



Occurrence of Samarskite-Y in the Mineralized Umm Lassifa Pegmatite, Central Eastern Desert, Egypt

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Prejeto / Received 5. 7. 2015; Sprejeto / Accepted 10. 12. 2015; Objavljeno na spletu / Published online 30. 12. 2015

Key words: Samarskite-Y, microprobe analysis, Umm Lassifa granitic pegmatite, Eastern Desert, Egypt.

Abstract

Samarskite-Y, with an average assay of about 43.23% Nb₂O₅ and 17.43% Y₂O₃ has been identified in the mineralized pegmatite bodies injected in Gabal Umm Lassifa monzogranite. The mineral is associated with columbite, zircon, monazite, cassiterite, ilmenite and rutile. The mineralogy and geochemistry of the studied samarskite variety were determined using microscopic examination and X-ray Diffraction (XRD) as well as quantitative analysis by both Field emission scanning electron microscope and electron microprobe analysis. Microscopic investigation revealed that the defined samarskite crystals are characteristically velvet-yellow brown to bloody red in color and having a characteristic pendent vitreous or resinous luster.

Analytical data confirmed the presence of samarskite-Y whose composition corresponding to empirical formula: [(Y_{0.42}, REE_{0.44}, Th_{0.076}, Si_{0.05}, Ca_{0.007}, U_{0.07}, Fe_{0.077}) Σ_{1.15} (Nb_{0.61}, Ta_{0.04}, Ti_{0.14}) Σ_{0.86} O₄]. Accordingly, the mineralized Umm Lassifa pegmatite can be considered as a promising target ore for its rare-metal mineralization that includes mainly Nb, Ta, Y, REE and Zr together with U and Th.

Introduction

Several studies worldwide have revealed the presence of granite-pegmatite-hosted rare-metal mineralization including Nb-Ta oxides and zircon (e.g., MATSUBARA et al., 1995; HANSON et al., 1999; ERIC, 2005; WILLIAM et al., 2006; PAL et al., 2007; RASLAN et al., 2010). The Umm Lassifa area is located some 70 km to the southwest of El Qusier city at the Red Sea Coast, Central Eastern Desert of Egypt. It lies between longitudes 34° 12' and 34° 20' E and latitudes 25° 36' and 25° 38' N (Fig.1). Several workers studied the regional geology of the studied area (e.g., AMIN & MOHAMED, 1954; KAMAL EL-DIN., 1995, KHUDIER et al., 1995; ALI, 2001, ABDEL WAHED et al., 2005).

The studied pegmatites present in the monzogranite of Umm Lassifa pluton are restricted to along the contact with granodiorite (Fig. 1). The monzogranite forms the main granitic mass of Umm Lassifa pluton. The studied pegmatites occur either as small pockets or as vein like bodies and usually of composite type. These pegmatite bodies are of variable size ranging between 1–3 m in width and 2–6 m in length (Fig.1). The mica pockets are common and restricted in association with feldspar.

Most occurrences of radioactive minerals of Egypt are in granites and associated pegmatites. Several Nb-Ta occurrences have been recorded in

different localities of the Eastern Desert, namely, El Naga, Abu Khurg, Abu Dabbab, Noweibi, and Abu Rushied (HUSSEIN, 1990; RASLAN & ALI, 2011). It is interesting in this regard to mention that author identified Samarskite-Y, columbite and zircon from Ras Baroud granite –pegmatite in the Central Eastern Desert (RASLAN et al., 2010) and in the stream sediments surrounding the Ras Baroud granitic pluton (RASLAN, 2009). Moreover, ishkawaite (uranium-rich samarskite) with an average assay of approximately 50% Nb₂O₅ and 26% UO₂ has been identified for the first time in Egypt in the mineralized Abu Rushied gneissose granite (RASLAN, 2008).

Abu Rushied gneissose granite (RASLAN, 2008). In addition, RASLAN and ALI (2011) identified ferrocolumbite, ishkawaite, uranopyrochlore, and fergusonite in the rare-metal pegmatites of Abu Rushied granitic gneisses. Accordingly, the aim of the present paper is to identify the mineralogical and geochemical characteristics of samarskite-Y variety in the studied area.

