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Soils and land use at ancient Greek colonial temples of southern Italy

G.J. Retallack

Department of Earth Sciences, University of Oregon, Eugene, OR 97403, United States of America

A B S T R A C T

Soils at ancient Greek temples in Greece are distinct for each deity, reflecting an economic basis for their cults, but did this pattern also extend to classical Greek colonies? This study of 24 temples in southern Italy reveals little assimilation by Greek colonists of indigenous cults at first, because their temples are on the same kinds of soils, reflecting similar cults for each of the Olympian deities as in Greece. Worship of Hera was more widespread in Italy than in Greece and the Aegean, and also on Alfisol soils suitable for pastoralism. Temples of Demeter in contrast were on Mollisols best for grain cultivation. Rocks and grottos sacred to Persephone are comparable with those in Greece, but were popular with hellenized Sikels for an indigenous hybrid cult of Demeter and Kore.

1. Introduction

The nature of western Greek colonialism has been controversial, with one extreme interpretation emphasizing the superiority of Greek over indigenous culture, as has been assumed for British colonization of Australia (Dunbabin, 1948). Colonies in southern Italy were well provisioned expeditions from a variety of ancient Greek cities (Stillwell et al., 1976), and also from local expansion of Greek colonies nearby in Sybaris and Siracusa (Table 1; Waters, 1974, Greco, 2006). Many colonies were platted on an ideal grid by first colonists, above, or apart from, preexisting settlements (Dominguez, 2006). Strong ties with the Greek mainland are revealed by participation of Empedocles of Akragas (grandfather of the famous philosopher) in horse racing at the Olympic Games of 496 BCE, and of Exaenetos of Akragas in running (στάδιον) at the Olympic Games in 416 and 412 BCE (Wright, 1981). Euthymos from Lokri Epizephuroi won at the Olympic Games for boxing in 484, 476 and 472 BCE. Milo of Kroton won 6 times at the Olympic Games for wrestling (Pausanias Description of Greece 6.4 and 6.14: Jones and Ormerod, 1918). Other cultural exchanges involved poets such as Pindar of Thebes in Akragas (Demand, 1975), and playwrights such as Aeschylus of Eleusis in Siracusa and Gela (Herington, 1967), and philosophers such as Plato of Athens in Siracusa (Bury, 1966) and Pythagoras of Samos in Tauromenion, Taras, and Kroton (Reidweg, 2002). Aeschylus and Pythagoras retired to Gela and Kroton, respectively. Maritime commerce around the Mediterranenan Sea united it as a "small Greek world" (Malkin, 2011).

The other extreme interpretation envisages a more equal role for Italians, as partners in trading posts, spouses, labour, and mercenaries (Burgers, 2005; Malkin, 2011), before later political rebellion, in a model more like British colonization of India (Nehru, 1946). Ornamented garment pins (*fibulae*) in female burials are evidence of intermarriage with local Italians before 700 BCE in the trading post of Pithecoussae, but there is little comparable evidence for intermarriage in later Sicilian burials (Hodos, 1999). Sikels before colonization had sophisticated metal utensils and weapons, fortified villages, chamber tombs, longhouses, and Sant'Angelo Muxaro and Siculo-Geometric pottery (de Angelis, 1998; Antonaccio, 2001; Attema et al., 2010). Sikel elites before colonization had already attained by trade such status items as bronze hoplite armour, and the paraphernalia of symposium (Hall, 2004). By the 5th and 6th centuries, Sikels were accumulating Athenian black and red figure ware pottery (Osborne, 2007). By 415 BCE, the speech of Alcibiades in Athens urging an expedition to Sicily implies some mixing of races: "The cities in Sicily are peopled by motley rabbles, and easily change their institutions and adopt new ones in their stead" (Thucydides *Peloponnesian Wars* 6.17.2: Dent, 1910). Relationships between Greek colonists and natives, eventually turned hostile, and Carthaginians also entered the fray. Lokroi Epizephuroi repelled Kroton ca. 550 BCE. Siracusa and Akragas were victorious against the Carthaginians in 480 BCE. Siracusa won a naval battle against Etruscans in 473 BCE, and both naval and land battles against Athenians in 415–413 BCE. Iapygians took Taras ca 473 BCE, Lucanians invaded Paestum ca 400 BCE, and Morgantina fell to Ducetius of the Sikels in 459 BCE. Ducetius was defeated by Akragas ca. 450 BCE. Carthaginians conquered Gela, Akragas and Selinus in 405–409 BCE (Stillwell et al., 1976).

Four phases of colonization outlined by Dietler (2010) for ancient Greek colonization of southern France apply also to southern Italy. His phase 1 is entanglement of indigenous populations in pan-Mediterranean maritime trade (625–600 BCE). Phase 2 is colonial settlement and establishment of trading posts (600–450 BCE). Also in Phase 2 was establishing shrines to figurehead deities of pioneer colonists (de Polignac, 1984). Phase 3 is urban stability and construction of the most imposing temples (450–300 BCE). Phase 4 is increased conflict and social transformation (300–125 BCE). Phase 3 temples and texts are the

E-mail address: gregr@uoregon.edu.

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Table 1
Geology, topography, soil and vegetation at the temples of ancient Greece.

