10. Contact Metamorphic Rocks

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Introduction

A Study Group under the leadership of E. Callegari was set up to look at definitions concerning contact metamorphism and contact metamorphic rocks. The Study Group was also asked to consider metamorphism associated with other localised heat sources, such as combustion metamorphism and ligthning strikes. This paper presents the report of the Study Group.

Brief historical notes on contact metamorphism

Les roches de ces derniers terrains (Vosges) ont souvent subi, à proximité du granite, des modifications si variées que leur nomenclature précise devient un sujet d'embarras pour le géologue.
Daubrée, 1857.

The first mention of contact metamorphic phenomena dates back to the end of eighteenth century when James Hutton observed that the rocks surrounding a granitic body at Glen Tilt (Perthshire, Scotland) had suffered marked changes in either colour or structure especially in zones crossed by granitic veins (Playfair, 1822). At that time Neptunists and Plutonists were still debating the sedimentary vs igneous origin of granitic rocks, and the terms 'metamorphism' (Boué, 1820; Lyell, 1833) and 'contact metamorphism' (Delesse, 1857) had still to enter the geological vocabulary.
In the first decades of the nineteenth century rock alterations close to contacts with granitic rocks were increasingly discovered in other localities of England and Scotland (MacCulloch, 1819) as well as in other European countries. They were observed in a variety of settings (plutonic and volcanic) involving a wide spectrum of rock types. Many names appeared for this particular and localised type of metamorphism and its varietie. Eventually Delesse (1857) proposed the term *contact metamorphism* which found general acceptance and is still widely used today.

Most names for contact metamorphic rocks (see Appendix) entered geological literature between the end of the eighteenth and the first two thirds of the nineteenth century. Many of these names were coined before the study of thin sections developed and the subsequent widespread use of microscope techniques, particularly in the last quarter of the nineteenth century, did much to improve the existing definitions removing most of the uncertainties and ambiguities. At the same time unnecessary rock names were gradually abandoned or superseded by more appropriate synonyms. The pioneering works of the early petrographers also provided a general framework for many aspects of contact metamorphism including definitions or basic concepts of *contact aureole* (von Buch, in Humboldt, 1831), *endo*- and *exomorphism* (Fournet, 1847), *contact metasomatism* (Durocher, 1846) and many other terms which are still current. Unfortunately, most of the original definitions were in languages other than English, and in some cases the original name was lost in translation.

At the onset of the twentieth century, there was, in many countries, a renewed interest in the study of contact aureoles. However, the interest of metamorphic petrologists was mainly directed towards the interpretation of the relationships between rock microstructures, mineral assemblages, rock chemistry and metamorphic conditions. It was the time when the concepts of metamorphic zones (Becke, 1903b; Grubenmann, 1904, 1906; Barrow, 1912) and metamorphic facies (Eskola, 1920) opened new horizons in the field of metamorphic petrology and Golschmidt (1911) discovered very simple and fixed relations between rock chemistry and mineral assemblages in the contact metamorphic rocks of the Christiania (Oslo) region, Norway. Only a restricted number of new contact metamorphic rock names appeared at this time including the important term 'skarn' (Törnebohm, 1881a, b; Goldschmidt, 1911). Further attempts to introduce new rock names based on the mineral composition, (e.g. Salomon, 1898) did not achieve much success and names such as *aviolite*, *astite, seebenite, edolite* created for different types of hornfelses were short-lived.

In the middle part of the twentieth century there was relatively little attention paid to contact metamorphism and indeed the question was raised as to whether the distinction between contact and regional metamorphism should be maintained or whether the two should be regarded as a part of the general system of rock metamorphism and metasomatism (Barth, 1962), even though Delesse (1857) had argued that *contact metamorphism* was the natural base for all metamorphic research because, on a limited scale, it was possible to see both the cause and the product of metamorphism. Arguments in favour and against separation of contact from regional metamorphism were brought by Read (1949), Yoder (1952) and Miyashiro (1973a); today, however, there is a general consensus on the necessity for studying contact aureoles as a tool for a better understanding of the physico-chemical processes controlling regional metamorphism (Kerrick, 1991).

Following the procedures of the SCMR, the Study Group dealing with contact metamorphism examined the existing names of contact metamorphic rocks and processes in order to select a group of 'recommended names'. The Study Group also considered the metamorphic terminology associated with other localised heat sources. The reasoning and results of this process are given below.

Towards a redefinition of contact metamorphism

Contact or thermal metamorphism?

The term *thermal metamorphism* was introduced by Harker (1889) for metamorphism caused by elevated temperatures in the absence of directed stress as opposed to dynamic metamorphism. Harker argued that the rise of temperature could be due to more than one process and that contact metamorphism was therefore a type of thermal metamorphism (Harker, 1932; see also Holmes, 1920). Tyrrell (1926) regarded thermal metamorphism as the process of change where "heat is the dominating factor", but took this to mean "in the proximity of igneous masses" and he subdivided thermal metamorphism into various types, namely: pyrometamorphism, contact metamorphism, optalic (or 'caustic') metamorphism and pneumatolytic (or 'additive') metamorphism, although previously, following Delesse (1857), all these types had been included under contact metamorphism. As Harker's division into thermal and dynamic was increasingly seen as too simplistic his distinction between thermal and contact also diminished and increasingly these two terms were taken as synonymous, ‘thermal’ relating to the cause of metamorphism, ‘contact’ to the field relationships (Turner, 1948; Barth, 1962; Spry, 1969; Yardley 1989).

However, the term ‘thermal metamorphism’ conveys the idea that the metamorphism is essentially temperature dependent, the effects of directed pressure being immaterial. This is certainly not the case where the metamorphism is associated with forceful magma intrusions or where magma emplacement occurs in a region undergoing deformation, as for instance in the Donegal area of Northern Ireland (Pitcher & Read, 1963) or in the Kwoiek area of British Colombia (Hollister, 1969). Accordingly, “distinctions between contact and regional metamorphism can only be based on spatial, genetic, kinetic or textural characters, rather than on P-T differences alone” (Pattison & Tracy, 1991).

Therefore to avoid any further ambiguity the SCMR proposes that the term ‘thermal metamorphism’ is no longer accepted as a recommended synonym of ‘contact metamorphism’ and should be given restricted status. The recommended definition of contact metamorphism is, therefore, as follows:

Contact metamorphism: *Type of metamorphism of local extent that affects the country rocks around magma bodies emplaced in a variety of environments from volcanic to upper mantle depths, in both continental and oceanic settings.*

The magmas are the sources of heat, mass and mechanical energy necessary for this type of metamorphism. The zone where contact metamorphism occurs is called the **contact aureole**, while the products of such metamorphism are called **contact rocks**. The thickness of the aureole ranges from the millimetre- to the kilometre-scale. The intensity of contact metamorphism decreases from the innermost to the outermost parts of the aureole. It is customary to separate the metamorphic effects caused by the magma on its wall rocks (**exomorphism**) from those induced by the wall rocks on the magma itself (**endomorphism**). Contact metamorphism accompanied by substantial mass transfer (change of the original rock composition) is called **contact metasomatism**.

How many types of contact metamorphism?

In the past two centuries several divisions have been made within the field of contact metamorphism based on geological, chemical, physico-chemical, mineralogical, petrological, structural or genetic grounds. Those found in literature are given in Appendix 1. They have been arbitrarily grouped under three headings. The first two are isochemical and allochemical (or metasomatic) contact metamorphism, whereas the third corresponds to a specific kind of contact metamorphism known as *pyrometamorphism*.

Pyrometamorphism redefined

Unfortunately, the current usage of pyrometamorphism is at times quite different from that originally proposed, covering not only igneous-related changes but also thermal transformations due to, for example, combustion metamorphism (Cosca et al., 1989), flash-heating of meteoritic material during atmospheric entry (Rietmeijer, 2004), artificial firing of carbonate-clays mixtures (Bauluz et al., 2004) and even burning of rocks in prehistoric sacrificial sites (Tropper et al., 2004).

