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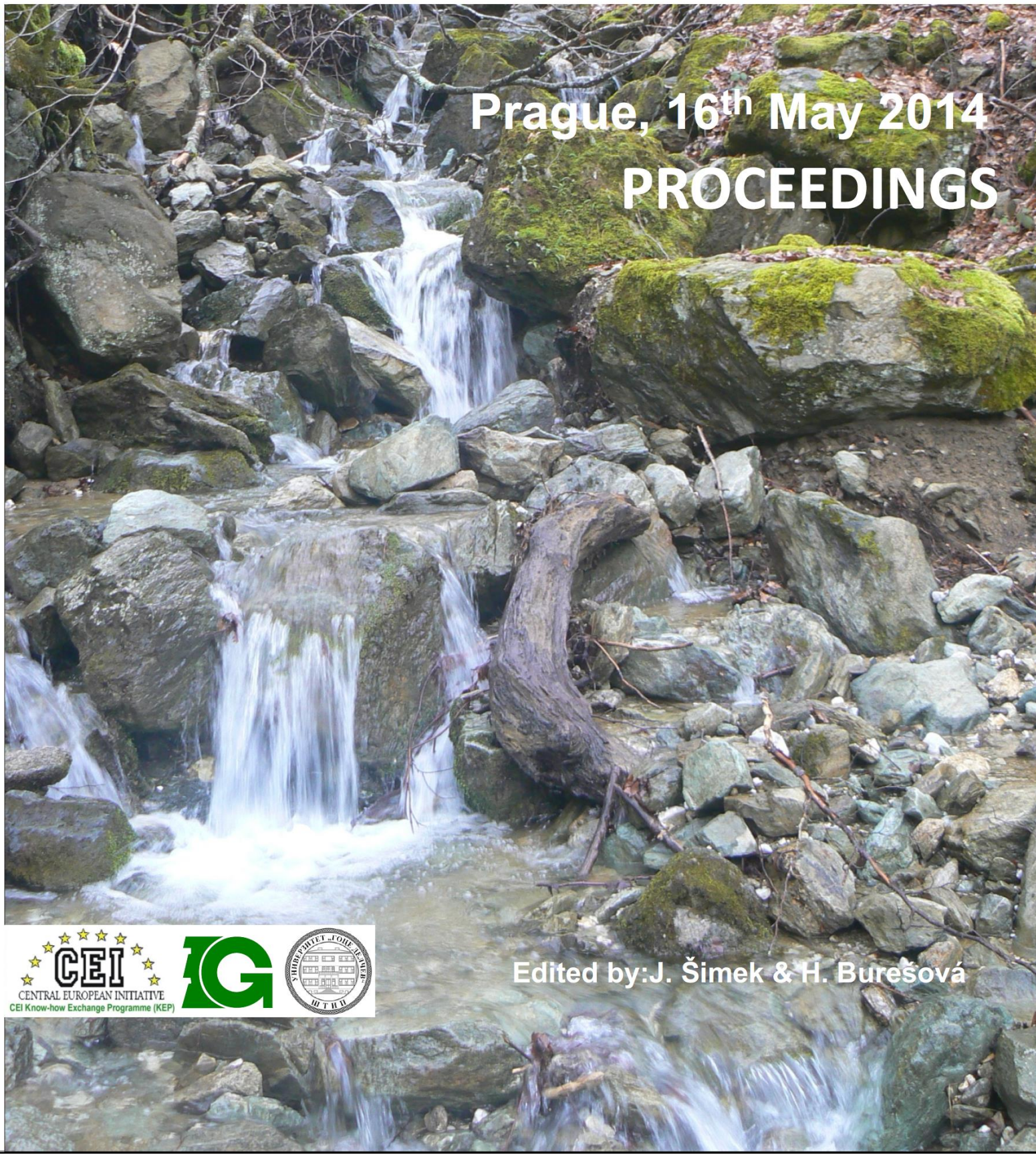
2nd INTERNATIONAL WORKSHOP

