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GOLD METALLOGENY OF THE SERBOMACEDONIAN-RHODOPE METALLOGENIC BELT (SRMB)

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Abstract

The Alpine-Balkan-Carpathian-Dinaride (ABCD) metallogenic belt, which tectonically evolved during Late Cretaceous to the present, is Europe's premier metallogenic province, especially for gold. Three spatially distinct tectonic and metallogenic belts are associated with this belt. One of them is the Serbomacedonian-Rhodope Metallogenic Belt (SRMB) which intersects with a NNW-SSE trend the south eastern Balkan countries. This belt includes the geotectonic zones of Vardar (Axios), Circum-Rhodope, and the Serbomacedonian and Rhodope Massives. It comprises dominantly carbonate replacement or porphyry metal deposits, stratiform volcano-sedimentary deposits, skarns and various isolated magmatic-hydrothermal deposits. The most significant Au metallogeny centers of this belt are found in Bulgaria (i.e., Madjarovo, Ada Tepe, Madan, Lozen), Greece (i.e., Perama Hill, Sapes, Maronia, Olympias-Stratoni-Skouries, Gerakario-Vathi-Pontokerasia), F.Y.R.O.M. (i.e., Buchim, Ilovitza, Alshar), Kosovo (i.e., Trepca), and Serbia (i.e., Lece District: Kiseljak, Bakrenjaca). The metal reserves of all categories in the SRMB are 24 t Au, 14 t Ag and >100 Mt (Pb+Zn) ore in Bulgaria, 743 t Au, 4100 t Ag, 5345 th.t Cu and 3125 th.t (Pb+Zn) in Greece, 106 t Au, 96 t Ag and 834 th.t Cu in F.Y.R.O.M., >150 Mt (Pb+Zn) ore in Kosovo, 118 t Au and 1270 th.t Cu in Serbia. In addition many other sites inside this belt exist which are very promising for precious metals.
Keywords: *Precious metals, metal concentrations, reserves.*

Περίληψη

Η μεταλλογενετική ζώνη Alpine-Balkan-Carpathian-Dinaride (ABCD), η οποία τεκτονικά εξελίχθηκε κατά τη διάρκεια του τέλους του Κρητιδικού έως σήμερα, είναι η κύρια μεταλλογενετική επαρχία της Ευρώπης, ιδιαίτερα για το χρυσό. Τρεις χωρικά διακριτές τεκτονικές και μεταλλογενετικές ζώνες συσχετίζονται με αυτή τη ζώνη. Μία από αυτές είναι η Σερβομακεδονική-Ροδοπική Μεταλλογενετική Ζώνη (SRMB), η οποία διατέμνει με κατεύθυνση ΒΒΔ-ΝΝΑ τις νοτιοανατολικές Βαλκανικές χώρες. Αυτή η ζώνη περιλαμβάνει τις γεωτεκτονικές ζώνες του Βαρδάρη (Αξιού), της Περιροδοπικής, και τις Μάζες της Σερβομακεδονικής και Ροδοπικής. Περιλαμβάνει κυρίως κοιτάσματα μετάλλων αντικατάστασης ανθρακικών ή πορφυρικά, στρωματόμορφα ηφαίστειο-ιζηματογενή κοιτάσματα, skarns και ποικίλα απομονωμένα μαγματικά-υδροθερμικά κοιτάσματα. Τα πιο σημαντικά κέντρα μεταλλογένεσης χρυσού αυτής της ζώνης βρίσκονται στη Βουλγαρία (π.χ. Madjarovo, Ada Tepe, Madan, Lozen), Ελλάδα (π.χ. Λόφος Περάματος, Σάπες, Μαρώνεια, Ολυμπιάδα-Στρατώνι-Σκουριές, Γερακαριό-Βάθη-Ποντοκερασιά), Π.Γ.Δ.Μ. (π.χ. Buchim, Ilovitza, Alshar), Κόσοβο (π.χ. Trepca) και Σερβία (π.χ. Lece District: Kiseljak, Bakrenjaca). Τα

