



Takahashi, Daisuke and Caldwell, David H. and Cáceres, Iván and Calderón, Mauricio and Morrison-Low, A. D. and Saavedra, Miguel A. and Tate, Jim. (2007)

Excavation at Aguas Buenas, Robinson Crusoe Island, of a gunpowder magazine and the supposed campsite of Alexander Selkirk, together with an account of early navigational dividers. *Post-Medieval Archaeology*, 41 (2). pp. 270-304. ISSN 0079-4236

<http://repository.nms.ac.uk/57>

Deposited on: 2 April 2010

# Excavation at Aguas Buenas, Robinson Crusoe Island, of a gunpowder magazine and the supposed campsite of Alexander Selkirk, together with an account of early navigational dividers

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*SUMMARY: Excavations were undertaken of a ruined building at Aguas Buenas, identified as an 18<sup>th</sup>-century Spanish gunpowder magazine. Evidence was also found for the camp site of an early European occupant of the island. A case is made that this was Alexander Selkirk, a castaway here from 1704 to 1709. Selkirk was the model for Defoe's Robinson Crusoe. A detailed discussion is given of a fragment of copper alloy identified as being from a pair of navigational dividers.*

## BACKGROUND

The main aim of the project from the beginning was to identify evidence for the activities of the Scottish sailor, Alexander Selkirk, marooned on the island from 1704 to 1709, or at least other early castaways. Selkirk is presumed to be the model for Daniel Defoe's hero in the novel first published in 1719, *The Life And Strange*

*Surprising Adventure of Robinson Crusoe, Of York, Mariner.* The novel is not by any means an exact account of Selkirk's adventure, nor is there clear evidence that Defoe and Selkirk actually met, though Defoe must have been well aware of Selkirk's adventure.<sup>1</sup>

Daisuke Takahashi had spent some time exploring the island in 1994-95 in the hope of identifying Selkirk's campsite. In 2001 he was shown the overgrown traces of a building at Aguas Buenas by an elderly islander. The latter had discovered these in 1955 and they had remained unknown and unvisited ever since. Takahashi realised that the location corresponded well with his views on where Selkirk's campsite might be located and believed that the ruins were worthy of further examination.<sup>2</sup> With sponsorship from the National Geographic Society, Washington DC, USA, excavations were undertaken in early 2005.

## ROBINSON CRUSOE ISLAND

This island lies about S 33° 38', W 78° 50' in the South Pacific, over 400 miles west of Valparaíso (Fig.1). It is one of three islands, volcanic in origin, in the Juan Fernandez Archipelago, and the only one that is permanently inhabited, with a population of about 500. It used to be known as *Mas-a-Tierra* but was renamed Robinson Crusoe Island to commemorate the stay of Alexander Selkirk. Confusingly, the other main island in the group, *Mas Afuera*, some 90 miles to the west, has been renamed Alexander Selkirk Island, even though Selkirk never set foot there. The third island, Santa Clara Island, is only about one mile by two miles and lies close to the west end of Robinson Crusoe Island. There is no historical or archaeological evidence

for human occupation on any of the islands prior to their discovery by Europeans in the late 16<sup>th</sup> century.

Robinson Crusoe Island (*Isla Robinson Crusoe*) has an area of about 58 square miles, a length east to west of about 14 miles and is under 5 miles in maximum width from north to south. It is mostly mountainous, rising to a height of 915m, and much of the coastline consists of cliffs. The only reasonably accessible point for ships is Cumberland Bay (*Bahía Cumberland*) to the north-east and here is the only settlement, San Juan Bautista. The climate is mild all year round and there is an abundance of water. There is a unique native flora, largely consisting of evergreen rain forest that has been under attack from axes and introduced species since the coming of man.<sup>3</sup> Native seals and humming birds are much in evidence, and human inhabitants have traditionally harvested the supplies of fish and lobsters around the coasts. Of introduced species the most notable are the goats left by the Spanish in the late 16<sup>th</sup> century and now largely kept under control. Most of the island is now a national park administered by *CONAF (Corporación Nacional Forestal)*.

The ancestors of the present population only came to the island in the middle of the 19<sup>th</sup> century. Before that there were various unsuccessful attempts at colonisation, and the establishment of a fort by the Spanish in 1750 with a view to curtailing the activities of European pirates and privateers. The island was unoccupied when Alexander Selkirk arrived there in 1704.<sup>4</sup> At that time it was owned along with the two other islands of the Juan Fernandez Archipelago by the Jesuits, having been gifted to them in 1667 by Juan Fernandez, a descendant of the original discoverer. They remained in the possession of the Jesuits until 1767 when they were expelled from Chile. They are said to have re-introduced goats to Robinson Crusoe Island in 1667 but there is no evidence that they established a base there or had it settled.<sup>5</sup>

Prior to this project only a limited amount of archaeological investigation had been undertaken on the island. This included some work in Puerto Inglés in 1999 by Cáceres and Saavedra with excavations inside and in front of Robinson Crusoe's Cave. They found no convincing evidence of human occupation in this area prior to the establishment of a Spanish gun battery in the middle of the 18<sup>th</sup> century.<sup>6</sup> Other work on sites at La Vaquería, Puerto Inglés, Cumberland Bay and Puerto Francés reported by Anderson *et al.* has also failed to identify remains which are likely to pre-date the mid-18<sup>th</sup>-century.<sup>7</sup> Environmental analysis of a sediment core taken on Alexander Selkirk Island has traced the impact on the local vegetation since the late 16<sup>th</sup> century of the introduction of goats, the burning of forests and the spread of introduced species. This charts a situation that must have been similar to developments on Robinson Crusoe Island.<sup>8</sup>

## ALEXANDER SELKIRK

Alexander Selkirk was born in the small seaside town of Lower Largo, Fife, Scotland in 1676, a younger son of a shoemaker.<sup>9</sup> Members of the Selkirk, or Selcraig, family feature several times in the Kirk Session Records of Largo in the years from 1693 to 1703 for fighting and drunkenness. In 1701 there was a serious scuffle in the family that involved Alexander assaulting his father and two of his brothers. His mother even expressed a desire to be separated from her husband.<sup>10</sup> Alexander was clearly a man with a temper, not happy with small town ways. He was drawn to a life at sea where he spent much of his time, finally dying aboard *HMS Weymouth* off Cape Coast, Ghana, on 13 December 1721.

He apparently first went to sea in August 1693 to avoid the wrath of the Kirk session 'for indecent carriage'.<sup>11</sup> Where is not clear. A modern author suggests, but with no supporting evidence, that he might have taken part in Scotland's disastrous attempt to establish a colony on the Panama isthmus, the ill-fated Darien scheme.<sup>12</sup> There is, however, a clue contained in a 19<sup>th</sup>-century inventory of jewellery, etc at Drummond Castle in Perthshire:

'an inkholder said to have belonged to daughter of the Sophy of Persia, captured on her way to be married to the Grand Mogul by a pirate in a ship also containing Robinson Crusoe, to whom she gave it and he gave it to Robert Lundin of that ilk'.<sup>13</sup>

This refers to one of the most famous piratical adventures of all time when a group of English ships led by Henry Avery attacked and captured the *Ganj-i-Sawai*, a treasure ship belonging to the Moghal emperor of India in the mouth of the Red Sea on 8 September 1695.<sup>14</sup> The inkwell to which the tradition was attached by the 19<sup>th</sup> century was of later date but this does not necessarily invalidate the memory that there was such a gift.

The Selkirk family squabble in November 1701 is the only evidence for Alexander's return home, and it is not known how soon after this he was off to sea again. Certainly he sailed on the *Cinque Ports* in September 1703, one of two ships bound on a privateering voyage into the Pacific Ocean. The other ship was the *St George* under the command of William Dampier, the overall leader of the expedition. Dampier was then well known for his book *A New Voyage Round the World*, first published in 1697, recounting some of his previous experiences. Selkirk later claimed that he was master of the *Cinque Ports*, under the overall command of Captain Charles Pickering. As master Selkirk would have had the responsibility for navigating

the vessel, but a study a number of years ago by Lee of depositions made by Selkirk in 1712 for the trial of William Dampier suggests this was not strictly true. Lee believed it possible that Selkirk was recruited as a foremastman and he was encouraged to talk his role up as part of a process of casting doubt on Dampier's abilities. Lee is also sceptical as to whether a ship like the *Cinque Ports* would have had a master, this role belonging *ex officio* to the captain.<sup>15</sup> An account of the expedition, however, by William Funnell, one of the officers on the *St George*, describes how he, on behalf of Captain Dampier and the master of the *Cinque Ports* on behalf of Captain Stradling, were put in charge of a prize in May 1704. This master of the *Cinque Ports* was surely Selkirk.<sup>16</sup>

Whatever the case, the fact that Selkirk had significant interest in navigating, and ability in that field, cannot be doubted since his navigational instruments were amongst his prized possessions, and after his rescue he was appointed master of the Spanish prize the *Nuestra Señora de la Encarnación* which was sailed all the way back to England.<sup>17</sup> Selkirk's role as a navigator is of some significance as we shall show below.

If Selkirk was indeed master of the *Cinque Ports*, her captain Charles Pickering must have had evidence of, or previous knowledge of Selkirk's ability. There is one other piece of circumstantial evidence that is worth recounting in this respect and that is to do with Selkirk's sea-chest, now in the collections of the National Museums of Scotland. The chest is a fine example of a 'Spanish chest' (*cassa di Spagna*) from the Marchesato di Finale in Liguria, Italy.<sup>18</sup> The significance of this is that Pickering, as captain of a ship named the *Charles*, had been operating as a privateer out of Livorno, also in north-west Italy, prior to sailing for the Pacific.

In July 1696 Pickering had captured a rich French prize called the *Madona di Carmina* but the French brought pressure to bear on the Grand Duke of Tuscany so that one of the owners of the *Charles*, William Plowman, was imprisoned in Florence and the goods that had been seized were returned to the French. By April 1703 Pickering, now apparently no longer captain of the *Charles*, was suspected by the English authorities of selling goods under Swedish colours to the French in Marseilles. Perhaps things had by that summer got so hot for him in the Mediterranean that he had no choice but to seek opportunities in some other part of the world.<sup>19</sup>

It is possible that Selkirk's association with Pickering went back further than 1703. Perhaps it was Pickering that had Selkirk promoted to master for the voyage in September 1703. Pickering died on the passage out and was succeeded as commander of the *Cinque Ports* by Thomas Stradling, a man not popular with many of the crew, including Selkirk. The two ships made for Robinson Crusoe Island, reaching it in the middle of February 1704. Dampier had visited the island on a previous voyage and knew it was a good place for them to replenish their supplies with fresh food, wood and water and rest their crews in comparative safety before getting down to the serious business of attacking Spanish shipping and settlements.

