ON INLAND WATERS CHEMISTRY OF INDIAN OCEAN'S ISLANDS (SEYCHELLES, COMORES, RÉUNION, MAURITIUS)

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ABSTRACT

The stages of surface weathering on the younger volcanic islands are most variable, depending on the local climate and widespread effects of deforestation. The rocks are partially highly porous causing subterraneous water-drains. The increasement of ions downstreams is inhomogeneous or absent. The hydrochemistry of rivers from old volcanic islands is similar that from crystalline (granitic) watersheds. Especially the headwaters are surface drains of acidic soils. They are poor in ions, sodium and chloride is relatively enriched. The increasement of conductivity in downstream direction is mostly homogeneous.

ZUSAMMENFASSUNG

Die Stadien der Oberflächenverwitterung junger vulkanischer Inseln sind äußerst verschiedenartig, je nach dem lokalen Klima und den weitgespannten Wirkungen der Abholzung.

Das Gestein ist teilweise äußerst porös, was ein unterirdisches Ablaufen des Wassers bewirkt. Die Ionen nehmen flußabwärts ungleichmäßig oder gar nicht zu.

Der Wasserchemismus von Flüssen alter vulkanischer Inseln ist ähnlich jenem von kristallinen (granitischen) Einzugsgebieten, besonders die obersten Quellbäche, die oberflächliche Abläufe saurer Böden darstellen. Sie sind arm an Ionen, Natrium und Chloride sind relativ angereichert. Die elektrische Leitfähigkeit nimmt flußabwärts größtenteils gleichmäßig zu.

RÉSUMÉ

L'altération des roches superficielles des îles volcaniques d'origine récente de l'Océan Indien, est très variable et dépend du climat local et de l'importance du déboisement.

Une partie des roches est très poreuse et il en résulte un écoulement souterrain des eaux. La teneur en ions augmente de manière hétérogène de l'amont vers l'aval; dans certains cas on n'observe aucun accroissement de la teneur des eaux en sels dissous.

L'hydrochimie des eaux des rivières des îles volcaniques plus anciennes est comparable à celle des bassins cristallins (granitiques). Les cours supérieurs drainent les écoulements des sols acides, les eaux sont plus pauvres en ions, le sodium et les chlorures sont proportionnellement plus abondants. L'augmentation de la conductivité de l'amont vers l'aval est relativement homogène.

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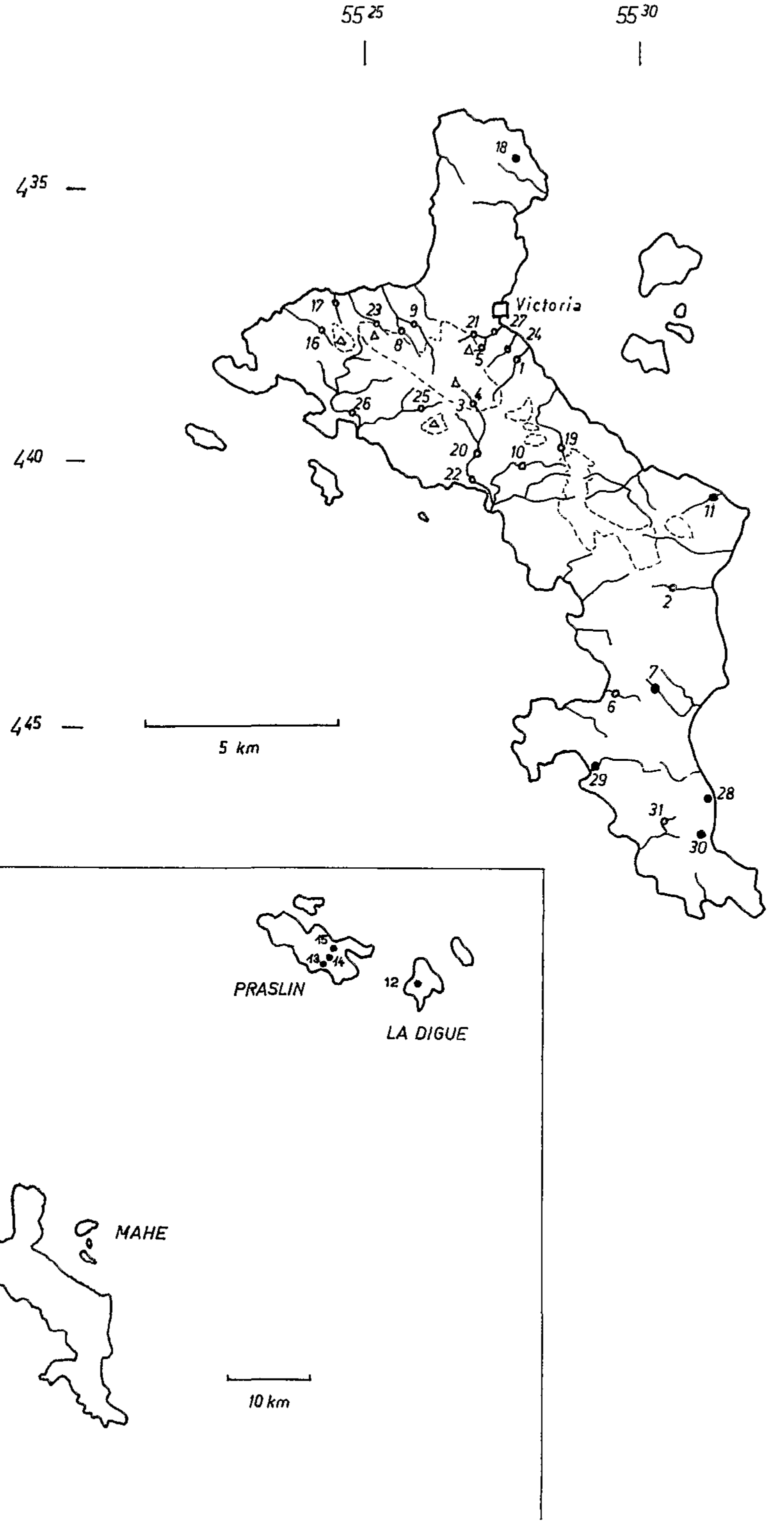

Fig. 1. — Seychelles, Mahé. — Collecting stations. Full points are river-systems with water of higher conductivity (more than 70 µS/cm).

Seychelles, Mahé. — Stations de prélèvements. Les points noirs correspondent aux rivières ayant une conductivité des eaux supérieure à 70 µS/cm.

INTRODUCTION

The ecology and chemistry of running water systems, marshes and small crateric lakes of tropical islands in the Indian Ocean had been studied (catchment from February till early May 1974).

The investigated islands of the Seychelles' archipelago (Mahé, Praslin, La Digue) are all granitic. The other studied islands are completely of volcanic origin—Mauritius like Anjouan (Comoro Islands) with extincted volcanos and especially Mauritius in a far advanced stage of erosion, Réunion with an extincted and an active volcano.

The water samples were partially analysed by field measurement (PH, conductivity, alkalinity, calcium, magnesium, ammonia, nitrite), the remaining analyses were made in the laboratory.

1. SEYCHELLES

1.1. Climate and Geology

The Seychelles archipelago lies in the tropical trade-wind belt between 4° and 11° south. It consists of more than 100 islands, 24 of them are granitic. The largest island is Mahé (fig. 1) with mountains reaching 912 m (Morne Seychellois). Praslin, La Digue and Silhouette are the next largest of the same granitic-syenitic type.

The total population is about 53000; the area is 179,5 km² (Mahé). The seasonal weather is governed primarily by the two monsoons—the south-east monsoon which blows between May and November and at intervals during the remainder of the year (steady moderate wind, little rainfalls), and the north-west monsoon which occurs between November and May (variable winds or calm periods accompanied by squalls, high rainfalls and generally higher temperature and humidity). Both temperature and humidity are uniformly high throughout the year, the most humid months being December and January. Tropical cyclons reach only as far north as the southernmost province of the Seychelles archipelago (Farquar and Providence) and do not touch the Mahé-region.

Date of catchment—February 1974.

Annual precipitation (mm) (Met. Dept. Fort Victoria 1974).

Port Victoria (Mahé, 62 years mean)

Feb. 1974 458 mm

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
383	260	230	183	175	87	88	74

Sep.	Oct.	Nov.	Dec.	mean (annual)
131	169	219	331	2328

Precambrian granites form the principal group of islands—the grey Mahé-granite and the reddish Praslin-La Digue-granite. They are composed of microperthite, quartz, oligoclas, minor amphibol and occasionally biotite. Mahé is almost entirely formed of hornblende granite. Dolerite and basalt dykes (early Tertiary) cut cross the granitic massif (BAKER, 1963).

The granite of Mahé weathers deeply to a reddish brown lateritic soil. Granitic feldspars and ferromagnesian minerals have weathered to kaolinitic red brown iron-stained clay in which quartz grains are set in their original position. The granites have therefore weathered deeply in site. A true soil layer is generaly thin or absent. Above 600 m (rain forest belt) the soil is a wet clay.

Analyses of granite sub-soils (BAKER, 1963): (per cent)

SiO_2 17,1-36,9 Al_2O_3 31,5-38,1 Fe_2O_3 14,3-17,9 FeO 0,35-0,57 MgO 0,09-0,17 CaO 0,00 TiO_2 1,6-2,4 MnO 0,33 Loss on ignition 15,1-21,8

1.2. Collecting stations (February 1974), altitude (alt.) in m; mean daily discharge (MDD) in. m³/s; temperature (T) in °C

Mahé

St. 1 Mamelle River, lower course; alt.: 20; MDD: 0.6; T:24-26
2 du Cap River, upper course; alt.: 60; MDD: 0.25; T 26
3 Grand Bois River, headwater region, Casse Dent; alt.: 480; MDD:0,1; T: 21.7
4 Grand Bois River, upper course, Forêt Noire Road; alt.: 400; MDD: 0.6; T: 22
5 Rochon River, middle course, Forêt Noire Road; alt.: 360; MDD: 0.1; T: 23
5a Rochon River, same place after one week's dry period; MDD: 0.05
6 Anse de la Mouche River, west-coast, mouth (brackish); MDD: 0.75; T: 32
7 Royal River, upper course, Les Canelles Road; MDD: 0.2; T: 26,3
8 St. Louis River, middle course-region, tributary; alt.: 220; MDD: 0.9; T: 23,8
9 Grand St. Louis River, middle course, „Leniol"; alt.: 220; MDD: 0.8; T: 24.3
10 Seche River, upper course; alt.: 310; MDD: 0.5, T: 23.5
11 Baleine River, lower course near the mouth; alt.: 3; MDD: 0.1; T: 26
16 Jasmin River, middle course, cascades; alt.: 80-100; MDD: 0.1; T:25,3
17 near "Danzilles", small stream (Bell Ombre); alt.: 3; MDD: 0.1; T: 25

18 backwater marsh, north-cap (Anse north-east); alt.: 1; MDD: 0.2, T: 33.5
19 Pleasance River, upper course; alt.: 100; MDD: 0.1; T: 24.8
20 Grand Anse River, west-coast, middle course; alt.: 150; MDD: 2.4, T: 26.5
21 Rochon River, east coast, middle course; alt.: 300; MDD: 0.6; T: 26
22 Grand Anse River, lower course near the mouth; alt.: 2; MDD: 0.15; T: 27
23 Athanas River, north-west of Mahé, upper course; alt.: 300-350; MDD: 0.1
24 Quenet River (College River), lower course; alt.: 30; MDD: 0.8; T: 25.5
25 Desert River, Forêt Noire Road, upper course; alt.: 150; MDD: 0.2; T: 23.5
26 Cascade River, west-coast, lower course; alt.: 10; MDD: 2.7; T: 26
27 Rochon River, lower course near the mouth; alt.: 2; MDD: 0.3; T: 26
28 Bougainville, water supply
29 Takamaka River, south-west of Mahé, lower course; alt.: 10; MDD: 0.1; T: 26
30 Anse Forbans River, lower course; alt.: 15; MDD: 0.1; T: 26.3
31 Bon Espoir River, near Quatre Bornes, upper course; alt.: 150; MDD: 0.2; T: 24

Praslin

St.13 Cascade River, Valée du Mai, gorge below the large water-fall; alt.: 130; MDD: 0.2; T: 25.5
14 Cascade River, Valée du Mai, headwater-region; alt.: 200; MDD: 0.1; T: 24.1
15 north-eastern flanks of the central mountain risde, small stream; alt.: 100; MDD: 0.2; T: 25

La Digue

St.12 Shoppy River, headwater-region; alt.: 30; MDD: 0.15; T: 25.3
mean discharge of all investigated streams and rivers : 0.44 m³/s.

1.3. Classification of the investigated river-systems of the Seychelles' archipelago

1.3.1. River-systems from the humid northern part of Mahé.

In this mountain streams the lowest conductivity-measurements were registrated.

