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Analysis of the influence of marl raw materials on the properties of portland cement

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Abstract. This study presents a comprehensive analysis of the mineralogical composition of marl samples from the Meshkli mine using modern analytical methods. By employing combined X-ray diffraction and thermogravimetric analysis (TGA), complemented by high-resolution differential scanning calorimetry (DSC), we identified four distinct periods within the TG and DSC curves. Each of these periods is characterized by specific thermal effects, providing critical insights into the presence of hygroscopic water, combustion of organic compounds, oxidation of iron compounds, and thermal decomposition of calcite. Additionally, X-ray analyses reveal a variety of minerals, including calcite, quartz, montmorillonite, kaolinite, and hematite. These findings significantly enhance our understanding of the mineralogical aspects of the Meshkli mine marls. The purpose of this work is to investigate the physicochemical characteristics of Meshkli mine marl, which is novel for the silicate industry, and to assess its suitability for use in cement compositions. Macroscopically, the marl samples from the Meshkli mine exhibit a green color with yellow and brown spots. They consist of dense rock composed of finely dispersed calcite, clay minerals, and siltstone quartz grains. Chemical analysis indicates that Meshkli mine marl has a homogeneous chemical composition.

1 Introduction

Meshkli mine has attracted the attention of researchers and geologists for a long time due to its unique features. The mine is interesting not only for its geological value, but also for the potential uses that can be revealed when its mineralogical chemical composition is studied.

Sedimentary rocks consisting of various combinations of aluminum minerals and calcium (in the form of calcite) are an important component of Meshkli mine marls. Understanding the complex interactions of minerals in marls and their responses to heat is of great importance in geology. In addition, these studies may have a direct impact on marl-dependent industries such as construction, agriculture, ceramics, and portland cement production.

It is known that most marls present themselves as a mixture of clay with dolomite or limestone (with the addition of gypsum). Calcareous marl is one of the main raw materials

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for cement production. There are also clay-like marls, the main part of which is clay or silicates.

The geological condition of the Meshkli deposit makes it a subject of special interest for scientific research. As the research on mineral resources and their exploitation continues, the need for complete exploration of geological formations such as the Meshkli mine is increasing. Therefore, this research is aimed at showing the composition of Meshkli mine marls, focusing on their mineralogical composition and properties [1].

Marls, sedimentary rocks composed mainly of aluminum minerals and calcium carbonate (often in the form of calcite) are of great importance. Marl deposits often have significant variations in mineral composition, with aluminum components often including aluminum minerals such as montmorillonite. The crystal structure of calcite, which is common in marls, can vary. The mineralogical composition of marls is very important for building materials, portland cement and ceramics [2]. Another aspect of marls studied in research is the period of heat exposure and their complex mineralogical composition. Studies have shown that water release and calcite decomposition are common thermal phenomena in marls. In addition, studies have highlighted the importance of considering the role of impurities in marl deposits. Organic compounds often associated with marls can significantly affect their thermal behavior, exothermic reactions associated with their combustion being one of the characteristic features. In addition, iron oxides also greatly contribute to changes in thermal phenomena in marls. The mineralogical composition of marl deposits and their location in different geological conditions have been studied, allowing a deeper understanding of the mechanisms of their formation and the environmental conditions in which they were formed. In addition, these studies have helped us to understand the history of formation of marl deposits.

2 Materials and methods

The search for Meshkli mine marls began with a careful selection of samples from different areas of the mine. The selection of different samples was important to fully cover the study of the mineralogical diversity of the deposit. Each sample collected was subjected to a series of rigorous analyzes using modern advanced techniques [3].

X-ray diffraction analysis, which is the basis of our study, allowed us to identify the mineral phases present in the marl samples. Using X -ray diffraction, we were able to reveal the crystallographic properties of these minerals, including their d -spacing. This method not only revealed the properties of the minerals that make up the marls, but also allowed a deeper understanding of their structural properties.

