

= Origin and use of the term metalloid =

The origin and usage of the term metalloid is convoluted . Its origin lies in attempts , dating from antiquity , to describe metals and to distinguish between typical and less typical forms . It was first applied to metals that floated on water (lithium , sodium and potassium) , and then more popularly to nonmetals . Only recently , since the mid @-@ 20th century , has it been widely used to refer to elements with intermediate or borderline properties between metals and nonmetals .

= = Pre @-@ 1800 = =

Ancient conceptions of metals as solid , fusible and malleable substances can be found in Plato 's Timaeus (c . 360 BCE) and Aristotle 's Meteorology .

More sophisticated classification arrangements were proposed by Pseudo @-@ Geber (in the Geber corpus , c . 1310) , Paracelsus (De Natura Rerum libri nonem , 1525 ? 6 ; and later works) , Basil Valentine (Conclusiones , 1624) , and Boerhaave (Elementa Chemiæ , 1733) . They attempted to separate the more characteristic metals from substances having those characteristics to a lesser degree . Such substances included zinc , antimony , bismuth , stibnite , pyrite and galena . These were all then called semimetals or bastard metals .

In 1735 Brandt proposed to make the presence or absence of malleability the principle of this classification . On that basis he separated mercury from the metals . The same view was adopted by Vogel (1755 , Institutiones Chemiæ) and Buffon (1785 , Histoire Naturelle des Minéraux) . In the interim , Braun had observed the solidification of mercury by cold in 1759 ? 60 . This was confirmed by Hutchins and Cavendish in 1783 . The malleability of mercury then became known , and it was included amongst the metals .

In 1789 Fourcroy highlighted the weakness of this distinction between metals and semimetals . He said it was evident from the fact that

between the extreme malleability of gold and the singular fragility of arsenic , other metals presented only imperceptible gradations of this character , and because there was probably no greater difference between the malleability of gold and that of lead , which was considered to be a metal , than there was between lead and zinc , which was classed among semi @-@ metals , while in the substances intermediate between zinc and arsenic the differences were slight .

This idea of a semimetal , as a brittle (and thereby imperfect) metal , was gradually discarded after 1789 with the publication of Lavoisier 's ' revolutionary ' Elementary Treatise on Chemistry .

= = 1800 ? 1959 = =

In 1800 , Pinkerton used the word metalloid , in its literal sense , to describe a mineral variety of pyroxene ' with metallic splendour.'

In 1808 , Erman and Simon suggested using the term metalloid to refer to the newly discovered elements sodium and potassium . These elements were lighter than water and many chemists did not regard them as proper metals . Erman and Simon 's proposal may have been made ' [in] an attempt to revive this old distinction between metals and substances resembling metals ' . Their suggestion was ignored by the chemical community .

In 1811 , Berzelius referred to nonmetallic elements as metalloids , in reference to their ability to form oxyanions . A common oxyanion of sulfur , for example , is the sulfate ion SO_4^{2-} ?

4 . Many metals can do the same . Chromium , for instance , can form the chromate ion CrO_4^{2-} ?

4 . Berzelius ' terminology was widely adopted although it was subsequently regarded by some commentators as counterintuitive , misapplied , incorrect or invalid . In 1825 , in a revised German edition of his Textbook of Chemistry , Berzelius subdivided the metalloids into three classes . These were : constantly gaseous ' gazolyta ' (hydrogen , nitrogen , oxygen) ; real metalloids (sulfur , phosphorus , carbon , boron , silicon) ; and salt @-@ forming ' halogenia ' (fluorine , chlorine , bromine , iodine) .

In 1844 , Jackson gave the meaning of ' metalloid ' as ' like metals , but wanting some of their

properties . ' In 1845 , in A dictionary of science , literature and art , Berzelius ' classification of the elementary bodies was represented as : I. gazolytes ; II. halogens ; III. metalloids (' resemble the metals in certain aspects , but are in others widely different ') ; and IV. metals .

In 1864 , calling nonmetals ' metalloids ' was still sanctioned ' by the best authorities ' even though this did not always seem appropriate . The greater propriety of applying the word metalloid to other elements , such as arsenic , had been considered .

By as early as 1866 some authors were instead using the term nonmetal , rather than metalloid , to refer to nonmetallic elements . In 1875 , Kemshead observed that the elements had been subdivided into two classes ? ' non @-@ metals or metalloids , and metals . ' He added that ' [t] he former term , although not so convenient , because a compound word , is more correct , and is now universally employed.'

In 1876 , Tilden protested against , ' the [still] too common though illogical practice of giving the name metalloid to such bodies as oxygen , chlorine or fluorine ' . He instead divided the elements into (' basigenic ') true metals , metalloids (' imperfect metals ') and (' oxigenic ') nonmetals .