Deity	Location	Coordinates soil pit	Geology	Topography	Soil	Founder city
"Artemis"	Akrai	N37.05742 E14.89532	Miocene Palazzolo Fm	Hillslope	Xerept	Siracusa
"Zeus"	Akragas	N37.28879 E13.60000	Pleistocene calcarenite	Highest knoll	Anthropic	Gela
Apollo	Ortygia	N37,06433 E15.29277	Miocene Mt. Carrubia Fm	Coastal terrace	Xerept	Corinth
Apollo	Selinus	N37.58335 E12.82576	Pleistocene Marsala Calcar,	Coastal terrace	Xerept	Megara
Artemis	Kephaloidion	N38.03833 E14.02457	Cretaceous Kefalu Form.	Hillsope	Xerept	(Unknown)
Athena	Paestum	N40.42471 E15.00617	Alluvial gravel, tiles	Coastal plain	Anthropic	Sybaris
Athena	Ortygia	N37.06607 E15.29369	Miocene Mt. Carrubia Fm	Coastal terrace	Anthropic	Corinth
Athena	Gela	N37.06289 E14.25850	Mio-Plio. Terravecchia F.	Ridge top	Anthropic	Rhodes
Demeter	Heloros	N36.84133 E15.10692	Pleistocene calcarenite	Coastal terrace	Xeroll	Siracusa
Demeter	Selinus	N37.58493 E12.82014	Holocene silt	Floodplain	Xeroll	Megara
Demeter	Lokroi Epiz.	N38.21073 E16.24001	Holocene siltstone	Floodplain	Xeroll	Lokris
Hera	Paestum	N40.43027 E15.00365	Holocene silt	Coastal plain	Xeralf	Sybaris
Hera	Selinus	N37.58595 E12.83481	Pleistocene Marsala Calcar,	Coastal terrace	Xeralf	Megara
Hera	Kroton	N39.02439 E17.20112	Pleistocene calcarenite	Coastal terrace	Xeralf	Achaia
Hera	Metapontum	N40.38141 E16.82512	Pleistocene alluvium	Coastal terrace	Xeralf	Achaia
Persephone	Akrai	N37.05726 E14.89512	Miocene Palazzolo Fm	Cave margin	Orthent	Siracusa
Persephone	Enna	N37.56931 E14.28889	Plioc.Capodarso Calcarenite	Cave margin	Orthent	Siracusa
Persephone	Lago Pergusa	N37.52086 E14.30626	Pliocene Enna Marls	Cave margin	Orthent	Siracusa
Persephone	Morgantina	N37.43105 E14.47981	Pliocene Geracello Marls	Cave margin	Orthent	Siracusa
Poseidon	Taras	N40.47623 E17.22853	Cretaceous Altamura Ls.	Coastal terrace	Calcid	Sparti
Poseidon	Taras	N40.44143 E17.25697	Cretaceous Altamura Ls.	Coastal terrace	Calcid	Sparti
Zeus	Tauromenion	N37.85513 E15.29044	Holocene colluvium, tiles	Ridge top	Anthropic	Naxos
Zeus	Siracusa	N37.05056 E15.25802	Pleistocene calcarenite	Coastal terrace	Anthropic	Corinth
Zeus	Akragas	N37.29104 E13.58436	Pleistocene calcarenite	Ridge top	Anthropic	Gela
Zeus	Lokroi Epiz.	N38.21034 E16.23993	Holocene siltstone	Coastal terrace	Anthropic	Lokris

Note: Two soil profiles were measured at Taras, because the one closest to the temple was visible, but with access to examine in detail denied.

main subject of this study, but their soils provide clues to earlier cults and agricultural potential.

This paper adds observations of soils at temples of Italian *Magna Graecia* to further test the multicultural hypothesis for polytheism, and colonial links to the mother country versus native influences in matters of religion. Soils at 84 sacred sites on the Greek mainland, Aegean Islands and Cyprus showed a systematic relationship between local soil resources and particular deities, revealing the livelihoods celebrated by each cult (Retallack, 2008). That study supported a multicultural hypothesis for derivation of Greek polytheism from individual cults that came together in classical city states (Sourvinou-Inwood, 1990). Ionian and Italian colonies were excluded from that original study because colonies may develop hybrid religions different from those of their mother country, but Italian colonies are the main subject of this contribution. Ancient examples of colonization and cultural blending may inform ongoing colonial devolution.

2. Background to soils and geology of southern Italy

Mountainous topography of southern Italy (Fig. 1) is maintained by subduction of oceanic crust south of the Bay of Taranto in the Calabrian Trench, which continues on land as major thrust faults in Apulia and southern Sicily (Butler et al., 1992). Subduction to the south fuels active volcanoes to the north, including Etna, Vesuvius, Stromboli, and Vulcano (Sartori, 2003; Goes et al., 2004). The Apulian block as well as the spine of the Appenines and northern Sicily are mainly Mesozoic limestones (Elter et al., 2003; Dewever et al., 2010), with local ophiolites along sutures (Piccardo, 2003). Many temple sites are products of uplift within the subduction complex, either on high ridges of Neogene carbonate (Atzori et al., 1995; Sgarrella et al., 1999; di Grande and Giandinoto, 2002; Guglielmo et al., 2006; Sadori et al., 2013), or on extensive flights of marine terraces in Campania (Amato et al., 2012), Sicily (Piro and Versino, 1995; Amadori et al., 1999), and the Gulf of Taranto (Belluomini et al., 2002; Bentivenga et al., 2004). The substrates to these temples are either Neogene limestone and marl (Piro and Versino, 1995; Panzera and Lombardo, 2013) or Quaternary alluvium (Hearty and Pra, 1992; Bentivenga et al., 2004). Earthquakes are frequent in southern Italy (Valensise et al., 2003), and were violent enough to topple ancient temples in 370–300 BCE, ca 250 CE, and 365 CE (Galli et al., 2006; Bottari et al., 2009). Nevertheless, more Doric temples of southern Italy have survived intact (Fig. 2a) than temples in mainland Greece (Higgins and Higgins, 1996).

