BUNMAHON DISTRICT

Background information

Mine Name: Tankardstown, Stage Cove, Knockmahon

Mine District: Bunmahon

Alternative Names:
Bonmahon

Elements of interest:
Cu

Project Prefix: BUN-

County:	**Townland:**	**Grid Reference:**
Waterford	Knockmahon	E243962, N98996

The Bunmahon mine district is located 15km west of Tramore on the Waterford coast. It comprises numerous individual sites among which Bunmahon, Tankardstown, Stage Cove and Knockmahon (Fig. 1) were the most important. All are located within a 5km-long stretch of coastline. The district has a significant physical mining heritage, principally in the form of the recently conserved Tankardstown engine house complex (photo, right). The district is the focal point for the Copper Coast European Geopark.

Production and Mining History

Mining at Bunmahon may have taken place as early as the Bronze Age. According to Cole (1922) systematic mining began in the Bunmahon district in 1730 but it was only after the Mining Company of Ireland (MCI) began exploring in 1824 that extensive development occurred. For 50 years between 1828, when the company declared the vein system economic, and 1878 MCI mined continuously at Bunmahon (Tietzsch-Tyler 2005). Over the 30 years when the mines were being operated profitably (1834-46 and 1851-68) annual output ranged up to 7,000 tons of 10-13% copper ore. In the other, unprofitable years production was as low as 100-270 tons of 4-5% copper ore (Tietzsch-Tyler 2005). Total profits in the good years were £331,126 (average: £11,000 per annum) far outweighed total losses in the bad years of £47,757 (average: £1,447 per annum) (Tietzsch-Tyler 2005).

Mining initially began in Knockmahon where dressing floors were established with water-powered pumping and ore dressing (Tietzsch-Tyler 2005). During the 1830s and 1840s the mining was focused on Stage Cove, where five stream engines were erected for pumping and winding. Ore dressing continued at Knockmahon. The workings at Stage Cove extended under the sea but were eventually abandoned as sea water began to flood them. Subsequently, Tankardstown, less than 1 km to the

east, was established as the centre of mining by 1850. Steam engines at the other two sites were dismantled and brought to Tankardstown. A tramway was also built to bring ore to the dressing floor at Knockmahon.

Geology and mineralization

The Bunmahon mineralization is hosted by volcanic rocks of similar age to those that host the Avoca ores. However, in contrast to the essentially contemporaneous volcanism and mineralization at Avoca, the Bunmahon mineralization is hosted by quartz veins that are younger than their host rocks. The host rocks are chiefly members of the Ordovician Duncannon Group which consists of a variety of acid and intermediate volcanic rocks, shales and limestone as well as intrusive igneous rocks (Fig. 2). OBrien (1959) considered the mineralization to be pre-Devonian because an unmineralized Devonian Old Red Sandstone (ORS) basal conglomerate overlies one of the mineralized veins unconformably. However, many veins are situated on north-south faults which cut the ORS, suggesting a Devonian or post-Devonian age for mineralization (Sleeman and McConnell 1995). The mineralized veins contain fragments of brecciated wallrocks, suggesting they were emplaced during active deformation, and some are sheared. They occupy steeply-dipping faults consistently oriented NNW-SSE and intersect the coast where they are exposed in cliff sections (Wheatley 1971). All of them are repeatedly offset by cross-cutting faults and these, together with numerous problems relating to rent and taxation, contributed to the eventual cessation of mining in 1878. The veins are up to 20 m thick and have been traced to depths of 300 m (Cole 1922) and along strike for more than 2 km. At least five major lodes or vein complexes were exploited. Chalcopyrite was the main ore.

