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# PROBLEMS AND POTENTIAL OF MINERAL MAGNETIC MEASUREMENTS AS A SOIL PARTICLE SIZE PROXY

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**Abstract**. The use of mineral magnetic concentration parameters ($\chi_{LF}$, $\chi_{ARM}$ and SIRM) as a potential particle size proxy for soil samples collected from the Isle of Man (British Isles) is explored as an alternative means of normalizing particle size effects. Comparison of soil-related analytical data by correlation analyses between each magnetic parameter and *individual* particle size classes (i.e. sand, silt and clay), more discrete intervals within classes (e.g. fine sand or medium silt) and cumulative size fractions (e.g. clay + fine silt) are reported. Both $\chi_{LF}$ and $\chi_{ARM}$ parameters reveal significant ($p$ <0.05; $n$ = 46), but relatively weak ($r_s$ = 0.297 and 0.369), associations with clay content, while $\chi_{LF}$, $\chi_{ARM}$ and SIRM parameters have no significant relationship with sand and silt content or any discrete or cumulative size fractions. Contrary to earlier research findings, this indicates that magnetic measurements are not always a suitable particle size proxy and it is only certain environments and/or specific settings that are appropriate for granulometric normalization by this technique. However, if future researchers working in other soil settings can identify a formal predictable relationship, the technique is known to offer a simple, reliable, rapid, sensitive, inexpensive and non-destructive approach that could be a valuable particle size proxy for normalizing particle size effects in soil contamination studies.

**Keywords:** environmental magnetism, soil texture, data normalizing, particle size effects, soil pollution, public health, Isle of Man.

## 1. Introduction

Soil contamination by heavy metals (Wilcke *et al*. 1998), radionuclides (van der Perk *et al*. 2000) or persistent organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs) (Maliszewska-Kordybach 1996) and polychlorinated biphenyls (PCBs) (Klamer *et al*. 1990) are important public health concerns (Rowat 1999; Roos *et al*. 2004). Assessment of the extent and severity of soil contamination requires thorough investigation before remediation can proceed (Manz *et al*. 1999; Zhu and Shaw 2000), but soil-related analytical data can be strongly affected by particle size effects. Before directly comparing samples of different particle sizes, it is necessary to correct for such size effects. This is because, generally, the finer a sediment, the greater its concentration of both natural and anthropogenic pollutants (Camacho-Ibar and McEvoy 1996; McCubbin *et al*. 2000). It is necessary, therefore, to first remove this influence by either normalizing data relative to the abundance of a specific particle size interval or fractionating samples into specific sizes (e.g. <16 μm (Klamer *et al*. 1990), <20 μm (Ackermann *et al*. 1983), <50 μm (Aston and Stanner 1982), <60 μm (Ackermann 1980), <63 μm (Araujo *et al*. 1988;), <75 μm (Clifton and Hamilton 1982), <100 μm (Langston 1986), <150 μm (Jones and Turki 1997), <250 μm (Hornung *et al*. 1989). Although these methods can be considered reliable and advantageous, they require additional and, in the case of fractionating samples into specific size ranges, time-consuming laboratory work.

Other techniques have also been adopted involving comparison with 'conservative' elements (such as aluminium (de Groot *et al*. 1982; Ergin *et al*. 1996), iron (Lapp and Balzer 1993), caesium (Ackermann 1980), rubidium (Middleton and Grant 1990) or titanium (Forstner and Wittmann 1979) or a correction factor for an inert or organic material (Ergin *et al*. 1996; Camacho-Ibar and


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McEvoy 1996). In general, these approaches employ extrapolation from regression curves or sometimes entail a mathematical formulation of correcting particle size effects after analysis of bulk samples (de Groot *et al.* 1982; Covelli and Fontolan 1997; Szava-Kovats 2002).

Where a particle size proxy can be measured efficiently (that is, shorter analysis time or lower cost than determination of the particle size distribution or preparation of specific size fractions for analysis), it can offer potential advantages. However, to assess the suitability of an analytical technique as an efficient particle size proxy, and as an accurate means of normalizing data, it is necessary that the nature of the relationship between the proposed parameters and particle size follow a predictable pattern (like those of trace metals, radionuclides and BCPs with particle size).

