

PROPERTIES AND CONSTITUTION OF  
A VOLCANIC SOIL, BUILT IN 50 YEARS  
IN THE EAST-INDIAN ARCHIPELAGO

BY

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WITH 2 MAPS; 2 PHOTOGRAPHS; 6 MICROPHOTOGRAPHS  
AND A COMPLETE BIBLIOGRAPHY  
OF THE GEOLOGY OF THE KRAKATAU-GROUP  
SAMENVATTING IN HET NEDERLANDSCH  
ZUSAMMENFASSUNG IN DER DEUTSCHEN SPRACHE  
RÉSUMÉ EN FRANÇAIS



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# PROPERTIES AND CONSTITUTION OF A VOLCANIC SOIL, BUILT IN 50 YEARS IN THE EAST-INDIAN-ARCHIPELAGO

by Prof. J. van Baren, Wageningen

Everyone knows the history of the stupendous volcanic explosion of the Krakatau (Krakatoa; Rakatoa) in the Sunda Strait, between Sumatra and Java, on the 26th and 27th August 1883, so elaborately described in VERBEEK'S famous work. A large part of Krakatau disappeared, enormous quantities of dust were projected into the atmosphere spreading around the globe and the two neighbour-islands, Verlaten Eiland (Forsaken Isle) and Lang-Eiland (Long Isle) were covered with volcanic material.

Though many botanists and zoologists visited Krakatau to study the flora and the fauna, no scientist was interested to study the soil, its properties and constitution, built since 1883.

Thanks to the cooperation of Mr. A. C. DE JONGH, Chief of the Netherlands East Indian Geological Survey (Bandoeng); Mr. CH. E. STEHN, Chief of the Netherlands East Indian Volcanological Survey (Bandoeng); the Director of the station for water-research in Manggarai, Mr. P. C. MOM and the volcanological observator on Lang-Eiland Mr. F. ECOMA VERSTEGE, I was able to obtain material to study the microscopical, physical, chemical and bacteriological constitution. Dr. L. MÖSER in Giessen (Germany), verified on my request the presence (or absence) of 27 constituents.

My Colleague in microbiology at this University arranged the study of the microbes by his scholar Mr. SCHUTEMAKER (now in the East Indian Archipelago).

My hearty thanks to all these collaborators.

The methods used are described in *English* in: J. VAN BAREN, Microscopical, physical and chemical Studies of limestones and limestone-soils from the East Indian Archipelago (Communications from the Geological Institute of the Agricultural University, Wageningen, Holland, No. XIV, 1928);

and in *German* in: J. VAN BAREN, a.o., Vergleichende mikroskopische, physikalische- und chemische Untersuchungen von einem Kalkstein und einem Löss-Bodenprofil aus den Niederlanden; Vergleichendes Studium von einem Kalkstein-Bodenprofil aus Holland und einem Kalkstein-Bodenprofil aus Java. (Ibidem, No. XVI, 1930.)

## I. TOPOGRAPHY

According to VERBEEK the square area of Lang-Eiland (Malayan: Poeloe Rakata Ketjil) was before 1883: 2,9 km<sup>2</sup>, in 1885: 3,2 km<sup>2</sup>.

The topographical map of the Krakatau-group shows, that the highest point is 147 m above sea-level.

## II. GEOLOGY

Whoever is interested in the geology of the Krakatau-group may consult the complete bibliography at the end of this memoir.

CH. E. STEHN, in his paper entitled, *The geology and volcanism of the Krakatau-group* (printed as part I of the booklet Krakatau, offered to the members of the Fourth pacific science congress, Batavia 1929) gives the latest summary. In this paper 3 chemical analyses of seawater are given, in order to study the influence of the latest eruptions of Krakatau on the composition of the sea-water and 8 analyses of the older and newer volcanic material of Lang-Eiland.

The analyses give the percentages of 13 constituents, viz.: SiO<sub>2</sub> - Al<sub>2</sub>O<sub>3</sub> - Fe<sub>2</sub>O<sub>3</sub> - FeO - MnO - MgO - CaO - Na<sub>2</sub>O - K<sub>2</sub>O - TiO<sub>2</sub> - Cl - SO<sub>3</sub> - P<sub>2</sub>O<sub>5</sub> - H<sub>2</sub>O + - H<sub>2</sub>O -.

## III. CLIMATE AND VEGETATION

By kind permission of Mr. CH. E. STEHN, Chief of the Netherland East Indian Volcanological Survey, I here communicate the rainfall and the temperature observed on Lang-Eiland during 1929.

## a. Rainfall

Jan. 356,5 13,61 % of the total	Febr. 619,5 23,65	March 266,5 10,17	April 178 6,79	May 72 2,75	June 138 5,27	
July 9 0,34	Aug. 79 3,01	Sept. -	Oct. 68,3 2,61	Nov. 244,7 9,34	Dec. 588,5 22,46	Annual 2620 mm 100 %

## b. Temperature

Jan. 27,7° C	Febr. 27,9	March 27,4	April 27,8	May 28,2	June 27,3	
July 26,9	Aug. 27,6	Sept. 28,6	Oct. 28,7	Nov. 28,2	Dec. 26,9	Annual 27,8° C

## c. Rainfactor (LANG)

$$\frac{\text{Annual rainfall}}{\text{Annual temperature}} = \frac{2620}{27,8} = 94.$$

## d. Chemical constitution of rainwater from Lang-Eiland and Batavia

	Lang-Eiland		Manggara Mr. Cornelis near Batavia
	Febr. 1930	June 1930	Nov. 1931
pH .....	5,2	6,6	4,6
HCO <sub>3</sub> .....	nihil	nihil	6,1 mg/l
KMnO <sub>2</sub> .....	3,6 mg/l	1,1 mg/l	6,6 mg/l
NH <sub>3</sub> .....	0,1 mg/l	trace	0,18 mg/l
proteid NH <sub>3</sub> .....	nihil	nihil	nihil
NO <sub>2</sub> .....	0,02 mg/l	0,01 mg/l	nihil
NO <sub>3</sub> .....	trace	0,1 mg/l	nihil
Hardness (German grades)	0	0,8	0
Ca .....	nihil	trace	nihil
Mg .....	nihil	trace	nihil
Fe .....	nihil	nihil	nihil
Mn .....	nihil	nihil	nihil
CO <sub>2</sub> .....	—	11,- mg/l	2,2 mg/l
SO <sub>4</sub> .....	nihil	nihil	nihil
Cl .....	trace	trace	nihil
Dry-rest .....	20 mg/l	55,2 mg/l	5,2 mg/l
Rest after ignition.....	15 mg/l	30,4 mg/l	2,1 mg/l

These analyses are the first, as far as I know, from rain-water of the isle of Java.

## e. Vegetation

Ferns; grasses (*Imperata* sp.); *Casuarina*; *Ficus*.

## IV. THE SOIL-PROFILE

On the 31st October 1928, Mr. F. ECOMA VERSTEGE collected on the westcoast of Lang-Eiland, 50 m from the southern radio-antenna, height about 50 meter above sea-level, on a spot, where the total thickness of the pumice was > 40 meter a profile, consisting of 3 samples:

- A. the under-layer = the mother-rock. Thickness: 42 meters.
- B. the middle-layer, between A and C. Thickness?
- C. the upper-layer, surface-soil. Thickness: 35 centimeters.
- D. weathered rock-fragments in C.

## V. MINERALOGICAL RESEARCH

*a. Thin sections*

Glassy pumice; magnificent amorphous fluidal structure; a great number of gasbubbles in pearlchains; hypersthene, amphibole with inclusions, augite and andesine in well-built crystalline form; the last often with anormal double-refraction; the amorphous mass often partly dark-black.

