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The Significance of Periglacial Phenomena in Iceland

By K. Priesnitz and E. Schunke*

Summary: This paper gives a systematic survey of the periglacial landforms of Iceland. The presentation is centered on the question of the significance of distinct periglacial features on certain climatic and edaphic environmental conditions, and on the question of the place which the volcanic island of Iceland holds within the periglacial zone.

Zusammenfassung: Die vorliegende Arbeit gibt eine zusammenfassende Übersicht über den periglazialen Formenschatz Islands. Dabei wird dem Problem der Signifikanz der Periglazialerscheinungen für bestimmte klimatische und edaphische Milieubedingungen innerhalb Islands sowie für die besondere Stellung der Vulkaninsel in der arktischen Periglazialzone nachgegangen.

INTRODUCTION

One of the main problems of current research in periglacial geomorphology is that forms or complexes of forms may or may not be significant of certain environmental conditions. The example of Iceland allows one to pursue the problem of the significance of periglacial phenomena under two aspects:

1) The effects of climatic and edaphic conditions on the distribution and differentiation of specific periglacial landforms.
2) The special character of the Icelandic periglacial environment within the polar periglacial zone.

These questions were discussed during a fieldtrip in August 1982 to the Central Highlands of Iceland (cf. Fig. 1) of the IGU-Commission on "The Significance of Periglacial Phenomena" (Chairman: H. M. French).

The Central Highlands of Iceland comprise an elevated plateau approximately 500 to 800 m a. s. l., fringed by more or less wide lowlands and coastal plains. The highland is overtopped by the ice shields of Vatna-, Hofs- and Langjökull as well as by mountain ranges and isolated mountains. Since these mountains exceed the climatic snowline the complete range of subnival altitudinal differentiations exists.

Bedrock consists of basalts, hyaloclastites and rhyolites. The main geologic structure is that of two areas of Tertiary basalts, occupying the major part of the island, separated from each other by a southwest-northeast striking neovolcanic inner zone. The solid rock is covered in most parts by young lava flows, by allochthonous glacial, fluvioglacial and pyroclastic deposits of mainly sandy and gravelly texture, by loess-like fines ("móhella") and by autochthonous frost debris.

The climate of Iceland is characterized by a great number of freeze-thaw cycles. The lowland has a humid climate with cool summers (Cfc-climate following Köppen), while the interior belongs to the tundra-zone (ET-climate following Köppen). Parts of the tundra zone possess discontinuous permafrost. Lowland vegetation is mostly subpolar grassland and some birch woodland. The highland is occupied by different tundra types and nearly vegetation-free moraine-, lava- and frost debris-deserts, interrupted by bog and fen areas.

*Dr. Kuno Priesnitz and Prof. Dr. Ekkehard Schunke, Geographisches Institut der Universität, Goldschmidtstr. 5, D-3400 Göttingen.

PERIGLACIAL PHENOMENA

In that periglacial forms are significant of certain environmental conditions one problem in Central Iceland is to distinguish those which require permafrost and those which do not require permafrost for their formation. Furthermore, one must differentiate between features belonging to the micro- or meso-relief. Following KUGLER (1975) and BARSCH & STÄBLEIN (1978), forms having a length of less than 10^2 m are considered microforms while those having a length of 10^2—10^4 are considered mesoforms. There is a difference between these two categories relative to their significance for periglacial conditions. Although mesoforms are of far greater importance for the whole relief, the short-lived microforms are more indicative of present day periglacial morphodynamics. For that reason, this paper concentrates upon microforms. In addition, mesoforms very often are polyphase forms (resulting from various genetic phases under changing climates) and/or convergence forms (same forms resulting from different geomorphic processes, e. g., periglacial versus tropical or subtropical pedimentation, cf. MORTENSEN, 1930; PRIESNITZ 1980; POSER & SCHUNKE, 1983). Most microforms are built of loose material while mesoforms have developed generally in solid rocks.

Periglacial Phenomena without Permafrost

Iceland possesses most of the known spectrum of periglacial phenomena, except those requiring severe frost conditions with either continuous or widespread permafrost.

a) Micro-relief features

Nearly all known periglacial microforms are present in Iceland. They include forms of frost-weathering, patterned ground, mass wasting and surface flattening, gelifluction and deflation.

