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The Geological Structure of Kagoshima Prefecture, Kyūshū District, Japan.

by

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Contents.

[With Plate 1]

Abstract.

The tectonic lines of Kagoshima Prefcture* are geologically to be classified and thus, "The Kagoshima Central Tectonic Line"(1) is proposed.

Introduction.

The writer has been studing the granitic rocks of "the Outer Zone of the South West of Japan" for five years. He was asked to make the geological map of Kagoshima Prefecture by the Authorities of Kagoshima Prefecture in 1951. This report is a by-product of his survey at that time.

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* 鹿児島県　　(1) 鹿児島中央構造線

Brief Description of Rocks and Their Distribution.

(a) Palaeozoic Formation (Chichibu System ="Permo-Carboniferous"?)

The limestone bed of the Chichibu-System* is developed in the right side of the down-stream of Sendai Gawa.(2) This bed includes fusulinids. The complex of sandstone, clayslate and chart is developed in the vicinity of Akune-Shi.(3) This formation is the oldest one in this Prefecture.

(b) Mesozoic Formation. (Younger Mesozoic=Jurassic-Cretaceous?)

The formation is formed by the alternation of sandstone and shale, with a thin layer of schalstein and radiolarian-slate in rare occasions. There is the small mass of the limestone at Noma-Ike,(4) Satsuma-Hantō.(5) The limestone is similar in colour to the "Torinosu Limestone"* and includes *Isastrea tabulata* etc.(I) The thickness of the sandstone ranges from 1 *m* to 50 *m*; the shale is not so common. The total thickness was estimated several thousand meters,(II) and the writer could not find the fossils in this formation. At the Naga-Shima,(6) a sandstone bed is developed, which belongs to the Upper Cretaceous.(III)

(c) Tertiary Formation.

1. Eocene.

This formation is composed chiefly of sandstone with subordinate shale, and is exposed near the northern region of Naga-Shima.(III)

2. Oligocene.

This formation is composed chiefly of shale with subordinate sandstone, and is developed at the north region of Tanega-Shima.(7) (IV)

At the vicinity of Shibushi-Chō,(8) "Nichinan formation"* is developed. The character of this formation is as follows: The lower part consists principally of black shale; the upper part consists of the alternation of sandstone and shale, and often includes the glauconite-bearing muddy sandstone; the middle part consists principally of the sandstone bed, in some part of the alternation of mudstone and shale, calcareous sandstone, coal seam, occasionally with false bedding. The thickness of this formation is ± 450 *m*. The upper most part consists of a shale bed containing an amount of flakes of muscovite. This formation yields many fossils. It's folding is very complex.(V) It is of Oligocene (?) Series.

3. Miocene-Pliocene.

This series consist of two formations; the upper part is "Kaminaka Group"* composed of conglomerate, sandstone, sandy calyslate, iron sand and pumice bed; the lower part

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* 秩父系
(2) 川内川　(3) 阿久根市　(4) 野間池　(5) 薩摩半島
* 鳥の巣石灰岩
(6) 長島　(7) 種子ヶ島　(8) 志布志町
* 日南層群　* 上中層群

is "Kukinaga Group"* composed of sandstone, conglomerate, clayslate and *Ostrea* bed. Each of the both groups is ± 100 *m* in thickness and they are mutually conformable.

This series is developed in Tanega-Shima. From the Sumiyoshi,* the vicinity of Nishino-omote-Chō,(9) the fossils of fishes were discovered in the Ostrea-Bed. These fossils are the new species of *Clupea* and *Percichytys*. This series is correlated to the formation of Miocene in Europe and America.(VI)

Mudstone including *Bathyrarea* is developed in the Kegarazaka, Kagoshima-Shi.(10) This is of pliocene Series.(VII)

"Nagano-Bed"*, "Nagano-Age-Sediments"*, "Imuda-Age-Sediments"* are composed of tuff, tufaceous sandstone, mudy shale and conglomerate.(VIII) (IX)

The formations which consist of tufaceous shale, tufaceous sandstone and tuff, are developed in many places but they are not occupy large area.

In the tufaceous shale, diatom is discovered rarely. The fossils of the plant are found abundantly.

(d) Alluvium Formation.

