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THE VALLEY CRYOPEDIMENTS IN EASTERN SIBERIA

Abstract

The paper concerns the problems of pedimentation in the subnival environment of Eastern Siberia (mainly n the area of the Stanovoj Range, the Elginskoye Plateau and the Čerski Range). A concave erosion surface at the foot of valley sides occurs here, gently sloping to the valley bottoms. The erosion surface attains up to 3 km in width with an inclination of usually 3 to 10°. In some places the piedmont surface is bound directly on the valley bottom, in other places on low river terraces of Middle up to Upper Pleistocene age. The gentle erosion surface usually extends headwards from the main valleys into the side valleys. The studied surface is cut in solid rocks and covered with a thin layer of slope deposits (usually 1–2 m only).

The erosion surface develops by backwearing of steep valley sides due to Pleistocene and present-day cryogenic slope processes. On steep slopes mainly frost weathering, frost creep and suffosion manifest themselves. These processes are mainly active in shallow dells. Sapping of the steep slope by nivation together with the dells activity are the main reasons for parallel slope recession. The foot is exposed by further transportation of material mainly due to frost heaving and solifluction. Linear transport on the gentle erosion surface is also concentrated in shallow dells.

The authors consider the gentle erosion piedmont surfaces a subnival variety of the pediments of arid and semi-arid regions and call them cryopediments.

INTRODUCTION

In the years 1966 and 1969 we dealt with the problems of slope development in the present-day subnival climate of Eastern Siberia. We simultaneously studied pedimentation under conditions of permafrost occurrence. Our investigations were concentrated mainly on the regions of the upland and mountain relief of the Stanovoj Range, the Elginskoye Plateau and the Čerski Range.

In these regions valleys are deep but widely open. On their bottoms misfit streams underfit to the valleys occur. Free meanders are common in valley bottoms. A gentle concave surface often rises from the valley bottoms with an inclination of dominantly 3 to 10° its width ranging from several hundreds of metres to 1.5 km and/or even 3 km. In places it is in direct contact with the valley floor, elsewhere it is separated by a step from the valley bottom. The piedmont surface passes over in a break of slope into steeper valley sides. The gentle surface usually extends headwards from the main valley into the side valleys.

The localities investigated occur in the taiga zone. The valley floors are often muddy and covered with peat bogs, grass, shrubs and trees. The piedmont surfaces are usually overgrown with taiga consisting predominantly of *Larix dahurica*. Sometimes, muddy places are found on them. The steep valley sides are partly covered with taiga and partly with debris and block fields. The bedrock often outcrops directly on them. In the north, the upper slope sections are already above the timber line and extend into the zone of mountain tundra and/or frost desert with cryoplanation terraces.

The piedmont surfaces are developed in various geological structures. They occur in both the hard rocks of the Siberian Platform (granites, gneisses) and in soft Mesozoic sandstones and shales of the Verhkoyansk complex in the young mountain ranges of NE Siberia. It is evident at first sight that they are no structural surfaces.

In former papers the gentle concave piedmont surfaces were usually considered erosion or accumulation river terraces. Subsequent works (Timofeev, 1962, 1963; Kašmenskaya & Khvorostova, 1965; Simonov, 1966; Panasenko, 1968; Keyda, 1970; etc.) point to the share of pedimentation prosesses in their development.

THE CLIMATE

The area investigated belongs climatically to the continental type of subnival climate with severely cold, dry winters and short, warm summers with the maximum of precipitation. The mean annual temperatures are lower than 0°C (Aldan: −6.2°C, Yakutsk: −10.2°C, Khandyga: −11.7°C, Deputatskij: −15.2°C, Ust-Nera: −15.3°C, Verkhoyansk: −15.6°C). The maximum July temperatures exceed 30°C. The mean July temperatures amount e.g. in Verkhoyansk to 15.3°C, Ust-Nera to 15.5°C, in Aldan to 16.8°C, in Yakutsk to 18.8°C. The absolute minimum in Verkhoyansk in the Yana River valley is −67.8°C and in Ojmyakon in the Indigirka River valley −77.8°C. The amount of precipitation is very low. The mean annual precipitation amounts in Verkhoyansk to 154 mm, in Ojmyakon to 194 mm, in Yakutsk to 202 mm, in Deputatskij to 218 mm, in Ust-Nera to 225 mm, in Khandyga to 430 mm, in Aldan to 564 mm. The present-day climate resembles that of the last glacial period.

PERMAFROST

Owing to the negative thermal balance continuous permafrost is developed in the area investigated. On the whole the permafrost is in thermal equilibrium with the present-day climate of Eastern Siberia. Its thickness varies and ranges from several tens of metres to several hundreds of metres. In the Arkagala River valley this thickness is from 120 to 200 m. In some regions of Eastern Siberia the thickness of permafrost attains as much as 1500 m. Open or closed taliks are developed beneath lakes and larger water courses. In the regions investigated the thickness of the active layer ranges from about 0.5 m in the north to 3 m in the south.

In connection with the climatic conditions and the presence of permafrost a complex of cryogenic processes are operating on slopes. Several facts are characteristic of the intensity of their effects, such as:

(a) considerable and relatively rapid oscillation of air temperatures,

(b) mean annual temperatures below 0°C and extremely low winter temperatures,

(c) short transition seasons (spring and autumn) with temperatures ranging usually around 0°C and the occurrence of numerous freeze–thaw cycles,

(d) considerable aridity and exceedingly small quantities of snow,

(e) temperature inversions in mountain basins,

(f) presence of permafrost of very low temperatures (mainly in the north – as low as −12°C).

