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The Miocene Volcanic Activity in San-in District, Southwestern Japan.*

Part I.

By

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Contents

I Introduction

Since 1949 the members of the "Research Group of San-in Tertiary" in the Geological Institute of Hiroshima University have under the leadership of Prof. S. IMAMURA continued to study on the straitigraphy and volcanic activity of Tertiary in San-in District, Southwestern Japan. Many valuable investigations have been reported by them on every annual meeting of the Japanese Geological Society and on periodical meetings of the West Japan Branch of the same society.

Since 1951, the author, as a member, has been playing a part in field observations of the southern area of Izumo city, the environs of Matsue city and Dôgo, Oki Islands with some members of the group. and especially studied volcanostratigraphically and petrographically the volcanic activity of Tertiary in the localities concerned. In the laboratory, massive data and slides of specimens collected by all the members are being investigated by the author. The outline of the miocene volcanic activity and chemical properties of some volcanic rocks will be reported in this paper.

Many thanks must be stated to Prof. S. IMAMURA for his helpful guidance and at the same time, the aid as well as the great efforts of

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the members of the Research Group of San-in Tertiary are greatly appreciated. Also the kind assistance of Mr. T. HABARA, graduate student of Hiroshima University, concerning chemical analysis is greatefully acknowledged. Finally, particular thanks are due to the Ministry of Education for grant in aid which has rendered possible this study.

II 4 Cycles of the Miocene Volcanic Activity

Concerning the Cenozoic volcanic rocks of San-in district, Dr. T. TOMITA has since 1935 exceedingly contributed especially to the study on the alkaline rock of the East-Asiatic province.[1,2,3] His investigations were abundant in the most various important suggestions with respect to the present study and accordingly the volcanostratigraphical and petrographical inspection as to the San-in Tertiary, which is to be dealt with in this paper, will be correlated to his works.

The areas, the central part of Shimane Prefecture, consisted mainly of the Tertiary which have been investigated by the members of the Research Group, are situated on the peripheral zone along the Japan Sea and include (1) the central part of Shimane peninsula[4,7,8] 島根半島中央部, (2) the environs of Matsue City[3,11] 松江市近郊, (3) the southern area of Izumo City[10,15] 出雲市南域 and (4) the surroundings of Ômori-chô[6,11] 大森町周辺. In this paper they are called simply Shimane peninsula area, Matsue City area, Izumo City area and Iwami Province respectively.

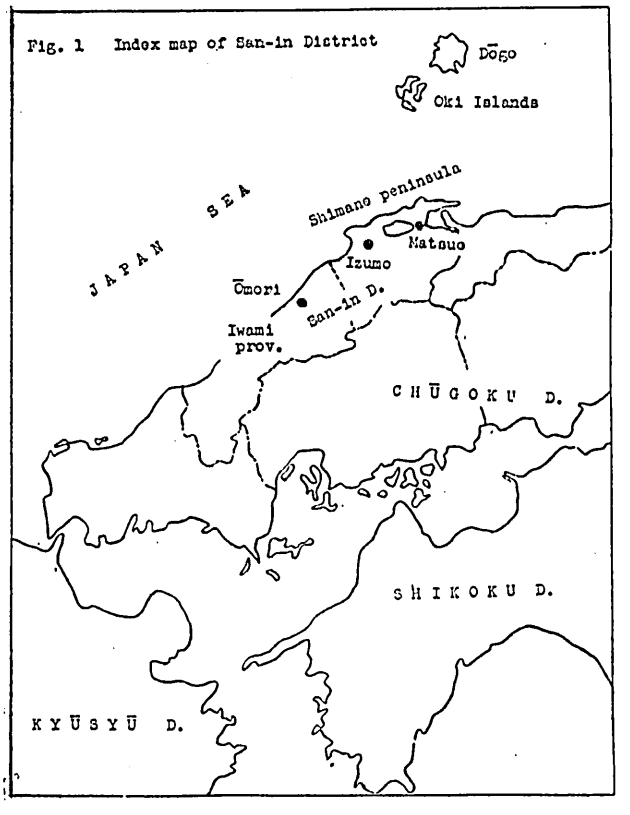

Fig. 1 Index map of San-in District

In the Tertiary, which are mainly Miocene, of these areas in San-in district, 4 conspicuous cycles of

volcanic activity are observable, and magmatic differentiation is distinct in each cycle. The relation[2,7,9,14] between Tertiary stratigraphy and volcanic cycles are shown in Table 1.

