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CORRELATING THE TRAVERSE GROUP LIMESTONE FROM SUBSURFACE TO OUTCROP, MICHIGAN BASIN

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INTRODUCTION

The Michigan Basin is a 400 km diameter structural basin with a geologic record spanning from the Ordovician through the Permian (Howell and van der Pluijm, 1991). Much of the basin's sedimentary record throughout the Devonian is correlated across the basin while other sections are difficult to recognize in both subsurface and outcrop, such as the Mid-Devonian Traverse Group. The Traverse Group is a series of limestones and calcareous shales that overlies the Dundee Formation and underlies the "Squaw Bay Formation" -Antrim Shale sequence (Gutschick and Sandberg, 1991). Over the years, terminology surrounding this group has been inconsistent and difficult to parse; some studies combine these limestones with the "Squaw Bay Formation" and classify the "Traverse Limestone" varyingly as a formation and group (Ehlers and Kesling, 1970; Gutschick and Sandberg, 1991, and references therein). Oil and gas logs simply refer to the topmost unit as the Traverse Limestone due to its lack of economic importance as a less significant hydrocarbon producer than the overlying Antrim Shale. Subsurface records only officially identify two units in the Traverse Group: the thinner Bell Shale and the overlying thick Traverse Limestone (Catacosinos et al. 2001). This simple division is not utilized in the outcrop belt which has been divided into a large number of units (see Wylie and Huntoon, 2003, and references therein). In addition to this, correlating these units is challenging because of a paucity of continuous exposure. Cores produced by oil and gas exploration have provided good subsurface data throughout the basin but Pleistocene glacial deposits have made good outcrops rare and difficult to fully correlate with the subsurface data. For instance, at the type section for the Thunder Bay Formation, upper and lower contacts of the unit are not visible, making thickness estimates very difficult (Ehlers and Kesling, 1970). Finally, the input of clay and clastic material from the Acadian Mountains to the east of the basin cause the facies observed across the basin to display different compositions and textures even when they should be the same temporal unit for correlation.

To gain a better understanding of the Traverse Group and its subsurface versus outcrop expression, this project describes and compares the Traverse Group in the State Chester Welch #18 (SCW-18) core to determine which outcrop unit it corresponds to. With its intact upper contact the SCW-18 core can provide a useful reference for future correlation in the Michigan Basin.

METHODS

To describe the subsurface Traverse Group limestone in detail, the SCW-18 core from a gas exploration well in north central Michigan was used (Figure 1). Prior to this study, the core was slabbed and included the upper 9 ft (2.75 m) of the Traverse Group to its contact with the "Squaw Bay Formation" (SB Formation.) For this project, the core was subdivided into facies based on the lithologic features and fossil assemblages. Fossil analysis was based on the content and preservation, and when possible, fossils were classified to the genus level. Next, hand samples taken from outcrops of the Traverse Group and SB Formation were assessed. These hand samples originated from across northern Michigan; one set of samples came from the Michigan Geologic Society 1949 field trip and the other set included samples from the Thunder Bay, Beebe School, Petoskey, and Whiskey Creek formations at their type sections collected by J. Zambito in the 2010s. These outcrop samples were

Figure 1. Map of locations of the SCW-18 core and the Thunder Bay Formation type section outcrop (Image from Google Earth).

also described based on their composition and fossil content. Published stratigraphic columns from the type areas of Michigan Basin units were also consulted for comparison, especially from Wylie and Huntoon (2003), Kesling et al. (1976) and Ehlers and Kesling (1976). Finally, the closest match to the lithology of the core sample was selected to identify its geologic unit from the type area descriptions and samples.

