



TIRAMISU

Toolbox Implementation for Removal
of Anti-personnel Mines, Submunitions and Uxo

STATISTICAL ANALYSIS OF THE MINEFIELD RECORDS AND INDICATORS OF MINE PRESENCE

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Statistical analysis of the minefield records

- Mine record is one of the strongest indicators of mine presence (IMP) on the scene.
- The practice of humanitarian demining shows incompleteness of minefield records.
- Analysis of minefield records should be conducted to gain an objective insight into their quality and reliability.

Statistical analysis of the minefield records - 1

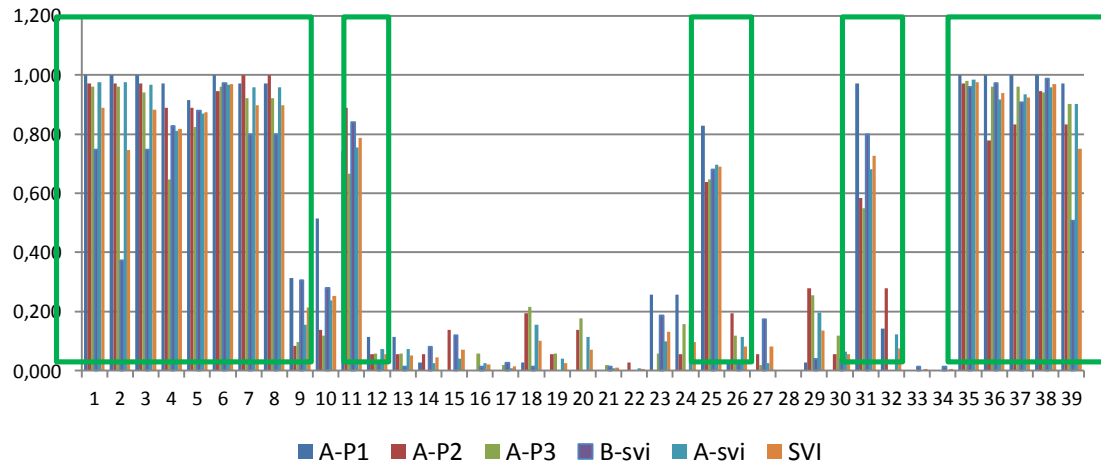
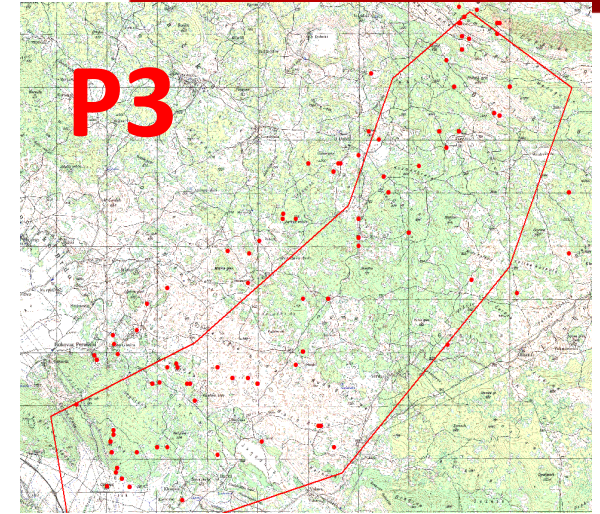
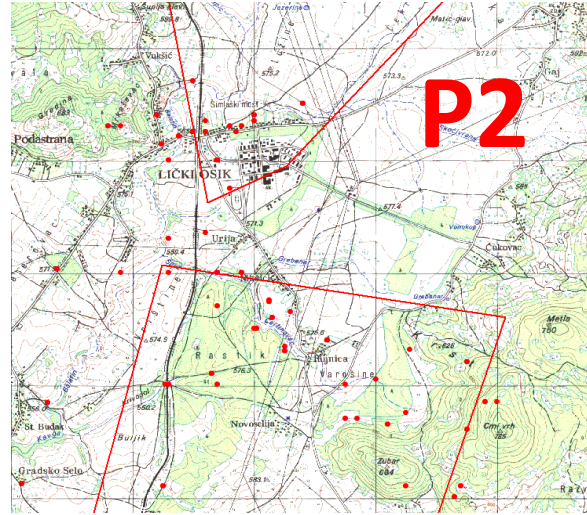
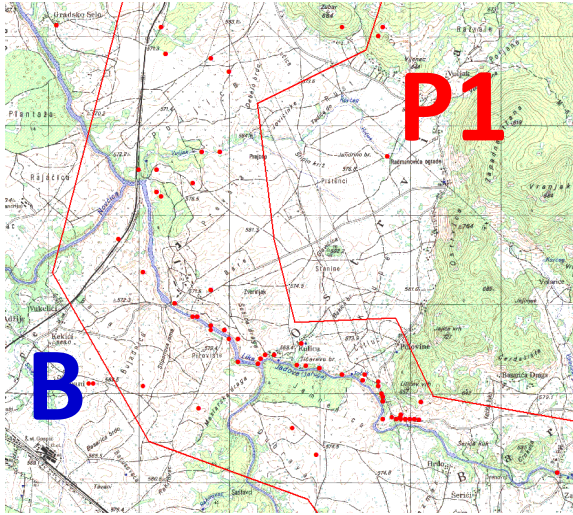
- 197 minefield records of one MSP-a.

- 122 from side A,
- 75 from side B.

- Office analysis revealed the existence of 39 different pieces of information (data from the 2011 i Croatia, nowadays is 44) that can be found in a minefield record.

