18. *The Land-slide at the Ogusi Mine.*

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Introduction. On Nov. 11, 1937, the radio broadcasted that a serious land-slide had occurred at the Ogusi[1] mine in Gumma[2] Prefecture, burying alive over 300 miners, and totally destroying the mine. With a view to making investigations, the writer left Tokyo the following day (Nov. 12) for the scene of the disaster.

Ogusi is a sulpher mine in Tumagoi[3] Village, Aduma[4] District, Gumma Prefecture, although it spreads also into Nagano[5] Prefecture. It is 20 km distant from the volcano Kusatu-sirané[6], and 17 km from the town of Susaka[7], Nagano Prefecture. A cable-way for hauling the refined sulpher and other loads operates between this mine and Susaka. The location of the mine may be seen in Fig. 1.

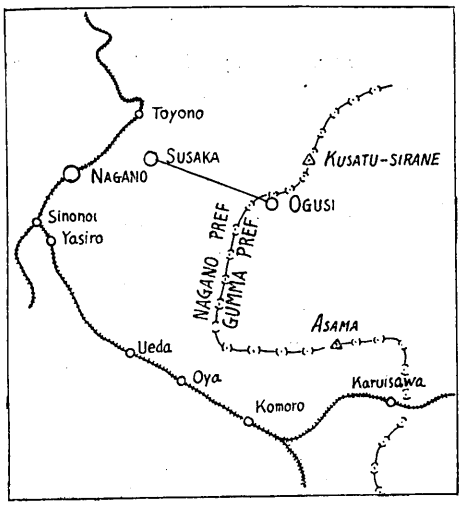

Fig. 1. Location of the Ogusi mine.

Topography and Geology. The topography of the mine and vicinity is shown in Fig. 2. To the west of the mine, beyond the the valley of the Aka-gawa[8], rise Donabé-yama[9] and Habu-daké[10], and to the north we see soaring high a ridge consisting of the Kenasi Pass[11], and the two peaks, Ogusi-daké[12] and Omesi-daké[13]. These mountain ranges divide the prefectures of Gumma and Nagano. The eastern side of the mine is bounded by a small ridge called Myôzin-daké[14], which extends southward from Ogusi-daké. The southern side of the mine opens out into a broad expanse, looking towards volcano Asama far beyond the valley of the Aduma-gawa[15]. According to T. Matumoto[16], the large semi-

1) 小串 2) 群馬 3) 嬬戀 4) 吾妻 5) 長野 6) 草津白根 7) 須坂 8) 赤川 9) 土鍋山 10) 破風岳 11) 無毛峠 12) 小串岳 13) 御飯岳 14) 明神岳 15) 吾妻川
16) Graduate thesis.

circular depression surrounded by the mountain ridges just mentioned is an old explosion crater, but it is now so dissected that its original form is not apparent. North of the mine, on the way to the summit of Ogusi-daké, there is a small semi-circular depression fringed by a cliff several meters high, as shown in Fig. 3, (Plate XV). The slope is gentle in this depression, but it steepens downward to the scene of the present land-slide, and again forms a fan of gentle slope at the lower reaches, until it eventually ends in the valley of the Aka-gawa.

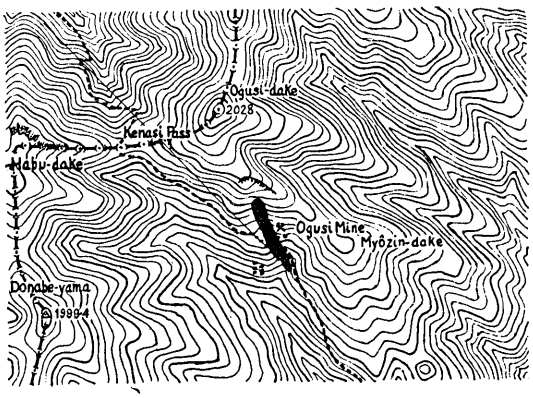

Fig. 2. Topography of the mine and vicinity.

