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THE SAND-PATCH OF PONTA DE SÃO LOURENÇO, MADEIRA

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R e s u m o . Os resultados derivados da investigação da área arenosa perto do Cabeço da Nossa Senhora da Piedade na Ponta de São Lourenço da Ilha da Madeira são descritos. Escavações no sítio e o perfil Geológico apresentado por ZBYSZEWSKI et al. (1975) tornaram possível explicar a formação deste pedaço de areia, sedimento quaternário único na Madeira, contendo grande quantidade de gastrópodes que já no princípio do século passado atrairam a curiosidade de investigadores.

S u m m a r y . Results derived from investigation of the «sand-patch» near the volcanic cone of Nossa Senhora da Piedade on the peninsula of Ponta de São Lourenço in Madeira are described. Exposures by mining and the geological profile by ZBYSZEWSKI et al. (1975) made it possible to explain the formation of this for Madeira unique (Post-) Quaternary sediment, with its abundance of gastropods which attracted the curiosity of investigators already in the beginning of last century.

The NE point of the Middle Atlantic Island of Madeira ends in a peninsula, called Ponta de São Lourenço. At its point of junction with the island the Ponta is about 2.25 km wide, narrowing towards E to a point situated at a distance of about 5.5 km. There it forms an angle of about 45° to the SE, and ends after 1.25 km at the small sea-gap, Boqueirão, at Ponta do Furado. Opposite the cape two small islands continue in the same direction, the first 1.75 km long, Ilhéu do Agostinho, the second very small, Ilhéu de São Lourenço, with the light house of São Lourenço. Its light is visible during the night from

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a great distance. The width of the peninsula varies from 1.5 km (between Ponta do Rosto and Ponta das Gaivotas) to 200 m at the Estreito.

The N coast consists of cliffs, up to a height of 120 m with steep precipices down to the sea. The S coast mostly slopes gently straight down to the sea, but where land meets the sea there the waves have moulded a step of 1-1.5 m height into the basaltic material. At some places on the S coast of the peninsula the land is higher, because of small old volcanos. Their wonderfully proportioned cones border the land, where it meets the sea. The surf eats away the coasts on both sides of the peninsula and exposes the geological structure of the Ponta. Sometimes the very regular forms of basaltic columns spread out near the tops of the hills, as for example below the height of 140 m on the N coast, E of the «sand-patch», which will be described below. Just off the coasts on either side of the peninsula there are many broken off rocks of varying sizes. Some of the rocky platforms in front of the S coast are densely covered with sea-pocks (Balanidae), crustaceans of the sub-class Cirripedia, as for example at the Laginha, directly E of the volcano of Nossa Senhora da Piedade.

The surface of the peninsula E of that hill is very uneven and rough. The geological map of Madeira (Carta Geológica de Portugal, Ilha da Madeira, Folha «B») shows, that the E part of the peninsula consists of Mio- and Pliocene volcanic magmas and is covered extensively by tuffs. The landscape seems to show that it originates from a large volcanic fissure or crack in the floor of the sea, out of which magmatic material flowed. A fair amount of closely adjoining small volcanic cones were formed, some of them not being very elevated, others coneshaped. The depressions between them filled with tuff and turned into something like small valleys. Due to weathering they are today covered with a thin layer of reddish soil, called Ranker. Some Gramineae and other plants which are able to live under extreme and arid conditions are growing on this soil. It is possible that there were bushes, even trees in former times, just as we find trunks and roots in the area of the sand-patch too.

At the foot of the hill of Nossa Senhora da Piedade to the N and to the W there is the sand-patch, the subject of this paper, and to the W of this patch the landscape is different from that to the E of this hill. The surface of the former slopes steeply from the highest point of about 120 m at the N coast to the lowest at the S coast. The distance between both amounts to about 500 m, so that the gradient of inclination is about 13° or 20%. The geological map shows volcanic material of the Mio- and Pliocene overlain by tuffs in the area of the old volcano called Cabeço da Cancela. From the road from Caniçal to the Prainha dykes of basaltic material can be seen. These rose to the surface at the same time at which the Cabeço was active. The top of these basaltic dykes is overlain by tuff and recent soil.

