

Radiocarbon Ages of Mineral and Thermal Waters of Slovakia



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ABSTRACT: The sources of mineral and thermal waters (MTW) are on the territory of central Slovakia mainly in the Inner-western Carpathians. The majority of springs outflow in the Inner Carpathian depressions and/or at margins of lowlands. The springs are always bound to crossing of longitudinal (older) and transversal (younger) faults. The aquifers of MTW are formed by Triassic limestones and dolomites, which are found in the mountains as well as in the pre-Tertiary substratum of depressions and lowlands. MTWs occur in Triassic carbonates of envelope and nappe units, they are of artesian and/or open structures. Travertines have been deposited from many MTW springs. Therefore the ages of travertines indicate the periods when these waters were formed. The ages of travertines from 24 localities with 61 deposits were estimated by paleontological finds and by radiocarbon dating. The radiocarbon ages plus ¹⁸O and ¹³C of MTW were determined in samples from 43 localities with 61 sources. At present, there are only boreholes available, as natural outflows have already been caught by them. A comparison of all the available data, also regarding the snow line changes during the last 35 000 y, was carried out with the aim to draw conclusions on MTW flow development during the Quaternary period. The time interval of MTW flows from their recharge to discharge areas was evaluated by means of radiocarbon dating as well. The analysis of all available data resulted in the conclusion that MTWs in Slovakia begun to issue 2 million year ago at the end of the Late Pliocene, and they were increasingly flowing mainly during interglacial periods. The radiocarbon ages of MTW vary within the interval of 32 000 and 9 000 y. Consequently, the present-day waters might be recharged during the Würm 2-3 and Würm 3 Interstadials and the Holocene period.

