

The Talpetate of the Central-Pacific Region of Nicaragua: a Palagonitized Tuff from the Masaya Volcano

Christian Prat* and Paul Quantin**. *ORSTOM, Col. Los Morales, A.P. 57297, 06501 México, Mexique; **ORSTOM, 93143 Bondy CEDEX, France.

Abstract: In the Central Pacific area of Nicaragua, a talpetate (an indurated horizon) was studied through field morphological observations of soils profiles along toposequences, microscopy of thin sections, mineralogical, physical, and chemical analyses. The results of this study show that this talpetate is a volcanic tuff spread over 2 500 km², mainly west of the Masaya caldera. This tuff is composed of basaltic andesite ashes with labrador and pigeonite of the tholeiitic series. Most of the basaltic glasses were "palagonitized" when the tuff was deposited, or shortly afterwards, thus leading to the formation of ferriferous smectites. However, a subsequent meteoric weathering was superimposed on this primary one. As a result halloysite was formed under a tropical climate characterized by a well-pronounced dry season. Under a more humid climate and with Andisols over the talpetate, gibbsitans, mangans, and allophanes were formed on the surface and in the cracks of the talpetate. This tuff is the result of one or several piroclastic surges that took place during the phreato-magmatic explosions in the caldera of Masaya some 2000 years ago. We propose a change from the ambiguous term talpetate by "palagonitized tuff of Masaya" in order to name this indurated horizon of the Central-Pacific area of Nicaragua.

Introduction.

In some volcanic soils of Nicaragua and in other countries of Latin America, there is an indurated horizon called "talpetate" which makes agriculture difficult and whose origin is controversial (Terra, 1992). The word *talpetate* comes from *tepetate* a náhuatl word (*te* = rock and *petat* = bed). In spite of the fact that its etymology indicates that it is an indurated horizon, it does not give more information about its characteristics. Until the work of Prat (1991), there were two opposite points of view on the origin and the characteristics of *talpetate*. According to geologists, this horizon is the equivalent of a tuff called "Masaya tuff" or "Retiro tuff", which has as its origin a pyroclastic flow from a phreato-magmatic explosion (Williams, 1983) or could be an aerial volcanic deposit (the "triple layer" of Bice, 1980). In both cases, the Masaya caldera is identified as the source of this material. On the other hand, pedologists consider *talpetate* as an aerial deposit of fine volcanic ashes cemented later by lixiviation and accumulation of clay, silica and oxides of iron and aluminium, such as what happens in a B horizon (Marín *et al.*, 1971; Rodríguez, personal communication, 1985). However Prat (1991) clearly showed that it is a tuff emitted by the Masaya volcano with a phreato-magmatic origin, which under some special conditions suffers changes due to pedogenic processes.

Our purpose is to detail some aspects which clearly show the origin and the characteristics of *talpetate* as well as its presence in the soils of the Central-Pacific region of Nicaragua.

Materials and Methods.

Through its spatial distribution and its characteristics, it is possible to deduce the volcanic origin of the *talpetate*. However, differences in climate between the banks of the lake of Managua and those of the Pacific coast, and the heights of the Sierras of El Crucero-Las Nubes, have as a result different soil performances. On the other hand, it is sometimes difficult to determine with precision *talpetate* from all the others horizons more or less indurated.

That's why we study the spatial distribution of the *talpetate* whether at the profile, toposequence or regional level. We complet this work through macro and microscopic observations (optical microscopy, SEM with a Castaing probe, TEM, XRD), as well as physical-chemical analysis of the characteristics of some indurated horizons from a series of profiles distributed along a northeast - southwest cross-section of the Central Pacific region of Nicaragua.



Rest
Talpe
posit
that
passi
layer
Ther
hemu
main
proc
site.
The
palag
these
one.
mon
glass
kind
glass
The
field
whic
Talpe
layer
explc
explc
Nicar
mater
and s
surge
partly
Due t
call t
appea
more

Liter
Bice,
Nicar
Fishe
Honn
Palag
Marín
la ger
Prat,
Nicar
dans
Sheri
Geoth
Willia
D., D.

Results.