The extreme W of the Ponta de São Lourenço, round the village of Caniçal and N of it consists again of Mio- and Pliocene volcanic material. The village lies near the mouths of two small rivers, which have carved deep valleys with steep scarps into these layers. In the upper- and northernmost parts of that landscape we find pyroclastic material of very small size, perhaps ashes, which seems to have covered the middle and S parts of that landscape in former times and has since been washed down. The features of the relief are more like those of the main part of the island of Madeira than those of the Ponta de São Lourenço. They seem to form one large slope, starting near the Pico das Roçadas (536 m). Into it some small rivers have worn their valleys and at some places it is dangerous to walk down as the surface slopes at a gradient of 25% and more.

The tuffs between Caniçal and the sand-patch are used to make blocks for building, similar to those made of pumice-stone of the Maifeld, close to the highland of the Eifel, in Germany.

The geological map of Madeira shows two other sand-patches besides the one near Nossa Senhora da Piedade, but both are quite small. One is situated slightly W of the whaling-station at the S coast of the Ponta de São Lourenço and belongs to a private country-house, the other is situated NW of the Cabeço da Cancela. But the largest one, the sand-patch at Nossa Senhora da Piedade, is the only one described as «Areias de dunas com moluscos terrestres da Ponta de São Lourenço» on the Mapa Geológico de Portugal and seems to be a large area of about 500 × 1000 m on the map.

A visit to this area shows that we can divide the sand-patch into two parts. One, N of the hill of Nossa Senhora da Piedade, covers the volcanic, i.e. mainly magmatic/basaltic material of that region with only a thin layer of 3-3.5 m of sand. This volcanic material shows on its surface, where it has been exposed to interference by man, that it has been decomposed into soil after the end of the volcanic activity of that part of the peninsula. In the soil we find the remains of stumps of trees, mainly roots, which spread from the centre of the trunks in all directions. Sometimes there are trunks of trees still standing up to 1-1.5 m in such places, where the sand has been removed for industrial purposes (sand-pits). In a sand-pit close to the road which climbs up from the Prainha to a small radio-station NE of Nossa Senhora da Piedade, I found such an old ruin of a trunk. It seems to have been first covered by the sand, then it died and the remaining trunk in the sand decayed. After the end of the deposition of the sands the new surface was covered by plants. Their roots are still in the interior of the old trunk, but are all calcified in the same way as the whole old trunk itself. Judging by the stratigraphy of this plot it seems certain, that this thinly layered part of the sand-patch has developed either at a very late period of the formation of the sand-patch landscape or that the sands in this part have been steadily chang-

ing and moving with the wind during the whole time of the gradual unfolding of the patch from and towards the coasts and out of and into the sea.

The main and most important part of the sand-patch is situated NW of Nossa Senhora da Piedade. It is bordered by two small valleys, one at the E side of the sand-patch ending at the Prainha, the other at the W side. There is no name for the place, where the latter ends. Both valleys are clearly shown on the geological map, which also shows the Mio- and Pliocene volcanic material below the sandlayers. Visitors to the two valleys observe striking differences between them.

Walking from Caniçal to the Prainha, one passes the above mentioned side covered with volcanic ashes and tuffs S and SE of the Cabeço da Cancela. The road has been cut through this material with bulldozers and forms high walls on either side of it. The surface of the landscape on the top of the wall to the N is nearly flat, to the S it slopes down to the sea.

Suddenly the view broadens and the road passes over an artificial dam to the sand-patch itself. This dam crosses a very astonishing valley, the first or W one of the two above mentioned valleys bordering the sand-patch. The dam may be 3-4 m above the deepest part of the valley. The tuffaceous material of the landscape we just left lies near the road another 4-5 m at least above the level of the road, so that the W or right side of the valley is about 8-9 m high, perhaps even more. The surface of the W landscape is covered with calcareous crusts, the edges of these crusts at the rim of the W side of the valley have the appearence of bombed roofs of army bunkers. The loose tuffaceous material situated under the rim of the calcareous crusts has slipped down the slope under it.

