

Geociências, Rev. Univ. Aveiro (1996), vol. 10, fasc.1, (25-30)

**ALUMINOUS MAGHEMITE AS PALAEOENVIRONMENTAL MARKER IN
LATERITIC SOILS : THE CASE STUDY OF THE SALITRE AREA, MINAS
GERAIS, BRAZIL**

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INTRODUCTION

There has recently been some interest in the magnetic properties of soils and occurrence of maghemites in connection with palaeo-environmental studies as they have recognised as an thermal transformation product of aluminous goethite (Schwertmann et al, 1984). Maghemites (γ - Fe_2O_3) are known to be important constituents of many magnetic soils. This ferrimagnetic form of Fe_2O_3 with spinel structure, commonly occurs in tropical and subtropical soils, and is often concentrated in the topsoil (Taylor and Schwertmann 1974a; Coventry et al. 1983; Anand and Gilkes 1987). There are basically three mechanisms that may lead to the formation of maghemite in soils: oxidation of magnetite, conversion of some other iron oxides (e.g., goethite and hematite) by forest fires, and less commonly, deshydration of lepidocrocite. No attempt will be made to give a full account of these mechanisms here; useful reviews are given by Lindsley, 1976; Mullins, 1977 and Waychunas, 1991. Research has largely been concentrated on the synthesis of aluminous maghemite and an extensive literature exists for synthetic maghemites (Schwertmann et al, 1984).

But very little is known about the properties of natural maghemite and their occurrence. Highly magnetic soils, are widespread in Brazil where several researchers as Resende et al, 1988, Curi and Franzmeier, 1987; Allan et al, 1989; Fabris et al, 1995) have characterized Mg-rich maghemite and Ti-rich maghemite in mafic alteration products. This paper provides analytical data on occurrence of high aluminous maghemite in the loose latosolic cover of the ultramafic-alkaline complex of Salitre, Minas Gerais, (Brazil).

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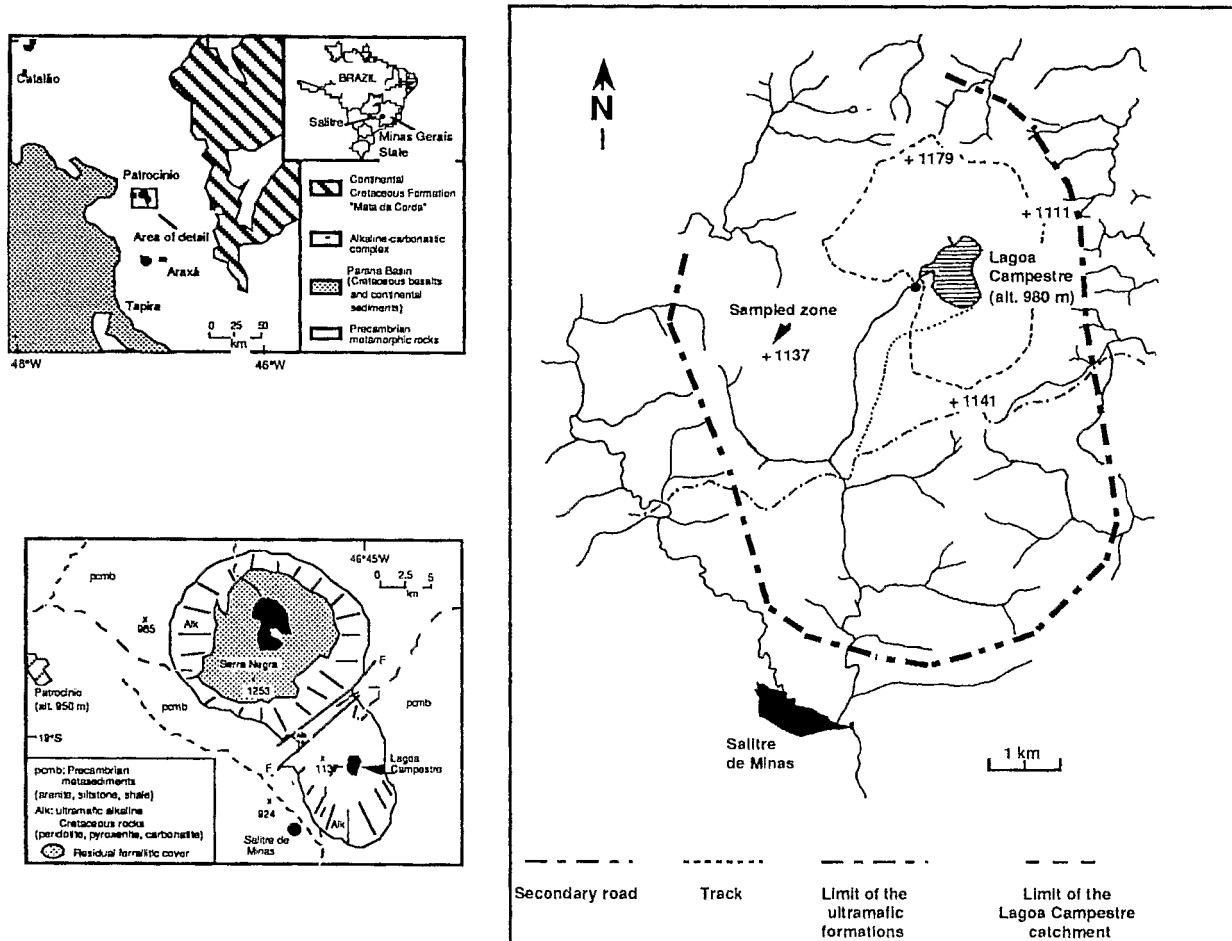
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GENERAL FEATURES OF AREA

