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SECRETARY'S & EDITOR'S ADDRESS
Department of Archaeology and Classical Studies
Stockholm University
106 91 Stockholm, Sweden
secretary@ecsi.se | editor@ecsi.se

DISTRIBUTOR
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YVONNE BACKE FORSBERG & RICHARD HOLMGREN with contributions by ROBERTO CROCETTI

The Etruscan missing link

Traces of Italy's oldest bridge construction?

Abstract

The recently discovered traces of an Etruscan wooden bridge may reveal the oldest known bridge construction on the Italian peninsula. The Spina bridge at San Giovenale holds significant importance for understanding early architecture, building techniques and infrastructural practices. Functioning as a vehicular viaduct, the 30-m-long structure spanned the Dogana gorge, connecting the Casale Vignale necropolis with the Spina area on the settlement plateau. Etruscan remains along the roads leading to the bridge were utilized to establish its chronology. Tentatively dated to the second half of the 7th century BC, the bridge is contemporaneous with Rome's legendary Pons Sublicius—a structure traditionally recognized as Italy's oldest bridge, though no extant archaeological evidence corroborates its existence. This context renders the San Giovenale site unparalleled. Early scholars doubted the existence of such a long bridge, positing that access to the Spina plateau was achieved via a ramp. Proponents of the bridge hypothesis, meanwhile, faced a lack of physical proof. The present study confirms the existence of these remains and demonstrates how they illuminate both the original construction and perhaps the bridge's diverse functions.*

Keywords: aristocracy, beam cavities, carpentry, Etruscan, funeral road, infrastructure, load-bearing capacity, Pons Sublicius, reconstruction, remote sensing, San Giovenale, strut frame, viaduct, wheel ruts, wooden bridge

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Introduction

The Etruscan inland towns were entirely dependent on their road networks, which functioned as the backbone of socio-economic, political and religious activities. These networks facilitated the movement of animal flocks, transportation of munitions, exchange of goods and ideas, relocation of raw materials and delivery of masonry and timber for construction. Etruscan settlements developed along these thoroughfares, rather than the reverse. Pathways traversed or bordered markets and workshops, as well as burial mounds and temples, where the presence of past generations remained ever tangible. Local pathways frequently transitioned into roads that interconnected settlements and city-states through administrative frameworks and profitable taxation systems. Etruscan infrastructure mobilized all societal classes to transform a chaotic landscape into systematic constructions: tunnels, drainage systems, bridges and levelled elevations that facilitated the transversing of gorges. The Romans inherited much of their engineering knowledge from Etruscan road-building practices in Central Italy, and the deeply rutted Etruscan network was enhanced with stone paving in Roman times. There is no doubt that the Etruscan street and road system held critical importance from the earliest phases of settlement foundation. Consequently, a focused examination of a specific segment of this infrastructure—namely, the narrow passages of Etruscan bridge complexes—is of particular significance. Beyond their historical and architectural value, these bridges also served as bottlenecks within the broader road network.[1] A detailed study of one such complex could illuminate the chronology and development of an entire urban area. At San Giovenale, the Spina bridge exemplifies such a bottleneck. Specifically, it pertains to the primary north-eastern entrance, where the isolated Acropolis connects to the mainland necropolis of Casale Vignale and territories beyond.

[1] Tuppi 2010; 2014.

Fig. 1. The Spina bridge, miniature model reconstruction in wood (model by R. Holmgren). Copyright: Richard Holmgren ARCDOC.

The Missing Link (TML), a project initiated by the authors in May 2022, sought to address a key question regarding the potential existence of a central Etruscan bridge in San Giovenale (*Figs 1*, *2A–B*). This structure involved a viaduct spanning the Dogana road—an ancient rock-cut transhumance road[2]—to link the Casale Vignale necropolis with the Borgo/Spina habitation area.[3] The term "bridge" is adopted here instead of "viaduct", while acknowledging their substantial definitional overlap. However, viaducts typically denote elevated structures traversing terrestrial features such as roads or gorges, whereas bridges are more commonly designated for spanning aquatic features.[4] This distinction aligns with the Etruscan context, as their reliance on river systems for transportation and communication prioritized structures crossing waterways—a pattern corroborated by the archaeological record at San Giovenale, where bridges represent the primary structural type attested. The region's topography further elucidates this preference: the mineral-rich Tolfa Mountains historically served as vital transportation corridors linking inland Etruria to coastal areas. To the south lies the Marangone river, while to the north, the Vesca river flows through San Giovenale and Luni sul Mignone before converging with the Mignone river, which ultimately discharges into the Tyrrhenian Sea (*Fig. 2A*).[5]

The Missing Link project originated as an extension of the earlier *Vignale Archaeological Project* (VAP), which investigated the Vignale plateau and its connections to other sites at San Giovenale. The study culminated in the recent publication *What's beyond the Etruscan bridge?*, which documents another Etruscan bridge from the 6th century BC, spanning the Pietrisco brook in the same territory.[6] Through terrestrial and aerial surveys employing LiDAR, the question of a potential bridge over the Dogana road re-emerged. Early scholars contested the existence of such an extensive bridge, positing that access to the Spina plateau was achieved via a ramp.[7] Following archival research at the Swedish Institute of Classical Studies in Rome and 2022–2023 field surveys, a site inspection by *The Missing Link* team revealed unexpected physical remains of bridge abutments on the cliff faces above the gorge. In addition to wheel ruts leading to the precipice above the southern cliff, the northern abutment exhibits modifications to the tufa rockfaces, interpreted as abutments accommodating the bridge piers (*Fig. 3A–B*). These features provide critical insights into otherwise ephemeral wooden bridge constructions of this period, with San Giovenale's remnants offering rare evidence of early architectural techniques. These remains may constitute the oldest known architectural traces of a wooden bridge on the Italian peninsula. The dating of the

[2] The Dogana road, an ancient rock-cut transhumance system known during the 13th centrury AD as Dogana dei Pascoli del Patrimonio di S. Pietro in Tuscia. *San Giovenale* VI:2–3, 35, n. 21. The ancient road cutting was used by the Etruscans at San Giovenale and later during the 2nd century BC; Varro, *Rust.* 2.2.9–11; Santella & Ricci 1994, 56–58; Santillo Frizell 1996; 2004; 2009; Hemphill 2000, 84, fig. 116, see fold-out map Civitella Cesi, site no. 129.

[3] Boëthius 1962; Forsberg 1984; Forsberg & Thomasson 1984; Backe Forsberg 2005; *San Giovenale* VI:2–3.

[4] On the definitions of viaduct and bridge, see Galliazzo 1994, 153–154.

[5] Zifferero 1991; Edlund-Berry 2016; *San Giovenale* VI:2–3, app. 2.

[6] *San Giovenale* VI:2–3, 20–24.

[7] *San Giovenale* V:3.

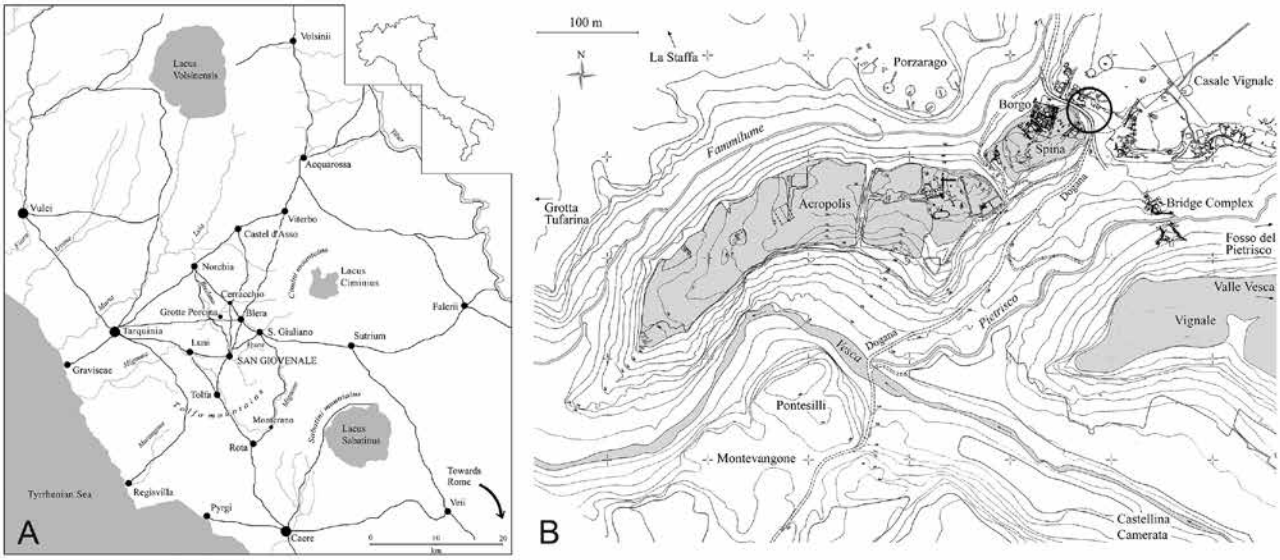

Fig. 2A–B. A. Map of South Etruria showing the positions of San Giovenale, Luni sul Mignone (Luni) and Blera among other major sites (illustration by M. Lindblom in Backe Forsberg 2005, fig. 1, after Gierow 1986, fig. 1, courtesy of the Swedish Institute of Classical Studies in Rome). B. Plan of San Giovenale, showing the Acropolis (left) and the Borgo area (upper right), directly adjacent to the Spina, and with the position of the Spina bridge encircled (illustration based on computerized drawing by S. Tilia and A. Tilia 2002, courtesy of the Swedish Institute of Classical Studies in Rome).

