

DISTRIBUTION OF LIMESTONE IN THE BRAZIL FORMATION (PENNSYLVANIAN) IN THE SUBSURFACE OF SOUTHWESTERN INDIANA AND WESTERN KENTUCKY

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ABSTRACT. Electric logs and samples of well cuttings indicate the existence of limestone bodies in the lower and middle Brazil Formation of southwestern Indiana and western Kentucky. The limestone bodies are elongated north-east-southwest, are as much as 60 feet thick, are as much as 3 miles in length, are interpreted to have formed on slight elevations on the sea floor, and were accumulated contemporaneously with adjacent terrigenous muds and sands until they were finally smothered by these terrigenous sediments.

KEYWORDS: Brazil Formation, limestone, Pennsylvanian, subsurface southwestern Indiana, subsurface western Kentucky.

INTRODUCTION

The Brazil Formation in Indiana lies below the Staunton Formation and above the Mansfield Formation in the Raccoon Creek Group (Figure 1). In the type area (Brazil, Clay County, Indiana), the Brazil includes rocks from the base of the Lower Block Coal Member to the top of the Minshall Coal Member (Hutchinson, 1976). The Upper Block Coal Member is the only other named member of the Brazil Formation. The Brazil coals have irregular distributions along the outcrop and very limited distributions in the subsurface. Because the Minshall coal is of limited extent, the stratigraphic position of the base of the more widespread Perth Limestone Member, or of the sandstone that replaces it, was used in an earlier subsurface study (Droste and Horowitz, 1995) to mark the top of the Brazil. This "working" definition of the top of the Brazil is used in the present study. Following conventional usage, the base of the Brazil is placed at the stratigraphic position of the base of the Lower Block Coal.

This study expands geographically the earlier report of limestones in the Brazil Formation in Vanderburgh County, Indiana (Droste and Horowitz, 1995) by including all the subsurface area of southwestern Indiana and western Kentucky.

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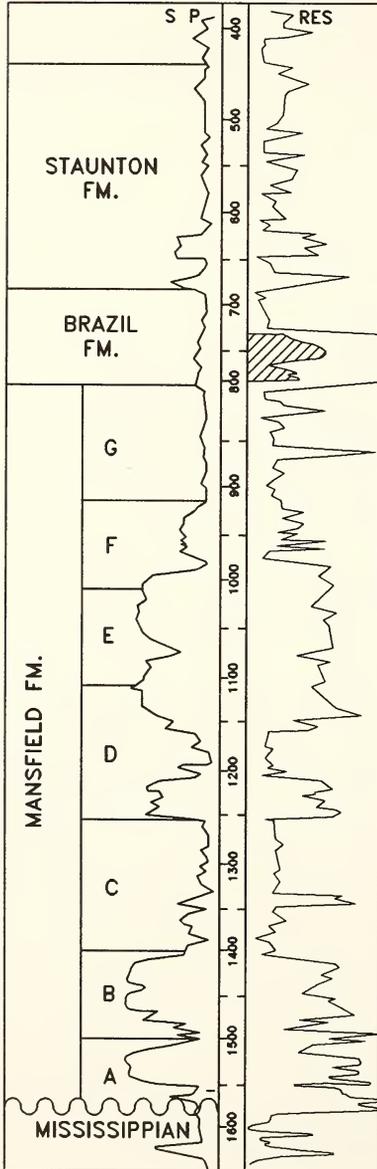


Figure 1. An electric log from a well in Vanderburgh County, Indiana, showing thick limestone in the Brazil Formation and the stratigraphic nomenclature used in this report. The position of the well is shown in Figure 4 at location 4C.

