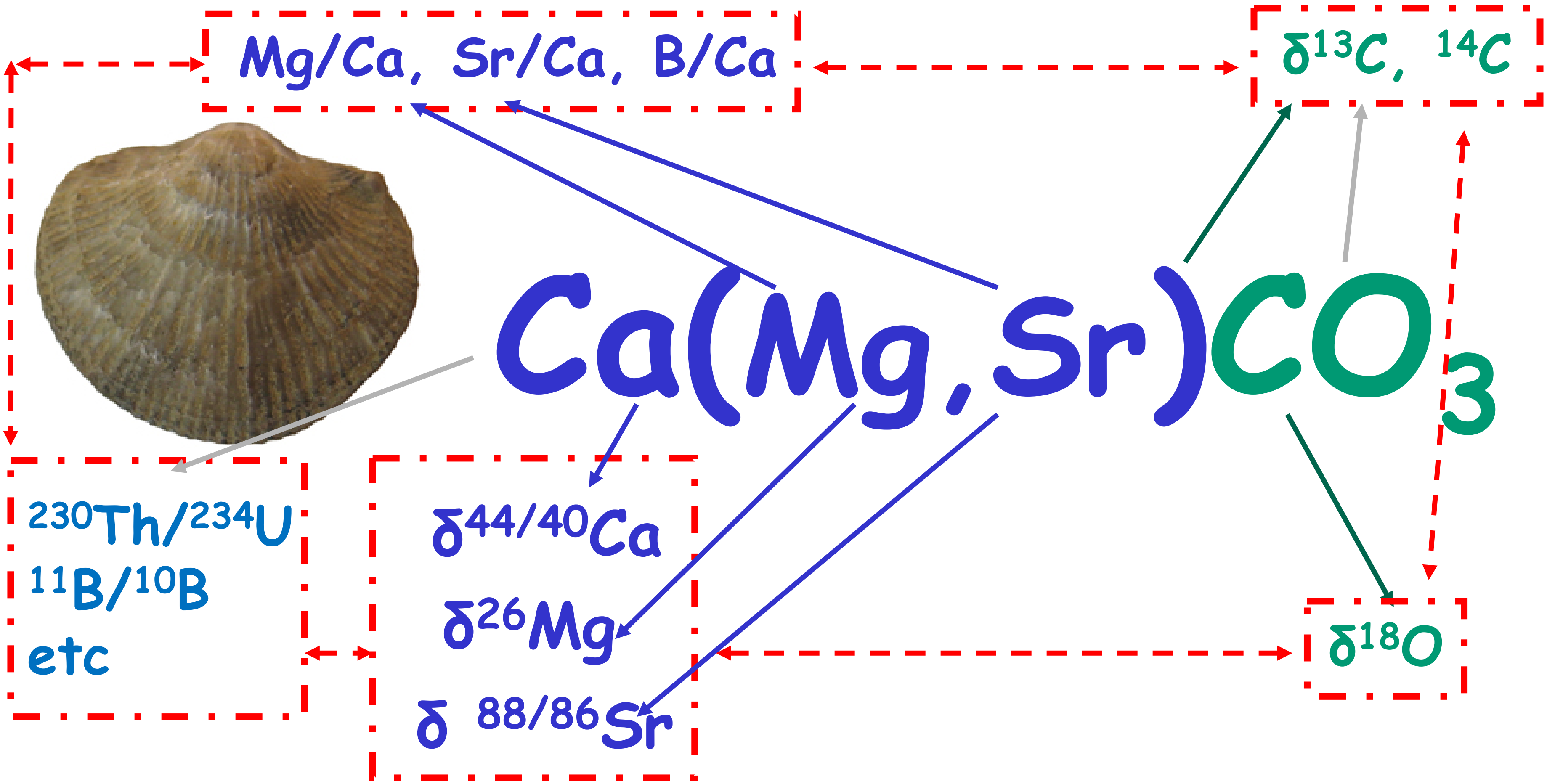
Application of isotope fractiontion?

UNIT 4

Multi-Proxy Approach

BASE-LiNE Earth



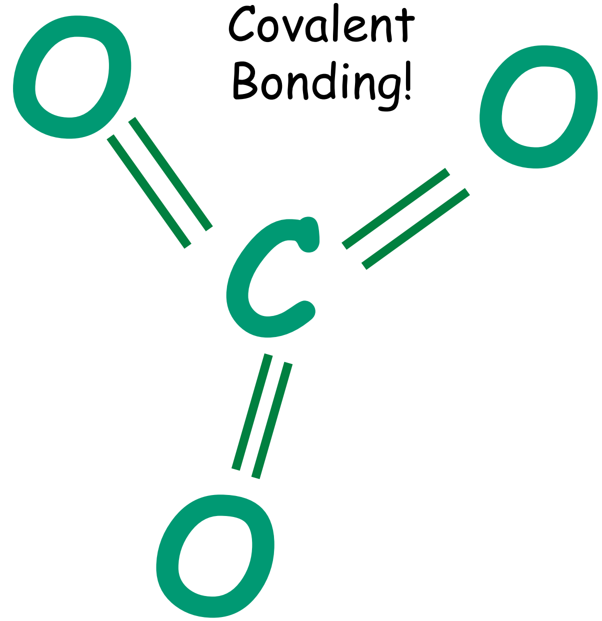
Type of bonding matters

$CaCO_3$

Electrostatic Crystal Bonding!

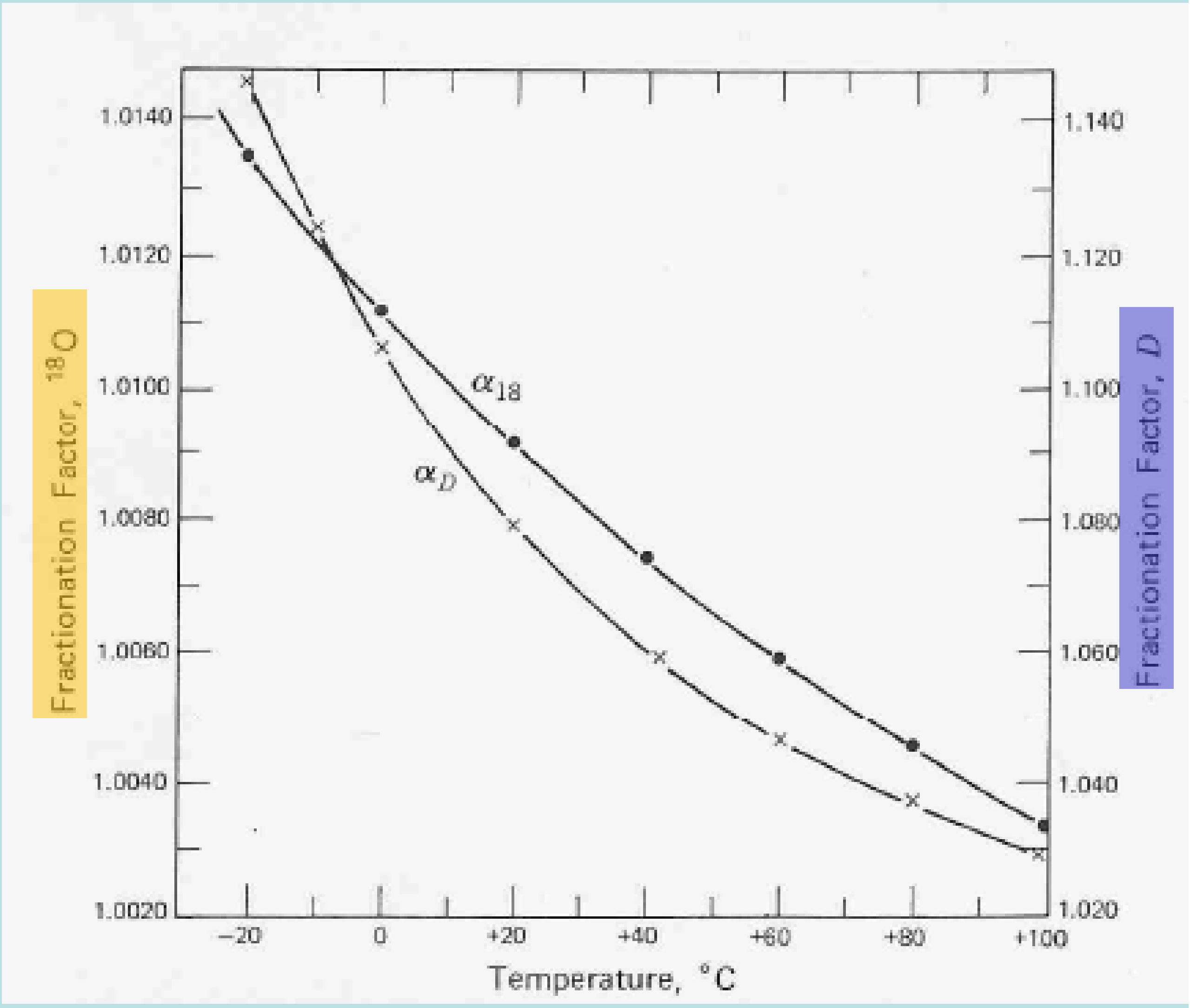
$Ca^{2+}CO_3^{2-}$

Covalent Bonding!



