29. *Activities of the Gassan Volcano**.

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Introduction

At the southern part of Northeast Japan, there are several important volcanoes almost neglected for a long time without receiving any detailed geological investigation. One of these is the Gassan Volcano which belongs to the Chōkai volcanic zone and rises up on the eroded surface of large granitic masses and overlying Tertiary sediments.

This volcano had geologically and petrologically been unexplored until the field and laboratory works were recently started by the writer and his colleagues[1]. Moreover, it is noteworthy in its characteristic topographical features from which an aspite-type of volcano may be supposed.

In 1954, the writer spent about three weeks in the vicinity of this volcano and was able to make clear the number of activities which took place after its first eruption. It was also confirmed that the present form of the Gassan Volcano with its very gentle slope was not caused by the fluidity of overlapped lavas, but resulted from the destruction of its upper part due to the big explosion which happened at the final stage of activities. These problems are summarized in this paper, with a brief description of some lavas and ejecta.

Location

The Gassan Volcano extends over three counties of Yamagata Prefecture, namely Mogami-gun, E. Tagawa-gun and W. Murayama-gun. The main peak is respectively accessible from Hijiori, Hondōji, Iwanezawa (Tsunatori), Shizu, Yudono-san and Tōge. Of these, the Hijiori course, passing through Ōmori-yama, Akasuna-yama, Ko-take and Nenbutsugahara, is longest and hard of access when compared

* Communicated by N. Nasu.

1) The Gassan Volcano has been investigated by N. Jimbo and T. Konda. The details of this volcano are to be published before long by Konda.

with others. It is about 27 km. from Hijiori to the summit. The Yudono-san course, on the other hand, is the shortest and is the most easy approach to the highest point.

Topographical and geological features of the Gassan Volcano

The Gassan volcano consists of the main peak of Gassan (1979.5 m.), Ubaga-take (1669.7 m.), Kenga-mine (1402.7 m), Shinakura-yama (1210.9 m) and others. It has quite different topographical features at its eastern and western sides. The eastern side slopes down gently to the deep valley of the Tachiyazawa-gawa where it abruptly ends and forms a sharp cliff, whereas the western side is much deformed by erosion and explosion, and is characterized by the formation of a horse-shoe-shaped hollow opening northwestwards and an exposure of quartz diorite at its bottom.

The adjacent district of this volcano is almost unexplored and thickly forested. It is, therefore, difficult to approach such a highly mountainous area consisting of Waradahage-yama (1217.1 m.), Shimo-yanagizawa-yama (1178.4 m.), Senbonmatsu-yama (1260 m.), etc. which are deeply dissected by several rivers, viz., the Tachiyazawa-gawa, Karasu-gawa, Yotsuya-gawa, Tamugi-gawa, Sasa-gawa and their tributaries (Fig. 1).

The area mentioned above is extensively covered by lavas and ejecta. Besides these, it is composed of granite (granodiorite) and its associated intrusives, Tertiary sediments, liparite, felsophyre, dacite, propylite, basalt and Quaternary fluviatile deposits, as well as of talus deposits. Most of the lavas and ejecta exposed here rest upon the eroded surface of granite and Tertiary sediments (Fig. 2).

(1) Granite (granodiorite) and associated intrusives:—Granite is the most predominant intrusive of this area. It is not only found at the foundation of the Gassan Volcano, but is widely exposed at its adjacent area, being partly overlain by the Tertiary formation and being traversed by many dykes of liparite, felsophyre, propylite and basalt. The surface of the granitic mass is remarkably undulated, and its highest point rises up to about 1400 m.[2] above the sea-level at the uppermost course of the Yotsuya-gawa and Sasa-gawa where the Gassan lavas and ejecta directly cover this rock. So far as is

2) Granitic rocks elevated to a height of about 1400 m. are similarly seen on the Zaō volcanoes and Azuma volcanoes.

