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Oligo-Miocene coal in a microtidal environment reworked under Quaternary periglacial conditions (Western Falkland Islands/Isla Gran Malvina) – Coal formation and natural sand processing

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ABSTRACT

The Western Falkland Islands are characterized by landforms and sediments of Quaternary age originating from the interplay of periglacial and marine processes. These have left their imprints on siliciclastic sediments and subbituminous coal, peatland, and podzolic soil. Our depositional study focuses on interpreting a stratigraphic sequence which contains white quartz sand with an interbedded coal seam by using petrography (coal petrography, carbon isotope analysis, sedimentary petrography, clay mineralogy, granulometric, morphometric studies), and geochemistry. The study of the coal-sand couple sheds some light on two contrasting sedimentary geological settings. Firstly, it broadens the knowledge of the regional geology at the southern tip of South America by examining how coal seams may be emplaced in a periglacial-microtidal environment. Secondly, the study is also relevant for applied geology by investigating how sand is processed in a coal-bearing paralic regime. The coal-sand couple evolved during 6 discrete stages. Stage I: The detrital parent material was derived from the Siluro-Carboniferous Gran Malvina Group. Stage II: From the Oligocene through the late Miocene under a warm tropical climate organic matter was accumulated in a paralic environment giving rise to subbituminous coal. Stage III: During the Pleistocene alternating erosion and deposition in a wave-dominated coastal-marine regime gave rise to the build-up of coal interbedded with sand. The hydrodynamic regime reduced the grain size to the level of medium to fine sand and enhanced its sorting coefficient causing the separation of minerals according to their specific gravity (mechanical processing). Stage IV: The coal seam has been reworked by the last glacial progradation. Stage V: Weathering by wind and waterworn sand grains into semispherical to spherical forms and the content of heavy minerals increased along backshore and in dune belt environments. Stage VI: Organic acids derived from the coal promoted chemical leaching and significantly contributed to the decrease of the labile constituents of arenites (feldspar, carbonate minerals, and calcareous tests of faunal remains). Chemical alteration was grinded to a halt by another sea level rise, which gradually destroyed the coal layer. The depositional environment most effective for the processing of sand is located in the microtidal setting. In the meso- to macrotidal hydrodynamic regime the chemical leaching becomes the only efficacious tool to improve the quality of the footwall rocks. Due to the predominance of argillaceous sediments there, the quality of clay is enhanced and kaolin deposits may come into existence.

1. Introduction

Considering the economic geology of the Quaternary, two commodities stand out by their widespread occurrence: Peat and sand. Coal is rare. The predecessor of the Holocene sediments, the Pleistocene arenaceous series were, in places, described to host subeconomic coal-like beds (Stephan, 2014). Subbituminous coal of economic grade is known from the Neogene and Paleogene sedimentary series (Holdgate et al., 1995).

Aggregates, sand, and gravel are rated up as the premier raw material, followed by quarry and dimension stones, and lastly by lignite and peat (Prentice, 1990; Lorenz, 1991; Lüttig, 2007). On the map illustrating the deposits of fossil fuels, ore, and industrial minerals of Central Europe sand could not be shown. It would have covered almost the entire map and thus, it was shown on a different one of a regional scale (Dill and Röhling, 2007). The primary use of sand is as raw material

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for construction. High- and ultra-high purity quartz sands composed of almost 100% SiO_2 which are required for the production of silica glass, optical, and electronic devices, are rare. Although common, these high-silica quartz sands were only rarely investigated on their own with regard to their origin, such as the Sable the Fontainbleau, France (Cojan and Thiry, 1992; Delhaya-Prat et al., 2005).

High purity white sand deposits being encountered stratigraphically side-by-side with subbituminous coal and peatlands occur on the Falkland Islands at the southeastern tip of South America (Mitchell-Thomé, 1970; Greenway, 1972). According to McAdam and Upson (2010), who gave an overview of the distribution of peatland in the Falkland Islands, about 11,408 km^2, being equal to 93.7% of the land area are covered with peatland. For the present study the accumulations of organic matter and white sands at the isthmus of the Neck of Saunders Island (West Falkland Islands) have been taken as a reference (Fig. 1).

The aim of the current study is: (1) to provide a dataset of siliceous rocks interbedded with coal as to their coal petrographic, sedimentary, and chemical compositions, including carbon isotopes as well as mineralogical associations, (2) to disentangle the genetic relationship between organic matter and sand in a paralic environment under a periglacial regime, (3) to determine the physical-chemical conditions in a paralic coal-bearing environment (4) to study this environment in comparison with terrigenous shoreline processes in periglacial coal-siliciclastic couples on the northern hemisphere, (5) to model the "natural dressing plant" powered mechanically by marine aquatic and aeolian forces and at an advanced level by chemical processes related to the coal layer.

