

STOP 8: Morphology and arrangement of glaciokarst kettles at Vietalva village

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The stop site at the glaciokarst kettles (25°47'59"E, 56°42'58"N) is located about 2 km S of Vietalva village, at the SW corner of the Vidzeme Upland, in the transition zone to the East-Latvian Lowland. The toponym *Vietalvas katli* ('Vietalva Kettles') signifies the peculiar topography of this area. According to Dauškans (2011), this small area (about 10 km²) contains 98 kettle holes (Fig. 8.1). The maximum depth of the individual kettles is up to 30 m. The kettle slopes are predominantly very steep and in some places reach the critical angle of repose. In this case the slopes are complicated by topographic forms resembling small-scale landslides or exhibit other finer-scale mass wasting features.

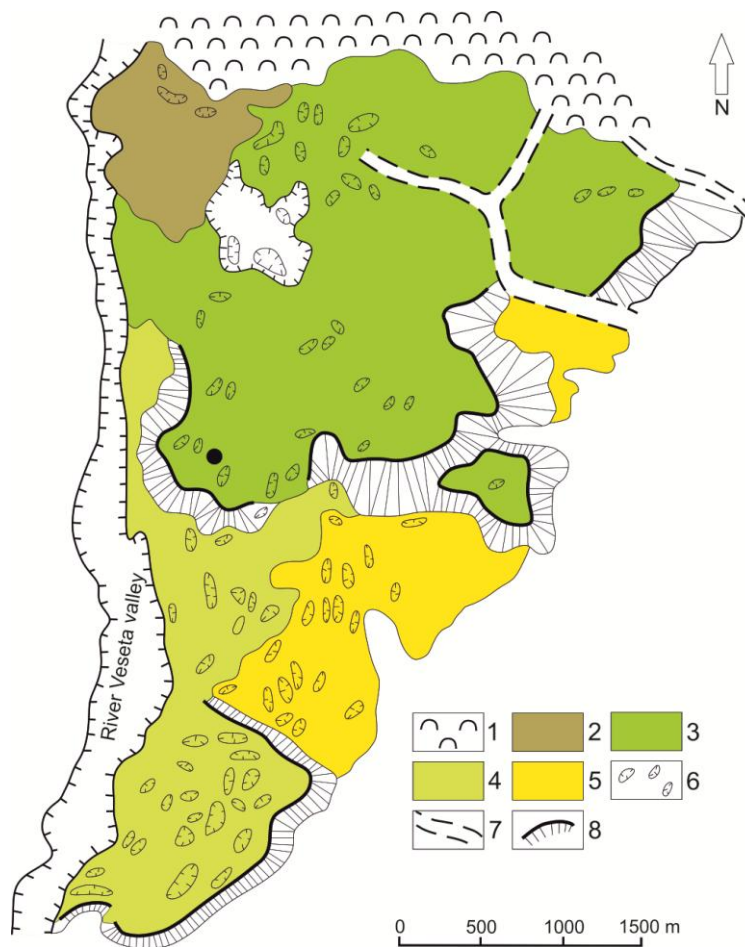


Fig. 8.1. Morphological features of the surface topography of the stretch of the Jāņukalns (Veckalsnava) kame terrace along the left bank of the River Veseta. Modified by the authors after Straume (1979) and Dauškans (2013). Legend: 1 – interlobate hummocky moraine; 2–5 kame terrace levels: 2 – highest, 3 – higher, 4 – medium, 5 – lower; 6 – major glaciokarst kettles; 7 – drainage channels; 8 – ice contact slopes. Black circle denotes stop site.

