Assessing stress levels on faults using clumped isotope thermometry of gouges and vein arrays

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Stress on low-angle normal faults

\[ \sigma_1 \]

\[ \sigma_3 \]

At failure, shear stress \( \tau = \mu \sigma_n \)

Where \( \mu \) is the coefficient of friction and \( \sigma_n \) is the normal stress

Shear heating

Shear stress is related to heat produced along a fault by:

\[ q = \tau \cdot v \]

where \( q \) is heat flux, \( \tau \) is shear stress, and \( v \) is long-term velocity along a fault

Clumped Isotope Thermometry

Reaction:

\[ \text{Ca}^{13}C^{18}O_2 + \text{Ca}^{12}C^{18}O_2 \rightarrow \text{Ca}^{13}C^{18}O^{16}O_2 + \text{Ca}^{12}C^{16}O_3 \]

The forward reaction causes "clumping" of the heavy isotopes. This is more favorable at low temperatures.

The sample is dissolved in acid to release CO_2 gas, which is measured for masses 44-46.

Mass 47 (the clumped molecules) is related to temperature by:

\[ T = \frac{45870}{A_{47}} + 0.129 \]

Where \( \Delta A_{47} \) is the difference between the measured mass 47 and that expected from random distribution

Temperature vs \( \delta^{18}O \)

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