The excavation and dismantling of Angra D, a probable Iberian seagoing ship, Angra bay, Terceira Island, Azores, Portugal. Preliminary assessment

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Abstract

This article will present an overview of the archaeological excavation done on the two wrecks, Angra C and Angra D, discovered during the underwater archaeological intervention related with the construction of a marina in Angra do Heroísmo bay (Terceira, Azores).

It will briefly describe the main structures of the two hulls: keel, floor timbers, futtocks, outer and ceiling planking, etc, as well as a general description of the stratigraphy and the artefacts encountered during the archaeological work, focusing on Angra D, a ship believed to be Iberian built and dating from the last quarter of the XVIth century.

Overview

The Azores archipelago is located about 1500 km to the west of the Iberian Peninsula, roughly between latitudes 37° and 39° north, to the west of Lisbon. Located on the intersection of the tectonic plates of Europe (Terceira, Graciosa, São Jorge, Faial and Pico islands), Africa (São Miguel and Santa Maria islands) and America (Flores and Corvo islands), the archipelago is set out in a long semicircle along the mid-Atlantic Ridge.

The climate is Atlantic temperate, heavily influenced by the Gulf Stream, with the prevailing wind from the west, sometimes changing to the South and Southeast. This wind pattern permitted sailing ships to depart Europe via the North, towards Canada; via the centre, heading towards the Caribbean; and via South, heading towards Africa and Asia. There is only one way back from all those locations, however, and that is via the Azores.

It is not known when the islands were first discovered, although one knows that they were first inhabited in the first half of the XVth century. During the remaining part of that century, the Azores islands were gradually colonised, with Portugal obtaining in them the much-needed wheat, always scarce for the ever-expanding maritime empire. Only with the more frequent appearance of ships — which, on their way back from the Gulf of Guinea, had to head for these latitudes in order to find favourable winds for their return to Europe, did the archipelago's role switch from granary to watchful and protective mid-Atlantic trading post.

Forecasting what would happened years latter, Christopher Columbus passed through Santa Maria island, where he fought a little skirmish with the local islanders, on his way back from the Caribbean. Five years latter, Vasco da Gama, returning from India, stopped over in Angra where he buried his brother, Paulo da Gama. Since that event, almost all of the Portuguese ships carrying goods from Africa and Asia began using Angra bay, on Terceira Island, for supplies, repairs and protection against piracy. From the middle of the XVIth century onward, as a result of an Iberian treaty of Cupertino, Spanish ships joined them with goods from the West Indies.

The resulting development of the Azores and mainly of Terceira island, led to the creation, in Angra, of several institutions that supported the transatlantic navigation's, most notably a hospital built to cure wounded and ill sailors and a Purveyor's Office for the Armadas from India, to support the ships and protect the passing wealth from the many French corsairs and pirates who had begun to appear in the area, at the beginning of the XVIth century. On August 21, 1534, the town of Angra was given its charter by King John III, becoming the oldest city in the Azores. In the same year, the Azores became a diocese with the bishop having its seat at Angra.

After that, one of the main engines of the island's economy was the provision of services to ships and travellers, with the archipelago reaching the peak of its development in 1583, when Philip II of Spain became King of Portugal. All the Iberian ships coming from overseas passed then through the Azores, making the islands a very attractive target for the northern European privateers that went rampant on the two last decades of the XVIth century. The end of the Iberian union in 1641 significantly reduced the Azores islands role as a trading post. That event, together with the fierce competition from the Dutch and English East Indies companies, which had been growing since 1600, spelled the end of the role of the Azores as a trading post.

1. Azores submerged cultural resources management plan

With Azores's extensive maritime history and abundant coastline, shipwrecks are an important component of the region's underwater heritage. The vast majority of shipwrecks in Azorean waters do not contain gold, silver, jewellery, or other precious metals. So-called "treasure" galleons that were lost in the Azores were salvaged soon after the event whenever possible, since economic effects of so great a loss were profoundly felt throughout Spain and Portugal.

More than 900 ships are recorded as lost in the Azores; only 142 — circa 15% — of these ever carried treasure, of which 22 were wrecked inside Angra bay, in depths that go as deep as 60 meters.

As Azores's rapid growth increasingly impacts the natural and cultural resources of the islands, resource management and preservation assume greater importance. Since 1994, a growing awareness of the significance of these resources has resulted in increasing concern for their protection and preservation since Azorean submerged cultural resources, like its natural resources, are composed of an assortment of often accessible but fragile assets. This growing awareness has also served as a way to identify the many ways in which underwater sites may be impacted. Some of these causes are natural, like storms and erosion. Others are related to human activities and are potentially controllable. Of these human impacts, many are unintentional or inadvertent.

Potentially damaging activities such as dredging and boating, reflect the many demands placed on Azores's finite submerged cultural resources. Some human impacts, however, are more deliberate. Waterfront development in the Azores meant vast dredging and filling operations that turned small areas of coastline into sidewalks and building lots separated by seawalls. Such activities are no longer occurring, but the pace of development along the coast continues and increases. Projects that have the potential to disturb submerged lands that might contain cultural resources, are now happening all over the islands, be it the construction of fishing harbours or the construction of marinas.

These projects have all proceeded in the belief that no adverse impact to submerged sites would occur and there were never means available to actually examine shoreline construction areas in advance of work that might damage shipwrecks or other archaeological sites.

It was considering that the Azorean submerged cultural resources represent unique and valuable, publicly owned resources that have the potential to provide sustained cultural, recreational, and economic values and benefits, while significantly representing archaeological and historical values that are not renewable, that the Azorean Cultural Direction of the Regional Government (DRAC, actually DRC), the Institute of Nautical Archaeology from the Texas A&M University (INA) and the Portuguese Centre for Nautical and Underwater Archaeology (CNANS) have developed, over time, isolated actions on this field, and promoted several initiatives in collaboration with the non-profit cultural association Arqueonautica, to locally create a group of interested and qualified people to develop the protection of the underwater cultural heritage.

