January 1988

1988: Fifth International Symposium on Vulcanospeleology Excursion Guide Book Pre-Activity: November 4-9, 1988 Post-Activity: November 13-20, 1988

International Symposium on Vulcanospeleology

November 4. 1988

Preface

The first International Symposium on Vulcanospeleology was held in White Salmon in Washington, U.S.A., when the convention of National Speleological Society was held in 1972. Later on, the second one was held in Catanya City, Sicily Island, Italy in 1975; the third in Bend, Oregon, U.S.A. in 1982; the fourth, again in Catanya City, Italy, in 1983.

The 5th Symposium was decided to be held in the Japan-Korea Area. This region was chosen because the Japan Volcanospeleological Society and Speleological Society of Korea had researched Billemot Kul Cave on Cheju Island since 1977. This cave is considered to be the longest in the world, and announced result of this study caused a respectable reaction among the scholars in this field worldwide.

The Speleological Society of Korea has initially decided to open the Symposium in Cheju Island, but this was cancelled in 1987 due to circumstances. We, the Society of Japan, therefore had to be in a position to act instead of Korea. The Korean Authority have permitted us to carry out research inside the lava caves in Cheju Island. This has been a restricted area to Koreans until now, including their scholars. Therefore we are very fortunate to have this opportunity. We will not be able to do research inside these caves in future.

Furthermore, Vulcanospeleology is a relatively new study, even in Japan which has 186 Volcanic caves, of which 111 are around Mt. Fuji in Central Japan. The reason why this study is new and there are few scholars in this field is because there are reliable vulcanospeleology books yet published anywhere.

Nevertheless, we of the Japan Volcanospeleological Society have been studying these caves for 27 years with good results. The investigation of biology in volcanic caves has proven the existence of systemization for the creatures underground, which has reformed the existing theories.

This being the situation we have decided with much pleasure to open 5th Symposium at Izunagaoka Hot Springs in our country, and invite all of you concerned with this study to exchange the results of our studies mutually.

Takanori Ogawa
Convener: 5th International Symposium on Vulcanospeleology

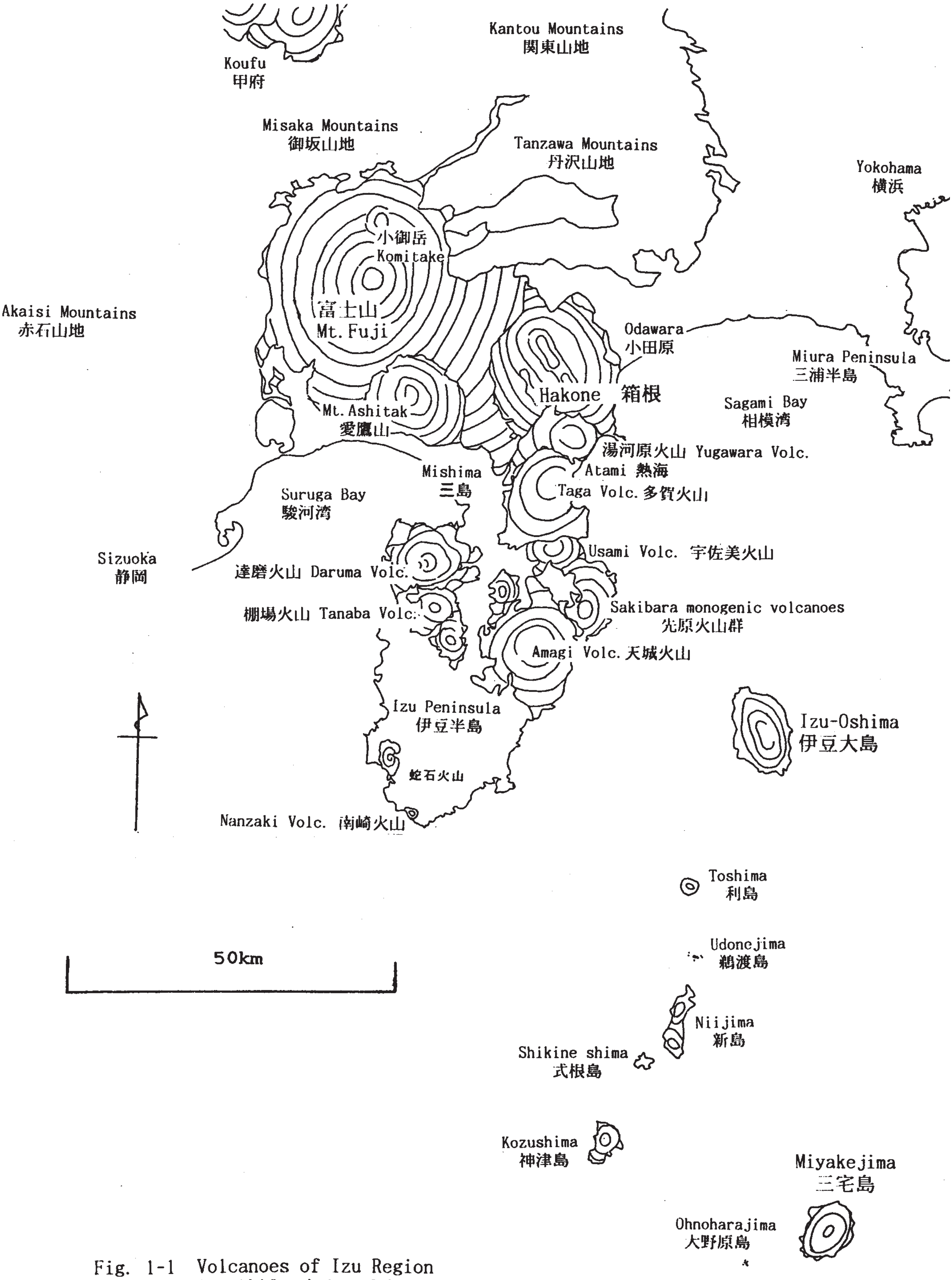


Fig. 1-1 Volcanoes of Izu Region
図 1-1 伊豆地域の火山の分布

5th International Symposium on Vulcanospeleology, Izunagaoka, Japan

Outdoor Guidebook

1. General aspects of the area

There is a volcanic zone trending NNW-SSE at about 100km west of Tokyo, in central Japan, including Mt. Fuji, Hakone, Volcanoes of Izu Peninsula, Oshima Island and Miyake Island (Figure 1-1).

Hakone is a complex volcano with a caldera and several central cones. Odawara City at the eastern foot of Hakone is easily accessible by the New Tokaido line which takes about half an hour and by the combined train-cablecar-ropeway or bus services which lead to the mountain top. Tomei expressway from the Eastern suburbs of Tokyou passes through the saddle between Mt. Fuji and Hakone, where Gotenba Interchange provides a ready access to Hakone from the north. This is a one and a half hour drive to the mountain top from Tokyo to Hakone. State highway No 1, Tokaido, passes over the Hakone mountain between Odawara and Mishima City at the south-western foot.

There are no written records of eruptions at Hakone but it is believed that the last eruption took place about 3000 years ago at the northern flank of Kamiyama, at Owakidani. Hakone has three active solfataras, Owakidani, Sounzan and Yunohanazawa, and the central cone Kamiyama causes occasional swarm earthquakes. There are many hot springs in Hakone and most of them are distributed in the Hayakawa valley.

Mt. Fuji is also accessible from Gotenba at its eastern foot, or from Fuji City on the south, where there is a Shinkansen Station. It is also accessible from the n orth by the Central expressway from the western suburbs of Tokyo in just over an hour's drive. Mt. Fuji is the highest peak in Japan with its peak 3776m above sea level, which is almost 500m higher than of the second highest non-volcanic Shirane-Kitadake in the Southern Alps of Japan measuring 3192m. Not only is Mt. Fuji greater in altitude than the other 200 volcanoes of Japan, she is also much larger in volume, with some 20 written historical records of eruption since 780 AD.

Oshima is an active volcano which has a large number of recorded eruptions and it erupted in 1912, 1950-51 and in 1986 with tens of millions of tons of basaltic lava effusion. This island is accessible by airliner from Haneda Tokyo Domestic Airport in about 40 minutes or from Atami City, located on the New Tokaido line, by boat in an hour or so.

Miyake Island is south of Oshima and the two are similar in that they have both been active through history. Miyake Island has had recent eruptions in 1940, 1962 and 1983 with a few tens of millions of tons fo lava expelled from fracture vents open on her flank. The last eruption in 1983 demolished 400 houses in less than fifteen hours. Rift caves of the flank openings may be visited on the excursion.

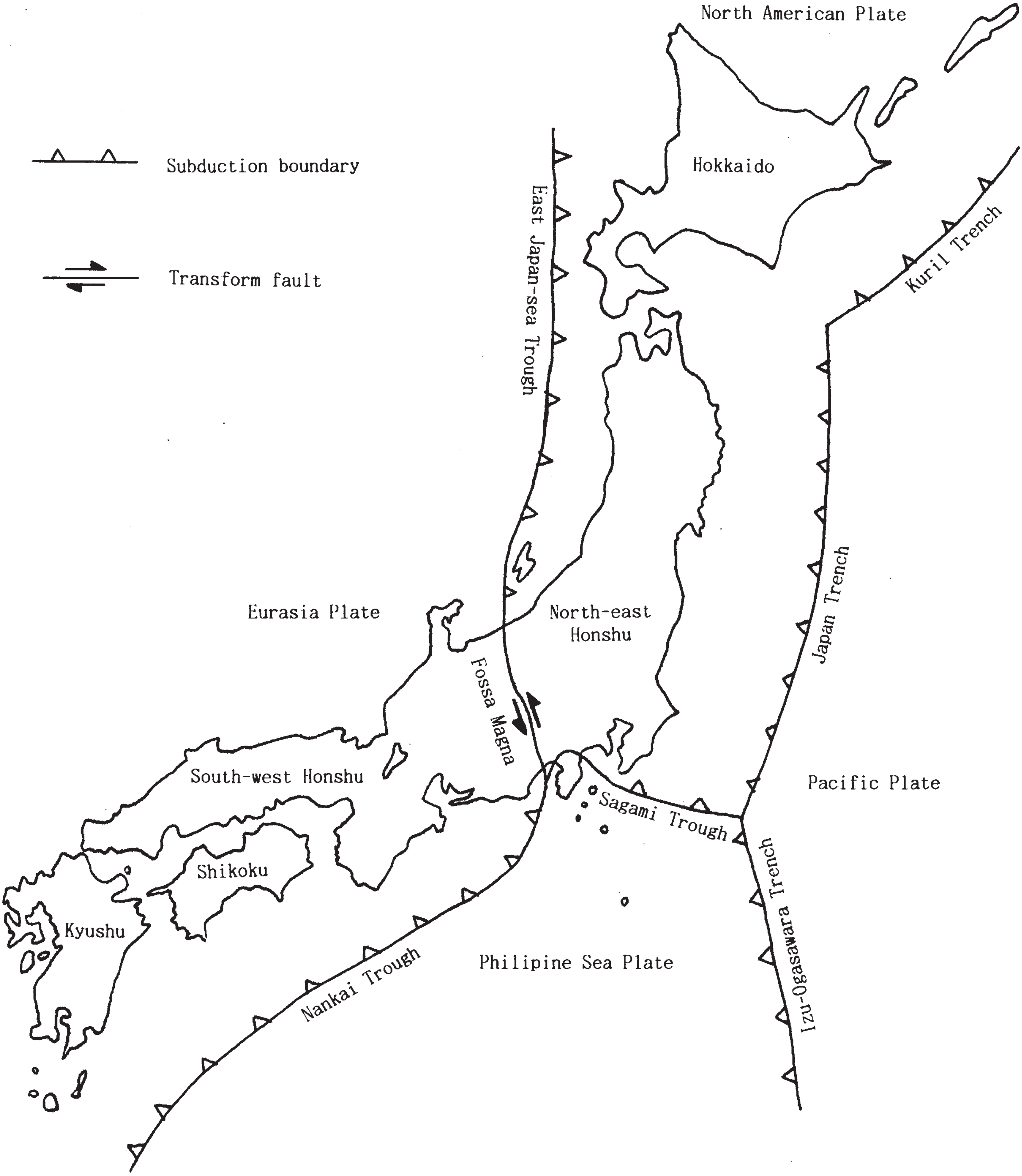
There are about 20 volcanoes between Mt. Fuji and Miyake Island (Figure 1-1), and active volcanoes among them are Mt. Fuji, Hakone, Ohima, Niishima, Kozushima and Miyake Island. Besides these there are many monogenic volcanoes under the sea between Oshima and Izu Peninsula. Monogenic volcanoes are also distributed on the Izu Peninsula to the south of Ito City. There are some 70 small volcanoes in a 15×20km area, and of these 4 rhyolite-dactite and 4 basaltic volcanoes have been dated at around 3000 years BP. This seismic-volcanic active region is situated on the complex active plate boundaries, including subduction, collision and translational relations.

According to the Plate Tectonics theory developed in the 1960's, the globe is covered by several rigid plates of several tens of kilometres in thickness. These plates are bounded to each other by active boundaries, spreading, subducting, translational and collision. Spreading boundaries are also called diverting boundaries, where basaltic magma squeezed up from the mantle fills the gap opened by tensional stress to form dikeswarms. The Mid-Atlantic Ridge has turned out to be a volcanic chain under the ocean where the oceanic crust is made. Spreading ridges were then found in the southern Pacific Ocean, and in the middle of the Indian Ocean. The spreading speed of the oceanic crust (2-10cm/yr) is probably controlled by the strength of the tension and amount of supply of the basaltic magma material from the mantle.

Oceanic trenches deeper than 6000m are all representing the subduction boundaries of

図　1-2　日本列島周辺のプレートの境界

Fig. 1-2　Plate Boundaries around Japan



the plates. The trench can be paired with either an island arc or a mountain range on the edge of the continent. The subduction margin is active in seismicity and large scale earthquakes occur at the land side of the trench at shallow depths. Subduction zones are traceable by the three dimensional plot of seismic hypocentres, which are called Wadachi-Benioff zones after the authors first recognised this.

The continental crust consists of lighter materials than the oceanic crust, and spreads along with an oceanic crust. It may not subduct of its bouyancy, and may collide with other Continental crusts. India Peninsula is a typical example, which is colliding in to the Eurasian Plate where the Himalayas have risen. Translational boundary is the boundary of the transform fault, which is an active fault with horizontal displacement with both sides ending with a trench or spreading centre. A typical example of it is the Alpine Fault of the South Island of New Zealand, where the west side Indian Plate is passing the east side Pacific Plate.

Recent interpretation shows that there are four plates around Honshu Island of Japan, bounded by subduction, translational and collision relations(Figure 1-2).

Pacific Plate subducts at Kuril Trench, Japan Trench and Izu-Ogasawara Trench, underneath the Kuril Island's Arc, Honshu Arc and Izu-Ogasawara Arc, respectively. To the west of the Izu-Ogasawara Island Arc there is a Phillipines Sea Plate which is moving NNW, subducting under central Honshu, Shikoku, Kyusyu and Ryukyu Islands Arcs. Near the western margin of the Phillipines Sea Plate there are the Izu Peninsula and the Seven Izu Islands, which has been revealed to have a 30-40km thick continental crust, and thus not being able to subduct has collided in to the Honshu Arc continental crust. Izu Peninsula probably collided with Honshu about a million years ago, pushing up the Misaka and Tanzawa mountains to a height of almost 2000m in a short time.

There is evidence indicating that the Izu Peninsula used to be in the far south. The fossil evidence of warm water low lattitude dwellers in Miocene sediments and palaeomagnetic evidence of much more gentle original inclinations found in the Miocene rocks of the peninsula. The Miocene sediments must be deposited at 10-15 ° lattitude south and moved up north to collide with Honshu Arc some time ago.

The Honshu Arc is subdivided by the Itoigawa-Fujikawa transform fault in the western

margin of the Fossa Magna graben. The fault bounded Eurasia Plate on its west and North American Plate on the east. The fault transforms to the Nankai Trough at the south and to the Japan Sea Trough at the north, and these troughs are thought to be depths caused by the subdection of the Phillipines Sea Plate and Eurasian Plate but the subductions have initiated recently and trench formation is still in an immature stage.

There are a couple of triple junctions on the four plates boundaries. One exists at about 200km south-east of Tokyo at the junction of the Japan Trench and the Izu-Ogasawara trenches. The other exists in Suruga Bay just 30km south-east of Mt Fuji. The former triple junction is at where the Pacific, Phillipines Sea and and North American Plates join and the latter triple junction is where the phillipines Sea, North American and Eurasian Plates join.

This region has been very active in seismicity and volcanism during historical time, which is from the seventh century onwords, and in the twentieth century the following events have been recorded(Table 1-1).

Table 1-1 20th Century Seismic and Volcanic Activities in the Mt. Fuji-Izu-Miyake Island Region

1900	Miyake Island Earthquake M6.8
1905	Oshima Earthquake M7.0
1912-14	Oshima Eruption 1×10^7 m^3ejecta
1923	Kwanto (Tokyo) Earthquake M7.9 (Epicentre in Sagami Bay) 142807 Dead
1924	Tanzawa M7.2, 19 Dead
1930	Ito Swarm Earthquakes (Felt 4880, Maximum M5.5)
1930	Kita-Izu M7.3, 272 Dead
1936	Niishima M6.3, 3 Dead
1940	Miyake Island Eruption 1.9×10^7 m^3 ejecta
1950-51	Oshima Eruption 3×10^7 m^3 ejecta
1962	Miyake Island Eruption 1×10^7 m^3 ejecta
1974	Izu Peninsula M6.9, 29 Dead
1976	Kawazu Earthquake M5.8
1978	Oshima Earthquake M7.0, 25 Dead
1980	Izu Peninsula Earthquake M6.7
1983	Miyake Island Eruption 2×10^7 m^3 ejecta
1986	Oshima Eruption 5×10^7 m^3 ejecta
1987	Fuji Earthquake swarm (Felt 4)
1988	Izu Peninsula Earthquake swarm (Felt several thousands)

November 4. 1988

Preface

The first International Symposium on Vulcanospeleology was held in White Salmon in Washington, U.S.A., when the convention of National Speleological Society was held in 1972. Later on, the second one was held in Catanya City, Sicily Island, Italy in 1975; the third in Bend, Oregon, U.S.A. in 1982; the fourth, again in Catanya City, Italy, in 1983.

The 5th Symposium was decided to be held in the Japan-Korea Area. This region was chosen because the Japan Volcanospeleological Society and Speleological Society of Korea had researched Billemot Kul Cave on Cheju Island since 1977. This cave is considered to be the longest in the world, and announced result of this study caused a respectable reaction among the scholars in this field worldwide.

The Speleological Society of Korea has initially decided to open the Symposium in Cheju Island, but this was cancelled in 1987 due to circumstances. We, the Society of Japan, therefore had to be in a position to act instead of Korea. The Korean Authority have permitted us to carry out research inside the lava caves in Cheju Island. This has been a restricted area to Koreans until now, including their scholars. Therefore we are very fortunate to have this opportunity. We will not be able to do research inside these caves in future.

Furthermore, Vulcanospeleology is a relatively new study, even in Japan which has 186 Volcanic caves, of which 111 are around Mt. Fuji in Central Japan. The reason why this study is new and there are few scholars in this field is because there are reliable vulcanospeleology books yet published anywhere.

Nevertheless, we of the Japan Volcanospeleological Society have been studying these caves for 27 years with good results. The investigation of biology in volcanic caves has proven the existence of systemization for the creatures underground, which has reformed the existing theories.

This being the situation we have decided with much pleasure to open 5th Symposium at Izunagaoka Hot Springs in our country, and invite all of you concerned with this study to exchange the results of our studies mutually.

Takanori Ogawa
Convener: 5th International Symposium on Vulcanospeleology

2. Hakone

Hakone is especially popular to the people because the major Pacific coast route, Tokaido, has been passing over it since the early ninth century, and the ancient government had set the major check point en route here. Today, Hakone is one of the most popular resort places, accessible within two hours from Tokyo, and is full of hot spas and historical remains.

Hakone is a caldera volcano consisting of old somma, young somma, seven central cones, a caldera lake "Ashinoko", and a barraco "Hayakawa". Its rather complex volcanic history was studied by the late Professor H. Kuno(1950, 1951, 1952). Figure 2-1 is after Kuno(1951). Studies have also been done by Professor Machida(1968, 1977).

The first volcanic activity of Hakone took place about 300,000 years ago and built an andesite strato-volcano of the Mt. Fuji shape, with an altitude of about 2,700m. An andesite parasitic volcano Kintokisan and a dacite parasitic volcano Makuyama were formed on the north-western and south-eastern flanks respectively. In the last stage of this activity, the top of the conical volcano collapsed or depressed and formed the first stage caldera. The caldera had been enlarged by the erosion during the quiescent period after its formation.

The young somma activity started about 130,000 years ago when it formed a 300m thick dacitic shield volcano filling the old caldera. Flat top hills Takanosuyama and Byobuyama at the east and south-east part of the caldera are young somma lavas.
Then after a long quiescent period 75,000 to 50,000 years ago, a huge scale pumice eruption occurred three times. These caused Plinian air fall deposits and ignimbrite flows. Remnants of the pumice flow deposits are found at 50km east from the source near Yokohama City and also 25km south-west near Izunagaoka. The pumice eruption caused the caldera present today, with an oval shape measuring 12×7km.

The central cone activity took place 30000 years ago. There are Kozukayama, Daigatake, Kamiyama, 1325m peak, Komagatake, Kami-futago and Shimo-futago from north to south. Among them, Kamiyama is a strato-volcano and others are monogenic lava domes. Ejecta from Kami-futogo has been dated at 4840 BP and it seems that this lava dome is

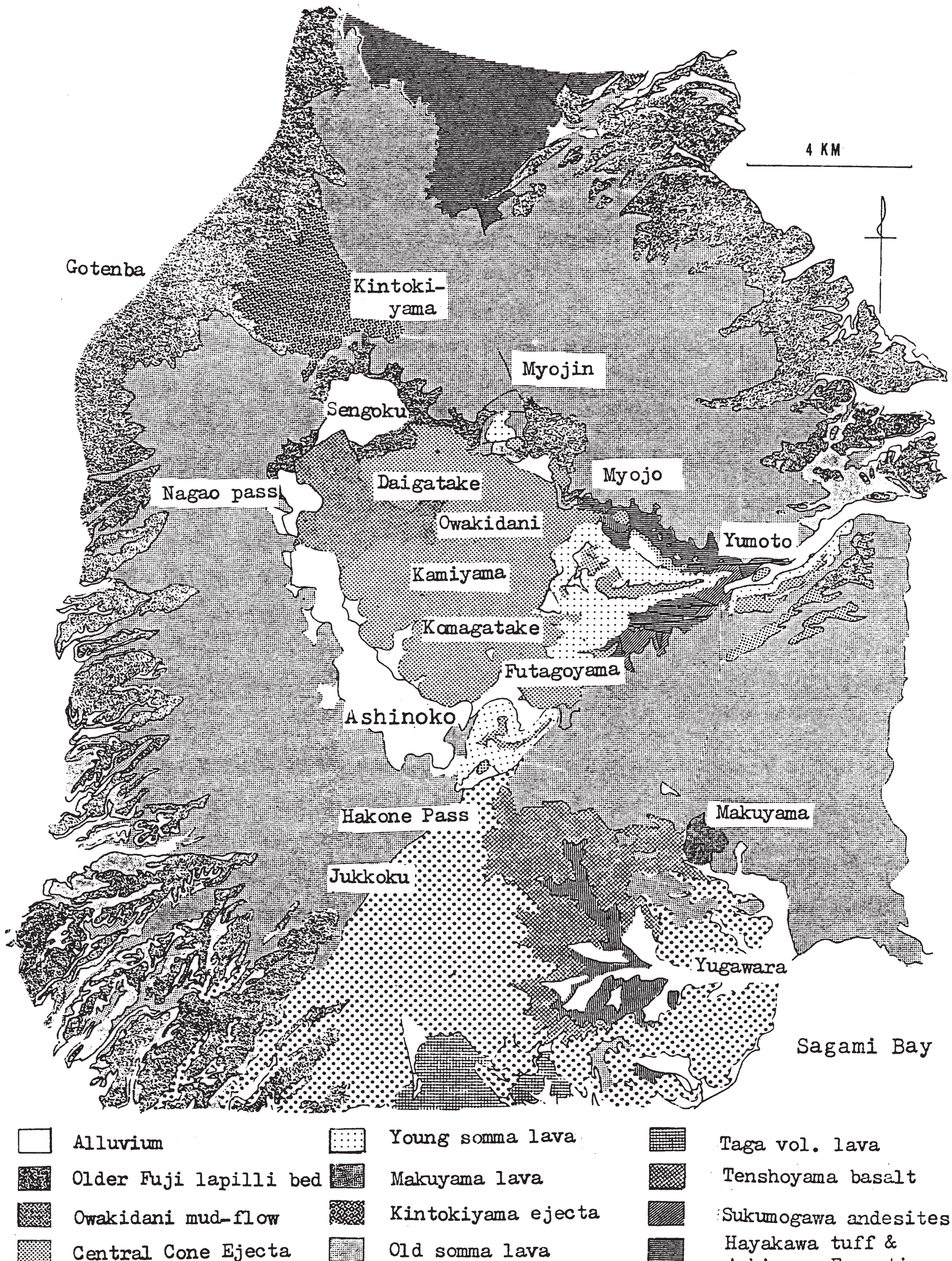


Figure 2 - 1 Geological Map of Hakone Volcano After Prof.H.Kuno(1950)

the youngest among the seven, and it appears that the northern ones are older. Kamiyama is the highest peak of Hakone with an altitude of 1438m above sea level, and this cone seems to have a history of repeated eruptions. The last magmatic eruption of Hakone took place on its flank as the lava spine Kanmuri-gatake and recent swarm earthquakes also occured underneath this cone.

An explosion caused a mudflow on the north-west flank of Kamiyama dated at 3100 BP, and this mudflow dammed up the lake Ashinoko. Pyroclastic flow covering the mudflow has been dated at 2900 BP and this material turned out to be similar to the lava spine Kanmuri-gatake material. This lava spine is probably the last magmatic extrusion activity of Hakone, about 3,000 years ago.

Ashinoko is an elongated lake with a size of 6.5×1.5km, and area of 6.9km², maximum depth of 42m and water surface altitude of 723m. A 1,400m long water tunnel was dug in 300 years ago to give drainage on the western flank of Hakone, and is called Hakone-yosui.

Hakone occasionally causes swarm earthquakes. In 1786 AD about 100 earthquakes occured in 2 days causing boulders to fall down from Futago-yama, damaging houses at Ashinoyu Hot Spa. In 1917, 242 earthquakes were felt in a day and two months later a fierce hot mudwater spring appeared at Owakidani. In 1934, there were felt swarm earthquakes and a landslide occured at Owakidani. In 1952, there were felt swarm earthquakes and half a year later a great landslide occured at Sounzan solfatara, causing 10 deaths and injuring 16 when a temple was washed away. In 1966 felt swarm earthquakes led to a sudden rise in hot spring temperatures about 10 months later. Changes of up to 20° C were observed. This evidence indicates that the swarm earthquakes were caused by thermal water ascending up from the depths under Kamiyama, and is probalby related to the magmatic activity which occurs at these depths.

Seven natural hot springs have been known through history, and in the last 50 years boring wells have been drilled and new spas have been developed. Now there are 15 hot springs with a total of more than 220 wells yielding 18 tons/min, with an average spring temperature of 55° C .

References

Kuno H. (1950) Geleogy of Hakone Volcano and Adjacent Areas Part 1 Jour. Faculty of Sciences Univ. Tokyo Sec. 2, 7, 257-279.

Kuno H. (1950) Petrology of Hakone Volcano and Adjacent Areas, Japan. Bull. Geol. Soc. Amer. 61, 957-1020.

Kuno H. (1951) Geology of Hakone Volcano and Adjacent Areas Part 2 Jour. Faculty of Sciences Univ. Tokyo sec 2, 7, 351-402.

Kuno H. (1952) Geological Map 1:50000 Atami and Explanatory text. 141 p. Geol. Survey Japan.

Machida H. (1964) Tephrochronological study of Volcano Fuji and Adjacent Areas. Jour. Geogr. Tokyo 73, 298-308, 337-350.

Oki Y, Aramaki S, Nakamura K. and Hakamata K. (1978) Volcanoes of Hakone, Izu and Oshima. Bull. Hot Spring Res. Inst. Kanagawa Pref. 2, 1-88

3. Mt. Fuji

Mt.Fuji with its superb height and volume, eminent snow capped peak, and symmetrical beauty of flank line has become a symbol of Japan. She has over twenty eruption records during historical time, and the latest eruption in 1707 was the most furious Plinian event with over 1300 million tons of air fall ash devastating some hundreds of square kilometres.

In 864 AD huge amounts of lava flowed out from the vents on the northern flank of Mt.Fuji, covering an area of 30km² which is now covered by dense wood and is called Aokigahara Wood-sea. This lava flow is almost unpassable because of the rough surface of the flow and sight restriction by the wood. 69 lava caves have been found in the flow and new caves are still being discovered. Several other lava flows of Mt.Fuji bear lava caves, and in all over 111 are now known. Some of the caves are compound treemolds formed after huge trees were knocked down and the trunks were buried in the flowing lava. Many of the fallen trees crossed over and made complex systems of tree trunk mold chains.

Mt.Fuji is accessible from Gotenba City at the eastern foot, on the Tomei expressway, JR and Odakyu Railway lines, and from Fuji City at the southern foot, on Tokaido and Shinkansen lines and the Tomei expressway. It is also possible to go from Fujiyoshida City in the north using the Chuo expressway and Fujikyukou Railway line. The foot of the mountain is densely popueated with about one million people. The northern foot is a plateau with an altitude of 600-1000m and there are five lakes, Yamanaka, Kawaguchi, Sai, Shoji and Motosu, and has several resort places.

The geology and eruption history of Mt Fuji were studied by Professor H. Tsuya(1935, 1938, 1940, 1943, 1955, 1962, 1968, 1971, 1981) and by Professor H. Machida(1964, 1968, 1971, 1981). Recently Doctor N. Miyachi(1988) published his study on the volcanic activity of Mt. Fuji.

Professor Tsuya(1938)found that an old volcano Komitake is partly buried under Mt. Fuji and the top of this has appeared on the northern flank at an altitude of 2500m.

