Polarforschung 53 (2): 21—29, 1983

Icelandic Perspectives on Periglacial Research

By M. J. Clark*

Summary: This report focusses on general themes which were discussed during the IGU-Periglacial Commission field excursion on Iceland in 1982 and evaluates their significance within the broader context of present and future perspectives of periglacial research: problems of terminology, classification of periglacial phenomena on morphological and genetic grounds, the relationship between periglacial, proglacial and paraglacial conditions, the distinction between permafrost and deep seasonal frost, the function of a conceptional model for periglaciation and the role of non-climatic factors in the periglacial environment are discussed.

Zusammenfassung: Dieser Bericht greift wesentliche Themen auf, die während der Feldkampagne der IGU-Periglaziärkommission auf Island 1982 diskutiert wurden, und stellt sie kritisch bewertend in den größeren Zusammenhang gegenwärtiger und zukünftiger Schwerpunkte der Periglaziärforschung. Zu diesen Fragestellungen gehören Probleme der Terminologie, die Klassifikation von Periglaziärerscheinungen nach morphologischen und genetischen Kriterien, die Steuerung rezenter periglaziärer Formung durch präexistente glazigene und glaziäre Prozesse und Ablagerungen, die unterschiedliche Einflußnahme von Permafrost und intensiver saisonaler Gefrornis, die Entwicklung eines umfassenden Modells periglaziärer Formung, die Rolle aklimatischer Faktoren im periglaziären Milieu.

INTRODUCTION

The Icelandic field meeting of the International Geographical Union Commission on the Significance of Periglacial Phenomena brought together scientists from nine countries to discuss present problems and future priorities of periglacial research. The aim of this paper is to explore the extent to which these features may be used to identify general issues of importance to periglacial research.

The location map (Fig. 1) demonstrates that the penomena examined are concentrated within the Central Highlands of Iceland, a region with considerable access problems for both reconnaissance and systematic research. The absence of permanent settlement in this huge region, apart from a single weather station at Hveravellir, highlights the familiar data-deficiency problems common to most areas of current periglaciation, and is a partial explanation of the extent to which Icelandic investigations have tended to focus on morphology and material rather than on process. Nevertheless, the sites investigated do offer considerable scope for process speculation, since they represent several well-marked environmental contrasts — altitudinal, latitudinal, geologic and edaphic — which can be used to infer likely process explanations for observed morphological attributes and distributions. Whether such inference can be accepted as anything other than a basis for interim explanation pending more rigorous hypothesis-testing is clearly open to debate.

The Icelandic landscape provides a context within which to discuss both specific problems of periglacial geomorphology and more general issues of approach to geomorphological investigation or of priorities for future research. In several senses, therefore, the topics raised briefly below are highly pertinent to a consideration of the "significance" of periglacial phenomena.

LESSONS OF THE ICELANDIC EXPERIENCE

Although it is always conceded that there are several categories of periglacial environment (maritime and continental, or Icelandic and Siberian, being two relevant examples), the extent to which this range of environment can reflect variation in form and process can easily be underestimated by a researcher working exclusively in one region. Excursions in Lapland in 1980 (KARTE, 1980), Belgium and Netherlands

*Dr. M. J. Clark, Geography Department, University of Southampton, Southampton S09 5NH (U.K.).

