# GEOCHEMISTRY OF CHERT, SILICIFIED LIMESTONE, AND LIMESTONE OF THE OCALA LIMESTONE

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## Abstract

Chert is a sedimentary silicate that typically forms on the bottom of marine environments from siliceous ooze made up of the skeletal remains of planktonic organisms such as diatoms and radiolarians; though chert can also form as a precipitate. Chert is commonly found in the Eocene upper Ocala Limestone. It occurs alongside soft, muddy limestone, and silicified limestone. Using specimens collected from the Ocala Limestone in Center Hill, Florida, portable x-ray florescence (pXRF) was used to determine the geochemistry of the chert and the surrounding rock. Geochemistry can reveal where the chert was deposited and how its formation affected the geochemistry of the surrounding limestone. Limestone is high in Ca and low in Si. Silicified limestone is relatively high in both Ca and Si. Chert is high in Si, low in Ca, Al is below detection limit of the pXRF, and Fe2O3/SiO2 ratios are below 1. The low Fe/Si ratio suggests a shallow marine environment for the cherts. The high Fe and lack of Al suggests the cherts formed as precipitates in the limestone. This is in concordance with the depositional environment of the Ocala Limestone and the nodular structure of the chert deposits. The linear Si-Ca relationship between the chert, silicified limestone, and limestone demonstrates a chemical exchange between the cherts and limestones. This is visible in the rocks themselves as a banded gradient of dark cherts, lighter silicified limestone, and fossiliferous limestone.

## Introduction

Chert is a silicate rock commonly associated with marine environments. The geochemistry of chert can be used to determine the paleoenvironment of the area in which deposition happens. This can also be used to determine where the cherts came from after being removed from the area in which they were extracted. Cherts, limestones, and silicified limestones were collected from the upper Ocala Limestone in Center Hill, Florida. The Ocala Limestone ranges from the upper Eocene (55 mya) to the uppermost Oligocene (33 mya) (Miller, 1986). In the Ocala Limestone chert is found in the upper Eocene portion in nodular masses surrounded by fossiliferous limestone (Scott, 1992).

