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Some notes on the pitchstones from the Shimane peninsular district, Shimane prefecture, Japan.

By

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I. Introduction

The Shimane peninsular district is a part of the San-in Neogene province situated in the most southwestern marginal region composed of the so-called "Green Tuff".

The work taken by the writer is the study of the pitchstone interbedded with plagioliparite flow and its pyroclustics occured especially in the Shimane peninsular district.

On the basis of the results, the writer wants to describe the petrographical and petrochemical data and thus to discuss the petrological probrems.

II. Stratigraphical relationships

Rocks diagnozed by the writer as the pitchstone, interbedded with plagioliparite flow

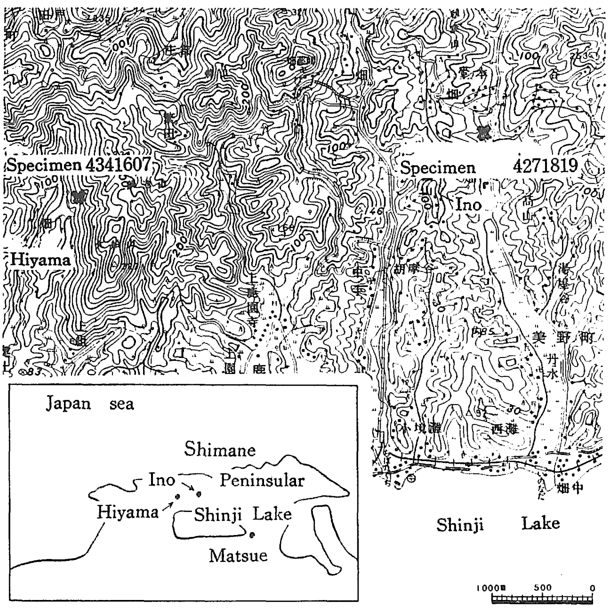

Fig. I. Map showing the pitchstone localities.

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and its layers of more normal pyroclastics, are correlated to the acidic volcanic member of the Omori formation belonging to the San-in Neogene.

The Omori formation consisting of alternated beds of volcanics from acidic to intermediate properties, sandstone, conglomerate, and black shales, is widely distributed-along the Shimane peninsular district.

According to IMAMURA and his group (1951-1957), the Omori formation produced in the upper Miocene(G) in age, where the letters with suffix in the respective parentheses indicate the biochronologicalscale suggested by IKEBE (1948).

As showen in Eig. I, the pitchstones described in this paper are exposed in the areas of about 4 square Km, situated about 20 Km west of Matsue.

The pitchstones of this localities are classified into two types :

(1) autoclastic lava brecciated by congealing and subsequent movement,

(2) tuff breccia composed mainly of pitchstone fragments.

Generally, these are intercalated in plagioliparite flow or its pyroclastics in comformable relation.

III. Microscopic observation

The pitchstones from this areas are a dull, pitchy luster glassy rocks, being largely composed of glassy groundmass cut by curving cracks. Long green prismatic microlites of pyroxene visible only under the microscope are included in glassy groundmass of these pitchstones.

In general, prismatic pyroxene microlites have a distinct parallel arrangement. In some specimens they have nearly even distribution, but commonly they occur in distinct swarms.

The size of the pyroxene microlites varies within narrow limits, and the elongation along the c axis is commonly about 7 times the diameter of the prisms. Prismatic pyroxene microlites in these rocks are dominantly 0.015 to 0.005 mm in length, and 0.001 to 0.002 mm in diameter, and many of them show pyramidal termination.

It is rarely the case that the aggregation of globulites of pyroxene microlites take the form of globulitic needles, spikes and tendrils.

Hornblende and biotite microlites are not found in glassy groundmass.

Except for some samples, these rocks shows usually porphyritic texture composed of the phenocrysts of plagioclase and opaque minerals. Plagioclase phenocryst embedded in groundmass are soda rich varieties and shows corroded texture.

Along the curving cracks owe to rapid solidification, radiating fibers of zeolitic minerals and cristobalite as alteration products are found.

IV. Chemical analyses

Chemical analyses of pitchstones are given in Table I-A.

Analyses shown by Table I-B were recalculated free of volatiles, for the pitchstones are too hydrous to justify comparison on any other basis. With these some analyses of the plagioliparites of the Omori formation from the Shimane peninsular district are arranged in Table I-C.

Table I. Compositions of the pitchstones and comparable rocks from the Shimane peninsular district.

