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# SOME PORTUGUESE CLAY SEDIMENTS USED AS RAW MATERIALS FOR CURATIVE CLAY PASTES: A STUDY OF PHYSICAL AND TECHNOLOGICAL PROPERTIES

**Mario REBELO [1], Paulo GONÇALVES [1], Emilio SILVA [2] and Fernando ROCHA [1]***

[1] *Industrial Minerals and Clays Centre, Departemento de Geociências, Universidade de Aveiro, 3810-193 Aveiro, Portugal*
[2] *ELMAS Research Centre, Departemento de de Geociências, Universidade de Aveiro, 3810-193 Aveiro, Portugal*
**Corresponding author's e-mail*: frocha@geo.ua.pt

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ABSTRACT
The assessment of mineralogical, physical and thermal properties of silt-clay fraction from several sedimentary rocks, aimed at the pelotherapy paste preparation, is presented. All clay separates commonly exhibit a higher clay fraction content (as a rule >50 wt %), despite different genesis (Jurassic, Upper Cretaceous and Miocene marly clay as well as marl, Miocene clayey sandstone and mudstone). After benefition, the majority of clay pastes can be suitable for the use in pelotherapy, due to higher proportion of swelling Ca-smectite and mixed-layer illite/smectite among other clay minerals, such as illite, kaolinite, and chlorite. The clay pastes from Vimeiro 2 (smectite > kaolinite + illite) and from Torres Vedras 6 (kaolinite>illite, smectite, interstratified illite-smectite) can be candidate materials. Their plasticity index (P.I. = 14 - 17 %), cation exchange capacity (CEC = 16 - 25 meq/100 g), higher water adsorption as well as low abrasivity index (0.16 - 0.19 mg/m$^2$), low cooling rate (29 min.) and ease of handling are comparable with peloid properties commonly used in the Portuguese spas-centres. Morerover, Miocene marly clay from the locality Monfortinho shows a palygorskite admixture, the CEC of about 20.2 meq/100 g, and highest plasticity index (P.I. = 35). However, lower clay-sized proportion (36 %) and sand-sized particles reduce the stickiness on the skin and heat retention.

KEYWORDS: clay separates, physical-technological testing, pelotherapy, Portugal

## 1. INTRODUCTION

The pastes prepared with high quality bentonites are suitable for use in both internal and external therapeutic applications since historical times. Their typical properties, mainly high swelling, heat retention, and ease of handling have been characterized empirically only. The pelotherapy of rheumatism, arthritis and bone-muscle traumatic damages, the treatment of skin diseases and cosmetic cleaning masks are most successfully applied (Ferrand and Yvon, 1991; Veniale and Setti, 1996; Yvon and Ferrand,1996; Cara et al. 2000). In Portugal, there are several natural occurrences of clays/mudstones which are used for these purposes, either indoor treatments in Thalassotherapy Centres and Thermal Spas, or outdoor applications in natural sites (Gomes et al., 2002, 2003, Silva et al., 2003), generally located near the seaside (beaches, coastal lagoons). Peloids and the para-mud, representing the peloid with paraffin admixture, are commonly applied for arthritis and bone-muscle traumatic damages. Clay-water baths, affecting human living quality, are successfuly used to recover lipo-dystrophies and cellulitidae.

The thermal muds (peloids), prepared with appropriate clay separates from the clay sedimentary rocks, have been recently tested for physical and mechanical properties and compared with peloids commonly used in the proximal spas. The aim of this study is the assessment of their mineralogical, physical and technological properties relevant for the pelotherapy.

## 2. MATERIALS, METHODS AND RESULTS

The tests have been performed with eight representative samples from Mesozoic-Cenozoic clayey formations (at Torres Vedras, Penedo Beach near Costa da Caparica, Galé Beach near Sines, Monfortinho, and Vimeiro). A location is seen in Fig. 1. Outcrops of the grey-coloured marly clay (Monfortinho), red-brownish clayey sandstone (Torres Vedras), grey marls and marly clays (Vimeiro), dark clays (P. Setúbal) and clayey fine-grained sandstone (Galé Beach near Sines) are illustrated by photographs 2a, 2b, 2c, and 2d, respectively. For comparison, the available data were selected from other sites, either where indoor commercial applications (Silva et al., 2003) are already practicized, e.g.

