Independent Geological Review of
Vardar Minerals’ License Areas
in the Republic of Kosovo

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Executive Summary

Currently Vardar Minerals Ltd is holding six exploration license areas in the Republic of Kosovo, one of them is north of Mitrovica (Stan Terg license area) in the north of Kosovo (Mitrovica Project), two of them (Orlan and Brvenik licenses) in an area between the polymetallic Drazna deposit and the Serbian border, next to the recently discovered Kiseljak Cu-Au porphyry deposit, here referred to as the Drazna Project, the remaining three are all around the town of Viti (or Vitina), that is, the Viti, Viti-North and Viti-East license areas, collectively referred to as the Viti Project, in the southeast of the country. All three projects are located in a geological setting that is ideal for the formation of porphyry Cu-Au (±Mo) and related peripheral Cu-Au-Zn-Pb skarn, carbonate replacement Zn-Pb-Ag (±Au or Cu) and epithermal Au-Ag (-Cu-Zn) deposits. All of them are positioned within the Palaeogene magmatic arc that stretches from western Romania through Serbia, Kosovo, Macedonia, southern Bulgaria, northern Greece into northern Turkey. Although the Cretaceous magmatic arc, which stretches roughly parallel to the north of the Palaeogene arc, has been traditionally regarded as more prospective for subduction-related porphyry Cu-Au and associated epithermal gold deposits because of well-known major deposits therein, the Palaeogene arc is becoming more and more focus of exploration for major companies (Dundee, Eldorado, First Quantum) since the relatively recent discoveries of a number of porphyry Cu-Au deposits in this younger, post-subduction arc.

The Mitrovica license area is immediately west and northwest of the largest Pb-Zn-Ag deposit (Stan Terg mine) of the famous Trepća metallogenic belt. The Stan Terg deposit is interpreted as carbonate replacement mineralization related to phreatomagmatic breccia formation, which, in turn, is regarded as part of a larger porphyry mineralization system. The corresponding porphyry mineralization has not been discovered so far and the best area to look for that appears to be in the southern part of the Mitrovica license area. First reconnaissance field observations and analyses of grab samples indicate the presence of suitable subvolcanic porphyry rock types and porphyry-typical alteration there, especially argillic and advanced argillic, variably oxidized disseminated sulfides, sulfide-quartz veins and stockworks, well as locally elevated Ag, As, Cu, Pb, Zn and Au concentrations.

The Viti Project is centred on a distinct geophysical circular feature that is interpreted, based on limited surface outcrops, as subvolcanic intrusive body, possibly underlying a large caldera structure. Topographic highs, at least in the northern part of the project area, contain alteration that is typical of lithocaps on top of porphyry-style mineralization systems. Argillic and to a lesser extent propylitic alteration is evident in some exposed (sub)volcanic units. On the southeastern fringe of the project, outside the license areas, an anomalous Cu-Zn-Ag occurrence was found to occur within a larger propylitic alteration zone with associated diorite porphyry that cross-cuts Jurassic to Upper Cretaceous country rocks. This is interpreted as distal expression of a larger porphyry system, which is suspected to spatially overlap with the geophysical feature beneath the Viti Project area.

The Drazna Project is located in the southwestern portion of the well-endowed Lece Magmatic Complex and, based on known mineral occurrences and observed alteration styles as well as preliminary assays of
a few grab samples, bears a high potential to host porphyry and epithermal-type deposits similar to those at Kiseljak in Serbia.

For all three projects the currently available observations and data suggest a high potential for the existence of porphyry Cu-Au, high-sulfidation epithermal gold and/or low-sulfidation polymetallic deposits. This alone justifies investment into further exploration activities. In order to minimize risk, it is recommended to split such activities into two phases. Phase 1 should involve detailed geological field mapping with focus on magmatic rock types and alteration zones, shallow trenching and systematic geochemical soil sampling over selected areas. This should be accompanied by the processing and interpretation of whatever geophysical data might be available (or could be purchased) for the project areas. Thereafter, Phase 2 should involve high-resolution airborne and ground geophysical surveys and eventually drilling of targets identified during the previous work steps.
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1. Preamble

Over the last few years, Vardar Minerals Ltd, a UK-registered privately owned exploration company (Company No. 10474687), has re-evaluated large portions of southeastern Europe with regard to base and precious metal potential. The company engaged in a lengthy and very extensive capturing of available geological, geophysical and geochemical data, as well as data on known mineral occurrences and deposits across southeastern Europe. Applying a GIS-based prospectivity mapping approach, they delineated a number of geological domains with elevated potential of hosting base and/or precious metal deposits. From a metallogenetic point of view, these domains relate to ophiolite-related magmatic chromite as well as Ni-Cu deposits, volcanic hosted massive sulphide (VMS) deposits of the Besshi type, sedimentary exhalative (SEDEX) and Mississippi Valley-type (MVT) deposits as well as porphyry Cu-Au deposits with related peripheral styles of mineralization, such as epithermal, skarn and carbonate replacement deposits. With the aid of their extensive data base, the company subsequently focused its exploration strategy on the latter group of mineral deposits, that is, porphyry and related base and precious metal deposits, and identified numerous exploration target areas, specifically in Kosovo and Bulgaria. In 2017 this resulted in the awarding of already six license areas in the Republic of Kosovo to Vardar Geoscience Kosovo. They encompass one area near Mitrovica (hereafter referred to as the Mitrovica Project), one area in the Drazna ore field between the Drazna mine and the Serbian border in northeastern Kosovo (hereafter referred to as the Drazna Project) and three areas near Vitina (hereafter referred to as the Viti Project). Further exploration license applications of the company are pending in Bulgaria. The latter include Sredna Gora, where an extension of a major well-known mineralized porphyry trend, defined by the Elatsite and Assarel porphyry deposits and the Chelopech epithermal deposit, under thin cover is suspected; a group of license areas around Bakabjkij to the east of the Prohorovo copper porphyry deposit and within a domain of historical mining for lead, zinc and silver ores with potential for continuation of the porphyry system beneath thin cover; and finally the Lozen Project in an area of large-scale alteration with known lead, zinc and copper anomalies in a setting that bears strong similarities with the Madjaravo Pb-Zn-Ag district and the ancient Ada Tepe gold deposit where currently a modern mine is being developed.

Recently, in November 2017 reconnaissance exploration fieldwork, coupled with petrographic and mineralogical studies, was carried out by Murgana Geological Consulting in the three project areas in Kosovo (Georgiev et al. 2017).

This report is aimed at assessing those areas for which licenses have already been granted to Vardar Minerals with regard to their exploration potential from a geological point of view and to examine whether any follow-up exploration work on them appears justified and can be recommended. The report is based on available literature, the above referred to first reconnaissance work by Murgana, first preliminary interpretations of geophysical and geochemical data (stream samples and geochemical assays of >200 grab samples) acquired by Vardar Minerals, and past experience and two field visits by the author in November 2016 and June 2017 to Bulgaria and Kosovo, respectively. The author is a Competent Person who is a Fellow of the Geological Society of South Africa (GSSA), Fellow of the Society of Economic Geologists (SEG) and an Executive Council Member (incl. Past President) of the Society for Geology Applied to Mineral Deposits (SGA). He has close to 30 years of experience that is relevant to the style of
mineralization and types of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the Joint Ore Reserves Committee (JORC) ‘Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves’ as well as the ‘South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves’ (the SAMREC Code).

