

Carboniferous Stoddart Group: An Integrated Approach*

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Abstract

The Carboniferous Stoddart Group is recognized as a complex stratigraphic unit within the Western Canadian Sedimentary Basin (WCSB) with high exploration risk. While syn-depositional tectonics controlled primary depositional thickness and facies distribution, post-depositional uplift and erosion significantly influenced unit preservation and interrupted facies belt continuity. Reservoir facies predictability is further reduced due to pervasive cementation, namely early anhydrite cement that was precipitated during transgressive events. The cement dissolved preferentially proximal to the hanging wall side of tilted fault blocks during post-burial uplift. Integration of tectono-stratigraphic, sequence stratigraphic, sedimentologic and diagenetic analyses is a key to understanding this complex deposit.

Introduction

The Stoddart Group was deposited under an active extensional setting within the Peace River Embayment in Alberta and northeastern British Columbia. Detailed analysis of relative mode (i.e. vertical or rotational), rate and timing of fault block movements is critical to understand basin evolution, sedimentation and stratigraphic architecture of this complex unit. Identification of Maximum Flooding Intervals (MFI) (Galloway, 1989 a and b) allowed delineation of discrete basin evolution and tectono-stratigraphic stages that conform to contemporaneous tectono-stratigraphic events elsewhere along the western margin of North America.

Initiation of the proto-rift stage led to deposition of Golata Formation marine mudstone and was followed by a proto-rift unconformity characterized by uplift and pedogenesis. Syn-rift stage sedimentation was dominated by progradational Kiskatinaw Formation siliciclastics. Post-rift stage carbonate-dominated Taylor Flat Formation deposition terminated distally due to high subsidence accompanied by counter clock-wise (i.e. towards basin axis) fault block rotation and proximal (basin margin) erosion (see Nøttvedt et al., 1995). The post-rift

unconformity, a basin-wide major angular unconformity, partially or completely removed Stoddart Group deposits from uplifted basin margin areas resulting in stratigraphic and facies belt discontinuities.

Four Transgressive-Regressive (T-R) sequences (Frostick and Steel, 1993; Folkestad and Satur, 2008; Martins-Neto and Catuneanu, 2010) are linked to discrete tectonic stages and can be identified using five identifiable MFIs. Major progradations, punctuated by MFIs, were triggered by major tectonic readjustments (fault block uplift and rotation) along basin margin areas that experienced waning storage and accommodation. Identification of these T-R sequences (Frostick and Steel, 1993; Folkestad and Satur, 2008) can enhance facies predictability.

Facies associations interpreted within a stratigraphic context can help predict primary reservoir facies within the Kiskatinaw Formation. Although early anhydrite cementation commonly destroyed primary reservoir quality, preferential dissolution from structurally preferred locations (Yousuf and Henderson, 2006) appears to have created good secondary reservoir properties. Integration of tectono-stratigraphy, sequence stratigraphy, sedimentology and diagenesis is a key to understanding the complex Stoddart Group deposits and lowering the exploration risk.

Method

This study focuses within the eastern part of the Stoddart Group depositional basin, including the basin margin area within Alberta ([Figure 1](#)). Data included sedimentary core samples, palynologic samples, petrographic thin sections, over 740 digital wireline logs and three Lithoprobe seismic profiles.

Sedimentologic core analysis, palynology, core-calibrated (where available) wireline log cross sections ([Figure 2](#) and [Figure 3](#)), mapping and simple gamma log 3D model slices assisted sedimentologic, tectono-stratigraphic and sequence stratigraphic analysis. Sequence stratigraphic analysis followed Galloway (1989 a and b) model. A modified Wheeler Diagram ([Figure 4](#)) was also constructed. Petrographic thin section analysis was conducted to construct a diagenetic model ([Figure 5](#)).

Conclusions

Integrated detailed analyses of the stratigraphic architecture and depositional history in relation to tectono-stratigraphic evolution of the Stoddart depositional basin can significantly contribute towards our understanding of the carboniferous Stoddart Group and similar deposits elsewhere along the western margin of the North America. The Galloway sequence stratigraphic approach provided a better analysis tool over the commonly used Exxonian model. This is due to paucity of well-developed sub-aerial unconformity and abundance of flooding surfaces.

