

## The *Purísima Concepción* Archaeological Project (Tierra del Fuego, Argentina) - An Interdisciplinary Approach

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## The *Purísima Concepción* Archaeological Project (Tierra del Fuego, Argentina) - An Interdisciplinary Approach

Dolores Elkin <sup>ea</sup>, Martin Vazquez <sup>G</sup><sup>b</sup>, Michael Krivorc, Michael D. Glascock <sup>Q</sup><sup>d</sup>, Catherine E. Klesner <sup>ee</sup> and Brandi L. MacDonald <sup>Q</sup><sup>d</sup>

aCONICET - Instituto Nacional de Antropología y Pensamiento Latinoamericano, Buenos Aires, Argentina; bCentro Austral de Investigaciones Científicas (CADIC-CONICET), Ushuaia, Tierra del Fuego, Argentina; cC/O RECON Offshore PO Box 30210, Pensacola, Florida, USA; dArchaeometry Laboratory, University of Missouri Research Reactor, Columbia, USA; eDepartment of Materials Science and Engineering, University of Arizona, Tucson, Arizona, USA

### ABSTRACT

In January 1765, the Spanish merchant frigate *Purísima Concepción* went aground on the Atlantic coast of Tierra del Fuego while sailing along the Cape Horn route from Cadiz to Lima. The shipwreck survivors remained in the island for nearly three months, time devoted to the construction of another vessel while interacting peacefully with the native population. In view of the historical significance of this event, an archaeological project was conducted to locate the shipwreck and survivor's camp. The searches were conducted both on land and underwater in the areas that were considered to have the highest potential based on previous archaeological surveys and thorough documentary research. Positive results were reinforced by an interdisciplinary approach and specialized archaeometric studies, allowing us to meet the project's goals.

### El proyecto arqueológico *Purísima Concepción* (Tierra del Fuego, Argentina): un abordaje interdisciplinario

#### RESUMEN

En enero de 1765, la fragata mercante española *Purísima Concepción* encalló en la costa atlántica de Tierra del Fuego mientras navegaba por la ruta del cabo de Hornos desde Cadiz hacia Lima. Los sobrevivientes del naufragio permanecieron en la isla por casi tres meses, tiempo que dedicaron a la construcción de otra embarcación mientras interactuaban pacíficamente con la población nativa. En vista de la importancia histórica de este evento, se llevó a cabo un proyecto arqueológico para localizar el naufragio y el campamento de los sobrevivientes. Se realizaron búsquedas tanto en tierra como subacuáticas en áreas que se consideraron de mayor potencial en base a prospecciones arqueológicas previas y a una exhaustiva investigación histórica. Los resultados positivos fueron reforzados por un enfoque interdisciplinario y estudios arqueométricos especializados, lo cual nos permitió alcanzar los objetivos del proyecto.

### KEYWORDS

Maritime archaeology; shipwrecks; 18th century AD; *Purísima Concepción*; Tierra del Fuego; Archaeometry

### PALABRAS CLAVE

Arqueología Marítima; Pedos; Siglo 18 DC; *Purísima Concepción*; Tierra del Fuego; Arqueometría

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## مشروع بورييسما كونسبسيون الأثري (تييرا ديل فويغو، الأرجنتين): نهج متعدد التخصصات

التييرا ديل فويغو هي جزيرة كبيرة تقع في الطرف الجنوبي من أمريكا الجنوبية، وهي جزء من إقليم تييرا ديل فويغو في الأرجنتين. الجزيرة معروفة بتاريخها الغني، بما في ذلك اكتشافات البشري المبكر. مشروع بورييسما كونسبسيون الأثري يهدف إلى دراسة الآثار التاريخية والثقافية للجزيرة. يتضمن المشروع أعمالاً ميدانية وأبحاثاً علمية متعددة التخصصات، تشمل التاريخ، والأنثروبولوجيا، والعلوم الطبيعية. الهدف من المشروع هو فهم الحياة اليومية للسكان المحليين في الماضي، وكذلك التفاعل بين الثقافات المختلفة. سيتم إجراء دراسات ميدانية في مواقع أثرية مختلفة، بما في ذلك المواقع السكنية، والمواقع التجارية، والمواقع الدينية. سيتم أيضاً إجراء دراسات علمية، بما في ذلك التحليلات الجينية، والتحليلات الكيميائية، والتحليلات البيئية. سيتم نشر النتائج في شكل أوراق علمية، وكتب، ومواقع إلكترونية.

### Introduction

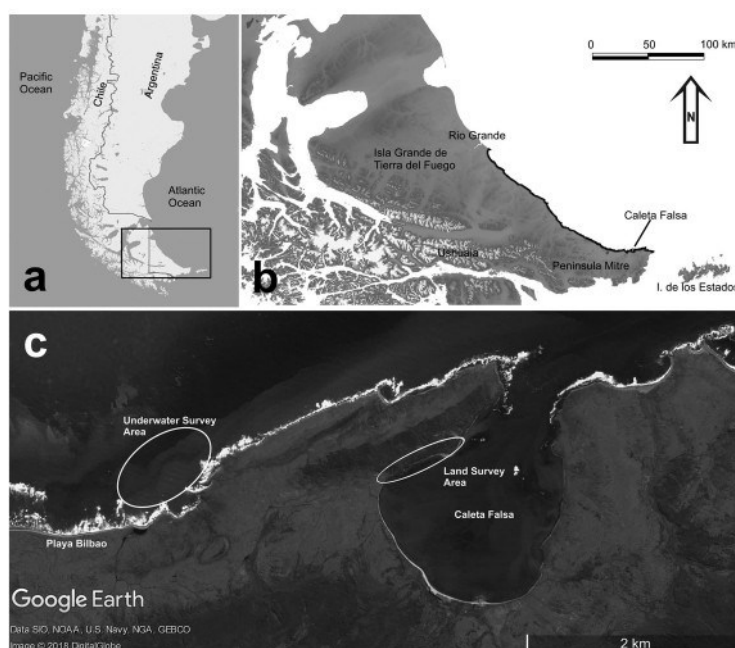
On 12 January 1764 the Spanish merchant frigate *Purísima Concepción* set sail from Cadiz (Spain) to El Callao (Peru). After crossing the Atlantic Ocean, it stopped in Montevideo and continued its southbound voyage along the Patagonian coast. The entry corresponding to 9 January 1765 of the ship's logbook (NN, 1765), almost a year after the departure from Spain, indicates that the sky was overcast all day, and they had not spotted land. A few hours later, at 2.30 am on 10 January, they suddenly found themselves 'stranded and still unable to see the shore in the island called Fire' (NN, 1765, folio 135).