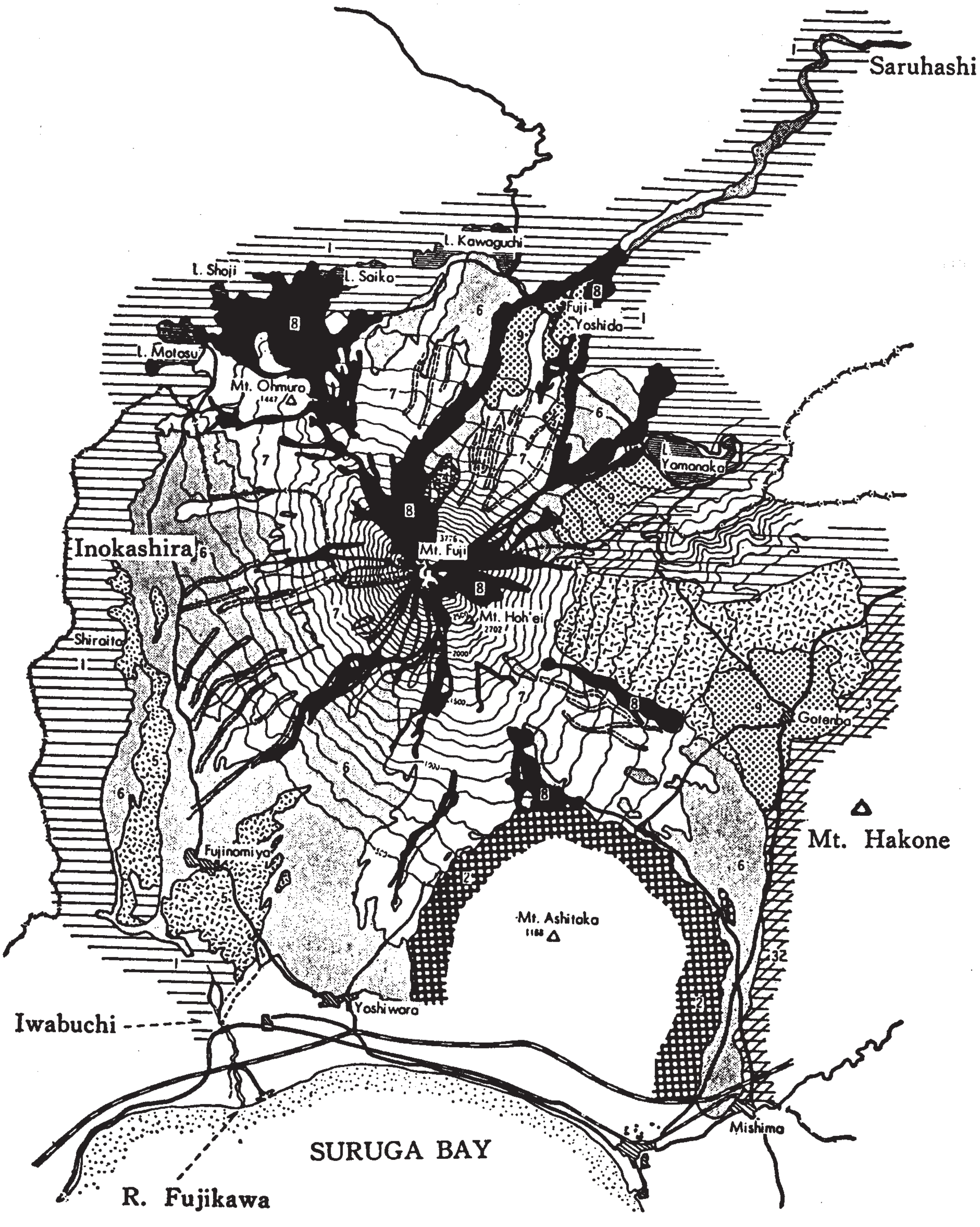


Figure 3-1 Geologic sketch map of Mt. Fuji and vicinity. After TSUYA (1971)
1. Tertiary formations 2. Volc. Ashitakayama 3. Volc. Hakoneyama 4. Volc. Komitake exposed partly on the north flank of Mt. Fuji 5. Volcanic mud-flows and other ejecta of Ko-Fuji (older Fuji) 6. Older ejecta of the present (younger) Fuji 7. Middle ejecta of the present Fuji 8. Younger ejecta (lava-flows mostly left uncovered with volcanic ash and other pyroclastics) 9. Volcanic ash and alluvial fan deposits

Komitake is actually a hump near the terminus of Subaru-line driveway where komitake Shrine is situated. The northern slope of Komitake is grooved by many small gullies, distinctly different from smooth flank slopes elsewhere. Professor Tsuya examined the laves exposed on the Komitake flanks and found they are of different rock types compared with the lavas of Mt.Fuji.

Ashitakayama Volcano is situated 15km south of Mt.Fuji, the highest peak of which is 1504m, while the saddle between Mt.Fuji where Jurigi Village is located is 800m above sea level. Ashitakayama Volcano is a somewhat dissected cone and the lavas are dated between 100,000 to 200,000 years old, consisting of an early basaltic cone and later andesites covering the cone. Though Komitake lava has not been dated, the rock resembles some Ashitakayama rocks and the dissection states of these volcanoes are similar, so possibly they are of the same age group.

Professor Tsuya divided the Mt.Fuji activity into older and younger stages, calling the older stage volcano "Older Fuji" and the younger stage "Younger Fuji". The Old Fuji is characterised by mudflows distributed at the south-west, east and northern foot of Mt.Fuji, and by sporadic exposures of oxidised aglutinates on the flank, as well as by tuff breccia 250m under the surface excavated in the tunnel dug for finding water at the south-eastern flank at 1040m above sea level.

The Older Fuji mudflows were dated by the carbon 14 method, showing between 16,000 and 24,000 BP. As this period corresponds to the last glacial era and at the time Mt. Fuji must have had an ice cap on its peak and an eruption of hot ejecta causing a flood by melting the ice cap and the flood gouged flank yielded mudflow similar to those of Nevado del Ruiz Volcano in Columbia when it erupted in 1985.

Professor Machida studied thick tephra beds east of Mt.Fuji. He recognised several thin rhyolitic-dacitic tephra among the Mt.Fuji origin tephra and they were then identified with southern Kyusyu origin tephra and Kiso-Ontake origin tephra. Akahoya tephra from Kikai caldera off the south of Kyusyu(6300 BP), Aira-Tanzawa tephra from Aira caldera in southern Kyusyu(22000 BP), and Pm-1 tephra from Kiso-Ontake Volcano in the Northern Alps of Japan (about 80000 years old) were identified among them. As Pm-1 tephra was found near the bottom of the tephra sequence the activity of Mt.Fuji must

have commenced about 80000 years ago.

The tephra sequence shown in the Older Fuji stage of volcanic activity has been very consistent materially and in effusive rate. However, it shows a calm period existed 9000 to 5000 years ago represented by a fume rich band in the tephra beds. The Akahoya tephra is found in the upper part of the dark band rich in carbonaceous meterial. Professor Machida called the dark band "Fuji darksoil".

Professor Tsuya(1968, 1971)divided "Younger Fuji" ejecta into older, middle and younger ejecta, and discriminated between more than 100 lava flows. The older ejecta is characterised by large 5-10mm size plagioclase phenocrysts and large scale lava flow of this age are distributed at the south-west, south-east and northern foot areas. Cave-bearing Obuchi flow has not been dated but this lava flowed underneath the Alluvial material reaching a level of -120m, confirmed by drilled water well data. This shows the Obuchi lava flowed out before the deposition of the Alluvial material, when sea level was -120m or so in the glacial period, probably some 15000 years ago.

The Mishima lava flow at the south-east foot is cave-bearing, which has been dated at 10490 BP. Motomurayama lava flow has been dated at 9350 BP and Saruhashi lava flow at the northern foot which is the longest lava flow reaching 35km from the summit, has been dated at 8530 BP. From these dating data, it seems large quantities of lava effused in the period around 10000 years ago.

Combined with the tephra evidence of the quiescent period 9000 to 5000 years ago, it is likely that Mt. Fuji erupted a gread amount of lava between 15000 to 9000 years ago and then the activity decreased for four thousand years. This rise and fall of activity may be related to the post glacial sea level rise which added a huge burden to the island arc crust and caused large amounts of magma production by a squeezing effect on the upper mantle under the crust, and when the sea level reached maximum and stabilised at that level. Around 9000 years ago magma production temporarily slowed down after the excess squeeze out period.

The cave-bearing flow of Mt. Fuji is almost restricted to the older lavas of the younger Fuji stage, with the major exception of Aokigahara lava flow dated 864 AD. Lava caves are found in Obuchi, Mannobara, Zunazawa, Mishima and Futagoyama flows of the older ejecta stage.

Table 3-1 List of parasitic Cones of Mt.Fuji. After Miyachi(1988).

Name	Stage of formation	Name	Stage of formation
1. Hoei craters	SS(1707 AD)	29. Kenmarubi crater	SS(10 Century)
2. Futatsu-zuka	S	30. Ohnagaremaruyama	S
3. Akatsuka	S	31. Oniwa & Okumiwa	S
4. Nishifutatsuzuka	S	32. Nishi-okuniwa	M
5. Jiroemonzuka	M	33. Kosukemaru	M
6. Katabutayama(S)	O	34. Nishikohsukemaru	M
7. Kitakansuyama	S(ca. 6 Century)	35. Hakkenyama	M
8. Kansuyama	S(ca. 6 Century)	36. Sawarayama	MO
9. Kurozuka	S(3-4 Century ?)	37. Usuyama	M
10. Hiratsuka	M	38. Hakudairyuou	SS(8 Century ?)
11. Takayama	SO	39. Kori-ike	SS(8 Century ?)
12. Asagizuka	SO	40. Kitakori-ike	S
13. Higashiusuzuka	M	41. Yumiizuka	M
14. Koshikirizuka	M	42. Katabutayama(N)	M
15. Nishikurozuka	MO	43. Shikanokashira	M
16. Takahachiyama	S(ca. 5 Century)	44. Tsugaoyama	M
17. Nishiusuzuka	M	45. Ohmuroyama	SO
18. Nishiasagizuka	SS	46. Kooriana crater	SS(9 Century)
19. Ohbuchi crater	S(ca. 3 Century)	47. Igadonoyama	SS(9 Century)
20. Myogatake	M	48. Tenjinyama	SS(9 Century)
21. Shiratuuka	M	49. Nagaoyama	SS(864 AD)
22. Hinokizuka	M	50. Ohhirayama	S
23. Futagoyama	O	51. Sajikiyama	S
24. Toyazuka	O	52. Higashiken	M
25. Inusuzumiyama	O	53. Nishiken	S
26. Nagayama	M	54. Gannoana crater	SO
27. Futatsuyama	O	55. Ishizuka	SS(864 AD)
28. Ushigakubo crater	SS(11 Century)	56. Ohusu & Kousu	MO

SS=250-1200y. B. P., S=1200-2000y. B. P., SO=2000-3000y. B. P., M=3000-4500y. B. P., MO=4500-8000y. B. P., O=8000-11000y. B. P.

Since 5000 years ago, the activity of Mt.Fuji has risen again and air fall tephra and lava effused from the summit crater and flank openings. Professor Tsuya's middle ejecta of the younger Fuji corresponds to effusives from 5000 to 2000 years ago.

A number of lava flows and several parasitic cones(Hiratsuka, Koshikirizuka, Higashi-usuzuka, Hinokizuka, Kosukemaru, Katabutayama (North) and Yumiizuka) formed between the years 4500 and 3000 BP and they are covered by later air fall tephra of Zunazawa, Ohsawa and Ohmuro scoria beds. There are some 60 parasitic cones, and about one third of them formed in this stage. (see Table 3-1, Stage M).

About 3000 years ago, a Plinian eruption from the summit crater and from Ohmuro-yama successively ocurred with about 3km³ of ejecta.

About 2500 years ago, there was a large scale collapse on the south-eastern face causing Gotenba debris flow to deposit which has been dated at 2360 BP (Machida, 1964) abd 2580 BP (Miyachi, 1988). The total quantity of collapsed material is 1-2km³ and is somewhat less than the debris left by the 1980 Mt.St.Helens event, which was 2.6km³

Miyachi(1988) showed a 2000 year old 0.5m³ scale tephra (Yubune-daini scoria bed) and Asagizuka and Gannoana crater activity took place at about the same time. Gannoana lava flow from the Gannoana crater bears Kuzureana cave.

Historical records of Mt.Fuji eruptions start at 781 AD and some twenty activities were recorded in 1200 years. According to the records, Mt.Fuji was very active between the period 781 to 1083, then suddenly quietened down for 400 years until 1511, then five eruptions were recorded between 1511 and 1709 and since then no eminent activity was recorded for 290 years (Table 3-2).

In the 800-802 eruption (also called the Enryaku eruption), effused air fall from the summit crater choked the Tokaido road passed through Gotenba. The Hakone route was opened instead and this has become the major Tokaido route since then.

The 864-865 eruption (also called the Johgan eruption) occurred at the northern flank's new openings now called Nagaoyama and Ishizuka parasitic cones, from which approximately 5×10^{8} tons of lava flowed out and covered an area of some 30Km². The lava went into Motosu and Semoumi(Saiko of today) and partly covered them. The area covered by the lava flow now called Aokigahara wood-sea is almost impenetrable and there 69 caves were discovered. A few new caves are still being discovered every year. Professor

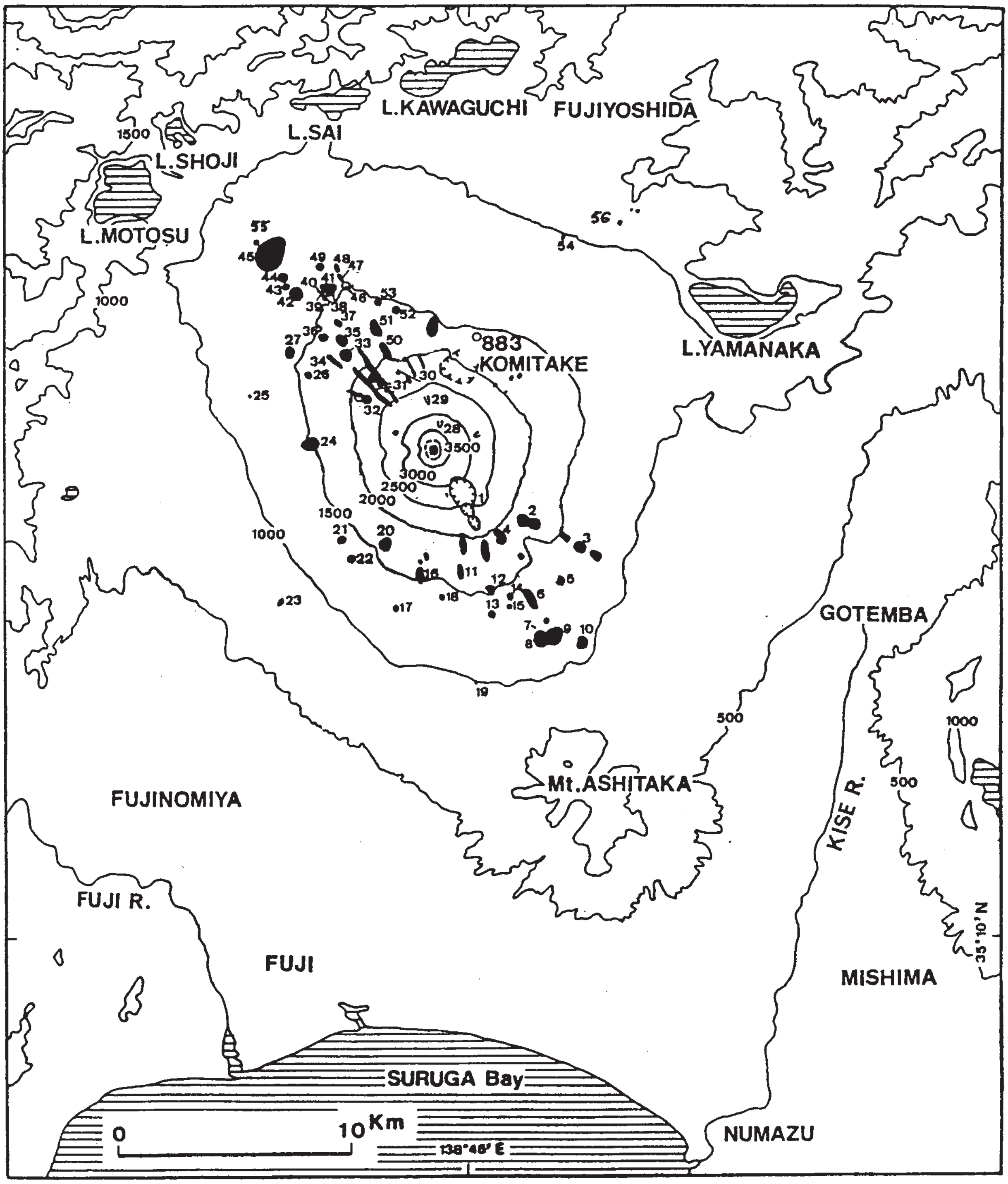


図 3-2　富士山の寄生火山・側火口の分布。　宮地(1988)による。
　　　　寄生火山等の傍らの小番号が、表 3-1　の番号に対応。
Fig. 3-2 Parasitic cones and flank craters of Mt. Fuji. After MIYACHI (1988)
Small size numbers in the figure showing sites are correspond to the numbers on Table 3-1.

Tsuya(1972)and Mr.Ogawa (1972) described these caves and interpreted their formation mechanisms.

The 937 eruption (also called the shohei eruption) records indicated lava flowed into a lake and this incident is likely to correspond to Takamarubi and Hinokimarubi lava flows which flowed into Yamanaka lake causing a rise in its water level.

The 1707 eruption (also called the Hoei eruption) was a large scale Plinian eruption effused from southern flank openings, with 13×10^{8} tons or 0.8km^3 of tephre distributed to the east as air fall deposits. The 16 days of eruption started in the early afternoon when a huge white smoke pillar blew up and deposited white dactic pumice lapilli. After four hours the colour of the smoke pillar distinctly became darker and dark coloured basic andesite lapilli was deposited. The plinian phase continuously lasted for four days from the three crater chain and activity became rather intermittent before suddenly stopping when a strong tremor occurred and a hump between the first and second crater was formed on the 16th day of eruption. The hump was then named Hoei-zan, the top of which is 2700m above sea level.

A large number of documents are available concerned with this event and it seemed there were no casualties at the time of the eruption but later there were cases of severe starvation among the people who lived in the devastated area. The 3m thich lapilli deposit of the 1707 eruption can still be observed in the Subashiri district at the eastern foot of Mt.Fuji having a distinct 15cm thick basal white pumiceous lapilli bed. Some 5-10cm of ash fall was recorded in Tokyo, or Edo as it was known at the time. This eruption was extraordinary in four aspects: as dacitic material effused at an early stage, no lava effused and it was a totally Plinian phase eruption, the eruption was preceded just 49 days by the great Tokai earthquake of M8.4(known as the great Hoei earthquake), and because it was the largest eruption in 3,000 years.

The historical record shows that the activity of Mt.Fuji is intermittent with rather long quiescent intervals. Since 1083 the only large eruption was that of 1707 and this activity did not contribute to the construction of the volcanic cone, and thus Mt.Fuji has only been subjected to erosional force for about 1000 years.

A large scar or gouge developed on the western slope of the summit and is called "Ohsawa-kuzure". The deep gully is betwen 3500 and 2500m in altitude and the estimated loss is of 0.02km^3 or the equivalent of 4×10^{7} tons of rock from the flank. A narrow gouge combines Ohsawa-kuzure to an alluvial fan at the foot, (900m below)where about 3

$\times 10^7$ tons of debris rests(Figure 3-3). The early debris bed was dated at 950 BP, which indicates the Ohsawa-kuzure started to collapse around 1000 AD. There are two records of Mt. Fuji collapse, in 1181 and 1331 AD, and the latter record describes "several hundred metres of collapse near the summit occurred at an earthquake" and this was most likely to be a collapse which occurred at Ohsawa-kuzure.

Some people are keen on trying to prevent the top of Ohsawa-kuzure eroding, as they are afraid the advanced erosion may cause deformation in summit symmetry. However, it is likely to take at least 1000 years before the gully cuts into the summit and deforms the symmetry, and it may be more probable that within the next 1,000 years an eruption of the summit crater will pour out lava along Ohsawa-kuzure which will restore the scar.

Only at times of heavy rainfall every several years, debris at the bottom of Ohsawa -kuzure is carried down in the form of a mudflow to the alluvial fan. Such a mass transportation was first observed in 1958 when some 100,000 tons of debris flowed down to the fan at about 300mm of rainfall. Recently a remote control TV camera was installed and all such mudflows are observsable.

The National Centre for Preventing Disasters set microseismographs at Shimobe, 20km west of Mt. Fuji, in 1979. On accumulating the records observed it was revealed that microseismicity continuously occurred under Mt. Fuji, in high and low frequencies. The Earthquake Research Institute of Tokyo University then installed geophysical equipment in a tunnel at the south-western flank of Mt. Fuji in 1982.

In 1939 a swarm earthquake occuring under Mt. Fuji was felt, but since then there have been no felt earthquakes of Mt, Fuji recorded. In 1987 seismicity under Mt. Fuji became somewhat active, including rather eminent low frequency tremors characteristic of active volcanoes, then a few felt earthquakes were observed at the summit observatory.

References

Tsuya H. (1935) On some lavas of volcano Fuji. Bull. Earthq. Res. Ins. 13, 645-649.

Tsuya H. (1938) Geological and petrological study of volcano Fuji I, Distribution of the Aokigahara lava and its vent. Bull. Earthq. Res. Inst. 16, 637-657.

Tsuya H. (1940) Geological and petrological study of volcano Fuji III, Geology of the souty-western foot of volcano Fuji. Bull. Earthq. Res. Inst. 18, 419-445.

Tsuya H. (1943) Geological and petrological study of volcano Fuji IV, Structure and

distribution of parasitic cones. Bull. Earthq. Res. Inst. 21, 376-393.

Tsuya H. (1955) Geological and petrological study of volcano Fuji V, On the 1707 eruption of volcano Fuji. Bull. Earthq. Res. Inst. 33, 341-383.

Tsuya H. (1962) Geological and petrological study of volcano Fuji VI, Geology of the volcano as observed in some borings on its flanks. Bull. Earthq. Res. Inst. 40, 767-804.

Machida H. (1964) Tephrochronological study of volcano Fuji and abjacent areas. Jour. Geogr. Tokyo 73, 298-308, 337-350.

Machida H. (1967) The recent development of the Fuji volcano, Japan Geogr. Rept. Tokyo Met. Univ. no. 2 11-20.

Tsuya H. (1968) Geological map of Mt. Fuji (1:50000) and the explanation text. Geol. Surv. Japan

Tsuya H. (1971) Topography and geology of volcano Fuji. Result of Co-operative Scientific Study of Mt. Fuji. 1-127. Fuji Kyukou Co. Ltd.

Ogawa T. (1971) Lava caves of volcano Fuji. Result of Co-operative Scienctific Study of Mt. Fuji. 38-45.

Miyachi N. (1988) Volcanic history of New Fuji volcano. Jour. Geol Soc. Japan. 94 433-452.

Table 3-2 Historical Records of Mt. Fuji Eruptions

781(Ten oh 1) Volcanic ash fell like rain, trees killed. (Shoku-Nihongi).

800-802(Enryaku 19-21) Summit eruption darkened daytime, and fire lit the night sky. Ashigara route was closed because of the ash fall, and Hakone route was newly opened. (Nihon-koki).

826(Tencho 3) Eruption. (Samukawa Shrine record).

859(Johgan 1) Eruption? (Ruiju-kokushi).

864-865(Johgan 6-7) 3 earthquakes occurred and eruption started with a 70m high fire column. Lava flowed into Motosu and Senoumi lakes, part of it directed to Kawaguchi lake. Many houses were demolished. (Sandai-Jitsuroku).

870(Johgan 12) Fierce eruption at the summit. (Samukawa Shrine record)

932(Shohei 2) Fierce eruption with the ejection of magma and scoria which caused Omiya-Sengen shrine to burn down. (Fujishi).

937(Shohei 7) God's fire buried the lake. (Nihonkiryaku).

952(Tenryaku 6) Eruption at the north-eastern side of Fuji.

993(Syoureki 4) North-eastern flank eruption.

1017(Kannin 1) Eruption occurred from three openings on the northern flank. (Fujishi).

1033(Chogen 6) Fire arose at the summit and then down to the foot. (Nipponkiryaku).

1083(Eiho 3) Eruption. (Husoryakki). Lava and scoria ejected from seven openings. Mt. Fuji volcanic activity ceased from then on. (Fujishi).

1331(Genko 1) Earthquake caused a Fuji summit collapse of several hundred metres. (Taiheiki).

1511(Eisho 8) Fuji Kamaiwa burned. (Myohoji-kyuki).

1560(Eiroku 3) Eruption. (Nipponsaiishi).

1700(Genroku 13) Eruption. (Nipponsaiishi).

1707(Hoei 4) Swarm earthquake followed by eruption on the next day on the southern flank. Four hours later the white cloud turned darker. Suddenly stopped on the 16th day. (Many references).

1709(Hoei 5) Fuji erupted again. (Kokufu-nenpyo).

1825(Bunsei 8) Swarm earthquake. (Kinoene-yawa).

1854(Ansei 1) Minor eruption?

1939(Showa 14) Swarm earthquake. (Nihon-Katsukazan-soran).

1987(Showa 62) Swarm earthquake. (Jour. Group. Pred. Volc. Activity).

4. Miyake Island

Miyake Island is situated 34.1° N, 139.5 ° E , at 200km south of Tokyo and about 75km south of Oshima. The round island is about 8km in diametre with an area of 55km³ and the summit "Oyama" is 815m above sea level.

The island is inhabited by 4,300 people in five villages, Tsubota, Ako, Igaya, Izu and Kamitsuki. Boat accesses are at Ako and Miike according to wind direction, and the airport is at Tsubota.

Ohnoharajima island is at 8km west of Miyake Island consisting of 3 major rocks and 3 small reef rocks, and these dissected remnants of a dacite volcano has long been used as the bombing and fire arms targets of the US military.

Isshiki(1960)examined the geology of this volcanic island and published a 1/50000 geological map. Soon after the publication an eruption took place in 1962 and then in 1983, and the areas of these eruptions need to be modified on the map.

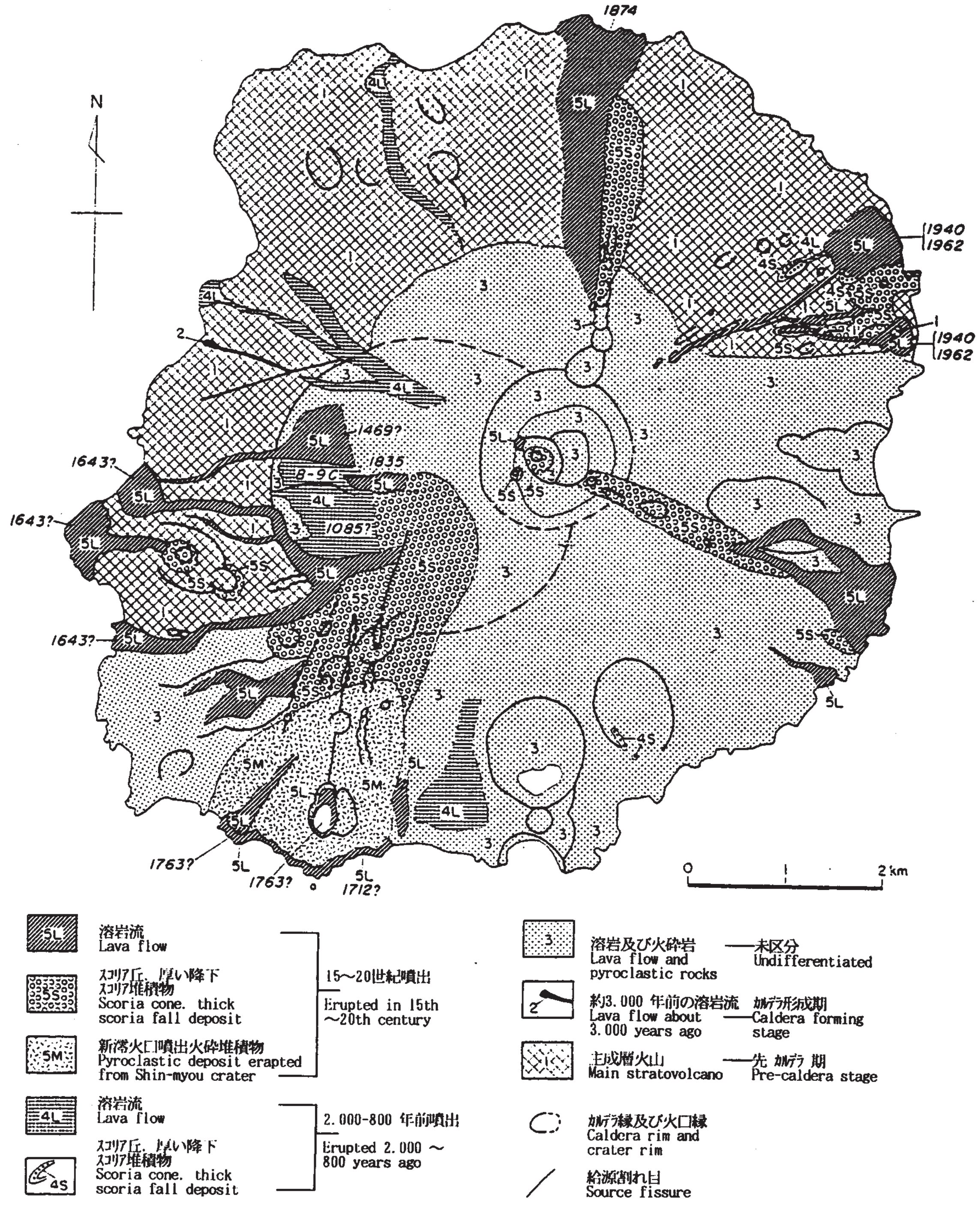
Miyake Island consists of a strato-volcano cone truncated by a 3km depression caldera, and the eastern half of the caldera is covered by a later strato-volcano, Hayonotairo volcano. There is a 1.5km diametre caldera on the top of the Hayonotairo volcano in which there is a central cone Oyama.

Older ejecta of the major strato-volcano is exposed at 30～80m sea cliffs on the north and north-western coasts. At the north fo Igaya village there are exposed older ejecta beds containing occasional diorite and altered volcanics derived from basement formations.

3,000 year old Jomon-pottey cultural remains at Izu village were immediately covered by a thick single cycle lapilli and pisolite air fall bed. Isshiki(1960, 1984) interpreted this 3,000 year old eruption to have occurred at the summit crater and it effused more than 0.2km³ of material, and that after the large scale eruption the 3km caldera depression may have taken place.

