ARCTOS

ACTA PHILOLOGICA FENNICA

VOL. XLIV

HELSINKI 2010

INDEX

Arctos 44 (2010) 263–288

TRAFFIC BOTTLENECKS IN SOUTH ETRURIA? COMPARING THE ARCHAIC ROAD CUTTING WIDTHS WITH ANCIENT VEHICLES

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Abstract

During the 7th and 6th centuries BC a population increase in central Italy led, among other things, to increased contacts and trade and consequently to widespread adoption of wheeled vehicles. At the same time the use of quarried stone and tiles were introduced to architecture. These innovations placed new demands on roads, especially in southern Etruria, where the terrain is riddled with gorges and ravines. The soft volcanic tuff bedrock, while being partly the reason for the problem, also presented a solution: the roads were dug into the soft tuff where necessary in order to mitigate the slope.

This paper considers the widths of the pre-Roman road cuttings in context of the known sizes of the ancient wheeled vehicles in order to determine whether there was a certain general width considered to be sufficient to allow fluent traffic. In addition, the measure of Osco-Italic or Oscan foot and the continuity of its utilization in road engineering from the pre-Roman times to the Roman era are discussed based on the examples and data presented in this article.

Introduction

The 7th and 6th centuries BC are a very interesting period regarding the transportation via land in the Mediterranean region. In central Italy, the population increase had speeded up the traffic, which – along with the widespread adoption of the wheeled transport[1] – naturally created the demand for better roads and connec-

[1] S. Piggott, *The Earliest Wheeled Transport. From the Atlantic Coast to the Caspian Sea,*

tions.[2] The Romans were beginning to challenge their neighbors in a manner that would lead to the dominance of the Roman Empire in Italy (and consequently in most of Europe and the Mediterranean) and the Etruscans were already fashioning a comprehensive road network in Etruria that would allow heavy traffic.[3]

The effects of these events can perhaps be seen best in southern Etruria, where the soft, volcanic tuff bedrock[4] still bears in many places the ancient tracks and marks of the traffic.[5] The Etruscans had previously mostly exploited the natural ravines, valleys and routes that the flow of water and erosion had created into the tuff bedrock,[6] perhaps cutting some routes suitable for pedestrians,[7] but now, as the developments in architecture introduced the use of quarried stone in buildings and infrastructure, the former roads proved to be less than adequate for the heavily-loaded carts as well as the increased traffic, spurred by the growth of population and trade.[8] In order to facilitate the heavy traffic, the roads needed to be improved to meet the new demands.

London 1983, 138; G. Colonna, "L'Italia antica: Italia centrale", in A. Emiliozzi (ed.), *Carri da guerra e principi etruschi*, Roma 1999, 15–23, 15.

[2] T. W. Potter, *A Faliscan Town in South Etruria. Excavations at Narce 1966–71*, London 1976, 81; G. Cifani, "Notes on the rural landscape of central Tyrrhenian Italy in the 6th–5th c. B.C. and its social significance", *JRA* 15 (2002) 247–60; M. Martinelli – G. Paolucci, *Etruscan places*, Firenze 2006, 116–7.

[3] T. J. Cornell, *The beginnings of Rome. Italy and Rome from the Bronze Age to the Punic Wars (c. 1000–264 BC)*, London 1995, 310; L. Quilici, "Land transport, part 1: Roads and bridges", in J. P. Oleson (ed.), *The Oxford Handbook of Engineering and Technology in the Classical World*, Oxford 2008, 551–79, 559.

[4] J. B. Ward-Perkins, "Etruscan Towns, Roman Roads and Medieval Villages: The Historical Geography of Southern Etruria", *GJ* 128:4 (1962) 389–404, 390; M. Jackson – F. Marra, "Roman Stone Masonry: Volcanic Foundations of the Ancient City", *AJA* 110:3 (2006) 403–36, 408–9, fig. 2.

[5] E.g. T. W. Potter, *The changing landscape of South Etruria*, London 1979, 79–80.

[6] E.g. J. B. Ward Perkins, "The Via Gabina", *PBSR* 40 (1972) 91–126, 105–6; U. M. Rajala, *Human landscapes in Tyrrhenian Italy. GIS in the study of urbanization, settlement patterns and land use in south Etruria and western Latium Vetus*, a dissertation submitted for the degree of Doctor of Philosophy in the University of Cambridge (2002), 180–1.

[7] G. Barker – T. Rasmussen, *The Etruscans*, Oxford 1998, 172.

[8] Martinelli – Paolucci (above n. 2) 116–7.

Fig. 1. The tuff plateau of southern Etruria (after *Carta Geologica d'Italia*) and relevant sites mentioned in the text. All illustrations presented in this article are made by the author.

Lay of the land

In order to comprehend better the Etruscan road engineering, one must acquaint oneself with the geographical features of southern Etruria. The area in question, bordered roughly from the east and north by the rivers Tiber and Paglia and from the west by the river Fiora, is mainly a plateau of volcanic rock belonging to the volcanic districts of Monte di Bolsena, Monte Cimino and Monti Sabatini (Fig. 1).[9] By the geological timescale the plateau is quite recent; the Monti Sabatini district being formed 600 000–400 000 years ago and the last hydromagmatic deposits dated to *c.* 89 000 years in the past.[10] As a result of the volcanic erup-

[9] S. Judson – A. Kahane, "Underground Drainageways in Southern Etruria and Northern Latium", *PBSR* 31 (1963) 74–99, 75; S. Judson – P. Hemphill, "Sizes of Settlements in Southern Etruria: 6th–5th centuries B.C.", *SE* 49 (1981) 193–202, 193.

[10] R. Cioni – M. A. Laurenzi – A. Sbrana – I. M. Villa, "$^{40}Ar/^{39}Ar$ chronostratigraphy of the initial activity in the Sabatini volcanic complex (Italy)", *Bollettino della Società Geologica*

tions, different types of volcanic rocks, sands and ashes are superimposed on earlier limestone bedrock, causing the durability and hardness of the bedrock to vary greatly in southern Etruria, although the relatively soft volcanic tuff rock can be seen to dominate the area.[11] The mixing of the different strata and the abundance of tuff makes the landscape also very vulnerable to erosion, which can be witnessed in deep ravines and gorges created by the flow of water.[12] The uneven landscape made wheeled traffic problematical in many cases. However, the volcanic tuff seems to have also provided means to the solution. In order to lessen the effects of the slope, the Etruscans (and the Faliscans, for that matter[13]) dug their roads through the obstacles, into the easily moldable tuff.[14] Perkins observers in his study of the Etruscans in central coastal Etruria that the assumed road network of this region is poorly preserved compared to the areas with volcanic tuff in southern Etruria, and the scarce traces of the roads can be found only in the imminent vicinity of the coastal settlements.[15] Both Ward-Perkins and Perkins note that the coastal area of Etruria is nearly void of volcanic tuff.[16] In addition, Oleson gives similar reasons in his study of the Etruscan necropolises for the ap-

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Italiana 112 (1993) 251–63; C. Campobasso – R. Cioni – L. Salvati – A. Sbrana, "Geology and paleogeographic evolution of a peripheral sector of the Vico and Sabatini volcanic complex, between Civita Castellana and Mazzano Romano (Latium, Italy)", *Memorie Descrittive della Carta Geologica d'Italia* 49 (1994) 277–90; Jackson – Marra (above n. 4) 408–9, fig. 2.

[11] Ward-Perkins (above n. 4) 390; Potter (above n. 2) 1–3; Cioni *et al.* (above n. 10); Campobasso *et al.* (above n. 10); Jackson – Marra (above n. 4) 408–9, fig. 2.

[12] Ward-Perkins (above n. 4) 390; Potter (above n. 2) 3; Barker – Rasmussen (above n. 7) 172; P. Hemphill, *Archaeological Investigations in Southern Etruria* 1. *The Civitella Cesi Survey* (Skrifter utgivna av Svenska Institutet i Rom 4,28:1), Stockholm 2000, 19–20; T. Rasmussen, "Urbanization in Etruria", in R. Osborne – B. Cunliffe (eds.), *Mediterranean Urbanization 800–600 BC*, Oxford 2005, 71–90, 74.

[13] E.g. G. Cifani – R. Opitz – S. Stoddart, "Mapping the *Ager Faliscus* road-system: the contribution of LiDAR (light detection and ranging) survey", *JRA* 20:1 (2007) 165–76, 176.

[14] M. W. Frederiksen – J. B. Ward-Perkins, "The Ancient Road Systems of the Central and Northern Ager Faliscus (Notes on Southern Etruria, 2)", *PBSR* 25 (1957) 67–203, 186; A. Kahane – L. Murray Threipland – J. B. Ward-Perkins, "The Ager Veientanus, North and East of Rome", *PBSR* 36 (1968), 4; Potter (above n. 5) 79; Barker – Rasmussen (above n. 7) 172. According to the Civitella Cesi survey in southern Etruria (Hemphill [above n. 12] 135), areas of tuff bedrock were especially favoured from the 7th into the 5th century BC when choosing the site for a settlement.