*b. The minerals, prepared from the material: a. dry; b. after treating with water and c. after boiling with diluted HCl.*

C. The humic surface-layer.

**Amphibole**, lightgreen till darkgreen, often with cristallographical planes, with inclusions of unknown nature. The surface possesses often a burned crust.

**Amphibole**, brown, strong-pleochroitic.

**Anhydrite**, microchemical reaction on  $\text{SO}_4$  positive.

**Apatite**, colorless; occurs only as an inclusion in plagioclase and hypersthene; one time in plagioclase as a crystal with prism, pyramid and basal plane; in needles with beautiful basal cleavage.

**Augite**, darkgreen, with good cleavage and burnt surface.

**Hypersthene**, green till yellow, pleochroism well-defined, many fragments with crystal-planes.

Inclusions of magnetite. On the surface gas-bubbles.

As an inclusion in plagioclase and in this hypersthene an inclusion of apatite.

**Ilmenite**, well-built crystals, often with impressions.

**Kyanite**, blue till colorless (fig. 1), one time as an inclusion in plagioclase.

**Magnetite**, in magnetic <sup>1)</sup> grains, rare as octahedron.

**Olivine**, green; irregular grains.

**Plagioclase**, (Andesine) the most frequent occurred mineral; idiomorphic crystals often in polysynthetic twinnings; zonal buildings; optical anomalous extinction (molecular strain?).

Inclusions from hypersthene, magnetite and apatite.

Refractory index = 1,555.

<sup>1)</sup> See for non-magnetic grains my study on limestone and limestone-soils (Communication No. XIV of this laboratory, p. 15).

Plagioclase often luted with amphibole, augite, ilmenite, magnetite and - plagioclase itself.

Remarkable is the occurrence of a great number of gasbubbles in the andesine and the often gaseous surface. One time a little isomorphic crystal in a great isomorphic one.

**Pyrite**, with coloured lustre.

**Quartz**, some colorless grains; clear uni-axial positive.

**Volcanic glass**, colorless with gasbubbles, inclusions of apatite-needles; when colored brown and black (= obsidian); one time brown with white inclusions of unknown nature. Some round, black buttons of (what seems to be) *Billitonite* (?), but pits or furrows absent.

**Wollastonite**, colorless; fibrous; rare.

B. Partly weathered middle-layer, between C and A.

The minerals, found in this layer, are the same as the minerals of the C-layer, but luted.

A. The under-layer = the mother-rock.

Great fragments of the rock = pumice with small holes in which glassy threads, glassy feldspar with gasbubbles along the sides and inclusions of apatite, amphibole, ilmenite in the middle.

#### REPARTITION OF THE MINERALS IN THE 3 LAYERS

	C Surface-layer (soil)	B Middle-layer (transition between rock and soil)	A Rock
Amphibole, green .....	×	×	×
Amphibole, brown.....	○	○	—
Anhydrite* .....	○	—	—
Apatite .....	○	○	○
Augite .....	×	×	×
Hypersthene.....	×	×	×
Ilmenite .....	×	×	×
Kyanite.....	○	○	×
Magnetite.....	×	×	×
Olivine .....	○	○	○
Plagioclase .....	+	+	+
Pyrite* .....	○	—	—
Quartz .....	○	—	—
Volcanic glass .....	×	×	×
Wollastonite* .....	○	—	—
	15	11	10

+ = very much; × = much; ○ = few; — = absent; \* = new-built.

Tridymite and Cordierite meet by VERBEEK (tridymite) and HARLOFF (Cordierite) have not been found.

#### V. CHEMICAL ANALYSES

From the volcanic ashes and the pumice, fallen on the isles of the Krakatau-group a great number of chemical analyses were made. Whoever is interested in these must read the French edition of VERBEEK's standardwork on Krakatau and the work of Mr. CH. E. STEHN already cited.

The analyses, communicated here, were made, on my request, by Dr. L. MÖSER (Giessen). They are the first complete analyses from Lang-Eiland and the most complete one, ever made from rocks and soils of the Dutch East Indies.

	A Rock in %	B Middle-layer in %	C Surface-layer in %	D weathered fragments from C. in %
1. SiO <sub>2</sub> .....	67,55	65,87	61,13	63,77
2. TiO <sub>2</sub> .....	0,70	0,83	0,93	0,96
3. ZrO <sub>2</sub> .....	0,03	0,015	0,01	0,025
4. Al <sub>2</sub> O <sub>3</sub> .....	15,19	16,31	17,24	15,67
5. Fe <sub>2</sub> O <sub>3</sub> .....	1,52	1,74	2,56	2,89
6. Cr <sub>2</sub> O <sub>3</sub> .....	0,01	0,01	0,005	trace
7. V <sub>2</sub> O <sub>5</sub> .....	0,005	0,005	0,005	trace
8. FeO .....	2,15	2,05	2,59	2,15
9. MnO .....	0,17	0,18	0,18	0,14
10. NiO .....	0,001	trace	—	trace
11. CaO .....	2,89	3,07	3,61	2,86
12. SrO .....	trace	trace	trace	trace
13. BaO .....	0,027	0,030	0,025	0,016
14. MgO .....	0,72	0,74	0,76	1,09
15. Na <sub>2</sub> O .....	4,47	4,01	3,90	4,28
16. K <sub>2</sub> O .....	1,95	1,53	1,78	1,70
17. Li <sub>2</sub> O .....	trace	trace	trace	trace
18. H <sub>2</sub> O + 110° C. ....	2,46	3,17	3,25	3,16
19. H <sub>2</sub> O - 110° C. ....	0,04	0,33	1,53	1,27
20. CO <sub>2</sub> .....	—	—	0,04	0,06
21. SO <sub>3</sub> .....	0,005	0,007	0,007	0,007
22. SO <sub>2</sub> .....	—	—	—	—
23. Sulfid-S .....	0,040	0,032	0,025	0,025
24. P <sub>2</sub> O <sub>5</sub> .....	0,04	0,22	0,22	0,17
25. Cl .....	0,024	0,198	0,017	0,010
26. Organic matter .....	—	—	0,45	—
	99,992	100,347	100,264	100,253
27. Later on Dr. Möser determined also the N-percent.	0,018	0,012	0,035	0,027

Exchangeable Ca of the surface-layer: 0,027 %  
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a. *Molecular-ratio.*

	A. Rock in %	B. Middle-layer in %	C. Surface-layer in %	D. weathered fragments from C. in %
SiO <sub>2</sub> .....	69,015	66,002	60,128	62.815
TiO <sub>2</sub> .....	0,536	0,628	0,687	0,712
ZrO <sub>2</sub> .....	0,018	0,009	0,005	0,014
Al <sub>2</sub> O <sub>3</sub> .....	9,155	9,643	10,005	9,106
Fe <sub>2</sub> O <sub>3</sub> .....	0,585	0,658	0,948	1,075
Cr <sub>2</sub> O <sub>3</sub> .....	0,006	0,006	0,002	trace
V <sub>2</sub> O <sub>3</sub> .....	0,001	0,001	0,001	trace
FeO .....	1,842	1,721	2,135	1,776
MnO .....	0,147	0,151	0,148	0,118
NiO .....	0,0006	trace	—	trace
CaO .....	3,172	3,304	3,819	3,029
SrO .....	trace	trace	trace	trace
BaO .....	0,010	0,012	0,008	0,005
MgO .....	1,102	1,105	1,115	1,603
Na <sub>2</sub> O .....	4,442	3,909	3,730	4,098
K <sub>2</sub> O .....	1,275	0,978	1,120	1,069
Li <sub>2</sub> O .....	trace	trace	trace	trace
H <sub>2</sub> O .....	8,551	11,739	15,734	14,606
CO <sub>2</sub> .....	—	—	0,053	0,083
SO <sub>3</sub> .....	0,003	0,004	0,004	0,004
SO <sub>2</sub> .....	—	—	—	—
Sulfid-S .....	0,073	0,054	0,041	0,041
P <sub>2</sub> O <sub>5</sub> .....	0,018	0,090	0,088	0,071
Cl .....	0,030	0,332	0,027	0,017
	99,9816	100,346	99,798	100,242



