Environment inferred from stable carbon and oxygen isotope records of living gastropod shells collected from Chiku, Tainan, SW Taiwan

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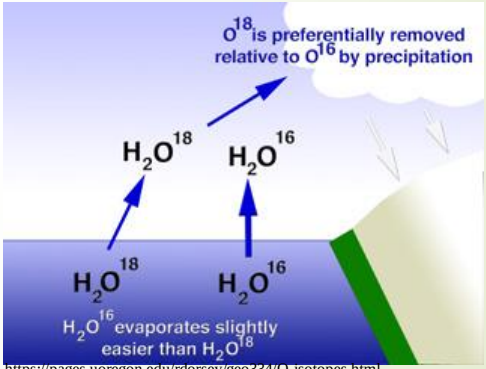
Objective of this study

- Oxygen isotope values of calcium carbonate shells can record the temperature and oxygen isotope values of the water which they lived in (Urey, 1947).

Applied to all kind of mollusk shells ?

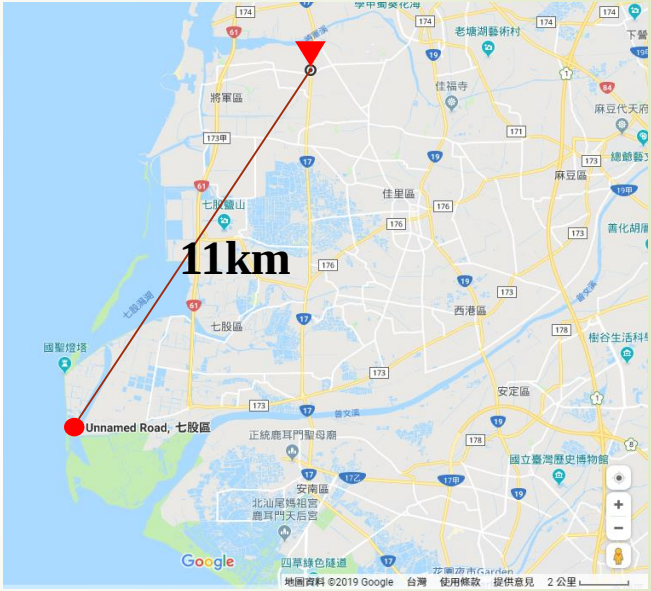


https://pages.uoregon.edu/rdorsey/geo334/O-isotopes.html

- Whether the oxygen isotope records of gastropod *Cymatium pileare* shells collected from Chiku Area reach isotopic equilibrium with the water which they lived in and thus can be used to reconstruct the paleoenvironment.

Study Area

- Aquafarm in the Dachaogou, Chiku Area, Tainan City
- Brackish and semi-fresh water area
- Monthly average temperature of 17.1 to 29.1 °C
- Annual rainfall in 2017 was 1087mm, maximum rainfall was 321mm in July.
- Jiangjun Station of Central Weather Bureau.



Collection location

Jiangjun Station

Materials

Gastropod specimens

- *Cymatium pileare* shells collected in aquafarm in December 2017
- Length = 7 mm.
- Lives in a shallow water environment with depth of 3 to 8 meters.
- Spindle-shaped, taupe and shelly
- Three layers：outer, middle, and the inner layer.

Water sample

- The water sample is collected in aquafarm each month from 2017~2019
- Water temperature and oxygen isotope composition were analyzed by 張世安
- Surface water was taken with water bottle, filtered and brought back for analysis.

Method

Raman analysis

- Verify the composition
- Different crystalline minerals produce different Laser Raman spectra.
- Raman spectrometer of the National Taiwan Museum

Stable carbon and oxygen isotope :

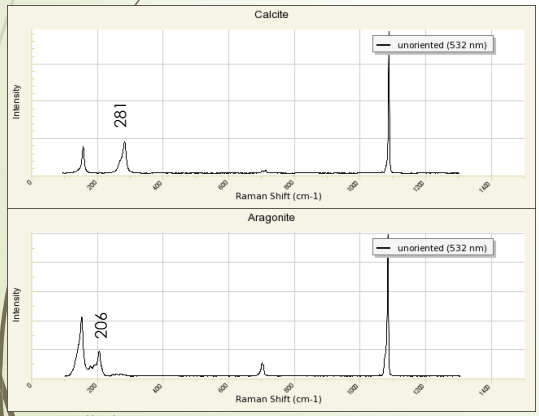
- Sampled with inner
- sampling point spaced 2 mm
- 125 points.

- Grinding the surface layer expose the middle and inner layer.
- Drill 0.1mg powder.
- Send it to Gilson Automatic Analyzer and react with phosphoric acid under 90 ˚C to generate CO_2 gas .
- Enter the Micromass IsoPrime Isotope Ratio Mass Spectrometer to analyzes carbon and oxygen isotopes.

