Radiogenic Isotope Laboratory (RIL)

Figure 1. TIMS instrument in RIL

An isotope ratio of a natural or an artificial material occupies an important place in its characterization. Radiogenic isotopes provide critical data on the source and evolution processes of materials as tracers and are also used for radiometric dating. Radiogenic isotope experiments have many application areas like geology, mining, oil, nuclear energy, environmental pollution control, forensic science, anthropology, archaeology, archaeometry etc. The instrument that detects the radiogenic isotope ratios most precisely is the Thermal Ionization Mass Spectrometer (TIMS) (Figure 1).

BASIC PRINCIPLES

Isotopes are atoms of an element with same proton but different neutron amounts, thus they have different masses. Atom formed by radioacative decay of another atom is named as radiogenic isotope. Time elapsed for radioactive decay of half of a mother atom is defined as half-life. Radioactive decay to a daughter isotope, depending on a special constant for this isotope, is directly proportional to the number of atoms in a given time, thus allowing formulation of isotope systems. If the closed system condition is turned out and conserved, by measuring the current isotope ratio of a sample its initial isotope ratio and age can be detected.

In our laboratory, Strontium and Neodymium isotope ratio experiments are performed. Whole-rock samples are crushed by a jaw crusher and pulverized to <63 microns by an agate disc mill in our rock crushing and mineral enrichment laboratory.

Weighing, chemical dissolving, chromatography and filament loading procedures are done in a 100-class clean laboratory, where ultra-pure acids and water are used. Experiment quality is monitored by using internationally certified standards. Samples, weighed in certain amounts (Figure 2) and put into PFA vials, are dissolved with different acids on hotplates in safety hot-boxes.

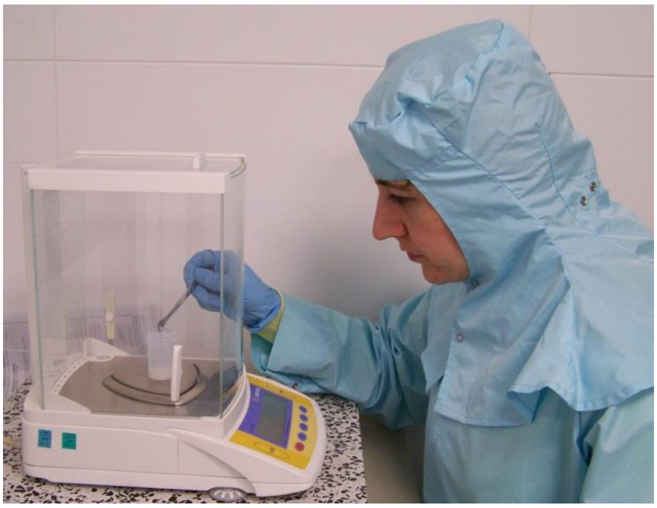

Figure 2. Weighing of a sample with an analytical balance

Strontium and Neodymium are separated from other elements by an ion chromatography method in which teflon columns with special resins and acid combinations are used (Figure 3).

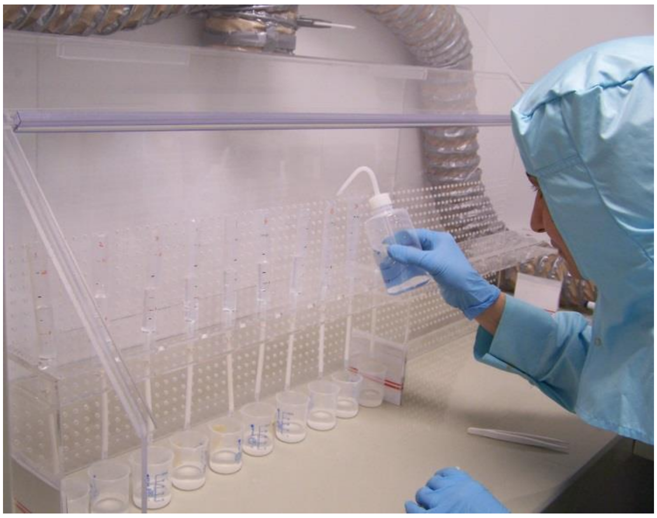

Figure 3. Neodymium chromatography

Enriched sample is loaded on a rhenium filament as few hundred nanograms in a dissolved form (Figure 4). Measurements are perfomed by using Triton Thermal Ionization Mass Spectrometer (Thermo-Fisher) with multi-collection (Figure 1). Data are reported as $^{87}Sr/^{86}Sr$ and/or $^{143}Nd/^{144}Nd$ isotope ratios with 2 sigma standard errors (Table 1).


Figure 4. Loading of a sample on a filament

During measurements, Sr NBS 987 and Nd LaJolla standards are measured for instrument calibration, and necessary bias corrections are made.

USGS rock standards, which are subjected to same chemical procedures and measured in same conditions, are used for periodically monitoring the quality of the whole process.

SAMPLE CHARACTERISTICS

In our laboratory, generally rock samples, minerals, archaeological and anthropological materials are analysed. Materials must be suitable to RIL sample acception criteria and should include sufficient content of an element to be isotopically measured. Rock samples have to be pulverized in a clean and proper environment preventing contamination and prepared for chemical treatment. For this reason whole sample preparation cycle, including crushing and disintegrating should be performed in our laboratory.

CASE STUDIES

Most of the experiments in our laboratory are performed on whole-rock samples. Experiment results are reported as $^{87}Sr/^{86}Sr$ and/or $^{143}Nd/^{144}Nd$ isotope ratios (Table 1). It is highly recommended to researchers to calculate and use the initial isotope ratios by using the measured ratios reported by us (Table 1).

An initial radiogenic isotope ratio of a rock manifests its isotopic character when it formed and gives hints on evolution conditions and possible sources of that rock. Therefore radiogenic isotope geochemistry is a method used in earth sciences not only for understanding of petrological processes but also for mining and oil exploration. When combined with the elemental concentration data radiogenic isotope ratios can be used for radiometric dating.

Table 1. Presentation of experiment results (from Köksal et al., 2012, Contributions to Mineralogy and Petrology, 163: 725-743).

No:	$^{87}Sr/^{86}Sr$ (measured)	$^{143}Nd/^{144}Nd$ (measured)	$^{87}Sr/^{86}Sr$ (initial)	εNd (initial)
1	0.717927± 4	0.512139± 4	0.715191	-8.84
2	0.712307± 15	0.512234± 5	0.709561	-6.90
3	0.711590± 4	0.512252± 3	0.709174	-6.48
4	0.711830± 5	0.512245± 3	0.709143	-6.70
5	0.720031± 8	0.512197± 4	0.710265	-7.64
6	0.710560± 5	0.512231± 3	0.709331	-7.18

By evaluation of radiogenic isotope data in archaeological and anthropological studies information related to the ancient periods can be obtained.

ANALYTICAL METHODS

In our laboratory Strontium and Neodymium isotope geochemistry experiments are performed by applying in-house TLM-ARG-RİL-01 (Sr Isotope Ratio Analysis Experiment Instruction) and TLM-ARG-RİL-02 (Nd Isotope Ratio Analysis Experiment Instruction) methods. These methods are based on methods applied in the Isotope Geochemistry Laboratory of German Research Centre for Geosciences (GFZ- Hemholtz Centre – Potsdam) and our studies followed up from literature. Applicability and validity of these methods are proved by periodical measurement of internationally certified and accepted standards and data produced from our laboratory are being presented in various international papers. Besides these two methods our studies on lead isotopes have also been continued in RIL.

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