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RESOURCE MODELLING AT THE ILOVICA-ŠTUKA PORPHYRY COPPER-GOLD DEPOSIT, EASTERN MACEDONIA

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A b s t r a c t: The Ilovica-Štuka porphyry system is located in southeast Macedonia, within the Tertiary belt associated with tectonic accretion along the western Tethyan belt. The intrusive is about 1.5 km in diameter and comprises a dacite-granodiorite plug, emplaced along the northeastern border of the Strumica graben. Mineralization is typical porphyry style veining, most intense within the potassic zone. The mineralization shows good continuity and homogeneity that lends itself well to bulk-mining methods. Modelling and estimation has been completed using Geovia Surpac. Exploratory data analysis highlighted a number of statistically differentiated grade populations, which were interpreted to be controlled by the following: alteration style, lithology, oxidation state elevation and stockwork intensity. Statistical and grade continuity analyses were completed to characterize the mineralization and subsequently used to develop grade interpolation parameters. Grade estimation was completed using ordinary kriging. The search ellipsoid dimensions and orientations were chosen to reflect the continuity revealed by geostatistical studies and optimized using quantitative kriging neighbourhood analysis. The mineral resource was classified according to CIM Definition Standards on Mineral Resources and Mineral Reserves (CIM 2010).

Key words: Canadian Institute of Mining; Metallurgy and Petroleum (CIM) Definition Standards; EDA (exploratory data analysis); domaining; block model; ordinary kriging; kriging neighbourhood analysis

INTRODUCTION

Initial explorations at Ilovica were carried out by means of mining exploration works (adits and digs) by the contractor Vojo Žegarec. The exploration was located at the Kremen Čuka creek represented by a 12 m long Adit I and only 2 m long Adit II. Eastwards of the adits, to the right of the Ilovica creek, a couple of digs were excavated. To our knowledge, Pb-Zn dyke mineralization was explored.

Historical data about the Ilovica originate since 1936, when Ogražden limonite hill was described in details (Tomič, 1936). Later on at a request of the Zletovo mine, the Bureau of Geology carried out mapping activities on the south-western slopes of Ogražden between the villages of Novo Selo and Hamzali. Based on mapping of the south western slopes of the Mt. Ogražden it was concluded that there were indicators of an ore body that included a deep sulphide deposit (Ivanovski and Čedomil, 1958). Regional geological explorations of the eastern Macedonia area, which included the location of Ilovica-Štuka continued in the 1970's (Stojanović, 1971).

Mineralization discovery of copper, lead and zinc, before 1970, by the Skopje Bureau of Geology team, was linked to the dacite intrusions at Ilovica (Denkovski, 1974).

Later on exploration and presented results of the geological exploration of primary gold at Ilovica-Štuka, carried out only in the quartz-alunite dykes at the southern slopes of Čukar, were unsatisfactory in terms of Au content, and especially in terms of probable quantity (Denkovski et al., 1993).

In the period between 2004 and 2006 Phelps Dodge Exploration completed a series of drilling campaigns. In 2007, Euromax Resources Limited acquired the property and completed extensive exploration work and a series of technical studies over the subsequent years. The latest resource estimate was undertaken as a pre-cursor to completing a feasibility study for the project, which was undertaken to support fund raising and to form a basis for advancing into front and engineering design.

The compilation of all studies was perforemed during 2011 when it was prepared elaborate of geological ore reserves of the Ilovica deposit (Stolić, 2011).

GEOLOGICAL SETTING AND MINERALIZATION

Ilovica is a porphyry copper-gold deposit, located in a northwest-southeast striking Cenozoic magmatic arc, that covers large areas of central Romania, Serbia, Macedonia, southern Bulgaria, northern Greece and eastern Turkey (Figure 1).

The porphyry deposits in the region are in close spatial and temporal association with intermediate to felsic, medium to high potassium calc-alkaline igneous rocks. The low to mid-sulphidation epithermal deposits are related to bimodal volcanic rocks.

The Ilovica-Štuka porphyry Cu deposit is located in the border area between the Serbo-Macedonian massif (SMM) and the Vardar zone (VZ). In terms of its metallogeny, it belongs to the Lece-Bučim-Chalkidiki metallogenic zone (Serafimovski, 1990), which is a part of the Alpine-Balkan-Carpathian-Dinarides metallogenic belt (Heinrich & Neubauer, 2002). There is a well recorded, systematic thickening of the crust from southwest to northeast across the metallogenic belts, from 34 to 35 km in thickness beneath the Lece-Bučim-Chalkidiki belt, approximately 37 km in thickness below the Ilovica deposit, 41 to 45 km in thickness below the Osogovo-Besna Kobila belt (Serafimovski, 1990; Janković et al., 1995; Tasev, 2003). and greater than 50 km in thickness further northeast under the Rodope mountains.

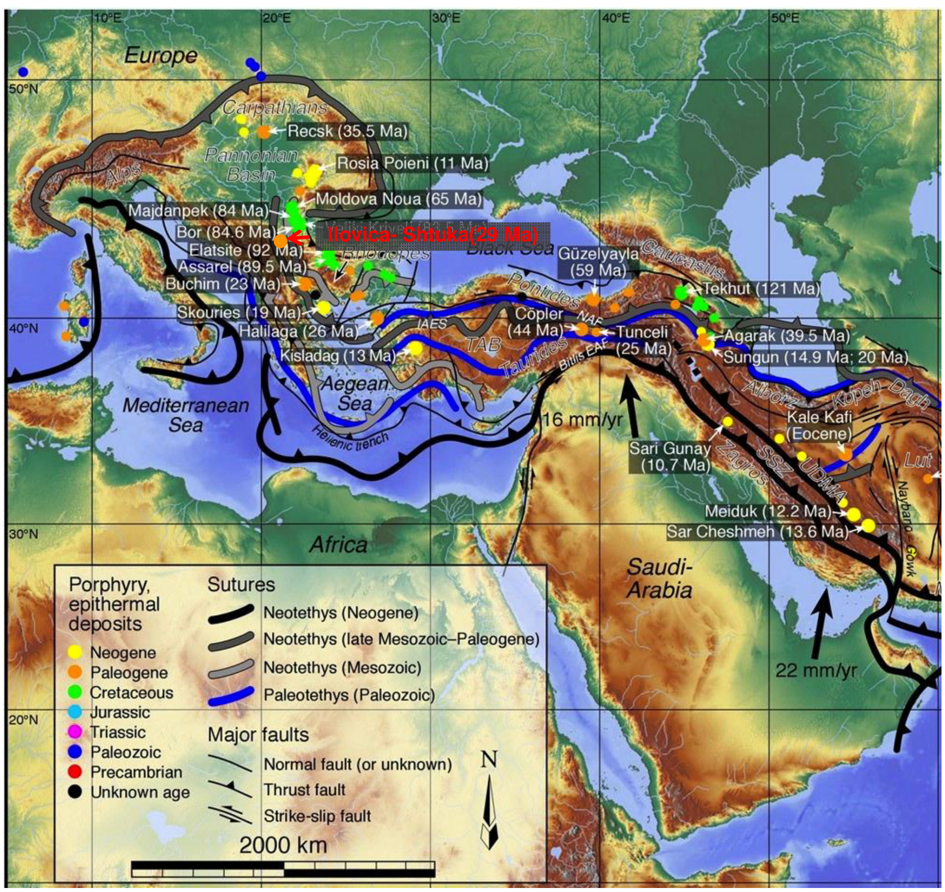

Fig. 1. Regional geological setting

The intrusions of the district belong to the Late Eocene–Oligocene magmatic zone (Harkovska et al., 1989), which cross cuts older tectonic structures (Sinclair, 2011), and occurs within the Circum Rhodope unit according to the compilation map of Schmid et al. (2013). The Late Oligocene–Miocene intrusions are associated with both economic and uneconomic ore mineralization.

Subvolcanic bodies (stocks) and dykes and related Ilovica-Štuka Cu-Au deposit are formed during the Oligocene in the area of Ilovica village, Macedonia. The magmatic rocks cros cut Triassic coarse orthoclase-phyric granite which is intruded in the orthogneisses and amphibolites of Vertiscos-Ograždes Unit of the Serbo-Macedonian massif. The rocks are high-K calc-alkaline with total alkalis in the range from 6.6 to 7.55 wt.%. They show high contents of LILE and teep LREE and MREE chondrite-normalized patterns and almost flat HREE normalized patterns. The Eu anomaly is 0.6 – 0.9, with LaN/Yb ratio ranging from 7.2 to 13.4. On a primitive-mantle normalized diagram, the rocks show peaks in LILE (U, Th, Pb) and trough in Nb, Ta, Ti and P. The $^{87}Sr/^{86}Sr$; ratio of 0.70791 – 0.70883 and Nd of 5.25/–7.14 is most probably due to mantle derived magma affected by crust assimilation. To distinguish the small temporal variations between the Tertiary magmatic rocks the precise ID-TIMS method is used. The granodiorite-porphyry stock that hosts the Cu-Au mineralization is formed in two magmatic phases dated by ID-TIMS at 30.31 ± 0.054 Ma and 30.126 ± 0.032 Ma, respectively. The ages of the dykes range in the interval of 28.8 – 29.6 Ma but inherited zircon grains with age around 31.5 Ma are also found. The hosting coarse orthoclase-phyric granite is dated at 251.9 ± 0.89 Ma and the metagranite xenolith age is 549.0 ± 4.6 Ma. The xenocrystic zircons and inherited cores are poorly presented (Georgiev et al., 2012).

At surface, the Ilovica intrusive complex consists of a central dacitic breccia diatreme, approximately 1.3 km in diameter. The diatreme is intruded by at least one dacite and two granodiorite porphyry stocks that have generated several hydrothermal pulses, resulting in widespread multi-phase veining within a mineralized stockwork.

The Ilovica porphyry is centred on a hill of more than 400 m of absolute relief, surrounded at lower elevations by numerous small dykes and irregular bodies of dacitic tuff and breccias and intermediate volcanic rocks.

The Ilovica magmatic complex is emplaced into lower Palaeozoic granite. The granite is locally weakly foliated, coarsely porphyroblastic, and forms a roughly northwest elongate body some 4 by 12 km in size, intruding Precambrian mica-schist and gneiss (Rakičević et al., 1973). Portions of the main dacitic diatreme locally contain abundant xenoliths of basement granite near the lithological contact.