F r o s t   w e d g i n g can be observed above a lower limit of 500 to 600 m a.s.l. in southern Iceland and

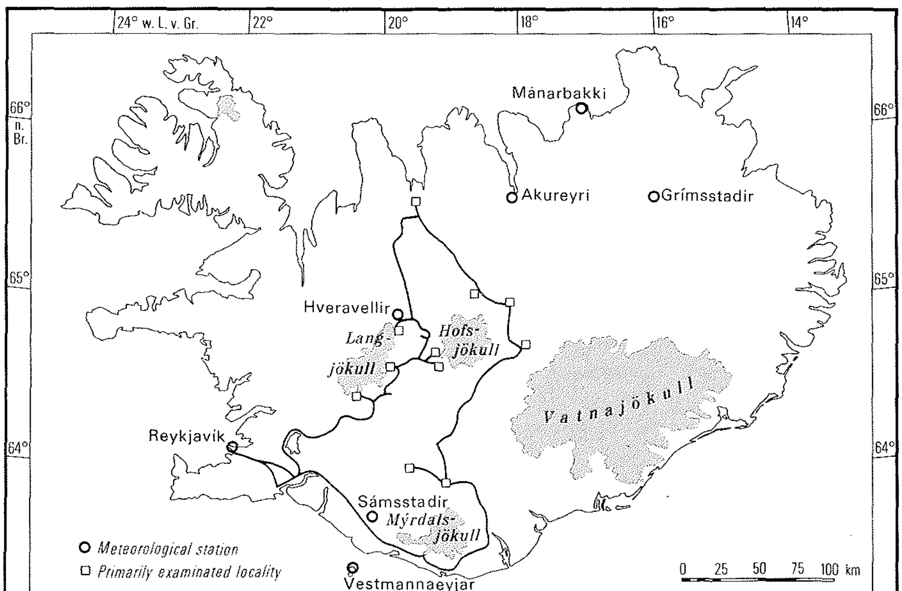

Fig. 1: Orientation map: field trip route of the IGU-Commission „The Significance of Periglacial Phenomena" in Iceland. 22 August to 2 September, 1982.

Abb. 1: Übersichtskarte: Exkursionsroute der IGU-Kommission „The Significance of Periglacial Phenomena" auf Island, 22. August bis 2. September 1982

350 to 450 m a.s.l. in the north. Scree slopes and blockfields of frost-weathered debris are the most common features. Extensive undulating areas of frost debris are characteristic of the marginal basalt plateaus while in the Central Highlands of Iceland, the surface is mainly covered with unconsolidated glacial or fluvioglacial material. The latter is relatively unsusceptible to frost wedging by virtue of its permeability and dryness. In the Central Highlands frost wedging mainly affects big erratic blocks in the form of ''Kernsprung'' (wedging into a small number of large particles). In Central Iceland coarse blockfields are limited to the tablemountain-volcanoes (''stapi''). The material furnished by frost weathering shows variable composition depending on the parent rocks: frost debris of basalt consist of blocks with or without fines, those of hyaloclastites of sandy-silty fines with very rare blocks.

P a t t e r n e d g r o u n d in Iceland includes sorted and non-sorted forms, frost mounds and large frost-fissure polygons. Sorted patterned ground phenomena are widespread. They include stone polygons, stone stripes, debris islands, debris stripes and stone-rosettes. They can be classified into large forms (with diameters over 0.5 m, usually between 1 to 3 m) and small forms (diameters between 0.1 and 0.5 m). The miniature forms are of little significance, since they occur ubiquitously. The larger forms of patterned ground are limited to the highlands, with a lower altitudinal limit near 650 to 700 m a.s.l. in the south and near 350 to 400 m a.s.l. in the north. These larger forms require a surface regolith with a thickness of at least 0.3 m and containing at least 10% pelitic fines. Such conditions are met mainly on basalt outcrops, namely on the marginal plateaus and on the tablemountain-volcanoes of Central Iceland. Areas covered by debris of less than 0.3 to 0.4 m in thickness show, even under the most favourable climatic conditions, only miniature forms; surfaces with a debris cover of variable thickness show both large and small scale patterned ground phenomena.

