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TWO-STOREYED FROST-WEDGES IN THE VICINITY OF YAROSLAVL, U.S.S.R.

Abstract

Structures of thermal contraction occurred in the Norsk Quarry near Yaroslavl on the right bank of the Volga are discussed. An evident two-storeyed pattern of wedge structures is connected to vigorous activity of freeze- and thaw processes in the active zone of permafrost.

The outcrop at Norsk (Norsk Quarries) is situated to the North of Yaroslavl on the right bank of the Volga. It lies in the lowland of the upper Volga, the surface of which seldom exceeds 130 m above sea level. Its relief is of glacial origin. There are flat surfaces and morainic hills reaching up to 160—170 m above sea level (BRESLAV, 1975). The older subsoil is built of Cambrian to the Cretaceous formations and fills Central Russian syneclise, the axis of which runs along to the line of Moscow—Yaroslavl. These sediments occur almost horizontally and determine, to some extent, the low relief of the region; they are covered by Quaternary deposits and outcrop to the surface only in some places, in undercuts of valleys of larger rivers. Tertiary deposits have not been observed (NOVSKIJ, 1975).

After NOVSKIJ (1975) the thickness of Quaternary deposits is about 25 m in Yaroslavl surroundings. Morainic deposits of three glaciations are separated by sandy-clayey sediments containing peat interlayers. He distinguishes some formations within the Quaternary series. He suggests that the moraine of the Oka (Cracovian) glaciation, represented by boulder clay of ca. 20 m thickness is considered to be the oldest. It is separated from the moraine of the Dneper glaciation (the maximum stage of the Central-Polish glaciation) by a five meters series of intermorainic clays containing humus and peat. Dark-brown clay of Dneper glaciation is overlain by interglacial sandy-clayey and sandy deposits. Three levels of boulder clay enter into the moraine complex of the Moscow glaciation (the Warta stage). They are generally up to 20 m thick.

According to MOSKVITIN (1967) the limit of the Valdai (Baltic) glaciation runs from Furmanov towards Kostroma and further to Galin. The clay overlying the Kalinin moraine (the oldest stage of the Baltic glaciation) in the vicinity of Rostov, Rybinsk and Yaroslavl, is considered as the Mologo-Shekninsk Interglacial in age, corresponding to the Masurian Interglacial (fig. 1).

Another group of investigators (MARKOV, 1939; GRIČUK, 1965) think that the Valdai glaciation limit has run more to the west, i.e. along Vyžhnyi Voloček (fig. 1). They think that the moraine lying under a series of lake-muddy formations are

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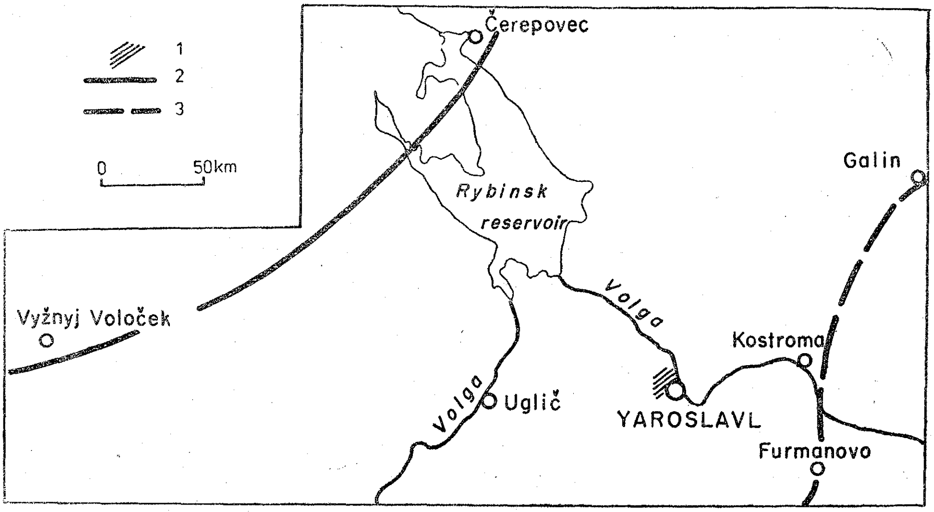