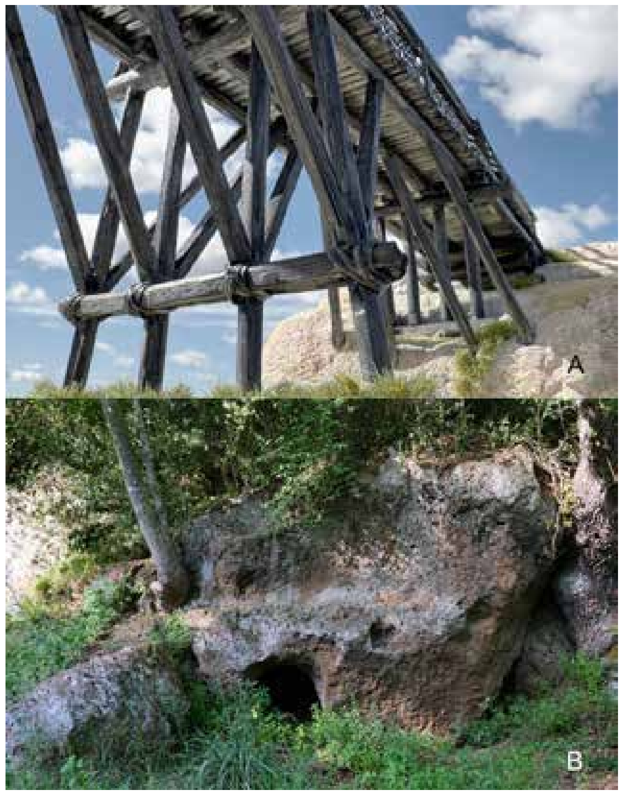

Fig. 3A–B. A. Photograph of the Spina bridge model showing the northern bridge abutment (model and photograph by The Missing Link *2024). Copyright: Richard Holmgren. B. Field photograph taken from the same angle as reconstruction A, showing the subsequent collapse of the cliffside including platform T4 and BA1 (see below,* Fig. 8*). The four cavities for inclined struts (BH3–BH4) are clearly visible, along with a cavity—breached by looters to access chamber tomb CV9—located behind them (photograph by R. Holmgren).*

bridge discussed in this article is established through relative chronologies derived from studies of bridge abutments and associated structures. These findings are primarily detailed in the section below titled 'The Spina bridge complex—documented features and chronology'. Furthermore, to establish a robust framework for reconstructing the bridge, the project initiated an interdisciplinary collaboration with Prof. Roberto Crocetti of KTH Royal Institute of Technology's Department of Civil and Architectural Engineering in Stockholm. Crocetti's knowledge was essential for hypothesizing the bridge's construction and appearance, input on the project's model bridge reconstruction in wood (scale 1:50) and drawings as well as calculating its load-bearing capacity for heavy transport—given the extraordinary span of approximately 30 m between

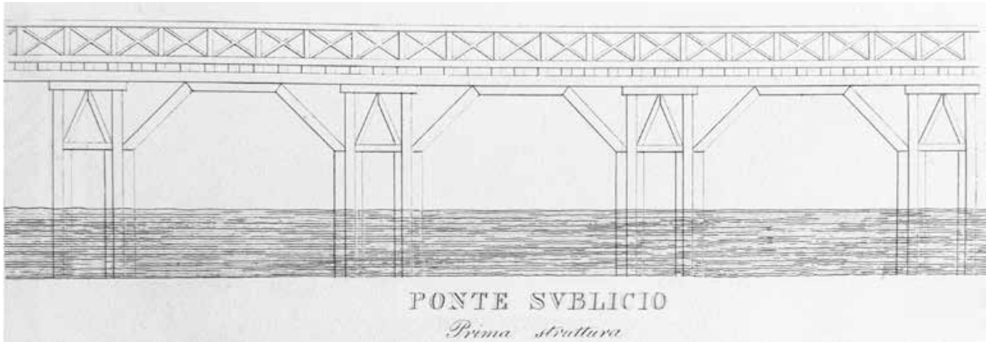

Fig. 4. An early reconstruction of Pons Sublicius over the Tiber, drawing by architect Luigi Canina, from Canina 1830–1842, pl. CLXXXI. Courtesy of the Swedish Institute of Classical Studies in Rome.

rock ledges.[8] The hypothesis posits that the bridge not only provided convenient access to the settlement but was vital for transporting heavy materials such as stone, tiles and timber, particularly as the late 7th-century BC construction boom became prevalent.[9] This connection would have unified higher plateaus, circumventing arduous descents and ascents.

The authors contend that scholarly approaches to the existence of early wooden bridge constructions have been unnecessarily cautious, despite well-documented evidence of advanced Etruscan infrastructure—including wooden roof supports in houses and temples[10] and sophisticated shipbuilding techniques.[11] This discrepancy likely stems from the scarcity of preserved organic materials and the absence of contemporaneous visual depictions.

The earliest wooden bridges in Italy

The earliest bridges were likely constructed from logs with simple wooden decks, which have rarely left any surviving traces. An exception consists of horizontally laid and U-shaped wooden beams, along with several posts, discovered buried in the riverbank adjacent to a 2nd-century BC Roman bridge which was built along the Via Annia near Venice. The wooden material has been radiocarbon dated to the Late Bronze Age, with one beam attributed to the 9th–5th centuries BC. However, reconstructing the structural configuration of the pre-Roman bridge remains challenging at present.[12] Such rudimentary wooden constructions were later succeeded by bridges incorporating stone abutments and more sophisticated wooden substructures, which were eventually replaced by ashlar blocks to form arches.[13] According to ancient sources, the earliest reference to a wooden bridge is generally recognized as being to the Pons Sublicius in Rome. This represents the earliest written reference to a wooden bridge in Italy and the structure is traditionally attributed to the legendary King Ancus Marcius, grandson of King Numa Pompilius, whose reign is placed in the latter half of the 7th century BC (assumed date 640–616 BC) (*Fig. 4*).[14] Since this period is deeply intertwined with mythological traditions—and given that references to the bridge emerged nearly 500–600 years later—the exact timeline of its construction, its appearance and the historical events surrounding it remain highly uncertain.[15] According to the ancient authors, the bridge was constructed entirely of wood, as the use of metals—including iron nails—was prohibited. As noted by Plutarch and Livy, the Pontifex Maximus was forbidden from handling metal objects.[16]

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8 Crocetti 2014; 2016a; Crocetti *et al.* 2016b.

9 *San Giovenale* IV:1; V:1; Wikander 2024, 113–150.

10 Boëthius 1970, 91–92; Wikander 1981; 2013; 2017; 2024; Winter 2000; 2002–2003.

11 De Boer 1992–1993; Polzer 2010; Bruni 2013; Pomey 2017, 372, 381–386; Ibrahim Ali 2017.

12 Busana *et al.* 2011, 92–94, figs 3, 5, 8.

13 Wetter 1962, 170; Barker & Rasmussen 1998, 173; Backe Forsberg 2005, 106–107, see tables 33–34 on Pre-construction phase 3, Orientalizing/Early Archaic periods (675–565 BC); *San Giovenale* VI:2–3, 67–69; on Pons Aemilio, and Caesar's wooden bridge crossing the Rhine, see Canina 1830–1842, part 2, 652–653, pl. CLXXXII.

14 The earliest reference to the legend of the bridge (and Horatius Cocles) in surviving sources was by the Greek historian Polybius 6.54.6–6.55.4 (*c.* 150 BC) and the earliest reference in the surviving Latin sources was by Cicero, *Leg*. 2.10 (*c.* 45 BC). Galliazzo 1994, 25–26, n. 9, discusses a unique medallion from Antoninus Pius (medallion dated to 140–144 AD) depicting the restoration of the bridge after the event in the late 6th century BC, when the Roman officer Horatius Cocles fought the Etruscan king Lars Porsenna on the Pons Sublicius. The medallion shows five wooden piles anchored in the river and a wooden arch; Palladio 1928, 157; Griffith 2009, 301–310. See technical comments on Pons Sublicius, Pons Aemilio and the Pietrisco bridge in Quilici 1984, 107. See a late reconstruction by Canina 1830–1842, part 1, 466–468, part 2, 652–653, pl. CLXXXI.

15 Livy, *Hist*. 1:32.

16 Plutarch, *Vit. Num*. 9.4; Livy, *Hist*. 1.33.6; Griffith 2009, 296–297; Tucci 2011–2012, 177; Partov *et al.* 2016, 93–94, 97, fig. 4. On

The bridge is believed to have spanned the Tiber downstream from Tiber Island, connecting the Forum Boarium marketplace on the left bank (near the Temple of Hercules Victor) with the Janiculum Hill on the Etruscan-occupied *Trans Tiberim*.[17] Livy and Dionysius of Halicarnassus assert that the bridge was built by the aforementioned king during fortification efforts at the Janiculum Hill.[18] Though positioned at a point where the river was easily fordable, the bridge's exact location remains a subject of scholarly debate.[19] A notable distinction between the Pons Sublicius and the Spina bridge in San Giovenale lies in the former's construction traversing water. Consequently, the technical innovations of the assumed Pons Sublicius hold particular significance, especially regarding flood mitigation. Temples in the vicinity were erected atop elevated podia to withstand inundation, and street-level drainage systems were implemented to manage water flow.[20] As the bridge's precise location remains unidentified, no physical remnants of its wooden structure or substructural attachment points—such as cavities in the rock (supports for the bridge piers) and/or abutments—have been discovered. Thus, our current understanding of the bridge relies largely on generalized accounts by ancient authors, including Polybius, Livy, Varro, Plutarch, Ovid, Cicero and Dionysius of Halicarnassus.[21] This makes the Spina bridge in San Giovenale the oldest documented construction to date in Italy. Its timeframe corresponds approximately to the period associated with the construction and use of the Pons Sublicius, but as we shall see, it is probably even older.

