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Mineral Composition of Some Latgale Lake Sediments

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***Abstract*—Our research is focused on sedimentological conditions and postdepositional changes of recent fine grained lake sediments. We used bulk sediment mineralogical composition and grain size distribution as indicators to identify sediment source areas and possible changes during Holocene. We analysed fine grained (clayey) sediments from three Latgale lakes - Zeili, Pauguļi and Plusons, situated in Latgale upland. Lake sediments cover Late Pleistocene glacial deposits – loam and sandy loam. Bulk mineral composition of 6 sediment samples was determined by X-ray diffraction (XRD). Sediments contained typical minerals found in surrounding glacial sediments: rock-forming minerals as quartz, plagioclase, albite, enstatite, dolomite, calcite, and clay minerals - illite, kaolinite. To identify postdepositional changes in lake sediments of Holocene age clay minerals in clay fraction (<2 mkm) should be analysed. Particularly illite, smectite mixed layered minerals - illite/smectite (I/Sm) and chlorite. Additionally, grain size distribution of studied lake sediments was analysed. Accordingly, our studied sediments are clays, silty clays and clayey silts with bimodal particle distribution, except two samples from Zeiļi and Plusons with unimodal distribution.**

Keywords — lacustrine sediments, minerals, clay, XRD, Latgale.

I. Introduction

Recent (Holocene) lake deposits in Latvia are widely studied, but most of research covers organic deposits – sapropel and peat [1], [2]. On the other hand, much research has been done on lacustrine mineral sediments, but mostly glacial lake sediments [3], [4]. Sediment grain size distribution [5], mineral composition and clay minerals alone [6], [7] or combined with other parameters are widely used to reconstruct past climates from marine and lacustrine sedimentary record [1]-[4], [8]-[10]. Better than bulk mineral composition, clay minerals may serve as effective tools to establish the origin of fine-grained terrigenous sediment of seas [11, 12] and lakes [13]. Review of scientific literature revealed that clay minerals, their ratios and variety of mineralogical indices, as crystallinity degree of illite (Kübler index), crystallinity degree of chlorite (Àrkai index), P index (describes mutual relations between neoformed and detrital mineral phases) as well as others may be applied for sedimentological and paleoclimatic reconstructions [6, 7], [15, 16].

The goal of this study is to assess clay mineral composition and grain size distribution of fine grained recent lacustrine sediments as indicators for sedimentological conditions, and postdepositional changes of recent fine grained lake sediments. In this article, we are presenting pilot stage of the study where mineralogical composition, with particular interest in clay minerals, of lake sediments were analysed. Hence, amount of samples was insufficient for further analysis, grain size analysis served mostly for classification purpose.

II. Materialas and methods

We analysed lacustrine sediments from 3 Latgale (historical and cultural region in eastern part of Latvia) lakes - Zeili, Pauguļi and Plusons (see Fig. 1). Studied lakes are situated in marginal zone of Latgale upland which is an insular accumulative-glaciostructural upland. Zeili and Pauguļi lakes are situated in morainic hummocky area, in the north of Latgale upland. Plusons on the other hand is situated in area dominated by kames and eskers formed of glaciofluvial and glaciolimnic sediments. According to database of Latvian lakes [17] studied lakes are shallow, with mean water depths from 1.1 to 2.5 metres. Area of water surface of Zeili and Pauguli is 44.8 ha and 22.0 ha accordingly but Plusons – 480 ha [17]. Lake beds are formed in Weichselian age glacigenic and glaciofluvial sediments and filled with mainly fine grained sediments. Clays and silty clays in Zeili and Pauguli and fine sand, silt and clayey silt in Plusons. In all studied lakes inorganic sediments are covered by organic mud and sapropel up to 4 metres thick (in Zeili).

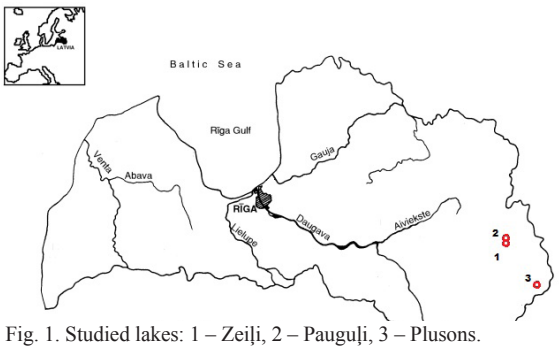

Fig. 1. Studied lakes: 1 – Zeiļi, 2 – Pauguļi, 3 – Plusons.

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In total 6 samples of fine grained lacustrine sediments were analysed. Zeiļi represents four samples from two boreholes at various depths (6 to 8 m) and two from lakes Pauguļi (3.5 m) and Plusons (8.0 m) accordingly. Sampling was carried out in winter with help of geological hand auger (the "Eijkelkamp" type). Clay samples were placed into sterile plastic zip lock bags and stored refrigerated. Grain-size and mineralogical composition within the clay samples is analysed in Riga Technical University Institute of Silicate Materials, Faculty of Materials Science and Applied Chemistry.

X-ray diffraction (XRD) analyses [18] of samples were run by *Rigaku – Ultima +* diffractometer with Cu tube at 40 kV and 5 mA in spinning mode. The analyses range was from 5º to 60º 2θ and scanning speed 1º /min. Data processing was carried out by MDI Jade 9 software and identification of minerals using ICDD data base (PDF-4 Organics2017) [19].

Grain size analyses were run by Broohkaven Instruments particle size analyser based on the principles of Dynamic Light Scattering (DLS). Instrument allows to detect particles in range from 1.5 nm to 3 mkm.