The SG considered this position and discussed the redefinition of pyrometamorphism as follows.

The term pyrometamorphism was proposed by Brauns (1911) for a high-temperature type of metamorphism observed in ejected schist fragments found in the Laacher See tuffaceous rocks, in the Eifel region of Germany. The unusual mineral assemblage (sanidine, corundum, spinel, cordierite ± hypersthene ± glass), overprinted on both regional and contact metamorphic assemblages, suggested to him formation temperatures higher than those found in common contact metamorphism. Brauns attributed the pyrometamorphism to a steep increase in the magma temperature while it was stationary in a shallow chamber. This led to the exsolution of hot gases, which reacted with the country rocks, the latter becoming subsequently incorporated in the magma and ejected. The typical end-product of this metamorphism is a sanidine-rich rock. Eskola (1920) proposed the name *sanidinite facies* to cover the particular P-T conditions under which the sanidinite rocks were formed. Subsequently, Grubenmann & Niggli (1924) interpreted Brauns' pyrometamorphism as a variety of their pneumatolytic (metasomatic) contact metamorphism. Later, Tyrrell (1926) expanded the term to cover all the metamorphic products formed at very low pressure and very high magmatic temperatures whether or not associated with chemical interchange. Subsequently, Turner & Verhoogen (1960) considered pyrometamorphism as a distinct, though minor, type of metamorphism characterised by a volcanic to near-surface setting and unusual mineral assemblages typical of the sanidinite facies. The particular kinetic conditions under which pyrometamorphism occurs may favour disequilibrium melting and overstepping of equilibrium mineral reactions (Kerrick et al., 1991; Grapes, 2003). The formation of quenched melts (glass or microgranophyre) either as small pods and vein fillings or as relatively thick contact zones suggests boundary conditions overlapping with ultrametamorphism (Spry & Solomon, 1964). Reverdatto (1973) offered a compilation of the 'pyrometamorphism critical minerals' for different rock systems which the SG has included in the definition of pyrometamorphism. Those for carbonate and calc-silicate rocks, however, should be handled cautiously because the temperatures needed for their formation are strongly dependent on the values of X_{CO2} (Tracy & Frost, 1991).

Following the opinion of several authors (e.g. Turner, 1968; Miyashiro, 1973; Reverdatto, 1973), the SCMR recommends that 'pyrometamorphism' is defined as a specific type of contact metamorphism, thus:

Pyrometamorphism: *a very high-grade type of contact metamorphism occurring in volcanic settings or around near-surface intrusions and characterised by mineral assemblages stable at or near atmospheric pressure and very high temperatures. Critical minerals are: spurrite, tilleyite, rankinite, larnite and merwinite in silica-deficient carbonate rocks; mullite and glass in aluminous rocks; tridymite and glass in silica-oversaturated rocks.*

Non-critical minerals may include monticellite, melilite, scawtite, ferruginous wollastonite in carbonate rocks; sanidine, sillimanite, cordierite, corundum, spinel and orthopyroxene in aluminous rocks. Under the P-T conditions of pyrometamorphism aluminous and quartzofeldspathic rocks may show variable degree of melting, which is indicated by the presence of glass among the component minerals or, more rarely, by the formation of glassy rocks (buchites). In the field it is found in (a) xenoliths ejected from volcanic vents or embedded in lavas, (b) narrow rims of contact rocks at the base of basaltic lava flows, (c) small contact aureoles (centimetre- to metre-scale) surrounding sheets, dykes or plugs of predominantly basaltic magmas.

It should be noted that contact metamorphic effects associated with volcanic and near-surface intrusive rocks may only be defined as pyrometamorphic if at least one of the 'critical minerals' listed above is present. Otherwise contact effects, characteristic of lower temperatures, come under the general heading of contact metamorphism and may be described according to their metamorphic grade or facies.

Tyrrel (1926) proposed the term *optalic metamorphism* for the indurating, baking and fritting effects produced by lava flows or small dykes on their contact rocks: the upper boundary of 'optalic metamorphism' was characterised by incipient fusion without melting (fritting) thus marking a boundary with pyrometamorphism. However the SCMR does not regard the process as a distinct type of contact metamorphism and considers that the term is therefore unnecessary.

Combustion metamorphism and other kinds of non-igneous related local metamorphism

Local metamorphic processes (excluding dislocation and impact metamorphism) unrelated to an igneous heat source may sometimes affect solid rocks and produce metamorphic aureoles with a zonal pattern similar to that of true contact aureoles. The classic occurrence of such processes is the rims or haloes of burned rocks (thermantides of Haüy, 1822) surrounding burned coal seams or other natural combustibles. However, there are other possible localised heat sources producing metamorphic effects, for example: (a) thermal shocks due to lightning; (b) flash-heating during atmospheric entry of extra-terrestrial materials; (c) the tectonic transport of hot crust or mantle slices onto cooler sedimentary or metasedimentary rock piles; (d) heat supply from 'gneiss domes' to their surrounding rocks. The resulting metamorphism is commonly accompanied by the formation of melts, which, on cooling, may generate glass if near the surface (a, b), or migmatites if at depth (c, d).

The SCMR recommends that the terms 'contact metamorphism' and 'pyrometamorphism' should not be used to describe the above processes but the following names should be used as appropriate: *combustion metamorphism, lightning metamorphism, impact metamorphism and hot-slab metamorphism* (Smulikowski et al., this vol.).

The SCMR's definition of **combustion metamorphism** is: *A type of metamorphism of local extent produced by the spontaneous combustion of naturally occurring substances such as bituminous rocks, coal or oil.*

In literature the process has been long considered as a distinct type of metamorphism (e.g. Delesse, 1857; Naumann, 1858; Zirkel, 1893; Kalkowsky, 1886; Arnold & Anderson, 1907; Mc Lintock, 1932; Bentnor & Kostner, 1976). The SCMR prefers the terms *combustion metamorphism* for the process and **burned (or burnt) rocks** as a collective name for the various kinds of rocks (porcellanites, buchites, paralavas) formed around burned coal seams, oil or gas fountains and bituminous shales.

Aureoles produced by combustion metamorphism usually do not exceed a few metres in width, exceptionally they may reach a few tens of metres. In some circumstances combustion metamorphism has been described improperly as pyrometamorphism (Cosca et al., 1989; Clark & Peacor, 1992; Sokol et al., 1998).

The SCMR's definition of **lightning metamorphism** is: *A type of metamorphism of local extent that is due to a lightning strike* (Smulikowski et al., this vol.).

This is an exceptional type of metamorphism in which very high-temperatures (c 2000°C) are reached in a few microseconds, causing melting, vaporisation and extreme chemical reduction (with formation of metal globules) on the rock surfaces struck by lightning (Essene & Fisher, 1986). Shock wave compression structures have also been observed in unmolten mineral grains (Frenzel et al., 1989). Most products of lightning-strike fusion form glassy crusts, tubules or drops to which the name *fulgurite* was first given by Arago (1821). Tube-like fulgurites are common in soils or in loose sediments, especially sands (Shrock, 1948). Their diameter does not usually exceed a centimetre, while their length may reach up to ten metres. Glassy crusts, small tubules and drops form preferentially on rock surfaces, especially on high mountains. The largest exposure of a single mass of fulgurite so far recorded has a maximum diameter of 0.3 m and a length of 5 m. It is part of a single-event system of fulgurites which extends for 30 m near Winans Lake, Livingstone Co., Michigan (Essene & Fisher, 1986).

The SCMR's definition of **hot-slab metamorphism** is: *A type of metamorphism of local extent occurring beneath an emplaced hot tectonic body* (Smulikowski et al., this vol.).

