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Second Projet de Renforcement Institutionnel du Secteur Minier de la République Islamique de Mauritanie (PRISM-II)

Mineral Potential Tracts for Polymetallic Pb-Zn-Cu Vein Deposits:

Phase V, Deliverable 71

By Georges Beaudoin

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This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards or for stratigraphic nomenclature.

The report is being released in both English and French. In both versions, we use the French-language names for formal stratigraphic units.

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
decimeter (dm)	0.32808	foot (ft)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
megagram (Mg)	1.102	ton, short (2,000 lb)
megagram (Mg)	0.9842	ton, long (2,240 lb)
metric ton per day	1.102	ton per day (ton/d)
megagram per day (Mg/d)	1.102	ton per day (ton/d)
metric ton per year	1.102	ton per year (ton/yr)
	Pressure	
kilopascal (kPa)	0.009869	atmosphere, standard (atm)
kilopascal (kPa)	0.01	bar
	Energy	
joule (J)	0.0000002	kilowatt hour (kWh)

ppm, parts per million; ppb, parts per billion; Ma, millions of years before present; m.y., millions of years; Ga, billions of years before present; 1 micron or micrometer (μor μm) = 1×10^{-6} meters; Tesla (T) = the field intensity generating 1 Newton of force per ampere (A) of current per meter of conductor

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Coordinate information is referenced to the World Geodetic System (WGS 84)

Acronyms

AMT	Audio-magnetotelluric
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVIRIS	Airborne Visible/Infrared Imaging Spectrometer
BIF	Banded iron formation
BLEG	Bulk leach extractable gold
BGS	British Geological Survey
BRGM	Bureau de Recherches Géologiques et Minières (Mauritania)
BUMIFOM	The Bureau Minier de la France d'Outre-Mer
CAMP	Central Atlantic Magmatic Province
CGIAR-CSI	Consultative Group on International Agricultural Research-Consortium for Spatial Information
DEM	Digital Elevation Model
DMG	Direction des Mines et de la Géologie
EC	Electrical conductivity
EMPA	Electron Microprobe Analysis
EM	Electromagnetic (geophysical survey)
EOS	Earth Observing System
eU	Equivalent uranium
GGISA	General Gold International
GIF	Granular iron formation
GIFOV	Ground instantaneous field of view
GIS	Geographic Information System
HIF	High grade hematitic iron ores
IHS	Intensity/Hue/Saturation
IAEA	International Atomic Energy Agency
IOCG	Iron oxide copper-gold deposit
IP	Induced polarization (geophysical survey)
IRM	Islamic Republic of Mauritania
JICA	Japan International Cooperation Agency
JORC	Joint Ore Reserves Committee (Australasian)
LIP	Large Igneous Province
LOR	Lower limit of reporting
LREE	Light rare-earth element
METI	Ministry of Economy, Trade and Industry (Japan)
MICUMA	Société des Mines de Cuivre de Mauritanie
MORB	Mid-ocean ridge basalt
E-MORB	Enriched mid-ocean ridge basalt
N-MORB	Slightly enriched mid-ocean ridge basalt
T-MORB	Transitional mid-ocean ridge basalt
Moz	Million ounces

