RRVD #8A

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Weathered Precambrian Basement Rocks of the Red River Valley

- Part of the Superior craton of the Canadian Shield
- Consists of metavolcanic and metasedimentary rocks
- Weathered portion can be up to 200 ft thick. In our location it is 65 ft thick (Kelley, 1980)
- The weathered zone is high in Kaolinite-rich clays (Moore, 1978)
- Above the weathered zone, an nonconformity is present (Moore, 1978)
- At the location of well 8A, the weathered Precambrian is overlain by the Ordovician WInnipeg group (Moore, 1978)

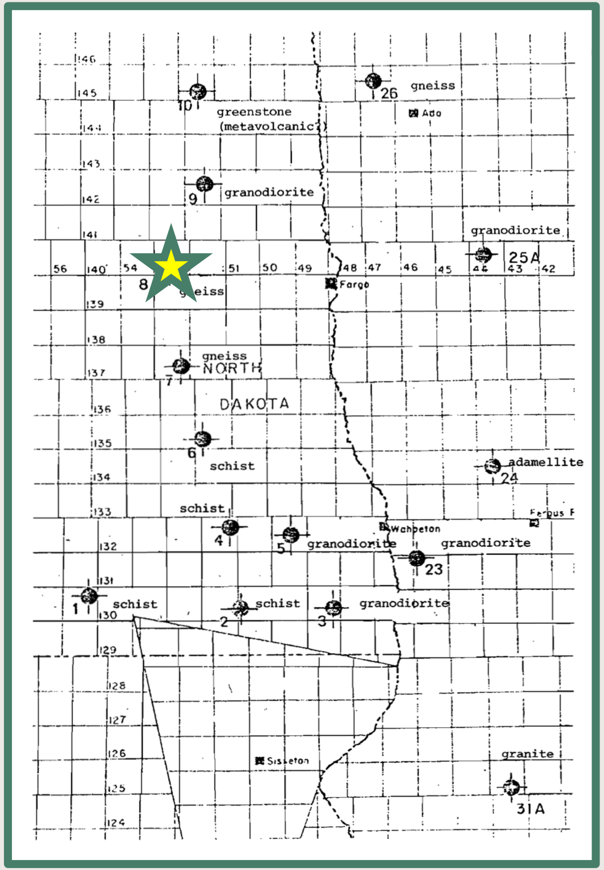
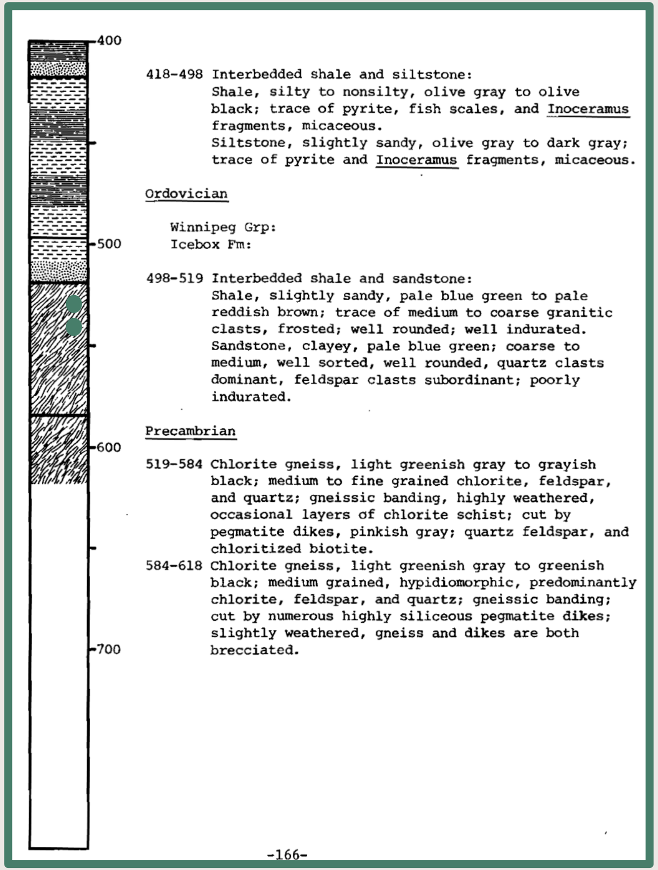


Fig 1: Location of drill cores in the RRVD project (Moore, 1978). RRVD 8A marked with a star.