This term has been proposed by the SCMR to cover the following situations: (a) the small aureoles surrounding hot slices of obducted mantle rocks (Karamata, 1968, 1985; Coleman, 1977; Okrush et al., 1978) for which Williams & Smyth (1973) proposed the term 'contact dynamo-thermal aureoles'; (b) the relatively wide aureoles of the so-called 'inverted metamorphism' observed, for example, in the High Himalayan Crystalline Sequence at the margins of hot crustal slices tectonically emplaced at upper crustal levels (Medlicott, 1864; Gansser, 1964; Le Fort, 1975; Jaupart & Provost, 1985; Swapp & Hollister, 1991; Vannay & Grasemann, 2001); (c) the aureoles mantling typical 'gneiss domes' may be considered as similar phenomena (Allen & Chamberlain, 1989; Barton et al., 1991b).

The rocks of contact metamorphism

The appendix presents a list of contact metamorphic rock names found in literature. Apart from some general names these have been subdivided on the basis of their protolith (pelitic to quartzofeldspathic, carbonate to marly, mafic to ultramafic, and special rock types). Many of the names given are now obsolete. Other names are not specific to contact metamorphism, for example, *marble*, *quartzite*, *calc-silicate rock*, *emery rock* are also used for regional metamorphic rocks, and *buchite*, a glassy metamorphic rock, may form by either contact or combustion metamorphism. In these cases, the SCMR recommends the use of *contact* as a prefix (e.g. contact marble, contact buchite) if it is desirable to stress the contact metamorphic origin of a particular rock type (see below).
The names recommended by the SCMR are highlighted in the appendix. Some of these, although established in international literature, were initially found to have ambiguous definitions or usage, partly inherited from the original definitions, partly as a result of subsequent modifications. Redefinition of such terms was therefore necessary. The background discussion and recommended definitions are given below.

Hornfels
Today this name is widely used for a group of compact, highly metamorphosed contact rocks, typically found in inner aureoles. It derives from an ancient term used by miners in Saxony (Germany) for hard compact rocks of various origins, characterised by their *horny appearance* and *conchoidal to subconchoidal fracture*, and commonly associated in the field with granitic rocks (Leonhard, 1823). Initially, their geological status was uncertain since at that time the igneous nature of granite was still in doubt. Boué (in Leonhard, 1823) noted a transition from hornfels to unaltered graywacke and schist, although Leonhard considered that the hornfels was in part a very fine-grained variety of granite. Cordier (1868) found the same degree of ambiguity in the corresponding French terms 'cornéenne' or 'pierre de corne'. The geological significance of the hornfels rocks emerged as the igneous character of the granitic rocks was established (Boué, 1829; Delesse, 1857; Zirkel, 1866). Rosenbusch's paper (1877) on the contact rocks in the aureole of Alsace granites represents a landmark in the modern interpretation of hornfels and other contact rocks. At the end of the nineteenth century the term 'hornfels' was firmly established in geological nomenclature as a type of contact metamorphic rock (Loewinson-Lessing, 1893). Since then different definitions of hornfels have appeared with varying emphasis placed on compositional and structural features. For some, hornfels is an aluminous rock derived, for example, from shale; for others it also includes quartzofeldspathic protoliths such as graywackes and for some the term can be applied to any contact-metamorphic rock (including calc-silicate hornfels, quartz-hornfels, mafic and ultramafic hornfelses) provided they possess the distinctive structural characters recognised by the old Saxon miners. Another controversial point concerns the grain size of a hornfels; to some (especially those supporters of an aluminous character of the hornfels) it is very fine- to fine-grained; others regard it as very fine to coarse. Another source of uncertainty concerns whether the term hornfels should be defined in a genetic sense (for

contact metamorphic rocks only) or should be used as a structural class of metamorphic rocks. Further difficulty arises from the extended use of the name hornfels by some workers to cover the partially metamorphosed rocks of the outer aureole.

To resolve these problems the SG decided that the name ‘hornfels’ should only be used for contact metamorphic rocks dominantly composed of silicate + oxide minerals in varying proportions. Contact marble and coal are considered as separate rock types. For hornfels-looking rocks produced by regional metamorphism the SCMR recommends the use of ‘granofels’ (e.g. calc-silicate granofels) or, alternatively, *hornfelsoid*. The SG farther decided to base the definition mainly on structural criteria.. The recommended definition of hornfels is therefore as follows:

Hornfels: *A hard, compact contact-metamorphic rock of any grain size, dominantly composed of silicate + oxide minerals in varying proportions, with a horny aspect and a subconchoidal to jagged fracture.*

It may retain some structural features inherited from its protolith such as bedding, sedimentary laminations or metamorphic layering. Different types of hornfels may be distinguished according to structural (e.g. fine-grained, coarse-grained, spotted, layered), chemical (e.g. peraluminous) or mineralogical criteria (e.g. mafic, ultramafic, cordierite-sillimanite-spinel hornfels, diopside-wollastonite-garnet hornfels). Hornfels occurs mostly, but not exclusively, in the innermost part of contact aureoles.

The transition from unaltered schist to hornfels is marked by a gradual loss of the original fissility; the primary foliation, however, is hard to destroy and persists, as compositional differences, even in true hornfelses. Hornfelsic rocks with traces of a pre-existing schistosity have been called either ‘schist hornfels’ (*Schieferhornfels*) or ‘schistose hornfels’ (*schiefriger Hornfels*) (e.g. Rosenbusch, 1897; Salomon, 1898). The SG considered that neither term is satisfactory: schistose hornfels because it conveys the idea of a schistose rock, and schist hornfels because it is a compound of two different rock names. Therefore the SCMR recommends that, for such rocks, the term **hornfelsed schist** should be used. Although Harker (1932) considered that the use of hornfels as a verb “affronted the English language”, the use of ‘hornfelsed’ is now widespread in metamorphic literature (e.g. Spry, 1969). The term *schistose hornfels* may be retained only for the particular rock type known in the old literature as *leptynolite*, that is a totally recrystallised rock of the innermost aureole (with the same mineralogical composition as the associated hornfelses), which is characterised by a schistose structure.

Non-hornfelsic contact rocks

According to the definition of hornfels given above, not all contact metamorphic rocks are hornfelses. Among them are various rocks of the outermost aureole that commonly retain most of their original mineralogical and structural characteristics (e.g. sandstones, some limestones, schists) and can be difficult to distinguish from their unmetamorphosed equivalents, apart from a slight colour change or the development of an indistinct spotted structure. The transition from rocks unaffected by contact metamorphism to typical hornfels is marked by progressive changes in the mineral content and structure of the rocks. The classification of these transitional rocks was discussed in detail by Salomon (1898), who proposed that the rocks of the outer aureole, whose original characters are largely retained are simply named by use of the prefix ‘contact’ (e.g. contact sandstone, contact schist). Unfortunately, the same prefix was used by Salomon (1891), although in hyphenated form, to mean a rock derived by contact metamorphism, thus, a contact-pyroxenite or a contact-peridotite were rocks having the composition of a pyroxenite or a peridotite and produced by contact metamorphism regardless of the nature of the protolith (e.g. a pyroxenite might be derived from a recrystallised pyroxenite, or from a marly rock).

To further complicate the nomenclature the term 'hornfels' has been used for all the products of contact metamorphism, including rocks of the outer aureole. This usage followed the introduction of two new facies[1] of contact metamorphism namely hornblende hornfels facies and albite-epidote hornfels facies (Fyfe et al., 1958). Accordingly, all contact-metamorphic rocks became part of a single hornfels family. This meant that although the rocks of Eskola's (1920) original hornblende hornfels facies were true hornfelses of the inner aureole this was not the case (or only partially the case) for rocks belonging to the albite-epidote hornfels facies.

To resolve this situation, the SCMR recommends the following:

1. That the term 'hornfels' is used in accord with the above definition, that is, the rock is named on its structural or mineralogical characteristics, not on the facies to which it belongs.

2. To use the prefix **contact** in front of a metamorphic rock name to distinguish that rock from another of similar composition generated by other types of metamorphism. Thus, a contact marble or contact amphibolite is a marble or an amphibolite formed by contact metamorphism and not by regional metamorphism. And also, contact *buchite* is used to distinguish a buchite formed by contact metamorphism from a coal-fire *buchite*.