Example

Temperature Isotope Fractionation of Hydrogen and Oxygen Isotopes in Calcite



$$\alpha(°C) = \frac{\left(\frac{^{18}O}{^{16}O}\right)_{Calcit}}{\left(\frac{^{18}O}{^{16}O}\right)_{Water}}$$

Temperature Dependence!!!

The higher the water temperature the calcite precipitated from, the lower is the **Fractionation factor!**

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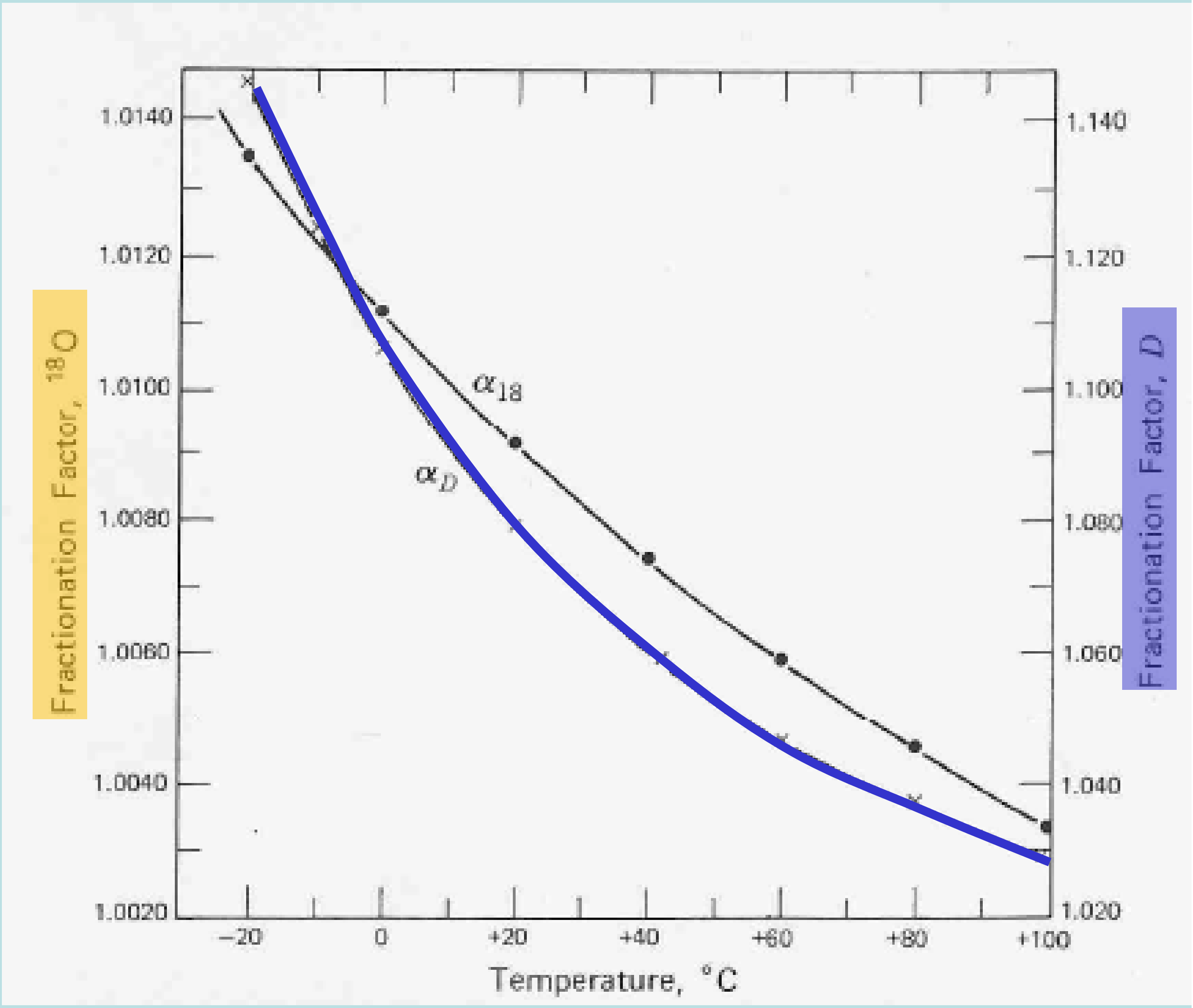

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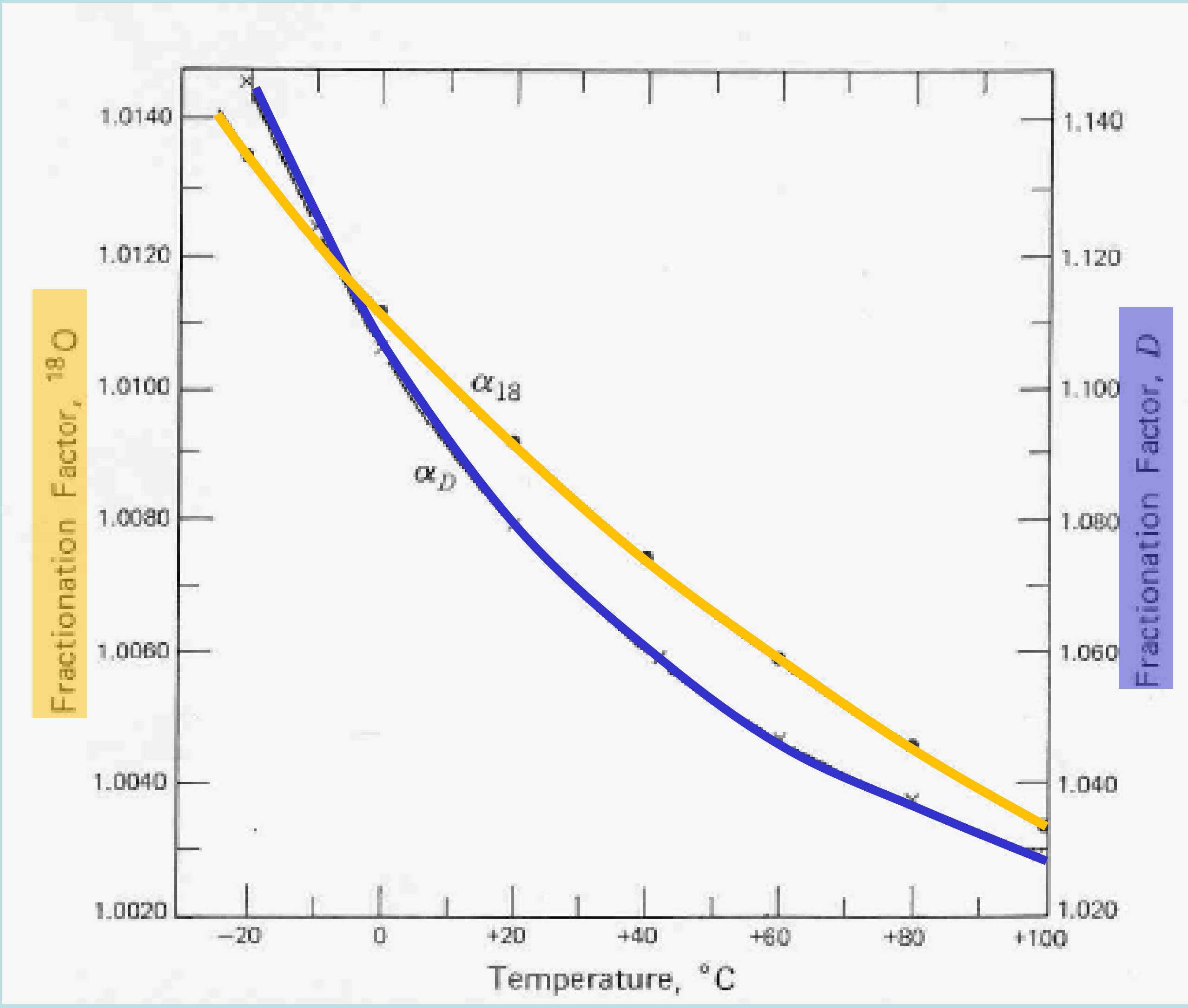