As late as 1888 , classifying the elements into metals , metalloids , and nonmetals , rather than metals and metalloids , was still regarded as peculiar and potentially confusing .

Beach , writing in 1911 , explained it this way :

Metalloid (Gr . " metal @-@ like ") , in chemistry , any nonmetallic element . There are 13 , namely , sulfur , phosphorus , fluorin [e] , chlorin [e] , iodine , bromine , silicon , boron , carbon , nitrogen , hydrogen , oxygen , and selenium . The distinction between the metalloids and the metals is slight . The former , excepting selenium and phosphorus , do not have a " metallic " lustre ; they are poorer conductors of heat and electricity , are generally not reflectors of light and not electropositive ; that is , no metalloid fails of all these tests . The term seems to have been introduced into modern usage instead of nonmetals for the very reason that there is no hard and fast line between metals and nonmetals , so that " metal @-@ like " or " resembling metals " is a better description of the class than the purely negative " nonmetals " . Originally it was applied to the nonmetals which are solid at ordinary temperature .

In or around 1917 , the Missouri Board of Pharmacy wrote that :

A metal may be said to differ from a metalloid [that is , a nonmetal] in being an excellent conductor of heat and electricity , in reflecting light more or less powerfully and in being electropositive . A metalloid may possess one or more of these characters , but not all of them ... Iodine is most commonly given as an example of a metalloid because of its metallic appearance .

During the 1920s the two meanings of the word metalloid appeared to be undergoing a transition in popularity . Writing in A Dictionary of Chemical Terms , Couch defined ' metalloid ' as an old , obsolescent term for ' nonmetal . ' In contrast , Webster 's New International Dictionary noted that use of the term metalloid to refer to nonmetals was the norm . Its application to elements resembling the typical metals in some way only , such as arsenic , antimony and tellurium , was recorded merely on a ' sometimes ' basis .

Use of the term metalloid subsequently underwent a period of great flux up to 1940 . Consensus as to its application to intermediate or borderline elements did not occur until the ensuing years , between 1940 and 1960 .

In 1947 , Pauling included a reference to metalloids in his classic and influential textbook , General chemistry : An introduction to descriptive chemistry and modern chemical theory . He described them as ' elements with intermediate properties ... occupy [ing] a diagonal region [on the periodic table] , which includes boron , silicon , germanium , arsenic , antimony , tellurium , and polonium.'

In 1959 the International Union of Pure and Applied Chemistry (IUPAC) recommended that ' [t] he word metalloid should not be used to denote nonmetals ' although it was still being used in this sense (around that time) by , for example , the French .

= = 1960 ? present = =

In 1969 the classic and authoritative Hackh 's Chemical Dictionary included entries for both ' metalloid ' and ' semimetal ' . The latter term was described as obsolete .

In 1970 IUPAC recommended abandoning the term metalloid because of its continuing inconsistent use in different languages . They suggested using the terms metal , semimetal and nonmetal instead . Despite this recommendation , use of the term ' metalloid ' increased dramatically . Google Ngram Viewer showed a fourfold increase in the use of the word ' metalloid ' (as compared to ' semimetal ') in the American English corpus from 1972 to 1983 . There was a sixfold increase in the British English corpus from 1976 to 1983 . As at 2011 , the difference in usage across the English corpus was around 4 : 1 in favour of ' metalloid ' .

The most recent IUPAC publications on chemical nomenclature (the " Red Book " , 2005) and terminology (the " Gold Book " , 2006 ?) do not include any recommendations as to the usage or non @-@ usage of the terms metalloid or semimetal .

Use of the term semimetal , rather than metalloid , has recently been discouraged . This is because the former term ' has a well defined and quite distinct meaning in physics ' . In physics , a semimetal is an element or a compound in which the valence band marginally (rather than substantially) overlaps the conduction band . This results in only a small number of effective charge carriers . Thus , the densities of charge carriers in the elemental semimetals carbon (as graphite , in the direction of its planes) , arsenic , antimony and bismuth are $3 \times 10^{18} \text{ cm}^{-3}$, $2 \times 10^{20} \text{ cm}^{-3}$, $5 \times 10^{19} \text{ cm}^{-3}$ and $3 \times 10^{17} \text{ cm}^{-3}$ respectively . In contrast , the room @-@ temperature concentration of electrons in metals usually exceeds 10^{22} cm^{-3} .

References to the term ' metalloid ' as being outdated have also been described as ' nonsense ' noting that ' it accurately describes these weird in @-@ between elements ' .