- Classified into 5 categories

A - Kartografski podaci MEZ-a			C - Vrste i broj postavljenih mina			D - Karakteristike MEZ-a		
Br.	Informacija	Frekv.	Br.	Informacija	Frekv.	Br.	Informacija	Frekv.
1.	Naziv kartte	175	Protuoklopne mine			29.	Mješoviti MEZ	27
2.	Mjerilo karte	147	16.	TMM-1	4	30.	Protuoklopni MEZ	11
3.	Broj lista	174	17.	TMA-3	3	31.	Protupješački MEZ	143
4.	Naselje	161	18.	TMA-4	20	32.	Širina MEZ-a	15
5.	Objekt	172	19.	TMA-5	5	33.	Dubina MEZ-a	1
B - Podaci za orijentaciju u određivanju pozicije MEZ-a			20.	TMRP-6	14	E - Podaci o izvršenju miniranja		
			21.	Vrsta nepoznata	2			
6.			Protupješačke mine			34.		
			Opis orijentirne točke (OT)					
7.			23.	PMA-2	26	35.		
X koordinata OT			24.	PMA-3	19			
8.			25.	PMR-2A	136	36.		
Y koordinata OT			26.	PROM-1	16			
9.			27.	MRUD	16	37.		
Azimut prema OT			28.	Vrsta nepoznata	0			
10.			12.			38.		
Udaljenost od OT								
11.			13.			39.		
Opis pomoćnih OT			Y koordinata pomoćne OT					
12.			14.					
X koordinata pomoćne OT			Azimut prema pomoćnoj OT					
13.			15.					
Y koordinata pomoćne OT			Udaljenost od pomoćne OT					
14.								
Azimut prema pomoćnoj OT								
15.								
Udaljenost od pomoćne OT								

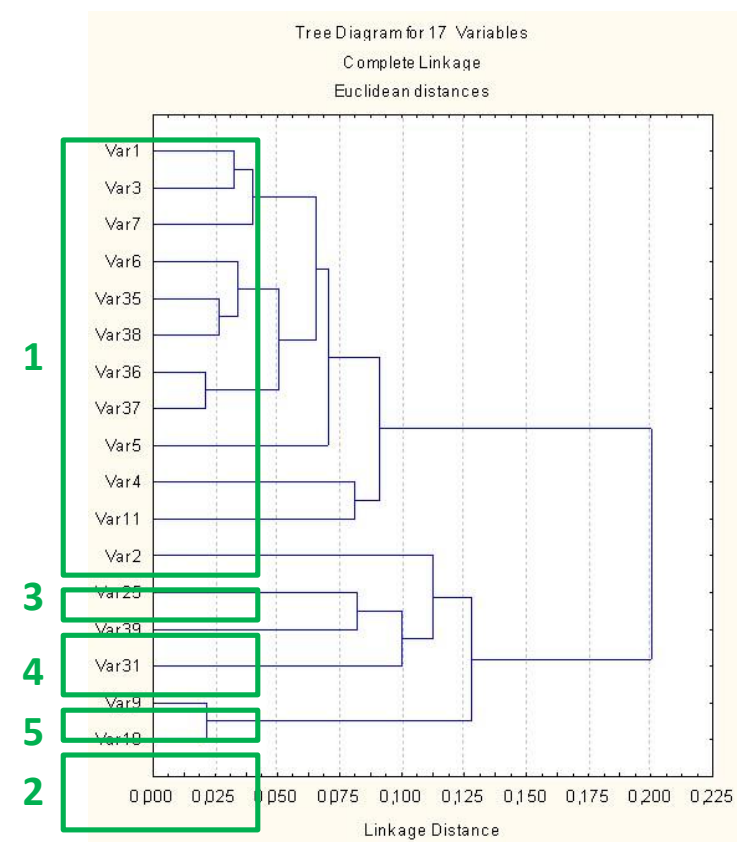
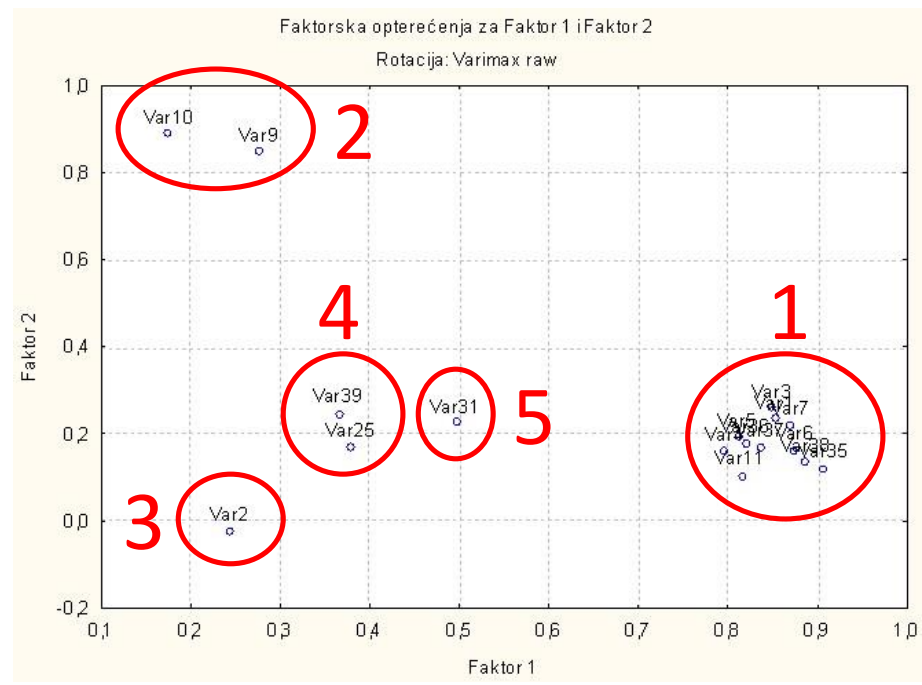


Frequency distribution of information throughout whole set and all subsets of minefield records with 5 characteristic frequency window.

Factor and cluster analysis

- Factor and cluster analysis performed on the whole set of minefield records (197) - (statisticali) a small number of cases.
- The number of variables (information) that are included in the factor and cluster analysis (selected variables that most influence the ability and accuracy of the positioning) is 17.
- Exploratory factor analysis - determining the number of latent factors.

- 1. factor - GIS factor (name of the map, location coordinates of ground control points of minefields,...),
- 2. factor - the additional factor of positioning minefields records,
- 3. factor - the scale maps factor,
- 4. factor - the factor of units and predominant explosive device,
- 5. factor - the minefields types factor .



