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HISTORICAL, GEOLOGICAL AND ECOLOGICAL ASPECTS OF TRANSMISSION OF INTESTINAL SCHISTOSOMIASIS IN MANIEMA, KIVU PROVINCE, ZAIRE

by

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Summary — Characteristically, open-cast tin times in Maniema are located along the contacts of the granite mother rock and the surrounding and covering sedimentary deposits. During the early years of cassiterite exploitation, the small-scale activities were limited to the alluvial deposits. No extensive water works were required and schistosomiasis did not become established. Later, when the eluvial deposits and primary veins were to be exploited, extensive systems of artificial lakes and canals had to be constructed. Sometimes, the water required for the mining activities is obtained from streams and artificial lakes in the nearby granite rocks. This water is extremely poor in mineral nutrients; no snails are found and schistosomiasis did not establish. In other places, however, water is obtained from the schists outside the granite areas. In that case thriving populations of *Biomphalaria pfeifferi* can be found and both prevalence and intensities of infection are extremely high.

KEYWORDS: Schistosomiasis, Epideliology; *Schistosoma mansoni*; Cassiterite Exploitation; Tin Mining; Zaïre.

Introduction

It has been shown (13) that *Schistosoma mansoni* is highly prevalent in many of the tin-mining communities in Maniema, but not in all. Since the latter group of communities is located close to some of the highly infected ones, it is likely that many of the lightly infected subjects in these villages contracted their infection in the nearby endemic villages. As a result, an even more striking picture emerges of two groups of villages; one being heavily infested, and the other slightly or not at all. How should this particular distribution be explained?

In the next paragraphs, a somewhat unorthodox descriptive approach will be followed. At first a brief description of the present topographical and social situation will be given. Then, some geological features and methods of cassiterite exploitation will be described and subsequently, the history of the introduction of schistosomiasis into the area during the last decades will be discussed along with the changing methods of cassiterite exploitation. Finally, it will be attempted to explain the actual patchy distribution of schistosomiasis on the basis of geological features and as a consequence of man's changing activities and way of life.

Description of the area

The mining district of Maniema is situated between 1° and 3° S in latitude and between 26° and 28° E in longitude in Kivu Province, Eastern Zaire (see figure 1, ref. 13). The altitude of this area varies from 400 m in the valleys of the river Lualaba and its tributaries, to about 1,000 m on some of the plateaus.

The present day aspect of the area is profoundly affected by the presence and activities of the «Société Minière et Industrielle du Kivu» (SOMINKI). This Zairian mining company now employs some 15,000 labourers. These labourers and their families (totalling about 70,000) are living in villages which have been constructed especially for them. Farmers, fishermen, retired labourers and their families (altogether perhaps 150,000) are living separately, in other villages.

Cassiterite exploitation in Maniema started around 1932 and well-functioning Medical Services came soon into existence. Although the doctors in the area were familiar with each of the three African schistosomes of man elsewhere in Kivu (5, 18), transmission of neither of these species occurred in the mining district of Maniema. Only occasional cases of imported schistosomiasis brought into the area by newly contracted labourers, were discovered and treated when these new labourers were in quarantaine before being employed (Dr. Schyns, pers. comm.). It is quite certain that one was aware of the possible existence of schistosomiasis, one looked for it, but it wasn't endemic.

Primary and secondary cassiterite deposits and their exploitation

The Sominki exploits cassiterite in open-cast tin mines. The mineralization of tin in the area is considered to be a late-magmatic process resulting in the crystallization of cassiterite — often mixed with wolframite and other minerals — in quartz veins which filled the crevices of the greisenized granite outcrops. Nowadays, as a result of peneplainization, only the remainders of these granite outcrops are exposed. They are surrounded by basement rocks (schists, quartzites, basic rocks) and deposits of sedimentary origin (eluvial soils and alluvial deposits).

Cassiterite, together with wolframite and colombite/tantalite can be found in veins (primary) in the granite mother rock as well as in the much younger eluvial soils and alluvial river deposits (secondary). The tin-mineralization and the subsequent geological processes of weathering, erosion and deposition of cassiterite-bearing sediments in the Maniema district has been carefully described by Varlamoff (19), while Taylor (17) has treated the geology of tin deposits in a more world wide framework.

