# 53. *A Note on the Daruma Volcano, Izu, Japan.*

By Hisashi KUNO,

Earthquake Research Institute.

(Read May 17, 1938.—Received Sept. 20, 1938.)

## Introduction.

The Daruma volcano, which lies close to the western coast of north Izu (Fig. 1), has received but little attention from investigators, notwithstanding that many other volcanoes in the Fossa Magna region, especially those in Izu and adjacent areas, have been studied in detail during the last ten years. For the purpose of comparing the structure and petrology of this volcano with those of the volcanoes on the eastern coast of north Izu, on the latter of which the writer has been engaged in detailed study, a short trip was made across the area in the spring of 1938,[1] when the general outline of the geology and petrology of the volcano was brought out. The scope of this paper is to present the result of this preliminary investigation.

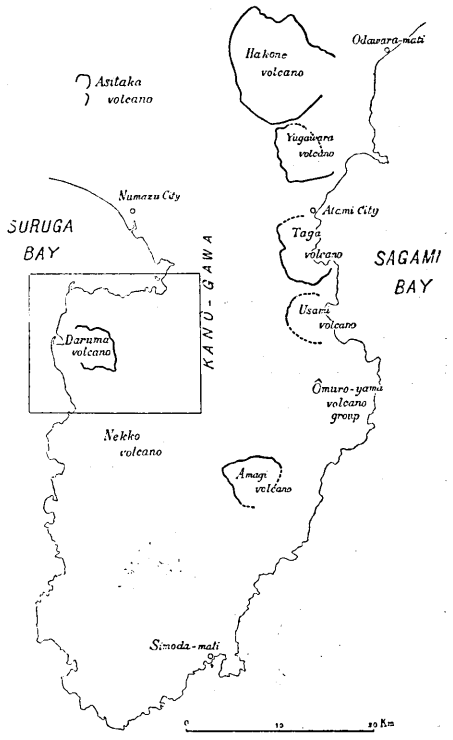


Fig. 1. Map showing the distribution of chief volcanoes in Izu peninsula.

As early as 1897, Hatutarô Isiwara, in his classical memoir on the volcanoes of Izu,[2] briefly referred to the geology of the Daruma volcano. He recognized a breached central crater, surrounded by a horseshoe-shaped ridge that stretches from Sanagi-yama, through Daru-

1) The trip took the routes from Ôhito, through Huruu, to Heta, thence to Hunayama, and from Heta again, to Syuzenzi-mati.

2) H. ISIWARA, *Report of the Earthq. Invest. Committee*, **17** (1897).

ma-yama (981·9 meters), the highest peak of the area, to a point southeast of Heta, and also a side crater which now is represented by a small pond near the summit of Sanagi-yama. According to him, the volcano is underlain by Tertiary tuffs and agglomerates. From observations made on the eastern crater wall, he established the following succession of lavas: first a flow of pyroxene-andesite; second an agglomerate lava; and third a flow of two-pyroxene-andesite. Most of Isiwara's conclusions are confirmed by the present investigation, except that the present writer had no opportunity of visiting the Sanagi-yama crater pond.

## Topography.

The Daruma volcano is bounded by Suruga Bay on the north and west, by the valley of Kanô-gawa on the east, and abuts against the Nekko volcano, which lies southward, and is presumably older than the former.

Although Daruma is deeply dissected, its eastern half still retains an elegant slope, for which reason, when looking from the north, say, a point near Numazu City, for some distance southward, one finds an even slope descending gently (at about 10°～5°) from Daruma-yama to the Kanô-gawa valley, a marked contrast to the northerly lying Huzi and Asitaka volcanoes, the flanks of which dip at about 30° near the summits. This slope is bounded on the west by a ridge that extends horseshoe-shape, opening westward. The inner side of this ridge is a precipitous steep slope more than 700 meters high, overlooking the village of Nitta. As already noted by Isiwara, this topography is obviously the remnant of the former crater, although later erosion may have more or less modified the original form.

The western part of the volcano, where dissection is more pronounced, presents a rather complicated topography, scarcely any of the original surface of the volcano being preserved. Numerous spurs, reaching the sea from the western margin of the horseshoe-shaped ridge already referred to, are cut abruptly by a great cliff more than 100 meters high. This cliff extends continuously from north to south, suggesting a fault, along which the western part of the volcano was thrown down into Suruga Bay, although no geological evidence for it is to be found.

