DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 81

BIBLIOGRAPHY OF SCIENTIFIC LITERATURE RELATING TO HELIUM

ISSUED SEPTEMBER 10, 1919

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CONTENTS

[1] Prepared by E. R. Weaver, Bureau of Standards, Washington, D. C.

I. INTRODUCTION

It is particularly appropriate at this time to issue a bibliography of the scientific literature relating to helium. The development, during the war, of great fractionating plants capable of separating from natural gas a sufficient quantity of helium to supply a fleet of airships has aroused the keen interest, not only of engineers and scientists, but also of the general public in the unique properties of this gas.

The year 1918 certainly marks the beginning of a new era in the history and use of helium. Before that time only a few liters of the gas had ever been collected, and the cost per liter was enormous. The separation of millions of liters of the gas at a very moderate cost, therefore, makes the gas at once available for many purposes which formerly seemed impossible of accomplishment.

Helium has probably been the most interesting of all the elements to the theoretical scientist on account of the romantic history of its discovery, its occurrence in a remarkable condition of solid solution in many minerals, its formation as a product of the disintegration of the radioactive elements, its liquefaction after a decade of unsuccessful attemps by some of the world's greatest experimenters, the attainment by its use of temperatures below those at which the resistances of pure metals vanish, its many unique physical properties, and the many important theoretical conclusions which have been drawn from its behavior.

All of these points of interest have been the subjects of very thorough investigation. The important developments of the future will probably be along the line of the applications of helium, many of which have already been suggested; but in order to make the most of these possible applications it is necessary to know the properties on which they are based. It is as a guide to these properties that, it is hoped, this bibliography will find its chief usefulness.

This bibliography was first prepared at the beginning of the development of helium for balloon-gas purposes and was intended as an aid in that enterprise. It has since been brought up to date, and is believed to contain practically everything published up to January 1, 1919, except reviews and other articles containing no original work which were published in inaccessible foreign journals and contained no material which was not available in English or American publications. Such articles have been purposely omitted.

II. ARRANGEMENT OF TITLES

The arrangement of material under each subhead has, in general, been such that closely related articles occur together in their chronological order. The bibliography is thus, in effect, a brief outline history of the subject. An exception to this arrangement is made in the case of articles on the occurrence of helium, which have been arranged alphabetically according to the authors' names. This was done because the papers by different authors are usually but slightly related to each other, and the chronological development seems of less importance than the bringing together of the papers, often numerous, of each author.

III. DISCOVERY AND IDENTIFICATION

1. DISCOVERY

JANSSEN. Compt. rend., **67**, p. 838; 1868: Discovery of new spectrum lines in sun, since found to belong to helium.

FRANKLAND and LOCKYER. Proc. Roy. Soc., Lond., **17**, p. 91; 1868: Announce the existence of an element in the sun unknown on earth and name it helium.

PALMIERI. Gazz, Chim. Ital., **12**, p. 556; 1882: Discovery of helium spectrum in rocks from Vesuvius.

NASINI and ANDERLINI. Atti. Accad. Lincei. Roma. (5), **13**, I, p. 368; 1904: Recognition of helium in Vesuvius lavas confirming the discovery of Palmieri.

HILLEBRAND, W. F. Am. J. Sci. (3), **40**, p. 384; 1890: Observed the presence in uraninite of gases since found to be helium and nitrogen. Condensed form of following reference.

HILLEBRAND. Bull. U. S. Geol. Survey, No. 78, p. 43; 1890: Chemical and spectroscopic tests of gases obtained from uraninite led to conclusion that gas was nitrogen.

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RAMSAY. Proc. Roy. Soc. (Lond.), **58**, pp. 65, 81; 1895: Reports partial identification of helium spectrum in gas from cleveite.

LOCKYER. Proc. Roy. Soc. (Lond.), **58**, p. 67; 1895: Partial confirmation of Ramsay's identification of helium.

RAMSAY. Chem. News, **71**, p. 151; 1895: Discovery of helium in cleveite.

CROOKES. Chem. News, **71**, p. 151; 1895: Measured the wave lengths of the spectrum lines of the gas isolated from cleveite by Ramsay and identified the gas as helium.

RUNGE and PASCHEN. Chem. Ztg., **19**, p. 997; 1895: Observed double lines in spectrum of helium from minerals and cast doubt upon identity of mineral and solar helium.

HUGGINS, W. Chem. News, **71**, p. 283; 1895: Differences in spectra of helium from minerals and in the sun.

HUGGINS, W. Chem. News, **72**, p. 27; 1895: Observed double helium lines in solar spectrum.

RUNGE and PASCHEN. Math. natw. Mitt. Berlin, p. 323; 1895: Identity of spectra of solar and mineral helium.

WILDE. Phil. Mag. (5), **40**, p. 466; 1895: Identity of spectra of solar and mineral helium.

LOCKYER. Proc. Roy. Soc., Lond., **62**, p. 52; 1897: Existence of helium in fixed stars and nebulæ.