LIMESTONES OF THE BRAZIL FORMATION

Perhaps the only significant mention of limestone in Brazil rocks at the surface is the report of the fusulinid genus *Fusulinella* in an unnamed limestone between the Lower and Upper Block Coals in Clay County, Indiana (Shaver, 1981). The rather common occurrence of limestone in the Brazil in the subsurface initially appeared to be limited to Indiana. However, the authors have found "Curlew" (referring to the Curlew Limestone Member of the Trade-water Formation) on electric logs in Kentucky that are assigned to any of several limestone intervals in rocks equivalent to the upper part of the Brazil Formation of Indiana. One to three intervals of limestone, each less than 10 feet thick, are present in numerous wells in southwestern Indiana and western Kentucky. These thin intervals of limestone in the upper Brazil are principally wackestones that in places contain chert. Packstones are less abundant and typically are not cherty.

This report focuses on thick limestone intervals in the middle and lower part of the Brazil. Samples (well cuttings at 10-foot spacing) in the interval of high resistivity in the Brazil Formation in the Kamp and Rollett #2 well (Figure 1) record almost 60 feet of limestone, which is the thickest limestone interval for which samples were available for this study. The sample studies have been restricted to materials from the Brazil interval in wells on file at the Indiana Geological Survey. Samples from wells in Kentucky were not examined. Samples, typically taken at 10-foot intervals, from many wells in southernmost Vanderburgh County (Droste and Horowitz, 1995) form the basis for the following description of thick limestones in the Brazil interval.

