Post-Earthquake Architecture at Olympia: The Impact of Natural Phenomena upon the Builders' Attitude in the 4th Century BC

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Damaged or decayed parts of religious edifices in antiquity were repaired and restored. Their immediate or delayed remedy depended primarily on financial factors and the contemporary socio-political conditions. In the case of the temple of Apollo at Delphi, the raking cornice of the gable may have rested unrepaired for a long time,[1] although damaged guttae on the cornice of the Athenian treasury[2] and the limestone temple of Athena Pronaia[3] were fixed. At Olympia, repairs to the treasuries' roofs after the earthquake of 464 BC were postponed.[4] In the restoration of the temple of Zeus during the 1st century BC there is a two decades gap, justified either by the large scale of the operations or by the occurrence of two consecutive destructive events.[5] Difficult to explain is the reasoning behind the prolonged abandonment of the Echo stoa in an unfinished state for almost three centuries. One comes to realize that the structural context of ancient Greek sanctuaries was not at all still or steady. Particularly the panhellenic places of cult and pilgrimage were busy worksites, unceasingly transformed and developed. The fact that our ancestors prioritized works by their own criteria is inferred from the deliberate dismantling of the Altis monuments, in order to raise a fortification wall to defend the temple of Zeus against the Herulians' incursion in AD 267.

Building programs in antiquity comprised also emergency operations, such as replacements, repairs or consolidation necessitated by natural catastrophes,[6] an earthquake or a flood. Observing that natural calamities and their aftermath were not recorded in the extant inscriptions either from Delphi or from Olympia[7] (as a rectification account, a payment of extraordinary expenses or an assignment to some contractor), we rely on the actual architectural remains and on the spatial layout, in order to assess what the ancient builders learnt from the effects of a natural phenomenon, and whether any special building modes were practiced afterwards, to ensure durability, embodying the experience from a disaster. Equally difficult is to date a deformation, to designate a recorded ancient earthquake as responsible for a particular distortion. We may approximately calculate *when* certain blocks were re-employed but not precisely when the respective source-edifice was ruined. Besides, signs of damage would be concealed by the constant maintenance and conservation of religious monuments and, in some cases, by the sequence of remodeling, conversions or modifications.[8] The four renovations of the roof of the South stoa[9] at Olympia suggest the respective monument's longevity. Probably an earthquake incited the replacement of the metopes of the temple of Zeus, where Mummius had suspended shields.[10] The new metopes are distinct, showing no trace of attachment. Having 146 BC as a *terminus post quem*, the most plausible cause for this replacement was the earthquake of 40 BC, which released the temple's old roof tiles (of Parian marble) to serve as boards for the engraving of lists of priests or magistrates.[11] Then one of the anta-capitals of the temple was replaced[12] and the South stoa's colonnade and epistyle were rebuilt.[13] The sequence of earthquakes additionally burdens our struggle to correlate repairs with a particular event. Less than one century separated the earthquake of Sparta (464 BC) from that of Helike (373 BC).

Along a notional straight line, the distance between Helike and Olympia is 77 km. Between Helike and Delphi the distance is 44 km. The propagation of seismic waves and rippling spread the agitation, perhaps activating other faults, so both panhellenic sanctuaries sensed the shock of 373 to a certain degree. In the course of the 5th International Conference on Ancient Helike and Aigialeia,[14] and especially during the last session, dedicated to earth sciences, the communications by geologist Yannis Koukouvelas, seismologist Gerassimos Papadopoulos and sedimentologist Nikos Kontopoulos shed ample light to the tectonic events in 373 BC - in fact, agreeing with the conclusions we reached from the study of the archaeological and architectural evidence, presented during the same conference.[15] Since trial trenches along the overland Helike fault yielded no trace of distortion, upheaval or disturbance associated with that date, a submarine fault is more likely to have been activated, instead. Jelle De Boer has always preferred to refer to the rift *of the Corinthian Gulf*. Koukouvelas and Papadopoulos converge in favour of a submarine epicenter in 373 BC. The repercussions of an earthquake generated by a submarine rift would spread -and be sensed- much further. So, the disastrous effects upon distant areas, such as Olympia and Delphi discussed below, can be explained by a submarine fault rather than by theoretically increasing the intensity of the tremor in 373 BC.

The effects of an earth-tremor can also be localized, damaging a monument partially,[16] but more often they are legible on a group of buildings. The simultaneous application of a pattern of strengthening devices on a group of buildings can be interpreted as providence for structural coherence, resilience and durability, in the aftermath of a disaster. Looking for such evidence, we chose to examine the impact of the earthquake of 373 BC upon different sites, comparatively.