In Maniema cassiterite is sometimes exploited from the primary veins in the granite rocks but cassiterite present in the younger deposits can often be recovered much easier. Consequently, exploitation normally starts with the alluvial deposits, then the eluvial deposits are exploited and finally the activities shift to the wheathered primary veins. Since the cassiterite is rather friable, the crystals rapidly decrease in size when they are transported downstream by river water. A few kilometers downstream from the origin of erosion, the texture becomes so fine that it is no longer exploitable. As a consequence, the economically interesting eluvials and alluvials are situated in the proximity of the granite mother-rock. A geological sketchmap (fig. 1) of the centre of Sominki's present mining activities around Kalima, clearly shows the characteristic localization of the mining villages. They are all built along the contact zone of the granite massive with the surrounding metamorphic basement.

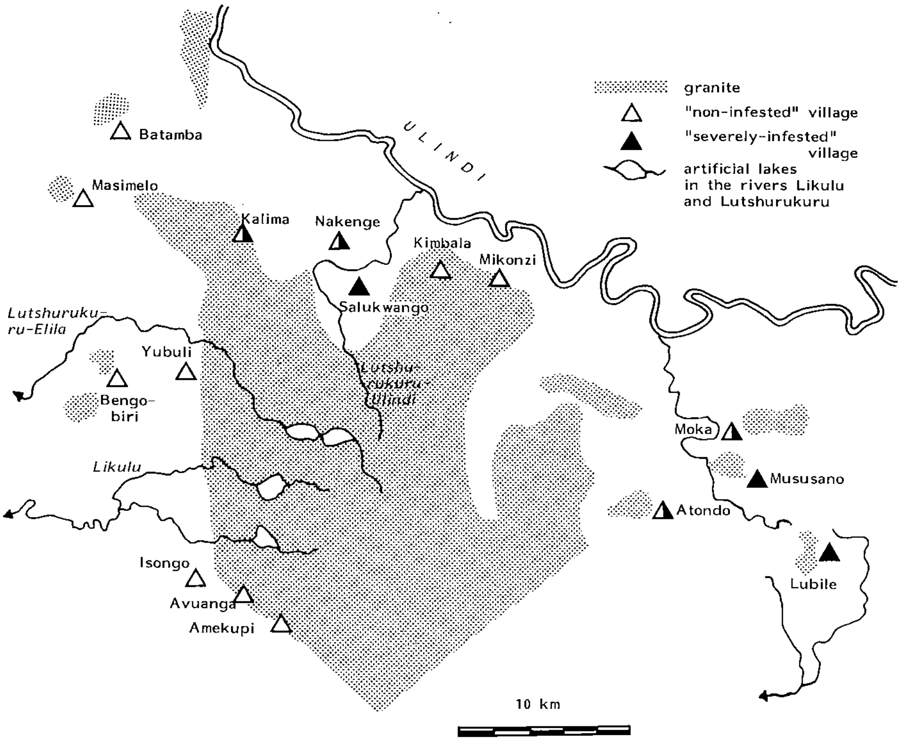


Figure 1.
Sketch map of Kalima region, indicating the granite massive and the labourers' villages along the granite-schists contacts.

In the early days of exploitation in Maniema, it was primarily the alluvial sediments in the river beds which were exploited. Mining was done at a comparatively small scale. For these exploitations local river water was used for the panning of the heavy cassiterite fractions. Shortage of water was an important limiting factor to the further expansion of the exploitations. Later, however, the exploitations shifted towards the eluvial soils and still later to the weathered primary veins and sufficient quantities of water were no longer available at the site of exploitation itself. Consequently, water had to be brought into the mines from elsewhere. On some occasions (e.g. on the Bokanga Plateau) artificial lakes were constructed in the mountains and the water was led into the mines by gravity. Later, lakes were constructed for the production of hydroelectricity. From that time onwards, smaller «*barrages*» could be made in the neighbourhood of the exploitation, the water being pumped into small reservoirs before used in the mines. The stretches between the barrage, the reservoir and the mine are largely covered by open canals following the contours and referred to as «*races*». Frequently, small reservoirs, additional pumping stations and iron tubes in stead of *races* have to be used to pass the hills or to arrive at a higher altitude. This system of artificial lakes, pumping stations, canals and reservoirs can be properly manipulated as to provide the required amounts of water.

