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Holocene ochreous lacustrine sediments within the Famatina Belt, NW Argentina: A natural case for fossil damming of an acid drainage system

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A B S T R A C T

A 44 m-thick lacustrine succession of silty-clay banded ochres and subordinated sandstones, and conglomerates (known as the Corral Amarillo Formation) is superbly exposed within the Famatina Belt (Central Andes of Argentina) after deep entrenchment by the present-day Amarillo river due to strong recent uplifting and consequent relative drop in base level. The unusual ochreous-rich succession was produced by natural damming (3.48–3.54 ^{14}C kyr BP) of an acid drainage system linked to the alteration cap of polymetallic deposits. Facies of silty-clay ochre (wet season) and banded ochre (dry season) from the paleolacustrine setting are composed of jarosite + goethite and goethite respectively. Geochemically, these layers record high concentrations of Fe_2O_3 (25–55 wt. %) and trace elements (Cu, Zn, Co, As, and Mo with mean concentrations of 2759; 2467; 109; 375 and 116 ppm, respectively). Their origin is inferred from a comparative analysis with the present-day Amarillo river, which has a pH of ~3, $(SO_4)^{2-}$ concentrations of ~5000 mg/l, and jarosite as the dominant phase, in the upper catchments. Waters downstream have pH values of 3–4.5, $(SO_4)^{2-}$ concentrations of ~3000–480 mg/l, and schwertmannite as the dominant phase. Thus goethite in the paleolake facies is likely related to schwertmannite transformation by an aging process, whereas jarosite is probably transported from the river but could also be associated with post-depositional formation regulated by variations in grain size and the pore fluid chemistry. The Corral Amarillo Formation offers a Natural model, which may be employed to infer the effect on nature of acid drainage of mineralized areas.

1. Introduction

Acid drainage related to the oxidation of sulfide ore deposits either natural (acid rock drainage: ARD) or originated from mining activities (acid mine drainage: AMD) has been widely recognized as a major environmental problem in terrestrial aquatic ecosystems around the world (Bowell and Bruce, 1995; Cornell and Schwertmann, 1996; Nordstrom and Alpers, 1999; Dold, 2010). Sulfide oxidation is complex and its effects can vary depending on the geology, climate, and microbiology of a given region (Acero et al., 2006). However, the integrated study of rivers associated with ARD provides means of understanding various physical, chemical, and biological processes that control its formation and spatio-temporal variations. This understanding is essential for the control and remediation of ARD environmental impacts. Ochreous precipitates associated with ARD/AMD (e.g., schwertmannite, jarosite, goethite) effectively trap trace elements, and thereby attenuate dissolved metals generated by these systems (Bigham et al., 1992; Jambor and Blowes, 1994; Nordstrom and Alpers, 1999).

In the central region of the Famatina Belt (Central Andes of Argentina), side-canyon rock avalanches naturally dammed the middle stretch of the Amarillo river, creating temporary lakes, during Holocene time. The river headwaters drain an important

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alteration halo of high-sulfidation epithermal deposits (Au–Cu–Ag–As–Sb) and Cu and Mo porphyries in the Nevados de Famatina mining district (NFMD; Losada-Calderon and McPhail, 1994; Pudack et al., 2009). The Amarillo river is characterized by acidic waters and widespread deposition of ochreous sediments along its banks. The lacustrine sediments consist of more than 44 m of rhythmic silty-clay ochres and subordinated iron-rich sandstones, conglomerates, and breccias, and are known as the Corral Amarillo Formation (Limarino et al., 1994, Fig. 1). This unit is exceptionally preserved as elevated terraces at both sides of the river, which form a canyon about 2 km long. The ochreous sediments in this lacustrine succession represent an almost unique example of ancient sedimentation associated with ARD, in this case linked to the Neogene uplift of the Famatina Belt and the progressive unroofing of high-sulfidation mineralization. In addition, the Amarillo river drainage system was impacted by mining activities between 1890 and 1925 (La Mejicana mine).