ANALYSIS OF THE LOCALITIES

LOCALITY NORTH OF THE TOWN OF TYNDINSKIJ

In the Stanovoj Range we studied the piedmont surfaces in a 10 km long valley section 30–40 km north of the town of Tyndinskij. On both sides of the granite ridge, about 12 km in length and 3 km in width, situated between the NS sections of the rivers of Olenij and Kovykta, distinct piedmont surfaces occur. The tops of the ridges reach heights of about 800 m above sea level and are divided by distinct broad saddles developed in the places of intersection of the flat dell-like valleys. On ridges, tors are often found.

As an example of the piedmont surfaces of this territory can be mentioned the slightly inclined slopes in the valley of the Kovykta River and of its tributaries. At the foot of the western Kovykta River valley side (Fig. 1) displaying in its lower section inclinations from 16 to 20° there are two piedmont surfaces separated by a step having 8 m in height with an inclination of 16°. The upper piedmont surface is 170 m in length and its inclination

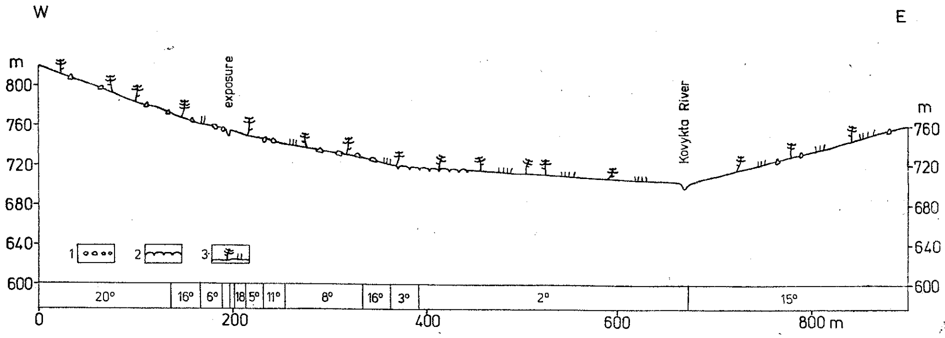

Fig. 1. Profile through the Kovykta River valley some 30 km north of the town of Tyndinskij in the Stanovoj Range

1. angular granite fragments; 2. non-sorted polygons; 3. vegetation (*Larix dahurica*, grass). Surveyed by the authors, May 24, 1969

(with the exception of two small steps) ranges from 5 to 11°. Distinct solifluction traces can be found on it. The surface is cut in porphyric granite and covered with angular granite fragments mixed with coarse sandy loam and loamy sand of 1 m in thickness (as shown by the exposure). The lower piedmont surface is 300 m long and has inclinations from 2 to 3°. It is also overgrown with taiga (*Larix dahurica*) with bent trees („drunken forest"). Non-sorted polygons are found here.

The described piedmont surfaces enter the valleys of the tributaries of the Kovykta River (Fig. 2). On this profile too, two piedmont surfaces separated by a 10 m high step inclined 10 to 13° can be seen. On the higher piedmont surface (length 140 m, inclination predominantly up to 10°), widespread evidence of solifluction activity can be observed. On the lower

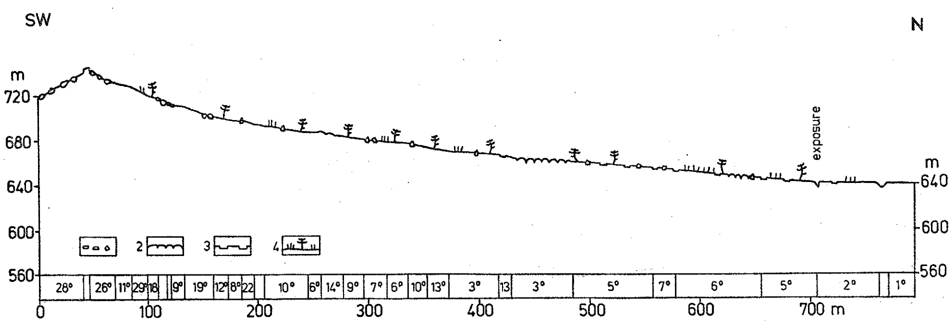

Fig. 2. Profile through the cryopediments in the valley of the tributary of the Kovykta River some 30 km north of the town of Tyndinskij in the Stanovoj Range

1. angular granite fragments; 2. non-sorted polygons; 3. water-filled depressions; 4. vegetation (*Larix dahurica*, grass)

