Studia UBB Geologia, 2011, **56** (1), 33 – 42

State of the art and challenges in cave minerals studies

Bogdan P. ONAC[1,2*] & Paolo FORTI[3]

[1]Department of Geology, University of South Florida, 4202 E. Fowler Ave., Tampa, USA
[2]Department of Geology, "Babeş-Bolyai" University, Kogălniceanu 1, 400084, Cluj / "Emil Racoviță" Institute of Speleology, Clinicilor 5, 400006 Cluj-Napoca, Romania
[3]Italian Institute of Speleology, University of Bologna, Via Zamboni 67, 40126, Bologna, Italy

Received January 2011; accepted March 2011
Available online 23 April 2011
DOI: 10.5038/1937-8602.56.1.4

Abstract. The present note is an updated inventory of all known cave minerals as March 2011. After including the new minerals described since the last edition of the *Cave Minerals of the World* book (1997) and made the necessary corrections to incorporate all discreditations, redefinitions, or revalidation proposed by the Commission on New Minerals, Nomenclatures and Classification (CNMNC) of the International Mineralogical Association (IMA), we summed up 319 cave minerals, many of these only known from caves. Some of the minerals building up speleothems are powerful tracers of changes in Quaternary climate, other minerals are useful for reconstructing landscape evolution, or allow discriminating between various speleogenetic pathways. Thus, it is expected that the search for new cave minerals will continue and even more attention will be given to those species that carries information that allow for addressing different problems in various earth sciences fields. In view of the exponential increase of cave minerals over the past 50 years, cave mineralogy conceivably has the potential to grow in the future, especially considering the new advances in analytical facilities.

Key words: Cave minerals, nomenclature, classification, database.

INTRODUCTION

Likewise other fields across earth sciences, mineralogy has witnessed over the last decade a rapid growth as a result of fast-paced and revolutionary advances of analytical facilities. For cave mineralogy this translates into an exponential increased of the number of minerals identified (Fig. 1) and described from a variety of cave environments (Onac, 2005, 2011).

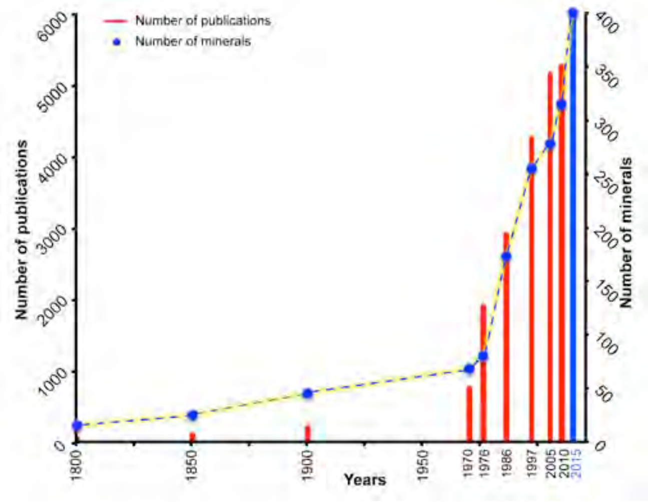

Fig. 1. *The evolution of cave mineral studies since 1800; number of minerals vs number of cave minerals-related publications.*

*Correspondence: B.P. Onac (bonac@usf.edu)

Below are some milestones in cave mineral studies since 1750 to present. Although short, non-scientific descriptions on mainly calcite and gypsum from caves are scattered throughout various publications prior to 1750, the beginning of cave mineralogy as a novel field of research dates back to the second part of the 18th century, when the first detailed presentation of calcite from Dâmbovicioara Cave (Romania) appeared in *Mineralogia Magni Principatus Tranylvaniae* treatise (Fridvaldszky, 1767). By the beginning of 1800, a total of ten cave minerals were described from Dâmbovicioara, Stufe di San Calogero, Alum, and Pulo di Molfetta caves in Romania and Italy (Forti, 2002; Onac and Forti, 2011). Detailed studies carried out at the end of the 19th century on some cave deposits from Mona Island, USA, and Australia, increased the number of cave minerals and related publications on this topic to about 50 and 250, respectively. Moore (1970), published a checklist of 68 cave minerals from around the world. The exponential trend seen in Fig. 1 has its origin, however, in the publication of *Cave Minerals* book (Hill, 1976). Although it includes only 80 minerals, primarily described from United States caves, the number of publications cited nearly topped 2000. Subsequently, Hill and Forti (1986, 1997) published two editions of the *Cave Minerals of the World* pushing the number of cave minerals to 173 and 255, respectively. About half of these minerals (*i.e.*, 86 and 125) were either ore-related or were precipitated in some very particular cave settings (sulfuric-acid caves, lava tubes, caves hosting large quantities of guano, gypsum caves, etc.). It was not only the number of cave minerals that increased, but also the number of publications dedicated to them, which exceeded 4000 titles in the 2nd edition of their book. At the threshold of the third millennium, almost 275 minerals had been described in over 5000 publications (Forti, 2002; Hill and Forti, 2007), and these numbers are going up every year (*e.g.*, Onac, 2005, 2011; Forti et al., 2006; Onac et al., 2007a, 2009a, 2011).

CHALLENGES IN CAVE MINERAL STUDIES

Although it is a major factor in cave mineral investigations, the nature of each sample and the available analytical resources aspect has not been often discussed within the cave science community. Yet the success of a detailed and accurate mineral description depends precisely on which investigation method is used and how well the sample was preserved since the time of collection, until it is ready to be analyzed. As a consequence of the analytical challenges posed, details of various cave mineralizations (*e.g.*, earthy crusts and powders) remain unknown. Even in the case of the growth of calcite or aragonite helictites and eccentrics, with studies spanning several decades focused on these issues — formation mechanisms remain ambiguous.

The main analytical challenges associated to cave mineral investigations are related to (i) the complexity of heterogeneous natural samples, which often contain multiple mineral phases, (ii) extreme sample environments, and (iii) the size and nature of some of the compounds. However, recent developments in a suite of techniques (*e.g.*, X-ray powder or single-crystal diffraction, X-ray fluorescence, inductively coupled plasma-mass spectrometry, electron microprobe, scanning electron microscopy, stable isotopes, etc.) give mineralogists unprecedented opportunities to advance the understanding of caves as minoregenic environments. The results of cave minerals studies, when integrating stable isotope analyses with other micro-analytical techniques, can be reassembled to test and improve conceptual ideas in mineral precipitation and to quantify the geochemical processes associated with it.

ABOUT THIS NEW CAVE MINERALS LIST

Because mineral nomenclature has suffered a number of revisions (Nickel and Grice, 1998; Burke, 2006, 2008; Mills et al., 2009; Nickel and Nichols, 2009; Pasero et al., 2010) and new cave minerals were reported since 1997 (Rodgers et al., 2000; De Waele and Forti, 2005; Forti, 2005; Forti et al., 2003, 2006, 2007, 2009; Onac & White, 2003; Onac and Effenberger, 2007; Onac et al., 2002, 2005, 2006, 2009a, b), a compilation of all cave minerals became essential for the cave science community, but not only. The present list incorporates all grandfathered species and species that have been redefined, renamed, or revalidated as proposed by the IMA-CNMNC (Nickel and Nichols, 2009). Also included, but written in *italics* are names used to designate a group of species (series) and species that were discredited or not approved by the CNMNC. Names of mineral species reported since the last edition of the book *Cave Minerals of the World* (CMW2; Hill and Forti, 1997) are in bold face.

The format of mineral presentation follows the class scheme presented in the book *Dana's New Mineralogy* (Gaines et al., 1997), in which each mineral is in alphabetic order, followed but its chemical formula, and the cave type locality of the mineral. The crystal system was included only for polymorphs (e.g., calcite, aragonite, vaterite, etc.) and abbreviations are as follow: monoclinic (mon.), triclinic (tric.), orthorhombic (orth.), tetragonal (tetr.), trigonal (trig.), hexagonal (hex.), and cubic (cub.). To understand the stoichiometry of mineral formulae the charge for altervalent elements is also shown. A vacancy in a structural position is denoted by the □ symbol. With very few exceptions, all mineral formulas included in our compiled list are identical to those reported by Nickel and Nichols (2009). These exceptions were dictated by changes that occurred after the IMA-CNMNC list of minerals was released (e.g., Pasero et al., 2010).

