

BEACH SLAGS OF THE NORTH WALES COAST

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Introduction.

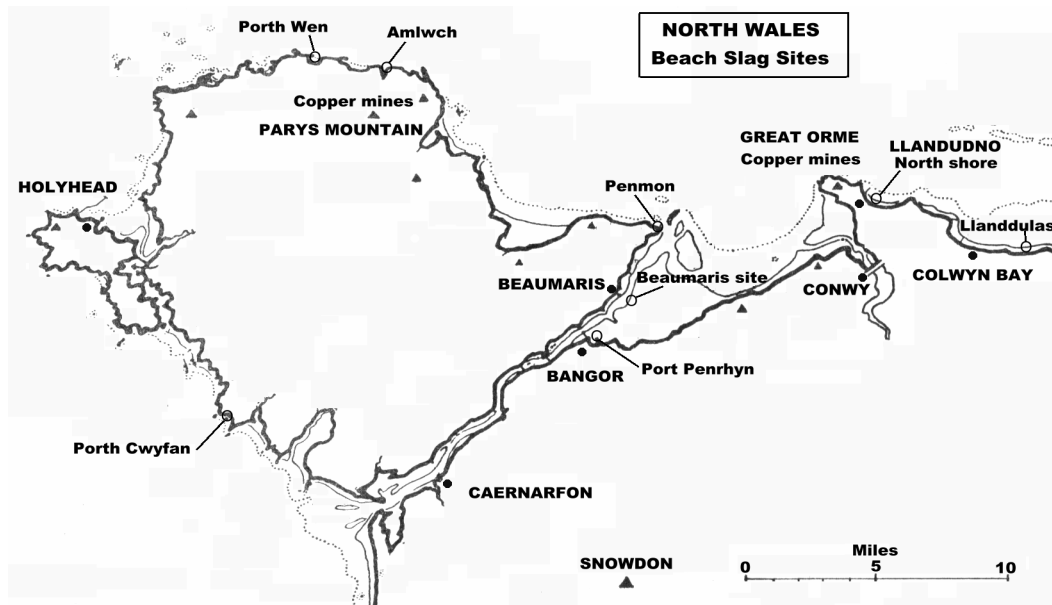
Why can slag from copper smelting be found on many North Wales beaches?

In 1992, in 'Bronze age smelting - A Discussion Paper on possible smelting sites for Great Orme copper ore', the possibility was discussed that, as in other mining areas, local fuel supplies would not be sufficient for smelting ore. 'Fire-setting' that is mining by shattering ore and rock with fires lit against the work face would further increase demand, as would domestic use. It was proposed that the ore mined on the Great Orme would have been taken, perhaps by sea, to sites where fuel - charcoal - could be easily obtained. This recognises the fact that the whole smelting process requires, by weight, far more fuel than ore. [Bannerman. 1992] After much research into smelting Professor E. Slater has estimated a ratio of 15-20 to 1 charcoal to ore by weight. [pers. comm.] When wood is burnt to produce charcoal there is an 80% reduction in weight, hence to smelt 10,000 tonnes of copper ore would require 150,000 - 200,000 tonnes of charcoal. To produce this quantity of charcoal 750,000 - 1,000,000 tonnes of selected hardwood would be needed. This illustrates the size of the fuel industry as estimates of ore mined on the Great Orme alone in the Bronze Age vary between 10,000 and 50,000 tonnes.

[In 1997 a very small Bronze Age metal working site [2.2mx1.8m] was discovered on a narrow ledge at Pentrwyn on the Great Orme where fragments of copper slag were found dating to more than 3,000 B.P. [Chapman D. 1997]. No large sites have as yet been found. 2011]

The aim of the 1992 paper was, as the title implied, to encourage debate, and the examination and investigation of areas indicated by the conclusions drawn, as possible smelting sites. Proven evidence of Bronze Age copper ore smelting in the British Isles is, at the time of writing, very sparse. The absence of prehistoric copper slags has several explanations, perhaps the most popular being that only carbonate [e.g. malachite] ores were smelted in a "non slagging" process, while sulphide ores [e.g. chalcopyrite] were discarded. [Craddock, 1990] This theory being based upon smelting conducted under laboratory conditions with specimen quality malachite. In fairness, when this work was done, known Bronze Age mines were nowhere near as extensive as the Great Orme and Parys Mountain discoveries have since proved to be. It would be reasonable to suppose that small scale smelting could be practised using only very pure ore, but, when smelting operations of the scale indicated by the Great Orme mines are considered, it is felt that it is necessary to think on more industrial lines. Furthermore the apparently extensive prehistoric workings on Parys Mountain would have been likely only have produced sulphide ores.

