MAKING THE MOST OF ABANDONED MINES: THE ECTON MINE EDUCATIONAL TRUST

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Abstract

The Ecton mines, in the south-west part of the Peak District National Park, were major producers of copper and lead in the 18th and early 19th centuries, with zinc also produced later in the 19th century. Underground mining had ceased by 1890 and the workings have long been flooded to river level, but with still accessible passages above here. The late Geoff and Elizabeth Cox developed Deep Ecton mine as an educational resource in the late 20th century, and generously bequeathed it to a charitable trust (EMET) which has continued and expanded this role.

Deep Ecton mine is designated by Historic England as a Scheduled Monument and it is a geological SSSI, while the surrounding hillside is an SSSI for its ecology. The Ecton mines are now the focus for a wide range of educational and research activities, including:

- Formal education, mostly led by volunteers in EMET's sister organisation the Ecton Hill Field Studies Association: one-day field courses (surface and underground) at primary, secondary (GCSE and A-level), and university levels, for applied geology and chemistry
- Informal education: U3A, National Trust, and other organisations
- Archaeological studies in and around Ecton Hill exploring the date and character of the mine workings
- Provision of research facilities: recent projects have included geology, ground-penetrating radar, isotope geochemistry, laser profiling, and microseismic
- Joint EU projects: UNEXMIN, UNEXUP: submersible robot exploration of flooded sections of the mine; follow-up work at Keele University
- Activities: supervised access for caving groups and mine history societies, always with a significant educational component

EMET maintains a well-equipped study centre, land around the mine portals, the main underground mines themselves, and also has safety obligations (at least 40 known shafts and adits, many within the Trust's mineral ownership). All work by the Trust is provided by volunteers, including several active minerals industry professionals, providing on-going links with the industry and professional institutions including IOM3.

Introduction

The Ecton mines, comprising a group of mines and exploration on a high ridge to one side of the valley of the Manifold river, within Staffordshire, in the south-west of the Peak District area underlain by Lower Carboniferous limestones, were exploited for copper, lead and zinc. Maximum production rates were achieved during the second half of the 18th century, but working had ceased altogether by the late 19th Century

By far the most important of these mines, in terms of mineral production, was Deep Ecton Mine, in the northern part of Ecton Hill (Figure 1). Although this mine produced large tonnages of several metallic ores, it was its copper production that was economically the most important and Deep Ecton is commonly referred to as a copper mine.

Deep Ecton was mined to a depth of over 300 metres (1000 feet) below the main adit level, but was flooded to river level after cessation of most production in the 1850s. However, some upper workings remain accessible and two levels are regularly entered. The upper one of these, Salts Level, is now used as an integral asset in teaching programmes for schools and universities as well as educational visits by the National Trust and other organisations.

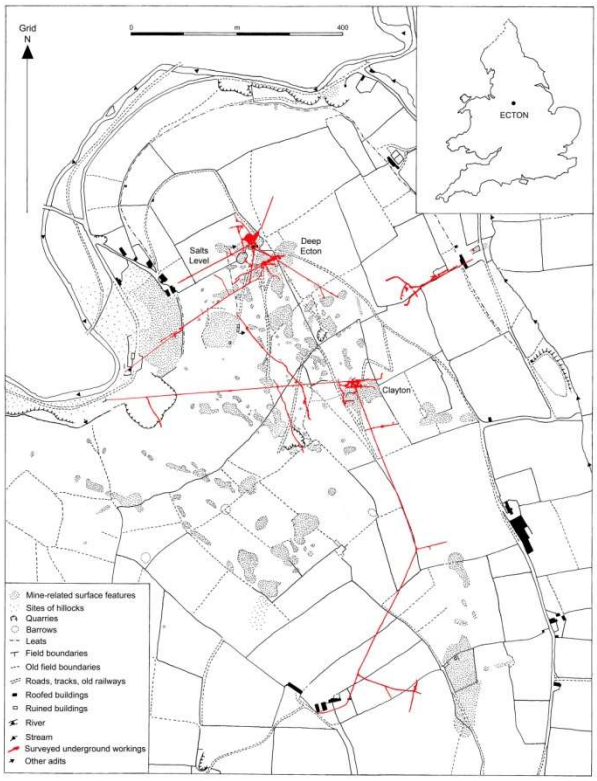

Figure 1. Ecton Hill and the location of the main underground workings at river level, and also of Salts Level *c.* 35m above Deep Ecton Adit.