MVT	Mississippi Valley-type deposits
NASA	United States National Aeronautics and Space Administration
NLAPS	National Landsat Archive Processing System
OMRG	Mauritanian Office for Geological Research
ONUDI	(UNIDO) United Nations Industrial Development Organization
PRISM	Projet de Renforcement Institutionnel du Secteur Minier
PGE	Platinum-group elements
RC	Reverse circulation drilling
REE	Rare earth element
RGB	Red-green-blue color schema
RTP	Reduced-to-pole
SARL	Société à responsabilité limitée
SEDEX	Sedimentary exhalative deposits
SIMS	Secondary Ionization Mass Spectrometry
SNIM	Société National Industrielle et Minière (Mauritania)
SP	Self potential (geophysical survey)
SRTM	Shuttle Radar Topography Mission
SWIR	Shortwave infrared
TDS	Total dissolved solids
TIMS	Thermal Ionization Mass Spectrometry
TISZ	Tacarat-Inemmaudene Shear Zone
TM	Landsat Thematic Mapper
UN	United Nations
UNDP	United Nations Development Program
US	United States
USA	United States of America
USGS	United States Geological Survey
UTM	Universal Transverse Mercator projection
VHMS	Volcanic-hosted massive sulfide
VisNIR	Visible near-infrared spectroscopy
VLF	Very low frequency (geophysical survey)
VMS	Volcanogenic massive sulfide deposit
WDS	Wavelength-dispersive spectroscopy
WGS	World Geodetic System

Second Projet de Renforcement Institutionnel du Secteur Minier de la République Islamique de Mauritanie (PRISM-II)

Mineral Potential Tracts for Polymetallic Pb-Zn-Cu Vein Deposits:

Phase V, Deliverable 71

By Georges Beaudoin[1]

1 Summary

In Mauritania, mineral occurrences of the polymetallic Pb-Zn-Cu vein deposit type are found near the Florence-El Khdar shear zone in northeast Mauritania. The deposits visited were deemed representative of other similar occurrences and consist of quartz veins with trace sulfides. The low sulfide and Pb-Zn-Cu content in the quartz veins is unlike producing polymetallic Pb-Zn-Cu vein deposits, such that the veins are not considered to belong to this deposit type. Mineral potential tracts for polymetallic Pb-Zn-Cu veins are highly speculative considering the lack of known mineralization belonging to this deposit type. Mineral potential tracts for polymetallic Pb-Zn-Cu veins are associated with and surround major shear zones in the Rgueïbat Shield and zones of complex faulting in the southern Mauritanides, at the exclusion of the imbricated thrust faults that are not considered favorable for this deposit type. No skarn and replacement deposits have been documented in Mauritania and the low mineral potential is indicated by lack of causative Mesozoic and Cenozoic mafic to felsic stocks.

2 Introduction

The class of mineral deposits known as polymetallic Pb-Zn-Cu veins comprise galena-sphalerite-chalcopyrite in a gangue of quartz, carbonate, fluorite or barite. The veins have strike lengths of hundreds of meters to kilometers and widths up to tens of meters. They occur in shear zones subsidiary to major crustal fault zones or peripheral to felsic intrusions in sedimentary, igneous and metamorphic rocks. Polymetallic Pb-Zn-Cu veins can be divided in two subtypes:

1. "Cordilleran" Pb-Zn-Cu veins distal to porphyry-skarn-epithermal systems which are typically found in Mesozoic-Cenozoic orogenic belts intruded by high-level, intermediate to felsic plutons (for example, Catchpole and others, 2011).

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2. Ag-Pb-Zn veins in clastic metasedimentary rocks, associated with major crustal shears in extending and collapsing late-stage orogenic events (Beaudoin and Sangster, 1992).

Skarn and replacement Pb, Zn and Cu deposits share an association with Mesozoic to Cenozoic mafic to felsic plutonic rocks intruded in volcanic or continental arc terranes with carbonate rocks (Meinert and others, 2005).

3 Mineral Deposits and Occurrences in Mauritania

3.1 Polymetallic Pb-Zn-Cu Veins

In Mauritania, mineral occurrences previously ascribed to the polymetallic Pb-Zn-Cu vein deposit type have been reported in the the Conchita-Florence area of the eastern Rgueïbat Shield (fig. 1, Blanchot, 1975). Most veins are hosted by Birimian metasedimentary rocks of the Paleoproterozoic Aguelt Nebkha Formation (Blekhzaymat Group) intruded by the Bou Ameïna granite (1995 Ma) west of the Florence-El Khdar shear zone, but also in biotite gneisses of the Adam Anajim Complex (2129 Ma) and granite of the Tin Bessaïs Complex, east of the shear zone.