Surveyed by the authors, May 24, 1969

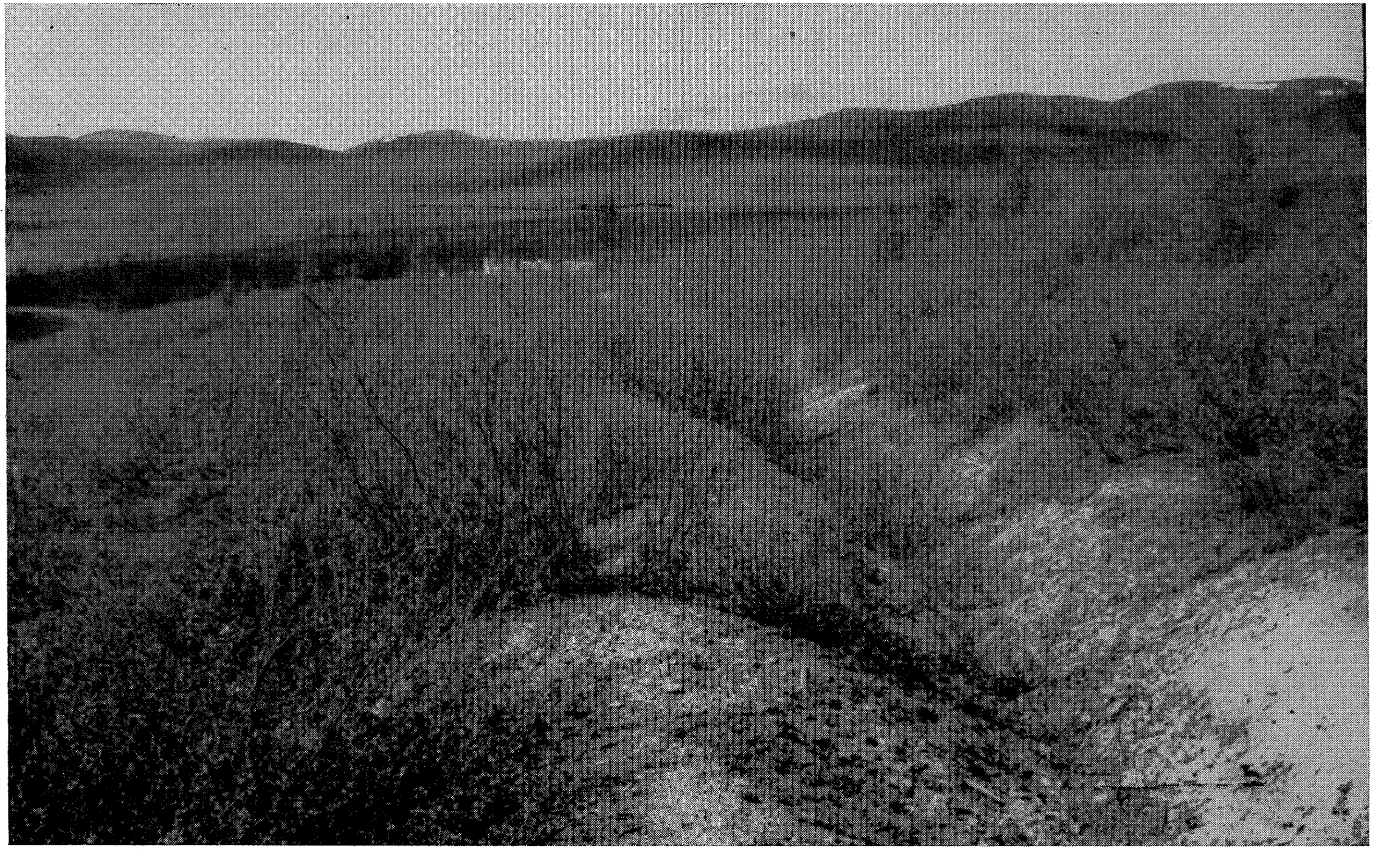

Photo J. Demek, Jane 19, 1969

Pl. 2. Exposure on the cryopediment in the Svetlaya River valley near the placer of Polevoj in the Čerski Range