Of the more than 5500 references describing these minerals, over 4000 are listed in Hill and Forti (1997). To keep the length of this note within reasonable limits, we choose to include a selective reference list that contains the major contributions in which the new 63 minerals were reported since 1997. A Commission of Cave Minerals was established in 1997 within the International Union of Speleology with the main purpose of keeping track of all minerals described from caves, including lava tubes and caves intersected by mines.

The official cave mineral database of this commission it is assembled now (work is in progress) and can be accessed at https://www.lib.usf.edu/caveminerals/ca/.

Native elements

Bismuth – Bi; Oilloki Mine Cave, France (Audra, 2007)
Sulfur – S; Turia Cave, Romania
Gold – Au; Valea Rea Cave, Romania (Ghergari et al., 1997)

Sulfides

Chalcocite – Cu_2S; Tyuya-Muyun, Kyrgyzstan
Chalcopyrite – $CuFeS_2$; Magian & Marguzor caves, Tajikistan
Cinnabar – HgS (trig.); Magian & Marguzor caves, Tajikistan
Galena – PbS; Dalnegorskaya Cave, Russia
Marcasite – FeS_2 (orth.) – Dachstein-Mammuthöhle, Austria
Metacinnabar – HgS (cub.); Fata Morgana caves, Turkmenistan
Orpiment – As_2S_3; Aghia Paraskevi caves, Greece (Lazarides et al., 2011)
Pyrite – FeS_2 (cub.); Lauback Cave, TX, USA
Pyrrhotite – $Fe_{1-x}S$ ($x < 0.17$) (mon.); Dalnegorskaya Cave, Russia

Realgar – AsS; Chauvai, Kyrgyzstan
Sphalerite – ZnS (cub.); Trzebionka mine caves, Poland
Stibnite – Sb_2S_3; Alay Ridge caves, Kyrgyzstan

Oxides & Hydroxides

Akaganeite – $(Fe^{3+},Ni^{2+})_8(OH,O)_{16}Cl_{1.25}\cdot nH_2O$; Ruatapu Cave, New Zealand (Rodgers et al., 2000)
Arsenolite – As_2O_3 (cub.); Corkscrew Cave, AZ, USA (Onac et al., 2007b)
Asbolane – $Mn^{4+}(O,OH)_2(Co,Ni,Mg,Ca)_x(OH)_{2x}\cdot nH_2O$; Tyuya-Muyun, Kyrgyzstan
Birnessite – $(Na,Ca,K)_{0.6}(Mn^{4+},Mn^{3+})_2O_4\cdot 1.5H_2O$; Weber Cave, IA, USA
Böhmite – AlO(OH) (orth.); Dachstein-Mammuthöhle, Austria
Braunite – $Mn^{2+}(Mn^{3+})_6SiO_{12}$; Vântului Cave, Romania
Cesàrolite – $Pb(Mn^{4+})_3O_6(OH)_2$; in Santa Barbara Cave, Sardinia, Italy (De Waele and Forti, 2005)
Chalcophanite – $Zn(Mn^{4+})_3O_7\cdot 3H_2O$; Bisbee mine cave, AZ, USA
Claudetite – As_2O_3 (mon.); Corkscrew Cave, AZ, USA (Onac et al., 2007b)
Coronadite – $Pb(Mn^{4+})_2(Mn^{2+})_6O_{16}$; in Santa Barbara Cave, Sardinia, Italy (?) (De Waele and Forti, 2005)
Cristobalite – SiO_2 (tetr.); Medicine Lake lava tubes, California, USA
Cryptomelane – $K(Mn^{4+},Mn^{2+})_8O_{16}$; cavities in Nikopol'skoye iron ore, Russia
Cuprite – Cu_2O; Bisbee mine cave, AZ, USA
Gibbsite – $Al(OH)_3$ (mon.); Harlansburg & Hineman caves, PA, USA
Goethite – FeO(OH) (orth.); Tintic district, UT, USA
Hausmannite – $Mn^{2+}(Mn^{3+})_2O_4$; Vântului Cave, Romania
Hematite – Fe_2O_3; cavities in the Tintic district, UT, USA
Hetaerolite – $Zn(Mn^{3+})_2O_4$; in Santa Barbara Cave, Sardinia, Italy (De Waele and Forti, 2005)
Hollandite – $(Ba,K,Ca,Sr)(Mn^{4+},Mn^{3+},Ti,Fe^{3+})_8O_{16}$; Vântului Cave, Romania (Onac et al., 1997)
Hydrohetaerolite – $HZn(Mn^{3+})_{1.7}O_4$; in Santa Barbara Cave, Sardinia, Italy (De Waele and Forti, 2005)
Ice – H_2O; Kungur Cave, Russia
Lepidocrocite – $Fe^{3+}O(OH)$ (orth.); Dachstein-Mammuthöhle, Austria
*Limonite – **NOT** a mineral but generic term used for undifferentiated hydrated iron oxides; **NOT** approved by IMA-CNMNC*
Lithiophorite – $(Al,Li)Mn^{4+}O_2(OH)_2$; Martel Cave, Venezuela
Maghemite – $(Fe,\sim)_3O_4$; Cueva la Milagrosa, Venezuela
Magnetite – $Fe^{2+}(Fe^{3+})_2O_4$; Dachstein-Mammuthöhle, Austria
Manganite – $Mn^{3+}O(OH)$ (mon.); Najdema Cave, Slovenia
Monteponite – CdO; cave in Monteponi mine, Sardinia
Nordstrandite – $Al(OH)_3$ (tric.); Lechuguilla Cave, USA (Polyak and Provencio, 2001)
Opal – $SiO_2\cdot nH_2O$; Doombera granite cave, Ceylon
Periclase – MgO; Valea Rea Cave, Romania
Plattnerite – PbO_2; Bisbee mine cave, AZ, USA
Portlandite – $Ca(OH)_2$; lava tube on Mt. Etna, Italy
Pyrolusite – MnO_2; Blue John Cavern, UK
Quartz – SiO_2 (trig.); granite cave near Rio de Janiero, Brazil
Ralstonite – $Na_{0.5}(Al,Mg)_2(F,OH)_6\cdot H_2O$; volcanic caves on Surtsey Island, Iceland
Ranciéite – $(Ca,Mn^{2+})_{0.2}(Mn^{4+},Mn^{3+})O_2\cdot 0.6H_2O$; *cave type locality unknown*
Romanèchite – $(Ba,H_2O)_2(Mn^{4+},Mn^{3+})_5O_{10}$; Zbrasov Cave, Czech Republic
Silhydrite – $Si_3O_6\cdot H_2O$; Gaping Hole/Arch Sink, Mammoth, and Table Mountain, lava tubes in California, USA
Tenorite – CuO; Bisbee mine cave, AZ, USA
Todorokite – $(Na,Ca,K,Ba,Sr)_{1-x}(Mn,Mg,Al)_6O_{12}\cdot 3\text{-}4H_2O$; caves in KY, TN, GA (USA)
Tridymite – SiO_2 (tric.); Cango Cave, South Africa
Vernadite – $(Mn,Fe,Ca,Na)(O,OH)_2\cdot nH_2O$; Shopov's cave system, Bulgaria (?)
*Wad – **NOT** a mineral but a generic term used for poorly crystalline, undifferentiated hydrated manganese oxides and hydroxides; **NOT** approved by IMA-CNMNC*
Woodruffite – $Zn_2(Mn^{4+})_5O_{12}\cdot 4H_2O$; Cueva de las Velas, Naica, Mexico (Forti et al., 2007)

Halogenides

Atacamite – $Cu_2Cl(OH)_3$ (orth.); Jingemia Cave, Australia
Bromargyrite – AgBr; Bisbee mine cave, AZ, USA
Carnallite – $KMgCl_3\cdot 6H_2O$; Verhnekamsk caves, Russia
Chlormagnesite – $MgCl_2$; Pelagalli Cave, Italy
Fluorite – CaF_2; Blue John Cavern, UK
Halite – NaCl; *cave type locality unknown*
Salammoniac – NH_4Cl; volcanic cave on Vulcano Island, Italy; *Renamed with approval from IMA-CNMNC*
Sylvite – KCl; Cutrona Cave Mt. Etna, Italy

