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Production, Destruction, Dilution, and Accommodation— The Many Paths to Source-Rock Development

The accumulation of organic matter in marine depositional environments appears to be controlled by complex, non-linear interactions of four main state variables: production, destruction, dilution, and accommodation. Significant accumulations of organic-rich rocks can arise from many different combinations of these factors. Although some organic accumulations are dominated obviously by one or another of these factors, most organic-rich rocks record a variety of optimized interactions of all the variables.

The Mowry Shale (Cretaceous, western interior, USA) clearly illustrates a transition from dilution-controlled organic accumulation to production-driven accumulation along a 450-km long onshore-offshore transect. Production-related variations in organic content appear to be driven by the disparate relative rates of r-controlled primary producers and K-controlled consuming organisms.

The most organically enriched portions of the Monterey Formation (Miocene, California) paradoxically do not represent the most highly productive intervals. Times of highest productivity suffer from dilution by biogenic material and correspond to highly siliceous lithologies (cherts, porcelanites). Excellent preservational conditions and moderate primary production rates appear to control significant concentrations of organic matter.

Organic enrichment in the upper Brushy Canyon and lower Cherry Canyon Formations (Permian, west Texas) arises from local optima of burial rates and pelagic organic-matter input. Significantly enriched strata occur in siltstones (with minimal clay contents) interbedded with slope and basin-floor sandstones deposited under oxic to sub-oxic conditions. Enrichment is demonstrably not linked with evidence of oxygen deficiency. Advected organic matter from the shelf is of minimal importance.

Conceptually, organic enrichment can be expressed as a simple relation:

(Production - Destruction)/Dilution

Optimum organic enrichment occurs where production is maximized and destruction and dilution are minimized. Any appropriate combination of these factors can produce potential source rocks.