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FOSSIL PERIGLACIAL PHENOMENA IN CZECHOSLOVAKIA AND THEIR PALEOCLIMATIC EVALUATION

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SUMMARY

It is generally accepted, that during cold phases of Pleistocene permafrost developed in the area of the Central European Periglacial Zone. Many periglacial features bounded on Pleistocene permafrost were studied on the territory of Czechoslovakia (ice-wedge casts, large sorted patterned grounds, rock glaciers, cryoplanation terraces, cryopediments, post-cryogene textures, etc.) All these periglacial features generally imply mean annual air temperature 0 °C and lower. Therefore, fossil periglacial phenomena in the Central Europe can be used for the determination of the mean annual temperature increase since Pleistocene. According the author, the temperature increase was about 15 °C in lowlands and about 1° to 2 °C in high mountains of Czechoslovakia

INTRODUCTION

There is the extensive evidence, that during cold phases of Pleistocene permafrost developed in the area of the Central European Periglacial Zone. On the territory of the present-day Czechoslovakia probably developed continuous permafrost. Author presumes, that permafrost developed several times during the Pleistocene Period. The last Würmian permafrost melted about 10 000 years B.P.

The presence of permafrost in several cold phases of the Pleistocene is on the territory of Czechoslovakia recognized especially by the presence of periglacial phenomena bounded on permafrost. There are specially following Pleistocene periglacial features:

i. ice wedge-casts; when ice wedges melt as the result of environmental change, they leave polygonal depressions and intervening mounds; the space vacated by an ice wedge is filled with the bordering and overlying soil, resulting in ice-wedge casts; buried ice-wedge casts, often forming polygonal patterns, were described in various Pleistocene deposits on the territory of Czechoslovakia (e.g. K. Žebera, 1943, Q. Záruba, 1944, J. Sekyra, 1960, J. Demek—J. Kukla, 1969, etc.);

ii. large sorted patterned grounds, especially stone polygons were found on the present-day terrain surface and also buried in the pleistocene sediments; it is accepted, that fossil (inactive) forms exceeding 2 meters in diameter are presumptive evidence of former permafrost or at least of climatic conditions approaching it (A. L. Washburn, 1980, p. 348); such large stone polygons are reported from the Hrubý Jeseník Mts. (M. Prosová, 1954), Šumavské podhůří Piedmont in the Southern Bohemia (St. Chábera, 1955, J. Demek, 1969), Carpathians Mts. (e.g. Vysoké Tatry Mts. — J. Sekyra, 1960), etc.; the diameter of large stone polygons in the

Southern Bohemia (e.g. locality Na hradě near the town Vimperk) is over 10 meters, diameter of stone polygons in the Vysoké Tatry Mts. over 5 meters (J. Sekyra, 1960, Fig. 45);

iii. rock glaciers; there are relic glacier-like tongues and lobes of angular rock waste in the Vysoké Tatry Mts., Nizké Tatry Mts. and Hrubý Jeseník Mts.; rock glaciers are forming conspicious deposits in glacial cirques and at the heads of glacial throughs; about 50 localities of rock glaciers are known in Czechoslovak's mountains at the present-time; the origin and development of rock glaciers was connected with the cold Pleistocene climate, because rock glaciers contained the ground ice for more than 2 years and had the mean annual temperature below 0 °C;

iv. cryoplanation terraces; they are hillside or summit benches, that are cut in the bedrock, transect lithology and geological structure and are confined to cold climates; according some investigators, the terraces can form without permafrost (J. Demek, 1969), but recent work in Alaska by R. D. Reger and T. L. Péwé (1976) convinced them, that cryoplanation terraces are not only undoubted permafrost features, but that they record more rigorous climatic conditions than those required for ice-wedge polygons or large sorted patterned grounds; cryoplanation terraces are developed on many localities in Czechoslovakia; in the Bohemian Highlands they developed in Pleistocene in altitudes from 300 meters over 1 500 meters (T. Czudek—J. Demek, 1961, J. Demek, 1969) in Carpathians even higher. Their origin is probably connected with nivation and solifluction over permafrost in several cold phases of Pleistocene;