The reddish material of the right or W side of the valley is in sharp contrast to the greyish material of the calcareous sands of the left or E side of the valley. On top of these sands we find calcareous crusts too, but it is obvious to the visitor, that the surface of this sandy landscape is much lower than the surface of the landscape of the side of the valley. This gave rise to the conception, that this valley was not made by water, but has its origin in a large fault, which divided the W part of the peninsula from the area of the sand-patch. Could the place of the sand-patch perhaps be a depression?

Visiting the place in the early summer of 1977 I found at the NE corner of the dam, that the surface of the calcareous crust of the sand-patch had an inclination of perhaps 40° towards the E. The outcrop of the different sandy layers of the sand-patch, which will be discussed later in this paper, could be seen very distinctly. The strike was N 73° E. It seems to be one large slab or consolidated segment of the westernmost part of the sand-patch, which has lost its natural position and was tipped into a more eastern depression. The whole has the appearence of a large wedge, coming out of the

sand-masses. At the S side of the road and the dam the inclination of the outcrop of the sand-layers is less impressive than at the N side, but it is obvious on both sides that the inclinations were not caused by the removal of sands for building purposes. Tectonic movements which perhaps caused the inclination of the slab seem to continue and the progress of inclination seems to press the underlying volcanic tuffs out of the scarps of the valley into itself.

In the centre of the sand-patch a large sand-pit has been dug with bulldozers right down to the bottom of the sand-patch and one can see that it is the same reddish tuffaceous material of the Mio- and Pliocene and that the same soil has developed on it, as the one we find at other places of the peninsula too. The nearest one of such places is on the right side of the valley which borders the sand-patch to the W.

The sand-pits showed in 1977, when I visited the place, profiles, of about 20 m together. KREJCI-GRAF (1961) has given the most exact description of the sand-patch of all visitors there since the beginning of the investigations in about 1823 (BOWDICH, 1825) and writes: «The sands show a great variety of components: on the one hand about 1/4 of calcareous skeletal residues, 1/4 reddish and brownish slag-material, 1/2 blackish basaltic material; on the other hand all transitions up to 1/5 volcanic material. 1/2-3/4 calcareous skeletal material, the remainder lime mortar. The sizes of the grain of the calcareous skeletal material are mostly 'Grobsand' (coarse-grained sand), those of the volcanic material mostly 'Mittelsand' (medium-grained sand) with some 'Feinsand' (fine-grained sand) and a few 'Grobsand-Körner' (grains of coarse-grained sand) (Nomenclature after Füchtbaur)». The calcareous parts of the sands have their origin in myriads of pieces of molluscs, which lived in the neighbourhood of the sand-patch and occasionally on it during its development. MITCHELL-THOMÉ (1976) writes that ALBERS studied 62 species of *Helix* there. He mentions nearly all other investigators of the gastropod-fauna there till 1957. Some gastropods are specified also by KREJCI-GRAF (1961) and ZBYSZEWSKI et al. (1975).

It is obvious to the visitor to the sand-pits at the lowest part of the sand-patch, that the sands have been deposited not during o n e phase of accumulation, but that there have been quite a number of phases of accumulation, interrupted by phases of soil development: The sandy layers are interrupted by fossil calcareous crusts and brownish horizons at irregular distances from the basic level to the top of the profiles. ZBYSZEWSKI et al. (1975) noticed a profile in the sand-patch, when they were working there in 1970 and 1971 for the Carta Geológica de Portugal, Folha «B» da Ilha da Madeira (ZBYSZEWSKI et al., 1975). It is 13.10 m high at least and shows 20 different horizons or levels:

20 — Sands, grey-brown (about 2 m)
19 — Sands, with some Helix (0.40 m)
18 — Sands, brown with calcareous cementation (0.30 m)
17 — Sands, grey, with Helix (1.20 m)
16 — Sands, brown, with subsequent calcareous infiltrations (0.20-0.30 m)
15 — Sands, grey, with numerous small Helix and some calcareous concretions in the form of tubes and roots (2-3 m)
14 — Sands, loose, brown
13 — Clay with calcareous infiltrations (0.40-0.50 m)
12 — Sands, brownish-yellow, consolidated, with calcareous concretions in the form of tubes (0.30-0.70 m)
11 — Sands, consolidated, dark-grey, with Helix and calcareous veins (1 m)
10 — Sands, consolidated, calcareous, brown, with whitish roots (0.80 m)
9 — Sands, consolidated, grey-brown, with calcareous tubes in the form of roots (0.50-0.60 m)
8 — Sands, consolidated, with a large amount of Helix (0.80 m)
7 — Brownish material (0.10-0.30 m)
6 — Sands, consolidated, greyish-brown, with fragments of Helix and with calcareous concretions in the form of tubes and roots mixed with sharp-edged, gravelly, brown intercalations (0.60 m)
5 — Sandy crusts, brown, with fragments of Helix (0.10 m)
4 — Fine sands, consolidated, with Helix (0.05-0.10 m)
3 — Sands, grey, with Helix (0.20-0.30 m)
2 — Sands, brown (0.10 m)
1 — Basaltic tuffs, red

When I visited the sand-patch in 1977 I saw partially similar geological profiles in different layers of the sand-patch, some in higher, others in lower sand-pits. In my opinion the above shown geological profile has developed as follows:

On the basaltic tuffs of the Mio- and Pliocene reddish soil (= level 1) formed. On level 1 wind blew up some sand. It is brown, perhaps because of tuffaceous material among its components.

The origin of this sand and any other sands of the higher levels is not clear. Since HARTUNG (1864) there have been a fair amount of conceptions about the former «landscape» N of the N coast of today, partially based on the fact that there exists a large submarine platform 70-100 m beneath sealevel, on which no exact stratigraphical and geophysical investigations have ever been made. HARTUNG (1864)

discusses extensively the possibilities as to how the old N coast of the island of Madeira and the peninsula of Ponta de São Lourenço could be imagined. He, however, comes to the conclusion that it is not possible to do this, as in some places the inclination suggests that the former land reached 8000 feet to the N and close by another inclination suggests that the land reached 18 400 feet into the sea of today. He also points out, that «only the destructive power of the sea and the resistance of the lower layer beaten by the waves is important. The masses above tumble down by themselves, however compact and high they may be». (HARTUNG, 1864: 17). It is still believed (MITCHELL-THOMÉ 1979) that the platform developed by the sinking of the N landscape down into the earth, while others believe that the platform shows the final state of an intensive erosion of that N landscape caused by the sea. Following HARTUNG (1864) MITCHELL-THOMÉ (1976) points out that marine fossils «were pulverized by the waves at a time prior to the progressive sinking of this part of the coast and the development of cliffing, and were later thrown up upon the strand as comminuted shell fragments, winds transporting the material up and inland to present heights. As per this explanation, therefore, these calcareous sands are naught else but indeterminate fossil débris.» (MITCHELL-THOMÉ 1976: 128).

GRABHAM (1948) presents two sketches to illustrate these opinions. His «diagrama 10» shows the actual situation, but does not correspond to reality, for the sands are not only deposited on the top the landscape at the N coast, but down to the S coast in very thick layers. Also the cliff at the N coast slopes vertically down to the sea, whereas GRABHAM (1948) shows the coast with a concave mould at its lower part.

If HARTUNG (1864) and his succeeding investigators of the sandy landscape of the Ponta de São Lourenço were right, the sands of the sand-patch would have to be very old, as the sands would have to have been deposited at a time before the sinking or the erosion of the presumedly old N part of the peninsula had started extensively. As the submarine platform extends 4.5 km into the sea to the N and must have worn down mountains up to 3-400 m height above sea level (KREJCI-GRAF 1961 and similarly HARTUNG 1864), we must strongly suggest that the point, where the sinking or erosion started — and the sand deposition ended — was a very long time ago.

However, my paper demonstrates that the sands are very young and were deposited presumedly during the Würm-glaciation period. At that time sinking or erosion had already greatly altered the N landscape (if it ever existed)!

Only HARTUNG (1864) also considered the other submarine platform of 70-100 m beneath sea level, but in front of the S coast of the peninsula and extending 2 km into the sea, i.e. half as far as the one of the N coast. Therefore the ridge of the Ponta de São Lourenço

does not run along the middle of the submarine platform. It also would not seem strange that, following the conceptions of the erosion of the N coast, the surge has produced a cliff of 100 m height there at the same time at which the surf at the S coast produced a «cliff» of only 1.5 m height along the coast of the sand-patch!