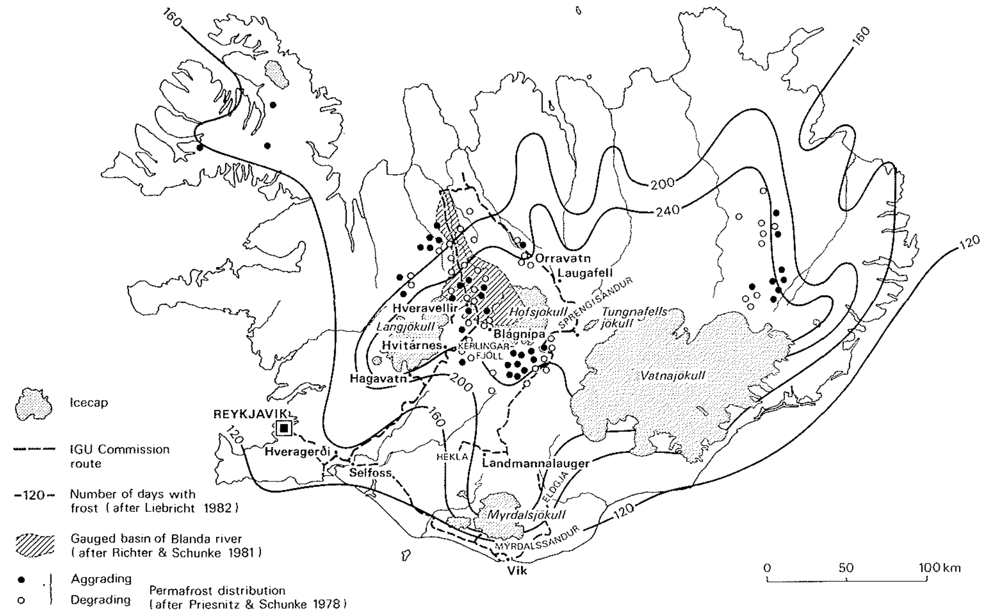

Fig. 1: Location map of Iceland showing the IGU Commission excursion route, major topographic features, and permafrost-related information (after PRIESNITZ & SCHUNKE, 1978).

Abb. 1: Übersichtskarte von Island mit der Exkursionsroute der IGU-Kommission, vereinfachter Topographie und Angaben zum Permafrost (nach PRIESNITZ & SCHUNKE 1978).

(1978) and Japan (ONO et al., 1982) provide a background to the present discussion, which focusses on six distinct but related issues.

Problems of nomenclature

It is clear that despite several decades of effort, periglacial science still lacks a rigorous and unambiguous terminology. Many existing terms have both morphological and genetic overtones, leading to different usage depending on which of these two attributes is stressed. Even if the inertia of past usage could be overcome, it remains difficult to design an ideal terminology. Tight definition has the advantage of precision, but leads to a burdensome proliferation of sub-types in order to encompass the full range of associated features. On the other hand, if a broad definition is chosen so as to emphasize major similarities rather than minor differences, then there is a danger that a single term will be applied by different workers to genetically distinct features.

Two particularly relevant examples of this problem are the terms thufur and sandur — both of Icelandic origin, and offering an interesting contrast between "type-site" (i. e., original) meaning and common usage in the periglacial literature. The true Icelandic thufur (Fig. 2) has diagnostic characteristics of morphology, material and process which distinguish it from other forms of hummock (SCHUNKE, 1977). Examination of several thufur fields in 1982 confirms that the use of the term thufur as either synonymous with, or a subset of, the term earth hummocks leads to both descriptive and explanatory confusion. The Icelandic sandur illustrates the opposite case in which the type-site meaning is much wider than the subsequent technical usage. The original meaning is dominated by the attribute of absence of vegetation (edaphic desert), so that some of the largest examples such as the Sprengisandur (Fig. 3) bear little physical or genetic resemblance to the geomorphological concept of pro-glacial or periglacial sandur, whilst others such as Myrdalssandur are much closer — albeit with a much greater reliance on extreme

