



New IMA CNMNC guidelines on combustion products from burning coal dumps

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Received: 17 October 2019 – Accepted: 13 November 2019 – Published: 19 February 2020

Abstract. New IMA CNMNC guidelines were established for minerals crystallizing on burning coal dumps. These phases are now acceptable as minerals, if it can be proven that the fire responsible for the formation of these phases is the result of natural events. In that case, these substances have to be treated as normal new mineral species, and their complete characterization has to be submitted to the CNMNC *via* the new mineral proposal form. The authors are specifically asked, however, to give strong arguments in the proposal clearly demonstrating the non-anthropogenic origin of the burning process.

1 Introduction

In the Commission on New Minerals, Nomenclature and Classification (CNMNC) of the International Mineralogical Association (IMA) procedures and guidelines on mineral nomenclature, Nickel and Grice (1998) state that

substances formed by combustion are not generally regarded as minerals. A contentious issue is the occurrence of substances in the combustion products of coal mines, waste dumps or peat bogs. The origin of a particular fire is often difficult to determine, and therefore the possibility of human intervention cannot be entirely eliminated, nor can the possibility of human artefacts contributing to the combustion products. It has therefore been decided that, as a general rule, products of combustion are not to be considered as minerals in the future.

The application of these simple and rather arbitrary guidelines in practice creates many doubts and difficulties. In order to avoid constructing artificial obstacles to the development of mineralogical studies, these guidelines are discussed below, and new recommendations are established, in agreement with the CNMNC (approved nomenclature proposal IMA 16-F).

2 Spontaneous burning of coal dumps

Burning coal dumps, located near collieries all around the world, are the source for many combustion products, which are not regarded as mineral species by the current CNMNC guidelines. However, the weathering of bituminous coal remnants, deposited on coal dumps with barren rocks, often leads to spontaneous combustion of coal, and therefore the fire thus initiated is a purely natural phenomenon. This process of relatively rapid oxidation of bituminous coal, leading to the heating up of coal piles stored for long periods of time and occasionally causing their self-ignition, is widely known. Products of such natural fires, if they form from non-anthropogenic material, meet the general criteria for defining mineral species and should be regarded as such.

On the other hand, initiation of fire in those environments can also be the result of human activity, such as for example deposition of hot slag, accidents, or human carelessness. In those conditions, combustion products are of an artificial nature, and they should not be regarded as valid mineral species.

Undoubtedly, the crystallization of many phases on burning coal heaps, studied by mineralogists in the USA, Russia, Germany, the Czech Republic, Poland, and other countries, is a natural process. In these burning coal heaps, the fire is usually located deep inside the heap, and it is therefore hard to imagine human agency in igniting such a fire. Products of

these fires are assemblages of high-temperature phases, typical of the so-called “combustion metamorphism”, as well as exhalative phases forming on the cold dump surfaces from hot fire gases escaping the dump (Sokol et al., 2005; Stratcher et al., 2010, 2012, 2014). Surface fires, which could sometimes be induced by human activity, do not produce any sublimate mineral accumulation and are generally of poor interest from a mineralogical point of view. Fire gases are then dispersed into the atmosphere, and their condensation cannot produce sublimate phases.

Certainly there may arise situations where it would be difficult to unambiguously determine the origin of a particular fire. In those situations, it is the responsibility of the authors of new mineral proposals to clearly explain, with strong arguments, the reasons why these phases should be considered non-anthropogenic.

3 Combustion products approved by the CNMNC

Other difficulties result from the literal application of the current CNMNC guidelines. Indeed, several mineral species formed by combustion were approved before the guidelines of Nickel and Grice (1998), such as for example acetamide, CH_3CONH_2 (Srebrodol'skiy, 1975), and downeyite, SeO_2 (Finkelman and Mrose, 1977). It is not easy to accept a situation where phases described before the introduction of the guidelines are accepted as minerals, whereas similar phases found later are not valid species. Moreover, the CNMNC recently accepted as minerals ammoniomagnesiovoltaite, $(\text{NH}_4)_2\text{Mg}_5\text{Fe}_3^{3+}\text{Al}(\text{SO}_4)_{12} \cdot 18\text{H}_2\text{O}$, which crystallized on a burning coal dump (Szakáll et al., 2012), as well as carlsonite, $(\text{NH}_4)_5\text{Fe}_3^{3+}\text{O}(\text{SO}_4)_6 \cdot 7\text{H}_2\text{O}$, and huizingite-(Al), $(\text{NH}_4)_9\text{Al}_3(\text{SO}_4)_8(\text{OH})_2 \cdot 4\text{H}_2\text{O}$ (Kampf et al., 2016), which were produced from an oil shale fire.