v. cryopediments; there are gently inclined erosional surfaces developed at the foot of valley sides or marginal slopes by cryogenic processes in Czechoslovakia, especially in less resistant rocks of Carpathians Mts.; the permafrost control of these forms is stil open to question in my opinion, but on numerous localities in the Southern Moravia, in the central part of Czechoslovakia, are cryopediments developed in loose and permeable deposits (e.g. in fine grained Miocene sands, silts, etc.); the development of cryopediments in such places could occur on impermeable permafrost table only; under present-day environmental conditions (mild humid climate) are these forms inactive (fossilized); the paleoclimatic significance of fossil cryopediments requires further research; nevertheless, they appear to be periglacial features indicative of at least near permafrost, if not permafrost conditions; in my opinion, at least some cryopediments on mentioned localities in the central part of Czechoslovakia are proof of the Pleistocene permafrost in Czechoslovakia;

vi. angular debris layers in caves; several Czech speleologists described layers of large angular debris divided by loam and clays of the Pleistocene age in Czechoslovak's caves; these angular debris layers are developed not only near to the cave entrances, but also deep in caves up to more than 100 meters below the contemporary terrain surface; in my opinion, these layers in deep caves can be related only to agradation and degradation of permafrost during cold and warm phases of the Pleistocene; otherwise, the temperature changes in mentioned caves cannot be suitable for frost shattering and formation of congelifractates in several periods of the Pleistocene;

vii. post-cryogene textures; depending upon its mode of origin and development, permafrost usually contains various kinds of ground-ice; "texture ice", involving ice crystals from some tens of millimetres up to a few centimetres in size, forms a typical cryogenic texture in the case of ground freezing; the type of texture depends on the genesis of the permafrost and the conditions under which it develops; during permafrost degradation, ground-ice thawing and changes of rock properties take place; on gentle slopes or in the case of low degree of saturation of ground with water, rock consolidation takes places, without any disturbance of the cryogenic texture; in places of ice crystals, fine cracks are preserved forming so-called post-cryogenic texture; the presence of several kinds of postcryogenic textures in deposits is the evidence of an earlier permafrost; various types of post-cryogenic textures are very common in different types of deposits in Czechoslovakia;

Climatic evaluation of fossil periglacial features in Czechoslovakia

The discussed periglacial features generally imply mean annual air temperatures 0 °C and lower and the presence of permafrost. Use of fossil permafrost features as paleotemperature indicators is complicated by problems of correct identification and dating, soil type, and local and regional environmental variables such as precipitation and vegetation. Nevertheless, the fact that certain maximum paleotemperatures can be reasonable established in places warrants expanded research in former periglacial areas to evaluate temperature increases to the present (A. L. Washburn, 1980, p. 327).

The paleoclimatic evaluation of some mentioned Pleistocene periglacial features on the territory of Czechoslovakia can be resumed as follows:

i. ice wedge casts; according T. L. Péwé (1966) the southern extend of active ice-wedges in Alaska is delimited by the −6 °C to −8 °C isotherm; on the basis of presently available datas, A. L. Washburn (1980, p. 392) has concluded that the −6 °C to −8 °C mean annual temperature criterion is probably too low a maximum for some areas and that −5 °C is preferable for normalizing and comparing various reported minimum temperature changes based ice-wedge casts and fossil permafrost soil wedges in different regions.

For the paleoclimatic analyse of Pleistocene ice-wedge casts we have chosen some typical localities as