**Table 1** Particle size assessment and mineralogical representation of smectites

| Locality | Ve-3 | Ve-4 | Ve-6 | Mo-1 | Vi-1 | Vi-2 | Si-1 | Se-1 |
|---|---|---|---|---|---|---|---|---|
| <63 µm | 89 | 63 | 96 | 39 | 53 | 72 | 11 | 60 |
| < 2 µm of which | 50 | 35 | 55 | 36 | 42 | 37 | 68 | 63 |
| smectite (wt%) | 10 | 5 | 25 | 20 | 25 | 50 | 15 | 61 |
| exchangeable cation | Ca | Ca | Ca | Ca | Ca | Ca | Mg | Ca |

Ve – **Torres Vedras,** Mo **– Monfortinho,** Vi – **Vimeiro,** Si **– Sines,** Se **– P. Setúbal**

**Table 2** Main physical and technological properties of the samples

| Locality/sample | Plasticity Index (P. I.) wt. % | Abrasivity Index (mg.m$^{-2}$) | CEC meq/100g | SSA (m$^2$ g$^{-1}$) | Specific heat (Cp in J/g °C) | Cooling rate (min.) |
|---|---|---|---|---|---|---|
| Torres Vedras 3 | 23 | 0.16 | 17.2 | n.d. | n.d. | 27.5 |
| Torres Vedras 4 | 8 | 0.21 | 8.4 | n.d. | n.d. | 23 |
| Torres Vedras 6 | 17 | 0.16 | 16 | n.d. | n.d. | 29 |
| Monfortinho | 35 | 0.11 | 20.2 | n.d. | n.d. | 19.5 |
| Vimeiro 1 | 10 | 0.17 | 12.8 | n.d. | n.d. | 27.5 |
| Vimeiro 2 | 14 | 0.19 | 25 | n.d. | n.d. | 29 |
| Sines | 10 | 0.01 | 11.8 | n.d. | n.d. | 27.5 |
| P. Setúbal | 22 | 0.22 | 13.4 | n.d. | n.d. | 19.5 |
| Praia do Meco | 34 | 0.27 | 18.6 | 14.5 | 1.22 | 18 |
| Praia da Consolação 1 | 17 | 0.15 | 17.3 | 6.9 | 1.20 | 19.5 |
| Praia da Consolação 2 | 21 | 0.14 | 16.9 | 20.9 | n.d. | 15.5 |
| Praia da Consolação 3 | 18 | 0.24 | 12.4 | 20.9 | n.d. | 17 |
| Parede 1 | 11 | 0.11 | 24.2 | 15.5 | 1.46 | 16 |
| Parede 2 | 9 | 0.32 | 6.1 | 5.5 | n.d. | 14 |
| Serra de Dentro | 161 | 0.11 | 89 | 79 | 3.55 | 25 |
| Vale das Furmas | 60 | 0.15 | 25 | 50 | 3.15 | 16.5 |
| Vale de Cucos | 8 | 0.35 | 11 | 18 | 3.45 | 19.8 |

- Vale dos Cucos Thermal Spa (near Torres Vedras),
- Serra de Dentro (in Porto Santo Island, Madeira archipelago),
- and Vale das Furmas Thermal Spa (in San Miguel Island, Azores archipelago);
  or where outdoor empirical applications are made, e.g., in the beach areas (Gomes et al. 2002):
- Meco Beach (near Costa da Caparica)
- Consolação Beach (near Vimeiro),
- Parede Beach (near Lisbon).

Particle size distribution was assessed using wet sieving and the X-ray grain size analyzer (Sedifraph, model 5100 of Micromeritics). Results are inclosed in Table 1. Each sample was dried, washed with distilled water, and sieved under water to separate the silt/clay sized fraction. Semiquantitative mineralogical analyses of both fractions were performed by XRD utilizing ramdomly-oriented powders (< 63 µm) and oriented aggregates (< 2 µm). Some criteria recommended by Barahona (1974), Schultz (1964), Thorez (1976), Mellinger (1979), Peaver and Mumpton (1989) were followed. Major element analyses of clays (not shown here) were carried out by X.ray fluorescence and frame-spectroscopy methods (the latter only for Na and K). Exchangeable cations were determined by flame-spectroscopy and atomic absorption method.

Technological properties of these clays, such as cation exchange capacity (CEC), specific surface area (SSA), plasticity index (P.I.), abrasivity index, and heat diffusiveness have been assessed earlier. The CEC was estimated by the ammonium acetate method. Abrasivity was measured with an Einlehner AT-1000 Abrasivimeter instrument. The plastic and liquid limits (and plasticity index) were determined in accordance with the Portuguesse norm NP 143-1969. Heat diffusiveness was assessed by a Dual thermometer. Results are given in Table 2.