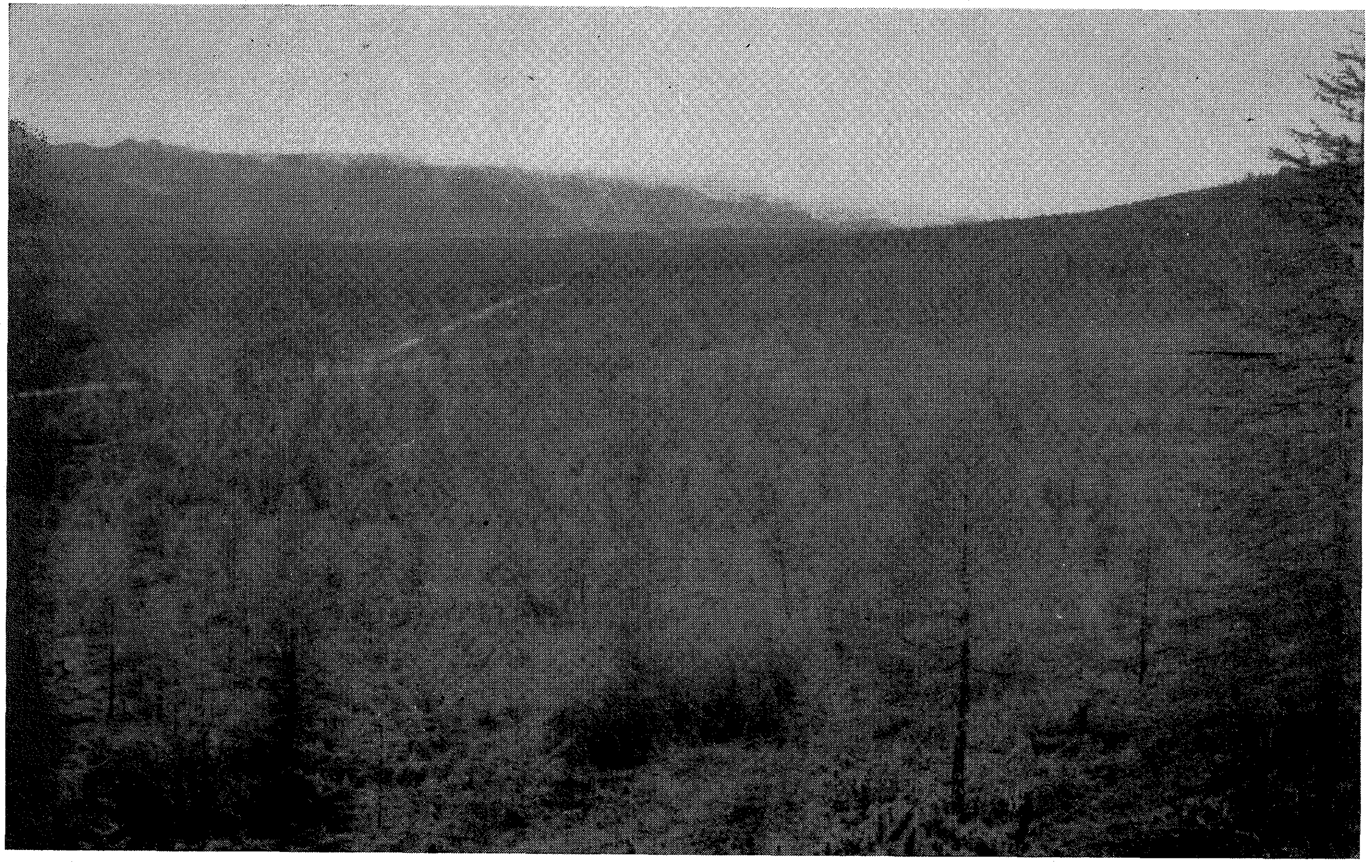

Photo J. Demek, June 18, 1969

Pl. 1. Cryopediment in the Arkagala River valley near the village of Arkagala in the Čerski Range one (length 360 m, inclination mostly 3 to 7°) there is a large number of non--sorted polygons and depressions 0.20 to 0.40 m deep filled with water at the time of research (May 24, 1969). Beneath the water, ice evidently from ice wedges outcrops. On other places of the piedmont surface the thickness of the active layer was only 0.05 m beneath the moss cover at that time. The exposure in the lowest part of the piedmont surface has shown that below the 2 m thick layer of granite fragments mixed with coarse sandy loam and loamy sand the bedrock of porphyric granite outcrops. In places, the sand has an open-work structure. Both piedmont surfaces are overgrown with taiga with bent trees.

The steep valley side has even in this locality an indistinct foot. It is stepped and its inclination reaches as much as 29°. Angular granite blocks mixed with loamy sand, small flats of cryoplanation terraces (inclination 8 to 12°) and in its upper parts nivation hollows can be found on it. There are tors on the top of the ridge.

LOCALITY NEAR THE VILLAGE OF ZOLOTINKA

In the Stanovoj Range we also studied the valley side development in a 30 km long section north of the village of Zolotinka (30 km north of the village of Nagornyj) in the Gorbyllakh River valley and in the valleys of its affluents. The relief in the surroundings of the said village shows distinct watershed ridges separated by broad saddles and open valleys with typical gently inclined surfaces at the foot of their steep slopes. On the floor of the

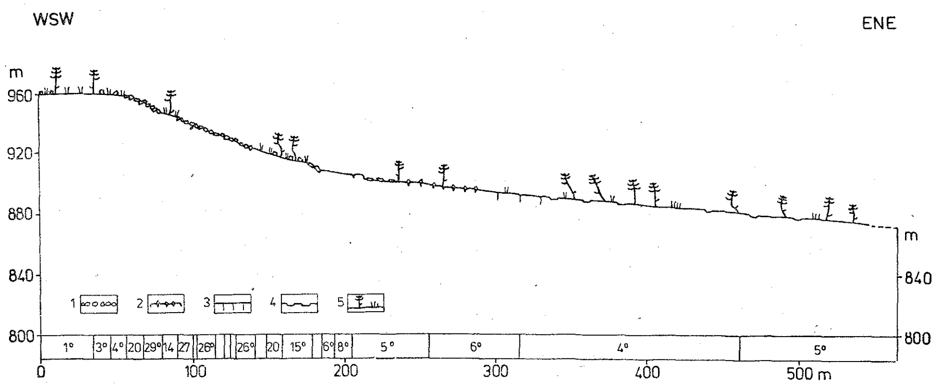

Fig. 3. Profile through the cryopediment in the Gorbyllakh River valley some 11 km north of the village of Zolotinka in the Stanovoj Range

1. angular diaphtorite fragments; 2. sorted stone polygons; 3. thermal contraction cracks; 4. water-filled depressions; 5. vegetation (*Larix dahurica*, grass)
Surveyed by the authors, May 26, 1969

wide valleys tectonically sagged narrow stripes of Jurassic deposits occur in places.

As an example of piedmont surfaces north of the village of Zolotinka can be mentioned the gently inclined surface represented in Fig. 3. The steep slope section has an inclination of predominantly more than 20° (max. up to 29°) in the place of the profile and passes into the watershed ridge at an altitude of 960 m above sea level. The slope is overgrown with thin taiga and dissected by shallow dells (about 1 m in depth and about 5 to 8 m in width) on the bottoms of which block streams occur consisting of fragments of Proterozoic diaphtorites. The blocks reach dimensions of as much as 1 m in their longer axes. The block streams are overgrown with mosses and lichens. Among the boulders occurring on slopes even outside the dells there was ice at the time of investigation (May 26, 1969). The main processes operating in these block streams are frost creep and suffosion. In places of greater accumulation of fine soil solifluction is acting too. The slope passes with a distinct foot into a gently inclined surface sloping towards the valley bottom of the Gorbyllakh River. Its upper section has an inclination of 4 to 8° and a length of 360 m (Fig. 3). The lower part of the piedmont surface displaying 200 to 300 m in length has not been drawn in the profile. The exposures on the piedmont surface have shown that the bedrock crops out below the 0.50 to 0.80 m thick layer of diaphtorite fragments (of 5 cm mean size) mixed with sandy loam. Accordingly this is a piedmont surface linked with the valley floor and/or a low river terrace. The surface is overgrown with taiga. The tree trunks are distinctly bent (drunken forest). On the surface sorted polygons (2 to 3 m in diameter) occur, as well as shallow water-filled depressions and traces of slope movements (mainly frost creep and solifluction).

