CATASTROPHE ON AN ENCHANTED ISLAND: FLOREANA, GALÁPAGOS, ECUADOR

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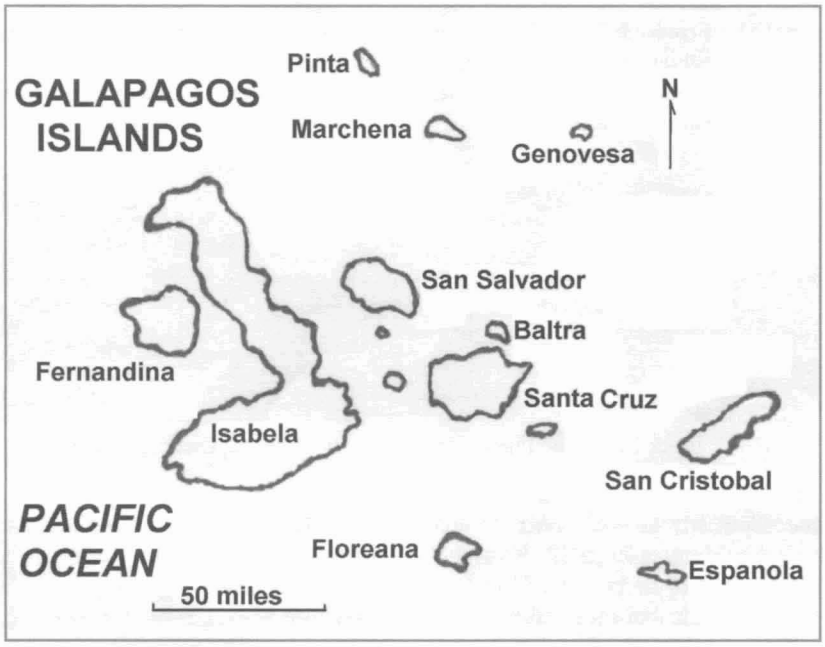
"The thick fog that had settled over the island dispersed. I recognized the sea once again. It had turned an ugly, brownish-yellow soup, coloured from the island's soil. It seemed as if there was no more soil left on Floreana. On the shore, I saw only stones. Stones...stones...."

Margret Wittmer's description of the consequences of a strong El Niño rainfall at Black Beach on May 1, 1953 (Wittmer 2004:327).

The Humboldt Current first runs toward the equator parallel to the South American Pacific coast and then, near the equator, it is driven westwards to the Galápagos Islands. These waters possibly bring about the highest biological productivity on earth. The current around the Galápagos Islands became known as "La Niña".

If the east wind dies around the equator, the upward trend of the cool water will be blocked by warm, nutrient poor, surface water flowing back from the West Pacific Ocean and then the biological productivity in the East Pacific decreases dramatically. At the same time, rain-bearing air masses flow eastward, leading to excessive rainfall in the dry areas just west of the Andes. This ocean current and wind flow cycle happens regularly about every three to eight (or sometimes more) years, an it usually starts at Christmas time and goes on for many months; it is called "El Niño" by oceanographers and climatologists. The name is explained by the starting time of these events for El Niño is Spanish for Christ Child. Misleading and tautological is ENSO, an acronym used synonymously for El Niño – Southern Oscillation (Philander 2004, Schönwiese 2003).



Map of the Galápagos. Names for the islands have varied over time. The Galápagos were officially claimed by Ecuador in 1832 and "Charles" Island was renamed Floreana after the president of Ecuador [*ed*].

The ocean current and wind flow conditions just described continuously and cyclically change in the atmosphere both above and in the tropical and subtropical South Pacific Ocean. One cycle is a succession of El Niño and La Niña conditions alternating with normal conditions, in which the ocean current streams from east to west near the equator, and the wind flows in the same direction.

El Niño situations differ significantly with regard to their temporal and spatial course, their duration and intensity, and the local, regional and global consequences. Some El Niño situations are hardly measurable; however, a "Super-El Niño" situation can cause a temperature increase of up to 5° to 6° C in the Pacific along the Peru coast (Philander 2004, Schönwiese 2003). Anomalies in the air temperature and rainfall occur as well. Arid regions can receive a remarkably high amount of precipitation, whereas an area that normally receives a lot of rain can be drought-stricken.