Since the controlling factor is obviously the debris cover thickness, the size of patterned ground forms in Central Iceland is not significant of climatic conditions in the sense of TROLL (1943, 1944), who attributed small forms of patterned ground to diurnal freeze-thaw cycles (''tropical type of patterned ground'') and large forms to seasonal freeze-thaw cycles (''polar type of patterned ground''). Consequently, miniature forms can only be significant of a diurnal freeze-thaw regime where the detritus cover exceeds the depth of frost penetration. Besides these major correlations, certain types of patterned ground reflect special environmental conditions. Stone stripes, for example, are common not only on inclined surfaces but also show an irregular and often interrupted development on nearly horizontal surfaces, wherever the soil is water-saturated (cf. SCHUNKE, 1975).

The differentiation of non-sorted patterned ground largely resembles that of sorted phenomena. Small forms occur both in the lowland and the highland, but large forms are limited to the latter. The main areas of occurrence of these large forms are morainic and fluvioglacial deposits; that is, deposits without detritus sorting because of the lack of pelitic fines.

Turf hummocks (thufurs), often classified as phenomena of non-sorted patterned ground (cf. WASHBURN, 1956: 830), are the most common periglacial features of Iceland (cf. Fig. 2). There are several varieties of forms and a number of different density patterns (cf. SCHUNKE, 1977). They can be observed in both the lowlands and the highlands. The tundra-thufurs of the highlands are less regular and less sharply delimited than the grassland-thufurs of the lowlands. This means that the genesis of thufurs does not require a special frost regime but rather, a threshold of minimum frost conditions which exist everywhere in Iceland.

This implies that the Iceland thufurs are not indicative of permafrost. This is opposite to the observations of SCOTTER & ZOLTAI (1982) for the earth hummocks (thufurs) of the higher elevation in the Alberta Rockies. Nevertheless, there is a distinct control by edaphic conditions: thufur genesis requires a pelit-rich fine material with high water sorption capacity and a closed vegetation cover. Thufurs are absent on homogeneous sandy material but are very common on the loess-like ''móhella'' sediment. Another factor controlling thufurs is the water saturation of the soil: water-clogged lands and areas with a groundwater

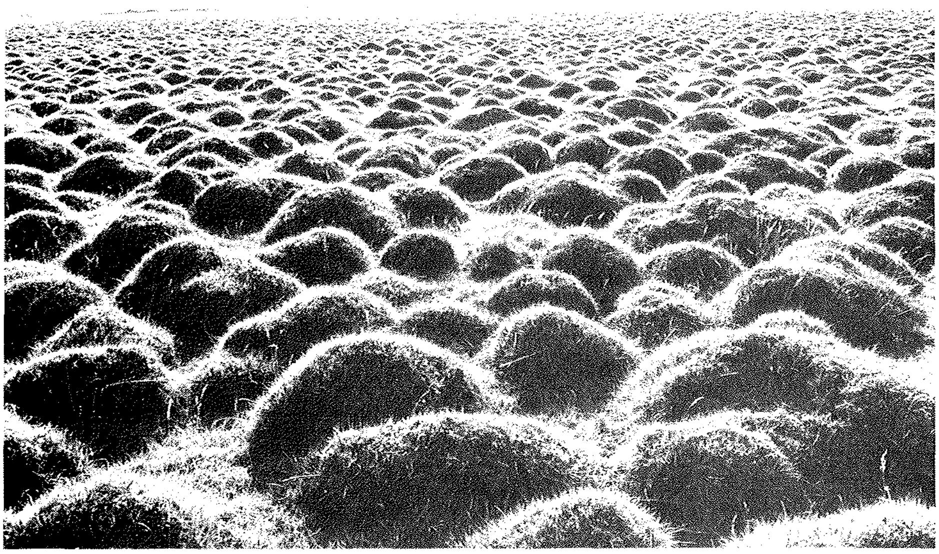

Fig. 2: Thufur field at the Icelandic lowlands. Mýrdalur, South Iceland, 30 m a.s.l. (09/01/1982).

Abb. 2: Thufurfeld im isländischen Tiefland. Mýrdalur, Südisland, 30 m ü. N. N. (09/01/1982).

table near the surface never show thufur development.

