HIGH-GRADE DIAGENETIC DICKITE AND 2M₁ ILLITE FROM THE MIDDLE PROTEROZOIC KOMBOLGIE FORMATION (NORTHERN TERRITORY, AUSTRALIA)

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Abstract—The aim of this paper was to define the nature and the relative chronology of the diagenetic clay bearing assemblages within sandstones of the Middle Proterozoic Kombolgie formation (Northern Territory, Australia). The detrital minerals of these rocks comprise quartz, accessory zircon, tourmaline, rutile and rare phengitic white micas. Diagenetic features consist of pore-sealing secondary quartz overgrowths, strong compaction shown by interlocked structures and stylolith joints, local hematization and the occurrence of two distinct clay parageneses. Blocky crystals of dickite constitute the earliest diagenetic clays. Their FTIR spectra and their DTA curves, with a sharp dehydroxylation endothermic peak near 680°C, are characteristic of the well-ordered dickite already encountered in many deeply-buried sandstones. Quartz overgrowth may be contemporaneous with the crystallization of dickite. Illite occurred during a subsequent stage as grain coatings and as pseudomorphs of dickite in the residual pores of the sandstones. Illite seems to be contemporaneous with the major deformation features associated with compaction phenomena at the maximal burial conditions experienced by the sandstone formation. These illites are essentially of 2M₁ polytype. They display pseudohexagonal platy crystals with average diameters ranging from 2 to 10 µm. Their chemical composition is Al-rich (Ca₀.₀₁Na₀.₀₂K₁.₇₂)(VIAl₃.₈₂Fe³⁺₀.₁₃Mg₀.₀₅Mn₀.₀₁)(Si₆.₂₇IVAl₁.₇₃)O₂₀(OH)₄. These Proterozoic rocks provide a natural reference for the illite end-member occurring as a replacement of kaolin subgroup minerals during burial diagenesis of sandstones. The textural properties of the Kombolgie sandstones (absence of fracture network, low porosity, well-developed macroscopic stylolith joints...) and the crystal structure of both the diagenetic dickite and illite would tend to indicate that the Kombolgie sandstones were buried at a depth exceeding 5 km.

Key Words—Crystal Form, Crystal Structure, Diagenesis, Dickite, DTA Data, FTIR, Illite, Kombolgie, Proterozoic Sandstone, XRD.

INTRODUCTION

Although Proterozoic basins cover a large portion of the continental crust, knowledge of their diagenetic history is limited by the paucity of data published in the literature. The best described are those on the North American and Australian continents (the Athabasca and McArthur basins, respectively) because of numerous ore deposits. The Alligator Rivers Uranium Field (Northern Territory, Australia) contains ~15% of the world’s low-cost uranium resources and comprises the Jabiluka, Naborlek, Ranger and Koongarra uranium deposits. Nevertheless only a few data are available on clay paragenesis and fluid evolution in the McArthur Basin and in the sandstones from the Kombolgie formation which directly overlie the mineralized metamorphic basement (Gustafson and Curtis, 1983; Wilde et al., 1989; Kyser et al., 2000). Some confusion still persists between clays resulting strictly from diagenetic processes and clays related to hydrothermal fluid circulations along the unconformity with the metamorphic basement. One goal of this paper was to define the nature and the relative chronology of the diagenetic clay assemblages within the Middle Proterozoic rocks of the Kombolgie sandstones by studying areas far away from the unconformity-related uranium deposits of the region and not affected by the hydrothermal alterations associated with the deposition of uranium.

Generally, as seen in younger sedimentary basins, the diagenesis of sediments like sandstones and shales results in characteristic sequences of phyllosilicates as a function of burial depth which involve trioctahedral clays (transformation of 7 Å layer minerals to chlorite or saponite to chlorite) (Reynolds, 1988; Ryan and Reynolds, 1996) and dioctahedral clays. The latter is expressed in silicilastic sediments by (1) the kaolinite-to-dickite transformation and (2) the illitization of kaolin subgroup minerals and/or direct precipitation of illite from pore-waters (Šrodoň and Eberl, 1984; Ehrenberg et al., 1993; Lanson et al., 1996; Beaufort et al., 1998, among others). At the same time, in more argillaceous sediments, a significant reaction involves the progressive change of smectite through interstratified illite-smectite to illite (Eberl and Hower, 1976; Nadeau and Reynolds, 1981; Jennings and Thompson, 1986; Velde and Vasseur, 1992; Altaner and Ylagan, 1997, among others). Concomitantly, chlorite may increase in abun-