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NOMENCLATURE OF EPIDOTE ROCKS

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ABSTRACT. Rocks composed mostly of epidote result from a number of different geologic processes. Terminology dealing with such rocks is confused, and definitions contain limiting conditions of origin that are objectionable. A review of terminology shows that the terms *unakite* and *helsinkite* can have no general application and are intrinsically undesirable. The term *epidosite* suffers from a number of definitions that impose restrictions on mode of origin and occurrence. As originally defined and as generally used, the term *epidotite* is a satisfactory descriptive petrographic term that demands no special mode of origin or occurrence.

TWO descriptive petrographic names and two geographic petrographic names have been applied to rocks composed mostly of epidote: (1) the French term *epidotite;* (2) the German term *epidosit* (from which the English form *epidosite* was subsequently derived); (3) the term *unakite*, taken from Unaka Range on the border of North Carolina and Tennessee; and (4) the term *helsinkite*, taken from the Finnish city of Helsinki. The term *saussurite* prefixed to rock names (*e.g.*, saussurite-gabbro) has a special meaning that does not concern us here.

Definitions of epidotite.—(1) the term *épidotite* was originated by Cordier (1868, p. 153) who defined it as follows:

> Roche stratiforme, *composée d'épidote* soit grenue, fibreuse ou prismatique, soit plus ou moins a l'ètat compacte; de couleur communément vert-pistache.

As accessory minerals Cordier lists quartz, calcite, talc, amphibole, garnet, feldspar, sphene, pyrite, magnetite, chromite, etc. He notes the occurrence of epidotites in thin beds or reniform masses in metamorphic terranes (" . . . dans les terrains primitifs stratifiés."). Although Cordier's notebooks (1868, p. 154) show that his observations pertained to epidotites of metamorphic origin, his definition is general. He gives *Épidosite*, *Pistazitkels*, and *Pistacite Rock* as synonyms.

(2) De Lapparent (1923, p. 151) has defined *epidotite* as follows:

> Les épidotites, roches compactes et denses, sont faites d'epidote ou de zoisite associées parfois à des amphiboles (actinote ou hornblende) à des pyroxènes, à du sphène, à de la calcite, à du quartz et à de l'orthose; . . . .

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De Lapparent discusses epidotites as members of the calcium-silicate contact-metamorphic suite. However, he does not restrict the term to contact-metamorphic rocks and, discussing glaucophanites (1923, p. 470), states that when epidote is more abundant than glaucophane the rock becomes an epidotite. De Lapparent might well have referred to amphibolites in general and not limited himself to glaucophanites. This definition contains no limiting conditions of origin or occurrence and, with one exception, is essentially a restatement of Cordier's original definition. Cordier, probably because of his experience with epidotites in metasedimentary terranes, included the word *stratiforme* in the original definition. De Lapparent makes no mention of stratification.

(3) Loewinson-Lessing (1901, p. 1085) gives *Epidotgestein* as a synonym for *epidotite* and refers to Inostranzeff (1879, p. 113). Inostranzeff (1879, pp. 112-114, 119-128) distinguishes between *Epidotgestein* and *Epidosit*. He defines *Epidotgestein* as a dark aphanitic rock made up of epidote, remains of oligoclase, hornblende, hematite, and diverse other accessory minerals. Discussing *Epidosit*, Inostranzeff states that he is not using the term in the strict sense of a pure epidote-quartz rock. He found that epidote and quartz were invariably accompanied by actinolite (in his area) and modifies the definition to include actinolite. Inostranzeff also discusses varieties of "Epidotgestein" and epidosite such as "Chlorit-Epidotgestein" or chlorite-epidosite. (*Gestein* here has a special meaning and *Epidotgestein* cannot be freely translated as *epidote rock*.) "Epidotgestein" is distinguished from epidosite by mineral composition and grade of metamorphism. Both types, according to Inostranzeff (1879, p. 205), are derived from metamorphism (hydrothermal alteration) of diorite: diorite→ epidote-diorite→ "Epidotgestein"→ epidosite.