αποθέματα μετάλλων όλων των κατηγοριών στη SRMB είναι 24 t Au, 14 t Ag και >100 Mt κοιτάσματος (Pb+Zn) στη Βουλγαρία, 743 t Au, 4100 t Ag, 5345 th.t Cu και 3125 th.t (Pb+Zn) στην Ελλάδα, 106 t Au, 96 t Ag και 834 th.t Cu στην Π.Γ.Δ.Μ., >150 Mt κοιτάσματος (Pb+Zn) στο Κόσοβο, 118 t Au και 1270 th.t Cu στη Σερβία. Επιπλέον μέσα σ' αυτή τη ζώνη υπάρχουν πολλές άλλες περιοχές οι οποίες είναι πολύ ελπιδοφόρες για πολύτιμα μέταλλα.
Λέξεις κλειδιά: *Πολύτιμα μέταλλα, συγκεντρώσεις μετάλλων, αποθέματα.*

1. Introduction

The Alpine-Balkan-Carpathian-Dinaride (ABCD) metallogenic and geodynamic belt is considered Europe's premier Pb-Zn-Cu (-Mo-Sb-Ag-Au) province, especially for gold-rich deposits. This orogenic system is the result of convergence of the African, Arabian and Indian plates and their collision with Eurasia. This belt tectonically evolved from Late Cretaceous to the present. The segmented geodynamic character of the orogen is reflected in a discontinuous distribution of ore deposits. Three spatially and temporally distinct tectonic and metallogenic belts are associated with the ABCD belt (Heinrich and Neubauer, 2002). One of them is the Serbomacedonian-Rhodope Metallogenic Belt (SRMB), which intersects with a NNW-SSE trend south western Serbia, Kosovo, F.Y.R.O.M., north eastern Greece and south Bulgaria. This arcuate belt is about 500 km long and 130-180 km wide and includes the geotectonic zones of Vardar (Axios), Circum-Rhodope, and the Serbomacedonian and Rhodope Massives (Fig. 1).

The SRMB comprises dominantly carbonate-replacement Pb-Zn-Ag-Au deposits, several porphyry Cu-Mo-Au deposits, stratiform volcano-sedimentary deposits, skarns, and various isolated magmatic-hydrothermal deposits. All are genetically related to Oligocene-Miocene post-subduction magmatism (Kalogeropoulos *et al*., 1989; Frei, 1995; Mitchell, 1996; Kroll *et al.*, 2002; Serafimovski *et al*., 2010). Several other types of gold mineralization (e.g., intrusion-related systems, epithermal, Carlin-type), are, in general, genetically related to arc- magmatic rocks, and, in part, are controlled by exhumation structures in this belt (Melfos *et al.*, 2002; Marchev *et al.*, 2005; Eliopoulos and Kilias, 2011; Fornadel *et al.*, 2011).

The gold metallogeny of the Serbomacedonian-Rhodope Metallogenic Belt (SRMB) is the focus of this paper.

2. Bulgaria

The Madjarovo ore district is located within the Madjarovo volcanic center of the eastern Rhodope Massif (Fig. 1). This district is characterized by abundant low-sulphidation epithermal base and precious metal (Pb-Zn-Cu-Ag-Au) deposits and sub-economic porphyry Cu-Mo deposits. Advanced argillic, sericitic, silicic and propylitic alterations were recognized in the area. In the last 55 years of mining, more than 10 Mt of (Pb+Zn) ore have been extracted, while another 6.5 Mt of (Pb+Zn) ore reserves remain unexploited. Although the probable reserves are about 2 Mt grading at 3.9 g/t Au, a feasibility study completed in 1995 by Euraust Mineral Developments indicated that the ore is economically not viable for gold (Harkovska *et al.*, 1989; Marchev *et al.*, 2005). Most of the gold occurs as small crystal inclusions with sizes up to 100 μm and is associated with pyrite, galena and sphalerite (Melfos *et al.*, 2003).

The Ada Tepe gold deposit is located approximately 3 km south of Krumovgrad and 15 km east of Zvezdel in the Kardjali District (Fig. 1). The region belongs to the Kessebir metamorphic complex of the eastern Rhodope Massif. Its basement consists of Precambrian and Paleozoic rocks such as metasediments, gneisses, and amphibolites. These rocks are unconformably overlain by Tertiary conglomerates, sandstones, siltstones and limestones. The Sharovo Formation, which primarily hosts the Au-Ag mineralization, consists of a large accumulation of breccias and sands. The Pb-Zn (Au-Ag) epithermal vein deposits are related to the volcanic activity of the Upper Eocene to Upper

Oligocene, which affected all the south-eastern Bulgaria and north-eastern Greece. Ada Tepe is a t ypical sedimentary-hosted low-sulfidation epithermal mineralization associated mainly with detach ment faults (Márton *et al.*, 2010). Its proven / probable reserves are 7.2 Mt (Au+Ag) of ore with 3.4 g/t Au (~24 t Au) and 1.9 g/t Ag (~14 t Ag) (Balkan Mineral and Mining EAD 2012).

