Appendix 12. Report by Nikolay Kharkov on the 2003 SAR test entitled:

Report about analysis results of the production samples of the SAR mining metallurgical complex and decoding results of the check samples formed on the basis of production samples.

24 samples of "at-risk" processing products of Pl/Pt containing ores picked from different processing sections of 4 SAR mining metallurgical Companies (comparison samples) and 3 check mixed samples formed on their basis were rendered to the Institute of Criminalistics of the Russian Federation in 2003. The purpose of this was testing of the Complex Analytical Procedure correspondence with its stated goals and tasks. Samples were rendered in the form of fine-dispersed powder-like substances. They are listed in the Table 1.

1. Determination of the samples element composition.

As it could be seen from the list of samples each of the SAR Companies presented 2 samples of similar products. Analysis has demonstrated that samples have similar composition. Average meaning for two probes was accepted as the determination results. Results of the element composition achieved after the conducted analysis of the SAR Companies products are presented in the Table 2. Check mixed samples are marked in the Table 2 as "MIX 1", "MIX 2" and "MIX 3".

As it is clear from the data presented in the Table 2, production samples of the SAR Companies have original composition, which allows identifying them as products from definite processing section.

Table 1.

SAMPLE NUMBER		DESCRIPTION OF SA	WEIGHT	DESCRIPTION OF PROCESS
1. IMPALA PLATINUM SAMPLES				
1.	Sample 1a	Convertor Matte	50,0	Mill Float and Smelt Convertor Process - Mixed Merensky plus UG2 Ore - 60/40 split
2.	Sample 1b	Convertor Matte	50,0	Mill Float ahd Smelt Convertor Process - Mixed Merensky plus UG2 Ore - 60/40 split
2. ANGLO PLATINUM SAMPLES				
3.	Sample 1a	Granulated Matte	50,07	Furnace Process
4.	Sample 1b	Granulated Matte	50,0	Furnace Process
5.	Sample 2a	WCM	50,09	Furnace Process
6.	Sample 2b	WCM	50,09	Furnace Process
7.	Sample 3a	Waterval Metallics	50,13	Flotation Process
8.	Sample 3b	Waterval Metallics	50,0	Flotation Process
9.	Sample 4a	RBMR FIC	50,12	Electroletic Copper / Nickel Refining Process
10.	Sample 4b	RBMR FIC	50,02	Electroletic Copper / Nickel Refining Process
11.	Sample 5a	Concentrate	50,04	Mill plus Flotation Process
12.	Sample 5b	Concentrate	50,02	Mill plus Flotation Process
3. NORTHAM PLATINUM SAMPLES				
13.	Sample 1a	Final Concentrate	50,01	Electroletic Copper / Nickel Refining Process
14.	Sample 1b	Final Concentrate	50,03	Electroletic Copper / Nickel Refining Process
4. LONMIN PLATINUM SAMPLES				
15.	Sample 1a	Pt Sponge WPR 2	50,07	Primary Separation Platinum Process after Ignition
16.	Sample 1b	Pt Sponge WPR 2	50,03	Primary Separation Platinum Process after Ignition
17.	Sample 2a	PGM Concentrate	50,03	Oxidising plus Reduction leads Formic plus Sulpheric Acid Process
18.	Sample 2b	PGM Concentrate	50,02	Oxidising plus Reduction leads Formic plus Sulpheric Acid Process
19.	Sample 3a	Matte after Granulation	50,0	Oxidizing to extract Sulphur (not metal) - Water granulation
20.	Sample 3b	Matte after Granulation	50,02	Oxidising to extract Sulphur (not metal) - Water granulation
21.	Sample 4a	Pressure Leach	50,0	Oxidising plus Sulpheric Acid Process
22.	Sample 4b	Pressure Leach	50,02	Oxidising plus Sulpheric Acid Process
23.	Sample 5a	PHS Cake	50,05	Primary Separation Secondary Ruthenium Process
24.	Sample 5b	PHS Cake	50,0	Primary Separation Secondary Ruthenium Process

Table 2.

A17/A18	PGM concentrate	3.05 %	1.66 %	5706 ppm	6056 ppm	28.3 %	13.2 %	3.56
A19/A20	After granulation matte	45.6 %	32.2 %	64 ppm	100 ppm	4035 ppm	2024 ppm	535
A21/A22	Lye aquiered under pressure (Pressure leach)	5.76 %	6.4 %	2543 ppm	4624 ppm	13.3 %	6.34 %	2.53
A23/A24	PHS Cake	2.91 %	18.3 %	6 ppm	2844 ppm	1614 ppm	7197 ppm	8.67
MIX 1		30 %	19.4 %	24.7 ppm	62 ppm	1110 ppm	592 ppm	126
MIX 2		6.49 %	6.91 %	8074 ppm	5514 ppm	21.7 %	10.7 %	2.35
MIX 3		49.4 %	25.8 %	78 ppm	98 ppm	2490 ppm	1595 ppm	386

Table 2 S

Sample #	Product denomination	Co	Co	Se	Se	Te	Te	Fe	Fe	S	S	Pb	Pb	Sn
A1/A2	Converter matte	3380	ppm	551	ppm	141	ppm	7500	ppm	14.1	%	882	ppm	1.81
A3/A4	Granular matte	3660	ppm	70	ppm	<10	ppm	41.3	%	21	%	578	ppm	25
A5/A6	WCM	4865	ppm	377	ppm	134	ppm	2.37	%	10.8	%	700	ppm	4
A7/A8	Waterval Metallics	3800	ppm	43	ppm	7222	ppm	25.74	%	8.13	%	2.27	%	386
A9/A10	RBMR FIC	1475	ppm	1.67	%	4154	ppm	3.21	%	3.08	%	5300	ppm	198
A11/A12	Concentrate	210	ppm	<1	ppm	<10	ppm	7.63	%	7084	ppm	75	ppm	4.2
A13/A14	Ready for use concentrate	891	ppm	3.88	%	1.63	%	3.71	%	5.46	%	3656	ppm	293

Table 2.2.

Table 2.2

Samples' composition render by SAR Companies.

Sample #	Product denomination	Ni	Ni	Cu	Cu	Au	Au	Ag	Ag	Pt	Pt	Pd	Pd	Rh
A1/A2	Converter matte	44.1	%	31	%	56	ppm	106	ppm	1900	ppm	1010	ppm	195
A3/A4	Granular matte	15.9	%	9.66	%	12	ppm	34	ppm	646	ppm	387	ppm	89
A5/A6	WCM	53.5	%	19.2	%	113	ppm	113	ppm	986	ppm	1548	ppm	286
A7/A8	Waterval Metallics	19.5	%	3.74	%	9000	ppm	478	ppm	7.86	%	2260	ppm	35
A9/A10	RBMR FIC	9.84	%	3.57	%	1.41	%	4337	ppm	32.54	%	19	%	3.8
A11/A12	Concentrate	6875	ppm	3894	ppm	1.3	ppm	6	ppm	13	ppm	13	ppm	1
A13/A14	Ready for use concentrate	3.93	%	9.68	%	8900	ppm	7500	ppm	21.3	%	8.96	%	1.01
A15/A16	Platinum spong WPR 2	5	ppm	74	ppm	95	ppm	82	ppm	98.11	%	8790	ppm	345
A17/A18	PGM concentrate	3.05	%	1.66	%	5706	ppm	6056	ppm	28.3	%	13.2	%	3.56
A19/A20	After granulation matte	45.6	%	32.2	%	64	ppm	100	ppm	4035	ppm	2024	ppm	535
A21/A22	Lye aquiered under pressure (Pressure leach)	5.76	%	6.4	%	2543	ppm	4624	ppm	13.3	%	6.34	%	2.53

2. Determination of the substance phase composition

Determination results of the samples phase composition in the form of X-ray diffraction patterns are given in the Appendix.

Sundry materials samples X-ray diffraction patterns differs one from another. At the same time comparison of diffraction patterns of the parallel samples demonstrate their complete coincidence (Fig. 1).