[15] P. Perkins, *Etruscan Settlement, Society and Material Culture in Central Coastal Etruria* (BAR International Series 788), Oxford 1999, 25.

[16] Ward-Perkins (above n. 4) 390; Perkins (above n. 15) 4, fig. 1.1.1.

parent lack of rock-cut tombs in northern Etruria: the bedrock is not suitable for rock-cut tombs, whereas the situation seems to be quite different in the south.[17] Again, Judson and Kahane also note the connection between volcanic tuff and *cuniculi*, the drainageways dug underground: the areas with numerous field *cuniculi* are situated only on tuff bedrock.[18] This does not mean that the cuttings were never done into harder bedrock types where necessary: only that on volcanic tuff the cutting was easier and more efficient to execute, and in that way, the presence of tuff bedrock certainly affected on the extent of rock-cut engineering on those areas.

Pre-Roman road surfaces

Archaeological evidence suggests that the Etruscans rarely paved their roads anywhere else than in the cities or in their immediate vicinity:[19] the common practice seems to have been to cut a new surface to the tuff bedrock when the old road deteriorated and got too worn with wheel ruts and the effects of erosion,[20] such as the accumulation of the loose soil and rubble that prevent the water seeping into the porous tuff, thus decreasing the friction and making the road surface more slippery. The renewal of the road surfaces caused the road cuttings to get deeper and deeper, which – while presenting an opportunity to make the slopes even more gentle and gradual – made a certain aspect of rock-cut roads more in-

[17] J. P. Oleson, "Regulatory Planning and Individual Site Development in Etruscan Necropoleis", *The Journal of the Society of Architectural Historians* 35:3 (1976) 204–18, 209; J. P. Oleson, "Technical Aspects of Etruscan Rock-Cut Tomb Architecture", *MDAI(R)* 85:2 (1978) 283–314, 285–6.

[18] Judson – Kahane (above n. 9) 76, fig. 1.

[19] The Etruscan cities of Acquarossa, Satricum and Veii apparently had roads paved with pebbles during the Archaic period (C. E. Östenberg, *Case Etrusche di Acquarossa*, Roma 1975, 25–6, 190–3; M. Maaskant-Kleibrink, *Settlement Excavations at Borgo Le Ferriere <Satricum> volume II (The Campaigns 1983, 1985 and 1987)*, Groningen 1992, 22–5; B. Belelli Marchesini, "Veio: Comunità", in A. M. Moretti Sgubini (ed.), *Veio, Cerveteri, Vulci. Città d'Etruria a confronto*, Roma 2001, 23–4, fig. 1). According to Y. A. Pikoulas, "Travelling by land in ancient Greece", in C. Adams – J. Roy (eds.), *Travel, Geography and Culture in Ancient Greece, Egypt and the Near East* (Leicester–Nottingham Studies in Ancient Society 10), Oxford 2007, 78–87, 80, 82, the urban roads in ancient Greece were "usually laid with condensed earth/dirt mixed with gravel or sherds".

[20] Frederiksen – Ward-Perkins (above n. 14) 148–9, 186; J. B. Ward-Perkins, "Etruscan and Roman Roads in Southern Etruria", *JRS* 47 (1957) 139–43, 140.

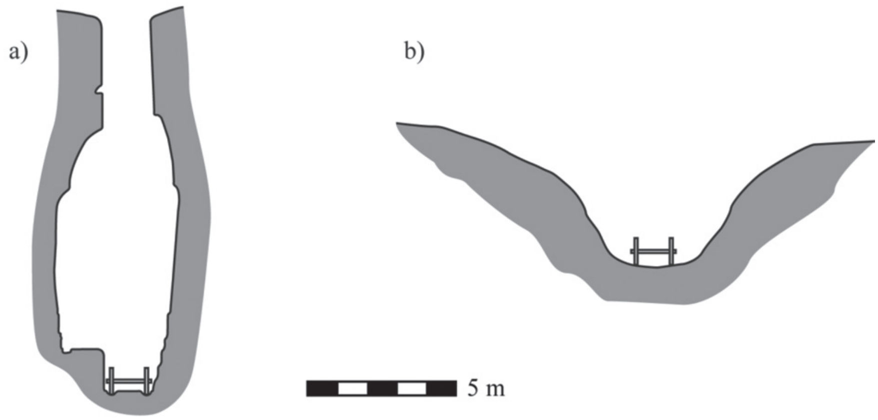

Fig. 2. The deep-mined road cuttings, *vie cave*, naturally placed more concrete restrictions than more open, gentle-sloped cuttings. The sections presented above are from a) Fantibassi road cutting near Civita Castellana and b) Trincea viaria road cutting at Crustumerium (section based on documentation on site in 2005).

convenient: the width of the road suddenly became extremely important in order to prevent vehicles getting stuck or being unable to use the road because of the narrowness (Fig. 2).

Fitting in the ancient vehicles

The wheeled vehicles can be basically divided into three types: four-wheeled wagons, two-wheeled carts and two-wheeled chariots. The first two are commonly used in labour and practical uses, whereas the chariot is generally lighter and intended for warfare, racing or festivities.[21] In the areas of ancient Mesopotamia and northern Iran, the A-framed two-wheeled cart possibly developed from the travois around 3000 BC, followed by an oxen-pulled four-wheeled wagon.[22]

[21] Piggott (above n. 1) 23, 90, 95; M. Cristofani, "Veicoli terrestri e imbarcazioni", in *Strade degli etruschi. Vie e mezzi di comunicazione nell'antica Etruria*, Milano 1985, 49–51, 49; K. Jones-Bley, "The Sintashta 'Chariots' ", in J. Davis-Kimball – E. M. Murphy – L. Koryakova – L. T. Yablonsky (eds.), *Kurgans, Ritual Sites, and Settlements: Eurasian Bronze and Iron Age* (BAR International Series 890), Oxford 2000, 135–40, 135–6; M. A. Littauer – J. H. Crouwel – P. Raulwing (eds.), *Selected Writings on Chariots, other Early Vehicles, Riding and Harness* (Culture and History of the Ancient Near East 6), Leiden – Boston – Köln 2002, 45; M. Pogrebova, "The emergence of chariots and riding in the south Caucasus", *OJA* 22:4 (2003) 397–409, 402–4; cf. Diodorus Siculus (5,29,1), reporting that the Gauls used chariots for journeys as well as for battles.

[22] M. G. Lay, *Ways of the World. A History of the World's Roads and of the Vehicles That Used*

It has been suggested that in central Europe and Russia, the four-wheeled wagon pulled by oxen was the earliest type of wheeled vehicles,[23] and the two-wheeled carts and chariots appeared along with the domestication of the horse;[24] however, in the light of the vehicle development in the Near East, this view is probably influenced by the four-wheeled vehicles commonly used in the third millennium BC central European vehicle burials[25]. Nevertheless, in order to gain the maximum benefit from the speed possible for a chariot with spoked wheels, harnessing the horse was certainly required.[26] Although the wheeled vehicles are pictured in art and decorations abundantly,[27] the actual, measurable examples are limited to burial finds.

The practice of vehicle burials was a continuous tradition in central Europe and Russia at least from the third millennium BC onwards.[28] As noted earlier, the third and second millennia BC vehicle burials seem to consist mostly of

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Them, New Jersey 1992, 28; cf. Littauer – Crouwel (above n. 21) 184.

[23] Piggott (above n. 1) 10; E. Kuzmina, "The Eurasian Steppes: The Transition from Early Urbanism to Nomadism", in J. Davis-Kimball – E. M. Murphy – L. Koryakova – L. T. Yablonsky (above n. 21), 118–25, 119. In the Near East during the 3rd millennium BC, the four-wheeled wagon was apparently the first type of vehicle utilized for military purposes (Littauer – Crouwel [above n. 21] 26, 48).

[24] E.g. Piggott (above n. 1) 10.

[25] Piggott (above n. 1) 51–60, 67–75; Kuzmina (above n. 23) 119; Littauer – Crouwel (above n. 21) 48, 50. K. D. White (*Greek and Roman technology*, London 1984, 133) suggests two different lines of vehicular evolution, one developing to four-wheeled wagon from sledge, and other from two-wheeled chariot.

[26] Jones-Bley (above n. 21) 135–6; M. A. Littauer – J. H. Crouwel, "The earliest evidence for metal bridle bits", *OJA* 20:4 (2001) 329–38, 332–4.