San Giovenale — a site of many bridges

The Spina bridge is far from the only Etruscan bridge documented at San Giovenale, though it remains the sole viaduct and appears to be the oldest bridge structure on the site. The remains of a larger bridge complex spanning the Pietrisco brook were first documented by the Swedish Institute in Rome between 1959 and 1963.[22] Additional remnants of potential bridges, dating from the Late Orientalizing to Roman periods—the latter adhering to Etruscan infrastructural models—have been identified at various locations across San Giovenale, constructed over both the Pietrisco brook and the Vesca river (*Fig. 5*, *Table 1*).[23] The Pietrisco bridge complex revealed two massive stone abutments in the ravine flanking the brook. A road, Via Pontalto, led to the bridge complex,[24] which likely supported a wooden deck approximately 18 m in length, resting on horizontal beams.[25] Although it is reasonable to hypothesize that the bridge featured an elaborate substructure, no cavities potentially accommodating wooden piers were documented. Based on excavated remains situated above the abutments, the crossing's use has been dated from the pre-earthquake period (early 6th century BC) to the Byzantine era (*c.* 8th century AD) (*Fig. 5*, *Table 1*). Substantial damage affected the northern and southern bridge abutments, which were rebuilt shortly after the earthquake. This is evidenced by traces of a landslide that led to the replacement and reconstruction of the infrastructure associated with the bridge.[26] Pottery and small finds dating from the 10th to 7th centuries BC suggest the possible existence of an earlier wooden bridge predating the Etruscan complex. Unlike the Spina bridge, which relied on permanent cliffside abutments, the Pietrisco complex utilized ashlar masonry to stabilize the unstable slopes.[27] The cliffsides, as opposed to masonry, provide insight into the Spina bridge's usage and potential renovations over time, aspects that are otherwise largely indiscernible in the case of the Pietrisco bridge complex.

Beyond these larger constructions, San Giovenale features several low-lying, shorter bridges. A second Etruscan bridge abutment, designated Bridge 2, was discovered downstream

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the sanctity of the Pons Sublicius and other bridges, see Adams Holland 1961, 332–342; Griffith 2009, 310–319.

17 See Tucci 2011–2012, fig. 6 depicting the Forma Urbis, a monumental marble plan, approximately 13 m high and 12 m wide. This Severan-period map, from the first quarter of the 3rd century AD, labelled the locations of Rome's monumental buildings. It was originally displaced on the south-eastern wall of the Templum Pacis near Forum Romanum.

18 Livy, *Hist*. 1.33.6; Dion. Hal. *Ant. Rom*. 3.45.1–2.

19 Hirst 1938; Tucci 2011–2012, 177–185, 187–188, 209, figs 1–2, 4–5. New deep soil samples from San'Omobono have altered the historical chronology of Tiber Island, see Brock *et al.* 2021; 2025.

20 Galliazzo 1994, 25–26, 316–327.

21 Livy, *Hist*. 1.33.6–7; Varro, *Ling*. XV.83 and Plutarch, *Vit. Num*. 9. 2–4 describe a bridge constructed on piles. Ovid, *Fast*. 5.6.22 refers to a bridge made entirely of wood. Dionysius of Halicarnassus wrote: "He also is said to have built the wooden bridge over the Tiber, which was required to be constructed without brass or iron, being held together by the beams alone", Dion. Hal. *Ant. Rom*. 3.45.2.).

22 Hanell 1962; Forsberg 1984; Backe Forsberg 2005.

23 Backe Forsberg 2005, 51, 110–114, figs 2a–b, 20–22, 73a–b. *Fig. 5* is based on a LiDAR survey in 2010. See Backe Forsberg *et al.* 2008a; 2008b; Lasaponara *et al.* 2012.

24 *San Giovenale* VI:2–3, 64–65, 67–70, 78–80, figs 30:2, 30:2b, 34–35, 37, 39–40, 42, 45.

25 Hanell 1962, 304–306, figs 279–280; *San Giovenale* I:1; Forsberg 1984, 73–80, pls 5–6; Pohl 1985, 54–55; Gierow 1986, 27; Nylander 1986, 37–38, figs 5–6, 13; Backe Forsberg 2005; *San Giovenale* VI:2–3.

26 Nylander 1997; Blomé & Nylander 2001; Backe Forsberg 2005; *San Giovenale* VI:2–3.

27 Backe Forsberg 2005, 51–52, 60–69, 80–82, 103–104, tables 3, 34.

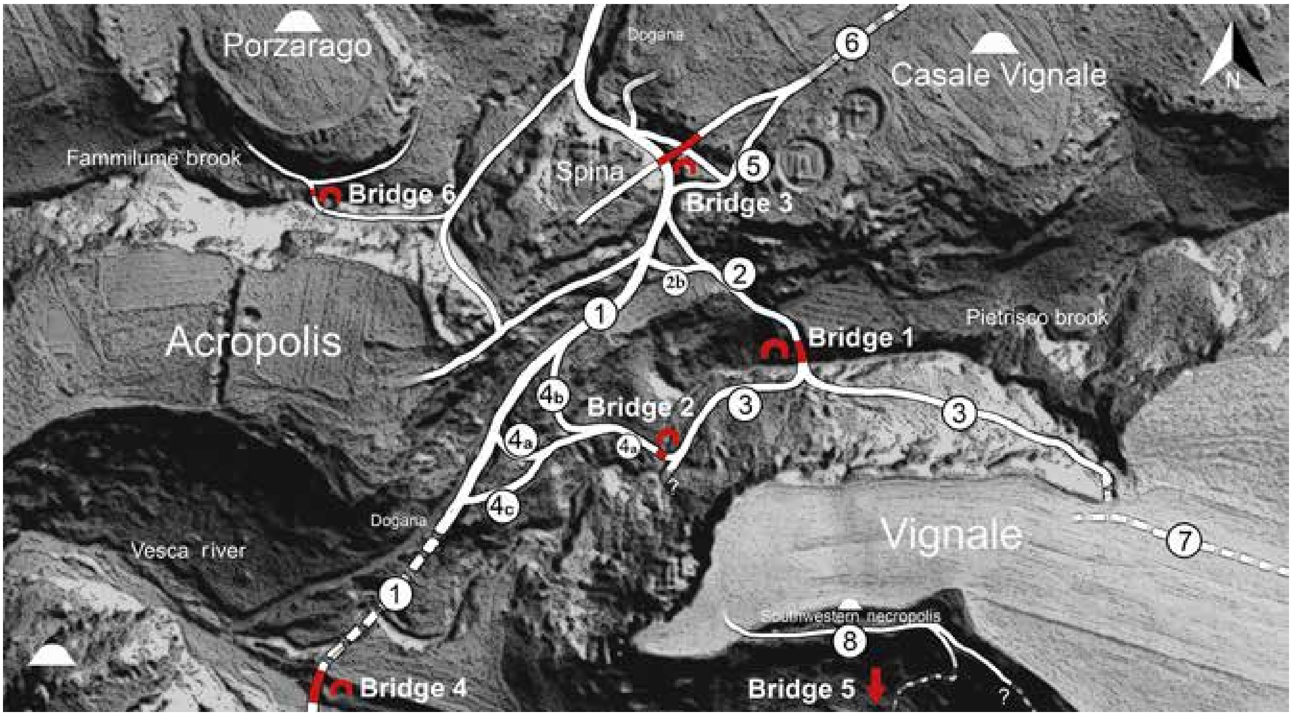

Fig. 5. The central area of San Giovenale, highlighting key local roads/streets and the position of Etruscan bridges (nos 1–6, marked in red): 1. The Dogana (Via Ceretana). 2. Via Pontalto (with side track 2b). 3. Via Vignale Nord. 4a–c. Vie Ponte Basso. 5. La strada delle Poggette. 6. Casale Vignale funeral road. 7. Vignale eastern access. 8. Vignale southern access (funeral road). Illustration by R. Holmgren and Y. Backe Forsberg, based on LiDAR data by Geocart srl with processing by N. Masini (CNR/IBAM) and R. Lasaponara (CNR/IMAA); from San Giovenale *VI:2–3, fig. 30.*

Table 1. San Giovenale's bridges.

Feature	Area	Date (preliminary)	Remark	Reference	Figure
Bridge 1	Spanning Pietrisco brook, between Dogana road and Vignale plateau	From early 6th century BC	Wooden bridge (*c*. 18 m) with two ashlar abutments	Hanell 1962, 304–307; Wetter 1962; Forsberg 1984; Backe Forsberg 2005; *San Giovenale* VI:2–3	*Fig. 5*
Bridge 2	Spanning Pietrisco brook, between Dogana road and lower Vignale area	From 6th century BC	One bedrock abutment	Wetter 1962, 206; Backe Forsberg 2005; *San Giovenale* VI:2–3	*Fig. 5*
Bridge 3 Spina bridge	Spanning Dogana gorge, between Casale Vignale necropolis and Spina area	From mid-7th century BC	Wooden bridge (*c*. 30 m) with bedrock abutments (platforms and cavities for inclined struts)	Hanell 1962, 296; Backe Forsberg 2005, 104, 110; *San Giovenale* V:1; *San Giovenale* VI:2–3	*Figs 5, 6B, 7, 13*
Bridge 4	Spanning river Vesca, along Dogana road	From late 7th century BC (?)	Boulder with girder support	Hanell 1962; Wetter 1962, 170; Backe Forsberg 2005, figs 20–21; *San Giovenale* VI:2–3	*Fig. 5*
Bridge 5	Spanning river Vesca, between lower Vignale area and Castellina Cammerata necropolis	From late 7th century BC (?)	One stone abutment	*San Giovenale* VI:2–3	*Fig. 5*
Bridge 6	Spanning Fammilume brook, between lower acropolis area and Porzarago necropolis	From late 7th century BC (?)	Hypothetical position, connecting to Porzarago funeral road	*San Giovenale* VI:2–3	*Fig. 5*

along the Pietrisco brook and may have functioned as an alternative or potentially earlier iteration of the larger bridge complex (*Fig. 5*, *Table 1*).[28] In 2006, the *Vignale Archaeological Project* identified traces of two significant crossings with Etruscan bridges—later replaced by Roman counterparts—along the Vesca river (*Fig. 5*, *Table 1*). A large cut-out ledge in a boulder adjacent to the Dogana road marks the location of an Etruscan wooden bridge abutment, subsequently supplanted by a Roman bridge featuring a riverbed foundation constructed of *opus caementicium* (*Fig. 5*).[29] These bridges underscore the strategic importance of the Dogana transit road linking the coastal region with the interior.[30] A separate crossing upstream along the Vesca river connected the San Giovenale settlement area to the Castellina Camerata necropolis (*Figs 2B*, *5*).[31]

