Almost Forgotten Anniversaries in 2019

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Abstract:
As we celebrate the International Year of the Periodic Table, the 50th anniversary of Apollo 11 and the meteorite falls of Allende and Murchison in 1969, other noteworthy science events with round birthdays seem to be overlooked and almost forgotten Several scientific organizations celebrate the birthdays of their foundation; and key events and discoveries related to meteoritics, astronomy, geo- and cosmochemistry, and nuclear sciences can be commemorated this year, including the anniversaries of the discoveries of eleven chemical elements, and the advancements of our knowledge of the elemental and isotopic abundances. Introduction.

Introduction
The 150th anniversary of the discovery of the periodic system of the elements by Dmitri Ivanovich Mendeleev (8 Feb. 1834 – 2 Feb. 1907) and independently by Julius Lothar Meyer (19 August 1830 – 11 April 1895) is the reason for celebrating the International Year of the Periodic Table in 2019. Not only that, but several scientific organizations celebrate the birthdays of their foundation: The Astronomical Society of the Pacific (1889), The American Astronomical Society (1899), the American Geophysical Union (1919), the Mineralogical Society of America (1919), and the International Astronomical Union IAU (1919).

The anniversaries in 2019 give us reasons to reflect on the major impacts of space exploration. In 1969, the first men landed on the moon and Apollo 11 safely returned with lunar rocks for study. The same year was blessed by the fall of the important carbonaceous chondrites Allende and Murchison. But let us not forget the other events with round birthdays. Other space missions worth mentioning are the Voyager 1 and 2 fly-bys at Jupiter in 1979 (5 March and 9 July), and Voyager 2 at Neptune on 25 August 1989. These lead to unprecedented imagery and sent first comprehensive data about the giant planets and the outer solar system.

There are other anniversaries of significant developments in meteoritics than 50-years Allende and Murchison. Two centuries ago, E.F.F. Chladni (1819) in his second book “About fiery-meteors and the masses that fell with them” presented much more overwhelming evidence for the existence of extraterrestrial rocks and that they do fall and come from outer space. He already speculated about the origin of meteorites, and that they are parts of a broken-up planet. And he also wondered about chondrules (and we still don't know...). While it took some time for scientists to accept that meteorites can fall out of the sky, the science caught on and by 1889, Yu I. Simashko suggested the term "meteoritika" (Russian for "meteoritics") for meteorite research. In the same year (1889) the Mighei meteorite fell - the name sake of the CM-chondrites. (The namesake of the CI chondrites, Ivuna, fell in 1938, and that of the CO-chondrites, Ornans in 1868 – both a year too early or we celebrate those anniversaries too late).

