UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# THERMAL MATURATION VALUES (CONODONT COLOR ALTERATION INDICES) FOR PALEOZOIC ROCKS IN ARIZONA

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature

## PURPOSE

The geographic, stratigraphic, age, and conodont color alteration indices given in this report form the data base for a conodont-based thermal maturation evaluation of Paleozoic rocks in Arizona (Wardlaw and Harris, in press). Many of the sample localities shown on the statewide Paleozoic thermal maturation maps of Wardlaw and Harris represent the range in values of several collections distributed through the Paleozoic section or within an area too small to show at thier compilation scale; such samples are listed separately here. Moreover, the publication scale of the thermal maturation maps of Arizona does not allow precise recovery of geographic coordinates. Consequently, we are presenting our detailed locality data here to further aid resource assessment, exploration, and other geologic investigations.

About 70 percent of the localities are U.S. Geological Survey collections; most localities were specifically sampled for this study and all are from outcrop samples. The remainder are from collections made by other conodont specialists in the course of their biostratigraphic studies. We gratefully acknowledge the cooperation of R. H. Bruns, D. L. Clark, R. L. Ethington, William Purves, and Dietmar Schumacher for making their collections available to us for indexing.

## EXPLANATION OF TABLE NOTATIONS

(Samples are listed alphabetically by county, then chronologically by decreasing geologic age, and lastly by increasing latitude.)

| | |
|---|---|
| Devonian (U) | Conodonts indicate a Late Devonian age |
| Devonian | Conodonts indicate a Devonian age but are not biostratigraphically diagnostic of series |
| Devonian/Mississippian (U/L) | Conodonts indicate a short interval across the Upper Devonian/Lower Mississippian boundary |
| Pennsylvanian (L-M) | Conodonts indicate an Early through Middle Pennsylvanian age |
| CAI | Conodont color alteration index of Epstein and others (1977). A range in values of half (1-1.5) and even a whole (1-2) index is common in many samples. A wider range in values (3-5 or even 1-7) is generally indicative of hydrothermal activity |

Table 1.--Conodont age and thermal maturation values for Paleozoic rocks in Arizona.