Increasing skill in smelting high-grade ore would soon lead to more impure ores being used. Mineral extraction without iron tools is extremely difficult and anything that came out of the mine, which looked like copper ore, would be experimented with in the 1,300 years or more that copper was exploited in North Wales in prehistory. There is a tendency in some quarters to think that because no prehistoric sulphide slags have been found, no sulphide ore was smelted. This reasoning has been illogically extended to imply that therefore there is no point in looking for sulphide slag as any that is found will be from another period. Discussions and work with D. Chapman during some preliminary trials in smelting Great Orme ore indicate that, even with carefully sorted copper carbonate ores, considerable amounts of waste products are produced. Prof. E. Slater has also noted quantities of waste



remaining after smelting copper carbonate ores. At all times it is important to remember that of thousands of tonnes of ore were removed from the Great Orme during the Bronze Age. Processing and smelting this amount of ore must have resulted in the production of large amounts of wastes, whatever type of ore was smelted. [Slag found at the Pentrwyn site was from sulphide ores [Chapman1997].]

During the 18th. and 19th. Centuries large quantities of copper ore were mined at Parys Mountain, and to a lesser extent on the Great Orme. Much of this ore was taken to Swansea and Warrington for smelting; for although Parys Mountain was then the world's largest copper mine there was insufficient fuel locally to smelt the ore. Great Orme ore was shipped in reasonably small vessels, 30 - 90 tons burden, such as the 'Flat' 'John'.



The copper ore carrier the 'John' drying her sails whilst beached at Llandudno in 1859. Vessels of this type were known as 'Flats'.

Smelting works set up around Parys Mountain depended on coal being brought in from elsewhere, often as a return cargo by vessels taking ore to Swansea and Warrington. However there was still the basic fact, as pointed out by J.Rowlands in "Copper Mountain" [p.30], that three tons of coal were needed to smelt one ton of ore. [Rowlands 1996] Once again it made more sense to take ore to fuel. Masters and Owners of vessels taking ore to distant smelters would always try to find a return cargo that they would be paid for carrying. When none was available or when the cargo was a light one, i.e. having a low specific gravity, it would be necessary to take on ballast to stabilise the vessel. Copper slag was ideal for this purpose and readily available at the smelting works but as there was no financial advantage to the operation, detailed recording of the process did not have a high priority. [Mr Aled Eames, pers. comm.] Crew agreement lists often indicated a vessel sailed 'In Ballast' without specifying what type of ballast was taken aboard. This practice resulted in quite large amounts of unrecorded copper slag being brought into the area, thereby rather confusing the search for Bronze Age slags. It was therefore decided to 'clear the ground' by first investigating these 18th. and 19th. Century deposits, taking care of course, to keep alert for older deposits at all times.

Initial results

During preliminary investigations and after finding copper slag at Port Penrhyn, the help of a few of the author's friends was enlisted in examining local beaches. Even before the discussion paper was published previously unreported copper slags were starting to turn up all over the North Wales coast. The largest was a deposit of many tonnes on the North shore at Llandudno, discovered by T.Parry, T.Davies and Dr.D.Smith, fellow members of the Great Orme Exploration Society. This particular find is within a kilometre of the prehistoric mine site, and although it is fairly certain that the deposits are 19th century, it does rather emphasise the point that, until research for this discussion paper was started, the search for copper slag had been none too thorough.

It also became clear that the amount of slag being found in so many different locations was going to present a problem, in that detailed documentation of every site, would take a very long time. It was decided therefore:

- 1.To identify and classify slag types.
- 2.To visit as many locations as possible, and form a general picture of, and possible reasons for, the deposits.
- 3.To examine closely the Llandudno North Shore deposit and other selected sites.

Classification

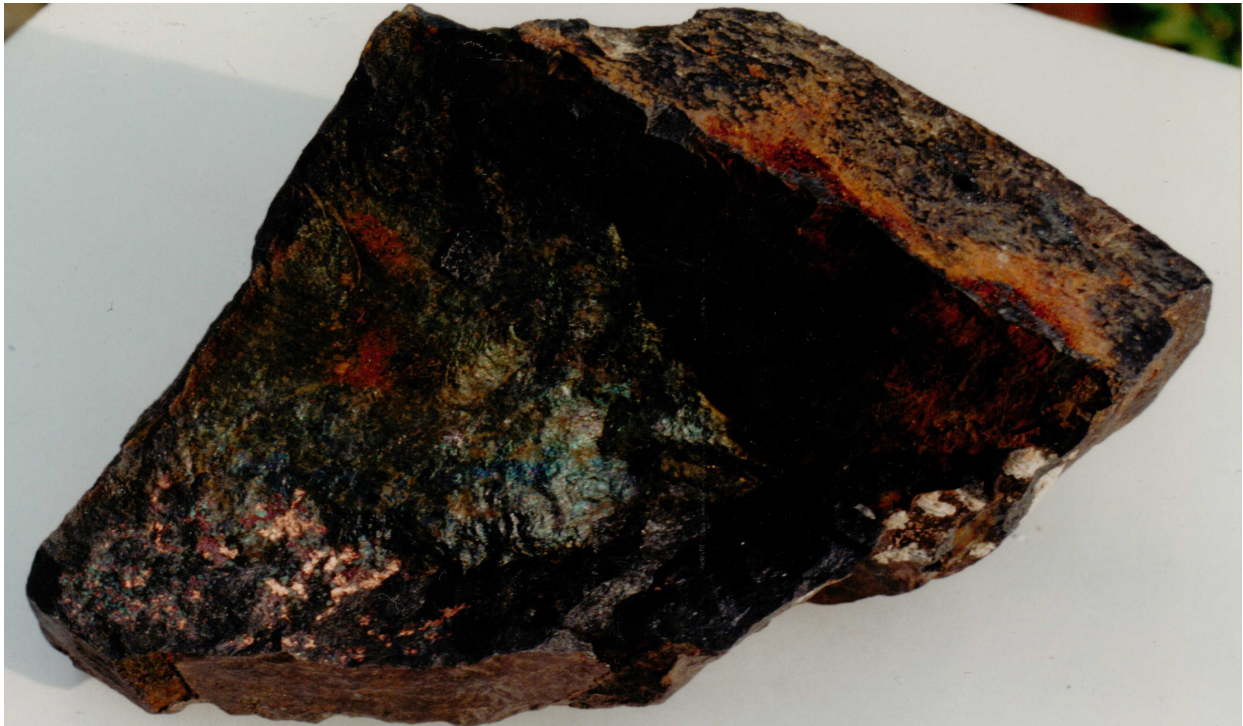
The commonest slags appearing on North Wales beaches appear to fall into two types which for convenience were called Types 1 & 2. Dr. D.Jenkins was kind enough to prepare reports on two samples 'A' [Type 1.] and 'B' [Type 2.], which are included in the following descriptions:

Type 1

Dark red / brown or black, dense, fine grained with flow marks on some surfaces. In one location, Llanddulas, metallic copper was found attached to, and in association with, this type. Dr.Jenkins states with regard to sample 'A' taken from sandbanks opposite Beaumaris at National Grid reference SH 6040 7535: - *"This is a uniform dense [S.G.=3.8] slag sample showing a smooth chilled surface with few vesicles, and an internal perpendicular prismatic structure. This is a typical fayalitic slag, and the mineral composition has been confirmed as fayalite [FE2 SiO4] by XRDA [X-Ray Diffraction Analysis: 0.252, 0.282 & 0.295nm]. Freshly exposed areas of the interior proved to be rich*

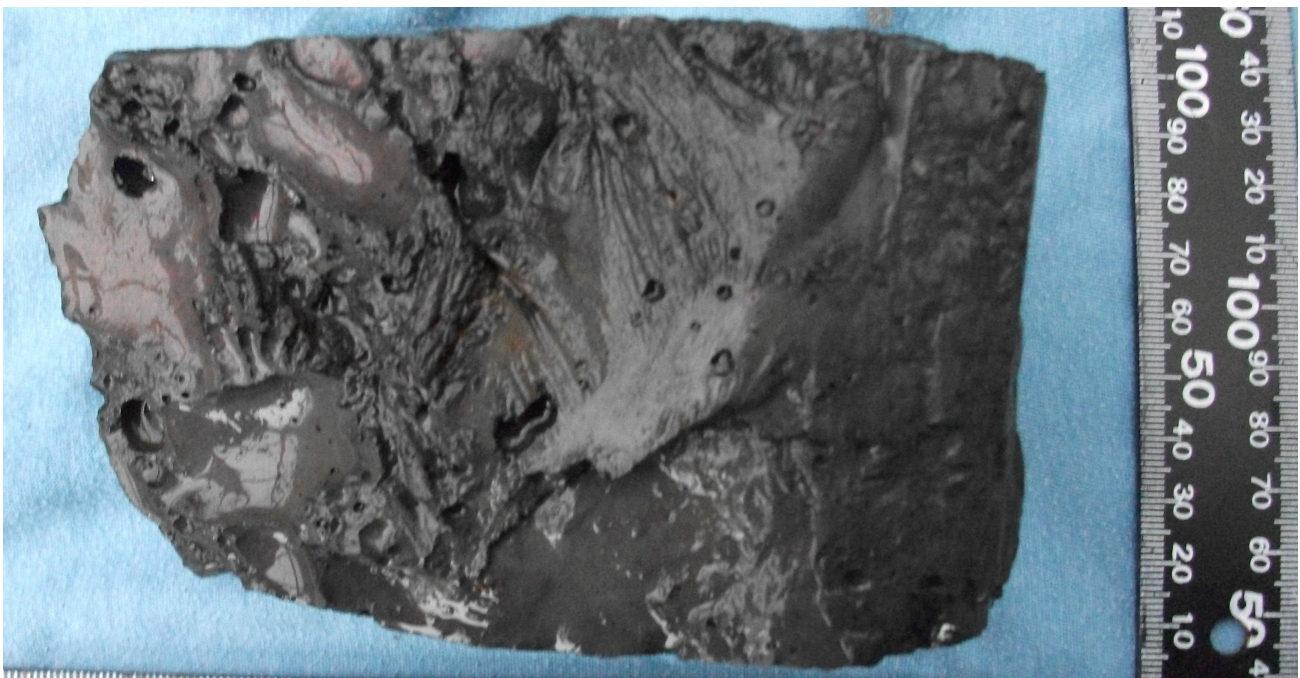
in copper prills, which confirms that this is a slag from the copper rather than the iron industry. It could derive from Mynydd Parys."*

