How to Log Core (With Examples from the Williston Basin of Southeast Saskatchewan)

D.M.Kent (D.M.Kent Geological Consulting Ltd., Regina, Sask.), and J.H.Lake, (Lake Geological Services Inc, Swift Current, Sask).

In the past couple of decades, geologists have become increasingly inclined to depend on geophysical well logs for their subsurface information, consequently core examination techniques are becoming a lost art. In fact, many geologists become uncomfortable when confronted with the possibility of having to look at cores, and core studies are being assigned more and more to a rapidly diminishing group of core-orientated consulting geologists.

This presentation is intended to demonstrate the importance of the information obtained from cores as well as outlining a systematic procedure to follow in core examination. Some of the points made will be specific to carbonate rocks, but others are more general. Core examination can be systematically divided into three phases, preparation, description and interpretation. An important aspect of preparation is becoming familiar with the pitfalls of core layout, for example misplaced cored intervals or improper order of core box layout. In the matter of description, emphasis will be on getting the most important information from cores in order to make acceptable interpretations of facies, facies controls on reservoir characteristics and diagenesis. Software such as the StraTerra's LogManager (www.straterrainc.com) greatly simplifies core logging. To make acceptable interpretations of the information from carbonate cores the examiner should have a working understanding of the origins of carbonate rock components. These will be discussed and demonstrated through the cores laid out for this presentation. Three dimensional facies relationships determined from core studies can resolve lithostratigraphic problems created using merely geophysical log correlations.

Lithostratigraphy (the concept of correlating similar lithologies or "log tops") is now obsolete. The major shortfall of Lithostratigraphy is that we cross time lines in correlation. Most stratigraphic traps involve a shoreline or barrier to stop the migration of hydrocarbons. Seismic appears to reflect off identical facies rather than time.

Using a simple modeling technique involving Walther's Law, we can arrive at a first approximation of facies relationships in three dimensions. Walther's Law states that facies are stacked vertically in the same manner that they are arranged laterally. If we "dissect" the vertical succession in the core boxes, we can predict what is occurring laterally. Computer modeling makes this idea of facies modeling easier to accomplish because of the cross-section and fence diagram capabilities for the third dimension. We must correlate the section to see the changes in facies in multiple well studies. The correlations must be accomplished during the description of each core rather than trying to correlate afterwards. The Red River core shows marine regression with salina evaporate overstepping the inner barrier facies. Moving the successive packages in a basinward direction explains the vertical stratigraphy that we see in one dimension (core). The salinas become progressively more Mg-rich with precipitation of anhydrite. The regression liberates these fluids to dolomitize everything in their way (inner barrier and very restricted lagoon). The volume of Mg-rich fluid is related to the volume of the salina. Papers by Harvey, Kent and Qing (2004) and Jones and Xiao, (2005) further detail how this mechanism works (not to be confused with reflux dolomitization, since the fluids only dolomitize their contemporaneously stratigraphic equivalents.

The Midale Beds core shows shoaling cycles in which wave energy on the shelf has winnowed the fines to create a calcareous algal grainstone with excellent reservoir properties. This shoaling reservoir should be exploited using horizontal wells along the linear shoal features.

The three examples of facies modelling based on cores from the Ordovician Red River (1-33-14-12W2M Chapleau Lake), Mississippian Midale Beds (7-7-7-11W2M Weyburn).of southeast Saskatchewan as well as two cores from the South Heward Pool. Despite their age difference, the first two cores show similar responses to sea level in terms of facies relationships. Both are created in response to marine regressions in which the Williston Basin was shrinking with time.

The key concepts include the extremely shallow nature of the carbonate platform and development of multiple barriers (Lake, 2007) (hence the tendency to exposure of inner and outer barrier and resulting tendency to karsting of these features during sea level drops). James and Bourque (1992) outline the principal bioligical components of the outer barrier/reef environment through time. The end of Devonian mass extinction of colonial corals makes it difficult to recognize the outer barrier during Mississippian sedimentation.

