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"BALL ANDESITE" FROM USHIO, SOUTH KYUSHU, JAPAN*

By

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The name "ball andesite"* was given by S. TANEDA, one of the writers, to the andesite including, in a few words, many balls of the same andesite. It was found from Ushio,** Kagoshima prefecture, South Kyushu, Japan. It shows a special structure constructed from many balls and matrix, each of them being almost the same to each other in the petrological properties. The ball andesite occurs occupying a part of the lava (two-pyroxene andesite) constructing the mother rock of the gold deposits of the Ushio Mine.

Megascopically it is a dark gray lava with somewhat glassy luster, carrying phenocrysts of white plagioclase (up to 5 mm in length), sporadic black pyroxene (usually less than 1 mm), scattered uniformely through a dark gray matrix.

The form of the ball is nearly spherical or ellipsoid. At some times two or three balls attach to each other and take a form of cocoon, rosary, etc. (Fig. 1). Not so rarely the aggregates of several numbers of balls are also found. The size of ball is variable, usually ranging from 3 cm to 1 cm in diameter, though at sometimes it is much less, as small as microscopic size, and at the other hand rarely large over 5 cm in diameter. From the megascopical observation it is rather easily presumed that the ball may be not the lithophysae, spherulite, bomb, pisolite or any xenolithic block.

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* S. TANEDA: "Ball andesite" from the Ushio Gold Mine, Kagoshima pref., Jour. Geol. Soc. Japan, Vol. LIV, No. 635, 1948.

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Under the microscope the form and feature of balls, as well as other petrological properties, were examined chiefly by S. Taneda carefully and some notable facts were found, that is;

(1) The petrological property of the ball is the same with that of the matrix, excepting one point that the groundmass glass of the ball is more or less darker than that of the matrix.

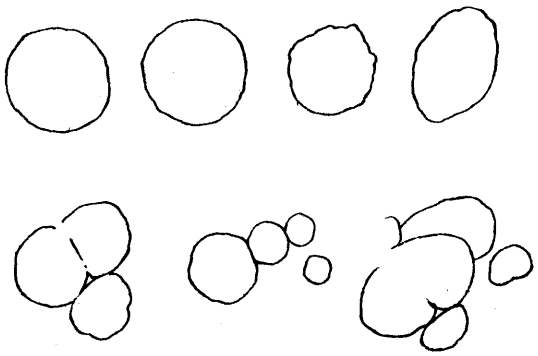

Fig. 1 Schematic Sketch of the balls

There are phenocrysts of zoned plagioclase (bytownite-labradorite), augite and hypersthene, the last of which, not uncommonly, shows the reverse zonal structure, besides those of a few magnetite; while the groundmass consists of plagioclase, hypersthene, a few augite, magnetite and interstitial glass.

Although the description is omitted in this part, optical constants of the rock-forming minerals are given in Tables I & II. In this place the mode of zoning of plagioclase (Fig. 2) and hypersthene (Tables I & II), and the relation in the optical properties as well as in the chemical composition between phenocrystic minerals (especially hypersthene) and those of the groundmass (Tables I & II) should be remarked.

Table I Matrix

	Phenocryst	Micro phenocryst	Groundmass
Rhombic pyroxene	(−) 2V: 56°, 57°, 59°, 59°, 60°, 61°, 61°, 62°, 66°, 66.5°, 68°, 70°,	64°, 64°, 63°,	66°, 68°, 69°, 77°, 78°,
	av: 62° (Fs 37.5)* 58° (Core)—68° (Margin)	av: 64°	av: 72° (Fs 26.6)*

		56° (Core)—65° (Margin)	
		57° 〃 —74° 〃	(aggregates
$\rho > \nu$		58° 〃 —69° 〃	63°<, 62.5°, 62°,59°)
		59° 〃 —68° 〃	
		60° 〃 —66° 〃	
		60° 〃 —69° 〃	
		60° 〃 —71° 〃	
		av: 59° 〃 —69° 〃	
		β: 1.693—1.705±0.002	
		Fs: 32—45.5±0.002	
Monoclinic pyroxene	(+) 2V:	46°, 47°, 4.7°, 48°, 48.5°, 49°, 49°, 49°, 50°, 53°,	(Aggregates 51°, 44°,
	av:	49°	
$\rho > \nu$	β:	1.703±0.002	51°,
	Wo:	34.5 En 39, Fs 26.5**	
Plagioclase	An	84—55 (±5)*** zonal structure (ref. Fig. 2)	69—49 (±5)