**small inclusions of metal.*



Type 1 Slag Beaumaris site. SH 6040 7535 Note copper 'prills'

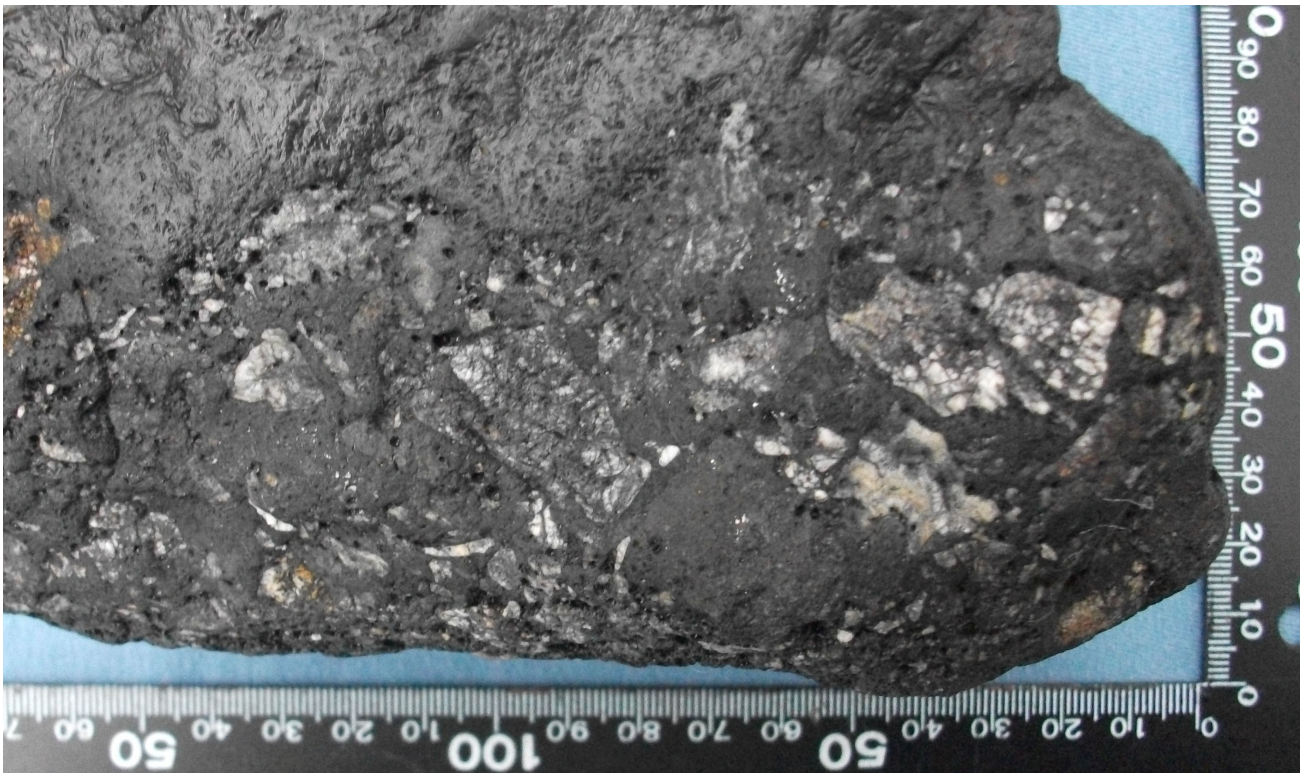
Sample A: -Specimen size; 14cm. x 10cm. x 10cm. Jagged profile. Type 1 slag, Fayalite, [FeSiO₄] Dense. Specific gravity 3.8. Colour, dark reddish brown. This sample had a patch of iron-stained concretion adhering to one side perhaps from a nail or similar [upper right]. Upon being broken, prills of metallic [copper lower left] were visible on the fresh faces as well as an iridescent sheen. Dr. D. Jenkins



Type 1 Slag. Amlwch Port Anglesey.
Showing surface flow marks.

Type 2

Grey / black, rather "frothy" in appearance with white angular inclusions as well as bright green stains and inclusions, and occasional specks of bright blue. In some specimens small particles of what appears to be unburnt coke are found. It gives indications of copper with a simple flame test. Dr. Jenkins states with regard to sample 'B' taken from Llandudno North Shore at National Grid reference SH7 825 8256: - *"This shows a surface zone 1-3cm thick comparable to sample 'A' in its structure [i.e. a fayalitic slag]. This surface zone overlies a mixture of slag and sub-angular fragments [1-3cm] of shattered/veined white fine-grained rock [quartzite?]; overall the sample is less dense [S.G. 2.8]. The Slag was examined petrographically in thin sections in the hope of identifying the white rock material and so determining the source of the slag. Microscopic examination revealed a fibrous structure typical of fayalite, but the white rock fragments were largely recrystallised, although there are suggestions of an original rounded grain structure [i.e. sorted quartzite?]; this might for example derive from the Craig Rofft sandstone, as seen at the Great Orme Mines, or from one of the quartzites around Mynydd Parys. There are superficial green stains suggesting malachite derived from the weathering of copper sulphide ores, and small pink-brown patches [of cuprite?]; this again indicates derivation from the copper industry."*



Type 2 Slag showing 'shattered/veined white fine-grained rock [quartzite?]