In the Vietalva kettle area the bedrock surface is composed of Upper Devonian dolomite, clay, silt and sandstone. The bedrock surface reaches 78 m a.s.l. According to geological mapping data (Juškevics and Skrebels 2003), the thickness of the Pleistocene deposits ranges from 40 to 60 m, thinning in the direction of the lower levels of the kame

terrace. Mainly poorly- and medium-sorted Late Weichselian sand and gravel with pebbles, up to 30 m thick, constitute the upper part of the Pleistocene sequence. Due to this composition, it was formerly speculated that the glacial topography of this locality consisted of typical kames (Mironov 1973). Later Straume (1979) and Straume et al. (1981) classified and mapped this glaciofluvial moulding as a kame terrace with a widespread occurrence of kettles. The results of recent investigations (Dauškans 2013) support the latter interpretation.

The kame terrace segment between the villages of Vietalva and Veckalsnava, known also as Jāņkalns kame terrace (Straume 1979) or Veckalsnava kame terrace (Dauškans 2013), forms the distal and wider part of the Cesvaine-Veseta kame terrace. The Jāņukalns terrace is 5.4 km wide and about 10 km long. The glaciokarst kettles are mainly concentrated in the downglacier portion of the Jāņukalns terrace (Fig. 8.1). Here the absolute height of the kame terrace treads vary from approx. 105–110 m up to 145–150.1 m a.s.l., and the highest part of this terrace segment rises up to 60–70 m above the surrounding plains of the East-Latvian Lowland (Dauškans 2013).

The Cesvaine-Veseta kame terrace itself runs in an ENE–WSW direction alongside the south-eastern slope of the Vidzeme Upland (Straume 1979; Dauškans 2013). It is the biggest kame terrace in Latvia. This terrace extends between the town of Cesvaine and the village of Vietalva, over a distance of 40 km. The Madona-Trepe push moraine (Āboltiņš 1989; Zelčs et al. 2011), which marks the position of the Lubāna lobe terminus during the Gulbene (Middle Lithuanian) deglaciation phase, splits the kame terrace into two separate stretches. The Sauleskalns-Vietalva stretch was formed alongside the Lubāna lobe during the Kaldabruņa (South Lithuanian) deglaciation phase, whereas the Cesvaine-Madona stretch was built up by lateral meltwater activity in the course of the Gulbene (Middle Lithuania) deglaciation phase (Zelčs and Markots 2004; Dauškans 2013). Several kame terrace levels which have been detected alongside the terrace show a well-expressed surface sloping in a downglacier direction and towards the Lubāns lobe. In addition to the glaciokarst kettle features the kame terrace has also been eroded by meltwater streams and deeply incised valleys of small rivers flowing from the neighbouring Vidzeme Upland area. Moreover, the highest upstream levels at 145–160 m a.s.l. between the towns of Cesvaine and Madona, which resemble kame terrace treads and abut risers, probably represent beds of the lateral drainage valleys, because of the occurrence of high concentrations of boulders or boulder pavements on the tops as a result of removal of finer particles of glacial deposits, supposedly till, by meltwater flow streams (Zelčs et al. 2011).

During the fieldwork several glaciokarst kettles were inspected within the Jāņkalns kame terrace segment. After assessment of their morphology, the most impressive kettle hole was selected for further studies (see Fig. 8.1 for location). This glaciokarst kettle hole was surveyed with a *Nikon NPL-332* total station, using reference points obtained with a *Magellan ProMark3* post-processing GPS system and data from the reference station service provider *LatPOS*. The elevation above mean sea level has been calculated using the LV'98 geoid model. The topographical survey plan was drafted using *QGIS* software, whereas the digital elevation model (DEM) was generated using the kriging interpolation method of the *SAGA GIS* software.

During studies of the internal composition of the glaciokarst kettles we encountered difficulties, the most significant of which was the lack of outcrops in kettles. Accordingly, in further studies we had to use other methods, such as ground penetrating radar (GPR) profiling. GPR profiling was carried out with a *Zond 12-e* GPR manufactured by *SIA Radar Systems*, using a common offset configuration. In the course of research two antenna systems were used: 75 MHz and 300 MHz. The GPR profiles were processed and analysed with the *Prism*

2.5 software. Unfortunately, the direct electromagnetic wave propagation speed in the sediments using common midpoint or a similar method was not determined. Therefore, the depth that the identified signals had been received from was calculated using the theoretical dielectric permittivity values for dry sand ($\epsilon=6$) (Neal 2004). The geological structure of the selected glaciokarst kettle and surrounding area was inspected using a hand drill.