	Soluble in HCl			Insoluble in HCl		
	A. Rock in %	B. Middle- layer in %	C. Surface- layer in %	A. Rock in %	B. Middle- layer in %	C. Surface- layer in %
SiO <sub>2</sub> .....	1,72	3,83	7,87	65,83	62,04	53,26
TiO <sub>2</sub> .....	0,09	0,16	0,25	0,61	0,67	0,68
ZrO <sub>2</sub> .....	traces	traces	traces	0,03	0,015	0,010
Al <sub>2</sub> O <sub>3</sub> .....	0,17	0,58	2,98	15,02	15,73	14,26
Fe <sub>2</sub> O <sub>3</sub> .....	0,56	0,79	1,88	0,96	0,95	0,68
Cr <sub>2</sub> O <sub>3</sub> .....	0,008	0,008	0,005	0,002	0,002	0
V <sub>2</sub> O <sub>5</sub> .....	0,005	0,005	0,005	0	0	0
FeO .....	0,25	0,30	0,72	1,90	1,75	1,87
MnO .....	0,02	0,03	0,06	0,15	0,15	0,12
NiO .....	traces	0	0	0,001	traces	0
CaO .....	0,20	0,21	0,67	2,69	2,86	2,94
SrO .....	0	0	0	traces	traces	traces
BaO .....	0	0	0	0,027	0,030	0,025
MgO .....	0,10	0,11	0,47	0,62	0,63	0,29
Na <sub>2</sub> O .....	0,36	0,32	0,22	4,11	3,69	3,68
K <sub>2</sub> O .....	0,13	0,12	0,12	1,82	1,41	1,66
Li <sub>2</sub> O .....	traces	traces	traces	0	0	0
SO <sub>3</sub> .....	0,005	0,007	0,007	0	0	0
P <sub>2</sub> O <sub>5</sub> .....	0,04	0,10	0,18	0	0,12	0,04
	3,658	6,570	15,437	93,770	90,047	79,515
Rest .....	93,58	89,61	79,11			
H <sub>2</sub> O .....	2,50	3,50	4,78			
Cl, S, N ...	0,082	0,242	0,527			
	99,820	99,922	99,854			

## MOL. RATIO

	Soluble in HCl			Insoluble in HCl		
	A. Rock in %	B. Middle- layer in %	C. Surface- layer in %	A. Rock in %	B. Middle- layer in %	C. Surface- layer in %
SiO <sub>2</sub> .....	2,00	4,42	9,38	71,62	67,98	58,72
TiO <sub>2</sub> .....	0,08	0,14	0,22	0,50	0,55	0,33
ZrO <sub>2</sub> .....	0	0	0	0,01	0,01	0,01
Al <sub>2</sub> O <sub>3</sub> .....	0,12	0,39	2,09	9,62	10,13	9,26
Fe <sub>2</sub> O <sub>3</sub> .....	0,24	0,34	0,83	0,39	0,39	0,28
Cr <sub>2</sub> O <sub>3</sub> .....	0	0	0	0	0	0
V <sub>2</sub> O <sub>5</sub> .....	0	0	0	0	0	0
FeO .....	0,24	0,29	0,72	1,73	1,60	1,72
MnO .....	0,02	0,03	0,06	0,14	0,14	0,11
NiO .....	0	0	0	0	0	0
CaO .....	0,25	0,26	0,86	3,14	3,36	3,48
SrO .....	0	0	0	0	0	0
BaO .....	0	0	0	0,01	0,01	0,01
MgO .....	0,17	0,19	0,84	1,01	1,03	0,48
Na <sub>2</sub> O .....	0,40	0,36	0,26	4,33	3,90	3,93
K <sub>2</sub> O .....	0,10	0,09	0,09	1,27	0,99	1,17
Li <sub>2</sub> O .....	0	0	0	0	0	0
SO <sub>3</sub> .....	0	0,01	0,01	0	0	0
P <sub>2</sub> O <sub>5</sub> .....	0,02	0,05	0,09	0	0,06	0,02
	3,64	6,57	15,45	93,77	90,15	79,52

*b. Weathering-quotient.*

$$ki = \frac{SiO_2}{Al_2O_3} \times 1,7.$$

$$K = \frac{ki \text{ soil}}{ki \text{ rock}}$$

$$ki \text{ A, rock} = \frac{67,55}{16,19} \times 1,7 = \dots\dots\dots 7,56$$

$$ki \text{ B, middle-layer} = \frac{65,87}{16,31} \times 1,7 = \dots\dots\dots 6,86$$

$$ki \text{ C, surface-layer} = \frac{61,13}{17,24} \times 1,7 = \dots\dots\dots 6,03$$

$$\frac{ki \text{ surface-layer}}{ki \text{ rock}} = \frac{6,03}{7,56} = K = \dots\dots\dots 0,93$$

$$\frac{ki \text{ middle-layer}}{ki \text{ rock}} = \frac{6,86}{7,56} = K = \dots\dots\dots 0,91$$

$$\frac{ki \text{ surface-layer}}{ki \text{ middle-layer}} = \frac{6,03}{6,86} = K = \dots\dots\dots 0,87$$

$$ba = \frac{CaO \times 1,822 + Na_2O \times 1,646 + K_2O \times 1,082}{Al_2O_3}$$

$$B = \frac{ba \text{ soil}}{ba \text{ rock}}$$

$$ba \text{ A, rock} = \frac{2,89 \times 1,822 + 4,47 \times 1,646 + 1,95 \times 1,082}{16,19} = \dots\dots\dots 0,96$$

$$ba \text{ B, middle-layer} = \frac{3,07 \times 1,822 + 4,01 \times 1,646 + 1,53 \times 1,082}{16,31} = \dots\dots 0,85$$

$$ba \text{ C, surface-layer} = \frac{3,61 \times 1,822 + 3,90 \times 1,646 + 1,78 \times 1,082}{17,24} = \dots\dots 0,86$$

$$\frac{ba \text{ surface-layer}}{ba \text{ rock}} = \frac{0,86}{0,96} = B = \dots\dots\dots 0,89$$

$$\frac{ba \text{ middle-layer}}{ba \text{ rock}} = \frac{0,85}{0,96} = B = \dots\dots\dots 0,89$$

$$\frac{ba \text{ surface-layer}}{ba \text{ middle-layer}} = \frac{0,86}{0,85} = B = \dots\dots\dots 1,01$$

c.  $\text{Al}_2\text{O}_3 = 1$ .