A copy of the 1992 discussion paper and a sample of Type 2. slag was sent to Dr.P.Craddock of the British Museum, who observed that, although the specimen sent to him was rather large, such slags had been found elsewhere that dated back to antiquity. Other types of slag from iron works can be found at Port Penrhyn where it was poured in a molten state onto the beach from the foundry there. It has also been noted on the beach of Hiracl bay where there was another foundry at one time. No doubt there is more in other places, as during the Industrial Revolution iron foundries appeared all over the area, as at Llanwrst and Furness in the Conwy valley. Care should be taken to avoid confusing iron and copper slags, which have some similarities. Ilmenite or 'Bog Iron' such as was pointed



Type 2 Slag, Port Penrhyn, showing numerous 'frothy' holes.

out to the author by T. Williams at Porth Cwfan, Anglesey, where it can be seen eroding out of a clay bank at high water mark, this can also be mistaken for iron slag.



A cone shaped deposit of iron foundry slag on the east side of Port Penrhyn resulting from molten slag being discharged from the now demolished foundry onto the beach.

General discussion

Having already examined sites where slag was predicted and found, it was decided to examine beaches and shorelines where slag might not be expected, such as Penmon Point Anglesey, which is a rather wild and rocky promontory. It was hoped that this would establish a number of control sites, but after a quite cursory examination at Penmon Point and other places even more slag came to light. Indeed it seemed that there was scarcely a beach in the area on which the odd lump of slag Types 1 or 2, could not be found. From the start it was fairly evident that much of the slag being reported was ballast discharged from the 19th century sailing vessels that took copper ore from the mines of North Wales to the smelters at Swansea and Warrington, returning with slag as ballast. In conversation with the late Mr Aled Eames with regard to this ballast theory he agreed that this made sense; however, he remarked that he could not recall any detailed report of such a practice, suggesting, among other things, that the port records should be researched. There was also the problem that, apart from obvious ballast banks, slag is present in small quantities in many other places, sometimes just one lump in isolation on a beach of normal pebbles. Furthermore there are also large deposits away from recognised ports.

Llandudno North Shore

The slag / ballast deposits on this beach form quite a distinct feature and an area marked on large scale [1:10,000] Ordnance Survey maps as stones has a large amount of slag present. The author is also in possession of a photograph of a three masted vessel beached on the same contour. Taking advantage of very low tides it was possible to examine the beach along its length, right down to low water mark. Though small sandbanks tend to move about in places, it was possible to ascertain that the majority of the slag was at about, or just below, the half tide mark. No slag was initially evident at low water mark though after storms some well-defined heaps appear through the sand. In the pebbles at high water mark a few small pieces of slag were found here and there. Patches of slag can be found along almost the whole beach around half water mark, but are most concentrated towards the western end.

On the 20:8:93 a dig was arranged through The Great Orme Exploration Society with permission from Aberconwy Council. Gwynedd Archaeological Trust, Cadw [the Welsh conservation agency] and the R.N.L.I. who launch their Lifeboat across the beach were also informed beforehand. Because of the size of the deposit, the difficulty of excavating waterlogged sand, and the short time that is available around half tide mark, a J.C.B. excavator was employed. Five excavations were opened to a depth of 1.5m.

In all instances the slag was not apparent more than .30m beneath the surface of the beach. Beneath the deposits of slag and large shingle, sand or fine shingle, underlain with clay, was observed. The impression was gained that the slag had been dumped on the beach and had stayed pretty much in place. Quite well defined patches can still be seen consistent with having been thrown out of a vessel engaged in taking ore from the Gt. Orme mines to a smelting works, and returning with slag and other material as ballast.

Initially it was rather puzzling that the extreme western end of the North Shore, in the same area of the Ty Gwyn Adit entrance, was comparatively free of slag. Subsequent research into fish weirs in the area revealed the existence of large one thereabouts known as 'Clawd y Gorad' [The Dyke of the Fish Weir] It appears on a photograph of around 1858 soon after which it was apparently removed and about that time the copper mines also ceased production. This 300m. long structure, a type 7 Fish Weir would have comprised an

embankment of stones into which 3m. high posts intertwined with wattle were set. Obviously it would have been too risky to attempt to manoeuvre large boat close to such a danger to navigation which was actually shown on the 1835 Admiralty chart. [Bannerman & Jones 1999]

Prior to the arrival of the railway in 1862, by which time the mines had virtually closed, the only practical way of moving the ore was by sea. Whether the Railway Company hoped to benefit in any way from the mines is not certain, but they never reopened. It is much more probable that the branch line was built solely to service the developing 'Victorian Watering Place'