## Location

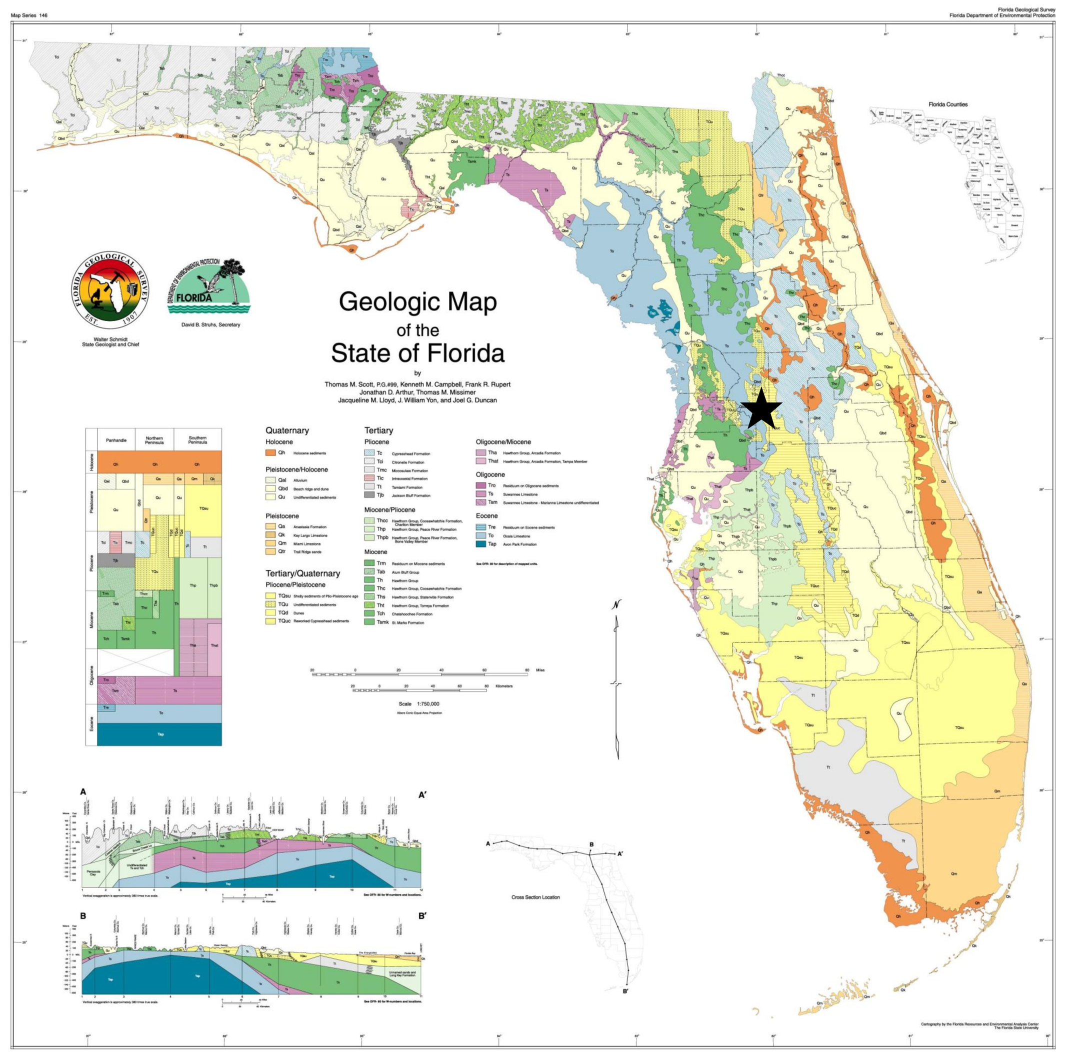


Figure 1: Geologic Map of the State of Florida (Scott, et. al, 2001). Center Hill marked with a star

## Methods

A SciAps X-550 pXRF was used to measure major and trace elements using two modes of measurement, soil and mining. Soil mode was used to measure elements with low ppm concentrations while mining mode was used to measure major elements by weight percentage (wt. %). The results were calibrated using pXRF X-550 correction factors.


Figure 2: Cherty rocks from CEMEX's Center Hill quarry.

