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Geology of the world-class Kiaka polyphase gold deposit, West African Craton, Burkina Faso

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A B S T R A C T

The Kiaka gold deposit is a major resource in West Africa, with measured and indicated resources of 124 Mt at 1.09 g/t Au (3.9 Moz) and inferred resources of 27 Mt at 0.83 g/t Au (0.8 Moz). Located within the Manga-Fada N'Gourma greenstone and plutonic belt in south of the Burkina Faso, the deposit is hosted by a metamorphosed volcano-sedimentary sequence of lithic-, quartz-biotite metagreywackes, aluminosilicate-bearing metapelites and garnet-orthopyroxene-bearing schists and volcanic units.

Structural observations indicate four local deformation events: DK_1, DK_2 and DK_3 and DK_4. Respectively, these events are linked to regional D_1 E-W compression, D_2 NW-SE compression and lastly, D_3- and D_4-related reactivations along D_2 shear zones. The S_2 foliation and D_2 shear zones are developed during lower amphibolite facies metamorphism whereas retrogression occurs during $D_{3\text{-}4}$ reactivations along these shear zones at upper greenschist facies conditions. The emplacement of a dioritic intrusion, dated at 2140 ± 7 Ma (Concordia U-Pb age on magmatic zircon), is interpreted to be contemporaneous with sinistral displacement along mineralized, NE-trending D_2 shear zones. The intersection of these shears zones and the Markoye shear zone (dextral-reverse D_1 and sinistral-reverse D_2 reactivations) controlled the final geometry of the host rocks and the ore zones.

Four subparallel elongated ore bodies are mainly hosted within D_2-related shear zones and some are developed in an apparent axial plane of a F_2 isoclinal fold. Detailed petrographic studies have identified two main types of hydrothermal alteration associated with two stages of gold mineralization. The stage (1) corresponds to replacement zones with biotite and clinozoisite during the D_2 event associated with pyrrhotite ± pyrite, chalcopyrite (disseminated gold stage). The stage (2) occurs during reactivations of the D_2-related auriferous shear zones (vein stage) and is characterized by diopside ± actinolite D_3 veins and veinlets and D_4 pervasive muscovite, ± chlorite, ± calcite in quartz-carbonate vein selvages and associated with pyrrhotite + arsenopyrite ± electrum, ± native gold and tellurobismuthite. The latter stage (2) could be divided into two sub-stages based on mineralogy and crosscutting relationship. A weighted average Re-Os pyrrhotite age at 2157 ± 24 Ma (Re-Os age based on 3 replicates) constraints the timing of the disseminated gold stage and represents the first absolute age for gold mineralization in the Manga Fada N'Gourma area. The timing of gold at Kiaka may be also coeval with one of the two lode gold event at ~ ca. 2.16–2.15 Ga and occurred concomitant with tectono-thermal activity during Eo-Eburnean orogeny.

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The study of the Kiaka gold deposit emphasizes the importance of a multi-scale and multidisciplinary approach (field observations, petrography geothermobarometry and geochronology) to decipher the polyphase character of some Paleoproterozoic gold deposits.

1. Introduction

Orogenic gold deposits represent a major source for global gold production (Goldfarb et al., 2001; Frimmel, 2008). These ore deposits formed from the Paleoarchean (gold mineralization in the Pilbara craton dated at ca. 3.4–3.3 Ga; Neumayr et al., 1998) to the early Cenozoic (gold-bearing quartz veins in the Southern Alps formed during the last 7 Ma; Craw and Koons, 1989). The term “orogenic” is linked to their close association with accretionary and collisional orogens (Groves et al., 1998). Ore in such deposits is (i) epigenetic and hosted by deformed and variably metamorphosed rocks at mid- to shallow crustal levels (Böhlke, 1982; Goldfarb et al., 2001, 2005), (ii) spatially associated with major crustal structures (Sibson et al., 1988; Colvine et al., 1988; Kerrich et al., 2000). Some authors have also argued for a spatial and/or temporal association between gold and granitoids of variable composition (Colvine et al., 1988; Champion and Sheraton, 1997; Cassidy et al., 2002; Goldfarb et al., 2005; Doublier et al., 2014). The relationship between gold and magmatism is probably due to the late-orogenic extensional tectonics that also focuses plutonism along auriferous structures. Granites can also provide thermal perturbations, competence contrasts at belt to deposit scale and/or may also contribute some metals and/or ligands that are district specific (Wyman et al., 2016).

