February 22, 2021

Hydrogen, Helium, Lithium

Introduction

In last week's post on where the elements originated I noted that Hydrogen, Helium and Lithium were the only three elements created in the Big Bang. So, what is the geology of these three elements?

Hydrogen

Although it is the most common element in the Universe, free hydrogen is not common on the Earth. this is because free hydrogen is very reactive and the use of hydrogen can come to explosive ends as in Figure 1.

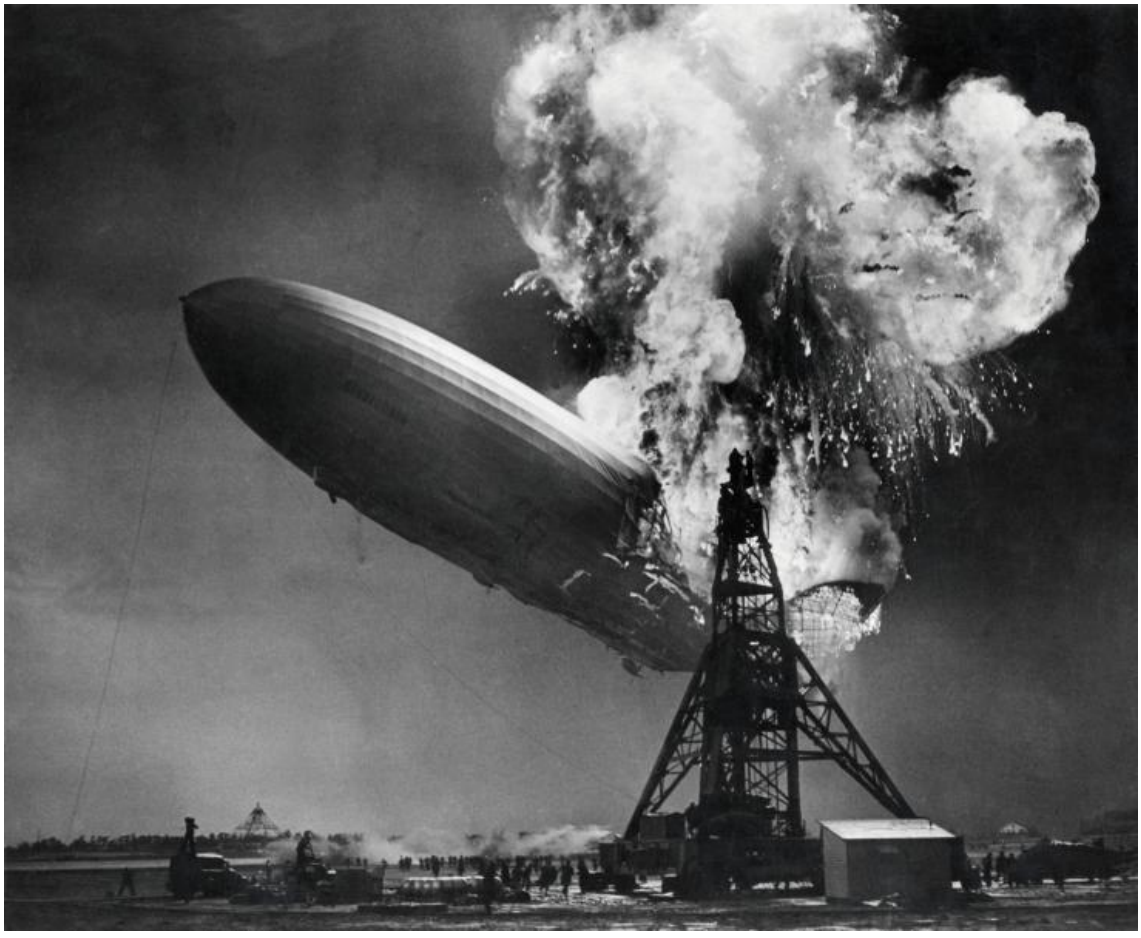

Figure 1 - Hydrogen is Very Reactive
https://commons.wikimedia.org/wiki/File:Hindenburg_disaster.jpg

Most of the hydrogen on earth is found in water, which is made up of hydrogen and oxygen. Hydrogen is also found in hydrocarbons: petroleum, natural gas and coal.