The climate of southern Italy is Mediterranean, with most rain and snow falling during a cool fall and winter. At Enna, in central Sicily, mean annual temperature is 13.4 °C and mean annual precipitation between 500 and 700 mm (Sadori et al., 2013) The native vegetation of Lago Pergusa near Enna some 4000 years ago was grassy woodland of evergreen oak (*Quercus ilex*) and downy oak (*Q. pubescens*), with lesser olive (*Olea europea*), field elm (*Ulmus minor*) and beech (*Fagus sylvatica*). The native soils of southern Italy are limited in variety and similar to those of mainland Greece (Food and Agriculture Organization, 1980): largely Entisols (Fluvents, Orthents, Psamments of streamsides), Inceptisols (Xerepts, Andepts of low terraces), Alfisols (Xeralfs of high terraces), Mollisols (Xerolls of grassy floodplains), and Vertisols (Xererts of poorly drained sumps). In most of the Italian sites examined most of these soil types were found within a small area of varied topography. Two important Italian soils for agriculture uncommon in Greece are Andisols (Vitrands) on the flanks of Mt. Etna and in the Dittaino Valley of Sicily (Egli et al., 2007, 2012), and Alfisols (Aqualfs) on low terraces at the head of the Gulf of Taranto (Wagner et al., 2007; Sauer et al., 2010). The suborder Anthrept previously used (Retallack, 2008) is no longer recognized (Soil Survey Staff, 2014), and these soils dominated by tiles and other cultural debris are here simply called anthropic.

3. Materials and methods

This study measured soil profiles in available roadcuts, canals, and excavations near Doric temples (Fig. 2A) and other sacred sites (Fig. 2B) of ancient Greek classical (480–338 BCE) colonies in southern Italy (Fig. 1). Segesta and Eryx were not included because literary sources suggest that they were Trojan (Stillwell et al., 1976), although there is archeological evidence of Athenian influence (Mertens, 1996). Information on the Doric temples of southern Italy comes not only from archeological evidence, but from classical writers, Strabo writing in 23 CE (Jones, 1927, 1950), Diodorus of Sicily writing about 39 BCE (Oldfather, 1939; Geer, 1954), and Empedocles of Akragas

Fig. 1. Location of Doric temples visited for this study (closed circles), together with other temples of Trojan colonies (open circles).

(495–430 BCE), a pre-Socratic philosopher best known for his theories of Earth, Fire, Water and Air, and transmigration of souls (Wright, 1981).

Some temples have little or conflicting information on the deity worshipped. At Akrai, for example, an inscription indicates that Aphrodite, Artemis and Persephone were worshipped, without specifying where (Bernabò Brea, 1986). The Temple of Aphrodite was on the highest part of the acropolis and largely unexcavated (Stillwell et al., 1976), the temple on the slope below the theater and bouleterion is likely the temple of Artemis, and the shrine of Persephone near caves west of the bouleterion. The so-called "temple of Juno" near modern Agrigento has long been recognized as a misnomer, because the painting by Zeuxis which Pliny the Elder supposed was in the "Temple of Hera Lacinia in Agrigentum" was actually a painting of Helena in the Temple of Hera Lacinia in Kroton, according to both Cicero and Dionysos of Halicarnassus (Bostock and Riley, 1855). Evidence from elevation, compass orientation, and other temples in this complex, now indicates that the "Temple of Juno" at Akragas was more likely a temple of Apollo (Hannah et al., 2015).

Another problem for this study are numerous temples in groups on comparable soils, for example, those attributed to Zeus, Nike (?), Herakles, and Dioskouri on the main ridge at Akragas (Stillwell et al., 1976). Such groups of temples around the Acropolis of Athens were regarded as subsidiary to the temple of Athena from classical literary insistence of primacy of her worship there (Retallack, 2008), but little literary evidence of preference is available for Italian temples. Only three temples at Selinus have inscriptions indicating dedication: temple E of Hera is the most impressive temple on the eastern plateau (Østby, 2009), temple C of Apollo is central on the crest of the western acropolis (Marconi, 2007), and the sanctuary of Demeter Malophoros is in the valley to the east (Stillwell et al., 1976). Within a space of only a kilometer these three temples are on very different soils (Table 1). Other temples of Selinus are variously attributed to Zeus, Dioscouri, Herakles, Empedocles, and unknown (Mertens, 1996). In the case of the main archeological area of Metapontum, the temple of Hera is not only larger and better preserved, but was constructed before the temple of Apollo Lykeios, and smaller temples of unknown deities (Stillwell et al., 1976; Mertens, 1996).

Other temples are built over so effectively that finding a soil exposure is a matter of luck. The temple of Zeus at Tauromenion is the foundation of the Church of San Pancrazio in modern Taormina (Stillwell et al., 1976), and I am indebted to Marta Vernuti for permission to examine the archeological excavation across the street. The temple of Athena on Ortygia is completely built over, but parking areas to the east expose soil.

At each of the sites visited a soil profile was documented (Figs. 2C–H, 3), using a milliner's tape, Munsell soil color chart, and acid bottle. The soil profiles were in excavations for roads or in creek banks. Depth (cm) in the profile to stones > 5 cm in diameter was measured as an impediment to plowing. Degree of development of the soils was assessed on a 100 point scale (Retallack, 2008), pegged to 50 for the acquisition of a diagnostic argillic or calcic horizon, or histic epipedon in the taxonomy of the United States (Soil Survey Staff, 2014). Geographic coordinates of each examined soil exposure were recorded using a hand-held 12-channel Garmin GPS unit, and are given in Table 1: coordinates of the archeological sites are readily available