Methodology

To verify the objectives of this study, a representative sample of the mineralized Umm Lassifa pegmatite was collected. The sample was properly crushed, ground and sieved to size fractions between 0.800 mm – 0.063 mm before subjected to heavy liquid separation using

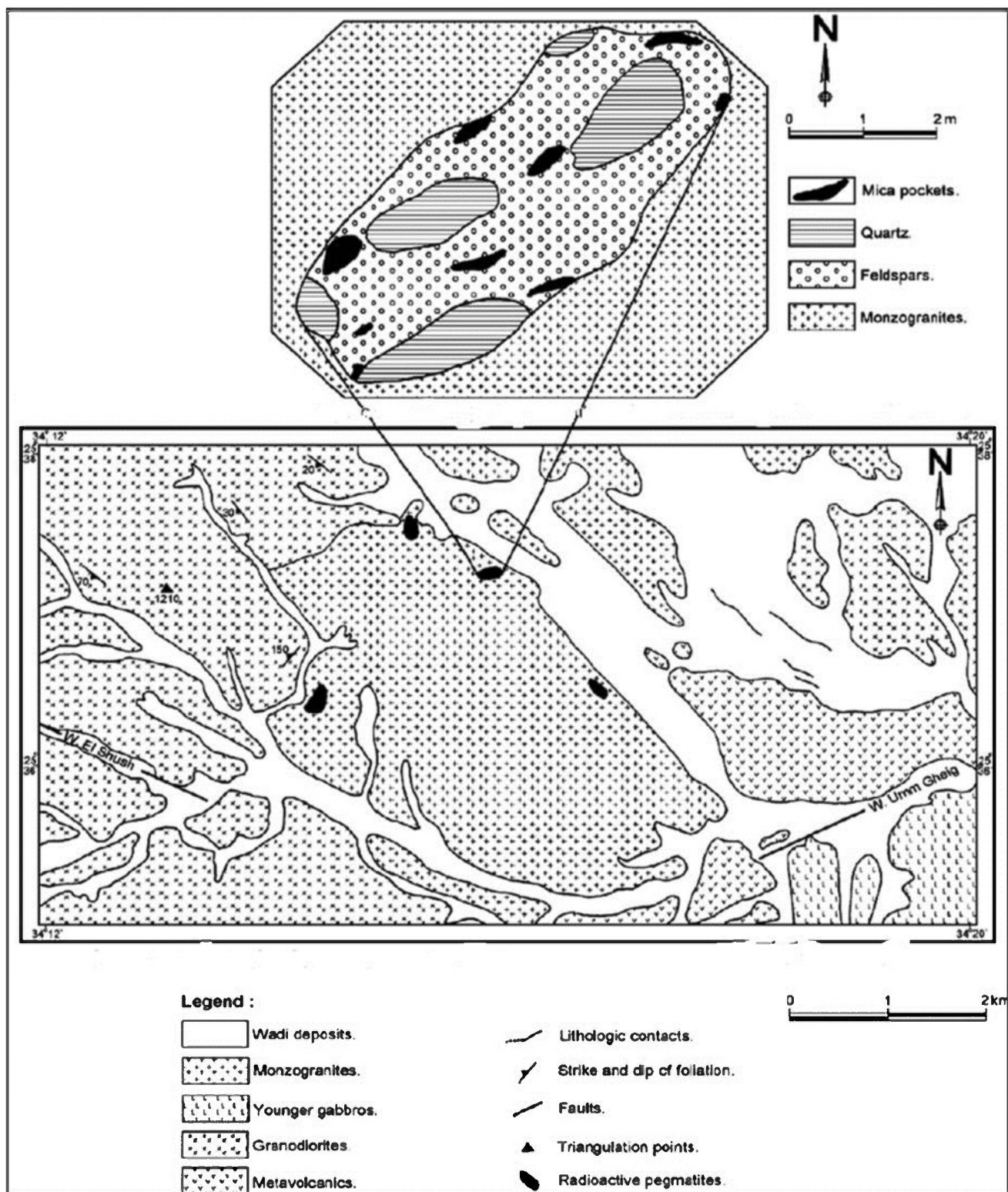


Fig.1. Geologic map of G. Umm Lassifa, Central Eastern Desert, Egypt and sketch showing the studied composite pegmatite pocket in the monzogranite of G. Umm Lassifa.

bromoform (specific gravity=2.85 gm/cm³). From the obtained heavy fractions, pure mineral grains of samarskite variety were handpicked and investigated under the binocular microscope. Some of the picked mineral grains were subjected to X-ray Diffraction analysis using a Phillips X-ray diffractometer (Model PW-105018) with a scintillation counter (Model PW-25623/00) and Ni filter and an environmental scanning electron

microscope (ESEM). This instrument includes Philips XL 30 energy-dispersive spectrometer (EDS) unit. The applied analytical conditions were an accelerating voltage of 30 kV with a beam diameter of 1–2 µm for a counting time of 60–120 s and a minimum detectable weight concentration ranging from 0.1 to 1 wt%. All these analyses were carried out at the laboratories of the Egyptian Nuclear Materials Authority (NMA).

