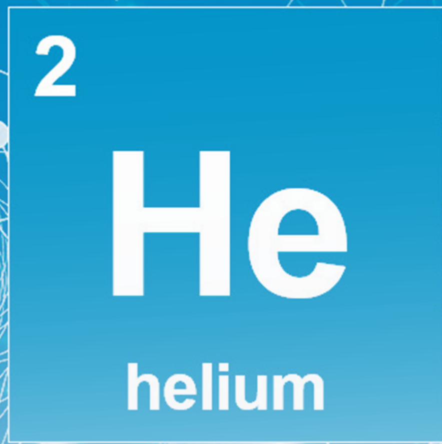

Helium Listed as a Critical Mineral

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Introduction

In May of 2018, The United States Department of Interior published a list of 35 minerals considered critical to economic and national security. Included on this list was the prime ingredient of a well-established party favor, the element helium (fig. 1). Helium is produced by the radioactive decay of uranium and thorium and accumulates below Earth's surface in natural gas deposits. These gas accumulations have been developing throughout Earth's history, but it is now estimated that more helium is produced each year than is generated as a decay product.

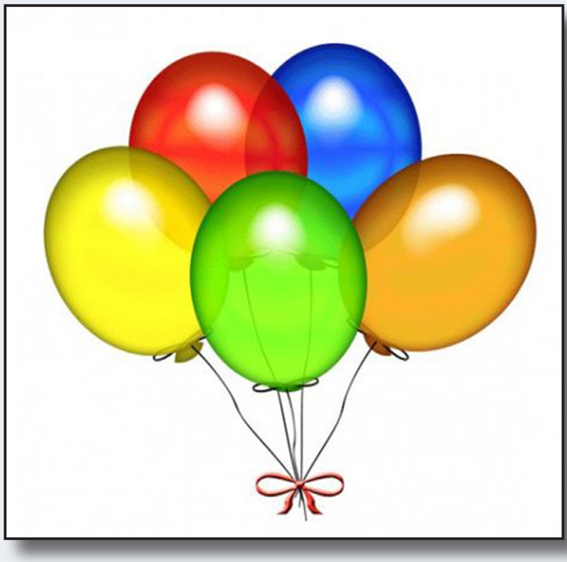

Figure 1. A longtime staple of birthday parties, proms, and other celebrations, bouquets of helium balloons are becoming harder to find at party supplies stores due to shortages in helium supply.

The United States is the world's leading producer of helium, with fourteen extraction plants in operation in the states of Arizona, Colorado, Kansas, Oklahoma, Texas, and Utah. These plants extracted an estimated 64 billion cubic feet (1.8 billion cubic meters) of helium from natural gas in 2018 (Peterson, 2019). Much of this production comes from the Panhandle-Hugoton field which stretches from southwestern Kansas across the panhandles of Oklahoma and Texas (Brown, 2019). The U.S. currently supplies over half of the world's production, but its share has been decreasing in recent years, with increased production coming from Qatar and Algeria.

Helium Properties – a second place element?

Helium is the second-most abundant element, estimated to account for approximately 24% of the total elemental mass in the observable universe, as well as the second lightest, ranking behind hydrogen in both cases. While hydrogen is seven percent more buoyant than helium, it is a very reactive element, eagerly sharing its lone electron with heavier elements like carbon and oxygen to form molecules which effectively anchor hydrogen atoms down. Helium on the other hand is monatomic and nonreactive. Helium is so light that Earth's gravitational pull is insufficient to contain it, or stated differently, once an atom of helium reaches the atmosphere it will eventually be lost to space. It has only one electron shell, which is full and has never been observed bonding to another element to form a compound. As such helium is placed in the 18th column on the Periodic Table, perched atop the other non-reactive "noble elements" with full outer shells. Fellow noble element neon is the least reactive of all elements, followed by… helium. Second again. But there are characteristics for which helium rises (pun intended) to the very top.

