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The geochemistry of platinum group elements in marine oil shale—A case study from the Bilong Co oil shale, northern Tibet, China

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ABSTRACT

The Bilong Co oil shale zone is located in the South Qiangtang depression. This zone, together with the Shengli River-Changshe Mountain oil shale zone in the North Qiangtang depression, northern Tibet plateau, represents the potentially largest marine oil shale resource in China. Seventeen samples including oil shale and micritic limestone were collected from the Bilong Co oil shale area to determine the concentrations, distribution patterns, occurrences and origins of platinum group elements (PGEs) in marine oil shale. The oil shale samples from the Bilong Co area exhibit very low total PGE contents ranging from 1.04 to 2.96 ng/g with a weighted mean value of 1.686 ng/g, while the micritic limestone samples from the Bilong Co area exhibit a little lower PGE value ranging from 0.413 to 1.11 ng/g. PGEs in oil shale samples are characterized by high contents in Pd (average 0.79 ng/g), Os (average 0.123 ng/g) and Pt (average 0.644 ng/g) compared with Ru (average 0.068 ng/g), Rh (average 0.033 ng/g) and Ir (average 0.026 ng/g). The highest values for individual PGEs are not uniformly distributed in the section. Clearly, the PGEs are generally enriched in the oil shale samples near the boundary between micritic limestone and oil shale.

The individual PGEs in oil shale samples from the Bilong Co area exhibit various modes of occurrence. Ruthenium and Pt occur mainly in pyrite, while Pd is associated mainly with organic matter and Mg-minerals. Rhodium and Os are controlled mainly by pyrite and organic matter. Iridium is present mainly in other Fe-bearing minerals, rather than pyrite. The PGEs in the Bilong Co oil shale are mainly of seawater origin and possibly influenced by terrigenous supply.

1. Introduction

Oil shale, as an alternative energy resource, has received much attention in recent years (Qian and Wang, 2003; Fu et al., 2011a). In China, the amount of exploit available resources of oil shale is about 243.2 billion tons (Liu et al., 2009). Most of oil shales were deposited in lacustrine environments, such as Tertiary oil shale in the Maoming (Zhang et al., 2007) and Fushun areas (Qian and Wang, 2003), and Cretaceous oil shale in the Songliao Basin (Liu et al., 2009). Marine oil shale was mainly found in the Qiangtang Basin, northern Tibet, China (Fu et al., 2008, 2009, 2010a), including the Shengli River-Changshe Mountain oil shale zone and the Bilong Co oil shale zone. These zones represent a large marine oil shale resource in China. Therefore, studies of these oil shale zones are important for assessing petroleum prospects in the Qiangtang Basin and the overall significance of marine oil shale researches in China.

In recent years, platinum group elements (PGEs) in coal and shale have received much attention (Sawlowicz, 1993; Jaffe et al., 2002). Finkelman and Aruscavage (1981) reported that the concentration of Pt in coal was generally less than 5 ng/g, that of Pd generally less than 1 ng/g, and Rh less than 0.5 ng/g. Dai et al. (2003) studied the concentrations of noble metals in Chinese coals and proposed five sources of noble metals in coals. A study by Yang (2006) showed that low-temperature hydrothermal fluids could play a dominant role in the enrichment of noble metals in the coal. Oil shale may also contain PGEs (Fu et al., 2010a) due to its similar composition with coal. Understanding the concentrations and occurrences of PGEs in oil shale is significant, because these geochemical data may refer to the potential role of organic matter in the distribution/redox behaviour of PGEs. However, up to now very few works have been done on the distribution of PGEs in oil shale, especially in marine oil shale. In this paper, we report the results

