9. Soil Samples from the Nahuel Huapí Region of Northern Patagonia.[1]

By

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With an Appendix on Diatoms from Lago Frey.

By

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[1] Report No. 9 of the Swedish Expedition to Patagonia 1932—1934.

I. Introduction.

In the spring of 1939 Docent ERIK LJUNGNER of Uppsala handed over to me for working up a number of soil samples, collected by him during his third expedition to Northern Patagonia in 1932—1934. Later a few samples of lapilli and of eolian material obtained in particular from epiphytic mosses, mainly collected in the course of the same expedition, were also added to the investigation material. Owing to unforeseen contingencies the results of the work have not been available for publication until now.

All particulars given here about the position, geology and general appearance of the localities have been supplied by Docent LJUNGNER. For these particulars, for all help in compiling the results, and for the task of working up this material, I beg to express my sincere thanks to Docent LJUNGNER. The investigation has been carried out at the Institute of Mineralogy and Geology at Uppsala. To its Director, Professor H. G. BACKLUND, I tender my thanks for much valuable advice and discussion during the course of the work. For help and advice of different kinds I am further indebted to Docent N. G. HÖRNER and to Docent TORSTEN KROKSTRÖM and also to Fil. dr WALTER LARSSON. My thanks are due to Preparator W. PLAN for making thin sections and particle mounts in Canada balsam.

In November 1941 I obtained a copy of SALMI's paper on »Die postglazialen Eruptionsschichten Patagoniens und Feuerlands» (1941). The results published there do not anticipate my own. They are, if anything, partly the basis of my argument. As will be shown, the samples collected by LJUNGNER are for the most part of different character and of different origin from those of SALMI. This is in part due to the fact that SALMI was able to make use of the numerous cuttings along the magnificent road constructions within the area, carried out after the completion of LJUNGNER's expedition. SALMI (o. c., p. 7) himself points out the great importance this had for his investigation. The samples at my disposal are in addition partly from different kinds of localities and from different levels. Thus my problem was a different one from SALMI's.

II. Material and methodology.

The material comprises 26 soil samples, including a bottom sample from a lake and a sample of a clay from the shore of a lake, and also lapilli from a small number of localities. It has been collected in the neighbourhood of Lago Nahuel Huapí. With the exception of three samples collected in Chile within Dept° Llanquihue of Prov. Chiloë, the

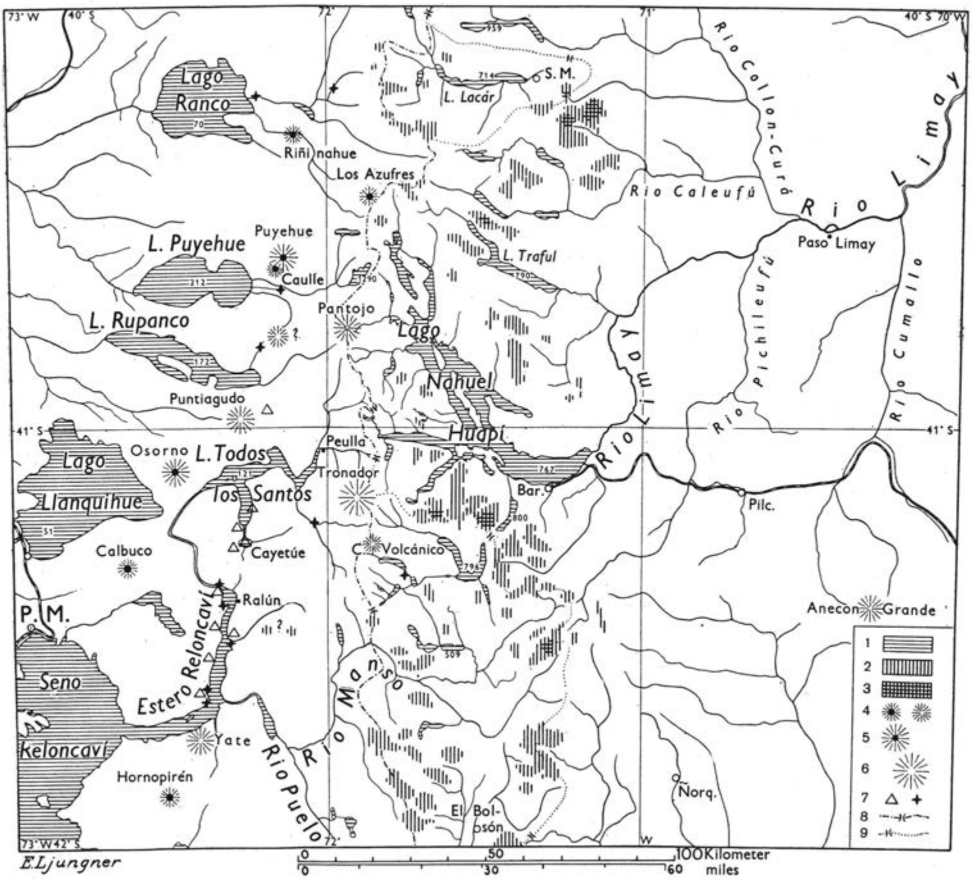


Fig. 1. Sketch map showing the orographical conditions of Sheet 72 Nahuel Huapí (1928) of the map of the Argentine Ordnance Survey, with corrections by LJUNGNER. Scale 1 : 2 000 000.

1. Water surfaces (with the altitudes above sea-level).
2. Areas exceeding 2000 metres above sea-level.
3. » » 2300 » » » »
4. Active and extinct volcano, altitude < 2000 metres above sea-level.
5. Active volcano, altitude between 2000 and 3000 metres above sea-level.
6. Extinct volcano, altitude > 3000 metres above sea-level.
7. Eruption centre (according to REICHERT 1917 and STEFFEN 1919). — Hot spring.
8. The Chilean-Argentine boundary, with a pass below 1200 metres above sea-level.
9. Continental divide, with a pass below 1200 metres above sea-level.

samples have been collected in Argentine territory within the most north-westerly corner of Terr° Rio Negro (Dept° Bariloche) and the most south-westerly part of Terr° Neuquen (Dept° Los Lagos). The position of the area and of the localities is clear from the maps in Figs. 1 and 2 and from the description of the localities. The bedrock of the area has been described by LJUNGNER (1931) and by LARSSON (1940).

The loss of ignition has been determined for most of the samples. The

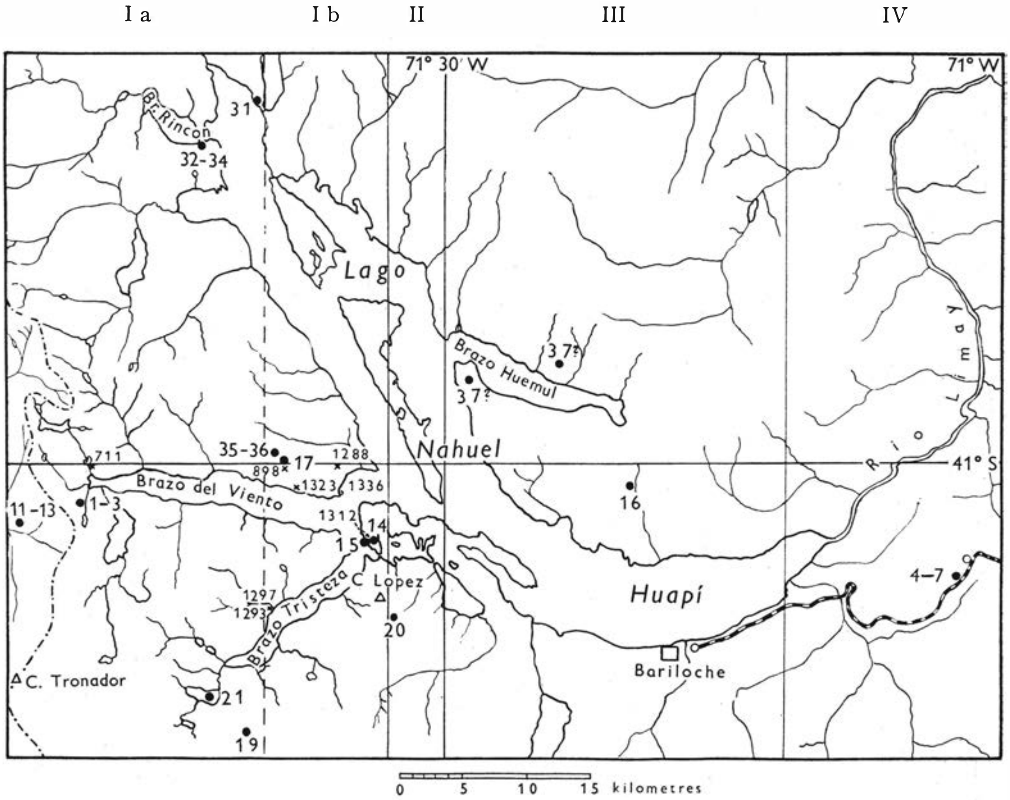


Fig. 2. Index map showing the situations of the sample localities. Scale 1:600 000. The samples obtained from mosses are marked with crosses, the others with dots. The Roman figures at the upper edge of the map refer to LJUNGNER's vegetation zones, whose boundaries are indicated by lines running from north to south.

samples were dried at 110—120° during one hour, after which they were brought to incandescence. The loss of ignition is calculated in percentages of the original amount (after drying). The results have been put together in Table I (p. 177).

When sufficient material of the samples has been available, they have been divided up into a number of size grades by means of sieving with square meshed sieves and by elutriation. Before the sieving the material was treated with hydrogen peroxide according to ROBINSON 1922. In a wet state that part of the sample intended for the elutriation was separated with the help of a 0.06 mm sieve (Cf. however sample No. 15, p. 185). The grade intervals used at the sieving besides and at the elutriation are seen from the histograms given. The particulars about the dimensions of the sieves have been furnished by Docent HÖRNER. The sieving time was 8—10 hours. The elutriations were as a rule carried out with Atterberg sedimentation cylinders according to the instructions in EKSTRÖM 1927, pp. 78—86. One single elutriation (sample No. 15) was done by the pipette method according to the description in KRUMBEIN and PETTIJOHN 1938, pp. 166—168. The times of settling are computed according to STOKES' law, the specific gravity of the quartz, 2.65, being taken into account. — In the mechanical analysis at the transition between sieving and elutriation a fraction is obtained throughout that according to the sieving should be finer but according to the elutriation coarser than 0.06 mm. This may probably be partly explained by the fact that the value for the dimension of the finest sieve, 0.06 mm, is very uncertain. The mesh width of the sieve will probably as a matter of fact be somewhat larger; further, it is not constant over the whole bolting-cloth. This »homeless» fraction, afterwards referred to as the »problematic fraction», has been placed in the histogram at the 0.06—0.0312 mm grade, and has been indicated with vertical hatching. As regards the construction of the histograms the following may further be mentioned. On the horizontal axis the diameters are laid off on a logarithmic scale. The total surface of the histogram blocks are equal to 100 per cent. A small square representing 1 per cent is marked in the upper left corner of the diagrams. For the particle size distribution it is a question of weight percentage frequency, for the particle group distribution of number percentage frequency. The total loss during the whole analysis and the amount of material finer than 0.00195 mm are indicated with small squares to the right in the histograms, the former with a broken line and the latter with a continuous one. — For sample No. 15 the cumulative curve has been given in addition to the histogram.

In samples Nos. 1, 2 and 4 the sieve grades have been divided up with bromoform of specific gravity 2.85. The surface between the base line of the histogram and the broken line with stipples represents the heavier part of the sieve grades examined; this upper boundary line is plotted in independently of the lines bounding the different kinds of particle groups dealt with below.

In samples Nos. 1, 2, 3, 4, 17 and 20 and in the tuff from Cerro Lopez counting of particles belonging to a number of differentiated groups, particle groups, was made within the sieve grades. In this connection representative part samples of the respective sieve grades were used, which had been separated by means of an Otto microsplit (Cf. KRUMBEIN and PETTIJOHN o. c., pp. 357—358), and had been mounted in Canada balsam. The particles of the coarser sieve grades were previously ground down to a suitable thickness. For the sake of clarity, the differentiated groups are quite few in number, as is seen from the histograms (Cf. the explanation of symbols in Fig. 4). A more detailed description of them is given in connection with the treatment of samples Nos. 1—3 (p. 176—8). Of each sieve grade about 300 particles were usually counted. This number will probably be sufficient in the present case (Cf. BOOBERG 1939, p. 195 and von Engelhardt 1939/1940, p. 454). For the sake of clearness it may here be mentioned that in accordance with, for instance, Mogensen (1941, p. 6) particles here mean the smallest free parts into which a sediment or the like may be disperged. A particle may consist of one or more grains. In the elutriation grades no counting of particles has been made, with the exception of samples Nos. 4 and 20.

The plagioclase determinations were made partly by the immersion method, using the diagram in Goranson 1926, p. 152, and partly on the universal stage, making use of Nikitin's stereogram (Nikitin 1936). The refractive index of the glasses was determined by the immersion method, using sodium light. The percentages of silica corresponding to the refractive indices were taken from the diagram in George 1924, p. 365.

For a more detailed description of the physical geographical and geological conditions of the investigation area the reader is referred, in addition to the previously mentioned works by Ljungner and Larsson, to Ljungner's account of »A forest section through the Andes of Northern Patagonia» (Ljungner 1939) and to his coming paper on »Nahuel Huapí. Ein geographischer Querschnitt durch die Anden in Patagonien».

III. **Descriptions of samples.**

The most important data on the different samples has, for the sake of comparison, been put together in Table I below. Further particulars are to be found in the brief descriptions of samples which follow.

Samples Nos. 1—3: Arg., Terr? Rio Negro, by an old bridle-path over Paso Raulí to Chile, 35 minutes walk from the innermost end of Brazo del Viento, 878 m above sea-level, 1.6.1934, in a dense rain forest of *Nothofagus Dombeyi* with *Laurelia sempervirens* (Ljungner's (1939) vegetation zone I a). The samples were taken in the vertical wall of a pit dug earlier, in apparently homogeneous material, sample No. 3 10 cm, No. 2 60 cm and No. 1 112 cm below the surface of the ground.

Of the minerals contained in sample No. 1 the following — in addition to what is clear from Table I — may be stated, which in relevant parts also applies to the other samples in the material. The hypersthene occurs as prisms or fragments of such. Their refractive indices are $\alpha' = 1.684 \pm 0.005$, $\gamma' = 1.695 \pm 0.002$, which according to Winchell 1933 indicates 21 % $FesiO_3$. $2 V_\alpha$ was determined on the universal stage (Nikitin's method) to 86°, which gives 17 % $FesiO_3$. The value is somewhat uncertain, as the crystal fragment examined was rather thick for using the Berek compensator. The pleochroism is γ grass-green $> \alpha$ yellowish red. In one case a penetration twin on (013) was observed of the type described by Becke (1886, p. 95). In those cases in which control has

Table 1.

Data on samples Nos. 1—21.