These initiatives were, unfortunately, in response to particular problems or issues[1] rather than having the benefit of comprehensive planning. So, taking into account the archaeological potential of the islands, the absence of a comprehensive management plan for submerged cultural resources in the Azores was striking. This absence, mostly due to non-existing staff and lack of ability to survey, identify, and assess the resources, has since then been partly fulfilled by site investigations conducted on an occasional and informal basis by volunteers, framed by Portuguese or American underwater archaeologists.

One of these site investigations involved the execution of a pre-disturbance survey, prior to the construction of a yachting harbour, in Angra bay, Terceira Island. In 1996, related with the project of the construction of a marina in Angra bay, the national department of cultural heritage (IPPAR) agreed with the DRAC to promote preventively the archaeological survey of the bay. A strategy was then drawn and developed with the co-ordination of the Museum of Angra do Heroísmo, with the Portuguese underwater archaeologist Francisco Alves as an adviser.

In the same occasion, the Institute of Nautical Archaeology (INA), from the Texas A&M University was invited to develop a survey project in Azorean waters. Professor Kevin Crisman accepted to begin it in Angra bay with a geophysical survey.

The INA team[2] used for that purpose a CHIRPS sub bottom profiler. Although no conclusive data could be obtained, the divers found that bottom conditions were ideal for shipwreck preservation and, as such, a hand held metal detector and test pit phase were in order. Magnetometer use was in vain, due to the volcanic origin of the sea bottom.

The project was developed in two phases. The first phase happened between September 1996 and February 1997. A four-member team of divers performed a pre-disturbance underwater archaeological survey of Angra bay, specifically in the zone of the future marina. The survey, designed to retrieve the maximum amount of information with a minimal amount of disturbance to the site, used non-intrusive archaeological techniques, which included a visual survey, a sub bottom profiler (Crisman, 1998, p. 6) and a metal detector, as well as sample excavations done at the location of several metallic anomalies. During the first phase of the project, three historical wrecks were discovered and summarily identified on the East Side of the bay.

One of those wrecks was identified as being the American Civil war blockade runner *CSS Run'Her*, run aground on the 4th, November, 1864, with bits of the wreckage spread all over the north area of the bay (AA, 1864). The other two were two wooden hulls, buried under 1 to 2 meters of sediments, in depths of water of circa 7 meters, identified for archaeological purposes as Angra C and Angra D[3]. Six samples of wood, taken from both wrecks, suggested that both dated from the same period, the last quarter of the XVth century or the first quarter of the XVIth century. In spite of the little size of the identified areas of Angra C and D, it was clear — and the radiocarbon datations confirmed it — that those two wrecks should be completely excavated.

Therefore, a second phase of the project was necessary, and the three entities already involved in the first phase prepared a new protocol of collaboration, that was sent by the National Centre for Nautical and Underwater Archaeology (CNANS) of the Portuguese Institute of Archaeology (IPA) to the regional authorities in June 1997[4].

The project was placed under the responsibility of the CNANS by inherence. Under the terms of that protocol, an archaeological team of eight people would be created during 14 months, and a period of eight months was defined for the intervention. The regional authorities would assume all the expenses. More than eight months later, in March 1998, with the protocol not yet returned by the regional authorities, the CNANS was suddenly contacted by the Administration of the Angra Harbour to prepare an immediate intervention, because the works of the marina would begin the following week. The second phase was carried in four months, from April to July, by a team of 16 people of six nationalities[5].

Although the visibility was very low during the winter site examinations[6], the conditions at shipwreck site were very workable due to shallow depths (7 meters), a coarse sand bottom, and the potential for periods of good visibility (2 - 20 meters, exceptionally), in the springtime. The site's close proximity to docking facilities, a protected harbour, lifting equipment, and storage space was also an advantage.

As external consultants, the CNANS invited Eric Rieth, from the Centre National de la Recherche Scientifique (CNRS) and archaeology professor at the University of Paris 1, and Peter Waddell, from Parks Canada, the former a specialist in medieval and post-medieval ship building, the later a world leading expert in hull dismantling.

Both did extended dives on both sites.

After the complete removal of Angra C, the 16 crewmembers were devoted 12 hours a day, 6 days a week, to the complete removal of Angra D. While dealing with the inherent complexity of the task, the team also had to make do with logistical and physical constraints, like the lack of proper facilities for the archaeological studies and analysis. Space was very limited at this facility, with the 16-member team working from a 20-foot container on the first month of the project. This included temporary storage, artefact cleaning, cataloguing, analysis, filling operations, briefing space and changing rooms. Impacts from natural forces were a very real threat, especially during site excavations. A plan of protective measures, such as covering or buffering fragile portions of the shipwreck site, was thought out and developed prior to the advance of catastrophic storms, that did not occur for the project duration.

After the excavation, the two shipwrecks had their elevations and hull contours recorded by digital goniometer (Cozzi, 1998, p. 64-80) and were, finally, completely dismantled piece by piece (Waddel, 1986, p. 137-139), with the timbers being stored in several giant palettes that were placed outside the intervention area of the marina works, in a deeper zone of the bay.

2. Project design

The whole campaign was laid out in accordance to the UNESCO Recommendation on International Principles Applicable to Archaeological Excavations[7], the ICOMOS Charter for the Protection and Management of the Archaeological Heritage[8] and the new ICOMOS Charter on the Protection and Management of Underwater Cultural Heritage[9].

According to the fundamental principles stated on the article 1 of the ICOMOS Charter, public access to the wrecks was encouraged, with local divers visiting the site and been shown around the site and the archaeological archives. Articles published in the local, national and international press and TV also promoted public awareness.