Results and Discussion

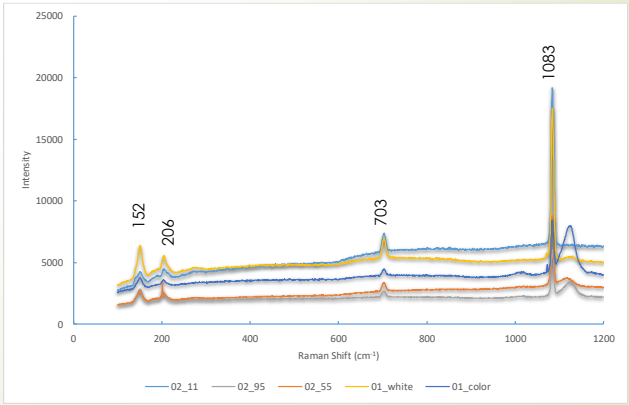
Raman spectra

- Analysis is performed on the five points of the shell.
- Peaks appear at frequencies at 152, 206, 703, and 1083.
- Raman spectra of calcite and aragonite are compared



http://rruff.info/

Standard



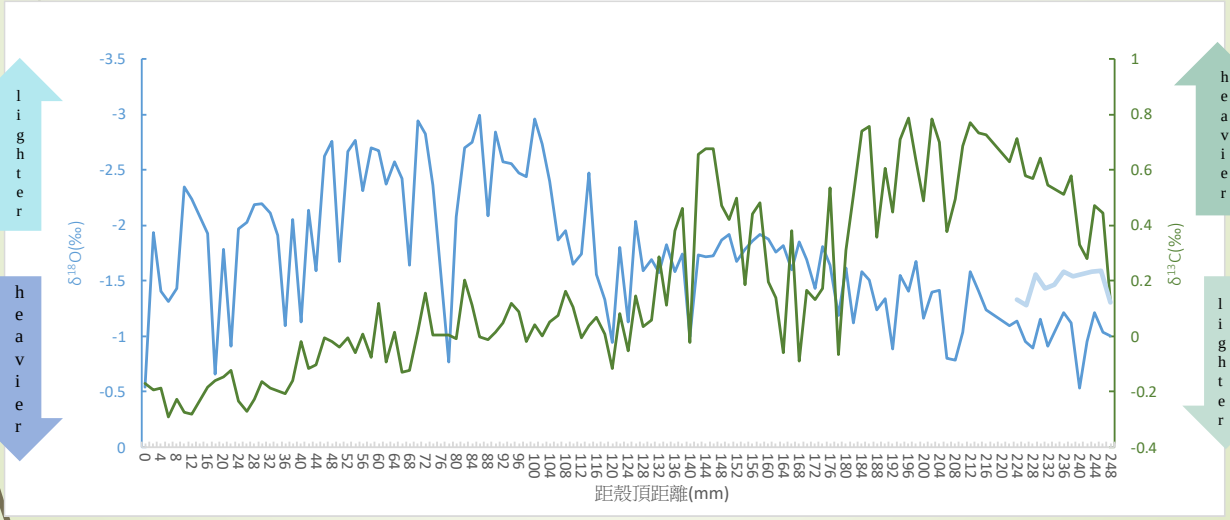
Carbon and oxygen isotope :

- Oxygen and carbon isotope plotted against the distance.
- Both of the value becomes larger as the shell grows.

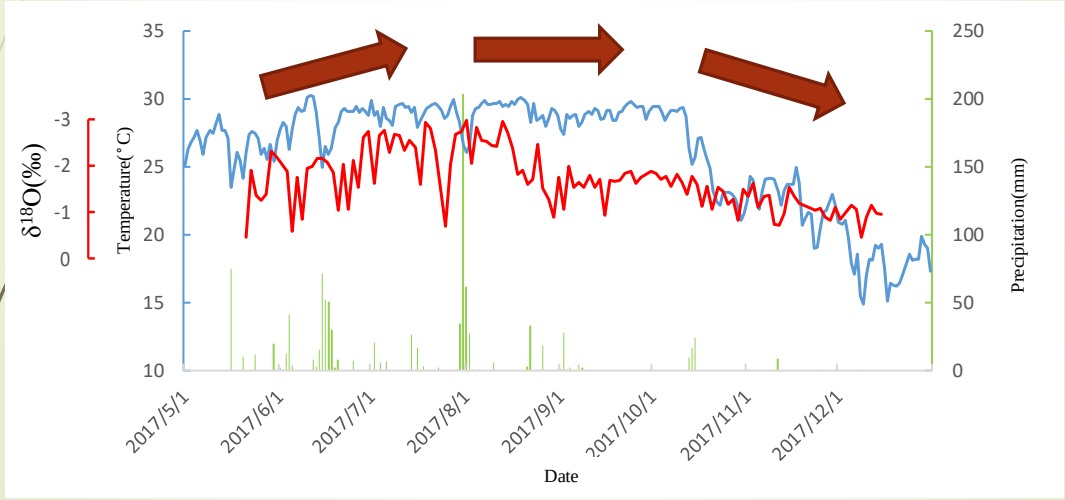
$$R_o = \frac{^{18}O}{^{16}O}$$

$\delta^{18}O(‰)$ = -2.99‰～ -0.75‰
$\delta^{13}C(‰)$ = -0.29‰～ 0.78‰
(N=125，VPDB)

$$\delta^{18}O(‰) = \frac{R_o - R_{std}}{R_{std}}$$



- The oxygen isotope recorded in the gastropod shell is influenced by the water oxygen isotope.
- The snail grows from summer, end of life in winter.
- Temperature and oxygen isotope records have similar oscillations



- R=0.14
- No obvious linear relationship between the carbon and oxygen isotopes.
- Less signal of mixing of water and seawater.