Analysis of strong indicators interactive prominent by remote sensing

- Description and identification interactively extracted strong indicators via: **spectral**, **radiometric** and **features of the general form**.
- These indicators cover a certain characteristic surface. Sets of pixels that form such surface on images have specific spectral and geometric features.
- The following indicators were analyzed:

Linear IMP	Surface IMP
trench	dug in artillery position
drywall	bunker
stone dam	river drafts
	bridge

Analysis of strong indicators interactive prominent by remote sensing - 2

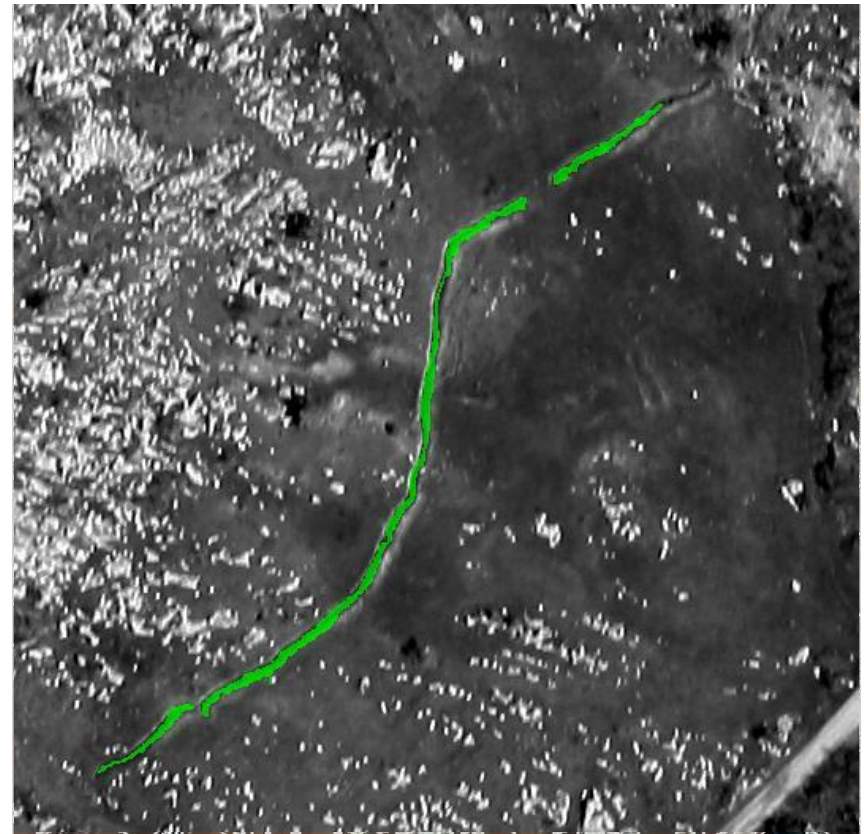
- Interactive extraction of strong IMP:
 - Image segmentation i
 - merging segments based on similar features.
- Subjective expression and detection of IMP replaced by interactive merging segments of the same features. Strong indicators are created in this way.

Segmentation of digital image

Segmentation of digital image is a process of decomposition of digital image into smaller components (objects) that have common characteristics.



a



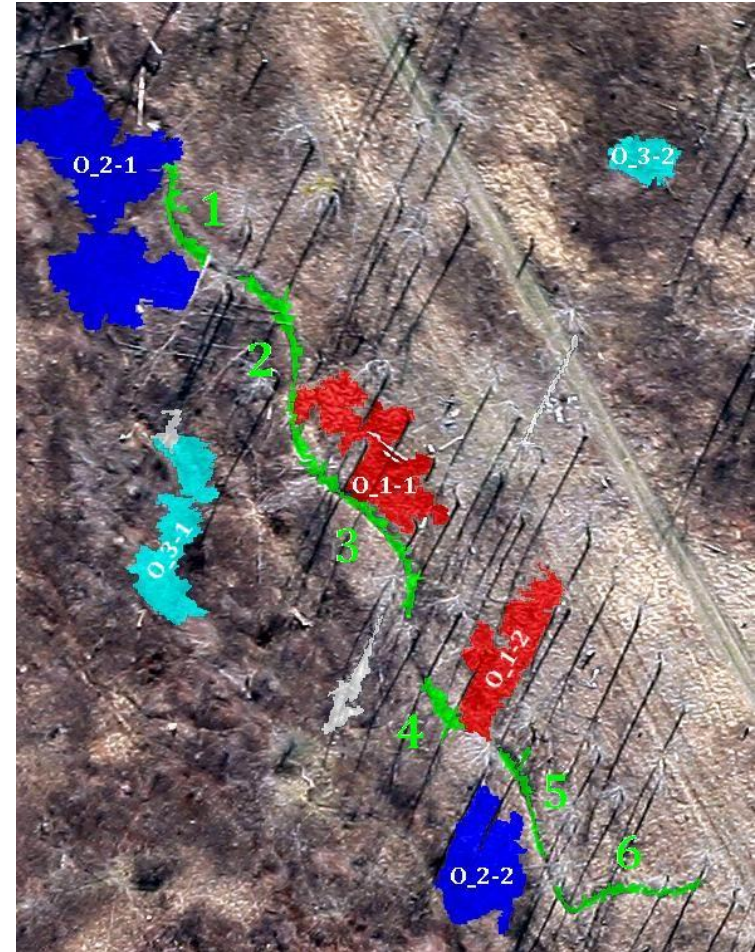
b

a) RGB image of the scene with a trench and shelter for heavy weapons. b) segmented image on the basis of the following parameters: scale parameter 25, color 5, shape 5, compact size 3, smoothness: 7.

- a) part of the color (RGB) images (Canon EOS 5D) of the trench in the plain terrain types,
- b) Display of the trench (Light), in sections, and environmental samples (red, dark blue, light blue).