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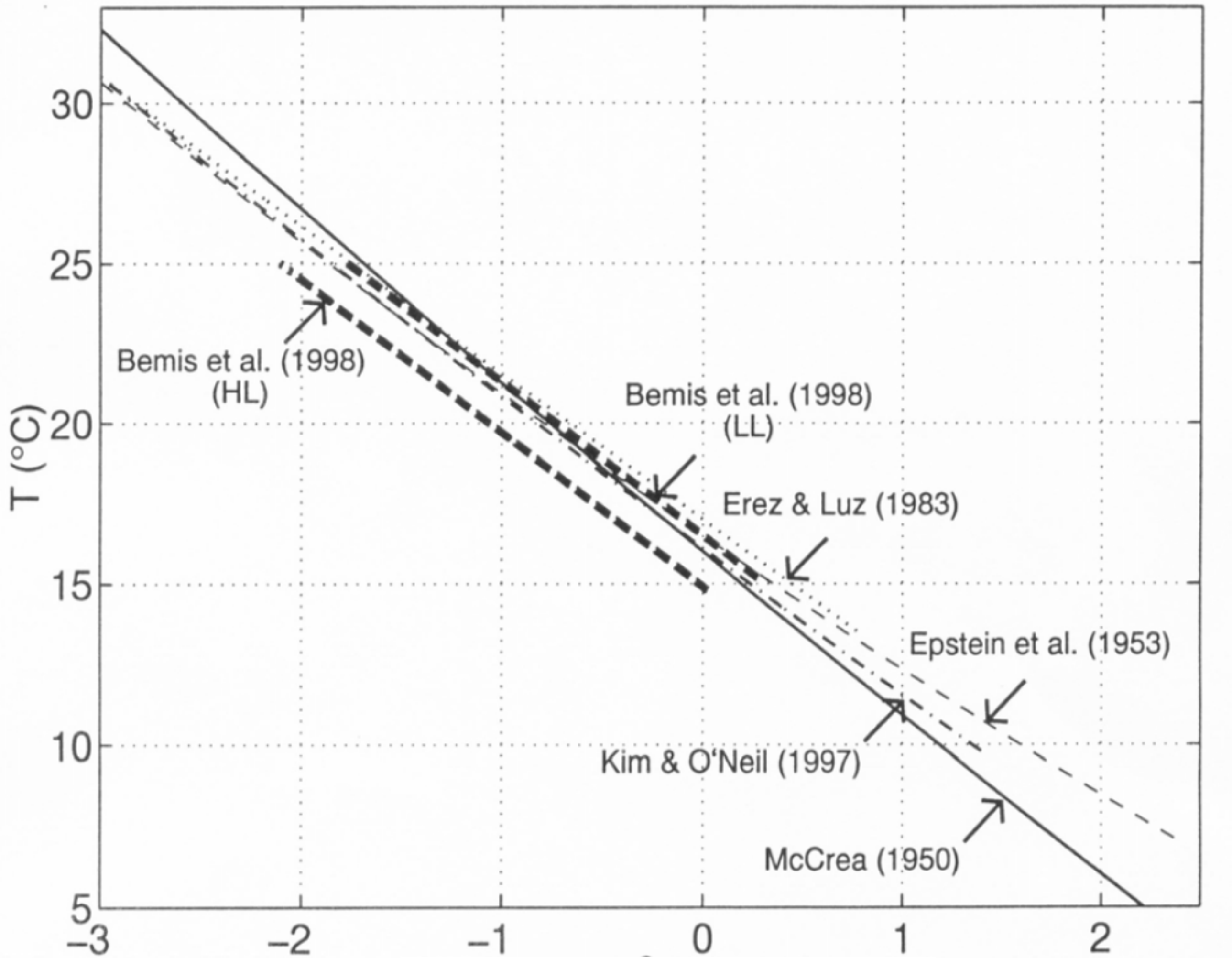
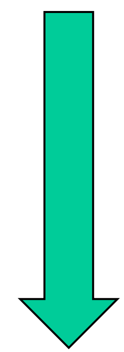
BASE-LiNE Earth



$\Delta \approx 1000 \cdot \ln \alpha_{Calcite\text{-}Water}$



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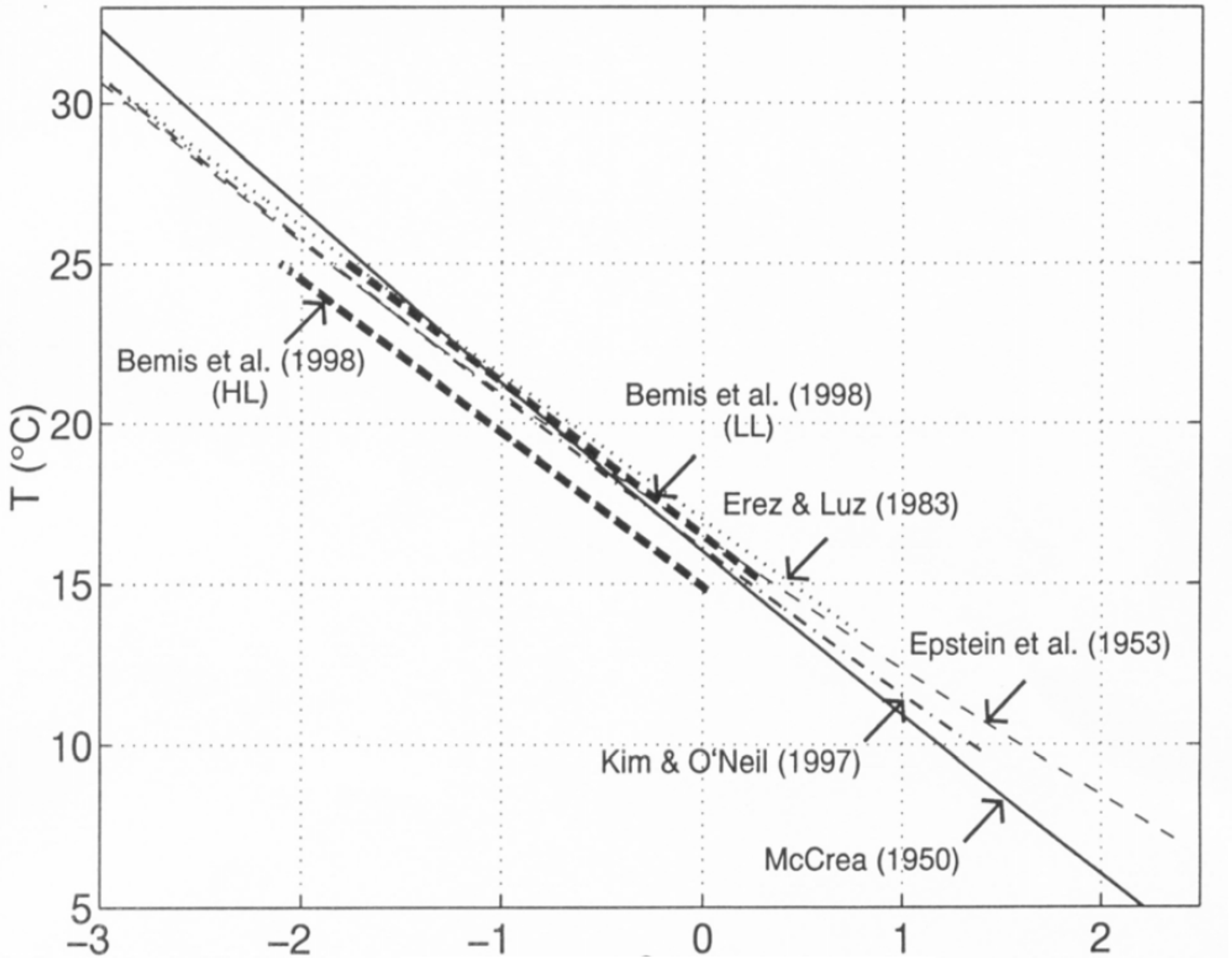

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Future:
Clumped isotopes: Δ_{47} are independent of this knowledge

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- Primary signal (exclude diagenesis)