Two main types are distinguished—main rivers draining the central ranges with a most homogeneous chemical composition from the upper courses to the mouths—and the mostly smaller rivers and streams draining the flanks, watersheds that are in more advanced stage of weathering mostly draining towards the east coast.

(a) Headwater-region and upper course-region of the windward northwestern flanks of the central ranges of Mahé (stations 8, 9, 16, 23), running partially over bare rocks, and also the upper courses of systems draining the northeastern flanks (stations 5, 5a, 19, 21) within an altitude of 100-360 m (conductivity 25-35 µS/cm) typical are high contents of humic acids and of ammonia due to the influence of the mountain rain-forest) (tabl. I).

TABLE I

Seychelles (Mahé): northeastern headwater-region. Water's chemical composition (in ppm).
Seychelles (Mahé): composition des eaux (en ppm). Région des sources du nord-est.

Station	5	5a	19	21	8	9	16	23
Conductivity (20 °C, µS/cm)	25	30	35	33	31	29	34	31
PH	5,40	6,45	6,45	7,20	6,60	6,80	6,10	6,70
Humic acids (ppm)	6,42	2,08	0,62	1,85	0,51	1,33	0,54	0,37
Ca^{++}	0,32	0,44	0,64	1,40	0,08	0,60	0,20	0,48
Mg^{++}	0,22	0,24	0,26	0,23	0,16	0,29	0,40	0,10
Na^{+}	3,70	3,40	4,50	3,70	4,00	3,50	4,00	3,50
K^{+}	1,15	1,00	0,90	0,75	0,90	0,60	0,50	0,55
Fe-total	0,10	0,01	0,13	0,16	0,05	0,05	0,02	0,00
Al^{+++}	0,25	0,37	0,34		0,08	0,15	0,23	
NH_4^{+}	0,40	0,05	0,10	0,05	0,02	0,05	0,05	0,02
NO_3^{-}	0,07	0,09	0,07	0,08	0,07	0,07	0,07	0,07
Cl^{-}	4,4	5,6	4,8	4,9	5,0	4,8	7,0	5,7
F^{-}	0,09	0,07	0,05	0,07	0,01	0,08	0,07	0,08
PO_4^{---}	0,01	0,02	0,02	0,01	0,02	0,02	0,01	0,01
SiO_2^{-}	6,0	9,5	10,6	6,5	10,9	8,4	6,8	8,1
SO_4^{-}	1,2	0,3	1,6	1,4	0,8	0,8	0,7	1,3
HCO_3^{-}	1,8		9,2	4,9	9,2	6,1	3,1	3,7
CO_2 aggr			7,7	8,1	9,9			
$KMnO_4$-consump	82		29	28	15	20	25	

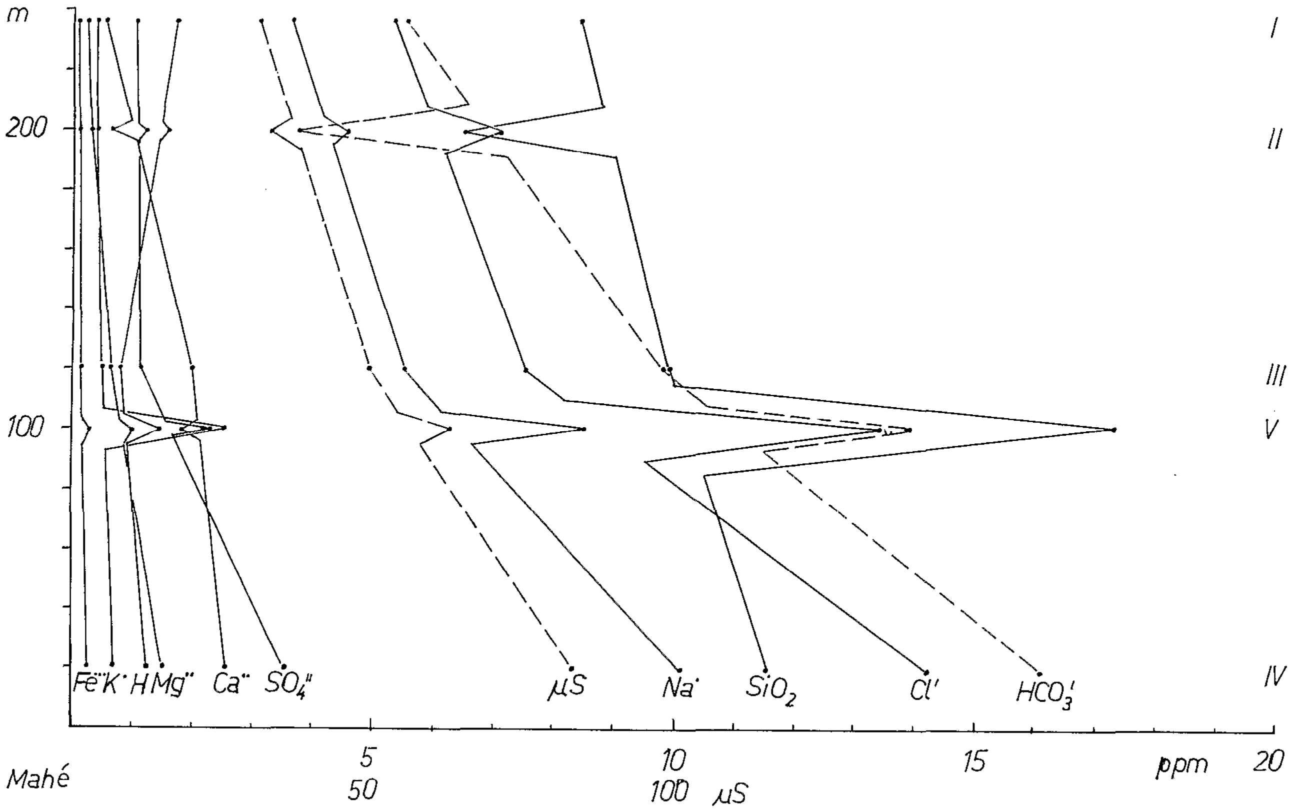

Fig. 2. — Seychelles.—Survey of hydrochemistry in relation to altitude (m). Analytical means from the regions.
I headwater region of northern-and northeastern Mahé.
II main-river systems of northwestern Mahé flowing towards west.
III upper lower courses from river-systems in the north and northeast and upper courses from leeward watersheds of Mahé.
IV water-systems from the less mountainous leeward south of Mahé. (upper lower courses).
V water-systems in Praslin and La Digue.
H = Humic acids.

Seychelles. — Relations entre la chimie des eaux et l'altitude (m). Moyennes des observations effectuées dans les différentes régions.
I *Région des sources du nord et du nord-est de Mahé.*
II *Principaux cours d'eaux du nord-ouest de Mahé coulant en direction de l'ouest.*
III *Cours moyen des rivières du nord et du nord-est et cours supérieur des bassins sous le vent de Mahé.*
IV *Cours moyen des rivières des bassins sous le vent du sud de Mahé.*
V *Rivières de Praslin et La Digue.*
H = acide humique.

(b) Main river-systems flowing towards the west coast of Mahé (Grand Bois-Grande Anse-system, Cascade River, stations 3, 4, 20, 22, 26), that are all most homogeneous in their chemical composition within an altitude of 2-480 m (conductivity 25-36 µS/cm, humic acids are abundant in small headwater torrents, they fluctuate distinctly with the amount of rainfall). The decomposition of humic acids and ammonia occurs already in the upper course region (tabl. III).

(c) Lower course region of the northeastern and northern river-systems (also humid part) (stations 1, 17, 24, 27) within an altitude of 20-40 m (tabl. II) (conductivity 46-54 µS/cm). Upper courses of partially leeward watersheds (stations 2, 10, 25, 31) altitude 100-310 m, conductivity 44-49 µS/cm.

1.3.2. Streams outside the humid region of the central mountain ranges (in Mahé Praslin, La Digue)

(a) The water-systems from the leeward districts of southern Mahé and coastal regions within an altitude of 1-100 m, contain more dissolved compounds (conductivity 44-110 µS/cm), (stations 7, 11, 18, 28, 29, 30) (tabl. IV).

(b) Streams from the smaller granitic islands Praslin and La Digue (stations 12, 13, 14, 15),

TABLE II

Seychelles (Mahé) : lower courses of northeastern and northern river-systems (windward watersheds) (st. 1,17, 24, 27) and upper courses of partially leeward watersheds (st. 2, 10, 25, 31). Water's chemical composition (in ppm).

Seychelles (Mahé): cours inferieurs des rivières du nord-est et du nord (bassins au vent) (st. 1, 17, 24, 27) et cours supérieurs des rivières partiellement sous le vent (st. 2, 10, 25, 31). Composition chimique des eaux (en ppm).

Station	1	17	24	27	2	10	25	31
Conductivity (20 °C, µS/cm)	54	58	46	50	49	47	47	44
PH	6,90	6,20	6,90	7,25	7,20	6,55	6,40	6,80
Humic acids (ppm)	0,56	0,48	0,50	0,63	1,22	1,46	0,93	0,58
Ca^{++}	3,40	1,20	1,40	2,80	2,20	2,65	1,00	1,12
Mg^{++}	0,74	0,79	0,58	0,69	0,01	0,79	0,56	0,90
Na^{+}	5,00	7,20	5,80	4,00	5,80	5,00	5,80	8,70
K^{+}	0,80	0,80	0,60	0,75	1,00	0,50	0,70	0,70
Fe-total	0,10	0,00	0,16	0,21	0,01	0,48	0,13	0,02
Al^{+++}	0,02	0,21		0,24	0,03	0,17	0,11	0,33
NH_4^{+}	0,04	0,03	0,02	0,02	0,07	0,06	0,02	0,02
NO_3^{-}	0,01	0,09	0,08	0,09	0,07	0,07	0,08	0,10
Cl^{-}	6,1	9,2	7,1	6,9	8,2	7,0	8,5	7,2
F^{-}	0,06	0,06	0,01	0,07	0,06	0,06	0,06	0,06
PO_4^{---}	0,02	0,02	0,02	0,02	0,01	0,02	0,01	0,03
SiO_2^{--}	5,4	18,8	10,5	6,6	0,8	0,9	10,3	9,2
SO_4^{--}	0,7	0,9	1,4	1,6	0,8	0,9	1,4	1,5
HCO_3^{-}	12,8	9,2	7,3	16,5	8,5	1,2	6,1	6,1
CO_2 aggr.	7,0					13,2		
$KMnO_4$	18	27			16	21		

TABLE III

Seychelles. Mahé: main river-systems in the northwest (st. 3, 4, 20, 22, 26) and brackish estuary (st. 6, 6a); La Digue (st. 12). Chemical composition of waters (in ppm).

Seychelles. Mahé: principaux bassins hydrologiques du nord-ouest (st. 3, 4, 20, 22, 26) et estuaires (st. 6, 6a) : La Digue (st. 12). Composition chimique des eaux (en ppm).

Station	7	4	20	22	26	6	6a	12
Altitude (m)	480	410	100	2	10	0,5	0,5	30
Conductivity (20 °C, µS/cm)	33	25	36	35	33	12000	10500	75
PH	5,30	5,90	6,80	6,75	6,60	7,70	7,70	6,1
Humic acids (ppm)	9,68		1,73	1,26	1,91	1,97	1,36	1,60
Ca^{++}	0,40	0,20	0,80	0,80	0,80	144	112	2,0
Mg^{++}	0,17	0,40	0,38	0,38	0,30	231	210	1,0
Na^{+}	3,90	3,70	3,70	4,20	4,00	2000	2720	11,0
K^{+}	1,00	0,50	0,70	0,50	0,60	80	80	2,9
Fe-total	0,31	0,01	0,08	0,12	0,08	0,08	0,31	0,05
Al^{+++}	0,20	0,34	0,02			0,28	0,27	0,13
NH_4^{+}	0,70	0,10	0,04	0,02	0,05	0,05	0,05	0,08
NO_3^{-}	0,07	0,06	0,07	0,09	0,08	0,07	0,10	0,08
Cl^{-}	5,7	5,0	6,0	5,8	6,7	3980	3450	14,0
F^{-}	0,07	0,05	0,07	0,06	0,05	0,29	0,29	0,17
PO_4^{---}	0,02		0,01	0,02	0,02	0,05	0,04	0,03
SiO_2^{--}	6,7	2,3	8,0	7,0	8,4	5,8	9,0	16,2
SO_4^{--}	2,3	0,12	1,0	1,3	1,3	20,0	34,0	3,8
HCO_3^{-}	1,8		4,9	4,7	4,9			0,20
CO_2 aggr.	10,3			8,4				
O_2	9,5		8,4					
$KMnO_4$ consump.	116		25		30			

TABLE IV

Seychelles: streams in southern Mahé (leeward watersheds) (st. 7, 11, 18, 28, 29, 30) and Praslin (st. 13, 14, 15). Chemical composition of waters (in ppm).