In addition, the studied samples were analyzed using the field emission scanning electron microscope (JEOL 6335F) at the Particle Engineering Research Center (PERC), University of Florida, USA. This instrument is fitted with an Oxford Energy Dispersive X-ray spectrometer (EDS) for elemental analysis of micro areas, a backscattered electron detector that allows compositional imaging. The applied analytical conditions were an accelerating voltage of 0.5 – 30 kV, 1.5 nm (at 15 kV/5.0 nm (at 1.0 kV). The imaging modes were secondary electron imaging (SEI) and backscatter electron imaging (BEI). Lines scan of relative concentrations of multiple elements, and X-ray maps of relative concentrations of multiple elements were also performed.

Finally, thin, polished sections of some mineral grains were also analyzed using a JEOL Superprobe 733, at the Particle Engineering Research Center (PERC), University of Florida, USA, with an accelerating voltage of 15 kV and a beam size of approximately 1 μm . The used standards for analysis included niobium metal (for Nb), tantalum metal (for Ta), biotite (for Ti-Fe-Si), uranium metal (for U), monazite (for Th), fluorite (for Ca), and cubic zirconia (for Zr-Y).

Results and discussion

Microscopic investigation

Under the binocular microscope, the examined samarskite crystals were found to be distributed in almost all size fractions between 0.800 mm - 0.063 mm. The defined samarskite crystals are generally massive with a granular form and having a characteristic vitreous or resinous luster (Fig. 2). Also, the investigated mineral crystals are generally translucent, compact, metamict and hard. Under a polarizing microscope, the samarskite grains are mainly velvet-yellow brown to bloody red in colour (Figs.3 A,B,C and D). They occur as translucent grains that are 0.1– 0.5 mm in size (Fig.3). Separated samarskite grains are present as short prismatic to tabular crystals, exhibiting vitreous luster and

conchoidal fractures. Samarskite grains commonly exhibit partial to complete alteration effects along micro cracks and grain boundaries as well as the metamictization effect (Fig.3). Altered varieties are darker brownish to opaque in thin sections and whitish grey in reflected light (Figs.3E and F).