In order to give a general topographic outline of the volcano, the map Fig. 2 was constructed by drawing a tangent to each contour line at intervals of 100 meters, using the topographic maps "Numazu" and "Syuzenzi" published by the Land Survey Department. The contour

lines in Fig. 2 indicate the most probable extension of the volcano as inferred from the topography.

The features mentioned in the foregoing are also shown in this map.

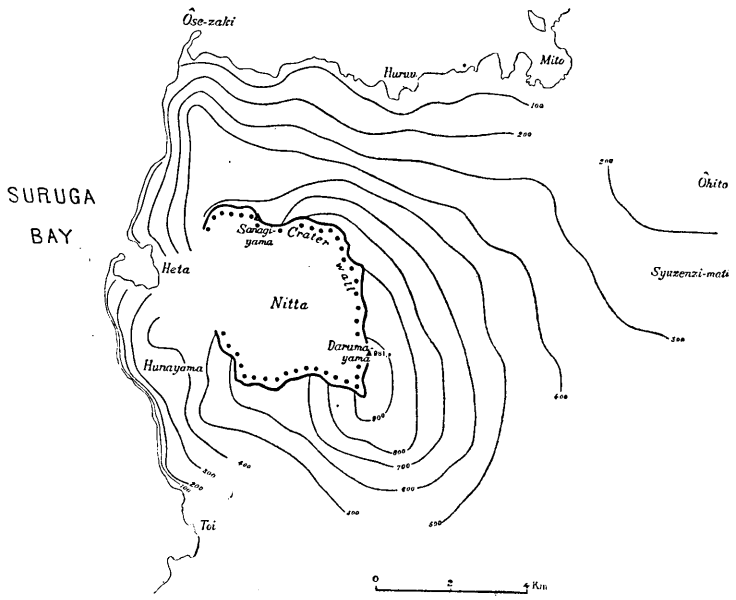


Fig. 2. Map showing the general topographic outline of the Daruma volcano. Heights are shown in meters.

## Geology.

*Basement.* The bedrocks underlying the volcano are altered dark green andesites, propylite, and the associated pyroclastics, most of which belong to the Yugasima Series[3] (Older Miocene) that form the basement of the whole Izu region. These rocks appear along the numerous valleys around the volcano, namely, between Ôhito and Syuzenzi-mati, and further south; and also near Toi. Although no exposure of these rocks is to be found in the crater bottom around Nitta[4] or along the sea cliff near Heta, it is highly probable that they will be found also underneath the volcano. Some volcanic rocks younger than the Yugasima Series, which seem to form also a part of the basement of

3) R. TAYAMA, Report of the Saitô-Hôonkai, Sendai, **11** (1931).
R. TAYAMA and H. NIINO, Report of the Saitô-Hôonkai, Sendai, **13** (1931).

4) Except some doubtful decomposed rocks that are exposed immediately east of Nitta.

the area, may be seen at several localities.

*Structure of the volcano.* The volcano is made up chiefly of lavas of hypersthene-augite-andesite, which dip periclinally from the central crater, usually conforming with the topography, although, in the area between Heta and Hunayama, they dip to the north or northwest.

The outstanding feature of this volcano is the remarkable paucity of true pyroclastic rocks, such as tuffs and tuff breccias, lying between the lavas.

On the other hand, each of the lavas is associated with scoriaceous blocky parts both above and below the solid interior, there being a complete gradation between these two parts. The blocks, which, in their lithologic characters, differ in no way from the associated solid parts, are cemented by means of comminuted fragments of the same material. Obviously, these blocky parts represent the auto-brecciated top and base of the lava flow, the interior part of which consolidated into a homogeneous solid mass. Rocks with similar brecciated appearance occur in greater bulk than the solid lavas, and are widely distributed throughout the area. Upon weathering, these rocks look like tuff breccia, and toward the lower part of the flank (between Mito and Huruu), pass into volcanic conglomerate. At any rate, most of these rocks may be classed as blocky lavas, provided that breccias of true explosive origin may not be entirely absent.

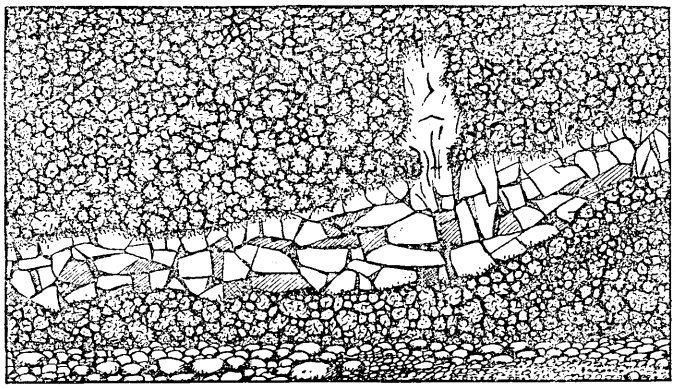

Fig. 3. Auto-intrusion in a lava flow (3~5 meters thick). Beach-gravel is shown in the lower part of the sketch.

