TERMINOLOGY OF THE CHEMICAL SILICEOUS SEDIMENTS*

W.A. Tarr

"Chert. -- The origin of the word 'chert' has not been determined. The Oxford Dictionary suggests it was a local term that found its way into geological usage. 'Chirt' (now obsolete) appears to have been an early spelling of the word. In comparison with 'flint,' 'chert' is a very recent word. 'Flint,' from very ancient times, was applied to the dark varieties of this siliceous material. Apparently, the lighter colored varities, now called 'chert,' were unrecognized as siliceous material; at any rate, no name describing the material has been found in the very early literature. The first specific use of the word 'chert' seems to have been in 1729 (1), when it was defined as a 'kind of flint.' The French name for chert is commonly given as silex corne (horn flint) or silex de la craie (flint of the chalk), but Cayeux (2) states that the American term 'chert' corresponds to the French word silexite. He uses chert to designate a related material occurring in siliceous beds (3). The German term for chert is Hornstein. 'Phtanite' (often misspelled 'ptanite') has been used as a synonym for chert. Cayeux uses the term synonymously as the equivalent for silexite, and 'hornstone' has also frequently been so used. So common was the use of the term 'hornstone' during the early part of the last century that there is little doubt that it was then the prevalent name for the material chert, as quotations given under the discussion of hornstone will show. But most common among the synonyms for 'chert' is 'flint,' and since 'flint' had other synonyms, 'chert' acquired many of them. In recent literature, the terms 'white chert' (for chert) and 'black chert' (for flint) (4) are coming into use.

Chert has long been regarded as a variety of flint; in fact, has been quite consistently designated as 'an impure flint.' Charles Lyell (5) defines chert as 'a siliceous mineral, approaching in character flint, but less homogeneous and simple in character.' Robert Bakewell (6) describes 'strata or rather seams of siliceous stone called chert, resembling flint, but less splintery in the fracture, and fusible.' Humble (7) defines chert as 'a kind of flint. Chert is also, by some, called horn-stone. A siliceous stone, resembling flint *** ' It should be noted that both these authors (and many others besides) use the term 'siliceous stone.' 'Siliceous' is derived from the Latin silex (silici-) which means 'flint;' in fact, the French now use the word silex for 'flint' (See Cayeux, op. cit., p. 397). According to the Oxford Dictionary, the English use of 'silex' for flint and silica dates back to 1592, and antedates the use in 1656

---

* Reprinted from pp. 9-15, 26 of W.A. Tarr. Terminology of the Chemical Siliceous Sediments. Report of the Committee on Sedimentation, 1937-1938; National Research Council, Washington, 1938.

Italicized numbers in parentheses refer to published works listed in "References" at end.

of 'siliceous' by nearly 60 years. Thus, 'silex,' 'flint,' 'siliceous,' and 'chert' are all interrelated terms, and our word 'silica' reached us through the Latin and not the Greek. The term 'siliceous' applied to limestones and chalks was consistently used to imply that chert and flint are present. Note the definition of chert given by Page (8): 'A mixed siliceous or impure flinty rock,***, as in limestone. Resembles some varieties of flint and hornstone, but is less conchoidal in the fracture, tougher and fusible***. A limestone so siliceous as to be worthless for the limekiln, is said to be cherty.' Or the following from Lyell (9): 'Siliceous limestone is an intimate mixture of carbonate of lime and flint, and is harder in proportion as the flinty matter predominates.'

The above definitions bring out as differences between chert and flint, the less conchoidal but more splintery fracture and the greater fusibility of chert. As time passed, other points of difference were noted, thus St. John (10), in 1872 said that chert resembled flint but was coarser in texture. Geikie (11) introduced composition as a factor, thus: 'chert (phtanite) is a name applied to impure calcareous varieties of flint***.' In a later edition (1892) he again emphasized impurity in the chert as a point of difference. Van Hise (12) introduced the character of the silica in the chert as a factor. He included amorphous, partly amorphous, cryptocrystalline, and crystalline quartz as constituents of chert. The composition was further emphasized by Kemp (13) who defined chert as 'a compact siliceous rock formed of chalcedonic or opaline silica or both.' Merrill (14) says simply: 'Chert is an impure flint.' It may be stated here that there is no essential difference in chemical composition between chert and flint. Both consist essentially of silica and contain the same impurities which may be as high as 10 per cent in the impure forms, but are usually from 1 to 3 per cent.

