



# Archaeometallurgical analysis of metal remains from the Dor 2006 shipwreck: A clue to the understanding of the transition in ship construction



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## ABSTRACT

The Dor 2006 Byzantine shipwreck was discovered in 2006, 800 m south of Dor (Tantura) lagoon, Israel, about 100 m offshore, in a water depth of 4 m, covered by sand. It was a large ship about 25 m long, and its timber remains spread over 10.5 m by 4.5 m. The shipwreck was dated between the mid-6th and the first quarter of the 7th centuries AD. Among the finds were remains of metal objects, comprising two coins, a lead sheet, and concretions of nails and a sickle. Metallurgical non-destructive and destructive analyses of the metal remains demonstrated that the coins were made of copper–lead alloy with a high concentration of lead, produced by casting, later stamped with coin die. The lead sheet was produced by casting, and later shaped into its final form. SEM-EDS, XRD, and XRF analyses revealed that the nail remains were essentially completely corroded iron. Analysis of the completely corroded sickle remains revealed that it was made of bloomery iron. It is suggested that the use of lead in the coins and tin in the lead sheet was due to economic constraints. Iron nails, although widespread, also indicate a preference for a cheaper metal than copper alloy. The lead isotope signature of the lead sheet indicates that the source of the ore was Greece or the Taurus Mountains, which may hint at the origin of the ship or her sailing routes. The ship was built during the period of the transition in ship construction from shell-first to frame-based. The reasons for this transition, which is a well-known process, have been explained only in abstract terms, such as economics, sociology and geography. The use of low-grade metals may be an example of economic pressure, and a specific explanation for the transition.

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## 1. Introduction

The Dor 2006 shipwreck was discovered in 2006, 800 m south of Dor (Tantura) lagoon, on the Mediterranean coast, 30 km south of Haifa, Israel (Fig. 1). It was found 100 m offshore at a depth of 4 m, covered by a layer of sand, the thickness of which (up to 2 m) varied with sea conditions.

Four underwater excavation seasons were conducted between October 2009 and June 2012 by an expedition of the Leon Recanati Institute for Maritime Studies at the University of Haifa (Navri et al., 2013). The wooden hull remains spread over an area of 10.5 by 4.5 m on the seabed, comprising sections of shell planking, frames, stringers, ceiling planking, and various attachments.

It is estimated that the original ship was about 25 m long (Fig. 2). Among the finds were wooden objects, pottery, ropes, food remains, and metal objects; comprising two coins, a lead sheet, and metal concretions of nails and a sickle. The shipwreck was dated between the mid-

6th century and the first quarter of the 7th century AD (Barkan et al., 2013a; Navri et al., 2013, p. 317). She was built in the period of the transition in ship construction from shell-first to frame-based (Pomey et al., 2012, 2013). One of the explanations of the transition is economic pressure. This study may perhaps highlight the contribution of metallurgical research to the understanding of the change in ship construction in Late Antiquity. Below is a short description of the metal objects, followed by the archaeometallurgical analysis.

### 1.1. Coins

Two coins were discovered between hull components in the south-eastern section of the shipwreck (Fig. 2). Coin 1 was studied in detail; it was typically 9 mm diameter and 2 mm average thickness, and was broken at its edge. Coin 2 was irregular in shape, 9.5 mm long, 8.6 mm wide, and 1.1 mm thick (Fig. 3).

Both coins were identified by G. Bijovsky of the Israel Antiquities Authority, based on considerations of size, thickness, and general appearance, as Byzantine *Minima* (*Nummi*) dated between AD 450 and

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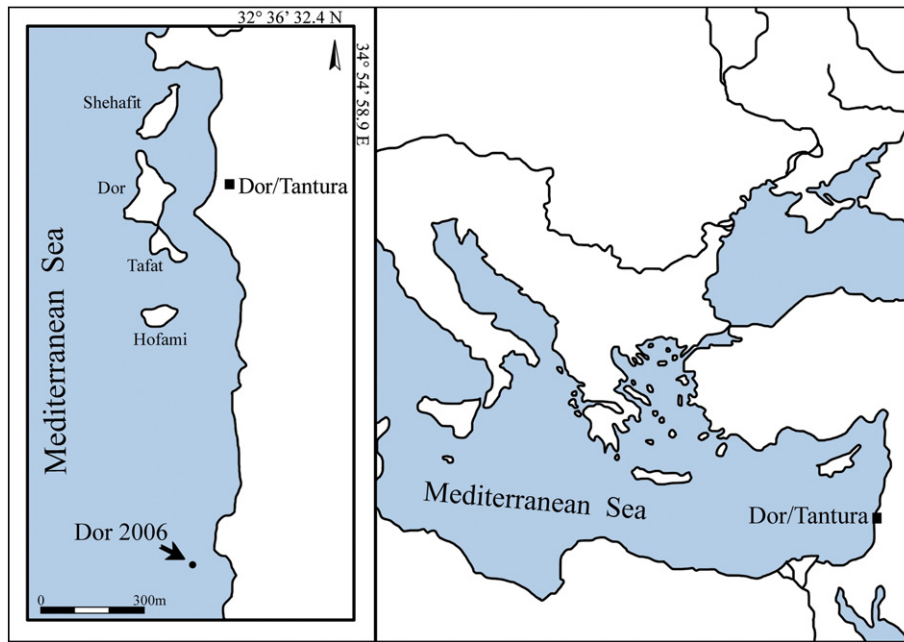