Helium has the lowest boiling and melting points of all elements, becoming a liquid at -450.3 degrees Fahrenheit (5.2 °K) and remaining a liquid at absolute zero. This property makes it extremely useful in the field of cryogenics, the production and behavior of materials at very low temperatures. Cryogenic uses include magnetic resonance imaging (MRI) machines (fig. 2), semiconductor processing, and both large-scale research (such as the Large Hadron Collider at CERN) and small-scale scientific research. Being the smallest of all elements, non-toxic, and inert, helium is a useful medium for leak detection. Its nonreactivity and low cost make it an effective shielding gas in welding. Helium is also used for pressurizing and purging rocket tanks, in complex fabrication processes, as a lifting gas, and other uses (like making your voice sound funny).

Figure 2. Liquid helium is necessary to cool the superconducting magnets used in magnetic resonance imaging (MRI) machines.

If you are someone who has regularly purchased balloons for birthday and graduation parties or other special occasions, over the past decade you may have noticed that it is getting a little bit harder to find helium-filled balloons, and if you do find them, that the prices have, well… ballooned. At least some of the reasons for this can be traced back to a history of public policy enacted to promote helium gas as advantageous to national defense and in the development of commercial aeronautics.

The Helium Acts

On March 3, 1925 President Calvin Coolidge signed into law the Helium Act of 1925, a law concerning the conservation, production, and exploitation of helium gas. The law authorized the federal government to acquire lands with potential for helium gas production, established the National Helium Reserve within a vast underground reservoir (Bush Dome) near Amarillo, Texas, and assigned the United States Department of the Interior and the United States Bureau of Mines regulatory power over it.

The build-up of the National Helium Reserve at Bush Dome and the infrastructure of the associated Cliffside storage facility continued with Helium Acts Amendments of 1960, signed by President Dwight Eisenhower. These amendments made provisions for the Bureau of Mines to construct 425 miles (684 km) of pipeline from Kansas to the Cliffside facility, connecting the National Helium Reserve to plants which separate helium from natural gas.

A deflating of previous policy took place via the Helium Privatization Act of 1996, signed into law by President William Clinton. After more than a decade of price and supply stability, this law required the federal government to begin liquidating its stake in the National Helium Reserve and let private industry gradually meet all production needs for the resource. However, when federal sales began, price was determined by a formula meant to recover the debt of approximately 1.4 billion dollars which had been incurred while building the Reserve, rather than selling at a true market price. Initially this formula resulted in a price for federal helium that was approximately 25% above the market price, but as time passed and more uses for helium came online the market price eventually exceeded the formula-based price. This resulted in federal helium being sold at a low price and likely held back private industry's exploration for and production of new supply (National Resource Council, 2000). By 2009, shortages of helium began to be noticed.

A proposed remedy for this problem was legislated by the Helium Stewardship Act of 2013, signed by President Barack Obama, which opened auctions for a portion of federal helium sales. While this did restore competitive market forces to the industry, it has not fully re-established the desired stability in helium prices or supply.

Helium in the Williston Basin

An indication of helium potential in the Canadian portion of the Williston Basin was first discovered in southwestern Saskatchewan in 1952, and production occurred from four wells north of the town of Swift Current during the years of 1963 to 1977. Recent reporting of gas analysis from wells in southwestern Saskatchewan suggests the Deadwood Formation and other lower Paleozoic formations tend to have the highest helium concentrations (Yurkowski, 2016).

In 2018, the NDGS began a search through the digital well file records stored in the DMR Oil & Gas website for additional laboratory reports of gas samples which include an analysis for helium. Part of this search included targeting wells near the Canadian border and wells completed in the Deadwood Formation. More than 200 well files were searched, but no helium analyses were found. The United States Bureau of Mines has published analytical results of 14,242 gas samples collected nation-wide from 1917 through 1985 (Moore & Sigler, 1987), 55 of which were from wells in North Dakota. The NDGS generated a map highlighting the stratigraphic units from which these gas samples had been collected, and the range of helium concentrations (fig. 3). This map indicates that late Paleozoic rocks, such as those of the Deadwood Formation, are more likely to produce natural gas with higher levels of helium concentration in the North Dakota portion of the Williston Basin.

Natural gas with a helium concentration of at least 0.3 percent is considered potentially economic for helium production as a primary product. Only one of the 55 samples from North Dakota reported by Moore & Sigler (1987) exceeds this threshold, a commingled sample collected from Devonian and Ordovician source rocks. Three of the five samples collected from either the Winnipeg Group or the Deadwood Formation had helium concentrations greater than 0.16 percent.

