Bulletin of the Geological Survey of Japan, vol. 69 (2), p. 135–139, 2018

Notes and Comments

Method for making high-quality thin sections of native sulfur

Takayuki Sawaki[1,*], Akira Owada[1] and Eri Hirabayashi[1]

Takayuki Sawaki, Akira Owada and Eri Hirabayashi (2018) Method for making high-quality thin sections of native sulfur. *Bull. Geol. Surv. Japan*, vol. 69 (2), p. 135–139, 5 figs.

Abstract: This paper proposes a method for making high-quality thin sections of native sulfur (i.e., highly transparent and with a very smooth surface) that are suitable for microscopic observation in mineralogical studies. Generally, native sulfur is too fragile and too easily altered by heating to prepare thin sections for mineralogical study using conventional methods. The proposed method combines dry and wet polishing methods with a special abrasive made of zeolite powder. Using this method, 30-μm-thick sections of native sulfur can be made. The proposed method allows more detailed geochemical and mineralogical studies of volcanic and geothermal fluids and sedimentary environments.

Keywords: thin section, native sulfur, polishing method, zeolite powder

1. Introduction

Native sulfur is generally deposited from volcanic gas and geothermal water near fumaroles and hot springs. It is also associated with evaporite and oil-bearing deposits (Lapidus, 1990). Therefore, native sulfur may contain geochemical information regarding the fluids in its crystals.

Thin sections of native sulfur, and other minerals such as quartz and feldspar, are essential for mineralogical studies. However, sulfur crystal is very fragile (hardness: 1.5–2.5) and easily damaged by conventional processes for making thin sections using water with abrasives. Sulfur crystal is also easily altered by heating; the melting point of α-sulfur (orthorhombic, stable below 95.5 °C) is 112.8 °C (Katayama *et al.*, 1970). Extra heating on drying up wet samples must thus be avoided during the preparation of sulfur thin sections.

Making high-quality thin sections of sulfur crystal (i.e., highly transparent and with a very smooth surface) is challenging. This paper proposes a method for making high-quality thin sections of native sulfur that are suitable for microscopic observation in mineralogical studies. The proposed method combines dry and wet polishing methods with a special abrasive made of zeolite powder. The proposed method can be used to obtain new mineralogical information regarding native sulfur crystals.

2. Preparation of thin sections of native sulfur

Native sulfur collected from the Matsuo Mine, Iwate Prefecture, Northeast Japan, and stored by the Geological Survey of Japan (Sample No. GSJ M658: Fig. 1) was used. The Matsuo Mine was one of the largest sulfur mines in Japan. Its sulfur deposit was found in 1882 (Kawano and Uemura, 1964). The mine was closed in 1972 (Iwate Prefecture, 2016).

The native sulfur sample was cut into a chip 24 mm × 32 mm in size using a rock cutter with water. The chip was dried at 40 °C in a drying machine. It was then impregnated with Epoxy Resin Type 301 of Logitech (Scotland). The chip embedded in resin was slowly hardened in a refrigerator for five days in order to prevent damage to the chip from self-heating during the solidification of the resin. The resin-coated chip was then dried at 40 °C in a drying machine (A in Fig. 2).

In order to prevent damage to the sulfur crystals during grinding, a special holder made of granite, which is much harder than sulfur crystal, was prepared. The resin-coated chip was cut into an appropriately sized piece for the holder using a rock cutter with water. The resin-coated chip was ground and adhered to the holder (B in Fig. 2) with an epoxy resin adhesive (CEMEDINE Super, 60-minute type).

To shape the smooth surface of the chip for better bonding to slide glass, the chip with the holder was ground with abrasive grinding papers (SiC) #180, #320, #500, and #800 in sequence under dry conditions (i.e., without

[1] AIST, Geological Survey of Japan, Geoinformation Service Center

[*] Corresponding author: T. Sawaki,Central 7,1-1-1 Higashi, Tsukuba, Ibaraki 305-8567, Japan. Email: t-sawaki@aist.go.jp

Fig. 1 Photograph of the used native sulfur sample from the Matsuo Mine (Sample No. GSJ M658).

