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Geochemical fingerprints in topsoils of the volcanic Brava Island, Cape Verde

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ABSTRACT

Topsoils developed on different lithologies of all the geological units of the volcanic Brava Island (Cape Verde archipelago) were studied by neutron activation analysis and Mössbauer spectroscopy. Sampling was performed according to the recommendations of the IGCP 259 ("International Geochemical Mapping"). Significant chemical contents variations were found even within the same volcano-stratigraphic unit, inherited from the parent rock composition under the semi-arid climate of the island. The chemical heterogeneity of topsoils within the same geological unit, particularly in the Upper Unit, was evidenced by a multivariate statistical analysis. Some differences found can be related with the geographical location/underlying basement. High contents of Mn, Co, Ga, Ba, La, Ce, Nd, Sm, Eu, Tb, Ta, W, Th and U were observed in soils related to carbonatites and phonolites. REE and W can be used to trace outcrops of extrusive carbonatites. In general iron is strongly oxidized occurring in the silicates structure as well as in hematite, oxidized magnetite and maghemite. The global iron oxidation degree, the fraction of Fe^{3+} in silicates and the fraction of nanosized oxides, which are higher in topsoils of the older units, may be an indicator of weathering degree. As, Br and Sb contents were also found to increase with weathering. Topsoils developed on extrusive carbonatites are clearly distinguished due to the absence of Fe^{2+} in the silicate phases and the remarkable predominance of low oxidized magnetite.

1. Introduction

The chemical elements content of soils and their spatial distribution constitutes a fundamental knowledge for many domains such as environmental monitoring, soil science, geology, mineral explorations, geomedicine (Inácio et al., 2008; Ódor et al., 1997; Prohic et al., 1997; Prudêncio et al., 2010, 2011; Rivera et al., 2015; Xuejing and Hangxin, 2001; Yang et al., 2010; Zhizhong et al., 2014). The analysis of whole samples to evaluate total concentrations determines the true extent of chemical elements levels in soils (Wilson et al., 1997). These data allow the assessment of the extractable fraction of the chemical elements by aqua regia digestion (Marques et al., 2012), by other acidic solution or by water (Sonneveld et al., 1990), thus contributing to a better understanding of the elements dynamics on the Earth surface. The use of topsoil or regolith samples for geochemical mapping is recommended by Darnley et al. (1995).

The geology, volcanology, geoecology and hydrogeology of the Cape Verde archipelago have been the subject of several studies (Assunção et al., 1965; Carreira et al., 2010; Gomes and Pina, 2003; Madeira et al., 2008, 2010; Matos Alves et al., 1979; Marques et al., 2014a, b, 2015; Martins et al., 2010; Monteiro Santos et al., 2006; Mourão et al., 2010; Pina et al., 2005). The first low sampling-density survey of the geochemistry of rocks, soils, stream and sediments was done in Santiago Island in the frame of a large project aiming to construct an environmental atlas of the Cape Verde archipelago. Soil samples were collected in 2005/2006 in Santiago with a density of 0.28 samples per km^2. Studies of these samples were performed including the chemical (aqua regia extractable solution) and mineralogical characterization, as well as grain-size distribution (Cabral Pinto, 2010; Cabral Pinto et al., 2014; Hernandez, 2008). The total content of major, trace and rare earth elements (REE), and the evaluation of the extractable fraction of selected elements by aqua regia digestion and its correlation with the grain size, was extensively discussed by Marques et al. (2012).