Table II Ball

		Phenocryst	Micro phenocryst	Groundmass
Rhombic pyroxene	(−) 2V:	57°, 57°, 57.5°, 58°, 58°, 59°, 59°, 60°, 60°, 61°, 62°, 62°, 63°, 64°, 64°, 66°, 66°, 69°, 76°,	65°, 66°, 66°, 68°	67°<, 70°, 78°,
	av:	62° (Fs 37.5)*	av: 66°	av: 72° (Fs 26.6)*
		58° (Core)—68° (Margin)		
		61° 〃 —70° 〃		
		62° 〃 —76° 〃		
		60° 〃 —68° 〃		
$\rho < \nu$	av:	60° 〃 —71° 〃		
		64° 〃 —56° 〃		
	β:	1.693—1.705±0.002		
	Fs	32—45.5±0.002*		

* S. Taneda: Journ. Geol. Soc. Japan. LIV, 628-630, 1948.
S. Taneda: Memoir Fac. Sci. Kyusyu Imp. Univ., D, III, 1, 1947.
** H. Kuno: Jap. Journ. Geol. Geog., vol. III, Nos. 1-2, 1936.
*** Determined by S. Tsuboi's diagram from the max. sym. ext. angle.

Monoclinic pyroxene $\rho > \nu$	(+) 2V : 45°, 47°, 48°, 48°, 49°, 50°, 50°, 52°, av : 49°	
	43° (Core)—48° (Margin)	
	50° 〃 —45° 〃	
	β : 1.703±0.002	
	Wo 34.5 En 39 Fs 26.5**	
Plagioclase	An 38.5—53 (±5)*** zonal structure (ref. Fig. 2)	69—56— (±5)

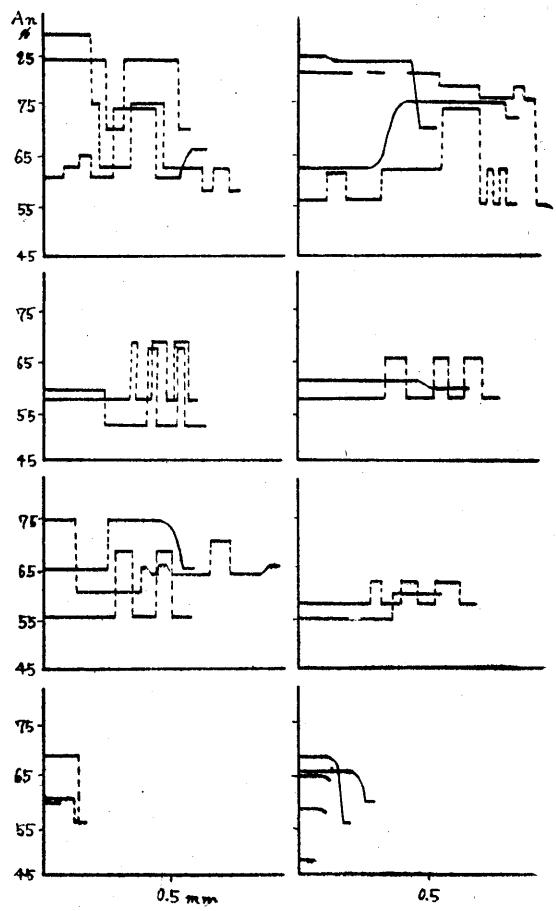

Fig. 2. The mode of variation of An content in zoned plagioclase in the ball (Left) and matrix (R:ght)

(2) The surface of the ball is not a simple spherical surface, but composed from many little spherical surfaces, usually the convex side being inside of the ball.

(3) The boundary between the ball and matrix is sometimes clear, but in other cases it is shown as a crack filled up by the brown material. In the latter case the groundmass glass of the ball is not so dark as in the former case.

From the geochemical standpoint, N. SAITO and N. KOKUBU carried out the chemical analysis of such brown material, the result of which were indicated in Table III, together with those of ball and matrix.