Altogether, five GPR profiles that cross or reach the bottom of the glaciokarst kettle were obtained. Five boreholes were made along GPR profile I-II. The spatial location of the GPR profile lines and boreholes was recorded with the total station to combine GPR profiles with DEM and borehole data. A topographic model of the glaciokarst kettle and the spatial location of GPR profiles is shown in Fig. 8.2.

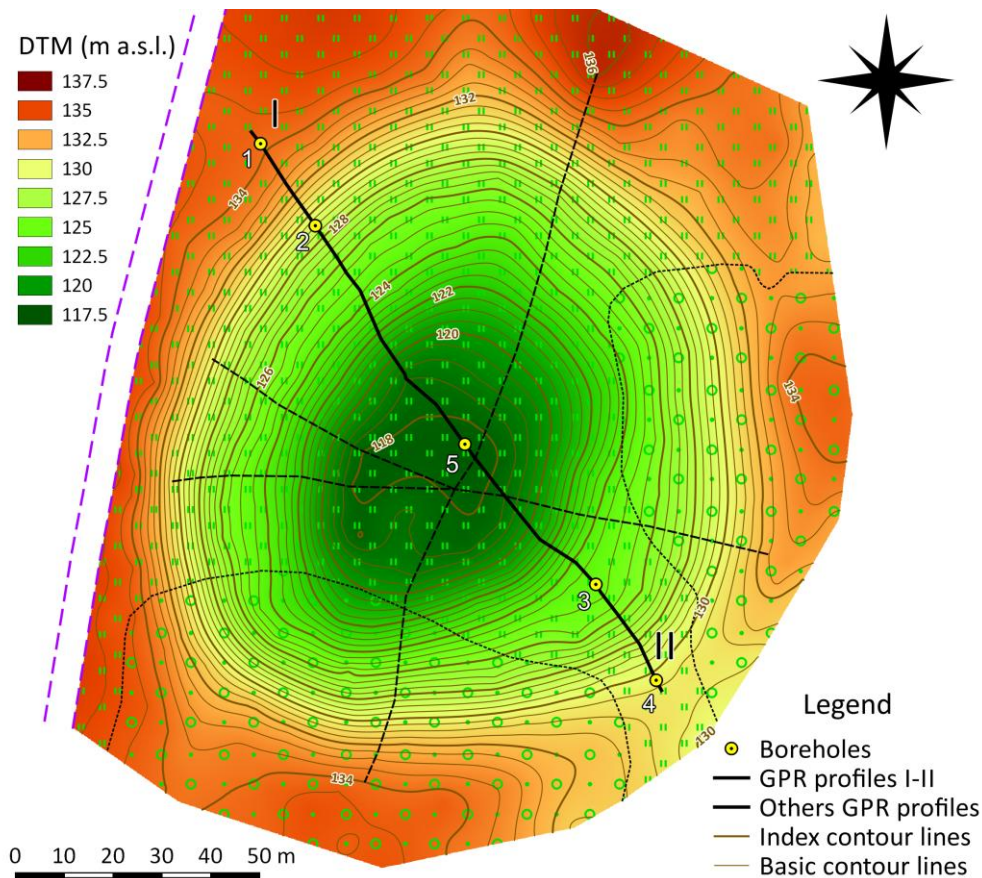


Fig. 8.2. DEM of the glaciokarst kettle hole with respect to the spatial location of GPR profiles.

