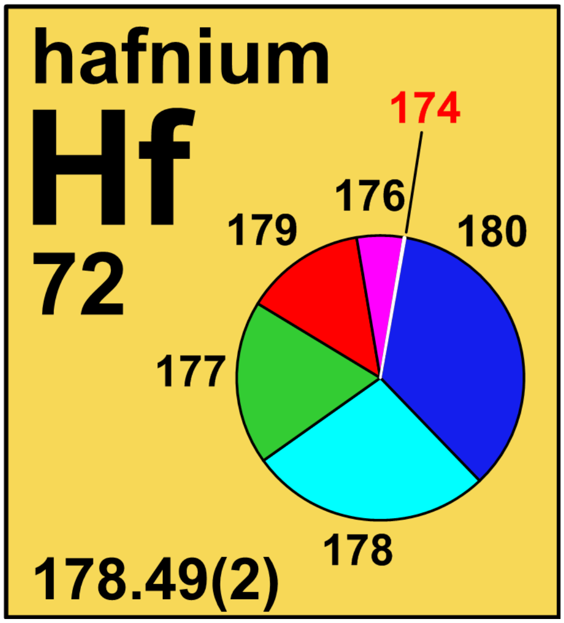
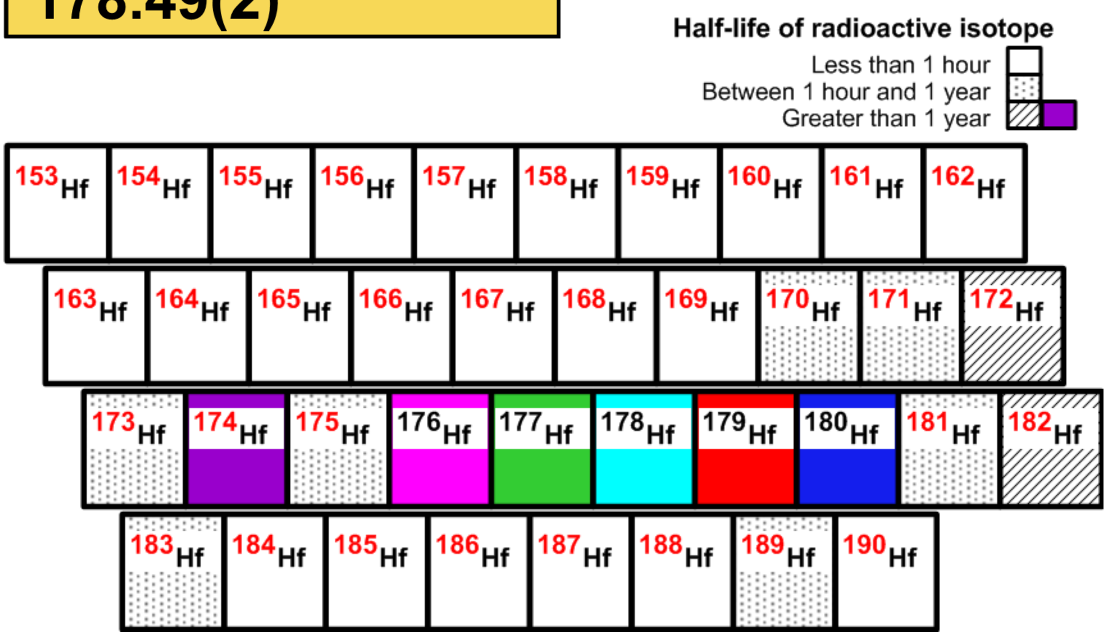
4.72 hafnium



Stable isotope	Relative atomic mass	Mole fraction
$^{174}Hf^{\dagger}$	173.940 05	0.0016
^{176}Hf	175.941 41	0.0526
^{177}Hf	176.943 23	0.1860
^{178}Hf	177.943 71	0.2728
^{179}Hf	178.945 82	0.1362
^{180}Hf	179.946 56	0.3508

† **Radioactive isotope** having a relatively long **half-life** (2.0×10^{15} 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**.



4.72.1 Hafnium isotopes in geochronology

Some ^{176}Hf is **radiogenic** as a result of it being formed as a product of **beta decay** of radioactive ^{176}Lu (**half-life** = 3.73×10^{10} years) [298]. Thus, relations between the **isotope-amount ratios** $n(^{176}Hf)/n(^{177}Hf)$ and $n(^{176}Hf)/n(^{176}Lu)$ have been used to determine the ages of minerals and rocks. Because of the long half-life of ^{176}Lu, these ratios have been used in geochronology studies that document some of the oldest rocks in the Solar System and on Earth (Figure 4.72.1).