2. Prospectivity of the Tethyan Belt in southeastern Europe

All of the existing and potential new license areas of Vardar Minerals in southeastern Europe are located within the Tethyan Belt, which is a historically most important metallogenic province of Europe with regard to base and precious metals and most recently has become again focus of global exploration and mining initiatives. In this section, the prospectivity of the Tethyan Belt across southeastern Europe is briefly reviewed with emphasis on base metals and gold as these are the principal commodities of interest in the given target areas of Vardar Minerals.

The Late Alpine Tethyan orogenic belt, which stretches from the Alps via the Carpathians-Balkans, Turkey, Iran, across southern Asia to Indochina, resulted from the closure first of the Palaeotethys, later of the Neotethys oceans, and subsequent collision of various continental fragments with Eurasia (palaeogeographically the eastern part of Laurasia). In some places, Neotethyan oceanic lithosphere is still being subducted, such as in the eastern Mediterranean and the Makran seas, whereas elsewhere orogeny has reached already an advanced stage of continental collision, as in the Alps and Himalayas. The Palaeotethys Ocean opened during the mid-Palaeozoic. Tectonic inversion set in as the large continental masses of Gondwana in the south and Laurentia in the north converged and eventually collided during the Variscan (Hercynian) orogeny to form the supercontinent Pangaea in the late Palaeozoic. Permian-Early Triassic rifting of continental fragments off the northern margin of Gondwana heralded the opening of the Neotethys Ocean, while closure of the Palaeotethys led to the accretion of these continental fragments onto the southern margin of Laurasia at Late Triassic-Early Jurassic times. Thereafter, the Neotethys Ocean closed due to northward subduction underneath the accretionary Laurasian margin. At the same time, back-arc basins along that margin opened up (Pindos and Vardar seas) before continental collision between Africa-Arabia and India with the eastern portion of Laurasia, while the Central Atlantic Ocean began to open up between western Laurasia and Gondwana, thus triggering counter-clockwise rotation of Gondwana – the main driving force behind the closure of the Neotethys Ocean (Fig. 1).

Relatively little is known about the metal endowment associated with the Palaeotethys Ocean, but numerous world class ore deposits are known to have formed during both opening and closure of the Neotethys Ocean. Examples related to Neotethys oceanic crust formation include major chromite deposits. Subduction of the Neotethys oceanic lithosphere led to the development of an extensive magmatic arc with numerous porphyry and epithermal deposits therein (Fig. 2).

The outstanding position of southeastern Europe’s Balkan region as highly endowed mineral province is evident from its rich mining history. Archaeological evidence suggests that the oldest know gold mines were in that region: the Ada Tepe deposit in southeastern Bulgaria had been exploited as early as c. 4500 BC (Tsintsov et al. 2016) and is regarded as Europe’s oldest pre-historic gold mine. Similarly, the earliest
mining of copper ore, with the Bor copper deposit in Serbia as example, is likely to have had prehistoric beginnings. Smelting of silver-bearing lead-zinc ore in today’s Kosovo can be dated back to pre-Roman times. The Balkans were a major source of base and precious metals in Roman times\(^1\). From the Roman Period to the Middle Ages, the area between Serbia and Greece was one of the most important sources of silver, lead and zinc, the Artana deposit in Kosovo being a prime example.

More recently (since the 1930s), more and more commercial resources of base and precious metals have been identified, and industrial production set in, e.g. in 1930 with the opening of the Stan Terg mine near Trepća in today’s Kosovo. Soon thereafter, several deposits in that area, which became known as the Trepća metallogenic belt, advanced to become one of Europe’s leading supplier of lead and zinc. At the same time, the Balkan region became Europe’s major source of copper, and from the 1970s to 1990 the western Balkan, mainly Albania, rose to one of the world’s leading producers of chromite. This was achieved under central economic planning by communist governments. Following the collapse of the Union of Soviet Socialist Republics (USSR) in 1991, the transition from central economic planning to market economy systems led to a severe cut in the region’s mining industry with many mines being closed down. Political, social and ethnic tensions and conflicts in the 1990s left much of the mining infrastructure deteriorated or even destroyed and hindered further investment. Consequently, little modern exploration

\(^1\) Gaius Plinius Secundus (Pliny the Elder), Natural History, books XXXIII–XXXVII.
was carried out in spite of the fact that almost all of the previously operating mines did not close because of a lack of resources.

Fig. 2. Major sutures along the western Tethyan Belt, also showing location (and age in Ma) of porphyry Cu±Au (and related epithermal) deposits; from Richards 2015).

Thus, from a geological point of view, effectively all of the known deposits in the region have to be considered as prospective for brownfields exploration. The lack of modern exploration initiatives during the last decades of the 20th century opens up, however, also great possibilities for rewarding greenfields exploration, especially for deposits under cover without any expression on surface. Not surprisingly, this opportunity has attracted numerous exploration companies to show interest in the region during the past decade when the socio-political situation in the region improved considerably. Alone in Serbia, more than 120 licenses were under application in 2016. This renewed interest in the Balkan region has already led to several major new discoveries. Most of them relate to the discovery of porphyry deposits, such as the Kiseljak deposit in the Lece Magmatic Complex in Serbia (Márton et al. 2013) by Dunav Resources (now owned by Dundee Precious Metals) with an inferred resource of 459 Mt at 0.22 % Cu and 0.2 g/t Au (Arnold and Malhotra 2014), the Skouries deposit in Greece by Eldorado Gold with reserves and resources
of 226 Mt at 0.54 % Cu and 0.91 g/t Au\textsuperscript{2}, expected to go into production in 2020, and Euromax Resources’ Illovica deposit in Bulgaria with reserves and resources of 198 Mt at 0.21 % Cu and 0.32 g/t Au\textsuperscript{3}, scheduled to go into production in 2018. Today the Tethyan Belt in southeastern Europe can be regarded as Europe’s chief Cu-Au (Pb-Zn-Ag) province, especially for gold-rich deposits that are genetically linked to calc-alkaline magmatism.

As Vardar Minerals’ projects are all within the magmatic arc(s) that developed during the closure of the Neotethys Ocean, the remainder of this report will focus on arc-related units and base and precious metal mineralization therein. The most important sector associated with arc magmatism within the system of the Alpine, Carpathian, Balkan and Dinaride belts extends through southeastern Europe from Slovakia via eastern Hungary to Romania, following a roughly north-south trend, continuing via Serbia, Kosovo and Macedonia into Bulgaria and Greece where the trend is east-west. This igneous belt of predominantly calc-alkaline geochemistry is nearly continuous over a total length of some 1500 km (Fig. 2). Metallogenetically significant, and probably of great importance for future exploration strategies, is the recognition, based on available age data, that this magmatic arc consists of three different domains of different age, that is a Late Cretaceous arc to the north(east), a Palaeocene to Oligocene arc in the middle, and a Miocene arc towards the south(west), cross-cutting the older arc domains in the north (Fig. 3).