Carbonates

Aragonite – $CaCO_3$ (orth.); *cave type locality unknown*
Ankerite – $CaFe^{2+}(CO_3)_2$; cave in Russia
Artinite – $Mg_2CO_3(OH)_2 \cdot 3H_2O$; Shopov's cave system, Bulgaria
Aurichalcite – $Zn_5(CO_3)_2(OH)_6$; Blanchard mine caves, NM, USA
Azurite – $Cu_3(CO_3)_2(OH)_2$; Bisbee mine cave, AZ, USA
Baylissite – $K_2Mg(CO_3)_2 \cdot 4H_2O$; Shopov's cave system, Bulgaria
Brianyoungite – $Zn_3CO_3(OH)_4$; cave in Su Zurfuru mine, Sardinia, Italy (De Waele and Forti, 2005)
Burbankite – $(Na,Ca)_3(Sr,Ba,Ce)_3(CO_3)_5$; Cioclovina Cave, Romania (Onac et al., 2009a)
Calcite – $CaCO_3$ (trig.); cave in the Julian Alps, Italy
Cerussite – $PbCO_3$; Blue John Cavern, UK (?)
Dolomite – $CaMg(CO_3)_2$; cave in France
Gaspéite – $NiCO_3$; cave in San Benedetto mine, Sardinia, Italy (De Waele and Forti, 2005)
Glaukosphaerite – $(Cu,Ni)_2CO_3(OH)_2$; Water Cave from Codreanu mine, Romania (Onac, 2002)
Huntite – $CaMg_3(CO_3)_4$; Dorog, Hungary
Hydromagnesite – $Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$; Carlsbad Caverns, NM, USA
Hydrozincite – $Zn_5(CO_3)_2(OH)_6$; Island Ford Cave, VA, USA
Ikaite – $CaCO_3 \cdot 6H_2O$; Scărişoara Cave, Romania (Onac, 2008)
Kutnohorite – $CaMn^{2+}(CO_3)_2$; Caverna Pocala, Italy
Lansfordite – $MgCO_3 \cdot 5H_2O$; Valea Rea Cave, Romania (Onac, 2003)
Magnesite – $MgCO_3$; Moulis Cave, France (?)
Malachite – $Cu_2CO_3(OH)_2$; Bisbee mine cave, AZ, USA
Monohydrocalcite – $CaCO_3 \cdot H_2O$; Eibengrotte, Germany
Natron – $Na_2CO_3 \cdot 10H_2O$; Pisgah lava tubes, CA, USA
Nesquehonite – $MgCO_3 \cdot 3H_2O$; Wolkberg Cave, South Africa
Norsethite – $BaMg(CO_3)_2$; Crystal's Cave, Codreanu mine, Romania (Onac, 2002)
Paralstonite – $BaCa(CO_3)_2$; Cova des Pas de Vallgornera, Mallorca, Spain (Merino et al., 2009)
Phosgenite – $Pb_2CO_3Cl_2$; cave in Monteponi mine, Sardinia, Italy (De Waele and Forti, 2005)
Rhodochrosite – $MnCO_3$; cavities in Andalgala mining district, Argentina
Rosasite – $(Cu,Zn)_2CO_3(OH)_2$; Bisbee mine cave, AZ, USA
Siderite – $FeCO_3$; Jewel Cave, SD, USA
Smithsonite – $ZnCO_3$; cave in Iowa, USA
Strontianite – $SrCO_3$; cave in Terrace Mountain, NY, USA
Thermonatrite – $Na_2CO_3 \cdot H_2O$; Salzburgerschacht, Austria
Trona – $Na_3(HCO_3)(CO_3) \cdot 2H_2O$; Pisgah lava tubes, CA, USA
Vaterite – $CaCO_3$ (hex.); Closani Cave, Romania
Witherite – $BaCO_3$; Lilburn Cave, CA, USA

Nitrates

Darapskite – $Na_3(SO_4)(NO_3) \cdot H_2O$; Flower Cave, TX, USA
Gwihabaite – $(NH_4)NO_3$; Gwihaiba Cave, Botswana
Hydrombobomkulite – $(Ni,Cu)Al_4(NO_3)_2(SO_4)(OH)_{12} \cdot 14H_2O$; Mbobo Mkulu Cave, South Africa
Mbobomkulite – $(Ni,Cu)Al_4(NO_3,SO_4)_2(OH)_{12} \cdot 3H_2O$; Mbobo Mkulu Cave, South Africa
"Nickelalumite" – not approved by IMA-CNMNC (use mbobomkulite)
Niter – KNO_3; Pulo din Molfetta caves, Italy
Nitrammite – NH_4NO_3; *discredited by IMA-CNMNC (use gwihabaite)*
Soda niter – $NaNO_3$; *cave type locality unknown*
Nitrocalcite – $Ca(NO_3)_2 \cdot 4H_2O$; Pulo di Molfetta caves, Italy
Nitromagnesite – $Mg(NO_3)_2 \cdot 6H_2O$; Great Cave, KY, USA (?)
Sveite – $KAl_7(NO_3)_4(OH)_{16}Cl_2 \cdot 8H_2O$; Autana Cave, Venezuela

Borates

Tincalconite – $Na_2B_4O_5(OH)_4 \cdot 3H_2O$; Tincalconite Cave, CA, USA

Sulfates

Alpersite – $(Mg,Cu^{2+})SO_4 \cdot 7H_2O$; Cave at -150 m in Naica Mine, Mexico (*originally described as Cu-pentahydrite*; Forti, 2010)
Alum-(K) – $KAl(SO_4)_2 \cdot 12H_2O$; Doombera granite cave, Ceylon; *Renamed with approval from IMA-CNMNC*
Alum-(Na) – $NaAl(SO_4)_2 \cdot 12H_2O$; Alum Cave, Italy; *Renamed with approval from IMA-CNMNC*
Aluminite – $Al_2SO_4(OH)_4 \cdot 7H_2O$; Mbobo Mkulu Cave, South Africa
Aluminocopiapite – $(Al,Mg)(Fe^{3+})_4(SO_4)_6(OH,O)_2 \cdot 20H_2O$; Alum Cave, Italy
Alunite – $KAl_3(SO_4)_2(OH)_6$; Fourgassié Cave, French Guiana
Alunogen – $Al_2(SO_4)_3(H_2O)_{12} \cdot 5H_2O$; Grotta dello Zolfo, Italy
Ammoniojarosite – $NH_4(Fe^{3+})_3(SO_4)_2(OH)_6$; Cueva Alfredo Jahn, Venezuela