An interesting example of an auto-intrusion is seen in one of the flows that are exposed along the sea cliff near Hunayama (Fig. 3). A

small offshoot from the solid interior part of the flow, which seems to have been sufficiently fluid at the time of emplacement, is seen to cut the overlying blocky part that had already consolidated then.

The virtual absence in this volcano of layers of tuffs or tuff breccias, combined with the predominance of blocky lavas, gives rise to a peculiar landscape. In the other strato-volcanoes of Izu and Hakone, which are built of solid lavas regularly interbedded with nearly equal amounts of tuffs, the crater walls and the valley walls exhibit a characteristic step-like topography, the resistant lavas forming lines of cliffs that alternate with those of somewhat gentle slope formed of less resistant tuffs. Such a feature is rather an exception in the Daruma crater wall, the chief characteristics of which, however, is a uniformly craggy scarp.

So far as the writer's observations go, dikes are rare in this volcano; he saw one from the valley bottom, immediately south of Sanagi-yama, and another from the sea cliff immediately west of Heta, both trending from northwest to southeast.

## Petrology and Succession of Lavas.

The majority of the rocks that were collected from various parts of the volcano are found to be of the same general petrographic type. They are hypersthene-augite-andesite, often with subordinate olivine. Rock types somewhat richer in olivine, and in composition, transitional to basalt, are also represented by a few specimens.

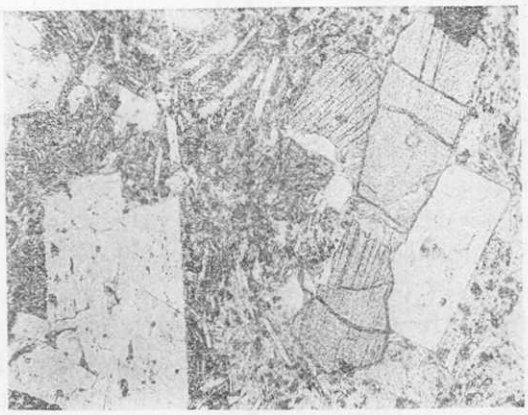

Fig. 4. Olivine-bearing hypersthene-augite andesite, showing phenocrysts of plagioclase, hypersthene, and magnetite. Northeast of Daruma-yama. ×41

1) *Hypersthene-augite-andesite.* This wide-spread type shows, in fresh specimens, abundant phenocrysts (usually less than 2 mm) of white plagioclase and black pyroxene, occasionally with subordinate yellow olivine, scatterred uniformly through a greyish compact matrix.

Under the microscope (Fig. 4), it carries phenocrysts of zoned plagioclase, light-green augite, weakly pleochroic hypers-

thene, and magnetite, sometimes attended by a few olivine and apatite. Olivine is often resorbed with formation of corona of hypersthene grains, occasionally accompanied with vermicular magnetite. In a more advanced stage of resorption, it is completely replaced by dense stellate groupings of vermicular magnetite, which are again surrounded by corona of hypersthene (Fig. 5). Apatite is usually rich in inclusions of minute rods or needles of brownish pleochroic mineral (brownish black in the direction parallel to the elongation of the needle, and brownish in the direction perpendicular to the elongation).

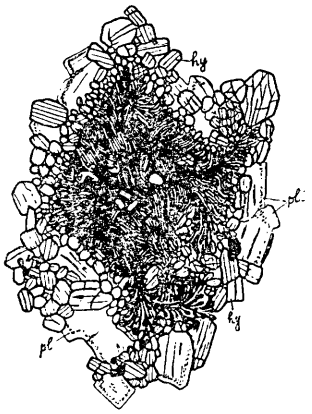


Fig. 5. Olivine phenocryst pseudomorphed with vermicular magnetite. *pl*-plagioclase. *hy*-hypersthene.