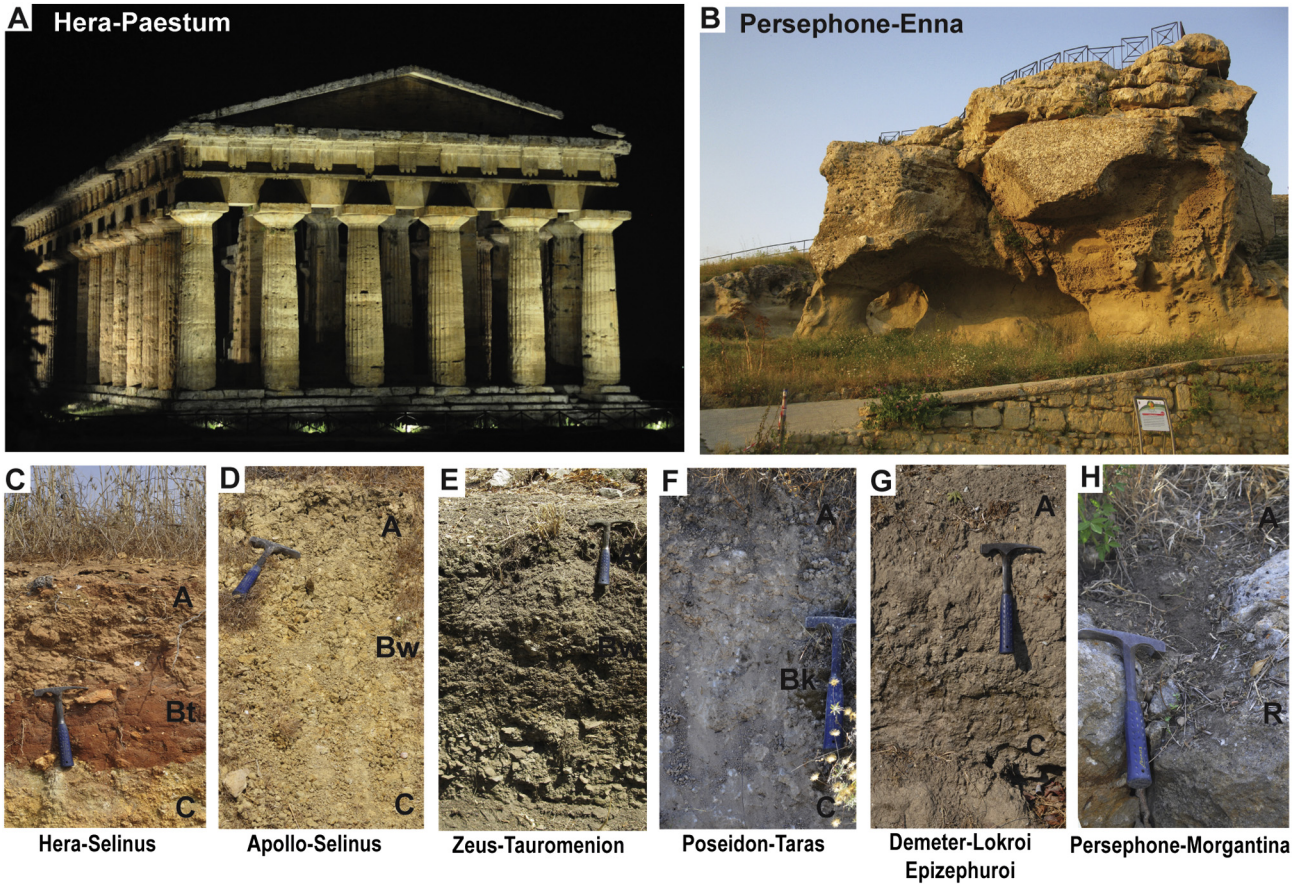

Fig. 2. "Temple of Juno" at Paestum (A) and "Rocca di Cerere" at Enna (C), and soils near a variety of Doric temples in southern Italy: C, Xeralf of Hera at on coastal terrace in Selinunte Archaeological Site; D, Xerept of Apollo at edge of coastal terrace in Selinunte Archaeological Site; E, anthropic soil of Zeus near San Pancrazio in Taormina; F, Calcid of Poseidon in Taranto; G, Xeroll of Demeter at Lokroi Epizephuroi Archaeological Site; H, Orthent of Persephone at Morgantina Archaeological site.

online.

4. Are there differences between soils at western Greek and classical Greek temples?

No. The principal result of this study is that the temples of particular deities in Italy are consistently found on the same kinds of soils as temples for those same deities in Greece and Aegean Islands (Table 2), although these 25 Italian soils do not show all the diversity of the 84 soils previously studied in Greece, which define the ellipses shown in Fig. 4. Depth to stones larger than 5 cm was measured (Fig. 4A), because stones of this size prevented use of the classical, or ard plow (Sallares, 1991). Plowing was also difficult in the best developed soils (Xeralf of Fig. 4B), which have heavy clays that harden during the long dry summer. Xeralfs of the coastal plain at Paestum and Metapontum are also unusually gray for such soils due to poor drainage (Fig. 3A, C), and have been cultivated in modern times only with deep modern irrigation ditches. As in Greece, soils of temples of Athena and Zeus overlap with those of Artemis and Apollo (Fig. 4A), but are distinguished by abundant brick, tile and other cultural debris. This distinction is also made clear in soil taxonomic classification as an anthropic horizon (Soil Survey Staff, 2014). Similarities between soils and deities of classical Greece and Doric Italy (Fig. 4) do not favor the view that these colonies were founded by persecuted religious minorities, or cities with unique religious traditions.

Nor is there evidence from temple placement (Fig. 4) for Greek adoption of pre-existing indigenous religious cults. Sikel gods associated with particular sacred grottos around Mt. Etna included Hybla, a fertility goddess later conflated with Aphrodite, Hadranus, a god later conflated with Hephaistos, and Palikoi, twin gods of local geyser lakes (Dunbabin, 1948; La Rosa, 1996; Manisalco and McConnell, 2003). Another fertility goddess, Oxxo, was worshipped before Greek colonization in Puglia (the heel of Italy), and like the Mt. Etna sites, her worship centered on rock grottos (Mastronuzzi and Ciuchini, 2011). Her worship was most similar to that of Kore. The worship of Demeter and Kore proliferated in Sicily (de Polignac, 1984), mainly at unusually shaped rocks like those of Enna and Lago Pergusa, rather than temples (Stillwell et al., 1976).