Alteration related to Cenozoic magmatic activity at Ilovica is variably present over an area of about 8 km^2 (Figures 2 and 3). Pervasive alteration is largely confined to a roughly 1.5 km^2 area in and adjacent to the main intrusive complex. Smaller areas of pervasive and structurally-controlled alteration extend somewhat asymmetrically to the south and east of the intrusive complex. Alteration has not been studied in detail, but visual observations document the following zones (Lowell and Guilber, 1970):

- **Advance argillic (Distal):** Structurally controlled silicification, and silica or silica-alunite sulphide / iron oxide (FeOx) altered rocks (‘advanced argillic’), surrounded by narrow zones of clay alteration and bleaching, hosted in both fractured zones within basement granite, or within dykes of Cenozoic tuff-breccia. Such occurrences are present in zones of a few metres up to approximately 100 m in maximum dimension, and occur throughout the entire 8 km^2 altered area.
- **Phyllic (Proximal):** Pervasive quartz-sericite-clay-iron oxide (‘phyllic’) alteration, which contains larger bodies of quartz-alunite alteration, hosted in both basement granite and Cenozoic magmatic rocks. Proximal stockwork (phyllic): quartz-pyrite / iron oxide alteration and intense clay-sericite alteration largely confined to Cenozoic dacitic breccia and dacite-granodiorite intrusive rocks.
- **Potassic (Central):** Quartz-magnetite-sulphide / iron oxide stockwork and dissemination, with matrix alteration of illite-sericite, chlorite (‘intermediate argillic alteration) containing patches of residual secondary biotite and potassium feldspar, hosted in dacite-granodiorite porphyry, and minor andesite and latite-andesite porphyry dykes.
- **Supergene:** Sulphide oxidation, leaching and argillization and underlying secondary sulphide enrichment, locally extending as much as 150 m below surface.

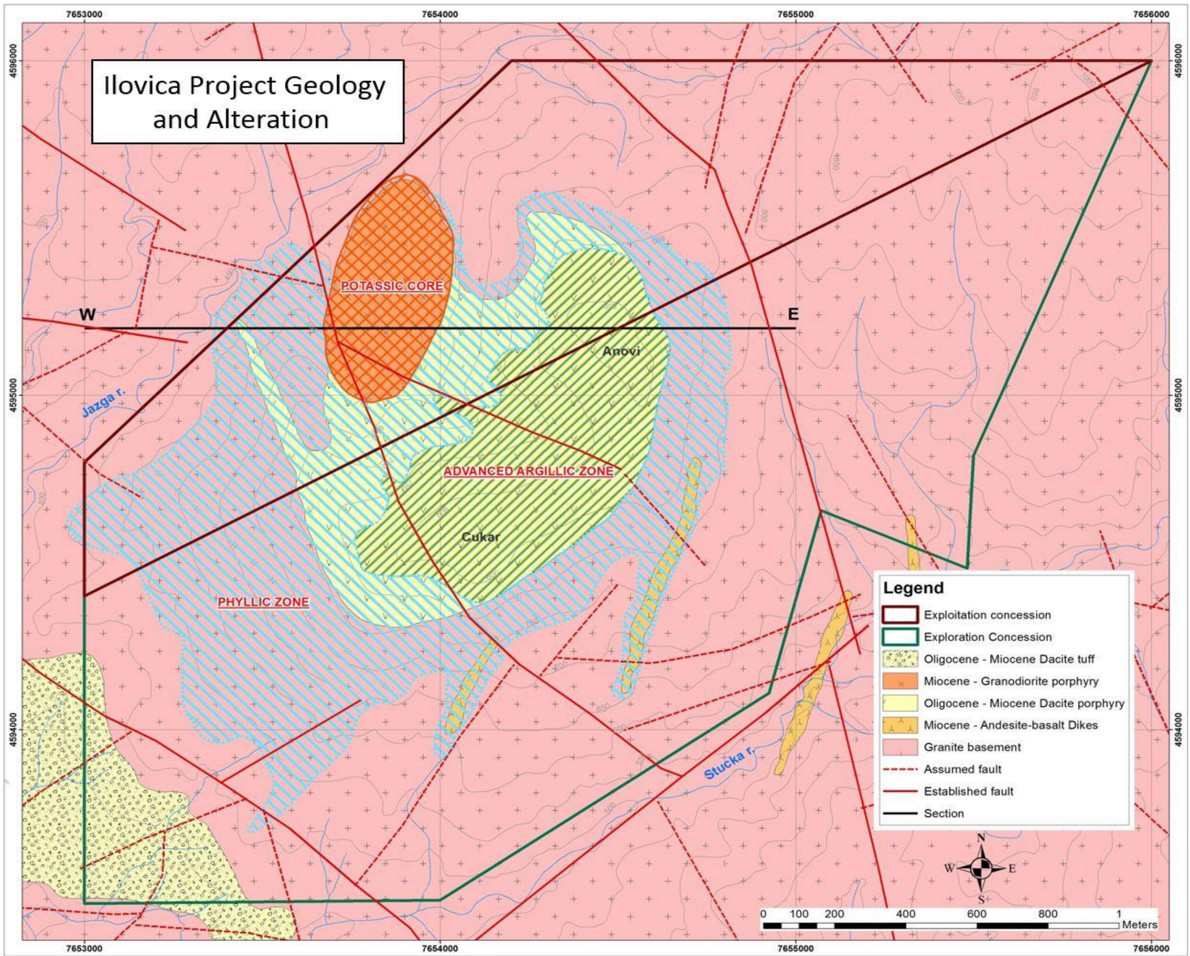

Fig. 2. Property geology and alteration plan

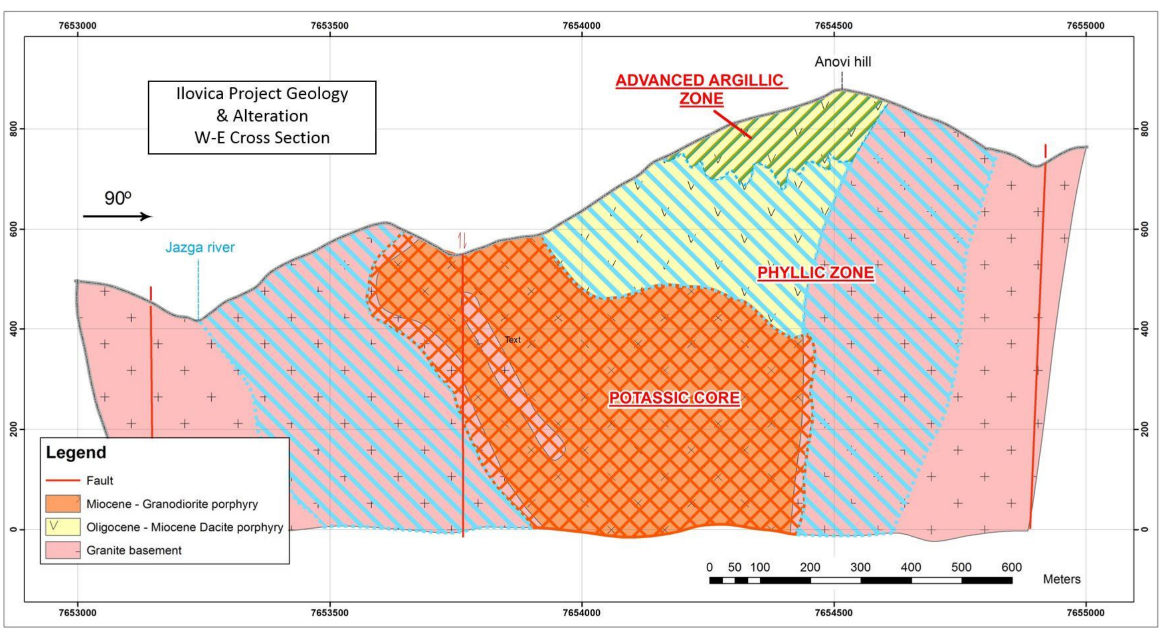

Fig. 3. Property geology and alteration (west-east cross section)

The main sulphide mineral at Ilovica is chalcopyrite, followed by pyrite and secondary copper sulphides such as chalcocite, covellite and bornite. Molybdenite, galena and sphalerite are present in minor amounts, and occasional traces of sulphosalt minerals such as tetrahedrite-tennantite and tellurides of gold and silver are observed.

High temperature oxide mineralization such as magnetite, dominates at depth, associated with pyrrhotite and chalcopyrrhotite in what is interpreted as the core of the system.

A variety of iron hydroxide group minerals are largely developed within the oxidation and cementation zones. The main and basic copper mineral is chalcopyrite, commonly accompanied by pyrite, and, depending on the mineralization level, the accompanying minerals are grouped in typical Fe-hydroxide, remarkably occurring secondary sulphides of chalcocite, covelline, bornite, and the specific sulphides such as molybdenite, galena, sphalerite, and the accompanying sulfosalt minerals such as tetrahedrite and tennantite, and telluride of silver and gold. Going deeper, the high-temperature oxide associations dominate, mostly represented by magnetite, hematite, martite, pyrotine, chalcopyrotine and chalcopyrite. Gold is present the individual fine grains in chalcopyrite and in the hydrothermally silica-altered mass within the bedrock. Specific allotriomorphic to hypodiomorphic grain structures have been established the corrosive and relict structures as well as the sub-graphic structures specific for the secondary products (chalcocite, covelline). The typical textures are stockwork, pro-vein and impregnation. Oxide paragenesis is remarkably occurring in the form of nest-like and individually developed magnetite aggregates (sporadically martitized) as well as classically developed hematite sticks combined with a later generation chalcopyrite (Serafimovski and Tasev, 2011).

MINERAL EXPLORATION

Geological mapping, rock chip sampling, soil geochemistry sampling, induced polarization (IP) / resistivity and magnetic geophysical surveys were completed between 2004 and 2015.

Mapping was completed on 1:2 000 and 1:5 000 scales and comprised observations with respect to petrology, style of alteration and mineralization.

In total, three phases of soil sampling have been undertaken on the property, resulting in a total of 540 sampling points arranged on a 100 m by 100 m grid covering an area of circa 5 000 m^2 (Figure 4).