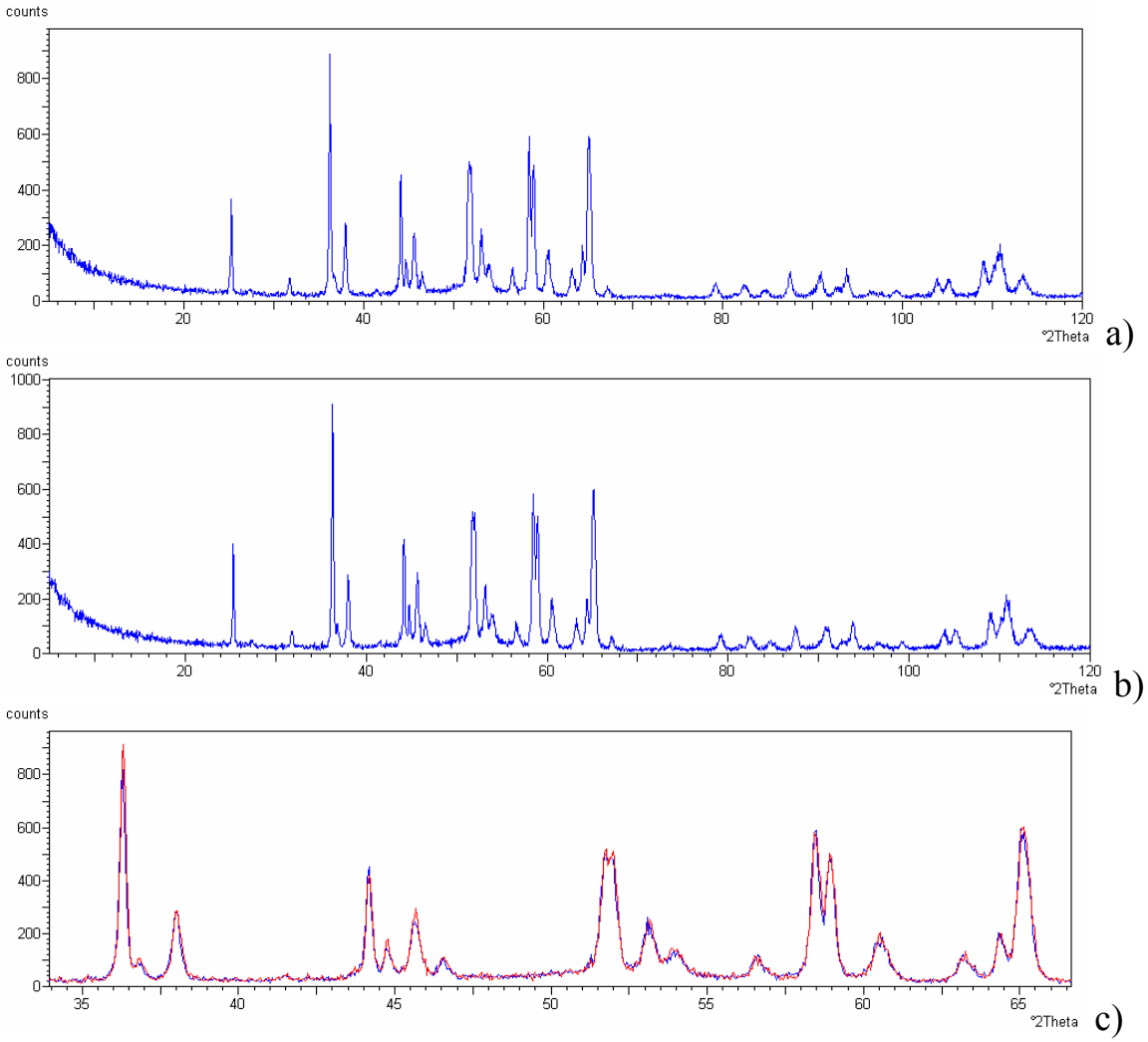


Fig. 1 Comparison of the parallel samples X-Ray diffraction patterns

a) Sample A1 X-ray diffraction pattern.
b) Sample A2 X-ray diffraction pattern.
c) Multiplied superposition of X-ray diffraction pattern fragments (sample A1 – blue, Sample A2 – red)

3. Determination of the check samples composition

Decoding of the mixed samples was conducted on the basis of the complex analysis results, which included quantitative element analysis, X-Ray phase

analysis (X-Ray diffraction pattern), and Scanning Electron Microscopy with Micro Analyzer in the X-Ray Spectrum (SEM-EDM).

Element analysis data of the mixed samples and comparison samples was introduced into data processing pack. For each of mixed samples regression dependence simulating its composition as superposition of comparison samples compositions was plotted. Plotted multivariate linear regression dependence is described with the help of the following formula (function):

$$Y_{ij} = \sum_{j=1}^{n} a_j X_{ij} ,$$

Where
$\mathbf{Y_{ij}}$ – concentration of the *i*-element of the mixed sample;
$\mathbf{a_j}$ – regression factor;
$\mathbf{X_{ij}}$ – concentration of the *i*-element *j*-comparison sample;
n – number of samples compared.

While plotting regression dependences almost all existing professional data processing packs calculate several statistical criteria:

- Correlation factor reflecting proximity of the experimental data to the results predicted by the regression model;
- Fisher criteria, which allows to evaluate stability of the plotted model;
- Student criteria for model factors reflecting their significance;
- Normalized regression factors (β), reflecting input of each component into the plotted model.

Professional data processing packs automatically exclude from the regression model components with insignificant correlation factors.

Regressive models produced for SAR mixed samples were characterized by the correlation factor value close to one and Fisher criteria value considerably exceed its critical value. That means that produced artificial compositions adequately described mixed samples and also that produced models are nonrandom.

Results achieved after automatic decoding are presented in Table 3. Here are listed samples included in the model, and also normalized regression factors (β).

Comparison samples which were excluded from the final model because of the low value of (β) are printed in italic. The fact of appearance in the model samples with low values is explained by errors in spectra processing.

Table 3

Mix 1		Mix 2		Mix 3	
Comparison sample number	β	Comparison sample number	β	Comparison sample number	β
3/4	0,53	9/10	0,47	5/6	0,42
5/6	*-0,04*	13/14	0,36	19/20	0,59
19/20	0,73	21/22	0,19		
21/22	*-0,01*	*15/16*	*-0,01*		

After conducting examination using methods of element analysis hypothesis made were confirmed by other methods.

At the first stage of decoding by the method of X-Ray phase analysis X-ray diffraction patterns of individual products were in turn superposed on X-ray diffraction pattern of the mixed sample. In case all diffraction maximums of individual sample are present at mix sample diffraction pattern (see Fig 2 for example), substance of that sample can be a part of the composition of the mixed sample. In case there are no any analytical lines matching lines on the final X-ray diffraction pattern (Fig. 3) that is the evidence of absence of the corresponding substance in the composition of the mixed sample (at level of method sensibility). This way it was determined that substance of samples A1/2, A3/4, A5/6, A19/20 may be part of the composition of Mix 1; Mix 2 - A9/10, A13/14, A17/18, A21/22; and A1/2, A5/6, A19/20 may be a part of Mix 3.