[27] E.g. H. L. Lorimer, "The Country Cart of Ancient Greece", *JHS* 23 (1903) 132–51; M. A. Littauer, "Rock Carvings of Chariots in Transcaucasia, Central Asia and Outer Mongolia", *Proceedings of the Prehistoric Society* 43 (1977) 243–62; Piggott (above n. 1); C. F. E. Pare, *Wagons and Wagon-Graves of the Early Iron Age in Central Europe*, Oxford 1992, 12, 14, fig. 13, 17–8; E. Anati, *Valcamonica Rock Art. A New History for Europe* (Studi Camuni 13), Valcamonica 1994, 156, 167, fig. 116–7, 128; N. Camerin, "L'Italia antica: Italia settentrionale", in A. Emiliozzi (above n. 1), 33–44, 40–2, fig. 9–12; Colonna (above n. 1) 16–9, fig. 1–6; J. H. Crouwel, "Il mondo greco", in Emiliozzi (above n. 1), 11–3, 12–3, fig. 3–5; M. Egg – C. F. E. Pare, "Il mondo celtico", in Emiliozzi (above n. 1), 45–51, 50, fig. 3; M. A. Littauer – J. H. Crouwel, "Antefatti nell'Oriente mediterraneo: Vicino Oriente, Egitto e Cipro", in Emiliozzi (above n. 1), 5–10, 6–8, 10, fig. 2–4, 7; F. Quesada, "La penisola iberica", in Emiliozzi (above n. 1), 53–9, 54, 58, fig. 1, 4.

[28] Witnessed for example in wagon burials from the Pressehaus site in Zürich, Switzerland or Elista site in the Republic of Kalmykia, Russia (Piggott [above n. 1] 51–2, 56–7).

four-wheeled wagons that probably served last as a funeral wagon carrying the deceased to the final resting place.[29] However, the situation appears to change by the emergence of the two-wheeled vehicles towards the end of the 2nd millennium BC.[30] Eventually, chariots become common in the vehicle burials in Europe – especially in central Italy – not later than from the 8th century BC onwards, possibly reflecting the meaning of the chariot as a status symbol and a ceremonial vehicle in the "princely" tombs.[31] The appearance of chariots in burials may also be partly due to the possible utilization of a modified chariot as a funeral vehicle in antiquity.[32]

[29] Jones-Bley (above n. 21) 136; cf. L. E. Lundeen, "In search of the Etruscan priestess: a re-examination of the hatrencu", in C. E. Schultz – P. B. Harvey, Jr. (eds.), *Religion in Republican Italy* (Yale Classical Studies 33), Cambridge 2006, 34–61, 38, 44, on the significance of four-wheeled vehicle in context with ritual and status during the 8th–5th centuries BC.

[30] Pare (above n. 27) 14; Camerin (above n. 27) 36; Pogrebova (above n. 21) 397, 401. The invention of a horse-drawn chariot presumably took place in the Near East around 2000 BC (Pare [above n. 27] 12; Littauer – Crouwel [above n. 21] 45).

[31] Piggott (above n. 1) 208; Cristofani (above n. 21) 49; A. E. Feruglio – A. Emiliozzi, "Il carro I da Castel San Mariano di Corciano (Rep. 96)", in Emiliozzi (above n. 1), 207–25, 208; M. Landolfi – G. De Palma – C. Usai – A. Emiliozzi – B. Wilkens, "Sirolo, necropolis picena "Il Pini". Tomba monumentale a circolo con due carri (520–500 a.C.)", in Emiliozzi (above n. 1), 229–59, 234; A. Emiliozzi – A. Romualdi – F. Cecchi, "Der Currus aus dem "Tumulo dei Carri" von Populonia", *JRGZ* 46:1 (2000) 5–16; Jones-Bley (above n. 21) 138–9; F. Fulminante, *Le "sepolture principesche" nel* Latium Vetus. *Tra la fine della prima età del ferro e l'inizio dell'età orientalizzante*, Roma 2003, 239–40; Pogrebova (above n. 21) 404; M. Cupitò, "Addenda interpretativi sul sistema figurativo del carrello di Bisenzio", in P. Attema – A. Nijboer – A. Zifferero (eds.), *Papers in Italian Archaeology VI. Communities and Settlements from the Neolithic to the Early Medieval Period. Proceedings of the 6th Conference of Italian Archaeology held at the University of Groningen, Groningen Institute of Archaeology, The Netherlands, April 15–17, 2003, Volume II* (BAR International Series 1452 [II]), Oxford 2005, 739–41. The practice of wagon burials apparently still remained alongside the chariot burials in eastern Europe and the Hallstatt culture (J. Biel, "A Celtic Grave in Hochdorf, Germany", *Archaeology* 40:6 [1987] 22–9, 28). See also M. Schönfelder, *Das spätkeltische Wagengrab von Boé (Dép. Lot-et-Garonne). Studien zu Wagen und Wagengräbern der jüngeren Latènezeit*, Mainz 2002, for later La Tène chariot burials.

[32] Piggott (above n. 1) 206–8.

Table 1. Iron Age and Archaic vehicle burials

Site	Vehicle	Dating (BC)	Gauge (m)	Axle length (m)
Hexenbergle, Wehringen (Germany),				
Tumulus 8	Wagon	8^{th} century	1.40	-
Großeibstadt, Rhön-Grabfeld District (Germany),				
Cemetery I, Grave 1	Wagon	8^{th} century	1.16	-
Cemetery I, Grave 4	Cart?	7^{th} century	1.10?	-
Cemetery II, Grave 14	Wagon	8^{th} century	*c.* 1.20	-
Hradenín, Kolín (Czech Republic),				
Grave 24	Wagon	8^{th} century	*c.* 1.22	1.36
Grave 28	Wagon	Late $7^{th}/6^{th}$ cent.	1.10	-
Grave 46	Wagon	8^{th} century	*c.* 1.26	1.55–1.66
Riedenburg-Untereggersberg, Kelheim (Germany),				
Tumulus 2	Wagon	$8^{th}/7^{th}$ century	1.20	-
Salamis (Cyprus Republic),				
Grave 2	Cart	Late $8^{th}/7^{th}$ cent.	1.25	-
Grave 3	Cart	Late $8^{th}/7^{th}$ cent.	1.30	-
Grave 79	Chariot	Late $8^{th}/7^{th}$ cent.	*c.* 1.80	*c.* 2.10
Vulci, Viterbo (Italy),				
Tomba del Carro	Chariot	680–670	*c.* 0.75	*c.* 1.10
Populonia, Livorno (Italy),				
Tumulo dei Carri	Chariot	7th century	*c.* 1.25	*c.* 1.75
Hohmichele, Heuneburg (Germany),				
Grave I	Wagon	Late $7^{th}/6^{th}$ cent.	1.10–1.15	-
Grave VI	Wagon	Late $7^{th}/6^{th}$ cent.	1.18–1.30	*c.* 1.80
Offenbach-Rumpenheim, Hesse (Germany)	Wagon	$6^{th}/5^{th}$ century	1.30	-
Eberdingen-Hochdorf, Baden-Württemberg (Germany)	Wagon	Late 6^{th} century	1.13	-
Castel San Mariano di Corciano, Perugia (Italy)	Chariot	Late 6^{th} century	*c.* 1.05	*c.* 1.50
Monteleone di Spoleto, Perugia (Italy)	Chariot	*c.* 530	*c.* 1.05	*c.* 1.50
Stuttgart-Bad Cannstatt, Baden-Württemberg (Germany),				
Grave 1	Wagon	Late $6^{th}/5^{th}$ cent.	*c.* 1.25	-
Lohe, Hilpoltstein-Weinsfeld (Germany),				
Tumulus 4, Grave 5	Wagon	Late $6^{th}/5^{th}$ cent.	*c.* 1.17	-
Les Jogasses, Chouilly (France),				
Grave 16	Wagon	Late $6^{th}/5^{th}$ cent.	1.20	-
Bell, Rheinland-Pfalz (Germany),				
Tumulus 1	Wagon	Late $6^{th}/5^{th}$ cent.	1.10	-
Castro, Ischia di Castro (Italy),				
Tomba della Biga	Chariot	Late $6^{th}/5^{th}$ cent.	-	1.40

Site	Vehicle	Dating (BC)	Gauge (m)	Axle length (m)
Hundheim, Rheinland-Pfalz (Germany),				
Tumulus 1	Chariot	Late 6th/5th cent.	1.35	-
Tumulus 2	Chariot	5th century	1.35	-
Sirolo, Ancona (Italy)	Cart	520–500	*c.* 1.05	*c.* 1.30
Vix, Côte-d'Or (France)	Wagon	*c.* 500	*c.* 0.90	-
Oberlahnstein, Rheinland-Pfalz (Germany),				
Tumulus 3, Grave 2	Chariot	5th century	1.29	-
Sedlec-Hůrka, Plzeň District (Czech Republic),				
Grave 44	Cart?	5th century	*c.* 1.30	-
Manětín-Hradek, Plzeň District (Czech Republic),				
Grave 196	Cart?	5th century	1.16–1.30	-

Vehicle remains and reconstructions

There are ten known 3rd–2nd millennium BC vehicle burials from Armenia[33], Georgia[34], southwest Russia[35] and Switzerland[36] that were sufficiently intact upon discovery to provide information about the gauges and axle lengths. Of these vehicles, six are four-wheeled wagons, one a two-wheeled cart and the rest three assumedly chariots. The wagon gauges range from 1.3 to 1.75 m, whereas the axle lengths measure approximately 1.7–2.1 m. Two-wheelers have gauges from 1.1 to 1.7 m, and the only three measurable axle lengths from Sintashta Grave 12 in Russia and Lchashen site in Armenia are 1.8, 2.25 and 2.35 m. Piggott notes that in the two cases from Trialeti region in Georgia, the gauge spacing seems to be settling towards the figures associated with the general cases in European antiquity (i.e. 1.4–1.45 m).[37]

33 Barrows 2, 9 and 11 at Lchashen, Geghargunik Province in Armenia (Piggott [above n. 1] 72–6).

34 Burial from Zelenyy, Tsalka District and barrows 5 and XXIX from Trialeti region in Georgia (Piggott [above n. 1] 59, 67–9).