Cayeux (15) introduces the place of occurrence (the sea, lakes, lagoons) and the type of associated rock (calcareous, siliceous) as factors in the nomenclature of these siliceous materials. Various names have been used in France. 'Chert' has appeared in the French literature at intervals for 100 years, but without a rigorously accepted definition. Cayeux retains the word 'chert' for siliceous rocks occurring in marine siliceous deposits, as the radiolarian cherts; but proposes the term silexite for chert (and phtanite) that occurs in calcareous beds, for example, chert in the Mississippian in the United States (see op. cit., p. 554). Silex denotes 'flint,' and chailes (p. 491) certain types of siliceous concretions occurring in calcareous rocks in the Jurassic formations.

The mineralogical composition of chert and flint, likewise, is very similar. Both usually consist dominantly of crypto-crystalline silica (Holmes (16) does not even mention the mineralogical varieties of silica), which is chiefly chalcedony but includes quartz, and amorphous silica (opal). According to Sosman (17), chert and flint consist of 'natural micro-fibrous silica.' This micro-fibrous silica is chalcedony (French name, Calcedonie; German name, Chalcedon). Tarr (18) states that both chalcedony and quartz are present, the latter normally in smaller quantities and of more variable texture. Both chert and flint may be so extremely dense as to appear to be composed almost entirely of amorphous silica (opal), although this is not common. An outstanding example of cherts that consist dominantly of opal are those in the Monterey of California group. Taliaferro (19)

states that 'they are largely made up of opal with minor amounts of chalcedony***.' Of the two forms of silica, coarse-grained chert is more common than coarse-grained flint. Tarr also states that minute spheres or globules of amorphous silica (gel or opal) and chalcedony are common to both. Rapid changes in texture are also common in both.

Inasmuch as chalcedony is the dominant constituent of most chert (and flint), its characteristics and position among the siliceous sediments will be given here. Sosman (20) defines chalcedony as a 'natural microcrystalline fibrous silica' with the atomic arrangement of quartz. He insists, however, that chalcedony is not a submicroscopic variety of quartz because of its dominantly fibrous structure; optical character; elongation, -; index of refraction, 1.533-1.540 compared with 1.55 for quartz; birefringence of 0.009 to 0.011; density; heat capacity; and an absence of a strongly marked thermal effect at 573°C. Although chalcedony consists dominantly of micro-fibrous silica, it is still an open question as to whether there are not also present variable amounts of 'micro-fibrous amorphous silica or even micro-fibrous hydrated amorphous (opaline) silica.' Washburn and Navias (21) express the view that 'flint and chalcedony consist of colloidal quartz. In the purer forms of chalcedony, the colloid is the gel type and the individual colloid particles are microscopic or submicroscopic in size.' Sosman says of this view that it would be best to stress shape and not size, i.e., that the particles are threadlike or fibrous. He says that when the fibers of chalcedony are short and arranged heterogeneously the fracture is likely to be conchoidal, as in chert and flint.

The writer's microscopic studies of a large number of slides of chert and flint show that, although chalcedony predominates, quartz is also present in many cherts and flints and predominates in some with opal as a subordinate constituent. There is often in a single slide (using high power) a range from barely visible grains to coarse quartz crystals. The coarser quartz crystals generally replace calcareous fossils entombed in the chert (or flint). This range in size and the association with chalcedony strongly favor the view that the micro-fibrous silica of the chalcedony may, in time, pass over into quartz. This thought is an extension of Sosman's (22) idea that 'pure chalcedonic silica is one end-member in a series of natural minerals of the composition $SiO_2 + H_2O$. The other end-member is opal.' The hydrous opal may represent an original hydrous gel, which has subsequently crystallized, first to chalcedony and then to quartz.

There remains to be noted a significant megascopic feature of chert that has been used in distinguishing it from flint and related forms of silica. This is color. With so many other characteristics in common and since 'flint' from early times has been used to designate the dark-colored varieties, there would seem to be every reason for designating light-colored varieties as 'chert.' Color, being a megascopic feature, has afforded a ready means of distinguishing between chert and flint in the field. Apparently, the color of chert had not been considered as an important distinguishing feature, until it was so used by Tarr (25) in 1917. He stated: 'In this paper the term chert will include those cryptocrystalline varieties of quartz which are white, gray or blue-gray in color. Dark gray to black varieties will be called flint, while those which owe their color to iron oxides will be referred to as jasper.' In a later

paper (24), Tarr included pink and green colors also for chert. A color distinction has been followed by Tarr and Twenhofel (25) in the last edition (1932) of the Treatise on Sedimentation.

