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Preliminary results of ^{10}Be dating of glacial landscape in the Giant Mountains

JEAN-LUC MERCIER[1], JAN KALVODA[2], DIDIER L. BOURLÈS[3], RÉGIS BRAUCHER[3], ZBYNĚK ENGEL[2]

[1] Université Louis Pasteur, Strasbourg
[2] Faculty of Science, Charles University in Prague
[3] CEREGE, Université d'Aix Marseille III, Aix en Provence

ABSTRACT

The ^{10}Be exposure age method was applied to 21 samples of crystalline rocks from cirques, roches moutonnées, tors and glacial sediments in two valleys of the Giant Mountains in the Bohemian Massif: the Obří důl and the Labský důl Valleys. Geomorphological evidence combined with ^{10}Be dating shows that deglaciation occurred between (23.2 ± 3.8) (^{10}Be) ka and (8.0 ± 1.5) (^{10}Be) ka. Permanent ice and firn fields were still present in the upper parts of cirques and on plateaus up to around 3 – 4 thousand years ago.

Key words: ^{10}Be dating, Giant Mountains, glaciation in the Pleistocene

1. Introduction

Radiometric dating of exposure ages of rock surfaces using ^{10}Be method was described by Lal (1988, 1991), physical and chemical processing of quartz for measurements of cosmogenic production was published e. g. by Kohl, Nishiizumi (1992) and Carling, Craig (1994). Report on glacial geomorphological aspects of ^{10}Be radiometric dating prepared on extensive amount of relevant publications has been summarized by Mercier et al. (1999). It also includes description of sampling, laboratory and interpretation steps of ^{10}Be method of dating including cosiderations about topographic, snow cover or vegetation shielding and possibilities of rock surface weathering and small-scale erosion. Presented paper is concerned with preliminary results of ^{10}Be dating of glacial landforms exposures in the Giant (Krkonoše) Mountains situated in the northern part of the Bohemian Massif (Fig. 1). Geomorphological position of ^{10}Be dated samples G 01 – G 09 (Fig. 2) and L 10 – L 21 (Fig. 3) is described and the chronology of last deglaciation of the Obří důl and Labe důl Valleys is discussed.

The Giant Mountains are made up of two morphostructurally distinctive geological units: the northern part is composed by Hercynian granites and granodiorites (Královík, Sekyra 1969, 1989), the southern one consists of metamorphosed rocks. The fine grained granite build up the main Giant Mountains ridge (1400–1600 m a.s.l.), while south of it, coarse grained granite form a plateau area (1300–1450 m). A micaschists and

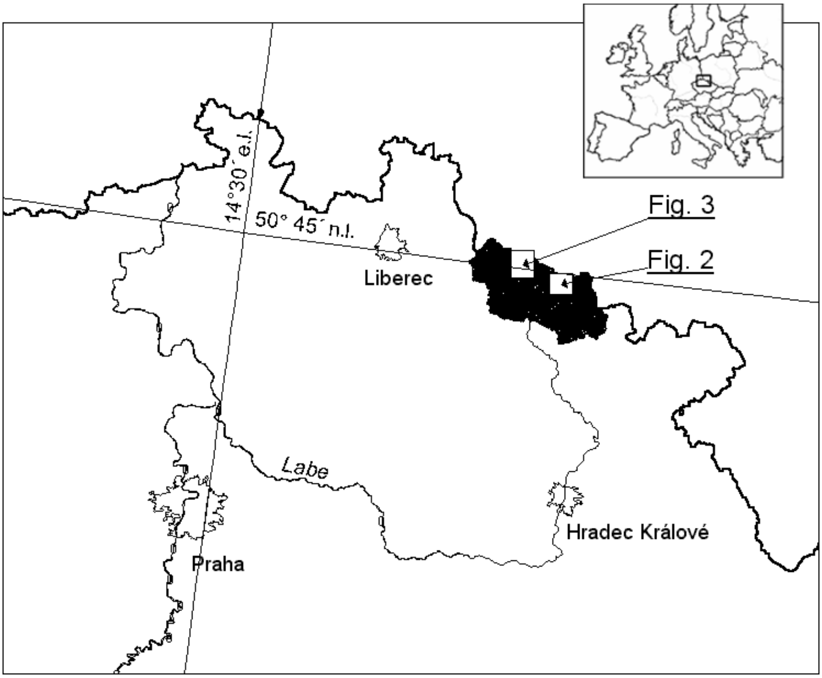

Figure 1: Geographical position of the Giant Mountains in central Europe.

