October 2019 Narrative Progress Repot for:

1. PRF # 58927-ND8
2. Title: Thermal Modeling of the Michigan Basin: Why are Hydrocarbons Mature?
3. PI: Dr. Michelle A. Kominz

Personnel support and progress: Funding began July 1, 2018. Two MS candidates, Jack Hybza and Derek Patterson were supported during the summer months, July and August 2018. The primary goal of the summer work was to submerge the students in the literature for the Michigan basin. Hybza began his work during the writing phase of this proposal so the goal was to make sure that he understood the context in which his modeling was being done. Derek was reading to prepare him to begin a research project involving thermal modeling of the Michigan Basin. Derek was also introduced to and encouraged to familiarize himself with the Michigan basin data repository data base.

In Fall 2018 Jack Hybza was supported on this grant as he completed his MS thesis: "" . He defended in December 2018 and graduated in Spring 2019. Subsequently there have been no students working on the grant. About a week of funding to PI Kominz in Summer 2019 supported her work reviewing work to date and outlining a manuscript to be submitted to the AAPG Bulletin.

Several students have expressed an interest in pursuing a MS degree working on thermal modeling of basin sediments. This would begin, at earliest in Spring 2019, or more likely, in Summer 2019. As such, I hope to get a no-cost extension of the grant.

Progress on promised deliverables:

Adding a unit on thermal maturation to Kominz' graduate course *Quantitative Basin Analysis*. Kominz taught the course in Fall 2018 and added a unit on thermal maturation, added TTI (Time temperature index) code to the backstripping program used in this course. All 10 students in the course found this unit to be a particularly valuable portion of the class.

Mr. Hybza's MS Thesis consisted of modeling Michigan basin 6 wells. Three wells were located above the Michigan Continental Rift (MCR) and three were located off-rift. Of the off-rift wells one was located in an extensive rift system which is also a region in which hydrocarbons have been exploited. Maturation models were compared to observed maturation data from within 30 to 40 km of the well modeled. Observed maturation levels are quite variable for all wells. Thus, to model observed data it was necessary to apply multiple geodynamic models. In particular models with and without fluid flow, bringing warm water from deep in the basin were required in order to generate the highest levels of hydrocarbon maturation at any depth in the cores. This was true for both the wells above the MCR and those off of the MCR. That is, without non-conductive heat transport, maturation levels could not be reached. In retrospect, as is usually the case for any geodynamic modeling work, this is entirely consistent with the available data. As indicated in Figure 1, below, there is a broad range of maturations in a very narrow region, for any given burial depth and/or age of sediment. That is, within any given region there must have been a wide range of thermal conditions in close proximity. The most likely source of such variable local conditions is advection of heat through fluid flow.

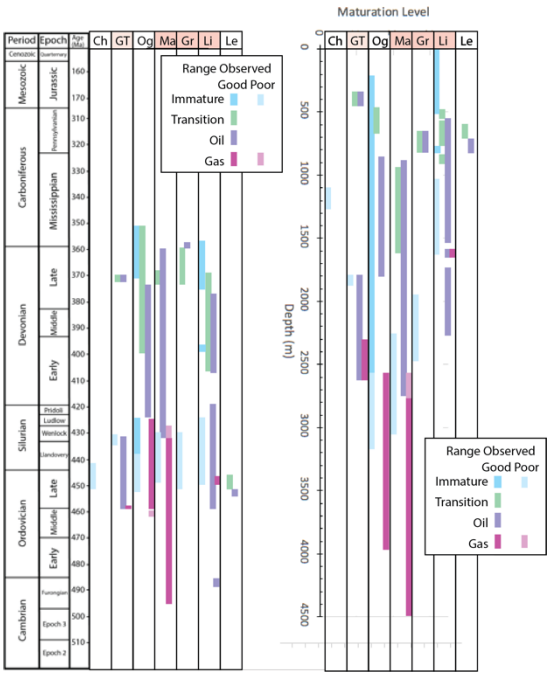
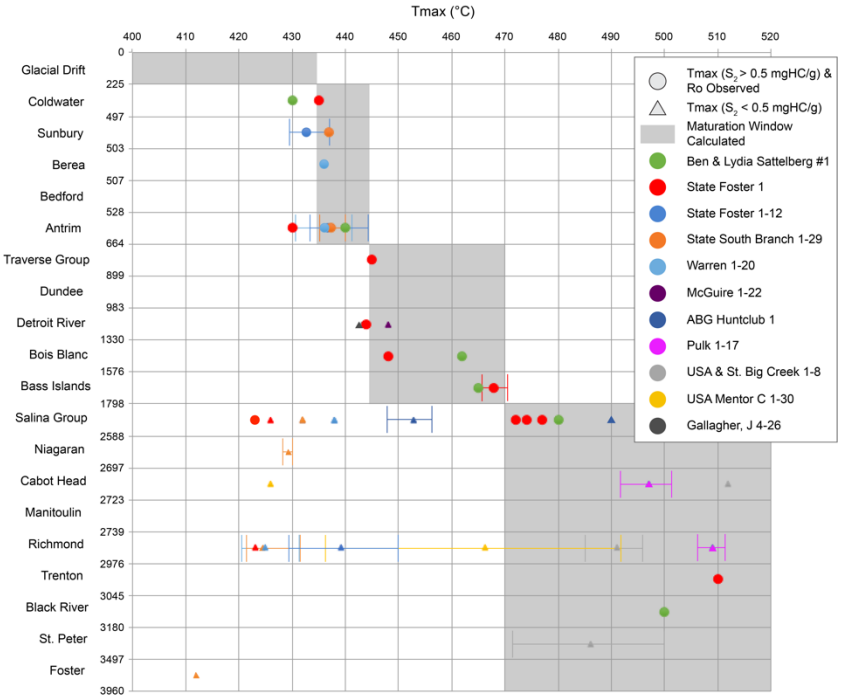


Figure 1 (left): Observed thermal maturation data with depth or time. Surrounding data was gathered within a 30 Km area of each well location. Different colors represent thermal maturation windows. Different shades of each color represent good (S_2 > 0.5 mgHC/g or Ro) vs. poor quality data (S_2 < 0.5 mgHC/g). Highlighted well name (orange color) = above the MCR. Ch = Cheboygan, GT = Grand Traverse, Og = Ogemaw, Ma = Missaukee, Gr = Gratiot, Li = Livingston, and Le = Lenawee

Figure 2 (below)- Thermal maturation plot of advection of heat model for well 25099 (Ogemaw, Og in Fig. 1). Circles represent the best quality observed Tmax and Ro data. Triangles represent poor quality Tmax data. Different colors correspond to different surrounding wells with observed thermal maturation data.



Impact on Personnel:

Jack Hybza is currently employed as an Area Geologist in the Oil, Gas, and Minerals Division of the Michigan Department of Environment, Great Lakes, and Energy.

Dr. Kominz will continue to upgrade software, is working on a publication based on student research to date and expects to begin working with one or two new MS candidates on thermal maturation studies within the next 6 months.