Journal of Iberian Geology **41 (2) 2015:** 223-232
http://dx.doi.org/10.5209/rev_JIGE.2015.v41.n2.48265

www.ucm.es/info/estratig/journal.htm
ISSN (print): 1698-6180. ISSN (online): 1886-7995

Journal of Iberian Geology
AN INTERNATIONAL PUBLICATION OF EARTH SCIENCES

Primary Au prospecting results in the Logrosán area (Central Iberian Zone, Spain)

E. Cheremazova[1*], S. Skublov[1,2], K. Novoselov[3], A. Mikhailov[4], O. Galankina[2], V. Alexeev[1]

[1]*Dpt. of Mineralogy, Crystallography and Petrography, Faculty of Geological Prospecting, National Mineral Resources University (University of Mines), 199106, St. Petersburg, Russia.*
[2]*Institute of Precambrian Geology and Geochronology RAS, 199034 St. Petersburg, Russia.*
[3]*Institute of Mineralogy, Urals Branch of RAS, 456317 Miass, Russia.*
[4]*Mineral Exploration Network (Finland) Ltd., CF 14 ONY, Cardiff, UK.*

e-mail addresses: kate@kareliangold.com (E.C., corresponding author); skublov@yandex.ru (S.S.); const@ilmeny.ac.ru (K.N.); amik@kareliangold.com (A.M.); galankinaol@mail.ru (O.G.); wia59@mail.ru (V.A.)*

Received: 22 January 2014 / Accepted: 17 June 2015 / Available online: 20 July 2015

Abstract

The Central Iberian Zone presents an exceptional geological interest for its great exploration potential for a number of elements including gold. Metallogeny within the area is mainly related to regional metamorphism and late magmatic activity during the Variscan orogeny. In 2013-2014 junior company Mineral Exploration Network Ltd. has carried out an extensive prospecting field work with a primarily view to discover Au within the area around Logrosan granitic pluton (Cáceres, Spain). The main output of the survey was a localization and presorting of potentially mineralized territory unites at the extensive spatial scale (more than 240 sq. km). The known gold showings in the Central Iberian zone are considered to be synorogenic with a mainly metamorphic fluid source. As arsenic commonly forms widespread geochemical haloes near practically all orogenic gold deposits and appears to be easily and credibly measured by express analytical methods (XRF), it was selected as one of the major pathfinder elements for the initial prospecting. Designed geochemical survey allowed delineating potential target area with contrastive complex As-W-Zn-Pb anomaly in soil sediments and significant quantities of gold particles in heavy mineral concentrates. Placer gold particles analyses and their typomorphic features confirmed nearby primary gold source existence. The suggested scope of work proved to be efficient for assessing mineralization potential and selecting perspective target areas for a detailed drilling.

Keywords: gold exploration, Central Iberian Zone, pan concentrate, geochemical soil sampling, Iberian Variscan Belt

Resumen

La Zona Centro Ibérica muestra un interés geológico excepcional debido a su gran potencial de exploración de gran número de elementos, incluido el oro. La metalogenia en esta área está relacionada con un metamorfismo regional y posterior actividad magmática durante la orogenia Varisca. Durante el periodo 2013-2014, la compañía Mineral Exploration Network Ltd llevó a cabo una prospección importante en el campo con una primera observación de Au dentro del área del plutón granítico de Logrosan (Cáceres, España). El primer objetivo de la campaña fue la localización y acotamiento de la zona potencialmente mineralizada a gran escala (más de 20 Km2). El oro descrito es considerado sinorogénico con una fuente principal relacionada con fluidos metamórficos. Como el arsénico aparece frecuentemente constituyendo geoquímicos halos cerca de la mayoría de los depósitos orogénicos de oro y parecen ser medidos fácilmente mediante métodos analíticos (XRF), fue seleccionado como uno de los principales elementos marcadores para realizar la prospección inicial. Los análisis geoquímicos seleccionados permitieron delimitar la zona de interés mediante el contraste del complejo anómalo As-W-Zn-Pb en los sedimentos del suelo y cantidades significativas de partículas de oro en concentraciones de minerales pesados. Los análisis de las partículas de los placeres de oro y sus características tipomórficas confirmaron inicialmente la presencia de oro. El objetivo inicial de este trabajo consistió en mostrar la eficiencia para tasar el potencial de mineralización y seleccionar las áreas idóneas para realizar perforaciones.

Palabras clave: exploración de oro, Zona Centro Ibérica, concentrado en gamella, muestreo geoquímico en suelos, Cinturon Varisco Ibérico

1. Introduction

Since the dawn of civilization in the Iberian Peninsula, mining has been one of the most important drivers for economic development in Extremadura region (Spain). Numerous occurrences of different types (Sn-W, P, Pb-Zn, Pb-Zn-Cu, Pb-Ag, Sb, Au) have originated as a result of intensive collisional magmatic activity and regional metamorphism during Variscan orogeny (Gumiel and Arribas, 1990). Different native inhabitants since Roman Empire took advantage of the rich deposits of iron, copper, lead, zinc, gold, silver, tungsten and tin within the region (Frías *et al.*, 2008).

Since the mid-twentieth century, the importance of metal mining to the gross national product of Extremadura steadily decreased, and today production of metals in the region deserves better extension (Mining Journal, 2005). However, the Central Iberian Zone (CIZ) presents an exceptional geological interest and has great exploration potential for a number of minerals including gold.

The Central Iberian Zone of Spain and Portugal contains numerous vein style gold deposits of varying size, age and host lithology. According to Murphy and Roberts (1997), the majority of showings throughout the region are synorogenic related to post-peak metamorphic Variscan deformation stage. Gold mineralization within the Neoproterozoic Schist Greywacke Complex (SGC) which is the largest domain in the CIZ is mainly presented by quartz veins with complex sulphide deposition: frequently massive stibnite (Mari Rosa deposit), Fe-As sulphides, W minerals and more rarely Cu-Pb-Zn sulphides (Sarzedas and Pomar deposits) (Murphy and Roberts, 1997; Shepherd, 1993).

In 2013-2014 junior company Mineral Exploration Network Ltd has carried out an extensive first-stage prospecting field work in the south CIZ area around Logrosan granitic pluton with a main view to discover Au and cocurrent W deposits. Designed exploration program allowed delineating significant geochemical anomalies and confirmed gold evidence within the region. Although several exploration works have been conducted in the area during the second half of the XX century, there were no significant gold indications investigated until now. Detailed mineralogical study of gold grains collected from stream sediments has proved the possibility of nearby ore body existence.

2. Geological setting

The Central Iberian Zone is the inner and most stable part of the Iberian Massif and represents the southwestern extension of the European Variscan Belt (Fig. 1a). The Neoproterozoic Schist Greywacke Complex (SGC) is the largest domain of the CIZ which is characterized by a thick (up to 11 km) metasedimentary turbiditic sequence, consisting mostly of pelitic and psammitic beds (Villaseca *et al.*, 2014; Chicharro *et al.*, 2014).

The SGC was strongly affected structurally by the Variscan deformation which occurred in three main stages. The earliest (D1) was the most intense, and was synchronous with peak greenschist metamorphism. D1 deformation stage induced an initial shortening and involved the formation of kilometer-scale folds with subvertical axial planes and a pervasive subvertical cleavage striking ≈ 140°.