The expedition did not prove very successful, and since Dampier and Stradling could not agree on a course of action, the two ships parted company, the *Cinque Ports* returning to Robinson Crusoe Island in September in the hope of picking up supplies abandoned the previous March. These had in the meantime been lifted by a French expedition but two of their own sailors left behind by accident rejoined the ship, giving an immediate demonstration that it was possible to live a reasonable life there



with limited resources. The ship, which was badly affected by marine worms, was overhauled.

Relations between Selkirk and Stradling now completely broke down, partly because Stradling had effectively demoted Selkirk.<sup>20</sup> Selkirk also doubted – rightly – that the *Cinque Ports* was sound enough to survive a long ocean voyage. He therefore decided to stay behind on the island by himself when the *Cinque Ports* set sail. He possibly reckoned that he would be there by himself for only a few months at most before another privateer or friendly ship came along.<sup>21</sup> In fact Selkirk was to be alone on the island until February 1709 when another privateering expedition from England, this time under the command of Captain Woodes Rogers, visited the island. Woodes Rogers' account of his voyage is one of the main sources of information on Selkirk's stay. He describes how he had with him his clothes and bedding, a gun with some gunpowder and bullets, tobacco, a hatchet, a knife, a kettle, a Bible, 'some practical pieces', and his mathematical instruments and books.<sup>22</sup>

In December 1713 the English writer Richard Steele published a brief essay on Selkirk which contains similar information to that given by Rogers and which may, indeed, be largely derived from Rogers' account. We should nevertheless believe Steele's statement that he met him on several occasions. Steele lists Selkirk's possessions when he was abandoned on the island as a sea-chest, his wearing clothes and bedding, a gun, a pound of gunpowder, a large quantity of bullets, a flint and steel, a few pounds of tobacco, a hatchet, a knife, a kettle, a Bible, and other books of devotion; together with pieces that concerned navigation, and his navigational instruments.<sup>23</sup>

According to Rogers it took Selkirk eight months to get over his fear and depression but eventually he settled down to lead a reasonably happy life, reading his

Bible and becoming a better Christian than ever before (or indeed later) in his life. He built two huts, one for use as a kitchen, the other as a dwelling. They were constructed with 'piemento' trees, covered with long grass and lined with goatskins. Which of the native species were 'piemento' trees is by no means certain, but on the basis that Selkirk also used their fruits as a substitute for pepper, they may be identified as naranjillo (*Fagara mayu* (Bertero ex Colla) Engler). Steele only mentions one hut and says that it was beside a substantial wood.

He found plenty to eat, especially goats which he first shot and eventually learnt to outrun. There were lobsters (crayfish) and fish in abundance, though he was not keen on the latter, and also turnips planted by previous visitors and the leaves of the 'cabbage trees' (*Dendroseris litoralis* Skotts.). During his stay on the island several ships passed by but only two came into anchor. They were Spanish and Selkirk was lucky to escape capture. By the time he was picked up by Woodes Rogers' expedition he was clad in goatskins and had difficulty stringing together sentences.<sup>24</sup>

There is no precise description in Roger's book of where exactly Selkirk lived, but it must have been fairly accessible from Cumberland Bay on the north side of the island, then and now the only reasonably sheltered point where ships could anchor in safety for any length of time. Rogers provides the circumstantial information that Selkirk lived in the mountains, and he could apparently see from there to the south end of the island which was 'plainer' – that is not covered with forest. There were many goats there but he could not get to them because the way down was so steep and rocky. Selkirk had probably also been able to see the ships approaching from west-south-west and heading up past the east end of the island at a distance of 12 or more miles. In any case he was well prepared to light a fire down by the water's edge to

attract the attention of the expedition's pinnace as it approached on the evening of 31 January.<sup>25</sup>

All this suggests that Selkirk must have based himself near a hollow in the ridge of mountains that forms the backbone of the island (Fig.2). This spot is identified as Selkirk's lookout on a plaque erected there by the officers of a British Navy ship, the *HMS Topaze*, in 1868. There is evidence of an old path that climbed to this spot from Cumberland Bay (Fig.3). There are at least three large boulders on its route which are cut with inscriptions, including the name Pedro Arredondo, identified as the ancestor of some present day islanders, and the date 1866, showing that the path was there by the time of the *Topaze's* visit. Selkirk's lookout appears to be the only reasonably accessible point from which it is possible to see down over Cumberland Bay and also south-westwards over the sea in the direction from which other ships might come to the rescue.

Nowadays there is a modern path which zigzags from the Lookout (*El Mirador*) down through a steep, narrow, wooded valley known as Villagra and from there to the airstrip at the west end of the island. Without the path Selkirk may have found it too difficult to get beyond the Lookout. He would, however, have been able to see a considerable stretch of the west end of the island, then as now probably largely unforested. An English map of the island made in 1681 is orientated as if the west end is to the south and marks it as the 'Goat Quarters'.<sup>26</sup> Selkirk would certainly have been able to see goats from the Lookout away in the distance beyond Villagra.

All this suggests that Selkirk was largely confined to the hinterland of Cumberland Bay. He may not even have found it practical to get over the mountain ridge into Puerto Inglés where 'Robinson Crusoe's Cave' is traditionally said to have been used by him. The site at Aguas Buenas is on the old path to the Lookout (Fig. 3).

Using early sources and basic observations on the placing of human settlements, Takahashi had come up with the following list of criteria for the probable location of Selkirk's campsite:

1. proximity to fresh water
2. readily available food
3. level ground
4. shelter from sun and rain
5. access to a viewpoint to look for ships approaching from the north and the south.

The site at Aguas Buenas (Fig.4) is adjacent to a good supply of freshwater – a vigorous stream that tumbles down the valley to the sea in Cumberland Bay. The surrounding forest still provides many things to eat and in Selkirk's day was probably full of goats. There was enough level ground to erect one or two huts and the spot was reasonably sheltered. Some naranjillo trees still grow in the area. There is a good view over Cumberland Bay and the Lookout could be readily reached, perhaps in less than thirty minutes by a fit man. The trip down to the shore at Cumberland Bay need have taken no longer, but Selkirk seems, in any case, to have been less interested in utilising maritime food resources.

For all these reasons Aguas Buenas seemed a good place to look for traces of Selkirk's stay on the island, although it was clear from the start of the archaeological work that the chances of finding such evidence were very limited.

## AGUAS BUENAS

The site at Aguas Buenas is in endemic forest. Its GPS location is 33°38' 19.1" S by 78° 50' 47.1" W at a height of 274m above sea level. It consists of a piece of ground about 12m E-W by 7m N-S terraced into a gentle slope. It appears that there was a small piece of level ground here the size of which has been increased by the removal of a large mass of soil, estimated to be as much as 150 tons. Around the south and west ends can be seen the quarry face left by the workers when they finished the job (Fig. 5). To north, south and west a ridge of mountains, including the Lookout, forms the horizon. To the east the ground slopes down gently revealing a view over Cumberland Bay. The ground slopes away more steeply westwards and southwards to a stream, a tributary of the river that flows into the sea in the village of San Juan Bautista. The trees are less dense at the site than in the surrounding forest, with an absence of mature specimens, suggesting the presence of a clearing in the past. At the east end of the level ground, prior to excavation, the ruins of a rectangular building could be seen, about 7.5m E-W by 5m N-S, the walls apparently of stone and standing little more than 0.5m high (Fig. 6).

## THE ARCHAEOLOGICAL INVESTIGATION

Fieldwork was undertaken in January and February 2005 by Takahashi, Caldwell, Cáceres, Calderón and Saavedra. With permission from CONAF and the National Monuments Council (*Consejo de Monumentos Nacionales* (CMN)) the site was first of all cleared of non-endemic vegetation. This still left a significant number of trees and saplings, mostly luma (*Myrceugenia fernandeziana* (Hook. & Arn.) Johow), in and about the ruined building. Fieldwork was divided into two stages. Firstly, from 13

to 18 January initial planning was done of the site and small trenches (1 to 5) excavated outside the building to test for archaeological deposits and as a guide to where to place the main trenches. From 26 January to 10 February excavations (trenches 6 to 12) were undertaken within the building and the area immediately adjacent to it.

Surveying and planning were undertaken with a limited range of equipment – a 5m and a 30m tape, a line level, string and two ranging rods. Planning was achieved by triangulation, using trees as fixed points. Levels were all related to a site bench-mark assigned a value of 274m above sea level. Cross-checking would indicate an accuracy for levels of  $\pm 100\text{mm}$  or better.

An initial survey of the whole area including the building was made with a metal detector, and ‘hits’ marked, but not excavated. It was hoped that this might provide some useful clues as to where to locate trenches. In the event, trench 3 was laid out partially to check a group of hits but it is probable that the machine readings were of a geological nature.

All deposits excavated in trenches 1 to 8 were sieved and all artefacts, including fragments of tile and brick, retained. The deposits in trenches 9 to 12 were sieved more selectively and only representative pieces of tile and brick kept. Soil samples were taken from occupation deposits and features for possible dating and archaeobotanic analyses.

All contexts – deposits, walls, post-holes, etc – have been given a four or five digit context number, the first one or two digits being the number of the trench in which the context was encountered. For this report, contexts which demonstrably stretch through more than one trench are generally referred to by a unique context number. A Munsell Soil Colour Chart was used for describing the colour of deposits.

## STAGE 1

### TRENCH 1

A sondage, half a metre square, excavated at the west end of the site (Figs 5 and 7), exposed a thin layer of topsoil [1001] overlying natural clay [1003]. There is a cut in the natural, back-filled with silty clay [1002]. This is interpreted as the result of quarrying to create the level area of the yard and to provide clay for the construction of the building. The natural here and elsewhere on the site consists of clay with some silt and small angular stones, varying in colour from dark yellowish brown (10YR 3/4) to dark brown (10YR 3/3).

### TRENCH 2

A sondage, half a metre square, positioned near the south-west corner of the building, exposed a more complex sequence of deposits than was evident in trench 1 (Figs 5 and 7). There is a relatively new layer of topsoil [2001] overlying a thick deposit of sandy silt [2002-2003], perhaps material washed from the wall of the building. Under that is an earlier ground horizon [2004] on top of natural [2005].

### TRENCH 3

This trench was located towards the west end of the site and was about 1m by 2m, orientated approximately N-S (Figs 5 and 7). A thin layer of topsoil [3001] covers a subsoil deposit [3002] containing fragments of roof tile from the ruin of the building. It overlies natural clay [3004] with crumbly rock [3003]. This appears to be a natural soil profile developing after the abandonment of the building.

