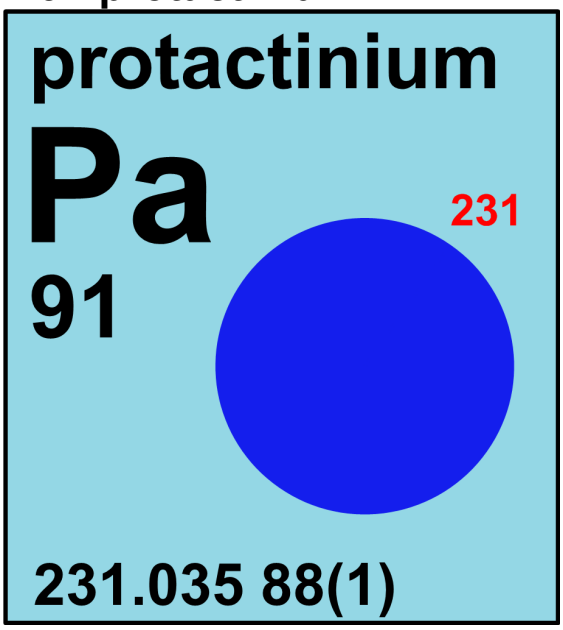
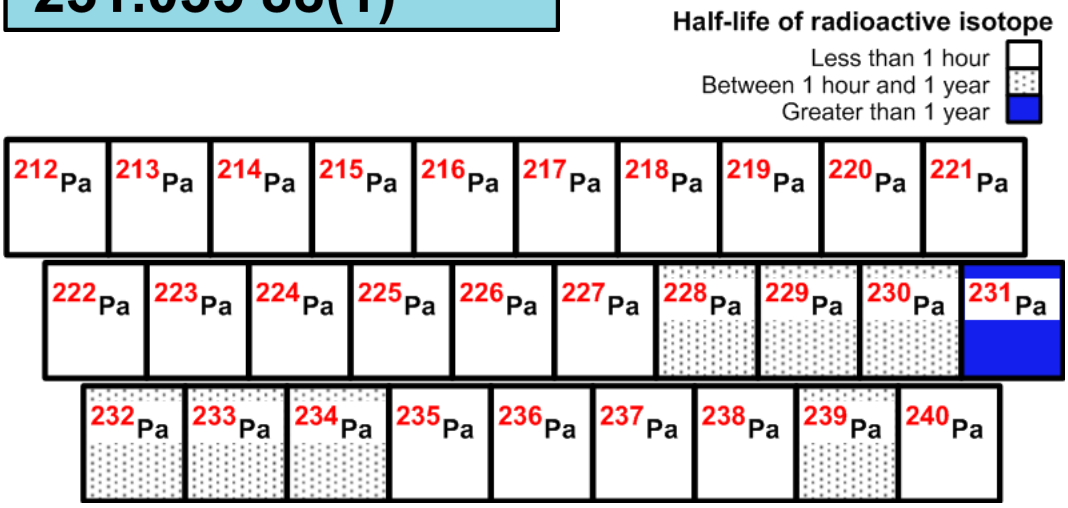
4.91 protactinium



Stable isotope	Relative atomic mass	Mole fraction
^{231}Pa†	231.035 88	1

† **Radioactive isotope** having a relatively long **half-life** (3.25×10^4 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**.



4.91.1 Protactinium isotopes in Earth/planetary science

^{231}Pa and ^{230}Th (with a half-life of 7.56×10^4 years) are produced in seawater by **radioactive decay** of ^{235}U and ^{234}U. The **mole ratio** of radioactive production of ^{231}Pa and ^{230}Th, $n(^{231}\text{Pa})/n(^{230}\text{Th})$, is 0.093. ^{230}Th is removed from seawater in settling particulates more efficiently than ^{231}Pa, and ^{231}Pa tends to be transported farther in ocean currents. Therefore, the mole ratio $n(^{231}\text{Pa})/n(^{230}\text{Th})$ in settling particulates tends to be less than the production ratio of 0.093 unless the water mass is stationary and allows both products to settle out. Thus, sedimentary records of excess $n(^{231}\text{Pa})/n(^{230}\text{Th})$ mole ratios can provide information for changes in the relative magnitude of major ocean circulation (Figure 4.91.1) [590, 591].

