JOURNAL GEOLOGICAL SOCIETY OF INDIA
Vol. 30, Sept. 1987, pp. 239 to 243

CLAY MINERAL TRANSFORMATION IN THE WEATHERING CRUST: EVIDENCE FROM THE KUNDARA CLAY MINE, KERALA

D. THOMAS[1], M. LALITHAMBIKA[1] AND K. SOMAN[2]
[1] Regional Research Laboratory, Pappanamcode, Trivandrum
[2] Centre for Earth Science Studies, Trivandrum 695 031

Abstract

SEM and DTA investigations of the clays from the famous clay mine at Kundara show that kaolinite and halloysite constitute the clay minerals, and that halloysite is transformed into well-crystalline kaolinite. This indicates that kaolinite formation is preceded by the formation of halloysite in the weathering crust at Kundara. This finding is consistent with the recent experimental results of halloysite-kaolinite transformation.

Introduction

The china clay deposit at Kundara in south Kerala is known for long as a source of good quality kaolin, used for ceramic industry and export. Mining of clay is from the residual kaolin bed developed on weathering of the gneisses. Various accounts of the mineralogy of the weathering profiles in Kerala have shown kaolinite as the major clay mineral with evidences for the presence of halloysite in them (Raymahashay *et al*, 1985). The mineralogy of the clays at Kundara is no exception. Though transformation of clay minerals in the weathering crust is mostly confined to the three layered structural types, transformation of the two-layered kaolinite type is not uncommon (Millot, 1970). Transformation of clay minerals in the weathering crust, however, has not received much attention by workers who have studied the weathering profiles in Kerala. The purpose of this communication is to report the transformation of halloysite into well-crystalline kaolinite as observed in the weathering profiles of china-clay mine at Kundara, as a result of SEM and DTA investigations.

Geologic setting

The Kundara clay mine is located at the eastern periphery of the Cenozoic sedimentary basin of Kerala (Fig. 1). Cenozoic sediments belonging to the Warkalli Group are underlain by kaolinised gneiss. Sediments of the Warkalli Group here have a thickness of about 15 m, and comprise, from top to bottom : lateritic rubble, hard laterite, current-bedded ferruginous sandstone, pebble beds and a few beds of variegated, carbonaceous and bauxitic clays. Examination of the kaolinised portion of the gneiss at the mine face below the sediments indicates that the gneiss contains garnet-rich, biotite-rich and feldspar-rich bands. Kaolinite and halloysite are the major clay minerals.

Clay mineral transformation

Clay mineral examination under SEM shows abundance of tubular forms (Fig. 2a, b), morphologically identical to halloysite (Grim, 1962, 1968; Millot, 1970) and undergoing transformation into kaolinite (Fig. 2b, c, d), often giving rise to subhedral and euhedral kaolinite crystals. DTA curves (Fig. 3) substantiate the presence of halloysite with initial endothermic peaks at 198° and 203°C. Endothermic and exothermic peaks at 516°–535°C and 969°–973°C respectively are features

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identifying presence of kaolinite. Slight endothermic peak just before the intense exothermic peak is attributed to the well-crystalline nature of kaolinite (Grim, 1968), a feature which was also noticed under SEM. The observation of Nagasawa and Noro (1985) that tubular forms of halloysite are characteristic of the weathering product of feldspars in granitic rocks is consistent with our finding.