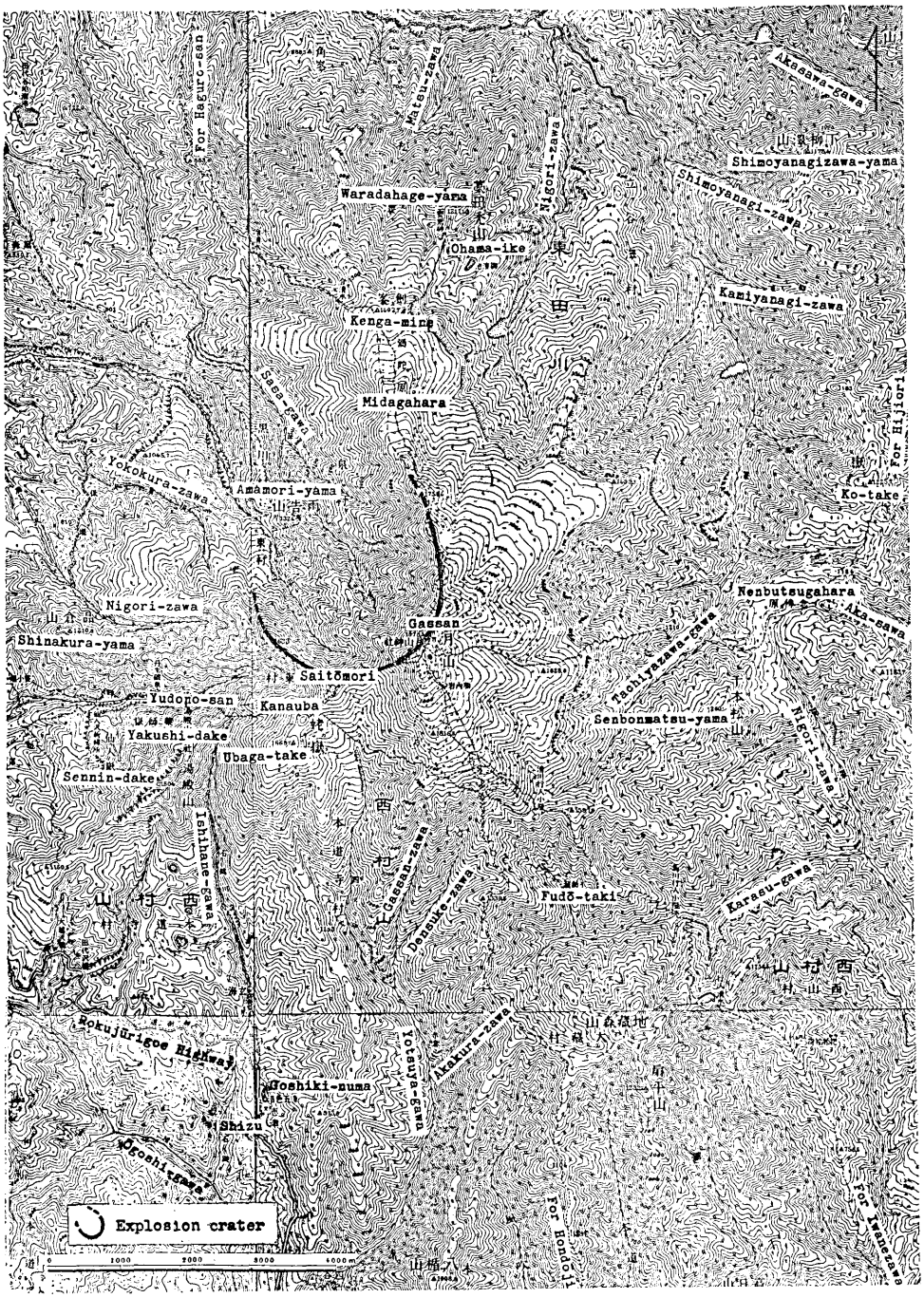

Fig. 1. Topographical map of the Gassan Volcano and its vicinity.

known at present, such a granite is mostly distributed at the area including Ko-take, Nenbutsugahara, Senbonmatsu-yama as well as at the upper courses of the Tachiyazawa-gawa, Karasu-gawa (Dōzan-gawa) and their tributaries such as the Akasawa-gawa, Aka-sawa, Nigori-zawa, etc.

Though usually a coarse or medium-grained biotite granite or granodiorite, the occurrence of some leucocratic varieties with a very coarse texture is also known along the Tachiyazawa-gawa and Karasu-gawa or elsewhere. They are composed of quartz, orthoclase, andesine or labradorite, biotite, magnetite, apatite, zircon, pyrite, chlorite, titanite, epidote and leucoxene.

