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Where Does This Stuff Come From?

My previous blog posts discussed minerals that are either single elements or are compounds of multiple elements. By human standards, the Earth is very large, 5.9724×10^{24} kg [1]. That is a lot of material.

So where did this stuff come from?

At one time, most people were satisfied with a supernatural explanation, God or The Gods were responsible for creating the Earth and everything in it. For people with more important things on their minds, like survival, it was good working hypotheses. However, some people still asked questions and the answer to the question "where does this stuff come from" eventually was found through one of our oldest scientific pursuits - Astronomy.

The systematic study of the stars probably goes back far in the human past. However, it wasn't until the 20th Century that we were able to build instruments that could look deep into the far reaches of the Universe. The discovery of other galaxies by Edwin Hubble in 1925 was followed a few years later by his announcement that the these galaxies were in fact, moving away from each other [2].

Working back from the observed expansion of the Universe led some people to postulate a "Big Bang" [3] as the origin for the Universe. So is that the answer, that all the 92 elements we have found in nature originated in the Big Bang?

Not quite. Work by physicists looking at the physics of the fundamental particles of matter [4], led to the discovery that only hydrogen, helium and some lithium were created in the Big Bang [5, 6]. The other 89 elements were created through the following processes:

Galactic cosmic ray reactions

- Be & B as well as some isotopes of H, He and Li

Dying low mass stars:

- Some isotopes of most elements except for Be, B, Tc, and Pm

Exploding massive stars:

- Some isotopes of most elements except for H, Li, Be, B, Tc, and Pm

Exploding white dwarf stars:

- Some isotopes of Si, S, Ar, Ca, Ti, V, Cr, Mn, Fe, Co, Ni and Zn

Merging neutron stars:

- Some isotopes of Nb, Mo, Ru, Rh, Pd, Cd, In, Sn, Sb, Ce, W and Re

Radioactive Decay of other Elements

- The decay of radioactive isotopes produces numerous elements, most of them unstable. He and Ar are the most common stable elements produced by radioactive decay of other elements. All isotopes of Tc and Pm are radioactive and decay into other elements.

Figure 1, below, graphically shows the origin of the various elements

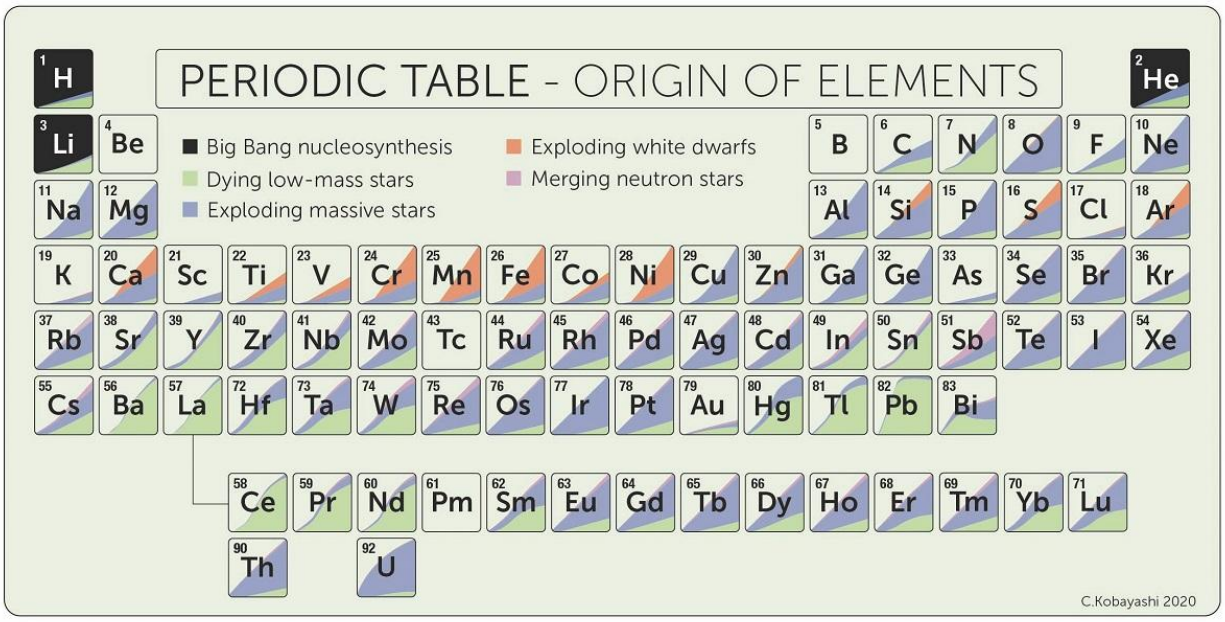

Figure 1 - Stellar Origin [7]

So How did this Stuff Form the Earth?

Between the time of the Big Bang, approximately 13.7 billion years ago [3] and the formation of the Earth, 4.54 billion years ago, the stellar processes noted above cooked up most of the elements and spread them in massive explosions. The dust of those explosions later coalesced into various nebulae. The Sun and planets formed out of one of these nebulae approximately 4.6 billion years ago.

We are made of star dust.

Figure 2 - Colliding Galaxies

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