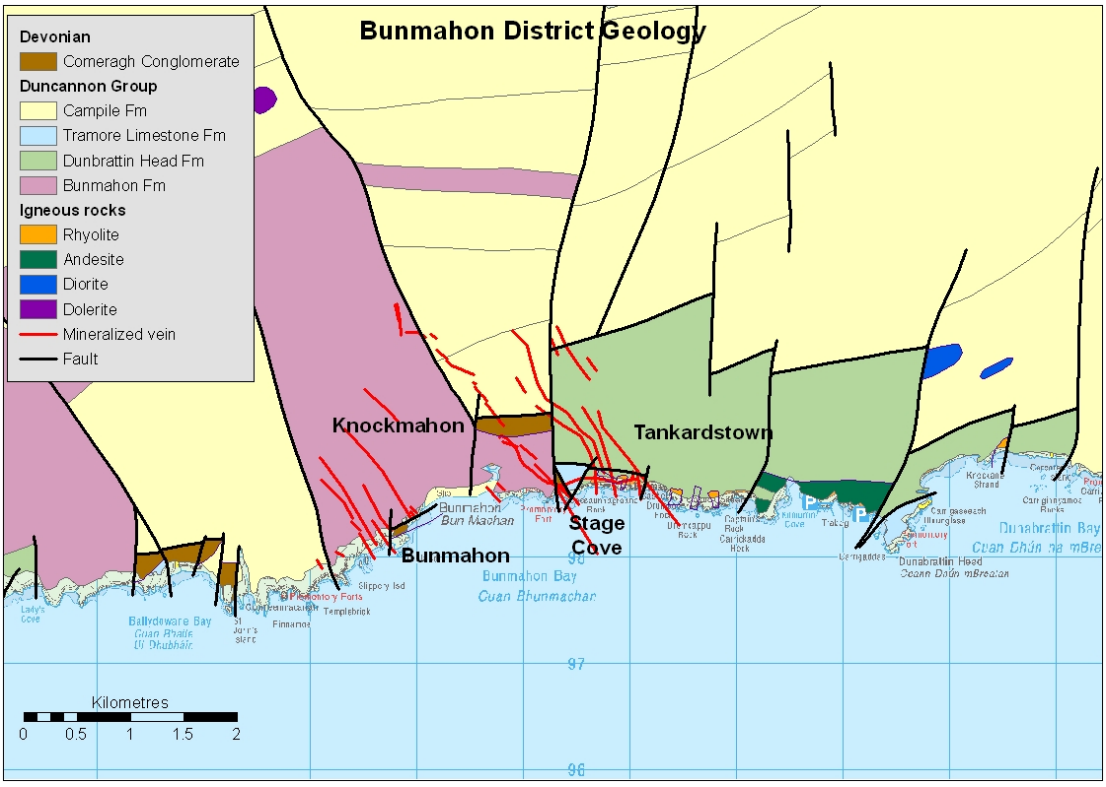

Fig. 1 Bunmahon District geology

There are few modern accounts of the geology of the mineralization at Bunmahon. The following description is based on Wheatley (1971). The mineralization consists of two distinct types: (i) siliceous veins with disseminated chalcopyrite and pyrite (Cu lodes) and (ii) siliceous veins with sphalerite, galena and minor chalcopyrite and pyrite (Pb-Zn lodes). The Pb-Zn lodes occur as shallow veins, averaging 1 m in thickness, but they are subordinate to the Cu lodes which average 3 m in thickness and extend to depths in excess of 300 m. Gangue material is mostly quartz but calcite, dolomite and barite are common constituents of the Pb-Zn lodes. Chalcopyrite fills the interstices between quartz grains and has a grain size of 0.2 - 1.0 mm. Pyrite is present in both veins and wallrock. A crude pattern of metal zoning has been noted with a Cu-rich zone centred on the Stage and Tankardstown Lodes and an outlying zone of Pb-Ba mineralization.

Site Description and Environmental Setting

Three sites were visited in the course of the HMS-IRC project, Knockmahon, Stage Cove and Tankardstown. The Tankardstown site has been subjected to a major conservation effort and is now a visitor attraction, with signage that describes the history and operation of the site. It is not considered further in this report. The remaining two sites include dressing floors and have been assessed geochemically.

The Bunmahon area is today well populated with a significant growth in recent years in the number of single houses. Many of these are located close to the sites of former mine workings, particularly shafts (Fig. 2). The scenic Waterford coast is also popular with tourists and the designation of the area as a Geopark has enhanced the attraction of the area. The land along the coast is mainly used for farming, both pasture and tillage.

The Knockmahon site (Fig. 2) was the main processing area for the Bunmahon district during the MCI operations. Processing plant included an engine house, crusher, hoppers, stamps and buddles. Numerous mine buildings were also on site including the magazine and the extant remains of the MCI Directors' house, mine manager's house and count house (Tietzsch-Tyler 2005). The cobbled remains of the dressing floor can still be seen near the site of the former crusher (photo, right). The site of the dressing floor is partly overgrown by gorse and grass but there are large areas of unvegetated solid mine waste of various textures and colours that marks the site of the former stamps and buddles. A large fan of waste that silted up the river channel during mining (Tietzsch-Tyler 2005) has been reclaimed as a flat, grassy area in use as a pasture field.