A total 130 holes have been drilled over 10 campaigns between 2004 and July 2015. Of the 130 holes, 20 were drilled for geotechnical investigation, 15 were drilled for hydrogeological investigation, and 95 were drilled for mineral resource determination. In total, 42 032 m have been drilled. The drill locations are illustrated in Figure 5.

The cross section presented in Figure 6 illustrates the interpretation of the drilling results in relation to copper depletion in the oxide materials and supergene enrichment beneath. The gold assays show a similar but less pronounced distribution.

The quality assurance / quality control (QA/QC) programme conducted by Euromax Resources was appropriate and meets industry standards. In Tetra Tech's opinion, the sample preparation and security procedures are acceptable and the data can be relied upon for resource estimation.

MINERAL PROCESSING AND METALLURGICAL TESTING

Metallurgical tests are reported from the phase II (PII) samples. The work was undertaken on two drill holes which were used to generate an overall master composite (MC) sample. The PII work was extended as phase II residual (PIIR), using the PII MC and supplemented by two additional samples covering higher grade domains designated high granodiorite (H) and dacitic (D), the latter so named because of the presence of secondary sulphides such as chalcocite and bornite. The PIIR work was essentially to evaluate and confirm the results obtained from the PII work to the level of locked cycle test (LCT), especially in the higher grade material which is encountered in the early years of production. The phase III (PIII) work has to date focussed on the comminution, with flotation work to optimise reagents and flotation variability work in order to assess recoveries in the early years. PIII test work is continuing into the engineering design phase in particular to investigate future optimisations of the leaching circuit.

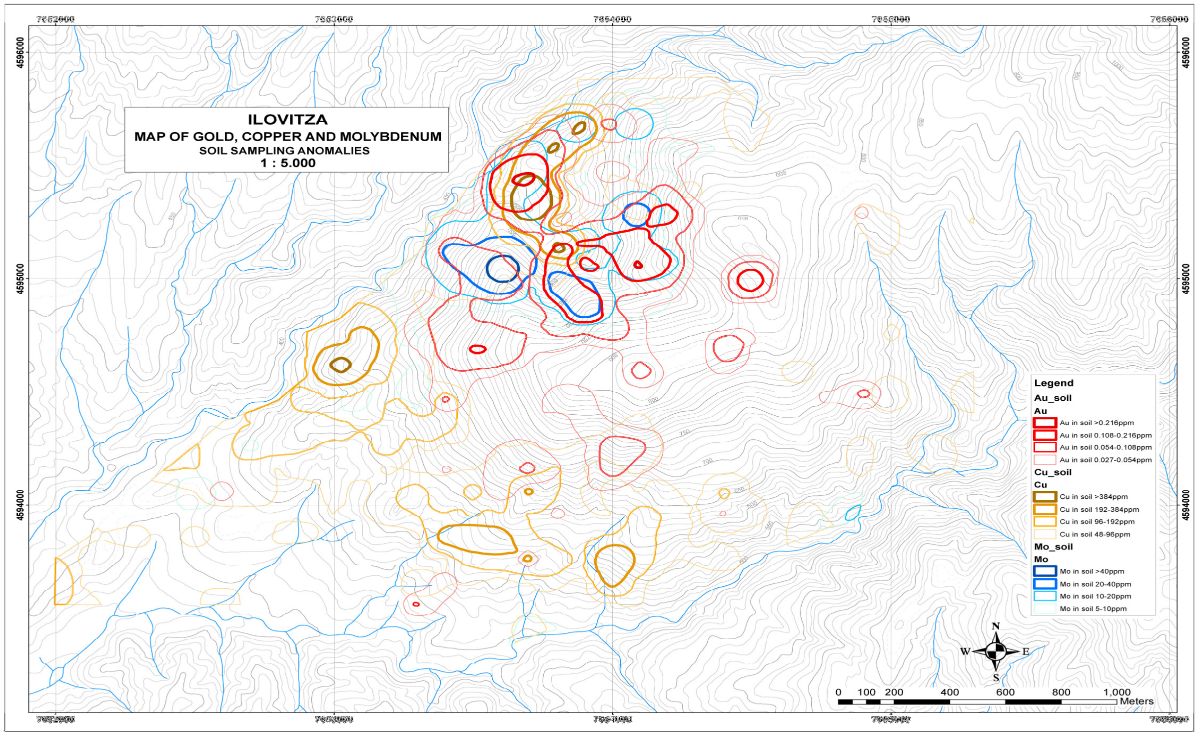

Fig. 4. Map of soil anomalies

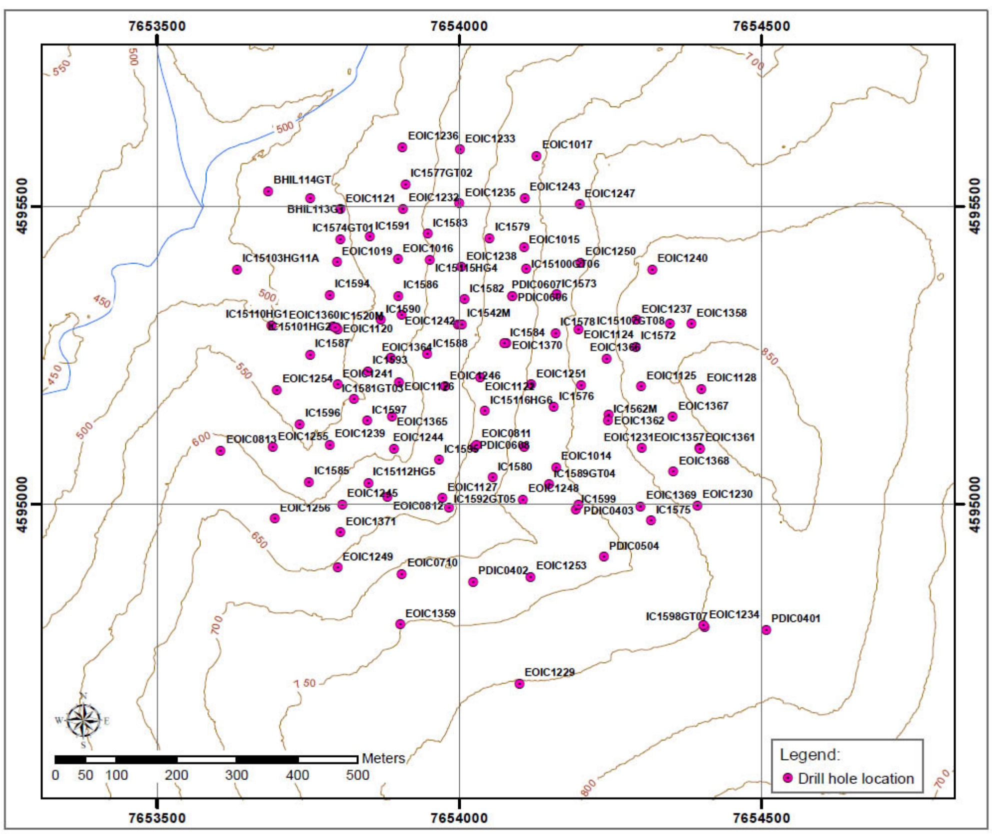

Fig. 5. Drill hole locations on the Ilovica-Štuka property

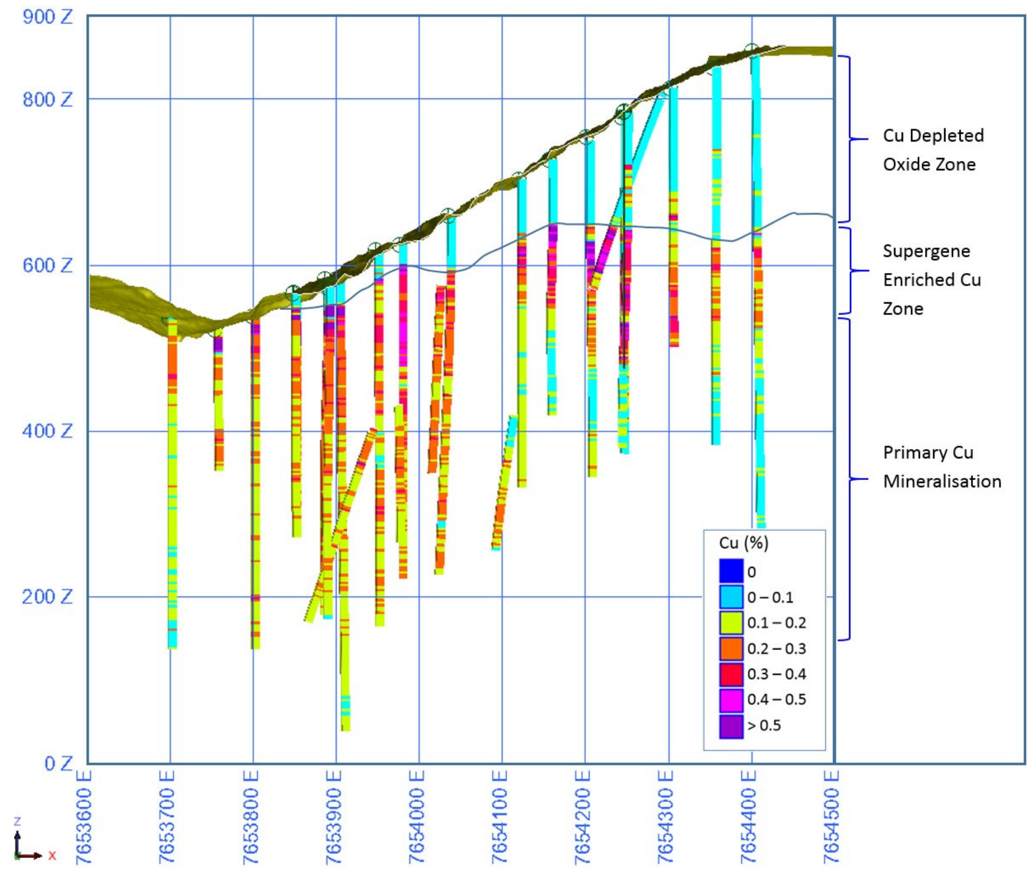

Fig. 6. Typical section – copper assays (%)

Mineralogy

The main mineralization of the sample tested was chalcopyrite and pyrite. Both minerals were of a fine grain size, with chalcopyrite, D50 of 30 μm, being finer than pyrite, D50 of 45 μm. The distribution of Au was mainly in the mineral grains, with a minor amount in the silicate gangue. No free gold was visible.