Marot and others (2003) report a swarm of polymetallic Pb-Zn-Cu veins characterized by km-scale strike length and width up to 10 m (fig. 1). The veins are filled by drusy, cockade, and chalcedonic quartz overprinted by hydraulic breccia structures cemented by drusy quartz (fig. 2). None of the mineral occurrences visited (BIA-600, 610, 611, 621) displayed abundant sulfides and none returned any significant Au, Ag, Cu, Pb, or Zn values (table 1). Native gold in quartz with grades from 1.6 to 2,001 g/t Au, and 2 to 407 g/t Ag are reported by Ranchin (1961) and Blanchot (1975). An interesting aspect of these deposits is that the migmatitic host rock of the Adam Anajim Complex has yielded gold grades between 1.6 and 1.9 g/t up to 5 m from the vein. Because the host rock was weathered, Ranchin (1961) considered this result suspicious but it is obvious that this gold dissemination in host rocks should be re-examined.

The geological features of the quartz veins with trace sulfide, low base-metal content, and occasional gold are not consistent with a classification of the veins in the polymetallic Pb-Zn-Cu vein deposit type. Instead, the occasional gold grades obtained from veins suggest the quartz veins could belong to the orogenic-gold vein deposit type.

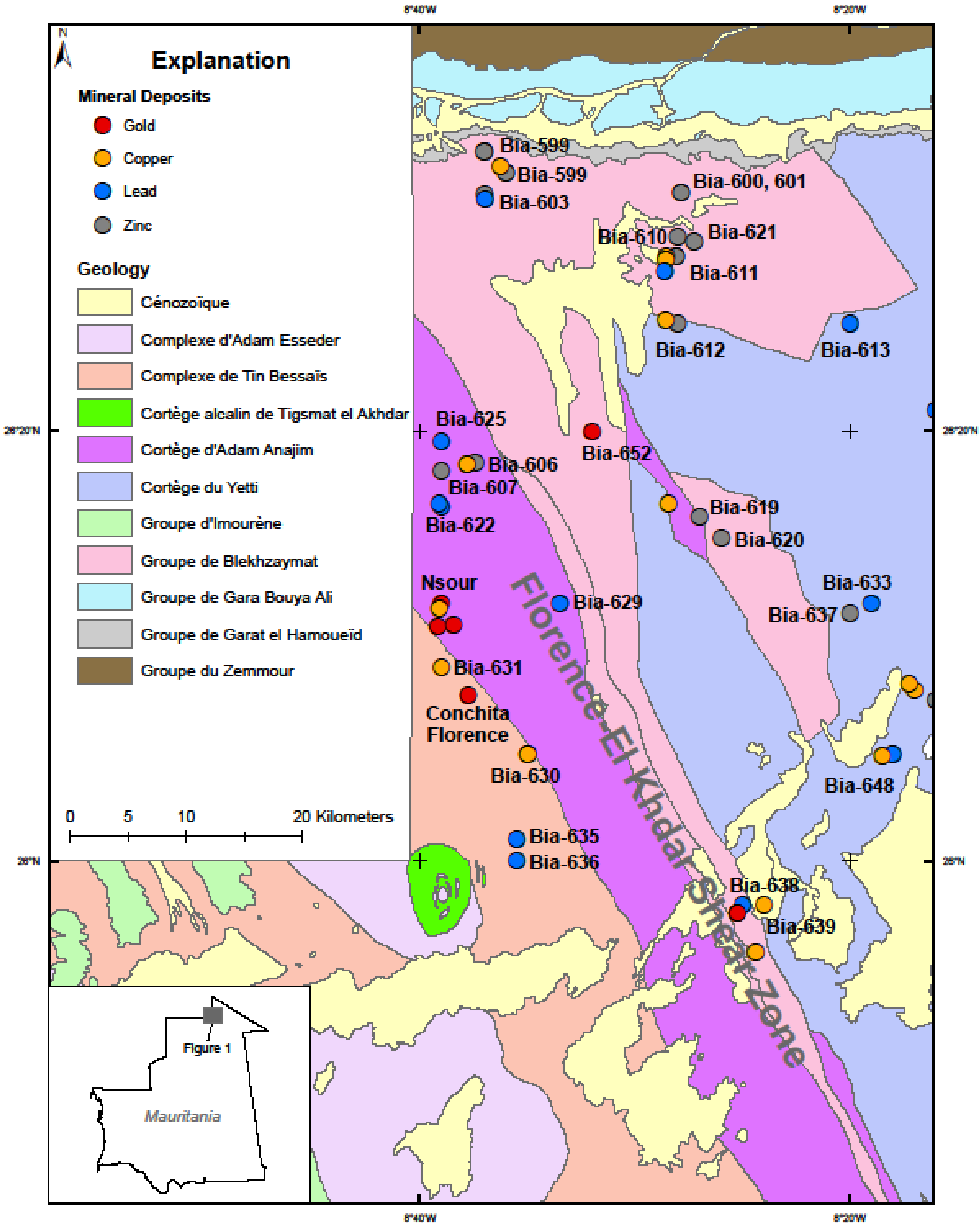

Figure 1. Distribution of Pb-Zn-Cu vein and gold occurrences at the northern end of the Florence-El Khdar shear zone (northeastern Mauritania).

Table 1. Chemical composition of quartz vein samples.