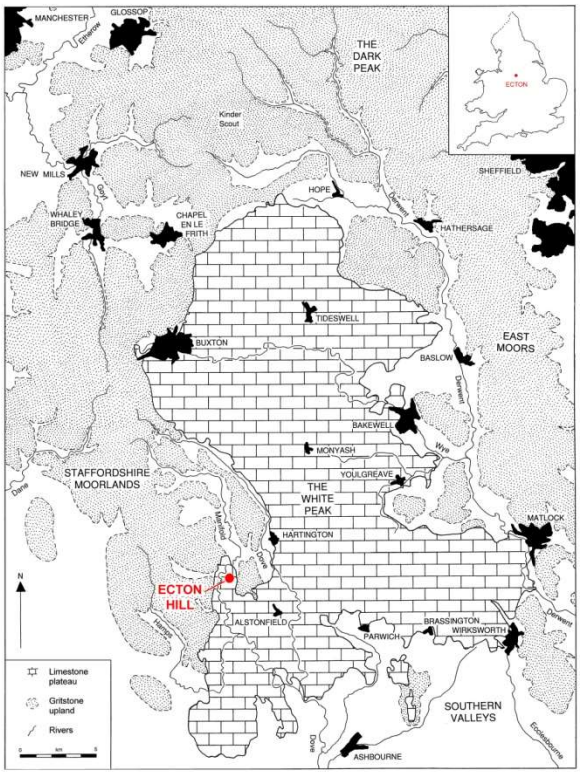

Figure 2. Location of Ecton Hill relative to the 'White Peak' Lower Carboniferous limestone inlier.

The presence of a large proportion of copper ore is very unusual for a mine within the Derbyshire - south Pennines region of "Mississippi Valley" type lead-zinc mineralisation, and combined with tectonic deformation which is unusually intense for rocks of this age in central England, makes Ecton a particularly interesting target for geological research.

The Deep Ecton adit, at river level, 35 metres below Salts Level, is important for its range of accessible geological and mining technology features. The workings at this level are considerably more extensive than in Salts Level, and access is normally restricted to *bona fide* researchers. The two levels are connected underground by a ladderway within the 'pipe' workings in the steeply dipping ore body which originally hosted most of the mineralisation, and which extended to the full depth of the mine.

Geology

The Ecton Mines are located to the south-west of a Lower Carboniferous limestone inlier in central England (Figure 2), sometimes called the 'Derbyshire Dome' which represents a shallow-water lagoon surrounded by a ring of reefs. Ecton lies outside the lagoon and is hosted by limestones and shales of a deeper water facies.

The geology is documented in detail by Ford (2000), and Porter (2004) and has been reviewed recently (Shaw 2020). The primary mineral deposit consisted of copper and other metal sulphides in a near vertical 'pipe' and associated fracture-filling veins, within a Lower Carboniferous deep-water (predominantly) limestone sequence. The mine was a major producer of copper, as well as lead and zinc, in the second half of the 18th century, with production at lower volumes continuing until the 1850s. The deeper parts of the mine were abandoned and the pumps were stopped in 1855, and the mine had flooded to river level by 1858.

The Deep Ecton Mine is situated within Ecton Hill which comprises a sequence of mainly limestone strata of Dinantian (Lower Carboniferous) age.

In the Ecton area the Dinantian limestones are divided into four units (Aitkenhead et al, 2002):

- Mixon Limestones with Shales (Brigantian)
- Ecton Limestones (Asbian)
- Milldale Limestones (Chadian and Arundian)
- Rue Hill Dolomites and Red House Sandstones (Courceyan)

The oldest of these beds, the Rue Hill Dolomites/Red House Sandstones, are only exposed several kilometres to the south of Ecton but are probably present at depth beneath Ecton Hill. It is unlikely that they were reached by the Deep Ecton or Clayton Mine pipe workings both of which went for 300m below river level.

Figure 3 Tight syncline in limestone at 46m depth below water level in the Ecton winding shaft

On the macro scale, Ecton Hill is an asymmetric anticline that plunges to the north with a steep dipping eastern limb and a more gently dipping western limb.

