KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 1966-6

Prediction of Effective Porosity in
Some Marine Oolite Deposits

by

Stanton M. Ball

Kansas Geological Survey
1930 Constant Avenue
University of Kansas
Lawrence, KS 66047-3726

KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 66-6

AMOCO REPORT - 41

"Prediction of Effective Porosity in Some Marine Oolite Deposits," by Stanton M. Ball, Amoco Production Company, Liberal District Exploration Report no. 41, January 18, 1966.

USER PLEASE NOTE: This report has been released to the Kansas Geological Survey Open-file through the cooperation of Amoco Production Company, under the express provisions that the report will be used for studies of subsurface geology in this state, that the report will not be fragmented in reproduction, and that proper credit be given Amoco, by citation of the title given above, if any of the data are published or quoted. Your cooperation in these matters is required if we hope, in the future, to receive other such material.

This report has been retyped and reproduced by the Kansas Geological Survey.

Liberal District
January 18, 1966

NE M-24

Exploration Report No. 41

Re: Prediction of Effective Porosity in Some Marine Oolite Deposits

Ref: Base Map M-24

Mr. W. L. Adams
Building

Dear Sir:

A mapping technique useful for prediction of the most permeable oolite facies in some marine oolite reservoirs is submitted herein. Data upon which the technique is based was collected during a study (Project LD-65-3) of the Meramecian strata of southwestern Kansas. No specific recommendation is being considered at this time. The following discussion and exhibits are presented as reference with informational data that may be useful in other areas of oolite reservoir exploration.

CONCLUSIONS

1. Shoal oolites form the reservoirs of the Pleasant Prairie Field in Finney County, Kansas, which has produced 10,000,000 BO with ultimate estimated reserves of 30,000,000 BO. In addition, 14 other pools produce from these strata in southwestern Kansas, with total estimated reserves of 21,000,000 BO.

2. Facies distribution controls the distribution of effective porosity throughout the Pleasant Prairie Field.

3. The most permeable facies of the Pleasant Prairie Field is oolith-skeletal lime grainstone. Although neither the coarsest (skeletal-oolith lime packstone) nor the best size-sorted (oolith lime grainstone), the oolith-skeletal lime grainstone is the cleanest (most lime mud free) facies and is characterized by the highest primary intergranular porosity.

4. Facies analysis indicates direction of better permeability and, to a limited extent, distance from the optimum facies.

5. Oolites of the Pleasant Prairie Field correspond closely to Bahamian shoal oolites and are believed to be generally representative of other oolite areas within the St. Louis formation of southwestern Kansas.

6. The mapping technique is believed to be generally applicable to the oolites of the St. Louis formation of southwestern Kansas and should be applicable in many other areas where Pan American is exploring for shoal oolite reservoirs.

7. Uses of this mapping technique include extension of established trends into areas of sparse control, the establishment of new trends in areas of sparse control, and determination of direction of the shoal facies from a single bore hole. The last-mentioned usage is dependent upon knowledge of the general direction in which transgression (or regression) proceeded in an area.

8. Once a model is established for an area, the technique may be utilized by visual estimation of per cent oolitically-coated grains, per cent lime mud matrix, grain size (elasticity index of Table 1, Enclosure 2), roundness, and sorting.

INTRODUCTION

Facies analysis is believed to be a directional indicator and, to a limited extent, a distance (relative, not absolute) indicator in exploration for permeability in marine oolitic shoal deposits. A detailed grain count of the productive oolite zones in the St. Louis resulted in 5 principal facies identification parameters: (1) The per cent of oolitically coated grains within a correlative zone increases from the foreshoal to the backshoal facies, (2) The relative grain size decreases from foreshoal to backshoal facies, (3) The relative grain roundness increases from foreshoal to backshoal facies, (4) The relative grain sorting increases from foreshoal to backshoal facies, (5) The per cent lime mud increases in both directions from shoal axes.

