

Task Group on Isotopes in Geosciences
Activity Report 2015-2020

In 2016, The Task Group has reviewed 23 papers, published after 2000, that contain new data relevant for the determination of the half-lives of the U isotopes. A part of the papers deal with the $^{238}\text{U}/^{235}\text{U}$ ratio in artificial and natural materials; other papers apply a revised U isotopic composition to calculate ages by geological intercomparison. While standard solutions can be measured with complete traceability and great accuracy, measuring geological samples is subject to compromises on sample size, sample characterization, and analytical equipment. A re-evaluation of the uncertainty budget in the papers based on U-Pb dating of natural samples has revealed systematic artefacts $> 0.1\%$. As both the desired total uncertainty and the provisional modification of the currently recommended ^{235}U half-life is $< 0.1\%$, it is clear that additional effort is required before systematic biases will have been reduced to satisfy this goal. As a result of its re-assessment, the TGIG is not in a position to recommend a revision of the ^{238}U and ^{235}U half-lives that have been in use since 1971.

The ^{234}U half-life can be estimated from samples in perfect secular equilibrium. As the equilibrium $^{234}\text{U}/^{238}\text{U}$ ratio measurements disagree by 0.1% among the published papers, it must be concluded that a bias of 0.1% affected at least one of the measurements. The re-evaluated ^{234}U half-life must take into account systematic bias; the provisional uncertainty interval ($k = 2$) for it is (244.55 - 247.77) ka.

Future work will need to improve the recognition and the understanding of systematic analytical effects that had been considered of minor importance in past decades, and the recognition and acceptance of the fact that the choice of a natural material that is fit-for-intended use as a calibrator must rely on human expertise capable of evaluating the geological/petrological context in its entirety.

Villa I.M., Bonardi M.L., De Bièvre P., Holden N.E., Renne P.R., 2016. IUPAC-IUGS status report on the half-lives of ^{238}U , ^{235}U and ^{234}U . *Geochimica et Cosmochimica Acta*, 172, 387-392. doi: 10.1016/j.gca.2015.10.011.

The Task Group is saddened to announce that two of its IUPAC members passed away in 2016: Dr. Mauro Bonardi (Italy) in March, and Dr. Paul De Bièvre (Belgium) in April.

After this, IUPAC has decided to name Dr. Antonio Possolo (National Institute of Standards and Technology) as new Task Group member.

A first meeting has been held at NIST, Gaithersburg, MD (USA), from December 8th to December 10th, attended by Holden and Possolo (IUPAC) and Villa (IUGS). The new Task Group member has been made acquainted with the geological side of the re-evaluation of half-lives; his work at NIST includes precisely the expertise on metrology, statistics, and the assessment of uncertainties, which had been missing since the passing of the two analytical chemists earlier this year. The outcome of the meeting was the renewed establishment of a tight cooperation, and the launching of a new round of re-evaluations on one or more of the following three nuclides: ^{40}K , ^{147}Sm , ^{176}Lu .

In 2017, the activity of the TGIG was dominated by the need to find suitable replacements for the two deceased members. In addition to Dr. Antonio Possolo, who joined TGIG in December 2016, we interviewed and included one IUPAC representative (Prof. em. D. Brynn Hibbert, Sydney) and one IUGS representative (Dr. Ryan B. Ickert, Glasgow). A meeting was held in Paris in August, when the three IUGS representatives (Ickert, Renne, Villa) laid out a roadmap for the rest of 2017. As anticipated in the 2016 report, it was agreed to launch a re-evaluation on ^{147}Sm , with a status report on ^{146}Sm (a short-lived nuclide present in the first few hundreds of Ma after Solar System formation and actively studied by cosmochemists).

In 2018, the TGIG activity was reviewed by an IUGS ad-hoc review committee. The following Terms of Reference were defined for the Task Group Isotopes in Geosciences:

Objectives

The objective of the TGIG is the definition of a set of recommendations regarding the isotopic compositions and the half-lives of radioactive isotopes, mainly, but not exclusively, for elements used by the geological community for geochronology

Strategies

Distribute and cross-calibrate standards of isotopic composition

Hold periodic meetings to update conventional acceptance of reference values

Increase awareness in the chemical and geological communities

After 10 years, the objectives are being met with regularity. The awareness of the geological community to the recommendations is very good, as attested by the number of citations.

During the past year 2018, considering funding limitations, the TGIG has mostly had electronic meetings; the three IUGS members (Ickert, Renne, Villa) have met in person once.

The work of the Task Group is especially long, as each member is asked to independently unravel the contrasting publications in the literature, then jointly discuss all issues, and derive an agreed recommendation that is expected both by the chemical and by the geological community to be accurate and to last for at least a generation.

The TGIG has submitted to a peer-refereed journal (*Geochimica et Cosmochimica Acta*) a fourth recommendation after those of 2011, 2015, and 2016.

In 2019, the work of the Task Group Isotopes in Geosciences was centered on refocusing the Sm half-life recommendation. One reviewer of the submitted manuscript raised a large number of objections to our treatment of statistical versus systematic errors. This prompted the Task Group to an extremely detailed, time-consuming clarification of the criteria of this, and future, evaluations. During the entire year 2019 the Task Group mostly had electronic meetings; the three IUGS members (Ickert, Renne, Villa) have met in person in December, keeping intensive e-mail contact with the three IUPAC members and finalizing the revised manuscript for submission.

In 2020, the recommendation on the samarium half-lives has finally been published:

Villa I.M., Holden N.E., Possolo A., Hibbert D.B., Ickert R.B., Renne P.R., 2020. IUPAC-IUGS recommendation on the half-lives of ^{147}Sm and ^{146}Sm . *Geochimica et Cosmochimica Acta*, 285, 70-77. doi: 10.1016/j.gca.2020.06.022.

Due to travel restrictions, no meeting in person has been possible. The evaluation of the next nuclide, ^{176}Lu , has been started.