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Palaeoenvironments and palaeotopography of a multilayered city during the Etruscan and Roman periods: early interaction of fluvial processes and urban growth at Pisa (Tuscany, Italy)

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ABSTRACT

A critical geoarchaeological approach, based on fully integrated archaeological, geomorphological and stratigraphic data, allowed for the identification of the palaeoenvironments, palaeotopography and urban growth patterns of Pisa (NW Italy) during the Etruscan (first half of the 5th century BC–first half of the 1st century BC) and Roman (second half of the 1st century BC–2nd century AD) periods. This powerful methodology, based on aerial and satellite images, electrical resistivity tomography, LiDAR, and core analysis, led to the reconstruction of landscape evolution, highlighting human–environment interactions. During the Etruscan and Roman periods, Pisa saw a fast urban expansion in a dense and unstable fluvial network. Wide portions of the city were characterised by poorly drained conditions until the 1st century AD, when the alluvial plain became well drained under increasing anthropogenic pressure (Roman *Centuriatio*). Poorly drained floodplains and channel-related backswamps represent the topographically lowest zones of the ancient Pisa. This city developed within an intricate pattern of palaeochannels, related to two main rivers: the palaeoArno, which flowed in proximity of its present position, and the former palaeoSerchio river, known as *Auser* flowing in the northern part of the city. Since Etruscan times, a mounded relief was formed in the historical city centre of Pisa, becoming wider and more prominent (up to ca. 2 m a.s.l.) during the Roman period, concomitant with a southward rapid expansion of the urban tissue. Nevertheless, the urban growth patterns substantially followed the Etruscan city's fabric, with marked concentration of the urban structures (public and private buildings) and manufacturing sites on the northern relief, close to the *Auser*. The *Auser* River thus played a crucial role in the environmental and topographic evolution of the city area.

1. Introduction

During the last millennia, human and natural processes have become strongly intertwined, modifying the Earth's surface and its physical, biological, and chemical characters in many different ways (Zalasiewicz et al., 2011). Evident traces of this joined human–nature activity can be detected in long-settled city areas (multilayered cities), where an enduring synergistic relationship between landscape, ancient cultures and society evolution is commonly recorded (Butzer, 2008; Bruno et al., 2013; Ninfo et al., 2011; Schuldenrein and Aiuvalasit, 2011; Stefani and Zuppiroli, 2010; Zanchetta et al., 2013). In the complex alluvial landscape around multilayered cities, the application of mono-disciplinary studies can furnish merely partial and limited results. Only through a comprehensive geoarchaeological analysis can we identify and map historical ground layers and contribute to resolve the complexity of areas in which urbanisation tends to hide the geomorphological features and the natural deposits (Amorosi et al., 2013a; Bini et al., 2009, 2012a, 2013; Bruneton et al., 2001; De Smedt et al., 2013; Ghilardi and Desruelles, 2009; Marriner et al., 2012; Parker et al., 2008; Price et al., 2011).

In the context of the MAPPA Project (www.mappaproject.org), aimed to the development of the archaeological potential map

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of the multilayered city of Pisa (NW Italy, Fig. 1), an extensive geomorphological, stratigraphic and archaeological digital dataset (MAPPAGIS project; http://mappaproject.arch.unipi.it) was acquired.

In this work, we focus on the palaeoenvironments, palaeotopography and urban growth patterns of Pisa during the Etruscan–Roman periods (first half of the 5th century BC–2nd century AD), a particular historical phase that saw the development of structured urban settlements (Fabiani et al., 2013a) in the context of a dense and unstable fluvial network. Through the integration of geomorphological (satellite images, multitemporal aerial photos, LiDAR images, and electrical resistivity tomography), stratigraphic and archaeological data, we aim to reconstruct this past landscape scenario, furnishing new data about the human–environment interactions during a crucial period in the history of the Mediterranean civilisation. A specific objective of this paper is to provide and test an effective cross-disciplinary methodology that can potentially be used to reconstruct ancient surfaces and buried landscapes from other urban contexts.