At least part of the temple of Zeus at Olympia was reconstructed[17] after that appalling tremor. Indicative of the labour and effort to economize is the recycling of building material, not only by re-shaping elements[18] but also by changing their position in the superstructure of the temple. Entablature elements were re-cut into column drums and, inversely, drums were trimmed to fit next to cornice blocks. Other blocks were abandoned unused, even though they had been re-worked into a shape entirely different from their original one (see a half capital preserving a regula from its former use as an epistyle). Sometimes material can help us recognize a replacement. Even though the marble krepis of the Echo stoa and the Philippeion declare an artistic preference, column capitals of yellow sandstone in the South stoa[19] and the Palaestra propylon, as well as sandstone blocks of the Echo stoa,[20] were carved during repairs. The quality of oolithic stone with shell inclusions (Muschelkalk) dropped in the course of centuries, as the quarry-layers were being exhausted. The finest oolithic was used in the temple of Zeus by Libon and in the treasuries. Architectural forms and treatment also help us identify certain members as replacement-blocks.[21] In this paper we focus on monuments of the 4th century BC and later, in order to decipher and gauge the architects' post-seismic reaction.

Like Delphi, Olympia reached a peak of construction in the 4th century BC. We should not overlook the political grounds for remodeling in 362 BC, when Elis regained administration of the sanctuary.[22] Nor should we underestimate the sudden availability of ready-made material, since the dismantling of only the façade of the temple of Zeus yielded 573 cubic meters[23] of fine Muschelkalk, quite soft to re-shape. This material was subsequently re-employed in various monuments[24] - a frequent and legitimate practice in ancient Greek sanctuaries, on condition that the recycled stones remained within the worshipped deity's domain, on sacred premises. Blocks possibly from the archaic Telesterion were re-used in the precinct of the Eleusis sanctuary, and others in the construction of a bridge on the Sacred Way.[25] Notable is the word αναλίσκοντες (consuming) as if the stones would be wasted in an inferior new place. A decree of 324 BC permits exploitation of presumably obsolete or unfinished blocks from the temenos of Dionysos in the theatre-stage at Piraeus.[26] Between 335 and 322 BC builders were allowed to use blocks from the theatre of Oropos[27] in the construction of a drain in the bath of the sanctuary of Amphiaraos. In such a context, we understand why triglyphs from Zeus temple at Olympia were split and hollowed out, to serve as a conduit[28] between Echo stoa and the South-Eastern edifice.

The South-Eastern edifice, with the sacred precinct of Hestia[29] and its innovative tongue-shaped spouts,[30] was built after 373 BC nearly exclusively of architectural blocks from the temple of Zeus,[31] adjusted by stone-cutters to the required, much smaller dimensions. Its foundations, too, contained re-used material together with stone-chippings (λατύπη) probably cleared from some workshop.[32] Unfortunately, both the SE edifice and the precinct of Hestia were brutally demolished in the 1st century AD, to make room for their successor, Nero's villa, which blurred the picture since it eradicated evidence of the post-373 BC era.

During the 4th century BC a chain of porticos[33] were inaugurated at Olympia. Renowned is the Echo and the South stoa. Less known is another stoa, remains of which are visible beneath the Leonidaion. Architectural spolia from the temple of Zeus (fragments of cornice and column drums of fine oolithic), plausibly released during its post-373 restoration, were embedded in the foundation of this unidentified portico. We consider this likely to be the 'Stoa B', which, in turn, lent its colonnade and superstructure to the Echo stoa, despite their unequal dimensions.[34] Stoa B is not mentioned by Xenophon in the famous passage (*Hellenika* 7, 4.28) where he delineates the monumental topography of in the eastern sector of the Altis in 364 BC, and it was dismantled or destroyed prior to 330 BC (when Leonides offered his dedication).

After 373 BC an Ionic porch connected the two absidal components of the council-house.[35] This dating is disputed[36] on stylistic grounds and on the hypothesis that the cornice from Zeus temple, found underneath the porch, had been removed earlier, during the earthquake of 464

Figure 1. *Part of the Philippeion epistyle at Olympia showing traces of repairs.*

BC – in which case, it belongs to an older phase of the temple. Even if the porch was erected in 460 BC, a second series of a clay roof has been attributed to it, seemingly imitating the original motif. By comparison, however, it appears rather hastily manufactured, lacking the embroidery-like execution of the original sima. Instead, the second series is rather flat carved off a compact, solid ground without the cut-out relief outline of the original roof. It is very likely to represent some rectification after 373 BC.

Roofs can be classified among highly vulnerable architectural registers, as deduced from the quantity and sequence of lion-head waterspouts bordering the roof of Zeus temple. Luckily erosion, which is not evident on clay roofs, can be a clue on marble. At Delphi a second series of sima, ascribed to the tholos in the sanctuary of Athena Pronaia, entailed the theoretical restoration of the rotunda's roof as two-storeyed with two concentric simas of unequal diameter.[37] However, the low degree of weathering on one of the two series allows us to assume that this sima was not old enough to be replaced but, instead, some destruction necessitated its replacement.[38] The earthquake of Helike could have been the cause, given that the rotunda was erected in circa 380-375 BC.

