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Partitioning of mineralogical and inorganic geochemical components of coals from Santa Catarina, Brazil, by industrial beneficiation processes

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ABSTRACT

Comparative studies of the mineral matter and trace elements in 12 pairs of run-of-mine (ROM) and clean-coal products from beneficiation plants in Santa Catarina, southern Brazil, have been carried out using low-temperature oxygen-plasma ashing, X-ray diffraction and chemical analysis techniques with the aim of evaluating the effect of coal preparation on the mineralogy and chemical composition of the final coal products. The results show that substantial reductions in mineral matter and ash percentages are associated with beneficiation of coals mined from the different deposits. These reductions are accompanied by changes in the percentages of Fe_2O_3 in the respective coal ashes, due to the reduction in the proportion of pyrite in the mineral matter, and also by a reduction in the percentage of Na_2O, possibly due to ion exchange within the clay minerals. The relative proportions of quartz, clay minerals, and minor phases such as calcite and feldspar (mainly albite) within the mineral matter are not, however, significantly changed by the beneficiation processes.

The concentrations of most trace elements in the beneficiation products are similar to the respective concentrations in the relevant ROM materials, or are reduced to an extent similar to that of the total mineral matter percentage for the respective coal samples. This suggests an association mainly with the clay-rich mineral matter. The concentrations of As and Pb, however, are reduced to a greater extent for most samples by the beneficiation processes, consistent with a pyrite association. Concentrations of Ge, U and Zr are higher in many of the clean coals than in the respective run-of-mine materials, suggesting the possibility of preferential association, at least for some deposits, with the organic-rich fractions of the coals concerned.

1. Introduction

The principal coal deposits mined in Brazil are of Early Permian age, and distributed in a lenticular belt across the SE part of the country that extends from the state of Paraná in the north to the state of Rio Grande do Sul in the south (Kalkreuth et al., 2004; Thomas, 2002). Brazil's total coal resources are in the order of 32×10^9 tonnes (Kalkreuth et al., 2006), the majority of which (89%) are located in Rio Grande do Sul. Most of the remainder (a little over 10%) are located in the adjoining state of Santa Catarina (Fig. 1), and small amounts are located in Paraná and the adjacent state of São Paulo.

These resources occur within the Paraná Basin, a large intracratonic basin located in the central-eastern part of the South American Platform (Holz et al., 1999; Kalkreuth et al., 2006), covering a total area of around 1.7×10^6 km^2. The sedimentary fill of the basin ranges from Ordovician–Silurian to Late Cretaceous in age, and has been divided by Milani et al. (1994) into six second-order depositional sequences. The coal-bearing interval is located within the Early Permian (Artinskian/Kungurian) Rio Bonito Formation, a fluvial to marine unit (Holz et al., 1999; Kalkreuth et al., 2006) located near the base of the third sequence, which itself is Carboniferous to Early Triassic in age. This interval is 2800 m thick at its depocentre, and represents the thickest sedimentary succession in the basin.

Petrographic and sequence stratigraphy studies (Holz et al., 1999; Kalkreuth et al., 2006) indicate that the coal seams, at least in the southern part of the basin, were formed in limno-telmatic mires, with plant material building up to produce inertinite-rich coals in back-barrier depositional settings. The peats from which the coals originated were formed in small lagoons (Klepzig, 2001), with vegetation growing and being transported inside the lagoons, and deposited along with clay-