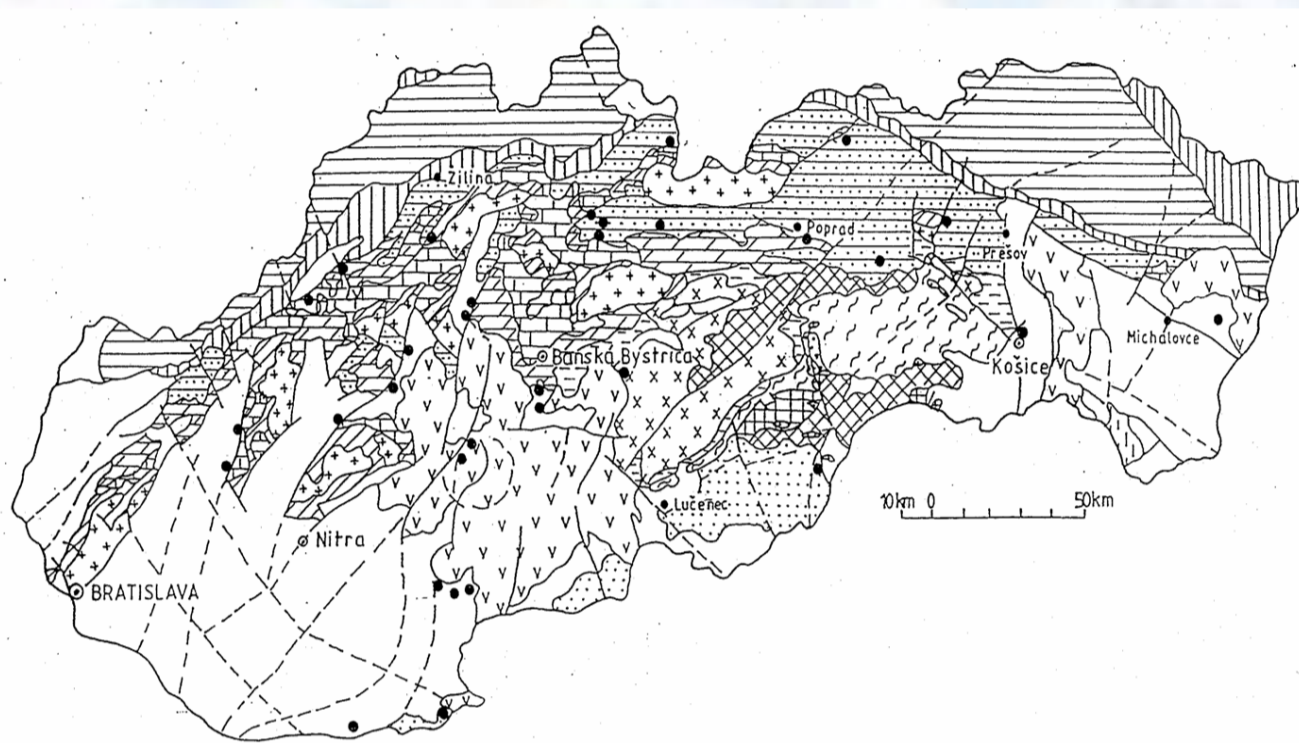


Fig. 1 Geothermal springs of Slovakia

1-Outer Flysch belt; Krosno zone, Magura zone; 2-Klippen belt; 3-Tatricum basement; 4-Tatricum cover unit; 5-Fatricum; 6-Veporicum basement; 7-Veporicum and Zemplinicum cover unit; 8-Hronicum; 9-Gemicum; 10-Meliaticum; 11-Turnaicum; 12-Silicium; 13-Inner Carpathian Paleogene, Buda basin; 14-Neogene basins; 15-Neogene volcanics; 16-main faults; 17-Springs

The sources of mineral and thermal waters (MTW) are mainly on the territory of central Slovakia (Figs. 1, 2) in the Inner Western Carpathians. The issues of waters are bound to marginal faults between the mountains and depressions and/or lowlands. A less amount of issues is bound to horsts (elevations) of the pre-Tertiary substratum inside depressions and lowlands. The springs are always bound to crossing of longitudinal (marginal = older) and transversal (younger) faults. The aquifers of MTW are formed by Triassic limestones and dolomites, which are found in the mountains as well as in the pre-Tertiary substratum of depressions and lowlands.