Sample No.	Locality	Country rock	Appearence of the samples in natural state	Loss on ignition %	Mineralogical composition	Plagioclase: Refractive indices	Plagioclase: Composition	Glass: Refractive indices	Glass: % SiO_2	Fig.
1	Arg., 71°50'W, 41° 2'S.	Granite, with incl. of metam. schists and sandst. Intergl pyrocl. and eff. (N.E, E and S.SE, 2.5 km, S.SW, 10km)	Yellowish brown, pa. 2-5(-10) mm i.d.	8.3	Hy., au., ap., pl. and gl.	$\alpha'=1.550 \pm 0.003$ $\gamma'=1.566 \pm 0.001$	An_{45-56}	1.508-1.517	~69-~65	5
2	Ibidem.	Idem.	Yellowish brown, pa. 1(-3) mm i.d.	6.0	Idem.	$\alpha'=1.564 \pm 0.003$ $\beta'=1.576 \pm 0.002$	An_{75-87}	1.545 ±0.002- 1.571 ±0.003	~55-~52	4
3	Ibidem.	Idem.	Brown, pa. 2-5 (-10) mm i.d.	13.2	Hy., au., ol., ap., pl., and gl.	$\alpha'=1.564 \pm 0.003$ $\gamma'=1.571 \pm 0.003$	An_{75-67}	1.509 ±0.005- 1.588 ±0.003	~68-~49	3
4	Arg., 71° 1'W, 41°4.5 S.	Tert. pyrocl. and eff. (see the text)	Brownish gray, pa. <0.5 mm i.d.	4.7	Hy., au., ap., pl., gl. and keratophyr.	$\alpha'=1.555 \pm 0.005$ $\gamma'=1.572 \pm 0.002$	An_{52-70}	1.510 ±0.004- 1.577 ±0.002	~68-~51	6
5	Ibidem.	Idem.	Grayish brown, pa. 0.5(-1) mm i.d.	4.7	Idem.	$\alpha'=1.557 \pm 0.003$ $\gamma'=1.571 \pm 0.004$	An_{55-67}	1.538 ±0.002- ~1,58	~57-~50	7
6	Ibidem.	Idem.	Brownish yellow, pa. <0.5 mm i.d.	-	Idem.	$\alpha'=1.543 \pm 0.004$ $\gamma'=1.571 \pm 0.003$	An_{28-67}	~1.54- ~1.58	~56-~50	-
7	Ibidem.	Idem.	Yellowish brown, pa. 1(-2)mm i.d.	6.6	Au., hbl., ap., pl., gl. and keratophyr.	$\alpha'=1.545 \pm 0.001$ $\gamma'\sim 1.574$	An_{36-77}	~1.567- 1.576 ±0.002	~51-~52	8
11	Chile, 71°55'W, 41° 3'S.	Granite, with incl. of older rocks. Tronador's Intergl volcanic mass (S, 5 km).	Reddish-yellowish brown, pa. -2 mm i.d.	9.2	Hy., ap., pl., gl. and loc. mat.	$\alpha'=1.557 \pm 0.003$ $\gamma'=1.571 \pm 0.003$	An_{55-67}	1.530 ±0.006- ~1.58	~59-~50	9
12	Ibidem.	Idem.	Idem.	8.5	Au., ap., pl., gl. and loc. mat.	$\alpha'\sim 1.567$ $\gamma'=1.576 \pm 0.003$	An_{82-80}	1.538 ±0.001- 1.604 ±0.008	~57-~48	10
13	Ibidem.	Idem.	Brownish yellow, pa. <0.5(-2) mm i.d.	15.4	Hy., hbl., ap., pl., gl. and loc. mat.	$\alpha'=1.557 \pm 0.003$ $\gamma'=1.564 \pm 0.003$	An_{55-54}	1.520 ±0.004- 1.579 ±0.004	~63-~50	11
14	Arg., 71°35'W, 41° 4'S.	Granite.	Grayish black, pa. very fine.	27.9	Hy., au., ap., pl. and gl.	$\alpha'=1.564 \pm 0.004$ $\beta'=1.576 \pm 0.003$ $\gamma'=1.579$	An_{75-87}	~1.487- 1.587 ±0.004	~77-~50	12
15	Ibidem.	Idem.	Dry: gray, moist: greenish blue.	-	Au., pl., pot. feldsp., gl., rock fragments and clay substance.	$\alpha'=1.557 \pm 0.003$ $\gamma'=1.564 \pm 0.003$	An_{55-54}	1.530 ±0.005- ~1.58	~59-~50	13
16	Arg., 71°20.5 W, 41° 1'S.	Quartz-diorite, Tert. pyrocl. and eff. (higher levels), granite (at some distance).	Grayish brown, pa. -1 mm i.d.	7.1	Hy., ap., mu., pl., gl. and loc. mat.	$\alpha'=1.564 \pm 0.004$ $\gamma'=1.571 \pm 0.004$	An_{75-67}	1.520 ±0,005- ~1.58	~63-~50	14
17	Arg., 71°39'W, 41° 0'S.	Tert. pyrocl. and eff., granite (see the text).	Rusty brown. pa. <2(-10) mm i.d.	12.7	Hy., au., hbl., ap., pl., gl. and rock fragments.	$\alpha'=1.563 \pm 0.004$ $\gamma'=1.576 \pm 0.003$	An_{70-80}	1.530- ~1.58	~59-~50	15
19	Arg., 71°41'W, 41°12'S.	Granite.	Yellowish brown, pa. -1 mm i.d.	5.4	Hy., au., ap., pl. and gl.	$\alpha'\sim 1.562$ $\beta'=1.564 \pm 0.003$ $\gamma'=1.571 \pm 0.004$	An_{62-67}	1.538 ±0.001- 1.593 ±0.002	~57-~49	-
20	Arg., 71°34'W, 41° 7'S.	Quartz-diorite(E), gneiss (S), granite (W); above those quartz-porphyry and Intergl. pyrocl sediments (see below).	Black.	5.3	Hy., au., ap., pl. and gl.	$\alpha'=1.571 \pm 0.004$ $\gamma'=1.583$	An_{90-91}	1.543 ±0.004- 1.587 ±0.004	~55-~50	18
21	Arg., 71°43'W, 41°11'S.	Granite; quartz-diorite(S) and gneiss(S).	Blackish gray detritus ooze.	-	Orth. pyr., pl. and gl.	$\alpha'=1.548$ $\gamma'=1.576 \pm 0.003$	An_{43-80}	1.541 ± 0.002- ~1.58	~56-~50	-
C. Lopez	Arg., 71°34.5 W, 41° 6.5 S.	Quartz-porphyry.	Layered tuff.	3.5	Orth. and mon. pyr., pl., gl. and rock fragments.	$\alpha'=1.543 \pm 0.004$ $\gamma'=1.557 \pm 0.003$	An_{28-43} ($An_{60,70}$)	1.538 ±0.002- 1.543 ±0.003	~56-~55	19

ap. apatite
au. diopsidic augite
eff. effusives
gl. glass
hbl. basaltic hornblende
hy. hypersthene
i.d. in diameter
incl. inclusions
Intergl. Interglacial
loc. mat. local material
metam. metamorphic
mon. pyr. monoclinic pyroxene
mu. muscovite
ol. olivine
orth. pyr. orthorhombic pyroxene
pa. particle aggregates
pl. plagioclase
pot. feldsp. potash feldspar
pyrocl. pyroclastics
Tert. Tertiary.

been made the hypersthene of the remaining samples has proved to be of the type now described. — The diopsidic augite is optically positive, has $c/\gamma = 44^\circ$ and shows a very weak pleochroism: γ bluish green, α reddish yellow. It occurs as prisms or fragments of such. It seems to be of similar type in the whole material. Like the hypersthene it resembles the one described by SALMI (o. c., pp. 25 and 18 respectively). — The apatite occurs as small prismatic crystals in the glass, mainly in »other types of glass».

The plagioclase crystals are for the most part tabular, but also prismatic, usually twinned, and most frequently show a marked zonation; homogeneous crystals also appear, however.

The glass is of very varying character. A black opaque glass with a high refractive index (N~1.58) dominates. Quite an important role is also played, as shown by the diagram in Fig. 5, by a yellowish brown, often small-vesicled, partly devitrified glass. The group »other types of glass» comprises colourless, pale brown and dark brown homogeneous glass and also mainly pale brown-coloured or colourless fibrous and globulous glass. The black opaque glass in part shows transitions to other types of glass.

As regards the differentiated types of particles otherwise found in the diagram, it may be pointed out here that »pyroxene, amphibole, with glass» and »plagioclase with glass» refer to the respective minerals lying in a glassy mesostasis. The »problematic fraction» has already been dealt with (p. 175. Cf. also p. 206).

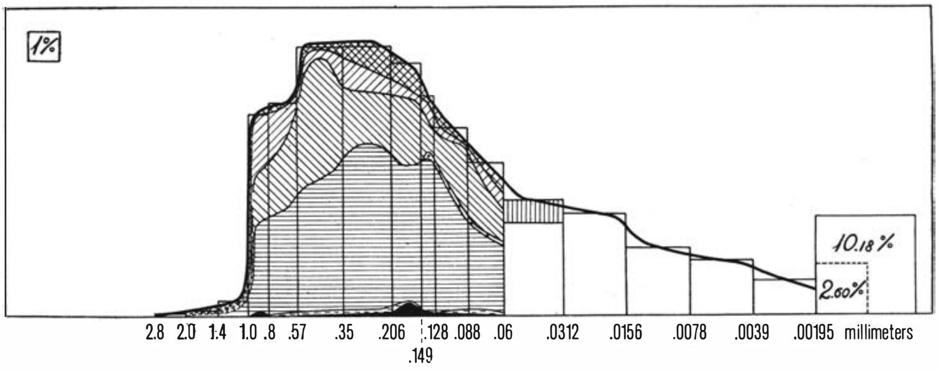
The 1.4—2.0 mm grade contains a rock fragment composed of quartz and greatly altered potash (?) feldspar.

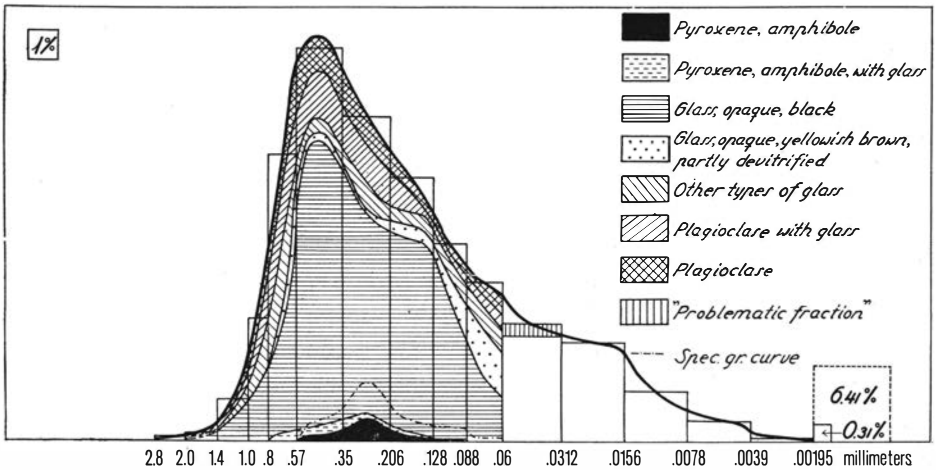
It holds good of the entire sample material that the degree of roundness of the particles is low. A certain rounding may possibly be observed at times in some particles of the black opaque glass particularly; other glass particles often have very irregular shapes, which is, of course, to be expected in view of their frequently rich vesication and otherwise unhomogeneous texture.

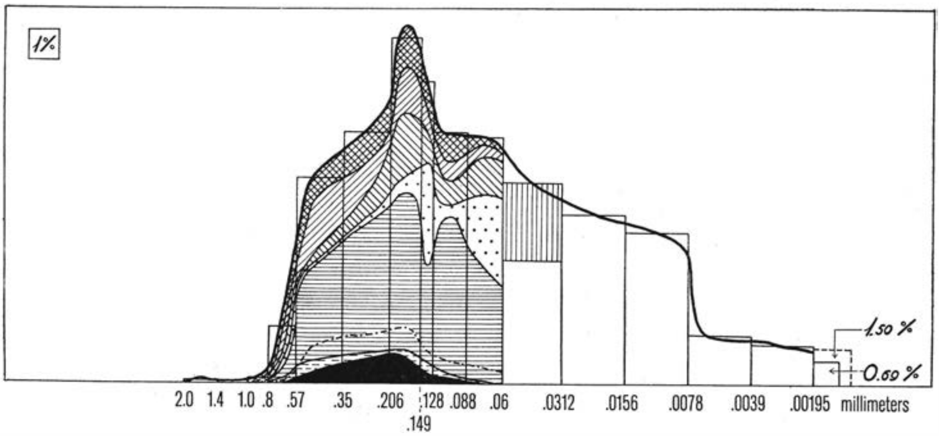
In sample No. 2 »other types of glass» chiefly comprises pale brown homogeneous glass, but in addition colourless homogeneous and pale brown globulous and fibrous glass.

The olivine in sample No. 3 occurs partly as small phenocrysts in the black opaque glass and partly in one or two cases as solitary particles. The yellowish partly devitrified glass plays an unimportant part. »Other types of glass» consists chiefly of pale brown homogeneous glass; colourless —pale brown globulous and fibrous types occur besides.

The particle size distribution is illustrated by the diagrams in Figs. 3—5. Sample No. 2, the middle one in the profile, proves to be the coarsest with a pronounced top in the 0.35—0.57 mm grade. The fairly great loss, 6.41 %, has been sustained by the finest elutriation grades. Sample No. 3 shows a broad, flat maximum and more than 10 % of the material finer than 0.00195 mm. Sample No. 1 differs from the others by its narrow maximum fairly centrally placed in the sieve part of the histogram. The pronounced bend at 0.0078 mm is probably due to some fault in elutriation. As regards the different particle groups, it may first be established that the group »glass, opaque, black» plays the greatest part







Figs. 3—5. Diagrams of samples Nos. 1—3, near the innermost end of Brazo del Viento. Sample No. 3 (upper diagram) was taken 0.1 m, No. 2 (middle diagram) 0.6 m and No. 1 (lower diagram) 1.12 m below the surface of the ground.

and shows frequency curves almost entirely corresponding to the total curves of the respective samples. This is particularly clear in the middle diagram, where the other curves too, with the exception of those of the heavy minerals, mainly behave in the same way. The yellowish partly devitrified glass increases from the surface towards the depth and has its main distribution in the finer sieve grades. In samples Nos. 1 and 3 the distribution and the positions of the maxima are irregular. The occurrence of two frequency maxima in several curves in the lowest diagram ought to be noted. The plagioclase curve shows even three maxima. Of greatest interest in samples Nos. 2 and 3 are the heavy minerals, »pyroxene, amphibole», »pyroxene, amphibole, with glass», and that part of the black opaque glass that has a specific gravity greater than 2.85, as the tops of the curves fall within finer size grades than those of the curves of the whole samples. This circumstance will be discussed in a later connection. The general impression and explanation of the appearance of the histograms is that the transportation and sedimentation conditions have varied greatly. It may be said of the whole material of samples that soilforming processes, on the other hand, do not seem to have played a part worth mentioning in the particle size distribution, as the material is almost entirely unweathered.

Samples Nos. 4—7: Arg., Terr? Rio Negro, in the steppe area (LJUNGNER's (1939) vegetation zone IV) east of Lago Nahuel Huapí, in the eastern slope of a hill situated between Estancia San Ramón and the railway station of Los Juncos, c. 950 m above sea-level, 15.8.1934. Sample No. 4 is the surface soil in the mountain slope and No. 7 is from the railway cutting near the foot of the hill in apparently unstratified soil, 3 m below the surface of the ground. Samples Nos. 5 and 6, which have lost their labels, ought also to belong to the railway cutting and represent the horizon just below the surface of the ground and the medium depth respectively. The bedrock consists of a plagioclase-porphyrite (specimen No. 1390), covered by a light, dense keratophyre (specimen No. 1391).

In sample No. 4 the group »other types of glass» comprises colourless—brown homogeneous, pale yellowish brown fibrous glass and colourless—pale yellowish brown globulous glass.

The keratophyre present in samples Nos. 4—7 consists mainly of plagioclase in micrographyric intergrowth with quartz; there are besides small grains of orthorhombic (?) pyroxene, ore and, very sparingly, almost colourless glass. The plagioclase is a pure albite, since the refractive indices are: $\alpha' = 1.528 \pm 0.003$, $\gamma = 1.538 \pm 0.001$, which gives An_{1-0}. The refractive index of the glass is 1.510 ± 0.005, which indicates a content of silica of about 68 %. The keratophyre is not noticeably weathered.

The plagioclase-porphyrite forming the substratum of the keratophyre has been found in the samples in exceptional cases only. Some data may, however, be given here. Its ground-mass is chiefly microgranophyric, but is built up in certain parts of tables placed parallelly, probably of tridymite. In the rock orthorhombic (?) pyroxene, apatite and ore have moreover been found. The phenocrysts consist of plagioclase. This is only exceptionally changed into chlorite. The composition of the plagioclase is given in Table II.

Table II.

Optical data on the plagioclase phenocrysts.

	1	2	3
% An	39	41	42
2V	-89°, -	-83°-84°	-82°-83°
Tw. law	Carlsbad	Albite	Albite

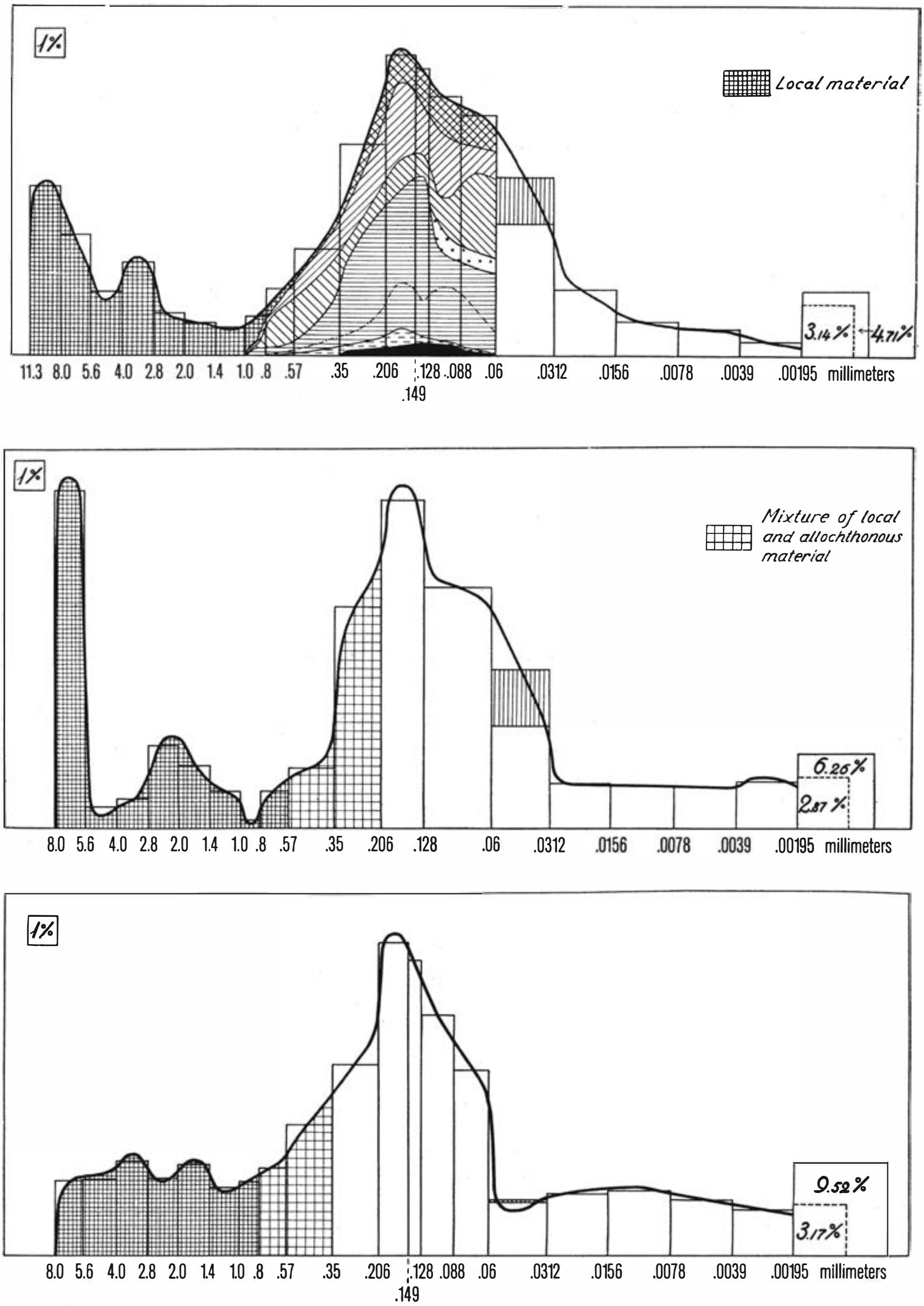
In one of the Albite twin individuals the maximum extinction $\alpha'/(010)$ of the core was determined to 22° and that of the margin to 20°, which, according to CHUDOBA 1932, gives An_{40} and An_{37} respectively.

