知床博物館研究報告 Bulletin of the
Shiretoko Museum 39: 1–20 (2017)

Explosive eruption which blew out molten sulfur at the Crater I on Volcano Shiretokoiozan

Yamamoto Mutsunori

Earthscience.jp, 2-11-7 Sakuradai, Minamitsutsujigaoka, Kameoka, Kyoto 621-0847, Japan. ✉*yamamoto@earthscience.jp*

Volcano Shiretokoiozan is known for its molten sulfur eruption. In 1936, approximately 116,523 tons of molten sulfur was expelled at the side mountain crater called "the Crater I" and flowed into the Kamuiwakka Creek. However, explosive eruptions which blew out molten sulfur have not been reported. This is the first study focusing on the explosive eruption relevant to molten sulfur. I observed sulfur ejecta around the Crater I and found air bubble cavities and small rock fragments in those sulfur grains and then closed up the feature of the molten sulfur's explosive eruption.

Introduction

Volcano Shiretokoiozan located in the middle of the Shiretoko Peninsula is well known for its molten sulfur eruption (Fig. 1). In 1936, a huge amount of molten sulfur was expelled at the Crater I on the northwestern side of the mountain and flowed into the Kamuiwakka Creek (Watanabe 1940; Watanabe & Shimotomai 1937). All the sulfur was mined during and after the eruption and its total amount was reported as 116,523 tons (Geological Survey of Japan 1967). Yamamoto & Goto (2015) established a mechanism of the generation and eruption of the molten sulfur after having carried out Self Potential and DC resistivity survey and geological research. However, the explosive eruption involving molten sulfur has not been reported in detail. This paper focuses on the two types of sulfur, tear-drop one and rock-coating one and their distributions. Furthermore, I established explosive eruptions at the Crater I which blew out the melt of mixture of molten sulfur, gas and hot water with rock fragments sand.

Researches

Tear-drop sulfur grains are mostly round shaped small lump. The molten sulfur which was expelled and flowed in 1936 was located at lower elevation than the Crater I, but the tear-drop sulfur grains and rock-coating sulfur are located both lower and higher locations than the Crater I. So they assumed to have been splashed at the Crater I and traveled in the air to reach at the final destinations.

I carried out those researches as shown below:

1. Creation of a distribution map of tear-drop sulfur grains
I plotted the locations of tear-drop sulfur grains on a map and assigned serial-numbers to distinguish the locations of samples. Tear-drop sulfur grains are mostly found between rocks in the study area.

2. Observation and documentation of individual tear-drop sulfur grains
Tear-drop grains were carefully brushed or washed by water so that they were observed. I observed by ten-times magnifier and weighed the grains one by one and documented on small cards and then sealed into small plastic bags.

3. Creation of a distribution map of rock-coating sulfur
I looked for pieces of sulfur which coated on the surface of rocks and plotted locations on a map.

4. Observation and documentation of individual lumps of sulfur on the rocks
Some characteristic sulfur lumps were observed. Features and sizes were carefully documented.

5. Measuring the directions of rock surface with rock-coating sulfur
Directions of planes of rock surfaces with sulfur were measured. A direction of an imaginary straight line perpendicular to the plane with sul-

Fig. 1. The location of study area, Volcano Shiretokoiozan.

fur were measured from the north by clockwise using a compass.

Results

1. Distribution of tear-drop sulfur

As shown in the Fig. 2, most of tear-drop sulfur grains were located to the northeast and southwestward from the Crater I. The distribution area of the southwestern direction is slightly farther from the Crater I than northeastern area. The distribution area might extend farther to the southwestern direction but heavy bush prevented me to walk farther.

The numbers in the Fig. 2 indicate the locations of tear-drop sulfur grains and they correspond to the numbers in the Fig. 3.

2. Features of individual tear-drop sulfur grains

The Fig. 3 shows features of tear-drop sulfur grains.

The first one or two digits of the number before the hyphen indicate the location and the third digit after hyphen is a serial number at the location. E.g. "Tear-Drop 15-2" means this sample was observed at the location 15 on the Fig. 2 and secondarily observed in the several samples at the location.

a) Tear-Drop 1-1

This is a typical type of tear-drop-sulfur grains (Fig. 3-a, b) . Rounded disk with a concave at the center with approximately 12 small bosses. The location is 120 meters to the west and 27 meters below the Crater I.

b) Tear-Drop 1-2

An ellipsoidal tear-drop grain with a large boss and four small bosses (Fig. 3-c, d).

c) Tear-Drop 1-3

A round disk with a concave in the center with many cuts on both sides. Two hydrothermally-altered rock fragments are seen (Fig. 3-e, f).

d) Tear-Drop 2

This sample was found at approximately 100 meters northeast and 50 meters above the Crater I. Irregular shaped body with a large crack at the center has some bosses (Fig. 3-g, h). It is assumed that those bosses were originally separated grains and pushed into the main body when the sulfur was still hot and in low viscosity.

e) Tear-Drop 3-1

The location 3 is approximately 130 meters southwest of the Crater I. Circular cylinder shape with spaces inside and with large and small bosses (Fig. 3-i, j). Some white hydrothermally-altered rock fragments are included. Relatively larger than other grains in this location.

f) Tear-Drop 3-2

Thin irregular shaped disk with a lot of air bubbles and one rock fragment (Fig. 3-k, l).

g) Tear-Drop 3-3

This is a typical type of tear-drop sulfur grains of rounded disk with a concave in the center (Fig. 3-m, n). At the bottom view, ground mold (small dents) and cuts with some rocks are observed.

h) Tear-Drop 3-4

Stick shaped grain with some small bosses (Fig. 3-o, p).

i) Tear-Drop 4

This sample was observed at the location 80 meters northeast from the Crater I and 45 meters above it. Elongated irregular shaped grain covered by many bosses and dents (Fig. 3-q). It has 9 air bubbles and two rock fragments in it.

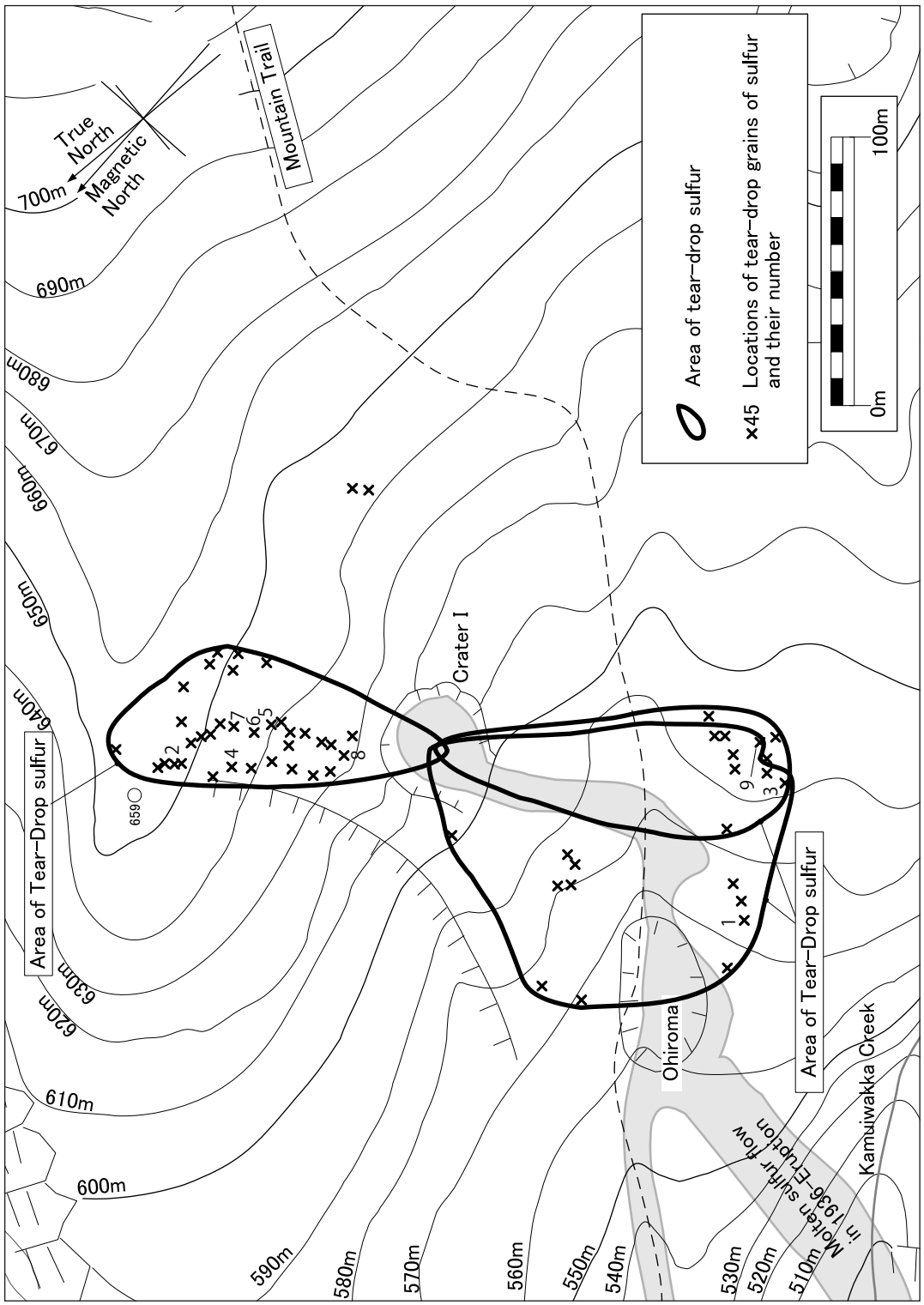

Fig. 2. The distribution of tear-drop sulfur grains.