Perhaps we should consider the whole submarine platform as a base of an old part of the island of Madeira, which was eroded in the Pre-Miocene. Later, in the Mio- and Pliocene, a small mountain range of volcanic material was formed and this range was not broader than double the width of the peninsula of today. As the submarine base of the Ponta de São Lourenço is connected with that of the Ilhas Desertas, SE of the peninsula, investigations of the submarine platform of those three isles will be of great significance for these considerations. Perhaps the dynamics of some volcanic events blew away parts of the original N coast of the Ponta de São Lourenço and helped to prepare there the site of today. This will be discussed below.

Also the hypothesises of HARTUNG (1864) and his successors and later GRABHAM (1948) give no explanation for the fact that the sands have been accumulated to that thickness only at the area of the sand-patch. If these authors were right in their theories regarding the old landscape we would have to expect this same landscape along the whole N coast of the peninsula and other parts of the island to have been composed of sand-layers, which, in reality, is not the case.

Therefore, I believe that the whole of the Ponta de São Lourenço was, during the Würm-glaciation period, a small peninsula which changed its appearance occasionally and that this area was originally sometimes not in the position where it is today, having the appearance of a roof, sloping from the top in the N to the gutter in the S. The geological map shows the peninsula to be divided in various areas with their boundaries straight across the Ponta from N to S. I therefore believe that the different parts developed in different ways and the positions we find them in today are due to tectonic movements, either separately or as a whole, perhaps at one time separately, and at another all in one.

Perhaps the former volcano in front of the N coast of the sand-patch was involved in the beginning of the development of the sand-patch. Today we see only some basaltic columns, which spread outward at the flat top of the hill. The semicircular inlet at the coast suggests that at some time long ago there occurred a big explosion which changed the landscape there and left some rocks standing in the sea. The waves destroyed the remains, but the more recent rocks are still to be seen. There may also have been at times large platforms free of water in front of the N and the S coast, as described below. Today we find such distinct platforms at the E foot of Nossa Senhora da Piedade near a modern villa. On these basaltic platforms I saw large colonies of seapocks, which may also have provided calcareous sand.

There is also a strong, dry wind from the S, but the winds from the N blow more frequently. The layers of the sand in the S parts of the sand-patch are less thick thar those at the N rim of it. This may also indicate, that the sand came from the S. MITCHELL-THOMÉ (1979) points out that the prevailing winds at the Ponta are at present blowing from the SW.

Dunes have the same profile as the sand-patch in its N-S cross-section: on the flat windward side the wind blows the sand upward, at the steep leeward side the sands drop down.

Now, in my opinion, the floor of the sand-patch at Nossa Senhora da Piedade was in a deeper and flatter situation when the patch began to develop. The brown sands overlying level 1 were perhaps blown off from the tuffaceous material nearby. There may have been less or no vegetation.

In the beginning of the next phase the sea gave way to a large plain in front of the S shore, which became mostly dry. That may have been during the first part of the Würm-glaciation time, when the level of the sea had gone down all over the world by 70 m below the level it is today. ZBYSZEWSKI et al. (1975) even state that the sea-level at that time was 100 m below that of today around the Ponta. They think that the sand-masses were transported to the sand-patch by NE winds. But the configuration of the surface of the Ponta de São Lourenço in this part of the peninsula makes such transport from NE impossible, because a small plateau lies as a high barrier exactly there and prevents the sand-patch from receiving sands from that direction. Besides, the evidence of the above mentioned N-S cross section of the sand-patch stands against the theory of sand transport by NE winds.

On the mostly dry, large plain in front of the S shore of today molluscs and other animals settled, their shells were broken up by the wind and perhaps by water too, and were later blown to the area of the sand-patch. On level 2 the grey sand of level 3 was deposited, first more coarse-grained, then in level 4 finer, perhaps due to change in intensity of the wind. After the deposition of level 5, i.e. about 0.5 m of material above level 2, the climate and the environment changed from that of the deposition time, perhaps it became moister and warmer. Soil formed, the sand turned brown, the calcareous components of level 5 disolved and migrated down to level 4, which became consolidated by the lime on top. The process of browning of the soil involves vegetation. The German pedologist MÜCKENHAUSEN (1962) pointed out, that the Central European Parabraunerde takes 2000-2500 years to develop. The development of subtropical soils may be quicker than that of Parabraunerde, on the other hand the «sandy crusts» on top of level 5 show that there have been dry climatic periods too. Therefore we should not think of the period of soil development as

short. Perhaps it was connected with an interglaciation period and a rising sea-level.