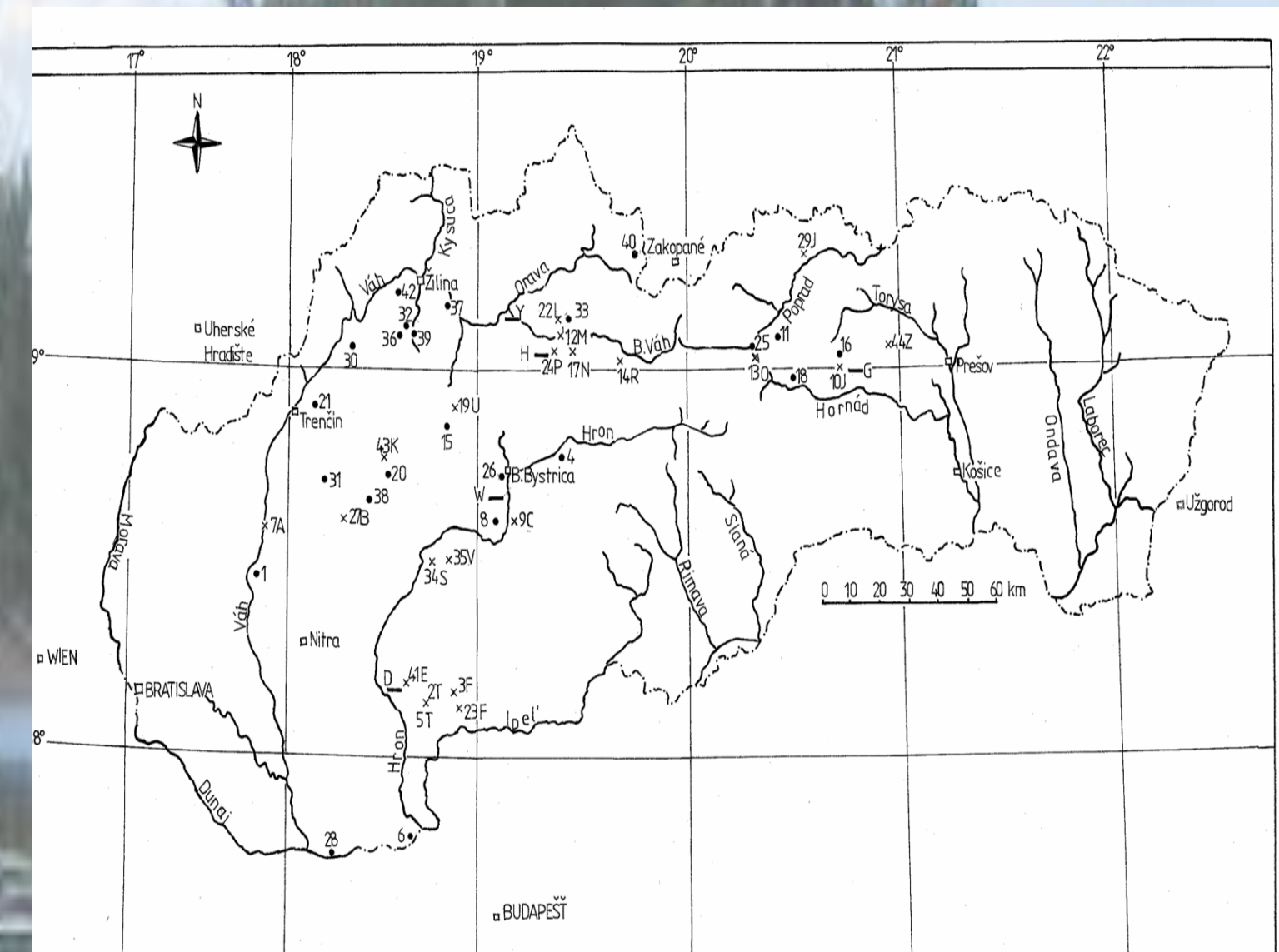


Fig. 2 Location map of mineral and thermal waters and deposits of travertines in Slovakia

The geological age of travertines is summarised in Figs. 3-5. We may state that MTW started to issue earliest at 6 deposits of travertines in the Late Pliocene dated back 2 My. Further outflows of waters are concentrated to the Günz-Mindel, Mindel-Riss and Riss-Würm Interglacials. The outflows of MTW continue in the Holocene practically at all the localities or in their surroundings. It is to be seen from Fig. 4 that with later interstadials and interglacials the number of water outflows is generally higher.