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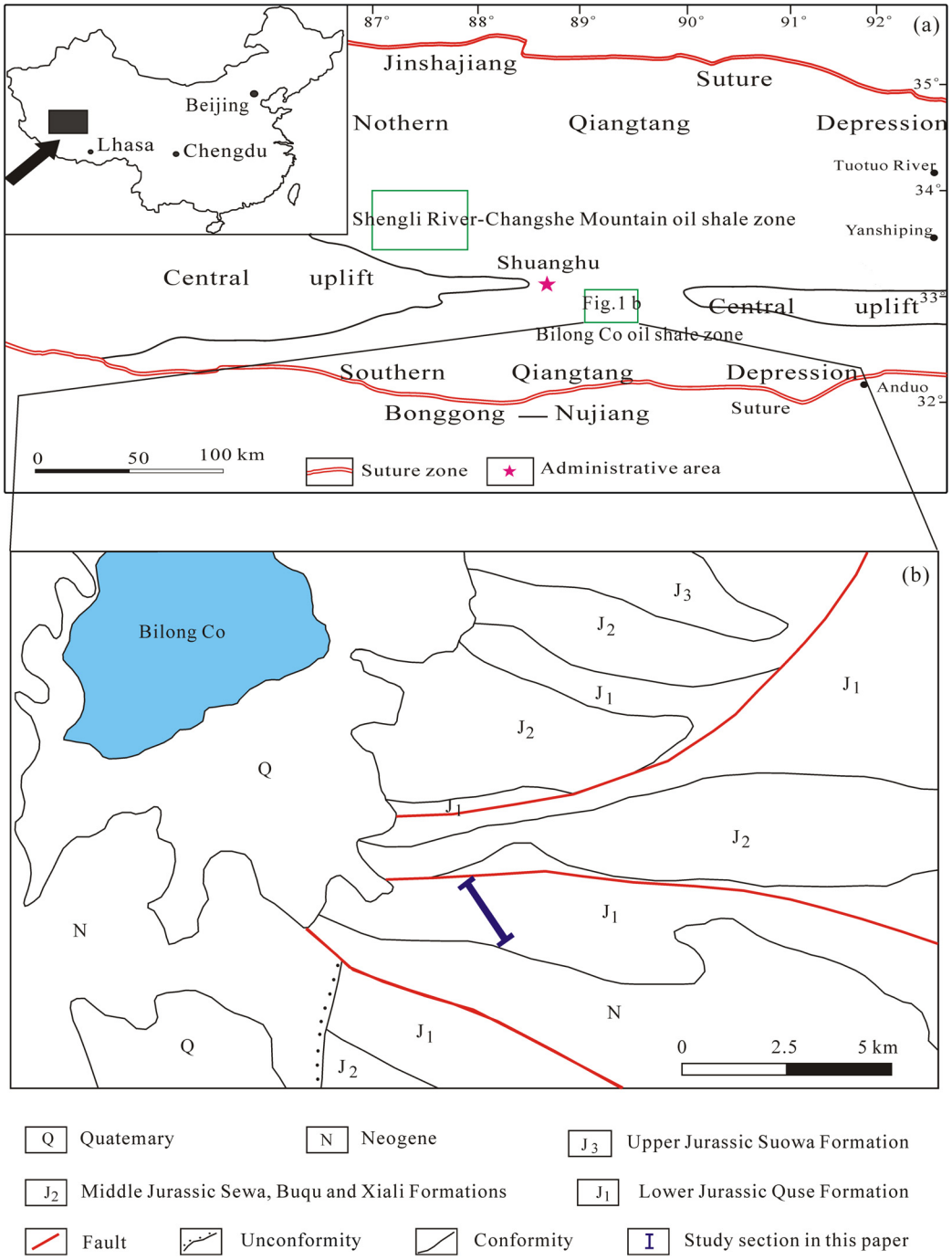

Fig. 1. (a) Generalized map, showing location of study area (modified from Fu et al., 2010c). (b) Simplified geological map of the Bilong Co area, showing location of oil shale section (after Fu et al., 2010c).

of PGEs in marine oil shale from the Bilong Co area, northern Tibet, China and discuss the possible modes of occurrence and origins of PGEs in marine oil shale.

2. Geological setting

The Qiangtang terrence, bounded by Hoh Xil-Jinsha River suture zone to the north and Bangong Lake-Nujiang River suture zone to the south, consists of the North Qiangtang depression, the central uplift and the South Qiangtang depression (Fig. 1a), which together form the Qiangtang Basin. During Permo-Trassic time, the Paleo-Tethys Ocean was consumed by southward subduction beneath the Qiangtang terrence and northern subduction beneath the Kunlun terrence (Kapp et al., 2003), resulting in a large-scale regression in the Qiangtang Basin. During this interval, most parts of the Qiangtang Basin were uplifted and exposed to erosion (Fu et al., 2010b). Meanwhile paleo-weathering crusts occurred widely in the Qiangtang Basin (Fu et al., 2010b). Subsequently, these paleo-weathering crusts were overlain unconformably by a succession of volcanic-volcaniclastic strata that marked the onset of the Mesozoic Qiangtang Basin (Fu et al., 2010b). As a result, the sediments are almost exclusively Mesozoic marine deposits that crop out in the North Qiangtang depression and in the South Qiangtang depression, while Paleozoic marine sedimentary sequences are preserved locally in the central uplift.