3. To use the prefix **contact-metamorphosed** in front of the name of a protolith for the rocks of the outer aureole which have been slightly modified by contact metamorphism but still retain most of their original structural and/or mineralogical characteristics; the prefix may be used in front of metamorphic protoliths, for example, *contact-metamorphosed eclogite*.

Structural terms like *spotted, maculose*, or *knotted schists* may be used to describe contact-metamorphosed schists in which the new metamorphic minerals form either spots or nodules growing on a pre-existing unaltered or slightly altered schistose matrix.

Mafic and ultramafic hornfelses

Igneous rocks of mafic composition and/or ultramafic rocks of either oceanic or continental provenance may be present in some contact aureoles (e.g. Isle of Skye, Scotland; Sudbury layered intrusion, Ontario; Bushveld igneous complex, South Africa; Bergell pluton, Italy and Switzerland). The metabasic rocks are rather insensitive to temperature variations in this context and do not produce a great variety of contact rocks, essentially because most related chemical reactions are multivariant and do not involve the appearance or disappearance of many phases (Tracy & Frost, 1991). In the hottest part of the aureole, however, most basaltic or gabbroid rocks are converted into fine-grained hard rocks, essentially composed of plagioclase + pyroxene(s) ± olivine ± opaque minerals ± amphibole, which were described with different names in different countries (e.g. *muscovadite, granulitised rocks, granoblast, sudburite, beerbachite*). The SG considered these names as unnecessary and recommends the use instead of the general term **mafic hornfelses** (in preference to *basic hornfels,* Spry, 1969). Further distinctions are possible on the basis of the metamorphic grade (e.g. medium-grade mafic hornfels, high-grade mafic hornfels) or the mineral assemblage (e.g. plagioclase-hornblende mafic hornfels, magnetite-olivine-augite-plagioclase mafic hornfels). In a similar manner, for the various hornfelsic rocks generated from ultramafic rocks close to igneous contacts, the SG recommends the use of the general term **ultramafic hornfels** (in preference to *ultrabasic hornfels,* Williams et al., 1954; Spry, 1969).

Contact-metamorphic carbonate rocks

In accord with Rosen et al. (this vol.) *a contact marble is a contact rock containing more than 50% vol. of carbonate minerals (calcite and/or dolomite). Pure contact marble contains more than 95% vol. of carbonate minerals; the remainder is classified as impure contact*

[1] Note: these two facies are not recommended by the SCMR (see Smulikowski et al., this vol.).

marble. Depending on the prevailing carbonate minerals a distinction may be made between dolomitic and calcitic marble. Further differentiation can be given by reference to the metamorphic mineral assemblage (e.g. spinel-forsterite-calcite (-contact) marble, diopside-wollastonite-calcite (-contact) marble, scapolite (-contact) marble), the microstructure (e.g. fine-grained, coarse-grained, saccharoidal) or other characteristics observable at hand specimen scale (e.g. colour, banding, veining).
In many contact aureoles, pre-existing dolomitic rocks are largely converted to dolomitic marble; however, in the innermost part of many low-pressure aureoles, the existing T-X_{H2O} conditions favour the formation of calcite + periclase and/or brucite from the breakdown of dolomite. As a result brucite marble is relatively common close to the igneous contact. In literature, two types of brucite marble have been distinguished by reference to their chemistry, namely: **pencatite** (Roth, 1851) for a brucite marble having CaO and MgO amounts similar to those found in pure dolomite rocks (31% and 21% by weight respectively), and **predazzite** (Petzholdt, 1843) for brucite marble (derived from dolomitic limestones) having a much lower amount of MgO and a correspondingly higher value of CaO than in dolomite. The SCMR proposes that these two terms have restricted status and their use is only permissible if the rock chemistry is known. In the absence of chemical data or for general use the recommended name is **brucite marble**. In some marbles the brucite may form coarse tabular grains unrelated to the former presence of periclase (Williams et al., 1954)

Contact-metamorphic glassy rocks
Rocks heated to very high temperatures in a very short time, followed by a rapid dissipation of heat, may be converted into vitreous or semivitreous materials. Such rocks have received different names according to the cause of heating, for example tektite (by meteoritic impact), pseudotachylite (by frictional heating in fault zones), fulgurites (by a lightning strike). In volcanic to subvolcanic environments, very high-grade contact metamorphism of the immediate country rocks or of xenoliths commonly produces glassy hornfelses. Various terms have been proposed for these rocks, namely: porzellanjaspis (Leonhard, 1823, 1824), basaltjaspis (Zirkel, 1866), systil (Zimmermann, in Nöggerath, 1822), thermantide (Cordier, 1868), buchite (Möhl, 1873) and porcellanite (e.g. Cordier, 1868; Rinne, 1928). The last two names are still widely used in modern literature, buchite being mostly used where the protolith is a quartzofeldspathic rock, porcellanite when it is an argillaceous rock. However, it is of interest to note that the two terms were originally coined for fused rocks of different origin: porcellanite for the products of combustion metamorphism (Leonhard, 1823, 1824) and buchite for the products of contact metamorphism (Möhl, 1873). The use of the terms, however, varied greatly and gave rise to many ambiguities; for example, Delesse (1857) used porcellanite to include glassy rocks formed by both combustion and contact metamorphism. Similarly although the term buchite was originally created for vitrified sandstones formed by contact metamorphism, it was subsequently enlarged to include rocks of pelitic composition (for further details see Tomkeieff, 1940). An attempt by Tomkeieff (1940) to differentiate, on structural grounds, porcellanite (as a finely crystalline rock) from buchite (vitreous or semivitreous rock) was not particularly successful. The position is further complicated by the use of the term porcellanite by sedimentary petrologists for a special class of silica-rich rocks (e.g. Williams et al., 1954; Moorhouse, 1959).
It is therefore not surprising if the terms buchite and porcellanite are used by some workers as synonyms, and by others as indicators of either the kind of metamorphism or of the protolith. Also there is a recent tendency to use buchite and/or porcellanite for any glassy material produced by any metamorphic process: from meteoritic impact to burned rocks in sacrificial sites or burned artificial mixture of clay and carbonate materials.

Against this background the SG agreed on the the following points:
1. It is convenient to have a single name for vitreous or semivitreous rocks of contact-metamorphic origin;
2. The selected name should also be applicable to similar rocks produced by combustion metamorphism but it should not be used for vitreous rocks formed by other processes where acceptable names exist, for example, fulgurite, tektite and pseudotachylite (see above);
3. The definition of names for metamorphic glassy rocks should state the minimum glass content and rock structure.

A thorough discussion about these points reached the following conclusions:
1. Vitreous rocks of contact-metamorphic origin should be named *buchites*. The name porcellanite is unnecessary and should be dropped because of its ambiguity. The name ‘buchite’ has no compositional implications, but the protolith lithology may be indicated by appropriate qualifiers (e.g. aluminous, marly, arenaceous).
2. Vitreous rocks produced by combustion metamorphism should also be named ‘buchites’. The name porcellanite, originally proposed for such burned rocks, should be dropped because of its ambiguity.
3. The minimum glass content of buchite should be 20% by volume; contact metamorphic or burned rocks with a lower glass content should be named *fritted rocks*.

The structure of buchite ranges from massive to vesicular or slaggy. In some outcrops it may show columnar jointing. It has a glassy matrix containing abundant unmelted or partially melted mineral grains from the protolith together with new mineral grains in assemblages typical of pyrometamorphism. Fritted rocks have a structure similar to buchite, but show a wide range of colour. Sometimes they have a glazed appearance, hence their original name of ‘porcellanite’. The microstructure of fritted rocks resembles that of buchite, from which they differ by their lower glass content.