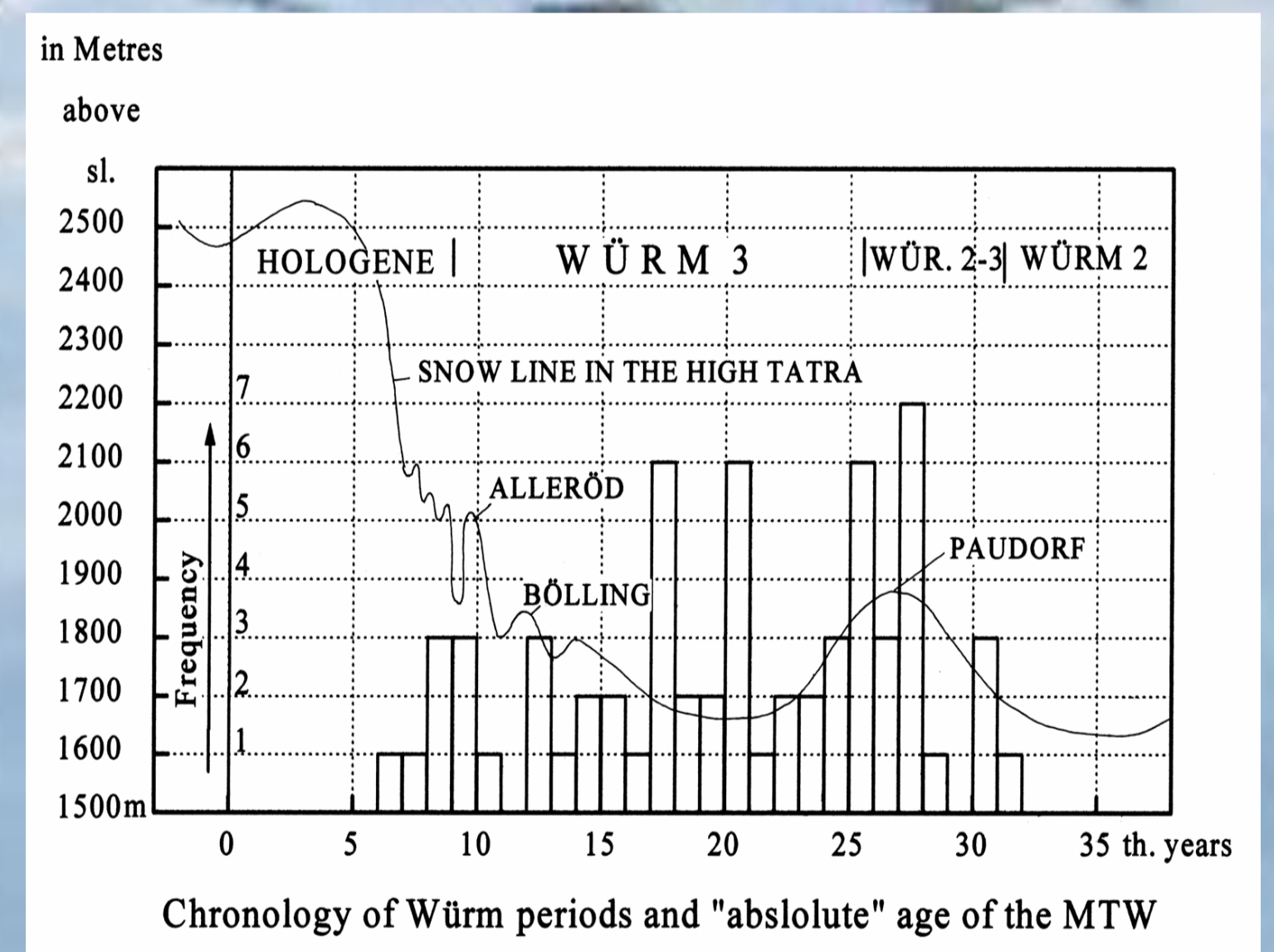


Fig. 5 Correlation of "absolute" age distribution of the MTW according to ¹⁴C isotope and snow line