A critical examination of recent and prevalent usage in America of these two terms, 'chert' and 'flint' shows an unmistaken trend to drop 'flint' and refer to the siliceous nodules, lenses, and beds in carbonate rocks as 'chert.' Such usage eliminates the need for a color distinction, as noted in the last paragraph. If color variations are noted, the appropriate color adjective is used to indicate the color, as gray chert, red chert, and grayish-blue chert. This method at once eliminates any necessity for using 'flint,' which might be reserved for artifacts, if indeed there is any justification for its retention as a name for siliceous sedimentary materials. Even in England, where the term 'flints' of the chalk is deeply rooted, some geologists are using the designation 'white' and 'black' chert.

In closing the discussion of the nomenclature of chert, 'chrome-chert' (26) may be noted, but it does not belong in this last, as it is evidently a cherty-looking rock due to silica replacement of a chromite peridotite. Radiolarian cherts (27) are well known, and are cherts which contain variable quantities of the remains of radiolaria. Similar names could be applied to many fossiliferous cherts and flints.

Recently the term, 'chertification,' (28) has appeared in a paper relating to the geology of the Tri-State Mining district, but it does not seem to be particularly more advantageous than the common word 'silicification' for the process of introduction of silica into limestone, which they were describing.

Flint. -- The term 'flint' has been in use as a word meaning 'anything hard' since about 700 A.D., and as 'a variety of stone' since 1000 A.D. It is an Old English term and was spelled the same as it is now. In Middle Dutch, it was vlint; old High German, flins (some modern German dialects are the same); Danish, flint; and Swedish, flinta. It is of interest to note that, although the English spelling 'flint,' has been in use since 700 A.D., between 1200-1600 the following variants appeared: 'vlint,' 'vlynt,' 'flent,' 'flynd,' and 'flyntee.' From among the quotations in the Oxford Dictionary giving the early use of the word, the following is most suggestive of a geological use. 'A pillar offlint in the rocks of Hanga (29)***.' Flint was utilized for striking fire as early as 1300, and in buildings by 1662. The French word for flint is 'silex or pierre a feu' (firestone), and the German name is Feuerstein.

Although there are synonyms for 'flint,' its presence in the language, 1,00 years longer than chert has established its meaning very firmly; in fact, the name 'flint' was applied to any material closely resembling it. Arrowheads made of chert, quartz, or quartzite are commonly called'flint arrowheads' or 'flints.' Synonyms are 'chert,' 'silex' (French name for flint)? 'Feuerstein' (German name), and hornstone. Bakewell (30), in 1839, defined flint as follows: 'Flint is siliceous earth nearly pure.' Humble's (31) definition is very similar: 'Siliceous earth, nearly pure. Flint is the commonest form in which quartz exhibits itself***.'

Shepard (32), in 1844, called attention to the translucency of flint on thin edges and its perfect, flat conchoidal fracture. Others, also emphasized these characteristic features. The dark color (given as gray or black) of flint was noted early, and these dark colors have been consistently assigned to it, only one author having described it as light in color. It is thus not only logical, but in keeping with past usage to refer to the dark varieties of crypto-crystalline or chalcedonic siliceous rocks as 'flint,' and the light-colored varieties as 'chert.'

Kemp (33) introduced mineralogical composition into the definition of flint, thus: Flint is 'a compact and crypto-crystalline aggregate of chalcedonic and opaline silica.' Sosman (34) defines flint as 'an opaque variety of natural micro-fibrous silica; color, gray to black.' In our discussion of chert, the features assigned to it were contrasted with those of flint, hence it would only be repetition here to discuss in detail the characteristics of flint which differ in no way (unless that of color) from chert. Chemically, it is similar to chert, mineralogically the two materials are composed dominantly of 'natural micro-fibrous silica,' with some 'micro-fibrous hydrous amorphous silica' and quartz. On the whole, flint possesses a denser texture than chert, a more perfect conchoidal fracture, and does not contain so much quartz. If it must be recognized as a distinctive variety of chert or as a separate rock name, its color is its most distinctive characteristic and its only identification tag. Holmes (35) would restrict the term 'flint' to the siliceous modules in chalk, a needless restriction."

Suggested Usage [p. 26].

