

# Speciation of metal trace elements (MTE) in two soils developed from basaltic rocks of the French Massif Central.

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## 1. Introduction :

In the French Massif Central, soils developed from basaltic parental rocks regularly present too high natural contents in metal elements to allow to recycle municipal sewage sludge in agricultural fields. Objectives of the present work are : (i) to determine the natural distribution of MTE in such basaltic rocks in soils, (ii) to identify the MTE-bearing phases in rocks and soils and (iii) to evaluate these phases stability in soils for environmental risk assessment (MTE bio-availability and release in water).

## 2. Materials and Methods :

Two soil profiles were examined on Tertiary basaltic rocks of the Cantal mountains (French Massif Central). Besides the pedological characterisation, total amounts of trace and major elements were analysed by ICP-MS and ICP-AES in soil and parental rocks. Assessment of MTE and major elements enrichment in soil compared to rock was established assuming the amount of Al to be constant. Primary and secondary MTE-bearing minerals were characterised by petrographical (XRD, SEM-EDS, EMPA) and chemical approaches (selective extractions and batch experiments).

## 3. Results and discussion :

***Pedological features*** : The two studied soils are developed on basalts with olivine and pyroxene phenocrysts. Fe-Ti spinel represents 20 percents of the whole rock. The two studied soils are shallow (55<sup>1</sup> and 75<sup>2</sup> cm) and very gravelly. They both present andic features : low bulk density (< 0,9 g/cm<sup>3</sup>), consistent organic matter content (20<sup>1</sup> and 40<sup>2</sup> g/100g) and high NaF-pH values (10,2<sup>1</sup> and 11,4<sup>2</sup>). Values of soil water-pH range between 5 and 5.5 for all horizons. Though these similar characteristics, degree of horizonation of the two studied soils differ from a [A-C]<sup>1</sup> to [A-B-C]<sup>2</sup> sequence.

***Chemical evolution*** : According to the bulk chemical analysis, Cr and Ni are the most abundant MTE found in the studied soils and rocks. As shown for the site of Mauriac<sup>2</sup>, the

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<sup>1</sup> Saint-Thomas profile – locality of Mauriac, Cantal - France

<sup>2</sup> Labarrière profile – locality of Tournemire, Cantal - France

chemical variations calculated from the rock to the soil display important losses for alkaline earth metals, Si (Tableau 1) and Cr, Ni (Tableau 2).

Tableau n° 1 : Chemical variations of major elements in soil for the site of Mauriac - Cantal.

Horizons	Profondeur cm	Si %	Fe %	Ti %	Mg %
A <sub>1</sub>	0 4	-36,9	-13,2	-18,1	-85,6
	4 8	-38,2	-12,5	-17,2	-86,2
A <sub>2</sub>	8 24	-41,7	-13,5	-18,2	-85,5

Tableau n° 2 : Chemical variations of MTE in soil for the site of Mauriac - Cantal.

Horizons	Profondeur cm	Cr %	Ni %	Cu %	Zn %
A <sub>1</sub>	0 4	-29,2	-29,4	-3,7	8,7
	4 8	-24,8	-28,1	-0,8	4,9
A <sub>2</sub>	8 24	-27,2	-28,5	0,0	-8,2

**Mineralogical speciation** : Cr and Ni variations follow the same trend than those of Fe and Ti. Petrographical analysis of MTE in the basalt confirm these associations. Indeed the main MTE-bearing primary minerals are titanomagnetites, olivines, and pyroxenes to a lesser extent. From basaltic rock to A<sub>1</sub>-horizon, titanomagnetites and pyroxenes remain in the same amount with similar MTE contents whereas olivines disappear to form phyllosilicates which present very low MTE contents (Tableau 3).

Tableau n°3 : Chemical composition of MTE of primary and secondary phases (EMPA)

MTE	olivines ppm	pyroxenes ppm	titanomagnetites ppm	phyllosilicate s ppm
Cr	110-110	200-1300	600-38800	30-200
Ni	900-2300	180-2200	250-2500	90 -350
Cu	10-70	10-130	15-250	80-120
Zn	30-490	35-170	50-480	60-210

#### 4. Conclusions :

This study allowed the identification of primary MTE-bearing minerals, their transformations and the behaviour of MTE during pedogenesis. Selective extractions and batch experiments in fixed pH-Eh conditions both in progress will allow to determine the stability of primary and secondary phases and the potential release of MTE in natural water.