The Madan district (Fig. 1) comprises the largest and richest Pb-Zn ore accumulation in the Rhodopes. During the second half of 20th century the extensive underground mining in more than 50 deposits in this area led to a production of more than 100 Mt of ores with mean content of 2.5% Pb and 2.1% Zn. Another 95 Mt of (Pb+Zn) ores have been left unexploited. Additional minor components are 300-1200 ppm Ag and 130-1410 ppm Sb (Table 1). Due to the economic crisis after 1990 most of the deposits were ranked unprofitable and many of the underground mines were closed. Considerable ore reserves are still available and some mines have a potential for development (Marchev *et al.*, 2005; Bonev, 2007; Vassileva *et al.*, 2009).

In the Lozen (Fig. 1) low-sulphidation epithermal Pb-Zn-Cu ore veins and lenses are hosted by Ca-alkaline volcanic complex. Adularia-sericite host rock alterations are dominant, while chlorite is more abundant close to the contacts of the ore bodies. The mode of gold occurrence is similar to the adjacent Madjarovo epithermal mineralization. The gold is associated with pyrite, galena and sphalerite and its grain sizes vary from 10 μm to 100 μm (Melfos *et al.*, 2003).

3. Greece

Greece presents a large number of occurrences and ores of Pb, Zn, and Cu, which are often accompanied by Mo, Sb, Ag and Au. Occurrences of placer gold exist in many regions of Macedonia and Thrace (northern Greece), such as in Langadas and along the riverbeds of Strymon and Gallikos. The deposits of Gallikos River (Thessaloniki-Kilkis area, Fig. 1) were the only Au-bearing deposits of Greece exploited in modern times. During the period of 1953-1960, 1355 kg of gold were collected. Placer gold and minerals of the platinum group (alloys of Os-Ir-Ru, Os-Ir-Rh, Os-Ir-Pt, and Pt-Fe) were also found in Servia Kozani and along the riverbeds of Aliakmonas and Axios and their tributaries. The most important and economically significant ores of gold are located in the regions of Thrace and Macedonia (Kalogeropoulos *et al*., 1989; Michael, 2004; Shawh and Constantinides, 2001; Charistos, 2010; Voudouris *et al*., 2011; Tsirambides and Filippidis, 2012).

The Pagoni Rachi/Kirki Cu-Mo±Re±Au deposit (Fig. 1) is a porphyry-epithermal system that contains molybdenite with up to 4.7 wt% Re. Tellurides and Ag-Au alloy occur in the epithermal veins. The D-type veins contain the highest Au grades (up to 5 g/t) and include Ag-, Bi-, Te-, and Se-bearing minerals. Based on the Au and Re grades, Cu/Mo ratios, and the extremely high Re content in molybdenite, Pagoni Rachi may be considered as a distinct Cu-Mo±Re±Au porphyry deposit derived from rocks transitional between calc-alkalic and alkalic porphyries (Voudouris *et al.*, 2009, 2013a).

In Sapes area (Fig. 1) three high epithermal mineralizations with significant ores have been discovered: the “St. Demetrios”, the “Viper” and the “Scarp” prospects. Tertiary volcanic and pyroclastic rocks of andesitic and rhyodacitic composition are the dominant rock types of the area. The main alterations recognized are silicic, argillic, sericitic, and rarely a zone of adularia. The proven / probable reserves are 1.32 Mt of ore at an average grade of 15.1 g/t Au (~16 t Au), 8.2 g/t Ag (~8 t Ag), and 0.3% Cu (~3000 th.t Cu) (Table 1) (Shawh and Constantinides, 2001; Glory Resources, 2012).