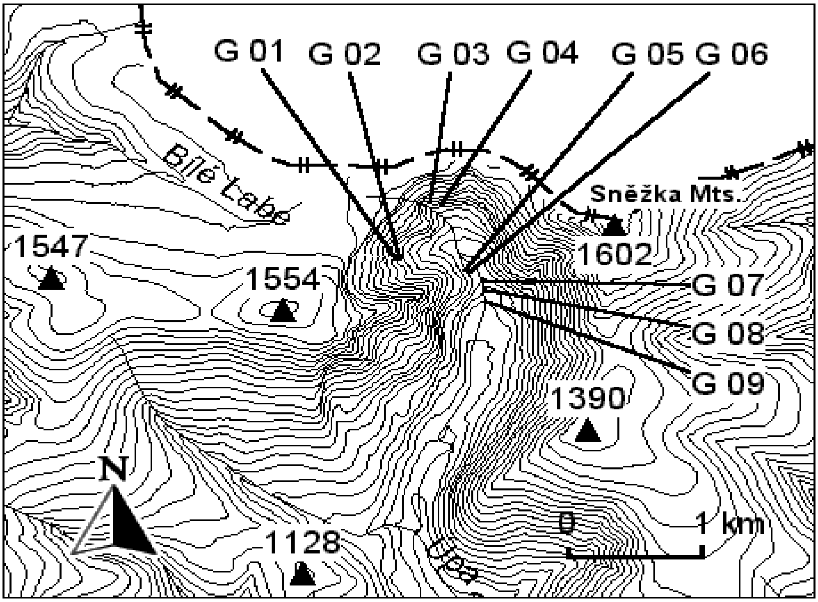

Figure 2: Location of ^{10}Be dated samples of exposed crystalline rocks in the Obří důl Valley.

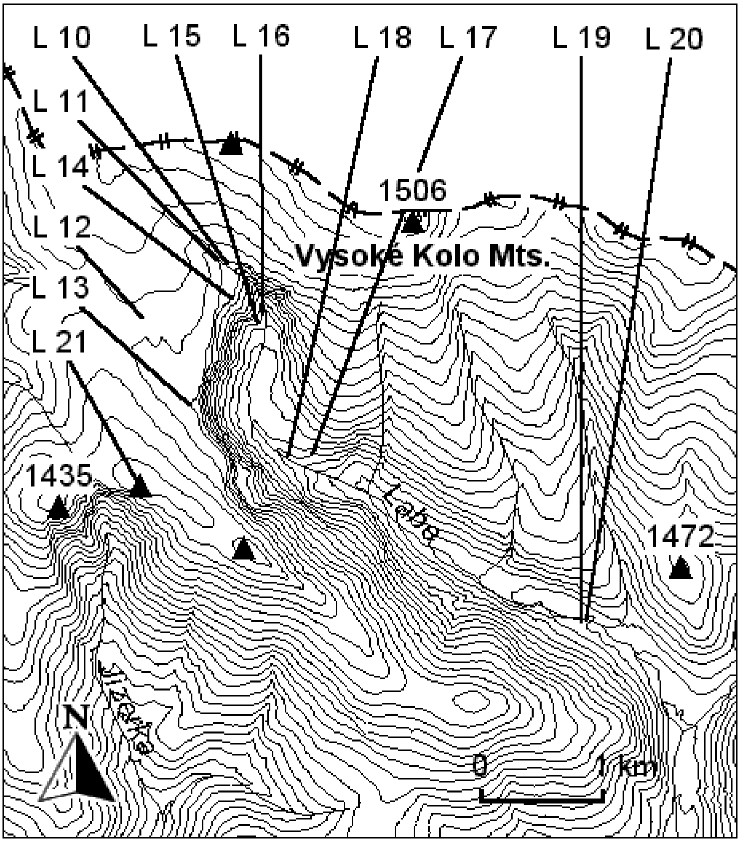

Figure 3: Location of ^{10}Be dated samples of exposed crystalline rocks in the Labský důl Valley and neighbouring areas.

metamorphic hornfels zone limit the southern boundary of the plateau and acts as a secondary ridge (1300–1500 m). The southern regions of the mountains are mainly carved in micaschists. The general relief pattern of the main Giant Mountains ridge is a large plateau limited to the North by a NW – SE oriented abrupt slope of 700–800 m high, and to the South by a parallel lower ridge. The whole area is inclined to the South which have strongly influenced the development of the river network. The northern rivers flows directly from the main divide to the North and the upper courses of the southern ones begin on the summit plateaus, however, their valleys are mainly controlled by morphostructural features.

