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Organic matter characterization of sediments in two river beaches from northern Portugal for forensic application

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ABSTRACT

In a forensic investigation, the analysis of earth materials such as sediments and soils have been used as evidence at a court of law, relying on the study of properties such as color, particle size distribution and mineral identification, among others. In addition, the analysis of the organic composition of sediments and soils is of particular value, since these can be used as complementary independent evidence to the inorganic component. To investigate the usefulness of organic indicators in sediment characterization and discrimination, seventy-seven samples were collected during a period of one year in two river beaches located at the southern bank of the Douro River estuary in the North of Portugal. Isotopes of total carbon, pollen and plant wax-marker analyses were performed. In both beaches, an increase of the organic matter concentrations was noticeable, moving landward, related with the higher cover of associated plant material. The results obtained showed that the combination of all the techniques adopted showed a clear discrimination between samples from the two beaches, and also showed a differentiation of samples in relation to distance from the river in both beaches. The results also show that seasonality in these beaches was not a determining factor for discrimination, at the times considered. In addition, the effects of time was not marked.

1. Introduction

The use of soils (the term soils is applied in its "latum sensum" including soils and sediments) as trace evidence in criminal and civil matters has increased, and is now increasingly being adopted worldwide [1]. This is as a result of the fact that this type of material holds within it multiple fingerprints, each soil having a combination of different features which can potentially lead to its uniqueness [2,3]. Thereby, a forensic investigation carried out on soils benefits from a multidisciplinary approach to enable the association or dissociation between soils in a forensic context with an evidential questioned sample [2,4,5]. There are potentially a large number of analyses that can be performed on soils in order to evaluate its inorganic and organic features; such as spectral color, density distribution of particles, particle size distribution, magnetic susceptibility, light and heavy mineral analysis, stable isotope analysis, elemental analysis, pollen analysis, microorganisms, plant wax compounds [2–5]. Therefore, it is important to develop and optimize standardized analytical procedures that can be reliable, easily and rapidly executed in a forensic context and that are also reproducible. It is possible to try to carry out the combined series of analyses on just tens of milligrams of soil or less. However, it is known that if low concentrations are suspected, more material should be examined if available [6]. In a forensic investigation, the choice of the methods to be used depend on the size and condition of the soil samples, the associated costs, the instruments available [5] and also if there is a need to study a particular feature for a specific purpose.

Having well established protocols is important to also construct reliable soil databases where information about spatial and temporal variability on soil properties is accurate and desirable. Databases that have samples well-referenced supply important information to potentially eliminate areas of land from further police enquires [5].

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The common contact between soils and person/objects leads to the natural transference of its components (inorganic and/or organic) which can be used as potential evidential in courts. The inorganic features have been the most commonly used in soil forensic investigation rather than the organic ones [5]. The organic compounds can originate from plants, animals and micro-organisms (present, past or in decomposition) belonging to the local biotic or from external biotic sources [7]. Furthermore, the organic matter content of sediment samples has been poorly studied in the context of forensic application.

To investigate the usefulness of organic matter signatures in beach sediments for forensic discrimination, seventy-seven samples were collected in different seasons during a period of one year in two river beaches located at the southern bank of the Douro River estuary in the North of Portugal and isotope, pollen, and plant wax analyses were performed. These two river beaches although isolated, are very busy areas during the summer and other seasons due to its popular water sports. Therefore, beach sediments from these localities can be useful in investigative intelligence, either as a known origin sample referenced in a database or via its retrieval from a suspect's clothing, footwear, vehicle, or crime scene.

2. Materials and methods

2.1. Sample collection and handling

The locations selected for sampling were two river beaches, Oliveira do Douro and Avintes, in northern Portugal, on the southern bank of the Douro River in Vila Nova de Gaia, near Porto.

The surrounding geology of both beaches is characterized by several distinct lithologies, the most important of which is the Porto two-mica Hercynian granite, and "Schist-graywacke complex", composed of micaschists, metagraywackes and gneisses, ante-Ordovician in age (Fig. 1).