400

418-498 Interbedded shale and siltstone:
Shale, silty to nonsilty, olive gray to olive black; trace of pyrite, fish scales, and Inoceramus fragments, micaceous.
Siltstone, slightly sandy, olive gray to dark gray; trace of pyrite and Inoceramus fragments, micaceous.

Ordovician

Winnipeg Grp:
Icebox Fm:

500

498-519 Interbedded shale and sandstone:
Shale, slightly sandy, pale blue green to pale reddish brown; trace of medium to coarse granitic clasts, frosted; well rounded; well indurated.
Sandstone, clayey, pale blue green; coarse to medium, well sorted, well rounded, quartz clasts dominant, feldspar clasts subordinant; poorly indurated.

Precambrian

600

519-584 Chlorite gneiss, light greenish gray to grayish black; medium to fine grained chlorite, feldspar, and quartz; gneissic banding, highly weathered, occasional layers of chlorite schist; cut by pegmatite dikes, pinkish gray; quartz feldspar, and chloritized biotite.
584-618 Chlorite gneiss, light greenish gray to greenish black; medium grained, hypidiomorphic, predominantly chlorite, feldspar, and quartz; gneissic banding; cut by numerous highly siliceous pegmatite dikes; slightly weathered, gneiss and dikes are both brecciated.

700

-166-

Fig 2: Approximate depth of samples at 524.5' and 534.5' deep.

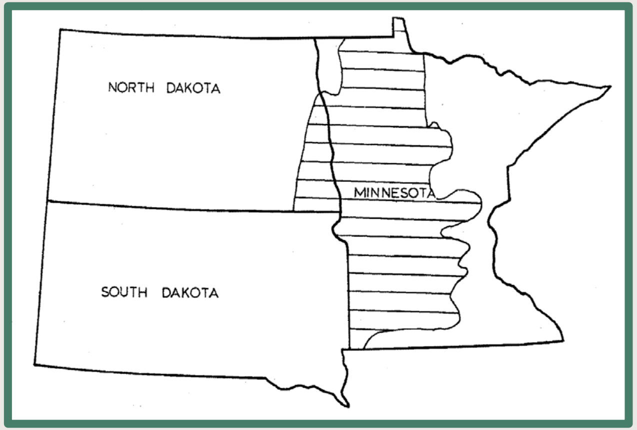


Fig 3: Extent of the weathered Precambrian (Kelley, 1980)