Since the period of Partsch (1894) explorations geomorphologists working in the Giant Mountains (e. g. Vitásek 1923, 1956, Kunský, Záruba 1950, Král 1950, 1952, Králík, Sekyra 1969) interpreted glacial landforms on the Bohemian (southern) side of the mountains as relics of one or two glaciations in the Pleistocene. General explanations of geomorphological development of the Giant Mountains related to glacial and periglacial processes in the Quaternary are described by Loučková (1965), Králík, Sekyra (1989) and

Migoň (1999). However, they are any radiometric dating of the age of glacial landforms and deglaciation processes in the Giant Mountains. The concentration of “in situ” produced cosmogenic ^{10}Be in crystalline rocks on the surface of cirque walls, tors, roches moutonnées and morainic boulders is directly related to the exposure age of these landforms after melting of glaciers and permanent ice and firn fields.

2. Geomorphological position of ^{10}Be dated samples

2.1. The Obří důl Valley

Crystalline rock samples were taken at sites G 01 and G 02 in the western and the best developed part of the bottom of the Úpská jáma Pit cirque. This part of the cirque is situated on the northwestern slope of the Studničná hora Mountain (1554 m) and is limited at the SW by the morphostructurally conditioned Čertův hřebínek Crest and at the W by the upper cirque edge of the Úpská jáma Pit. It is separated from the northern part of the cirque by an inexpressive crest forming the watershed line between the Úpa River and its left-side affluent Lavinový potok Brook. The western part of the Úpská jáma Pit is situated above the principal cirque bottom of the Obří důl Valley (1050 m) and limited by a steeper step which the Lavinový potok Brook overcomes by cascades. The step is mainly buried by boulder debris and the rock underlayer only locally appears on the surface. Above this step there is a small slope depression (1100 to 1130 m), in which the Sněžná strouha Ditch mouths into the Lavinový potok Brook. This depression of glacial origin is now largely filled up by niveo-deluvial accumulations. Above this depression there are steep rocky slopes rising up to 1300 m, where the slope inclinations temporally get milder. At that level there is a narrow plateau (so-called Krakonošova zahrádka Garden) bordered by „passive“ moraines. Above this plateau there is the steep Studniční stěna Wall terminated at its upper part (1400–1500 m) by a cirque edge. The site of samples G 01 and G 02 is situated in the area of a slope depression in the lower western part of the Úpská jáma Pit (Photo 1). Both samples were taken from rock surfaces on the left (N) bank of the Sněžná strouha Ditch, and that 20 m and 18.5 m from its course at the altitude of 1200 m and 1180 m. The rock surfaces inclination is 20° (G 01) and 17° (G 02), the direction 88° and 92°.

Samples G 03 and G 04 were taken in the northern part of the Úpská jáma Pit. The Úpa River steps down into the cirque from the summit etchplain in the area of the cirque-shaped Úpská hrana Edge by a pronounced erosional notch below which it flows through a glacially remodelled valley deepened into the Giant Mountains granite. At altitudes between 1350 to 1250 m the valley has rock walls locally even 20 m high. Below the mouthing of the ravine an accumulation mound with sharp edged boulders is situated as a passive moraine with slope movement products. This mound is linked by an elongated dejection cone descending down to the main cirque bottom of the Úpská jáma Pit. The Úpa River has deepened a secondary 5 m deep notch in the dejection cone. The sample G 03 was taken at the foot of the northern

Photo 1: Crystalline rock samples of roches moutonnées were taken at sites G 01 and G 02 in the western and the best developed part of the bottom (1200 m a. s. l.) of the Úpská jáma cirque in the Obří důl valley. (Photos 1 – 4: Zbyněk Engel.)

Photo 2: Sampling sites G 07 (roche moutonnée) and G 08 (rock exposure) are situated in the upper part of the lower cirque step of the Úpská jáma Pit at 1020 – 990 m a. s. l. and the site G 09 (boulder) in its lower part, that is just above the bottom (970 m a. s. l.) of the Obří důl Valley.