Over this sequence and between the 2,000 year old horizon, represented by Yayoi-pottery cultural remains, there are only a few air fall tephra beds. But in the next 1,200 years, until the twelfth century tephra, 11-12 eruption cycles are recognised in the tephra sequence.

図 4-1　1983 年の噴火以前の三宅島火山地質概念図
Figure 4-1 Geological sketch map of Miyakejima volcano (before the 1983 eruption)



一色 (1960, 1977, 1984). Issiki (1964)及び一色 (未公表資料) による。
Compiled from Issiki (1960, 1964, 1977, 1984; unpublished data)

An eminent white rhyolitic pumice bed derived from the Kohzushima 838 AD or the Niishima 886 AD eruption is easily traceable among dark Miyake Island tephra and useful as a time marker.

Seventeen eruptions have been recorded in the history of Miyake Island, which was recently studied by Miyazaki (1984) and the summary is shown in Table 4-1.

The 1154 AD eruption was on a considerably large scale judging from corresponding tephra layers, and there was a 315 year period of quiescence until the next eruption in 1496 AD. It is likely that the depression of the Oyama caldera occurred immediately after the 1154 eruption.

From the 1496 eruption onwards, the mode of eruption changed to flank eruptions which occur frequently every 20 to 60 years. The recent four eruptions occurred in 1874, 1940, 1962 and 1983, and the effused eruption materials have been estimated at 1.6, 1.9, 0.9 and 1.3×10^7 tons, respectively, with intervals of 66, 22 and 21 years. Severe swarm earthquake activity accompanied these eruptions with the exception of the 1874 event.

There are four large maar type craters on the south to east coasts. From the west, they are Shinmyo, Furumyo, Mizutamari (or Yaema) and Miike. Shinmyo crater was 400×300m and surrounded by steep walls and filled with water, this was formed at the 1763 eruption and is said to have been active for seven years. Shinmyo crater reactivated in and eruption in 1983 and half buried with new ejecta. Furumyo is a 1km diametre crater, the southern half of its bottom being Tairoike lake, 500x300m in size. 2000 year old Yayoi-pottery cultural remains were found underneath the ejecta from Furumyo and this crater is known to be 2000 years old. Mizutamari crater immediately east of Furumyo is a 1×0.6km oval shape, and is also called Yaema. The crater today is not filled with water, but the name Mizutamari means "pool". The crater is buried by Furumyo ejecta and thus it is older than the latter, but probably formed just before, because of the similar states of preservation. Miike on the east coast is some 400m in diametre and looks much older. The sand beach at the eastern front of this crater is called Miike-hama where the sand contains brownish-yellow olivine crystals, 3-5mm in size.

The 1983 eruption started on the south-western flank at an altitude of about 450m and soon the crater chain extended both above and below, to between 505m and 350m. One and a half hours later crater chains opened at the sea coast including Shinmyo crater and the whole of the crater chain reached a length of 4.5km. A fierce eruption phase lasted ten hours and then gradually died out to cease at about fifteen hours after

commencement. Magma-steam explosions at coastal craters caused an 8cm ash fall at Tsubota, situated 4km to the east. Lava flowed down from the flank craters covering a large part of Ako village and 432 houses were burnt or buried, but fortunately no one was hurt.

An A-3 rift cave at a height of 500m and B-5 and B-9 rift caves at about 480m in height can be inspected internally. These caves are formed orifices of the dike form magma vent, after magma level dropped at the final stage of the eruption.

References

Kikuchi Y. (1889) On Anorthite from Miyakejima. Jour. Coll. Sci. Imp. Univ. Tokyo 2, 31-47.

Tsuya H. (1941) The eruption of Miyake-shima, one of the seven Izu Islands, in 1940 I, II. Bull. Earthq. Res. Inst. 19, 263-294, 492-522.

Isshiki N. (1960) Geological map of Miyakeshima (1:50000) and explanation text. Geol. Surv. Japan.

Issiki N. (1964) Mode of eruption of Miyake-jima volcano in historic times. Bull Volcan. 27, 1-20.

Minakami T. (1964) The 1962 Eruption of Miyake-shima, one of the seven Izu Islands, Japan. Bull. Volcanology, 27, 225-234.

Miyazaki T. (1984) Some characteristics of Miyake-shima Eruption in Historical Record. Jour. Volc. Soc. Japan 2nd Ser, 29, S1-S15.

Aramaki S. & Hayakawa Y. (1984) 3rd and 4th October 1983 Miyakeshima eruption. Jour Volc. Soc. Japan 2nd Ser. 29, S24-S35.

Table 4-1 Eruption History of Miyake Island After Miyazaki (1984)

5th Century (Ko-an21)	Eruption
1085 (Ohtoku 2)	Eruption
1154 (Kuju 1)	Eruption
1496 (Ohnin 3)	Eruption
1535 (Tembun 4)	Eruption
1595 (Bunroku 4)	Eruption
1643 (Kan-ei 20)	A flank eruption caused Ako village to burn down completely.
1712 (Shotoku 1)	Eruption started at Kuwakidaira and then a great smoke column rose at the beach. Lava flowed out 200m offshore and a few hundred metres north-west. Many houses of Ako village were buried by mudflow. The eruption ended in two weeks.
1763 (Hohreki 13)	Summit eruption started in the night, and the next day an eruption occurred at Usuki near Ako village. Thick scoria and lapilli was deposited on Ako and Tsubota villages, ash also fell on the other villages. The crater at Usuki was immeasurably deep.
1777 (An-ei 6)	Eruption at Oyama.
1781 or 1782 (Tenmei Era)	Strombolian activity at summit crater.
1811 (Bunka 8)	Fierce summit eruption made the night as light as day, ceased in six hours.
1835 (Tempo 6)	At the western flank, eruption began at Nagane in Igaya village when a crater opened at the former Nakayama-kannon on Kasajiyama. Also from a high place on Toga Hirabeyama to the Tsubota road 13 craters opened up and erupted. Hot water sprung out at Yuba, Ako.
1874 (Meiji 7)	Summit fire was seen at night from Niijima and the next noon an old crater at Ikenosawa on the upper northern flank started to erupt. Large and small stones were ejected with a fierce noise. Two hours later 6 other craters appeared suddenly and effused lava flows. More than 30 houses in Higashigo village were demolished. Eruption stopped in four days. Total ejecta was estimated at $1.6 \times 10^7 m^3$ (Isshiki 1960) and the ejecta contained large anorthite crystals described by Kikuchi (1889).
1940 (Showa 15)	Eruption started at the north-eastern flank 200m above sea level, then craters opened at 450m and at Akabakkyo shore. Lava flowed down and several cindercones were built. This phase ceased in 30 hours then summit

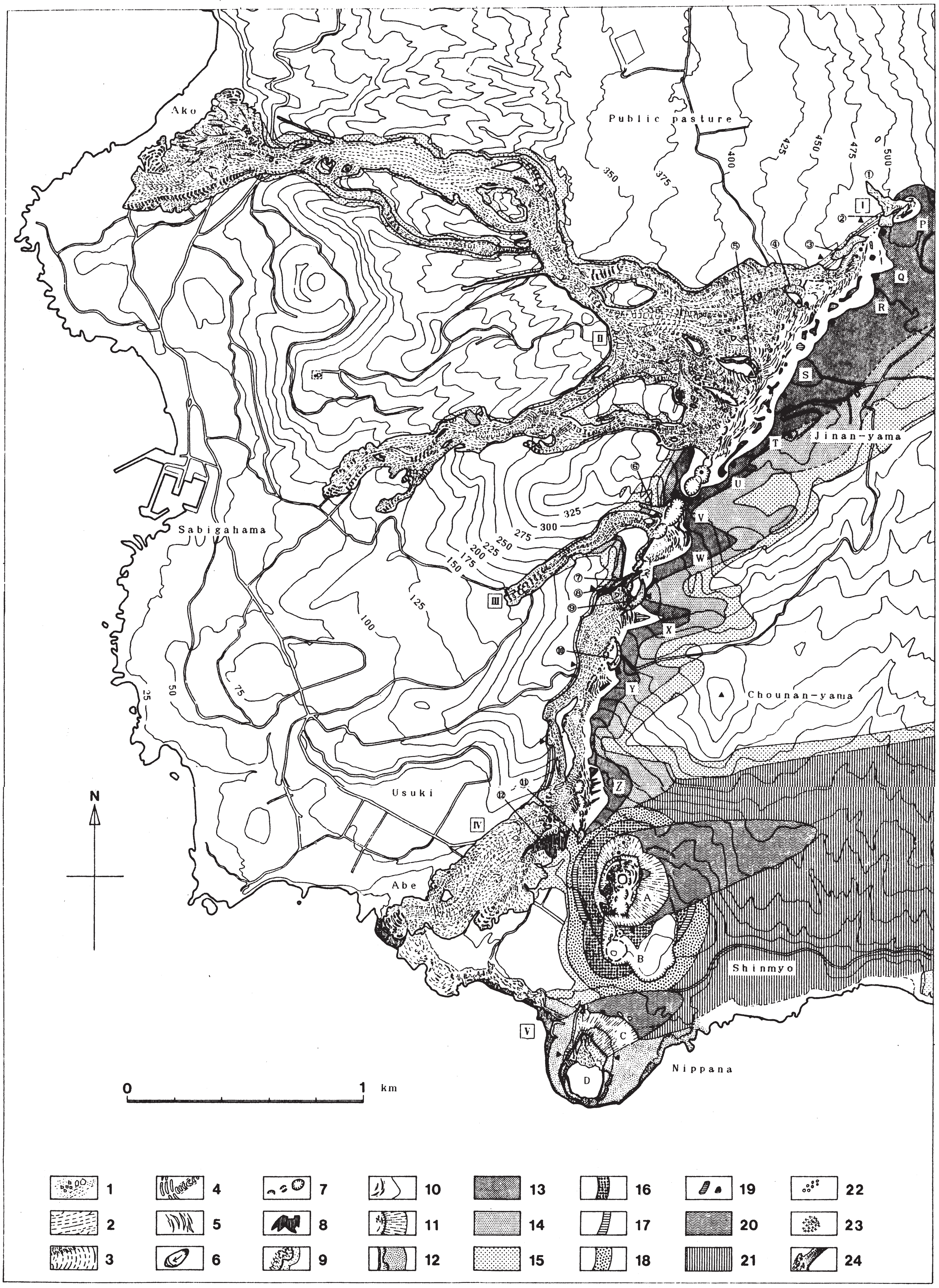


Fig. 4-2 Geological and hazard map of the 1983 Miyake-jima Eruption based mainly on the photo-interpretation.
(Coastline around the Shinmyo area is that of Oct. 7.) (after Endo et. al)

1-9: micro-topography of lava flow
10-12: type of cone
13-15: grade in damage for vegetation around spatter cones
16-18: grade in damage for vegetation around explosion craters
20-21: grade in damage for vegetation by scoria or ash fall

1: blocky lava, 2: flow liniation on lava surface, 3: extention crack on lava surface, 4: pressure ridge, 5: open cracks and graben-like depression along spatter rampart and cone, 6: landslide of lava, 7: explosion or pit crater, 8: rootless spatter cone, 9: marginal features of lava and damaged tree zone, 10: spatter cone, 11: scoria cone, 12: tuff cone, 13: zone of downed tree whose foot was burnt by spatter or scoria fall, 14: zone of stripped tree by spatter or scoria fall, 15: zone of leafless tree by spatter or scoria fall, 16: zone covered by breccia, 17: zone of damaged tree by breccia fall and fire scorching, 18: zone of damaged tree by breccia, 19: summit of cone with sublimate, 20: stripped tree zone covered by heavy scoria fall, 21: zone of tree coated with muddy ash, 22: secondary scoria mound, 23: spatter or driblet covering explosion crater, 24: coast. P-Z, A-D: name of grouped cones (rampart) or craters, those boundaries are shown by a pair of solid triangle. I-V: lava flow. 1-12: minor lava flow, secondary flow or rootless spatter cone.

eruption began and lasted for 23 days. Total ejecta was estimated at 1.9×10^7m^3 (Tsuya 1941). This eruption killed 11.

1962(Showa 37) Eruption occurred at the north-eastern flank 200m above sea level close to the site of the 1940 eruption, meanwhile chain craters opened above and below the initial one and ejected fire columns in chain. About an hour later effusion activity weakened at the high level craters, but lower level craters were active for 30 hours. Total ejecta was estimated at 0.9×10^7m^3 by Suwa(1963)

1983(Showa 58) Eruption started at Futaoyama on the south-western flank, then a chain of craters opened up above and below and effused lava. 432 houses of Ako village were demolished by the lava flow. Fierce magma-steam explosions occurred at Shinmyo crater and off Shinbana beach. Activity ceased in 15 hours. Ejecta total was estimated at 1.3×10^7 m^3

5. Sakibara Monogenetic Volcanoes.

On the north eastern coast of Izu Peninsula there are about 70 monogenetic volcanoes often called East Izu Monogenetic Volcanoes and this distribution of volcanoes is extends to the eastern off shore where these are about 50 sea bottom monogenetic volcanoes (Figure 5-1).

Volcanic geology of this area has been studied repeatedly by Kuno(1954),Sameshima (1966),Harumo(1978,1985)and Miyajima et al(1985).

Three rock types of volcanoes,basaltic,andesitic and rhyolitic are among them and were formed within the same period of time. The oldest known has been measured at 30000 years ago,and the most recent,about 3,000 years BP,has been dated for Kawagodaira ejecta. This is a depression crater at a high place on Amagi volcano,an andesitic strato-volcano of some 300,000 years old. Kawagodaira effused rhyolitic lapilli of a mixture of pumice and obsidian,and this characteristic lapilli bed is easy to trace and offers a good time marker. Some volcanoes turned out to be younger than Kawagodaira as their ejecta are covered by the Kawagodaira lapilli bed. Rhyolitic domes Iwanoyama, Kohnoyama and Yahazuyama,and a basaltic lapilli effused centre Iwanokubo,and an andesite volcano Iyuzan are younger than 3000 years,not yet precisely dated.

Omuroyama, a basaltic-andesite cinder cone,is by far the greatest of the volcanic cones,and large quantities of lava flowed out from lava fountains called Iwamuroyama at the north eastern side of the Omuroyama cinder cone and also from the southern face hump. A south easterly flow from the latter fountain,flowed down to the coast and buried large areas forming new land. A north bound lava flow reached about 2km south of Ito City township.

The Iwamuroyama is now used as the Cactus Park,and near the top of this rocky hill there is a small cave,open to the public. Another collapsed lava cave is located at the western foot of the Omuroyama cone.

References

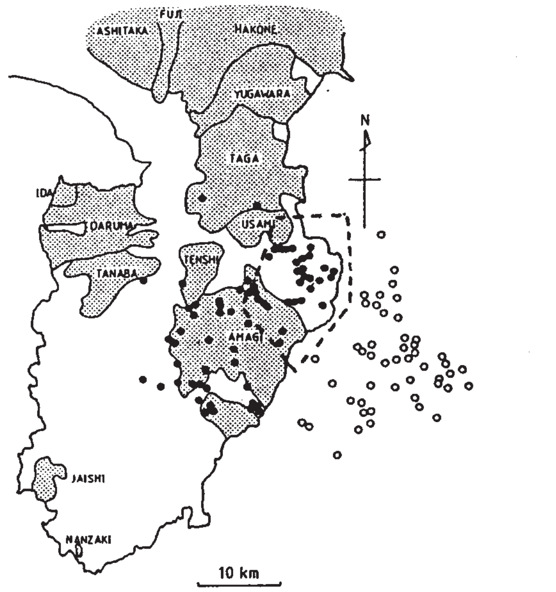
Kuno H.(1954) Geology and Petrology of Omuroyama Volcano group,northern Izu. Jour.Fac. Sci.Univ.Tokyo 9,241-265.

Sameshima T.(1966) Geological Guidebook of Izu Peninsula 1-32. Shizuokaken Chigakukai (in Japanese).

Hamuro K.(1978) Geology of Omuryama Volcano group. Jour.Geol.Soc Japan 84,433-444.

Hamuro K.(1985) Petrology of the Higashi-Izu Monogenetic Volcano group. Bull.Earthq. Res.Inst.60,335-400.

Miyajima H. Yoshida K. & Aoki K.(1985) Geochemical studies of Higashi-Izu Monogenetic Volcanoes. Rep. Kakuriken 18,158-174(in Japanese).



The relation between the Higashi-Izu monogenetic volcanoes and the off shore sea bottom monogenetic volcanoes.
* Area of lower map is indicated by dotted line.
東伊豆単成火山群と、その東沖の海底単成火山群との関係。
* 点線で囲つた部分が下図の地域。

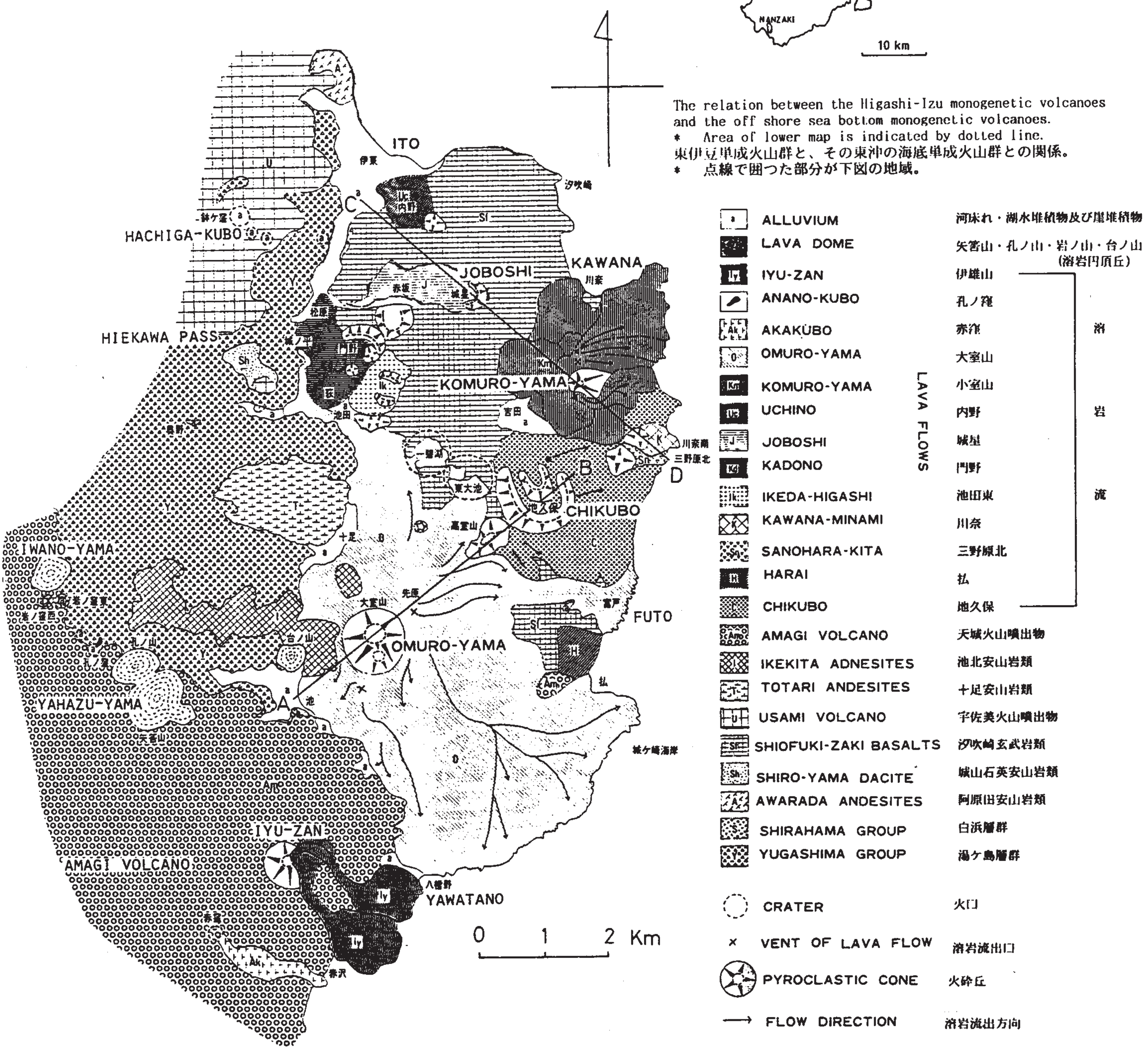


図 5-1 先原火山群の地質 ： 葉山(1978)による
Fig. 5-1 Gelogic map of Omuroyama area. (Hamuro. 1987)

6. Cheju Island (Korea)

Cheju Island lava caves have been systematically surveyed since 1977 as a joint project between the Japan Volcanospeleological Society and Speleological Society of Korea.

Part of the survey results were reported at the Third International Symposium on Vulcanospeleology held in the U.S.A. where the Billemot kul (kul=cave) of Cheju Island has been officially recognized as the world's longest known lava cave, based on the survey result showing the total length to be 11.749m. In the Fourth Symposium, held in Sicily, Italy, delegates requested the next (the Fifth) Symposium to be held on Cheju Island in 1986. However, Korea could not be the host convener under unavoidable circumstances, thus the delayed Symposium has been set to be held in Japan with the post session excursion to Cheju Island in co-operation with the Speleological Society of Korea.

Geography of Cheju Island

Cheju (Jeju or Saishu) Island is situated in the Korean Strait at 126.5° E, 32.5° N, which is at about 80km south of the southern tip of the Korean Peninsula and at about 200 km west of Nagasaki on the western coast of Kyusyu Island. This is the largest island of Korea, a long ellipse in shape with a 73 km east-west major axis and a 31 km north-south minor axis, its perimetre is 263 km and covers 1800km². (figure 6-1)

Near the centre of the island is Mt. Halla (or Hanlasan) 1952 m, the highest peak in south Korea. Near the summit of the mountain there is a 400 m size central crater, Paeknoktam or Backlockdam. The fluidal alkaline lava of Mt. Halla, alkali basalts and trachytes, costructs a shield volcano which forms the major part of the island.

Cheju Island is inhabited with nearly 400,000 people of which 150,000 is in Cheju City on the northern coast and some 30,000 in Seogwipo (Seoguipo) City on the southern coast. A paved road joins these two cities through the 800 m high flank of Mt. Halla, also a good paved coastal road enables a round drive of the island in four hours.

The major products of the island used to be cattle, horses, fisheries, mushrooms and black coral, but since 1965 the orange industry has successfully taken a major part. Orange orchards have been greatly helped with irrigation systems using large quantities of well water successfully drilled out since 1970. Owing to the Kuroshio,

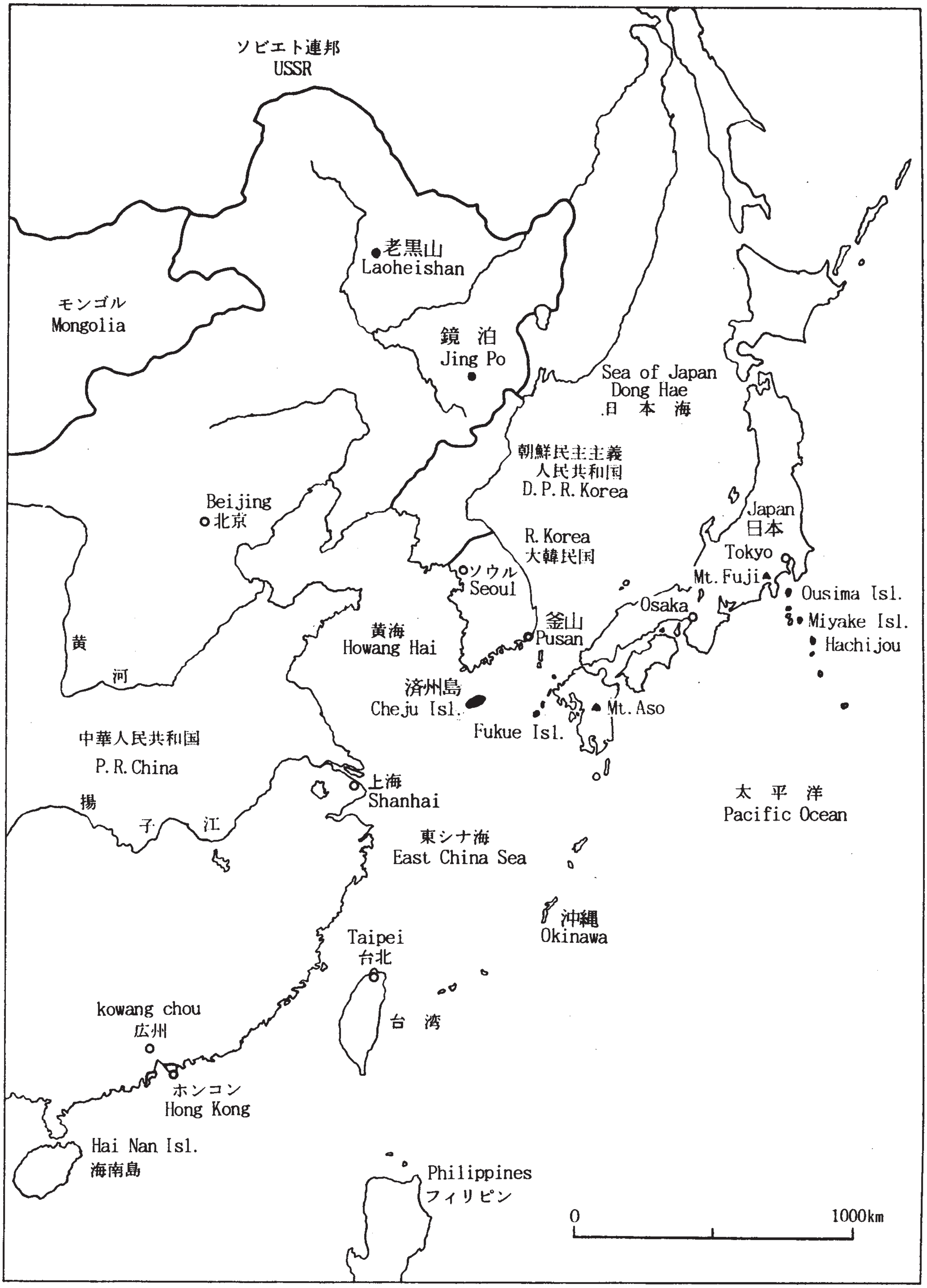


図 6-1 極東地区の火山洞窟所在地図

Fig. 6-1 The map of the seats of Volcanic Caves in the Far East area.

the West Pacific warm ocean current, coastal region air temperatures never drop down below freezing point and is favorable to the orange industry, although the upper part of Mt.Halla is covered by snow from November to February.

Annual rain fall at Cheju City on the north-coast is 1450 mm, while Seogwipo City in the south has 1800 mm. The island is windy in all seasons, especially in winter when northerly gales often reach 80 km/h, and the island is even occasionally hit by destructive tyhoon during summer.

Geology of Cheju Island

Lavas of the shield volcano Mt.Halla (or Hanla) covers up most of the island. Historical records of four eruptions in 1002, 1007, 1455 and 1570 A.D. shows the volcano is still active.

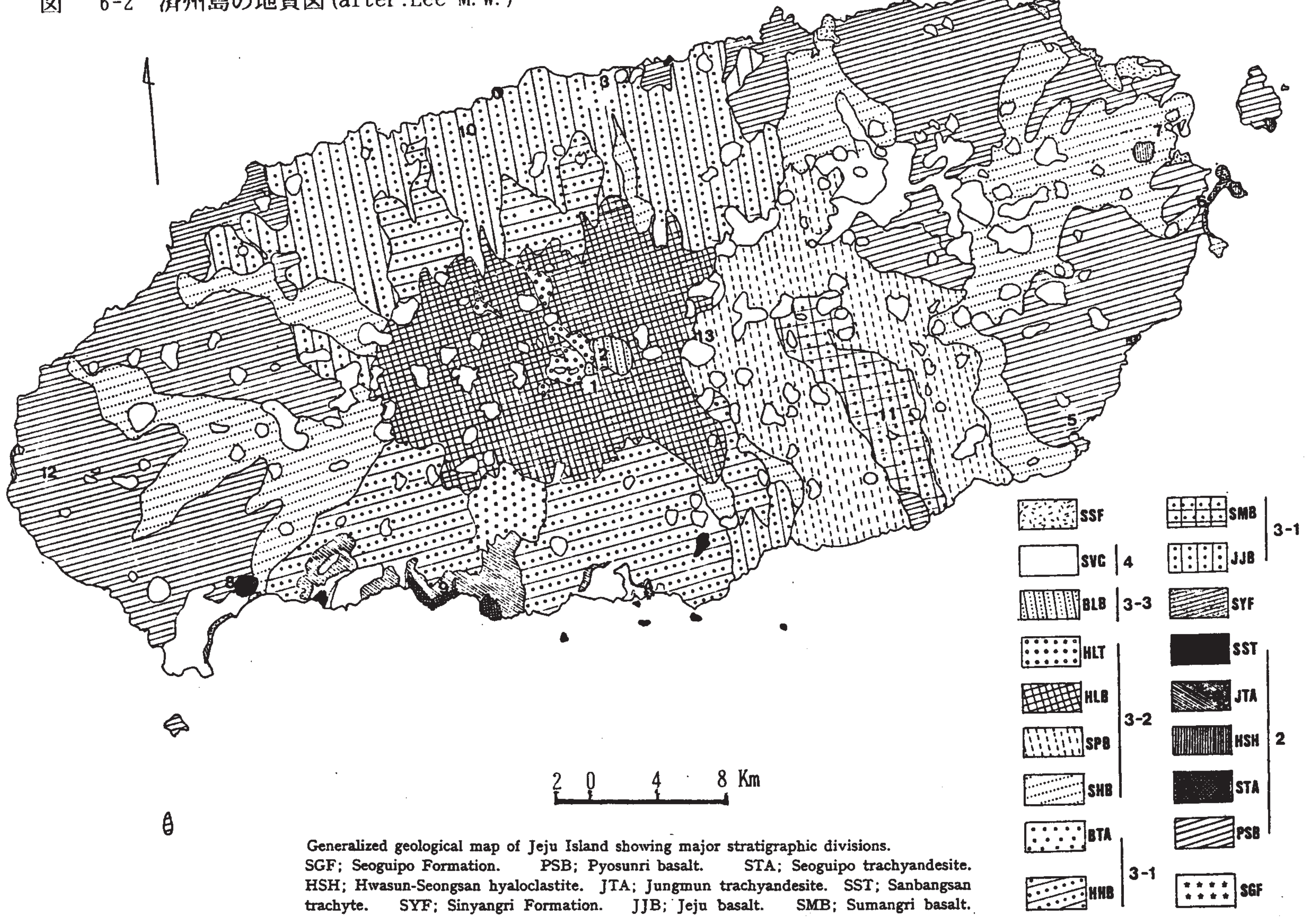
Haraguchi(1930,1931) first published a Cheju Island geological map, and he also added extended survey results (Haraguchi 1960). He recognized seven rock types in Mt.Halla lavas and set their ages in upper Pleistocene to Holocene. He also clarified that the gently sloped shield has been formed by a large scale eruption of Cheju basalt and Feldspar basalt flow in the initial stages of Mt.Halla activity.

