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ESR DATING OF FLUVIAL SEDIMENTS USING GE CENTER IN QUARTZ

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ABSTRACT: Using the Ge centers of quartz sediments, the buried ages of fluvial sediments were determined by ESR technique. The ESR ages obtained from Ge centers are consistent with the TL ages, correspond with their horizons, accord with the geological background, and every ESR age is available. In this paper, determination of total dose of natural radiation (TD) and the reliability of ESR age using Ge center are also discussed.

KEY WORDS: quartz, GE centers, sediment, EAR dating

I. INTRODUCTION

In ESR dating of aeolian sediments using E′ center in quartz, the most perplexing problem is that the ESR signals of E′ center do not diminish but increase after bleaching under light[1], so it is difficult to satisfy the premise of the dating method for sediments. In this case the ESR ages of sediments by using E′ center may be the ages of quartz when they underwent the last thermal process other than the ages of sedimentation. After bleaching the ESR signal of Ge center in quartz could be completely reset to zero, and some researchs dated the ages of beach sands and faults[2–4]. In view of the ESR charateristic of Ge center in quartz, we carried out the experiments and reseaches on ESR dating of fluvial sediments using Ge center in quartz.

II. SAMPLES AND EXPERIMENTAL RESULTS

Rich sand gold deposits are stored in the seashore around Shandong Peninsula, China.

The placer gold deposits are mainly concentrated on the bottoms of fluvial beds and on the surfaces of weathered mantle of base rocks, it is, theoretically and practically, of great importance to date the ages of formations of placer gold deposits. Samples are gravelly sand, sandy silt and clayey sand. They were taken from two cores in old river beds as well as fluvial terraces which contained rich placer gold deposits in Zhaoyuan County, Shandong Province, China. Sample sites and horizons are shown in Table 1.

Table 1 ESR ages and relevant parameters of samples

No.	Sample No.	Sampling sites	Sample	Horizon (m)	Th (mg/ kg)	K_2O (%)	TD (GY)	ESR age (ka)
1	57/ CK19-2	Core of old Jiehe River bed	Sandy silt	2.5	43.0	3.16	74.6	14.7
2	57/ CK19-12	Core of old Jiehe River bed	Gravelly sand	7.5	23.8	3.89	198.2	46.2
3	57/ CK19-16	Core of old Jiehe River bed	Gravelly sand	10.9	14.2	3.90	1555.8	421.6
4	Ej-14	Core of old Zhuliu River bed	Sandy silt	5.7	14.0	3.78	291.3	108.1
5	Ej-1	Core of old Zhuliu River bed	Gravelly sand	11.2	9.2	3.88	631.8	188.0
6	Ej_2-1	Fluvial terrace of Lanjia River	Clayey silt	3.2	33.1	3.10	133.8	30.4
7	Ej_2-3	Fluvial terrace of Lanjia River	Clayey silt	5.8	18.9	3.06	277.7	81.4
8	R-3	Fluvial terrace of Zhongliu River	Gravelly sand	1.5	47.5	3.10	592.6	110.9

Samples were washed by water, sieved to obtain 0.1-0.25 mm grain fraction and treated with H_2O_2 to remove organic material. After cleaning the separated grains were soaked in 6N hydrochloric acid for more than one day to dissolve carbonate. Then, they were etched in 40% (W/ W) hydrofluoric acid for 1-2 hours to remove feldspar as well as the outer layer of the quartz grains. The samples were thoroughly washed in water and dried at 40℃. Finally, the magnetic minerals in these samples were removed by a WCF-2 magnetic separator. Samples were divided into 5-8 aliquots ($\approx$ 250mg each), and were artificially irradiated with ^{60}Co -source in different doses. Some alanine/ ESR dose meters were mixed in samples. By means of measuring alanine/ ESR dose meters, the exact dose values can be given[5]. The irradiated samples were laid more than one week, then measured with a JES-FEIXG ESR spectrometer under the measurement condition of room temperature, X-band, microwave power 2 mW, modulation amplitude 0.008 mT, and magnetic field scanning range 337 ± 5 mT. We selected the Ge center as the dating signal in spectra of samples (Fig.1) , and the measurement results are shown in Table 1. The K_2O contents were determined by atomic absorption spectrometer and U, Th contents were determined by cascake α-pair-counting. The U contents were so low that they seem to be absent, and only a few counts were determined in a day. We used a finite medium model to calculate annual dose rate[6], and the contributions of α radiation were neglected because the outer layer of the quartz grains were etched by 40%(w/ w) hydrofluoric acid. The calculation of the contribution of cosmic rays is the same as in Prescott, et al.[7] The water contents of samples were about 20%, so the corrected coefficients of β and γ radiation were taken as 0.8[8].