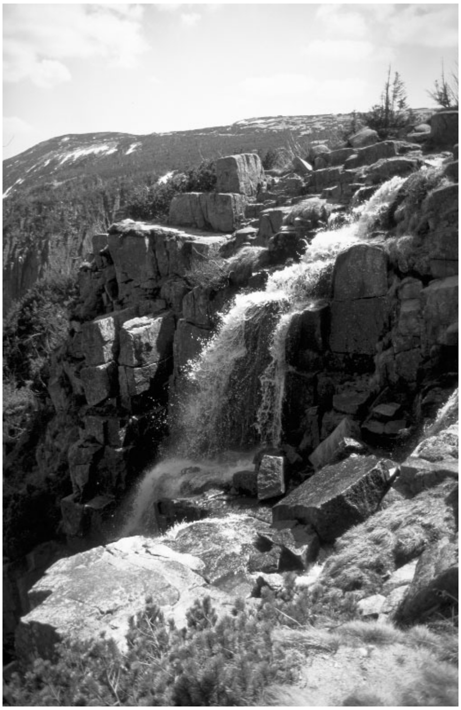

Photo 3.: The rock tower of sample L 13 is situated on the upper cirque edge of the Pančavská jáma Pit (1300 m a. s. l.), in the immediate proximity of the Pančavský vodopád Waterfall.

Photo 4: The lower part of the Labský důl Valley is represented by rock samples L 19 (see photo) and L 20, taken from granite blocks of the terminal moraines, situated nearly 100 m above the mouthing of the Medvědí potok Brook into the Labe River. Foot part of moraines on flat valley bottom is at 820 m a.s.l.

wall's erosional ravine at an altitude of 1250 m. The inclination of the rock surface in the sampling place is of 36.5°, the direction 128°. The sample G 04 was taken from a rock block in the above-mentioned mound at the altitude of 1200 m. The sampling surface is horizontal, a slight change of inclination due to slope movement of the whole accumulation cannot, nevertheless, be excluded.

The rock samples G 05 and G 06 were taken at the foot of the Čertův hřebínek Crest in the central part of the Úpská jáma Pit. The Čertův hřebínek Crest protrudes westward from the eastern slope of the Studničná hora Mountain (1554 m) and then turns to the NE. A pronounced relief of this crest is morphostructurally conditioned, because it was formed by selective erosion in the zone of by contact transformed rocks. The contact area of granite and crystalline rocks continue via the cirque step of the Úpská jáma Pit and the Rudník rock up to the Sněžka Mountain summit (1602 m). The Úpská jáma Pit, situated to the N from that area, is deepened into granites. The Obří důl Valley, situated to the S from the Čertův hřebínek Crest, is, on the contrary, formed in gneisses and related crystalline rocks. The Čertův hřebínek Crest is characterized by highly steep slopes. The northern slopes of the crest fall down to a depression in the northeastern slope of the Studničná hora Mountain. The southern slopes, articulated by rock furrows (the so-called Čertova zahrádka Garden and the Čertova rokle Ravine) are turned towards the Obří důl Valley. Rock outcrops in the lower part of the Čertův hřebínek Crest, that is in places where the Úpa glacier descended from the cirque, bear traces of glacial modellation. On the surface, round rock surfaces can be seen up to an altitude of 1100 m. The rock samples G 05 and G 06 were taken in the round rock surfaces of the Čertův hřebínek Crest foot (at 1060 m and 1040 m a. s. l.). The inclination of the sampled rock surfaces is 26.5° (G 05) and 14° (G 06), orientation 42° and 90°. Considering the position of the reference points on the lateral valley slope and their different altitudes in the transversal slope profile, they can also bear interesting information about the rate of the glacier mass and thickness reduction.

The sampling sites G 07 and G 08 are situated in the upper part of the lower cirque step of the Úpská jáma Pit and the site G 09 in its lower part, that is just above the bottom of the Obří důl Valley. The cirque step (960–1050 m a. s. l.) is situated in the place where the ancient glacier fell under the form of an icefall into the trough of the Obří důl Valley. This cirque step is (similarly to the Čertův hřebínek Crest) probably conditioned by geological situation, as it is found on the limit of granites and crystalline rocks. It is thus formed in harder granites, while the line of the contact itself passes at the foot of the Dolní Úpský vodopád Waterfall. A rather steep cirque step has a mean inclination of 20° and, because of a small inclination of the valley bottom both above and below the step (1° respectively 0.5°), it is well visible in the longitudinal profile. At the upper part of the step the Úpa River has formed an asymmetrical notch, with a depth of up to 4 m on the right bank and up to 10 m on the left one. Lengthwise crevasses, the direction of which the notch copies played a role during the notch formation. The middle and the lower part of the step is formed by granite plates which conform to the surface inclination. The step foothill is covered by slope sediments, which, in the downstream direction, link at the alluvial terrace relics.