RESULTS

The lithology of the Traverse Group section of the SCW-18 core was dominantly a gray calcareous shale to limestone with abundant fossils (Figures 2 and 3). Throughout the core crinoid fossils were common as well as stylolites from post-deposition alteration. The lowest units A and B were matrix-supported mudstones with a higher portion of clay sediment than the overlying subsections. A stromatoporoid as well as pyrite were found in unit B. Bryozoans were most common in the lower three units. The middle of the core succession studied had the most abundant fossil material, with unit E approaching a packstone concentration recrystallized fossil material. Stromatoporoids and corals were found in the units C and E. After a gap of missing core, units G, H, and I have lower fossil abundance, but pyritized fossil material. This portion of the core was highly crystalline and the fossil material present was difficult to identify due to recrystallization, suggesting this segment was diagenetically altered near the upper contact with the SB Formation.

After consulting the literature and the hand samples from type areas around the Michigan Basin, it was determined that the SCW-18 core most closely resembles the Thunder Bay Formation. The hand samples from the Thunder Bay type area were similarly a gray calcareous shale to limestone with abundant crinoids, stylolites, and some stromatoporoids visible (Figure 2). The outcrop hand samples weren't highly crystalline like the upper units in the core samples, suggesting that it correlates best to calcareous shales and shaley limestones near the base of the core.

Compared to the Thunder Bay outcrop descriptions in the type areas published in Ehlers and Kesling (1976),

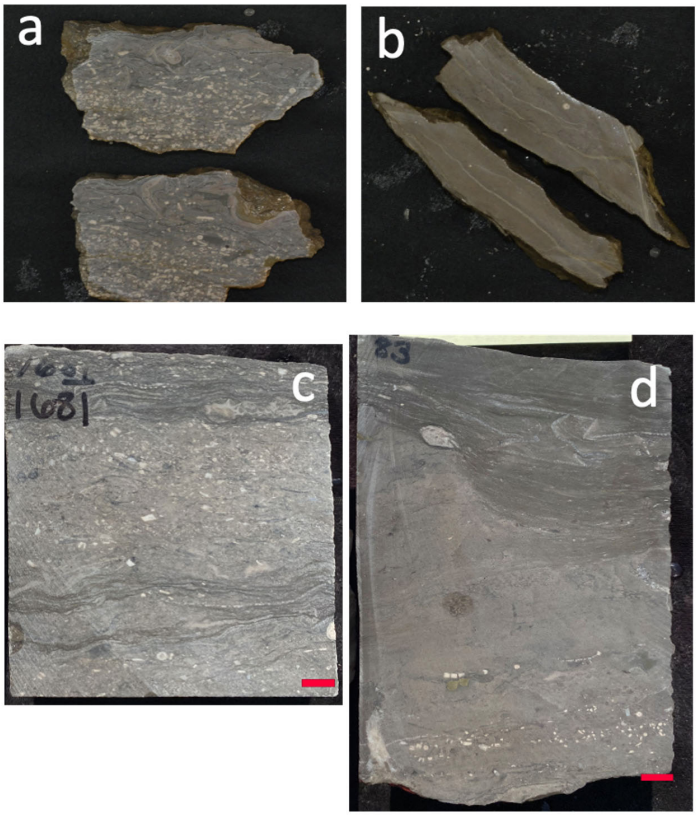

Figure 2. Examples of the SCW-18 core's texture compared to hand samples from the Thunder Bay type area. Fauna, color, and texture of hand sample a matches SCW-18 units C & E. Hand sample b resembles lower SCW-18 unit B. Red bar = 1 cm. 2a.) Thunder Bay outcrop sample with shaley limestone texture, packstone with crinoids and corals. Evidence of stylolites. 2b.) Thunder Bay outcrop sample. is a gray mudstone with stylolites and bryozoans. 2c.) SCW-18 core sample. This is a shaley limestone packstone with crinoids and coral.Several silhouettes surrounding bryozoan sheets are present. 2d.) SCW-18 core sample. This is a calcareous shale mudstone with sparse crinoid fossils and larger secondary stylolite features. Outcrop sample a and SCW-18 sample C closely resemble each other in fossil concentration and color while sample b and SCW-18 sample D have very similar textures.

the majority of the SCW-18 core closely resembles units 1 and 3 due to its fossil content and shaley limestone texture which grades into a crystalline limestone (Figure 3). There was no data on relative fossil abundance or the degree of crystallization at the outcrop but the overall texture, color, and fauna was the same. There was no pyrite recognized at the outcrop, possibly suggesting a higher level of diagenetic alteration in the subsurface.