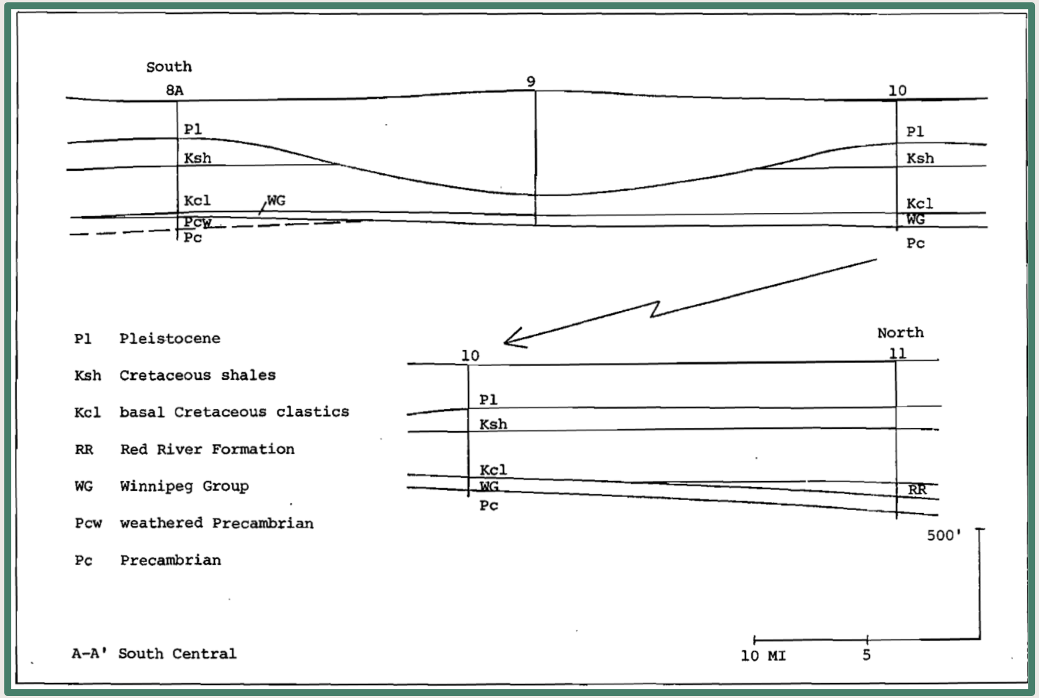


Fig 4: South to North cross section based on drill cores near the eastern border of North Dakota (Moore, 1978).

Our Core Samples

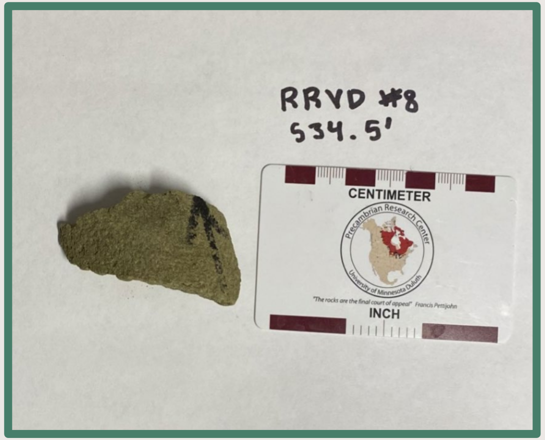


Fig 5: RRVD #8A 534.5’

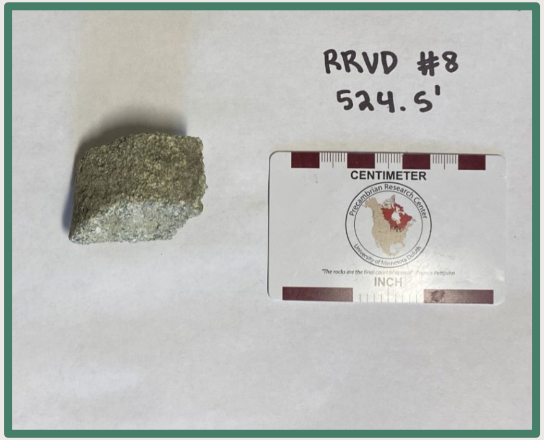


Fig 6: RRVD #8A 524.5’

Thin Section N/A

Thin Section Methods 534.5’

- Our first step was to “Stabilize” our highly weathered sample
- Used a vacuum chamber to saturate the sample with resin
- Sanded our sample to create a smooth surface
- Glued our sample to a slide
  - While cutting our sample the resin did not fully saturate the sample resulting in it failing and falling apart

Thin Section Methods 524.5'

- Our first step was to "Stabilize" our highly weathered sample
- Used a vacuum chamber to saturate the sample with resin
- Sanded our sample to create a smooth surface
- Glued our sample to a slide
- We were able to cut our sample thin enough for microscope observation
- We were unable to get our sample thin our due to its weathered nature
- Our mineral grains were not showing up properly

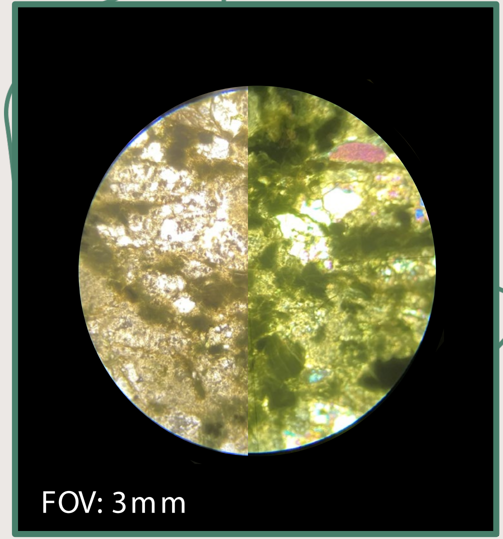


Fig 7: Sample 8A 524.5' in Plane Polarized Light (left) and Cross Polarized Light (right)

