Ante Creek Beaverhill Lake B Pool: Porosity and Permeability Systems - a New Look at Old Rock

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INTRODUCTION

The Ante Ck. Beaverhill Lake B Pool is located in central Alberta (Fig. 1). It was discovered in 1966, and to date has produced 595500 m^3 of oil under primary drive. The producing unit is the Swan Hills Formation of the Beaverhill Lake Group (Fig. 2).

STRATIGRAPHY

The Swan Hills at Ante Ck may be subdivided into a platform member (Stage 1), and 6-7 overlying reef or shoal stages (Fig. 2). The contacts between the stages, where preserved, appear to be erosional, although the exact natures of these surfaces (exposure vs. drowning?) are contentious. As defined in this abstract, Stage 2 builds upon the underlying platform stage, and may be considered the first proper stage of the Ante Ck B Pool. Stages 2-5 are reef rimmed stages with back-reef lagoonal facies. Stage 4 is regressive, whereas stages 3 and 5 may overstep the margins of their respective underlying stages (Figs. 2,3). Stages 6-7 generally do not have well-defined margins or lagoonal facies, and are considered to be shoal units.

RESERVOIR

The Swan Hills at Ante Ck is predominantly composed of cryptocrystalline or microcrystalline limestones, with some coarse grained calcite cements. These rocks have been locally overprinted by a dolomitizing event that was for the most part contained in Stage 3.

The limestones are moderate porosity, low permeability rocks, with the most porous zones have porosities ranging from 2-6%, and typical unstressed permeabilities in the 0.1-4 mD range (Fig. 4). The porosity system consists of leached fossil moldic and pinpoint vuggy porosity. Fracturing may play a role in the connectivity of the limestone porosity, but this role appears to be limited given the low frequency of fractures visible in the core (with the exception of core from 16-2-66-25w5).

These dolostones are interesting from a diagenetic point of view, but also form the main reservoir unit in the Ante B Pool. Porosities range between 8 and 30%, with permeabilities ranging between 10-150 mD. The dolostones are constrained for the most part to the top of Stage 3, and it appears that the dolomitizing fluids were trapped by the overlying unconformity that separates Stages 3 and 4. This trapping of the dolomitizing fluid was so complete that very little of Stage 4 is dolomitized. The presence of grainstone facies in Stage 4 ought to have permitted the passage of dolomitizing fluids, and today Stage 4 exhibits leached limestone porosity. The effective isolation of the dolomitizing event is therefore surprising, and must have something to do with the nature of the unconformity atop Stage 3.

The dolomite is partially fabric-destructive, yet skeletal structures of bulbous stromatoporoids and amphipora may be preserved as limestone floating in a microcrystalline calcite and micro- to mesocrystalline dolomite matrix (fig. 5,6). It is this microcrystalline character that leads to another interesting characteristic of the Ante Ck BHL B pool- low resistivity pay. The dolostone zone produces low water-cut oil from zones with resistivities as low as 8-10 ohm-m, and calculated water saturations of 40%. This has lead to difficulties in determining where the water-oil contact lies in the reservoir, and to date the water line has been arbitrarily assigned on the basis of an abandoned well at 11-2-66-25w5 that DST'd 136' of filtrate-contaminated salt water from the Swan Hills.

THE VOLUMETRIC QUESTION

Because the exact limits of the oil leg are not clearly defined, there exists some question as to the amount of oil contained in the pool, and what percentage of this oil has been recovered. Assuming that the 11-2 well defines the structural position of the oil-water contact, and assuming that the limestone facies contribute to oil production, the pool should currently be at ~20% recovery of oil in place. If one assumes that the majority of production has come out of the dolostone reservoir, however, and that the limestone facies contributes minimally to production, then the pool has produced 33% of the oil in place IN THE DOLOSTONE.

The question then, is this: have we really recovered 33% of oil from an extremely fine grained rock strictly under the drive of solution gas and a weak water aquifer? If so, what remains to be recovered? Or, if we assume that the limestone facies has contributed significant production, what can we do to take this pool beyond the meager 20% recovery it currently sits at?

COMPARING APPLES AND ORANGES

The limestone facies in the Swan Hills Formation in the Ante Ck B Pool tend to be well cemented by calcites, and appear to have poor inteconnectivity between pores. Furthermore, the low porosities (i.e. <6%) means there is low storage capacity in the rock. Without the presence of numerous open fractures, the limestone facies is low productivity rock. The dolostone facies, on the other hand, has extremely high storativity due to high porosities, and the good to excellent permeabilities mean the dolostone reservoir has high deliverabilities. On the basis of these criteria, the dolostone facies is the main target in the pool.