Later (D2) deformation was less intense and more brittle than D1, with widespread faulting and localized shearing. D2 locally formed a steep NW±SE trending crenulation cleavage, and small scale subvertical sinistral-verging folds. D1 and D2 correspond to the collisional stage of the Variscan orogeny and are thought to be of Mid-Upper Devonian to Early-Mid-Carboniferous age. The Final (D3) deformation stage resulted in minor subhorizontal folding and abundant intrusion of granitoids and associated low-pressure contact metamorphism. (Ribeiro, 1990; Chicharro *et al.*, 2015). These granite plutons are predominantly peraluminous, whereas metaluminous varieties and related basic rocks are extremely scarce (Villaseca *et al.*, 2008).

The Logrosan granite is one of the post-kinematic bodies of the Central Extremadura Batholith (Fig. 1b). It is a small late Variscan felsic cupola of no more than 4 km^2 in outcrop, represented by biotite-bearing monzogranite to two-mica peraluminous leucogranite (S-type) with a marked perphosphorous trend (Chicharro *et al*., 2014). The Logrosan granite was affected by an intense hydrothermal alteration accompanied with tourmalinization, greisenization and formation of an intragranitic stockwork of Sn (W) veins (Vindel *et al.*, 2014).

The SGC sequence in this area is characterized by a monotonous centimetric to decimetric alternation of greywackes and slates with minor presence of sandstones and conglomerates. It has undergone greenschist-facies regional metamorphism (Chl-Bt). Subsequently the late Variscan Logrosan granite intrusion gave rise to a contact metamorphic aureole represented by an inner hornfels zone and an outer zone of spotted phyllites and chlorite schists (Chicharro *et al.*, 2015). This metamorphic aureole holds several quartz-apatite veins, quartz-cassiterite and quartz-scheelite veins and stockworks.

3. Sampling and methods

The Logrosan area was selected for detailed prospecting survey based on historical mining activities and as a consequence of the results obtained in the regional stream sediment sampling program carried out by national company ADARO in 1982 and IGME (Spanish Mining Geological Institute) in 1984 (ADARO, 1982; Perianes Valle and García Isidro, 1993) and MAYASA company in 1987 – 1990 (Boixereu *et al.*, 2003).

There is a number of old Sn, W and Cu mining pits and the phosphate deposit La Costanaza which had been exploited during decades until it was closed in 1944 (Chicharro *et al.*, 2011; Boixereu, 2004). During these historical workings several gold nuggets were found around the hill of St. Cristobal that forms the Logrosan granite intrusion. Subsequently an artisan alluvial gold mining was performed in surrounding streams (Mikhailov, 2014). However, there was still no accurate research provided with modern analytics regarding gold evidence within the area.

Field operations in Logrosan area have been carried out in October-November 2013, February- April, October-November 2014 and included:

Soil sampling at the grid 200/100 by 20 meters – 41683 samples

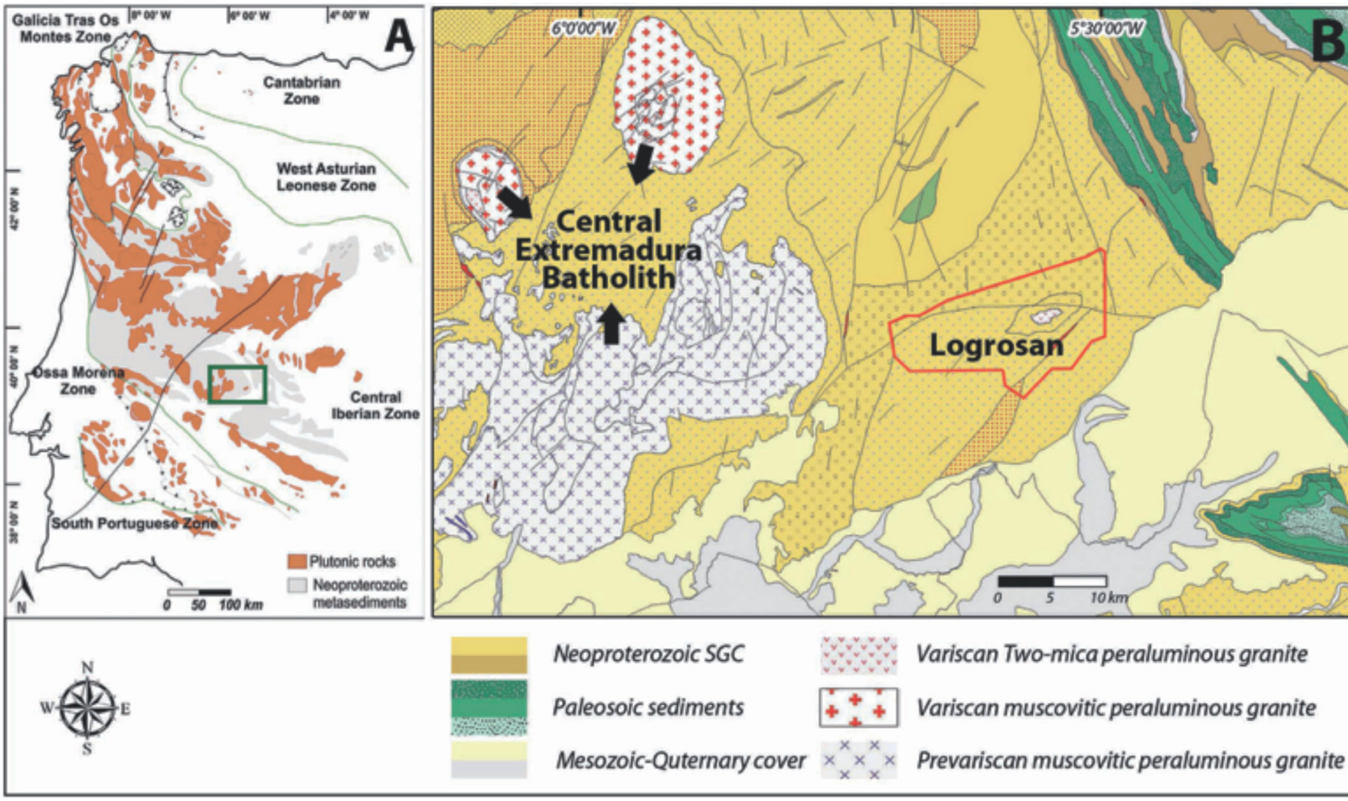

Fig. 1. – (a) Geological setting of the Logrosan Project area in the Central Iberian Zone (modified from Chicharro *et al.*, 2015). (b) Regional geological map showing the studied area modified from Junta de Extremadura (2010).

Pan concentrate (heavy minerals) stream and valley slopessampling – 327 samples

Ground magnetic survey at the grid 100 by 2 meters – 1620 line km

Trench sampling – 36 m/ 36 representative samples

The high density of sampling is a function of high dispersion of the elements in surface sediments and permits anomalies localization with a higher degree of reliability (Kellaway, 2013). Based on the results of the orientation work, we made the decision to use B horizon for soil sampling. All soil samples were analyzed in field by portable XRF analyzer (Innov-X Delta) with silicon drift detector according to EPA Method 6200 for metals in soil. The assay was performed for a standard number of elements: Mg, Al, Si (limit of detection 0,1-0,5%); P (LOD 500 ppm); S (LOD 100 ppm); K, Ca (LOD 20-30 ppm); Ti, V, Cr (LOD 5-10 ppm); Mn, Fe, Co, Cu, Pb, Zn (LOD 3-5 ppm); As, Mo, Sr, Rb, Zr (LOD 1-2 ppm); W, Ni, Sn, Sb (LOD 5-10 ppm). All data was visualized using the desktop mapping system MapInfo.