Grain focus

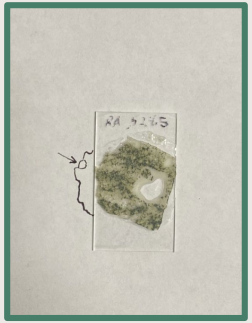


Fig 8: Thin section for sample 8A 524.5'

- We selected a grain of focus
- We were not sure if it was quartz or not

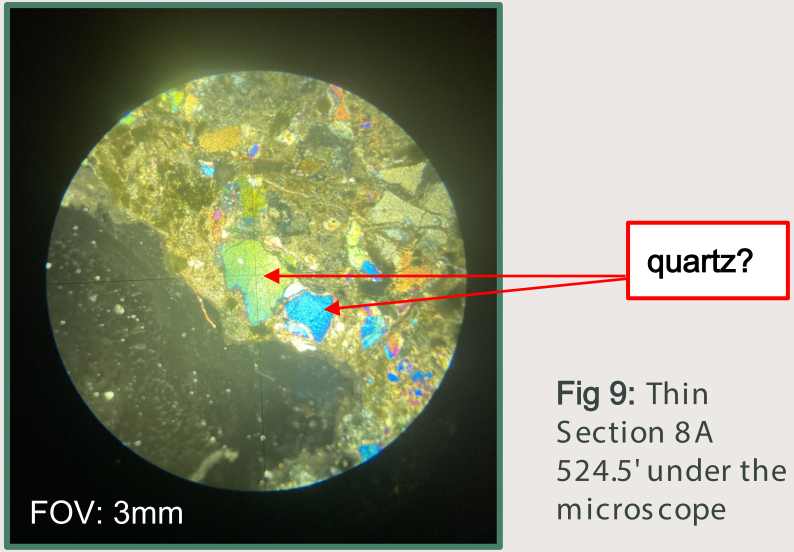


Fig 9: Thin Section 8A 524.5' under the microscope

- High retardation color range
- Quartz is supposed to be near colorless
- Did we sand it enough?

SEM Methods

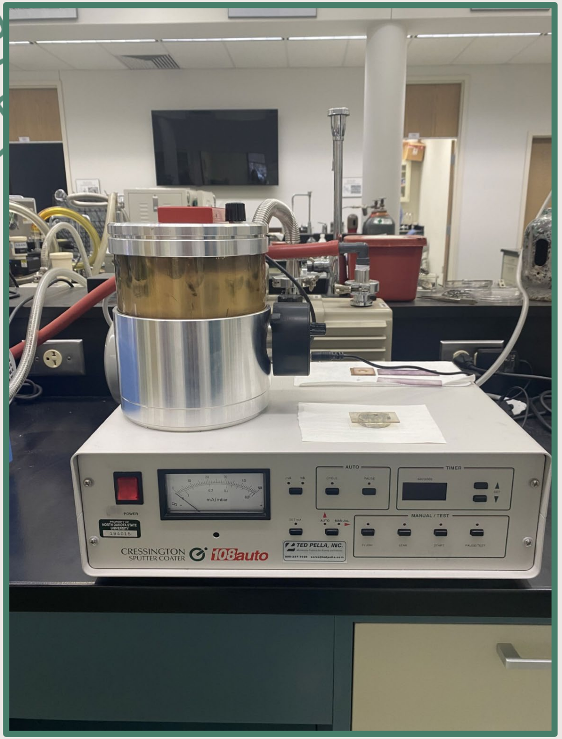


Fig 10: Sputter coater used to coat the thin section in gold (Au)

- Thin section 8A 524.5'
- Sputter coater placed a very thin layer of gold onto our sample
    - Helps with conductivity in the SEM microscope
    - Shows up on the tests
- JEOL JSMT200LA
- Energy-dispersive X-ray Spectroscopy (EDS) analysis used to identify individual mineral grains