Frost-crack macro-polygons, another type of nonsorted patterned ground (cf. WASHBURN, 1956: 832), occur on detritus with or without vegetation cover. They are tetra-, penta- or hexagonal in shape, with a mesh-width of between 15 and 50 m. Macro-polygons in the tundra are limited to the pelitic "móhella" while in vegetation-free areas they have also been observed on sandy and gravelly materials (moraine, sandur). The frost-crack macro-polygons of Iceland do not contain ice, even in permafrost areas. The cracks penetrate the ground to a depth of 0.6 to 0.8 m and are infilled with tephra transported by the wind (cf. Fig. 3). They are best described as sand or soil wedges. Fresh, open fissures of 1 to 5 cm width and about 0.2 m depth in the wedge fillings or in the continuation of cracks prove the actual activity of polygon formation (cf. FRIEDMAN et al., 1971; SCHUNKE, 1974). They seem to be caused by present intensification of frost action in Iceland (cf. SCHUNKE, 1979).

Forms of surface flattening, stone pavements are most common in those basalts and rhyolits, that tend to disintegrate into slabs or other flat debris. Stone pavements indicate places with seasonal snowbanks; they are limited to the highland.

Apart from patterned ground gelifluction forms are the most characteristic phenomena of periglacial environments. All known form types have been observed in Iceland. The most important are amorphous gelifluction sheets, gelifluction terraces and gelifluction lobes. Gelifluction phenomena occur on all kinds of loose materials in Iceland without showing any material control. However, generally gelifluction forms are more pronounced in pelitic than in sandy or gravelly detritus.

Gelifluction is limited to the highlands, the lower limit being situated near 450 to 500 m a.s.l. in the south and near 250 to 300 m a.s.l. in the north.

Eolian forms are another very characteristic component of the morphology of the Icelandic peri-

Fig. 3: Sand wedge above permafrost. Immediately above the permafrost table: cryoturbations in rhyolitic Heklatephra. Orravatn, Central Iceland, 740 m (08/09/1982).

Abb. 3: Sandkeil über Permafrost. Unmittelbar über der Permafrosttafel: Kryoturbationen in rhyolithischer Hekla-Tephra. Orravatn, Zentralisland, 740 m (08/09/1982).

glacial environment. The most common deflation features are gravel pavements and vegetation cliffs. The erosional effect of the wind is demonstrated by ventifacts and wind-sculptured rocks (cf. Fig. 4). Sto-

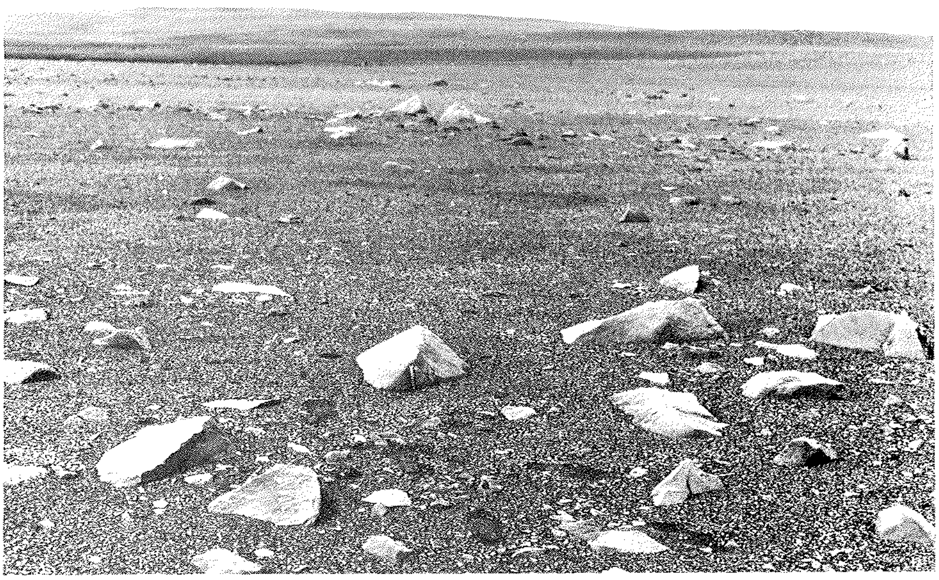

Fig. 4: Gravel pavement with ventifacts at the Icelandic highlands. Sprengisandur, Central Iceland, 770 m (09/05/1982).