	A		B		C	
	1	2	3	4	5	6
SiO_2	68.90	69.08	77.22	78.49	78.85	77.01
TiO_2	0.20	0.17	0.22	0.19	0.19	0.38
Al_2O_3	11.79	11.09	13.21	12.60	11.44	11.75
Fe_2O_3	0.83	0.58	0.93	0.66	0.98	1.26
FeO	0.97	0.82	1.09	0.93	0.90	0.60
MnO	0.20	0.04	0.22	0.05	0.05	0.14
MgO	0.37	0.55	0.41	0.63	0.30	0.41
CaO	2.57	3.16	2.88	3.59	0.94	1.39
Na_2O	2.37	2.03	2.66	2.31	2.46	4.76
K_2O	0.89	0.44	1.00	0.50	2.78	0.28
P_2O_5	0.14	0.04	0.16	0.05	0.05	0.05
$H_2O(+)$	6.70	6.77			0.31	1.09
$H_2O(-)$	4.40	5.23			0.31	0.18
Total	100.34	100.00	100.00	100.00	99.56	99.29
q	45.66	47.40			50.96	44.64
c	2.65	1.53			2.67	1.12
or	5.00	2.78			16.68	1.67
ab	19.91	17.29			20.96	40.35
an	11.95	15.57			4.39	6.67
Sal total	85.17	84.57			95.66	94.45
en	0.90	1.40			0.70	1.00
fs	1.19	0.79			0.79	
mt	1.16	0.93			1.39	1.16
hm						0.48
il	0.46	0.30			0.30	0.76
ap	0.34	0.10			0.17	0.13
Fem total	4.05	3.52			3.35	3.53
H_2O	11.10	12.00			0.62	1.27
Total	100.32	100.09			99.63	99.25

Table I-A : pitchstones from the Shimane peninsular district.
1. pitchstone from Ino, Hirata city (specimen 4271819).
2. pitchstone from Hiyama, Hirata city (specimen 4341607).

Table I-B : analyses recalculated to 100 %, free of volatiles.
3. pitchstone from Ino, Hirata city (specimen 4271819).
4. pitchstone from Hiyama, Hirata city (specimen 4341607).

Table I-C : plagioliparites ofthe Omori formation from the Shimane peninsular district.
5. plagioliparite from Hiyama, Hirata city (specimen 4341602).
6. plagioliparite from Otoshi, Hirata city (specimen 4350903-A)

The composition of the pitchstones are similar to that of the acidic volcanic rocks of plagioliparite composition accompanied with pitchstones under the consideration, except that proportion of lime is increased and alkali is decreasd slightly.

These results suggest a close relationship between the pitchstones and the plagioliparites in genesis.

V. X-ray powder patterns

Two X-ray powder patterns were taken with the specimens analysed chemically. These results are shown in Fig. II.

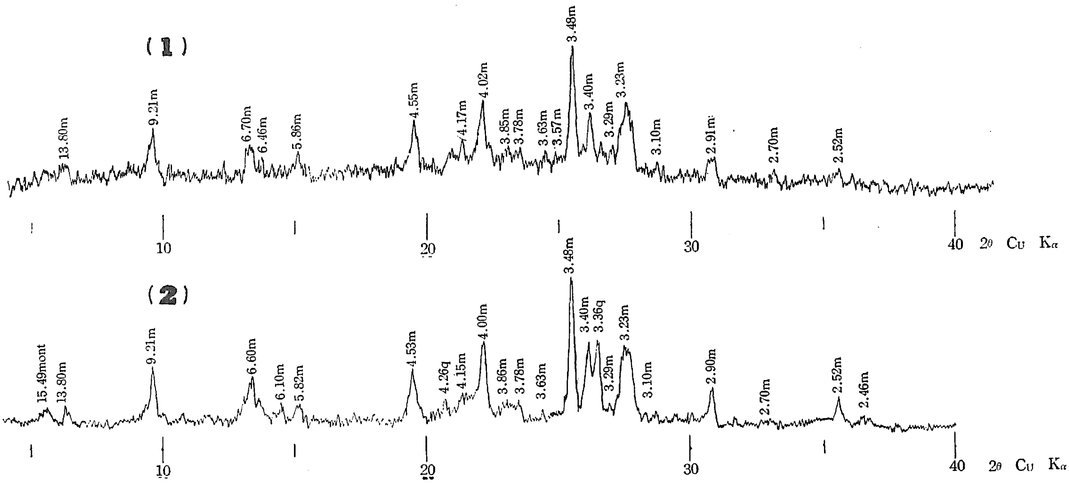

Fig. II. X-ray powder patterns of pitchstones from the Shimane peninsular district:
(1) pitchstone from Ino, Hirata city (specimen 4271819).
(2) pitchstone from Hiyama, Hirata city (specimen 4341607).
(m : mordenite mont : montmorillonite q : quartz)

Diagrams taken with powder specimens show smooth and continuous diffraction lines without obvious broadening ; the crystal size is, therfore, estimated to be about 1-5 μ.