Cassiterite exploitation and schistosomiasis

The way of cassiterite exploitation has had a great impact on the introduction and the distribution of schistosomiasis. At present, *Biomphalaria pfeifferi* is found in many *barrages*, but not in all. Many *races* are harbouring large numbers of snails and since certain of these *races* pass the labourers' living quarters at short distances, the *races* are considered to be important foci of transmission. In several places the drainage of the natural river system of the area is blocked by debris originating from the old exploitations, and swamps arise. In these swamps, too, many *B. pfeifferi* can be found. In a few places flourishing snail populations are even found within unprotected wells.

The changes in the type of exploitation, the history of construction of the required systems of water supply and the events secondary to these changes are briefly brought together for a number of mining villages in a descriptive list (table 1). This table shows that in a number of mining villages schistosomiasis became endemic a comparatively long time ago: just before or just after 1960 (Tshamaka, Moga, Lubile, Mususano) (see also table 1, ref. 13). In other localities, it became endemic more recently (parts of Lulingu, Salukwango, Nakenge, and parts of Kalima itself) although mining activities started long ago around most of these villages. In still other communities (Amekupi, Avuanga, Isongo, Yubuli, Bengobiri, Kakaleka, Kimbala, Mikonzi, Masimelo, Batamba), it did not establish at all.

In Tshamaka, Moga, Lubile and Mususano, the introduction of schistosomiasis followed the construction of the local *barrages* with a few years' delay. In the second group of villages no large artificial lakes have been constructed. There, the most important transmission takes place in other types of habitats (see discussion). In the last group of villages (Amekupi etc.), however, local schistosomiasis did not establish at all. There, no snails are found in the lakes, the canals or the marshes, the prevalence of *S. mansoni* in man is low and, even more strikingly, the egg counts are low (table 2).

How to explain this permanent absence of the parasite in some villages while the socio-economic conditions, sanitary facilities, and «general way of

TABLE 1

The history of cassiterite exploitation and the settlement of schistosomiasis in Maniema

Tshamaka, Kakota, Amakinga, Ungbe

Among the latest exploitations of Symétain. Construction of the villages in 1951-1952. Alluvial diggings started in 1951; eluvials soon afterwards. The artificial lakes Kembaye and Kabota were constructed in 1954. Electricity from the hydro-electric plant of Belia became available in 1954.

B. pfeifferi is now abundantly present in entire system of races, in several old exploitations (now marshes) and in the lakes Kembaye and Kakota. The man-made lake in river Belia fed by water from the granite massive, contains no snails. First cases of schistosomiasis registered in 1956, now all villages are severly infested.

Moga

Cobelmin's exploitations in Moga started in the early thirties. From 1948 onwards eluvial soils were also exploited. Present day villages were constructed between 1947 and 1949. The hydro-electric power station of Misoke, fed by river Lubiadja was constructed in 1948.

B. pfeifferi is now found in all races, parts of the rivers around the exploitations, some reservoirs and marshes and parts of the lake.

S. mansoni appeared around 1960 (no exact dat available) and is now highly prevalent.

Lulingu

The villages (the latest of Cobelmin) were built in 1957-1958. A thick layer of alluvial and eluvial deposits is situated on a granite underground. In the flat and broad old riverbeds square holes are dug («cellules») and the cassiterite-containing sediment is washed out systematically. Formerly, the tailings of a new *cellule* were used to fill the old one. Following the rebellions of 1964 and 1967, which severely hit the area, exploitation was less systematic: old abandoned mines were no longer filled. Instead, they filled with water and were used as fish ponds.

B. pfeifferi is now found in most of the ponds.

The first cases of *S. mansoni* are said to have occurred in 1974. Others claim that a few cases were seen from 1969 onwards. Schistosomiasis is now highly prevalent.

Western escarpment of the Bokanga Plateau

Around 1946 an extensive system of races was constructed to bring down water from the barrage Likulu Sud into the exploitations of eluvial soils and weathered primary veins which gradually replaced the alluvial diggings.