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Cochise | 31°33.8'/109°19.1' | Ordovician (L) | El Paso Formation | 3.5-4 |
| " | " | 31°35.2'/109°30.7' | Ordovician (L) | El Paso Formation | 4 |
| " | " | 31°38.1'/109°18.3' | Ordovician (L) | El Paso Formation | 3.5 |
| " | " | 32°01.7'/109°58.1' | Ordovician (L) | El Paso Formation | 4 |
| " | " | 32°02'/109°11.5' | Ordovician (L) | El Paso Formation | 3.5-4 |
| " | " | 32°10.9'/109°38.9' | Ordovician (L) | El Paso Formation | 1-1.5 |
| " | " | 32°11'/109°40' | Ordovician (L) | El Paso Formation | 4-4.5 |
| " | " | 32°09.9'/109°26.9' | Ordovician (U) | Montoya Dolomite | 6-7 |
| " | " | 31°24.4'/109°54.4' | Devonian (U) | Martin Formation | 3.5-4 |
| " | " | 31°27'/109°55' | Devonian (U) | Martin Formation | 2.5-3 |
| " | " | 31°35.0'/109°30.9' | Devonian (U) | Martin Formation | 4 |
| " | " | 31°45.7'/109°47.8' | Devonian (U) | Martin Formation | 4.5-6 |
| " | " | 31°50'/110°23.5' | Devonian (U) | Martin Formation | 5 |
| " | " | 31°50.7'/110°20.8' | Devonian (U) | Martin Formation | 4.5 |
| " | " | 31°59.3'/109°10.3' | Devonian (U) | | 4 |
| " | " | 32°01.2'/109°11.4' | Devonian (U) | Portal Formation | 4.5 |
| " | " | 32°01.3'/109°57.7' | Devonian (U) | Martin Formation | 6.5 |
| " | " | 32°08.6'/110°10.6' | Devonian (U) | Martin Formation | 3-5 |
| " | " | 32°09.9'/109°26.9' | Devonian (U) | | 6 |
| " | " | 32°10.9'/109°38.8' | Devonian (U) | Martin Formation | 5-5.5 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Cochise | 31°24.4'/109°52.7' | Mississippian (L) | Escabrosa Limestone | 6 |
| " | " | 31°24.4'/109°54.3' | Mississippian (L) | Escabrosa Limestone | 3.5 |
| " | " | 31°33.9'/109°19.3' | Mississippian (L) | Escabrosa Limestone | 3.5 |
| " | " | 31°33.9'/109°19.4' | Mississippian (L) | Escabrosa Limestone | 3.5 |
| " | " | 31°34'/109°19' | Mississippian (L) | Escabrosa Limestone | 3.5 |
| " | " | 31°35.1'/109°31.0' | Mississippian (L) | Escabrosa Limestone | 3.5 |
| " | " | 31°41.5'/110°04.0' | Mississippian (L) | Escabrosa Limestone | 5.5 |
| " | " | 31°47.0'/110°23.2' | Mississippian (L) | Escsbrosa Limestone | 4.5 |
| " | " | 31°49.4'/110°24.1' | Mississippian (L) | Escabrosa Limestone | 4.5-5 |
| " | " | 32°02.4'/109°59.9' | Mississippian (L) | Escabrosa Limestone | 6 |
| " | " | 32°05.6'/110°12.4' | Mississippian (L) | Escabrosa Limestone | 5-5.5 |
| " | " | 32°08.3'/110°05.7' | Mississippian (L) | Escabrosa Limestone | 6 |
| " | " | 32°08.7'/110°10.4' | Mississippian (L) | Escabrosa Limestone | 3-3.5 |
| " | " | 32°12.2'/110°1[illegible].5' | Mississippian (L) | Escabrosa Limestone | 5.5-6 |
| " | " | 31°51.2'/109°58.0' | Mississippian (U) | Escabrosa Limestone | 5-5.5 |
| " | " | 32°11.0'/109°39.2' | Mississippian (U) | Escabrosa Limestone | 3.5 |
| " | " | 31°50.1'/110°24.3' | Mississippian | | 4-4.5 |
| " | " | 32°11.3'/109°39.5' | Mississippian | | 2 |
| " | " | 32°13'/110°12.5' | Mississippian | | 4.5-5 |
| " | " | 31°22.9'/109°58.3' | Pennsylvanian (L) | Horquilla Limestone | 1.5-2 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Cochise | 32°02.6'/109°58.5' | Pennsylvanian (L) | Horquilla Limestone | 4 |
| " | " | 32°08.4'/110°05.4' | Pennsylvanian (L-M) | Horquilla Limestone | 5.5 |
| " | " | 31°24.6'/109°52.2' | Pennsylvanian (M) | Horquilla Limestone | 4 |
| " | " | 31°41.4'/110°03.8' | Pennsylvanian (M) | Horquilla Limestone | 6 |
| " | " | 31°31.3'/110°02.4' | Pennsylvanian | Horquilla Limestone | 2 |
| " | " | 31°35.0'/110°01.7' | Pennsylvanian | Horquilla Limestone | 2 |
| " | " | 31°35.1'/109°31.1' | Pennsylvanian | Horquilla Limestone | 2 |
| " | " | 31°38.8'/109°18.6' | Pennsylvanian | Horquilla Limestone | 3 |
| " | " | 31°42.5'/109°48.0' | Pennsylvanian | Horquilla Limestone | 4 |
| " | " | 31°43.4'/110°23.7' | Pennsylvanian | Horquilla Limestone | 3 |
| " | " | 31°44.4'/109°48.2' | Pennsylvanian | Horquilla Limestone | 6 |
| " | " | 31°46.7'/110°23.5' | Pennsylvanian | Horquilla Limestone | 4 |
| " | " | 31°46.8'/110°24.1' | Pennsylvanian | Horquilla Limestone | 6 |
| " | " | 31°47.2'/109°48.8' | Pennsylvanian | Horquilla Limestone | 5.5 |
| " | " | 31°50.6'/110°21.0' | Pennsylvanian | Horquilla Limestone | 3 |
| " | " | 31°51.1'/109°58.3' | Pennsylvanian | Horquilla Limestone | 5.5 |
| " | " | 32°05.5'/110°00.9' | Pennsylvanian | Horquilla Limestone | 3 |
| " | " | 32°07.1'/110°11.2' | Pennsylvanian | Horquilla Limestone | 5.5 |
