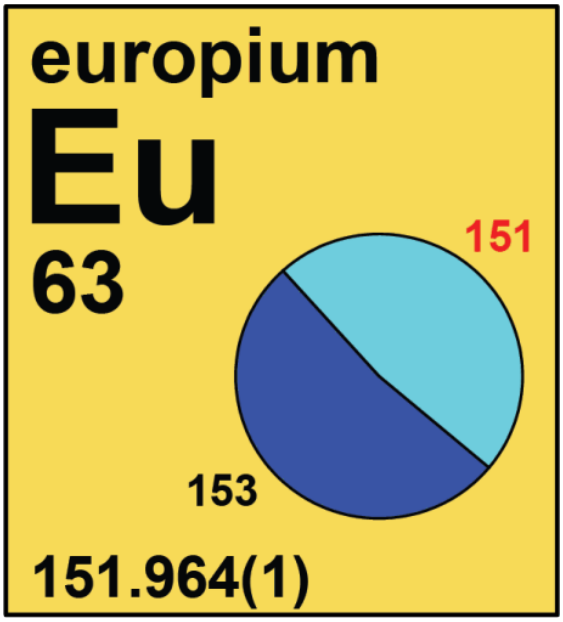
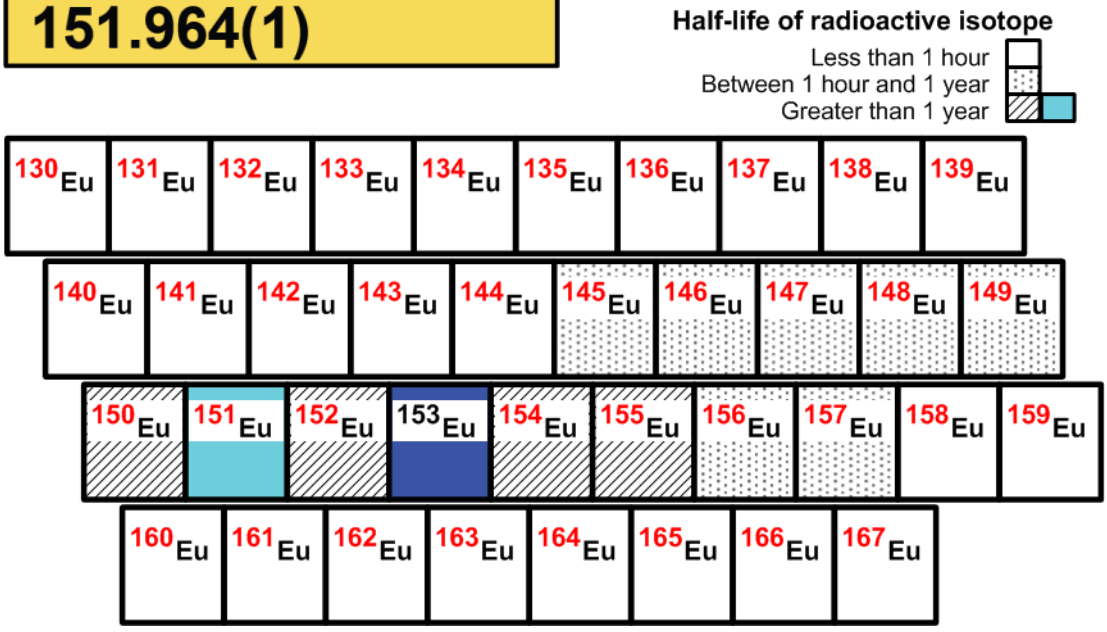


Stable isotope	Relative atomic mass	Mole fraction
^{151}Eu[†]	150.919 86	0.4781
^{153}Eu	152.921 24	0.5219

[†] **Radioactive isotope** having a relatively long **half-life** (5×10^{18} years) and a characteristic terrestrial **isotopic composition** that contributes significantly and reproducibly to the determination of the **standard atomic weight** of the **element** in **normal materials**.