The recommended definitions for buchite and fritted rock are as follows:

Buchite: *A compact, vesicular or slaggy metamorphic rock of any composition containing more than 20% by vol. of glass, produced by either contact metamorphism in volcanic to subvolcanic settings or generated by combustion metamorphism.*

It is also used for partially melted materials obtained in laboratories by burning or heating natural rocks or artificial mineral mixtures. In hand specimens the rock is commonly characterised by a conchoidal fracture. In some outcrops buchite may show columnar jointing. In thin section the rock is composed of a glassy matrix and unmelted or partially melted mineral grains of the protolith. The glass commonly contains small grains of newly formed minerals in phase assemblages typical of pyrometamorphism. Locally the original glassy matrix is partially converted into very fine quartz-K-feldspar intergrowths resembling granophyre. Buchites formed by different metamorphic processes can be distinguished by appropriate qualifiers (e.g. contact, combustion, or artificial buchite).

Fritted rock: *Compact, vesicular or slaggy metamorphic rock of any composition with a glass content ranging from a few per cent up to a maximum of 20% by vol. and produced by either contact metamorphism in volcanic to subvolcanic settings or generated by combustion metamorphism.*

It is also used for glassy materials obtained in laboratories by burning or heating natural rocks or artificial mineral mixtures. Fritted rocks commonly show changes from the protolith in either the structure or the colour even at the hand specimen scale, commonly developing a streaky aspect due to bands of different colours. The glass is mostly interstitial between the protolith grains or is irregularly distributed in small patches or along microfractures. The glass may contain the same new minerals as in buchite, though in lesser amounts.

Burned rocks

The products of combustion metamorphism have received different names in the past, for example, thermantide, thermantide porcellanite, fused shale, porcellanite, porcelain jasper. However, most of these names have also been used for the products of contact metamorphism in volcanic or near-surface settings. Thus the SG decided to find a general name for all rocks generated by combustion metamorphism and an agreement was found for the term burned (or burnt) rock, which has been defined as follows:

Burned rock*: General term for a compact, vesicular or clinkery, glassy to holocrystalline metamorphic rock of various colours, produced by the combustion metamorphism of pre-existing sedimentary rocks.*

In the fused varieties the glass coexists with refractory grains and/or newly formed minerals (e.g. melilite, wollastonite, mullite, cristobalite, spinel), whose nature reflects both the very high temperature metamorphic conditions and the variable chemical composition of the original rock. The term burned rock supersedes such old names as thermantide, thermantide porcellanite, fused shale, porcellanite, porcelain jasper. The glassy or glass-bearing varieties of burned rocks are called buchite (coal-fire buchite) or fritted rock respectively. The term burned rocks also includes some typical ash deposits of refractory material remaining after the combustion of coal seams, giving rise to soft, clay-like rocks resembling volcanic cinerites, and for which the SG proposes the name of **coal-fire ash** to distinguish it from ash deposits of volcanic origin.

Special contact metasomatic rocks: the adinole series

The contact metasomatic rocks are discussed elsewhere (Zharikov et al., this vol.). The discussion here is restricted to a particular type of contact metamorphism, well known in the Harz mountains, Germany, where it was observed in the proximity of stratiform diabase dykes injected into slates and other metasediments of Devonian to Lower Carboniferous age. Characteristic of this kind of metamorphism is the development of narrow (<2 m) aureoles with a particular zonation of the contact rocks. At the immediate contact with the diabase there is a fine-grained compact rock predominantly composed of albite and subordinate quartz, that passes rapidly into schistose or gneissic albite-rich rocks, with a characteristic spotted or banded structure, that in turn pass into slates unaffected by contact metamorphism. This rock association was interpreted by Lossen (1872) as a typical *diabase contact metasomatic aureole*, and, making use of already existing terms, he proposed the name *adinole*, for the compact albite-quartz rock, and *spilosite* and *desmosite* for the spotted and banded albite-rich schists respectively. Lossen (1872), however, also recognised the existence of other adinole rocks, with an aspect recalling the Swedish hälleflintas (the adinole of Beudant, 1824). These rocks occur as layers intercalated in a metasedimentary sequence, unrelated to diabase dykes and thus excluding a contact metamorphic origin. They were interpreted as metamorphosed silicified acid tuffs by Rosenbusch (1910). Subsequent workers (Milch, 1917; Mempel, 1935-36) tried to make a distinction between these two types of adinole-rocks as described by Lossen. For example, Mempel proposed the name ‘adinolit’ for the contact-type rock, and ‘adinole’ for the hälleflinta-looking type. However in most textbooks and geological glossaries the term *adinole* is generally identified with Lossen’s (1872) contact-metasomatic type.

The SG considered this complex position and decided the following:

1. to maintain the term adinole as a general name for all the rocks described above;
2. to mantain the distinction between the two types of adinole so far recognised, rejecting, however, because of their potential ambiguity, the two names proposed by Mempel;

3. to accept Milch's (1917) idea of an adinole-series, in which the various members represent different stages of an adinolisation process, whose final product is the adinole rock. The resulting proposals for the corresponding terms are the following:

Adinole: *A compact, fine-grained rock with a splintery fracture, commonly with a finely banded aspect due to alternating gray, green or reddish layers of variable colour intensity; mineralogically it is essentially composed of a fine- to very fine-grained mosaic of albite and subordinate quartz, with minor amounts of other constituents (muscovite, sericite, chlorite, actinolite, epidote, rutile and/or anatase); chemically it is characterised by high (up to 10% by weight) amounts of soda, a character that easily distinguishes it from the hard siliceous shales or slates that it resembles. Hence* ***adinolisation****, a Na-metasomatic process leading to the formation of adinole.*

There exist two different varieties of adinole distinguished according to their geological settings, namely: **contact adinole** found in the contact aureoles of diabase dykes and **tuffaceous adinole** found as layers within metasedimentary sequences and unrelated to the proximity of diabase dykes.

Adinole series *A group of rocks in the aureole of a diabase intrusion that show stages of contact metasomatism (adinolisation) leading ultimately to the formation of adinole.*

The intermediate stages of the process, still retaining part of the original schistosity, give rise to *spotted or banded albite-rich schist* called *spilosite* and *desmosite* respectively. Following Milch (1917) the intermediate stages could be alternatively called *adinole schist* and *adinole hornfels* according to the amount of relict schistosity.

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APPENDIX 1

Summary lists of selected terms found in the literature and arranged in chronological order. Recommended terms are shown in bold font, restricted terms in regular font and unnecessary terms in italics. Not all the terms listed are given in the glossary: the full lists along with source references are given in Appendix 2. m. = metamorphism

1. Names for contact-metamorphic processes and other types of metamorphism related to localised heat sources

ISOCHEMICAL CONTACT METAMORPHISM

Abnormal m.
Caloric m.
Everse vs inverse m.
Exo- vs endomorphism
Hydatocaustic m.
Hydatothermic m.
Contact m.
Special m.
Local m.
Juxtaposition m.
Diabase contact m.
Pyromorphism
Paroptesis
Accidental m.
Peripheral m.
Exogenic vs endogenic m.
Selective contact m.
Exo- vs endomorphic contact m.
Thermal m.
Thermometamorphism
Piezo-contact m.
Anaphryxis
Normal contact m.
Thermal contact m.
Thermo-contact m.
Hydrothermal contact m.
M. by regeneration
Load-contact m.
Alembic contact m.
Ultra-contact m.
Isochemical contact m.
High-pressure contact m.

ALLOCHEMICAL/METASOMATIC CONTACT METAMORPHISM

Metasomatism
Pneumatolysis
Perimetral m.
Atmogenic m.
Methylosis
Metachemic m., metachemical m.
Paramorphism
Contact metasomatism
Additive vs subtractive metasomatism
Pneumatolytic metasomatism
Hydrothermal metasomatism
Metasomatic pneumatolysis
Pneumatolytic contact m.
Endo- vs exopneumatolytic contact m.
Apomagmatic contact metasomatism
Perimagmatic contact metasomatism
Perimagmatic additive contact metasomatism
Additive contact m.
Metasomatic contact m.
Endo vs exosmotic m.
Pneumatolytic to hydrothermal contact m.
Enhanced m.
Pyrometasomatism
Pneumatolytic m.
Allochemical contact m.