At the southern coast he found a marine fossiliferous sedimentary bed, Seogwipo Formation, for which he inferred lower Pleistocene age from the molluscan faunal assemblage he described including Turritella saishuensis. Later the fossil fauna have been reexamined and upper Pliocene age is given by Taneda et al (1970), Kim (1972) and Yoon (1988). Alkaline volcanic rock formation underneath the Seogwipo F. is thought to be representing Pliocene volcanic activity. (Figure 6-2)

Haraguchi(1930,1931) also found that there are several small lava domes of trachy-andesite. These small scale monogenetic volcano lavas are often hornblende-bearing, distributed in south-west and north coastal regions, including the Mt.Sanbang (Sanbasngsan) at the south-west. He postulated the middle Pleistocene age for them and considered them to be the products of weak volcanism prior to the Mt.Halla activity.

Taneda et al (1970) studied petrochemistry and paleomagnetism of Cheju lavas. They confirmed Haraguchi's volcanic successions and measured paleomagnetic pole direction for several lava samples. They found all five lava samples of Mt.Halla, including early stage "alkali basalt" (Pyoseonri basalt of Won, C.K. 1975 and Lee 1982) are "normal" in polarity, while Mt.Sanbang lava showed "reverse" polarity. They postulated that the Mt.

Fig. 6-2 Geological map of Cheju Island
図 6-2 済州島の地質図(after:Lee M.W.)



Generalized geological map of Jeju Island showing major stratigraphic divisions.
SGF; Seoguipo Formation. PSB; Pyosunri basalt. STA; Seoguipo trachyandesite. HSH; Hwasun-Seongsan hyaloclastite. JTA; Jungmun trachyandesite. SST; Sanbangsan trachyte. SYF; Sinyangri Formation. JJB; Jeju basalt. SMB; Sumangri basalt. HHB; Hahyori basalt. TAB; Beobjeongri trachyandesite. SHB; Shiungri basalt. SPB; Seongpanak basalt. HLB; Hallasan basalt. HLT; Hallasan trachyte. BLB; Backlockdam basalt. SVC; Scoria volcanic cones. SSF; Shell-sand Formation.
1; Hallasan. 2; Backlocksam. 3; Jeju. 4; Seoguipo. 5; Pyosunri. 6; Seongsan. 7; Sihungri. 8; Sanbangsan. 9; Jungmun. 10; Kwangyeong. 11; Sumangri. 12; Mosulpo. 13; Seongpanak.

Sanbang lava possibly erupted during the Matsuyama Epoch (0.69-2.50 m.y.).

Won, C.K. (1975) examined the Shinyangri Formation, a fossiliferous shallow marine deposit distributed at the eastern tip of the island, and he inferred the lower-middle Pleistone age to it. As the Shinyangri F. covering the Pyoseonri basalt he set the age of this basalt at lower Pleistocene.

Lee (1982a) published a geological map of the island based on his survey and described the volcanic succession. He followed Won (1975) in setting the Pyoseonri basalt at lower Pleistocene. (Table 6-1)

Lee (1982b) chemically analysed 63 lava samples and treated them on variation diagrams. He concluded that there were two cycles of alkali basalt－mugearite － trachyte differentiation in lower to middle Pleistocene and in upper Pleistocene to Holocene.

Won, J.K. et al (1986) measured paleomagnetism on three Mt. Halla summit area trachytes (Backlokdam group) and five Mt. Sanbang group trachytes. They found "normal" for the summit trachytes, and "reverse" for the Mt. Sanbang group lavas. These results cofirmed those of the Taneda et al (1970) attempt. They also measured K－Ar ages using equipment of the Okayama Science University, for a Backlokdam trachyte and three Mt. Sanbang group trachytes. The age was determined at 0.025 ±.003 m.y. and average of 0.733±.05 m.y., respectively. As recently discussed by Nagao & Itaya (1988) and Itaya & Nagao (1988) 0.025 m.y. (=25.000 y) is marginal value for the method and a subject of large errors involved. The "dead" Ar contamination often causing errors to the positive side in the age which is not included in the experimental error value attached.

The Pyoseonri lava represens the largest scale activity in Mt.Halla volcanism and the lava contains a large number of caves. This situation is very similar to the basalt lavas of Mt. Fuji, for which ^{14}C ages have been measured at around 10,000 y.BP.

Evidences such as only low sea cliff developed where Pyoseonri lava reached to the shore, and the "normal" polarity is measured by Taneda et al (1970) indicates that the Pyoseonri lava is unlikely be three quarter of a million years old, but several thousands to a few tens of thousands years old. The Shinyangri Formation molluscan shell has been dated by ^{14}C method at 4780 ±60 y.BP (Yamada, O. 1987, unpublished report) and this age suggests the formation is a Yurakucho-transgression product. Covered by this formation the underneath lava age is restricted at older than 5.000 years.

表　6-1　各研究者の、済州島の主要な火山岩と堆積層の層序の比較表

Table 6-1 The stratigraphic succession of the principal volcanic and sedimentary units in Cheju Island as determined by previous studies (after Lee M. W.)

		Haraguchi (1931)	Taneda (1970)	Won, C. K. (1975)	Lee, M. W. (1982)	Remarks
Recent	Upp.	1007, 1002 activities Groups of small basalt cones	1007, 1002 activities	1007, 1002 activities	1007, 1002 activities Groups of small basalt cone	Old manuscripts of Koryŏ Dynasty
	Low.			Volcanic cone I Volcanic cone II		
Pleistocene	Upp.	Suikido basalt Hallasan basalt Aphanitic basalt Augite basalt Feldspar basalt Cheju basalt	Hallasan basalt Aphanitic basalt Augite basalt Cheju basalt Alkali basalt	Paeknoktam basalt Hallasan trachyandesite Hallasan basalt Sŏngp'anak basalt Shihŭngri basalt Pŏpchŏngri trachyte Hahyori basalt Cheju basalt	Shinyangri Formation Hallasan trachyte Hallasan hawaiite Sŏngp'anak hawaiite Shihŭngri hawaiite Pŏpchŏngri mugearite Hahyori hawaiite Cheju hawaiite	0.025±0.008 Ma
	Mid.	Hornblende trachy-andesite Sanbangsan lava	Sŏgwip'o lava Sanbangsan lava	Shinyangri Formation	Hornblende mugearite Sanbangsan trachyte	0.74 ± 0.023 Ma
				Chungmun trachyte Sŏngsanp'o Formation Sŏgwip'o trachyte P'yosŏnri basalt	Chungmun hawaiite Sŏngsanp'o Formation Sŏgwip'o hawaiite P'yosŏnri alkali basalt	Matsuyama's reversal epoch
	L	Sŏgwipo Formation				
Pliocene	Upp.		Sŏgwip'o Formation	Sŏgwip'o Formation	Sŏgwip'o Formation	
	Mid.	Hallasan alkaline	Hallasan alkali trachyte	Basal basalt	Basal basalt	Boring core (1971)
	Low.					
Pre-Tertiary		Granite?	Granite?	Granite?	Granite?	

Many tree trunk molds were found in Sihungri lava, charcoal has not yet been collected but is likely to be obtainable from these tree molds. ^{14}C dating of Cheju lavas is necessary to clarify the chronology of Mt. Halla volcanic activity.

References

Haraguchi, K. (1930) Saishu Volcanic Island. Memorial Vol. Prof. Ogawa 1-55. (In Japanese)

Haragushi, K. (1931) Geology of Saishu Island. Bull. Geol. Surv. Gov. Gen. Chosen (Korea) 10, 1-34. (in Japanese)

Haraguchi, K. (1960) Saishu Volcanic Island, Supprimental remarks Rep. Yamagata Univ. Nat. Sci. 5, 11-20. (in Japanese)

Taneda, S., K. Tsuji and M. Nakamura (1970) Geological, petrological and palaeomagnetic studies on the volcanic rocks of Cheju Island. Bull. Volc. Soc. Japan Ser. 2, 15, 96-108. (in Jap with Engl summary)

Kim, B. K. (1972) A stratigraphic and paleontologic study of the Seoguipo F. Cheju Island. Mem. Vol. Prof. Chi Moo Son 167-187.

Won, C. K. (1975) Study of geologic development and the volcanic activity of the Cheju Island. Bull. Kon-kuk Univ. Soeul Korea 1, 7-48. (in Korean)

Lee, M. W. (1982a) Geology of Jeju volcanic island, Korea. J. Ass. Min. Petrol. & Econ. Geol. 77, 55-64. (in Jap with Engl sum)

Lee, M. W. (1982b) Petrology of Jeju volcanic island, Korea. J. Ass. Min. Petrol. & Econ. Geol. 77, 203-214. (in Jap with Engl sum)

Won, J. K., J. Matsuda, K. Nagao, K. H. Kim, M. W. Lee (1986) Paleomagnetism and radiometric age of trachytes in Jeju island, Korea. J. Korean Inst. Mining Geol. 19, 25-33.

Yoon, S. (1988) The Seoguipo molluscan fauna of Jeju Island, Korea Mem. Vol. Prof. Kotaka 539-545.

7. China

There are several lava plateaus in Dongbei Province consisting of alkali basalts (Fig.7－1). Near Lake Jingpo in southern Heilongjian Shun four lava caves are known. In the northern part of Heilongjian Shun is a shield volcano Wutaiienchi, where an eruption took place in 1720-1722 A.D. to form Laoheishan and Huoshaoshan. Laoheishan is 1200m in basal diametre, 166 m high and the 350 m size crater is 50 m deep. Huoshaoshan is 670 m in diametre, 73 m high and has a 415 m size crater of 63 m depth. Lava caves are reported in Huoshaoshan lava. (Fig. 7-2)

Lava caves are said to be found near Tongnin on the border of USSR, but this information has not been confirmed. Mt.Paektusan on the border to North Korea is reported to have caves in welded tuff.

References

Vlodavetz,V.I.,Php.B.I. (1959) Catalog of the volcanoes of the world. Part Ⅷ. 105-109.

Demek.J. (1986) Pseudokarst in volcanic tuff of the Paektusan Mt.,People's Republic of Korea. 9th Intern.Cong.Speleol.2, 23-24.

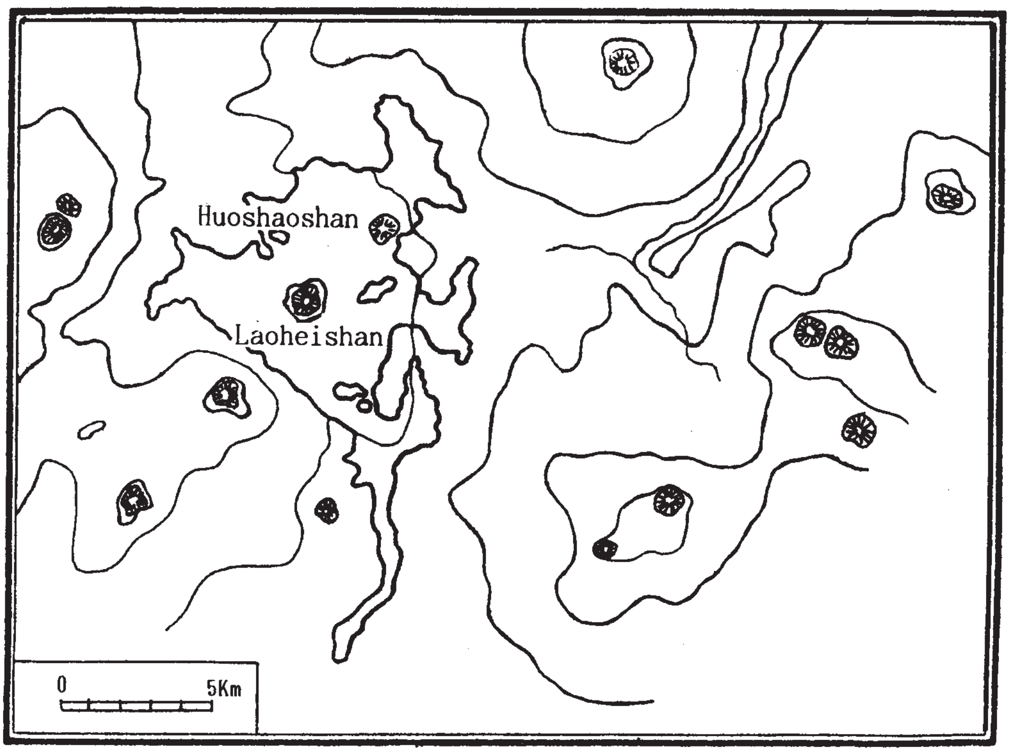


図 7-2 中国東北黒竜江省老黒山地域図
Fig. 7-2 The map of Laoheishan region area Heilongjiang Shun in China

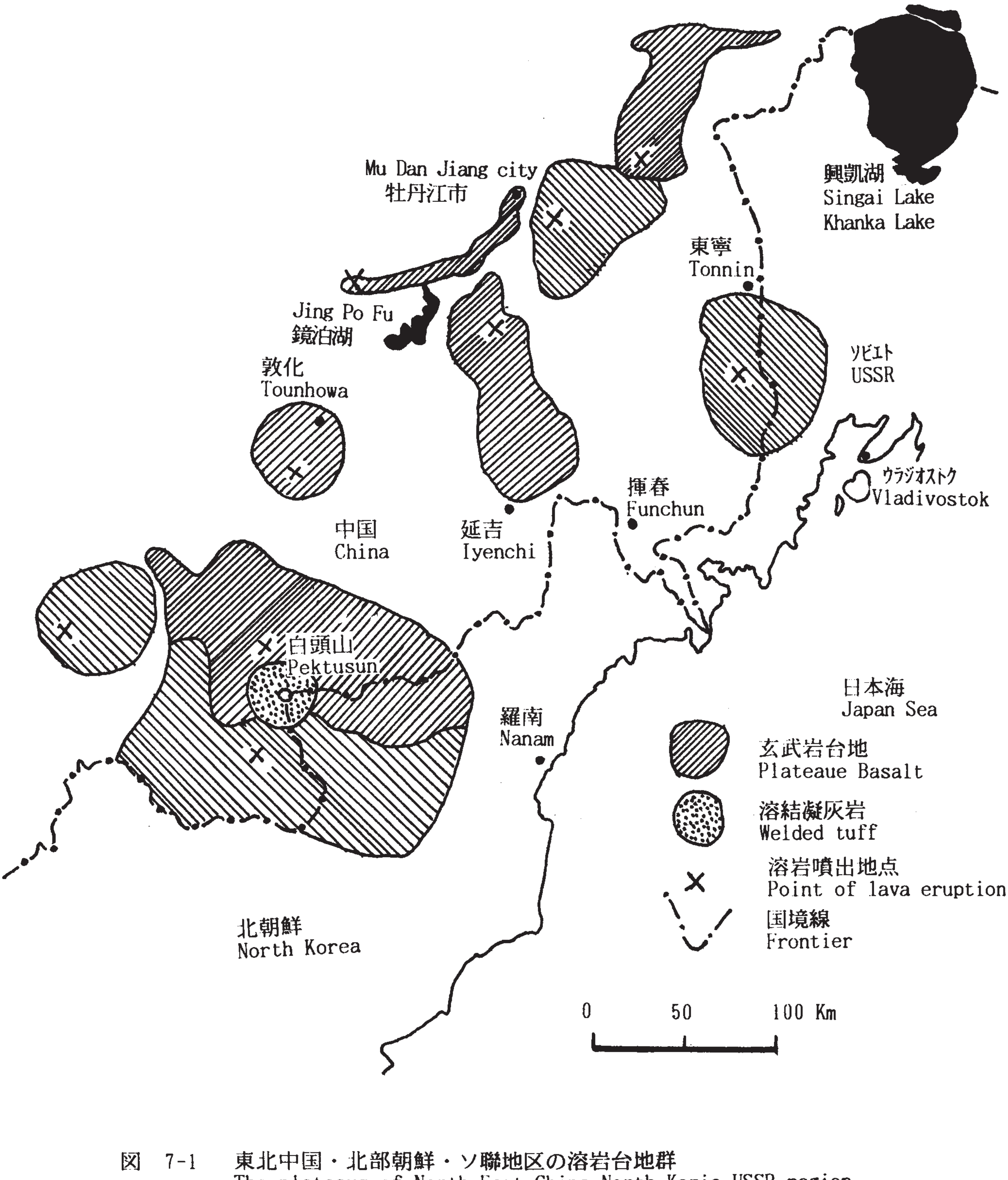


図 7-1 東北中国・北部朝鮮・ソ聯地区の溶岩台地群
Fig. 7-1 The plateaus of North-East China·North Koria·USSR region.

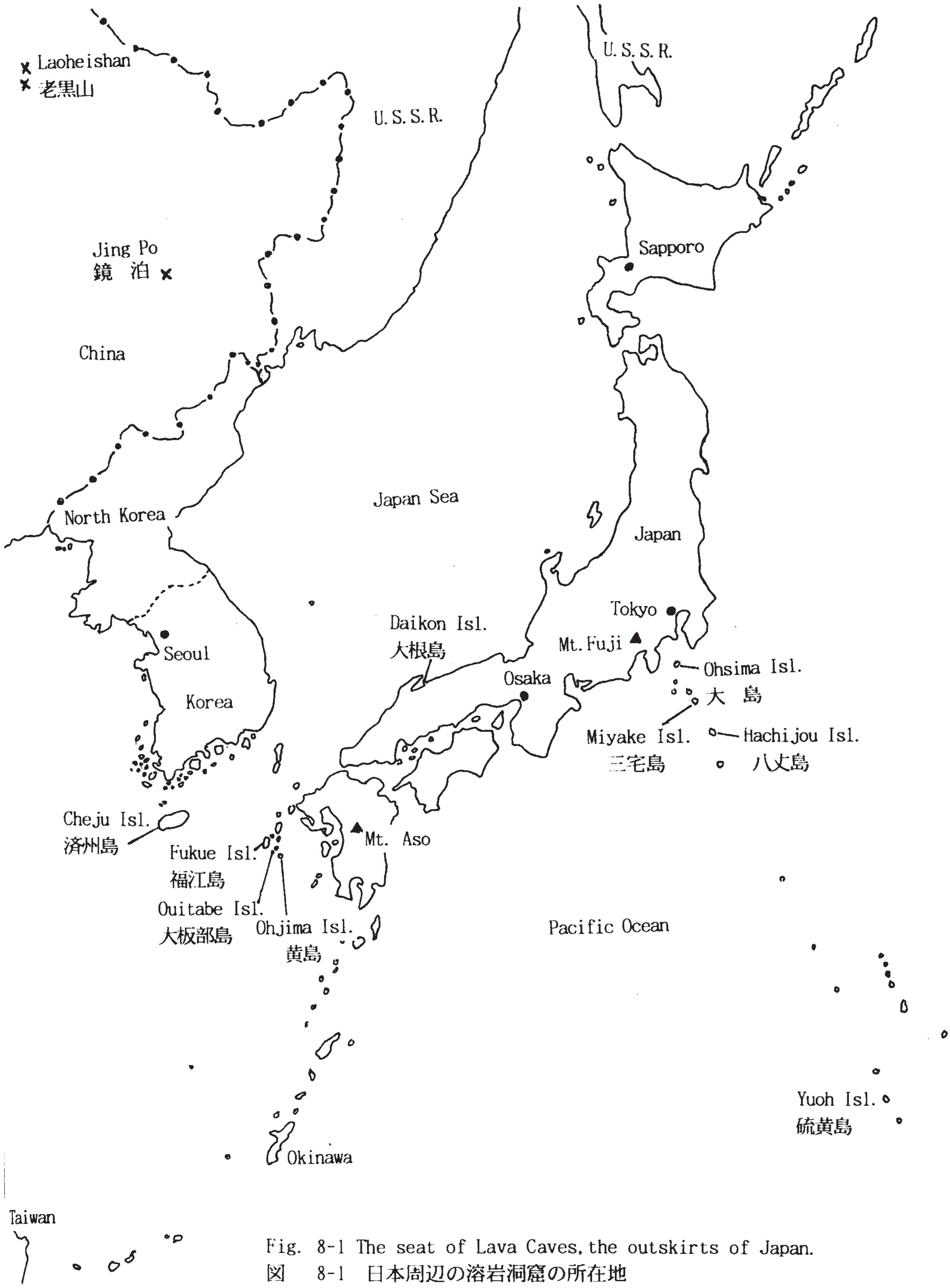


Fig. 8-1 The seat of Lava Caves, the outskirts of Japan.
図 8-1 日本周辺の溶岩洞窟の所在地

Volcanic Caves in Asia

8. Japan

One hundred and eleven caves have so for been found from Mt. Fuji lava, 100 km west of Tokyo (Fig. 8-1). 69 of the Mt. Fuji caves were found in Aokigahara lava flow, erupted in 864 A.D., and 6 were found in Mishima lava flow of some 10,000 years old. (Table 8-1)

One cave was known in Izu-Oshima volcano at its summit area inside of Miharayama crater but it has been demolished by the Nov. 1986 eruption.

Three rift caves have been formed by the Oct. 1983 eruption in Miyake Island, on its southern flank at 400-500 m level.

Hachijo Island has the second longest lava cave (Fig. 8-2) and the deepest rift cave of Japan.

Daikon Island at the western tip of Honshu Island, Fukue Island and minor islands attached to it, belong to the Goto Island Group on the north-western coast of Kyushu Island, and have lava caves in alkaline suite basaltic lavas.

Volcanoes of Kyushu, Aso (SiO_2 52-54%) and Unzen (58-66%) have caves. There is a cave in andesite somma lava of Aso caldera (Fig. 8-3).

There are vast ignimbrite fields in middle and southern Kyushu. 19 caves have been reported in the ignimbrite. Most of these caves are believed to have been formed by inner gas pressure similar to the basalt lava caves, and forming cave crusts (Table 8-2).

Miyake Island

Three rift caves have been formed by the 1983 eruption (Fig. 8-4). A-3 rift cave (Fig. 8-5) is at the upper margin of the fissure openings extended to the shore line. A 33 m vertical descent is required through the passage with the narrowest width of 30 cm to reach the bottom of it where beautiful gypsum crystals grow. B-5 rift cave (Fig. 8-6) shows a profile of ash beds of the caldera which is covered by 3-5 cm thin lava. The white pumiceous ash bed of Kozu Island erupted in 838 A.D. is seen embedded in dark coloured basaltic scoria. This cave bends in a right angle and unstable deposits threaten collapse. B-9 rift cave is actually a narrow crack thus helmets may get stuck

during the survey.

Mt. Fuji

Mitsuike-ana (ana=cave)

The longest lava cave in Japan, formed in lava flow from Inusuzumi flank opening (Fig. 8-7). The activity of it is later than the age known Namesawa lava, which is dated by ^{14}C method at 2800±30 y.BP and lay beneath the Inusuzumi lava. There are large size lava stalagmites, twelve exceed 1 m and the lengthiest reaches 1.91 m, which is probably the world's longest (Fig 8-8). Lava balls are numerous and it seems they even obstruct the formation of the lava cave. Features of cavity joining, laminas and crusts, platy and columner joints on the crust, are observable.

Motosu-fuketsu No.1. (fuketsu=cave)

Formed in the upper part of Aokigahara lava erupted from Ishizuka crater on the northern flank of Omuro-yama cone. The lava flow is likely to have filled a swamp surrounded by Omuroyama scoria and formed large blister filled by gas and steam. The scoria bed is exposed inside the cave at its upper end where the crust of the cave broke and the scoria slid inside.

The cave has two blow holes (Fig. 8-9) made up spatter cones outside. Where two cavities joined through a narrow passage, a grape bunch stalactite formed. This is formed by hollowed lava pellets sprayed in gas blow and sticked together.

Motosu-fuketsu No.2.

This cave was found in the Aokigahara lava erupted from Ishizuka crater in 1960. The cave has the largest cavity among known Japanese lava caves, and has a typical ropy lava floor in one of the branch cave. A chip of wood with a carbonised surface has been found in the scoria at the upper stream of the cave inseide. The ^{14}C dating on this wood gave 1100 and 1000 y.BP which support the 864 A.D. eruption date inferred from historical records. There is a cavity filled with ice through summer near the entrance.

Yoshida-tainai multiple tree trunk molds

There are 22 known multiple tree trunk molds in Mt.Fuji lavas, nine of which are in the Yoshida-tainai area. The lava flow erupted in 800 A.D. is too thin to have caves

but contains numerous tree trunk molds including several multiple molds large enough to enter. Charcoal collected from tree molds have been dated at 1070, 1110 and 1190 y.BP, supporting the inferred date of 800 A.D. from historical records.

Features showing several large tree trunks piled up in the molten lava caused a large quantity of gas generation which inflate the tree mold cavity. This example of the cavity formation mechanism may be important in understanding the general cave formation mechanism. No evidence exist inside the cavity that any large size differrential motion of lava has taken place.

Other caves

Karumizu-fuketsu (Fig.8-10) has grape bunch stalactites radially grown on wall.
Jinza-fuketsu No.1. (Fig.8-11) Typical joined cavities are observable.

Banba-ana (Fig.8-12) This cave has an upside down funnel shape gas blow hole which makes up the only entrance to the cave.

図　　8-1　　溶岩洞窟・溶岩樹型分布図
Figure 8-1　Distribution map of Lava Caves & Lava Treemolds of Mt. Fuji.

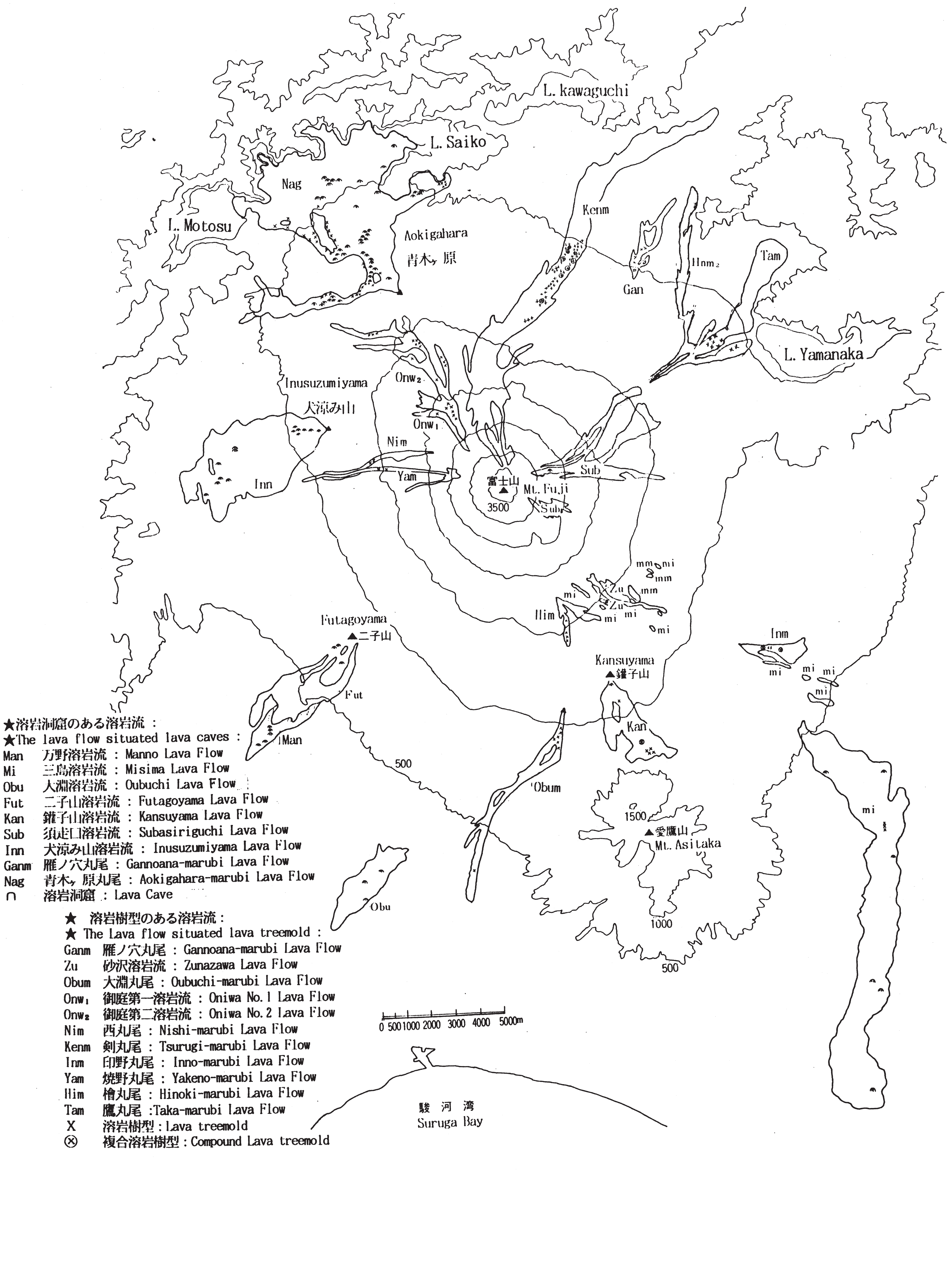


Table 8－1 Chemical composition of lavas

図 8－1 溶岩の化学分析表

Cuntry	China	Korea	Japan				
Lava	Laoheishan	Pyosonri	Miyake	Mishima	Inusuzumiyama	Aokigahara	Hachijou
SiO_2	47.96	48.79	53.93	49.18	49.09	51.30	49.97
TiO_2	2.83	2.14	1.32	1.03	1.44	1.43	1.14
Al_2O_3	13.24	15.21	14.57	16.74	16.95	18.74	18.80
Fe_2O_3	2.93	1.71	14.11	4.00	3.68	1.83	2.16
FeO	7.87	9.25	----	8.48	9.20	8.34	9.68
MnO	0.02	0.15	0.25	0.15	0.29	0.28	----
MgO	7.48	8.98	3.83	5.28	5.50	4.80	3.83
CaO	8.02	8.48	9.01	10.42	9.74	9.76	10.99
Na_2O	3.79	3.12	2.23	2.42	2.42	2.55	2.53
K_2O	4.89	0.83	0.55	1.16	1.16	0.71	----
H_2O +	0.42	0.41	----	0.17	0.57	0.22	----
H_2O −		0.41	----	0.19	0.07	0.06	----
P_2O_5	1.13	0.35	0.07	0.54	0.48	0.29	----
Total	100.48 (1)	100.02 (2)	99.87	99.76 (3)	100.53 (3)	100.31 (3)	----

Analysts:

1) E.A. 'Sverzhinskaia, B.M. Frenkel

2) M.W. Lee

3) S.Nakajima

Fig. 8 — 8 (A)The Stalagmites in Mitsuike — Ana Cave,
the longest one is 191cm.