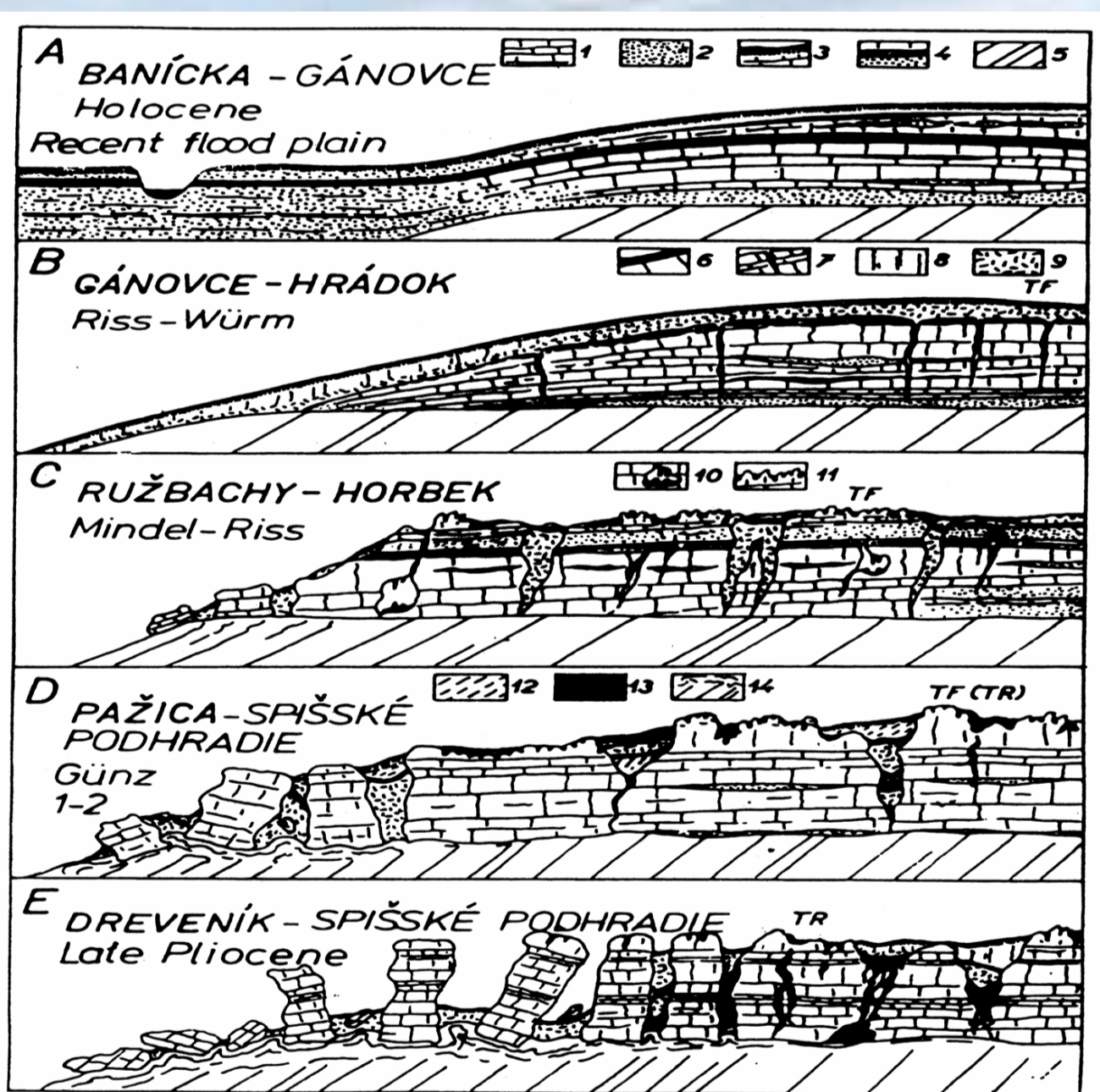


Fig. 3 Relative age of travertines according to their disintegration

1-Solid travertines, 2-loose tufas, 3-surficial rendzimas, 4-buried rendzimas, 5-substratum of travertines, 6-frost disturbing of solid travertines surface, 7-joints in travertines, 8-loess, 9-loamystone scree, 10-small caves with sinter decoration, 11-karren, 12-layers of loess in holes, 13-terraces (TF-terra fusca, TR-terra rossa), 14 - pressuredeformed substratum

CONCLUSIONS

- The first MTW started to outflow by the end of the Upper Pliocene (2 million years ago, Fig. 4) as evidenced by the oldest travertine occurrences.
- Next MTW outflowed during the interglacial (Günz-Mindel, Mindel-Riss, Riss-Würm) and interstadial periods (Günz 1-2, Würm 1-2) 900000 - 70000 years ago (Fig.4) after the geologic and relative age of travertine deposits.
- The number of outflows of MTW increases with the younger age of interglacials in general (Fig. 4).
- Radiocarbon age of MTW ranges between 32000 - 9000 years, thus indicating the approximate time interval between MTW recharge and their present-day outflows from wells.
- MTW outflowing at present infiltrated during the interstadials Würm 2-3, Würm 3 and Holocene (Fig. 5).
- The values of ^{δ18}O isotope of MTW are varying within the limits of -9.89 ‰ to -11.83 ‰. The values of the same isotope in the oldest waters (23000 - 32000 years) are varying within the limits of -10.75 ‰ to -11.83 ‰. The oldest waters infiltrated in the Paudorf (melting of snow and ice, Fig. 5). Younger waters with heavier oxygen infiltrated later. This regularity on the territory of Slovakia is shown in Fig. 6.