The groundmass varies slightly in texture, ranging from an exceedingly fine-grained compact type to a medium-grained holocrystalline type. The constituent minerals are plagioclase, pyroxenes, magnetite, ilmenite, alkali-feldspar, quartz, tridymite, apatite, biotite, and pale brown glass. In most specimens, hypersthene and augite ((+) 2 V about 50°) occur side by side in the groundmass, while in only one example, quasi-uniaxial pigeonite is found instead of the two pyroxenes. Ilmenite (or an isomorphous mixture of ilmenite and hematite), which is fairly abundant in the relatively coarse-grained, crystalline types, occurs in irregular-shaped plates, and is subtransparent with chestnut-brown colour. Alkali-feldspar, quartz, and biotite, all closely associated with one another, tend to occur in holocrystalline groundmass or in coarsely crystalline patches. Biotite, which occurs in irregular flakes, and which sometimes forms a thin rim around porphyritic magnetite, is pale reddish brown with a weak greenish tinge, and has a small optic angle ((−) 2 V about 20°) with strong dispersion $\rho < v$.[5]

2) *Cognate inclusion.* Cognate inclusion of plutonic texture is found in one of the lavas (hypersthene-augite-andesite) that are exposed along the sea cliff 2 km west of Heta. In hand specimen, it is vesicular, somewhat friable, and equigranular with visible crystals of pyroxene and feldspar. In thin section, the rock consists of a hypidiomorphic aggregate of zoned plagioclase, weakly zoned, light-green au-

5) These groundmass minerals have many characters in common with those found in the rocks of the Hakone and the adjacent volcanoes. They will be described in detail in a later paper dealing with the general petrography of these volcanoes.

gite, pleochroic hypersthene, olivine, dark-brown hornblende which is mostly replaced with iron ore, and magnetite. The interstices of these crystals are filled with meshes of acicular crystals of plagioclase, which the latter is rimmed with alkali-feldspar, besides those of hypersthene and smoky apatite, together with patches of cristobalite and tridymite. In its mineral composition, the rock is gabbroic.

3) *Olivine-andesite and -basalt.* A specimen collected from a roadside 2 km northeast of Sanagi-yama, which represents one of the younger flows of the volcano, is an augite-bearing olivine-andesite, transitional to basalt in mineral composition. Megascopically, it carries phenocrysts of abundant white plagioclase (up to 5 mm), sporadic yellowish olivine, and a few dark-green augite. Microscopically (Fig. 6), there are phenocrysts of zoned calcic plagioclase (anorthite-bytownite) and olivine, the latter of which is rimmed with groundmass pigeonite, besides those of a few magnetite and augite; while the groundmass consists of plagioclase, pigeonite ((+) $2V \fallingdotseq 40° \sim 0°$), magnetite, and interstitial cristobalite and pale brown glass.

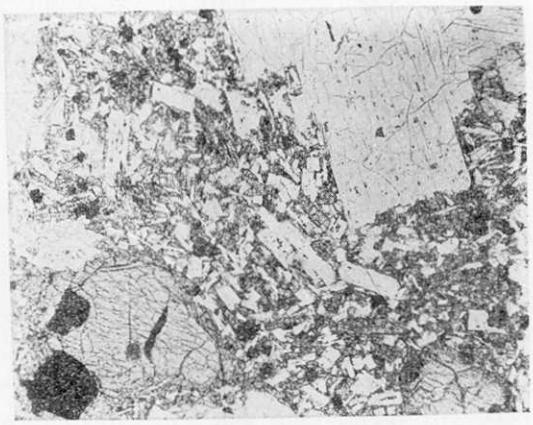

Fig. 6. Augite-bearing olivine-andesite, showing phenocrysts of plagioclase, olivine, and magnetite. Northeast of Sanagi-yama. ×41

Another specimen collected from the dike west of Heta, already referred to, may be classed as olivine-basalt, carrying, in hand specimen, large sporadic phenocrysts of anorthite (up to 1 cm) together with those of smaller plagioclase and olivine in a slightly vesicular dark-grey groundmass. In thin section, we find phenocrysts of calcic plagioclase (anorthite-bytownite) and olivine set in an intergranular basaltic groundmass consisting of plagioclase, pigeonite ((+) $2V \fallingdotseq 40° \sim 0°$), magnetite, and interstitial brown glass and cristobalite.

It was found that in the Daruma rocks, porphyritic hypersthene tends to decrease in amount in the more olivine-rich rocks until it finally disappears in the most olivine-rich basaltic types—a feature worthy of special mention in view of the fact that a similar tendency generally holds in the series of lavas that belong to the other volcanic complexes of north Izu.