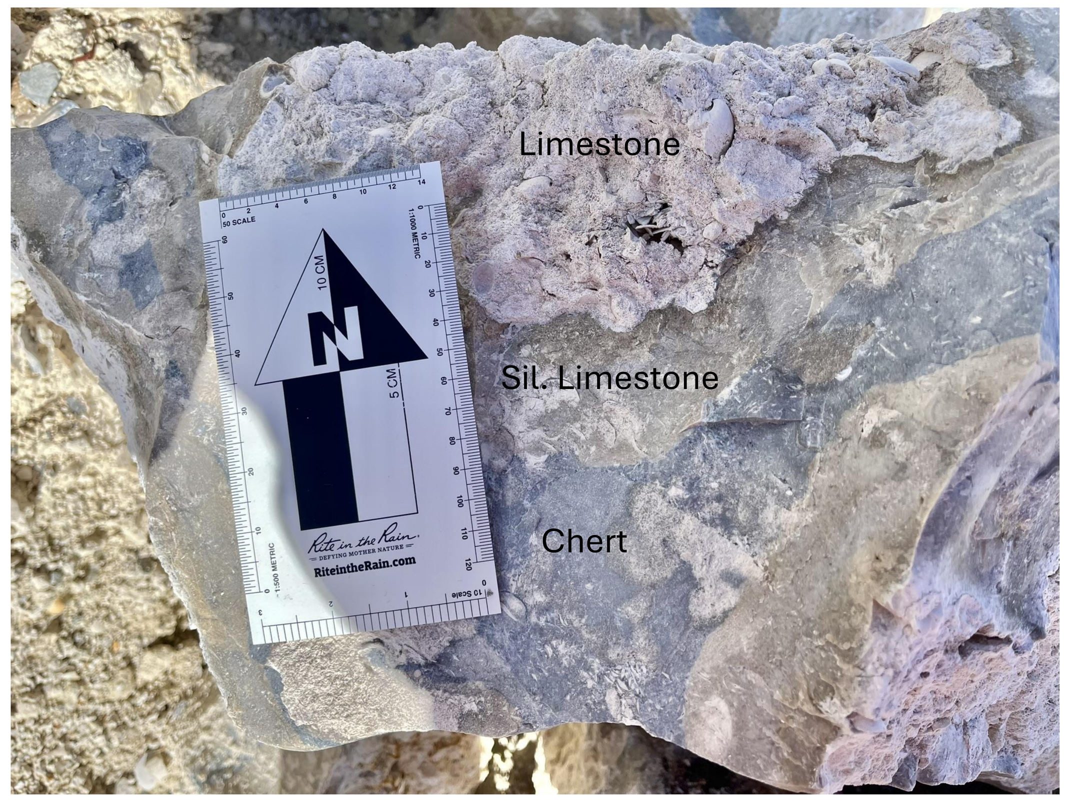


Figure 3: Fossiliferous limestone, silicified limestone, and chert from Center Hill, Florida. The banding of the different sedimentary rocks can be clearly seen.

## Results

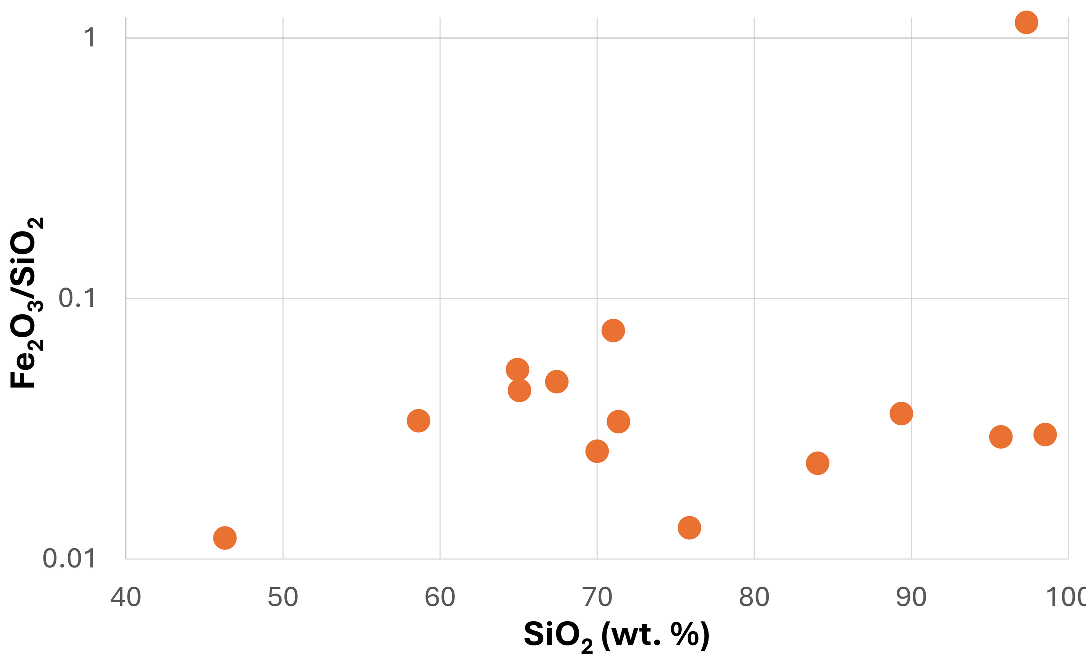


Figure 4: Iron/Silicon ratio to Silicon by weight percent. Data is plotted semilogarithmic. The values generally being under 1 is indicative of precipitated chert (Murray, 1994).