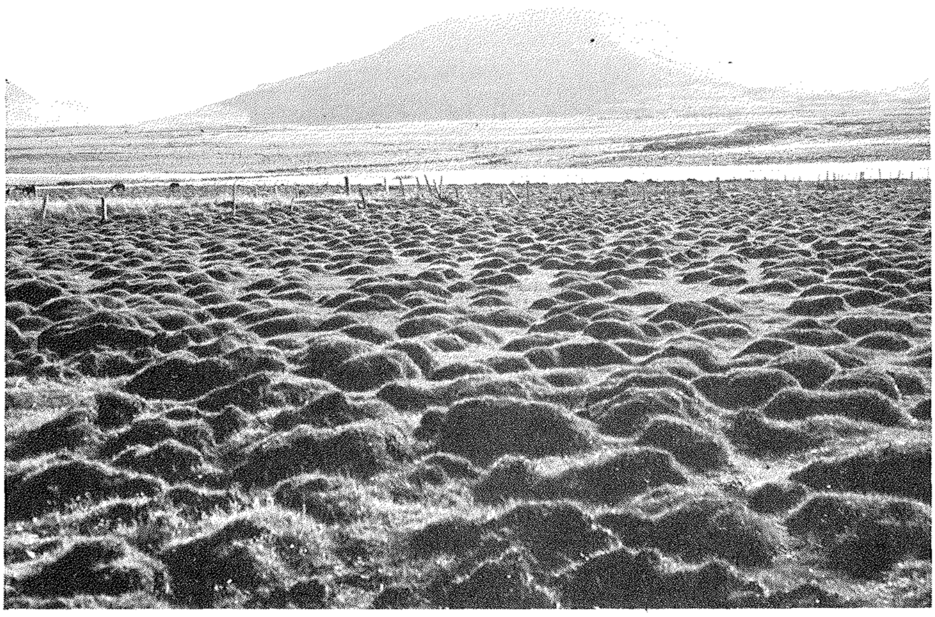

Fig. 2: Thufurs in the lowlands of northern Iceland, near Audbuluheidi. Note their absence in the adjacent cultivated fields.

Abb. 2: Thufur im nordisländischen Tiefland bei Audbuluheidi. Auffallend ist, daß sie auf den benachbarten bearbeiteten Feldern nicht auftreten.

jökulhlaup events than would normally be the case. The resulting differences in interpretation are sufficiently significant to justify publication of an expanded multilingual periglacial glossary.

The use of morphological classification

The terminological problems associated with thufurs typify the difficulty of erecting a satisfactory geomorphological classification based on morphology alone. The true thufur, as described by SCHUNKE (1977), is created by seasonal frost, ice segregation, and limited fine-particle eluviation within a cell-like net. Similar forms in Canada tend to relate either to small desiccation cracks with vegetation-stabilized centres and meltwater scoured margins, or to upward soil flow and cryoturbation at the centre associated with a depression of the permafrost table to give an approximate mirror-image of the ground surface (e. g., MACKAY, 1980; SCOTTER & ZOLTAI 1982). In such cases, the incorporation of all the resulting forms within a single genetic term, however broadly defined, is inappropriate.

Another potential source of classificatory conflict within the Icelandic context concerns the application of the term palsa. General geomorphological usage has been codified by SEPPÄLÄ (1972), primarily on the basis of Fennoscandian typesites, suggesting that the term should be restricted to areas of peat within which ice-segregation induces mound formation by uplift. This strict use certainly applies to many active features in the Blágnipa bog south-west of Hofsjökull and around Orravatn to the north of this icecap. However, the extension of the term to include so-called palsa plateaus (SCHUNKE, 1973) is more problematic. Such plateaus (Fig. 4) are interpreted by SCHUNKE (1933) as remnants of an original land surface created by peat formation and the accumulation of móhella (wind-blown silt) in old lake basins. Following aggradation by permafrost either during or after deposition, the terrain is carved into blocks by a combination of stream incision and pool-edge back-wearing thermokarst. Since the plateau has not been uplifted by ice segregation, it is genetically distinct from the true palsa which grows in the depressions surrounding the retreating plateau edges. Further confusion derives from the fact that the term palsa pla-

Fig. 3: General view of the Sprengisandur, Central Highlands of Iceland.

Abb. 3: Überblick über den Sprengisandur, zentralisländisches Hochland.