![Fig. 3. Location of the three magmatic arc segments of different age in southeastern Europe and western Turkey (from Arnold and Malhotra 2014); also shown are the areas currently of interest to Vardar Minerals (red ellipses).](image)

\textsuperscript{2} http://www.eldoradogold.com/assets/resources-and-reserve, as of 31/12/2016, accessed on 16/10/2017

\textsuperscript{3} http://www.mining-technology.com/projects/ilovica-gold-copper-project, accessed on 16/10/2017
2.1 Late Cretaceous arc magmatism and mineralization

The Late Cretaceous magmatic arc, which is perceived by most workers as having resulted from subduction of oceanic lithosphere underlying the Vardar Sea to the northeast beneath the Serbo-Macedonian continent (Neubauer 2002), hosts a number of large porphyry Cu-Au and related high-sulfidation epithermal Au deposits. This metallogenic belt has become known as the Bananitic Magmatic and Metallogenic Belt (BMMB; Ciobanu et al. 2002) or the Apuseni–Banat–Timok–Srednogorie Belt (ABTS; von Quadt et al. 2005). Major porphyry Cu-Au deposits related to this stage of arc formation are Moldova Nouă in Romania (65 Ma), Majdanpek, Veliki Krivelj and Bor in Serbia, and Elatsite and Assarel in Bulgaria, all of which have ages between 92 and 84 Ma (Richards 2015). The large epithermal gold deposit of Chelopech, Bulgaria, appears to be genetically linked to nearby porphyry magmatism and thus part of the same mineralizing episode (Fig. 4). The recent discovery of the Cukuru Peki deposit with an indicated and inferred resource of 36.7 Mt @ 2.9 % Cu and 1.7 g/t Au for the upper epithermal part (Pitluck and McGurk 2016), underlain by a lower porphyry-type deposit in the Timok Complex near the Majdanpek and Bor deposits, in Serbia illustrates the potential of discovering new deposits under cover in this metallogenic belt.

As evident from Figure 2, subduction and subsequent collision along the Serbo-Macedonian continental margin was highly oblique. This might have facilitated the ascent of magma and porphyry formation along transtensional or transpressional structures, thus explaining the particularly high metal endowment along that margin.

![Fig. 4. Major porphyry Cu-Au and related epithermal Au deposits in the Late Cretaceous magmatic arc in Serbia and Bulgaria.](image_url)
2.2 Palaeogene arc magmatism and mineralization

After the Vardar Sea had been closed in the Palaeogene, Neotethys subduction jumped to the Hellenic trench while the Late Cretaceous arc domain became subject of collisional tectonics. Collision-related magmatism in the Late Eocene to Oligocene produced further porphyry and epithermal mineralization in the Balkans and eastern Rhodopes. Examples are the Bucim deposit in Macedonia, the Skouries deposit in Greece and the recently discovered Kiseljak deposit near the Lece magmatic complex in Serbia, all of which are porphyry deposits. They might be related to late orogenic extension and metamorphic core complex formation, possibly as a result of lithospheric mantle delamination (Marchev et al. 2005; Schefer et al. 2011). Similarly, the in places auriferous Pb-Zn deposits of the Maaden and Madjaravo districts in southern Bulgaria might be related to the same stage of mineralization. At the northern end of the belt, the Recsk porphyry copper deposit and its associated skarn and epithermal deposits in the Hungarian part of the Carpathians belong to this stage as well.

Porphyritic shallow crustal intrusive bodies of Palaeogene age are of particular significance for future exploration in the region. Traditionally, the classic subduction-related Late Cretaceous arc rocks have been considered as the most fertile hosts of porphyry deposits in the region. There is, however, a growing awareness that Palaeogene magmatic complexes can be as prospective, in spite of them post-dating subduction, with the discovery of the 33 Ma Kiseljak deposit serving as good example. The currently favoured explanation for this post-subduction stage of porphyry and epithermal mineralization is partial melting of subcontinental lithospheric mantle that had previously been metasomatised (and thus fertilized) by the Late Cretaceous subduction (Richards 2015). This genetic model for post-subduction, syn-collisional mineralization elevates the potential of finding new porphyry and epithermal deposits not only in the, probably better explored, Late Cretaceous arc domain but now also in the Palaeogene arc domain.

2.3 Neogene arc magmatism and mineralization

The third mineralizing episode is probably related to post-collisional deformation and continental block rotation in the Neogene since 13 Ma when collision of the Adriatic microplate with the European foreland caused roll-back of the remaining oceanic slab (Neubauer et al. 2005). The Roșia Poieni porphyry Cu–(Au) deposit, and low-sulfidation epithermal gold deposits, such as Roșia Montană and Sacarimb in the Carpathians, are related to this stage. Similarly as with the Palaeogene stage of arc magmatism, it is suggested that Miocene largely calc-alkaline magmatism in the Carpathians and the Balkans was due to partial melting of subcontinental lithospheric mantle that had previously been metasomatised (and thus fertilized) by the Late Cretaceous subduction. Bearing in mind the younger age of this stage of magmatism, erosion has reached in most areas only such shallow levels at which epithermal systems occur, with the corresponding porphyry systems still below depths at which they could be exploited economically. Hence the potential for discovering minable porphyry deposits of Neogene age is considered comparatively low but the potential of discovering related epithermal deposits exists.
Fig. 5. Major porphyry Cu-Au and related epithermal Au deposits in the Palaeogene magmatic arc in Serbia, Kosovo, Macedonia, Greece and southern Bulgaria; also shown are important Pb-Zn (-Ag-Au) districts that are likely to be genetically related to calc-alkaline Palaeogene magmatism.

3. Vardar Minerals’ Projects in the Republic of Kosovo

Currently, Vardar Minerals is pursuing exploration in Kosovo through six license areas that constitute three projects (Fig. 6). For two of them, Mitrovica and Viti, exploration licenses have been awarded to Vardar Geoscience Kosovo, for the third project, Drazna, an earn-in agreement with the current license holder exists. All three projects aim at discovering porphyry and/or epithermal Cu-Au deposits within the Palaeogene magmatic arc. In the following the three project areas will be evaluated in more detail.

3.1. The Mitrovica Project

The Mitrovica license area is located immediately to the west, northwest and north of the Stan Terg (Stari Trg) Pb-Zn mine in the Trepča ore field. Its exploration potential is thus directly linked to our understanding of this ore field, which includes a number of skarn, hydrothermal replacement and vein-type Pb-Zn-Ag deposits along a well-known mineral belt (Fig. 7) that extends northward into western Serbia (Kiževak, Sastavci, Rudnik and Veliki Majdan) and easternmost Bosnia (Srebrenica). The most productive mines in the Trepča ore field have been Trepča Stan Terg (Stari Trg), Crnac, Belo Brdo, Kišnica, Availija, and Novo Brdo with a combined past production of >61 Mt of ore at 8 % Pb+Zn and >4500 t of Ag. More than half of that (>34 Mt at 3.45 % Pb, 2.30 % Zn and 80 g/t Ag) comes from the Stan Terg deposit, where 29 Mt remain as reserves (as per 2001, reported by Strmić Palinkaš et al. 2013).
ore body occurs along the contact between a 23 Ma phreatomagmatic breccia and Upper Triassic limestone (Fig. 8). Convincing mineralogical, geochemical and isotopic evidence has been provided for the Pb-Zn-Ag mineralization being genetically related to magmatic fluids released during the phreatomagmatic explosion that led to the formation of the breccia (Strmić Palinkaš et al. 2013; 2016).

Prograde skarn formation was triggered by the reaction between magmatic fluids and adjacent limestone. Ore formation is related to the transition from prograde to retrograde skarn formation, triggered by phreatomagmatic explosion and brecciation, which led to a drastic decrease in pressure and increase in sulfur fugacity. Sulfur isotope data clearly confirm a magmatic origin of the sulfur (Strmić Palinkaš et al. 2013). Overall, available data undoubtedly point at a setting comparable with distal mineralization near a porphyry system.