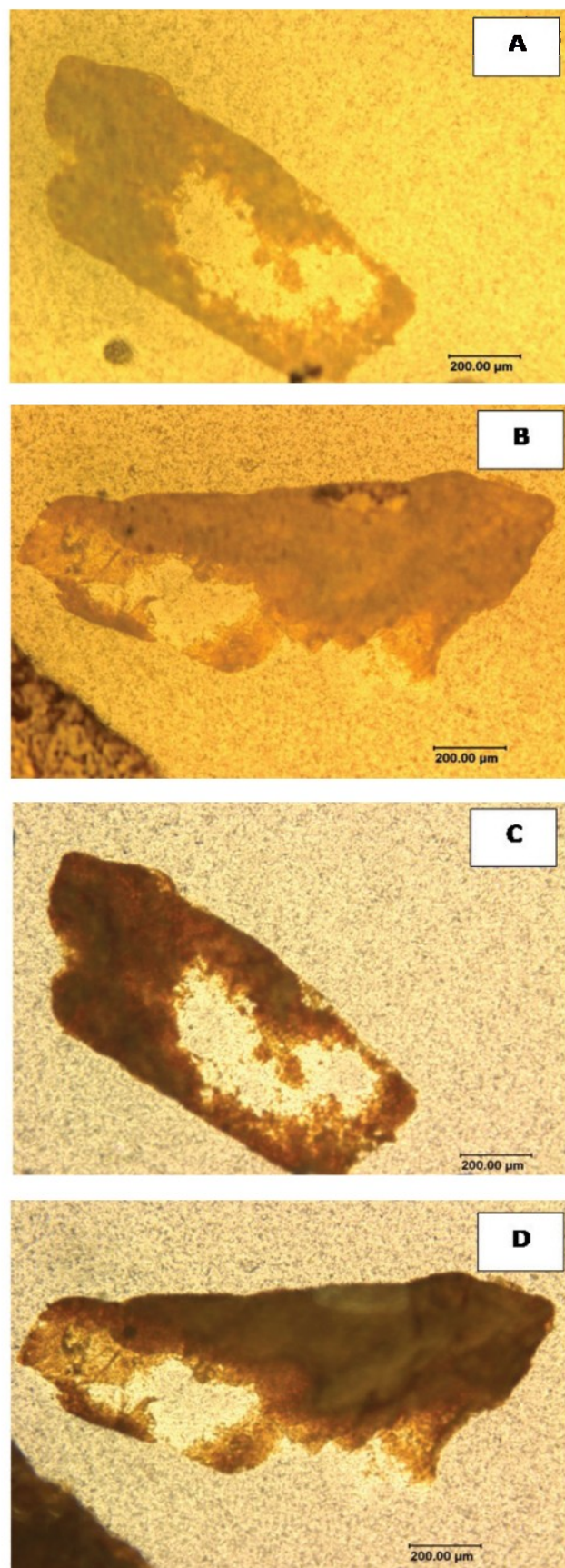


Fig. 2. Samarskite-Y crystals exhibiting massive granular shape with reddish brown colour, Binocular microscope

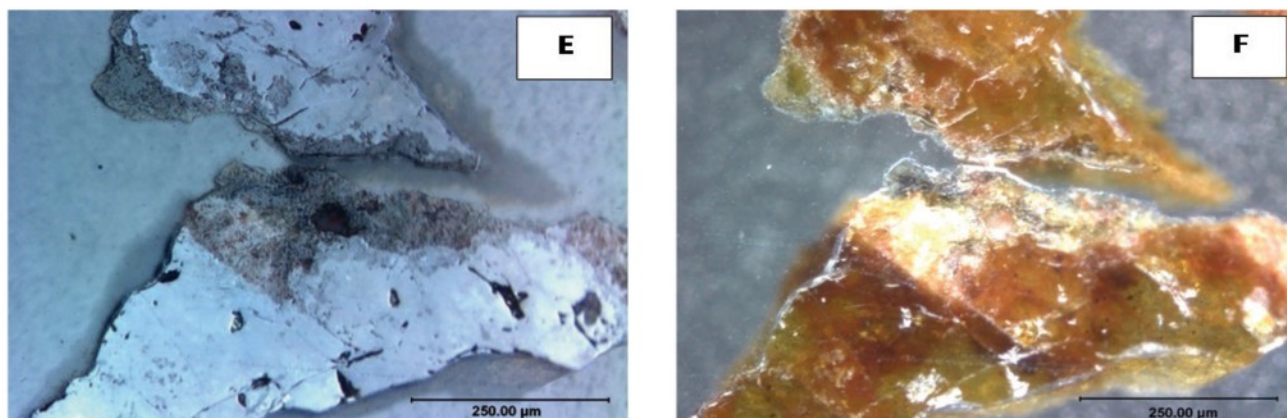


Fig. 3. Umm Lassifa samarskite-Y crystals in thin sections:

A-B: velvet-yellow brown to bloody red crystals exhibit partial to complete alteration effects along micro cracks and grain boundaries, Polarized light, PL. C-D: The same crystals as in previous photos between crossed Nichols, C.N. E-F: Altered crystals showing variation in colour between reflected light and crossed Nichols respectively.

X-ray Diffraction

Pure monomineralic sample from samarskite grains was prepared by hand picking and subjected to XRD analyses. The obtained XRD data for samarskite after annealing (heat treatment) are presented in (Fig. 4). The data conforms to the ASTM card index No. 2-0690 for samarskite.

Scanning electron microscope study

ESEM data of the studied samarskite grains (Figs. 5A and B) show that the mineral is enriched in Nb and Y whereas the contents of the other REEs are much lower such as Ce, Nd, Sm, Gd and Yb. Uranium and thorium are commonly present as minor elements. On the other hand, several samarskite grains have also been subjected to semi-quantitative analyses using a field emission scanning electron microscope coupled with EDS. The obtained EDS data (Figs. 5E and F) show Nb, Y and REE as the essential components and U and Th as minor elements, which confirmed the ESEM/EDS results. The distribution of uranium and thorium within the crystal is actually heterogeneous and their contents increase in the bright parts within the crystal and also with increasing Y. Scan-line elemental analyses along the crystals (Figs. 5C and D) and the elemental scan maps for some samarskite crystals reflect the predominant elements in the mineral such as Nb and Y (Fig. 6). The presence

