BGSG

Volume 59

Research Paper

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DOI number:
http://dx.doi.org/10.12681/bgsg.28851

Keywords:
Poseidon-Polybotes myth, ceramic, earthquake, rock avalanche, tsunami

Citation:
de Boer, J.Z, Pe-Piper, G. and Piper, D.J.W. (2022), The Myth of the Battle between Poseidon and Polybotes: Was it Inspired by a Late Holocene Rock Avalanche at Zini, Kos Island? Bulletin Geological Society of Greece, 59, 1-22.

Publication History:
Received: 06/12/2021
Accepted: 28/02/2022
Accepted article online: 13/03/2022

The Editor wishes to thank three anonymous reviewers for their work with the scientific reviewing of the manuscript and Ms Emmanouela Konstantakopoulou for editorial assistance.

THE MYTH OF THE BATTLE BETWEEN POSEIDON AND POLYBOTES: WAS IT INSPIRED BY A LATE HOLOCENE ROCK AVALANCHE AT ZINI, KOS ISLAND?

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Abstract

Scenes of the legendary battle between Poseidon and the giant Polybotes, which occurred on the Greek island of Kos, are depicted on dozens of surviving ceramic objects. Poseidon is shown killing his opponent with his trident, while carrying a huge rock that he had ripped off the island of Kos to bury Polybotes. The legend is interpreted to represent a strong earthquake that caused a large coastal rock fall or rock avalanche. The oldest ceramics representing this disaster date from ca. 560–540 BCE. The disaster is interpreted to date from this time and was a major event that reverberated throughout the Greek world, triggering the imagination of its artists for several generations. Legend and ancient literary sources suggest that the event took place in southwestern Kos, near the then capital city of Astypalaia, located NW of Zini mountain. Geological studies show a large, relatively recent, rock avalanche on the steep coast on the SE side of Zini mountain. Possible tsunami sand deposits with reworked marsh foraminifera are found 7 m above sea level on NE Zini, only 1 km from the archaeological site of the old city of Astypalaia and large boulders are stranded on the opposite rocky coastline up to 6 m above sea level. Noise and dust from a rock avalanche would have been terrifying for the inhabitants of Astypalaia and any tsunami would have overwashed the port at Kamari. In the absence of suitable geological dating methods, ceramics provide the best chronology for the event.

Keywords: *Poseidon-Polybotes myth; ceramics; earthquake; rock avalanche; tsunami*

Σκηνές από τη θρυλική μάχη μεταξύ του Ποσειδώνα και του γίγαντα Πολυβώτη, η οποία έλαβε χώρα στο Ελληνικό νησί της Κω, αναπαρίστανται σε δεκάδες διασωθέντα κεραμικά αντικείμενα. Σε αυτές τις αναπαραστάσεις, ο Ποσειδώνας φαίνεται να σκοτώνει τον αντίπαλο του με την τρίαινα του, ενώ ταυτόχρονα κουβαλά έναν τεράστιο βράχο, τον οποίο είχε αφαιρέσει από το νησί της Κω για να θάψει τον Πολυβώτη. Ο μύθος αυτός έρχεται να ερμηνεύσει έναν δυνατό σεισμό, ο οποίος προκάλεσε μια τεράστια παράκτια πτώση βράχων ή μια ροή κορημάτων. Τα παλαιότερα κεραμικά, τα οποία αναπαριστούν την καταστροφή, χρονολογούνται πίσω στο 560-540 π.Χ. Το καταστροφικό αυτό συμβάν φαίνεται να τοποθετείται χρονικά σε αυτό το διάστημα και αποτέλεσε ένα σημαντικό γεγονός, το οποίο αντήχησε σε όλο τον τότε Ελληνικό κόσμο, πυροδοτώντας τη φαντασία αρκετών γενεών καλλιτεχνών. Θρύλοι αλλά και αρχαίες βιβλιογραφικές πηγές προτείνουν πως το συμβάν έλαβε χώρα στη νοτιοδυτική Κω, κοντά στην τότε πρωτεύουσα της Αστυπάλαιας, βορειοδυτικά του όρους Ζηνί. Οι γεωλογικές έρευνες υποδεικνύουν μια μεγάλη, σχετικά πρόσφατη, κατολίσθηση στην απόκρημνη ακτή της νοτιοανατολικής πλευράς του όρους Ζηνί. Αμμώδεις αποθέσεις, πιθανώς προερχόμενες από τσουνάμι, οι οποίες περιέχουν επανεπεξεργασμένα τρηματοφόρα ελώδους περιβάλλοντος, βρέθηκαν 7 μέτρα πάνω από το επίπεδο της θάλασσας στη βορειοανατολική πλαγιά του όρους Ζηνί, μόλις 1 χιλιόμετρο μακριά από τον αρχαιολογικό χώρο της αρχαίας πόλης της Αστυπάλαιας, ενώ τεράστιοι ογκόλιθοι βρίσκονται απομονωμένοι στην αντίπερα βραχώδη ακτή, σε ύψος έως και 6 μέτρα πάνω από την στάθμη της θάλασσας. Ο θόρυβος και η σκόνη, ως αποτελέσματα της κατολίσθησης, θα ήταν τρομακτικά για τους κατοίκους της Αστυπάλαιας και σε κάθε περίπτωση ένα τσουνάμι θα είχε πλημμυρίσει το λιμάνι στην περιοχή Καμάρι. Καθώς δεν υπάρχουν επαρκείς γεωλογικές μέθοδοι χρονολόγησης, τα κεραμικά αντικείμενα παρέχουν τον καλύτερο τρόπο χρονολόγησης για το συγκεκριμένο γεγονός.

