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Unveiling the geochemical and physical traits of clay minerals in Gurha Lignite Mines, Kolayat, Bikaner District, Rajasthan

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Abstract
The Bikaner district is situated in the north western region of Rajasthan, at the heart of the vast Great Indian Thar Desert. It is renowned for its abundant deposits of non-metallic minerals, such as Gypsum, Lignite, Fuller's earth, Clays, Silica Sand, Siliceous Earth, Bentonite, Sandstone, and Limestone, which are highly regarded both within the country and internationally. These mineral resources close to the Bikaner district serve as crucial raw materials for various industries, thereby creating employment opportunities for the local population and contributing to the enhancement of socio-economic conditions in certain areas of the district.

Notably, mining operations, specifically opencast clay, lignite, and fuller's earth mining, are currently active approximately 60 kilometres southwest of the Bikaner district at Gurha area of Kolayat tehsil of Bikaner district. In recent research geochemical characteristics and physical properties of clay deposits found in Lignite mines of Gurha village, Kolayat, Bikaner are studied. Gurha Lignite mines is operated by a company "V.S. Lignite Power Private Limited." Lignite deposits of this area are overlain by another important minerals-Clay. It is a prime responsibility of every mine owner is that to segregate all secondary minerals encountered during the mining of the mineral for which the lease is granted to him. Hence it is important to check the characteristics of the clay found associated with lignite deposits.

Keywords: Clay mining, geochemical characters, physical properties, Gurha, Bikaner, lignite mining

Introduction

Clay minerals play a fundamental role in numerous geological and environmental processes, serving as key indicators of past and present geological conditions. The Gurha Lignite Mines, located in the Bikaner District of Rajasthan, India, host a unique geological setting where clay minerals are prominently featured. These mines offer an exceptional opportunity to investigate the geochemical and physical traits of clay minerals within this specific geological context.

Understanding the clay mineralogy of the Gurha Mines holds significant scientific and practical implications. Such knowledge can provide insights into the depositional history, diagenetic processes, and environmental conditions that have shaped the clay mineral assemblages in this region. Furthermore, given the growing importance of clay minerals in various industrial applications, their characterization can offer valuable information for potential industrial utilization.

Clay, a composite of minerals capable of absorbing water and adopting either a plastic or liquid state, is a rock composed of multiple minerals, whether in solidified or loose form. Throughout the course of human history, clay has stood as one of the earliest mineral materials harnessed by civilizations, finding diverse applications in domestic and artistic contexts. Clay consists of silicate compounds that have undergone natural weathering processes. However, clay can also manifest as silicate minerals profoundly altered by hydrothermal solutions emanating from igneous sources.

The chunks of clay found in this area appear slightly damp in in-situ conditions. This clay undergoes a transformation as it comes into contact with the air, losing its moisture content and becoming crumbly. Clays are characterized by their minuscule particle size of less than 1/16 mm. various colours of clay are reported in this area. Organic impurities impart a range of colours to the clay, including greyish black, grey, greyish white, pale white and creamy white. These colorations are likely attributed to the presence of carbon, iron, and sulphur within the clay composition.

This research paper endeavours to unveil the geochemical and physical characteristics of clay minerals within the Gurha Lignite Mines. By employing a comprehensive approach encompassing mineralogical, chemical, and physical analyses, we aim to shed light on the origin, distribution, and properties of clay minerals in this geologically significant area. Additionally, the insights gained from this research may hold relevance for industrial sectors seeking to harness the potential of clay minerals in various applications.

Study area

Our study area is an area named Gurha in Kolayat tehsil of Bikaner District of Rajasthan. In this area, one of the two active lignite mines of the Bikaner district is present in the territory of Gurha village. This lignite mining lease is run by VS Lignite Power Private Limited and covers a region of approximately 1241.25 hectares. Along with lignite, many other minerals are also found associated in this area. Clay, silica sand, sand stone, carbonaceous shale, are present as overburden.