Fig.1. Situation of the Salitre area, Minas Gerais, Brazil



Several ultramafic-alkaline complexes occur in the west of Minas Gerais State (Brazil) and in the Alto Paranaíba area (Ulbrich and Gomez, 1981). One of these, the Salitre complex, composed mainly of carbonatites and micaceous pyroxenites, has a thick, loose latosolic cover (Fig. 1) surrounding depression, overlying a thick saprolite (50-100 m). The central, dolina-shaped, depression ("Lagoa Campestre") occupied by a lake partially filled with sediments (Sondag et al., 1993; Bertaux et al, 1996).

MATERIALS AND RESULTS

The parent materials of the studied profile (40 m, depth) (Fig.2), is an micaceous pyroxeno-peridotite cut by carbonatite veins. X-ray diffraction and diffuse reflectance spectroscopy were used for this investigation.

The abundance of magnetic well rounded micronodules (50-100 μ), is a characteristic feature of the upper part of the profile (0-12m). They were separated with a handmagnet. These nodules are red to dark-reddish brown, similar (size and shape) to others non-magnetic iron oxide micronodules but darker in color, perhaps because of the presence of organic matter.

Fig.2-The studied profile (MN 86) of lateritic cover differentiated at expense of ultramafic-alkaline complexe (Salitre, Minas Gerais)