Λέξεις-Κλειδιά: Μύθος Ποσειδώνα – Πολυβώτη; Κεραμικά; Σεισμός; Ροή κορημάτων; τσουνάμι

1. INTRODUCTION

Strabo, the Greek geographer, provided descriptions of several of the Dodecanese islands offshore southwestern Anatolia and referred to a legend dealing with Kos and Nisyros (Fig. 1a). In the first century BCE he wrote, “They say that [the island of] Nisyros is a fragment of Kos, and they add that Poseidon, when he was pursuing one of the Gigantes, Polybotes[1], broke off a fragment of Kos with his trident and hurled it up on him, and the missile became an island, Nisyros, with the giant lying beneath it, but some say that he lies beneath Kos." (*Geography* 10.5.16). Pseudo-Apollodorus, a Greek mythographer, wrote in the second century CE, "[In the war of the Gigantes] Polybotes was pursued through the sea by Poseidon until he reached Kos. There Poseidon ripped off a part of that island and hurled it upon him." (*Bibliotheca* 1.37). The geographer Pausanias in the second century CE remarked of Polybotes that "there is a story prevalent among the Koans about the promontory of Chelone" (*Description of Greece*, 1.2.1), referring to Akra Chelona, on the east side of Kefalos Bay in southwestern Kos (Fig. 1a).

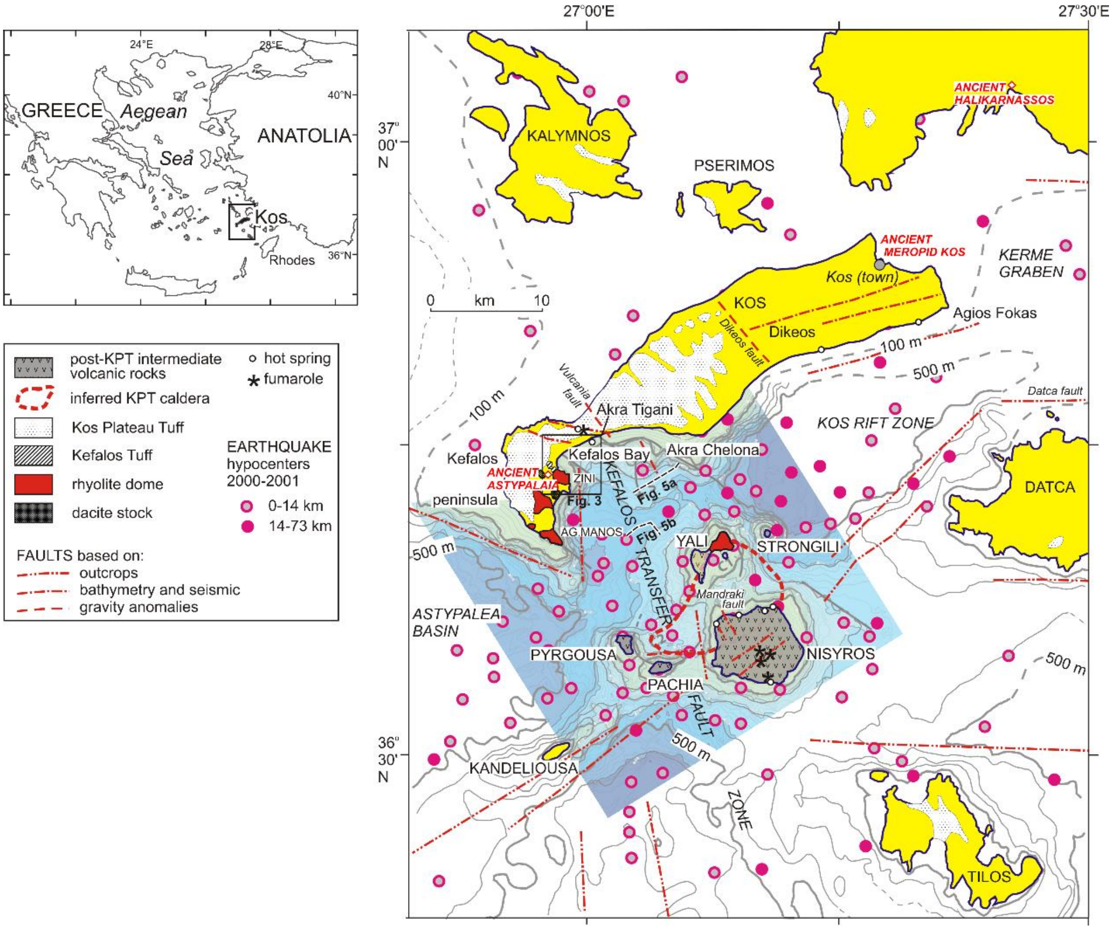

Fig. 1: Geological map of Kos and surrounding islands, showing principal volcanic and tectonic features. Modified from Pe-Piper et al. (2005). Detailed bathymetry from Papanikolaou and Nomikou (2001). Seismic activity from Geowarn (2003).

Myths, such as the battle between Poseidon and Polybotes, may have many origins. They are cultural accounts of major events in the past, transmitted by traditional

[1] Modern transliteration of Πολυβώτης is Polyvotis, but the name Polybotes is entrenched in the English language literature.

knowledge keepers (Masse et al., 2007). Myths may not point to facts, but to something that informs the facts (Campbell, 1989). Many of the most famous Greek myths have their foundation in political and religious history (Masse et al., 2007). Nevertheless, there is a class of myths that appears to be based on natural geological phenomena (Vitaliano, 1973; Piccardi, 2000; Santacroce and Di Paola, 2006; Mariolakos and Theocharis, 2010) and may be of value in assessing geohazards.

Polybotes' demise represents a catastrophic event that burned in upon human memory and captivated the Greek art world. The scene of Poseidon's battle with Polybotes is shown on more than two dozen ceramic objects in both black- and red-figured style. Most show Poseidon using his trident to kill the falling giant, while carrying a massive rock on his left shoulder (Fig. 2a). Land and sea creatures are shown on several of these rocks. The former include a deer, fox, hare, hedgehog, scorpion and snake. The marine fauna is represented by a dolphin and octopus or prawn (Fig. 2b, c). These images were intended to represent a coastal fragment of Kos that became detached and ended up in Poseidon's realm. In the images, Poseidon appears with his trident that he allegedly used to shatter rocks, force or subdue storms, and shake the earth (Nur and Cline, 2000; Güney, 2015). The fact that it was Poseidon who killed this specific giant with his trident, the symbol for seismicity, and not Zeus working his lightning or any of the other gods shooting arrows or throwing rocks, suggests that one or more earthquakes were most likely responsible for this destructive event.

