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A contribution to the synsedimentary versus epigenetic origin of the Cu mineralizations hosted by terminal Neoproterozoic to Cambrian formations of the Bou Azzer–El Graara inlier: New insights from the Jbel Laassel deposit (Anti Atlas, Morocco)

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ABSTRACT

The Neoproterozoic to Cambrian formations that compose the cover of the Bou Azzer–El Graara inlier, host a great number of Copper occurrence whose origin is largely discussed. To bring some light to this debate, structural, petrographic and geochemical observations were performed on the copper deposit of Jbel Laassel. This deposit, located at the extreme ESE of the Bou Azzer–El Graara inlier, is mined since 2012. At the district scale, the ore bodies localize in a folding band that extends along a NE–SW direction. At macroscopic, microscopic and scanning electron microscope scales the mineralization appears as banding veins, with locally cockade breccia and comb quartz textures. From the macroscopic scale to the scale of the scanning electron microscope, all these mineralized textures are connected there between forming a stockwork with an auto-similar structure in the range of used scales of observation. At the district scale, this stockwork is preferentially located in the anticlinal hinges of the folding band. Principal component analyses of geochemical database enable to distinguish several groups of chemical elements, each of these groups corresponding to the different lithologies and to the copper mineralization. This last group does not show any correlation with the distinguished lithological groups. All these observations bring new arguments to an epigenetic origin for the copper mineralization of the Jbel Laassel deposit, with a formation contemporary or posterior with the folding band development attributed to Variscan deformation.

1. Introduction

More than 200 Copper mineralizations are known over a large part of the Neoproterozoic to Cambrian cover in the Anti-Atlas (Fig. 1A) (Bouchta et al., 1977). They are localized at different stratigraphic levels within the cover and present different characteristics. Their origin remains in most cases currently poorly understood and there is no general model for this copper mineralization. Several genetic interpretations have been proposed on specific deposits: (i) based on textural and petrological observations, Leblanc (1986) suggests that Alous mineralization crystallized during the cooling of an ignimbrite; (ii) For the Cu-occurrences of Tizert, Talat N'Ouamane, Tizirt and Amadouz, Pouit (1966), Bouchta et al. (1977) and Skacel (1993) consider these mineralizations generated through a synsedimentary process arguing of a strong paleogeographic control of the ores. Moreover, the Cu-mineralizations hosted in the Neoproterozoic to Cambrian cover in the Anti-Atlas can be differentiate by their morphologies as veins, dissemination or stratiform bodies, without relationship have been established between these morphologies yet (Pouit, 1966; Skacel, 1993). As the result, the syngenetic or epigenetic nature of that mineralization remains still undetermined (Pouit, 1966). New data and evidences are then necessary. The Jbel Laassel deposit is one of these numerous cover-hosted copper occurrences known in the Anti-Atlas terminal Neoproterozoic to Cambrian cover, often called Adoudounian cover (Pouit, 1966; Bouchta et al., 1977; Benssaou and Hamouni, 1999). Since the 60's, various

