Clays and Clay Minerals, Vol. 29, No. 3, 233–235, 1981.

NOTES

SCANNING ELECTRON MICROSCOPY OF A REGULAR CHLORITE/SMECTITE (CORRENSITE) FROM A HYDROCARBON RESERVOIR SANDSTONE

Key Words—Chlorite, Corrensite, Mixed layer, Reservoir sandstone, Scanning electron microscopy, Smectite.

INTRODUCTION

The clay minerals in a sandstone reservoir rock significantly affect fluid flow, radioactivity, and total cation-exchange capacity. Detailed mineral identification of such rocks is therefore necessary to determine a completion/stimulation program for petroleum production. Although they are essential in identifying and quantifying the types of clay minerals present, X-ray powder diffraction (XRD) techniques do not indicate the crystal morphology or textural relationships of clay particles in the intergranular pore system of a sandstone. Scanning electron microscopy (SEM) is therefore needed to document completely the type of clay minerals present, their particle morphology, and their spatial distribution within a reservoir rock.

SEM characterization of the major clay minerals groups (i.e., kaolin, chlorite, smectite, illite) is well established (e.g., Neasham, 1977a, 1977b; Wilson and Pittman, 1977), and various species can be identified on the basis of morphology and elemental composition, as determined by energy dispersive X-rays (EDX). Due to their rarity in sandstone reservoir rocks, less information is available in the literature on of the morphology of mixed-layer clays. The morphological characterization of authigenic corrensite, for example, in the clay mineral suites of such rocks is rare. The present study presents XRD and SEM characteristics of a regularly interstratified chlorite/smectite (corrensite) from two wells in a reservoir sandstone unit of the Guadalupe Formation (Permian age) in West Texas, and contrasts its morphology with admixed chlorite in the same samples.

EXPERIMENTAL

Samples were obtained from several conventional and sidewall core samples from two wells. Oriented films deposited on ceramic tiles were used to identify clay minerals in the <5-μm fraction by XRD techniques, using Ni-filtered CuKα radiation. Diffractograms were obtained for films dried at 25°C, and glycolated at 25°, 110°, and 550°C. Chips showing freshly fractured surfaces for SEM analyses were removed from each core under the binocular microscope. Each chip was cemented to an aluminum stub with silver paste and coated with a 50-Å film of gold before examination in an ISI-100A microscope. Reference minerals were analyzed with the Kevex 7100 EDX system to provide comparison spectra for the determination of elemental ratios of the samples.

RESULTS AND DISCUSSION

XRD analysis of the <5-μm fraction from both wells showed interstratified chlorite/smectite to be the dominant mineral constituent, with lesser amounts of illite, chlorite, and possible smectite (Figure 1). The untreated chlorite/smectite has a 29-Å unit cell containing a 14-Å layer. Glycolation expanded the latter and gave spacings of 32.7 Å (001), 16.1 Å (002), and 8.01 Å (004). Heating the samples to 550°C produced spacings of 21.6 Å (001), 12.1 Å (002), 7.97 Å (003), and 5.91 Å (004) (Figure 1). Peaks at 14.2 Å and 9.9 Å represent chlorite and illite, respectively.

SEM examination of the sandstone from the "A" well revealed aggregates of chlorite and illite (Figures 2A and 2B) and chlorite/smectite (Figures 2C and 2D) coating framework quartz grains and lining available intergranular pore throats. The chlorite/smectite has the distinctive "honeycomb" structure of smectite consisting of the rigid, bladed plates characteristic of chlorite (Neasham, 1977; Wilson and Pittman, 1977). As indicated by XRD, this mixed-layer species visually dominates the clay mineral assemblage of the "A" well sandstone (Figure 2C). Thus, the SEM analysis supports the XRD identification of this material as a mixed-layer corrensite species.

SEM examination of the sandstone from the "B" well, which exists in the same unit at a greater depth, shows a different crystal morphology for the mixed-layer chlorite/smectite (Figure 3). Straight, bladed, chlorite-like plates are arranged in a slightly curved fashion which resembles the normal smectite "honeycomb" structure. Although the morphology of the corrensite from each of the two intervals from these wells is different, no apparent difference was detected between their XRD patterns with respect to either d-values or relative intensities. On the other hand, energy dispersive X-ray (EDX) analysis of both corrensites showed a difference between the relative amounts of Ca and Fe. The "A" well corrensite, which has a smectite-like morphology contains approximately equal amounts of Ca and Fe, whereas the corrensite from the deeper "B" well contains Fe but no detectable Ca. The correlation between this variation in elemental composition and corresponding changes in crystal morphology with depth suggests that these two occurrences of corrensite