Fig 11:Ashley and Grace using the SEM

SEM findings

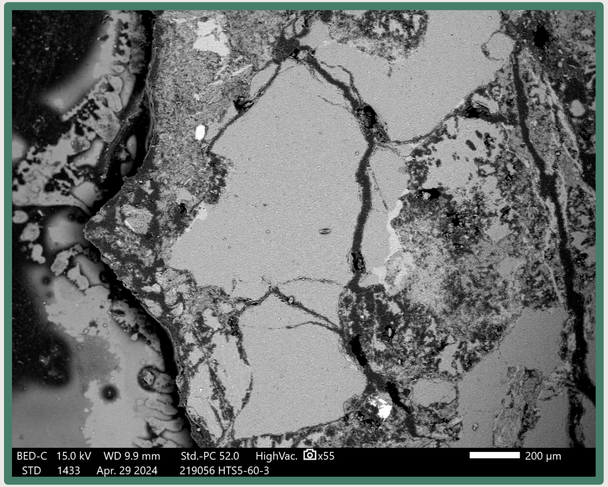


Fig 12: SEM image of quartz grains in sample 8A 524.5'

- Quartz is a common mineral in our sample
- Iron oxides
- Monazite
- Zircon

Unique mineral findings

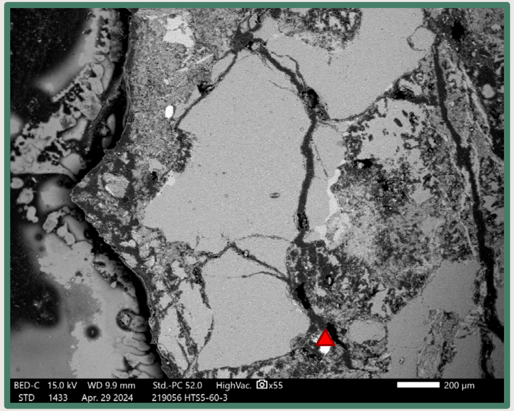


Fig 13: Red triangle shows the location of the Monazite grain

Monazite

- A phosphate mineral that contains rare - earth elements (REE)
- Found a single grain in our #8A 524.5 sample in the SEM
- Potential mining opportunities for REE's

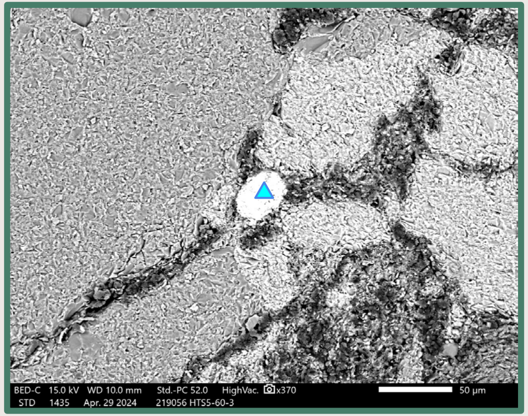
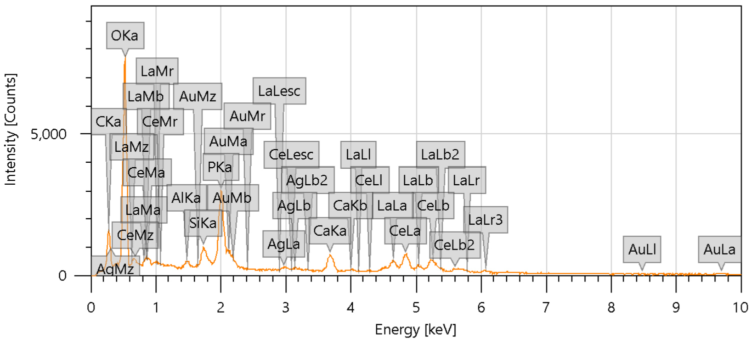


Fig 14: Zircon grain in sample 8A 524.5' marked with blue triangle

Zircon

- Found a grain in our #8A 524.5
- If we had time we could have done age dating

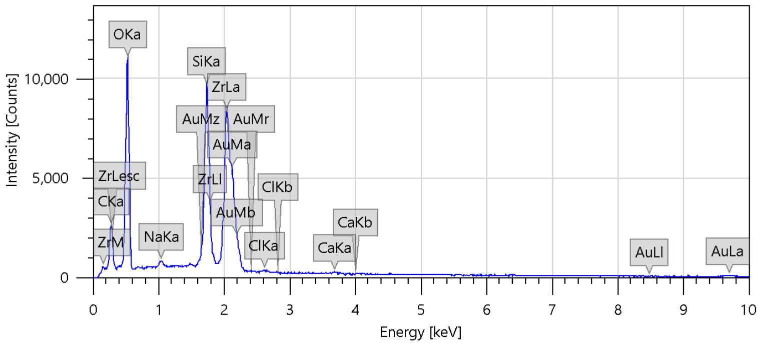


Items	Value
measurement conditio	
Acceleration voltage	15.00 kV
Probe current	-
Magnification	x 55
Process time	T4
Measurement detector	First
Live time	30.00 seconds
Real time	34.99 seconds
Dead time	14.00 %
Count rate	9576.00 CPS