The rock sample G 07 was taken at a rock outcrop on the left bank of the Úpa River in the upper part of the cirque step. It was taken at a distance of 3.3 m from the present waterbed from a rock surface (1020 m a. s. l., inclination 11°, orientation 210°), the surface of which is situated 5 m above the erosional notch of the Úpa River (Photo 2). The rock sample G 08 comes from the middle part of the cirque step, from a small granite plateau (990 m a. s. l., inclination 15°, orientation 155°), situated 5 m from the left bank of the present course of the Úpa River. The rock sample G 09 was taken from a rock block (inclination 25°, orientation 155°) at an altitude of 970 m.

2.2. The Labský důl Valley and neighbouring areas

Rock samples L 10 and L 11 were taken from the highest part of the Labský důl Valley closure, from the Labská rokle Ravine. Development of that erosional ravine was influenced by the fact that a more weathering-resistant type of granite reaches to its northern (left) margin. This is also apparent in the defile's profile, where the left side is sensibly higher than the right one. The defile of the Labská rokle Ravine was formed by erosion along primary fissures and is thus of morphostructural origin. The more than 200 m long and 30 to 50 m wide defile is oriented and open to the SE. Its bottom is covered mainly by debris. The upper part of this Labe River defile is limited by a pronounced edge of rock slopes which higher up link to a slightly inclined planation surface. The Labe River, springing on an uplifted peneplain probably of Tertiary age, overcomes the mentioned edge by a waterfall and on the right side of the defile it continues its course through the Labská rokle Ravine. The upper part of the ravine was formed in a mylonite zone with an orientation of 150–155°/330–335°. A large dejection cone was formed in the lower end of the ravine with foot slope debris in the place where the inclination of the bottom gets reduced. The rock sample L 10 has been taken from a small rock outcrop on a small tower in the upper part of the ravine. The rock tower appears in the place where the ravine turns to the N and where the Labský vodopád Waterfall mouthes into it from the right slope. The rock outcrop is, similarly as the waterfall wall, bound to a mylonitized, largely altered zone with a breccia texture. The sampling place is situated at 1280 m a. s. l. on a small horizontal rock surface. The sample L 11 originates from a site above the upper edge of the waterfall. This site is situated on the left bank of the Labe River near an ancient observation bridge (1290 m). The rock surface has an inclination of 11° oriented 145°.

The rock sample L 12 comes from the watershed plateau Labská louka Meadow which, together with the plateau Pančavská louka Meadow, forms a relic of an uplifted graded surface, qualified as an etchplain. The slightly undulated surface of both plateaux results from the long-term influence of denudational processes continuing from the Mesozoic up to the end of the Palaeogene. This planation surface has been uplifted to its present position (1300 to 1400 m a. s. l.) by Neogene tectonic activity, manifested in the Giant Mountains region mainly by block uplifts. The areas of the Labská and the Pančavská louka Meadows are probably relics of a Tertiary peneplain, which has also been denuded during the Quaternary. The surface of this area is very little dissected and it is characterized by mild slopes with inclinations inferior to 9°.

During the Quaternary, the Labská and the Pančavská louka Meadows were repeatedly in periglacial and glacial climate-morphogenetic zone. The sample L 12 was taken from a smaller granite block at an altitude of 1335 m situated 250 m to the W from the Labe River and the Mumlavský potok Brook watershed. The sampling surface of the rock block with an inclination of 4° is oriented to 140°.

The site of the rock sample L 13 is situated on the upper cirque edge of the Pančavská jáma Pit, in the immediate proximity of the Pančavský vodopád Waterfall (Photo 3). This rock edge forms the boundary line between the relic of the etchplain of the Pančavská louka Meadow and the composed cirque of the Labský důl Valley, by the largest of its cirque-in-cirque landforms, the so-called Pančavská jáma Pit. In the area of the Pančavský vodopád Waterfall, the etchplain is covered mainly by stony eluvium, through which the upper course of the Pančava Brook flows in an unpronounced cutting. In the area of the cirque edge, a rock underlayer appears on the surface and the Pančava Brook overcomes it by a waterfall to get into the cirque-in-cirque form of the Pančavská jáma Pit. This hanging cirque depression is built of medium grained biotitic granite, in which the primary fissure system LSQ is prevailing. This conditions ashlar fissuring and disintegration of granite, which is visibly manifested in the detailed modellation of the upper cirque edge of the Pančavská jáma Pit. Congelifraction and slope movements of rock slopes cause loosening and inclination of rock blocks. The rock wall, situated at about 80 m to the N from the Pančavský vodopád Waterfall, is a very good example of ashlar dissociation of granite in the Giant Mountains. The frontal surfaces of these rock slopes with pronounced manifestation of block movements are slightly overhanging and locally reach a height of over 40 m. The rock sample L 13 was taken from a rock surface (1300 m a. s. l.) on the right side of the Pančavský vodopád Waterfall with an inclination of 8° and orientation of 52°.