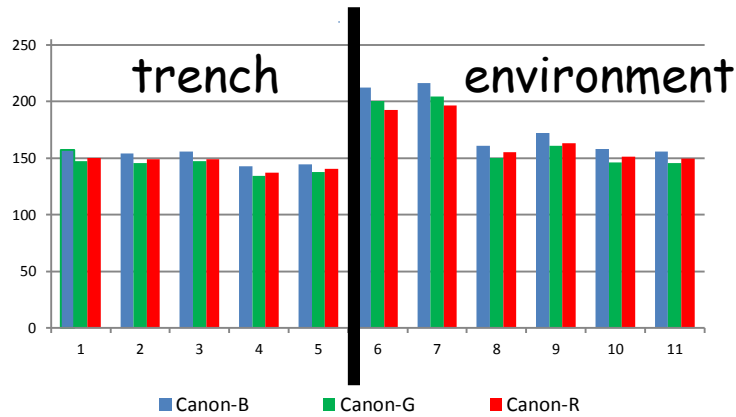
a



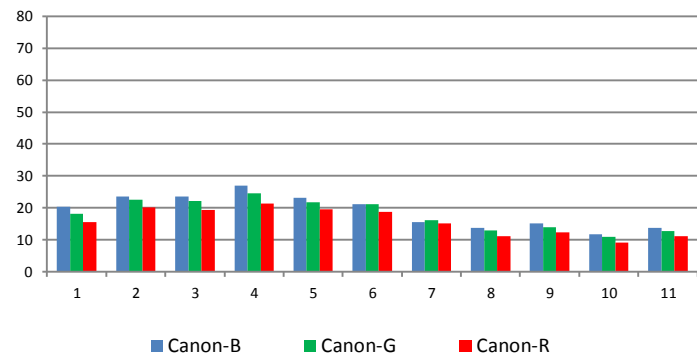
b

Analysis of spectral and radiometric characteristics of indicators

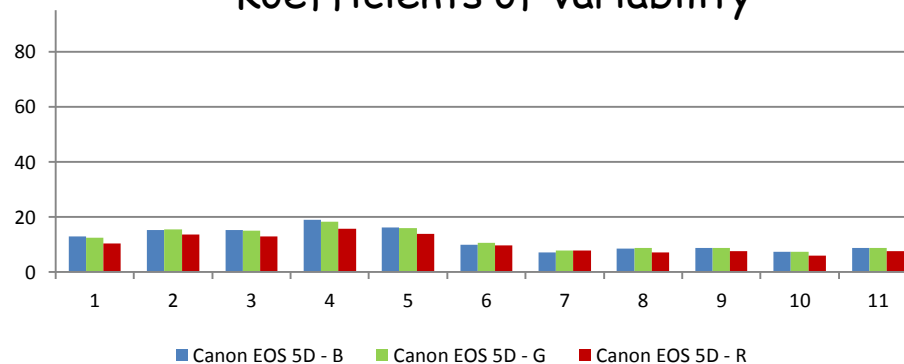
Averages

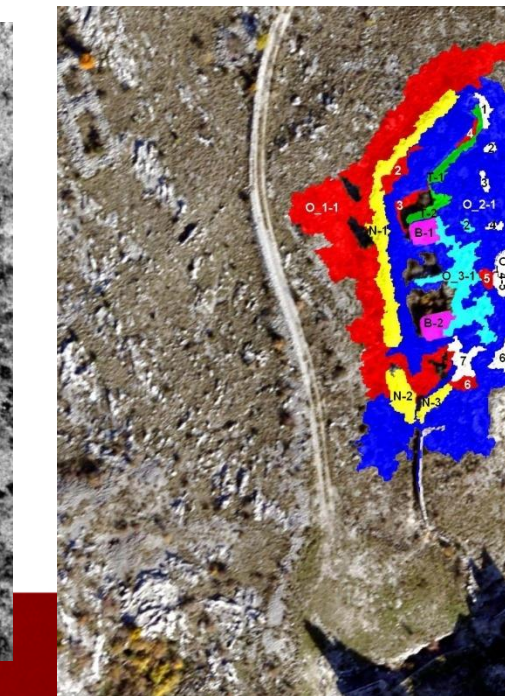
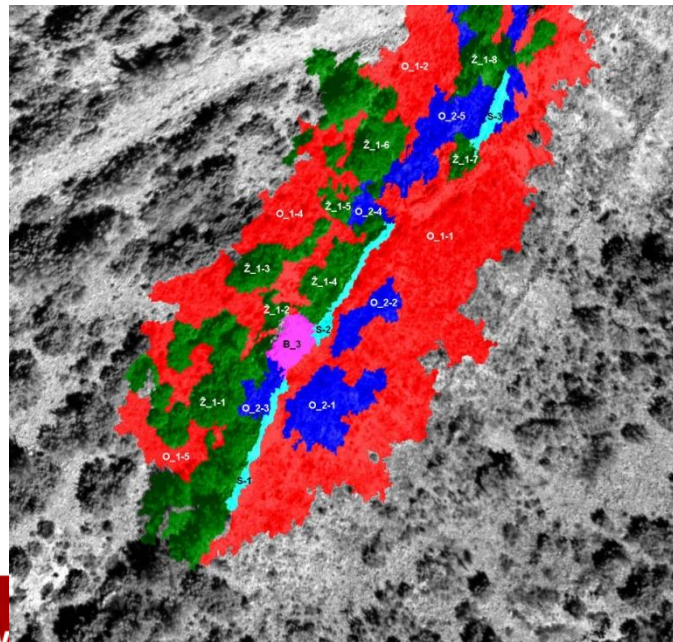
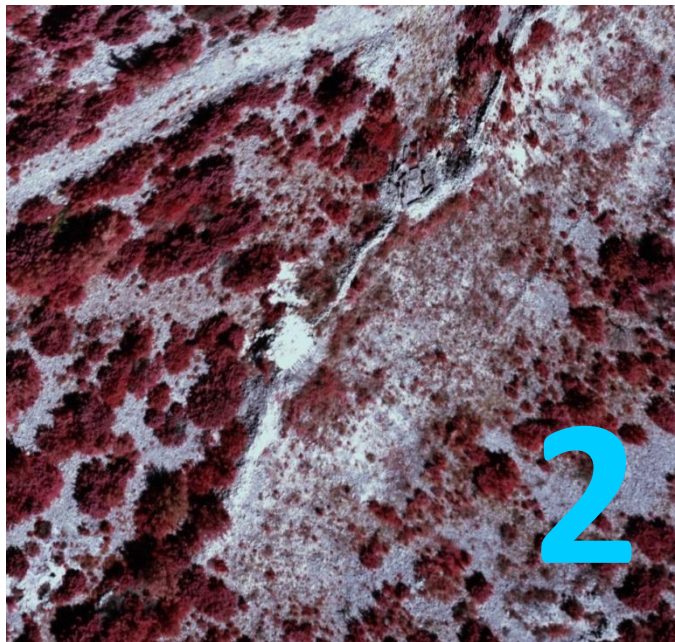
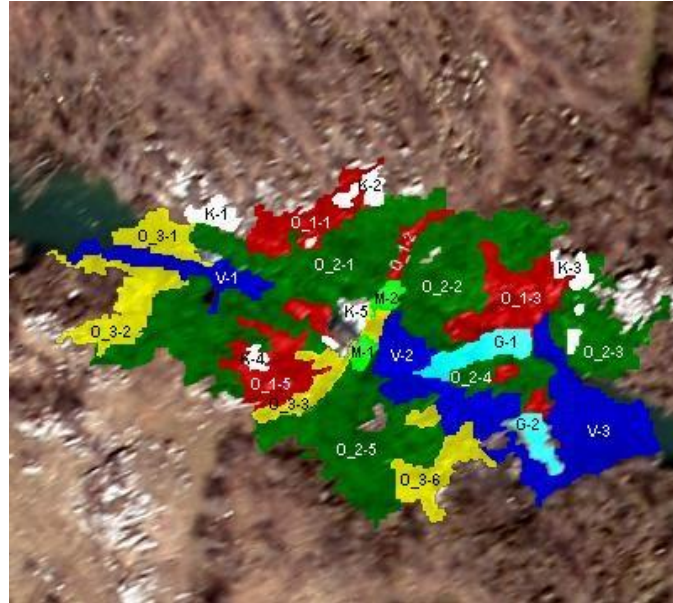