Beaumaris

On the 4.9.93 The author sailed up the straits from Bangor hoping to explore the shore at Penmon at low water, unfortunately a brisk S.E. breeze sprang up that would have made anchoring there very uncomfortable. The engine was stopped, sail hoisted, and the vessel proceeded back towards Menai against the ebb. Just after passing Buoy no.12 a combination of current, veering wind and inattention ran the "Eryri Wen" aground on the sandbanks opposite Beaumaris. Within a short time the ebbing tide left us high and dry. Right at low water, between two sandbanks alongside where the boat had grounded, a two-metre diameter patch of material was noted which seemed to be out of context with surrounding sand beach. The material had the appearance of being in a mound buried in the sand. Due to the incoming tide very little time was available to examine the site, or probe the sandbanks to try to determine the extent of the mound beneath the sand. It was however possible to take three fairly representative samples of the material, which in places seemed to include iron staining perhaps from corroded fixings or fittings. Dr. D.Jenkins was kind enough to help with their identification, which follows: -

Sample A: -Specimen size; 14cm. x 10cm. x 10cm. Jagged profile. Type 1 slag, Fayalite, [FeSiO₄] Dense. Specific gravity 3.8. Colour, dark reddish brown. This sample had a patch of iron-stained concretion adhering to one side perhaps from a nail or similar. Upon being broken, prills of metallic copper were visible on the fresh faces as well as an iridescent sheen.

Sample B: -Specimen size; 8cm. x 6cm x 5cm. Ovoid smooth profile - pebble. Fine-grained. Thought to be rhyolite. Buff coloured.

Sample C: -Specimen size 12cm. x 10cm. x 10cm. Jagged profile - Broken rock. Probably rhyolitic tuff. Colour greyish green.

Material sizes varied but typically 12cm. - 25cm.diameter lumps. It appeared that at sometime in the past someone had been caught out as had the author and had jettisoned ballast or had been wrecked there in more stormy conditions. If indeed this is what had happened it could be that this particular deposit could be used as a 'type site'. Up to this point it had been supposed that where slag had been used as ballast it would have been used in a more or less "pure" form. However, this incident and find, pointed out that anything with a high specific gravity can be used as ballast, and that there is a possibility that a collection of various different substances could have been used for this purpose depending upon what was available at any particular port.

As on the North Shore at Llandudno, where the opinion was formed that the slag there was ballast, it was felt that the shingle and broken rock associated with it could also fall into this

category. Thus there are two explanations for the appearance of 'Ballast Slag', firstly, that it was jettisoned in a planned manner, in a designated area or 'Ballast Bank' such as exists just to the N.E. of Port Penrhyn, or secondly, it was thrown overboard in an emergency.

A third possibility also suggests itself, which is that a deposit of slag could mark the position of, and also help to date and identify a wreck, as the exploitation of North Wales copper occurred in a fairly well defined period. Furthermore as the vessels that were involved in the transport of ore may also have been used in international trade, the presence or absence, of ballast slag in a wreck, almost anywhere in the world, may be a useful indication of the age of the vessel and its previous ports of call.

Llanddwyn Island

On 8:11:1993, the author went with D.Chapman and T.Parry to examine a bank of stones that Dr. C. Jones had pointed out on a slide of the Llanddwyn Island area. Dr C. Jones had mentioned, in an extramural lecture, that this could possibly be ballast, but that there was no positive evidence that it was. This was an ideal opportunity to test the theory that the presence of slag could help to identify a possible wreck site. An examination of the site, which is a little to the East of Llanddwyn Island, soon revealed a quantity of what appears to be copper slag. The slag, mainly type 1, is mixed with other material but appears to form a large proportion of the whole, and could well be of a similar type to the slag deposits on Llandudno's North Shore. These would seem to date from the middle of the last century, and possibly the Llanddwyn deposit is from that period also. An investigation of this deposit should reveal whether there are any timbers below from a wreck. The amount of material would point to quite a large vessel; a careful estimate would suggest how large. The percentage of slag in the heap, if high, as it appears, may indicate that the vessel came in ballast, possibly from Swansea. It is also possible that the material was jettisoned from a vessel engaged in the copper trade before being towed 'light' into the Menai Straits to pick up cargo at one of the ports there.

A flame test was tried on a sample but there was no indication of copper, which was not surprising, as the copper content of this type of slag is very low. The majority of the slag seems to be Type 2 and although it is present in the oval shaped heap it is not evident elsewhere on the beach.

Llanddulas

On 23:1:94 Llanddulas beach was visited after a message from David Smith of G.O.E.S. that a quantity of slag had been found in an excavation. D. 'yr Ogof' Jones first reported slag there, in small amounts, in August 1992. S. Lee, D.Chapman, T.Parry and the author went along. From the cross-section of the deposit it appeared that the slag, which appeared to be only of Type 1, had been dumped in a depression in the beach shingle in a more or less pure form, that is, not mixed with any other material. The fragment sizes varied from 30cm diameter right down to less than 1mm. The deposit is sited 4m. seaward of the railway embankment, 200m east of Thornley's caravan site underpass. The depression in section is about 7m across deepening to 1.5m in the middle. The deposit was covered with a layer of shingle .75m deep. From 1921 to 1970 this area was used as a rubbish tip, and the impression was that the slag dated from either before this time or, more likely, that it was used as fill to level out the beach for access before dumping commenced. The large amount of fine and small size particles raised questions as to whether it had been used as ballast, and the possibility that it had come from an unrecorded local smelting site was considered. On further reflection however It was felt that

it was ballast dumped from a vessel engaged in loading ore from mines inland from Llanddulas. A small amount of metallic copper was found adhering to, and in association with the slag - the first found at any North.Wales beach site [one specimen 8cm x 3cm x 1cm]