Selected soil samples (for verification) and all trench bottom bed-rock samples were analyzed by ME-MS81 technique at ALS Minerals analytical laboratory (Seville, Spain). Each sample was added to lithium metaborate flux and fused in a furnace at 1000°C. The resulting melt was then dissolved with 4% HNO_3 / 2% HCl_3 solution. This solution was then analyzed by inductively coupled plasma - mass spectrometry (W detection limit is 1 ppm). Details of the quality control procedure for these analyses can be found on the ALS Minerals Web site *www.alsglobal.com*.

Pan heavy mineral concentrates have been used to prove the presence of gold mineralization. Heavy minerals were concentrated by panning in field (20 liters each sample) using a round-bottomed plastic “dulang”. Sample examination directly upon washing allowed identification of gold and provided an immediate guide to further direction. Initially the samples were taken only from alluvial rivers and streams sediments. After gold identification in a particular area the valley slopes were also sampled.

For detailed mineralogical study 20 representative samples (exclusively alluvial) were separated. They were divided and classified into fractions of -0.5, +0.5,-1, +1 mm and subjected to magnetic separation using a magnet and chemical bromoform solution (2.9 g/cm^3). The fractions were viewed under microscope for primary mineralogical identification and gold presence confirmation.

For detailed morphological study selected gold grains were examined under SEM Tescan VEGA 3 at the Institute of Mineralogy UB RAS, Miass, Russia. Polished briquettes were performed for chemical composition analysis from above-mentioned samples. Major element analyses of minerals were done by energy dispersion X-ray spectrometry (EDS) on a scanning electron microscope (SEM) JEOL JSM-6510LA with JED-2200 detector at the Institute of Precambrian Geology and Geochronology (Saint-Petersburg, Russia). Analyses were performed using an acceleration voltage of 20 kV, a probe current 1.5 nA. Standards were natural minerals and pure oxides and metals. The ZAF algorithm was used for matrix correction. Pictures of gold particles are backscattered electrons BSE composition images.

4. Results and discussion

According to Murphy and Roberts (1997) an orogenic metamorphic model may best explain the genesis of existing gold deposits in the CIZ. Metamorphism of the Schist Greywacke Complex, which is several kilometers thick, provided a source for the large quantities of fluid required to form the volume of quartz veining and to leach, collect and transport gold. Metamorphic fluids produced from prograde metamorphism flowed upwards along major faults, fractures and shear zones, mixing with meteoric component in the shallower levels. Gold was leached from SGC at depth during prograde metamorphism and deposited wherever suitable traps occurred (Murphy and Roberts, 1997).

However the magmatic fluid source could not be totally excluded especially in deducing a genetic relationship for gold deposits spatially associated with intrusions. Ortega *et al.* (1996) suggested that the batholith of Alburquerque played a major role in the complex fluid-rock interactions at the Mari Rosa gold deposit. This late Variscan intrusion triggered hydrothermal activity and possibly contributed metals (Sb) and sulphur to the system.

Orogenic gold deposits have typically formed from reduced, near neutral, CO2-rich and H2S-bearing fluids of low salinity. They are commonly referred to as ‘Au only’ deposits, highlighting their low base metal content. The ores typically have an association of Au-Ag-As-W-Sb-Te, with variable Cu-Pb-Bi-Mo-Zn. Pyrite and arsenopyrite are the main associated sulphide minerals and commonly form a broad mineralized halo. Elements that show useful primary dispersion (up to 200 m) include As (hosted in dispersed pyrite or arsenopyrite) and, to a lesser extent, Sb, Te, W and Au, as well as Cu, Zn and Ba where these are significant in the ore (McQueen, 2005).

4.1. Geochemical sampling results

The main output of the field work was localization and presorting of potentially mineralized territory unites at the extensive spatial scale (more than 240 sq. km). As arsenic commonly forms widespread geochemical haloes near practically all orogenic gold deposits and appears to be easily and credibly measured by express analytical methods (XRF), it was selected as one of the major pathfinder elements for the initial soil geochemical sampling. Based on the available studies of orogenic gold deposits in general and particularly in the Central Iberian Zone, the following elements were also considered as indicators towards gold ore: Sb, W, Cu, Pb, Zn. Even though there is sometimes no correlation between As and Au in the ore (in case of Mari Rosa deposit) (Ortega *et al.*, 1996), arsenopyrite mineralization is always associated spatially depositing during another hydrothermal stage. The Sarzedas-Pomar region could be a good example of effective above-noted elements contribution in gold deposits secondary haloes hosted by Schist Greywacke Complex in the CIZ, where W, Sb and As anomalies in soils are close and related to W–Au–Sb quartz veins, Sb–Au-bearing felsitic dykes and mine wastes. The good correlation between W, Sb and As in soils from Sarzedas deposit is due to the weathering of ferberite, stibnite and arsenopyrite from the mineralized veins and dykes, and precipitation of these elements in soils (Carvalho *et al.*, 2009). At the same time at Pomar deposit, rare visible gold is associated with Cu-Pb-Zn sulphides and quartz-carbonate veining, determining the good correlation in soils between As-W-Pb and Zn-Cu (Murphy and Roberts, 1997; Carvalho *et al.*, 2009).

As it could be seen on Figure 2, the results of soil sampling show significant regional As anomalies up to 10000 ppm in surface sediments. Consequently, four perspective target areas have been selected for detailed research, two of which deserve special attention (Fig. 2).

Target Area 1 is represented by an isometric arsenic anomaly of 2.4 by 1.5 kilometers elongated in NS direction and spatially correlated with W concentrations. On the eastern flank it is cut by a linear Pb-Zn anomaly of NE-SW trending and consistently followed up with significant quantities of gold particles (up to 111 grains) found in heavy mineral concentrates (Fig. 3). Such zonality could assume a possible presence of blind granitic intrusion and gradual distribution of proximal W-As and distal lower temperature Pb-Zn-As and Au (Au-As) mineralization. The Target area is located between Zorita granites on the west and Logrosan intrusion on the east and is characterized by extensive quartz-veins contamination. The host SGC schists mainly consist of quarts-feldspar-sericite and often contain quartz veinlets and clustered segregations which shall be considered as background. Vein zones extend for few meters and occur as a close alternation between host schist and vein material where the quantity of veins may reach 10 per long meter (Fig. 4a). The lodes width typically is less than 10 cm but could also come to 0.5 m. The observed veins orientation is commonly subcomfortable to the host foliation. At the same time there are several veins and veinlets with chaotical orientation, sometimes straight lined and fracturing the foliation (Fig. 4b) or strongly curved and boudinaged (Fig. 4c). The field observations indicate the presence of different veining episodes in a reference to the deformation stages. Although there was no visible ore mineralization found, the wide extension of barren quartz veins point to a large quantity of fluid reaching the area. Murphy and Roberts (1997) suggested a high fluid flux as criteria for gold deposition in the Central Iberian Zone. Nonetheless several sulphidized and silicified outcropping sandstones have been reported. These are characterized by disseminated scheelite, arse-