It is critical to realize that the individual facies in the sedimentary record do not span the entire basin, but were deposited contemporaneously with all the other facies present. You will have great difficulty in discovering new strat traps if you ignore this concept. High resolution satellite imagery of the modern Exuma Platform (Harris, 2010) shows that water depth is critical for winnowing and wave movement of sediment as well as facies distribution of the shoaling events. There must be a critical depth for wave activity to winnow the shoals which cross the platform. An ancient example of shoaling is observed in the 7-7-7-11W2M Midale core. The core contains both in situ calcareous algae facies wackestone non-reservoir which grades to algal grainstone reservoir. Mapping the trend of the shoaling features makes it easier to horizontally exploit the hydrocarbon potential of this high perm rock. The rock record indicates that oolites, calcareous algae and crinoids were all capable of winnowing and transport as shoal facies.

References

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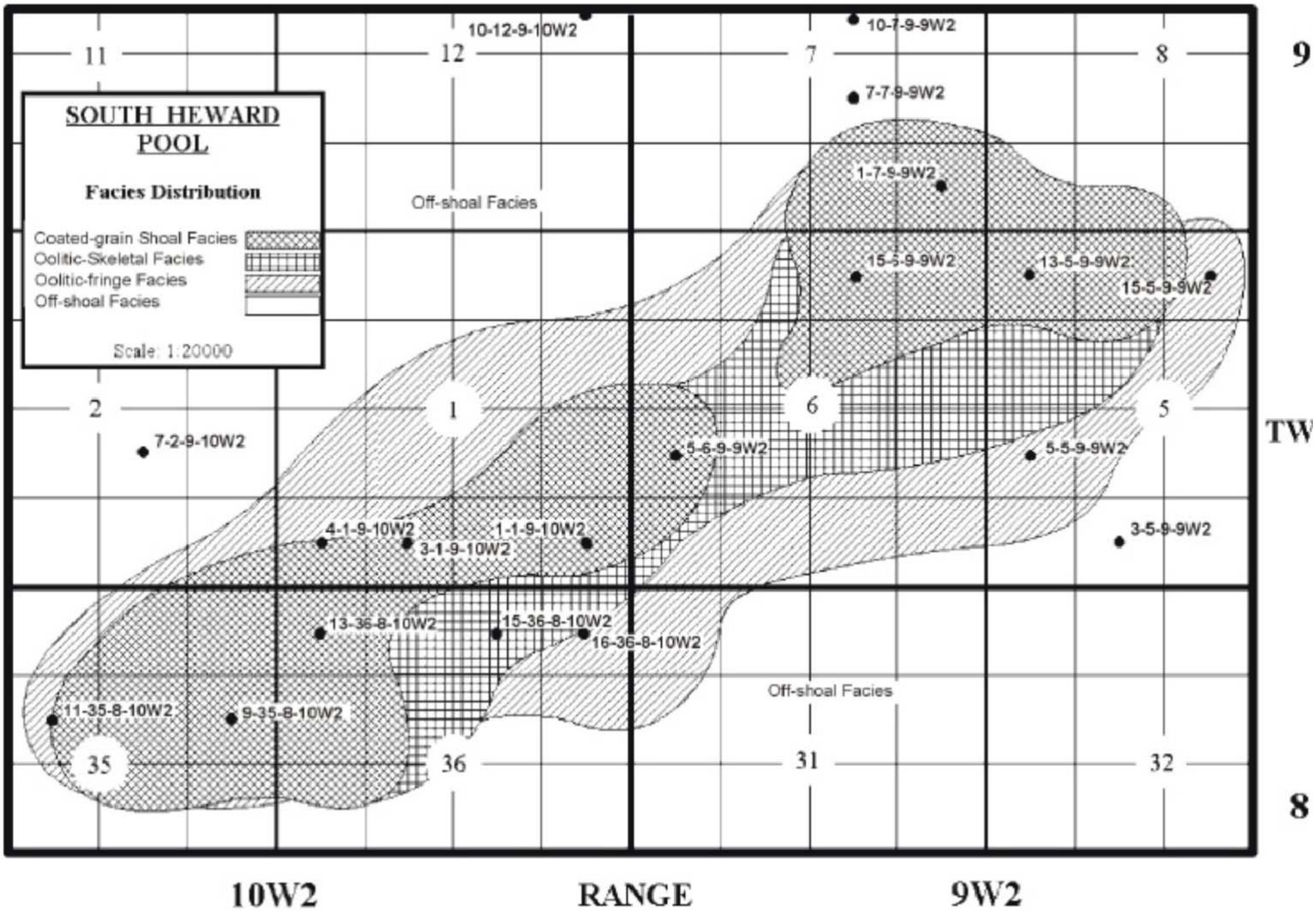


Figure 4 - Map showing facies distribution in the lower Frobisher Beds of the South Heward Pool.