Table 1 The relation between the Miocene Stratigraphy and Volcanic Activity in Shimane Prefecture.

Geol. age	Stratigraphy: Letter Nomin.	Stratigraphy: Izumo City and Iwami Prov.	Stratigraphy: Peninsula	Volcanic Activity: Chem. comp.	Volcanic Activity: Cycle	Volcanic Activity: Sign of rocks	Rocks of Dôgo, Oki Islands (T. Tomita)
Pliocene	H_2						C AT_2 ALP
	H_1					A_4	AT_1
Miocene	G	Izumo G. / Huzina F.	Shinji G. / Matsue F.	Alkalic	4	PA_4 HTB_4 OTB_4	TB
	F_3	Izumo G. / Kimati F. Izumo G. / Ômori F.	Shinji G. / Furue F.	Calc-alkalic	3	$2PA_3'$ D_3 $2PA_3$ B_3	$2PA_3$ $2PA_2$ B
	F_2	Tamatukuri and Kawai Group	Shinji G. / Furue F.		2	LP_2 PA_2	LP PA_1
	F_2	Tamatukuri and Kawai Group	Shinji G. / Koura F.				
	F_1	Hata and Kimitani Group			1	LP_1 D_1 PA_1 $2PA_1$ B_1	
Olig.	E						

1) *The First Cycle in the Lower Miocene* (F_1–F_2).

The first cycle is observed distinctly in Izumo City area and Iwami Province. In Shimane peninsula area and Dôgo, Oki Islands, it is not conspicuous. The Hata group[6,15] in Izumo City area and the Kimitani group[6] in Iwami Province are mainly composed of volcanics of this cycle. The main rocks of this cycle are basic two-pyroxene-andesite,

augite-andesite, dacite and liparite in both areas, and in Izumo City area, augite-basalt too is observed. The sequence of extrusion of these volcanic rocks in Izumo City area was stratigraphically observed to be almost from basic to acidic; i. e., from older, augite-basalt, hypersthene-augite-andesite, dacite and liparite. Among these rocks, two-pyroxene- and augite-andesites are most extensive and abundant. In Iwami Province, the sequence of extrusion is quite similar to that in Izumo City area, but the different points are that biotite-liparite is observed extensively at the last stage of this cycle and basalt has not been observed yet.

From the mineral assemblage and chemical composition, the rocks of this cycle seem to belong to the calc-alkalic rock-series. Chemical composition of this cycle will be reported in Part II of this report. As mentioned above, the volcanic rocks of this age seem to indicate a suite of magmatic differentiation from basic to acidic. The rocks have usually been altered to the so-called green rocks and green tuffs.

2) *The Second Cycle in the Middle Miocene* (F_2).

The second cycle is observed in all areas but far less distinct than the first cycle. Andesite and plagioliparite at the middle stage of the Tamatukuri-Kawai group belong to this cycle. The volcanic activity of this cycle seems most vigorous in Shimane peninsula area[4,7,8] where propylite, green tuff, etc., and a large amount of plagioliparite and quartz-porphyry are observed subsequent to the sedimentation of the Jôsôji shale-member. The rocks of this cycle are observed in other areas too; i. e., apo-andesite which at the southern coast of the Shinji Lake[3] was studied by T. TOMITA and E. SAKAI, andesitic tuff-breccia and liparite in Izumo City area and plagioliparite in Kutagi and Kawai, Iwami Province.

These kinds of andesite seem to be correlate to the first pyroxene-andesite and these plagioliparites, to potash-albite-quartz-liparite and plagioliparite at Dôgo, Oki Islands.[2] Basalt in this age has not been observed in all areas yet. The author believes that these andesites and plagioliparites make a suite of magmtic differentiation.

3) *The Third Cycle in the Middle Miocene* (F_3).

The volcanic activity of the third cycle is the most conspicuous one of all and throughout all areas in the San-in district.