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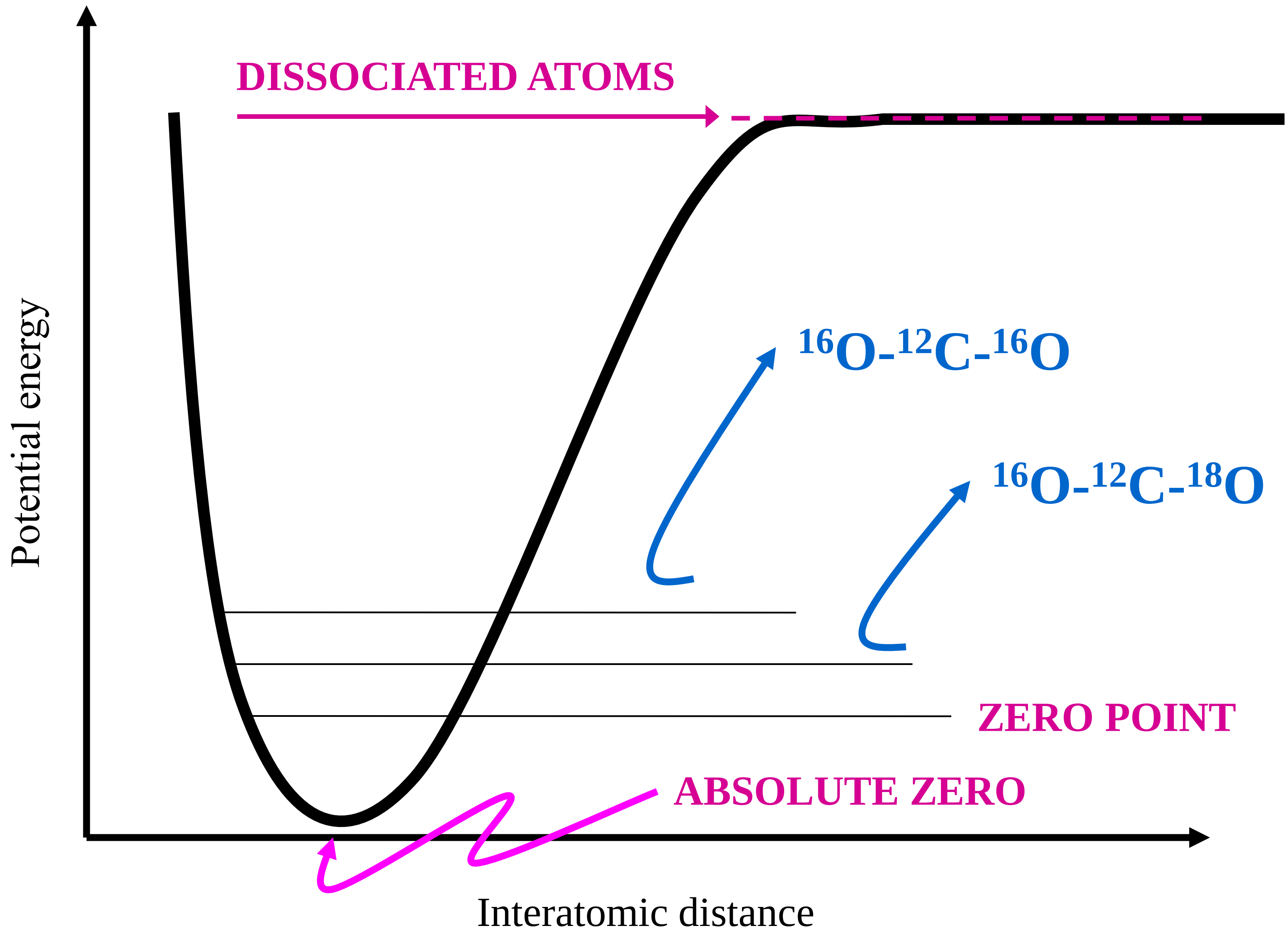
- Knowledge of past oxygen isotope composition

Isotope effect associated with zero-point energy:



Equilibrium Fractionation

BASE-LiNE Earth

II. Understanding of Natural Dependent $^{44}Ca/^{40}Ca$ Fractionation

m_h= heavy isotope

m_l = light isotope

Equilibrium fractionation tends to enrich the **heavy** isotope with decreasing temperature!

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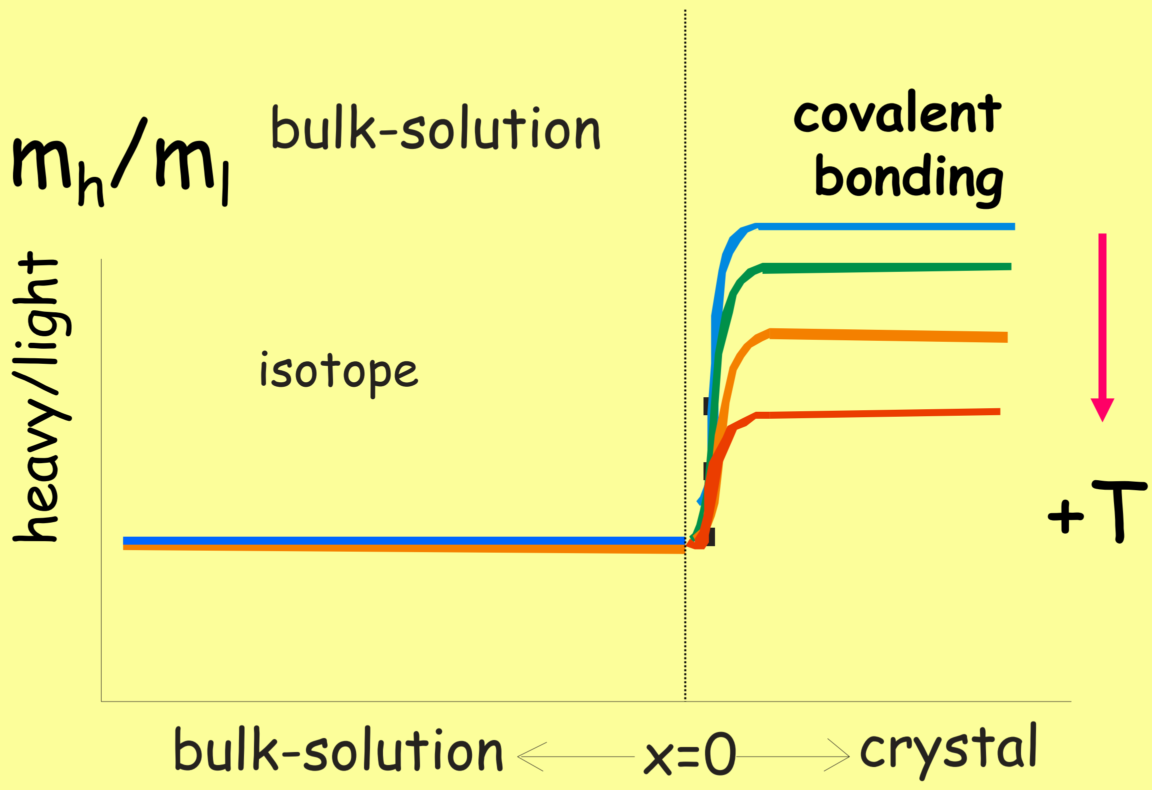