I won't spend too much time on hydrogen geology in this week's post since it can include a lot of topics, each of which is worth a post, or series of post, of its own:

Water

- Erosion and sedimentary deposition;
- Ocean and coastal geology,;
- Caves and karst topography;
- Glacial geology and periglacial landforms;
- Hydrogeology and groundwater;
- Minerals containing water such as hydrates.

Hydrocarbons

- Exploration and extraction of petroleum, natural gas and coal deposits;
- The origin of petroleum, natural gas and coal;
- The economics of hydrocarbons including depletion.

The Hydrogen Economy

- Hydrogen as an alternative energy source

I'll explore these themes in future posts.

Helium

Although helium is the second most abundant element in the Universe, it is rare on Earth. As a noble gas , it does not combine with other elements and, as a light gas, little would have remained in the atmosphere after the initial formation of the Earth. Most helium found in the Earth today is found as a component of natural gas, having been formed as a result of the radioactive decay of Uranium 238, as in Figure 2.

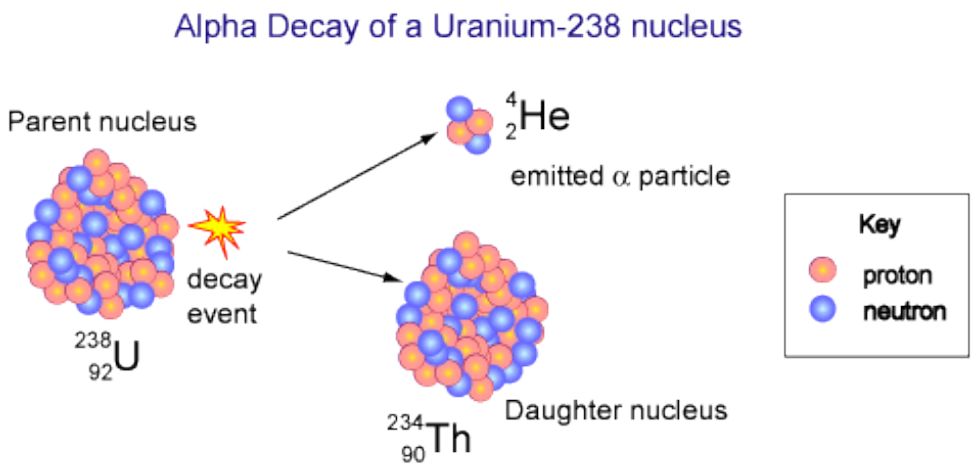

Figure 2 - Helium from Radioactive Decay of U 238
From : Weebly.com, *Radioactive Decay*,
https://radioactivedecay9.weebly.com/what-is-radioactive-decay.html

According the U.S. Geological Survey, helium is used for the following applications:

- magnetic resonance imaging, 30%;
- lifting gas, 17%;
- analytical and laboratory applications, 14%;
- welding, 9%;
- engineering and scientific applications, 6%;
- leak detection and semiconductor manufacturing, 5% each;
- and various other minor applications, 14%. 1

The United States has the largest reserves of Helium, estimated at 3,100 million cubic metres (MCM), followed by Algeria (1,800 MCM) and Poland (25 MCM) [1].

In Canada, most helium is produced in Saskatchewan and Alberta as a by-product of natural gas production. Construction of a new helium purification facility was announced in May 2020 [2] for completion in July 2021 3. This is expected to be Canada's largest helium purification plant [2, 3].