Environmental impact assessment of the Kozuf metallogenic district in southern Macedonia in relation to groundwater resources, surface waters, soils and socio-economic consequences (ENIGMA)



Prague, 16th May 2014

PROCEEDINGS

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Edited by:J. Šimek & H. Burešová

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ON THE PROJECT

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16th May 2014, Prague – Czech Republic

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PLACER GOLD AND FOLLOWING MINERALS ALONG THE STARA REKA AROUND THE LUKAR WATER INTAKE, KOZUF AREA, R. MACEDONIA

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Abstract: This paper presents study of the chemical composition and forms of gold aggregates that were found during schlich prospection along the Stara Reka and Lukar river in the Kozuf volcanic area, which is associated with Tertiary magmatism in the R . Macedonia. Study have shown that it is native gold characterized by high purity ranging from 892 to 994 with certain impurities. Silver concentrations range from 0.57 to 11.61 %Ag, other impurities (Fe, Cu, Se, Te, Bi) are present under 1 % in total. Morphological forms of gold usually with irregular-isometric shapes dominate, while it can be seen elongated and round shapes too. The size of the gold aggregates ranges from 100 to 200 μm.

Key words: schlich prospection, morphology, chemical composition, irregular forms, gold grains.

INTRODUCTION

Kozuf area is a large volcanic complex located in the southern part of the Republic of Macedonia and has been developed in the area of the mountain range Kozuf. The geological structure of Kozuf area (Fig. 1) includes more stratigraphic complexes (Boev et al 1993; Jankovic et al. 1997, Volkov et all, 2006).

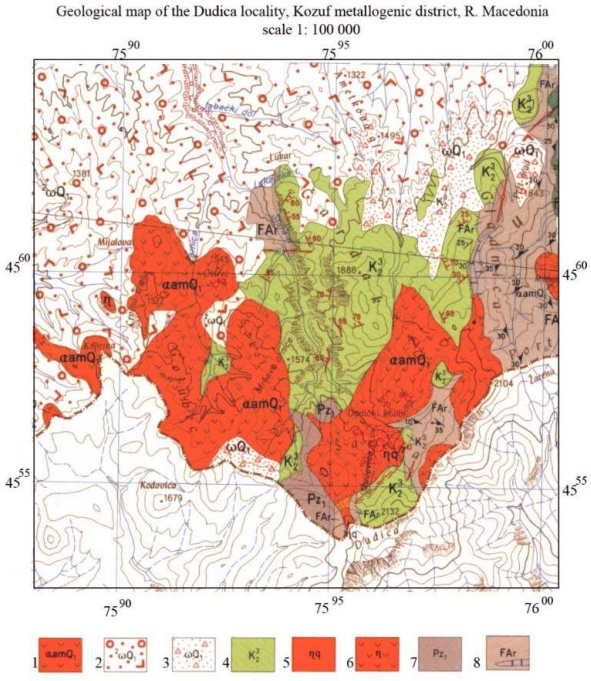


Fig. 1. Geological map of part of Kozuf area (section of BGM)
1. Amphibolitic andesite; 2. Agglomerative breccia tuff; 3. Breccia tuff; 4. Tabular limestone; 5. Quartz keratophyre; 6. Keratophyre; 7.Quartz porphyries; 8. Phyllite, slate, sandstone and marble

More specifically this includes: Precambrian metamorphic rocks, Paleozoic metamorphic rocks, Triassic-Jurassic sedimentary rocks, sediments of Upper Cretaceous complex of rocks, sediments of the Upper Eocene complex , a complex of Pliocene and pyroclasts, complex Quaternary sediments.

The geological structure includes magmatic rocks. Previous studies indicate volcanic activity represented by volcanic neck or hardened inlet channels and a large amount of pyroclastic material. Also recorded are the phenomena of post-volcanic activity .