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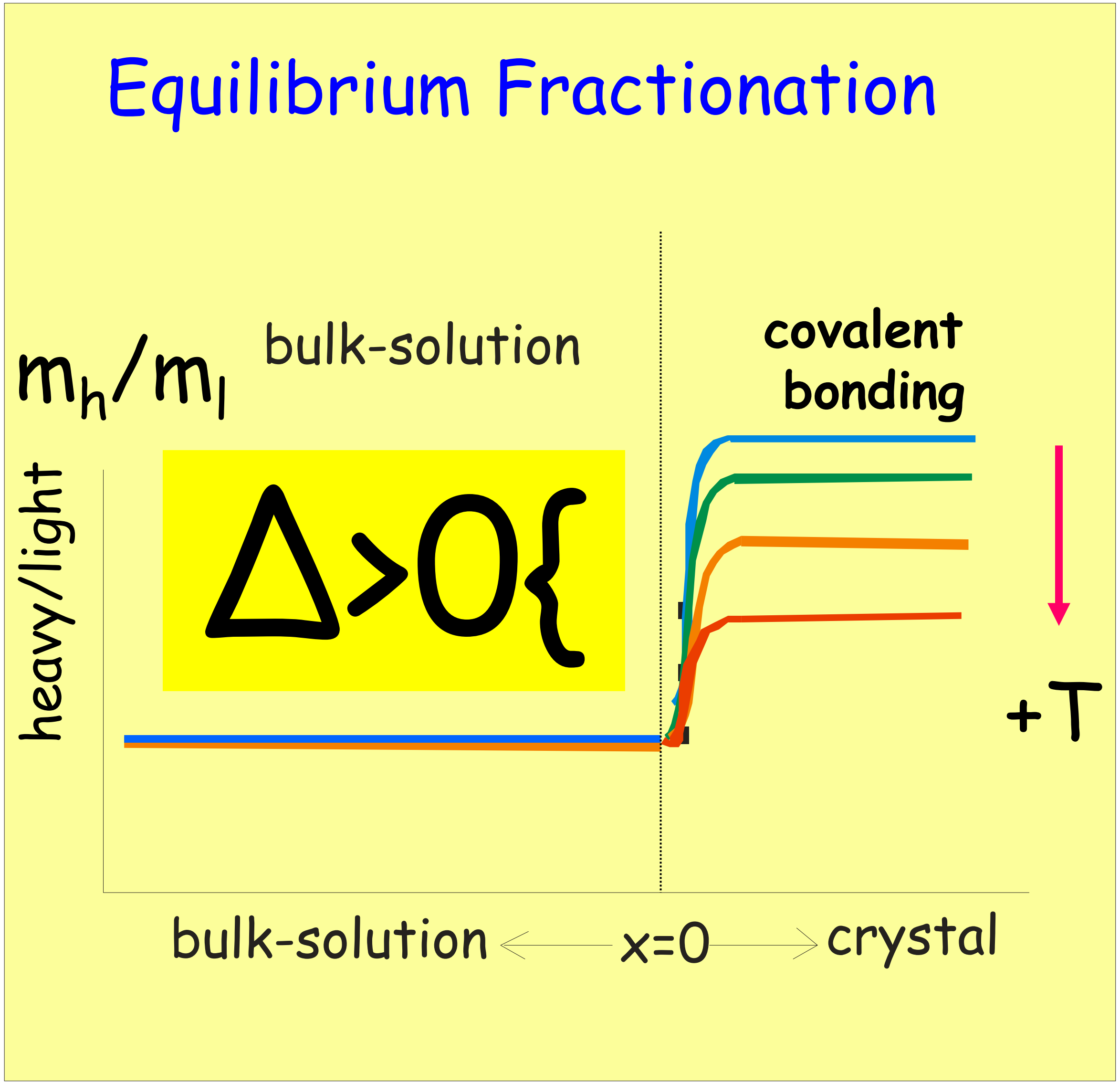

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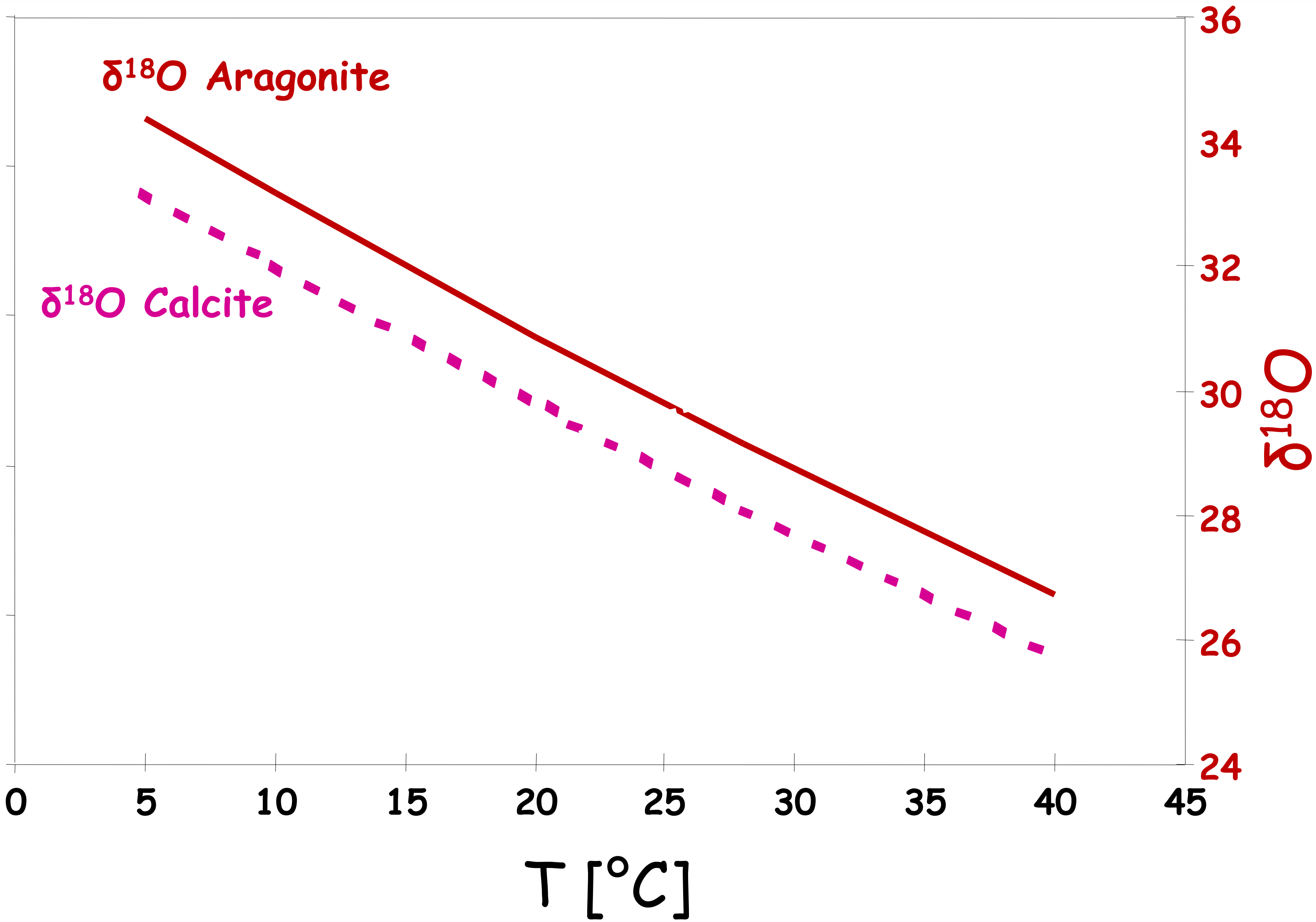

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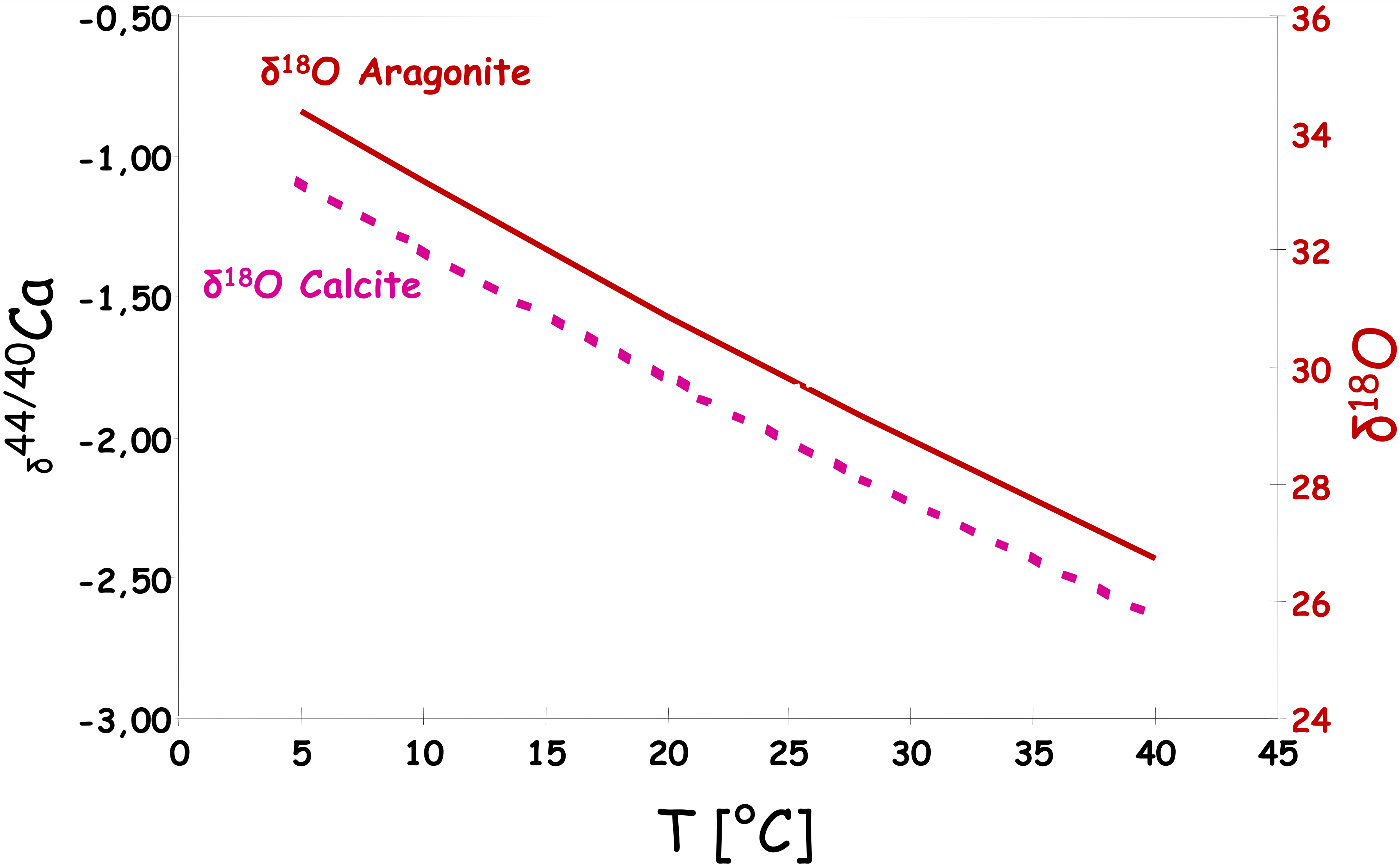