In the past thousands of years, El Niño's intensive rainfalls have completely infiltrated into the volcanic rocks at many Galápagos islands. The soil and young hard rocks were not very water permeable, and local runoff was only possible during intensive rainfall. The intensive washing away of soil was prevented by the thick vegetation and the raw, uneven ground surface. Only the eruption of volcanoes, especially on the western islands of the Galapagos archipelago, was able to create new areas for the formation of runoff. The rawness of the lava surface and the permeability of the stones allowed the runoff, with very little suspended matter, to infiltrate after a short flowing distance. The high resistance of the hard lava against erosion prevented the formation of gullies.

Domestic animals (goats, donkeys, cattle, horses, pigs, dogs) that were released by European visitors and settlers from the 16th century on changed this stable situation. Since they had no natural enemies, these animals reproduced sig-

nificantly, and many were no longer domesticated. The now-wild animals (Figure 1) increasingly destroyed the vegetation and, in local areas, compacted the predominantly thin soils at the surface. This resulted in small amounts of surface runoff during strong rainfalls; erosion became relevant in some animal paths, where rills cut in.

The direct and indirect consequences of human interventions were very serious for vegetation and fauna, but initially did not crucially modify the soil, water and nutrient balances of the Galápagos Islands.

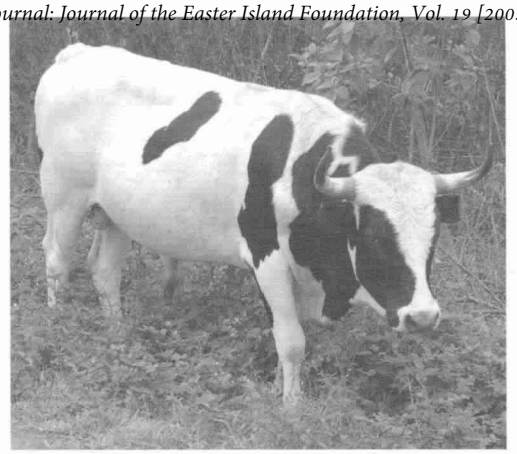


Figure 1. Wild cattle in the highlands of Floreana.

Floreana, one of the southern islands of the Galápagos Archipelago, has an especially interesting history of settlement and land usage. The authors investigated the effects of human actions on the landscape and the soils. Whereas the highlands and the north coast of Floreana were temporarily settled in the 19th and early 20th centuries, the west coast remained uninhabited until the mid 20th century. The Berliner dentist, Dr. Friedrich Ritter, lived on Floreana from 1929 to 1934 with his partner, Dore Strauch, until this vegetarian died of food poisoning from eating meat.

The settlement on the west coast, farming, and growing fruits, the cultivation of the land by clearing, creating roads and paths, fires, as well as the inhabitant's growing need for wood, changed the vegetation more than ever before. The protection of the soil was lost at several sites. For the first time in thousands of years, the strong rains of the El Niño in 1952-3 effected not only the vegetation and fauna, but also the soil, as was vividly described by contemporary witness Margret Wittmer (2004: 320 ff.):

"The water ran in streams down the mountains. [...] The road to the farm is, at places, a thirty-meter wide river. [...] Rivulets flowing from the heights tore the ground apart and washed it away. The sea was coloured brown for miles. The water dug deep gullies in the loose earth all around my henhouse. [...] The ground in front of my kitchen door was washed up almost one meter high."

Figure 2. Black Beach and Puerto Velasco Ibarra, Floreana, Galápagos, Ecuador

Heinz Wittmer left Cologne, Germany to settle on Floreana with his son Harry and his wife Margret in 1932. Rolf and Inge Wittmer, the first children ever to be born on Floreana, still live on the island. The Viennese baroness Eloisa von Wagner-Bosquet lived on the island with her many lovers from 1932 until she disappeared without a trace in 1934 (Wittmer 2004). First of all, Ritter, Strauch, the Wittmers and the baroness with her lover settled in the humid highlands in an altitude from about 300 to 350 m above sea level in order to farm the land and plant gardens as well as to hunt the now-wild animals for meat. The Wittmer family constructed the first building in the west on Black Beach after the 2nd World War in order to ship produce from the highlands and to accommodate tourists. A small settlement named Puerto Velasco Ibarra came into being (Figure 2); in 2004, about 80 people lived in this settlement. A flourishing exchange of goods developed between the fruitful semi-humid highlands and the semi-arid west coast. The highland's fruits were transported to the inhabitants of other Galápagos Islands as supplies. Many wealthy tourists visited the Wittmers on the west coast and the highlands.