Seychelles: rivières du sud de Mahé (bassins sous le vent) (st. 7, 11, 18, 28, 29, 30) et Praslin (st. 13, 14, 15). Composition chimique des eaux (en ppm).

Stations	7	11	18	28	29	30	13	14	15
Altitude (m)	100	1	0,5	10	15	10	13	250	100
Conductivity (20 °C, μS/cm)	110	70	75	82	74	89	57	61	61
PH	7,20	6,45	7,20	7,30	7,00	6,40	6,9	6,5	6,5
Humic acids (ppm)	0,79	0,69	1,25	0,22	2,61	1,86	1,62	0,97	1,81
Ca^{++}	5,80	1,60	1,40	2,20	2,40	2,00	1,90	1,60	1,70
Mg^{++}	2,50	0,94	1,45	1,14	1,36	1,40	0,87	0,98	1,20
Na^{+}	12,5	9,00	10,3	8,70	7,40	10,0	6,60	7,50	8,70
K^{+}	0,90	0,90	0,75	0,80	1,00	0,95	2,10	2,40	2,80
Fe-total	0,42	0,07	0,23	0,00	0,42	0,28	0,61	0,24	0,28
Al^{+++}	0,06	0,26	0,34	0,16	0,18	0,18	0,37	0,21	0,10
NH_4^{+}	0,08	0,03	0,10	0,02	0,06	0,04	0,05	0,05	0,05
NO_3^{-}	0,08	0,07	0,10	0,09	0,11	0,11	0,03	0,07	0,07
Cl^{-}	16,3	12,0	12,2	13,1	10,1	15,5	9,6	12,0	9,6
F^{-}	0,06	0,06	0,06	0,07	0,06	0,06	0,08	0,09	0,10
PO_4^{---}	0,01	0,01	0,02	0,02	0,03	0,03	0,01	0,02	0,02
SiO_2^{--}	7,6	10,0	16,8	11,3	9,7	13,6	17,9	15,1	20,0
SO_4^{--}	4,4	1,8	2,0	6,3	2,9	3,8	1,9	1,9	1,4
HCO_3^{-}	30,5	11,0	15,3	12,2	15,3	12,2	0,25	0,20	0,25
O_2		8,1							

altitude 30-250 m, are similar to systems from southern Mahé (conductivity 57-75 μS/cm) (tabl. III and IV).

A comparative view (fig. 2) shows the tendencies of the main compounds within the different regions.

2. COMORO ISLANDS

2.1. **Climate and Geology**

The Comoro archipelago is entirely of volcanic origin and consists of 4 main islands with an area of 2170 km² and a population of 240.000. Largest is the Grande Comore (1148 km²) and the only one with a still active volcano (Khartala, 2360 m). The river erosion on the flanks is minimal, due to the subterraneous drainage of the water.

The rocks are typical block lavas. The lavas of the northern half are highly undersaturated olivine basalts grading to oceanites.

The mainly studied island was Anjouan (fig. 3) situated to south-east from the Grande Comore, with an area of 424 squ. km and a population of more than 70.000. Because of the dense settlement and the cultivation of parfumplants most of the flanks and the coastal regions are deforestated, except the central mountain massif. Highest elevation is the

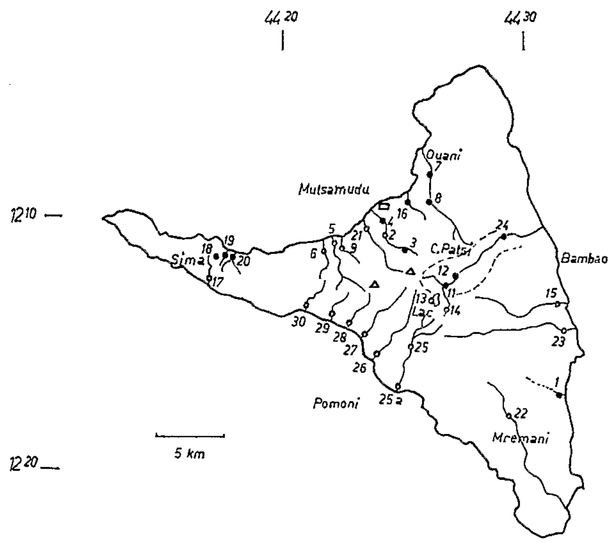

Fig. 3. — Comoro Islands. Anjouan. — Collecting stations. Full points are river-systems with water of higher conductivity (more than 130 μS/cm).

Comores, Anjouan. — Stations de prélèvement. Les points noirs correspondent aux rivières ayant une conductivité des eaux supérieure à 130 μS/cm.

N'Tingui (1595 m). The Comoro Islands show a simple age progression east-south-eastwards. De SAINT OURS (1960) considered the basaltic activities in Mayotte (the oldest and most eroded island of the Comores) to be in Miocene or even Cretaceous times. Anjouan is deeply dissected by erosion and has amphitheatre-valleys, as a result of river erosion of older basalt compositionally analogous that of the Grande Comore, modified by the constructional slopes of younger lava flows and well preserved cinder cones. The younger series are highly alkalic and feldspathoidal, including basanites, hornblende-trachybasalts and phonolites, Esson et *al.* (1970).

The humid tropical climate shows seasonal contrasts. The rain-season from November till April (accompanied by higher temperatures) is caused by the north-west monsoon, while a rather dry season is predominated by south-east trades (May-October).

Annual precipitation (mm), means 1965-1974 (1) (only 1974): (Mét. Nat. Moroni)

Jan.	Feb.	Mar.	Apr.	May	June	July
369	274	365	300	171	105	96
(369)	(449)	(758)	(409)	(234)	(128)	(127)
414	325	282	258	50	81	67
(435)	(289)	(457)	(190)	(81)	(92)	(52)

Aug.	Sept.	Oct.	Nov.	Dec.	mean	(annual)
68	64	164	109	364	2450	Mremani
(39)	(150)	(82)	(22)	(221)	2988)	alt. 600 m
49	56	165	110	374	2263	Mutsamudu
(77)	(97)	(87)	(11)	(132)	(1780)	alt. 0 m

Annual mean temperature — Mremani: 22,1 °C - Mutsamudu: 26,6 °C.

2.2. **Collecting stations** (March 1974), altitude (alt.) in m; mean daily discharge (MDD) in m^3/s, temperature (T) in °C

Grande Comore

cistern in a village to the north of Moroni (2 × 2 m)

Anjouan

St. 1 Papani River, mouth, partially subterraneous system; alt.: 2; MDD: 0.04; T: 23.6

2 Mutsamudu River, middle course; alt.: 200; MDD: 0.12; T: 24.8

3 affluent of the Mutsamudu River, upper course; alt.:500; MDD: 0.05; T: 22.8

3a trickling drain near station 3, lateritic soil; alt.: 500

4 Mutsamudu River, lower course; alt.: 50; MDD: 4.5; T: 24.5-24.9

5 Pouzine River, lower course; alt.: 1; MDD: 0.5; T: 25.7-26

6 Hanghoué River, middle course; alt.: 90; MDD: 0.75; T: 23.6-25.8

7 Ouani River, lower course; alt.: 20; MDD: 0.;5 T: 25.5-26

8 Ouani River, fountain-pool (subterraneous system); alt.:250; MDD: 0.5; T: 24.8

9 Oichiconi River, lower course; alt.: 5; MDD: 1.2; T: 24.2-24.6

10 Bouélamorou, two headwater streams near Bazimini; alt.: 520; stream to the right— MDD: 0.05; T: 23, stream to the left — MDD: 0.07; T: 23.5

11 Tatinga River, upper course; alt.: 600; MDD: 0.6; T: 22.2-22.9

12 mineral spring (gaseous water) rising from the Tatinga-banks; alt.: 600; T: 22.5

13 Lac Sacré, Dzialandse, crateric lake, below the N'Tingiu peak; alt.: 900; Br. 250 m; T: 25

14 Mdzihe River, affluent of the Tatinga, torrent; MDD: 0.02; T: 20, alt.: 800

15 Gégé River, lower course; alt.: 20; MDD: 1.1; T: 25.6-27.3

16 Mahavouli River, periodic stream, near Mirontsi; alt.: 10; MDD: 1.5; T: 25

17 Hachéla River, lower course near Sima, south-west coast; MDD: 0.12; T: 26.4

18 Foumboni River, lateritic torrent near Sima; alt.: 150; MDD: 0.1; T: 26

19 periodic stream near the Bandajou-River, lower course; alt.: 5; MDD: 0.2

20 Bouékoni River, lower course, all north-west coast; alt.: 10; MDD: 0.6

21 Pagé River, lower course near Mutsamudu; alt.: 3; MDD: 2.5; T: 25.3

22 T'Santsa River, upper course, south-east coast; alt.: 750; MDD: 0.05; T: 24.2

23 Jamoni River, lower course, south-east coast; alt.: 2; MDD: 2.6; T: 26.5

24 Tatinga River, lower middle course; alt.: 210; MDD: 2.3; T: 24.5

25 Pomoni River, upper course, south-west coast; alt.: 200; MDD: 4.5; T: 22.5

25a Pomoni River, lower course near the mouth; alt.: 5; MDD: 4.5; T: 25

26 Choungouni River, lower course near Bandani, south-westcoast; MDD: 0.75

27 Bandani River (Fouroujo River), lower course, south-west coast; MDD: 0.6

28 Vouani River (M Ro'Oivouani), lower course; alt.: 4; MDD: 0.5; south-west

29 Imèré River, lower course, south-west coast; alt.: 5; MDD: 0.5

(1) Catchment.

30 Vassi River, lower course, south-west coast; alt.: 5; MDD: 0.5
mean discharge of all investigated streams and rivers: 1.01 m^3/s

2.3. A short survey of the principal regions

The whole island seems a very complicated "weathering-system", mostly "inhomogenous" similar to that of Réunion but in addition influenced by subterraneous drains and a most advanced weathering of the basaltic rocks. Different from the granitic islands where the cut of the original forest accelerates the permanent loss of soil untill bare rocks occur advances weathering of volcanic rocks like on Anjouan just at the windward flanks.

(a) Rivers flowing towards the southwestern coast mostly draining the flanks (stations 17, 25, 25a, 26, 27, 28, 29, 30). The large Pomoni-River seems to be the principal drain of the highest flanks (windward). Altitude 5-300 metres, conductivity (mean) 100 µS/cm (72-126 µS/cm p_H 7,6, hardness 1,9°G (tabl. V).

(b) River — systems in the central, northern (Mutsamudu) and eastern part (stations 2, 5, 11, 14, 15, 21, 22, 23) (Bamboo) with a slightly higher conductivity (94-125 µS/cm, mean 114), mean of p_H 7,89 and of hardness 2,29 °G (tabl. VI).

(c) Central crateric mountain lake (station 13) and flooded river near Mutsamudu (station 9). Most influenced by the extended rainfall. Conductivity 35-43 µS/cm, p_H 8,6-7,6 hardness 0,5-1,0° G (tabl. II).

(d) Streams and rivers strongly influenced by advances weathering of the soil and the subsoil (Stations 3, 4, 6, 7, 16, 19, 20, 24), conductivity 130-186 µS/cm (mean 179 µS/cm), p_H 7,9-8,4 (8,1), hardness 2,2-4,3 °G, mostly slightly acidic (tabl. VII).

(e) Partially subterraneous systems (stations 1, 3a, 8, 10, 18) and gazeous mineral sources (12) (tabl. VIII).

TABLE V

Anjouan: southwestern watersheds. Chemical composition of waters (in ppm).
Anjouan: bassins hydrologiques du sud-ouest. Composition chimique des eaux (en ppm).

Station	17	25	25a	26	27	28	29	30	13
Conductivity (20 °C, µS/cm)	126	125	125	94	85	72	86	90	35
PH	7,73	7,8	7,9	7,5	7,4	7,42	7,6	7,5	8,6
Humic acids (ppm)	0,90	0,78	0,52	0,81	1,61	1,74	0,83	1,32	1,72
Ca^{++}	4,8	8,8	8,8	7,2	4,8	3,6	4,0	5,0	1,6
Mg^{++}	3,8	5,9	5,9	4,3	4,4	3,9	4,6	4,0	1,6
Na^+	15,0	9,0	11,2	5,0	7,0	7,0	9,0	6,0	1,5
K^+	1,9	2,5	2,3	0,8	0,9	0,8	1,1	0,6	1,1
Fe-total	0,72	0,16	0,46	0,35	0,02	0,02	0,32	0,18	0,36
Al^{+++}	0,19	0,08	—	0,22	—	0,14	0,23	0,12	0,07
NH_4^+	0,02	0,02	0,02	0,02	0,02	—	0,02	0,02	0,02
NO_3^-	4,5	0,1	—	0,10	0,11	0,12	1,3	0,13	0,09
Cl^-	14,8	4,7	4,4	4,3	4,6	5,7	5,9	5,8	2,2
F^-	0,22	0,10	0,10	0,08	0,07	0,07	0,08	0,10	0,06
PO_4^{---}	0,03	0,03	—	0,01	0,02	0,04	0,04	0,02	0,02
SiO_2^{--}	27,1	31,7	31,7	25,8	25,2	20,0	24,4	36,6	0,43
SO_4^{--}	0,54	0,36	0,18	—	0,36	0,66	0,42	0,12	0,24
HCO_3^-	48	82	79	58	13	41	49	55	13,4
CO_2 aggr								1,1	4,0

TABLE VI

Anjouan: river-sections with lower conductivity (central, northwestern and northeastern parts). Chemical composition of waters (in ppm).
Anjouan: rivières ayant la plus faible conductivité (zones centrale, nord-ouest et nord-est). Composition chimique des eaux (en ppm).