35 Barrow 5, grave 9 from Elista, Kalmykia and graves 12 and 19 at Sintashta, Chelyabinsk Oblast in southwest Russia (Piggott [above n. 1] 57, 91; Littauer – Crouwel [above n. 21] 52, fig. 3).

36 Pressehaus site at Zürich, Switzerland (Piggott [above n. 1] 52).

37 Piggott (above n. 1) 68.

However, a new development becomes apparent in the Iron Age and Archaic vehicle burials: the general gauge with wagons and two-wheelers is now around 1.10–1.30 m (Table 1),[38] clearly narrower than with the earlier examples. The axle lengths vary between 1.10–1.80 m, with one Cypriot chariot exception from Salamis (Grave 79),[39] which has possibly been used in high speed activities due to its wide gauge.[40] In addition, regarding the axle and wheel nave lengths of the vehicles discussed in this paper, it appears that the wheel naves brought 14–65 cm in addition to the gauge when determining the overall width of the vehicle, setting the average nave length to *c.* 44 cm.[41] Since wagons are still well represented in the burials, the introduction of chariots or the tradition of chariot burials in central Italy from the 7th century BC onwards cannot be held solely accountable for the diminished gauge. Instead, the apparent structural similarity in the wagons suggests that there was a consistent method of construction,[42] which could be the result of the emergence of purely ceremonial vehicles in the 1st millennium BC. The narrow gauge (particularly in comparison with earlier vehicles) implies that these vehicles were not designed for high speeds, since the stability

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38 R. Joffroy, "Le char de Vix et les tombes à char", *CRAI* 2 (1957) 113–9; Piggott (above n. 1) 143–4, 146, 157–8, 206, 212, fig. 86, 89–90; Pare (above n. 27) 33–4, 133–4, 151–2, 164, 223, 237–8, 242, 248, 268, 293, 296, 324–5, 328, 345, fig. 157; F. Boitani, "Il carro di Castro dalla tomba della Biga (Rep. 100)", in Emiliozzi (above n. 1), 203–6, 203; M. Bonamici – A. Emiliozzi, "Il carro di Monteleone di Spoleto (Rep. 87) dalla necropoli al Colle del Capitano", in Emiliozzi (above n. 1), 179–190, 182, fig. 2; Feruglio – Emiliozzi (above n. 31) 209, 211, fig. 2, 4; Littauer – Crouwel (above n. 27) 8–9, fig. 5–6; A. Romualdi – A. Emiliozzi – F. Cecchi – F. Fiesoli – F. Gennai – R. Pecchioli, "I veicoli dal tumulo dei Carri di Populonia. Necropoli di San Cerbone (Rep. 123–124)", in Emiliozzi (above n. 1), 155–77, 164, 166, fig. 2, 4; A. M. Sgubini Moretti – A. Emiliozzi – G. F. Priori, "Il carro di Vulci dalla necropolis dell'Osteria (Rep. 195)", in Emiliozzi (above n. 1), 139–153, 144, 147, fig. 10, 13; Littauer – Crouwel (above n. 21) 229.

39 Littauer – Crouwel (above n. 27) 8–9, fig. 5–6.

40 Cf. Jones-Bley (above n. 21) 137; Littauer – Crouwel (above n. 21) 54, 151; B. I. Sandor, "The rise and decline of the Tutankhamun-class chariot", *OJA* 23:2 (2004) 153–175, 154, 163.

41 E.g. Pare (above n. 27) 19, 22, 32, 64, 66–70, 85, fig. 23, 27, 35, 60–4, 71a; Bonamici – Emiliozzi (above n. 34) 182, fig. 2; Feruglio – Emiliozzi (above n. 31) 209, 211, fig. 2, 4; Littauer – Crouwel (above n. 27) 8–9, fig. 5–6; Romualdi *et al*. (above n. 38) 164, 166, fig. 2, 4; Sgubini Moretti *et al.* (above n. 38) 144, 147, fig. 10, 13; Littauer – Crouwel (above n. 21) 51, 54; Sandor (above n. 40) 166, 169; cf. Table 2.

42 Piggott (above n. 1) 152–4; cf. Pare on late Bronze Age (above n. 27, 23–8) and early Iron Age (above n. 27, 134–5) traditions of wagon construction.

of the vehicle was greatly dependent of the sufficient width of the gauge.[43] In addition, the decorations and details on the wagons found in burials[44] back up on their part the interpretation of ceremonial function. It probably would be too narrow-sighted to assume that these wagons were made only for the funeral use; more likely they were symbols of status and used in ceremonies,[45] finally to be used as a funeral wagon and buried with their owner.

While providing interesting information about the Iron Age vehicle construction, the ceremonial vehicles found in burials do not shed much light upon the common traffic: without a doubt, the purely functional wagons and carts used in everyday chores were much more practical and less decorated than their ceremonial counterparts.[46] In order to examine the common traffic during the Iron Age and the archaic period, the tracks left on the ancient roads will be scrutinized next.

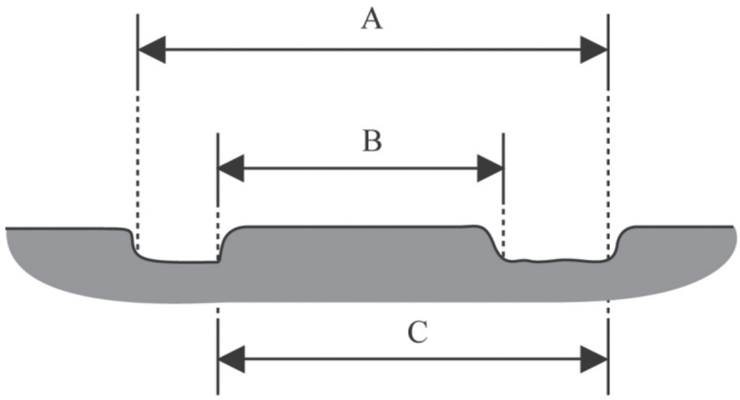

Fig. 3. A schematic illustration the measuring of the wheel ruts. A) width between the outer edges of the ruts, B) space between the ruts and C) technical gauge.

Wheel ruts

The wheel ruts visible on the ancient road surfaces also provide information about the gauges of the ancient vehicles. However, the documentation of the ruts holds some difficulties: for example, the ruts cannot be dated as such, only in context with the road or possible site stratigraphy. Another problem concerns multiple tracks: in the case of several similarly aligned ruts, which of them go together?

[43] Jones-Bley (above n. 21) 137; Sandor (above n. 40) 154, 163; Littauer – Crouwel (above n. 21) 45–6, 50, 54, 151.

[44] E.g. Piggott (above n. 1) 122–5, 154–5, 183; Pare (above n. 27) 93–105, 134–5, fig. 73–4.

[45] Pare (above n. 27) 135; Littauer – Crouwel (above n. 21) 50.

[46] Pare (above n. 27) 135.

Finally, in order to get comparable data, the method of measuring should be specified. In general terms measuring the wheel track[47] should prove sufficient, but in some cases, one of the ruts (or both) might be excessively wide due to the eroding effects of continuous use or deliberate modification; in these cases, the width between the outer edges of the ruts as well as the space between the ruts should be documented in addition to the wheel track (Fig. 3). It should also be noted that in some cases the ruts are known to have been pre-made to the road surface in order to direct the traffic and help the vehicles to stay on the road;[48] this kind of tracks, the *hodopoiia*, may not reflect the actual gauges of the vehicles.