Elluvial - alluvial gold undoubtedly bears particular marks of the endogenic gold. To the physic- chemical features of this gold contribute various factors: nature of primary gold , water power , morphology of the riverbed, transport distance and chemical composition of river water. Chemical features of alluvial grains and inclusions, if present, allows to determine the type of mineralization source, which in the early stages of regional research can help focus attention on the fields with the highest potential economic significance.

The main objective within this research was to study gold aggregates that were found during schlich prospection along the Stara Reka and Lukar, which drain a wide region within the Kozuf area. Sampling positions of particular samples are givenin Fig. 2

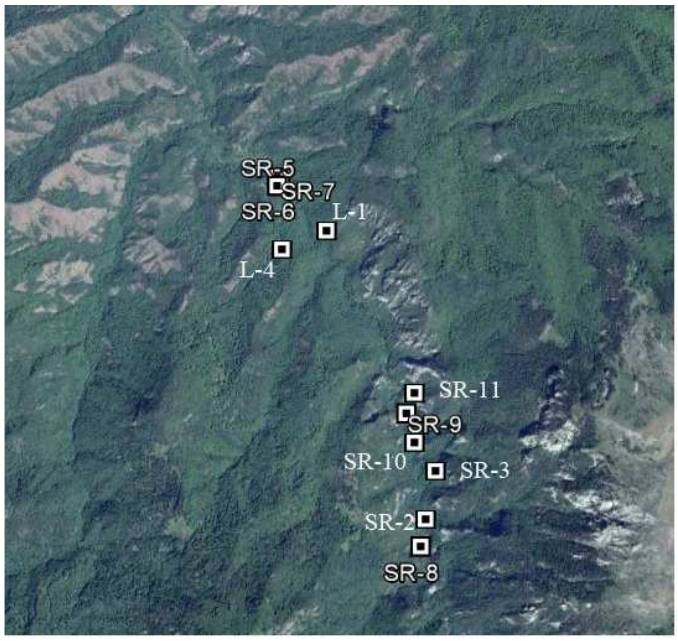


Fig. 2 Location of sampling position of schlich samples: SR-2 to SR-11-Stara Reka and L1-L2-Lukar

Methods and materials

Gold prospection was applied, where material of about 10–15 kg from each sampling location was taken. After panning, magnetic separation of the magnetic fraction was undertaken manually. Both fractions obtained were observed under binoculars. The gold aggregates found were separated manually and subjected to further study. To determine the morphological features of the gold – primarily the roundness, flatness, and serration of the grains – scanning electron microscopy (SEM) was used. This type of analysis allowed the length of the transport and nature of the environment in which the pan material was deposited to be determined. The SEM study was undertaken in the electron microscopy laboratory within the Faculty of Stip University, Macedonia.

Analyses were performed on a VEGA3 LMU.
The etalons were from TESCAN. The specific operating conditions were:
-Tension: 20 keV
-Test Method: EDS
-Type of analysis: Quantitative
- X-act: 10 mm^2 (Slicon Drift detector)
-Max resolution: 125 EV
-Resolution of MnKα, FKα,CKα: according to ISO 15632:2012

Results and discussion

Our research has shown the presence of gold in the two studied rivers. Total of 11 schlich samples were taken, nine from the Stara Reka and two samples from the Lukar. In 5 of the studied samples was determined the presence of gold, in Stara Reka total of 5 gold aggregates and in the Lukar 3 gold aggregates were found.

Table-1 Number of gold aggregates in sampels

	Number of gold aggregates
Samples 1-Lukar	1
Samples 2-Old River	2
Samples 3- Old River	1
Samples 4 -Lukar	2
Samples 5- Old River	2

Beside gold aggregates in schlich samples there was determined presence of other metal and non-metallic minerals, which relative presence is given inTable2