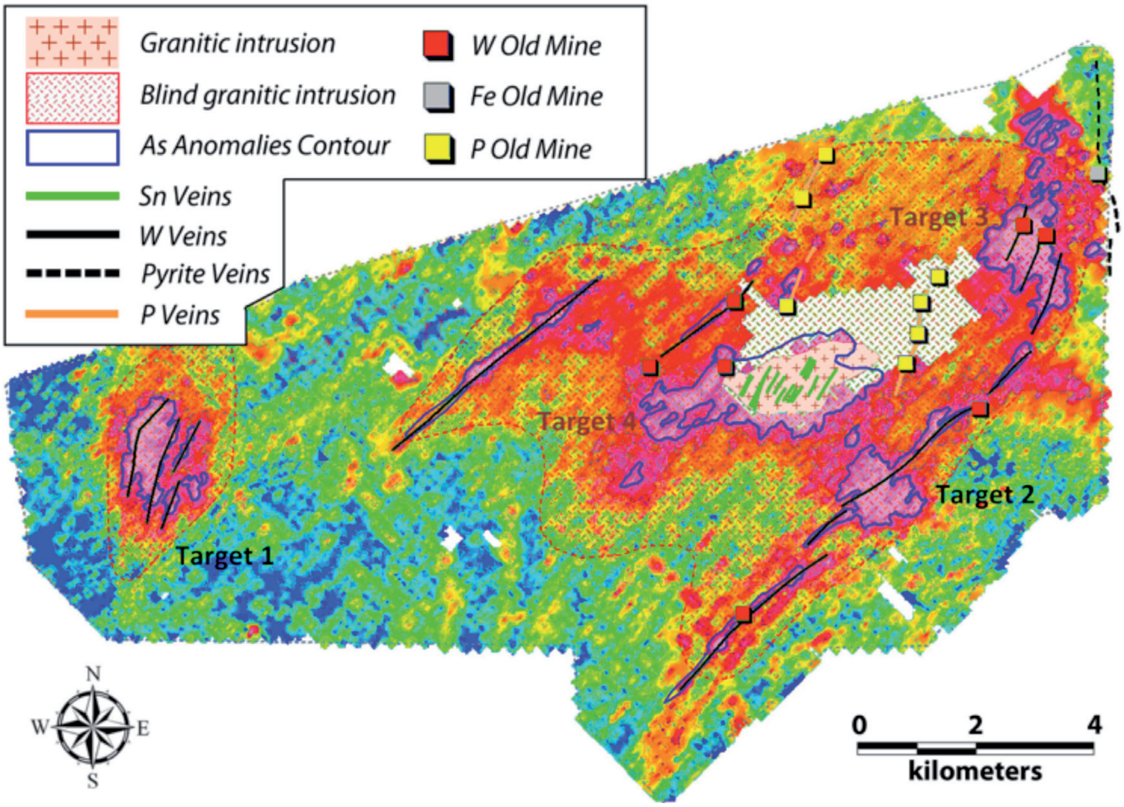

Fig. 2. – Map with schematic geological features of the Logrosan Project area and gradient plot of geochemical soil results for As on the background (modified from Mikhailov, 2014; E.N. Adaro, 1982).

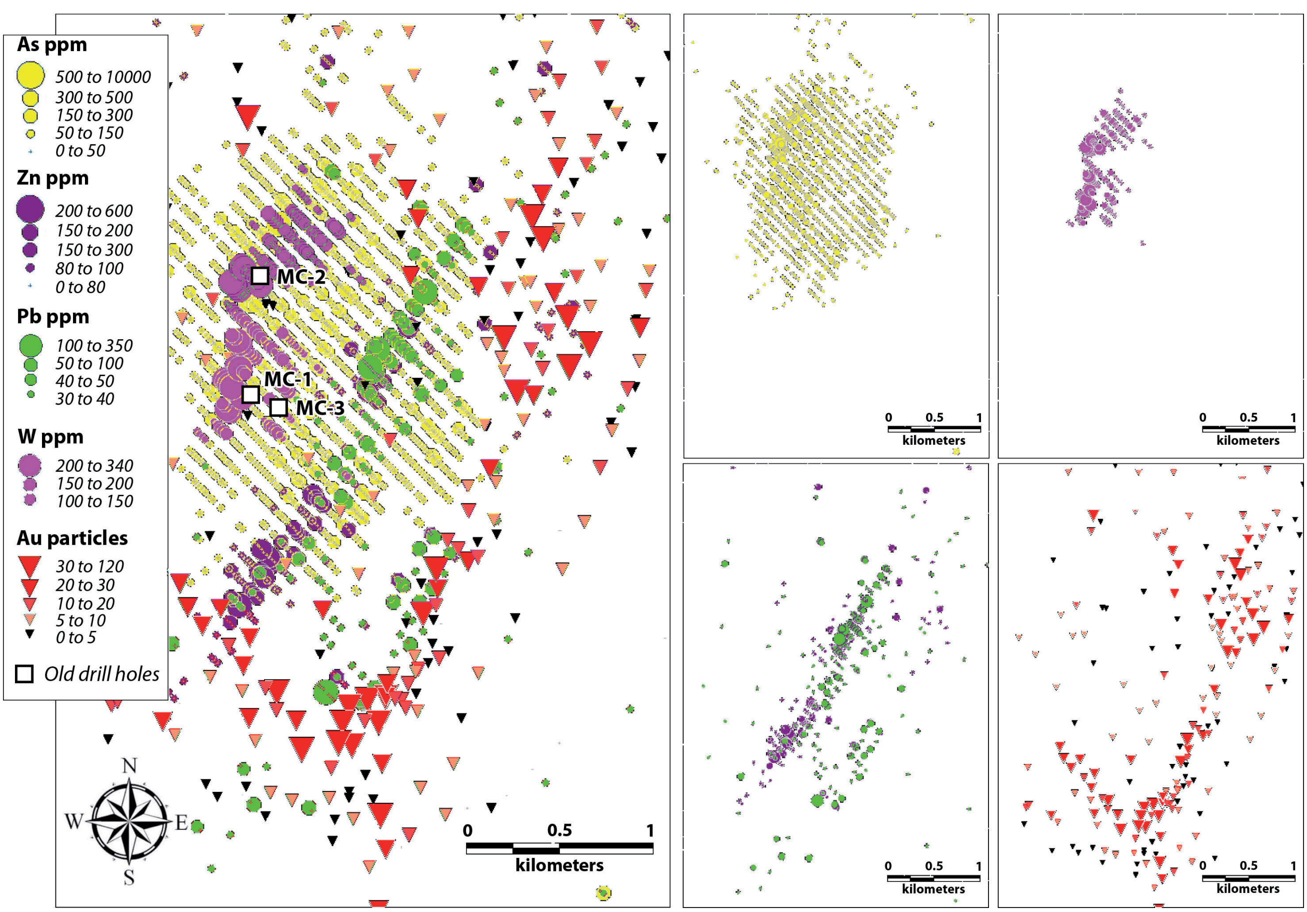

Fig. 3. – Geochemical map of the Target area 1 displaying soil sampling results for As, Zn, Pb, W; pan-concentrate sampling results for Au and old drill holes were made by MAYASA in 1980.