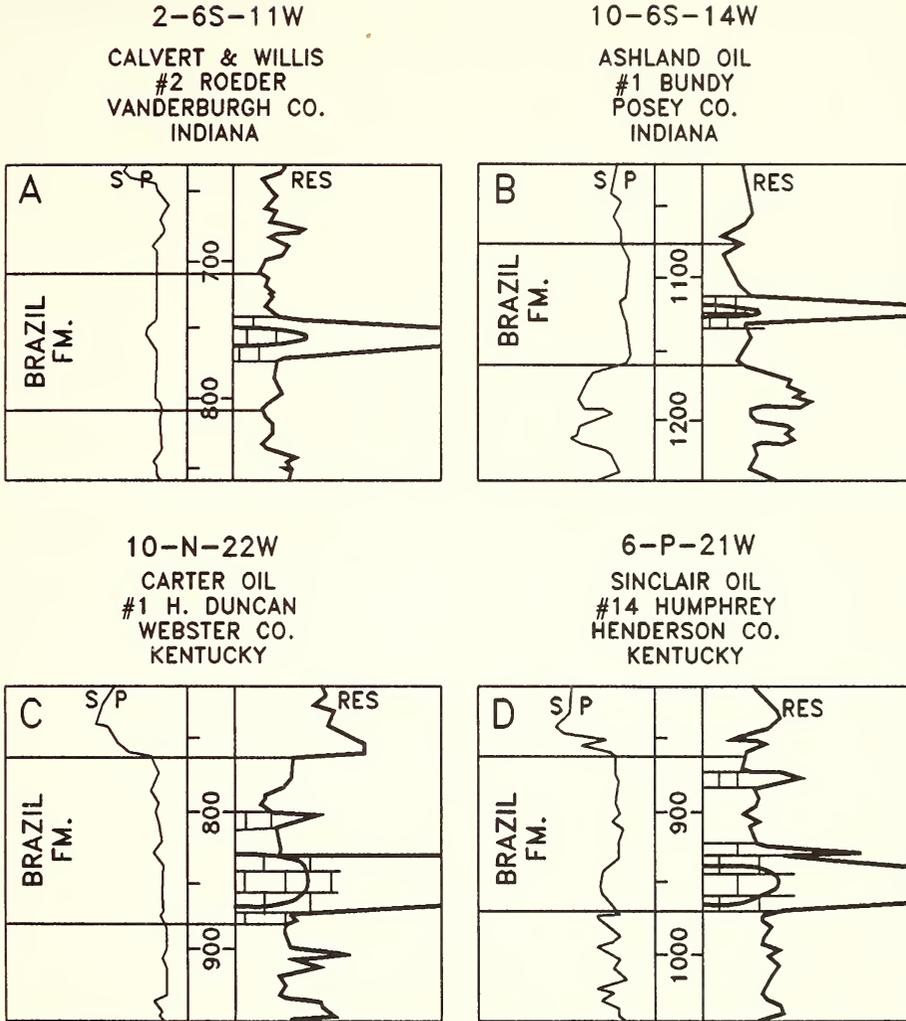


Figure 2. Typical electric logs from wells in Indiana and Kentucky that show limestone intervals from 20 to more than 40 feet thick. The positions of the wells are shown in Figure 4 at locations 2A, 2B, 2C, and 2D.

The biotic skeletal components of the limestone are primarily echinodermal fragments, bryozoans, and brachiopods, a typical late Paleozoic faunal association interpreted as living on shallow marine shelves. Other minor faunal components identified in sample fragments are mollusks, ostracodes, and trilobites. The sample from the basal 10 feet of the limestone contains mainly wackestone with lesser amounts of packstone. This interval is locally cherty, suggesting the presence of silica-bearing organisms, perhaps sponges. The next higher 10-foot interval shows a much reduced abundance of wackestone and a greatly increased abundance of packstone. Chert is seldom encountered in samples of