In the research area high-quality geophysical data were obtained that provides indirect information on the geological structure of the research area. During GPR data processing and analysis it was recognised that the GPR profiles obtained with the 300 MHz antenna system contain more information about the geological structure of the research area. It is probable that good-quality data were not obtained from GPR profiling using the 75 MHz antenna system because the presence of vegetation meant that it was necessary to keep the antenna system relatively high above ground surface. On the other hand, the GPR profiles obtained using the 300 MHz antenna system provided detailed information about the geological structure of the research area approximately to 10 m depth. Several informative signals were identified in the GPR profiles, which are connected with boundaries of sediment layers having different electromagnetic properties (Fig. 8.3A).

From the GPR profiles several step-like features in the side walls of the glaciokarst kettle were identified. In the central part of the kettle hole subhorizontally bedded sediments were identified (Fig. 8.3B).

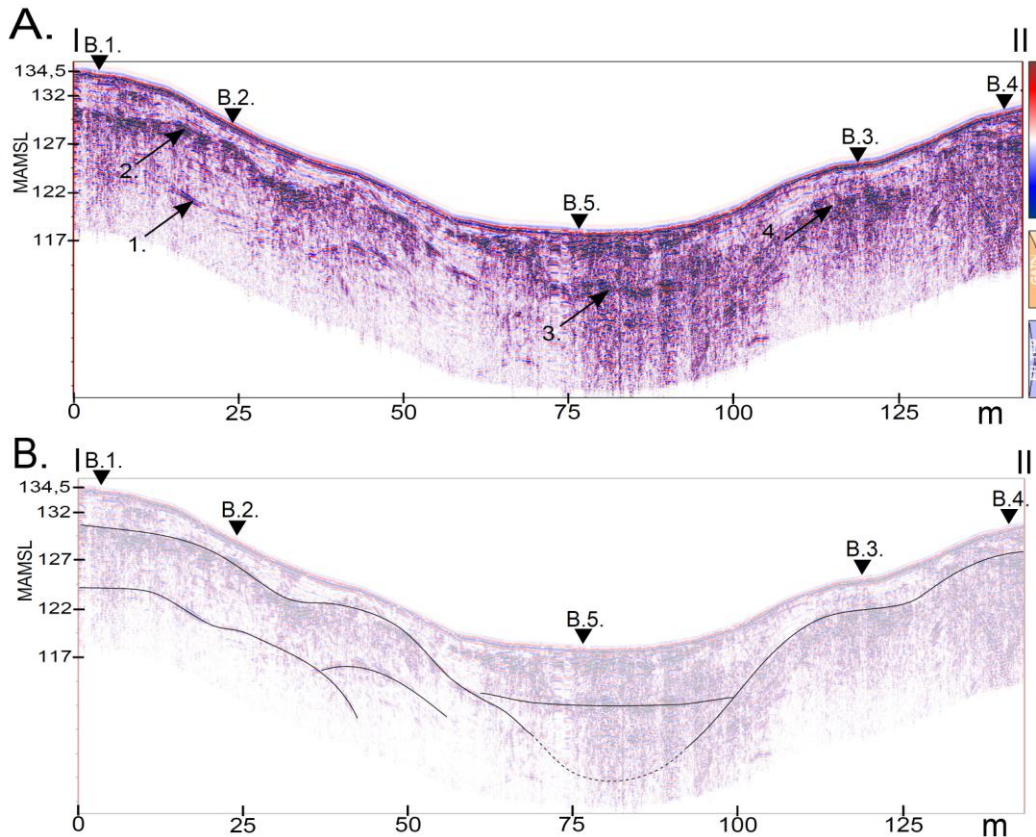


Fig. 8.3. GPR profile showing identified informative signals (A) and reconstructed internal structure of glaciokarst kettle (B). Legend: black arrows denote identified GPR signals related to boundaries of sediment layers; black triangles show coring sites; black dashed lines indicate possible continuation of identified boundaries.