The 193 people traveling on board *Purísima Concepción* survived the wrecking because the ship went aground close enough to the shore, and everyone was eventually able to reach firm land. The same diary indicates that they settled in a small bay a few leagues away from the wreck site, where they built some barracks. They stayed in that place for nearly

three months living in harmony with the native people and sharing various activities with them, including the first Catholic mass celebrated in Tierra del Fuego (NN, 1765, folio 139). Their main goal, however, was to build a new vessel, for which they used elements salvaged from *Purísima Concepción* and timber from the nearby forest. Finally, on 2 April 1765, the sloop named *San Joseph y las Animas* was launched, enabling them to return safely to the Rio de la Plata.

Despite the historical significance of all these events, no systematic attempts have been made to locate archaeological evidence associated with the shipwreck or survivor's camp. However, an iron cannon accidentally found on the coast of southeastern Tierra del Fuego, recovered in 1981, and displayed at the Museo del Fin del Mundo in Ushuaia, is attributed to the remains of *Purísima Concepción* (Santos & Elkin, 2017).

In 2010, a program coordinated by archaeologist Martin Vazquez in his role as Director of Heritage and Museums of Tierra del Fuego set forth to search



**Figure 1.** a and b. Main island of Tierra del Fuego and geographical area of the Atlantic Coast Archaeological Project indicated with a black line. le. Close-up of the Caleta Falsa area, in the eastern part of Tierra del Fuego, where underwater and land surveys were conducted in search for *Purísima Concepción* (authors).

for material evidence of past human activity along the Atlantic coast of the island. The surveys were conducted along a coastal strip of around 180 km, starting just south of the city of Rio Grande and reaching Peninsula Mitre, the easternmost part of the island (Figure 1a and b). The archaeological remains identified and recorded range from indigenous artefacts to historic shipwrecks. The investigation of historic shipwrecks was left to the underwater archaeology unit of Argentina's National Institute of Anthropology. Surveys were conducted throughout various field seasons, providing a clearer understanding of past human activities on that part of the island (Vazquez et al., 2010; 2012; 2017).

During the 2014 field season, two archaeological discoveries were made that seemed promising in the search for the remains of *Purísima Concepción* (Elkin & Murray, 2014; Elkin et al., 2017): the first discovery included the identification of seven iron cannon balls located within the intertidal zone (Figure 2). These artefacts are indicative of the types of munitions that could belong to *Purísima Concepción* for several reasons. The primary reason is that the area where they were found is considered the location with the highest probability of where the ship stranded and the crew disembarked (Cornejo, 1987). Moreover, *Purísima Concepción* is the only known 18th-century AD ship lost along the Atlantic coast of Tierra del Fuego which carried armament. Finally, the calibre of the ammunition appears to match that of the 20 cast iron cannons that the vessel carried on board (Contratación, L., 1755).

The other promising find consists of a single green glazed ceramic fragment that was found still inserted in what remained of a naturally collapsed portion of an embankment adjacent to a pebble beach at Caleta Falsa. Despite being relatively small, the general characteristics of the artefact (including its manufacture techniques, shape, the coarse paste, and glaze)



**Figure 2.** One of the iron cannon balls found during the first surveys of the study area (authors).

suggested it could be part of a Spanish olive jar (Figure 3).

### The *Purísima Concepción* Archaeological Project

On the basis of the archaeological finds identified and documented during the 2014 field season, a research project was designed to identify the location of *Purísima Concepción* and the associated survivors' camp. Geographical descriptions provided in the ship's diary (NN, 1765) and interpretations made by previous authors about the location with the greatest potential for both sites (Cornejo, 1987) were integrated into the research design. An additional data source was the general description and a few photographs of the place where the iron cannon attributed to *Purísima Concepción* had been found in the 1980s. One expected outcome was that the location of the two sites would provide information about the circumstances of the wrecking event, the technological characteristics of the remains of *Purísima Concepción* and associated material culture, the type of settlement and construction techniques used by the survivors, insight into their daily activities, and the survivor's interaction with the local indigenous population.

The work was guided by two hypotheses: the first hypothesis was that the shipwreck survivors settled



**Figure 3.** External (top) and internal (bottom) sides of the first green glazed ceramic fragment found in Caleta Falsa (authors).

in a favourable location where fresh water and other essential resources were readily available. This location would likely be situated along a topographic feature large enough to accommodate about 200 people. In addition, the location would have to have sufficient useful raw material for the construction of a new ship - including material salvaged from *Purísima Concepción* - and proximity to a place where construction and launching of the vessel could take place. Caleta Falsa (see Figure 1), particularly on its northwestern shore, appears to meet those requirements. It also matches the geographic description of the bay that the survivors selected for their settlement (NN, 1765).

The second hypothesis was that the remains of *Purísima Concepción* were located in the intertidal or subtidal zone, with a low depth even at high tide (this presumption is based on the accounts that state that the ship ran aground close to shore), and probably not far from where the cannon balls were found. This location is west of Caleta Falsa.

The goals of the project required work on both land (to search for the survivors' camp) and under water (to search for the shipwreck). Fieldwork was conducted in December 2017 focusing on two loci for which their potential was reinforced after the finds of 2014: Caleta Falsa, and a beach to the west of it called Playa Bilbao (Figure 1e).

## Methodology

### Land Surveys

Land surveys were conducted mainly in the northwestern coast of Caleta Falsa, although the intertidal sector where the cannon balls had been found in 2014 (Playa Bilbao) was also briefly inspected. The Caleta Falsa survey area was surveyed both in an open grass plain located near the beach, and within the adjacent forest. The grass plain and the forest were respectively considered the most promising loci for both the shipwreck and survivor's campsite and the place where native people lived and with whom *Purísima Concepción's* crew would have established contact.

Five 1 m<sup>2</sup> test pits were excavated in the grassland plain (Figure 4). The space selected for the stratigraphic surveys coincides with the geomorphological feature where the ceramic sherd had been located in the 2014 campaign. The area corresponds to a small coastal plain of approximately 70 x 10 m which extends in a SW-NE direction. It is delimited by a bank approximately 8 m high on its northwest side and by the current beach on the southeast front. On the bank there is an evergreen forest of southern beech trees, with a shrub substrate. On the plain, the substrate is covered by juncaceous peat bogs with