A detailed Fe speciation study by Mössbauer spectroscopy of topsoils of Fogo, another island of the same archipelago, showed that oxidation is a major weathering mechanism under semi-arid climate, and a correlation between the fraction of nanosized iron oxides and some trace

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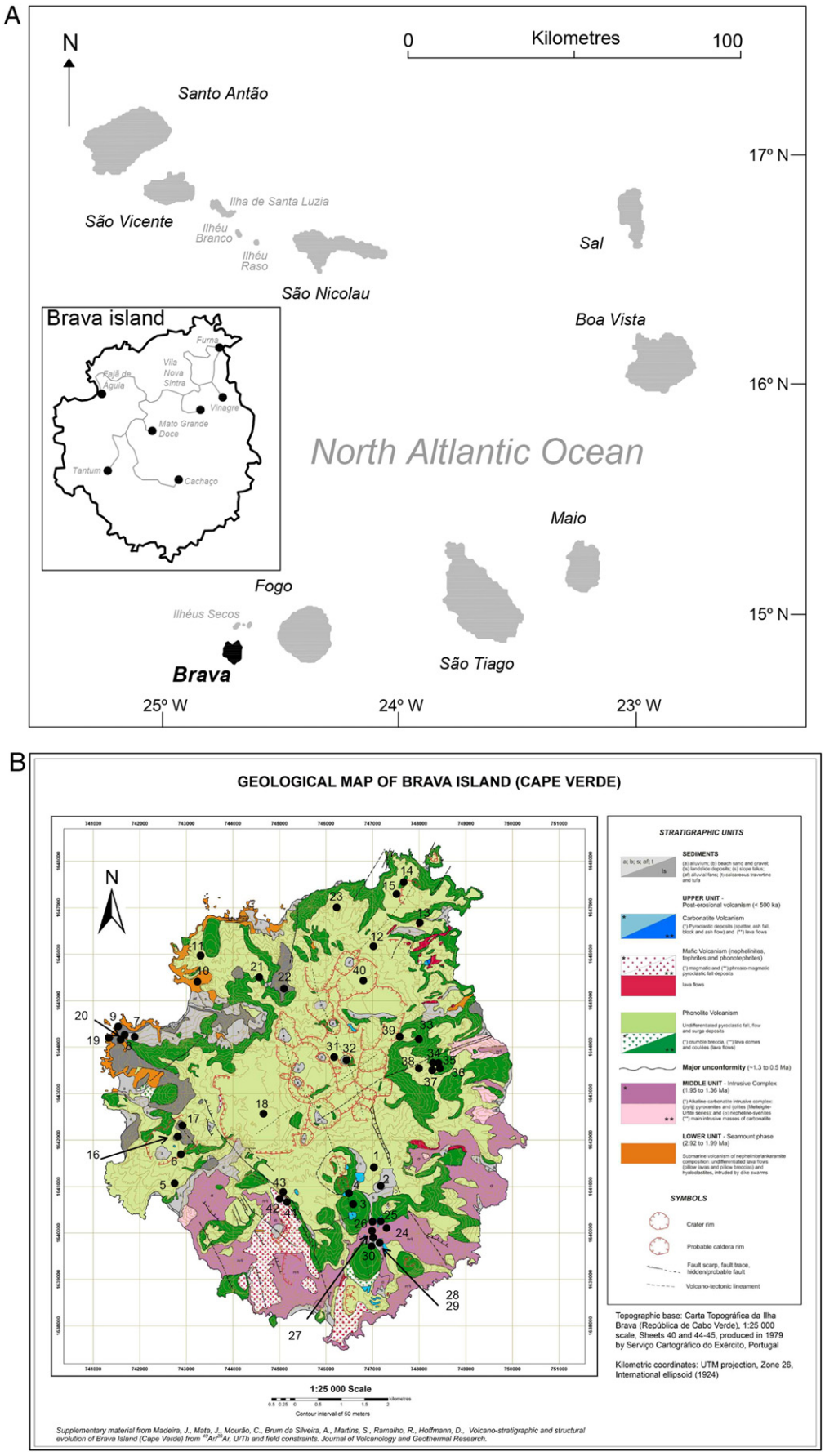

Fig. 1. (A) Location of Brava Island in the Cape Verde archipelago and (B) sampling location of 43 studied topsoils of the Brava Island (superposed to the Brava geological map by Madeira et al. (2010)).