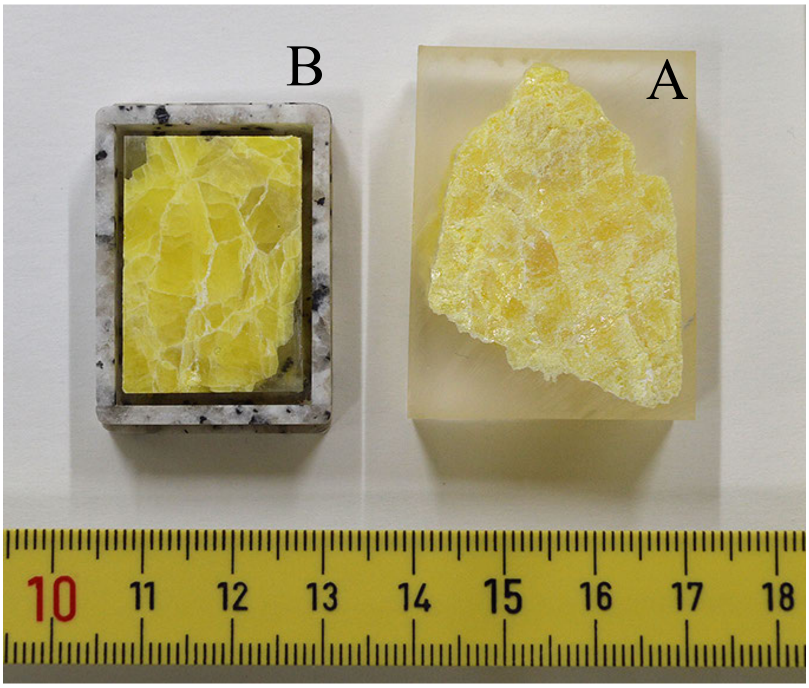

Fig. 2 Close-up views of (A) resin-coated chip of native sulfur and (B) cut chip on holder of granite with epoxy resin adhesive.

liquids as coolants or lubricants). Dust on the chip with the holder from grinding was blown off using compressed air after each grinding process. The chip was reinforced via impregnation with a resin (Cyanobond RP-X, Taoka Chemical Co. Ltd.). Then, the chip with the holder was polished with abrasive grinding papers (SiC) #1,200, #2,000, and #4,000 in sequence. Dust was blown off and no reinforcement was used. After these processes, the chip with the holder was polished with a polishing cloth (MD-Dur, Struers; ϕ300 mm) and a slurry that included a fine powder (ϕ1 μm) of natural zeolite (ZEEKLITE Co. Ltd.) with a polishing machine (Rotopol-35, Struers; speed: 40-50 rpm). The polished chip with the holder was washed with water, which was blown off using compressed air.