Tight small scale folding (Figure 3) is a feature of Ecton within the more thinly bedded beds, particularly around the anticlinal crest zone, and such folds are well exposed at Apes Tor at the north end of the hill, as well as within the underground mines. The miners referred to these small folds as 'huckle saddles' (anticlines) and 'trough saddles' (synclines) (Watson; 1860).

Ford (2000) describes three types of mineral deposit at Ecton. These are:

- Lodes – steeply dipping to near vertical fissure veins perhaps occupying faults;
- Saddles – Ores deposited in the limbs and joints of the smaller scale fold structures;
- Pipes – The main ore deposits at Ecton are more or less cylindrical features, steeply inclined and cutting through the strata.

The principal metallic minerals at Ecton are chalcopyrite, galena and sphalerite with some pyrite. The major gangue minerals are calcite, fluorite and barite. There are a large number of minor primary and secondary minerals present, including malachite and azurite. These are described by Ford (2000).

The mineral assemblage and the tectonic setting make Ecton an unusual mine for what is otherwise a typical Mississippi Valley mineral province typified by lead, zinc, fluorite and barite mineralisation within veins and paleokarst cavities in weakly deformed limestone. Even though there is now almost no copper (or any other metallic ore) to be seen after the mine was stripped of all visible ore during the 19th century, the geological evidence that remains is still of great value to researchers, and is key to interpreting the regional geological history.

History and archaeology

Deep Ecton Mine was one of the most important copper mines in Britain in the 18th century. Here there are large flooded workings that extend down to over -300m below river level (Meads, 1858; Figure 4). These had not been seen since the later 1850s after the mine pumps were turned off, until the UNEXMIN project provided information on some of the flooded workings by the use of robot submersibles (see below). The accessible underground passages above the water, and the surface remains, are of national importance as archaeological features that tell of the long history of mining at Ecton and the then 'state of the art' mine developed for the Duke of Devonshire in 1760-90.

The history of the Ecton Mines and what survives today have been described in detail by Porter and Robey (2000), Porter (2004) and Barnatt (2013; 2020b). We now know that copper mining here started just under 4000 years ago in the Bronze Age (Timberlake 2014). Lead was mined at small scale in medieval times and miners again became interested in the copper in the 17th century AD. With the dewatering of the 'pipe' deposits in the 1720s-30s by a company of 'Adventurers', who drove the Deep Ecton Level from next to the River Manifold, exceptionally rich mineral deposits at the heart of the hill were first discovered. The Duke of Devonshire took the mining 'in-house' in 1760 and for the

next 30 years earned a small fortune. By 1790 the 'pipe deposits had been followed vertically downwards to about 220m, where they 'failed' at depth; below here they were significantly more constricted and became uneconomic. In the first two decades of the 19th century an adjacent deposit, at Clayton Mine, was also followed down to depth. The rest of the nineteenth century was a period when a series of private mining companies tried their luck at Ecton, with funding from investors who knew of Ecton's profitable past history. These were all short-lived ventures that were wound up once shareholders' money was gone.