#### TRENCH 4

A metre square sondage was excavated down slope of the east end of the building in the hope that debris from the building or other occupation deposits might be recovered (Figs 5 and 7). The deposits consist solely of topsoil [4001], subsoil [4002] and natural clay [4003], with a few fragments of tile and brick in 4001 and 4002.

#### TRENCH 5

Another metre square sondage to the east of the building but closer to it than trench 4 (Figs 5 and 7) produced an identical sequence of deposits: topsoil [5001], subsoil [5002] and natural clay [5003]. There are fragments of tile and brick in 5001 and 5002.

Excavation of these trenches provided little clue to the function of the building. The ceramic material from the trenches and recovered as surface finds – roof tiles, bricks



and pottery – tended to suggest a date in the 18<sup>th</sup> or 19<sup>th</sup> century, almost certainly all later than Selkirk’s stay on the island. It also seemed reasonable to conclude that the levelling of the site, perhaps to create a yard, was likely to be associated with the use of the building. It would have removed any earlier traces of occupation. It was therefore decided in stage 2 to concentrate attention on the building itself with the intention of explaining its purpose and date, and hopefully uncovering earlier occupation deposits preserved underneath it.

## STAGE 2

### TRENCHES 6 & 7

Trench 6, 1m by 2m, was laid out in the south-west corner of the building (Figs 8 and 9). Its excavation demonstrated that there is a metre or more of debris, earth and stones [6001-6004] from the collapse or destruction of the building (Figs 10 and 11). The walls of the building are of clay, faced inside and out with stone, mostly ‘field stones’, undressed, locally gathered and of a size and weight that could readily be handled by individual men (Figs 7 and 12). The walls are about 1m thick and survive to a height of over 1m above the level of the floor internally. No actual floor surface was found but only the upper surface of the natural clay [6007], scarped to form a level surface for a floor. A small sondage was dug into 6007 for a depth of about 0.5m revealing that the natural here was mottled rather than flecked with small stones. Neatly sectioned by the east baulk of the trench was a shallow, circular, basin-shaped

pit [6006] containing a deposit [6005] of dark brown silt with many small pieces of charcoal (Fig. 13).

Trench 7, contiguous with the east side of trench 6 and with an area of 2m by 1m, was opened, thus exposing the whole area of feature 6006 (Figs 8 and 9). It is 0.7m by 0.8m with a depth of up to 0.2m. It is interpreted as a hearth of earlier date than the building, the upper part of it, and the associated living surface, having been removed during the levelling for the floor of the building.

## TRENCHES 8 & 9

The next trench to be opened was trench 8, 2m E-W, and extending the full width of the building (Fig. 8). It was placed over what was supposed to be the position of the east wall and entrance into the building. This turned out to be the case. The entrance is located centrally in the east wall, is slightly over 1m wide, splaying internally to a width of 1.8m. The original floor surface survives in the entrance as rough paving, extending eastwards beyond the entrance into the area of a porch formed by two flanking buttresses, the 1m long extensions to the building's north and south walls. There is a clear break in the paving, probably a slot [8006] for the timber of the doorway, 0.25m wide, running the full width of the threshold. It was not excavated (Fig. 14).

Trench 8 was extended westwards into the interior of the building as trench 9, with an E-W width of 1m (Fig. 8). This demonstrated that the paving in the entranceway does not continue beyond the thickness of the east wall. The floor level in the interior was clearly at a higher level, at least 0.01m higher, and about 0.02m if the floor was

paved with the bricks of which many fragments were found in the debris within the ruins. Only a few bricks were actually recovered lying flat on the make-up level for the floor. Although the evidence for a brick floor is not overwhelming there is no other obvious explanation for the quantities recovered from the excavations.

The paving in the entrance was left in place, but excavation below the floor level in trench 9 revealed further evidence of earlier occupation of the site (Figs 15 and 16). Only half exposed, since the rest of it is stratified under the paving, is a hearth [8016] with a complex sequence of deposits of ash, charcoal and small fragments of burnt bone (Figs 17 and 18), from top to bottom as follows:

8010: ash and charcoal, yellowish brown in colour (10YR 5/8) with small fragments of burnt bone, maximum thickness 50mm.

8011: powdered, black charcoal (10YR 2/1), maximum thickness 10mm.

8012: ash and charcoal, dark red in colour (2.5YR 3/6), maximum thickness 40mm.

8013: powdered charcoal and ash, black in colour (10YR 2/1), maximum thickness 35mm.

8014: powdered ash, dark reddish brown in colour (5YR 3/3), maximum thickness 30mm.

Like hearth 6006, 8016 appears to be a shallow, basin-shaped hollow. It has a diameter of about 1.1m and it is possible that some smallish stones around its rim served as a kerb. These stones lay over a thin layer of sandy silt [8015] also surrounding this hearth. From 8015 was recovered a small copper alloy artefact, identified as the point from a pair of dividers.

A sample from 8010 in the hearth was submitted to Carolina Belmar and Luciana Quiroz for archaeobotanical analysis. A summary of their report is given below, but here it may be noted that the plant remains recovered appeared to represent local weeds and plants with no bias towards those that might have been exploited for food or other uses by humans.

A sample from 8012 in the hearth was submitted to the Beta Analytic Radiocarbon Dating Laboratory in Miami, Florida for dating. The calendar calibration for this sample is complex, providing multiple calendar range segments. The sample data is as follows:

Laboratory sample number: beta-203314

Analysis: AMS-Standard delivery

Material/Pre-treatment: (charred material): acid/alkali/acid

Measured Radiocarbon Age: 270±40 BP

<sup>13</sup>C/<sup>12</sup>C Ratio: -25.6 ‰

Conventional Radiocarbon Age: 260±40 BP

2 Sigma Calibration: Cal AD 1520 to 1590 (Cal BP 430 to 360) AND Cal AD 1620 to 1670 (Cal BP 330 to 280). Cal AD 1770 to 1800 (Cal BP 180 to 150) AND Cal AD 1940 to 1950 (cal BP 10 to 0).

Interception of the radiocarbon age with the calibration curve gives a date of AD 1650 (Cal BP 300), and a 1 Sigma calibrated result (68% probability) of AD 1640 to 1660 (Cal BP 310 to 290).<sup>27</sup>

Hearth 8016 is partially cut by the foundation trench [8009] for the building's east wall, demonstrating that it was no longer in use during the initial stages of the

building's construction. It is set into the surface of 9011-9012 – or 8017-8018, as it is labelled in the trench 8 sequence. This complex layer of silty clay is dark brown (10YR 4/3) in its upper part, changing, without any distinct break, to dark yellowish brown (10YR 4/4) in its lower part. It is interpreted as the old ground surface containing an A and a B horizon. It directly overlies the parent material, in archaeological terms, natural clay [8019/9019]. This old ground surface is present in trenches 8 and 9 but not in 6 and 7 because the ground falls away quite steeply in an easterly direction (Fig. 19). Whereas the builders had to cut into the natural at the west end of the building to create a level surface for the floor, further east they had to dump clay on to the ground surface. This is layer 9006 (also labelled 8007), a compact layer of silty clay with small stones. It is, essentially, re-deposited natural, pressed firmly into place.

Further indications of human activity prior to the construction of the building were discovered in trench 9, and also in an extension to trench 9, about 1m square, added on its west side. Firstly there is the evidence for a group of small post- or stake-holes (Figs 16 and 20). One of these, 9014, could clearly be traced by its darker fill [9013] showing against the dark yellowish brown of 9012 (Fig. 15). This indicates that it was dug from the old ground surface that supported hearth 8016. It has a diameter of about 140mm and is cut into the natural clay for a depth of about 100mm. Its original depth when dug, however, would probably have been about 300mm. Its fill [9013] consisted of clay, with some silt.

At least two other post-holes [9016, 9018] were tentatively identified as shallow cuts in the natural clay, 9019. It is possible that all three post-holes represent part of the side of a structure supported on a wooden framework.

Also pre-dating the erection of the building is a thin deposit of dark brown (7.5YR 3/2) powdered ash [9009] set in or on the old ground surface 9011, encountered in the trench 9 extension, and to a lesser extent in trench 9 adjacent to the north wall of the building (fig. 19). It is not clear if it might have been cut away by the digging of a foundation trench for the north wall, in which case it might be the tenuous remains of another hearth. Perhaps a more likely interpretation is that it represents ash cleared from hearth 8016 and dumped down the hillside.

With the excavation of trench 9 and its extension it became clear that much of the interior of the building had had a large pit or trench dug into it when already choked with debris from its collapse. It was back-filled soon afterwards, mostly with a mixed deposit of silty clay containing many fragments of brick and roof tiles. This deposit is identified in trench 9 as 9004, elsewhere as 8002, 7004 and 6004 (figs 10, 11 and 19). This pit extended up to the west and south walls of the building, cutting below the floor level in places. Fortunately, an area was left unaffected at the east end of the interior. The edge of this pit was traced in trench 9 running approximately NNE- SSW and cutting through 9012 to the natural clay. It can also be seen in the N-S section of the trench 9 extension cutting through the clay [9005] slumped from the north wall, the make-up for the floor [9006], and into the old ground surface [9011]. The date and purpose of this excavation is unrecorded.

## TRENCHES 10 & 11

The area to the east of the building's entrance was opened up as trenches 10 and 11 in order to explore the porch and the extent of the paved surface (Figs 8 and 14). It was

not possible to dig all of this owing to the presence of indigenous trees, but eventually the margins of the paving were uncovered, lying under a thin layer of topsoil. Overall, it forms an area the full width of the building (5.5m) and slopes down hill for almost 2m in front of the entrance. From its surface and within the area of the entrance were recovered several sherds of an earthenware storage vessel, glazed internally. Perhaps because they had not been dug up and smashed by the excavators of the pit within the building there were also many more substantial pieces of roof tile here.

## TRENCH 12

This trench, about 1m by 1.5m, was excavated adjacent to the exterior of the south wall of the building, as an extension at the south-west corner of trench 11 (figs 8, 14 and 21). The intention was to check for the presence of earlier occupation deposits outside the building. A recent topsoil [12001] and subsoil [12002] was found overlying the silty clay [12003] collapse from the wall and a compressed layer of roof tiles [12004] that had slid off the roof. An earlier ground surface [12009-12010] was covered by a layer [12008] of re-deposited natural clay, perhaps something to do with the building operations. It had been cut through by the foundation trench [12006] of the south wall. To the south of the trench it had been worn away, perhaps, rather than cut, and replaced by a deposit [12007] of silt and small stones, representing the path that ran up the side of the building.

## THE FINDS

The finds have all been lodged in the Museum in San Juan Bautista.