Facies Map of lower Frobisher Beds of South Heward Pool (Kent and Curry, 2002).

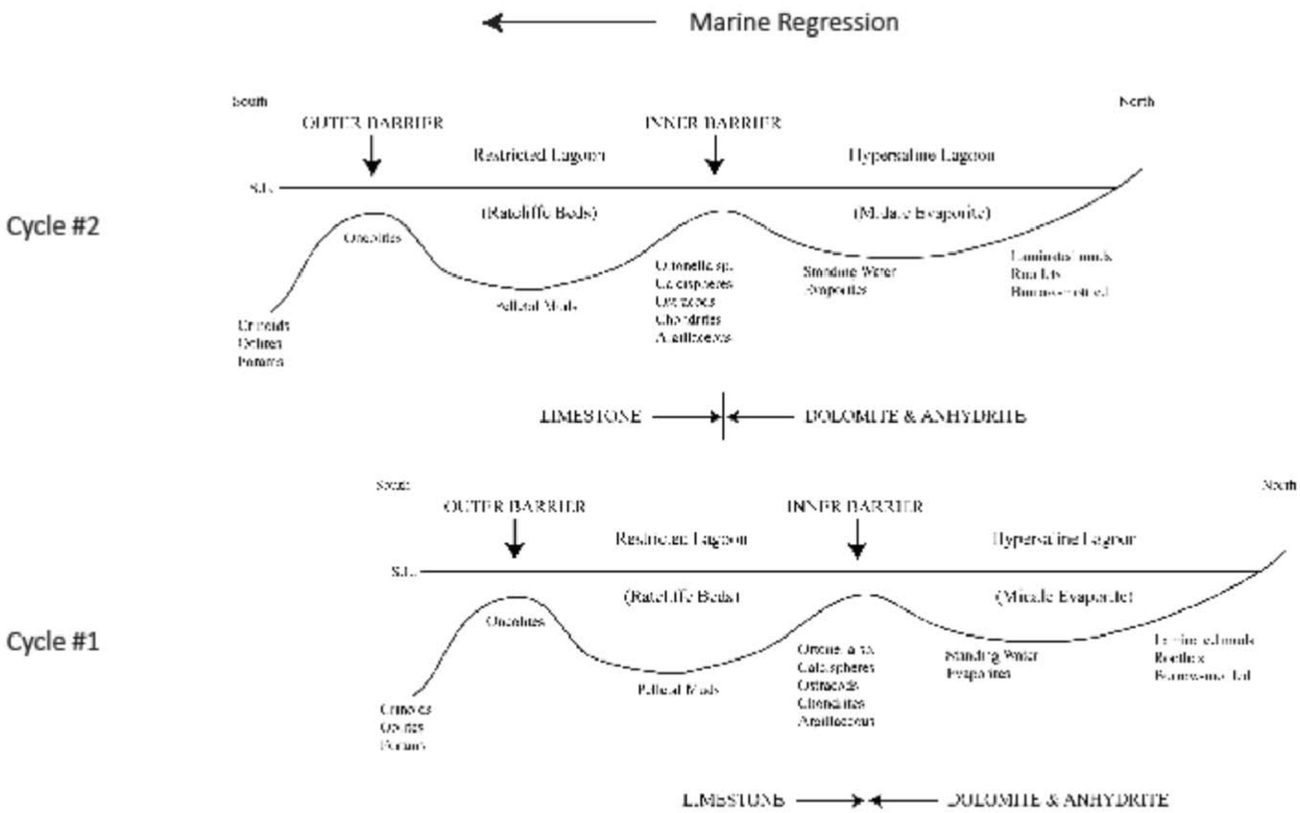
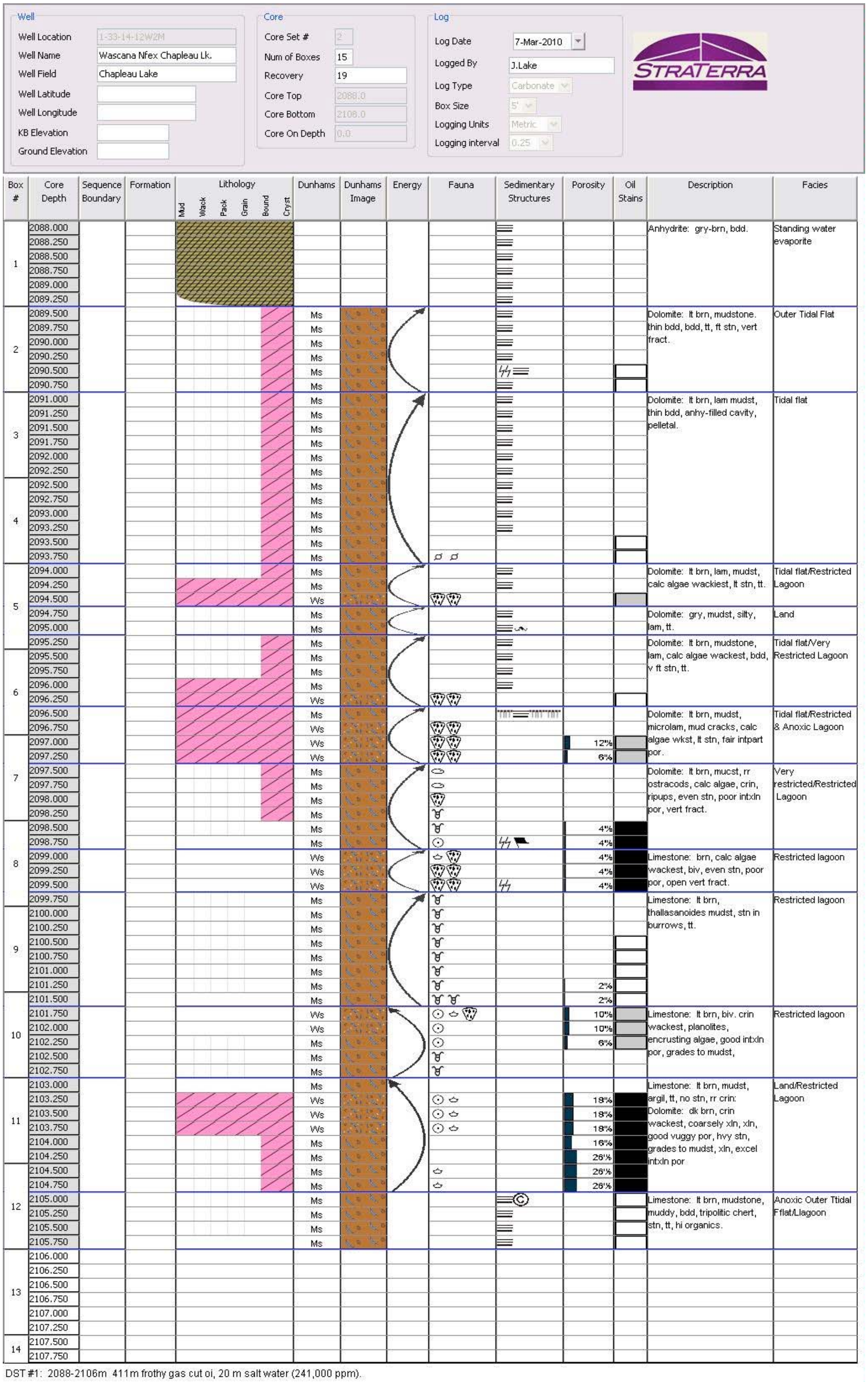