Station	2	5	11	14	15	21	22	23	9
Conductivity (20 °C, µS/cm)	117	122	120	94	120	102	125	108	43
PH	8,10	7,65	7,95	7,80	8,02	7,70	8,02	7,90	7,60
Humic acids (ppm)	0,65	1,00	0,82	1,27	0,74	0,65	1,04	0,94	1,14
Ca^{++}	10,6	8,0	8,8	7,6	8,0	8,4	7,6	6,0	3,6
Mg^{++}	5,7	5,9	5,9	3,6	5,2	4,0	5,8	4,2	2,2
Na^+	6,6	7,2	7,5	6,5	8,2	9,0	7,5	8,0	4,0

K^+	1,6	1,3	1,3	1,3	1,9	1,2	2,6	2,2	0,9
Fe-total	0,12	0,10	0,05	0,14	0,52	0,10	0,34	1,40	0,42
Al^{+++}	—	—	0,03	0,16	0,13	0,08	—	0,08	0,07
NH_4^+	0,02	0,01	—	0,01	0,01	—	0,02	0,02	0,04
NO_3^-	0,11	0,14	0,35	0,12	2,5	2,0	0,1	0,1	0,14
Cl^-	4,3	6,8	4,2	4,7	5,8	5,5	5,5	3,9	1,6
F^-	0,09	0,08	0,11	0,08	0,09	0,08	0,07	0,10	0,06
PO_4^{---}	0,01	0,01	0,03	0,02	0,03	0,03	0,03	0,02	0,01
SiO_2^{--}	27,1	20,0	36,6	20,0	36,6	36,6	24,4	26,2	9,5
SO_4^{--}	1,2	0,72	0,84	0,72	0,36	—	0,18	—	0,36
HCO_3^-	67	67	73	55	67	61	73	61	27
CO_2 aggr.	3,5								6,6

TABLE VII

Anjouan: river-sections with higher conductivity (central and northwestern watersheds). Chemical composition of waters (in ppm).
Anjouan: rivières ayant la plus forte conductivité (bassins du centre et du nord-ouest). Composition chimique des eaux (en ppm).

Station	3	4	6	7	16	19	20	24
Conductivity (20 °C, µS/cm)	142	135	130	180	180	145	186	146
PH	8,0	8,2	7,9	8,4	8,2	7,8	8,1	8,0
Humic acids (ppm)	0,73	0,71	1,22	0,81	1,47	0,88	1,20	1,25
Ca^{++}	10,8	10,6	8,0	14,4	15,6	6,8	12,8	10,4
Mg^{++}	7,1	6,1	6,4	6,4	8,8	6,7	9,1	6,6
Na^+	7,3	7,5	7,5	13,5	12,0	13,5	14,0	11,5
K^+	1,5	1,8	1,2	3,1	2,2	1,8	1,7	2,4
Fe-total	0,16	0,16	0,10	0,36	1,16	0,20	0,02	2,60
Al^{+++}	0,10	0,04	0,16	0,25		0,04	0,17	0,17
NH_4^+			0,01		0,02	0,03		0,02
NO_3^-	0,11	0,12	0,10	0,13	3,00	1,50	4,00	0,10
Cl^-	4,3	5,0	6,8	5,3	4,4	11,3	9,6	14,5
F^-	0,12	0,10	0,08	0,19	0,15	0,15	0,11	0,13
PO_4^{---}	0,02	0,06	0,01	0,01	0,09	0,04	0,13	0,03
SiO_2^{--}	22,0	24,4	19,7	27,8	34,9	27,1	32,3	28,7
SO_4^{--}	0,54	0,72	0,72	0,60	0,60	0,18		0,13
HCO_3^-	88	91	73	110	122	73	104	88

TABLE VIII

Anjouan: partially subterraneous systems (st. 1, 3a, 8, 10, 18, 12): and Grande Comore (G. C.): cistern. Chemical composition of waters (in ppm).
Anjouan: réseaux hydrologiques en partie souterrains (st. 1, 3a, 8, 10, 18, 12) et Grande Comore (G.C.): citerne. Composition chimique des eaux (en ppm).

				left	right			
Station	1	3a	8	10	10	18	12	G.C.
Conductivity (20 °C, µS/cm)	216	160	180	130	130	255	1600	102
PH	7,65	7,15	7,10	7,10	7,00	6,80	6,00	8,05
Humic acids (ppm)	0,37	1,03	1,14	0,48	0,85	0,61		0,82
Ca^{++}	10,8	12,8	12,0	9,6	10,0	20,8	212	15,2
Mg^{++}	9,4	8,6	7,0	4,3	4,7	11,1	102	1,8
Na^+	16,5	6,5	13,5	13,7	10,5	14,5	25	5,5
K^+	3,0	1,3	3,2	4,0	2,6	0,6	9	2,3
Fe-total	0,02	1,4	0,39	0,52	0,72	0,20	13	0,05
Al^{+++}	0,05	0,00	0,13	0,18	0,16	0,25	0,00	0,12
NH_4^+	0,00	0,07	0,00	0,00	0,00	0,02	0,01	0,05
NO^{3-}	0,15	2,42	0,14	0,13		0,09	0,17	0,07
Cl^-	8,5	4,3	5,5	4,5	3,2	10,2	0,21	8,82
F^-	0,13	0,09	0,18	0,24	0,16	0,14	0,11	0,10
PO_4^{---}	0,01	0,02	0,02	0,05	0,02	0,03	0,03	0,02
SIO_2^{--}	32,7	27,1	35,5	36,8	27,8	46,5	147	2,6
SO_4^{--}	3,40	0,36	0,78	1,44	0,48	0,36	5,20	0,60
HCO_3^-	122	98	98	73	73	140	1312	73
CO_2 aggr.	5,5		13,2	11,0			0,0	
CO_2 free							550	

The contents of nitrate are increased mainly in the regions of denses settlement and intensivated agricultury, around Sima (Stations 17, 19, 20) where one sample contained also more phosphate (20), in the surroundings of Mutsamudu (Stations 16, 21, 3a) and to the south from Bamboo (15). In the regions of advanced weathering we find an increasement of dissolved compounds and of p_H (ultrabasic rocks).

A few mineral sources rise just near the Tatinga-River draining the amphitheatred valley (Cirque de Bambao). This gazeous sources contain high quantities of free carbondioxide (550 ppm), total iron (13 ppm), silicic acid (147 ppm), sodium (44 ppm) and potassium (17 ppm!), alkalinity (53 mval/l), while chloride (0,21 ppm) is nearly absent. The influence from the soil-drainage gives a sample taken from the immediate neighbourhood of one of the upper branches of the Mutsamudu-River (Station 3) where a little water drain from a lateritic profile beyond a babana-plantation is trickling into the torrent. This trickling water (Station 3a) separates much iron-oxihydrate. This sample points the influence from the ferralitic soil, a rather neutral p_H, high contents of iron, humic acids, ammonium and nitrate (agricultury!) silicon and bicarbonate (alkalinity), only a slightly increasement of phosphate while calcium and magnesium increase obviously. In opposition to these compounds decrease the contents of sodium and potassium, a bit also these of fluoride, while these of chloride do not change.

Comparison—*trickling soil drain* (station 3a) and the neighbouring torrent

(station 3) :	st. 3 a	st. 3
conductivity	160	142
PH	7,15	8,00
humic acids, ppm	1,03	0,73
calcium/magnesium	12,8/8,7	10,8/7,1
sodium/potassium	6,5/1,3	7,3/1,5
total-iron	1,40	0,16
ammonium/nitrate	0,07/2,40	0,00/0,11
SiO_2/HCO_3	27/232	22/82

The extraordinary amount of rainfalls during the period of the catchment (precipitation in February 1974—more than 700 mm) caused heavy erosional processes to the deforestated watersheds. After rain-periods the sea around the island was highly reddish due to the washing down of ferralitic soils and gravel.

3. RÉUNION-ISLAND

3.1. Climate and Geology

This Mascarene island is built by two volcanos, the now extincted Piton des Neiges (3069 m) and the still active Piton de la Fournaise (2631 m). The area is 2512 km² with a population of 430.000.

The climate is mainly influenced by the south-east trades. The wind—exposed east, south-eastern and north-eastern coast and mountain-flanks get

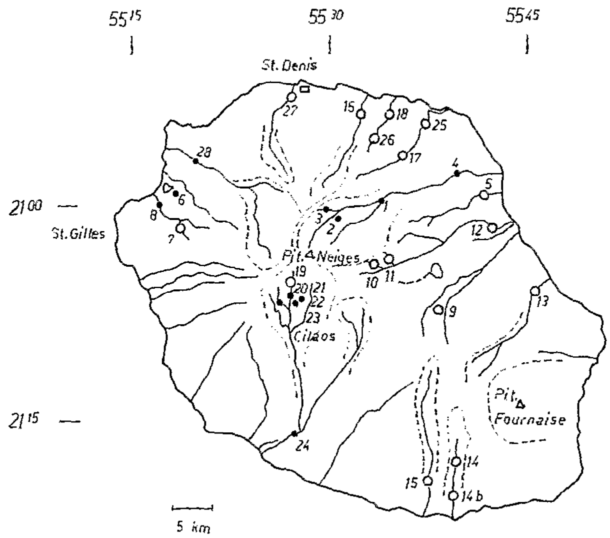

Fig. 4. — Réunion. Collecting stations. Full points are "Cirque-rivers" with water of high conductivity (more than 130 µS/cm).

La Réunion. — Stations de prélèvements. Les points noirs sont les « rivières des Cirques » dont la conductivité des eaux est supérieure à 130 µS/cm.

rainfalls of 3000-7600 mm a year, while the leeward western and south-western parts have only 500-1000 mm. The wet season endures from December till April. The mean temperature at St. Denis is 23.6 °C.

Annual precipitation (10 years mean, mm) : (Mét. Nat. St. Denis)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
219	182	268	101	58	44	41	21
93	96	107	49	19	38	9	5
866	971	1563	739	380	387	471	447
505	369	733	216	91	61	50	31

Sep.	Oct.	Nov.	Dec.	mean	
27	27	71	120	1157	St. Denis alt. 5 m
11	20	36	61	542	St. Gilles alt. 5 m
386	321	365	685	7578	Takamaka alt. 850 m
35	53	68	180	2394	Cilaos alt. 1200 m

Both volcanos are large shield volcanos. The most recent geological map is that compiled by BUSSIERE, 1967 (cit. MCDOUGALL, 1971). The central regions of the extincted Piton des Neiges have been eroded into great cirques, an extreme development of amphitheatre-headed valley erosion. The rate of downcutting in certain deep valleys (Cirque de Salazie eroded in youngest lava of 0.07 m.y. age) reaches 680 cm/1000 years.

The oldest exposed rocks occur in the cirques (Cirque Agglomerate), overlying is a sequence of olivine basalts, the Oceanite Series, about 1000 m thick in some areas. These main dome building lavas are overlain by the Differentiated Series consisting of massive flows of alkali andesite (hawaiite, mugearite) and feldsparphyric basalt. They have a thickness of about 700 m in the central regions but weaken rapidly outwards (UPTON and WADSWORTH, 1965). The leeward western flanks of Piton des Neiges are almost completely covered by the Differentiated Series, while in contrast marked erosion of these layers had occured on the windward eastern slopes of the volcano. Erosion has revealed the less resistant olivine basalts of the Oceanite Series below the Differentiated Series in the walls of the cirques and in the gorges and deeper valleys and cut into the outer flanks of Piton des Neiges.

The lavas of Piton de la Fournaise situated in the windward south-eastern part of Réunion, are similar to the Oceanite Series of Piton des Neiges. The main dome building phase of Piton des Neiges occured between 1.8 m.y. and 0.43 m.y. The last date may coincide with the initiation of basaltic eruptions from Piton de la Fournaise. The range of measured age on the Differentiated Series is from 0.35-0.07 m.y. (MCDOUGALL, 1971).