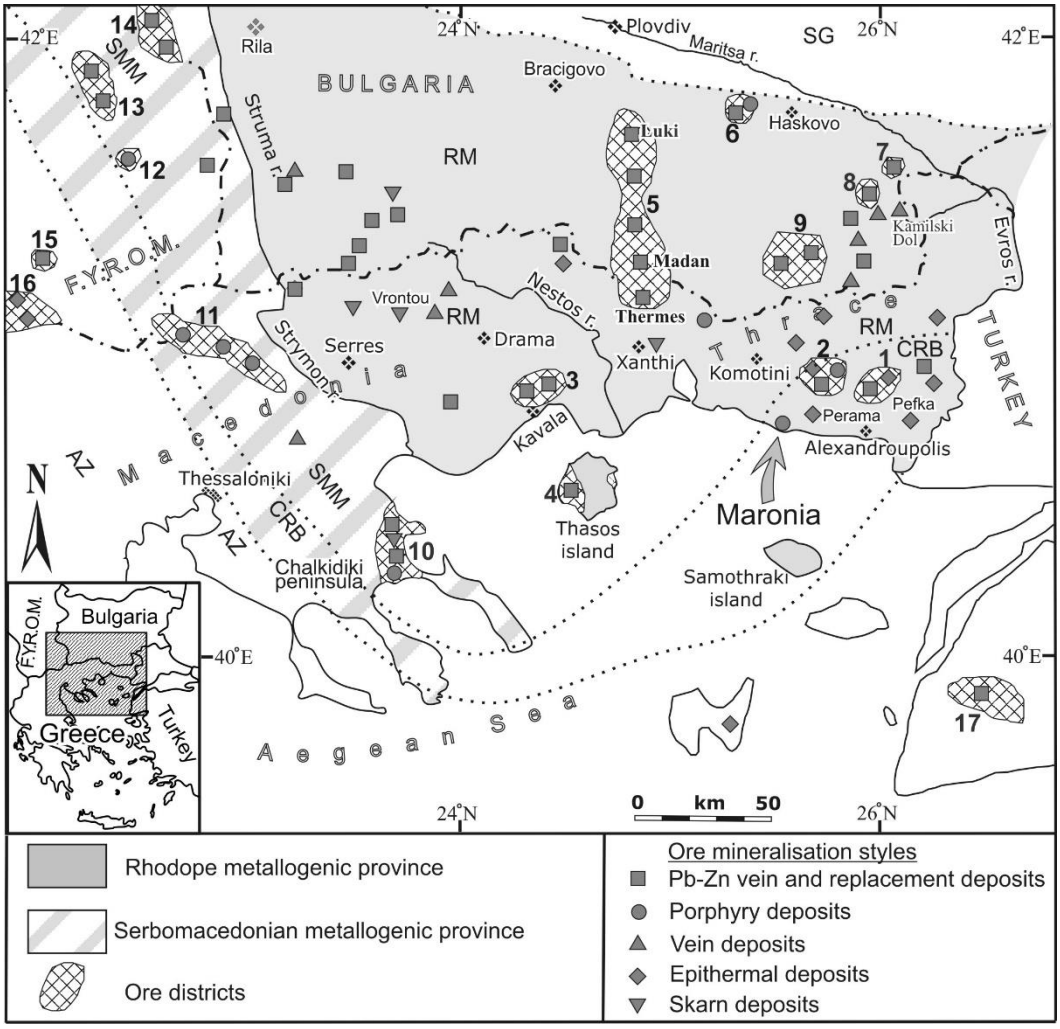

Figure 1 - Geologic sketch map showing the gold metallogeny centers of the Serbomacedonian Rhodope Metallogenic Belt (SRMB). AZ = Axios (Vardar) Zone, CRB = Circum Rhodope Zone, SMM = Serbomacedonian Massif, RM = Rhodope Massif, SG = Srednogorie Zone. 1. Esymi, 2. Kirki-Sapes, 3. Palea Kavala, 4. Thasos, 5. Thermes-Madan-Luki, 6. Spahievo, 7. Lozen, 8. Madjarovo, 9. Zvezdel, 10. Chalkidiki (Olympias-Stratoni-Skouries), 11. Kilkis (Gerakario-Vathi-Pontokerasia), 12. Buchim, 13. Kratovo-Zletovo, 14. Osogovo-Sasa-Toranica, 15. Borov Dol, 16. Aridea-Kozuf, 17. Balikesir (Melfos *et al.*, 2002).