The study area can be marked on topo-sheet number 45A/13given by the Survey of India. While traveling on the Bikaner - Jaisalmer highway (NH-15) about 60 kilometers from Bikaner, our study area is located on the right side of the highway, about 5 kilometres off the road. The distance between the site and Kolayat town is about 12 kilometres.

The area's local climate is primarily characterized as semi-arid to arid. In the summer season, temperatures typically fluctuate between 40°C to 50°C, while during the winter months; the thermometer can drop below 0°C. The Gurha region confronts the issue of limited rainfall, with an average annual precipitation of merely around 260-270 millimeters.

Geology of the study area

The Gurha area falls within the western section of the significant Palana basin, a substantial portion of which is covered by Aeolian sands. Mineral Exploration and Consultancy Limited (MECL) and the Department of Mines and Geology, Rajasthan, have both conducted a significant amount of drilling in this region. The lithological data collected from these drilling operations provides valuable insights into the subsurface geology of the Gurha area. Table 1 presents the generalized geological sequence for the Gurha block as provided by MECL.

During the drilling activities in this block, lignite associated with carbonaceous horizons is commonly recorded in conjunction with overlying sequences consisting of alternating layers of clays, friable sandstones, and fuller's earth, with thicknesses spanning from 38 to 100 meters. The area exhibits characteristics such as a prominent basinal ridge, variations in the thickness of the lignite seam, and rolling geological structures, without any major structural disruptions.

Table 1: The geological sequence of the Gurha area given by MECL

AGE	FORMATION	LITHO-UNIT
Recent and Sub-recent	Aeolian Sand and Kankar Formation	Aeolian Sand (0-4 m)
		Kankar (2-4 m)
Eocene to Paleocene	Marh Formation	Alternating Sandstone with thin lignite seams (4-7 m)
		Lignite with carbonaceous clays (0-72 m)
		Oolitic Sandstone and Glauconitic clay alternating (15-20 m)
		Sandstone-Ferrugenous (Continuing bottom wise)

Source: VS Lignite Power Private Limited

Methodologies

Analysing the chemical and physical properties of clay samples collected from mines requires a systematic methodology. The following steps were followed to determine these properties. First of all, 10 representative samples were collected from different locations within the mine to ensure a comprehensive analysis. Clean containers were used to prevent contamination of the samples. The collected samples were air-dried to remove moisture, but they were not heated, as this could alter their properties. The dried samples were crushed and ground into a fine powder using a mortar and pestle. X-ray diffraction (XRD) and X-ray fluorescence (XRF) methods were used for the chemical analysis of the collected samples. Various physical parameters like water plasticity, pH, TDS, Drying shrinkage, maturity, MOR, whiteness, etc. of clay samples were also analyzed using different standard methods. The data obtained from the various chemical and physical tests is compiled and analyzed.

Chemical characteristics of clays of Gurha

The results of chemical analysis of 10 collected samples are shown below in table 2. The average of all ten samples is taken for obtaining the average value of SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, Na_2O, K_2O, and LOI.

Table 2: Chemical analysis results of 10 collected clay samples

Sample Number	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	LOI (%)
1	59.96	26.18	1.20	3.10	0.33	0.24	0.27	0.23	8.48
2	58.93	27.11	1.26	2.97	0.34	0.34	0.35	0.33	8.36
3	57.98	28.05	1.18	3.19	0.41	0.20	0.24	0.23	8.51
4	61.11	24.97	1.25	3.09	0.37	0.38	0.42	0.37	8.03
5	63.01	23.79	1.25	3.03	0.36	0.22	0.23	0.24	7.86
6	58.93	27.13	1.11	2.98	0.51	0.26	0.28	0.25	8.54
7	59.95	26.42	1.30	2.94	0.36	0.38	0.35	0.36	7.93
8	57.91	28.01	1.13	3.13	0.36	0.35	0.34	0.35	8.41
9	59.58	26.78	1.12	3.11	0.21	0.22	0.22	0.23	8.52
10	60.12	25.81	1.21	2.97	0.32	0.36	0.37	0.36	8.47
Average	59.75	26.43	1.20	3.05	0.36	0.30	0.31	0.30	8.31

Physical properties of clay samples

The results of physical analysis of 10 collected samples are shown below in table 3. The average of all ten samples is taken for obtaining the average value of Water Plasticity, pH, TDS, Drying Shrinkage at 110^{0}C, Firing Shrinkage at 1180^{0}C, Maturity (W.A.) at 1180^{0}C, Dry MOR, Fired MOR, and Whiteness.