One of characteristic features indicated by this granitic rocks is the abundance of xenoliths, large and small. As can be seen at the upper course of the Tachiyazawa-gawa and Karasu-gawa, they are mostly found in a state of gradual transition to the mother rock and are represented by dioritic or lamprophyric rocks consisting of such primary or secondary minerals as plagioclase, quartz, hornblende, biotite, magnetite, apatite, chlorite, epidote, titanite, leucoxene, pyrite and calcite. Moreover, the granite under consideration has a tendency to pass into quartz diorite or diorite southwards, particularly at the area between the Hondōji-zawa and Yotsuya-gawa, where they may be supposed to have been formed by the contamination of foreign rocks.

These intrusives are strikingly subjected to the tectonic disturbance and frequent impregnation of pyrite, as is indicated by liparite, felsophyre and the Tertiary green tuff.

(2) Tertiary sediments:—The Tertiary formation covers the eroded surface of biotite granite and associated intrusives mentioned above, disappearing partly beneath the accumulation of lavas and ejecta of the Gassan Volcano as well as beneath the talus deposits. It is also found in close association with such extrusives as liparite, felsophyre, propylite and basalt. This undoubtedly suggests that it was deposited during repeated volcanic activities in the Upper Miocene.

The formation exposed here is mainly composed of tuff and shale. It is represented by green tuff at its lower horizon, but is rich in shale at the upper half, being occasionally intercalated by tuffaceous rocks. The exposures of these sediments are traceable from north to south across the Tachiyazawa-gawa and its tributaries at the area including Waradahage-yama, Shimoyanagizawa-yama and Akasuna-yama.