The function and preconditions of the Spina bridge

Like the Pons Sublicius, the Spina bridge likely served multiple functions during its existence, including defensive, religious, practical and prestige-related purposes. Spanning the Dogana gorge (*Fig. 6A–B*), the bridge carried the road from the Casale Vignale plateau into the Spina area and the Acropolis beyond, functioning as the primary entrance during the early construction phase when heavier materials were transported. Practical considerations likely involved the movement of building materials—such as timber, tufa ashlars[32] and roof tiles—to habitation sites.[33] Evidence for this lies in the deep wheel ruts etched into the tufa bedrock of the Spina road, indicating sustained heavy cart traffic.[34] The bridge also probably facilitated the import and export of commodities. Notably, wine production on the Spina, which peaked during the Late Etruscan period (5th–3rd centuries BC), represents a key example of such economic activity.[35] A particularly intriguing practical feature is how small-scale industries, such as winemaking, allowed for the direct loading of wagons from elevated terrain into the deep Spina road cut, adjacent to the wine processing site (*Figs 7B:5*).

The bridge's role as a direct link between the settlement and the Casale Vignale necropolis further underscores its importance for funerary processions and transportation between the living community and the "city of the dead" (*Fig. 7B:1–2*).[36] This connection also established a liminal boundary from the Middle Orientalizing period (7th century BC) onwards, during which Etruscan infrastructure established a cosmological interconnectivity not only between spaces of life and death but also between élite power and ancestral ties.[37] The necropoleis surrounding San Giovenale, marked by numerous monumental burial mounds (tumuli) (*Fig. 2B*), reflect a highly organized familial hierarchy dominated by élite families who governed through a system of clients.[38] Their authority likely derived from control over land, goods and production resources.[39] The construction of monumental structures such as tumuli, roads and bridges required both materials and specialized engineering knowledge, possibly provided by local artisans, carpenters or migrants from other Etruscan cities.[40] The erection of a bridge of such scale would have symbolized wealth and power, a notion reinforced by its strategic placement along the approach to the settlement, past the tumuli of affluent families.[41] Evidence for a pathway or a funerary road leading to the northern bridge abutment is suggested by findings from the Casale Vignale necropolis, dating to the 7th century BC and the era of tumuli construction.

In San Giovenale, multiple indirect lines of evidence suggest the presence of affluent families who possessed both the resources and, likely, the motivation to construct a monumen-

[28] *San Giovenale* VI:2–3, 65–67, 69–71, 78–79, figs 30:4a, 42–46.

[29] Backe Forsberg 2005, fig. 21; Backe Forsberg & Holmgren 2017; *San Giovenale* VI:2–3, 63–64, figs 30:1, 34.

[30] *San Giovenale* VI:2–3, 63–64, figs 30, 35.

[31] *San Giovenale* VI:2–3, 73, 75–76, fig. 50.

[32] This applies to buildings where ashlars were quarried outside the settlement or where quarries were situated at higher elevations than the building site, thus avoiding uphill transportation.

[33] *San Giovenale* IV:1, 155–157, figs 290–293. See for example House 1, building phase 2 (625–550/530 BC).

[34] Tuppi 2014; Tobin-Dodd 2015, 50, n. 286, on iron wheel-dressings found in tumuli at San Giovenale; Emiliozzi 2017.

[35] Based on the material remains and their relative chronology presented in this article, there is no evidence that the ravine between the settlement and necropolis underwent topographic changes due to quarrying or erosion. However, the bridge's design and function likely evolved over time. The impact of the 550/530 BC earthquake on its construction remains unclear. Our thesis posits that the bridge remained operational at least until the Late Etruscan period, when wine presses and cellars on the Spina are indicative of winemaking taking place (see 'Chapter 5. Vignale and the wine connection', and 'Chapter 6. A concise chronology of Vignale' in *San Giovenale* VI:2–3.

[36] Naso 2017a, 326, on funeral transports with bed and four-wheeled wagon (Greek words prothesis and ekphora).

[37] Backe Forsberg 2005, 33–42; Edlund-Berry 2006, 116–131; Izzet 2007, 115–121, 188–189; Tuppi 2012; D'Ercole 2017, 148–149; Naso 2017a.

[38] *San Giovenale* I:4; *San Giovenale* I:5; *San Giovenale* I:6; *San Giovenale* I:7; *San Giovenale* I:8; *San Giovenale* I:9; Sannibale 2013, 115; Tobin-Dodd 2015; Olsson 2021, 67.

[39] Olsson 2021, 115.

[40] Izzet 2007; Amann 2017; Potts 2022.

[41] Tuppi 2012; 2014.

Fig. 6A–B. A. "La Piazzetta" *near one of the western entrances to the Casale Vignale necropolis. Chamber tombs are visible (left) with the Dogana road passing to their right, looking south-east. B. Same view with the position of the Spina bridge superimposed (photographs by R. Holmgren).*
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tal bridge. From the late 7th century BC onwards, references to specific family names—corroborated by excavation findings—directly associate them with the Pietrisco bridge complex (*Fig. 5:2*).[42] Pottery excavated from a structure near the bridge's northern abutment, interpreted as a *sacellum*, features inscriptions bearing divine epithets, personal names and family names.[43] Among these, the family names (*gentes*) Urqena and Alsi[44] stand out, potentially linked to the bridge's earliest construction phase or its immediate aftermath during the early 6th century BC—a chronology attested by inscriptions on bucchero vessels.[45] However, no direct connections between these family names and the construction of the Pietrisco bridge have been established. As for evidence of earlier families in San Giovenale, contemporary with the construction of the Spina bridge (and as potential bridge builders) aristocratic families that held prominence during the Orientalizing period are notable.[46] Insights into this social structure derive from epigraphic records of at least five *gentes* found on pottery, tomb walls and settlement artefacts dating from the late 7th to the early 6th centuries BC.[47] These élite families include Avhircina (*c.* 625 BC), Alsi (7th–6th centuries BC), Vefuna (7th–mid-6th centuries BC), Zixana (?) (7th–6th centuries BC) and Utre (7th–6th centuries BC).[48]

42 Backe Forsberg 2005, 96–99.

43 Colonna & Backe Forsberg 1999; Backe Forsberg 2005, 77–79, 99–100, table 25.

44 Backe Forsberg 2005, 99; Olsson 2021, 140, 163–164.

45 Colonna & Backe Forsberg 1999; Backe Forsberg 2005, 123, fig. 91:1, 11.

46 Naso 2017b, 869–874; Nijboer 2017, 902–920; Olsson 2021, 137. See Amann 2017 on social structure of the Etruscan family and different social classes, 182–190.

