# A Relationship between Crystallographic Properties of Illite and Chemical Properties of Extractable Organic Matter in Pre-Phanerozoic and Phanerozoic Sediments

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**Abstract:** Crystallographic properties of illite and chemical properties of organic matter in various mudstones ranging in age from Archean to Miocene were investigated. The breadth of the (001) X-ray powder diffraction peak of illite correlates significantly with the ratio of aliphatic to condensed.-aromatic components and the degree of condensation of aromatic rings of the polar ( " humic " ) fraction of extractable bituminous organic matter. The broader the diffraction peak, the less highly condensed and aromatic (i.e. less highly humified) is the organic matter associated with the illite. Breadth of illite diffraction peak and degree of humification of polar organic matter vary in a complex and apparently systematic way through geologic time. All of the three different suites of mudstones investigated ( " calcareous, " " non-calcareous, " and " glacial " mudstones) gave similar patterns of secular variation. In addition, the ratio of diffraction intensities for the (002) and (001) reflections ($I_{002}/I_{001}$) of illite in calcareous mudstones and limestones showed a strong negative correlation with geologic age, indicating that the illites in the older rocks are enriched in magnesium with respect to aluminum.

The correlation between crystal structure of illite and degree of humification of its associated organic matter could, by itself, be interpreted as an effect of post-depositional maturation processes, whereby " crystallinity " and degree of humification both increased as functions of heat and pressure. However,the patterns of secular variation suggest that the observed variations are primary, or were pre-determined by primary characteristics of the sample materials. The possibility that the original structure and composition of the organic matter influenced post-depositional changes in the crystallographic properties of sedimentary clay minerals, or post-depositional genesis of clay, would seem to merit consideration. The demonstrated relationship between crystallographic properties of illite and the nature of the " humic " matter constitutes evidence that most of the extractable organic matter is truly indigenous to the rock in which it occurs. The results also imply that molecular structure of extractable organic matter can be used in place of the breadth of the (001) diffraction peak of illite as an index of incipient metamorphism within a single formation or stratigraphic sequence, provided the primary characteristics of the organic matter are nearly the same in all samples. This method would have the advantage of being applicable to all sediments, not just those containing illite (specifically, aluminum-rich illite).

The secular variation of the $I_{002}/I_{001}$ ratio of illite in calcareous sediments is provisionally ascribed to diagenetic processes whereby magnesium is abstracted from pore water and groundwater and is gradually assimilated into the cystal structure.

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