## Results cont.

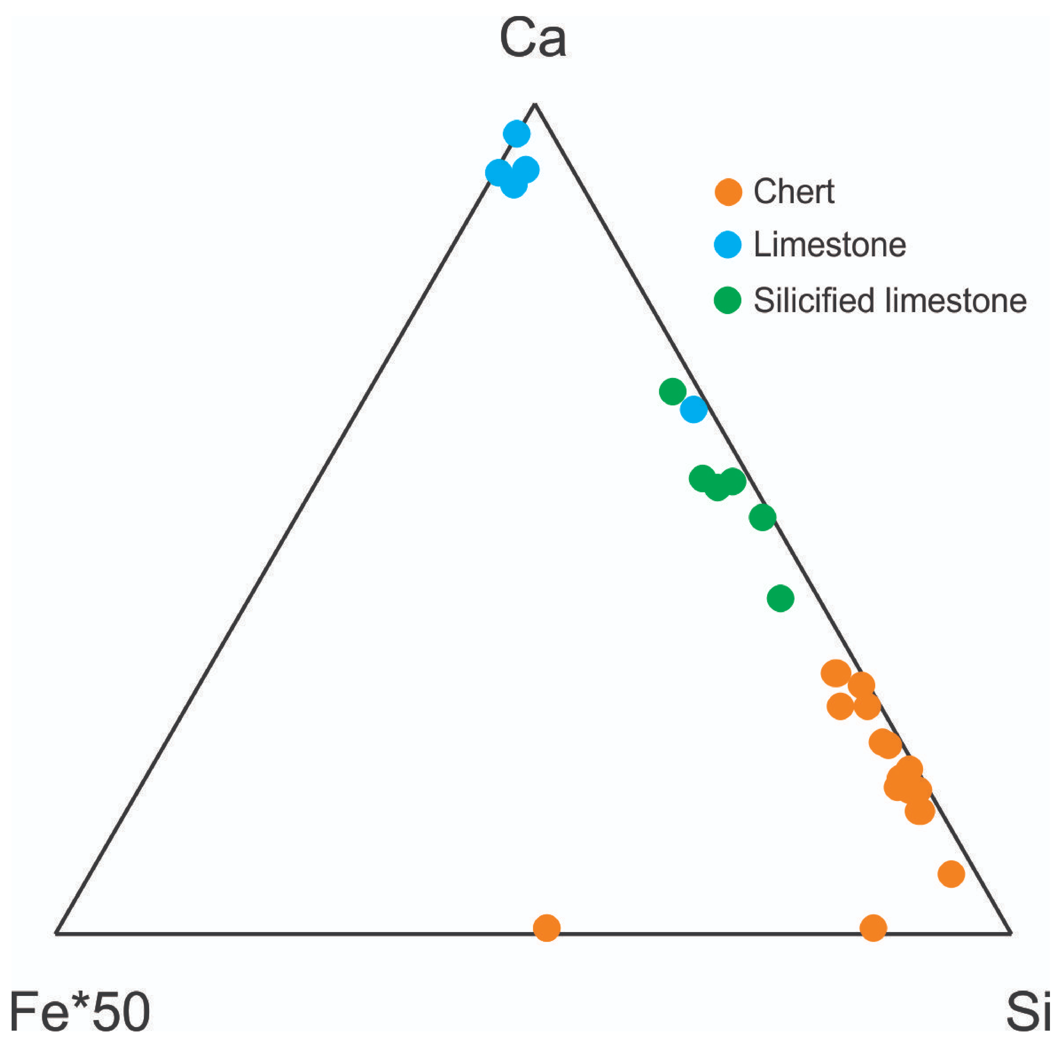


Figure 5: Iron, Calcium, Silicon diagram showing a linear relationship in the geochemistry of chert, silicified limestone, and limestone in Ocala Limestone rocks.

