Bedrock Map of Kona Formation Type Section

Marquette County, Upper Peninsula Michigan, United States

T46N &T47N R25W

2013

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Geologic Map, Units, and Cross Section Legend

Geologic Contact

Approximate Geologic Contact

Outcrop Area

Unconformity

Syncline

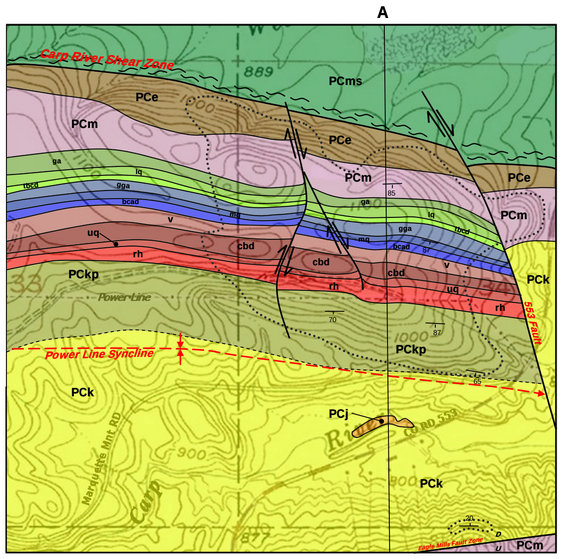
A — Cross Section Line — A'

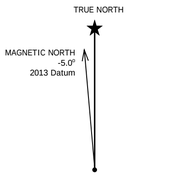
Strike-Slip Fault

Reverse Fault (D / U)

