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OUTLINE OF MAN'S IMPACT ON THE NATURAL ENVIRONMENT IN CENTRAL MEXICO

By Klaus Heine*

I.

During the Ice Age, when the sea level was lowered (submerged sea levels lay 17,000 years before present -130 m to -170 m in Australia and -90 m to -130 m off north east America)[1], Asian people could pass the Bering strait between Asia and Alaska. From there they spread all over North, Central, and South America. At some sites in Mexico bones of mammoth and other early-dated extinct Pleistocene faunal assemblages were found associated with human artefacts. The Tepexpan skull of the Basin of Mexico was thought to be the first Mexican for many years, but nowadays we have evidence of much older human sites.

The stone age hunter did not influence his natural environment in Mexico. Yet, as early as 5,000 years before Christ the people of Mexico began to cultivate different plants[2]. Primitive irrigation schemes were built more than 4,000 years before present. Therefore, we must be aware of the influence of men on the natural environment – on purpose or unintentionally. During thousands of years civilizations developed and declined, migrating people reached the Central Mexican Highland; breakdowns of civilizations occurred, new ones rose. The population density varied, although through the times the number of human beings

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*) Acknowledgement: Financial support for this research was received through the Deutsche Forschungsgemeinschaft.

1) David Bowen, Quaternary Geology, a Stratigraphic Framework for Multidisciplinary Work, Oxford – New York – Toronto – Sydney – Paris – Frankfurt 1978, pp. 1–221.

2) Frederic Johnson, Chronology and Irrigation, The Prehistory of the Tehuacán Valley, vol. IV, ed. Richard S. MacNeish, Austin & London 1972, pp. 1–290. Christine Niederberger, „Early Sedentary Economy in the Basin of Mexico. New data suggest significant variants in early post-Pleistocene human occupations in Middle America", in: Science, vol. 203, 1979, pp. 131–142.

increased. The settlement or colonization of the antecedents of the modern agrarian societies led to distinct changes of the natural environment. The natural vegetation of the high plateaus was replaced by succesive plant communities that were used to poorer soils and less water. During the mid-Holocene an oak woodland flourished where today a thorn-thicket covers the slopes. Erosion has destroyed the soils where 2,500 years ago the ancient people for the first time cleared the woodland. Soil erosion – in connection with other environmental damages (e.g. lowering of the ground water table) – is due to human influence in Mexico. In the Puebla/Tlaxcala area soil erosion started at 800 years before Christ together with an extensive acquisition of land. Soil erosion has played an important role in history.

In this article I give a brief report on the role of soil erosion in the evolution of the cultural landscape of the Puebla/Tlaxcala area.

II.

A scheme of the three-dimensional development of the natural environment of the Central Mexican Highland during the late Quaternary is given in Figure 1. Full details regarding the interpretation of the scheme are given elsewhere[3]. Periods of normal or catastrophic processes, stability, and erosion during the past 36,000 years are immediately recognizable. The processes (Fig. 1), which are controlled by the bioclimatic milieu, create distinctive soils and landforms. However, before the processes are considered, the climatic criteria which determine the nature of processes need to be considered. During the past 36,000 years three major periods with high erosion intensities can be distinguished: (a) 36,000 to > 32,000 years before present, (b) circa

[3]) Klaus Heine, Quartäre Pluvialzeiten und klimamorphologischer Formenwandel in den Randtropen (Mexiko, Kalahari), Arbeiten aus dem Geographischen Institut der Universität des Saarlandes, vol. 29, Saarbrücken 1980, pp. 135–157.