SO?

Production and completion practices to date have treated the Ante Ck. B Pool as a large "tank", lumping the limestone and dolostones together as the lesser and greater parts of one large system. While this is to some extent true, on a fluid flow basis the Swan Hills at Ante Ck is anything *but* a tank. Attempts at open hole completions have been unsuccessful, and completing both limestone and dolostone porous zones in the same wellbore has been of limited success. On the other hand, completions aimed specifically at the either the dolostone or limestone porosity have resulted in the best production. Similarly, on a pool management scale, treating the dolostone porosity as separate from the limestone porosity will hopefully result in better management of the pool as Anderson considers a waterflood for the pool.

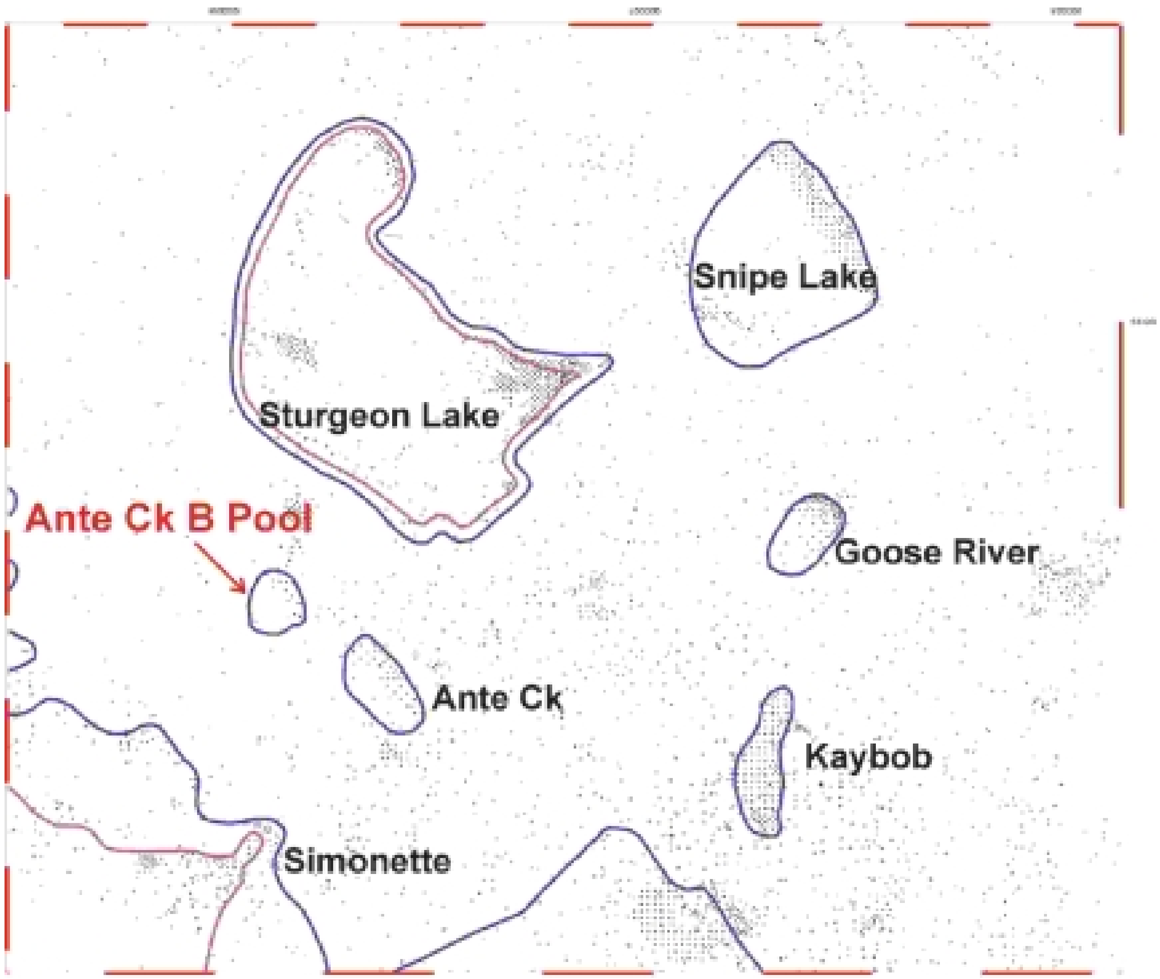


Fig.1 Location of Ante Ck BHL B Pool in west central Alberta

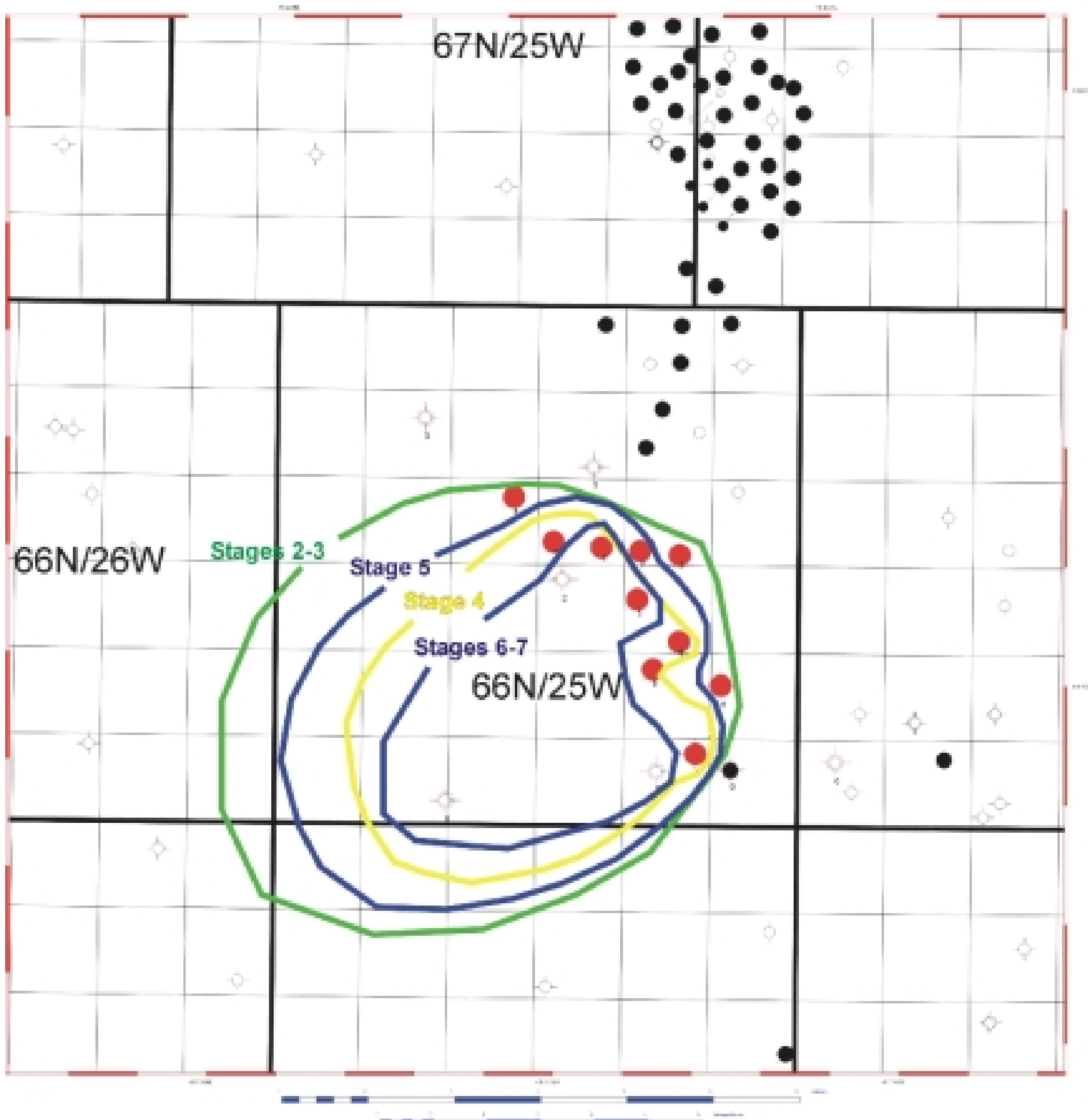


Fig.2 Ante Ck BHL B Pool Stage Map

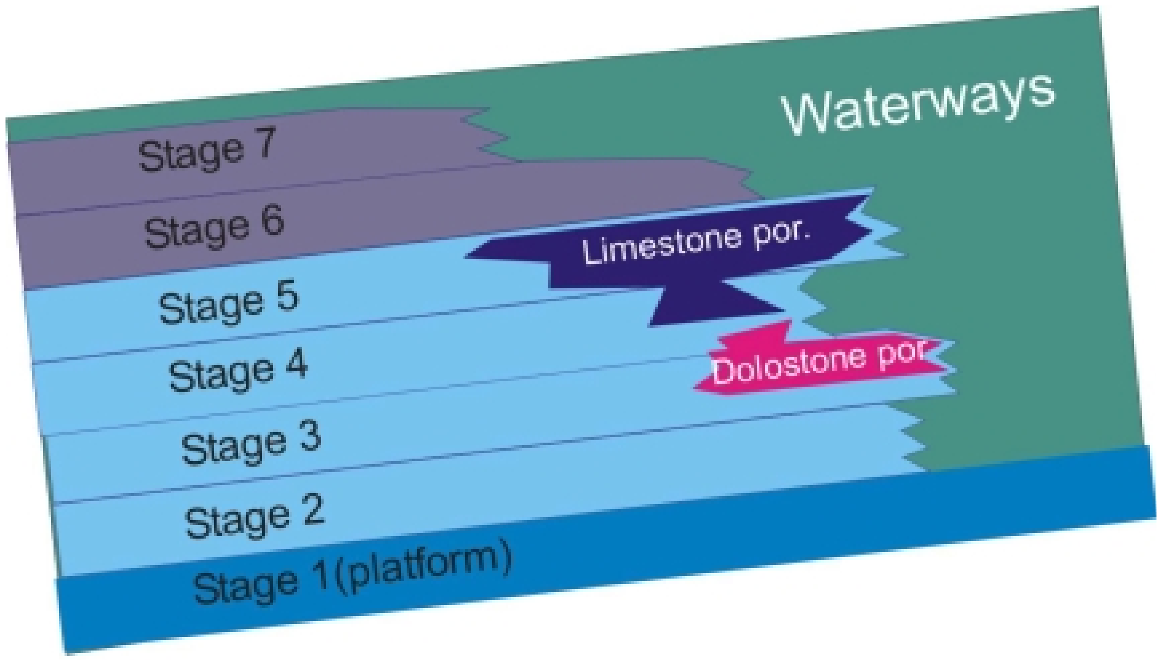
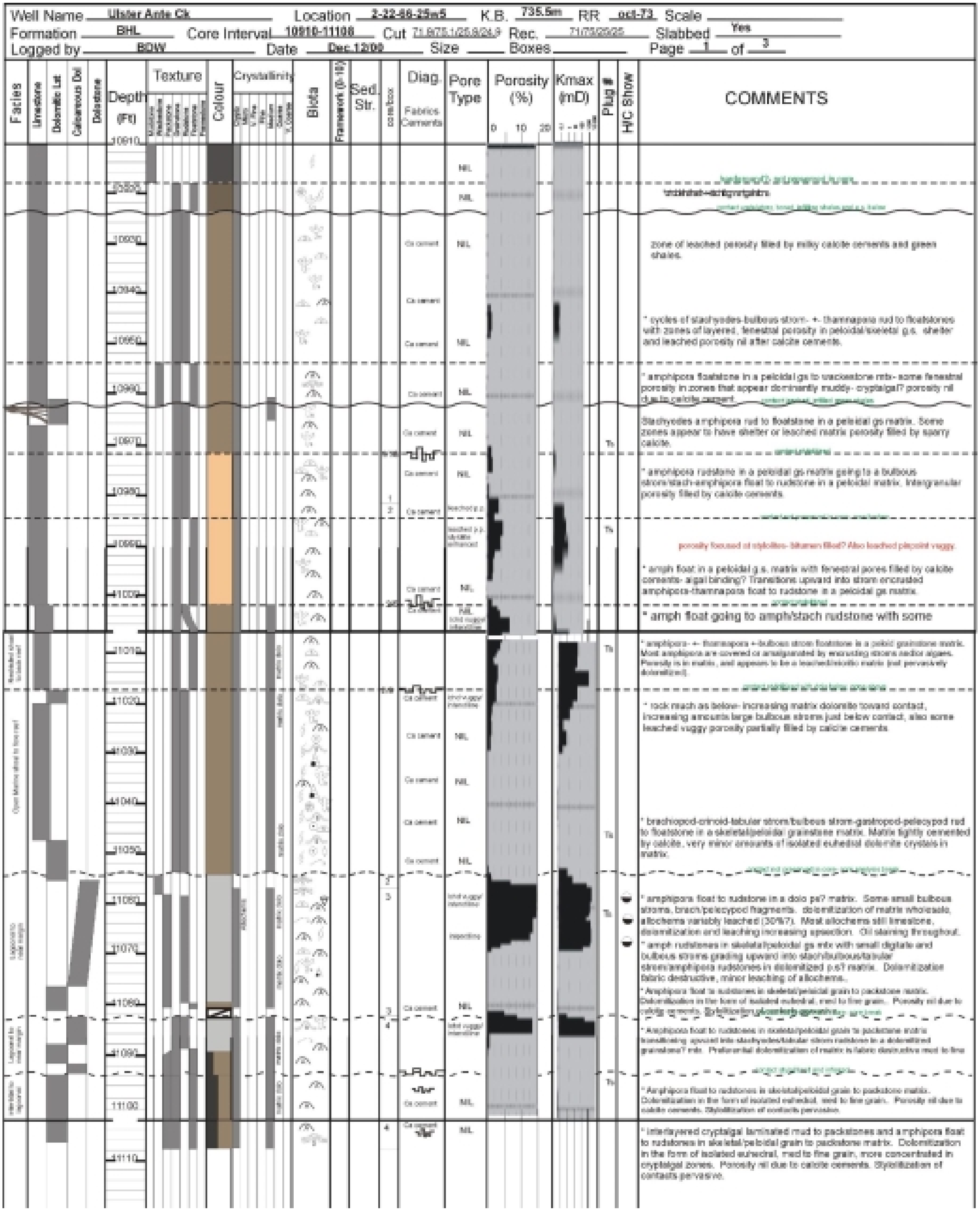