(3) Extrusives independent of the activities of the Gassan Vol-

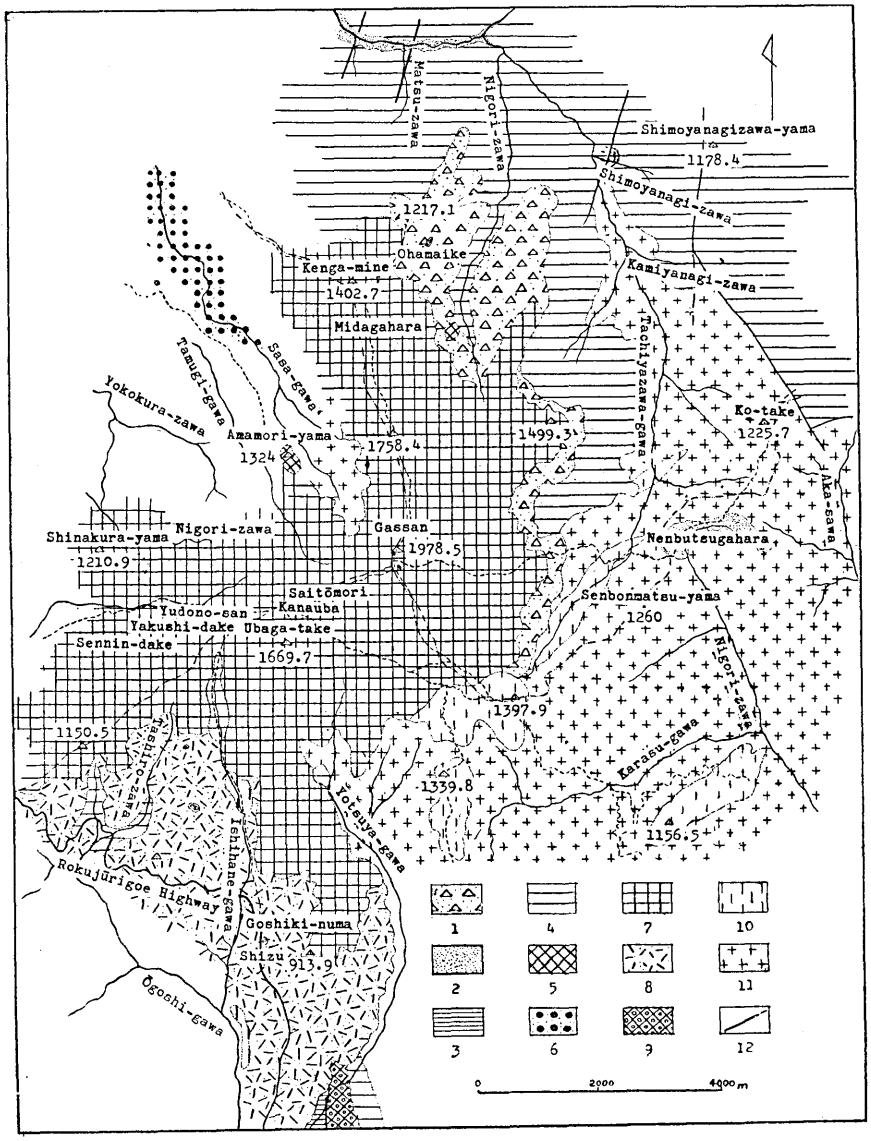

Fig. 2. Geological map of the Gassan Volcano and its vicinity. 1. Talus deposits, 2. Fluviatile deposits, 3. Shale and tuff (U. Miocene), 4. Green tuff (U. Miocene), 5. Dacite, 6. Sasa-gawa mud flow, 7. Gassan lavas and ejecta (Ol. two-pyroxene andesite), and Ol.-bearing or Ol.-hornb.-bearing two-pyroxene andesite), 8. Ishihane-gawa mud flow, 9. Ol. basalt or dolerite, 10. Liparite and felsophyre, 11. Biot. granite (granodiorite), quartz diorite and diorite, 12. Fault.

cano:—Liparite and felsophyre are well exposed at the uppermost course of the Tachiyazawa-gawa where they traverse the granitic mass here and there. The specimens collected from here have a porphyritic texture and light greenish grey or grey color, being characterized by the groundmass with a microgranitic texture. These extrusives are more or less decomposed and consist of quartz, plagioclase, orthoclase, biotite, magnetite, apatite, sericite, chlorite, calcite, titanite, leucoxene, limonite and some unknown substances. They are also very common extrusives in the surrounding district.

The occurrence of propylite and basalt or dolerite is, on the other hand, very scarce at the granitic area, although they are frequently seen in association with the Tertiary formation. Several examples of the former case were noticed by the writer along the Tachiyazawa-gawa. They are exposed as small dykes, 30–100 cm. in width. Of these, basalt or dolerite has a black color and mineral ingredients represented by plagioclase, augite, hypersthene, olivine and magnetite.

(4) Lavas and ejecta erupted from the Gassan volcano:—Lava flows and various kinds of ejecta were erupted from the Gassan Volcano. They are the Ishihane-gawa mud flow, Gassan lavas and ejecta and Sasa-gawa mud flow.

(i) Ishihane-gawa mud flow:—The area watered by the Ishihane-gawa, Tashiro-zawa and Ōgoshi-gawa is extensively covered by the Ishihane-gawa mud flow which is underlain by the Tertiary formation and granite. It partly disappears beneath the Gassan lava of Ubaga-take and Sennin-dake, extending southwards along Ōgoshi-gawa. This mud flow is supposed to have had its source in the pre-existing crater and contains abundant angular or subangular fragments of olivine two-pyroxene andesite or olivine-bearing two-pyroxene andesite comented by tuffaceous substance.

(ii) Gassan lavas and ejecta:—The Ishihane-gawa mud flow was followed by the eruption of the Gassan lavas and ejecta which took place within the same crater. It spreads over the area including the summit of Gassan, Kenga-mine, Midagahara, Ubaga-take, Yakushi-dake and Sennin-dake. The eastern half of this lava flow is intercalated with thin beds of ejecta and is represented by gently sloping flank, where it gradually decreases its height (Fig. 3). The terminal cliff is frequently estimated to be 100 m. or more along the valley of the Tachiyazawa-gawa and its tributaries (Fig. 4).

The western half is, on the other hand, remarkably subjected to

the dissection due to erosion and deformation resulting from the explosion. It forms, therefore, a sharp cliff here and there, particularly on the crater wall just beneath the summit of Gassan (Fig. 6.).

It is also very noteworthy that quartz diorite is exposed at the bottom of this explosion crater, where the Gassan lava is 400 m. thick above the exposure of quartz diorite.

The lava flows extending westwards or southwards construct Yakushi-dake, Sennin-dake, Shinakura-yama and Ubaga-take respectively. Among them, the southern end of the lava flow branched on Ubaga-take is now found near Shizu. The lowest point of the Gassan lavas and ejecta is about 800 m. above the sea-level near Shizu and at the bottom of the area between Shinakura-yama and Sennin-dake.

