



Reference Sheet for Reference Materials

(in cooperation with the U.S. National Institute for Standards and Technology (NIST))

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|---------------|--------------------------|--|
| NBS 28 | Silica sand-optical | ($\delta^{18}\text{O}_{\text{VSMOW}}$, $\delta^{30}\text{Si}$) |
| NBS 30 | Biotite, silicate powder | ($\delta^2\text{H}_{\text{VSMOW}}$, $\delta^{18}\text{O}_{\text{VSMOW}}$) |

Reference value for the relative difference in stable hydrogen isotope-amount ratio ($\delta^2\text{H}$)

Table 1: Reference $\delta^2\text{H}_{\text{VSMOW}}$ -value of the reference material NBS 30.

| Name | NIST code | Material | $1000 \times \delta^2\text{H}_{\text{VSMOW}}$ | $1000 \times \delta^2\text{H}_{\text{VSMOW}}$ standard uncertainty (1 sigma level) | Number of accepted results n (reported results) | References |
|--------|-----------|----------|---|--|---|------------|
| NBS 30 | RM 8538 | Biotite | -65.7 | 0.3 | 3(3) | [1] |

Reference values for the relative difference in stable oxygen isotope-amount ratio ($\delta^{18}\text{O}$) of the reference materials

Table 2: Reference $\delta^{18}\text{O}$ -values versus VSMOW of the reference materials NBS 30 and NBS 28. These recommended values are the results compiled in one initial data set [1], see Table 4.

| Name | NIST code | Material | $1000 \times \delta^{18}\text{O}_{\text{VSMOW}}$ | $1000 \times \delta^{18}\text{O}_{\text{VSMOW}}$ standard uncertainty (1 sigma level) | Number of accepted results n (reported results) | References |
|--------|-----------|---------------------|--|---|---|------------|
| NBS 30 | RM 8538 | Biotite | +5.12 | 0.06 | 4(5) | [1] |
| NBS 28 | RM 8546 | Silica sand-optical | +9.57 | 0.10* | 7(7) | [1] |

* Please note the remark on possibly larger uncertainty below based on individual measurement results in Table 4.

The traceability chain for $\delta^2\text{H}$ and $\delta^{18}\text{O}$ measurement results of NBS 28 and NBS 30 performed in testing laboratories, using VSMOW2 and SLAP2 as calibration standards, ends with the δ -values of these two materials, serving as international measurement standards, expressed on the VSMOW-SLAP scale.

The reference values are based on one data compilation only [1]. No changes for the reference values were applied despite the considerable number of individual determinations performed so far by various laboratories (see Table 4). This is due to complications in the comparison of different analytical methods for oxygen extraction by fluorination, the differences between analytical methods using O_2 or CO_2 as well as the variability of used CO_2 - H_2O fractionation factors for CO_2 measurements. The obtained δ -values cannot be easily compared, since not all studies reported the necessary information on used parameters. This results in estimated residual $\delta^{18}\text{O}$ uncertainties of up to 0.4 ‰. A re-evaluation of the reference values should be applied preferably only after consultation with and consensus of the concerned scientific community. The content of this reference sheet complies with the requirements of ISO Guide 31[2].

Definition of the $^{30}\text{Si}/^{28}\text{Si}$ scale

Although no absolute isotope abundance measurement of NBS 28 has been performed until now, this material served as the reference for relative $^{30}\text{Si}/^{28}\text{Si}$ measurements for more than two decades; thus, $\delta^{30}\text{Si}_{\text{NBS 28}} = 0 \text{ ‰}$.

Intended Use

The reference materials listed above provide samples with well known values for their relative difference in $^2\text{H}/^1\text{H}$ and/or $^{18}\text{O}/^{16}\text{O}$ isotope-amount ratios (δ -values) expressed in parts per thousand (‰) from the Vienna Standard Mean Ocean Water (VSMOW) based δ -scales[3]. NBS 28 is additionally intended for the isotope analysis of the relative difference of $^{30}\text{Si}/^{28}\text{Si}$ isotope-amount ratios.

The use of these reference materials allows comparability of $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values obtained in different testing laboratories. NBS 30 is intended for calibration purpose in the determination of $\delta^2\text{H}$ and $\delta^{18}\text{O}$ in geological materials. Its hydrogen isotope-amount ratios should be determined on the water fraction (3.5 % by weight). NBS 28 is intended for calibration purpose of $\delta^{18}\text{O}$ and $\delta^{30}\text{Si}$ values in geological materials.

Origin and preparation of the materials

NBS 30 was prepared by I. Friedman, J.R O'Neil and G. Cebula of the US Geological Survey from a sample of Lakeview tonalite (Southern California batholith) provided by L. Silver, California Institute of Technology, Pasadena. NBS 28 was obtained by I. Friedman, U.S. Geological Survey, from Corning Glass Company. It was washed with acid to remove impurities and the fraction between 100 μm and 177 μm was separated and packaged.

Distribution and Storage

NBS 30 is issued in units of 1.8 g. NBS 28 is issued in units of 0.5 g.

It is recommended that these reference materials be stored tightly closed in the original containers in which they are supplied to the user.