Fig.3 Ante Ck BHL B Pool stratigraphy


Well Name Ulster Ante Ck
Location 2-22-68-25w5
K.B. 735.5m
RR oct-73
Scale
Formation BHL
Core Interval 10910-11108
Slabbed Yes
Logged by BDW
Date Dec 12/00
Size
Boxes
Page 1 of 3
Facies
Limestone
Dolomitic Lst
Calcareous Dol
Dolostone
Depth (Ft)
Texture
Colour
Crystallinity
Biota
Sed. Str.
Diag. Fabrics Cements
Pore Type
Porosity (%)
Kmax (mD)
Plug #
H/C Show
COMMENTS
10910
10920
10930
10940
10950
10960
10970
10980
10990
11000
11010
11020
11030
11040
11050
11060
11070
11080
11090
11100
11110
NIL
zone of leached porosity filled by milky calcite cements and green shales.
* cycles of stachyodes-bulbous strom- +- thamnapora rud to floatstones with zones of layered, fenestral porosity in peloidal/skeletal g.s. shelter and leached porosity nil after calcite cements.
* amphipora floatstone in a peloidal gs to wackestone mtx- some fenestral porosity in zones that appear dominantly muddy- cryptalgal? porosity nil due to calcite cement.
Stachyodes amphipora rud to floatstone in a peloidal gs matrix. Some zones appear to have shelter or leached matrix porosity filled by sparry calcite.
* amphipora rudstone in a peloidal gs matrix going to a bulbous strom/stach-amphipora float to rudstone in a peloidal matrix. Intergranular porosity filled by calcite cements.
* amph float in a peloidal g.s. matrix with fenestral pores filled by calcite cements- algal binding? Transitions upward into strom encrusted amphipora-thamnapora float to rudstone in a peloidal gs matrix.
* amph float going to amph/stach rudstone with some
* rock much as below- increasing matrix dolomite toward contact, increasing amounts large bulbous stroms just below contact, also some leached vuggy porosity partially filled by calcite cements.
* brachiopod-crinoid-tabular strom/bulbous strom-gastropod-pelecypod rud to floatstone in a skeletal/peloidal grainstone matrix. Matrix tightly cemented by calcite, very minor amounts of isolated euhedral dolomite crystals in matrix.
* amphipora float to rudstone in a dolo ps? matrix. Some small bulbous stroms, brach/pelecypod fragments. dolomitization of matrix wholesale, allochems variably leached (30%?). Most allochems still limestone, dolomitization and leaching increasing upsection. Oil staining throughout.
* amph rudstones in skeletal/peloidal gs mtx with small digitate and bulbous stroms grading upward into stach/bulbous/tabular strom/amphipora rudstones in dolomitized p.s? matrix. Dolomitization fabric destructive, minor leaching of allochems.
* interlayered cryptalgal laminated mud to packstones and amphipora float to rudstones in skeletal/peloidal grain to packstone matrix. Dolomitization in the form of isolated euhedral, med to fine grain, more concentrated in cryptalgal zones. Porosity nil due to calcite cements. Stylolitization of contacts pervasive.