According to Adam, the average gauge of wheel ruts documented from the Roman roads is 1.3 m;[49] Lafon appraises the typical gauge of Roman ruts to be 1.35–1.45 m,[50] whereas Mollo Mezzena reports the Roman wheel rut gauges from the Valle d'Aosta in northern Italy ranging from 1.3 to 1.6 m, speculating that the variance may be due to the long period of continuous usage.[51] Concerning the Archaic wheel ruts, Pikoulas notes that the ancient road network in Greece, with its beginnings in the 7th century BC, shows the average width of the wheel ruts to be 1.40 m.[52] The principal wheel ruts found on the *diolkos* at the Isthmus of Corinth (assumedly originating from the 6th century BC) are approximately 1.5–1.6 m apart.[53] The wheel ruts found in Etruscan and Faliscan sites in southern

47 Definition of wheel track by Littauer – Crouwel (above n. 21): "The distance between the centres of the treads of the two wheels".

48 J.-P. Adam, *L'arte di costruire presso i Romani. Materiali e tecniche,* Milano 1984, 303; White (above n. 25) 92, 97; M. J. T. Lewis, "Railways in the Greek and Roman world", in A. Guy – J. Rees (eds.), *Early Railways. A Selection of Papers from the First International Early Railways Conference*, London 2001, 8–19; Pikoulas (above n. 19) 82; G. Raepsaet, "Land transport, part 2: Riding, harnesses, and vehicles", in J. P. Oleson (ed.), *The Oxford Handbook of Engineering and Technology in the Classical World*, Oxford 2008, 580–605, 593–4.

49 Adam (above n. 48) 302.

50 X. Lafon, "La voie littorale Sperlonga-Gaeta-Formia", *MEFRA* 91:1 (1979) 399–429, 404.

51 R. Mollo Mezzena, "La strada romana in Valle d'Aosta: procedimenti tecnici e construttivi", in *Tecnica stradale romana*, Roma 1992, 57–72, 58–9.

52 Y. A. Pikoulas, "The Road-Network of Arkadia", in *Defining Ancient Arkadia. Acts of the Copenhagen Polis Centre* 6, Copenhagen 1999, 248–319, 251–2, 306–9; Pikoulas (above n. 19) 82.

53 R. M. Cook, "Archaic Greek Trade: Three Conjectures. 1. The Diolkos", *JHS* 99 (1979) 152–5, 152; G. Raepsaet, "Le diolkos de l'Isthme à Corinthe: son tracé, son fonctionnement", *BCH* 117:1 (1993) 233–56, 238, 241–3, fig. 4–5; Pikoulas (above n. 19) 82; Raepsaet (above n. 48) 593–4; cf. Lewis (above n. 48, 12), reporting the ruts to be 1.57–1.67 m apart.

Etruria have gauges from 1.3 to 1.52 m,[54] of which a measure of 1.4 m appears to be quite common.[55] According to Quilici, the Archaic road of Tor de' Cenci southwest from Rome also shows wheel ruts with a *c.* 1.3 m gauge.[56]

The above discussion of the gauges of ancient wheel ruts (table 2) shows that a a gauge of 1.3–1.4 m can be seen in nearly every example, with only a few cases where the maximum gauge reaches 1.5–1.6 m. This appears to agree with Piggott's estimation of the general gauge of ancient European vehicles.[57]

Table 2. Ancient wheel rut gauges from Italy and Greece

Source or location	**Dating**	**Track gauge (m)**
General Roman wheel rut gauge		
according to Adam (1984)	Roman	1.3
according to Quilici (1992)	Roman	1.3
according to Lafon (1979)	Roman	1.35–1.45
Vulci (Italy)	Roman?	1.30–1.52
Valle d'Aosta (Italy)	Roman	1.3–1.6
General wheel rut gauge		
according to Pikoulas (2007)	7^{th} cent. BC onwards	1.40
Blera (Italy),		
Ponte della Rocca	Pre-Roman?	1.4
Grotta Porcina	Pre-Roman	1.4
Civita Castellana (Italy),		
Fantibassi road cutting	Pre-Roman	1.4
Corchiano (Italy),		
Cannara road cutting	Pre-Roman	1.4
Isthmus of Corinth (Greece),		
the Diolkos	6^{th} cent. BC onwards	1.5–1.6

54 Measures from Blera and Vulci presented in Table 2 have been documented on site by the author, with an exception of the Grotta Porcina road at Blera, which is referenced from S. Quilici Gigli (*Blera. Topografia antica della città e del territorio* [Sonderschriften des Deutschen Archäologischen Instituts Rom 3], Mainz am Rhein 1976, 242, fig. 436), and they represent the width between the outer edges of the ruts.

55 E.g. L. Quilici, "La cava buia di Fantibassi e le vie cave del territorio Falisco", in L. S. Olschki (ed.), *La civiltà dei Falisci. Atti del XV convegno di studi Etruschi ed Italici, Civita Castellana – Forte Sangallo, 28–31 maggio 1987*, Firenze 1990, 197–222, 199, 213, fig. 1.C–E, 5.

56 L. Quilici, "Evoluzione della tecnica stradale nell'Italia centrale", in *Tecnica stradale romana*, Roma 1992, 19–32, 20; the approximate gauge of 1.3 m is given in the text; however, according to the sections by Quilici (above n. 56, 21, fig. 2), the ruts rather appear to be 1.4–1.5 m apart.

57 Piggott (above n. 1) 68.

Measuring the road cuttings

According to the examples discussed above, a supposed general gauge of 1.3–1.4 m combined with the length of hubs (14–65 cm)[58] suggests that a road cutting *c.* 2 m wide at its base would have been sufficient to support most of the Iron Age and Archaic wheeled traffic going in one direction. In order to determine how well the pre-Roman road cuttings actually accommodated wheeled traffic, a sample of 53 documented cases from southern Etruria and the Faliscan region (Table 3) will be scrutinized next. The examples are taken from the sites at Pitigliano, Sovana, Veii, Blera, Civitella Cesi, Castel d'Asso, Monterano, Caere, Sutri, Corchiano and Falerii Veteres due to the appropriate amount and detail of documentation[59] available concerning road cuttings in these areas.

The Etruscan sites near the river Fiora, northwest of Lake Bolsena – Pitigliano and Sovana – have many road cuttings in their vicinity. The Annunziata cutting, west of Pitigliano, varies in width between 1.3–2 m.[60] The San Sebastiano cutting southwest of Sovana has a general width of 3 m,[61] which is also the width of a road cutting beginning from the northeast gate of ancient Veii.[62] The rock-cut roads in the vicinity of Blera have widths between 1.5–3.9 m,[63] whereas a monumental road cutting at Castel d'Asso, near Viterbo, has a width of 4.2 m.[64] Two

58 Utilization of the wheel hub lengths is based on the assumption that the gauge/axle length/wheel hub proportions remained approximately the same with ceremonial wagons as they did with common vehicles. Hesiod (*Op.* 424) reports the axle to be cut seven feet long, which – depending from the type of ancient Greek measure – converts approximately to 1.89–2.45 m (e.g. C. Wikander, "Weights and Measures", in J. P. Oleson (ed.), *The Oxford Handbook of Engineering and Technology in the Classical World*, Oxford 2008, 759–69, 767, tab. 30.4).

59 In some cases the width of a road cutting is reported without decimals. These figures are assumed to represent a measure with an accuracy of one decimal that can be rounded to full metres (e.g. 2 m standing for 2.0 m), meaning that the possible inaccuracy or rounding up/down of the measure stays under 5 cm error marginal. All widths referred to in this paper are presented exactly as they have been originally reported.

60 S. Nanni, *Le vie cave. Gli Etruschi nei territori di Sorano, Sovana e Pitigliano*, Firenze 2005, 34.

61 Nanni (above n. 60) 30.

62 J. B. Ward-Perkins, "Etruscan Engineering: Road-building, Water-Supply and Drainage", in M. Renard (ed.), *Hommages à Albert Grenier* 3 (Collection Latomus 58), Bruxelles 1962, 1636–43, 1640.