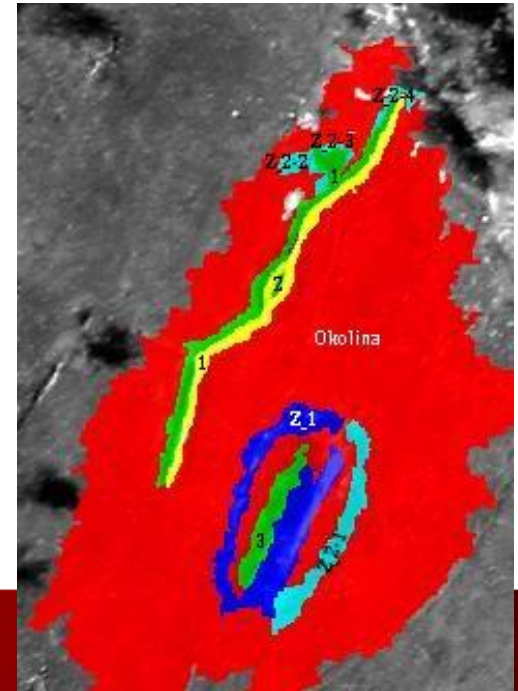
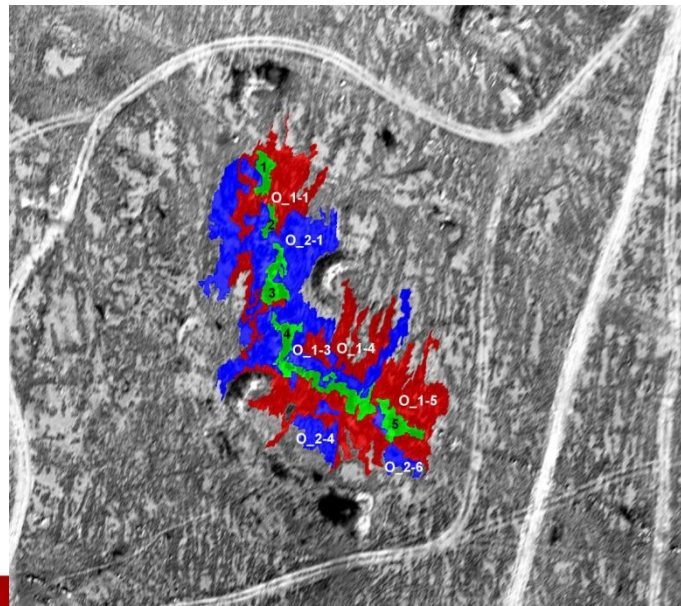
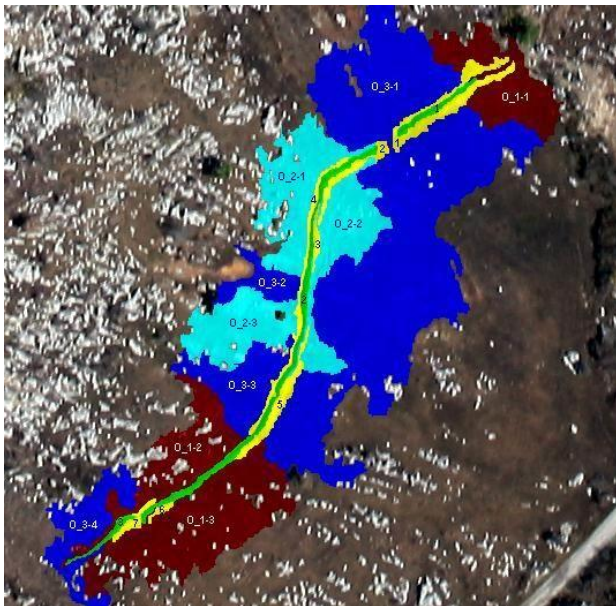
Standard deviations



Koefficients of variability







Analysis of the characteristics of the general shape of indicators

- Fuzzy sets in the field of radiometric characteristics observed strong IMP can not provide sufficient discrimination in relation to the environment, and even each other.
- It is necessary to find a more efficient way of defining discrimination and strong IMP.
- This is done in an object-based analysis of multiple types of features of the general form.

Analysis of the characteristics of the general shape of indicators - 2

- Features of general form used in the analysis are the following :
 - *length/width (LW)*,
 - *asymmetry (ASY)*,
 - *density (DEN)*,
 - *shape index (SI)*,
 - *border index (BI)*,
 - *compactness (COM)*,
 - *roundness (ROU)*,
 - *elliptic fit (ELF)*,
 - *rectangular fit (REF)*,
 - *radius of smallest enclosing ellipse (RSE)*,
 - *radius of largest enclosed ellipse (RLE)*.