**Fig. 6.** Location of Vardar Minerals’ three projects in Kosovo, also shown are major structures and exposures of rocks related to the Palaeogene magmatic arc as well as known base metal and gold deposits and their relative metal endowment.
Such a genetic interpretation of the Pb-Zn-Ag mineralization in the Trepča ore field suggests the presence of one or more larger, well-endowed porphyry system(s) either adjacent or beneath this ore field. Interestingly, this concept had not been followed up by exploration in the area in the past, and it invariably raises the question whether there is any surface or subsurface evidence of one or more nearby porphyry system(s).

Available geological maps of the area around the Stan Terg deposit (Fig. 9) show the presence of felsic to intermediate volcanic and volcanoclastic rocks of the same age as the Trepča mineralization (Oligocene). Their surface outcrops define a more or less circular structure of some 15 km diameter, which could well represent the remnants of a former volcanic edifice. In that case, porphyry rocks of similar composition should exists at a subvolcanic level.

Fig. 7. Geological setting of the Trepča Pb-Zn-Ag mineral belt within the External Vardar Zone of southeastern Europe; External Vardar Zone: JB – Jadar Block, KB – Kopaonik Block; CVZ – Central Vardar Zone, IVZ – Internal Vardar Zone; DOB – Dinaride Ophiolite Belt, DIT – Drina-Ivanjica Terrain, PZ – Pelagonian Zone, SMM – Serbo-Macedonian Massif; from Strmić Palinkaš et al. (2016).

Fig. 8. Cross-section through the Trepča Stan Terg Pb-Zn-Ag skarn deposit; from Strmić Palinkaš et al. (2013).
The Mitrovica Project area (c. 50 km²) covers a significant portion of Oligocene to Early Miocene volcanic and volcanoclastic rocks that are exposed in the southern portion, immediately west of the Stan Terg mine (Fig. 10). The suspected porphyry facies could be confirmed by reconnaissance field work, which revealed the presence of variably altered, porphyritic subvolcanic rocks to the west of the Stan Terg mine (Fig. 11A,B). First petrographic analysis of these rocks (Georgiev et al. 2017) suggests a lithological variety ranging from predominantly trachyte to dacite. Noteworthy is their observation of magmatic amphibole (though highly altered) in almost all of the subvolcanic rocks. The possibility exists that further porphyry rocks occur under cover, where they could form shallow intrusive bodies within the Mesozoic country rocks in the central and northern portion of the license area. Further critical field evidence is the finding of highly silicified, in places gossanous, sub-volcanic rocks as well as an argillic alteration zone with cross-cutting veinlets of iron-hydroxides that are likely to represent weathered former sulfide veinlets (Fig. 11C-F).

Satellite imagery of the area to the west of the Stan Terg mine in the southern portion of the license area show very light patches on hill slopes reflecting a conspicuous lack of vegetation (Fig. 12). This is unlikely an anthropogenic feature but most probably represents particularly poor soil as typical of argillic to advanced argillic alteration zones. Similar observations can be made throughout the area where advanced argillic alteration is evident on the ground (Fig. 13). Large areas of argillic alteration and smaller domains of advanced argillic alteration in addition to propylitic alteration, mainly affecting the Palaeogene volcanic and volcanoclastic units and only to very limited extent the Mesozoic basement, could be confirmed by reconnaissance field mapping by Murgana (Georgiev et al. 2017) (see Fig. 10). That work also revealed the presence of disseminated and stockwork-type, variably oxidized pyrite-quartz and pyrite-chalcopyrite veinlets in zones of strong argillic alteration.
First arbitrary grab samples from outcrops of silicified alteration shown in Figure 12B returned elevated Au contents of as much as 2.72 g/t\(^4\). A further batch of 50 samples\(^5\) from various outcrops across the southern part of the license area included a few with Au contents on the order of a few grams per ton (maximum of 7.21 g/t for a highly silicified sample from near the eastern border of the license area). Noteworthy are also a few samples with elevated Ag contents (as much as 39 g/t Ag in a gossanous sample that contains thin chalcopyrite veinlets), and elevated Zn (2620 ppm), Pb (2210 ppm) and As (1420 ppm) in an Fe-rich gossan that is also marked by anomalously high Tl (810 ppm). All these anomalous samples come from advanced argillic alteration zones.

\(^4\) Analyses by ICPMS conducted by Scientific Services, Cape Town, South Africa

\(^5\) Geochemical analyses by ICP-AES and AAS conducted by ALS Laboratory Services, Bor, Serbia, lower limit of detection for Au is 0.005 g/t
The analyses available so far are by no means representative or conclusive, but the above numbers do indicate the presence of anomalous base and precious metal concentrations in the license area.

Fig. 11. Field photographs of (A) unaltered porphyry, (B) slightly silicified porphyry, (C) argillic alteration zone with brownish Fe-hydroxide veinlets representing weathered former sulfide veinlets, (D) advanced argillic alteration, (E) weathered mineralization zone with secondary Fe-oxides (pink-brown) and malachite (green); and (F) highly silicified subvolcanic porphyritic rock; c. 4 km west of Stan Terg mine.
Fig. 12. Google Earth satellite image of the area west of the Stan Terg mine (A), showing light patches (yellow arrows) that reflect a natural lack of vegetation, presumably due to argillic to advanced argillic alteration; B – zoomed-in area outlined by yellow rectangle in A.

Fig. 13. Vegetation-free patches on hill slope mark areas of advanced argillic alteration in southern part of Mitrovica license area (note the light foreground is a field).
3.2 The Viti Project

The Viti Project encompasses three license areas, Viti North, Viti and Viti East (labelled I, II and III, respectively, in Fig. 14), covering altogether some 300 km² around the town of Viti (Vitia, Vitina) in the southeastern corner of Kosovo, some 40 km southeast of Priština and 18 km southwest of Gjilan. Outcrop in the area is limited to License areas I and III (Viti North and Viti East), most of the area is agricultural, and the town of Vitina is built up, housing c. 47000 inhabitants (Fig. 15). Geotectonically, the region around Viti is within the External, Central and Internal Vardar subzones of the larger Vardar Zone (Fig. 7), rocks of which make up the pre-Cenozoic basement. The latter comprises a variety of probably Palaeozoic metamorphic rocks, Jurassic metabasalt and related oceanic rocks and Upper Cretaceous siliciclastic flysch deposits. These are covered by Palaeogene volcanic, subvolcanic and volcanoclastic rocks, and by Neogene and Quarternary sediments (Fig. 16).

Fig. 14. Aeromagnetic map and location of the Viti North (I), Viti (II), Viti East (III) license areas for the Viti Project; also shown are outcrops of Palaeogene, probably Oligocene volcanic and volcanoclastic rocks as well as known ore mineral occurrences.
Fig. 15. Google Earth image of the area around Vitina, showing the main land use for agriculture and only limited outcrop.

Fig. 16. A – Part of the geological map of Kosovo, pertaining to the area around Vitina; for legend see Fig. 16 B.
Critical for the assessment of this project are two main features, one being based on currently available geophysical data, the other on the nature of the “pyroclastic” rocks shown on available geological maps of Kosovo (Fig. 16). The area of outcrops of mapped Tertiary trachyte and pyroclastic rocks as shown on Figure 16 features a conspicuous aeromagnetic anomaly, extending to the subsurface domain in between the outcrops. This anomaly is of roughly circular shape (Fig. 14) and can be interpreted as expression of a subvolcanic intrusive body, possibly underlying a large subsurface caldera structure.