Chemical components	Molecular ratio	$\text{Al}_2\text{O}_3 = 1$
A. Rock		
$\text{Al}_2\text{O}_3$ .....	15,19 %	0,1486 = 1,—
$\text{SiO}_2$ .....	67,55 %	1,1202 $\frac{1,1202}{0,1486}$ = 7,54
$\text{CaO}$ .....	2,89 %	0,0515 $\frac{0,0515}{0,1486}$ = 0,35
$\text{MgO}$ .....	0,72 %	0,0179 $\frac{0,0179}{0,1486}$ = 0,12
$\text{K}_2\text{O}$ .....	1,95 %	0,0207 $\frac{0,0207}{0,1486}$ = 0,14
$\text{Na}_2\text{O}$ .....	4,47 %	0,0721 $\frac{0,0721}{0,1486}$ = 0,49
$\text{H}_2\text{O} + 110^\circ \text{C}$ .....	2,46 %	0,1365 $\frac{0,1365}{0,1486}$ = 0,92
$\text{H}_2\text{O} - 110^\circ \text{C}$ .....	0,04 %	0,0022 $\frac{0,0022}{0,1486}$ = 0,15
B. Middle-layer		
$\text{Al}_2\text{O}_3$ .....	16,31 %	0,1596 = 1,—
$\text{SiO}_2$ .....	65,87 %	1,0924 $\frac{1,0924}{0,1596}$ = 6,84
$\text{CaO}$ .....	3,07 %	0,0547 $\frac{0,0547}{0,1596}$ = 0,34
$\text{MgO}$ .....	0,74 %	0,0183 $\frac{0,0183}{0,1596}$ = 0,11
$\text{K}_2\text{O}$ .....	1,53 %	0,0162 $\frac{0,0162}{0,1596}$ = 0,10
$\text{Na}_2\text{O}$ .....	4,01 %	0,0647 $\frac{0,0647}{0,1596}$ = 0,41
$\text{H}_2\text{O} + 110^\circ \text{C}$ .....	3,17 %	0,1759 $\frac{0,1759}{0,1596}$ = 1,10
$\text{H}_2\text{O} - 110^\circ \text{C}$ .....	0,33 %	0,0183 $\frac{0,0183}{0,1596}$ = 0,11

Chemical components	Molecular ratio	$\text{Al}_2\text{O}_3 = 1$
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## C. Surface-layer

$\text{Al}_2\text{O}_3$ .....	17,24 %	0,1687		= 1,—
$\text{SiO}_2$ .....	61,13 %	1,0138	$\frac{1,0138}{0,1687}$	= 6,01
$\text{CaO}$ .....	3,61 %	0,0644	$\frac{0,0644}{0,1687}$	= 0,38
$\text{MgO}$ .....	0,76 %	0,0188	$\frac{0,0188}{0,1687}$	= 0,11
$\text{K}_2\text{O}$ .....	1,78 %	0,0189	$\frac{0,0189}{0,1687}$	= 0,11
$\text{Na}_2\text{O}$ .....	3,90 %	0,0629	$\frac{0,0629}{0,1687}$	= 0,37
$\text{H}_2\text{O} + 110^\circ \text{C}$ .....	3,25 %	0,1804	$\frac{0,1804}{0,1687}$	= 1,07
$\text{H}_2\text{O} - 110^\circ \text{C}$ .....	1,53 %	0,0849	$\frac{0,0849}{0,1687}$	= 0,50

## D. Weathered fragments from C.

$\text{Al}_2\text{O}_3$ .....	15,67 %	0,1533		= 1,—
$\text{SiO}_2$ .....	63,77 %	1,0575	$\frac{1,0575}{0,1533}$	= 6,90
$\text{CaO}$ .....	2,86 %	0,0510	$\frac{0,0510}{0,1533}$	= 0,33
$\text{MgO}$ .....	1,09 %	0,0270	$\frac{0,0270}{0,1533}$	= 0,18
$\text{K}_2\text{O}$ .....	1,70 %	0,0180	$\frac{0,0180}{0,1533}$	= 0,12
$\text{Na}_2\text{O}$ .....	4,28 %	0,0690	$\frac{0,0690}{0,1533}$	= 0,45
$\text{H}_2\text{O} + 110^\circ \text{C}$ .....	3,16 %	0,1754	$\frac{0,1754}{0,1533}$	= 1,14
$\text{H}_2\text{O} - 110^\circ \text{C}$ .....	1,27 %	0,0705	$\frac{0,0705}{0,1533}$	= 0,46

## VIII. PHYSICAL RESEARCH

## a. Color.

	A	B	C
	Rock white	Middle-layer white	Surface-layer grey
(Klinksieck and Valetta) No. . . . .	153a	153a	148

## b. Mechanical analyses (With KRAUSS elutriator).

	B	C
	Middle-layer	Surface-layer
2 -0,2 mm . . . . .	25,2 %	29,1 %
0,2 -0,1 mm . . . . .	11,4 %	14,9 %
0,1 -0,05 mm . . . . .	15,9 %	14,0 %
0,05-0,02 mm . . . . .	18,7 %	15,9 %
0,02 mm . . . . .	22,4 %	26,1 %
floating on the water . . . . .	6,4 %	—
	100,0 %	100,0 %
c. Watercapacity . . . . .	50,25%	51,94%
d. Hygroscopicity . . . . .	4,5%	5,9%

e. Ph value, colorimetric determined by means of the „Hellige Komparator“.

A	B	C
Rock	Middle-layer	Surface-layer
5,3	5,8	6,0

## f. Radio-activity.

On my request, Prof. Dr. FERD. SCHMIDT, Heidelberg, examined the radio-activity of the surface-layer (C), the middle-layer (B) and the rock (A) and wrote me, dd. 28th Nov. 1930: „Die mir übersandten drei Proben Vulkanasche habe ich mehrmals mit der empfindlichsten gamma-Strahlmassmethode unseres Institutes auf Radio-aktivität untersucht. Alle drei Proben zeigen *keine* Radio-aktivität“.

## VIII. MICROBIOLOGICAL RESEARCH

My colleague in microbiology at this University, Prof. Dr. N. L. SÖHNGEN, wrote me (date 8-10-1929): „Mr. SCHUITEMAKER, agricultural engineer, studied, on your request, in my laboratory the microbes in the surface-layer (C) of your material from Lang-Eiland and compared the results with those of the surface-soil of the garden of my laboratory.

The approximative numbers (in 1 gram soil) are the following:

	Lang-Eiland	Wageningen
Bact. coli .....	10.000-100.000	100-1.000
Anaerobic organisms fermenting starch (amylum) .....	10.000-100.000	1.000-10.000
Organisms fermenting ureum .....	100.000-1.000.000	10.000-100.000
Denitrifying bacteria (nitrate) .....	10-100	100-1.000
Denitrifying bacteria (nitrite) .....	100-1.000	10-100
Azotobacter .....	100-1.000	100-1.000
Nitrifying bacteria (CaCO <sub>3</sub> ) .....	100-1.000	10-100
Nitrifying bacteria (MgCO <sub>3</sub> ) .....	100-1.000	100-1.000
Aerobic organisms fermenting starch (amylum) .....	1.500.000	2.500.000

These results are to be considered as preliminary.

### IX. CONCLUSIONS

In Lang-Eiland we have for the first time an excellent occasion to get an idea about the rapidity and intensity of „tropical weathering”<sup>1)</sup> far from human influences. We learn from the given dates, that in a period of 50 years humus has been formed for 0,45%; SiO<sub>2</sub>, Na<sub>2</sub>O and K<sub>2</sub>O are decreased; Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub> and H<sub>2</sub>O(-110° C) increased. For the rest, one can study the following table:

	Lang-Eiland (pumice)	Java (limestone)	Holland (limestone)	Holland (loess)
K. (see p. 12) .....	0,93	0,74	0,28	1,20
B. (see p. 12) .....	0,89	0,0003	0,0008	0,28

(Al<sub>2</sub>O<sub>3</sub> = 1; mol. ratio).

	Lang-Eiland		Java		Holland		Holland	
	Pumice	Pumice soil	Lime-stone	Lime-stone-soil	Lime-stone	Lime-stone-soil	Loess	Loess soil
SiO <sub>2</sub> .....	7,54	6,01	3,61	2,66	58,56	16,39	14,82	17,70
CaO .....	0,35	0,38	626,75	0,12	630,13	0,24	1,89	0,21
MgO .....	0,12	0,11	6,76	0,06	9,78	0,13	0,43	0,16
K <sub>2</sub> O .....	0,14	0,11	0,04	0,002	1,43	0,20	0,29	0,23
Na <sub>2</sub> O .....	0,49	0,37	0,03	0,003	0,65	0,12	0,24	0,23
H <sub>2</sub> O (+110°C.)	0,92	1,07	9,19	2,28	17,73	2,21	1,37	1,19
H <sub>2</sub> O (±110°C.)	0,15	0,50	1,77	2,45	15,95	2,31	1,18	1,15

<sup>1)</sup> Compare the rain-analyses.