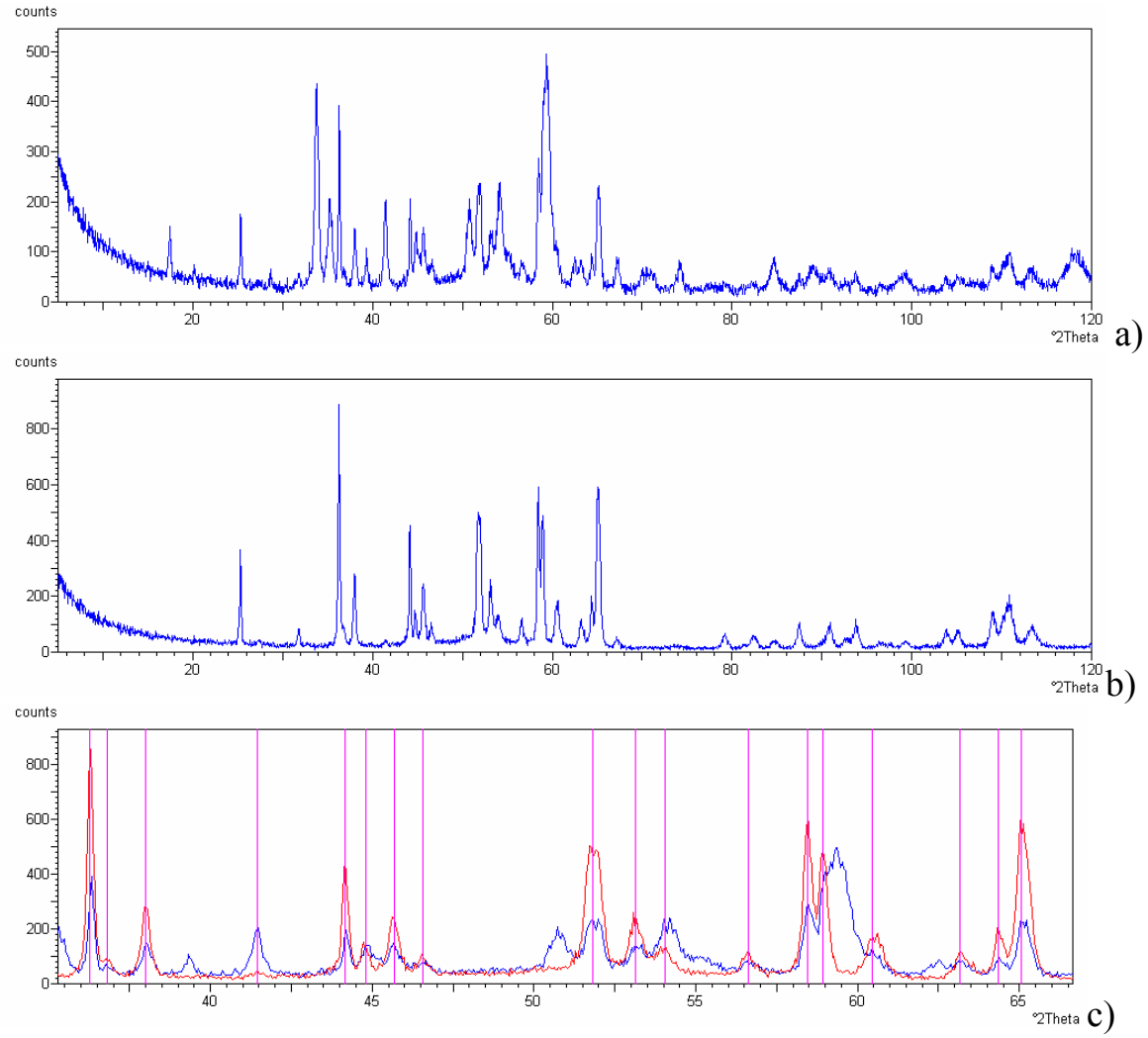


Fig. 2. The first stage of decoding by the method of X-Ray phase analysis

a) Mix sample X-ray diffraction pattern

b) Sample A1 X-ray diffraction pattern

c) Fragment of superposition of X-ray diffraction patterns of the named above samples (sample Mix 1 – blue, Sample A1 – red, vertical lines show position of diffraction maximums on sample A1 diffractogram): diffraction maximums on sample A1 diffraction pattern are present also on sample Mix 1 X-ray diffraction pattern.

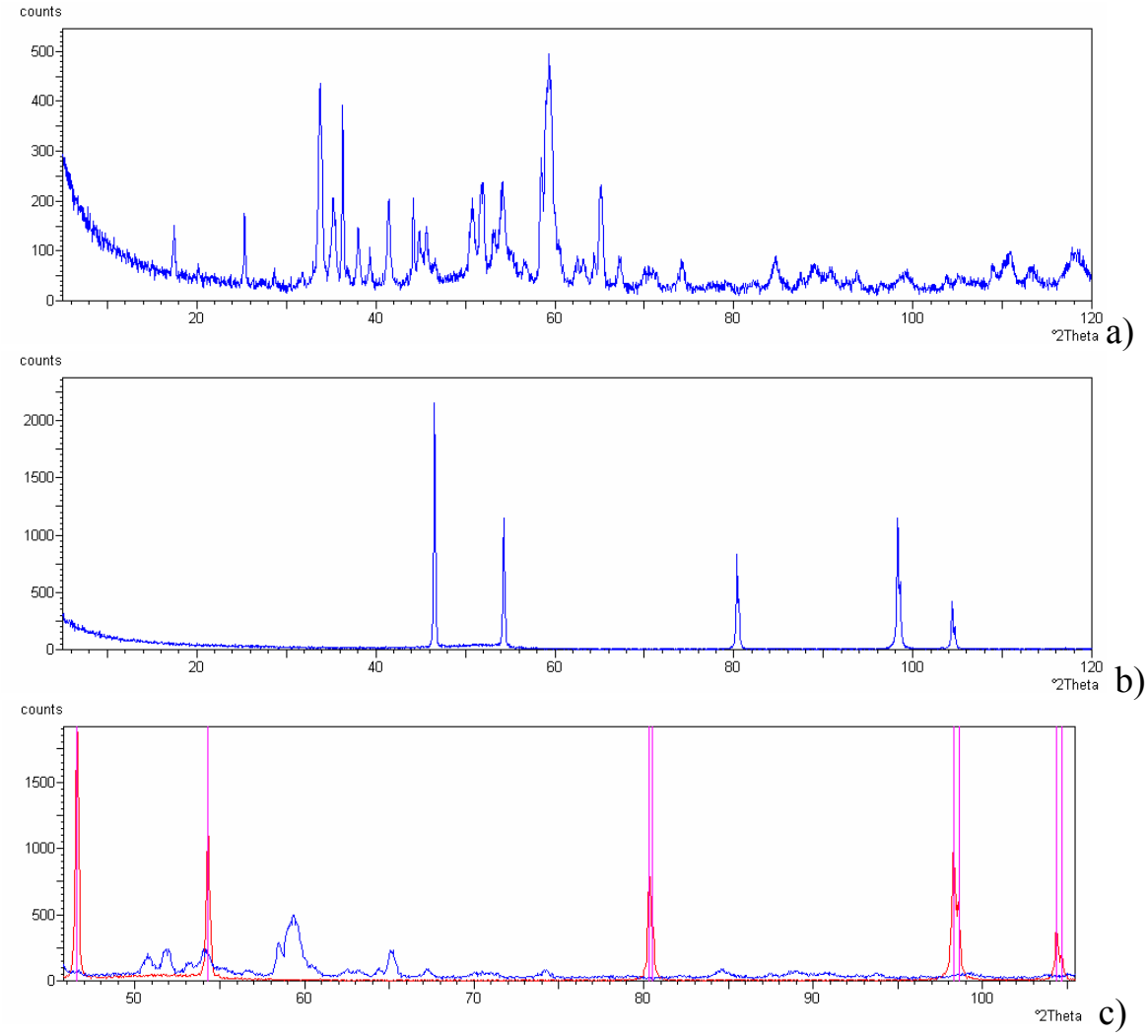


Fig. 3 The first stage of decoding by the method of X-Ray phase analysis

a) Sample Mix 1 X-ray diffraction pattern;
b) Sample A15 X-ray diffraction pattern;
c) Fragment of superposition of X-ray diffraction patterns of the named above samples (sample Mix 1 – blue, Sample A15 – red, vertical lines show position of diffraction maximums on sample A1 diffraction pattern): Diffraction maximums of Sample A15 are not present at the diffraction pattern of the mixed sample.

The study of the possibility of obtaining mixed sample X-ray diffraction pattern by superposition of X-ray diffraction patterns of substances which at the first stage were referred to as part of the possible components of the mix composition is conducted at the second stage. Basing on the results a conclusion may be made that some of them are deliberately part of the sample composition, either they are deliberately not a part of it at the level of the main component (but

they may be a part of composition at the level of additive); there also a conclusion can be made that some substances could alternatively be a part of Mix (in case they have similar phase composition). In the last case a conclusion about the most likely component could be made. Application of this method to the presented samples allowed to mace the following conclusions.

Substance of the samples A1/2 and A3/4 are the part of the Mix 1 at the level of the main component. Presence of samples A19/20 and (or) A5/6 substances are also not excluded.

Substance of the samples A9/10, A13/14 and A21/22 are the part of the Mix 2 at the level of the main component. Substance of sample A17/18 may also be a part of it as additive.

Substance of the samples A5/6 and A19/20 are the part of the Mix 3 at the level of the main component. Presence of sample A1/2 substance is also not excluded.

Results are demonstrated at Fig. 4.