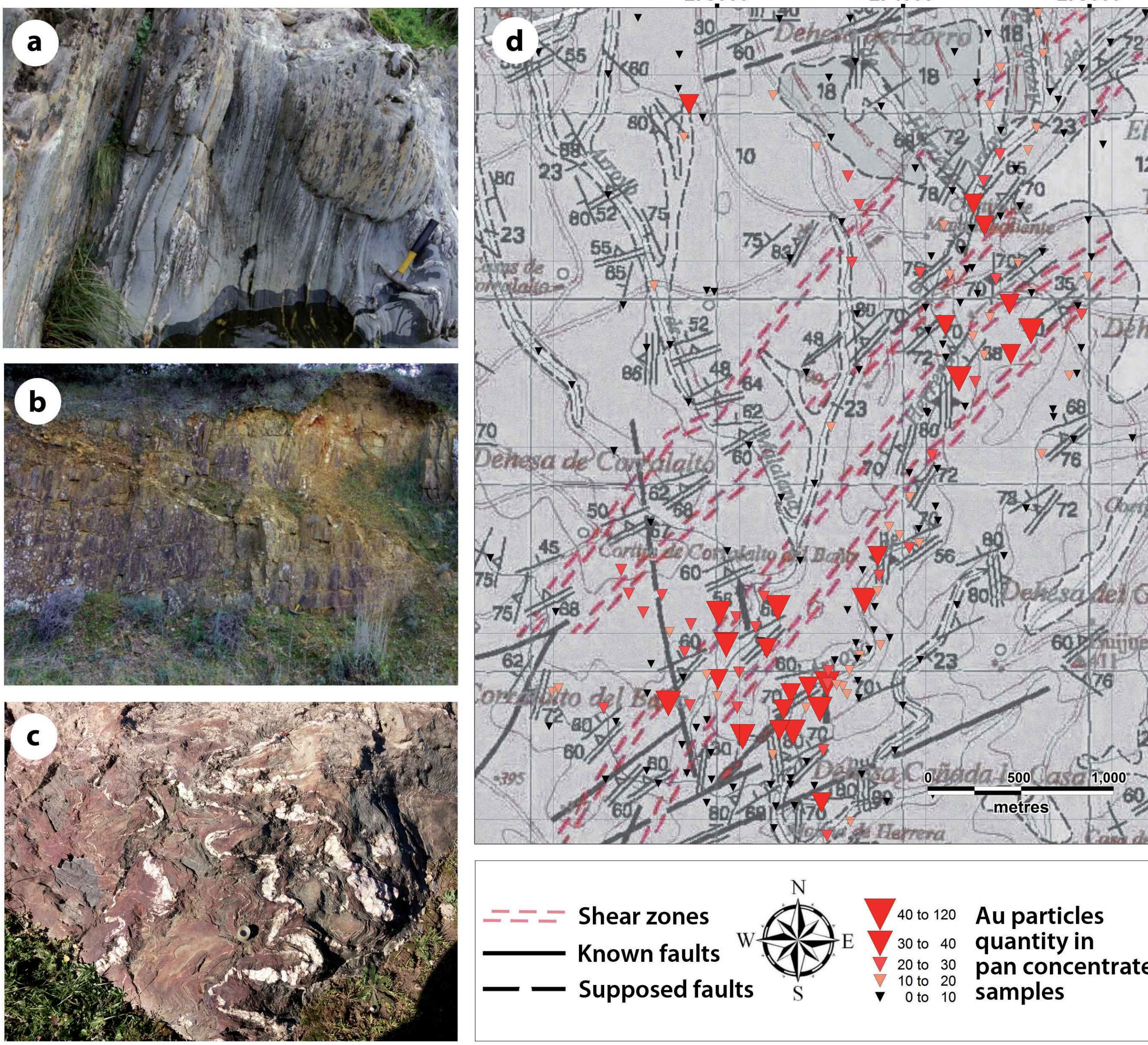

Fig. 4. – (a) Close quartz veins alternation zone. (b) Different quartz systems intersecting. (c) Boudinaged quartz veinz. (d) Geotectonic sketch of the Target Area 1 displaying the local share zones and pan concentrate sampling results (modified from Matas *et al.*, 1995).

nopyrite and pyrite. According to Matas *et al.* (1995) this territory unit is intersected by four local subparallel shear zones of NE-SW trending truncated in the south by dextral faults striking ≈ 60° and one fault sub-meridianal extension (Fig. 4d). The shear zones conform to anomalies orientation and could possibly serve as a fluid channel for the potential mineralization.

It should be noticed that in 1980 three core drill holes were drilled in the area by MAYASA-ITGE-ENCASUR Company (Almadén-IGME, 1987). The drill hole MC-2, located in the most intensive part of As-W anomaly (Fig. 3), recorded high tungsten contents (up to 2000 ppm) viable for commercial exploration. Nevertheless, drill holes MC-1 and MC-3, located 600 meters away on the southern flank, intercepted tungsten mineralization at a concentration level below commercial interest. Samples from drill holes had not been analyzed for gold.

In conclusion, this target performs an exceptional exploration potential for both gold and W and deserves a future intensive drilling program.

Target Area 2 is also characterized by intensive As and W anomalies (Fig. 5). The hihest intensive part of the As-W anomaly had been studied by making an exploration trench (Fig. 5c). Results of the trench sampling yielded tungsten contents close to commercially mineable (up to 1805 ppm) (Fig. 5b). However there were no significant gold contents found in the trench samples and heavy mineral concentrates of this area. Nonetheless this particular target still remains a great potential for W.

4.2. Gold particles research

The heavy mineral concentrates mainly consist of Fe-Ti oxides - rutile and ilmenite, widespread cassiterite, wolframite and scheelite. Less common is zircon, monazite with xenotime inclusions, and iron oxides/ hydroxides. Chalcopyrite, galena and bismuthite appear as accessory single grains and were rarely observed as inclusions in oxide phases. Pyrite is very scarce and appears as inclusions within goethite.

Most native gold grains were identified in the -0.5 mm fraction class. However approximately 5% of gold flakes are characterized by more than 1 mm in size (Fig. 6a). Gold mainly appears as isolated grains but also sparsely occurs in the form of intergrowths with quartz (Fig. 6b).

Placer gold internal textural features allow an estimation of its history and time duration under exogenous conditions. In complex with another typomorphic features it becomes an additional criterion for primary source determination (Glushkova and Nikiforova, 2011; Nikolaeva *et al.*, 2013).

The shape of gold is mainly (70%) angular (ore, crystalline) with numerous irregular protuberances a few micrometers in size (Fig. 6c). Another part of gold population is represented by sharp, flattened particles often less than 10 micrometers in thickness. Furthermore, some gold that is generally smaller in size can be classified as rounded graines with thin crater-like indentations and scratches in random directions (Fig. 6d). The preservation of at least part of the crystalline morphology is characteristic of alluvial gold particles transported for short distances in rivers and streams (Hallbauer and Utter, 1977).