Analysis of relative mode, rate and timing of fault block movements is critical to understand stratigraphic complexities and facies belt discontinuities. Integration of tectono-stratigraphic, sequence stratigraphic, sedimentologic and diagenetic analyses is a key to understanding resource potential within the complex Stoddart Group deposit.

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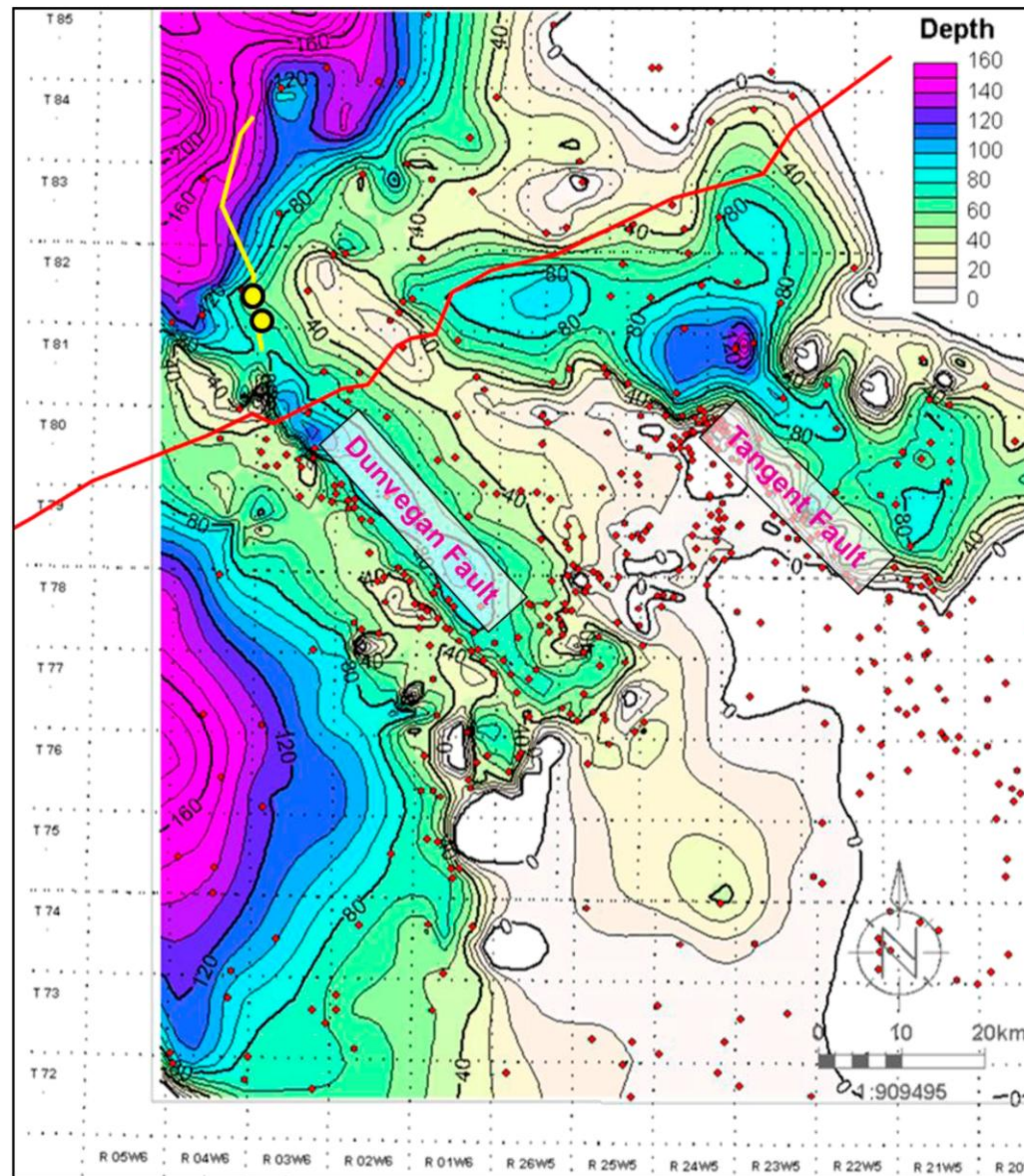


Figure 1. Map shows overall study area, Stoddart Group isochore (10 m contour interval) and [Figure 2](#) (red solid line) and [Figure 3](#) (yellow solid line) cross section locations. [Figure 2](#) cross section continues further southwest beyond the mapped area. Approximate core locations marked by yellow dots. Note absence of Stoddart Group deposit within eastern basin margin area. Note also major fault (Dunvegan and Tangent) locations.