Flotation

A variety of flow sheets were simulated in the laboratory as individual open-circuit flotation tests during the PII and PIIR stages. Initially, the work concentrated on differential flotation, i.e. the production of a separate Cu concentrate to maximise Cu recovery at a saleable grade of Cu, followed by the recovery of a pyrite concentrate which would then be cyanide leached with Au recovery by carbon-in-leach (CIL). However, a final flow sheet of rougher flotation to a bulk concentrate followed by two stages of cleaning with gold recovery by CIL confined to the cleaner scavanger tailings was found to be optimal and selected as the final process route.

METHODOLOGY

The Ilovica-Štuka ore body modelling project starts with a critical review of existing drill hole and surface or underground sample data as well as maps and plans with current geological interpretation. Drill hole and/or sample databases are set-up to suit all the quantitative and qualitative information necessary to build a resource model. From there, the workflow: Database import and validation, exploratory data analysis (EDA), domaining / wireframe modelling, compositing, further EDA (including spatial analysis / variography), setup of empty block model, domain block model, estimation of grades / values of interesting into blocks, block model validation and resource classification with application of the Canadian Institute of Mining and Metallurgy (CIM) code.

MINERAL RESOURCE ESTIMATES

The definition of mineral resource as outlined within the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards on Mineral Resources and Mineral Reserves (CIM 2010) was adopted.

Statistical and grade continuity analyses were completed to characterize the mineralization and subsequently used to develop grade interpolation parameters for the deposit.

Exploratory data analysis (EDA) / domaining

The following attributes were analyzed to assess their control on copper and gold mineralization:

- alteration style,
- lithology oxidation state,
- elevation,
- stockwork intensity.

A three dimensional (3D) wireframe model defining the limit of mineralization was created for the deposit (Figure 7). The wireframe model was used within the sample selection and compositing routine and subsequently as a constraint to the grade estimation. Modelling and estimation were completed using Geovia Surpac.

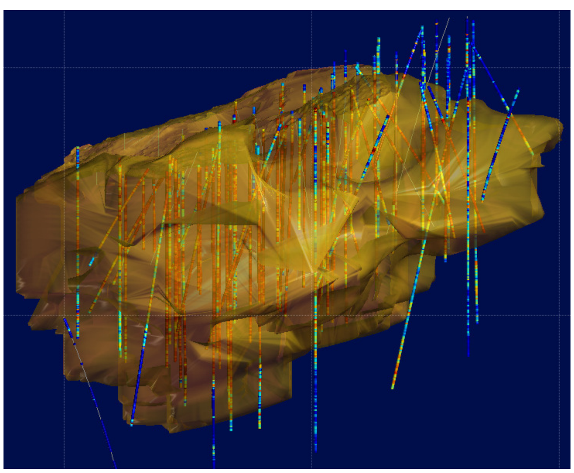

Fig. 7. Three dimensional (3D) wireframe model of the limit of mineralization

Exploratory data analysis highlighted a number of statistically differentiated grade populations, which were interpreted to be controlled by the following (Table 1):

- stockwork intensity;
- oxidation state;
- supergene leaching and enrichment.

T a b l e 1

Estimation domains

Domain	Stock-work index	Enrichment wireframe	Mineralization limit wire-frame	Oxidation state
Au Domain 1	<2	Outside	Inside	Any
Au Domain 2	≥2	Inside	Inside	Any
Cu Domain 1	Any	Any	Inside	Oxide
Cu Domain 2	0	Outside	Inside	Mixed and fresh
Cu Domain 3	>0	Inside	Inside	Mixed and fresh

The stockwork index is a numeric index that was established as the sum of the logged vein percentages. The stockwork index was used to implicitly model stockwork intensity iso-shell wireframes in Leapfrog Geo 3D. The wireframes were subsequently applied to the Surpac block model as a stockwork index integer attribute.

Compositing

Lithology and alteration observations dictated sample interval selection for all drilling campaigns at Ilovica. The mean sample length for all raw samples is 2.055 m.

A 3 m best fit routine was utilized to produce composites within hard domain boundaries. The compositing was completed in Surpac.

POPULATION ANALYSIS AND DOMAINING

Gold domaining

Multiple statistical grade populations were noted in the samples contained within the overall mineralization wireframe.

Overall the gold population approximates to a log normal distribution however differentiation based upon the estimation domains results in better defined log normal populations (Figure 8).

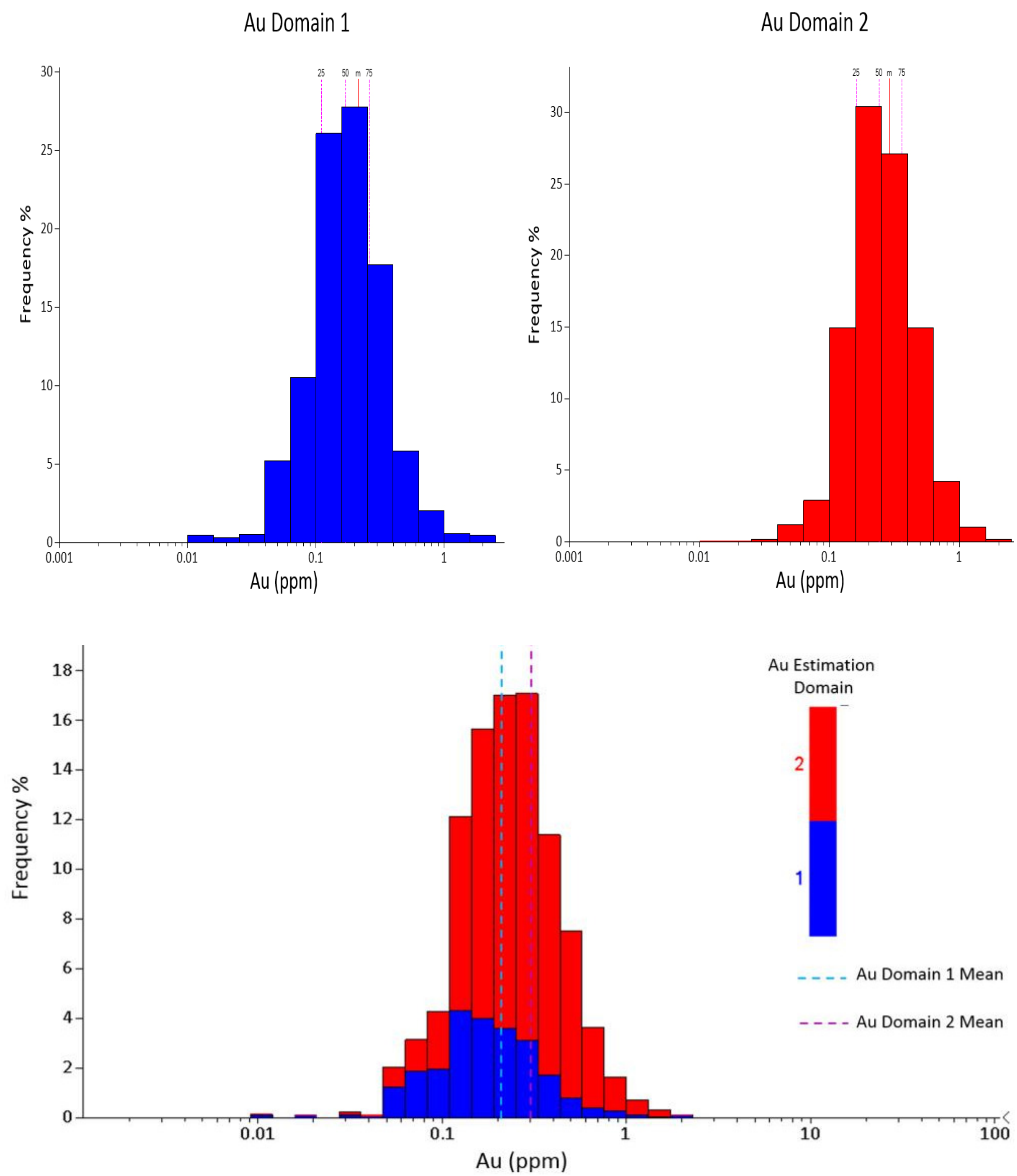

Fig. 8. Histograms of the population analysis and domaining of Au

Copper domaining

Separating the composites into the three estimation domains results in log normal populations for Cu domains 2 and 3 and a mixed population for Cu domain 1. Domain 1 is the Cu depleted oxide zone, which is sub-economic with respect to copper. The oxide copper is not included in the resource (Figure 9).