Many studies have explored relationships between mineral magnetic measurements and the physico-chemical properties of soils, sediments and dusts (Clifton *et al.* 1997, 1999; Xie *et al.* 1999, 2000; Booth *et al.* 2006a, 2007). Based on these investigations, mineral magnetic measurements have been identified as a suitable proxy for geochemical, radioactivity, organic matter content and particle size data (Bonnett *et al.* 1988; Oldfield *et al.* 1993; Hutchinson and Prandle 1994; Clifton *et al.* 1997, 1999; Xie *et al.* 1999, 2000; Zhang *et al.* 2001; Booth *et al.* 2005a; Shilton *et al.* 2005).

To date, most work has not examined the extent to which mineral magnetic parameters are reliable indicators of differences in soil texture. Therefore, using a database of soil properties collected from the Isle of Man (Booth *et al.* 2005b, 2006b), this study addresses two methodological issues. Firstly, the extent to which particular magnetic concentration parameters can be used as a soil particle size proxy and, secondly, whether soil texture and mineral magnetic data associations follow the predictable trends of other studies.

## 2. Methods

### 2.1. Study area and sampling

The Isle of Man (N 54° 15′, W 4° 27′) covers 572 km$^2$ (Fig. 1). Despite its relatively small size, the Island possess a diverse range of soil–types, which reflects the complex interactions of geology, topography and climate through an altitudinal range of 0–621 m (Kear 1980).

This complexity is reflected in the variety and spatial patterns of the soil-types, which includes (i) Typical brown podzolic soils; (ii) Typical brown calcareous soils; (iii) Typical brown sands; (iv) Typical brown earths and (v) Earthy oligo-fibrous peat soils. Based on the sub-categories and phases of the five soil-categories identified by Harris *et al.* (2001), 46 A-horizon soil samples were collected at 0-20 cm depth, during Winter 2002, from the locations shown in Fig. 1.

### 2.2. Magnetic analyses

All samples were subjected to the same preparation and analysis procedure (Walden *et al.* 1999; Booth *et al.* 2004). Samples were dried at room temperature (<40 °C), weighed, packed into 10 ml plastic pots and immobilized with clean sponge foam and tape prior to analysis.

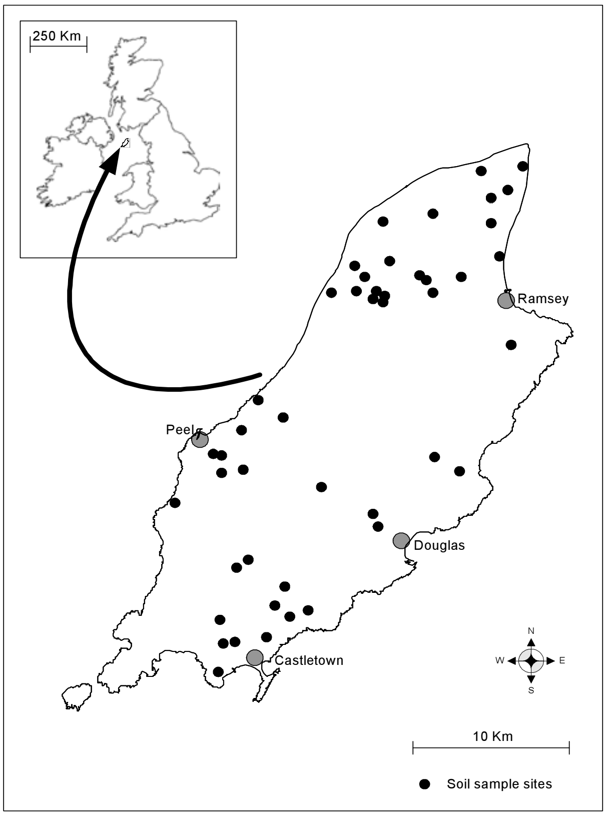


**Fig. 1.** Sample location map of the Isle of Man

Initial, low-field, mass-specific, magnetic susceptibility ($\chi$) was measured using a Bartington (Oxford, England) MS2 susceptibility meter. By using a MS2B sensor, low frequency susceptibility was measured ($\chi_{LF}$). Anhysteretic Remanence Magnetisation (ARM) was induced with a peak alternating field of 100 mT and small steady biasing field of 0.04 mT using a Molspin (Newcastle-upon-Tyne, England) A.F. demagnetiser. The resultant remanence created within the samples was measured using a Molspin 1A magnetometer and the values converted to give the mass specific susceptibility of ARM ($\chi_{ARM}$). The samples were then demagnetized to remove the induced ARM and exposed to a series of successively larger field sizes up to a maximum ‘saturation’ field of 800 mT, followed by a series of successively larger fields in the opposite direction (backfields), generated by two Molspin pulse magnetisers (0–100 and 0–800 mT). After each 'forward' and 'reverse' field, sample isothermal remanent magnetisation (IRM) was measured using the magnetometer.