(iii) Sasa-gawa mud flow:—A big mud flow erupted from the explosion crater mentioned above extends 18000 m. northwestwards and is traceable down to the eastern margin of the Shōnai Plain, where it is 7000 m. wide at its end. Various features of the mud flow can be seen along the Sasa-gawa, Konno-gawa, Tsumeta-gawa and Harai-gawa, which are not included in the writer's map.

(5) Amamori-yama dacite:—The occurrence of the Amamori-yama dacite[3] is restricted to a small extent. It constructs a tiny relief at the bottom of the explosion crater which is now deeply dissected by the Sasa-gawa and Tamugi-gawa (Fig. 5).

(6) Quaternary fluviatile deposits:—Fluviatile deposits here are mainly sand and gravel accumulated at the bottom of present rivers and swamps.

(7) Talus deposits:—The northern or eastern end of the Gassan volcano is mostly skirted by thick talus deposits supplied from high cliffs.

Structure of the Gassan Volcano

Gassan is a strato-volcano resting upon the foundation composed of granitic rocks, Tertiary sediments and associated extrusives which are exposed at the maximum elevation of 1300 m.–1400 m. above the sea-level. The structure of this volcano is much complicated by the successive eruption of the Ishihane-gawa mud flow, Gassan lavas and ejecta, Sasa-gawa mud flow and Amamori-yama dacite. It can be investigated along the Tachiyazawa-gawa, Yotsuya-gawa, Ishihane-gawa, Ōgoshi-gawa, Nigori-zawa, Yokokura-zawa, Tamugi-gawa, Sasa-gawa and

3) Personal Communication by T. Konda.

their tributaries. The best example is indicated on the wall of explosion crater just beneath the summit, Saitōmori and Kanauba, where the exposures of lavas and ejecta are highly cliffed. These lavas and ejecta have a thickness of about 400 m. above the surface of quartz diorite and spread out from here with several trends and an inclination of 10°–13°. The structure of this area is also complicated by the exposure of the Amamori-yama dacite.

So far as has been confirmed by the writer, the main part of the Gassan Volcano is built up of the Gassan lavas and ejecta underlain by the Ishihane-gawa mud flow. They are supposed to have been supplied from the pre-existing crater which seems to have been opened somewhere near the present explosion crater. At that time, the Gassan Volcano was probably a homate, but it is probable that it increased its height by erupting lavas and ejecta successively, passing into a konide (?) higher than the present volcanic body. Moreover, it is inferable that such a konide (?) lost its upper part and lowered its height in the subsequent explosion. This is the reason why the Gassan Volcano now looks like an aspite on its eastern half with an inclination of 10°–13° (Fig. 3). This idea may be supportable from the large explosion associated with the eruption of the Sasa-gawa mud flow.

Explosion Crater

One of important events which happened on the Gassan Volcano is the formation of explosion crater opening northwestwards (Figs. 6∼7). It is a horse-shoe-shaped hollow with a diameter of about 2.5 km. from east to west, and its deepest part is about 700 m. below the summit. The crater wall here is highly cliffed and is composed of the Gassan lavas and ejecta resting upon the eroded surface of quartz diorite exposed at the bottom.

The crater wall is represented by an exposure of thick lava flows intercalated with ejecta, showing some disturbances due to explosion on its southern cliff. The highest wall is found at the southeastern corner, where the Gassan lavas and ejecta are estimated to be about 400 m. up to the summit, inclining gently eastwards.

The bottom of the crater is irregularly undulated and is partly buried with fragmental rocks which crumbled down from the wall. At such an area, Amamori-yama projects out as a small mass, about 200

m. high above the bottom of the Tamugi-gawa and Sasa-gawa (Fig. 4). It consists of biotite hornblende dacite with a light grey color and porous structure.

Besides this, Konda[4] noticed a small exposure of similar dacite somewhere near the source of the Nigori-zawa, a tributary of the Tachiyazawa-gawa.

Mineral Composition of the Gassan Lavas and Ejecta

The Gassan lavas and ejecta are a thick accumulation of lava intercalated with various kinds of ejecta. They construct the main part of this volcano.

