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Three-dimensional geochemical patterns of regolith over a concealed gold deposit revealed by overburden drilling in desert terrains of northwestern China

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ABSTRACT

Desert terrains are widespread in northwestern and northern China, and these areas present particular challenges for exploration. In recent years, partial extraction techniques have been proven to be effective in the search for concealed deposits in arid desert terrains in some cases. However, we still lack an understanding of the dispersion patterns of ore-forming elements in regolith. In this study, air reverse circulation drillings were used to create three-dimensional (3D) distribution patterns of elements in regolith over the Jinwozi gold deposit in China, which is covered by tens of metres of regolith, in order to trace the migration of elements and to understand the dispersion mechanisms. The 3D distribution maps of elements show that (1) coherent anomalies occur at different depths of transported cover over the ore body, (2) Au tends to be enriched in the top and bottom horizons and depleted in the middle horizon in the vertical direction, (3) the anomalous distribution of Au at the bottom is restricted to places at the interface of sediments and bedrock, and (4) the anomaly in the bottom sediments is confined to a width of tens of metres, whereas that in top soils is much wider and can extend up to several kilometres. In addition, close positive correlations were found between the As, Hg, and Au distributions.

1. Introduction

Desert terrains are widely distributed in northwestern and northern China, and these areas are covered by widespread transported materials that can mask geochemical signals from ore bodies; such geomorphological structures present major obstacles to mineral exploration (Wang et al., 2007). Over the past 20 years, partial extraction techniques have been developed and proven effective in the search for concealed deposits in certain terrains (Antropova et al., 1992; Bajc, 1998; Cameron et al., 2004; Clark et al., 1997; Cohen et al., 1998; El-Makky and Sediek, 2012; Hamilton et al., 2004a,b; Kelley et al., 2003; Mann et al., 1995, 1998; Noble and Stanley, 2009; Wang, 1998; Wang et al., 2007; Williams and Gunn, 2002; Xie and Wang, 2003; Xie et al., 2011; Yeager et al., 1998), while at the same time, some migration models have been constructed and employed to explain the formation mechanisms of geochemical anomalies (Anand and Robertson, 2012; Aspandiar et al., 2008; Cameron et al., 2004; Garnett, 2005; Hamilton, 1998; Hamilton et al., 2004a,b; Kelley et al., 2003; Lintern, 2007; Luz et al., 2014; Mann et al., 2005; Smee, 1998; Wang, 2005; Wang et al., 2007). However, there is still a critical need to study the three-dimensional (3D) distribution of elements in regolith. Such information is important for further elucidating the potential mechanisms for the transfer of elements from the ore body upwards through the regolith cover to the surface and for understanding how to conduct successful explorations in regolith-dominated terrains, whether for deposits concealed by the regolith or for those hosted within it.

In this study, we used air reverse circulation (ARC) drilling technology over the Jinwozi gold deposit in China, which is covered by several to tens of metres of transported materials, to determine the 3D distribution patterns of ore elements in regolith and to investigate the migration mechanisms.

2. Study area

The Jinwozi gold field is located 200 km southeast of Hami city at the boundary of the Xinjiang and Gansu provinces in northwestern China (Fig. 1). There are two NE-trending mineralized zones in the Jinwozi gold field (Fig. 1). In the northern zone, the mineralization is characterized by an epithermal quartz-vein type. The auriferous quartz veins occur at the contact between porphyry and Devonian sequences. In the southern zone, the mineralization is characterized by tectonic alterations. The ore bodies occur in a structural shear zone, which is

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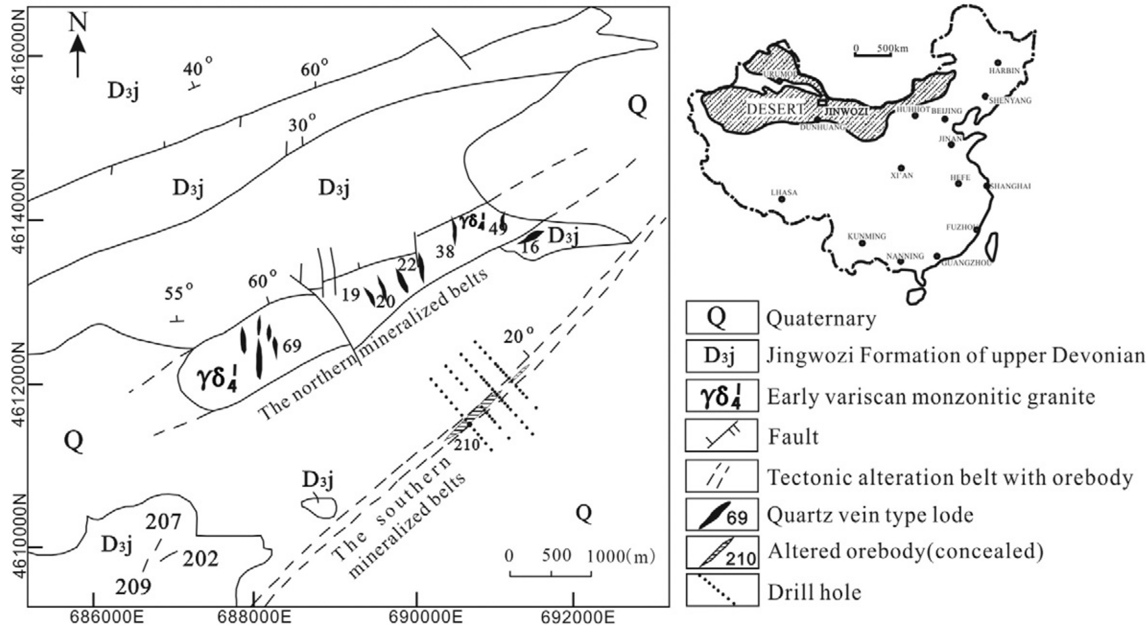

Fig. 1. Location and geology of the study area with drill hole sites. Coordinates are UTM Zone 46.

mainly controlled by a NE trending fault that lies within the Devonian sequence. The ores are mainly composed of pyrite, galena, and chalcopyrite. The pyrite is the primary Au-bearing mineral. The average Au grades of the two mineralized zones are *c.* 7 g/t and 4 g/t (Wang et al., 2007). The proven total Au reserve of the gold field is *c.* 10 t.