The clay, sand and conglomerate are the principal components of the formation.

(e) Sand-Dune.

The sand-dune is formed at the shore-line. The thickness of it is over 30 meters at Irikihama,* Satsuma Hanto.(X)

(f) Grano-Diorite and Quartz-Diorite.

Grano-diorites are developed in Shimokoshiki-Zima,(11) and have on schistosity. This region lies on an extension line of "the Median Dislocation Line of Japan",* nevertheless, they have not the characters of the granitic rocks which are developed in "the Outer-Zone of the South-West of Japan".* (XI)

Quartz-diorites are developed in Kamikoshiki-Zima,(12) but the sedimentary rocks are not metamorphosed by their heat, perhaps the intrusion of them was previous to the formation of the sedimentary rocks.

(g) Biotite Granite.

Yaku-Shima(13) is composed mostly of Biotite-Granite. In this mass he could collect the great porphyroblast of Orthoclase which is twinned under the Calsbad's-law. Largest one is attained 12.5 *cm* in Length, 10 *cm* in width, 5.5*cm* in thickness.(XII)

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* 茎永層群　* 住吉
(9) 西之表町
(10) 鹿児島市貝殻坂
* 永野層　* 永野期堆積物　* 蘭牟田期堆積物　* 入来浜
(11) 下甑島
* 日本中央構造線　* 西南日本外帯
(12) 上甑島　(13) 屋久島

These gigantic porphyroblasts are not found in another district of Japan. The similar one is developed in Unzan-Gun, Heianhokudo, Korea* as microcline porphyroblast.

In the southern part of Ōsumi-Hanto,(14) there is the greatest exposure of granite in "the Outer Zone of South-West of Japan." Principal mafic components of it are biotite. As the result of invasion of the alkali-feldspars, the reaction rims are seen in many parts of the rocks (exsolutions).

Sericitisation of the plagioclase and chloritisation of the mafic minerals are very distinct. Most part of this mass has homogeneous chemical composition, however the marginal parts have the schistosity or the texture of injection and he could collect many xenolithes in these parts. He discovered the aggregerates of andalusite, sillimanite in the argillaceous xenolith, and in the marginal part of andalusite, many spinels and biotites were found. In these xenolithes he could find many interesting aggregerations of several minerals. He interprets it petrologically as follows.

In the course of granitization K_2O-components invade in the xenolith and SiO_2-components go away from the xenolith. So he found andalusite in the center of the argillaceous xenolith, and he found spinel and biotite in the outer part of andalusite and kalifeldspar in the marginal zone of andalusite.

The granitic mass of Uwajima, Shikoku* and the granitic mass of Owase, Kisyū* have also the aggregeration of andalusite and sillimanite in the xenolithes. He thought that the characteristic xenolithes show the marginal facies of the shallow granite enriched volatile components.(XIII)

At Takakuma-Yama(15) there is moderate mass of granite similar to them. The granitic rocks of Taniyama,(16) Kinpō-Zan(17) are also similar to them, but the granite exposed in the vicinity of Suzuyama Tin Mine(18) is very leucocratic. The granitic rocks of the Kusami, Hiokigun(19) are fine-grained and predominated mafic minerals. The granitic rocks exposed in the vicinity of Sibi-San(20) are slightly porphyritic, so they are of another type, he submits.

(h) Granite-Porphyry, Quartz-Porhyry and Porphyrite.

These rocks are predominated in Noma-Hantō,(21) and are white, greyish white, greenish or pale brownish grey in colour, coarse-grained massive rocks, in which he could find quartz, orthoclase, plagioclase, biotite and hornblende; but hornblendes are rare, most of them are replaced the aggregeration of epidote. Ground-mass often shows the flow texture, so the mass varies from the Granite-porphyry to the Quartz-porphyry. The Augite-porphyrite intrudes into the Quartz-porphyry at the eastern region of

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* 朝鮮 平安北道 雲山郡
(14) 大隅半島
* 四国宇和島 * 紀州尾鷲
(15) 高隈山 (16) 谷山 (17) 金峰山 (18) 錫山鉱山 (19) 日置郡草見 (20) 紫尾山
(21) 野間半島

Ōura.* Porphyrite intrudes into the Grano diorite and the series of the Mesozoic Epoch as the dike at the southern part of Shimokoshiki-Zima.(XIV) At Bishamon, Hiokigun,(22) the small exposure of Diorite-porphyrite is developed.