Definitions of epidosite.—(1) Loewinson-Lessing (1901, p. 1085) credits the origin of the term *epidosite* to Reichenbach (1834, p. 55)[1] and defines the term as follows:

[1]Reichenbach, Karl Ludwig Friedrich, Freiherr von, Geologische Mittheilungen aus Mähren. Geognostiche Darstellung der Umgegenden von Blansko. Vienna. 1834. This report is not listed in any library in this country.

> Roches schisto-crystalline formées d'épidote et de quarz; parfois elles sont grenues, massives.

(2) Holmes (1928, p. 92), likewise referring to Reichenbach, defines *epidosite*:

> Epidosite—a term applied to altered igneous rocks, or veins traversing them, essentially containing epidote and quartz, and generally other secondary minerals such as uralite and chlorite.

This definition differs considerably from the Loewinson-Lessing definition and restricts the rock to a secondary mode of origin.

(3) Zirkel (1893, pp. 374-375; 1894, p. 371) notes three modes of occurrence of epidosite: (a) in calcium-silicate contact-metamorphic suites, (b) in crystalline schist sequences, and (c) as a product of secondary alteration. He states (1894, p. 371):

> Wenn schon im Vorhergehenden Epidot als ein sehr häufiger accessorischer oder wesentlicher Gemengtheil gennant wurde, so gibt es auch zu den krystallinischen Schiefern gehörige Gesteine, welche zum grössten Theil aus diesem Mineral bestehen, wozu sich dann weiter in der Regel noch Quarz oder ein Glied der Amphibolgruppe, Glimmer oder Chlorit gesellen, während Feldspath oder Pyroxen sehr selten zu scheint. Die Structur ist bald ausgezeichnet schieferig, bald mehr richtungslos körnig und namentlich *letztere Vorkommnisse hat man Epidosit gennant.* [Writer's italics.]

A good point in this definition is that the term *epidosite* must apply to massive rocks; schistose epidote rocks are then appropriately named *epidote schists.*

Zirkel (1894, p. 371) discusses epidosites formed by secondary processes:

> Es mag hier daran erinnert werden, dass der Epidot secundär aus manchen anderen Mineralien hervorgehen kann, dass Epidosit auch als Umwandlungsproduct verschiedener, z. Th. eruptiver Gesteine bekannt ist (. . . . von denjenigen Epidositen, welche so als Metamorphosen oder auch wohl gewissermassen als Auslaugungsproducte von Massengesteinen vorkommen, ist daher an dieser Stelle nicht die Rede; eine solche Masse, reiner Epidot mit Quarz, beschrieb z. B. Bergeat von Starvo-Vuni auf Cypern als wahrscheinliches Auslaugungsproduct zersetzter Diabase, ... *Reichenbach erwähnt eine feinkörnige apfelgrüne Epidositmasse an der Grenze des Syenits von Blankso*). [Writer's italics.]

Apparently as originally used by Reichenbach the term *epidosite referred* to epidote rocks of secondary origin.

(4) Cordier (1868, p. 153) credits the term *épidosite* to Pilla (no reference given). Cordier evidently considered the term *épidosite* a French term (note acute accent) synonymous with *épidotite.*

(5) Pilla (1845, pp. 63-65) defines and discusses *epidosite* in an article entitled (in translation) *Epidosite, A New Rock Type from the Gabbro Family.* Evidently this article was responsible for Cordier's crediting the origin of the term *epidosite* to Pilla. However, this article postdates Reichenbach's work by 11 years. Pilla lists four varieties of epidosite: granular, variolitic, aphanitic, and earthy. He says:

> Die Charakteristik des Epidosits wäre folgender Maasen festzustellen:
>
> Bestand—Körner von Pistazien-grünem Epidot und von Quarz, bald schärfer geschieden, bald inniger mit einander verschmolzen.
>
> Lagerungs-Verhältnisse: der Epidosit gehort zu den . . . . . *Gabbro-Gesteinen* und erscheint bald in Gesellschaft der Ophiolithe, bald zeigt er sich dem Granite verbunden.