In sample No. 5 the yellowish, partly devitrified glass plays a subordinate part. »Other types of glass» comprises (fibrous and) globulous glass and a good deal of homogeneous, more or less uncoloured, but also brown-coloured glass.

Sample No. 6 presents several different types among the glass particles, black opaque, yellowish partly devitrified, colourless and brown homogeneous, fibrous and globulous glass.

Among the types of glass in sample No. 7 the yellowish, partly devitrified one is predominant. Black opaque, brown, reddish and colourless homogeneous, brown and colourless globulous as well as brown, somewhat opaque, fibrous glass occur besides. To the characterization of the plagioclase it may be added that in one case the extinction angle $\alpha'/P\perp\gamma$ was measured to 44°, which, according to CHUDOBA o. c., means An_{69}.

The particle size distribution in samples Nos. 4, 5 and 7 is given in the histograms in Figs. 6—8. The resemblance between the three diagrams is very great, apart from the minimum in the coarsest elutriation grade of sample No. 7. The amount of material finer than 0.00195 mm varies somewhat however, and is greatest in No. 7. The top in the coarser sieve grades that characterizes the diagrams, is formed by the local material, chiefly the keratophyre. Only sample No. 4 has been subjected to counting of the particles, but the diagram may be assumed to represent the principles of the particle group distribution also in Nos. 5 and 7, where the relation between local and allochthonous material could only be illustrated qualitatively. It may be pointed out here that the material falling within the coarsest sieve grades is too small to permit of the histograms



Figs. 6—8. Diagrams of samples Nos. 4, 5 and 7, between Estancia San Ramón and the railway station of Los Juncos. Sample No. 4 (upper diagram) represents surface soil in the mountain slope, Nos. 5 and 7 (middle and lower diagrams respectively) are from the railway cutting, from the horizon immediately beneath the surface of the ground and 3 m deep respectively.

being more correct in detail in this part. The occurrence of two tops in the frequency curve is correct, however. The diagram of sample No. 4 partly resembles that of sample No. 1 owing to the varying positions and the occurrence of two or three maxima in the curves. The yellowish partly devitrified glass plays the same role as in sample No. 3, and the black, opaque glass dominates. The maximum of the pyroxene curve falls to the right of that of the curve of the whole sample. The curve of the specific gravity is peculiar owing to the occurrence of two tops. The particle group distribution in the coarser elutriation grades of sample No. 4 will be examined in a later connection.

It is clear without further explanation that the formation conditions of the soils last dealt with have been partly unlike those of the soils represented by the samples Nos. 1—3. It is appropriate here to quote verbatim what LJUNGNER has stated about this: »In consequence of the position on the steppe (vegetation zone IV) with only occasional hummocks there are in this locality in part different pre-requisite conditions for the origin of a soil cover than in the rain forest, even if the eolian supply should have been the same. The wind has an opportunity of carrying away and re-stratifying, washing-off and mass-movement have a certain scope. The substratum thereby becomes sufficiently exposed, at least at points, to take part in soil production by weathering, which it was possible to establish as a fact at the place itself.»

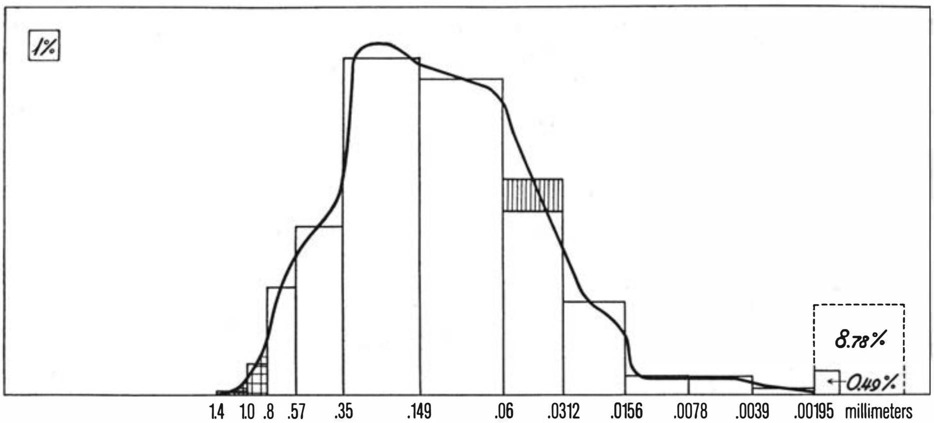
Samples Nos. 11—13: Chile, Prov. Chiloë, Dept° Llanquihue, in the western slope of Paso Pérez Rosales between Peulla (Chile) and Lago Frio (Arg.), 710 m above sea-level, 21.7.1934, in the rainiest part of the rain forest (vegetation zone I a). The samples come from a section, 3 to 4 m deep, in apparently unstratified and homogeneous soil, No. 11 0.6 m, No. 12 2 m and No. 13 3 m below the surface of the ground. The locality is separated from Tronador's slope by a transverse valley (See the map by LARSSON 1940, Pl. III, northern edge).

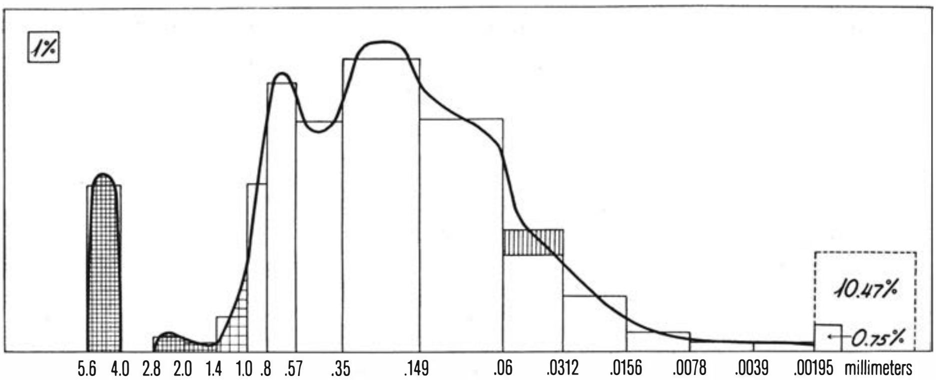
The glass group in sample No. 11 comprises black opaque, yellowish partly devitrified, brown homogeneous and colourless—yellowish brown globulous and fibrous glass.

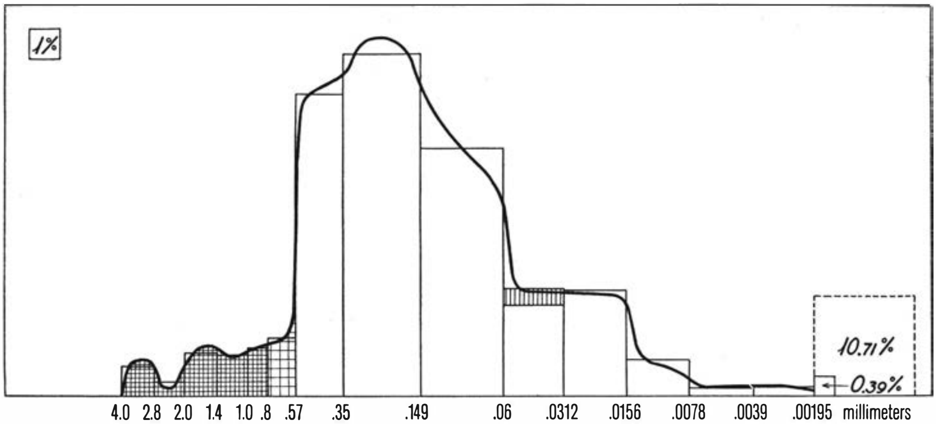
The black opaque glass dominates among the glass particles in sample No. 12, as in No. 11. In addition there has been found yellowish partly devitrified, brown homogeneous and colourless—light brown globulous glass, the latter very rich in inclusions of apatite. The brown glass has $N > 1.583$ ($< 50\ \%\ SiO_2$) and the more or less colourless glass has $N < 1.543 \pm 0.004$ ($> 55\ \%\ SiO_2$).

In sample No. 13 one finds, in addition to the dominant black opaque glass, yellowish partly devitrified, colourless homogeneous and globulous glass as well as yellowish brown globulous glass.

The particle size distribution in samples Nos. 11—13 is given







Figs. 9—11. Diagrams of samples Nos. 11—13, between Peulla and Lago Frio. Sample No. 11 (upper diagram) was taken 0.6 m, No. 12 (middle diagram) 2 m and No. 13 (lower diagram) 3 m below the surface of the ground.

in the histograms in Figs. 9—11. Nos. 12 and 13 contain in the coarser sieve grades partly weathered fragments of granite and effusives. Whether the latter in their entirety are to be regarded as »local material» can scarcely be decided. In the diagrams in Figs. 10 and 11 the distribution of local and allochthonous material has only been able to be indicated schematically. Owing to incomplete methodology at the beginning the losses at the mechanical analysis were great. A comparison with other diagrams may perhaps nevertheless be ventured upon. Their similarity to each other is striking. Transportation and sedimentation conditions may thus be assumed to have been similar in principle during a fairly long period of time. Upon comparing with samples Nos. 1—3 it is evident that Nos. 1 and 3 are somewhat finer and No. 2 somewhat coarser than those now dealt with. The diagrams of Nos. 4, 5, and 7 are, by intermixture of local material, in principle drawn up like those of samples Nos. 11—13, although there are differences in the distribution otherwise. To enter upon a more detailed comparison will probably be anything but profitable.

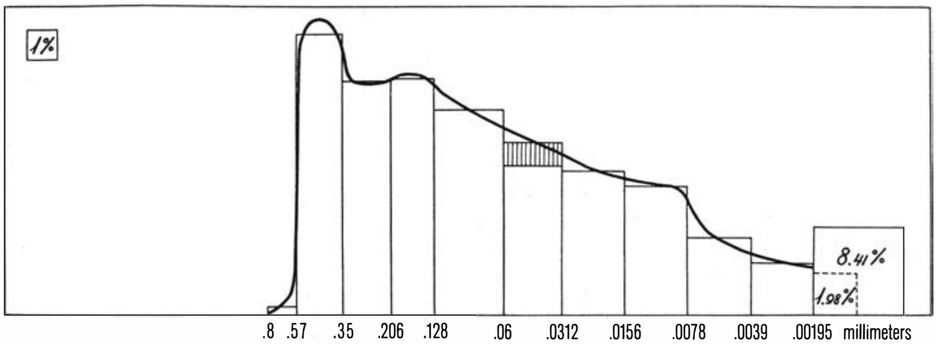
Sample No. 14: Arg., Terr^{o} Rio Negro, Peninsula Llau Llau, N of Puerto Nuevo, 769 m above sea-level, March 1934. The locality has marshy ground, overgrown with *Equisetum bogotense*, and lies in a dense forest of *Myrceugenia pitra*, skirting a tarn in a forest of *Nothofagus Dombeyi*, which dominates, and *Libocedrus chilensis* (vegetation zone I b, near the boundary of II).

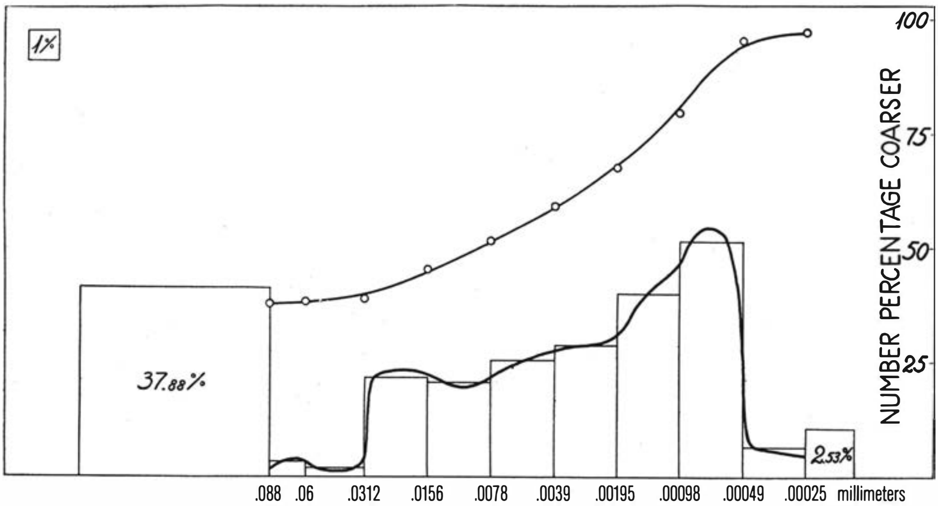
Among the glass particles the black opaque glass dominates. In addition yellowish partly devitrified, colourless (and light brown) homogeneous glass as well as colourless and dark brown globulous and fibrous glass have been noted.

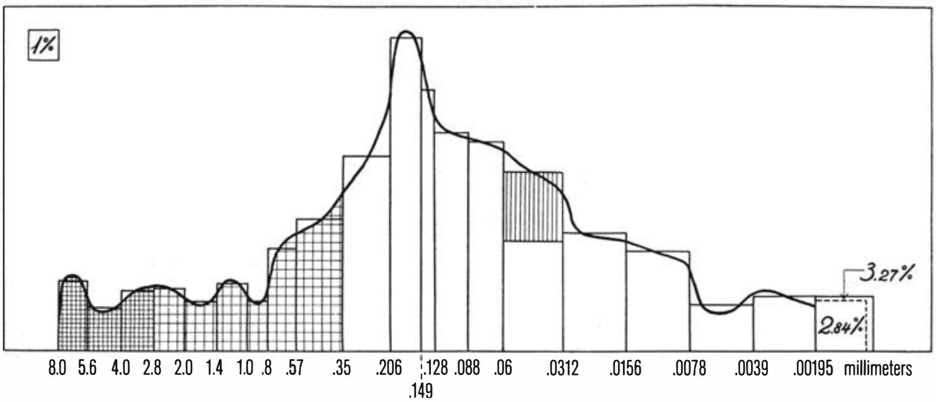
The histogram of sample No. 14, which is reproduced in Fig. 12, is the only one of its kind in the material. It is characterized by a maximum removed far to the left to the next coarsest sieve grade, and by in proportion to this large quantities of material in the elutriation grades. The diagram may possibly be compared with that of sample No. 3, and be regarded as an extreme form of that.

Sample No. 15: Arg., Terr^{o} Rio Negro, by Puerto Nuevo on Peninsula Llau Llau, 766 m above sea-level. The sample is a clay from the shore of Lago Nahuel Huapí, and was probably taken immediately above the water-line, at low water. The age of the clay is uncertain. Megascopically it differs from the ashy clays from Isla Mellizas in the Brazo del Viento fjord and from the western shore of Peninsula Huemul in the central part of Lago Nahuel Huapí, described by LARSSON (1940, pp. 347—349) and regarded as Interglacial.

The dividing-line between sieving and elutriation lies at 0.088 mm for this sample. The part coarser than 0.088 mm could not be further divided owing to the smallness of the whole sample. It is entirely formed of







Figs. 12—14. Diagrams of samples Nos. 14—16. Nos. 14 and 15 (upper and middle diagram respectively) were collected on Peninsula Llau Llau, No. 16 (lower diagram) on Pampa de Godoy.

allochthonous material, which is hardly present in the part finer than 0.088 mm. The clay substance forming the main bulk of the sample has not been able to be examined more closely. The sieve fraction contains, inter alia, rock fragments (glass of different kinds with plagioclase and apatite). Within the glass group one finds black opaque, yellowish partly devitrified, uncoloured and pale brown homogeneous glass as well as brown globulous and fibrous glass. The refractive index of the black opaque glass is ~ 1.58 (~ 50 % SiO_2) and that of the pale brown homogeneous glass has been determined to ~ 1.56 (~ 53 % SiO_2). The colourless glass, finally, has $N = 1.530 \pm 0.005$ (~ 59 % SiO_2).