Thermogravimetric analysis (TGA) and high-resolution differential scanning calorimetric (DSC) methods were used to study the thermal dynamics of marls. These techniques have allowed us to identify and quantify various thermal phenomena and explain the energy changes associated with each of these phenomena [4].

In addition, the results of the chemical analysis provided valuable information about the elemental composition of the marl of the Meshkli mine. The compositional analysis carried out using modern methods showed the following % (percentage) of the main elements:

Table 1. Results of chemical analysis of marl from Meshkli mine.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO_2	Na_2O	K_2O	P.P.P.
34.1	8.75	2.85	23.62	1.51	0.38	0.45	1.42	2.07	24.85

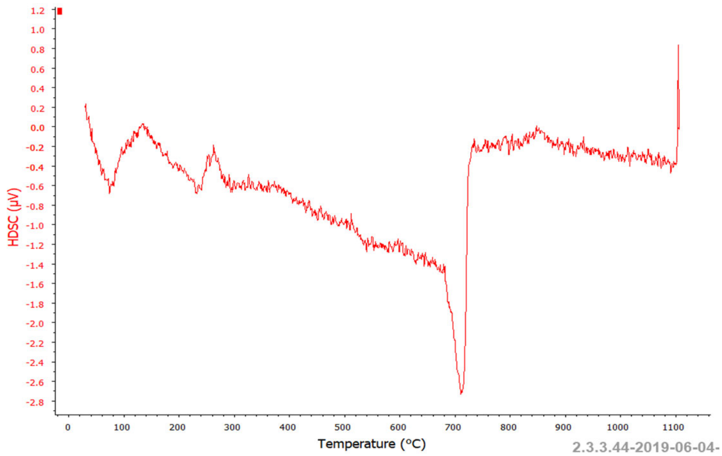

Fig. 1. HDSC curve of Meshkli mine marl.

The mineralogical composition of the marl of the Meshkli mine revealed thermal movements and formed a holistic approach to them.

3 Results

The conclusion of our study showed a series of results that we identified in thermogravimetric (TG) and high-resolution differential scanning calorimeters (DSC) that constitute four distinct periods. Each of these periods is characterized by its own thermal effects.

According to the results of X-ray analysis, the presence of the following minerals was determined: calcite with d=0,384; 0,333; 0,302; 0,248; 0,208; 0,227; 0,191; Quartz with 0,187 nm, d=0,425; 0,245 nm, montmorillonite d=1,319 nm, hydromica minerals d=0,504; 0,497; 0,447; 0,370 nm, as well as mixtures of kaolinite and hematite. Thus, according to the mineralogical composition, the marl samples studied from the Meshkli mine are calcite rock with a mixture of clay minerals and quartz, hematite, etc.

The first period, represented by a weak endothermic effect at about 95°C, indicates the desorption of hygroscopic water from the marl matrix. This phenomenon is common in geological samples and reflects the effect of environmental moisture on the material. Although seemingly commonplace, this serves as an important point in understanding how marls interact with their environment.

The next two periods covering the temperature range of 100-230°C and 240-290°C are characterized by clear exothermic effects. These exo-effects, with maxima at around 140°C and 260°C, are of interest and imply complex chemical processes occurring in the marls. Although further studies are needed to identify the compounds involved, these exo-effects may be related to the combustion of organic contaminants incorporated into the marl matrix. In addition, the oxidation of iron compounds may also play a role in these exothermic reactions. These results reveal promising directions for further study of the origin, distribution and geological significance of these materials in the Meshkli mine marls.

The fourth and final endothermic effect, with a distinct peak at 710°C in the temperature range 670–720°C, indicates thermal decomposition of calcite in the marl matrix. This endo-effect reveals an important aspect of thermal effects properties of Meshkli mine marls. Calcite is an important mineral in this mineralogical composition and is not only an important component of marls. Its decomposition over the observed temperature range reveals a history of metamorphism and thermal alteration that reveals the long and complex geological evolution of the deposit.