	ASY	BI	COM	DEN	ELF	L/W	RLE	RSE	REF	ROU	SI
Bun_K1	0,129	1,235	1,233	2,319	0,8316	1,179	0,078188	0,1384	0,9402	0,5499	1,26
Bun_K2	0,353	1,392	1,604	2,232	0,7154	1,228	0,059532	0,1603	0,8619	0,9209	1,423
Bun_K3	0,474	1,983	1,622	2,233	0,7918	1,72	0,022771	0,040543	0,888	0,5924	2,066
Suh_K1	0,990	2,235	2,35	0,7579	0,2876	8,481	0,0081536	0,050761	0,619	1,42	3,651
Suh_K2	0,988	2,428	2,593	0,7294	0,032453	7,576	0,0073231	0,053426	0,5174	1,537	3,800
Suh_K3	0,935	2,126	2,338	1,317	0,5567	4,031	0,01448	0,048728	0,7544	1,142	2,668
Nas_K1	0,910	3,157	5,089	0,7589	0	3,702	0,0004519	0,3222	0,1919	2,941	3,871
Nas_K2	0,685	1,546	1,638	2,018	0,6003	1,78	0,070428	0,1664	0,7975	0,8769	1,634
Nas_K3	0,858	1,557	1,8	1,617	0,6518	2,792	0,062194	0,1663	0,78	0,9512	1,795
Tra_K1	0,945	2,341	3,164	0,9313	0	3,896	0,017817	0,2581	0,4739	2,196	2,916
Tra_K2	0,782	2,143	3,043	1,501	0,2769	1,794	0,017786	0,2341	0,6068	1,977	2,263
Rov_R1	0,911	2,813	3,036	0,9657	0	3,935	1,42E-05	0,0007007	0,4241	1,946	3,511
Rov_R2	0,877	3,141	4,648	1,06	0,052363	2,665	5,72E-05	0,0009629	0,4931	2,567	3,592
Rov_R3	0,967	3,971	5,563	0,6275	0	5,229	3,16E-05	0,0010466	0,3267	2,877	5,483
Rov_R4	0,937	3,054	4,78	0,8006	0	3,758	7,68E-05	0,0008992	0,4416	2,331	3,851
Rov_R5	0,966	3,087	4,411	0,7298	0	5,031	7,22E-06	0,0008966	0,4514	2,521	4,216
Rov_B6	0,989	1,765	1,993	0,8062	0,4408	9,207	0,3955	1,443	0,6981	1,047	3,011
Rov_B7	0,960	4,379	13,33	0,364	0	5,878	0,017307	4,844	0,014255	4,827	6,263
Rov_B8	0,974	2,059	2,873	0,7837	0,1812	6,914	0,138	2,143	0,58	2,005	3,160
Rov_B9	0,870	4,324	4,291	1,0170	0	2,567	0,00223	0,16570	0,3329	2,263	4,823
Rov_B10	0,983	3,108	5,306	0,5571	0	7,374	7,03E-05	0,0009233	0,3339	2,418	4,852
Zak_B1	0,560	2,391	2,089	1,604	0,2819	2,04	0,020474	1,573	0,6632	1,553	2,581
Zak_B2	0,695	3,267	2,356	1,404	0	2,286	7,56E-06	0,0005365	0,4212	1,499	3,561
Zak_B3	0,946	2,103	3,176	0,8926	0,010078	4,332	7,20E-06	0,0008138	0,463	2,286	2,744
Gru_B1	0,934	2,466	4,188	0,8241	0	3,934	0,057774	2,889	0,3671	2,831	3,115
Gru_B2	0,988	3,500	8,476	0,3738	0	9,161	0,060326	3,67	0,2005	3,609	5,928
Gru_B3	0,973	2,079	2,906	0,8708	0,4411	7,354	0,3558	2,322	0,6854	1,966	3,224
Gru_B4	0,98	2,991	5,229	0,5627	0	8,533	0,00000	0,00097	0,4396	2,744	4,919
Gaz_B1	0,901	1,466	1,795	1,436	0,5957	3,376	0,1533	0,5029	0,8013	1,004	1,764
Gaz_B2	0,783	1,565	1,88	1,65	0,5927	2,126	0,127	0,5222	0,7868	1,135	1,722
D_M_B1	0,298	1,0555	1,208	0,8425	0,11435	0,692	0,038193	0,2968	0,3114	0,743	1,0785
M_Z_B2	0,93	1,507	1,468	1,362	0,7404	4,504	0,0001071	0,0004385	0,884	0,9394	1,977
B_M_B3	0,973	1,212	1,213	1,134	0,7823	7,435	0,000273	0,0004673	0,9214	0,5506	1,883

- 33 strong IMP were included in the analysis.
- On the basis of the value of these features have been implemented subjective, factor and cluster analysis.
- Purpose - to determine the characteristics of general form on the basis of which they can be better defined and mutually discriminating strong IMP.

Subjective analysis of the values of general shapes according to features

- Based on the diagram values for general shape, they can be divided into five clusters.

1. cluster	2. cluster	3. cluster	4. cluster	5. cluster
<u>BI, COM, L/W, ROU,</u> <u>SI</u>	DEN, ELF, REF	ASY	RSE	RLE

- Diagrams of features RSE and RLE have uniformly structure and each makes a separate cluster.
- If we disregard RSE and RLE, or be incorporated into one of the three remaining clusters, the three more meaningful clusters are

formed.

Subjective analysis of the values of general shapes according to indicators

- In this classification in the clusters reveals a division into smaller, shorter and more regular objects (the first cluster), long (line) objects (second cluster) and the third cluster in which there are representatives of their fuzzy type.

1. cluster	2. cluster	3. cluster
Bun_K1	Suh_K2	Rov_B7
Bun_K2	Nas_K1	Rov_B10
Bun_K3	Nas_K4	Gru_B2
Gaz_B2	Rov_K11	Gru_B4
D_M_B1	Zak_B1	
	Gaz_B1	
	B_M_B2	
	B_M_B3	

Factor and cluster analysis of the value of the general characteristics of shape according to features

- Confirmatory factor analysis, by using principal components analysis, and cluster analysis, using the centroid (k-means), were carried out in two ways.
- The first manifest variables were analyzed by the general features of shape, and the second by the strong indicators of mine presence.