Although the preservation of underwater cultural heritage *in situ* was considered as a first option, building constraints ruled out the use of non-destructive techniques, non-intrusive survey and sampling for the second phase. Since both of the wrecks were in the precise path of the breakwater soon to be built[10], all the authorities involved in the process agreed to conduct the excavation, the dismantling and the removal of both wrecks to a secondary location, in deeper water, to allow further study of them, while the construction of the breakwater could proceed.

In all the steps, the investigation was accompanied by adequate documentation. Accordingly to the article 2 of the Chart, the project design took into account the mitigatory objectives of the project by devising an adequate methodology to be used. All the techniques to be employed were discussed on national and international levels of academic underwater archaeology.

Fourteen months served as a timetable for the completion of the project while a mix of sixteen underwater archaeologists and divers from Portugal, France, Italy, Spain, Canada and United States of America formed the investigating team. This team was co-ordinated by the Director of CNANS, Francisco Alves who, according to the article 6 is an underwater archaeologist with recognised qualifications and experience appropriate to the investigation. The leading archaeologist provided on-site management, together with two local co-ordinators, who took care of all the documentation, the health and safety code of practice and the report preparation.

Unfortunately, no provisions were made regarding the material conservation of the artefacts recovered, although all the items brought to the surface were stabilised according to basic conservation procedures. On matters regarding article 3, the funding of the campaign, adequate funds were not assured in advance of investigation to complete all stages of the project design including conservation, report preparation and dissemination. The project design did not include contingency plans that would ensure the conservation of underwater cultural heritage and supporting documentation in the event of any interruption in anticipated funding, which as occurred immediately after the physical removal of the wrecks.

3. Angra C wreck

Angra C is a segment of the bottom of a wooden hull, measuring 14,75 meters in length and having 6 meters at its maximum width. Angra C was located below 2 meters of sediment, composed of fine silt and sand, at an average depth of 7 meters below MSL. The wreck had a northeast-southwest orientation.

Excavation at Angra C begun by clearing away the sand and loose ballast stones in the central area of the wreck. The site was grided off into 4 square meters as a framework for accurate recording of the shipwreck. 3 water dredges and 2 air dredges removed the sand overburden, while the ballast stones were removed by hand. Divers did sample collecting of bilge sediments for microanalysis, of organic remains for species studies, and of wood sections for dendrocronology and species identification.

The team removed all the overburden, excavated until the wreck's level was reached and then proceeded to dug out a trench around it's perimeter, 4-5 meters away from the hull, with a ship borne high suction pump, in order to achieve maximum working visibility and to speed up the sediment excavation. Since the main objective of the project was to examine, record and dismantle the ship, the excavation strategy was directed toward uncovering specific features of the hulls.

3.1 Ballast

Angra C ballast was in surprisingly small quantity for the size of the ship timbers, a fact that might points to the hypothetical use of shingle as a primary ballast resource. The surviving ballast stones were calcareous in nature, rough-shaped, white coloured, with a maximum weight of 50 kg and a maximum diameter of 50 cm.

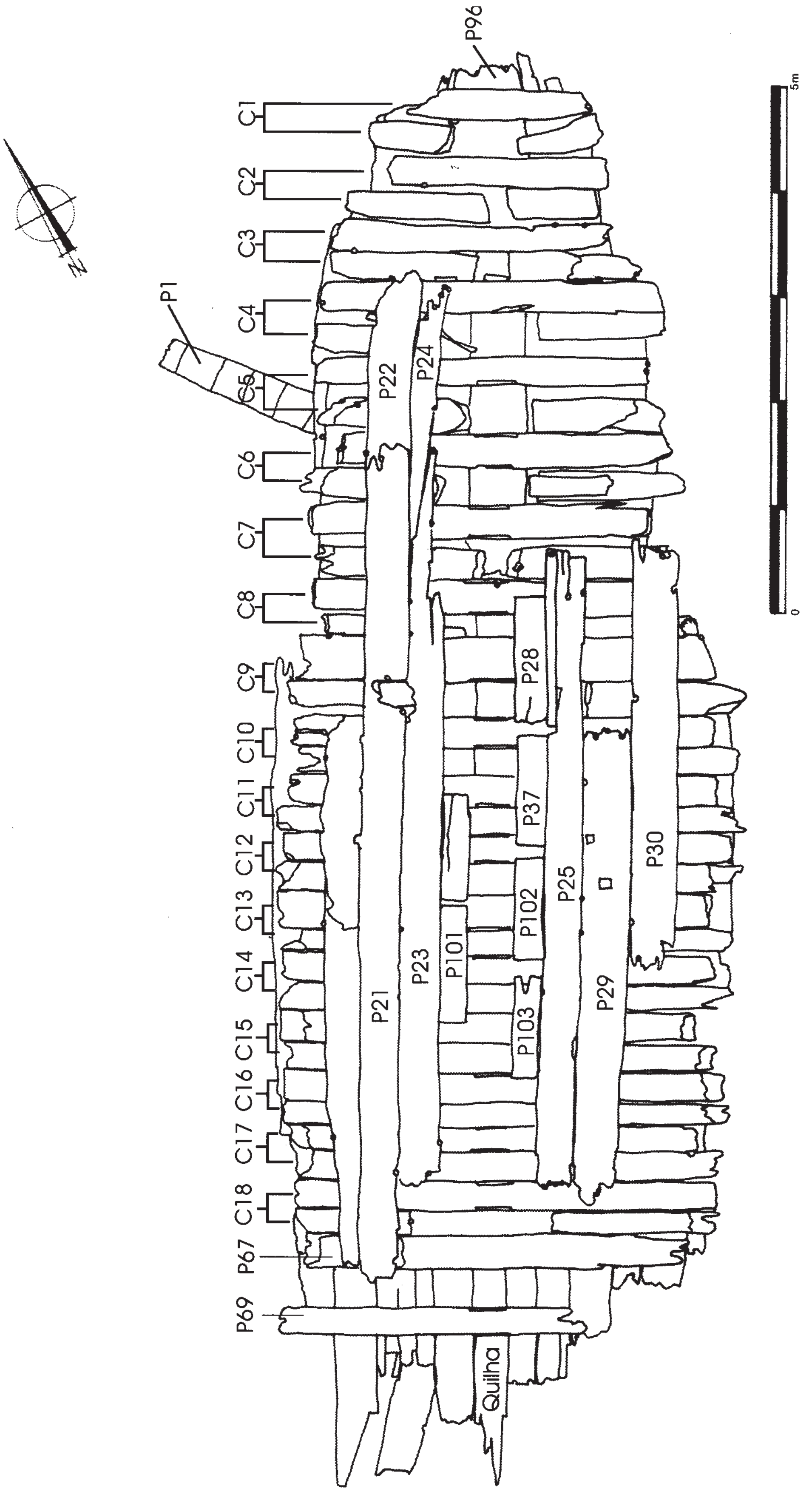

FIG. 1 – Angra C plan of the hull.