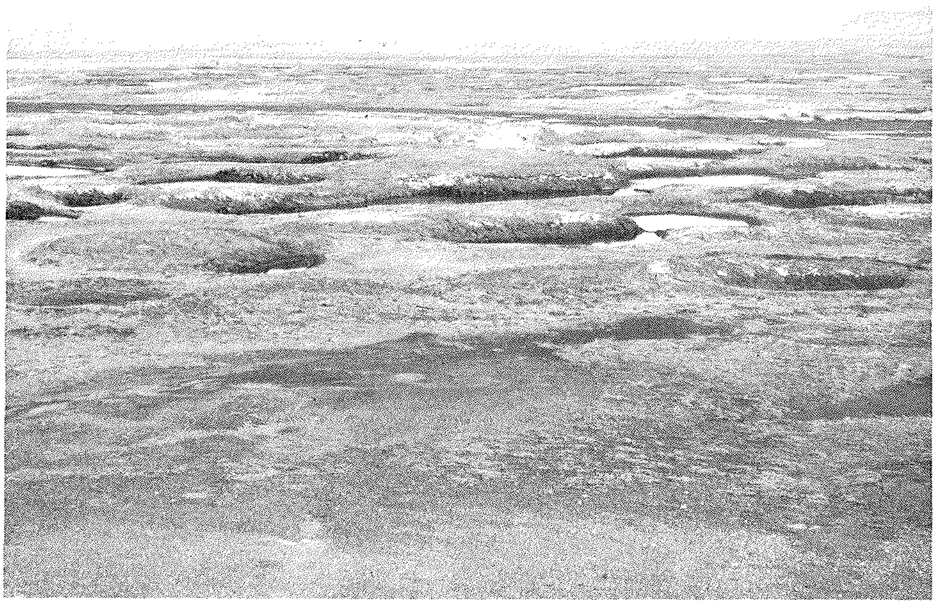

Fig. 4: Permafrost terrain occurs in association with organic material and poorly drained sites near Nyidalur, Central Highlands of Iceland.

Abb. 4: Permafrostgelände in Verbindung mit organogenem Material und schlecht entwässerten Standorten bei Nyidalur, zentralisländisches Hochland.

teau has already been applied to uplifted forms in Fennoscandia and Canada. In the circumstances, it may be preferable to reserve a separate term for the Icelandic permafrost-cored plateau remnants, perhaps based on the Icelandic rust (for the mounds) or rustir (for the area of mounds and pools).

These two examples highlight the more general problem of ensuring a clear and consistent terminology and classification for a science concerned with a globally variable set of phenomena.

The relationship between periglacial, proglacial and paraglacial conditions

Problems of definition are also apparent in the overlap between the notions of periglacial and proglacial geomorphology. The blending of the glacial and periglacial systems is of particular importance in the context of hydrology since glacier-fed rivers exhibit different seasonal and diurnal discharge patterns to those of snow-fed basins, which are in turn quite distinct from precipitation-dominated rivers. The development of periglacial hydrology is hampered by problems of data quality and quantity. Studies of the Blanda River in Iceland (RICHTER & SCHUNKE, 1981) are significant therefore, in the light of the unusually long discharge record for this river. Unfortunately, the denudational implications of fluvial sediment transport in these rivers are limited by inadequate sediment sampling frequency and design.

In this context, the significance of paraglacial conditions (CHURCH & RYDER, 1972), referring to the dynamic and possibly critical geomorphological environment found at the peak of the glacial decay phase, must be highlighted. With young unconsolidated sediment, seasonal fluvial discharge peaks at their maximum, and vegetation development at a minimum, considerable geomorphological dynamism would be expected in the periglacial zone. With the process rate thus enhanced, many of the larger periglacial features might owe their origin to this phase (or to a sequence of such phases during a multiglacial period). Thus, while many Icelandic valleys exhibit the characteristic box-shaped cross section which may be in equilibrium with the current hydrological regime, others were found to have a marked ''two-stage'' profile. In such cases (and in many others in the arctic environment), a major valley-cutting phase might relate to paraglacial conditions, leaving current conditions only responsible for minor channel incision within the larger valley. Regardless of its detailed implications for morphological explanation, however, the notion of a paraglacial activity peak in periglacial areas does have major repercussions in terms of the validity of long-term extrapolation of erosion rates or sediment transport rates, since it is quite clear that extrapolation from paraglacial to periglacial phases or vice versa is wholly unjustified.

Distinctions between permafrost and deep seasonal frost

Behind much of periglacial geomorphology is the desire to distinguish periglacial from non-periglacial phenomena, and to identify diagnostic criteria for environmental predictive purposes. One important and problematic aspect is to determine the role of deep seasonal frost as opposed to permafrost in the formation of periglacial phenomena. Iceland is an excellent location for such discussion, since permafrost is, at best, marginal.

A case in point is the development of frost cracks and their integration into macro and micro polygonal patterns. Although sometimes referred to as tundra polygons in the literature, the Icelandic forms such as those examined at Hvitárnes (east of Langjökull) and Orravatn (north-east of Hofsjökull) show no sign of present or past incorporation of ice wedges. Their surface expression is a partial polygonal net of 20 to 30 cm wide grooves in tundra vegetation on móhella silts (Fig. 5a). Sections demonstrate signs of crack disturbance to depths of 60 to 80 cm, with a sand infill lacking vertical foliation. Some structural downturning of surrounding sediments was observed. Active cracks 5 to 10 mm in width cut cleanly through both surface sediments and vegetation, suggesting that cracking is a winter (frozen ground) process. Similar forms of polygon were examined at the edge of Sprengisandur close to Tungnafellsjökull, developed in a vegetation-free stony sand (Fig. 5b). Reasons for localization of polygons in this and a few other parts of Sprengisandur is that at depths of about 30 cm there is a zone of higher silt content than is present in surrounding areas. The shallow depth of cracking, the apparently primary nature of the sand in-

Fig. 5: Frost fissures and macro polygons, Central Iceland, on Sprengisandur.