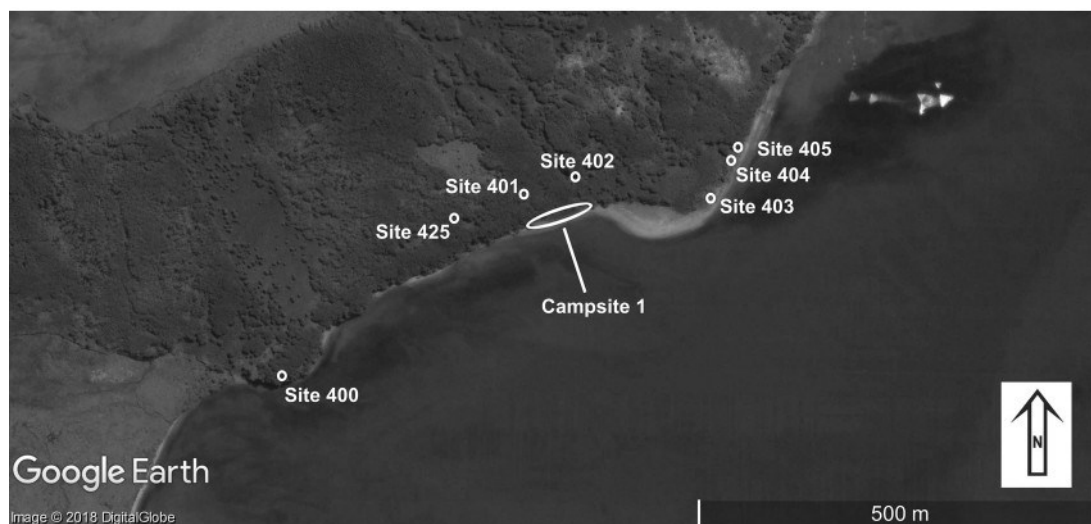


**Figure 4.** General view of the plain and the adjacent forest where stratigraphic test pit excavations were conducted in search of the shipwreck survivors' campsite and places occupied by native peoples (authors).

grasses in its basal stratum. In the central area of the plain the sediment is peaty, and in general it is a very wet area, even with flooded sectors. The boundary between this plain and the beach consists of an erosion scarp with a height between approximately 80 and 30 cm above the current beach level. The ocean environment surrounding the area offers a variety of fish, molluscs, birds and marine mammals.

As stated above, one of the objectives of the project was to explore the possibility of identifying evidence of the interaction between the native groups inhabiting the region and the crew of *Purísima Concepción*. As is evident from the chronicles, this interaction took place repeatedly during the period when the survivors stayed on the island. Moreover, once the survivors left the island, the local native groups likely continued to collect abandoned material that could be useful, such as glass or metal. The expectation was that European artefacts would be identified within hunter-gatherer contexts and/or these objects would be modified by indigenous peoples of the region.

The methodological strategy employed in this case was to carry out 50 x 50 cm test pits in three shell midden sites located in the forest less than 500 m away from site *Campamento 1* (Campsite 1). These shell middens, typically associated with exploitation of coastal resources conducted by indigenous peoples, had been previously identified during the surveys carried out in 2014. In fact, the interior of Caleta Falsa is one of the areas within the northern coast of Peninsula Mitre where the archaeological signal is most intense (Vazquez, 2017; 2019). Particularly in its northwestern margin, seven sites were located concentrated on a coastline of approximately 1200 m (Figure 5). These sites are composed of shell middens of varying characteristics and dimensions. In relation to the present coastline, two groupings can be distinguished, in different relative positions. The first group - sites



**Figure 5.** Location of archaeological shell middens - associated with indigenous occupations - in relation to the campsite of the crew of *Purísima Concepción* (authors).

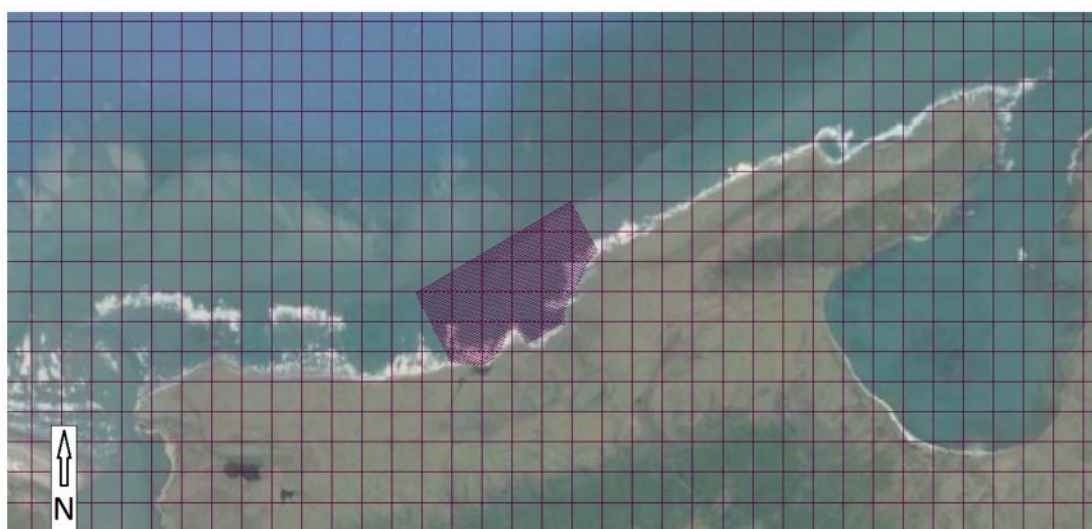
400, 401, 402 and 425 - is located on the coastal bank. The other group - sites 403, 404 and 405 - is located in a lower topographic position, adjacent to the beach. Unlike the previous group, these are flat shell middens of lesser size, although some of them have a considerable areal extension.

The historical context of these middens was also considered in the overall project's research design. In particular, within the chronicles detailing the shipwreck the forest is described as being recurrently occupied by the local native population (NN, 1765; Ratto, 1940). This information reinforced the project team's decision to test the shell middens located in the forest. Stratigraphic test pits were done in three of the seven sites located no more than 500 m away from Campsite 1, those identified with the numbers 400, 401 and 402 (Figure 5).

The last category of work on land in search of archaeological evidence potentially related to the *Purísima Concepción* shipwreck took place in the intertidal zone in Playa Bilbao (see Figure 1b). It consisted of a pedestrian survey, conducted during low tide, in the same location where the cannon balls were documented in 2014. The survey area corresponds to a large wavecut rocky platform and adjacent pebble beach where the iron cannon of the same calibre had been found in the 1980s.

### Underwater Surveys

Considering that the wrecking event occurred in shallow water and that the crew was able to salvage wood, metal fasteners, cargo, and many other items (NN, 1765), the archaeological remains of the vessel likely



**Figure 6.** Planned survey lines (dark rectangle in the centre), spaced at 15 m, overlaid on an aerial photograph. The grid squares are 200 x 200 m. The inlet to the right (east) of the survey area is Caleta Falsa (authors).

consist of the lower section of the hull, the vessel's ballast, and most of the 20 iron cannons that were aboard at that time.

On the basis of those predictions (particularly the large number of cannons that might still lie underwater), the search for the shipwreck site was conducted using a magnetometer.

The remote sensing survey for *Purísima Concepción* included the use of a Genesis GNSS Global Positioning System (GPS) integrated with a Marine Magnetics SeaSPY2 magnetometer. In addition, HYPACI(TM navigation software was utilized to design the survey area, control the acquisition of data, and contour the magnetic data after the survey. The software allows the display of digital navigation charts or aerial maps with the survey area, including pre-planned track lines superimposed (Figure 6).