There is little evidence to show whether this depression is a small explosion crater that formed secondarily in the great explosion crater mentioned above, or whether it is the remains of an old land-slide that occurred in the great explosion crater. In view, however, of the fact that the soil is thin on the east, north, and west sides of the depression, while it is very thick in the depression itself as well as on its south side, and also that the base rock, the lavas of volcano Omesi-daké, are scooped out at the depression and its lower reaches, it would seem more reasonable to regard the depression as a small explosion crater. A small trace of lava effusion on the east side of the depression, which was found by S. Watase[17] of the Geological Survey, seems to support this interpretation. The matter that slid down in the present land-slide consequently seems to be the old ejecta from this explosion crater.

A rough idea of the geology of this region, as investigated by T. Matumoto, is given in Fig. 4. The lava of Omesi-daké, denoted by *A* in the figure, which is a two-pyroxene andesite intercalated by tuff, forms the base rock of this region, as one finds in the valley of the Aka-gawa as well as in the bottom of the explosion craters. The present sulpher bed of the Ogusi mine was deposited in this tuff through the hydro-thermal action of volcanic gas and water. Another lava that flowed from Omesi-daké, denoted by *B* in Fig. 4, is a gray two-pyroxene andesite, completely overlying lava *A*.

17) Read before the investigation committee of the present land-slide, held on Nov. 25, at the Patent Bureau, under the auspice of the Department of Commerce.

The soil that forms the bulk of the land-slide is a brown, rather porous clay, mixed in its deeper part with blocks of andesite, and of propylite derived from andesite, besides blocks of hard clay derived from andesite through sulpherization. The size of some of the blocks of propylite and sulpherized clay are as large as 2 cubic meters. In view of these facts, it is more likely that the soil that slid down is the debris of an explosion crater, and not that of a land-slide. The hills surrounding the mine are all covered with bushes of Kumazasa (*Bambusa veitchii*), with scarcely any other noticeable vegetation.

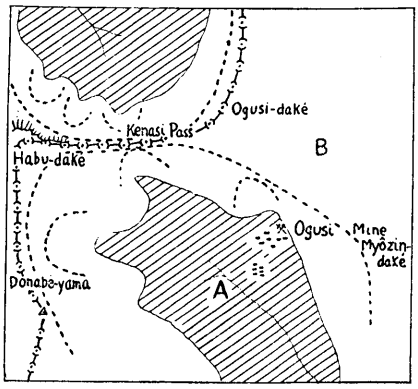

Fig. 4. Geological map of the mine and vicinity. Semi-circles in dotted line show the explosion craters.

The sulpher bed of the Ogusi mine, which is situated as shown in Fig. 5, is a disc-shaped deposit inclined to the east, with its only outcrop at the point marked *A*. Of the four adits, which are separated by heights of 18 m, the one from the other, only the second, third, and fourth are being worked. The first adit, which is the highest of all, is used for hauling in the sand for packing up the excavated galleries. As this mine has a very poor water supply, the dry packing system is in vogue.

The land-slide. The land-slide occurred at 15 h 32 m, Nov. 11 at the slope immediately north of the area, where are situated all the important parts of the mine, such as the refineries, office, school, miner's dormitories, and other buildings, all crowded together. The soil that broke loose crushed nearly all of them, buried them under the debris, and killed a large number of the miners.

The volume of the soil that broke loose is estimated at 140,000 cubic meters. The damage caused by this land-slide, as investigated by the police of both Nagano and Gumma, amounted to

Persons killed	234,	
〃 severely wounded	12,	
〃 wounded	20.	