| " | " | 32°10.9'/109°39.1' | Pennsylvanian | Horquilla Limestone | 2 |
| " | " | 32°12.1'/110°11.0' | Pennsylvanian | Horquilla Limestone | 5.5 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Cochise | 31°25.0'/109°52.1' | Permian (L) | Colina Limestone | 3 |
| " | " | 31°31.4'/109°21.1' | Permian (L) | Concha Limestone | 3 |
| " | " | 31°32.2'/109°22.1' | Permian (L) | Concha Limestone | 3 |
| " | " | 31°35.5'/110°02.4' | Permian (L) | Colina Limestone | 2 |
| " | " | 31°38.2'/110°26.3' | Permian (L) | Concha Limestone | 2 |
| " | " | 31°39.0'/109°57.5' | Permian (L) | Colina Limestone | 2 |
| " | " | 31°40.9'/110°27.4' | Permian (L) | Rain Valley Formation | 2 |
| " | " | 31°41.6'/110°23.2' | Permian (L) | Colina Limestone | 2 |
| " | " | 31°42.6'/109°48.2' | Permian (L) | Epitaph Dolomite | 4 |
| " | " | 31°46.3'/110°23.9' | Permian (L) | Epitaph Dolomite | 6.5-7 |
| " | " | 31°46.4'/110°24.0' | Permian (L) | Epitaph Dolomite | 7 |
| " | " | 32°05.8'/110°00.3' | Permian (L) | Concha Limestone | 3 |
| " | " | 32°06.7'/110°01.4' | Permian (L) | Colina Limestone | 6.5 |
| " | " | 32°07.4'/109°57.9' | Permian (L) | Concha Limestone | 2 |
| " | " | 32°11.2'/109°41.1' | Permian (L) | Concha Limestone | 1 |
| " | " | 32°12.9'/110°15.3' | Permian (L) | Epitaph Dolomite | 2 |
| " | " | 31°40.8'/110°01' | Permian | | 1-1.5 |
| " | Coconino | 36°05'/112°05' | Devonian | Temple Butte Formation | 1.5-2 |
| " | " | 36°20'/112°40' | Devonian | | 1.5-2 |
| " | " | 36°05'/112°05' | Mississippian (L) | Redwall Limestone | 1.5-2 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Coconino | 35°15.5'/111°36.3' | Mississippian | | 1 |
| " | " | 36°12.5'/112°02.5' | Mississippian | | 1 |
| " | " | 35°01'/111°48' | Permian (L) | Kaibab Limestone | 1-1.5 |
| " | " | 35°11.3'/111°38.3' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°20'/111°28' | Permian (L) | Kaibab Limestone | 1-1.5 |
| " | Gila | 33°09.8'/110°47.5' | Devonian (U) | Martin Formation | 5.5 |
| " | " | 33°10.8'/110°48.4' | Devonian (U) | Martin Formation | 2.5-3 |
| " | " | 33°24.1'/110°59.5' | Devonian (U) | Martin Formation | 4.5 |
| " | " | 33°24.9'/110°46.7' | Devonian (U) | Martin Formation | 3 |
| " | " | 33°26.3'/110°50' | Devonian (U) | Martin Formation | 2.5-3 |
| " | " | 33°26.7'/110°48.3' | Devonian (U) | | 2 |
| " | " | 33°39.6'/110°29' | Devonian (U) | | 1-1.5 |
| " | " | 33°00.4'/110°45.3' | Mississippian (L) | Escabrosa Limestone | 6 |
| " | " | 33°10.0'/110°31.7' | Mississippian (L) | Escabrosa Limestone | 1 |
| " | " | 33°10.9'/110°48.6' | Mississippian (L) | Escabrosa Limestone | 1.5-2 |
| " | " | 33°15.4'/110°46.0' | Mississippian (L) | Escabrosa Limestone | 1.5 |
| " | " | 33°15.4'/110°46.1' | Mississippian (L) | Escabrosa Limestone | 1-4 |
| " | " | 33°21.9'/110°32.7' | Mississippian (L) | Escabrosa Limestone | 2-3 |
| " | " | 33°24.1'/110°59.4' | Mississippian (L) | Escabrosa Limestone | 4-4.5 |
| " | " | 33°24.9'/110°46.7' | Mississippian (L) | Escabrosa Limestone | 3 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Gila | 33°26.9'/110°49.5' | Mississippian (L) | Escabrosa Limestone | 3-3.5 |
| " | " | 33°27'/110°49' | Mississippian (L) | Escabrosa Limestone | 2.5-3 |
| " | " | 33°45.1'/111°03.0' | Mississippian (L) | Escabrosa Limestone | 1 |
| " | " | 33°14.6'/110°44.8' | Mississippian | | 2 |
| " | " | 33°17.5'/110°48.1' | Mississippian | | 2 |
| " | " | 33°27'/110°49' | Mississippian | | 3.5-4 |
| " | " | 33°40.4'/111°04.7' | Mississippian | | 2 |
| " | " | 33°47.8'/110°29.5' | Mississippian | | 1.5 |
| " | " | 33°48.8'/110°21.9' | Mississippian | | 1.5 |
| " | " | 33°49.1'/110°27.8' | Mississippian | Escabrosa Limestone | 1.5 |
| " | " | 34°19.5'/111°05.6' | Mississippian | | 1.5 |
| " | " | 33°24.6'/110°46.9' | Pennsylvanian (L) | Naco Group | 2 |
| " | " | 33°00.6'/110°45.1' | Pennsylvanian | Naco Group | 6 |
| " | " | 33°09.8'/110°47.5' | Pennsylvanian | Naco Group | 2 |
| " | " | 33°15.3'/110°46.2' | Pennsylvanian | Naco Group | 1 |
| " | " | 33°24.0'/110°59.4' | Pennsylvanian | Naco Group | 2 |
| " | " | 33°49.6'/110°27.3' | Pennsylvanian | Naco Group | 1.5 |
| " | " | 34°25'/111°21.5' | Permian (L) | Fort Apache Limestone | 1 |
| " | " | 34°36.7'/111°05.9' | Permian (L) | Kaibab Limestone | 1-1.5 |
| " | Greenlee | 33°12.0'/109°22.7' | Ordovician (L) | El Paso Formation | 2 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Greenlee | 33°12.6'/109°22.8' | Mississippian | Escabross Limestone | 1.5-2 |