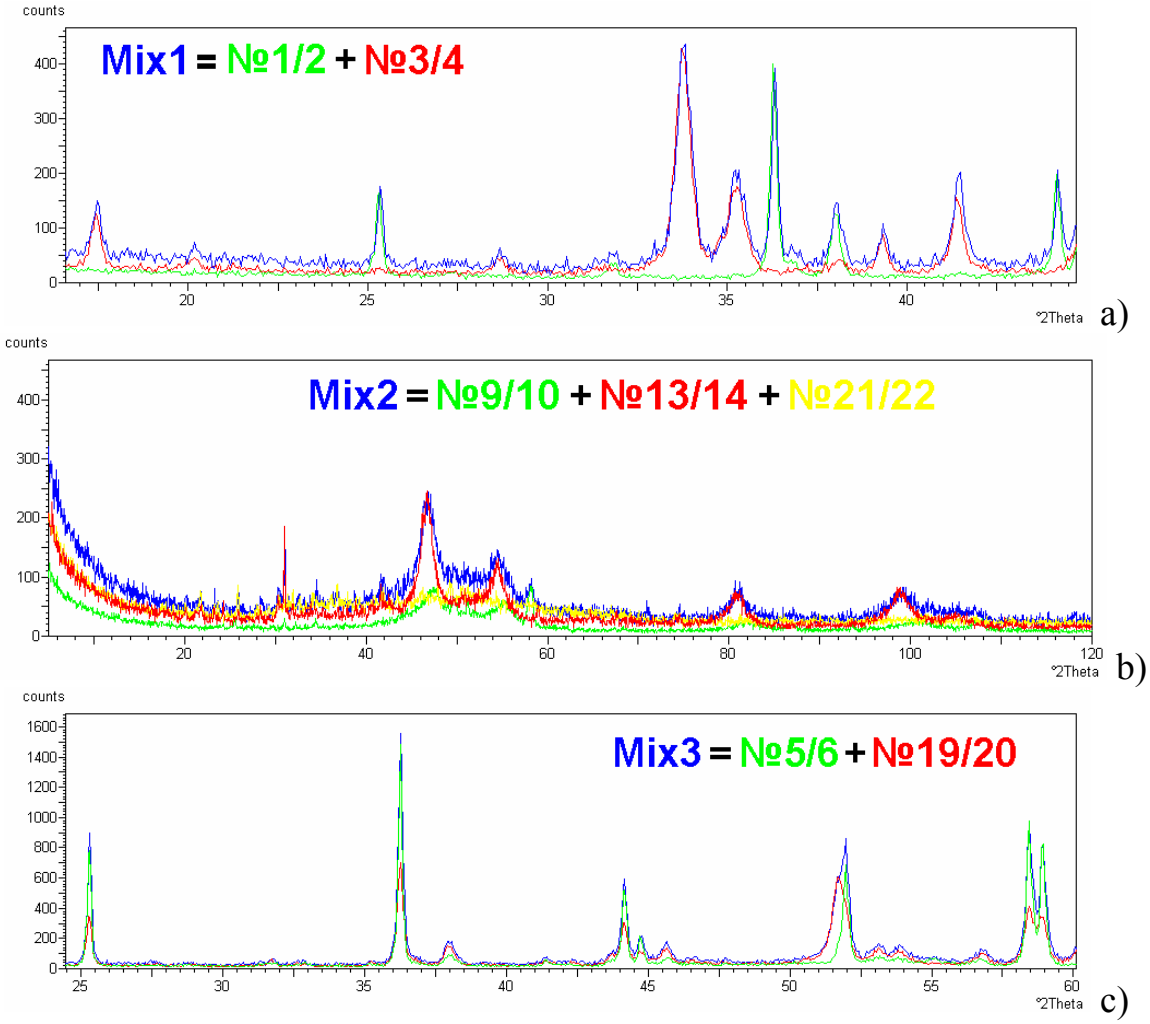


Fig. 4.Decoding of the mixed samples.

a) Sample Mix 1 (blue color); Sample A1 (green color) and A3 (red color).

b) Sample Mix 2 (blue); sample A9 (green), sample A13 (red), sample A21 (yellow).

c) Sample Mix 3 (blue); sample A5 (green), sample A19 (red).

Micro particles were examined by the Scanning Electron Microscopy with Energy Dispersive Micro Analyzer (SEM-EDM). Types of micro partials discovered in the composition of checked samples were compared with micro particles type discovered in the comparison samples.

Conducted comparative analysis allowed to make a conclusion that checked samples contain the following products of the SAR Mining Metallurgical Complex.

Mix # 1 contain converter matte produced by ”IMPALA PLATINUM” Company (A1/A2) and granular matte produced by ”ANGLO PLATINUM” (A3/A4).

MIX # 2 contain material RBMR FIC produced by ”ANGLO PLATINUM” (A9/A10), ready for use concentrate produced by ”NORTHAM PLATINUM” (A13/A14) and material Pressure Leach produced by ”LONMIN PLATINUM” (A21/A22).

MIX # 3 contain material WCM produced by ”ANGLO PLATINUM” (A5/A6) and after granulation matte produced by ”LONMIN PLATINUM” (A19/A20).

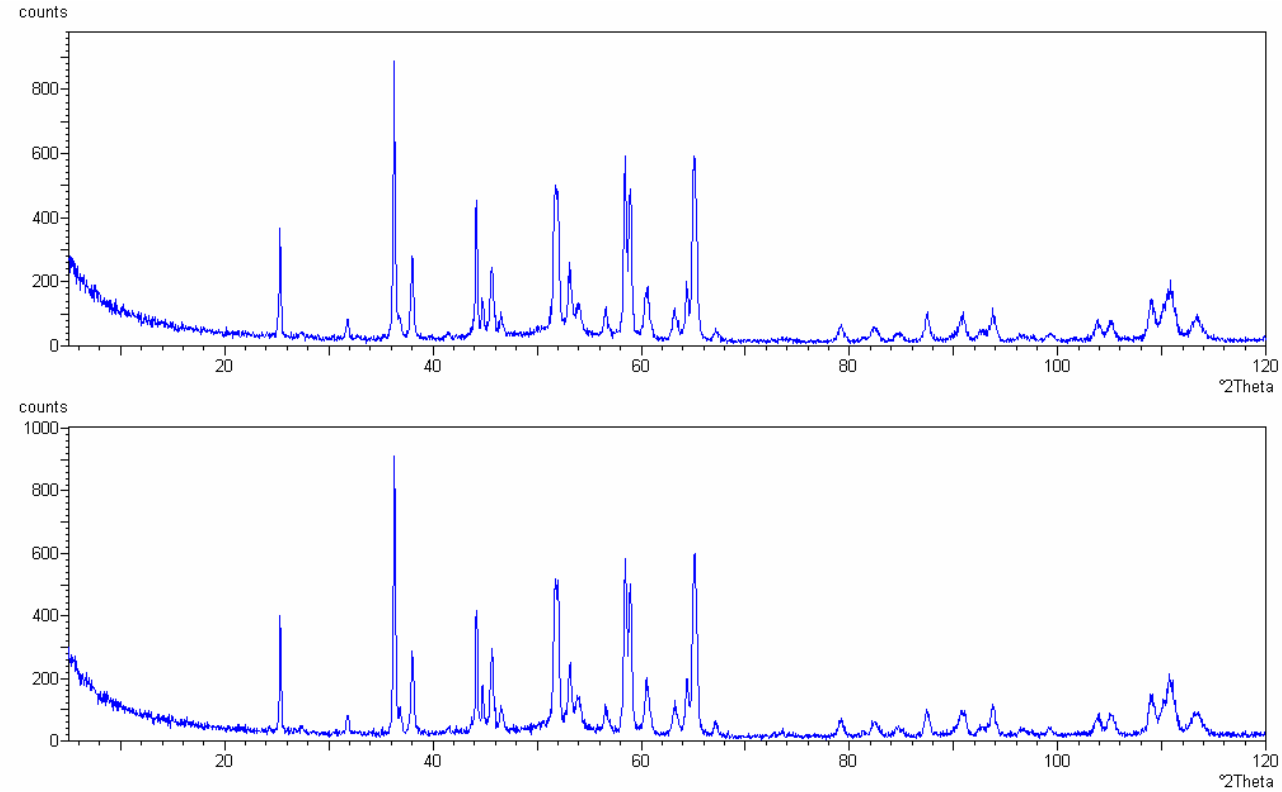
Thus in accordance with the collection of data received in the process of complex analysis of the mixes' composition we determined components that are part of them at the qualitative level. In accordance with the correlation of the elements and using regression dependences it turned out to calculate the approximate ratio of the components. Final decoding of the mixers looks as follows:

Mix 1 = A1/2 (50%) + A3/4 (50%)

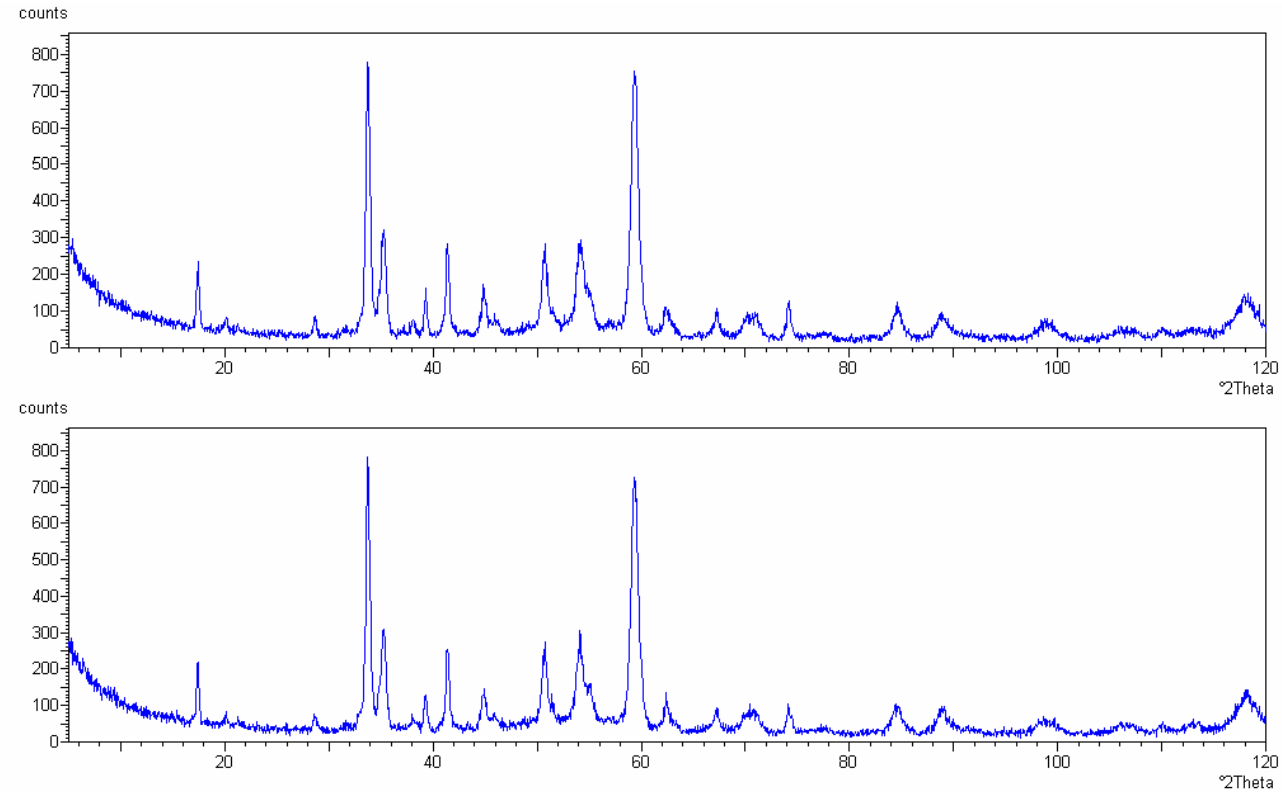
Mix 2 = A9/10 (30%) + A13/14 (35%) + A21/22 (35%)