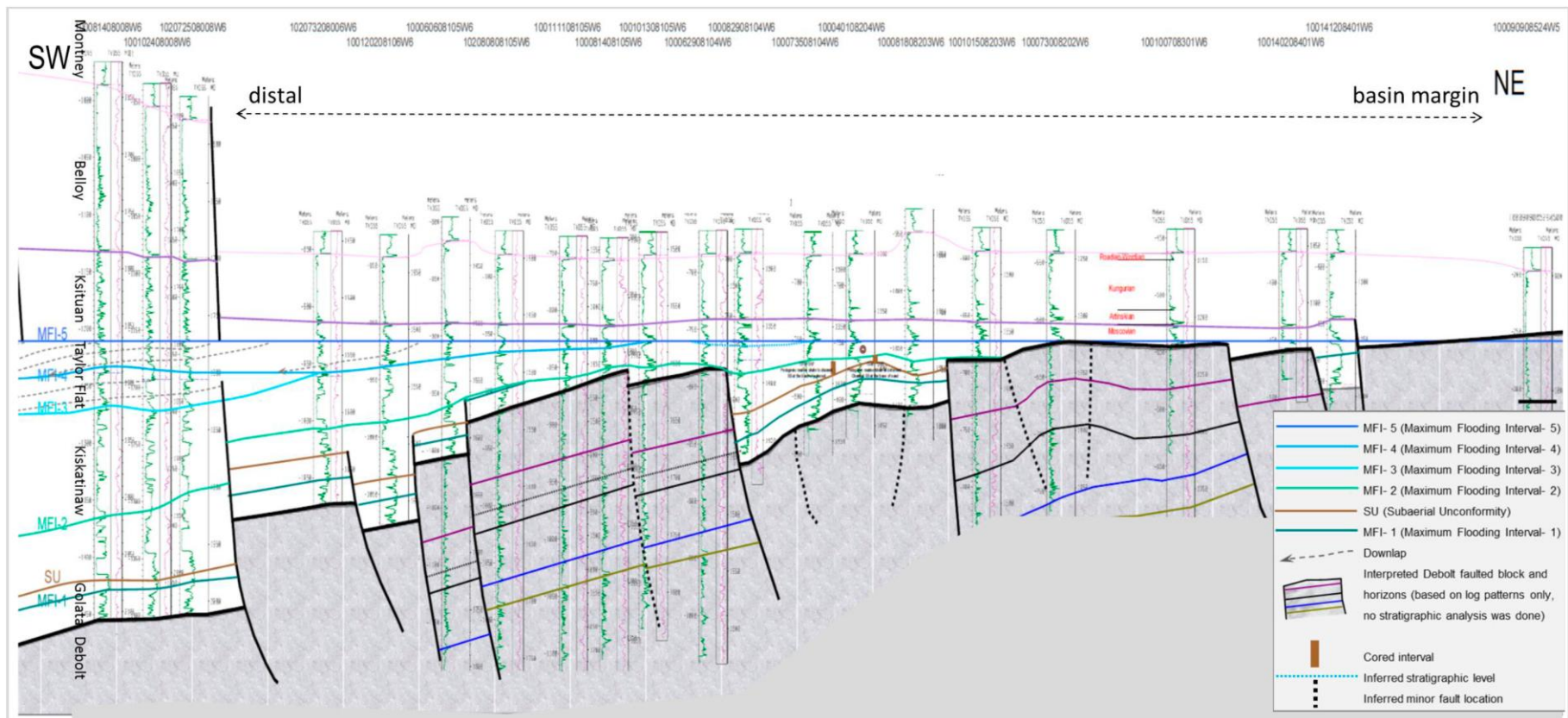


Figure 2. Example of semi-regional cross section constructed along assumed depositional dip and across the fault blocks depicted from restored 3D Debolt Formation surface. See [Figure 1](#) for location. Kiskatinaw Formation progradational packages can be followed. See also progradational Taylor Flat deposits (indicated with dashed arrow). Note Maximum Flooding Intervals (MFI) and Subaerial Unconformity (SU) as marked. Note that the cross section goes beyond the study area presented in [Figure 1](#).