Fig. 8 — 8 (B) The beautiful lamina in Mitsuike — Ana Cave.

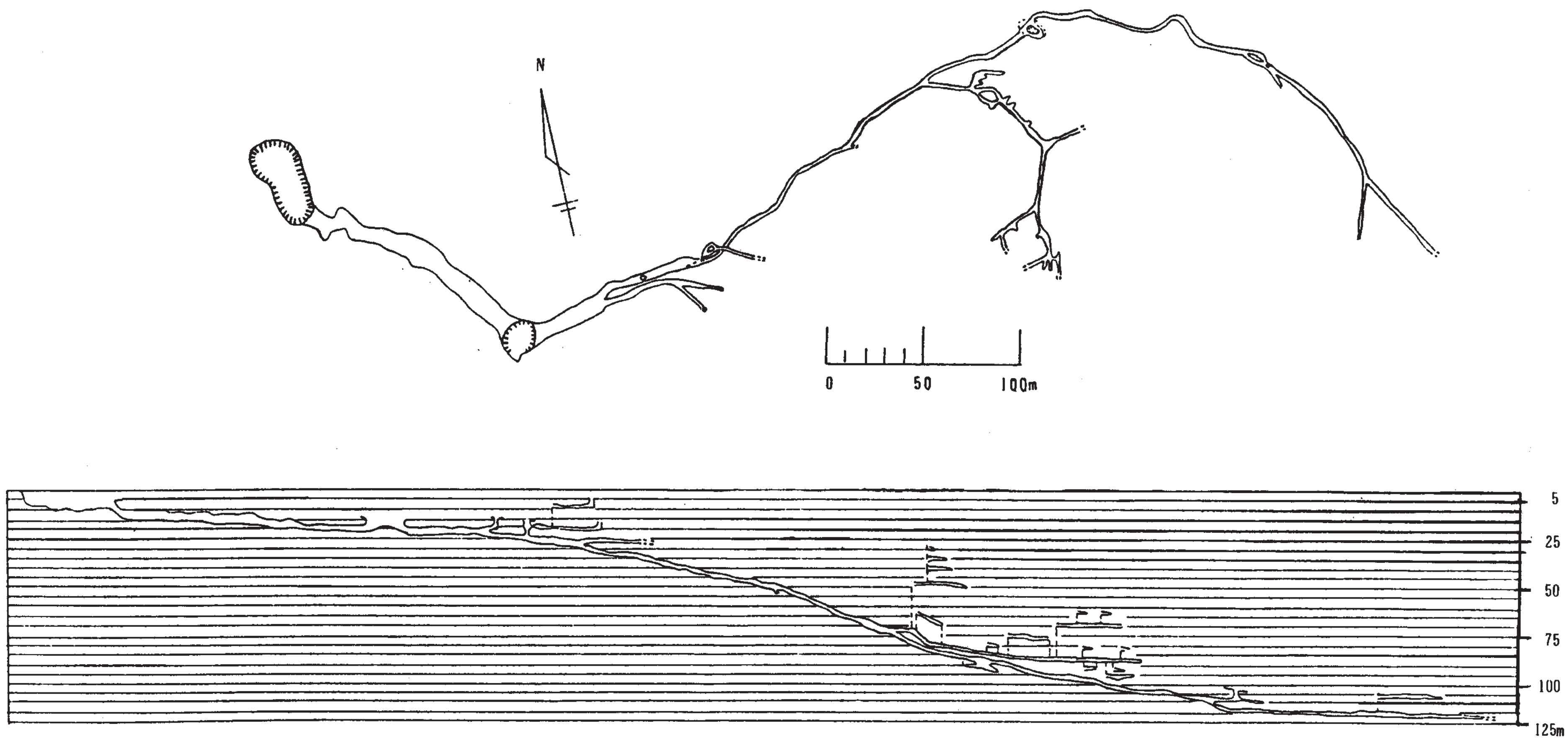
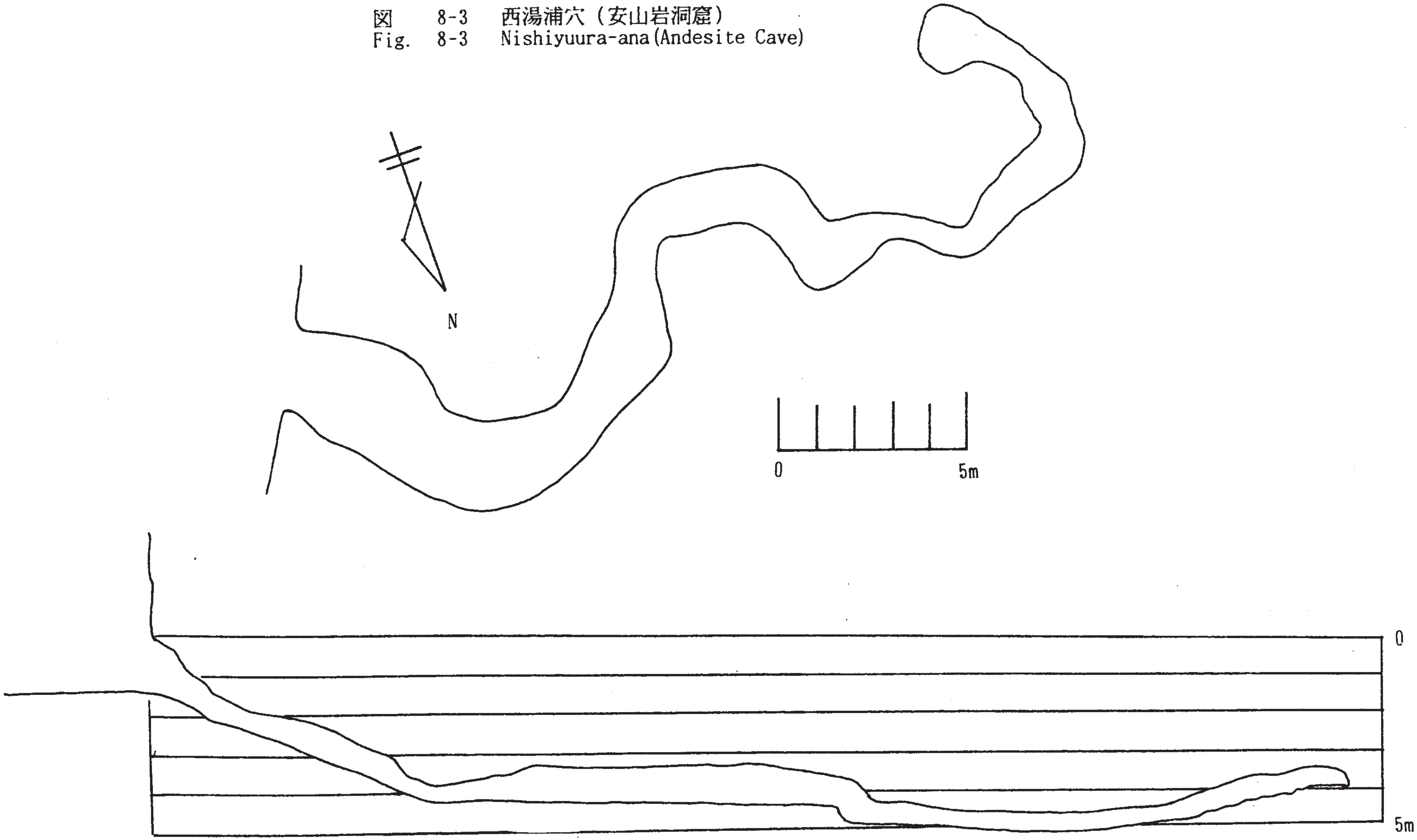


図　8-2　　　八丈風穴第一

Fig. 8-2 (Hachijou Fuketsu No. 1)

図　8-3　西湯浦穴（安山岩洞窟）
Fig.　8-3　Nishiyuura-ana (Andesite Cave)



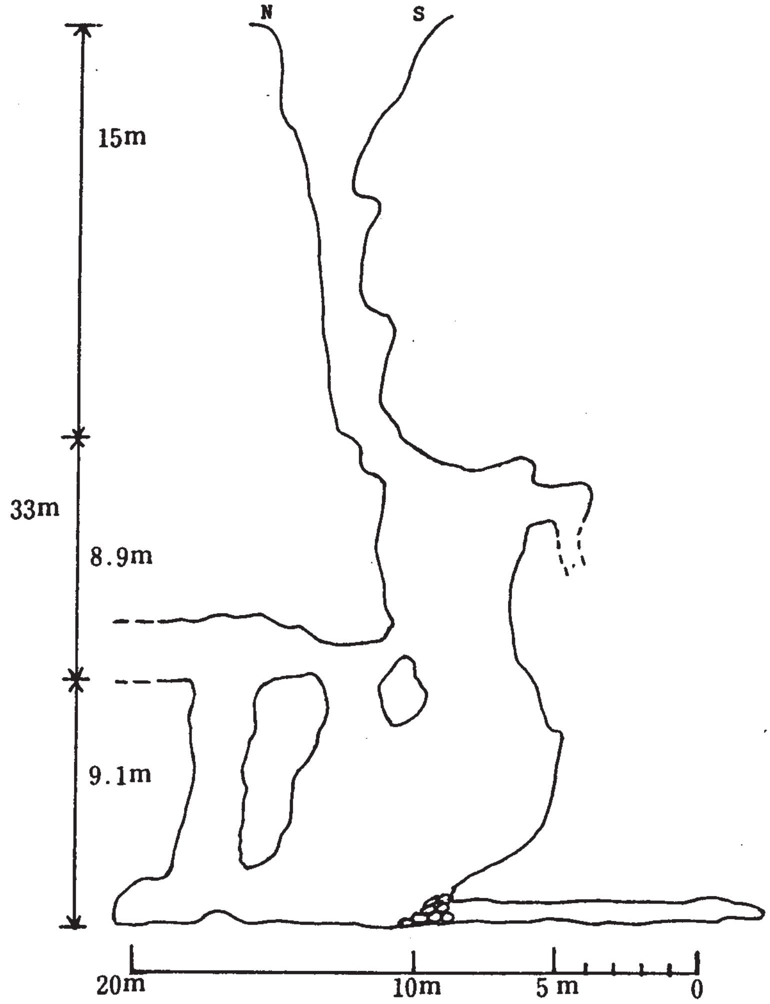


図　8-5
Fig. 8-5　　A-3　Lift Cave（縦断面図）

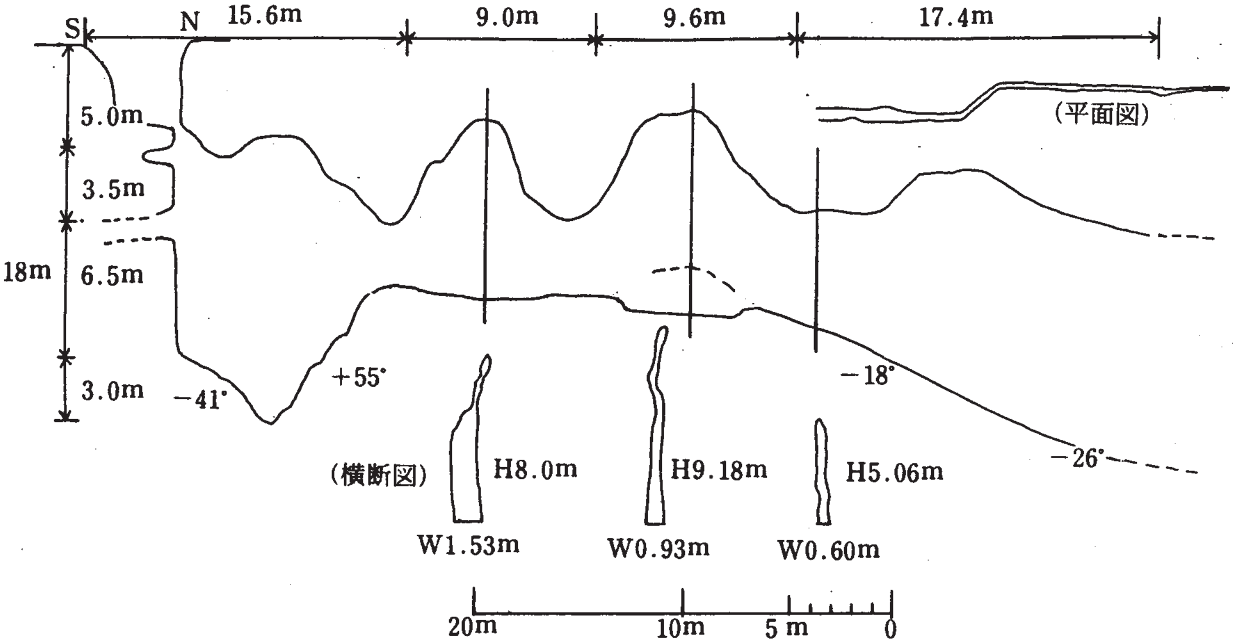


図　8-6
Fig. 8-6　　B-5　Rift Cave（縦断面図）

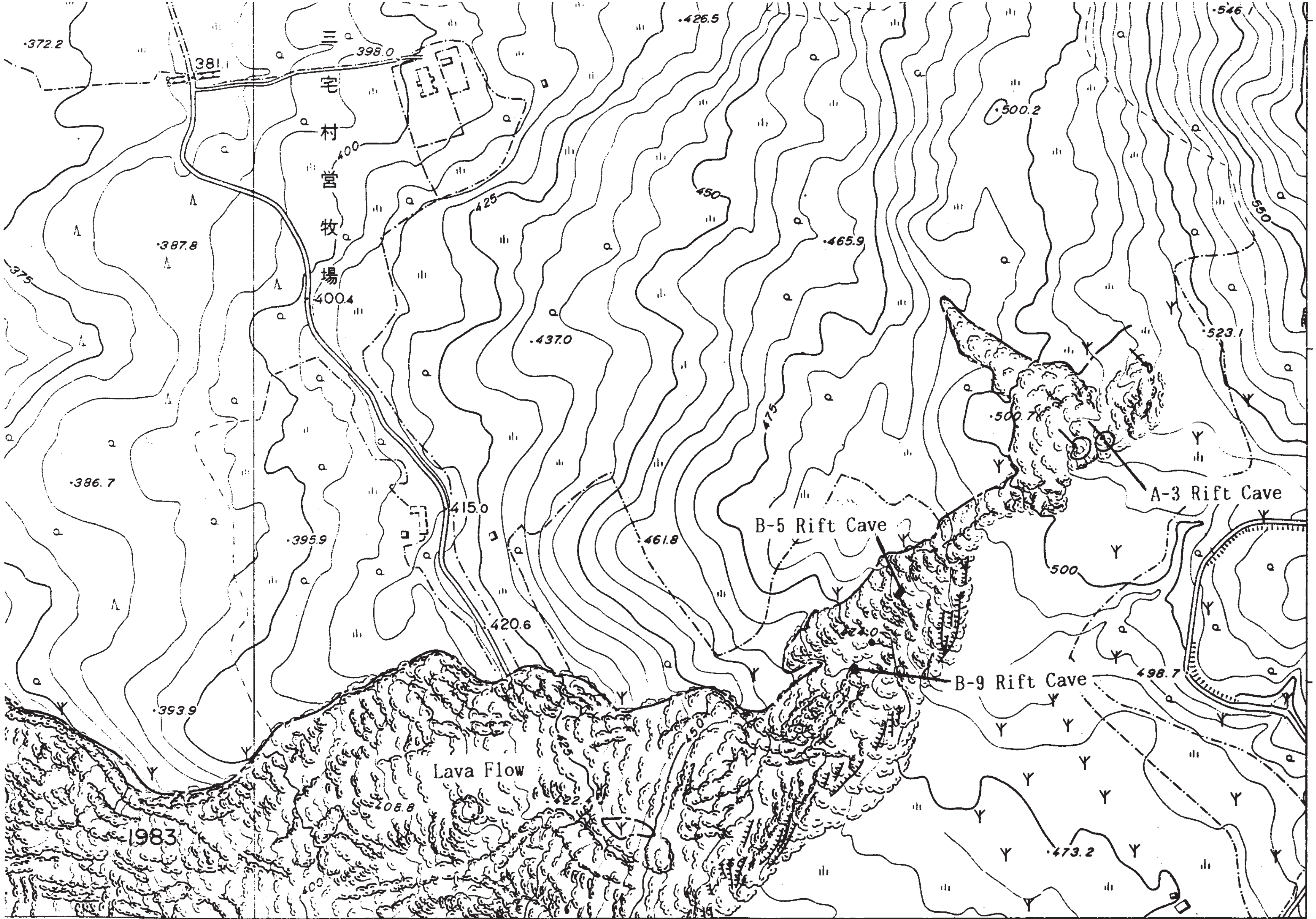


図　8-4: 三宅島のRift Cavesの位置図.

Fig. 8-4: The position map of Rift Caves at Miyake Island.

Table 8－2 The List of all Volcanic Caves in Japan

(1988.8.30)

The Lava Caves at Mt.Fuji

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
	Subashiri & Gotenba Lava Flow						
1	Subashiri Tainai	5-goume Aza Fujisan Subashiri Suruga Oyama-chou Sunto-gun,Shizuoka	* 20.0m	2,630m	35° 22′ 01″	138° 45′ 33″	
	Mishima Lava Flow						
2	Ouno Fuketsu NO.1	Kanmubanchi Suyama Susono-shi,Shizuoka	*	480m	35° 15′ 35″	138° 53′ 05″	Buried
3	〃 〃 NO.2	〃	375.4m	480m	35° 15′ 34″	138° 53′ 05″	
4	Komakado Fuketsu	69 Komakado Gotenba-shi,Shizuoka	625.3m	355m	35° 14′ 49″	138° 55′ 02″	
5	Iwanami Fuketsu	109-1 Toukaido Susono-shi,Shizuoka	219.7m	260m	35° 12′ 56″	138° 55′ 25″	
6	Susono Fuketsu NO.1	527-7 Chabatake Susono-shi,Shizuoka	116.0m	115m	35° 09′ 52″	138° 54′ 59″	
7	〃 〃 NO.2	1059 Sano Susono-shi,Shizuoka	120.8m	125m	35° 10′ 16″	138° 54′ 36″	
8	Mishima Fuketsu	1-9-14 Bunkyo-chou Mishima-shi,Shizuoka	298.9m	42m	35° 07′ 29″	138° 54′ 52″	
	Zunazawa Lava Flow						
9	Suyama Tainai Cave	2878-1 Nanzan Aza Fujisan Gotenba-shi,Shizuoka	40.0m	1,485m	35° 19′ 00″	138° 46′ 56″	
	Oubuchi Lava Flow						
10	Fudou Ana	3465-3 Aza Anagahara Oubuchi Fuji-shi,Shizuoka	124.5m	201m	35° 12′ 32″	138° 40′ 39″	
11	Hachiman Ana	1253-1 Aza Oukubo Kuzawa Fuji-shi,Shizuoka	187.3m	150m	35° 12′ 23″	138° 39′ 59″	
12	Atsuhara Fuketsu	1461-6 Atsuhara Fuji-shi,Shizuoka	88.9m	110m	35° 11′ 49″	138° 39′ 51″	
	Kansuyama Marubi Lava Flow						
13	Kaminari Ana	2427 Aza Fujiwara Suyama Susono-shi,Shizuoka	35.0m	1,210m	35° 16′ 58″	138° 47′ 06″	
	Futagoyama Lava Flow						
14	Banba Ana	3760-6 Aza Banno Yamamiya Fujinomiya-shi,Shizuoka	621.2m	675m	35° 17′ 23″	138° 39′ 23″	
15	Koumori Ana NO.1	3763-63 Aza Sasayama Yamamiya Fujinomiya-shi, Shizuoka	68.0m	685m	35° 17′ 41″	138° 39′ 09″	
16	〃 〃 NO.2	〃	* 127.0m	675m	35° 17′ 40″	138° 39′ 05″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
	Manno Lava Flow						
17	Yashiki Ana	2408 Aza Shimokamazawa Yamamiya Fujinomiya-shi, Shizuoka	238.8m	305m	35° 15′ 56″	138° 37′ 26″	
18	Koubou Ana	2191 Aza Nagaana Yamamiya Fujinomiya-shi,Shizuoka	* 40.0m	285m	35° 15′ 45″	138° 37′ 20″	
19	Mado Ana	2142 Aza Suteishi Yamamiya Fujinomiya-shi,Shizuoka	510.1m	270m	35° 15′ 37″	138° 37′ 17″	
20	Ginga Fuketsu	2179 Aza Nagaana Yamamiya Fujinomiya-shi,Shizuoka	185.8m	250m	35° 15′ 31″	138° 37′ 00″	
21	Dainichi Ana	〃	908.3m	253m	35° 15′ 30″	138° 37′ 11″	
22	Chikushou Ana	2204 Aza Togami Togami Fujinomiya-shi,Shizuoka	71.6m	235m	35° 15′ 26″	138° 37′ 00″	Buried
	Inusuzumiyama Lava Flow						
23	Inusuzumiyama Fuketsu NO.1	15-1 Hitoana Fujinomiya-shi,Shizuoka	91.5m	1,140m	35° 22′ 42″	138° 38′ 28″	
24	Muzina Ana	〃	118.2m	1,095m	35° 22′ 45″	138° 38′ 18″	
25	Inusuzumiyama Fuketsu NO.2	〃	130.0m	1,070m	35° 22′ 49″	138° 38′ 11″	
26	〃 〃 NO.3	〃	* 50.0m	1,000m	35° 23′ 04″	138° 37′ 42″	
27	〃 〃 NO.4	〃	*120.0m	995m	35° 22′ 56″	138° 37′ 39″	
28	〃 〃 NO.5	〃	701.0m	970m	35° 22′ 51″	138° 37′ 31″	
29	〃 〃 NO.6	〃	*250.0m	985m	35° 22′ 49″	138° 37′ 48″	
30	〃 〃 NO.7	〃	93.7m	975m	35° 22′ 41″	138° 37′ 37″	
31	〃 〃 NO.8	〃	76.3m	980m	35° 22′ 41″	138° 37′ 40″	
32	〃 〃 NO.9	〃	49.0m	985m	35° 22′ 42″	138° 37′ 40″	
33	〃 〃 NO.10	〃	85.0m	1,100m	35° 22′ 41″	138° 37′ 47″	
34	〃 〃 NO.11	〃	35.0m	1,000m	35° 22′ 49″	138° 37′ 47″	
35	〃 〃 NO.12	〃	*	1,150m	35° 22′ 34″	138° 38′ 35″	
36	Mitsuike Ana	777 Aza Nishiogidaira Hitoana Fujinomiya-shi, Shizuoka	2,165.0m	815m	35° 22′ 30″	138° 35′ 56″	
37	Uba Ana	851-15-22 Aza Ouhatakedaira Hitoana Fujinomiya-shi, Shizuoka	123.0m	750m	35° 22′ 03″	138° 35′ 45″	
38	Uzura Ana	744 Aza Nishiogidaira Hitoana Fujinomiya-shi, Shizuoka	820.1m	733m	35° 21′ 32″	138° 36′ 15″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
39	Shin Ana	205-12 Aza Zechouzuka Hitoana Fujinomiya-shi, Shizuoka	149.7m	720m	35° 21′ 40″	138° 35′ 50″	
40	Hito Ana	206 Aza Ishitsubo Hitoana Fujinomiya-shi, Shizuoka	83.3m	700m	35° 21′ 31″	138° 35′ 41″	
41	Mamashita Ana	168 Aza Mamashita Hitoana Fujinomiya-shi, Shizuoka	154.6m	665m	35° 21′ 15″	138° 35′ 26″	Buried

Aokigahara-marubi Lava Flow (864 Lava Flow)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
42	Karumizu Fuketsu	8536 Aza Zinza Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun, Yamanashi	432.8m	1,250m	35° 26′ 17″	138° 40′ 16″	
43	Zinza Fuketsu NO.1 &	〃	443.1m	1,245m	35° 26′ 19″	138° 39′ 52″	
	Kamaboko Ana		28.0m	1,245m	35° 26′ 20″	138° 39′ 53″	
44	Zinza Fuketsu NO.2	〃	51.3m	1,240m	35° 26′ 21″	138° 39′ 50″	
45	Megane Ana	〃	154.5m	1,210m	35° 26′ 28″	138° 40′ 00″	
46	Zinza Fuketsu NO.4	8533 Aza Karumizu Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun, Yamanashi	*100.0m	1,165m	35° 26′ 45″	138° 40′ 25″	
47	〃 〃 NO.5	〃	105.3m	1,160m	35° 26′ 48″	138° 40′ 25″	
48	〃 〃 NO.6	〃	42.3m	1,160m	35° 26′ 45″	138° 40′ 22″	
49	Zinza Raleigh Fuketsu	〃	61.8m	1,150m	35° 26′ 52″	138° 40′ 15″	
50	Zinza Fuketsu NO.7	〃	* 80.0m	1,150m	35° 26′ 54″	138° 40′ 16″	
51	〃 〃 NO.8	〃	*100.0m	1,150m	35° 26′ 54″	138° 40′ 20″	
52	〃 〃 NO.9	〃	*	1,145m	35° 27′ 07″	138° 40′ 11″	
53	Oumuro Fuketsu NO.1	8536 Aza Zinza Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun, Yamanashi	170.3m	1,190m	35° 26′ 32″	138° 40′ 02″	
54	〃 〃 NO.2	〃	40.0m	1,170m	35° 26′ 38″	138° 39′ 58″	
55	Shoiko Fuketsu NO.1	〃	230.0m	1,160m	35° 26′ 41″	138° 39′ 57″	
56	〃 〃 NO.2	〃	55.3m	1,145m	35° 26′ 44″	138° 39′ 53″	
57	〃 〃 NO.3	〃	35.0m	1,140m	35° 26′ 45″	138° 39′ 51″	
58	〃 〃 NO.4	〃	32.1m	1,130m	35° 26′ 46″	138° 39′ 48″	
59	〃 〃 NO.5	〃	* 30.0m	1,125m	35° 26′ 49″	138° 39′ 46″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
60	Motosu Fuketsu NO.1	151 Aza Ishizuka Motosu Kamikuisshiki-mura Nishiyatsushiro-gun,Yamanashi	494.3m	1,140m	35° 26′ 35″	138° 39′ 10″	
61	〃 〃 NO.2	〃	235.7m	1,155m	35° 26′ 31″	138° 39′ 00″	I.C.
62	〃 〃 NO.3	〃	94.8m	1,135m	35° 26′ 43″	138° 39′ 09″	
63	〃 〃 NO.4	514 Aza Aokigahara Shouji Kamikuisshiki-mura Nishiyatsushiro-gun,Yamanashi	32.0m	1,125m	35° 26′ 46″	138° 39′ 13″	
64	〃 〃 NO.5	〃	49.0m	1,140m	35° 26′ 40″	138° 39′ 02″	
65	Motosu Hyouketsu	151 Aza Ishizuka Motosu Kamikuisshiki-mura Nishiyatsushiro-gun,Yamanashi	68.1m	1,145m	35° 26′ 39″	138° 39′ 08″	I.C.
66	Fuji Fuketsu NO.1	8533 Aza Karumizu Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun,Yamanashi	582.0m	1,110m	35° 26′ 49″	138° 39′ 19″	I.C.
67	〃 〃 NO.2	〃	57.0m	1,110m	35° 27′ 04″	138° 39′ 46″	
68	〃 〃 NO.3	〃	52.0m	1,110m	35° 27′ 05″	138° 39′ 50″	
69	〃 〃 NO.4	〃	118.0m	1,110m	35° 27′ 06″	138° 39′ 50″	
70	〃 〃 NO.5	〃	143.0m	1,110m	35° 27′ 06″	138° 39′ 53″	
71	〃 〃 NO.6	〃	60.0m	1,110m	35° 27′ 07″	138° 39′ 53″	
72	〃 〃 NO.7	〃	130.0m	1,105m	35° 27′ 10″	138° 39′ 54″	
73	Aokigahara Fuketsu NO.1	〃	61.0m	1,065m	35° 27′ 51″	138° 39′ 58″	
74	〃 〃 NO.2	514 Aza Aokigahara Syouji Kamikuishiiki-mura Nishiyatsushiro-gun,Yamanashi	141.5m	1,060m	35° 28′ 02″	138° 39′ 34″	
75	Fugaku Fuketsu	〃	258.7m	1,000m	35° 28′ 27″	138° 39′ 37″	I.C.
76	Narusawa Hyouketsu	8533 Aza Karumizu Karumizu Hoka 10 Narusawa-mura Mimamitsuru-gun,Yamanashi	155.7m	1,025m	35° 28′ 17″	138° 40′ 12″	I.C.
77	Syoujioana-Nichidou	514 Aza Aokigahara Syouji Kamikuishiiki-mura Nishiyatsushiro-gun,Yamanashi	160.6m	990m	35° 28′ 04″	138° 38′ 29″	
78	〃 -Gatsudou	〃	247.3m	985m	35° 28′ 04″	138° 38′ 26″	
79	Syouji Fuketsu NO.1	〃	47.1m	960m	35° 28′ 27″	138° 38′ 29″	
80	Shounin Ana	〃	46.5m	960m	35° 28′ 26″	138° 38′ 29″	
81	Syouji Fuketsu NO.2	〃	46.4m	960m	35° 28′ 28″	138° 38′ 24″	
82	〃 NO.3	〃	53.3m	960m	35° 28′ 29″	138° 38′ 27″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
83	Syouji Fuketsu NO.4	514 Aza Aokigahara Syouji Kamikuishiiki-mura Nishiyatsushiro-gun,Yamanashi	*103.0m	960m	35° 28′ 30″	138° 38′ 20″	
84	Katabuta Ana	216 Aza Ousaka Motosu Kamikuishiiki-mura Nishiyatsushiro-gun,Yamanashi	* 30.0m	1,195m	35° 25′ 44″	138° 39′ 08″	
85	Gyoujya Ana	〃	* 94.0m	1,195m	35° 25′ 45″	138° 39′ 07″	
86	Kazuhito Ana NO.1	〃	253.6m	1,190m	35° 25′ 54″	138° 38′ 58″	
87	〃 〃 NO.2	〃	44.2m	1,185m	35° 25′ 56″	138° 38′ 55″	
88	〃 〃 NO.3	〃	* 30.0m	1,175m	35° 25′ 53″	138° 38′ 51″	
89	〃 〃 NO.4	〃	101.5m	1,060m	35° 25′ 51″	138° 38′ 45″	
90	〃 〃 NO.5	〃	* 60.0m	1,135m	35° 25′ 50″	138° 38′ 39″	
91	Narusawa Koumori Ana NO.1	8532-26 Aza Chirakonno Narusawa-mura Minamitsuru -gun,Yamanashi	69.2m	1,005m	35° 28′ 20″	138° 41′ 13″	
92	〃 〃 〃 NO.2	〃	70.2m	1,005m	35° 28′ 20″	138° 41′ 15″	
93	〃 〃 〃 NO.3	〃	40.0m	1,005m	35° 28′ 19″	138° 41′ 17″	
94	〃 〃 〃 NO.4	〃	48.0m	1,005m	35° 28′ 20″	138° 41′ 17″	
95	Ryuguu Ana	2068 Aza Aokigahara Ashiwada-mura Minamitsuru-gun, Yamanashi	95.9m	965m	35° 28′ 52″	138° 41′ 17″	I.C.
96	Saiko Fuketsu NO.1	〃	72.3m	945m	35° 28′ 59″	138° 40′ 07″	
97	〃 〃 NO.2	〃	31.7m	950m	35° 28′ 59″	138° 40′ 03″	
98	〃 〃 NO.3	〃	41,4m	945m	35° 29′ 00″	138° 40′ 05″	
99	〃 〃 NO.4	〃	114.0m	960m	35° 28′ 58″	138° 39′ 54″	
100	〃 〃 NO.5	〃	142.0m	965m	35° 28′ 59″	138° 39′ 55″	
101	〃 〃 NO.6	〃	32.0m	965m	35° 28′ 58″	138° 39′ 54″	
102	〃 〃 NO.7	〃	42.3m	975m	35° 28′ 52″	138° 39′ 49″	
103	Saiko Koumori Ana	〃	386.3m	925m	35° 29′ 21″	138° 40′ 34″	
106	Jinza Toukai Fuketsu	8533 Aza Karumizu Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun,Yamanashi	40.0m	1,150m	35° 26′ 54″	138° 40′ 16″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
107	Jinza Fuketsu NO.10	8533 Aza Karumizu Karumizu Hoka 10 Narusawa-mura Minamitsuru-gun, Yamanashi	50.0m	1,166m	35° 26′ 45″	138° 40′ 10″	
108	Jinza Kawagoe Fuketsu	〃	85.0m	1,163m	35° 26′ 47″	138° 40′ 09″	
109	Jinza Fuketsu NO.11	〃	*	1,162m	35° 26′ 49″	138° 40′ 09″	
110	〃 〃 NO.12	〃	*	1,159m	35° 26′ 50″	138° 40′ 10″	
111	〃 〃 NO.13	〃	*	1,160m	35° 26′ 48″	138° 40′ 12″	
	Gannoana Marubi Lava Cave						
104	Kuzure Ana	5606 Aza Ganno-ana Kamiyoshida Fujiyoshida-shi, Yamanashi	* 130.0m	1,010m	35° 26′ 37″	138° 47′ 41″	
	Narusawa Lava Flow						
105	Heijibara Fuketsu	6463-1 Aza Heijibara Narusawa-mura Minamitsuru-gun, Yamanashi	106.9m	980m	35° 28′ 34	138° 42′ 16″	