Nor is there evidence from local soils that local subsistence demanded cultural changes: the Catanian slope of Sicily and the Tarantine and Campanian plains were lands of plenty. "When the mountain [Etna volcano] is in action, the fields of the Catanaeans are covered with ash-dust to a great depth. Now although the ash is an affliction at the time, it benefits the country in later times, for it renders it fertile and suited to the vine, the rest of the country not being equally productive of good wine; further, the roots produced by the fields that have been covered with ash-dust make the sheep so fat" (Strabo Geography 6.2.4: Hamilton and Falconer, 1854). Cultivation of vines, olives and cereals introduced from the motherland were unusually successful in Italian colonies, which thrived on agriculture (Waters, 1974). According to Empedocles the philosopher "The Agrigentines live delicately as if tomorrow they would die, but they build their houses well as if they thought they would live forever" ("τρυφῶσι" here translated as "delicately" also means sumptuously, luxuriously: Diogenes Laertius Lives of Philosophers 8.2.63: Hicks, 1972). Architecturally the Doric peripteral temples of Italy are comparable with mainland Greek temples

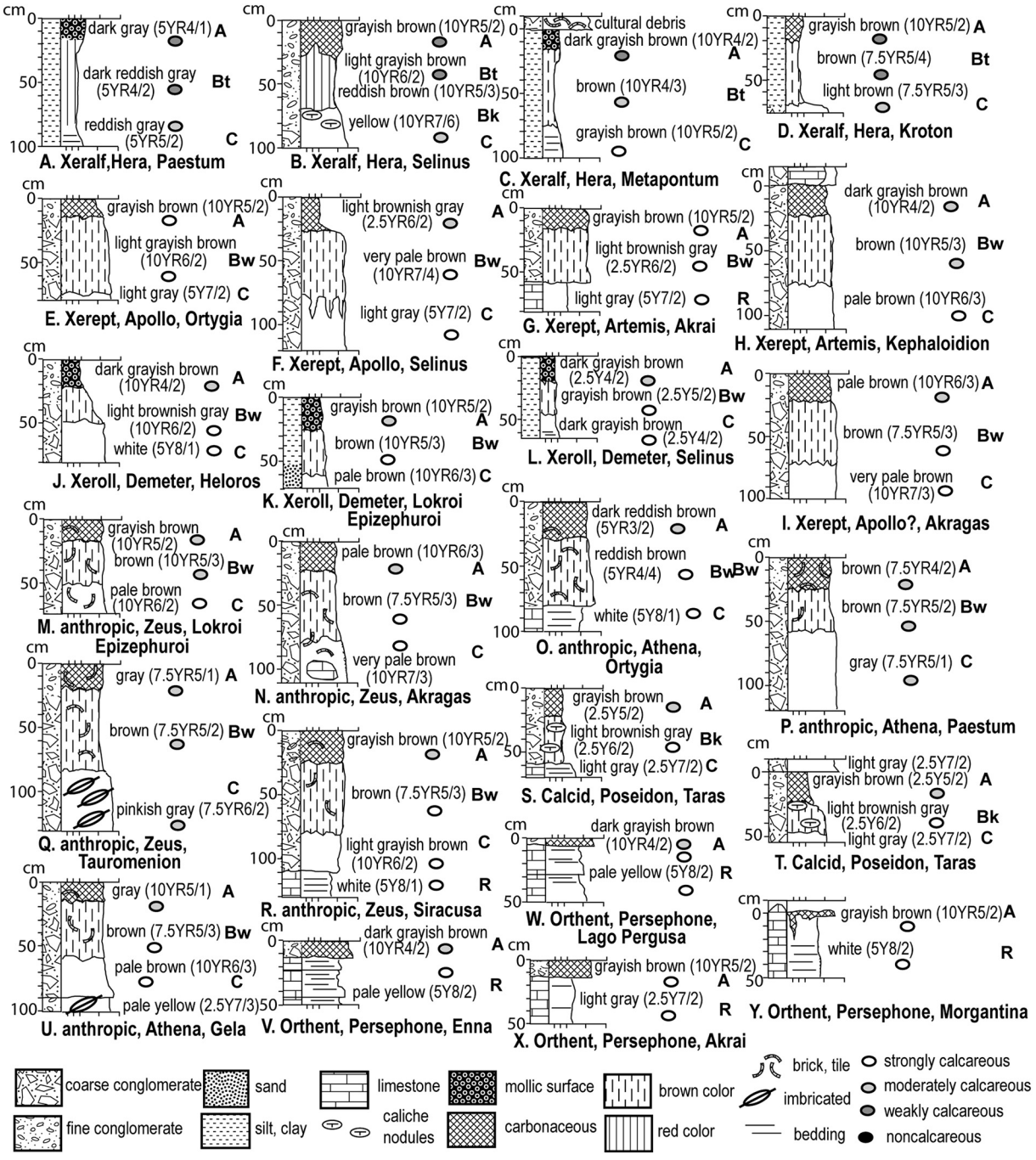

Fig. 3. Measured sections of soils near each of the 24 Doric temple sites in southern Italy (Table 1). Two profiles were measured for Poseidon at Taras: one in a downtown construction site and another in a road cut.

Table 2
Characteristic plants and soils at the temples of ancient Greece.