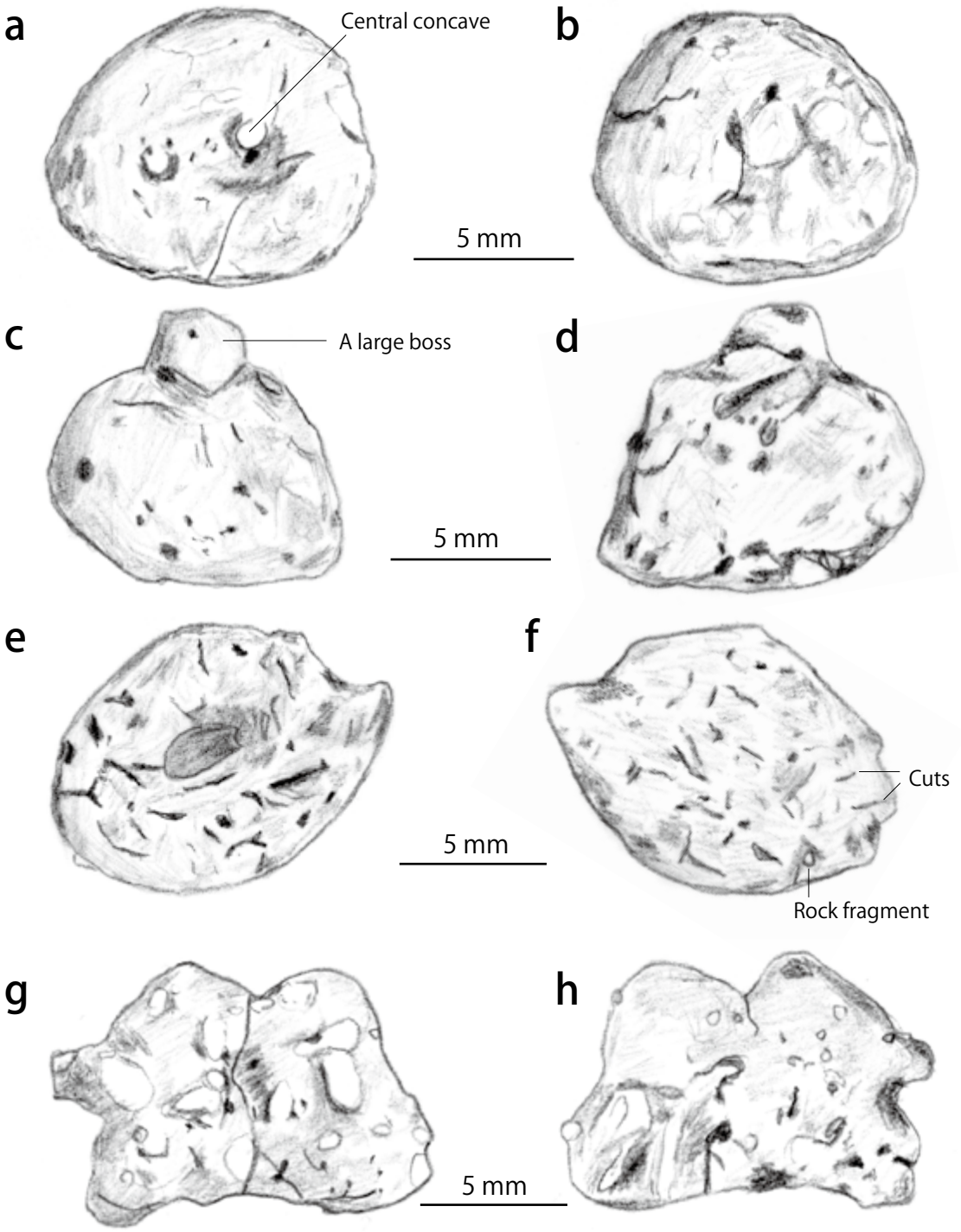

Fig. 3. The details of tear-drop sulfur grains. **a, b**: Tear Drop 1-1. A disk shaped sulfur in approximately 10 mm in dia. with concaves in the center and 12 small bosses. Includes no rock fragment. **c, d**: Tear Drop 1-2. Ellipsoidal tear drop sulfur with a large boss and four small bosses. Contains no rock fragment. **e, f**: Tear Drop 1-3. A disk shaped sulfur with a concave at the center and with numerous cuts on both sides. **g, h**: Tear Drop 2. Irregular shaped disk with two large sulfur grains and many other small grains on the main body. **g**: There is a crack at the center.

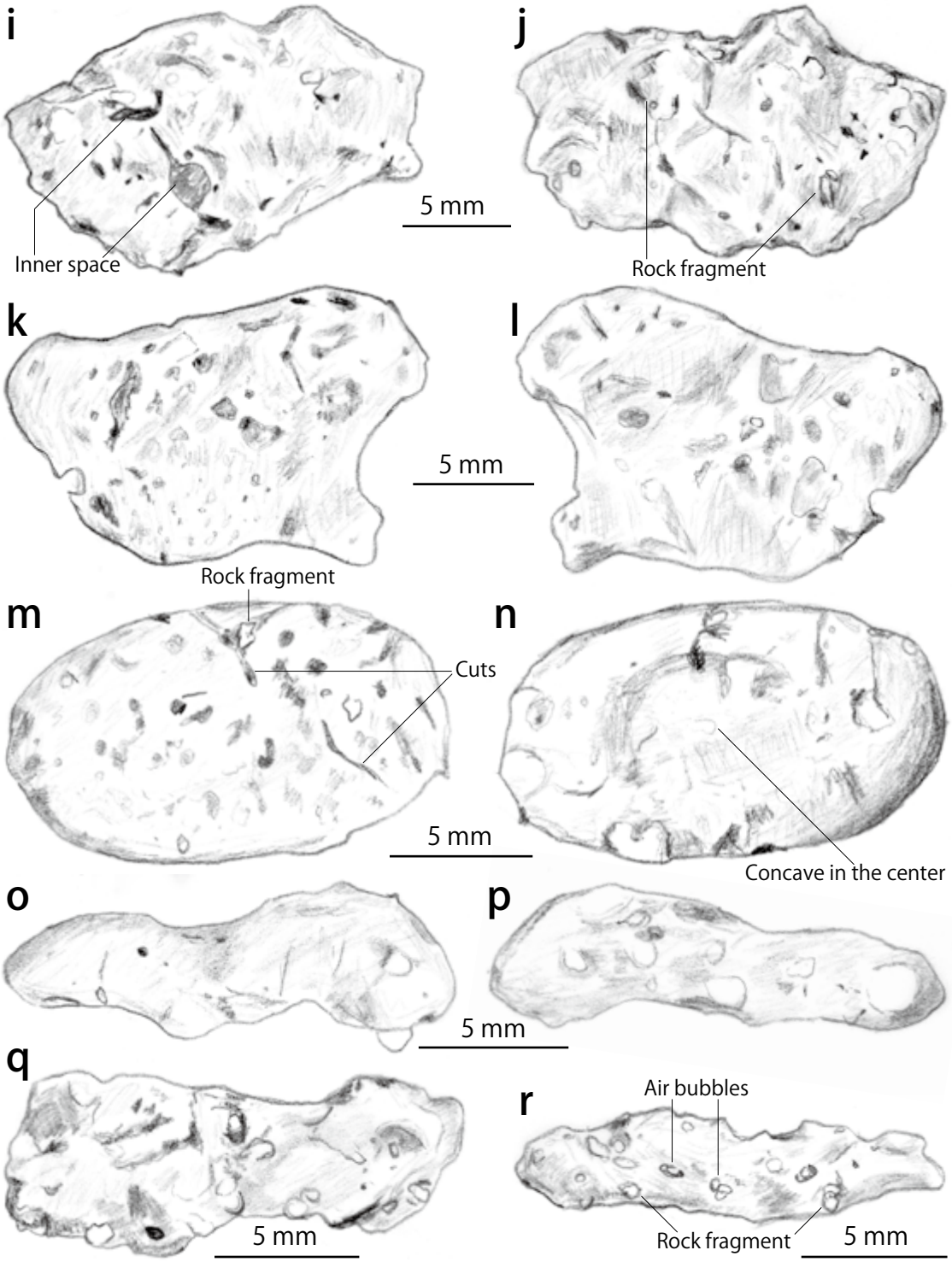

Fig. 3. Continued. **i, j**: Tear Drop 3-1. Circular cylinder shape with space inside and large and small bosses. Some white hydrothermally altered rock fragments are included in the sulfur. **k, l**: Tear Drop 3-2. Irregular shaped shin disk with air bubbles. **m, n**: Tear Drop 3-3. Elongated thin biconcave disk with ground mold and cuts on the bottom surface. Small dents on the bottom side are mold of ground. **m**: Bottom. **n**: Top. **o, p**: Tear Drop 3-4. Stick shape with some bosses. **q**: Tear Drop 4. Elongated irregular shape with small bosses. **r**: Tear Drop 5.