Ancient masons and architects learnt from the traumatic experience of an earthquake, as reflected in the variety of methods and techniques, which they adopted afterwards. The use of girders and multiple clamps or different types of clamps can be interpreted as an effort to increase stability and structural coherence. The tall monument dedicated by Ptolemy in the early 3rd century BC secured the articulation of its columns by means of firm doweling.[39] Its

Figure 2. *Triglyph-blocks from the Echo stoa at Olympia with roof-beam sockets.*

behavior during an earthquake would be worth monitoring, given that normally column drums were allowed to rotate. At Olympia the employment of T-clamps in foundations began rather late,[40] practiced first in the propylon of the Pelopion and in the Metroon (early 4th century BC). We assume that the driving force in its adoption was another earthquake, possibly that of 402 BC, attested to by Xenophon, *Hellenika* (3, 2.24)[41] and by at least two damaged roofs at Olympia, one ascribed to the workshop of Pheidias[42] and another tentatively associated with the Theokoleon.[43] However, from the mid-4th century BC onwards every building was systematically equipped[44] with dowels, including the Cronion retaining-wall and the thick eastern precinct of the Altis with its interlocking headers and stretchers and with stepped landings, like the eastern precinct of the Apolloneion at Delphi. Numerous clamps fastened the foundations of the Echo stoa,[45] too.

On its exterior the epistyle of the Philippeion features hooks[46] placed horizontally across vertical joints, to fasten cracked or adjoining blocks loosened apart (Fig. 1). Similar hooks mended the corner epistyle and triglyph of the temple of Zeus,[47] the frieze of the Echo stoa,[48] and perhaps also pedimental sculpture at Delphi.[49] The 'patch' on the Philippeion epistyle, no different from a 'patch' in the limestone temple of Athena Pronaia,[50] probably represents another ancient repair. These consolidation operations could be concealed under a coat of fine

Figure 3. *Buttressed toichobate of the Gymnasium east stoa at Olympia.*

plaster (stucco). Buildings of the 4th century BC at Olympia (the Philippeion, the South stoa and the Echo stoa,[51] among others) feature a supposedly indigenous montage technique, the doweling of three blocks at their edges, near the joints. For practical reasons, lead was poured in only two of the three sockets.

Roof reinforcement also reveals foresight and precaution on the builders' part. In the limestone temple of Athena Pronaia, 380-370 BC, the size of the sockets implies thick roof-beams.[52] At Olympia, the treasury of Megara acquired additional roof-beams[53] in smaller sockets, as an afterthought. The cutting of beam-sockets on the rear side of triglyphs of the Echo stoa (Fig. 2) allude to an abbreviated/shortened entablature and lowered roof, perhaps dictated by the excessive length of the stoa. Similarly the beam-sockets in the limestone temple of Athena Pronaia were cut at frieze-level. Roof-beams of considerable length are also inferred for the treasury of Gela at Olympia. Common denominator is the setting of the latter two buildings, each on a terrace at the foot of a hill, having to withstand the thrusting forces of the slope.

Despite the flat terrain at Olympia, buttresses were judged necessary after the 4th century BC. Along the outer side of the stone toichobate of the Gymnasium east stoa (perhaps a Hellenistic xystus) we notice projections at regular intervals, where the lowest stone-block was cut at a right angle, to form a projection and to support upper courses buttressing the stoa wall (Fig. 3).

Figure 4. *Detail of the Kladeos wall at Olympia.*

We also notice that, despite the leveled ground at Olympia, ancient builders did use retaining-walls, all the more so, stepped. Hardly discernible is the stepped cross-section of the west retaining-wall[54] of the classical Stadium, later embedded in the foundations of the Echo stoa. At some points the Kladeos embankment-wall was stepped, too.[55] The treasuries' terrace-wall, built in the mid-4th century BC,[56] exemplifies the technique of a graded cross-section.[57] Worth noting are the traces of analemmata behind -and slightly later than- the treasuries of Selinus, Gela and Sicyon,[58] which were also graded. Noting that dedicators held responsibility for the maintenance and repairs to their ex-votos,[59] we would argue that dedicators or commissioners originating from an area of seismic risk were more conscious of the danger.

Behind the treasuries, the wall containing the foot of Cronos hill[60] displays a whole pattern of reinforcing and solidifying devices: a row of strut-pillars against stepped courses dowelled to each other, with blocks with alternating joints and anathyrosis on three sides, additionally fastened by dove-tail clamps and dowels.[61] This robust structure, probably contemporary with the east Altis precinct and following the events of 373 BC, epitomizes the experience from the disaster. Apparently the NE sector of the Altis represents one substantial building program of the mid-4th century BC.[62] After 373 BC the treasuries' terrace was bracketed between two nearly parallel retaining-walls. It is probably not fortuitous but, instead, the result of deliberate site-planning that this scheme duplicates the bracketing of Apollo temple at Delphi by the grand polygonal wall and –notably, after 373 BC- the *Ischegaon* wall, to contain earthwork to the north.

Solid foundations contributed significantly to a structure's coherence. Exemplar is the sturdy foundation of the South stoa and particularly its *proedria* with interlocking headers and stretchers.[63] Substructures sometimes included second-hand blocks or were filled in with flakes from stone-cutting, as in the case of the South stoa[64] and the SE edifice with the Hestia shrine,[65] all erected after 373 BC. Besides filling void space, stone-flakes would help filter the moisture.