Margret Wittmer fought for her life and saved her animals and possessions from being washed away by the streams of water coming down the mountains on Black Beach on May 1st, 1953. Cut off from her family, who were trapped in the highlands because of the extreme situation,

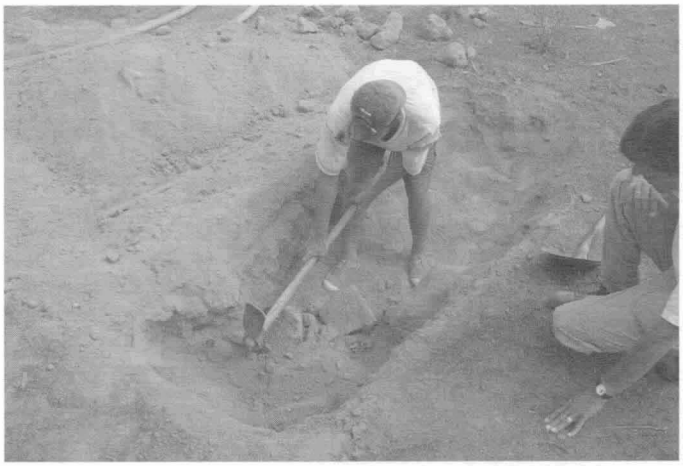


Figure 3. Exposure with debris cover and brownish soil (Cambisol)