| " | Mohave | 36°55.1'/113°51.7' | Mississippian (L) | Arrowhead Limestone | 1.5 |
| " | " | 36°55.1'/113°51.7' | Mississippian (L/U) | Monte Cristo Limestone | 1.5-2 |
| " | " | 36°55.1'/113°51.7' | Mississippian (U) | Monte Cristo Limetone | 1.5 |
| " | " | 35°32.9'/113°22.7' | Mississippian | Redwall Limestone | 1-1.5 |
| " | " | 36°05.6'/114°03.6' | Mississippian | Redwall Limestone | 1.5-2 |
| " | " | 36°55.9'/113°50.3' | Mississippian | Muddy Peak Formation | 1.5 |
| " | " | 36°55.9'/113°50.2' | Mississippian | Muddy Peak Formation | 1.5-2 |
| " | " | 35°47'/113°36.2' | Pennsylvanian | Supai Formation | 1-1.5 |
| " | " | 36°06.5'/114°03.1' | Pennsylvanian | Callville Limestone | 1.5-2 |
| " | " | 36°26,7'/113°58.9' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°28.9'/113°59.4' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°32'/113°20' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°38.1'/113°41.9' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°42.3'/113°43.4' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°50.1'/113°39.8' | Permian (L) | Kaibsb Limestone | 1 |
| " | " | 36°51.8'/113°39.3' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°54.2'/113°39.8' | Permian (L) | Kaibab Limestone | 1 |
| " | " | 36°55.8'/113°38.7' | Permian (L) | Kaibab Limestone | 1 |
| " | Navajo | 34°24.1'/110°31.5' | Permian (L) | Kaibab Limestone | 1-1.5 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| " | Pima | 31°43.9'/110°45.9' | Devonian (U) | Martin Formation | 4-6 |
| " | " | 32°22.7'/111°34.9' | Devonian (U) | Martin Formation | 5.5 |
| " | " | 31°43.9'/110°45.8' | Mississippian (L) | Escabrosa Limestone | 1-7 |
| " | " | 32°21'/111°29.5' | Mississippian | | 4 |
| " | " | 32°22.7'/111°34.7' | Mississippian | Escabrosa Limestone | 5.5 |
| " | " | 31°52.5'/110°37.8' | Pennsylvanian (L) | Horquilla Limestone | 5.5 |
| " | " | 32°03.7'/110°37.3' | Pennsylvanian (L) | Horquilla Limestone | 5.5 |
| " | " | 32°22.6'/111°34.7' | Pennsylvanian (L) | Hoquilla Limestone | 5.5 |
| " | " | 32°26.3'/110°31.3' | Pennsylvanian (M) | Naco Group | 5.5 |
| " | " | 31°43.6'/110°45.4' | Permian (L) | Rain Valley Formation | 2 |
| " | " | 31°44.9'/110°28.4' | Permian (L) | Rain Valley Formation | 2 |
| " | " | 31°52.2'/110°37.8' | Permian (L) | Rain Valley Formation | 5.5 |
| " | " | 31°55.9'/110°39.4' | Permian (L) | Rain Valley Formation | 5-5.5 |
| " | " | 31°57.9'/111°04.7' | Permian (L) | Concha Limestone | 5.5 |
| " | " | 32°02.1'/110°40.7' | Permian (L) | Epitaph Dolomite | 6 |
| " | " | 32°02.2'/110°40.4' | Permian (L) | Concha Limestone | 5.5 |
| " | " | 32°09.5'/111°06.8' | Permian (L) | Concha Limestone | 5.5 |
| " | " | 32°14.2'/112°07.5' | Permian (L) | | 4 |
| " | " | 32°20.4'/111°27.8' | Permian (L) | Concha Limestone | 5.5 |
| " | " | 32°20.9'/111°27.1' | Permian (L) | Colina Limestone | 3 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|---|
| ARIZONA | Pima | 32°22.1'/111°34.6' | Permian | (L) | Concha Limestone | 5.5 |
| " | Pinal | 32°50.5'/110°43.5' | Devonian | (U) | Martin Formation | 1.5-2 |
| " | " | 32°53.1'/110°36.1' | Devonian | (U) | Martin Formation | 1.5-3 |
| " | " | 33°17.3'/111°05.3' | Devonian | (U) | Martin Formation | 4 |
| " | " | 33°17.6'/111°05.5' | Devonian | (U) | Martin Formation | 5.5 |
| " | " | 32°32.6'/110°42.5' | Dev./Miss. | (U/L) | Escabrosa Limestone | 5.5 |
| " | " | 33°17.6'/111°05.4' | Dev./Miss. | (U/L) | Escabrosa Limestone | 5.5 |
| " | " | 32°53.0'/110°36.1' | Mississippian | (L) | Escabrosa Limestone | 1 |
| " | " | 32°53.0'/110°36.1' | Mississippian | (L) | Escabrosa Limestone | 4 |
| " | " | 32°31.6'/110°42.5' | Mississippian | | | 4-4.5 |
| " | " | 32°33.2'/112°06.4' | Mississippian | | | 5.5 |
| " | " | 32°50.5'/110°43.4' | Mississippian | | Escabrosa Limestone | 1 |
| " | " | 32°58.9'/110°38.8' | Mississippian | | | 1.5 |
| " | " | 33°17.3'/111°05.4' | Mississippian | | | 4-4.5 |
| " | " | 33°10.1'/110°31.8' | Pennsylvanian | (L-M) | Naco Group | 1 |
| " | " | 33°18.3'/111°05.1' | Pennsylvanian | (M) | Naco Group | 2-3 |
| " | " | 32°50.5'/110°43.5' | Pennsylvanian | | | 1.5-2 |
| " | " | 33°00.2'/110°45.9' | Pennsylvanian | | Naco Group | 2 |
| " | Santa Cruz | 31°25.9'/110°42.7' | Mississippian | (L) | Escabrosa Limestone | 5-5.5 |
| " | " | 31°26.1'/110°42.8' | Mississippian | | | 6 |