3.2 Keel

A segment of the keel, 10,5 m long, was still *in situ* at Angra C's southwest end, with both its extremities ending in a scarf. The keel was 28 cm moulded and 33 cm sided at its upper surface. Ten centimetres lower, the sides of the keel would taper down narrowing to form a lower surface 16-cm sided. The surviving fragment of the keel showed no outer planking rabbets.

3.3 Keelson

The keelson was missing from its original position, although a segment of it was found, pinned below the hull, on it's northwest side. The keelson was dented, in order to fit over the upper surface of the floors, and was 45 cm sided, being 15 cm thick at the carving used to sit over the futtocks and 21 cm thick in between carvings.

3.4 Floors and first futtocks

Floors alternate between 55 cm (maximum) and 24 cm (minimum), with an average of 32,4 cm sided. They are between 30 cm (maximum) and 20 cm (minimum), with an average of 25,4 cm moulded. Floors are between 2 m and 4 m long. Floors are spaced between 25 and 40 cm.

Two of the floors were connected to the first futtocks by one dovetail mortise or two dovetail mortises for each of the futtocks. The floors were fixed to the keel, to the rising deadwood and, eventually, to the keelson by iron nails. All floors had centred limber holes and had a semicircular cut, either on one face or on both faces that was used to receive the keelson.

This mortise was, in average, 40 cm long by 4,5 cm in width. The first futtocks alternate between 34 cm (maximum) and 20 cm (minimum), with an average of 28,6 cm sided. They are between 35 cm (maximum) and 14 cm (minimum), with an average of 23,1 cm moulded. The floors and futtocks were not laterally connected by fasteners, just as happened with the *Dartmouth* (Steffy, 1994, p. 157).

3.5 Planking

Angra C has a double layer of outboard planking, each layer being between 6 and 8 cm thick, making the whole outboard side between 16 and 18 cm thick. The west side garboard, 10 cm sided, had been lowered by 3 cm so as to make a bilge waterway, in a manner comparable to the Dutch SL4 wreck (Adams et al., 1990, p. 89). The presence of double hull is a typical characteristic of a Dutch construction as can be seen on the *Mauritius* (L'Hour, Long et Rieth, 1989, p. 208), the *Batavia* and the Scheurrak SO1 (Maarleveld, 1998, p. 125)

The average side dimension of the outboard planks is 30 cm. No evidence of sheathing was found. Three bilge stringers run on each side of the hull. They were in between 35 to 60 cm sided to 8 cm moulded.

The inner planks were, in average, 6 cm thick. Several limber boards were in place, near the axis of the wreck. An opening, carved in between a bilge stringer and a ceiling plank, may correspond to an insertion for the pump well (Oertling, 1996, p. 35).

3.6 Rising deadwood

On the northwest extremity of the wreck, a rising wood was sandwiched between the floors and the missing keel. It was made of one piece of wood, being 75 cm sided at it's northwest end and 4,5 m long. A parallel for this structural element can be found on the wreck of the *H.M.S. Dartmouth* (Martin, 1978, p. 32) and in the SL4 wreck, that shows a rising deadwood at the bow and at the stern (Adams, Holk and Maarleveld, 1990, p. 89).

The first 3 floors, counting from the northwest end of the wreck, were notched in order to fit over the rising wood. The remains of two iron bolts were clearly seen in the terminal part of this element.

3.7 Fasteners

Angra C showed, at ceiling level, more than 1300 treenail heads. These trunnels were the main fastening element and had an average diameter of 3 cm. Iron bolts were used, as stated above, only to fix the floors to the keel and to the rising wood. Iron nails, with a square cross-section of 1 cm, were used to fasten the outboard planks, although the trunnels were the main means of connecting both outboard and inboard layers to the floors and futtocks. Iberian shipbuilders did not use treenails because they believed that they would be a doorway for *Teredo navalis* (Lavanha, 1996, p. 33-34) but they were favored by northern European shipbuilders (L'Hour, Long et Rieth, 1989, p. 207).

3.8 Artefacts

The ship was obviously salvaged at the wrecking event and artefacts recovered were scarce, with leather soles, a copper cauldron, an intact pipe, some pipe stems and shreds of ceramic coarse, light and blue being the most notable. Organic material, like fruit pits, grains, corn, straw and a tar-like caulking substance, were also recovered.

3.9 Assessment

The majority of Angra C characteristics point to a Dutch built vessel (Maarleveld, 1998, p. 125), probably according to shell first technique. Pipe typology (Higgins, 1997, p. 133) might date the wrecks to the mid-1600's, but conclusions will only be reached as soon as dendrocronology and palinological analysis can be performed on the materials recovered from Angra C.

4. Angra D wreck

The shipwreck conventionally named Angra D, was lying in only 7 meters of water, some 50 meters away from the town's coastline, oriented on a west to east axis, parallel to the shore, 28 meters away from the midpoint of Angra C.