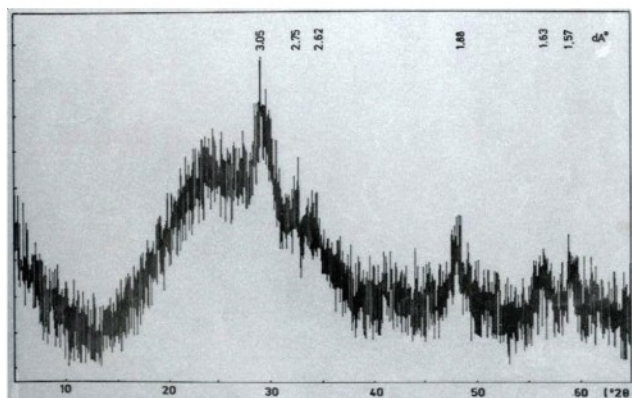


Fig. 4. XRD diffractogram for samarskite (ASTM card No. 2-0690).

of Br and Rb indicated in Figs. 5e, f and Fig. 6 is probably a result of spectral overlap between Al K α and Br L α peaks, and between Rb L α and Si K α .

Electron microprobe analyses

The obtained microprobe analyses (Table 1) of the investigated samarskite have resulted in the following average composition in wt%: Nb₂O₅, 43.23; Ta₂O₅, 3.66; TiO₂, 0.44; UO₂, 4.38; ThO₂, 4.65; Y₂O₃, 17.43; MnO, 0.32; CaO, 0.26; FeO, 2.30; SiO₂ 1.74 and total REE of 22.09 with an average sum of 100.50 wt%. Table 1 shows the chemical empirical formulae that is recalculated on the basis of 4 oxygen; viz, [(Y_{0.35}, REE_{0.44}, Th_{0.07}, Si_{0.05}, Ca_{0.007}, U_{0.07}, Fe_{0.07}) $\Sigma_{1.05}$ (Nb_{0.67}, Ta_{0.55}, Ti_{0.01}) $\Sigma_{0.74}$ O₄]. The microprobe analyses were plotted on a ternary diagram of HANSON et al., (1999) which shows the A-site occupancy of the samarskite group of minerals (Fig. 7). It was found that all the data points plot in the samarskite-Y field.

Samarskite belongs to a group of Nb-Ta mineral varieties that occur in granite pegmatite and have the general formula A_mB_nO_{2(m+n)}, where A represents Fe, Ca, REE, Y, U and Th whereas B represents Nb, Ta and Ti. According to HANSON et al., (1999), samarskite-group minerals should include only those that have Nb>Ta and Ti in the B-site. Additionally, this group of minerals contains at least three species based on A-site chemistry. If REE+Y are dominant, the name samarskite-(REE+Y) should be used with the dominant of these cations as a suffix. If U+Th is dominant, the mineral is properly named ishikawaite whereas if Ca is dominant, the mineral should be named calciosamarskite. However, the exact nature of these minerals cannot be determined due to inability to quantify the valence state of iron present and dominant at the A-site in these minerals. Ishikawaite and calciosamarskite are light rare-earth element (LREE) depleted and heavy rare-earth element (HREE) enriched with Y dominant. Recently, samarskite-Yb has been identified as a new species of the samarskite group (WILLIAM et al, 2006). NICKEL and MANDRINO (1987) described samarskite-Y as a mineral with Y+REE dominant at A-site.

