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PEGMATITIC PHOSPATE: A TRIBUTE TO FRANÇOIS FONTAN, ANDRÉ-MATHIEU FRANSOLET, AND PAUL KELLER

PREFACE

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The 6th International Symposium on Granitic Pegmatites (PEG 2013), New Hampshire-Maine (May 26th–June2nd 2013), held a special session on phosphate minerals as an important part of the program in honor of François Fontan, Paul Keller, and André-Mathieu Fransolet. These three exceptional researchers have contributed enormously to the advancement of our knowledge of pegmatitic phosphates over the last three decades. They worked individually and jointly, always in an enthusiastic, effective, and tireless way. They passed on their knowledge and interest in phosphates to many younger researchers.

Phosphate minerals are considered very important and interesting accessories in granite pegmatites, where they occur as well-formed crystals in miarolitic cavities, or as masses that in some instances can reach

gigantic proportions. Despite negligible economic interest, except for the world of mineral collectors and museums, these accessories are of key importance in understanding the petrologic processes involving both single pegmatite dikes and entire pegmatitic swarms or fields. Generally, pegmatitic phosphates occur as very complex associations of primary and secondary phosphate mineral species, typically showing intricate textures revealing the geological history of the hosting pegmatite.

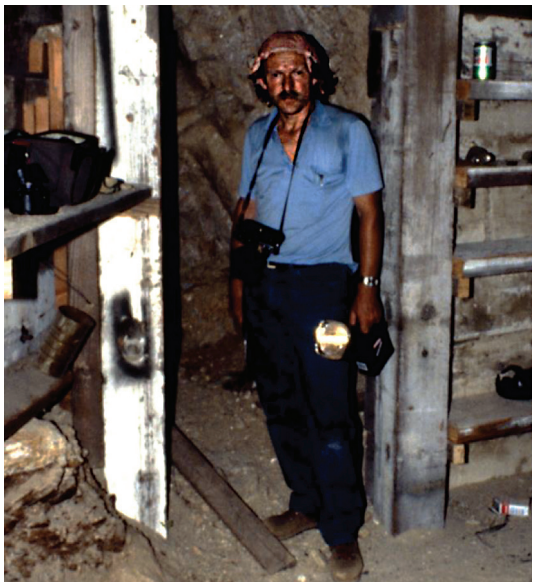
The central part of the 20th century was characterized by the activity of many important scientists who began to describe phosphate mineral species, their crystal chemistry, paragenesis, occurrence, and the features of the hosting pegmatite. As an example, the first complete descriptions of phosphate paragenesis characterizing a specific pegmatite are due to Mason (1941) and Quensel (1952), who described the primary and secondary phosphate paragenesis occurring at Varuträsk in Sweden. Heinrich (1951) gave a complete description of the mineralogy of triplite. Paul Brian Moore described a great number of new phosphate mineral species including "jahnsite", segelerite, robertsite, and "whiteite" (Moore 1974, Moore & Ito 1978) as well as the crystal-chemistry of important phosphate mineral groups such as alluaudite, wyllieite, and arrojadite (Moore & Ito 1979) or individual species such as sarcopside (Moore 1972) or wyllieite (Moore & Molin-Case 1974). The paper published by Moore (1973) in the nascent *Mineralogical Record*, which represents the first attempt to give a global description of pegmatitic phosphates, their crystal-chemistry, and petrological implications, was very influential. These scientists, with their work, underlined the extreme complexity and importance of these accessories typical of LCT pegmatites (Simmons *et al.* 2003, Černý & Ercit 2005). During the last decades of the 20th century and the beginning of the 21st century, François Fontan, Paul Keller, and André-Mathieu Fransolet made great contributions to the study of petrology of pegmatitic phosphates. Of great interest are their studies about: primary hagendorfite at the Kibingo pegmatite (Fransolet *et al.* 2004); the minerals belonging to the jonsonmervilleite–fillowite series in African pegmatites (Fransolet *et al.* 1998); the phosphate mineral associations of the Tsaobismund pegmatite (Fransolet *et al.* 1983, Fransolet *et al.* 1986); the intercrystalline cation partitioning between minerals of the triplite-zwieselite-magnotriplite and triphylite-lithiophilite series (Keller *et al.* 1994a); and the relationships about genesis and textures of the minerals belonging to the triphylite-lithiophilite and triplite-zwieselite series in granitic pegmatites (Keller *et al.* 1994b). Such works represent the result of the intense field survey and analytical activity performed by the three scientists.