B. pfeifferi is not found in the canals nor in the small reservoirs around the exploitations. School boys attempted to seed *B. pfeifferi* from elsewhere in a small barrage near Avuanga, but the snail populations did not establish. In the barrages of Likulu and Lutshurukuru, too, no *B. pfeifferi* are found.

S. mansoni never became endemic in the area.

Kalima

Symétain's exploitatons in Kalima area started around 1932. From the early sixties onwards, the main importance of Kalima has shifted from its exploitations to its role as the administrative centre of mining activities. There used to be several races and many smaller reservoirs which were used as fish ponds in later years. Water for the exploitations was drawn from the rivers Mukwale and Lutshurukuru flowing down from the Bokanga Plateau.

B. pfeifferi has never been found in the old races nor in the fish ponds. Now they are found in a certain stretch of a tiny river running along the backyards of the «Camp Plessy» and «Avenue Famille».

S. mansoni probably was not found untill 1970 and it's only since 1978 that a steady increase of the number of cases is recorded in some quarters of Kalima.

Salukwango, Nakenge

These labourers' villages were constructed by 1945. The eluvial deposits to the south of the road, were abandoned by 1965. Subsequently these old diggings turned into marshes. The old diggings as well as the new ones were fed by water from the river Lutshurukuru-Ulindi.

B. pfeifferi are now found in the marshes and in a few reservoirs.

It is not exactly known when *S. mansoni* appeared, but before 1976 few cases were seen in the nearby hospital of Kalima (7 km). Now, infection rates are high.

Communities to the East of the Bokanga Plateau

In Lubile, Moka, Atondo and Mususano, too, the alluvial diggings started a long time ago: between 1934 and 1935. At present the exploitations are fed by several fairly big artificial lakes. These were constructed between 1946 and 1948 to meet the increased water demand. They are not fed by water from the plateau.

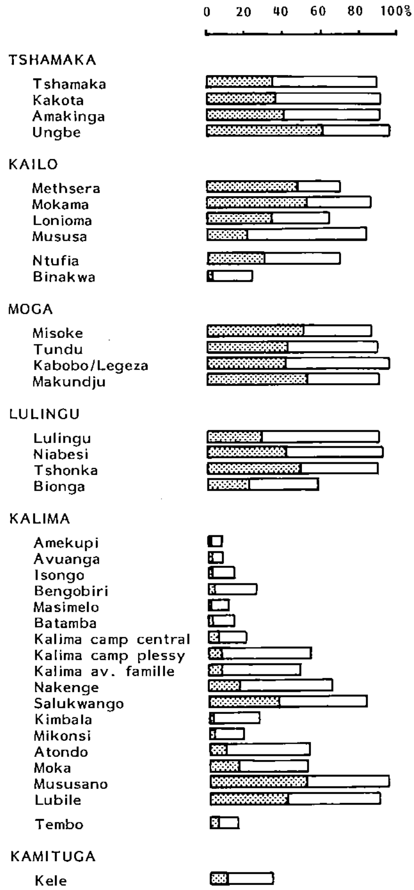
B. pfeifferi is found in all barrages, in most parts of the races and in marshes which arose from old exploitations.

S. mansoni is endemic in each of the villages. The first cases have been registered in Lubile in 1957.

life» are very similar to those in the heavily infected villages? The absence of schistosomiasis in Masimelo and Batamba might be due to the fact that the exploitation in the eluvial soils started only three years ago; untill that time only the alluvial sediments in the riverbeds were exploited. The other non-infected communities, however, belong to the oldest centres of mining activities.

TABLE 2

Summary of the prevalence and the intensities of infection in a number of miners' villages in Maniema
(shaded: more than 600 epg)



Water chemistry and the distribution of *Biomphalaria spp.*

As a first attempt to explain why some labourers' villages did not get infected while many others did, a preliminary and rather incomplete surveillance was made of some chemical characteristics of water bodies with and without *B. pfeifferi.* The results of this surveillance are summarized in table 3.