Abb. 5: Frostspalten und Makropolygone in Zentralisland auf dem Sprengisandur.

fill, and the absence of the high rims normally associated with active ice-wedge polygons in permafrost regions all suggest that these features are the product of seasonal frost cracking. If this is the case, then 'tundra polygon' may be an inappropriate term, and the substitution of frost fissure polygon or primary soil wedge polygon would be preferable. A further implication is that surface macrocracking, visually very prominent when picked out by linear vegetation patterns, is not a reliable indicator of past or present permafrost.

A similar questioning of the role of permafrost is pertinent in the context of the micro sorted stripes and sorted polygons commonly found on low angle footslopes, plateau surfaces and zones of micro-relief in the vegetation-free parts of the Central Highlands. Although a pebble lag surface is often present, high silt contents below this surface can lead to supersaturation and high sediment mobility during the melt period. While needle ice and surface wash may be contributory factors, the transition of well-marked stripes into closed nets as slope angle reduces suggests that other processes are also at work. Nevertheless, sections show that the coarse stripes are no more than 5 to 10 cm deep, and certainly would not require anything older than seasonal frost for their formation. The very small scale of the features may relate simply to the paucity of the coarse fraction.

The function of a conceptual model for periglaciation

Periglacial geomorphology must develop a comprehensive (i. e. integrative) conceptual model through which to identify research priorities, formulate research designs and interpret results. In the absence of such a framework, research may become fragmentary and limited to a descriptive/classificatory level. It may be that periglacial studies in Iceland (and elsewhere) have now developed to the point where general model building could play a creative and useful role. However, the search for, and evaluation of, a general periglacial model may fail to identify a single agreed formulation. For example, those who are concerned with slope processes, sediment yield and denudational development of the periglacial landscape may welcome an integrating model built around snowpack processes viewed as a system in dynamic metastable equilibrium. Others however, concerned with Quaternary paleogeographic reconstruction, will reject

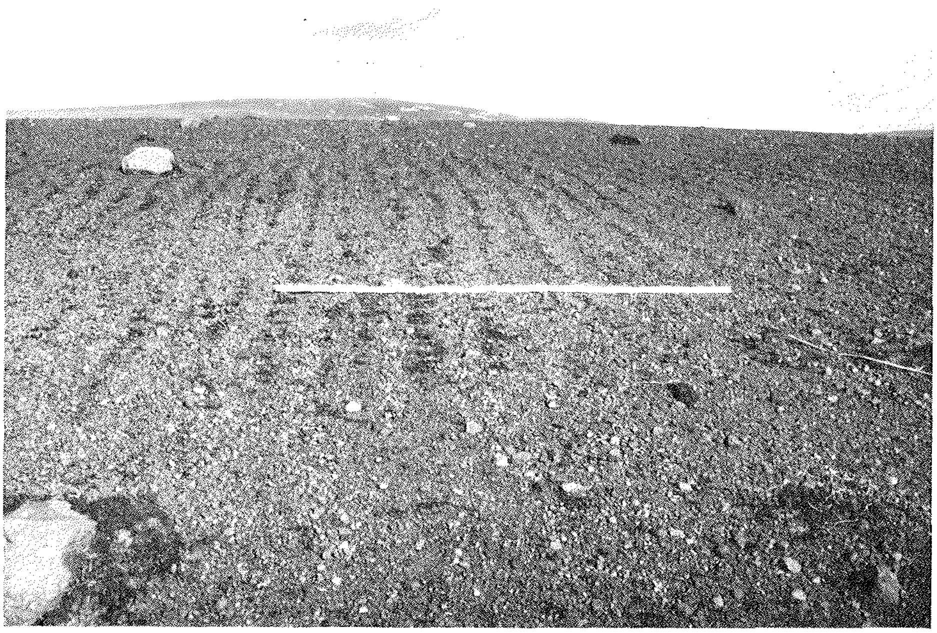

Fig. 6: Micro scale sorted stripes, Central Highlands of Iceland.