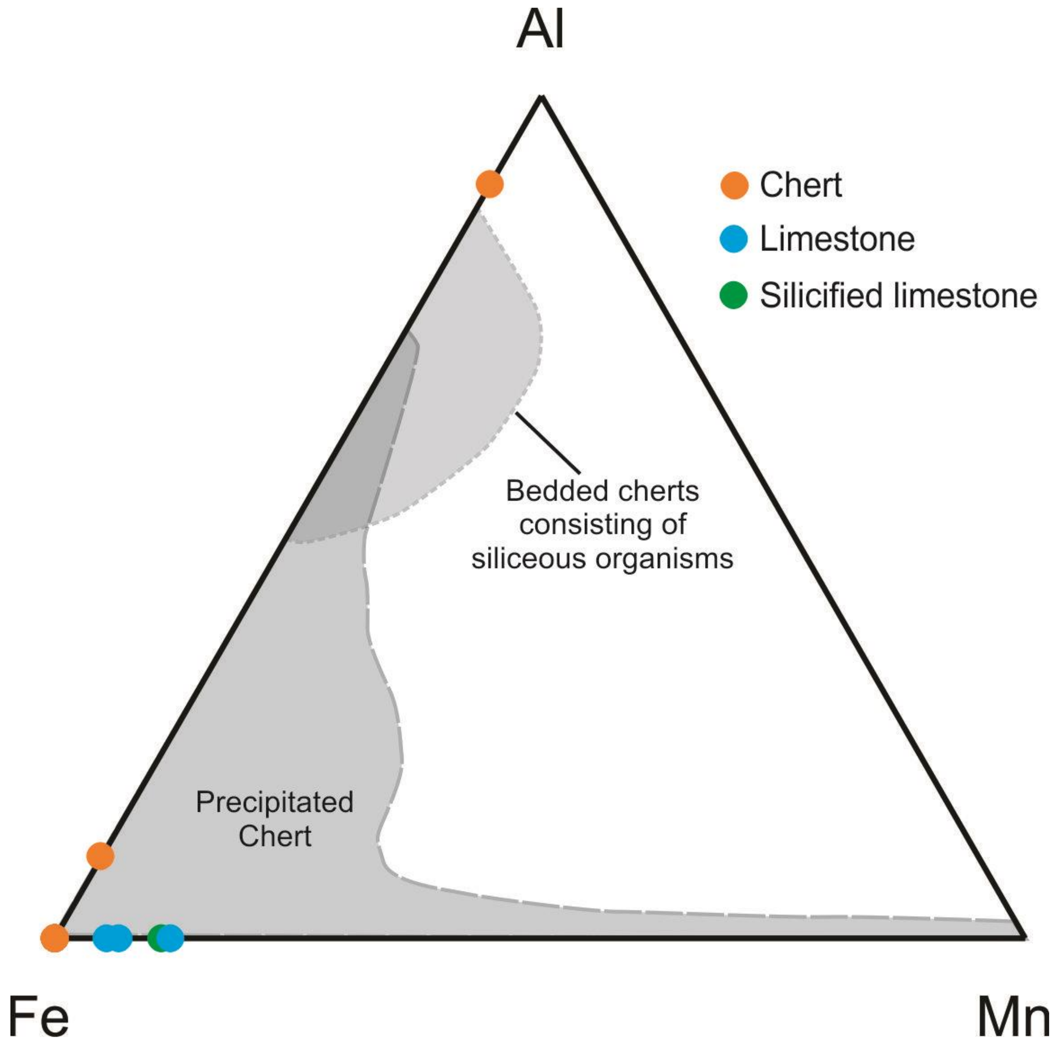


Figure 6: Iron, Aluminum, Manganese diagram illustrating the presence of Fe in Center Hill rocks. Iron is terrigenous in origin, indicating chert formation by precipitation through a matrix. Aluminum would be expected in bedded cherts formed through lithification of planktonic skeletons. Fields for precipitated and bedded chert are from Yamamoto (1987).