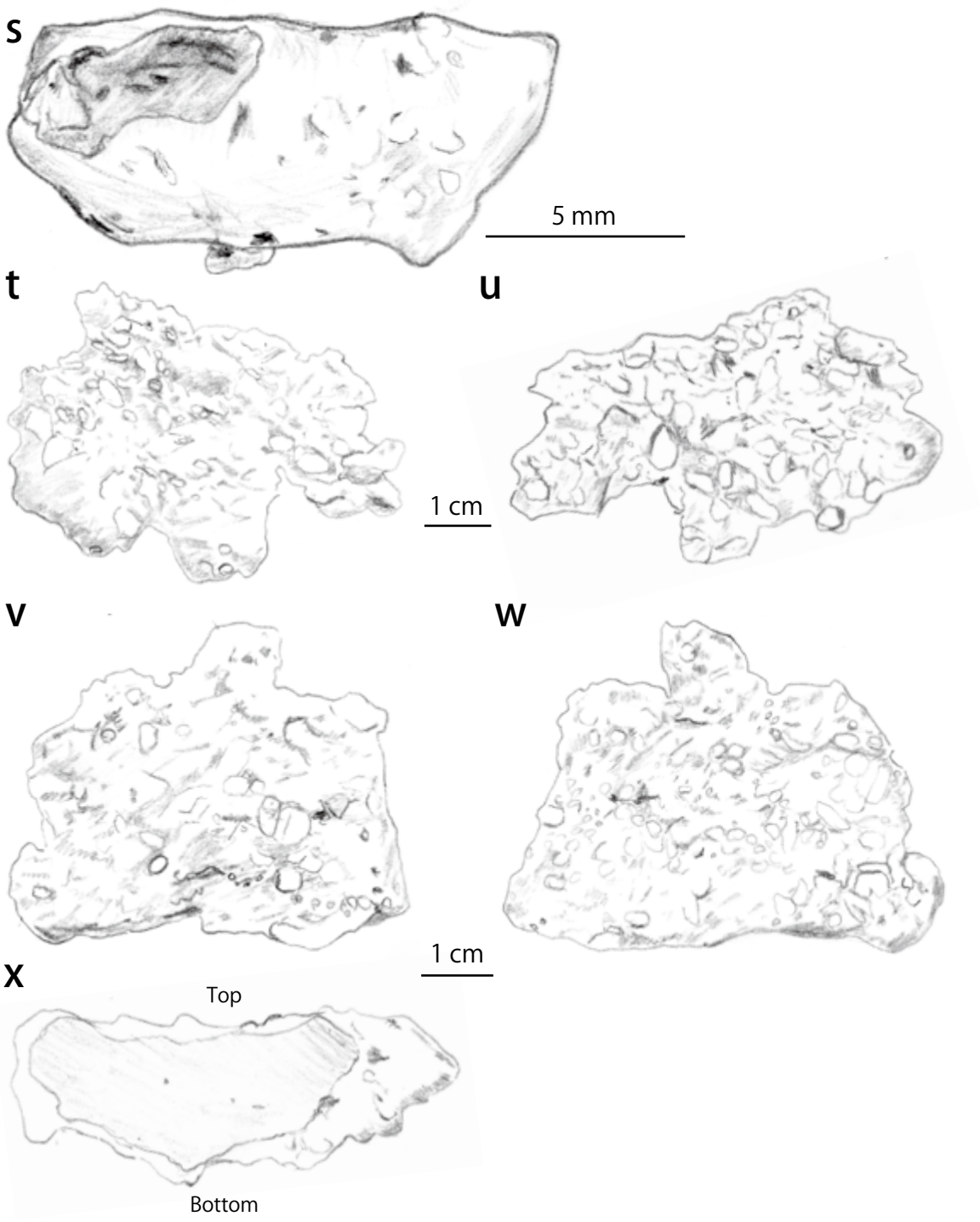

Fig. 3. Continued. **s**: Tear Drop 6-1. A spindle shaped sulfur with a large air bubble. **t, u**: Tear Drop 6-2. **t**: Bottom. Small grains are combined together with the large lump. Some cracks are seen. **u**: Top. It seems that the small grains were pushed into the larger soft body before cooled. **v, w, x**: Tear Drop 7. Platy body with small grains welded on both the top and bottom surface. It seems that shortly after the sulfur was blown by the explosion small grains were pushed into the large lump of sulfur when they were still hot and in low viscosity. **v**: Bottom. **w**: Top. **x**: The section view shows the inner part of the lump is dense and completely welded.

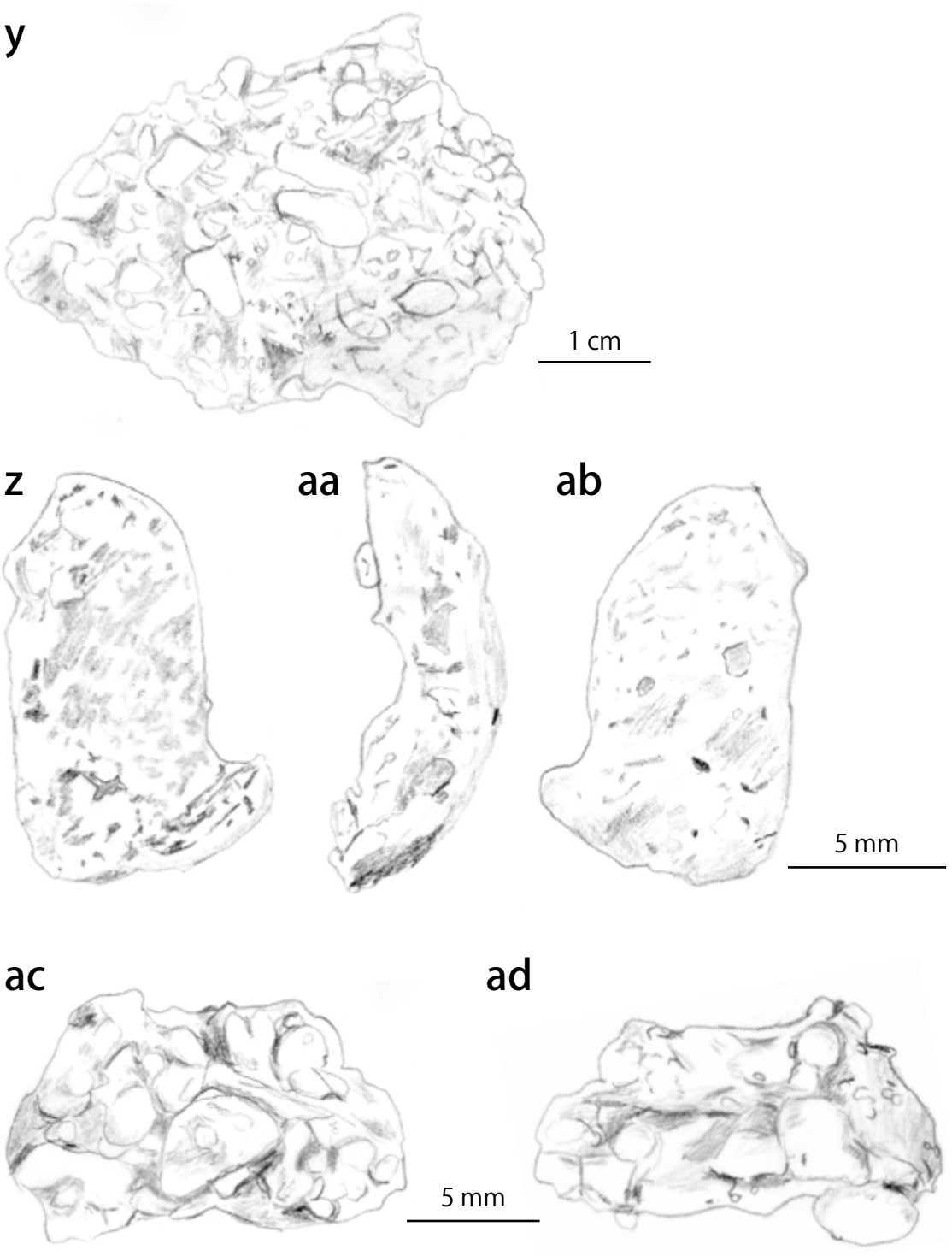

Fig. 3. Continued. **y**: Tear Drop 8. A group of grains. A lot of small grains are combined together. **z, aa, ab**: Tear Drop 9. It seems originally to be a large spherical body. But later broken into crescent shape. **z**: shown inner side of the spherical lump at the broken part. **aa**: At the side view a part of spherical outline is seen. **ab**: The outer surface with bubble holes is seen. **ac, ad**: Tear Drop 10. Small grains were put together on the larger lump. It seems that small grains were pushed into the larger body. **ac**: Top. **ad**: Bottom.

j) Tear-Drop 5
Location 5 is approx. 65 meters northeast from the Crater I and 40 meters above it. The grain is stick shaped with several bosses on one side and air bubble holes on the entire surface (Fig. 3-r). Some white rock fragments are observed on the surface and in the cavities.

k) Tear-Drop 6-1
Location 6 is approx. 70 meters northeast from the Crater I and 40 meters above. The spindle shaped sulfur grain has a big air bubble hole and some small bosses are seen and no rock fragment (Fig. 3-s).

l) Tear-Drop 6-2
An irregular platy lump (Fig. 3-t, u). It is assumed that small grains were pushed into the large soft lump when it was hot and in low viscosity. On the bottom, small rounded grains gathered on the large lump.

m) Tear-Drop 7
Location 7 is approx. 80 meters northeast from the Crater I and 45 meters above it. The sample is a platy body with small grains welded together with the large lump on the top (Fig. 3-v, w, x). The section view is showing that inner part of this sample is dense and it seems that it is completely welded.

n) Tear-Drop 8
Location 8 is approx. 38 meters northeast from the center of the Crater I and 15 meters from the crater rim; relatively close to the Crater I. The lump is composed of numerous small grains (0.5–6 mm), which seems to be welded together (Fig. 3-y).

o) Tear-Drop 9
Location 9 is approx. 120 meters southwest from the Crater I and 8 meters below. This crescent shaped grain is assumed to have been a larger spherical body and a part of it was blown away by the expansion of air bubble (Fig. 3-z, aa, ab). Several air bubble holes are also seen on the outer surface.

p) Tear-Drop 10
The location is not definite but somewhere around in northeast from the Crater I. The large lump in 15 mm long has several smaller grains on it (Fig. 3-ac, ad). It seems that those small grains were pushed into the larger lump.

3. Creastion of a distribution map of rock-coating sulfur
As shown in the Fig. 4, the rock-coating sulfur is distributed in the area centered on the Crater I.