The practice of re-employment perpetuated. Newly carved blocks, used as replacements during the post-373 restoration, were recovered immured elsewhere (see anta-capitals from the temple of Zeus).[66] By contrast, Delphi does not display such a wide dispersal. Blocks from early archaic monuments were re-employed in Cassotis fountain[67] and some poros blocks from the old Apollo temple found a place in the Theban treasury's substructure.[68] Customarily, however, at Delphi the dismantled members were laid in the foundation of the successor-building, e.g. the temple of Apollo and the Sicyonian treasury, in which case the commissioners were entitled to the management and disposal of building material from the monopteros of Cleisthenes and the tholos of Sicyon. Spolia in the substructure of the Sicyonian treasury at Olympia, too, suggest a predecessor.[69]

Deliberate and conscious was also the choice and mixture of building material at Delphi and Olympia. The conglomerate foundations of the South stoa at Olympia supported an oolithic superstructure, which proved sturdy and resilient enough[70] to be immured in the Late Roman fortification-circuit. Likewise, the artificial embankment of river Kladeos was built of conglomerate stone (Fig. 4). It is regarded as Cyclopean by J.Knauss,[71] archaic by K.Herrmann, of the mid-4th century BC by H.Schleif and A.Mallwitz.[72] Some groundwork must have been laid early, to control river flow. Seeing the variations in its masonry and the use of conglomerate, part of its construction reasonably postdates the earthquake. And this brings us to counter-erosion provision, which at Delphi is conspicuous in the stone drains running behind the xystus and the grand west stoa 'of the Aetolians', both built against sloping ground. This practice was first adopted in the 4th century BC[73] and later by the Pergamene architects at Delphi, behind the stoa of Attalos. The duct between the Stadium and the Echo stoa at Olympia[74] is reminiscent of such works.

All treasuries at Olympia date in the archaic period. Traces of repairs or replacement[75] in elements of their superstructure are difficult to attribute to a particular cause and we should reckon also with the earthquake of 464 BC, which damaged at least parts of the treasuries' roofs.[76] Yet, their post-373 analemma implies their state of preservation: no one would care to secure the treasuries, if they had been ruined. Since they were not superposed by any structure and their terrace not occupied by another installation, the treasuries must have been maintained. Among the debris recovered in the earth-fill of the early classical Stadium, various roof revetments and an archaic entablature of white limestone and of west Greek provenance were attributed to treasuries,[77] suggesting their replacement or renewal. Besides, most of them supplied the Late Roman fortification[78] with building material wherefrom the entire façade, inscription and pediment (gigantomachy) of the Megarian treasury were retrieved.[79]

By comparison, the majority of treasuries at Delphi were archaic. Yet, the most recent two,