Shear Zone

Geologic Map





MAP SCALE = 1:12 000

MAP AREA = 1.413 miles²

500 meters

2000 feet

Contour Interval = 20 feet

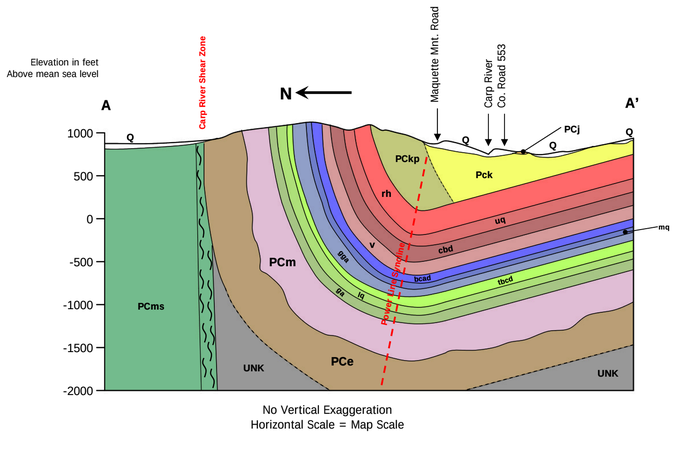
Geologic Time Scale

Ya = years ago
Mya = millions of years ago
Gya = billions of years ago

Geologic Map Units

Lithostratigraphic Scale		Geologic Description
Phanerozoic Eon, Cenozoic Era, Quaternary Period, 15,000 to 9,000 Ya	Q	**Quaternary (undivided):** Reddish brown to pale yellow brown, unconsolidated till and outwash of SAND and GRAVEL with CLAY, and with modern stream deposit SILT and CLAY (0-200 feet thick) *Cross Section Only*
		Great Unconformity
Proterozoic Eon, Neoproterozoic Era, Tonian Period, 910 to 925 Mya	PCj	**Jacobsville Formation:** Reddish purple mottled pale yellow brown, thin to medium cross bedded, subrounded medium to coarse SUBARKOSE to LITHARENITE, some fine rounded conglomerate beds (0-40 feet thick)
		Major Regional Unconformity
Proterozoic Eon, Paleoproterozoic Era, Rhyacian Period, 2.24 to 2.26 Gya — Chocolay Group of the Marquette Range Supergroup — PCk = Kona Formation (undivided) — Carp River Member	PCkp	**Kona Formation, Little Pelissier Member:** Pink to light gray, DOLOSTONE, interbedded with gray argillaceous DOLOSTONE (440-470 feet thick)
	rh	**Kona Formation, Carp River Member, ragged hills bed:** Pink to light gray, DOLOSTONE, interbedded with dark brown ARGILLITE and orange brown dolomitic silty ARGILLITE (150-245 feet thick)
		Minor Diastem Unconformity
	uq	**Kona Formation, Carp River Member, upper quartzite bed:** Pinkish gray, fine crystalline QUARTZITE, with middle variable beds of dolostone and argillite of the same color (45-60 feet thick)
	cbd	**Kona Formation, Carp River Member, color banded dolostone bed:** Light colored DOLOSTONE, interbedded with dark argillites, some light colored quartzite and algal beds (315-340 feet thick)
	v	**Kona Formation, Carp River Member, valley bed:** Various shades of red, brown, and gray, dominantly massive DOLOSTONE, with impure beds and some argillite (500-540 feet thick)
		Moderate Unconformity
Harvey Quarry Member	bcad	**Kona Formation, Harvey Quarry Member, big cusp algal dolostone bed:** Dark gray to red, laminated to bedded, algal DOLOSTONE, with argillite at the base (115-130 feet thick)
	mq	**Kona Formation, Harvey Quarry Member, middle quartzite bed:** Pink to red, massive, crystalline fine to medium grained QUARTZITE (105-130 feet thick)
	gga	**Kona Formation, Harvey Quarry Member, gray-green argillite bed:** Olive green to greenish gray ARGILLITE, with beds of cherty dolostone and quartzite (150-285 feet thick)
Buschell Lake Member	tbcd	**Kona Formation, Buschell Lake Member, thin bedded cherty dolomite bed:** Yellow, pink, and white, cherty and sandy, thin bedded, micritic DOLOSTONE (40-50 feet thick)
		Moderate Unconformity
	lq	**Kona Formation, Buschell Lake Member, lower quartzite bed:** Gray to light gray, bedded, somewhat dolomitic, crystalline fine QUARTZITE, with dolomitic and sandy argillites (100-135 feet thick)
	ga	**Kona Formation, Buschell Lake Member, gray argillite bed:** Gray, laminated to massive, silty ARGILLITE, copper sulfides present at the top (120-170 feet thick)
Proterozoic Eon, Paleoproterozoic Era, Rhyacian Period, 2.26 to 2.30 Gya	PCm	**Mesnard Quartzite:** Whitish gray, thick bedded to massive with cross beds and ripple marks, crystalline fine to medium grained QUARTZITE (200-600 feet thick)
		Regional Unconformity
Proterozoic Eon, Paleoproterozoic Era, Siderian Period, 2.33 to 2.34 Gya	PCe	**Enchantment Lake Formation:** Light brown to gray, coarse conglomerate DIAMICTITE with ARKOSE, SLATE, and METAWACKE above (370-820 feet thick)
		Regional Unconformity
Archean Eon (Undivided), 2.70 to 2.75 Gya	PCms	**Mona Schist:** Dark gray to green, bedded, AMPHIBOLITE SCHIST, stretched pillow structures present (>1000 feet thick)
		Unconformity
	UNK	**Unknown Archean Lithology:** Most likely rock is green to black SCHIST, or red pegmatite GRANITE to GNEISS with black cross cutting dikes (>500 feet thick) *Cross Section Only*

Geologic Cross Section



No Vertical Exaggeration
Horizontal Scale = Map Scale

Introduction

This publication contains a geologic map, cross section, stratigraphic column, and sea level curve of the Kona Formation (or Kona Dolomite) as described by Taylor in his 1972 Ph.D. thesis. It is an attempt to better organize Taylor's original interpretation of the 11 members that he designated as part of the Kona Formation. A remapping of the type section was conducted by the author along with a reinterpretation based on the results of the field mapping. This publication is also an attempt for those interested in the Kona as a quick color reference guide and a simplification of the Kona as defined by Taylor. Taylor's 1972 thesis is very detailed and was printed in black and white. It is also a bit complex for a non stratigrapher to identify Taylor's 11 members in the field. Herein the author attempts to simplify and build upon what Taylor so elegantly described in 1972.