3.2. **Collecting Stations** (April 1974) altitude (alt.) in m; mean daily discharge (MDD) in m³/s; temperature (T) in °C

St. 1 Rivière du Mat, Cirque de Salazie, upper course; alt.: 450; MDD: 0.5; T: 22.5
2 Mare aux Poules d'Eau, crateric lake; alt.: 680; Br.: 150-200; T: 27.5
3 affluent of the Rivière du Mat, Cirque de Salazie, cress-cultivation; alt.: 650; MDD: 0.05; T: 23
4 Rivière du Mat, lower middle course, St. André-bridge; alt.: 145; MDD: 2.5; T: 23.8-24.5
5 Rivière des Roches, lower course near the mouth; alt.: 10; MDD: 3.2; T: 27.5
6 Etang St. Paul and Source de la Moulin d'Eau; alt.: 30; stream MDD: 0.15; T: 21.2
7 affluent of the Rivière St. Gilles; alt.: 150; MDD: 0.25; T: 19
8 Rivière St. Gilles, lower course; alt.: 15; MDD: 2.1; T: 25.4
9 Grand Bras de la Ravine Seche, Plaine de la Palmistes, stagnant pool of a periodic stream system; alt.: 500; Br.: 5-10; T: 23
10 Ravine Mathurine, affluent of Rivière Marsouin, Takamaka Road; alt.: 700; MDD: 0.2; T: 18
11 affluent of Rivière Marsouin, Takamaka Road; alt.: 600; MDD: 0.25; T: 19
12 Rivière des Marsouin, lower course near St. Benoit; alt.: 10; MDD: 5.0; T: 22.7
13 Rivière de l'Est, lower course, alt.: 15; MDD: 4.0; T: 23
14 Rivière Langevin, upper course; alt.: 400; MDD: 1.0; T: 17.8 (Piton de la Fournaise)
14a same place, stagnant water pool
14b Rivière Langevin, lower middle course; alt.: 100; MDD: 1.0; T: 20
15 Rivière des Remparts, lower course, alt.: 50-80; MDD: 0.7; T: 20.5 (Fournaise)
16 Rivière des Pluies, lower middle course; alt.: 100; MDD: 0.8; T: 23.5
17 Rivière St. Suzannes, lower middle course, "Cascades de Niagara"; alt.: 172; MDD: 6.0; T: 23.5
18 Ravine de Charpentier, lower course; alt.: 20; MDD: 0.5; T: 23
19 Coteau Kerveguen, Cirque de Cilaos; alt.: 1400; MDD: 0.05; T: 16
20 Bras de Benjouin, upper reaches of the Bras de Cilaos; alt.: 1400; MDD: 0.08; T: 15.2
21 small spring near the Bras de Benjouin
22 hot springs (hot gazeous water), Cilaos; alt.: 1200; T: 39
23 Mare de Cilaos, two ponds, Br. 20-30 m; alt.: 1220; T: 23,7
24 Bras de Cilaos, lower middle course (Cirque-system); alt.: 200; MDD: 2.0; T: 24
25 Rivière St. Suzannes, lower course; alt.: 50; MDD: 3,5; T: 22.1
26 Rivière St. Marie, upper course; alt.: 156; MDD: 0.2; T: 21.3
27 Rivière St. Denis, lower course; alt.: 25; MDD: 1.4; T: 23.2
28 Rivière des Galets, lower course; alt.: 118; MDD: 3.0; T: 24; draining the Cirque de Mafate

mean discharge of all investigated streams ans rivers: 1.81 m³/s

3.3. **Classification of the water-systems in La Réunion**

3.3.1. PITON DES NEIGES MASSIF (extincted shield volcano)

(a) Main rivers draining the amphitheatre-headed valleys (cirques). These valleys are an extreme form of river-erosion, downcutting towards the less resistant older Oceanite Series (olivine basalts) which are overlain by the more resistant younger Differentiated Series (alkaliandesite, feldsparphyric basalts). Following the most recent geology by BUSSIERE (cit. McDOUGALL, 1971).

The water-systems of the fully windward exposed Cirque de Salazie (stations 1, 2, 3) and also these of the partially leeward Cirque de Cilaos (with gazeous hot-springs, stations 20, 21, 23) have an slightly alkaline p_H (at least 8,3) and increased contents of calcium, magnesium, sodium, potassium, fluoride (tabl. IX). All these details are mentioned for the interior part of the amphitheatred valleys while the lower courses of the drains are poorer in dissolved salts in case of the windward Cirque de Salazie as a result of the flow in of a lot of "rain-like" cascades all around the flanks (station 4). This is unlike the Cirque de Cilaos where the outflow is increased by dissolved compounds (station 24). The fully leeward Cirque de Mafate-system is eroding through more extended Differentiated Series (station 28). Conductivity of this drain is the lowest of all Cirque—systems similar that of less eroded leeward valleys (stations 7, 8) (tabl. X).

(b) Rivers originating from less eroded smaller valleys in the Differentiated Series (stations 5, 12, 16, 17, 25, 26, 27). These systems have a water of a lower conductivity and p_H, only the contents of chloride and sometimes these of nitrate (agricultural areas) are enriched (tabl. XI).

(c) Cascades, torrents and highland-marshes (stations 10, 11, 19, 24) towards the windward moutainflanks are most influenced by the permanent heavy rainfalls (tabl. X-XII).

(d) Gazeous hot-springs (station 22, interior of the Cirque de Cilaos) and large fountains originating from the depth situated on the leeward coastal plateau (station 6) with chloridic-water (tabl. IX-X).

3.3.2. PITON DE LA FOURNAISE (active shield volcano)

The drains from the volcano's watersheds are similar in hydrochemistry that of the less eroded valleys in the Differentiated Series of the extincted massif, which are also similar in geology (station 13, 14, 15). The differencies are higher contents of sodium, potassium, fluoride, phosphate, sulphate and silicon.

TABLE IX

Réunion — Piton des Neiges: interior of the « Cirques » (extremely eroded amphitheatred valleys). Chemical composition of the water (in ppm).

Réunion — Piton des Neiges: rivières de l'intérieur des « Cirques » (vallées très érodées en forme d'amphithéâtre). Composition chimique des eaux (en ppm).

Station	1	2	3	20	21	23	22
Conductivity (20 °C, µS/cm)	202	207	215	136	193	144	2850
PH	8,30	8,60	8,30	8,00	7,70	9,20	6,35
Humic acids (ppm)	0,38	0,41	0,20	0,30	0,25	0,93	
Ca^{++}	18,0	17,2	20,0	14,8	24,1	15,6	184
Mg^{++}	10,3	11,1	12,6	4,0	4,3	6,9	82
Na^{+}	17,0	17,0	16,0	14,0	16,5	8,5	200
K^{+}	2,5	3,8	3,0	1,7	1,6	1,9	16,5
Fe-total	0,24	0,11	0,01	0,00	0,00	0,25	3,40
Al^{+++}	0,21	0,01	0,00	0,32	0,00	0,11	0,00
NH_4^{+}	0,00	0,01	0,00	0,00	0,00	0,01	0,01
NO_3^{-}	0,10	0,11	0,07	0,11	0,23	0,07	0,07
Cl^{-}	2,6	3,9	3,1	1,5	2,4	3,3	0,3
F^{-}	0,14	0,14	0,13	0,11	0,10	0,10	0,05
PO_4^{---}	0,00	0,00	0,01	0,00	0,02	0,00	0,00
SiO_2^{--}	20,9	4,7	29,0	18,4	19,7	21,8	84
SO_4^{--}	3,8	2,6	2,0	2,8	11,0	0,4	14,5
HCO_3^{-}	146	152	162	85	116	104	1867
CO_2 free							30

TABLE X

Réunion — Piton des Neiges: lower courses of the « Cirque » rivers (st. 4, 24, 28) and water systems in the leeward east (st. 6, 7, 8). Chemical composition of waters (in ppm).

Réunion — Piton des Neiges: cours inférieurs des rivières venant des « Cirques » (st. 4, 24, 28) et bassin de la côte est sous le vent (st. 6, 7, 8). Composition chimique des eaux (en ppm).

Stations	4	24	28c	6	7	8
Conductivity (20 °C, µS/cm)	139	236	133	1600	115	156
PH	8,15	88,80	8,65	8,00	7,40	7,50
Humic acids (ppm)	0,38	0,30	0,36	0,40	0,53	0,71
Ca^{++}	14,0	20,8	9,6	22,0	10,0	10,4
Mg^{++}	4,9	7,3	4,8	33,0	3,9	7,9
Na^{+}	12,0	30,0	16,0	263	12,3	16,0
K^{+}	1,2	2,2	1,5	13,5	2,1	2,2
Fe-total	0,10	1,50	0,07	0,01	0,01	0,72
Al^{+++}	0,30	0,05	0,00	0,23	0,21	0,11
NH_4^{+}	0,00	0,01	0,00	0,00	0,00	0,06
NO_3^{-}	0,11	0,06	11,8	1,80	0,10	0,11
Cl^{-}	5,3	5,0	4,3	463	7,0	11,4
F^{-}	0,09	0,14	0,10	0,13	0,11	0,11
PO_4^{---}	0,00	0,01	0,00	0,00	0,00	0,02
SiO_2^{--}	24,0	25,1	26,6	34,7	36,8	31,0
HCO_3^{-}	94	140	94	122	61	92
CO_2 aggr.		0,0				

TABLE XI

Réunion — Piton des Neiges: smaller less eroded valleys (differentiated series). Chemical composition of waters (in ppm).

Réunion — Piton des Neiges: petites vallées moins érodées. Composition chimique des eaux (en ppm).

Station	5	12	16	17	18	25	26	27
Conductivity (20 °C, µS/cm)	68	69	93	84	60	58	50	96
PH	7,40	8,10	7,85	7,40	7,10	7,40	7,60	8,40
Humic acids (ppm)	0,43	0,36	0,31	0,51	1,08	0,95	0,87	0,50
Ca^{++}	6,0	4,4	7,2	5,2	3,2	3,6	3,2	8,8
Mg^{++}	2,8	3,8	4,7	4,0	2,4	2,4	2,4	5,5
Na^{+}	5,0	6,0	10,5	10,7	9,0	5,0	6,6	6,6
K^{+}	0,6	1,2	1,0	0,8	1,3	0,7	0,9	1,2
Fe-total	0,07	0,04	0,12	0,13	0,34	0,28	0,45	0,05
Al^{+++}	0,10	0,07	0,06	0,32	0,14	0,03	0,18	0,00
NH_4^{+}	0,00	0,00	0,01	0,01	0,05	0,08	0,05	0,20
NO_3^{-}	0,10	0,11	0,07	0,18	0,07	0,07	0,07	13,5
Cl^{-}	6,4	3,5	5,3	9,5	7,3	7,2	7,7	6,4
F^{-}	0,07	0,05	0,10	0,09	0,08	0,07	0,06	0,06
PO_4^{---}	0,01	0,00	0,00	0,01	0,00	0,01	0,00	0,02
SiO_2^{--}	13,8	19,4	18,6	18,9	13,2	16,2	12,4	16,3
SO_4^{--}	1,6	0,7	0,8	2,3	1,2	0,4	1,0	0,4
HCO_3^{-}	43	43	58	31	27	27	24	64
CO_2 aggr.				6,6	7,7		4,4	

TABLE XII

Réunion — Piton de la Fournaise (st. 13, 14, 15); Piton des Neiges: torrents and cascades (st. 9, 10, 11, 19). Chemical composition of waters (in ppm).

Réunion — Piton de la Fournaise (st. 13, 14, 15); Piton des Neiges: ravines et cascades (st. 9, 10, 11, 19). Composition chimique des, eaux (en ppm).

Station	13	14.	14a	14b	15.	9.	10.	11.	19
Conductivity (20 °C, µS/cm)	78	70	78	70	89	24	54	53	54
PH	8,00	7,75	7,20	7,85	7,70	6,95	7,80	7,85	7,90
Humic acids (ppm)	0,18	0,36	3,00	0,39	0,32	1,58	0,22	0,41	1,30
Ca^{++}	3,6	3,2	2,0		7,2	1,2	4,0	3,6	4,0
Mg^{++}	3,2	2,8	3,6		3,8	1,2	3,6	3,2	2,5
Na^{+}	8,0	10,0	7,8	10,0	8,0	4,0	4,5	4,0	7,2

K^+	2,7	3,0	4,7	3,2	2,9	0,4	0,8	0,4	2,3
Fe-total	0,01	0,10	0,85	0,01	0,13	0,45	0,04	0,28	0,01
Al^{+++}	0,37	0,06	0,01	0,20	0,04	0,17	0,29	0,00	0,09
NH_4^+	0,00	0,01	0,05	0,01	0,00	0,05	0,00	0,00	0,01
NO_3^-	0,13	0,11	2,20	0,11	0,07	0,12	0,11	0,11	0,06
Cl^-	3,8	3,6	9,5	3,6	5,3	3,0	3,8	3,8	2,0
F^-	0,16	0,38	0,09	0,37	0,16	0,07	0,05	0,05	0,08
PO_4^{---}	0,09	0,15	0,02	0,11	0,07	0,00	0,00	0,00	0,01
SiO_2^{--}	27,8	32,3	5,7	32,6	22,9	2,1	16,2	14,5	19,3
SO_4^{--}	2,7	4,1	1,7	3,6	2,6	0,8	0,5	0,4	3,6
HCO_3^-	46	40	37		55	15	35	35	38
CO_2 aggr.						6,6	7,7		5,5

4. MAURITIUS

4.1. **Climate and Geology**

This island of the Mascarene archipelago is also of entirely volcanic origin although much older than Réunion. Heavy erosion has reduced the elevations (Piton Rivière Noire, 826 m). The island has an area of 1843 km² and is dense populated (more than 782000 inhabitants). The greater part is urbanized land used for cultivation of sugar cane. Only the Southern Highlands are partially reinforestated. The humid climate of the highlands favourizes the development of acidic soils.

