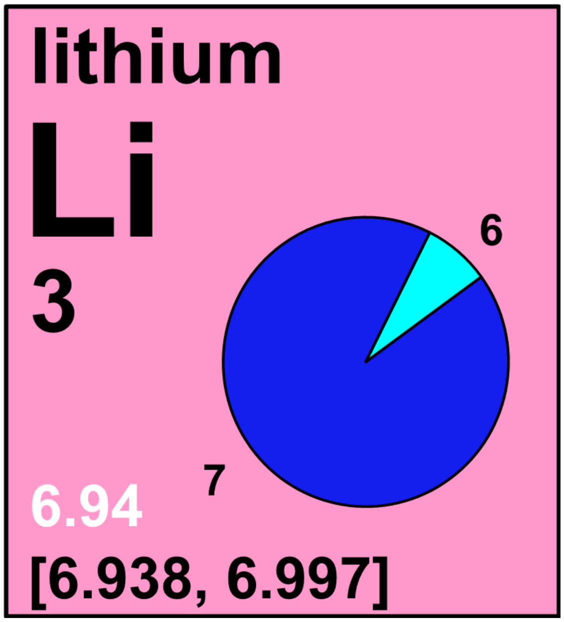
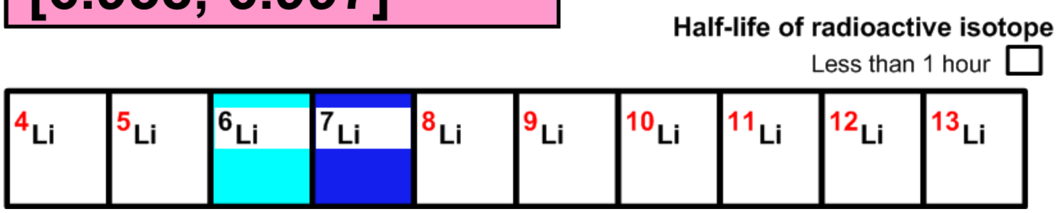
4.3 lithium



Stable isotope	Relative atomic mass	Mole fraction
^{6}Li	6.015 122 887	[0.019, 0.078]†
^{7}Li	7.016 003 44	[0.922, 0.981]†

† Materials depleted in lithium-6 are common sources of commercial laboratory shelf reagents, which is the reason for the wide interval of isotopic abundances given.



4.3.1 Lithium isotopes in Earth/planetary science

Because molecules, atoms, and ions of the **stable isotopes** of lithium 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**. Natural terrestrial materials show a substantial variation in lithium isotopic abundance (Figure 4.3.1), and these natural isotopic abundances have been used to determine sources of dissolved lithium and to investigate environmental processes [10, 32].

Variations in **isotope-amount ratios** $n(^{7}\text{Li})/n(^{6}\text{Li})$ can help determine the source of some water. Because the relative abundances of lithium **isotopes** can change during hydrothermal processes, isotopic analysis of lithium in water can help distinguish water derived from marine sedimentary rocks from water derived from hydrothermally altered **igneous** rocks (Figure 4.3.2) [33, 34].

