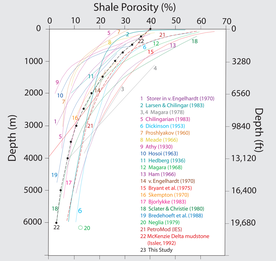
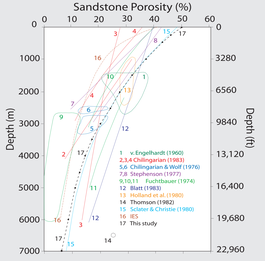
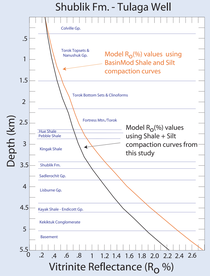
Compaction Curves from the Literature

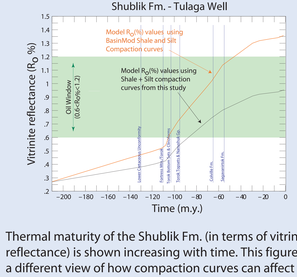




Summary plots showing the wide range of compaction curves in the literature (modified from Poelchau et al., 1997). The black dashed lines show the compaction curves defined in this study for sand (#17) and for shale (#23). The closest published analog to our shale curve is from a study of McKenzie Delta mudstones (shale #22, Issler, 1992). These mudstones compact along a trend very similar to that of the North Slope shale until about 10,000 ft. Below that depth the curves diverge to a maximum porosity difference of 7.5%.

Effect of Compaction Curves on Thermal Maturity Calculations



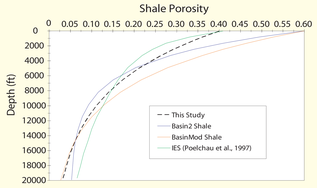


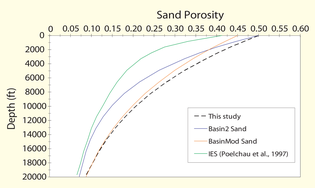
Different compaction curves can result in significant differences in calculated thermal maturities. Vitrinite reflectance is calculated here for the Tulaga well using 1) the compaction curves defined in this study (in black) and 2) default shale compaction curve in BasinMod, chosen to illustrate the effects of a significantly different curve. Sandstone curves are the same in both cases. The calculations were made with Basin2.

Thermal maturity of the Shublik Fm. (in terms of vitrinite reflectance) is shown increasing with time. This figure provides a different view of how compaction curves can affect model calculations of thermal history and timing of source rock maturation.

In this example, use of this study's shale and siltstone compaction curves leads to the prediction (in black) that the Shublik Fm. would enter the oil window at about 87 m.y., during deposition of the Colville Gp. The same calculation (in orange) made using BasinMod default compaction curves predicts that Shublik would enter the oil window (Ro > 0.6%) at about 105 m.y., during deposition of the Torok Fm.

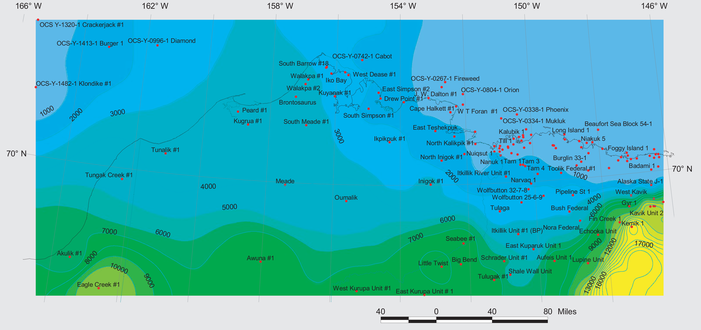
Comparison of Model Compaction Curves





Comparison of default sand and shale compaction curves from several basin modeling packages with the sand and shale curves defined in this study.

Estimated Erosion -- North Slope, Alaska



Erosion Since the End of Brookian Deposition

Alaska state boundary
NPRA boundary
Wells Used for Erosion Estimate

Erosion (ft)
0 - 1000
1000 - 2000
2000 - 3000
3000 - 4000
4000 - 5000
5000 - 6000
6000 - 7000
7000 - 8000
8000 - 9000
9000 - 10000
10000 - 11000
11000 - 12000
12000 - 13000
13000 - 14000
14000 - 15000
15000 - 16000
16000 +
No Data

Map showing erosion since the end of Brookian sedimentation. The map was created by W.M. Burns from erosion estimates made for each well shown, using compaction curves defined for sand, silt, and shale. These erosion estimates are incorporated into burial and thermal history modeling.

Limitations

The compaction curves defined here are based on sonic-porosities for the Cretaceous and Tertiary Brookian section. The curves do reasonably well (errors generally < 5%) at predicting porosities in Brookian rocks through the Upper Cretaceous Colville Group and its equivalents. However, in certain wells in the Nanushuk and Torok Fms. (mid-Cretaceous), and in the Canning Fm. (Upper Cretaceous-Tertiary), distinct intervals of typically 1000-1500 ft show sonic-derived porosities uniformly 2-5% lower than the porosities predicted from our curves.

The discrepancies may be due to differences in lithology and/or diagenetic history. A volcanic component in the Upper Cretaceous and Tertiary sediments, including bentonites and potassium-rich clays, may alter their compaction properties relative to the older, volcanic-poor sands and shales. In addition, several mid-Brookian unconformities have been noted in seismic sections, but are not widely documented across the North Slope. Geographically, we have found it difficult to predict which wells will show the offset in porosity. Work is ongoing to better define the wells that are affected and the reason for the discrepancy.

Summary

Compaction curves specific to a study area can improve the accuracy of basin models when adequate sonic and gamma ray logs are available to define them. The curves determined for the North Slope have allowed geologically reasonable erosion estimates for individual wells and a regional erosion map that is consistent with present day topography, i.e., greatest erosion in the Brooks Range, decreasing northward toward the coastline. The compaction-derived erosion estimates are generally more modest than estimates made using vitrinite reflectance. We believe they may be more reliable because the well log data are more continuous and internally consistent than the vitrinite data, and because the 'recycling' of dispersed vitrinite is thought to be significant on the North Slope. Finally, the compaction curves defined here improve the accuracy of our model calculations of thermal history and timing of maturation of each of the source rocks.

Selected References

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Hearst, J. R., Nelson, Philip H., and Paillet, Frederick L., 2000, Well Logging for Physical Properties, A Handbook for Geophysicists, Geologists, and Engineers, Second Edition: New York, John Wiley & Sons Ltd, 483 p.

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