A method of predicting effective porosity in some marine oolite deposits with limited control is presented below. Discussion of both the theoretical basis and the factual basis for the technique is followed by considerations of application, limitations, and a summary of the procedure.

THEORETICAL ASPECTS OF MARINE OOID FORMATION

Studies of recent marine ooids (e.g., Newell and others, 1960) indicate general agreement that: (1) a physio-chemical gradient to create the condition of supersaturation with respect to $CaCO_3$; (2) a source of grains necessary as nuclei; (3)current intensity sufficient to transport the grains along the bottom into, or to winnow grains from lime mud within, the area of supersaturation; and (4) turbulence to lift the grains off the bottom into supersaturated waters, are conditions needed for marine ooid formation. An optimum combination of these conditions occurs within intertidal zones of shallow warm seas over shoals that are markedly steeper on their seaward side.

Carozzi (1960) reported that the geometrical properties of oolitic deposits may be explained in a simplified manner by considering the interference of two main factors, current and turbulence intensities. Where current energy exceeds greatly that resulting from local agitation, only the smallest grains transported into the environment may be picked up and coated. If current and turbulence intensities are nearly equal, only the largest grains will remain uncoated. Where local agitation exceeds current intensity, the resulting deposit is entirely oolitic.

Assuming the theory outlined by Carozzi is valid, and knowing that current energy diminishes landward from the outer limit of the intertidal zone whereas local agitation diminishes in both directions from shoal axes, facies transverse to the long axes of shoal ooid deposits should be developed systematically. Grain size decrease from seaward to landward of such shoals should be expected in cases where the source of ooid nuclei is the zone of optimum invertebrate growth, seaward from the shoal area. Other expected seaward to landward changes would be grain roundness increase and degree of sorting increase. Per cent of oolitically-coated grains should increase from the seaward to the landward edge of the shoal area, whereas lime mud content should increase in both directions from the shoal area. Such changes in characters of facies are developed across the short dimensions of both the ancient and recent examples of shoal ooid deposits described below. In the example from the ancient record, these facies control the effective porosity. Similar facies changes should be expected in many areas of marine oolite reservoirs.

EXAMPLES OF MISSISSIPPIAN OOLITE RESERVOIR ROCKS PLEASANT PRAIRIE FIELD, FINNEY COUNTY, KANSAS, AND A RECENT DEPOSIT, SOUTH CAT CAY-BROWN'S CAY AREA, BAHAMAS

This report is an outgrowth of a project study (LD-65-3) of the southwestern Kansas Meramecian section. Mississippian oil production is largely from oolite reservoirs within the St. Louis formation. The

Pleasant Prairie Field (Enclosure 1) is the best field in the area and may produce ultimately as much as 30,000,000 barrels of oil. Because of this and because of dense control, this field was selected for detailed study. Aspects of the geology of the Pleasant Prairie Field and immediate vicinity that are pertinent to this discussion are exhibited on Enclosures 1 and 2. Reservoir limitations (Enclosure 2), determined by study of six St. Louis "D" zone core analyses and ten St. Louis "C" zone core analyses, indicate that the optimum porosity and permeability are associated with the shoal facies as illustrated. in the case of the Pleasant Prairie Field, the trap is draped over a structural nose.

Within this area, Meramecian (St. Louis) ooids were deposited under marine conditions as evidenced by the character of the ooid nuclei and by gradation, both vertically and laterally, of the oolitic zones into other definitely marine deposits. About 62 per cent of the ooid nuclei counted (Table 1, Enclosure 2) were derived from skeletons of marine invertebrates, and some of the nuclei in the unidentified category were likely of a similar origin.

The South Cat Cay-Brown's Cay Area, Bahamas, is illustrated for comparative purposes on Enclosure 1. Data about this area of recent ooid formation is taken from Newell and others (1960) and Purdy (1963). Facies characteristics including grain size, sorting, roundness, and per cent uncoated versus oolitically-coated grains are associated spatially in much the same manner as in the ancient example described herein.