Mix 3 = A5/6 (50%) + A19/20 (50%)

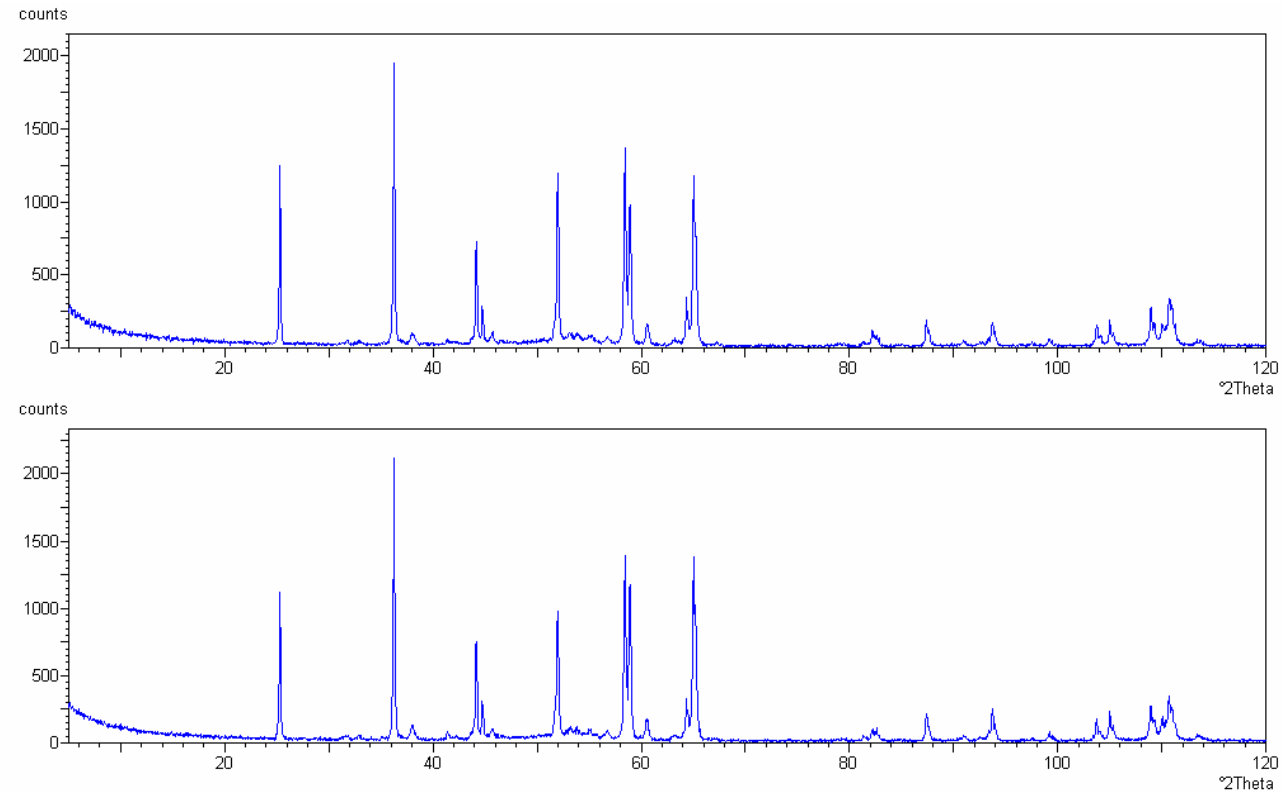
Accuracy of decoding was confirmed by the representatives of the SAR Companies during their visit to The Institute of Criminalistics in 2003.



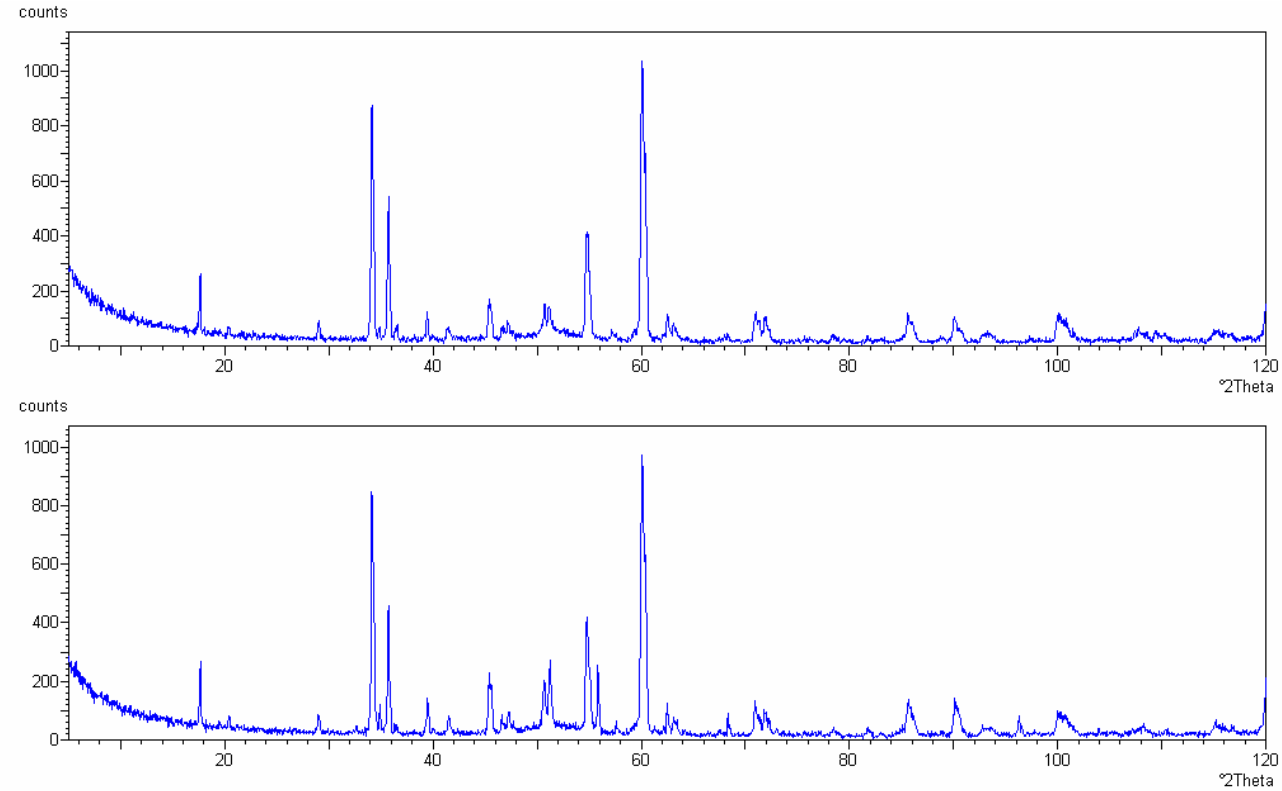
Samples A1 & A2 X-ray diffraction patterns



