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Geological controls on mineralogy and geochemistry of the Late Permian coals in the Liulong Mine of the Liuzhi Coalfield, Guizhou Province, Southwest China

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ABSTRACT

This paper investigates the mineralogical and geochemical compositions of the Late Permian coals in the Liulong Mine, Liuzhi Coalfield, Western Guizhou Province, China, by using XRD, SEM-EDX, ICP-AES and ICP-MS. Both the No.3 and No.7 Coals are classified as low volatile bituminous coal. However, the No.3 Coal is a medium-ash (29.8% on average) and high-sulfur (4.76% on average) coal while the No.7 Coal is a low-ash (12.4% on average) and medium-sulfur (2.16% on average) coal. Major minerals in both coal seams include quartz, pyrite, marcasite, kaolinite, calcite, and to a lesser extent, gypsum and anatase. Illite, chlorite, rectorite, albite, ankerite and siderotil are only present in the No.3 Coal. The No.3 Coal contains higher elemental concentrations than the No.7 Coal probably due to the higher mineral contents in the No.3 Coal, and is enriched in Nb and Ta, and to a lesser extent in K, Ti, Li, V, Co, Cu, Sr, Zr, Mo and Ba.

The mineralogical and geochemical data presented in this study have shown that the No.3 Coal was formed under a higher degree of marine-influenced coal-forming environment than the No.7 Coal. However, the both Coals have the Kangdian Upland (made of mafic igneous rocks, such as basalt rocks) as sediment-source region like other coals from Guizhou Province. Three geological factors control the geochemical patterns of the No.3 and No.7 Coals, namely: (1) the high detrital input in the No.3 Coal causing high ash yields; (2) the sediment-source region (Kangdian Upland basalt) causing high Ti, Nb and Ta contents, and a minor proportion of Co, Cr, V and Cu, when combined with the high detrital input in the No.3 Coal; (3) the higher degree of marine influenced depositional environment in the No.3 Coal causing a high S, Sr and Ba contents.

1. Introduction

The geochemical patterns of the coals from Western Guizhou Province, Southwestern China, have attracted much scientific interest, not only because of endemic arsenosis and fluorosis poisoning and the related environmental impact of utilization of this coal (Dai et al., 2012; Ding et al., 2001; Finkelman et al., 2002; Zheng et al., 1999), but also because economically valuable elements in the coals and coal-bearing strata in this area are abundant (Dai et al., 2003, 2005a, 2005b, 2016; Seredin and Dai, 2012). Additionally, some geochemical anomalies in the coals from Western Guizhou Province have also been reported (Dai et al., 2003, 2004, 2005b, 2012, 2016; Ren et al., 2006; Zhang et al., 2004) and geological factors controlling these anomalies have been analyzed in previously-published literature (Dai et al., 2003, 2004, 2016; Ren et al., 2006). For example, Dai et al. (2003) reported that synsedimentary volcanic ash results in elevated concentrations of Fe, Cu, U, Mo, Zn, and Zr in the No.9 Coal seam of the Zhijin Coalfield, Guizhou Province. Dai et al. (2004, 2005b) found that the enrichment of some elements in the coals from the Zhijin and Dafang Coalfields, Guizhou Province, was caused by the influence of low-temperature hydrothermal fluids. Dai et al. (2016) documented that the Zr (Hf)–Nb (Ta)–REE and U (Mo, Se)–REE ores occurring in the coals and coal-associated strata (roof, floor and parting strata) in the Southwest China are primarily associated with the evolution of plumes ascending from deep mantle and/or asthenospheric flow which plays a significant role in extensive volcanism and ore-generating hydrothermal activity.

The mineralogy and geochemistry of the coals in the Liuzhi Coalfield in Western Guizhou Province have been only investigated by a few studies, which focused on elemental concentrations and affinities (Dai et al., 2005a; Zhuang et al., 2000). In the present study, we focused on the No.3 and No.7 Coals in the Liuzhi Coalfield with the aim of: (1) investigating mineralogical patterns, concentrations and modes of occurrence of major and trace elements; and (2) discussing the geological factors influencing mineralogical and geochemical characteristics.

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2. Geological setting

The Liuzhi Coalfield is located in Western Guizhou Province of Southwest China, and has a complex geological setting because of extensive faulting (Fig. 1) (Zhou et al., 2000; Xu and He, 2003; Wang, 1996). The Kangdian Upland, situated to the West of Liuzhi Coalfield, is the major sediment-source region for the coalfield in this study and is mainly composed of mafic basalt (Liao, 2013; Xu, 2006). In the Late Permian, paleoenvironment changed successively from a terrigenous environment through paralic delta, to a marine environment from Kangdian Upland to Eastern Guizhou Province (Fig. 1) (Shao et al., 2013; Xu and He, 2003).