47 On the Etruscan *nomen gentilicium*, see Olsson 2021, 115–117, 137–164, 167, 169, 198, table 8.

48 Colonna & Backe Forsberg 1999; Backe Forsberg 2005; Tobin-Dodd 2015.

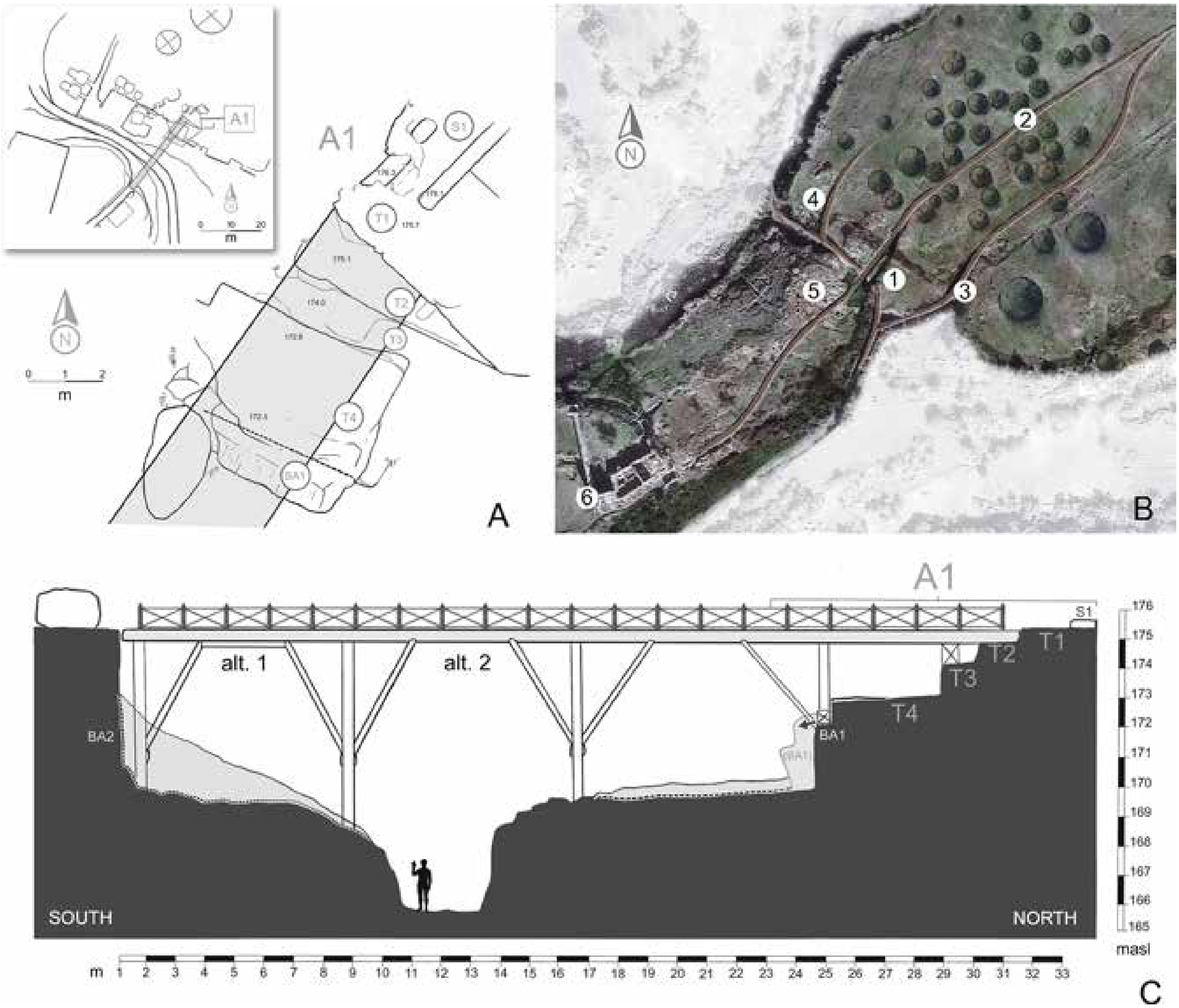

*Fig. 7A–C. A: Plan of Area 1 (A1) showing the northern bridge abutment with an area overview inset. The S1 track on platform 1 (T1), leads down to the bridge's girder support, platform T2, and platform T4 with the vertical bridge support BA1. Dark shading shows the estimated width of the bridge. B: Superimposed reconstruction drawing on an aerial photograph from 1961, showing the Spina bridge (1), a possible central funeral road (2), and funeral roads connecting the necropolis to the Dogana (3–4), the Spina/Borgo area (5) and Acropolis (6). C: Profile drawing of the northern and southern bridge abutments with a reconstructed strut frame bridge of c. 30 m. Platform T4 with BA1 is shown both in its original location and its later collapsed position in light grey. Note that the bridge profile shows two alternative structural systems, alt. 1 and alt. 2, marked in the image. The reconstructed model of the bridge (*Fig. 1*) consistently uses system 2. Illustration based on a 1961 aerial photograph (Aerofototeca Nazionale AM); archaeological archive at the Swedish Institute of Classical Studies in Rome; drawings by R. Holmgren.*

The Spina bridge complex — documented features and chronology

To establish a chronology for the Spina bridge and its earliest phase, it was essential to document and reassess its associated archaeological remains.[49] Given that the bridge formed a direct link between the Casale Vignale necropolis and the settlement on the Spina plateau, features directly connected to this strategic bottleneck were prioritized (*Figs 2B*, *7B:1*, *7B:5*,). The individual structural elements within the northern bridge

[49] E. Berggren 1956, N_1140, 11–12; Rundqvist & Carlestam 1957; Wetter 1962; Nylander 1986, 38, 44, fig. 17; Backe Forsberg 2005, 111–112, figs 73a–b; *San Giovenale* V:3; *San Giovenale* VI:2–3, 61–62, figs 30:1, 31:2, 32.

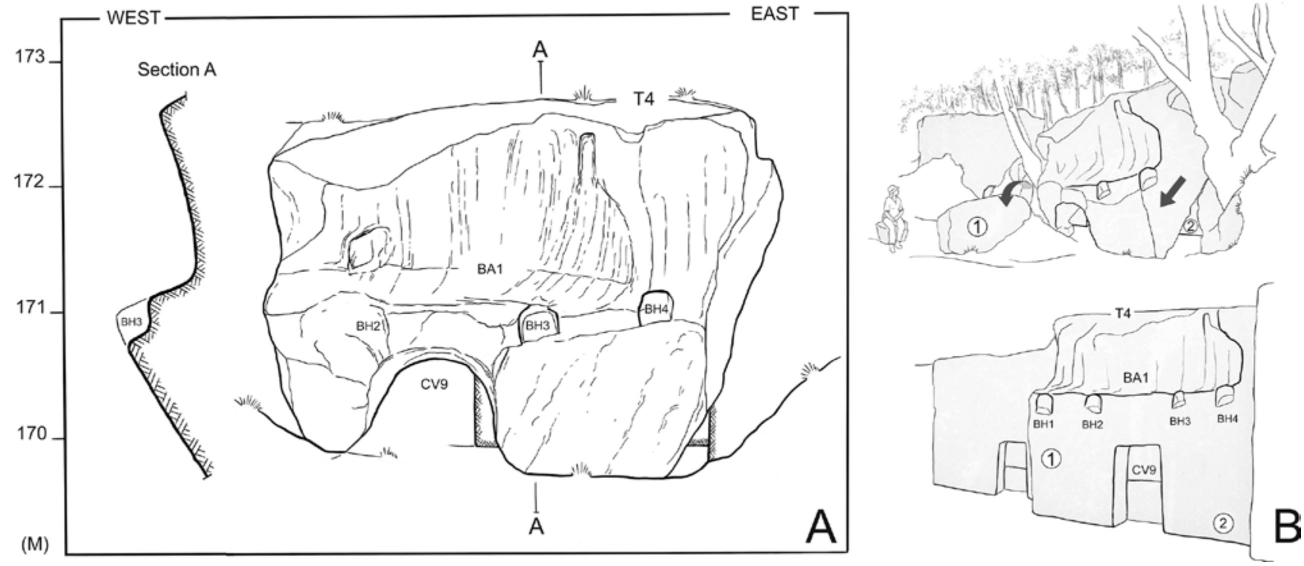

Fig. 8A–B. A. Technical profile drawing with section (A) of the northern bridge abutment, showing platform T4's detached front façade with the rock-cut bearing for vertical support (BA1), and three out of four cavities for inclined struts (BH2–BH4). B. Reconstruction of the partly detached platform T4 with BA1 (below), alongside a depiction of the current state of the façade (above). The upper part of T4 is currently obscuring the façade of chamber tomb CV9 (2), now positioned behind T4 and BA1. A secondary fragment of the same façade has come loose and is concealing BH1 (1). Drawing by R. Holmgren. Copyright: Richard Holmgren ARCDOC.

abutment currently lack secure dating. However, indirect traces of the thoroughfare linking the abutment (Area 1, *Fig. 7A, B:2*) to the northbound interregional road are noteworthy. This thoroughfare traversed the necropolis and likely functioned as a processional or funeral road. Beyond its two parallel roads in the south-east (Via delle Poggette, *Fig. 7B:3*) and north-west (*Fig. 7B:1*), both linking Casale Vignale with the Dogana road, the most significant aspect is the potential dating of this central route, which suggests its earliest phase may belong to the Middle Orientalizing period (680–625 BC). A 2010 LiDAR survey[50] and a 2022 ground survey examined traces of a connection between Area 1 and the northbound interregional road. Particularly revealing was the identification of a straight, unobstructed stretch approximately 300 m long and 4 m wide, passing between tumuli tombs (*Fig. 7B:2*). The absence of tumuli cropmarks along this path—clearly visible in a 1961 aerial photograph (*Fig. 7B*)[51]—supports the hypothesis that a road indeed occupied the central necropolis. Since the youngest adjacent tombs (based on circular cropmarks) likely date to the late 7th or early 6th century BC,[52] the bridge's initial phase must predate this period. The two large tumuli flanking the Poggette funeral road, located south-east of the road (*Fig. 7B:3*), are dated to 650–625 BC.[53]

The northern bridge abutment comprises three bedrock-cut stepped platforms (T2–T4) and remnants of a northbound track S1 (*Fig. 7A*). T1 is interpreted as the bridge's approach, with T2 serving as support for its girders. The latter's triangular shape and deliberate south-eastwards tilt align it with the southern abutment (*Figs 7A*). Platform T3 may have functioned as an intermediate pier support between the T2 platform and the southern edge of platform T4 (*Figs 7A, 7C*). T4, which contains the critical structural element BA1 (potentially clarifying the bridge's construction), is discussed in detail below, in the section 'Reconstructing the Spina bridge'. Originally part of the lower, southernmost platform, T4 has detached from the rock face and shifted diagonally to its current position (*Figs 3A–B, 8A–B*). Whether this fracture resulted from structural stress caused by the bridge's weight remains speculative. Illicit excavations have further compromised T4, leaving a tunnel-like entry through its lower façade to access the underlying chamber tomb Casale Vignale 9 (CV9) (*Figs 3B, 8A–B*).[54] All these bridge components may have been used concurrently or modified over time. The extent to which the 550/530 BC earthquake necessitated struc-

[50] *San Giovenale* VI:2–3, 55.

[51] Fig. 7B is based on a 1961 aerial photograph (Aerofototeca Nazionale AM stored in the Archaeological archive at the Swedish Institute of Classical Studies in Rome), but cannot be reproduced here due to copyright restrictions. The original image appears in *San Giovenale* VI:2–3, 49, fig. 20.

[52] Alvino & Paolelli 2001; Tobin-Dodd 2015.

[53] Tobin-Dodd 2015, 164, 172–173, tombs 212 and 240.

[54] Tobin-Dodd 2015, 173, tomb 241.

