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# Diagenetic Structural Transformations in North Sea Jurassic Illite/Smectite

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**Abstract:** The Kimmeridgian-Volgian(-Ryazanian) claystone is the principal oil source rock in the troughs of the North Sea. Randomly (R0) ordered mixed-layer illite/smectite (I/S) appears to have transformed to R1-(IS) or R3-(ISII) ordered simultaneously with oil generation. The proportion of illite layers in I/S increased to 95% during diagenesis in these claystones. Exceptions are three samples of I/S of probably bentonitic origin; these have apparently changed during diagenesis to R0-ordered I/S containing 40– 50% illite layers. Fine fractions of the claystones dominated by I/S were analyzed by <sup>27</sup>Al and <sup>29</sup>Si magic-angle spinning (MAS)-nuclear magnetic resonance (NMR) spectroscopy, <sup>57</sup>Fe Mössbauer spectroscopy, and X-ray powder diffraction (XRD), and for total chemical composition. Si/Al ratios determined from MAS-NMR agree closely with those calculated from total chemical analysis; however, tetrahedral and octahedral Al occupancies were most accurately determined by NMR. An increase in the percentage of illite layers and in the ordering of the I/S was accompanied by fixation of K<sup>+</sup> and NH<sub>4</sub><sup>+</sup> in the I/S, by tetrahedral Al-for-Si substitution, and by octahedral Al-for-(Mg + Fe) substitution, resulting both in an increase of charge in the 2:1 layers and in a migration of charge from octahedral to tetrahedral sheets. The I/S of probably bentonitic origin had a larger tetrahedral and a smaller octahedral charge than expected from its content of illite layers. MAS-NMR showed a significantly higher content of tetrahedral Al (most likely in smectitic sites) than expected from the percentage of illite layers calculated from XRD. Correspondingly, XRD of K<sup>+</sup>-saturated and glycolated specimens showed that several smectite layers possessed a significant charge. A constant *b*-dimension of the I/S and the presence of a significant charge in the smectite layers suggest that a transformation of smectite to illite layers in the I/S by tetrahedral Al-for-Si substitution followed by interlayer cation fixation and interlayer contraction is the most probable genesis for the I/S investigated.

**Key Words:** Chemical composition • Diagenesis • Illite/smectite • Mössbauer spectroscopy • Nuclear magnetic resonance • X-ray powder diffraction

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