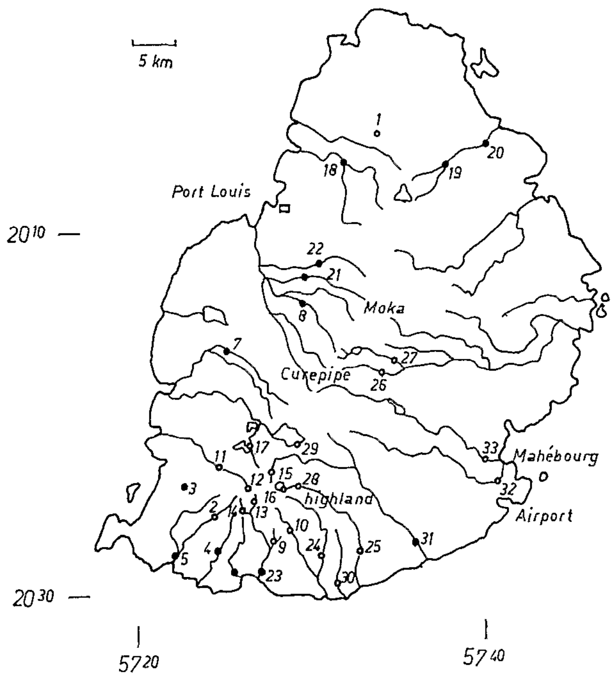

Fig. 5. — Mauritius.—Collecting stations.
Maurice. — Stations de prélèvements.

The climate is predominated by south-east trades, causing higher amounts of precipitations for the windward west—and south-west coast.

Annual rainfall, mm: Plaisance (Airpor)t-2009, west coast (Met. Dept. Port Louis) Curepipe (central highlands)-3398, Port Louis-1184, east coast highest regions of the southern and central highlands-5000, plateaux 3200-4000.

Annual rainfall—Sugar Cane Districts, 1972, mm:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
98	264	57	140	13	146	22	78
280	371	170	307	191	225	183	289
209	264	229	288	255	216	184	251
(21)	(30)	(16)	(7)	(2)			

Sep.	Oct.	Nov.	Dec.	mean	region
13	87	57	46	1021	west
22	193	363	124	2718	east
25	182	360	218	1681	south
		(2)	(8)	frequency of cyclons	

Mauritius is the summit of a volcanic edifice near the southern end of the Mascarene Plateau that extends in a gentle arc from the Seychelles Archipelago over 2300 km to the south. Like Réunion Island it seems to be closely related to the development of this major structure (McDOUGALL and CHAMALAUN, 1969). Between the eruption of the two main series—the main dome building phase of the Older Volcanic Series (7,8 to 6,8 m.y. ago) and a Younger Volcanic Series (Early Lavas—3,5 to 2,0 m.y.ago) and Late Lavas— 0,7 to 0,17 m.y.ago)—there was a long period of erosion (SIMPSON, 1951).

Rocks of the Older Volcanic Series form the large massifs that occur in an arc along the west coast and adjacent to the central east coast, representing probably remnants of a large shield volcano. Basaltic composition predominates with basalts ranging from aphyric to strongly phyric types including olivine basalts, picrite, ankaramite, feldsparphyric basalts, also alkali andesites. Chemically the lavas are undersaturated alkaline types (WALKER and NICOLAYSEN, 1954).

The Early Lavas of the Younger Volcanic Series are now only exposed in the south-west of Mauritius near Baie du Cap (olivine basalts), while the Late Lavas cover the remainder of the island between the older massifs. Their surface has been little modified by erosion although a number of gorges have been cut by streams. The lavas are thin (1-8 m), highly vesicular and entirely basaltic, characterized by remarkably low contents of potassium according to olivine basalts. Olivines are always abundant, titanaugite is the dominant pyroxene.

4.2. **Collecting stations** (May 1974) altitude (alt.) in m; mean daily discharge (MDD) in m^3/sec, temperature (T) °C

St. 1 stream in the botanical garden of Pamplemousses; alt.: 70; MDD: 0.05; T: 26.3
2 Ruisselet Le Canal, leftside affluent of Rivière Baie du Cap; alt.: 300; MDD: 0.6; T: 21.2
3 fountain-head near the road Chamarel-Grand Case Noyale; alt.: 130; MDD: 0.03
4 Rivière de Citronniers, middle course; alt.: 130; MDD: 0.2; T: 23.6
5 Rivière Baie du Cap, lower course, south-coast; alt.: 10; MDD: 1.4; T: 22.4
6 Rivière Jacotet, lower course, south coast; alt.: 15; MDD: 0.9; T: 23.8
7 Rivière du Remparts, middle course, west-coast; alt.: 260; MDD: 1.5; T: 22.7
8 Rivière Cascade, affluent of the Grand River NW; alt.: 300; MDD: 1.7; T: 23.8
9 Rivulet Jacot, leftside affluent of Riv. des Galets, south-coast; alt.: 130; MDD: 0.05; T: 22.4-23.4
10 Ruisseau Patates, upper course, southern flanks of the Savanne mountains south-coast; alt.: 220; MDD: 0.75; T: 22.6
11 Black River-Gorge, middle course, southwest coast; alt.:40; MDD: 3.4; T: 24.5
12 Black River-Gorge, Viewpoint-headwater branch; alt.: 850; MDD: 0.03
13 Rivière des Gallets, headwater, Plaine Champagne; alt.: 700; MDD: 0.3; T: 20
14 Rivière des Gallets, headwater branch; alt.: 700; MDD: 0.4; T: 20.3
15 Rivière du Poste, upper reaches, Grand Bassin Road; MDD: 0.8; T: 21.2
16 Grand Bassin, crateric lake; alt.: 730; T: 22.2
17 Mare Longue, marsh (reservoir); alt.: 630; T: 23
18 Rivière Tombeau, middle course; alt.: 70; MDD: 0.4; T: 22.5
19 Rivière du Remparts-Est (east-coast), middle coast; alt.: 140; MDD: 2.4; T: 24
20 Rivière du Remparts-Est, lower course; alt.: 20; MDD: 4.0; T: 25.4
21 Rivière Profonde, affluent of the Grand River NW; alt.: 380; MDD: 1.8; T: 23
22 Rivière Moka, upper reaches of the Grand River NW; alt.: 400; MDD: 0.9; T: 21.2
23 Rivière des Gallets, lower course, south coast; alt.: 5; MDD: 2.4; T: 23.2
24 Rivière des Savannes, Rochester Falls; alt.: 100; MDD: 1.0; T: 21.7
25 Rivière des Anguilles, lower course, south coast; alt.: 60; MDD: 2.0; T: 23
26 Rivière Doudy, tributary of the Grand River SE; alt.: 400; MDD: 1.4; T: 19.9
27 Grand River South-East, upper course; alt.: 400; MDD: 2.0; T: 20.9
28 Rivière des Anguilles, upper course; alt.: 580; MDD: 1.5; T: 19.5
29 Mare Vacoas, marsh (reservoir), extent. 7 squ. miles; alt.: 625; T: 23
30 Rivière St. Armand, lower course, south-coast; alt.: 5; MDD: 2.0; T: 23.5
31 Rivière du Poste, lower course, south-coast; alt.: 15; MDD: 4.0; T: 23.6
32 Rivière La Chaux, lower course, Mahébourg, east coast; alt.: 10; MDD: 3.5; T: 24.3
33 Rivière des Créoles, lower course, east coast; alt.: 10; MDD: 5.0; T: 24.5
mean discharge of all investigated streams and rivers: 1.54 m^3/s

4.3. Classification of the water-systems in Mauritius

In contrast to the geologically younger islands Anjouan and Réunion the whole erosional system seems rather "homogenized" or stabilized. The content of dissolved compounds increase therefore homogenously similar to crystallin watersheds.

a. Upper courses and headwater-region of rivers in the Southern Highlands (stations 12, 13, 14, 15 with an altitude of 680-800 m). This slightly acidic streams are poor on calcium, magnesium and silicon while the contents of humic acids, ammonia, total-iron are increased (tabl. XIII)

b. The crateric highland lakes and marshes (reservoirs), stations 16, 17, 29, altitude 630 m (tabl. XIII).

c. The south-eastern flanks of the Le Reduit Highlands (station 26, 27, alt. 400 m) enclosing the headwater-region of the Grand River South-East (tab. XIII). The greater part of this plateau is reserved for the cultivation of tea. The rivers are still acidic. In contrast to the Southern Highlands—systems the contents of most dissolved compounds are increased, also nitrate. The water-colour is opalescing.

d. Middle and upper courses of main river-systems originating from the Southern Highlands (southern and western flanks) (stations 2, 10, 11, 24, 28) altitude 40-580 m. The contents of humic acids are still high while these of ammonia and total-iron are already decreasing (tab. XIV).

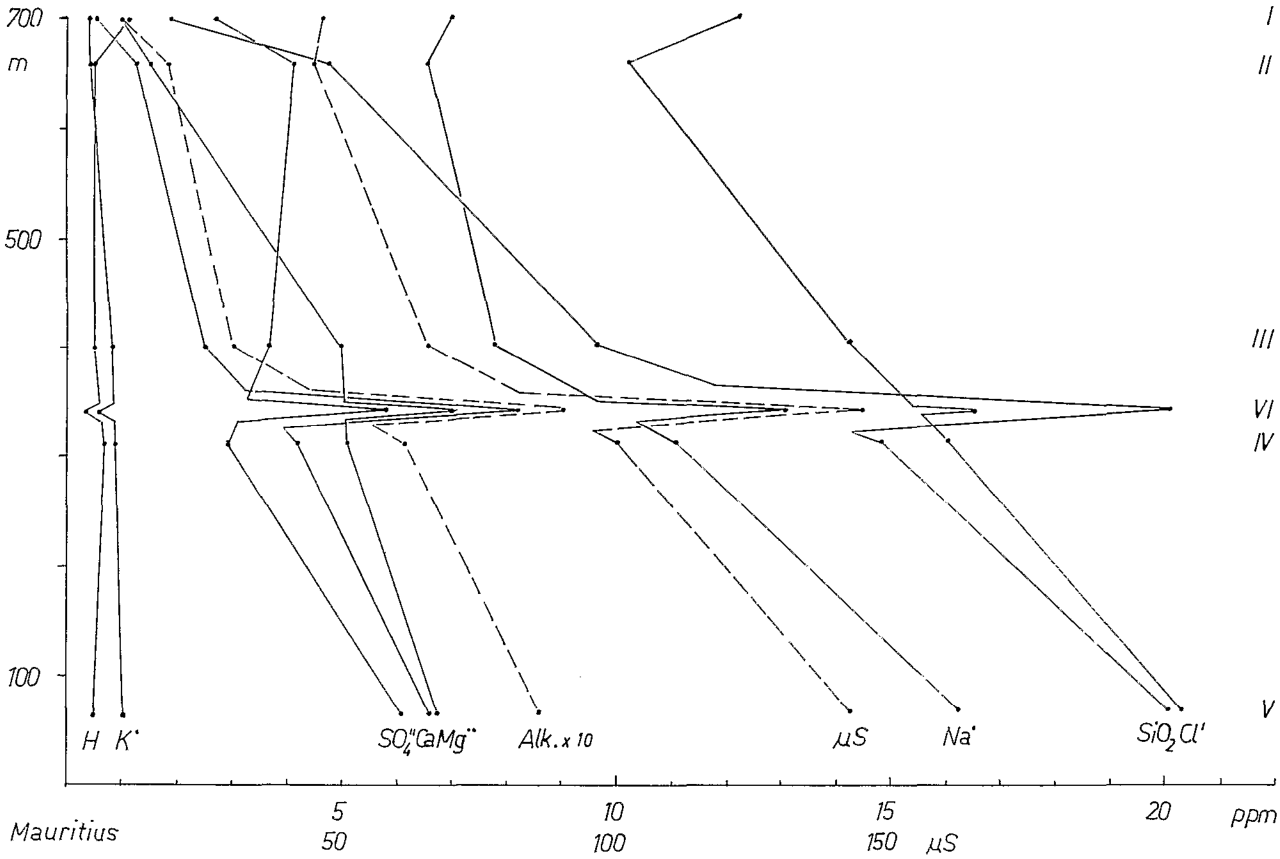

Fig. 6. — Mauritius.—Survey of hydrochemistry in relation to altitude (m).