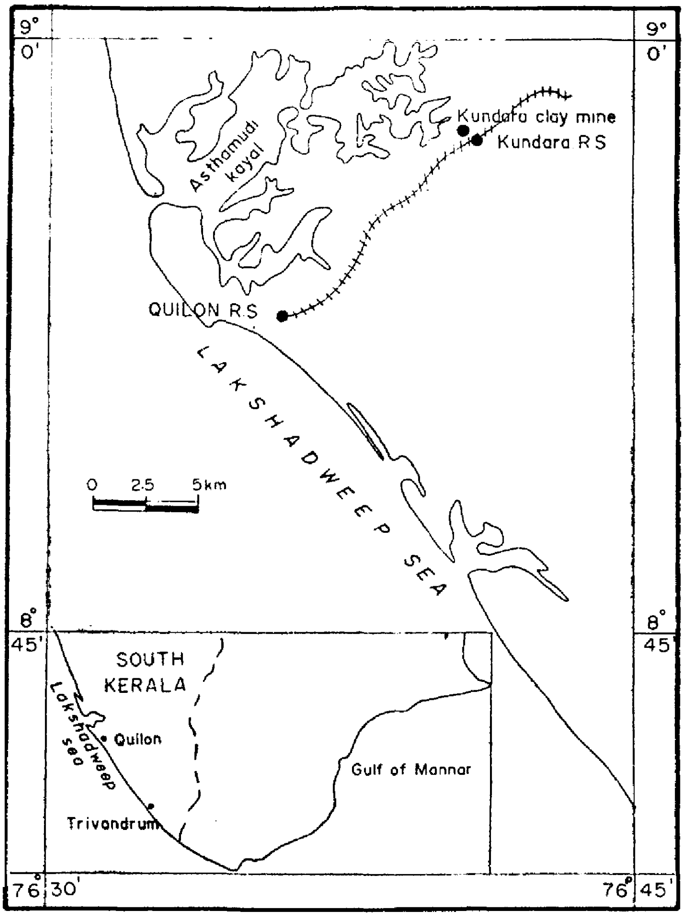

Figure 1. Location map of the Kundara clay mine

EXPLANATION OF FIGURE 2

SEM photomicrographs of clays.

a) Tubular forms of halloysite. Sample from near the surface of the profile.

b, c) Tubular forms of halloysite showing transformation to kaolinite. Sample from the middle portion.

d) Halloysite is almost entirely transformed into kaolinite. Note the development of well-crystalline kaolinite in the bottom middle of the picture. Sample from the lowest part of the profile (1.5 m below 2a). K - Kaolinite, H - Halloysite.

Scales and instrumental set up are shown on photographs.

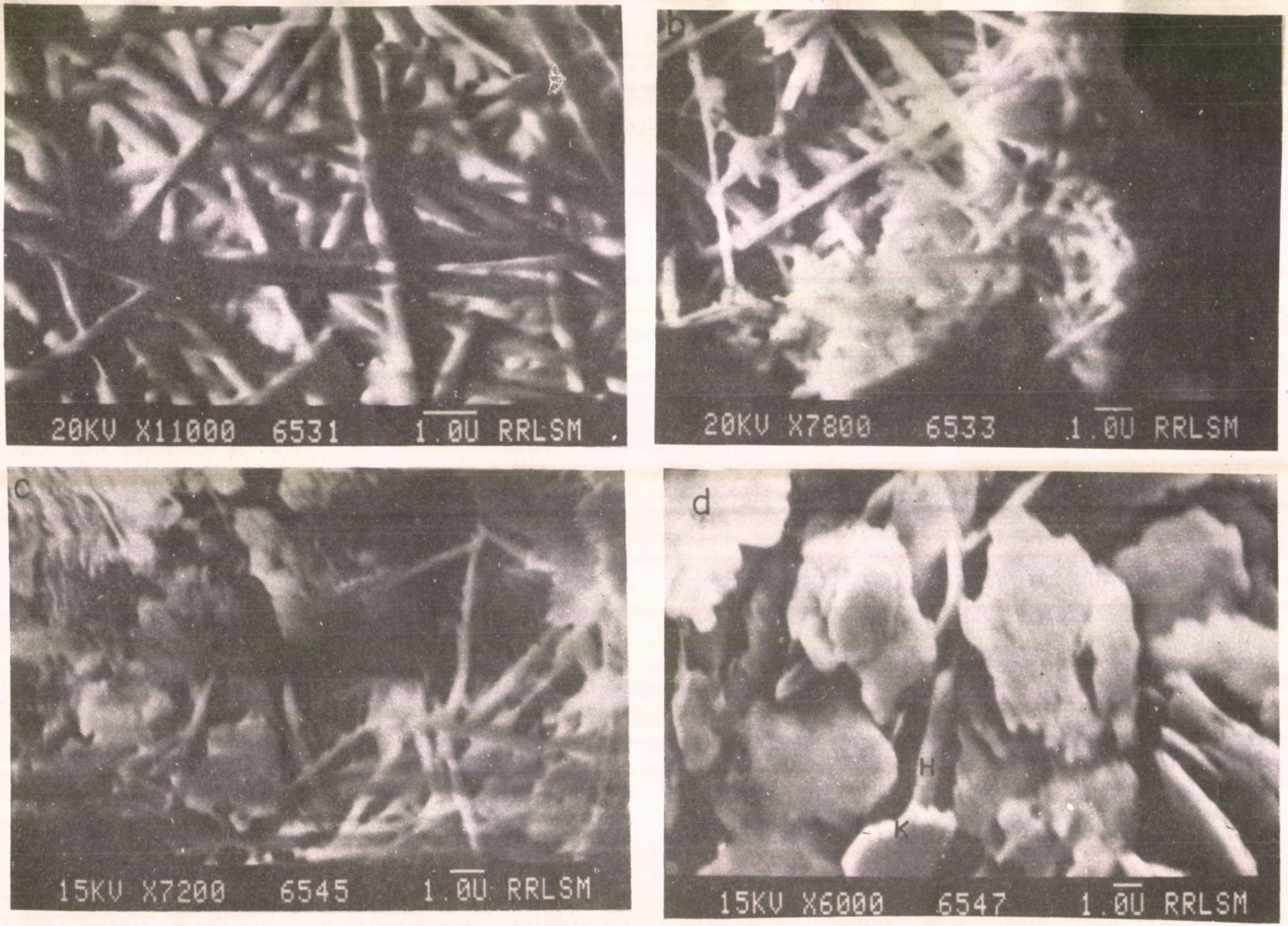
20KV X11000 6531 1.0U RRLSM
b
20KV X7800 6533 1.0U RRLSM
c
15KV X7200 6545 1.0U RRLSM
d
H
K
15KV X6000 6547 1.0U RRLSM