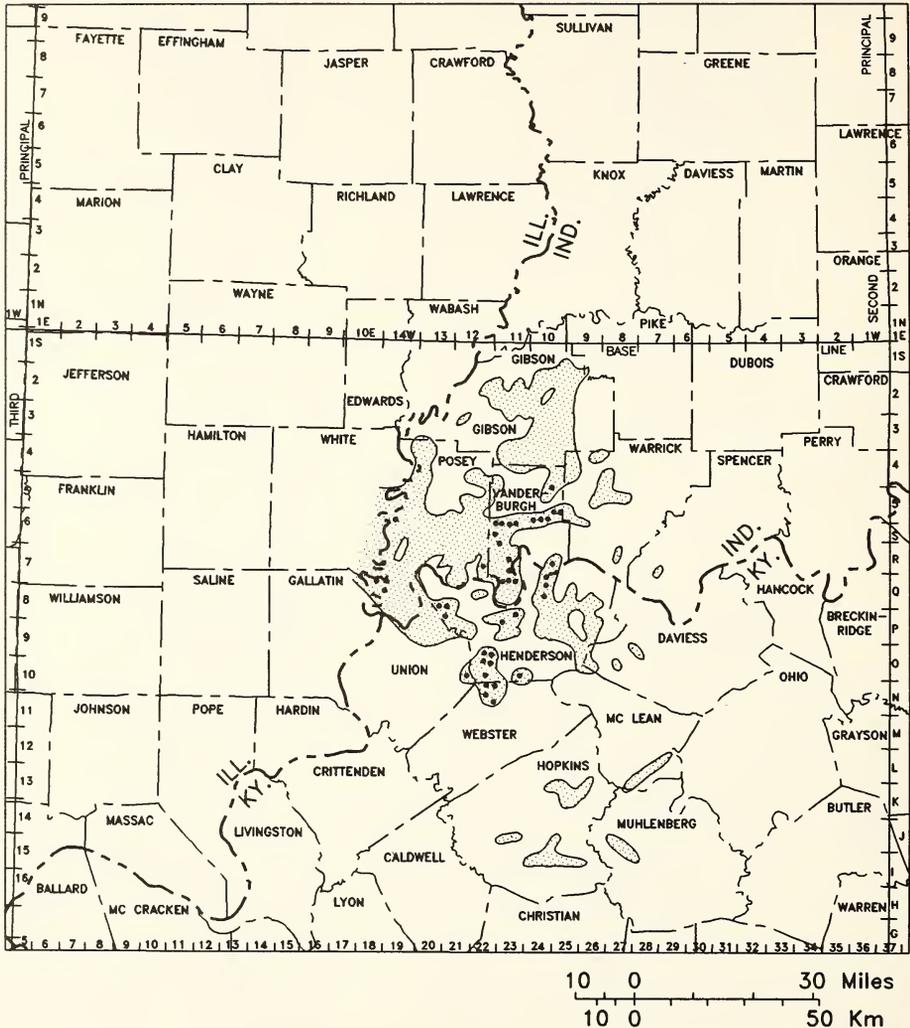


Figure 3. A map showing the distribution of thick limestone intervals in the Brazil Formation. Stippling indicates areas within which at least one well per section (square mile) contains an interval of limestone 10 or more feet thick. Heavy dots show locations of sections in which at least one well has a limestone interval 20 or more feet thick.

the second 10-foot interval. In the sample of the third 10-foot interval, grainstone is almost as abundant as packstone. Limestones more than 30 feet thick are composed mainly of grainstone and have the appearance of typical late Mississippian limestone. However, oolites, common in numerous late Mississippian limestones, have not been observed in the limestones in the Brazil Formation.

LIMESTONE DISTRIBUTION

The unusually thick limestone in the Brazil interval in southernmost Vanderburgh County (Figure 1) is an uncommon occurrence. Several electric logs

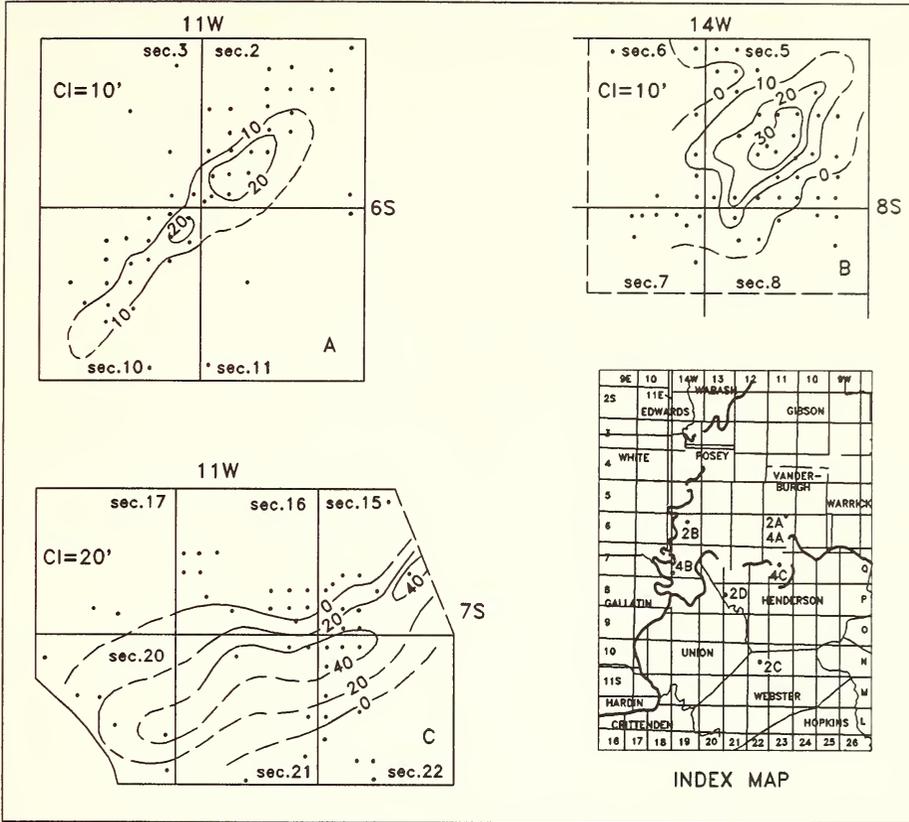


Figure 4. Maps showing the northeast-southwest alignment of the thick limestone bodies in the Brazil Formation of Vanderburgh County (A, C) and Posey County (B), Indiana. Contour interval as specified; dots indicate locations of well log control. For the location of these areas, see the index map.

from wells in other locations show the more typical thickness of Brazil limestone bodies (Figure 2). The thick limestone intervals in the two wells from Kentucky (Figure 2C and 2D) and from southernmost Vanderburgh County, Indiana (Figure 1), are in the lower Brazil. At two locations farther north in Indiana (Figures 2A, 2B), the thick limestone interval is in the middle Brazil. The environment suitable for limestone deposition clearly is younger in the more northerly locations in Indiana.