The horizontal diameter of the suspected subsurface intrusive body is approximately 10 km and this body is centred at the intersection of the three license areas Viti North, Viti and Viti East. The lithological nature
of this intrusive body remains, at this stage, unknown but it could be, by analogy to the numerous porphyry systems in the region, an intermediate porphyry of probably Oligocene age.

Higher resolution aeromagnetic data collected by the Geological Survey of Finland (GTK) and acquired by Vardar Minerals make it possible to clearly delineate the boundary of the suspected shallow intrusive body with some domains showing potential for porphyry deposits from a geophysical perspective (circled in blue in Fig. 17). Furthermore, geochemical data of stream samples⁶ show a number of anomalously high Cu contents in the vicinity of, and within, the Viti license areas (Fig. 17).

Reconnaissance field work revealed that much of the “pyroclastic rocks” outlined on the geological map (Fig. 16) are highly altered, that is, largely silicified (Fig. 18). Geomorphologically, this silicification expresses itself in the form of erosion-resistant flat hills near the villages of Devajë and Zhiti (Fig. 15) east of Viti North with likely extension into the license area. The resistance to erosion of these flat hill tops is similar to the so-called lithocaps on top of porphyry systems (Fig. 19). Locally developed argillic alteration, in places overprinted by propylitic alteration, has been identified in the course of reconnaissance field mapping (Georgiev et al. 2017). The latter also report coral reefs above red beds within the volcanoclastic succession as well as clasts of travertine in the volcanoclastic rocks as well as veinlets of Fe-hydroxide (most likely oxidized sulfide). Regionally pervasive argillic alteration of the Palaeogene volcanoclastic and sedimentary rocks is weak, but locally in can be strong and then contains veinlets of azurite (Georgiev et al. 2017). Argillic alteration increases towards the contacts with subvolcanic trachyte and latite, subordinately also lamprophyre dykes, and can contain stockworks of Fe-hydroxides Mn-hydroxides and hydrothermal quartz veins.

Fig. 17. Aeromagnetic anomalies on Viti license areas (outlined in black) showing domains that could be potential porphyry targets (blue circles); magnetic data from Geological Survey of Finland (GTK); also shown are Cu anomalies (green squares) in stream samples (unpubl. data from Beak Consultants).

⁶ The data was collected between 2007 and 2008 by Beak Consultants in preparation of developing the Kosovo Mineral Resources Management Plan (KMRMP) and purchased by Vardar Minerals.
First petrographic analyses of variably altered volcanic rocks from the project area (Georgiev et al. 2017) identified these as porphyritic trachyte, dacite and lamprophyre. Of possible importance for the assessment of this area’s mineral potential is the lack of any amphiboles observed in thin sections. In spite of field evidence of hydrothermal activity in the region (occurrence of travertine, various types of hydrothermal alteration, hot spring in Viti), a first batch of 67 grab samples did not reveal any markedly anomalous base and precious metal concentrations. Anomalies therein are with up to 1.9 g/t Ag and 106 ppm Cu and 430 ppm Zn only minor but nevertheless existing.

Several base metal occurrences have been reported in the area around the Viti Project (Fig. 14). The name of the village Zllatar in the western part of the license area Viti North is most likely related to the Albanian and Serbian term “zlato”, which means gold, thus possibly hinting at historical findings of the precious metal in the area. To the southeast of license area Viti East, a copper occurrence has been revealed by previous digging of an exploration trench (Fig. 20A). There the country rocks consist of Jurassic mafic chloritic metavolcanic rocks, chlorite schist and serpentinite, whose generally green appearance can be confused, at a first glance, with propylitic alteration. This notwithstanding, the Cu minerals (mainly chalcopyrite) occur in a strongly silicified and sulfidized zone as a network of thin veinlets (Fig. 20B), spatially associated with propylitically altered diorite porphyry (evident from green, altered plagioclase phenocrysts within a chloritic matrix). According to the current license holder of that area, the trenched material is also enriched in Zn, to a lesser extent in Pb and allegedly, some samples returned as much as 150 g/t Ag. The porphyry is not deformed, in contrast to the Jurassic mafic to ultramafic country rocks as...
well as tectonically juxtaposed Upper Cretaceous flysch deposits further west. Thus the porphyry is interpreted, in the absence of absolute age data, as being younger than the Cretaceous, probably Tertiary in age. The spatial extent of the porphyry as well as the alteration zones remains unknown but is suspected, based on geomorphology and mode of vegetation cover, to be at least continuous for about 1 km, following the general NNW-SSE strike direction of the country rocks. Although this occurrence lies outside the Viti Project area, it is in so far of importance as it is most likely genetically related to a larger porphyry system. Considering the predominant propylitic alteration and alleged metal association of Cu-Zn-Pb-Ag, it can be regarded as a distal alteration facies, which opens up the possibility that it is the distal expression of a larger porphyry system underlying the Viti Project area.

3.3 The Drazna Project

The Drazna Project comprises the Orlan and Brvenik license areas, which cover together an area of 64 km² near the northeastern border of Kosovo (Fig. 6) in the southwestern portion of the Oligocene Lece Magmatic Complex within the Internal Subzone of the Vardar Zone (Fig. 7). The Lece Magmatic Complex is the second largest magmatic complex in the region after the Cretaceous Timok volcanic field. On the Serbian side, immediately east of the Drazna Project area, the Lece Magmatic Complex has already proven to be highly prospective with the relatively recent discovery of the Kiseljak and nearby Yellow Creek porphyry Cu-Au deposits within the Tulare ore field (Márton et al. 2013). Inferred resources of 459 Mt at 0.22 % Cu and 0.2 g/t Au have been reported for the Kiseljak deposit, 88 Mt at 0.30 % Cu and 0.3 g/t Au for the Yellow Creek deposit (Arnold and Malhotra 2014). There andesitic tuff and pyroclastic breccia are
distinguished from subvolcanic dioritic porphyry. The latter occurs in the form of dioritic stocks and dykes emplaced within metamorphic basement and unconformably overlying Palaeogene volcanic and sedimentary rocks. Geophysical data suggest a larger pluton at depth and several hydrothermal plumbing systems at various erosion levels. The age of massive, sheeted vein- and stockwork-type mineralization is constrained by a main porphyry stage, dated at 33.0 ± 0.3 Ma, and an intra-mineral porphyry, dated at 32.6 ± 0.3 Ma; a post-mineral porphyry, dated at 31.8 ± 0.3 Ma was followed by epithermal mineralization (Márton et al. 2013). In the vicinity of the dioritic rocks, the country rocks are hydrothermally altered, with a sequence, from oldest to youngest and from proximal to distal, of potassic (± calcic) alteration, intermediate argillic and phyllic to propylitic, and to carbonate plus argillic alteration with silicification (Márton et al. 2013). High-grade ore consists of chalcopyrite-pyrite-magnetite-quartz, whereas pyrite-molybdenite-quartz veins are not economic.

To the north further ore fields are distinguished: the Lece and Brjsor ore fields in the eastern part of the complex, the Karavarske Planine ore field in the western part and the Djavolja Varos ore field in the northern part.

The Drazna Project covers the area from the Serbian border and the adjacent Tulare ore field on the Serbian side in the southeast to the historic Drazna (Draznja, Drazhnje) Pb-Zn-Ag mine in the northwest (Fig. 21). The Drazna deposit is a low-sulfidation epithermal polymetallic Pb-Zn-Ag-Mn-Cu (±As, Sb) stockwork of stringers and veinlets within a mixed succession of Cretaceous marble, flysch and volcaniclastic deposits (Fig. 22) and slivers of serpentinite, into which dioritic porphyry was emplaced at subvolcanic level. Previously, an “indicated reserve” of 4.743 Mt @ 2.44% Pb, 4.29% Zn, 45 g/t Ag and with a low gold of max. 0.14 g/t had been reported (Monthel et al. 2002), but a subsequent NI 43-101-compliant re-evaluation by White (2009) led to a somewhat reduced inferred resource of 3.214 Mt @ 2.51 % Pb and 5.11 % Zn.