Crustal scale processes are invoked for the formation of orogenic gold systems (McCuaig and Hronsky, 2014; Wyman et al., 2016) as they form in a very short time in relation with tectonic triggers, controlling the transfer of fluids within the crust (Sibson et al., 1988; Cox, 2005; Weatherley and Henley, 2013). They are products of aqueous-carbonic fluids released during metamorphic reactions in middle to lower crust. Increases in disequilibrium between fluids and host rock induce destabilization of gold-carrying complexes such as $Au(HS)_2$ and AuHS (Tomkins and Mavrogenes, 2002). Possible sources of fluids for orogenic gold deposits are: (1) metamorphic rocks and fluids generated with increasing metamorphism and (2) felsic intermediate magmas and associated fluids. The first source is very consistent with geological, geochronological and geochemical data (Goldfarb and Groves et al., 2003), while the second source remains inconsistent as no universal temporal link has been described to date.

The Baoulé-Mossi domain (Abouchami and Boher, 1990; Boher et al., 1992; Taylor et al., 1992) hosts abundant gold deposits (Fig. 1) within deformed volcanic and sedimentary rocks that have undergone regional greenschist to locally contact amphibolite facies metamorphism (Béziat et al., 2000, 2008; Castaing et al.,

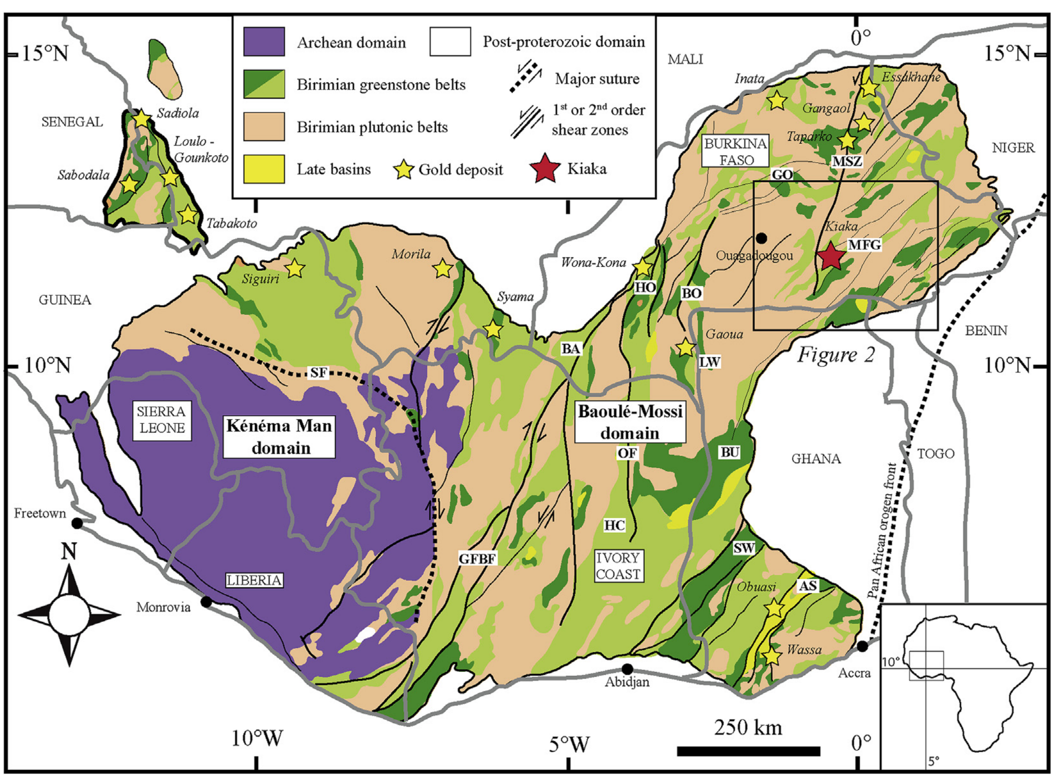

Fig. 1. Geology of West African craton (modified after Castaing et al., 2003; Naba et al., 2003; Milesi et al., 2004; Vegas et al., 2007; Ganne et al., 2011). The Kénéma Man domain (Archean nucleus) and the Baoule-Mossi domain (Paleoproterozoic juvenile crust) form two distinct domains separated by the Sassandra Fault (SF). Volcano-sedimentary belts include Banfora (BA), Houndé (HO), Boromo (BO), Lawra (LW), Goren (GO), Bui (BU), Ashanti (AS) and Sefwi (SW), Haute Comoé basin (HC) and Manga Fada-N'Gourma belt (MFG). These belts are separated into dark green for mafic volcanics rocks and light green for volcano-sedimentary rocks and intermediate to felsic igneous rocks (Baratoux et al., 2011). A spatial association between gold deposits of the Baoulé-Mossi and major structures such as the Grenville-Ferkessedougou-Bobo-Dialousso (GFBF), Ouango-Fitini (OF) and Markoye (MSZ; this study) shear zones is observed in the Baoulé-Mossi domain. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)