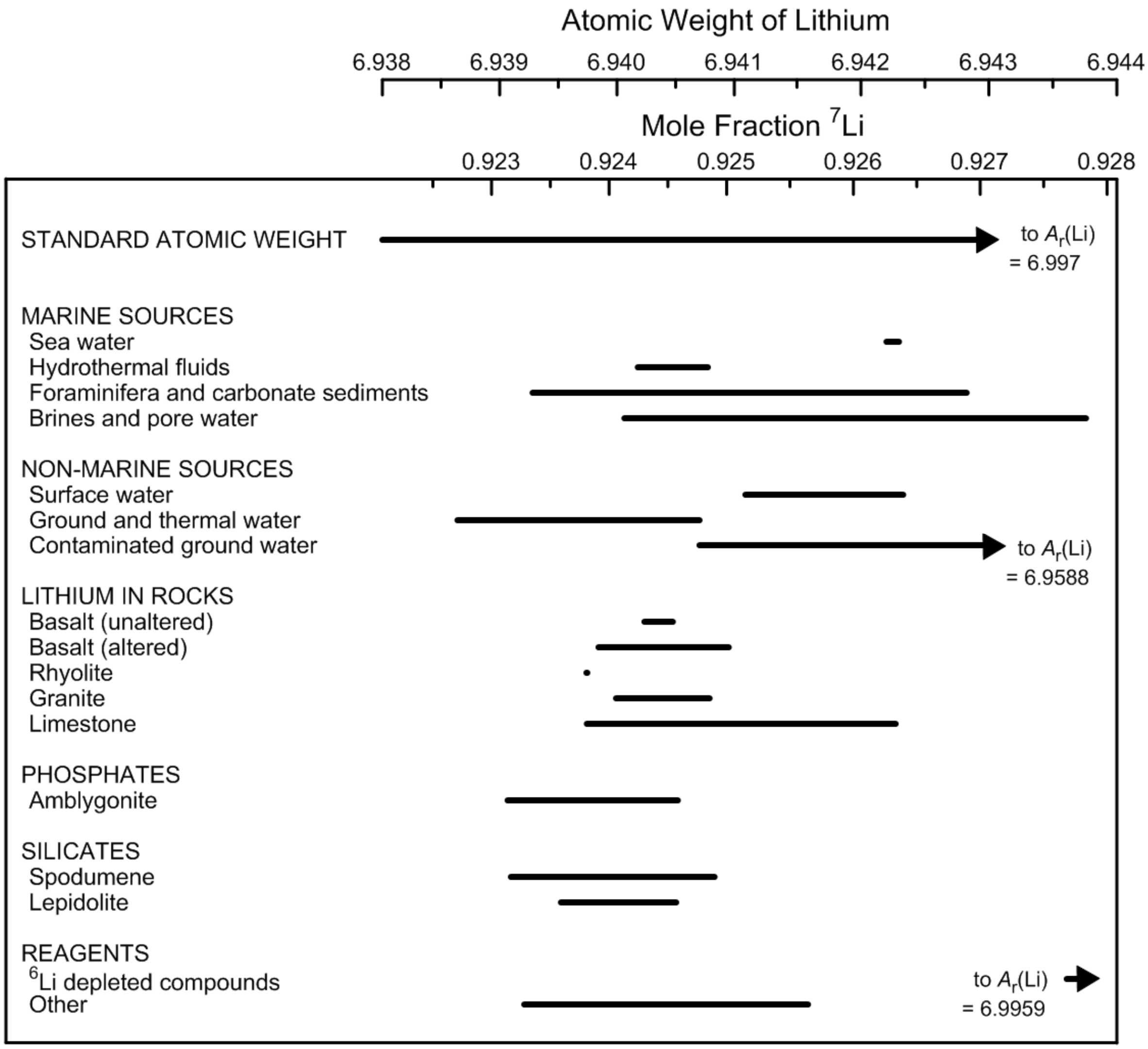


Fig. 4.3.1: Variation in **atomic weight** with **isotopic composition** of selected lithium-bearing materials (modified from [10, 14]).