The sample is the only one of its kind in the material. Its particle size distribution is illustrated by Fig. 13, where both the histogram and the cumulative curve are given. The percentage figures of the ordinate naturally refer only to the latter. The maximum of the frequency curve falls between about 1 μ and about 0.5 μ. The amount of material finer than 0.5 μ is inconsiderable. In the coarser elutriation grades the curve falls slowly to be followed at 0.0312 mm by a steep drop. Without in any way wishing to express any surmise for that reason about the age and method of formation of the clay, I will here point out the great resemblance, not to say identity, between the histogram given here and those of GRIPENBERG's »Type 5» (GRIPENBERG 1934, pp. 191 (Fig. 30) and 213 et seq.), drawn up on the basis of analyses of sediments from the North Baltic and the Gulf of Finland. »Type 5» is stated to be »the most common type for post-Glacial sediments». »Its chief characteristic, — — —, is the poor sorting.» »Very often there is a small secondary maximum in the dusty sand or coarse silt group, the amount of particles > 50 μ, however, seldom exceeding a few per cent.» — There is scarcely reason to assume that the material coarser than 0.088 mm ought to be regarded as anything other than an interspersion in the clay after its sedimentation.

Sample No. 16: Arg., Terr? de Neuquen, Peninsula Huemul, Pampa de Godoy, between Cerro Chacayal and Cerro Alto, 840 m above sea-level, 9.1.1934. The locality lies on a low piece of ground, sloping N.NE, between the mountains. Its vegetation consists of steppe of hummocks and shrubs, near the verge of transversing gallery forest (vegetation zone III).

The black opaque glass dominates; brown homogeneous and colourless —brown globulous and fibrous glass have been noted besides. — The local material consists of fragments of granite and effusives.

The particle size distribution is illustrated by the histogram in Fig. 14. The long-drawn-out part in the coarser sieve grades owes its occurrence to the local material. The resemblance to the diagrams of samples Nos. 4, 5 and 7 (Figs. 6—8) is great. The formation milieu is

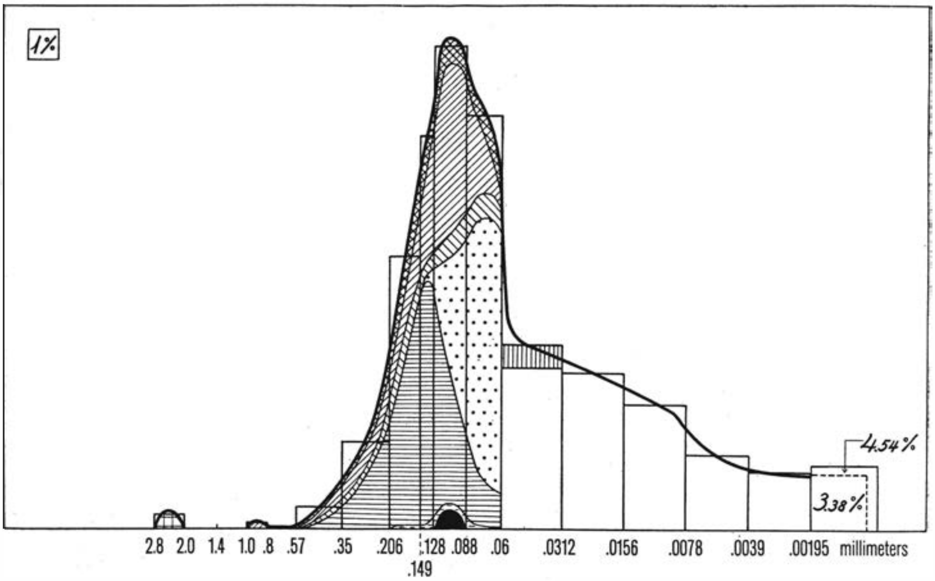


Fig. 15. Diagram of sample No. 17, from the northern side of Brazo del Viento.

also the same on the whole. The diagram of sample No. 1 (Fig. 5) also shows great agreement, apart from the fact that that sample lacks local material. The profile formed by samples Nos. 11—13 (Figs. 9—11) shows throughout somewhat coarser soils than that represented by the sample just treated.

Sample No. 17: Arg., Terr° de Neuquen, on the northern side of the fjord of Brazo del Viento, c. 1600 m above sea-level, 5.2.1934, in forest of *Nothofagus pumilio*, not far below the tree line (vegetation zone I b), in a cutting made by a small stream in the eolian soil cover about 3 m deep and of homogeneous appearance. The overlying alpine belt consists of an east to west ridge, composed in the west of granite, with certain enclosed portions, in the east of Tertiary pyroclastics and effusives, the boundary being N.W. of the locality. In the map in Fig. 15, p. 235, in LARSSON 1940, the locality lies east of the trigonometric point 1923 and south-west of the trigonometric point 1758.

The basaltic hornblende of the sample is prismatic, brownish yellow-green and optically negative; it has a small extinction angle γ/c. »Other types of glass» comprises pale brown homogeneous and pale yellowish brown globulous and fibrous glass. — The 2.0—2.8 mm grade contains a tube-shaped aggregate of limonite (Swedish »roströr») and a rock fragment (quartz as the chief mineral, in addition grains of chlorite and orthorhombic pyroxene). The rock fragments forming the bulk in the 0.57—0.8 mm and the 0.8—1.0 mm grades, consist of glass and plagioclase.

Photo E. LJUNGNER. 4.2. 1934.

Fig. 16. Cloud of eolian material driving from the alpine belt, built up of Tertiary bedrock, out over the forest in the slope down towards Brazo del Viento. Peninsula Llau Llau is visible in the background. Looking south-east from a point immediately north-west of the locality for sample No. 17.

They have been transferred to the allochthonous material. It is uncertain whether this is correct.

The frequency distribution of the particle sizes and the particle groups is given in the diagram in Fig. 15. It differs from those already treated by the small breadth of the sieve part and by the maximum in the next finest sieve grade, 0.088—0.128 mm. It forms a transition to the type represented by the diagrams of sample No. 20 (Fig. 18) and of the sample of the Interglacial tuff from Cerro Lopez (Fig. 19). The particle group distribution is rather confused as usual. The yellowish partly devitrified glass is confined to the finer sieve grades, as was also the case with other samples examined in respect of the particle group distribution. It dominates entirely in the 0.06—0.088 mm grade, whereas the black opaque one plays the most important part in coarser sieve grades, reaching its maximum in the 0.128—0.149 mm grade. The maxima of the pyroxene-amphibole curve and of the plagioclase curve coincide with that of the frequency curve of the whole sample. It ought further to be noted that the »plagioclase with glass» curve has its maximum to the right of that of the curve of the black opaque glass. The contrary is otherwise the rule on the whole.

LJUNGNER has told me that on February 4th, 1934, during a storm from the north-west, thick clouds of dust were seen to drive out from the

Photo E. LJUNGNER. 30.4. 1933.

Fig. 17. Isle-shaped erosion remnant at the tree line in the pass between Cerro Bonete and Cerro Almenas. Sample No. 19 is from this locality. The upper surface of the eolian cover is on a level with the men's heads.

alpine belt, from the granitic as well as from the Tertiary one, out over the forest in the slope of the fjord (Fig. 16). It is therefore surprising to find that granitic material plays such a subordinate part in sample No. 17. Even if a small part of such material should have been overlooked at the analysis, which is far from likely, it is clear that the soil at the locality must in the main be derived from a considerably more basic material.

Sample No. 19: Arg., Terr? Rio Negro, in a mountain valley which from Brazo Tristeza runs southwards to Lago Mascardi and in the saddle between Cerro Bonete and Cerro Almenas forms a pass c. 1800 m above sea-level in the interoceanic watershed. The sample was taken from the northern, Atlantic side of the pass, at the tree line, c. 1650 m above sea-level, 30.4.1933. The dwarf forest of *Nothofagus pumilio* (vegetation zone I b) is with its substratum, the eolian soil cover, broken up towards the alpine belt into fringes and isles with erosion escarpments, separated by surfaces of exposed, somewhat frost-cleft granite. The sample was taken in the steep wall of such an isle (Fig. 17). For a more detailed description of the vegetation conditions round the tree line the reader is referred to LJUNGNER 1939, pp. 330—331.

The glass is made up of the following types: black opaque, yellowish partly devitrified, colourless and yellowish brown homogeneous, colourless globulous and yellowish brown fibrous glass. — The sample is too small to be subjected to sieving and elutriation.

Sample No. 20: Arg., Terr? Rio Negro, Sierra Lopez, in the upper end of a niche-valley open to the N.NE, in a forest of *Nothofagus pumilio* (vegetation zone I, near the boundary of II), 1470 m above sea-level, 10.5. 1934, in an erosion section, 3 m in depth, in a little hanging mire at the bottom of the valley. LJUNGNER has given the following profile from the mire:

a plastic brown soil, with roots of still living grass vegetation (30 cm)
b coarse red sand (6 cm)
c plastic brown soil with many parts of plants
d plastic brown soil
e black »sand» with two layers of brown silt
f brown silt
g black »sand»
h peat
i black »sand»
j peat
k black »sand»
l peat
m black silt
n peat
o »sand»
p peat
q »sand»
r half-humified peat
s red »sand»
t »grass» peat with a layer of stubble, 0.5 m thick, at a depth of 1.5—2 m
u »sand»
v pebbles } 25 cm
x »sand»
y unhumified »grass» peat to unknown depth (at least 0.5 m thick).

The sample is a »black 'sand'». Unfortunately information is lacking as to which of the four horizons it is derived from. »Other types of glass» comprises pale yellowish brown homogeneous glass (dominant in the group), colourless homogeneous as well as pale brown fibrous and globulous glass. Only occasional particles of the yellowish partly devitrified glass have been observed. By reason of their small number it has not been possible to include them in the diagram of the sample.

The frequency distribution of the particle sizes and the particle groups is illustrated by the diagram in Fig. 18. Here we have to do with an entirely different type from those treated previously, with the possible exception of the diagram of sample No. 17, which was characterized as providing a transition to the type represented by this and by the following diagram. The histogram is distinguished by its small »width», by the maximum in the finest sieve grade and the small amount of material in the finer elutriation grades. The frequency curves of the particle groups run on the whole in the same way as the curve of the whole sample. The black opaque glass entirely dominates. It will be appropriate to examine the particle group distribution within the coarser elutriation grades in a later connection.

Sample No. 20 is the only one that may at once be fitted into one of the five »Eruptionsschichten» established by SALMI in the Nahuel Huapí

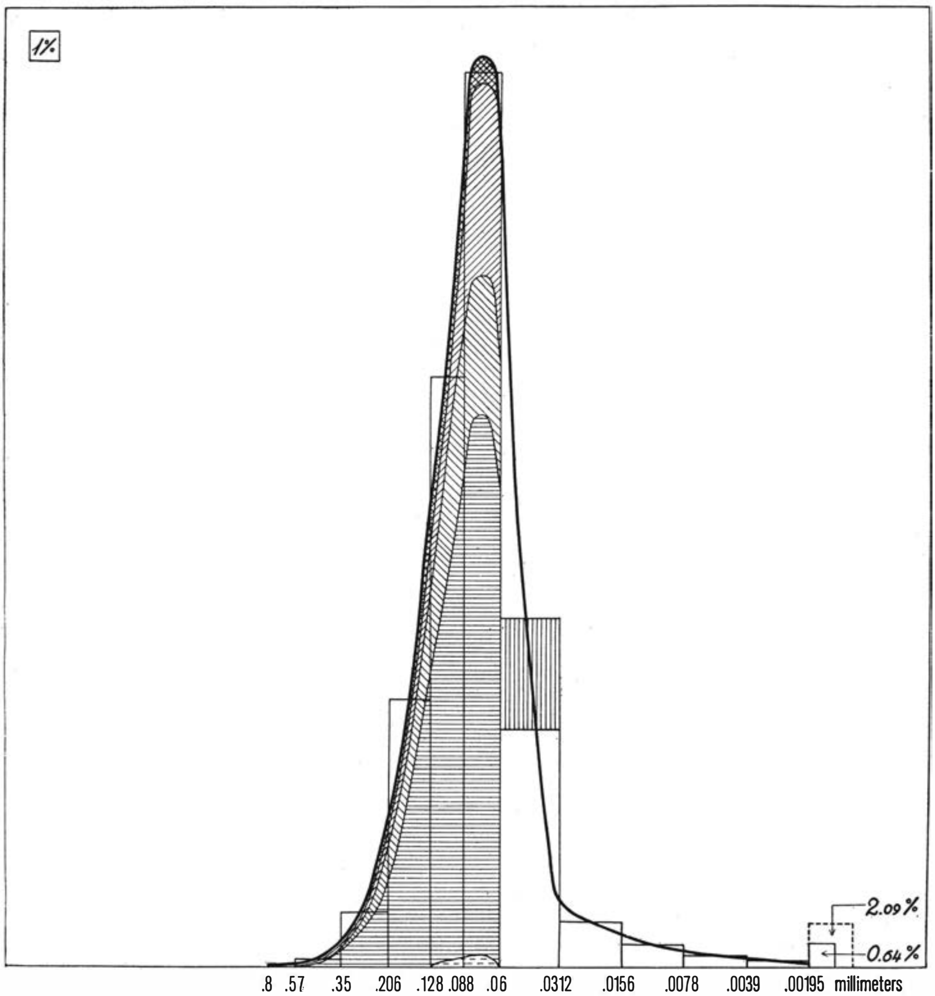


Fig. 18. Diagram of sample No. 20, from a mire in a glen near Sierra Lopez.

region. The content of anorthite of the plagioclase, 90—91 %, makes it probable that we are concerned with the so-called slag layer, the upper part of SALMI's layer I (SALMI o. c., pp. 19—22). The small difference between SALMI's value for the percentage of anorthite, 88—90 %, and mine lies entirely within the error limits. The absence of coarser slag particles in sample No. 20 is undoubtedly due to the fact that the locality lies in an area where layer I, according to SALMI, shows very great thinning. The refractive index of the glass and consequently also the content of silica varies for layer I in the different localities. There is nevertheless distinct agreement with sample No. 20.

Sample No. 21: Arg., Terr° Rio Negro, in Lago Frey (vegetation zone I a), c. 900 m. above sea-level, 15.1. 1933. The sample comes from the almost plane bottom at a depth of 85 m. The kettle-shaped lake is deeply cut in granitic bedrock (Tristeza granite). Only in the south at an altitude of 1500—2000 m above sea-level is quartz-diorite found, and above that gneissose older bedrock (Cf. the geological map in LJUNGNER 1931, p. 205 and the photo on p. 212).

The sample consists of a detritus ooze, blackish grey in a dry state, greatly intermingled with minerogenous material. The diatoms of the sample are treated by Fil. dr ASTRID CLEVE-EULER in an appendix to this paper. — A dark brown glass dominates among the glass particles; it presents larger particles than other types; there is besides bluish green homogeneous and more or less colourless homogeneous, globulous and fibrous glass.

The last sample subjected to mechanical analysis is an Interglacial tuff from Cerro Lopez, Terr? Rio Negro, Arg. The tuff has earlier been thoroughly examined by LARSSON (1940, pp. 233—237 and 301—302), who gives besides its geological field relations, which I will briefly repeat here. The beautifully layered tuff, which is about 12 m in thickness, lies between two till beds. The strata are either horizontal or show a slight dip to the west or south-west. In one case current bedding was observed of such a kind that the current must have come from the south or south-east. The tuff or tuffaceous sandstone is »obviously deposited in flowing water».

The specimen that I have examined shows a beautiful alternate stratification of black and yellowish brown layers. In addition to the minerals given by me LARSSON reports olivine. LARSSON has obtained the values An_{60} and An_{70} in a thin section. — The black opaque glass dominates. The yellowish partly devitrified one plays a subordinate part in the two finest sieve grades. »Other types of glass» contains mainly light brown homogeneous glass; yellowish brown globulous and fibrous glass as well as light brown homogeneous glass, richly impregnated with ore, occur besides. — The rock fragments consist of glass with laths of plagioclase. The texture is most often hyaloophitic, but pilotaxitic mesostasis fragments also occur.