USES

Fully and partially tested uses of the mapping technique include extension of established trends into areas of sparse control (Examples 1A, 1B and 1C of Enclosure 3) establishment of trends in areas of sparse control (Example 2, Enclosure 3), and determination of direction to move from a single borehole (Examples 3A and 3B, Enclosure 3). These uses indicate direction of the shoal facies. Relative distance from the shoal facies is indicated by relative grain size and relative per cent oolitically-coated grains.

EXTENSION OF AN ESTABLISHED TREND INTO AREAS OF SPARSE CONTROL

Once established that the facies associated with an oolitic deposit are developed more or less parallel to the long aces of such deposits in an area and that permeability is controlled by facies, different facies in two wells may delineate a trend extension through the localities of these wells. Three examples are given on Enclosure 3.

Facies in two tight wells, X and Y, for example, skeletal lime packstone and oolith lime grainstone indicate an oolitic and more permeable facies between (1A). The directions of the optimum facies are determined. Grain size decrease from foreshoal areas toward shoal axes and from the latter toward backshoal areas gives an approximation of distance from the shoal facies. For example, smaller ooids form in the landward marginal parts of shoals than nearer shoal axes (see Reconstructed Section on Enclosure 1). 1/ Distribution of the oolitic facies may be extended through an area similar to that in the established trend.

If the same facies is in two tight wells, X and Y, only one facies trend extension is established (1B). Only one direction of the shoal

---

1/ The facies referred to is that labeled backshoal and colored yellow on the Enclosures. For the purposes of emphasis, simplicity, and elimination of burdensome repetition of rock type terminology (from Dunham, 1962) that may not yet be familiar to all, the discussion and Enclosures are restricted to the three productive facies, which are termed foreshoal, shoal, and backshoal. Therefore, sediment deposited in the landward marginal parts of the area of shoaling is herein referred to as the backshoal facies.

facies is indicated. A guess as to the distance of the more permeable facies must be based upon the size of oolite leases characteristic of an area. Since there is generally a significant range in size of oolite lenses within an area, the extended facies distribution shown by Case 1B may be overly optimistic. Examples 1A and 1B are hypothetical as regards the area shown, but are known to exist in other parts of southwestern Kansas within the St. Louis formation.

Example 1C is based on the porous development of the St. Louis "C" zone in wells X and Y and the tight development in a cored well Z. The C zone tested considerable water with good oil shows in the two porous cases, X and Y, and is tight in the cored well Z. Sample examination may not be necessary in wells X and Y. Since porosity and permeability have been well established by testing, it can be assumed therefore the the optimum facies has been located and its limits more nearly established by well Z.

ESTABLISHMENT OF TRENDS IN AREAS OF SPARSE CONTROL

Initially, only the rough orders of magnitude of productive oolite lenses in an area are known. Rock types in five tight wells, A, B, C, D and E, are determined by thin section study. The map shown as Example 2, Enclosure 3, has been prepared with the rock type distribution plotted and the anticipated area of the most permeable facies outlined. This example is hypothetical, but insofar as testing has progressed, it is substantiated by some areas of the St. Louis formation of southwestern Kansas.

DIRECTION TO MOVE FROM A SINGLE WELL

If the direction of transgression or regression of the sea during an increment of geologic time in an area is known, the direction of a more permeable facies from a tight facies may be predicted. The needed information may be obtained by comparing the rock type correlative with and adjacent laterally to the productive oolite facies with the rock type either immediately above or immediately below the oolite (Enclosure 2, lower right). During transgression, a facies seaward from a shoal deposit of ooids would be shifted landward and be deposited above the oolitic deposit. During regression a reverse disposition of the seaward facies in vertical profile would develop. The facies landward from the shoal would be developed below and above the oolitic deposit during transgression and regression, respectively.