No. Lab.	No. Échan.	Indice minéral	Lithologie	Au ppm	Ag ppm	As ppm	Ba ppm	Bi ppm	Cd ppm	Co ppm	Cu ppm	Pb ppm	Sb ppm	Sn ppm	Te ppm	Zn ppm	S %
C-318131	GB07RIM40A	BIA600	quartz vein	0.078	<1	4	163	4.37	<0.1	1.4	282	1.2	0.36	0.2	<0.1	11	0.02
C-318044	GB07RIM40B	BIA601	quartz-sericite vein	0.008	<1	<1	1550	<0.04	<0.1	0.5	11.5	6.4	0.11	0.1	<0.1	12	0.04
C-318045	GB07RIM41A	BIA621	quartz-sericite vein	<0.005	<1	8	527	<0.04	<0.1	0.8	36.8	5	0.07	0.3	<0.1	15	0.02
C-318132	GB07RIM42A	BIA610	quartz vein	0.043	<1	9	35	1.37	<0.1	0.4	117	1.2	0.12	0.1	<0.1	1	<0.01
C-318046	GB07RIM42B	BIA611	quartz-sericite vein	<0.005	<1	1	402	<0.04	<0.1	0.3	9.4	4.7	0.06	0.4	<0.1	5	<0.01

Figure 2. Typical outcrops of the quartz veins with trace sulfides (left: BIA-610; right: BIA-621). USGS photos.

The quartz veins occasionally contain sericite. At occurrence BIA-600, quartz with abundant sericite was dated by $^{40}Ar/^{39}Ar$. The argon age spectrum is irregular, without an age plateau such that no quantitative geochronological information can be interpreted (figure 3). After the initial ~20 percent release of argon with an apparent age of ~2.4 Ga, the age spectrum shows a gradually climbing pattern from circa 2.0 Ga to 2.4 Ga, before decreasing again in the last 5 percent of the argon released. The spectrum could indicate that the sericite was either affected by a thermal event at ~2.0 Ga that partially reset the initial 2.4 Ga, or that the sericite sample contains two generations of sericite formed perhaps at ages close to the maximum and minimum ages of the spectrum.