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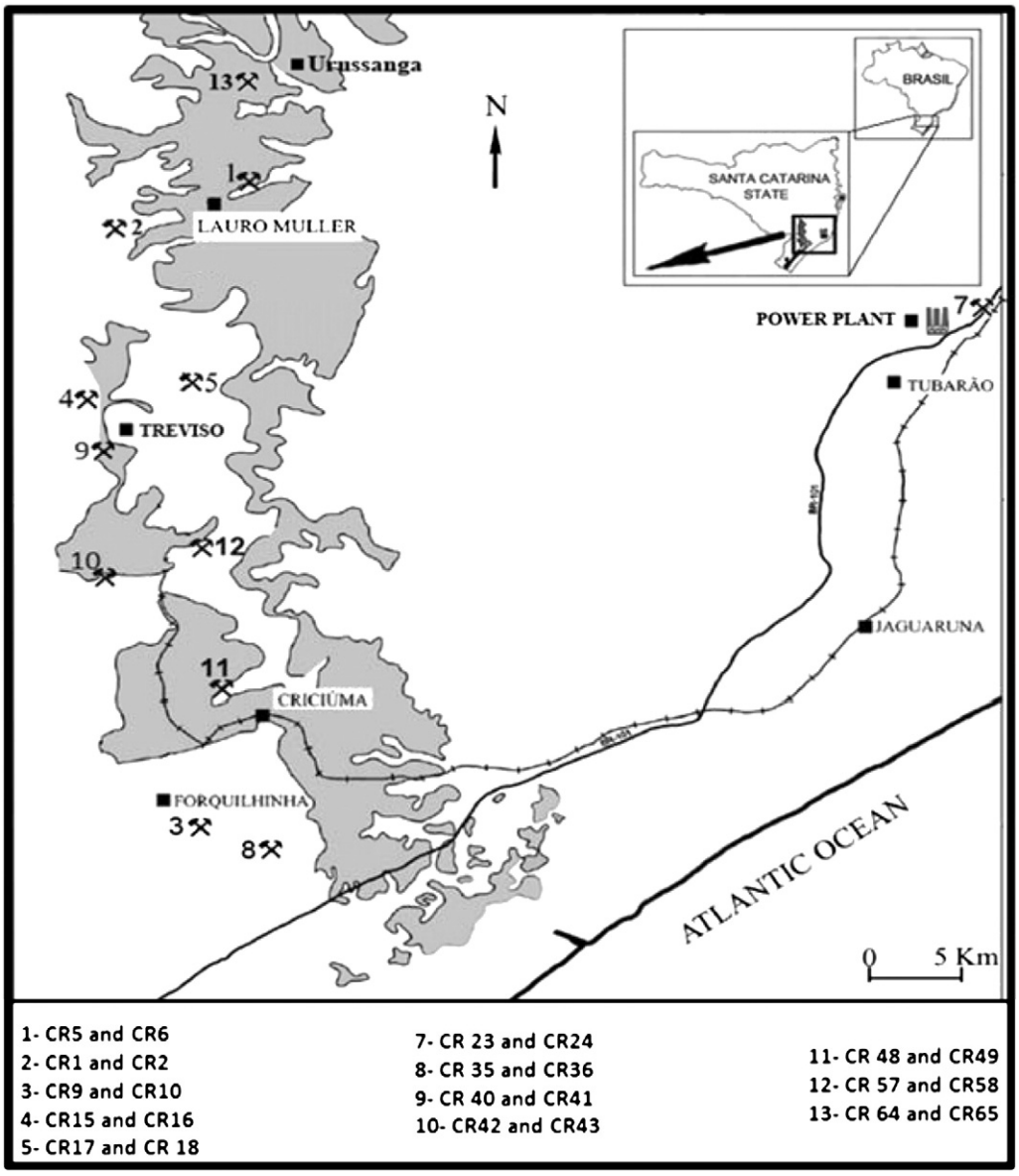

Fig. 1. Location of sample sources, and also of Jorge Lacerda (Tractebel-Suez) power station.

rich sediment. The clay-rich material thus became intimately admixed with the organic matter, resulting in coals with high ash yields (typically around 50%; Pires and Querol, 2004). The coals are commonly overlain by marine sediments, a setting that typically produces high sulphur contents (average 2.2%; Kalkreuth et al., 2006).

The coals in the southern part of Rio Grande do Sul are mainly subbituminous, but those further to the north, including the coals in Santa Catarina, are mostly high volatile bituminous in rank (Kalkreuth et al., 2004, 2006). Some coals have been locally raised to higher rank levels by igneous (diabase) intrusion effects (Kalkreuth et al., 2004). Oliveira et al. (2012) have reported mean maximum vitrinite reflectance values for Santa Catarina coals ranging from 0.44 to 1.38%, although most deposits have values between 0.7 and 1.0%. Kalkreuth et al. (2004) found that the vitrinite in Paraná Basin coals is typically perhydrous in character, and may show anomalously low (suppressed) reflectance characteristics.

Brazil's total coal production is currently around 6 Mt per annum (Departamento Nacional de Produção Mineral, 2010). Rio Grande do Sul is the largest producer in terms of tonnage, with 53.1% of the total production; Santa Catarina produces 45.6% and Paraná 1.3%. However, because of its higher rank and calorific value, the coal from Santa Catarina currently provides 68.3% of the country's production in energy terms, with 28.5% of the coal-derived energy being produced from Rio Grande do Sul and 3.2% from the Paraná deposits.

Because of the high ash yield and high sulphur content, the run-of-mine (ROM) coals are typically beneficiated to prepare a product with lower ash and sulphur for utilisation purposes. Marcello et al. (2008) indicate that some 3.5 Mt per year, or approximately 58% of the ROM production, are rejected by this process and emplaced in landfills. Almost all of the clean coal is used for power generation, supplying five plants with a total installed capacity of about 2000 MW (Agência Nacional de Energia Elétrica, 2012). Power from these plants provides approximately 11% of Brazil's total electricity requirements (Silva et al., 2010). Three of these plants are located in Rio Grande do Sul, one in Santa Catarina, and one in Paraná.

Most of the seams mined in Santa Catarina have marginal coking properties, but current production is almost entirely used for electricity generation at the Jorge Lacerda (Tractebel Suez) Power Station