But when reckoned by the number of families,

Families buried	120,	
〃 burnt out	38,	
〃 intact	12.	
Buildings buried	30	of which 46 were dwellings
〃 burnt	25	and 9 were warehouses etc.
〃 intact	4	

The four buildings that remained are two miner's dormitories and two

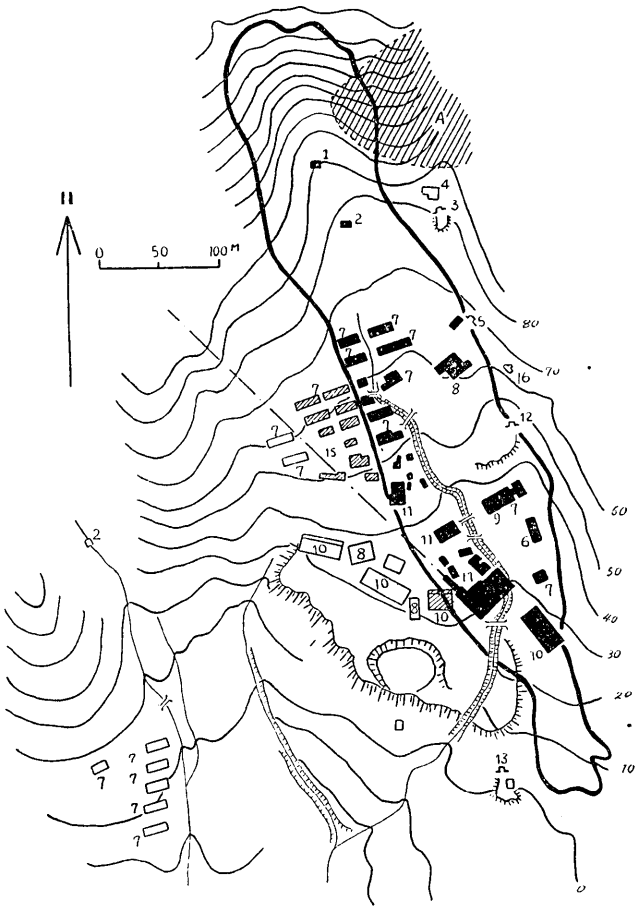

Fig. 5. Topography of the present land-slide. Contour lines drawn every 10 m. The thick closed curve in the figure gives an outline of the land-slide. Buildings painted black were destroyed; the hatched ones, burnt. The shaded area at the upper right corner shows the location of the ore deposit. *A*, the out-crop.

1. Powder magazine.
2. Water tank.
3. First adit.
4. Engine room for packing the galleries with sand.
5. Second adit.
6. School.
7. Miner's dormitories.
8. Ore storehouses.
9. Office.
10. Refineries.
11. Storehouse, etc.
12. Third adit.
13. Fourth adit.

refineries. The total population of the mine at the time was 1090. The damage caused by this land-slide is estimated at ¥ 300,000.

A detailed topography of the scene of the present land-slide will be

found in Fig. 5, which, before the event, was a shollow valley dug in the steep slope already mentioned, the slope of the valley-bottom gradually easing from the head to the end of the valley. Owing to these topographies, the rain that fell in the small explosion crater mentioned above might have always accumulated in this valley and from thence seeped into the ground toward the mine. In support of this idea, trickling water have been reported from various parts of the new cut that was opened by the land-slide.

The mean slope of the slid soil ranges from 28° to 30° at the upper part of the land slide, from 12° to 15° at the middle part, and from 5° to 7° at the lower part. The inclination of the sliding surface was measured to be 50°~60° on the cut newly formed at the uppermost end of the land-slide.

According to eye-witnesses, the slid soil, being mixed with a large quantity of water, was so soft at the time of the land-slide that one could not tread on it. By Nov. 13, however, when the writer arrived at the mine, the soil had already solidified sufficiently to permit walking over it. The velocity of the slide is estimated from various data as having been about 10 m/sec.

According to the mine watchman, immediately before the event, a red band was seen at the foot of the steep slope mentioned above. He had probably seen the lower end of the sliding surface.

The cause of the land-slide. It is usually very difficult to ascertain the true cause of such phenomena as land-slides. As to the cause of the present land-slide, various opinions have been advanced by the press, some of them being erroneous, as for example, the one that it was caused by the explosion of the powder magazine of the mine.

This powder magazine, which, at the time of the land-slide, was at the middle of the steep slope mentioned above, contained 3100 kg of dynamite. After the land-slide, the powder magazine was found half destroyed at a lower level of the slope in the middle part of the slid soil, where half the quantity of the dynamite originally stored was found on the soil, the remaining half being probably embedded in the debris.