François Fontan was born in Toulouse (France) in 1942, and passed away in July 2007 at the age of 64. François spent his career in research with the CNRS at the Université Paul-Sabatier in Toulouse (France). He obtained his Doctorat d'Etat (Ph.D.) in 1971, under the guidance of François Permingeat, defending the thesis entitled: "Etude minéralogique et essais expérimentaux sur des phosphates de fer et de manganèse de pegmatites des Jebilet (Maroc) et des Pyrénées (France)" (Fontan 1978). He was particularly involved in investigations of the mineralogy and genesis of phosphate minerals in the European granitic pegmatites at Cinco Villas, Fregeneda, Cañada, and Pinilla de Fremoselle in Spain (Fontan & Fransolet 1986, Pesquera *et al.* 1986, Roda *et al.* 1996, 1999, 2004). François Fontan also devoted part of his research activity to the study of silicate minerals and internal evolution of pegmatites (Fontan & Fransolet 1982, Mallo *et al.* 1995, Keller *et al.* 1999, Roda-Robles *et al.* 1999, 2004, 2005, Wang *et al.* 2006, 2007). During his career François Fontan discovered or contributed to the description of the following new mineral species: krautite (Fontan *et al.* 1975), luzacite

(Moelo *et al*. 2000), ferrorosemaryite (Hatert *et al*. 2005a), stanĕkite (Keller *et al*. 1997), and joosteite (Keller *et al*. 2007). The mineral species fontanite, $Ca[(UO_2)_3(CO_3)_4]\bullet 3(H_2O)$, a calcium uranyl carbonate from the Rabejac uranium mine (Lodève, Hérault, France), was named in recognition of his accomplishments (Deliens & Piret 1992). His last publication concerns pegmatitic phosphates with a structural study of the lithiophilite-sicklerite series (Hatert *et al*. 2012).

André-Mathieu Fransolet was born in Heusy (Belgium) in May of 1947. He took his degree in Geology at the Université de Liège in October of 1969. In 1975 he obtained his Ph.D. in Geological and Mineralogical Sciences at the same University defending the thesis: "Etude minéralogique et pétrologique des phosphates de pegmatites granitiques". At the Laboratoire, André-Mathieu Fransolet developed most of his fruitful research as Professor of Mineralogy and, for more than 20 years (1990–2012), also as Director of the Laboratoire de Minéralogie, until his retirement in October 2012. He is also a member of the Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique since 2004. During his research activity he was particularly active in studying mineralogy, crystal-chemistry, and petrology of pegmatitic phosphates (Fransolet 1975, 1977a, 1989, Hatert *et al*. 2006a, Vignola *et al*. 2011, Hatert *et al*. 2011). He studied the phosphate mineral associations of the African pegmatites of Buranga (Rwanda) and Angarf-Sud (Morocco) (Fransolet 1974, 1980, Fransolet & Abraham 1983, Fransolet *et al*. 1985, Fransolet 1987a, 1995). He was one of the pioneers of using experimental petrology of phosphates to understand the extreme efficacy of this science in deciphering the petrological characteristics of natural phosphate associations in granitic pegmatites (Antenucci *et al*. 1995, 1996, Hatert *et al*. 2000, 2002a, 2005b, 2006a, 2006b, Keller *et al*. 2006). During his career, André-Mathieu Fransolet discovered or contributed to the description of the following new mineral species: melonjosephite (Fransolet 1973), gatumbaite (von Knorring & Fransolet 1977), drugmanite (van Tassel 1979), mantiennéite (Fransolet *et al*. 1984), vantasselite (Fransolet 1987b), foordite (Černý *et al*. 1988), ercitite (Fransolet *et al*. 2000), graulichite-(Ce) (Hatert *et al*. 2003), stavelotite-(La) (Bernhardt *et al*. 2005), ferrorosemaryite (Hatert *et al*. 2005), and karenwebberite (Vignola *et al*. 2013). He had a particular interest in the systematic mineralogy of Belgium and published numerous papers on the mineralogy of Belgium (Fransolet 1972, Fransolet *et al*. 1974a, 1974b, 1974c, Fransolet & Mélon 1975, Fransolet & Bourguignon 1975, Fransolet 1977b, Fransolet *et al*. 1977, Fransolet & Bourguignon 1978a, 1978b, Fransolet 1978, 1979, 1982, Langer *et al*. 1984, Theye & Fransolet 1994, Hatert *et al*. 1996, Fransolet & Deliens 1977, Hatert *et al*. 1998, Schreyer *et al*. 2001, 2004) and two volumes on this subject (Mélon *et al*. 1976, Hatert *et al*. 2002b).