Anglesite – $PbSO_4$; Ahumada mine cave, Mexico
Anhydrite – $CaSO_4$; Diana Cave, Romania
Antlerite – $(Cu^{2+})_3SO_4(OH)_4$; Cave at -150 m in Naica Mine, Mexico (Forti, 2010)
Aphthitalite – $K_3Na(SO_4)_2$; Murra-el-elevyn Cave, Australia
Arcanite – K_2SO_4; Murra-el-elevyn Cave, Australia *(originally described as taylorite, name that is now discredited by IMA-CNMNC)*
Aubertite – $Cu^{2+}Al(SO_4)_2Cl\cdot 14H_2O$; Alum Cave, Italy
Barite – $BaSO_4$; paleokarst cavities in Derbyshire, UK
Basaluminite – Discredited by IMA-CNMNC (use felsőbányaite)
Bassanite – $CaSO_4\cdot 0.5H_2O$; Tăuşoare Cave, Romania
Bechererite – $Zn_7Cu(OH)_{13}[SiO(OH)_3SO_4]$; cave in Su Zurfuru mine, Sardinia, Italy (De Waele and Forti, 2005)
Bianchite – $ZnSO_4\cdot 6H_2O$; cave in Campo Pisano mine, Sardinia, Italy (De Waele and Forti, 2005)
Blödite – $Na_2Mg(SO_4)_2\cdot 4H_2O$; Lee Cave (Mammoth cave system), USA
Boussingaultite – $(NH_4)_2Mg(SO_4)_2\cdot 6H_2O$; Gwihaiba Cave, Botswana
Brochantite – $Cu_4SO_4(OH)_6$; Bingham mine caves, USA
Burkeite – $Na_4(SO_4)(CO_3)$; El Malpais lava tubes, USA
Celestine – $SrSO_4$; Crystal Cave, Ohio, USA
Cesanite – $Na_7Ca_3(SO_4)_6(OH)\cdot H_2O$; Lighthouse Cave, San Salvador, Bahamas (Onac et al., 2001a)
Chalcanthite – $CuSO_4\cdot 5H_2O$; Bisbee mine caves, USA
Chalcoalumite – $CuAl_4SO_4(OH)_{12}\cdot 3H_2O$; Mbobo Mkulu Cave, South Africa
Clairite – $(NH_4)_2(Fe^{3+})_3(SO_4)_4(OH)_3\cdot 3H_2O$; Lone Creek Fall Cave, South Africa
Copiapite – $Fe^{2+}(Fe^{3+})_4(SO_4)_6(OH)_2\cdot 20H_2O$; Alum Cave, Italy
Coquimbite – $(Fe^{3+})_2(SO_4)_3\cdot 9H_2O$; Alum Cave, Italy
Cyanotrichite – $Cu_4Al_2SO_4(OH)_{12}\cdot 2H_2O$; Bingham mine caves, USA
Despujolsite – $Ca_3Mn^{4+}(SO_4)_2(OH)_6\cdot 3H_2O$; Shopov's cave system, Bulgaria
Devilline – $CaCu_4(SO_4)_2(OH)_6\cdot 3H_2O$; Monte Rosso Cave, Italy
Epsomite – $MgSO_4\cdot 7H_2O$; gypsum cave near Bologna, Italy
Felsőbányaite – $Al_4(SO_4)(OH)_{10}\cdot 4H_2O$; Tateishi-Shônyû-dô Cave, Japan
Ferrohexahydrite – $Fe^{2+}SO_4\cdot 6H_2O$; Cupp-Coutunn Cave, Turkmenistan
Fibroferrite – $Fe^{3+}SO_4(OH)\cdot 5H_2O$; Ferrata Cave, Umbria, Italy
Galeite – $Na_{15}(SO_4)_5ClF_4$; volcanic caves on Surtsey Island, Iceland
Glauberite – $Na_2Ca(SO_4)_2$; Grillid volcanic cave, Surtsey Island, Iceland
Gypsum – $CaSO_4\cdot 2H_2O$; Mammoth cave system, USA
Halotrichite – $Fe^{2+}Al_2(SO_4)_4\cdot 22H_2O$; Alum Cave, Italy
Hexahydrite – $MgSO_4\cdot 6H_2O$; Wyandotte Cave, Indiana, USA
Hydrobasaluminite – $Al_4SO_4(OH)_{10}\cdot 15H_2O$; Alum Cave, Italy
Hydroglauberite – $Na_{10}Ca_3(SO_4)_8\cdot 6H_2O$; Grillid volcanic cave, Surtsey Island, Iceland
Hydroniumjarosite – $(H_3O)(Fe^{3+})_3(SO_4)_2(OH)_6$; Iza Cave, Romania (?) (Tămaş and Ghergari, 2003)
Jarosite – $K(Fe^{3+})_3(SO_4)_2(OH)_6$; Turia Cave, Romania
Jurbanite – $AlSO_4(OH)\cdot 5H_2O$; Serpents Cave, France (Audra and Hobléa, 2007)
Kainite – $KMg(SO_4)Cl\cdot 3H_2O$; Grillid volcanic cave, Surtsey Island, Iceland (Forti, 2005)
Kalinite – $KAl(SO_4)_2\cdot 11H_2O$; Alum Cave, Italy
Kieserite – $MgSO_4\cdot H_2O$; Tana di Val Serrata Cave, Italy
Kogarkoite – Na_3SO_4F; Cave #13 (lava tube), Mt. Suswa, Kenya (Forti et al., 2003)
Koktaite – $(NH_4)_2Ca(SO_4)_2\cdot H_2O$; Cueva Alfredo Jahn, Venezuela
Konyaite – $Na_2Mg(SO_4)_2\cdot 5H_2O$; Tăuşoare Cave, Romania (Onac et al., 2001b)
Kröhnkite – $Na_2Cu(SO_4)_2\cdot 2H_2O$; Cioclovina Cave, Romania (Onac et al., 2011)
Lecontite – $(NH_4)Na(SO_4)\cdot 2H_2O$; cave near Las Piedras, Honduras
Leonite – $K_2Mg(SO_4)_2\cdot 4H_2O$; Tăuşoare Cave, Romania (Onac et al., 2001b)
Lonecreekite – $NH_4(Fe^{3+})(SO_4)_2\cdot 12H_2O$; Lone Creek Fall Cave, South Africa
Löweite – $Na_{12}Mg_7(SO_4)_{13}\cdot 15H_2O$; Grillid volcanic cave, Surtsey Island, Iceland
Mascagnite – $(NH_4)_2SO_4$; Ruatapu Cave, New Zealand (Rodgers et al., 2000)
Melanterite – $FeSO_4\cdot 7H_2O$; Wilson Cave (?), Nevada, USA
Mendozite – $NaAl(SO_4)_2\cdot 11H_2O$; Kitum Cave, Kenya (Forti et al., 2003)
Meta-aluminite – $Al_2SO_4(OH)_4\cdot 5H_2O$; Valea Rea Cave, Romania (Feier, 2003)
Metavoltine – $K_2Na_6Fe^{2+}(Fe^{3+})_6O_2(SO_4)_{12}\cdot 18H_2O$; Alum Cave, Italy
Millosevichite – $Al_2(SO_4)_3$; Alum Cave, Italy
Mirabilite – $Na_2SO_4\cdot 10H_2O$; *cave type locality unknown*
Misenite – $K_8(SO_4)(SO_3OH)_6$; Grotta dello Zolfo, Italy
Natroalunite – $NaAl_3(SO_4)_2(OH)_6$; Lechuguilla Cave, USA
Natrojarosite – $Na(Fe^{3+})_3(SO_4)_2(OH)_6$; Jungle Pot Cave, South Africa
Pickeringite – $MgAl_2(SO_4)_4\cdot 22H_2O$; Grotta dello Zolfo, Italy
Picromerite –$K_2Mg(SO_4)_2\cdot 6H_2O$; Cutrona lava tube, Mt. Etna, Italy
Plumbojarosite – $Pb_{0.5}(Fe^{3+})_3(SO_4)_2(OH)_6$; +50 Cave Naica, Mexico (Forti, 2010)
Polyhalite – $K_2Ca_2Mg(SO_4)_4\cdot 2H_2O$; Cutrona lava tube, Mt. Etna, Italy

Rapidcreekite – $Ca_2(SO_4)(CO_3)\cdot 4H_2O$; Diana Cave, Romania (Onac et al., 2009b)
Römerite – $Fe^{2+}(Fe^{3+})_2(SO_4)_4\cdot 14H_2O$; Carlsbad Caverns, USA
Rozenite – $Fe^{2+}SO_4\cdot 4H_2O$; Faggeto Tondo, Italy
Sabieite – $NH_4Fe^{3+}(SO_4)_2$; Lone Creek Fall Cave, South Africa
Serpierite – $Ca(Cu,Zn)_4(SO_4)_2(OH)_6\cdot 3H_2O$; Cave #4, Runcului Hill, Romania (Zaharia et al., 2003)
Siderotil – $(Fe,Cu)(SO_4)\cdot 5H_2O$; Ruatapu Cave, New Zealand (Rodgers et al., 2000)
Spangolite – $Cu_6AlSO_4(OH)_{12}Cl\cdot 3H_2O$; Bingham mine caves, USA
Starkeyite – $MgSO_4\cdot 4H_2O$; Cueva de las Velas, Naica, Mexico (Forti et al., 2007)
Syngenite – $K_2Ca(SO_4)_2\cdot H_2O$; Murra-el-elevyn Cave, Australia
Szmikite – $MnSO_4\cdot H_2O$; Cueva de las Velas, Naica, Mexico (Forti et al., 2007)
Szmolnokite – $FeSO_4\cdot H_2O$; Cueva de las Velas, Naica, Mexico (Forti et al., 2007)
Tamarugite – $NaAl(SO_4)_2\cdot 6H_2O$; Grotta dello Zolfo, Italy
Thenardite – Na_2SO_4; Grotta delle Argille, Modena, Italy
Tschermigite – $NH_4Al(SO_4)_2\cdot 12H_2O$; Ruatapu Cave, New Zealand
Voltaite – $K_2(Fe^{2+})_5(Fe^{3+})_3Al(SO_4)_{12}\cdot 18H_2O$; Grotta dello Zolfo, Italy
Zaherite – $Al_{12}(SO_4)_5(OH)_{26}\cdot 20H_2O$; Alum Cave, Italy (Forti et al., 1996)