LOCALITY NEAR THE VILLAGE OF ELGINSKIJ

The authors studied the slope development in the Artyk-Yuryakh River valley (left affluent of the Elgi River) in the Elginskoye Plateau. The valley of this river is broad, trough-like with steep asymmetrical sides. A piedmont surface (Fig. 4) passing even into the valleys of the tributaries of the Artyk-Yuryakh River is developed at the locality about 80 km W of the town of Ust-Nera and 15 km E of the village of Elginskij. The NW slope displays a declivity of 20 to 28° in its lower section. The slope deposits are in places as much as 0.50 m thick but they are absent in places and the bedrock crops out directly to the ground surface built of sandstones and shales. At the slope foot the gently inclined erosion surface begins to have an inclination of predominantly about 10° in its upper part and of 6 to 7° in the lower ones.

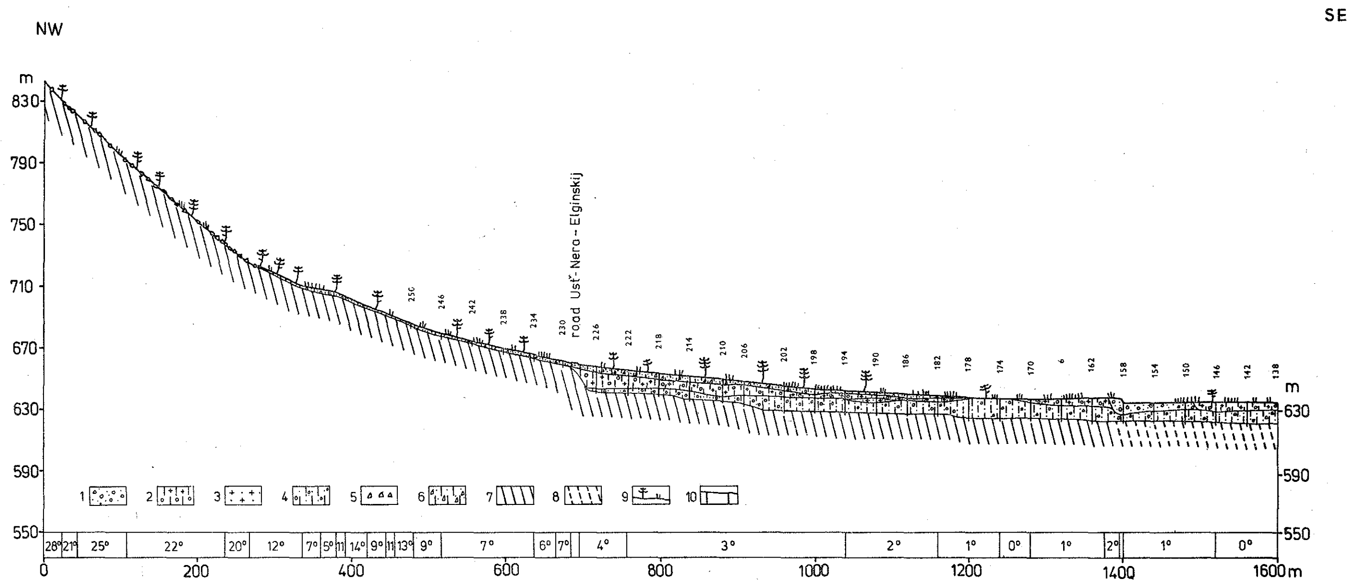

Fig. 4. Profile through the lower slope section, the cryopediment and the valley bottom of the Artyk-Yuryakh River some 80 km west of the town of Ust-Nera in the Elginskoye Plateau

1. gravel and sand; 2. gravel and sand, and loamy gravel and sand with ground ice; 3. sand with high ground ice content; 4. gravel with loamy sand; 5. angular sandstone and shale fragments; 6. slope deposits (angular sandstone and shale fragments mixed with loam and sand); 7. slightly weathered bedrock (sandstone, shales); 8. weathered bedrock (sandstone, shales); 9. vegetation (*Larix dahurica*, grass); 10. borings.

Constructed by the authors according to the borings of the Upper-Indigirka Geological Expedition of the Ministry of Geology, RFSSR and on the basis of their own investigations, June 13, 1969

The length of this surface is 430 m. The surface is covered with angular fragments of local rocks mostly up to 10 cm in size mixed with loam and sand and overgrown with taiga (*Larix dahurica*). The thickness of the slope deposits attains according to the borings of the Upper-Indigirka Geological Expedition of the Ministry of Geology of the RSFSR 1.40 to 2.20 m.

These slope deposits overlap below the road Ust-Nera–Elginskij the margin of the valley floor over a length of 520 m. The declivity of the ground surface is here 1 to 4° and the thickness of the colluvial deposits 0.80 to 2.60 m. The fluvial deposits of the valley floor consist of gravels and sands involving, mostly in their upper parts, ground ice. In the valley floor three buried river terraces can be distinguished. The differences in height of their bases are small amounting to 2 to 8 m. The base of the uppermost terrace occurs some 4 to 6 m above the floodplain surface near the river bed. In the surface of fluvial deposits these terraces do not manifest themselves. The material created during slope development smoothed the surface of the terrace deposits and pushed the river away. The floodplain has as much as 1250 m in width. The two highest terraces are chronologically linked with the origin of the piedmont surface. The erosion surface obviously originated towards the end of the Pleistocene and develops even at present. It is accordingly a very young erosion surface.

