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THE TYPICAL FEATURES OF CRYOGENIC ELUVIUM ON SLOPES

In permafrost areas, deposits which were never displaced are very common; such deposits underwent however comminution and deformation *in situ,* in some places even complete intermixtures as a result of water freezing within them. Such grounds are called cryogenic eluvium.

Cryogenic eluvium is rarely derived from weathering-resistant rocks. Liable to frost-caused alterations are chiefly marls, aleurites, tuffs and limestones, on account of their capacity to retain water.

Investigations of a large number of trenches dug in connection with the search for diamonds in Western Yakutia have shown that one and the same rocks may disintegrate to various degrees. Also the thickness, the content of ice and the structure of the frost-weathered waste derived from these rocks depend on the nature of the process of freeze and thaw. The present writer has distinguished three varieties of cryogenic eluvium (K a t a s o n ov, 1961) [1].

(1) S u r f i c i a l c r y o g e n i c e l u v i u m is derived from such parent rocks which once constituted a seasonally active layer. The component sediments of that layer, before they reached a lasting frozen condition, were repeatedly subjected to alternate freeze and thaw and thereby to intense disintegration. Surficial cryogenic eluvium consists, therefore, predominantly of rock debris, including silts and dusty sands, which did not undergo any chemical alterations under low-temperature conditions and have therefore retained their original color. Surficial eluvium is characterised by

[1] E. M. K a t a s o n o v — Investigations of the composition and structure of permafrost. In: Polevye geokriologicheskie (merzlotnye) issledovaniya. Metodicheskoe rukovodstvo. Izdat. Akad. Nauk SSSR, Moskva, 1961 (in Russian).

a large content of ice. Ice forms irregular lenses 5—6 cm in thickness, which by merging into each other, give rise to large reticulate and basal cryogenic structures. Ice amounts often to as much as 70—80% of the entire rock volume (pl. 1).

(2) Deep cryogenic eluvium is formed by parent rocks which were reshaped by frost action operating at a certain depth. This variety of eluvium comes usually into existence at the cost of already partly weathered horizons. The cryogenic alteration of rocks is in that case due to the fact that the fissures, widened by the ice forming within them tend to crush the softened and weathered rocks. Compact dolomites and limestones interbedded with flints are broken up into separate plates which, moved from their primary (horizontal) position, are pushed upwards or aside to a distance ca. 1.5 m. Planes of sliding are sometimes encountered, over which the route followed by the particular rock fragments can be easily traced and which thus facilitate an estimate of the movement. The ice content in such rocks may vary in volume and form of occurrence. Most common are ice-coatings, which either completely or partly cover the surface of a rock fragment. Deep eluvium derived of homogeneous rocks (diabases, kimberlite) consists predominantly of small rock fragments, displaced up- or sidewards by the developing ice-nests, some 15—20 cm in size (pl. 2). Ice veins in deep eluvium attain up to 3.5 m in length and 1.2 m in width (pl. 3).

(3) Cryogenic bottom eluvium consists of rocks freezing up beneath the bottom of water basins or streams. Being saturated with water, such deposits were subjected — in the course of up-freezing — to alterations as a result of cryogenic processes. A characteristic feature of such formations is their irregular, crumbled structure. Marls, aleurites, argilites, diabases etc. are not entirely converted to gravelly-sandy-clayey material. Separate blocks, lumps and fragments of these rocks are preserved in a semi non-disintegrated condition, in the form of more or less compact fragments of various size. The top part of bottom eluvium often contains pebbles. The geologic conditions under which the parent rocks underwent frost weathering (the long-lasting existence of „talik" i.e. of a non-frozen lense, followed by slow and interrupted upfreezing, proceeding from all sides and from below) facilitated the formation of various cryogenic structures, similar to those in water-laid sediments. Typical of bottom eluvium are obliquely

