Introduction

Due to increasing gold prices, gold exploration has intensified in the last 10 years, especially in the West African craton where many prospects exist. Among these, the three copper-gold occurrences Dienemera, Gongondy and Mont Biri, of the Gaoua district (B2Gold), southern Burkina Faso, are thought to be part of a porphyric system (Sillitoe, 2007) but have not been so far subjected to detailed studies to confirm this hypothesis.

This study presents mineralogical and fluid inclusion data for the mineralization and associated gangue phases that allow us to propose a metallogenic model for the formation of the Gaoua copper-gold system. In addition, the age of the mineralizing event was determined by Re-Os dating of sulfides.

Geological Setting

Archean domains of the West African craton are composed of TTG-type lithologies and greenstone belts formed by metasedimentary and metavolcanic rocks. Birimian formations (i.e. Paleoproterozoic) formed as a result of a magmatic accretion event which took place between 2.25 and 2.15 Ga (Feybesse et al., 2006; Baratoux et al., 2011). The formation of Birimian rocks was followed by tectonic accretion of this juvenile crust onto Archean terrains during the Eburnean orogeny which began around 2.15 Ga and which lasted about 130 Ma (Feybesse et al., 2006).

On a large scale, the geology of Burkina Faso consists of Birimian greenstone belts with a NE-SW orientation, intruded by granitoids. The Gaoua mining prospect is situated in south-western Burkina Faso, at the southern extremity of the Boromo-Goren greenstone belt. The local geology at Gaoua is essentially represented by volcano-plutonic rocks of andesitic to basaltic composition, granitoids and metasediments. Dienemera, Gongondy and Mont Biri copper-gold occurrences are located along a N-S structural corridor, and are separated from each other by a few kilometers. Copper and gold mineralizations are hosted by dioritic-andesitic rocks metamorphosed in the greenschist facies.

In the same mining property, the gold occurrence of Nassara is situated 10 kilometers to the west of the N-S corridor hosting Dienemera, Gongondy and Mont Biri. In contrast to these latter deposits, Nassara presents only gold mineralization.

Characterization of the Gaoua Deposit

In Dienemera, Gongondy and Mont Biri samples, two main types of mineralization can be identified: brecciated zones strongly mineralized in copper, and pyrite-rich zones (the “pyrite front”) which locally have high gold grades (up to 10 g/t) but low copper contents.

Characterization of the copper mineralization

Copper-mineralized breccias are the results of the first
deformation event affecting the Gaoua district. They are composed of dioritic or andesitic clasts cemented by anhydrite, quartz, carbonate, chalcopyrite and pyrite. The brecciation is associated with vein networks of the same composition. In these breccias, a first generation of chalcopyrite (Cpy1), accompanied by anhydrite and carbonate, fills cavities or is disseminated within clasts of diorite and andesite in association with a first generation of pyrite (Py1). Microprobe analyses indicate that these first generation pyrites are As and Au-free. No visible gold is associated with these copper zones. Fluid inclusions associated with copper mineralization are hosted in quartz and contain solid phases such as NaCl, KCl, hematite, carbonate, anhydrite and chalcopyrite. Their analysis reveals high homogenization temperatures that exceed 450°C.

The dioritic nature of the host rocks and the preponderance of breccias and veins are consistent with a porphyry-style for the copper mineralization, which is confirmed by fluid inclusion analyses.

3.2 Characterization of the gold mineralization

Both the copper breccias and the pyrite front are crosscut by highly localized sheared and fractured zones linked to a second episode of deformation. These NE-SW and NW-SE subvertical shearbands crosscut all other structures and are associated with the crystallization of quartz, calcite, muscovite and a new generation of chlorite (Chl2) and sulfides (Py2 and minor Cpy2). These highly chloritized sheared and fractured zones host the only observed occurrences of visible gold. Gold is observed as micrometric (up to 50 μm) inclusions in pyrites, infilling fractures of sulfides of all generations and disseminated in host rocks in association with secondary chlorite (Chl2).

Microprobe and LA-ICP-MS investigations reveal that the main difference between Py2 and Py1 is the higher concentrations of As and Cu in Py2, as well as of Pb, Bi, Sb and Au. The petrographic and chemical characteristics of Py2 are observed in the pyrites of the nearby Nassara gold deposit, suggesting that Nassara is the expression of the same gold event that affected Gaoua occurrences.

Solid-free H2O dominated inclusions and H2O-CO2 inclusions were observed in fractures and planes crosscutting quartz crystals in both copper zones and the pyrite front. These have variable salinities and relatively low homogenization temperatures (120-200°C).

The specific chemical signature of Py2 marked by enrichment in As, Cu and Au, together with the characteristics of the fluid inclusions suggests an orogenic origin for the gold mineralization.

4 Re-Os Dating

4.1 Re-Os dating of the copper event

To yield geochronological constraints on the formation of the porphyry copper mineralization, seven samples of pyrite of the first generation were selected for Re-Os dating. The resulting isochron gives an age of 2161 ± 23 Ma (MSWD=3.1, Fig. 1). Given the highly radiogenic character of the samples and thus the very limited proportion of 188Os in the total osmium, the points were plotted in a 187Os – 187Re diagram (Stein et al., 2000).

This age, which can be interpreted as the age of the porphyry formation, is in agreement with studies of the magmatic accretion event predating the Eburnean orogeny which occurred, according to different authors, between 2250 and 2150 Ma.

4.2 Geochronological constraints on the gold event

The separation of Py2 from Gaoua samples was problematic because they were difficult to distinguish from Py1. So, to provide age constraints on this second sulfide generation and the associated gold mineralization, pyrites from the Nassara occurrence were analyzed, under the assumption that their formation was contemporaneous with that of Py2 in Gaoua.

Six pyrite separates were analyzed. Re and 187Os contents obtained for these samples are much lower than those of the Py1 sulfides from Gaoua, though 188Os contents are similar. The higher relative proportion of common Os, coupled with the uncertainty on its 187Os/188Os ratio, inevitably led to considerably higher uncertainties on the ages obtained. The resulting weighted average age for the six samples is 2102 ± 71 Ma (MSWD = 3.2).

![Fig. 1. 187Os-187Re isochron diagram for 7 analyses of Py1 (Isoplot, Ludwig, 2008)](image-url)
The high uncertainty associated with this age does not permit chronological distinction of this mineralizing episode from the porphyry stage in a statistically robust manner. Nevertheless, the weighted average age of 2102 ± 71 Ma is, at face value, younger than the age of 2162 ± 23 Ma obtained for the first generation pyrites and is thus consistent with the petrographic evidence which shows that the orogenic gold event postdates the porphyry copper episode.

5 Conclusion

The combined techniques showed that copper and gold ores in the mining district of Gaoua were formed by two different events. The first was the development of a primary copper porphyry deposit dated at 2161 ± 23 Ma. The Gaoua porphyry is both the first porphyry copper deposit described in the West African craton, and also one of the rare Paleoproterozoic porphyries known from throughout the world. The second, revealed by the comparison of the three copper-gold occurrences (Dienemera, Gongondy and Mont Biri) with the nearby Nassara gold deposit, was a younger orogenic gold mineralization event that overprinted the porphyry mineralization.

References