Cromates

Crocoite – $PbCrO_4$; Scărişoara Ice Cave, Romania (?) (Onac, 2001)

Phosphates, Arsenates, Vanadates

Phosphates

Archerite – H_2KPO_4; Petrogale Cave, Australia
Ardealite – $Ca_2(PO_3OH)(SO_4)\cdot 4H_2O$; Cioclovina Cave, Romania
"Arnhemite" – $K_4Mg_2(P_2O_7)\cdot 5H_2O$; Arnhem Cave, Namibia; *Not approved by IMA-CNMNC*
Berlinite – $AlPO_4$; Cioclovina Cave; Romania (Onac et al., 2002)
Biphosphammite – $H_2(NH_4)PO_4$; Murra-el-elevyn Cave, Australia
Bobierrite – $Mg_3(PO_4)_3\cdot 8H_2O$; Imperial Canyon lava tubes, Kenya
Brushite – $Ca(PO_3OH)\cdot 2H_2O$; Skipton lava tubes, Australia
Carbonate-fluorapatite – Discredited by IMA-CNMNC
Carbonate-hydroxylapatite – Discredited by IMA-CNMNC
Chlorapatite – $Ca_5(PO_4)_3Cl$; Lyon Cave, Philippines
Churchite-(Y) – $YPO_4\cdot 2H_2O$; Cioclovina Cave, Romania (Onac et al., 2005)
Collinsite – $Ca_2Mg(PO_4)_2\cdot 2H_2O$; Blue Lagoon Cave, South Africa
Crandallite – $CaAl_3(PO_4)_2(PO_3OH)(OH)_6$; caves on Isla Mona, Puerto Rico
Diadochite – $(Fe^{3+})_2(PO_4)(SO_4)(OH)\cdot 6H_2O$; Feengrotten, Germany
Dittmarite – $(NH_4)MgPO_4\cdot H_2O$; Skipton lava tubes, Australia
Evansite – $Al_3PO_4(OH)_6\cdot 6H_2O$; sandstone cave in Columbia, SouthAmerica
Fluorapatite – $Ca_5(PO_4)_3F$; Slaughter Canyon Cave, New Mexico, SUA
Foggite – $CaAlPO_4(OH)_2\cdot H_2O$; Cioclovina Cave, Romania (Onac et al., 2005)
Francoanellite – $K_3Al_5(PO_3OH)(PO_4)_2\cdot 12H_2O$; Castellana caves, Italy
Gordonite – $MgAl_2(PO_4)_2(OH)_2\cdot 8H_2O$; Parwan Cave, Victoria, Asutralia
Hannayite – $(NH_4)_2Mg_3(PO_3OH)_4\cdot 8H_2O$; Skipton lava tubes, Australia
Hopeite – $Zn_3(PO_4)_2\cdot 4H_2O$ (orth.); Broken Hills mine caves, Zambia
Hydroxylapatite – $Ca_5(PO_4)_3(OH)$; caves on Isla Mona, Puerto Rico
Kingsmountite – $Ca_4Fe^{2+}Al_4(PO_4)_6(OH)_4\cdot 12H_2O$; Rossillo Cave, Quatro Cienegas Desert, Mexico (Forti et al., 2006)
Koninckite – $Fe^{3+}PO_4\cdot 3H_2O$; Oni-Ana Cave, Japan
Leucophosphite – $K(Fe^{3+})_2(PO_4)_2(OH)\cdot 2H_2O$; Bomi Hill caves, Liberia
Lipscombite – $Fe^{2+}(Fe^{3+})_2(PO_4)_2(OH)_2$; Perak Tong Cave, Malaysia
Minyulite – $KAl_2(PO_4)_2F\cdot 4H_2O$; Boon Cave, Transvaal, South Africa
Mitridatite – $Ca_2(Fe^{3+})_3O_2(PO_4)_3\cdot 3H_2O$; Boon Cave, Transvaal, South Africa
Monetite – $Ca(PO_3OH)$; caves on Isla Mona, Puerto Rico
Montgomeryite – $Ca_4MgAl_4(PO_4)_6(OH)_4\cdot 12H_2O$; et-Tabun Cave, Israel
Mundrabillaite – $(NH_4)_2Ca(PO_3OH)_2\cdot H_2O$; Petrogale Cave, W. Australia
Newberyite – $Mg(PO_3OH)\cdot 3H_2O$; Skipton lava tubes, Australia
Niahite – $(NH_4)Mn^{2+}PO_4\cdot H_2O$; Niah Great Cave, Sarawak, Malaysia
Parahopeite – $Zn_3(PO_4)_2\cdot 4H_2O$ (tric.); Hudson Bay mine caves, British Columbia, Canada
Phosphammite – $(NH_4)_2(PO_3OH)$; Toppin Hill caves, Australia
Phosphosiderite – $Fe^{3+}(PO_4)\cdot 2H_2O$; Bomi Hill caves, Liberia
Purpurite – $(Mn^{3+},Fe^{3+})PO_4$; Gunong Keriang, Malaysia
"Pyrocoproite" – $(K,Na)_2Mg(P_2O_7)$; Arnhem Cave, Namibia; *Not approved by IMA-CNMNC* (Martini, 1997)
Pyromorphite – $Pb_5(PO_4)_3Cl$; cave in Friedricksgessen mine, Germany
"Pyrophosphite" – $K_2CaP_2O_7$; Arnhem Cave, Namibia; *Not approved by IMA-CNMNC*

Sampleite – $NaCaCu_5(PO_4)_4Cl{\cdot}5H_2O$; Mbobo Mkulu Cave, Transvaal, South Africa
Sasaite – $Al_6(PO_4)_5(OH)_3{\cdot}36H_2O$; West Driefontein Cave, South Africa
Schertelite – $(NH_4)_2Mg(PO_3OH)_2{\cdot}4H_2O$; Skipton lava tubes, Australia
Scholzite – $CaZn_2(PO_4)_2{\cdot}2H_2O$; cave in Virginia, USA
Spencerite – $Zn_4(PO_4)_2(OH)_2{\cdot}3H_2O$; Hudson Bay mine caves, British Columbia, Canada
Stercorite – $(NH_4)Na(PO_3OH){\cdot}4H_2O$; Petrogale Cave, W. Australia
Strengite – $Fe^{3+}PO_4{\cdot}2H_2O$; Bomi Hill caves, Liberia
Struvite – $(NH_4)MgPO_4{\cdot}6H_2O$; Skipton lava tubes, Australia
Swaknoite – $(NH_4)_2Ca(PO_3OH)_2{\cdot}H_2O$; Arnhem Cave, Namibia
Taranakite – $K_3Al_5(PO_3OH)_6(PO_4)_2{\cdot}18H_2O$; Minerva Cave, France
Tarbuttite – $Zn_2PO_4(OH)$; Broken Hills mine caves, Zambia
Tinsleyite – $KAl_2(PO_4)_2(OH){\cdot}2H_2O$; Cioclovina Cave, Romania (Marincea et al., 2002)
Tinticite – $(Fe^{3+})_{5.3}(PO_4)_4(OH)_6{\cdot}6.7H_2O$; cavity in the Tintic district, UT, USA
Variscite – $AlPO_4{\cdot}2H_2O$; Drachenhöhle Cave, Austria
Vashegyite – $Al_{11}(PO_4)_9(OH)_6{\cdot}38H_2O$; Oni-Ana; Tateishi-Shônyû-dô caves, Japan
Vivianite – $(Fe^{2+})_3(PO_4)_2{\cdot}8H_2O$; Niah Great Cave, Sarawak, Malaysia
Wavellite – $Al_3(PO_4)_2(OH)_3{\cdot}5H_2O$; Valea Rea Cave, Romania
Whitlockite – $Ca_9Mg(PO_3OH)(PO_4)_6$; El Chapote Cave, Mexico
Woodhouseite – $CaAl_3(SO_4)(PO_4)(OH)_6$; Jade Lotus Cave, Yangshuo, China

