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バライト結晶年代測定：プレート境界の流体移動様式の解明

ESR Barite dating: understanding fluid movement at plate boundaries

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Abstract

The age of flowing hot fluid is crucial to the understanding of the geological evolution and activities in subduction zones. International Ocean Discovery Program (IODP) Expedition 370 discovered characteristic barite mineralization in the Nankai Subduction Zone (NSZ) off Japan[1]. The barite enables us to determine the age of its formation fluid, i.e., hot fluid flowed in the underthrust domain of the NSZ, with electron spin resonance (ESR) dating. In 2021, we used samples irradiated in the National Institutes for Quantum Science and Technology to confirm the closure temperature of barite for ESR dating and that ESR dating can be applied to the barite from the NSZ. We then irradiated the NSZ barite for ESR dating and are currently measuring ESR signals and calculating the ages of the NSZ hot fluid.

Keyword: ESR dating, barite, Nankai Subduction Zone, geochronology

1. Introduction

1.1 Fluid flow, mineral formation and dating

Fluid has a profound effect on the fault mechanics and the transition of seismogenic behavior of subduction zones[2]. The migration of high-temperature fluid is a common phenomenon in subduction zones, including the Nankai Subduction Zone (NSZ) off Japan. However, it is difficult to track the development of such fluid migration below the seafloor with direct observations.

Expedition 370 of the IODP (Site C0023) discovered barite formed in fluids up to 219 °C at 1 km below the seafloor in the underthrust section of the NSZ[1]. Identifying the age of the barite is essential to construct the history of hot fluid flowing in the NSZ. Dating the barite is thus desirable and the ESR dating method is suitable for the age range of the Quaternary barite.

However, the barite is now buried in sediment at about 100 °C. Questions arise regarding how stable the ESR signal in this barite is and whether the hot sediment can change the dating result. It is thus a prerequisite to confirm the thermal stability of barite for ESR dating prior to dating studies on the NSZ barite.

2. Methods and Materials

We applied isochronal and isothermal heating to natural and irradiated barite samples, observed the decay of their ESR signals, and carried out the associated calculations on the thermal stability of the barite samples[3].

3. Results and Implications

We confirm that the closure temperature of barite is generally between 190 °C and 340 °C[3]. In the NSZ, barite crystals are currently buried in sediments at 91 – 107 °C[1]. The sediment temperature of 107 °C is significantly lower than the closure temperature of barite. Therefore ESR dating can be applied to the NSZ barite without significant concerns that the hot sediments erased ESR signals in the barite[3].

We also confirm that ESR signals decay similarly in natural barite and irradiated barite. Irradiation of barite samples for ESR dating does not affect the thermal stability of their ESR signals. The confirmation of the thermal stability and closure temperature will allow the application of ESR dating to barite not only from the NSZ but also in a wide range of geological settings.

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2.6 Figure

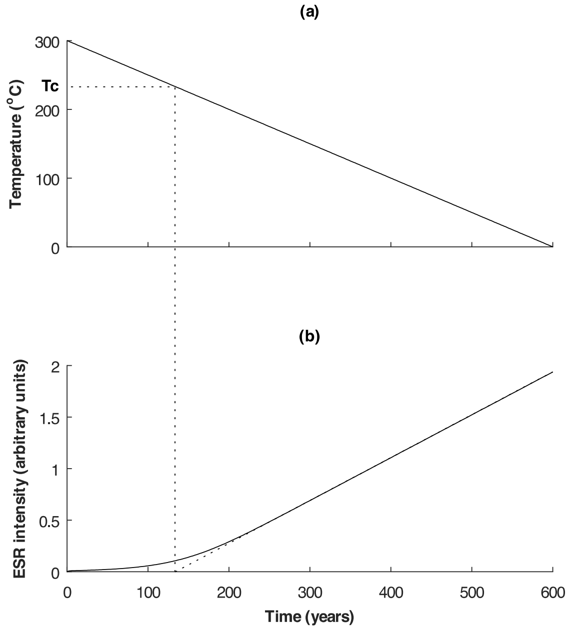

Figure 1. Obtaining the closure temperature of barite for ESR dating by extrapolating the linear increase of ESR intensity to the x-axis in (b), and identifying the corresponding system temperature in (a)[3]. The closure temperature of this irradiated barite sample is 233 °C[3].

Reference

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