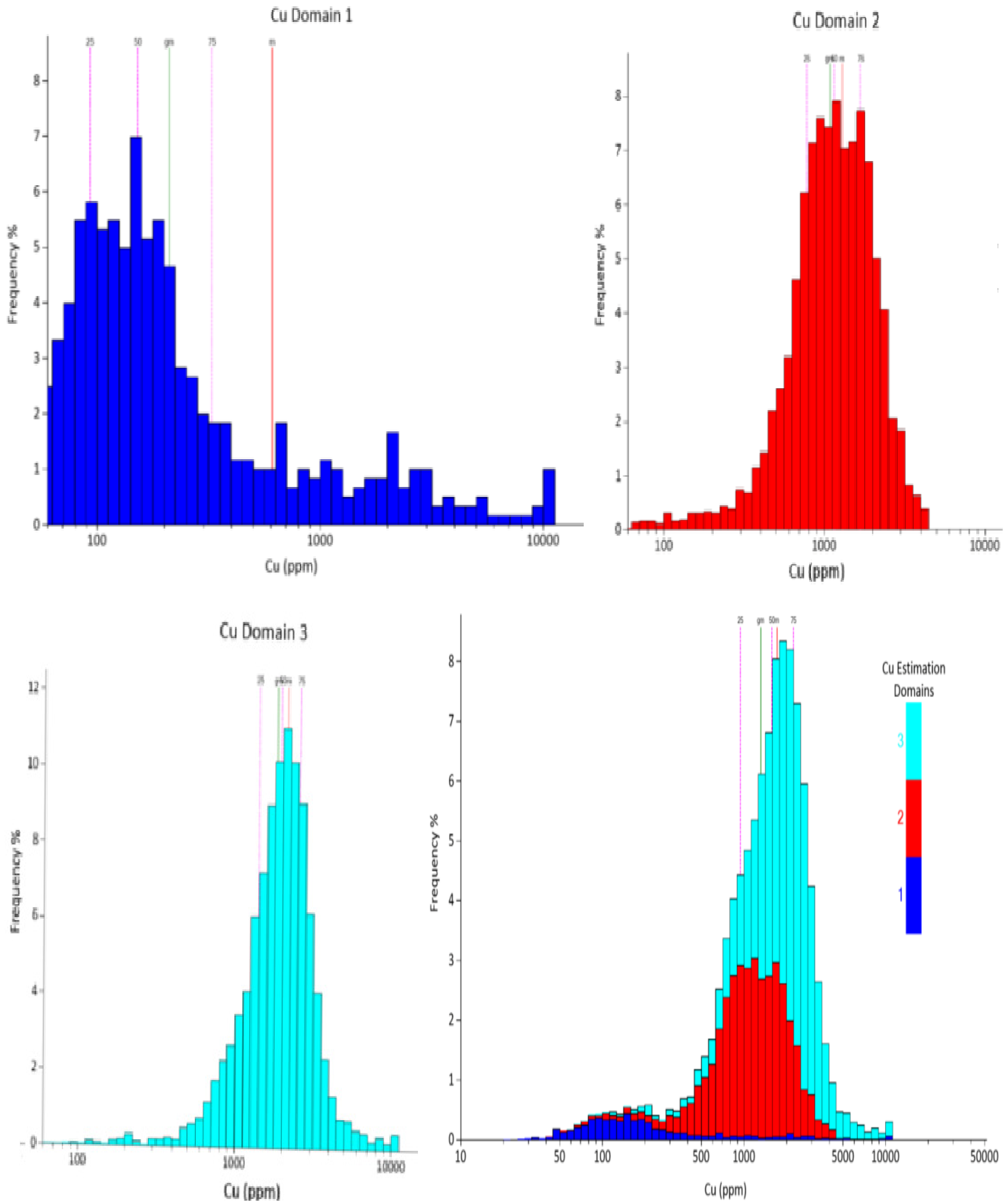

Fig. 9. Histograms of the population analysis and domaining of Cu

Further domaining using both lithology and alteration wace investigated. Neither were shown to be effective in isolating grade populations. Domains based upon a combination of lithology and oxidation state provided no benefit in isolating grade populations compared to oxidation state alone, and sub-dividing the domains based upon lithology and alteration resulted in a decrease in the number of composites available for each interpolation. Therefore, lithology and alteration style were not used for domaining.

Variography

Variography was completed in Snowden Supervisor software.

Experimental semi-variograms were produced in a plan view initially, with the strike, dip and plunge established independently thereafter. The nugget value has been established from a down hole variogram (Figures 10 and 11).

Moderate directional control has been established in the majority of the domains for both copper and gold.

Capping analysis was completed for copper and gold in each domain using the 3 m composites. Decile analysis (Parrish, 1997) was completed and the grade distributions were plotted as histograms and probability plots on normal and log scales.

Capping requirements were based upon the need to exclude outlier results and to avoid having a significant concentration of metal within the final deciles/centiles in the Parrish analysis. The capping applied to the composites prior to estimation are presented in Table 2.