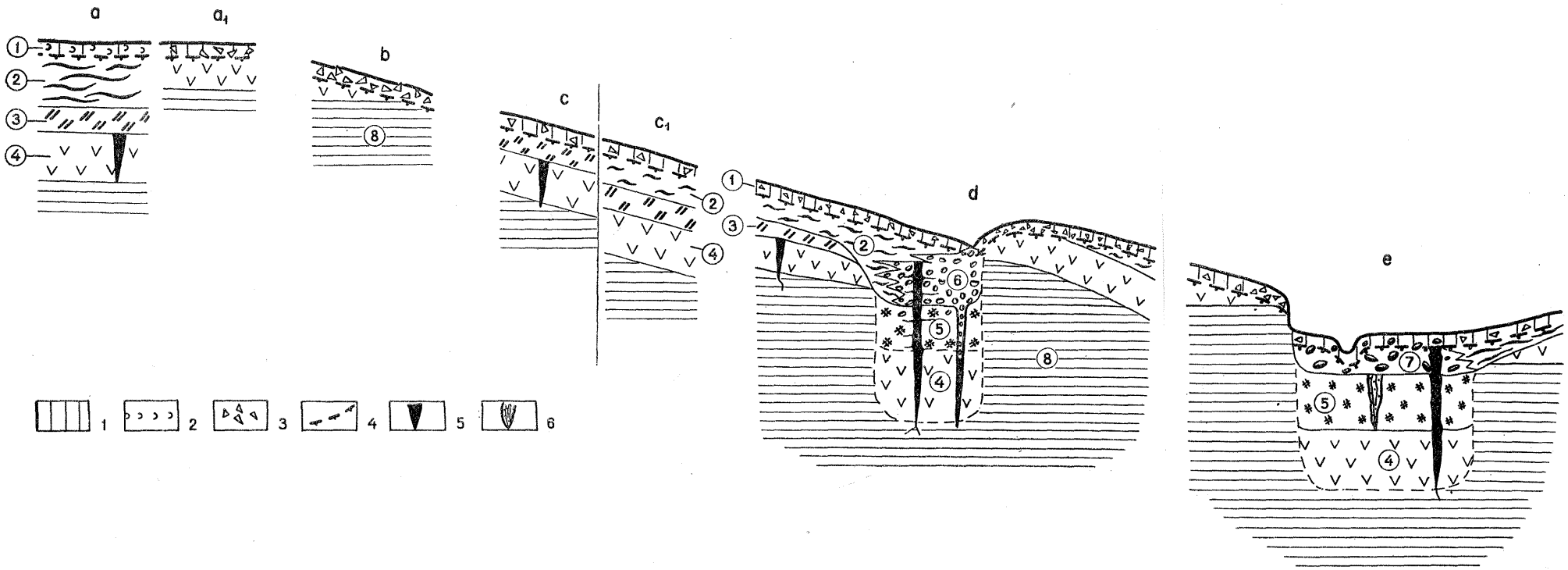

Fig. 1. Cryogenic eluvium overlying various elements of denuded surfaces (schematic profile)

The encircled figures mark: 1. the seasonally thawing layer; 2. perennially frozen slope deposits; 3. surficial cryogenic eluvium; 4. deep cryogenic eluvium; 5. bottom cryogenic eluvium; 6. stream-bed alluvium; 7. alluvium; 8. bedrock, comparatively resistant to weathering

Explanation of signatures: 1. semi-disintegrated rocks of the seasonally thawed layer; 2. peat; 3. gravels and debris; 4. limit of the active layer; 5. ice-veins; 6. ground veins

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oriented rock fragments and ice-lenses, some 2—3 cm in thickness which branching or breaking off and splitting aside, abruptly change their direction as soon as they approch a more compact rock packet. A specific characteristic of bottom eluvium is the occurrence of „shouldered" veins with adherent ice-bands, which provide evidence of gradual growth of these veins along with accumulation of the overlying alluvial and slope deposits. Some of these veins are half filled with well-sorted material consisting of sand and pebbles. Such veins with primary mineral infilling have already been described by various writers.

Figure 1 shows a schematic profile drawn on the basis of generalized data derived from numerous exposures. It illustrates the relationship between the particular varieties of cryogenic eluvium and their correlation with certain well-defined elements of denudation surfaces. The parts of the profile that are marked with letters refer to: (a) flat interfluve surfaces (either boggy or dry — a_1); (b) steep slopes, over 5°; (c) gentle slopes; (d) slope surfaces cut by furrows; (e) bottoms of small streams which dissect the interfluves.

Surficial cryogenic eluvium is the most widespread of the three varieties. It occurs in the form of a not very thick (no more than 1.5—2.0 m) but well-developed and continuous horizon on almost all the gentle slopes which in West Siberia extend over vast areas.

As shown in the profile (fig. 1) surficial cryogenic eluvium lies at the base of slope deposits (either deluvial or soliflual) and thus testifies to a well-marked, though perhaps only succession stage in the development of gentle slopes and interfluve surfaces. Typical of this kind of eluvium is — as already mentioned above — a high content of ice; though at the same time the ice-veins which are fairly common in deep eluvium, never reach the surficial variety (fig. 1, pl. 3).

A notable fact is that also the slope deposits which overlie surficial eluvium do not contain any ice-veins, though their growth developed along with sedimentation of aluvium, both synchronous and contemporary. Such inhibition of ice-vein growth in surficial cryogenic eluvium is clearly attributable to changes in the moisture regime of the seasonally thawing layer, connected with the initial stage of accumulation of slope deposits.

Surficial cryogenic eluvium, containing neither ground- nor ice-veins — which, in case it achieves a completely unfrozen condition may be taken for a plain eluvium — is in fact a rather peculiar

geologic frost-caused formation, that deserves investigation for it constitutes a vital item in the history of slope development. The same applies as well to the other varieties of cryogenic eluvium.

The present writer's purpose is not to analyse existant cross-cuts or to reconstruct the paleogeomorphic conditions of West Yakutia. He only wishes to attract by the present paper the attention of investigators to the very fact of the general occurrence in permafrost regions of disintegrated rocks with a large content of ice. The existence of such formations ought to be considered not only from a practical, but also from a scientific point of view. A knowledge of the rules that control their occurrence may elucidate such problems as the formation on interfluves built of local rocks, of thermokarst depressions and lakes, irregularly developed corrasional valleys, etc.

The writer wishes furthermore to give a general description of eluvium formed under permafrost conditions. This formation exhibits the following characteristics: (a) an almost complete absence of traces of chemical weathering, (b) the presence of typical cryogenic structures, (c) the occurrence of ice- and ground-veins with signs of syngenesis. The writer believes that a correct identification of the individual varieties of these peculiar geologic formations, a sound knowledge of their structural properties and of their occurrence in the profiles, both vertical and horizontal, may prove useful in the course of investigations of planation surfaces and in the solution of certain problems relating to periglacial morphology.

Translation by T. Dmochowska

Pl. 1. Surficial cryogenic eluvium. Ice (light and dark spots) cements the fine waste and rock fragments. Photo taken in the diamond ditch „Udachnaya", Western Yakutia

Pl. 2. Structure of deep cryogenic eluvium. Ice bursts kimberlite fragments

Pl. 3. Ice vein in deep cryogenic eluvium truncated at the top by surficial cryogenic eluvium, Udachnaya region, Western Yakutia