III. Results and discusion

Mineralogical (XRD) analyses of some Latgale lakes fine grained sediments shows that their mineralogical composition is similar. Mineral composition of quaternary clay (fraction <2 µm) in Latvia is quite uniform, most abundant clay mineral is illite (75-80%) followed by kaolinite (until 20%) and chlorite (5-10%) [20].

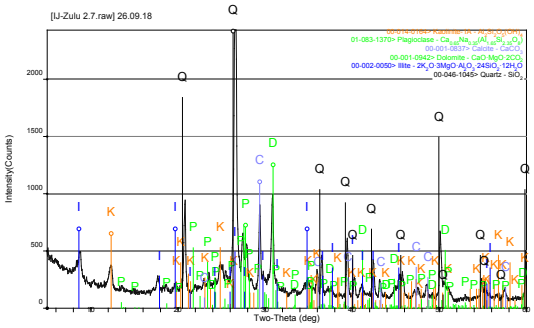

Fig. 2. X-ray difraction pattern of clayey sample from lake Zeiļi, sampling depth 7 m. Minerals: Q – quartz, P – plagioclase, C – calcite, D – dolomite, I – illite, K – kaolinite.

Studied lake sediment mineral assemblages consist of rock forming minerals as quartz, plagioclase, albite, enstatite, dolomite, calcite, and clay minerals – illite and kaolinite (Fig. 1 - 3). In lake Zeiļi we analysed mineralogical composition from two cores - 6 to 8 m and 1 sample from 8 m. Depth wise bulk mineral composition does not change – quartz, feldspars, illite and kaolinite. But if analysed low angle (2Θ <20º) area of diffractograms, particulary illite peak at 2Θ = ~7º (Fig. 1 and Fig. 2) there are some features in XRD spectra indicating changes in illite. Our hypothesis is that there is a mixed layer of illite/smectite as well as illite with various degree crystallinity. To confirm our hypothesis more detailed sampling and analysis of mentioned features as well as quantitative analysis of clay minerals is needed.

Mineralogical composition of fine grained sediments of lakes Pauguļi and Zeiļi is similar (Fig. 1 and Fig. 2). Similarly to case of Zeiļi, sediments of Pauguļi hypothetically may contain illite with various degree of crystallinity and admixture of interlayer illite/smectite (I/Sm).

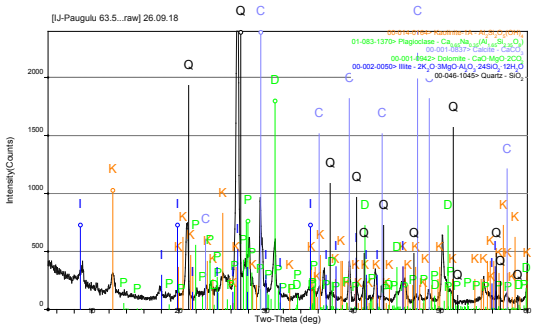

Fig. 3. X-ray difraction pattern of clayey sample from lake Pauguļi, sampling depth 3.5 m. Minerals: Q – quartz, P – plagioclase, C – calcite, D – dolomite, I – illite, K – kaolinite.

In contrast, fine grained sample from Plusons contained no clay minerals, but it contains calcite, dolomite, quartz, albite and pyroxene mineral – enstatite (Fig. 3). Pyroxenes are one of first silicate minerals to be dissolved and that why are rear in sediments [21]. Lack of clay minerals might reflect grain size distribution of sample. According to grain size analysis, Plusons is the coarsest of all samples and still consists of very fine silt particles. Hence there is only one sample from Plusons it is not possible to draw any more conclusions.

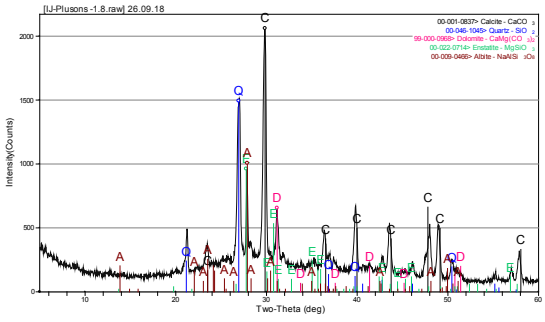

Fig. 4. X-ray difraction pattern of clayey sample from lake Plusons, sampling depth 8 m. Minerals: Q – quartz, A – albite, E – enstatite, C – calcite, D – dolomite.

Grain size distribution of studied lake sediments allow to classify them as clays, silty clays and clayey silts. Most of analysed sediments are characterized by bimodal particle distribution except two samples from Zeiļi and Plusons accordingly by unimodal distribution. Hence we have only 6 samples, no further analysis is reasonable. Scientific literature review indicates that there is still uncertainty in explaining genesis of lake sediment grain size components due to complexity of their bi- and polymodal distributions [22, 23].

IV. Conclusions

Our study let us to draw some conclusions and envision further development of the study. The bulk

mineral composition of studied lake sediments reflects mineral composition of typical Quaternary glacial sediments of Latvia. Mineral assemblage of studied sediments is overall similar, except of Plusons because of lack of clay minerals. We detected some features in XRD spectra indicating changes in illite. We advanced a hypothesis that there is a mixed layer of illite/smectite as well as illite with various degree crystallinity. To confirm our hypothesis more detailed sampling and analysis of mentioned features as well as quantitative analysis of clay minerals is needed. According to grain size distribution, studied lake sediments are clays, silty clays and clayey silts. Analysed sediments are characterized by bimodal and unimodal particle distribution.

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