## ROOF TILES

No whole examples of roof tiles were recovered but when complete they were about 220mm in width and greater in length than 430mm. They are of red earthenware and have a curved profile, giving them a maximum height of about 50mm. They could all belong to the one batch from the one kiln. Fragments were found in all trenches apart from 1 and 2 with heavy concentrations in trenches 10, 11 and 12, apparently lying where they had fallen off the roof of the building. Fragments of similar tiles can be found around the ruins of the fort in San Juan Bautista, built by the Spanish in 1751 and garrisoned until 1837.

## BRICKS

Fragments of red bricks were recovered in all trenches except 1 and 2. They were mostly in the deposits within the building, with some lying at floor level. The bricks when whole were about 135mm by 270mm by 45mm. If, as suggested above, they formed the floor of the building, there would have been about 404 of them. At least one appears to have been cut neatly, diagonally, perhaps indicating that they were not laid parallel to the walls.



## CERAMICS

A total of 75 sherds of pottery were found, some in clearing the vegetation from the site, the rest from the trenches, all except trenches 5 and 12. The sherds from the trenches within the walls of the building were all from deposits backfilled or collapsed in and over the pit dug through its ruins.

The following notes are derived from a report prepared by Daniela Baudet and Lorena Sanhueza.**28**

### *Monochrome pottery*

26 sherds of monochrome pottery were found. By monochrome is meant plain, earthenware, made by hand without the use of a wheel. This traditional way of making pottery continued after the Spanish conquest of Chile. It is often difficult to tell whether such earthenware, commonly found on archaeological sites, is of pre- or post- Hispanic manufacture. Systematic archaeological studies in the past few years of historical contexts with ceramics have, however, determined certain morphological, technological and decorative differences between pre- and post-hispanic pottery. They have also allowed certain conclusions on the origin of different types. The minerological inclusions of volcanic origin visible in many of the sherds from Aguas Buenas suggest that they could have been made on the island.**29**

### *Lead glazed earthenware*

9 sherds of lead glazed earthenware were recovered. They are typical of Hispanic assemblages from historic sites of the central zone of Chile, mainly in urban areas.<sup>30</sup> Findings of this type in other areas of the island have previously been reported.<sup>31</sup> They are of Spanish-American origin, though the precise source of these sherds is still under investigation. Lead glazed earthenware manufacturing sites seem to have been widespread throughout South America during the Colonial Period.<sup>32</sup>

#### *Earthenware storage vessels*

A total of 31 sherds were recovered. Of these, 18 sherds appear to come from the one vessel called a *botija* in Spanish, approximately 30cm to 40cm in height with a flat base, everted rim, and green glaze on the interior. On typological grounds it can be dated to the 18<sup>th</sup> century.<sup>33</sup> Another 13 sherds are from thick walled vessels (15mm to 23mm in thickness). Although abraded, many have traces of a black resin on the interior. Such vessels were used from the 16<sup>th</sup> to the 20<sup>th</sup> century for the transport, trade and storage of food and other products.<sup>34</sup>

#### *Stoneware*

Nine sherds of whiteware with a colourless glaze, probably English, 19<sup>th</sup> century.<sup>35</sup>

#### NAILS

The remains of nine iron nails were recovered, eight of them with shanks that are rectangular in cross-section. The most complete (no 3) had a length of over 165mm. Two of them (nos 3 and 5) were found in the topsoil covering the paved surface in front of the building, the rest in the debris filling the building. Most came from the vicinity of the entranceway and may have served originally to secure the timber of the door and its frame. A small length of iron, about 23mm in length and circular in cross-section may be the remains of a ninth nail. It was recovered in trench 9 from the backfill [9004] of the pit dug through the collapse and deposits filling up the interior of the building.

#### A COPPER ALLOY TIP – FROM A PAIR OF DIVIDERS?

A small piece of copper alloy with various layers of rather powdery green/blue/grey corrosion was recovered from deposit 8015, a thin layer of sandy silt surrounding hearth 8016 (Figs 22 and 23). It is about 16mm long and has a square cross-section at one end about 3mm by 3mm. Here it appears to have been cleanly broken before the on-set of corrosion. From this end to the other it tapers on three of its four sides to form a point.

The sure identification of such a fragment is difficult. It is not unlike the tip of a pin from a buckle, or the shaft from a rivet or a nail. The particular way it tapers, however, suggests that it is from a pair of dividers. Another similar tip could be positioned alongside, the two together forming a single point. Other early dividers have legs which are either triangular in cross-section or rectangular as with the fragment from Aguas Buenas.

It was submitted to the Analytical Research Section of the National Museums of Scotland for examination in May 2005. The resulting report is summarised here:

*XRF and SEM examination of copper alloy fragment from Aguas Buenas.*

*Analytical Research Section Report No. AR 06/25 (C&AR 13214)*

By Jim Tate

The copper alloy tip from Aguas Buenas was examined along with seven pairs of dividers, five of which came from the collections of the National Museums of Scotland:

- three pairs of dividers (Fig. 24) from HMS *Dartmouth*, sunk off the Island of Mull, Scotland, in 1690 (reg. nos HXD 381, HXD 326 and HXD 327).
- dividers from an unidentified shipwreck at Duart Point off the Island of Mull, Scotland, (unreg.).
- German made dividers, unsigned, mid 18<sup>th</sup>-century (reg. no T.1985.79).
- two pairs of dividers, thought to be European (Nuremberg?) 16-17<sup>th</sup> century (Private collection, D. Coffeen).

The physical form of the fragment was similar to the points of the HMS *Dartmouth* dividers HXD 381 and HXD 327, although each of these has a more triangular cross section. The other instruments had finer pointed legs and again triangular or semi-circular cross sections. Physically the fragment was in a considerably more unstable and corroded state than any of the complete instruments.

The tip was first examined under a low power optical microscope. Surface analysis was then undertaken using X-Ray Fluorescence (XRF) to determine the main alloy components.<sup>36</sup> The whole fragment was then examined in a Scanning Electron Microscope (SEM) to look for surface detail. The SEM examination also included some further Energy Dispersive X-ray analysis (EDX).<sup>37</sup> Following this examination a small area of the surface was cleaned and re-analysed by XRF and SEM-EDX.

The complete dividers were analysed in a number of places using XRF with no surface preparation. The averaged results of these semi-quantitative analyses are given in table 1.

	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb
<i>Fragment</i>	2.6	0.0	81.1	0.4	1.4	0.4	0.1	13.9	0.2
	5.2	0.0	87.1	0.7	0.5	0.3	0.0	6.3	0.0
<i>HXD 327</i>	0.7	0.0	74.4	22.0	0.0	1.3	0.1	1.4	0.0
<i>HXD 381</i>	0.9	0.0	67.8	25.9	0.1	1.0	0.4	3.8	0.1
<i>HXD 326</i>	0.4	0.0	69.8	28.3	0.0	1.0	0.1	0.3	0.0
<i>Duart</i>									
<i>Point</i>	0.7	0.0	69.7	28.3	0.0	1.0	0.2	0.3	0.0
<i>Coffeen</i>									
<i>1</i>	0.2	0.5	71.9	27.0	0.1	0.3	0.1	0.0	0.1
<i>Coffeen</i>									
<i>2</i>	0.3	0.3	70.4	28.8	0.1	0.2	0.1	0.0	0.0

Table 1: average surface analysis XRF data from the Aguas Buenas fragment and complete instruments.

XRF has the great advantage that it is non-destructive: however it has the disadvantage that only the surface composition can be determined, *ie* the material within the upper 0.1mm or less. This means that the analyses include surface corrosion and any changes to the body metal from chemical alteration or cleaning. Following the surface analysis it was therefore agreed that the end of one flat face of the sample could be lightly cleaned to reveal the underlying metal. The area (about 2mm by 2mm) was abraded using fine silicone carbide paper (final surface 1000 grade) and then polished with diamond paste to get a reasonably clean and smooth surface. However it was clear that the corrosion was deeper than it was possible to polish without removal of an unacceptable amount of metal, so pitted areas remained.

Figure 25 shows the cleaned area as examined in the SEM, back-scatter detector (BSC) images at increasing magnification. The variation in grey indicates different atomic number composition: the areas of corrosion pitting are dark grey, with medium grey showing as an oxide layer (where the corrosion has not been fully removed). The pale grey is the underlying metal alloy. Isolated areas where corrosion remains show sulphur and chlorine. The small bright spots are bismuth.

Inspection of the higher magnification image in figure 25 shows bands of alternating phases which have different amounts of tin in the copper alloy. Areas of lead lie mainly between these bands (although it was not possible to distinguish unambiguously between lead and sulphur corrosion), while small areas rich in bismuth show up as bright spots, occurring in the tin-rich phase.

The analytical results from the cleaned surface obtained by XRF are given in table 2.

	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb
XRF Analysis	0.1	nd	91.6	0.3	0.4	0.2	nd	7.2	tr

Table 2. XRF data for cleaned area. Various parts of this area were also analysed by SEM-EDX confirming the presence of variable levels of tin, as well as the other metal impurities

Three separate copper alloy standards were analysed at the same time as the sample and the instruments. The full results are not presented here but can be found in the internal report.

#### Discussion

The analyses presented here clearly show that the metal fragment is bronze, different in composition from the complete dividers examined which were brass, (or a further example which was in fact steel decorated with brass and is not included in the data here). Although two of the dividers (HXD 327 and HXD 381) do contain tin above 1%, the levels are less than the surface analyses of the Aguas Buenas fragment. The tin level in the fragment is lower in the polished area, illustrating the extent of surface corrosion. There are differences in other elements, but most fundamentally it is the high levels of zinc in all the complete instruments which show that they are basically brass rather than bronze.

The surface analyses of the corroded sides of the fragment showed higher levels of tin and arsenic than from the metal with the surface layer removed. This is most likely to be because of the corrosion process (the iron level also drops, and is assumed to be contamination from burial soil included in the corrosion surface). The tin and arsenic levels of the broken end are midway between the sides and the clean metal: this could

indicate that the break occurred after the sides had already started corroding, although it would be unwise to read too much into the differences as all the analyses were from rough surfaces providing less than ideal analytical conditions.

The SEM EDX maps show clearly the presence of small, distinct, amounts of bismuth. This could not be quantified in the XRF analyses, but was estimated to be similar to the amount of lead, *ie* less than 0.5%. Bismuth does not normally occur in significant quantities in copper alloys, however its presence in 18<sup>th</sup>-century Cornish copper has been reported by Craddock and Hook.<sup>38</sup> They note that the presence of up to 1% Bi would lead to a brittle alloy (*ie* copper containing bismuth rather than bronze).

The structure of the metal shown in the SEM images suggest that it is cast rather than heavily worked.