63 Quilici Gigli (above n. 50) 96, 179–80, 207–8, 234–5, 240–1, 244, 261, 271.

64 L. Quilici, "Le antiche vie dell'Etruria" in *Secondo congresso internazionale Etrusco. Firenze 26 Maggio – 2 Giugno 1985. Atti vol.* 1 *(Supplemento di Studi Etruschi)*, Roma 1989,

road cuttings from the Civitella Cesi area are both approximately 4 m wide,[65] while the average width of the Cavone road cutting around Monterano is 2.2 m.[66]

Table 3. Road cutting widths from southern Etruria

Site and road cutting	Width (m)	Site and road cutting	Width (m)
Caere (modern Cerveteri),		**Blera,**	
Pian Cerese (W of Ceri)	1.5	Casale Sciabolino	1.7
"	1.8	Pian dell'Anguillara	1.85–2.3
"	2	Pontone di Graziolo	1.86–2.1
Pian Cerese (N of Ceri)	1.65	Boccale Cave	2–2.2
"	1.7	Ponte della Rocca	2–3.9
"	2.3	Ricozzano	*c.* 2.1
Monte Abbadoncino	*c.* 1.8	Cerracchio	*c.* 2.3
"	*c.* 2.7	**Castel d'Asso**	4.2
Monte Abbadone	*c.* 2	**Civitella Cesi,**	
"	*c.* 4.6	Pian Fagiano/Costa	
Bufolareccia	1.93	Acquafredda	4
Porrazzeta	2	Passo di Viterbo	*c.* 4
Fosso di Fonte dei Santi	2	**Falerii Veteres**	
Quarto del Cecio	3	**(modern Civita Castellana),**	
Quarto di Montelungo	3.2–3.5	Fantibassi	1.7
Casale del Ferraccio	*c.* 3.5	Casale Santa Lucia	2
Fosso della Caldara	4	Tenuta Terrano	*c.* 2.5–3
Poggio Formicoso	4	Monte Picchiato	2.6
Ponte Vivo	4	Tenuta Franca	4–9.2
Tre Cancelli	4	**Monterano,**	
Polledrara	4–5	Cavone	*c.* 2.2
Corchiano,		Pitigliano,	
Corchiano	*c.* 2	Annunziata	1.3–2
Rio Fratta	*c.* 2	Sovana,	
Madonna delle Grazie	2.1	San Sebastiano	*c.* 3
Santa Edigio	2.1	**Veii,**	
Spigliara	2.2	NE Gate	3
Fallarese	2.3–2.6	**Sutri,**	
Cannara	*c.* 3	Piazzano	1.6–2.6
Blera,		Mazzano	2.1
Grotta Porcina	1.5–1.6	Monte Fosco	2.7–3.1
Fosso dei Caprari	1.55–1.7	Madonna del Carmine	3.1–4.1

451–508, 490–1, fig. 15.

65 Hemphill (above n. 12) 80, 84, fig. 116.

66 O. Cerasuolo – L. Pulcinelli – T. Latini, "Monterano, la viabilità in epoca etrusca", in P. Attema – A. Nijboer – A. Zifferero (eds.), *Papers in Italian Archaeology VI. Communities and Settlements from the Neolithic to the Early Medieval Period. Proceedings of the 6th Conference of Italian Archaeology held at the University of Groningen, Groningen Institute of Archaeology, The Netherlands, April 15–17, 2003, Volume II* (BAR International Series 1452 [II]), Oxford 2005, 842–7, 844.

The region of ancient Caere around modern Cerveteri shows the traces of a road network present in antiquity. In general terms, the widths of the road cuttings in the area that have supposedly preserved their original measures range from 1.5 to 5 m; only six cuttings out of 21 are narrower than 2 m.[67]

The *ager Faliscus*, the ancient Faliscan region bordered from the west by Monte Cimino and Lake Bracciano and from the east by the river Tiber also has many road cuttings: the examples near Sutri have widths between 1.5–4.1 m,[68] whereas the cuttings around Corchiano range from 2 to 3 m.[69] The road cuttings in the vicinity of Falerii Veteres, modern Cività Castellana, have widths from 1.7 m up to 9.2 m,[70] although the average road cutting width in the area appears to be 3 m.[71] Regarding all the minimum widths[72] of the road cuttings discussed above (Table 4), the singular cases appear to peak around the 2 and 4 m widths. According to the documented wheel ruts and vehicle reconstructions presented in this article, the width of 2 m would have been sufficient for nearly any vehicle going in one direction,[73] and consequently 4 m for two-way traffic. Of the 14 documented cases out of 53, where the cutting width is less than the supposed general width (i.e. 2 m) required by the wheeled traffic in the Iron Age and Archaic period, at

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67 G. Nardi, "La viabilità di una metropoli: il caso di Caere", in *Strade degli etruschi. Vie e mezzi di comunicazione nell'antica Etruria*, Milano 1985, 157–66, 158–62; G. Nardi, "Nuovi dati dalla ricognizione a Caere e nelle aree adiacenti: principali vie etrusche dell'entroterra", in *Secondo congresso internazionale Etrusco. Firenze 26 Maggio – 2 Giugno 1985. Atti vol.* 1 *(Supplemento di Studi Etruschi)*, Roma 1989, 517–23, 518; F. Enei, *Progetto Ager Caeretanus. Il litorale di Alsium. Ricognizioni archeologiche nei comuni di Ladispoli, Cerveteri e Fiumicino (Alsium-Caere-Ad Turres-Ceri)*, Ladispoli 2001, 125–6, 133–4, 140–4, 187, 245–6, 252, 263, 270, 289, fig. 121–4, 141, 159, 168–9, 175–6, 461–3.

68 Quilici (above n. 64) 486–9, fig. 14.4–6.

69 Frederiksen – Ward-Perkins (above n. 14) 169; P. Moscati, "La viabilità di una regione: l'Agro Falisco", in *Strade degli etruschi. Vie e mezzi di comunicazione nell'antica Etruria*, Milano 1985, 91–7, 93; Quilici (above n. 64) 496–8, fig. 18.1–2, 18.4–6; Quilici (above n. 56) 209, 212.

70 Frederiksen – Ward-Perkins (above n. 14) 143, 167; Quilici (above n. 64) 494–5, 497, 505–6, fig. 17.1, 20.14; Quilici (above n. 56) 200; Cifani *et al.* (above n. 13) 171.

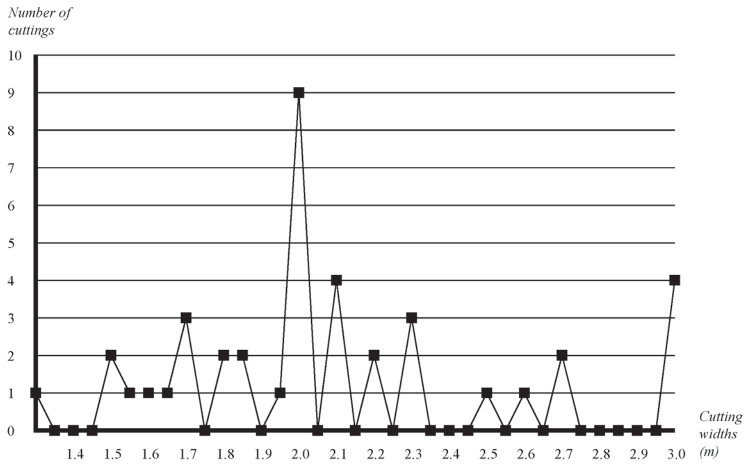
71 Frederiksen – Ward-Perkins (above n. 14) 143, 148, 167, 169; Moscati (above n. 69) 93, 95–6.

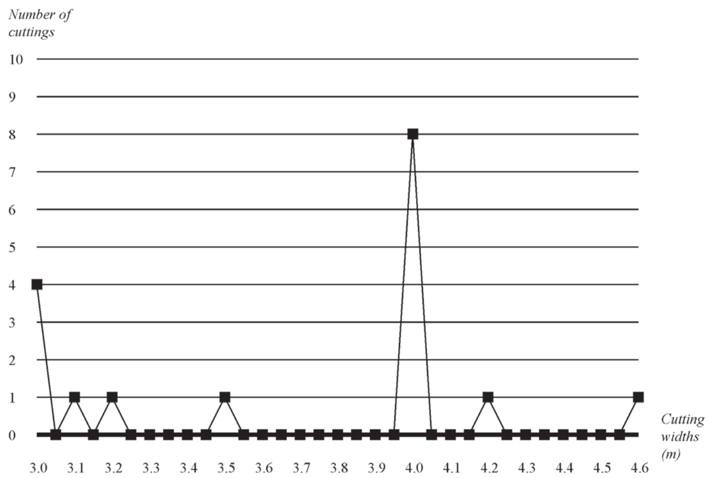
72 Only the narrowest points of the road cuttings are taken into account since they define whether the cutting is passable by a vehicle of certain width or not.

73 In the case of Fantibassi cutting near Falerii Veteres, according to the wheel ruts visible on the road surface, the width of 1.7 m appears to have been enough for one-way wheeled traffic (Quilici [above n. 64] 494–5, fig. 17.1).

least seven seem to be associated with burial grounds;[74] in these cases, the narrowness might have been intentional in order to prohibit general traffic and to protect the sanctity of the deceased.[75]

Table 4. Graphical presentation of the road cutting widths with 0.05 m accuracy





Regulations and measures

Concerning the pre-Roman measure of Osco-Italic or Oscan foot, a length of *c.* 27 cm is often referred to, due to the archaeological evidence.[76] However, Lo-

[74] The Annunziata cutting at Pitigliano (Nanni [above n. 60] 34, 48–50), Pontone di Graziolo, Pian dell'Anguillara, Grotta Porcina and Fosso dei Caprari cuttings at Blera (Quilici Gigli [above n. 55] 207–8, 231–5, 240–1, 244) and Pian Cerese cuttings at Caere (Enei [above n. 67] 140–2). Similar connections to burial grounds can be seen at *ager Faliscus* (Potter [above n. 2] 19; Rajala [above n. 6] 182–3).

[75] U. Losacco, "Le cave: arcane strade d'Etruria", *L'Universo* 49:6 (1969) 937–54, 940.