Fig. 1. The shipwreck site (Map: H. Itzkovitch).

550, and were in circulation until the beginning of the 7th century AD (Barkan et al., 2013b; Bates, 1971, p. 8; Bijovsky, 2011, pp. 250–265).

1.2. Iron nails

The ship's components were typically connected by nails, and in this case by iron nails of rectangular cross-section and various sizes. The smallest nails had a square cross-section of 4 mm and length of about 10 cm. Frames, hull planks, and ceiling were connected by nails of 4–10 mm in cross-section and 10–27 cm long. A bolt in frame F211 was 17 × 19 mm in cross-section and about 50 cm long. Other large

bolts, which did not survive, would have been maximum 40 mm in diameter and about 73 cm long (Navri et al., 2013, p. 313).

Several wooden parts covered with encrustations and concretion coatings have been examined in the present study. These pieces included nail-shaped corroded substances (Fig. 4, nails N1 and N2).

1.3. Lead sheet

The lead sheet was found near the two coins in the south-western section of the hull on hull plank P9, between framing timbers F118 and F119

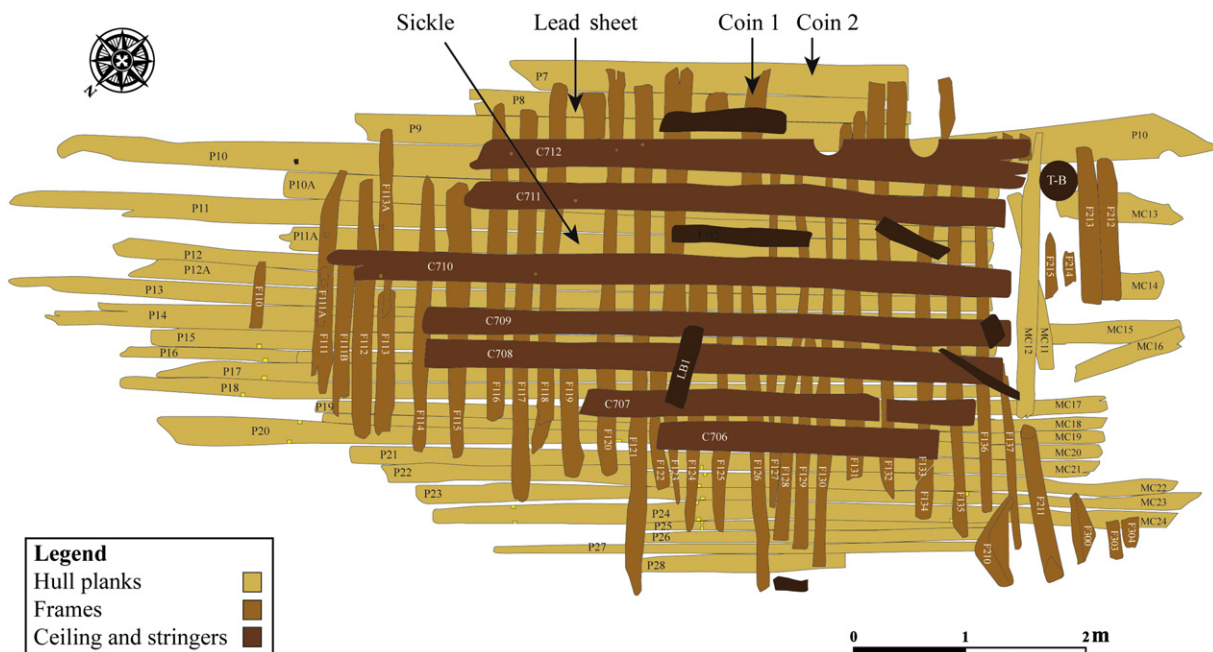


Fig. 2. Preliminary plan of the Dor 2006 shipwreck and location of the finds (E. Hendl, A. Shalom, and P. Weinman Barak. Adapted by K. Asuli and S. Shiloni).

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