GEOCHEMICAL AND MINERALOGICAL RECORD OF HISTORICAL MINING, HAYLE ESTUARY, CORNWALL, UK

G.K. ROLLINSON[1], D. PIRRIE[1,2,3], M.R. POWER[3], A. CUNDY[4] AND G.S. CAMM[1]

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The release of particulate waste as a result of major historical mining activity within the polymetallic Cornubian orefield, Cornwall UK, has locally caused significant contamination of estuarine sediments. In this study the impact of historical mining on the southwest Hayle Estuary, Cornwall, UK, was evaluated by examining the sediment geochemistry and mineralogy of nine shallow (<1 m) cores along with surface sediment sampling throughout the intertidal areas of the estuary. The sediment geochemistry of all of the cores shows very elevated levels of tin and copper (maximum Sn value of 7041 ppm and Cu 29,869 ppm). Surface (uppermost 5 cm) sediment samples are also contaminated, with up to 4520 ppm Cu, 5455 ppm Sn, 2292 ppm As, 522 ppm Pb and 1777 ppm Zn. Core dating indicates that the sediments currently exposed at the surface were deposited prior to 1880. The detrital heavy mineral assemblage is dominated by cassiterite, chalcopyrite, arsenopyrite, sphalerite and pyrite along with minor galena, monazite, zircon, stannite, wolframite, plumbogummite, covellite, bornite and ilmenite. In addition, man made slag and smelt products are common. Diagenetic pyrite, chalcopyrite and atacamite are also present. The sediment geochemistry and mineralogy are interpreted to represent (a) the input of historic mine waste tailings and smelt waste into the estuary probably prior to 1880, and (b) the subsequent exposure of these contaminated sediments as a result of recent erosion.

[1]*Camborne School of Mines, University of Exeter, Cornwall Campus, Penryn, Cornwall, TR10 9EZ, U.K.*

[2]*Helford Geoscience LLP, Menallack Farm, Treverva, Penryn, Cornwall, TR10 9BP, U.K.*

[3]*Intellection UK Ltd, North Wales Business Park, Abergele, Conwy, LL22 8LJ, U.K.*

[4]*School of the Environment, University of Brighton, Cockcroft Building, Lewes Road, Brighton, BN2 4GJ, U.K.*
(E-mail: dpirrie@helfordgeoscience.co.uk).

INTRODUCTION

Modern sedimentary systems commonly retain a geochemical and mineralogical record of the impact of industrial activity on the environment (e.g. Cundy *et al.*, 2003). Mining has had a major impact on the global environment, with the discharge of contaminants either initially in solution through mine drainage or as a result of the discharge of particulate waste (usually referred to as tailings). Whilst the management of mine drainage is one of the main environmental challenges for the present-day mining industry (e.g. Salomons, 1995), the release of mine waste tailings during historical mining activity has had the most significant long term effect (e.g. Hudson-Edwards *et al.*, 1999; Leblanc *et al.*, 2000; Borrego *et al.*, 2002). The estuaries of Cornwall, UK, provide an ideal area to examine the long term impact of the release of particulate mining waste on the environment because: (a) different estuaries have received waste streams from different mining operations, (b) the contaminated sediments have been in the environment, in many cases for >100 years, without subsequent remediation, and (c) there have been limited subsequent industrial operations impacting upon the coastal sediments which could otherwise obscure the mining-related signatures.

Mining of metalliferous minerals in Cornwall, extends back 3000 years to the Bronze age (Penhallurick, 1986; Gerrard, 2000). Tin, copper, lead, arsenic, zinc, tungsten and iron were all extracted on a large scale with smaller scale operations extracting a variety of other metals, including silver and uranium. The industry left the environment contaminated from centuries of sustained mining-related discharges. Particulate waste products from mining activity and related processing and smelting were routinely discharged into the fluvial catchments which flow into estuaries around the Cornish coastline. Consequently, Cornish estuaries such as the Fal (Pirrie *et al.*, 1997, 1999a, 2003), Camel (Pirrie *et al.*, 2000), Gannel (Pirrie *et al.*, 2000), Fowey (Pirrie *et al.*, 2002a), Helford (Pirrie *et al.*, 2002b) and Hayle (Copperhouse) (Yim, 1976; Merefield, 1993; Healy, 1995; Pirrie *et al.*, 1999b) (Figure 1a) are highly contaminated and preserve a record not only of the extent and timing of historical mine waste contamination but also the type of mining activity in the respective fluvial catchments. For example, particulate contamination in the Fowey Estuary can be attributed to placer tin mining activity prior to 1880 (Pirrie *et al.*, 2002a) whilst contamination within the Fal Estuary is attributed to polymetallic hard rock mining during the late 1800s (e.g. Pirrie *et al.*, 1997, 2003). When the levels of mine waste contamination in Cornish estuaries are compared with other mining-related contaminated areas globally (Table 1), the extent of the impact in Cornwall can be appreciated. Today, the estuaries are important marine habitats but are also key sites to understand the long-term fate of mining related particulate contaminants in the environment. In this paper, a geochemical and mineralogical study of the impact of mining on sedimentation in the Hayle Estuary, UK is presented. This estuary records the impact of the release of tailings from both Cu and Sn mining operations, and allows an understanding of the longevity of the environmental impact of this historical mining activity.