Abb. 4: Pflasterboden mit Windkantern im isländischen Hochland. Sprengisandur, Zentralisland, 770 m (09/05/1982).

ne pavements, the result of deflation, slopewash and upfreezing of stones, occupy wide areas of the moraine and sandur surfaces of Central Iceland. These are the most extreme desert (serir) areas of the island.

The most prominent forms caused by deflation are vegetation cliffs varying in height between 0.3 and 2.5 m. Very effective agents promoting deflation are cryoturbation processes which damage the vegetation cover and the soil loosening activity of needle ice. Other processes working in the same direction are overgrazing, linear erosion by running water, and the destruction of vegetation by hot volcanic ashes. Deflation cliffs are common in all areas covered by fines (ashes as well as the silty "mohélla") both in the highland and the lowland, save the bogs and fens.

In summary, the main factors responsible for the high frequency of deflation phenomena in Iceland seem to be: (a) High wind speed and frequency, (b) a great number of freeze-thaw cycles and (c) the edaphic aridity caused by the extreme permeability and the lack of silt and clay in the volcanic ashes.

b) Meso-relief features

Of the different mesoforms (slope-, valley-, mountainforms) only those of unequivocal periglacial character are discussed. These are nivation and cryoplanation forms and asymmetric valleys.

Nivation and cryoplanation forms are the result of the combination of processes called nivation. Besides nivation hollows and benches, ravines are strongly influenced by snow infill. Cryopediments and stepped cryoplanation terraces are less frequent. The kind and size of the nivation forms depend mainly on the size and extent of the seasonal or perennial snowbanks. Transverse snowbanks usually accumulate and survive in structural cavities. The nivation process consists of a combination of frost shattering, subnival slopewash, rill- and sheetwash below the snowbank, snow creep, snow pressure and gelifluction. The details of these processes and the reasons of differentiation stay somewhat obscure (cf. THORN, 1978).

The existence of nivation and cryoplanation phenomena is limited to the higher regions of the Central Highlands, where snowpatches last until mid-summer or are perennial. The lower limit of perennial snowpatches is situated near 800 m a.s.l. in S- and near 500 m a.s.l. in N-Iceland. Most of the nivation and cryoplanation forms are located in basaltic areas. In the hyaloclastite area snow-filled "nivation ravines" are more common.

Asymmetric valleys are another characteristic feature of the periglacial meso-relief. Generally speaking the valleys of Iceland which have never been glaciated are box-shaped in form with a wide valley floor, just as in other parts of the arctic or subarctic. Valley asymmetry in Iceland is not connected with permafrost. Instead, it depends mainly on the varying snow filling of the valleys and on the position of seasonal or perennial snowbanks at the valley slopes (cf. SCHUNKE, 1975). The position of snowbanks controls the distribution of the above-mentioned nivation processes, thus causing different rates of slope retreat and lateral erosion on opposite valley sides. Valley asymmetry in Iceland depends mainly on varying lee- and luff-effects. It must be classified as "niveo-fluviatile asymmetry" in the sense of KARRASCH (1970: 206). It is not a primary or a secondary asymmetry which, according to POSER (1947, 1948) is the result of varying depths of the acitve layer on south- and north-facing slopes.

Valley-asymmetry is limited to the Central Highlands, and is most apparent in hyaloclastitic rocks of low resistance.

Periglacial Phenomena Connected with Permafrost

The following periglacial forms are always connected with permafrost which in Iceland only occurs as sporadic permafrost (cf. PRIESNITZ & SCHUNKE, 1978). The main distinction is between aggradation and degradation features.

The only forms related to aggradation of permafrost in Iceland are palsas. Different morphological types have been observed, namely hump-, shield-, dike-, ring-, and plateaushaped. They occur in bogs or fens, always in groups (cf. Fig. 5). They may reach heights up to 3 m and diameters up to 30 m. Palsas vary as to the material: most are built of peat but those with a core of mineral soil are also numerous (about 20% of the total number). The frozen core consists usually of segregation ice although some exceptions contain massive ice (cf. SCHUNKE, 1981). Palsas only occur in the highlands, mainly localised in the bog and fen areas which are scattered oasis-like, over the groundmoraines and sandur surfaces. The lower distribution limit is situated near 450 m a.s.l.