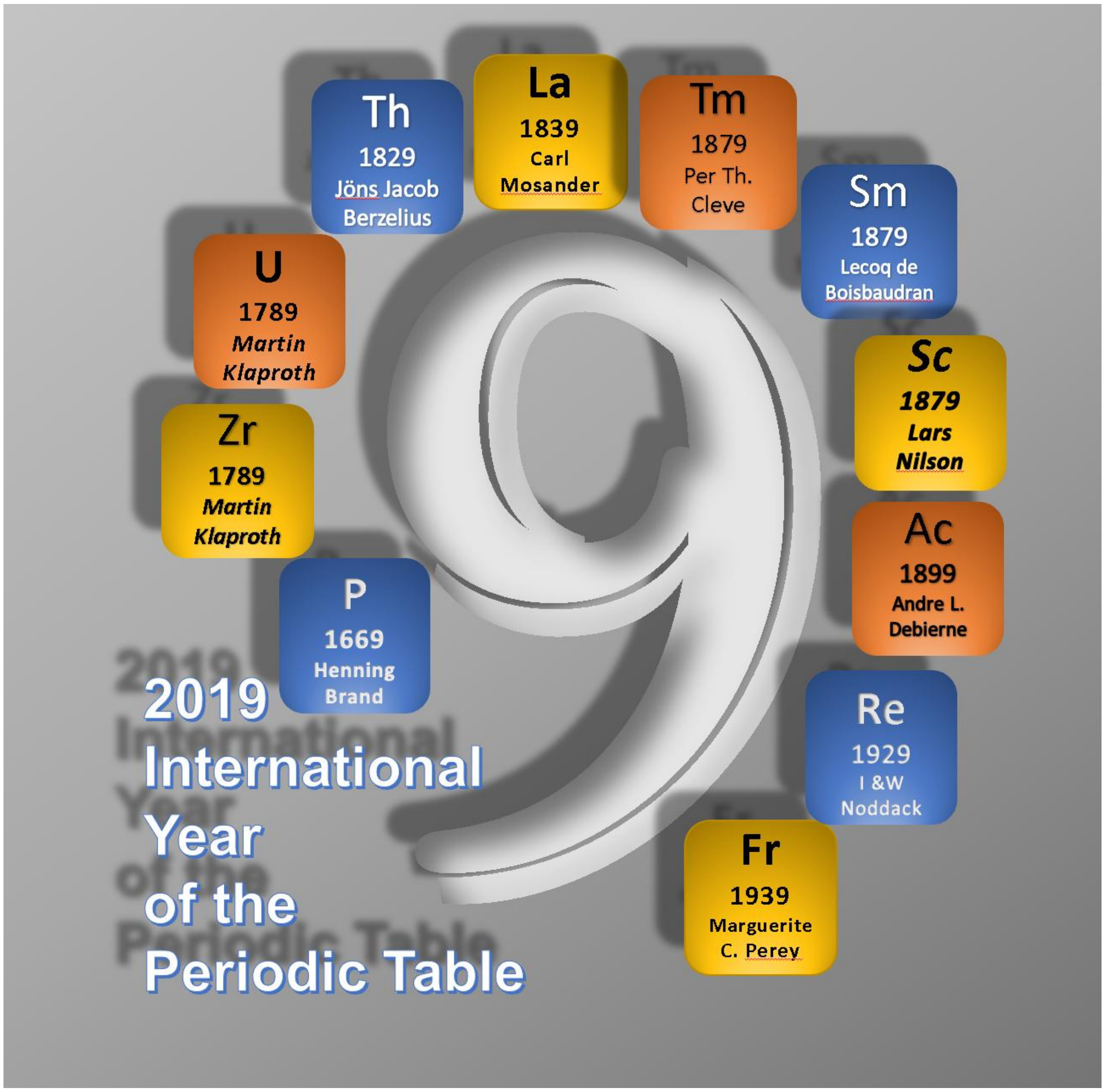

Figure 1. Elements discovered in anniversary years.

Elemental Anniversaries

In 1789, the book "Elements of Chemistry" by Antoine Laurent Lavoisier (26 Aug. 1743 – 8 May 1794) and his wife Marie-Anne Paulze Lavoisier (20 Jan. 1758 – 10 Feb. 1836) debut a table listing 31 chemical elements - substances no further divisible by chemical means. Only nine elements (Au, Ag, C, Cu, Fe, Hg, Pb, S, Sn) were known to the ancients, and the alchemists added As, Bi, and Sb. The earliest recorded date of the discovery of a chemical element is 1669, when Henning Brand discovered Phosphorous. The last stable element to be discovered in the periodic table, Rhenium, was found 260 years later in 1929 by Ida Noddack, Walter Noddack and Otto Berg. Other elements with round anniversary years are Zirconium and Uranium both in 1789 by Martin Klaproth (pure U was isolated in 1841 by Peligot), Thorium by Jöns Jacob Berzelius in 1829, Lanthanum by Carl Gustaf Mosander in 1839; Samarium by Lecoq de Boisbaudran in 1879; Scandium by Lars Fredrik Nilson in 1879; and Thulium by Per Theodor Cleve in 1879. The preponderance of elemental discoveries towards the end of the 19th century was no coincidence but resulted from the keen predictions of Mendeleev's periodic table of 1869, and the development of new analytical technologies that started with Gustav R. Kirchhoff's thermal radiation law and the application of the spectroscope by him and Bunsen in 1859/1860. Mendeleev published an interesting review in 1889 about his "periodic law of the chemical elements", it is worth reading to gain insight about the scientific thinking at the time, and how influential researchers can advance (and hold back) progress.

Around the beginning of the 20th century, nuclear sciences lead to the discoveries of the radioactive elements Actinium by André-Louis Debierne in 1899, and Francium by Marguerite Perey in 1939. Also in 1939, Otto Hahn and Fritz Strassmann succeeded to split the Uranium atom opening the door to applications in nuclear fission.

Table 1. Elemental Discoveries with Round Anniversaries in 2019

Year Found	Element	Discoverer(s)
1669	P	Henning Brand (ca 1630 - 1710)
1789	U, Zr	Martin Klaproth* (1 Dec. 1743 -1 Jan. 1817)
1829	Th	Jöns Jacob Berzelius* (20 Aug. 1779 - 7 Aug. 1848)
1839	La	Carl Gustaf Mosander (10 Sept. 1797 - 15 Oct. 1858)
1879	Sm	Lecoq de Boisbaudran* (18 April 1838 - 28 May 1912)
1879	Sc	Lars Fredrik Nilson (27 May 1840 -14 May 1899)
1879	Tm	Per Theodor Cleve (10. Feb. 1840 -18 June 1905)
1899	Ac	André-Louis Debierne (14 July 1874 - 31 Aug. 1949)
1929	Re	Ida Noddack* (nee Tacke, 25 Feb. 1896 -24 Sept. 1978) Walter Noddack* (17 Aug. 1893 -7 Dec. 1960) Otto Berg (23 Nov. 1873 -1939)
1939	Fr	Marguerite Catherine Perey (19 Oct. 1909 - 13 May 1975)

* also published research on meteorites.

