYSIS DETAILS

17.1.1 Bulk density (BD), in conjunction with volume, is a critical parameter for the accurate estimation of mineral resources and reserves. It is governed by both the intrinsic density of the constituent mineral particles and their spatial arrangement within the ore body, including the presence of inter-particulate voids and fractures. Bulk density is defined as the mass of material per unit volume, where the volume encompasses both solid material and associated pore spaces. It is typically expressed in grams per cubic centimeter (g/cm^3) or tonnes per cubic meter (t/m^3) and is an essential input parameter in tonnage calculations for resource evaluation.

17.2.0 BULK DENSITY DETERMINATION PROCEDURE

17.2.1 A total of five representative core samples were selected for bulk density determination to evaluate the physical characteristics of the glauconitic sandstone. The objective of this study was to obtain reliable bulk density values, which constitute a critical input parameter for resource estimation and tonnage calculations. The methodology and procedural steps adopted for bulk density measurement are described below.

17.2.2 **Applicability**: This method shall be applicable in hard litho units, where regular solid cylindrical drill cores are obtained during the course of drilling. The drill core samples to be used for the study should be of NQ or larger diameter.

17.2.3 **Sample Preparation:** Take a full cylindrical drill core sample of minimum ten (10) centimeters - length with both ends trimmed smoothly at right angle to the core axis using a mechanical core cutter to form a regular cylinder.

17.2.4 **Measurement:** Measure the length of the sample, at-least at four locations along its axis by suitably rotating the sample. Measure the diameter of the sample using a calliper scale, at least at four locations, preferably at regular interval. Weigh the air-dried sample in a platform balance.

17.2.5 **Calculation:** Take mean average of all the readings for length and diameter. Divide the average mean value of diameter by two to arrive at the radius of the sample. The volume of a core sample is obtained by using formulae: $V = \pi r^2 h$ (where V = volume, r = radius and h = height or length of the cylindrical core). The bulk density of the sample is determined by using the formula:

B.D=M/V where B. D= bulk density, M= mass (weight) of the sample and V= volume of the sample.

17.2.6 **Number of Samples studied:** A total of five observations is carried out for each sample. The average of these observations results for each sample may be taken as the final bulk density for the purpose of estimation of resources. Bulk density determination results are mentioned below:

Table 17.1

Bulk density study results of glauconite mineralisation for Ambara West Block

Sl. No.	Sample no.	Borehole no.	From (m)	To (m)	Bulk Density (gm/cm^3)
1	MKAW-01BD1	MKAW-01	11.45	11.66	1.82
2	MKAW-03BD1	MKAW-03	22.85	23.00	2.17
3	MKAW-04BD1	MKAW-04	13.10	13.27	1.93
4	MKAW-09BD1	MKAW-09	13.70	13.85	1.93
5	MKAW-10BD1	MKAW-10	21.38	21.55	1.87
				Average Bulk Density	**1.94**

CHAPTER-18

18.0.0 BENEFICIATION STUDIES

18.1.0 Beneficiation studies were not carried out in the current exploration, MECL strongly recommends for beneficiation and other studies to establish its suitability as a fertilizer raw material in the next level of exploration i.e., G-3/2/1.

CHAPTER-19

19.0.0 RESOURCE ESTIMATION TECHNIQUE

19.1.0 GENERAL

19.1.1 MECL carried out Reconnaissance Stage (G-4) exploration for glauconite in the Ambara West Block. The exploration programme comprised systematic geological mapping on a 1:12,500 scale, bedrock sampling, pitting, and exploratory drilling through 10 vertical boreholes at a spacing of approximately 1,600 m × 1,600 m.

19.1.2 Through this integrated surface and sub-surface exploration approach, MECL comprehensively evaluated the exploration block, delineated zones of glauconite mineralisation, and subsequently estimated Reconnaissance Mineral Resources in accordance with the UNFC classification under Category 334.