Enclosure 2 shows that for the Pleasant Prairie Field area, and the area four miles north, transgression caused the cessation of ooid formation and proceeded toward the east-northeast. Whether this condition of transgression prevailed throughout southwestern Kansas during deposition of the St. Louis "C" and "B" zones has not been completely tested. However, study thus far indicates that post-"C" zone and post-"B" zone transgressions did proceed toward the east-northeast as regards the larger areas of ooid deposition in the eastern half of the project study area. Examples 3A and 3B, Enclosure 3, are hypothetical and show how direction of the optimum facies is predicted from knowledge of the rock type developed in a single well and knowledge of transgression (or regression) direction.

LIMITATIONS

Limitations upon use of the mapping technique described above are enumerated below.

1. Density of control and quality of samples must be sufficient to establish detailed correlations.

2. Foreshoal and backshoal facies merge near the axial termini of oolite shoals. Consequently, if a single well penetrates a tight facies near the axial terminus of a shoal, better permeability will not be encountered in either direction.

3. This mapping technique is applicable only to cases where sites of ooid formation correspond essentially to sites of oolite preservation, for example, shoal areas of ooid deposition. Reworked (transported away form depositional site) oolitic deposits may indeed by systematically developed, but more mixing of sediment types and less sharp facies limits will result. Therefore, transported oolite will not only be harder to delimit but also be generally poorer reservoirs than shoal oolites.

4. Only in cases where the type of porosity explored for is exclusively, or in larger part, primary intergranular will this technique be generally successful. Where some types of secondary porosity, for example, oolicastic or preferential leaching of particular skeletal grain types, are targets, a lesser measure of success may be expected.

5. the mapping technique described above is not good for finding smaller shoal oolites. If opposite directions of the shoal facies are indicated by facies analysis of two wells six miles apart, these wells could be on opposite sides of two small shoal areas rather than one larger shoal area.

6. If the only control is within the distant foreshoal (skeletal lime wackestone to mudstone) and the distant backshoal (quartzose pelletal lime packstone) facies (Enclosure 1), there may not be an intermediate shoal facies developed.

SUMMARY OF PROCEDURE

The procedure is summarized in numerical sequence below. It is presupposed that marine oolite is an important reservoir target in the area being studied.

1. Establish electric log correlations.

2. Establish rock sequence and check correlations by study of available cores, core chips, and cuttings.

3. Have thin sections made to determine if facies are systematically distributed.

4. Make grain counts to establish critical facies parameters.

5. Study available core analysis and establish that there is facies control of effective porosity. If such analyses are not available, production history of wells producing form the various facies should give a strong indication.

6. Map facies and extend established trends into areas of sparse control.

7. Establish trends in areas of sparse control.

8. Use the rock sequence developed in two wells in which different facies exist to determine the direction of transgression or regression in an area.

9. If step 8 is successful, an indication of which direction to move from a single well to improve chance of effective porosity is obtained.

Yours very truly,

S. M. Ball

SMBS:mls

SELECTED REFERENCES

Carozzi, Albert V., 1960, Microscopic Sedimentary Petrography, John Wiley and Sons, Inc., 485 pp.

Dunham, Robert J., 1962, Classification of Carbonate Rocks According to Depositional Texture, in Classification of Carbonate Rocks, A.A.P.G., Mem. 1, William E. Ham, Ed., pp. 108-121.

Irwin, M. L., 1965, General Theory of Epeiric Clear Water Sedimentation, Bull. A.A.P.G., Vol. 49, No. 4, pp. 445-459.

Newell, Norman D., Purdy, Edward G., and Imbrie, John, 1960, Bahamian Oolitic Sand, Jour. Geol., Vol. 68, No. 5, pp. 481-497.

Purdy, Edward G., 1963, Recent Calcium Carbonate Facies of the Great Bahama Bank. 1. Petrography and Reaction Groups. 2. Sedimentary Facies, Jour. Geol., Vol. 71, Nos. 3 and 4, pp. 334-355 and pp. 472-297.