Porth Wen

A few lumps of slag types 1 and 2 were also found on the beach at this location on the North Coast of Anglesey where refractory bricks were produced at one time. This would seem to indicate that vessels carrying bricks for lining smelters from Porth Wen were also using copper slag as ballast on the return voyage.

Further observations

A fairly clear picture of beach slag was starting to emerge by this time and on the 27:1:94 at Penrhyn Dock the author met Mr. D. Cale, a retired sail maker. He was able to give crucial information about the use of slag as ballast. Apparently it was known by the old sailors as 'Copper dross'. The following quotation is revealing: -

"Copper dross was often used by schooners as ballast. Schooners going to Runcorn with slate from Port Penrhyn would pick it up there as ballast for the trip back. The schooner 'Mary B. Mitchell' used to dump her ballast in Hiracl Bay, and eventually a bank built up that was known as the Mitchell or Copper bank. It was great stuff because it was so heavy and if I had a boat now I'd use it rather than cast iron, it doesn't rust you see. Smaller local boats were ballasted with Copper dross from the Mitchell bank up to quite recently. One thing that they used to do every year or so, was to beach the boat for painting and take out all the copper dross from the bilges and put it on the shore where it would soon be washed clean by the tide, nothing sticks to it you see. Pillars of slate were also used as ballast but slate is nowhere near as heavy as copper dross. No, copper dross was the best"

This would account for slag being all over the place in small quantities, and further establishes that copper slag was used as ballast by sailing vessels engaged not only in the copper, but also the slate and refractory brick trade and also by local fishing boats. It also helps to explain a small amount of slag found by T.Parry and the author to the East of Amlwch port on the site of the shipbuilding yard of William Thomas and Sons. [Eames, 1981]

These slags, being jagged in profile, have good mechanical interlock and would be less likely to shift in heavy weather than for example shingle or other smooth rocks. This is an important characteristic as shifting ballast can seriously affect the trim and stability of a vessel and could lead to a capsizing.



The Schooner 'Mary B. Mitchell' 1890

Copper dross was used as ballast

[In the First World War the Mary B. Mitchell, as 'Q' ship no.9, carried concealed armament and is believed to have sunk two German U.Boats]

The length of time this practice went on for is still an open question, but where copper slag is discovered, there is the possibility of it marking: -

1. In large amounts, the wreck of a schooner, flat, or other type of sailing vessel engaged in trade. Where small amounts are found on wild, rocky and exposed coastlines this may mark where a vessel has been wrecked and smashed to pieces in some violent storm.
2. In large amounts, an area where vessels were beached to discharge ballast prior to taking on cargo such as copper ore, as in the case of Llandudno's north shore, or slate at Port Penrhyn and Hiracl Bay.
3. In small amounts, when found on relatively sheltered beaches or in inlets or harbours, a site where small boats had been hauled out for cleaning and painting.
4. A much earlier site as proposed in the introduction.

Obviously the presence or absence of copper slag or dross could be useful in the identification of wrecks, and not only locally, for sailing vessels using North Wales ports traded, and came to grief, all over the world. These slags tend to remain fairly clear of

growth, possibly because they are slightly poisonous, and their distinctive appearance makes them easy to identify in the field, once a researcher knows what to look for. To date, as far as is known, no work has been done on identifying slags underwater. Dr.C.Jones raised the possibility that they may be detectable with a magnetometer, which would be rather useful, as long they were not dismissed as natural iron-rich rock of some type.

The 19th. Century slag deposits on the North Shore at Llandudno demonstrate another 'spin off' of this research, in that they demonstrate that the beach where they were dumped about 150 years ago has not been subjected to significant coastal erosion since that time. Clearly discernible patches of ballast can be identified at the half tide mark and as the dig revealed, the original beach is immediately below them. Thus they establish a 'time horizon' as well as calling into question claims that the North Shore at Llandudno is subject to erosion and requires extensive sea defence work.

The pollution aspect of the slags is possibly worthy of enquiry in that copper leaching out of them may affect shellfish. This effect could perhaps be significant for any such organisms that were in the immediate vicinity of a deposit, especially as 'Type 1'. slag seems to contain quite significant amounts of copper.

At both the Beaumaris site and on Llandudno's North Shore jagged, broken rock was observed in conjunction with copper slag. At other sites such as the Conwy Morfa, where there is very little slag to be found, there are patches of angular rock which have quite a different appearance from the predominant shingle and sand. These lumps of what appear to be recently broken rock seem to be out of context with the rest of the beach material, and the question must be asked whether these are also ballast marking a wreck or landing place?