Table II compares the powder data for the alteration products from Arran pitchstone examined by HARRIS and BRINDLEY (1953), for the pitchstones from Shimane peninsular district, and a natural mordenite examined by BARRER and transcribed to numerical basis as follows ; s, 10 ; ms, 8 ; m, 6 ; mw, 4 ; w, 2 ; vw, 1.

Powder data for natural mordenite have been recorded by BARRER and data for alteration product of pichstone have been described by HARRIS and BRINDLEY show general agreement with the present data.

Microscopic observation and X-ray data combine to show that the present pitchstones were altered to zeolite mordenite along the curving cracks.

VI. Interpretation and discussion

The close similarity in chemical composition of the pitchstones and the plagiolipar-

Table II. X-ray powder data for mordenite.

1		2		3		4	
d	I	d	I	d	I	d	I
13.80	2	13.80	1	13.7	6	13.5	10
9.21	4	9.21	4	9.10	9	8.66	10
6.70	3	6.60	3	6.60	8	6.54	10
6.46	2			6.39	5		
		6.10	1	6.09	2		
5.86	3	5.82	1	5.80	5	5.72	6
4.55	4	4.53	4	4.535	8	4.50	10
4.17	3	4.15	2				
4.02	6	4.00	5	4.008	9	3.99	10
3.85	1	3.86	1	3.854	4		
3.78	1	3.78	1	3.778	4		
3.63	1	3.63	1				
3.57	1						
3.48	10	3.48	10	3.486	10		
3.40	5	3.40	5	3.398	9	3.40	10
3.29	1	3.29	1	3.315	1	3.15	10
3.23	5	3.23	5	3.224	9		
3.10	1	3.10	1				
2.91	2	2.90	3	2.899	7	2.90	8
				2.746	1		
2.70	1	2.70	1	2.707	1	2.70	1
				2.569	3		
2.52	1	2.52	2	2.534	5	2.50	6
		2.46	1	2.469	1		
				2.440	1	2.43	2

1. Pitchstone from Ino, Hirata city (specimen 4271819).
2. Pitchstone from Hiyama, Hirata city (specimen 4341607).
3. Alteration product from Tomore, Isle of Arran, Scotland.
4. Natural mordenite, examined by Barrer (1948).

ites of the Omori formation from the Shimane peninsular district suggests that there are petrogenetically intimate relation between the both rock types. The geologic relationships that they occur in close association supports a this fact.

Before further discussion, we must call attention to the interesting report of TILLEY (1957) disccussed for Arran pitchstone.

Five Arran pitchstones (A–E of Fig. III) by his report seen to cluster along the central portion near the ternary minimum of the quartz-feldspar boundary curve of the system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2 at 1,000 Kg/cm^2 water vapour pressure. TILLEY is of opinion that Arran pitchstone magma closed to the normal granite magma in chemical composition must have solidified under at a depth of about two kilometers (500 Kg/cm^2), at about 800°C. With these, the chemical datas of the pitchstones and plagioliparites of the Omori formation from the Shimane peninsular district are also plotted in same figure.