* =Approximately
L =Length
I.C.=Ice Cave

(1988.8.30)

The Lava Cave at Oushima Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
	1951 Lava Flow						
1	Mihara Fuketsu	Muban Aza Harano Nomasu Oushima-chou,Tokyo	26.94m	675m	34° 43′ 39″	139° 23′ 54″	Buried

The Lava & Lift Caves at Hachijou Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Hachijou Fuketsu NO.1	5429-1 Mitsune Hachijou-machi Hachijou-Island,Tokyo	1,404.0m	136m	33° 07′ 59″	139° 47′ 28″	
2	〃 〃 NO.2	〃	* 100.0m	125m	33° 07′ 56″	139° 47′ 31″	
3	Gokuraku Ana	Mubanchi Mitsune Hachijou-machi Hachijou-Island,Tokyo	* 200.0m	10m	33° 08′ 01″	139° 47′ 59″	
4	Shin Gokuraku Ana	〃	676.0m	20m	33° 08′ 07″	139° 47′ 52″	
5	NO.20 Bokku Fuketsu	5627-3 Ouga-go Hachijou-machi Hachijou-Island,Tokyo	35.0m	513m	33° 07′ 38″	139° 45′ 54″	
6	NO.21 Bokku Fuketsu	5627-2 〃	45.0m	528m	33° 07′ 41″	139° 45′ 55″	
7	Eigo Rift Cave NO.1	6290 Mitsune Hachijou-machi Hachijou-Island,Tokyo	-65.0m	85m	33° 09′ 07″	139° 45′ 23″	Rift Cave
8	〃 〃 NO.2	6288 〃	-12.0m	115m	33° 09′ 06″	139° 45′ 22″	〃
9	〃 〃 NO.3	6285 〃	L30m -12m	125m	33° 09′ 05″	139° 45′ 21″	〃
10	Nazumado Rift Cave	5449-4 Ouga-go Hachijou-machi Hachijou-Island,Tokyo	* 30.0m	110m	33° 08′ 33″	139° 44′ 49″	〃
11	Hachijou Fuji Fuketsu	6440-2 Mitsune Hachijou-machi Hachijou-Island,Tokyo	* 300.0m	780m	33° 08′ 13″	139° 46′ 02″	

The Rift Caves at Miyake Island

1983 Lava Flow

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Miyake A-3 Rift Cave	221 Aza Oyama Miyake-mura,Tokyo	-33.0m	505m	34° 04′ 26″	139° 31′ 03″	Rift Cave
2	Miyake B-5 Rift Cave	〃	L52m -18m	475m	34° 04′ 20″	139° 30′ 55″	〃
3	Miyake B-9 Rift Cave	〃	-14.0m	470m	34° 04′ 19″	139° 30′ 54″	〃

The Lava Caves at Daikon Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Yuuki Do	1323-3 Osoe Yatsuzuka-machi Yatsuzuka-gun, Shimane	* 200.0m	5m	35° 29′ 40″	133° 10′ 41″	
2	Ryusei Do	246-8 Teratsu Yatsuzuka-machi Yatsuzuka-gun, Shimane	* 80.0m	16m	35° 29′ 21″	133° 11′ 13″	

(1988.8.30)

The Lava Caves at Mt.Aso

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
	Kometsuka Lava Flow						
1	Kometsuka Fuketsu	2391-7 Aza Kometsuka Nagakusa Aso-machi Aso-gun, Kumamoto	20.0m	870m	32° 54′ 11″	131° 02′ 37″	
2	Ougawara Fuketsu	2045-2 Aza Ougawara Kurokawa Aso-machi Aso-gun, Kumamoto	*	645m	32° 55′ 15″	131° 03′ 29″	Buried
3	Nagaobane Fuketsu NO.1	2395-5 Aza Nagaobane Nagakusa Aso-machi Aso-gun, Kumamoto	44.3m	750m	32° 54′ 34″	131° 02′ 22″	
4	〃 〃 NO.2	〃	* 20.0m	750m	32° 54′ 35″	131° 02′ 23″	
5	Mizonokuchiue Fuketsu	2115-1 Aza Mizonokuchiue Otohime Aso-machi Aso-gun, Kumamoto	* 25.0m	600m	32° 55′ 20″	131° 02′ 51″	
6	Mizonokuchiue Koumori Ana	〃	* 15.0m	600m	32° 55′ 21″	131° 02′ 52″	
7	Inuotoshi Fuketsu	2391-14 Aza Inuotoshi Otohime Aso-machi Aso-gun, Kumamoto	* 40.0m	640m	32° 55′ 02″	131° 02′ 24″	
8	Kaninome Fuketsu	2398-4 Aza Kaninome Otohime Aso-machi Aso-gun, Kumamoto	*	635m	32° 55′ 23″	131° 03′ 12″	
9	Jano-O Fuketsu	Aza Shimo-Jano-O Nagakusa Aso-machi Aso-gun,Kumamoto	*	522m	32° 55′ 17″	131° 01′ 39″	
	The Somma of Mt.Aso(Andesite)						
1	Nishiyuura Ana	Aza Nishiyuura Uchimaki Aso-machi Aso-gun,Kumamoto	32.3m	800m	32° 59′ 27″	131° 01′ 03″	
	Aso Welded Tuff (Pyroclastic)						
1	Takenoedao-no Ana	1986 Aza Takenoedao Oukawachi Shiiba-mura Higashiusuki-gun,Miyazaki	9.7m	500m	32° 26′ 17″	131° 07′ 52″	
2	Yanaibara Do	1673-1 Aza Sakonouchi Haebaru Tougou-chou Higashiusuki-gun,Miyazaki	47.5m	70m	32° 25′ 07″	131° 30′ 31″	
3	Togawa-Sakenotani Do	7202-2 Aza Tashita Nanaore Hinokage-machi Nishiusuki-gun,Miyazaki	106.83m	240m	32° 41′ 10″	131° 23′ 58″	
4	Oni-no-Iwaya	577-5 Aza Yakushiwaki Ohya Kikusui-machi Tamana-gun,Kumamoto		50m	33° 00′ 33″	130° 38′ 14″	

(1988.8.30)

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
5	Anahachiman-no-Ana	621-1 Aza Endaiji Endaiji Ueki-machi Kamoto-gun, Kumamoto		110m	32° 52′ 54″	130° 39′ 22″	
6	Nanathuzako-no-Ana	156 Aza Takakage Soyou-machi Aso-gun,Kumamoto		700m	32° 40′ 02″	131° 08′ 27″	
7	Shiraishi-no-Ana	〃		670m	32° 40′ 05″	131° 08′ 28″	
8	Anamori-no Ana	1431 Aza Kunigata Kanbara Takeda-shi Naoiri-gun, Ouita		510m	32° 51′ 07″	131° 22′ 49″	
9	Ouiwaya Fuketsu	813 Ouaza Kami-madama Madama-machi Nishikunisaki-gun, Ouita		110m	33° 35′ 33″	131° 31′ 53″	

The Lava Caves at Fukue Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Sakishirazuno I Ana	1637 Notari Dakego-shimo Tomie-chou Minami -Matsuura-gun,Nagasaki	397.0m	17m	32° 35′ 23″	128° 46′ 38″	System
2	Tourinuke I Ana	〃	85.0m	17m	32° 35′ 21″	128° 46′ 38″	System
3	No-Ana	〃	413.0m	23m	32° 35′ 30″	128° 46′ 19″	System
4	Toushi Ana	〃	* 40.0m	25m	32° 35′ 38″	128° 46′ 16″	System
5	Shishikomankuchino Ana	〃	* 30.0m	28m	32° 35′ 38″	128° 46′ 10″	System
6	Yurunkuchino Ana	〃	41.0m	25m	32° 35′ 33″	128° 46′ 19″	
7	Ipponmatsu Ana	〃	105.0m	32m	32° 35′ 40″	128° 46′ 17″	
8	Kichiga Ana	〃	*	25m	32° 36′ 01″	128° 46′ 30″	
9	Kuroseno Ana	Aza Amayasu Kurose Tomie-chou Minami-Matsuura-gun, Nagasaki	* 20.0m	28m	32° 35′ 51″	128° 45′ 28″	
10	Iyano Ana	〃	* 30.0m	18m	32° 35′ 53″	128° 45′ 07″	
11	Furuzutsumino Ana	〃	* 5.0m	18m	32° 35′ 53″	128° 45′ 06″	
12	Iankawano Ana	〃	* 60.0m	18m	32° 35′ 53″	128° 45′ 05″	

The Lava Cave at Ouitabe Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Ouitabe Ana	Ouitabe-chou Fukue-shi Minami-Matsuura-gun,Nagasaki	* 70.0m	10m	32° 35′ 02″	128° 54′ 12″	

(1988.8.30)

The Lava Caves at Oujima Island

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Jyouno Ana	1209 Oujima-chou Fukue-shi Minami-Matsuura-gun, Nagasaki	* 131.2m	5m	32° 33′ 31″	128° 54′ 26″	
2	Unnashi Ana	〃	54.6m	5m	32° 33′ 39″	128° 54′ 31″	

The Lava Caves at Mt.Unzen-dake

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
1	Fuketsu	552 Aza Ryunobaba-kanoe Onsenmyou Shimabara-shi Minamitakagi-gun,Nagasaki		1,300m	32° 45′ 37″	130° 17′ 50″	
2	Hato Ana	1205 Aza kaedegi-kou Kizakimyou Shimabara-shi Minamitakagi-gun,Nagasaki		1,195m	32° 45′ 49″	130° 18′ 08″	

(1988.8.30)

The list of the Pumice & Welded Tuff Caves at Kyushiu

No.	Lava Flow & Cave Name	Location	Length	Elevation	Latitude(N)	Longitude(E)	Note
	Ata Welded Tuff (Pumice)						
1	Kimino Gongen Ana	3185 Aza Gongendani Kamiyamada Kawanabe-machi Kawanabe-gun,Kagoshima	39.8m	150m	31° 21′ 21″	130° 20′ 17″	
2	Sakashita Ana	3617 Aza Sakashita Kamiyamada Kawanabe-machi Kawanabe-gun,Kagoshima	30.4m	100m	31° 20′ 36″	130° 20′ 37″	
	Aira Welded Tuff (Pumice)						
1	Kuronida Ana	6875 Aza Kuronida Daizaka Kinpou-chou Hioki-gun, Kagoshima	53.6m	230m	31° 28′ 33″	130° 26′ 17″	
2	Kurokawa Douketsu	9185 Aza Sunahashiri Nagayoshi Fukiage-chou Hioki-gun,Kagoshima	57.7m	84m	31° 33′ 00″	130° 24′ 11″	
3	Iwa Ana NO.1	2752-1 Aza Iwaida Shimono Yokogawa-chou Aira-gun, Kagoshima	* 25.0m	190m	31° 51′ 00″	130° 42′ 40″	
4	Iwa Ana NO.2	1769-1 Aza Iwaida Shimono Yokogawa-chou Aira-gun, Kagoshima	* 18.3m	170m	31° 51′ 04″	130° 42′ 50″	
5	Kumaso Ana Douketsu	4382-9 Myouken Kareigawa Hayato-machi Aira-gun, Kagoshima	28.0m	70m	31° 48′ 34″	130° 45′ 26″	
6	Mizonokuchi Douketsu	5783 Otsu-no 2 Otsukahara Shimo-Takarabe Takarabe-chou So-O-gun,Kagoshima	213.0m	230m	31° 46′ 34″	130° 57′ 47″	
7	katano Do	2634 Aza Miyamae Uchinokura Shibushi-machi So-O-gun, Kagoshima	84.9m	80m	31° 31′ 47″	131° 09′ 41″	
8	Hyakudou Ketsu	1669 Aza Iwado Anraku Shibushi-machi So-O-gun, Kagoshima	69.7m	30m	31° 29′ 21″	131° 04′ 57″	
9	Monju Iwaya	6530 Aza Houman Chou 〃 〃 , 〃	98.0m	10m	31° 28′ 37″	131° 06′ 42″	
10	Obirano Do	3400-1 Aza Yasuhisa-chou Miyakonojou-shi Kitamorokata-gun,Miyazaki		220m	31° 38′ 08″	131° 08′ 24″	

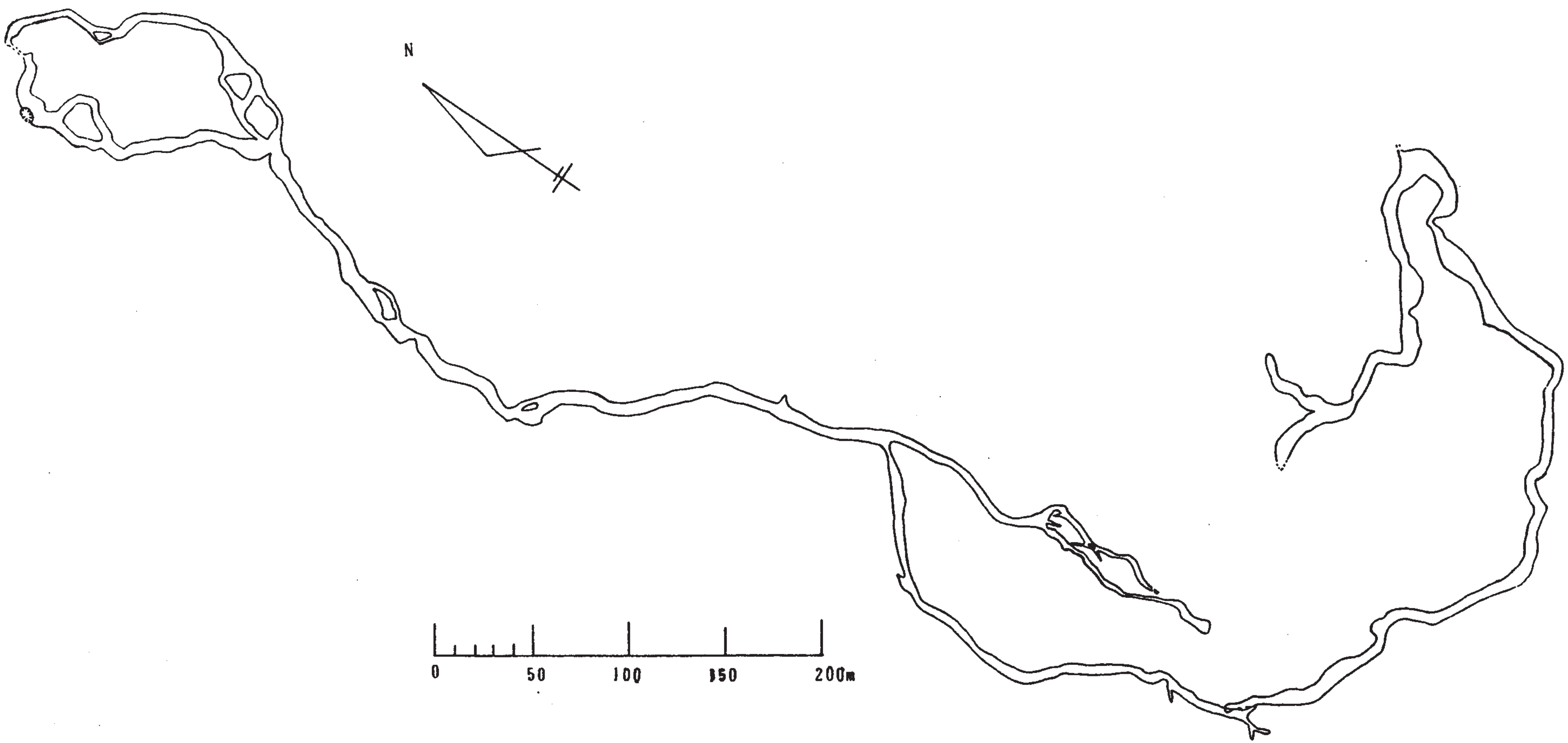


図　8-7　三ッ池穴
Fig. 8-7 (Mitsuike Ana)

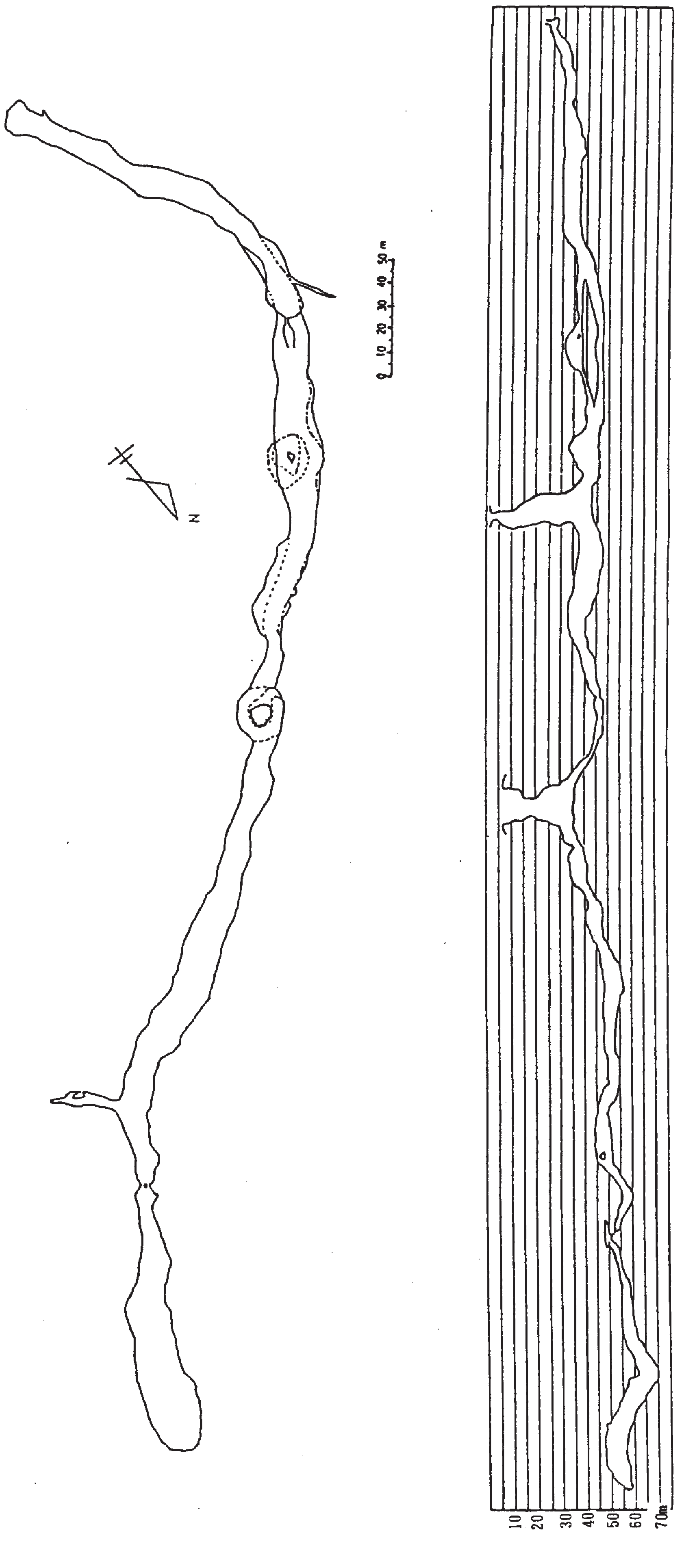


図 8-9 本栖風穴第一
Fig. 8-9 (Motosu Fuketsu Cave No,1)

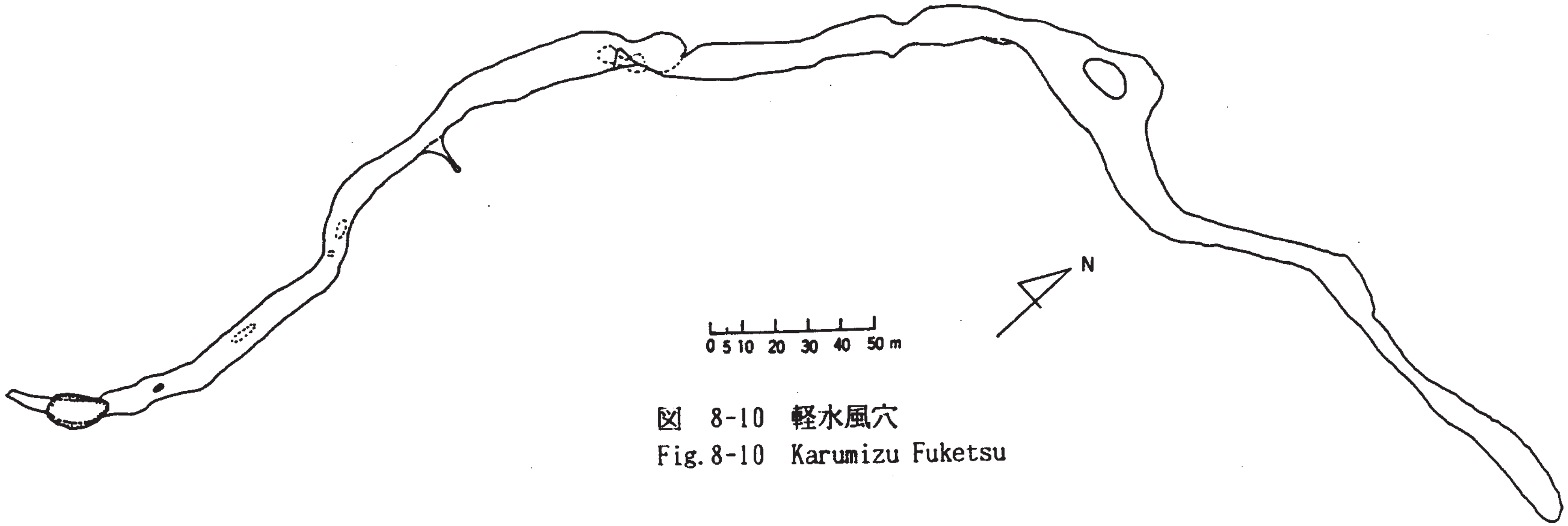
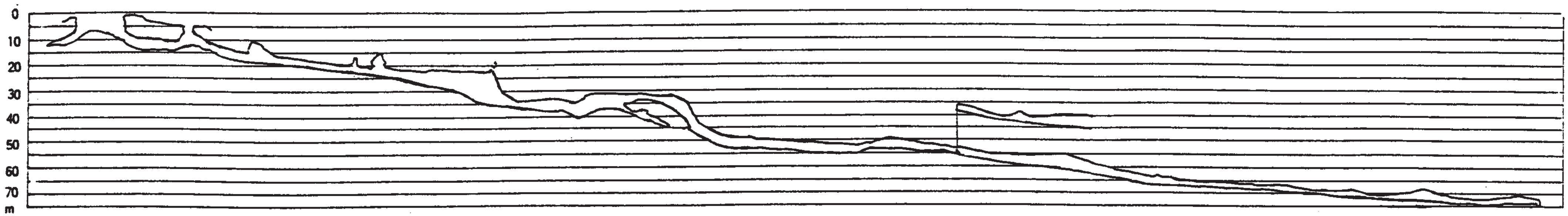


図　8-10　軽水風穴
Fig.8-10　Karumizu Fuketsu



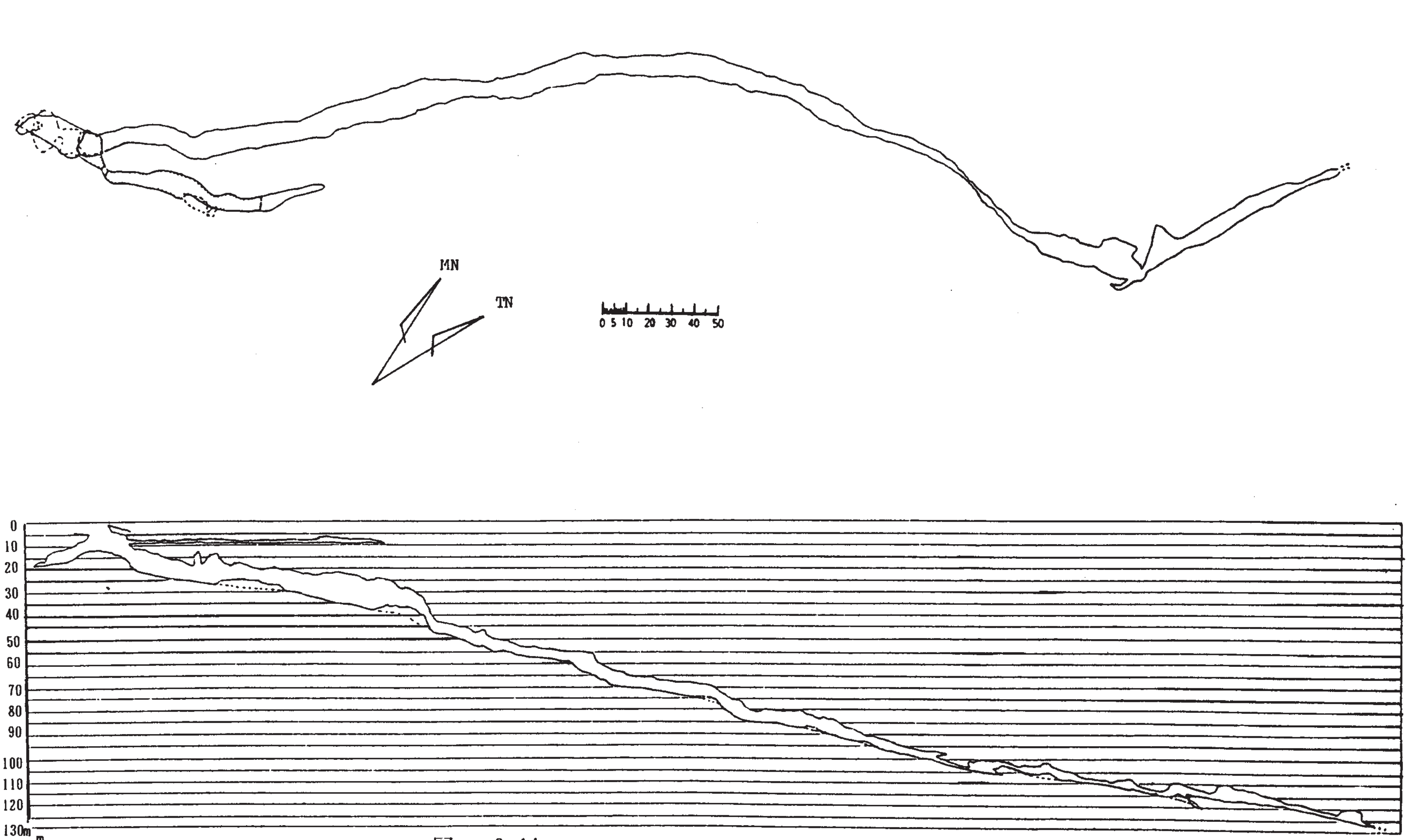
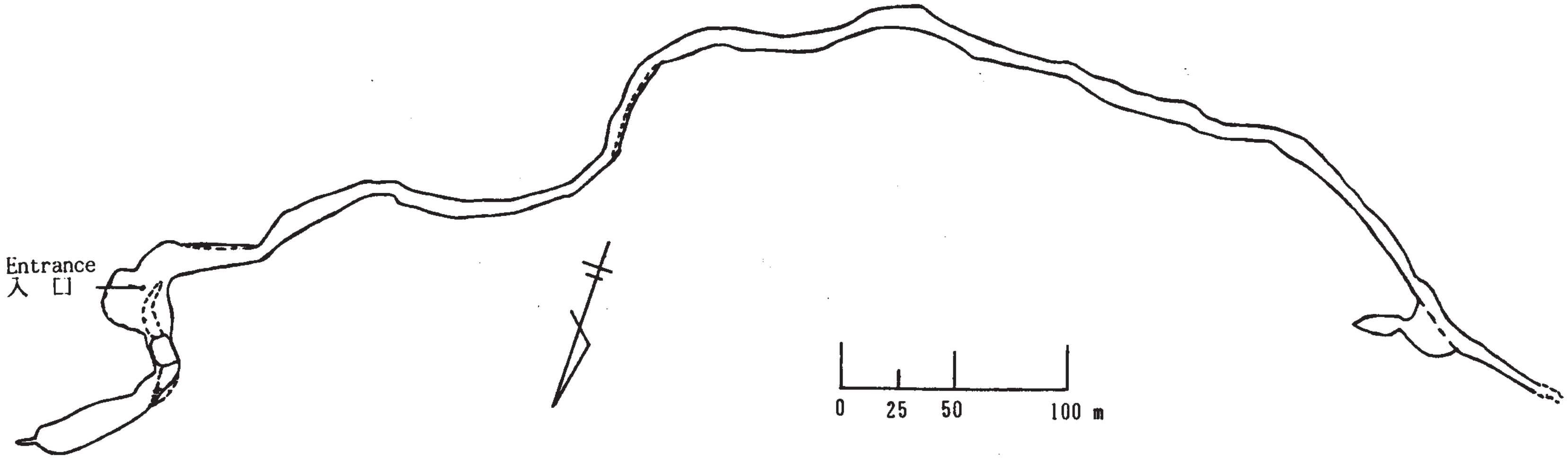
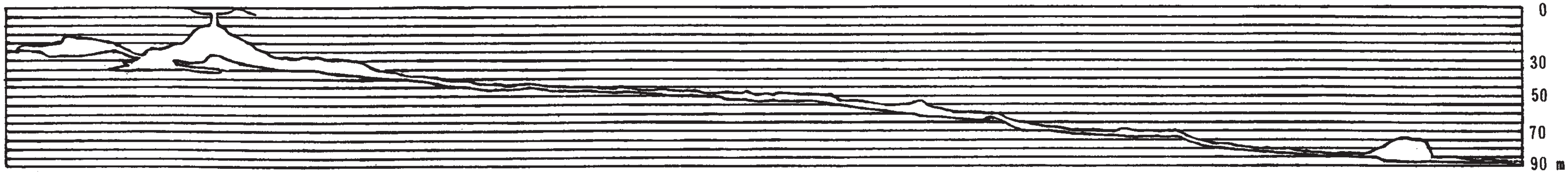