Fig. 1. Location of the study area

1. the Norsk quarries; 2. extent of the Valdai glaciation (after A. I. Moskvitin); 3. extent of the Valdai (Baltic) glaciation (after K. K. Markov and B. P. Gričuk)

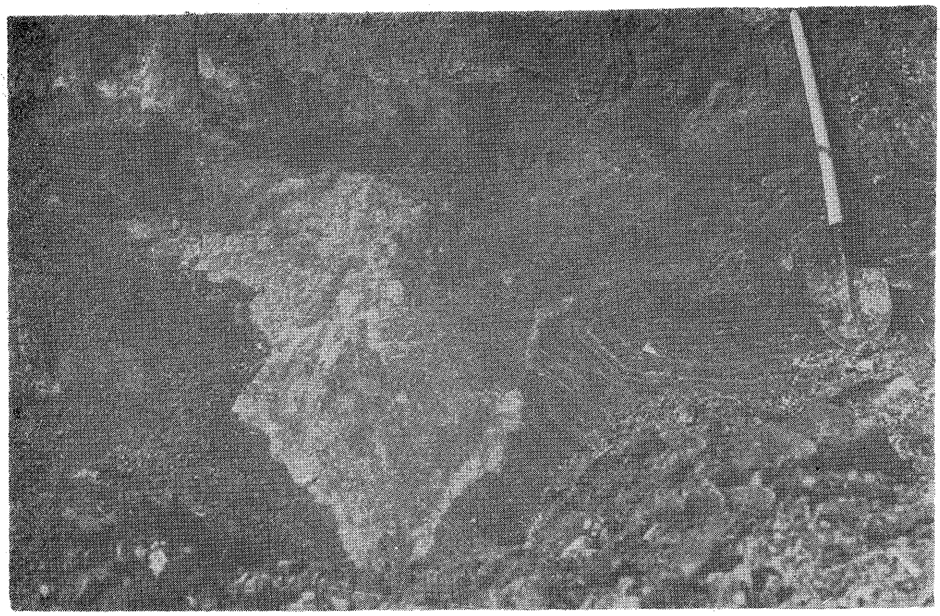
of Moscow glaciation age. To MARKOV (1939) mind the examined area has occurred on the Valdai glacier foreland, thus, Moscow glaciation moraine occurs on the surface. BERDNIKOV (1976) also agrees with the above mentioned investigators; based on the most recent data from palynologic analyses and C^{14} he considers this moraine to be of Moscow age.

The outcrop in the brick-yard No 1 in Norsk is situated in the III Volga terrace. The terrace is built of varved clays connected to the Moscow glaciation, which occur generally in Yaroslavl region; their thickness reaches to 8 m in places. They possess laminae, characteristic of deposits of this type, alternating light and dark. The laminae consist of very fine particles of a different thickness: clayey and sandy-clayey ones, light-beige and beige.

The formation of permafrost and the development of thermal contraction structures, perfectly shaped in Yaroslavl region, is connected to the period of Moscow glacier invasion and to a subsequent climatic cooling. These structures have been qualified by Soviet investigators (BERDNIKOV, 1976; NOVSKIJ, 1975; and others) to categories of pseudomorphoses after ice-wedges.

The above mentioned structures possess such features which allow them to be classified as wedges with secondary in-filling. They form polygons in the plane, but they have an evident wedge-shaped form in the cross-section. A flexion of clay layers on the contact with wedges is also observed (pl. 2, 3). The distance between particular fissures amounts to 14—25 m. These structures are characterized by much bigger dimensions compared with their Polish equivalents; their width is of from 2 to 5 m and their depth exceeds 4 m (pl. 1, 2). NOVSKIJ (1975) observed fissures developed in varved clays even 5—6 m deep.

These fissures are filled with structureless clayey sands, beige-grey in colour, just as in Poland. In some cases small quantities of humus enter into the composition of the filler.