The Perama Hill deposit (Fig. 1) is a high-sulphidation Au-Ag-Te-Se epithermal system hosted in silicic and argillic altered andesitic rocks and in sandstones. The deposit covers an area of approximately 700 m in length to 300 m in width and is oxidized. Sulphides are found at a depth of approximately 120 m. The probable / indicated reserves of this deposit are ~11.7 Mt of ore at an average grade of 3.1-3.5 g/t Au (~74 t Au) and 2.8-4.2 g/t Ag (~62 t Ag) (Table 1). Eighty percent of the gold is hosted by sandstones (oxidized upper part of the deposit) and the rest is associated with base metal sulphides and tellurides hosted within andesitic breccias and conglomerates (Michael, 2004; Voudouris *et al.*, 2011).

The Maronia Cu-Mo deposit (Fig. 1) is located in an area dominated by metamorphic rocks (marbles, calc-schists, and schists) and plutonic to subvolcanic intrusions. The marbles and schists are intruded by an Oligocene pluton of gabbroic to monzonitic composition and younger porphyry microgranite,

which hosts the Cu-Mo mineralization. Surface samples of altered rock contain as much as 7600 ppm Mo, 5460 ppm Cu and 1 ppm Au. Geochemical data from a drill core revealed a 10-m-thick horizon containing up to 12 ppm Au, up to 17 ppm Ag and up to 2.0% Cu. The Maronia deposit presents the potential of containing large quantities of high-grade Cu-Mo porphyry ore, as well as economic grades of Au (Melfos *et al.*, 2002).

Table 1 - Gold metallogeny of the Serbomacedonian-Rhodope Metallogenic Belt (SRMB)[1].

Country	Region/Site	Type	Metals	Metal concentrations	Metal reserves[2]
Bulgaria	Madjarovo	EV	Pb, Zn, Au	3.9 g/t Au	6.5 Mt (Pb+Zn) ore
	Ada Tepe	EV	Au, Ag	3.4 g/t Au, 1.9 g/t Ag	24 t Au, 14 t Ag
	Madan	EV	Pb, Zn, Ag, Sb	2.5% Pb, 2.1% Zn, 300-1200 ppm Ag, 130-1410 ppm Sb	95 Mt (Pb+Zn) ore
Greece	Thrace/ Perama Hill	DED	Au, Ag	3.1-3.5 g/t Au, 3.8-4.2 g/t Ag	74 t Au, 62 t Ag
	Thrace/ Sapes	DED	Cu, Au, Ag	0.3% Cu, 15.1 g/t Au, 8.2 g/t Ag	3000 th.t Cu, 16 t Au, 8 t Ag
	Thrace/ Maronia	CAP	Cu, Mo, Au, Re	2.0% Cu, 0.8% Mo, 12 ppm Au, 17 ppm Ag	
	Macedonia/ Olympias-Stratoni[3]	RBMS	Pb, Zn, Au, Ag	4.4-6.2% Pb, 5.9-8.6% Zn, 8.7-10.0 g/t Au, 132.1-176.7 g/t Ag	3125 th.t (Pb+Zn), 250 t Au, 4030 t Ag
	Macedonia/ Skouries	CAP	Cu, Au	0.49% Cu, 0.67 g/t Au	1205 th.t Cu, 166 t Au
	Macedonia/ Gerakario-Vathi-Pontokerasia	CAP	Cu, Au	0.4% Cu, 0.9 g/t Au	1140 th.t Cu, 237 t Au
F.Y.R.O.M.	Ilovitza	CAP	Cu, Au	0.2% Cu, 0.3 g/t Au	474 th.t Cu, 70 t Au
	Buchim[3]	CAP	Cu, Au, Ag, Mo	0.3% Cu, 0.3 g/t Au, 0.8 g/t Ag	360 th.t Cu 36 t Au, 96 t Ag
	Alshar	Carlin	Au, Sb, As, Tl	2.5% Sb, 1.5% As, >1 g/t Au	
Kosovo	Trepca	RBMS	Pb, Zn, Ag, Au	6% Pb, 4% Zn	>150 Mt (Pb+Zn) ore
Serbia	Kiseljak	CAP	Cu, Au	0.2% Cu, 0.2 g/t Au	1270 th.t Cu[4], 118 t Au[4]
	Bakrenjaca	EV	Cu, Au		

[1]references are presented in the text, [2](proven/probable)+(measured/indicated) reserves,[3]mines in operation, [4]reserves from both sites. EV = Epithermal Vein, DED = Disseminated Epithermal Au-Ag Deposit, CAP = Cu-Au Porphyry, RBMS = Replacement Base Metal Sulphide.