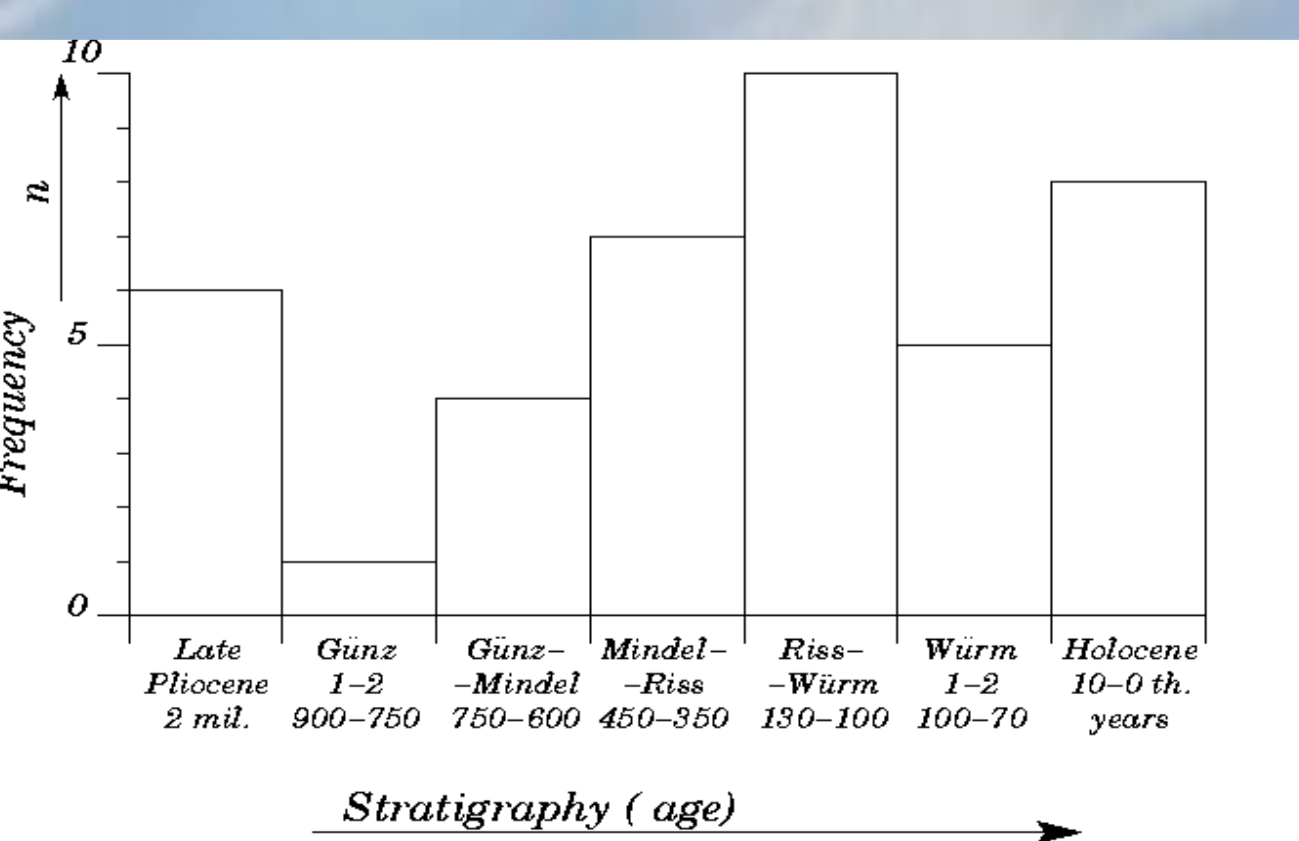


Fig. 4 Histogram of travertines deposit distribution