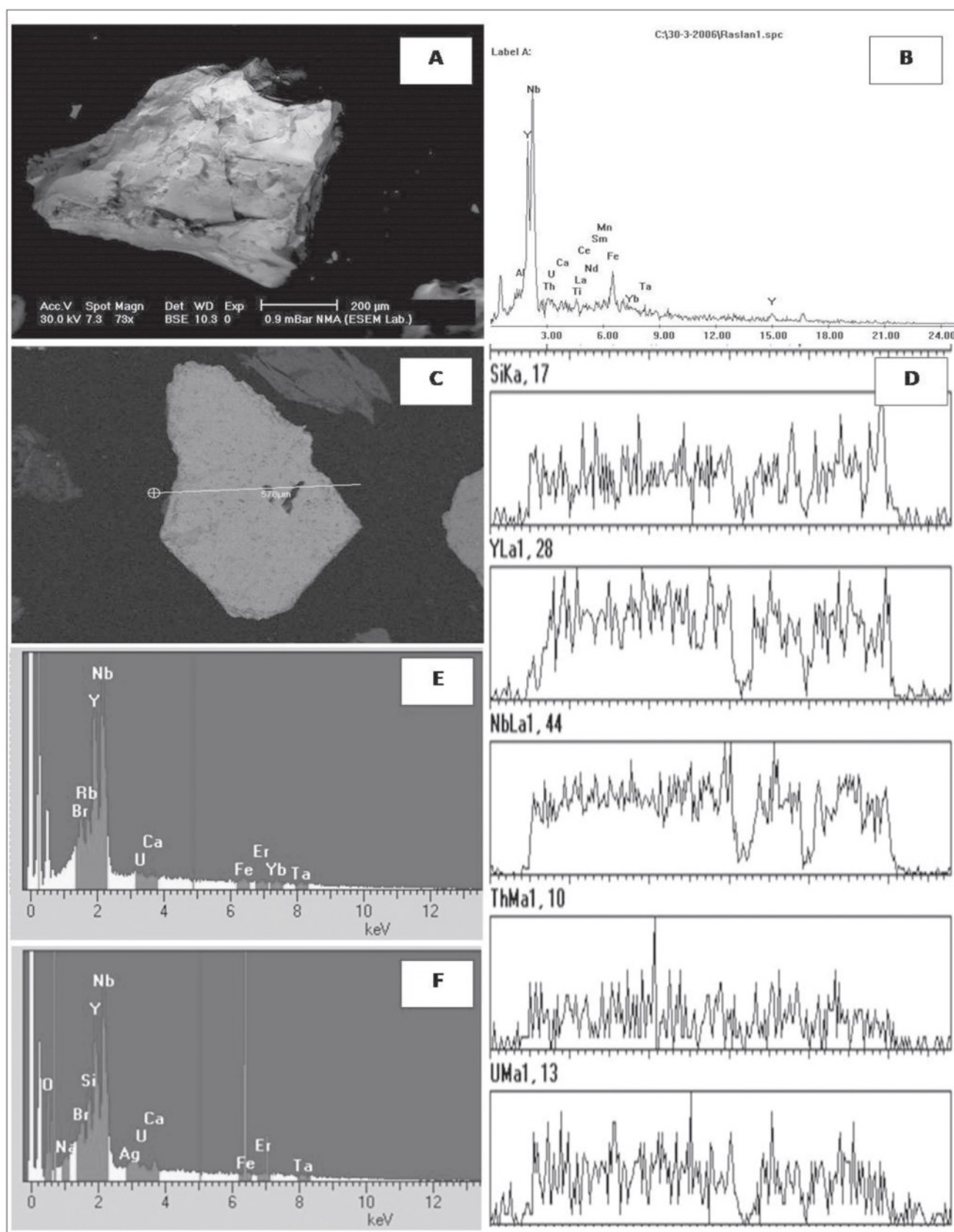


Fig. 5. SEM data of Umm Lassifa samarskite-Y. A-B: Backscattered electron image and corresponding EDX spectrum. C-D: BEI of a samarskite crystal with scan-line and its elemental scan-line analyses. E-F: EDX spectrum of samarskite-Y.