Gold grains could be clearly divided on yellow and white varieties at the panning stage. Subsequent chemical composition analysis has shown that the yellow one, which is predominant, has fineness of 800-950 ‰ and is formed by Au-Ag alloy. The white variety is typically homogenous silverish gold (up to 40 % Ag) that could be classified as electrum (Table 1; Fig. 7a). Some grains are defined by heterogeneous composition with a main Ag-rich alloy sector and local Au-

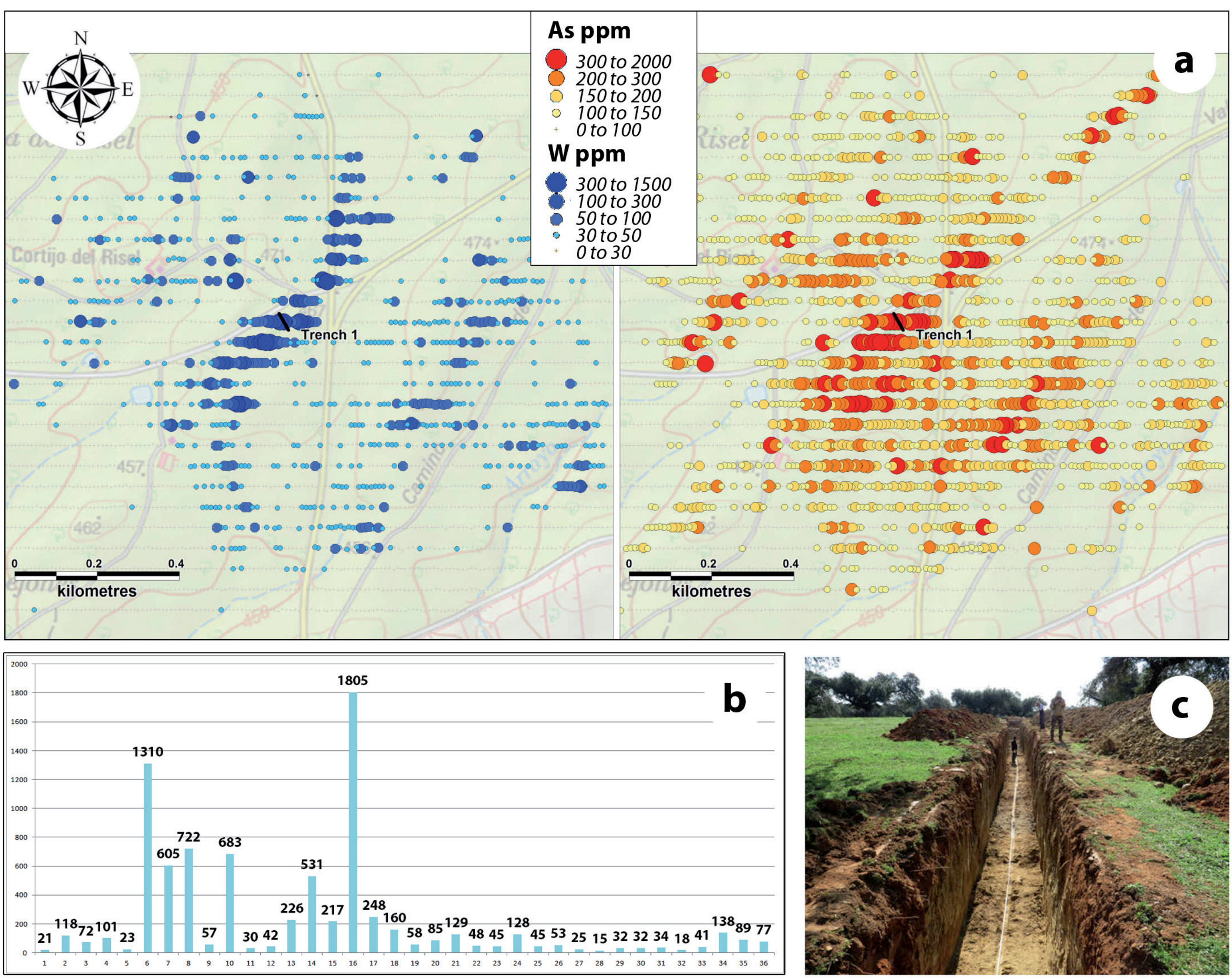

Fig. 5. – (a) Geochemical map of the Target area 2 displaying soil sampling results for As (on the left) and W (on the right) and exploration trench location (modified from Mikhailov, 2014). (b) ICP-MS results for W (ppm) of the exploration trench samples. (c) Exploration trench.

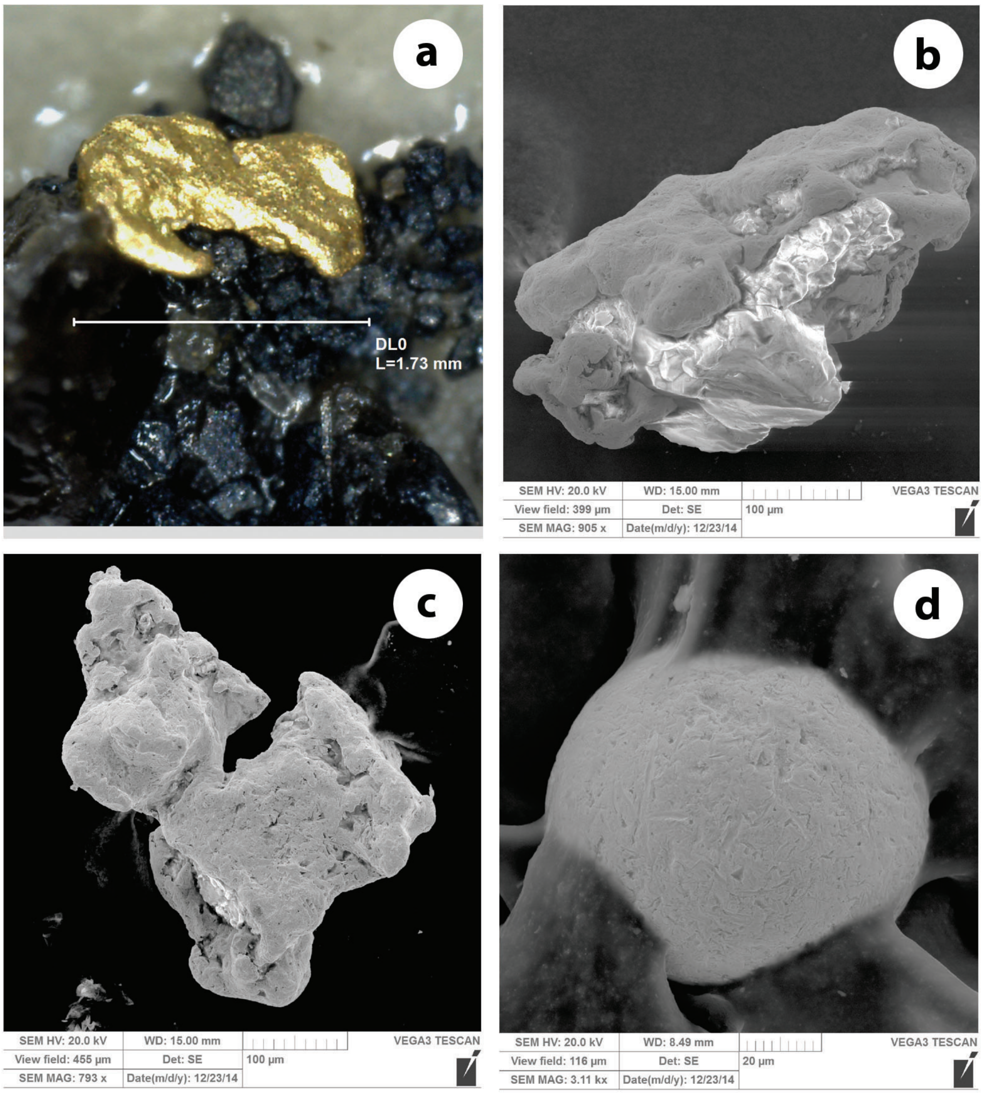

Fig. 6 – (a) Gold particle of 1.73 mm size. (b) BSE image of gold intergrowth with quartz (bright). (c) BSE image of gold particle with ore-crystalline morphology (d) BSE image of rounded gold grain with thin crater-like indentations and scratches in random directions (analyst Blinov I.).