**HET BODEMPROFIEL  
VAN HET VULKANISCHE LANG-EILAND  
(KRAKATAU-GROEP)**

Ofschoon wij van de flora en fauna van het eiland Krakatau, na de uitbarsting van 1883 meer of min goed onderricht zijn, weten wij van den verweeringsgrond, waarin de planten wortelen, niets af, noch van dit eiland, noch van de twee naburige eilanden: het Verlaten-Eiland en het Lang-Eiland. Dit was aanleiding te trachten materiaal te verwerven voor een uitvoerig onderzoek en wel van het Lang-Eiland, omdat hier een waarnemer van den Vulkanologischen Dienst tijdelijk is gestationeerd.

In dezen mag een woord van hartelijken dank aan Dr. CH. E. STEHN, Ir. A. C. DE JONGH en den Heer F. ECOMA VERSTEGE niet ontbreken.

Onderzocht werden van het uit 3 lagen bestaande profiel, nl. gesteente, tusschenlaag en bovenlaag met verweerde brokjes (de dikte dezer laag bedroeg 35 cm), de navolgende eigenschappen en samenstelling:

I. DE NATUURKUNDIGE EIGENSCHAPPEN

Kleur - korrelgrootte - watercapaciteit - hygroscopiciteit - zuurgraad en radioactiviteit.

II. DE SCHEIKUNDIGE SAMENSTELLING

Bepaald werd het procentisch gehalte van 27 verbindingen, nl.  $\text{SiO}_2$  -  $\text{TiO}_2$  -  $\text{ZrO}_2$  -  $\text{Al}_2\text{O}_3$  -  $\text{FeO}_3$  -  $\text{Cr}_2\text{O}_3$  -  $\text{V}_2\text{O}_3$  -  $\text{FeO}$  -  $\text{MnO}$  -  $\text{NiO}$  -  $\text{CaO}$  -  $\text{SrO}$  -  $\text{BaO}$  -  $\text{MgO}$  -  $\text{Na}_2\text{O}$  -  $\text{K}_2\text{O}$  -  $\text{Li}_2\text{O}$  -  $\text{H}_2\text{O}$  (+ 110° C) -  $\text{H}_2\text{O}$  (- 110° C) -  $\text{CO}_2$  -  $\text{SO}_3$  - S -  $\text{P}_2\text{O}_5$  - Cl - N - humus, en ten slotte het % uitwisselbare kalk.

III. DE MINERALOGISCHE SAMENSTELLING

Hierbij kon de aanwezigheid van 15 mineralen aangetoond worden, waarvan 3 nieuw gevormd (na 1883) nl. anhydriet, pyriet en wollastoniet.

IV. DE MICROBIOLOGISCHE EIGENSCHAPPEN

Een cultuurgrond van Wageningen werd vergeleken met den cultuurgrond van Lang-Eiland.



Gegevens t.a. van de *flora*, de *temperatuur*, den *regenval* en de *scheidkundige samenstelling van het regenwater* worden medegedeeld.

Uit de groote hoeveelheid gegevens is wellicht het belangwekkendste feit, dat in ongeveer *vijftig* jaar 0,45% humus is gevormd, op uitsluitend natuurlijke wijze, zonder invloed van den Mensch.

Dit eerste onderzoek verkrijgt eerst dan waarde, indien het na verloop van een aantal jaren herhaald wordt met nieuw materiaal, op dezelfde plaats verzameld, met dezelfde methoden onderzocht en waarbij aan dezelfde oogmerken gedacht wordt. Dit onderzoek zou zeer goed in Ned.-Indië kunnen verricht worden, indien er dan althans belangstelling, hulpmiddelen en onderzoekers voor aanwezig zijn.

**EIN BODENPROFIL DES VULKAN-INSELS LANG-EILAND**  
**(KRAKATAU-GRUPPE)**  
**GEBILDET INNERHALB 50 JAHRE**

Wie bekanntlich, erlebte der Vulkan Krakatau (Rakata) im Jahre 1883 eine grossartige Explosion, wobei die zwei Nachbarinsel: Verlaten Eiland und Lang-Eiland mit einer grossen Menge Auswurfsmassen überdeckt wurden. Die Frage, wie aus dieser Masse im Verlaufe von nahezu 50 Jahren ein Boden war entstanden, war bisher noch nie in Angriff genommen. Die zufällige Anwesenheit eines Beobachters des vulkanologischen Dienstes (Bandoeng), behufs Studium des wiedererwachten Vulkans Krakatau, veranlasste mich die Hilfe einzurufen der betreffenden Herren und so sammelte im Jahre 1928 Herr F. ECOMA VERSTEGE ein 3-schichtiges Profil und zwar:

A. Gestein (Bimstein); B. Zwischen-Schicht; C. Oberste Schicht (vgl. Abb. II). Diese 3 Schichten zusammen mit verwitterten Fragmenten des Bimsteins aus C (hier angedeutet mit D) wurden nun einer ausführlichen Untersuchung unterworfen, wobei der Analytiker Dr. L. MÖSER (Giessen) für die nötigen Analysen sorgte und Prof. Dr. FERD. SCHMIDT (Heidelberg) für eine Untersuchung nach der Radioaktivität.

**I. PHYSIKALISCHE EIGENSCHAFTEN (vgl. S. 15)**

Farbe; Körnergrösse; Wasserkapazität; Hygrosopizität; Ph (kolorimetrisch); Radioaktivität.

**II. CHEMISCHE ZUSAMMENSETZUNG (vgl. S. 8)**

Eine so ausgebreitete Untersuchung, wie Herr MÖSER auf meiner Bitte für mich ausführte ist bisher weder Stein wie Boden in Indien teil geworden. Aus den Bauschanalysen sind die Molekular-Verhältnisse berechnet und nebenbei die Quotiente im Sinne HARRASSOWITZ und STREME. (S. 12, 13.)

**III. PETROGRAPHISCHE ZUSAMMENSETZUNG (vgl. S. 6)**

Die folgenden Mineralien werden gefunden:

Amphibol; Anhydrit; Apatit; Augit; Cyanit; Hypersthen; Ilmenit; Magnetit; Olivin; Plagioklas; Pyrit; Quarz; Vulkanisches Glas; Wollastonit.

Anhydrit, Pyrit und Wollastonit sind Neubildungen.

## IV. BAKTERIOLOGISCHE ZUSAMMENSETZUNG

	Kulturboden Lang-Eiland	Kulturgarten des In- stituts für Bakteri- ologie in Wageningen
Bact. coli .....	10.000-100.000	100-1.000
Anaerobe Stärke-spaltende Organismen.	10.000-100.000	1.000-10.000
Ureum-spaltende Organismen .....	100.000-1.000.000	10.000-100.000
Denitrifizierende Bakterien (Nitrat) ....	10-100	100-1.000
Denitrifizierende Bakterien (Nitrit) ....	100-1.000	10-100
Azotobacter .....	100-1.000	100-1.000
Nitrifizierende Bakterien (CaCO <sub>3</sub> ) .....	100-1.000	10-100
Nitrifizierende Bakterien (MgCO <sub>3</sub> ) .....	100-1.000	100-1.000
Aerobe Stärke-spaltende Organismen..	1.500.000	2.500.000

Dieses Resultat muss als vorläufig angesehen werden.

## V. KLIMA UND VEGETATION

Jahrestemperatur: 27,8° C.

Jährliche Regenmenge: 2620 mm.

Regenfaktor (LANG): 94.

Chemische Zusammensetzung des Regenwassers: vgl. S. 5.

Vegetation: Farnen, Gras, *Casuarina*, *Ficus*.