Arsenates

Arseniosiderite – $Ca_2(Fe^{3+})_3O_2(AsO_4)_3{\cdot}3H_2O$; Tyuya-Muyun Cave, Kyrgyzstan
Beudantite – $Pb(Fe^{3+})_3(AsO_4)(SO_4)(OH)_6$; Island Ford Cave, USA
Conichalcite – $CaCuAsO_4(OH)$; Corkscrew Cave, Grand Canyon, USA
Hedyphane – $Ca_2Pb_3(AsO_4)_3Cl$; cave in Santa Barbara mine, Sardinia, Italy (De Waele and Forti, 2005)
Hörnesite – $Mg_3(AsO_4)_2{\cdot}8H_2O$; Corkscrew Cave, Grand Canyon, USA (*not cited in CMW2*) (Wenrich and Sutphin, 1994)
Manganberzeliite – $NaCa_2(Mn^{2+})_2(AsO_4)_3$; Cueva Alfredo Jahn, Venezuela
Mimetite – $Pb_5(AsO_4)_3Cl$; Bisbee mine cave, AZ, USA
Olivenite – $Cu_2AsO_4(OH)$; cavities in the Tintic district, UT, USA
Pharmacolite – $Ca(AsO_3OH){\cdot}2H_2O$; Corkscrew Cave, Grand Canyon, USA (Onac et al., 2007b)
Strashimirite – $Cu_4(AsO_4)_2(OH)_2{\cdot}2.5H_2O$; Dupkata na Mara Cave, Bulgaria
Talmessite – $Ca_2Mg(AsO_4)_2{\cdot}2H_2O$; Corkscrew Cave, Grand Canyon, USA
Yukonite – $Ca_7(Fe^{3+})_{15}(AsO_4)_9O_{16}{\cdot}25H_2O$ (?); Grotta della Monaca, Italy (Garavelli et al., 2009)

Vanadates

Calciovolborthite – Discredited by IMA-CNMNC (use tangeite)
Carnotite – $K_2(UO_2)_2(VO_4)_2{\cdot}3H_2O$; Tyuya-Muyun Cave, Kyrgyzstan
Descloizite – $PbZnVO_4(OH)$; Tyuya-Muyun Cave, Kyrgyzstan
Metatyuyamunite – $Ca(UO_2)_2(VO_4)_2{\cdot}3H_2O$; Spider Cave, New Mexico, USA
Tangeite – $CaCuVO_4(OH)$; Zelania Cave, Tyuya-Muyun, Kyrgyzstan
Tyuyamunite – $Ca(UO_2)_2(VO_4)_2{\cdot}3H_2O$; Tyuya-Muyun Cave, Kyrgyzstan
Vanadinite – $Pb_5(VO_4)_3Cl$; Broken Hills mine caves, Zambia

Molybdates

Powellite – $CaMoO_4$; Corkscrew Cave, Grand Canyon, USA (*not cited in CMW2*) (Wenrich and Sutphin, 1994)

Organic compounds

Acetamide – CH_3CONH_2; Prilepnata Cave, Bulgaria
Glushinskite – $MgC_2O_4{\cdot}2H_2O$; Temple of Dome Cave, Namibia
Guanine – $C_5H_3(NH_2)N_4O$; Murra-el-elevyn Cave, Australia
Mellite – $Al_2C_6(COO)_6{\cdot}16H_2O$; Romanelli Cave, Apulia, Italy
Oxammite – $(NH_4)_2C_2O_4{\cdot}H_2O$; Petrogale Cave, W. Australia
Urea – $CO(NH_2)_2$; Wilgie Mia Cave, W. Australia
Uricite – $C_5H_4N_4O_3$; Dingo Donga Cave, W. Australia
Weddellite – $CaC_2O_4{\cdot}2H_2O$; Toppin Hill Cave, W. Australia
Whewellite – $CaC_2O_4{\cdot}H_2O$; Parakietgat Cave, Namibia

Silicates

Allophane – $Al_2O_3(SiO_2)_{1.3\text{-}2.0}{\cdot}2.5\text{-}3H_2O$; Tyuya-Muyun Cave, Kyrgyzstan
Apophyllite-(KOH) – $KCa_4Si_8O_{20}(OH,F){\cdot}8H_2O$; Kitum Cave, Kenya (Forti et al., 2003)
Benitoite – $BaTiSi_3O_9$; Iza Cave, Romania
Boltwoodite – $KUO_2(SiO_3OH){\cdot}H_2O$; cave in northern Chihuahua, Mexico
Chrysocolla – $(Cu,Al)_2H_2Si_2O_5(OH)_4{\cdot}nH_2O$; Tyuya-Muyun Cave, Kyrgyzstan

Clinochlore – $Mg_6Si_4O_{10}(OH)_8$; Monte Rosso Cave, Reggio Emilia, Italy
Clinoptilolite-Na – $Na_6(Si_{30}Al_6)O_{72}\cdot20H_2O$; Cave in the Culachao mine, Chile (De Waele et al., 2009)
Dickite – $Al_2Si_2O_5(OH)_4$; Iza Cave, Romania
Endellite – Discredited by IMA-CNMNC (use Halloysite-10Å)
Epidote – $Ca_2Fe^{3+}Al_2(Si_2O_7)(SiO_4)O(OH)$; Santo Cave, Mt. Etna, Italy
Fraipontite – $(Zn,Al)_3(Si,Al)_2O_5(OH)_4$; Cupp-Coutunn Cave, Turkmenistan
Halloysite-7Å – $Al_2Si_2O_5(OH)_4$ (mon.); Faggeto Tondo Cave, Italy
Halloysite-10Å – $Al_2Si_2O_5(OH)_4\cdot2H_2O$; caves in the Guadalupe Mountains, USA
Hectorite – $Na_{0.3}(Mg,Li)_3Si_4O_{10}(F,OH)_2\cdot nH_2O$; Cueva de las Espadas, Naica, Mexico (Forti et al., 2009)
Hemimorphite – $Zn_4Si_2O_7(OH)_2\cdot H_2O$; Hudson Bay mine caves, Canada
Howlite – $Ca_2SiB_5O_9(OH)_5$; Ordinskaya Cave, Kungur, Russia (Potapov and Parshima, 2010)
Hydroxyapophyllite – Discredited by IMA-CNMNC [*use Apophyllite-(KOH)*]
Hydroxylellestadite – $Ca_{10}(SiO_4)_3(SO_4)_3(OH)_2$; Cioclovina Cave, Romania (Onac et al., 2006)
*Illite – **NOT** a mineral; Name used to designate a group of species*
Ilvaite – $CaFe^{3+}(Fe^{2+})_2O(Si_2O_7)(OH)$; hydrothermal skarn caves at Primarsky Kray, Russia
Kaolinite – $Al_2Si_2O_5(OH)_4$ (tric.); Cupp-Coutunn Cave, Turkmenistan
Montmorillonite – $(Na,Ca)_{0.3}(Al,Mg)_2)Si_4O_{10})(OH)_2\cdot nH_2O$; Carlsbad Caverns, USA
Nacrite – $Al_2Si_2O_5(OH)_4$ (mon.); Valea Rea Cave, Romania (Ghergari and Tămaş, 1996)
Natrolite – $Na_2(Si_3Al_2)O_{10}\cdot2H_2O$; Big Cave from Bolfu mine III, Romania
Nontronite – $Na_{0.3}(Fe^{3+})_2(Si,Al)_4O_{10}(OH)_2\cdot nH_2O$; Kartchner Caverns, USA
Orientite – $Ca_8(Mn^{3+})_{10}(SiO_4)_3(Si_3O_{10})_3(OH)_{10}\cdot4H_2O$; Cueva de las Velas, Naica, Mexico (Forti et al., 2007)
Palygorskite – $(Mg,Al)_2Si_4O_{10}(OH)\cdot4H_2O$; Broken Hill caves, New Zealand
Phillipsite-K – $K_6(Si_{10}Al_6)O_{32}\cdot12H_2O$; Kitum Cave, Kenya (Forti et al., 2003)
Rectorite – $(Na,Ca)Al_4(Si,Al)_8O_{20}(OH)_4\cdot2H_2O$; Kartchner Caverns, USA
Saponite – $(Ca,Na)_{0.3}(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2\cdot4H_2O$; Vântului Cave, Romania
Sauconite – $Na_{0.3}Zn_3(Si,Al)_4O_{10}(OH)_2\cdot4H_2O$; Cupp-Coutunn Cave, Turkmenistan
Sepiolite – $Mg_4Si_6O_{15}(OH)_2\cdot6H_2O$; Zbrasov Cave, Czech Republic
Shattuckite – $Cu_5(SiO_3)_4(OH)_2$; Bisbee mine caves, USA