(i) Aplite and Pegmatite.

A number of aplite are found in the region of granitic rocks. These rocks include almost tourmaline. Pegmaties are very rare in comparison with the aplite.

(j) Trachy-dolerite.

The alkali-hornblende is found in it. This rock intrudes into the Tertiary-system in the north-western region of Tanega-Shima.

(k) Pyroxene Andesite and Basalt.

These rocks are abundant in the north-western region of this Prefecture. He classified Pyroxene andesites into many types, but Basalts are exposed in a small region.

(l) Hornblende-bearing Pyroxene Andesite.

These rocks are developed in the vicinity of Fuke Mine,(23) and Kirishima-Yama,(24) the north-eastern region of this Prefecture.

(m) Hornblende Andesite and Dacite.

These rocks are developed in Naga-Shima; the vicinity of Imuda-Ike(25) and the outside of the Ata-Caldera.(26)

(n) Rhyolite.

In the northern district, Rhyolite is exposed in many places.

(o) Mud Lava. (So-called "Haiishi-rui"*)

Mud Lava (welded tuff) has a great many types, the upper part has mineral assemblages different from those the lower part of the lava flow.

The writer found two types of Mud Lava in Kagoshima-Shi, and recognised as another type the Mud Lava which occurs in the Sin-Kana(27) region. Moreover he found two types of the Mud Lava in Shibusi region and two types of it in Izashiki region.(28) These types are slightly different from each other.

These Mud Lavas are erupted by the Caldera-Type Eruption and are found in Hokkaido,* the environ of Towada-Ko,* the surroundings of Naruko Volcano,* etc. in Japan.

(p) Volcanic Ash and Lapilli. (So-called "Shirasu-So".*)

These beds are composed principally of volcanic ash, volcanic sand, volcanic

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* 大浦
(22) 日置郡毘沙門　(23) 布計鉱山　(24) 霧島山　(25) 蘭牟田池　(26) 阿多カルデラ
* 灰石類
(27) 新川　(28) 伊坐敷
* 北海道　* 十和田　* 鳴子火山　* 白砂層

conglomerate and pumice, and accessary component is the breccia of andesitic rock, granitic rock, sandstone and shale. These beds are sedimented by the eruption of Caldera, and the Mud Lava is formed as a lava-flow.

(The Mud Lava, the Volcanic Ash and Lapilli are formed on the low-land or in the shallow-sea. He coloured these rocks including the pumice bed, volcanic ash bed which are formed in Quarternary Period, in the geological map.)

(q) Pyroxene Andesite and Basalt.

The Younger Kirishima Volcanic Zone(29) runs in this Prefecture from the north to the south. In Quarternary Period, Shin'moye-Yama,(30) Sakura-Zima,(31) Kaimon-Dake,(32) Shōwa-Iwō-Tō(33) flowed an amount of Lava. Sakura-Zima are the central cone of the Aira-Caldera,(34) Kaimon-Dake is Ata-Caldera's and Shōwa-Iwō-Tō are situated in the Kikai-Caldera.(35) (These three mountains lie on the one line.)

(r) Hornblende-bearing Pyroxene Andesite and Hornblende Andesite.

At Nabeshima-Dake,* the vicinity of Ibusuki-Chō,(36) these rocks are exposed as a dome-like volcano.

Geological Relations of Rocks

(a) Relations of the Sedimentary Rocks.

The geological relation which lies between the Palaeozoic System and the Mesozoic System is a fault. The Mesozoic System is overlain by Tertiary System as the relation of Clino-Uncomformity. The relation between the Eocene Formation and the Oligocene Formation is not clear. The relation between the Oligocene Formation and the Miocene-Pliocene Formation is a Clino-Uncomformity.

(b) Age of the Granitic Rock intrusion.

Quartz-diorite which is developed in Kamikoshiki-Zima was formed in the Age prior to the Mesozoic Era.