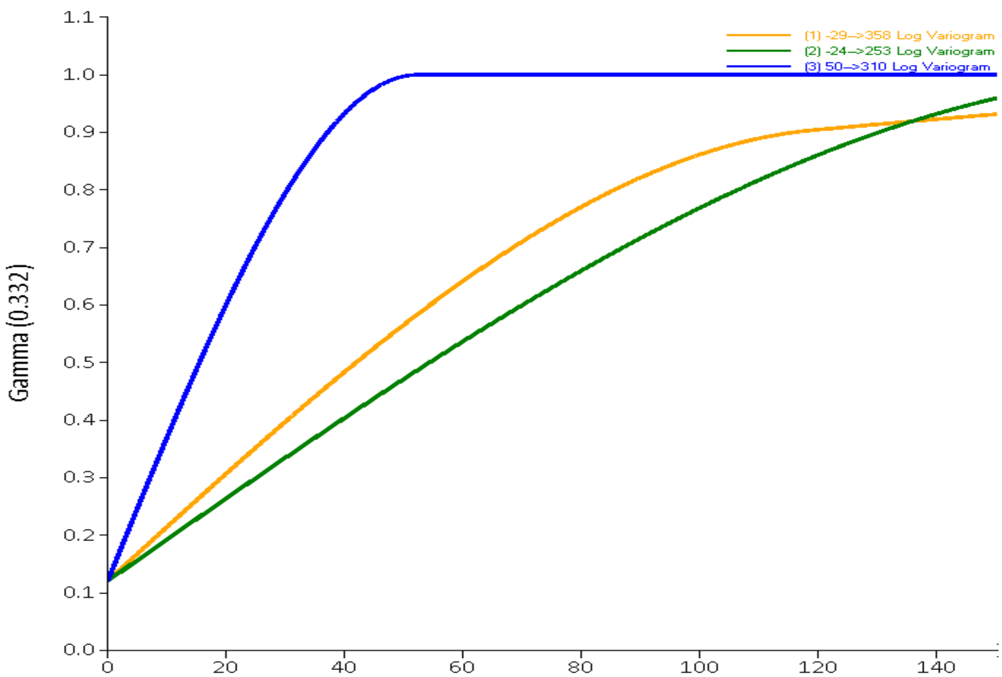

Fig. 10a

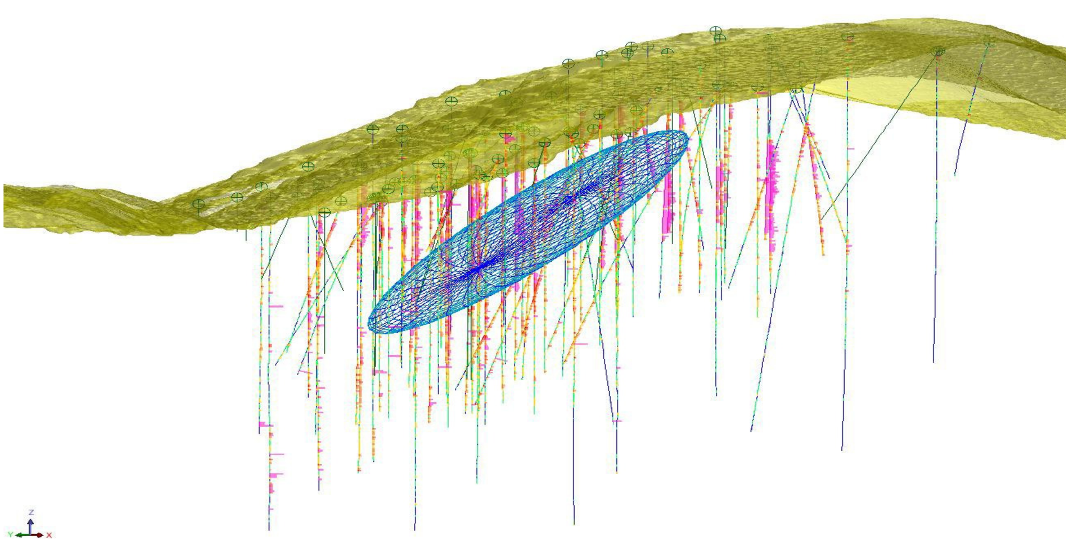

Fig. 10b

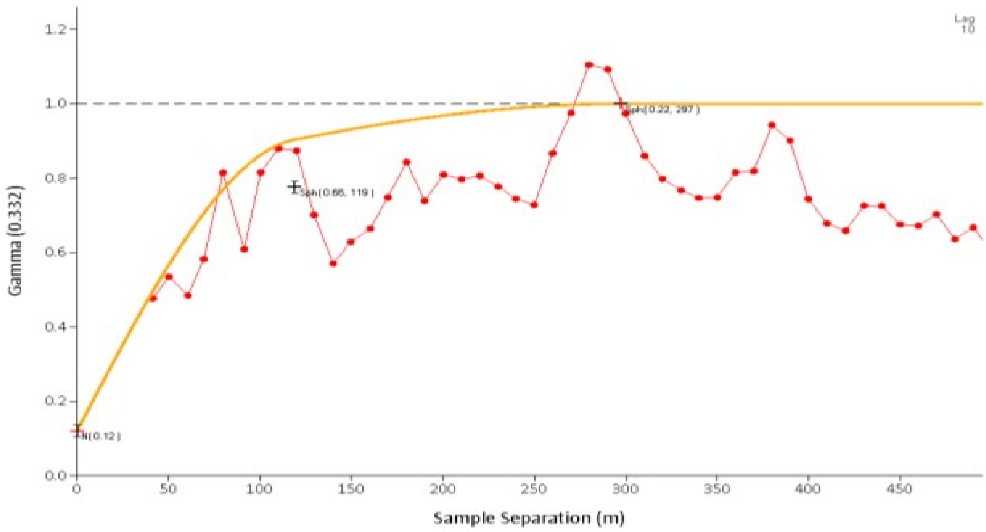

Fig. 10 c

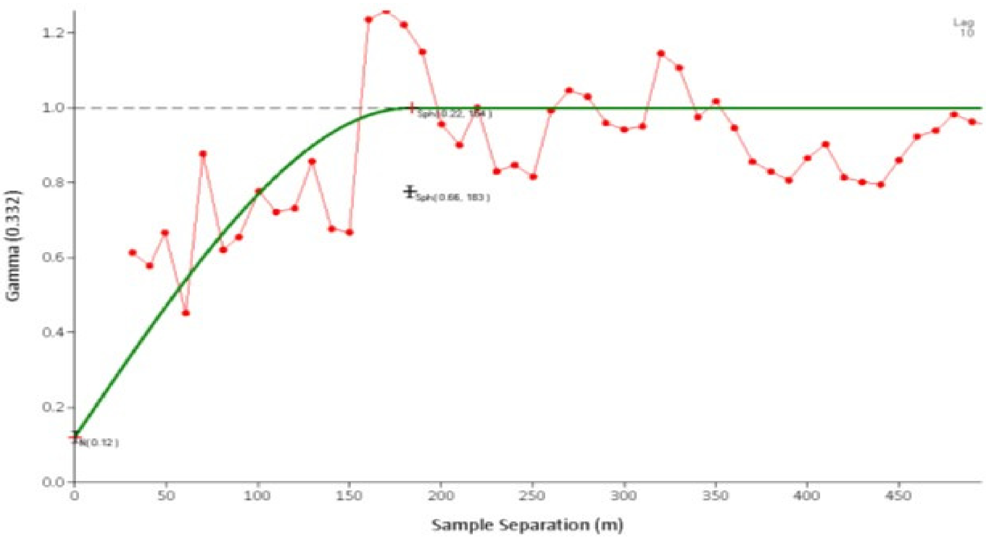

Fig. 10d

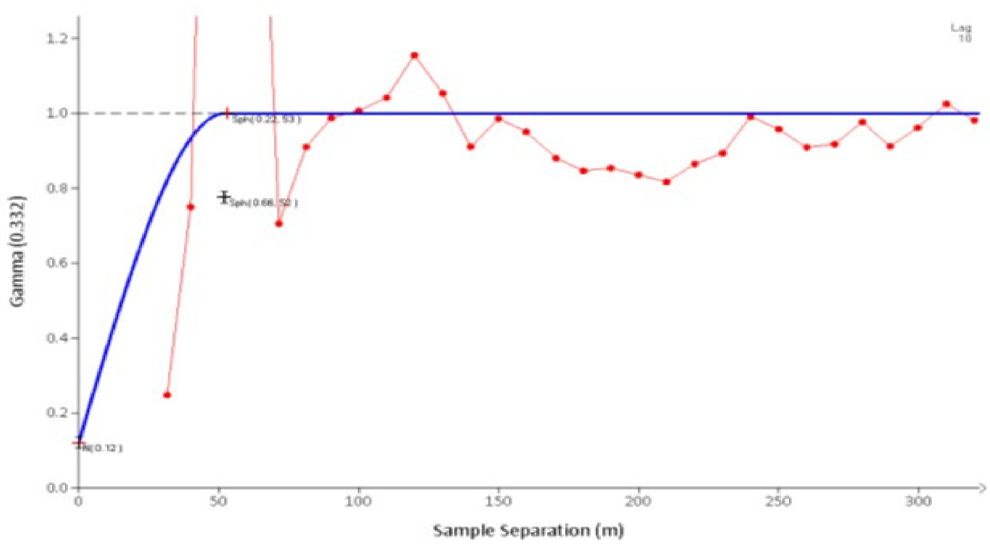

Fig. 10e

Fig. 10. Variography – Au domain 2

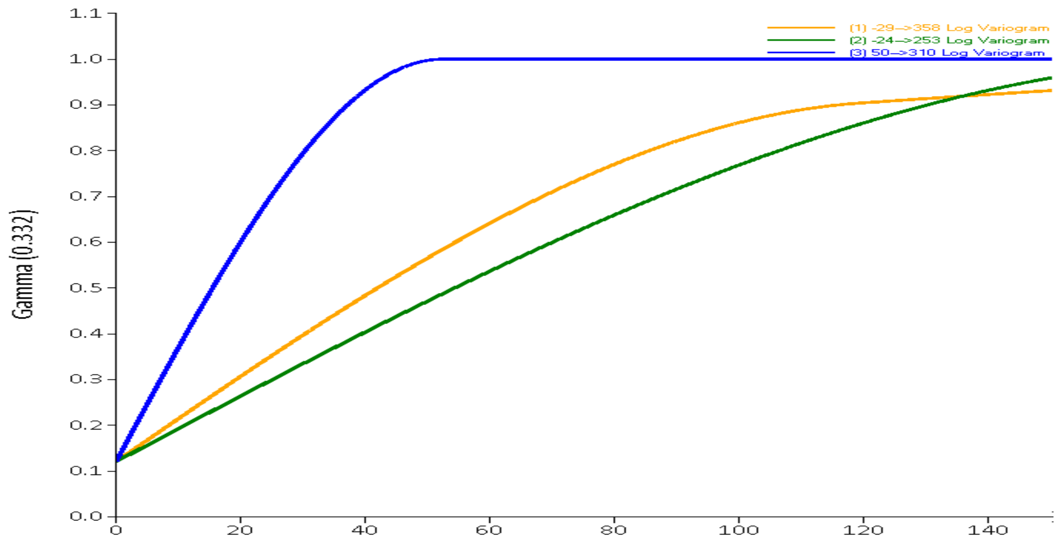

Fig. 11a.