Factor analysis by features

- Factor analysis was conducted on five parameters specified in the subjective analysis.

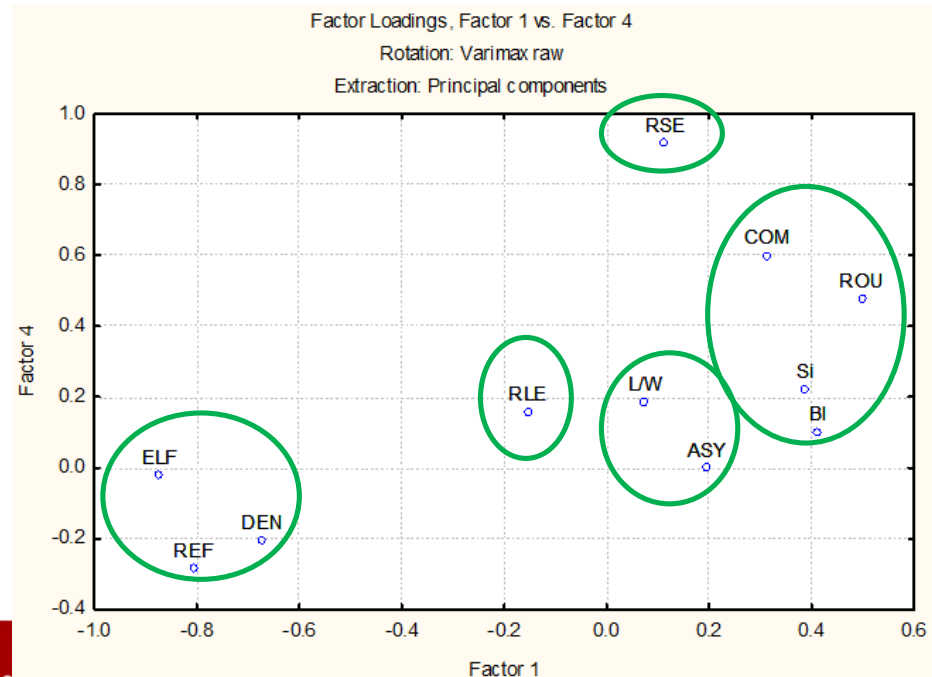
- **I. factor** - the factor of low density of strong indicators of the mine presence.

- **II. factor** - the factor of length of indicator.

- The following two factors are highly independent burden because the distribution of values significantly different from all others and are called conditional factors.

- **V. factor** - the compactness factor.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
ASY	0.197354	0.859039	0.007099	-0.003592	0.272551
BI	0.413553	0.138306	-0.150687	0.099876	0.871762
COM	0.315470	0.201334	-0.174395	0.595968	0.658345
DEN	-0.670730	-0.652854	0.008851	-0.207090	-0.228434
ELF	-0.871630	-0.178206	0.135461	-0.025364	-0.399967
LAW	0.076537	0.907173	0.182896	0.181804	0.111931
RLE	-0.152836	0.127617	0.947171	0.154695	-0.177616
RSE	0.115468	0.110791	0.268739	0.913594	0.173069
REF	-0.804769	-0.101442	0.151896	-0.287622	-0.461542
ROU	0.499850	0.236204	-0.144510	0.475290	0.627992
Si	0.389974	0.425480	-0.085803	0.219060	0.762757



Factor analysis by features - 2

- Factor analysis was conducted on three logical parameter.

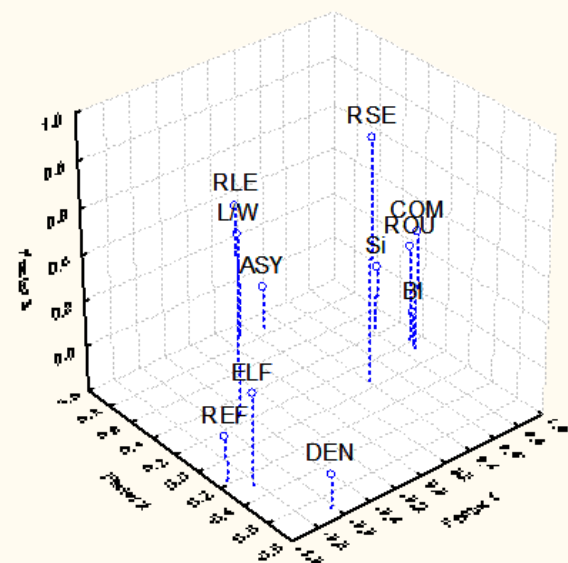
- I. factor - the compactness factor highlights smaller, compactness objects (indicators).

II. factor - the factor of length points out elongated, not compact geometric objects (indicators).

- III. factor is called a correction factor (no observable characteristics of discrimination).

Variable	Factor 1	Factor 2	Factor 3
ASY	0.289674	0.862576	-0.017997
BI	0.901238	0.179201	-0.061959
COM	0.880752	0.145956	0.322555
DEN	-0.617987	-0.708475	-0.055552
ELF	-0.828073	-0.290560	0.196218
L/W	0.121915	0.895389	0.249663
RLE	-0.446416	0.264109	0.715307
RSE	0.415350	0.060783	0.859779
REF	-0.925545	-0.169494	-0.009922
ROU	0.918187	0.230348	0.215733
Si	0.835191	0.443987	0.074174