This story about the battle between a god and a giant is certainly imaginative, but our hypothesis is that it represents an actual geologic event. In this paper, we attempt to unravel the geological events that might have led to the Polybotes myth. The particular geologic setting and seismicity of Kos, especially in the area of Kefalos Bay near the ancient capital city of Astypalaia, is interpreted in terms of the details of the Polybotes myth recorded on ceramic objects.

Fig. 2: Attic red-figured ceramics showing the battle between Poseidon and Polybotes, Poseidon (upright, bare-headed) uses his trident symbolizing seismicity and holds a large rock, which represents part of the island of Kos. Detailed zooms show land and sea creatures illustrated on the rocks. (a) Kylix from Vulci (Italy), ~475–470 BCE, showing rock with hare, scorpion and snake. [21 in Table 1; *Musée des Monnaies, Médailles et Antiques, Paris*; *in public domain*]; (b) Amphora from Vulci ~490–480 BCE, showing rock with octopus, scorpion and hedgehog. [20 in Table 1; *image copyright by Vatican Museum, used with permission*]; (c) Krater ~ 480 BCE, showing rock with dolphin, deer, scorpion, snake, and octopus. [19 in Table 1; *image copyright by Kunsthistorisches Museum, Vienna, used with permission*]. (d) Kylix, ~ 410–400 BCE. Ge (Gaia, on left) rising in horror from the earth imploring Poseidon not to kill Polybotes, one of her sons. Note absence of rock. [25 in Table 1; *Staatliche Museen zu Berlin, Germany. Image licensed under the Creative Commons Attribution 3.0 Unported license, available at* [*File:Aristophanes, kylix attica con gigantomachia, 410 ac ca. 02.JPG - Wikimedia Commons*]].

2. GEOLOGICAL SETTING OF KOS

The island of Kos consists of a variety of basement metamorphic rocks that form the prominent Dikeos horst in the east, onlapped by Miocene and younger sedimentary rocks (Fig. 1a). On the south side of the horst is the Kos rift zone, a submarine depression that represents the western segment of the Kerme (Gökova) graben, which originated in the Late Miocene or Early Pliocene. It is controlled mainly by the northward dipping Datça fault which has listric geometry and has filled with ~ 2.5 km of sediments (Kurt et al., 1999). The 2017 earthquake in the graben caused ground failure in eastern Kos (Papathanassiou et al. 2019) and local rockfalls in Dikeos mountain (Lekkas et al., 2018). The Kefalos peninsula in western Kos encloses Kefalos Bay. Here the Neogene strata are intruded by a series of Plio-Pleistocene dacite and rhyolite domes including the 0.5 Ma Zini dome (Pe-Piper and Moulton, 2008; Bachmann et al., 2010). The 161 ka Kos Plateau Tuff, 20–30 m thick, covers much of the central and western parts of the island (Allen et al., 1999). It was erupted from a caldera now beneath the sea 15 km southwest of the Kefalos peninsula. The entirely volcanic island of Nisyros has been built on the southern edge of the caldera since that eruption (Pe-Piper and Piper, 2002). Large sector collapses have been recognized on Nisyros, but all are of Pleistocene age (Vanderkluyzen et al. 2005; Tibaldi et al. 2008). Most identified geohazards in the region are either related to volcanism or seismicity (Nomikou et al., 2021)

The neotectonic deformation of Kos is inferred from the distribution of seismicity and structural studies of young rocks, including in offshore areas (Anagnostopoulos and Anastasakis, 2020). The distribution of seismic events in the period 1900-2000 (M_s>4.0) and detailed monitoring in the period 2000-2001 by the National Observatory of Athens (Fig. 1; Geowarn, 2003) indicated the presence of a highly active seismic zone between western Kos and Nisyros (Fig. 1). This structure, the Kefalos transform fault (KTF), represents a segment of a major NNW trending fault zone that crosses the Hellenic arc. It has facilitated and controlled magmatic activity since the Pliocene. The KTF is about 30 km wide and more or less vertical, cutting sharply through the relatively thin (~27 km) lithosphere (Sodoudi et al., 2006) and intersects the prominent ENE trending normal fault system that defines the Kos rift zone. The axial segment of the KTF zone in western Kos is characterized by a shallow rift, a negative gravity anomaly and geothermal activity (Lagios et al., 1994).

The Kos Plateau Tuff is a useful marker for the magnitude of neotectonic uplift, tilting and faulting (Piper and Pe-Piper, 2020). In eastern and central Kos, late Quaternary uplift rates were at least 1 m/ka, diminishing westward to 0.25 m/ka at Akra Tigani. A raised marine terrace on the western Kefalos Peninsula was dated as > 145 ka by Jarrige (1978). This terrace reaches an elevation of 180 m south of Kefalos village and is overlain by the ~161 ka Kos Plateau Tuff, implying that the terrace dates from the MIS 7 highstand and experienced a mean uplift rate of 0.9 m/ka in the late Quaternary. The higher east slope of Zini probably has a greater rate of uplift, adjacent to the fault-bound deep water of Kefalos Bay. The Kos Plateau Tuff in the area shows neotectonic faulting (Ebner and Grasemann, 2007).

3. THE LITERARY AND ARCHEOLOGICAL CONTEXT

Greek philosophy began in the seventh century BCE in the Greek cities along the southwest coast of Anatolia. Around the turn of that century, Hesiod wrote his *Theogony* that includes the battle between the Gigantes and Olympians. He did not describe the specific role Poseidon played in that battle. Instead, he had him “fix gates of bronze at the ends of the huge earth”. The myth of the battle between Poseidon and Polybotes therefore, most likely, originated after Hesiod wrote this famous work.

Thales of Miletus (640–546 BCE), following Homer, modeled the world as a flat disc floating in and surrounded by water. Homer in the Iliad regarded Poseidon as the “powerful shaker of the earth”. Thales preferred an interpretation that avoided godly intervention, regarding the earth as floating on water like a ship on the sea and being disturbed naturally (O’Grady, 2017).