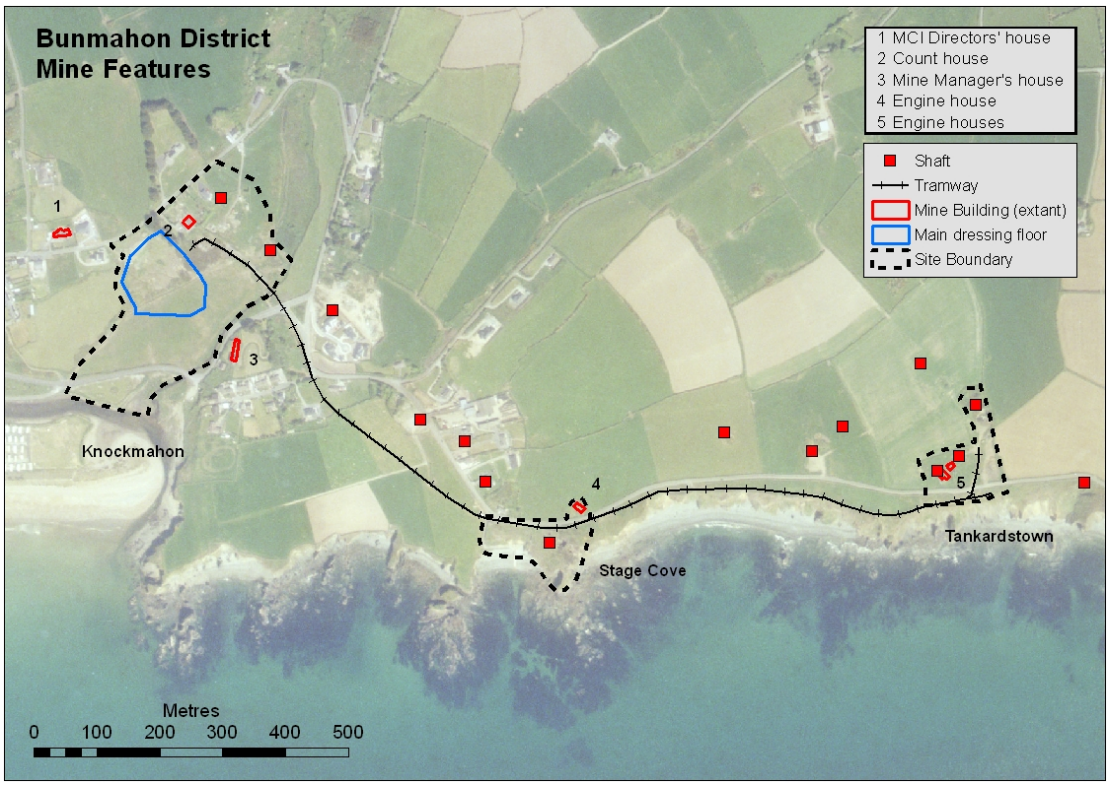

Fig. 2 Bunmahon District Mine Features

Stage Cove was a smaller site but still had a substantial engine-house complex (Tietzsch-Tyler 2005). Much of the site is grassed over. One ruined engine house remains on the landward side of the road while only a vague outline of the site of the remainder of the complex remains on the seaward side. Also on the seaward side of the road are the walled, cobbled processing yard and some shafts. There is an adit in the cliff-face below the yard. There are no apparent solid waste heaps at Stage Cove but, as it was a processing yard, several XRF analyses of "soil" were carried out.

The Tankardstown site has been the subject of a major conservation project in recent years. The site has been cleared of overgrowth and the buildings made safe through structural repairs. Excavations revealed many of the features linking the buildings, allowing a fuller interpretation of the operation of the site. Fencing and signage have been installed. The site is now a major locus for the Copper Coast Geopark. The walled yard contains the partially restored pumping engine house (photo, right), the ruins of the winding engine house, a restored chimney and the foundations of the boiler houses (Tietzsch-Tyler 2005). The three shafts on the site are filled in. No mine waste was identified on the site and no geochemical assessment was carried out at Tankardstown.

Solid waste was analysed mainly at Knockmahon, with some additional work carried out at Stage Cove (Fig. 3). Table 1 shows the estimated areas and volumes of the waste investigated for scoring under the HMS-IRC Site Scoring system.