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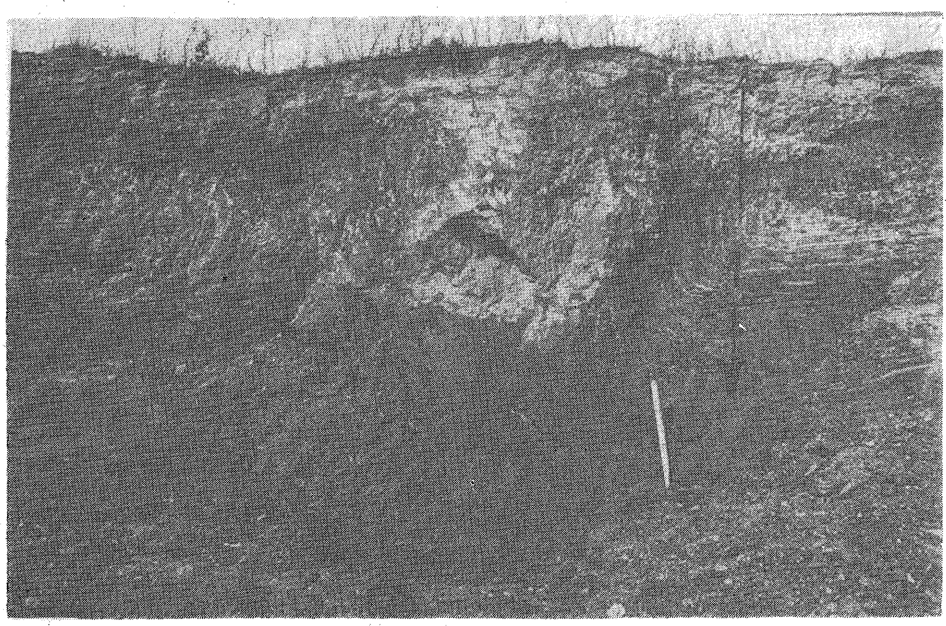
Pl. 1. Norsk. Two-storeyed thermal contraction structure in clayey material (suglinok)



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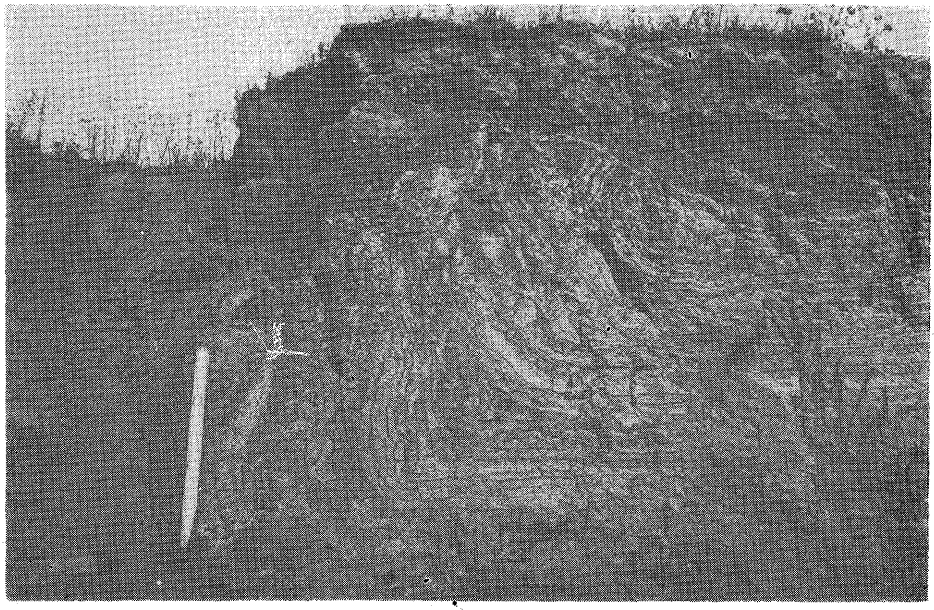
Pl. 2. Norsk. Fissure structure in varved clays

1. extent of active layer of permafrost (an evident widening of the structure); 2. intensive deformations of deposits at the contact with the wedge