PYROMETAMORPHISM

Caustic m.
Pyrocaustic m.
Pyromorphism
Thermometamorphism
Pyrometamorphism
Optalic m.

COMBUSTION METAMORPHISM

Firing m.
Burning m.
Pyromorphism
Pyrogenic m.
Combustion m.

2. *Names for contact-metamorphic rocks and rocks generated by other types of metamophism related to localised heat sources*

GENERAL NAMES

Vitreous tube
Fulgurite
Thermantide
Burned rock, burnt rock
Lightning tube
Contact rock
Fritted rock
Neptunopyrogenic rock
Diabase contact rock
Normal contact rock
Pneumatolytic contact rock
Endo- vs exopneumatolytic contact rock
Contact-deposit
Contact metamorphic ore deposit
Contactolite
Baked rock

PELITIC TO QUARTZOFELDSPATHIC PROTOLITHS

Killas
Porcellanite, Porcelain-jasper
Cornéenne
Tripoli
Basalt-jasper
Hornfels
Keratite
Keralite
Ebensinite
Hornstone
Systil
Vitrified shale
Spotted slate/schist
Kornite
Cornubianite
Proteolite
Adinole, *adinole schist*
Desmosite
Spilosite
Leptynolite
Knotted schist
Hornschist
Buchite
Corneite
Schistose hornfels
Schist-hornfels
Contact schist
Astite
Aviolite
Seebenite
Edolite
Quartz hornfels
Injected hornfels
Paralava
Pelitic hornfels

MARLY AND CARBONATE PROTOLITHS

Marble
Calciphyre
Predazzite
Pencatite
Thermocalcite
Plakite
Calc-hornfels
Calc-silicate hornfels
Barégienne
Limurite
Calc-silicate rock
Lime-silicate hornstone
Calc-flinta
Vullinite
Skarn
Calc -iron silicate rock
Tactite
Marmorite
Lime- silicate rock
Calc-magnesian silicate rock
Contact marble
Magnesian marble

MAFIC AND ULTRAMAFIC PROTOLITHS

Basic hornfels
Mafic hornfels
Beerbachite
Sudburite
Granoblast
Silicoferrolite
White trap
Ultrabasic hornfels
Ultramafic hornfels
Magnesian hornfels

SPECIAL PROTOLITHS (COAL, LATERITE)

Cokeite
Carbonite
Coal-fire ash
Corundolite
Corundum-spinel hornfels
Emery rock

APPENDIX 2

Table 1 Names for the process of contact metamorphism found in literature, and arranged in chronological order, according to their references.
Recommended names are in bold, restricted names in regular font and unnecessary names in italics

NORMAL CONTACT METAMORPHISM

Abnormal metamorphism, Métamorphisme anormal, Abnormer Metamorphismus, 'extraordinary metamorphism'	Elie de Beaumont 1833 (in Touret & Nijland, 2002, p115); Dufrenoy & Elie de Beaumont 1841, p42; Naumann 1858, p718-21
Métamorphisme par incandescence	Boubée 1844, p460
Caloric metamorphism, Metamorphisme produit sur l'action de la chaleur sans apport de matière exteriéure	Durocher 1846, p576 ; Milch 1922, p288
Métamorphisme maclifère	Durocher 1846, p606
Everse vs inverse metamorphism	Cotta 1846, p103
Exo- vs Endomorphism	Fournet 1847, p243
Hydatocausthic metamorphism	Bunsen 1849, p16
Hydatothermic metamorphism	Bunsen 1849, p16
Contact Metamorphism	Delesse 1857, p90-91; Kerrick 1991, p1
Special metamorphism, Métamorphisme spécial	Delesse 1857, p90
Local metamorphism, Lokalmetamorphismus	Naumann 1858, p721

Juxtaposition metamorphism, Métamorphisme de juxtaposition	Daubrée 1859,p393; 1879, p133
Diabase contact metamorphism, Diabase-Contactmetamorphose	Lossen, 1869, p286 and ff.
Pyromorphism p.p.	Lasaulx 1875, p444
Paroptesis	Kinahan 1878, p176
Accidental metamorphism ,Métamorphisme accidentel	Daubrée 1879, p145
Métamorphisme d'influence	De Lapparent 1882, p1117-1118; 1893, p1402
Peripheral métamorphism, Métamorphisme Péripherique	De Lapparent 1882, p1117-118; 1893, p1402
Exogenic vs. Endogenic metamorphism, Exogenous vs endogenous metamorphism, 'Exogene vs endogene Metamorphismus'	Kalkowsky 1886, p33
Selective contact metamorphism	Bonney 1886, p105; Bianchi & Dal Piaz, 1948, p85
Exo-vs Endomorphic contact metamorphism	Milch 1922, p288
Thermal metamorphism, *Thermometamorphism*	Harker, 1889, p16
Piezocontact metamorphism, 'Piezocontactmetamorphose, Contactdruckmetamorphose	Weinschenk 1900, p326; 1902a, p464; 1902b, p214; Erdmannsdörffer 1924, p312.
Anaphryxis	Gürich 1905, p250
Normal contact metamorphism	Goldschmidt 1911, p119.
Thermal contact metamorphism, Thermo-contact metamorphism	Irving J.D, 1911, p298; Niggli 1954, p521
Hydrothermal contact metamorphism	Irving J.D. 1911, p298
Metamorphism by regeneration	Spurr et al. 1912, p455
Load contact metamorphism	Daly 1917, p408-409.
Alembic contact metamorphism	Daly 1917, p410
Ultra-contact metamorphism	Niggli, 1954
Isochemical contact metamorphism	Reverdatto et al., 1970, p311-12; 1974, p287
High pressure contact metamorphism	Delor et al., 1984, p55

METASOMATIC CONTACT METAMORPHISM

Metasomatism, *Metasomatismus* or *Metasomatose*	Naumann 1826, p. 209; Lindgren 1925; Barton et al., 1991, p321
Métamorphisme avec apport d' élément étranger	Durocher 1846, p558
Pneumatolysis	Bunsen 1851, p238-239, 258
Perimetral metamorphism, metamorfismo perimetrico	Stoppani, 1873, III, p42-43
Atmogenic metamorphism, 'Atmogen Metamorphismus'	Kalkowsky 1886, p35
Methylosis	King & Rowney (in: Bonney 1886, p59)
Metachemic metamorphism, metachemical metamorphism	Dana 1886, p70
Paramorphism	Irving A. 1889, p5
Contact metasomatism	Barrell 1907, p117
Additive vs subtractive metasomatism	Barrell 1907, p117
Pneumatolytic metasomatism	Barrell 1907, p117
Hydrothermal metasomatism	Barrell 1907, p117
Metasomatic pneumatolysis	Goldschmidt 1911, p212
Pneumatolytic contact metamorphism, *'Pneumatolytische Kontaktmetamorphose'*	Goldschmidt 1911, p119, 211; Irving 1911, p298
Endo- vs exopneumatolitic contact metamorphism	Goldschmidt 1911, p211
Apomagmatic contact metasomatism	Bergeat 1912, p11
Perimagmatic contact metasomatism	Bergeat 1912, p11
Perimagmatic additive contact metasomatism	Bergeat 1912, p11
Additive contact metamorphism	Spurr et al. 1912, p455 ; Tyrrell 1926, p252
Metasomatic contact metamorphism	Hatch & Rastall 1913, p260-261
Endo- vs exosmotic metamorphism	Johnston-Lavis 1914, p382
Pneumatolithic to hydrothermal contact metamorphism, 'Pneumatolytische bis Hydrothermale'	Grubemann & Niggli 1924, p282-284; Niggli 1954,p523
Enhanced metamorphism, Potenzierte, Kontaktmetamorphose	Grubemann & Niggli 1924 , p8, 284

Pyrometasomatism	Lindgren 1928, p781
Pneumatolytic metamorphism	Zirkel 1893, p583; Harker, A., 1932, p116
Allochemical contact metamorphism	Reverdatto et al., 1974 , p287