"The following definitions are in keeping with the leading use of the more important terms applied to the chemical siliceous sediments.

Chert. -- A dense crypto-crystalline rock; composed mineralogically of chalcedony (micro-crystalline fibrous silica, and micro-fibrous amorphous silica or opal) and crypto-crystalline quartz; with a tough, splintery to conchoidal fracture; and having numerous colors: white, gray, green, blue, pink, red, yellow, brown, or black.

Flint.-- Identical with chert in texture and composition. Seems best that it should be dropped or reserved for artifacts, although one reader of this paper suggests that since 'flint' has priority as a name, it should be adopted as the general class name, with 'chert' as a variety. Widespread common usage is opposed to this."

REFERENCES

1. Martyn, Phil. Trans., vol. 36 (1729), p. 30.

2. L. Cayeux, "les Roches Sedimentaires de France, roches siliceous," Paris (1929), p. 554.

3. Ibid., p. 397.

4. P.B. King, Am. Assoc. Petroleum Geol. Bull., vol. 15 (1932), p. 1073.
   Ross Engelman, Am. Assoc. Petroleum Geol. Bull., vol. 19 (1935), pp. 586-587.
   T.S. Lovering, U.S. Geol. Surv., Bull. 811 (1930), p. 25.
   Westgate and Ross, U.S. Geol. Surv., Bull 814 (1930), p. 32.
   E. Neaverson, Proc. Geologists Assoc., vol. 36 (1925), p. 246.

5. Charles Lyell, "Principles of Geology," vol. 3 (1830), appendix, p. 65.

6. Robert Bakewell, "Introductory Geology," 3rd Am. Ed. (1839), p. 27.

7. Wm. Humble, "Dictionary of Geology and Mineralogy," 2nd Ed. (1843), p. 45.

8. David Page, "Handbook of Geological Terms," (1865), p. 139.

9. Charles Lyell, "Elements of Geology" (1839), p. 27.

10. St. John, "Elements of Geology" (1872), p. 324.

11. A. Geikie, "A Textbook of Geology " 2nd Ed. (1885), p. 122.

12. C.R. Van Hise, U.S. Geol. Surv., Mon. 47 (1904), p. 847.

13. Kemp, "Handbook of Rocks" (1906), p. 177.

14. G.P. Merrill, "Rocks, Rock-Weathering, and Soils" (1906), pp. 103-104.

15. L. Cayeux, op. cit., p. 397.

16. A. Holmes, "Principles of Petrology" (1926), p. 223.

17. R.B. Sosman, "The Properties of Silica" (1927), p. 794.

18. W.A. Tarr, "The Origin of Chert and Flint," University of Missouri Studies, vol. 1 (1926), pp. 8-12.

19. N.L. Taliaferro, Bull. Geol. Soc. Am., vol. 45 (1934), p. 195.

20. R.B. Sosman, op. cit., pp. 157-161, 272, 789-798.

21. Washburn and Navias, Jour. Am. Ceram. Soc., vol. 5 (1932), p. 565.

22. R.B. Sosman, "The Properties of Silica" (1927), p. 794.

23. W.A. Tarr, "Origin of Chert," Am. Jour. Sci., vol. 44 (1917), p. 413.

24. W.A. Tarr, "The Origin of Chert and Flint," University of Missouri Studies, vol. 1 (1926), p. 2.

25. W.A. Tarr and W. H. Twenhofel, "Twenhofel, "Treatise on Sedimentation" (1932), p. 519.

26. Arthur Holmes, "Nomenclature of Petrology" (1928), p. 57.

27. Hutch and Rastall, "Textbook of Petrology" (1931), p. 233.

28. G.M. Fowler and J.P. Lyden, Tech. Pub. No. 466-I, 39, Am. Inst. Min. and Metal. Eng. (1932), p. 14.

29. Johnson, "Idler," No. 96 (1758), p. 1.

30. Robert Bakewell, "Introductory Geology," 3rd Am. Ed. (1839), pp. 244-245.

31. Wm. Humble, "Dictionary of Geology and Mineralogy," 2nd Ed. (1843) p. 96.

32. C.V. Shepard, "Mineralogy" (1844), p. 146.

33. J.F. Kemp, "Handbook of Rocks" (1906), p. 187.

34. R.B. Sosman, "The Properties of Silica" (1927), p. 794.

35. A. Holmes, "Principles of Petrology" (1926), p. 223.