Talpetate is made of andesite with pigeonite and labrador; this means it is a volcanic product whose composition borders between basalts and andesites. It belongs to the series of the tholeiites, which indicates that the magma had its origin in the fusion of the oceanic plate but was a little bit "contaminated" when passing through the tephra crust. The primary minerals prevailing in the soldered cinders and the "triple layer" (Bice) are essentially dark basaltic glasses and, to a certain extent, andesitic and dacitic glasses. There are also plagioclases (labrador, andesite), augite, magnetite, and traces of cristobalite, quartz and hematite. In the case of the secondary minerals, the palagonitization of glasses (Honnorez, 1967) led mainly to the formation of ferrous smectites. Under humid tropical climate and Andisol, there are processes of illuviation-concentration around the voids and formation of gibbsite, allophane and halloysite. Under dry tropical climate and brown soils with andic features there is halloysite but little allophane.

The presence in *talpetates* and in soldered cinders of products such as magnetite, microlites of glasses, palagonite, armoured nodules (Fisher and Schmincke, 1984) among others, prove the volcanic origin of these materials. The difference between them is not due to a meteorological weathering, but to a geological one. That means *talpetates* are a phase of a phreato-magmatic eruption where the conditions at the moment of the explosion (specially the water/solid ratio) were different. In one case weathering of the glasses by water resulted in palagonite and later in ferrous smectites, whereas in other cases, this kind of weathering did not happen. Nevertheless, in all cases, the fusion and/or weathering of the glasses soldered them together, which is the main cause of the induration of *talpetates*.

The physical-chemical and microscopic characterization of *talpetates* and soldered cinders confirm the field observations. So, through them, we could define the source and possible development of events which generated these materials.

Talpetates, also called "Masaya tuff" or "The Retiro tuff" (whereas the soldered cinder is the "triple layer" of Bice) are volcanic tuffs deposited 2,000 years ago during one or several phreato-magmatic explosions of the Masaya volcano as a precolombian pottery proves it (Prat, 1991). These kinds of explosions are the result of the contact between the phreatic water supplied by the lakes of Managua and Nicaragua with the magma of the volcano. These explosions generated devastating surges of semi-liquid material destroying and molding the vegetation and people. They formed also clouds of dust, cinders, and sand and inside them, the armoured nodules were formed (Fisher and Schmincke, 1984). These surges and aerial deposits covered 2,500 km² mainly west of the Masaya caldera. This orientation is partly due to the orientation of the winds blowing from east to west the main part of the year.

Due to their physical-chemical and morphological characteristics as well as their origin, we propose to call the *talpetates* that we studied "palagonitized tuff of Masaya". We must not forget that this product appears a few years after Christ, which means yesterday in geological time. It also covers the richer and more crowded region of Nicaragua. The Masaya volcano is still active...

Literature cited.

- Bice, D. C. 1980. Tephra stratigraphy and physical aspects of recent volcanism near Managua, Nicaragua. Ph. D., Univ. California, Berkeley, California, 420 pp.
- Fisher, R. V. and H. U. Schmincke. 1984. Pyroclastic rocks. Springer-Verlag, Berlin, RFA.
- Honnorez, J. 1967. La palagonitisation: l'altération sous-marine du verre volcanique basique de Palagonia (Sicile). Thèse, Université Libre, Bruxelles, Belgique, 227 p.
- Marín Castillo, E. J., E. Ubeda Gonzales y J. Viramonte Otero. 1971. Contribución al conocimiento de la genesis del "talpetate". San José, Costa-Rica. Febrero de 1971. 31 p.
- Prat, C. 1991. Etude du talpetate, horizon volcanique induré de la région Centre-Pacifique du Nicaragua. Genèse, caractérisation morphologique, physico-chimique et hydrodynamique, son rôle dans l'érosion des sols. Thèse de Doctorat, Univ. Paris 6, Paris, France. 320 p.
- Sheridan, M. F. y K. H. Wohletz. 1983. Hydrovolcanism: basic considerations and review. J. Volc. Geotherm. Res. 17: 129.
- Williams, S. N. 1983. Geology and eruptive mechanisms of Masaya caldera complex, Nicaragua. Ph. D., Dartmouth College, Hanover, New Hampshire, 170 p.