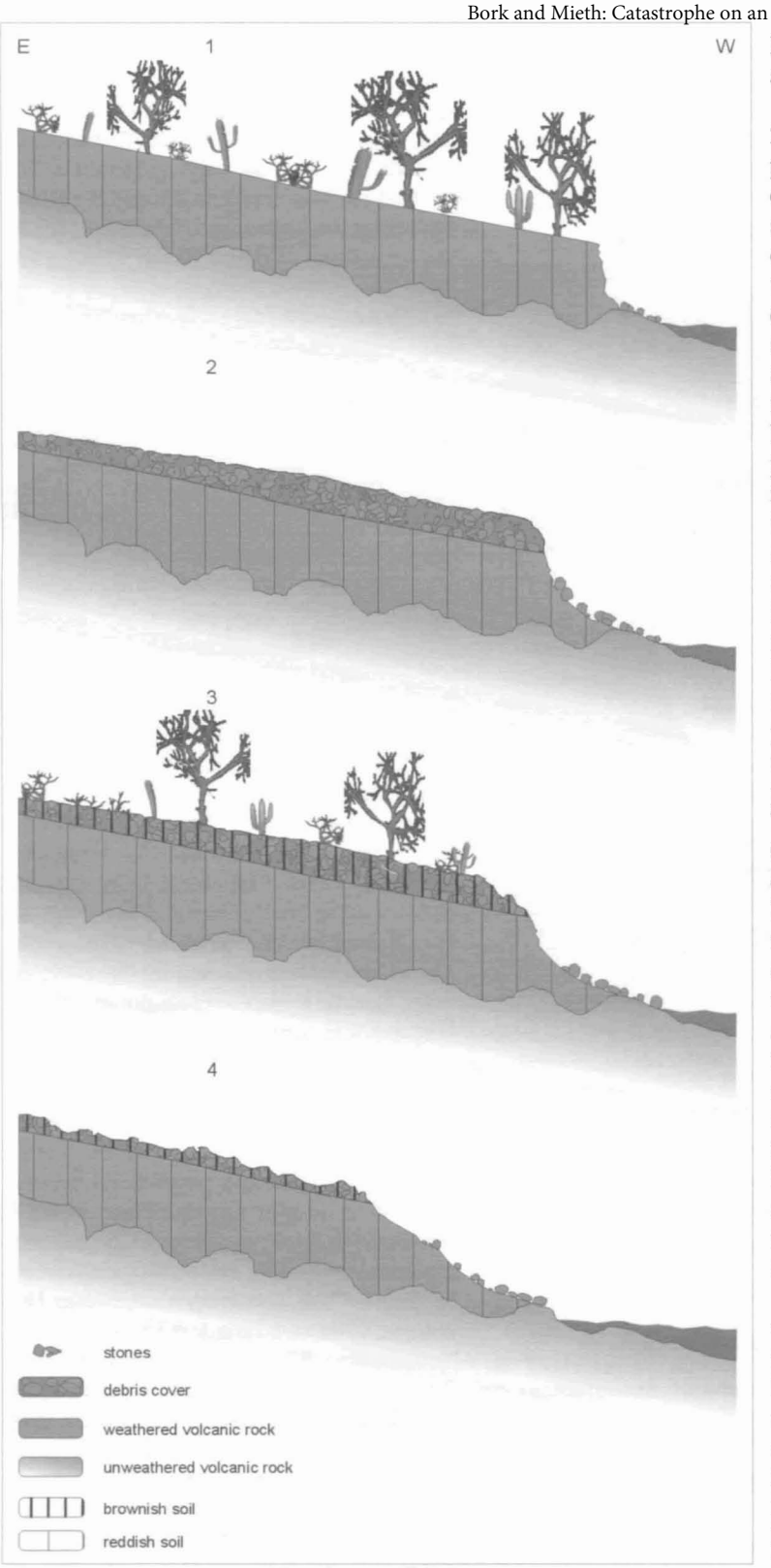


Figure 4. The development of the slopes near Black Beach in the west of Floreana - longitudinal profile of the slope near the coast
Phase 1: Development of an intensive reddish-brown soil during the Younger Pleistocene
Phase 2: Deposit of layers of debris in the end of the Pleistocene
Phase 3: Development of a brown soil in the layers of debris (Cambisol)
Phase 4: Runoff wore away the layers of debris at some sites and eroded gullies during the El Niño of 1952/3

Margret Wittmer had to wait two days until the damaged roads were passable.

With the support of Inge Wittmer in September 2004, the authors successfully searched the Wittmer's property in Puerto Velasco Ibarra for the extraordinary effects of the many strong El Niño rainfalls such as described by Margret. In 1952-3, fine sediments were eroded from a large brown silty layer of debris in the west of Floreana (Figures 3 and 4). Stones have covered the ground surface ever since. At the same time, stones with a diameter of many decimetres were eroded and washed into the Pacific. Rills and gullies were formed by erosion south and west of the Wittmer's henhouse. Layered brown sands were filled in completely during the El Niño of 1953. The sand contained relics that definitely date to that time period, such as fragments of broken pottery, worked metals and plastic, and even older ceramics. Thor Heyerdahl visited Floreana with the Norwegian archaeologist Arne Skölsvold in 1953, and found relics of visitors that were there before the Spaniards. During their visit, the rills and gullies on the Wittmer's property were created by erosion (Figures 4 and 5). Margret Wittmer found broken pieces of pottery in the gullies (Wittmer 2004:320); these fragments of broken ceramics were not only proven to be pre-Spanish (the Bishop of Panama, Fray Tomas de Berlanga, accidentally discovered the Galápagos archipelago in 1535), but were proven to be definitely pre-Incan (Heyerdahl and Skölsvold 1956). Unfortunately, the Heyerdahl expedition was not able to identify the location from where the pottery had eroded from and was not able to find the location where the ancient people may have stayed or settled. South American fishermen probably visited Floreana in the first thousand years before, or the first thousand years, after Christ in order to fetch precious drinking water from the only spring in the highland. A certain talent for observation was needed in order to find the small, hidden spring; the first visitors probably followed paths made by the giant tortoises that led from the coast to the spring – just as the Spanish did centuries later (Darwin 1986: 268).

The El Niño of 1952-3 was the first to leave still-visible traces in the landscape. Neither of the El Niños from the centuries in which humans interfered with the landscape, nor the thousand of years earlier than that in which humans did not interfere with nature, caused erosion and sedimentation that can be detected today. Two theories could explain this. The first theory is that the incident in 1952-3 was far stronger than all others that had happened during the Holocene and, thus, it was an El Niño incident that only happens once every thousand or ten thousand years. Findings that confirm this theory have not been located for the Galápagos archipelago nor for the neighboring areas; moreover, this El Niño tended to be weaker in this area (e.g. Philander 2004, Schönwiese 2003). The second theory is that human interference in the middle of the 20th century was so strong that the surface of the investigated area in the