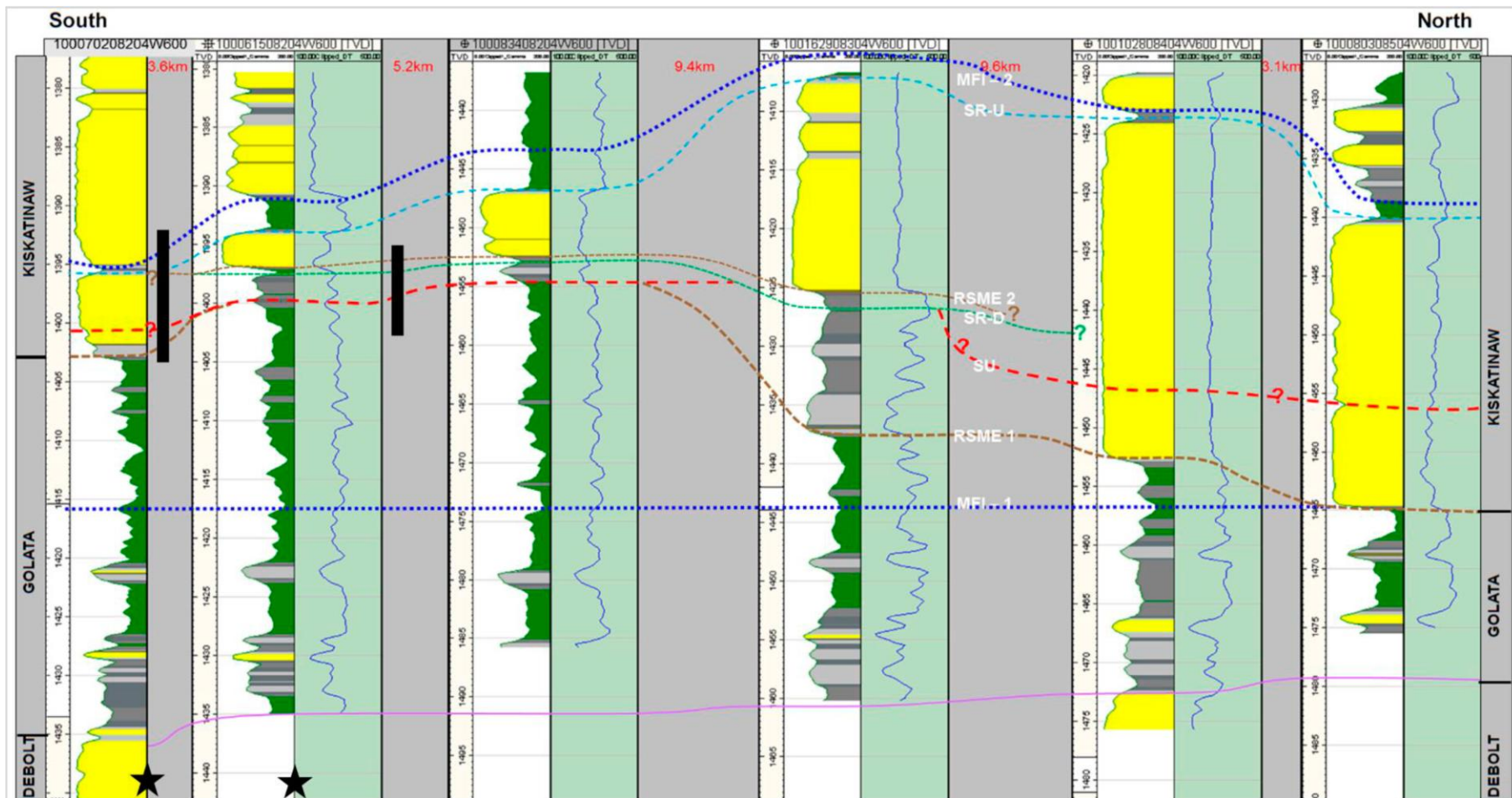


Figure 3. Core (070208204W6 and 061508204W6 marked by black star) calibrated well log correlation showing one Galloway Sequence. Displayed core intervals are marked by black bar. Maximum Regressive Surface (MRS) could not be identified within the study area. Well log correlation uses Maximum Flooding Interval (MFI-1) as a datum to display erosion of the Golata Formation mudstone by Regressive Surface of Marine Erosion (RSME) -based sandstone. Subaerial Unconformity (SU), Shoreline Ravinement-unconformable (SR-U), and MFI-2 are identified from core note RSME-1 above MFI-1 incised into Golata Formation mudstone removed MFI-1 with about 18 m of incision (well 080308504W6).