Deities	Soil	Modern vegetation	Interpreted native vegetation
Zeus-Athena	anthropic	Garden and park	Broadleaf oak forest
Apollo-Artemis	Orthent, Xerept	Montane phrygana	Montane fellfield
Hermes-Hera	Xeralf	Citrus orchard, olive grove, pasture	Grassy oak woodland
Dionysos-Demeter	Xeroll	Pasture, market garden, vineyard	Lightly wooded grassland
Ares-Hephaistos-Hestia	Fluvent	Market garden, vineyard	Riparian woodland
Poseidon-Aphrodite	Calcid	Coastal heath and maquis	Coastal heath
Hades-Persephone	Orthent, cave	Clilff flora	Cliff flora

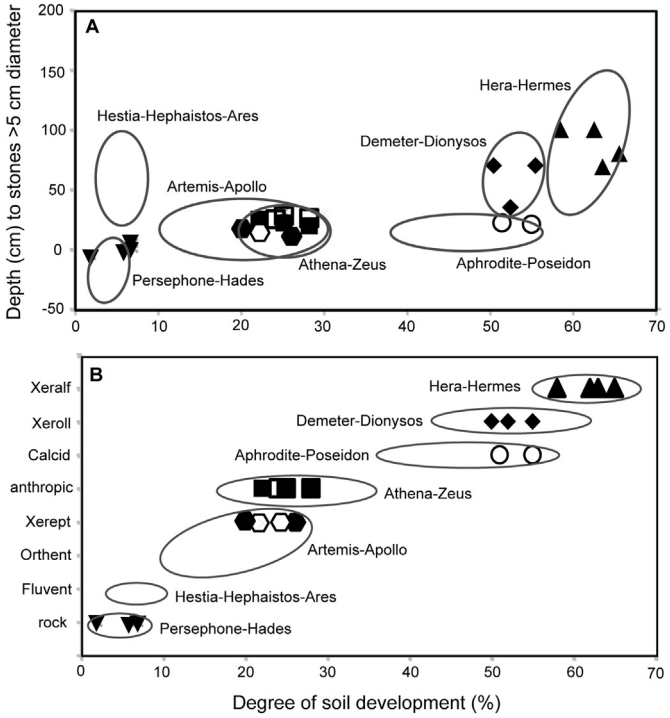

Fig. 4. Discriminatory diagrams for soils at 24 Doric temple sites in southern Italy, which fill only part of the space defined by soils and similar sites in Greece, Aegean Islands and Cyprus (grey ellipses). Depth to stones reflects ease of plowing, with negative depths for stones protruding from the ground. Degree of development is related to time available for soil formation (Retallack, 2008), and is also a consideration in soil classification (Soil Survey Staff, 2014). Filled symbols are female and open symbols male deities of the following pairs Athena-Zeus (squares), Artemis-Apollo (hexagons), Demeter-Dionysos (diamonds), Hera-Hermes (triangles), Hestia-Hephaistos-Ares (rectangles), Aphrodite-Poseidon (circles) and Persephone-Hades (inverted triangles).

(Spawforth, 2006). Nevertheless, some differences characterize a Western Greek temple "Severe Style": thick columns, with marked entasis, and simple tabular capital, in patterns of 6 by 14 columns (Mertens, 1996, 2006).

4.1. Soils of city dwellers (Athena, Zeus)

Italian Doric temples of the warrior cults of Athena and Zeus are on knolls and commanding vantage points of long human occupancy, as in ancient Greece (Retallack, 2008). Paleolithic tools near Paestum and Akrai, Neolithic tools near Taras and Siracusa, and chalcolithic artifacts at Gela and Morgantina (Stillwell et al., 1976), are evidence of long occupation of such strategic sites prior to Greek colonization. This is most obvious from fragments of brick, tile, and other artifacts in the soil profile (Fig. 3M–R, U), especially notable at Tauromenion (Figs. 2E, 3Q), which like many other temples of Athena and Zeus remain completely built over. The Athenaion of Ortygia is underlain by a Sikel village (Dunbabin, 1948). Soil formation at these sites was reset by construction during classical times, so have a weak degree of soil development represented by limited iron staining (Bw or cambic horizon of Soil Survey Staff, 2014).

4.2. Soils of hunter-gatherers (Artemis, Apollo)

Temples of the hunter-gatherer cults of Artemis and Apollo share thin rocky soil profiles, bright red to yellow colors, low organic carbon, and a strong sense of wilderness, set apart from villages and cities (Retallack, 2008). These soils have weakly developed profiles (Figs. 2D, 3H–I), varying from simple organic-weathered (A-C profiles or Orthents) to organic-discolored-weathered (A-Bw-C profiles or Xerepts). Some of these soils have been degraded from Xerepts to Orthents by sheet wash on steep slopes (Ferro et al., 1991). Abundant stones and steep slopes render these soils unsuitable for plowing, and shrublands (macchia) of holly oak (*Quercus ilex*) and broom (*Genista aetnensis*) limit their use for grazing (Egli et al., 2012). Sanctuaries of Artemis and Apollo are commonly in marginal areas redolent of wild nature (Cole, 2004; Retallack, 2008).

4.3. Soils of herders (Hera, Hermes)

The pastoral cults of Hermes and Hera are represented in the current set of sites only by temples for the goddess (Table 1). All four sites have thick clayey soils (Xeralfs), with subsurface horizons stiff with illuviated clay (Bt or argillic horizon). At Kroton the soil is deeply cracked in late summer (vertic in soil terminology: Soil Survey Staff, 2014). At both Kroton and Selinus the soil is red and excessively drained (Figs. 2C, 3B,D), but at Metapontum and Paestum the soil is brown with a high water table (Fig. 3A,C), and modern cultivation is facilitated by deep irrigation channels. All four temples of Hera are on coastal terraces, dated as Holocene or late Pleistocene (< 16 ka) near Metapontum (Bentivenga et al., 2004; T0 of Sauer et al., 2010), late Pleistocene (70 ka) at Kroton (Galli et al., 2006), and late Pleistocene (isotope stage 5, or ca. 135 ka) at Selinus (Wagner et al., 2007), and Paestum (Amato et al., 2012). Archeological excavations around Metapontum are evidence of a decline of native sheep and goats in favor of cattle of the first Greek colonists, who also introduced horses, pigs and hens (Carver, 2004).

