

SEQUENCE STRATIGRAPHY OF THE CARBONIFEROUS LISBURNE GROUP CARBONATES, NORTHEASTERN BROOKS RANGE, NORTHERN ALASKA

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The Carboniferous Lisburne Group carbonates, specifically the proximal upper Lisburne, is an important oil-producing reservoir at Prudhoe Bay. We have found that distal lower Lisburne reservoir facies are in coral boundstone and storm-generated coarse-grained bioclastic units. This differs from the proximal upper Lisburne reservoir influenced by subaerial exposure and later unconformity related diagenesis. A sequence stratigraphic interpretation is necessary to define successful exploration strategies for the distal Lisburne Group.

We have identified four sequences and corresponding systems tracts within the Lisburne Group based on bounding surfaces, parasequence and parasequence set stacking patterns, and lateral lithofacies relationships. The spatial distribution of the sequences documents northward onlap during TST deposition of sequences 1 through 4. The Pre-Permian Unconformity truncates sequence 4 to the north and sequences 3 and 4 to the south. Sequence 1 distal systems tracts are thick and are interpreted to have been deposited during a long-term increase in accommodation space. Proximal systems tracts, with the exception of sequence 1, have a progradational geometry that thins towards the south.

A change in parasequence stacking patterns is observed between the Mississippian and Pennsylvanian Lisburne Group. We interpret the differences between sequences 2 and 3 to be related to changes in paleoclimate. Relatively thick parasequences and non-cyclic intervals record minor migration of facies in sequences 1 and 2 and are interpreted to have been deposited during a greenhouse climate. Parasequences in sequences 3 and 4 are thin, juxtapose deep over shallow water facies and are interpreted to have been deposited during an icehouse climate.

- McGee, M. M. and Whalen, M. T., Sequence Stratigraphy of the Carboniferous Lisburne Group Carbonates, Northeastern Brooks Range, Northern Alaska, American Association of Petroleum Geologists Annual Meeting, May 2003, Salt Lake City, Utah, v. 12, p. A-116

FACIES STACKING AND RESERVOIR POTENTIAL OF GREENHOUSE TO ICEHOUSE CARBONATES: CARBONIFEROUS LISBURNE GROUP, NORTHERN ALASKA

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The Carboniferous Lisburne Group, northern Alaska, represents a laterally extensive carbonate ramp deposited on a passive continental margin. The Lisburne Group is subdivided into the Mississippian Wachsmuth and Alapah Limestones and Mississippian to Pennsylvanian Wahoo Limestone. We observed a dichotomy in cycle stacking pattern that cuts across traditional lithostratigraphic boundaries. In relatively distal settings the lower Lisburne (Wachsmuth and most of the Alapah Formation) consists of relatively thick cycles or parasequences and non-cyclic intervals deposited during a long accommodation increase. The upper Lisburne (uppermost Alapah and Wahoo Formation) consists of thinner parasequences deposited during a long decrease in accommodation. The parasequences thicknesses and facies stacking patterns indicate variations in accommodation generation that we interpret to be influenced by a change from greenhouse to icehouse conditions. The relatively thick lower Lisburne, greenhouse cycles record minor migration of facies belts and were probably deposited under low-amplitude/high frequency sea level fluctuations. The thinner upper Lisburne, icehouse cycles juxtapose deep over shallow water facies. Considerable facies migration was likely controlled by high amplitude/high frequency glacioeustatic sea level fluctuations. Current production from proximal upper Lisburne reservoirs at Prudhoe Bay is influenced by successive episodes of intraformational subaerial exposure and associated diagenesis and later unconformity-related diagenesis. We have identified two possible reservoir facies in more distal lower Lisburne deposits that include laterally and vertically extensive coral boundstones and thick coarse-grained bioclastic shoal facies. The thicker cycles and deeper depositional setting decreases the likelihood of subaerial exposure-related diagenesis, but reservoir potential is locally diminished by calcite cement or silica porosity occlusion. Different exploration strategies will be necessary to predict reservoir potential in more distal lower Lisburne, greenhouse reservoir facies than for more proximal upper Lisburne, icehouse reservoirs.