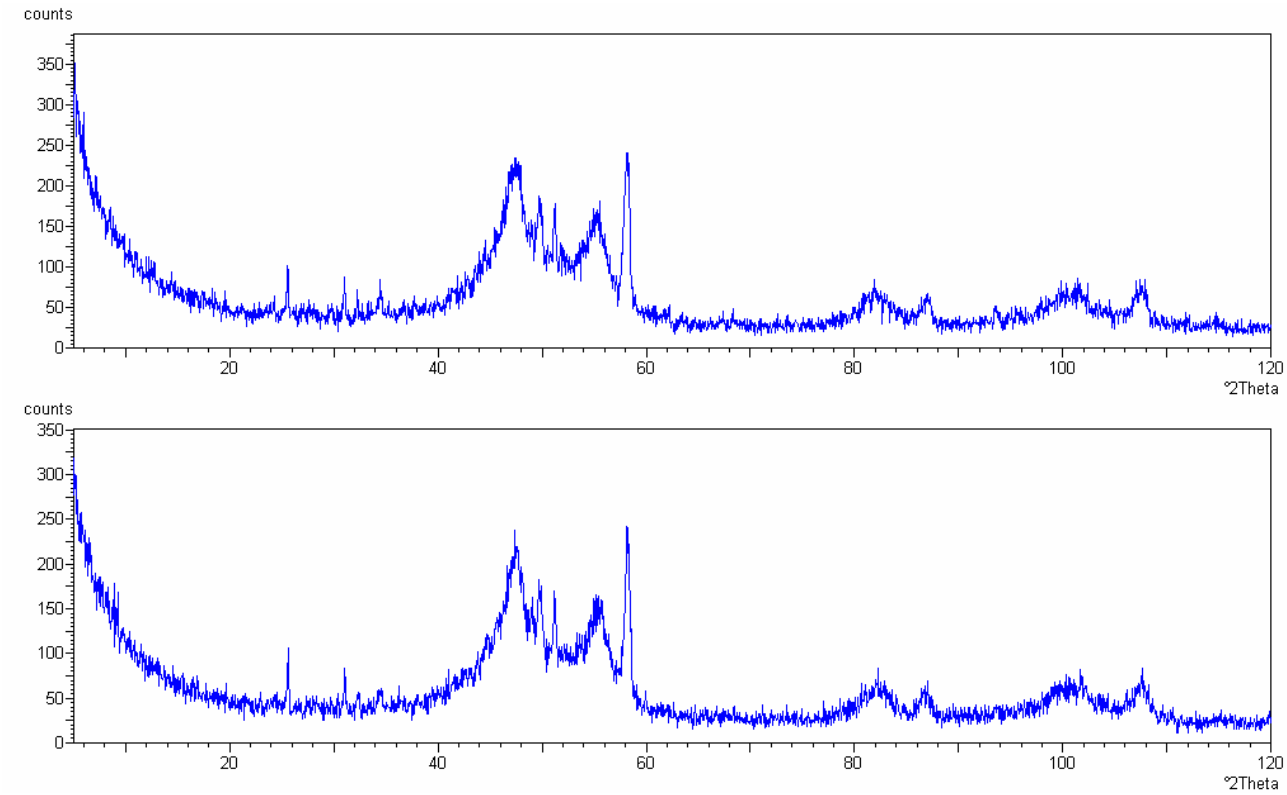
Samples A3 & A4 X-ray diffraction patterns



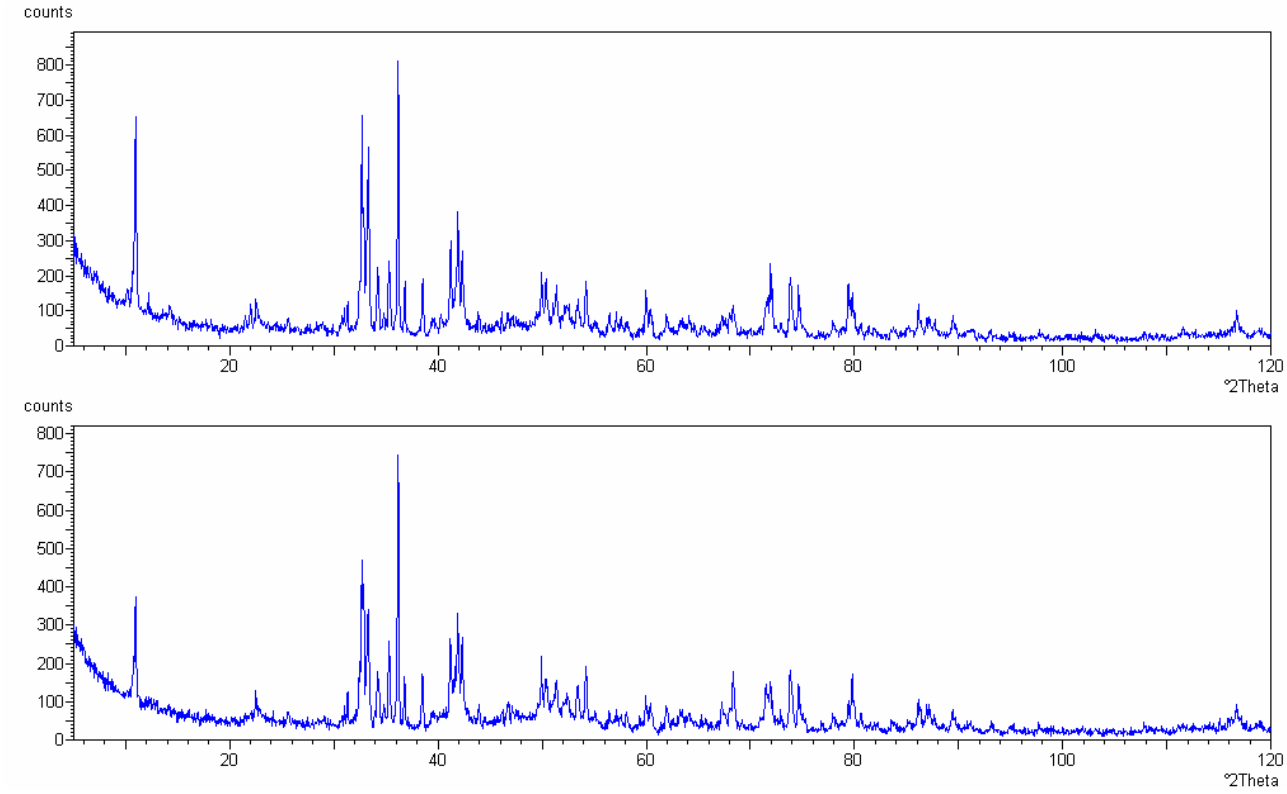
Samples A5 & A6 X-ray diffraction patterns



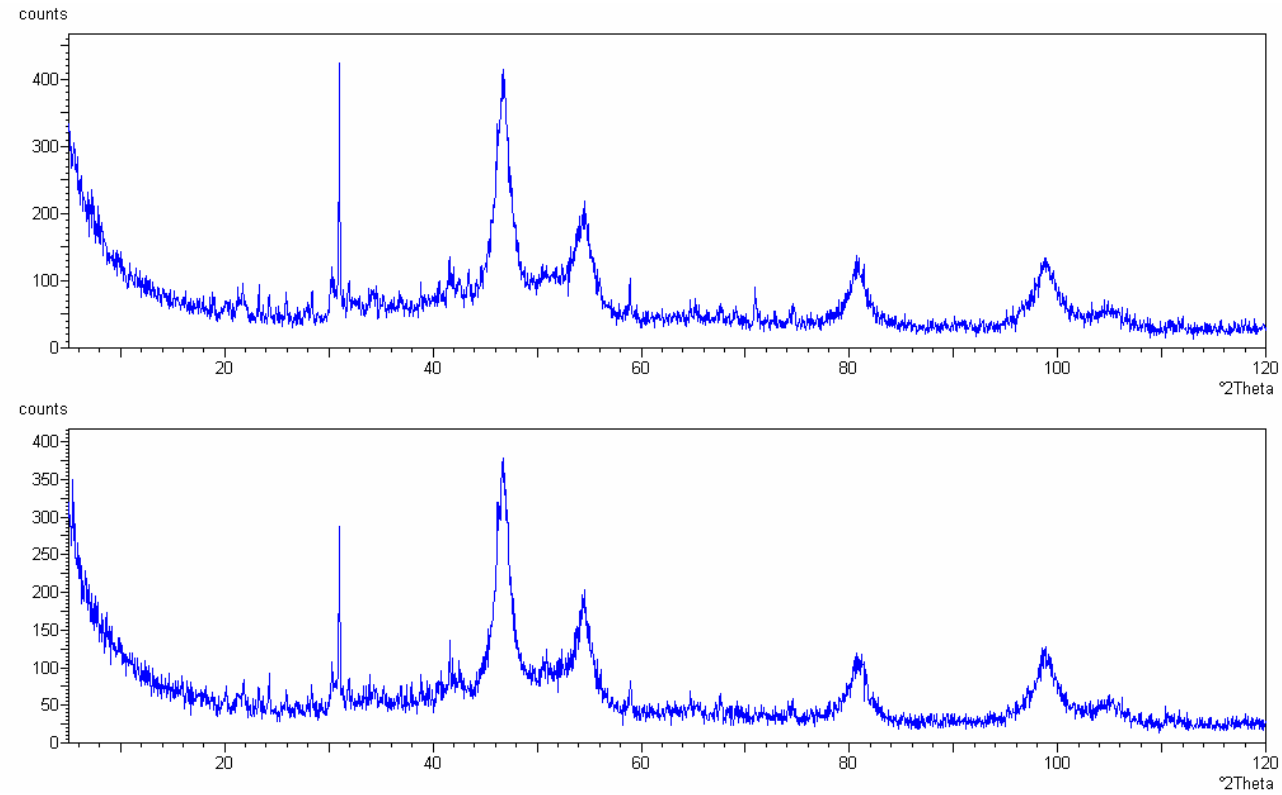
Samples A7 & A8 X-ray diffraction patterns