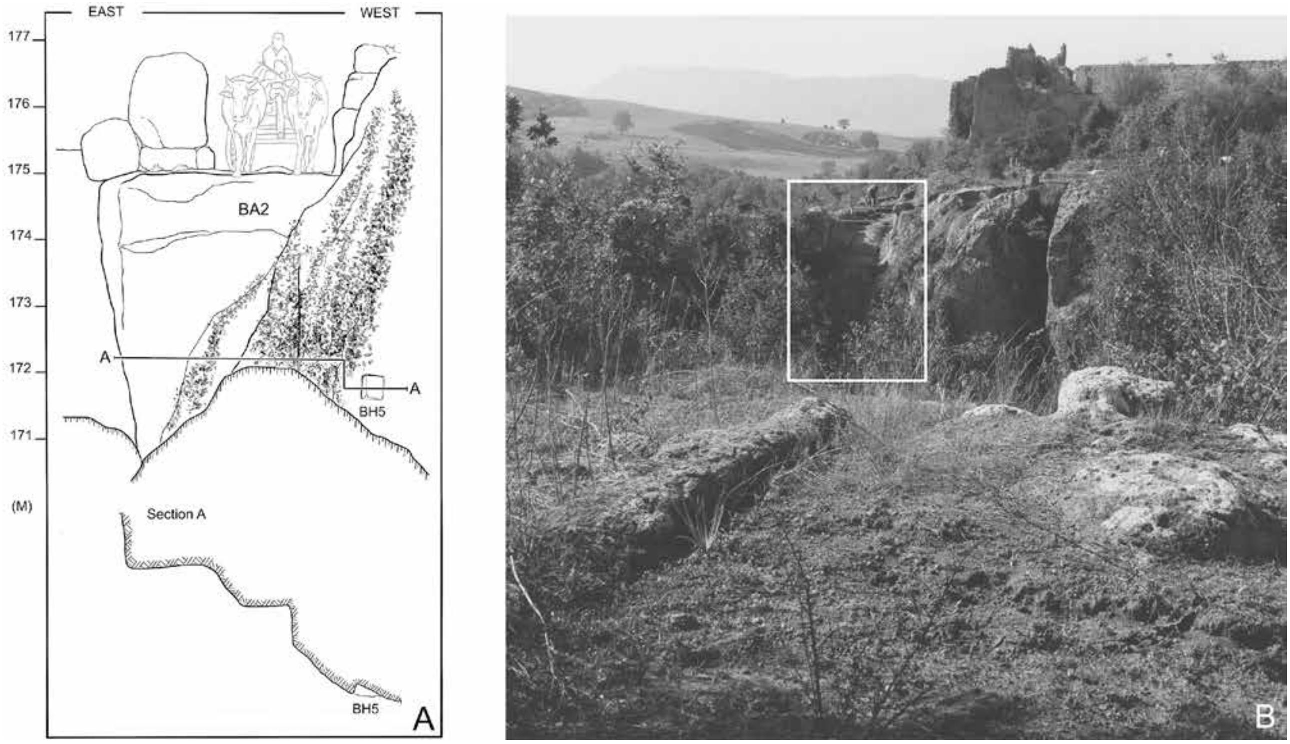

Fig. 9A–B. A: Profile drawing of the southern bridge abutment (BA2), viewed from the north, with a section (A) showing a cavity for an inclined strut (BH5). BH5 is positioned 3 m below the estimated bridge deck, matching the original height of cavities BH1–BH4 in the northern abutment (T4 and BA1). B: View from the northern abutment (S1/T1) towards the southern abutment (BA2) with the Spina road framed in white. Drawing by R. Holmgren and photograph by J. Mark; courtesy of the Swedish Institute of Classical Studies in Rome.

tural consolidation or alterations remains unclear.[55] The track segment (S1) presents interpretive challenges. The two parallel curbs leading to the stepped platforms, seen in *Figs 7A* and *9B*, are too narrow (1.2 m) to accommodate vehicles of the width indicated by wheel ruts on the Spina road (*Figs 10A–B*, *11B*).[56] Further study may determine whether these curbs functioned as part of the bridge itself, potentially replacing wooden girders and extending into the Casale Vignale plateau. An earlier iteration of the wooden bridge deck might have rested atop these curbs. No stepped platforms exist in the southern abutment, BA2 (*Figs 7C*, *9A*). Here, the Spina road terminates abruptly at the gorge, with preserved wheel ruts leading to the cliff edge. This striking discontinuity was noted in 1950s by Prof. Carl Nylander: "On top of the Borgo, at the northern end, there is an Etruscan road cut into the bedrock [...] deeply marked by the wheels of wagons. However, it disappears dramatically and mysteriously at a precipice above the Dogana."[57] This sudden termination could reflect a wooden pier built against the cliff face—a design possibly motivated by spatial constraints or defensive needs, as evidenced by the narrow, elevated corridor near the bridge's southern threshold (*Fig. 9A*).[58] A cavity in the bedrock, BH5 (*Fig. 9A*), located 3 m below the original bridge deck and aligned diagonally upwards, mirrors the size, position and probable function of BH1–BH4 in the northern abutment. Soil deposits from 1950s excavations obscure the area beneath the Spina road, preventing visual inspection in 2022 (*Fig. 9A*). Beyond BH5, interpretations of the southern abutment remain speculative but align with the reconstructed spatial distribution of piers.

The documented features of both abutments and the hypothesized funeral road provide architectural evidence for the bridge and a preliminary chronology based on this street. Additional chronological data derive from structures along the Spina road beyond the southern abutment. A well-preserved 30-metre stretch of this road, excavated in 1956–1958, remains partly exposed (*Fig. 12*).[59] Adjacent wall foundations,

[55] *San Giovenale* V:1, 141–142.

[56] Rundqvist & Carlestam 1957.

[57] *San Giovenale* V:1, 30, 33, figs 10, 13.

[58] Tuppi 2014, 54.

[59] See E. Berggren 1956, N_1140, 11–12; 1957, N_1239; Rundqvist & Carlestam 1957; E. Berggren *et al.* 1957–1958; Berggren & Moretti 1960, 3–5.

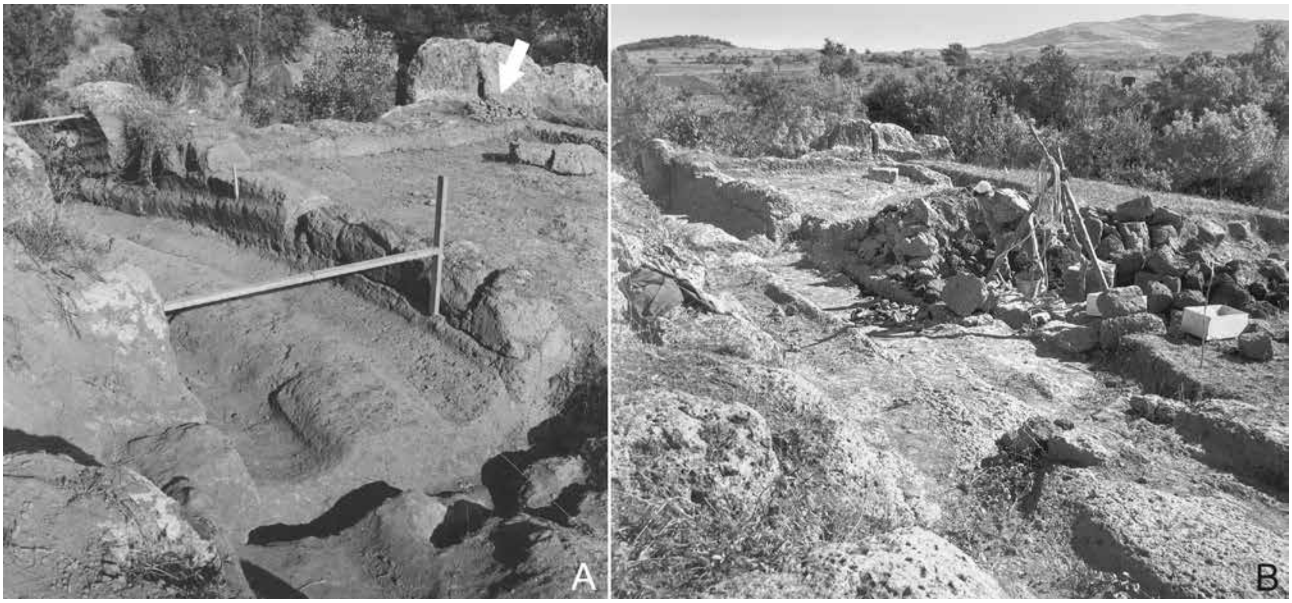

Fig. 10A–B. A. The Spina road ends abruptly at the southern bridge abutment (behind the curve), alongside the wall foundation of House G, constructed partly from bedrock and ashlars. B. The Spina road further south, seen during excavation and the emptying of well P7 in House H. Photographs by J. Mark; courtesy of the Swedish Institute of Classical Studies in Rome.

wells/cisterns and smaller installations—some bonded to the road—offer valuable dating references. A 2023 photogrammetric survey documented these features for phase analysis (*Tables 2–3*, *Fig. 11B*). The foundation wall of House G is carved out of the natural bedrock, a continuos formation that extends to form the road surface immedatially outside the wall (*Figs 10A*, *11B:2*, *11B:5–6*).[60] Initially labelled "*Tempio Tuscanico*" by 1950s excavators,[61] this building's proposed monumental status rests solely on its prominent location near the bridge. It would have been the first structure visible upon entering the settlement.[62] South of House G lies House H. Both houses are equipped with a well (P6 and P7, respectively) (*Figs 10B*, *11B:3–4*, *11B:7*, *12*). Relative chronology, based on roofing tiles and well fillings, suggests the bridge was in use from the second half of the 7th century BC into the Late Etruscan period.[63] Wells P6 and P7 contain demolition debris (ashlars, tile fragments and pottery) from the pre-earthquake period (late 7th to early 6th centuries BC), indicating prior urban development.[64] These demolished buildings, together with their wells, point to an urban planning and construction period prior to the earthquake, since the edifices must have been established before the destruction in the middle of the 6th century BC.[65] Since the wells are filled, we must assume that the buildings (G and H) were abandoned. How long these houses and wells were used prior to the earthquake is open for discussion, but the pre-earthquake period already showed wear and tear from vehicles along the house foundation of House G, facing the Spina road (*Figs 10A*, *11B:5–6*). Furthermore, the foundation trench of House H clearly cuts an already worn-down Spina road (*Figs 11B:2*, *11B:7*, *12*). On the highest elevation of the Spina there are an additional three wells (P3–P5), which are filled with ashlars, tiles and pottery, in a similar manner to wells P6 and P7—evidently from the same clean-up activities after the earthquake. Beneath the de-

[60] *San Giovenale* V:3.