- McGee, M. M. and Whalen, M. T., 2002, Facies Stacking and Reservoir Potential of Greenhouse and Icehouse Carbonates: Carboniferous Lisburne Group, Northern Alaska (abs.), American Association of Petroleum Geologists Annual Meeting, Houston, March 2002, v. 11, p. A117 (poster).

STRATIGRAPHY OF THE CARBONIFEROUS LISBURNE GROUP, PORCUPINE LAKE VALLEY, BROOKS RANGE, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

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The Lisburne Group, northern Alaska, is a thick sequence of Carboniferous carbonate rocks deposited as a laterally extensive, south-ward dipping carbonate ramp on a passive continental margin. The relatively distal Lisburne in the Porcupine Lake Valley is approximately 700 meters thick and can be subdivided into the Mississippian Wachsmuth and Alapah (informally lower, middle, and upper) Limestones based on lithofacies and weathering patterns. The 200 m thick Wachsmuth changes laterally from resistant meter thick shale-coral facies in the northern part of the field area to resistant dark (cherty) and light (limestone) banded wackestones with a few crinoid grainstone packages to the south. The 200 m thick, lighter colored, resistant lower Alapah in the north contains ½ m thick cycles that coarsen-upward from shales to crinoid grainstones and then becomes non-cyclic. Cycles to the south are significantly finer-grained and chertier. The recessive, darker colored middle Alapah is about 100 m thick. Cycles in the north are 0.25 m thick, recessive, and coarsen-upward from a shaley base through crinoid wackestone, packstone, and rarely grainstone or rudstone. Cycles to the south are less recessive, thicker, and coarser-grained. In the 260 m thick upper Alapah, the lightest and most resistant unit, cycles coarsen upward and are a few meters to tens of meters thick. The upper Alapah was not described in the northern part of the field area. Overall, the Lisburne Group records initiation of deep-water carbonate ramp sedimentation atop the underlying Kayak Shale. Facies stacking patterns indicate progressive northward onlap of the basal Lisburne and two major episodes of transgression and regression indicating significant relative changes in sea-level.

- McGee, M. M. and Whalen, M. T., 2002, Stratigraphy of the Carboniferous Lisburne Group, Porcupine Lake Valley, Brooks Range, Arctic National Wildlife Refuge, Alaska (abs.), American Association of Petroleum Geologists Pacific Section meeting, Anchorage, AK, May 2002, p. 91 (poster).

SEQUENCE STRATIGRAPHY OF THE CARBONIFEROUS LISBURNE GROUP CARBONATES, NORTHEASTERN BROOKS RANGE, NORTHERN ALASKA

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The Carboniferous Lisburne Group carbonates, specifically the proximal upper Lisburne, is an important oil-producing reservoir at Prudhoe Bay. We have found that distal lower Lisburne reservoir facies are in coral boundstone, dolomitic, and coarse-grained bioclastic units. This differs from the proximal upper Lisburne reservoir influenced by subaerial exposure and later unconformity related diagenesis. A sequence stratigraphic interpretation is necessary to define successful exploration strategies for the distal Lisburne Group.

We have identified several sequences and corresponding systems tracts within the Lisburne Group based on bounding surfaces, parasequence and parasequence set stacking patterns, and lateral lithofacies relationships. The spatial distribution of the sequences documents overall northward onlap during the deposition of the Lisburne Group. The Pre-Permian Unconformity truncates the top sequence to the north and at least two sequences to the south. The lowermost sequence to the south has thick distal systems tracts that are interpreted to have been deposited during a long-term increase in accommodation space. Proximal systems tracts in the north, with the exception of the lowermost sequence, have a progradational geometry that thins towards the south.

A change in parasequence stacking patterns is observed between the Mississippian and Pennsylvanian Lisburne Group. We interpret the differences between sequences to be related to changes in paleoclimate. Relatively thick parasequences and non-cyclic intervals record minor migration of facies in the Mississippian sequences and are interpreted to have been deposited during a greenhouse climate. Parasequences in the Pennsylvanian sequences are thin, juxtapose deep over shallow water facies and are interpreted to have been deposited during an icehouse climate.