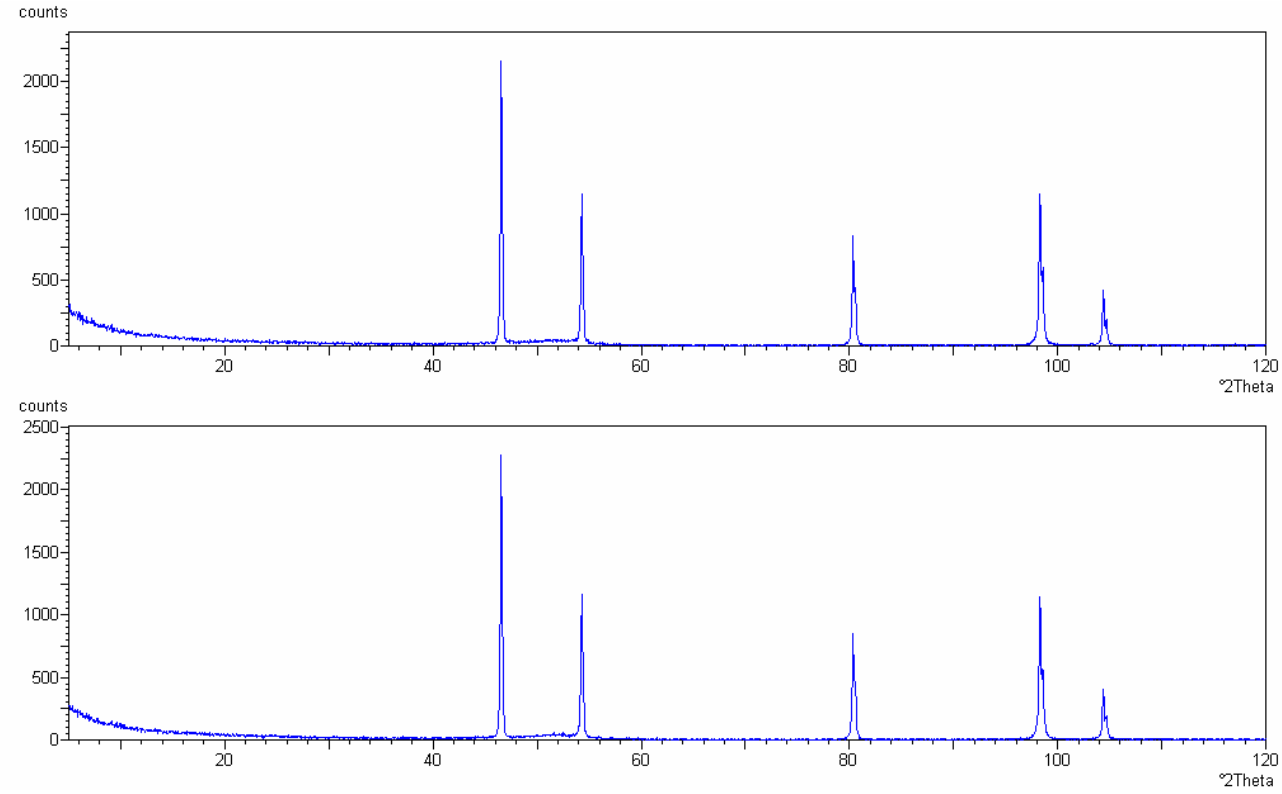
Samples A9 & A10 X-ray diffraction patterns



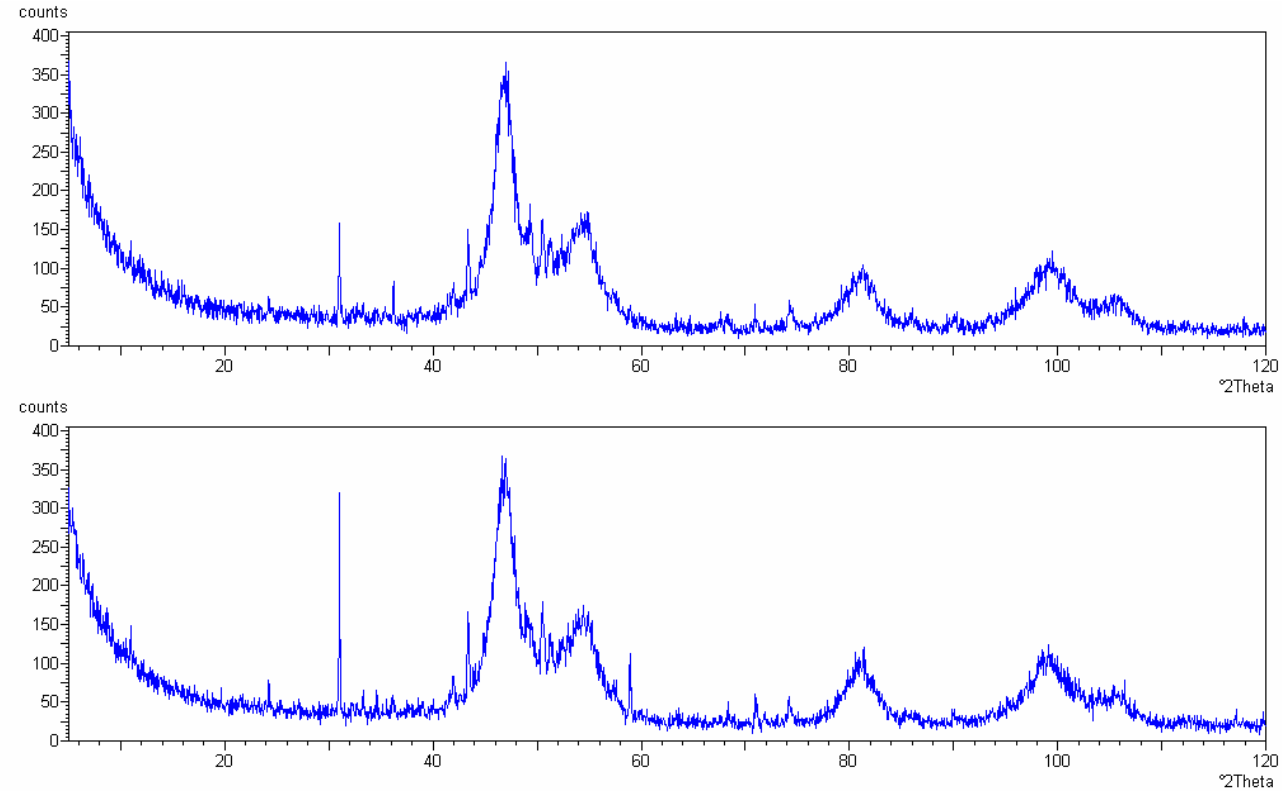
Samples A11 & A12 X-ray diffraction patterns