## Conclusions

The *Aguas Buenas* fragment is bronze, different in composition from the small number of dividers which it has been possible to analyse in the early stage of this project, each of which was brass (or a mixed alloy predominantly brass). The sample size of comparison instruments is far too small to draw any definite conclusions, and it may well be that further analyses reveal other early dividers made from a similar bronze. As a further comparison we note however that analysis by NMS of 177 individual components of 8 astrolabes from the 11<sup>th</sup> to the 18<sup>th</sup> century were all brass (with zinc levels typically above 20% and always above 10%).<sup>39</sup> Analysis of 58 large copper-alloy brooches of a form typical of Late Medieval Highland Scotland (one of which was recovered from the wreck of HMS *Dartmouth*) also showed that they were all brass, with an average of 25% zinc.<sup>40</sup> From analyses of 31 Scottish Late Medieval



cooking pots, only 1 had a composition close to that of the *Agua Buena* fragment.<sup>41</sup> Other published data on early scientific instruments shows the prevalence of brass, initially from Germany, Holland and Sweden, with increasing amounts of zinc.<sup>42</sup> The conclusion is that the use of bronze for scientific instruments of this type or for decorative brooches in Scotland at this period is unusual.

The bronze composition, containing bismuth, could indicate that the copper came from Cornwall, where a bismuth containing alloy was known to have been exploited in the 17<sup>th</sup> century.

The presence of bismuth may make the alloy brittle and hard: possibly why it has broken quite cleanly, with no obvious distortion or bending of the remaining fragment.

The cross-section shape of the fragment is similar, but does not closely match, the pointed end of the legs of the dividers examined. Again the comparative samples are too few to draw any firm conclusions.

## REPORT ON SOIL SAMPLE FROM HEARTH 8016 **43**

By Carolina Belmar P. and Luciana Quiroz I.

### *Methodology*

A 2.8 litre soil sample was submitted for environmental sampling. The sample came from context 8010, a layer about 50mm thick of yellowish brown ash and charcoal, with small fragments of burnt bone, none of which was identifiable. Context 8010 is the uppermost layer in hearth 8016.

The sample was processed by means of flotation with the intention of recovering plant remains, particularly fruits and seeds. Flotation results in minimal damage of fragile remains. The technique involves placing the soil sample over a constant flow of water. This allows the separation of a light fraction (material that floats, like plant remains) and a heavy fraction (ceramic, lithics, bone, shells, etc.). The heavy fraction is deposited in a sieve with a 3mm mesh. The remaining sediment is washed away.

#### *Analysis of the light fraction*

The plant remains were separated from the light fraction using a binocular microscope (magnification x20). They were then identified, taking note of their completeness and whether or not they were carbonised. Identification was supported by the use of a reference collection of modern seeds and fruits and others derived from archaeological contexts, and also by consultation of appropriate text books.<sup>44</sup> Finally, taxa were grouped, as is conventional, according to their origins:

- endemic (exclusive to Chilean territory and contiguous countries)
- native non-endemic (introduced to Chilean territory before the Spanish conquest)
- accidental (foreign, introduced after the Spanish conquest).

No plant remains have been identified to species level. The remains with a strong probability of corresponding to a species have the abbreviation *cf* placed in front of the denomination (example: *cf Brassicaceae*). Remains whose identification did not reach species level are ascribed to a family (example: *Brassicaceae* sp.).

#### *Results*

A total of 41 plant remains were rescued, from which the calculation can be made that there is a density of 18.63 per litre in context 8010. 95.12% of the remains have been identified. 73.17 were carbonized.

Taxon	Condition		Total
	Carbonised	Not Carbonised	
cf. <i>Brassicaceae</i> sp.	28		<b>28</b>
<i>Silene</i> sp.		11	<b>11</b>
Seed 1	1		<b>1</b>
Seed 2	1		<b>1</b>
<b>Total</b>	<b>30</b>	<b>11</b>	<b>41</b>

Table 3: plant remains from soil sample taken from hearth 8016.

The only taxon that was not carbonised is *Silene* sp. (family, quilloi-quilloi, 11 pieces). Examples of cf *Brassicaceae* sp. (family, yuyo, 23 pieces) make up the group of carbonised remains. Two seeds were also carbonised. Both belong to taxa corresponding to herbaceous plants, probably common weeds. The presence of these carbonised remains may result from the burning of wild herbaceous plants and weeds along with grass, not necessarily intentionally. The two seeds, however, might have been carbonised elsewhere. This can be deduced from the fact there are only two, their size, and the type of plant they come from.

### *Conclusion*

Given the imprecise identification of the few plant remains recovered in this deposit it is difficult to conclude that they have any link with any economic activity. Rather they may result from the burning of herbaceous plants and weeds of no economic use. There is no evidence for the processing of vegetable resources.

## **INTERPRETATION**

Three phases of human activity can clearly be distinguished at Aguas Buenas.

### **PHASE 1**

A small level piece of ground was occupied by one or more men, probably of European origin, some time prior to the mid 18<sup>th</sup> century. The calibrated radiocarbon determination from a piece of charcoal in hearth 8016 suggests that a date about 1640 to 1660 is quite likely. The piece of wood that was carbonised may have been long dead or have included core material from a trunk, and could thus give a date many years earlier than the date of the fire that consumed it. The mid 17<sup>th</sup>-century is essentially a *terminus post quem* date, though on this basis we might not expect the fire to have been lit much later than the early years of the 18<sup>th</sup> century. There is evidence for two hearths which might represent the activities of more than one person or two distinct episodes of different date. The post-holes suggest the presence of some form of shelter. Historical sources provide us with a limited range of possible residents in the years from the mid 17<sup>th</sup> to the mid 18<sup>th</sup> century. Most who came to the

island were visitors seeking to stock up on supplies, repair their ships or rest sick men. They stayed a few weeks at most and probably did not venture far from Cumberland Bay except to cut wood and hunt goats. There was no requirement for any of these visitors to camp or settle far from the bay other than those who were renegades and castaways abandoned by their shipmates.

Apart from Alexander Selkirk, the most likely candidates are:

1. A Miskito Indian called Will, abandoned by mistake in 1681 at Puerto Inglés by English privateers. He was rescued by another English expedition in 1684 and is generally considered to be the prototype for 'Friday' in Defoe's *Robinson Crusoe*.<sup>45</sup>
2. A group of five English buccaneers and four negro boys left on the island at their own request in 1687 by the same buccaneering expedition that had picked up Will the Miskito Indian. They had gambled away their share of the prize money and hoped to be picked up by the next expedition to land on the island so that they could have another chance to make money. They were provided with a small boat, a porridge pot, axes, machetes, corn seed and some other provisions. They were eventually rescued by an English privateering expedition under Captain John Strong in 1690.<sup>46</sup>
3. Two men contrived to escape in 1719 from the privateering voyage led by Captain John Clipperton and Captain George Shelvocke but were picked up after two months by a ship sent by the Spanish Viceroy of Peru.<sup>47</sup>
4. In May 1720 Captain Shelvocke's ship the *Speedwell* was wrecked in Cumberland Bay, but he and his men managed to escape in October in a boat they built themselves from the wreckage of the *Speedwell*. Eleven or twelve renegades, with a similar number of Blacks and Indians, had deserted the main

party while on the island, and refused to leave the island with the rest.<sup>48</sup> They had been removed by the Spanish by early 1722.<sup>49</sup>

If the metal tip from Aguas Buenas is part of pair of dividers then it is of crucial importance in identifying the early occupant of the site. Only a ship's master or navigator is likely to have had such an instrument. Of all those renegades and castaways known to have been abandoned on the island only Selkirk held such a position, had such skills. What is more, he is specifically said by his rescuer, Woodes Rogers, to have had 'his mathematical instruments and books' with him. In archaeological terms, the evidence for a pair of dividers at Aguas Buenas is probably the closest one can get to proving that Alexander Selkirk lived there.

If the pair of dividers were Selkirk's so must also have been at least one of the hearths [8016]. The presence of small fragments of bone in context 8010 in this hearth suggests the cooking of meat, and for what it is worth, there is no evidence for grain or other foodstuffs which would have been unavailable to a castaway like Selkirk. It is probable that the post-holes were made by him as well as the other hearth [6006]. It is possible that the two hearths represent his two huts, one serving as a dwelling the other as a kitchen. There is no indication in Woodes Rogers' account of whether these two huts were adjacent to each other or far apart. Whatever the case, Selkirk would have found it easier to build two small huts rather than one large one.

In Selkirk's day, and much later, there was still a tradition in many parts of Scotland of taking the cattle and sheep in the summer months away from the growing crops to pasture in the hills. Here little huts known as *shielings* were constructed by those looking after the animals. They were often circular in plan, constructed of a framework of branches covered in turf, as the huts on the island of Jura described by a travel writer in 1772.<sup>50</sup> In the mid 19<sup>th</sup> century it was noted how, on the island of

Harris and Lewis, there were often two huts together, one serving as a dwelling, the other for keeping utensils and the butter and cheese made from the animals' milk.<sup>51</sup> Given Selkirk's limited range of equipment and resources, and his cultural background, he might have been expected to erect simple huts with a framework of stakes, set in post-holes and tied together at the top, rather like Scottish shieling huts. Without a ready supply of turf he may have woven bits of grass in a framework of branches, creating a structure rather like a basket. A lining of goat skins would have been necessary to make the structure weather tight. Even the concept of having two huts rather than one may derive from some memory or experience of life at the shielings. The excavated post-holes, while clearly not amounting to much as evidence, would, at least, not be inconsistent with such an interpretation.