Exclusive of decomposed specimens, these rocks have a dark grey color and are characterized by a remarkable porphyritic texture. The rocks are composed of such minerals as plagioclase, augite, hypersthene, olivine, hornblende, magnetite, apatite, quartz, tridymite, bowlingite and brown glass, being represented by olivine two-pyroxene andesite and olivine-bearing or olivine-hornblende-bearing two-pyroxene andesite. The relationship between olivine-rich and olivine-poor andesites can be investigated along several courses, where the writer collected many specimens and examined their thin sections. In these cases, the former passes gradually into the latter as the altitude increases.

One of predominant minerals in these andesite is plagioclase which occurs abundantly as phenocrysts and also in the groundmass. In general, the phenocrystic plagioclase is euhedral or subhedral and has a tabular or rectangular form. It is well zoned and occasionally turbid at its periphery or inner part. Sometimes, the crystal reveals a worm-eaten structure due to the invasion of the groundmass and encloses augite, hypersthene, magnetite and brown glass. It is also noteworthy that there are some lava flows and andesite fragments of ejecta with large phenocrysts. They are seen in the specimens from Kanauba and several places of the eastern or southern flank. In these specimens, the largest one is 1.1 cm. long and 0.7 cm. across. The indices refraction suggest that the phenocrystic plagioclase belongs to andesine or labradorite with a composition of An_{39-61}.

The plagioclase in the groundmass occurs commonly as small lath-shaped or rectangular crystals 0.02 mm.–0.16 mm. long.

The next important ingredients are augite and hypersthene. Of

4) Personal Communication by T. KONDA.

these two minerals, phenocrystic augite takes a long or stout prismatic form, the former resembling the augite crystal of the Zaō volcanoes[5]. The crystal is mostly subhedral or anhedral, but it is sometimes euhedral and is 6 mm. long and 2.5 mm. across in the largest one. Such a phenocryst is occasionally twinned on (100) or (101). It is, however, uncertain whether the crystal is twinned on $(\bar{1}22)$ or not, as in the case of the Zaō volcanoes. The maximum extinction angle, $Z/\backslash c$, is 40°. When this mineral is intergrown with hypersthene, the latter is always fringed by the narrow zone of the former. The phenocrystic augite commonly encloses magnetite, but the crystal containing plagioclase and apatite is very rare.

Minute augite crystals are abundantly found in the groundmass, in which they take a prismatic or granular form, generally 0.01 mm.–0.1 mm. in length or diameter.

Hypersthene is mostly present as phenocryst in nearly the same amount as that of augite. The crystal has a long prismatic form, euhedral or subhedral. It is 1.87 mm. long and 0.51 mm. across in the largest phenocryst and contains magnetite.

Besides these, a noticeable feature is the frequent occurrence of olivine phenocryst in most of specimens collected by the writer from various parts of the Gassan lavas and ejecta, although it gradually decreases its amount at the later stage of eruption. The crystal is always subhedral or anhedral and reveals high frequency in the specimens obtained from Matsukura, Suzumekura, the ridge opposite to the Akakura-zawa, Ubaga-take and the lower part of the eastern flank. The largest one is 1.7 mm. in diameter, and the lava of the eastern flank is rich in large phenocrysts. Frequently, olivine passes into bowlingite along its periphery or crack and includes magnetite.

It is also noteworthy that hornblende occur frequently in some specimens. This mineral appears in olivine-poor lavas, as is indicated by olivine-hornblende-bearing two-pyroxene andesite of the Yake-yama Volcano[6], being represented by the occurrence of oxyhornblende with a subhedral or anhedral form, 2.07 mm. long and 0.68 mm. across in the largest crystal. Such oxyhornblende is distinctly pleochroic from light yellow (X) to yellowish brown (Y) or reddish brown (Z). The absorption is $Z>Y>X$, and its maximum extinction angle, $Z/\backslash c$, is 4°. It is partly or almost wholly opacitized and changed into aggregates

5) T. ICHIMURA and H. MINATO, *Bull. Earthq. Res. Inst.*, **29** (1951), 342–348.
6) T. ICHIMURA, R. MORIMOTO & H. TSUYA, *Bull. Earthq. Res. Inst.*, **27** (1949), 110–112.

of minute magnetite and augite crystals.

Magnetite is a very common ingredient in the groundmass or as enclosure of other phenocrystic minerals. Generally, it has an octahedral or granular form and is mostly 0.01 mm.–0.85 mm. in diameter. The largest crystal is, however, 0.76 mm. across in its thin section.