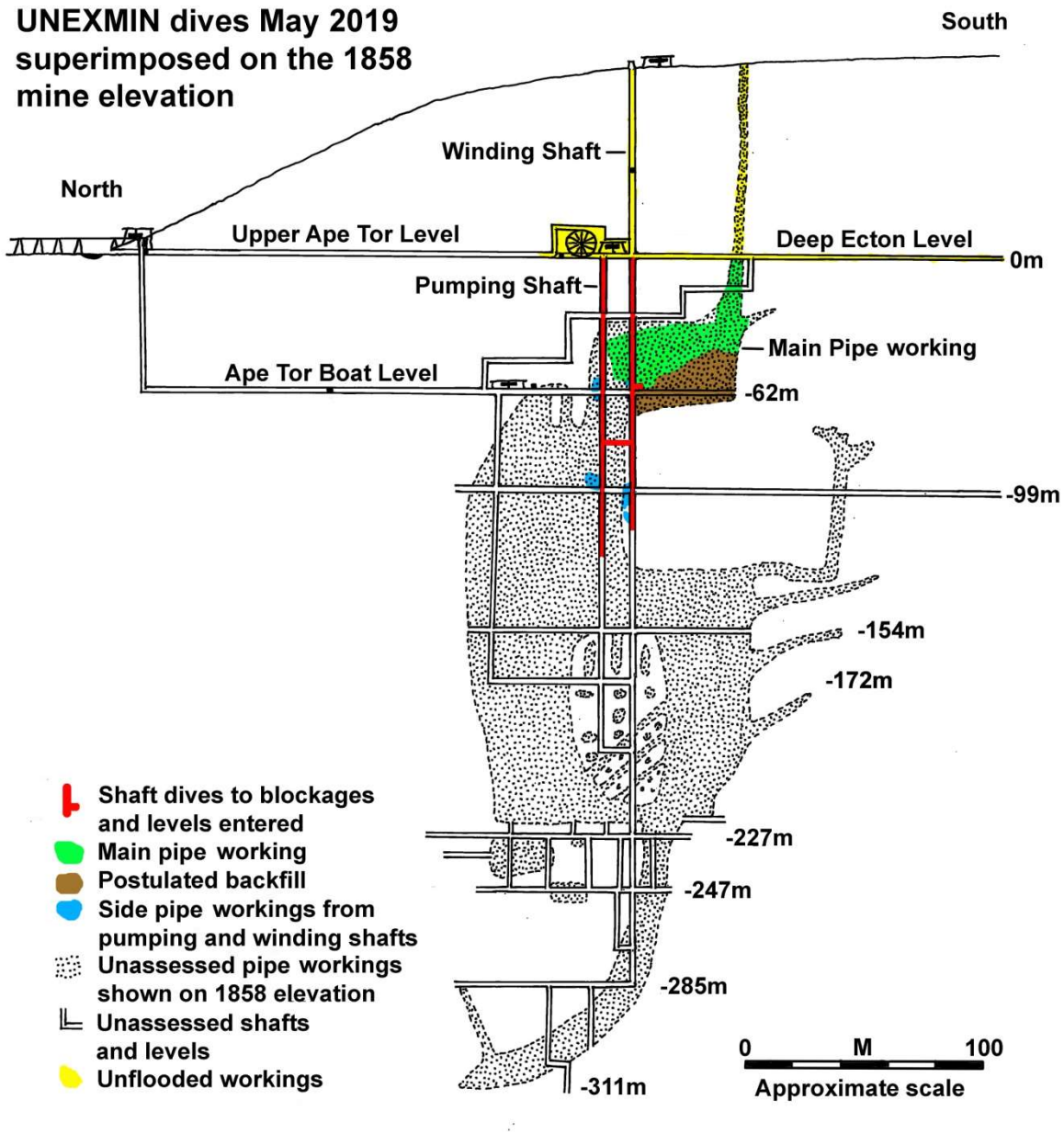

Figure 4 The approximate extent of passages explored during the UNEXMIN dives undertaken in May 2019 at Deep Ecton Mine, with these superimposed on the schematic 1858 mine elevation drawn by Meads, with feature names and recorded depths and a scale added (the scale bar is only approximate as the drawing shows the lower parts of the workings at a slightly larger scale than those parts above).

Important archaeological remains at Ecton survive both at surface and underground. High on the ridge there is the 1788 Boulton and Watt steam winding engine house. This is now owned by the National Trust and is thought to be the oldest mine winding engine house in the world that survives in good condition. The shaft here was the deepest in Britain in the 1780s and James Watt designed the

first tapered ropes used in the world to bring up the ores here. There are mine hillocks across the ridgetop, dating from the Bronze Age to the 19th century AD, together with entrances to adits, shafts and 'pipe workings'. The main Deep Ecton dressing floors lie part way up the hillside, on top of a massive waste hillock, and here a high 1880s dressing shed wall with ore bins behind has been restored (Barnatt 2017). Nearby there is a well preserved powder house.

In small dangerous workings on the ridgetop there are distinctive shotholes that show Ecton was one of the first places in Britain where gunpowder blasting was employed, using a continental technique, here by a Dutchman Jacob Mumma in 1665-68.

Salts Level, which from 1807 was used to bring ore out to surface, enters the mine at dressing floor level close to the education centre. It runs through competent rock to the main winding shaft and then the 'pipe deposit'. This allows education centre groups to easily view a small part of the workings. For many this is their first chance to enter a mine and look down a deep shaft and view impressive mineral workings. There are also important details dating to 1804-07 to see, such as gunpowder shotholes and stone sleeper blocks for an iron plateway that was laid for mine tubs.