LOCALITY NEAR THE VILLAGE OF ARKAGALA

The Arkagala River displays near the village of Arkagala (some 150 km SE of the town of Artyk) in the Čerski Range a wide and in its cross profile asymmetrical valley. The right valley side facing NE is steeper, the left one exposed SW is gentler. The NE slope has in its lower section an inclination of 16 to 22°, in its middle and upper sections of 17 to 33°. In the lowest slope section there is a dense moss growth moving slowly downslope and creating moss terracettes as much as 1 m high. In cracks, water occurs above the permafrost. Higher upslope angular fragments of sandstone mixed with sandy loam with numerous traces of downslope movements are found forming small solifluction terraces in the uppermost part of the slope. Bedrock often crops out on this slope.

At the foot of the left valley side a gentle piedmont surface is developed (Pl. 1). The inclination of the surface is 5 to 10° and decreases successively down to 3°. In the place of the profile (Fig. 5) its width is 540 m. In the cross profile it is slightly undulated by shallow dells. The piedmont surface is separated by a 15 m high step from the Arkagala River floodplain. On this step terrace gravels occur. The terrace gravels are found in non-sorted circles of 0.5 m in diameter at a distance of 200 m from the step edge. In higher

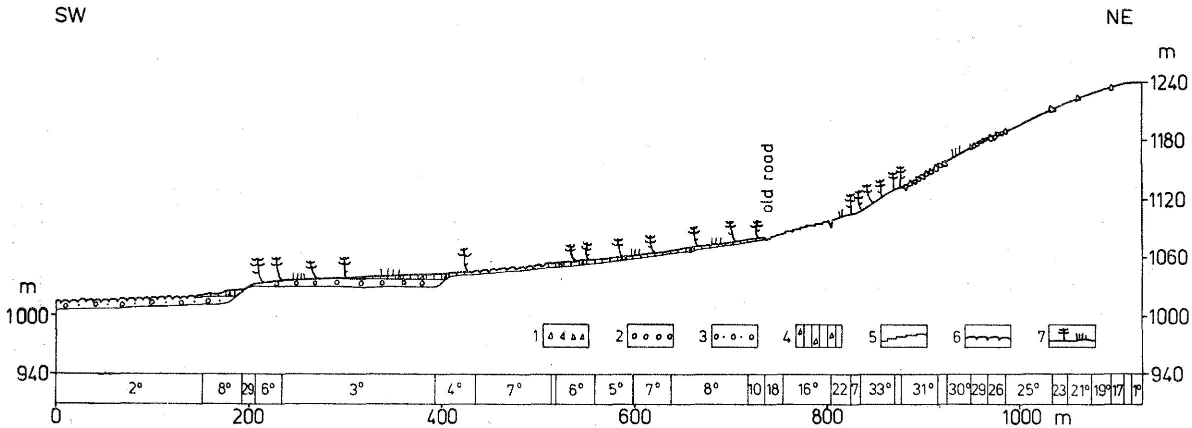

Fig. 5. Profile through the cryopediment in the Arkagala River valley near the village of Arkagala in the Čerski Range

1. angular sandstone fragments; 2. terrace gravel; 3. floodplain gravel; 4. slope deposits (angular sandstone and shale fragments with sandy loam); 5. moss terracettes; 6. non-sorted circles and polygons; 7. vegetation (*Larix dahurica*, grass)
Surveyed by the authors, June 18, 1969

sections of the piedmont surface the gravels do not occur any more. On the basis of the cut of the old road in the uppermost part of the piedmont surface, the thickness of the mantle can be estimated to have 1 to 2 m. Bedrock (sandstone) occurs beneath the mantle. On the basis of the facts mentioned the upper part of the piedmont surface may be regarded as an erosion surface, and the lower one as a river terrace partly covered with slope material (Fig. 5).

The piedmont surface is overgrown with taiga (*Larix dahurica*) with bent tree trunks. Downslope, intensive processes of frost heaving are taking place. Mainly on bottoms of flat dells traces of present-day frost heaving and solifluction can be found manifesting themselves in the development of small solifluction terraces and the elongation of non-sorted circles in the direction of the slope. The non-sorted circles are formed of brown loam with small fragments, predominantly shales of Triassic age. The movements are indicated also by cracks in the moss and turf cover which were open and water-filled during the observations on June 18, 1969.