Sericite disseminated in the quartz vein of occurrence BIA-610 (fig. 2) yielded a coherent age spectrum with a plateau at 2,063±7 Ma that represents ~80 percent of the argon released (fig. 4). This plateau age is considered a valid date for the quartz vein at occurrence BIA-610. This age coincides with the lower age from sample GB07RIM40B from occurrence BIA-600, which suggests that the lower ~2.0 Ga component in sample GB07RIM40B also represents the age of formation of the quartz vein.

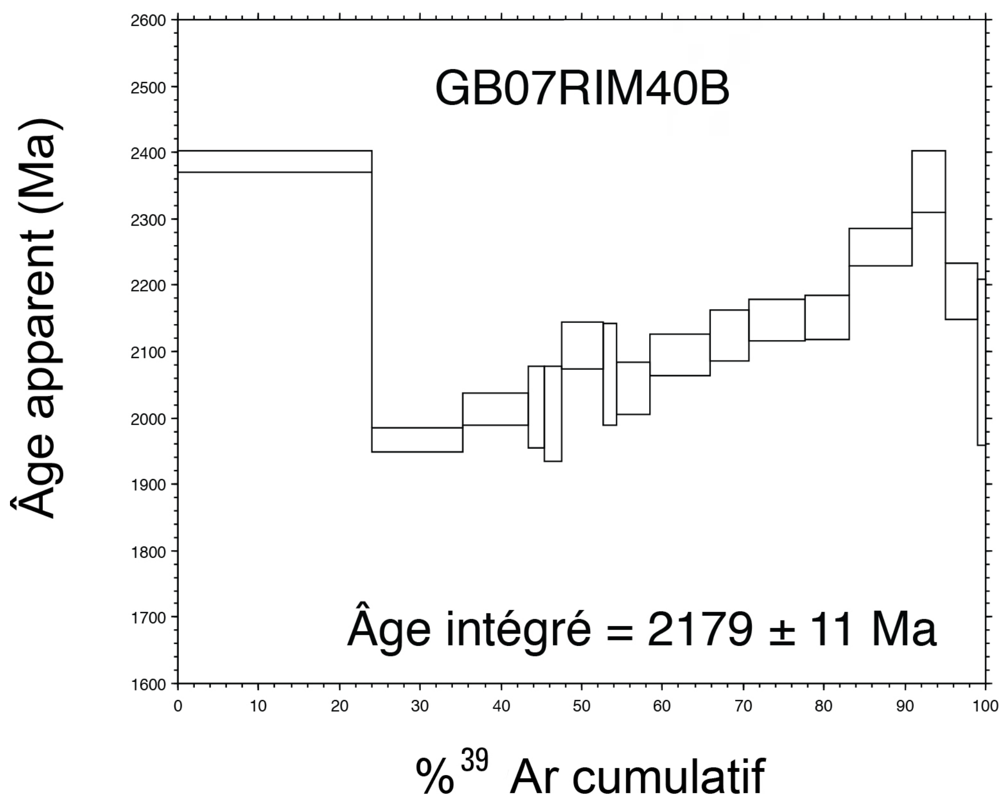

Figure 3. $^{40}Ar/^{39}Ar$ age spectrum from the quartz vein at occurrence BIA-600.