Grano-diorite, Biotite granite, granite porphyry, Quartz porphyry and Porphyrite intruded in the Mesozoic System as one series of the igneous activity. The age of the intrusion is, Post-Jura-Period, Pre-Miocene. The writer could not find the exposures owing to which the Tertiary System is contacted by the granitic rocks, but he presumes that the age of the intrusion is the early age of the Tertiary Period, judging from the similarity of characteristic xenolith of another district.

The thermal metamorphism of the granitic rocks formed many mines of W, Mo, Au, Ag, Sn, Cu, Pb, Zn, etc., in the Yaku-Shima region, in the southern region of Ōsumi Hantō, in Takakuma region, in Noma region, in Suzuyama region, in Koshiki-Zima region and in Shibi-San region.

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(29) 新期霧島火山帯 (30) 新燃山 (31) 桜島 (32) 開聞嶽 (33) 昭和硫黄島
(34) 姶良カルデラ (35) 鬼界カルデラ
* 鍋島岳
(36) 指宿町

(c) The Eruption Age of the Andesites.

Older one is about Miocene Epoch and younger one is about Post Tertiary Period.

There are many gold and silver mines in this Prefecture, for example; Kushikino(37)-Arakawa(38) region, Yamagano(39) region, Fuke-Ushio(40) region, Yamada(41) region, Ōno-Yama(42) region, Kasuga(43)-Akeshi(44) region, the western region of Ikeda-Ko,(45) Izashiki region and Miyanoura(46) region. The most of these Mines are formed by the older volcanic action.

Geological History and Geological Structure

(a) The writer studied the geological structure according to the data of the Geomorphology, Geology and Geophysics,(XV)-(XIX)found the four directions which are predominated in this prefecture; namely N 60°±10° E, N 10°±10°E, N 50°±10° W and the directions of N 10°–20°W which are existing as an exceptional case.

The directions of N 60°±10°E are paralleled to "the Median Dislocation Line of Japan". These direcions are recognized in the Mesozoic System which is developed in the north-eastern district, and in the granitic rocks which are exposed in the southern region of Ōsumi Hantō.

The directions of N10°±10°E are developed in the Older Kirishima Volcanic Zone,(47) the Younger Kirishima Volcanic Zone and the Zone of the granitic rocks which are formed by Cryptvolcanoes(48) and the Zone of the Tertiary System.(49)

The directions of N 50°±10°W are not developed so long, but the number of them is numerous.

The exceptional direction of N 10°–20° W is found in the Akune-Sendai(50) region, Taniyama-Kiire(51) region and Furue(52)-Takasu(53) region.

There are several quartz calcite veins with chlorite have the strike N 60°-70° E, the dip is 70°-80°NW in the propyrite at Fuke-gold mine. These veins are paralleled each other, the width of the two veins is about 350 *m* or multiple meters of it. Another quartz-calcite veins have the strike N46°W, the dip 70°-80°SW; these veins also are paralleled each other, the width of the two veins is about 250 *m* or multiple meters of it. And the vein of water has the strike N10°-15°E, the dip is vertical.(XX)

At Kushikino Gold Mine, four directions of vein, namely N 50°E, N 70°-80° E, N 80°W and N 40°-60°W are found, the gold ore are pregnant with these veins. The direction of N 50° E, N 70°-80° E is superior to the others, and the direction of N 40°-60° W cuts clearly the direction N 50° E, N 70°–80° E. After the formation of the ore deposit, the faults are fomed in the direction of N 10°–20°W, N 80°W.(XXI)

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(37) 串木野 (38) 荒川 (39) 山野 (40) 布計 (41) 山田 (42) 王の山 (43) 春日 (44) 赤石 (45) 池田湖 (46) 宮之浦 (47) 旧期霧島火山帯 (48) 深火山性花崗岩帯 (49) 第三紀層帯 (50) 川内 (51) 喜入 (52) 古江 (53) 高須

By the way, the strikes of the vein are almost E-W, the dips are almost north side in the region of southern Satsuma, and the vein has similar direction in Takakuma region and the south region of Ōsumi Hantō.

