

# United States Geological Survey

## Reston Stable Isotope Laboratory

# Report of Stable Isotopic Composition

## Reference Material VSMOW

### (Hydrogen and Oxygen Isotopes in Water)

This reference material (RM) is an international measurement standard [1] that defines the zero of the  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  Vienna Standard Mean Ocean Water–Standard Light Antarctic Precipitation (VSMOW–SLAP) isotope scales in water [2] and in all other hydrogen-bearing substances and in selected oxygen bearing-substances [3]. VSMOW was prepared by H. Craig (University of California, La Jolla, California, USA) [2]. A unit distributed by the Reston Stable Isotope Laboratory (RSIL) consists of three autoclaved 5-mL glass ampoules of VSMOW, for a total of 15 mL of VSMOW. The equivalent name for this RM, as used by the International Atomic Energy Agency (IAEA) [4], is VSMOW, and that use by the U.S. National Institute of Standards and Technology (NIST) is RM 8533 [5]. The  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  expanded uncertainties of VSMOW are both zero because this RM defines the zero points of the  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  VSMOW–SLAP scales.

**Recommended Values:** Stable hydrogen and oxygen isotopic compositions are expressed herein as delta values [6] relative to VSMOW (Standard Mean Ocean Water) on scales normalized such that the  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  values of SLAP (Standard Light Antarctic Precipitation) are  $-428\text{‰}$  and  $-55.5\text{‰}$ , respectively [2,3].

Stable hydrogen isotopic composition:  $\delta^2\text{H}_{\text{VSMOW-SLAP}} = 0$  exactly

Stable oxygen isotopic composition:  $\delta^{18}\text{O}_{\text{VSMOW-SLAP}} = 0$  exactly

Technical coordination for this RM was provided by Haiping Qi of the RSIL.

**Source of the RM:** At the request of the IAEA, H. Craig (University of California, La Jolla, California, USA) collected ocean water from the equator and 180° longitude, distilled it, and slightly adjusted its hydrogen isotopic composition so that it would be in agreement with that of NBS 1 isotopic reference water [7], which is no longer distributed. He assigned the name SMOW-1 to this material (see Figure 1). To avoid confusion with the virtual SMOW defined in terms of NBS 1 reference water [8], it was recommended at the IAEA Consultants' meeting in 1976 that the name be changed to Vienna-SMOW [2], now abbreviated VSMOW. The RM has been sealed in glass ampoules having volumes of 5-mL. Each ampoule was inverted and autoclaved at ~120 °C for a minimum of 20 minutes. Ampoules with leaks in the glass lost water and were discarded.



Figure 1. Original container of SMOW-1 water (now called VSMOW). Note the lower name below “Do Not Move”. “V. Craig” is Valerie Craig, wife of Harmon Craig, and she assisted in the collection and preparation of the RM.

**Stability:** VSMOW is stable at normal room temperatures. The reference values in this Report of Investigation apply only to freshly opened ampoules.

**Expiration of Reference Value:** The reference value for the isotopic composition of VSMOW is valid for a period of 40 years (until July 13, 2058), provided the RM is handled in accordance with the instructions given in this Report of Stable Isotopic Composition (see “Instructions for Use”). The reference value is nullified if the glass ampoule containing the RM is broken.

**Instructions for Use:** This RM is intended for calibration of instrumentation and for calibrating local laboratory isotopic reference waters. The unused fraction of this RM should be discarded after opening an ampoule due to the strong possibility of evaporative losses causing significant isotopic fractionation.

**Reporting of Stable-isotope-delta Values:** The following recommendations are provided for reporting stable hydrogen and oxygen isotope-delta values [3]. It is recommended that:

- The  $\delta^2\text{H}$  values of all hydrogen-bearing substances be expressed relative to VSMOW-SLAP on a scale where  $\delta^2\text{H}_{\text{SLAP}} = -428 \text{‰}$  exactly or  $\delta^2\text{H}_{\text{SLAP2}} = -427.5 \text{‰}$  [10].
- The  $\delta^{18}\text{O}$  values of all oxygen-bearing substances be expressed relative to VSMOW-SLAP or relative to Vienna Peedee belemnite (VPDB; for carbonates) on a scale such that the  $\delta^{18}\text{O}$  of SLAP =  $-55.5 \text{‰}$  relative to VSMOW, and for carbonates, such that  $\delta^{18}\text{O}$  of NBS 19 calcium carbonate =  $-2.2 \text{‰}$ .
- Authors report  $\delta$  values of international distributed (secondary) isotopic reference materials as though they had been interspersed among and used for normalization of unknowns, 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.
- Reporting of  $\delta$  values relative to SMOW and PDB (Peedee belemnite) be discontinued [9].

## REFERENCES

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