Rock samples L 14, L 15 and L 16 were taken from the upper closure of the Labský důl Valley, from slopes below the Labská bouda Chalet. These slopes are oriented at the N and W to the Labská rokle Ravine and at the S they are limited by the margin of the cirque form of the Navorská jáma Pit. In their upper part the slopes pass by an inexpressive margin edge into a round denudational relief of a watershed plateau etchplain. In the upper half of the slopes on granites between 1280 and 1200 m a. s. l., locally there are smooth rocks on the surface, while in their lower part there are more frequent steep rock steps and frost cliffs. These structural denudational slopes are separated from the Navorská jáma Pit by a 10 to 20 m high rock step, the upper margin of which is bordered by pronounced rock slopes. The rock sample L 14 was taken from the upper half of the above-described slopes from smooth rock plate with an inclination of 11° and orientation of 120°. The rock samples L 15 and L 16 were obtained from the lower parts of these slopes. The rock sample L 15 was taken at an altitude of 1 098 m from denuded granite rock (inclination 12°, orientation 150°) directly above the margin edge of the Navorská jáma Pit. The sampling locality of the rock L 16 is situated near the previous one and practically at the same altitude (1095 m). The rock surface of this site is situated 40 m from the Labe river course, its inclination is 19° and orientation 132°.

The rock samples L 17 and L 18 represent rock outcrops of the cirque step of the Labský důl Valley which has an increased inclination of the valley bottom between 920 m and 1010 m a. s. l. This pronounced increase of the valley bottom inclination at the lower margin of the cirque part of the Labský důl Valley (8–9° compared to 1–3° of the cirque and trough part of the Labe River Valley) is mainly of morphostructural origin. As the Labský důl Valley is formed only by medium grained biotitic granite, there is a change of descent in the longitudinal profile of the valley mainly in connection with differences in the course and frequency of fissures in these rocks. While in the cirque part of the Labský důl Valley (above 1025 m a. s. l.) the surface inclination of bed L-fissures in biotic granite is conform to the slope surface, in the segment with increased descent these geomorphologically significant surfaces are intercrossing. Bed fissures there are inclined northwards, which causes a bending of the Labe River course and a sensible lateral erosion of its left bank. More pronounced rock steps occur in the so-called Labské kaskády Cascades in places, where steeply inclined fissures are more frequent. While in their upper part the Labské kaskády Cascades link to the flat part of the bottom of the Labský důl Valley cirque, in the lower part they pass into an enlarged valley of trough type. This valley step is an area where a tongue of the ancient Labský ledovec Glacier used to flow away from the cirque and passed to the trough bottom by an icefall. The rock sample L 17 comes from a horizontal surface of a pronounced rock exposure at 995 m a. s. l. situated above the bottom of the upper part of the cirque step. The rock sample L 18 was taken at 970 m a. s. l. from the above-described rock threshold.

The lower part of the Labský důl Valley is represented by rock samples L 19 and L 20, taken from granite blocks of the terminal moraine, situated nearly 100 m above the mouthing of the Medvědí potok Brook into the Labe River. Its foot is at 820 m a. s. l. in the place where the flat valley bottom is more than 150 m wide. The mound height increases from the place of erosional notch from 10 m up to about 20 m on the slope of the valley. The whole left side of the moraine is cut through by the Labe River course that has probably taken away the moraine material. This is proved mainly by fluvioglacial accumulations in front of the terminal moraine lower in the valley. Their present shape of a transitional cone has been created by the washing away of moraine material and in addition partly transformed by erosion by the Medvědí potok Brook. The observed part of the frontal moraine of the ancient Labský ledovec Glacier is characterized by a great quantity of small-grained material with numerous granite boulders of different sizes. This terminal moraine passed into relatively well developed lateral moraines. The moraine accumulation on the left side of the valley is relatively well maintained. It rises from the flat valley bottom at an altitude of 825 m and covers the slope up to an altitude of about 855 m with a total length of more than 600 m. The best developed part of this lateral moraine can be observed up to the foot of the valley slope (now covered by wood) at about 300 m below the mouthing of the Dvorský potok Brook. The moraine mound is formed by typical boulders and by debris of crystalline rocks. A short segment of nearly 100 m is removed from the right lateral moraine; it ends below the mouthing of a smaller right-side affluent of the Labe River. The rock sample L 19 has been taken from a moraine bloc of dimensions

2.4 x 2.0 x 1.8 m (Photo 4), situated at the summit of the terminal moraine at an altitude of 830 m. Also, the next rock sample L 20 comes from another granite bloc (1.4 x 1.1 x 0.7 m, 828 a. s. l.) on the ridge of the moraine. The sampling areas on the rock blocs of the moraine are in both cases horizontal.