(**b**) Compilating these geological facts, he found that the direction of N60°±10°E is predominated in the sedimentary rocks which are well developed in the northern districts, he submits the genesis of this direction is not found in so deep a place. The direction of N10°±10°E is due to the magma-reservoir which is thought existing 10-20Km in depth. The direction of N50°±10°W is formed owing to the unstability of the medium depth. However the direction of N 50°±10° W is formed prior to the direction of N 10°±10° E as the force of disturbance acted from the north-westernward in the deep place.

(**c**) Among the directions of N 50°±10° W, the tectonic line which passes Ijūin,(54) Higashi-Ijūin(55) is very long; the elongation of it is recongnized as Furue-Kanoya(56) region. And this tectonic line is interrupted by the granitic mass, and the effects are recognized as the group of the little fault in the granite region.

The southern region of this tectonic line moves in a south-easterly direction to the northern region.

The southern region of this tectonic line goes up relatively to the northern region.

(**d**) The writer studied petrologically the granitic rocks and its contact behaviors at Shibi-San, Ijuin, Suzuyama, Noma-Hantō, Takakuma-Yama, Izasiki, Southern Ōsumi, Koshiki-Zima and Yaku-Shima and compared the ore deposit related these intrusives. He submits that these intrusives are cooled very slowly in the shallow place and he can see the top of the mass in the field.

The mass of Ōsumi granite has the greatest area in "the Outer Zone of South-West of Japan" in comparison with another mass. The cause of this fact is the effect of this tectonic movements; and the direction in the granite also was the effect of them, he submits.

(**e**) The writer has compiled this data according to the geological history as follows:

1. In the end of the Mesozoic Era, the base of this district was up-heaved. This land had the tendency of direction NE-SW.

2. In the early age of Tertiary Period, the activity of the Riūkiū Arc, that is the compression, or the force of the push up from the north-west had happened.

The writer surmises that the intrusion of granite which is the For-Runner of the activity of volcanic intrusion had happened in the region which is paralleled to the Kirishima Volcanic Zone, so that the mass of this granitic rocks is recongnized principally in the eastern part of the older Kirishima Volcanic Zone.

He concludes the origin of the intrusion of the granitic rocks is as follows;

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(54) 伊集院　(55) 東伊集院　(56) 鹿屋

(i) The basaltic magma goes up into the Sial Zone from the Sima Zone through the weak zone.

(ii) The Sial Zone which is remained fluidal condition under the high pressure, high temperature, is irritated by the movement of the basaltic magma.

(iii) The mass of the granitic rocks intrudes the upper layer gradually. (This is the granitic rocks formed by Cryptvolcanoes, he submits.)

Those granitic rocks occur in a small area and indicate the feature of the shallow facies.

Secondary, the compression, or the force of the push up from the north-west results in the eruption of many volcanoes and formed the Older Kirishima Volcanic Zone.

3. In the age of the Quarternary Period, the movement added from the north-west formed the Younger Kirishima Volcanic Zone, between the Older Kirishima Volcanic Zone and the zone of the granitic rocks which are formed by Cryptvolcanoes.

The early stage of this volcanic activity is characterised by the Caldera-Type Eruption. The cause is as follows, he submits.

(i) Andesitic magma intrudes the granitic solid mass.

(ii) As the granitic mass has an amount of gas, so the eruption was very severe, erupted an amount of pumice, flowed the Mud Lava (Welded Tuff) several times and then gushed out the volcanic ash, sand, pebble and pumice.

4. On reflection, the compression, or the force of the push-up which had happened from the early age of Tertiary Period push south-easternward "the Usuki-Yatsushiro Tectonic Line"* (a part of "the Median Dislocation Line of Japan") and formed the tectonic line which lies from Akune to Sendai. And the surplus force of this action formed "the Kagoshima Central Tectonic Line", and the southern district of this line moved about 10 kilometers south-easternward to the northern district.

5. From the early age of Alluvial Epoch to Recent Age, the Younger Kirishima Volcanic Zone is active, but this is the geological phenomena on the surface, the compression, or the force of the push up from the north-west is active moderately in the deep layer.

Summary and Conclusion

(1) The structural directions, N 60°E, N 10°E, N 50°W, are recognized topographically.

(2) The structural directions, N 60°±10° E, N 10° E, N 50°±10° W are recognized geologically.

(3) These three directions reflected to the genesis of the ore deposit.