In Shimane peninsula[4,7,8], intrusive bodies of gabbroic and doleritic rocks, and diorite, extrusive beds of spilitic and basaltic rocks, and thick beds of andesitic lavas and green tuffs are recognized contemporaneous with the Ushikiri alternation-member. In Izumo City area,[15] and Ômo-

ri,[6,11] Iwami Province, this cycle is most distinct too and there are relics of centers of strong activity in both areas. Generally, throughout all areas, the sequence of extrusion is considered from basic to acidic; i. e., titaniferous augite-basalt or gabbroic rocks, two-pyroxene-andesite, dacite and two-pyroxene-leucoandesite. This cycle represents a good example for magmatic differentiation.

These rocks of this cycle are correlated to the cycle of basalt, the second pyroxene-andesite and the third pyroxene-andesite at Dôgo, Oki Islands.

The alteration of these rocks is less than for the rocks in the former cycles, while only gabbroic, doleritic or basaltic rocks in Shimane peninsula area are altered to spilitic rocks. The period of this activity seems to have been prolonged partly to the stage of the Kimati formation in Izumo area.[15]

According to the chemical composition of some rocks of this cycle, they undoubtedly belong to a sort of the calcic rock-series. Up to this cycle, no alkalic rocks have been found yet in San-in district.

4) *The Fourth Cycle in the Upper Miocene* (G).

The fourth cycle is confirmed in the middle stage of the Matsue formation in Matsue City area.[3,7,8,12]

Olivine-trachy-basalt, olivine-dolerite and augite-andesite belong to a group in this cycle. Hornblende-cristobalite-bearing-andesite may also belong to the last one in the same cycle. There is one great different point that basaltic rocks in this cycle always have larger amounts of olivine than those in the former cycles. These rocks, undoubtedly belong to the so-called alkalic rock-series and are correlated to the alkaline rock-series of Dôgo, Oki Islands. Doleritic rocks, distributed at Kawazu, Matsue City, are severely altered to green rocks.

Conclusively, in the San-in district, 4 cycles of volcanic activity are ascertainable and members of the first, second and third cycles belong to the calc-alkalic rock-series, and a suite of the fourth cycle belongs to the alkalic rock-series. In other words, characteristics of the Miocene volcanics in the San-in district change from calc-alkalic to alkalic in the course of geological age.

According to the field investigations in Izumo City area and Iwami Province, the center of each volcanic activity is regarded to move from the south or the higher mountain zone to the north or the lower coastal zone during the former three cycles.

III Chemical Composition of Volcanic Rocks of the Third Cycle.

The chemical composition of 6 specimens belonging to the third cycle are shown in Table 2.

Table 2 List of chemical composition of volcanic rocks of the third cycle. (Analyst: M. MUKAE)

No.	1	2	3	4	5	6
SiO_2	50.00	58.51	59.41	65.25	63.26	65.65
TiO_2	0.41	0.77	0.94	0.59	1.30	1.05
Al_2O_3	14.73	16.11	15.69	12.83	12.40	11.75
Fe_2O_3	5.20	1.85	2.99	5.87	2.97	5.68
FeO	7.49	5.01	4.72	2.83	3.02	2.75
MgO	4.31	2.98	3.17	4.63	3.40	1.33
CaO	10.06	8.51	7.50	1.56	1.03	4.71
Na_2O	1.71	1.94	2.06	2.45	2.93	3.10
K_2O	2.02	1.75	0.93	1.91	2.27	1.60
P_2O_5	—	—	—	—	—	—
MnO	—	0.24	—	—	0.35	0.21
H_2O+	0.70	0.29	0.81	0.56	0.88	0.71
H_2O-	2.53	1.49	1.03	0.82	0.57	1.19
Total	99.16	99.45	99.25	99.42	99.38	99.73
Q	5.70	17.70	22.03	33.24	35·01	31.62
C	—	—	—	3.77	3.47	—
or	11.68	10.01	5.56	11.12	12.79	9.45
ab	14.15	16.30	17.82	20.96	24.63	26.20
an	26.69	30.30	3.05	8.05	5.00	13.34
Wo	9.74	4.99	2.78	—	—	4.18
En	10.80	7.50	7.90	11.60	8.50	3.30
Fs	8.71	6.60	4.62	—	1.72	—
mt	7.66	2.78	4.41	7.66	4.41	6.50
hm	—	—	—	0.64	—	1.28
il	0.76	1.52	1.67	1.05	2.43	2.13
Class	3	2	2	2	2	2
Order	5	4	3	3	3	3
Rang	4	4	4	3	4	3
Subrang	3	3	4	4	4	4

The localities and brief petrographical notes of the examined specimens are as follows:

No. 1. Augite-basalt; B_3; Fig. 4.