This table indicates that the conductivities and calcium contents are very low, both in the snail-infested and in the non-infested water bodies. In the latter type of water bodies, however, both variables are significantly lower than in the former. The water is acid in all sites but the pH is higher in the

TABLE 3

Presence of *B. pfeifferi* in relation to some chemical characteristics of the water of some of the larger *barrages* in Maniema

Water body	Absence/ presence *B. pfeifferi*	Conductivity in μmhO/cm	Calcium contents in ppm	pH
Barrage Kembaye Tshamaka	+	43		
Barrage Kakota Tshamaka	+ +	29		
Barrage Lubliadja Misoke (Moga)	+ +	28	2.4	6.2
Barrage Makundju (Moga)	+ +	33	2.4	5.7
Barrage Lubile à mont Lubile (Kalima)	+ +	55	3.7	5.6
Barrage Kishwa Moka (Kalima)	+ +	44		6.4
Barrage Mususano Musosano (Kalima)	+ +	36		
Barrage Belia/Saulia Punia/Tshamaka	—	15		
Barrage Avuanga (western esc. Kalima)	—	10	1.6	5.1
Barrage Likulu Nord (Kalima)	—	10	1.2	
Barrage Likulu Sud (Kalima)	—	12	0.8	6.4
Barrage B4 in Lutshurukuru (Kalima)	—	13	1.1	6.4
Rain water		7	3.0	4.9

N.B.: — On some occasions the pH-meter did not function properly; those data are left out of the table.
— Calcium contents were determined with a flame spectrophotometer (Perkin-Elmers Instruments Inc.).
— The presence of snails has been checked routinely on a great number of occasions.

snail-infested water bodies than in the others. The table is limited to observations on the larger artificial lakes.

In the former Belgian Congo, Dupont was struck by the paucity of molluscs a long time ago (4) and Pilsbry and Bequart attributed this to the low calcium contents in the waters, more than 50 years ago (12). More recently, Symoens analysed the mineral contents of a large number of natural waters in Shaba (16). He registered very low conductivities (less than 18 μmho/cm) in rivers and stagnant water in areas with basement rocks mainly constituted by granites and quarzites. In those water bodies he did not find *B. pfeifferi*. The minimum amounts of calcium in water bodies which did contain *B. pfeifferi* in Lumumbashi area, was around 8 mg/l. In Lower Zaire, between Kinshasa and Matadi, Mandahl-Barth *et al.* (9) have pointed out that the presence of *B. pfeifferi* is dependent on the nature of the bottom: they are only present in the zone where the surface soils occur above calcareous schists. A similar correlation between soiltypes and the distribution of schistosomiasis had been reported earlier on the other side of the Zaire river in Congo-Brazzaville (10).

Elsewhere, too, conductivity and calcium concentration have been shown to be important factors governing the presence and absence of *Biomphalaria* (e.g. 7, 14). The level beyond which the conductivity is considered to be a limiting factor elsewhere, is much higher than the values found in Maniema (6). The lowest conductivity registered in water bodies containing populations of *Biomphalaria*, is — to our knowledge — 37 μmho/cm, as measured in the Malagasy Republic by Pflüger (11).

Discussion

In Maniema, the calcium contents and the conductivity of many of the *barrages* were shown to be very low. Rain water contained even more calcium than the majority of the water samples from the *barrages*. Before the introduction of cassiterite exploitation and in a number of villages even up till the present day, schistosomiasis transmission did not occur. In those villages where infection rates in man are high and where flourishing populations of *B. pfeifferi* are found, conductivity and calcium contents appear to be as low as, and often lower than the lowest values found in the literature. The water bodies offer habitats which are unfavourable in some places and «just about favourable» to the snails in others. The differentiation between favourable and unfavourable habitats would seem to be linked to historical factors, to geological factors and to pollution by man.

It was shown that, in the region of Kalima, the great majority of exploitations and mining villages is located along the contact zone of the granite massive with the surrounding basement schists. This is not accidental but it's the consequence of the regional characteristics of tin-mineralization along the granite-schist contacts. Those villages which receive their water directly from the *barrages* in the granite mountains of the Kalima massive, have remained free of schistosomiasis. Those villages, on the other hand, where the catchment area of the nearby granite massive is too small to provide the exploitations with sufficient quantities of water, and where *barrages* were constructed in areas with nutrient-richer metamorphic basement rocks, became badly infested. This general picture will be commented upon in some more detail in the next paragraphs.

