AZTEC SOIL SCIENCE

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RESUMEN

La evidencia etnográfica, arqueológica y documental indica que los pueblos prehispánicos del Valle de México desarrollaron una bien elaborada tecnología para explotar su medio físico.

SUMMARY

Ethnographic, documentary and archaeological evidence indicates that the pre-Hispanic peoples of the Valley of Mexico developed a sophisticated technology to exploit their physical environment.

Ethnographic, documentary, and archaeological evidence indicates that the pre-Hispanic peoples of the Valley of Mexico developed a sophisticated technology to exploit their physical environment. Hydrological engineering projects and agricultural systems suggest some systematic understanding of the natural environment, and the fauna and flora collections from all parts of the realm indicate a basic intellectual curiosity, which is the foundation of scientific inquiry. Much of what is known of pre-Hispanic ethnoscience in the Valley of Mexico is related to botany and hydrology, partly because of the Spanish interest both in curing practices and in continued and expanded agricultural exploitation of the Valley What is curious is that little is known of aboriginal soil science. In this paper I shall discuss the morphology of Aztec soil terms, their etymology, some aspects of the classificatory system, and finally possible contributions which the study of Aztec pedology may make in the field of ethnohistory.

As so often is the case in Mexican ethnohistory, sources are fragmentary, sporadic and dispersed. Thus, this paper is an exploratory one and does not constitute a definitve study of what I have labeled "Aztec" soil science. The term "Aztec" as used here refers to the Nahuatl speaking peoples of the Valley of Mexico at the time of the Conquest. The most comprehensive etnographic source extant on native terminology relating to soils is Sahagun's *Florentine Codex: General History of the Things of New Spain*. I have relied most heavily on the Dibble and Anderson edition although the Robledo and del Paso y Troncoso editions were also consulted. Other sources for soil terminology—both glyphic and textual—include Peñafiel's *Nomenclatura Geográfica de México,* Molina's *Vocabulario en Lengua Castellana y Mexicana,* Santamaría's *Diccionario de Mejicanismos,* Islas' *Diccionario Rural de México,* the Cruz-Badianus Herbal, and Hum-

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bolt's Fragment VIII published by Eduard Seler. None of these latter sources compare with Sahagún in comprehensiveness, and thus the major portion of what follows is based on the Florentine Codex.

In Book 12, Chapter 12, Paragraphs 3, 4, and 5, Sahagún records 55 terms "which telleth of the nature of the soils, which telleth of still other characteristics of useless lands and which telleth of a kind of earth of which are made ollas and water jars." Of these 55 terms, ten are not soil terms, which leaves a universe of 45 lexemes under discussion. Morphologically, most (75%, 35) of these terms are compound stems, one of which is *tlalli*, meaning earth or soil. In over half of the terms (25), *tlalli* is a suffix as in:

tepetlalli, derived from *tepetl*, hill and *tlalli*, meaning upland soil;
atlalli, derived from *atl*, water and *tlalli*, meaning irrigated field;
contlalli, from *comitl*, pottery jug, and *tlalli*, meaning a certain kind of clay.

In another pattern, *tlalli* is a prefix as in:

tlalzoztli, from *tlalli* and *coztic*, yellow, meaning yellow soil;
tlalzolli, from *tlalli* and *zozoltic*, worn out, meaning worn out soil;
tlaltzacutli, from *tlalli* and *tzacuhtli*, paste, meaning a pasty or sticky soil.

Only a few terms(10) are not formed with *tlalli*, but interesting'y several of them are basic to Aztec soil terminology. For example, *atoctli*, derived from *atl*, water, and *totoca*, it runs, twisted means fertile alluvium. *Xalatoctli*, derived from *xalli*, sand, and *totoca* means water-borne sand, or sandy alluvium. *Zoquitl* is clay and *tezoquitl* is gravelly clay, from *tetl*, rock, and *zoquitl*. It is tempting to suggest that terms formed with *tlalli* are contrived or technical terms used to express a soil classification, but the evidence does not seem to warrant this conclusion. Since Nahuatl is an agglutinative language, the morphology merely reflects the normal word-forming process.

But, even though the morphology of the soil lexemes does not reflect a classificatory system per se, the etymologies do indicate that various differentiating criteria were used to distinguish one soil from another. Most of these criteria are commonly found among agricultural peoples everywhere, since they are largely based on simple observation and generations of agricultural experience. The forty-five lexemes with which we are dealing may be grouped under six differentiating criteria: 1) texture, structure and consistence; 2) organic or chemical content; 3) color; 4) drainage and topographic position; 5) initial or parent material, and 6) genesis or agent. These six criteria are not mutually exclusive, but they do correspond, in general, to the primary attribute of each soil type.