[61] E. Berggren 1956, N_1140, 11–12, N_1240; 1957, N_1239; Rundqvist & Carlestam 1957; Pohl 1985, 43–63; *San Giovenale* V:1, 34, figs 13–14, Nylander referred to the building as a small shrine; see Olsson 2021, 67; Edlund-Berry 2013, 695–707, on architectural elements in the article 'Vitruvius and the Tuscan temple' by Edlund-Berry; Steingräber 2013, 659.

[62] Backe Forsberg 2005.

[63] The Spina road appears to have remained in use after the earthquake and the clearing of Houses G and H. This is supported by the dating of wine production on the Spina (*San Giovenale* VI:2–3, chapters 4 and 5), and the chronology of House K, with its well P8 located at the road's terminus (*San Giovenale* V:3).

[64] E. Berggren 1957, N_1239; *San Giovenale* VI:2–3.

[65] E. Berggren 1956, N_1140, 11–12, N_1240 and 1957, N_1239 document scattered fragments of roof tiles from House G's excavation, suggesting an Archaic type. These tile fragments, though neither documented nor stored, are visibile—some with clear profiles—jumbled together in *Fig. 10A* (white arrow) from the excavation. See Wikander 2024.

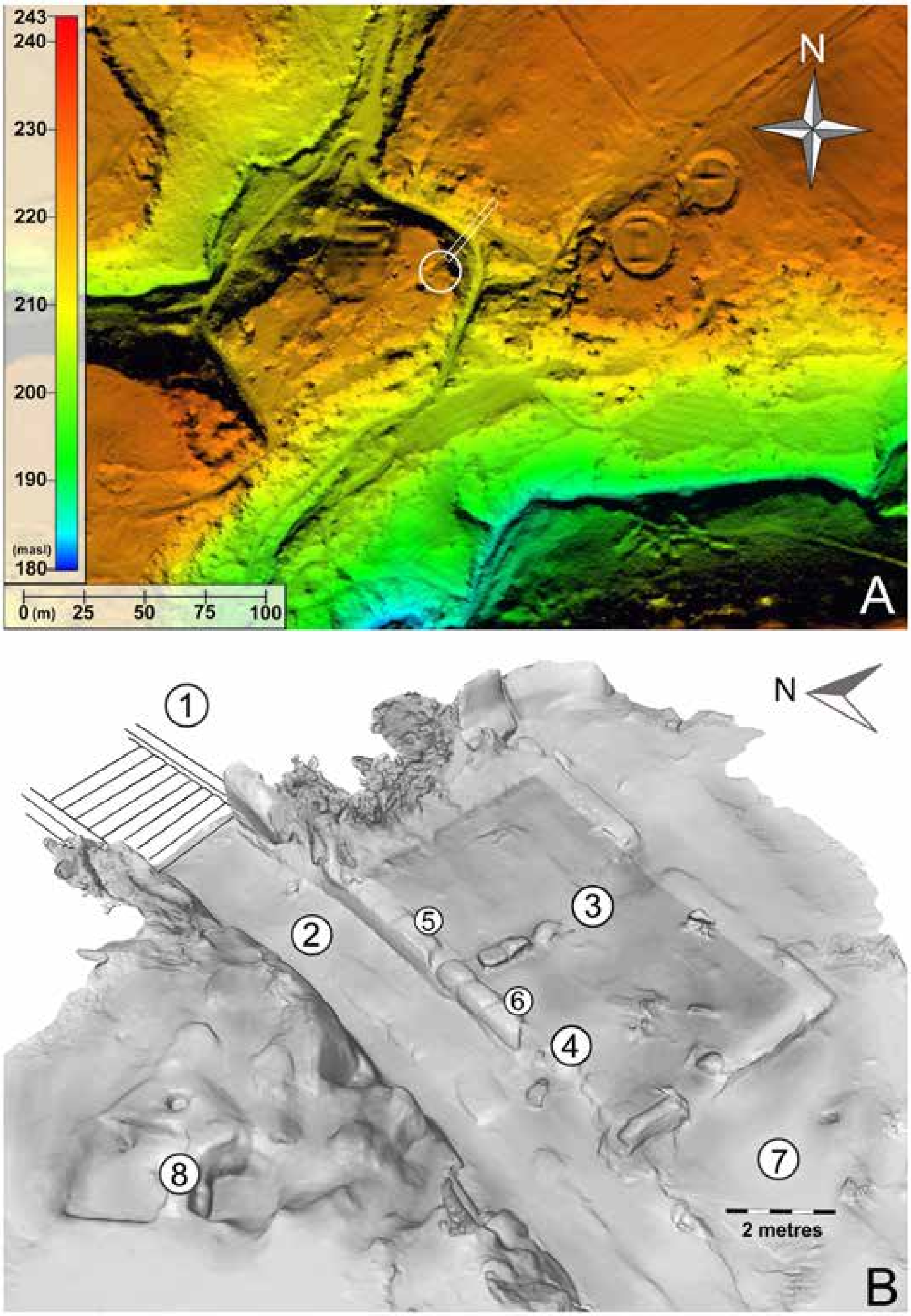

Fig. 11A–B. A. Remote sensing aerial view (LiDAR) over eastern part of San Giovenale. White circle shows the position of the Spina road and House G, with the bridge marked in white parallel lines (LiDAR data by Geocart srl with processing by N. Masini (CNR/IBAM) and R. Lasaponara (CNR/IMAA). B. Photogrammetry over the Spina area, next to the southern bridge abutment. 1. Spina bridge. 2. Spina road. 3. House G. 4. Well P6. 5. Western foundation wall of House G partially carved out of bedrock. 6. Western foundation wall of House G, ashlars on bedrock. 7. Position of House H (obscured by soil during documentation). 8. One of three wine presses (WP5) on the higher elevation of the Spina area. Photogrammetry by R. Holmgren and Y. Backe Forsberg. Copyright: Richard Holmgren ARCDOC.

Table 2. Evidence for the Spina bridge—documented features.

Feature	Area	Abbreviation	Period of use (preliminary)	Remark	Figure
Funeral road	Casale Vignale necropolis	-	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	A *c.* 300-m road stretch from the northern abutment	*Figs 5:6, 7B:2*
Track remains/ bridge approach	A1, northern abutment	S1, T1	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	Level of Casale Vignale plateau	*Figs 2B, 3A, 7A, 7C, 9B, 11A, 13D–E*
Support for girders	A1, northern abutment	T2	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	Triangular platform connecting the bridge to the plateau (T1), orienting towards the southern abutment	*Figs 3A, 7A, 7C, 13D–E*
Vertical support (pier) with inclined struts	A1, northern abutment	BA1/T4, BH1–BH4	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	Hewn rock façade with combined structural elements for vertical support, with four cavities for inclined struts	*Figs 3A–B, 7A, 7C, 8A–B, 13D–F*
Inclined strut	Southern abutment	BA2/BH5	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	One cavity for an inclined strut	*Figs 7C, 9A, 13A*
Spina road	North-eastern Spina	-	Middle Orientalizing 7th century BC to Late Etruscan 5th–3rd centuries BC	Spina road with wheel ruts, connecting to the southern abutment	*Figs 2B, 5, 7B, 9A–B, 10A–B, 11A–B:2, 12, 13G*

bris in one of the wells (P5), pottery was found dating from 625 BC to the time of the earthquake.[66] While these findings provide compelling chronological clues, further investigation is required to refine the timeline.

Reconstructing the Spina bridge

Based on documented features such as cavities used as supports for wooden beams, bridge abutments with connecting infrastructure and the topography of the Dogana gorge itself (*Fig. 6A–B*), we may now attempt to reconstruct the Spina bridge. A critical factor to consider is the presence of four cavities in the bedrock (BH1–BH4), which likely served as supports for wooden members and were positioned adjacent to the vertical support structure BA1 (*Figs 3A–B, 7A, 7C, 8A–B*). These cavities, oriented towards the gorge, indicate a bridge width of 3–4 m (including space for rails) and potentially reveal the number of supporting members. The estimated width aligns with the Spina road's approximate 2-metre width. Significantly, the BH cavities imply the use of inclined struts, suggesting the remains of a strut-frame bridge in which Yshaped wooden supports distributed the deck's weight to each vertical column (piers) (*Figs 7C, 13F*). This design mirrors the function of a temple capital, which transfers the weight of an overlying structure to the column below. Consequently, the central debate in this article whether the construction of a monumental 30-metres-long wooden bridge, connecting the plateaus, was ahead of its time, implies that a strut-frame design may not be as groundbreaking as it seems.[67] In the current authors' view, this scepticism is misplaced. The technology of the late 7th century BC appears advanced enough to accomplish such a feat, meaning that such a bridge likely was within the technical limits of its time.

The strut-frame bridge represents a variation of truss bridges, defined as interconnected frameworks of beams designed to bear loads. The distance between the outermost cavities (BH1 and BH4) exceeds the width of the vertical support BA1, implying that the outermost vertical supports in each pier were slightly inclined inwards (compare the cavity positions with the lower strut placements on opposing columns in *Fig. 13E*). This inclined arrangement of some of the struts would have given lateral stability to the bridge. The bridge's weight and transported loads were distributed through abutments at either end or, in the case of the Spina bridge, central piers. Unlike, for example, suspension bridges (which bear loads from above) or deck arch bridges (with support from below), the strut bridge with inclined piers enhances the roadway's lateral stability, enabling it to remain cohesive under load.[68]

66 *San Giovenale* V:3.

