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United States Geological Survey

Reston Stable Isotope Laboratory

Report of Stable Isotopic Composition

Reference Materials USGS37, USGS38, and USGS39

(Chlorine and Oxygen Isotopes in Perchlorate)

These reference materials (RMs) are intended for normalizing stable chlorine ($\delta^{37}Cl$) and oxygen ($\delta^{18}O$, $\delta^{17}O$) relative isotope-ratio measurements of perchlorate (ClO_4^-) and other chlorine- and oxygen-bearing samples. A unit of USGS37, USGS38, or USGS39 consists of approximately 1 g of dry $KClO_4$ salt. Preparation, specifications, and analyses of these materials are described by Böhlke et al. [1].

Recommended values: Stable chlorine isotopic compositions are expressed as delta values [2] relative to SMOC (Standard Mean Ocean Chloride) [3]. Calibrations were performed by single-point normalization and are consistent with $\delta^{37}Cl_{SMOC}$ values of +0.06 ‰ for ISL354, +0.44 for SRM975, and +0.01 ‰ for SRM975a [1]. For ISL354 and SRM975, these are indistinguishable from reported values of +0.05 ‰ and +0.43 ‰, respectively [4]. To facilitate comparisons with published isotopic data for perchlorate, previously reported $\delta^{37}Cl_{SMOC}$ values are also listed for USGS37 and USGS38 [5, 6]. Stable oxygen isotopic compositions are expressed as delta values relative to VSMOW (Vienna Standard Mean Ocean Water) on a $\delta^{18}O$ scale normalized such that the $\delta^{18}O$ value of SLAP (Standard Light Antarctic Precipitation) is –55.5 ‰ [7, 8]. Values of $\delta^{18}O_{VSMOW\text{-}SLAP}$ and $\delta^{17}O_{VSMOW\text{-}SLAP}$ for USGS37, USGS38, and USGS39 represent combined results of multiple techniques, normalized to be consistent with reported data for nitrate isotopic reference materials [1, 9]. Approximate uncertainties (1σ) are estimated from data in Böhlke et al. [1]. $\Delta^{17}O_{VSMOW}$ values listed below are defined by $\Delta^{17}O = \delta^{17}O - 0.52 \times \delta^{18}O$; other definitions of ^{17}O-excess yield slightly different $\Delta^{17}O$ (or $^{17}\Delta$) values for the same $\delta^{18}O$ and $\delta^{17}O$ values [1].

Description	$\delta^{37}Cl_{SMOC}$	$\delta^{18}O_{VSMOW\text{-}SLAP}$	$\delta^{17}O_{VSMOW\text{-}SLAP}$	$\Delta^{17}O_{VSMOW}$	Data source
USGS37	+0.90 ± 0.05 ‰	–17.00 ± 0.10 ‰	–8.96 ± 0.10 ‰	–0.12 ‰	[1]
	+0.6 ‰				[5, 6]
USGS38	–87.9 ± 0.3 ‰	+52.5 ± 0.3 ‰	+102.4 ± 0.6 ‰	+75.1 ‰	[1]
	–87.2 ‰				[5, 6]
USGS39	+0.05 ± 0.05 ‰	+122.3 ± 0.6 ‰	+62.6 ± 0.6 ‰	–1.0 ‰	[1]

Technical coordination for this report was provided by J.K. Böhlke and S.J. Mroczkowski.

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Maintenance of RM certification: The Reston Stable Isotope Laboratory (RSIL) will monitor these RMs. The RSIL will notify the purchaser if substantial technical changes are observed that affect the stable chlorine or oxygen isotopic compositions over time.

Distribution and stability: Units of USGS37, USGS38, and USGS39 are supplied in glass vials that are vacuum sealed in plastic pouches. Perchlorate salts should be kept in a dry environment, as they may attract water when exposed to air. There is no documented exchange of oxygen in perchlorate with oxygen in water; wetting and drying these RMs should not affect their isotopic compositions unless other contaminants are present.

Instructions for use: These RMs can be dried in a low-temperature oven or under vacuum before being weighed for analysis. They can be used at the beginning, the middle, and the end of an analysis sequence to enable satisfactory correction of drift with time. Commonly, two or three of the perchlorate isotopic reference materials are used together in an analytical batch, depending on the ranges of $\delta^{37}Cl$, $\delta^{18}O$, and $\Delta^{17}O$ values in the batch. Because $KClO_4$ can be decomposed quantitatively to KCl and O_2, these reference materials also may be useful for normalizing isotopic analyses of other chlorine- and oxygen-bearing substances in addition to perchlorate.

Reporting of stable-isotope-delta values: The following recommendations are provided for reporting stable chlorine and oxygen isotope-delta values:

- The $\delta^{37}Cl$ values of all chlorine-bearing substances should be expressed relative to SMOC [3, 10].
- The $\delta^{18}O$ values of all oxygen-bearing substances should be expressed relative to VSMOW-SLAP on a scale where the $\delta^{18}O$ of SLAP = –55.5 ‰ exactly [7, 8].
- Authors should report delta values of internationally distributed secondary isotopic reference materials that were assumed for normalization of data for samples of similar chemical composition, as appropriate for the measurement method. In this manner, measurement results can be adjusted in the future as analytical methods improve and consensus values of internationally distributed isotopic reference materials change.

References

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