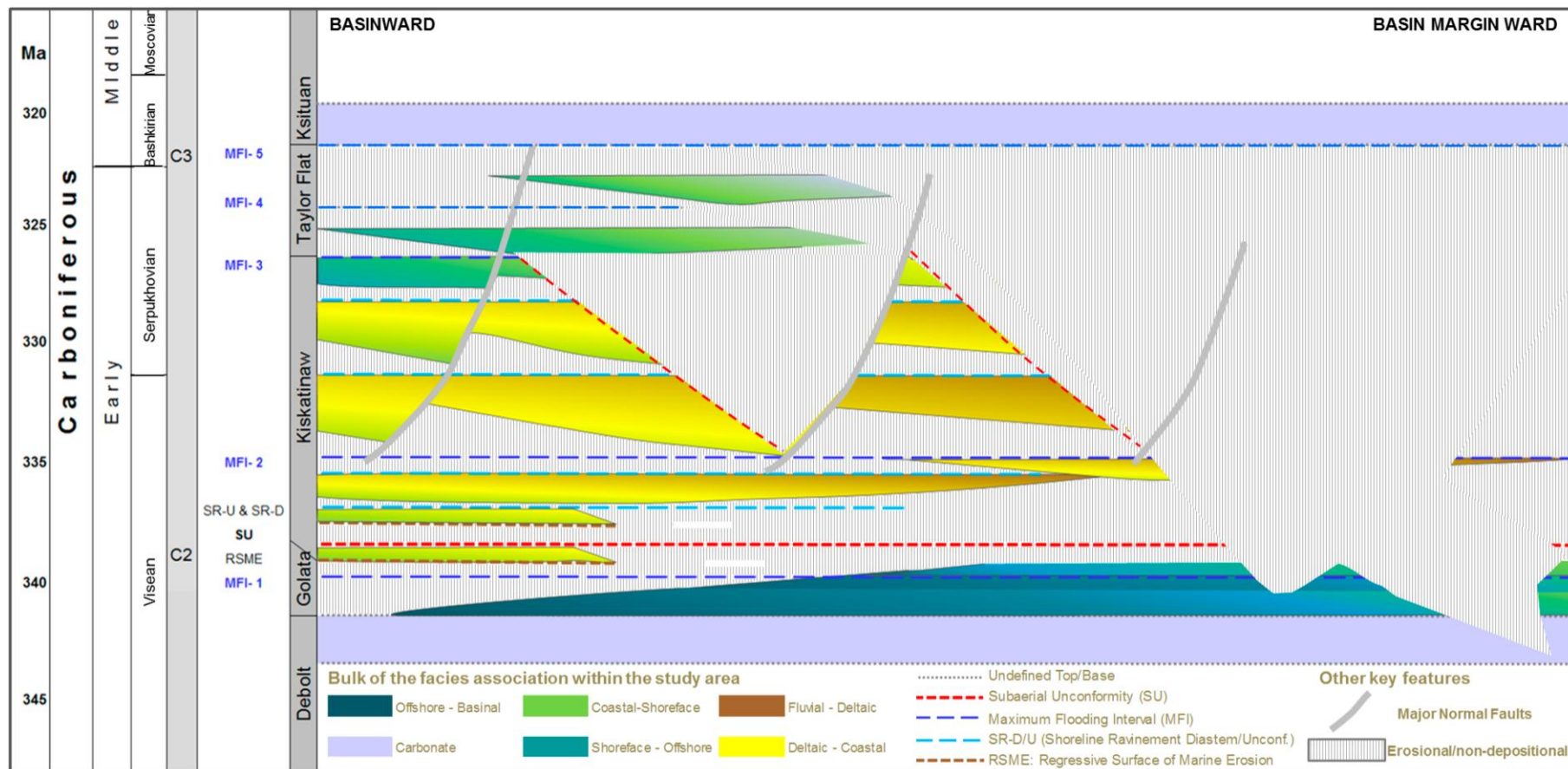


Figure 4. Generalized stratigraphic chart following Wheeler Diagram for Stoddart Group sediments. The diagram mostly follows the relations present in [Figure 2](#) and [Figure 3](#). Bulk of the facies associations show present overall depositional motifs as interpreted. Due to variations in syn- and post-depositional tectonics along depositional strike and dip, local stratigraphic record may differ. Note Kiskatinaw Formation shows several regressive packages that are bounded by Maximum Flooding Intervals (MFI). RSME and SR surfaces, as interpreted for Galloway Sequence in [Figure 3](#), are also illustrated here. Note also comparison of tectonically generated unconformities observed in Nevada (C2 and C3, Trexler et al., 2003) two stratigraphic surfaces (e.g. SU and MFI-5) compared to this study.