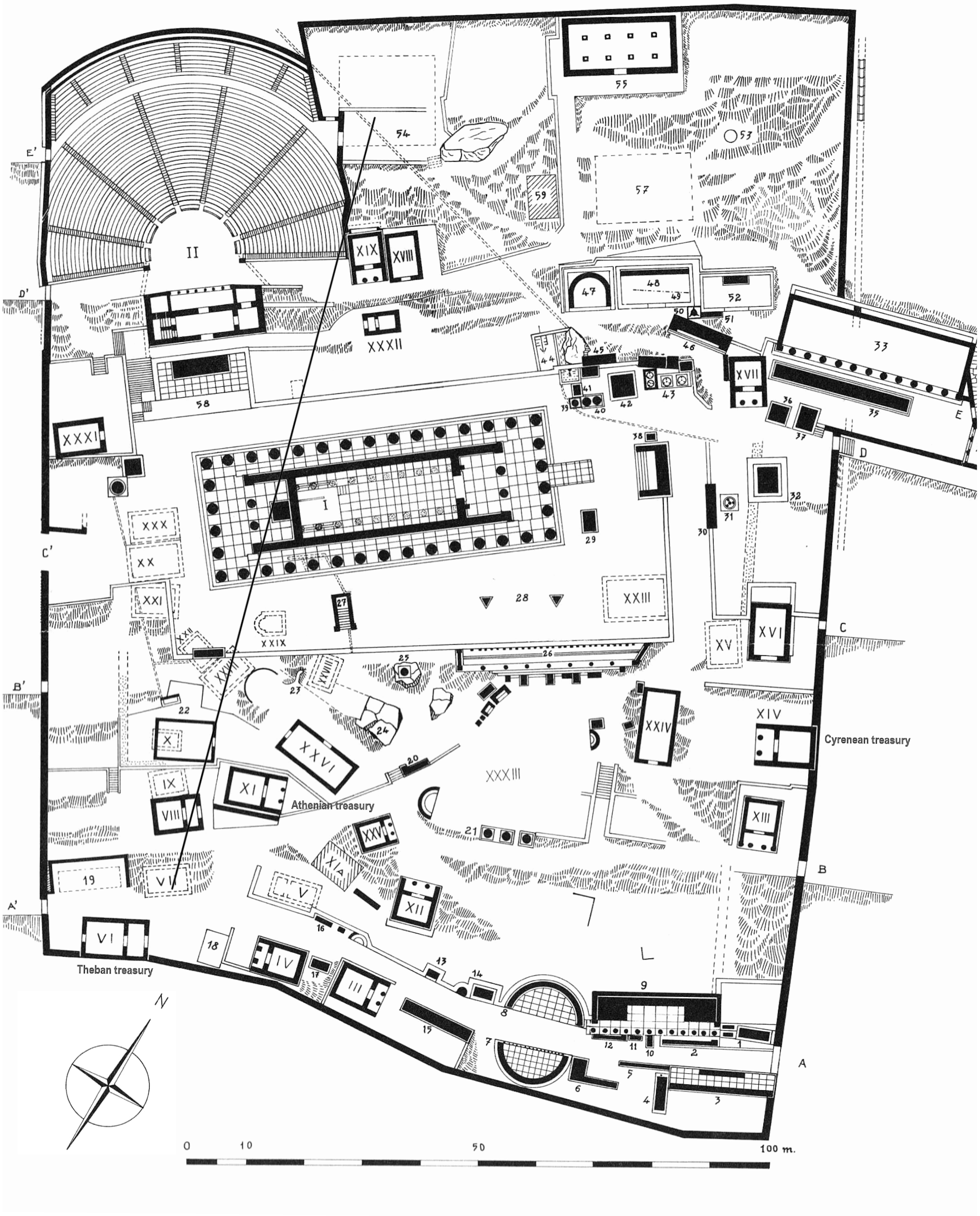

__Figure 5.__ Plan of the Delphi sanctuary of Apollo (confined within the boundaries of the sacred precinct) showing the alignment of traces of damage or distortion along a straight line running N/S.

Figure 6. *Marble figure from the pediments of the Athenian treasury at Delphi.*

dating in the 4th century BC, betray concern for integrity. Blocks of the Theban treasury were from the outset braced with iron girders,[80] while the Cyrenean one (after the mid-4th century BC) clings onto the eastern precinct of the Apolloneion. With regard to the archaic treasuries situated west of the Athenian one, we have already drawn attention[81] to their dislocated foundations, caused either by torrential flood or by liquefaction activated usually after an earthquake[82] with repercussions such as land sliding. Plausibly this was another consequence of the catastrophe in 373 BC. This string of treasuries falls into a series of damaged points in the sanctuary of Apollo, which are axially aligned (Fig. 5). If prolonged northwards, the string of deformation, crossing through the SW corner-buttress of the temple, reaches the monument by the theatre (atlas *609) destroyed perhaps while still unfinished. So far, we have not observed any deformed or shifted foundation at Olympia. No building could survive such damage. So, a shrine to Asklepios was established in the 4th century BC in the sector west of the Athenian treasury at Delphi. Right opposite to the Boeotian treasury (with shifted foundations), its Theban successor was erected supposedly to commemorate the battle at Leuktra, two years after the 373 BC earthquake.

Other earth-tremors were to follow[83] in 40 BC, AD 300 and later. In the complicated process of evaluating what the ancient architects learnt from each natural phenomenon, we reach the conclusion that building activities in the second half of the 4th century BC breathe an overall tendency for corroboration, reinforcement and reduction of vulnerability. The fact that precaution, as well as distortion or deformation, are more obvious at Delphi can be justified by geomorphology and the abrupt ground inclination. Opposite to the alluvial sediments deposited by rivers at Olympia, Delphi features torrential action, rock-falls, liquefaction and landslides or soil-creep that may have swept foundations. At Delphi the underground water-level may have been disrupted due to tectonic movement, since the springs were aligned along a N/S fault running vertical to the rift of the Corinthian gulf.[84] The difference in landscape and geological properties (sandstone at Olympia, carstic limestone at Delphi) explains why the embedding of ground-protruding rocky masses in buildings' foundations, a reinforcement technique adopted diachronically at Delphi, was not applied at Olympia.

On the other hand, a feature shared by Delphi and Olympia was the lack of inscribed building accounts involving post-earthquake works, the lack of reference to natural calamities *per se*. Let us note one more common denominator: At Delphi the natural phenomena pervade mythology, literature, the historic repulsion of barbarian foes (the Persians, the Gauls)[85] with huge rocks still standing as witnesses allegedly of divine apparition but literally of natural phenomena. Earthquakes were personified in art: the poros pediment of the Alkmaeonid temple of Apollo portrayed goddess Athena annihilating Εγκέλαδος,[86] as on the gigantomachy relief (Akr. 120) from the Athenian Akropolis and on sherds of a white kylix in Eleusis Museum. We propose an analogous subject-matter for the Athenian treasury's pedimental composition, if the fragmentary fallen figure is correctly interpreted as an injured giant (Fig. 6). By analogy at Olympia, coping with natural phenomena was allegorically represented in the relief metope from the pronaos of Zeus temple. It alludes to works of hydraulic engineering, created by mortals but credited to semi-god Herakles. The iconographic restoration proposed by J.Knauss,[87] with Herakles handling a crowbar (rather than a shovel), in order to loosen the joints of the Kladeos dam and to divert water-flow, sounds fascinatingly convincing.