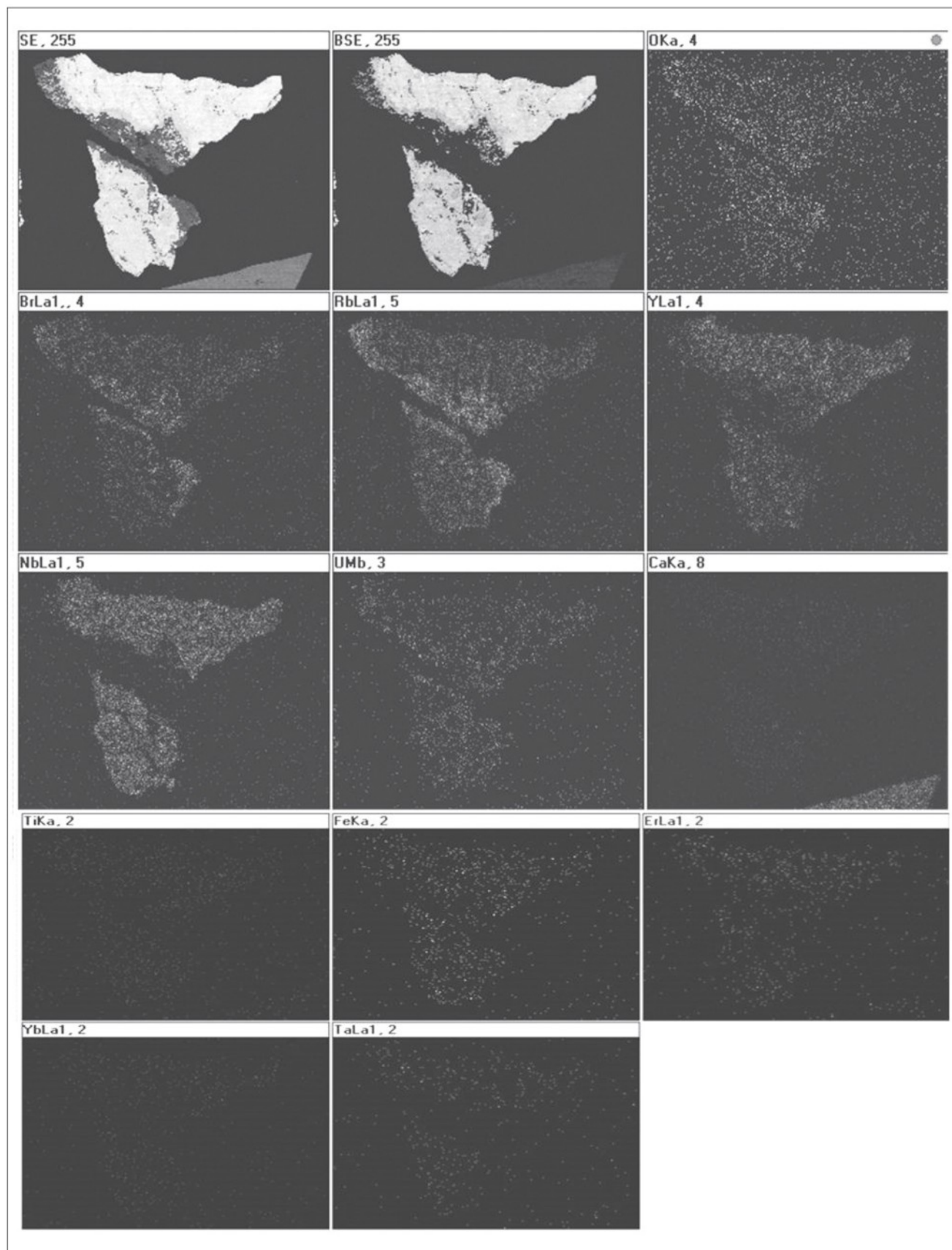


Fig. 6. Scan-maps showing the distribution of major and minor elements within samarskite-Y crystals.

From the obtained data, it is quite clear that the studied Nb-Ta mineral variety of Umm Lassifa pegmatite reflects the chemical composition of Y- and REE-rich samarskite species. The lines of evidence of the latter (samarskite-Y) can be summarized as follows:

1. The obtained EMPA data revealed that Nb_2O_5 is dominant in the investigated mineral where it attains content of 43.23 wt% in average. The sum of average content of Ta_2O_5 and TiO_2 attains 4.10 wt%, which is much lower than content of Nb_2O_5 . The samarskite group comprises only those species in which the Nb content in B-site is higher than that of Ta and Ti. (HANSON et al., 1999).
2. The studied mineral actually falls within the compositional limits of both samarskite-Y and ishikawaite. Both samarskite-Y and ishikawaite have a dominant Nb in the B-site and the distinction between the two varieties must be based on the content of A-site occupancy.
3. In the studied Umm Lassifa samarskite species, the Y_2O_3 content ranges from 16.25 wt% to 18.87 wt% with an average of 17.43 wt% and the sum of REE ranges from 18.20 wt% to 24.19 wt% with an average of 22.09 wt%. Accordingly, the average Y+REE would attain up to 39.52% and samarskite-Y has been described as the mineral species in which Y+REE are the dominant components at the A-site (NICKEL & MANDARINO, 1987).
4. The studied samarskite species separated from Umm Lassifa pegmatite is characterized by the dominance of Y+REE in the A-site whereas Nb in the B-site is higher than both Ta+Ti. Therefore, the studied mineral species belongs to the compositional limits of samarskite-Y mineral species as specified in the literature.

Table 1. Selected EMPA analyses of samarskite-Y from Umm Lassifa pegmatite. Oxide contents are in wt%.