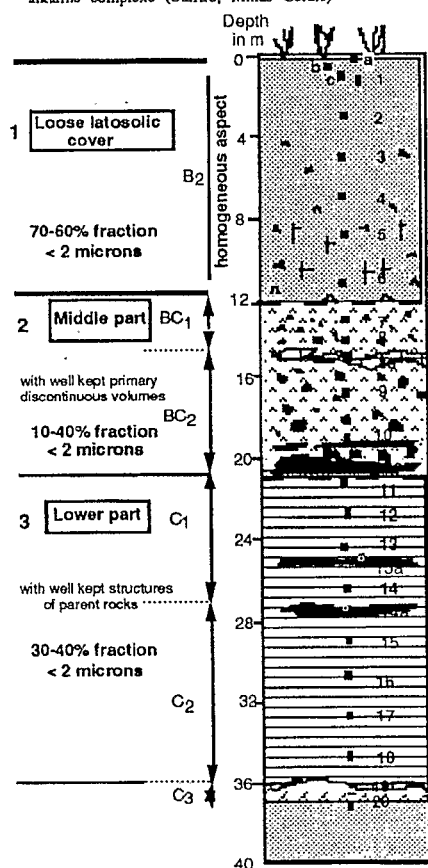
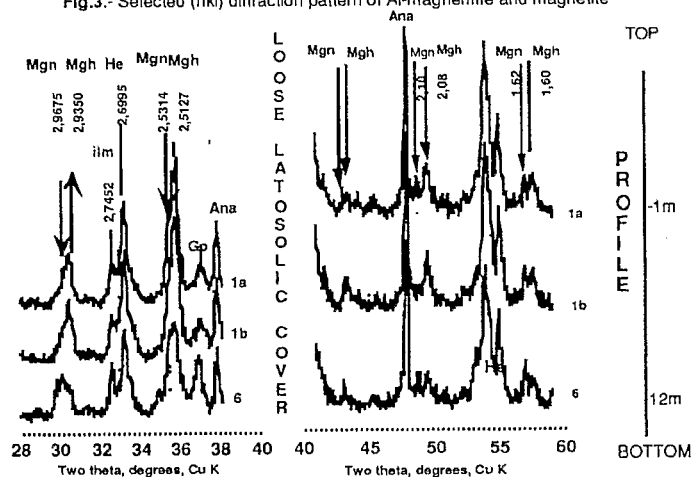


Fig.3.- Selected (hkl) diffraction pattern of Al-maghemite and magnetite



The XRD pattern of this separated magnetic fraction indicates that maghemite is the dominant iron mineral (Fig.3). Hematite (Fe_2O_3) was also identified, which suggests that the magnetic grains are aggregates of both minerals. The strongest peak at 2,51 Å of the samples is characteristic of maghemite. The 2,93 Å, 2,08 Å, and 1,60 Å peaks are used for aluminous maghemite identification and the 2,69 Å, 2,20 Å, and 1,84 Å peaks for hematite identification. Differentiation between maghemite and magnetite by XRD is generally difficult because both have similar crystal structures (Table 1).

Table 1. X-ray powder diffraction data of magnetic fraction separated from soil samples (upper part of profile) and selected data of reference iron oxide minerals