ACAPULCO, MEXICO
JULY 10-16, 1994



VOLUME 6b:
COMMISSION V: POSTER SESSIONS

Transactions

15th World Congress of Soil Science
15 Bodenkundlicher Weltkongress
15^{ème} Congrès Mondial de la Science du Sol
15° Congreso Mundial de la Ciencia del Suelo

p. 226-227

Symposium ID-13. Indurated Volcanic Soils: Use and Management

	Page
Induration of air-dried volcanic ash soil in Aso area of Japan. <i>H. Kubotera, and I. Yamada. (Japan).</i>	214
Les formations volcaniques indurées des Andes de Colombie: une distribution et des processus géochimiques liés à des conditions climatiques sèches. <i>P. Faivre, et S. Gaviria. (France).</i>	216
Indurated horizons in poorly drained volcanic soils. <i>W. Luzio, and T. Palma. (Chile).</i>	218
Formation of petrocalcic horizons in soil from basic pyroclastics under the semiarid climate of Lanzarote (Spain). <i>R. Jahn, and K. Stahr. (Germany).</i>	220
Micromorphology of placic horizons of andosols of the azores. <i>J. Pinheiro and A. Rodríguez. (Spain).</i>	222
Characterization and agricultural assessment of two "talpetate" profiles in Nicaragua. <i>A.W. Vogel, D. Creutzberg and J.H. Kauffman. (The Netherlands).</i>	224
The talpetate of the Central-Pacific region of Nicaragua: a palagonitized tuff from the Masaya volcano. <i>C. Prat and P. Quantin. (France).</i>	226
Utilisation de différentes formes d'amendements organiques pour la restauration de sols volcaniques dégradés par érosion anthropique au El Salvador (Amérique Centrale). <i>J. Collinet. (Costa Rica).</i>	228
Dorbank, a reddish brown hardpan of South Africa - A proto-silcrete?. <i>F. Ellis, and J.J.N. Lambrechts. (South Africa).</i>	230
Relation géométrique et variations minéralogiques des différents termes d'une séquence d'altération de tufs pyroclastiques de la région de Texcoco (Mexique). <i>J. Bertaux, et P. Quantin. (France).</i>	232
Les sols à tepetate de la région de xalapa-coatepec, mexique. Caractérisation, dégradation et conservation. <i>J.P. Rossignol. (France).</i>	234
Une étude "microstructurale" des traits pédologiques de sols volcaniques indurés ("tepetates") de la vallée de Mexico. <i>C. Hidalgo, F. Elsass, and P. Quantin. (France).</i>	236
Premiers résultats d'essais agronomiques visant à la réhabilitation agricole du tepetate t ₂ (Texcoco, Mexique): I cas de l'orge et de la vesce. <i>A. Baéz, C. Prat, A. Márquez et B. Chora. (Mexico).</i>	237

ly 14
Page
214
216
218
220
222
224
226
228
230
232
234
236
237

Premiers résultats d'essais agronomiques visant à la réhabilitation agricole du tepetate t₂ (Texcoco, Mexique): II essais agronomiques. *B. Chora, A. Márquez, C. Prat et A. Baéz. (Mexico)*. 239

Premiers résultats du suivi de l'érosion hydrique et de l'hydrodynamique des sols à tepetate (Texcoco, Mexique). *A. Márquez, C. Prat, E. Huerta, E. Carrillo, and J.L. Janeau. (Mexico)*. 241

La réhabilitation agricole de la cangahua en Equateur. *G. Trujillo, E. Custode, G. De Noni, M. Viennot and C. López. (Ecuador)*. 243

Variabilité de la productivité du Maïs selon l'aptitude de ses ressources phylogénétiques dans un sol induré. *H. Navarro et D. Flores. (Mexico)*. 245

Utilisation agricole des sols volcaniques indurés. *M.A. Pérez et H. Navarro. (Mexico)*. 247

Determination of microbial biomass and its fluctuation on base of agroecological management of tepetate. *M. Crisóstomo S. and R. Ferrera-Cerrato. (Mexico)*. 249

Agronomics practices for soil conservation. *J.D. Rios, J.L. Oropeza and M.R. Martínez. (Mexico)*. 251