Table 3: Physical analysis results of 10 collected clay samples

Sample Number	Water Plasticity (%)	pH	TDS	Drying Shrinkage at 110^{O}C (%)	Firing Shrinkage at 1180^{O}C (%)	Maturity (W.A.) at 1180^{O}C (%)	Dry MOR Kg/cm^2	Fired MOR Kg/cm^2	Whiteness (%)
1	40	8.0	740	0.87	8.41	8.44	28.82	367.82	50.44
2	42	8.2	772	0.74	7.98	8.93	29.21	382.42	48.19
3	45	7.9	805	1.11	7.86	7.89	30.11	355.49	49.88
4	39	8.0	732	0.89	9.01	7.46	27.79	347.98	49.94
5	50	7.7	724	0.79	9.13	7.98	26.86	337.12	49.84
6	38	7.9	741	0.90	9.19	7.86	32.10	417.82	51.59
7	43	7.8	752	0.85	8.88	9.01	28.99	350.73	50.97
8	41	8.1	811	1.12	8.94	9.13	27.45	374.84	5234
9	51	8.0	746	1.03	7.93	9.19	28.92	390.63	47.47
10	33	7.9	736	0.88	7.98	8.88	29.10	349.06	48.21
Average	42.2	8.0	755.9	0.9	8.5	8.5	28.9	367.4	49.9

Conclusions

The chemical analysis of the clay sample provides important insights into its composition, which can help determine its suitability for various applications. Based on the chemical composition, the clay sample appears to be predominantly composed of silica (SiO_2) and alumina (Al_2O_3). This suggests that it may be a type of clay known as kaolin or kaolinite, which is valued for its use in ceramics, paper manufacturing, and other applications due to its high alumina content and low levels of impurities. The low iron oxide (Fe_2O_3) content (1.20%) is favourable for many applications, as excessive iron can impart undesirable coloration to ceramics and other products. The presence of titanium dioxide (TiO_2) at 3.05% may have implications for certain applications. Titanium can affect the colour and opacity of ceramics, so this clay might be suitable for white or light-coloured ceramics. The low levels of calcium oxide (CaO) and magnesium oxide (MgO) indicate that the clay is not heavily contaminated with these elements, which is generally preferred for ceramics and other applications. The levels of sodium oxide (Na_2O) and potassium oxide (K_2O) are relatively low, which is typically desirable for ceramics and pottery, as high levels of alkali metals can lead to glaze defects. The LOI value of 8.31% suggests that there is a significant amount of organic matter or water trapped within the clay. This indicates that the clay may require processing to remove the volatile components before use in certain applications, such as ceramics or refractories. The high alumina (Al_2O_3) content relative to silica (SiO_2) suggests that this clay sample may be suitable for high-temperature applications, such as refractories and porcelain, where alumina content is important for heat resistance. Based on this chemical analysis, the clay sample appears to have characteristics suitable for ceramics, pottery, and possibly refractory applications. However, further testing and evaluation would be necessary to determine its exact suitability and to address the impact of the LOI on its processing requirements.

The physical analysis indicates that this clay sample has favourable characteristics for ceramic and pottery applications, including good plasticity, appropriate pH, minimal drying shrinkage, and excellent strength both in its dry and fired states. The whiteness level also suggests its suitability for applications where a light colour is desired. However, specific application requirements and further testing may be necessary to determine its suitability for a particular use.

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