19.1.3 The cut-off grade of 3% K_2O has been adopted for the present study based on the guidelines and practices followed by the Indian Bureau of Mines for evaluation of glauconite-bearing sandstones. Glauconite is a potassium-bearing mineral, and K_2O content serves as the primary indicator of glauconite concentration in the host rock. Accordingly, a minimum threshold of 3% K_2O is considered suitable at the reconnaissance (G4) stage to delineate glauconite-bearing horizons and to identify zones with potential for further exploration and resource assessment. Few zones demarcated at less than 3% K_2O, based on the logging and confirmation of green pellets in the lithology by megascopic study.

19.1.4 Out of 10 boreholes, 8 boreholes intersected the glauconitic sandstone horizon and have been considered for resource estimation. The remaining two boreholes (MKAW-6 and MKAW-7) did not intersect the glauconitic sandstone; therefore, they are excluded from resource estimation.

19.1.5 The details of the mineralised zones intersected in the Ambara West Block are presented at chapter-10.

19.2.0 PARAMETERD AND ASSUMPTIONS FOR RESOURCE ESTIMATION

19.2.1 The mineral resources of the Ambara West Block have been estimated using the Polygonal method applied, in accordance with accepted exploration and resource estimation practices. While applying these method, certain axiomatic and geological assumptions were inherently considered for determining the grade continuity and overall resource potential of the deposit, as outlined below.

19.2.2 A total of 214 numbers of primary core samples collected from Ambara West Block were analyzed at the in-house chemical laboratory of MECL, Nagpur. To ensure analytical accuracy and reliability of the primary analyses, 10% of the primary samples were sent to a NABL-accredited external laboratory, Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, for check analysis.

19.2.3 The K_2O-bearing zones were delineated based on the results of primary sample analyses. A cut-off grade of 3% K_2O has been adopted for the present study in accordance with the exploration practices followed by the Indian Bureau of Mines for evaluation of glauconite-bearing sandstones. Since glauconite is a potassium-bearing mineral, the K_2O content is the most reliable geochemical indicator of glauconite concentration in the host rock. Further, a minimum true thickness of 1.0 m of the K_2O-bearing zone has been considered for inclusion in the resource calculation under the polygonal methods.

19.2.4 To determine bulk density, a total of five (05) borehole core samples from the K_2O-rich horizon were analyzed. The measured bulk density values are considered representative of the glauconite-bearing mineralised zone in the area. Based on these determinations, an average bulk density of 1.94 g/cm^3 has been adopted for tonnage calculations, thereby improving the reliability and accuracy of the estimated resources.

19.2.5 In order to account for unseen geological factors, such as the possible presence of cavities, caverns, minor structural disturbances, and other geological uncertainties, a uniform deduction of 20% has been applied to the gross in-situ resources estimated by the polygonal method. The resulting values represent the net in-situ resources of the block.

19.3.0 METHODOLOGY ADOPTED FOR POLYGONAL METHOD FOR RESOURCE ESTIMATION

19.3.1 The resource estimation for K_2O-rich glauconite mineralisation in the Ambara West Block was carried out using the Polygonal Method to estimate the resources.

19.3.2 In this method, the mineralised bodies delineated through surface and sub-surface exploration were treated as distinct mineralised zones, within which resource calculations were performed. The polygonal approach ensures systematic allocation of resources based on the spatial distribution of boreholes and the interpreted geological continuity of mineralisation.

19.3.3 The polygonal resource map, presented as Plate–IV, illustrates the area of influence of individual boreholes and their corresponding polygons based on the surface. The entire glauconite-bearing zone intersected in 8 boreholes has been subdivided into 8 numbers of polygons of varying thicknesses (Plate–IV).

19.3.4 The influence area of each borehole was determined by constructing polygons using perpendicular bisectors of lines joining adjacent boreholes, forming triangular and rectangular polygons as dictated by borehole geometry. The area of each polygon was computed using AutoCAD Map 2025 software.

19.3.5 The thickness assigned to each polygon corresponds to the cumulative thickness of glauconite-bearing horizons/bands encountered in the respective borehole within the polygon. The volume of mineralisation for each polygon was obtained by multiplying the polygonal area by the corresponding cumulative thickness of the mineralised zone.