CONCLUSION

Summarizing our remarks, we point out that unscheduled building projects in antiquity could have been dictated by natural disasters. By reading the architectural remains, we may evaluate what the ancient builders learnt from such catastrophes and which –probably new-building practices they adopted subsequently. During the reconstruction of the temple of Zeus at Olympia, after the earthquake of 373 BC, some of its original architectural members were re-used (recycled), while others were re-carved to fit a different place/register either in the temple itself or in other monuments of the Altis. Re-usage of structural parts was practiced also (during the 4th century BC) at Eleusis, Piraeus and Oropos, as inferred from epigraphic evidence, and at Delphi, as suggested from the study of architecture. Especially after the earthquake of 373 BC (with an epicenter in the fault of the Corinthian Gulf, in the submarine region of Helike, as revealed by up-to-date research) certain monuments at Olympia show signs of reinforcement in the clamping system and roof beams, the application of idiomatic indigenous modes of assemblage, the employment of buttresses and retaining walls, the preference for solid foundations and specific kinds of stone, the measures for counteracting (or, preferably, preventing) corrosion, and the overall –clearly preconceived- layout. We observe that, during the second half of the 4th BC, building enterprises betray a tendency for reinforcement, precaution, coherence and static adequacy. Despite their differences, the two panhellenic sanctuaries –of Olympia and Delphi- share some common threads: (1) the total lack of accounts/

epigraphic records of the post-earthquake restoration projects, as well as of the calamities themselves, and (2) the personification of natural phenomena and the allegorical allusions to them in architectural sculpture.

ACKNOWLEDGEMENTS

Investigation of this topic at Delphi, among several other sites, is in progress with satisfactory results (Partida 2013). With regard to Olympia, I am deeply obliged to the late Klaus Herrmann for an invaluable discussion on the site, reviewing some of the actual remains. My sincere thanks go to Joachim Heiden, of the German Archaeological Institute, who willingly facilitated my study, and also to the 7th Ephorate of Prehistoric & Classical Antiquities for their kind hospitality. The results of the investigation presented hereby were briefly communicated in the course of the *1ο Αρχαιολογικό Έργο Πελοποννήσου* (Tripoli, November 2012) receiving wide acceptance. Proceedings have not been published, as yet.

NOTES

1. Judging by the degree of erosion on the knee and other parts of the central pedimental figure (Apollo). Otherwise, this statue should be restored on the apex.
2. Audiat 1933, 42.
3. Michaud 1977, fig. 134-135.
4. Heiden 1995, 165. Such attitudes and the unfinished state of the Echo stoa seem to overrule the criterion of aesthetics discussed by Radis 2012, 304-311.
5. In 56 and 36 BC. Willemsen 1959, 89; Treu 1897, 93ff.
6. Incidents of fire were frequent, sometimes following an earthquake. On the combustibility of ancient temples: Partida 2012.
7. Ancient authors' references are also restricted. Mallwitz 1999, 239, 246.
8. The Leonidaion, consecrated in 330 BC, was subject to radical changes and re-arrangement by the Romans.
9. Heiden 1995, 129. After an earthquake in the 1st century BC, the stoa columns and epistyle were rebuilt: Willemsen 1959, 82.
10. Grunauer 1981, 261, 277.
11. Mallwitz 1972, 110, 233 and 1988, 26.
12. Herrmann 1981, 302-317.
13. Willemsen 1959, 62.
14. *Poseidon, God of Earthquakes and Waters* (Helike V, 4-6 October 2013, Aigion, proceedings in press).
15. Partida 2013.
16. Both short sides of the temple of Zeus were restored. The degree of damage might be relevant to the axis of the temple in relation to the seismic wave's direction.
17. Treu 1897; Dinsmoor 1941; Mallwitz 1972, 233-234; Grunauer 1971; Willemsen 1959; Herrmann 1981. Some pedimental figures were renewed, while architectural blocks were re-used in other monuments. Hennemeyer [2010, 188-189] refers to repairs to the temple soon after its completion, in the mid-5th century BC, under unknown circumstances.
18. Grunauer 1971, fig. 18-19.