The northern mineralized zone is located in an outcropping area and has a relatively high relief. The southern mineralized zone is situated in an area that is covered by the Gobi Desert with depths of a few metres to tens of metres. The regolith is composed of windblown sand, alluvium, colluvium, and residuum. The typical zonal structure of the regolith cover is illustrated in Fig. 2. The sequence of regolith materials from top to bottom: black gravels (lag), desert crusts, brown sands with interbedded gravels, brown yellow sands, purple red sands, eluvium, and bedrock. The lags are always covered by a dark and shiny substance called desert varnish. Such coatings represent a fine mixture of clay minerals and Fe–Mn oxyhydroxides, which form micrometre-thick

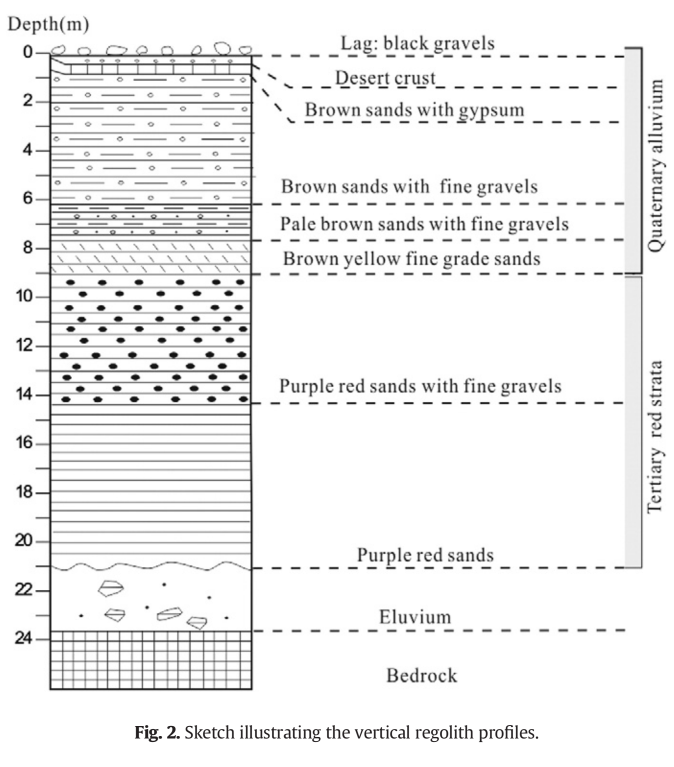

Fig. 2. Sketch illustrating the vertical regolith profiles.

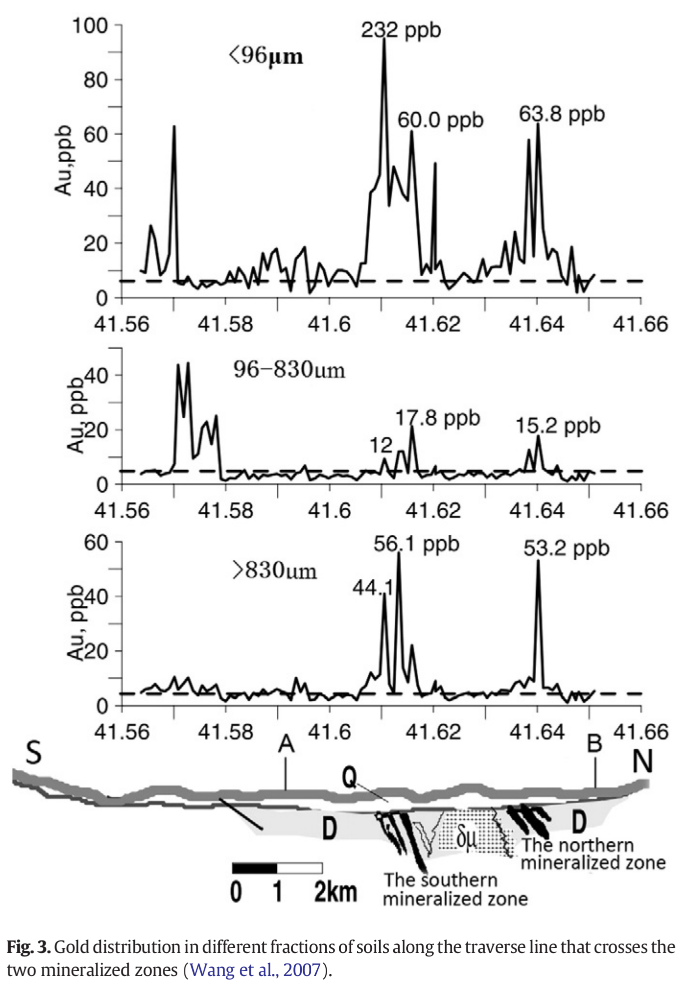

Fig. 3. Gold distribution in different fractions of soils along the traverse line that crosses the two mineralized zones (Wang et al., 2007).