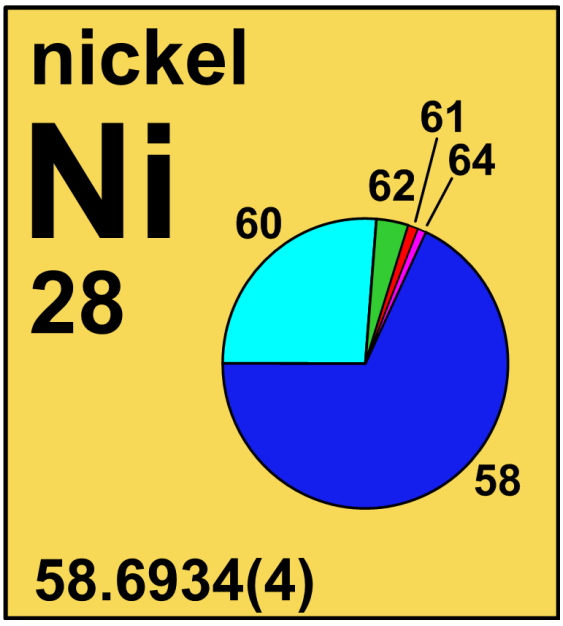
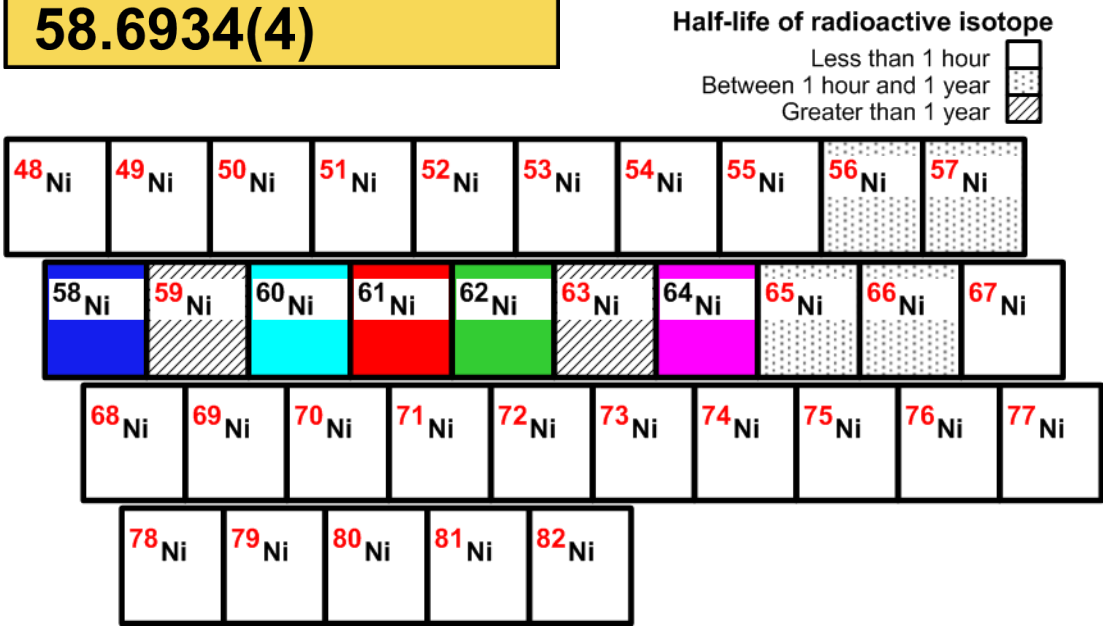
4.28 nickel



Stable isotope	Relative atomic mass	Mole fraction
^{58}Ni	57.935 342	0.680 769
^{60}Ni	59.930 786	0.262 231
^{61}Ni	60.931 056	0.011 399
^{62}Ni	61.928 345	0.036 345
^{64}Ni	63.927 967	0.009 256



4.28.1 Nickel isotopes in Earth/planetary science

Because molecules, atoms, and ions of the **stable isotopes** of nickel possess slightly different physical and chemical properties, they commonly will be fractionated during physical, chemical, and biological processes, giving rise to variations in **isotopic abundances** and in **atomic weights**. There are measureable variations in the isotopic abundances of nickel in terrestrial silicate rocks (Figure 4.28.1) [225].