Methods

Field mapping of Taylor's 1972, Kona Dolomite occurred on May 11, 2013. Standard geologic tools were used to include a Brunton Compass (with inclinometer), rock hammer, global positioning system (GPS) receiver, and field map. Field results were compared with Taylor's 1972 report and the data collected on May 11, 2013. Based on the data collected, it was decided to make the following additions and changes to Taylor's 1972 thesis study. The results and conclusions are discussed below.

Discussion

Taylor divided the Kona Formation, which he referred to as the Kona Dolomite, into 11 members. He never formally named any of them. This map keeps his original members as he described them in 1972. However, none of his named members follow the North American Stratigraphic Code, which was new at the time. Based on the 2013 field observations, it was concluded that 11 members is impractical at most locations. Taylor's members have been reduced to informal beds, and will not be formally named herein. What Taylor described as beds have been reduced to informal facies herein, as their lateral extent cannot be verified in most outcrops and rock cores, without detailed study. Patterns observed in the field led the author to decided to take Taylor's members and group them into more manageable, laterally extensive, and easily identified formal members. This publication recognizes four formal members that are extensive and mappable over the entire area where the Kona Formation is present. Member boundaries are placed at distinct lithological breaks for all of the members. All boundaries are placed at the top the most identifiable algal dolostone immediately above the most distinct quartzite within the member. If an algal dolostone layer is missing, the top boundary is placed on top of the most identifiable quartzite (see the Geologic Map and Stratigraphic Column).

Stratigraphy

In general the Kona Formation is an argillite that becomes dominantly dolostone as you go up in section. The four formal members from oldest to youngest are as follows. The basal Buschelle Lake Member, rests conformably on the older Mesnard Quartzite. The Buschell Lake Member is typically gray argillite and capped with a pale quartzite. It also contains most of the copper sulfide mineralization in the Kona, such as chalcopyrite. It is named for Buschell Lake (GPS: 46.50018 –87.39514).

The next member is the Harvey Quarry Member, which is typically green, gray, or pink argillite and is capped by the first thick major occurrence of cherty algal dolostone. It also contains most of the iron associated minerals of the Kona to include hematite and pyrite, most of which occurs in the dominant red quartzite bed of the member. It is named after the abandoned Harvey Quarry off US-41 at Lake Superior (GPS: 46.50343 –87.36393).

The overlying Carp River Member (the bulk of the Kona) is mostly a light colored and mottled algal dolostone that grades upwards into argillite and quartzite that is capped with cherty algal dolostone. It is named for the Carp River, which passes through the type section of the Kona (GPS of the river's mouth at Lake Superior: 46.51867 –87.38406).

The uppermost Little Pelissier Lake Member is a light to dark colored, mostly impure grayish dolostone and argillite, which is cherty at the base. It is named after the Little Pelissier Lake (GPS: 46.49361 –87.44497). It grades upwards into the argillite and slate of the Wewe Formation. The type section for all units divided out of the Kona Formation are at the map location defined in this publication, which is also the type section defined by Taylor in 1972.

Sedimentation

The entire Kona Formation is marine in origin. Most of the deposits are marine shelf to restricted shelf lagoon or tidal flat deposits. During the beginning of Kona sedimentation sea level appears to have been rising and falling in sync with deposition. This results in a relatively stable sea level curve, as vertical sea level regression appears to have kept pace with the deepening of the basin. In the upper part of the Kona, sea level probably did not change much vertically (see the Sea Level Curve). However, lateral sea transgression and regression was probably great due to the very low topography that developed at this time. There are three known unconformities within the Kona and likely many more unrecognized ones. The oldest unconformity on top of the Buschell Lake Member is erosional. The entire lower quartzite bed is missing just a couple of miles to the east at Harvey Quarry near Lake Superior, just south of Marquette Michigan. The middle unconformity exists within the Harvey Quarry Member and also appears to be erosional but minor. The upper unconformity exists within the ragged hills bed of the Carp River Member. It appears to be a small diastem unconformity representing a period of non deposition where a hardground developed on top of what Taylor described as the PS dolostone facies.