A few string bogs are found in the southern parts of Central Iceland at about 400 m a.s.l.

Two forms due to the degradation of permafrost may be distinguished, namely thermokarst depressions (alasses) and thermokarst mounds. The two occur together as well as separated from each other.

Thermokarst mounds may be hump-shaped, dike-shaped, ring-shaped or plateau-shaped. There exists a perfect formal convergence to palsas. All kinds of forms can be observed in one area resulting from the degradation of the same permafrost plateau.

The differences between thermokarst mounds and palsas mainly concern their inner structure: Thermokarst mounds contain less peat, the dominant ice type is pore ice, and the stratification is not domed but more or less horizontal. The genesis of thermokarst mounds by degradation of a permafrost plateau can be induced by different processes: by deflation following cracking of the vegetation cover by frost action, by fluvial erosion and by animal acitivity. Thus, these degradation features are not significant of a climatic change in the sense of temperature increase.

Thermokarst depressions are common in Icelandic bogs and fens. In most cases they are waterfilled.

Fig. 5: Recent palsas at the Icelandic highlands. Background: The Kerlingarfjöll mountains (1,477 m). Blágnipuver, Central Iceland, 710 m (08/27/1982).

Abb. 5: Rezente Palsas im isländischen Hochland. Im Hintergrund: Kerlingarfjöll-Bergland (1,477 m). Blágnípuver, Zentralisland, 710 m (08/27/1982).

	Highlands (> 250 m a.s.l.)		Lowlands (< 250 m a.s.l.)	
	Central	Marginal	Southern	Northern
Block fields, scree slopes	×	××	—	—
Pingos	—	—	—	—
Palsas	××	×	—	—
String bogs	×	—	—	—
Earth hummocks (thufurs)	×	××	××	××
Frost crack polygons with ice wedges	—	—	—	—
Frost crack polygons without ice wedges	××	—	—	—
Sorted patterned ground (large forms)	×	××	×	×
Nonsorted patterned ground (large forms)	×	—	—	—
Sorted patterned ground (small forms)	×	××	××	××
Nonsorted patterned ground (small forms)	×	×	×	×
Gelifluction sheets	××	××	—	—
Gelifluction terraces	××	××	—	—
Gelifluction lobes	××	××	—	—
Braking blocks, ploughing blocks	×	×	—	—
Block streams	×	×	—	×
Stone pavements	××	×	—	—
Gelideflation cliffs	××	××	××	××
Gravel pavements with ventifacts	××	×	×	×
Rock glaciers	×	—	—	—
Rectilinear slopes	×	×	—	—
Tors	×	×	—	—
Nivation hollows, cryopediments, cryoplanation terraces	××	××	—	—
Aquatic landforms (flat-floored valleys, gullies, rill- and slopewash)	××	×	—	—
Asymmetric valleys	×	—	—	—
Thermokarst features (thermokarst mounds, thaw lakes)	××	—	—	—

×× common   × rare   — absent

Fig. 6: Table on the distribution of recent periglacial phenomena in Iceland.

Abb. 6: Tabellarische Übersicht zur Verbreitung rezenter Periglazialerscheinungen auf Island.

They are caused by local degradation of permafrost. Some of the thaw lakes are oriented having their long axes — very similar to other areas (cf. WASHBURN, 1979) — at right angles to the dominant wind direction.

In many cases the form of thermokarst depressions depends on the position of the thermoerosion-cliffs (ground ice slumping scarps, cf. MACKAY, 1966), which are mostly south-facing.

Some thaw lakes start as elongated forms at the southern edge of a permafrost plateau with their long axes oriented east-west. Subsequently, they grow to a more rounded form. Others start on the permafrost plateau as circular alas depressions and then become elongated in a north-south direction by the faster retreat of the south-facing scarp accelerated by insulation.

As permafrost is limited to the Central Highlands, the degradation phenomena are also restricted in occurrence.