Locality: Kanetsuki, Hiebara-mura, Hikawa-gun, Shimane Prefecture. 島根県簸川郡稗原村鐘築

In the field, this basalt has an abundance of distinct columnar joints and is megascopically compact, fine-crystalline, black-colored, and of very fresh properties. Under the microscope, it has clearly basaltic texture without phenocrysts and is very fresh. The essential minerals included are as follows: Labradorite～basic andesine, characteristic titaniferous augite, iron ores and no olivine.

No.2. Two-pyroxene-andesite; $2PA_3$; Fig. 5.

Locality: Yawatabara, Kubota-mura, Hikawa-gun, Shimane Prefecture. 島根県簸川郡窪田村八幡原

This specimen was collected from the new cutting of the northern road along the Kando river. Under the microscope, it is fine crystalline without phenocrysts, having rather basaltic texture, and very fresh. The essential minerals are as follows: Basic andesine, augite, hypersthene and iron ores.

No.3. Two-pyroxene-andesite; $2PA_3$; Fig. 6.

Locality: Kentabara, Asayama-mura, Hikawa-gun, Shimane prefecture. 島根県簸川郡朝山村見田原

The specimen, a part of lava flow, is very fresh, compact and aphanitic. Under the microscope, it is porphyritic, having a little amount of phenocrysts in aphanitic groundmass. The phenocrysts are as follows: Andesine～oligoclase (An_{33-22}), augite and a few amount of hypersthene.

No.4. Dacite; D_3; Fig. 7.

Locality: At the quarry near the branch of the primary school at Mimigu, Asayama-mura, Hikawa-gun, Shimane Prefecture. 島根県簸川郡朝山村見々具

This is a porphyritic rock with a large phenocryst of quartz and plagioclase and very fresh. Under the microscope, the phenocrysts are as follows: Andesine, corroded quartz and a small amount of opacitized hornblende.

The groundmass is fine-crystalline and composed of plagioclase, augite, iron ores, quartz, etc.

No.5. Dacite; D_3; Fig. 8.

Locality: At the quarry of Magi, Kamiasayama, Asayama-mura, Hikawa-gun, Shimane Prefecture. 島根県簸川郡朝山村上朝山馬木

This is quite similar to No. 4, both megascopically and microscopically.

No.6. Two-pyroxene-leucoandesite; $2PA'_3$; Fig. 9.

Locality: At the quarry of Sugezawa, Oda, Kiku-mura, Hikawa-gun, Shimane Prefecture. 島根県簸川郡岐久村小田菅沢

Megascopically, this is aphanitic, compact and very fresh. Under the microscope, it is very leucocratic, with scarce phenocrysts which are mainly oligoclase but rarely accompanied with chloritized augite and hypersthene. The groundmass is microcrystalline, and composed of feldspathic materials and shows felty texture. It is a special feature of this rock to be leucocratic.

Chemical compositions are diagramatically shown in Fig. 2 and 3. Although the values obtained for each oxide are somewhat deviated from the average, it may be deduced from these diagrams that all rocks are the derivatives from the same magma. A reason for these deviations seems to be ascribable to the selection of specimen, some of which have large amounts of phenocrysts and the other, on the contrary, contain almost no phenocryst. As is clarified in Fig. 2, both lime and total