In parallel with the thermal analysis, the X-ray diffraction analysis provided reliable insights into the complex mineralogical composition of the Meshkli mine marls. Minerals identified include calcite, quartz, montmorillonite, hydromic minerals, kaolinite and minor amounts of hematite. Each of these minerals plays a role in shaping the geological history of the deposit.

In addition, comprehensive chemical analysis of Meshkli mine marls reveals a variety of elemental compositions, which paves the way for our understanding of the mineralogical composition of marls and their application in various fields.

4 Discussion

The discussion section serves as the interpretive core of this study, which allows us to further explore the mineralogical composition of the Meshkli deposit, thermal effects, and separate mineralogical results and chemical composition.

The first endothermic effect, characterized by hygroscopic water desorption, is a recurring feature of geological samples and reflects the material's response to environmental moisture. This effect highlights the importance of considering external factors that may affect the properties of marls under different geological conditions.

The following two exothermic effects are particularly interesting in the temperature range of 100-230°C and 240-290°C, associated with combustion of organic compounds and oxidation of iron compounds. These processes provide valuable information about the mineralogical composition of the deposit. The presence of organic matter in marls indicates episodes of biological activity or organic deposition in the geological past of the deposit. Understanding the origin and distribution of these compounds can determine the environment in which the deposit formed. Similarly, the oxidation of iron compounds provides information about the redox equilibrium conditions operating during the formation of the deposit. These results show the dynamic processes that formed the Meshkli mine marls [5].

Gives impetus to our understanding of the mineralogical composition of the Meshkli mine marls. Calcite, an important mineral in mineralogical composition, is not only an important component of marls, but also a sign of geological changes. Its decomposition over the observed temperature range reveals a history of metamorphism and thermal alteration that reveals the long and complex geological evolution of the deposit.

The results of the X-ray diffraction analysis confirm the complex nature of the mineralogical composition of the Meshkli mine marls. The amount of calcite, quartz, montmorillonite, hydromic minerals and kaolinite and hematite indicates the structural complexity of the deposit. Each of these minerals contributes to the mineralogical composition, revealing details of the sedimentary alteration processes and environmental conditions that formed the Meshkli mine marls [6].

A comprehensive chemical analysis of Meshkli mine marls revealed a variety of minerals with significant percentages of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, TiO_2, Na_2O, K_2O and P_2O_5 reveals its elemental composition. These elemental data expand our understanding of the mineralogical composition of marls and pave the way for further research on their industrial use.

5 Conclusion

In conclusion, this study Contributed to important insights into mineralogical composition, thermal behavior and elemental composition of Meshkli mine marls. Identification of various thermal effects, from desorption of hygroscopic water to combustion of organic compounds, oxidation of iron compounds and decomposition of calcite, provided a multifaceted understanding of the geological complexity of the deposit.

The variety of minerals found by X-ray diffraction analysis, including calcite, quartz, montmorillonite, hydromic minerals, and amounts of kaolinite and hematite, allow us to understand the mineralogical history and composition of the Meshkli mine marls. It sheds light on the elemental composition of Meshkli mine marls, expands our understanding of their mineralogical composition, and paves the way for research on their application in various fields.

This research has enriched our understanding of Meshkli mine marls, but also laid the groundwork for further research into their application in various fields, including construction, industry, ceramics, ceramics, and portland cement production. We believe that there is interest in industry in scientific research and our research has helped to expand our knowledge about them.

Thus, as a result of complex investigations, according to the mineralogical composition, the Meshkli mine marl is mainly composed of clay minerals and calcite rock, and consists of quartz, hematite and other additives.

As a conclusion from the above, it can be said that there is a possibility to use this Meshkli mine marl as an easy complex aggregate component in the production of portland cement and other cement products.

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