Deep Ecton Level, with a fine arched entrance tunnel restored in 2018 (Barnatt 2020a), gives access to the 'pipe workings' and for over 150 years was the main way into the mine. Here infrastructure was installed to facilitate mining at depth. From 1773 until 1807 ore from below was unloaded here from the winding shaft for transport to surface. Nearby there are two large 1780s chambers where water was pumped out of the workings using water-powered machines, and items such as tubs and pipes were lowered down using a horse- and man-powered capstan. It is thought the main level was converted to an underground ore canal, used between 1773 and 1784, and we know from documentation that there was a second one at just over 60m down into the now flooded workings.

Site recognition and conservation

Ecton Hill, including the mines, lies entirely within the Peak District National Park and is subject to the National Park planning regulations and constraints imposed by designation. It is heavily visited by walkers and those with an interest in our industrial past.

Most of Ecton Hill is within the Hamps and Manifold Valleys Site of Special Scientific Interest (SSSI), and Deep Ecton Mine is itself an underground SSSI for its geology.

The archaeological importance of the Ecton Mines is also recognised by a Historic England listing[1] as a Scheduled Monument.

All of these might be seen in the mining industry as unwelcome constraints on its activities, but as far as EMET is concerned, in the context of using Deep Ecton Mine as an educational and research resource, they are positive. There is an informal "partnership" arrangement between EMET, EHFSA, and the various statutory and regulatory bodies, for whom education is seen as a positive and even an integral part of their function. As owner of some of the land around the adit portals, and of the mineral rights across much of the hill, EMET itself has a role to play in ensuring safety for the general public, especially as half of Ecton Hill is designated as Access Land, and its fulfilment of this role in maintenance of secured mine entrances, gates, doors, etc is particularly appreciated by the County and National Park authorities - who recognise that this can usefully be funded through EMET's educational and research activities.

EMET and the Geoffrey Cox study centre

Geoffrey Cox was the director of the Minerals Industry Manpower and Careers Unit (MIMCU) at Imperial College, London. In 1972 he was invited by the Duke of Devonshire to purchase Deep Ecton Mine for educational use. He organised a group of teachers from various schools in the region to run day and weekend courses. It was Geoff's intention to set up a Trust and had initially wanted the mine to be donated to the Institute of Materials, Metallurgy and Mining (IOM3). After IOM3 had declined to take on the responsibility of ownership of the mine, an independent Trust was proposed as the way forward. Starting in 2003, negotiations with a number of interested parties including John Bramley and

[1] https://historicengland.org.uk/listing/the-list/list-entry/1021175

Tony Brewis (both Fellows of IOM3), Graham Woodrow (deputy CEO of IOM3), and Eileen Barrett (Geoff Cox's former PA), led eventually to formation of the Ecton Mine Educational Trust on 6th September 2005, sadly delayed by the death of Geoff Cox in November 2003.

The principal aim of the Ecton Mine Educational Trust (EMET) was the use of the mine to promote education in applied geology, mining and mineral extraction. Thanks to the generosity of the late Mrs Elizabeth Cox, Geoff's widow, the Trust is the owner of the relevant mineral rights on Ecton Hill, the study centre, and the main mines here.

The Trust provides the facilities for school and university teachers to run one-day or two-day field courses that introduce young people to subjects relevant to the minerals industry.

The G A Cox study centre (Figure 5) can be used as a meeting place, a lecture room (with a capacity of 25) or a laboratory (with all the equipment required for the EHFSA courses and more). There is also a changing room containing the necessary safety equipment for underground visits.

An outdoor meeting place/lecture area (Figure 6) provides a pleasant alternative for fine weather activities.

Figure 5. Group preparing for an underground visit into Salts Level, in the GA Cox study centre lamp room.

Figure 6. The outdoor classroom in use for an applied chemistry lesson

Education

EMET's sister organisation, the Ecton Hill Field Studies Association (EHFSA), runs formal educational courses for schools, colleges, universities, and U3A and other groups studying Geology, Science or History of Science/Technology (Figure 7). Activities generally include an underground visit to see the mineralisation, and to understand how the miners were able to make the mine such a profitable enterprise. Most activities include a hill walk to see evidence of past mining techniques and the 1788 Boulton and Watt steam engine house.