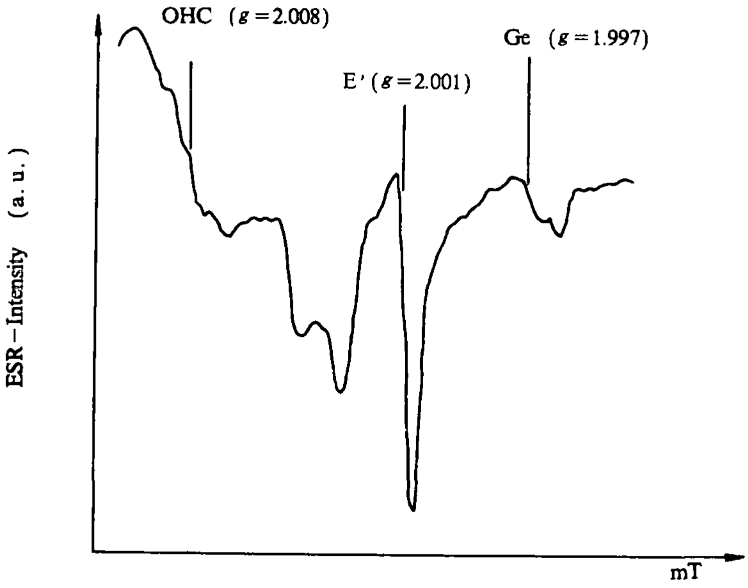

Fig.1 ESR spectrum of quartz

III. DISCUSSION

1. Determination of Total Dose of Natural Radiation(TD)

In the determination of total dose (TD) with additive dose method, two fitting manners are commonly used, i.e. Linear fitting and exponential fitting. We used linear fitting to determine TD, considering that the ESR signal sensitivitied in response to irradiation dose of Ge centers in the samples were low,and the natural ESR signals of Ge centers in some samples were difficult to distringuish from the noise signals of instruments. If we had used exponential fitting, the values of TD would have been smaller or become, positive values, therefore this is obviously unreasonable. Two cases on the ESR signal increase curves in response to irradiation dose of the samples existed, (1) the ESR signal intensities of Ge center grow with the increase of irradiation dose, such as No. 1, 2, 3, 4, 5, 6 and 8 samples, (2) the ESR signal intensities of Ge center now grew, now attenuate with the increase of irradiation dose, such as No. 3 and 7 samples. We suggest that this phenomenon be related to the samples themselves. Fluvial sediments and flood deposits differ from intrafault material, they might consist of various quartz grains which underwent different transport processes, i.e. the origin and burial time of quartz grains were differnt from each other, and these quartz grains were mixed together by fluvial action. It is probable that the quartz grains were not uniformly mixed up before they were divided into some aliquots. In this case only the burial age of quartz with the smallest TD value approached the sedimentation age of the sidiments in the largest degree. Second, now that the linear fitting was used, the dose-response curve should obey the law that ESR signal grew linearly with increaseing dose, so the linear correlation coefficients should by large. Third, in order that the fittin curve be representative the datum points should be as many as possible. Based on the above three considerations, we selected the value with large linear correlation coefficient, many datum points and the samllest dose value as TD. The detail is shown in Fig.2. The TD value of every sample was obtained in this way.