On the basis of the number of terms associated with each, texture, structure or consistence, and organic or chemical content were the two most important differentiating criteria. Lexemes based on texture include the following:

tetlalli	stoney soil, gravelly soil
xalalli	sandy soil
zoquitl	clay
tezoquitl	gravelly clay
palli	special pottery clay
tlaltzacutli	fine-textured clay
teuhtlalli	top soil, loess
atizatl	white, spongy, light, airy

Four additional terms might also be considered textual terms, although their descriptions indicate only utility as an attribute. These refer to various clays as well: *tlalpantlalli*, earth from which house roofs are made; *contlalli*, clay for making jars; *comatlalli*, clay for making griddles (*comales*), and *caxtlalli*, clay for making bowls. Nahuatl textural classes, then, included stoney or gravelly soil, sandy soil, and clayey soil. There appears to have been no generic term for loams, but some textual sections of Sahagún (e. g. the description of *tepetlalli*) and the Humbolt Fragment VIII (discussed below) indicate that soil terms could be strung together, whereby loamy conditions could be described. For example, sandy clay loam might have been expressed by *xallalli, tezoquitl*. In order to test this hypothesis, it is necessary to examine Nahuatl texts to determine syntactical structures within which the terms occur.

A second important differentiating criterion was organic or chemical content. Three lexemes indicate the identification of humus:

cuauhtlalli, soil of decayed wood and leaves; *tollali,* soil of decayed reeds; and, *tlazollalli,* a general term for soil derived from decayed organic matter, or compose (from *tlazolli,* or compost heap). Two other terms refer to so-called 'useless lands": *tequixquitlalli,* nitrous soil and *iztatlalli,* salty soil. As Gibson noted (1964, p. 300) nitrous soil, *tequixquitlalli,* is one of the few Nahuatl soil terms which has survived into the present century, along with *tepetate,* and a few others.

Topographic position as a differentiating criterion is found in three terms: one is *tepetlalli,* top soil of the upland, derived from *tepetl,* hill and *tlalli;* it is rain-sown, that is, temporal soil. Another upland soil is *tetlalli,* a soil differentiated according to stoney or gravelly texture, but in addition it has the attribute of occurring "near or on the mountain." And, it is also dry, or *temporal.* Another term associated with topographic position is *techiyauitl,* which occurs in a similar position, on the uplands, but it has greater field capacity than *tetlalli,* and possibly would be *tierra de humedad.*

Drainage is another factor which occurs as a differentiaeing criterion. *Chiauhtlalli* is clearly *tierra de humedad,* i. e. "This always lies wet although unirrigated," while *nantlalli* is impermeable soil. "The water extends on top; it does not soak in; it does not reach below."

Parent material distinguishes *tezontlalli,* from *tezontli* (a porous volcanic rock); *nextlallili,* ashen earth (possibly volcanic ash); *tecpatlalli,* chert or flint earth; and, *tenextlalli,* limestone earth. These four lexemes are included in Sahagún under "useless lands" in the sense of useless soils, but they are more properly rock types; in this case the *tlalli* suffix is probably better translated as "place of" rather than "earth." In fact, in Sahagún one finds the contrast between rock and soil explicity stated with reference to *tenextlalli* and *tlaltenextli. Tenextlalli* is "limestone land, bad, undesirable," while *tlaltenextli* "is not limestone bue soil, as for adobes."

Color as a primary attribute is found only in four terms. One is a general term for yellow soil (*tlalcoztli*) "because yellow soil is good, fine, fertile." *Tlalcoztli* also has a second meaning, that of an earth used as a yellow dye or wash. *Tlalchichilli* and *caxtlauitl* are fine and poor grades, respectively, of red ocre, phile *tlaliztlalli* is a whitish soil and also impermeable, similar in that regard to *nantlalli.*