4. Features of individual rock-coating sulfur
Features of individual rock-coating sulfur are shown in the Fig. 5. The first two digits of the number indicate the location where the sample was observed and the third digit after hyphen is a serial number of the sample observed in the location. E.g. "Rock 14-2" means this sample was observed at the location 14 in the Fig. 4 and the secondarily observed sample in the several samples on the same rock in that location. When the sample has no number after hyphen, that means only one sample was observed on the same rock.

a) Rock 1
The Rock 1 is located approximately 80 meters northeast and 50 meters above the Crater I (Fig. 5-a–d). The sample with air bubble holes and rock-fragment sand covering the top was found in a narrow and deep ditch on the Rock 1. Under the sample there is a space between the sample and the bottom of the ditch. The reason why there is an open space below the sulfur lump is unknown. Further research is necessary.

b) Rock 2
The Rock 2 is located approximately 57 meters northeast and 40 meters above the Crater I (Fig. 5-e–h). The sample was also found in a narrow ditch in the rock and also there is a space under the sample. Some part of the sulfur lump contacts to the rock surface and the contact zone has some cracks. Lower part of the sample which does not contact with the rock has rounded bosses.

c) Rock 3-1
The Rock 3-1 is located approximately 50 meters northeastward and 35 meters above the Crater I (Fig. 5-i–l). The sample approximately 7 cm long has small rounded relics of small grains. The lower part of this sample which does not contact with the rock surface has small rounded bosses.

The section photograph shows that inner part is composed of dense and massive sulfur with some cavities. The ditch in the rock faces to the direction 67 degrees from the north by clockwise while the direction of the Crater I is 220 degrees.

d) Rock 3-2
Fragile lump with numerous cavities in the cut section (Fig. 5-m–n). Spherical bosses are observed on the side surface.

e) Rock 4
This rock is located at 60 meters NNE direction from the Crater I and 35 meters above (Fig. 5-o–q). The sulfur lump is tightly fixed in the rock ditch and hardly removed. The side face of this sulfur lump is partly covered by thin rock fragments sand. The bottom was composed of rounded bosses. There is a space under the sulfur lump.

f) Rock 5
This rock is located approximately at 136 meters west from the Crater I and 32 meters below (Fig. 5-r–s).

The plane of the rock with the trickling sulfur faces the direction 98 degrees from the north by clockwise while the direction to the Crater I is 86 degrees. Dirt and rock fragments sand covers on the trickling sulfur.

g) Rock 6
This rock is located approximately at 130 meters west from the Crater I and 25 meters below (Fig. 5-t–u). This lump of the sulfur is fragile with a lot of cavities and some large rock fragments. It was found at the opposite side of the rock from the Crater I. This might have traveled in the air and flew over the rock on the right in this photograph and landed at this point at a high angle (at 68 degrees from the level).

h) Rock 7
This relatively large sample was found under the rock (Fig. 5-v–x). Pahoehoe patterns are observed on the top view. The cracks at the lower part of this photograph are seemed to be created by quenching because this part of the sulfur had contacted to the rock surface. On the bottom view the mold of the ground are seen.

i) Rock 8
Numerous dots of sulfur are seen on this lower part of the Rock 8 which is indicated by the broken circle (Fig. 5-y). It is seemed that those dots were sprayed when a lump of molten sulfur landed on the ground and bounced back.

j) Rock 9
This sample was found on a shallow depression on the rock (Fig. 5-z–aa). On the top view the pahoehoe structure is observed, which means the sample was melt and flowed some distance. On the bottom, numerous cracks are observed, which seems to be created by quenching.

k) Rock 10
The location is 110 meters southeast from the Crater I and 45 meters above (Fig. 5-ab–ad). Sulfur pieces are on the surface of this rock facing to the direction 332 degrees while the direction to the Crater I is 305 degrees. No sulfur is found on the plane facing to 160 degrees.

l) Rock 11
The location is 110 meters southeast from the Crater I and 45 meters above (Fig. 5-ae–af). Most of the sulfur pieces are seen from the direction to the Crater I (330 degrees). However, some sulfur pieces are also seen on the surface opposite from the Crater I.

m) Rock 12
The location is 110 meters southeast from the Crater I and 45 meters above (Fig. 5-ag–ai). The surface facing to the direction 295 degrees holds most of the sulfur pieces on this rock and the direction of the Crater I is 299 degrees. The rock planes facing to the direction 88 and 165 degrees hold no sulfur.

n) Rock 13
This rock is located at 130 meters east from the Crater I and 55 meters above (Fig. 5-aj–al). The surface facing to 240 degrees from the north holds sulfur pieces and other planes facing to 25 and 134 degrees have no sulfur. The Crater I is located to the direction of 284 degrees from this rock.

Discussion

To my knowledge this is the first study on ex-

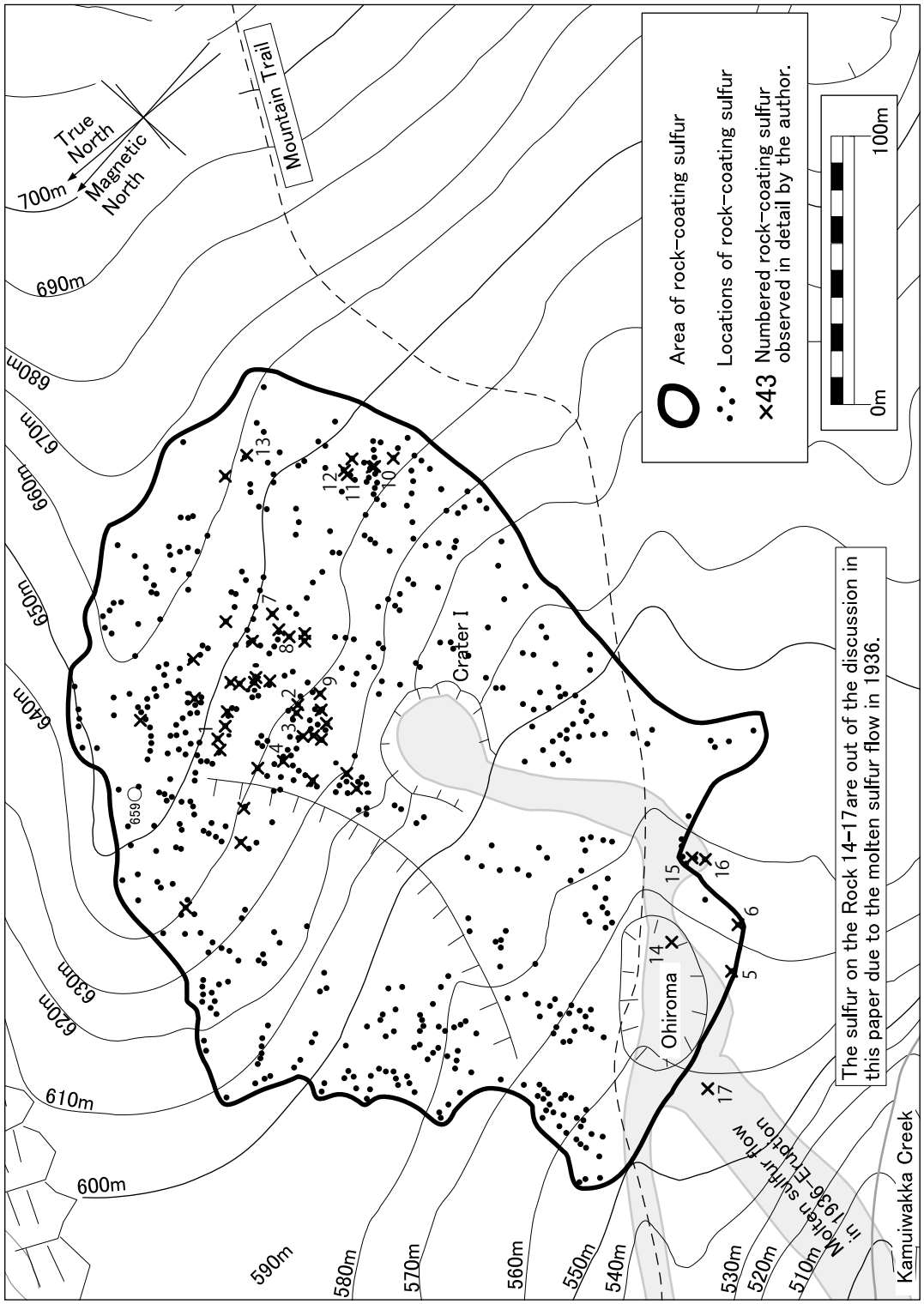

Fig. 4. The distribution of rock-coating sulfur.