Apatite and quartz are contained in a negligible amount. The former has a long prismatic form, 0.43 mm. long and 0.08 mm. across in maximum and a dark grey or grey color due to decomposition, being traversed by cracks, whereas the latter is corroded xenocryst captured probably from granite or liparite or other quartzose rocks. The writer found these minerals in the lavas exposed on the summit of Kanauba or elsewhere.

Tridymite is very scarce and fills up the interspaces of various ingredients in the groundmass. The same can be said of brown glass, and it is almost absent in the writer's specimens.

The groundmass consists of oligioclase, andesine, augite, hypersthene, magnetite, apatite, tridymite and brown glass. Commonly, it exhibits a pilotaxitic texture, but its texture is rather orthophyric in some specimens. The rocks mentioned above, furthermore, contain basaltic or gabbroic xenoliths in which mineral ingredients are plagioclase, augite, hypersthene, olivine, biotite, magnetite and brown glass. It is a non-porphyritic rock with a grey color and compact appearance, being sharply bordered against their mother rocks.

History of Volcanic Activities

The Gassan Volcano seems to have repeated its activity on the upheaved area composed of granite (granodiorite), quartz diorite, diorite, liparite, felsophyre, dacite, propylite, basalt and Tertiary sediments.

The first eruption of this volcano probably took place through the weak point of base rocks where the pre-existing crater is supposed to have been opened.

The forerunner of repeated activities is indicated by the eruption of the Ishihane-gawa mud flow which covered the southern part of the volcanic area. It is believed to have poured forth from the pre-existing crater now obscured. This activity was followed by the ejection of the Gassan lavas and ejecta. It started with the eruption of olivine two-pyroxene andesite and was succeeded by olivine-bearing or olivine-hornblende-bearing two-pyroxene andesite during the same activity.

These lavas are intercalated with various kinds of ejecta and are thickly piled up on the base rocks as well as on the Ishihane-gawa mud flow. During this activity, the Gassan volcano is inferred to have gradually increased its height above the level of the present summit. It is also supposed that the summit of this volcano was once situated at farther west.

The next activity is represented by the formation of the large explosion crater and ejection of the Sasa-gawa mud flow which is traceable north-westwards down to the Shōnai Plain. It resulted in an extensive destruction of the Gassan volcano. At that time, the upper half of konide (?) was blown off and a quite different form of volcano was left behind. This is the present Gassan Volcano which has a very gentle slope on the east, but is highly cliffed on the west.

The activities were closed by the big explosion which erupted the Sasa-gawa mud flow. Such activities were probably repeated successively at the pre-historic time. It is, however, not clear whether the first eruption took place in the beginning of the Quaternary or not, since there is no Pliocene sediment overlain unconformably by the lavas and ejecta of the Gassan Volcano at this area under consideration.

On the contrary, the relationship between the Ha-yama Volcano and Pliocene sediments of the neighbouring district has recently been investigated by Konda[7]. He concluded that the eruption of this volcano had already started in the Pliocene and had repeatedly supplied a large amount of tuffaceous or andesitic substance to construct the main part of the volcano and Pliocene sediments intercalated with lignite beds. In his paper, however, the possibility of a clino-unconformity between folded Pliocene sediments and newly erupted lavas or ejecta of the present Ha-yama Volcano seems to have been neglected without any description. To the writer, this seems to be an important key point in making clear the period of the first activity shown by the Gassan Volcano.

Summary

(i) The Gassan Volcano rises up on the boundary between W. Murayama-gun and E. Tagawa-gun or Mogami-gun of Yamagata Prefecture. It is approachable by several courses from various sides.

(ii) It is composed of the Ishihane-gawa mud flow, Gassan lavas

7) T. KONDA, *Bull. Yamagata Univ. (Nat. Sc.)*, **3** (1954), 127–131.

and ejecta and Sasa-gawa mud flow which successively erupted on the eroded surface of granite (granodiorite), quartz diorite, diorite, liparite, felsophyre, dacite, propylite, basalt and Upper Miocene sediments elevated frequently to 1300 m.–1400 m. above the sea-level.