Pilla contributes some useful observations on the occurrence of epidosite on the island of Elba, but assignment of the rock to the gabbro family was unfortunate. Cotta (1855, p. 74) credits the origin of the term to Pilla and uses his definition.

(6) Rosenbusch (1910, p. 670) defines *epidosite*:

> Epidotfelse oder Epidosit von bald körniger bald schiefriger Struktur . . . . die wesentlich aus Epidot, oft mit night unbeträchtlichem Quarzgehalt und meistens mit etwas Granat, Vesuvian, Titanit, Hornblende usw., bestehen.

This definition is very similar to de Lapparent's definition of *epidotite* and has the merit of being free from genetic implications. Like de Lapparent, Rosenbusch discusses epidosites as rocks formed by contact-metamorphism of impure limestones, but he cites a connection between granular contact-metamorphic epidosites and calcite-epidote schists in the mica schist-phyllite sequence.

(7) Clarke (1911, p. 572) discusses epidosite:

> Epidotization, then, represents a reaction between the feldspars and the ferromagnesian minerals of a rock, and when it is complete a mixture of quartz and epidote remains. Such a rock is known as epidosite and its formation has been many times recorded.

(8) Harker (1932, p. 267) mentions epidote in some Highland quartzites and in granulites of the Moine series. He says:

> An epidote-quartz rock or *"epidosite,"* in which the distinctive mineral bulks largely, is not a common type.

Harker states that most rocks of this composition have a dif-

ferent origin, not related to metamorphism proper. He is probably referring to a secondary origin.

(9) Johannsen (1932, vol. I, p. 250) defines *epidosite* as "a metamorphic rock composed of a mixture of quartz and epidote."

(10) Grout (1932, p. 369) classes *epidosite* as a special term under the heading *Metamorphic Carbonate and Carbonate-Silicate Rocks* and does not refer to epidosites formed by alteration.

(11) Flett (1946, pp. 37-44), describing the petrography of the metamorphic rocks of the Old Lizard Head series, mentions a layered sequence of green schists, mica schists, granulites, and epidosite. He states (p. 40):

> Some of the quartzite bands are so rich in epidote that they become epidosites . . . .

Here the epidote seems to be a primary metamorphic mineral. However, Flett (1946, p. 127) describes also a pillow lava and notes that the central cavity of the pillow is commonly filled with yellow masses of epidosite. The epidote here is certainly of secondary origin, and Flett seems to use the term *epidosite* as a descriptive term only.

Definitions of unakite.—Bradley (1874, p. 519) proposed the term *unakyte* for a variety of granite in which epidote replaces the mica of common granite and the hornblende of syenite. The granite referred to forms part of the Unaka Range of North Carolina and Tennessee. The amount of epidote in the rock is variable and may exceed 50 percent. Pink orthoclase (25 to 30 percent), quartz (about 25 percent), and small scattered grains of magnetite are also present. Phalen (1904) described this rock and noted that all transition stages between unakite and epidosite occur. Watson (1904, pp. 394-398; 1906, pp. 171-174; 1910, pp. 156-159) described the occurrence of unakite in veins that penetrate the granite. He stated that the epidote is secondary and is "derived from the interaction of the ferromagnesian constituent and the feldspar." This is identical with the process suggested by Clarke (1911, p. 572) for the formation of epidosite. Johannsen (1932, vol. II, p. 60) stated:

> There seems to be no doubt but that the unakite originated from the alteration of the associated hypersthene-akerite by

dynamic metamorphism and the percolation of meteoric waters. The chemical analyses and the whole appearance of the thin sections indicate this.

Jonas (1935, p. 51) confirmed the replacement origin of the epidote and showed that it formed through hydrothermal alteration of granodiorite.

By definition unakite is limited in mineral composition, mode of occurrence, and mode of origin. The term can be applied only to a special kind of altered granite.