Abb. 6: Streifenbodenkleinformen im zentralisländischen Hochland.

such a unifying model, not because it is wrong, but simply because it is not central to their own research priorities.

Caution is necessary when one considers the role of lower level process models incorporating relatively small segments of the periglacial system. The valuable framework of preconception can operate negatively to produce subconscious observational bias and interpretative restriction. The tendentious issue of nivation (i. e. process and resulting form) is an excellent example of this tendency. In the Icelandic context it can be argued that nivation is an active periglacial process based on sub-snow micro-gullying, wash and solifluction producing hollows by increasing the inflexion of initial slope concavities and using frost to prepare material for evacuation. Proponents of this view draw support from the visual association between summer snow patches and existing hollows, and from the extreme mobility of saturated debris at the lower retreating margins of snow patches. Opponents argue that nivation is an ill-defined concept encompassing a varied suite of processes, many of which take place beyond the snowpatch rather than beneath it. On this basis, slope concavity is generally interpreted as a product of sheetwash, with soliflual convexity being found further down the ''apron'' in front of the snowpatch. Crucial to the debate is a detailed understanding of the temperature and moisture conditions throughout the year beneath and around the snowpatch. Such information is rarely available, rendering much of the current argument speculative. In part, the intensity of the debate reflects the power of strongly-held model assumptions, but it also indicates a possible underestimation of inter-site variations. Arctic/continental/high altitude snowpatches may output only 30% of their water content as runoff, rendering the patch itself passive and concentrating geomorphic activity beyond the snow margin. Temperae/maritime/low altitude snowpatches may, on the other hand, output 70% as runoff thus greatly increasing the possibility of erosion, transport and even weathering beneath the snow. If a general model is to be applied in periglacial geomorphology, then it must be flexible enough to incorporate a considerable degree of environmental variability.

Non-climatic factors in marginal periglacial areas

A specific motivation for the study of periglacial phenomena in Iceland is that factors other than macro-climate are significant. Since local edaphic site factors are so dominant, all features (thufurs, frost polygons, sorting intensity, microstripes, lobes etc.) exhibit complex distribution patterns. Paradoxically, it may be that Iceland is particularly suited to deductive morphologically-based reasoning, and that the need for substantial inputs of process data is not quite as great here as it would be in other periglacial environments (e. g. high-arctic areas). It is also difficult to avoid the conclusion that the regionalization and interpretation of periglacial phenomena in Iceland is currently based upon air climate rather than ground and soil climate. As stressed by PRIESNITZ & SCHUNKE (1983) it appears likely that moisture availability is sufficiently important to warrant study at a level of detail beyond that provided by surrogate morphological indices such as particle size distribution or indicator plant species. Even in the absence of such detail, however, Iceland remains a valuable location within which to assess the significance of factors controlling the broad pattern of distribution of periglacial phenomena.

OVERALL PERSPECTIVES

Periglacial geomorphology is characterised by diversity of aspiration and approach. At the broadest level, one may distinguish between those who are concerned with palaeo-environments and problems of classification, and those who focus on process-explanation and prediction.

Interest in Pleistocene environmental reconstruction tends to place a premium on skills of spatial and temporal classification and mapping. The designation of limits and stages revolves around tasks of stratigraphical correlation. In this context, specific periglacial features are of value mainly as relict indices of past environment — and emphasis is thus placed on the diagnostic attributes of the feature rather than on process explanation in its own right. With the concern for identification and classification of indices will come a tendency towards analysis rather than synthesis. The classical approach is based on meticulous recording of observations for type sites, which are frequently chosen on the basis of access (a quarry face or river bank) rather than as a product of a conscious sampling design. Stratigraphical evidence prevails over surface morphology and, apart from the limited use of morphometric properties, such studies are not heavily quantitative. The investigative process is often lengthy and usually dominated by the interest of the individual scientist.