Following the destruction of Miletus in 494 BCE, philosophy spread throughout Greece and new ideas emerged concerning the origin of natural events. Thucydides of Athens (471–399 BCE), a younger contemporary of Herodotus, described earthquakes in as many as nine passages in his *History of the Peloponnesian Wars*. He saw earthquakes as due to natural convulsions of the earth, just as wars were due to natural convulsions of human societies (Luginbill, 2020). In book 8, section 41, Thucydides wrote that the Spartan admiral Astyochus landed at the Meropid Cos in 412 BCE, “which had been lately tumbled into ruins by an earthquake, the greatest that had been felt there in the memory of us now living” [translation W. Smith, 1831]. The location of Meropid Cos and the severe earthquake have been an issue of scholarly debate, but the modern archeological consensus (e.g., Constantakopoulou, 2005) is that Meropid Cos was located near the modern Kos city in the northeastern part of the island. Astypalaia, overlooking Kefalos Bay, was the most important city in Kos prior to 366 BCE, as attested by passages from Diodorus (15, 76) and Strabo (14, 657) (Bean and Cook, 1957).

The acropolis of Astypalaia is located on a hilltop 2 km south of the modern village of Kefalos (Mackenzie, 1898) at Panagia Palatiani and shows evidence of continuous habitation from the mid-ninth century BCE onwards (Bean and Cook, 1957). A small 5th century BC temple dedicated to Demeter was excavated in 1902 (Herzog, 1903). A younger Hellenistic theatre and small Doric temple were excavated on the hillside a short distance to the south (Sherwin-White, 1978, p. 27), overlooking the harbour at Kamari. There, Laurenzi located an unwalled fishing settlement going back to the Geometric period (8–9th century BCE) (Bean and Cook, 1957). A harbour mole is located at the southern end of Zini mountain, apparently but not explicitly above modern sea level (Bean and Cook, 1957).

4. ARCHEOLOGICAL EVIDENCE FOR THE DATE OF POSEIDON'S SEISMIC EVENT

None of the reports of archaeological excavations at Astypalaia (Mackenzie, 1898; Herzog, 1903) are sufficiently detailed to provide direct evidence of any seismic damage. Thus, established techniques of archaeoseismology (Stiros & Pirazolli, 1995; Stiros, 1996; Rodriguez-Pascua et al., 2011) cannot be applied. The painted ceramics depicting the battle between Poseidon and Polybotes thus provide the main evidence for interpreting a catastrophic geological event in southwestern Kos. Dating ceramics is based on stages of artistic development in style and technique. By the end of the sixth century, records and writings by Greek historians made it possible to obtain more accurate information, and from the beginning of the fifth century the dating of Attic pottery becomes more precise (Beazley, 1963; Folsom, 1975, 1976). In this study, we have identified 25 scenes of the battle between Poseidon and Polybotes, dated between 575 and 400 BCE, using the Lexicon Iconographicum Mythologiae Classicae (1988) and the Beazley Archive Pottery Database at the Classical Art Research Centre of Oxford University (Table 1). The older images appeared on black-figured ware and the two oldest were dated 575–525 BCE (Nos. 1, 2 in Table 1). In each, Poseidon carries the large stone ripped off Kos on his left shoulder. In some early images, Poseidon and Polybotes are both shown in full armour. The red-figured style supplanted the black-figured style around 500 BCE, but overlap occurred for several decades. On many black-figured ceramics dated 550–500 BCE, Poseidon was shown nude fighting Polybotes in full armour, suggesting the emergence of new ideas concerning the god's immortality (e.g., 4, 5, 12 in Table 1). Other, mostly younger, scenes show Poseidon and Polybotes in a variety of clothing.

Table 1. Ceramics with images of the Polybotes-Poseidon battle.

No	Type	LIMC No	Beazley Vase No	Beazley age BCE	other age BCE	Animals on rock	Fig. No
Black figured							
1	Amphora	27194	745	575-525	575-525		
2	Amphora	52	14590	575-525	~ 560		
3	Amphora	10812	301545	550-500	540-530		
4	Amphora	29786	24134	550-500	540-530		
5	Amphora	14228	320065	550-500	~520		
6	Amphora	29791	7596	550-500	520-500		
7	Amphora	11554	301538	550-500	~540		
8	Amphora	11556	301642	550-500	520-510		
9	Cup	n/a	5049	550-500			
10	Lekythos	29363	41122	525-475	500-480		
11	Amphora	29366	305531	525-475			
12	Wine jug	29796	41244	525-475	510-490		
13	Cup	29799	331711	525-475	500-480		
14	Lekythos	29800	n/a	n/a	500-480		
Red figured							
15	Cup	11564	203909	500-450	490-480	fox or dog *or horse*	
16	Lekanis	29853	205509	500-450	470-460		
17	Stamnos	29874	202490	500-450	490-480		
18	Amphora	2871	202485	500-450	~460		
19	Krater	11561	202916	500-450	~480	dolphin, dragonfly, deer *or goat*, scorpion, snake, octopus *or prawn*	2c
20	Amphora	11560	202472	500-450	490-480	octopus *or polyp*, scorpion, hedgehog	2b
21	Kylix	11562	204546	500-450	475-470	hare *or goat*, snake, scorpion *or hedgehog*	2a
22	Kantharos	29880	205038	500-450	470-460		
23	Stamnos	29926	275166	500-450	490-475		
24	Krater	8052	213529	475-425	440-430		
25	Kylix	10641	220533	450-400	410-400		2d

LIMC = Lexicon Iconographicum Mythologiae Classicae https://weblimc.org

other age = ages from various literature compiled by JZdB

Beazley age = conservative half-century age range from the Beazley database

Beazley = Beazley Archive Pottery Database

https://www.beazley.ox.ac.uk/carc/pottery

Animals on rock: from Beazley database; italics from Cook (1940)

The longevity of the use of the battle scenes in ceramics may indicate that the memory of the event that triggered the myth continued to be of interest for at least two generations. The most detailed battle scenes, those with animals shown on the rock from Kos hurled by Poseidon (Fig. 2), have been dated to the period 500–450 BCE (most probably in the range 490–480 BCE; 19, 20, 21 in Table 1).