What is of chief interest in this case, however, is the frequency distribution of the particle sizes and the particle groups. The mechanically analysed part of the specimen comprises several layers. An analysis of a single layer would naturally have given a still more extreme type of diagram than that in Fig. 19. The diagram coincides in type with that of sample No. 20. The maximum nevertheless falls in a coarser size grade, 0.128—0.206 mm. The two coarsest sieve grades contain rock fragments and black opaque glass. — Thus we find almost identical distribution pictures in two tuffs that have obviously arisen in widely different ways. The one, represented by sample No. 20, has arisen

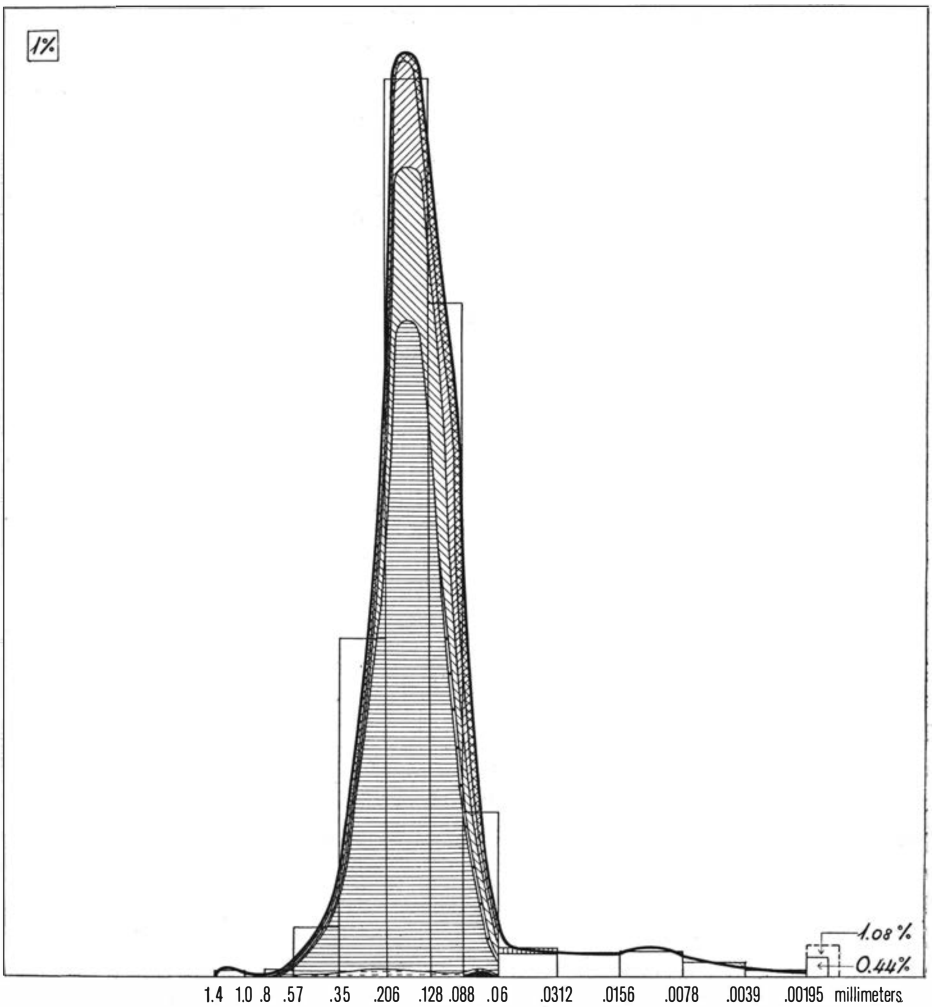


Fig. 19. Diagram of the Interglacial tuff from Cerro Lopez.

by wind transportation and wind sorting (Cf. LARSSON 1936) of volcanic explosion products, the other, represented by the tuff from Cerro Lopez, by water conveyance and water sorting of explosion products of volcanic origin, probably previously exposed to the influence of the wind.

In order to form an opinion of the type and composition of the recent eolian material in the Nahuel Huapí region, I quickly looked through a small number of soil samples obtained by shaking out mosses in particular. The mosses were collected by LJUNGNER during the expedition of 1932—1934, and have been described by HERZOG (1940). One sample is from a cushion plant (*Azorella trifurcata*). The mosses are in part epiphytic. All the samples included here are from vegetation zone I.

The numbers used are LJUNGNER's and are found in HERZOG. The soil samples are throughout rich in organic matter of various kinds. The minerogenous material is mainly fresh. The results have been assembled below.

No. 711 (*Dendroligotrichum dendroides*): inner part of Brazo del Viento, Lago Cantaros, 800 m above sea-level: plagioclase, black opaque and colourless homogeneous glass.

No. 898 (*Drepanocladus uncinatus*): northern side of the outer part of Brazo del Viento, »Mallin del Zorro», 1500 m above sea-level: plagioclase, black opaque as well as colourless and pale brown homogeneous glass. The amount of organic matter is very high.

No. 1288 (*Azorella trifurcata*): Brazo del Viento region, on the plateau at the summit of C. Milleaqueo, by a spring in a forest of *Nothofagus pumilio*, partly with naked surfaces: plagioclase, black opaque, brown and more or less colourless homogeneous as well as somewhat more or less colourless globulous and fibrous glass.

No. 1293 (*Rhizogonium mnioides*): western side of Brazo Tristeza, 768 m above sea-level: plagioclase, black opaque, colourless and pale yellowish brown as well as (sparsely) more or less uncoloured fibrous glass.

No. 1297 (*Lophocolea laxiretis*): *Ibidem*, 770 m above sea-level: hypersthene (sparsely), plagioclase, black opaque, yellowish partly devitrified, colourless and pale brown homogeneous as well as (sparsely) colourless fibrous glass.

No. 1312 (*Zygodon inermis*): Peninsula Llau Llau, at Puerto Nuevo, 775 m above sea-level: plagioclase, black opaque as well as colourless and pale brown homogeneous glass.

No. 1323 (*Dicranoloma robustum*): outer part of the northern side of Brazo del Viento, 770 m above sea-level: plagioclase, black opaque, colourless and pale brown as well as pale yellowish brown glass.

No. 1336 (*Anisothecium Jamesonii*): *Ibidem:* plagioclase (abundant), black opaque, yellowish partly devitrified, colourless—pale brown and reddish brown homogeneous as well as pale brown globulous and fibrous glass.

In summing up it may be said that ashy material is entirely preponderant. The possible occurrence of smaller amounts of local rock material, possibly overlooked in the summary examination, changes nothing in this estimate. The glass types are numerous, as in the samples met with in the preceding section. Thus there is hardly reason to assume that the recent eolian material noticeably differs from that illustrated by the samples from the deeper horizons in the eolian cover, treated in the preceding pages.

By way of conclusion to this descriptive part I will give short accounts of some small collections of lapilli from the Nahuel Huapí region.

Sample No. 31: Arg., Terr? de Neuquen, W of the outflow of Lago Correntoso into Lago Nahuel Huapí, 71° 20′ W and 39° 44′ S, March 1928, in the rain forest (vegetation zone I a).

The sample consists of lapilli of light pumice-stone, gathered in the bottom and field layer of the vegetation. LJUNGNER reports as follows about the collection: »In the forests near Nahuel Huapí one often saw similar deposits in the early part of 1928. The volcanic eruption was said to have taken place in the summer of 1921—1922. The ejectamenta had then formed a cover increasing in thickness towards the north and north-west. In the centre of Victoria island it had reached 8 cm, at the northern end of the island 12 cm, and at Puerto Manzano, to the north of it, 15 cm. To the west it had been still thicker. The greatest amount within the littoral zone of Nahuel Huapí was said to have fallen at Rincón, which is that point of the lake situated furthest to the north-west. The bamboo vegetation had died in that region. The pasture-land had been badly damaged. At Correntoso hardly any cows survived, it was said. Even at Estancia San Ramón, which lies at the south-eastern end of the lake, 70 km from Rincón, 800 out of 6000 cows had died. Their teeth had become like spikes. The horses had had diarrhœa with much blood.»

No one at Lago Nahuel Huapí could localize the eruption. At a distance of only 30 km from Brazo Rincón in a north north-westerly direction there is, however, the volcano Los Azufres, which erupted in an old volcanic district on the 13—19 December, 1921, pumice-stone being carried over 100 km and ashes as far as La Plata (according to KRUMM 1923; Cf. also STEFFEN 1922). — SALMI (o. c., p. 87) derives his layer IV from Los Azufres. As shown, inter alia, by the optical data below, there is as regards the glass, great agreement between layer IV and the pumice-stone of sample No. 31. A small difference can be noted for the percentage of anorthite of the plagioclase. Hypersthene occurs in both cases.

In 1933 lapilli were no longer seen in the vegetation, but where they happened to be missing, the same type of lapilli were present as an important part of the surface layer of the ground (Cf. sample No. 32).

The dimensions of the largest of the pumice pebbles are $16 \times 7 \times 3$ mm. The pebbles consist of globulous—fibrous, more or less uncoloured glass, partly slightly impregnated with ore, with phenocrysts of plagioclase and orthorhombic pyroxene. The refractive index of the glass is 1.508 ± 0.003, which indicates a content of silica of ~ 69 %. — The orthorhombic pyroxene is a hypersthene with strong pleochroism, thus fairly rich in iron. The composition of the plagioclase is given in Table III.

Sample No. 32: Arg., Terr? de Neuquen, Brazo Rincón, at Arbolito, 71° 45′ W and 41° 47′ S, 17.9.1933. It consists of lapilli of light pumice-stone. The largest of the pebbles measures $15 \times 11 \times 9$ mm. These lapilli evidently come from the same volcanic eruption as those of the preceding sample. The appearance and refractive index of the glass entirely coincide, too.

Samples Nos. 33—37: Arg., Terr.º de Neuquen. »In the neighbourhood of Lago Nahuel Huapí dark lapilli were sometimes seen. This type is never seen in the vegetation cover, as was the case with those in samples Nos. 31 and 32. These lapilli lie on vegetationless or eroded or

Table III.

Optical data on the plagioclase phenocrysts.

	1	2	3
% An	45	46	47
2V	-84°; -	-84°;+86°	+84°;+88°
Tw. law	Carlsbad	Albite	Albite

ploughed surfaces in the eolian soil cover and, only when that is absent, directly on the till or bedrock. Thus the type cannot be older than this cover. Its occurrence exclusively in localities which form, or (sample No. 36) may be regarded as, wounds in this cover, speaks in favour of the fact that it occurs interstratified in it, although all the cuttings observed, perhaps owing to weathering, presented an entirely homogeneous appearance. This type of dark lapilli reaches its largest size towards the west. — Indians of Rincón remembered a rain of dark lapilli about 1905, emanating from Puyehue» (LJUNGNER).

Sample No. 33: southern side of Brazo Rincón, near Arbolito, 71° 45′ W and 41° 47′ S, 17.9. 1933, under a steep bank of the lake, abraded in the eolian cover, at the altitude of Lago Nahuel Huapí, 767 m above sea-level. The dimensions of the largest lapilli are 29×21×20 mm.

Sample No. 34: the same day as the preceding sample, on hills earlier cultivated above the locality of that sample, c. 900 m above sea-level. The dimensions of the largest of the cobbles of lapilli are 30×22 ×7 mm.

Samples Nos. 35 and 36: c. 1 km N.W. of the locality for sample No. 17, c. 1650 m above sea-level, 2.1. 1934, on bare ground at the tree line, No. 36 on the till. The largest of the lapilli in sample No. 35 measures 38×23×17 mm and the largest in sample No. 36 25×18×14 mm.

Sample No. 37: eastern part of Lago Nahuel Huapí (the label has disappeared), either from the top of a diorite mountain on the southern side of the entrance to Brazo Huemul, 1188 m above sea-level (21.11. 1933), or from a lateral terrace on the inner northern side of Brazo Huemul, c. 850 m above sea-level (11.7. 1933). The dimensions of the largest of the pebbles are 13×9×7 mm.

The lapilli are slaggy and consist of an almost globulous, dark brown —brownish black glass with small laths of plagioclase as well as small grains of ore and monoclinic (?) pyroxene. Phenocrysts of plagioclase and in one case (sample No. 34) olivine also occur sparsely. The optic axial angle of the olivine was determined on the universal stage (NIKITIN's method). The result obtained was $2\,V_\alpha = 88°$, which, according to WINCHELL o. c., gives 18 % fayalite. The composition of the plagioclase is given in Table IV.

Table IV.

Optical data on the plagioclase phenocrysts.

Sample No.		1	2	3	4
33	% An	90	90		
	2V	-80°,-86°	(-74°),-87°		
	Tw. law	Roc Tourné	Albite		
34	% An	91			
	2V	- , -			
	Tw. law	Roc Tourné			
36	% An	87	89	90	91
	2V	- , -	-81°, -	-78°, -	- , -
	Tw. law	Manebach-Esterel	Roc Tourné	Albite	Roc Tourné
37	% An	88	90	91	
	2V	+88°, -	- , -	(-71°), -	
	Tw. law	Albite	Roc Tourné	Roc Tourné	

The similarity between samples Nos. 33—37, here regarded as of equal value, is as clear as one could wish from the plagioclase determinations. In consideration of LJUNGNER's above-cited observations about the method of occurrence of this type of lapilli, it is perhaps not altogether too venturesome to assume that we here simply have to do with material from SALMI's so-called slag layer. The resemblance between the percentage of anorthite of the plagioclase and in appearance is, as we see, striking. The observation that the largest dimensions of the lapilli are reached towards the west, may be regarded as coinciding well with SALMI's views on the position of the volcano from which the slag layer originated (o. c., pp. 87—88).

IV. Discussion.

The eolian differentiation. The soils already dealt with in samples Nos. 1—21 — with the exception of No. 20 — and the soils from mosses are to be regarded as loess-like compositions. Before entering upon a discussion of the eolian soil cover of the Nahuel Huapí region, its formation conditions and the origin of its material, I will, however, say a few words about the so-called eolian differentiation and about certain features in the diagrams conditioned thereby.

In aerial transportation of a material that is unhomogeneous from a specific gravity point of view, a process takes place that LARSSON (1936, p. 41) has designated eolian differentiation. This involves a segregation of the particles conveyed not only according to size and shape, but also according to specific gravity. With examples from LACROIX (Montagne Pelée) and v. WOLFF (Krakatau and Lassen Peak) LARSSON discusses the importance of the eolian differentiation from a petrochemical and particle size distribution point of view. Several authors have previously dealt with this question. To those enumerated by FREE (1911, p. 36) may be added KREUTZ and JUREK (1928, p. 5 et alia and 1932, p. 324 et seq.) and SAHLSTEIN (SAHAMA) (1933, p. 26 et seq.). In the literature I have, however, been unable to find any account dealing with the effects of the eolian differentiation on the particle size distribution in a material that is unhomogeneous from a specific gravity point of view in the light of quantitative analyses of the frequency distribution of the part components within different size grades. The water sediments, in which the conditions are in principle the same as in the eolian ones, have, on the other hand, been fairly generally discussed from this point of view.

The specific gravity conditions of the material. In one respect the material examined is not ideal for a discussion of the conditions just touched upon, namely as regards the specific gravities of the particle groups. These were chosen with a view to a characterization of the samples by counting of the particles. Thus it was necessary for them to be kept separate in microscoping. Unfortunately it was not possible at the division into groups also to take into consideration the specific gravity conditions. Nevertheless the groups on the whole came to represent well-defined specific gravity classes of not too great amplitude of variation. Worst in this respect are the groups »other types of glass», whose specific gravity varies between 2.3—2.4 and 2.6—2.7 (in exceptional cases somewhat $>$ 2.8), and »glass, yellowish brown, partly devitrified», whose specific gravity falls between the extreme values of the preceding group. The specific gravity of the black opaque glass is 2.8—2.9, possibly in some cases even $\sim$ 3.0. The values have been obtained partly from the diagram in GEORGE o. c., p. 367 and partly by direct determinations. By means of the anorthite percentages the specific gravity of 2.66—2.75 is obtained for the plagioclase by using the diagram in GORANSON o. c., p. 153. As most of them fall within the 2.70—2.75 range, the plagioclase group is somewhat heavier than the group »other types of glass», whose dominant types lie within the lower part of the specific gravity range given above for the group. An intermediate position is naturally taken by the group »plagioclase with glass». For »pyroxene, amphibole» the specific gravity is $\gtrsim 3.1$ and for »pyroxene, amphibole, with glass» naturally somewhat lower.

The shape factor. For the mechanical analysis the so-called shape factor plays a part that is most often difficult to define in detail. At the analysis one strives to obtain a division of the material into size grades of particles equally large in volume, which ideal it would be possible to attain only on condition that they were spheres. TRÖGER (1940, pp. 420—421) has pointed out how at the sieve analysis prismatic mineral particles by reason of their shape find their way into finer size grades than those to which they rightly belong owing to their volume.

If we examine the material before us from the above-mentioned point of view, it may be stated as regards the pyroxenes and the amphiboles that the prismatic shape is represented mainly within the coarser size grades, where, however, crystal fragments also appear. The finer size grades, the elutriation ones too, contain more or less irregular fragments and to a less extent small prismatic particles. As extreme prismatic types are not common, the influence of the shape factor on the distribution must in this case not be exaggerated, and not as regards the plagioclase crystals either. These are both tabular and more or less prismatic. More or less irregular fragments are common, especially in the finer size grades. It is the same on the whole with the glass particles as with the tabular crystals. Their shape varies considerably, however. On the whole most of them may nevertheless be characterized as more or less irregular, usually strongly flattened ellipsoids of rotation. The type of the glass to quite a large extent conditions the shape of the particles. The globulous and fibrous glass is predestined to give rise to the most irregular shapes. — Thus there is a slight risk that the size distribution of the glass particles is somewhat displaced in the direction of too coarse size grades at the sieving. The risk is not to be exaggerated, however. We may state that a displacement, if any, owing to the shape factor, operates in one direction for the glass and in the opposite direction for the prismatic minerals, which is worth remembering for the coming discussion on the positions of the maximum of the pyroxene-amphibole curve in particular.

The roundness conditions of the particles. In this connection it is appropriate to touch upon the roundness conditions of the particles too. Within the 0.35—0.206 mm and the 0.088—0.06 mm grades of samples Nos. 4 and 20 and of the tuff from Cerro Lopez 20 particles of black opaque glass were measured from each size grade according to WADELL's method (WADELL 1935). The results, which may probably on the whole be regarded as representative for other samples too, are given in Table V. As will be seen from this, the degree of roundness varies somewhat, but is low throughout. It is lowest in sample No. 20, the ashy eruption

Table V.

The degree of roundness (P) of particles from some selected size grades.