Visher, G. S., 1965, Use of Vertical Profile in Environmental Reconstruction, Bull. A.A.P.G., Vol. 49, No. 1, pp. 41-61.

Liberal District
January 18, 1966

NE M-24

Exploration Report No. 41

Re: Prediction of Effective Porosity in Some Marine Oolite Deposits

Ref: Base Map M-24

Mr. W. L. Adams
Building

Dear Sir:

A mapping technique useful for prediction of the most permeable oolite facies in some marine oolite reservoirs is submitted herein. Data upon which the technique is based was collected during a study (Project LD-65-3) of the Meramecian strata of southwestern Kansas. No specific recommendation is being considered at this time. The following discussion and exhibits are presented as reference with informational data that may be useful in other areas of oolite reservoir exploration.

CONCLUSIONS

1. Shoal oolites form the reservoirs of the Pleasant Prairie Field in Finney County, Kansas, which has produced 10,000,000 BO with ultimate estimated reserves of 30,000,000 BO. In addition, 14 other pools produce from these strata in southwestern Kansas, with total estimated reserves of 21,000,000 BO.

2. Facies distribution controls the distribution of effective porosity throughout the Pleasant Prairie Field.

3. The most permeable facies of the Pleasant Prairie Field is oolith-skeletal lime grainstone. Although neither the coarsest (skeletal-oolith lime packstone) nor the best size-sorted (oolith lime grainstone), the oolith-skeletal lime grainstone is the cleanest (most lime mud free) facies and is characterized by the highest primary intergranular porosity.

4. Facies analysis indicates direction of better permeability and, to a limited extent, distance from the optimum facies.

5. Oolites of the Pleasant Prairie Field correspond closely to Bahamian shoal oolites and are believed to be generally representative of other oolite areas within the St. Louis formation of southwestern Kansas.

6. The mapping technique is believed to be generally applicable to the oolites of the St. Louis formation of southwestern Kansas and should be applicable in many other areas where Pan American is exploring for shoal oolite reservoirs.

7. Uses of this mapping technique include extension of established trends into areas of sparse control, the establishment of new trends in areas of sparse control, and determination of direction of the shoal facies from a single bore hole. The last-mentioned usage is dependent upon knowledge of the general direction in which transgression (or regression) proceeded in an area.

8. Once a model is established for an area, the technique may be utilized by visual estimation of per cent oolitically-coated grains, per cent lime mud matrix, grain size (clasticity index of Table 1, Enclosure 2), roundness, and sorting.

INTRODUCTION

Facies analysis is believed to be a directional indicator and, to a limited extent, a distance (relative, not absolute) indicator in exploration for permeability in marine oolitic shoal deposits. A detailed grain count of the productive oolite zones in the St. Louis resulted in 5 principal facies identification parameters: (1) The per cent of oolitically coated grains within a correlative zone increases from the foreshoal to the backshoal facies, (2) The relative grain size decreases from foreshoal to backshoal facies, (3) The relative grain roundness increases from foreshoal to backshoal facies, (4) The relative grain sorting increases from foreshoal to backshoal facies, (5) The per cent lime mud increases in both directions from shoal axes.

A method of predicting effective porosity in some marine oolite deposits with limited control is presented below. Discussion of both the theoretical basis and the factual basis for the technique is followed by considerations of application, limitations, and a summary of the procedure.

THEORETICAL ASPECTS OF MARINE OOID FORMATION

Studies of recent marine ooids (e.g., Newell and others, 1960) indicate general agreement that: (1) a physio-chemical gradient to create the condition of supersaturation with respect to $CaCO_3$; (2) a source of grains necessary as nuclei; (3) current intensity sufficient to transport the grains along the bottom into, or to winnow grains from lime mud within, the area of supersaturation; and (4) turbulence to lift the grains off the bottom into supersaturated waters, are conditions needed for marine ooid formation. An optimum combination of these conditions occurs within intertidal zones of shallow warm seas over shoals that are markedly steeper on their seaward side.