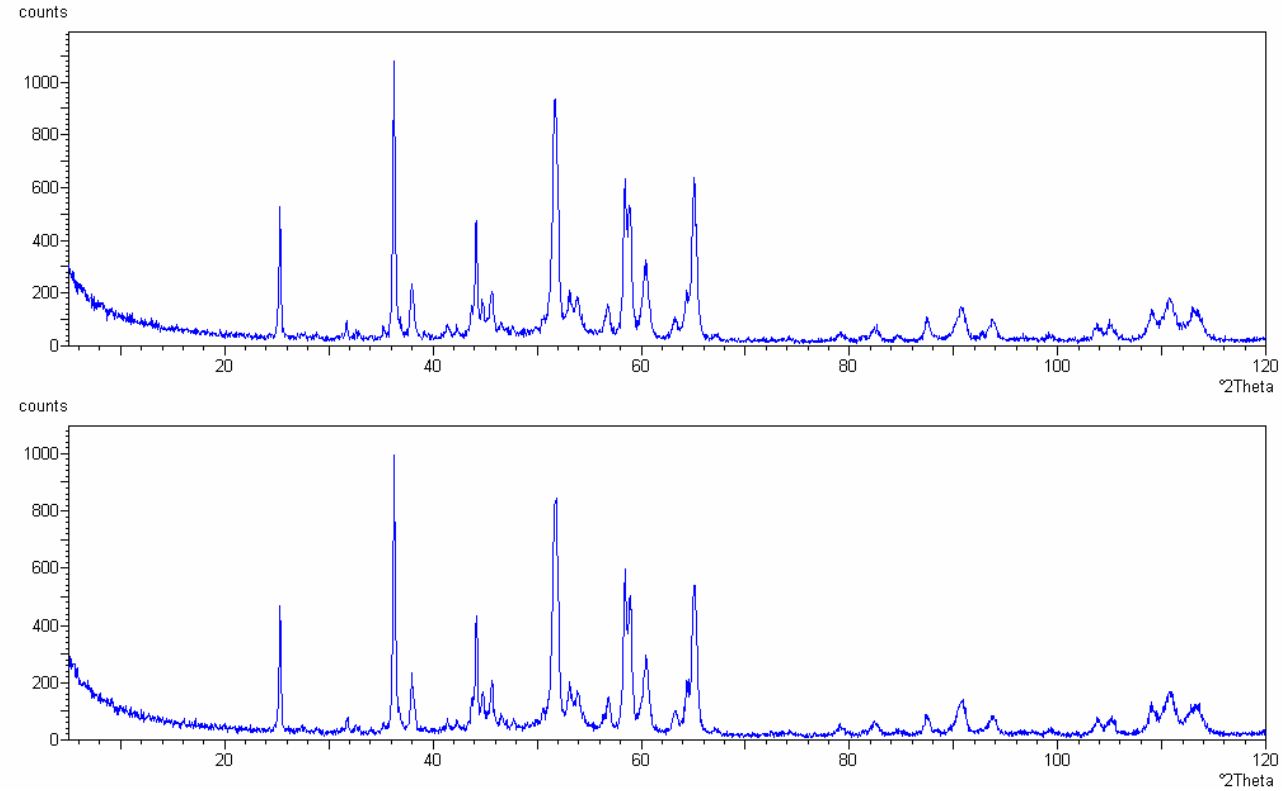
Samples A13 & A14 X-ray diffraction patterns



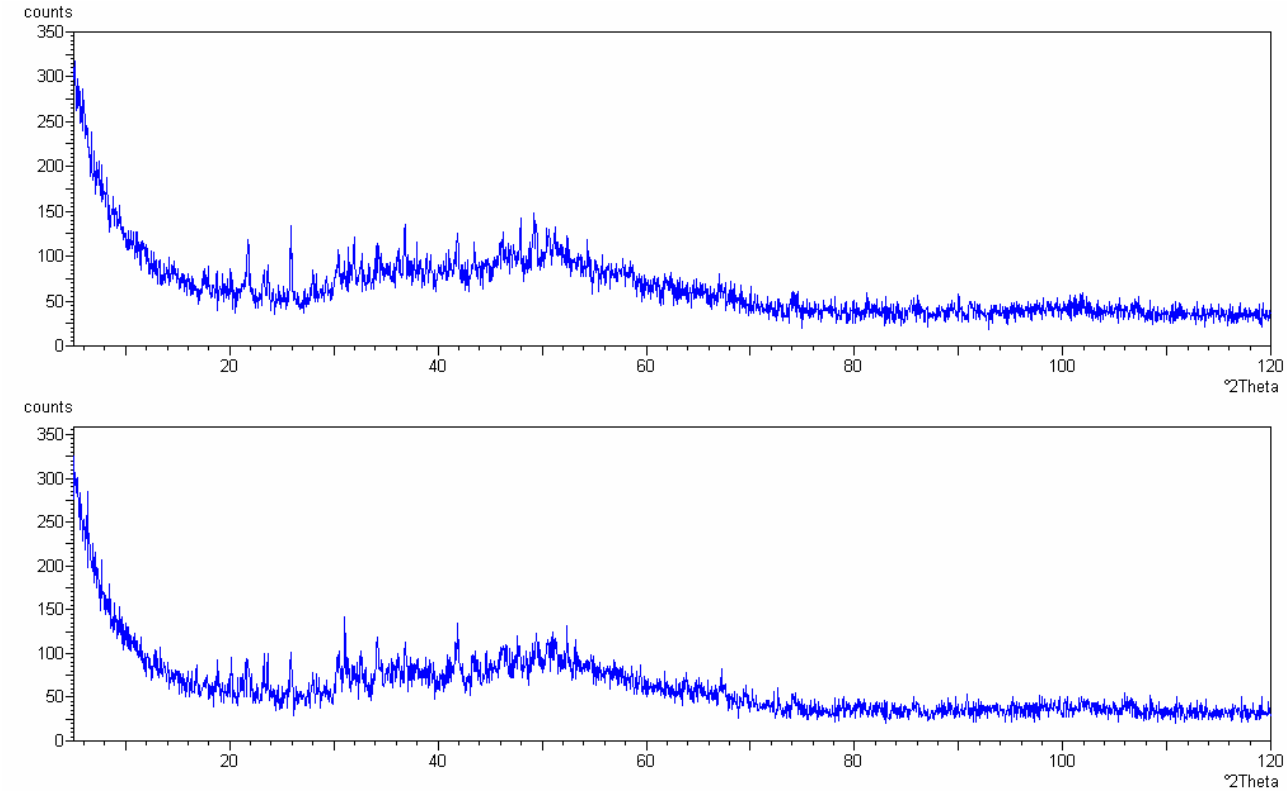
Samples A15 & A16 X-ray diffraction patterns



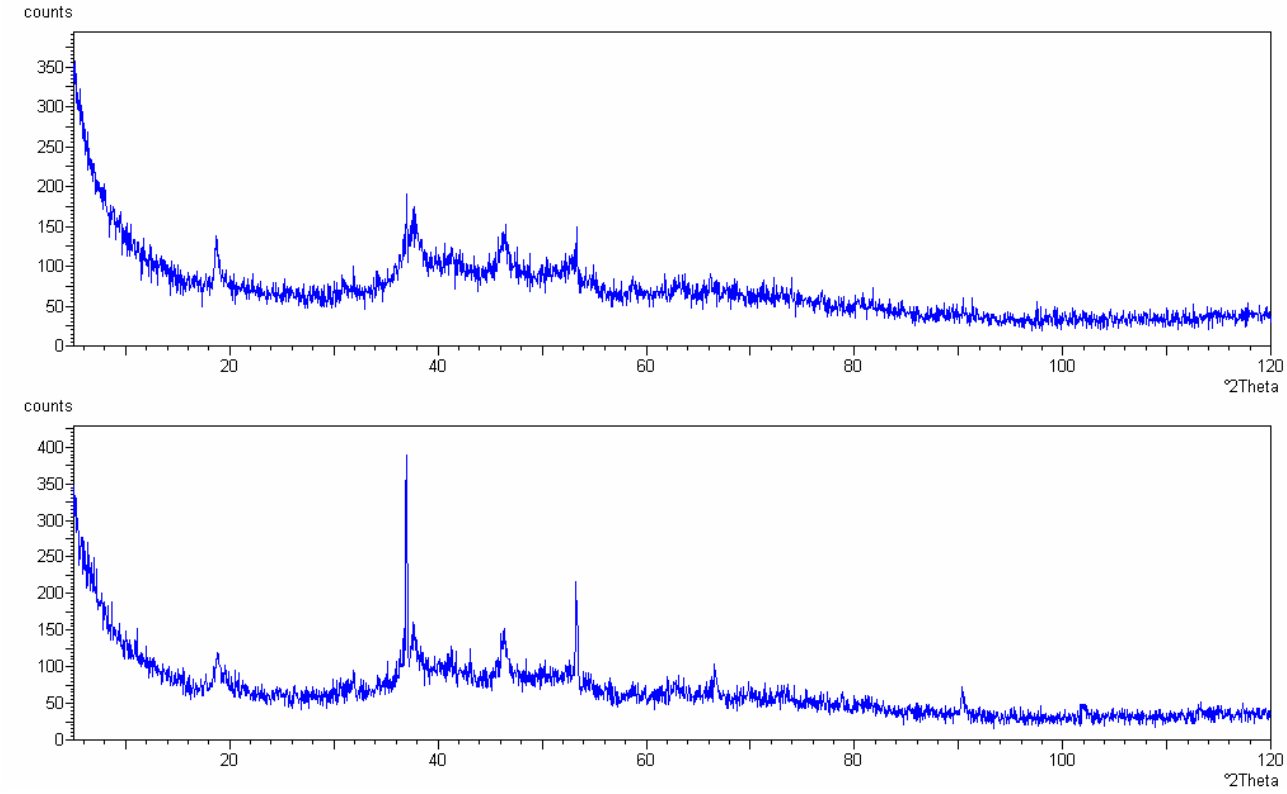
Samples A17 & A18 X-ray diffraction patterns



Samples A19 & A20 X-ray diffraction patterns



Samples A21 & A22 X-ray diffraction patterns



Samples A23 & A24 X-ray diffraction patterns