The soils specified according to genesis (here including Man) are of particular interest because of the implication for agricultural technology and also because of the quality of observation implied. Three terms refer to water-borne and deposited materials. One is generic—*atoctli,* derived from *atl,* water and *totoca,* it runs, or twists, which one might infer to be a meandering stream. It "is water-borne yellow soil */tlalcoztli/,* water-borne sand */xalatoctli/.* It is soft, porous, very porous, good, good smelling. It is that which is fertile, esteemed, well considered: it is food-producing." Another term, *xalatoctli,* is specific, "sand borne by the water. It is very loose." Another alluvial soil is *azoquitl,* defined as "clay or mud by the water." Just as water is recognized as an agent, so is wind, for *teutli* is earth "which is very fine—that which swirls up..." Man as a soil forming agent is recognized in several terms. *Callalli* "is the land upon which a house has rested, and also the surrounding houses. It is fertile; it germinates." Here then is recognition of the fertility of house plots, midden heaps and uninhabited archaeological sites. Another term related to *callalli* perhaps in space as well as concept is *axixtlalli,* land which has been urinated upon. Also, a soil which has been fertilized with dung (*cuicatl*) or compost (*tlazolli*) is called *tlalauiyac.* And, tilled land is *tlaluitectli.* "Tilled" is perhaps not the most approprite translation of the term since it means breaking up of soil clods or pulverizing the soil. Presumably, only certain soil could be *tlaluitectli,* and I have identified one of them in another place as *tepetate* (Williams, 1972). Irrigated land or land with a potential for irrigation also had a separate term—*atlalli:* "It is good, fine precious; a source of food; esteemed; a place of fertility." Finally, *tlalzolli,* is the antithesis of *atlalli.* It is bad soil because nothing can be grown there... It is worn out soil." That there is a specific term for worn out soil raises some interesting historical and technological questions. For example, was *tlalzolli* o soil which had become worn out through long agricultural exploitation at a low technological level? Was *tlalzolli* considered a permanent

soil state, or could it be reclaimed by fertilizing? Such questions cannot be answered until documents come to light placing *tlalzolli* in an agricultural or historical context.

These latter terms indicate that fertility or productivity was a major criterion in soil terminology. In fact, the majority of the lexemes have a productivity attribute—fertile or infertile, which is to be expected, particularly among groups of intensive agriculturalists. Of the soil terms relevant to agricultural productivity, nine are considered fertile: alluvial soil, woodland humus, compost, old house plots, peat or muck, yellow soil, fertilized soil, irrigated fields and *tierras de humedad* (*atoctli, cuauhtlalli, tlazollalli, callalli, tollalli, tlalcoztli, tlalauiyac, atlalli, chiauhtlalli*). Infertile soils include: sand, ashen land, nitrous or salty land, urinated soils, and worn out soil (*xallalli, nextlallilli, tequixquitlalli, iztatlalli, axixtlalli,* and *tlalzolli*). Ordinary soils were upland soils (*tepetlalli, tetlalli,* and *techiyauitl.*) Productivity characteristics are not explicitly stated in Sahagún for *xalatoctli,* water-borne sand although this is included as a component of the fertile *atoctli*; *tlalcocomoctli,* topsoil and the upland; *teuhtlalli;* gravelly-clay, *tezoquitl;* water-deposited clay, *azoquitl; nantlalli* and *tlaliztatlalli,* both impermeable; *tlaltzacutli,* sticky clay.

For agricultural purposes, then, it is clear that the soil lexemes reflect the major characteristics of soils which effect productivity—texture, chemistry, and drainage. On the other hand, differentiating characteristics are not systematically applied, and hence one cannot speak of a scientific classificatory system. The terms do not imply an analytic, descending, genetic ordering, nor a synthetic, ascending generic (morphological) ordering (Manil, p. 397). The closest approximation to a generic classification is that of the clays-gravelly clay, water-borne clay, and various pottery clays for different objects; the alluviums, whether sandy or clayey; and the sands, whether water-borne or not. Nevertheless, some observations, such as distinguishing *nantlalli,* "where the water just spreads out," indicate more than just a utilitarian viewpoint. It might be noted in passing that utilitarian classifications are not *a priori* non-scientific. Pedologists in the Soviet Union consider fertility an essential property of soil and they maintain that the classification must reflect that property (Basinski, p. 403), and of course the U.S.D.A. maintains that element in its classification also. Furthermore, it should be noted that the modern science of pedology is in itself very young. Only in the late 19th century was it recognized that "soils display consistent and distinctive morphological characteristics (soil profiles) which are the result of the integrated affects of climate, (initial material), vegetation and associated organisms, relief of land, and time. More recently the chemical, physical and biological processes by which these factors of soil formation operate to produce horizon differentiation have been the subjects of scientific investigation" (Crompton, p. 3). It is noteworthy that the concept of horizon differentiation may have existed pre-Hispanically as seen in the drawings of the Cruz-Badianus herbal, and that also some factors of soil formation were recognized, as demonstrated in the terminology. But, there is little evidence to support the view that processes of soil formation were conceptualized. One example of the latter is found in the description of *tlazolli* and *tollalli,* which contain references to humus and reeds which *turn into* soil. Whether this indicates a knowledge of the processes of change from an organic to a mineral horizon is problematical, but clearly the change was recognized.