## NAVIGATIONAL DIVIDERS AND ALEXANDER SELKIRK

By A. D. Morrison-Low

The discovery of a metal fragment which might have formed the tip of a pair of navigational dividers belonging to Alexander Selkirk raises a number of questions, to which some speculative answers will be given here. The accident of geography and Alexander's Selkirk's birthplace had much to do with his juvenile yearnings to become a sailor. Lower Largo is one of many small towns that line the estuary of the river Forth, or Firth of Forth, as it is marked on contemporary maps. A recent architectural guide characterises it as 'a fishing village made a burgh of barony in 1513', a status not as elevated as neighbouring royal burghs, but giving it certain

trading privileges.<sup>52</sup> During Selkirk's lifetime, much of the sea-borne traffic in the Firth was on its way to or from Leith, the port for Scotland's capital city, Edinburgh, trading with the Low Counties, and less frequently with the Baltic, Portugal and Bordeaux. Another component of this flotilla, the more local inshore vessels, would have been fishing for the rich and varied harvest of the sea and would have had less need of navigational instruments, being usually always in sight of the coast.<sup>53</sup>

Nevertheless, Selkirk's youthful and successful desire to run away to sea begs the question: where did this shoemaker's son learn his navigation skills? A biography published in Edinburgh over a century after his death states that:

At a proper age he was sent to school, where he made considerable progress in the branches usually taught, more especially in navigation as the whole bent of his mind was to go to sea. [Footnote: John Selcraig, his grand-nephew, remembers quite well, that, when he was a child, his father often gave him as a plaything the scale he used, to amuse himself. It was kept as a relic by his friends.].<sup>54</sup>

Conversely, it would appear that there is evidence for only a handful of schools where navigation was taught in Scotland before 1707, and those were based mainly in Leith or Edinburgh. After the Union of the Parliaments, Glasgow was in a position to exploit its west coast location and the trade across the Atlantic, and it seems that at least six navigation teachers were active there by about 1760, as well as others in the south-west, and along the Firth of Forth.<sup>55</sup> By the late 19th century, 'it was well known, however, that despite the availability of teaching facilities on land, the majority of seamen learned part, or all of their navigation on ships'.<sup>56</sup> Even so, sources for the late 17th century are scanty, and so it is impossible to provide a complete picture of the various aspects of teaching of navigation at that time,<sup>57</sup> and



so where Selkirk might have learned this skill must remain a matter of speculation, either at a school in Scotland, or on a ship once he had run away to sea.

There is certainly no need to doubt that Selkirk was literate, and amongst the books he had on the island was a 'journal of his observations', the existence of which is known about since his widow sought its return from the Duke of Hamilton soon after Alexander's death in 1721.<sup>58</sup> Perhaps it was in this that he kept the account of the 500 goats he killed while on the island.<sup>59</sup>

What were Selkirk's 'Mathematical Instruments' likely to have been, and where might he have acquired them? In fact, what did early 17th-century oceanic (as opposed to inshore) navigators need to find their position on the earth's surface? As described by Peter Ifland, it is measurement of 'the angles – the angle between the horizontal and a star, the angle between the vertical and a star, or even the angle between one celestial body and another'.<sup>60</sup> When the horizon is invisible, as it becomes in bad weather, then a plumb bob will always produce a straight line pointing towards the Earth's centre, and 'these two reference lines, a horizontal line to the horizon or a vertical line established by the force of gravity, form the basis for design of virtually every instrument that mariners have used for measuring the angles need for celestial navigation'.<sup>61</sup>

Navigating the oceans had been undertaken since antiquity, and generations of observations since then had produced nautical knowledge and wisdom that could be built upon. Experience had taught sailors to name the winds from the quarter they came from, and to recognise the changing night skies throughout the year. Sailing directions apparently survive from about 500 BC, giving course and distance (in terms of a day's sail) between various ports, including descriptions of the coastline, information about anchorages, currents and depths. By the 15th century, Portuguese

mariners under the leadership of Prince Henry the Navigator found that using the Mediterranean methods of dead-reckoning and the Scandinavian technique of sounding the sea bed were inadequate in the Atlantic and for voyages further a field. Astronomical sailing, or ‘running down the latitude’ was developed about this time in which ‘the navigator sought the latitude of his destination and followed it rather than taking the direct route which he could not determine. The new rule told the pilot simply how far on each of the sixteen half-winds or compass directions he would have to sail to “raise a degree”, that is to alter his latitude by one degree, and how much easting or westing he would then make’ .**62**

The angle-measuring instruments available to the ocean-going mariner in the late 17<sup>th</sup> century would have been the mariner’s astrolabe,**63** the cross-staff **64** or the back-staff **65**. Neither the octant nor the sextant was developed until the mid-18th century, and so would have been unavailable to Alexander Selkirk and his contemporaries. Before the development of the ocean-going chronometer, or even the invention, improvement and cheapening of mechanical clocks, the most widespread timekeeper was the sundial. This instrument is impractical at sea, as it has to be set for particular latitudes; and it is useless at night or in adverse weather conditions. Instead, sailors used a device known as the nocturnal, which dates from the 15th century, and acted as a star-pointer: brass examples are known, but many cheaper wooden patterns survive.**66** Other navigation instruments that would have been available – but not necessarily considered as part of the mariner’s own tackle, more as ship’s equipment - would have been the magnetic compass (for direction), the log-line (for depth and an estimation of speed), and the traverse board, used for course-plotting in association with a sandglass.**67** Nevertheless, most of these devices were made of wood, only the mariner’s astrolabe and the occasional nocturnal being constructed of brass or bronze.

All of these would, however, have been expensive, and although not unknown in Scotland, they would certainly not have been produced there, as an indigenous instrument manufacturing trade did not emerge there until the mid-18th century.<sup>68</sup> Even so, a number of examples of these instruments with a 17<sup>th</sup>-century Scottish provenance have been noted.<sup>69</sup> It is more likely that Selkirk would have obtained any navigation instruments on the unrecorded voyages he made in the years of silence away from Lower Largo, in any of the major ports of England, Ireland or Europe. Navigational instruments, new or second-hand, would have been widely obtainable in the docks around the Thames, or possibly in Bristol, England's second port. Daniel Defoe was to describe Bristol in 1724 as 'the greatest, the richest, and the best port of trade in Great Britain, London only excepted. The merchants not only have the greatest trade, but they trade with a more entire independency upon London, than any other town in Britain'.<sup>70</sup>

In an unpublished analysis of Bristol probate inventories between 1640 and 1775, Jonathan Barry found that seafarers were those most likely to be found in possession of scientific instruments: 'The well-equipped mariner possessed plots and charts, as well as books for the sea, with compasses and dials, a prospecting or spy glass, and a range of such things as cross staffs, fore staffs, scales and quadrants.' Barry located two inventories which contained all these items, both dating from 1684, but instruments other than these essential navigation tools were only occasionally mentioned in the inventories.<sup>71</sup>

There was another pair of somewhat less glamorous instruments that was an essential part of the navigator's kit, used in conjunction with his charts and tables: his dividers and scale. The item found on Robinson Crusoe Island may have been the tip of one side of a pair of navigational dividers. Dividers have been known since

antiquity, a pair of proportional dividers having been found at Pompeii, ‘but few surviving examples of dividers are dateable and it is therefore difficult at present to determine anything about their development’.<sup>72</sup> Replicas of a variety of dividers uncovered at Pompeii have been illustrated.<sup>73</sup> Subsequently, ‘dividers were ubiquitous instruments in the Middle Ages used in a variety of trades and differing greatly in size’.<sup>74</sup> However, Turner remarks that whereas Roman dividers were generally made from bronze, iron occurred more plentifully in north-west Europe than around the Mediterranean, and he surmises that ‘dividers had been made of this material from at least the 10<sup>th</sup> century’.<sup>75</sup> Dividers – also known as compasses – have long been used to draw circles in a variety of occupations and survive in a number of different forms.<sup>76</sup>

For navigators, dividers were principally used in plotting course or distance on sea charts, and were also used with plain scales. The plain scale was a boxwood mathematical ruler, based on the 17th-century Gunter’s rule, with a number of different logarithmic scales.<sup>77</sup> One modern author writes that ‘in addition to the line of numbers, Gunter scales eventually evolved to include at least seventeen other scales for use in trigonometry and navigation’.<sup>78</sup> It is probable that Selkirk’s wooden scale, mentioned by Howell, was one of these: unfortunately, it has not been seen since some time before 1829. The plain scale ‘was designed to project spherical problems on a two-dimensional plane, for example reducing a calculation from the earth’s surface into a flat chart’.<sup>79</sup>

During Selkirk’s lifetime, the sea chart was in its formative stages, and the voyages in which he somewhat unwittingly participated contributed to their improvement.<sup>80</sup> After Selkirk was abandoned on Robinson Crusoe Island, William Dampier got back to England in late 1707 after a disastrous privateering voyage and his second

circumnavigation. He was criticised in print as a poor leader by William Funnell and John Welbe, and this led to something of a pamphlet war; and he was in legal trouble with his disappointed financial backers.<sup>81</sup> However, these Bristol merchants wished to recoup their losses, and proposed another privateering voyage to the South Seas, this time led by the more promising young commander, Woodes Rogers (c.1679-1732), whose leadership skills were such that, in due course, he became colonial governor of the Bahamas.<sup>82</sup> Two merchant ships, the *Duke* and *Dutchess*, were fitted out, and William Dampier, now aged 56, was appointed master of the *Duke* and pilot of the expedition, as there was no more experienced navigator to be had. Leaving Bristol in August 1708, with the intention of intercepting the Manila galleon in December 1709, the two ships arrived at Robinson Crusoe Island for watering and refitting at the end of January 1709. There, they famously encountered the marooned Alexander Selkirk.<sup>83</sup>

Taking Selkirk aboard, 'Dampier recommended Selkirk as having been the best man in the *Cinque Ports* and Rogers duly appointed Selkirk to be mate in the *Duke*'.<sup>84</sup> In March 1709, off the Chilean coast, Rogers took a prize, which was renamed the *Increase*, and Selkirk was appointed master.<sup>85</sup> In April the expedition captured the town of Guayaquil (Ecuador) and Selkirk played an interesting role as the commander of a party of men who frisked Spanish ladies of the jewellery concealed in their clothing.<sup>86</sup> After further dangerous and hair-raising adventures, Rogers captured the Manila galleon, full of treasure, bound for Acapulco, in December 1709. There were now four ships in their convoy, with the treasure ship, the *Nuestra Señora de la Encarnación*, renamed the *Batchelor*. Selkirk was appointed her master under the command of Captain Thomas Dover.<sup>87</sup>

They then set out eastwards across the Pacific Ocean, first to Guam, then to Batavia (present day Jakarta on the Island of Java), where Selkirk was involved in apportioning the booty. As an officer, he also got 80 pieces of eight expenses to provide himself with necessities for the long journey home.<sup>88</sup> After a refit, they sailed for the Cape of Good Hope, and from thence to the Shetland Islands, on to the Texel and finally back to anchor in the Thames on 14 October 1711.<sup>89</sup>

Most dividers now in museum collections are made of bronze or brass, with iron or steel tips, or are entirely made of iron or steel. Those described in the British national inventory seem to conform to this pattern.<sup>90</sup> A selection from some major British museums with instrument collections is given below.

<b>Museum</b>	<b>Inventory number</b>	<b>Description</b>
National Maritime Museum	NAV0521	Dividers with angle scale, brass with steel points, German c.1650
National Maritime Museum	NAV0522	Brass with steel points, c.1650
National Maritime Museum	NAV0542	Brass hinge and legs, steel points, Dutch? c.1650
National Maritime Museum	NAV0535	Brass with steel points and arc, signed 'Henry Burnet. Born XXV, MDCXCVII', c.1720
National Museums of Scotland	NMS.T.1966.72	Brass dividers, with steel points, c.1800
National Museums of Scotland	NMS.T.1985.79	Single handed dividers, iron, probably German, early 17 <sup>th</sup> century.
Museum of the History of Science, Oxford	42018	Single handed dividers, iron, probably French?, 18 <sup>th</sup> century?