19.3.6 The polygon-wise volumes were subsequently multiplied by the average bulk density adopted for the block to derive the polygon-wise resource tonnage. The summation of all polygon-wise resources represents the total geological gross / net in-situ resource estimated by the Polygonal Method.

Table- 19.1

Boreholes and corresponding Polygonal area and corresponding zone thickness in Ambara West Block

Polygon No	BH No.	Polygon Area (m^2)	Zone Thickness (m)
P1	MKAW-01	2231388	8.20
P2	MKAW-02	1826493	3.90
P3	MKAW-03	2560000	5.00
P4	MKAW-04	2337232	17.50
P5	MKAW-05	2544810	8.50
P6	MKAW-08	2560000	1.00
P7	MKAW-09	2146141	2.00
P8	MKAW-10	2235545	13.00

19.3.7 The calculated volume for each borehole was multiplied by the respective bulk density values to arrive at the resource tonnage. The sum of resources from all boreholes provided the total in-situ geological resource for the Ambara West Block. The formula of resource estimation is as follows:

$$\mathbf{R = P_A} \times \mathbf{Th} \times \mathbf{Average\ bulk\ density}$$

Where, PA = Area of Polygon

R= Resource/ Tonnage

Th= Thickness of Glauconite zone

CHAPTER-20

20.0.0 REPORTING OF RESOURCES

20.1.0 RESOURCE AND GRADE

20.1.1 The resource estimation for K_2O-rich glauconite mineralisation in the Ambara West Block has been carried out considering the bedded nature of the deposit and the level of geological confidence achieved through Reconnaissance Stage (G-4) exploration. Accordingly, the resources have been classified and reported in conformity with the United Nations Framework Classification (UNFC) system.

20.1.2 Resource estimation has been undertaken using the Polygonal Method. All primary samples generated during the present exploration stage were analyzed for eight (08) chemical radicals, and the analytical results were used for delineation of mineralised zones and grade determination. K_2O-bearing zones were delineated based on primary sample analysis, using a 3% K_2O cut-off grade as per standard IBM exploration practices for glauconitic sandstone. Since glauconite is a potassium-bearing mineral, K_2O content serves as the key indicator of its concentration in the host rock.