Display name	Standard data	Quantification method	Result Type
Spc_006	Standardless	ZAF	Oxide (Number of oxyg

Chemical formula	Line	Mass%	Mol%	Cations
C	K			
O	K			
Al2O3	K	1.91±0.09	2.54±0.12	0.42
SiO2	K	5.01±0.14	11.33±0.31	0.93
P2O5	K	36.00±0.33	34.43±0.32	5.65
CaO	K	7.48±0.14	18.09±0.34	1.48
Ag2O	L	1.84±0.10	1.08±0.06	0.18
La2O3	L	13.77±0.30	5.74±0.12	0.94
CeO2	L	33.99±0.45	26.80±0.36	2.20
Au2O3	M			
Total		100.00	100.00	
Spc_006				Fitting ratio 0.0279

Fig 15: EDS intensity counts for a monazite grain in 8A 524.5''



Items	Value
measurement conditio	
Acceleration voltage	15.00 kV
Probe current	-
Magnification	x 370
Process time	T4
Measurement detector	First
Live time	30.00 seconds
Real time	38.62 seconds
Dead time	22.00 %
Count rate	15780.00 CPS

Display name	Standard data	Quantification method	Result Type
Spc_009	Standardless	ZAF	Oxide (Number of oxyg

Chemical formula	Line	Mass%	Mol%	Cations
C	K			
O	K			
Na2O	K	0.93±0.04	1.35±0.05	0.33
SiO2	K	32.52±0.18	48.82±0.27	5.98
Cl	K	0.38±0.03	0.96±0.06	0.00
CaO	K	0.47±0.04	0.76±0.07	0.09
ZrO2	L	65.70±0.33	48.10±0.24	5.89
Au2O3	M			
Total		100.00	100.00	
Spc_009				Fitting ratio 0.0176

Fig 16: EDS intensity counts for a zircon in 8A 524.5''

X-Ray Diffraction Methods

- A powder was created from each sample
- Each powder was placed on a slide then wet
- The powder was spread out on the slide to create a thin even layer
- The slides were labeled with the sample number
- Each slide was analysed at the NDSU Research 2 facility using an X-Ray Diffractometer
- X'PERT HighScore software was used to define peaks and search for matches

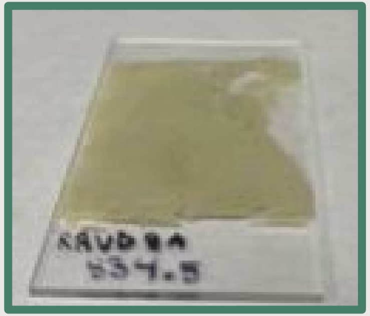


Fig 17:RRVD 8A 534.5' prepared for XRD

XRD Results: 524.5'