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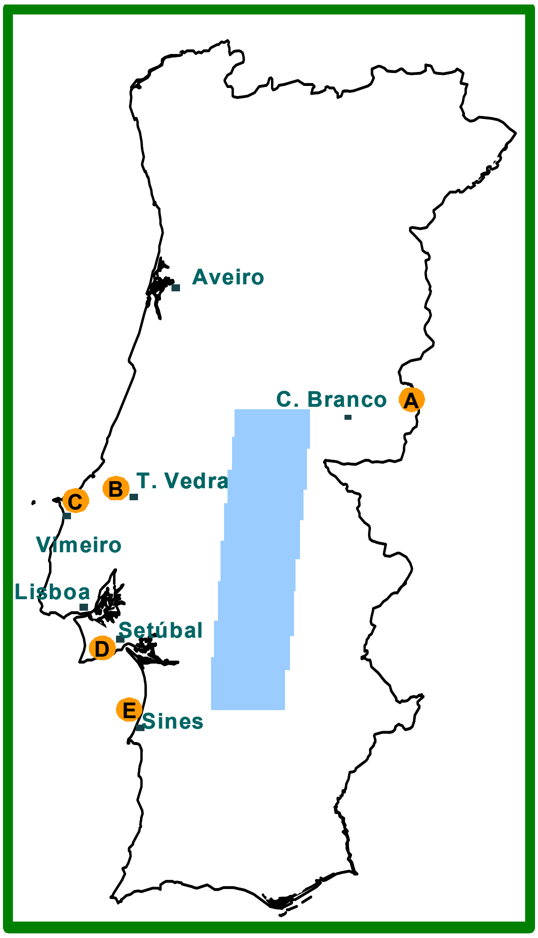


**Fig. 1** Studied samples location. A - Monfortinho; B - Torres Vedras; C - Vimeiro; D - Penedo Beach; E - Galé Beach (Sines).

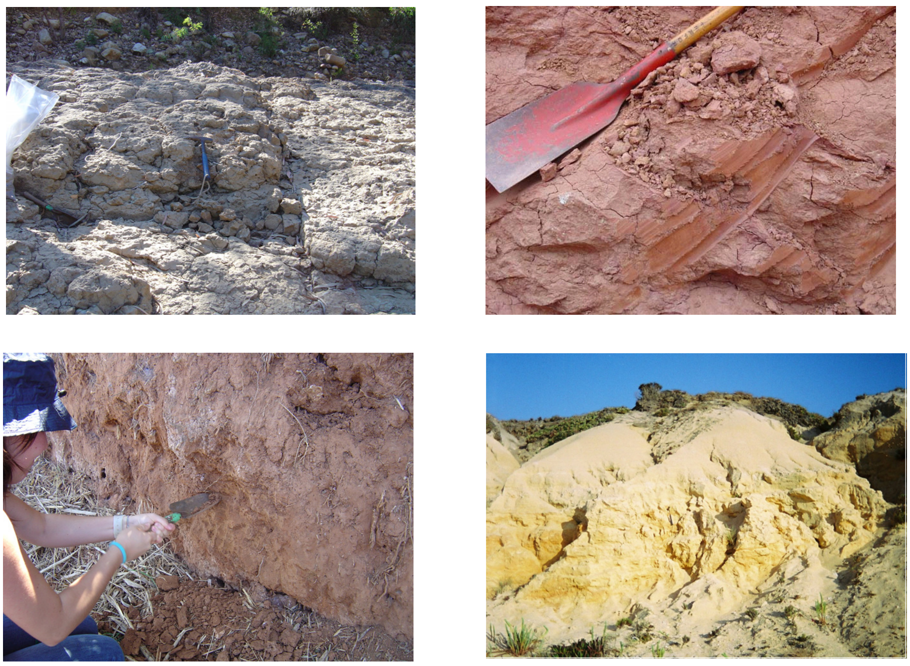

**Fig. 2** Studied outcrops; from top left to bottom right: Monfortinho Miocene marly clays (a), Torres Vedras Lower Cretaceous clayey sandstones (b), Vimeiro Jurassic marls/marly clays(c), and Galé Beach (Sines) Miocene clayey fine sandstones (d).