Some of the mapped andesite at the Drazna deposit (as shown on Fig. 23) could be subvolcanic diorite (Fig. 24A). The principal ore minerals are sphalerite, galena, pyrite, marcasite, and boulangerite, which occur in locally widespread hydrothermal alteration and boxwork-type veinlets (see also Fig. 24C) as well as massive sulfide in breccias. Interestingly, the deposit also contains elevated tin concentrations, evident from the occurrence of stannite and up to 28000 ppm Sn within sphalerite (Kołodziejczyk et al. 2016), which might point to an involvement of more acid, highly fractionated melts in the local metallogenesis. Although felsic intrusive rocks are not shown on the map on Figure 23, which was adopted from White (2009), the same report mentions “Neogene? Microgranite” as well as “Neogene rhyolite/dacite” (White 2009: Fig. 25). The age of this magmatism is suspected to be, by analogy with precisely dated rocks from the Tulare ore field (see above), Oligocene and not Neogene. At the mine, parts of the mineralized system occurs in the form of a steeply dipping, in places manganiferous, pyrolusite-bearing gossan zone (Fig. 24B). Thus some of the base metals, especially Zn, are likely to be concentrated also in this oxidation zone. Trenching and drilling conducted by Lydian International suggests that the gossan zone marks a “continuous zone of mineralization over a strike length of some 1.2 km” (White 2009: p. 46).

In the last documentation of the Drazna deposit, White (2009) placed the timing of the primary sulfide mineralization into the Upper Cretaceous, prior to Tertiary, probably Oligocene, magmatism of the Lece
Magmatic Complex (Fig. 25). This interpretation is problematic and does not explain the elevated Sn contents in the ore, nor the regional setting. Here it is suggested that the mineralization at Drazna is part of the Lece magmatism – an important aspect that will be discussed further in Section 5 below.

Fig. 21. Geological map of arc-related Oligocene volcanic, subvolcanic and volcano-sedimentary rocks of the southern Lece Magmatic Complex, showing the position of the Drazna license areas (outlined in red) and other license areas (in grey), also the Kiseljak porphyry Cu-Au deposit in the Tulare ore field and the Drazna Zn-Pb-Ag deposit (for more details see Fig. 22).

Fig. 22. Geological map of the southwestern part of the Lece Magmatic Complex in northeastern Kosovo, showing the position of the Drazna mine; for legend see Fig. 16B.
Although the Drazna deposit is just outside the license area, the underlying mineralized vein system continues southeastward into the more central parts of the Lece Magmatic Complex and thus into the license area of interest here. Preliminary petrographic analyses of the subvolcanic and volcanoclastic rocks in the area (Georgiev et al. 2017) confirmed the dioritic nature of many of the porphyry rock types, whereas the dominant rock type amongst the volcanic rocks is andesite. Most importantly, they all contain phenocrysts of amphibole in addition to plagioclase, ± clinopyroxene and ± biotite.

Widespread argillic alteration can be observed from the Drazna mine over several kilometres towards the southeast. Reconnaissance field mapping by Murgana (Georgiev et al. 2017) revealed two domains of argillic alteration in the northeast of the project area and a larger domain along the Kaljatička River (the main river in the project area), extending for more than 5 km in east-west direction in the southern part of the project area, as well as north of the Drazna deposit. Locally, propylitic alteration is evident next to, or overlaps with, the argillic alteration. Advanced argillic alteration was observed at the western end of
the alteration zone along the Kaljatička River, together with hydrothermal brecciation. In the central northern part of the project area, phyllic alteration was noted within andesite, together with narrow zones of intense argillic alteration and silicification (Georgiev et al. 2017).

![Fig. 24. A - Fresh porphyritic andesite from the Drazna mine; B – steeply dipping gossanous zone (right) within Drazna mine; C – Fe-hydroxides marking a former network of sulfide veinlets, Drazna mine.](image)

A particularly interesting domain is in the eastern part of the license area, about 5.5 km south-southwest of the village of Kalaticë, where the andesitic country rock has been affected by extensive Fe-argillic alteration with associated sheeted quartz-carbonate veins, striking approximately east-west and dipping at 80° N (Fig. 26). This locality is only some 5.5 km west of the Kiseljak deposit, where the highest Cu and Au grades are found in an easterly striking and steeply northward dipping sheeted vein and stockwork system (Márton et al. 2013). No staining by secondary Cu minerals was observed at this outcrop, but this could be the result of leaching of copper by weathering, which, at Kiseljak, affected the top 5 to 15 m of the ore body at similar geomorphological positions (Márton et al. 2013). Nevertheless, preliminary geochemical analyses of arbitrary grab samples returned up to 1021 ppm Cu, 457 ppm Pb and 227 ppm Zn. Gold is less soluble in surface waters than base metals, and indeed, for some of these grab samples Au contents of as much as 0.36 ppm could be determined. Silver contents in some of these samples reach values on the order of a few grams per ton, two samples returned 20 and 57 ppm (g/t) Ag, respectively.

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7 Analytical data from Wheal Jane Services, Truro, Cornwall
A circular patch of argillic alteration with an advanced argillic alteration core near the southern border of the project area showed anomalous Pb content (max. 6480 ppm). Also noteworthy are few samples with distinctly elevated Sb concentrations, reaching as much as 279 ppm, and as much as 0.36 g/t Au in argillic alteration near the western border of the license area near the Drazna deposit.

Fig. 25. Stratigraphic column for the surroundings of the Drazna deposit with interpretation of timing of mineralization as presented by White (2009).

Similarly, the area around the Drazna mine, just outside the western border of the license area (Fig. 27), is anomalous in gold. Historic drill core by Lydian International from the mine area (White 2009) contains typically on the order of 0.1 – 1 ppm Au, with a maximum value of 8.5 ppm. Rock chip samples from gossans returned a maximum of 1.25 ppm Au, soil samples as much as 1 ppm and trenching as much as 3.3 ppm Au. None of these data permit, by any means, an even semi-quantitative assessment of base and precious metal endowment of the area but they do indicate that at least some of the hydrothermally altered zones in the license area have anomalously high base and precious metal contents.

The Turkish company Esan drilled and indicated gold resources in their Prapashtica Project immediately south of the Drazna Project area but no data are publicly available.
Fig. 26. Sheeted vein system with oxidized former sulfide veinlets from a trench in the southeastern part of the Drazna license area (42°48’42’’N, 21°23’02’’E).

Fig. 27. Locations of anomalous gold concentrations in soil/grab samples around the Drazna mine (Point 9) and near Kalaticë (Point 8) within and close to the Drazna license area.
4. Recommendations

All of Vardar Minerals’ projects in Kosovo are positioned in geological settings that suggest the applicability of a porphyry copper (-gold) deposit model with a variety of peripheral mineralization styles. Adopting the generally accepted genetic model for porphyry deposits, as described in greater detail by Sillitoe (2010) and schematically illustrated in Figure 28, a number of key features observed at the above three projects can be directly linked with certain positions within an idealized porphyry system.