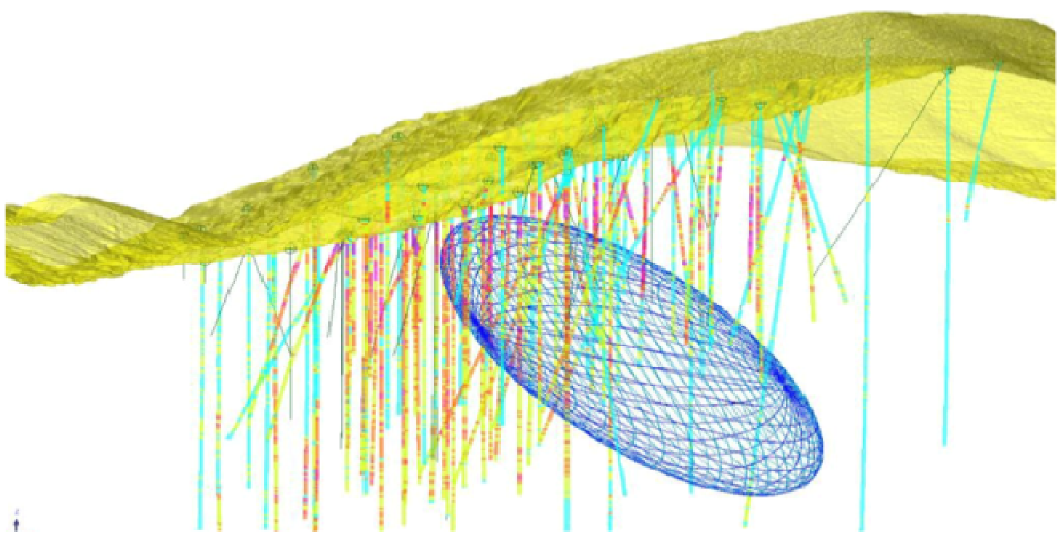

Fig. 11b

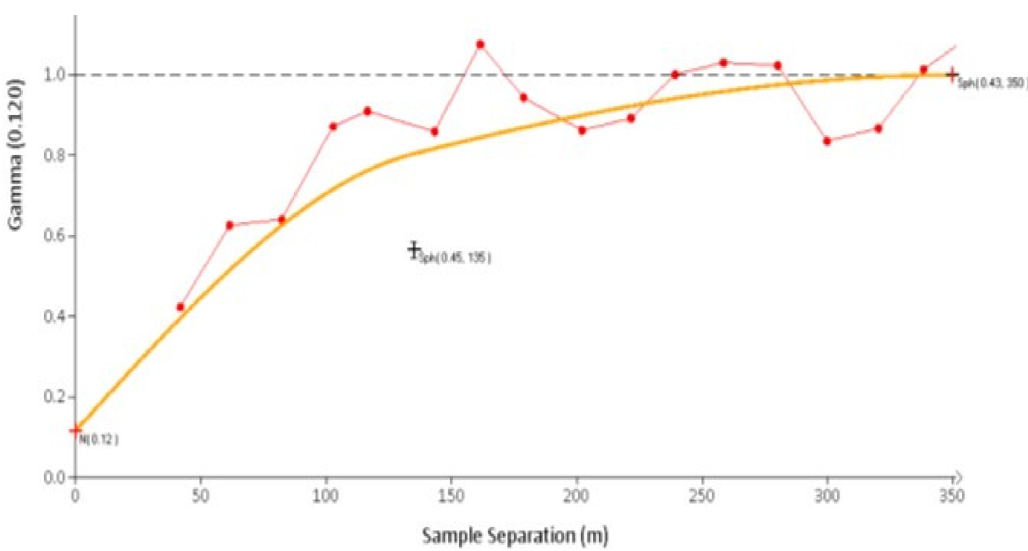

Fig. 11c

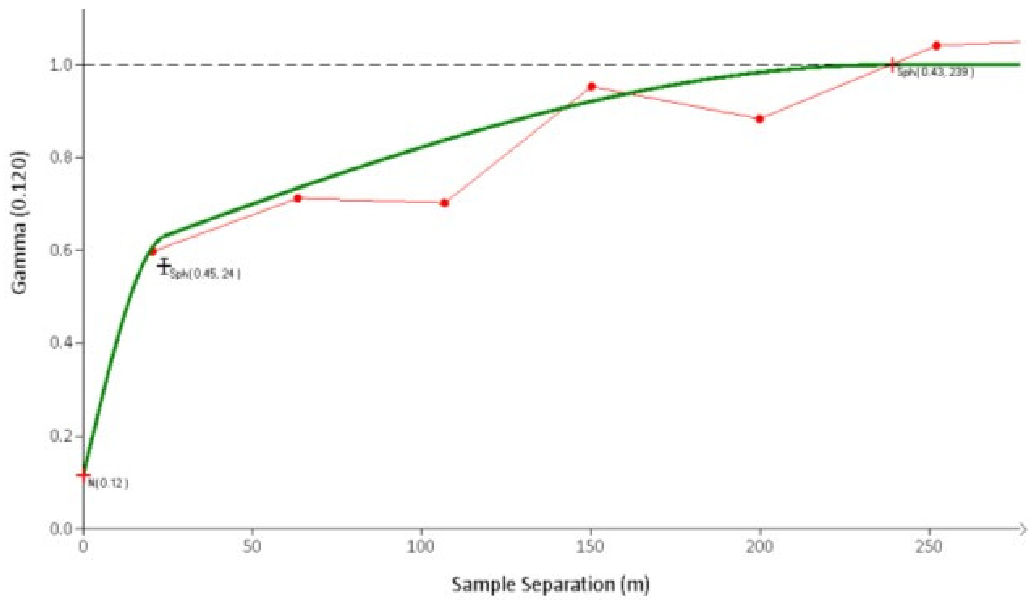

Fig. 11d

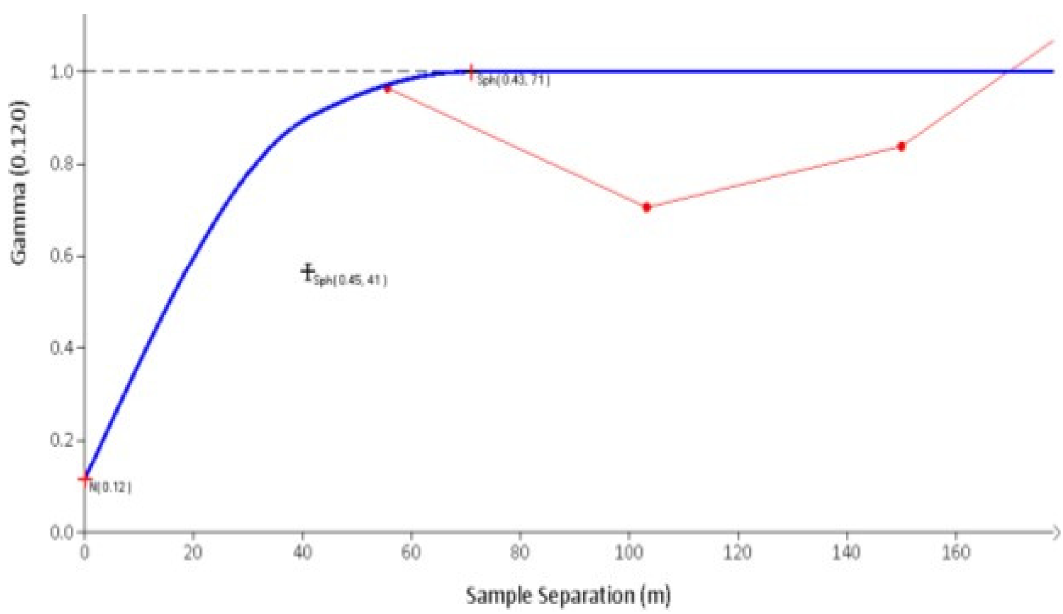

Fig. 11e

Fig, 11. Variography – Cu domain 3

T a b l e 2

Summary of grade capping

Domain	Cap (ppm)	Number of composites changed
Au 1	Not required	0
Au 2	5	7
Cu 1	10 000	6
Cu 2	4000	14
Cu 3	10 000	23

Density

The density was interpolated using an inverse distance weighting squared algorithm IDW^2 estimate based upon 8,283 measurements. The density values were estimated using copper domaining (Table 3).

A single block model has been constructed in GeoviaSurpac. The block model parameters are given in Tables 4 and 5.

Block model

Sub-blocks were used to accurately differentiate domains within the block model. The block model volume for a given zone was found to match well with its corresponding wireframe. A comparison of the overall mineralization wireframe and block model volumes is given in Table 6.

Table 3

Density values by oxide state

Oxide state	Density (t/m^3)
Mix	2.40
Oxide	2.31
Fresh	2.52
Grand total	2.49

Density values by rock type

Rock type	Density (t/m^3)
Dacite	2.40
Dacite breccia	2.39
Diluvium	2.32
Granite	2.55
Granodiorite	2.50
Quatz vein	2.79
Grand total	2.49

Table 4

Comparison of block model and wireframe volumes

Description	Unit	Volume
Mineralization wireframe	m^3	307,048,879
Block model	m^3	305,710,813
Difference	%	0.44

Table 5

Block model parameters and extents

Measure	*Y*	*X*	*Z*
Minimum coordinates	4,594,500	7,653,000	–200
Maximum coordinates	4,596,500	7,655,000	1,000
Parent block size (m)	20	20	10
Minimum block size (m)	5	5	2.5
Rotation (°)	0	0	0

Table 6

Comparison of block model and wireframe volumes

Description	Unit	Volume
Mineralization wireframe	m^3	307 048 879
Block model	m^3	305 710 813
Difference	%	0.44

GRADE INTERPOLATION STRATEGY

Cu and Au grades were estimated using ordinary kriging (Krige, 1996), adopting a multi-pass methodology. Estimation was constrained by estimation domains and within the limit of mineralization wireframe.

Quantitative kriging neighbourhood analysis was undertaken to optimise the block size, number of informing samples, discretization and search distances used in the estimation.

Estimates for silver and molybdenum were not undertaken as the silver assays are not made with a sufficiently low detection limit in the majority of the deposit and Tetra Tech considers that the potential for incremental value to be added by molybdenum is limited.

Block model validation

Block model validation was completed using graphical and statistical methods (Coombes, 2008), to confirm that the estimated block model grades appropriately reflect the local composite grades.

Graphical analysis of the informing samples versus estimated block grades was undertaken using horizontal and vertical sections (selected vertical sections are presented in Figures 12 and 13).

Figure 14 illustrates the correlation between the block gold grades estimated by ordinary kriging, and the informing composites. The plot illustrates a good correlation, with some smoothing within the block grades as would be expected during estimation.

Figure 15 illustrates the correlation between the kriged copper grades, and the informing composites. The plot illustrates a good correlation, with the composite trends being reflected in the block model.

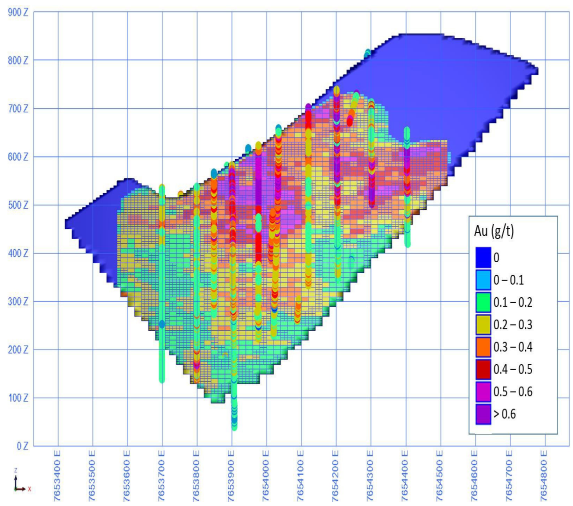

Fig. 12. Block model validation – Au g/t

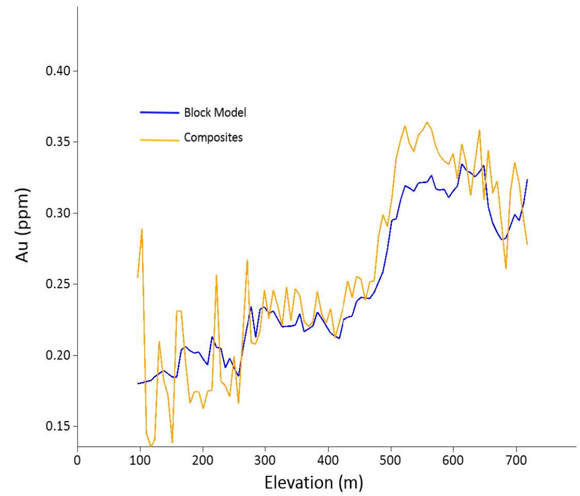

Fig. 14. Swath plot for gold by elevation

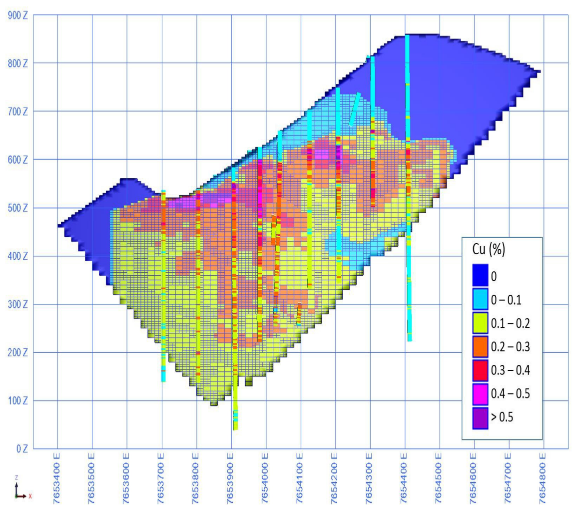

Fig. 13. Block model validation – Cu %

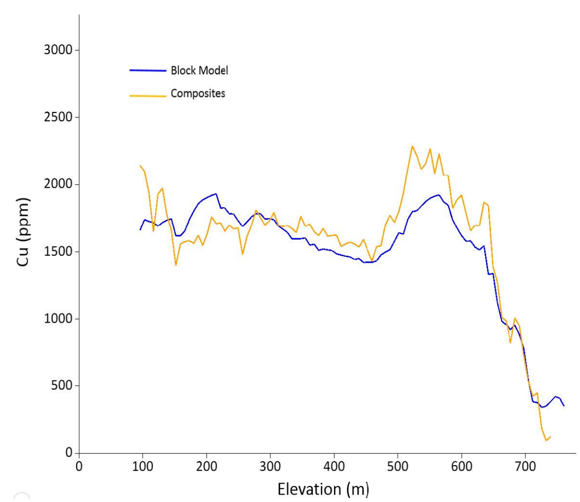

Fig. 15. Swath plot for Cu by elevation

RESOURCE CLASSIFICATION

At the Ilovica-Štuka deposit mineral resource classification scheme consistent with the CIM guidelines (2010) was applied. The estimates are categorized in the measured and indicated mineral resource categories, reported above a cut-off grade that defines the resource as potentially mineable by open pit mining methods.

The CIM Definition Standards provide standards for the classification of mineral resource and mineral reserve estimates into various categories. The category to which a resource or reserve estimate is assigned depends on the level of confidence in the geological information available on the mineral deposit; the quality and quantity of data available on the deposit; the level of detail of the technical and economic information which has been generated about the deposit, and the interpretation of the data and information.

The classification at Ilovica resource model considers the following criteria:

- Confidence in the sampling data and geological interpretation;
- Analysis of variogram parameters;
- The data distribution (based upon graphical analysis and average distance to informing composites);
- Kriging efficiency;
- Slope of regression.