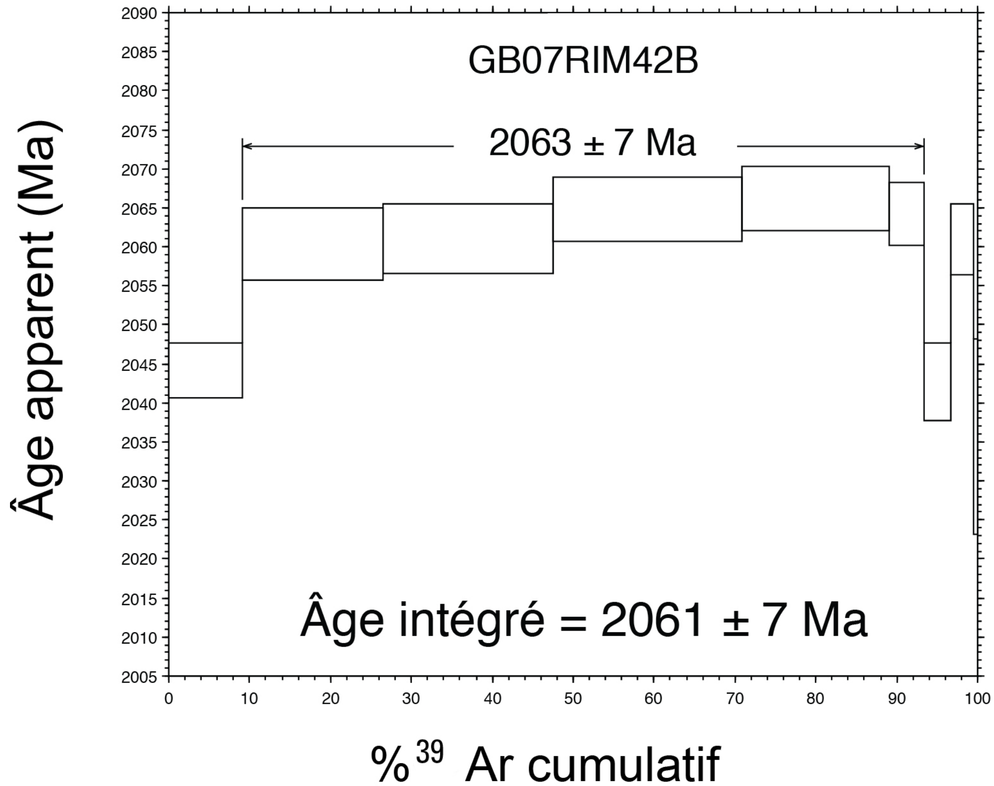

Figure 4. $^{40}Ar/^{39}Ar$ age spectrum from the quartz vein at occurrence BIA-610.

3.2 Polymetallic Pb-Zn-Cu Skarn and Replacement

There is no record of skarn Pb, Zn, Cu mineralization in Mauritania, although a geological environment favorable to skarn mineralization is considered to exist in the Rgueïbat Shield and in the northern Mauritanides where carbonate units crop out (Marot and others, 2003; Gunn and others, 2004).

4 Permissive Mineral Tracts

In Mauritania, the affiliation of quartz veins with trace sulfides with the polymetallic Pb-Zn-Cu vein deposit type is doubtful. Therefore, the potential tracts defined for this mineral deposit type are necessarily large and poorly constrained. By analogy, in Morocco where polymetallic Pb-Zn-Cu veins occur in Hercynian terranes, a first order permissive mineral tract for polymetallic Pb-Zn-Cu veins is considered to include the Rgueïbat Shield and the Mauritanides Belt. Within both terranes, specific mineral potential tracts are defined where permissive geological environments are encountered. The potential for subtypes “Cordilleran” and skarn polymetallic Pb-Zn-Cu vein and replacement deposits is considered very low because of the absence of known Mesozoic-Cenozoic high-level, mafic to felsic intrusions about which these deposit types are typically found (Catchpole and others, 2011; Meinert and others, 2005). Therefore, it is not considered justified to draw permissive mineral tracts for these deposits types.

Ag-Pb-Zn veins hosted in clastic metasedimentary terranes are typically found in association with major crustal shear zones that were active during the late stages of an orogen buildup, typically during extensional collapse of the hinterland or dissection by wrench faults as a result of late transtensional or transpressional events (Beaudoin and Sangster, 1992). Because of this strong association with major crustal shear zones and relative indifference to host rock compositions, with the exception of carbonate units where replacement can become the dominant style of mineralization, the potential mineral tracts for polymetallic Pb-Zn-Cu vein deposits are defined as broad zones surrounding major crustal shear zones, and zones of complex faulting, in both the Rgueïbat Shield and the Mauritanides. Because this deposit type is typically not associated with the compressive events that formed thrust faults, the imbricated thrusts of the southern Mauritanides are not considered permissive of polymetallic Pb-Zn-Cu vein deposits.