Acknowledgements. We are grateful to all members of the *Cave Minerals Commission* of the International Union of Speleology who provided us with news and suggestions. This note is part of the Cave Mineral Database (CAMIDA) project, a collaborative effort of the University of South Florida Libraries Karst Information Portal, UIS's Cave Minerals Commission, the "Emil Racoviţă" Institute of Speleology (Romania), and the Karst Research Group at the University of South Florida (USA).

REFERENCES

Audra, P. 2007, A mineralized hypogenic cave in Pierre Saint-Martin massif: the Oilloki Cave (Sainte-Engrâce, Pyrénées-Atlantiques). Preliminary investigations. *Karstologia Memoire*, 17: 176-182.

Audra, P., Hobléa, F. 2007, The first cave occurrence of jurbanite [$Al(OH\ SO_4)\cdot5H_2O$], associated with alunogen [$Al(SO_4)_3\cdot17H_2O$] and tschermigite [$NH_4Al(SO_4)_2\cdot12H_2O$]: thermal-sulfidic Serpents Cave, France. *Journal of Cave and Karst Studies*, 69 (2): 243- 249.

Burke, E.A.J. 2006, A mass discreditation of GQN minerals. *Canadian Minerologist*, 44: 1557-1560; DOI: http://dx.doi.org/10.2113/gscanmin.44.6.1557

Burke, E.A.J. 2008, Tidying up mineral names: an IMA-CNMNC scheme for suffixies, hyphens and diacritical marks. *The Mineralogical Record* 39: 131-135.

De Waele, J., Forti, P. 2005, Mineralogy of mine caves in Sardinia. *Proceedings of the 14th International Congress of Speleology*, Kalamos, Greece, 306-311.

De Waele, J., Forti, P., Picotti, V., Galli, E., Rossi, A., Brook, G., Zini, L. & Cucchi, F. 2009, Cave deposits in Cordillera de la Sal (Atacama, Chile). In: Rossi P.L. (Ed.), Geological Constrains on the Onset and Evolution of an Extreme Environment: the Atacama area. *Geoacta, Special Publication* 2: 113-117.

Feier, N. 2003, New data on the mineralogy of Valea Rea Cave, Bihor Mountains. *Ecocarst*, 4: 22-24 (in Romanian).

Forti, P. 2002, Speleology in the third millenium: achievments and challenges. *Theoretical and Applied Karstology*, 15: 7-26.

Forti, P. 2005, Genetic processes of cave minerals in volcanic environment: an overview. *Journal of Cave and Karst Studies*, 67 (1): 3-13.

Forti, P. 2010, Genesis and evolution of the caves in the Naica Mine (Chihuahua, Mexico). *Zeitschrift für Geomorphologie*, 54 (2): 115-135; DOI: http://dx.doi.org/10.1127/0372-8854/2010/0054S2-0007

Forti, P., Galli, E. & Rossi, A. 2003, Minerogenesis in some volcanic caves of Kenya. *International Journal of Speleology*, 32 (1/4): 1-16.

Forti, P., Galli, E. & Rossi, A. 2006, Peculiar minerogenetic cave environments of Mexico: the Cuatro Ciénegas area. *Acta Carsologica*, 35 (2): 79-98.

Forti, P., Galli, E. & Rossi, A. 2007, The mineralogical study on the Cueva de las Velas (Naica, Mexico). *Acta Carsologica*, 36 (3): 379-388.

Forti, P., Galli, E. & Rossi, A. 2009, Minerogenesis in the Naica caves (Chihuahua, México). *Proceedings of the 15th International Congress of Speleology*, Kerrville, 1: 300-305.

Forti, P., Panzica La Manna, M. & Rossi, A. 1996, The peculiar mineralogical site of the Alum cave (Vulcano, Sicily). *Proceedings of the 7th International Symposium on Vulcanospeleology*, Canarie, 35-44.

Fridvaldszky, J. 1767, *Mineralogia Magni Principatus Transylvaniae*. Claudiopoli, Typis Academicis Societatis Jesu, 206 p (in Latin).

Gaines, R.V., Skinner, H.C.W., Foord, E.E., Mason, B. & Rosenzweig, A. 1997, *Dana's New Mineralogy*. Wiley, New York, 1819 p.

Garavelli, A., Pinto, D., Vurro, F., Mellini, M., Viti, C., Balic-Zunic, T. & Della Ventura, G. 2009, Yukonite from the Grotta della Monaca Cave, Sant'Agata di Esaro, Italy: characterization and comparison with cotype material from the Daulton Nine, Yukon, Canada. *Canadian Mineralogist*, 47: 39-51; DOI: http://dx.doi.org/10.3749/canmin.47.1.39

Ghergari, L., Tămaş, T. 1996, Mineralogy of cave deposits from Bihor Mountains (Romania). In: *Contribucíon del studio cientifica de las cavidades kársticas al conocimiento geológico* (Andreo, B., Carrasco, F. & Duran J.J., Eds.), Patronato de la Cueva de Nerja, Nerja, p. 243-255.

Ghergari, L., Tămaş, T., Damm, P. & Forray, F. 1997, Hydrothermal paleokarst in Pestera din Valea Rea (Bihor Mountains, Romania). *Theoretical and Applied Karstology*, 10: 115-125.

Hill, C.A. 1976, *Cave minerals*. National Speleological Society, Huntsville, 167 p.

Hill, C.A., Forti, P. 1986, *Cave minerals of the world* (1st ed.). National Speleological Society, Huntsville, 238 p.

Hill, C.A., Forti, P. 1997, *Cave minerals of the world* (2nd ed.). National Speleological Society, Huntsville, 464 p.

Hill, C.A., Forti, P. 2007, Cave mineralogy and the NSS: Past, present, and future. *Journal of Cave and Karst Studies*, 69 (1): 35-45.

Lazarides, G., Melfos, V. & Papadopoulou, L. 2011, The first cave occurrence of orpiment (As_2S_3) from the sulfuric acid caves of Aghia Paraskevi (Kassandra Peninsula, N. Greece). *International Journal of Speleology*, 40 (2): *in press*

Marincea, Ş., Dumitraş, D. & Gibert, R. 2002, Tinsleyite in the "dry" Cioclovina Cave (Şureanu Mountains, Romania): the second occurrence. *European Journal of Mineralogy* 14: 157-164; DOI: http://dx.doi.org/10.1127/0935-1221/2002/0014-0157

Martini, J.E.J. 1997, Pyrocoproite ($(Mg(K,Na)_2(P_2O_7)$), monoclinic) a new mineral from Arnhem Cave (Namibia), derived from bat guano combustion. *Proceedings of the 12th International Congress of Speleology*, Le Chaux-de-Fonds, 1: 223-225.

