Homage to Becquerel

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Radioactivity: discovered by Herni Becquerel in 1896

Radioactivity materials were used before then:

Uranium glass from the 1830’s – popular 1880 – 1920.

Welsbach gas mantle invented in 1891: 99% thorium dioxide, 1% cerium dioxide
Crustal abundances in ppm:

Al: 82,000
Fe: 63,000
K: 20,000 (K$^{40}$: 2.4)
Th: 8
U: 2
Ag: 0.08
Au: 0.004
Primordial (stellar):

$^{19}\text{K}^{40} \text{ half-life: } 1.25 \times 10^{9} \text{ years}$

0.012% of naturally occurring potassium.
89% of time decay via $\beta^-$ emission to $^{20}\text{Ca}^{40}$
11% of time decay via EC to $^{18}\text{Ar}^{40}$

$^{90}\text{Th}^{232} \text{ half-life: } 1.40 \times 10^{10} \text{ years.}$

$^{92}\text{U}^{235} \text{ 0.7\%, half-life: } 7.04 \times 10^{8} \text{ years}$
$^{92}\text{U}^{238} \text{ 99.3\%, half-life: } 4.47 \times 10^{9} \text{ years}$
Non-primordial – cosmogenic or decay chains:

$^{6}\text{C}^{14}$ 5700 y half life. From cosmic ray interactions.

$^{88}\text{Ra}^{266}$ 1600 y half-life from decay of $^{92}\text{U}^{238}$

$^{88}\text{Ra}^{228}$ 5.1 y half-life from decay of $^{90}\text{Th}^{232}$

Radium: dangerous: frequently flaking paint. ingestion hazard. Produces radon gas. Radon decays to solids that are radioactive.
FIGURE 1. Natural Decay Series: Uranium-238

Source: Argonne National Laboratory

NOTES:

The symbols $\alpha$ and $\beta$ indicate alpha and beta decay, and the times shown are half-lives.

An asterisk indicates that the isotope is also a significant gamma emitter.

Uranium-238 also decays by spontaneous fission.
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**Figure N.3: Natural Decay Series: Thorium-232**

- **Thorium-232**: 14 billion years
- **Thorium-228**: 1.9 years
- **Actinium-228**: 6.1 hours
- **Thorium-228**: 5.8 years
- **Radium-224**: 3.7 days
- **Radium-224**: 61 minutes
  - **Polonium-216**: 0.15 seconds
  - **Polonium-212**: 310 nanoseconds
  - **Bismuth-212**: 61 minutes (84%)
  - **Bismuth-212**: 11 hours (36%)
- **Radon-220**: 56 seconds
- **Lead-212**: 3.1 minutes

**NOTES:**
- The symbols α and β indicate alpha and beta decay, and the times shown are half-lives.
- An asterisk indicates that the isotope is also a significant gamma emitter.
Catalogs of gamma-ray spectra at:
http://www.inl.gov/gammaray/catalogs/catalogs.shtml