On the other hand, the predominance, in the Daruma volcano, of the rock type with both hypersthene and augite in the groundmass, is a remarkable contrast to the volcanoes of the eastern coast (Taga, Yugawara, and Hakone), as most of the andesites of the latter volcanoes carry single pigeonite in the groundmass instead of the two pyroxenes.

The lava succession of the Daruma volcano can be observed almost from the base to the top in the eastern crater wall. In this craggy scarp, more than seven successive flows are exposed, each being accompanied with thick blocky parts. The lowest flow that is visible, appears immediately west of Nitta. It is a dark-green, very compact hypersthene-augite-andesite, showing a trace of deuteric or pneumatolytic alteration. As we go up the scarp along the shortcut between Nitta and the pass (735 meters high) north of Daruma-yama, traces of the alteration gradually disappear, while olivine phenocrysts, which first appear in the middle flows, progressively increase in amount toward the upper horizon. The topmost lava in this succession is an olivine-hypersthene-augite-andesite. The richness in olivine of the younger flows was verified also for other parts of the volcano (cf. p. 769).

## Summary and Conclusion.

The Daruma volcano may best be classed as a shield volcano of Hawaiian type. It has a breached central crater and a gently sloped flank. The volcano was built up chiefly by repeated gentle outpourings of lavas, and scarcely any violent explosive eruption seems to have occurred throughout the whole history of its activity. Each lava was accompanied with large masses of blocky parts above and below the solid interior,[6] which were formed by breaking down the already consolidated scoriaceous crusts. The compositions of these lavas did not change much during the successive effusions. They were mostly hypersthene-augite-andesite, which became slightly richer in olivine toward the later stage of activity. Augite-olivine-basaltic andesite and olivine-basalt were also erupted at some periods during the later stage.

Although no decisive conclusion can be drawn regarding the age of the volcano, a comparison of the extent to which dissection has proceeded in it with those of the other north Izu volcanoes, suggests that it is Older Pleistocene or slightly older.

---

6) Similar examples of shield volcanoes, which are made up essentially of blocky lavas, are described by Howel Williams from the Lassen Volcanic National Park, California, namely the Prospect Peak and Mount Harkness volcanoes. H. WILLIAMS: *Bull. Dep. Geol. Sci., Univ. California Publications*, **21** (1932).

In conclusion, the writer wishes to take this opportunity of offering his cordial thanks to Professor Seitarô Tsuboi for kindly reading the manuscript.

---

## 53. 伊豆達磨火山に就いて

地震研究所　久野　久

達磨火山は伊豆半島北部西海岸に存在する．本火山に就いては從來あまり詳細な研究が行はれて居なかつたが，筆者は北伊豆東海岸及び箱根等の諸火山との比較の爲，昭和 13 年春本地域の極く概察的な調査を試みた．其の結果本火山の構造・岩石等の大略を知り得たので茲に報告して置く．

達磨火山は所謂ハワイ式の楯狀火山に屬するもので，頂上には西方に向つて開いた解析火口（新田部落を中心とする）を有し，其の外側（特に東方）に緩かな斜面を引く．本火山は主として熔岩の靜かな流出がくり返し行はれて建設されて行つたもので，その間に烈しい爆發的な活動は殆んど行はれなかつたらしい．各熔岩の中層部は緻密に凝固して居るが，その上下層には厚い塊狀部（Blocky part）を伴ふ．熔岩の成分は火山の活動中著しい變化を示さなかつた．其等は大部分紫蘇輝石-普通輝石-安山岩であるが，後期の熔岩程僅かながら橄欖石斑晶の量を增加して行つた．又普通輝石-橄欖石-玄武岩質安山岩及び橄欖石玄武岩等も少量ながら後期に噴出されて居る．

本火山の時代に就いては何等決定的な事は云ひ得ないが，其の解析程度から考へると下部洪積期或は稍々古期に屬するものではなからうかと思はれる．

達磨火山が北伊豆東海岸の諸火山（多賀・湯河原・箱根等を含める）に比較して著しく異る點は，其の構成物質が主として熔岩より成り，純粹の火山抛出物（凝灰岩・角礫凝灰岩等）が極めて僅少な事と，其等熔岩に塊狀熔岩（Blocky lava）が多い事とである．又岩石學的には，達磨火山産安山岩には其の石基に紫蘇輝石並びに普通輝石の兩者を有する岩型が極めて優勢である點が特徵である．因に東海岸諸火山の安山岩の石基輝石は大抵の場合ヒヂオン輝石一種で代表されて居る．