[76] E.g., K. M. Phillips, Jr., "Bryn Mawr College Excavations in Tuscany, 1971", *AJA* 76:3

renzo Quilici has recently proposed a slightly shorter measure, 25.7 cm, based on the width of the Via Valeria at the Arsoli hill.[77] These two proposals will be scrutinized next by using the evidence referred to in the duscussion of Osco-Italic foot.

Building blocks and floor plans

Gabriele Cifani gives a wall dated to the beginning of the 6th century BC discovered near the Equus Domitiani in the Forum Romanum as an example of the use of 27.2 cm as an Osco-Italic foot: the measures of the tuff blocks used to construct the wall are, according to Cifani, 78–80 cm in length, 62–70 in width and 28 cm in height.[78] With a 27.2 cm Osco-Italic foot, the dimensions of the block would thus be *c.* 3 x 2.25–2.5 x 1 Osco-Italic feet with an error marginal of 3.6 cm. The width of the block, with its 8 cm variation, proves to be the most inconsistent. However, the use of quarter feet does have a precedent for example in the Greek measure of *palaistē*;[79] in addition, the Greek foot, *pous*, also varies between 27

(1972) 249–55, 249–51, ill. 1; Ö. Wikander, "Terracotta modules, Oscan feet and tile standards", in E. Rystedt – C. Wikander – Ö. Wikander (eds.), *Deliciae fictiles. Proceedings of the First International Conference on Central Italic Architectural Terracottas at the Swedish Institute in Rome, 10–12 December, 1990* (Skrifter utgivna av Svenska Institutet i Rom 4,50), Stockholm 1993, 67–70; G. Cifani, *Architettura romana arcaica: Edilizia e società tra Monarchia e Repubblica,* Roma 2008, 239; the notion of *c.* 27 cm long Oscan foot is also expressed by Amadeo Maiuri ("Pompei. Saggi e ricerche intorno alla Basilica", *NSA* 8,5 [1951] 225–60, 233), who suggests that the roof tiles of the Basilica at Pompeii with their length of 1.35 m reflect a measure of five Oscan feet; however, Karlfriedrich Ohr (*Die Basilika in Pompeji* [Denkmäler antiker Architektur 17], Berlin – New York 1991, 34, n. 142) does not agree with Maiuri's suggestion of use of the Oscan feet in the architecture of the Basilica, since the floor plan of the Basilica appears to conform to a measure unit of 29.35 cm.

77 Quilici (above n. 3) 563; cf. L. Quilici, "Le strade carraie nell'Italia arcaica", in Emiliozzi (above n. 1), 73–82, 75.

78 Cifani (above n. 76) 119, 239; E. Gjerstad, *Early Rome I. Stratigraphical researches in the Forum Romanum and along the Sacra Via* (Skrifter utgivna av Svenska Institutet i Rom 4,17:1), Lund 1953, 23, gives slightly different dimensions for the blocks, namely 75 x 60–70 x 27–30 cm, and notes (29, n.1) that of the three remaining block courses of the wall, the upmost has only one tuff block left in place, which has been chipped from the top to a maximum height of 25 cm.

79 Although the exact Greek measures slightly varied locally and according to epoch, the relative proportions of the units, based on 1/16 fractions, remained the same; the smallest unit was *daktylos* or finger breadth, whereas a *pous* or foot length consisted of 16 *daktyloi*. *Palaistē,* meaning palm width, was four *daktyloi*, or ¼ foot. The Romans used the same

and 35 cm.[80] In comparison, 25.7 cm, the approximate measure for Osco-Italic foot proposed by Quilici, would give the aforementioned tuff block the dimensions of 3 x 2.5–2.75 x 1 Osco-Italic feet with an error of 2.9 cm. The other early 6th century BC structure referred by Cifani,[81] the first and second building phase of the podium of the archaic temple on the sacred area of S. Omobono at Rome, is constructed of six rows of red tuff blocks varying in height around 25–27 cm with a total height of *c.* 1.70 m.[82] In addition, the first phase (late 7th–the first half of 6th century BC) of a suburban sanctuary at Gabii shows, according to Cifani, a wall thickness of *c.* 1 m with a floor plan of 10 x 11 m;[83] with a 27.2 cm foot, the dimensions would amount to wall thickness of 4 ft. and 36.75 x 40.5 ft. floor plan with an error marginal of 8.8 cm,whereas with 25.7 cm, the measures would be respectively 4 ft. and 39 x 43 ft., with an error of 5.1 cm.

The dimensions of the 6th-century BC sanctuary at Poggio Civitate (Murlo, Siena) make a strong case for the *c.* 27 cm long Osco-Italic foot: especially the consistent dimensions of the courtyard outline appear to fit exactly, in multiples of ten, to the aforementioned measure (Table 5).[84] However, since applying the 25.7 cm measure also gives nearly as perfect results with an error marginal of 2.3 cm, it becomes questionable whether the east or the west side of the courtyard shows the correct, intended measure. The last two examples come from ancient Ficulea in Latium and Tarquinia in Etruria: the tuff blocks from Ficulea have a common height of 25–27 cm according to Lorenzo Quilici and Stefania Quilici Gigli,[85] whereas the blocks used to build the archaic phase of the Ara della Regina temple at Tarquinia have dimensions of 50 x 50 x 90 cm,[86] clearly conform-

units and proportions (*daktylos*/*digitus*, *pous*/*pes*), although they also divided the foot into 12 parts, *unciae* (e.g. W. F. Richardson, *Numbering and Measuring in the Classical World. An introductory handbook*, Bristol 1985, 28–9; Wikander [above n. 58] 766–8, tab. 30.4).

80 Wikander (above n. 58) 766–8, tab. 30.4.

81 Cifani (above n. 76) 239.

82 Cifani (above n. 76) 167; an approximate total height of 1.40 m has also been reported (*Enea nel Lazio. Archeologia e mito*, Roma 1981, 115).

83 Cifani (above n. 76) 196.

84 Phillips (above n. 76) 249–51, ill. 1.

85 L. Quilici – S. Quilici Gigli, *Ficulea* (Latium vetus 6), Roma 1993, 63.

86 M. Bonghi Jovino, "La phase archaïque de l'Ara della Regina à la lumière des recherches récentes", in F. Gaultier – D. Briquel (eds.), *Les Étrusques, les plus religieux des hommes. État de la recherche sur la religion étrusque. Actes du colloque international Galéries nationales du Grand Palais 17–18–19 novembre 1992* (Rencontres de l'École du Louvre 12), Paris 1997,

ing better to 25.7 cm (2 x 2 x 3.5 Osco-Italic ft. with an error of 1.4 cm) than to 27 cm long Osco-Italic foot. In addition, Giuseppe Lugli notes that the common height of *cappellaccio* or granular tuff blocks from the 8^{th}–4^{th} centuries BC used in Roman architecture varies around 24–26 cm and that this measure relates to the Osco-Italic foot.[87]

Table 5. Dimensions of the 6th century BC sanctuary at Poggio Civitate (Murlo, Siena)

Sanctuary structures	Meters	Osco-Italic feet of 0.270 m	Osco-Italic feet of 0.257 m
Complex exterior,			
North side	61.25	226.85	238.33
East side	61.55	227.96	239.49
South side	60.00	222.22	233.46
West side	61.85	229.07	240.66
Courtyard outline,			
North side	43.20	160.00	168.09
East side	40.50	150.00	157.59
South side	43.20	160.00	168.09
West side	40.35	149.44	157.00
Distance between column centers,			
North colonnade	3.51	13.00	13.66
East colonnade	3.03	11.22	11.79
South colonnade	3.24	12.00	12.61
Large room within north flank,			
Length	23.25	86.11	90.47
Width	10.00	37.04	38.91
Distance between post hole centers	3.51	13.00	13.66

Terracotta tiles and plaques

Ancient architectural terracottas have occasionally been suggested to convey pre-Roman foot standards,[88] but the existent evidence shows too much variance in the dimensions of the terracotta artifacts to pinpoint the exact measures the manufacturers might have striven to attain.[89] Due to the manufacturing method, it was

69–95, 74.

87 G. Lugli, *La tecnica edilizia romana, con particolare riguardo a Roma e Lazio I*: *Testo,* Roma 1957, 192–3

88 E.g., Maiuri (above n. 76) 233; Phillips (above n. 76) 251, n. 5; Östenberg (above n. 19) 23, 28.

89 E.g., A. Andrén, *Architectural terracottas from Etrusco-Italic temples. Text*, Lund 1940,

impossible to get the dimensions exactly right every time: the terracotta pieces shrink notably during the drying and firing,[90] thus making the slight variation in the dimensions inevitable. In addition, the roof tiles often appear to conform to certain dimensions regionally and locally, but clearly differ from each other when comparing to the tile sizes from another region.[91] Apparently there were no general standards as such for the roof tile sizes: the manufacturers made the tiles to fit each other, not to follow some specific standard measure.