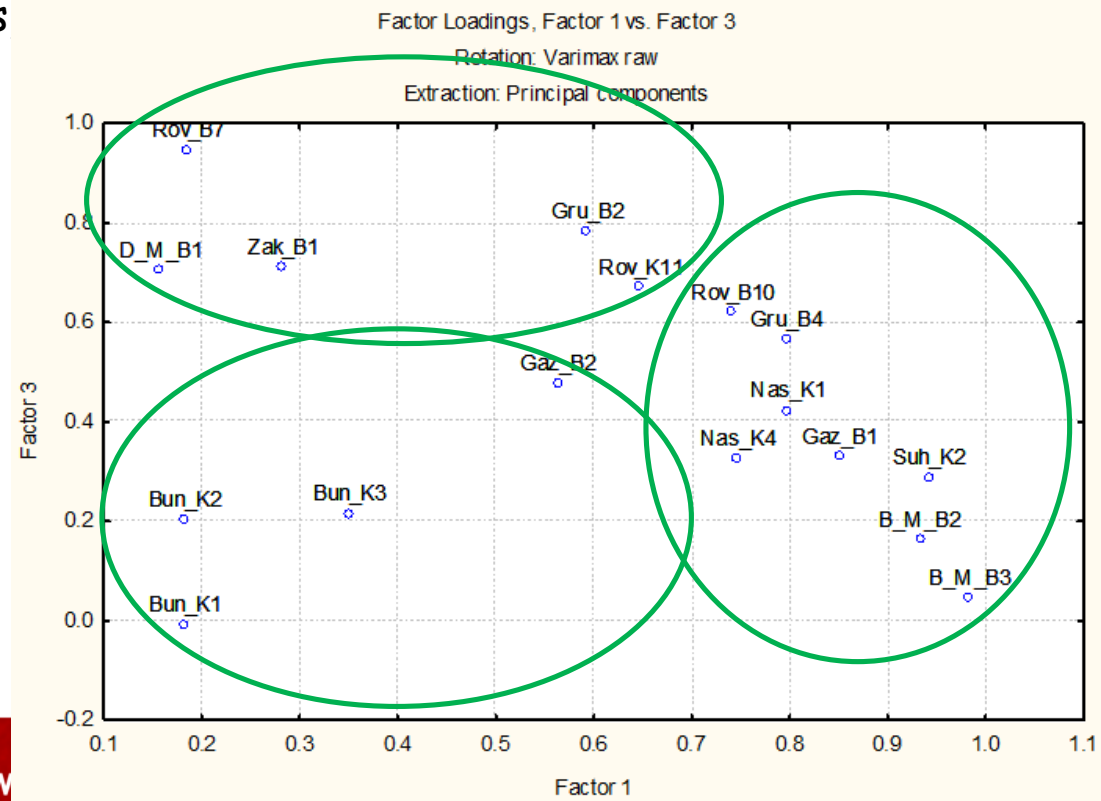
Factor Loadings, Factor 1 vs. Factor 2 vs. Factor 3
 Rotation: Varimax raw
 Extraction: Principal components



Factor analysis by indicators

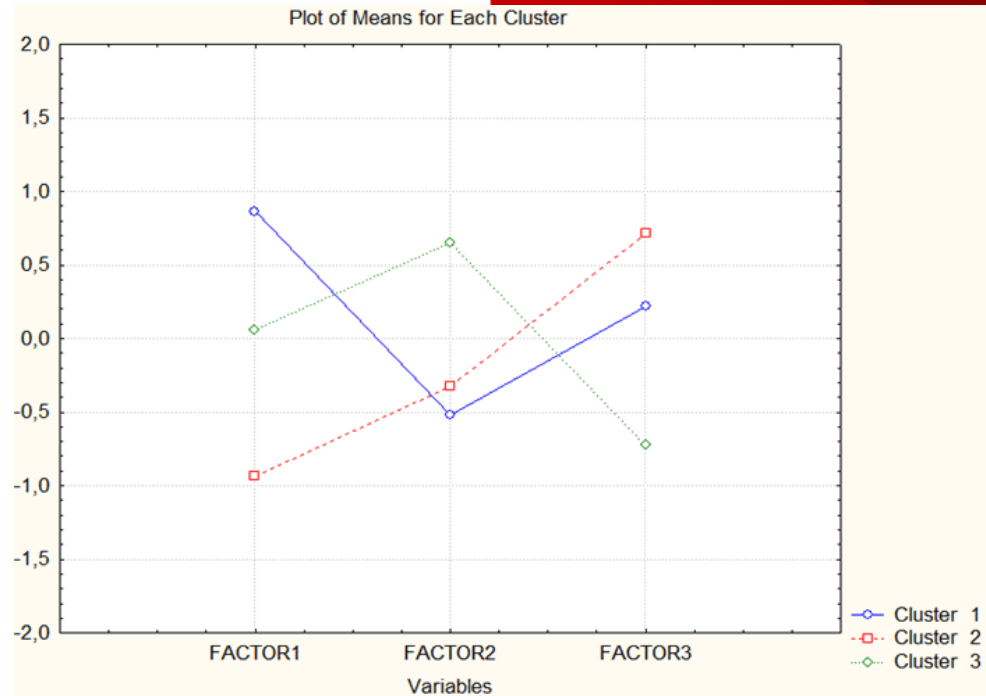
- I. factor - the length factor emphasizes more objects (indicators).
- II. factor - the compactness factor emphasizes the smaller, compactness objects (indicators).
- III. factor - called a correction factor (which contains all fuzzy cases from the previously described cases

Variable	Factor 1	Factor 2	Factor 3
Bun_K1	0.182963	0.965307	-0.010136
Bun_K2	0.182728	0.950265	0.203558
Bun_K3	0.351686	0.892450	0.214283
Suh_K2	0.942413	0.143534	0.287447
Nas_K1	0.798900	0.411567	0.421635
Nas_K4	0.747253	0.571904	0.324705
Rov_K11	0.648279	0.312511	0.669032
Rov_B7	0.186277	0.098280	0.945463
Rov_B10	0.742083	0.221479	0.618438
Zak_B1	0.283341	0.522443	0.710165
Gru_B2	0.593886	0.068593	0.782959
Gru_B4	0.797125	0.187411	0.563347
Gaz_B1	0.851842	0.393312	0.328719
Gaz_B2	0.563560	0.666501	0.476998
D_M_B1	0.158128	0.677763	0.702674
B_M_B2	0.933746	0.316131	0.162166
B_M_B3	0.984264	0.118419	0.046441



Cluster analysis by the features

- The first cluster is characterized by a strong positive correlation with the first factor of length.
- The third cluster has a strong positive correlation with second factor of compactness.
- The second cluster is a most strongly associated with corrective factor.



1. klaster	2. klaster	3. klaster
Suh_K2	Rov_B7	Bun_K1
Nas_K1	Zak_B1	Bun_K2
Rov_K11	Gru_B2	Bun_K3
Rov_B10	B_M_B1	Nas_K4
Gru_B4		Gaz_B1
B_M_B2		Gaz_B1
B_M_B3		



THANK YOU

ANY QUESTIONS?

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