12,000 years before present, and (c) 10,000 to 8,500 years before present. These periods with high erosion intensities coincide with climatic changes from relative aridity to greater humidity. Figure 1 shows that there is no synchroneous development of the trend of the temperature on the one hand and of the trend of the humidity on the other hand. The temperature curve for the last 36,000 years before present is marked in the tropics of the Central Mexican Highland by an increase between 36,000 and >26,000 years before present, a decrease between ca. 26,000 and ca. 16,000 years before present (with the last glacial temperature minimum around 17,000–16,000 years before present), and an increase of the temperature with minor fluctuations during the period <16,000 to 8,000 years before present. The postglacial climatic optimum is reached 8,000 to 5,000 years before present. Some minor temperature oscillations are recognizable after 5,000 years before present. Under warm but not extremely humid conditions, e.g. the period between ca. 30,000 and 25,000 years before present (Fig. 1), the geomorphic processes are mainly restricted to the preparation of the material by weathering, whereas the movement of the material and its export from the catchment is confined to short periods of activity during which considerable work is done. Extremely climatological events, especially in mountain areas, played the essential role in landform development during the late Quaternary in the Central Mexican Highland[4].

The Holocene portion of Figure 1 shows that the periods of slow or fast sedimentation, stability, and erosion during the past 8,000 years before present are not exclusively controlled by climatic causes. Relatively abrupt environmental changes, such as that caused by the ‚12,000 years before present event'[5], did not occur during the Holocene, but human clearance of forests and woodland led to sudden changes in the amount of denudation. Since 800 years before Christ soil erosion in the Central Mexican Highland is considered to be a serious problem.

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4) H e i n e, Quartäre Pluvialzeiten.

5) Klaus H e i n e, "Sintflutartige Niederschläge in Mexiko vor 12 000 Jahren", in: Ibero-Amerikanisches Archiv, NF, Jg. 7, Heft 1/2 (1981), pp. 69–76.

III.

The state of our current knowledge on the erosion processes of the Puebla/Tlaxcala area is given in Figure 2. This synthesis stresses the difficulty of understanding the Holocene erosion processes that led to the impact on the natural environment in Central Mexico. Some questions will be discussed here in brief: (a) Were the geomorphic processes controlled by the climatic milieu during the last 3,000 years? (b) Were the late Holocene processes controlled by man's activity? (c) Or must we think of several processes with varying periodicities that may occasionally coincide, reinforcing one another and creating an overall tendency that is strongly unfavorable or favorable to the geomorphic processes?

More humid periods compared with today occurred between ca. 1300 years before Christ and ca. 100 A.D. and between ca. 1100 A.D. and 1890 A.D. according to the data I obtained in connection with observations on glacial and periglacial landforms[6]. Higher and/or more accentuated precipitations and higher erosion rates are not correlated unless there are modifications of vegetation cover. Relatively rapid precipitation changes may cause an accelerated development of the *barrancas* of the gorges, the debris accumulation at the end of these gorges, the debris flows, the landslides, and the solifluction processes of the ‚periglacial' belt of the high volcanoes. Figure 2 shows that the erosional processes did not increase in intensity at the beginning of the period with a higher effectiveness of precipitation. Soil erosion started only when the population growth made possible improved irrigation systems and the cultivation of marginal areas of the Puebla/Tlaxcala basin. The Tlatempa Phase (1200–800 years before Christ)[7] was characterized by 66 settlements with

[6]) Klaus Heine, Studien zur jungquartären Glazialmorphologie mexikanischer Vulkane mit einem Ausblick auf die Klimaentwicklung. Das Mexiko-Projekt der Deutschen Forschungsgemeinschaft, vol. VII, ed. Wilhelm Lauer, Wiesbaden 1975, pp. 1–178. Heine, Quartäre Pluvialzeiten.

[7]) Angel García Cook, "Una secuencia cultural para Tlaxcala", in: Comunicaciones Proyecto Puebla-Tlaxcala 10, Fundación Alemana para la Investigación Científica (fortan: Comunicaciones), Puebla 1974, pp. 5–22.