On the basis of these considerations, it may be concluded that Aztec soil taxonomy was weakly developed and their pedology, rudimentary. Nevertheless, it is of interest to ask whether the soil classification system was systematic enough to be put into practical use, for example, in the land tenure system. Was there a situation in the Valley of Mexico similar to that of the second millennium B. C. in China where at that time soils of the kingdom were classified according to productivity. On that basis, size of individual land holdings and the tax to be paid the state were determined (Simonson, p. 416).

For pre-Hispanic Mexico documents recording land tenure occur in pictographic form as well as in Nahuatl and Spanish texts. The earlest records, or those based on early records, show that some soil types were expressed glyphically. *Atoctli,* for example, was shown by

a corn stalk (*toctli*, meaning maize) and the glyph for water. *Tetlalli* was shown by the glyph for rock. *Xallalli* was shown by the glyph for sand, wihch is a series of dots. *Cuauhtlalli* was shown by a tree, *contlalli* by a pottery jar, *callalli* by a house, *zoquitl* by a black splotch, *tezoquitl* by a rock plus a black splotch, peat or muck (*tollalli*) by the glyph for reed, and *tequixquitl* by a white daisy shape. These glyphs were used in place names and also were used to designate the soil types of particular agricultural fields, or *parajes*.

The Humbolt Fragment VIII, which was studied by Seler (1904, pp. 200-209), is an example. In this document the landholdings of five agriculturalists are depicted as quadrangles following their names. The dimensions of each field are given, as well as the name of *paraje* in which it is found. In the center of each field is a glyph or glyphs which indicate the soil type of the field. Sand, stoney soil (*tetlalli, xallalli*) is indicated by a composite sand-rock. gyph. Another composite glyph is formed by a tree growing out of a jar set upon a row of teeth. This translated as *cuauh-contlan* or *tlalli*, or *cuauhtlalli, contlalli*—clayey soil enriched by woodland humus. Also, some of the fields are *atoctli*, shown by the maize plant-water glyph. What is interesting is that four of the five agriculturalists had within their holdings all types of soils—some ordinary soil, some fertile soil and some exceedingly fertile soil (*tetlalli, xalalli; cuauttlalli, contlalli; atoctli*). In the fields of the fifth agriculturalist only ordinary soil occurred. The low productivity of his holdings probably explains why he owned more than twice as much land as the other four. If productivity were taken into account in this context it seems reasonable that taxes may also have been assessed according to productivity as well.

In conclusion, preliminary analysis indicates that Aztec soil taxonomy was incompletely developed, although variations in basic attributes of soils, such as texture, structure, consistence, color, drainage, physiographic position, organic or chemical content, initial material and genesis were recognized. Pedology was rudimentary but there are hints that time as factor in the process of soil formation may have been conceptualized. Further investigation is clearly warranted. Documentary evidence should be sought to establish the exent of the relationship between soil classification and land tenure and taxation. Also there is the problem of explaining why only several Aztec soil terms survived four centuries, for example, *zoquitl, tequisquitl*, and *tepetate*. Have these survived because most of the others were technical terms used more by the Aztec elite than by the campesino? Perhaps most of the terms were in fact "scientific" in this sense and were lost along with other aspects of elite culture during the post-Conquest period. Another problem area lies in the cross-cultural study of soil terminology. For example, apparently soil classification in the post-Classic Maya area is generic enough to be employed in a modern pedological context (see Stevens, p. 303 after Ortiz, 1950) while clearly the Aztec is not easily adaptable. By way of hypothesis, these developmental difference may be due in part to varying physical environments. Finally, the methods of historical linguistics may contribute to the study of Aztec soil classification and its relationship to other aspects of Aztec culture. By comparing vocabularies of closely related languages, such as Cora and Huichol, perhaps time-depth of some of the soil terms relating to intensive hydraulic agriculture (or extensive agriculture for that matter) may be ascertained. Thus, we may learn more of the details of the development of agriculture in the Central Plateau. It would seem that further examination of Aztec soil classification migth be as productive for ethnohistorical research as it was utilitarian for the Aztec agriculturalist.

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