The phosphate hydrate of calcium and beryllium from the Tip Top pegmatite (Custer County, South Dakota) $[Ca_3Be_2(PO_4)_2(HPO_4)_2\bullet 4H_2O]$ was named fransoletite in his honor (Peacor *et al*. 1983).



Paul Keller was born in Sarata (Romania) in 1940. In 1973 he obtained his degree in Geology defending

a thesis on the crystal-chemistry of phosphates and arsenates at the University of Stuttgart (Germany). At the Institut für Mineralogie und Kristallchemie of the University of Stuttgart he developed most of his fruitful research as Professor of Mineralogy until his retirement in 2006. During the same period Paul Keller curated the mineralogical collection of the Institut für Mineralogie und Kristallchemie. His research focused on the phosphate mineral associations of the pegmatites of the Karibib region in Namibia (Keller & von Knorring 1985, Keller & von Knorring 1989), of Cañada and Pinilla de Fermoselle, Spain (Roda-Robles *et al*. 1998, Roda *et al*. 2004). He was particularly active in studying and describing crystal-chemical features of phosphates and arsenates (Keller 1971, 1972, 1973, 1974a). Paul Keller published several papers concerning the systematic mineralogy of the Tsumeb mineralization (Otjikoto Region, Namibia) and of Namibia in general (Keller 1974b, 1977a, 1977b, 1981, Keller & Bartelke 1982, Keller 1984, 1985, Keller & Innes 1986, Keller *et al*. 1999, Grieser *et al*. 1998, Roda *et al*. 2007).

During his career Paul Keller discovered and described, or contributed to the description of, the following new mineral species: queitite (Keller *et al*. 1979a); koritnigite (Keller *et al*. 1979b); warikahnite (Keller *et al*. 1979c); giniite (Keller 1980); otjisumebite (Keller *et al*. 1981a), jamesite (Keller *et al*. 1981b); o'danielite (Keller *et al*. 1981c); bartelkeite (Keller *et al*. 1981d); lammerite (Keller *et al*. 1981e); johillerite (Keller *et al*. 1982); plumbotsubite (Keller & Dunn 1982a); arsendescloizite (Keller & Dunn 1982b); scotlandite (Paar *et al*. 1984); mathewrogersite (Keller & Dunn 1986); chenite (Paar *et al*. 1986); zincroselite (Keller *et al*. 1986); barstowite (Stanley *et al*. 1991); damaraite (Criddle *et al*. 1990); stanekite (Keller *et al*. 1997); ekatite (Keller 2001); ferrorosemaryite (Hatert *et al*. 2005a); and joosteite (Keller *et al*. 2007).

The iron and bismuth phosphate from Schneeberg (Erzgebirge, Saxony, Germany) $[Bi_2Fe^{3+}(PO_4)O_2(OH)_2]$ was named paulkellerite in his honor (Dunn *et al*. 1988).

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