Table III

	(1)	(2)*	(3)
SiO_2	58.60 %	57.18 %	58.44 %
Al_2O_3	19.68	17.04	18.94
Fe_2O_3	4.89**	6.64	4.17**
FeO	3.01*	2.92	3.50*
MgO	3.96	4.13	4.10
CaO	5.78	6.33	6.06
Na_2O	2.90	1.75	2.31
K_2O	2.08	0.17	2.18
$H_2O(-)$	n.d.	1.00	n.d.
$H_2O(+)$	n.d.	1.19	n.d.
TiO_2	n.d.	0.49	n.d.
Cl	0.16*	1.98	0.52*
NH_3(as N)	0.0033*	0.0064	0.0026*
	101.06	100.82	101.22
$-O=Cl$	0.07	0.89	0.23
Total	100.99 %	99.93 %	100.99 %

(1) ball
(2) brown material at the boundary (with some (1) and (2))
(3) matrix

The main chemical constituents of both (1) and (3) were determined by the chemical laboratory of the Asahi Kasei Co., Nobeoka city, Japan.

* determined by N. SAITO and N. KOKUBU.

** The value of total iron oxide by the Asahi Kasei Co., were corrected by subtracting the FeO value determined by present authors.

Concluding from the results of these chemical analyses, we can indicate that there is no remarkable difference among these different faces with regard to their main constituents, although a few ratios such as Fe_2O_3/FeO and Na_2O/K_2O are somewhat higher at the brown material.

As for minor constituents, on the contrary, it is clarified that several components, i.e. chlorine and ammonia are remarkably concentrated in the brown material.

These characteristic concentrations of several volatile constituents at the brown material seem to be very suggestive for the mechanism of the formation of ball andesite.

(4) In the microscopical taxture, the ball and the matrix are the same to each other, and moreover the fluidal arrangement of the crystals is not disturbed, but continuous throughout the ball and the matrix. There are crystals (phenocrysts, microphenocrysts and of the groundmass) which are laid across the boundary (Fig. 3).

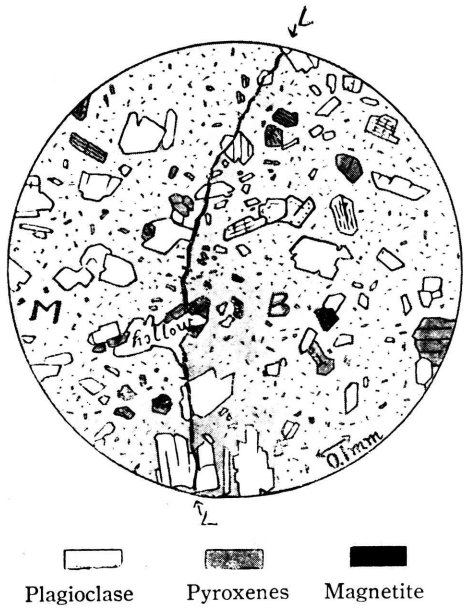

Fig. 3. Sketch of the photomicrograph showing the boundary (LL) of the ball (B) and matrix (M).

(5) On the other hand, from the petrological properties (i.e. the character of the rock-forming minerals, the feature of the groundmass, etc.), it is presumed that the "ball andesite" lava was rich in the volatile matters through the whole stage of the consolidation.

Ref. S. Taneda's paper ("Petrological Studies on the Volcanic Rocks from Japan, with Special Reference to the "Hornblende-Andesite". Mem. Fac. Sci. Kyūsyu Imp. Univ., Ser. D. Vol. III, No. 1, 1947) and Tables I & II and Fig. 2. in this report.

(6) In the matrix part, not uncommonly are found the dark area in patches where the groundmass glass is dark colour as well as that of the ball. The outline of the patch is apparently irregular, but composed of many little spherical surfaces as well as the surface of the ball as above (in (2)) mentioned. It should be remarked that it develops not uncommonly along the indented outline of a crystal and the defect part of the crystal aggregates (Fig. 4).

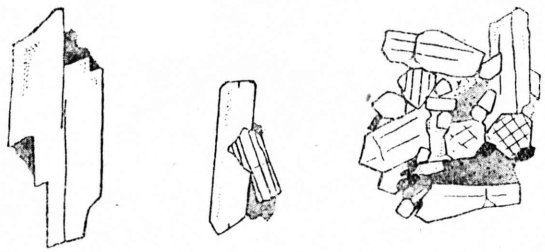

Fig. 4. Microscopic sketches of the dark area besides the crystals in the matrix.

This patch is considered to be an embryo or imperfect form of the ball.

On the basis of above facts, the special structure of the ball andesite may be interpreted as representing a feature of lava characterized by the action of volatile matters during the latest stage of consolidation of the magma under a certain condition, though it is not clear at the present.*

If it is true, the "ball andesite" should be attached great importance, because by the investigation of it we can expect to find the trace of fugitive matters in magma at the deuteric stage and then perhaps at the hydrothermal stage also.

* The details should be discussed on a later occasion.

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