To account for seasonal variability, samples were collected in all seasons of the year on both beaches and the same sampling procedure was followed on each date. All the samples were collected along a transect perpendicular to the river side and spaced 15 m apart. In the Oliveira do Douro beach the samples were collected from eight locations and in the Avintes beach the samples were collected from five locations. However, the Oliveira do Douro spring sampling and the Avintes winter sampling was obtained through the collection of three samples from the corners of a triangular array, 1 m apart at each location to evaluate the small-scale local variability, while in the other seasons only one sample was harvested due to the inexistence of differences between the samples within each triangle (Fig. 1). In the summer in Oliveira do Douro beach, the sample nearest the river was not collected due to the high water level. A total of seventy-seven samples were manually collected from the surface topsoil (depth less than 5 cm) using a plastic spatula. The spatula was thoroughly cleaned after each sampling location to avoid contamination between samples. At the same time that the samples were collected, a plant survey was carried out at each beach.

The samples were dried at 40 °C, homogenized and subsequently split into sub samples for the different analyses. The palynological analysis was performed on the unsieved bulk

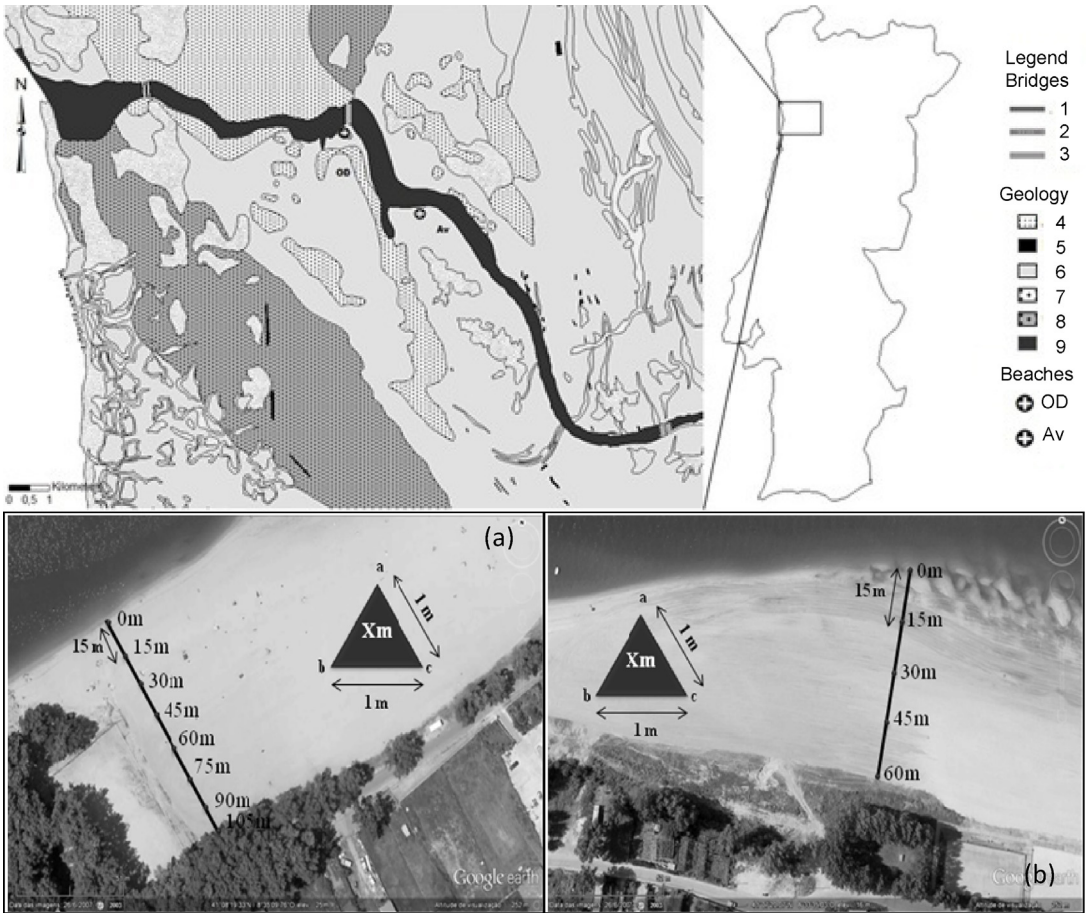

Fig. 1. Simplified geological map of the northern Portugal including Oliveira do Douro river beach and Avintes river beach (1 – Arrábida bridge; 2 – Freixo bridge; 3 – Crestuma-Lever dam; 4 – Quaternary deposits; 5 – Quartz; 6 – Metamorphic rocks; 7 – Two-mica granites; 8 – Biotitic granites; 9 – Douro River) and the sampling profiles performed at both places, (a) and (b) respectively. Map (a) and (b) data: Google, DigitalGlobe.