Most of the site was buried under the sand, with only a handful of timber ends protruding above the bottom's surface, in between some loose ballast stones. Beneath the ballast mound, the hull of the ship and some of its contents have remained well preserved in the sediments, mainly fine sand and silt. Preliminary excavations revealed that the wreck had an average length of 35 meters and a maximum width of 9 meters.

Divers first conducted a controlled visual search around the mound area to locate other exposed remains and also to establish the ends of the wreckage, and determine the extent and depth of cultural deposits. As opposite to the winter situation, the area immediately surrounding the mound appeared to have been recently scoured out, since there were more exposed timbers at the north side of the wreck. Numerous concretions were scattered about, all of them apparently belonging to the wreck of the *Run'Her*.

Once the search for additional remains outside the mound had been completed, reference baselines were installed to facilitate triangulation, elevation recording, grid placement, and photography. Location of the baseline was dependent on the exact position of shipwreck remains and the orientation of the hull structure. Marker and mooring buoys were also used in order to help divers reach and become quickly oriented to the site. The shipwreck site offered divers an advantage with regard to positioning since the excavated main mound was substantial and had identifiable features that could be used as points of reference, as happened with the boiler from the *Run'Her* that served as a stationary reference point. Radiocarbon dating for three samples recovered from Angra D pointed to a date of loss around the turn of the XVth century.

The wreck was very heavily ballasted and several tons of rocks were removed in the process. After the removal of about 20 tons of ballast stone, the team discovered that Angra D presented articulated remains of a lower hull, composed by 9 floor riders, the keelson with the mast step assembly, ceiling planks, a complete assembly of the stern post and several isolated timbers at the stern and bow ends of the wreck. The excavation of the test units provided also a sampling of artefacts to help estimate the number and variety preserved on the shipwreck site.

Angra D measured 35 meters in length and had a maximum beam of 8,1 meters. Surviving timbers included keelson, nine floor riders, bow knees, the main mast step, deck beams, stanchions and the sternpost assembly. The wreck was listing to starboard, where 5 meters of hull had survived, with only 2 meters of the port side breadth surviving, abeam of the mast step.

4.1 Sternpost

Articulated remains of the stern measured 8,1 meters long to 3,9 meters high on the sternpost. The sternpost assembly was only physically attached to the wreck by the keelson and the keel, all outboard and inboard plankings thorn around that line of fracture. The rake of the sternpost was measured and found to be circa 67°, with sixteen frames recorded in the tail section, as well as several cant frames, deadwood and outboard planking.

The stern section, which was resting on the sand at an angle of 20°, was massively sheathed in lead, with all the inner details of construction hidden beneath the sheathing. Three iron gudgeons — the first 85 cm from the keel plane, the second 195 cm from it and the third 240 cm away from it — are still in situ, while some planks resting besides the sternpost suggested that they constituted the remains of the rudder. Further analysis of those planks will confirm, or not, that suspicion.

The gudgeons were 14 cm sided, projecting outside from the sternpost about 13 cm. Gudgeon orifice was 7 cm in diameter. The sternpost had, in all, 19 hawse pieces. The structural integrity of the sternpost assembly permitted its complete lifting as a whole, without having to be dismantled, as soon as the keel and keelson were sawed.

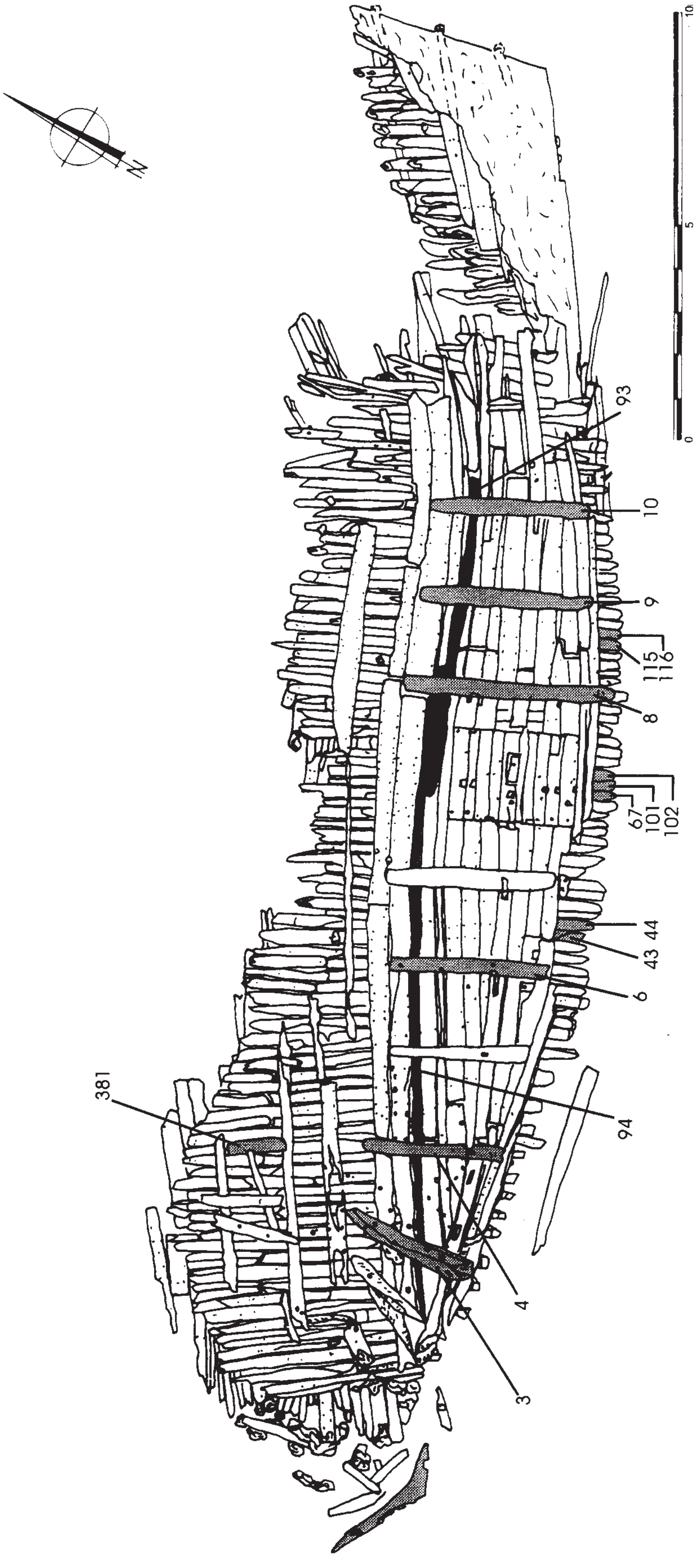

FIG. 2 – Angra D plan of the hull.