19. They represent repairs in the 3rd century AD, after an earthquake. Mallwitz 1972, 243.
20. Koenigs 1984, 7.
21. Column-capitals of the opisthodomus display echini of variant profiles. Capitals of the age of Diocletian feature separate abacus and uneven annuli. An analogous impression of hasty, hardly refined workmanship is gained from the grotesque latest series of lion-head spouts from the temple.
22. Repairs to the sima of the temple were also caused by hostilities [Willemsen 1959, 62] recounted by Xenophon, *Hellenika* 7, 4.31ff. Kondis [1958, 3-14, 35-53] reviewed changes to the sanctuary's spatial layout and arrangement, with reference to political and military circumstances, the rivalry and fight between Elis and Arcadia in 364 BC.
23. Grunauer 1981, 280 n.129.
24. Grunauer 1971, 131.
25. Marginesu 2008, 45.
26. Marginesu 2012, 154.
27. Petrakos 1997, 192-194.
28. Dinsmoor 1941, 404, 417; Mallwitz 1999, 250 and 1981a, 109 n.21.
29. Kondis 1958, 14-27.
30. Mallwitz 1972, 203, fig. 163; Heiden 1995, 123.
31. More precisely, from the façade of Libon's temple: Grunauer 1981, 280 n.129; Mallwitz 1981a, 109-110 and 1999, 250.
32. Mallwitz 1981a, 110.
33. The stoa of Agnaptos (named after its architect, according to Pausanias, *Ελλάδος Περιήγησις* V, 15.6) has not yet been located. Dispersed fragments of dentil cornices are tentatively attributed by Klaus Herrmann to the superstructure of stoas. Especially in the 4th century BC stoas symmetrically demarcated sacred or profane spaces.
34. Koenigs 1984, 4, 33-35. In the Echo stoa the joints of the epistyle blocks are not centered exactly above the middle of the abacus but a few centimeters off, which implies adjustment to the smaller dimensions of the second-hand blocks. The abbreviated intercolumniation bays and the modified proportions may be relevant to the disaster of 373 BC [Mallwitz 1972, 199]. Koenigs mentions the possible location of Stoa B beneath the South stoa but Kunze and Schleif [1938/39, 32] tentatively place the Agora there.
35. Mallwitz 1972, 239.
36. Heiden 1995, 119.
37. Proposed by H.Pomtow in 1912. For this and subsequent drawn restorations: Marmaria 1996, 60-63.
38. And the roof had the shape of a Chinese hat: Laroche 1992, figs. 8-9.
39. Professor Herrmann kindly showed me the members prepared for anastylosis. The pattern of dowels is unusual.
40. Perhaps before 388 BC. Mallwitz 1981a, 118 n.34-36.
41. Heiden 1995, 52, 165. Let us add the indications for some remodeling of the temple cornice during the first half of the 4th century BC [Grunauer 1981, 279], which might be due to that earth-tremor.
42. It consisted of two series, suggesting a rapid replacement by the team of ceramists who had manufactured the original roof. Heiden 1995, 49.
43. Heiden 1995, 52, nr 14.
44. Herrmann 1999, 386
45. Mallwitz 1972, 195.
46. Note also the increase of dowels at cornice and epistyle level: Van de Löcht 2009, 32, 64.
47. Dinsmoor 1941, 405; Grunauer 1971, 119.

48. Koenigs 1984, 68.
49. Note the Π-shaped hooks on the torso of a Maenad in the west pediment of Apollo temple, attributed by Croissant and Marcadé (1972, 892-893) to repairs by Emperor Domitian in AD 84, using marble from the Cyclades.
50. Michaud 1977, fig. 149-150.
51. Koenigs 1984, 66.
52. Without an interior colonnade and with an excessive length (10.30 m) to span, the temple roof ought to be strengthened. Michaud 1977, 106-107.
53. Herrmann 1974, fig. 2. He accepts some repair to the Megarian tresury but its date is hard to determine.
54. A footing in isodomic masonry. Mallwitz 1981a, 105; Koenigs 1981, 366-369, fig. 112 and 1984, pl.78.
55. Mallwitz 1981, 376.
56. Mallwitz 1981a, 103 n.8.
57. For its restoration: Mallwitz and Van De Löcht 1980, 361-367.
58. Herrmann 1999, 368-369.
59. Partida 2015a, 878.
60. Herrmann 1999, 370-381.
61. The metal used for clamps and dowels of this wall alone weighed 3.5 tones: Herrmann 1999, 381 n.43.
62. For the extent and scale of the undertaking which transformed the eastern sector of the Altis around the middle of the 4th BC: Kunze and Weber 1948, 492. Also for this sector's remodeling: Koenigs 1981, 366-369 and 1984, 2; Herrmann 1999, 367, 387.
63. Kunze and Schleif 1938/39, fig. 18.
64. Kunze and Schleif 1938/39, 30.
65. Here the stone-flakes were produced while re-working blocks from the temple of Zeus: Mallwitz 1999, 246.
66. Herrmann 1981.
67. Partida 2000a, 175-176, 267-271.
68. Partida 2000, 537.
69. Hermann 1980, 351. A cornice-fragment of yellow sandstone is attributed to this predecessor: Herrmann 1976, 325 and 1992, fig. 9.
70. Mallwitz 1972, 241-244. Heiden [1995, 129] describes four renovations at roof-level, the latest coinciding with Roman repairs. For its rebuilt colonnade in the 1st century BC: Willemsen 1959, 82.
71. Knauss 2004, 89.
72. Mallwitz 1981, 373; 1981a, 119 n.38.
73. The original xystus of the Delphi gymnasium, with a stone drain running behind it, slightly inclined in opposite directions, dates in the 4th century BC [Partida 2004, 151-185]. The grand west stoa is discussed as an arsenal of the 4th century BC, which later sheltered ex-votos of the Aetolians, although it is quite likely to have been erected by them in the 3rd BC [Partida 2015a, 877 and 2015b, 37-38]. The well-preserved conduit behind it may have not just collected rainwater dripping off the roof but also diverted water cascading from the slope. It is also possible that some other conduit from an upper level of the Apolloneion (perhaps the theatre) terminated behind the west stoa. A segment of this uncovered drain of gradient, articulated stone-slabs is visible beyond the west precinct.
74. From Cronos hill it ran towards the thermae in the direction of river Alfeios. Kunze and Schleif [1938/39, 36] describe a drain following an arched course through the Altis, beginning at the Pelopion.
75. Multiple clamp-sockets και holes for hoisting devices, which appear random (rhythm-less along a course of blocks), suggest maneuvering and replacement. Such random lewis-holes have been ob-

served in the treasuries of Megara and Gela: Kunze and Weber 1948, 495. Note that the former preserves ice-tong lifting holes, too, on its frieze blocks [Herrmann 1974, pl. 37.2-3]. The T-clamps in wall-blocks from the 'Pilaster-Bau' [Herrmann 1976, 340] did not fasten every joint.