I upper courses and headwaters from rivers in the Southern Highlands.
II crateric lakes and marshes from the Southern Highlands.
III watersheds from the southeastern flanks of the Le Réduit Highlands.
IV middle and upper middle courses of main rivers from the southern and western flanks of the Southern Highlands.
V lower middle—and lower courses of all investigated rivers.
H = Humic acids.

Maurice. — Relations entre la chimie des eaux et l'altitude (m).

I *Cours supérieurs et région des sources des rivières des zones montagneuses du sud.*
II *Lacs de cratère et marais des zones montagneuses du sud.*
III *Bassins des pentes sud-est de la montagne de Le Réduit.*
IV *Cours moyens et supérieurs des principales rivières du sud et des pentes ouest des zones montagneuses du sud.*
V *Cours inférieurs de toutes les rivières étudiées.*
VI *Rivières de la partie ouest de la montagne de Le Réduit.*
H = acide humique.

e. The lower middle and lower courses of all investigated rivers except those originating from the Southern Highlands (stations 4, 5, 6, 9, 18, 19, 20, 23, 25, 30, 31, 32. Especially the increasement of nitrate may be mentioned. Some rivers are opalescing (tabl. XV).

f. The drains from the wsetern flanks of the Le Reduit Highlands (stations 7, 8, 21, 22) (tab. XIV).

Most contents of dissolved compounds are increased, especially again these of nitrate possibly due to the influence of agricultury. All streams are opalescing.

A comparative sight concerning the details in hydrochemistry of the different regions verifies the increasement of conductivity and water hardness with falling altitude (fig. 6).

The dry leeward western flanks are in an advanced stage of weathering same as highly influenced by agricultury. All compounds except potassium and humid acids are enriched up to contents that occur in the lowest coastal regions. The samples have top contents of sodium, calcium, silicic acid, nitrate, while hydrogencarbonate, magnesium and sulphate are similar to the coastal region.

The diagram (fig. 6) confirms an simultaneous increasement of conductivity, sodium and chloride. Calcium, less magnesium, also silicic acid, parallelize with alkalinity (HCO_3).

The highly soluable sodium, chloride, nitrate, also potassium, shorten in regions of permanent rainfalls in stagnant water (highland marshes and reservoirs), while silicon and alkalinity increase.

TABLE XIII

Mauritius: headwater region. Chemical composition of waters (in ppm).
Iles Maurice: région des sources. Composition chimique des eaux (en ppm).

Station	12	13	14	15	16	17	29	26	27
Conductivity (20 °C, µS/cm)	51	43	44	53	44	47	49	66	67
PH	6,00	6,10	6,40	6,55	7,20	7,20	7,30	6,60	7,00
Humic acids (ppm)	0,89	0,93	1,35	1,18	0,29	0,57	0,44	0,54	0,44
Ca^{++}	0,32	0,32	0,40	0,80	1,40	1,00	1,40	2,40	2,60
Mg^{++}	1,10	1,00	1,10	0,38	1,30	1,40	1,70	7,10	2,80
Na^+	7,6	7,0	6,7	7,5	6,3	7,0	6,5	8,3	7,3
K^+	0,40	0,30	0,25	0,68	0,50	0,30	0,40	1,70	0,30
Fe-total (Fe^{+++})	0,66	0,68	0,68	0,52	0,05	0,40	0,42	0,36	0,46
Al^{+++}	0,10	0,37	0,10	0,16	0,09		0,17	0,05	0,22
NH_4^+	0,10	0,08	0,10	0,05	0,05	0,05	0,04	0,03	0,05
NO_3^-	0,08	0,08	0,08	0,09	0,07	0,07	0,08	5,50	0,06
Cl^-	12,9	12,4	11,5	12,1	8,8	11,4	10,4	15,0	13,7
F^-	0,04	0,05	0,04	0,04	0,05	0,04	0,04	0,05	0,04
PO_4^{--}		0,01	0,01	0,01	0,01	0,02	0,04	0,01	0,03
SiO_2^{--}	0,55	1,6	3,1	2,6	2,9	7,2	4,3	10,0	9,4
SO_4^{--}	2,8	2,5	2,6	2,9	3,1	4,4	4,7	3,8	3,6
HCO_3^-	4,9	6,1	5,5	9,2	15	9,2	11	21	21
CO_2 aggr.		7,3		6,6					

TABLE XIV

Mauritius: middle and upper courses of the river systems. Chemical composition of waters (in ppm).
Ile Maurice: cours supérieurs et moyens des rivières. Composition chimique des eaux (en ppm).

Stations	2	10	11	24	28	7	8	21	22
Conductivity (20 °C, µS/cm)	114	93	108	92	97	187	142	137	111
PH	7,70	7,90	7,82	7,90	7,65	7,50	7,65	7,20	6,65
Humic acids (ppm)	0,67	0,90	0,59	0,97	0,51	0,27	0,36	0,42	0,30
Ca^{++}	4,8	3,2	4,4	3,2	5.,1	14,0	7,6	7,6	5,6
Mg^{++}	5,1	4,3	5,5	4,7	5,3	9,8	7,5	5,8	4,6
Na^+	14,0	9,5	12,3	10,0	9,5	14,3	14,0	12,5	11,5
K^+	0,70	0,80	0,60	0,60	1,9	0,45	0,70	0,60	0,30
Fe-total (Fe^{+++})	0,36	0,52	0,02	0,20	0,10	0,22	0,02	0,20	0,16
Al^{+++}	0,22	0,09	0,06	0,20		0,05	0,14	0,16	0,11
NH_4^+	0,03	0,10	0,02	0,02	0,02	0,02	0,02	0,02	0,02
NO_3^-	0,07	0,10	0,10	0,08	0,11	6,00	4,10	8,40	6,30
Cl^-	18,8	13,8	16,9	14,8	15,6	16,6	15,8	18,2	15,8
F^-	0,06	0,05	0,05	0,04	0,04	0,06	0,06	0,04	0,04
PO_4^{---}	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,02	0,02
SiO_2^{--}	17,1	12,4	10,2	16,0	18,9	29,4	21,2	17,8	18,9
So_4^{--}	3,6	2,5	3,4	4,3	0,9	8,6	5,8	3,1	5,6
HCO_3^-	37	31	43	37	40	85	58	43	37
CO_2 aggr.	6,6	4,4			4,4	5,5			

TABLE XV

Mauritius: lower middle and lower courses of the rivers. Chemical composition of waters (in ppm).
Ile Maurice: cours inférieurs des rivières. Composition chimique des eaux (en ppm).

Station	1	3	4	5	6	9	18	19
Conductivity (20 °C, μS/cm)	110	193	154	154	179	125	168	149
PH	7,6	8,2	7,8	8,2	7,6	7,45	7,6	7,6
Humic acids (ppm)	0,32	0,58	0,39	0,56	0,49	0,44	0,49	0,77
Ca^{++}	4,8	10	6,0	7,6	6,0	4,8	7,6	6,8
Mg^{++}	4,9	8,2	6,5	6,8	7,8	7,2	6,2	5,8
Na^{+}	12,5	21,0	20,0	18,2	24,5	14,0	22,0	15,0
K^{+}	0,60	1,15	0,80	0,80	0,45	1,20	0,45	1,05
Fe-total (Fe^{+++})	0,72	1,16	0,60	0,32	0,64	0,50	0,64	0,44
Al^{+++}	0,19	0,07	0,32	0,13	0,24	0,21	0,10	0,09
NH_4^{+}	0,05	0,05	0,02	0,02	0,06	0,08	0,05	0,05
NO_3^{-}	0,07	0,07	0,07	0,07	0,07	0,01	1,0	0,8
Cl^{-}	17,6	28,2	25,8	22,7	27,0	18,4	25,8	20,8
F^{-}	0,06	0,07	0,06	0,06	0,06	0,05	0,03	0,05
PO_4^{---}	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01
SiO_2^{--}	4,6	23,3	16,5	20,4	22,3	15,8	25,1	17,6
SO_4^{--}	5,7	2,8	4,0	3,8	12,0	4,1	4,4	5,9
HCO_3^{-}	36	73	55	55	61	49	55	46
CO_2 aggr.				5,5				5,1

Station	20	23	25	30	31	32	33
Conductivity (20 °C, μS/cm)	157	142	124	131	137	122	119
PH	8,15	8,00	8,20	7,40	7,80	7,80	8,00
Humic acids (ppm)	0,52	0,34	0,59	0,98	0,65	0,52	0,20
Ca^{++}	7,2	7,6	5,6	6,0	6,8	6,8	7,2
Mg^{++}	7,1	6,4	7,4	6,9	6,7	5,8	6,0
Na^{+}	18,0	14,5	10,5	14,3	14,3	12,5	11,5
K^{+}	0,75	0,85	1,40	2,00	2,00	0,40	1,80
Fe-total (Fe^{+++})	0,02	0,16	0,10	0,05	0,07	0,52	0,16
Al^{+++}	0,13	0,11	0,20	0,04	0,27	0,22	0,33
NH_4^{+}	0,02	0,02	0,03	0,02		0,02	0,02
NO_3^{-}	1,50	0,08	1,70	5,10	0,13	3,30	17,5
Cl^{-}	20,0	18,7	15,9	17,6	17,3	15,9	13,8
F^{-}	0,05	0,05	0,05	0,05	0,04	0,04	0,04
PO_4^{---}	0,01	0,01	0,03	0,03	0,04	0,03	0,02
SiO_2^{--}	23,5	23,8	21,8	25,1	25,1	13,9	20,7
SO_4^{--}	6,8	6,0	4,5	7,3	6,2	8,3	5,3
HCO_3^{-}	49	58	55	49	58	49	49
CO_2 aggr.					5,5		

5. DISCUSSION

The downstream increasement of electrolyts as objected by the measurement of conductivity can be compared in the different islands (tabl. XVI):

Seychelles (granitic Mahé)—main river systems (west coast, altitude 410-55 m), increasement of conductivity: 1,4 μS/cm per 100 m. Headwaters towards the lower middle course (northeastern Mahé, altitude 235-119 m), increasement of conductivity: 15 μS/cm per 100 m.

Comores (Anjouan)—west coast systems (altitude 900-35 m): increasement of conductivity: 7,0 μS/cm per 100 m; those of the water systems running towards northwest (altitude 900-254 m): 12 μS/cm per 100 m; on highly weathered watersheds towards Col de Patsi (altitude 900-94 m): 14 μS/cm per 100 m; of subterraneous systems (altitude 900-360 m): 26 μS/cm per 100 m.

Réunion—less eroded valleys (altitude 800-70 m): 2,4 μS/cm per 100 m; a very high increasement of conductivity in subterraneous drains towards northeast: 146 μS/cm per 100 m, but an inverse decreasement of conductivity towards the outflow of the amphitheatric valleys ("Cirque-systems") (altitude 1000-160 m): 1,6 μS/cm per 100 m.