4.2 Floor riders

The floor riders, internal frames set atop the ceiling — averaged 30 cm to 40 cm moulded by 25 cm to 30 cm in sided thickness, and were, in general, spaced apart 1,5 m. They are 2,5 to 3,5 m long. There were at least 3 footwales, also embraced by the floor riders. Two of these footwales were scarfed with the keelson, at the bow section. The presence of riders was a complete surprise since they are typically found only in XVIIIth century warships. The only known example of floor riders in early post medieval ships is found on the *Mary Rose*.

Floor riders were a way to increase structural strength in the lower hull due to the ever-increasing size of ships and associated volumes of ballast and/or cargo. The use of floor riders in Portuguese and Spanish shipbuilding in the turn of the XVIth century is not known, but the more one dwells into Spanish shipbuilding treatises, the more one considers that one major cause for the adoption of floor riders and dovetail mortises was the prevention of breaking of the ship upon grounding. According to Tomé Cano (1611) *for the nao to leave the shipyard with great strenght, it must have (...) the floors crossing with the first futtocks, the more the better; and in these crossings to have two tenons, one opposite the other, and on top of these the two bilge stringers, one covering the extremity of the floor and the body of the first futtock and the other covering the wrongheads of the first futtocks and the (dovetail mortise) dented floors because if the nao grounds or keels over a shoal, she will break up, with all the caulking being spit out (from the plank joinings) and going to the bottom, if she does not have this fortification (...) All the (central) frames that are not . pre-assembled do not need to have the dovetail mortises because they do not rest upon the ground when the nao grounds (...) in naos with little depth of hold and so little floor length, there is no need for floor rides; but, if greater than 15 codos de manga, they will have to use floor riders.*

An anonymous author[11] also wrote, in 1631, that *in our Spain, when it's naturals had ships built without any Royal decrees, and according to each others will, they gave them the third part of the (manga) beam (as the length of the floor, up to the turn of the bilge), and others even less, with which they drew much water and it was very difficult to enter and leave shallow harbours; and as they were so deep in the sea, they were lost coming and going in them; and they were slow; and to correct so great defects, the legislation that now exists was adjusted and the said legislation now says that the ships built according to it shall have half of the beam of the galleon as floor length (...) It is true that the Flemish ships have big floor lengths and they roll a bit, and they make them like this because of the bad ports that exist in that coast; but, in order for the rolling action dos not cause any breaking of the ship, they make them flat, with very few dead weight, (few) masts and light rigging, with which their rolling action does not do any damage (...) and as the Dutch do not use so much deadrise, when their ships run aground in the harbours and beaches, and if they had this much deadrise it would be easier for them to break up, and so they make them like that, and I arrive to the conclusion that the Flemish nation has understood better than anyone else the things of the sea and that they practice them with much more perfection than any other (nation), and they go with their ships all over the world and to places where ours can not navigate, because of the great storms there are in those regions, and that the Turks from Argel and Zale, to practice piracy in the coasts of Italy and Spain, they do not use anything else than Flemish ships, capturing so many and of so many different nations, because they are the fastest (ships), and this because of the little water they draw (...) In Spain we do not know how to make the sternpost narrowing as they should, because we make them so narrow and filled with timber that it cannot be fortified from the inside and, as such, when (the nao runs) aground, she breaks from there. It must have an open angle, and wide like those that the Flemish carvels and ships have, where they can have floor riders on the inside, blocked by the timbers, and wood and stringers (...) She will take as many floor riders as may be fit between the bow and stern, over the (granel) ceiling, spaced one from each other two codos and three quarters (1,6 meters) and scarfed into the bilge stringers, that run from bow to stern (...) All the floor riders I have said she should have (built), and more if possible, because they are the greatest fortification (a nao can have) for all the occasions that might arise* *of a grounding accident, and having these elements, over which all weight will rest, well fortified, she will not break up, as they normally do when they are not fortified below* (Vicente Maroto, 1998, p. 183).

4.3 Keel

Total length of the keel was about 25,5 meters. It was 45 cm sided, below the mast step, and had 30 cm moulded. The upper surface of the keel was completely sheathed in lead. The severe dislocation of the 3 different parts that composed the keel — as well as the fact that the sternpost assembly was imposed over the east end of the keel — made the in situ measurements slightly uncertain. Total exact length of the keel will be obtained as soon as the keel will be pre-assembled on the third phase of the project.

The collapsing of the ship, during the shipwreck process, caused a severe list of the sternpost to the starboard with the rupture of the first keel scarf. The second keel scarf was severely twisted and bent but the keel was not broken, causing only a severe listing to the vertical of the second segment of the keel, the one that included the main mast step. At that location, the keel measured 44 cm sided with 40 cm moulded. An interesting detail of the keel was that its top face, where it contacted the floors, was completely sheathed in lead.

4.4 Keelson

The keelson, also totally preserved, was notched to fit over the floors. It measured, behind the mast step, 28 cm sided and 32 cm moulded — total height where it was not notched, 25 cm at the notches — and it featured two keyed hook scarfs, one below floor rider 4 and another between floor riders 8 and 9. The keelson enlarged to 46 cm sided, in order to form the mast step on which stepped the mainmast. The keelson showed two mortises — 25 cm long, 5 cm sided and 4 cm deep, between floor riders 3 and 4, separated by 80 cm — and another one, just forward of floor rider 6, with the same general dimensions.