(4) The direction, N60°±10°E, is predominated in the sedimentary rocks, so the genesis of this direction is not in so deep a layer (Upper layer). The direction, N10°E

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* 臼杵-八代構造線

is predominated in the Two Volcanic Zones, the Granitic Zone and Tertiary Zone. The origin of this directions exists in the deep-layer (Lower layer). The direction, N 50° ± 10°W is derived from the unstability which exists in the middle of two layers, but the stage of the formation of it is prior to the formation of the direction N 10° E on the surface of the earth.

(5) One of the directions, N50° ± 10°W, namely, the tectonic line lies in the Ijūin ~Higashi-Ijūin is recognized clearly the elongation of it is found also in the region of central Ōsumi. The writer proposed to name this tectonic line. "The Kagoshima Central Tectonic Line". The southern district of this line moved about 10 kilometers south-easternward to the northern district.

(6) Correlating the granites, their contact behaviours, related ore-deposits, the granite of Ōsumi is slightly deep facies of the shallow granite, he has found. So the writer thought that the southern part of that fault goes up to relatively the northern part.

(7) In the southern district of that line the writer has recognized the direction of N 10°–20° W, this direction is formed by the drifting of this region caused by the compression.

(8) Surveying the sea-map, he has found that the mass of Ōsumi is separated from the mass of Ōshima-Okinawa* by the fault, and the mass of Miyako-Zima* is separated also from the latter.

(9) He has found the map indicating the Palau-Kyūshū* geanticline in the recent literature.(XXII) This Palau-Kyūshū geanticline may be pass the central part of this Prefecture. In the morphological map of the sea-area, the topography of the elongation of the "Kagoshima Central Tectonic Line" is disturbed.

(10) The Welded Tuff of Ata-caldera and Aira-caldera, flowed out several times as "Nuée ardente". The volcanic ash and lappili are sedimented several times. These formations are controled by the errosion surface of tertiary rocks and effected by the tectonic movement above mentioned.

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Plate 1
Geological and Structural Map of Kagoshima Prefecture, Kyûshû, Japan.

Tadao Arita (1953)

130° 131° 32° 31°

1. "Kagoshima Central Tectonic Line"
2. Sendai-Gawa
3. Akune-Shi
4. Noma-Ike
5. Satsuma-Hantô
6. Naga-Shima
7. Tanega-Shima
8. Shibushi-Chô
9. Nishino-omote-Chô
10. Kagoshima-Shi
11. Shimokoshiki-Zima
12. Kamikoshiki-Zima
13. Yaku-Shima
14. Osumi-Hantô
15. Takakuma-Yama
16. Taniyama
17. Kinpô-Zan
18. Suzuyama
19. Kusami
20. Shibi-Zan
21. Noma-Hantô
22. Bishamon
23. Fuke
24. Kirishima-Yama
25. Imuda-Ike
26. Ata Caldera
27. Shin-Kawa
28. Izashiki
29. Younger Kirishima Volcanic Zone
30. Shin'moye-Yama
31. Sakura-Zima
32. Kaimon-Dake
33. Showa-Iwô-Tô
34. Aira Caldera
35. Kikai Caldera
36. Ibusuki-Chô
37. Kushikino
38. Arakawa
39. Yamagano
40. Ushio
41. Yamada
42. Ônoyama
43. Kasuga
44. Akeshi
45. Ikeda-Ko
46. Miyanoura
47. Older Kirishima Volcanic Zone
48. Granitic Zone
49. Tertiary Zone
50. Sendai
51. Kiire
52. Furue
53. Takasu
54. Ijûin
55. Higashi-Ijûin
56. Kanoya

"Kagoshima Central Tectonic Line"

Older Kirishima Volcanic Zone

Younger Kirishima Volcanic Zone

Granitic Zone

Tertiary Zone

10 km

10 km

Aira Caldera

Ata Caldera

Kikai Caldera

8 4 0 4 8 12 16 20 24 28 32
Scale (km)

N

W E

S

Legend

- Quaternary
- Tuff, etc.
- Andesite, etc.
- Granite, etc.
- Tertiary
- Jurassic-Cretaceous?
- Chichibu-System
- Tectonic Line
- Margin of Caldera