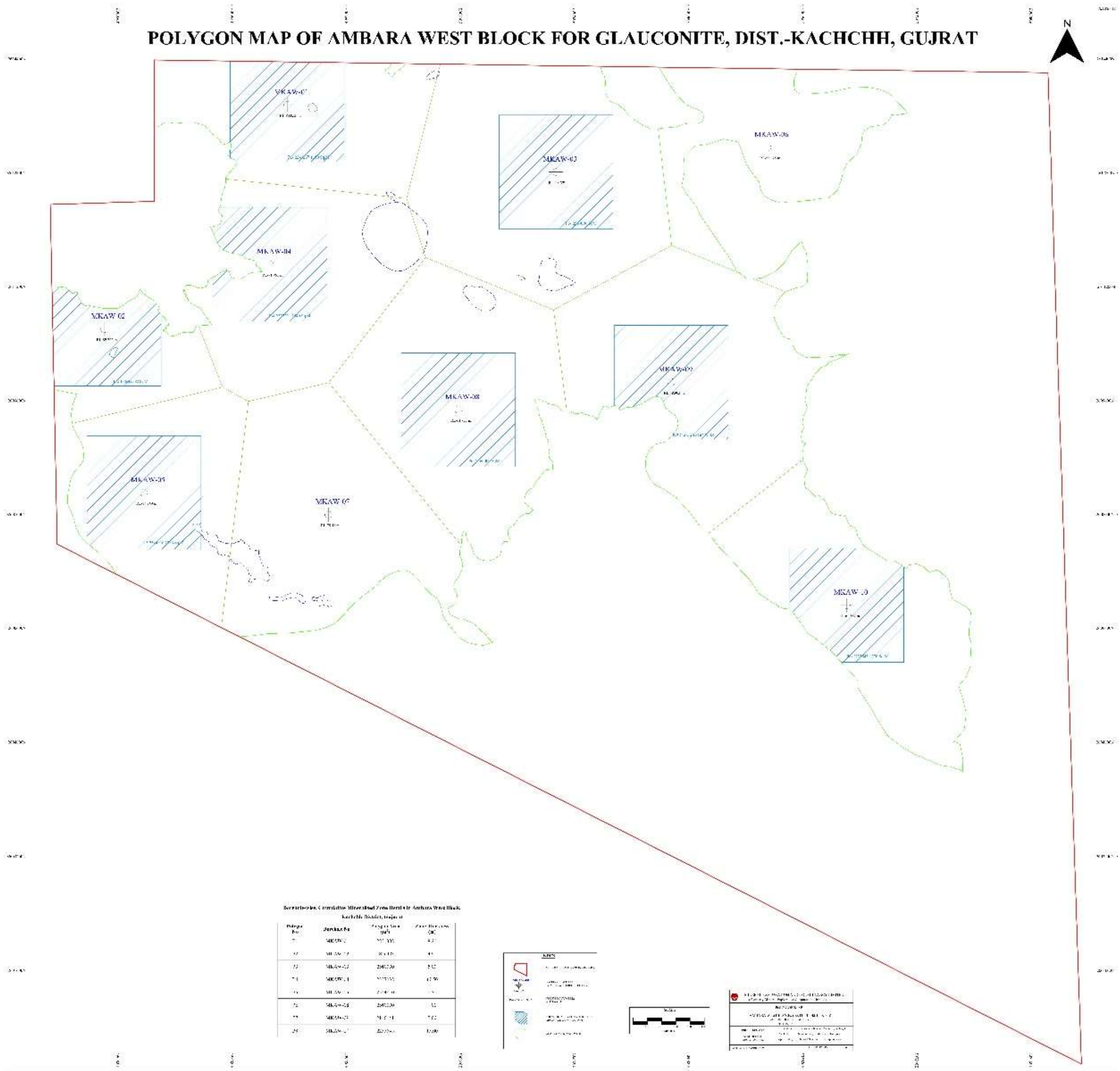
20.1.3 Under the Polygonal Method, resources have been estimated on a borehole-wise and polygon-wise basis. As per standard reporting practice, the gross geological in-situ resources have been reduced by applying a confidence factor of 20%, resulting in net in-situ geological resources. This deduction accounts for the reconnaissance level of exploration, geological uncertainties, possible recovery losses during drilling operations, and unforeseen sub-surface conditions.

20.1.4 Based on the available geological, analytical, and spatial data, the estimated resources fall under UNFC Category 334, corresponding to Reconnaissance Mineral Resources.

20.1.5 Using the Polygonal Method, a total of 212.11 million tonnes of Net in-situ Reconnaissance Mineral Resources (UNFC 334) with an average grade of 4.30 % K_2O has been estimated. The borehole-wise and polygon-wise distribution of these resources at >3.0% K_2O cut-off is presented in Table 20.1, with detailed calculations provided in Annexure-VIII.

Table 20.1
Statement showing polygon-wise and borehole-wise Reconnaissance Resources (334) of glauconitic sandstone (cut-off: 3.0% K_2O), estimated by the polygon method in Ambara West Block, Kachchh District, Gujarat