The distribution of periglacial forms in Iceland (Fig. 6) indicates that there must be marked differences in basic climatic parameters. The rich periglacial inventory of the Central Highlands of Iceland reflects its arctic character; besides the climatic conditions edaphic conditions help to explain the occurrence, distribution and frequency of periglacial phenomena.

SIGNIFICANCE OF PERIGLACIAL LANDFORMS

The following description of the climatic conditions of the Central Highlands is based on data from the Hveravellir Station (642 m a.s.l.). This station, the only one in Central Iceland, has been operating since 1966. The main thermal parameters concerning the period 1966 to 1979 are illustrated in Fig. 7. The Highlands experience an ET-climate following Köppen. The annual precipitation is 748 mm, about 71% falling as snow.

The freezing index, the number of freeze-thaw cycles, the number of days with temperatures below 0° C, and the freezing intensity are the most important climatic parameters. In addition, because of its importance to vegetation and the thawing processes, the warming index is also of interest. The mean annual freezing index is 1175° C·d, the extremes being 1379° C·d (1969/70) and 844° C·d (1971/72). There are 238 days with temperatures below 0° C, 108 of them are freeze-thaw days and 130 days experience maximum temperatures below 0° C.

Freeze-thaw cycles occur in every month, mainly during September/October and during April/May. The freezing intensity (i. e., the average temperature of all days with freezing temperatures), is 6.2° C. The warming index amounts to 765° C·d. These thermal data are characteristic of an arctic climate, comparable to that of W-Spitsbergen.

There is a continuous snow cover lasting 192 days, that is from November until May. The average maximum snow depth is 0.88 m with extreme values of 1.39 m (1975/76) and 0.35 m (1966/67). The strong winds cause considerable variations in the depth of snow.

	Highlands (>250 m a.s.l.)		Lowlands (<250 m a.s.l.)	
	Central Hv.	Marginal Grst.	Southern Vm.	Northern Mnbk.
Annual temperatures (°C)	−1.2	0.1	4.8	2.6
Temperatures of coldest month (°C)	−6.9	−5.8	1.5	−1.9
Temperatures of warmest month (°C)	6.8	8.3	9.6	9.0
Abs. minimum temperatures (°C)	−30.4	−30.0	−16.9	−22.9
Number of days with daily mean temperature below 0 °C (d)	190	161	49	117
Number of days with daily mean temperature below −10°C (d)	40	35	1	6
Degree days below 0°C (−°C·d)	1175	992	152	472
Degree days above 0°C (°C·d)	765	1080	1895	1415
Number of days with freeze-thaw cycles (d)	108	99	65	92
Number of days with maximum temperature below 0°C (d)	130	115	21	70
Frost intensities ($-°C \cdot d^{-1}$)	6.2	6.1	2.8	3.7
Annual precipitation (mm)	748	347	1635	548
Snowfall of total precipitation (%)	71	65	33	55
Number of days with complete snow cover (d)	192	176	11	95
Maximum snow depth (cm)	87.7	39.6	11.6	28.1

	Hv.		Smst.	Ak.
Duration of ground freezing period (d)	241		130	120
Depth of seasonal frost penetration (cm)	150		25	30
Number of days with freeze-thaw cycles at 10 cm depth (d)	9		16	29
Number of days with freeze-thaw cycles at 50 cm depth (d)	6		0	0

Hv.-Hveravellir (642 m a.s.l.) Grst.-Grímsstadir (384 m a.s.l.)
Vm.-Vestmannaeyjar (118 m a.s.l.) Mnbk.-Mánárbakki (17 m a.s.l.)
Smst.-Sámsstadir (90 m a.s.l.) Ak.-Akureyri (23 m a.s.l.)

Fig. 7: Table on thermal and frost-climatic parameters of the Icelandic highlands and lowlands. Mean values of the period 1965—1979 (Values after LIEBRICHT, 1982).

Abb. 7: Tabelle thermischer und frostklimatischer Parameter im isländischen Hochland und Tiefland. Mittelwerte der Beobachtungsperiode 1965—1979 (Werte nach LIEBRICHT 1982).

The pronounced differences between the highland station and the lowland stations of Vestmannaeyjar (118 m a.s.l.) and Mánarbakki (17 m a.s.l.) can easily be recognized in Fig. 7.