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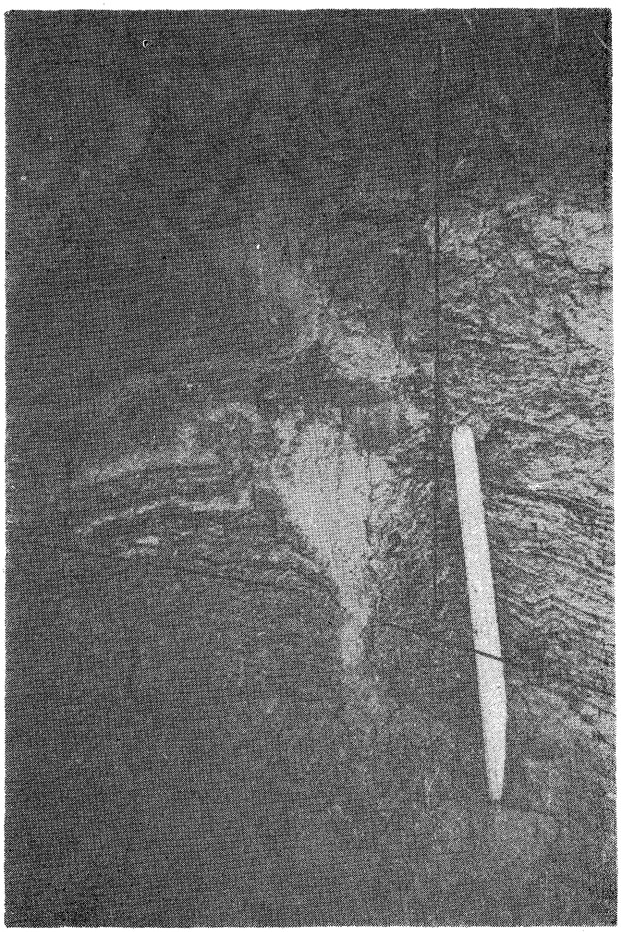
Pl. 3. Norsk. Evident deformation of layers at the contact with the wedge



Pl. 4. Fissure structure develcp ed in varved clays

1. extent of active layer of permafrost; 2. disturbances of layers at the boundary between varved clays and fissure structure

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The two-storeyed construction of the fissures is their characteristic feature (pl. 1, 2, 4). To the depth of 1 m to 2 m from the surface there occurs a field above which the fissures undergo a considerable widening forming in their upper part, approximating the shape of a funnel (pl. 1, 2). A similar dichotomy of fissures is observed in many structures in Poland, though the proportions of particular elements are different. The structures in Poland are much more narrow at their top (maximum 1 m) and their widening is already observed at a depth of 0.5 m to 0.8 m.

The dichotomy of structures drew Popov's (1959) attention some time ago. However this phenomenon has not been elaborated in more detail until now. He stated that only the wedge-shaped part of the structure proves that it developed under permanent permafrost conditions; the existence of only one storey demonstrates the development of a structure without the participation of permafrost. It seems to be likely that the zone, in which the widening of a structure takes place, corresponds approximately to the lower limit of the active zone of permafrost.

In the outcrops at Norsk, straight kettle-like forms are not observed. Such forms according to Popov (1959) should develop only in the active zone, without the presence of permafrost. This can occasionally be observed in Poland. The occurrence of such structures was found in the vicinities of Bełchatów and Kurnos, and is understandable, considering the increasing intensity of all the frost processes together with the increase of the climatic continentality.

An interesting phenomenon is observed at the contact of varved clays and fissures; the boundary between a fissure and a deposit in which it appears, is very irregular and rugged (pl. 2, 3, 4). The clays underwent a very violent deformation in this place, probably because of thawing and freezing. The deformations are most intensively developed where the structure is widest i.e. in the active zone (pl. 2, 4). This phenomenon does not occur in deposits of another type in which thermal contraction fissures are met. Similar deformations are also visible in Poland, but weakly developed. They do not occur in structures developed in boulder clay, instead they are often seen in sandy and sandy-silty deposits (Aleksandrów near Łódź, Łódź-Widzew, and others).

A high water content and a plasticity of material were favourable to the development of intensive deformations in the active zone. It is necessary to emphasize once more that the observed disturbances are clearly the greatest within the reach of widening of wedges, i.e. to a depth corresponding with the extent of ground freeze—thaw processes, and highly repetitive. It is unlikely that such intensive deformation is the result of processes acting during a short time interval.

One could suppose that the process of forming small, fine fissures of thermal contraction, sometimes occurring only in the active zone, is able to cause increasing deformations in the contact zone between structures and deposits. Elementary fissures, sometimes observed in the active zone and deformed afterwards as a result of subsidence of ground before its absolute freezing, can prove such a conception (pl. 2, 5).

Translation by F. Pietrzykowa

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