Curriculum-related Activities are structured events lasting a full day. A Level Chemistry Activity Days and KS4 Chemistry Activity Days also include some practical Chemistry, relating to the minerals occurring in the Ecton ore body. The A Level

Figure 7 Teaching mineral processing in the G A Cox study centre

Geology Activity Days generally concentrate on field work techniques, mineralisation and engineering geology appropriate to the specifications of both the OCR (Oxford, Cambridge and RSA) and WJEC (Welsh Joint Education Committee) awarding bodies.

Other School Activities for KS2 pupils upwards can be arranged for general interest with the opportunity to undertake Science/Geology-based activities or with an emphasis on specific aspects of the history and geology of the Ecton Mine. These school activities cover many aspects of the National Curriculum at KS2, although the programme is more flexible than the structured Curriculum Activity days and the day is usually of shorter duration.

Activities for General or Special Interest groups are available for any type of group of adults, or adults with children. Visitors can enjoy an underground visit, hear the fascinating story of the historic Ecton mines, and how science was developed and applied to the winning of an important metal – copper. These activities are tailored to suit the interests of the visiting group.

Several University Level groups regularly visit Ecton to add a new dimension to their programmes. The site provides obvious interest for Chemistry, Geology, Mining and Minerals Processing groups. PGCE (postgraduate certificate of education) Tutors have used Ecton for their students to plan an off-site visit for school students and to appreciate the importance of fieldwork in motivating children and improving learning in Science. University Tutors can either leave the leadership of such courses to the EHFSA tutors or take the lead themselves.

It is hoped that in the future educational activities at university level can be broadened to better cover the historical and archaeological aspects of Ecton Hill.

Research

Ecton Mine is now becoming a centre for scientific research. Apart from EMET involvement in the Horizon2020 UNEXMIN project[2], Ecton Mine has participated in a number of university-based and industry-sponsored projects as well as archaeological and historical research in partnership with The National Trust, Historic England, and the Peak District National Park. Some of these projects include:

- Archaeology and history of the Boulton & Watt engine house
- Archaeology and restoration of the back wall and mineral hoppers at the Ecton dressing-floor (Figure 8)
- Study of 'clumped isotopes' by the University of East Anglia to use the isotopic composition of calcite to determine temperatures of hydrothermal mineralising fluids
- Test of microseismic technology for locating moving objects within the mine
- Considered as a location for study of muon flux detectors (Durham and Sheffield Universities)
- Tests of new gravimeters with potential for detection of ore bodies or voids (Glasgow University)
- LIDAR mapping of the adits and pipe workings above water level (Figure 9)
- ground-penetrating radar to assist archaeological interpretation on Ecton Hill

Figure 8 Restoration of the Ecton Mine dressing floor wall following detailed archaeological investigations, as restored in 2016 with financial support from Historic England

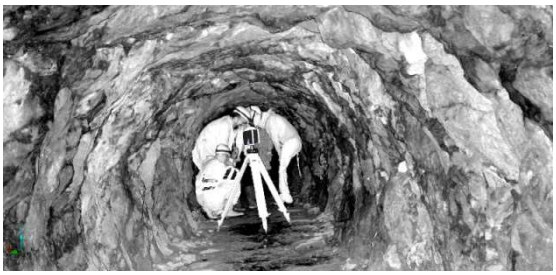

Figure 9 High resolution laser scanner point cloud from a survey of Salts Level sponsored by Arcelor Mittal.

[2] https://www.unexmin.eu/

EMET was a participant in the UNEXMIN project which was funded by the European Commission and ran for 45 months from February 2016 to October 2019. This project involved the development and testing of submersible robots for surveying and exploration of flooded underground mines. During May 2019, there were a total of ten dives by two of these robots, from three launch locations: the pumping shaft (Figure 10), the winding shaft, and the pipe workings. These dives reached a maximum depth of 125 metres and allowed exploration of about 10% of the recorded extent of the historic mine workings. Geological structures discovered included tight folding similar to that seen on surface at Apes or Ape? Tor (on the northern flank of Ecton Hill) as well as indications of multi-phase mineralisation events. Archaeological evidence discovered included proof of linkage (cross-cuts) between the two shafts as well as between the winding shaft and the pipe workings, together with discovery of pipe workings additional to those marked in the schematic cross section by Meads (1858), and possible location of the Ape Tor boat level (Figure 11). A number of locations were identified for further robotic exploration at a later date - at depths and in situations where it would be unsafe for human divers to access.