Hafnium **isotopic compositions** of terrestrial materials evolved differently depending on the relative rates of ^{176}Hf production. Geologists can use calculated lutetium-hafnium ages and the initial isotope-amount ratio $n(^{176}Hf)/n(^{177}Hf)$ along with other isotopic data from the oldest rocks in the Earth to infer that the Earth's crust differentiated within the first few hundred million years after condensation of the oldest solid matter in the Solar System [499].

Radioactive ^{182}Hf decays to ^{182}W with a half-life of 8.9×10^6 years, which is much less than the age of **meteorites** and the Earth. Therefore, measurements of the amounts of hafnium and tungsten **isotopes** in meteorites and terrestrial samples reveal the earlier presence of ^{182}Hf. As a result, this provides information about chemical differentiation and evolution of the early Solar System [500, 501].

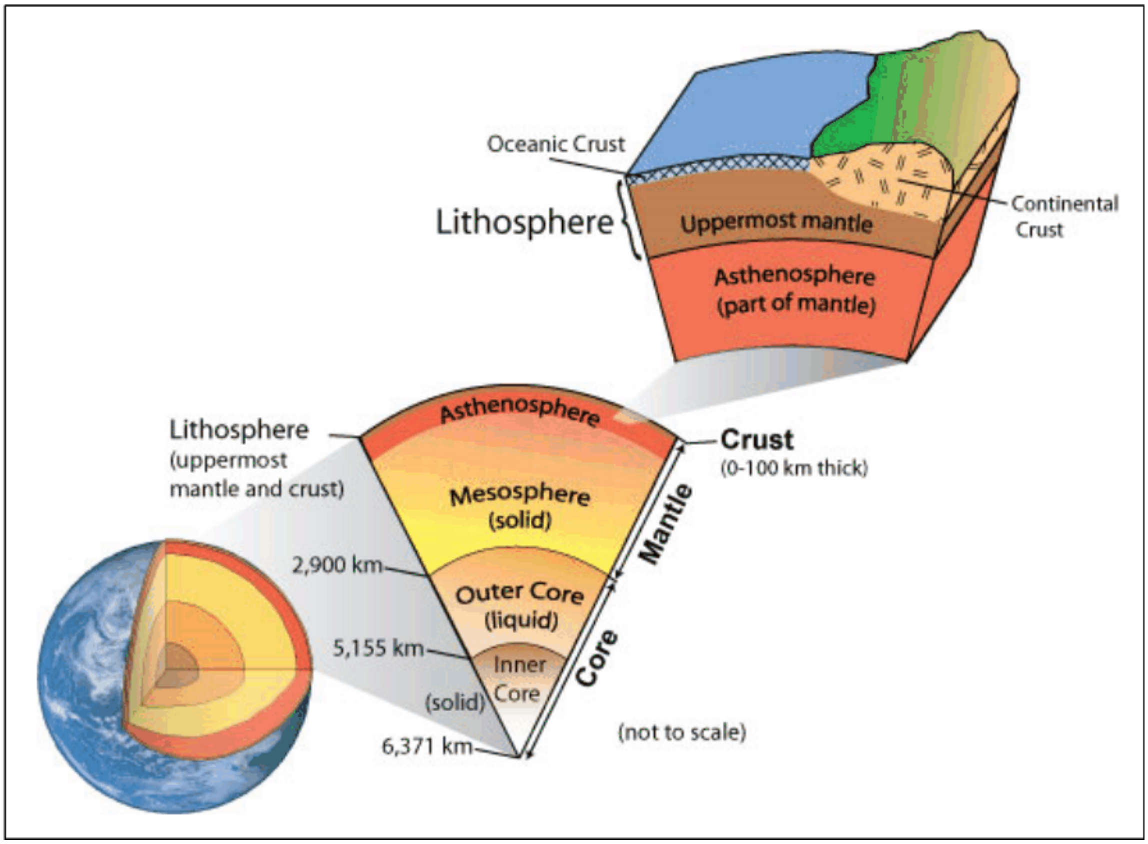


Fig. 4.72.1: Separation of the Earth into layers (crust, mantle, inner core, and outer core) was largely caused by gravitational differentiation (separating different constituents at temperature where materials are liquid or plastic, owing to differences in density) early in Earth's history. (Image Source: University of Wisconsin-Madison Space Science and Engineering Center) [502].