Carozzi (1960) reported that the geometrical properties of oolitic deposits may be explained in a simplified manner by considering the interference of two main factors, current and turbulence intensities. Where current energy exceeds greatly that resulting from local agitation, only the smallest grains transported into the environment may be picked up and coated. If current and turbulence intensities are nearly equal, only the largest grains will remain uncoated. Where local agitation exceeds current intensity, the resulting deposit is entirely oolitic.

Assuming the theory outlined by Carozzi is valid, and knowing that current energy diminishes landward from the outer limit of the intertidal zone whereas local agitation diminishes in both directions from shoal axes, facies transverse to the long axes of shoal ooid deposits should be developed systematically. Grain size decrease from seaward to landward of such shoals should be expected in cases where the source of ooid nuclei is the zone of optimum invertebrate growth, seaward from the shoal area. Other expected seaward to landward changes would be grain roundness increase and degree of sorting increase. Per cent of oolitically-coated grains should increase from the seaward to the landward edge of the shoal area, whereas lime mud content should increase in both directions from the shoal area. Such changes in characters of facies are developed across the short dimensions of both the ancient and recent examples of shoal ooid deposits described below. In the example from the ancient record, these facies control the effective porosity. Similar facies changes should be expected in many areas of marine oolite reservoirs.

EXAMPLES OF MISSISSIPPIAN OOLITE RESERVOIR ROCKS, PLEASANT PRAIRIE FIELD, FINNEY COUNTY, KANSAS, AND A RECENT DEPOSIT, SOUTH CAT CAY-BROWN'S CAY AREA, BAHAMAS

This report is an outgrowth of a project study (LD-63-3) of the southwestern Kansas Meramecian section. Mississippian oil production is largely from oolite reservoirs within the St. Louis formation. The Pleasant Prairie Field

(Enclosure 1) is the best field in the area and may produce ultimately as much as 30,000,000 barrels of oil. Because of this and because of dense control, this field was selected for detailed study. Aspects of the geology of the Pleasant Prairie Field and immediate vicinity that are pertinent to this discussion are exhibited on Enclosures 1 and 2. Reservoir limitations (Enclosure 2), determined by study of six St. Louis "D" zone core analyses and ten St. Louis "C" zone core analyses, indicate that the optimum porosity and permeability are associated with the shoal facies as illustrated. In the case of the Pleasant Prairie Field, the trap is draped over a structural nose.

Within this area, Meramecian (St. Louis) ooids were deposited under marine conditions as evidenced by the character of the ooid nuclei and by gradation, both vertically and laterally, of the oolitic zones into other definitely marine deposits. About 62 per cent of the ooid nuclei counted (Table 1, Enclosure 2) were derived from skeletons of marine invertebrates, and some of the nuclei in the unidentified category were likely of a similar origin.

The South Cat Cay-Brown's Cay Area, Bahamas, is illustrated for comparative purposes on Enclosure 1. Data about this area of recent ooid formation is taken from Newell and others (1960) and Purdy (1963). Facies characteristics including grain size, sorting, roundness, and per cent uncoated versus oolitically-coated grains are associated spatially in much the same manner as in the ancient example described herein.

USES

Fully and partially tested uses of the mapping technique include extension of established trends into areas of sparse control (Examples 1A, 1B and 1C of Enclosure 3), establishment of trends in areas of sparse control (Example 2, Enclosure 3), and determination of direction to move from a single bore hole (Examples 3A and 3B, Enclosure 3). These uses indicate direction of the shoal facies. Relative distance from the shoal facies is indicated by relative grain size and relative per cent oolitically-coated grains.