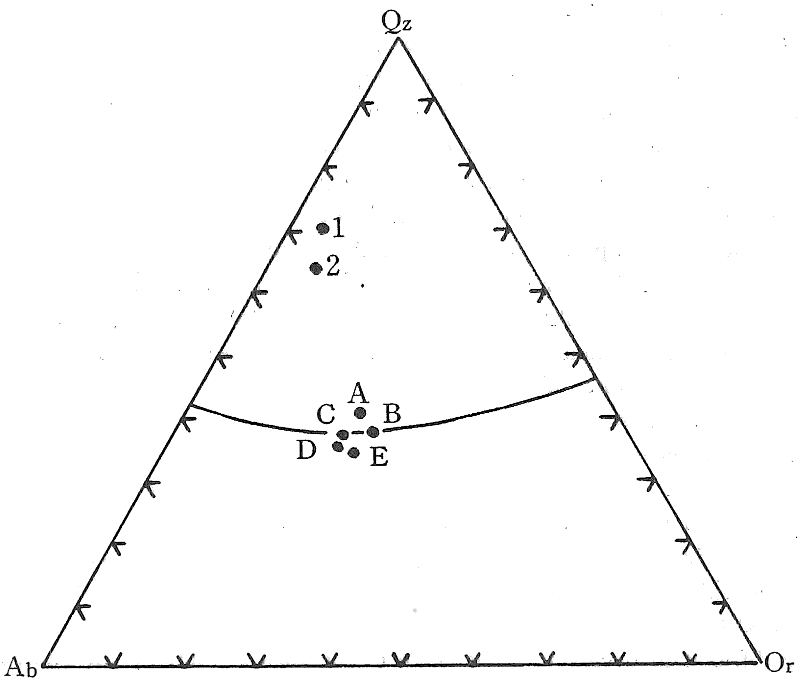

Fig. III. Plot of salic normative constituents of analysed pitchstones in the system $NaAlSi_3O_8KAlSi_3O_8$-SiO_2 at 1000 Kg / cm^2 water vapour pressure (Bowen and Tuttle 1952). The pitchstones from the Shimane peninsular district represented in solid circles (1-2) 1 Ino and 2 Hiyama. The Arran pitchstones (Tilly 1957) represented in solid circles (A-E).

The chemical properties of Arran pitchstones are quite different from the pitchstones now under consideration.

From their chemical properties, the pitchstones from the Shimane peninsular district cannot have solidified at the thermal valley in this hydrous system runs parallel to the quartz boundary.

Considering the following facts : (1) the chemical analyses of the pitchstones and the plagioliparites from the Shimane peninsular district closely resemble each other except volatile content, (2) these both rock types have mutually intimate relation in field occurrence, (3) the stable association of mordenite and silica minerals are found in the pitchstones as alteration products, (4) the pitchstones now under consideration have not the chemical composition of ternary minimum point in the hydrous system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2, present writer is of opinion that the pitchstones from the Shimane peninsular district are rapid cooling matrials of the plagioliparite magma rich in water at relatively low temperature hydrothermal conditions under the surface.

According to GORANSON (1931), the solubility of water in granite magma at 900° C. and 1375 bars water vapour pressure is 7 per cent. From this experimental data, it is natural that plagioliparite magma containing 7 % or a little more than 7 % water in solution (H_2O+) should exist at about 900°C. at depth of about 5.2 Km (approximately equivalent to 1375 bars).

If from this chamber magma instantaniously could ascend along the conduits to a level at shallow depth near the surface, the temperature of magma would drop quickly.

If the rock mantle surrounding the magma and the walls of this conduits were impervious to water vapour, excess water dissolved in magma would isolate as small globules in high viscous glassy magma until an equilibrium between the gas and liquid phase attained. Hardly had the curving crack due to cooling formed when excess water might tend to seal up such open spaces. And hydrothermal alteration was caused by such a excess water. Thus mordenites were formed in the solidified glassy rocks.

SEKI (1968) studied the zeolites in the active geothermal areas of Japan and divided into the following three subfacies from shallower part to deeper part:

a : Clinoptilolite-mordenite subfacies

b : Laumontite subfacies

c : Wairakite subfacies

Mordenite was discovered in the clinoptilolite-mordenite subfacies at the depth of about 100-30 m and the temperature of about 130-80°C.

The abovedata indicate that the main part of the pitchstones were solidified and altered to mordenite at the depth of about 100 or less than 100 m and the temperature of about 130-80°C.

It is very difficult to decide in what stage of the rock formation, the explosion took place. But, so far as the data suggest for pitchstone, the formation of mordenite by hydrothermal alteration would continue at a shallow depth under the surface until the overlying rock strata became incompetent to withstand the pressure accumulated in the solidifying magma, when rupture would take place with explosive force.

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Plate I

Fig. 1.

Fig. 2.

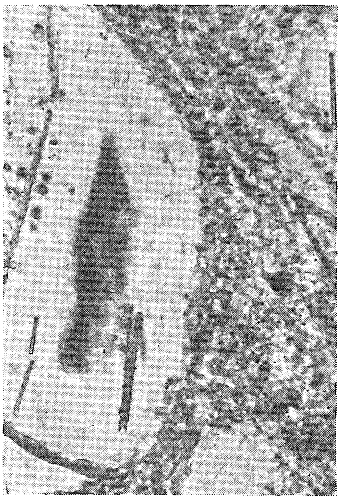

Fig. 3.

Fig. 4.

Explanation of Plate I.

Fig. 1. Pitchstone from Ino, Hirata city (specimen 4271819). Prismatic type of pyroxene microlites showing alignment imposed during emplacement. Magnification 400×.

Fig. 2. Pitchstone from Ino, Hirata city (specimen 4271819). Magnification 40×.

Fig. 3. Pitchstone from Hiyama, Hirata city (specimen 4341607). Prismatic type of pyroxene microlites showing alignment imposed during emplacement. Magnification 400×.

Fig. 4. Pitchstone from Hiyama, Hirata city (specimen 4341607). Magnification 40×.