Museum of the History of Science, Oxford	43731	Pair of dividers, brass and steel, 18 <sup>th</sup> century.
Museum of the History of Science, Oxford	43902	Pair dividers, by Jacobus Lusverg, Rome, 1687

However, dividers found on wrecks and in archaeological excavations appear to be more varied, and examples of all-brass construction with no steel or iron components have been recovered. Four pairs of all-brass single-handed navigational dividers were found on the *Mary Rose*, the flag ship of Henry VIII, which sank in 1545. Two pairs were found in the pilot's cabin, and two came from a chest on the upper deck and may have belonged to the ship's master.<sup>91</sup> Single-handed brass dividers have been recovered from the 1588 Armada wreck, the *Trinidad Valencera*, and from the Barents expedition of 1596, now in the Ulster Museum, Belfast and the Rijksmuseum, Amsterdam respectively.<sup>92</sup> Several of brass have been discovered from the wreck of the Swedish Royal Ship *Kronan* which sank off the Baltic island of Öland in 1676. <sup>93</sup> Two other all-brass examples found at Ellan Gheirrag Castle, Argyll, were dated by D.J. Bryden to 1685, and thought by him to be Dutch in origin.<sup>94</sup> Others from two wrecks in the Sound of Mull are discussed in another part of this report. The much later wreck in 1735 of the Dutch East India Company's ship the '*t Vliegende Hart*' has yielded 18 dividers or parts of dividers. The majority are of the single-handed type ... they are made of cast brass with steel or iron points which inevitably rusted away on the sea-bed. Some differ from this style, for example the all-brass pair of dividers which is not cast but made of thin folded brass plate'.<sup>95</sup> A pair of all-brass dividers was discovered during emergency archaeological excavations in the courtyard of the *Collegium Novum* of the Jagellonian University, Krakow in 2005.<sup>96</sup>

In addition, a number of complete brass dividers have passed through the antique trade in recent years, which are crudely constructed: they have poor hinges and no iron tips, and would therefore have been sold at a low price. Such instruments ‘tend to be rather small (typically 3½ inches to 4½ inches tall, i.e. about 10 cm tall), with a bulbous six- or eight-sided head, rather early (I think 17<sup>th</sup> [century] and earlier), usually of rather unrefined construction with visible areas of hammering and hand-filing, and often carrying an intriguing punch-mark presumably for the maker. Marks we have noted include a pelican, a goblet, a heart, and a bunch of grapes. There is often simple decoration with several boldly incised short straight lines crossing both legs, reminiscent of the bold lines on, for example, sight vanes of some mariners’ astrolabes...’<sup>97</sup> One such item has found its way into a museum collection, that of the Smithsonian Institution (inv. no. NMAH 316931 (2)), where there is an all-brass pair of dividers, measuring 3¼ inches (8.3 cm) long, with a spherical hinge at the top. Acquired at auction in 1959, ‘it has no maker’s name, but the outside of each leg has two groups of three stripes engraved horizontally. One leg also has a five-pointed asterisk with a circle around it’.<sup>98</sup> It has been suggested that these and others similar to them may have been made in Southern Germany, in the metalworking centres, for instance Augsburg and Nuremberg.<sup>99</sup> Such crudely made, and therefore cheap, items would have been made for the lower end of the market, and as such, these objects find their way into museum collections only rarely.<sup>100</sup> The results of archaeology perhaps give a better picture of the contemporary use of material culture rather than the selective criteria of museums.

To sum up: there is every possibility that Selkirk may have taken a cheap pair of single handed navigators’ dividers as part of the ‘Mathematical Instruments and Books’ he took ashore with him on Robinson Crusoe Island. That they were of bronze



rather than brass is a matter that requires further research. Just how he managed to break off the point remains a matter of conjecture, but using his dividers for some inappropriate task, such as attempting to lever off a piece of stronger metal (possibly iron or steel), would have resulted in some interesting South Sea language.

## PHASE 2

The level piece of ground, perhaps long abandoned by its previous occupant(s) but still evident as a clearing in the forest reached by a path from Cumberland Bay, was extended in area, partly to create a yard and partly to provide clay as a building material. In the process, much of the evidence for earlier occupation was removed. The building is aligned E-W and is about 4.5m by 3m internally, probably originally with a floor paved with bricks. The location of windows, if any, could not be ascertained, but the door was in the west wall and was sheltered by a porch formed by extensions of the two side walls. The porch and an area in front of it were paved with stones. Although no traces were recovered of whitewash, it is probable that the wall surfaces, inside and out, were coated with it, and there is abundant evidence that the roof was covered with red tiles.

The lack of any domestic features like a fireplace, and the E-W orientation, initially suggested that the building might be a church. A map of the island published by order of its Governor, Fernando de Amaya, in 1795, however, shows a building at this location, identifying it as the *Almacen de Polvora* (powder store).<sup>101</sup> The map provides a useful *terminus ante quem* for the building's construction which, given its

military function, could hardly have been erected before the fort in the middle of the 18<sup>th</sup> century.

In 1750 the Spanish engineer, Juan Francisco de Sobrecasas, was instructed by the Captain General of Chile to build a fort at Cumberland Bay and smaller fortifications at Puerto Inglés and Puerto Francés, two barely accessible points on the coast, the former about 4 kilometres to the north-west of Cumberland Bay, the latter at the east end of the island. This effort coincided with the first serious attempt by the Spanish to colonise the island with the establishment of the settlement of San Juan Bautista. On 25 May the following year the settlement at San Juan Bautista along with the fort was destroyed by a tsunami and a new fort (*Fuerte Santa Barbara*) commenced on higher ground, the one that stands today. It consists of a rectangular platform, 77m by 83m, terraced into sloping ground with one bastion at its exposed north-east corner. By 1779, apart from this fort, there were seven other gun batteries, including those at Puerto Inglés and Puerto Francés. The fort had 15 cannon and the batteries a further

**33.102**

There was clearly a need for a good supply of gunpowder to service these guns. Gunpowder magazines often consisted of substantial buildings designed to protect the powder from the elements and were located well away from any risk of accidental ignition by enemy shot or domestic fires. The location at Aguas Buenas, however, is remarkably far away from the fort and is most inconvenient for supplying any of the gun batteries. It is difficult to understand how it could have had any practical function, unless – and this is just speculation – it served as a centre for gathering together charcoal for the manufacture of gunpowder. An elderly islander informed us that charcoal used to be prepared in large pits in the ground that were covered over with earth.

The ancestors of the present population of the island only arrived in the mid 19<sup>th</sup> century, by which time the gunpowder store had probably fallen out of use and become a ruin. There was thus no memory of it on the island, and when its ruins were rediscovered in the 20<sup>th</sup> century, no one on the island had a clear idea as to what it was.

### PHASE 3

At some date after its ruin, perhaps in the 20<sup>th</sup> century, the interior of the building was largely dug out. Perhaps this was an amateur archaeological dig, a search for artefacts, or else an effort to salvage tiles and bricks. Whatever the case, the excavation was filled back in again so that this activity was not immediately evident.

### CONCLUSION

The main aim of the project was to identify evidence for the stay on the island of Alexander Selkirk. We believe that the remains represented by phase 1 at Aguas Buenas were left by Selkirk. Woodes Rogers, his rescuer, called him the governor of the island and describes his healthy existence, catching goats, singing psalms and praying.<sup>103</sup> Another impression provided by our excavations is of an enemy combatant behind enemy lines. He is forced to hide his huts well away from where they might be discovered by anyone arriving on the island, but near to the lookout from which he could scan the seas for any approaching ships. Several ships did pass

by the island during his stay and his dilemma would have been whether he should try and attract their attention or not – were they friend or foe?

The evidence may be meagre but also has a certain value as representing an early phase of settlement in this part of the world by Europeans. The gunpowder magazine of phase 2 deserves more study as part of the military strategy belonging with the Spanish settlement of the island in the mid 18<sup>th</sup> century.

Finally, we would like to suggest that our work has provided some justification for renaming the island Robinson Crusoe, and we hope that Aguas Buenas, with careful management, may be a site enjoyed by the increasing number of tourists searching for the inspiration behind Defoe's masterpiece.

## ACKNOWLEDGEMENTS

The project was sponsored by the National Geographic Society of Washington D.C., the United States of America, and was first featured in the *National Geographic* Magazine for October 2005. Further support was given by the Explorers Club of New York, the United States of America. The team is also very grateful to Comision Nacional del Medio Ambiente, Consejo de Monumentos Nacionales, Corporacion Nacional Forestal and Ilutre Municipalidad De Juan Fernandez of Chile for their support and encouragement.

Catherine Westfall assisted with translating reports from Spanish and Stephen Jackson provided the information on Selkirk's sea-chest. We are very grateful to Max Jahrehorn of the Kalmar Lans Museum, Sweden, for allowing us to study dividers from the wreck of the *Kronan*.

Dr Morrison-Low would like to record her thanks to the following in her quest for comparable all-brass dividers: Dr David Coffeen, Tesseract – Early Scientific Instruments; Dr Richard Dunn, National Maritime Museum; Dr Stephen Johnston, Museum of the History of Science, Oxford; Dr Peggy Kidwell, National Museum of American History; Dr Willem Mörzer Bruyns, formerly of the Nederlands Scheepvaartmuseum, Amsterdam. She is also grateful to Dr Jonathan Barry, Exeter University, for allowing her to use his unpublished work on Bristol probate inventories.

## NOTES

<sup>1</sup> Lee 1987 makes a strong case for considerable contact between Selkirk and Defoe in 1712.

<sup>2</sup> Takahashi 2002.

<sup>3</sup> The endemic flora is described by Danton 2004.

<sup>4</sup> The best general histories of Robinson Crusoe Island are those by Vicuña Mackenna 1883, Woodward 1969 and Orellana *et al.* 1975.

<sup>5</sup> Valdés 1985, 58, 71, 78, 106, 118.

<sup>6</sup> Cáceres and Saavedra 2004.

<sup>7</sup> Anderson *et al.* 2002.

<sup>8</sup> Haberle 2003.

<sup>9</sup> For a brief recent account of his life see Kelly 2004.

<sup>10</sup> St Andrews University Library, CH2/960/2, pp. 12, 13, 14, 15, 29, 30, 88, 89, 90, 119.

<sup>11</sup> It is important to note, given the account that follows of Selkirk's possible association with Henry Avery, that this date of 1693, verified from the original Kirk Session Records (CH2/960/2, pp. 29, 30) is erroneously given in other printed sources as 1695.