## Connection to the Curriculum

Knowledge from Coastal and Watershed Geology was indispensable for understanding the formation of the sedimentary rocks of the Ocala Limestone. Minerology and Petrology was likewise very useful due to its focus on the chemistry of rocks. Knowledge of sedimentary structures and geological processes from Structural Geology was used throughout. Hydrology was useful in background research, as the relationship between water and geological structures was a constant presence in this research.

## Discussion

A $Fe_2O_3/SiO_2$ ratio of under 1 suggests a shallow water depositional environment (Murray, 1994). Figure 4 shows that collected samples generally have a Fe2O3/SiO2 ratio under one. This is in concordance with Miller, 1984, which interprets the Ocala Limestone as shallow water based on the fossils found in the limestone (Miller, 1984).

The chemistry of chert is determined by the elemental composition of particulate matter included in the rock, elements in the water absorbed into the mix, and physical transformation that occurs during lithification. Chemical interactions between chert and other rocks commonly occur during deposition (Murray, 1994). In the Ocala Limestone this is evident in the interactions between the deposited cherts and the limestones found adjacent. The chemical interaction can be seen in the linear relationship between Ca and Si in collected specimens, Si being most present in the cherts, about 40% by weight, Ca in the limestones, 30% by weight, and the silicified limestones bridging the two, consisting of 20% Ca and 20% Si by weight (Figure 5). This interaction can be observed in the visible banding of the rocks at Center Hill (Figure 3) with the dark cherts being surrounded by lighter silicified limestone and fossiliferous limestone.

Chert can be deposited in uniform beds made up of the remains of siliceous organisms, such as diatoms, or form irregular bodies in other sedimentary, though usually carbonate, rocks through diagenetic replacement. The latter is referred to as nodular chert (Boggs, 2012). Ocala Limestone chert is nodular, and the geochemistry is in concordance with this. The high Fe, negligible Al and Mn (Figure 6) place all but one of collected specimens solidly in the field of precipitated cherts (Yamamoto, 1987). The silica content of the collected specimens is below 50% by weight, which is typical of nodular cherts (Cressman, 1962).

## Conclusion

The geochemistry of chert was shown to be consistent with the interpretation of the depositional environment of the Ocala Limestone as shallow water. A geochemical relationship between cherts at Center Hill, Florida, and the surrounding limestone was shown and is visible in the rocks themselves at Center Hill. By measuring the Fe, Al, and Mn content of collected specimens it was demonstrated that the Ocala Limestone cherts were formed through a precipitate.

## Works Cited

- Boggs Jr, Sam. Principles of Sedimentology and Stratigraphy. Pearson, 2012.
- Cressman, E.R. "Nondetrital siliceous sediments." Professional Paper, 1962, https://doi.org/10.3133/pp440t.
- Miller, James A. "Hydrogeologic framework of the Floridan Aquifer System in Florida and in parts of Georgia, Alabama, and South Carolina." Professional Paper, 1986, https://doi.org/10.3133/pp1403b.
- Murray, Richard W. "Chemical criteria to identify the depositional environment of chert: General principles and applications." Sedimentary Geology, vol. 90, no. 3–4, May 1994, pp. 213–232, https://doi.org/10.1016/0037-0738(94)90039-6.
- Scott, Thomas M. "A geological overview of Florida." Florida Geological Survey, 1992, https://doi.org/10.35256/ofr50.
- Scott, Thomas M., et al. Geologic Map of the State of Florida, Florida Geological Survey, 2001.
- Yamamoto, Koshi. "Geochemical characteristics and depositional environments of cherts and associated rocks in the Franciscan and Shimanto terranes." Sedimentary Geology, vol. 52, no. 1–2, Apr. 1987, pp. 65–108, https://doi.org/10.1016/0037-0738(87)90017-0.

## Acknowledgements

I would like to acknowledge the contributions of Dr. Jaime Macdonald, Ph.D, Joshua Woosley, Matthew Lewis, Cemex, and Kurt Holt