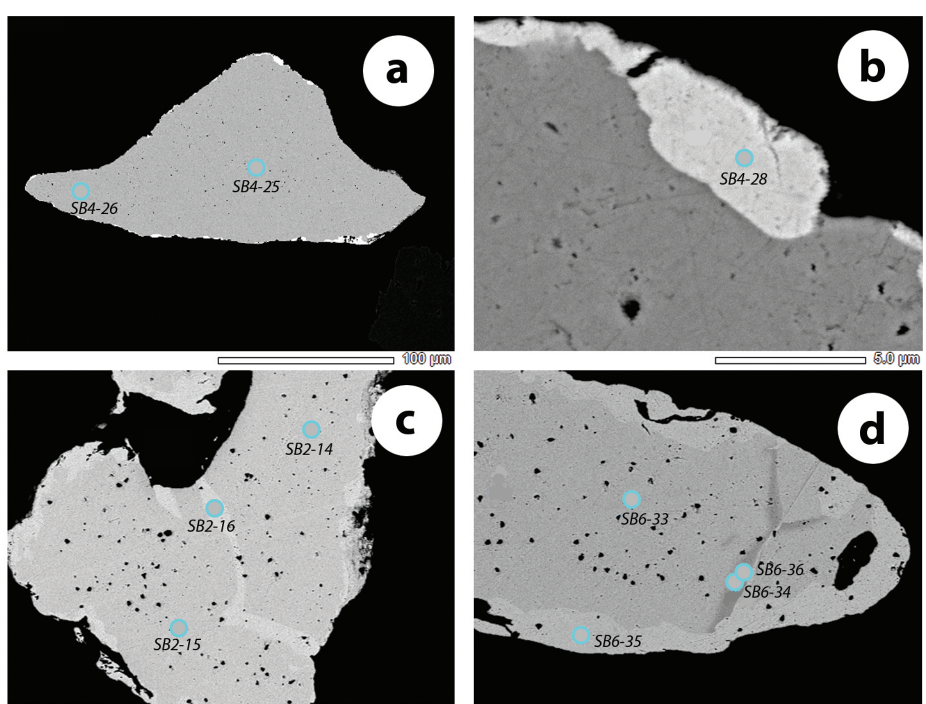

Fig. 7 – (a) BSE image of electrum, composition of spots: SB4-25 - $Au_{0.60}Ag_{0.40}$; SB4-26 - $Au_{0.61}Ag_{0.39}$; SB4-28 - $Au_{0.99}Ag_{0.01}$. (b) The fine gold rim of the grain from Figure 6 a. (c) BSE image of gold grain with heterogeneous composition: SB2-14 - $Au_{0.94}Ag_{0.06}$; SB2-15 - $Au_{0.94}Ag_{0.06}$; SB2-16 - $Au_{0.99}Ag_{0.01}$. (d) BSE image of gold grain with heterogeneous composition: SB6-33 - $Au_{0.92}Ag_{0.08}$; SB6-35 - $Au_{0.99}Ag_{0.01}$; SB6-36 - $Au_{0.76}Ag_{0.24}$ (analyst Galankina O.) (Table 1)

Au Particle	Sample	Bright rim	Ag %	Au %	Total %	Alloy Formula
SB1	SB1-11		8.65	91,35	100	$Au_{0.91}Ag_{0.09}$
	SB1-12		7.62	92,38	100	$Au_{0.92}Ag_{0.08}$
	SB1-13	+	0.24	99,76	100	$Au_{0.99}Ag_{0.01}$
SB2	SB2-14		6.20	93,8	100	$Au_{0.94}Ag_{0.06}$
	SB2-15		6.49	93,51	100	$Au_{0.94}Ag_{0.06}$
	SB2-16		0.18	99,82	100	$Au_{0.99}Ag_{0.01}$
SB4	SB4-25		39.77	60,23	100	$Au_{0.60}Ag_{0.40}$
	SB4-26		39.34	60,66	100	$Au_{0.61}Ag_{0.39}$
	SB4-28	+	0.51	99,49	100	$Au_{0.99}Ag_{0.01}$
SB5	SB5-29		26.45	73,55	100	$Au_{0.74}Ag_{0.26}$
	SB5-30		26.77	73,23	100	$Au_{0.73}Ag_{0.27}$
	SB5-31	+	0.57	99,43	100	$Au_{0.99}Ag_{0.01}$
SB6	SB6-33		7.94	92,06	100	$Au_{0.92}Ag_{0.08}$
	SB6-34		22.51	77,49	100	$Au_{0.77}Ag_{0.23}$
	SB6-36		23.66	76,34	100	$Au_{0.76}Ag_{0.24}$
	SB6-35	+	0.91	99,09	100	$Au_{0.99}Ag_{0.01}$
SB7	SB7-46		4.77	95,23	100	$Au_{0.95}Ag_{0.05}$
	SB7-47		4.75	95,25	100	$Au_{0.95}Ag_{0.05}$
	SB7-48	+	0.48	99,52	100	$Au_{0.99}Ag_{0.01}$

Table 1. – Chemical composition of representative gold particles from Target 1 (Logrosan area).

rich areas (Fig. 7c, 7d). Ag-rich sectors usually appear with a distinct cavernous texture. Trace amounts of copper, mercury and other elements have not been detected.

All particles are defined by fine pure gold rims (fineness 950-997 ‰) (Fig. 7b). In electrum samples the rims are commonly discontinuous and extremely thin (2-5 µm) which suggests a very short exogenous transfer (Glushkova and Nikiforova, 2010). The rims underwent silver leaching during stream transport. Well-aired river water has a high oxygen fugacity and provides the oxidizing environment necessary to dissolve silver (Hallbauer and Utter, 1977).

The ore morphology of gold particles detected in the alluvial sediments, the presence of large-sized grains and electrum with very thin discontinuous rims, all together indicate the proximity to a primary gold source and indicate the Target 1 as a highly perspective exploration area. It appears that the morphological differences, as well as the highly variable fineness of 600 ‰ to 950 ‰ could separate gold within the area into two genetically different types. This question, however, should be the subject of a future investigation.

5. Conclusions

Intensive geochemical survey carried within the area around Logrosan granites allowed selection of the two most promising areas for detailed exploration drilling. Target area 1 contains contrastive zonal As, W, Pb-Zn anomaly in soil sediments accompanied by significant quantities of gold particles (up to 111 grains) found in heavy mineral concentrates. The gold grains morphology and chemical composition indicate the proximity to a primary gold source. The area holds extensive quartz-veins contamination which requires a large quantity of fluid that could possibly contribute the sulphide metals and gold, flowing upwards and depositing along local shear zones and faults. All these factors together point to an exceptional exploration potential for both W and Au.

There were no significant gold contents found in the trench samples and heavy mineral concentrates of the Target area 2. Nonetheless this area still suggests a great exploration potential for W.

The suggested scope of work proved to be efficient for assessing mineralization potential and selecting perspective target areas for a detailed drilling.

Acknowledgements

The research was supported by the Ministry of Education and Science of Russia (design part of the state task in the scientific sphere № 5.2115.2014/K for 2014-2016). EC and KN also acknowledge Mineral Exploration Network Ltd., which supported their work in the Logrosan Project and provided geochemical data. EC thanks Eva Chicharro and Carlos Villaseca for introducing geological setting and mineral paragenesis within the Logrosan area and reviewing the paper. The authors also thank an anonymous referee who's thorough and helpful comments pointed to the right direction in deducing a genetic model for supposed mineralization and greatly improved the quality of the manuscript.