図 8-11 神座風穴第一

Fig. 8-11 (Zĭnza Fuketsu Cave No. 1)





Figuer 8-12 Banba Ana Cave

図 8-12 婆 々 穴

図 9-1 The distribute map of the lava caves
Fig. 9-1 at Cheju Island, Korea

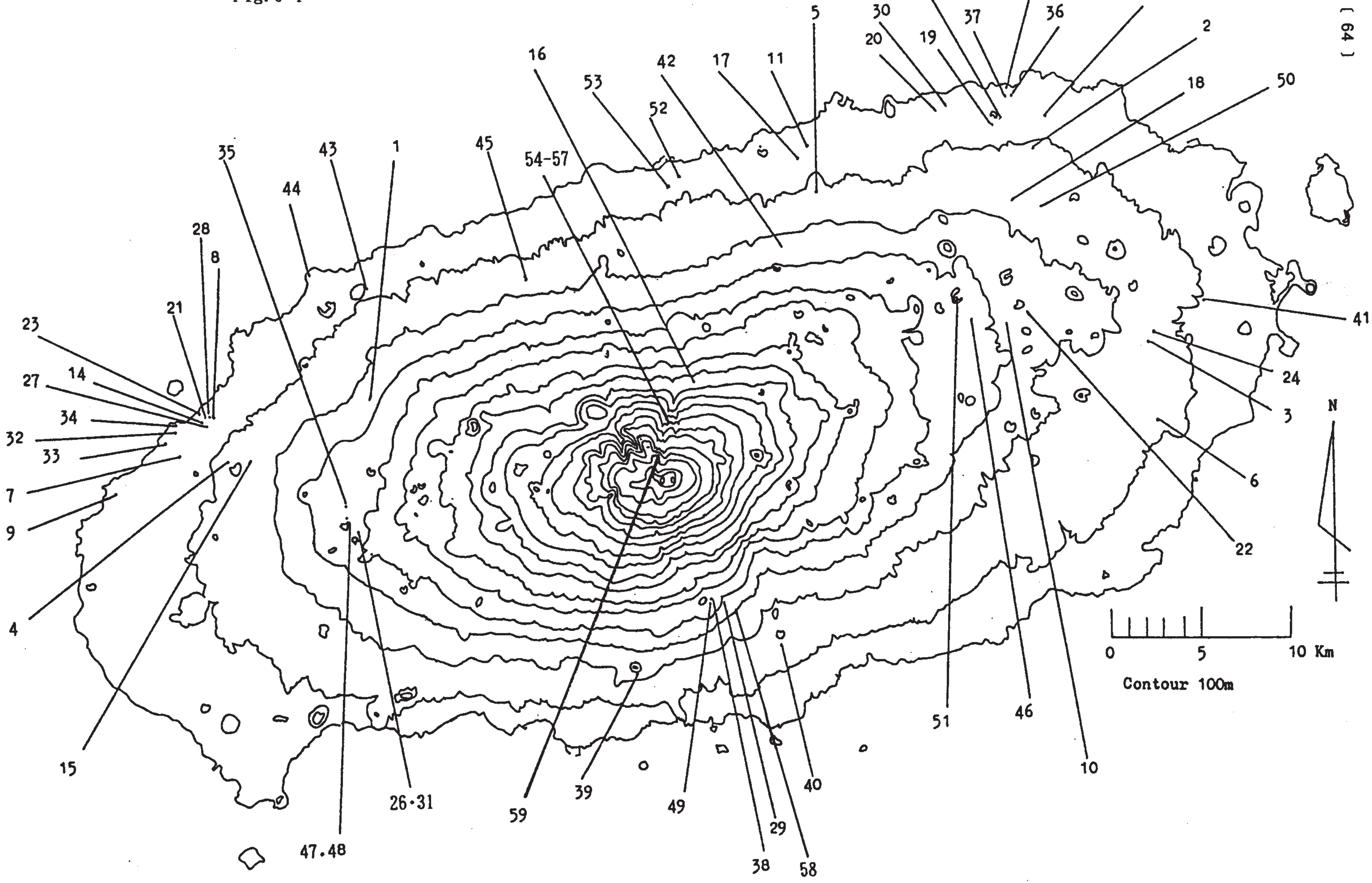


Table: 9-1 The List Of Lava Caves at Cheju Island (1988·10·5)

	Cave Name	Location	Length	Elev.	Ltitude(N)	Longitude(E)
1	Billemot Gul	Buk Cheju Kun, Aewol Eub, Eoum 2 Ri	11,749.0m	70m	33°24'01"	126°24'08"
2	Man Jang Gul	" " , Kucha Eub, Dong kumryeong Ri	8,924.0m	120m	33°31'26"	126°46'18"
3	Susan Gul	Nam " , Seongsan Eub, Susan Ri	4,674.0m	140m	33°25'30"	126°50'37"
4	Sochon Gul	Buk " , Hanlim Eub, Hyopche Ri	* 2,980.0m	130m	33°21'53"	126°15'38"
5	Wahol Gul	" " , Chocheon Eub, Wahol Ri	* 2,066.0m	130m	33°30'10"	126°38'10"
6	Michon Gul	Nam " , Seongsan Eub, Samdal Ri	1,695.0m	100m	33°23'03"	126°50'27"
7	Handul Gul	Buk " , Hanlim Eub, Kumryeong Ri	* 1,400.0m	30m	33°22'28"	126°13'56"
8	Chogi Wat Gul	" " , Hanlim Eub, Hyopche Ri	1,289.0m	50m	33°22'56"	126°14'50"
9	Shin Chang Gul	" " , Hankyeong Myun, Shinchang Ri	850.0m	20m	33°20'48"	126°11'20"
10	Song Dang Gul	" " , Kucha Eub, Songdang Ri	* 850.0m	265m	33°26'22"	126°45'31"
11	Yukutiki Gul	" " , Chocheon Eub, Shinchon Ri	* 800.0m	70m	33°31'36"	126°37'27"
12	Kumryeong Sa Gul	" " , Kucha Eub, Dong kumryeong Ri	705.0m	60m	33°32'26"	126°46'38"
13	Keuset Gul	" " , Kucha Eub , Seo kumryeong Ri	* 414.0m	10m	33°33'09"	126°45'22"
14	Ssang Ryong Gul	" " , Hanlim Eub, Hyopche Ri	392.3m	30m	33°23'00"	126°14'38"
15	Oksan Gul	" " , Hanlim Eub, Myongwol Ri	391.0m	140m	33°21'58"	126°16'34"
16	Kulin Gul	Cheju Si, Oteung Dong	380.0m	760m	33°24'19"	126°32'45"
17	Imolu Gul	Buk Cheju Kun, Chocheon Eub, Shinchon Ri	* 350.0m	70m	33°31'25"	126°37'26"
18	Kun Gout Gul	" " , Kucha Eub, Dukchun Ri	232.0m	155m	33°29'52"	126°45'30"
19	Koenegi Gul	" " , Kucha Eub, Seo Kumryeong Ri	* 200.0m	30m	33°32'18"	126°44'58"
20	Keyomol Gul	" " " , Kucha Eub, Dongbok Ri	* 170.0m	10m	33°32'38"	126°42'57"
21	Hwang Kum Gul	" " " , Hanlim Eub, Hyopche Ri	* 140.0m	35m	33°22'59"	126°14'39"
22	Sang Dang Gul(2)	" " , Kucha Eub, Dongbok Ri	138.0m	255m	33°26'39"	126°45'58"
23	Cheam Chon Gul	" " , Hanlim Eub, Hyopche Ri	114.0m	10m	33°23'19"	126°14'28"
24	Susan Gul(2)	Nam Cheju Kun, Seongsan Eub, Susan Ri	* 100.0m	150m	33°25'57"	126°50'21"
25	Pognam Mol Gul	Buk " , Kucha Eub, Dong Kumryeong Ri	* 100.0m	150m	33°32'24"	126°45'09"
26	Dang Olm Gul(2)	Nam " , Anduk Myun, Dongkwang Ri	90.6m	434m	33°19'48"	126°20'19"
27	Hyopche Gul	Buk " , Hanlim Eub, Hyopche Ri	89.8m	20m	33°22'59"	126°14'38"
28	Sol Rim Gul	" " , Hanlim Eub, Hyopche Ri	367.4m	30m	33°22'58"	126°14'44"
29	Kwan Um Gul	Seoguipo Si, Topyong Ri	* 80.0m	280m	33°17'32"	126°34'43"
30	Dote Pognan Gul	Buk Cheju Kun, Kucha Eub, Dongbok Ri	* 80.0m	30m	33°32'45"	126°43'36"
31	Dang Olm Gul(1)	Nam " , Anduk Myun, Dongkwang Ri	57.7m	434m	33°19'48"	126°20'19"
32	Cholyong Gul	Buk " , Hanlim Eub, Kumreung Ri	* 50.0m	30m	33°22'38"	126°13'39"
33	Kum Reung Gul	" " , Hanlim Eub, Kumreung Ri	*	10m	33°23'00"	126°13'43"
34	Pat Gul	" " , Hanlim Eub, Kumreung Ri	*	10m	33°22'58"	126°13'42"
35	Kum Ak Gul	" " , Hanlim Eub, Kumreung Ri	* 100.0m	350m	33°31'20"	126°19'50"
36	Kumryeong Pat Gul	" " , Kucha Eub, Dong Kumryeong Ri	*	10m	33°33'04"	126°45'27"
37	Kumryeong Jol Gul	" " , Kucha Eub, Dong Kumryeong Ri	*	10m	33°33'04"	126°45'22"
38	Mi Ak San Gul(1)	Seoguipo Si, Topyong Ri	41.3m	425m	33°17'53"	126°33'54"
39	Keng Sengi Gul	" " Seoho Ri	* 45.0m	280m	33°15'39"	126°30'57"
40	Yeo Woo Gul	" " Shinhyo Ri	*	50m	33°15'41"	126°36'28"
41	Mu Myong Gul	Nam Cheju Kun, Seongsan Eub, Susan Ri	*	* 100m	33°25' "	126°54' "
42	Konaen Gi Sul Gul	Cheju Si, Bonggae Dong	*	210m	33°28'39"	126°36'22"
43	Konaebong Gul	Buk Cheju Kun, Aewol Eub, Haka Ri	*	* 70m	33°27'12"	126°20'45"
44	Han Dam Gul	" " Aewol Eub, Aewol Ri	*	* 10m	33°27'36"	126°18'42"
45	Pheng Namu Gul	Cheju Si, Haean Dong	*	* 140m	33°27'34"	126°26'53"
46	Pujong Gul	Buk Cheju Kun, Chocheon Eub, Wasan Ri	* 200.0m	* 300m	33°25'57"	126°43'00"
47	Chong Mul Gul(1)	" " , Hanlim Eub, Kumak Ri	18.5m	350m	33°20'12"	126°20'03"
48	Chong Mul Gul(2)	" " , Hanlim Eub, Kumak Ri	5.6m	350m	33°20'12"	126°20'03"
49	Mi Ak San Gul(2)	Seoguipo Si, Topyong Dong	16.1m	420m	33°17'50"	126°33'54"
50	Tok Chon Gul	Buk Cheju Kun, Kucha Eub, Dukchun Ri	*	160m	33°29'40"	126°46'10"
51	Komun Olum Gul	" " , Chocheon Eub, Gyorae Ri	Depth -25m	350m	33°27'02"	126°43'19"
52	Namchongmul Olum Gul	Cheju Si, Bonggae Dong	* 60.0m	15m	33°29'55"	126°27'37"
53	Dot Lyanug Gul	" " , 1 To 2 Dong	* 70.0m	15m	33°23'45"	126°33'45"
54	Sang Kwae Gul	" " , Oteung Dong	*	* 1,450m	33°24' "	126°33' "
55	Neolbunsang Kwae Gul	" " , Oteung Dong	*	* 1,700m	33°24' "	126°33' "
56	Phyong Kwae Gul	" " , Oteung Dong	*	* 1,600m	33°24' "	126°33' "
57	Dung Tojin Kwae Gul	" " , Oteung Dong	*	* 1,750m	33°24' "	126°33' "
58	Mosimol Gul	Seoguipo Si, Sanghyo Dong	*	310m	33°17'15"	126°33'00"
59	Tong Kwae Gul	Cheju Si, Oteung Dong	*	* 1,600m	33°23'00"	126°34'43"
60						

9. Korea

Fifty nine lava caves are known in Cheju Island but some of them have not yet been scientifically surveyed (Fig.9-1.Table 9-1).

Most of the caves exist in Pyoseonri lava, the largest scale Mt. Halla early stage lava distributes to the eastern and western parts of the island. Thickness of the Pyoseonri lava reaches to 120 m at around Man Jang Gul, 28 km from the summit of Mt. Halla.

Man Jang Gul

A total length of 8,927 m ranks this cave at the fifth, and probably its cave volume is the greatest among the world lava caves. Three caves make a cave on the cave system, and the lower major cave mearures 5,164 m, the upper two are 2,031 m and 1,733 m (Fig. 9-2). This cave makes up the world's, second longest cave system with Kumryeong Sa Gul, Pat Gul, Jol Gul, and Keuset Gul, with the total length of 13,268 m (Fig.9-3).

At the upper stream of the upper cave, there are four floor holes which make passages to the main cave at the lower level. There are large scale lava bridges at the lower reaches of the upper cave. Twenty one lava balls were found in the main cave, and some are also found in the upper cave. The lava balls are left on the floor probably because of the slow movement of floor lava flow or due to the thinnes of the lava. It is clarified that the upper end of the cave is 125m while the lower end is 80m above sea level, and height difference between the ends which are 6 km apart is only 45 m, meaning the average slope is 0.4° . This near horizontal gentle slope must be a reason in forming such a large scale cave.

"Tortoise rock" is a large lava ball on a terrace, which has an eminent streak on its sede and indicates the lowering of the lava level when the ball was carried down.

There is a small "tube in tube" formation on the floor, and two places are the lavacicles. A 7.6 m large lava pillar was probably formed by lava dripping from the upper level cave. There is only a width of 2 m but an interesting ripple wave mark, formed when a strong gas blow occurred from a pressurised gas-filled cavity.

At two localities, in the middle and lower reaches of the main cave, there are xenoliths of obsidian and quartz rock in the lava.

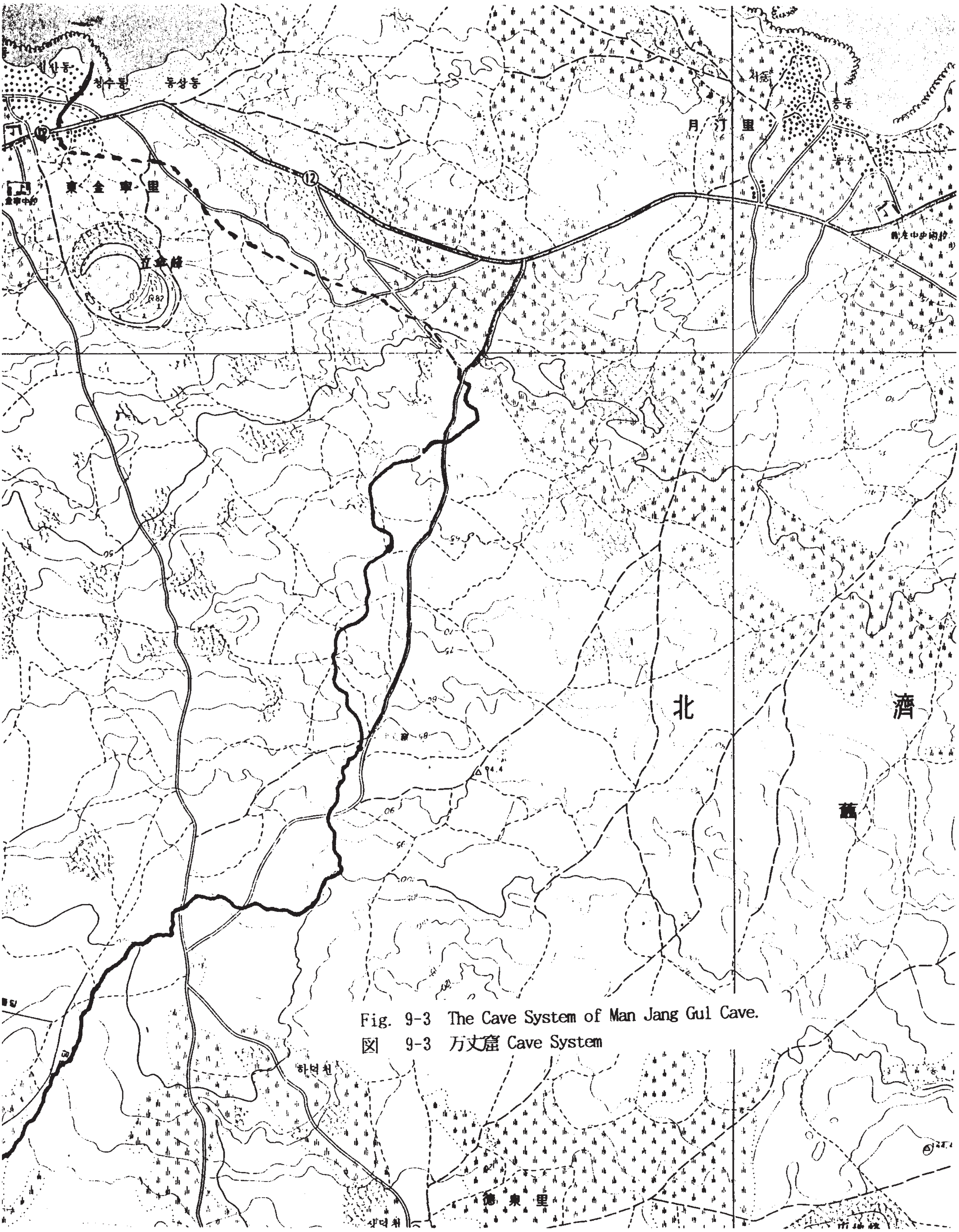


Fig. 9-3 The Cave System of Man Jang Gul Cave.
図 9-3 万丈窟 Cave System

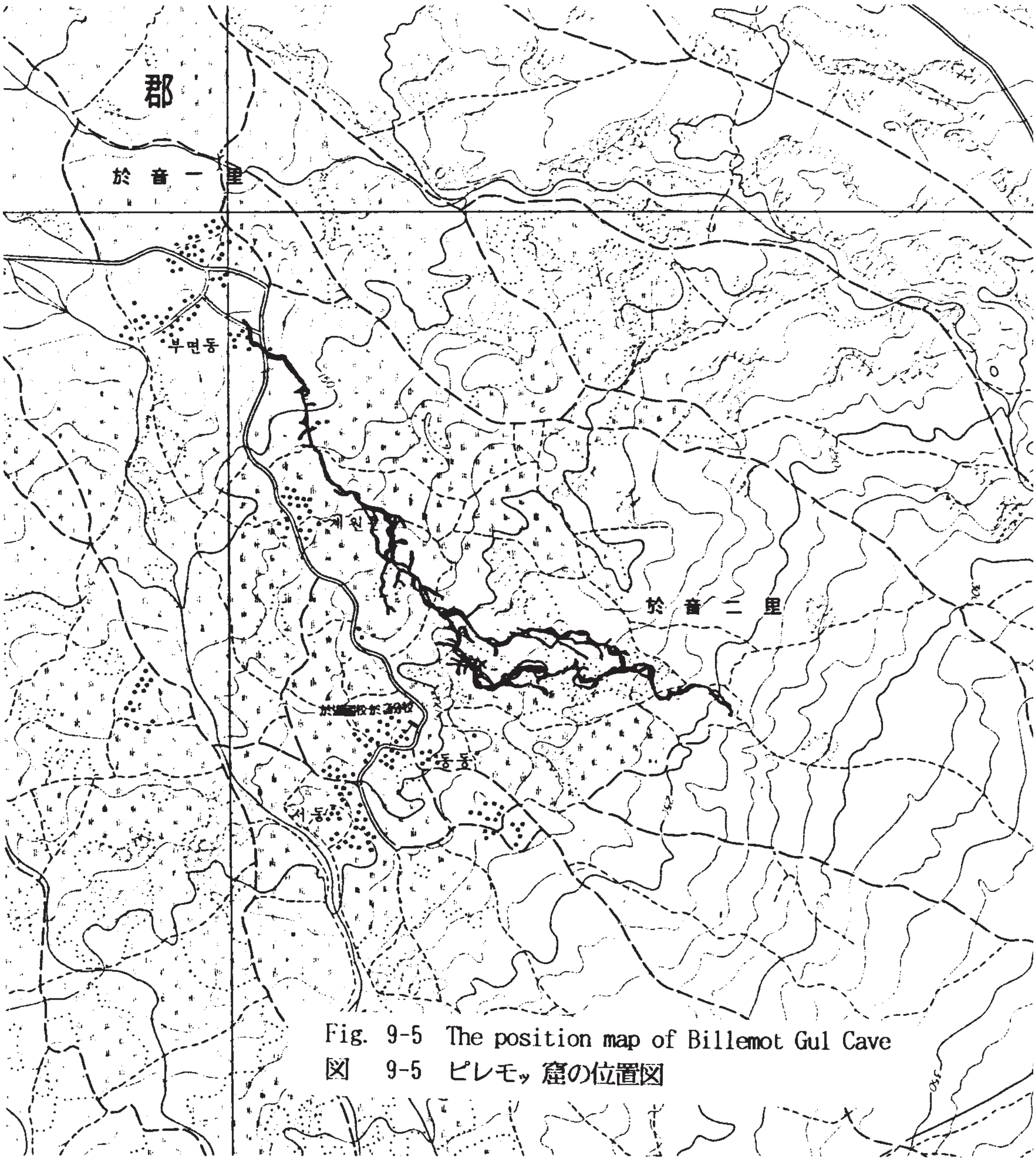


Fig. 9-5 The position map of Billemot Gul Cave
図 9-5 ピレモッ 窟の位置図

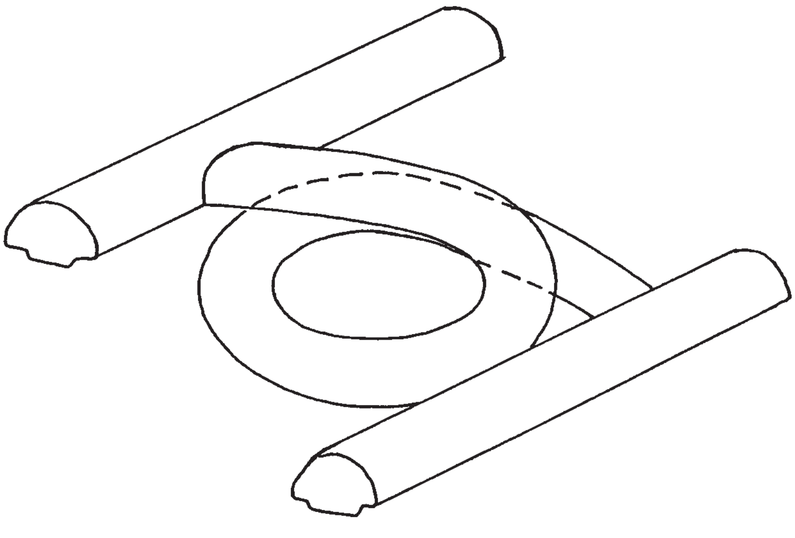


Fig. 9-6 The idial diagram of the spilal part
in Billemot Gul lava cave .
図 9-6 ピレモッ 窟の螺旋部の模式図。

Kumryeong Sa Gul

The down stream floor lava of the Man Jang Gul came into the upper end of this cavewhich choked the passage between. A large lava ball in the upper stream of this cave is likely to have dawned up the lava flow that contributed to the blockage of the passage.

The lower reaches of this cave are affected by the shell sand, and the dissolved calcium carbonate from it has seeped into the ceiling and coated walls with calcium carbonate, creating a pseudo-limestone cave, and anthodite growing at the ceiling.

Billemot Gul

The Japan Korean co-operative survey in 1982 clarified this cave to be the third longest lava cave in the world(Table 9-2). The main cave is only 2,917 m long but the length of the complexly developed branch cave system is 8,832m and makes the total length of 11,749 m (Fig. 9-4).

This cave is developed in the Sihungri lava where the lava flowed against a ridge of Pyoseongri lava and stagnated (Fig. 9-5). The narrow entrance barely allows a people to go through but leads to grand halls, and an extremely complex cave system of branching and crossing horizontally as well as in vertically. There is even a spiral passage between upper and lower parallel caves (Fig. 9-6).

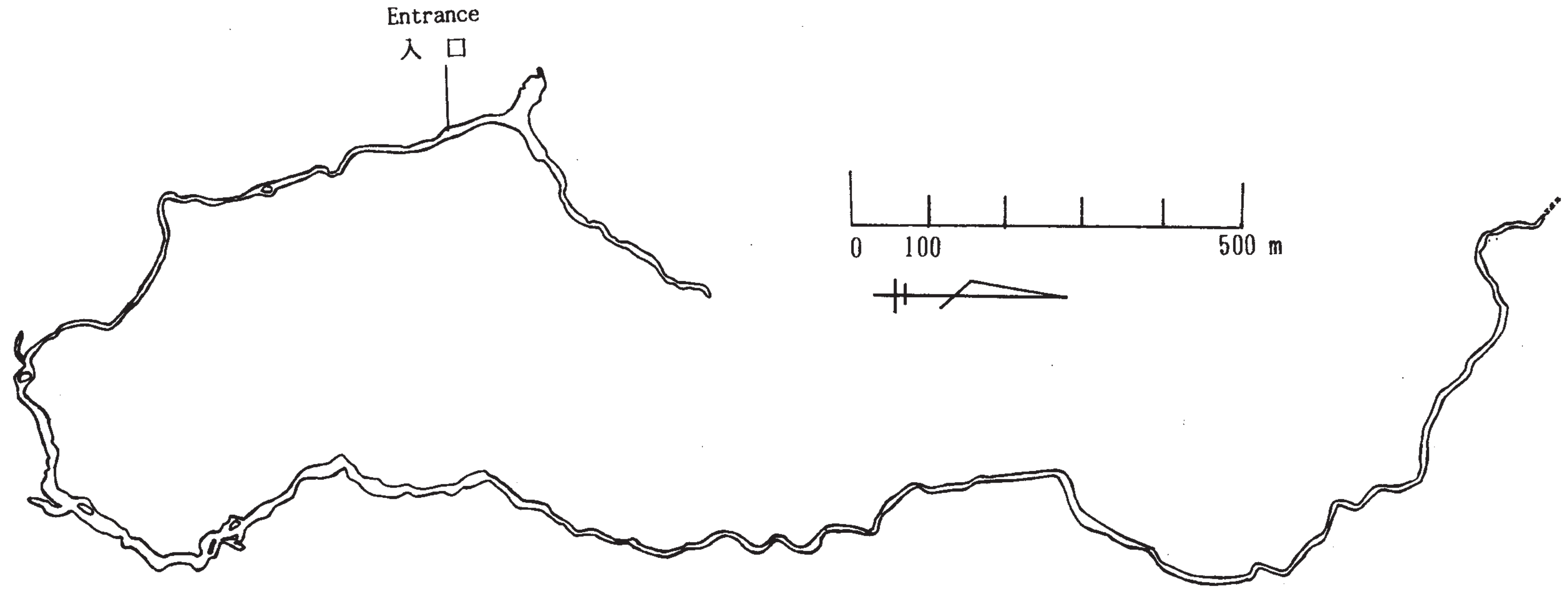
A 28 cm long silica pillar, and a 7 m × 5.2 m in size and 2.5 m high lava ball found in the cave are probably world largests of the sorts. The white wall coating mineral near the entrance may be gypsum.

Hyopche Gul

The cave is in Pyoseonri lava at the north-western coast. The cave system with Oksan Gul, Sochon Gul, Hwang Kum Gul and Ssang Ryong Gul make up the world's longest lava cave system. This coastal region is covered by calcareous shell sand and lower reaches of these caves are more or less affected with the seepage of calcareous water by dissolving the shell sand.