| STATE | COUNTY | LATITUDE/LONGITUDE | SYSTEM (SERIES) | STRATIGRAPHIC UNIT | CAI |
|---|---|---|---|---|---|
| ARIZONA | Santa Cruz | 31°25.8'/110°42.7' | Pennsylvanian (M) | Horquilla Limestone | 6 |
| " | " | 31°26.6'/110°43.4' | Permian (L) | Colina Limestone | 5.5 |
| " | " | 31°39.5'/110°57.2' | Permian (L) | Colina Limestone | 7 |
| " | " | 31°40.5'/110°56.5' | Permian (L) | Concha Limestone | 5.5-6 |
| " | " | 31°40.7'/110°57.0' | Permian (L) | Concha Limestone | 5.5 |
| " | " | 31°42.7'/110°45.6' | Permian (L) | Rain Valley Formation | 2 |
| " | Yavapai | 34°46'/112°06.5' | Devonian (M) | | 1-1.5 |
| " | " | 34°57'/112°54' | Devonian (M) | | 1.5 |
| " | " | 35°17'/112°55' | Devonian (M) | | 1.5 |
| " | " | 34°52'/112°04' | Devonian (U) | | 1.5 |
| " | " | 35°09'/113°15' | Devonian (U) | | 1.5-2 |
| " | " | 34°42.5'/112°12.3' | Devonian | | 1.5 |
| " | " | 34°53'/112°21.8' | Devonian | | 1.5-2 |
| " | " | 35°13.2'/112°53.0' | Devonian | | 2 |
| " | " | 34°44.5'/112°08.8' | Mississippian | | 1-1.5 |
| " | " | 34°38'/111°42.5' | Permian (L) | Fort Apache Limestone | 1 |
| " | Yuma | 33°38.3'/114°02.6' | Permian (L) | Kaibab Limestone | 5.5-6 |
| " | " | 33°46'/113°31.8' | Permian | | 7 |

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