Five permissive tracts, numbered 1 to 5, are defined in figure 5, shown in relation to the structural elements of the merged 1:500,000 scale maps. The tracts are shown in relation to Au, Cu, Pb, and Zn occurrences in Mauritania. Similarly, chapter I1, permissive tracts for polymetallic lead-zinc-copper vein deposits in the Islamic Republic of Mauritania (Beaudoin and Horton, 2015) shows the same tracts on a 1:1,000,000 scale map of Mauritania. Tract 1 is the region containing and surrounding the Florence-El Khdar shear zone in northeast Mauritania (fig. 5). Devonian to Recent sedimentary rocks and active aeolian sands cover the northern extension of the Florence-El Khdar shear zone, whereas the southern extension of the shear zone is overlain by Proterozoic sandstones and dolostones of the El Mreiti Formation. A mineral potential tract for polymetallic Pb-Zn-Cu veins is drawn as a ~70 km-wide zone covering rocks on both sides of the Florence-El Khdar shear zone (fig. 5). Tract 2 is defined by the broad, northwest-southeast trending Sfariat Shear zone, 100 to 200 km wide, where major NW-SE, WNW-ESE, and N-S shear zones form an interconnected network. Tract 2 is approximately halfway between Tract 1 and Zouérate (figure 5). Tract 3 is a curved region, almost north-south, about 300 km long and 50 km wide, with Atar near its mid-point. Tract 3 is characterized by a linear aggregate of NNW-SSE to NNE-SSW shear zones that could be the locus of polymetallic Pb-Zn-Cu vein deposits (fig. 5). Tract 4 is a broad area in northwest Mauritania, approximately 100 by 100 km, where a complex network of major shear zones cut across the Rgueïbat Shield (fig. 5). Some of the shear zones in Tract 4 are associated with orogenic gold mineralization (for example, the Tasiast deposit). It is not typical to find shear zones hosting orogenic gold deposits and polymetallic Pb-Zn-Cu veins, such that this Tract 4 is even less prospective than the previous tracts. Tract 5 is an area, oriented approximately N-S, about 100 km wide by 300 km long, east of the imbricated thrust faults of the southern Mauritanides, and northwest of Kiffa (fig. 5). Tract 5 is characterized by a complex network of shear zones underlying the area. The dominant orientations of the shear zones are N-S to NW-SE and E-W to NE-SW. Some of the shear zones appear to define a conjugate pattern (fig. 5). This complex network of shear zones is considered favorable for the infiltration of hydrothermal fluids into the Upper Ordovician rocks of the Tichit Group, underlying most of the area defined as Tract 5.