4.5 Floors

The average floor side thickness, at the keel, was 21 cm — minimum 15 cm, maximum 25 cm — with an average moulded height of 19 cm. The average centre spacing was 22 cm, equal to the sided thickness of the floor frames. Floor frames, amidships, had a sided thickness of 20 cm. Limber holes were dead center over the keel and averaged 6 cm high by 4 cm wide.

The master frame (C 101) was the larger floor, measuring 24 cm sided, with futtocks on both the aft and forward face of the floor, joined to the frame by a dovetail-mortice feature. To either side of the master frame were 7 central floor timbers, all joined to the first futtocks by dovetail scarfs, which lead us to believe that they were pre-assembled before being placed over the keel. The rest of the framing must have been added as planking progressed. If this is true, the floor/futtock sets number 43/44 and 115/116 were the bow and the stern *almogamas*.

The spaces between the lower ends of the first futtocks and the outer ends of the floors, on the starboard side of the ship, as well as the outer ends of the first futtocks and the lower ends of the second futtocks, were filled by overlapping both joining timbers, so that was a solid belt of wood beneath the stringers. Surviving frames included at least one berthing deck beams (n.° 381), on the starboard side of the wreck.

4.6 Main mast step

Beneath the main mast step assembly, there were five filling pieces, that separated the floors underneath the expanded keelson. The expanded keelson had a mortise to house the heel of the main mast and a chock at the forward end of the mortise to keep the foot of the mast from shifting. The mortise was 61 cm long and 20 cm wide.

Five pairs of perpendicular buttresses, 20 cm sided and 90 cm long, laterally supported and reinforced the mast step in the immediate vicinity of the enlarged portion of the keelson. These buttresses were lying over the floors and some of them had scarfs that fit into notched stringers on their outboard ends.

At the base of the mainmast mortise was a drilled hole on the floor right beneath the mortise, which may have been intended for a drain hole to allow seawater to escape into the bilge. There were two pump wells to house the shafts of the ship's bilge pumps, one in each side of the keelson, at the stern extremity of the mast step. The two pumps, one on either side of the keel at the lowest part of the hull, had their foot where water collected in the bilge (Waddel, 1985, p. 245)

Surviving vertical structure included a pump well, fitted around the main mast step, at least two bulkheads, eight limber boards and several stanchions in situ, that fit over the floor riders. The stanchions had a square section, 8 cm sided and had mortises to fit in the tenons on the floor riders.

The pump well was 3,4 square meters in area and was almost box like in structure, being 1,8 m long on the keel axis and 1,6 meters wide from side to side, centred on the main mast step. The vertical pump well timbers were 2,5 cm thick.

4.7 Sheathing

One method of protection against the shipworm borers was to nail strips of lead to the hull (Smith et al., 1995, p. 72). The hull of Angra D was completely sheathed with lead strips, some of which show weave impression from textile cloth, that might have been pressed between the lead and the hull (Smith et al., 1995, p. 63). All the loose strips have holes left by sheathing nails. After the removal of the outboard planks, a second layer, now of lead, was found beneath, composed of all the lead strips that, still attached to one another, had rusted away from the hull.

4.8 Planking

Outboard planking average 5 to 8 cm thick, with sided dimensions varying between 28 and 33 cm. Footwales are 13 cm sided and 14 cm moulded. Ceiling planks were 5 cm thick and were around 4,3 meters long, with a sided dimension of 35 cm.

4.9 Fasteners

Fastening was done by means of two different kinds of iron nails, both with a square cross-section that could be either 1 cm or 1,5 cm sided. Some treenails were located, in the outer hull planking, 2,5 cm in diameter.

4.10 Artefact distribution

Artefacts recovered are representative of the daily life on board a ship of the end of the XVIth century or the beginning of the XVIIth century. Several of these, like a brass fitting for a trunk, a copper pitcher, two staved buckets — one with the rope handle still attached — several wicker baskets and barrel staves and bottoms, might represent containers for cargo or ships's supplies (Hildred, 1997, p. 52), as well as personal possessions, like the wooden combs found (Redknap, 1997, p. 79).

Others once formed part of the ship rigging like a two-block pulley and several lengths of rope and cable found. Others represent past cargoes, like the mercury puddles found on the hold of the ship or ship's daily life, like a Our Lady figurine carved in resin, or the presence of a thimble and pins in context, too.

Mammal bones recovered include cow (*Bovis spp*.), pig and hog (*Sus spp*.). Chicken and fish bones also were found in the shipwreck. Coconut shell, almonds, seeds, raisins and corn represent the other dietary elements of the on board life (Matos, 1998, p. 383). Cockroach wings and exoskeleton remains, as well as bones and skulls of rats are the remains of the unwanted stowaways that competed with man for food resources (Smith et al., 1995, p. 72).

Hundreds of fragments of ceramic containers were found in the hull, the majority of them being several rims and shreds of olive jars, both glazed and unglazed on the inside. Two of the rims had the IHS sign from the Jesuistic Society, very much like the ones found at the Atocha wreck site (Marken, 1994, p. 32). White and blue porcelain shreds were also found, with the most significant of those being identified as a Ming dynasty porcelain, dating from the 1550´s onward[12].

Over 150 ml of mercury were recovered from the hull, with metallic puddles concentrated at the mast step assembly and amidships to the portside. The metal was recovered with syringes and stored for further analysis. The presence of mercury in the bilge of Angra D suggests that the vessel was carrying — or had in the past carried — a cargo which included quantities of that metal (Smith et al., 1995, p. 87), which was used mainly as a component for the extraction of silver and gold in Central and South America (Desroches, 1994, p. 113).