4.4. Soils of family farmers (Demeter, Dionysos)

"Demeter and Kore, the goddesses who protect Sicily," (Diodorus Siculus History 10.6.2: Geer, 1954) embodied family farming, on which the Sicilian bounty of food depended. As Plato noted during his visit "I was in no wise pleased at all with 'the blissful life', as it is there termed, replete as it is with Italian and Syracusan banquetings; for thus one's existence is spent in gorging food twice a day and never sleeping alone at night, and all the practices which accompany this mode of living" (Plato Epistles 326b: Bury, 1966). Wine was presumably a part of this life of dissipation, although no shrines to Dionysus, the god of wine were included in this study. Wine and olive oil were the main source of wealth for Selinus and Akragas, through trade with Africa (Waters, 1974).

Soils of Demeter have distinctive crumb-structured, thick (> 18 cm), dark brown, organic-carbon-rich surface horizons (mollic epipedon) of grassland soils (Xerolls: Figs. 2G, 3J–L). Such grassland soils are limited to narrow valley bottoms in the hilly southern coast of Sicily, but widespread in the plains of Catania, Campania, and around the Gulf of Taranto. Their stable structure and high concentrations of alkalis and alkaline earth nutrients are suited to cereal crops, as well as market gardening of fruits and vegetables (Retallack, 2008). Such calcareous and fertile soils overfeed grapevines to produce sweet and potent wines that would not be popular today (Retallack and Burns, 2016), but mythic censure of Dionysos recommended moderation and a water chaser (Olalla, 2002).

4.5. Soils of estate farmers (Hestia, Hephaestos, Ares)

Sites sacred to Hestia, goddess of the hearth, Hephaestos, artisan of the gods, and Ares, the warrior god, are alluvial soils (Retallack, 2008). These are on active floodplains (Fluvents of Soil Survey Staff, 2014), fertile with freshly eroded minerals, moist with shallow water table, and easy to plow (Sallares, 1991; Van Andel and Runnels, 1987). No sacred sites to these deities are in the current study set (Table 1). On the Greek mainland these gods were linked with large agricultural estates, comparable with large hydraulic civilizations of Egypt, Babylon and

Pakistan. This form of corporate agriculture can be contrasted with family farms (Hanson, 1995), which were evidently more widespread than estate farms in Italian Doric colonies.

4.6. Soils of fishers (Poseidon, Aphrodite)

Aphrodite, the goddess of love, and Poseidon, the earth-shaker, have temples with good views of the sea or large lakes (Retallack, 2008). Furthermore their soils are less than ideal for agriculture by reason of sandy texture, free drainage, and excess salt and carbonate (Figs. 3S–T), and so local subsistence is mainly derived from the sea. The coastal terrace of the Temple of Poseidon in the important port city of Taras is a good example (Fig. 2F). These soils and sites also are largely in climatically arid regions, and are Calcids (Soil Survey Staff, 2014), with subsurface accumulation of carbonate nodules (Bk) or salts (By).

4.7. Soils of hermits (Persephone, Hades)

The god and goddess of the underworld were worshipped in areas of rock outcrops, including caves and other evocative forms, with thin or no soil cover (Fig. 2B, H, 3V–Y). Their central story has been reimagined in central Sicily, although their original mythic sites were at Eleusis in Attica, Ephyra in Epirus, and Tainaron in Mani (Retallack, 2008). “There is a lake of greatest depth, not far from Henna's [Enna's] walls, long since called Pergusa…While Proserpina [Persephone] once dallied in that grove, plucking white lilies and sweet violets, and while she heaped her basket, while she filled her bosom, in a pretty zeal to strive beyond all others; she was seen, beloved and carried off by Pluto [Hades]” (Ovid *Metamorphoses* 385–396: More, 1922). Persephone (as Kore) was widely linked with Demeter as the harbinger of spring fertility, and also as codependent with the god of death. The symbolism of clay relief tablets (πίνακες) at Lokri Epizephuroi persuaded Sourvinou-Inwood (1978) that Persephone also had a role in Italian colonies as “protectress of women, marriage, and children” perhaps from assimilation of local deities, in addition to her usual roles in “fertility of the earth and with the funerary sphere.” These additional roles may have been assimilated from indigenous goddesses such as Hybla (Dunbabin, 1948) and Oxxo (Mastronuzzi and Ciuchini, 2011).

5. Competing explanations for temple sites

Alternative explanations for the placement of classical temple sites include (1) post-classical land use (Grove and Rackham, 2001), (2) geological peculiarities (Piccardi, 2000), (3) scenic location (Scully, 1979), (4) astronomical orientations (Richer, 1994), and (5) accidents of history (Stillwell et al., 1976). These alternatives have been discounted for temples of mainland Greece, Aegean Islands and Cyprus (Retallack, 2008), but are considered for Italian Doric colonies in the following paragraphs.

Could the pattern of deity-specific soils (Fig. 4) reflect post-classical changes in soils due to erosion, climate change, land subsidence, or other modifications? Erosion of hillslopes (Ferro et al., 1991) and subsidence of harbors (Bartoli, 2010) since classical times is local and not apparent from the Italian archeological sites excavated from protective cover (Stillwell et al., 1976). Paleobotanical records from pollen (Sadori et al., 2013) and charcoal (Egli et al., 2012) in Sicily show little climate change over the past 7 millenia. The time scales of development of moderately developed soils (Calcids and Xeralfs) predates by thousands of years the time of construction of the Doric temples (Galli et al., 2006; Wagner et al., 2007; Sauer et al., 2010; Amato et al., 2012).