PYROMETAMORPHISM

Caustic metamorphism	Leonhard 1832; Milch 1922, p288
Pyrocaustic metamorphism, Pyrocaustische metamorphismus	Bunsen 1849, p16-17 (in note)
Pyromorphism, Pyromorphose p.p.	Lasaulx 1875, p444
Thermometamorphism, Thermometamorphismus	Loewinson-Lessing 1893/94, p231
Pyrometamorphism, Pyrometamorphose	Brauns 1911, p12
Optalic metamorphism	Tyrrell 1926, p301

COMBUSTION METAMORPHISM

Firing metamorphism, 'Metamorphism durch Feuer'	Naumann 1858, p736-737
Burning metamorphism, *Metamorphismus durch Verbrennungsprocesse*	Naumann 1858, p721.
Pyromorphism p.p.	Lasaulx 1875, p444
Pyrogenic metamorphism, ' Pyrogene Metamorphismus'	Kalkowsky 1886, p34
Combustion metamorphism	Arnold & Anderson 1907, p750; Mc Lintock 1932, p208-12

Table 2. Names for contact metamorphic rocks *(sensu lato)* found in literature, and arranged in chronological order, according to theirreferences.
Recommended names are in bold, restricted names in regular font and unnecessary names in italics

GENERAL NAMES

Blitzröhre	Voigt 1805; Fiedler 1817
Blitzstein, Pierre foudroyée	Bruckmann 1806
Vitreous tube ,Tubes vitreux	Anonymous 1814 ; Arago 1821b
Fulgurite	Arago 1821a, p.415 -421
Tube de foudre	Arago 1821a, p.415
Thermantide	Haüy 1822, p.582; Cordier 1868, p. 247
Burned rocks , burnt rocks	Leonhard 1824, p.500; Arnold & Anderson 1907, p755; Reverdatto 1973, p87-89
Tubes fulminaires, lightning tubes, lightning holes	Beudant et al. 1828; Hitchcock 1861, p. 302; Merrill 1887
Contact rocks, *Contactfels, Kontaktgestein*	Bunsen 1851, p. 239; Salomon 1891, p482; 1898, p143, 145
Fritted rocks	Naumann 1858, p737 and ff.; Zirkel 1893 (I), p. 602-603.
Neptunopyrogenic rocks	Cordier 1868, p37
Diabase contact rocks, Diabasecontactgesteine	Lossen 1869, p288-291; Kayser 1870, p106 and ff.; Rosenbusch 1896, 1170-1172.
Normal contact rocks, *Normalkontaktgesteine*	Goldschmidt 1911, p120
Pneumatolytic contact rocks, *Pneumatolitische Kontaktgesteine*	Goldschmidt 1911, p211
Endo- vs exopneumatolytic contact rocks	Goldschmidt 1911, p211
Contact-Deposits	Kemp 1907
Contact metamorphic ore deposits, *Kontaktmetamorphe Erzlagerstätten*	Stutzer 1909, p145; Bergeat 1912, p9.
Contactolite	Loewinson-Lessing, 1925
Baked rocks	Tyrrell 1926, p301-302
Blitzglas	Frenzel & Ottemann 1978, p439

CONTACT METAMORPHIC ROCKS WITH PELITIC TO QUARTZO-FELDSPATHIC PROTOLITHS

Killas	Woodward 1728, vol.2, p2, 5 ; vol. 3, p.78; Mac Culloch 1821, p344 and ff.; Hawkins 1822, p251; Loewinson-Lessing 1893/94, p112; Holmes 1920, p132
Palaiopêtre	De Saussure 1779, p108 and ff ; 1786, p596; Zirkel 1866, p. 419
Porcellanite, Porzellanite, porcelanit	Werner 1789 (in Brochant 1798, p336); Peithner 1794 (in Kirwan 1794, p313); Leonhard 1824, p587; Naumann 1858, p685, 736
Porcelain-jasper, Porcellan-jaspis, Porzellanjaspis	Werner 1789 (in Brochant 1798, p336-338; Leonhard 1824, p587 – 588
Cornéenne	Dolomieu (in Cordier 1868, p101) Delesse 1857, p758
Roche de corne, Pierre de corne	De Saussure 1796-1803 (I), §95–100; Delesse 1857, p758
Thermantide porcellanite	Brochant 1798, p. 336-338; Haüy 1822, p510 , 582 ; Leonhard 1824, p587
Tripoli, Tripoléenne, Tripel	Brochant 1798, p381; Haüy 1822, p582; Cordier 1868, p249-250
Basalt-jasper, Basalt-jaspis	Werner (in Haüy 1822, p582); Leonhard 1823, p106; Leonhard 1824, p535
Hornfels	Werner (in Cordier 1868, p101-102); Hausmann 1805 (in Leonhard 1823, p139-141); Boué 1829, p131
Keratite	Delamethérie 1806, p347
Keralite	Pinkerton 1811, p153; Cordier 1868, p204
*Ebensinit*e	Pinkerton 1811, p46
Hornstone	MacCulloch 1819 (III), p13; Necker de Saussure 1821, p257–259; Barrell 1907, p119, 145; Shand 1931, p182-183; Shand 1959, p200-203
Systyl	Zimmermann 1822 (In: Nöggerath 1822, p109); Zirkel 1866, p620
Jaspe porcellaine	Leonhard 1824, p587
Vitrified shale, Verglaster Schieferthon	Leonhard, K.C., 1824, p587
Burnt Clay, Argile brulée	Leonhard 1824, p500
Erdschlacke	Leonhard 1824, p597
Schiste maclifère	Leonhard 1824, p463; Cordier 1868, p199
Spotted slate, spotted schist, *schistes tachetés, Fleckschiefer, Fruchtschiefer*	Leonhard 1824, p460; Naumann 1849, p559; 1858, p542; Harker, 1902, p385
Cornean	De la Beche 1826, p3
Kornite	Breithaupt 1830, p40
Cornubianite	Boase 1832, p390;Bonney 1886, p104
Proteolite	Boase 1832, p394; Bonney 1886, p104
Adinole, adinole schist, adinole hornfels	Beudant 1832, p126; Rosenbusch 1910, p626; Milch 1917, 352-357; Mempel 1935/36, p14, 16
Desmosite	Zincken 1841, p.394-395; Lossen 1869, p291-292; 1872, p728-731
Spilosite	Zincken 1841, p394-395; Lossen 1872, p735
Leptynolite	Cordier 1842-1848; Cordier 1868, p203
Nodular slate, nodular schist, **knotted schist,** *schistes noduleux, Knotenschiefer*.	Naumann 1849, p559; 1858, p543; Rosenbusch 1877a; 1877b, p38; Harker 1932, p15
Coal Ash	Delesse 1857, p105; Naumann 1858, p736
Jaspe	Delesse 1857a, p475, 757
Horn-schist, Hornschiefer	Lossen 1869, p291; Eisele 1907, p134 and 150-151
Buchite	Möhl 1873, p83
Corneite	Gosselet 1888, p767
Cornubianite-gneis	Rosenbusch 1896, p95
Schistose hornfels, Schiefrige Hornfels	Rosenbusch 1896, p96
Schist Hornfels, *Schieferhornfels*	Rosenbusch 1898, p96
Contact schist, Contactschiefer	Salomon 1898, p145

Contactfels	Salomon, 1898, p145
Astite	Salomon 1898, p150
Aviolite	Salomon 1898, p150
Seebenite	Salomon 1898, p150
Edolite	Salomon 1898, p149-150
Quartz Hornfels	Eisele 1907, p134; Tyrrell 1926, p300
Injected hornfels	Hall 1910, p66-67; 1932, p407
Paralava	Fermor (in Tilley 1924, p70); Lightfoot 1929, p32
Pelitic hornfels	Williams et al. 1954, p179; Spry 1969, p192.