The coordinate system for the current project was UTM South (Ellipsoid WGS-84), Zone 20 (66W-60W), Distance Unit: Metre. The magnetometer collected data at a sample rate of one reading per second and was towed behind the survey vessel at a distance of 15 m during all remote sensing survey operations.

The survey vessel utilized for the project was an 8 m Kiel RIB, equipped with dual 85-horsepower Yamaha two-stroke outboard engines. The vessel was ideally suited for the project area since it had ample cabin space as well as deck space for the deployment of the magnetometer.

Weather conditions were extremely variable during the survey. Winds were prevalent from the north-northeast and wave action varied from near calm conditions to large, breaking waves within the survey area. Remote sensing operations were limited to high tide and calm conditions due to the close proximity of the survey area to shore and exposed reef. Upon completion of the remote-sensing survey, the magnetometer data were edited and analysed for potentially significant anomalies located within the survey area.

Processing the magnetometer data involved reviewing each track line and ensuring there were no magnetic spikes that may affect the contouring of the edited data. Each magnetic anomaly detected during the current investigation was assessed for potential significance based on a number of criteria, including type of magnetic signature (monopole, dipole, and multicomponent), gamma deviation, gamma duration, and associated magnetic targets.

Various studies (Catsambis et al., 2011; Enright et al., 2006; Garrison et al., 1989; Gearhart, 2004) and subsequent diver visual inspection of magnetic anomalies suggest that historic vessels typically have a dipole or multi-component signature versus those anomalies that have a monopole signature. In addition, magnetic anomalies that extend across more than one survey track line have a higher likelihood of potentially

representing a submerged cultural resource than those that are only recorded on one trackline. Contouring of the magnetic data also assists archaeologists in determining the type of anomaly, total deviation (in gammas), duration (in metres), and association with other magnetic anomalies (on adjacent track lines).

Monopole anomalies can exhibit either a positive or negative deflection from the earth's ambient magnetic field (depending upon the orientation of the ferrous metal object relative to the magnetometer sensor at the time of the survey). Monopole targets recorded on only one-track line tend to represent single ferrous metal objects, such as crab pots, navigation buoys, or other isolated objects.

Dipole anomalies exhibit both a rise and fall above and below the earth's ambient magnetic field. Review of dipole anomalies for potential significance includes each individual target's total gamma deviation and duration (in metres). Generally, dipole anomalies with larger gamma deviation and longer duration are considered to have a higher likelihood of representing a shipwreck, especially when documented across more than one survey track line.

Earlier cultural resource studies tended to classify multicomponent magnetic anomalies as having the highest potential to represent historic shipwrecks.

However, a more recent study indicates that 'shipwreck anomalies as a rule are dominated by very predictable dipolar shapes' (Enright et al., 2006, p. 135).

Prior to fieldwork, planned survey vessel track lines were pre-plotted in HYPACI(TM based on discussions with the team from the Institute of Anthropology. Survivor's accounts, as well as recovered cannon and observed artefacts found onshore, identified a high probability area located approximately 3 km west of the mouth of Caleta Falsa. The planned survey area included 57 track lines, spaced at 15 m, oriented approximately northeast-southwest. Track line length varied in length from 9 m to 1,216 m in length for a total of 46,866 survey m.

### **Archaeometric Studies of Ceramic Samples**

In order to reinforce the initial interpretation of Spanish pottery in the study area, two samples were sent to the University of Missouri Research Reactor (MURR) for various analyses. They both came from *Campamento 1* (Campsite 1) site and were labelled DEA001 and DEA002. Neutron activation analysis (NAA) and Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) were employed to investigate the paste and glaze, respectively.

In accord with standard procedures at MURR (Glascock, 1992) for NAA, about 250 mg of powder was extracted from the interior of each sherd. At the same time, a small chip of glaze from the surface was removed for LA-ICP-MS.

## NAA

The powders were transferred to clean glass vials and dried for 24 h to remove moisture. Samples from each specimen were prepared for short and long irradiations. The short irradiation samples were weighed into clean polyvials, and the long irradiation samples were weighed into a high-purity quartz vial. Similar amounts of the certified reference materials SRM-1633b Flyash, SRM-688 Basalt Rock, and SRM-278 Obsidian Rock were also prepared. The SRMs are certified by the US National Institute of Standards and Technology.

The short irradiation samples were irradiated for five seconds each in a neutron flux of  $8 \times 10^{13}$  neutrons  $\text{cm}^{-2} \text{s}^{-1}$  and followed by a 25-minute decay and 12-minute measurement. The short-lived isotopes of elements Al, Ba, Ca, Dy, K, Mn, Na, Ti, and V were measured in each sample. The long-irradiation samples were irradiated for 24 h, allowed to decay for 8 days, and counted for 30 min each to determine the medium half-life isotopes for the following elements: As, Ba, La, Lu, Nd, Sm, U, and Yb. A third count was conducted on the long-irradiation samples about three weeks later to measure the long half-life elements: Ce, Co, Cr, Cs, Eu, Fe, Hf, Ni, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn, and Zr. By comparing the unknown samples to the SRM-1633b Flyash standard, concentrations were determined. The SRM-278 Obsidian Rock and SRM-688 Basalt Rock standards were used for quality control.

## LA-ICP-MS

Samples were prepared for LA-ICP-MS using procedures standard at the MURR Archaeometry Lab. Squares of about  $1 \text{ cm}^2$  were cut from each sherd using a geological saw. The cut samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the squares were mounted on a standard thin section slide with poster tack. Alongside the unknown samples on each slide, standards and quality control samples were similarly prepared. The standard reference materials used to assess instrument performance and calibrate the LA-ICP-MS data include NIST 610, NIST 612 (issued by National Institute for Standards and Technology), three glasses issued by Corning (Brill-B, Brill-C, Brill-D), and quality control sample Ohio Red Clay.

The analysis was performed using a PerkinElmer SCIEX NexION 300 Quadrupole ICP-MS coupled with a Teledyne Instruments Inc. Analyte Excite HelEx 193 nm laser ablation system. An inline camera displays the sample area on the computer screen at high magnification. With this visual aid, we were able to target the laser to ablate specific components of each standard and unknown sample. The laser was set to ablate five regions of interest, each with line length of  $40 \mu\text{m}$ . After each ablation, the laser

was paused for 25 s while the ICP-MS continued to collect data. The laser moves at a rate of  $5 \mu\text{m/s}$  firing laser bursts at a rate of 10/s. Laser power was set to 42.6 percent of the maximum output. The method used for this analysis collected data for 59 elements.