- the locality near the village Boršice in the vicinity of the town Uherské Hradiště in the Southern Moravia, where are ice-wedge casts dated about 700 000 B. P., the contemporary mean annual temperature is 9,5 °C, during the ice wedge formation the mean annual temperature was lower by about 15 °C;
- the locality Předmostí u Přerova in the Central Moravia with ice-wedge casts dated as Würmian 3, the contemporary mean annual temperature is 8,6 °C, during the W3 was lower by about 14 °C;
- the locality in the brick-yard in the town Vyškov in the Central Moravia with Würmian (W3?) ice-wedge casts, contemporary mean annual temperature is 8,4 °C, during Würmian was lower by about 13—14 °C,
- the locality in the brick-yard near to the town Hranice na Moravě in the Eastern Moravia, where J. Sekyra (1960) described ice-wedge cast dated Würmian 3, the present-day annual mean temperature is 8 °C, during the W3 was lower by about 13 °C;
- the locality Záhoří nad Labem (J. Sekyra, 1960) in the Central Bohemia with Würmian ice-wedge casts, the contemporary mean annual temperature is 9 °C, in the Würmian Period was lower by about 14 °C;
- the locality Sedlčany in the Central Bohemia with Würmian ice-wedge casts (J. Sekyra, 1960), contemporary mean annual temperature is 7,5 °C, during ice-wedge formation was about by 12—13 °C lower;

— the locality Český Krumlov in the Southern Bohemia, where St. Chábera descibed Würmian ice-wedge casts; the present-day mean annual temperature is 6,9 °C, during the Würmian cold phases was lower by about 12 °C.

ii. large sorted patterned grounds and rock glaciers are evidence of mean annual temperatures of 0° to −2 °C. But for the locality of large stone polygons called Na hradě in the Šumavské podhůří Piedmont is probably more reasonable to accept values of R. P. Goldthwait (1976, p. 34). According this estimation the large sorted patterned grounds are indicated mean annual temperature −4 °C to −6 °C. The contemporary mean annual temperature Na hradě is 7,2 °C and during the Rissian and Würmian cold phases was probably lower by 12 to 13 °C. In high mountains with Pleistocene rock glaciers the difference in temperature was much smaller (about 1° to 2 °C).

iii. cryoplanation terraces; the paleoclimatic significance of these periglacial features is stil controversary; we tried to summarize the increase of mean annual temperatures since Pleistocene using some typical localities of Pleistocene cryoplanation terraces in Czechoslovakia and two criterion's — Demek's 0 °C and Reger's and Péwé's −12 °C (see Table 1); some values of temperature increase received by using the criterion of R. D. Reger and T. L. Péwé (1976) are very high (more than 20 °C).

Table 1. Paleoclimatic Evaluation of Cryplanation Terraces Localities on the territory of the Czech Socialistic Republic

Locality	Altitude (M a.s.l.)	Age	Contemporary mean annual temperature	Increase of mean annual temperature since Pleistocene after	
				Demek	Reger—Péwé
Sokol, Šumava Mts.	1253	R and W	3.7	3.7	15.7
Kleť, Šumava Mts.	1083	R and W	4.8	4.8	16.8
Na hrádku, Šumavské podhůří Piedmont	881	R and W	6.5	6.5	18.5
Vysoké kolo, Krkonoše Mts.	1506	R and W	0,2	0,2	12,2
Petrovy kameny, Hrubý Jeseník Mts.	1446	R and W	0.9	0.9	12.9
Rolandova skála, Hrubý Jeseník Mts.	900	W	4.9	4.9	16.9
Pasecká skála, Žďárské vrchy Highland	819	R and W	6.3	6.3	18.3
Tisá skála, Kutnohorská plošina Hilly-land	392	W	8.1	8.1	20.1
Réna, Krumlovský les Highland	319	R and W	8.8	8.8	20.8

CONCLUSIONS

The analyse of Pleistocene periglacial features on the territory of Czechoslovakia has confirmed the statement about the presence of thick permafrost in the Central Europe during the several cold phases of the Pleistocene. Further, the analyse has shown, that the periglacial features can be used for the determination of the mean annual temperature increase since the Pleistocene. The temperature increase was about 15 °C in lowlands and about 1° to 2 °C in high mountains. The contemporary permafrost in Czechoslovakia is controlled by local climatic conditions (blind ice caves in Slovakian Mts.), not by regional climate. Very high values of the temperature increase based on occurence of cryoplanation terraces (more then 20 °C in comparison with cold phases of Würmian and Riss Periods) are still open to question.

The interresting result is — in my opinion — that permafrost developed already in the Lower Pleistocene (about 700 000 years B.P.) in the area of the Central Europe. This result is in good agreement with new datas about permafrost development in Siberia.

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