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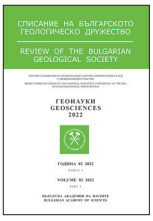

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New prolonged paleoclimatic cycles registered in calcite flowstones from the Duhlata cave, Bulgaria

Нови продължителни палеоклиматични цикли, регистрирани в калцитови натеци от пещерата Духлата, България

***Yavor Shopov*[1,2,3]**
***Явор Шопов*[1,2,3]**

[1] Sofia University St. Kliment Ohridski, Faculty of Physics, General Physics dept., Sofia, Bulgaria;
E-mail: yyshopov@yahoo.com
[2] Medical University of Sofia, Medical physics and biophysics dept., 2 Zdrave str., Sofia, Bulgaria
[3] Institute for Systems Science, Durban University of Technology, Durban, South Africa

Abstract. Studies of Quaternary climate change are particularly important for determining the extent and scale of the participation of natural and anthropogenic processes in global warming. For their research we applied measurements of paleoluminescent records and absolute dating of calcite flowstones from the Duhlata cave, Bosnek, Bulgaria. Using periodogram analysis of the obtained speleothem records, we established existence of new prolonged cycles of Quaternary climate change. Their intensity is comparable to that of the Milankovic cycles, which cause glaciations, so they have potential to produce similar impact on climate.

Keywords: caves, calcite, minerals, paleoclimate, speleothem records.

Introduction

It is well established that variations of the total amount of solar radiation at the Earth’s surface (insolation) produce global changes of the climate. Traditionally it has been considered that all such variations of the insolation are due to orbital variations (Milankovitch cycles). But theoretical curves of orbital variations of insolation explain only one half of the real paleoclimatic variations due to a number of arbitrary assumptions made by the Milankovitch theory (Stoykova et al., 2008). Real insolation contains also variations of the solar luminosity and climate friction (Shopov et al., 2004). In fact, the precise timing of the glacial periods differs from the one predicted by Milankovitch theory with up to ten thousand years. Such difference suggests existence of independent paleoclimatic cycles, which are as powerful as the Milankovitch cycles and are able to shift the timing of the glacial periods. So, the aim of this work is to find such cycles.

The luminescence of calcite speleothems precipitated in vadose (air-filled) caves provides one of the best preserved paleoclimatic records (Shopov et al., 1994). Here, we study such records in Calcite Flowstones from the Duhlata cave, Bulgaria to find prolonged paleoclimatic cycles recorded there.

Materials and methods

Luminescent records were obtained by microphotometry of a photometric quality photographic image of phosphorescence of a double side polished cross section of the sample along its growth axis, which was scanned on a high resolution scanning microdensitometer Joyce Loebl with 10 μm step and 20 × 200 μm window, allowing optical smoothing of the scan. Phosphorescence of the speleothem calcite was excited by impulse Xe-lamp. Such excitation produces luminescence of fulvic and humic acids incorporated in the relevant layers of calcite speleothems during their growth (Shopov et al.,

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1994; Shopov, 2006). Their concentration in each layer is proxy of a soil temperature during its formation, which is determined by solar insolation of the surface in the case of grass cover over the cave like the one over the Duhlata cave.

Studied calcite flowstone was dated with 7 TIMS U/Th dates in 2 independent labs (Stoykova et al., 2003, 2008; Shopov, 2021).

Results

We studied the region near to the village of Bosnek on the southern slope of Vitosha Mts., Bulgaria. Careful study of this flowstone from the Duhlata cave show that it grew continuously during the last 250 000 years (Stoykova et al., 2003). This is rather unusual for speleothems, because during full glaciations usually there is no water supply for speleothem growth or cave waters are not saturated with calcium carbonate and start to dissolve speleothems. Either way this leads to appearance of hiatuses in speleothems.

We studied a calcite flowstone growing over the floor of Urinarnika hall of the Duhlata cave near the village of Bosnek, Bulgaria. The sample is located approximately 50 meters below the surface and 500 m far from the cave entrance. We measured a paleoluminescence record from this speleothem, with time step of 251 to 445 years (Fig. 1) as established by (Stoykova et al., 2003), who determined precisely the variations of the growth rate of this speleothem. This record has constant linear step of 0.0208 mm/px, but variable growth rate measured in mm/yr, which produce variable time step of the record.