LOCALITY NEAR THE PLACER OF POLEVOJ

About 40 km east of the town of Susuman the Svetlaya River valley near the placer of Polevoj in the Čerski Range runs in E–W direction. The valley is asymmetrical in its cross profile. The slope facing south is gentler and has in its lower section an inclination of 22° (Fig. 6). There are fragments of sandstones of the Verkhoyansk complex on it and the bedrock outcrops often directly to the surface. At the slope foot begins a gentle surface (angle of slope 6 to 7°). This piedmont surface is 360 m wide and falls with a 5 m

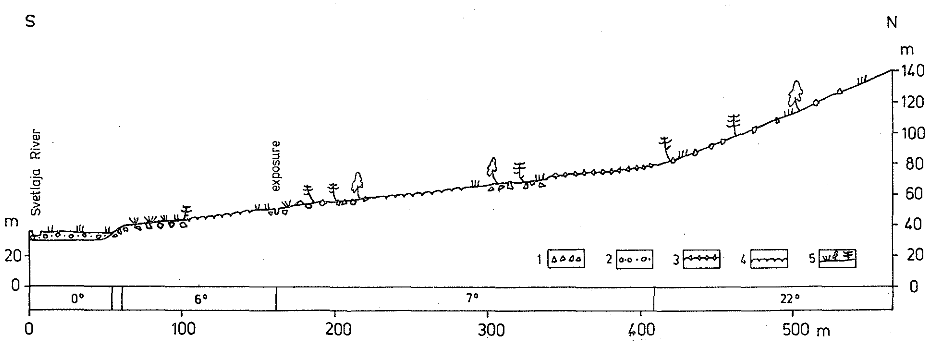

Fig. 6. Profile through the cryopediment in the Svetlaya River valley near the placer of Polevoj in the Čerski Range

1. angular sandstone fragments; 2. floodplain gravel; 3. sorted stone polygons; 4. non-sorted circles; 5. vegetation (birch, alder, larch, grass)
Surveyed by the authors, June 10, 1969
Note: Vertical scale is not related to sea level

high step down to the Svetlaya River floodplain (Fig. 6). The step is covered with coarse debris. A long exposure dug across the piedmont surface at a distance of 100 m from the step showed that there are slightly weathered sandstones of the Verkhoyansk complex below 1.40 up to 1.50 m thick loams mixed with sandstone fragments (Pl. 2). This surface can be therefore considered an erosion surface. It is overgrown with birch and alder shrubs and larches with bent tree trunks. On the surface there are non-sorted circles (with diameters of 1.5 m) and sorted stone polygons with diameters of as much as 3 m.

THE GENESIS OF THE PIEDMONT SURFACE

The analysis of the localities mentioned shows that gentle erosion surfaces have developed under permafrost conditions in many valleys of Eastern Siberia. They can be found on one or both sides of the valley bottoms. In some places low river terraces occur along the valley floor. In those cases the erosion surface passes into accumulation terraces which constitute the local erosion base level of its development.

The sides of the wide valleys are steep in the area described (inclined often above 20°). But they do not bear evidence of lateral sapping due to meandering of rivers. A typical feature is that the rivers are underfit to the width of the valleys. The valley gradient is small and the rivers usually flow in free meanders in the middle stripe of very wide floodplains. The development of the wide valleys can only difficultly be explained merely by river activity. The valley sides are mostly not within direct reach of the effects of river erosion. The present shape of the valleys may be assumed to be a result of slope processes on valley sides.

The studied test pits and exposures have shown that the piedmont rock surface is covered with a thin layer of slope deposits. Its thickness ranges usually from 1 to 2 m in the area investigated. It consists of fragments of local rocks mixed with sandy loam and loamy sand. Their structure shows that these deposits developed owing to the action of a complex of cryogenic processes, such as frost weathering, frost heaving, frost creep, solifluction and sheet wash. The piedmont surface shows a number of cryogenic forms. These are mostly non-sorted circles, non-sorted polygons, non-sorted steps, sorted stone polygons, solifluction terraces, etc. The presence of these forms together with that of bent trees (drunken forest) point to present-day development of the piedmont surface.

The main denudation lines on the forms described are the shallow dells. Dells are very common on the piedmont surface. Due to a higher quantity of water, intensive cryogenic processes take place within them. Movements occur not only in the direction of the longer axis of the dells, but even lateral movements can be observed. On the bottoms of the dells shallow furrows come into being during snow melt quickly filled up with the material sliding from the sides.

Many dells occur also on the steep rocky valley sides partly covered with angular debris. On these slopes frost creep acts in the area investigated, i.e. slow movement of debris due to sliding on ice crusts developing at the inferior surface of the fragments in debris mantles. The effects of needle ice are also important. Sometimes solifluction terraces develop. During snow melt suffosion acts too. The main denudation lines are even here the dells cutting continuously parallely into the slope. In the area investigated no accumulation of the material removed from the steep slope at its foot was observed. Although the transition between the steep slope and the piedmont surface is gentler than in arid regions the material supplied from the steep scarp is carried away. This is evidently promoted by snow accumulation on the break of slope and the nivation connected with this accumulation. With regard to the dry cold climate in the area studied the snow accumulation and its later thawing are an important source of water and consequently of the increased intensity of cryogenic processes. We could observe that the foot of the steep slope was even in summer wetter than the other parts of the piedmont surface. J. G. Simonov (1966) explains this fact by issues of shallow ground waters above the permafrost. The removal of the material supplied from the steep slope causes the sapping of its foot. The sapping due to nivation is together with the effects of the dells the main cause of the retreat of the steep slope.

The removal of the material on the piedmont surface is promoted by suffosion washing out the fine material of the block fields and debris mantles on the steep slope. The fine soil is transported on the piedmont surface assisting the development of frost heaving and solifluction.

It follows from the above mentioned facts that gentle erosion-denudation surfaces develop in the valleys of Eastern Siberia by the retreat of the steep valley side due to the effects of a complex of geomorphological processes connected with present-day climatic conditions. This is why these surfaces can be considered a subnival variety of the pediments of arid and semi-arid regions. The pediments developing in the subnival area under conditions of permafrost are called cryopediments (pediments of the Siberian type according to D. A. Timofeev, 1963).