Table 1 Bunmahon solid waste heaps: area and volume

Waste ID	Area (m^2)	Volume (m^3)
BUN-PROC01	2787	2787
BUN-PROC02	704	352
BUN-PROC03	25105	25105
BUN-PROC04	1593	797

Geochemical Assessment

1. Surface water

No surface water samples were collected at Bunmahon. No mine water discharges were observed on any of the sites investigated. Some adits in the sea cliffs are known to discharge small flows of into the sea and the cliff faces below the adits are stained blue-green from the copper in the water.

2. Groundwater

Groundwater samples were not collected in the Bunmahon area. Leachate from a composite sample taken from the processing waste at Knockmahon had high levels of dissolved Cu (308 µg/l) and low levels of other metals such as Pb (8 µg/l), Zn (29 µg/l) and As (9 µg/l).

3. Stream sediments

One stream sediment sample was collected downstream of the Knockmahon site, near the mouth of the river (Fig. 3). Another sample was collected in 1990 about 500m upstream of the site as part of the GSI Regional Geochemical survey. In both cases, the fine (<150 µm) fractions was analysed. In addition, a <2 mm-fraction was collected at the downstream sampling site to compare with the fine fraction. The upstream sample had relatively low Cu and Pb concentrations but elevated Zn (Table 2). The fine fraction of the downstream sample had a high concentration of Cu (2677 mg/kg) and low concentrations of other elements of interest (Table 2). Somewhat surprisingly, given the tendency of metals to concentrate in the fine fraction of stream sediments, the coarser (<2 mm) fraction has an even higher concentration of Cu (4909 mg/kg). There is thus a clear indication in the data of significant downstream contamination of stream sediments as a consequence of mining at Knockmahon. The concentration of Cu recorded is well above the recommended limits for livestock (100 mg/kg).

Table 2 Stream sediment geochemistry, Bunmahon

mg/kg	Cu	Pb	Zn
GSI-903018 (u/s)	114	64	590
BUN-SS001 (d/s) <150 µm	2677	27	131
BUN-SS001 (d/s) <2 µm	4909	83	129

4. Solid waste

Twenty three *in-situ* XRF analyses were carried out in the district, 20 on the waste at Knockmahon and three in the copper yard at Stage Cove (Fig. 3). The waste contains high concentrations of Cu relatively high As and Pb (Table 3). Spectral analysis of the data suggests the samples analysed also contained elevated Mo but this element was not analysed quantitatively.

Three areas of solid waste have been defined at Knockmahon (Fig. 3). BUN-PROC01 is the main area of processing waste and includes mainly fine, red-brown waste (photo, right) that occupies the area where buddles and stamps were located. The second area of waste (PROC02) is located in the area where ore was unloaded from the trams, probably cobbed on the dressing floor and then run through the crusher. The waste in this part is generally covered by coarse, pebbly material but beneath this there is fine red-brown waste. The third area (PROC03) is the large flat grassed area in the floodplain of the river where, according to the reconstruction of Tietzsch-Tyler (2005), a fan of waste developed from the outwash from the processing area. The material analysed here was mainly soil at the base of the grass root layer.

The highest concentrations of Cu (1697 – 4737 mg/kg; median: 3650 mg/kg) were measured in PROC01 (Fig. 3). One spot in PROC03, closest to the main processing area, had a measured Cu concentration of 4043 mg/kg but other measured concentrations were lower, perhaps not surprisingly since soil was analysed rather than mine waste. Nevertheless, the concentrations of Cu measured in the other four samples in PROC03 (109 – 813 mg/kg) were much higher than the concentrations measured in soils in the region (maximum 68 mg/kg) for the National Soils Database (Fay *et al*. 2007). Concentrations of Cu measured in PROC02 were generally in between those for PROC01 and PROC03. The median concentration of As in the processing waste in PROC01 was 268 mg/kg (range: 87 to 660 mg/kg), much higher than that for PROC02 and PROC03 (combined median: 56 mg/kg).

Measured element concentrations in the copper yard at Stage Cove were in the lower range for Bunmahon (Fig. 3), Cu ranging from 647 to 1190 mg/kg and As from 24 to 175 mg/kg.

The highest Cu concentrations measured in mine waste at Bunmahon are in excess of soil guideline limits for children. Those for As exceed limits for both adults and children (Table 3.1.2, main report).