Normalization

The values for $\delta^2\text{H}$ and $\delta^{18}\text{O}$ are stated in parts per thousand difference (‰) from the respective value of the VSMOW and SLAP international measurement standards. The adoption of VSMOW as zero on the δ -scale and of prefixed values for SLAP corresponds with the definition of the δ -value normalized on the VSMOW / SLAP scale [4, 5]

$$\delta = [(R_{\text{sample}} / R_{\text{VSMOW}}) - 1] \cdot 1000 \cdot f \quad (1)$$

$$f = \delta^{\circ}_{\text{SLAP}} / [(R_{\text{SLAP}} - R_{\text{VSMOW}}) / R_{\text{VSMOW}}] \quad (2)$$

where R is the measured isotopic ratio of D/H ($^{18}\text{O}/^{16}\text{O}$), and

$\delta^{\circ}_{\text{SLAP}}$ is the conventionally fixed δ -value of - 428.0 ‰ for deuterium and - 55.5 ‰ for oxygen-18 [4]

Please note that the reporting scales for $\delta^2\text{H}$ and $\delta^{18}\text{O}$ are still denoted and referred to as VSMOW-SLAP scales, despite the exhaustion of supply of VSMOW and SLAP and their replacement by the two new international measurement standards VSMOW2 and SLAP2.

Expiration of Reference Values

The reference values for the isotopic composition of the certified reference materials are valid until 31 December 2017, provided they are handled and stored in accordance with the instructions given in this reference sheet.

Limit of Distribution

Each of these reference materials may be ordered only once per laboratory in a three years period. This should ensure that the materials are kept available as long as possible for international use.

$\delta^2\text{H}$ values as reported in various literature

Table 3: Intercalibration average $\delta^2\text{H}$ -value and standard uncertainty (1σ) of NBS 30 in reference to VSMOW and SLAP.

| Name | Material | $1000 \times \delta^2\text{H}_{\text{VSMOW}}$ | $1000 \times \delta^2\text{H}_{\text{VSMOW}}$ standard uncertainty | Number of accepted results n (reported results) | Reference |
|--------|----------|---|--|---|-----------|
| NBS 30 | Biotite | -65.7 | 0.3 | 3 (3) | [1] |

$\delta^{18}\text{O}$ values as reported in various literature

Table 4: Intercalibration average $\delta^{18}\text{O}$ -values in reference to VSMOW, standard uncertainty (1σ) based on standard deviation for NBS 28 and NBS 30.

| Name | Material | $1000 \times \delta^{18}\text{O}_{\text{VSMOW}}$ | $1000 \times \delta^{18}\text{O}_{\text{VSMOW}}$ standard uncertainty | Number of reported results n ; [no of preparations] | Reference |
|--------|---------------------|--|---|---|-----------|
| NBS 30 | Biotite | +5.24 | 0.24 | 4 | [1, 6] |
| NBS 30 | Biotite | 5.10 | 0.02 | 1 [2] | [7] |
| NBS 30 | Biotite | 5.0 | 0.1 | 2 | [8] |
| NBS 30 | Biotite | 5.03 | 0.08 | 82 | [9] |
| NBS 30 | Biotite | 4.88 | 0.08 | 7 | [10] |
| NBS 28 | Silica sand-optical | +9.58 | 0.11 | 6 | [1] |
| NBS 28 | Silica sand-optical | 10.0 | 0.07 | 20 | [11] |
| NBS 28 | Silica sand-optical | 9.23 | 0.05 | 18 | [12] |
| NBS 28 | Silica sand-optical | 9.64 | 0.06 | 7 | [7] |
| NBS 28 | Silica sand-optical | 9.22 | 0.14 | | [13] |
| NBS 28 | Silica sand-optical | 9.7 | 0.1 | 4 | [8] |
| NBS 28 | Silica sand-optical | 9.34 | 0.09 | 13 | [14] |
| NBS 28 | Silica sand-optical | 9.46 | 0.19 | 44 | [15] |
| NBS 28 | Silica sand-optical | 9.3 | 0.2 | | [16] |
| NBS 28 | Silica sand-optical | 9.29 | 0.18 | 65 | [17] |
| NBS 28 | Silica sand-optical | 9.0 | 0.1 | 3 | [18] |
| NBS 28 | Silica sand-optical | 8.8 | 0.2 | 22 | [19] |
| NBS 28 | Silica sand-optical | 9.31 | 0.08 | 7 | [20] |
| NBS 28 | Silica sand-optical | 9.43 | 0.09 | 14 | [21] |
| NBS 28 | Silica sand-optical | 9.51 | 0.05* | 1 [9] | [22] |
| NBS 28 | Silica sand-optical | 9.18 | 0.07 | 20 | [10] |

Legal disclaimer

The IAEA makes no warranties, expressed or implied, with respect to the data contained in this reference sheet and shall not be liable for any damage that may result from the use of such data.

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Further Information

Users of these reference materials should ensure that the reference sheet in their possession is current. This can be accomplished by contacting the IAEA reference material site at:

<http://www.iaea.org/programmes/aqcs/>

or the Isotope Hydrology Laboratory website at:

http://www-naweb.iaea.org/NAAL/HL/reference_materials.shtml

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