EXTENSION OF AN ESTABLISHED TREND INTO AREAS OF SPARSE CONTROL

Once established that the facies associated with an oolitic deposit are developed more or less parallel to the long axes of such deposits in an area and that permeability is controlled by facies, different facies in two wells may delineate a trend extension through the localities of these wells. Three examples are given on Enclosure 3.

Facies in two tight wells, X and Y, for example, skeletal lime packstone and oolith lime grainstone indicate an oolitic and more permeable facies between (1A). The directions of the optimum facies are determined. Grain size decrease from foreshoal areas toward shoal axes and from the latter toward backshoal areas gives an approximation of distance from the shoal facies. For example, smaller ooids form in the landward marginal parts of shoals than nearer shoal axes (see Reconstructed Section on Enclosure 1).[1/] Distribution of the oolitic facies may be extended through an area similar to that in the established trend.

If the same facies is in two tight wells, X and Y, only one facies trend extension is established (1B). Only one direction of the shoal facies is indicated. A guess as to the distance of the more permeable facies must

---

1/ The facies referred to is that labeled backshoal and colored yellow on the Enclosures. For the purposes of emphasis, simplicity, and elimination of burdensome repetition of rock type terminology (from Dunham, 1962) that may not yet be familiar to all, the discussion and Enclosures are restricted to the three productive facies, which are termed foreshoal, shoal, and backshoal. Therefore, sediment deposited in the landward marginal parts of the area of shoaling is herein referred to as the backshoal facies.

be based upon the size of oolite lenses characteristic of an area. Since there is generally a significant range in size of oolite lenses within an area, the extended facies distribution shown by Case 1B may be overly optimistic. Examples 1A and 1B are hypothetical as regards the area shown, but are known to exist in other parts of southwestern Kansas within the St. Louis formation.

Example 1C is based on the porous development of the St. Louis "C" zone in wells X and Y and the tight development in a cored well Z. The C zone tested considerable water with good oil shows in the two porous cases, X and Y, and is tight in the cored well Z. Sample examination may not be necessary in wells X and Y. Since porosity and permeability have been well established by testing, it can be assumed therefore that the optimum facies has been located and its limits more nearly established by well Z.

ESTABLISHMENT OF TRENDS IN AREAS OF SPARSE CONTROL

Initially, only the rough orders of magnitude of productive oolite lenses in an area are known. Rock types in five tight wells, A, B, C, D and E, are determined by thin section study. The map shown as Example 2, Enclosure 3, has been prepared with the rock type distribution plotted and the anticipated area of the most permeable facies outlined. This example is hypothetical, but insofar as testing has progressed, it is substantiated by some areas of the St. Louis formation of southwestern Kansas.

DIRECTION TO MOVE FROM A SINGLE WELL

If the direction of transgression or regression of the sea during an increment of geologic time in an area is known, the direction of a more permeable facies from a tight facies may be predicted. The needed information may be obtained by comparing the rock type correlative with and adjacent laterally to the productive oolite facies with the rock type either immediately above or immediately below the oolite (Enclosure 2, lower right). During transgression, a facies seaward from a shoal deposit of ooids would be shifted landward and be deposited above the oolitic deposit. During regression a reverse disposition of the seaward facies in vertical profile would develop. The facies landward from the shoal would be developed below and above the oolitic deposit during transgression and regression, respectively.

Enclosure 2 shows that for the Pleasant Prairie Field area, and the area four miles north, transgression caused the cessation of ooid formation and proceeded toward the east-northeast. Whether this condition of transgression prevailed throughout southwestern Kansas during deposition of the St. Louis "C" and "B" zones has not been completely tested. However, study thus far indicates that post-"C" zone and post-"B" zone transgressions did proceed toward the east-northeast as regards the larger areas of ooid deposition in the eastern half of the project study area. Examples 3A and 3B, Enclosure 3, are hypothetical and show how direction of the optimum facies is predicted from knowledge of the rock type developed in a single well and knowledge of transgression (or regression) direction.