Since the mine is in a volcanic region and is very near the water divide already mentioned, the water supply is very meagre. For household and other uses, the water that trickled out from the slope behind the mine was allowed to collect into ditches, whence it was led by pipes to a concrete tank of 56 cubic meter capacity, situated at the foot of the steep slope mentioned above.

Water leaking from this tank is believed by some to have caused

the present land-slide, but seeing that the tank was at the lower end of the sliding surface of the land-slide, this opinion cannot be correct.

It is said that in the spring of 1937, the ground in the neighbourhood of the powder magazine subsided in the form of a funnel, 3 m in diameter and 2 m deep. According to another report, the date of this subsidence is placed in August. The depression was however immediately repaired. The locality of this subsidence corresponds to the SW corner of the underground gallery.

Since, owing to the poor water supply, the dry packing system is used in this mine for preventing the ceilings from caving in, as already stated, cases of imperfect packing are at times inevitable, with the result that the earth overlying the galleries is liable to cave in, so that it is not possible to reject the idea that some unknown subsidence of the earth had in some way started the present land-slide. The fact that the ore bed of the Ogusi mine lies partially under the area where the present land-slide occurred seems to support this opinion.

According to the studies of K. Nakamura[18], in Japan, especially in the two prefectures of Nagano and Niigata[19], land-slides occur most frequently in April and November, corresponding respectively to the times of melting of the snow and the frequent autumn-end rains. In these circumstances, the idea that the present land-slide is intimately related to the rains that fell prior to the land-slide in the Ogusi region, is highly probable. In fact, rainy weather is reported to have continued from Oct. 29 to Nov. 9. On Nov. 10 and 11, the weather was fine.

According to the Nagano Meteorological Observatory, the annual and daily precipitations are respectively as follows:

Precipitation observed at Nagano.

Year	Annual total	November				
		7	8	9	10	11
1930	1062 mm	0 mm	0 mm	9·2 mm	0 mm	0·7 mm
31	941	0·3	0	0	0	0
32	1047	7·7	2·2	0	0	0
33	866	0	0	0·1	0	0
34	920	3·0	0	0·2	0	2·3
35	928	0	0	0	0	2·0
36	1063	14·7	2·1	0	0	0
37	1042*	0·2	14·9	12·5	0·2	0

* Up to the end of October.

18) *The land-slide*, 1933, (in Japanese).
19) 新潟.

Seeing that the loosend soil was almost saturated with water, there is no doubt that water, probably rain, was the cause.

It is difficult, however, to explain just how the rains caused the land-slide, seeing that rain had frequently been experienced up to the time of the disaster. Perhaps some unknown invisible change of state, such as the formation of cracks due to subsidence of the earth, progress of sulpherization or weathering of the soil, or changes in the inclination of the earth due to crustal movement, had cooperated with the rain.

In this connection, we might mention here the eruption on Nov. 27 of Kusatu-sirané, an active volcano lying only 20 km distant from this mine. Seeing that a volcanic eruption is often preceded by changes in the inclination of the surface of the earth around the volcano, as observed at Asama[20] and Kilauea[21], it is highly probable that this eruption of Kusatu-siraé brought about changes in the inclination of the earth around the mine, which in turn caused a sudden change in the distribution of the water soaked in the soil, resulting eventually in a land-slide.

In conclusion, the writers wish to express their thanks to the authorities of the mine, the police authorities of Nagano and Gumma, and the members of the Mining Inspection Office for numerous facilities extended to them in the course of their investigation.