In the case of the Mitrovica Project, the position of the neighbouring Trepča Stan Terg deposit corresponds to that of a carbonate replacement Pb-Zn-Ag deposit that should be distal to, and at a similar depth level as, a porphyry Cu-Au deposit (Point 1 in Fig. 28). The distance of such carbonate replacement deposits to the central porphyry mineralization is typically on the order of 1 to 2 km. This corresponds very well to the distance of the southern Mitrovica Project area to the Stan Terg deposit. This, together with the field observation of variably altered subvolcanic dioritic porphyry in the southern part of the license area, points strongly at the possible existence of a mineralized porphyry system underneath that area. Specifically, the observed metal association in the few grab samples from siliceous portions within advanced alteration zones, that have returned elevated base and precious metal contents (Au-Ag-Pb-Zn±Tl), points at a possible high-sulfidation epithermal mineralization (approximating position 2 in Fig. 28) in the high ground of the southern portion of the license area.

In contrast to previously expressed opinion that mineralization at Drazna is Upper Cretaceous and thus preceded Palaeogene, mainly or exclusively Early Oligocene, magmatism in the area (White 2009), it is suggested here that effectively all known base and precious metal anomalies in the Drazna Project area are magmatogenic and related to the Early Oligocene Lece Magmatic Complex. The reasons for this are three-fold: (i) the strong spatial relationship between sites of mineralization and the Lece Magmatic Complex as known from surface outcrop (Fig. 21) – the true extent of this complex below surface could be even larger; (ii) the style of mineralization at the Drazna deposit conforms to that of a low-sulfidation epithermal polymetallic deposit typical of the distal regime above a porphyry-style mineralized system; and (iii) striking similarities exists between the sheeted vein quartz within a strongly argillically altered zone in the southeastern part of the project area (Fig. 26), which appears identical to the type of epithermal alteration around the adjacent Kiseljak Cu-Au porphyry deposit. In fact the observed sheeted quartz vein system with anomalous gold tenor latter could well be the direct continuation of the gold-bearing sheeted quartz vein and stockwork system described from the northern part of the Kiseljak license area (Márton et al. 2013). Such an interpretation of a genetic link between base and precious metal endowment in the Drazna Project area and shallow level magmatogenic hydrothermal mineralization near the top of the Lece Magmatic Complex makes the entire project area highly prospective because it covers a large sector of this magmatic complex – a sector that seemingly fills a gap between all the other known ore fields across this complex.
Fig. 28. Schematic illustration of porphyry Cu-Au system with peripheral styles of mineralization, with superimposed alteration zones; modified after Sillitoe (2010); red numbers refer to interpreted positions of the project areas of interest and related deposits: 1 - Trepča Stan Terg deposit, 2 - outcrops of the northern Viti Project area and eastern Drazna area, 3 – outcrops southeast of the Viti Project, 4 a, b, c – progressive positions of mineralization at Kiseljak from main porphyry stage to epithermal stage.

In the case of the Viti Project, the type of silicification found in the topographic highs of license area Viti North corresponds to Position 2 on Figure 28, that is, the upper part of the lithocap. This position holds promise to host high-sulfidation epithermal Au (±Ag) deposits and could be underlain by a porphyry Cu-Au deposit. The known Cu-Zn-Pb-Ag occurrence southeast of license area Viti East shows strong resemblance to the style of mineralization expected in the propylitic alteration zone at greater depth distal to a porphyry Cu (-Au) deposit, indicated by Position 3 on Figure 28. This, together with the position and size of the circular geophysical feature in the middle of the project area, leads to the suggestion that the Viti Project is positioned on top of a subvolcanic intrusive complex that could contain a sizeable porphyry Cu (-Au) deposit under cover. The three license areas cover about three quarters of the suspected subsurface subvolcanic feature, that is, all but the northeastern quadrant. Considering a distance from
the northwestern to the southeastern corners of the Viti Project of some 20 km, the project area could also include potential distal types of deposit, such as epithermal and subepithermal Zn-Cu-Au-Ag deposits.

The suspected partly eroded volcanic edifice centred on the Viti Project area was emplaced into and onto various carbonate rocks, largely limestone, of both Cretaceous and Palaeogene age (Fig. 16). This constellation of presumably Oligocene porphyry-type magmatism into partly calcareous host rocks is, similar as around the Stan Terg deposit, ideal for the formation of, with increasing distance from the intrusive body, proximal Cu-Au skarn, distal Au-Zn-Pb skarn, and carbonate replacement Zn-Pb-Ag (±Au or Cu) mineralization.

Applying a mineral system approach to the three projects, the requirements for the existence of an ore deposit can be assessed as follows.

1. Source of metals (Cu, Pb, Zn, Au, Ag) and binding anion complexes (S\(^2\)-): All projects are located within the Palaeocene (Oligocene) magmatic arc of southeastern Europe, which has become famous for hosting major porphyry Cu-Au deposits. The size of the known deposits is without exception larger than the global average for such deposits (140 Mt), which speaks for an above-average fertility of the subcontinental lithospheric mantle from which the parent magmas were ultimately derived. The same applies to the necessary ligands to bind the metals both in the melt and whatever hydrothermal fluids that were exsolved from them. A magmatic source of the sulfur in the Trepča Stan Terg deposit has already been established.

2. Source and composition of transport medium: as with any other porphyry system, the principal transport medium would have been magma with a high dissolved volatile content. Both project areas are spatially associated with large volumes of magmatic rocks (in the case of the Viti Project this is inferred from geophysical data). In as far these magmatic rocks represent former hydrous melts would have to be ascertained by petrographic studies focusing on the modal proportion of magmatic amphiboles in these rocks.

3. Pathways: The highly oblique collision of the Vardar oceanic lithosphere with the Serbo-Macedonian continental margin and subsequent oblique continent-continent collision most likely facilitated local dilation along which magma could rise to shallow crustal levels with subsequent formation of the known porphyry deposits. All three project areas are in comparable structural settings to the known major deposits. By analogy, suitable pathways for the ascent of fertile magmas can be assumed for the areas of interest here.

4. Energy source for fluid convection: The principal energy source driving hydrothermal fluid movement for the formation of porphyry (and associated peripheral) deposits is the heat from the genetically linked intrusive bodies. The extent of alteration observed in all three project areas provides strong evidence of extensive hydrothermal fluid flow in the vicinity of subvolcanic intrusive bodies.

5. Physical and chemical trap: Potential traps could have been boiling upon pressure decrease when country rock above a porphyry intrusive became shattered by hydraulic overpressure and/or sudden changes in chemistry and temperature upon mixing with surrounding meteoric waters. Indirect evidence for this is given by observations of alteration and stockwork veining in or near the license areas.
6. Right temporal sequence of events: It seems absolutely critical that the magmatic rocks in both project areas are of Tertiary, probably Oligocene, age. In the region, magmatism of this age has been shown to be particularly well-endowed with regard to porphyry and epithermal deposits.

7. Preservation: From the style of alteration inferences can be made about the likely level of erosion on top of a given porphyry system. Thanks to the relatively young (Palaeogene) age of shallow intrusive and extrusive magmatism, erosion has been limited and, in the project areas, has not reached the level of potential porphyry deposits yet. This is deduced from the generally predominating silicification and argillic alteration, which is typical of very shallow levels (Fig. 28), and the predominance of volcanic over intrusive rocks in outcrop. Sodic-calcic and potassic alteration, typical of deeper levels (Fig. 28), have not been observed in the project areas, suggesting that erosion has not reached such levels. At the top of the hilly terrain that characterizes the project areas, erosion has removed probably not more than a few hundred metres of cover. Adding to this a relative elevation difference between top of the hills and plains and valleys of some 200 to 300 m, leaves little vertical distance before reaching the depth level at which porphyry deposits can be expected underground. Such deposits, if present, can be expected at depths of not more than a few hundred metres below surface. Corresponding epithermal ore bodies are likely to occur at even shallower levels. Thus the present erosion level seems ideal for the discovery and exploitation of Palaeogene porphyry and epithermal deposits in the region.