The Late Permian coal-bearing strata in the Liuzhi Coalfield include the Emeishan, Longtan and Changxing Formations (Fig. 2). The Emeishan Formation consists mainly of tholeiite, volcanic breccia, tuff, and to a lesser extent, marine limestone strata (Dai et al., 2005a) and constitutes the majority of the Kangdian Upland. The Longtan Formation is the major coal-bearing strata and primarily consists of fine-sandstone, siltstone, mudstone, 2–14 limestone layers, and 7–34 minable and non-workable coal seams, with thickness ranging from 276 to 390 m in the Liuzhi Coalfield (Xu and He, 2003). The Changxing Formation, with an average thickness of about 33 m, mainly comprises mudstone, siltstone and 3–5 limestone layers and is deposited in subtidal environment (Xu and He, 2003).

The Longtan Formation can be classified into three sections in term of lithological compositions. The lower and upper sections of the Longtan Formation consist mainly of limestone, mudstone and siltstone and are deposited in a carbonate subtidal or lagoon-tidal flat coal-forming environment where a marine influence plays an important

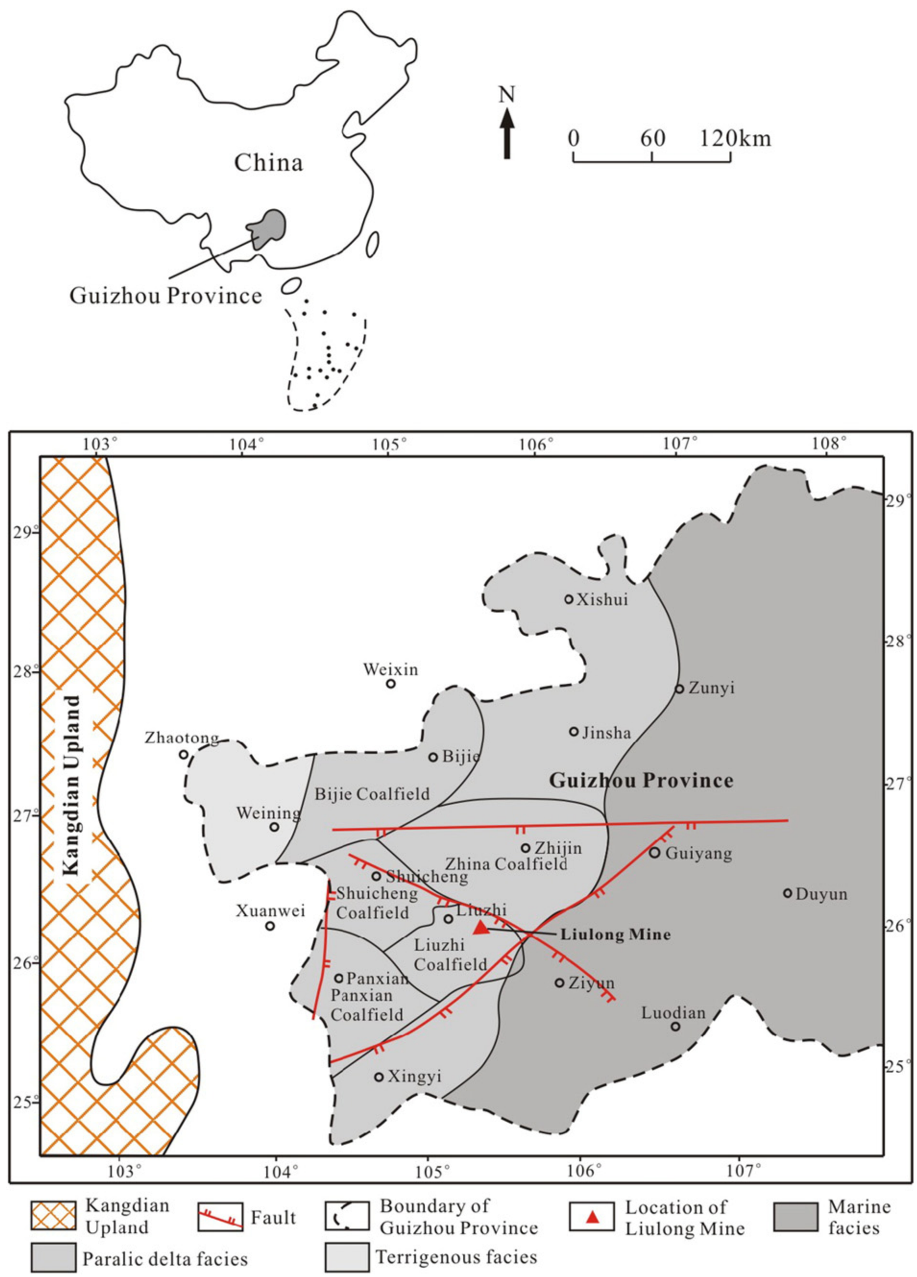

Fig. 1. The location of the Kangdian Upland and Liulong Mine as well as the distribution of faults and depositional environments during the Late Permian in Guizhou Province, China.