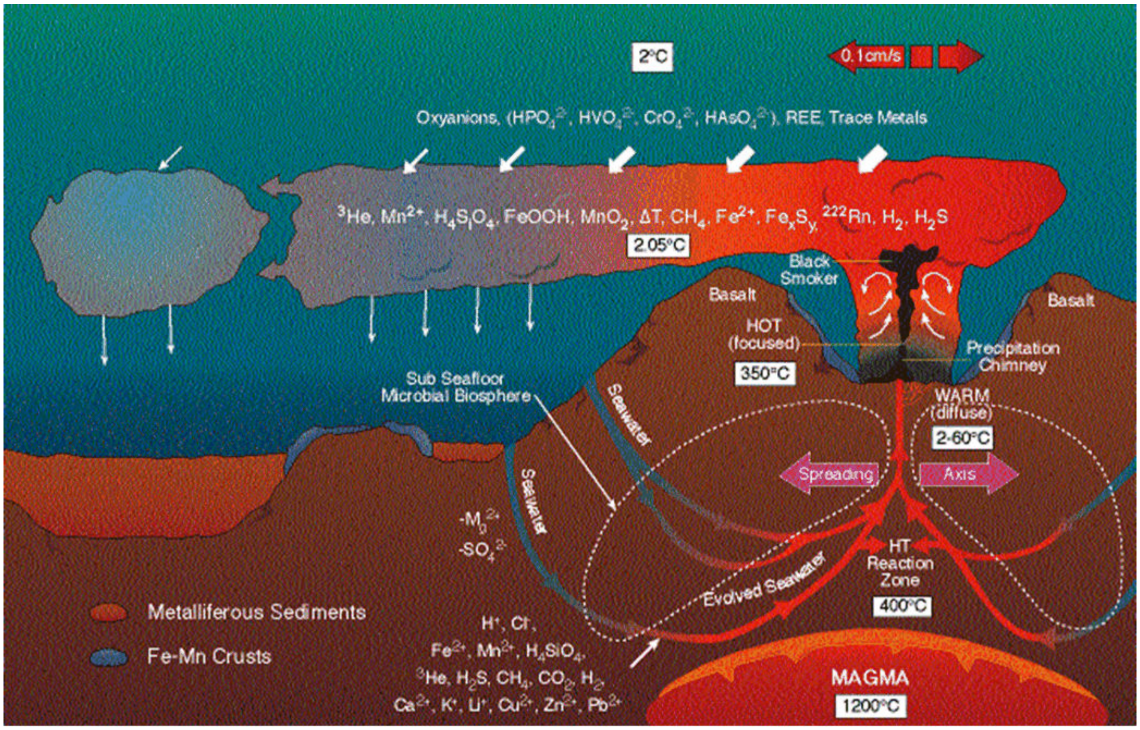


Fig. 4.3.2: Diagram of submarine hydrothermal vent processes. (Image Source: Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration) [35].

4.3.2 Lithium isotopes in industry

^{7}Li as hydroxide monohydrate (^{7}LiOH•H_2O) is used to maintain the pH level of the coolant used in pressurized water reactors in the nuclear power industry [36, 37]. Lithium plays a role in the construction of a **thermonuclear bomb**, which differs from a **fission** weapon in that it uses the energy released when two light atomic nuclei (i.e. deuterium (^{2}H) and tritium (^{3}H)) fuse to form helium and a high energy **neutron** via this DT reaction. ^{6}Li is used in the form of ^{6}Li deuteride (^{6}Li^{2}H) as fusion fuel that is capable of producing tritium when bombarded with neutrons within the weapon via the reaction ^{6}Li (n, ^{3}H) ^{4}He [38].

Li-based laboratory reagents have found their way into surface water and can be easily identified. Although a military secret in the 1950s, it is now known that substantial amounts of ^{6}Li (normally having an isotopic abundance of 0.076) were removed from chemical reagents to be used in nuclear-weapons' development. Reagents containing the remaining lithium depleted in ^{6}Li (having an isotopic abundance as low as 0.025) were sold to both chemical manufacturers and to laboratory chemists for their use [39]. The distinctive isotopic signature of depleted ^{6}Li, having a $n(^{7}\text{Li})/n(^{6}\text{Li})$ ratio of 39, compared to ratio of 12 in naturally occurring terrestrial materials, enables easier detection of this lithium source in polluted waterways and the environment [32, 34].

4.3.3 Lithium isotopes in medicine

^{7}Li is a **decay product** of the ^{10}B (neutron, alpha) ^{7}Li reaction, which has a peak value for room temperature neutrons. Brain tumor cells are typically found some 5 to 7 cm below the surface of the skull. After ^{10}B has been introduced to or entered the tumor cells, a beam of neutrons of energy slightly above room temperature is introduced to the affected areas. The energy of these neutrons is reduced to room temperature by the time they react with the ^{10}B, which then disintegrates into high energy charged particles (^{7}Li and ^{4}He), which deposit their kinetic energy in nearby (predominately cancerous) cells and destroys them. Any adjacent normal cells are unaffected [40].