Definitions of helsinkite.—The term *helsinkite* is the European counterpart of *unakite.* The term was proposed by Laitakari (1918) for dike rocks composed essentially of epidote and albite, *with epidote considered a pyrogenic mineral.* The type rock comes from the Island of Hogland in the Gulf of Finland. Asklund (1923, pp. 40-44) noted that similar rocks occur near Stavsjö, Sweden, that contain potassium feldspar and proposed an extension of the term *helsinkite.* Asklund recommended that the relative amounts of epidote and feldspar be neglected and proposed a *helsinkite facies* that specified a magmatic paragenesis of epidote. A magma with a high water content was suggested to explain crystallization temperatures low enough to permit pyrogenic crystallization of epidote. Later papers (Mellis, 1932; Eskola, 1946) argue for a non-pyrogenic origin of the epidote in helsinkite. Eskola (1946, p. 354) states that epidote is a hydrothermal mineral. Barth (1929, pp. 126-127) gives a list of 15 references before 1929 on the helsinkite problem.

This term, like *unakite,* suffers from too many restrictions on mineral composition, mode of occurrence, and mode of origin. There may be some justification in Asklund's proposal of a helsinkite facies (similar to charnockite facies) if the primary paragenesis of epidote in water-rich magmas can be accepted. This is dubious, however, and Johannsen (1937, p. 143) says: "Personally, I am skeptical about primary epidote."

CONCLUSIONS AND SUGGESTIONS

To summarize, rocks composed mostly of epidote occur (1) in contact-metamorphic zones as a result of thermal metamorphism and/or contact-metasomatism of calcium-silicate rocks; (2) in regional metamorphic sequences where epidote is a primary metamorphic mineral or the result of

retrogressive metamorphism (diaphthoresis); (3) in zones of alteration where epidote is a secondary mineral formed by hydrothermal or deuteric action; and (4) possibly by crystallization from a water-rich magma.

It is plain, therefore, that any definition which attempts to limit mode of occurrence or mode of origin is undesirable unless a separate term is proposed for each case. Such a solution results in terms such as *unakite* and *helsinkite* and presumes that the mode of origin can be positively determined. These terms are of little value outside of the district for which they were originally coined. Researchers who encounter similar rocks usually are forced to modify or extend the original definition. A descriptive petrographic term that makes the mineral composition obvious is eminently preferable if one is readily adaptable. For example, *epidote-granite* or *epidote-granodiorite* are superior to *unakite* where the epidote content of the rock is low, and *epidotite* is superior to *unakite* where the rock is composed mostly of epidote.

The choice lies between *epidotite* and *epidosite*. Holmes' definition of *epidosite*, which limits the rock to a secondary origin, has had wide circulation as a reference in the English language. Apparently this definition follows Reichenbach's original usage. If the term *epidosite* is to be applicable to rocks of other than secondary origin, it must be redefined. The definitions of *epidosite* by Rosenbusch and Zirkel are good and might be combined and restated to make a usable term. It is doubful, however, if another definition would do more than increase the confusion. In the writer's opinion the best solution is to abandon the term *epidosite* in favor of the French term *epidotite* and modify de Lapparent's definition of the term as follows:

> An epidotite is a compact massive rock composed mostly of epidote (or zoisite) with minor amounts of amphibole, pyroxene, feldspar, chlorite, quartz, sphene, calcite, vesuvianite, garnet, etc.

This follows Cordier's original usage. Moreover, the term *epidotite* is more logically derived from *epidote* than is *epidosite*. *Epidotite* has been seldom used as other than a purely descriptive term.

The writer has observed that in metasedimentary rocks of the Van Horn, Texas, area, amphibolite grades through epidote-amphibolite to epidotite. The question arises as to

how much epidote is necessary before the rock may be called an epidotite. The writer has found that when the epidote content of the rock exceeds 60 to 70 percent the rock takes on the massive, compact, waxy, yellow-green appearance of the epidotite. However, to set an arbitrary minimum limit is to remove the flexibility of the definition that is given by the phrase *composed mostly of epidote.*

Another problem arises if zoisite and not epidote is the principal rockmaking mineral. Is it then necessary to introduce a new term? The writer believes, following de Lapparent, that it is sufficient to allow for this possibility in the definition of epidotite and thus escape such a term as *zoisitite.* Zoisite is after all a member of the epidote group.

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