Sl No.	BH No.	Polygon Area (m^2)	From (m)	To (m)	Zone Thickness (m)	Volume (m^3)	Bulk Density	Gross Geological Resources (tonnes)	Net In-situ Resources (tonnes)	Average Quality							
										K2O %	SiO2 %	MgO %	CaO %	Na2O %	P2O5 %	Al2O3 %	Fe2O3 %
1	MKAW-01	2231388	0.00	2.00	2.00	4462775	1.94	8657784	6926227	3.95	43.58	3.61	3.79	0.48	0.19	20.37	12.79
2		2231388	8.80	12.00	3.20	7140440	1.94	13852454	11081963	5.23	61.52	2.71	0.22	0.17	0.08	17.32	6.33
3		2231388	15.00	18.00	3.00	6694163	1.94	12986676	10389341	4.82	67.62	1.28	0.46	0.17	0.06	15.89	4.64
4	MKAW-02	1826493	0.00	2.00	2.00	3652986	1.94	7086792	5669434	3.50	62.84	0.70	0.86	0.20	0.07	15.68	8.74
5		1826493	11.10	12.00	0.90	1643844	1.94	3189056	2551245	4.25	76.00	0.32	0.15	0.22	0.05	13.60	2.14
6		1826493	13.50	14.50	1.00	1826493	1.94	3543396	2834717	4.80	62.25	0.66	0.28	0.12	0.04	21.01	1.96
7	MKAW-03	2560000	0.00	4.00	4.00	10240000	1.94	19865600	15892480	3.30	78.50	0.98	0.59	0.16	0.04	9.21	3.77
8		2560000	9.00	10.00	1.00	2560000	1.94	4966400	3973120	4.50	61.36	1.62	2.28	0.16	0.07	16.82	5.84
9	MKAW-04	2337232	0.00	2.00	2.00	4674464	1.94	9068459	7254767	3.24	79.36	0.44	0.25	0.18	0.06	9.35	3.40
10		2337232	4.00	13.50	9.50	22203702	1.94	43075181	34460145	5.07	54.94	2.47	0.47	0.25	0.09	18.64	9.89
11		2337232	22.00	23.00	1.00	2337232	1.94	4534230	3627384	3.26	72.69	2.72	0.65	0.12	0.50	10.17	4.43
12		2337232	25.00	30.00	5.00	11686159	1.94	22671148	18136918	4.56	71.74	1.24	0.34	0.16	0.19	13.27	3.73
13	MKAW-05	2544810	0.00	2.00	2.00	5089620	1.94	9873864	7899091	5.07	53.04	2.13	3.20	0.91	0.37	18.28	6.79
14		2544810	5.50	8.00	2.50	6362026	1.94	12342330	9873864	3.87	48.44	3.73	7.65	0.21	0.08	13.69	6.34
15		2544810	25.00	27.00	2.00	5089620	1.94	9873864	7899091	3.13	47.73	3.58	5.32	0.56	0.36	15.29	9.26
16		2544810	28.00	30.00	2.00	5089620	1.94	9873864	7899091	3.38	49.83	3.09	2.69	0.48	0.10	17.70	10.07
17	MKAW-08	2560000	5.30	6.30	1.00	2560000	1.94	4966400	3973120	4.81	55.89	1.07	0.24	0.74	0.09	18.25	10.31
18	MKAW-09	2146141	0.00	2.00	2.00	4292282	1.94	8327026	6661621	4.90	54.76	2.01	3.21	0.84	0.06	16.74	7.21
19	MKAW-10	2235545	0.00	1.00	1.00	2235545	1.94	4336958	3469566	3.37	59.78	0.84	0.69	0.25	0.09	19.54	6.99
20		2235545	13.00	24.00	11.00	24590996	1.94	47706533	38165226	4.18	57.53	2.16	2.24	0.39	0.11	17.22	7.02
21		2235545	27.00	28.00	1.00	2235545	1.94	4336958	3469566	4.75	59.95	2.46	1.09	0.45	0.05	16.61	7.92
Resources in tonnes for glauconitic sandstone								**265134972**	**212107978**	**4.30**	**60.36**	**2.05**	**1.71**	**0.32**	**0.12**	**15.98**	**6.96**
Resources in million tonnes for glauconitic sandstone								**265.13**	**212.11**								



Text Figure.20.1: Polygon Map prepared for Resource calculation of Glauconitic sandstone in Ambara West Block for Glauconite, District- Kachchh, Gujarat

20.2.0 COMPUTATION OF AVERAGE GRADE

20.2.1 All calculations for grade estimation for glauconite 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:

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

Here `V' = Volume of glauconitic body in individual borehole

`G'= Grade of the respective glauconitic body in the corresponding borehole.

20.3.0 CATEGORY OF RESOURCES

20.3.1 The present exploration for glauconite in the Ambara West Block has been carried out at the Reconnaissance stage (G-4) of exploration, wherein exploratory boreholes have been drilled at an approximate strike interval of 1,600 m. The glauconite mineralisation occurs as a bedded deposit, exhibiting lateral continuity consistent with the regional geological framework.