2. The study area

2.1. Geomorphological and stratigraphic setting

The city of Pisa, worldwide famous for the Leaning Tower of Piazza Duomo, is placed ca. 10 km east of the Ligurian Sea coast, in

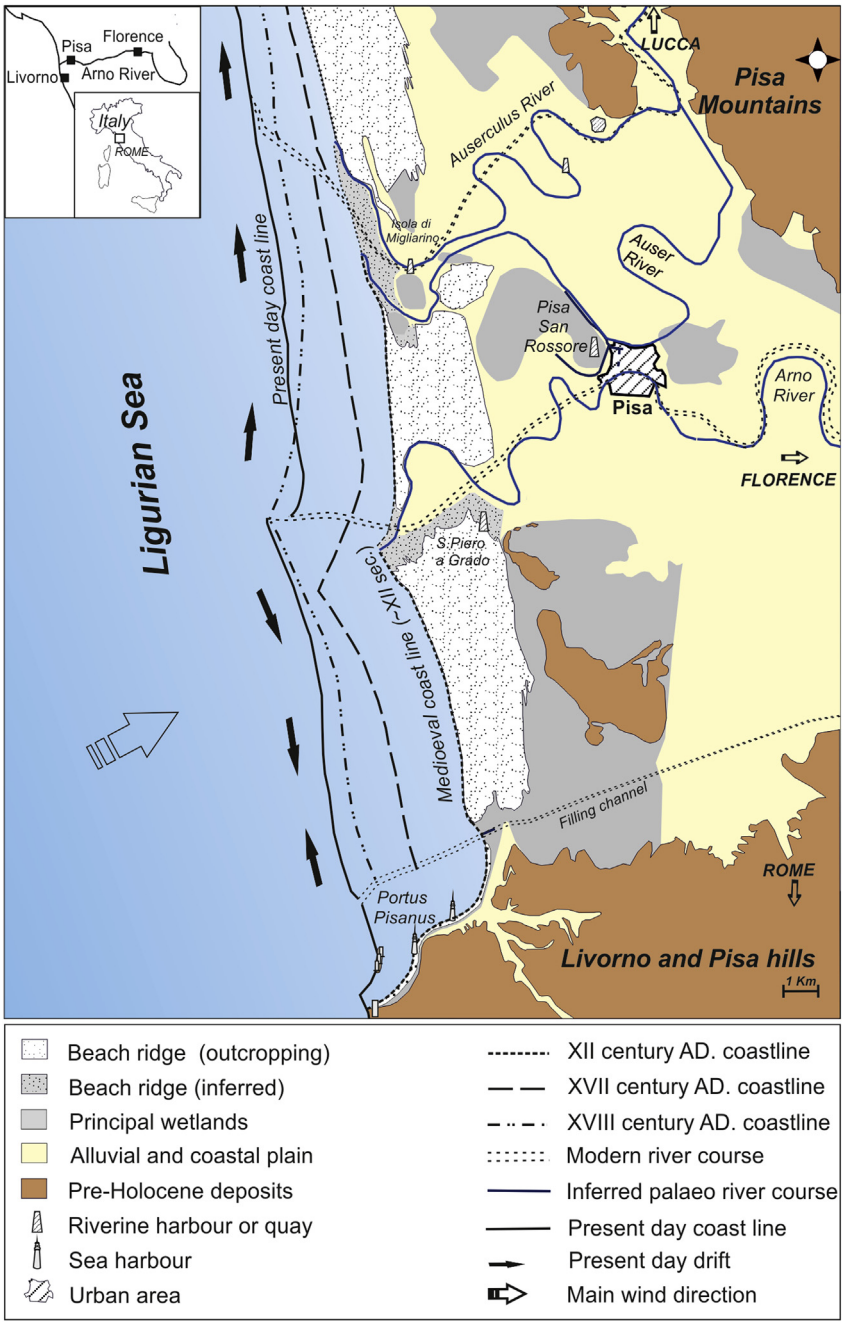

Fig. 1. The study area in the context of the Pisa alluvial plain (modified from Martini et al., 2010). The palaeocourses of Arno and Serchio (Auserculus and Auser) rivers derive from remote sensing analyses and historical sources (Sarti et al., 2010).