We consider that the event that led to the emergence of the Poseidon-Polybotes myth is unlikely to have been older than the *Theogony* of Hesiod (ca. 700 BCE) because of his lack of reference to the myth. However, interpretations based on the absence of an event must be treated with caution, as all authors are selective. The event probably occurred not long before the oldest ceramics on which it is depicted, perhaps around 560 BCE, so that the older ceramics were created within living memory of the event. The manner in which this seismic event was commemorated and represented on ceramics clearly indicates that it was especially destructive. The images of both land and sea creatures on the rock suggest a major coastal rock-fall. The mixed terrestrial-marine imagery might alternatively represent either a tsunami or subsidence of land into the sea, but such events were relatively common in classical Greece and not specific to western Kos. We can speculate that this destructive event impacted the early capital of Kos, Astypalaia. The longevity of the myth implies destruction on a large scale.

After an apparent gap of several decades, the Poseidon-Polybotes scene reappeared on a famous red-figured Attic kylix (cup) dated 410–400 BCE (Fig. 2d; 25 in Table 1). Poseidon is shown with his trident, but without his rock. This time he apparently did not rip a piece off Kos. In the background Gaia rises from the earth in horror as she witnesses the killing of her son. The artist may have painted this scene to commemorate the 411 BCE earthquake in Meropid Cos in the northeastern part of the island, which was recorded by Thucydides (Guidoboni et al., 1994).

5. GEOLOGIC EVIDENCE FOR THE SITE OF POSEIDON'S SEISMIC EVENT

The Poseidon-Polybotes myth includes a reference to the origin of Nisyros, clearly visible to the south from Kefalos Bay, but according to Strabo and Pseudo-Apollodorus, the actual battle between the sea god and the giant took place on Kos. The reference by Pausanias to Akra Chelona implies that the event at the origin of this myth most likely took place in the Kefalos Bay area of Kos island (Fig. 3).

South of ancient Astypalaia, the shelf of Kefalos Bay is very narrow and the floor of the bay is several hundred metres deep (Papanikolaou and Nomikou, 2001). There, the northeast flanks of the rhyolite domes of Zini and Agios Manos fall steeply to the sea (Fig. 1). The eastern flank of Zini is covered with scree or rock avalanche deposits, with alluvial fan deposits in the north and northeast (Fig. 4). Agios Manos has a precipitous bare rock face facing Kefalos Bay (Fig. 1). These unstable flanks are clear candidates as sources for rock falls and rock avalanches in the past.

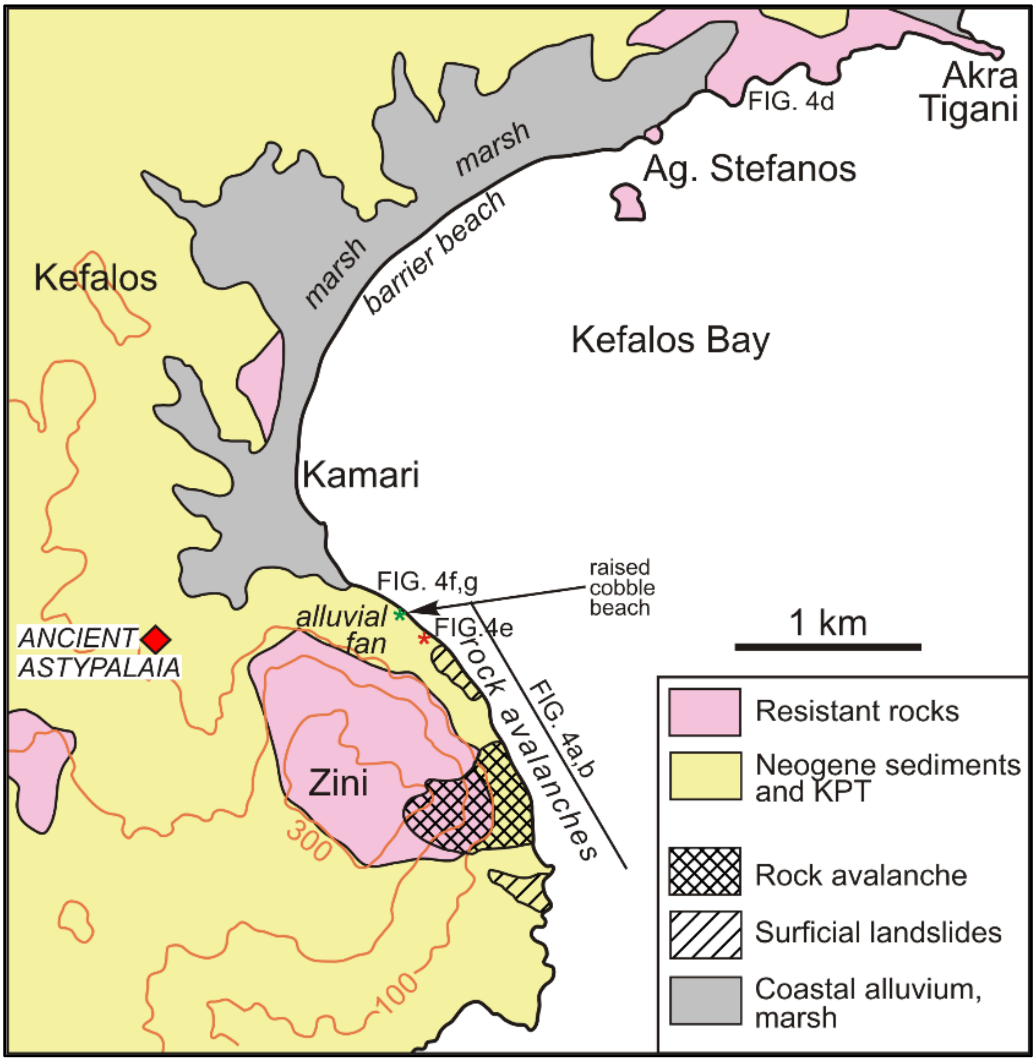

Fig. 3: Map of Kefalos Bay showing sites of geological events that may have contributed to the Polybotes myth.