Isotope Anniversaries

Undoubtedly, isotope research is a strong branch in geo- and cosmochemistry. The invention of the mass-spectrograph in 1919 by Francis William Aston (1 Sept. 1877 – 20 Nov. 1945) was the ground-breaking step for a technology that tremendously advanced in the past century and enables a lot of work done today. Before 1919, other methods were employed to detect and determine the isotopic composition of the elements. Earlier, in 1909 Ernest Rutherford (30 Aug. 1871 – 19 Oct. 1937) recognized the identity of the alpha particle and He^{2+} ion. Oxygen isotopes are of profound interest in meteoritics, so the 1929 spectroscopic discovery of the oxygen isotopes by William Francis Giauque & H.L. Johnston in 1929 (Nobel Prize for Giauque in 1949) must be mentioned here. Similarly, the first detailed sulfur isotope studies by Thode et al. (1949) and Trofimov (1949) opened the door to a large research area in isotope geochemistry. In his early review in 1949, Henry George "Harry" Thode (10 Sept. 1910 – 22 March 1997) emphasizes the importance of high-precision isotope studies of the elements for deciphering the mechanisms of chemical and physical processes in nature, and their notable contributions to geochemistry.

Elemental Abundances Anniversaries

Several influential studies on the elemental compositions have anniversaries in 2019. In 1889, Frank Wigglesworth Clarke (19 March 1847 – 23 May 1931) published a paper with the bold title "The relative abundance of the chemical elements", which was the first in a longer series of influential papers detailing the abundances in the Earth's crust.

First larger sets of elemental analyses of meteorites became available in 1909 with George Perkins Merrill (31 May 1854 – 15 Aug. 1929). These and his subsequent periodicals on meteorites were very influential, e.g., Harkins used them to discover the odd-even abundance rules of the elements. Merrill died in 1929, the year which saw one of the most seminal advances for "cosmic" and solar system abundances: the spectroscopic analyses of the composition of the solar photosphere by Henry Norris Russell (25 Oct. 1877 – 18 Feb. 1957). Russell noted in his 1929 paper "For the more prominent metallic elements, abundances in Sun resemble that in meteorites more closely than in the Earth's outer layers" which certainly helped to propel the importance of meteorite studies. The determination of the elemental abundances in the Sun and other stars required to understand the continuum opacity in their atmospheres and Rupert Wildt (1939) recognized that H^- ions from the very abundant hydrogen could explain this.

Elemental abundances advanced with better analytical techniques for both meteorite analyses and solar spectroscopy. Combined with the isotopic composition of the elements, plots of nuclide abundances versus mass number became influential as these reflected the nuclear properties and the nucleosynthetic origins of the isotopes and thus the elements. The nuclear systematics were exploited with the intricate distribution graphs by Hans E. Suess (16 Dec. 1909 – 20 Sept. 1993), Harrison Brown (26 Sept. 1917 – 8 Dec. 1986), and Alastair Graham Walter Cameron (21 June 1925 – 3 Oct. 2005). Only a few solar abundance tables predated that of Suess (1949), Brown (1949) and Cameron (1959a), but as a whole, these types of tables were instrumental in the development of theories for nucleosynthesis in stars (e.g., ter Haar 1949, Cameron 1959b and references therein).

The abundance tables in the second half of the 20th century were dominated by the use of CI-chondrites as meteorite abundance standard; earlier compilations did use averages of stony meteorites or weighted averages of meteoritic metal, silicate and sulfide compositions.

Hartmut Holweger (1979) made the case for CI-chondrites by comparison with his spectroscopic results of the solar photosphere. Edward Anders and Nicolas Grevesse (1989) critically surveyed the CI-chondritic and solar abundances and provided an elemental reference set that is still used today. I did not find solar abundance reviews from 1999; but two larger reviews appeared in 2009: solar abundances with strong focus on CI-chondrites were reviewed by K. Lodders, H. Palme, H.P. Gail (2009), and a self-consistent set for elements that can be analyzed in the solar photosphere with modern 3D-atmospheric models was given by M. Asplund, N. Grevesse, J.A. Sauval, P. Scott (2009). Last year I thought it is time to update the solar abundances with many new results, and not realizing it at first, this will keep well in the timeline of the decadal updates, but it seem that these results will only be published in Lodders (2020), when it is time to celebrate the round anniversaries of other elemental events .

Acknowledgments

This contribution came out of my interest in the history of science and the preparation of several review papers and talks. Many important papers not published in a year “ending with a 9” are not mentioned here since the point of this paper is commemorative. Events from other years might be covered in the future, when we will celebrate their anniversaries. Work supported in part by the McDonnell Center for the Space Sciences and NSF grant AST-1517541.

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