Silica, Orthoclase, Kaolinite

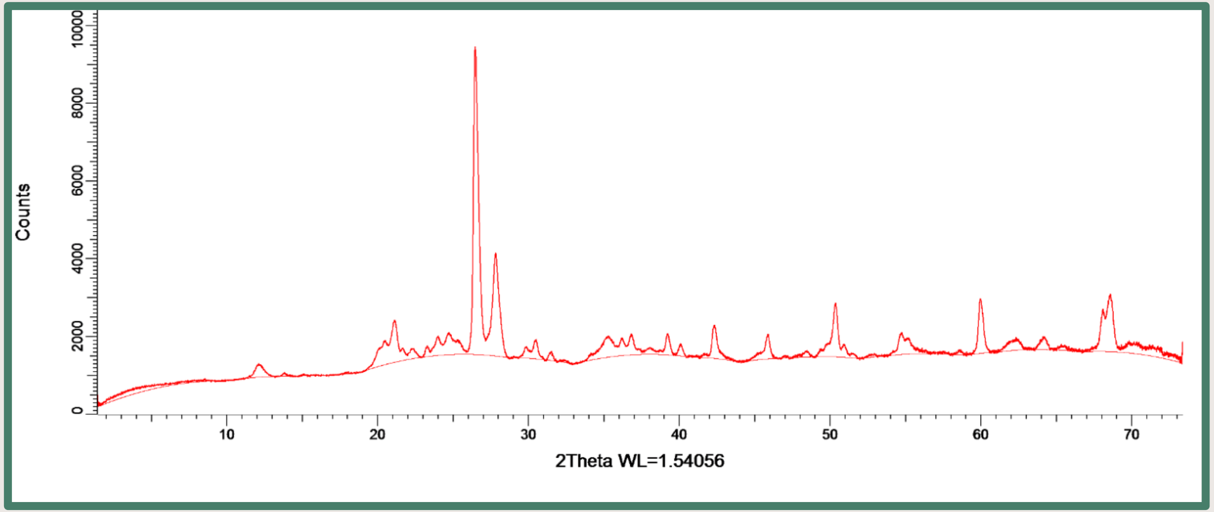


Fig 18: XRD pattern for the sample from 524.5' deep

XRD Results: 534.5'

Silica, Sanidine, Kaolinite, Kaolinite -Montmorillonite

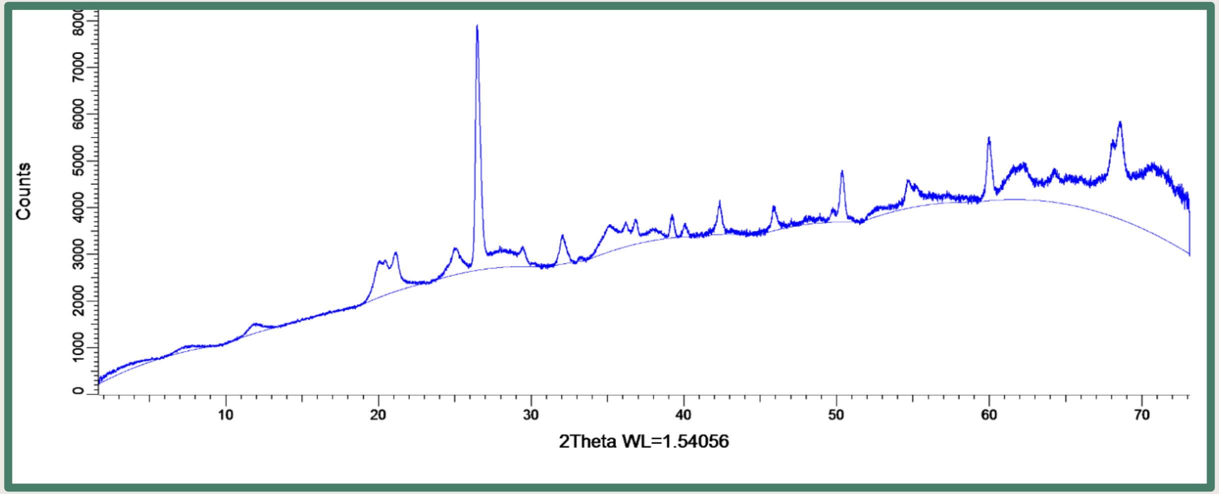


Fig 19: XRD pattern for the sample from 534.5' deep

XRF Methods

- The samples were ground into a fine, even powder
- Liquid plastic was thoroughly mixed in to the powder to provide cohesion
- The powder was pressed into a pellet
- The specimens were analyzed using an XRF spectrometer
- The weight percents of oxides were transferred to Microsoft Excel
- The Chemical Index of Alteration (CIA) was calculated for the two samples
- CIA was also calculated for other depth within drill core 8A using data from Kelley, 1980.