The granite Bokanga Plateau, south of Kalima, is big enough to contain a system of streams to feed several large water reservoirs. These reservoirs have a total volume of over 12 million m^3. Calcium contents and conductivity remain very low as a result of the granite nature of the mother rock. A large number of mining villages is built along the borderline of the plateau: Amekupi, Avuanga, Isongo, Bengobiri, Bunza (now closed down), Yubuli, Kakaleka (closed down), Kalima, Nakenge, Salukwango, Kimbala, Mikonsi (small administrative centre), and Kwanga. The exploitations along the western escarpment receive their water directly from the rivers and from the artificial lakes in the rivers Lushurukuru and Likulu. Consequently, no water suitable to harbour *B. pfeifferi* became available and schistosomiasis did not establish. Near the small camp of Bunza, situated some 7 km from the western fringe of the escarpment, there used to be a small barrage. The camp was closed down in 1970 and the artificial lake disappeared soon afterwards. It is interesting to note that — according to the personal observations of one of us (K.M.) — this water body used to contain some *B. pfeifferi*. Unfortunately, nothing is known about the presence of schistosomiasis in Bunza, those days.

Along the northern and eastern sides of the plateau, the situation is more complex. In Kimbala, as in the west, all water is supplied from the plateau, and in Mikonsi, no mines are present and the water from the plateau is sufficient to supply the village's needs. There are no barrages or marshes around and schistosomiasis never settled in these villages. In Nakenge and Salukwango, the area was properly drained at the time of active exploitations to the south of the road; the exploitations were fed directly with water from the Lutshurukuru-Ulindi, and conditions remained unfavourable for *B. pfeifferi*. When the mining activities shifted further to the north and the southern exploitations were abandoned in 1965, marshes developed in the abandoned and undrained exploitations. Although these marshes are still fed by the river Lutshurukuru, the richer soils of the basement schists have enabled the snails to settle. As a result, schistosomiasis became endemic although much later than in many other communities. The village of Lubile as well as the smaller ones of Atondo, Moka, and Mususano are located near small granite outcrops. They are too far from the Bokanga Plateau to be fed by its river systems so the exploitations are fed by water from local barrages which are comparatively rich in nutrients. These artificial lakes as well as the marshes which arose as a result of careless dumping of tailings from the mines and of the filling with water of the older diggings, became favourable habitats for *B. pfeifferi*, and schistosomiasis has been endemic for a long time since.

A similar situation might be expected to develop in Masimelo and Batamba. These villages are also located too far from the plateau to be fed directly by its river system. Untill 1980, however, solely alluvial exploitations were operational in the beddings of the rivers Miri and Batamba and their tributaries. Eluvial exploitations started since and marshes have not developed yet. The new exploitations are fed by water that is pumped directly from the rivers into a small reservoir on top of the mountains. The situations should be carefully monitored and the development of marshes in the schists around the small granite outcrops, should be prevented. For the time being schistosomiasis did not settle here.

In Kalima itself, most quarters remain relatively uninfested but in the «Camp Plessy» and the «Camp Famille» more and more cases are seen (personal observations J.P.M. & K.M.) and the prevalence is fairly high (13). Snails (*B. pfeifferi*) are found in one stretch of the small stream Kamisuku but not in others. The snail-infested part of the stream and its surrounding marshy areas, is located behind the backyards of the houses in this part of Kalima. It is likely that here the pollution of the small stream by man changes the originally uninhabitable water into habitats acceptable to the snail host. Further proof for this theory should still be given.

It is unfortunate that less geological background information is available for the other mining districts. The artificial lakes Belia/Saulia near Punia are fed by the corresponding rivers which have their catchment areas in the large granite massive south of Punia. In the mining-quarters of Punia, situated along the border of the granite plateau of Punia, occasional cases of schistosomiasis are found (pers. comm. Service Médical Punia) and snails are found in a few small barrages and pools. In Tshamaka, Kakota, Ungbe and Amakinga, however, on the other side of the river Lowa, water for the exploitations is obtained from the barrages Kembaye and Kakota which are located on, and fed by rivers originating from non-granite basement rocks. Saulia, situated between the granite plateaus of Punia and Belia, has been infested for a long time but the numbers of snails have been limited and the infection rates with *S. mansoni* are much lower than in other «highly infested» communities.