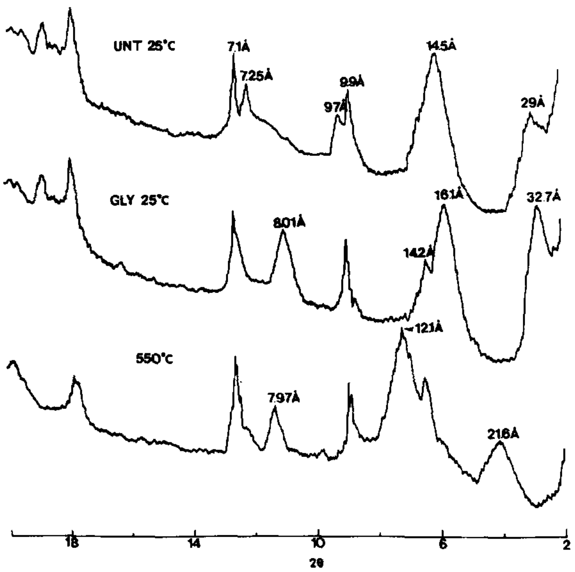

Figure 1. X-ray powder diffraction traces which represent the typical basal reflections for corrensites from the Guadalupe Formation. Note these graphs show basal reflections from untreated (UNT 25°C), glycolated (GLY 25°C), and glycolated and heated to 550°C samples.

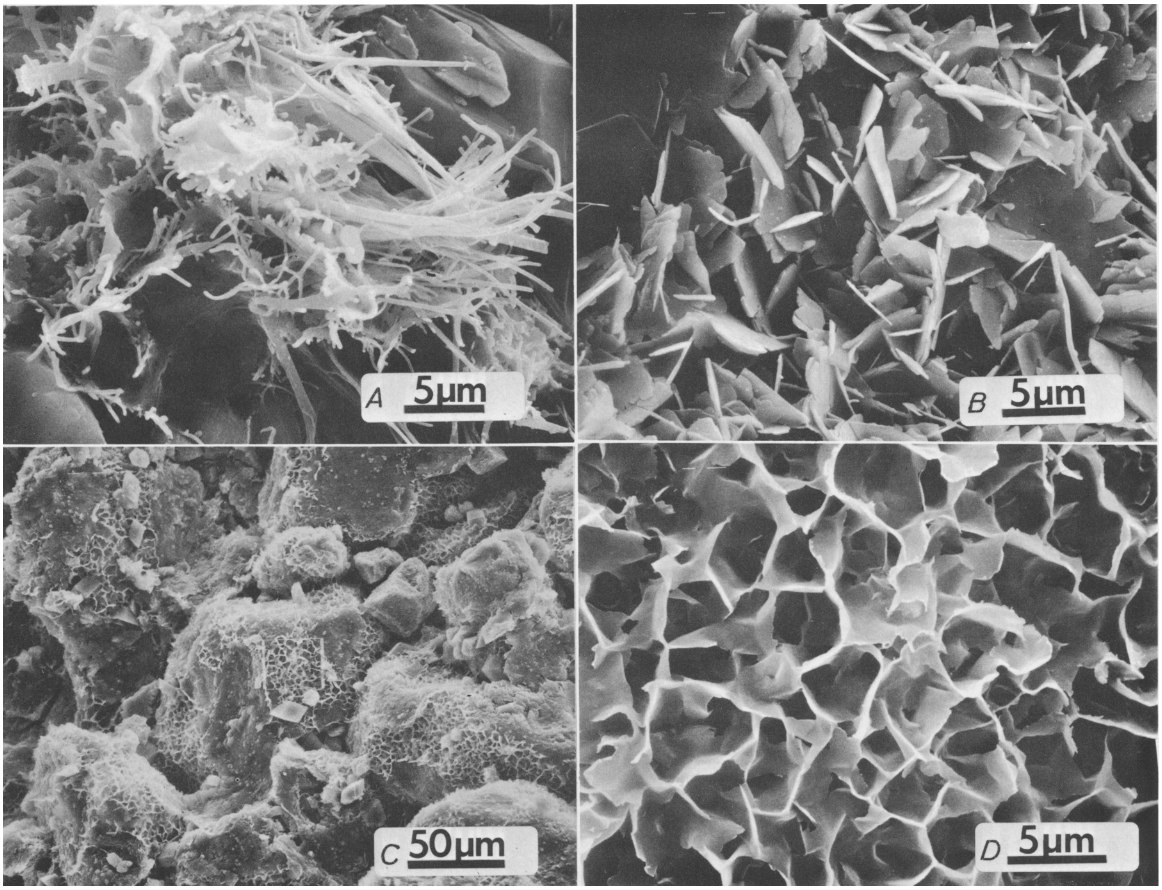

Figure 2. Scanning electron micrographs of the clay mineral assemblage from the upper part of the overall sandstone unit (2949–3310 feet). The clay minerals are (A) pore-lining and pore-filling diagenetic illite, (B) chlorite, and (C and D) regularly interstratified chlorite/smectite (corrensite), which dominates the clay mineral assemblage. The corrensite has a "honeycomb" morphology which is characteristic of smectite containing straight, bladed platelets similar to chlorite.