Europium isotopes in geochronology

For more than 40 years, weapons-grade plutonium was manufactured by the Krasnoyarsk Mining and Chemical Combine in the now closed town of Krasnoyarsk Krai, Russia, using single-pass uranium-graphite production reactors [451]. Water from the Yenisei River was used for heat removal from the reactor core. Radioactively contaminated water was discharged into the Yenisei River and was a primary source of contamination of bottom sediments and floodland for hundreds of kilometers down gradient from the Krasnoyarsk Mining and Chemical Combine. In 2002, radioactive contamination of the bottom sediments and floodlands was composed primarily of ^{137}Cs, ^{152}Eu, ^{154}Eu, and ^{60}Co [451]. The decrease in the **isotope-amount ratio** $n(^{154}\text{Eu})/n(^{152}\text{Eu})$ down the depth profiles (Figure 1) enables one to determine the age of bottom sediments and floodlands of the Yenisei River and calculate their average formation rates [451].

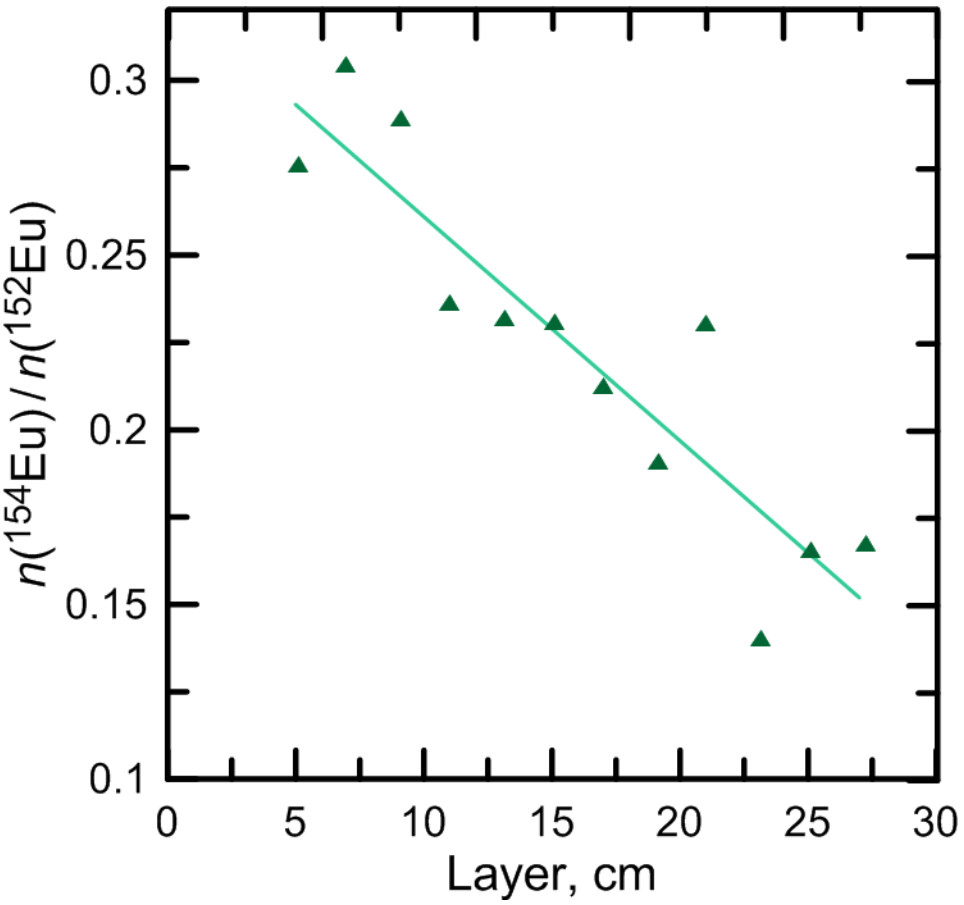


Fig. 1: Variation in the isotope-amount ratio $n(^{154}Eu)/n(^{152}Eu)$ along the vertical profile of floodland sediments at the tail end of Atamanovskii Island, Russia (modified from [451]).