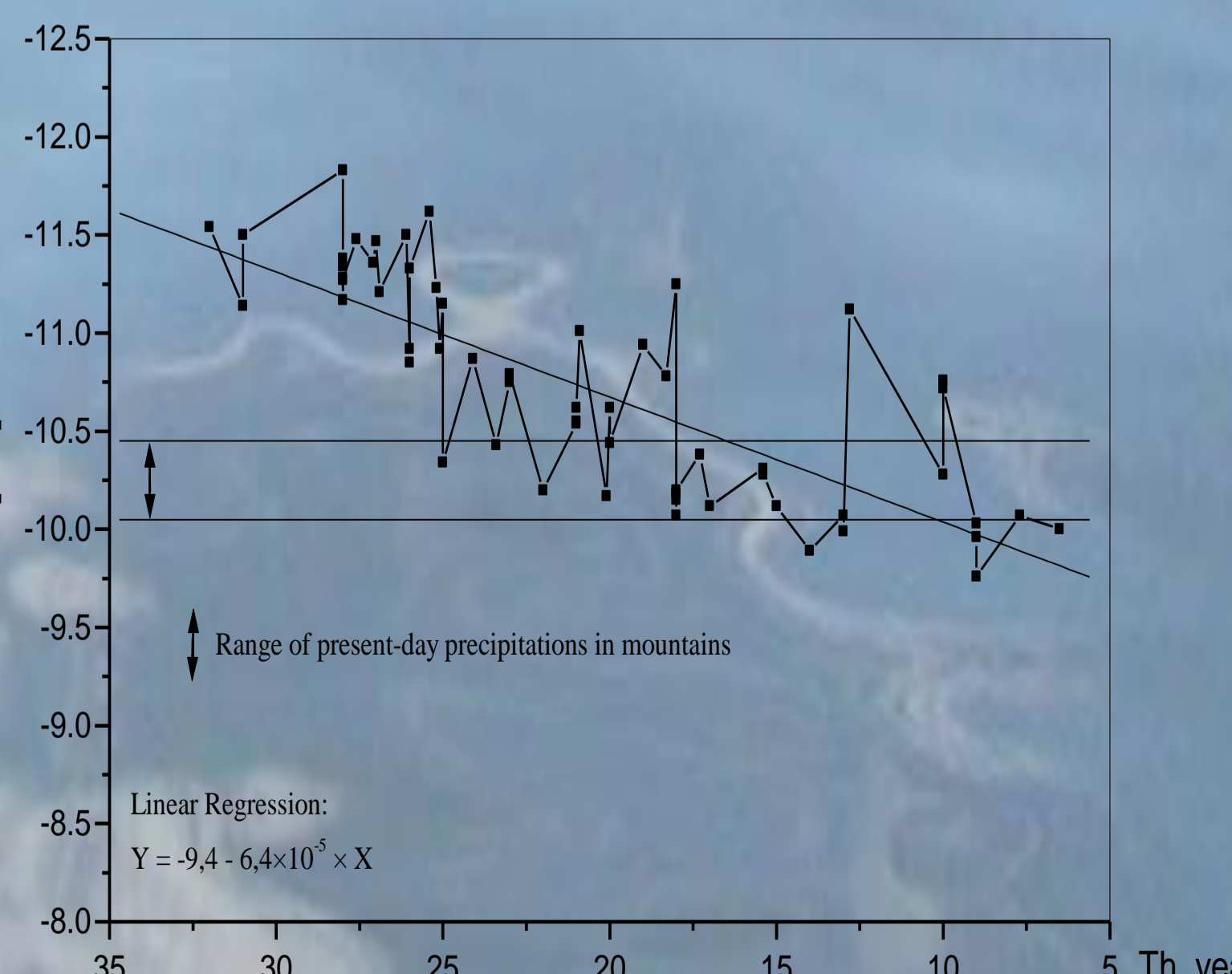


Fig.6 Correlation of the thermal waters age according to the ¹⁴C isotope and ^{δ18}O (‰)