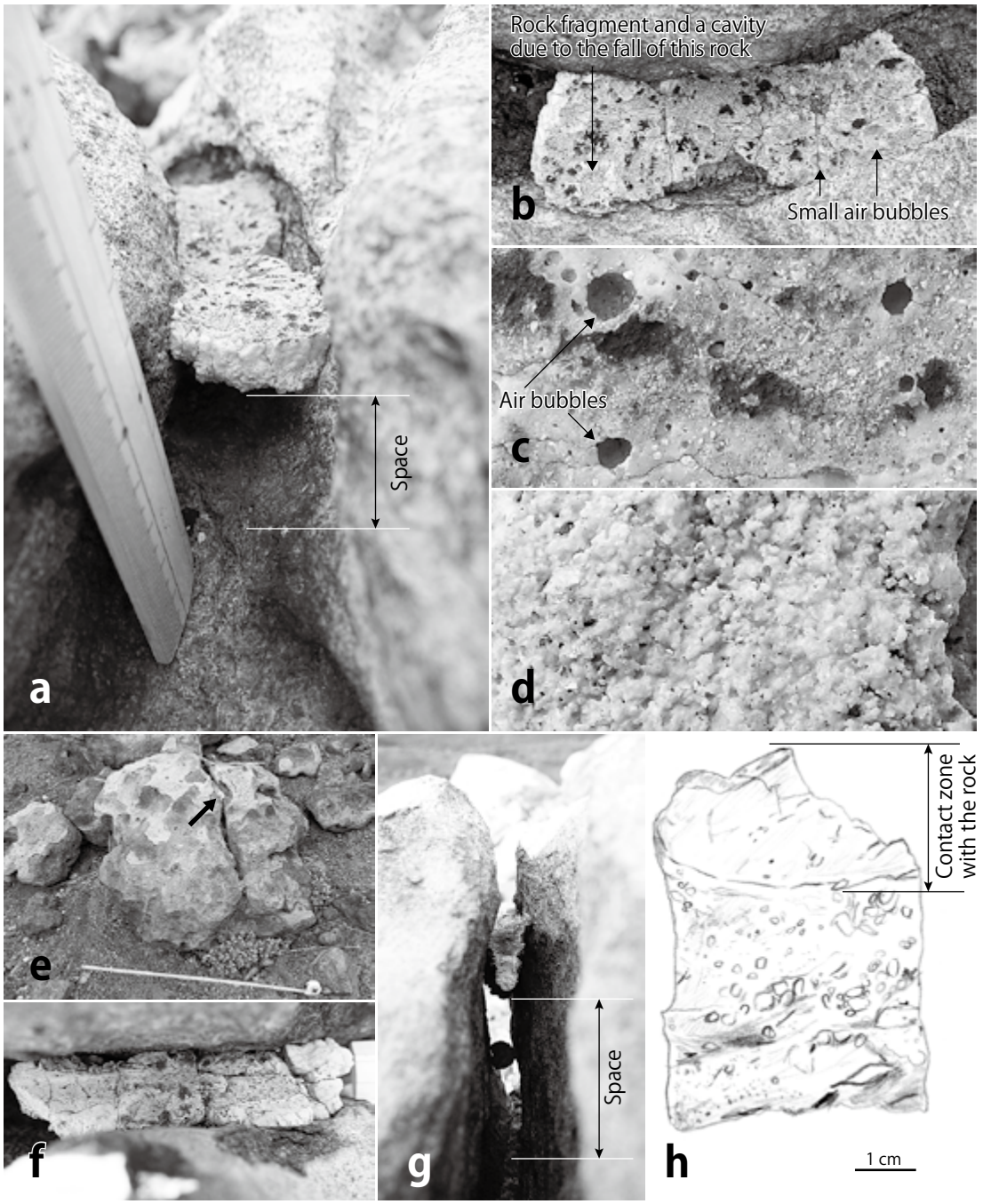

Fig. 5. The details of rock-coating sulfur. **a–d**: Rock 1. **e–h**: Rock 2. **b**: The sulfur lump in the ditch in the rock. **c**: A thin layer of rock fragments covers on the sulfur surface. **d**: The bottom side of the sulfur lump is composed of small rounded bosses. **h**: Small rounded bosses on the lower part of the sulfur lump. It seems that those round bosses are tear-drop sulfur.

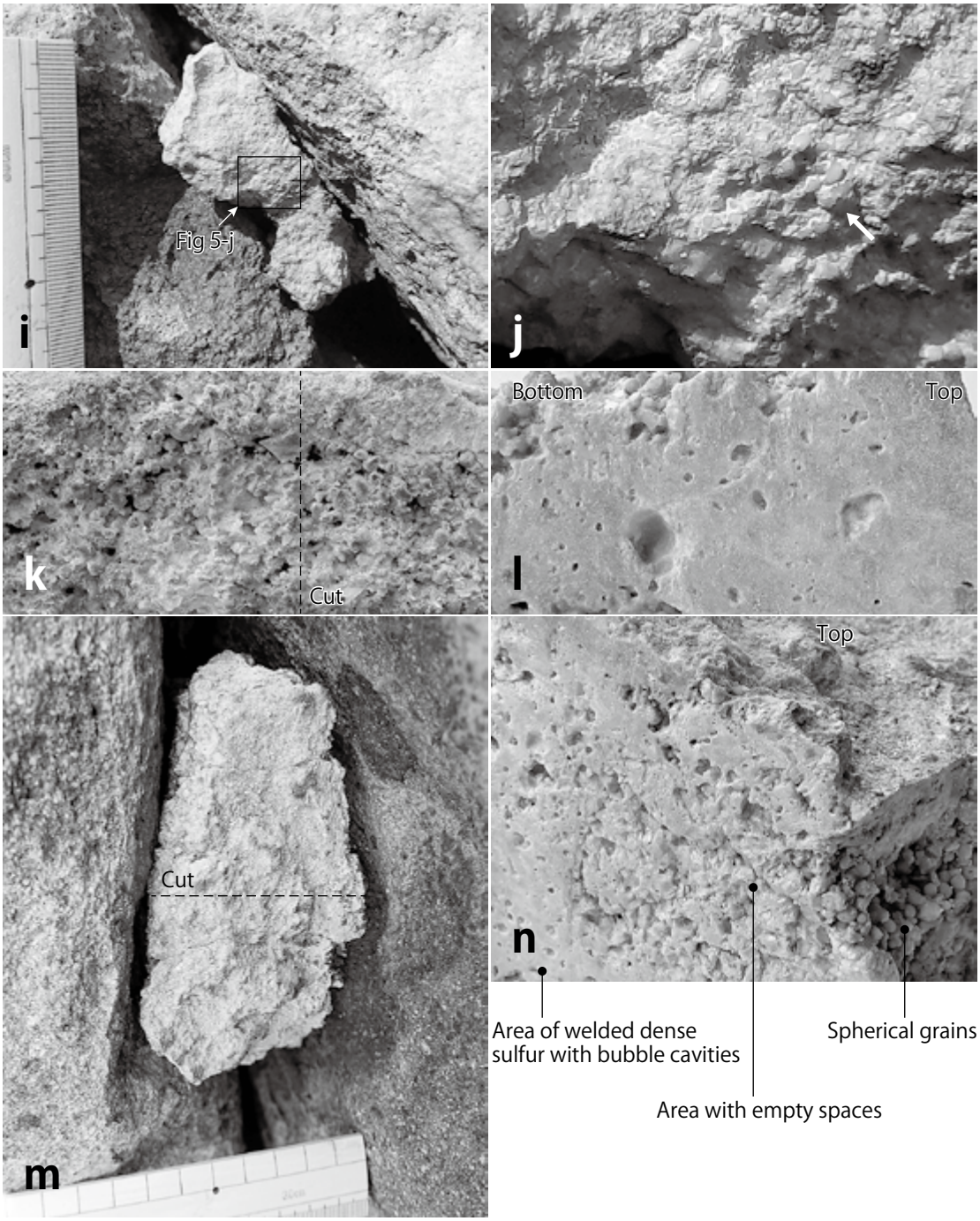

Fig. 5. Continued. **i–l**: Rock 3-1. **m–n**: Rock 3-2. **j**: Spherical relics on the surface of the sulfur lump which suggests that this lump is composed of small grains of sulfur. **k**: On the side the surface is composed of small sulfur spheres. **l**: A section photograph cut along the broken line in the Fig. 5-k. Most of this section is composed of massive and dense sulfur but some cavities are seen. Lower part of this lump has more cavities.

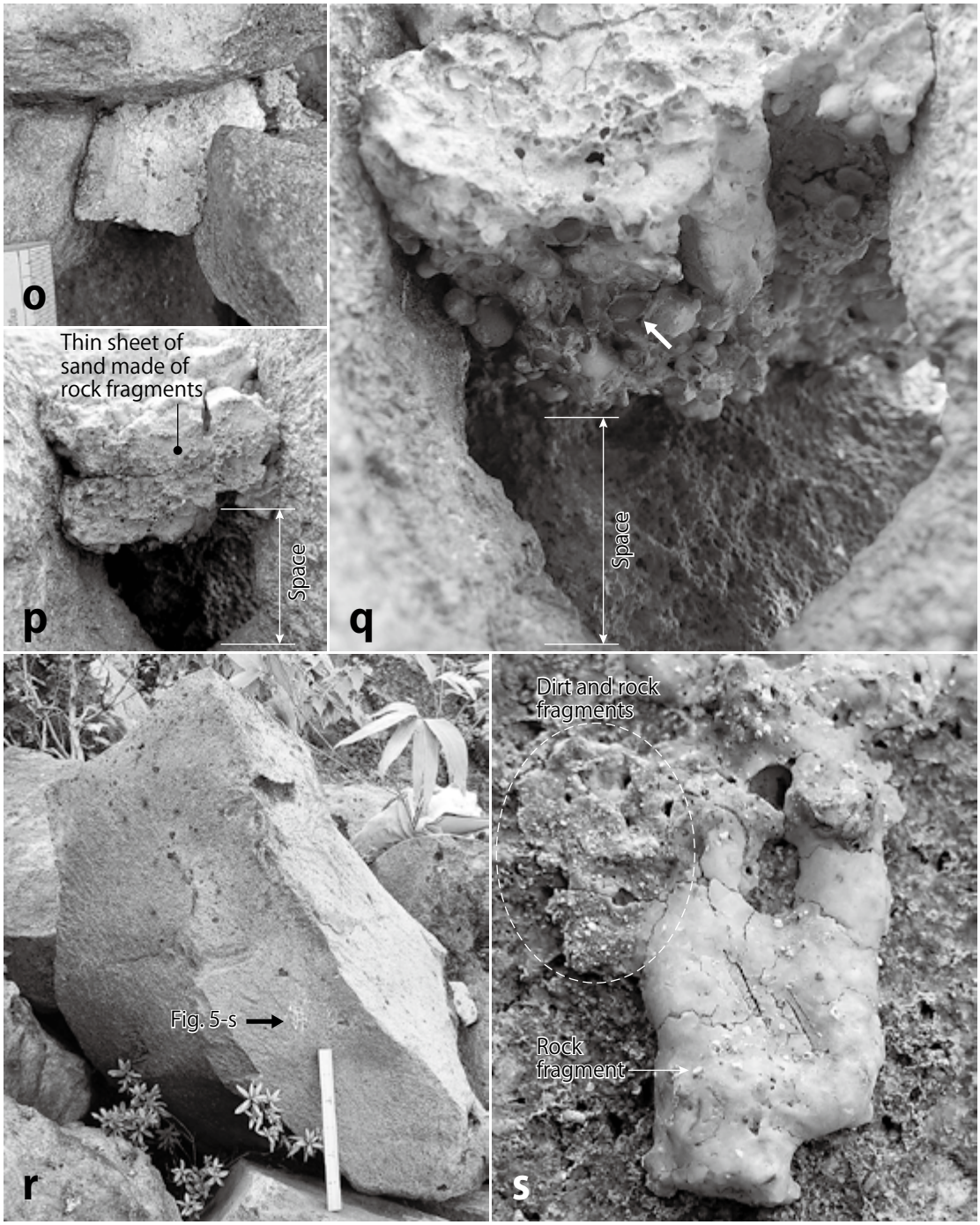

Fig. 5. Continued. **o–q**: Rock 4. **r–s**: Rock 5. **o**: Photographed on the top of the sulfur lump. The lump is tightly fixed in the ditch in the rock. **p**: On the side. Thin rock fragments sand covers on the side-surface. It seems that this plane was a crack right after the sulfur lump was fixed here and then sand with water sneaked into the crack. Later the other side of the crack dropped off. **q**: Spherical grains of sulfur on the bottom of the sulfur lump. There is a big space under the lump in the ditch. **s**: Trickling sulfur on the rock surface facing to the Crater I. Some part of the sulfur is covered by dirt and rock fragments and some air bubbles are observed. This rock surface is facing to the direction 98 degrees by clockwise from the north, while the direction of the Crater I is 86 degrees.