Europium isotopes in industry

Europium isotopes are being studied for possible use in nuclear-control applications because they are good **neutron** absorbers [452, 453]. ^{152}Eu, which is produced by ^{151}Eu via the neutron capture reaction ^{151}Eu (n, γ) ^{152}Eu and ^{54}Eu are used as reference sources for calibration in **gamma ray** spectroscopy (Figure 2) [452-454].

Fig. 2: ^{152}Eu is used as a reference source for calibrating gamma-ray spectrometer systems like the one pictured here. (Photo Source: Snyder and Duval, 2003. U.S. Geological Survey Open-File Report 03-029) [455].

Europium isotopes used as a source of radioactive isotope(s)

Reactions on ^{153}Eu can produce the therapeutic **radionuclide** ^{153}Sm via fast neutron irradiation ^{153}Eu (n, p) ^{153}Sm [454, 456].

Glossary

atomic number (*Z*) – The number of protons in the nucleus of an atom.

electron – elementary particle of matter with a negative electric charge and a rest mass of about 9.109×10^{-31} kg.

element (**chemical element**) – a species of atoms; all atoms with the same number of **protons** in the atomic nucleus. A pure chemical substance composed of atoms with the same number of protons in the atomic nucleus [703]. [return]

gamma rays (gamma radiation) – a stream of high-energy electromagnetic radiation given off by an atomic nucleus undergoing **radioactive decay**. The energies of gamma rays are higher than those of **X-rays**; thus, gamma rays have greater penetrating power. [return]

half-life (radioactive) – the time interval that it takes for the total number of atoms of any **radioactive isotope** to decay and leave only one-half of the original number of atoms. [return]

isotope – one of two or more species of atoms of a given **element** (having the same number of **protons** in the nucleus) with different atomic masses (different number of **neutrons** in the nucleus). The atom can either be a **stable isotope** or a **radioactive isotope**.

isotope-amount ratio (*r*) – amount (symbol *n*) of an **isotope** divided by the amount of another isotope of the chemical **element** in the same system [706]. [return]

isotopic composition – number and abundance of the **isotopes** of a **chemical element** that are naturally occurring [706]. [return]

neutron – an elementary particle with no net charge and a rest mass of about 1.675×10^{-27} kg, slightly more than that of the proton. All atoms contain neutrons in their nucleus except for protium (^{1}H). [return]

normal material – a reasonably possible source for an **element** or its compounds in commerce, for industry or science; the material is not itself studied for some extraordinary anomaly and its mole fractions (isotopic abundances) have not been modified significantly in a geologically brief period [4]. [return]

proton – an elementary particle having a rest mass of about 1.673×10^{-27} kg, slightly less than that of a **neutron**, and a positive electric charge equal and opposite to that of the **electron**. The number of protons in the nucleus of an atom is the **atomic number**.

radioactive decay – the process by which unstable (or radioactive) **isotopes** lose energy by emitting alpha particles (helium nuclei), beta particles (positive or negative **electrons**), **gamma radiation**, **neutrons** or **protons** to reach a final stable energy state.

radioactive isotope (radioisotope) – an atom for which **radioactive decay** has been experimentally measured (also see **half-life**). [return]

radionuclide – a nuclide that is radioactive [703]. [return]

stable isotope – an atom for which no radioactive decay has ever been experimentally measured.

standard atomic weight – an evaluated quantity assigned by the IUPAC Commission on Isotopic Abundances and Atomic Weights (CIAAW) to encompass the range of possible atomic weights of a chemical **element** that might be encountered in all samples of normal terrestrial materials. It is comprised of either an interval (currently for 12 elements) or a value and an uncertainty (a standard Atomic-weight uncertainty), and currently there are 72. A standard atomic weight is determined from an evaluation of peer-reviewed scientific publications. [return]

X-rays – electromagnetic radiation with a wavelength ranging from 0.01 to 10 nanometers—shorter than those of UV rays and typically longer than those of gamma rays.

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