(iii) The lavas and ejecta including mud flows erupted successively from pre-existing crater and also from the explosion crater. Of these, the pre-existing crater is now obscure, being covered by lavas and ejecta which erupted subsequently, whereas the explosion crater opened northwestwards with a horse-shoe-shaped hollow just beneath the present summit.

(iv) Most predominant are the Gassan lavas and ejecta which consist of olivine two-pyroxene andesite, olivine-bearing or olivine-hornblende-bearing two-pyroxene andesite and their fragments. One of characteristic features indicated by these rocks is the frequent occurrence of olivine phenocryst. This mineral is sometimes found in association with oxyhornblende.

(v) The activities of this area began with the eruption of the Ishihane-gawa mud flow and ended with the formation of a big explosion crater which poured forth a large amount of the Sasa-gawa mud flow.

(vi) By this enormous explosion, the Gassan Volcano lost its upper half of konide (?) and left behind a quite different from of volcanic body. It has a very gentle slope on the east and is highly cliffed on the west.

(vii) The first activity of the Gassan Volcano is supposed to have taken place in the beginning of the Quaternary, but it will be confirmed later in connection with the activities that happened at the Ha-yama volcanic area.

In conclusion, the writer's thanks are due to Mr. N. Jimbo and Mr. T. Konda for the valuable suggestions which they offered during his field and laboratory works.

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29. 月山火山の活動

山形大学 市村 毅

月山は，山形県の東田川郡，最上郡及西村山郡に跨り，鳥海火山帯の中でも特異な形態を有する火山である．その東側は，アスピーテを思わせる緩傾斜をみせ，西側は，大きな爆裂火口のために物凄い断崖をなしている．この火山は，花崗岩（花崗閃緑岩）石英閃緑岩，閃緑岩，石英粗面岩，珪長斑岩，石英安山岩，変朽安山岩，玄武岩，新第三紀（上部中新世）堆積岩などよりなる基盤岩の侵蝕面上に盛上り，その活動は，石跳川泥流，月山熔岩及砕屑岩，笹川泥流，順次に噴出せしめている．大爆裂火口は，月山熔岩及砕屑岩の噴出後に生じ，これがために旧月山火山の上半部が噴き飛ばされるに至つた．月山の現形態は，この際に生じたものであり，笹川泥流は，爆発に伴つて噴出したものと思われる．月山火山の活動は，恐らく第四紀の初期に始まり，大爆裂火口の生成と笹川泥流の噴出を以て，その終りを告げている．

Fig. 3. The Gassan Volcano viewed from Nenbutsugahara. This picture shows the eastern side of the volcano with a gentle slope. The lavas and ejecta exposed here rest upon the eroded surface of base rocks composed mainly of granite (granodiorite), quartz diorite, liparite, felsophyre and Tertiary sediments. 1=Gassan lavas and ejecta, 2=The terminal cliff of lavas and ejecta along the deep valley of the Tachiyazawa-gawa, 3=Base rocks.

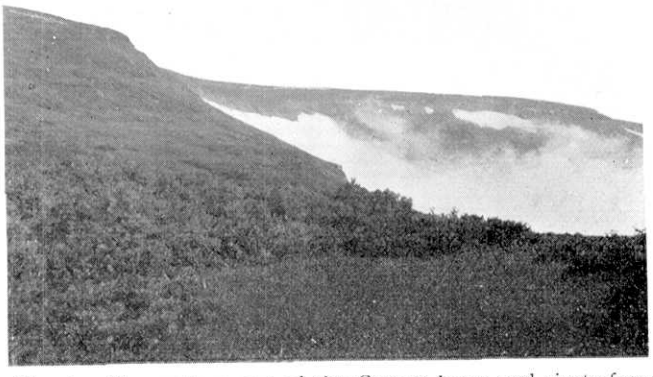

Fig. 4. The eastern end of the Gassan lavas and ejecta forming a sharp cliff along the deep valley of the Tachiyazawa-gawa.

Fig. 5. The bottom of the explosion crater viewed from the summit. Amamori-yama is a small relief built up of dacite. x= Amamori-yama.

Fig. 6. The summit of the Gassan Volcano. The rock of the foreground is olivine-bearing two-pyroxene andesite. x=Crater wall.

Fig. 7. The summit of the Gassan Volcano viewed from Kanauba near Ubaga-take. 1=Crater wall, 2=Saitōmori.