The Palea Kavala is considered an intrusion-related gold system (Fig. 1). Here the Miocene pluton contains ~150 minor hydrothermal and precious-metal occurrences. The presence of the

metallogenic assemblage of Bi–Te–Pb–Sb±Au, as well as of the magnetite and ilmenite, are consistent with this intrusion-related gold system (Fornadel *et al.*, 2011).

The Olympias carbonate-replacement Pb-Zn (-Au-Ag) sulphide ore (Fig. 1) is regionally distributed and structurally controlled. The deposit strikes NNE for 1500 m, dips 30-35º southeast to a depth of at least 300 m, and has an average thickness of 12 m. Both deformed and undeformed ore varieties formed during Tertiary by replacement of base metals from fluids of primarily magmatic derivation through reaction with the host marbles at low pressures (300-800 bars) and relatively high temperatures (300-400ºC) (Kalogeropoulos *et al.*, 1989). Current mining activity in the area produces about 220000 t/y of (Pb+Zn) concentrate. The ore contains 4.4-6.2% Pb, 5.9-8.6% Zn, 8.7-10 g/t Au, and 132.1-176.7 g/t Ag. The probable / indicated reserves of this deposit are 3125 th.t (Pb+Zn), 250 t Au and 4030 t Ag (Table 1) (Tsirambides and Filippidis, 2012).

Skouries is a typical Cu-Au porphyry deposit associated with alkaline magmatism (Fig. 1). The deposit occurs as a pipelike mineralized subvolcanic body with surface dimensions of 180 m north-south and 200 m east-west with a vertical extent of at least 700 m (Frei, 1995). The measured / indicated reserves of this deposit are 246 Mt of ore grading by average at 0.49% Cu (~1205 th.t Cu) and 0.67 g/t Au (~166 t Au) (Table 1) (European Goldfields Ltd 2011). This ore is hosted by at least four hypabyssal monzonite-porphyry phases. All four phases present specific compositions, such as high SiO_2, low MgO and low mg# [mg# = MgO/(FeOt+MgO)×100], as well as variable but low contents of mantle-compatible elements such as V, Ni and Co. Their mg# suggests increasing degrees of fractionation of the parental melts with decreasing age. Their high K_2O (up to 5.8 wt%) and K_2O/Na_2O ratios (>1), as well as their high Ce/Yb and Th/Yb ratios (>34 and >21 respectively), are typical of alkaline rocks of the shoshonite association. In addition the high initial $^{87}Sr/^{86}Sr$ ratios (0.7082) for the Skouries intrusions suggest crustal contamination during emplacement (Kroll *et al.*, 2002).

The Stanos area of the Chalkidiki Peninsula hosts several Cu-Bi-As-Au ore bodies, which are dissimilar to the existing Cu-Au porphyry and carbonate-replacement Pb-Zn-Au-Ag deposits of the same Peninsula, since these ores are syn-deformational and related to major shear zones. The ores are polymetallic featuring a wide mineralogical variety including native bismuth, bismuthinite, cosalite, and emplectite associated with native gold, galena, and chalcopyrite (Voudouris *et al.*, 2013b; Bristol *et al.*, 2015).

The potential for gold metallogeny in other areas extends further to the NW of the Serbomacedonian Zone (in Greece and F.Y.R.O.M.) for more than 250 km, where the Drakontio and Paliomylos (Thessaloniki regional unity), the Laodikino and Koronouda (Kilkis regional unity), and the Ilovitza and Buchim prospects occur (Vavelidis *et al.*, 1994, 1999, 2000; Serafimovski *et al.*, 1996, 2010).

The Cu-Au porphyry deposits of Gerakario-Vathi-Pontokerasia Kilkis may be considered the second most important center for gold in Macedonia Greece. The probable / indicated reserves are about 258 Mt of ore grading up to 0.4% Cu (~1140 th.t Cu) and up to 0.9 g/t Au (~237 t Au) (Kelepertsis *et al*,. 1986; Arvanitidis, 2012; Tsirambides and Filippidis, 2012).

The probable / indicated reserves of gold from Macedonia and Thrace Regions of Greece are approximately 743 t Au and their gross value exceeds €24 b. Sites, deposit types, metal concentrations and metal reserves are presented in Table 1. The first gold production in Greece is expected in 2018.