The average data for element isotopes in counts per second are then corrected to a total elemental signal using isotopic abundance ratios. This was conducted for the standard reference materials on each slide to assess instrument performance. A modified standardization method developed by Gratuze et al. (2001) was used. Elemental data are expressed as a ratio to an internal standard appropriate for the sample matrix. For pottery, Si is used as the internal standard because it is a stable and immobile major element that it abundant in all clays. The ratio expression is referred to as the standard signal. The standard signal is then referenced to published values for standard reference materials to arrive at the  $K_y$ :

$$K_y = \frac{\text{Standardized signal for } Y}{[Y] \text{ in the reference material} \times [\text{internal standard}] \text{ in the reference material}}$$

Where  $K$  is the conversion factor for element  $y$ . The standard signal is then divided by the  $K_y$  and the sum of all elements is normalized to 100 percent oxide. Standard geochemical coefficients to remove oxygen from all elemental concentrations were then applied, leaving the all data in parts-per-million (ppm). The elements that are high in concentration and are important components in lead glazes (Si, Na, Mg, Al, P, Cl, K, Ca, Sb, Mn, Fe, Cu, Sn, Ti, Pb, and Zn) are reported in oxide weight percent ( $\text{wt}\%$ ), for easy comparison with published literature.

## Results

### Land Surveys

The test pits excavated in the grassland plain yielded several intriguing finds. The most relevant artefacts with cultural and chronological diagnostic potential are several ceramic sherds. The majority of them consist of refined glazed earthenware, either completely green or in a combination of green, ochre, brown and cream. The monochrome green sherds have the stylistic basketwork decoration, used by English potters during the 18th century AD, and a single moulded fragment which is also of English origin (Barker & Halfpenny, 1990, p. 59; D. Barker, pers. com.). The polychrome sherds, when reassembled, suggest that they were part of a small container, possibly a bowl or cup and are made of a very thin paste. The colour combination is also typical of 18th century AD English ceramics.

In addition, there is another very different ceramic type found in the test pits excavated along the coastal plain. Represented by only a few sherds, these ceramic specimens are made of a coarse paste with visible inclusions. The sherds also have a glossy emerald green enamel on one side and an opaque olive-green coat on the other; likely used to waterproof the interior of a vessel. Like the isolated sherd found in 2014, these sherds also appear to be part of a typical Spanish container of the 18th century AD, likely a *botija* (olive jar). *Botijas* were used for transporting various trade products such as olives, olive oil, or wine, as well as water to drink on board. The typology and other aspects of these type of containers has been considerably studied (Goggin, 1960; Zunzunegui, 1969; James, 1988; Marken, 1994; Escribano Cobo & Mederos Martin, 1996, 1999; De Grandis & Roel, 2012; Valentini & Cano, 2012; Pasinski & Fournier, 2014; Gomez Ferrer, 2015; Velasquez & Salgado-Ceballos, 2018; Williams et al., 1992). Any Spanish merchant vessel of colonial times, like *Purísima Concepción*, would carry many *botijas* of this type, and these sherds suggest that there is evidence to support the working hypotheses for the project. This site is named *Campamento 1* (Campsite 1).

As for the test pits excavated in the shell middens, in general, these types of sites are mainly composed of accumulations of limpets (*Nacella (Patinigera)* sp.) and mytilids (mostly *Mytilus edulis*), contained in an earthy matrix. Among the associated materials, lithic artefacts and faunal remains were recorded, among which birds and otarids were the dominant taxa).

In relation to our objectives, in two of these test pits - sites 400 and 401 - cultural remains of European origin were recorded. In the first one, glass remains were found, some of them consisting of knapping debris, and in the second one, two glass necklace beads and a fragmented projectile point made of glass (Figure 7).

The glass used in tool knapping is a clear indication of foreign influence in the area. In addition, glass

beads have been reported in many archaeological contexts at colonial period sites (for sites in Argentina between the 16th and 18th centuries, see Tapia & Pineau, 2011, 2013). The glass beads are of Venetian origin, and the chronology of their manufacture, as well as their distribution over time in the archaeological record suggest that they could have been among the belongings or cargo from any Spanish vessel in the mid-18th century. The beads documented in the shell middens are of the type known as *Cornaline d'Aleppo* and are similar to the type IVa1 classified by Kidd and Kidd (1970). Beads of this type have been recovered in various 18th-century sites in French and Spanish colonial territories of the southeastern United States and the Caribbean (see, for example, Deagan, 1987; Marcoux, 2012).

Our investigation of the intertidal zone in 2017 yielded several artefacts, including more iron cannon balls, different types of ceramic sherds, glass artefacts and a few other items. The iron cannon shot have the same characteristics as those found in 2014, that is, measuring 9 cm in diameter - corresponding to a 6-pounder calibre cannon. Additional cannon projectiles were documented and left *in situ* as they are concreted to the substrate.

The ceramic fragments identified in the intertidal zone also include a refined glazed earthenware in brown, green and ochre colours. Similar to the artefacts documented in the test pit excavations in Caleta Falsa, the colour combination correspond stylistically to pottery decorations used in England during the 18th century, often referred to as tortoiseshell ware due to its appearance. One of the main producers of these type of ware was Thomas Whieldon, a partner of Josiah Wedgwood, and he began producing ceramic wares between 1754 and 1759 (<http://www.thepotteries.org/potters/whieldon.htm>). The wares decorated in this style are known as Whieldonware and became quite popular at the time. Other potters, such as William Greatbatch - who worked with Whieldon - also

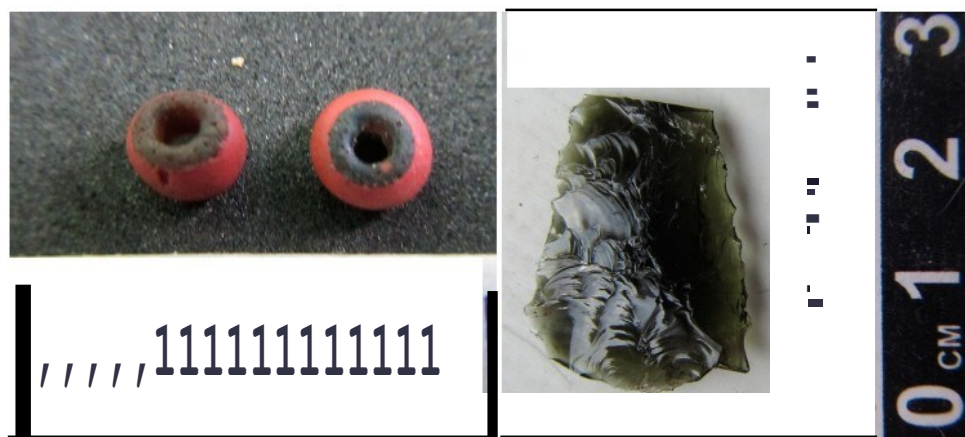


Figure 7. Glass beads and part of an arrowhead made with non-local glass, most likely European (authors).

produced stylistic similar pieces during the second half of the 18th century (Barker, 1999).