### 2.3. Textural analyses

All samples were subjected to the same textural preparation and analysis procedure (Booth *et al.* 2005a), using sieving followed by laser diffraction analysis. Low Angle Laser Light Scattering (LALLS), using a Malvern (Malvern, England) Mastersizer Long-bed X with a MSX17 sample presentation unit, enabled rapid measurement of particle sizes within the 0.1–2000 μm range. Macroscopic traces of organic matter were removed from representative sub-samples before being dampened by the dropwise addition of a standard chemical solution (40 g/l solution of sodium hexametaphosphate ($(NaPO_3)_6$) in distilled water) to help disperse aggregates.

To ensure complete disaggregation, each soil slurry was then subjected to ultrasonic dispersion in a Malvern MSX17 sample presentation unit. For greater precision, the mean of five replicate analyses was measured with a mixed refractive indices presentation setting. A standard range of textural parameters was calculated, including the percentage of sand, silt and clay class sizes and their sub-intervals. The Malvern instrumentation was regularly calibrated using latex beads of known size.

### 2.4. Data analyses

All data analyses were performed using MINITAB PC (version 13). Anderson-Darling normality tests demonstrated that not all variables were normally distributed, necessitating the use of non-parametric analyses. Spearman's rank correlations were therefore calculated between each magnetic parameter and individual particle size classes (i.e. clay, silt and sand), more discrete intervals within classes (i.e. fine silt, medium silt, coarse silt, fine sand, medium sand and coarse sand) and cumulative size fractions (e.g. clay + fine silt).

## 3. Results

Mineral magnetic properties of Manx topsoil samples are summarized in Table 1. Low-frequency magnetic susceptibility ($\chi_{LF}$) represents the total contribution of ferrimagnetic minerals. Susceptibility of Anhysteretic Remanent Magnetisation ($\chi_{ARM}$) is roughly proportional to the concentration of magnetic grains of stable single domain size (e.g. ~0.03–0.06 μm). Saturation Isothermal Remanent Magnetisation (SIRM) is related to concentrations of all remanence-carrying minerals in the sample, but is also dependent upon the assemblage of mineral types and their magnetic grain size (Walden *et al.* 1999).

Results show samples contained quite low to moderate quantities of magnetic minerals ($\chi_{LF}$ 0.55–34.31 $10^{-7}$ m$^3$ kg$^{-1}$; $\chi_{ARM}$ 0.02–5.03 $10^{-7}$ m$^3$ kg$^{-1}$; SIRM 19.73–2276.56 $10^{-5}$ Am$^2$ kg$^{-1}$), comparable with other British topsoils (Maher 1986; Dearing *et al.* 1996). Texture results for Manx topsoil samples are summarized in Table 2. Using the Soil Survey of England and Wales nomenclature (Hodgson 1985), the typical soil texture is silt loam (mean sand, silt and clay contents ~17, 76 and 7%, respectively).

Table 3 shows the Spearman's rank correlation coefficient values ($r_s$) between the mineral magnetic parameters and specific size fractions (Table 3a) and cumulative fractions (Table 3b).

Negative correlations exist between each mineral magnetic parameter and both the fine sand and coarse silt fractions (–0.017 to –0.195). In contrast, positive correlations exist between each mineral magnetic parameter and all other sand and silt fractions (0.022 to 0.233). It is apparent that each textural size, whether sand or silt, show notably different correlation strengths with each magnetic parameter. However, none of these relationships are significant ($p$ >0.05; $n$ = 46).