It appears that both proposals, according to the evidence discussed above, remain so far plausible candidates for the measure of the Osco-Italic foot and within the acceptable error margins. On this basis, the Quilici's proposal for the measure of Osco-Italic or Oscan foot, 25.7 cm, should be regarded as valid as the more widely adapted estimate of *c.* 27 cm. Admittedly, since the measures are not very far from each other, the consequential differences are difficult to discern in the tiles or blocks: the situation becomes clearer with larger dimensions such as in context with rooms, floor plans or roads.

Osco-Italic foot and road widths

As the roads were modified to accommodate the new requirements of wheeled traffic, the sufficient width depended on the vehicles that used them. This would suggest that there was a predetermined minimum width for the roads: there certainly were regulations concerning the Roman road-building at least from the 5th century BC onwards in the form of the Law of the Twelve Tables,[92] which stated that on straight stretches the road must be at least 8 ft. wide and in curves 16 ft.[93]

passim; N. Breitenstein, *Catalogue of Terracottas – Cypriote, Greek, Etrusco-Italian and Roman*, Copenhagen 1941, 82; Wikander (above n. 76).

90 E.g., G. Brodribb, *Roman Brick and Tile*, Gloucester 1987, 2, 4; Wikander (above n. 76) 67.

91 E.g., Andrén (above n. 89); Breitenstein (above n. 89); Adam (above n. 48) 229; Wikander (above n. 76).

92 R. Laurence, *The Roads of Roman Italy: Mobility and Cultural Change*, London – New York 1999, 58.

93 *Dig*. 8,3,8: *Viae latitudo ex Lege XII Tabularum in porrectum octo pedes habet, in anfractum, id est ubi flexum est, sedecim*.

Converted to the metric system, 8 Roman ft.[94] would have constituted 2.368 m, which clearly does not fit into the documented clusters at 2 and 4 m widths. While keeping in mind that the possible inaccuracy in archaeological records – most likely due to rounding up or down to the accuracy of one decimal – would be 5 cm, the measure of 25.7 cm would still provide closer matches than 27 cm regarding the peak values of road cutting widths: 8 ft. of 25.7 cm constitutes 2.056 m, whereas 8 ft. of 27 cm adds up to 2.160 m. According to the road cutting examples discussed above (data summarized in Table 6), there are 13 close matches[95] out of 53 with 8 Osco-Italic ft. of 25.7 cm; in addition, the other common width, 4 m, lacks only 11.2 cm from 16 Osco-Italic ft. when converted, thus suggesting pre-Roman origin for the road width regulations.[96] It seems plausible that as the wheeled traffic increased from the 7th century BC onwards, the 5th century BC law concerning the road widths originated in pre-Roman times as a response to the increased demands of traffic.[97] In addition, it is interesting to note that the quite common gauge of 1.3 m seems to correspond to a measure of five 25.7 cm Osco-Italic ft. with only 1.5 cm error; the pre-Roman measure was possibly utilized also in the vehicle construction.

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94 The supposed measure applied in this paper for one Roman foot is 29.6 cm (e.g. F. Hultsch, *Griechische und römische Metrologie*, Berlin 1882, 90; Lugli [above n. 87] 114, 189, 192–3).

95 Allowing a 5.6 cm error marginal.

96 According to the clusters in the road cutting widths discussed in this paper, the applied measure of Osco-Italic foot might have actually been closer to 25 than 26 cm; cf. Lugli (above n. 87) 192–3; *Enea nel Lazio* (above n. 82) 115; Quilici – Quilici Gigli (above n. 85) 63; Bonghi Jovino (above n. 86) 74. There are also Archaic roads matching the regulations of Law of the Twelve Tables when measured in Osco-Italic feet: for example the 6th century BC route assumedly preceding via Lavinate that has widths of 2–2.1 and 2.3 m, corresponding to 8 and 9 Osco-Italic ft. of 25.7 cm (Quilici [above n. 77] 75–6, fig. 2), whereas a late 7th century BC road on Via San Gennaro near the site of Fidenae is 4 m wide between the tuff blocks bordering the road (Cifani [above n. 76] 182–3), approaching 16 Osco-Italic ft. of 25.7 cm.

97 Quilici (above n. 77) 82.

Table 6. Road cutting widths in 27 cm and 25.7 cm Osco-Italic feet

Road cutting width (m)	***Number of cuttings***	***Osco-Italic feet of 0.270 m***	***Osco-Italic feet of 0.257 m***
1.3	1	4.815	5.058
1.5	2	5.556	5.837
1.55	1	5.741	6.031
1.6	1	5.926	6.226
1.65	1	6.111	6.420
1.7	3	6.296	6.615
1.8	2	6.667	7.004
1.85	1	6.852	7.198
1.86	1	6.889	7.237
1.93	1	7.148	7.510
2	9	7.407	7.782
2.1	4	7.778	8.171
2.2	2	8.148	8.560
2.3	3	8.519	8.949
2.5	1	9.259	9.728
2.6	1	9.630	10.117
2.7	2	10.000	10.506
3	4	11.111	11.673
3.1	1	11.481	12.062
3.2	1	11.852	12.451
3.5	1	12.963	13.619
4	8	14.815	15.564
4.2	1	15.556	16.342
4.6	1	17.037	17.899

Sticking to the tradition

Consequently, an interesting measure can be found from a Roman context of the Republican era: Concerning the Via Appia, Quilici notes that the paving width of 4.1–4.2 m would have easily allowed two vehicles to pass each other, and that this width relates to 14 Roman ft., which, according to Quilici, appears to have been a canonical measure for the heavily trafficked roads as well as some secondary roads.[98] This width seems to dominate road design from the 4th century BC onwards.[99] However, regarding the regulations stated in the Law of the Twelve Tables, it seems problematic that the canonical width of the road from the 4th century BC onwards would be 14 Roman ft. instead of 16: of course 14 ft. exceeds generously the required 8 ft., but if there are regulations stating the suggested

[98] Quilici (above n. 56) 30–2; Quilici (above n. 3) 555, 563, 565.

[99] Quilici (above n. 3) 563.

widths of 8 and 16 ft., why leave the road two feet narrower than required in the curves? It is possible that experience had shown that 14 Roman ft. was enough to allow fluent trafficking; but this would have meant that the original law was considered to be a moot point, and treated rather as a suggestion. On the other hand, supposing that the Law of the Twelve Tables still echoed the pre-Roman measures, the aforementioned 4.1 m would correspond to 16 Osco-Italic ft., meeting the requirements of the law: in this light, it seems probable that the Osco-Italic feet remained in use for a while even after the introduction of the Roman foot system.[100]

Conclusions

The developments that took place in the Mediterranean, beginning from the end of the 8th century BC, led to the appearance of the road cuttings in the tuff plateaus of southern Etruria. These rock-cut roads, while providing notable logistical benefits, also placed concrete restrictions to the wheeled traffic with their widths. However, as the cuttings were a result of increased traffic, their widths must have reflected the space needed for contemporary vehicles: as the general gauge for the common traffic during the Iron Age and the archaic period – according to the wheel ruts and vehicle reconstructions – was around 1.3–1.4 m, wheel hubs adding 14–65 cm to the width, a fluent one-way traffic needed at least 2 m wide road cutting. The relatively high amount of *c.* 2 m wide road cuttings amongst the examples discussed in this article seem to imply that this requirement was eventually met by constructing cuttings with a certain minimum width, namely 2 m. Since the measure of Roman foot, 29.6 cm, was clearly not applied here, the width may relate to the pre-Roman measure of Osco-Italic foot. From the most recent propositions for the measure of Osco-Italic foot, 25.7 and *c.* 27 cm, the former appears to conform better to the peak values in the road cutting widths. As the width of 4 m – approaching 16 Osco-Italic ft. of 25.7 cm – also seems to appear more often than other widths, it seems probable that the regulations concerning the road width stated in the Law of the Twelve Tables from the 5th century BC onwards originated in the pre-Roman era to accommodate the wheeled traffic to the road cuttings.

[100] Cf. Lugli (above n. 87) 192–3; G. Gambacurta, "Appunti sulla tecnica stradale protostorica nel Veneto antico", in L. Quilici – S. Quilici Gigli (eds.), *Viabilità e insediamenti nell'Italia antica* (Atlante tematico di topografia antica 13), Roma 2004, 25–42, 41; Cifani (above n. 76) 198–9; Quilici (above n. 3) 563.

In addition, the apparently common width for the long-distance, heavily trafficked Roman roads from the 4th century BC onwards, 4.1–4.2 m or *c.* 14 Roman ft., seems to contradict the Law of the Twelve Tables: however, if the width is converted to Osco-Italic feet, it measures up to *c.* 16 ft. thus following the regulations and implying that the pre-Roman measures were still utilized, at least for a period of time, after the introduction of the Roman foot.

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