## VI. ERGEBNISSE

Wie massgebend bei der Verwitterung der Einfluss des Gesteins und des Alters sind zeigen die nachstehenden Daten, welche aber für weitergehende Schlussfolgerungen noch nicht zu verwenden sind. Die Daten sind vollkommen richtig aber ihre Zahl ist zu wenig.

	Lang-Eiland (Bimstein) rezent	Java (Kalkstein) Tertiär	Holland (Kalkstein) Senon	Holland (Löss) Quartär
K. (vgl. S. 12) .....	0,93	0,74	0,28	1,20
B. (vgl. S. 12) .....	0,89	0,0003	0,0003	0,28

(Al<sub>2</sub>O<sub>3</sub> = 1; mol. Verhältnisse)

	Lang-Eiland		Java		Holland			
	Bimstein	Bimstein-Boden	Kalkstein	Kalkstein-Boden	Kalkstein	Kalkstein-Boden	Löss-Gestein	Löss-Boden
SiO <sub>2</sub> .....	7,54	6,01	3,61	2,66	58,56	16,39	14,82	17,70
CaO .....	0,35	0,38	626,75	0,12	630,13	0,24	1,89	0,21
MgO .....	0,12	0,11	6,76	0,06	9,78	0,13	0,43	0,16
K <sub>2</sub> O .....	0,14	0,11	0,04	0,002	1,43	0,20	0,29	0,23
Na <sub>2</sub> O .....	0,49	0,37	0,03	0,003	0,65	0,12	0,24	0,23
H <sub>2</sub> O (+110°C.)	0,92	1,07	9,19	2,28	17,73	2,21	1,37	1,19
H <sub>2</sub> O (-110°C.)	0,15	0,50	1,77	2,45	15,95	2,31	1,18	1,15

Was die Analysen betrifft, hat es sich gezeigt, dass sich innerhalb 50 Jahre 0,45% Humus hat gebildet; Kieselsäure, Natron und Kali (molekular) abgenommen sind; Aluminiumoxyd, Eisenoxyd und Wasser (—110° C) (molekular) dagegen zugenommen sind.

## LA FORMATION D'UNE TERRE ARABLE D'ORIGINE VOLCANIQUE PENDANT 50 ANNÉES

Dans le détroit de Soenda ou de la Sonde (entre Java et Sumatra) se trouve un groupe des îles volcaniques nommé : Krakatau, Verlaten Eiland (île abandonnée) et Lang-Eiland (île longue).

Lang-Eiland se compose à la surface des pierres ponceuses (fig. II), dont l'auteur a étudié un profil vertical :

- C. la terre végétale, puissance 30 centimètres;
- B. la couche au-dessous : ponce pulvérulente;
- A. la roche-mère (= des pierres ponceuses dures).

Les recherches exécutées sont les suivantes :

### I. PHYSIQUE

Couleur; analyse mécanique; capacité d'imbibition; hygroscopicité; réaction du sol; radioactivité.

### II. CHIMIQUE

Les éléments suivants sont déterminés :

$\text{SiO}_2 - \text{TiO}_2 - \text{ZrO}_2 - \text{Al}_2\text{O}_3 - \text{Fe}_2\text{O}_3 - \text{Cr}_2\text{O}_3 - \text{V}_2\text{O}_5 - \text{FeO} - \text{MnO} -$   
 $\text{NiO} - \text{CaO} - \text{SrO} - \text{BaO} - \text{MgO} - \text{Na}_2\text{O} - \text{K}_2\text{O} - \text{Li}_2\text{O} - \text{H}_2\text{O} (+110^\circ \text{C})$   
 $- \text{H}_2\text{O}(-110^\circ \text{C}) - \text{CO}_2 - \text{SO}_3 - \text{SO}_2 - \text{S} - \text{P}_2\text{O}_5 - \text{Cl} - \text{N} - \text{Humus} - \text{Ca}$   
 (échangé).

### III. MINÉRALOGIQUE

Les minéraux suivants sont trouvés :

amphibole; anhydrite; apatite; augite; cyanite; hypersthène; ilménite; magnétite; olivine; plagioclase; pyrite; quartz; verre volcanique; wollastonite. Anhydrite, pyrite et wollastonite sont formés *après 1883*.

### IV. MICROBIOLOGIQUE

Comparaison des microbes de la terre végétale d'un jardin du laboratoire microbiologique à Wageningen et de Lang-Eiland.

	Lang-Eiland	Wageningen
Bact. coli .....	10.000-100.000	100-1.000
Microbes anaérobies détruisant l'amidon.	10.000-100.000	1.000-10.000
Microbes détruisant l'urée .....	100.000-1.000.000	10.000-100.000
Microbes dénitrificateurs (nitrate).....	10-100	100-1.000
Microbes dénitrificateurs (nitrite).....	100-1.000	10-100
Azotobacter .....	100-1.000	100-1.000
Microbes nitrificateurs (CaCO <sub>3</sub> ) .....	100-1.000	10-100
Microbes nitrificateurs (MgCO <sub>3</sub> ) .....	100-1.000	100-1.000
Microbes aérobies détruisant l'amidon ..	1.500.000	2.500.000

Les résultats des recherches microbiologiques doivent être considérés comme provisoires.

### V. CLIMAT ET VÉGÉTATION

Température annuelle: 27,8° Celsius.

Quantité annuelle de pluie: 2620 mm.

Quotient LANG  $\left( \frac{\text{quantité annuelle de pluie}}{\text{température annuelle}} \right) = 94.$

### VI. CONCLUSION

Pendant 50 années se formait 0,45% humus; SiO<sub>2</sub>, Na<sub>2</sub>O et K<sub>2</sub>O diminuaient; Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub> et H<sub>2</sub>O(-110° C) augmentaient. Du reste, je me réfère aux données suivantes:

	Lang-Eiland (pierres ponces)	Java (calcaire)	Hollande	
			(calcaire)	(loess)
Quotient K. (p. 12) ..	0,93	0,74	0,28	1,20
Quotient B. (p. 12) ..	0,89	0,0003	0,0008	0,28

(Al <sub>2</sub> O <sub>3</sub> = 1)	Lang-Eiland (pierres ponces)		Java (calcaire)		Hollande			
	roche- mère	terre arable	roche- mère	terre arable	calcaire		loess	
					roche- mère	terre arable	roche- mère	terre arable
SiO <sub>2</sub> .....	7,54	6,01	3,61	2,66	58,56	16,39	14,82	17,70
CaO .....	0,35	0,38	626,75	0,12	630,13	0,24	1,89	0,21
MgO .....	0,12	0,11	6,76	0,06	9,78	0,13	0,43	0,16
K <sub>2</sub> O .....	0,14	0,11	0,04	0,002	1,43	0,20	0,29	0,23
Na <sub>2</sub> O .....	0,49	0,37	0,03	0,003	0,65	0,12	0,24	0,23
H <sub>2</sub> O (+110°C.)	0,92	1,07	9,19	2,28	17,73	2,21	1,37	1,19
H <sub>2</sub> O (-110°C.)	0,15	0,50	1,77	2,45	15,95	2,31	1,18	1,15

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The book which gives us the best review of our contemporary knowledge about the geology of the Indian Archipelago is the well-illustrated book of Prof. Dr. L. M. R. RUTTEN: *Voordrachten over de geologie in Nederlandsch-Indië*, Groningen 1927, 810 pp, with 243 fig.

A concise work is: H. A. BROUWER: *The geology of the Netherlands East Indies*, London 1925, 160 pp, 17 fig, 18 pl.

The history of geological science gives: *Science in the Netherlands East Indies* by L. M. R. RUTTEN, Amsterdam 1929, 432 pp.