In particular, there is geomorphic evidence for a relatively young rock avalanche and associated rotational slumps on the east flank of Zini. Field investigation shows a surface block field, also visible in erosional gullies, and the area lacks the mature low forest that covers much of Zini (Fig. 4a). The area of the main rock avalanche is ~0.3 km^2. On the northeastern flank of Zini, a line of cliffs with caves at 5–10 m above sea level (Fig. 4g) terminates at the edge of the rock avalanche area. These caves are interpreted as a raised marine shoreline, cut by and therefore older than the rock avalanche. Rounded 0.5 m boulders lacking marine bioencrustations were located in some of these sea caves at 5 m above sea level (Fig. 4h). At one locality, there is a sorted conglomerate of rounded cobbles with a sand matrix at about 6 m above sea level that may be a raised beach (Fig. 3).

At the northeastern end of the rock avalanche zone on Zini, a 50 cm thick bed of muddy medium-grained sand overlies openwork breccia interpreted as rock avalanche deposits at about 7 m above sea level (Fig. 4e, f). The sand bed was searched for fossils: we anticipated that any carbonate fossils would have been dissolved by meteoric water. The only fossils found were common agglutinated foraminifera (Fig. 4c). These are tubular forms that are occasionally branching. They closely resemble *Photoschista findens* or *Polysaccammina hyperhalina* described by Scott (1976) from southern Californian coastal marshes and by Petrucci et al. (1983) from coastal marshes at Venice, Italy (D.B. Scott, pers. comm. 2011).

We also searched the shoreline for other possible evidence of a tsunami, including marine boulders stranded above storm high-water level. The coastline between Agios Stefanos and Akra Tigani, facing northeastern Zini across the 3 km wide Kefalos Bay, (Fig. 3), consists principally of indurated Miocene tuffs. These tuffs form a low sloping terrace, with steeper weathered cliffs starting at 10–15 m above sea level (Fig. 4d). On the sloping terrace, up to 6 m above sea level, are a few subrounded boulders, quite different from the angular weathered blocks that have fallen from the cliffs at the inland edge of the terrace but lacking unequivocal marine bioencrustations.

In eastern Kefalos Bay, between Akra Tigani and Akra Chelona, seismic-reflection profiles show a series of head scarps in the marine sedimentary succession that are located along ENE apparently active faults (Fig. 5a). Below one of these scarps is an irregular erosional surface leading to a blocky submarine landslide on the deepest part of the basin floor (Fig. 5b). The submarine landslide covers an area of 15 km^2 and involves a volume of ~ 0.1 km^3 of sediment. Its age is likely Holocene, based on the lack of seismically-resolvable overlying sediment.

6. DISCUSSION: WAS THE ZINI ROCK AVALANCHE THE SITE OF POSEIDON'S SEISMIC EVENT?

The rock avalanche deposit on the east face of Zini is morphologically relatively fresh and has different vegetation cover compared to the rest of the east face. It appears to post-date the line of sea caves at 5–10 m above present sea level. This line of caves would represent the mid Holocene highstand of sea level at 6.5 ka, if the mean uplift rate was 0.75–1.5 m/ka, which is consistent with uplift rate of 0.9 m/ka in the Kefalos Peninsula discussed above. An older age from the last interglacial seems unlikely given the regional evidence for uplift.

There is no unambiguous evidence for a tsunami associated with the rock avalanche. However, as an example of the potential tsunamogenic capacity of such a rock avalanche, its area is about half that of the 2007 North Isla Mentirosa rock avalanche in Aisén Fiord, Chile. That event produced a 5–10 m tsunami wave in the deep-water fiord and ran up to elevations of at least 8 m at distances >4 km from where the rock avalanche entered the water (Naranjo et al., 2009). Tsunami size at Zini would depend on the detailed dynamics and size of the rock avalanche, which are unknown.

The medium sand bed at ~ 7 m above present sea level is unlike the modern sand-gravel barrier beach at Kamari in that it lacks granules, pebbles and molluscan debris. It is unlike the modern pocket beaches at the foot of Zini, again because of the lack of pebbles. We consider that it might be a tsunami deposit (e.g., Mamo et al., 2009), from which any carbonate microfossils have been leached by meteoric water, but positive evidence for this interpretation is lacking. Alternatively, it might have formed as a regressive beach deposit during late Holocene uplift, as coastal marshes were eroded.

The large subrounded boulders 5–6 m above sea level on the sloping terrace at Agios Stefanos (Fig. 4d) are unlikely to be storm deposits, as storm waves have a short fetch in the area (Fig. 1). The absence of subrounded boulders at the archaeological site at Agios Stefanos, only a few metres above sea level, also suggests that the boulders are unlikely to have been emplaced by storm waves. A tsunami origin is more likely, but the age of such an event is constrained only to be younger than the end of the post-glacial transgression a 6.5 ka but older than the 5th century CE archaeological site at Agios Stefanos.

In summary, although the occurrence of a tsunami associated with or post-dating the Zini rock avalanche is not demonstrated, there are several unusual features discussed above that are most readily accounted for by a tsunami. We are aware of the dangers of neo-catastrophism (Ambraseys, 2005) and suggest that borehole investigations of the coastal area at Kamari are needed to evaluate the tsunami hypothesis, and to provide a date if a tsunami deposit is present. The rock avalanche on Zini is located 2 km from ancient Astypalaia (Fig. 3), so that during the rock avalanche, the noise and likely dust cloud would have been alarming. If there were a tsunami with a 7 m high run-up, it would have risen to within a few hundred metres distance from Astypalaia and would have destroyed any flimsy harbour facilities and settlements at Kamari.