Lithium

The last of our three Big Bang elements is lithium. Most people are familiar with lithium as a component in lithium ion and lithium polymer batteries. The main uses of lithium are:

- batteries, 65%;
- ceramics and glass, 18%;
- lubricating greases, 5%;
- polymer production, 3%;

- continuous casting mold flux powders, 3%;
- air treatment, 1%; and
- other uses, 5%. [4]

Lithium is also a highly reactive metal and its use in lithium ion or lithium polymer batteries is known to cause fire in certain circumstances. Here is an example of what can happen [5]; as the man says **DON'T DO THIS AT HOME!**

About ten minerals are known to contain lithium; in igneous rocks the most common lithium minerals are spodumene, petalite and lepidolite 6. In sedimentary rocks, lithium is found in the clay mineral, hectorite. Lithium can also be extracted from brines [6]. The environments that lithium minerals and dissolved lithium are found include:

- Lithium-Cesium-Tantalum Pegmatite Deposits;
- Lithium-Enriched Granites;
- Lithium Brine Deposits in Closed Basins;
- Lithium in Other Brines;
- Lithium-Clay Deposits;
- Lithium-Zeolite Deposits. [6]

Figure 3 shows the location of Lithium-Cesium-Tantalum Pegmatite Deposits worldwide.

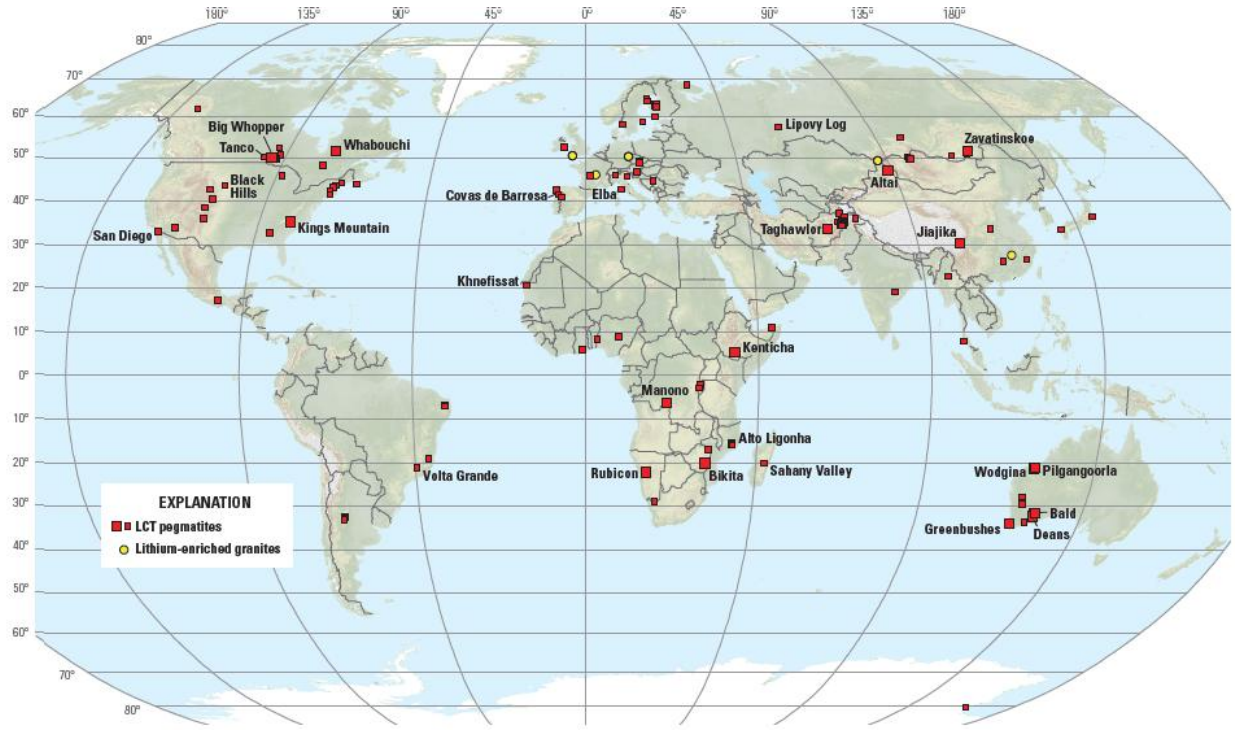

Figure 3 Worldwide Lithium-Cesium-Tantalum Pegmatite Deposits [6]

Figure 4 shows the location of lithium enriched brine and clay deposits worldwide