20.3.2 Considering the nature and style of mineralisation, the borehole density, and the exploration parameters achieved in the block are commensurate with the requirements of G-4 level exploration as prescribed under the UNFC system. Further, the exploration inputs and level of geological confidence satisfy the specifications laid down in Part III-I (Evidence of Mineral Content) of the Minerals (Evidence of Mineral Content) Rules, 2015.

20.3.3 Accordingly, based on the available geological, analytical, and spatial data generated during the present phase of exploration, the mineral resources estimated for the Ambara West Block have been classified as Reconnaissance Mineral Resources under UNFC Category 334.

CHAPTER-21

21.0.0 SUMMARY AND RECOMMENDATIONS

21.1.0 OUTCOME OF EXPLORATION WORK

21.1.1 The Ambara West Block, located in the northern part of the Kachchh Basin, hosts bedded glauconite mineralisation within the Katrol Formation of Late Jurassic–Early Cretaceous age, forming part of the Kachchh Supergroup. MECL carried out Reconnaissance Stage (G-4) exploration over an area of 143.15 sq. km, comprising geological mapping on 1:12,500 scale, pitting, bedrock sampling, and 10 numbers of exploratory drilling with boreholes spaced at approximately 1,600 m strike interval.

21.1.2 The Ambara West Block is underlain predominantly by Katrol Formation (Late Jurassic–Early Cretaceous) sediments, which constitute the principal host for glauconite mineralisation. Glauconitic sandstone occurs as stratigraphically controlled and laterally continuous horizons, deposited under shallow-marine to nearshore conditions during marine transgressive phases, indicating favourable geological continuity for resource evaluation. Minor exposures of the Bhuj Formation and limited Deccan Trap volcanics are present but are not associated with mineralisation. The sedimentary succession is gently deformed with gradational contacts and no major structural disruptions, supporting consistent geological interpretation at the block scale.

21.1.3 Structurally, the sedimentary succession in the Ambara West Block is influenced by the regional tectonic framework of the Kachchh Basin. The regional strike of bedding planes is broadly parallel to the Guneri Dome, showing variations from NE–SW, E–W, to NW–SE directions. The rock beds of the block is generally horizontal to gently dipping, with low-angle dips towards the southeast and southwest.

21.1.4 The mineralised horizons have been intersected at shallow to moderate depths within the drilled boreholes. Exploration has established both vertical and lateral continuity of glauconite horizons within the investigated depth range. Considering the stratigraphic continuity of the Katrol Formation, there is a reasonable possibility of continuation of mineralisation beyond the explored depth and strike limits, which warrants further detailed exploration.

21.1.5 The integrated analysis of bedrock, pit, and borehole core samples from Ambara West Block establishes the occurrence of glauconite-bearing sedimentary litho-units with variable grade and spatial continuity. Geochemical data indicate that K_2O values in bedrock samples range from 0.24% to 6.22%, in pit samples from 0.39% to 6.19%, and in borehole core samples from 0.19% to 6.03%. Based on the IBM threshold criterion of ≥3.0% K_2O for delineation of glauconitic horizons, a considerable proportion of samples qualify as glauconite-bearing, with relatively improved consistency observed in borehole core samples, indicating better preservation and continuity of mineralization at depth. Associated SiO_2 values (32.62%–94.54%) confirm the dominantly siliceous nature of the host rocks, while Al_2O_3 (1.89%–27.35%) and Fe_2O_3 (0.58%–37.19%) variations reflect clay mineral association and ferruginisation, particularly in near-surface and pit samples due to weathering effects.