## DESCRIPTION OF THE PLATES AND FIGURES

Photo 1. Outlet of the erosion-gully, westcoast of Lang-Eiland. Photo: W. PETROESCHEVSKY, Volcanological Survey, Bandoeng.

Photo 2. Erosion-gully, south of the observationstation of the Volcanological Survey on Lang-Eiland. The soilprofile was sampled in the pumicemass on the left.

Photo: Dr. CH. E. STEHN, Volcanological Survey, Bandoeng.

Fig. 1. *Kyanite*, cleavage-pieces, 200 ×. Under-layer.

Fig. 2. *Hypersthene*, with figures of combustion. 80 ×. Middle-layer.

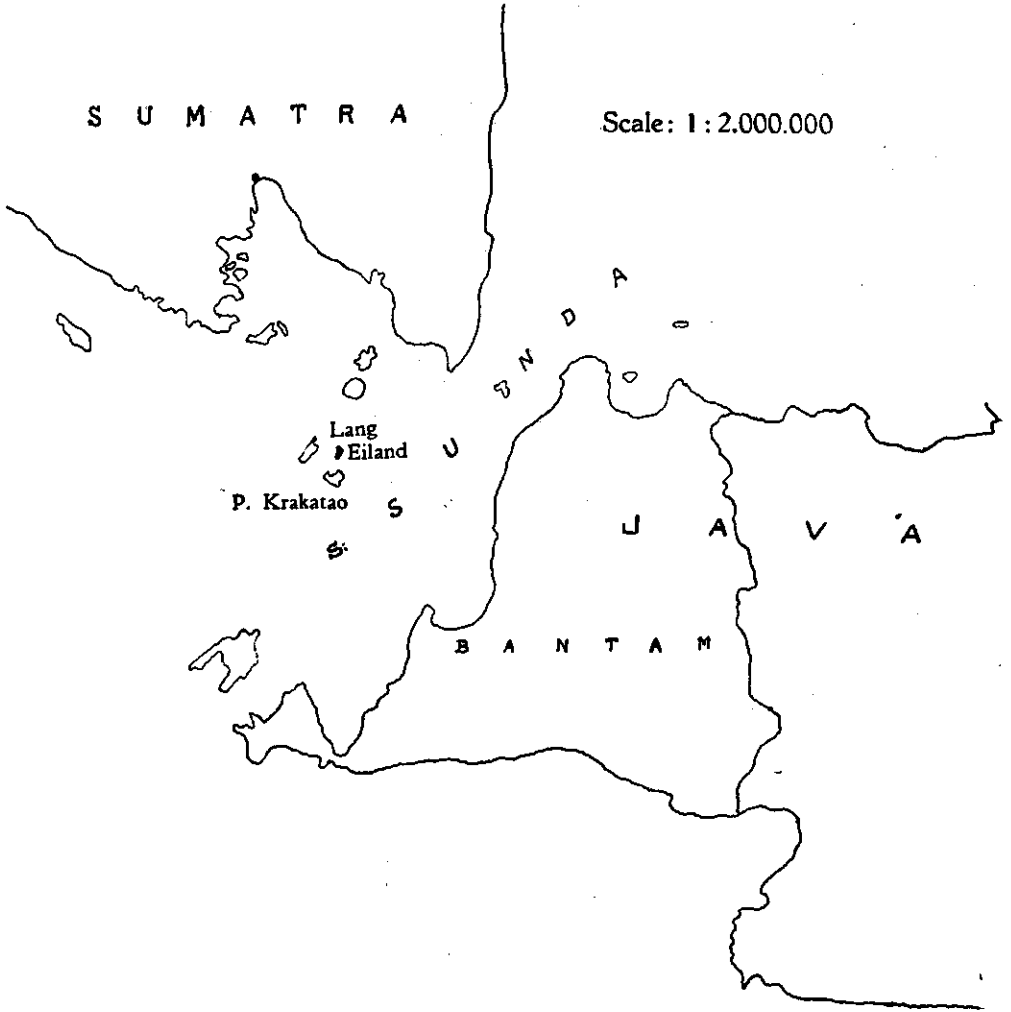
Fig. 3. *Plagioclase*, with inclusions of hypersthene, ilmenite and magnetite. 50 ×. Surface-layer.

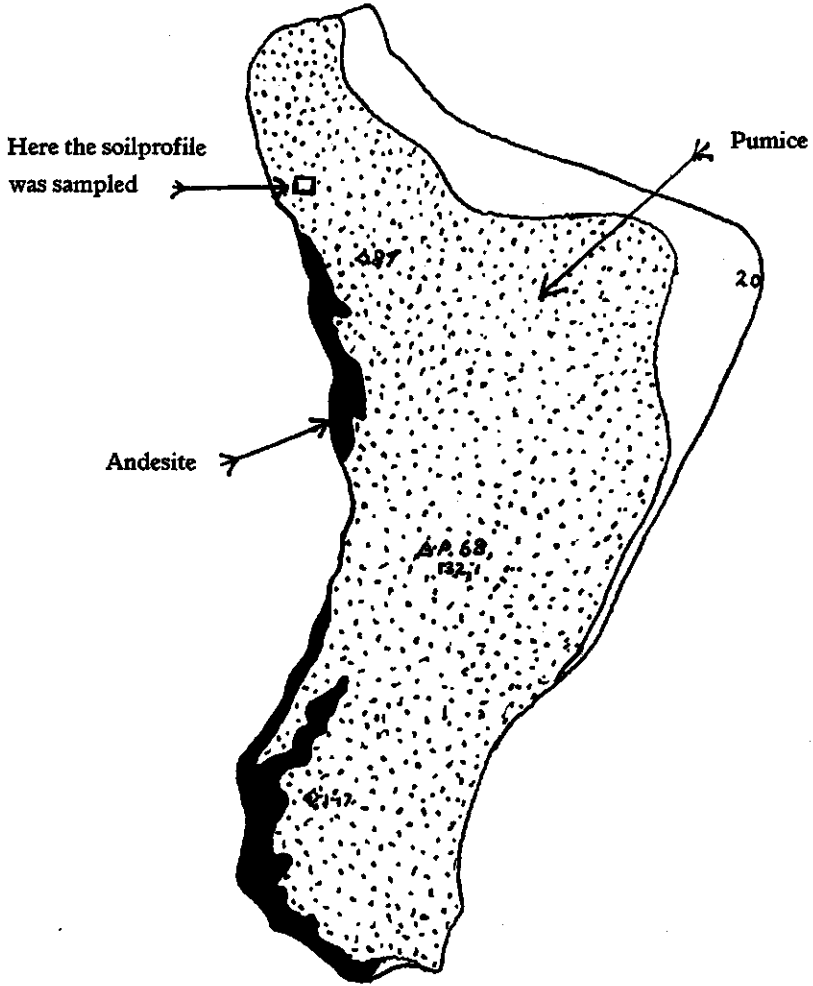
Fig. 4. *Plagioclase*, with gasbubbles and inclusions of apatite. 50 ×. Surface-layer.

Fig. 5. *Plagioclase*, with figures of combustion. 12<sup>1</sup>/<sub>2</sub> ×. Surface-layer.

Fig. 6. *Volcanic glass*, with gasbubbles. 200 ×. Surface-layer.

The figures are drawn by Mr. A. G. EYMERS, Wageningen.