CONTACT METAMORPHIC ROCKS FROM MARLY OR PURE AND IMPURE CARBONATE PROTOLITHS

Marble	Theophrastus ca 320 B.C., Ch. 20
Calciphyre	Brongniart 1813, p38; 1827, p97
Predazzite	Petzholdt 1843, p193-205
Pencatite	Roth 1851, p143
Calcaire pyro-épigène	Cordier 1868, p290
Thermocalcite	Cordier 1868, p290
Plakite	Cordella 1871 (in Lepsius 1893, p126)
Calc-hornfels, 'Kalkhornfels'	Lossen 1872, p777
Calc-silicate hornfels, *Kalksilicathornfels*	Lossen 1872, p.777; Rosenbusch 1877b, p44
Barégienn, barrégienne	Magnan 1877, p33; Lacroix 1898
Limurite	Zirkel 1879, p380-381; Lacroix 1892, p740
Skarnsteine, skarnsten	Törnebohm, 1881a, p201; 1881b, p400
Cornéenne calcaire	Lapparent, 1893, p1403
Marbres a silicates calciques	Jung 1963, p. 163
Calc-silicate rock, *roche à silicate de chaux*	Harker 1902, p397
Lime-silicate hornstone	Barrell 1907, p119; Shand 1931, p182
Calc-flinta	Barrow & Thomas 1908, p114-115; Harker 1932, p89
Vullinite	Shand 1910, p406-407
Skarn	Goldschmidt 1911, p213
Calc-iron-silicate rocks, *Kalkeisensilikatfels*	Goldschmidt 1911, p213
Tactite	Hess 1919, p.377; Jung, 1963, p164
Marmorite	Shand 1931, p183; 1951, p204
Lime- silicate rock	Harker 1932, p89; Harker 1968, p262
Contact metamorphic magnesian limestones	Harker 1932, p84
Calc-magnesian silicate rock	Niggli 1954, p525
Contact marble	Williams et al. 1954, p188; 1982, p487
Magnesian marble	Williams et al. 1954, p190-191; 1982, p490-491
Calcaire à minéraux, marbre à minéraux	Focault & Raoult 1984, p54, 193

CONTACT METAMORPHIC ROCK WITH MAFIC AND ULTRAMAFIC PROTOLITHS

Basic hornfels , mafic hornfels	Williams et al. 1954, p180; Spry 1969, p198
Beerbachite	Chelius 1892; Klemm 1926, p112-113; MacGregor 1931, p518
Sudburite	Thomson 1935, p427
Granoblast	Schwartz 1924, p117
Muscovadite	Winchell 1900a, p295; Schwartz 1924, p117
Silicoferrolite	Winchell 1900b, p353-359
White trap	Flett 1910, p311
Ultrabasic hornfels, *magnesian hornfels*	Spry 1969, p201; Williams et al. 1954, p197

CONTACT METAMORPHIC ROCKS WITH OTHER PROTOLITHS (COAL, LATERITES)

Cokeite	Lacroix, 1910, IV, p648; Cocquand 1857, p342-343; Zirkel 1893, I, p601
Carbonite	Heinrich 1875 (inTomkeieff, 1954, p35)
Corundolite	Wadsworth, 1893, p92
Corundum-spinel hornfels	Golschmidt 1911, p199-200
Emery rock	Holmes 1920, p89; Friedman 1956

Table 2.10.1. Lists of selected terms for local metamorphic processes and their products.

The terms, occurring in literature, are arranged in chronological order. Recommended terms are shown in bold font, restricted terms in regular font and unnecessary terms in italics. Not all the terms listed are given in the glossary: the full lists along with source references are given on the SCMR website. m. = metamorphism

1. Names for contact-metamorphic processes and other types of metamorphism related to localised heat sources

ISOCHEMICAL CONTACT METAMORPHISM

Abnormal m.
Caloric m.
Everse vs inverse m.
Exo- vs endomorphism
Hydatocaustic m.
Hydatothermic m.
Contact m.
Special m.
Local m.
Juxtaposition m.
Diabase contact m.
Pyromorphism
Paroptesis
Accidental m.
Peripheral m.
Exogenic vs endogenic m.
Selective contact m.
Exo- vs endomorphic contact m.
Thermal m.
Thermometamorphism
Piezo-contact m.
Anaphryxis
Normal contact m.
Thermal contact m.
Thermo-contact m.
Hydrothermal contact m.
M. by regeneration
Load-contact m.
Alembic contact m.
Ultra-contact m.
Isochemical contact m.
High-pressure contact m.

ALLOCHEMICAL/METASOMATIC CONTACT METAMORPHISM

Metasomatism
Pneumatolysis
Perimetral m.
Atmogenic m.
Methylosis
Metachemic m., metachemical m.
Paramorphism
Contact metasomatism
Additive vs subtractive metasomatism
Pneumatolytic metasomatism
Hydrothermal metasomatism
Metasomatic pneumatolysis
Pneumatolytic contact m.
Endo- vs exopneumatolytic contact m.
Apomagmatic contact metasomatism
Perimagmatic contact metasomatism
Perimagmatic additive contact metasomatism
Additive contact m.
Metasomatic contact m.
Endo vs exosmotic m.
Pneumatolytic to hydrothermal contact m.
Enhanced m.
Pyrometasomatism
Pneumatolytic m.
Allochemical contact m.

PYROMETAMORPHISM

Caustic m.	*Pyromorphism*	**Pyrometamorphism**
Pyrocaustic m.	*Thermometamorphism*	*Optalic m.*

COMBUSTION METAMORPHISM

Firing m.	*Pyromorphism*	**Combustion m.**
Burning m.	*Pyrogenic m.*	

2. ***Names for contact-metamorphic rocks and rocks generated by other types of metamophism related to localised heat sources***

GENERAL NAMES

Vitreous tube	*Diabase contact rock*	*Contactolite*
Fulgurite	*Normal contact rock*	**Baked rock**
Thermantide	*Pneumatolytic contact rock*	
Burned rock, burnt rock	*Endo- vs exopneumatolytic contact rock*	
Lightning tube	*Contact-deposit*	
Contact rock	*Contact metamorphic ore deposit*	
Fritted rock		
Neptunopyrogenic rock		

PELITIC TO QUARTZOFELDSPATHIC PROTOLITHS

Killas	**Spotted slate/schist**	**Schistose hornfels**
Porcellanite, Porcelain-jasper	*Kornite*	*Schist-hornfels*
Cornéenne	*Cornubianite*	*Contact schist*
Tripoli	*Proteolite*	*Astite*
Basalt-jasper	**Adinole**, *adinole schist*	*Aviolite*
Hornfels	*Desmosite*	*Seebenite*
Keratite	*Spilosite*	*Edolite*
Keralite	*Leptynolite*	*Quartz hornfels*
Ebensinite	**Knotted schist**	*Injected hornfels*
Hornstone	*Hornschist*	*Paralava*
Systil	**Buchite**	*Pelitic hornfels*
Vitrified shale	*Corneite*	

MARLY AND CARBONATE PROTOLITHS

Marble

Calciphyre

Predazzite	**Calc-silicate rock**	*Lime- silicate rock*
Pencatite	*Lime-silicate hornstone*	*Calc-magnesian silicate rock*
Thermocalcite	*Calc-flinta*	**Contact marble**
Plakite	*Vullinite*	*Magnesian marble*
Calc-hornfels	**Skarn**	
Calc-silicate hornfels	*Calc -iron silicate rock*	
Barégienne	*Tactite*	
Limurite	*Marmorite*	

MAFIC AND ULTRAMAFIC PROTOLITHS

Basic hornfels	*Granoblast*	**Ultramafic hornfels**
Mafic hornfels	*Silicoferrolite*	**Magnesian hornfels**
Beerbachite	*White trap*	
Sudburite	*Ultrabasic hornfels*	

SPECIAL PROTOLITHS (COAL, LATERITE)

Cokeite	**Coal-fire ash**	*Corundum-spinel hornfels*
Carbonite	*Corundolite*	**Emery rock**