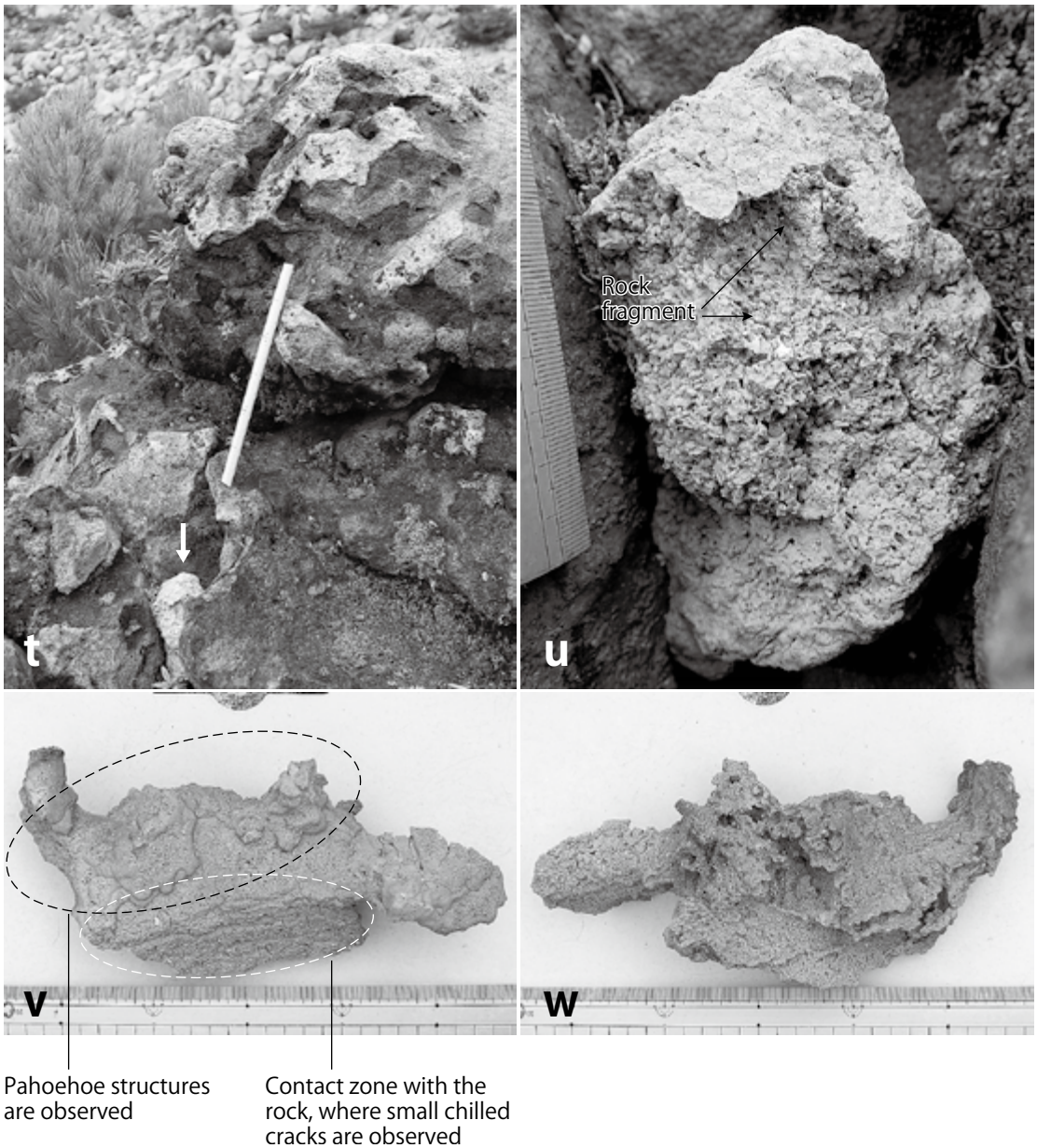

Fig. 5. Continued. **t–u**: Rock 6. Hydro altered rock fragments are seen in the broken part of the sulfur lump. One of the fragments is as long as 2 cm. The sulfur lump is fragile and containing a lot of air bubbles. The location of this sulfur lump is at the opposite side of the rock on the right from the Crater I that suggests this lump flew over this rock on the right into this location at a high angle. **v–w**: Rock 7. This sample was found in the space under the large rock behind two huge rocks as shown by the arrow in the 3D-photograph Fig. 5-x. It seems that molten sulfur flew onto the top of this rock and trickled down to the ground under the rock and cooled. Photographs taken at the field. **v**: Top. **w**: Bottom. The sulfur lump had been on the rock and sand. The mould of rock and sand are observed in this surface

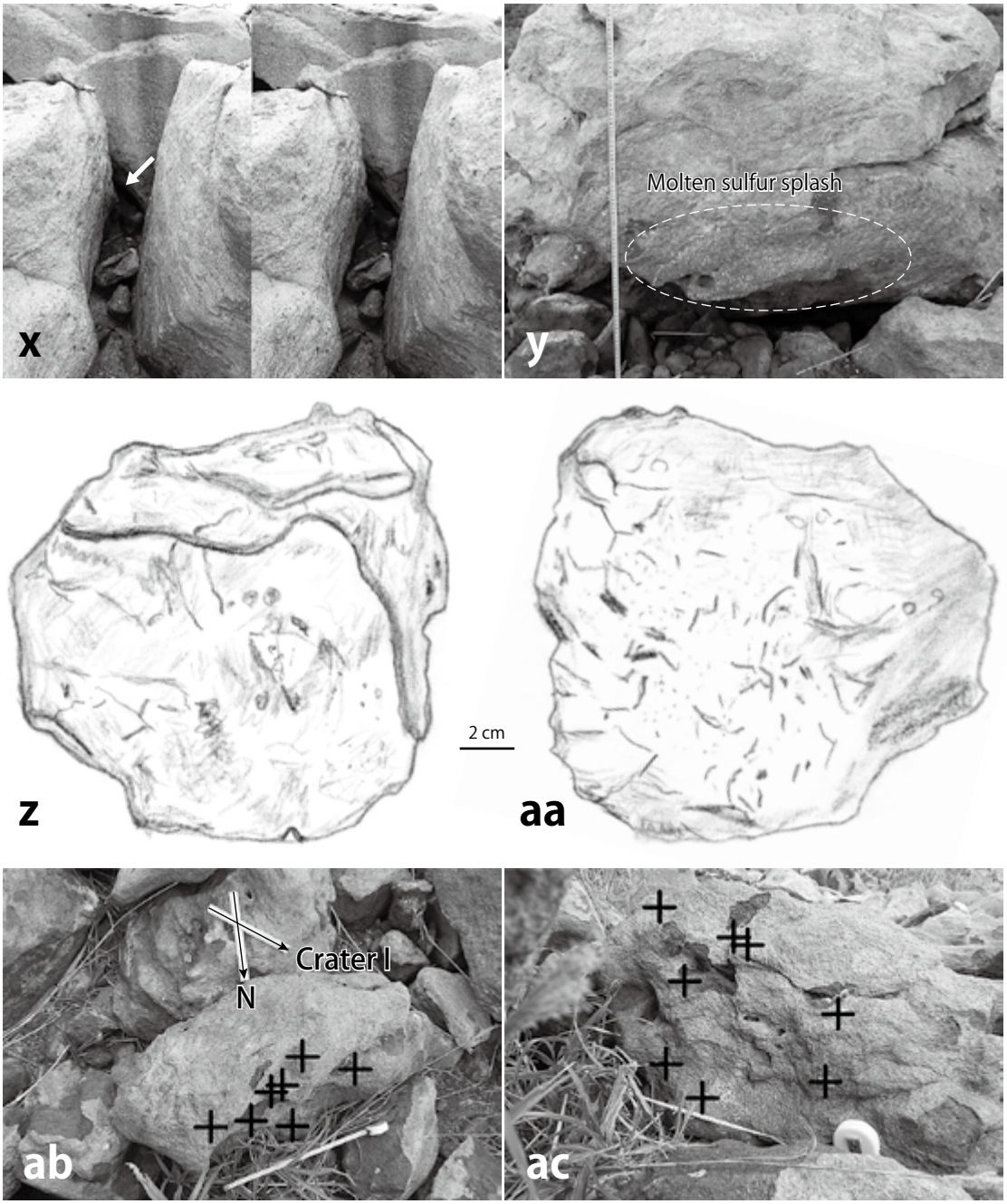

Fig. 5. Continued. **x**: Rock 7 (Continued). **y**: Rock 8. Sprayed sulfur on the opposite side on the rock from the Crater I. Small sulfur pieces are observed on the lower part of this surface. It seems that the molten sulfur flew onto the ground and splashed up to this part of the rock surface. The rock surface is facing to the direction 33 degrees by clockwise from the north, while the direction of the Crater I is 261.9 degrees. **z–aa**: Rock 9. **ab–ad**: Rock 10. Those photographs are showing the locations of sulfur pieces on the rock surface and the direction of the north and the Crater I. Locations of sulfur pieces are marked by +. Sulfur pieces are located on the rock surface facing to the direction to the Crater I. **z**: Top view. This sulfur in disk shape was on a shallow depression on a rock. The top surface shows pahoehoe structure which means low viscosity molten sulfur flowed. Some air bubbles are observed. **aa**: Bottom view. Contact zone with the rock with chilled cracks. **ab**: From above. **ac**: Seen from the direction of the Crater I. All sulfur pieces are on this side of the rock.

