The use of Middle Jurassic mudstones of the Dzhangur Formation as a Possible Raw Material in the Ceramic and Construction Industry

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Abstract: The article provides information about the field studies in the incision that folded with the Dzungur Formation mudstones of the Labino-Malkinskaya zone in the Scythian plate of the Central Ciscaucasia. The accumulation stages and post-sedimentation transformation have been researched. The field data of the petrographic study and the prospects of their possible implementation as raw materials in the construction is presented in this article.

Keywords: Argillite-like clays, Mudstones, Dzhangur Formation, Middle Jurassic age.

1. Introduction
The argillite-like clays and mudstones are considered as a promising raw material for various types of construction ceramics. According to GOST 21216–2014 "Clay raw materials. Test methods" these formations are classified as promising stone-like clayey raw materials. Based on those materials and the construction ceramics, developing technologies is possible in order to produce various types of clinker bricks. However, using argillite-like clays and mudstones has not been accepted widely in the field of ceramics production, most likely, as a result of poor reconnaissance of deposits, insufficient knowledge of chemical and mineralogical composition, and technological properties like raw materials for a variety of construction ceramics and wall materials [1, 2].

2. The Statement of the problem
The authors have undertaken steps in studying and collecting primary materials for further in-depth research in these deposits in terms of lithology, mineralogy, chemical properties, and the possible use of the Dzhangur Formation of Middle Jurassic mudstones as building raw materials in the ceramics and construction industry.

3. Field research
In June 2019, field trips were conducted along the lower and the Middle Jurassic parts of the Bolshoi Zelenchuk river basin in the Karachay-Cherkess Republic. From structural and features terms, this region is a part of the Labino-Malkinskaya zone of the Scythian plate, which was a part of paleotrough in the Early and Middle Jurassic. The lower and middle Jurassic deposits come out here to the surface in a depression bounded by the Peredovoy and Skalistiy ridges. The bottom depth of the sedimentary cover is in a range between 2000 and 4000 m.
The Bajocian marine and early Bathonian sediments that overlie on the Dzhigiat Formation are the most interesting, which are defined in this territory as the Dzhangur formation. The stratotype formation is located on the left bank of Kuban river at Krasnogorskaya station [3, 4]. The Dzhangur Formation stratotype at Krasnogorskaya station is comparatively well studied, but there is a lack in the research of the formation in the Bolshoi Zelenchuk river basin. The articles with a stratigraphic orientation, which are basically dedicated to the older deposits of the Jurassic, have mentioned the finds of late Bajos parkinsonian finds in the clays and mudstones. These finds were developed in the Zelenchuk basin. The formation thickness is estimated to be approximately 700 m. The insufficient knowledge has largely determined the choice of the study area.

The incision is on the right bank of Kyafar river (Figure 1). A series of dark gray to black mudstone outcrops, with interlayers (5-15 cm in thickness) that are scattered in the marl and siderite nodules strata is the longest (700-750 m) series. The apparent capacity of the individual outcrops varies from four to ten meters. The fluvioglacial sand and gravel sediments with a thickness of 0.5-1.5 m represent the size from the water edge to the cover of Quaternary sediments. The incision roof is composed of mountain meadow soils - 0.15 - 0.25 m. The strong turf, young willow, and alder do not allow to search all along the coastline stretches.

Figure 1. Mudstones from the lower part of the Parkinsonia parkinsoni Zone of the Upper Bajocian of Kafar river

Due to the fall of the layers, the total thickness of the studied mudstones is not less than 50 m. Numerous ammonites were collected in these rocks. Mainly represented by nuclei of the genus species (Parkinsonia, Patrulia) [5] (single sample), less often phylo- and lithoceratids, rarely belemnite rostra, and single nuclei of bivalve molluscs [6, 7].

Since 2014, representatives of the Paleontological Institute named by A.A. Borisyak RAS Moscow and JSC Geologorazvedka St. Petersburg have intensively studied the mudstone outcrops for the sake of maintenance of paleofauna [8]. In 2018, the microfauna and palynomorphs characteristic complexes were identified, which made it possible to clarify biostratigraphic subdivisions of the Middle Jurassic interval of the North Caucasus based on foraminifera and dinocysts [9, 10].