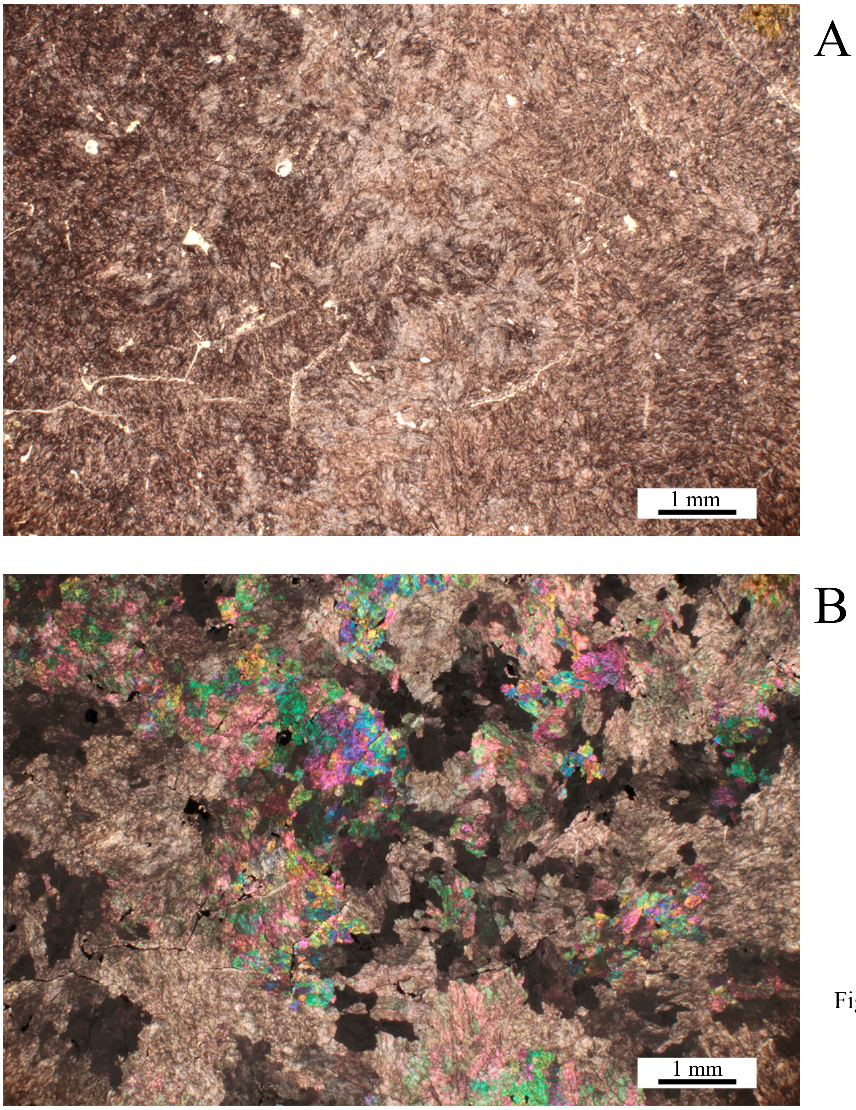

Fig. 3 Optical micrographs of 30-µm-thick section of native sulfur taken under (A) plane-polarized light and (B) cross-polarized light.

The chip with the holder was glued on a slide glass using CEMEDINE Super (30-minute type). The chip with the holder was sliced into a 1-mm-thick section using a rock slicer. The sliced chip was dried at 40 °C in a drying machine, and then reinforced with Cyanobond. The sliced chip was ground using abrasive grinding papers (SiC) #120, #220, #320, #500, and #800 in sequence under dry conditions. The target thicknesses of the sliced chip for the abrasive grinding papers were 150, 100, 70, 50, and 40 µm, respectively. Dust produced during grinding was blown off, and the sliced chip was reinforced with Cyanobond, as described above. Then, the thin chip, which was nearly a thin section at this stage, was polished with abrasive grinding papers (SiC) #1,000 (target thickness: 35 µm), #2,000 (30 µm), and #4,000 (30 µm) in sequence, with blowing and no reinforcement with Cyanobond. The thickness of the thin section was determined from the interference color of quartz in the granite of the holder. Finally, the thin section was polished with an MD-Dur cloth and the zeolite slurry for five minutes using a polishing machine (40 rpm). The thin section was washed with water. The water was then blown off and cover glass was glued onto the thin section with CEMEDINE Super (30-minute type).

During preparation of the thin section, frictional heat was prevented by using a low rotation speed for the grinding machine, a metallic (not synthetic resin) base disk for the polishing cloth, and short-duration cloth polishing (3 to 5 seconds per iteration) for the chip.

3. Thin sections of native sulfur

Optical micrographs of a 30-µm-thick section of native sulfur are shown in Figs. 3 and 4. The birefringence ($\gamma - \alpha$) of α-sulfur is 0.287 ($\alpha = 1.958$, $\gamma = 2.245$; The Association for the Geological Collaboration in Japan, 1981). The sample looks like carbonate rock under cross-polarized light (Fig. 3(B)). The sulfur crystals are very dusty, subhedral to anhedral, and 1 to several mm in size. Some crystals exhibit growth surfaces.

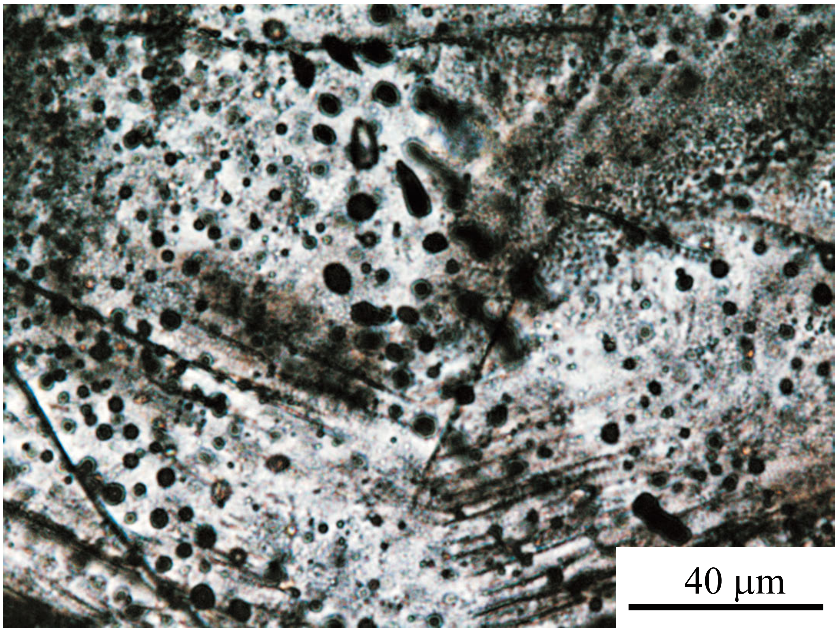

Fig. 4　Optical micrograph of gas-rich fluid inclusions in native sulfur (plane-polarized light).