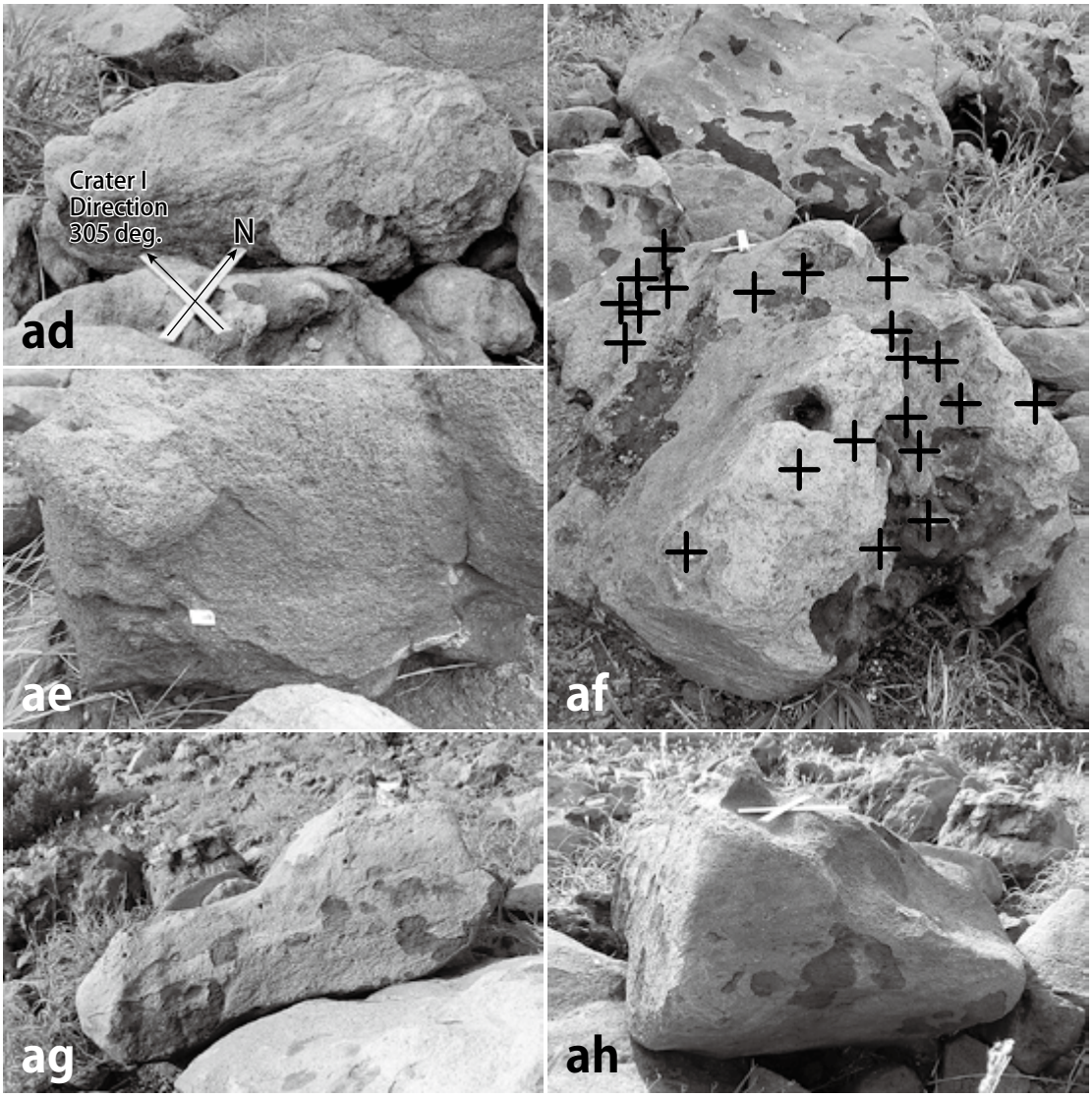

Fig. 5. Continued. **ad**: Rock10 (Continued). Seen from the opposite direction from the Crater I. No sulfur can be seen on this side. **ae–af**: Rock 11. **ag–ah**: Rock 12. **ae**: A streak of sulfur is seen on the surface (facing to the direction 78 deg.) opposite from the direction to the Crater I (direction 300 deg.). **af**: This photograph is taken from the direction from the Crater I (direction 300 deg.). Locations of sulfur pieces are marked by +. Most of the sulfur pieces are seen from this direction. **ag**: Direction 165 deg. **ah**: Direction 88 deg.

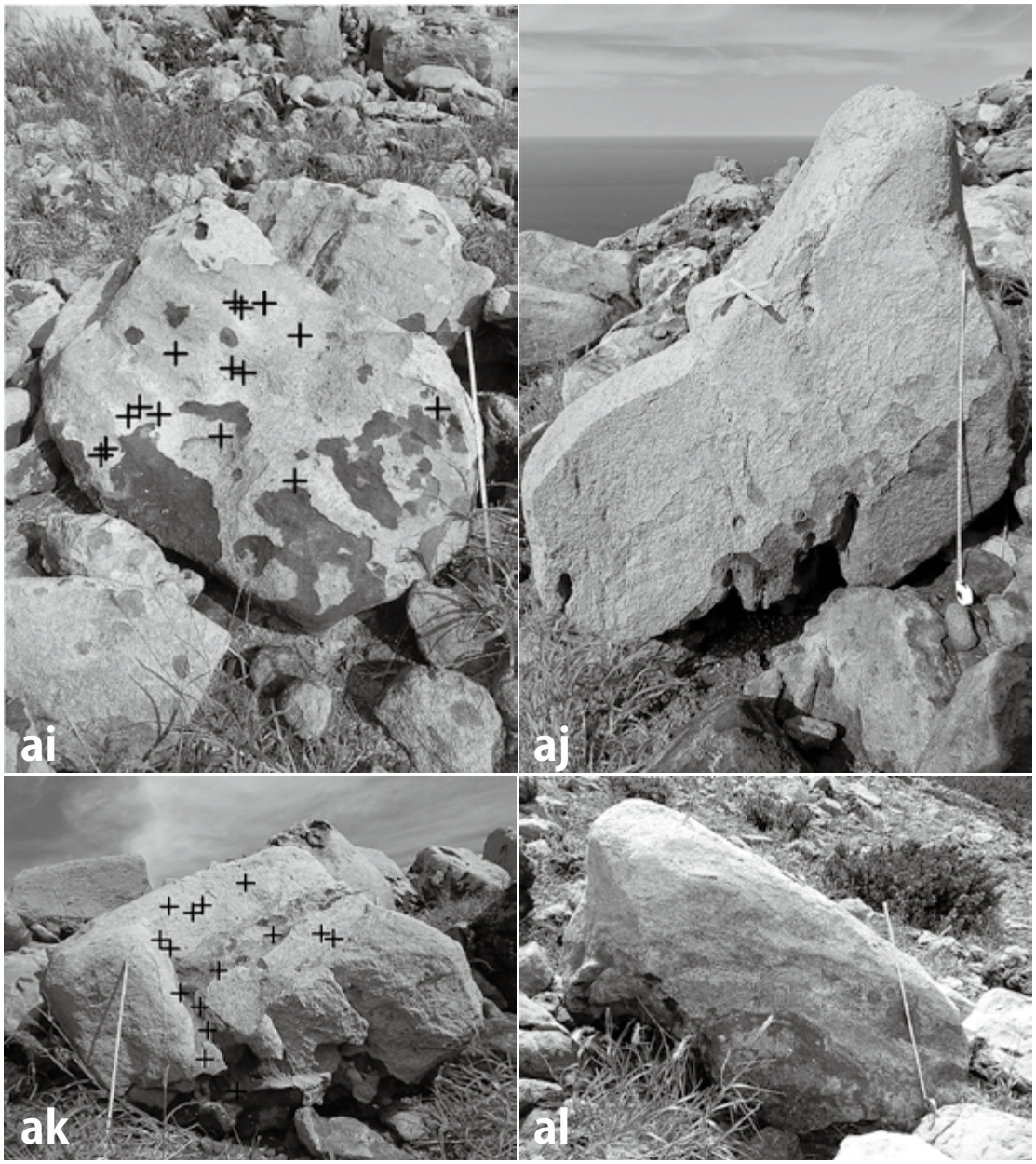

Fig. 5. Continued. **ai**: Rock 12 (Continued). Direction 295 deg. The direction of the Crater I is 299 degrees from the north by clockwise. By watching from the direction of the Crater I, sulfur pieces indicated by + are seen. **aj–al**: Rock 13. The direction of the Crater I is 284 degrees from the north by clockwise. Only the plane facing to the direction 240 holds sulfur pieces (indicated by +). **aj**: Direction 134 deg. **ak**: Direction 240 deg. **al**: Direction 25 deg.

plosive eruptions which blew out molten sulfur. Those results provide clear evidences that:

1. There were some explosive eruptions at the Crater I on volcano Shiretokoiozan,
2. Some of the molten sulfur was blown out around the crater I in the form of small grains of liquid sulfur,
3. The melt was composed mainly of molten sulfur, hot water, gas and sand of rock fragments.