Despite the wide distribution in the mudstone formation incision and their complex study in macro- and microfauna, mineralogy and chemical composition of these rocks have poorly been studied. Furthermore, attention has not been devoted to the lithology and the formation history
of the Middle Jurassic deposits, including the accumulation stages and the post-sedimentary transformation. The proposed study is an attempt to fill the lack of information in this field.

We have undertaken steps in studying and collecting primary materials, in order to conduct further deeper research about these deposits, in terms of lithology, mineralogy, chemical properties, and the possible use of Middle Jurassic mudstones as building materials in the ceramic and construction industries.

According to the applied compaction, clayey rocks form the following row: clays - compacted clays (argillite-like clays) - mudstones - shale mudstone - shale.

Figure 2. Rock samples

Only clays and compacted clays in this row possess plasticity and exchange properties. In this case, the samples from the middle Jurassic incision relegate to mudstones (Figure 2). While the formation has been placed in water for the whole three days, it did not get wet and did not acquire plasticity. This is the main difference between mudstone and argillite-like clays, which still become soaked very slowly through mechanical impact, and frequentative moistening and drying.

4. Paleoreconstruction the formation of the Dzhangur suite mudstones

For a better understanding of the materials formation features and technological properties of mudstones, it is required to consider their formation conditions. The mudstone properties formation is closely related to their genesis and existence history and the experienced processes since the time of the primary clay sediment formation until its significant transformation. The primary sediment accumulation and the primary clays occurred under the conditions of a moderate-deep-water facies type and an average depth of about 200 m. These deposits are quite monotonous and lithologically homogeneous. They can be traced over long distances. The total thickness of the Dzhangur Formation, which is up to 700 m positions confirm those positions. The depth of the deposit is primarily indicated by the presence of foraminifera, both littoral and pseudo-abyssal zones [10]. Besides, the presence of phyllo-lithoceratids can be an indirect sign of the moderate-deep-water facies type of deposits [8]. The ammonites of these suborders, which have a powerful thick-walled shell, are lower horizons inhabitants, comparing to ammonites.

During the diagenetic phase, the clays are compacted; in addition, the nodules are formed in them. In this incision, the pyrite and carbonate composition nodules scattered through the entire visible outcrop capacity. During the catagenesis, the clay rocks transform under the impact of elevated temperatures and pressures. These conditions form the mudstones. If the immersion in the underlying rocks continues, then a radical microstructures restructuring and textures already takes place in metagenesis. The rocks become shaly, the porosity sharply decreases to 1%, and the shale mudstones and shall are formed.

In this case, when conducting an express analysis on the spot and a field description of the formation, we received the following data:

- The outcrops of the Upper Bajocian mudstones are dark grey, which is related to the carbonaceous matter admixture.
The sandy-siltstone admixture is composed of quartz, feldspars, rock fragments, muscovite, and chlorite in the light fraction.

The heavy fraction contains pyrite, limonite, siderite, etc.

The average carbonate content of mudstones is from 2.6%.

The express analysis results of the elemental composition of several samples showed the following percentage: Al = 22%, Fe = 13%, K = 5.7%, Mg = 3%, Na = 2%. The rock also contains titanium, manganese, and barium. On the other hand, it has harmful impurities such as sulfur - 0.5%, and the content of sandy-silty impurities in the sample is about 40%. Thus, considering these rocks as silty mudstones might become possible in the future. As a first approximation, we can talk about increasing Al₂O₃ content in the rock. Aluminum oxide allows to expansion of the sintering interval and the melt viscosity in industrial production. That indicator reduce the deformation in future ceramics products during the firing process. A fusibility and a good sintering capacity of the raw material can be assumed, due to the presence of a sufficient amount of potassium and sodium; hence, their oxides. Additionally, the predominance of potassium oxide over sodium in the petrographic composition of this outcrop promotes the extension of the sintering interval. Iron oxides in the mudstone composition affect the final product color, which depends on their percentage in the composition. The color varies from red to cherry red, up to dark purple.

5. Conclusion
The presented preliminary data and specific accurate readings of elemental composition will be received after processing a series of samples, obtained along the incision. Laboratory research will show the possible suitability of formation as a potential raw material in ceramics and wall materials production, considering chemical, mineralogical composition and structural features of the rock.

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