Table 2- Mineralogical composition in schlich from the Stara Reka and Lukar

	Gold	Pyrite	Chalcopyrite	Galenite	Sphalerite	Magnetite	Zirkon	Epidote
Sample L-1	1	•	-	-	•	•••	•	•
Sample SR-2	2	••	•	•	-	•••	•••	•••
Sample SR-3	1	•••	-	•	-	•••	•••	••
Sample L-4	1	•	-	•	•	•••	•	••
Sample SR-5	2	••	•	-	-	•••	•••	•••
Sample SR-6	-	••	•	-	-	•••	•••	•••
Sample SR-7	-	••	-	-	-	•••	•••	•••
Sample SR-8	-	•••	-	-	-	•••	•••	•••
Sample SR-9	-	•••	-	•	•	•••	•••	•••
Sample SR-10	-	•••	•	•	-	•••	•••	•••
Sample SR-11	-	•••	•	•	-	•••	•••	•••

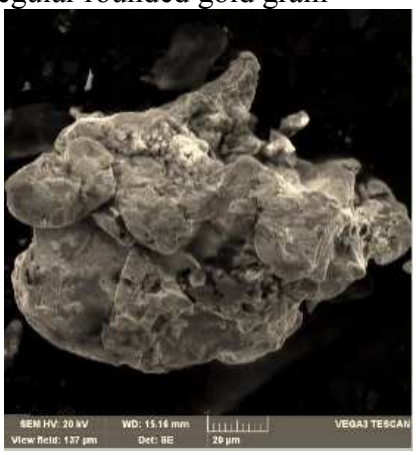
• rare
•• weakly present
••• present

The table shows that despite gold, of other metallic minerals was determined high presence of magnetite and low presence of galena, sphalerite and chalcopyrite. Gold is characterized by very small dimensions ranging from 100 to 200 μm. The morphology of the aggregates is different.

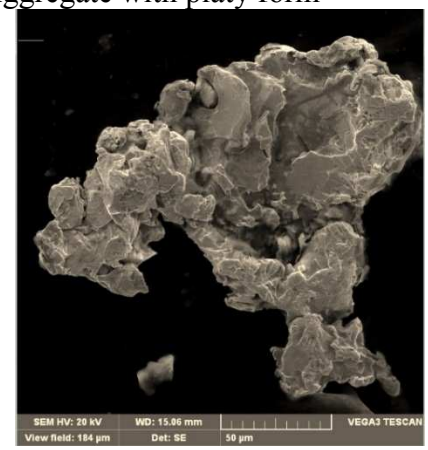
Prevails irregular-isometric form (see 4c, 4e), but also can be found irregular elongated circular forms (4a, 4e, 4g,), circular form (4f and 4h) and flat form (4b).