LIMITATIONS

Limitations upon use of the mapping technique described above are enumerated below.

1. Density of control and quality of samples must be sufficient to establish detailed correlations.

2. Foreshoal and backshoal facies merge near the axial termini of oolite shoals. Consequently, if a single well penetrates a tight facies near the axial terminus of a shoal, better permeability will not be encountered in either direction.

3. This mapping technique is applicable only to cases where sites of ooid formation correspond essentially to sites of oolite preservation, for example, shoal areas of ooid deposition. Reworked (transported away from depositional site) oolitic deposits may indeed be systematically developed, but more mixing of sediment types and less sharp facies limits will result. Therefore, transported oolite will ~~not only be harder~~ to delimit but also be generally poorer reservoirs than shoal oolites.

4. Only in cases where the type of porosity explored for is exclusively, or in larger part, primary intergranular will this technique be generally successful. Where some types of secondary porosity, for example, oolicastic or preferential leaching of particular skeletal grain types, are targets, a lesser measure of success may be expected.

5. The mapping technique described above is not good for finding smaller shoal oolites. If opposite directions of the shoal facies are indicated by facies analysis of two wells six miles apart, these wells could be on opposite sides of two small shoal areas rather than one larger shoal area.

6. If the only control is within the distant foreshoal (skeletal lime wackestone to mudstone) and the distant backshoal (quartzose pelletal lime packstone) facies (Enclosure 1), there may not be an intermediate shoal facies developed.

SUMMARY OF PROCEDURE

The procedure is summarized in numerical sequence below. It is presupposed that marine oolite is an important reservoir target in the area being studied.

1. Establish electric log correlations.

2. Establish rock sequence and check correlations by study of available cores, core chips, and cuttings.

3. Have thin sections made to determine if facies are systematically distributed.

4. Make grain counts to establish critical facies parameters.

5. Study available core analyses and establish that there is facies control of effective porosity. If such analyses are not available, production history of wells producing from the various facies should give a strong indication.

6. Map facies and extend established trends into areas of sparse control.

7. Establish trends in areas of sparse control.

8. Use the rock sequence developed in two wells in which different facies exist to determine the direction of transgression or regression in an area.

9. If Step 8 is successful, an indication of which direction to move from a single well to improve chance of effective porosity is obtained.

Yours very truly,

S. M. Ball

SMB:mls

SELECTED REFERENCES

Carozzi, Albert V., 1960, Microscopic Sedimentary Petrography, John Wiley and Sons, Inc., 485 pp.

Dunham, Robert J., 1962, Classification of Carbonate Rocks According to Depositional Texture, in Classification of Carbonate Rocks, A.A.P.G. Mem. 1, William E. Ham, Ed., pp. 108-121.

Irwin, M. L., 1965, General Theory of Epeiric Clear Water Sedimentation, Bull. A.A.P.G., Vol. 49, No. 4, pp. 445-459.

Newell, Norman D., Purdy, Edward G., and Imbrie, John, 1960, Bahamian Oolitic Sand, Jour. Geol., Vol. 68, No. 5, pp. 481-497.

Purdy, Edward G., 1963, Recent Calcium Carbonate Facies of the Great Bahama Bank. 1. Petrography and Reaction Groups. 2. Sedimentary Facies, Jour. Geol., Vol. 71, Nos. 3 and 4, pp. 334-355 and pp. 472-497.

Visher, G. S., 1965, Use of Vertical Profile in Environmental Reconstruction, Bull. A.A.P.G., Vol. 49, No. 1, pp. 41-61.

Kansas Geological Survey

Open-File Report:

AMOCO-41

"Prediction of Effective Porosity in Some Marine Oolite Deposits", by Stanton M. Ball, Amoco Production Company, Liberal District Exploration Report No. 41, January 18, 1966.

This report has been retyped and reproduced by the Kansas Geological Survey.

not the original copy.