The locality Harrachovy kameny Stones (1421 m) is situated on the southern ridge of the Giant Mountains, which has been formed on the contact of the granite massif and crystalline rocks. The zone of the contact metamorphosis runs parallel to the main ridge of the Giant Mountains under the form of a morphologically pronounced ridge between the village of Harrachov and the Sněžka Mountain (1602 m). In the western part of this ridge formed by porphyric biotitic granite, there are rock outcrops of the Harrachovy kameny Stones rising from the relatively flat ridge. A group of rock outcrops of torso type is placed on a ridge above the Velká Kotelní jáma Pit forming the southern margin of a large summit plateau of the Labská and the Pančavská louka Meadows. The up to 2.5 m high outcrops rising from the round ridge at 1410–1420 m a. s. l. are built of porphyric granite. In connection with a higher number of fissures, there are localities of lesser resistance in the granite which have influenced the articulation of outcrops. One of these belts of reduced resistance continues in the slope below the Harrachovy kameny Stones, in the form of an elongated depression crossing through granite plates on the steep and partly rocky slope of the Velká Kotelní jáma Pit. The rock outcrops and tors of the Harrachovy kameny Stones are relics of an uplifted planation surface probably of the Tertiary age. The neighbourhood of rock outcrops is partially denuded to the rock underlayer and partially covered by eluvial and slope sediments. The rock sample L 21 was taken from a horizontal position of a denuded rock underlayer at 1420 m a. s. l.

3. Results

Exposure ages of 21 samples from rock slopes of cirques, tors, roches moutonnées, moraines and boulders collected for ^{10}Be dating (Table 1) in very dissected relief of the Giant Mountains give evidence to strong influence of geomorphological position on the time of deglaciation. The set of samples (Figs 2 and 3) displays exposure ages in the range from (23.2 ± 3.8) (^{10}Be) ka to (3.3 ± 0.7) (^{10}Be) ka.

The earlier exposure age was found for a tor (sample L 21, (23.2 ± 3.8) (^{10}Be) ka) located at 1 420 m a. s. l. on the southern dividing ridge of the upper Labe plateau. The boulder L 12 in the central part of this plateau was dated at (19.2 ± 3.2) (^{10}Be) ka and two samples L 13 and L 11 on its eastern edge gives younger exposure ages at (11.1 ± 1.8) (^{10}Be) ka and (5.7 ± 1.0) (^{10}Be) ka. In the very deep Labský důl Valley, located on an elongated morphostructural zone, increasing exposure ages were found from the Dryas terminal moraine at 830 m up to the upper end of the cirque at 1 280 m a. s. l. Therefore, the deglaciation of lower parts of the Labský důl Valley is documented by ^{10}Be exposure ages of samples L 17, L 19 and L 20 (Table 1) between (12.3 ± 2.1) (^{10}Be) ka and (11.5 ± 2.0) (^{10}Be) ka. The valley bottom in the altitudes

Table 1: Preliminary results of ^{10}Be dating of glacial landforms exposures in the Giant Mountains.

Sample No	**Altitude (m a.s.l.)**	**Radiometric exposure age T_{min} ± relative error (^{10}Be) ka**
G 01	1200	7.32 ± 1.31
G 02	1180	7.97 ± 1.48
G 03	1250	7.90 ± 1.47
G 04	1200	4.17 ± 0.81
G 05	1060	8.56 ± 1.53
G 06	1040	4.14 ± 0.92
G 07	1020	6.83 ± 1.25
G 08	990	9.28 ± 1.83
G 09	970	3.34 ± 0.67
L 10	1280	3.72 ± 0.69
L 11	1290	5.70 ± 0.97
L 12	1335	19.20 ± 3.16
L 13	1300	11.08 ± 1.83
L 14	1275	8.50 ± 1.41
L 15	1098	9.68 ± 1.67
L 16	1095	9.00 ± 1.55
L 17	995	12.29 ± 2.12
L 18	970	8.74 ± 1.50
L 19	830	12.10 ± 2.05
L 20	828	11.53 ± 1.97
L 21	1420	23.21 ± 3.83