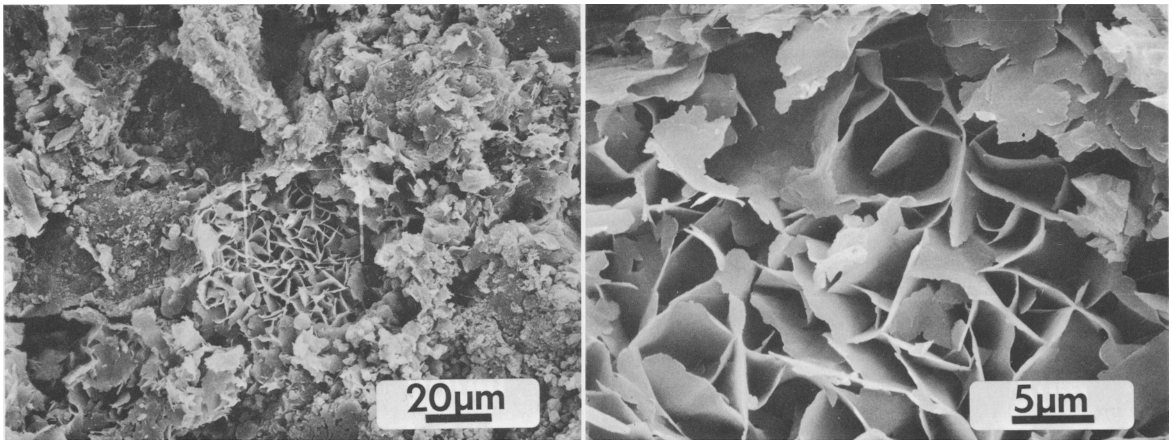

Figure 3. SEM photomicrographs of the corrensite aggregate morphology from the lower portion of the Guadalupe Formation (6500 feet). The morphology resembles that of curved chlorite platelets tending towards the smectite characteristic morphology.

https://doi.org/10.1346/CCMN.1981.0290310 Published online by Cambridge University Press

within a single formation may represent two distinct intermediate stages of diagenesis, i.e., (1) an early stage mineral at a depth of 3000 feet in the "A" well with a smectite-like "honeycomb" morphology and containing both Ca and Fe; and (2) a later stage mineral phase at a depth of 6000 feet in the "B" well with a chlorite-like, bladed-crystal morphology and containing Fe and no Ca. Regardless of these variations in elemental composition and crystal morphology, XRD demonstrates that the unit-cell dimensions of these two distinct corrensites are identical.

CONCLUSIONS

Two morphologically and compositionally distinct types of interstratified chlorite/smectite in the same reservoir sandstone have been recognized by a combination of XRD and SEM/EDX methods. These identifications are significant in a completion/stimulation program in that (1) the presence of water-sensitive clays with expandable layers that would clog pore throats when in contact with fresh water has been demonstrated; (2) the presence of acid-sensitive chlorite as a mixed-layer mineral has been demonstrated; and (3) different types of mixed-layer clays can be distinguished, thereby allowing closer stratigraphic and/or mineralogical control during reservoir completion processes.

Reservoirs, Inc.
1151-C Brittmore Road
Houston, Texas 77043

R. E. Tompkins

REFERENCES

Neasham, J. W. (1977a) Applications of scanning electron microscopy to the characterization of hydrocarbon-bearing rocks: *Proc. Workshop Scan. Elect. Micr.*, IIT Research Institute, Chicago, Illinois, 18–26.

Neasham, J.W. (1977b) The morphology of dispersed clay in sandstone reservoirs and its effect on sandstone shaliness, pore space, and fluid flow properties: *Proc. 52nd Ann. Tech. Conf. Soc. Petr. Eng. AIME*, Denver, Colorado, 8 pp.

Wilson, M.D. and Pittman, E. D. (1977) Authigenic clays in sandstones: Recognition and influence on reservoir properties and paleoenvironmental analysis: *J. Sediment. Petrology* **47**, 3–31.

(Received 26 February 1980; accepted 5 February 1981)