50 to >350 inhabitants. During the Tlatempa Phase no soil deterioration occurred. With the growing population density soil erosion stated during the Texoloc Phase and culminated during the Tezoquipan Phase (ca. 300 years before Christ – 100 A.D.). Studies of rates of erosion show[8] that relatively abrupt environmental changes, such as that caused by human clearance of forests and woodlands can lead to sudden changes in the amount of erosion. In Central Mexico the natural vegetation cover was removed rapidly more than 2500 years ago during the Texoloc Phase. The result was accelerated soil erosion which then occurred for the first time during the Holocene.

A second period of accelerated soil erosion started during the Texcalac Phase. After the Tenanyecac Phase of stagnation and of decreasing population, the Texcalac Phase reached another apex in the demographic expansion in pre-Spanish times. The erosion processes responded relatively rapidly to the impact on the natural environment that was caused again by the expansion of the rural population and the human clearance of the vegetation. Direct rainfall impact on the exposed soils washed much more material downslope than would have been eroded under the natural vegetation cover. This erosion period between ca. 650 A.D. and 1100 A.D. did not coincide with a period of higher precipitation; the soil damage occurred under the impact of the Texcalac agricultural technology and in response to growing food demands. There is evidence that during the Texcalac Phase the slopes of the volcanoes were intensively cultivated up to 3,000 m altitude.

The second destructive period which set in at the beginning of the Texcalac Phase continued until the colonial epoch. According to a rapid decrease in population after the Spanish Conquest[9] soil erosion damages diminished slightly. Although several minor climatic fluctuations are recorded for the Central Mexican High-

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8) Klaus Heine, "Mensch und geomorphodynamische Prozesse in Raum und Zeit im randtropischen Hochbecken von Puebla/Tlaxcala, Mexiko", in: 41. Deutscher Geographentag Mainz, Tagungsberichte und wissenschaftliche Abhandlungen, Wiesbaden 1978, pp. 390–406.

9) Wolfgang Trautmann, "Ergebnisse der Wüstungsforschung in Tlaxcala (Mexiko)", in: Erdkunde, vol. 28 (1974), pp. 115–124.

land during the last 2,000 years[10], no response of rates of erosion to climatic changes could be observed.

IV.

Figure 2 provides an opportunity to discuss the reasons for accelerated soil erosion. It is illustrated by the figure which shows not only the periods of soil erosion in relation to the different cultural phases but also in combination to some social (e.g. irrigation) and environmental (e.g. effectiveness of precipitation, vegetation history) factors, that we need multidisciplinary information in order to comprehend the multiplicity of processes involved in resolving and understanding soil erosion problems.

During the last 3,000 years before present, the geomorphic processes of the Central Mexican Highland up to about 3,000 m altitude were not controlled by the climatic milieu but by man's activity. It is possible to view civilizations as ecosystems that emerge in response to sets of ecological opportunities, that is, econiches to be exploited[11]. The study of soil erosion in Central Mexico makes clear that the responsible processes of the Tenanyecac period of decline involved at least three major factors, namely a decrease in precipitation, rural depopulation, and insecurity due to political instability. The same denominators of periods of decline are described from ancient Egypt where each retrograde phase coincided with negative social developments within, as well as negative environmental or social interventions from without[12].

In the Puebla/Tlaxcala area the rates of soil erosion demonstrate that periods of strong human impact on the natural environment coincided with phases of cultural and demographic

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10) Dieter Ohngemach and Herbert Straka, "La historia de la vegetación en la región Puebla-Tlaxcala durante el cuaternario tardío", in: Comunicaciones 15, 1978, pp. 189–204. Heine, Mensch und geomorphodynamische Prozesse.

11) Karl W. Butzer, "Civilizations: Organisms or Systems? ", in: American Scientist, vol. 68, no. 5, 1980, pp. 517–523.