<sup>12</sup> Souhami 2002, 45-48.

<sup>13</sup> National Archives of Scotland GD 160/359.

<sup>14</sup> Cordingly 2004. Daniel Defoe turned this exploit into a semi-historical tale, *The King of Pirates*, first published in 1724. Was Selkirk also a source for this?

<sup>15</sup> Lee 1987.

<sup>16</sup> Funnell 1707, 46.

<sup>17</sup> Rogers 1712, 72, 167; Cooke 1712, vol. 1, 341; Mégroz 1939, 194 (reproducing Richard Steele's Essay on Selkirk in *The Englishman*, 1<sup>st</sup> 3<sup>rd</sup> December 1713).

Rogers' account indicates that Thomas Dover was appointed captain of the prize ship, but since Dover was regarded as incompetent by many of the 'chief officers' on the expedition a compromise had to be thrashed out which involved having Captains Robert Frye and William Stretton take overall responsibility for navigating and sailing the vessel. Selkirk is then noted as master.

<sup>18</sup> Bardelli 2004 and Bardelli 2006.

<sup>19</sup> *CSPD* (1697), 39; (1698), 156; (1702-3), 35, 84-85, 637-8, 688.

<sup>20</sup> Lee 1987, 388.

<sup>21</sup> The above account summarises a story that has been well covered by many others.

See, particularly, Mégroz 1939.

<sup>22</sup> Rogers 1712, 126.

<sup>23</sup> Mégroz 1939, 193-7.

<sup>24</sup> Rogers 1712, 124-37.

<sup>25</sup> Rogers 1712, 122-24, 132-33.

<sup>26</sup> Taunton, U.K., Hydrographic Office, MS 4, p.147. The map was used to illustrate Cooke 1712, vol. 1, opposite p.99.

<sup>27</sup> For references for the calibration data and the mathematics applied to the data see Stuiver and van der Plicht 1998, Stuiver *et al.* 1998 and Talma and Vogel 1993.

<sup>28</sup> *Análisis Material Alfarero Sitio Aguas Buenas, Juan Fernández.*

<sup>29</sup> Urizar y Baudet 2002, Seelenfreund 2001, Urizar y Baudet 2001, Baudet 2003, Baudet y Urizar 2001a, Baudet y Urizar 2001b, Prado 2000.

<sup>30</sup> Baudet 2003, Baeza 2002 Ms., Westfall 2001 Ms., Reyes et al 1998, Prado 1997a & b, Botto 1989.

<sup>31</sup> Cáceres and Saavedra 2004.

<sup>32</sup> Deagan 1987.

<sup>33</sup> Marken 1994.

<sup>34</sup> Schávelzon 1999, 251ff.

<sup>35</sup> Stelle 1989, Therrien *et al* 2002.

<sup>36</sup> The XRF system used was an Oxford Instruments ED 2000 with Oxford Instruments software ED 2000SW version 1.31. The analysed area was irradiated with a primary X-ray beam produced by a Rhodium target X-ray tube. The primary beam was collimated to give an analysed area of about 2mm x 1mm. Secondary X-rays were detected with a silicon (lithium) solid state detector. The detection limit varies depending on the elements, matrix and analytical conditions, but is typically in the range of 0.05%-0.2%. As the analytical technique has a limited penetration depth, the reported compositions may not be representative of the bulk of the alloy if there is a chemically distinct surface layer. Spectra were collected under the conditions "Old XRF". This uses an operating voltage of 46kV and a current of up to 1000µA (set

automatically for a 45% dead time) without a primary beam filter to ensure detection of all elements of atomic number 19 or above of interest in copper and lead alloys.

Quantitative data were obtained using the Copper Alloys 2001 method following CPS and PPCS set-up.

<sup>37</sup> The SEM used was a CamScan MX2500 in controlled pressure mode at 10Pa. Collimators were wide open (Envac) and spot 2. The accelerating voltage was 20kV in all cases. Analysis was using a Noran Vantage EDX system. Count times were 30sec with around 30% dead time. The analysis was using the Vantage software with no standards, and assuming that Cu and Zn were the only elements present.

<sup>38</sup> Craddock & Hook 1995a & b.

<sup>39</sup> Eremin & Tate 2003.

<sup>40</sup> Eremin *et al.* 2005.

<sup>41</sup> Tate 2005.

<sup>42</sup> Mortimer 1989.

<sup>43</sup> The report that follows has been edited from the original in Spanish, entitled *Informe Análisis Carpológico*.

<sup>44</sup> Martin and Barkley 1973, Matthei 1995, Mösbach 1999, and Muñoz 1966.

<sup>45</sup> Woodward 1969, 25-26; Norris 1994, 47-50.

<sup>46</sup> Woodward 1969, 28-31.

<sup>47</sup> Woodward 1969, 57.

<sup>48</sup> Shelvocke 1928, 114-135.

<sup>49</sup> Woodward 1969, 63.

<sup>50</sup> Pennant 1998, 204.

<sup>51</sup> Thomas 1860, 130.

<sup>52</sup> Gifford 1988, 316.



- <sup>53</sup> Bennett 1987.
- <sup>54</sup> Howell 1829, 19.
- <sup>55</sup> Gavine 1982, 16-17.
- <sup>56</sup> *Gavine* 1982, 19.
- <sup>57</sup> Gavine 1990, 5.
- <sup>58</sup> The petition by Frances Selkirk is undated and uncatalogued and in the collection at Lennoxlove, East Lothian, the home of the Duke of Hamilton.
- <sup>59</sup> Rogers 1712, 72.
- <sup>60</sup> Ifland 1998), xiv.
- <sup>61</sup> Ifland 1998), xiv.
- <sup>62</sup> Taylor, & Richey 1962, 9.
- <sup>63</sup> Anderson 1973; Stimson 1988.
- <sup>64</sup> Mörzer Bruyns 1994.
- <sup>65</sup> Taylor & Richey 1962, 49-51.
- <sup>66</sup> Taylor & Richey 1962, 61-61.
- <sup>67</sup> Hutchinson 1994, 164-182.
- <sup>68</sup> Morrison-Low 2002, 17-53.
- <sup>69</sup> Morrison-Low 1993, 218-222.
- <sup>70</sup> Defoe 1724-26, 361-2.
- <sup>71</sup> Quoted in Morrison-Low forthcoming.
- <sup>72</sup> Turner 1994, 51.
- <sup>73</sup> Hambly 1988, 20.
- <sup>74</sup> Turner 1994, 99.
- <sup>75</sup> Turner 1994, 100.
- <sup>76</sup> Hambly 1988, 69-86.

- <sup>77</sup> Van Poelje 2004, 11-22.
- <sup>78</sup> Babcock 1994, 14.
- <sup>79</sup> Mörzer Bruyn, & van der Horst 2006, 321.
- <sup>80</sup> Howse & Sanderson 1973, 11-12.
- <sup>81</sup> Norris 1994, 245.
- <sup>82</sup> Mainwaring's 'Introduction' to Rogers 1712. This appears in the 1928 edition.
- <sup>83</sup> Rogers 1712, 70-74; Norris 1994, 245-251.
- <sup>84</sup> Rogers 1712, 71; Kelly 2004.
- <sup>85</sup> Rogers 1712, 83; Kelly 2004.
- <sup>86</sup> Rogers 1712, 98.
- <sup>87</sup> Rogers 1712, 167.
- <sup>88</sup> Rogers 1712, 205-7.
- <sup>89</sup> Rogers 1712, 215-24.
- <sup>90</sup> Holbrook, Anderson & Bryden 1992.
- <sup>91</sup> [www.maryrose.org/lcity/pilot/divider.htm](http://www.maryrose.org/lcity/pilot/divider.htm)
- <sup>92</sup> Rodríguez-Salgado 1988, 215.
- <sup>93</sup> Eight pairs of dividers from this wreck have now been confirmed to be of brass through XRF analysis undertaken at the National Museum of Scotland.
- <sup>94</sup> Bryden 1968, 77-84.
- <sup>95</sup> Mörzer Bruyn, & van der Horst 2006, 322.
- <sup>96</sup> Niemiec 2006.
- <sup>97</sup> Coffeen, D., personal communication to author, 22 September 2006.
- <sup>98</sup> Kidwell, P., personal communication to author, 21 September 2006.
- <sup>99</sup> Lockner 1981; Gouk 1988 45-48.
- <sup>100</sup> Weatherill 1988, 21.

<sup>101</sup> A copy of this map was studied in the public library in San Juan Bautista.

<sup>102</sup> Woodward 1969, 79-87; Orellana *et al.* 1975, 85-95.

<sup>103</sup> Rogers 1712, 74.

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## FIGURES

1. Map showing location of Robinson Crusoe Island.
2. View of site looking towards the Lookout. Photograph: D. Takahashi.
3. Map showing location of Aguas Buenas. The contours are derived from map information provided by CONAF.
4. View of the site with Cumberland Bay in the background. Photograph: D. Takahashi.
5. Plan showing the positions of trenches 1 to 5 and sections through the site.
6. Plan of the building prior to excavation.
7. Sections, trenches 1 to 5, and the external elevation of the west wall of the building.
8. Outline of the building with the positions of trenches 6 to 12 and sections A-B, C-D, E-F, G-H, I-J and K-L.
9. Plan of trenches 6 and 7.
10. Section A-B.
11. Section C-D.

12. Detail of the wall of the building demonstrating its construction of clay faced with stones. Photograph: D. H. Caldwell.
13. Trenches 6 and 7 from the north, with the hearth 6006 partially excavated. Photograph: D. H. Caldwell.
14. Plan of trenches 8, 10, 11 and 12.
15. Plan 1 of trench 9.
16. Plan 2 of trench 9.
17. Section I-J.
18. Hearth 8016 sectioned. The stones at the top are the paving in the doorway of the building. Photograph: D. H. Caldwell.
19. Sections E-F and G-H.
20. Trench 9 post-holes from the north. Photograph: D. H. Caldwell.
21. Section K-L.
22. a-b: The copper alloy tip. Photographs: J Tate.
23. The copper alloy tip, SEM BSC image at pointed end showing heavy corrosion. Photograph: J. Tate.
24. a-c: Dividers from the wreck of *HMS Darmouth*, sunk 1690. From left to right: (a) HXD 326, (b) HXD 327, (c) HXD 381. Photographs: National Museums Scotland.
25. a: SEM BSC image of Aguas Buenas fragment at broken end showing roughly square cross-section; b: SEM BSC image of cleaned area (20kV)x100 magnification. Bright spots are bismuth. The darker grey area has a higher level of oxygen and chlorine and so is where corrosion remains. Photographs: J. Tate.