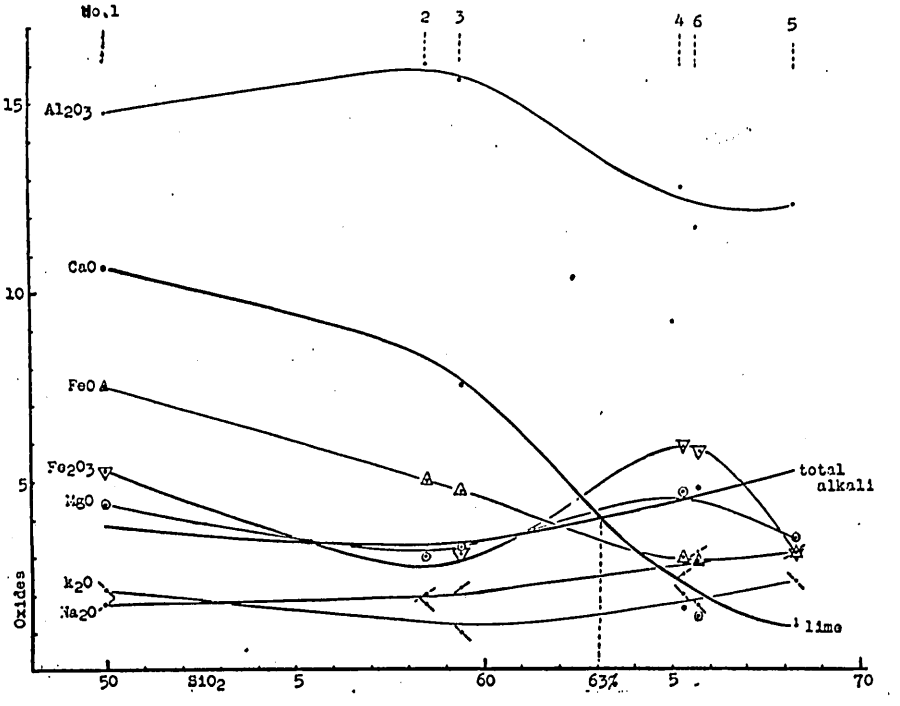

Fig. 2 The variation diagram for the rocks of third cycle.

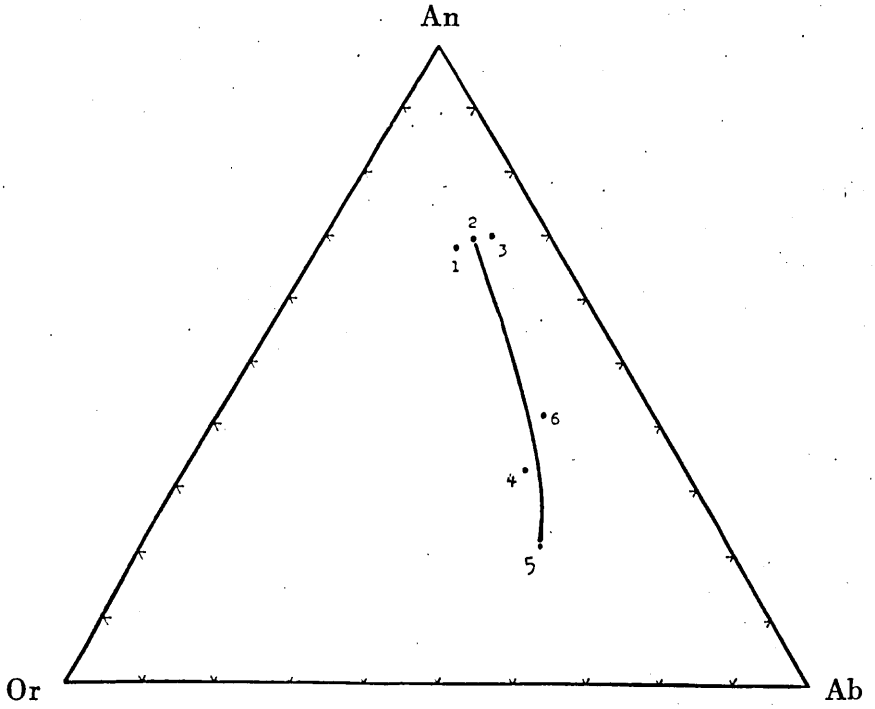

Fig. 3 The Or – Ab – An diagram. Mol. % of Norm.

alkalies are intersected at the point of 63% SiO_2.

Synthesizing this fact and mineralogical characters, the rocks in the third cycle are undoubtedly recognized to belong to the calcic rock-series,

IV Summary

1) As far as the Miocene volcanics appearing within the San-in district are concerned, 4 cycles of volcanic activity are clearly observable. It is almost undoubtful that volcanics in the earlier three cycles belong to the calc-alkalic rock-series, while merely those in the latest cycle belong to the alkalic rock-series. Until the present time it seems a fact that alkalic rocks are found nowhere within this district during the periods of the former three cycles. As mentioned above, the petrological characteristics of the volcanics in question change from calc-alkalic to alkalic in the course of geological age.