12) Butzer, Civilizations.

growth when land use was intensified and many new villages were founded. Periods of decline with rural depopulation led to a minor human impact on the natural environment. We cannot decide yet, whether the periods of decline were mainly caused by damages of the natural environment and/or fluctuations of some climatic elements (e.g. precipitation), because we cannot determine lags in the response of geomorphic processes at short time scales. Four possibilities are shown in Figure 3: (1) The maximum rate of soil erosion was reached at the beginning of a colonization phase and continued until the end of the period with dense rural population, (2) the maximum rate of soil erosion coincided with the rapid extension of the rural population but diminished soon, because of the adaptation to the new parameters, (3) the maximum rate of soil erosion was reached only at the end of the colonization period, (4) the maximum rate of soil erosion was due to several catastrophic events. The examples of Figure 3 demonstrate that soil erosion may have occurred in the beginning or the falling phase or throughout it; even individual catastrophic events may have caused the soil erosion. However, although the amount of change by soil erosion is known, the relative speed (rate) of change is not.

If there were severe damages of the environment caused by soil erosion throughout the Texoloc and Tezoquipan Phases, the decline of Tenanyecac Phase might be seen in connection with man's impact on the environment. The observed sedimentary records favor the idea that high rates of soil erosion occurred between ca. 600 years before Christ and 100 A.D., i.e. during 700 years. The widespread damage of the natural environment and the diminishing effectiveness of precipitation around 100 A.D. in connection with negative social developments might have been caused the decline of the Tenanyecac Phase.

V.

Man's impact on the soil environment is felt and registered in the form of increasing sedimentation rates in the basin of Puebla /Tlaxcala over the past 2,500–3,000 years. During the last decades it appears that agricultural activities have accelerated soil erosion in a great extent[13]. The montane forests of the volcanoes in altitudes between 3,000 and 3,600 m are being steadily depleted in all areas of the Central Mexican Highland. If present rates of misuse and clearance of the forests persist – and they are likely to accelerate –, the biome, now covering the slopes up to 4,000 m altitude, could be reduced to remnant fragments within less than half a century. This would represent one of the greatest environmental impoverishments in the foreseeable future, and a biological debacle with dimensions that did not occur at any time of the Holocene. If Central Mexico's montane forests disappear within a few decades, the Mexicans will suffer by way of environmental degradation, decline of watershed services, and the like[14]. Already the Valsequillo dam is rapidly being silted up, and Mexico's mountain areas near the Gulf of Mexico have undergone excessive hurricane damage due to loss of mountain forest cover[15]. If we agree with the postulation that civilizations behave as adaptive systems[16], then the unexpected coincidence of environmental perturbation, poor leadership, social pathology, and external political stress can trigger a catastrophic train of mutually reinforcing events that Mexico's civilization is unable to absorb. If we were able to understand better the long history of the ups and downs of the Mexican civilization, we could call for relevant proposals to resolve the recent environmental problems.

13) Heine, Mensch und geomorphodynamische Prozesse.

14) Klaus Heine, Ökologische Katastrophe in Mexiko?", in: Umschau in Wissenschaft und Technik, vol. 78, 1978, pp. 491–496.

15) Klaus Heine, "Photo der Woche – Geoökologie", in: Umschau in Wissenschaft und Technik, vol. 76, 1976, p. 202. Hartmut Ern, "Bedeutung und Gefährdung zentralmexikanischer Gebirgsnadelwälder", in: Umschau in Wissenschaft und Technik, vol. 73, 1973, pp. 85–86.

16) Butzer, Civilizations.

