FACIES ANALYSES OF THE NIAGARAN ROCKS IN ILLINOIS

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The Niagaran exposures in Illinois, which occur widely separated in the northeastern, northwestern, west-central, and southwestern parts of the State, contrast sharply in gross lithologic aspects as well as local facies development. The differences in gross lithology are basically expressions of broad regional facies differentiations. These regional sedimentation conditions are greatly modified in the two northern outcrop sections by a local environmental factor, the reefs, which formed local sediment sources. Complex small scale facies differentiation characterizes the reef enclosing strata here, indicating further the controlling effect that the reefs had on the sedimentation of the surrounding bottoms. These reef-bearing northern deposits stand out in sharp contrast to the reef-free southwestern Illinois deposits. The southwestern Illinois deposits consist entirely of normal shelf sediments, whereas the reef-bearing portion of the northern Illinois sections embrace reef and inter-reef deposits.

In broad environmental terms we may distinguish three major categories in the facies analyses: normal shelf deposits, reef deposits, and inter-reef deposits.

The normal shelf deposits consist principally of two recognizable source components: (1) terrigenous clastics, derived from the bordering land areas, and (2) skeletal debris, both calcareous and siliceous, supplied by the organisms that populated the shelf bottoms. The terrigenous clastics were apparently derived chiefly from the Appalachian upland or its southern extensions, and to a minor extent from the Ozark Island that existed in Niagaran time. Only in the Ozark bordering outcrop areas in southwestern Illinois do we find evidence of a major contribution of Ozark derived sediments. As to the other outcrop areas, their contributions appear to have been largely confined to the Joliet deposits of west central Illinois and the basal Joliet deposits of northeastern Illinois. There is no evidence at present to warrant the recognition of a chemical precipitate constituent in the carbonate fraction of the normal shelf deposits.

The reef facies differs radically from the shelf facies, as well as the inter-reef facies, in that it constitutes isolated bodies of essentially pure carbonate rock which is entirely organic in origin except for the secondarily introduced magnesian element. The reef frame was erected solely by reef-building organisms, principally stromatoporoids and tabulate corals, which produced rigid topographically raised structures that extended from the surrounding bottoms upward into the agitated surface waters. The interstices of the reef frame are largely filled with organic skeletal debris of reef dwell-

ing organisms and reef detritus, which occur commonly cemented into the frame by encrusting stromatoporoids. The reef bodies are commonly found flanked by reef-derived detritus. Secondary dolomitization has greatly altered the original textures and largely obscured the organic character of the reef bodies.

The inter-reef facies, up to the present ill-defined and interchangeably referred to as normal or lagoonal facies, may be broadly defined as the deposits which accumulated within the orbit of the detritus laden waters of reef outwash. The inter-reef deposits thus embody two distinct source elements, a regional and a local reef-derived one, the latter forming the most characteristic criterion for distinguishing the inter-reef facies from the normal shelf facies.

With this as a background, the facies of the individual outcrops may be analyzed.

Beginning with the northeastern Illinois outcrops, the Niagaran deposits consist of a succession of normal shelf deposits through the Joliet formation, which gradually gave way in the Waukesha transition phase to reef and inter-reef development in the Racine-Guelph formations. The regional environmental factors which can be deduced from the gross character of the sediments as a whole are fairly muddy waters (as indicated by the average of 15-20 percent terrigenous clastics) and soft muddy to sandy bottoms, generally lying slightly below effective wave base. Reef growth started in sporadic form during Waukesha deposition, which is marked by semi-rough water conditions and the influx of coarse silt and very fine sand. Curiously enough the main phase of reef development came only after lowering of the sea bottom below wave base, implying that deeper bottoms and fairly muddy waters were not detrimental to the Niagaran reef builders. Complex facies differentiation goes hand in hand with the main reef development, the inter-reef facies shifting horizontally and vertically in correspondence to the shifting reef spread. The inter-reef deposits are characterized by sharp horizontal f a c i e s differentiations ranging from quite muddy deposits of anaerobic through aerated quiet water facies all the way to rough-water deposits which are principally composed of reef-derived detritus. The inter-reef deposits thus contrast sharply with the early Niagaran normal shelf deposits; such facies changes as were gradually attained in time but not in space in the shelf deposits can be commonly found developed over short distances in the horizontal plane among the inter-reef deposits.

In the northwestern Illinois section, the Niagaran deposits also consist of a succession of normal shelf deposits in the Waukesha formation, followed by reef and inter-reef development in the Racine-Port Byron sequence. The facies contrast between normal shelf, reef, and inter-reef deposits is here less sharply defined, the chief contrasting features being sediment structures and facies shifts. This is primarily due to the negligible content of terrigenous clastics which average here less than 5 percent. Textural and composi-

tional criteria readily recognizable in limestones, which would aid in the analyses of a more detailed facies differentiation, have been obscured by secondary dolomitization. The broad environmental factors that characterize (and at the same time contrast) the northwestern and northeastern Illinois deposits are prevalent shallow-water bottoms, located largely above wave base, and clear water conditions. During the prevailing intervals of shallow water conditions, reef detritus was spread and redeposited entirely over the adjacent inter-reef bottoms, largely in the form of shifting sand bars rather than in detrital fans which, however, accumulated around reefs during periods of temporary subsidence below wave base.

The Niagaran deposits of west-central Illinois, as far as preserved, underlying the pre-Middle Devonian erosion surface, consist entirely of normal shelf deposits. As even the most extensively preserved sections in the Grafton area do not extend upward into the horizons of the reef-bearing strata in the northern outcrop areas, it is uncertain whether reef and inter-reef facies were originally present or not. The sections in the Hambury area consist of crinoidal limestone coquinas, of the semi rough-water type, whereas the Grafton deposits comprise dolomitized rough-water deposits at the base followed by semi rough-water deposits of the Waukesha facies type as developed in northeastern Illinois.

The southwestern Illinois deposits are represented in their entirety by normal shelf deposits in which the carbonates consist of limestone. Following an intial phase of semi rough-water conditions marked by clastic semi coquinas, the bulk of the succeeding section is composed of muddy bottom, quiet water deposits, evidently laid down at greater depth than any of those of the other outcropping areas. The prevailingly low density in burial population (consisting of small fragile forms) and lack of evidence of large scale reduction of the terra rosa muds derived from the adjacent Ozark upland point toward deposition under quiet water conditions, near or at the photosynthetic ceiling. Because of the pronounced muddiness, reflected in the terrigenous clastic content of about 40 percent, a considerably higher average than in any of the other areas, the photosynthetic ceiling was evidently above 600 feet, appreciably higher than its maximum extent under clear water conditions.