Structure

The local structure at the type section is typical of the Precambrian rocks in the area. The Kona type section is near the western edge of an easterly shallow plunging syncline. The syncline itself is tightly folded on the north limb and is nearly vertical. The south limb of the syncline dips more gently. The syncline is cross cut by several dominantly north-south strike-slip faults (see the Geologic Map). The strike-slip faulting is the youngest of the structures to develop in the area. Most likely in response to the closure of the Mid-continental Rift system around 1.05 Gya during the Grenville Orogeny. The unnamed split strike-slip fault in the middle of the Geologic Map was confirmed during the May 2013 field visit. It's age is uncertain, but probably formed during the Grenville Orogeny. The 553 Fault (named herein) is likely related to the other strike-slip faults in the area. A major regional shear zone exists parallel to the north limb and separates the Archean from the younger Proterozoic rocks. The shear zone is the oldest known fault structure in the area (see the Geologic Map and Cross Section). Only one reverse fault is inferred in the study area at the very southeast corner of the map area (Eagle Mills Fault Zone), where total displacement may be as much as 1,300 to 1,500 vertical feet. The age of the reverse fault is not known. The Kona is typically as much as 2,600 feet thick outside of the type area. However, in the type area it is around 1,800 to 2,000 feet thick. This thinning of units is probably due to the fact that the type section sits on the deep dipping north limb of the Power Line Syncline (see the Geologic Map and Cross Section). Some of the argillite beds may have been reduced in volume during compression.

Mineralization

Most of the observed mineralization occurs within the two lower members of the Kona. The Buschell Lake Member contains most of the copper minerals and the Harvey Quarry Member contains most of the iron minerals (see the Geologic Map and Cross Section). The copper mineralization appears to more or less follow bedding and maybe either primary in origin or precipitated from groundwater during the time of the Kona's deposition. The iron tends to follow veining and faulting in the Harvey Quarry Member (see Stratigraphic Column). It likely formed as secondary deposits during hydrothermal activity that occurred when the rocks underwent initial compressive metamorphism around 2.19 Gya at the time of an unnamed Orogeny in Southern Ontario.

Conclusions

The Kona is a thick Proterozoic formation of great lithological variation. Taylor's 11 members of the Kona, as defined in 1972, are not practical field divisions in most cases. The Kona can be divided formally into four easily recognized members in the field and in core samples. The two basal members are where thick quartzites and the majority of mineralization occurs within the Kona Formation. The upper two members are dominated by metamorphosed dolostones and argillites. The local area is a large syncline bounded by a shear zone to the north and a reverse fault to the south.

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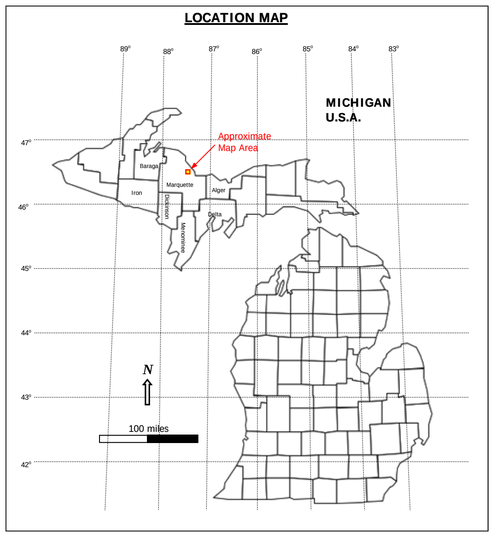
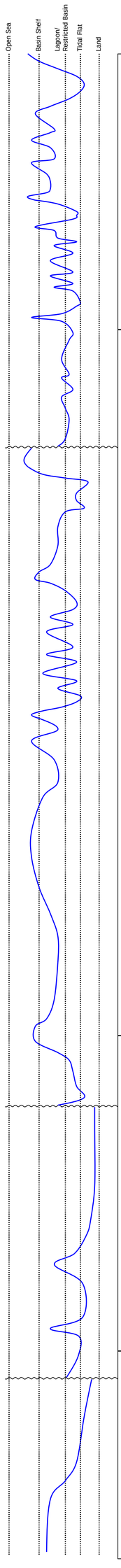
LOCATION MAP



Sea Level Curve



Kona Formation Stratigraphic Column at the Type Section

Column is adapted from Taylor 1972