Table 3 Summary statistics, *in situ* XRF analyses, Bunmahon

mg/kg	Cu	Pb	Zn	As
n	23	23	23	23
Minimum	109	27	0.0	16
Maximum	4737	481	91	806
Median	1943	111	46	175
Mean	2229	151	40	235

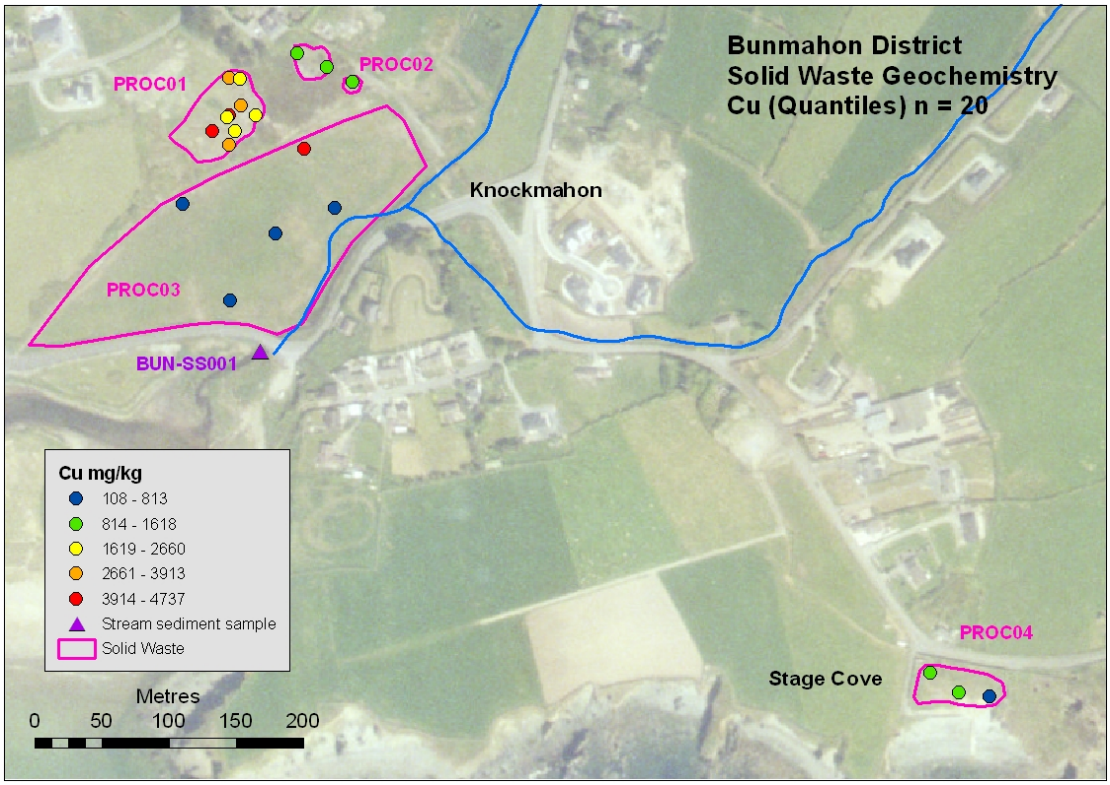

Fig. 3 Distribution of Cu in solid waste samples, Bunmahon

5. HMS-IRC Site Score

The HMS-IRC Site Score for Bunmahon is 14 (Table 4), a low score that reflects the relatively small amount of waste on the site and the absence of high concentrations of high-relative toxicity elements such as Pb, As, etc. No surface water samples were collected so there is no evidence of any impact by the mine site on the chemistry of surface water in the nearby river. The absence of any discharges of mine water to the river limits the potential for such impact, particularly since the most metal-rich waste (PROC01) is some distance from the river, reducing the possibility of contamination by diffuse groundwater flow. However, the stream sediment data do indicate an observed release from the site to the river.