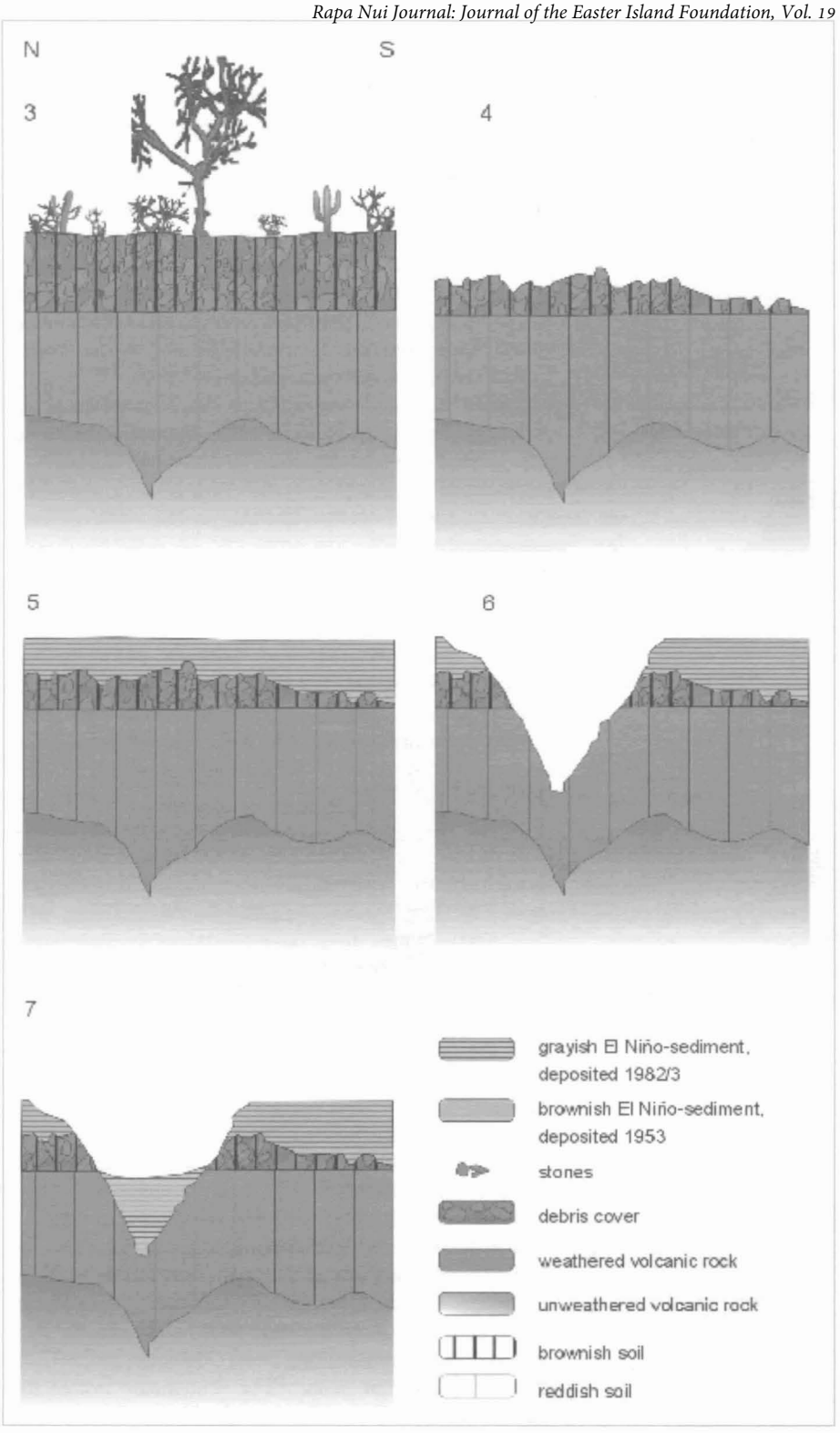


Figure 5. The development of the slopes near Black Beach in the west of Floreana - short profile parallel to the coast
Phase 3: Development of a brown soil in the layers of debris (Cambisol)
Phase 4: Runoff wore away the layers of debris at some sites and eroded gullies during the El Niño of 1952/3
Phase 5: Brown sediment filled in the small gullies in 1953
Phase 6: Runoff eroded gullies during the El Niño of 1982/3
Phase 7: Grey sediment partly filled in the gullies in 1983

west of Floreana was destabilized by strong rainfalls for the first time in ten thousand years. The many changes in the vegetation after the 2nd World War confirm this theory. In this way, inhabitants destroyed the vegetation in the small strip of land from the west edge of the highlands to the west coast of Black Beach, about 3 km away.