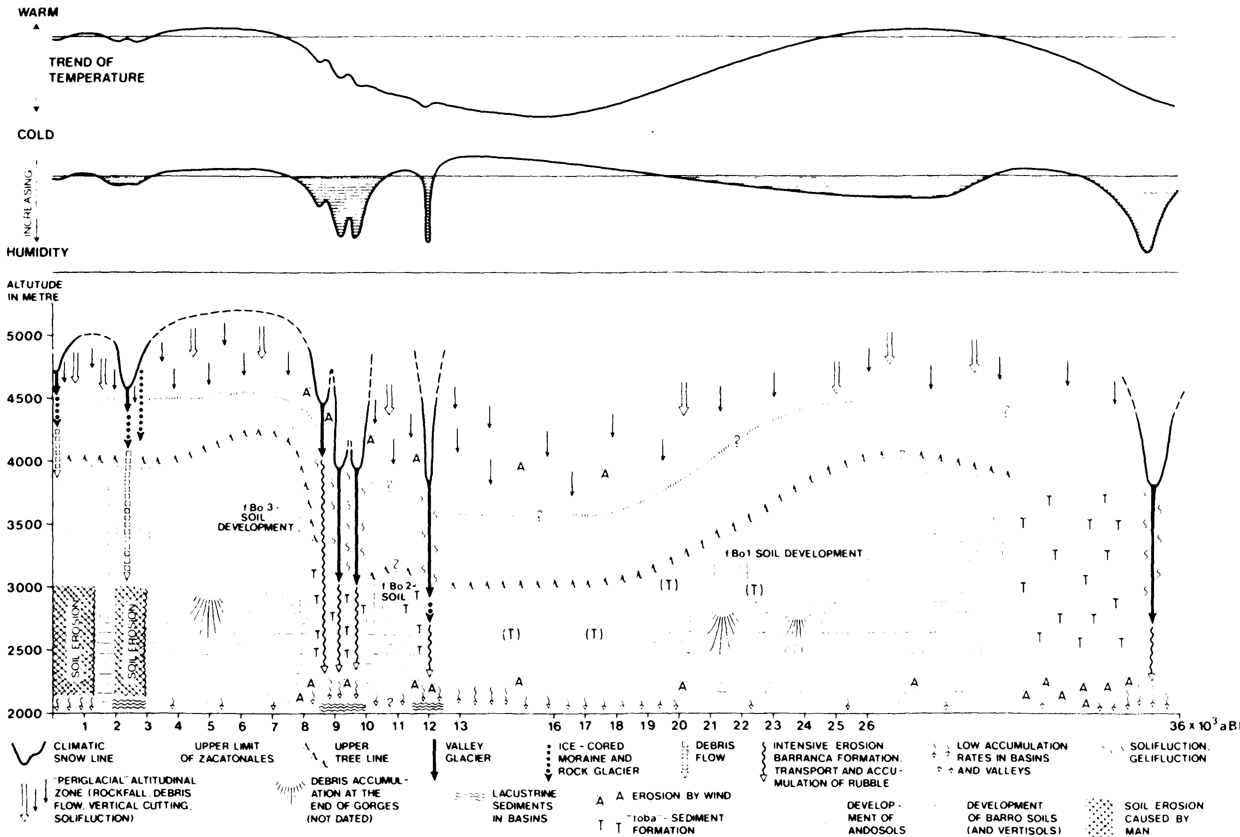
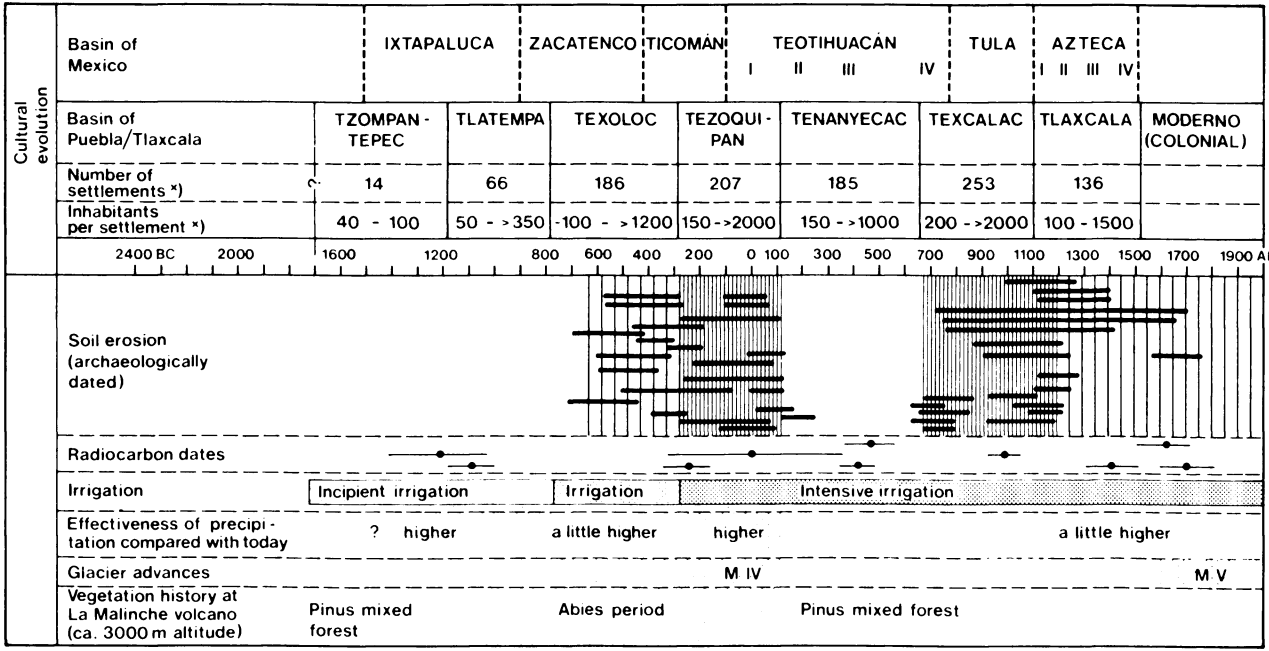