The boreholes reached a maximum depth of about 4.5 m. In all boreholes well-sorted, fine-grained and coarse-grained sand was recorded. Overall it was ascertained that with increasing depth the average grain size of the sediments increases from silty sand at the ground surface to coarse-grained sand with fine gravel at a depth of approximately 4 m. It was also found that the moisture content gradually increases with depth, although the groundwater surface was not reached anywhere.

The information obtained from the boreholes made in the side walls of the glaciokarst kettle concerning the sediment layers in the research area shows that there are no abrupt changes in granulometric distribution of sediments. As a result, the GPR signals cannot be securely related to identified boundaries of sediment layers. On the other hand, in the central part of the glaciokarst kettle, in borehole 5, glaciolacustrine sediments were identified and also the GPR data clearly shows that in the central part of the glaciokarst kettle the sediment layers have distinct horizontal bedding.

To sum up, it should be emphasized that the Jāņukalns kame terrace segment was located somewhat upglacier from the terminal coalescence zone of the Lubāns lobe and the Zemgale lobe (Zelčš and Markots 2004). This zone existed during the last glacier decay, up to the Kaldabruņa (South Lithuanian) deglaciation phase (Zelčš et al. 2011). Evidently such a position greatly facilitated glacier fracturing and formation of buried or partially buried blocks

of ice, as well as initially also accelerated melting. The geological structure, particularly the thick cover of the permeable kame terrace sediments and the location, next to the deeply incised valley of the River Veseta, prevented the formation of kettle lakes and paludification.

References

- Āboltiņš, O. P. 1989. *Glyatsiostruktura i lednikovy morfogenez [Glaciotectonic structure and glacial morphogenesis]*. Rīga: Zinātne, 284 pp. (In Russian).
- Dauškans, M. 2013. *Kēmu terases Austrumlatvijas augstienēs [Kame terraces in the eastern Latvian uplands]*. LU Akadēmiskais apgāds, Rīga, 126 pp.
- Juškevičs, V., Skrebels, J. 2003. Quaternary deposits. In: Āboltiņš, O., Brangulis, A.J. (eds.), *Geological Map of Latvia. Scale 1:200,000. Sheet 34-Jēkabpils. Sheet 24-Daugavpils. Explanatory Text and Maps*. State Geological Survey, Rīga, pp. 10-29.
- Mironov, G.I. 1973. *Karta četvertičnykh otlozheniy masshaba 1:200000 Pribaltiyskaya seriya, 0-35-XXVI (Cesis) [Map of Quaternary deposits at scale 1:200,000. Baltic region series, 0-35-XXVI (Cesis)]*. Aerologiya, Moskva.
- Neal, A. 2004. Ground-penetrating radar and its use in sedimentology: principles, problems and progress. *Earth-Science Reviews*, 66, 261-330.
- Straume, J. 1979. Geomorphology. In: Misans, J., Brangulis, A., Danilans, I., Kuršs, V. (eds), *Geologicheskoe stroyenie i poleznye iskopayemye Latvii*, p. 302-345. Riga: Zinatne (in Russian).
- Straume, J., Juškevičs, V., Meirons, Z. 1981. *Latvijas PSR ģeomorfoloģiskā karte. Mērogs 1:500000 [Geomorphological map of Latvian SSR. Scale 1:500,000]*. VSEGEI Ļeņingradas kartogrāfijas fabrika.
- Zelčs, V., Markots, A. 2004. Deglaciation history of Latvia. In: Ehlers, J., Gibbard, P. L. (eds.), *Quaternary Glaciations – Extent and Chronology. Part I: Europe. Developments in Quaternary Science*, 2. Elsevier, Amsterdam, pp. 225–243.
- Zelčs, V., Markots, A., Nartišs, M., Saks, T. 2011. Chapter 18: Pleistocene Glaciations in Latvia. In: Ehlers, J., Gibbard, P.L., Hughes, P.D. (eds.), *Quaternary glaciations – extent and chronology. A closer look. Developments in Quaternary Science*, 15. Elsevier, pp. 221-229.



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