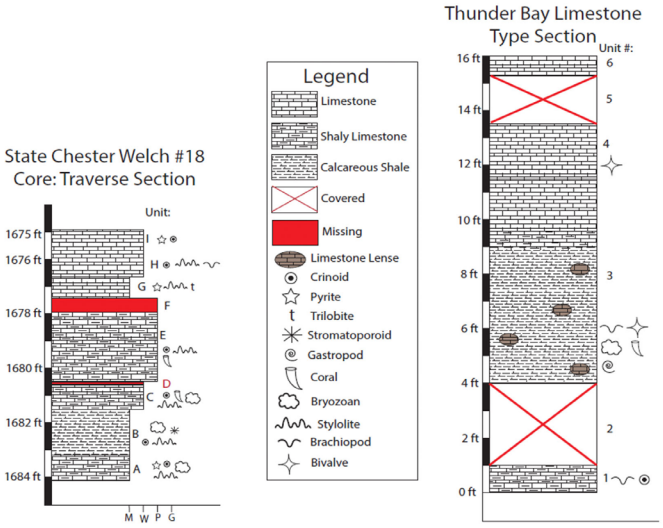

Figure 3. The SCW-18 core sequence of the Traverse Limestone compared to the Thunder Bay Formation type section in outcrop described by Ehlers and Kesling (1970). Lithology and fauna are similar, with the SCW-18 succession closely resembling units 1 & 3 of Ehlers and Kesling description.

DISCUSSION

Identifying the SCW-18 Traverse Group succession as the Thunder Bay Formation adds to the understanding of this relatively understudied unit by distinguishing differences between the subsurface and subaerial expressions of this unit and by establishing a reference for its contacts. Across the basin there appears to be variation in the extent of the Thunder Bay Formation. At the type area, the Thunder Bay had a total exposure of ~16 ft according to the literature and the hand samples from the area have ~19 ft of vertical distribution (Ehlers and Kesling, 1976). The SCW-18 core was drilled more centrally in the basin so although there was only 9 ft of the Thunder Bay Formation preserved in the core, a thicker package should be present in this part of the unit. If the core included the lower contact of the TB, there should be well over 20 ft of this lithology present.

Identifying the Thunder Bay Formation in this subsurface record can be used as a reference for the stratigraphic relationships in the Michigan Basin. Pleistocene glacial sedimentation has obscured much of the potential outcrop exposures around Michigan making comprehensive outcrops with conformable contacts uncommon. For instance, the type section for the Thunder Bay Formation has no visible contacts (Ehlers and Kesling, 1976). This makes the SCW-18 a useful reference section for study of the Thunder Bay Formation because it includes a clear upper contact with the overlying SB formation. Additionally, this identification bridges a gap between the subsurface and outcrop interpretations of the Traverse Group subdivisions. This correlation connects two regions that have had nomenclatural differences for the Traverse Group; in outcrops in North Central Michigan, the Thunder Bay Formation is not usually identified but in northeastern Michigan near the type area, the unit can be identified (Wylie and Huntoon, 2003). But given the lithological similarities between the eastern Michigan type area samples and the north-central Michigan, it is reasonable to suggest the Thunder Bay Formation could be a continuous unit across this portion of the basin.

To corroborate the identification of the Thunder Bay Formation in the subsurface, gamma ray logs from across the Michigan Basin were utilized. This data type assesses the level of natural gamma radiation from rocks lining the boreholes. High gamma values are typically associated with shaley rock textures with high organic carbon content. Wylie and Huntoon (2003) compiled a series of gamma ray logs from boreholes around the state that are near the sample localities used in this study; the Lake Horicon #1 borehole came from north-central Michigan near the SCW-18 core and the Cousineau “A” #1-16 data came from a location near the Thunder Bay type area. These logs revealed a trend of low gamma radiation in the upper most Traverse Group in the subsurface (Figure 4; Wylie and Huntoon, 2003). Typically crystalline limestones like the SCW-18 core interval should have low gamma levels, not the substantial peaks reflected in the Thunder Bay portion of the log. Based on these values, the core segment in this study is more likely the upper low-gamma Traverse Limestone rather than the true Thunder Bay unit that