Other fragments found in the intertidal zone correspond to a type of coarse-paste ceramic utilitarian ware with a green glaze. These artefacts are similar to the sherds attributed to *botijas* found in the land excavations. The specimens found on the shore are quite eroded. A particularly interesting type of find in the intertidal zone consists of three small glass artefacts which appear to be gems (Figure 8). They all have a dome shape on their front. They were probably intended as ornaments for rings, buckles or clothing. Two of them are decorated with short incisions that form eight triangular segments. One is turquoise-blue and the other one is dark green. A third one is translucent, and the top is decorated with brown and white dots. This one has a flat bottom while the other two are slightly concave. It is worth noting that glass finds also interpreted as jewellery pieces were identified at the site of the Spanish galleon *Nuestra Señora de Guadalupe* (Borre! et al., 1997, p. 56). Like *Purísima Concepción*, *Nuestra Señora de Guadalupe* had departed from Cadiz, but was lost in Santo Domingo in 1724.

Another interesting artefact found in the intertidal zone is a small metal divider made of a copper alloy, likely bronze. The term *divider* is used for the compass which has both arms ending in a pointy tip, and simply *compass* to the one which has one of its arms adapted for drawing. The first one is the one traditionally used in navigation to measure and transfer distances on a nautical chart. The second one, although it can be used for the same purpose, is more frequently associated with drawing in its different applications. The artefact found during our fieldwork seems to correspond to the second type and could have been used in carpentry.

### Underwater Surveys

Due to an abbreviated schedule, shortage of survey vessel fuel, and inclement weather the decision to reduce the size of the survey area was made in the field. A total of 12 magnetic anomalies were recorded within the refinement area. Of these, Targets RI and R2, are associated and likely represent one isolated ferrous metal target. The remaining targets (R3-R12) are all associated with one large clustered anomaly (Figure 9). No other magnetic anomalies were documented within the refinement area. The distance between Targets RI-R2 and Target R11 is approximately 190 m.

With the primary targets (including Targets R3-R12) sufficiently delineated and no additional track lines completed closer to shore (due to shallow water, exposed reef, and inclement weather) it was decided to extend the refinement area further north. This was done in order to determine whether additional magnetic anomalies may be located farther offshore. An additional 11 track lines, each 336 m in length, were added to the refinement survey area. Review of the data identified no magnetic anomalies within the additional refinement area.

The results of the remote-sensing survey investigation were successful in documenting two clusters of magnetic anomalies. These two clusters consist of Targets RI and R2 as well as Targets R3-R12.

Although Magnetic Targets RI and R2 comprise two distinct targets, located on adjacent track lines, it is likely they encompass one ferrous metal object. Target RI has a gamma deviation of -42 gammas and 20-m duration whereas Target R2 has a gamma deviation of +19 gammas and 22-m duration. While each target has a monopole signature, review of the magnetic contour map shows a distinct dipole

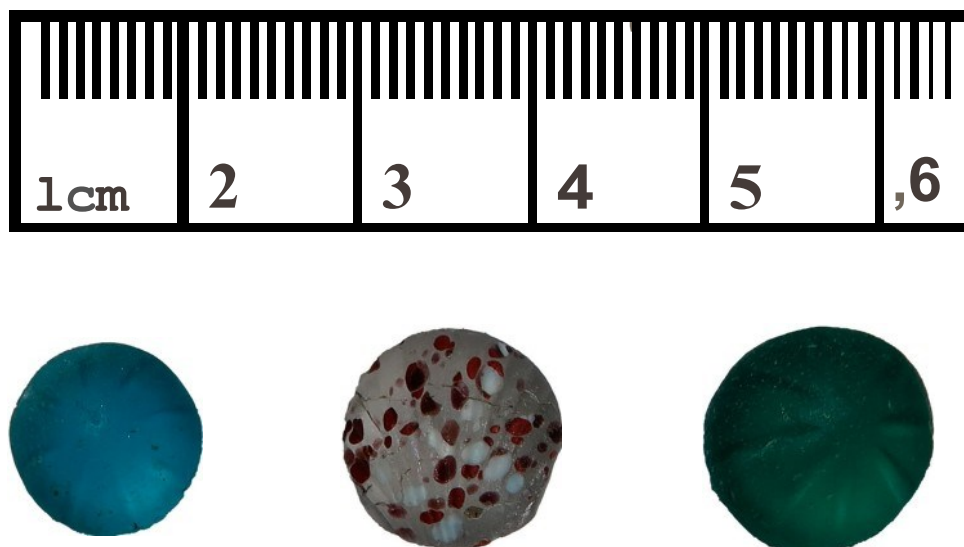
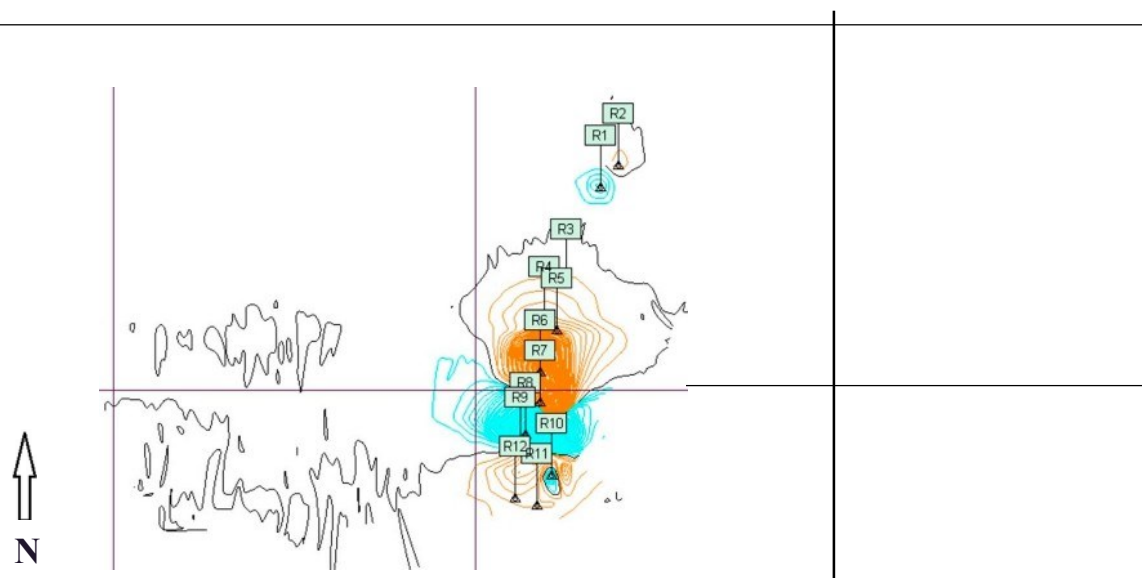


Figure 8. Glass jewellery pieces found in the intertidal zone (authors).