Fig. 1: Scheme of the three-dimensional development of the natural environment of the Central Mexican Highland during the late Quaternary.



*) in areas of the archaeological project of the DFG which comprise a part of the Puebla Tlaxcala basin.

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Fig. 2: Scheme of the soil erosion. The data of the cultural evolution after Angel *García Cook*, cf. note 7.

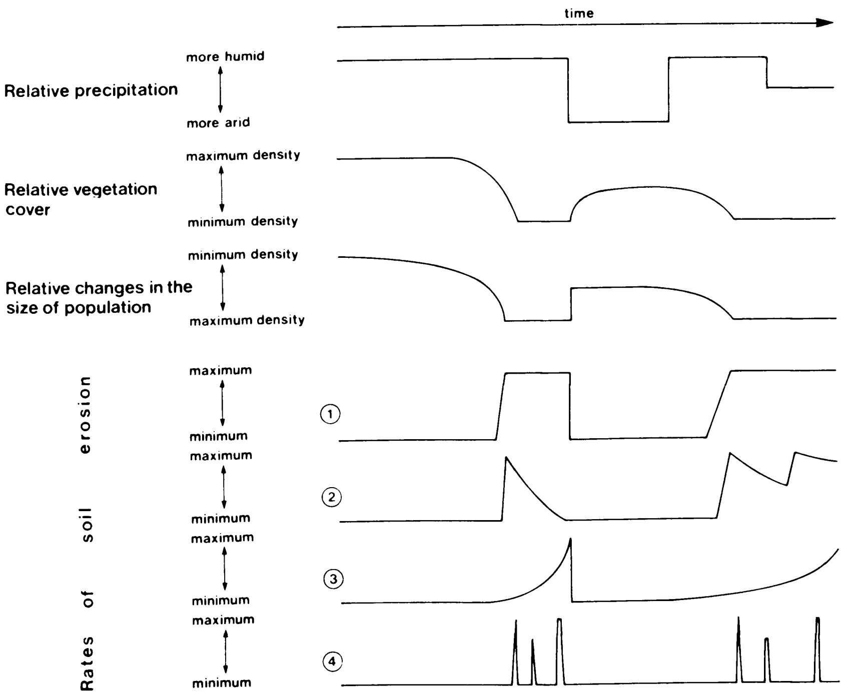

Fig. 3: Explanation in the text.