The clay fraction, on the other hand, shows positive correlations with both the χLF and χARM parameters, which are significant ($p$ <0.05; $n$ = 46), but not the SIRM parameter ($p$ >0.05; $n$ = 46). The cumulative fractions include both negative and positive correlations, but none are significant ($p$ >0.05; $n$ = 46). Figures 2a–i show bivariate scatter plots of $\chi_{LF}$ (x$10^{-7}$ m$^3$ kg$^{-1}$), $\chi_{ARM}$ (x$10^{-5}$ Am$^2$ kg$^{-1}$) and SIRM (x$10^{-5}$ Am$^2$ kg$^{-1}$) versus sand, silt and clay content (%).

Figs. 2a–i show bivariate scatter plots of $\chi_{LF}$ (x$10^{-7}$ m$^3$ kg$^{-1}$), $\chi_{ARM}$ (x$10^{-5}$ Am$^2$ kg$^{-1}$) and SIRM (x$10^{-5}$ Am$^2$ kg$^{-1}$) versus sand, silt and clay content (%). Since both the $\chi_{LF}$ and $\chi_{ARM}$ parameters have positive significant relationships with clay content (Figs. 2c and 2f), this

**Table 1.** Mineral magnetic data of bulk samples for Manx soils ($n$ = 46 samples)

| | Units | Mean | Maximum | Minimum | Standard deviation |
|---|---|---|---|---|---|
| $\chi_{LF}$ | $10^{-7}$ m$^3$ kg$^{-1}$ | 6.18 | 34.31 | 0.55 | 7.25 |
| $\chi_{ARM}$ | $10^{-7}$ m$^3$ kg$^{-1}$ | 0.85 | 5.03 | 0.02 | 1.07 |
| SIRM | $10^{-5}$ Am$^2$ kg$^{-1}$ | 523.72 | 2276.56 | 19.73 | 511.13 |

**Table 2.** Texture data (%) of bulk samples for Manx soils ($n$ = 46 samples)

| | Mean | Maximum | Minimum | Standard deviation |
|---|---|---|---|---|
| Coarse sand (600–2000 μm) | 0.30 | 2.76 | 0.00 | 0.58 |
| Medium sand (200–600 μm) | 4.73 | 27.26 | 0.00 | 5.55 |
| Fine sand (60–200 μm) | 11.54 | 22.68 | 0.82 | 4.63 |
| Coarse silt (20–60 μm) | 21.13 | 37.01 | 14.39 | 4.44 |
| Medium silt (6–20 μm) | 35.94 | 45.52 | 24.10 | 5.62 |
| Fine silt (2–6 μm) | 19.42 | 26.65 | 10.62 | 4.55 |
| Clay (<2 μm) | 6.93 | 10.43 | 2.24 | 2.13 |

**Table 3.** Spearman's rank correlation coefficients ($r_s$) between mineral magnetic concentration and textural parameters for Manx soils. Specific size fractions (a) and cumulative fractions (b) ($n$ = 46 samples)

| (a) | Clay <2 µm | Fine silt 2–6 µm | Medium silt 6–20 µm | Coarse silt 20–60 µm | Fine sand 60–200 µm | Medium sand 200–600 µm | Coarse sand 600–2000 µm |
|---|---|---|---|---|---|---|---|
| $\chi_{LF}$ | 0.297* | $0.106^{NS}$ | $0.038^{NS}$ | $-0.163^{NS}$ | $-0.168^{NS}$ | $0.116^{NS}$ | $0.104^{NS}$ |
| $\chi_{ARM}$ | 0.369* | $0.202^{NS}$ | $0.094^{NS}$ | $-0.178^{NS}$ | $-0.195^{NS}$ | $0.022^{NS}$ | $0.022^{NS}$ |
| SIRM | $0.281^{NS}$ | $0.027^{NS}$ | $-0.143^{NS}$ | $-0.168^{NS}$ | $-0.017^{NS}$ | $0.233^{NS}$ | $0.133^{NS}$ |

| (b) | <6 µm | <20 µm | <60 µm | >60 µm |
|---|---|---|---|---|
| $\chi_{LF}$ | $0.177^{NS}$ | $0.130^{NS}$ | $0.056^{NS}$ | $-0.056^{NS}$ |
| $\chi_{ARM}$ | $0.263^{NS}$ | $0.209^{NS}$ | $0.125^{NS}$ | $-0.125^{NS}$ |
| SIRM | $0.111^{NS}$ | $0.003^{NS}$ | $-0.095^{NS}$ | $0.095^{NS}$ |