After those periods the sea-level may have fallen again and the deposition of sands may have begun once more, starting at level 6 and stopping after level 7 with a thickness of 0.7-0.9 m and with another soil in the process of developing. It seems that trees and bushes grew on the soil: the «calcareous concretions in the form of tubes and roots» in level 6 are their remains.

Such calcareous tubes and roots in calcareous sands, mostly of the Quaternary, have been found also in other semi-arid and semi-humid parts of the world with formerly similar climatic conditions during periods of the Post-Quaternary. Osteocollae, as they are called, were first described from Central Europe, where they were used as medicine from the end of the 15th century to the end of the 19th century to heal broken bones, because of their similarity with them. They indicate subfossil vegetation at the places where they are found, and provide much information on the soil there. The author is dealing with this topic in an extensive paper to be published presently in two parts (ZIEHEN 1980-81).

The climate of that time was again moister than during the time the deposition was going on. Again the process of soil-development brought solution of lime into the uppermost horizons and migration downward. The sands in level 6 consolidated in nearly the same manner as formerly the sands of level 4. Perhaps there was another interglaciation period and another rising of the sea-level.

The sea-level went down once again, the plain in front of the shore dried up again and the wind started blowing again in the direction of the land. Levels 8 and 9 were deposited, the two together measuring 1.40 m in thickness. We find osteocollae and all other mentioned phenomena were put in motion once more (vegetation, soil development, consolidation, climatic alterations, etc.). But we must not think that the consolidation of level 9 took place at the same time as the process of soil development. It is possible that it happened after the deposition of level 10, which is brown again. It may be that the grey colour indicates a calcareous crust in process or that the soil should be considered something similar to the European Pararendzina or that the whole of level 9 is not independent soil but the border, the turning from the brown sands of level 10 to the grey sands of level 8, which did not turn brown. The «whitish roots» of level 10 suggest connections with the «calcareous tubes» of level 9. These considerations show that we cannot be sure if the sands of level 10 belong to a separate deposition period or if they are the uppermost horizon in the succession of levels 8-10 together. In the case of levels 3-5 we had already a succession of 3 horizons for one period. The consolidation of level 10 seems to be a secondary one in connection with levels 11 and 12.

These two levels of together 1.2-1.7 m thickness formed the next

period. The brownish yellow colour of the soil seems to indicate a typically subtropical soil on calcareous material. I have studied such soils with osteocollae also on the Mediterranean isle of Formentera (ZIEHEN 1981). Level 12 consolidated perhaps in connection with processes in level 13.

This level 13 shows the only clay in the whole succession of the profile. Perhaps this level was connected with levels 11 and 12 in a way that level 13 was the uppermost or A-horizon, level 12 the so-called B-horizon, and level 11 the C-horizon. When I visited the sand-patch in 1977 levels 13 and 12 were not evident to me. I was not aware of this problem at that time, as I received the publication of ZBYSZEWSKI et al. (1975) after my visit. The exploitation of sand-pits has of course destroyed their profile.

But I saw a brownish yellow soil horizon with osteocollae overlain by dark-red clayish material in the walls of the road leading the visitor to the sand-patch. This profile is situated about 100 m before one reaches the sand-patch and 15 m above levels 12 and 13. If we assume that the profile at the road and the profile of the levels 11-13 in the sand-patch developed at the same time, then the present situation of the two supports my opinion that there have been tectonic movements by the side of the sand-patch during its development.

The decay of level 13 into clay indicates that after the deposition of the probably originally sandy material of this horizon there was a period, which interrupted the sedimentation for a considerably longer period than in former times of soil-development in the profile. Also, the process of decaying seems to have been very intensive.