a- irregular rounded gold grain

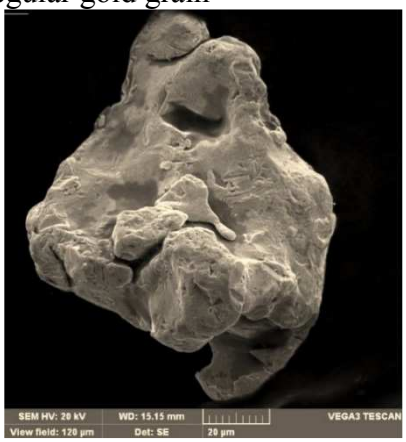
b- Aggregate with platy form



c- irregular gold grain

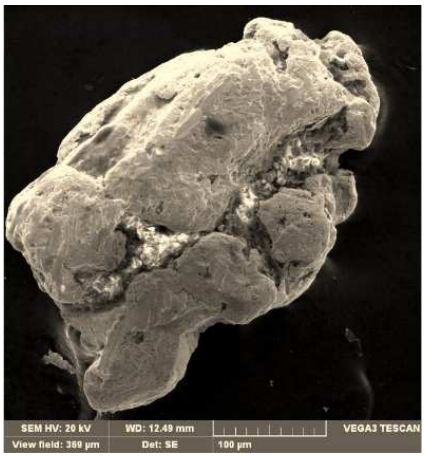


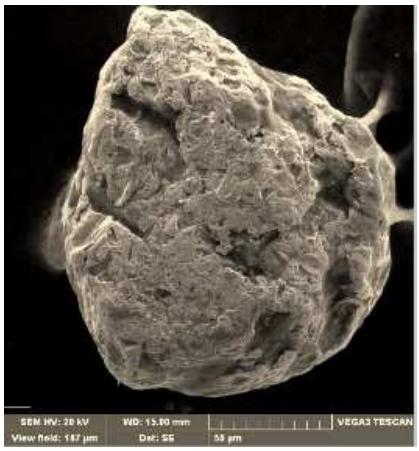
d- irregular elongated gold grain



e-irregular gold grain

f– Aggregate with spherical form





g- irregular elongated gold grain h- Aggregate with spherical form

Fig. 4 Morphological forms of matching gold aggregates of Stara Reka and Lukar river

The measurements of the shape of gold grains, mostly those with circularform, the degree of curvature and flatness may indicate the type of source and the length of the transport (Mudaliar et all. 2007, Knight, 1999).

The morphology of gold aggregates is poorly preserved. In studied gold grains observed curvature of the edges and smoothing of the grain surface (Figure 4) and simultaneous increase of flatness which may be due to the significant transport of gold and primarily due to the small hardness and malleability of gold as a mineral . This phenomenon may also indicate that the grains were subjected to secondary processes. Flatness can be explained by the fact that during transport the grains collide with grains of other minerals from harder rocks leading to increased flatness a function of the length of transport (Knight et al., 1999; Townley et al., 2003 ; Tishcenko et al, 1981) . Yet flatness varies , depending on the size of the grains because the larger grains (1-2 mm) are more exposed (Knight et al., 1999) , smaller than grains ranging in size from 8 -16 mm. Smaller grain than 60 microns are subject to much less flatness (Knight, 1994) .

As we concluded the non-metallic biotite and zircons are the most common minerals. Epidote is not that common. Analysis have shown that the chemical composition of gold content ranges from 88.87 – 99.43 % Au. The contents of silver ranges from 0.09 to 11.61 % Ag. Other admixtures of Fe, Cu, Se, Te and Bi are present in very small content below 1 %. This suggests that gold is of highest quality (Table-2).

Table -2 Chemical composition of gold aggregate

Sample	Analysis location	Fe	Cu	Ag	Au	Bi	Se	Te
L-1 grain-1	margin	0.02	0.25	10.76	88.87		0.11	
	center	0.41	0.19	9.66	89.15	0.04	0.11	0.44
SR-2 grain-1	margin	0.13	0.09	0.09	98.61	0.65		0.42
	center		0.74	0.82	98.44			
SR-2 grain-2	margin	0.02	0.12	8.58	90.97			0.30
	center			11.61	88.06			0.33
SR-3 grain-1	margin	0.65	0.72	1.63	96.83			0.17
	center	0.01		1.37	98.46			0.15
L-4 grain-1	margin	0.21		1.32	98.46			
	center	0.07	0.91	3.03	95.99			0.08
L-4 grain-2	margin	0.22		2.46	97.24			
	center	0.06	0.06	2.10	97.58			0.20
SR-5 grain-1	margin	0.30	0.45	0.71	98.54			
	center			0.57	99.43			
SR-5 grain-2	margin		0.06	2.93	96.16	0.44		0.41
	center	0.09	0.27	2.50	96.82	0.16	0.16	

Of particular interest in this schlich prospection was determination of the gold as mineral, the forms in which it occurs and chemical composition in order to determine, if possible, place the primary mineralization. This is especially important if you have in mind economic importance and interest that causes this metal. These results suggest the need for continuation of this surveying method that will encompass the entire flow of these streams and rivers that drainage this area.

CONCLUSION

- There are determined eight gold aggregates with small size ranging from 100-200μm.
- This results indicate the presence of gold and another metallic mineral
- Chemical composition provide high grade gold aggregate ranging from 892 to 994
-Other impurities such Fe, Cu, Se, Te, Bi are present under 1 % in total.
- Most frequently forms are irregular, elongated and round forms.

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