between 1000–1100 m (L 18, L 16, L 15) was exposed at (8.7 ± 1.5) (^{10}Be) ka and (9.7 ± 1.7) (^{10}Be) ka respectively. Deglaciation of the upper part of Labský důl Valley cirque was completed at (8.5 ± 1.4) (^{10}Be) ka. In the circular Obří důl Valley cirque, the deglaciation was dated around (9.3 ± 1.8) (^{10}Be) ka in 990 m a. s. l. and from (8.0 ± 1.5) (^{10}Be) ka to (7.3 ± 1.3) (^{10}Be) ka between 1200–1250 m. Permanent ice and firn fields were still present after (7.3 ± 1.3) (^{10}Be) ka in the upper part of the Obří důl Valley cirque, and at (5.7 ± 1.0) (^{10}Be) ka on the upper Labe plateau. Moreover, they probably persist in relief positions suitable for snow-drift accumulations up to around 3 – 4 thousands years ago.

These results can be understood as preliminary from two main reasons: a) geomorphological analyses of sampling sites for ^{10}Be dating and its correlation with similar studies in mountainous regions will narrow the range of relative errors of T_{min} (^{10}Be) exposure ages, b) radiometric dating using in-situ production rates of ^{10}Be is a relatively young method, and, therefore, it should be testified in different environmental conditions (comp. e. g. Lal 1991 and Cerling, Craigh 1994) and also compared with results of other radiometric methods of dating related to geomorphology.

4. Conclusions

Geomorphological interpretation of radiometric dating of the exposure age of rock slopes in cirques, tors, roches moutonnées and boulders in moraines using ^{10}Be method gives evidence that on the western high plateau (1200–1400 m a. s. l., Labe River source area) deglaciation occurred between (23.2 ± 3.8) (^{10}Be) ka and (11.1 ± 1.8) (^{10}Be) ka. In the Labe glacial valley, the last terminal morainic walls (828–830 m) were dated at (12.1 ± 2.1) (^{10}Be) ka and (11.5 ± 2.0) (^{10}Be) ka. Labe důl Valley deglaciation began near to these moraines and at South facing slopes (12.3 ± 2.1) (^{10}Be) ka ago, reached the valley bottom of 1000 m a. s. l. at (8.7 ± 1.5) (^{10}Be) ka, and the upper end of the cirque at (8.5 ± 1.4) (^{10}Be) ka. In the Obří důl Valley cirque, the deglaciation started in 990 m a. s. l. around (9.3 ± 1.8) (^{10}Be) ka and was completed in the main central cirque at (8.0 ±1.5) (^{10}Be) ka.

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PŘEDBĚŽNÉ VÝSLEDKY DATOVÁNÍ GLACIÁLNÍCH TVARŮ KRKONOŠ METODOU ^{10}BE

Résumé

Radiometrické datování reliktů glaciálních a periglaciálních tvarů, které vznikaly na krystalinických horninách Krkonoš, bylo provedeno metodou ^{10}Be. Jedná se o 21 vybraných vzorků ze skalních odkryvů v ledovcových karech, z oblíků, izolovaných skal typu torů a sedimentů glaciálního původu. Geomorfologická analýza reliéfu oblastí Obřího a Labského dolu a její korelace s výsledky radiometrického datování metodou ^{10}Be ukázaly, že ústup zalednění probíhal mezi (23,2 ± 3,8) (^{10}Be) ka a (8,0 ± 1,5) (^{10}Be) ka. Na západní horské plošině (1200–1400 m n. m., pramenná oblast Labe) se odledňování uskutečnilo mezi (23,2 ± 3,8) (^{10}Be) ka a (11,1 ± 1,8) (^{10}Be) ka. V údolí Labe byly čelní morény (820–830 m n. m.) datovány (12,1 ± 2,1) (^{10}Be) ka a (11,5 ± 2,0) (^{10}Be) ka. Regrese ledovců začala u těchto morén a na svazích s jižní expozicí před (12,3 ± 2,1) (^{10}Be) ka, dosáhla dno údolí v 1000 m n. m. před (8,7 ± 1,5) (^{10}Be) ka a horní konec karu před (8,5 ± 1,4) (^{10}Be) ka. Ústup zalednění v Obřím dole proběhl ve výšce 990 m před (9,3 ± 1,8) (^{10}Be) ka a byl dokončen v centrálním karu před (8,0 ± 1,5) (^{10}Be) ka. Dlouhodobá ledová a firnová pole se v horních částech karů a na hřbetových plošinách Krkonoš vyskytovala ještě před 3–4 tisíci lety.