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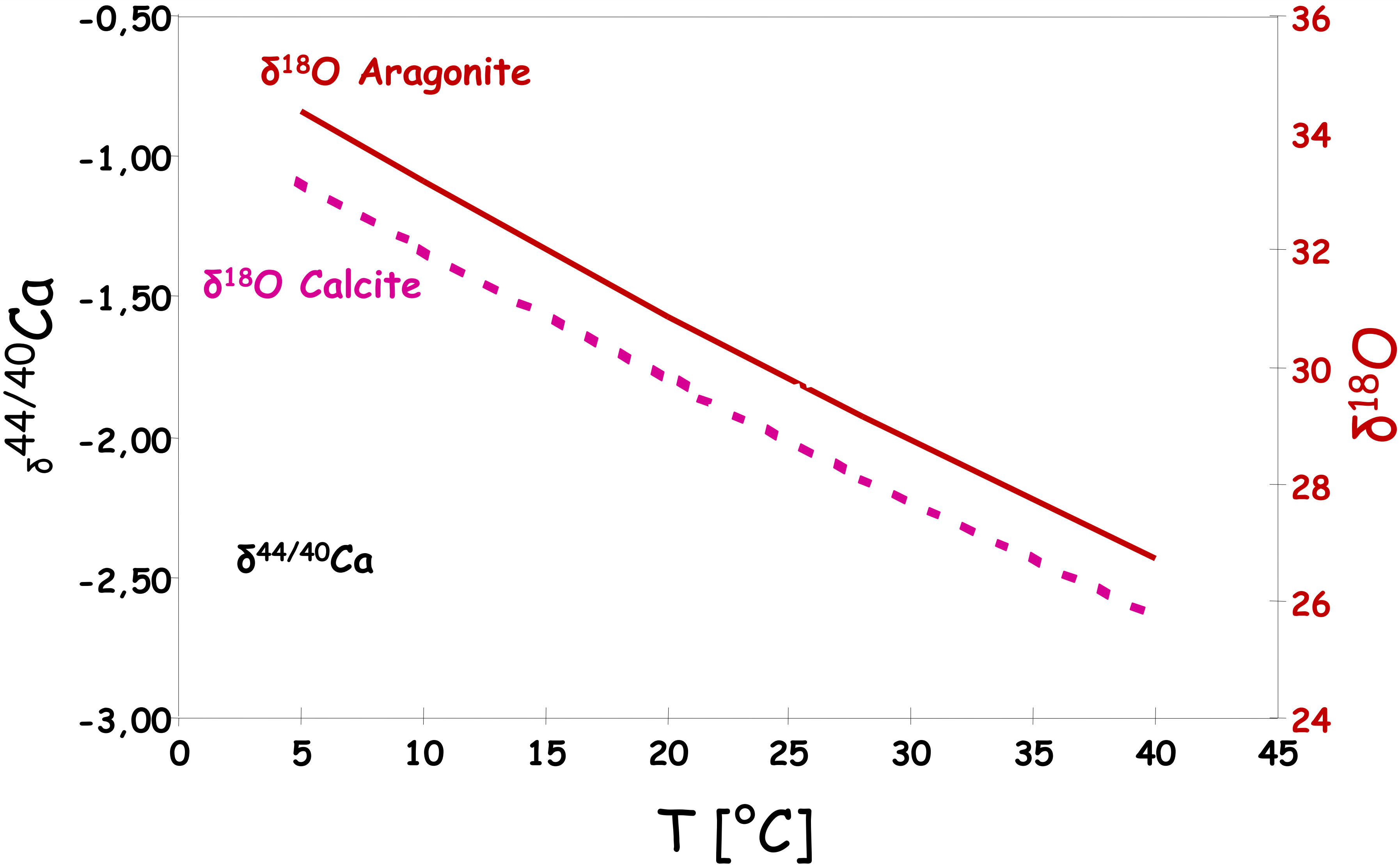

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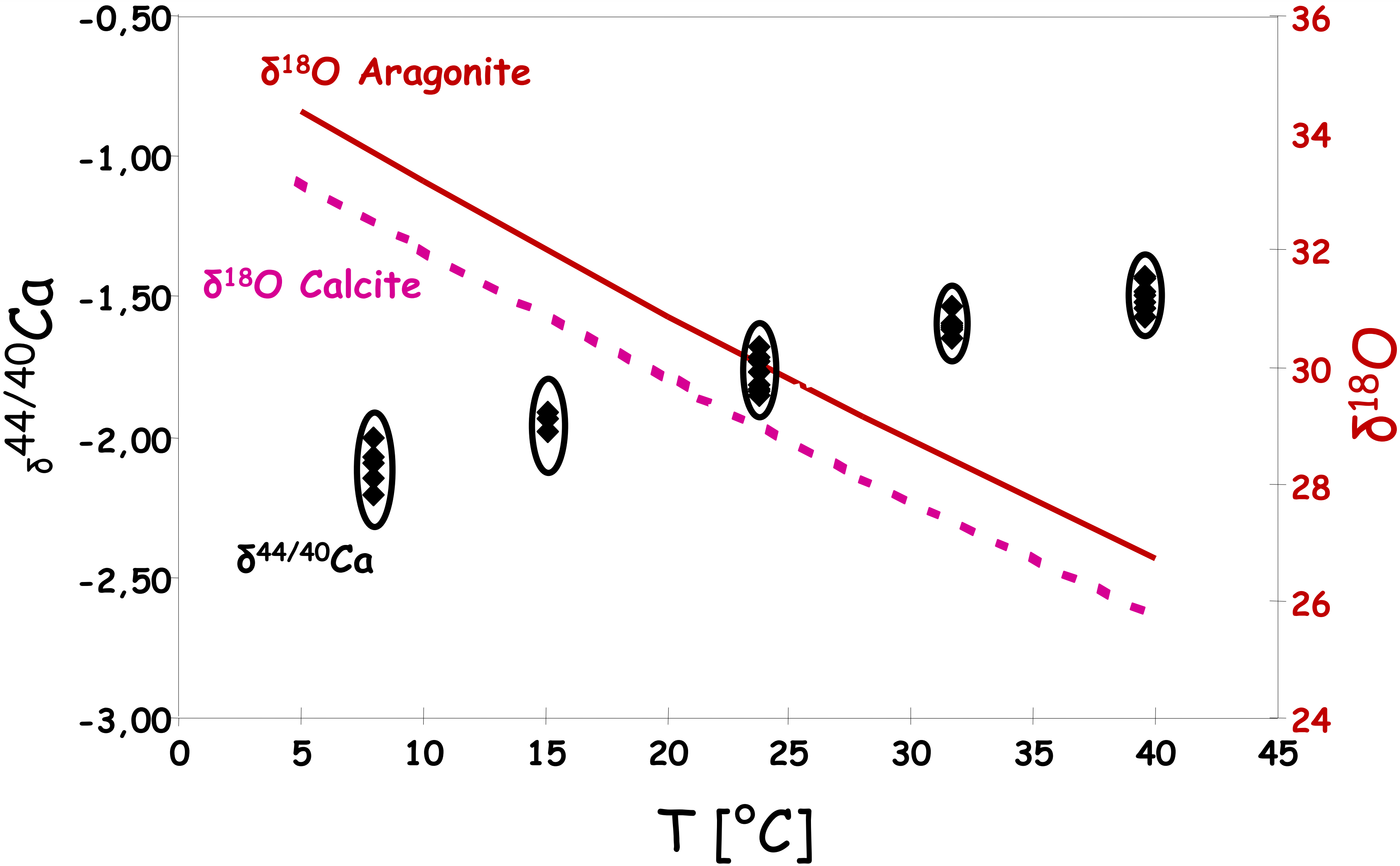

