Ultra-high resolution geological records – how far we can push the time resolution?

Геоложки записи със свръхвисоко разрешение – до къде можем да увеличаваме времевата разделителна способност?

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Резюме. Настоящата работа изследва до къде реално може да се увеличава разделителната способност на геоложките записи по време. За целта са използвани пещерни натечни калцити, чиято структура позволява получаване на геоложки записи с най-висока линейна разделителната способност от известните геоложки архиви. За целта е използван Лазерен луминесцентен микрозонален анализ (ЛЛМЗА) на един изключително добър образец. Получените резултати показват, че в него са записани реални вариации по-къси от една седмица.

Key words: geological records, calcite, paleoclimatic records, speleothems, caves.

Introduction

Paleoluminescence records represent records of luminescence intensity variations of different growth layers of the calcite speleothem. It can be measured properly to represent variations of the past temperature or insolation only using the original LLMZA (Shopov, 1987) or IPL (Shopov, 2004) equipment.

Results and discussion

Here we use LLMZA to measure several ultra-high resolution paleoluminescence speleothem records in an extremely high quality calcite speleothem sample from Cold Water Cave, Iowa. The sampling of these records is 6 and 12 hours per data (4 and 2 measurements per day accordingly). This particular sample allows resolving of real variations of the surface conditions above the cave longer than 24 hours due to the rapid percolation of the rain waters through the bedrock (Stoykova et al., 2008). These records still remain one of the highest- resolution paleoclimatic records ever measured. Some of them were reported previously (Shopov et al., 1992, 1994), but short cycles represented in these records were not discussed, because reliable mechanisms of production of such cycles were not established at that time.

We used a new real-space periodogramme analysis algorithm (Shopov, 2002) to calculate, compare and calibrate the real intensity of the cycles in the ultra-high resolution paleoluminescence records. In addition to the annual cycle produced by the Earth’s rotation we found sub-annual cycles with duration of 27–30 and 14 days in an extremely high-resolution luminescent record from Cold Water Cave, Iowa (Fig. 1). Such cycles can be caused by the period of rotation of the Sun, which produces such variations in the solar wind modulating the geomagnetic field (Shapiro, 1967; Mursula, Zieger, 1996). Both solar wind and geomagnetic field modulate cosmic rays flux. Cosmic rays are centres of condensation of the water in the clouds (Svensmark, Friis-Christensen, 1997). They are strongly modulated by the solar wind. Stronger solar wind produces weaker cosmic rays flux, so less clouds and higher sky transparency, and stronger irradiation at the Earth’s surface. Variations of Solar luminosity

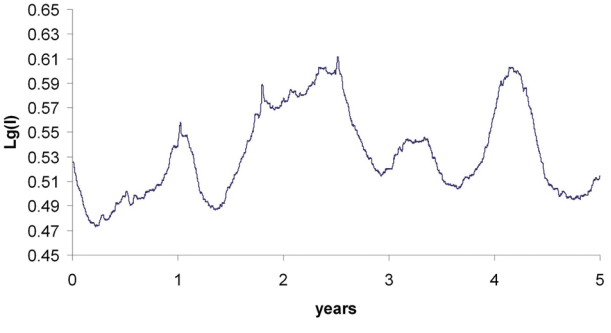

Fig. 1. High-resolution luminescence record from the Cold water cave, Iowa, approximately 1000 years ago. Time step of the record is ~2px/day (12 hours).

correlate with these of the solar wind. So, this mechanism may thus multiply about 100 times the impacts of variation of solar luminosity on the solar radiation reaching Earth's surface and to produce a strong positive correlation between the solar activity and global temperatures despite the small variations of solar luminosity (Stoykova et al., 2008).

Solar rotation can produce sky transparency cycles due to periodic appearance of coronal holes on the visible solar surface. They generate solar wind, which modulates cosmic rays flux.

Period of the appearance of sunspots and coronal holes on the visible solar surface vary from 27 to 30 days, depending on its latitude on the solar surface. The latitude of appearance of sunspots on the visible solar surface varies with the phase of the 11-year cycle. Sometimes different sunspots may appear at different latitudes during the same solar rotation. All this phenomena are producing a number of narrow cycles with slightly different periods. Combination of these processes may cause observed splitting (Fig. 2) of the solar rotation cycle in variations of the solar emissions.

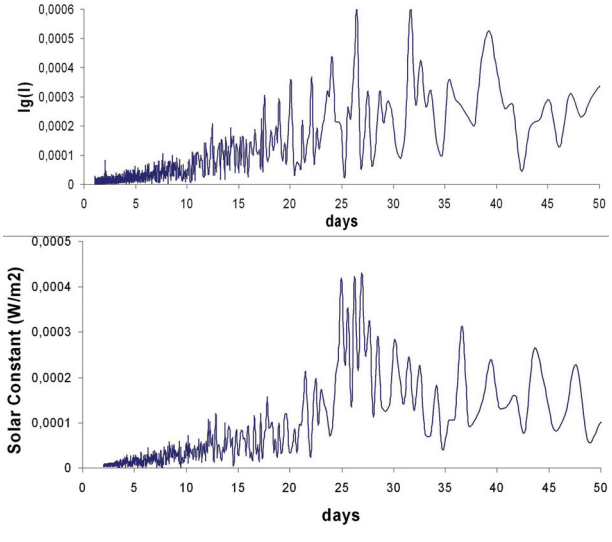

Fig. 2. Cycles of variations of high-resolution luminescence proxy record (up) and of variations of the total irradiance (down)

Conclusion

Paleoluminescence records in calcite speleothems can record real variations shorter than one week.

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