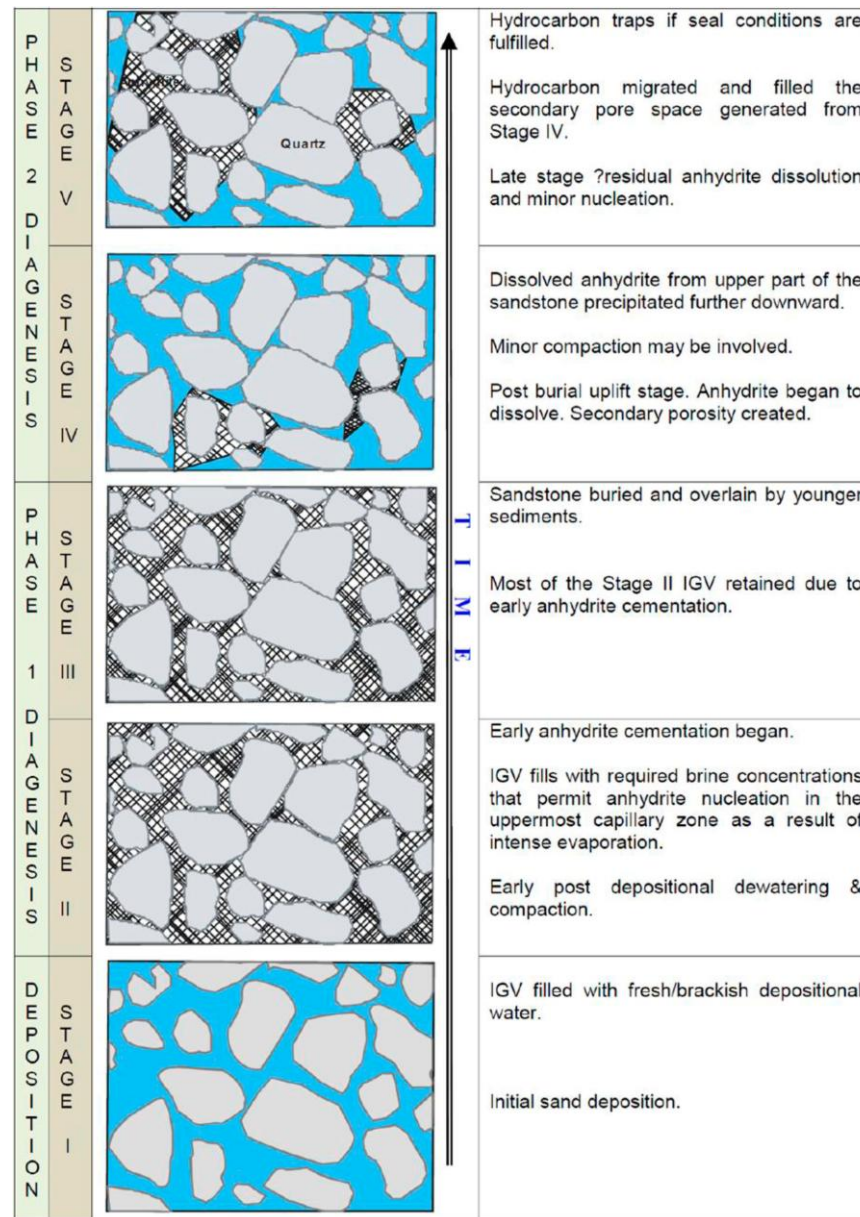


Figure 5. Five stage summary of the anhydrite cementation and porosity generation history of the Kiskatinaw Sandstone reservoirs. Note two major phases of diagenesis following deposition. Grey coloured grains represent quartz grains. Blue area represents porosity. Cross-hatched area represents anhydrite cementation.