The extent and the intensity of development of the valley cryopediments depend on both the tectonic stability of the territory and the climatically controlled intensity of cryogenic processes. The valley pediments develop in regions where lateral widening of the valleys prevailed over vertical erosion during the Pleistocene and in the Holocene due to slope processes.

As to the age of the cryopediments of the area investigated they can be considered young with regard to their relation to low terraces and/or the valley floor (see profiles). J. G. Simonov (1966) states that there are extensive valley pediments linked with the so-called main terrace of Middle to Upper Pleistocene age in the valleys of the large rivers, such as Šilka, Olona, Ingoda, Argun. In some places the pediments in the valleys of the said rivers display a width of several kilometres. This fact points to a relatively rapid development of the cryopediments.

The valley pediments penetrate from the main valleys into the side valleys. Under favourable conditions the cryopediments of two opposite valleys merge together and pediment passes develop. Thus a relief of isolated mountain groups and inselbergs comes into existence which was seen in the Stanovoj Range. In this region there are at least two pediment steps one above the other. The erosion base level for their development were evidently river terraces of various heights.

The pediments were observed in some places of Eastern Siberia even above the upper edge of deep incised valleys. An example is the Nera River valley (right-side affluent of the Indigirka) bordered with as much as several kilometres wide pediments at heights of 170 to 200 m above the valley bottom. The deep valleys of the Nera River and of its tributaries are incised into the pediments which are probably older and evidently developed before the Quaternary.

CONCLUSION

A number of authors (Baulig, 1952; Dylik, 1957; Khvorostova, 1970; Baranova & Čemekov, 1970; etc.) have already pointed out the common features of slope development in arid and semi-arid regions on the one hand and in subnival regions on the other. The analysis of the localities in the valleys in the continental subnival climate of Eastern Siberia confirms this opinion. In the dissected relief of upland and mountain regions built of solid rocks a parallel retreat of valley sides and the development of valley cryopediments take place owing to cryogenic processes operating in the presence of permafrost. On steep slopes, mainly frost weathering, frost creep and suffosion manifest themselves. These processes are concentrated chiefly in shallow dells with a high gradient (*Hangdellen*) which, together with the sapping of the foot by nivation are the main causes of the parallel slope retreat. The material supplied is removed from the foot mainly by frost heaving and solifluction. At the foot of the steep slope a pediment develops most often with an inclination of 3 to 10°. Even on the pediment, the most effective transportation is concentrated in shallow dells.

The authors believe that the pediments investigated are a subnival variety of the pediments of arid and semi-arid regions and call them cryopediments.

References

Baranova, J. P., Čemekov, J. F., 1970 – Penepleny, pedipleny i poverkhnosti vyravnivaniya skladčatykh oblastej (Peneplains, pediplains and planation surfaces of orogenetic regions). *Problemy poverkhnostej vyravnivaniya*, no. 1; p. 13–15; Akad. Nauk SSSR, Irkutsk.

Baulig, H., 1952 – Surfaces d'aplanissement. *Annales Géogr.*, No. 325: p. 161–183; No. 326: p. 245–262.

Dylik, J., 1957 – Tentative comparison of planation surfaces occurring under warm and under cold semi-arid climatic conditions. *Biuletyn Peryglacjalny*, No. 5; p. 37-49.

Kašmenskaya, O. V., Khvorostova, Z. M., 1965 – Geomorfologičeskij analiz pri poiskakh rossypej na primere Elginskogo zolotonosnogo rajona v verkhovyakh reki Indigirki (Geomorphological analysis in the research of mineral deposits in the gold-bearing Elginskij region, the Indigirka river basin). Ed. Akad. Nauk SSSR; 166 p., Novosibirsk.

Keyda, E. P., 1970 – Sovremennoye razvitiye dolinnogo pedimenta v nižnem tečeniji Irtyša (Present-day development of the valley pediment in the lower course of the Irtyš River). *Problemy poverkhnostej vyravnivaniya*, No. 1; p. 43-44; Akad. Nauk SSSR, Irkutsk.

Khvorostova, Z. M., 1970 – Problema obrazovanija pedimentov (Problem of the origin of pediments). *Problemy poverkhnostej vyravnivanija*, No. 1; p. 90-94; Akad. Nauk SSSR, Irkutsk.

Panasenko, V. I., 1968 – O četvertičnykh pedimentakh v rykhlykh porodakh Amuro-Zejskoj depressii (On Quaternary pediments in loose rocks of the Amur-Zeya depression). *Problemy izučeniya četvertičnogo perioda*; p. 39–41, Khabarovsk.

Simonov, J. G., 1966 – Dolinnye pedimenty lesnoj zony vostočnogo Zabajkala i jikh mesto v analize relefa (Valley pediments of the forest zone of Eastern Transbaikal and their role for an analysis of the relief). *Vestnik naučnoj informacii Zabajkalskogo filiala Geografičeskogo Obščestva SSSR*, No. 6; p. 26–33, Čita.

Timofeev, D. A., 1962 – K probleme proiskhoždeniya formy rečnykh dolin (na primere rečnykh dolin Yužnoj Yakutii) (On the origin of river valley forms as exemplified by the river valleys of South Yakutya). *Izvestiya Akad. Nauk SSSR, ser. geogr.*, no. 3; p. 82–89, Moscow.

Timofeev, D. A., 1963 – Poverkhnosti vyravnivaniya Aldano-Oljokminskogo meždurečya, Yužnaya Yakutiya (Surfaces of planation of the watershed between the Aldan and the Oljokma Rivers, South Yakutya). *Zemlevedenije*, t. 6; p. 169–183, Moscow.