It is also unfair that phases known from burning heaps may be described under mineral names only after being found in the genetically similar environment of volcanic exhalations or other environments, e.g. the Hatrurim Formation. An example of such an unfortunate situation may be the case of lesukite, steklite, or novograbenovite – phases known already from burning coal dumps, which were recognized as minerals only after having been found in volcanic exhalations. These minerals are formed in both environments in analogous circumstances, and they even form bigger and better developed aggregates on dumps than in volcanic exhalations, where they are rarely found. A submission of the phase known from the burning coal dumps as “redikortsevite” was rejected by CNMNC as being of anthropogenic origin, and the new mineral novograbenovite was accepted 3 years later for the same phase found in Kamchatka Peninsula, Russia (Okругin et al., 2019). Today mineralogists studying burning coal dumps are not motivated to submit proposals for new minerals even though they are certain that they meet the necessary criteria (Witzke, 1997).

Following the rules set by Nickel and Grice (1998) closely, phases described from the Hatrurim Formation, which are natural products of combustion (e.g. Sharygin et al., 2012; Galuskin et al., 2015a, b; Sokol et al., 2015), should not be accepted as minerals either. This leads to an abnormal situation in which the combustion metamorphism should be excluded from mineralogy, even though this phenomenon is perfectly natural in character.

4 Anthropogenic origin of minerals from ore mine dumps and from museum samples?

A wider application of the current CNMNC approach would also result, for example, in excluding some weathering phases (sulfates, arsenates, etc.) which crystallize during the oxidation of sulfides on ore mine heaps. In this case, indeed, a human influence on the oxidation process cannot be excluded. As we know, sulfide oxidation is usually accelerated by bacterial activity and it is difficult to prove that these bacteria have not been introduced by humans.

It is clear that the colliery dumps are of anthropogenic origin because, even if they consist of natural rock material, they have been created as a result of human activity. However, excluding those dumps as mineral-forming environments would have far-reaching consequences. Indeed, phases forming on ore mine dumps, in tunnels and in mining excavations, in quarries, and even on museum specimens, were also extracted from their natural environment by human activities, and they would consequently be excluded as well from the valid mineral species list. According to Hazen et al. (2017), these substances represent more than 75 mineral species.

Currently, secondary oxidation substances are accepted as valid minerals, and that practice should be upheld for the sake of clarity. It should remain as an uncontested rule that the phases accepted as minerals should form spontaneously from non-artificial materials. As long as environments such as burning dumps are not created intentionally in order to form new phases, they should be considered places where minerals are formed. Wholesale rejection of those environments does not solve the problem either. For example, how to precisely distinguish phases formed in the weathering zones of ore deposits but found on the dump, from phases which were formed on the dump itself? There will always be situations where arbitrary criteria will be needed, and establishing those criteria will remain a duty of the CNMNC.

5 New CNMNC guidelines for mineral substances formed on burning coal dumps

We hereby recommend treating the minerals formed by the combustion of the dumps of the collieries as the newly formed minerals found in the dumps and galleries of active or abandoned mines, thus admitting that the crystalline phases found in burning coal dumps can be the subjects of propos-

als to be presented to IMA CNMNC for approval. Similar to the formation of newly formed minerals, these species may in fact occur in mines and coal deposits that ignite by spontaneous combustion (oxidation reaction) or other natural causes (lightning/thunderbolt). It has to be proven that the burning (the combustion) took place naturally and was not due to human intervention, even accidentally or inadvertently. If this is not ascertainable, the combustion is considered anthropogenic and the crystalline phases cannot be approved as valid mineral species. The authors who present the new crystalline phases from burning coal dumps to IMA CNMNC for the approval as minerals, must prove at the same time that the fire occurred as a result of natural events (self-ignition or lightning) and, beyond a shadow of doubt, was not of anthropogenic origin.

Author contributions. JP wrote the first version of the proposal, and FH handled the proposal as vice chairman of the CNMNC. FH then re-organized the proposal and submitted it to the journal.

Competing interests. The authors declare that they have no conflict of interest.

Acknowledgements. The authors acknowledge the CNMNC members for their constructive comments on the proposal.

Review statement. This paper was edited by Sergey Krivovichev and reviewed by Marco Pasero and Ferdinando Bosi.

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