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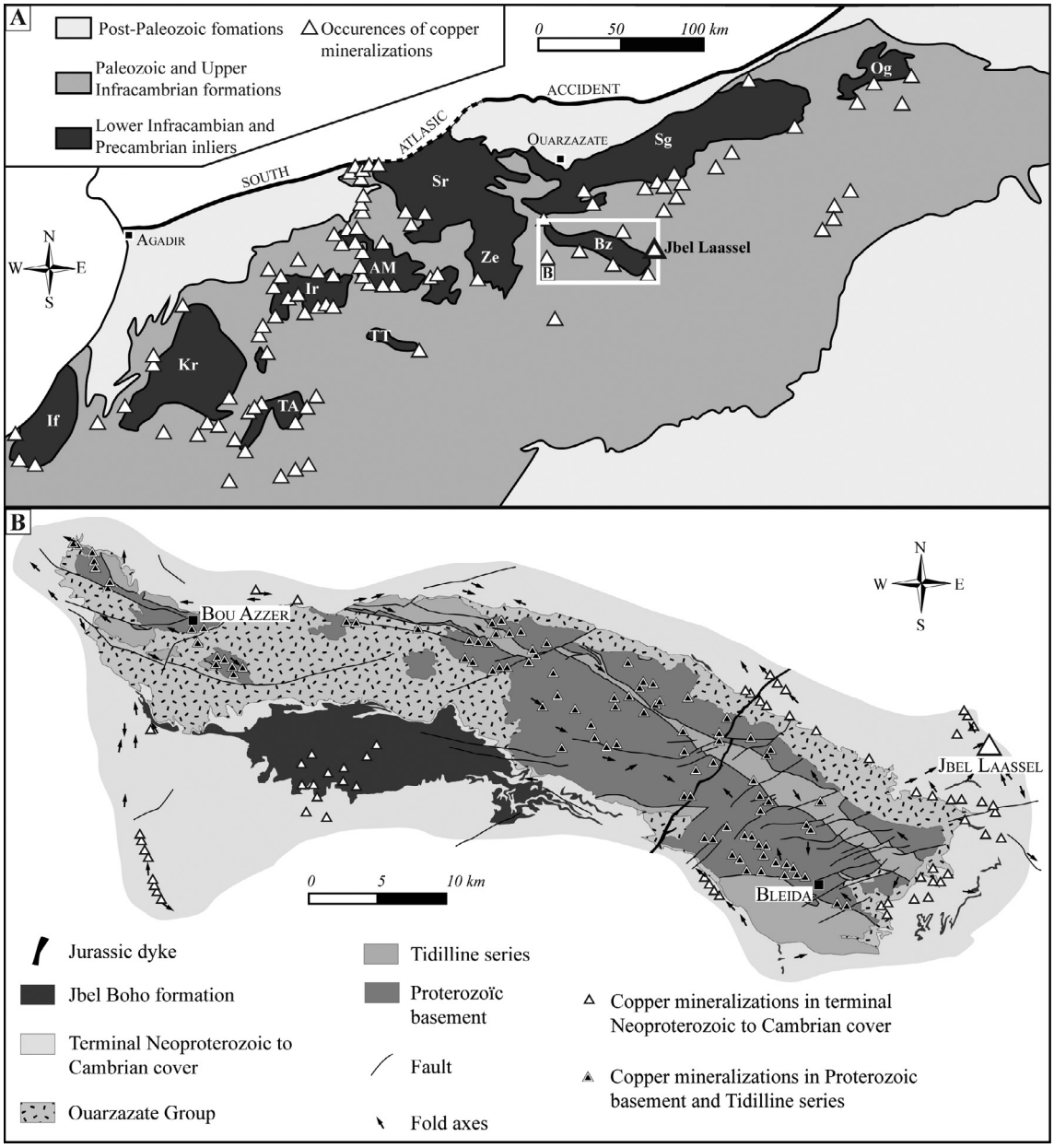

Fig. 1. (A) Schematic geologic map of the Anti-Atlas with occurrences of copper mineralizations modified from Bouchta et al. (1977). Inliers abbreviations: If, Ifni; Kr, Kerdous; Ir, Igherm; TA, Tagragra d'Akka; TT, Tagragra Tata; AM, Agadir Melloul; Ze, Zenaga; Sr, Sirwa; Bz, Bou Azzer–El Graara; Sg, Saghro; Og, Ougnate. (B) Geological and structural map of the Bou Azzer–El Graara area with occurrences of copper mineralizations, modified from Leblanc (1975).

genetic models were proposed by several geologists hired by Managem Group for the copper mineralization at Jbel Laassel site. Maacha et al. (2011) resumed these different models: in 1964 the mineralization was attributed to a porphyry copper type, in 1967 it was interpreted as a stratiform synsedimentary deposit, with a re-concentration stage associated to a Jurassic doleritic intrusion, in 1978 an epigenetic origin was proposed for this mineralization with a mainly vein-shaped texture and a close association with barite. Some authors evoked a synsedimentary genesis for the Jbel Laassel deposit, where mineralization is controlled by the basement paleogeography and were locally remobilized by a tectonic event (Pouit, 1966; Bouchta et al., 1977). According to Skacel (1993), copper should be synchronous with sedimentation; its precipitation being regulated by the redox conditions, themselves under the control on the deposition environment.

In 1984, the MANAGEM Group discovered the potential of the Jbel Laassel Cu-mineralizations. Different preliminary estimations were performed until 2006 (Maacha et al., 2011). In 2010 Managem decided to lead a core drill campaign to estimate the feasibility of this deposit. This work resulted in an estimation of 7.5 million tons at 1% Cu (Maacha et al., 2011) and the exploitation began in 2012 with SOMIFER as operator. In this article, based on MANAGEM Group pre-exploitation targeting, we report the main results of an original study performed on Jbel Laassel Cu-mineralization. This work consists of: (i) a structural analysis of ore bodies, (ii) a mineralogical study of samples collected both on outcrops and drill cores and (iii) a statistical analysis of the first chemical analyses carried out in this deposit. These new data bring out new insights on the debated, epigenic versus syngenetic origin of the Jbel Laassel deposit.