21.1.6 Mineralogical studies (XRD) confirm the presence of glauconite, quartz, feldspar, and clay minerals (kaolinite, illite/sericite) with subordinate carbonates. Trace element analysis indicates enrichment of Ba, Sr, and LREE (La, Ce, Nd) along with accessory minerals such as zircon and monazite, suggesting mixed detrital and authigenic contributions. Petrographic examination of representative samples (AW-235, AW-337, AW-633, AW-972, MKAW-03P1, MKAW-10BD1, MKAW-09BD1) establishes that the litho-units comprise biotite-rich shale, glauconite-bearing arkosic wacke, and shaly sandstone, characterized by very fine to fine-grained quartzo-feldspathic clasts within ferruginous to calcareous matrix. Glauconite occurs as fine subrounded pellets and relict pseudomorphs, commonly altered to limonite, indicating diagenetic modification.

21.1.7 On the basis of the adopted cut-off grade of ≥3.0% K_2O, the analytical results indicate the presence of glauconite mineralized zones, though the grade distribution is heterogeneous and laterally discontinuous at the present level of investigation (G-4 stage). However, based on borehole core analysis and subsurface geological interpretation, Reconnaissance Resources (334 category) of glauconitic sandstone have been estimated within the block. The relatively higher and consistent K_2O values in borehole samples suggest subsurface persistence of mineralized horizons, whereas pit and surface samples reflect variability due to weathering and leaching. The depositional environment is interpreted as shallow marine, followed by post-depositional alteration.

21.2.0 RESOURCES ESTIMATED UNDER VARIOUS CLASSES WITH GRADE

21.2.1 Resource estimation for the Ambara West Block has been carried out using the Polygonal Method with a cut-off grade of >3.0% K_2O. A 20% deduction has been applied to account for geological uncertainties at the reconnaissance stage, giving the net in-situ resources. Based on the level of exploration, the resources are classified as Reconnaissance Mineral Resources (UNFC 334), estimated at 212.11 million tonnes with an average grade of 4.30 % K_2O.

21.3.0 POSSIBILITY OF ECONOMIC EXTRACTION

21.3.1 Glauconite is a potassium-bearing mineral with potential application as an alternative source of potash, particularly for use in slow-release fertilizers and soil-conditioning formulations. The bedded geometry of the mineralisation, its shallow depth of occurrence, and the lateral continuity of glauconitic horizons constitute favourable geological attributes from a mining and resource-development perspective.

21.3.2 The block is supported by existing road connectivity, is situated in a low-population-density area, and, based on reconnaissance-level observations, does not indicate any significant environmental or social constraints. Subject to systematic detailed exploration, beneficiation studies, and techno-economic evaluation, the glauconite deposit demonstrates reasonable potential for future economic extraction, contingent upon prevailing market conditions.

21.4.0 ANTICIPATED HINDRANCES IN ECONOMIC EXTRATION

21.4.1 At the present stage, the key limitation is the reconnaissance level (G-4) of exploration, marked by wide borehole spacing and limited depth penetration, which restricts higher-confidence resource categorisation. Variability in glauconite grade, along with its mineralogical association and intergrowth with feldspar and mica, may pose challenges in beneficiation and effective K_2O recovery. However, no significant statutory, environmental, or social constraints are envisaged at this stage.

21.5.0 SUGGESTED FUTURE PLAN AND STRATEGY FOR FURTHER EXPLORATION AND MINING

21.5.1 The current exploration indicates that glauconite mineralisation in the Ambara West Block is bedded, laterally continuous, and geologically favourable, showing potential for resource upgradation. Based on the available data, Reconnaissance Resources (334 category) of glauconitic sandstone have been estimated; however, the level of exploration remains at an early (G-4) stage and is insufficient for high-confidence resource classification as per UNFC guidelines. Accordingly, it is recommended to undertake closer-spaced drilling, detailed litho-structural mapping, systematic sampling, refined geological modelling, and advanced mineralogical and beneficiation studies (including SEM–EDS and grain-size analysis) to better delineate the continuity, thickness, and economic potential of zones.

CHAPTER-22

22.0.0 PLATES AND MAPS

Plate–I: Location map of Ambara West Block for Glauconite, District Kachchh, Gujarat — Not to scale

Plate–II: Regional geological map showing Ambara West Block for Glauconite, District Kachchh, Gujarat — Not to scale

Plate–III: Interpreted geological map of Ambara West Block for Glauconite, District Kachchh, Gujarat — Scale: 1:15,000*.