Sample	No. 4		No. 20		Cerro Lopez	
P \ Grade	0.088–0.06	0.35–0.206	0.088–0.06	0.35–0.206	0.088–0.06	0.35–0.206
0.09–0.11		2		4		
0.12–0.14		5	2	9	1	4
0.15–0.17	1	5	7	3	2	6
0.18–0.20	7	2	3	3	1	4
0.21–0.23	2	2	4		6	5
0.24–0.26	1	2	2	1	7	
0.27–0.29	3		1		2	1
0.30–0.32	1	1				
0.33–0.35	1				1	
0.36–0.38		1				
0.39–0.41			1			
0.42–0.44	1					
0.45–0.47	2					
0.48–0.50						
0.51–0.53						
0.54–0.56	1					
	M=0.28 ±0.025 σ=0.11 ±0.018	M=0.18 ±0.015 σ=0.07 ±0.011	M=0.20 ±0.014 σ=0.06 ±0.010	M=0.14 ±0.008 σ=0.04 ±0.006	M=0.23 ±0.009 σ=0.04 ±0.007	M=0.18 ±0.008 σ=0.04 ±0.006

layer. What is striking is the slight dissimilarity in the shape and roundness of the particles between this sample and the others, and also, by estimation, regarding other types of glass particles. I consider that this argues in favour of the fact that, at least in less well rounded glass particles, it is most often probably not a question of real roundness, occasioned by transportation, but of primary fracture surface forms. It is further evident from Table V that the finer size grade has throughout somewhat better rounded particles than the coarser one, which is very remarkable.

MARSLAND and WOODRUFF (1937) have shown »that there is a close relationship between the hardness of a mineral and its rate of being rounded by air transportation». »This close relationship may be masked by other factors, such as parting, cleavage, crystal structure, original shape of the grains (= particles; author's remark), etc.» The hardness of the most common components, the glass and the plagioclase, is 5.5—7 (GEORGE o. c., p. 369) and 6—6.5 (DANA 1932, pp. 545, 548) respectively. Thus in this respect there exists no very considerable difference. Nor do I consider that I am able to say that any of the components show on an average a better roundness. The degree of roundness varies for the same component within the same sample and size grade, evidently principally due to the different original shapes of the particles. The unhomogeneous structure of the glass naturally plays an important part in this connection. The data given by MARSLAND and WOODRUFF (o. c.) refer to other minerals than those observed in LJUNGNER's material. It will nevertheless probably be possible to compare the plagioclase and the glass with the orthoclase and the magnetite respectively, both of which showed only slightly rounded corners in spite of ten hours of wear.

Discussion of the distribution diagrams. Without personal knowledge of the topographical and meteorological conditions in particular at and around the localities of the samples to discuss their distribution diagrams is rash. I will nevertheless advance a few opinions with great circumspection.

The effect of the eolian differentiation must quite naturally be that particles or particle groups with higher specific gravity are concentrated in finer size grades than those with a lower one. A distribution of that kind is well known from water sediments (Cf. for instance RUBEY 1933, RUSSELL 1936, VON ENGELHARDT 1939/1940 and SCHEIDHAUER 1939/1940). A tendency towards placing the maximum of the pyroxene-amphibole curve in finer size grades than those in which the curves of the other particle groups and those of the whole samples culminate, is evident for samples Nos. 2, 3 and 4 and possibly for the tuff from Cerro Lopez. That is also the case with the specific gravity in Nos. 2 and 4. I should like to interpret this as being mainly conditional upon eolian differentiation. In the diagrams of samples Nos. 1, 17 and 20 the maximum of the pyroxene-amphibole curve (and in No. 1 of the specific gravity curve) coincides, however, with those of the whole samples, which shows that the conditions may not be interpreted too schematically. The problem is too complicated to allow of being discussed without field experience from the region. It may, however, be pointed out that one must not expect too much from the diagrams from a differentiation point of view by reason of the relatively small differences in specific gravity within the material. It is very probable that when studying »narrow» sediments — Cf. for instance sample No. 20 and the tuff from Cerro Lopez, in which in the case of the latter the pyroxene-amphibole curve nevertheless has a maximum in a suitable position — one must work with considerably smaller grade intervals in order to permit of small differences in specific gravity making themselves noticeable.

The varying positions of the maxima and the occurrence of several such in the frequency curves of most of the particle groups accord well with the changing transportation and sedimentation conditions which, judging from all appearances, must prevail at the formation of the eolian cover.

If we bear in mind the — as will later be shown — most important source of the eolian material within the region, namely the showers of ashes, we may establish the fact that a material, well differentiated at the primary sedimentation, of a type more or less resembling that represented by sample No. 20, would in an exposed position very soon change its character. The intermixture of material of a different coarseness, particle size distribution, origin and mineralogical composition would soon cause the material to become more polymict, the diagram »broader» and the course of the curves more irregular. Most frequently the material is not in a position to be again subjected to an other than incomplete differentiation. The distribution picture must be somewhat in keeping with the diagram type that dominated within the material.

The part played by primary differences in the size distribution of the minerals in the final distribution of mineral particles has, for different kinds of water sediments, been discussed by, among others, RUBEY (o. c., pp. 22—25), VON MOOS (1935, pp. 179—180), VON ENGELHARDT (o. c., p. 464) and CORRENS (1942, pp. 6—7). Unfortunately it is not possible for me to form an opinion of the present material from that point of view. The primary size sets limits to the occurrence of the plagioclase, pyroxene and amphibole within coarser size grades. Beyond these limits there dominate bigranular and to a less extent trigranular particles (»plagioclase with glass» etc.).

Fil. lic. IVAR HESSLAND maintained in a lecture on November 9th, 1942, at the Geological Division of the Students' Association of Natural Science at Uppsala, that the degree of sorting of a sediment must not be judged entirely according to its total distribution curve. One must know the course of the frequency curves of at least two components, as different as possible from a specific gravity point of view. Only on condition that the specific gravity and preferably also the shape of the particles is homogeneous can the total distribution curve alone be considered to show the degree of sorting. The correctness of these views is to some extent supported by the diagrams given here. It is not exclusively of theoretic interest to point out that the distribution diagram of a sediment becomes »broader» the greater the differences in specific gravity within it. The degree of sorting in two sediments with varying maximum difference in respect of the specific gravities may thus be the same, even if the »breadths» of their distribution diagrams are different. In the case before us this circumstance plays but a small part, however, the whole material being so similar.

The particle group distribution within the elutriation grades. In the account of the methods used, it was pointed out that the counting of particles within the elutriation grades was made only in the case of samples Nos. 4 and 20. The specific gravity of the material varies within certain limits (Cf. p. 199), as a result of which a concentration of finer heavier particles takes place within the coarser elutriation grades upon elutriation. Further, the value for the specific gravity, 2.65, used in STOKES' formula, is found in only a small number of the particles, which involves some uncertainty regarding the real values of the grade size limits. The result is that an elutriation analysis will give an erroneous picture of the frequency distribution of the particle sizes and the particle groups within the finer size grades of the sample analysed (Cf. TRÖGER o. c., who discusses these conditions at some length). The specific gravity conditions that are characteristic of the material examined by me, entail a fairly general displacement towards coarser elutriation grades. The frequency curves must therefore be taken with a certain reserve as regards the sectors obtained by elutriation analysis. The most serious consequence is, however, the changes in the original compositions of the samples. In order to illustrate this to some extent, I counted the particles within the coarser elutriation grades of samples Nos. 4 and 20. A quantitative analysis of the finer ones was not made in view of its time-consuming and troublesome character; moreover it would not give anything beyond what is obtained by the analysis of the coarser size grades. An account of the results is given in the diagrams in Fig. 20, in which the finest sieve grade has also been included. The symbols are the same as those used previously. »M» indicates the mean between the »problematic fraction» and the 0.06—0.0312 mm grade.

A glance at the diagrams shows us how the heavier, black opaque glass in both samples steadily increases from finer to coarser elutriation grades at the expense of the lighter group »other types of glass». This distribution can hardly be a primary one. In accordance with what has been stated above about the effects of the eolian differentiation, upon air transportation the heavier particles remain in suspension only in the finer size grades, in other words they are concentrated in these. The material examined here ought thus before the elutriation analysis to have had the black opaque glass more abundantly represented in the finer elutriation grades than is shown by the diagrams. A tendency to a similar displacement may be traced in the plagioclase and the »plagioclase with glass» too. The distribution picture for »pyroxene, amphibole» and »pyroxene, amphibole, with glass» has the defect of showing some uncertainty owing to the share of these groups being so small. It is difficult to express an opinion as to the extent to which the prismatic shape of some of the pyroxene and amphibole crystals increases the uncertainty. TRÖGER (o. c., pp. 421—422) points out that in a Kopecky-Krauss elutriator the particles when sinking in the current of water successively take up different positions, »so dass alle Kornquerschnitte ihren Einfluss auf die Sinkgeschwindigkeit ausüben werden und das Korn (= particle; author's

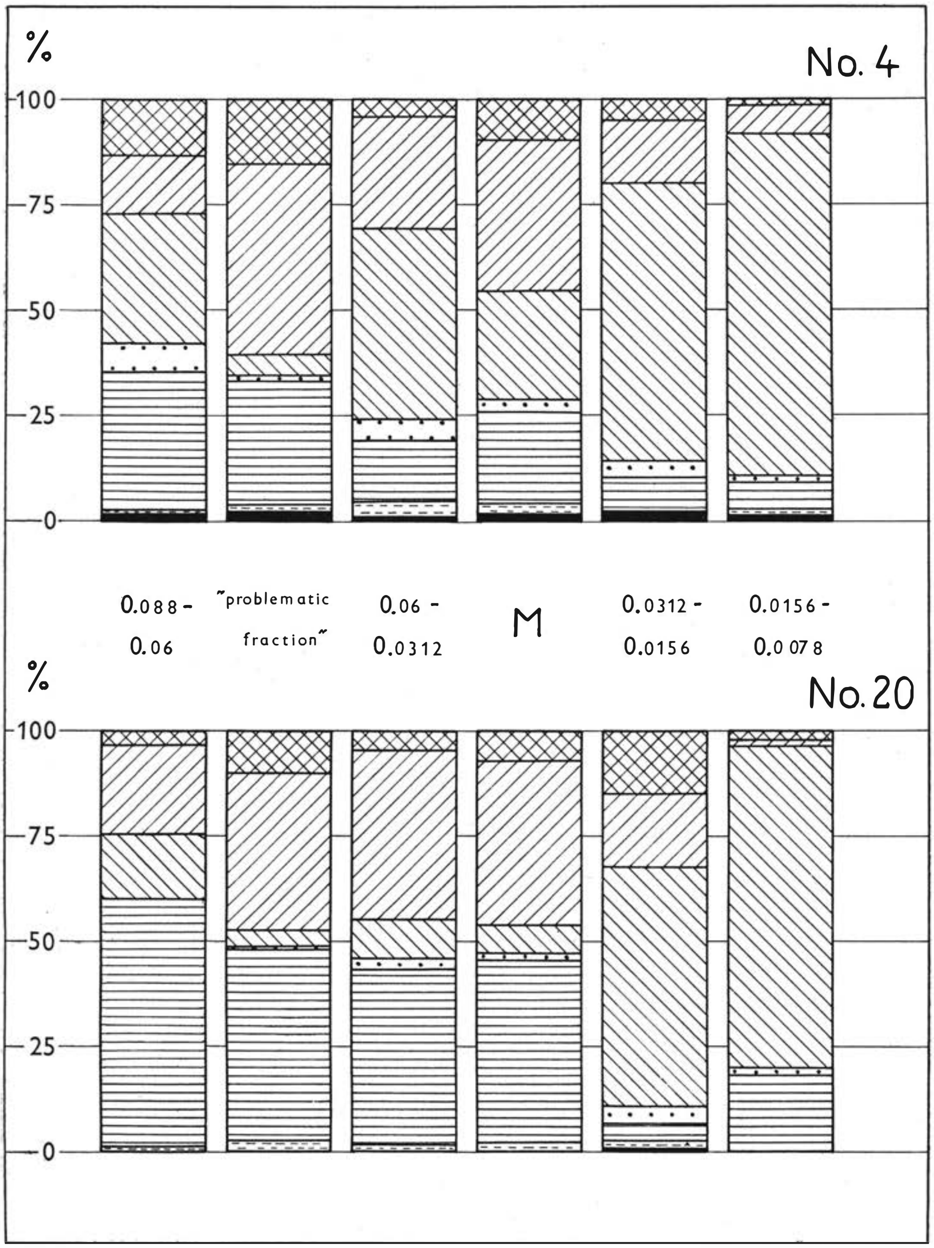


Fig. 20. Samples Nos. 4 and 21: the particle group distribution of the 0.088—0.06 mm grade, the »problematic fraction» and the coarser elutriation grades.

remark) nicht viel schneller oder langsamer fallen dürfte als eine volumgleiche Kugel». When using an Atterberg sedimentation cylinder and other similar apparatuses conditions are, however, possibly different, there being greater pre-requisite conditions for the particles when sinking to take up equilibrium positions conditioned by their shape, and as a result of this the final distribution picture may become influenced in one direction or another. This discussion is naturally also applicable to other prismatic minerals than those mentioned above.

The composition of the »problematic fraction», compared with that of the adjacent size grades, especially the 0.088—0.06 mm grade, argues in favour of that fraction, as already pointed out, at least partly having arisen through the above-mentioned displacement in the composition of the material. In this connection it may be pointed out that one must not entirely ignore the fact that within the group »glass, opaque, black», whose specific gravity varies somewhat, a displacement occurs in its turn of the same kind as the one affecting the whole elutriation part of the sample. This is not apparent, however, in the diagrams through counting of the particles. The argument also applies, naturally, to other particle groups with varying specific gravity. I consider that it would be going too far outside the scope of this investigation to study these conditions in greater detail. I have only wished to indicate the phenomenon here.

To what extent the original composition of the material subjected to the elutriation analysis is changed as a result of this analysis, is naturally very difficult to determine without thorough investigations. So much may, however, be stated at once, namely that the serious interference that an elutriation analysis undoubtedly implies in the present case, entails a displacement in a completely opposite direction from the one occasioned by the eolian differentiation. There are several reasons why I have not tried to apply the correction method used by TRÖGER (o. c.) to the present material. The most important one is to be found in the circumstance to which attention has already been drawn, namely that the specific gravities of the particle groups are not constant, but vary within certain limits.

Regional comparisons. As shown by the descriptions of the sample localities, the present soil samples were collected both in the evergreen forest (Nos. 1—3, 11—13 and 14), in the deciduous forest (Nos. 17 and 19) and on the steppe (Nos. 4—7 and 16). It will be appropriate to attempt to determine whether the sample material presents any differences corresponding to these varying surroundings.

As regards the losses on ignition (Table I, p. 177), it can only be stated that the steppe samples throughout have low ones, even though lower values have partly been obtained in the other two regions. The amount of organic material shows great variations locally. By way of comparison with the values from the steppe samples it may be mentioned that FREISE (1939/1940, p. 44) states that the proportion of organic matter in the eolian soils in the dry region of north-eastern Brazil is mostly lower than 1.2 %.

As regards the frequency distribution of the particle sizes and the particle groups one can only point out the great »breadth» of the diagrams of the steppe samples, conditional upon the local material within the coarser size grades. The steppe soils thus belong to the »eolian composite soils» (»Äolische Mischböden», PASSARGE 1929, p. 305). To be quite explicit I wish to point out here that I use the designation »local material» for that part of the material that I consider to have been transported a shorter way than the allochthonous main part of it. In the »local material» the autochthonous one is of course included. There do not exist any constant differences either as regards the mineralogical composition and the particle group distribution. It may only be mentioned that the greatest variation amplitudes in the anorthite contents of the plagioclases were established in two steppe samples (Nos. 6 and 7). Although this coincides well with the environmental conditions, altogether too far-reaching conclusions may not be drawn from this.

Part of the glass is devitrified, which is the only trace of weathering that can be noticed under the microscope in the allochthonous part of the material. No constant regional differences regarding the amount and degree of this can be established, which is very remarkable, for SALMI (o. c., p. 8) draws attention to the high degree of weathering in the eruption layers in the rain forest. One would expect to find the same state of things in the eolian material, which is similar from a mineralogical point of view. If one had access to a larger material of vertical profiles one might possibly find an explanation of the small, apparently local differences that exist. It is very probable that the regional displacements (Cf. p. 215) may provide the explanation here. — The devitrified glass has its main distribution within the finer size grades (Cf. also the diagram in Fig. 20).

Are the eolian soils of the Nahuel Huapí region to be classed as loess? The question as to whether the eolian soils of the Nahuel Huapí region may be classed as loess will be touched upon here to some extent. SALMI has not hesitated to make use of this term (Cf. for instance Fig. 3, o. c., p. 15). In the discussion one must leave out of account the »1,5 m dickes dichtes Lösspolster, das aus feinem, rotbraunem, tonartigem Material besteht», mentioned by SALMI, which lies between the o-layer and the bedrock (SALMI o. c., p. 17). It seems indeed to differ from other »Lösspolster».