**Figure 9.** Magnetic contour map identifying the location of each magnetic anomaly recorded within the survey area. Contour interval equals 10 gammas (authors).

anomaly characteristic of a single ferrous metal target. As stated above, the distance between Targets R1-R2 and Target R11 is approximately 190 m.

Discussions regarding the wreck event of *Purísima Concepción* indicate the crew may have deployed an anchor prior to grounding nearshore (NN, 1765). Analysis of the magnetic signature of Targets R1 and R2 may support this hypothesis.

Targets R3-R12 consists of 10 individual magnetic targets that form one large, complex anomaly. The distance between Target RS and RIO (considered the main body of the target) equals approximately 80 m. The width of the main target area is approximately 39 m. Target R7 retained the highest magnetic reading of all 10 targets with a total deviation of +934/-141 gammas and 56 m duration.

Review of the magnetic contour map identified similarities with other confirmed historic shipwreck sites. One interesting observation includes the prevalence of the negative contoured lobe of the previously confirmed shipwrecks whereas the magnetic signature of Targets R3-R12 is opposite with the positive lobe to the north. It may be surmised that all previously confirmed comparable examples are located in the Northern Hemisphere versus the potential *Purísima Concepción* site which is located in the Southern Hemisphere. Regardless of the orientation of the positive/negative lobes of the anomaly, the near northerly polar axis (declination) of Targets R3-R12 remains consistent with confirmed shipwrecks studied by Enright et al. (2006).

Diver investigations following the magnetometer survey were inconclusive with regards to the identification of Targets R3-R12 due to very poor visibility and unfavourable weather conditions. Water depths averaged 6.7 m near the magnetic anomalies with

shallower reef (approx. 3.3 m) located to the east. Preliminary diver investigation of the target location confirmed a relatively flat sand bottom with exposed reef nearshore and low visibility. No cultural materials were found during the dives.

Nonetheless, results of the remote sensing investigation strongly suggest the anomaly represents the remains of *Purísima Concepción*. In addition to the remote sensing data, other variables corroborate the presence of *Purísima Concepción* in the area including the survivor's accounts, the artefacts documented in the tidal zone (near Targets R3-R12), as well as a lack of visible ferrous metal debris such as industrial debris (wire rope/cable), modern debris (shipping containers, flotsam), and other intrusive material.

### Archaeometric Studies of Ceramic Samples

#### NAA

The concentrations of elements measured in each specimen are reported in Table 1.

To investigate the possible origins of the sherds based on their paste compositions, a Euclidean Distance (ED) search routine was used. The ED search compared all 32 of the measured element concentrations against a database of previous ceramics analysed at MURR consisting of more than 100,000 sherds. The routine identifies the ten nearest neighbours based on the following formula:

$$d^2 = (a_i - a_o)^2 + (b_i - b_o)^2 + (c_i - c_o)^2 + \dots + (z_i - z_o)^2$$

Where  $d$  = the straight distance between two specimens,  $a_i$ ,  $b_i$ ,  $c_i$ , ...  $z_i$  = concentrations of elements in

**Table 1.** Results from neutron activation analysis of sherd pastes.

Element	DEA001	DEA002
Na(%)	0.584	0.540
Al(%)	8.39	7.78
K(%)	2.54	2.26
Ca(%)	6.07	7.56
Sc	13.9	13.7
Ti (%)	0.401	0.498
V	126	105
Cr	%	102
Mn	648	686
Fe(%)	4.16	3.85
Co	17.6	17.6
Ni	< 50	< 50
Zn	80	73
As	10.6	8.9
Rb	114	97
Sr	340	338
Zr	94	112
Sb	1.00	1.13
Cs	6.17	4.73
Ba	433	412
La	34	32
Ce	68	66
Nd	29	29
Sm	6.1	6.1
Eu	1.25	1.26
Tb	0.75	0.83
Dy	4.7	5.1
Yb	2.4	3.1
Lu	0.34	0.35
Hf	4.2	4.2
Ta	1.0	1.0
Th	9.7	10.5
U	2.7	2.6

\*Concentrations are listed in parts per million unless otherwise indicated.

specimen *i*, and *ao*, *ho*, *eo*... *zo* = concentrations of elements in specimen 0.

For each sherd, the ten samples with the smallest values for *d* relative to other archaeological samples in the NAA database are listed in Table 2. All of the

**Table 2.** Results of squared-mean Euclidean distance search comparing samples in this study to ceramic pastes of specimens in the MURR NAA database. Ten closest samples based on 32-elements.

Specimens chemically most similar to sample DEA001:			
ID	Distance	Site Name or Region	Other Information in database
SEV012	0.0117	Sevilla	Olive jar; rim fragment
SEV013	0.0122	Sevilla	Olive jar; rim fragment
SEV045	0.0133	Sevilla	Olive jar; body fragment
SEV047	0.0135	Sevilla	<i>Cantaro</i> ; body fragment
SEV002	0.0136	Sevilla	Olive jar
SEV001	0.0136	Sevilla	Olive jar
SEV043	0.0139	Sevilla	Olive jar; body fragment
SEV060	0.0140	Sevilla	<i>Jarra</i> ; body fragment
SEV010	0.0140	Sevilla	Olive jar; green glazed
SEV046	0.0142	Sevilla	Olive jar; body fragment
Specimens chemically most similar to sample DEA002:			
ID	Distance	Site Name or Region	Other Information in database
SEV013	0.0132	Sevilla	Olive jar; rim fragment
SEV012	0.0140	Sevilla	Olive jar; rim fragment
SEV010	0.0141	Sevilla	Olive jar; green glazed
SEV043	0.0141	Sevilla	Olive jar; body fragment
SEV001	0.0146	Sevilla	Olive jar
SPA003	0.0150	Sevilla	Olive jar; green glazed
SEV047	0.0151	Sevilla	<i>Cantara</i> ; body fragment
SEV009	0.0155	Sevilla	Olive jar
SPA001	0.0157	Sevilla	Spanish <i>ca/care</i>
SEV046	0.0160	Sevilla	Olive jar; body fragment

nearest-neighbor samples were identified as originating in the Sevilla region of Spain which supports the assumption that the sherds were from Spanish (more specifically, Sevillian) origin.

### LA-ICP-MS

The concentrations of the major elements measured in each specimen are reported in Table 3a, while the concentrations of the minor elements are reported in Table 3b.