Note: Significance levels: non-significant = $^{N.S.}$; $P$<0.05 = *

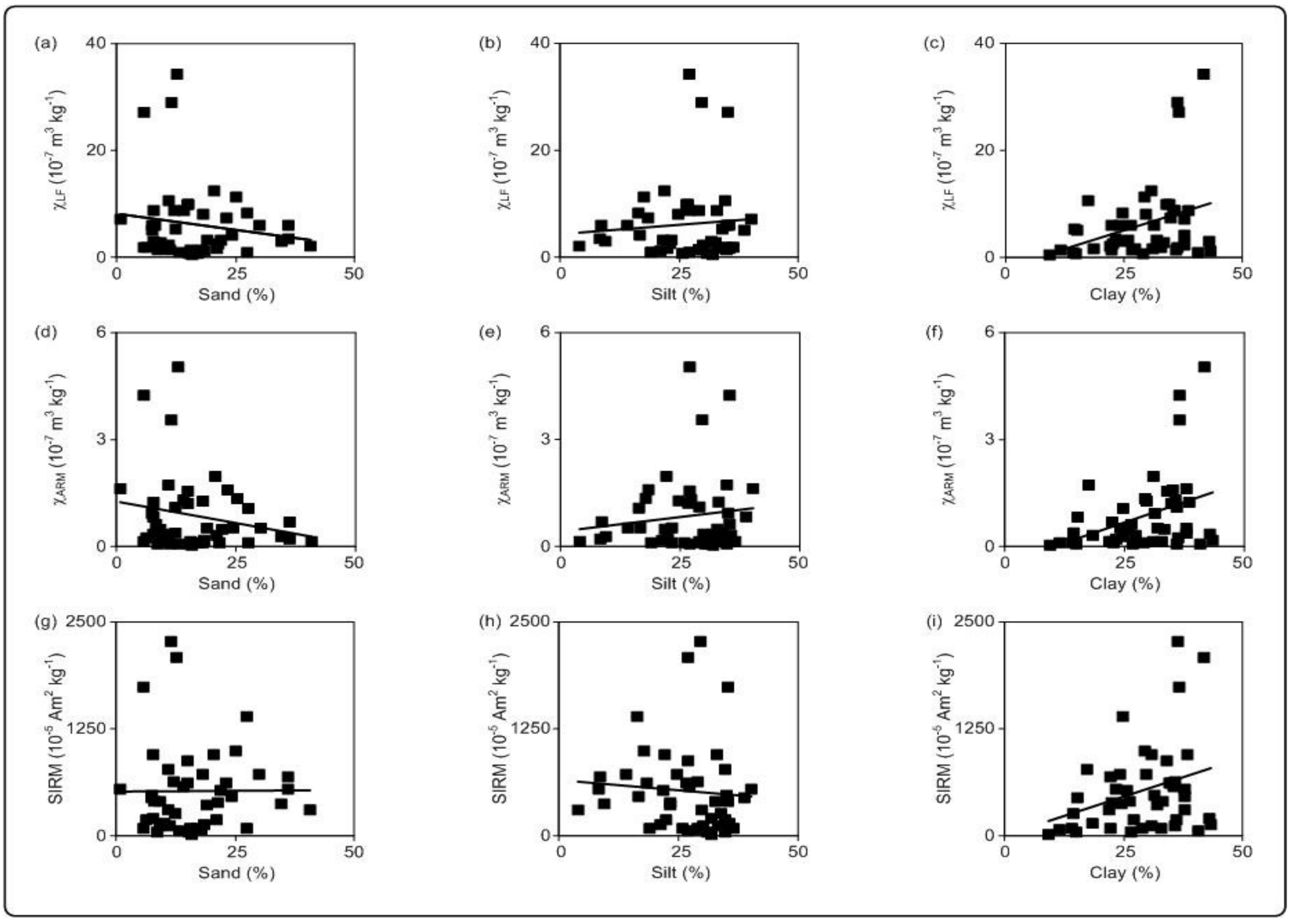


**Fig. 2.** Bivariate scatter-plots of $\chi_{LF}$ (x$10^{-7}$ m$^3$ kg$^{-1}$), $\chi_{ARM}$ (x$10^{-5}$ Am$^2$ kg$^{-1}$) and SIRM (x$10^{-5}$ Am$^2$ kg$^{-1}$) versus sand, silt and clay content (%) ($n$ = 46 samples)