Piccardi (2000) argued that the temple of Apollo at Delphi was located over a vent for hydrocarbons responsible for the oracle-inducing trance of the priestess of Pythian Apollo. No comparable geological peculiarity was noted at the sacred Greek sites of Italy visited for this study. The geologically remarkable summit crater of the active volcano Etna was not a sacred site, although some accounts have it as the suicide spot for the deified philosopher Empedocles (Wright, 1981). However, several grottoes and lakes around Etna were sacred to the indigenous Sikels (Dunbabin, 1948).

Scully (1979) proposed that the temples of ancient Greece were located in particularly scenic locations, like the illusion in the ridgeline of Salamis of a reclining woman as seen from Eleusis. The most evocative sites of the present study were the unusually sculpted Rocca di Cerere (rock of Demeter) at Enna (Fig. 2B), stunning rock promontory of Cefalú (Kephaloidion), and prow-like ridge of Agrigento (Akragas). None of these are especially amenable to anthropomorphism. Others sites such as Paestum, Metaponto, Selinus and Morgantina were in unremarkable coastal terraces or saddles in ridgelines.

Both Scully (1979) and Richer (1994) regarded classical Greek temples as calendrical devices oriented so that the sanctuary was illuminated by the rising sun on certain sacred days, and Richer conceived them as distributed at cardinal points around the navel of Delphi. No consistent orientation was seen in the whole dataset of temples in Greece, Aegean Islands and Cyprus (Retallack, 2008), but the issue has been restudied for Sicily (Aveni and Romano, 2000; Salt, 2009) with the result that 38 of 41 temples were oriented toward the rising sun. Nine temples within the single extensive site of Akragas had azimuths ranging from 77° to 90°, but one at 125° was out of alignment (Hannah et al., 2015). This relationship is thus not universal, and concerns only temple orientation at a site, rather than regional geographic distribution.

Were the temples sites where colonists accidently landed, or had transformative religious experiences, or where cities attained sufficient affluence for large public works? The main building program at Akragas including the so-called “Temple of Juno” (more likely of Apollo: Hannah et al., 2015) and “Temple of Nike” (unknown deity) and Temple of Olympeian Zeus (unfinished) were begun about 460 BCE after the victory over the Carthaginians at Himera, 75 km north of Akragas, and well after foundation of the city by Rhodo-Cretan colonists in ca 582 BCE (Stillwell et al., 1976). These monuments did not celebrate the site of victory, but may have been facilitated by its economic consequences, including captive labour. “Witness to the luxury of the inhabitants is also the extravagant cost of the monuments which they erected, some adorned with sculptured race-horses, and others with the pet birds kept by girls and boys in their homes” (Diodorus Siculus *History* 13.86.6: Oldfather, 1989). Nor is there record of indigenous veneration of these particular sites, prior to arrival of colonists with their preconceived concepts of divinity. At Gela for example the river was sacred to a river god of the Sikels, not the promontory on which the Greeks erected a temple to Athena (Dunbabin, 1948).

The most likely historical explanation for temple sites in Italy is choice by the founding colonists for the particular cult they brought with them from their homeland (de Polignac, 1984). These cults reflected a particular economic model, such as pastoralism or agriculture, and the first colonists chose soil resources that would best work for those purposes. They consistently picked the same kinds of soils and geomorphic settings for the deities as existed in mainland Greece and the Aegean Islands (Fig. 4), and this confirms the link between cults and soils (Retallack, 2008). There is no written record in Greek texts of soil preferences for new temples, but there are deity-specific instructions (*Vaastu Shastra*) for soil choice of new temples in the *Matsya Purana* and *Birhat Samhita,* ancient texts of Hinduism, begun during the first millennium BCE, but finalized by the 6th century CE (*Matsya Purana* CCLIII, 12–18: *Birhat Samhita* LII, 90–92; Kramrisch and Burnier, 1976).

6. Conclusions

This study of sites of 24 temples of classical (480–338 BCE) Greek colonies in southern Italy revealed consistent soil type for particular deities, as previously demonstrated for mainland Greece, Aegean Islands, and Cyprus (Retallack, 2008). Temples of Athena and Zeus on soils of citadels (anthropic) contrast with those of Artemis and Apollo

on rocky soils (Orthent, Xerept) of wilderness. Hera was worshipped on clayey soils (Xeralfs) suited to cattle grazing. Sanctuaries of Demeter are on fertile soils (Xerolls) suitable for mixed farming, whereas temples of Aphrodite and Poseidon are on arid soils (Calcids) near fishing harbors, and caves were sacred to Persephone and Hades. In Italian *Magna Graecia* such sensitivity to soils and lands in which particular deities would feel at home was imported as a multicultural polytheistic system from the Greek mainland (de Polignac, 1984), where it arose organically by chalcolithic or earlier melding of individual tribal cults (Sourvinou-Inwood, 1990). Such deity-specific land use near the major monuments of ancient Greece and its colonies confirm classical accounts of cultural and athletic exchange with the mother county. Nevertheless, the western Greek colonization was not comparable with British colonization of Australia in effective marginalization of natives (Dunbabin, 1948). Greek colonies more likely began as trading posts and agricultural enterprises aided by natives, who themselves became Hellenized over several generations, before revolting from Greek control (Hodos, 1999; Hall, 2004; Burgers, 2005; Dietler, 2010), a cycle of colonization and independence more like British India (Nehru, 1946).

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