References

ADARO (1982): *Proyecto de investigacion del area de Logrosán (Cáceres).* E.N. Adaro de Investigaciones Mineras, Madrid, planos 5-9.

Almadén-IGME (1987): Proyecto de exploración sistemática coordinada de las zonas de reserva "Hespérica", "Valdelacasa", "Alcudia" y "Guadalupe". *Servicio de Documentación IGME*

Boixereu, E. (2004): Mina de fosfato de Logrosán, Cáceres. *Tierra y Tecnología* 26, 26–34.

Boixereu, E., Amor, J.M., Locutura, J. (2003): Prospección geoquímica en suelos de un área en la zona de Majadacaliente, Zorita (Cáceres). *Boletín de la Sociedad Española de Mineralogía* 26, 63-64.

Carvalho, P.C.S., Neiva, A.M.R., Silva, M.M.V.G. (2009): Geochemistry of soils, stream sediments and waters close to abandoned W-Au-Sb mines at Sarzedas, Castelo Branco, central Portugal. *Geochemistry: Exploration, Environment, Analysis* 9, 341-352. doi: 10.1144/1467-7873/09-208

Chicharro, E., Boixereu, E., Villaseca, C., López-García, J.Á. (2011): Contribución a la puesta en valor del patrimonio geológico y minero del geoparque de las Villuercas: el cerro de San Cristóbal (Logrosán, Cáceres). De re metallica (Madrid). *Revista de la Sociedad Española para la Defensa del Patrimonio Geológico y Minero* 17, 47–54.

Chicharro, E., Martín-Crespo, T., Gómez-Ortiz, D., López-García, J.A., Oyarzun, R., Villaseca, C. (2015): Geology and gravity modeling of the Logrosán Sn–(W) ore deposits (Central Iberian Zone, Spain). *Ore Geology Reviews* 65, 294-307. doi: 10.1016/j.oregeorev.2014.10.005

Chicharro, E., Villaseca, C., Valverde-Vaquero, P., Belousova, E., Lopez-Garcia, J.A. (2014): Zircon U-Pb and Hf isotopic constraints on the genesis of a post-kinematic S-type Variscan tin granite: the Logrosan cupola (Central Iberian Zone*). Journal of Ibeian Geology* 40(3), 451-470. doi:10.5209/rev_JIGE.2014.v40.n3.

Díez Balda, M., Vegas, R., Gonzalez Lodeiro, F. (1990). Part IV, Chapter 2.2. In: R.D. Dallmeyer (ed.), *Pre-Mesozoic geology of Iberia*. Structure of Central Iberian Zone, Springer-Verlag, New York, Berlin, pp. 212-219. doi: 10.1007/978-3-642-83980-1

Frias, C., Lozano, J.I., Sanchez, F., Sundkvist, J.E., Vaduveskovic, Z. (2008): Report on case study comparison of mining activities in the context of regional development (Iberia vs. Balkans vs. Scandinavia). *BioMinE Deliverable D1.6, FP-6 Project*, p. 10.

Glushkova, E. G., Nikiforova, Z. S. (2010): Comperative description of typomorphic features of native gold of the middle Lena basin (south-east of Siberian platform). *Pacific Geology* 29, 34-44.

Glushkova, E. G., Nikiforova, Z. S. (2011): Internal structure of the placer gold of the middle Lena river basin (South-East of Siberian Platform). *Zapiski RMO CXXXX*, 76-83.

Gumiel, P., and Arribas, A. (1990). Part IV, Chapter 2.5. In: R.D. Dallmeyer (ed.), *Pre-Mesozoic geology of Iberia*. Metallogeny of Central Iberian Zone, Springer-Verlag, New York, Berlin, pp. 212-219. doi: 10.1007/978-3-642-83980-1

Hallbauer, D.K., Utter, T. (1977): Geochemical and morphological characteristics of gold particles from Recent River Deposits and the Fossil placers of the Witwatersrand. *Mineralium Deposita* 12, 293-306. doi: 10.1007/BF00206168

Junta de Extremadura (2010): *Mapa Geológico de Extremadura a escala 1:250.000.*

Kellaway, B. (2013): *Updated review of the mineral potential of the Piilola group of licenses, Eastern Finland.* SRK Exploration Services Ltd, Cardiff, 37 p.

Matas, J., Leyva, F., Moreno, F. (1995): Hoja geológica num. 731 (Zorita). *Mapa Geológico de España E. 1:50.000*. IGME., Madrid.

McQueen, K.G. (2005). Chapter B. In: C.R.M. Butt (ed.), Regolith expression of Australia ore systems: a compilation of exploration case histories with conceptual dispersion, process and exploration models. Ore deposit types and their primary expressions, CRC LEME 1, Perth, W.A., pp. 1-14.

Mikhailov, A. (2014): *Information notes on Logrosan Project (Extremadura. Spain).* Mineral Exploration Network Ltd., Spain, 2 p.

Mining Journal (2005): *Extremadura*. Mining Journal Special Publication, 16 pp.

Murphy, P.J., Roberts, S. (1997): Evolution of a metamorphic fluid and its role in lode gold mineralization in the Central Iberian Zone. *Mineralium Deposita* 32, 459-474. doi: 10.1007/s001260050115

Nikolaeva, L. A., Nekrasova, A. N., Milyaev, S. A., Yablokova, S. V., Gavrilov, A. M. (2013): Geochemistry of native gold from deposits of various types. *Geology of Ore Deposits* 55, 176-184. doi: 10.1134/S1075701513030045

Ortega, L., Oyarzun, R., Gallego, M. (1996): The Mari Rosa late Hercynian Sb-Au deposit, western Spain. *Mineralium Deposita* 31, 172-187. doi: 10.1007/BF00204025

Perianes Valle, A., García Isidro, P. (1993): *La Mineria en Extremadura.* Junta de Extremadura, Spain, 68 p.

Ribeiro, A. (1990). Par II, Chapter 1. In: R.D. Dallmeyer (ed.), Pre-Mesozoic Geology of Iberia. Central-Iberian Zone: Introduction. Springer Verlag, Berlín, pp. 143-144. doi: 10.1007/978-3-642-83980-1

Shepherd, T.J. (1993): Integrated Multidisciplinary Exploration Techniques for Gold and Precious Metals in the Western Iberian Peninsula. *Final Report, I.E.C*. Contract MA2M-0032, Portugal.

Villaseca, C., Merino, E., Oyarzun, R., Orejana, D., Pérez-Soba, C., Chicharro, E. (2014): Contrasting chemical and isotopic signatures from Neoproterozoic metasedimentary rocks in the Central Iberian Zone (Spain) of pre-Variscan Europe: Implications for terrane analysis and Early Ordovician magmatic belts. *Precambrian Research.* 245, 131-145. doi:10.1016/j.precamres.2014.02.006

Villaseca, C., Pérez-Soba, C., Merino, E., Orejana, D., Lopez-Garcia, J.A., Billstrom, K. (2008): Contrasting crustal sources for peraluminous granites of the segmented Montes de Toledo Batholith (Iberian Variscan Belt). *Journal of Geosciences* 53, 263–280. doi: 10.3190/jgeosci.035

Vindel, E., Chicharro, E., Villaseca, C., López-García, J.A., Sánchez, V. (2014): Hydrothermal phosphate vein-type ores from the southern Central Iberian Zone, Spain: Evidences for their relationship to granites and Neoproterozoic metasedimentary rocks. *Ore Geology Reviews* 62, 143-155. doi: 10.1016/j.oregeorev.2014.03.011