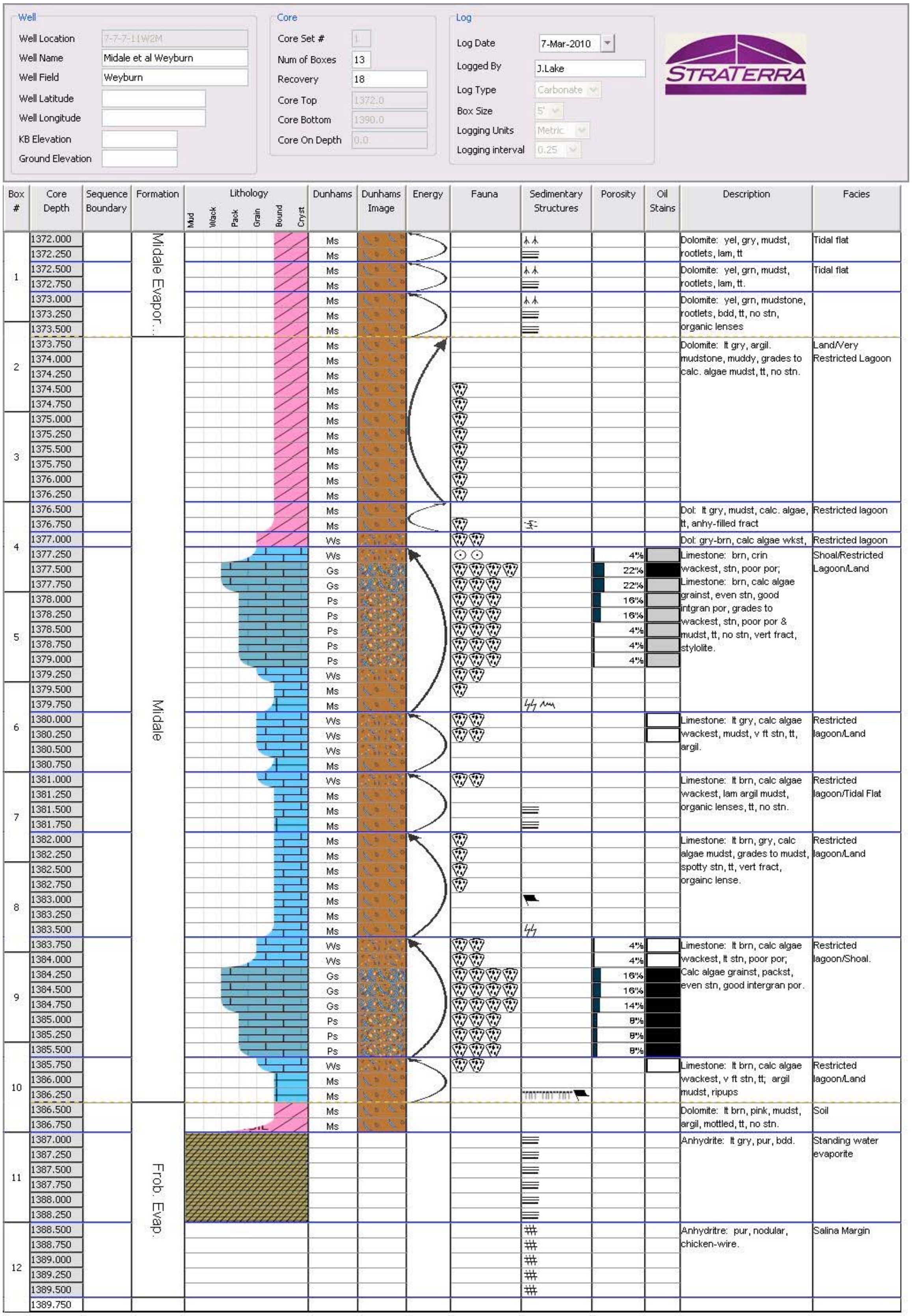
Diagram to illustrate the relationship of facies changes in a vertical sense in a marine regression. "Dissecting" the vertical succession in any core will give you the lateral facies picture. Note how easy it is to make the mistake of joining similar lithologies (lithostratigraphy).

Modified after Lake, 2007.



Logged with the StraTerra LogManager (www.straterrainc.com).

Core Description and photos for the 1-33-14-12W2M Chapleau Lake (Red River Formation). The sequence represents a marine regression which can be "dissected" to apply Walther's Law and interpret facies in a two dimensional model.



Good porosity and stain in calcareous algae grainstone at 1377.8m & 1384.4m

Logged with the StraTerra LogManager (www.straterrainc.com).

Core Description and Photos of the 7-7-7-11W2M Midale (Midale Beds) showing shoaling calcareous algae facies (heavily oil-stained) immediately above the Frobisher Evaporite. The Midale Beds represent a marine regressive sequence.