The glazes on both samples are typical high lead glazes ( $38.61 \pm 0.12$  wt% PbO). The green glazes are coloured with copper oxide (CuO) with an average composition of  $4.96 \pm 0.81$  wt%. There is a minimal amount of tin oxide (SnO<sub>2</sub>) in the glaze,  $0.88 \pm 0.10$  wt%, which is below the threshold usually needed to create opacification in a lead glaze (Tite, 2011), and well below what is typical of most tin-opacified glazes (4–15 wt% SnO<sub>2</sub>) (Molera et al., 2001). This amount of tin-oxide is more suggestive of being accidentally introduced with either the lead source or colorant. As these glazes have a copper green colorant, one plausible explanation for the elevated tin-oxide concentration is the use of bronze (copper alloyed with tin) as the source of the copper colorant (Shen, 2017).

### Discussion and Conclusions

The results obtained thus far for archaeological remains of *Purísima Concepción* are extremely encouraging in terms of the two main goals of the project, namely locating the shipwreck site and the shipwreck survivors' camp.

Admittedly, the material evidence is scarce and some of it could result from a historic shipwreck or nautical event other than *Purísima Concepción*. In particular, the English - or English style - ceramics are intriguing. It is also true that the region has seen a number of shipwrecks and other marine accidents related to navigation - not all of them necessarily on

**Table 3a.** Results from LA-ICP-MS analysis of glazes on DEA001 and DEA002, major element composition (reported in oxide weight percent).

Major composition (oxide wt%)	DEA001	DEA002
SiO <sub>2</sub>	44.12	43.53
Na <sub>2</sub> O	1.07	1.04
MgO	0.33	0.46
Al <sub>2</sub> O <sub>3</sub>	1.68	2.16
P <sub>2</sub> O <sub>5</sub>	0.08	0.11
Cl	0.00	0.09
K <sub>2</sub> O	3.52	3.67
CaO	2.21	2.95
Sb <sub>2</sub> O <sub>3</sub>	0.04	0.05
MnO	0.02	0.02
Fe <sub>2</sub> O <sub>3</sub>	1.39	1.55
CuO	5.53	4.38
SnO <sub>2</sub>	0.81	0.95
TiO <sub>2</sub>	0.18	0.18
PbO	38.70	38.53
ZnO	0.03	0.02

**Table 3b.** Results from LA-ICP-MS analysis of glazes on DEA001 and DEA002, minor element composition.

minor composition (ppm)	DEA001	DEA002	minor composition (ppm)	DEA001	DEA002
Li	70.0	82.2	Ce	9.2	10.5
Be	0.3	0.3	Pr	0.9	1.0
<b>B</b>	51.3	115.4	<b>Nd</b>	4.0	4.1
5	589.1	519.2	Sm	0.9	1.1
Sc	6.5	6.4	Eu	0.1	0.2
V	7.1	13.4	<b>Gd</b>	0.9	1.1
Cr	19.0	19.5	Tb	0.2	0.1
Co	287.0	269.8	Dy	0.7	0.6
<b>Ni</b>	47.1	40.4	Ho	0.2	0.1
<b>As</b>	124.5	136.5	Er	0.5	0.4
Rb	67.4	95.9	Tm	0.3	0.3
Sr	42.4	47.7	Yb	1.2	1.3
Y	4.2	4.1	Lu	0.1	0.1
Zr	36.9	%9	Hf	1.1	1.8
<b>Nb</b>	2.2	2.2	<b>Ta</b>	0.2	0.2
<b>Mo</b>	1.7	1.7	<b>W</b>	24.8	19.3
<b>Ag</b>	23.7	14.4	<b>Au</b>	0.0	0.0
I	21.0	20.0	Tl	0.4	0.5
Cs	2.0	2.7	Bi	132.3	146.2
<b>Ba</b>	70.7	72.6	Th	1.6	1.6
La	5.0	4.6	U	0.4	0.6

record - and for these reasons extreme caution is required when interpreting the results obtained and drawing conclusions. However, the different types of evidence taken into consideration in this project, and the multidisciplinary approach suggests that we are on the right track.

A necessary first step was the thorough analysis of written sources - both primary and secondary - related to the shipwreck event and the characteristics of the geographic scenario where all the events took place. This narrowed down the possible *loci* where to conduct the field searches. In addition, the first isolated finds that could be related to the topic under study - both accidentally found in the early 1980s and in the context of the Atlantic coast of Tierra del Fuego project - were taken into account for the selection of places where to conduct the searches in the field.

The finding of Spanish pottery in the general area where the survivors camp would have been located as well as in the coastal zone adjacent to where the shipwreck site is believed to have taken place, corroborated by Neutron Activation Analyses, is one of the strongest lines of evidence supporting the goals and hypotheses of the project. In addition, the content of lead in the glaze would be consistent with the fact that olive jars sometimes have a lead glaze on the interior to prevent seepage (Deagan, 1987, pp. 30-43).

Moreover, the results of the magnetometry surveys, as explained above, point in the direction of the type of shipwreck site searched for, in which a duster or iron cannons would still remain *in situ*. The second magnetic signature could, as suggested, represent the presence of one of the ship's anchors.

As for other artefacts found in all the areas which were surveyed, despite not being typically Spanish, do match the chronological period under study and could well be part of the cargo, the equipment, or the personal belongings carried on board a Spanish

vessel. In addition, the identification of artefacts such as an arrowhead made in (European) glass with indigenous techniques, provide further tantalizing evidence.

All the results obtained so far in the frame of this project, particularly in combination, are very strong. Because of all of the lines of evidence collected thus far, it is desirable to conduct more field work in the future, in order to obtain a better picture and understanding of the loss of *Purísima Concepción* and the events surrounding it. Of great interest is the intercultural contact between the shipwreck crew and the native peoples. Also, more underwater surveys in the place of the shipwreck itself would be useful, allowing more time - and consequently, a larger climatic window - for using divers and/or remotely operated vehicles equipped with cameras to check the magnetic anomalies found in the first surveys.

Until those future stages take place, one of the most significant chapters of the maritime history of Tierra del Fuego during colonial times, is already materializing.

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### Author Contributions

Dolores Elkin and Martin Vazquez were responsible for the general project design and field work and for drafting the majority of the article. Michael Krivor was in charge of the magnetometry survey and interpretation, and wrote the section corresponding to such topic. Michael D. Glascock and Brandi MacDonald were responsible for analysing the samples by Neutron Activation Analysis and for interpreting the results through comparisons to a database of ceramics from around the world to identify the probable provenance. Catherine Klesner and Brandi MacDonald did the Laser ablation-inductively coupled plasma-mass spectrometry.

All the authors participated in discussions and exchanges of texts prior to the final drafting of this article and contributed with the figures and/or tables related to their respective fields of expertise.

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### ORCID

Dolores Elkin  <http://orcid.org/0000-0002-4606-1285>

Martin Vazquez  <http://orcid.org/0000-0001-5113-4197>

Michael D. Glascock  <http://orcid.org/0000-0003-0686-7556>

Catherine E. Klesner  <http://orcid.org/0000-0002-2264-9383>

Brandi L. MacDonald  <http://orcid.org/0000-0003-2887-4351>

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