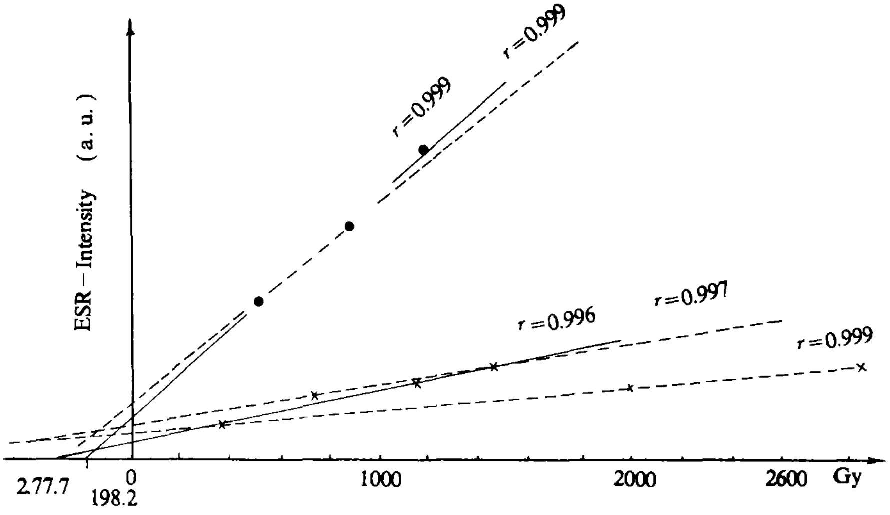

Fig.2 TD determination of quartz datum points of No.2 sample

x: datum points of No.7 sample; solid line, for TD determination; dotted line, for possible TD determination

2. Reliability of ESR Ages Using Ge Center

We are the first who determine TD with the above method. In order to compare with other dating methods we measured two TL ages. The TL age of No. 8 sample was 113.7 ka; the age of the sample which was taken from a slightly higher horizon than No. 5 sample in the same stratum near the road south to Dingjiazhuang village, the Zhuliu River, was 147.5 ka. The TL ages are consistent with the ESR ages of the samples. The ages of the sample correspond with their horizons and accord with the geological backgroud[9]. Every ESR age is available and reliable.

Buhay et al.[3] made bleaching experiment of quartz, and the ESR signal of Ge center in quartz can completely reset after bleaching for 10 hours under direct sunlight. Only the sediments bleached by sunlight before they were buried, could satisfy the premise of signal resetting for ESR dating. Otherwise, the ESR ages obtained from E′ centers of the samples are much older than those Ge centers, they are upside-down with their horizons and differ from the geological background far and away. It must be explained that the ESR ages of sediment using Ge centers are the oldest sedimentation ages, because the fluvial sediments might have been washed away by flood, not exposed to the sunlight before deposition and after being buried and deposited at the sampling sites. We estimate this process lasted not very long at the sample sites.

No papers about the life of Ge center in quartz of fluvial sediments in detail have been published, except that Fukuchi[4] reported the ESR ages obtained from Ge centers in quartz of intrafault material were older than 1 Ma, and approximately coincident with the ESR ages obtained from Al and OHC center, indicating that the life of Ge center might be over 1 Ma at least and thoroughly meets the needs of ESR dating of fluvial sediments in this paper.

IV. SUMMARY

Based on the above discussions we can see the ESR characters of Ge center (light effect, life and so on) could be satisfactory for ESR dating of sediments. The ESR ages obtained from Ge centers are consistent with TL ages, correspond with their horizons, accord with the geological backgroud, and every ESR age is available, implying that the ESR ages determined with the method in this paper are reliable. This technique advances in the ESR dating of quartz, must have a significant effect on the research on geochronology in young sediments, and reveals a interesting prospect for the ESR application to Quaterary Geology.

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