Lulingu is located at the south-eastern edge of the Punia-Kasese granite plateau. The alluvial exploitations are situated in wide flat river beddings which are fed from rivers originating from non-granite basement rocks. No barrages have been constructed in the granite massive and schistosomiasis is highly prevalent in many of the villages (see table 1 and 2). The regions of Kailo and Moga are largely characterized by schists while the granite outcrops are too small to influence the mineral contents of the waters to a great extent. There, too, schistosomiasis is highly prevalent.

Parts of the descriptions and observations given in this paper need further verification or a more elaborate analysis. Why are *B. pfeifferi* never found in the natural rivers in the area? Snail-infested water bodies (marshes, grossly modified parts of the streams) lose their snails very rapidly when they are overgrown by forest. Which are the factors which render the habitat unfavourable in those cases? To what extent does the role of human pollution add to the increase in calcium content and conductivity? Or, how likely are sanitary measures to reduce the human pollution in the infested water bodies, and how likely are these measures to result in efficacious snail control? Are the presence and absence of schistosomiasis reigned by similar geological factors in other tin-mining regions of Africa? More informations ought to be brought together on the situation in Manono (Shaba, Zaire), and on the tin-mines along the margins of the Jos-plateau in Nigeria as well as on those in SW Uganda and NW Tanzania. The situation in Rwanda is different due to the much higher altitudes. And finally, will schistosomiasis settle in the hitherto uninfested villages in Maniema such as Masimelo, Batamba or Tembo? Will it be possible to prevent, or at least to postpone the settlment of schistosomiasis in those villages? Further research and follow up studies are thought to be relevant and are in progress.

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Aspects historiques, géologiques et écologiques de la transmission de la schistosomiase intestinale au Maniema, Province du Kivu, Zaïre.

Résumé. — Les mines à ciel ouvert du Maniema sont localisées le long des contacts entre la roche mère granitique et les dépôts sédimentaires qui l'entourent et la recouvrent. Au début de l'exploitation de la cassitérite, les activités à petite échelle se limitaient à l'exploitation des dépôts alluviaux. Ces activités ne nécessitaient pas de travaux hydrauliques importants et la schistosomiase n'avait pas l'occasion de s'installer. Plus tard, lorsqu'on passa à l'exploitation des gisements primaires et sédimentaires, d'importants réseaux de canaux et de lacs artificiels furent créés. L'eau requise pour les activités minières provient parfois de cours d'eau et de lacs artificiels situés sur le soubassement granitique. Cette eau est extrêmement pauvre en constituants minéraux. On n'y trouve pas de mollusques et la schistosomiase ne peut s'installer. A d'autres endroits par contre, l'eau est obtenue à partir des dépôts schisteux entourant les affleurements granitiques. Dans ce cas, d'importantes populations de *Biomphalaria pfeifferi* peuvent y être trouvés et tant la prévalence que l'intensité de l'infection sont extrêmement élevées.

Historische, geologische en ecologische aspecten inzake de overdracht van schistosomiasis mansoni in Maniema, Kivu Provincie, Zaïre.

Samenvatting. — In Maniema, Oost Zaïre, wordt tin in dagbouw gewonnen langsheen de raakvlakken van het moedergesteente, graniet, met de omgevende en bedekkende sedimentla-

gen. Gedurende de eerste jaren van de cassiteriet ontginning waren de werkzaamheden kleinschalig en bleven zij beperkt tot de alluviale afzettingen. Er waren hiervoor geen grote waterbouwkundige kunstwerken nodig en schistosomiasis bleef afwezig. Toen later eluviale afzettingen en primaire ertsaders werden ontgonnen, moest een uitgebreid systeem van kunstmeren en kanalen worden gebouwd. Soms wordt het voor de ontginningsactiviteiten benodigde water betrokken uit beken en kunstmeertjes in de nabijgelegen granietrotsen. Dit water is extreem arm aan nutriënten; er worden geen slakken aangetroffen en schistosomiasis kreeg geen kans. Op andere plaatsen echter wordt water betrokken van buiten de granietzones. In deze gevallen treft men belangrijke *Biomphalaria pfeifferi* populaties aan en zijn zowel de prevalentie als de intensiteit van de infectie zeer hoog.

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