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References


Oxygen Isotope Climatic Record in a Carbonate Flowstone Layer from a Medieval Underground Mine in the Kutná Hora Ore District

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ABSTRACT: The 37 cm thick carbonate flowstone layer found in a gallery of abandoned medieval mine in the Kutná Hora ore district (65 km E from Prague) revealed partly flooded underground passages of a medieval mine in the Osel ore belt. One of the important phenomena observed in the medieval gallery was the presence of rich calcite dripstone decoration including floor flowstones up to 37 cm thick. Samples of the flowstone were taken for a stable isotope investigation.

Introduction

In 1967, a hydrological 22 m deep shaft located in the historical centre of the mining town Kutná Hora (65 km E from Prague) revealed partly flooded underground passages of a medieval mine in the Osel ore belt. One of the important phenomena observed in the medieval gallery was the presence of rich calcite dripstone decoration including floor flowstones up to 37 cm thick. Samples of the flowstone were taken for a stable isotope investigation.

Medieval galleries of the Ag (± Zn, Pb, Cu) ore zone Osel discovered in 1967 were later partly drained by clearing of a medieval adit about 250 m long, which today represents the only entrance into the mine (Pechovská and Hoffmannová, 1991). This adit, 0.5-1.0 m wide and 1.5-2.5 m high, is nearly horizontal and follows a local first-order geological and hydrological boundary between the folded, high-grade metamorphosed and faulted gneissic basement and the overlying horizontally layered Cretaceous platform sediments. At the boundary a transgression horizon of Cretaceous conglomerates is typically developed. The total thickness of Cretaceous rocks above the studied mine level varies between 12 and 20 m. The Cretaceous rocks are represented mainly by sandstone with calcite cement, containing from 15 to 30 wt.-% calcite. Dripping water penetrates into the gallery in many places, locally forming larger inflows of up to 0.3 l/sec. Today, the entire system is drained through the old draining adit; deeper levels are filled with water. The area above the studied mine belongs to the historical town centre.

Methods and material studied

The flowstone, which was precipitated on the gallery floor, is composed of several white-yellowish layers formed by hard, porous, dendritic calcite crystals with indistinct banding. Calcite crystals grew under water. Two block samples (A and B) were cut out from different places of the flowstone and used for
stable isotope study. Block A was cut vertically and 42 point samples for isotopic analyses were taken. Block B, which was collected from another part of flowstone layer, was cut horizontally into 11 larger segments, which were homogenised and used for isotopic analyses. Isotopic analyses were done according to McCrea (1950); the released CO₂ was measured on a Finnigan MAT 251 mass spectrometer.

Age of the flowstone

The age of individual layers of the flowstone is a very important parameter for the interpretation of stable isotope data. Historical evidence, precipitation rate and ²¹⁰Pb dating were combined to estimate the age of flowstone:

Open pit mining in the region of Kutná Hora probably began in prehistoric times but widespread underground mining of Au ores started in the late 13th century. There are no historic records on this particular mine, one of dozens of such mines operating at the same time in the region, but the general history of Kutná Hora is well known (Kofán, 1988). Two phases of mine abandonment must be considered. The first event is associated with the Hussite upheaval around AD 1420, the second event with flooding of the nearby Osel mine around AD 1515. An abandonment of the mine was a prerequisite for flowstone deposition because the sinter rests on decayed wooden floor now preserved as negative print of wooden textures on the flowstone base. The floor was used for the transport of ore by wheelbarrows. During the 16th century, the system of shafts was out of operation, forgotten and the collapse of the entrance sealed it off. The deep vertical mining excludes all dates older than approx. AD 1300, the position of the mine in the inner city excludes dates following the end of 15th century because at that time mining activities moved to surrounding areas. As the most probable date of the beginning of flowstone formation we take AD 1400.

The concrete pavement and vertical reinforcements of the tourist route from 1963–67 are locally covered by an up to 2 cm thick flowstone layer indicating recent formation rate of about 6 cm per century. Such rate is in good agreement with the thickness of 37 cm formed since approx. AD 1400. Since dating attempt using ²¹⁰Pb was not successful, a linear arbitrary scale (AD 1400–1960) was attributed to the profile.

Results and discussion

There was a good agreement between the two oxygen isotope profiles, one consisting of point data (A) and the other one consisting of homogenized intervals. Regarding sample A and B were cut at different locations of the flowstone layer, we concluded that calcite of the both profiles were deposited under similar conditions and under oxygen isotopic equilibrium with water. Profile A studied in detail was used for the interpretation and comparison with other palaeoclimatic records.

The measurements of air temperature have been recorded in Prague since 1771. Written chronicles and other records on climate exist for older periods. Oxygen isotope data obtained for the flowstone from Osel mine were compared with climatological records for the Czech Lands published by Brázdil (1994) and with δ¹⁸O values in tree-rings from the Black Forest (Lipp et al., 1991) and with data published by Mann et al. (1999).

While the temperature curves of Mann et al. (1999) and our curve from Kutná Hora are different, agreement between the Kutná Hora record and curves of Brázdil (1994) and Lipp et al. (1991) is much better.

Data of Brázdil (1994) are given as fluctuation of 10-years averaged air temperature (ΔT summer, winter and yearly averages) plotted as anomalies with respect to the 1851–1950 mean. The differences of δ¹⁸O values from mean δ¹⁸O (Δδ¹⁸O) were

Fig. 1. The comparison of summer air temperatures (Brázdil, 1994), Δδ¹⁸C of tree-rings (Lipp et al., 1991) with Δδ¹⁸O of flowstone from the Kutná Hora.
Changes in δ¹⁸O values of flowstone probably reflect changes in δ¹⁸O values of water feeding the gallery. Agreement between δ¹⁸O values and ΔT_{summer} indicates that summer precipitation was the main source of water penetrating into the gallery.

The period with the lowest recorded temperatures in Prague (65 km W of Kutná Hora) in the second half of the 19th century coincides with the lowest δ¹⁸O values of flowstone of the same model age.

A good agreement exists between the time position and amplitude of temperature oscillations calculated from δ¹⁸O of the flowstone and those based on tree-rings in the area of the Black Forest in Germany.

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References