is placed stratigraphically below it and separated by an unconformity. The lithologies of the samples from the type area were the sample texture, suggesting that a near-upper contact segment of the Traverse was successfully captured in the outcrop samples. Additionally, the package of this upper low-gamma section appears to be abbreviated in the eastern part of the basin near the outcrop. Rather than displaying two small peaks in the upper Traverse like in the basin-center samples (Lake Horicon #1), the outcrop area (Cousineau "A" #1-16) is condensed and does not include this full package of low-gamma lithology. Based on the distribution of these data points, the abbreviation of these profiles is probably due to the structure of the basin and difference in erosion from its center to the edge. Therefore it can be interpreted that the basin edge outcrop samples do not account for the full sequence observed in the subsurface core, even though the two don't include firm boundary indicators of both contacts.

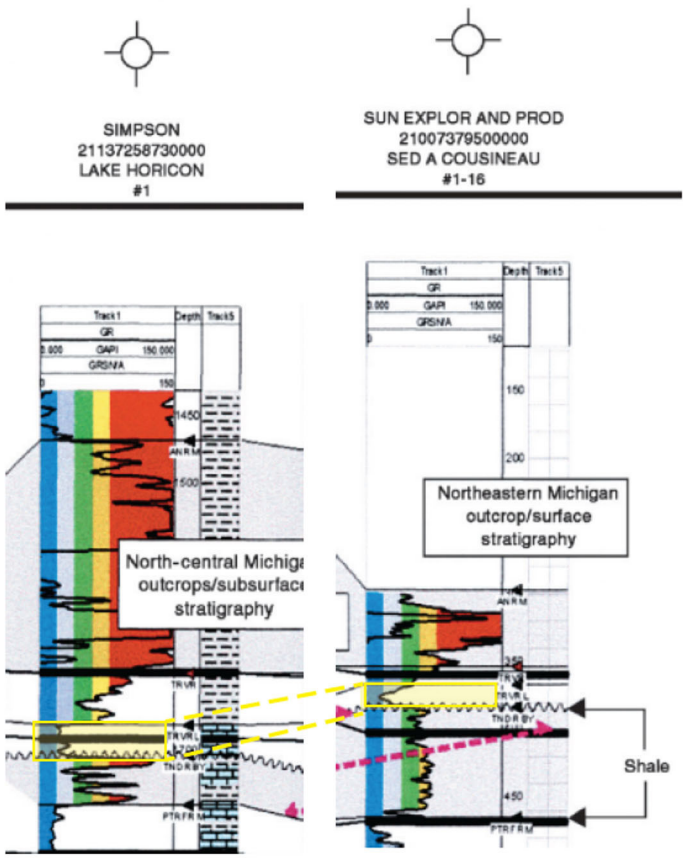

Figure 4. Gamma ray logs adapted from Wylie and Huntoon (2003). The Lake Horicon #1 bore hole was located near the SCW-18 drill site and the Cousineau "A" #1-16 bore hole is in northeastern Michigan near the Thunder Bay Formation type locality. Across the transect there is a peak in gamma radiation in the Thunder Bay unit over lain by a low gamma zone right near the upper contact of the Traverse with the SB.

CONCLUSIONS

By identifying the uppermost Traverse Group unit of the SCW-18 core, this study adds to the limited subsurface-to-outcrop correlation in the Michigan Basin and points to this core as a good reference for the contacts of the Thunder Bay Formation which have been difficult to study. Future studies could incorporate a temporal control on the subsurface and outcrop samples to establish relative distance from the contact with the SB formation in the type area. This work will help inform understanding of the relationships between regions of the Michigan Basin as well as its stratigraphic relationships which are essential to geologic research.

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