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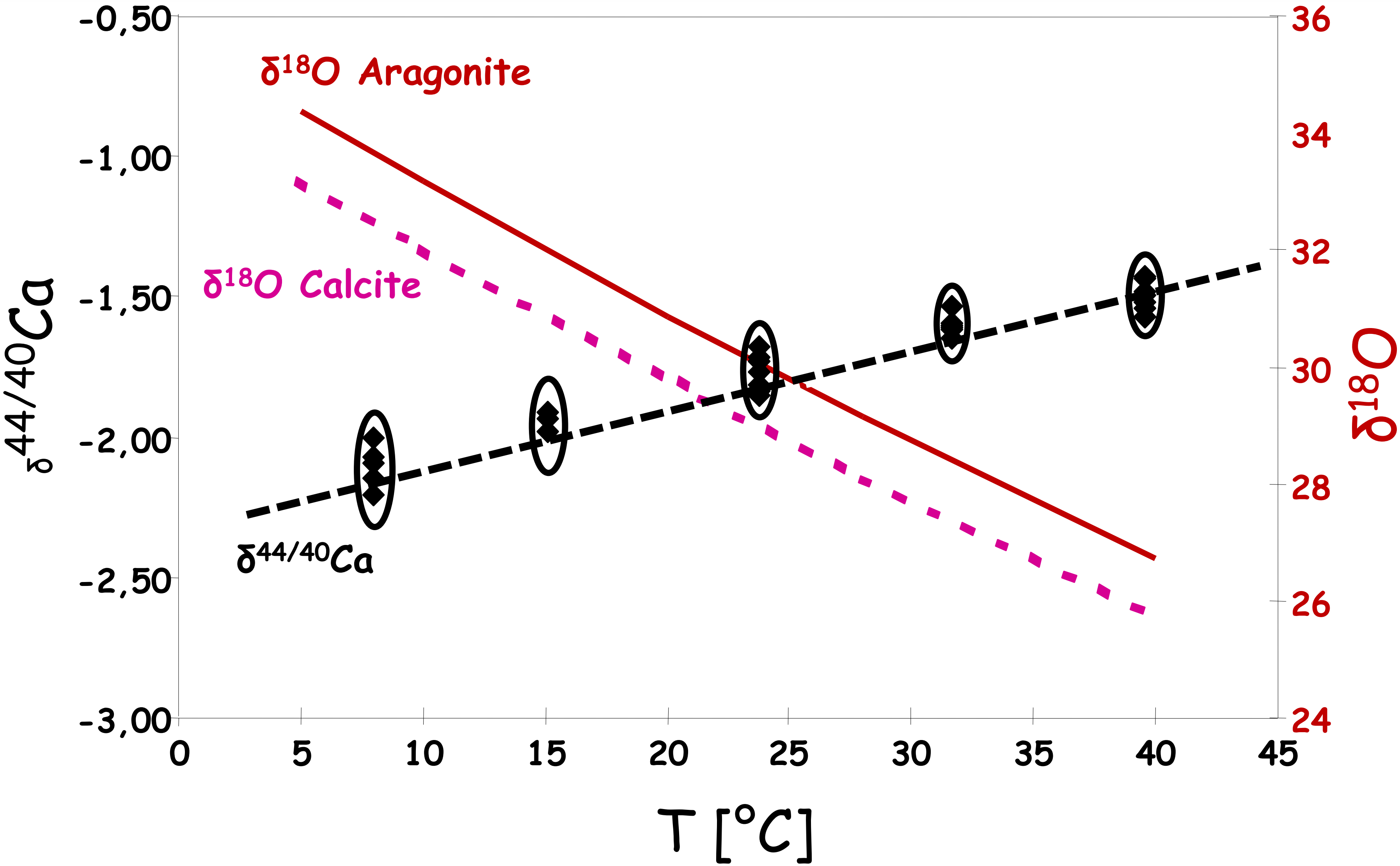


Kinetics

BASE-LiNE Earth

Isotope effect associated with Kinetic:

Because the kinetic energy for heavy and light isotopes is the same, we can write:

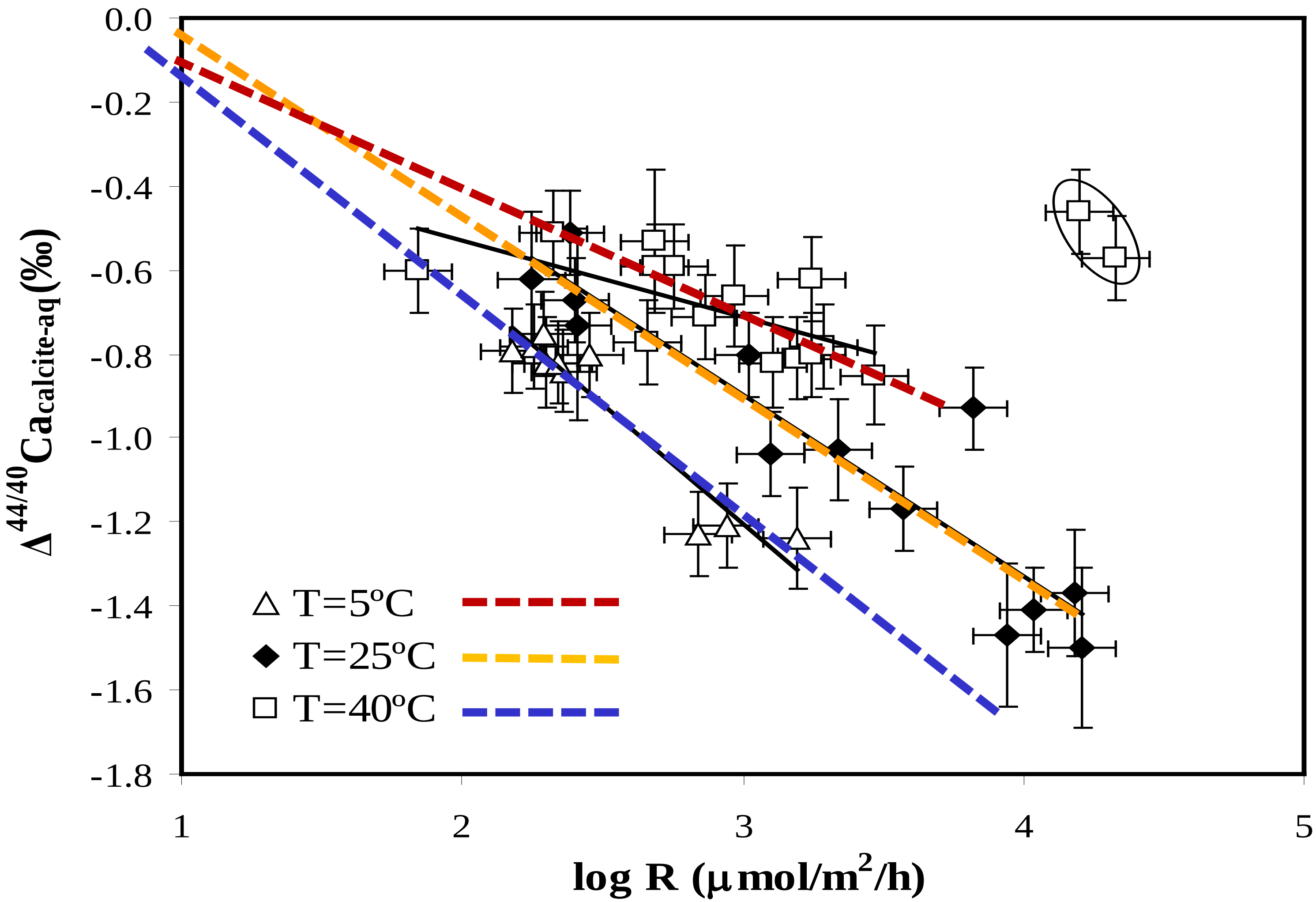
$$\frac{v_L}{v_H} = \sqrt{\frac{m_H}{m_L}} \qquad \frac{v_L}{v_H} = \sqrt{\frac{28.99827}{27.994915}} = 1.0177$$

This means for $^{12}C^{16}O$ and $^{13}C^{16}O$ that regardless of the temperature, the velocity of $^{12}C^{16}O$ is 1.0177 times that of $^{13}C^{16}O$, so the lighter molecule will diffuse faster and evaporate faster.