As any child waking to the disappointment of finding his birthday balloon resting on the floor has learned, helium is prone to escape. The same is true for gas samples, which must be collected and handled with care to mitigate loss. Without knowing the sample collection and laboratory procedures utilized to collect this data, they might be more appropriately viewed to be minimum helium concentrations of these sources.

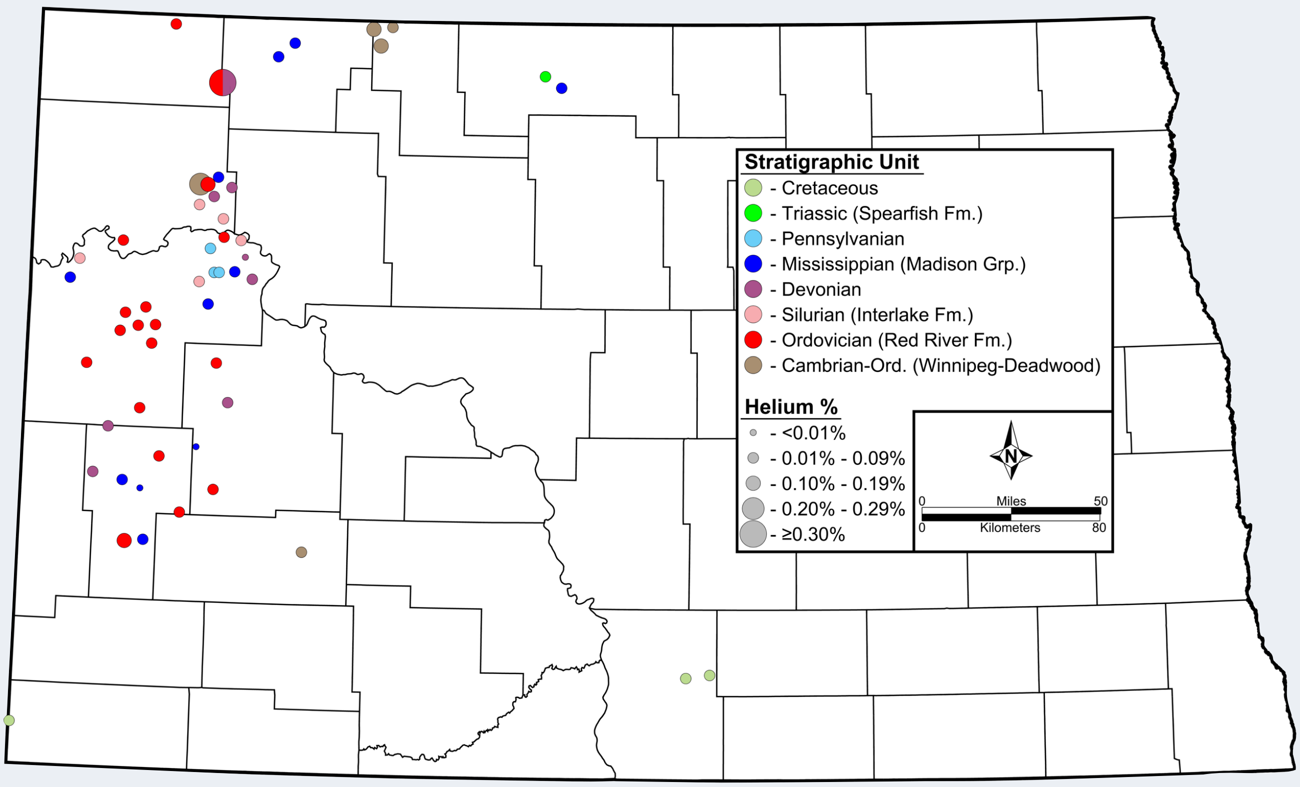

Figure 3. Map view of wells with helium concentrations generated from data reported in the U.S. Bureau of Mines Information Circular 9129. Sample location dots provide information on the stratigraphic units the gas samples were collected from and the range of helium concentrations measured. The highest concentration reported came from a commingled sample from the Winnipegosis Formation (Devonian) and Red River Formation (Ordovician).

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