An interpretation of level 14 seems to be difficult, especially because the sands are described as «loose». Also, nothing is said as to how coarse they were. The fact that they are described as loose, suggests, that they are mixed with tuffaceous material, perhaps?

Levels 15 and 16 represent the next period, together they are at least 3.3 m thick, and they also contain osteocollae. The last two periods were first levels 17 and 18, together 1.5 m, and then levels 19 and 20, together 2.4 m. Perhaps — the words «calcareous cementation» suggest it — level 18 had a subfossil calcareous crust on top. When I visited the sand-patch in 1977 I also saw many subfossil calcareous crusts at the borders of the earlier soil horizons, sometimes even within, which give good indications of the surface of the sand-patch landscape at their time, but these profiles in the sand-pits were situated at places rather different from those of 1970 and 1971, when ZBYSZEWSKI et al. investigated there.

It is remarkable, that the profile of ZBYSZEWSKI et al. does not show a calcareous crust on top. I saw calcareous crusts everywhere on top of the sand-patch, where the landscape was not destroyed by the presence of sandpits or other interference by man (for example the building of water-channels («levadas» in Madeira)); KREJCI-

GRAF (1961) describes calcareous crusts on top of the sand-patch too. These calcareous crusts are very important as they protect the surface and the sands of the sand-patch against erosion. In the calcareous crust on the surface we find the so-called arbustos calcificados and branqueiros of the Madeirans, i.e. trunks and roots of trees of a former wood, which grew there at a time before the middle of the 16th century.

We may assume this because the Portuguese priest and historian FRUCTUOSO pointed out, in his description of Madeira (1590), that the landscape near the above mentioned village of Caniçal was as flat as a pan-cake and that he saw woods on the mountains between Caniçal and the next village to the SW, Machico. We may assume therefore, that he would have mentioned woods on the Ponta de São Lourenço if there had been any at that time.

Such osteocollae as mentioned by ZBYSZEWSKI et al. (1975) I also saw in other profiles of the sand-pits in 1977; they were always there in abundance. To the back of the sand-patch, at the very steep N coast which drops 40-50 m down to the underlying tuffaceous and basaltic cliff the calcareous crust of the surface with its calcified trunks and roots of the former wood covered the sand-layers too.

In connection with the interpretation of levels 12 and 13 of the profile by ZBYSZEWSKI et al. (1975) I mentioned two similar soil-horizons at the road which leads to the sand-patch. These two soil-horizons are overlain by three further soils. They are composed of the reddish tuffaceous material of that area of the Ponta and they are both together about 2 m thick. In the profile by ZBYSZEWSKI et al. (1975) we had three soils too, the levels 15-20, but they measured 6.10-7.20 m in thickness and consisted of grey sands! This is striking evidence that the development of the sand-patch was separate from that of the neighbouring parts of the Ponta. The top of this profile at the road is presumedly about 10 m higher than the top of the profile by ZBYSZEWSKI et al. (1975). Both the differences between the altitudes of the sand-patch S of the presumed place where the profile by ZBYSZEWSKI et al. (1975) lay, and the altitudes of the tuffaceous area W of the sand-patch are different too. On the other hand, the differences between the altitudes become less the more one gets N to the rim of the N coast. The two above mentioned valleys to the W and to the E of the sand-patch are very deep near the S coast, but their heads — the place is situated remarkably deep — are situated a short distance S of the N coast. Their shape demonstrates that they are not watermade, but are faults. The W valley is perhaps a stretching fault, it seems to be the pivotal point for the whole site of the hill of Nossa Senhora da Piedade. Perhaps such tectonic movements are very old in this area of the Ponta and the pressure exerted by them caused the birth of the volcanic hill of Nossa Senhora da Piedade. This birth took place earlier than the development of the sand-layers

of the sand-patch, as we find sands on the slope of that hill too.

The interpretations of the profile by ZBYSZEWSKI et al. (1975) and of my own investifations in 1977 show that there are 7 soils in the sand-patch on the Ponta de São Lourenço, i.e. levels 5, 7, 10, 13, 16, 18, 20 (It is not clear, if we should think of levels 9 and 14 as original soils). Comparison with profiles of the Quaternary in other parts of the world, where likewise horizons such as here in 7-9 can be found, may possibly result in interesting conclusions.

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