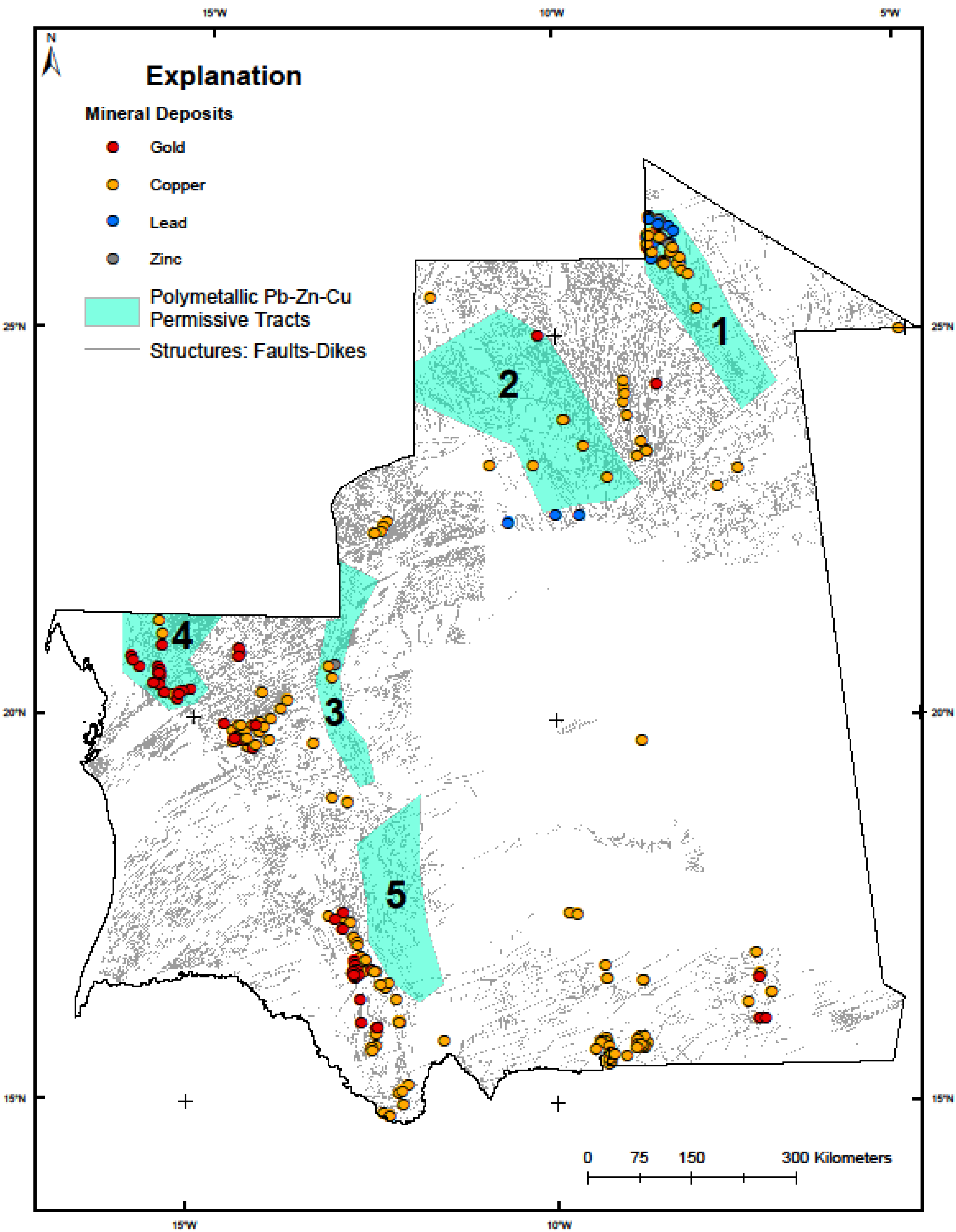

Figure 5. Permissive mineral tracts for polymetallic Pb-Zn-Cu vein deposits superposed on the 1:500,000 scale structural map. Black lines indicate structural elements such as faults and shear zones.

5 Conclusions

1. Vein occurrences previously ascribed to the polymetallic Pb-Zn-Cu vein deposit type consist of low sulfide quartz veins unlike the base-metal rich veins typical of this deposit type.
2. The low sulfide quartz veins could be assigned to orogenic-gold vein deposit type, considering the sporadic gold grades reported from some quartz vein occurrences.
3. Five broad permissive mineral tracts for polymetallic Pb-Zn-Cu vein deposits are defined based on areas with major shear zones or complex fault patterns. The imbricated thrusts of the southern Mauritanides are not considered to have potential for polymetallic Pb-Zn-Cu vein deposits.
4. Skarn and replacement deposits are unknown in Mauritania. The mineral potential for skarn and replacement deposits is very low considering the lack of Mesozoic and Cenozoic mafic or felsic stocks, in comparison to the close association of skarn and replacement deposits with intrusions of those ages.

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