CONTRIBUTION TO THE CLASSIFICATION OF SPELEOTHEMS OF THE GROTTE DE LA SARTANETTE (REMOULINS, GARD) BY MEANS OF ESR-DATING

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Résumé

Au cours des fouilles effectuées depuis 1967 dans la grotte de la Sartanette une coupe a mis en évidence un important plancher stalagmitique. Ce plancher, à peu près au milieu de la coupe de 6 mètres de haut, scelle des couches ayant livré récemment une faune à Machairodus rattachable à un ensemble prémindélien; mais supporte à son tour des niveaux würmiens (à Ours, Cheval et silex moustériens). Deux prélèvements effectués l'un à la base, l'autre au sommet de cette formation, traités par la méthode de résonance paramagnétique (E.S.R.) ont donné un âge de 351.000 pour le 1er et de 270.000 pour le 2e, à ± 40.000 ans près. Ce résultat est bien en accord avec les identifications paléontologiques précédemment proposées.

Abstract

During caving works realised since 1967 in the cave named Sartanette, a transect had occured a thick speleothem in the medium part. This speleothem is overlying on a two meters thick formation contening a premindelian fauna (Machairodus, Rh. etruscus, etc.). Above, this speleothem is overlyed by a thin layer dated by Ursus spoeleus, Equus caballus and mousterian flints. Two samples extrated one from the basis, another from the top of the speleothem were tested by Electron Spin Resonance. The first reveled an age about 351.000, and the second 270.000 years ± 40.000. This proposed age is quite convenient with the paleontological classifications previously proposed.

Introduction to ESR dating

The electron spin resonance (ESR) method was first applied by Ikeya (1975) for dating speleothems and was reviewed recently (Henning & Grün, 1984). The method is based upon the detection of unpaired, paramagnetic, quasi "free" electrons. Natural ionizing radiation (alpha-, beta- and gamma-rays) produced by the decay of uranium, thorium, and potassium generates free electrons. These can be caught by traps in the crystall lattice (e.g. lattice defects or rare earth elements like y^3+ substituting Ca^{2+} in calcite). The number of trapped electrons is increasing with time and, hence, the ESR-signal, which is proportional to it.

The age can be deduced by the equation:

$$\text{Age (a)} = \frac{\text{accumulated dose (AD)} \quad \text{(krad)}}{\text{annuel dose (Do)} \quad \text{(mrad/a)}}$$

The accumulated dose (AD), which the sample received since the time of its formation, is determined by ESR-spectroscopy, whereas the annual dose (Do) is evaluated from the analysis of the U, Th, and K contents of the sample and its surroundings.

Experimental

The AD is determined by the additive dose methode (Fig. 1): The sample is irradiated successively by definite gamma doses (e.g. 60 Co-source). The plot of the resulting ESR intensity against these doses allows the extrapolation towards zero ESR intensity. The intersection with the x-axis gives the AD. Interferences affecting this determination were considered by Grün & DeCanniere (1984). An important problem occurs with the thermal instability of the traps. For this investigation an ESR peak with $g = 2.0007$ was used, which has a high meanlife at ambient temperatures (about 10^7a at 10^0C).

The determination of Do is in general the more difficult part of this methode. The complexity of this procedure is discussed elsewhere (Hennig & Grün, 1984).

The annual dose is first produced by the radioactive elements of the sample itself (*internal dose-rate*), namely by uranium and its daughter products. The Th- and K-contents of speleothems is in general negligible. For the uranium analysis the fission-track technique was prefered. because this method has the advantage of dectecting very low masses (approx. 2 - 3 mg) with a high accuracy and one can be sure measuring only the uranium content of the investigated part of the sample and not an average content of the sample and its surroundings. Fission-track micromaps displayed that even in optical homogenious speleothem layers the uranium contents can vary largely (Walton & Debrenham, 1980).

During the uranium decay chain an important disequilibrium occurs between the isotopes 234U and 230Th. This has to be taken into account, when determining an average annual dose (see Hennig & Grün, 1984).

Additionally the so called alpha-efficiency (k-factor) has to be evaluated. This value gives the ratio of the efficiency in producing detectable electrons by alpha-particles compared to beta- or gamma-rays. This determination is rather time consuming and normally an average value depending on the mineral investigated is assumed (here $k = 0.2 \pm 0.05$).

When measuring the annual dose-rate of the surroundings (*external dose-rate*) one has to consider only the long ranging gamma rays. This value was measured at the original sites of the samples by means of a calibrated, portable gamma multichannel analyser (Canberra, Series 10).

Results

Two samples from the covering speleothem layer were analyzed :

Nr.	AD (krad)	Uranium (ppb)	int. Do (mrad/a)	ext. Do (mrad/a)	Age (a)
1	13.5 ± 1.3	454	23 ± 6	27	270,000 ± 42,000
2	13.7 ± 0.7	195	12 ± 3	27	351,000 ± 36,000

Discussion

The ESR-analysis leads to the conclusion, that the speleothem layer, which covers the fossil-bearing clay stratum, was build around 300,000 a. This finding supports the paleontological classification of the fossils, which are described as Premindelian (Battuel et al., 1980).

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Fig. 1 :
Determination of the accumulated dose (AD) by the additive dose methode