Chapter 4

THE AQUEOUS GEOCHEMISTRY OF THE RARE EARTH ELEMENTS AND YTTRIUM. PART 13: REE GEOCHEMISTRY OF MINE DRAINAGE FROM THE PINE CREEK AREA, COEUR D'ALENE RIVER VALLEY, IDAHO, USA

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1. Introduction

The production of acidity by the oxidation of sulfide minerals, whether occurring naturally or as a result of mining operations, is a serious environmental concern owing to the potential for acidification of lakes, streams and ground waters, and the concomitant increase in mobility of toxic heavy metals (see Alpers and Blowes, 1994; Jambor and Blowes, 1994). Acidified waters draining mine workings are usually referred to as acid-mine drainage (AMD). However, a more general term which also covers generation of acid by unexploited sulfide mineralization is acid-rock drainage (ARD). Recently, the geochemistry of REE in acid-rock drainage has received much attention (Carlson-Foscz et al., 1991; Miekeley et al., 1992; Webb et al., 1993; Nordstrom et al., 1995; Gimeno et al., 1996; Verplanck et al., 1997; Leybourne et al., 1998; 2000; Pearce et al., 1998; White et al., 1998; Elbaz-Poulichet and Dupuy, 1999; Hollings et al., 1999; Verplanck et al., 1999; Gimeno et al., 2000; Åström, 2001; Worrall and Pearson, 2001a,b; Gammons et al., 2003). The motivation for these studies is the possibility that the REE might be useful tracers in furthering our understanding of the processes controlling ARD.

The present study focuses on drainage from a number of abandoned mine sites (including adits and seeps from tailings piles) in the Pine Creek area (Figures 1 and 2) of Idaho, at the southern edge of the Bunker Hill Superfund Site, about 10 km south of Smelterville. With one exception, the mine drainage is neutral to slightly alkaline in pH. This is a result of the neutralization of acid produced during sulfide oxidation by the carbonate gangue minerals present in the mine workings. In spite of the generally near-neutral pH values, all the waters contain relatively high concentrations of zinc and some waters contain high concentrations of other heavy metals. We have analyzed these waters to improve our knowledge of the behavior of the REE during sulfide oxidation followed by neutralization via carbonate dissolution.

2. Study area

The mineralization of the Pine Creek area has been described in numerous theses and reports (e.g., Jones, 1919; Forrester and Nelson, 1944; Campbell, 1949; Gin, 1953; Silverman, 1957). Sulfide-bearing veins occur in argillites and interbedded quartzite bands and lenses of the Prichard formation of the Proterozoic Belt Series. Primary (post-metamorphic) minerals of the Lower Prichard Formation include graphite, ilmenite, magnetite, pyrite, pyrrhotite, quartz, white mica and/or illite, tourmaline, and

K.H. Johannesson,(ed), Rare Earth Elements in Groundwater Flow Systems , 89-110.
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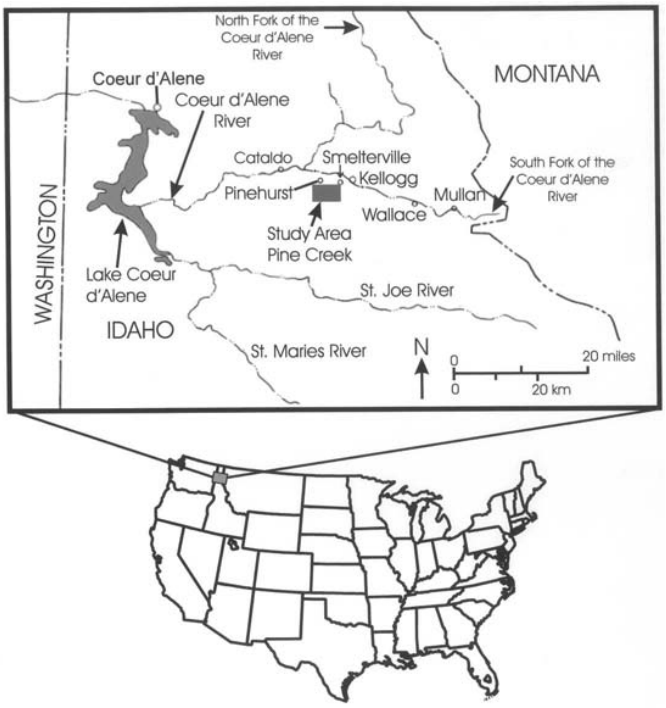


Figure 1. Location of the Pine Creek study area within the Coeur d'Alene mining district.

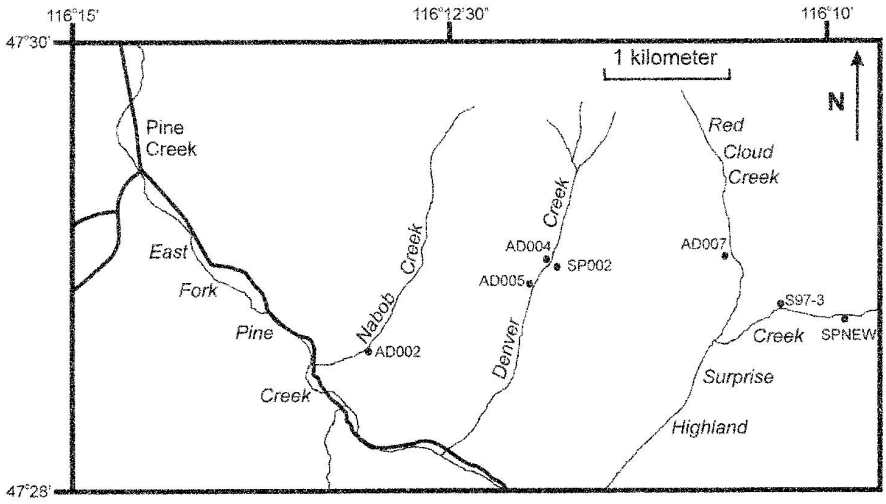


Figure 2. Location of the various sampling sites in the Pine Creek area. The heavy lines represent roads, whereas the lighter lines represent creeks. Identification numbers with an AD prefix denote sites where waters emerge from the adits of abandoned mines. Identification numbers with S or SP prefixes refer to seeps from tailings piles.