RAMSAY. Ann. Chim. Phys. (7), **13**, p. 433; 1898: Discovery of helium.

RAMSAY, W. The Gases of the Atmosphere, the History of their Discovery. Book. London, Macmillan & Co. Chem. Abs., **10**, p. 313; 1916.

2. ELEMENTARY NATURE OF HELIUM

BRAUNER, B. Chem. News, **71**, p. 271; 1895.
BRAUNER, B. Chem. News, **74**, p. 223; 1896.
HILL, E. A. Am. J. Sci. (3), **50**, 359; 1895.
RAYLEIGH. Chem. News, **74**, p. 260; 1896.

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1. IN MINERALS

[See also formation from radioactive substances.]

ADAMS, E. P. Am. J. Sci. (4), **19**, p. 321; 1905; Helium in carnotite.
BORDAS, F. Compt. rend., **146**, pp. 628–630, 1908; Chem. Abs., **2**, p. 1926: Search for small quantities of helium in minerals.
BORDAS. Compt. rend., **146** pp. 896–898; 1908; Chem. Abs., **2**, p. 2043: Helium in minerals containing uranium.
BROGGER, W. C. Pharmacia, **1**, pp. 49–53, 65–70; 1904: Ores of uranium containing helium and radium.
CLEVE. Compt. rend., **120**, p. 834, 1895; Chem. News, **71**, p. 201, 1895: Occurrence of helium in cleveite.
COLLIE, J. N., and TRAVERS, M. W. J. Chem. Soc., **67**, p. 684; 1895: Helium a constituent of certain minerals.
DEBIERNE, A. Ann. phys. (9), **2**, pp. 478–488; 1904: Preparation of helium from fluorspar crystals. Contains also an account of unsuccessful efforts to obtain helium from other sources.
KITCHIN, E. S., and WINTERSON, W. G. J. Chem. Soc., **89**, pp. 1568–1575; 1906: Malacone, a silicate of zirconium containing helium.
KOHLSCHUTTER, V. Ann. Chem., **317**, pp. 158–189; 1901: Helium in uranium minerals.
KOHLSCHUTTER and VOGDT. Ber., **38**, pp. 1419–1430, 2992–3002; 1905: Helium in uranium minerals.
LANGE, H. Z. naturw., **82**, pp. 1–34, 1910; Chem. Abs., **4**, p. 2920: Studien uber die zusammensetzung heliumfuhrender Mineralien. (Studies on the structure of helium-bearing minerals.)
LANGLET. Z. anorg. Chem., **10**, p. 289; 1895: Helium in cleveite.
LOCKYER. Compt. rend., **120**, p. 1103, 1895; Chem. News, **72**, p. 283, 1895: Occurrence of helium in minerals.
MAGLI, G. Rend. soc. chim. ital. (2), **5**, pp. 420–423, 1914; Chem. Abs., **9**, p. 1005: Helium in titanite. Occurs in amounts proportional to the radioactivity of the mineral.
MOISSAN and DESLANDERS. Compt. rend., **126**, p. 1689; 1898: Helium in cerite.
MOSS. Trans. Roy. Dublin Soc. (2), **8**, p. 153; 1904: Removal of helium from minerals by evacuation. Can obtain only a little over 1 per cent of total by this method.
VON OEFELE, F. Pharm. Zentralhalle, **57**, pp. 83–84, 1916; J. Chem. Soc., **110**, II, p. 284, 1916; Chem. Abs., **10**, p. 2654, 1916: Helium in samarskite and its relation to other elements present.
PIUTTI, A. Radium, **7**, pp. 146–149, 1910; Chem. Abs., **4**, p. 3055: Nonradioactive minerals containing helium.
PIUTTI. Radium, **7**, pp. 178–179, 1910; Chem. Abs., **5**, p. 247: Helium in recent minerals.

[1] The material under this heading is arranged alphabetically according to authors' names because of the general slight relation between papers by different authors.

PIUTTI. Nature, **84**, pp. 543–544, 1910; Chem. Abs., **5**, p. 626: The absorption of helium in salts and minerals. A hypothetical explanation of the accumulation of helium in certain minerals.

PIUTTI. Radium, **8**, pp. 204–205, 1911; Chem. Abs., **6**, p. 1255: The presence of helium in autintite and the period of life of ionium.

PIUTTI. Radium, **10**, pp. 165–168, 1913; Chem. Abs., **7**, p. 3076: Helium in glucinum minerals.

PIUTTI. Atti. Acad. Lincei, **22**, pp. 140–144, 1913; Chem. Abs., **7**, p. 2352: Helium and beryllium minerals.

RAMSAY, Compt. rend., **120**, p. 1049, 1895; Ann. Chim. Phys. (7), **13**, p. 433, 1898: Helium in meteorites.

RAMSAY and TRAVERS. Proc. Roy. Soc., Lond., **60**, p. 442; 1896: Occurrence of helium in minerals.

STRUTT, R. J. Nature, **75**, p. 271, 1907; Chem. Abs., **1**, p. 817: Helium and argon in common rocks.