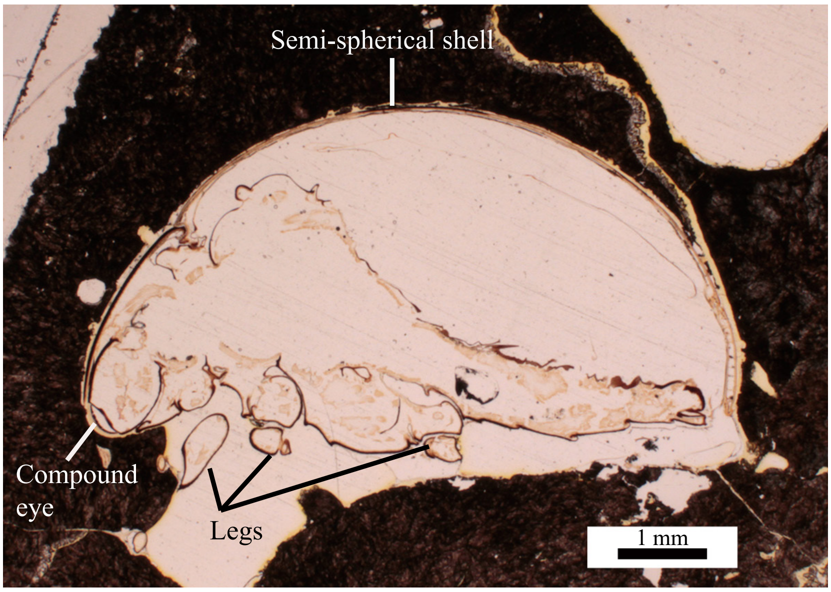

Fig. 5　Sliced insect (possibly lady beetle) in thin section (plane-polarized light).

Figure 4 shows many fluid inclusions in the native sulfur. The dark and round spots are gas-rich secondary inclusions, which cut through crystal growth surfaces. The dusty appearance of the native sulfur (Fig. 3) may be due to the inclusions of various sizes. The gas in the inclusions could be a volcanic gas, from which the native sulfur was deposited.

Unexpectedly, an insect (possibly a lady beetle) was found trapped in the sample. Cross sections of a semi-spherical shell, three legs, and a compound eye are shown in Fig. 5. The insect might have gotten trapped and died during the deposition of the native sulfur in a fumarole. The soft tissue of the insect was preserved by the proposed method.

4. Summary

This paper proposed a method for making high-quality thin sections of native sulfur that combines dry and wet polishing methods without heating. The study of thin sections of native sulfur may lead to new information on the geochemical and mineralogical properties of volcanic and hydrothermal fluids and sedimentary environments. The proposed method can be used to polish metal surfaces to a high-quality mirror finish without scratching.

Acknowledgement

The authors would like to thank Mr. Tomoaki Sumii for preparation of the native sulfur specimen, and Dr. Masaya Suzuki for supplying the zeolite powder for polishing.

References

Iwate Prefecture (2016) Outline of the Matsuo Mine, Outline of the Matsuo Neutralization Plant, http://www.pref.iwate.jp/kankyou/hozen/mizushigen/19190/049542.html (in Japanese; checked on November 30, 2017).

Katayama N., Morimoto, R., Kimura, T. and Takeuchi, H. (1970) *Shinban Chigaku Jiten (Dictionary of Geology, New Edition)*, Vol. 2, Kokon-Shoin, Tokyo, 656p (in Japanese).

Kawano, Y. and Uemura, F. (1964) *Geology of the Hachimantai District*, Quadrangle Series, 1:50,000, Geological Survey of Japan, 36p (in Japanese with English abstract 8p.).

Lapidus, D. F. (1990) *Collins Dictionary of Geology*, Collins, London and Glasgow, 565p.

The Association for the Geological Collaboration in Japan (1981) *Chigaku Jiten Zouhokaiteiban (Dictionary of Geology, Enlarged and Revised Edition)*, Heibonsha, Tokyo, 1612p (in Japanese).

Recieved January 16, 2018
Accepted June 5, 2018

高品質な自然硫黄薄片の作製

佐脇貴幸・大和田　朗・平林恵理

要　旨

これまで作製が困難であった，非常に滑らかな表面を持ち，透過性のある，高品質な自然硫黄薄片を作製することに成功した．よく知られているように，自然硫黄は非常にもろく，また熱により変質してしまうため，一般的な岩石薄片作製手法では薄片化することが難しかった．我々は，非加熱，乾式及び湿式研磨法により，厚さ30 μmの薄片を作製した．このような手法により作製した自然硫黄の薄片は，火山性流体や地熱流体，堆積岩の環境等に関わる新たな地球化学的あるいは鉱物学的研究に利用することが期待される．