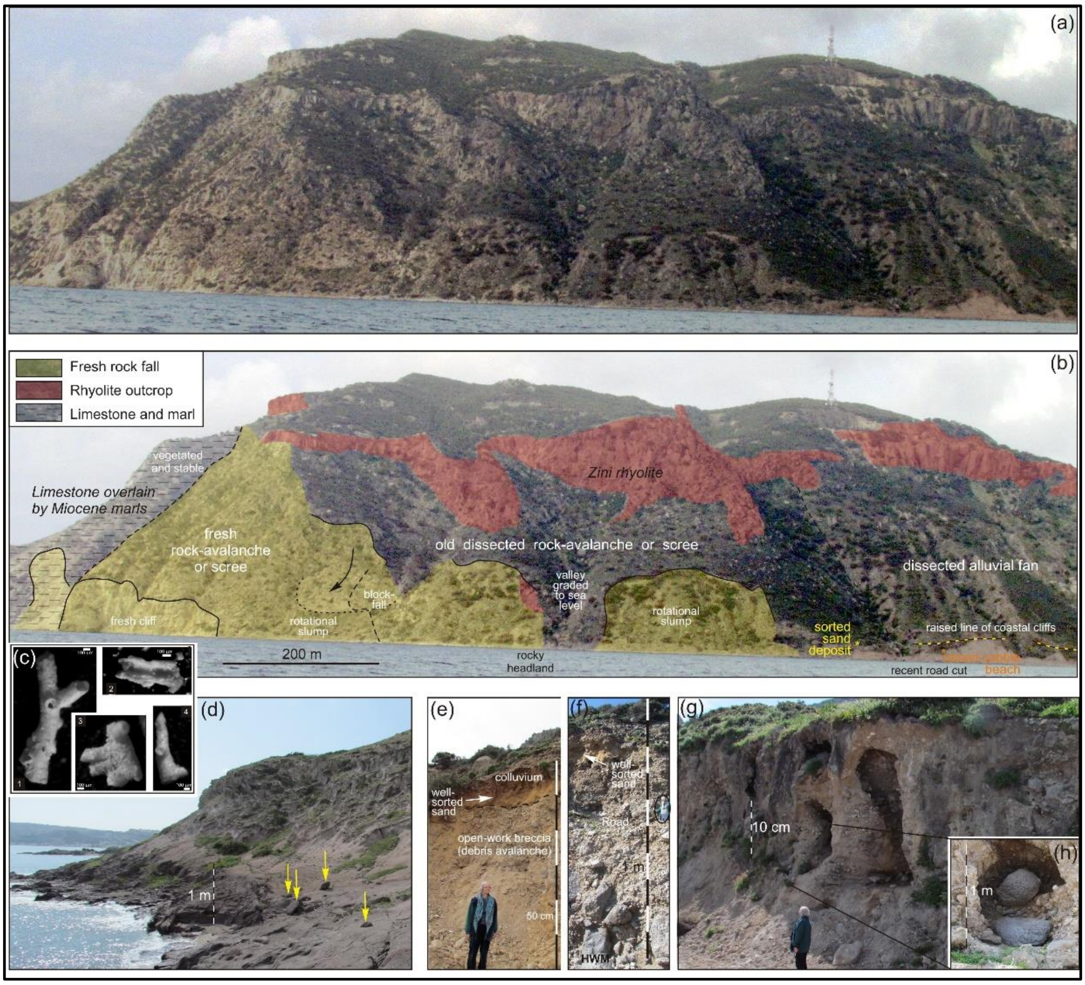

Fig. 4: (a) Photograph of the eastern side of Zini. **(b)** Interpretation of the geomorphology of the eastern side of Zini. **(c)** Microfossils from the sand bed in (e) identified as agglutinated foraminifera, probably from a coastal marsh. **(d)** Rocky coast in Miocene ignimbrites east of Ag. Stefanos (Fig. 3), showing bare rock platform up to 10 m above sea level, with rounded isolated boulders (yellow arrows) up to 6 m above mean sea level. **(e)** Road cut at the NE edge of Zini showing 50 cm thick sand bed overlying openwork breccia interpreted as old debris avalanche. **(f)** Another position on the road showing well sorted sand bed 8 m above HWM. **(g)** Line of raised cliffs along the northeastern flank of Zini at 5–10 m above sea level. **(h)** Fresh, rounded boulders in a cave in the cliffs.

The landslide on the floor of Kefalos Bay resembles in its size and morphology the 1956 submarine landslide along the northern coast of Anafi Island (Perissoratis and Papadopoulos, 1999), triggered by a Ms 7.5 quake on a normal fault that had ruptured over a length of about 25 km. There, the mass slid 5 to 6 km across the sea floor and left a typical "hummocky" folded surface, producing a 20 m high tsunami (Okal et al., 2009). By analogy, the Kefalos Bay submarine landslide would have initiated a major tsunami that could have severely damaged any harbour or coastal fishing settlement associated with the ancient city of Astypalaia. If triggered by the same earthquake as the rock avalanche on Zini, its tsunami effect would be indistinguishable from that of the rock avalanche.

In Greek and particularly Roman mythology, the Gigantes are commonly associated with volcanism. Polybotes, according to Strabo, lies beneath the volcanic island of Nisyros (or perhaps beneath Kos). In another Greek myth concerning volcanism, reported by Sophocles and Ovid, as Heracles was dying, he threw his servant Lichas into the sea, where he turned to stone and broke up, becoming the volcanic Lichades islands in central Greece. Papageorgiou and Stiros (1990) invoked an unknown volcanic eruption in historical times that ejected volcanic blocks to account for this myth. A volcanic origin for the Polybotes myth is in our view quite improbable. There is no evidence for any significant Holocene eruption on Nisyros (Marini et al., 1993; Vanderkluysen et al., 2005). Small phreatomagmatic eruptions in the central caldera and caldera inflation leading to uplift of a few metres (Stiros, 2000; Stiros et al., 2005) would not have produced blocks with a terrestrial fauna, neither would those blocks have acquired a marine fauna, nor would they have had a devastating impact on society. Likewise, the post-Neolithic thin air-fall tuff on Yali (Koutrouli et al., 2018), possibly as young as the second millennium BCE (Liritzis et al., 1996), would not have had the shock effect of a large rockfall. The Polybotes myth was centred on Kos: the burial of Polybotes beneath Nisyros provided an explanation for the minor phreatovolcanic activity there. An earthquake-triggered rockfall or rock avalanche that either caused or was synchronous with a fault- or landslide-triggered tsunami appears to be the most likely origin for the Poseidon-Polybotes myth. A rock avalanche on the northeast flank of Zini would have been particularly terrifying for the inhabitants of ancient Astypalaia, only 2 km distant, and the resulting tsunami would have hit the harbour and coastal settlements hard. We have been unable to find any datable material that would allow the timing of the Zini rock avalanche to be determined. Although methodologically unorthodox, we argue that the first depiction of the battle of Poseidon and Polybotes in ceramics around 560–540 BCE and its absence from the *Theogony* of Hesiod (ca. 700 BCE) provides a possible age estimate for the rock avalanche event.