Plate–IV: Polygon map prepared for resource calculation of Glauconitic sandstone in Ambara West Block for Glauconite, District Kachchh, Gujarat — Scale: 1:15,000*.

*Geological mapping of the Ambara West Glauconite Block was carried out at a scale of 1:12,500; however, due to paper size constraints, the map has been presented at a scale of 1:15,000 in the report).

CHAPTER-23

23.0.0 ANNEXURE / ENCLOSURES TO THE REPORT

23.1.0 The report includes all the relevant annexure and maps, plans, photographs etc. List of annexures, tables, maps/plans, photographs and Text figure etc are provided before the start of the text part of the Geological Report.

CHAPTER-24

24.0.0 ANY OTHER INFORMATION

24.1.0 ANY OTHER INFORMATION

No Such information is required to be mentioned additionally.

CHAPTER – 25

25.0.0 CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that geological report has been prepared in respect of Reconnaissance Survey (G-4 Stage) for glauconite in the Ambara West Block (Area: 143.15 sq. km), Tehsil Lakhpat and Nakhatrana, District Kachchh, Gujarat. The report was prepared by Mineral Exploration and Consultancy Limited (MECL) on behalf of the National Mineral Exploration and Development Trust (NMEDT). The report adheres to the Minerals (Evidence of Mineral Contents) Rules, 2015, as specified under the Mineral Auction Rules, 2015 and amended up to 2021.

NAME: SHRIKANT SHARMA

DESIGNATION: HOD (EXPLORATION)

DATE: 30-04-2026

MECL

LIST OF PERSONNEL ASSOCIATED WITH RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITE IN THE AMBARA WEST BLOCK (AREA: 143.15 SQ. KM), TEHSIL LAKHPAT AND NAKHATARANA, DISTRICT KACHCHH, GUJARAT

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2	Overall Planning, Co-ordination & Supervision	Shri S.N. Khadse, GM (Exploration)
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4	Project Management	Shri Khushi Ram, Manager (Drilling) Shri Anil Tiwari, Manager (Drilling)
5	Physical Execution of work	
	a) Geology	Shri Rajeev Pandey, Geologist Shri Shibasish Mohanty, Young Professional Geology
	b) DGPS Survey	Shri Punit Khandale, Sr. Technician (S&D)
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		Shri Rohit Sharma, Manager (Chemical Lab)
		Dr. Deepti Rahangdale, Manager (Chemical Lab)
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12	Proposal Formulation	Shri Bhuneshwar Kumar, Manager (Geology)
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MECL

ABBREVIATION

SL. No.	Abbreviation	Full form
1	UNFC	United Nation Framework Classification
2	IBM	Indian Bureau of Mines
3	DGCO	Directorate General Camp Office
4	GSI	Geological Survey of India
5	MECL	Mineral Exploration and Consultancy Limited
6	CPSE	Central Public Sector Enterprises
7	NMET	National Mineral Exploration Trust
8	TCC	Technical cum Cost Committee
9	EC	Executive Committee
10	NABL	National Accreditation Board for Testing and Calibration Laboratories
11	JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design Centre
12	F.S.P.	Field Season Programme
13	MEMC	Minerals (Evidence of Mineral Contents)
14	MMDR	Mines & Minerals (Development and Regulation)
15	NH	National Highway
16	WGS-84	World Geodetic System-84
17	UTM	Universal Transverse Mercator
18	RL	Reduced Level
19	cu m	Cubic Meter
20	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
21	DGPS	Differential Global Positioning System
22	DMS	Degree Minute Second
23	M / m	Meter
24	Sq. km	Square Kilometer
25	M. Sc.	Master of Science
26	M. Sc. Tech	Master of Science Technology
27	mRL	Reduced Level in metre
28	R.F.	Reserve Forest
29	QA/QC	Quality Assessment/ Quality Checks
30	WD-XRF	Wavelength Dispersive X-ray Fluorescence
31	CRM	Certified Reference Material
32	SARM	South African Reference Material
33	SoI	Survey of India