



## United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

TO: support@orisefinance.com

CC: isotopes

SUBJECT: Stable-isotope results (2026/06/01 Taylor, W-191180 ...)

The Reston Stable Isotope Laboratory has analyzed the following samples received from you for isotopic analysis. For questions please contact Email isotopes@usgs.gov or Haiping Qi at voice 703 648-6338 or fax 703 648-5274. Please refer to Our Lab ID. These isotopic results supersede any results that may have been submitted to you previously.

### Methods

Since May 1, 1990, hydrogen-isotope-ratio analyses have been performed using a hydrogen equilibration technique (Coplen and others, 1991; Revesz and Coplen, 2008a), rather than the zinc technique used prior to that date (Kendall and Coplen, 1985). The hydrogen equilibration technique measures deuterium activity, whereas the zinc technique measures deuterium concentration. For the majority of WRD samples, the difference in reported isotopic compositions between the two techniques is not significant. However, in brines, the difference may be significant (Sofer and Gat, 1972, 1975). Reported delta H-2 values of activity are more positive than delta H-2 values of concentration, and this difference is proportional to molalities of the major dissolved solids. Some examples of the differences between activity ratios and concentration ratios for delta H-2 in 1 molal salt solutions are as follows (Horita and others, 1993). The data for individual salts may be multiplied by molality to obtain adjustments to delta values based on concentration.

|           |                                          |
|-----------|------------------------------------------|
| Solution  | Delta H-2 (activity) - Delta H-2 (conc.) |
| (1 molal) | (30 degrees C)                           |

|                   |               |
|-------------------|---------------|
| NaCl              | +2.07 per mil |
| KCl               | +2.42 per mil |
| CaCl <sub>2</sub> | +5.31 per mil |
| MgSO <sub>4</sub> | +1.12 per mil |

Water samples are measured for delta O-18 using the CO<sub>2</sub> equilibration technique of Epstein and Mayeda (1953), which has been automated (Revesz and Coplen, 2008b). Therefore, both oxygen and hydrogen isotopic ratio measurements are reported as activities.

#### Reporting of Stable Hydrogen and Oxygen Isotope Ratios

Oxygen and hydrogen isotopic results are reported in per mil relative to VSMOW (Vienna Standard Mean Ocean Water) and normalized (Coplen, 1994) on scales such that the oxygen and hydrogen isotopic values of SLAP (Standard Light Antarctic Precipitation) are -55.5 per mil and -428 per mil, respectively. Oxygen isotopic results of a sample Z can be expressed relative to VPDB (Vienna Pee Dee belemnite) using the equation:

$$\text{Delta O-18 of Z relative to VPDB} = (0.97001 \text{ times delta O-18 of Z relative to VSMOW}) - 29.99$$

The 2-sigma uncertainties of oxygen and hydrogen isotopic results are 0.2 per mil and 2 per mil, respectively, unless otherwise indicated. This means that if the same sample were resubmitted for isotopic analysis, the newly measured value would lie within the uncertainty bounds 95 percent of the time.

#### References

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Horita, J., Wesolowski, D., and Cole, D., 1993. The activity-composition relationship of oxygen and hydrogen isotopes in aqueous salt solutions: I. Vapor-liquid water equilibration of single salt solutions from 50 to 100°C, *Geochim. Cosmochim. Acta*, v. 57, p. 2797-2817.

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Our Lab ID: W-191180

Field ID: 0004

Delta H-2: -954.5 per mil