7. CONCLUSIONS

Ceramic objects from the early 6th and late 5th century BCE portray Poseidon using his trident to kill Polybotes, while carrying a massive rock with both terrestrial and marine creatures on it. These images could be intended to represent a coastal segment of Kos that slid into Poseidon's realm, or the effects on land of a major tsunami. The disaster had a major artistic impact that lingered for at least two generations. The cause of the disaster was likely the mapped rock avalanche and possible tsunami deposits on the seaward slope of Zini mountain, only 2 km from ancient Astypalaia. A shallow landslide complex on the seafloor in the northeastern part of Kefalos Bay appears to be of Holocene age and may be related to this event.

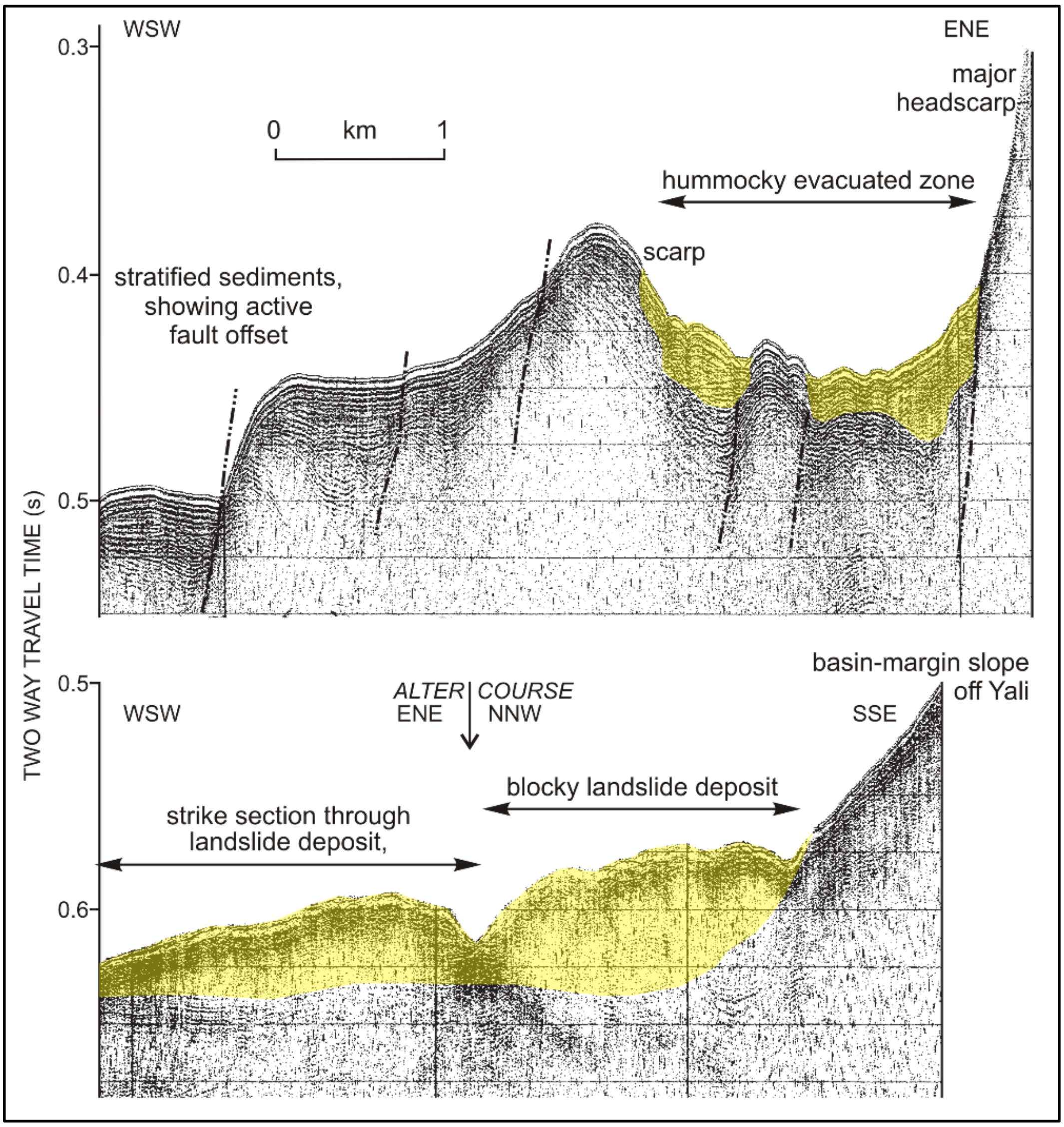

Fig. 5: Seismic-reflection profiles showing the submarine landslide in eastern Kefalos Bay. Locations shown as dashed black lines in Fig.1.

8. ACKNOWLEDGMENTS

GPP's work in Kos is funded by a Natural Sciences and Engineering Council of Canada Discovery Grant, most recently by DG 2016-04310. We thank IGME through Dr Constantine Perissoratis for making seismic reflection profiles available. We thank Dr George Anastasakis for discussions on the marine record and for providing the opportunity to photograph the east face of Zini. Reviews of a previous version, written before the death of Jelle de Boer, by S. Stiros, C. Morhange and an anonymous reviewer have been most helpful in revising this paper, without significantly changing those interpretations that derive from de Boer. We thank C. Perissoratis, S. Pavlides and an anonymous reviewer for their constructive critique of the present paper.

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