Several items of the ship's ordnance were recovered, including ammunition for the ship's artillery, which included a stone shot for a cannon, and four iron cannonballs, recovered right at the mast step, suggesting that the shot locker was located there (Vicente Maroto, 1998, p. 198).

Small arms ordnance were represented by the recovery of three wooden gunpowder boxes, triangular in shape, one of those being the one used for carrying the priming gunpowder. A wooden stock for the barrel of a musket was also excavated as well as several dozens of lead shot, circa 2 mm in diameter, probably for musket use (Smith et al., 1998, p. 150).

Unfortunately, no coins or other dated materials, with the exception of the Ming dynasty porcelain, were recovered. Olive jar chronology point to a late sixteenth century or an earlier seventeenth century wreck, a fact supported by the white and blue ceramics found. Also, the presence of a stone shot cannon ball also points to the same period in time. No intrusive materials were found, except the iron concretions of the *Run'Her*, earlier mentioned.

Conclusions

Examinations of elements of the hull remains, and measurements of various parts such as futtocks and floor timbers suggest a very large sailing vessel. Size of frames, floor timbers and futtocks, as well as distance and space between frames[13] suggest a ship of between 700 and 800 tons displacement, and an overall length of between 35 and 40 meters.

The materials recovered and the naval techniques used in the building of the ship (Oertling, 1989, p. 100-103) provide a late sixteenth-century or early seventeenth century date for the shipwreck, and the overall artefact assemblage, most notably the mercury, matches what might be expected from an Iberian ship of that period.

5. Hull scantling measurements from the Angra D wreck (meters)

General
Average depth of wreck: 6,5
Axis: E-W, parallel to coastline
Distance to coastline: 70

Hull overall
Length (estimated): 37,5
Beam (estimated): 12
Depth of hold (estimated): 5,76
Tonnage: 817 tons

Preserved hull measurements
Length: 35
Starboard breadth at the bow: 7
Starboard breadth at the stern: 5,5
Starboard breadth amidships: 5
Portside breadth amidships: 2
Height of hull remains at the pump box: 2,1
Ballast mound: 25 x 5

Keel
Length: 25,5
Moulded height: 30
Sided thickness amidships: 0,40
Sided thickness aft and fore: 0,25

Keelson
Length (estimated): 23
Moulded height: 0,25
Sided thickness amidships: 0,32
Sided thickness aft and fore: 0,22/0,25

Mainmast step assembly
Length: 1,75
Width: 2,35
Expanded keelson moulded height: 0,32
Expanded keelson sided thickness: 0,42

Step mortise
Length: 0,61
Width: 0,20

Buttresses
Number: 5 pairs
Length: 0,90
Maximum moulded height inboard: 0,20

Floor frames
Average moulded height: 0,19
Average sided thickness: 0,21
Average on centre spacing: 0,44
Limber holes: central; 0,06 x 0,04

Deck beam
Moulded height: 0,15
Sided thickness: 0,18

Floor riders
Length: min: 3; max: 4,2
Sided thickness: min 0,20; max: 0,30
Moulded height at centre: 0,25

Hull planking
Thickness: 0,07
Average width: 0,30

Stanchions
Square section: 0,08

Ceiling
Average length: 4,3
Thickness: 0,05
Width: 0,35

Stringers
Sided thickness: 0,13
Moulded height: 0,14

Stern
Length at base: 8,1
Maximum height (preserved): 3,9
Rake from horizontal line of the keel: 67°

6. Conclusions

Field studies provided critical information on vessel type, period of use, origin, and function for both shipwreck. Investigators also gained some insight into the site's layout, makeup, and surrounding environmental conditions.

Although much has been accomplished, more regional and site-specific data, more complete inventories, better management policies, and increased inter-agency co-ordination would improve the Regional Government's ability to promote its unique cultural resources for the public benefit. The project for the archaeological rescue of Angra C and D was hampered by the pressures from the media and political arena to speed up the excavation, conceivably at the expense of systematic and controlled scientific procedures. Were it not for the most recent developments, all might have been lost, and all the money, time and efforts devoted to the project would have been in vain. Worst, the underwater heritage recovered would have been forever lost.

Recently, adequate funds were finally made available by IPA and DRC in order to complete the investigation, including all the stages of the project design, i.e., conservation, report preparation and dissemination. In fact, the initial project design did not include contingency plans that would ensure the conservation of underwater cultural heritage and supporting documentation in the event of any interruption in anticipated funding, which has occurred immediately after the physical removal of the wrecks.

The availability of funds will now make it possible to undertake the post-fieldwork analysis of artefacts, wreck timbers and documentation, which is integral to the investigation. Only with further study of the remaining artefacts and the intensive study of the preserved timbers will it be possible to shed some light as to the origin and shipboard life, naval architecture, and other questions concerning sixteenth and seventeenth-century ships as well as the natural and/or intentional circumstances surrounding the wrecking episode, contemporary salvage and deterioration of the vessels now know as Angra C and Angra D.

NOTES

1 Like the knee jerk reaction against the treasure hunting lobbies that afflicted the Azores between 1993 and 1997.

2 Professor Kevin Crisman, leading archaeologist, Arthur Cohn, director of the Lake Champlain Maritime Museum, Vermont, and Professor William Bryant.

3 Angra A and Angra B being already located on the west side of the bay.

4 The position of the IPPAR was transferred to the IPA in May 1997 with the creation of this autonomous Institute.

5 Portugal, Spain, Canada, France, Italy, and USA.

6 Sometimes reaching zero visibility condition for days in a row.

7 New Delhi, 5 December 1956.

8 Lausanne, 1990.

9 Ratified on October 9, 1996 by the UNESCO's General Assembly, in Sofia.

10 And it's associated dredging activities.

11 Probably Pedro Lopez de Soto, *vedor* and *contador* in Lisbon, between 1631 and 1632.

12 Desroches, J. P., personal communication.

13 As well as the application of tonnage formulas to keel length and sternpost rake (Rubio Serrano, 1991, p. 104).

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