Limestone intervals ten or more feet thick in the Brazil Formation have a greater areal distribution in southern Indiana than in western Kentucky (Figure 3). The stippling in Figure 3 indicates areas where at least one well per section (square mile) contains an interval of limestone 10 feet or more thick, but within the shaded areas, the thicker limestone intervals are discontinuous even within a single section. The heavy dots (Figure 3) within the stippled areas mark

locations of sections where at least one well contains an interval of limestone 20 or more feet thick.

In several areas in Indiana, closely spaced wells with geophysical logs permit mapping of the distribution of single bodies of thick limestone. Two locations in Vanderburgh County and one location in Posey County (Figure 4) show the shape and orientation of the limestone accumulations. The limestone deposits are elongate in a northeast-southwest direction. These maps clearly illustrate, as noted above, that the thick limestone intervals are discontinuous within the same section.

The limestone intervals in the upper Brazil are thinner and more continuous than the thick limestone intervals in the middle and lower Brazil.

ENVIRONMENT OF DEPOSITION

We can only speculate about the environmental conditions that permitted the formation of the thicker limestone accumulations. Shallow marine shelf deposition was common to this area during the Mississippian Period and, at times, apparently continued into the Pennsylvanian based on the limited biotic evidence available. The fauna also indicates marine waters, and the abundance of echinodermal debris, presumed to be principally crinoidal plates, suggests that crinoidal thickets existed. These thickets would have needed a suitable substrate on which to grow and, in calm weather, sufficient energy in the form of waves and currents to bring in nutrients but not to carry sufficient terrigenous sand and mud to smother the thickets. Kvale, Furer, and Mastalerz (1996) have reported tidalites above the Lower Block Coal Member at the outcrop and in the shallow subsurface in Daviess County, Indiana. This confirms the presence of active tidal currents during Brazil time no more than 30 kilometers from the nearest subsurface carbonate buildup discussed here. The thickets are presumed to have been above storm wave base and probably would have been swept free of some accumulated carbonate or terrigenous debris during storms. The biotic debris is believed to have been produced locally as evidence is lacking for distant transport of skeletal debris to the site of deposition. Electric log correlations suggest contemporaneous terrigenous sands and muds accumulated adjacent to the loci of limestone accumulation.

The suggested environment of deposition for the thick limestone accumulations is as follows. Slight elevations on a shallow marine shelf permitted the establishment and growth of crinoid thickets above storm base. The accumulation of biotic debris accentuated the relief on the sea floor and permitted skeletal organisms to flourish. Accumulation continued until a change in currents or other water conditions led to smothering of the limestone bottoms by terrigenous debris. The northeast-southwest orientation of the elongate deposits may be the result of very minor tectonic control or slight variations in the rates of subsidence from area to area on the sea floor.

SUMMARY

The existence of thick normal marine limestone accumulations in the Brazil Formation clearly documents a strong marine influence in the environments of deposition in southwestern Indiana and western Kentucky during Brazil time. Crinoid thickets apparently colonized slightly elevated sites on the sea floor that were swept by waves and currents sufficient to bring in nutrients but lacking smothering terrigenous materials. Basal wackestones grade upward into packstones. In deposits 30 or more feet thick, the upper grainstones have the appearance of the better-known shallow water limestones of the underlying Mississippian rocks. The Brazil limestones were laterally contemporaneous with and were ultimately covered by terrigenous debris.

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