GENESIS OF VERMICULITE AND MIXED-LAYERED VERMICULITE IN THE EVOLUTION OF THE SOILS OF FRANCE

by

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ABSTRACT

Analysis of the argillaceous fraction of some podzolic soils and podzols of France has shown a double evolution of illite and chlorite through mixed layering into vermiculite.

illite → (illite–vermiculite) → vermiculite
chlorite → (chlorite–vermiculite) → vermiculite

Vermiculite is more concentrated in the upper zones of the profiles where it constitutes 50 to 90 percent of the argillaceous fraction.

Approximately one hundred pedological profiles have been studied in soils, including podzolic soils, podzols, and mesotrophic hydromorphous soils. These studies have shown that the argillaceous fraction changes in the course of pedogenesis, and they confirm the observations that have been made in other countries (MacEwan, 1948; Walker, 1949; Jackson *et al.*, 1952; Brown, 1953; Van der Marel, 1954; Hathaway, 1955; Droste, 1956; and Mitchell, 1955, 1961).

Twelve typical profiles are presented here.

The following symbols are used:

I: Illite
C: Chlorite
V: Vermiculite
K: Kaolinite
M: Montmorillonite
I–V: Illite–vermiculite mixed-layer
C–V: Chlorite–vermiculite mixed-layer
I–M: Illite–montmorillonite mixed-layer

PODZOLIC SOIL

Forêt de Salm (Vosges)	I	C	(I–V)	V
A_0	40		20	40
A_1	70	10	10	10
A_2	70		10	20
B	90	10		
Parent material, sandstone of Niederbronn	100			

Illite → (illite–vermiculite) → vermiculite

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PODZOLIC SOIL

Le Bonhomme (Vosges)	I	C	(I–V)	V
A_0	10		90	
A_2	20		80	
B	10			90
Parent material, granite of Tête des Faux	100 (mica)	traces		

Illite → (illite–vermiculite) → vermiculite (lixiviated to B)

PODZOLIC SOIL

Lande de Lessay (Manche)	I	(I–V)	V
A_0	40	10	50
A_2	60		40
B	60		40
Parent material, sands of St-Vigor			

Illite → vermiculite

PODZOLIC SOIL

Battenheim (Haut-Rhin)	I	C	(C–V)	V
A_1		40	40	20
A_2		40	40	20
B_1	traces	?	?	100
Parent material, gravels (Terrace of the Harth)				

In A horizons, chlorite + (chlorite–vermiculite) + vermiculite (lixiviated to B)

HUMUS PODZOL

Forêt de Bruyères (Vosges)	K	I	(I–V)	(C–V)	V
A_2	20	40	traces		40
B	20	20	traces	traces	60
C	20	50	traces	traces	30
Parent material, sandstone of Bruyères	20	80 (mica)			

Illite → vermiculite

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IRON HUMUS PODZOL

Lande de Lessay (Manche)	K	I	V
A_0	10	50	40
A_2	10	50	40
B_1	10	90	
B_2	10	90	
Parent material, sands of St-Vigor			

Illite → vermiculite

MESOTROPHIC HYDROMORPHOUS SOIL WITH GLEY

Bischoffsheim 2 (Bas-Rhin)	K	I	C	M	(C–V)	V
A_1	10	60	traces			30
A_2G	10	50	10	10	traces	20
Reduced gley	10	50	30	10	traces	
Reduced gley	10	50	30	10	traces	
Parent material, Rhenish alluvium						

Chlorite → vermiculite

MESOTROPHIC HYDROMORPHOUS SOIL

Innenheim 3 (Bas-Rhin)	K	I	C	M	V
A_1	10	40	10		40
A_2G	10	40	10		40
Oxydized gley	10	50	20	20	
Oxydized gley	10	50	20	20	
Reduced gley	10	50	20	20	
Parent material, Rhenish alluvium					

Illite + chlorite → vermiculite. Montmorillonite in gley horizon.

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IRON PODZOL

Herrenwald (Haut-Rhin)	I	C	(C–V)	V
A_1	traces		50	50
A_2	10	10	40	40
A_3	40	40	traces	20
C	100 (mica)			traces
Parent material, siliceous sands				

Illite and chlorite → mixed-layer → vermiculite

IRON HUMUS PODZOL

Barembach (Bas-Rhin)	I	C	(I–V)	V
A_0	20			80
A_1	20			80
A_2	20			80
B_1	20			80
B_2	20	10		70
C	60	20	traces	20
Parent material, granite of Barembach	80 (mica)	20		

Illite and chlorite → vermiculite

MESOTROPHIC HYDROMORPHOUS SOIL WITH GLEY

Innenheim 1 (Bas-Rhin)	K	I	C	M	V
A_1	10	20	traces		70
A_1'	10	20	traces		70
A_1''	10	20	traces		70
Reduced gley	10	60	10	20	
Reduced gley	10	60	10	20	
Reduced gley	10	60	10	20	
Parent material, Rhenish alluvium					

Illite → vermiculite. Montmorillonite appears in gley horizon.

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MESOTROPHIC HYDROMORPHOUS SOIL WITH GLEY

Bischoffsheim 1 (Bas-Rhin)	K	I	C	M	(I–M)	V
A_1	10	30	traces		10	50
A_1'	10	30	30		20	10
Reduced gley	10	30	30	30		
Reduced gley	10	40	30	20		
Parent material, Rhenish alluvium						

Chlorite → vermiculite. Montmorillonite in gley horizon.

In summary, it is possible to distinguish the following possibilities:

(1) Illite changes into a vermiculite-like mineral by an intermediate stage consisting of a mixed-layer illite–vermiculite.
(2) Chlorite changes into vermiculite by an intermediate stage; a mixed-layer chlorite–vermiculite is possible.
(3) Illite and chlorite change simultaneously into vermiculite.
(4) In the gley horizons, where drainage is poor, montmorillonite appears at the bottom of the profile.

In the evolved soils of France, montmorillonite is not the final stage of the transformation toward vermiculite, as opposed to the soil profiles described in other countries (Whittig and Jackson, 1955; Murray and Leininger, 1956; Brown and Jackson, 1958; Mitchell, 1955, 1961; and Gjems, 1960). It is possible to attribute the lack of montmorillonite to a podzolization less intense than those found in Wisconsin, Scotland, and Scandinavia. In the regions of the United States where the podzolization is more temperate, the lack of montmorillonite at the top of the profiles is also noted.

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