Hwang Kum Gul

This cave is intensely affected by the calcareous seepage and invasion of calcareous shell sand. Many calcareous stalactites and stalagmites make the cave a pseudo-limestone cave. Shell sand collected inside this cave has been dated by ^{14}C method with



Figuer 9-7 Susan Gul Cave

図 9-7 水 山 窟

the result 3820±90 y.BP. Distribution of the shell sand to a considerably high level from the coast may be explained by high sea water levels of the past or upheaval motion of the island in addition to the work of the strong wind. The Korean Government designated this cave as a Natural Monument and we are not allowed to examine the inside.

Ssang Ryong Gul

The cave is close to the Hyopche Gul but has more interesting features like a lava rose on the floor or partly collapsed lava shelf. Traces of initial stage cavities are observed on the ceiling suggesting the mechanism of the early formation stage.

Sochon Gul

A beautiful "tube in tube" and a "coffin" can be observed. Survey of this cave has not yet been completed.

Susan Gul

This cave has a U shape plan probably caused by a southerly flow prevented by an old volcanic cone and change in the flow direction to the north. There are many collapses at the bend and this may be related to the flow's directional change (Fig. 9-7).

Wahol Gul

The floor of this cave descends both to the upper and the down streams of the lava flow. There are distinctly different features in the upper stream and the lower reaches of the cave. There are large halls joined at the upper, while flat cavities joined by a tube cave at the lower reaches.

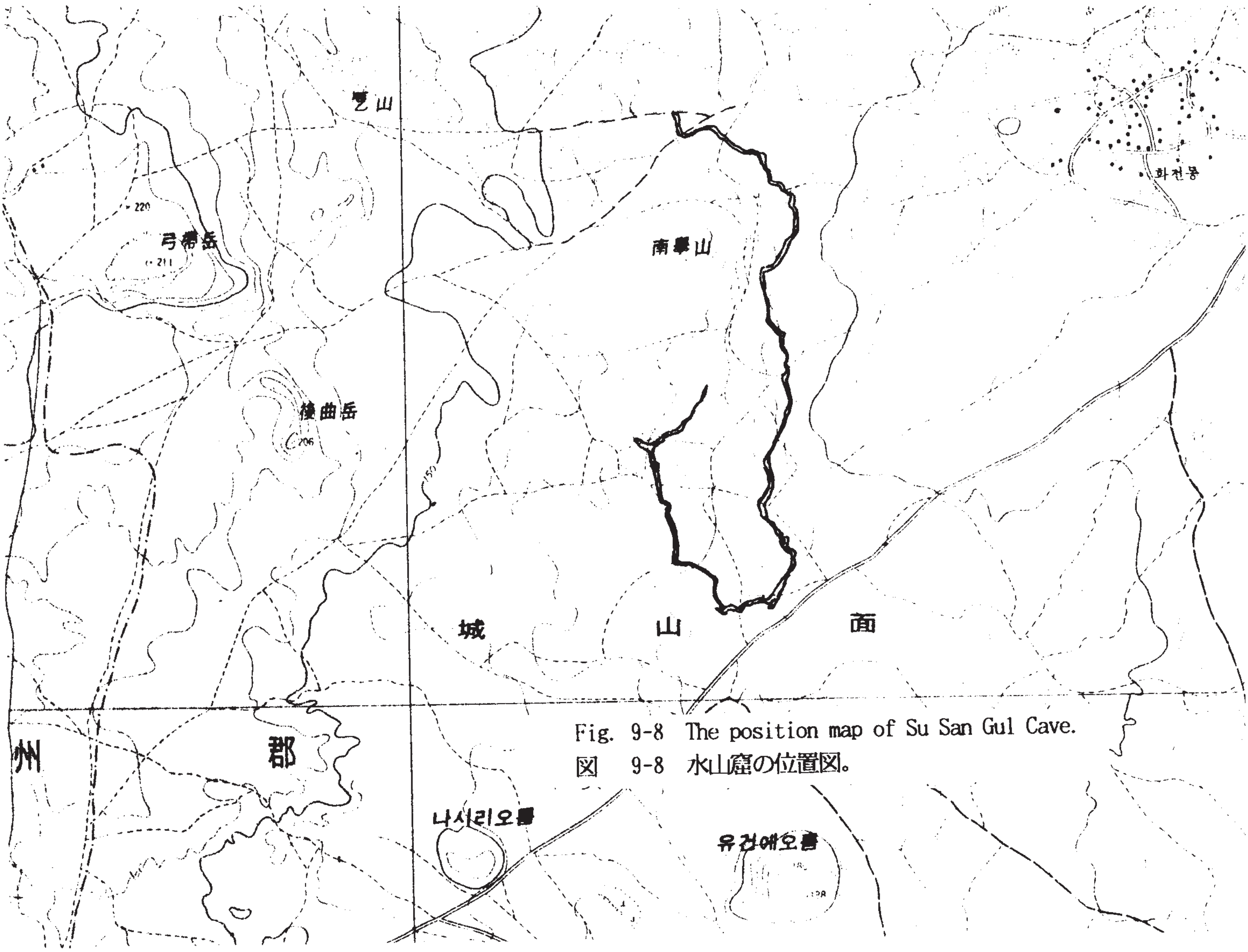


Fig. 9-8 The position map of Su San Gul Cave.
図 9-8 水山窟の位置図。

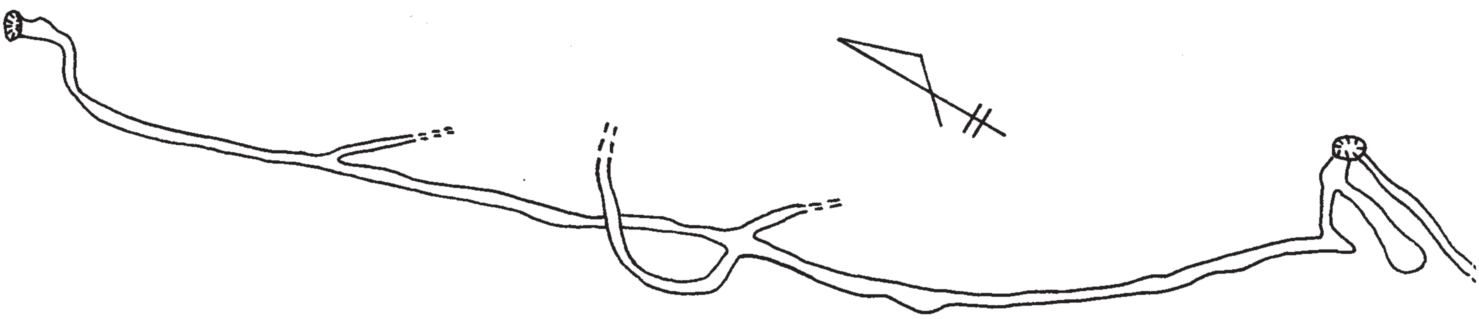
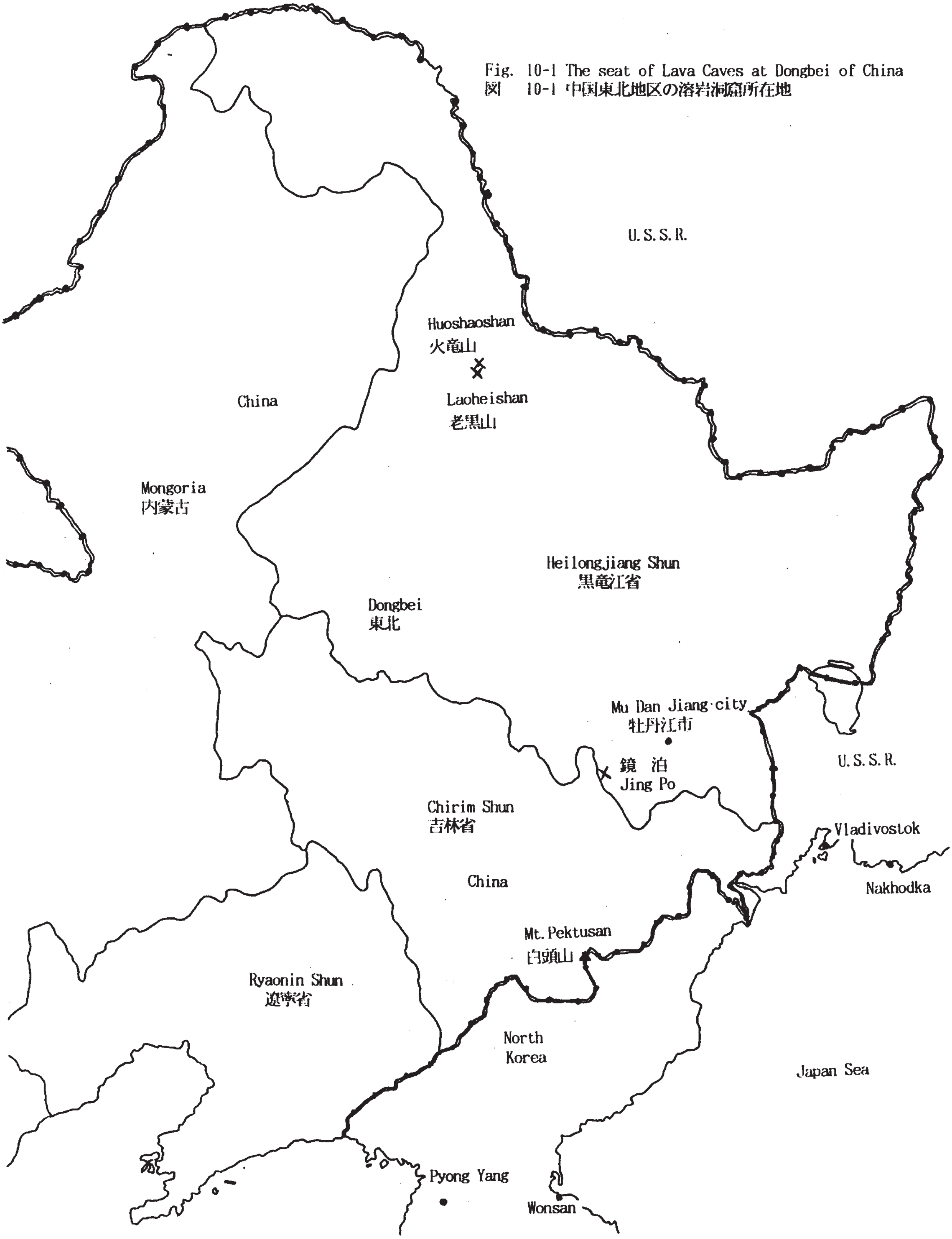


図 10-2 鏡泊溶岩洞窟 No. 1
Fig. 10-2 Jing Po Lava Cave No. 1

Fig. 10-1 The seat of Lava Caves at Dongbei of China
図 10-1 中国東北地区の溶岩洞窟所在地



10. China

Two localities are known in Dongbei Province (Fig.10-1). Wutaiienchi volcanic region in the northern part of Heilongjiang Shun near Meyuang Town (48.7 N, 126.1 E), there is a shield vocano on which two small volcanoes erupted in 1720-1722 A.D.

Laoheishan, the larger cone has a relative height of 166 m, and Huoshaoshan, the smaller cone is 73 m, and both have a large crater. A lava flow from Huoshaoshan contains caves.

South-west of Mu Dan Jiang City in the southern part of the Heilongjiang Shun, there is a lake called Jing Po. Four lava caves are known in this area. Two of them are at 50km south-west of Jing Po Shan Town, on the south end of the Chang Guan Chai Ling Range, where about ten craters of various sizes covered by dense forest and caves are 15 km down stream of a lava flow. One of the caves is 80 m plus an additional 8m in length, and another one is more than 400 m in length (Fig.10-2), and has beautiful ropy lava on the floor 20 m inside. It has two branches and bends in a right angle near the end where the floor is ice paved and then submerged into water.

The other two caves are on the cliffs of a river which flows into Lake Jing Po, and both caves are difficult to access(Fig.10-3).

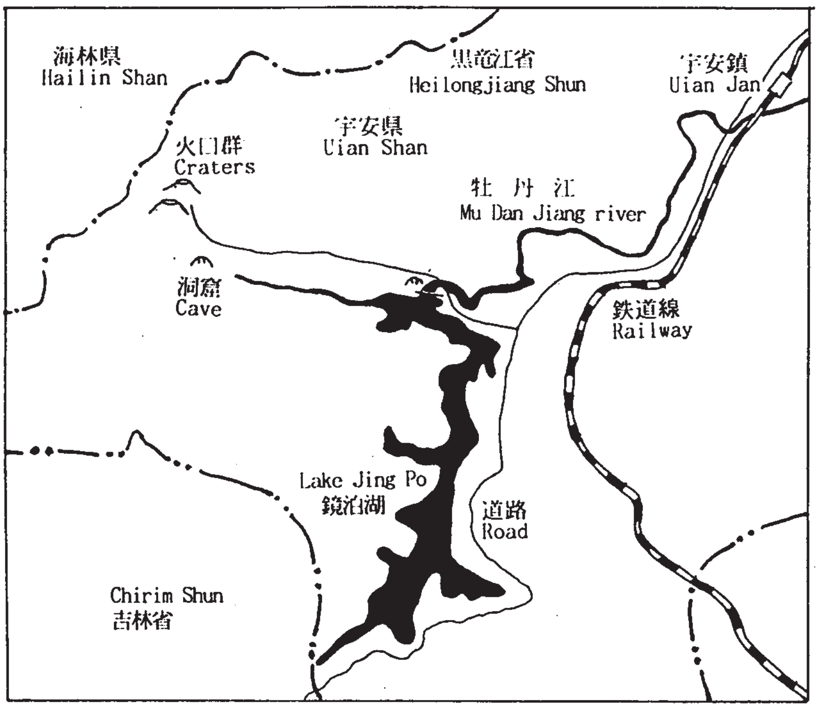


図 10-3 中国東北黒竜江省鏡泊湖周辺図
Fig. 10-3 The map of Jingpo Fu lake area
Heilongjiang Shun in China

11. The Volcanic Cave Mineralogy

1) Mineralogy of Miyake A-3 Rift Cave

The aspect of mineralization in Miyake A-3 Rift Cave which is coated on many walls as a frostwork(Fig. 11-1).

X-ray powder diffraction and energy-dispersive analyses indicated the presence of carbonate(magnesite)and sulfate(gypsum) minerals.

Magnesite($MgCo_3$); In the general calcareous caves, magnesite is the final evaporative
product of a magnesium-rich mineral sequence.

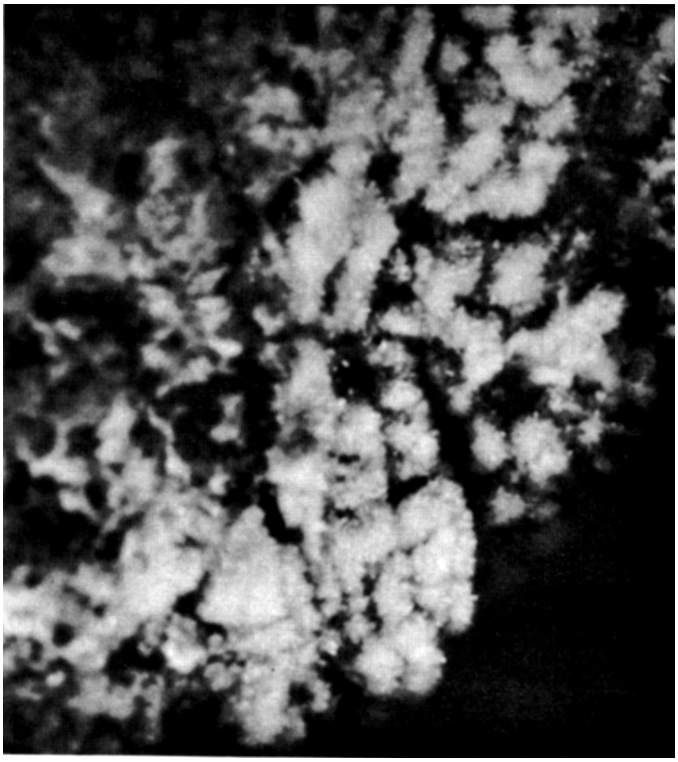


Fig. 11 — 1. The Crystal of gypsum and Magnesite in the Miyake A — 3 Rift Cave.

Althogh, the presence of magnesite speleothems is very rare(HILL, etal., 1986). The magnesite stability field is in needed of more higher temperature condition than the general caves.

Gypsum($CaSO_4 \cdot 2H_2O$)This mineral occurs both in calcareous and volcanic caves. The origin of volcanogenic gypsum was reported as a direct precipitation from volcanic gasses just after the eruption(OBA, et al., 1984).

These two minerals in Miyake A-3 Rift Cave probably were produced in sublimates from volcanic gasses.

References

C. A. HILL. and FORTI P. (1986) Cave minerals of the world. With a historical introduction by SHAW. T. R.. National Speleological Society. Huntsvill. 238pp.

OBA, N., TOMITA. K., YAMAMOTO. M., INOUE. K., NAKAMURA. T., ISHII. T. and KIYOSAKI. S. (1984) Mechanism of the formation of volcanic ashes from Sakurajima Volcano, Japan and its influences to the environ-ments. Rept. Fac. Sci. Kagoshima Univ., 17, 1-22.

2) Mineralogy of the Lava Caves at Mt.Fuji

Siliceous and calcareous sublimates and deposits have been previously reported from many lava tube caves at Mt.Fuji area.

TSUYA(1971)reported the occurrence of siliceous and calcareous sublimates and deposits as thin coatings, stalactites and cave corals on lave walls. NOGUCHI(1973)shows a result of chemical analysis for two samples(Ouno Fuketsu and Komakado Fuketsu Caves) of white sublimates(Table 11-1).

Recently, X-ray powder diffraction analysis reaveled that only two carbonate minerals (calcite and vaterite)account for the 7 samples.

On the other 11 samples, a mineralogical determination were not made by X-ray powder diffraction analysis, which did not occur as crystalline minerals.

TSUYA(1971)pointed out that the calcareous sublimates and deposits has been particularly distributed in lava tube caves of Aokigahara-marubi(864A.D.) lava flow (augite-hyperthene-olivin basalt).

Calcite($CaCO_3$)and Vaterite($CaCO_3$) Calcite is most common secondary cave mineral. Vaterite is the highest temperature polymorph of the calcium carbonate(more than the necessary 35 ℃).

The siliceous and calcareous sublimates from by high temperature volcanic gasses. On the other hand, siliceous and calcareous deposits mean the formation which were once in solution. It is the same mechanism by which carbonate and silicate minerals form the speleothems in the general caves.

In the following list of all minerals reported from lava tube caves at Mt.Fuji area (Table 11-2).

References

NOGUCHI, K. (1973) On the spring water and sublimates in lava caves on the foot of Mt. Fuji. Report of Mt.Fuji Lava Cave Research Group, 6, 1-13.

TSUYA, H. (1971) Topography and Geology of Volcano Mt.Fuji. Fuji-san. Result of the Co-operative Scientific of Mt.Fuji. 1-149. Fuji Kyuko Co., Ltd. Tokyo.

Table 11-2: A list of cave minerals in lava caves at Mt. Fuji

Caves	Minerals	
	This work	References
Ouno Fuketsu No. 2 Cave	calcite	silieous sublimates(NOGUCHI, 1973)
Komakado Fuketsu Cave	silieous	sublimates(NOGUCHI, 1973)
Susono Fuketsu No. 2 Cave	amorphous	silieous deposits(TSUYA, 1971)
Mishima Fuketsu Cave	Halloysite	
Hachiman Ana Cave	amorphous	silieous sublimates(TSUYA, 1971)
Atsuhara Fuketsu Cave	amorphous	
Banba Ana Cave	amorphous	silieous sublimates(TSUYA, 1971)
Yashiki Ana Cave	amorphous	silieous sublimates(TSUYA, 1971)
Koubou Ana Cave	amorphous	
Mado Ana Cave	amorphous	
Inusuzumi Fuketsu Cave No. 1	amorphous	silieous sublimates(TSUYA, 1971)
Inusuzumi Fuketsu Cave No. 5	calcite	
Zinza Fuketsu No. 1 Cave	calcite	
	vaterite	
Zinza Fuketsu No. 2 Cave	calcite	calcareous sublimates(TSUYA, 1971)
Megane Ana Cave	silieous	sublimates(TSUYA, 1971)
Shoiko Fuketsu No. 2 Cave	calcite	
Motosu Fuketsu No. 1 Cave	calcite	
Fuji Fuketsu No. 1 Cave	calcite	
Heijibara Fuketsu Cave	amorphous	

3) Mineralogy of Cheju Island Lava Caves

The occurrence of secondary cave minerals in lava tube caves at Cheju Island is poorly known.

Pseudo-calcareous Hyopche Gul lava cave system, a variety of carbonate speleothems which have been derived from overlying calcareous microcoquina sands. The carbonate-bearing groundwaters percolated into cave and deposited carbornate mineral (calcite), which cover bare lava walls and coexist with lava speleothems (PETERSON, 1972; KASHIMA, et al., 1984).

Taranakite ($(K,NH_4)Al_3(PO_3)_3(OH)\cdot 9H_2O$) was reported in Kulin Gul lava cave by KASHIMA (1973). This mineral must has been formed by the interaction of the water that leached by bat guano and the clay minerals of cave deposits.

Recently, X-ray powder diffraction analysis of two samples from Man Jang Gul Cave and Oksan Gul Cave revealed that the xenocryst of quartz (SiO_2) and cristobalite (SiO_2), and calcite ($CaCO_3$), respectively.

References

KASHIMA, N. (1973) Taranakite: A supplement of general remarks on the cave phosphate minerals in Japan. Mem. Ehime Univ., 〔D〕, 7, 73-77.

KASHIMA, N. and M. S. SUH (1984) Hyeobjae cave system, a pseudo-calcareous cave on Jeju Island, South Korea. J. Speleol. Soc. Japan, 9, 23-30.

PETERSON, L. (1972) Caving on Cheju-do, Korea. Cascade Caver, 11, 61.

SUH, M. S. (1983) A study on the binary appearance in pseudo limestone cavern. J. Geography, 10, 291-304.

Table 11-1 Chemical composition of white sublimates in lava caves

	Komakado Fuketsu	Ouno Fuketsu
H_2O	16.43	15.22
LOI	11.87	13.77
SiO_2	36.81	37.54
Al_2O_3	27.07	30.20
Fe_3O_3	1.78	0.28
CaO	1.47	1.23
MgO	2.11	0.28
Na_2O	1.07	0.87
K_2O	0.29	0.19
Total	98.90	99.58

表　9-2　世界の長大溶岩洞窟リスト

Table 9-2　The list of the long LAVA CAVES in the world

No.	Country	Cave Name	Location	Extention
1	Kenya	Laviathan Cave	Chyulu Hills, Kibwezi	12,400m
2	U.S.A.	Kazumura Cave	Hawaii Island, Waikahehahe	11,833m
3	Korea	Billemot Gul	Cheju Island, Aewol Eub	11,749m
4	Espana	Cueva de los Viento	Canarias, Tenerife, Icod	9,250m
5	Korea	Man Jang Gul	Cheju Island, Ku Cha Eub	8,928m
6	Espana	Cueva de Don Justo	Canarias, Hierro, Restinga	7,323m
7	U.S.A.	Ainahou Ranch Cave	Hawaii Island, Kalanaokuaiki	7,110m
8	U.S.A.	John Martin's Cave	Hawaii Island, Waikahehahe	6,263m
9	Espana	Cueva de los Verdes	Canarias, Lanzarote,Haria	6,100m
10	U.S.A.	Labyrinth Cave	California, Siskiyou	5,661m
11	Korea	Susan Gul	Cheju Island, Seong San Eub	4,675m
12	Rwanda	Ubuvumo bwa Musanze	Musanze, Ruhengueri	4,560m
13	Espana	Cueva del Sobrado	Canarias, Tenerife, Icod	4,000m
14	U.S.A.	Ape Cave	Washington, Skamania	3,904m
15	U.S.A.	Duke Creek Cave	Uta, Kane	3,674m
16	U.S.A.	Offal Cave	Hawaii, Maui Island	3,400m
17	Espana	Cueva de Felipe Reventon	Canarias, Tenerife, Icod	3,000m
17	Iceland	Kalmanshellir	Kalmanstuga	3,000m
19	Korea	Sochon Gul	Cheju Island, Han Lim Eub	2,980m
20	Portugal	Gruta dos Balcoes	Acores, Terceira, Biscoitos	2,713m
21	U.S.A.	Mammoth Cave	California, Modoc	2,509m
22	U.S.A.	Gaping Holes Cave	California, Siskiyou	2,420m
23	U.S.A.	Dynamited Cave	Washington, Shamania	2,388m
24	U.S.A.	Post Office Cave	California, Siskiyou	2,357m
25	U.S.A.	Catacombs Cave	California, Siskiyou	2,280m
26	U.S.A.	Pot'O Gold Cave	Idaho, Lincoln	2,250m
26	U.S.A.	Falls Creek Cave	Washington, Skamania	〃
26	Ecuador	Cueva de Gallardo	Galapagos Islands, Santa Cruz	〃
26	Espana	Cueva de los Naturalistas	Canarias, Lanzarote, Masache	〃
30	Japan	Mitsuike Ana	Shizuoka, Fujinomiya-shi	2,202m
31	U.S.A.	Gypsum Cave	Idaho, Lincoln	2,140m
32	Espana	Cuva de San Marcos	Canarias, Tenerife, Icod	2,130m
33	Korea	Wa Hol Gul	Cheju Island, Cho Cheon Eub	2,066m
34	U.S.A.	Catwalk Cave	California, Shasta	1,950m
35	U.S.A.	Lava River Cave	Oregon, Deschutes	1,884m
36	Iceland	Surtshellir	Hallmundarhraun	1,810m
37	U.S.A.	O'les Cave	Washington, Skamania	1,714m
38	Kenya	Mathioni Cave	Chyulu Hills, Kiboko	1,700m
39	Korea	Michon Gul	Cheju Island, Seong San Eub	1,695m
40	U.S.A.	Thanks Giving Cave	Washington, Skamania	1,623m
41	U.S.A.	Truckett's Guano Cave	New Mexico,	1,590m
42	Espana	Tunnel de la Atlantida	Canarias, Lanzarote, Haria	1,570m
43	U.S.A.	Bobcat Cave	California, Siskiyou	1,567m
44	U.S.A.	Tee Maize Cave	Idaho, Lincoln	1,554m
45	Rwanda	Ubuvumo Bwa Nyirabadogo	Bigowa,	1,500m
45	Kenya	Kimakia Cave	Chyulu Hills, Kiboko	〃
47	U.S.A.	Baker Cave	Oregon, Deschutes	1,496m
48	U.S.A.	Bandera Crater♯3 Cave	New Mexico, Valencia	1,480m
49	U.S.A.	Hercules/Juniper Cave	California, Siskiyou	1,467m
50	Iceland	Vidgelmir	Flotsutunga	1,460m

No.	Country	Cave Name	Location	Extention
51	Japan	Hachijou Fuketsu #1	Tokyo, Hachijou Island	1,404m
52	Korea	Handul Gul	Cheju Island, Han Lim Eub	1,400m
53	U.S.A.	Lake Cave	Washington, Skamania	1,360m
54	Iceland	Raufarholshellir	Hjalli	1,350m
55	U.S.A.	Arco Tunnel Cave	Idaho, Butte	1,316m
56	U.S.A.	Balcony Cave	California, Siskiyou	1,306m
57	Korea	Chogi Wat Gul	Cheju Island, Han Lim Eub	1,289m
58	U.S.A.	Lavacicle Cave	Oregon, Deschutes	1,234m
59	U.S.A.	Dead Horse Cave	Washington, Skamania	1,214m
60	U.S.A.	New Cave	Washington, Skamania	1,160m
61	U.S.A.	Goverment Cave	Arizona, Yavapai	1,120m
62	U.S.A.	Youngs Cave	Oregon, Deschutes	1,107m
63	U.S.A.	Bandera Crater #2 Cave	New Mexico, Valencia	1,100m
64	U.S.A.	Malheur Cave	Oregon, Harney	1,076m
65	Espana	Cueva de los Roques	Canarias, Tenerife, Las Canadas	1,048m
66	U.S.A.	Little Red River Cave	Washington, Skamania	1,032m
67	U.S.A.	Skeleton Cave	Oregon, Deschutes	1,010m
68	Espana	Cueva de Chiguergue	Canarias, Tenerife, Chiguergue	1,000m
69				
70				

FIG. 9-2
Man Jang Gul Cave (1)

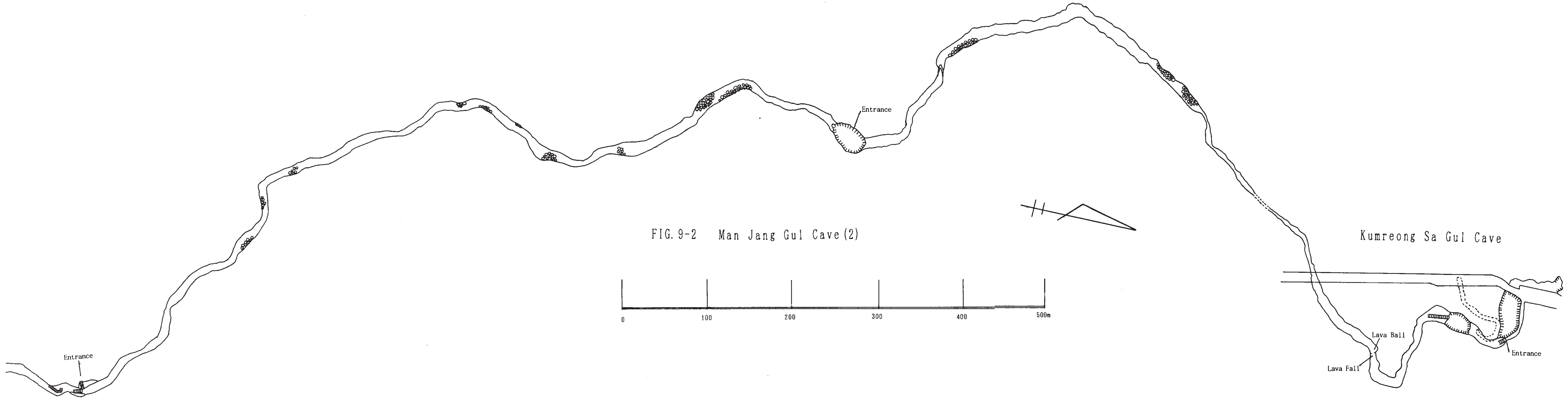


FIG. 9-2 Man Jang Gul Cave (2)

FIG. 9-4 Billemot Gul Cave