4. F.Y.R.O.M.

Ilovitza is an isolated Cu-Au porphyry deposit, located in a NW-SE striking Tertiary magmatic arc in the south eastern part of the country. The porphyry deposits are in close spatial and temporal association with intermediate to felsic, medium to high potassium (K) calc-alkaline igneous rocks. The deposit, which was emplaced 29 Ma ago, is located about 20 km west of the 33-38 Ma Osogovo-Besna-Kobila Pb-Zn belt and about 30 km east of the 22-27 Ma Lece-Buchim-Chalkidiki Cu-Au metallogenic zone (Fig. 1). The Ilovitza deposit is about 1.5 km in diameter and is associated with

a poorly exposed dacite-granodiorite plug, emplaced along the NW-SE elongate Strumitza graben. The measured / indicated reserves are 237 Mt of ore with 0.3 g/t Au and 0.2% Cu containing 2.54 moz Au (~70 t Au) and 1.1 b lb Cu (~474 th.t Cu) (Table 1) (Euromax Resources, 2014).

The Buchim Cu porphyry deposit (Fig. 1) is located in the border of the Serbomacedonian Massif and Circum Rhodope Belt. Primary Cu mineralization exists around magmatic cross-cuts. The deposit occupies approximately 150 km^2. It belongs to the Lece-Chalkidiki metallogenic zone (part of the SRMB) which is characterized by widespread Tertiary volcanic rocks of calc-alkaline composition. These rocks are accompanied by Pb, Zn, Cu, Fe, Mo, Au and Ag ore mineralization as it happens in Ilovitza F.Y.R.O.M. and Kilkis (Gerakario-Vathi-Pondokerasia) and Chalkidiki (Olympias-Stratoni-Skouries) Macedonia Greece (Serafimovski *et al.,* 1996, 2010). The Buchim mine is the only one in F.Y.R.O.M. that operates nowadays. Its Cu mineralization covers an area of 0.5 km^2 and is traced to a depth of 300 m. The probable / indicated reserves are 120 Mt of ore with an average grade of 0.3% Cu (~360 th.t Cu), 0.3 g/t Au (~36 t Au) and 0.8 g/t Ag (~96 t Ag) (Table 1). The deposit has been mined since 1979. At present, ore with 0.21% Cu, 0.2 g/t Au, and 0.8 g/t Ag is being mined. Thirty-two thousand tons of concentrate containing 18-21% Cu and 18 g/t Au (Au recovery is 50%) have been produced. The concentrate is delivered by trucks to smelters at Bor in Serbia and Pirdop in Bulgaria (Serafimovski *et al.,* 2010; Palinkaš *et al.,* 2013).

The complex Au-As-Sb-Tl Alshar deposit is unique in its mineral composition. In addition to economic Sb and As grades, the ore is substantially enriched in Tl. Furthermore, Alshar is the first Carlin type gold deposit discovered in the Balkan Peninsula in the late 1980s. The volcanic-plutonic complex of calc-alkaline rocks was emplaced in Pliocene on a basement of Precambrian gneisses, Triassic rocks (dominant), Jurassic ophiolites, and Cretaceous formations. The deposit is located at the intersection of the Vardar (Axios) and Kozuf-Aridea metallogenic zones at the western flank of the Vardar Graben and the Pelagonian crystalline massif approximately 50 km SW of the town of Kavadarsi and 3 km from the Greek-F.Y.R.O.M. border (Fig 1). The ore field covers an area of 21 km^2. It is a significant deposit that contains economic grades of Sb (up to 2.5%), As (1.5%), Tl (0.1-0.5%) and Au (>1 g/t) (Table 1) (Volkov *et al.,* 2006).

5. Kosovo

The Trepca mines are located in northern Kosovo near the village Stari Trg. They are within the Vardar zone of the Trepça mineral belt, consisting of Paleozoic basement rocks, Jurassic-Cretaceous sediments and ophiolites. This tectonic zone, within which the Pb, Zn, Ag and Au deposits are located, is marked by very strong lineaments and a fracture zone striking NW-SE. Trepça has >150 Mt of probable / indicated reserves of ores containing by average 6% Pb and 4% Zn (Table 1). Current primary product is (Pb+Zn) concentrate with significant content of Ag and Au. The company's production capacity is around 100000 t/month; currently production is around 10000 t/month, only a tenth of what it is capable because of lack of new processing technologies (Heinrich and Neubauer, 2002; Hyseni *et al.,* 2012).