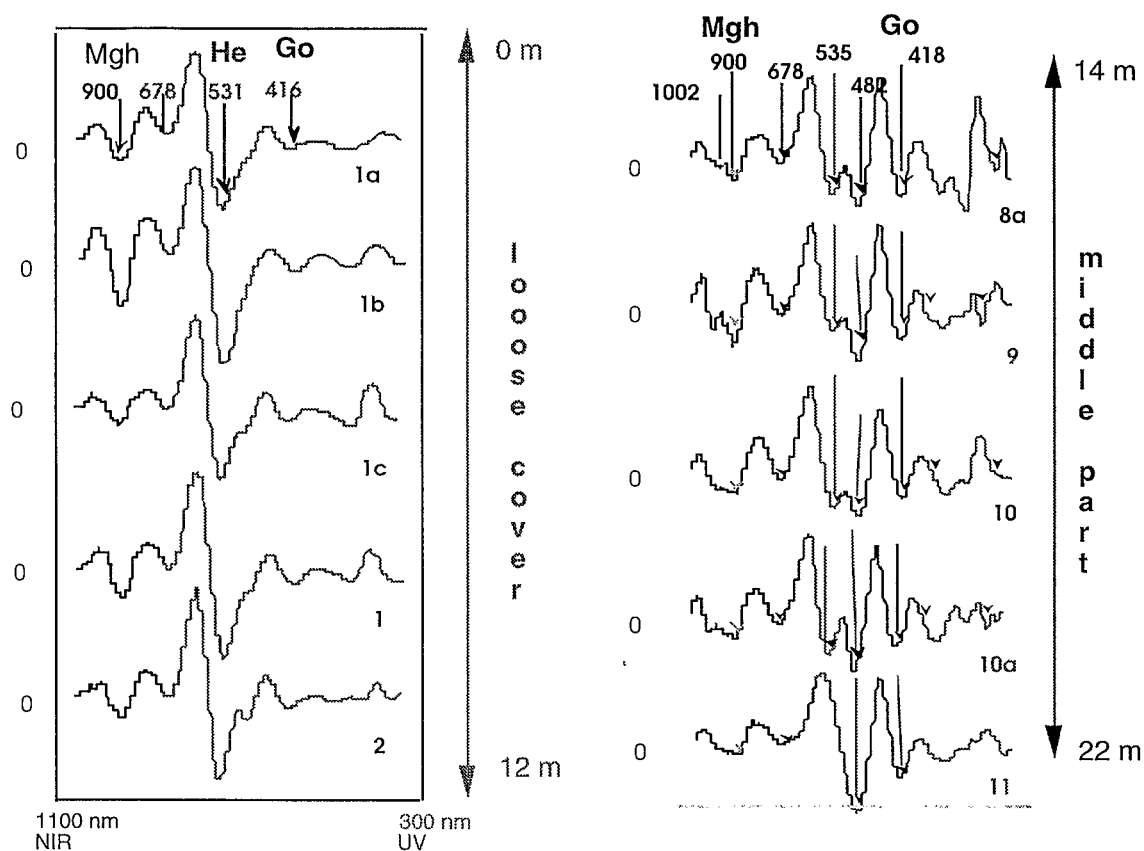
Soil sample		Magnetite		Maghemite		Hematite	
d(Å)	I/I _{max}	d(Å)	I/I _{max}	d(Å)	I/I _{max}	d(Å)	I/I _{max}
2,93	50	2,97	60	2,95	34		
2,69	70					2,69	100
2,51	100	2,53	100	2,51	100	2,52	70
2,20	20					2,21	17
2,08	23	2,10	50	2,08	24		
1,84	20					1,84	31
1,69	30	1,71	40	1,70	12	1,69	36
1,60	30	1,62	60	1,60	33	1,60	8

Al-Maghemite and magnetite are identified on XRD pattern, respectively, by the peaks: 2,93 Å vs. 2,97 Å, 2,51 Å vs. 2,53 Å, 2,08 Å vs. 2,10 Å, and 1,60 Å vs. 1,62 Å (Fig. 3). The d values differences, particularly at higher diffraction angles, together with the line broadening and the missing of weak diffraction peaks, that are typical for the small grain size of pedogenic maghemite, indicate that the magnetic mineral in the soil material (bulk material and micronodules) is maghemite rather than magnetite.

The lattice parameter for the maghemite, from X-ray diffraction, is 0,830-0,832 nm for the samples from latossol and 0,834-0,836 nm for the grains from lower horizons (>12m). The first group (latossol) of values is smaller than the accepted average value for end-member maghemite of 0,834 nm. The decrease in lattice parameter may reflect substitution of Fe³⁺ by Al³⁺ in the structure (Schwertmann and Fechter, 1984).

The obtained diffuse reflectance spectroscopy data in the UV/visible and NIR range confirm and show the spectral signature of maghemite, e.g., the presence of the ⁶A₁->⁴T₁(⁴G) crystal field band at 900 nm (Fig. 4).

Fig.4.- Second derivative optical spectra for maghemite, hematite and goethite in raw materials



In lower horizons (>12m) of the profile, the rounded dark-reddish brown magnetic micronodules are not observed and aluminous goethite, which is scarce in the upper part, is, in contrast, widely present. From the bottom to the top of the profile, an opposite trend is so, observed in the distribution of aluminous maghemite and aluminous goethite.

CONCLUSIONS

The two possible ways for the interpretation of this trend: (i) meteoric alteration of the primary magnetic iron oxides or (ii) thermal transformation of aluminous goethite linked to palaeo-fires. The accumulation of aluminous maghemite till 12m depth, should be the result of a strong biological "turn-over".

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