Discussion

To compare the intensities of all cycles presented in a time series Shopov (2002) designed a special algorithm and computer code – Real Space periodogramme analysis that plots the periodogramme in the coordinates Cycle Intensity/Period. We used it to calculate intensities of the cycles presented in the paleoluminescent record in Figure 1. It demonstrated the existence of new very powerful paleoclimatic cycles of 10 800, 15 100, 6900, 9400 and 8400 years. Their intensity is comparable to that of the Milankovic cycles, which cause glaciations. Orbital variations of insolation (Milankovic curves) are theoretically calculated with 5 approximations (arbitrary presumptions), as a result of which they describe only about 50% of the variations in the instrumental paleoclimatic records and have shifts of the timing of their maxima and minima with several to ten thousand years. The established cycles can explain the observed differences between the theoretical curves and the instrumental records.

We found also several less intensive new cycles with duration of 5500, 5000, 4700, 3600, 3100, 3000 and 2800 years (Table 1). They produced prominent millennial variations in the record in Figure 1. According to Stoykova et al. (2008) the paleoclimatic cycles with duration between 16 000 and 11 years are of solar origin, so these cycles probably are due to solar variations.

Paleoluminescent record in Figure 1 covers the last 250 000 years when this speleothem grew continuously. Before it in the speleothem exists several hiatuses of unknown duration. They might

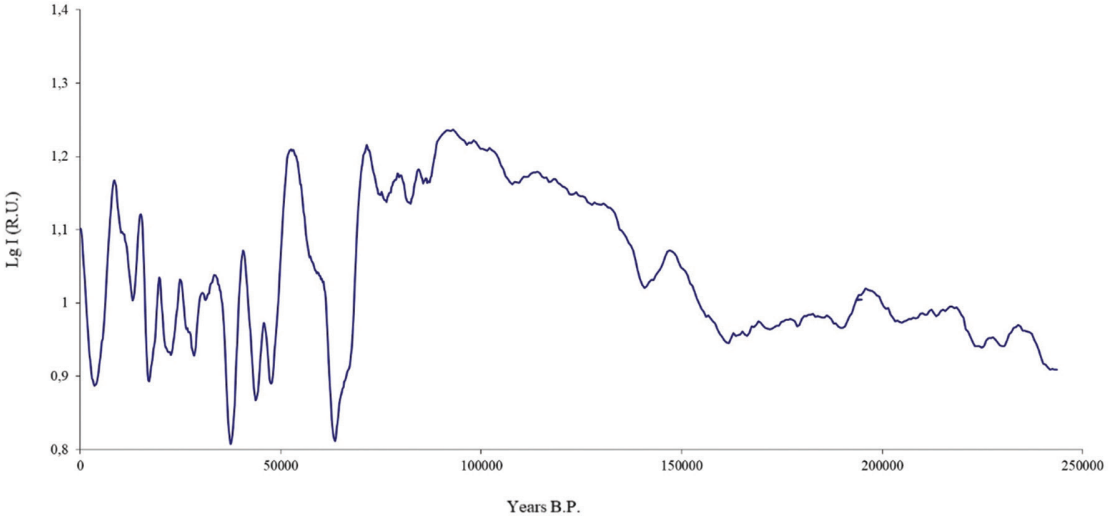

Fig. 1. Paleoluminescence proxy record from a Calcite Flowstone from the Duhlata cave near the village of Bosnek, Bulgaria, with time step from 251 to 445 years/px (in dependence on the growth rate of the speleothem). Linear step of this record is 48 px/mm (0.0208 mm/px).

Table 1. Paleoclimate cycles from the Duhlata cave (in years), error of determination the duration of the cycle (in years) and intensity of the cycles (in % of the most intense cycle)

Cycle (years)	Error (years)	Intensity (%)
15100	± 605	99.8
10800	± 308	100
9400	± 236	53.1
8400	± 186	49.1
6900	± 125	70.5
5800	± 89	16.4
5500	± 80	23.4
5000	± 67	34.5
4700	± 57	24.1
4000	± 42	18.8
3600	± 33	8.7
3300	± 29	11.3
3100	± 26	8.3
3000	± 25	6.2

be due to periods of severe glaciations or droughts (Shopov, 2021).

Conclusions

We demonstrate the possibility to use $\delta^{13}C$ speleothem records for determination of total covering of the ground by ice during glaciations. This way we found the existence of a total glaciation in Sofia region, Bulgaria, occurring before 600 ka, the limit of the U-Th dating that was applied. We established existence of very powerful cycles of the Quaternary climate change with a duration of 10 800, 15 100, 6900, 9400, 8400 as expressed in the luminescence record. Their intensity is comparable to that of the Milankovic cycles, which cause glaciations. The established cycles can explain the observed differences between the theoretical curves and the instrumental records. We found also several less intensive cycles with duration of 5500, 5000, 4700, 3600, 3100, 3000 and 2800 years. Probably these cycles are due to solar variations producing prolonged climatic cycles.

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