76. Mallwitz 1999, 240; Heiden 1995, 164-165.
77. Herrmann 1976, 331-334 and 1992, 30. The limestone entablature is tentatively associated with the treasury of Sybaris. However, who would undertake repairs after 510 BC, when the city-dedicator was destroyed by Croton?
78. The Sicyonian treasury certainly stood until then [Herrmann 1992, 28-31], while the Cyrenean one, by the age of Pausanias [VI, 19.10], sheltered statues of Roman emperors.
79. Herrmann 1974, 75 and 1992, 31.
80. Partida 2000a, 196 and 2000, 537, 560.
81. Partida 2000a, 271, 293-294, 304-305.
82. Stiros 1996, 135.
83. The massive damage to the pediments of Zeus temple, ascribed by Younger and Rahek 2009, 93-95 to a cataclysmic event in the 2nd century BC, was in fact inflicted by the earthquake of Helike. Younger and Rahek follow Dinsmoor's [1941] dating of the event in the Hellenistic period.
84. Partida 2000a, 267-271 and 2004, 114-127 (with bibliography). A tectonic movement would have been more drastic than the edict by Emperor Theodosios in enforcing silence of the λάλον ύδωρ at Delphi. Cataclysmic earthquakes shook up the eastern Mediterranean in AD 365 and 551.
85. Heroes or divinities throwing rocks at enemies echo natural phenomena. For military epiphanies: Kendrick Pritchett 1979, 25, 30.
86. Picard and De La Coste Messelière 1931, 26-32.
87. Knauss 2004, 76-77, 90-93.

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ABSTRACT

POST-EARTHQUAKE ARCHITECTURE AT OLYMPIA: THE IMPACT OF NATURAL PHENOMENA UPON THE BUILDERS' ATTITUDE IN THE 4th CENTURY BC

Unscheduled building projects in antiquity were dictated by natural disasters. By reading the architectural remains, we evaluate what the ancient builders learnt from such catastrophes and which –probably new- building practices they adopted subsequently. Re-usage or recycling of architectural elements is recorded during the 4th century BC at Olympia, Eleusis, Piraeus, Oropos, Delphi. Especially at Olympia we observe that, following the earthquake of 373 BC (with an epicenter in the submarine region of Helike), building enterprises betray a tendency for reinforcement, precaution, coherence and static adequacy. In a brief comparison between two panhellenic sanctuaries –of Olympia and Delphi- we note at least two common threads: (1) the total lack of accounts of the post-earthquake restoration projects, as well as of the calamities themselves, and (2) the personification of natural phenomena and the allegorical allusions to them in architectural sculpture.

ΠΕΡΙΛΗΨΗ

ΜΕΤΑΣΕΙΣΜΙΚΗ ΑΡΧΙΤΕΚΤΟΝΙΚΗ ΟΛΥΜΠΙΑΣ: Ο ΑΝΤΙΚΤΥΠΟΣ ΦΥΣΙΚΩΝ ΦΑΙΝΟΜΕΝΩΝ ΣΤΗ ΝΟΟΤΡΟΠΙΑ ΤΩΝ ΑΡΧΙΤΕΚΤΟΝΩΝ ΚΑΤΑ ΤΟΝ 4ο αι. π.Χ.

Έκτακτα οικοδομικά προγράμματα στην αρχαιότητα απαιτήθηκαν λόγω φυσικών καταστροφών. Από τα αρχιτεκτονικά κατάλοιπα μπορούμε να εκτιμήσουμε τι διδάχτηκαν οι αρχαίοι κτίστες από τις απώλειες, και ποιες ενδεχομένως ιδιαίτερες οικοδομικές πρακτικές εφάρμοσαν εν συνεχεία. Επανάχρηση ή ανακύκλωση δομικών στοιχείων σημειώνεται κατά τον 4ο π.Χ. αιώνα σε Ολυμπία, Ελευσίνα, Πειραιά, Ωρωπό, Δελφούς. Ειδικότερα στην Ολυμπία παρατηρούμε ότι, μετά το σεισμό του 373 π.Χ. (με επίκεντρο το υποθαλάσσιο ρήγμα στην περιοχή Ελίκης), η δόμηση διαπνέεται από μια τάση επίρρωσης, πρόληψης, εξασφάλισης της συνοχής και στατικής. Σε μια συνοπτική σύγκριση δύο πανελληνίων ιερών -Ολυμπίας και Δελφών- βλέπουμε ότι κοινός παρονομαστής είναι αφ' ενός η έλλειψη καταγραφής τόσο των μετασεισμικών εργασιών όσο και των ίδιων των καταστροφών, αφ' ετέρου η προσωποποίηση των φυσικών φαινομένων και οι αλληγορικοί υπαινιγμοί σε αυτά μέσα από την αρχιτεκτονική γλυπτική.