In this contribution, mineralogical and geochemical analyses from the fine-grained distal paleolake deposits are presented and compared with the alluvial sediments of the modern Amarillo river. These data allow an understanding of the evolution of the acid drainage system taking place nowadays along the Amarillo river

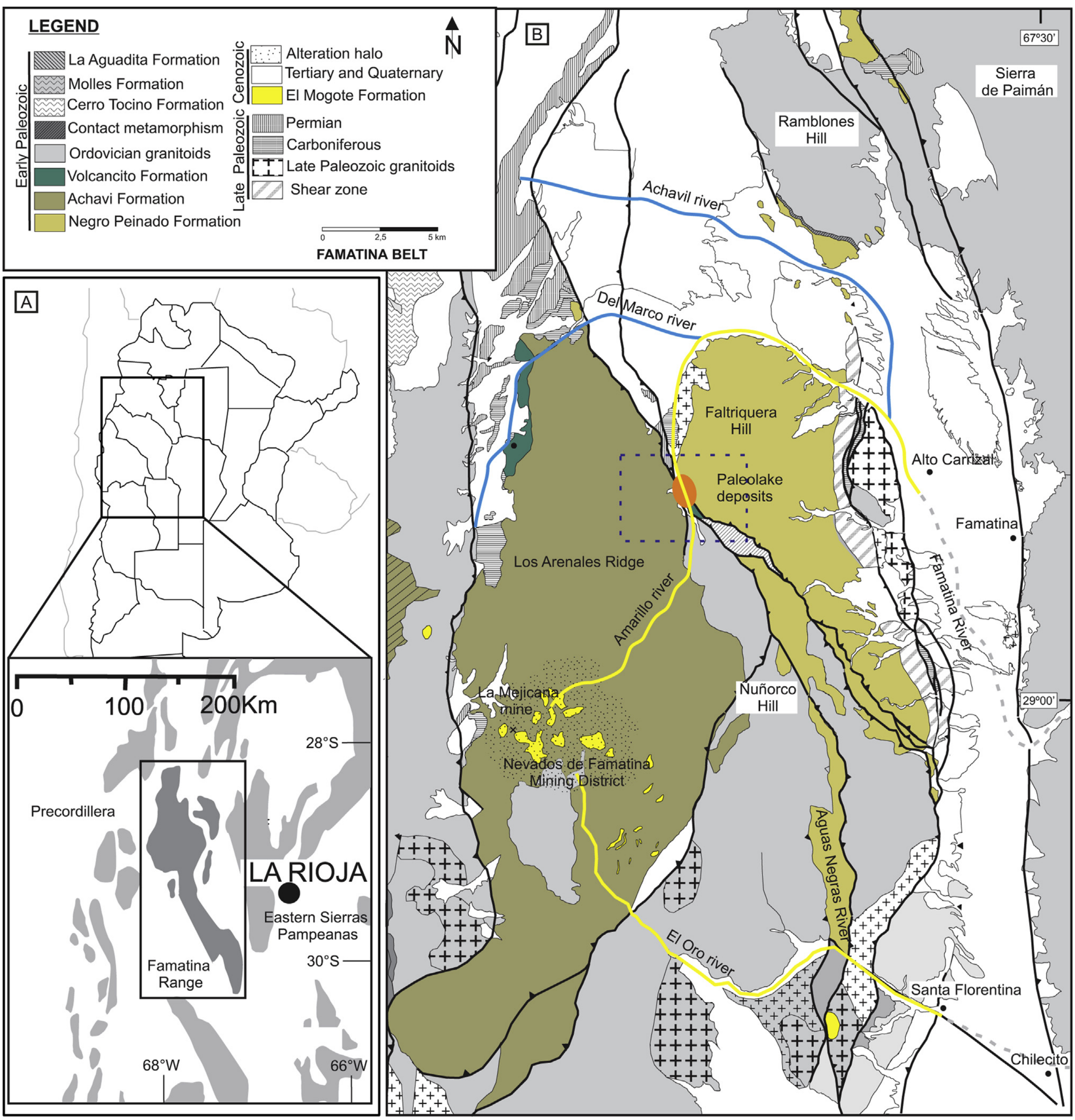

Fig. 1. A) Map of Argentina showing the study area. B) Geological map of the central region of the Famatina Belt. The rectangle shows the location of the lake deposits (modified from Collo et al., 2009). Yellow rivers indicated acid drainage, whereas blue rivers show circumneutral waters. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)