2) In Izumo City area and Iwami Province, the center of each volcanic activity is distinctly recognizable to have moved from the south-

ern higher mountain zone to the northern lower coastal zone, during the earlier three cycles.

3) It seems that the sequence of extrusion in each cycle shows a variability from basic to acidic and consequently a good example for magmatic differentiation.

Further discussions and investigations concerning mineralogical and chemical characters of the rocks in the other cycles will be reported in Part II of this paper. In the future, the fundamental study of the mutual relations between each volcanic cycle, sedimentary cycle and crustal movement must be done.

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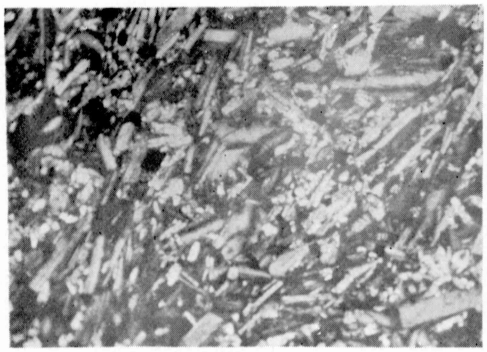

Fig. 4 Augite-basalt (No. 1). B_3. + nicol, × 20. Labradorite~basic andesine, titaniferous augite and iron-ores.

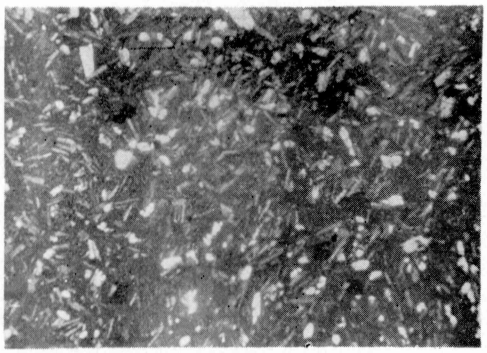

Fig. 5 Two-pyroxene-andsite (No. 2). $2PA_3$. + nicol, × 45. Basic andesine, augite, hypersthene and iron-ores.

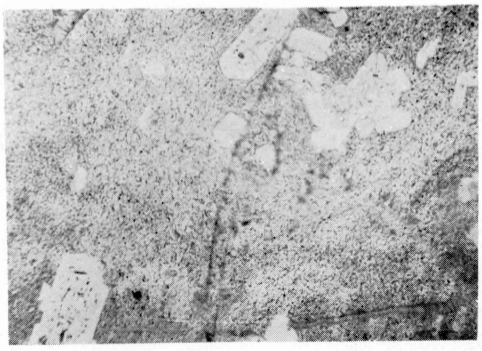

Fig. 6 Two-pyroxene-andesite (No. 3). $2PA_3$. // nicol, × 20. Andesine, augite and hypersthene.

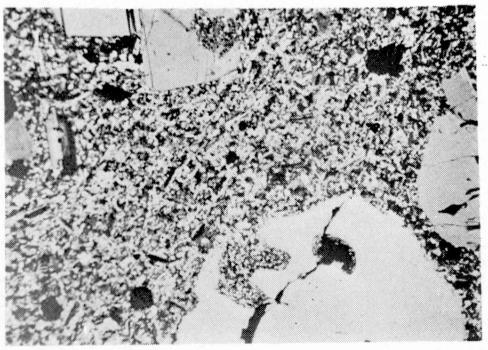

Fig. 7 Dacite (No. 4). D_3. + nicol, × 20. Quartz and andesine.

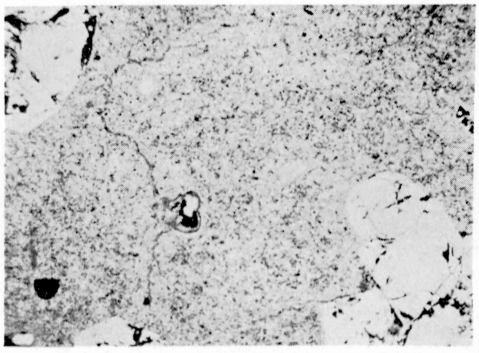

Fig. 8 Dacite (No. 5). D_3. // nicol, × 20. Quartz and andesine.

Fig. 9 Two-pyroxene-leucoandesite (No .6). $2PA_3'$. + nicol, × 20. Scarce phenocrysts of oligoclase.