All in all, the three projects are regarded as very promising and further exploration work on both of them is recommended. Independent of the geological reasons given above, it should be pointed out that effectively no license areas are available anymore on outcrop and subcrop of Tertiary magmatic complexes throughout the region, which highlights the strong interest by exploration companies in this particular setting.

Recommendations for a first phase of future exploration work specific to the two projects are outlined below. Once the results obtained from these first work steps have been properly evaluated, a second phase of exploration activities involving detailed geophysical surveys and eventually drilling may be recommended. At this stage, both projects are regarded sufficiently promising to expect that eventually such a second phase of exploration will be justified.

4.1 Further immediate work on the Mitrovica Project

As the terrain is hilly with little Neogene to Quaternary sediment cover, the first step should be detailed geological mapping with emphasis on (i) lithology of volcanic and subvolcanic intrusive rock types and (ii) on hydrothermal alteration (as opposed to weathering). Specifically, it should be tested to which extent the description on current geological maps of “trachyte, andesite and quartz-dacite” for the outcropping volcanic rocks in the area (see Fig. 9) is correct and to what extent some of these rocks might have been misidentified and in fact represent porphyritic intrusive equivalents (see Fig. 11 A,B). Although the presence of magmatic amphibole has already been ascertained by first petrographic analyses (Georgiev et al. 2017), such petrographic work should be extended also to relatively unaltered rocks and it should be complemented by lithogeochemical analyses to identify correctly the (sub)volcanic rock types and to
determine whether their geochemical signatures are akin to those typically hosting porphyry deposits. From a petrographic point of view it is recommended to systematically study the spatial distribution of glassy fragments (fiamme) in volcanoclastic rocks. The extent of devitrification might provide a vector to an underlying or adjacent heat source, that is, a hydrothermal mineralizing system. Following on from the reconnaissance traverse mapping conducted by Murgana (Georgiev et al. 2017), further alteration mapping will help in delineating the size of the hydrothermally altered domain, initially at least on the surface, and at the same time in establishing directions towards the potential source of the hydrothermal fluids and thus towards the position of suspected zones of mineralization. In this regard, careful distinction between different types of alteration in the field will be critical.

The, in places, poor outcrop situation and soil cover will necessitate field mapping to be augmented by trenching in order to achieve more reliable results. Based on the results thus obtained, it is recommended to conduct a soil sampling programme at least over those areas affected by hydrothermal alteration. It is suggested that this be concentrated first on the southern portion of the license area. Geochemical analyses of these soil samples should then help to identify anomalies both with respect to the commodities of interest (Cu, Au) and potential pathfinder elements that might help in assessing the proximity and direction of potential sites of mineralization.

Of critical importance will be the delineation of the size, shape and position of suspected shallow intrusive bodies at depth. Bearing in mind the limited surface exposure, this will require geophysical data, initially in the first instance magnetic and gravity data. If such data are available, they should be purchased, processed and interpreted. If not, such data should be acquired.

After completion of the above work steps and re-evaluation of the project, further follow-up work should involve high-resolution airborne and ground geophysical surveys, based on which first tests of whatever anomalies by drilling should be conducted.

4.2 Further immediate work on the Viti Project

The outcrop situation in the Viti license areas is very different, which requires a somewhat different exploration approach. As a first step, following the reconnaissance field work by Murgana (Georgiev et al. 2017), the outcropping magmatic rocks in the license areas Viti North and Viti East should be mapped in greater detail to (i) ascertain whether their description as “trachyte” and “volcano-sedimentary units” on existing geological maps (see Figs. 14 and 16) is correct or whether other rock types, especially intermediate subvolcanic ones, are present as well; and to (ii) delineate the areal extent and the variety of alteration zones, especially that of the interpreted lithocap making up the erosion-resistant positive morphological features in the area. First reconnaissance mapping by Murgana (Georgiev et al. 2017) confirmed trachyte is the dominant volcanic rock type. Future lithological mapping should focus on the identification of porphyritic subvolcanic rock types that contain amphiboles. This will require petrographic analyses of selected rock samples, supplemented by some lithogeochemical analyses to ascertain the chemical composition to be expected for a fertile magmatic porphyry system. Moreover, future field work should aim at identifying potential hydraulic breccias (as opposed to mapped volcanic breccias).
Field mapping should be followed by a geochemical soil sampling campaign over the topographically higher grounds of the license areas Viti North and Viti East, that is, the hills to the west of the village of Zhiti in license area Viti North and much of license area Viti East. Although this latter work step is unlikely to identify anomalies directly representing porphyry Cu-Au mineralization, it could lead to the discovery of anomalies related to high-sulfidation epithermal Au deposits on the one hand and to the identification of pathfinder element anomalies that provide vectors to potential underlying porphyry-type mineralization on the other hand. The largely agricultural land in topographic lows is considered less suitable for a geochemical soil sampling campaign as much of the sediment there is likely to have been transported. It can be omitted from this work step. Geochemical anomalies detected by the soil sampling campaign should be further documented by trenching.

As much of the Viti Project concerns geological units under Neogene to Quaternary cover, the analysis of geophysical data will play a pivotal role. The nature of the circular structure evident from aeromagnetic data (Fig. 14) needs to be established, which will require higher resolution magnetic data. Such data are partly available through a previous campaign by the Geological Survey of Finland (Fig. 17). This should be followed up and, where necessary, completed and complemented with gravity data.

Although beyond the scope of this report on the exploration potential for base and precious metals, it should be pointed out that the area around Viti bears geological resemblance to the Jadar Basin in Serbia, which recently has become famous for hosting one of the world’s largest lithium deposits. There the principal ore mineral, jadarite (Stanley et al. 2007), occurs in a lacustrine evaporate-bearing fill of an intramontane Miocene basin. Similarly, the graben fill around Viti contains Miocene lacustrine deposits though it is uncertain whether these include evaporate deposits. This should be tested. The spatial association with magmatism could have provided the heat source through magmatogenic hydrothermal activity that might have led to the devitrification of volcanic glass shards in the pyroclastic deposits and the formation of jadarite. It is suggested to test the Miocene deposits in the Viti Project area for the presence of Li-borates.

4.3 Further immediate work on the Drazna Project

Although first reconnaissance traverse mapping by Murgana (Georgiev et al. 2017) has provided already some clues, further detailed geological field mapping should be carried out with emphasis on delineating subvolcanic amphibole-bearing diorite porphyry bodies and alteration zones. Considering some structural control on mineralization, structural data should be collected while mapping. This should be followed by a geochemical soil and stream sampling campaign of selected areas, depending on extent and style of mapped alteration and on topography of the land surface. A priority target in this regard could be the southeastern corner of the license area near Kalaticë, where the sheeted quartz-carbonate veins had been observed. There a geochemical stream sampling programme could be supplemented by a ground

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magnetic survey. In a second phase, geophysical data should be acquired over the entire license area in order to identify subvolcanic intrusive bodies and potential target areas for later drilling.

5. References cited