Mauritius—Southern Highlands (altitude 700-

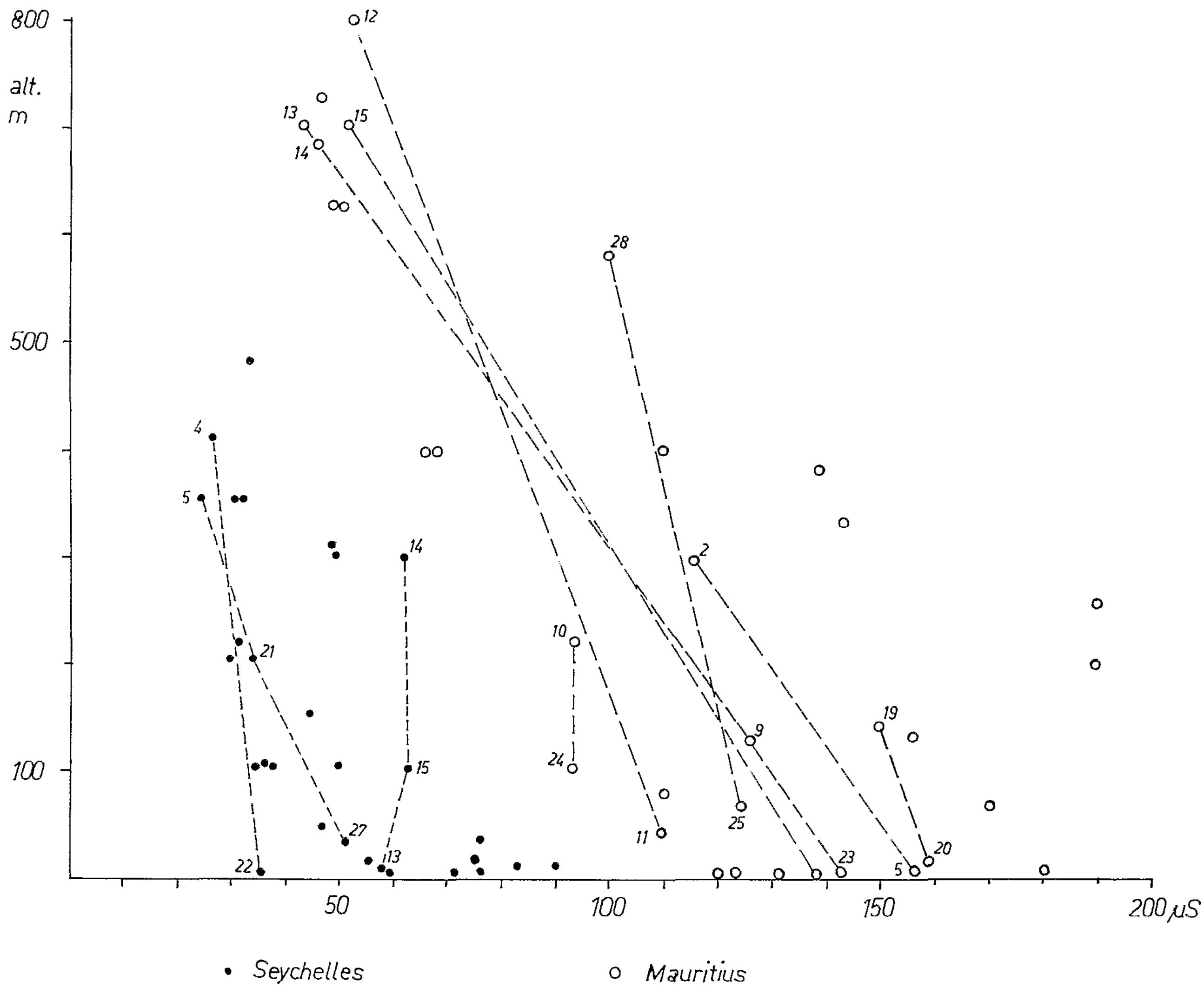

Fig. 7. — Diagramm of conductivities (µS/cm, 20 °C) in relation to altitude (m). Seychelles (Mahé, Praslin, La Digue)—full points. Mauritius—small circles. Connecting river systems are lined.
Diagramme des conductivités (µS/cm, 20 °C) en relation avec l'altitude (m). Seychelles (Mahé, Praslin, la Digue) : points noirs ; Maurice : cercles. Les stations situées dans un même bassin hydrographique sont reliées par un trait interrompu.

310 m), increasement of conductivity towards the upper middle courses: 13 µS/cm per 100 m; further on towards the lower courses (altitude 310-65 m): 17 µS/cm per 100 m.

The older islands—as well the granitic Seychelles as the volcanic island of Mauritius— are "stabilized" concerning their weathering processes. They have mostly surface water-drains and the increasement of electrolyts in the water-systems is related with falling altitude (fig. 7).

Anjouan and Réunion are built of highly porous volcanic rocks and a great share of the water drains is subterraneously. The different watersheds are in an extraordinary various stage of weathering. An increasement of ions downstreams cannot generally be stated (fig. 8).

The completely surface draining water-systems from crystalline mountain—ridges are usually poor in electrolyts. Later increase towards the lower course region step by step and connections between the contents of ions and altitude are obvious. The increasement of dissolved salts is extraordinary low

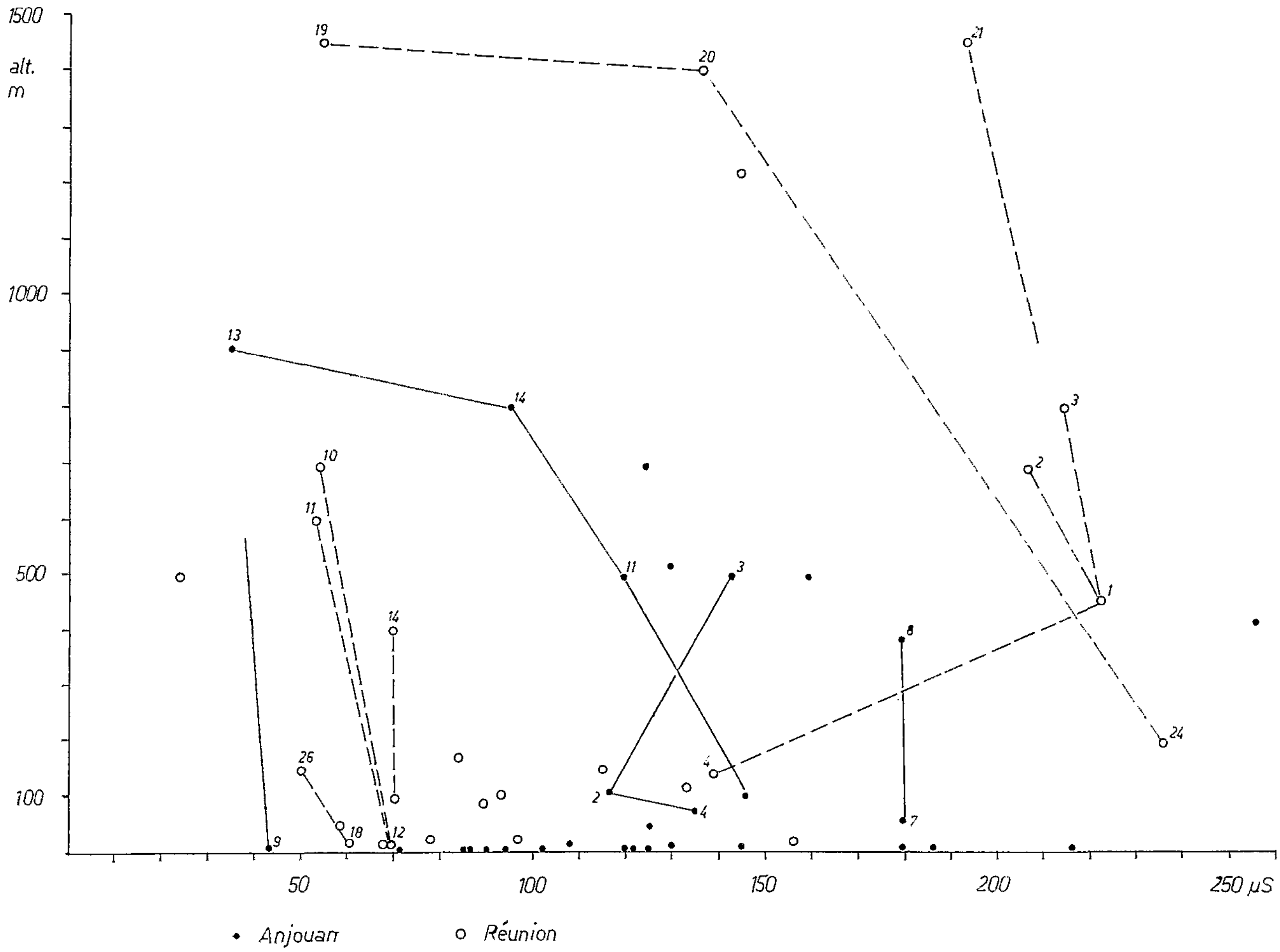

Fig. 8. — Diagramm of conductivities (µS/cm, 20 °C) in relation to altitude (m). Anjouan—full points, connecting systems in full lines. Réunion—small circles, connecting systems in interrupted lines.
Diagramme des conductivités (µS/cm, 20 °C) en relation avec l'altitude (m). Anjouan : points noirs, stations situées dans un même bassin reliées par un trait plein ; La Réunion : cercles, stations d'un même bassin reliées par un trait interrompu.

in the windward main drains of the dominating rivers, it's greater in drains of lateral flanks. An enrichment of salts and an important increasement of electrolyts results in areas leeward of the main winds where the annual precipitations are notably lower (tab. IV). The chemical weathering is here of importance because the washing out of the subsoil and soil is rather limited.

The similarity of highland-rivers of old volcanic islands with those of granitic watersheds (Mahé) is remarkable. It's again a slightly acidic soft water that is enriched by humic acids and ammonia like those from the upper courses in Mahé. The contents of dissolved calcium and magnesium are very low, while these of sodium and chloride are relatively high (tab. XIII-XV). This chemical water composition is untypically for basic volcanic rocks (olivin basalts). It results from the development of acidic soils (adapted for tea-cultivation) that lost the direct contact to the basical rocks. The totals of ions furtheron increase towards the lower course regions corresponding the tendencies on crystalline watersheds (fig. 6).

The hydrochemistry of water-systems from young volcanic islands is mostly bare of these regional regularities (fig. 8).

Their hydrochemical characteristics are mainly distincted by the specific weathering-resistance of the different lava-series.

The systems are frequently draining subterraneously or they pass regions that are in a far advanced

TABLE XVI

Survey of the mean chemical composition of waters (in ppm) in the main regions of the different water systems studied here.
Composition chimique moyenne des eaux (en ppm) des principales régions hydrologiques dans les îles étudiées.

Equatorial humid climate:

	Seychelles (Mahé)		Comores (Anjouan)		
	mountainous part	leeward lowlands	mountain lake	windward west coast	partially subterraneous
ppm					
HCO_3^-	3,7- 9,8	15,8	13,4	54,3	100
SO_4^{--}	1,0- 1,2	3,5	0,2	0,3	1,1
Cl^-	5,3- 7,5	13,7	2,2	5,1	6,0
Ca^{++}	0,5- 2,0	2,6	1,6	5,9	12,7
Mg^{++}	0,2- 0,6	1,5	1,6	4,6	7,5
Na^+	3,8- 5,9	9,7	1,5	8,7	12,2
K^+	0,7- 0,8	0,9	1,1	1,4	2,5
SiO_2	6,5- 9,9	11,5	0,4	27,8	34,4
Total	21,7-37,7	60,0	22,0	107,1	176,4

Seasonal humid climate (except the mountain regions):

	Mauritius		Réunion		
	highlands, headwaters	lower courses	mountain cascades	less eroded valleys	amphitheatre valleys
HCO_3^-	6,1	55,5	36,0	39,7	128,0
SO_4^{--}	2,7	6,0	1,5	1,1	3,8
Cl^-	12,2	19,6	2,9	6,8	2,6
Ca^{++}	0,5	6,6	3,8	5,2	18,3
Mg^{++}	0,9	6,3	3,1	3,5	8,3
Na^+	7,0	15,2	5,2	7,4	15,0
K^+	0,4	1,1	1,2	1,0	2,4
SiO_2	2,0	20,9	16,7	16,1	19,1
Total	31,9	131,2	70,4	80,8	197,5

TABLE XVII

Survey of the catchment's areas.
Caractéristiques des zones étudiées.

	Total area (km^2)	Highest elevation (m)	Mean-discharge of the rivers (m^3/s)	Period of investigation
Mahé	180	912	0,44	February
Anjouan	424	1595	1,01	March
Réunion	2512	3069	1,81	April
Mauritius	1843	826	1,54	April/May

The annual precipitation on the windward coasts of all these islands varies between 2000-3000 mm, in the highest mountain regions between 5000-8000 mm.

stage of weathering. These types of drainage exist in a comparable succession with increasing age of the island on Grand Comore (drains exclusively subterraneous) and on Anjouan (drains regionally subterraneous).

Concerning the resistance against weathering the younger—and older lavas in Réunion are extremely different. Because of deep erosion towards the older olivin basalts occur huge "amphitheatred valleys" ("Cirques"), which river-systems are highly enriched in dissolved minerals, especially calcium, sodium and silicic acid (tabl. IX).

Rivers of less eroded valleys draining the areas of the overlying younger lavas with higher resistance against weathering (alkaliandesites), have lower contents of dissolved salts which increase only slowly downstreams. An important increasement of electrolyts occurs in the mentioned subterraneous river-systems in Anjouan as well as on windward flanks where agriculture in connection with complete deforestation highly accelerated the processes of weathering. The water-systems of the still forest-covered mountain regions, especially the central crateric lake, are due to the enormous rainfalls, soft waters very poor in electrolyts (tabl. V). Similar soft waters exist in stagnant pools and windward mountain-cascades in Réunion (tabl. X-XII) again with dominance of sodium and chloride. The importance of influences from the rain-bringing seaside winds was not studied, but the washing out of the soils may be dominant (ionic exchange).

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