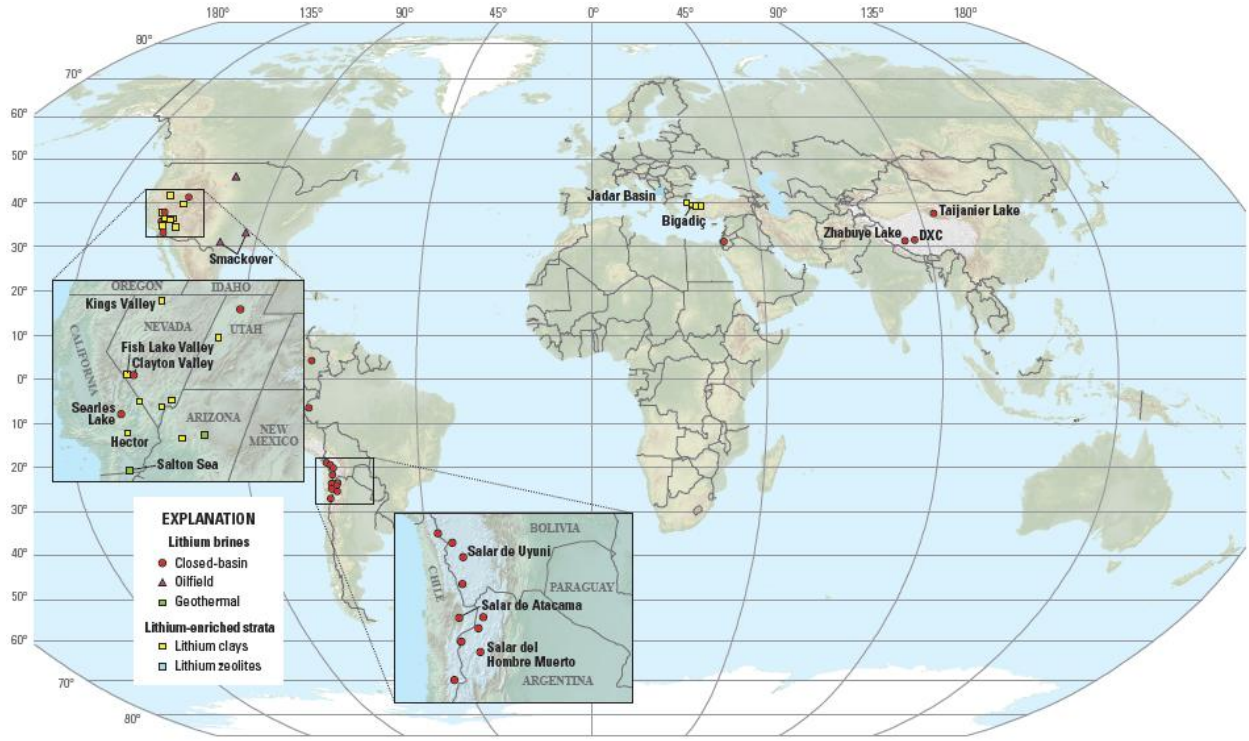

Figure 4 Worldwide Lithium Enriched Brine and Clay Deposits [6]

If electric vehicles (EV) become more popular, we can expect a greater demand for lithium to make the batteries for the EV. One estimate of future demand was published in Mining.com Jan. 27, 2021 indicating that if Tesla goes forward with their plan to build 20 million cars per year, it will require 127,302 tons of lithium per year [7].

Many people believe that EV are more environmentally friendly than internal combustion engine (ICE) vehicles. After all, EV make no emissions. However, the environmental cost of any vehicle system has to include not only the emissions of the individual vehicles, but also the environmental effects of building the vehicles. In the case of the lithium required for batteries, we should consider the environmental effects of lithium mining or brine extraction that can lead to surface and groundwater pollution as well as landscape destruction [8].

As always, environmental costs are a matter of trade offs. Switching to EV will reduce air pollution, especially in large cities where there are many motor vehicles. However, the trade off will be moving the environmental impacts from the prosperous urban environments to the places where the necessary minerals are extracted. Many of these places are poor and have little in the way of environmental regulation, thus shifting the burden of the environmental costs

from wealthy consumers to the impoverished people who live in the vicinity of the mineral production. That's our choice, that's the trade off for EV.

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