Table 4 HMS-IRC Site Score, Bunmahon

Waste	**PROC01**	**PROC02**	**PROC03**	**PROC04**	**Stream Sediment**	**Total**
1. Hazard Score	12	12	12	11	1	48
2. Pathway Score						
Groundwater	1.75	1.20	1.21	0.80	-	4.96
Surface Water	2.94	2.86	2.76	0.18	-	8.73
Air	0.01	0.00	0.00	0.00	-	0.01
Direct Contact	0.02	0.00	0.13	0.02	-	0.17
Direct Contact (livestock)					0.14	0.14
3. Site Score	**5**	**4**	**4**	**1**	**0**	**14**

Fig. 4 shows the contribution of the different pathways to the total site score at Bunmahon. Pathways are the routes by which receptors are exposed to the hazard. The surface water pathway dominates the scoring (62.3%), largely because of the

proximity of the river to the Knockmahon site and the fact that the stream sediment data indicate an observed release to the surface water pathway from the mine waste. Leachate data from PROC01 also indicate an observed release to groundwater but no data are available for the other waste heaps. Hence, the groundwater pathway contributes just 35.4% of the total though this might have been significantly higher if leachate data were available for the other waste heaps.

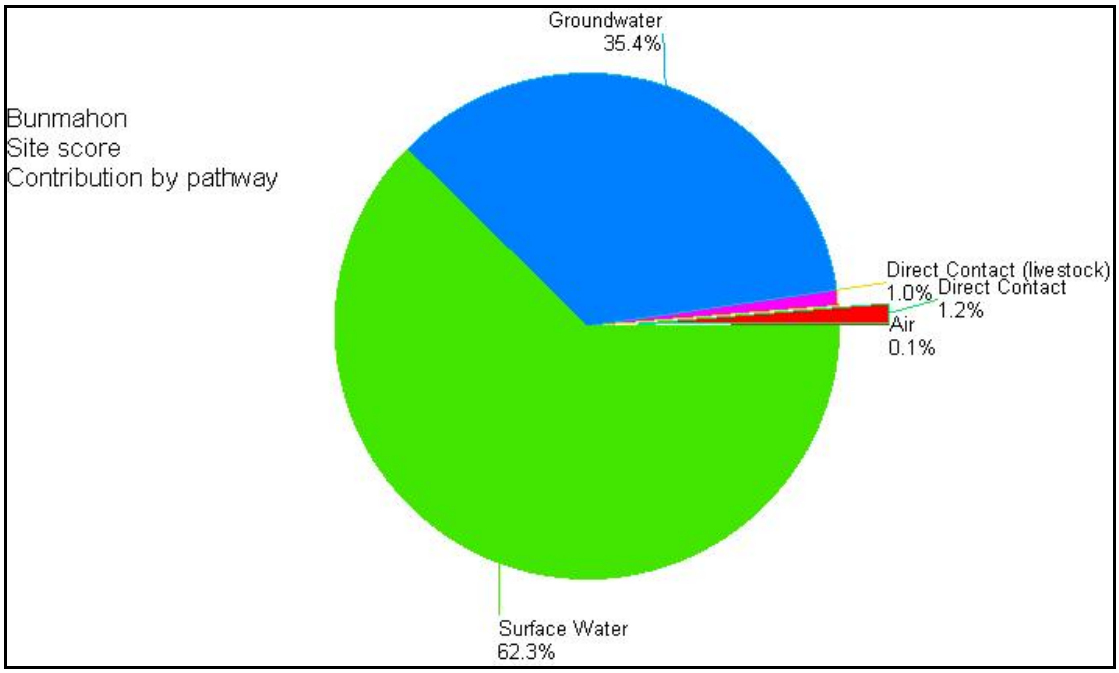

Fig. 4 HMS-IRC Site Score, Bunmahon: contribution by pathway

6. Geochemical overview and conclusions

Bunmahon was a highly productive and profitable mine district in the 19th century. Only limited mine waste remains on the three sites investigated for the HMS-IRC project, with most found on the old processing area at Knockmahon. High concentrations of Cu, in excess of recommended limits, were measured in both processing waste and in stream sediment downstream of the mine. Among other elements measured, only As is present in significant concentrations. The total site score is 14, placing Bunmahon in Class V.

References

COLE, G. A. J. 1922. Memoir and Map of Localities of Minerals of Economic Importance and Metalliferous Mines in Ireland.

Sleeman, A.G and McConnell, B. (1995) Geology of East Cork – Waterford. A geological description of East Cork, Waterford and adjoining parts of Tipperary and Limerick to accompany the bedrock geology 1:100,000 scale map series, sheet 22, East Cork-Waterford. Geological Survey of Ireland.

Tietzsch-Tyler, D (2005). Historical Reconstruction Drawings of the Copper Coast Mines, Co. Waterford. *Journal of the Mining Heritage Trust of Ireland*, 5, 29-46.