Trepca Mines and Minerals is the enterprise that has long played the key role in the Kosovo's economic development. The enterprise dates back to 1927 when Kosovo's mining resources were first exploited by a British firm. In 1948 Trepca became the biggest mining complex in the Balkans. Stari Trg was at the heart of the complex, which produced half of the complex's 3 Mt Pb, 2 Mt Zn, and 4500 t Ag (Feraud *et al.,* 2007). Until 1985 Trepca produced 8.7 t Au and 4000 t Ag. The Ag was mainly recovered from Pb concentrates in which it assayed between 1000 g/t and 1100 g/t (Monthel *et al.,* 2002).

During the 1970s Trepça had assets all around the ex-Yugoslavia. The complex began to have problems by the end of 1970s. Funds were poorly invested, deteriorating equipment was neglected, and little regulation of ore grades was done. Kosovo has never recovered from the 1999 civil war. Trepça itself was hardly damaged. Nowadays the company is in the process of restructuring.

6. Serbia

The Serbomacedonian Metallogenic Province in Serbia appears to have been under-explored for gold, particularly with the availability of modern methods. Most of the Pb-Zn deposits are largely endowed with Ag, associated with galena and Pb sulphosalts.

The Lece District in SW Serbia is without doubt one of the most promising for precious metals. It is centered on a Tertiary volcanic complex, with several nested volcanic cones and calderas. The gold mineralization at Lece, Djavolija Varos, Tulare and Sijarinska Banja is found in veins and silicified breccia of the adularia-sericite type. Between 1953 and 1959 the Lece deposit produced about 470 th.t of ore at 2.0% Pb, 4.5% Zn, 6 g/t Au, and 19 g/t Ag (Jankovic *et al.*, 1992; Serafimovski, 2000).

The Tulare Porphyry Cluster (TPC) area lies within the Lece Volcanic Complex and belongs to the SRMB. The most significant prospect defined is the Kiseljak Cu-Au porphyry, which was drilled predominantly during the 1980s. In total, 32 vertical drillholes, ranging from 109 m to 450 m depth, were completed between 1969 and 1990. This is a typical calc-alkaline Cu-Au porphyry deposit, forming a north plunging (~70°) dike intruded into amphibolite and biotite schist country rock. Mineralization within the potassic zone primarily comprises chalcopyrite veinlets (0.1 mm to 10 mm thick) and disseminated chalcopyrite and bornite. Gold mineralization occurs as native gold associated with gangue minerals and as blebs within sulphide minerals. The Kiseljak deposit extends at an area of 800 m by 300 m and has been traced to a vertical depth of 450 m. The total ore is estimated at 300 Mt grading an average of 0.2% Cu and 0.2 g/t Au in the inferred resource category, for 1.8 b lbs Cu and 2.5 moz Au (AMC Consultants UK Ltd 2013).

Drillings in late 2012 have identified a carbonate-base metal gold epithermal vein system at Bakrenjaca (Yellow Creek), located approximately 3 km south of the Kiseljak deposit. Dunav Co plans to commence a detailed drilling program area in order to determine the mineral ore potential of that epithermal system. The combined Kiseljak and Yellow Creek mineral inferred resources have been estimated at 547 Mt of ore grading an average of 0.2% Cu and 0.2 g/t Au, for 2.8 b lbs Cu (~1270 th.t Cu) and 3.8 moz Au (~118 t Au) (Table 1) (AMC Consultants UK Ltd 2013).

7. Conclusions

The metallogeny centers of the Serbomacedonian-Rhodope Metallogenic Belt (SRMB) in the Balkan Peninsula present world interest nowadays. Large global mining companies have invested significant funds in the research and exploitation of precious and basic metals in this area. The indicated and probable reserves of gold and silver in these regions are very promising. The most important of them are found in Macedonia Greece (Olympias-Stratoni-Skouries and Gerakario-Vathi-Pontokerasia) with 653 t Au and 4030 t Ag, Serbia (Kiseljak and Bakrenjaca) with 118 t Au and F.Y.R.O.M. (Ilovitza and Buchim) with 106 t Au and 96 t Ag.

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