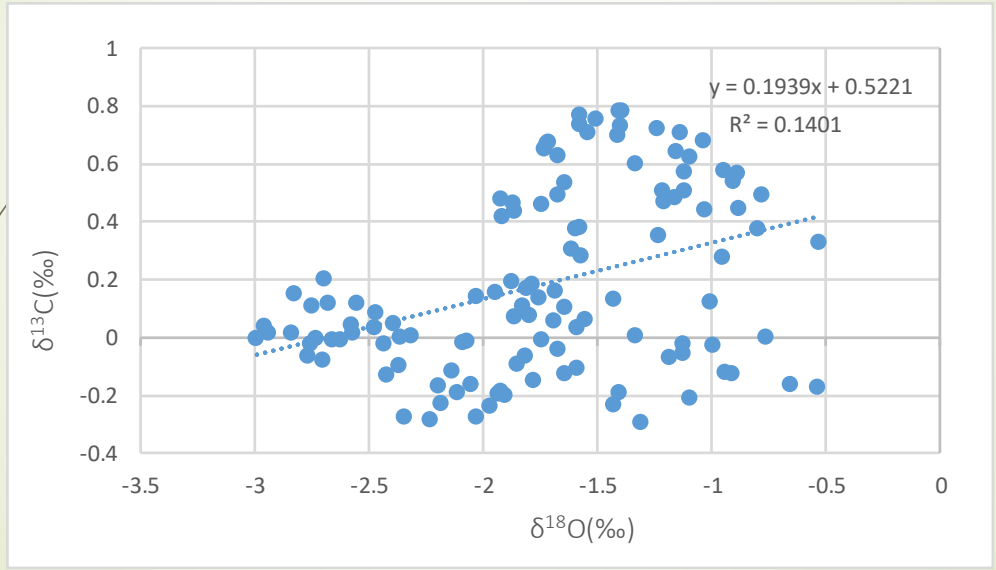
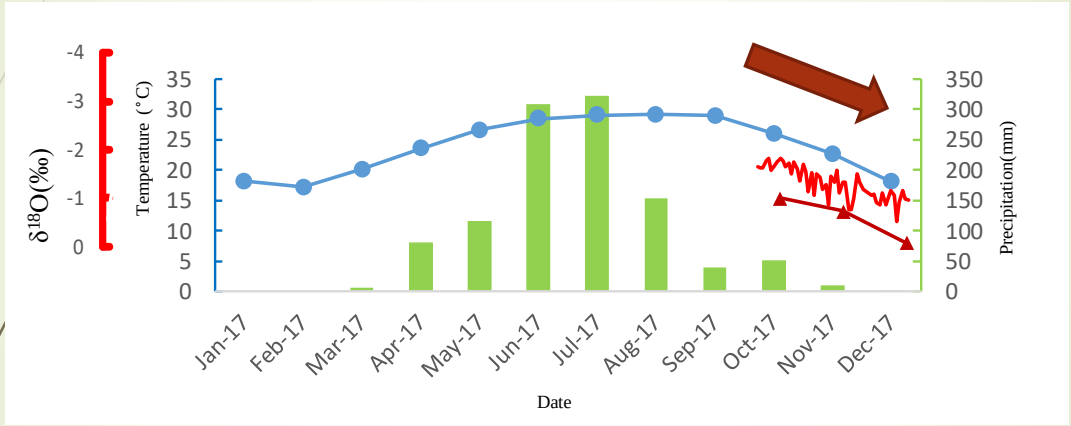


Fig. 11 Specimen carbon and oxygen isotope map.

- Theoretical equilibrium value

(Hudson and Anderson,1989)

  - $T^{\circ}C = 19.7 - 4.34 (\delta^{18}O_{sample,PDB} - \delta^{18}O_{water,SMOW})$



- The difference between theoretical equilibrium values and oxygen isotope of the gastropod shells：
  $\Delta\delta^{18}O(‰) = 0.7 \sim 0.8(‰)$

Station Temperature
Theoretical equilibrium value
Shell $\delta^{18}O(‰)$
Precipitation

Conclusions

- The $\delta^{18}O$ oscillation can better reflect the change of water temperature in winter. Whereas, in summer, it is cannot indicate the water temperature but may indicate amount of precipitation in summer for SW Taiwan.
- The equation to calculate the theoretical equilibrium value can't apply to *Cymatium pileare* directly, but still can reflect the similar temperature fluctuation.
- If the equation can make correction to apply on *Cymatium pileare*, maybe the species can be used to reconstruct the paleoenvironment.

References

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顏鳳儀，2010，臺灣恆春半島現生與考古遺址芋螺殼體穩定碳氧同位素所反映之環境記錄