The marked differences of air temperature also cause significantly distinct soil temperature regimes (cf. SCHUNKE & STINGL, 1973). Generally, the lowlands experience seasonal freezing of the ground which does not penetrate deeper than 0.3 to 0.5 m. There is not a clear variation with increasing latitude. Seasonal freezing is interrupted by many thawing phases: 20 to 30 freeze-thaw cycles in the ground (at 0.1 m depth) are usual. They reach a maximum frequency in November/December and March/April, but they may also happen in the middle of winter.

In the highlands, however, the depth of seasonal freezing exceeds 1.5 m. Another distinction is that, during the winter months (October to May), the soil stays permanently frozen. The number of freeze-thaw cycles is small (6 to 8) and they are limited to the beginning (September/October) and the end (May/June) of the winter. The duration, depth and temperature of seasonally frozen ground in Central Iceland approach permafrost conditions. The main controlling factors, with the best correlation fit with ground freezing depth and duration, are the freezing index of the air, the snowcover and the occurrence of special edaphic conditions.

The differences between the ground-freezing regimes of the lowlands and the highlands explain the hypsometric variation of periglacial features in Iceland. Contrary to the lowlands, the highlands everywhere offer climatic conditons sufficiently severe to allow the formation of periglacial features. If however, these features are absent in extensive parts of the highlands, then other factors rather than climatic ones must be the cause: these are edaphic in nature.

The widespread loose, unconsolidated materials can be grouped into four types: (a) allochthonous extremely permeable sands and gravels, (b) allochthonous loess-like silts ("móhella"), (c) autochthonous block debris fields with more or less fines on basalt outcrops and (d) autochthonous sandy-stony debris of hyaloclastites. These loose materials are underlain by highly porous and pervious hyaloclastites or by basalts with a low permeability.

The factor controlling whether or what kind of periglacial features occur is not so much mineralogy but mainly granulometry. The latter is decisive of the moisture and of the susceptibility to both cryoturbation and frost heave.

Characteristic features on móhella soils are turf hommocks, frost-crack polygons, gelifluction and deflation forms. On sandy-gravelly groundmoraine and sandur surfaces gravel pavements with ventifacts, stone pavements, frost-crack polygons, nonsorted circles and some gelifluction forms are typical. In bog or fen areas of both debris types, palsas and thermokarst features are common. On block fields rich in fines gelifluction and sorted patterned ground phenomena are predominant.

Of all the periglacial features in Iceland which are developed in loose debris, palsas and frost-crack macro-polygons require the most severe freezing regime of an arctic type. So they have special significance. Since the 1960's, both forms are known to experience a considerable increase in number and intensity of formation (cf. FRIEDMAN et al., 1971; PRIESNITZ & SCHUNKE, 1978; SCHUNKE, 1981). As the edaphic conditions have stayed constant, the climatic parameters of Hveravellir cited above must mark the critical or minimum values for the formation of these features.

CONCLUSIONS

Considering the special position of Iceland within the polar periglacial zone as an entirely volcanic island, the question arises as to what extent the periglacial features represent the normal zonal inventory or are exceptional. The main points that distinguish the Icelandic periglacial environment seem to be the following:

1) Occurrence and distribution of periglacial forms depend much more upon bedrock resp. soil material properties than in other periglacial regions.
2) A series of factors, which indicate the youthfulness of most surface features and deposits, the low restistance of many rocks to weathering, recent isostatic uplift, and previous glacial modelling, produces morphological activity and erosion rates far above the average.
3) The permeability and edaphic aridity of the widespread sandy and sandy-gravelly sediments cause a poverty in periglacial micro-forms, and a lack of runoff and slopewash features as well as of vegetation, which allows deflation to become important.
4) The silty móhella that covers wide areas is responsible for the frequency of turf hummocks (thufurs) and deflation islands. These are rare in other periglacial regions.
5) There is a strong influence of human activity on the vegetation (deforestation, pasture . . .) and therefore upon the distribution of periglacial phenomena such as turf hummocks, and deflation phenomena.

In summary, it may be said that the differentiation of periglacial phenomena in Iceland depends mainly on (normal) hypsometric and (rather special) granulometric reasons.

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