Oxides	Samarskite-Y				Average
	1	2	3	4	
TiO_2	0.54	0.20	0.57	0.46	0.44
Nb_2O_5	46.42	43.54	42.24	40.70	43.23
SiO_2	0.72	0.65	2.99	2.61	1.74
Ta_2O_5	2.53	3.53	5.13	3.46	3.66
MnO	0.25	0.36	0.12	0.55	0.32
UO_2	2.60	4.01	6.60	4.32	4.38
CaO	0.15	0.18	0.48	0.23	0.26
ThO_2	4.72	3.80	6.36	3.71	4.65
FeO•	1.56	1.19	2.72	3.74	2.30
Y_2O_3	17.05	17.55	16.25	18.87	17.43
ΣREE	22.50	24.19	18.20	23.48	22.09
Total	99.04	99.20	101.66	102.13	100.50
Chemical formula of Samarskite-Y based on 4 oxygen					
Ti	0.017	0.006	0.018	0.014	0.014
Nb	0.87	0.83	0.80	0.75	0.81
Si	0.02	0.02	0.09	0.08	0.05
Ta	0.03	0.04	0.06	0.04	0.04
Mn	0.009	0.013	0.004	0.019	0.01
U	0.04	0.06	0.11	0.07	0.07
Ca	0.004	0.005	0.013	0.006	0.007
Th	0.07	0.067	0.11	0.06	0.076
Fe	0.05	0.04	0.09	0.13	0.077
Y	0.41	0.43	0.39	0.44	0.42
ΣREE	0.45	0.48	0.36	0.46	0.44
Sum A	1.05	1.11	1.17	1.26	1.15
Sum B	0.917	0.876	0.878	0.804	0.86

FeO•= total iron as oxide

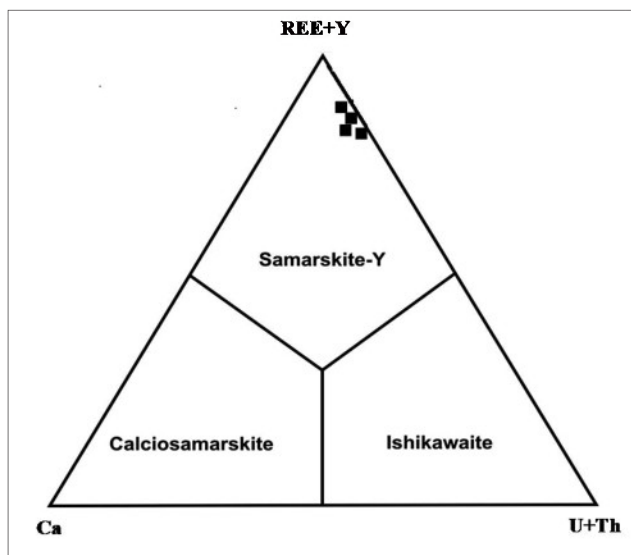


Fig. 7. Ternary diagram showing A-site occupancy of the samarskite group of minerals after HANSON et al. (1999). Umm Lassifa samarskite-Y is represented by closed squares.

Conclusions

Microscopic investigation, SEM, XRD and microprobe analyses confirm the presence of a samarskite-Y mineral species. The obtained microprobe analyses of the investigated samarskite have resulted in the following average in wt. %: Nb_2O_5 , 43.23; Ta_2O_5 , 3.66; TiO_2 , 0.44; UO_2 , 4.38; ThO_2 , 4.65; Y_2O_3 , 17.43; MnO , 0.32; CaO , 0.26; FeO , 2.30; SiO_2 1.74 and total REE of 22.09 with an average sum of 100.50 %. Also, the microprobe analyses revealed the empirical formula: $[(\text{Y}_{0.42}, \text{REE}_{0.44}, \text{Th}_{0.076}, \text{Si}_{0.05}, \text{Ca}_{0.007}, \text{U}_{0.07}, \text{Fe}_{0.077}) \Sigma_{1.15} (\text{Nb}_{0.81}, \text{Ta}_{0.04}, \text{Ti}_{0.14}) \Sigma_{0.86} \text{O}_4]$. The mineral is associated with columbite, zircon, monazite, cassiterite, ilmenite and rutile. The mineralized Umm Lassifa pegmatite can be considered as a promising target ore for its rare-metal mineralization that includes mainly Nb, Ta, Y, REE and Zr together with U and Th.

Acknowledgments

The performed analyses by field emission scanning electron microscope (JEOL 6335F) and a JEOL Superprobe 733 were carried out in the Material Science and Engineering Research Center. Major Analytical Instrumentation Center (MAIC) and Particle Engineering Research Center (PERC), University of Florida, USA.

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