- McGee, M. M. and Whalen, M. T., 2003, Sequence stratigraphy of the Carboniferous Lisburne Group carbonates, northeastern Brooks Range, northern Alaska, Alaska Geological Society Technical Meeting Abstracts, April 2003, Fairbanks, AK (poster)

STRATIGRAPHY OF THE CARBONIFEROUS LISBURNE GROUP, PHILIP SMITH MOUNTAINS, ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA

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The Lisburne Group is a thick sequence of Carboniferous carbonate rocks in northern Alaska. It was deposited on a passive continental margin as a laterally extensive, south-ward dipping carbonate ramp that thickens to the south and depositionally onlaps older rocks to the north. In autochthonous and parautochthonous areas (northernmost Brooks Range and North Slope subsurface) the Lisburne is subdivided into the Alapah and Wahoo Limestones. In allochthons to the south these units are underlain by the older Wachsmuth Limestone. The Wahoo is a producing reservoir rock at Prudhoe Bay and its stratigraphy has been documented in some detail. The Wachsmuth and Alapah have received much less attention and their stratigraphy is poorly understood.

During summer 2000 six partial Lisburne Group stratigraphic sections were described in the Philip Smith Mountains to document the stratigraphic architecture in this relatively unstudied area. Here the lower Lisburne is approximately 700 meters thick and is overlain by a thin veneer of Wahoo. The lower Lisburne can be subdivided into three informal units based on their weathering profile.

The lowermost 350 meters overlies the Kayak Shale, is relatively resistant, and displays dark (cherty limestone) and light banding (limestone) similar to that described in the Wachsmuth Limestone. The unit consists of several thick packages of nodular or bedded chert and crinoid-bryozoan wackestone with large subhorizontal, silicified burrows. These facies are overlain by meter-thick crinoid rudstones with reworked coral fragments. The cherty wackestones are interpreted to have been deposited below fairweather wave base in a deep ramp environment. Crinoid rudstones are interpreted as shoals. Conodonts recovered near the top of the interval indicate a Meramecian age.

The middle interval is 200 meters thick, cyclic, has a recessive weathering profile, and is darker colored than the lower unit. Cycles begin with greenish, calcareous shale that coarsens upward to crinoid-bryozoan-coral grainstone to rudstone and coral framestone. Basal shales drape over coral heads that form the top of subjacent cycles. Progressively coarsening upward cycles indicate a progradational facies stacking pattern. Calcite replaced evaporites observed at the Middle-Upper Alapah contact and the cycle stacking pattern are interpreted to indicate shallowing upward from deep ramp to shallow subtidal environments.

The upper 150 m thick package is relatively resistant, light in color, cyclic, and grainer than the middle interval. Cycles are a few meters to tens of

meters thick. They coarsen upward from crinoid-bryozoan wackestone to crinoid-bryozoan packstone to grainstone. The cycles become muddier and bryozoan and chert abundance increases upward. The stratal stacking pattern and fauna indicate a change from open to restricted lagoonal environments on a shallow ramp and conodonts indicate a Chesterian age.

The Lisburne Group in the Philip Smith Mountains records initiation of deep-water carbonate ramp sedimentation atop the underlying Kayak Shale. Two major episodes of transgression and shallowing upward indicate significant relative changes in sea-level. Meramecian conodonts and lithofacies similar to the Wachsmuth Limestone in the lower interval imply that these rocks are allochthonous and are most likely part of the Endicott Mountains allochthon. The upper two intervals appear to correlate with the Alapah Limestone to the north.

- McGee, M. M., Whalen, M. T., and Krumhardt, A. P., 2001, Stratigraphy of the Carboniferous Lisburne Group, Philip Smith Mountains, Arctic National Wildlife Refuge, Alaska (abs.), Alaska Geological Society Technical Meeting Abstracts, April 2001, Fairbanks, AK (poster).