Details will be discussed:

1. There were some explosive eruptions at the Crater I

Watanabe (1940) reported the molten sulfur flow restricted on the ground, but many of the localities of tear-drop and rock-coating sulfur are higher elevation than the Crater. At the same time the Crater I is located almost the center of the rock-coating sulfur distribution area. It clearly suggests that those tear-drop and rock-coating sulfurs are not a part of molten sulfur flow documented by Watanabe (1940) and implies that those sulfur pieces were blown by explosive eruption at the crater.

Most of tear-drop sulfur grains are in round shape. Some of them are in thin disk shape, others are stick type or irregular shape. It is evident that those grains traveled in the air while they were still hot and low viscosity. It is suggested that there was an explosive eruption at the Crater I and the molten sulfur was splashed and blown by the wind to the directions shown in the Fig. 2.

Rock-coating sulfur held by Rock 5, 10, 11, 12, 13 also supply good evidence that the Crater I had explosive eruptions. Those rocks hold sulfur pieces on the surface facing to or close to the Crater I.

Samples on the Rock 7 and Rock 9 shows that relatively large amount of molten sulfur in low viscosity was also blown out at the explosive eruption.

However, there are some minor result against this assumption. For instance, the rock surface with some pieces of sulfur in the Rock 11 faces to the direction 78 degrees while the direction of the Crater I is 300 degrees. Even though the rock surface faces to the almost opposite direction from the Crater I it holds small pieces of sulfur. Further work will be carried out for that.

Numerous sulfur pieces are held on the lower part of the surface facing to the direction 33 degrees on the Rock 8 while the direction of the Crater I is 261.9 degrees; in other words the surface is facing to the opposite direction from the Crater I. It is implied that the molten sulfur fell on the ground and splashed up to this part of the rock. Further research is also necessary.

2. Some of the molten sulfur was blown out around the Crater I in the form of small grains of liquid sulfur

Tear-drop sulfur grains are mostly rounded shaped with air bubble holes and rock fragments. It is evident that those grains were melt when they were traveling in the air. It is assumed that those grains were splashed by the explosive eruption at the Crater I.

Some samples like Tear-Drop 6-2, 7, 8, 10 shows characteristic features. Small grains in 2–7 mm in diameter look like pushed into larger soft sulfur body. It is suggested that when the molten sulfur grains landed on the ground those grains might be welded together.

The tear-drop sulfur grains shown in the Fig. 2 were light and might be easily blown by the wind when splashed into the air. They spread out at least three directions and it is the evidence that there were at least three explosive eruptions at the Crater I. Every time they were splashed the direction of the wind were different.

3. The melt was composed mainly of molten sulfur, hot water, gas and sand of rock fragments

Rock 5 shows that the splashed melt was composed of molten sulfur, gas and sand because the trickling sulfur is partially covered by gray rock-fragment sand and some air bubble cavities are seen on it It is evident that small cavities grew from the gas in the sulfur melt with rock fragment sand. Other samples also show evidences. Tear-Drop 3-1, 3-2, 6-1, 5, 9 and so on have air bubble cavities; it is implied that those samples contained gas. Rock-coating sulfur pieces also have air bubbles, e.g. Sulfur samples on Rock 1 and 4 and many others show large air bubble cavities.

The sample on the Rock 4 has a sand sheet on the side surface. It seems that it was made in a crack soon after the sulfur landed here. It is

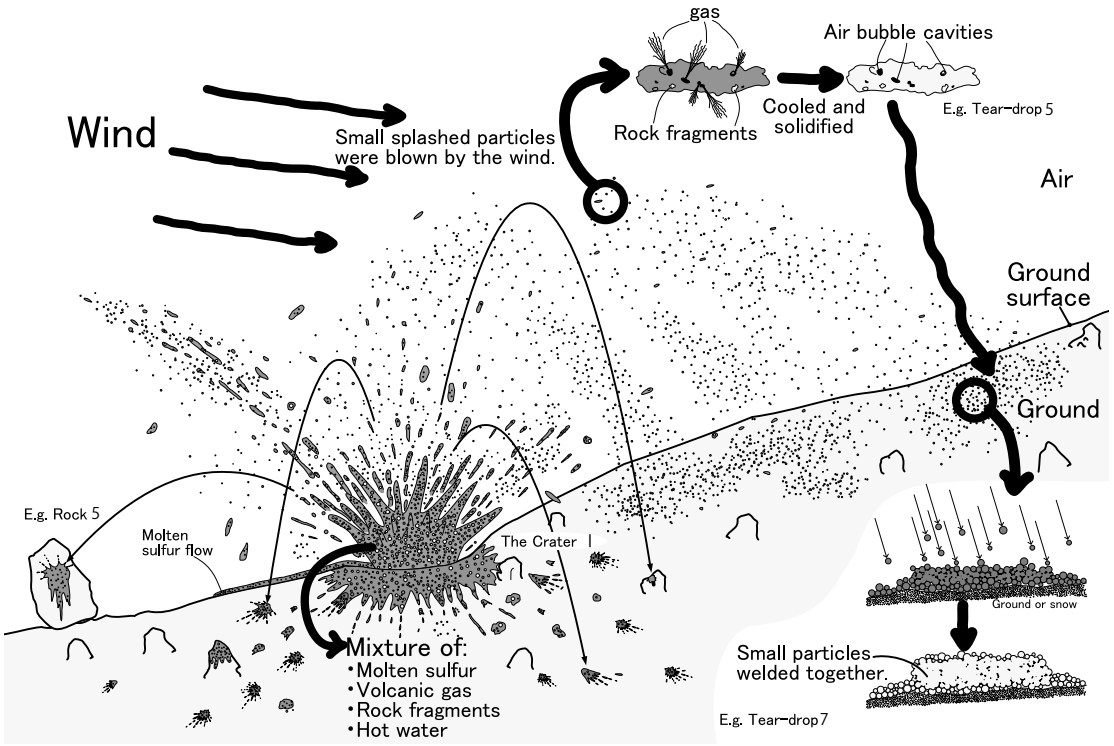

Fig. 6. Schematic diagram of the explosive eruption of the Crater I. Molten sulfur, a mixture of sulfur melt, volcanic gas, rock fragments and hot water, splashed by the explosion at the crater and small particles were blown by the wind while the large lumps followed the ballistic course. An elongated particle on the upper right of this diagram spewed gas while making air bubble cavities. A numerous small rounded particles of the molten sulfur fell on the ground and those hot melted particles were welded together. Large sulfur lumps touched down on the rocks trickled on the rock surface.

assumed that hot water contained sand when it was still in the crater, and the hot water with sand flowed into the crack when the lump landed here and then the sand was left on the side surface of sulfur sample before one side of the crack was lost later.

As those results and evidences shown above, there were several explosive eruptions at the Crater I and the crater blew out the melt (Fig. 6). It was mainly composed of molten sulfur with hot water, gas and rock fragments, which were scattered around the crater. Small grains of molten sulfur landed on the rocks in this area and today sulfur pieces are found on those rocks, which I call "rock-coating sulfur." The Crater I is located at the center of distribution of the rock-coating sulfur. Some of the molten sulfur blown by the explosion traveled in the air in the form of rounded grains in several millimeters and others are in the form of larger lumps. Those small grains were blown by the wind after they spewed up into the sky and tear-drop sulfur grains were formed. When those grains landed, some of them were still hot enough to keep themselves in low viscosity. Some of the lumps got ground mold as they were pressed to the ground. Other grains were welded together leaving some relics on the lump.

Acknowledgement

My warm thanks and appreciation to the vice president Michio Kiji at Mino-Higashi High School, who gave me special points of view on Mt. Shiretokoiozan; Dr. Takaharu Sato, a visiting researcher at Osaka Museum of Natural History, who advised me on sulfur samples; Mr. Koichi Nakamura at the National Institute of Advanced Industrial Science and Technology, who offered advices on this research and offered reference papers; and Mr. Nobuo Gochi at Shiretoko Museum, who supported for issuing this paper.

References

Geological Survey of Japan. 1967. Metallic and non-metallic mineral deposits of hokkaido. 575 pp. Geological Survey of Japan, Tokyo. (in Japanese)

Watanabe T. & Shimotomai T. 1937. Kitaminokuni Shiretokoiozan showajuichinenno katsudou. Hokkaido Chishitsu Chosakai Hokoku 9. 37 pp. + 1 map + 26 pls. Hokkaido Chishitsu Chosakai, Sapporo. (in Japanese)

Watanabe T. 1940. Eruption of molten sulphur from Siretoko-iosan Volcano, Hokkaido, Japan. Japanese Journal of Geology and Geography 17: 289–310. (in Japanese)

Yamamoto M. & Goto T. 2015. Near surface structure of a crater on mountain side of Mt. Shiretokoiozan and its mechanism of molten sulfur eruption. Poster session at Japan Geoscience Union in 2015. SVC49-P01. http://www2.jpgu.org/meeting/2015/session/PDF/S-VC49/SVC49-P01_E.pdf

知床硫黄山中腹１号火口で溶融硫黄を吹き飛ばした爆発噴火：山本睦徳

知床硫黄山は大量の溶融硫黄を噴出することで広く知られている．1936年の噴火では，山腹の1号火口から大量の溶融硫黄が噴出し，近くのカムイワッカ川に流れ込んだことが報告されている．地質調査所の資料から，その量は116,523トンにものぼるものと考えられる．しかしながら，溶融硫黄を吹き飛ばした爆発噴火については研究の報告がされていない．本研究は，溶融硫黄が関係する爆発噴火に焦点を当てた最初の研究である．筆者は1号火口からの硫黄噴出物の中の気泡や岩石片を観察し，溶融硫黄の爆発噴火の形態解明に迫った．