indicates that differences in clay content are roughly proportional to the concentration of ferrimagnetic minerals within the samples ($\chi_{LF}$) and reflects almost exclusively the presence of ultra-fine superparamagnetic ferrimagnetic grains ($\chi_{ARM}$). However, similar to all the other figures, neither Fig. 2c nor 2f show any obvious linear data trend, but display relatively large degrees of scatter around the best-fit line. This suggests low confidence levels in both $\chi_{LF}$ and $\chi_{ARM}$ parameters as a clay content proxy. In fact, all the magnetic and textural relationships become insignificant when the three outlying samples are removed (data not presented).

In case combining the properties of five soil-types influenced the non-significance, as an example, Table 4 shows the Spearman's rank correlation coefficient values ($r_s$) between the mineral magnetic parameters and specific size fractions (Table 4a) and cumulative fractions (Table 4b) for Soil-type A. These results demonstrate insignificant ($p$ >0.05; $n$ = 20) correlations for both negative and positive trends, irrespective of all the specific size fractions and cumulative fractions. In fact, comparatively, the correlation coefficients are much weaker than those presented in Table 3. Each of these observations also typifies the results for each soil-type (data not presented).

**Table 4.** Spearman's rank correlation coefficients ($r_s$) between mineral magnetic concentration and textural parameters for Manx Soil-type A. Specific size fractions (a) and cumulative fractions (b) ($n$ = 20 samples)

| (a) | Clay <2 μm | Fine silt 2–6 μm | Medium silt 6–20 μm | Coarse silt 20–60 μm | Fine sand 60–200 μm | Medium sand 200–600 μm | Coarse sand 600–2000 μm |
|---|---|---|---|---|---|---|---|
| $\chi_{LF}$ | $0.125^{NS}$ | $-0.090^{NS}$ | $-0.096^{NS}$ | $0.005^{NS}$ | $0.011^{NS}$ | $0.167^{NS}$ | $0.240^{NS}$ |
| $\chi_{ARM}$ | $0.126^{NS}$ | $-0.060^{NS}$ | $-0.005^{NS}$ | $0.026^{NS}$ | $-0.078^{NS}$ | $0.063^{NS}$ | $0.188^{NS}$ |
| SIRM | $0.141^{NS}$ | $-0.062^{NS}$ | $-0.108^{NS}$ | $0.006^{NS}$ | $-0.008^{NS}$ | $0.131^{NS}$ | $0.188^{NS}$ |

| (b) | <6 μm | <20 μm | <60 μm | >60 μm |
|---|---|---|---|---|
| $\chi_{LF}$ | $-0.018^{NS}$ | $-0.060^{NS}$ | $-0.054^{NS}$ | $0.054^{NS}$ |
| $\chi_{ARM}$ | $-0.002^{NS}$ | $-0.009^{NS}$ | $0.039^{NS}$ | $-0.039^{NS}$ |
| SIRM | $0.003^{NS}$ | $-0.042^{NS}$ | $-0.027^{NS}$ | $0.027^{NS}$ |

note: Significance levels: non-significant = $^{N.S.}$

## 4. Discussion

Given the combination of low-cost and sensitivity of the method, it can be argued that mineral magnetic measurements might have considerable potential to act as a particle size proxy. The method is also rapid; bulk samples require little preparation, and individual measurements of magnetic susceptibility ($\chi_{LF}$) can be made in ~1 minute, in either the field or laboratory. Previous workers have investigated this potential of the method. For example, Oldfield *et al*. (1993) identified: (a) that anhysteretic remanent magnetisation (ARM) measurements can reflect the concentration of fine-grained magnetite (<0.1 μm) in the clay fraction and (b) $\chi_{LF}$ measurements can be used to infer the presence of coarser multi-domain magnetite (>1.0 μm) in sands and coarse silts. In a more detailed investigation, (a) $\chi_{LF}$ was strongly associated with sands and medium silts, (b) susceptibility of ARM ($\chi_{ARM}$) was strongly associated with clay and fine silts, and (c) saturated isothermal remanent magnetisation (SIRM) was strongly associated with very fine to medium silts (Clifton *et al*. 1999). Zhang *et al*. (2001) suggested that both percentage frequency-dependent magnetic susceptibility ($\chi_{FD\%}$) and $\chi_{ARM}$ could be used as a proxy for clay content. In general, this evidence supports the inference that high magnetic concentration measurements are associated with large amounts of fine-grained sediments and an inverse relationship with coarse-grained sediments. However, more recently, Booth *et al*. (2005a) reported the strength and significance of $\chi_{LF}$, $\chi_{ARM}$ and SIRM parameter associations with sand, silt and clay content can be different for specific environments within an individual sedimentary setting.