The authors' excavations confirm that a second system of gullies, even deeper and wider than that of the rills and gullies in 1952-3, was created in a later period of runoff and erosion. The runoff took place mainly on paths between the highlands and the west coast where the surface lacked vegetation and was compacted. Especially steep and compacted sections of the paths were eroded locally by the runoff. The largest investigated gully lies on the south end of Black Beach and is more than 12 meters wide and more than one meter deep. Stones in the browned layer of debris were eroded and washed into the Pacific. The loose brown sandy fillings from the El Niño of 1952-3 were eroded as well. Layered, grey sediments were only partly filled in the gullies by some runoff. Therefore, some are still visible today in the surface just west of Black Beach. The Wittmer family observed this strong change of the environment during a super El Niño in 1982-3 (Figures 4 to 6).

The damage caused by this devastating El Niño totaled more than $10 billion worldwide. Eastern Australia was drought-stricken. Melbourne recorded the driest summer in 200 years. A storm deposited more than 11,000 tons of dust on Melbourne in only 40 minutes. 3325 mm precipitation fell at the meteorological station in Santa Cruz (Galápagos) between December 1982 and June 1983 instead of the "normal" 374 mm. (Schönwiese 2003:199). In the seaport of Guayaquil, Ecuador, thirteen times more rainfall than normal was measured. This resulted in an intensive geomorphologic activity: landslides, gullying, and streams of mud that destroyed buildings and streets on the west coast of South America (US Army Topographic Engineering Center, 2004). The excavations on the Wittmer family's property at Black Beach, Floreana, show that serious changes in the vegetation, soils and landscape caused by human interference are required in order for extreme El Niño weather events to affect the soils and the

surface, even in semi-arid climates. Because many humans visited and many wild (once-domestic) animals grazed Floreana four hundred years before the settlement period, the indigenous flora, vegetation and fauna was changed dramatically. However, the soils and the form of the surface hardly changed – evidence that the geomorphologic system of this island near the equator is surprisingly stable.

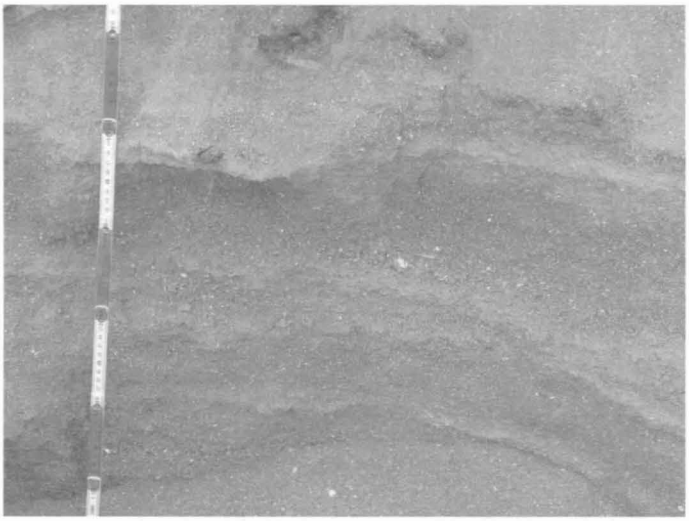


Figure 6. Grey sediment partly filled in the small gullies in 1983.

Can the devastation of the land, such as has taken place with the El Niño of 1952-3 and 1982-3 but did not happen in the west of Floreana in the thousands of years beforehand, be prevented in the future? It is to be expected that the number of tourists travelling to Floreana will increase. The destruction of the vegetation and the compaction of the surface between the highlands and the settlement of Puerto Velasco Ibarra made it possible for floods to demolish and cover the small village in the second half of the 20th century. The single road that runs between the highland and the village has a course that enabled intensive formation and concentration of runoff. The destruction caused by soil erosion, which is unstoppable during El Niño years, can only be met with considerable labour and much repair work. In the long run, the route of the road should be moved. The course should meander and the inclination of the road surface should change constantly in order to prevent the accumulation and concentration of runoff over long distances. A large area around the road between the west edge of the highlands and Black Beach should be temporarily fenced in to reduce damage caused by feral animals. These animals should be eliminated completely; hunting by qualified foreign hunters could have a positive effect on the conservation of nature and the economy of the island if the income is used to support the work of the nature conservation management. Except for the highlands, the road, the small village and the few pathways for tourists, human interference should cease completely in the long run. The number of inhabitants should not increase to more that it is now. Education in environmental problems should be an important topic in the school curriculum and in the adult education on the island. Intensification of the pasturing, as well as the garden and agricultural usage of land, and the possibility of individual touring will cause unwanted changes in the landscape and, in this way, destroy the foundation of tourism and the nutrition of the inhabitants. In the long run, a development difficult for humans to determine with a strongly decreased biodiversity is to be expected for this negative scenario.

Acknowledgements

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