**LANG-EILAND**

Scale: 1 : 25000



Photo 1

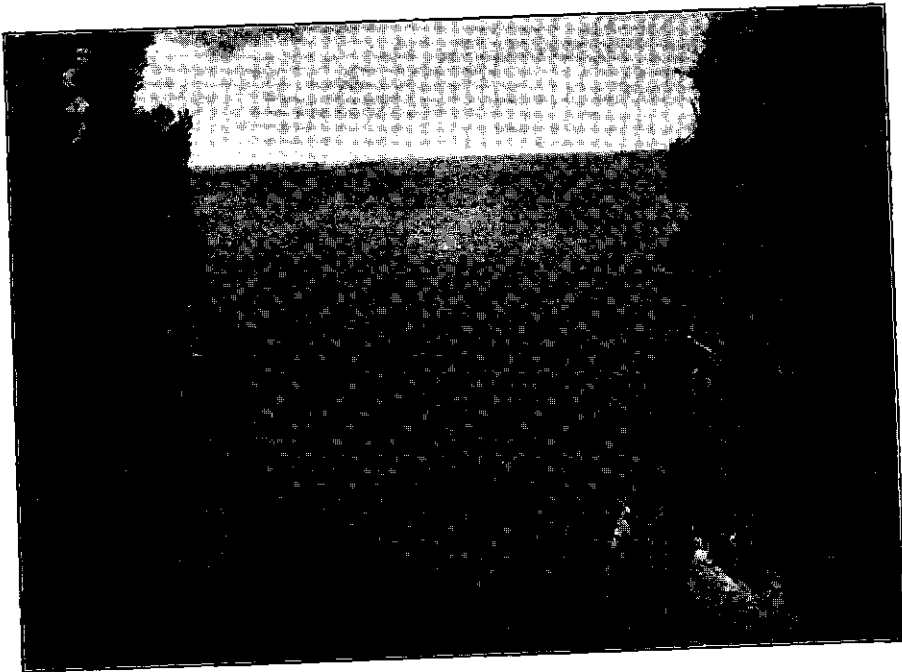


Photo 2

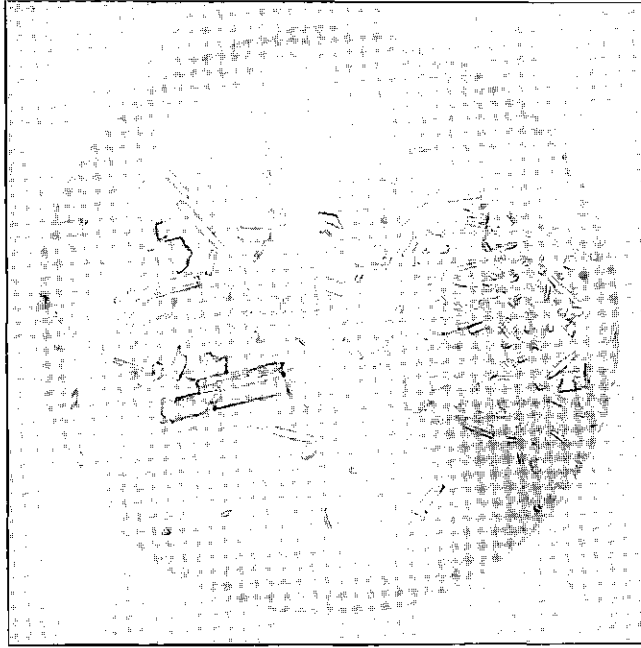


Fig. 1

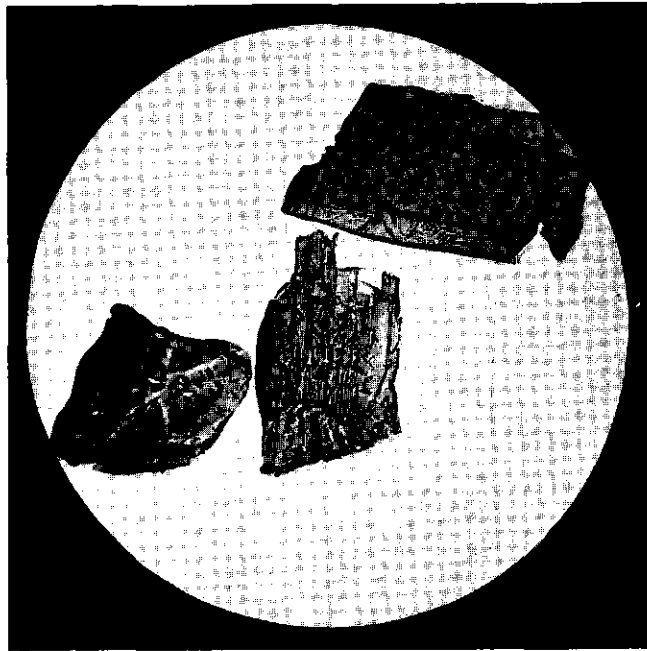


Fig. 2



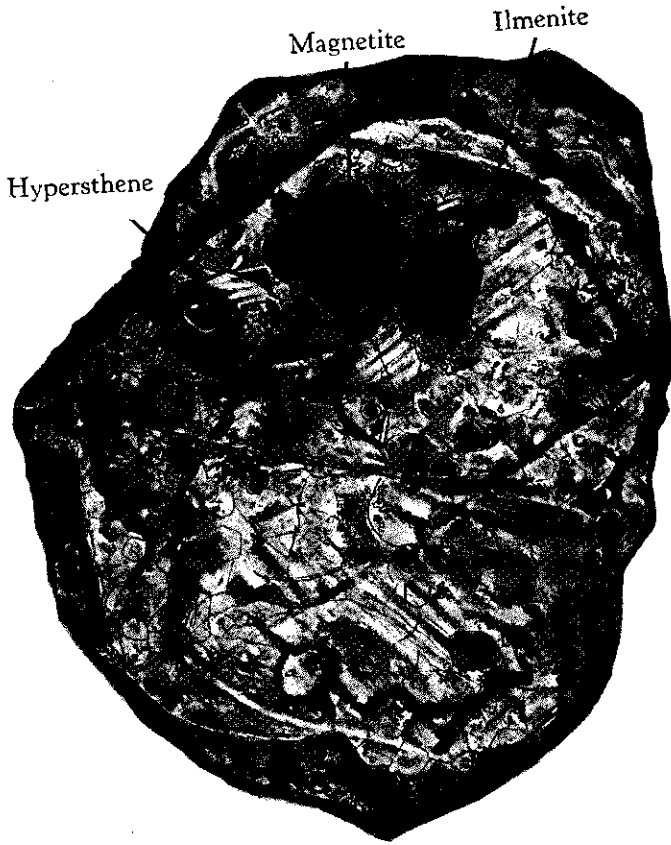


Fig. 3

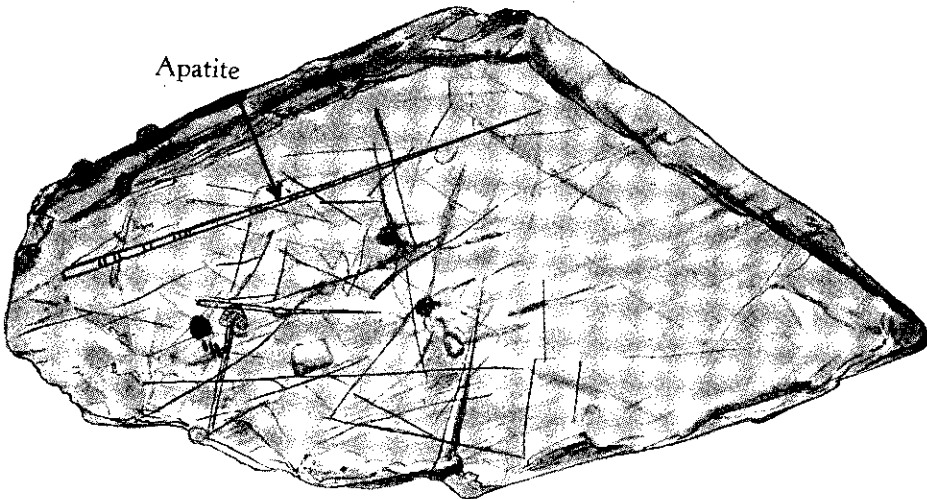


Fig. 4