2. Geological setting

The on-shore geology of the Falkland Islands is mainly based upon publications of Mitchell-Thomé (1970), Greenway (1972), Aldiss and Edwards (1999) and Clark et al. (1995). Hydrocarbon exploration studies off-shore Falkland Islands were conducted by Richards and Hillier (2000a, b). Major attention has focused on the geodynamic evolution of the Falkland Island along with the break-up of Gondwana (Mitchell et al., 1986; Marshall, 1994). Remnants of the initial 1.1 Ga old

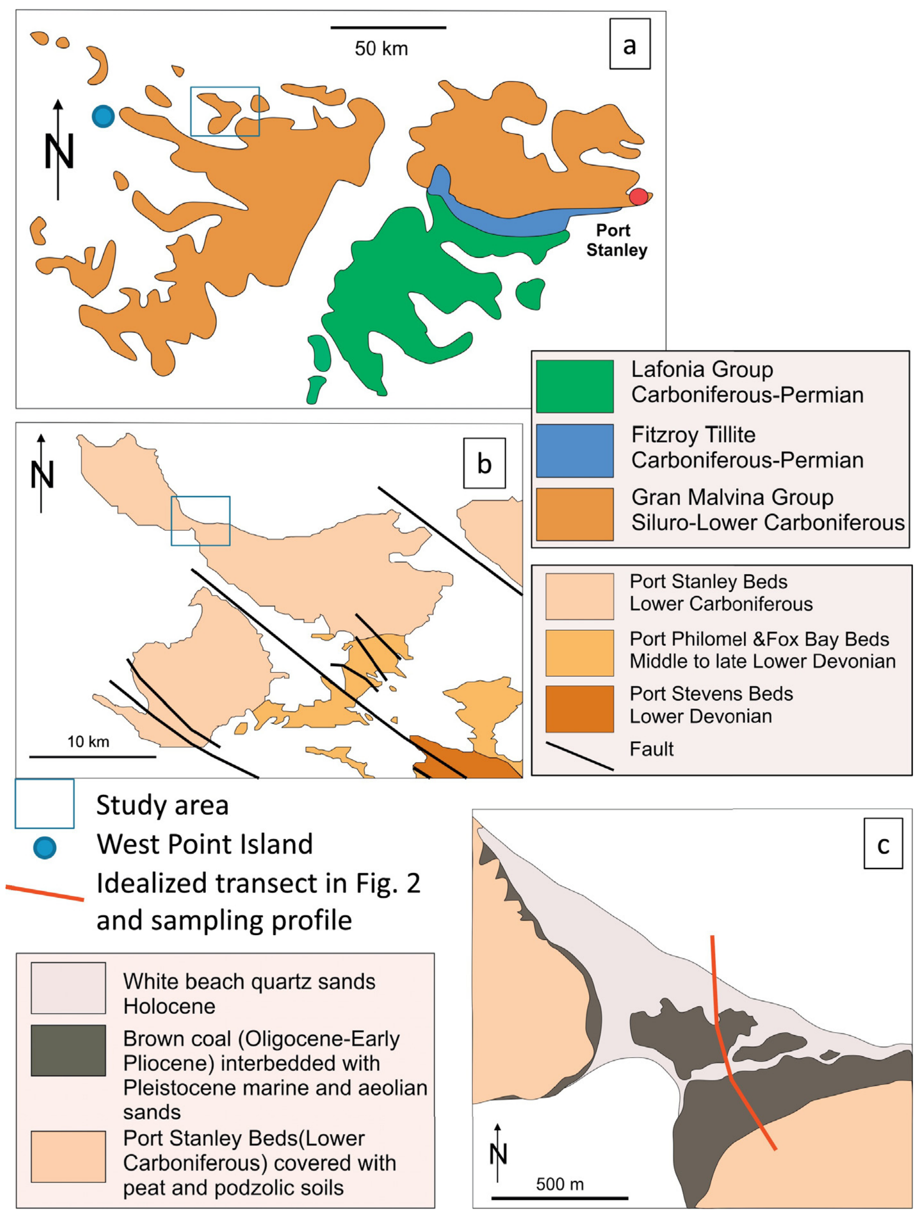

Fig. 1. The geological setting of the study side on the Falkland Islands/Islas Malvinas modified from Mitchell-Thomé (1970) and Greenway (1972). a) Geological overview of the Falkland Islands/Islas Malvinas. b) Geological overview of Saunders Islands/Isla Trinidad. c) Geological and lithological setting of the Isthmus ("Neck") of Saunders Islands/Isla Trinidad.