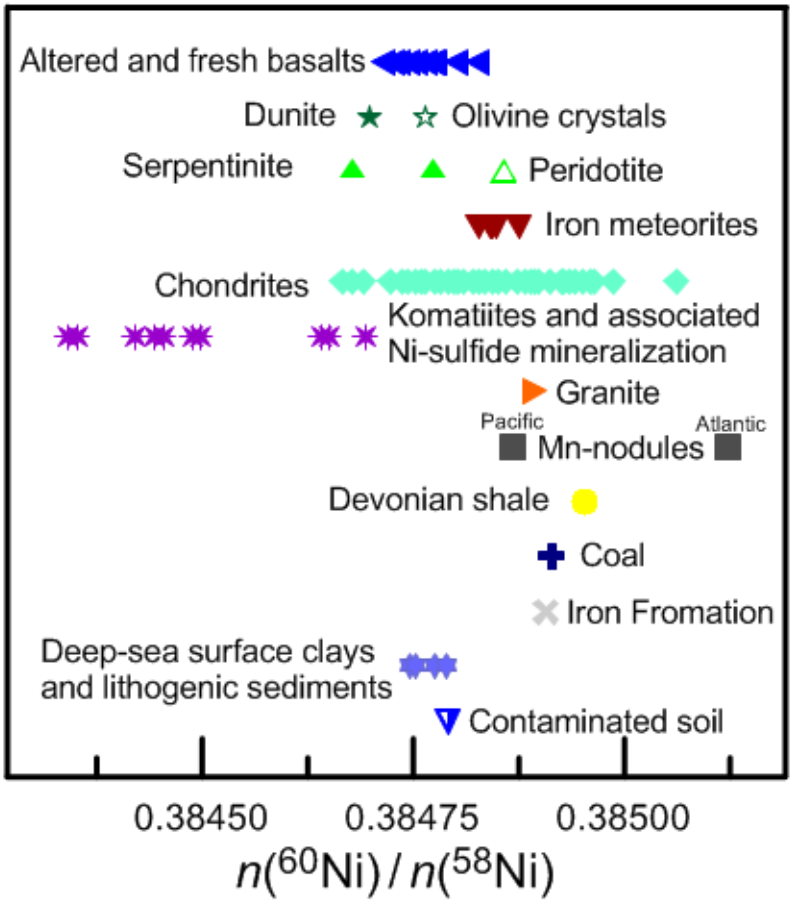


Fig. 4.28.1: Variation in **isotope-amount ratio** $n(^{60}\text{Ni})/n(^{58}\text{Ni})$ of terrestrial nickel-bearing silicate rocks (modified from [225], assuming a measured $n(^{60}\text{Ni})/n(^{58}\text{Ni})$ isotope-amount ratio of 0.385 198 [226].

4.28.2 Nickel isotopes in geochronology

Anomalies in ^{60}Ni abundance caused by decay of now extinct ^{60}Fe have been used to study the early history of our Solar System (see Iron isotopes in Earth/planetary science). ^{59}Ni is a **cosmogenic radionuclide** with a **half-life** of 7.6×10^4 years. Decay of ^{59}Ni has been used to assess the terrestrial age of **meteorites** and to determine abundances of extraterrestrial dust in ice and sediment [227].

4.28.3 Nickel isotopes in industry

^{63}Ni (with a **half-life** of 99 years) is produced from stable ^{62}Ni and is a beta-emitting radionuclide that serves as an **electron** source together with ^{55}Fe in **electron-capture detectors**. Electron-capture detectors are used as thickness gauges or as detectors for organic **analytes** in **gas chromatography** (Figure 4.28.2) [105]. ^{63}Ni is also used to ionize substances in ion mobility spectrometry–the basis of the instrument used in airports to screen passengers for drugs and

bombs [228]. ^{63}Ni is also used as a fluorescence-inducing source in elemental analysis by **X-ray fluorescence spectroscopy** and in miniaturized long-lived **nuclear batteries** [105]. Until the mid-1980s, nuclear batteries were used in pacemakers, but then they were replaced by long-lasting lithium batteries [229].

Fig. 4.28.2: Shimadzu GC-8A **Gas Chromatograph** (GC) with an **Electron-Capture Detector** (ECD). (Image Source: The Reston Chlorofluorocarbon Laboratory, U.S. Geological Survey) [230, 231].

4.28.4 Nickel isotopes used as a source of radioactive isotope(s)

^{61}Ni is used as a radiation target for production of the **radioactive isotope** ^{61}Cu (with a half-life of 3.3 hours), which emits **positrons** for **positron emission tomography** (**PET**) applications using the ^{61}Ni (p, n) ^{61}Cu reaction. ^{64}Ni is used as a radiation target for production of ^{64}Cu (with a half-life of 12.7 hours), which is used in **radioimmunotherapy** by attaching it to an antibody for delivery of cytotoxic radiation (toxic to living cells) to a target cell via the ^{64}Ni (p, n) ^{64}Cu reaction [232]. ^{60}Ni is used for the production of ^{57}Co (with a half-life of 0.75 year), which is used as a reference source for **gamma cameras** that are used in **nuclear medicine** via the ^{60}Ni (p, ^{4}He) ^{57}Co reaction [232].