FIG. 2

Discussion and Conclusions

Divergent views exist on the transformation of the two-layered structural types of clays—kaolinite and halloysite. Millot (1970) has proposed the following transformations taking place in the weathering crust :

Kaolinite $\rightleftharpoons$ disordered kaolinite (fire clays)
Kaolinite $\rightleftharpoons$ halloysite
Halloysite $\rightleftharpoons$ disordered kaolinite.

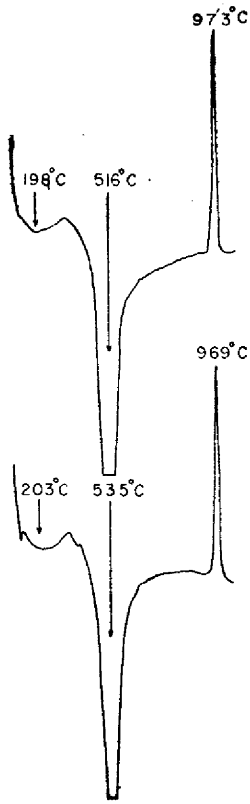

Figure 3. DTA curves of two clay samples.

Transformation of halloysite into kaolinite, according to him, takes place predominantly during the aggradation stage, that is, during sedimentation. Bates (1950) is of the opinion that the transition is from kaolinite to halloysite ($2H_2O$) which is simply the first part of a series leading to halloysite ($4H_2O$) and allophane as the H_2O content increased. From a study of the weathering and mineral formation sequence of the volcanic ashes, Wada (1985) has suggested that halloysite formation during the initial stages of weathering is possible in humid tropical regions.

Our observation suggests that the halloysite is most probably the $4H_2O$ modification as revealed by the tubular morphology (Bates, 1959) though it is to be substantiated by a basal peak at 10Å in XRD, and that the transformation is from halloysite to kaolinite, taking place in the kaolinised zone of the weathering profile developed over gneisses. This finding is consistent with the results of the experimental work of Minato *et al* (1985), who obtained kaolinite from halloysite under hydrothermal conditions, and with the description of Rodriguez (1982) about the transformation of halloysite into kaolinite in the upper portion of the weathering crust on basalts and rhyolites in Argentina.

SEM, XRD and DTA studies made earlier on the secondary kaolins from south Kerala have not revealed presence of halloysite in them, and the kaolinite was of the poor-crystalline variety (Soman and Terry Machado, 1986), while kaolinite developed in the weathering crust over the sediments was crystalline (Soman and Slukin, 1985). These, and the present results would suggest that halloysite-kaolinite assemblage is characteristic of the clay minerals of the weathering crust in south Kerala and that halloysite is undergoing transformation into well-crystalline kaolinite in the weathering crust while poor-crystalline kaolinite is the main clay mineral in the secondary kaolin deposits.

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(Received: Oct. 23, 1986; Revised form accepted: March 21, 1987)