Manx magnetic concentration and texture associations contrast with previous work (Oldfield *et al*. 1993; Clifton *et al*. 1999; Zhang *et al*. 2001; Booth *et al*. 2005a). For instance, in this study, $\chi_{LF}$ and $\chi_{ARM}$ parameters reveal significant ($p$ <0.05; $n$ = 46), but very weak ($r_s$ = 0.297 and 0.369) associations with clay content, respectively, while $\chi_{LF}$, $\chi_{ARM}$ and SIRM parameters have no significant relationship with sand or silt content. In contrast, previous magnetic concentration parameter associations have shown greater significance levels ($p$ <0.01; $n$ = 113) and much stronger correlations with sand ($r$ = –0.957), silt ($r$ = 0.958) and clay ($r$ = 0.943) content (Booth *et al*. 2005a). This indicates Manx soil texture data have no notable kinships with magnetic concentration parameters.

Correction of particle size effects relies on a formal correlation between analytical data and textural variation following a predictable relationship (i.e. the finer a sediment, the greater its pollutant concentration). Based on data presented here, such a simple relationship does not exist between the mineral magnetic concentration parameters and particle size. Contrary to earlier research findings, this indicates that magnetic measurements are not always a suitable particle size proxy. However, previous similar proxy work mainly focused on modern sedimentary environments and has not thoroughly examined the application of mineral magnetic measurements as a particle size proxy for topsoils. Therefore, this suggests it is only certain environments and/or specific settings where mineral magnetic measurements are appropriate for granulometric normalization. Furthermore, it also indicates the association may not be as simple as previous work proposes and highlights the importance of fully determining the nature of the relationship between texture and magnetic properties before applying mineral magnetic data as a particle size proxy. As described earlier, other workers have demonstrated significant relationships between mineral magnetic and particle size data (Oldfield *et al*. 1993; Clifton *et al*. 1999; Zhang *et al*. 2001; Booth *et al*. 2005a). The results presented here demonstrate that such a relationship cannot be considered predictable and, for a given soil or sedimentary environment, the form of the relationship must be tested prior to any attempt to use mineral magnetic properties as a particle size proxy. However, where such a relationship can be reliably demonstrated, mineral magnetic measurements can provide a simple, reliable, rapid, sensitive, inexpensive and non-destructive method for normalizing particle size effects in soil contamination studies.

## 5. Conclusions

1. The significant relationships between mineral magnetic and particle size properties observed in other environmental settings (Oldfield *et al*. 1993; Clifton *et al*. 1999; Zhang *et al*. 2001; Booth *et al*. 2005a) are not replicated in data presented here for soils from the Isle of Man.

2. Some magnetic parameters reveal significant associations with clay content, but the correlations are relatively weak. This indicates that for these soil samples, mineral magnetic measurements should not be employed as a proxy for particle size when attempting to normalize for particle size effects upon other compositional data.

3. The results presented here demonstrate that such a relationship cannot be considered predictable and, for a given soil or sedimentary environment, the form of the relationship must be tested prior to any attempt to use mineral magnetic properties as a particle size proxy.