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STRUTT. Proc. Roy. Soc., Lond. (A), **76**, pp. 80–101; 1908: Helium and argon in rocks.

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STRUTT. Proc. Roy. Soc., Lond. (A), **80**, pp. 572–594, 1908; Chem. Abs., **3**, p. 2651: Helium and radioactivity in minerals.

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STRUTT. Chem. News, **99**, pp. 145–146, 1909; Chem. Abs., **3**, p. 2531: The leakage of helium from radioactive minerals.

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STRUTT. Nature, **85**, p. 6, 1911; Chem. Abs., **5**, p. 626: Helium and geological time. An answer to Piutti's hypothesis of absorption to account for the presence of helium in rocks.

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TRAVERS. Nature, **71**, p. 248, 1905: Helium occurs in radioactive minerals in form of supersaturated solid solution.

TSCHERNIK, J. Russ. Phys. Chem. Soc., **29**, p. 291, 1899: Helium in cerium-bearing minerals from the Caucasus.

VALENTINER, S. Kali, **6**, pp. 1–3; Chem. Abs., **8**, p. 480; Neues Jahrb. Min. Geol., 1913, I Ref., p. 195: Helium content of blue rock salt.

WHERRY, E. T. Am. Mineral, **2**, pp. 105–108, 1917; Chem. Abs., **11**, p. 2570: The occurrence of the native elements. (Including helium.)

WILDE, H. Phil. Mag. (5), **40**, p. 466, 1895: The occurrence of helium in cleveite.

2. OCCURRENCE IN MINERAL WATERS

Bouchard and Troost. Compt. rend., **121**, p. 392, 1895: Helium in a spring at Cautcrets in the Pyrenees.

Czako, E., and Lautenschlager. Chem. News, **108**, p. 16, 1913; Chem. Ztg., **37**, p. 936, 1913; Chem. Abs., **7**, 3450: Helium content of gases from Hot Spring, at Wildbad, in the Black Forest. Gases contained 0.71 per cent helium.

Ewers. Physik. Zeit., **7**, p. 224, 1906: Helium and argon in hot springs.

Herrmann, A., and Pesendorfer, F. Physik. Zeit., **6**, pp. 70–71; 1905: Radioactivity of the gases evolved from the Karlsbad springs.

Kayser, H. Chem. News, **72**, p. 223, 1895; Chem. Ztg., **19**, p. 1549, 1895: Helium in the gases from springs at Wildbad, in the Black Forest.

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Moureu. Compt. rend., **142**, p. 1155, 1906.

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Moureu. Bull. Soc. Chim. (4), **9**, pp. 1–25, 1911; Rev. gen. sci. **49**, pp. 65–76, 1911: Investigations on the rare gases from hot springs.

Nasini, R. Atti. Accad. Lincei. Roma (5), **13**, I, pp. 217, 367, 1904: Helium in certain Italian springs.

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Prytz and Thorkelsson. Kgl. Danske. Vidensk, Selsk. Forh., p. 317, 1905: The occurrence of helium in warm island springs.

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Sieveking and Lautenschlager. Physik. Zeit., **13**, pp. 1043–1051, 1912; Chem. Abs., **7**, 1841; Ber. physik. Ges., **14**, p. 910, 1913: Helium in hot springs and natural gases. No direct relation between radioactivity and helium content was found.

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3. OCCURRENCE IN NATURAL GAS

Cady, H. P., and McFarland, D. F. Trans. Kan. Acad. Sci., **26**, Part II, p. 802, 1907; Sci., **24**, p. 344, 1906; Chem. Abs., **1**, p. 1528: Helium in Kansas natural gas. Some samples contained as much as 2 per cent. Geological zones of approximately equal helium content were located.

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Czako, E. Zeit. Anorg. Chem., **82**, pp. 249–277, 1913; Chem. Abs., **7**, p. 3450: The helium content and radioactivity of natural gases. The production of helium discharged yearly from two of the wells examined would require the disintegration of 165,000 and 28,000 tons of Ra, respectively.

Erdmann, E. Ber., **43**, pp. 777–782, 1910; Chem. Abs., **4**, p. 1957: Helium-containing gases of the German potash beds.

Moureu, C., and Lepape, A. Compt. rend., **155**, pp. 197–200, 1912; Chem. Abs., **6**, p. 3075: Some natural gaseous mixtures particularly rich in helium. Discusses gases from eight French sources.

Moureau, C., and Lepape, A. Compt. rend., **158**, pp. 598–603, 1913; Chem. Abs., 8, 1699: Helium from fire damp and the radioactivity of coal. Helium evolved from one mine is equal to 12 cu. m. per day. Radioactivity of gas and coal does not account for it.

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4. OCCURRENCE IN AIR

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Travers. Proc. Roy. Soc., Lond., **60**, p. 449, 1896: Separation of helium from the air.

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1. FROM RADIOACTIVE SUBSTANCES

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VI. SEPARATION AND PURIFICATION OF HELIUM

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IX. APPLICATIONS OF HELIUM

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