Thus far no deposits of Bronze Age material are claimed, though certain sites must be further examined. Dr.D.Jenkins [personal communication] pointed out that ancient slags might well be buried beneath more recent ones. Type 1 slag is evident at many sites, which may point to activity at other times, medieval or otherwise. It must be repeated that in this paper, the object was mainly to enquire into 18th and 19th century slag deposits so that they could be recognised and separated from earlier ones. It is however worthy of mention that what appears to be a very early, possibly Bronze Age, ore processing floor was revealed by the torrential downpour that flooded Llandudno in 1993. Water pouring down the Great Orme at Fynnon Galchog, scoured a gully through a tip of 'Fines', waste material containing ground dolomite, specks of malachite and other ores, and many pieces of copper/iron stained bone similar to those found in the Bronze age workings.

This area had been suspected as a possible mineral processing area as references exist to 'many tons of Roman copper slime' having been removed from there in the 19th century but a recent excavation had proved inconclusive. As the Fynnon Galchog area could be a Bronze Age mineral processing and concentrating site it must surely warrant further investigation. The term 'Roman' was applied by 19th century miners to early workings in the Great Orme which have since proved to be Bronze Age, and it would appear that by 500 B.C. the mines were 'worked out' until the advent of more modern mining methods in the 19th century. The area was very carefully examined but no slag was found which could indicate that, though the ore may have been processed there, it was taken elsewhere for smelting, perhaps being loaded onto boats in Porth Helyg which is directly below the Fynnon Galchog area.

The Ballast Trade

The supply of ballast for shipping, though very important, is not well reported. The inclusion of the following helps to illustrate its organisation.

After the first draft of this Paper was circulated Mr Bryan Hope of Moelfre very kindly sent the author a copy of a proposal made by three Amlwch men, Hugh Thomas of Dafarn Drip, Owen Owens of Laethdy Beach, and John Roberts of Tre'r Dard, on the 2nd of March, 1819:

'to enter into a contract with the proprietors of the Mona and Parys Smelting works at Amlwch Port for the entire of the copper dross conveyed to Liverpool. The proposers will pay 6d. per ton for every ton of copper dross shipped on board vessels for Liverpool, to the Proprietors of the smelting works or the clear yearly rent of £150 per annum which will be paid quarterly for at least 10 years because of heavy expense' Mona Mine mss #213.

The following observations made by Bryan are also most interesting:

'What can be deduced from this document, is that approximately 6000 tons of copper dross were already being exported annually to Liverpool at that time, and that the three men were simply bidding for the exclusive rights to that trade. Bearing in mind the thousands of tons of slag that would have been produced over the years in the Amlwch smelters, the fact that comparatively little is evident locally, suggests that an extensive market existed for what would otherwise have been a waste product. As has been rightly said in the paper, the specific gravity and good interlocking properties of rough copper slag made it ideal ballast material, and there can be little doubt that this was its intended purpose.'

Ballast suppliers, it would seem, considered anything with a reasonably high specific gravity as 'Grist to the Mill' as this record of the ballasting of the sailing ship 'Moshulu' at Belfast in 1938 shows: - *'At the quay we took in our ballast, fifteen hundred tons of coarse dark sand used in the manufacture of pig-iron, huge lumps of paving stone, granite blocks, and the best part of a small house. At the same time the stevedores added two dead dogs, but we did not discover this until we reached Australia in January, the hottest month of the year'* [Newby].

Slag in Buildings

It is evident also, that some of the slag was cast into building blocks. Michael Faraday, for example, records that prior to his visit to Amlwch in 1819, he had inspected Vivians copper smelter at Neath, where he had noticed that many of the walls were built of slag blocks. Similarly, a row of dwelling houses in Amlwch is built entirely of them, and examples can still be seen in the walls close to the harbour, as well as in the floor of a building which formed part of the original Treweek shipyard, known locally as Iard Ochr Draw.'

This then is a record and a description of finds to date. It has, of course, thrown up many more questions and possible future lines of research. The possibility that the source of a slag might be identified from quartzite inclusions has been suggested by Dr.D.Jenkins. Also worthy of consideration is that the typology of slag with reference to age based upon advancing technology may provide a dating method for sites. More detailed descriptions of sites with drawings could also help to provide more information, as might information on vessels in copper trade with relative tonnages of ballast.

Conclusion

Hopefully a new method of finding and identifying wrecks and landing places is emerging. It would seem that not only is copper slag an easily recognisable ballast material, but that jagged lumps of rock should also be noted as possible ballast, especially if they are not of a type found occurring locally. Identification of the source of any slag or rock type could indicate a vessel's last port of call; however, as has been remarked earlier, ballast slags were sometimes re-used by other vessels, and as always, caution should be observed before drawing any conclusions.

The fact that the excavations on Llandudno's North Shore revealed a sequence of sand underlain with clay beneath the mid 19th century ballast slag deposits demonstrates the stability of the beach profile over 150 years and provides an important insight into beach morphology.

These slags are a distinctive feature of the North Wales beaches and are, in many cases, the only memorial that remains of the sailing ships which were once ballasted with them.

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