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## MAGNETINIŲ MINERALŲ MATAVIMŲ, SIEKIANT JAIS PAKEISTI GRANULIOMETRINĖS SUDĖTIES ANALIZĘ, PROBLEMOS IR POTENCIALAS

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Santrauka

Tyrimuose atskleistas mineralų magnetinių koncentracijos parametrų panaudojimas ($\chi_{LF}$, $\chi_{ARM}$ ir *SIRM*) kaip potencialiai alternatyvus metodas granuliometrinės sudėties nustatymo analizei *Isle of Man* (Britų salos) surinktiems dirvožemio pavyzdžiams tirti ir dalelių dydžio reiškiniui normalizuoti. Aprašytas su dirvožemiu susijusių analizinių duomenų palyginimas koreliacinių analizių būdu, t. y. tarp kiekvieno magnetizmo parametro ir atskirų dydžių dalelių frakcijų (t. y. smėlio, dulkių ir dumblo) ir tarpinių šių intervalų frakcijų (pavyzdžiui, smulkaus smėlio ar vidutinio rupumo dulkių) ir jungtinių frakcijų (pavyzdžiui, dumblo + smulkių dulkių). Tiek $\chi_{LF}$, tiek $\chi_{ARM}$ parametrai atskleidžia reikšmingas ($p$ <0,05; $n$ = 46), bet palyginti nereikšmingas ($r_s$ = 0,297 ir 0,369) ryšių asociacijas su dumblo kiekiu, o $\chi_{LF}$, $\chi_{ARM}$ ir *SIRM* parametrai neturi reikšmingų priklausomybių nuo smėlio ir dulkių kiekių, nei su atskiromis ar jungtinėmis dalelių dydžių frakcijomis. Priešingai ankstyvesniems tyrinėjimų rezultatams, tai rodo, kad magnetiniai matavimai ne visada yra tinkama alternatyva granuliometrinės sudėties analizei pakeisti ir tiktai tam tikroje, specifinėje aplinkoje yra tinkami granuliometrinei sudėčiai normalizuoti. Tačiau jei ateityje tyrėjai, tiriantys kitas dirvožemio savybes, nustatytų proporcingas prognozuojamas priklausomybes, šis matavimų metodas siūlo paprastą, patikimą, greitą, tikslų, nebrangų ir neardomąjį metodą, kuris galėtų būti vertinga granuliometrinės analizės alternatyva normalizuojant dalelių dydžio reiškinius studijuojant užterštus dirvožemius.

**Reikšminiai žodžiai:** aplinkos magnetizmas, dirvožemio granuliometrinė sudėtis, duomenų normalizavimas, dalelių dydžio reiškinys, dirvožemio užterštumas, visuomenės sveikata, *Isle of Man*.

**ПРОБЛЕМЫ И ПОТЕНЦИАЛЬНЫЕ ВОЗМОЖНОСТИ ПРИМЕНЕНИЯ МАГНИТНЫХ ИЗМЕРЕНИЙ МИНЕРАЛОВ ДЛЯ ЗАМЕНЫ АНАЛИЗА ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА ПОЧВЫ**

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Р е з ю м е

Исследована возможность использования магнитных параметров ($\chi_{LF}$, $\chi_{ARM}$ и *SIRM*) как альтернативного потенциального метода для определения гранулометрического состава почв, отобранных в Isle of Man (Британские острова), и нормализирования эффекта по величине частиц. Описано сравнение связанных с почвой аналитических данных на основе метода корреляционного анализа, т. е. между каждым параметром магнетизма и частиц отдельных фракций (песок, пыль, глина) и промежуточных фракций этих интервалов (например, глина + мелкая пыль). Параметры как $\chi_{LF}$, так и $\chi_{ARM}$ показывают существенную ($p$ <0.05; $n$ = 46), однако сравнительно слабую ($r_s$ = 0.297 ir 0.369) связь с количеством пыли, в то время как параметры $\chi_{LF}$, $\chi_{ARM}$ и *SIRM* не имели существенной зависимости от количества глины и песчаных частиц как для отдельных, так и для смешанных фракций. В отличие от результатов предыдущих исследований данные результаты свидетельствуют о том, что магнитные измерения не всегда являются приемлемой альтернативой для замены метода определения гранулометрического состава и лишь в определенных специфических условиях могут применяться для этого. Если в будущем исследователи, изучающие другие свойства почвы, смогут установить пропорциональные прогнозируемые зависимости, этот магнитный метод измерения сможет применяться, так как он предлагает простой, достоверный, быстрый, точный, недорогой и неизменяющийся способ, который может быть альтернативой анализа гранулометрического состава с целью нормализации эффекта величины частиц при изучении загрязненных почв.

**Ключевые слова:** магнетизм окружающей среды, гранулометрический состав почвы, нормализация данных, эффект величины частиц, загрязнение почвы, здоровье общества, Isle of Man.

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