67 Potts 2022.

68 Potts 2014–2015; 2015; 2022; on tie-beam trusses, see MacIntosh Turfa 2022, 31–61; Fiore *et al.* 2020, fig. 2, proposing a methodology for the conceptual design of timber bridges; Zamperini 2015, 629–636, figs 2–3, discussing open/closed joint trusses and mortise-and-tenon techniques.

Table 3. Phases of the Spina bridge complex (preliminary).

Phase	Date (BC)	Feature	Area
Phase I	700–625 (Period 1)[I]	Necropolis (tumuli)	Casale Vignale
Phase II	650–550/530	Pozzi 3–5	Spina (higher plateau)
Phase III	650–625	Funeral road	Casale Vignale
Phase IVa	650–625	T1/S1	Northern abutment
Phase IVb	650–625	Girder support T2	Northern abutment
Phase IVc	650–625	BA1/T4 BH1–BH4, BA2/BH5	Northern and southern abutments
Phase IVd	650–625	Spina road	Spina
Phase V	625–550/530	House G/P6	Spina
Phase VI	625–575	Wheel ruts	Spina
Phase VII	600–550/530	House H/P7	Spina
Phase VIII	550/530	Earthquake fill in P6–P7/P3–5	Spina
Phase IX	530–400 (Period 3)[II]	Tomb CV9	Northern abutment
Phase X	400–275	Wine presses (WP3–5)	Spina (higher plateau)

[I] Tobin Dodd 2015, app. 2, chronology table.
[II] *San Giovenale* VI:2–3, 264.

Fig. 12. The continuation of the Spina road from the southern abutment (BA2), with the medieval castle visible in the distance. The foundation of House H, situated alongside Spina road, cuts the road surface. Well P6 in House G (lower left) and well P7 in House H are located near the far end of the wall. Photograph by J. Mark. Courtesy of the Swedish Institute of Classical Studies in Rome.

As illustrated in the Spina bridge profile (*Fig. 7C*), this design allowed the bridge to span the Dogana gorge while minimizing vertical supports beneath the deck—a contrast to a more traditional pier bridge lacking inclined struts. The struts extending from below BA1's vertical support would also have preserved open space near the Casale Vignale cliffside, accommodating a pathway and chamber tombs added from the early 5th century BC.[69] Cavities for inclined load-bearing members are present in both abutments: three (originally four) below BA1 and one in the southern abutment, BA2 (*Figs 7C*, *8A–B*, *9A*). These were initially positioned at approximately 172 metres above sea level (masl) or 3 m below the original deck. A current 1-metre height discrepancy stems from the downward slippage of the T4 façade. Each cavity (BH1–BH4) could have accommodated a strut roughly 0.2 m wide. Two cavities are visible on the eastern edge of T4, below BA1, with two others on the western edge—one partially fragmented (BH2) and the outermost (BH1) concealed on a detached section of the T4 bedrock (*Fig. 8A–B*). The southern abutment's cavity (BH5) is situated on a protruding cliff (*Figs 9A*, *13A*), likely due to spatial constraints preventing a full row of four vertical supports.

Considering material availability and practicality, the wooden components (vertical supports, struts and superstructure) likely ranged from *c.* 0.1 to 0.4 m in diameter and up to 7–8 m in length. For example, logs of 0.3 m diameter spaced at 6–8 m intervals would have sufficed to support pedestrian traffic or animal-drawn carts.[70] Such substructures could even withstand modern lighter vehicular loads. In the Spina bridge, the average spacing between vertical and diagonal supports likely did not exceed 4 m. The BH1–BH4 and BH5 cavities further suggest that all piers featured four vertical supports with opposing struts (*Fig. 7C*). The innermost columns and their struts were probably essential for bearing the deck's central load (*Fig. 13B*). The Etruscans likely used logs or squared timbers joined through carpentry joints rather than metal fastenings. Their expertise in wooden joints may parallel contemporaneous Phoenician techniques (Latin: *coagmenta punicana*), a pegged mortise-and-tenon method used in shipbuilding. This joinery method, originating in the Levant, proliferated across the Mediterranean by the mid-1st millennium BC.[71] Ropes may also have supplemented joints to prevent

[69] Tobin-Dodd 2015, 173–174, tombs 241–243.

[70] Crocetti 2014.

[71] De Boer 1992–1993; Polzer 2010; Zamperini 2015; Ibrahim Ali 2017; Pomey 2017; Scott 2018.

Fig. 13A–G. Spina bridge model reconstruction (scale 1:50) from multiple angles. A: Southern abutment (BA2) showing vertical supports (piers) and the position of the cavity for the inclined strut BH5 (black arrow). B: Central span over the Dogana road, originally c. *10 m high (see F). C: Hypothetical wooden deck with railings and protective planks for iron-wheeled vehicles. D–E: Northern abutment (T4 and BA1) with vertical support (pier) and cavities for inclined struts (BH1–BH4). F: Strut-frame bridge construction with three piers standing on the ground and the cliffside pier, BA1/T4 to the far right. G: Top view of the bridge deck (width* c. *3–4 m including rails), connecting to the Spina road. Note the narrowing cliffside (right), which required cavity BH5 to be attached directly into the bedrock instead of relying on a wooden pier (see A). Model and photographs by R. Holmgren. Copyright: Richard Holmgren ARCDOC.*

wear from movement (*Fig. 3A*). Suitable timber species for the structure could have included conifers such as pine, spruce and larch or hardwoods such as oak and chestnut,[72] all abundant in west-Central Italy, particularly near San Giovenale.[73] The deck likely comprised closely spaced wooden girders,[74] possibly topped with a protective layer of bricks or compacted earth to mitigate wear from animal hooves or iron-wheeled vehicles.[75] The project's reconstructed model (*Fig. 13C*, *13G*) includes replaceable wooden planks as an additional safeguard. As piers were anchored directly to bedrock, evidence of rock-cut stabilization may exist beneath the bridge. Today, the area north and south of the Dogana gorge is covered by a 0.3–0.5-m-thick soil layer; its excavation could yield additional insights into the bridge's construction.

Final remarks and conclusion

The title of this article, 'The Etruscan missing link', addresses an enigma encountered during the Swedish excavations at San Giovenale in the 1950s. After uncovering an Etruscan rock-cut road on the Spina plateau, visible wheel ruts abruptly vanished, disappearing mysteriously into the void of the Dogana Gorge. Speculations about a possible bridge were met with scepticism, given the 30-metres distance to the opposing plateau—the Casale Vignale necropolis. Did the Etruscans possess the technical knowledge and capacity to construct such a bridge? Following archaeological investigations initiated in 2022, the answer appears to be yes. This article presents recent discoveries of structural platforms, installations and anomalies in aerial imagery, which collectively support the conclusion that a bridge once connected the two plateaus. In collaboration with the KTH Royal Institute of Technology in Stockholm (Department of Civil and Architectural Engineering), the authors developed a plausible scaled wooden model (1:50). Cavities, combined with documented features such as BA1 and adjacent platforms, suggest a strut-framed wooden bridge measuring 3–4 m in width, spanning 30 m across the gorge with at least three piers. The existence of such a bridge, relying on load-bearing beams and inclined struts, should not be considered unusual for its period. The design principles mirror contemporary load-bearing wooden roof structures, as well as carpentry techniques akin to those used in shipbuilding. Notably, the bridge functioned as a viaduct with foundations on soil/rock, therefore not subjected to external actions such as flowing water, thereby reducing engineering challenges. The project's primary aim was to demonstrate the bridge's evident existence rather than to debate its feasibility. However, research on this topic remains in its nascent stages. This documentation allows for the examination and comparison of similar contexts in other sites. By doing so, it could help verify the bridge-building techniques of the period and perhaps demystify the construction capabilities implied by the surviving traces in the San Giovenale bedrock.

The infrastructure leading to the bridge indicates its use as an early Etruscan crossing, raising the central question posed in this article: how old might the bridge be? To establish a chronology, the project utilized previously obtained stratigraphic data from wells and insights from documented infrastructure at San Giovenale—including buildings, tombs and roads—many of which were damaged by the catastrophic earthquake of 550/530 BC.[76] The analysis focused exclusively on features directly linked to roads approaching the bridge, though sparse material remains precluded precise dating. A relative chronology approach situates the Spina road (connected to the southern abutment) in the late 7th century BC. For the northern abutment and its association with the Casale Vignale necropolis via a potential funerary road, the proposed dating falls within the period *c.* 650–600 BC. This would align the Spina bridge chronologically with Rome's legendary Pons Sublicius.

The article also explores the rationale behind constructing a bridge between the Spina settlement and the Casale Vignale necropolis. The most plausible explanation is the practical need to avoid steep slopes when transporting heavy materials—such as tiles, wooden beams and ashlars—via carts, particularly during the area's late 7th-century BC building boom, evidenced in archaeological research in San Gionvenale. Additionally, religious motivations are evident in the direct connection between the settlement and the necropolis, symbolizing a link between the living and the dead. The road's ceremonial passage through monumental tumuli into the settlement would have served as a status symbol, accentuated by the bridge's imposing presence. Such an undertaking would have required financial backing, likely provided by prominent families attested in San Giovenale's epigraphic records since at least the late 7th century BC, who possessed both the influence and resources to execute such projects.

YVONNE BACKE FORSBERG
Swedish Institute of Classical Studies in Rome
Via Omero, 14
001 97 Rome, Italy
forsberg.yvonne@gmail.com

RICHARD HOLMGREN
ARCDOC Archaeological Documentation
Follingegatan 29
596 33 Skänninge, Sweden
arcdoc@icloud.com

[72] Galliazzo 1994, 208; Vitr. II. 2.9–11; Crocetti 2014; Potts 2014–2015.

[73] Boëthius 1962; Fries 1962.

[74] Crocetti 2016a; Crocetti *et al.* 2016b.

[75] Palladio 1928 describes a deck covered with brushwood and iron plaques to prevent damage from iron wheel-dressings and animal hooves.

[76] *San Giovenale* VI:2–3.

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