Merino, A., Fornós, J.J. & Onac, B.P. 2009, Preliminary data on mineralogical aspects of cave rims and vents in Cova des Pas de Vallgornera, Mallorca. *Proceedings of the 15th International Congress of Speleology*, Kerrville, 1: 307-311.

Mills, S.J., Hatert, F., Nickel, E.H. & Ferraris, G. 2009, The standardisation of mineral group hierarchies: application to recent nomenclature proposals. *European Journal of Mineralogy*, 21: 1073-1080; DOI: http://dx.doi.org/10.1127/0935-1221/2009/0021-1994

Moore, G.W. 1970, Checklist of cave minerals. *National Speleological Society News*, 28: 9-10.

Nickel, E.H., Grice, J.D. 1998, The IMA Commission on New Minerals and Mineral Names: procedures and guidelines on mineral nomenclature, 1998. *Mineralogy and Petrology*, 64 (1-4): 237-263; DOI: http://dx.doi.org/10.1007/BF01226571

Nickel, E.H., Nichols, M.C. 2009, IMA/CNMNC list of mineral names (http://pubsites.uws.edu.au/ima-cnmnc/imalist.htm)

Onac, B.P. 2001, Mineralogical studies and Uranium-series dating of speleothems from Scărişoara Glacier Cave (Bihor Mountains, Romania). *Theoretical and Applied Karstology*, 13-14: 33-38.

Onac, B.P. 2002, Caves formed within Upper Cretaceous skarns at Băiţa, Bihor County, Romania: mineral deposition and speleogenesis. *Canadian Mineralogist*, 40 (6): 1693-1703.

Onac, B.P. 2003, Minerals of the Carpathians: first update. *Acta Mineralogica-Petrographica,* 44: 31-34.

Onac, B.P. 2005, *Minerals*. In: *Encyclopedia of caves* (Culver D.C., White W.B., Eds.), Academic Press, New York, 371-378.

Onac B.P. 2008, Ikaite in the Scărişoara ice deposit: precipitation and significance. In: *Proceedings 3rd International Workshop on Ice Caves* (Turri, S., Ed.), Perm State University, Perm, p. 28.

Onac, B.P. 2011, *Minerals*. In: *Encyclopedia of caves* (2nd ed.) (Culver D.C., White W.B., Eds.), *accepted*.

Onac, B.P., Effenberger, H.S. 2007, Re-examination of berlinite ($AlPO_4$) from the Cioclovina Cave, Romania. *American Mineralogist*, 92: 1998-2001; DOI: http://dx.doi.org/10.2138/am.2007.2581

Onac, B.P., Forti, P. 2011, Minerogenetic mechanisms occurring in the cave environment: an overview. *International Journal of Speleology*, 40 (2): 1-20.

Onac, B.P., White, W.B. 2003, First reported sedimentary occurrence of berlinite ($AlPO_4$) in the phosphate-bearing sediments from Cioclovina Cave, Romania. *American Mineralogist*, 88: 1395-1397.

Onac, B.P., Bernhardt, H.-J. & Effenberger, H.S. 2009a, Authigenic burbankite in the Cioclovina Cave sediments (Romania). *European Journal of Mineralogy*, 21: 507-514; DOI: http://dx.doi.org/10.1127/0935-1221/2009/0021-1916

Onac, B.P., Effenberger, H.S. & Breban, R.C. 2007a, High-temperature and "exotic" minerals from the Cioclovina Cave, Romania: a review. *Studia UBB Geologia*, 52 (2): 3-10; DOI: http://dx.doi.org/10.5038/1937-8602.52.2.1

Onac, B.P., Hess, J.W. & White, W.B. 2007b, The relationship between the mineral composition of speleothems and mineralization of breccia pipes: evidence from Corkscrew Cave, Arizona, USA. *Canadian Mineralogist*, 45: 1177-1188; DOI: http://dx.doi.org/10.2113/gscanmin.45.5.1177

Onac, B.P., Mylroie, J.E. & White, W.B. 2001a, Mineralogy of cave deposits on San Salvador Island, Bahamas. *Carbonates and Evaporites*, 16 (1): 8-16.

Onac, B.P., Pedersen, R.B. & Tysseland, M. 1997, Presence of rare-earth elements in black ferromanganese coatings from Vântului Cave (Romania). *Journal of Caves and Karst Studies*, 59 (3): 128-131.

Onac, B.P., White, W.B. & Viehmann, I. 2001b, Leonite $K_2Mg[SO_4]_2\ 4H_2O$, konyaite $Na_2Mg[SO_4]_2\ 5H_2O$ and syngenite $K_2Ca[SO_4]_2\ H_2O$ from Tăuşoare Cave (Rodnei Mts., Romania). *Mineralogical Magazine*, 65 (1): 1-7.

Onac, B.P., Breban, R., Kearns, J. & Tămaş, T. 2002, Unusual minerals related to phosphate deposits in Cioclovina Cave, Sureanu Mts. (Romania). *Theoretical and Applied Karstology*, 15: 27-34.

Onac, B.P., Effenberger, H., Ettinger, K. & Cînta-Pînzaru, S. 2006, Hydroxylellestadite from Cioclovina Cave (Romania): Microanalytical, structural, and vibrational spectroscopy data. *American Mineralogist*, 91: 1927-1931; DOI: http://dx.doi.org/10.2138/am.2006.2143

Onac, B.P., Ettinger, K., Kearns, J. & Balasz, I.I. 2005, A modern, guano-related occurrence of foggite, $CaAl(PO_4)(OH)_2 \cdot H_2O$ and churchite-(Y), $YPO_4 \cdot 2H_2O$ in Cioclovina Cave, Romania. *Mineralogy and Petrology*, 85: 291-302; DOI: http://dx.doi.org/10.1007/s00710-005-0106-4

Onac, B.P., Effenberger, H.S., Collins, N.C., Kearns, J.B. & Breban, R.C. 2011, Revisiting three minerals from Cioclovina Cave (Romania). *International Journal of Speleology*, 40 (2): 21-30.

Onac, B.P., Sumrall, J.B., Tămaş, T., Povară, I., Kearns, J., Dârmiceanu, V., Vereş, D. & Lascu, C. 2009b, The relationship between cave minerals and H_2S-rich thermal waters along the Cerna Valley (SW Romania). *Acta Carsologica*, 38: 67-79.

Pasero, M., Kampf, A.R., Ferraris, C., Pekov, I.V., Rakovan, J. & White, T.J. 2010, Nomenclature of the apatite supergroup minerals. *European Journal of Mineralogy*, 22: 163-179; DOI: http://dx.doi.org/10.1127/0935-1221/2010/0022-2022

Polyak, V.J., Provencio, P. 2001, By-product materials related to H_2S – H_2SO_4 influenced speleogenesis of Carlsbad, Lechuguilla, and other caves of the Guadalupe Mountains, New Mexico. *Journal of Cave and Karst Studies*, 63: 23–32.

Potapov, S.S., Parshina, N.V. 2010, Howlite $Ca_2B_5SiO_9(OH)_5$ from Ordinskaya cave in Perm region – the first find on the Ural. In: *Proceedings of Scientific Readings in Memory of P.N. Chirvinsky on Problems of Mineralogy, Petrography and Metallogeny*. Perm State University, 13: 83-91 (in Russian).

Rodgers, K.A., Hamlin, K.A., Browne, P.R.L., Campbell, K.A. & Martin, R. 2000, The steam condensate alteration mineralogy of Ruatapu cave, Orakei Korako geothermal field, Taupo Volcanic Zone, New Zealand. *Mineralogical Magazine*, 64 (1): 125-142.

Tămaş, T., Ghergari, L. 2003, Hydronium jarosite from Iza Cave (Rodnei Mts., Romania). *Acta Mineralogica-Petrographica Abstract Series*, 1: 102.

Zaharia, L., Tămaş, T. & Suciu-Krausz, E. 2003, Mineralogy og the Cave no. 4 from Runcului Hill (Metaliferi Mts., Romania). *Theoretical and Applied Karstology*, 16: 41-46.

Wenrich, K.J., Sutphin, H.B. 1994, Grand Canyon caves, breccia pipes and mineral eposits. *Geology Today*, 10: 97-104.