Kinetics

BASE-LiNE Earth

$\Delta^{44/40}Ca_{calcite\text{-}aq}$ vs. Precipitation Rate



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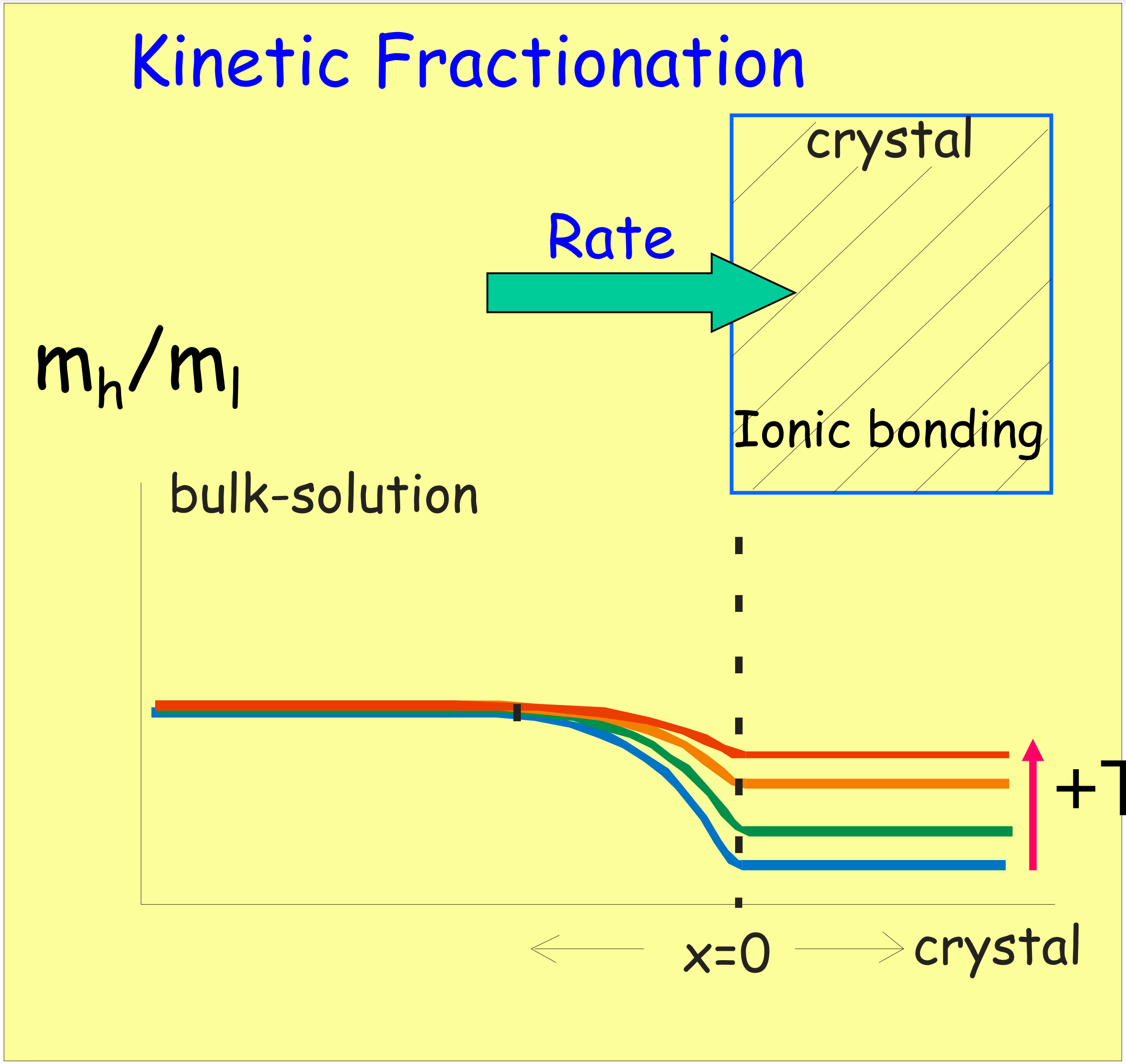

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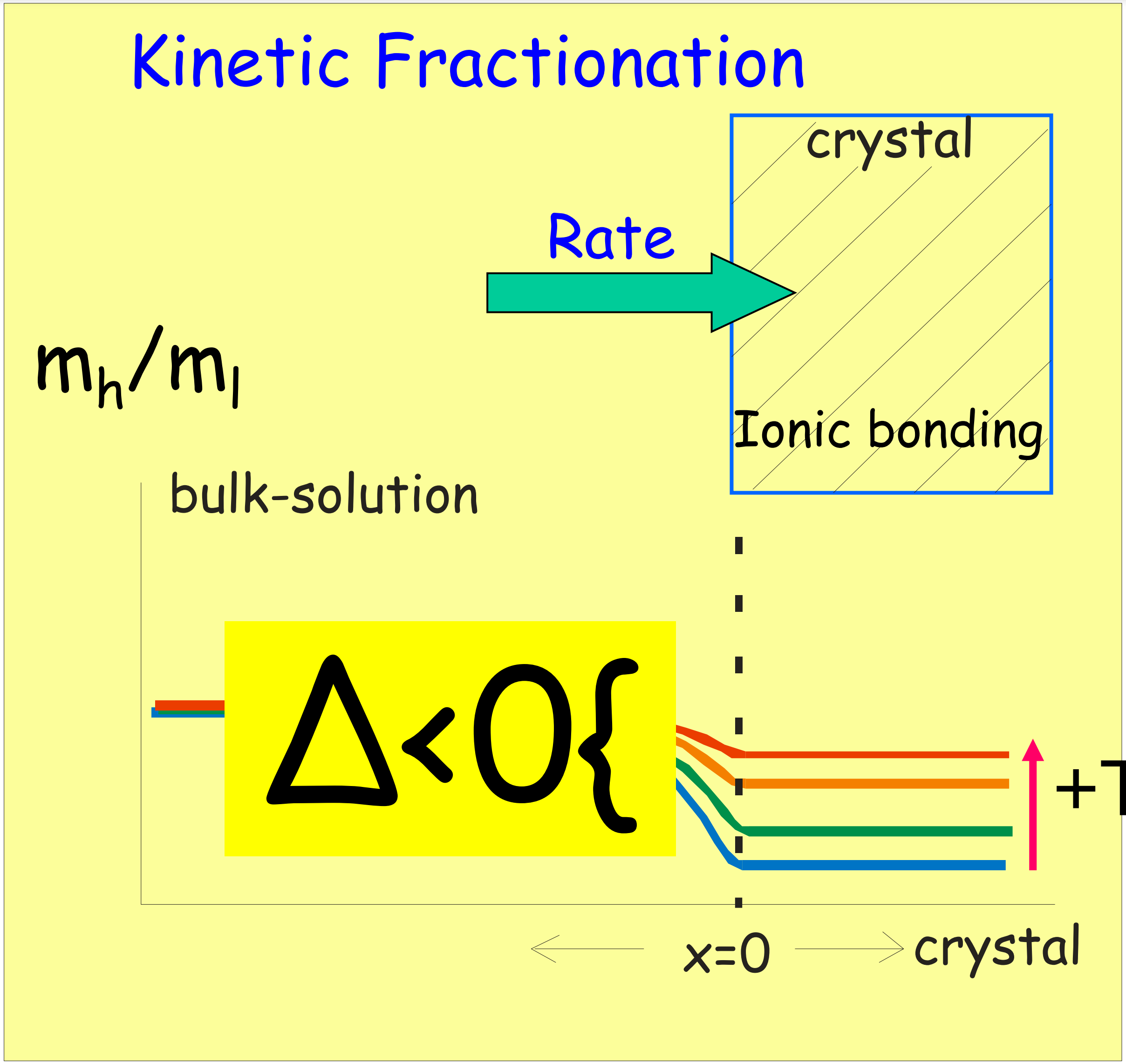

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