Figure 10. The launch platform, and the adjacent work station, at the pumping shaft, photographed as their installation was being completed (*Point size*?)

Figure 11. The carefully-built wall across a passage intersected by the pumping shaft at 65m below water level, with what appears to be clay in the interstices, appears to have been built as a dam to hold water back. Possibly the Ape Tor boat level

Conclusions

Deep Ecton was closed in the latter years of the 19th century after 100 years of decline from its peak metal production in the 1780s-1790s. However, what still remains both underground and at the surface provide a great opportunity for both education and research: an opportunity that was recognised by the late Geoffrey Cox whose work is now continued by the Ecton Mine Educational Trust and Ecton Hill Field Studies Association. Rather than leaving things to decay, re-working or bulldozing the surface remains, and blocking or infilling the underground workings, what is left of the mine is put to good use, giving many students their first (and often only) direct contact with industrial history, mining geology, and applied chemistry. The Trust is also actively developing and promoting the use of the mine as a research facility about which more information is available with every passing year.

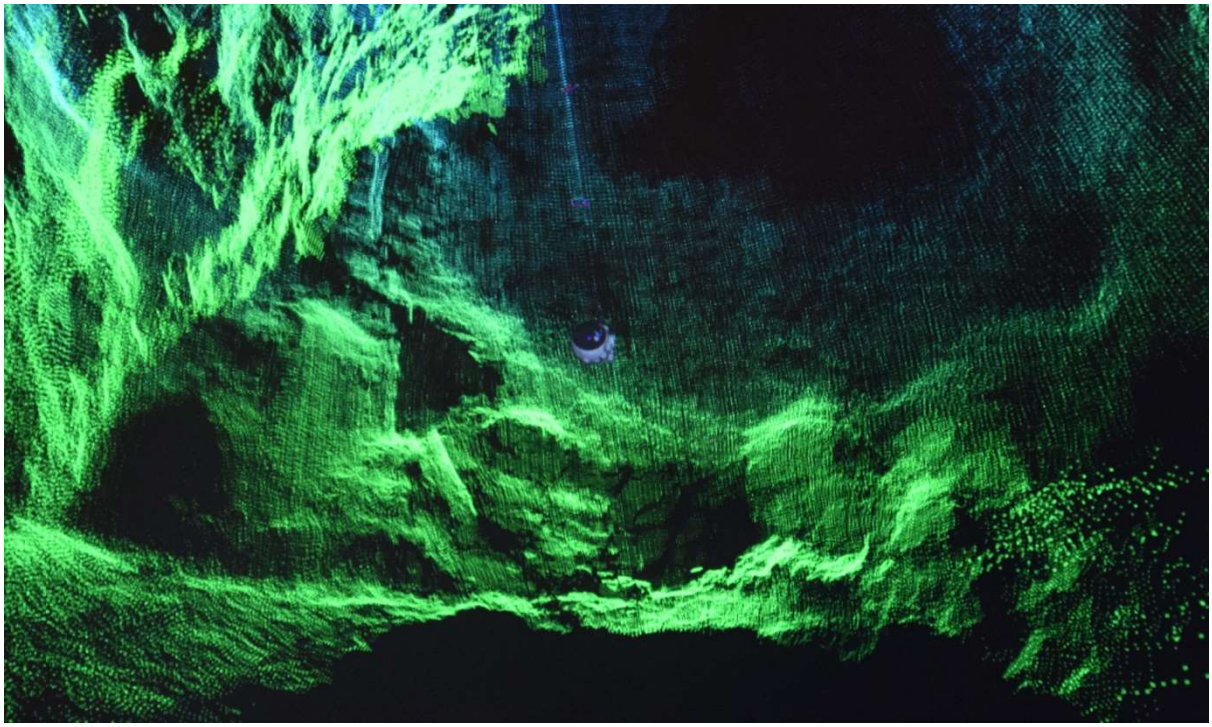

Figure 11. A sonar point-cloud image photographed from one of the dive monitors in the UNEXMIN control room in the G A Cox study centre, in late May 2019, showing part of the second chamber down in the 'main pipe workings' centred at about -35m below water level, showing the scale of the working and examples of side passages that have yet to be explored (the submersible at the centre is a graphic that allows its size and location to be identified). The submersible is approximately spherical, 60cm in diameter.

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