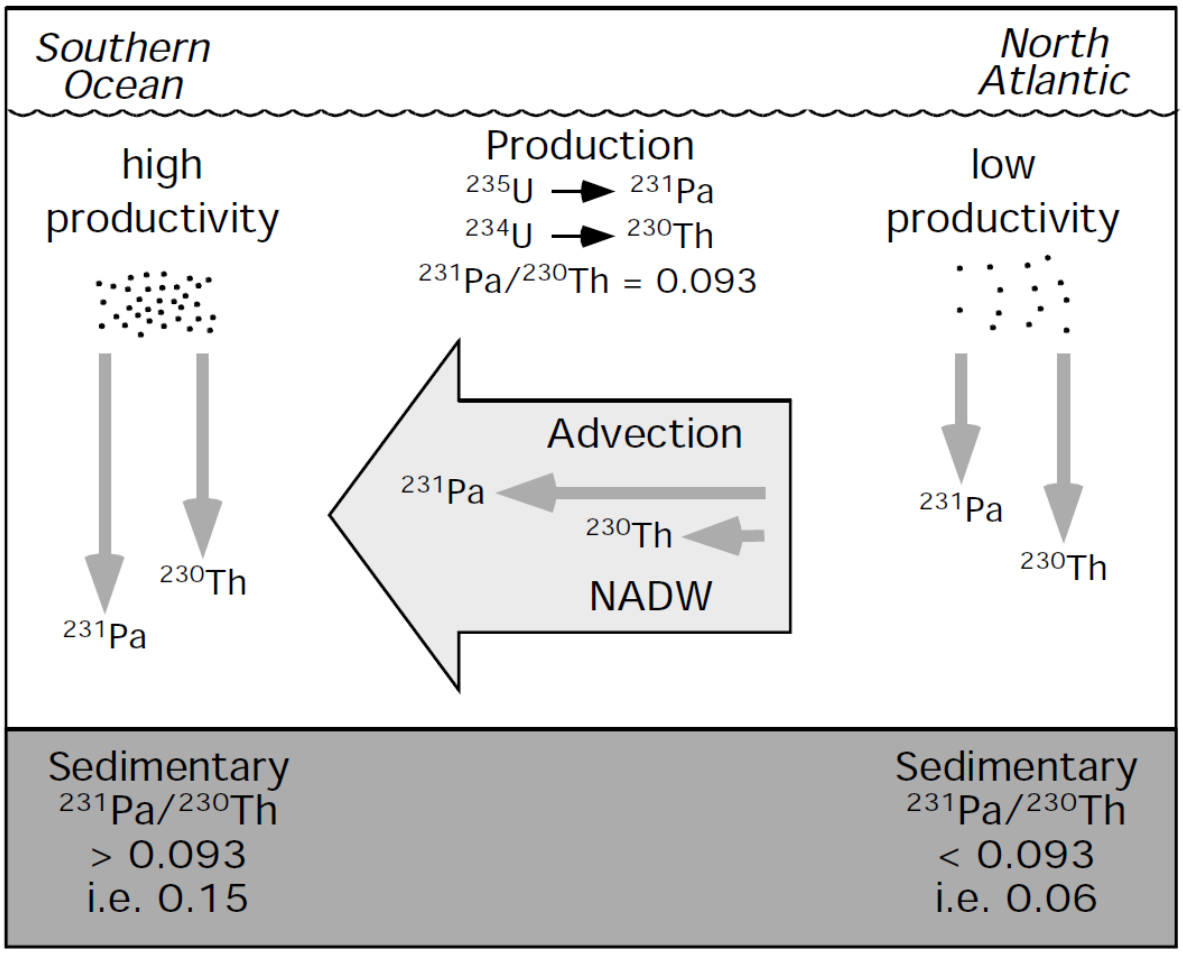


Fig. 4.91.1: Diagram of ^{231}Pa-^{230}Th fractionation (preferential separation) in the oceans. NADW is North Atlantic Deep Water. (Diagram Source: Henderson and Anderson, 2003) [592].

4.91.2 Protactinium isotopes in geochronology

^{231}Pa is a natural **radiogenic isotope** produced by **alpha decay** of ^{235}U to ^{231}Th, followed by beta emission to form ^{231}Pa. Although its behavior in the environment as a transient member of the U-series decay chain may be complex, measurements and modeling of ^{231}Pa in relation to the isotopes of uranium and thorium have been used in a variety of geochronologic applications on time scales of 10^3 to 10^5 years [593, 594]. Studies include movement of water masses and particles in the oceans, rates of magma melting and movement beneath volcanoes, and ages of carbonate mineral deposits, including corals in relation to climate change.