In the literature the definition loess is generally given a very limited scope. By way of comparison with the eolian material of the Nahuel Huapí region some of its attributes may be given here. The loess is, as a rule, an unlayered and calcareous eolian sediment with a fairly constant mineralogical composition and method of formation, and with characteristic particle size distribution, colour, structure, texture and other physical properties (Cf. for instance FREE o. c., pp. 124 et seq., GANSSEN 1922, SCHEIDIG 1934). The eolian soil of the Nahuel Huapí region appears to be unlayered throughout. — LJUNGNER's soil samples do not effervesce for hydrochloric acid. If calcium carbonate is present, then the proportion is low. It is worth pointing out that LEBEDEFF (1932, p. 4) reports slight, in many cases almost imperceptible effervescence for hydrochloric acid in soils from the Nahuel Huapí region. — FREE (o. c., p. 125) states that the loess particles are »angular and loosely arranged». In the preceding pages the roundness conditions of the present material have been to some extent discussed. In that connection it was pointed out that the degree of roundness was low throughout. It was mentioned particularly regarding the glass particles that in less well rounded particles it is most often probably not a question of real roundness occasioned by transportation, but of primary fracture surface forms. This assumption is supported by the great similarity in particle shape between sample No. 20, the eruption layer, and other samples. — The chief minerals in the loess are quartz and feldspar (SCHEIDIG o. c., p. 73). The same author (o. c., p. 41) speaks of loess of volcanic origin. However, nothing is said about its mineralogical composition. It is probable that it may be of the type that characterizes the material before us. As typical for the loess KEILHACK (1920, p. 157) gives the following size distribution:

<table>
<tr><td>> 2 mm</td><td>—</td></tr>
<tr><td>2 —1 »</td><td rowspan="2">0 — 0.5 %</td></tr>
<tr><td>1 —0.5 »</td></tr>
<tr><td>0.5 —0.2 »</td><td>0.5— 3.0 »</td></tr>
<tr><td>0.2 —0.1 »</td><td>1.0— 7.0 »</td></tr>
<tr><td>0.1 —0.05 »</td><td>8 —40 »</td></tr>
<tr><td>0.05—0.02 »</td><td>50 —65 »</td></tr>
<tr><td>< 0.02 »</td><td>16 —36 »</td></tr>
</table>

The diagrams given by SCHEIDIG (o. c., pp. 84—86) show a similar distribution of the particle sizes. The samples treated by me have varying amounts of material within the above size grades. The greater part of it falls within coarser grades, however. The diagrams are besides considerably »broader» than is usually the case with those of the loess soils. In other words, the material of the soil samples from the Nahuel Huapí region is less well differentiated than that of the loess. — No investigations have been made regarding the structure and the texture of the present sample material. It is clear, however, that they correspond but little with those characteristic for the loess. LJUNGNER has, however, called the author's attention to the fact that the eolian material of the Nahuel Huapí region shows a certain cohesion, which enables steep sections to be formed. In this respect there is thus a certain resemblance to the loess, even if the cause is not the same. Most of the loess is considered to be diluvial. That the formation of loess proceeds even at the present time is pointed out by several authors (STAPPENBECK 1926, p. 86; SCHEIDIG o. c., p. 51).

It is evident from this comparison between the loess and the eolian material of the Nahuel Huapí region, represented by LJUNGNER's soil samples, that there are similarities as well as differences between them. The latter are in the majority, however. Perhaps it may seem to be somewhat inappropriate for the term loess to be given such limited scope. Still it will probably be best to use it only for the eolian material that fulfils the requirements made in the limited definition of the term which is commonly employed. The eolian material from the Nahuel Huapí region, represented by LJUNGNER's soil samples, thus cannot be classed as »genuine loess». It will be best to class it as »loess-like soil». For such a soil the term »loessoid» may possibly be invented. It may be mentioned here that EMILSSON (1931) has described loess-like soil from Iceland, which in several respects resembles that of the Nahuel Huapí region. After a detailed comparison EMILSSON (o. c., pp. 15—17) states that the Icelandic »loess» is not a »genuine loess» but an independent type of soil. It may not be denied, however, that several authors have spoken in favour of its loess nature (KOFOED-HANSEN 1922, p. 365, NIELSEN 1933, p. 249; Cf. also IWAN 1937, p. 179).

V. On the origin of the eolian soil material of the Nahuel Huapí region.

Comparisons with SALMI's eruption layers. A comparison between the eruption layers established by SALMI within the Nahuel Huapí region and LJUNGNER's soil samples Nos. 1—21 is of interest. We will begin with the mineralogical composition. The mafic minerals are the same; olivine, which appears to be lacking in the eruption layers, has nevertheless been proved in sample No. 3. From a quantitative point of view large differences may be estimated. The hypersthene, which dominates or in some cases (samples Nos. 4, 14, 19 and 20) occurs in approximately the same amount as the diopsidic augite, has its maximum within SALMI's layers II and IV, but also appears in layers I (sparsely) and III. It has not been possible to prove hypersthene in samples Nos. 7, 12 and 15. The diopsidic augite, which has been found in somewhat varying quantities in all SALMI's layers, occurs alone in samples Nos. 12 and 15 and together with basaltic hornblende in sample No. 7. It has not been found in samples Nos. 11, 13 and 16. The basaltic hornblende plays a subordinate part in samples Nos. 7, 13 and 17. It has its maximum in SALMI's layers 0 and I, but is met with rarely also in layer III. It ought to be mentioned that in some samples particles of other pyriboles that have not been examined in greater detail, have very occasionally been found. Ore, which has not been specially noted in the preceding pages, is met with in all SALMI's layers, as free particles and as inclusions in glass. The latter form is common in LJUNGNER's samples too. Apatite has been found in all the samples except No. 21. It is found in all SALMI's layers.

Of the felsic minerals muscovite and potash feldspar have been found only occasionally. — The rock fragments are not included in this survey. — The plagioclase and the glass attract the greatest interest. The percentages of anorthite in each one of SALMI's layers are very constant, and consequently, together with the glass, played an important part in the connection. A comparison between the plagioclases of SALMI's eruption layers within the Nahuel Huapí region and those of LJUNGNER's material is made in the diagram in Fig. 21. It ought to be noted that, owing to the method of determination used, the values obtained have the disadvantage of showing an uncertainty that is perhaps greater than is suitable in the present connection. Certain differences stand out clearly. The variation amplitude of the anorthite percentage is, as a rule, less within the eruption layers than within LJUNGNER's samples. As already mentioned, sample No. 20 is besides the only one that may be entirely fitted into SALMI's system of eruption layers. The anorthite percentages in other samples seem for the eolian soil to demand a source beyond SALMI's eruption layers. It may very well be thought that not all stages are found between the extreme values for the anorthite percentage in the different samples. Even if that is so, the origin of the material for the area 52—88 % An must, however, be sought elsewhere than in the eruption layers.

In principle it is the same with the glass as with the plagioclase. Usually one glass type dominates within each eruption layer. In the samples that I have examined there is on the contrary usually a multitude of types. The variation amplitude of the refractive indices is also most frequently larger than within SALMI's eruption layers.

In respect of the colour one may sum up by saying that the soil in LJUNGNER's samples, with the exception of No. 20, generally appears to be »rustier» than the material in the eruption layers.

Of the very greatest interest and importance in the present connection is a comparative study of the frequency distribution of the particle sizes and the particle groups within the eruption layers, on the one hand, and LJUNGNER's material on the other. SALMI has unfortunately not made

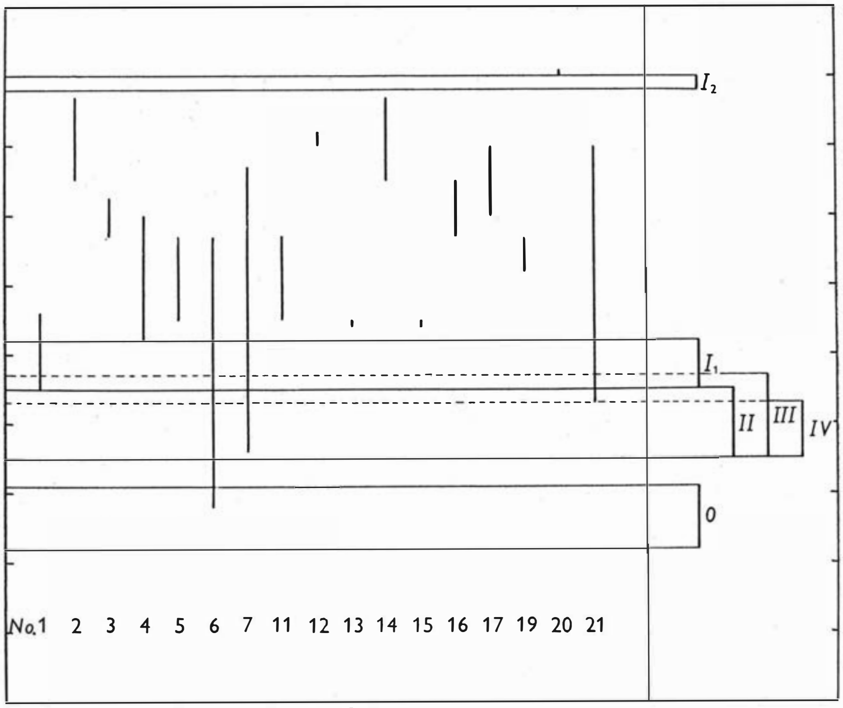


Fig. 21. Comparison between the anorthite percentages of the plagioclases of SALMI's eruption layers and those of LJUNGNER's soil samples Nos. 1—21.

any mechanical analyses of his material. As regards the particle size conditions that author only mentions for the sizes that come into question in connection with a comparison with the samples treated by me that the material is »feinsandförmig» or belongs to the »Feinsandklasse». By this is certainly meant the size group 0.2—0.02 mm (Swedish »mo»). The diagram of sample No. 20 (Fig. 18), which I consider represents SALMI's layer I_2, the slag layer, proves to have the maximum just within this size group. It will perhaps not be altogether too venturesome to assume that the diagram in its general type is representative of the ashy eruption layers. In this connection it must be noted that in making this assertion I have not denied that the dominating particle size may be and in many cases certainly is different from that in sample No. 20, which clearly represents a distal position. I will not enter upon a detailed comparison of any kind. The treatment of the different samples in the preceding pages will probably already have made clear the great difference in the frequency distribution of the particle sizes and the particle groups. In summing up attention may be drawn especially to the greater diagram »breadth» and the more irregular course of the curves of the particle groups, which characterize the diagrams of the soil samples in comparison with that of the ashy layer.

Possible Post-Glacial volcanic eruptions other than those established by SALMI. In Post-Glacial time — there is no doubt that the bulk of the eolian material is of Post-Glacial age[1] — several eruptions of ashes less extensive than those that in such a conspicuous way have been registered in the strata of the mires, have naturally taken place. When seeking for such thinner strata one must, however, realize that ash-like interstratifications in peat need not necessarily be primary ashes. In particular the upper layer of »grass» peat in the mire, where sample No. 20 was collected, is very rich in minerogenous material, viz. monoclinic and orthorhombic pyroxene, plagioclase and glass. Owing to the roundness of the corners particularly of the plagioclase particles, I am inclined to interpret the material as not primarily sedimented at the place. Other layers of »sand» in the profile, except those of the black »sand», will probably have originated through landslips or inundations.

I will briefly touch upon the above-mentioned possibility of tracing a part of the eolian soil. The volcanoes to the westward which may be taken into consideration and which were active in Post-Glacial time are Calbuco, Osorno, Puntiagudo (possibly active in Post-Glacial time), Caulle, Puyehue, Los Azufres and Riñinahue (Cf. the map in Fig. 1). The last-mentioned one erupted in 1907 (RIMBACH 1930, p. 105). As already mentioned, Los Azufres has been indicated by SALMI as the seat of eruption for layer IV. SALMI is uncertain about the origin of other layers. The discussion is rendered difficult by the fact that particulars are entirely lacking as to the activity of most of the volcanoes and as to the composition of their ejectamenta up to the present time. Particulars about the present volcanism are also very scanty. Owing to their size and to their relatively great eruption frequency (Cf. SALMI's (o. c., p. 77) survey) Calbuco and Osorno are entitled to consideration in the first place. About Calbuco's lava v. WOLFF (o. c., p. 337) says that it is a trachytic, hypersthene-andesite with 54.07 % SiO_2. Its minerals are labradorite-bytownite, olivine, hypersthene, augite and magnetite. The ashes from 1894 are somewhat more acid. STONE and INGERSON (1934, pp. 284—285) state that »the chief difference between the Calbuco lavas and the others studied is that hypersthene is the dominant ferromagnesian mineral in the Calbuco suite». This reminds one of SALMI's statement (o. c., pp. 23, 25) that the most important mafic mineral in his eruption layers II and IV consists of hypersthene. The volcano from which they originate may thus

[1] That its lower parts are of Late-Glacial age is evident from SALMI's (o. c., p. 17) statement that at his locality 1 the o-layer, forming a transition between Post-Glacial and Late-Glacial, is underlaid with »ein 1,5 m dickes dichtes Lösspolster, das aus feinem, rotbraunem, tonartigem Material besteht».

Table VI.

Optical data on the plagioclases.

		1	2	3	4	5
Lava	% An	86	88	60	62	
	2V	-86°, -	-84°, -	-88°, -	(+76°), -	
	Tw. law	Albite	Roc Tourné	Albite-Esterel	Roc Tourné	
Lapillo?	% An	83	84	85	89	75
	2V	-85°-87°	- , -	90°, -	90°, -	-82°, -
	Tw. law	Albite	Manebach?	Albite	Albite	Roc Tourné

Lava: Nos. 1,2. Phenocrysts. Nos. 3,4. Groundmass plagioclases.
Lapillo?: Nos. 1-4. Phenocrysts. No. 5. Groundmass plagioclase.

possibly be just Calbuco. The lighter-coloured lavas are classed as »olivine-bearing hypersthene basalts». Their plagioclases are labradorites. In the ashes from Calbuco's eruption in 1929 LARSSON (1936, pp. 47—49) has found plagioclase (anorthite contents from 53 % to 88 %), hypersthene, ore and brownish glass. — On the chemical and mineralogical composition of Osorno's ejectamenta PÖHLMANN (1893, pp. 1253—1254) reports that from the volcano there comes a dark grey, strongly porous, glassy augite-andesite, containing brownish glass, some augite, plagioclase and magnetite, the latter being in profusion. PHILIPPI (1852, pp. 571 et seq.) gives somewhat different data. BRUHNS (1898), who worked up the rock specimens collected during PHILIPPI's expedition, describes a number of augite- and olivine-bearing basalts and tuffs with plagioclases whose composition corresponds to that of the bytownite. In addition more acid rock types (with andesine-labradorite) are mentioned. I have examined two specimens from Osorno, collected by LJUNGNER in 1934. The one consists of a blackish grey, dense lava (specimen No. 2001) with occasional small vesicles, to be classed as an olivine-basalt, the other of a rounded, slaggy pebble (specimen No. 2002), probably a *lapillo*. In the rocks there occur phenocrysts of plagioclase and olivine in a cryptocrystalline-glassy mesostasis. The plagioclase laths are always fresh. In the lava they are often fluidally arranged. The composition of the plagioclase of the lava and the *lapillo* is given in Table VI. It will be seen from this that the plagioclases of the ground-mass are considerably more acid than the phenocrysts. — From Puyehue STONE and INGERSON (o. c., p. 284) have examined a rock specimen, which is characterized as »an altered, olivine-bearing basalt». Its plagioclase is labradorite.

The anorthite percentages of the plagioclases in Calbuco's, Osorno's and Puyehue's ejectamenta thus fall within the area 52—88 % in the diagram in Fig. 21. Consequently it is conceivable that a part of the eolian material may be traced from eruptions of these volcanoes, belonging to a smaller size category than those established by SALMI. The mafic minerals form no obstacle to this. Judging from all appearances, only those eruptions treated by SALMI have, however, been of sufficiently large size, and it is therefore clear that the source just dealt with has been of very little importance. The argument is perhaps rendered more difficult by the fact that the volcanoes just mentioned were certainly the places of origin of SALMI's older eruption layers (Cf. SALMI o. c., pp. 87—88). Alternation between »basic» and »acid» eruptions are known, however, for instance from Iceland (BJARNASON and THORARINSSON 1940, p. 23). It may also be stated in this connection that the above particulars on the composition of the ejectamenta of the volcanoes in the western part of the district compared with SALMI's on the composition of the eruption layers give a definite impression that these volcanoes should partly have a volcanism more basic than that indicated by the composition of the eruption layers. Perhaps we have to do with a phenomenon here comparable with the occurrence of liparites in basalt regions on Iceland (THORODDSEN 1891, BÄCKSTRÖM 1891, HAWKES 1916; Cf. also BACKLUND 1942, p. 14 et seq.).

The basement. A source of the eolian soils may probably be sought in the mechanically weathered material from the older bedrock, particularly the Tertiary and the Interglacial one (the Tronador series).

It holds good of the samples examined by me that granitic material plays a very subordinate role. It is uncertain to what extent this observation may be generalized and made to apply to the whole area. It may be mentioned here that LEBEDEFF (o. c.), who for forestry purposes examined soils at the shores of Lago Nahuel Huapí, assumed that weathered granitic material *in situ* formed the main constituent part of the soils, for he says (o. c., p. 4): »Los suelos en las costas del lago Nahuel Huapí provienen, en su mayor parte, de la desagregación de granito.» That that can hardly be the case is apparent, inter alia, from the fact that granitic bedrock is absent at some of LEBEDEFF's localities, for instance Isla Victoria and Correntoso (Cf. the map in LJUNGNER 1931, p. 205).

In order to try to illustrate a possible connection between the fast Tertiary bedrock and the eolian material I made an attempt at a comparison between sample No. 17 and a suite of rocks collected in the alpine belt above the locality of this sample (Cf. p. 188). No similarities whatever in respect of the mineralogical composition could be proved, however, either within coarser or finer size grades.

Regarding the Tronador series it may be mentioned that LJUNGNER on Cerro Lopez collected »black sand», constituting mechanically weathered material from the Interglacial pyroclastics to be found there. From there a new addition to the eolian cover in lower areas might very well have been able to take place. In addition to this there is the fact that the similarity is great between the black opaque glass in the tuff on Cerro

Lopez and that of the soil samples of the other localities. The anorthite percentages form no obstacle (Cf. the diagram in Fig. 38, p. 351, in LARSSON 1940), nor does the mineralogical composition for the rest. The localities for the Tronador series within the region are relatively few in number, however. Even if they were more numerous in older Post-Glacial time, their number having later been decreased by erosion, they will probably only have been of local importance as sources of the eolian material.