Those studies which centre on the present process system tend to have very different characteristics. The extreme temporal and spatial variability of the attributes used in the investigation of process-form-material interactions renders quantitative observation and data processing imperative. Realtime instrumentation and morphological monitoring combine with access problems to increase project budgets and reduce average duration. The investigative phase may in detail be controlled by rigorous scientific design, but overall location and topic are often heavily influenced by logistic and contract constraints — the latter indicating the extent to which such studies have come to exhibit (or at least claim) applied rather than purely academic targets. The systems dimension frequently renders synthesis as important as analysis, and encourages active interdisciplinary contact. This, together with logistic problems and time limitations, increases the use of team research rather than individual work.

These distinctions reveal some of the associations of expectation and preconception which colour much debate in periglacial geomorphology. What may appear to be criticisms of achievement are often, in fact, rooted in a contrast in aspiration. Given the power of the underlying conceptual model as a control of observation as well as interpretation, it is hardly surprising that periglacial geomorphology is characterized by a healthy intensity of controversy.

FUTURE PRIORITIES

To argue that the future of periglacial geomorphology lies in closing the gulf between contrasting viewpoints would be to fall into the trap of assuming that agreement and uniformity are signs of scientific success. Rather one might stress the advantages of concentrating on areas of potential conflict as the focus for fruitful discussion and investigation. It is relatively simple to argue that the stratigraphical/morphological approach could be strengthened by an input of quantitative process study. Less obvious, but no less important, is the realization that an over-dependence on instrumented micro study can reduce the general applicability of results, overlook the powerful deductive use of morphological and distributive patterns, and miss the opportunity to test the generality of models by applying them to relict mid-latitude situations. Icelandic landscapes contributed significantly to the early development of periglacial geomorphology. Today, by catalysing cooperative international ventures during the 1982 field meeting, they may be judged to play an equally important role in the scientific maturation of the subject.

ACKNOWLEDGEMENTS

This commentary draws extensively on views expressed by the delegates of the 1982 IGU Commission meeting, but its perspective and conclusions are the responsibility of the author alone and do not represent an official statement of Commission policy. Particular acknowledgements are made to Professor Dr. E. Schunke and Dr. K. Priesnitz, leaders of the excursion, who volunteered much information and experience concerning the periglacial conditions in Iceland.

References

Church, M. & J. M. Ryder (1972): Paraglacial sedimentation: a consideration of fluvial processes conditioned by glaciation. — Bull. Geol. Soc. Am. 83: 3059—3072.

Karte, J. (1980): Rezente, subrezente und fossile Periglaziärerscheinungen im nördlichen Fennoskandien. — Z. Geomorph. N. F. 24 (4): 448—467.

Liebricht, H. (1982): Das Frostklima Islands seit Beginn der Instrumentenbeobachtung. — Ph. D. Thesis, University of Bamberg, 125 pp., Bamberg.

Mackay, J. R. (1980): The origin of hummocks, western Arctic Coast, Canada. — Canadian J. Earth Sci. 17 (8): 996—1006.

Ono, Y., Hirakawa, K. & S. Iwata (1982): Meeting and field excursion of the International Geographical Union Co-ordinating Committee for Periglacial Research, Hokkaido, Japan, August 1980. — Arctic & Alpine Res. 14 (2): 167—172.

Priesnitz, K. & E. Schunke (1983): The significance of periglacial phenomena in Iceland. — Polarforschung 53 (2): 9—19.

Priesnitz, K. & E. Schunke (1978): An approach to the ecology of permafrost in Central Island. — Proc. 3rd Intern. Permafrost Conf. Edmonton 1: 473—479, Ottawa.

Richter, K. & E. Schunke (1981): Runoff and water budget of the Blanda and Vatnsdalsa periglacial river basins, Central Iceland. — Res. Institute Nedri As, Hveragerdi, Iceland, Bull. 34: 1—44, Hveragerdi.

Schunke, E. (1973): Palsen und Kryokarst in Zentral-Island. — Nachr. Akad. Wiss. Göttingen, Math.-Phys. Kl. 2: 65—102, Göttingen.

Schunke, E. (1977): Zur Ökologie der Thufur Islands. — Ber. a. d. Forschungsstelle Nedri As, Hveragerdi (Island) 26: 1—69, Hveragerdi.

Scotter, G. W. & S. C. Zoltai (1982): Earth hummocks in the Sunshine Area of the Rocky Mountains, Alberta and British Columbia. — Arctic 35: 411—416.

Seppälä, M. (1972): The term "palsa". — Z. Geomorph. N. F. 16 (4): 463.