Chemical Index of Alteration

$$CIA = [Al_2O_3/(Al_2O_3 + CaO^* + Na_2O + K_2O] \times 100$$

Fig 20: CIA formula (Nesbitt and Young, 1982)

- Measures the proportion of Al_2O_3 to easily weathered oxides
- Lower values occur in fresh rock.
- The higher the value, the more altered the rock is

Chemical Index of Alteration

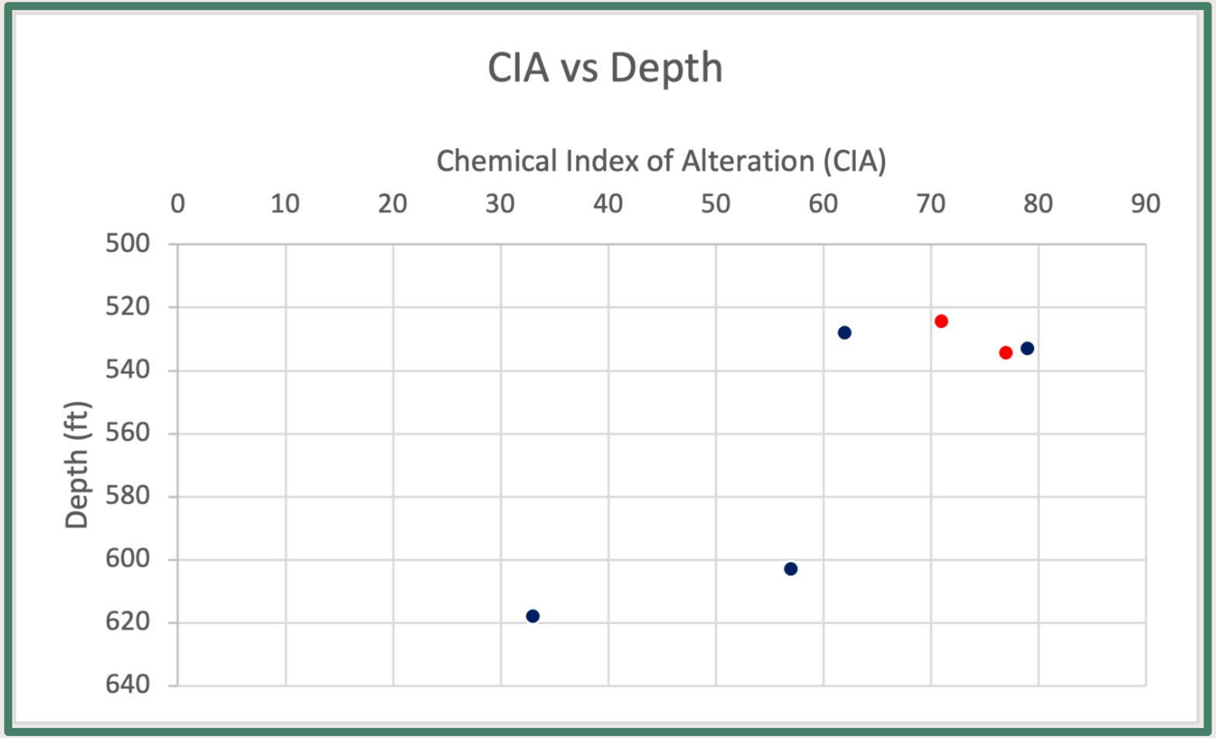


Fig. 21: A plot of the Chemical Index of Alteration (CIA) against depth. The points in red are the samples we analysed, while the points in blue were analysed by Kelley in 1980.

The CIA is higher at shallower depths, indicating greater weathering

The CIA at 618 ft deep is 33, which is in the same range as unweathered basalts (Nesbitt and Young, 1982)

Conclusion

- XRD and XRF analysis agree with the hypothesis that kaolinitic clays are present in these samples
- This is consistent with the idea that these Precambrian rocks were weathered during the time of the Great Unconformity
- Generally, the Chemical Index of Alteration is lower at greater depths
- This supports the claim of Moore in 1978 that the weathering was in situ

Works Cited

Kelley, L.I., 1980, Kaolinitic weathering zone on Precambrian basement rocks, Red River valley , eastern North Dakota and northwestern Minnesota [Ph.D. thesis]: University of North Dakota, 85 p.

Moore, W.L., 1978, A preliminary report on the geology of the Red River Valley drilling project, eastern North Dakota and northwestern Minnesota: , 293 p.

Nesbitt, H.W., and Young, G.M., 1982, Early Proterozoic climates and plate motions inferred from major element chemistry of lutites: Nature, v. 299, p. 715-717, doi:.1038/299715a0.

Acknowledgements

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Questions?