Sedimentation and resedimentation. To the extent to which the eolian material sediments in forests or in other surroundings where the vegetation can bind it, to that extent it naturally becomes stationary. The conditions are different in steppe-like or other more or less vegetationless areas. Erosion and resedimentation must be of common occurrence there. The material at one time bound by vegetation may also come into circulation again, however, in consequence of displacements of the vegetation regions. LJUNGNER has found that the tree line within the Nahuel Huapí region is in the act of sinking. Fig. 17 (p. 190) shows an isle-shaped erosion remnant at the tree line, an eloquent proof of this. The result is an erosion and retransportation of eolian strata of unknown, older date with interstratified eruption layers. How long this sinking has been continuing cannot be determined at present, nor consequently how great a role the resedimentation, occasioned by the sinking, has played. A certain, perhaps not so inconsiderable new addition to the eolian cover in lower areas will nevertheless certainly have to be taken into consideration. The conditions are similar when the vegetation is destroyed in one way or another and its soil-binding quality is reduced or ceases. Fig. 22 shows a cloud of eolian material driving from a wound in the deciduous forest down over the evergreen one.

A manifestation of a kind comparable with the sinking forest boundary is probably the circumstance established by SALMI (o. c., p. 92) in pollen diagrams from the Nahuel Huapí region that the forest is at present receding and giving way to the steppe, a phenomenon that was first indicated by AUER for Tierra del Fuego (AUER 1933; cf. also AUER 1942 and VON POST 1929 and 1931). The effect of this will in any case be the same as that of the sinking tree line. — The question of the rapidity of formation of the eolian cover is also connected with the climatic factor. One may learn from AUER's (1942, p. 664) work that a period with intensive stratification of eolian soil occurs before SALMI's eruption layer I.

Conclusions. As far as I am able to judge the conditions in the investigation area without field experience of it, its eolian material will probably mainly consist of resedimented volcanic ashes. A material settled in an exposed position after a volcanic eruption is added by the agency of the wind to the eolian cover, bound by vegetation. It is conceivable that one might establish a direct connection between the thickness of the

Photo E. LJUNGNER. 4.2. 1934.

Fig. 22. Cloud of eolian material driving from a wound in the deciduous forest down over the evergreen one. Looking south from a point immediately north-west of the locality for sample No. 17.

eolian cover and the size of the area situated above the tree line. It may further be stated that the greatest thickness of the eolian cover was observed by LJUNGNER in the western part of the area, by Lago Llanquihue below Osorno. There is hardly any doubt that the total amount of material belonging to SALMI's eruption layers, that during Post-Glacial time fell in an exposed position, that is to say in one not clothed with vegetation, well suffices as the source of the eolian soil cover. The insignificant part played by the firm bedrock in this respect is shown inter alia by the dominating quantities of volcanic glass of undoubted ash origin in the samples, by the extremely insignificant occurrence of granitic material in the soil within pure granite areas and by the homogeneity of the material practically throughout within the whole investigation area.

It is not possible for me to go further than these intimations without a larger sample material and field studies within the area.

VI. Comparisons with other areas.

In the literature I have tried to find data on the particle size distribution of volcanic ashes and restratification products of the same for comparisons with my own material. Such data are not common. Most often in the fairly frequent reports of showers of ashes an author contents himself with giving general particulars of but little interest in the present case.

The particle size distribution of ashes transported long distances has been investigated by KREUTZ and JUREK (1932, pp. 317—318) and LARSSON (1936, pp. 36—37). Particulars in this connection regarding ashes of moderate transportation distance ($\leqq$ 100 kilometres) I have found given by WENTWORTH (1926) from Oahu, one of the Hawaiian islands, and by DEGER (1932) from El Salvador. Several of WENTWORTH's histograms for volcanic ashes (o. c., Figs. 25 and 26 and pp. 96, 97) agree well with that of sample No. 20. It is pointed out that the tuffs probably have a mechanical composition resembling that of the ashes (p. 108), a fact which it has also been possible to establish as regards the Interglacial tuff from Cerro Lopez. Three of the four ashes examined by DEGER are coarser and one finer than LJUNGNER's sample No. 20. The degree of sorting is somewhat lower. The histograms given by CORRENS and LEINZ (1933) of tuffs from Sumatra do not allow of any comparisons with that of the tuff from Cerro Lopez. It is the same in the case of CLOOS' fine-layered »(feinkörnige) Ersttuffe» from Swabia (CLOOS 1941, pp. 719—720). These also have an entirely different method of formation of course. From WENTWORTH and WILLIAM's (1932) terminological paper we can only learn that the eruption layer may be classified as a »vitric fine essential ash» and the Interglacial tuff from Cerro Lopez as a »vitric fine essential tuff» (p. 52), since most of the particles are less than 0.25 mm.

As already mentioned (p. 208), SCHEIDIG (l. c.) speaks of loess of volcanic origin, although without a more detailed description. It is the same unfortunately in the case of PALMER's (1931) short account of the loess at Ka Lae on Hawaii. — The loess-like Icelandic soils have already been touched upon in another connection (p. 209). In conclusion may be pointed out the important part that volcanic ash material plays in the eolian parts of the Argentine Pampa formation (STAPPENBECK o. c., pp. 88—89). Here, however, it is clearly a question of more distal products than those within the loess-like soils of the Nahuel Huapí region.

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APPENDIX.

List of Diatoms from Lago Frey, with some critical remarks.

By

Astrid Cleve-Euler.

In a bottom sample from Lago Frey in the Nahuel Huapí region in Northern Patagonia, collected by Mr. E. LJUNGNER and sent to me for examination of the diatoms, I have noticed the following forms, mainly in few or solitary, more or less damaged specimens.

Forms occurring more commonly are marked with a +.

Achnanthes delicatula Kz.
» *hungarica* Grun.
Anomoeoneis brachysira (Bréb.) Grun.
Caloneis silicula (E.) Cl. v. *subinflata* Grun.
Ceratoneis arcus Kz.
» » v. *amphioxys* (Rbh.)
Cyclotella stelligera Cl. & Grun.
Cymbella amphicephala Naeg.
» » v. *hercynica* (A. S.) Cl.
» *aspera* E.
» *gracilis* (Rbh.) Cl.
» *helvetica* Kz.
» *Ljungneri* n. sp.
» *Stodderi* Cl.
» *ventricosa* Kz.
Diatoma hiemale v. *mesodon* (E.) Grun.
Diatomella Balfouriana Grev.
Diploneis subovalis Cl.
Epithemia argus Kz.
Eunotia arcus E.
» *exigua* (Bréb.) Grun.
» *flexuosa* Kz.
» *lunaris* (E.) Grun.
» » v. *attenuata* Cl. (Mag. Terr. F. 19)
» *major* W. Sm. v. *curta* A. Cl.
» » v. *linearis* A. Cl.
Eunotia obesa Cl. (Mag. Terr. F. 16—17).
» *pseudo-parallela* f. α Å. Berg 1939 s. 438 = »*pectinalis* v. *stricta* Rbh.?» Cl. Mag. Terr. F. 13.
» *tridentata* E. (Cl. Mag. Terr. F. 21).
Fragilaria inflata (Heid.) Hust.
» *pinnata* E.
» *Vaucheriæ* (Kz.) Boye Pet.
Frustulia amphipleuroides (Grun.) A. Cl.
» *rhomboides* v. *viridula* (Bréb.) Cl.
Gomphonema gracile E. var.
» *parvulum* Kz.
» *turris* E.
Melosira Dickiei (Thw.) Kz.
» *distans* (E.) Kz. +
» *fennoscandica* n. sp. v. ? *baccata* n. v.
» *granulata* (E.) Ralfs
» *italica* (E.) Kz. +
» *patagonica* O. M. (= *M.* sp. Cl. Mag. Terr. F. 15) +
» *Roeseana* Rbh.
Navicula bacilliformis Grun.
» (*Achnanthes*?) *capitellata* n. sp.
» *contenta* Grun. v. ? *opulenta* n. v.

Navicula (*gastrum* v.) *exigua* Greg.
» *Ljungneri* n. sp.
» *radiosa* Kz.
» » v. *subrostrata* Cl.
» *Rotæana* (Rbh.) Grun.
Neidium amphigomphus (E.) Cl.
» *affine* v. *amphirhynchus* (E.) Cl.
» » » f. *minor* Cl.
» *iridis* v. *oblonga* (Östr.) A. Cl.
Nitzschia amphibia Grun.
» *frustulum* Kz.
Pinnularia appendiculata (Ag.) Cl.
» *bicapitata* (Lgt) A. Cl.
» *borealis* E.
» *dactylus* E. v. *subundulata* A. Cl.
Pinnularia divergens W. Sm. v. *capitata* A. Cl.
» *hybrida* Per. & Hér.
» *lata* Bréb.
» *macrocephala* n. sp.
» *major* Kz. v. *turgidula* Cl.
» *stauroptera* Grun. f. *subundulata* May.
» *stomatophora* Grun.
» *subcapitata* Greg.
» *subsolaris* Grun.
Rhopalodia gibba (E.) O. M.
Surirella bidentata Krasske
» *Engleri* O. M. f. *sublaevis* O. M.?
» *robusta* E.
Tetracyclus ellipticus (E.) Grun. v. *lancea* f. *chilensis* Krasske

All the forms are fresh water inhabitants (*Achnanthes delicatula* lives in slightly brackish, occasionally in fresh w.), and many of them are known as common in northern-alpine regions.

Cymbella Ljungneri n. sp. V. slightly asymmetrical, tapering towards the obtuse, subcapitate ends. L. 75 μ, Br. 17 μ. Axial area moderately narrow, widened in the middle to a small, rounded, central area. Striae slightly radiating, 8.5 (middle)—11.5 (ends) in 10 μ, finely punctate. — Fig. 1.

Dimensions and area as in *C. Ehrenbergii* v. *delecta* A. S., but the outline is different.

Cymbella Stodderi has been determined so owing to the close resemblance of the specimens observed to CLEVE's figure of that Brazilian species (1881, T. 1, F. 5). L. 92 μ, Br. 14.5 μ. Str. 10 (middle)—15 (ends) in 10 μ.

Melosira fennoscandica n. sp. v. ? *baccata* n. v. Frustules in chains, isodiametric and subgloboid, diam. 10—11 μ. V. low, rounded convex with a cyclus of strong striae, 7—7.5 in 10 μ, close to the disci. The lower part of the valve and the rather large girdle zone are hyaline. Pseudosulcus a large annulus.

The main form of this species has not yet been described; it is distinguished from the present variation, or species, by more subcylindrical cells and smaller pseudosulci. Striae closer, 9—10 in 10 μ. — Fig. 2.

Melosira patagonica O. Müll., described by MÜLLER (1909, p. 2) as *Mel. lineolata* var. *patagonica*, was first found and figured with a short description by P. T. CLEVE in 1900 (T. XV, F. 15) as »*Melosira* sp.». An auxospore, diam. 27 μ, has been drawn by FRENGUELLI (1937, F. 31). The species is a sturdy and characteristic one, with very delicate, pervalvar rows of puncta. The sulcus is a deep furrow; none the less I do

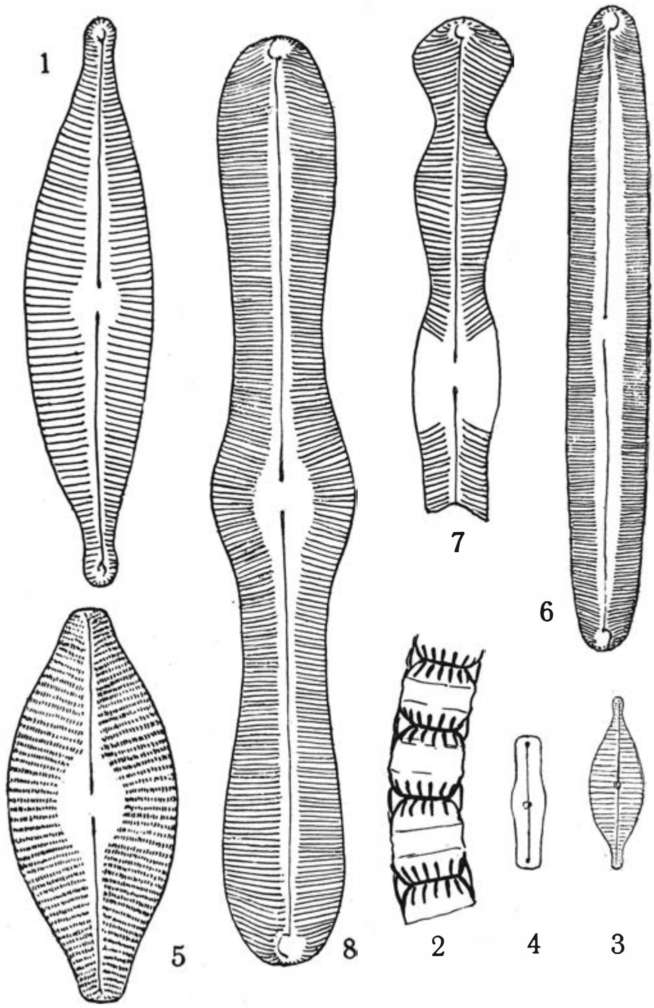

Fig. 1. *Cymbella Ljungneri* n. sp. 1000/1.
Fig. 2. *Melosira fennoscandica* var. ? *baccata* n. v. 1000/1.
Fig. 3. *Navicula* (*Achnanthes?*) *capitellata* n. sp. 1000/1.
Fig. 4. *Navicula contenta* var. ? *opulenta* n. v. 1000/1.
Fig. 5. *Navicula Ljungneri* n. sp. 1000/1.
Fig. 6. *Pinnularia hybrida* v. *perlonga* n. v. 500/1.
Fig. 7. *Pinnularia macrocephala* n. sp. 1000/1.
Fig. 8. *Pinnularia major* v. *turgidula* Cl. 500/1.

not think this species so closely related to *M. Roeseana* as does Mr. FRENGUELLI, who says that it might perhaps prove to be a mere variety of the latter.

Navicula (*Achnanthes?*) *capitellata* n. sp. V. elliptical with narrow, capitate ends. L. 23 μ, Br. 7 μ. Areas not developed; striae parallel throughout, 13—14 in 10 μ, not distinctly punctate. — Fig. 3.

I have seen only one valve of this elegant little form, which may be an *Achnanthes* to judge from the striation.

Navicula contenta var. ? *opulenta* n. sp. A small form, linear, with slightly inflated middle and ends and no visible striation (striae more than 25 in 10 μ), is probably related to *Nav. contenta*. It has, like that species, marked end-nodules, but is a little larger; L. 17 μ, Br. 4.2 μ. — Fig. 4.

Navicula Ljungneri n. sp. V. elliptical with broad, somewhat rostrate ends. Axial area small, narrow, expanding in the middle to a rather large, elongated elliptical area. Striae 8 in 10 μ, radiate to the ends, very finely lineate. L. 51 μ, Br. 23 μ. — Fig. 5.

As I have not been able to identify this form with any other known to me, I have made it a new species, dedicated to the collector of the present material.

Pinnularia dactylus v. *subundulata* A. Cl. 1939 F. 19. Large specimens, dimensions f. i. 305: 48 μ, with narrow bands, bear a great resemblance to *Pinn. dactylus* v. *sumatrana* Hust. 1934. Schm. Atl. 388, F. 2, and have a similar, somewhat complex raphe. But the striae are less close, only 4.7—5 in 10 μ, as in my Finlandic variety. The Patagonian form is hardly undulated at all.

Pinnularia hybrida Per. & Hér. occurs in large specimens, 170: 21 μ, with only 8.5 striae in 10 μ. Perhaps it should be considered a distinct variety, v. *perlonga* mh., the main form having 10 striae in 10 μ. In this Patagonian race, *P. hybrida* cannot be confused with *P. hemiptera*. It seems more akin to *P. major*, but the striae are closer and subparallel, except in the ends. Area $^1/_3$ of the breadth of the valve. — Fig. 6.

Pinn. macrocephala n. sp. *Pinn.* sp. Krasske 1939 T. XI, F. 39. V. linear, slender, triundulate with large, capitate ends, as broad as the subterminal inflations. Axial area narrow, expanding to a broad central fascia. Striae strongly divergent and, in the ends, convergent, 12—13 in 10 μ (KRASSKE gives the number 12—17, owing, as may be presumed, to his method of counting). End-fissures semicircular. L. 52—94 μ, Br. 6—12 μ — Fig. 7.

Both specimens hitherto met with lack one of the poles; so it has not yet been established whether both poles have the end-fissures turned in the same direction or not. In the Chilean specimen the central inflation has not been developed.

Pinnularia major v. *turgidula* Cl. Syn. Nav. D. II, p. 89. A specimen delineated in Fig. 8 is 245 μ in length and 36 μ in breadth in the central inflation, but only 24 μ in breadth in the adjacent constricted parts. Striae radiate in the middle, convergent in the ends, crossed by a narrow band, 6.5—7 in 10 μ. — Fig. 8.

There does not exist any drawing of this characteristic form recorded by CLEVE from different parts of America, but the Patagonian specimens are in strict accordance with CLEVE's diagnosis; so I think the determination is correct.

Surirella Engleri O. M. f. *sublaevis* O. M.? Müller 1904, I, p. 29, T. I, F. 9. Some large, sublinear specimens of *Surirella* with cuneate ends have been referred to this species on account of the missing projection of the wings and of the narrow channels, 1.9 in 10 μ. L. 90—180 μ, Br. 26—38 μ.

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