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18. 小串鑛山に於ける山崩の調査報告

地震研究所 高橋龍太郎
水上武

小串鑛山は群馬，長野兩縣の縣境にある硫黄鑛山である．昭和 12 年 11 月 11 日，此の鑛山に山崩が起つて，鑛山の諸施設の大部分が破壊され，270 名餘の死傷者を生じた．

本報文には此の山崩の狀況及び此の山崩の原因となり得る種々の現象に對する考察を述べた．此の山崩の原因を確かめる事は出來なかつたが，山崩前に降り續いた降雨と密接な關係があるのではないかと思はれる．

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20) R. TAKAHASI, *Bull. Earthq. Res. Inst.*, **11** (1933), 25.
T. MINAKAKI, *ibid.*, **13** (1935), 629.
R. TAKAHASI and T. MINAKAMI, *ibid.*, **15** (1937), 463.
21) T. A. JAGGAR and H. FINCH, *Bull. Seis. Soc. Amer.*, **19** (1929), 38.

Fig. 3. The upper part of the land-slide

Fig. 6. General view of the land-slide.

Fig. 7. The lower part of the land-slide.

Fig. 8. Character of the loosend soil.

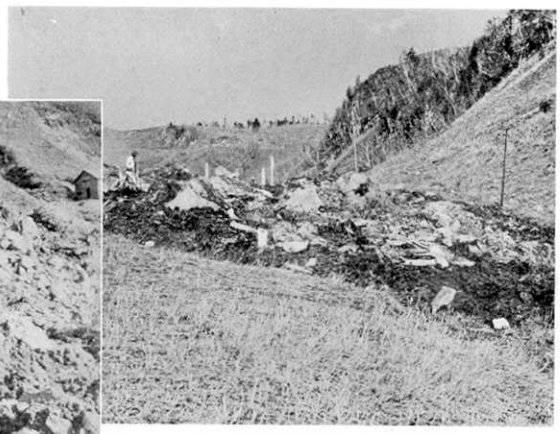

Fig. 9. The lowest end of the land-slide.

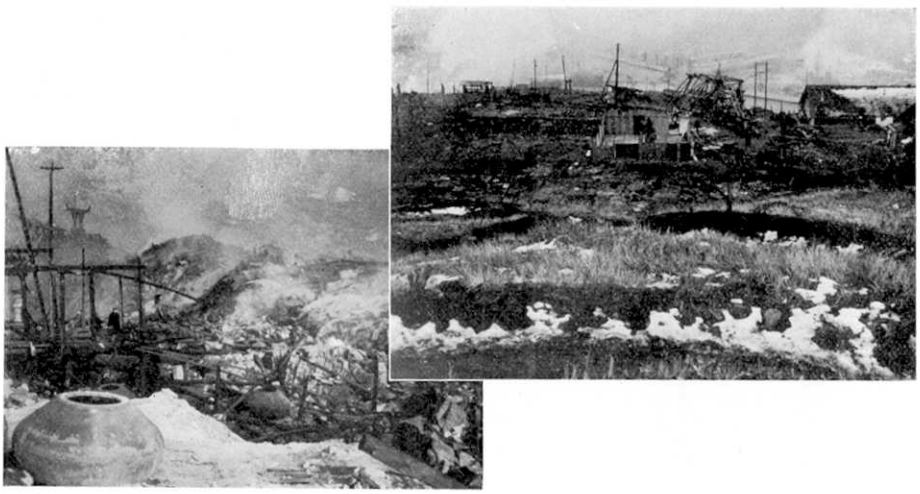

Fig. 10. Views of the general destruction.

Fig. 11. View of the destruction.

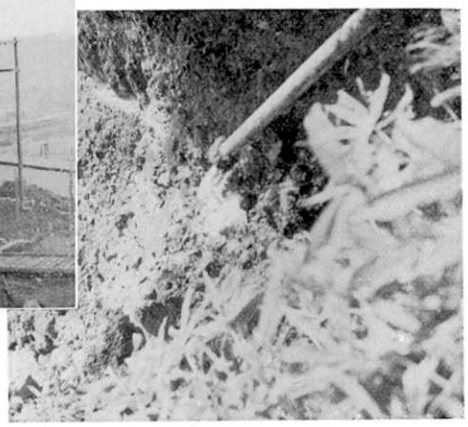

Fig. 12. Remains of the pipe that formerly conveyed water to the tank.