The block model was constrained based upon the kriging efficiency, slope of regression and average distance to informing composites. Whilst taking into account the confidence in the sampling and geological interpretation, along with the knowledge of the variogram parameters, three wireframe models were generated to define the measured, indicated and inferred resources. The models reflected the trends in the classification parameters, whilst ensuring that the classification resulted in appropriately coherent units.

In order to statistically validate the adopted classification, the weighted average block values within each classification domain were reported (Table 7).

In calculating the dollar equivalent block values, metal price forecasts were taken from Energy & Metals Consensus Forecasts, published by Consensus Economics Incorporated. The 12 July 2015 publication was referred to. The forecast for September 2016 was US$ 1 244 /t oz Au and US$ 2.87 /lb (6 333 /t) Cu, with a long-term forecast of US$ 1 271 /t oz Au and US$ 2.99 /lb (6 590 /t) Cu.

Table 7

Weighted average block values within each classification domain

Classification	Average distance to informing composites (m)	Kriging efficiency	Slope of regression
Measured	54	73	89
Indicated	73	52	78

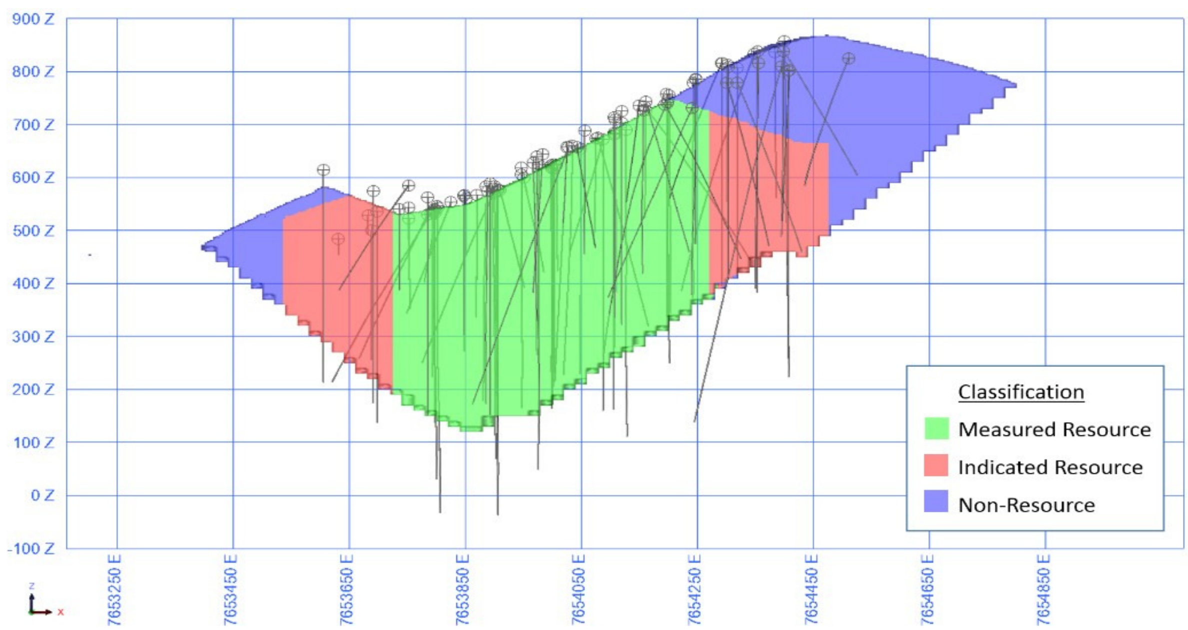

Fig. 16. Section taken along west-east at N : 4 595 250

For the purpose of assigning a dollar value to blocks, so that a cut-off can be applied to show reasonable prospects of economic extraction, Tetra Tech adopted US$ 1 250 /t oz Au and US$ 3.00 /lb Cu (6 612 /t). The dollar equivalent is calculated using the following formula:

$$\text{Dollar Eq} = [\text{Au} \cdot \text{recovery} \cdot \text{Au price}] + [\text{Cu recovery} \cdot \text{Cu price}]$$

The following assumptions were adopted for the calculation of the dollar equivalent:

- Au recovery in oxide of 74%
- Cu recovery in oxide of 0%
- Au recovery in fresh 88%
- Cu recovery in fresh 84%
- Forecast metal prices of US$ 1 250 /oz Au and US$ 3.00 /lb Cu.

Resource grade/tonnage sensitivity tables were created based upon a range of dollar equivalent cut-offs for blocks within the overall resource pit shell. A base case cut-off of US$ 16/t was chosen for sulphide materials and US$ 8 /t for oxide materials.

For the purpose of mineral resource reporting, the transitional material has been grouped with either the oxidized or fresh material based upon the copper content. Where the transitional material has less than 0.2% Cu, it is grouped with the oxide material, where the copper content is greater than 0.2%, it is grouped with fresh material. This approach reflects the fact that there would not be a separate process route for transitional material.

The mineral resource for fresh material is summarized in Table 8.

The oxide mineral resources within the constraining pit shell are summarized within Table 9.

Mineral resources that are not mineral reserves do not have demonstrated economic viability. The estimate of mineral resources may be materially affected by environmental, permitting, legal, title, taxation, socio-political, marketing, or other relevant issues.

Table 8

Measured and indicated fresh mineral resource based upon a dollar equivalent Cut-off of US$ 16/t

Classification	Tonnage	Grade		Contained metal	
		Au (g/t)	Cu (%)	Au (koz)	Cu (klb)
Measured	147,100,000	0.31	0.23	1,500	729,500
Indicated	109,700,000	0.33	0.20	1,100	479,000
Total M I	256,800,000	0.32	0.21	2,600	1,208,500

Table 9

Measured and indicated oxide mineral resource based upon a dollar equivalent cut-off of US$ 8 /t

Classification	Tonnage	Grade Au (g/t)	Contained metal Au (koz)
Measured	12 500 000	0.41	160
Indicated	9 600 000	0.37	110
Total M I	22 100 000	0.39	280

CONCLUSIONS

The geological and resource estimation work completed on the Ilovica-Štuka project has been completed using an international best practice approach and the has been reported and disclosed to the investment markets in accordance with National Instrument 43-101, the national instrument for the standards of disclosure for mineral projects within Canada.

The resource estimate was classified according to the CIM Definition Standards on Mineral Resources and Mineral Reserves (CIM 2010),

The statistical analysis and resource domaining appropriately reflects the understanding of the geological controls on mineralization and consequently facilitates a robust grade interpolation.

The resultant block model and resource classification provided a reliable basis upon which to complete a feasibility study for the project.

Statistics comparing estimated block grades and composite grades for each domain are shown in Table 10.

Table 10

Statistics comparing estimated block grades and composite grades for each domain (ppm)

Domain	Composite satistics					Model statistics				
	Au		Cu			Au		Cu		
	1	2	1	2	3	1	2	1	2	3
Samples	2334	7314	602	3631	5416	890 508	2 330 155	100 200	1 619 632	1 402 094
Minimum	0	0	22	42.37	58.14	0.02	0.04	64.69	290.81	293.82
Maximum	1.48	5.00	10 000	4000	10 000	1.02	1.77	7432.25	3081.95	9082.68
Mean	0.21	0.3	609.2	1283.72	2124.94	0.19	0.27	734.78	1209.57	1967.43
Variance	0.02	0.06	2 083 743	498 894.9	1 509 031	0.01	0.01	980 196.1	149 826.9	438 645.3
Standard deviation	0.15	0.25	1443.52	706.32	1228.43	0.08	0.12	990.05	387.07	662.3
Standard errorr	0	0	58.83	11.72	16.69	0	0	3.13	0.3	0.56
Skewness	2.94	7.19	4.63	0.98	2.56	1.94	1.81	2.55	0.55	1.69
Kurtosis	14.24	109.15	23.9	1.19	11.53	6.32	5.73	6.9	-0.27	7.2
GEOMEAN	0.18	0.24	210.56	1081.43	1834.06	0.18	0.25	395.21	1148.99	1870
Log estimate mean	0.22	0.32	445.35	1328.26	2162.52	0.19	0.27	692.58	1210.63	1966.2

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Р е з и м е

МОДЕЛИРАЊЕ НА РУДНИТЕ РЕЗЕРВИ ВО ПОРФИРСКОТО НАОЃАЛИШТЕ НА БАКАР И ЗЛАТО „ИЛОВИЦА-ШТУКА“ ВО ИСТОЧНА МАКЕДОНИЈА

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Клучни зборови: Канадски институт за рударство; металургија и нафта (CIM); стандарди за дефинирање; анализа на истражувачки податоци; одредување домен; блок-модел; кригинг-метод; квантитативна соседна кригинг-анализа

Порфирскиот систем Иловица-Штука се наоѓа во југоисточниот дел на Македонија, во рамките на терцијарниот појас поврзан со тектонските слоеви на западниот тетиден појас. Интрузивот е околу 1,5 километри во дијаметар и се состои од дацити и гранодиорити, сместен е по должината на североисточната граница на струмичкиот грабен. Минерализацијата е со жици од типичен порфирски тип, со најголем интензитет во калиумовата зона. Минерализацијата покажува континуитет и хомогеност која овозможува да бидат имплеметирани методите на екстракција на големи количини руда. Моделирањето и пресметката се извршени со користење на софтверот Geovia Surpac. Анализата на податоците покажа постоење на неколку популации на минерализација кои се контролирани од интензитетот на промена на карпата, литологијата, нивото на оксидацијата и штокворкот. Извршени се статистички анализи и оцена на континуитетот за да се одредат карактеристиките на минерализацијата, кои потоа беа искористени за одредување на параметрите на интерполацијата. Пресметката на рудните резерви е извршена со користење на методот кригинг. Димензиите на пребарување на елипсоидот и ориентациите се избрани така да го претстават континуитетот на минерализацијата дефиниран со геостатичка анализа на податоците. Оптимизирањето е направено со користење на методот на квантитативна соседна кригинг-анализа. Минералните резерви се класифицирани во согласност со стандардите за дефинирање минерални суровини и минерални резерви на Канадскиот институт за рударство, металургија и нафта (CIM, 2010).