Report to Ground Check Project

"The Kephissos fluvial system as an indicator of climatic change in central Greece from the Late Bronze Age to the Late Antiquity (3.2 – 1.4 ka BP)"

1 Introduction

Fluvial systems act as ideal response systems to climatic change – they not only reflect, but often multiply the effects of even small climatic changes, thereby offering key archives for high resolution reconstructions of Holocene environmental history under the influence of climatic change at various scales (Brown 1997, Dusar et al. 2012, Finne et al. 2011; Macklin and Lewin, 2003). Evidence for environmental changes triggered by large scale events, such as climate change, can be approached by inter-site comparison and the identification of regional patterns (Benito et al., 2015).

Mediterranean fluvial systems are characterized by wet and dry episodes of decadal to centennial duration with abrupt transitions, which are related to changes in atmospheric circulation. On a seasonal temporal scale, they are characterized by a high variability of the seasonal distribution of precipitation, causing maximum discharge during autumn/winter and minimum discharge during the summer months. Depending on geology, morphology and soil/vegetation cover Mediterranean fluvial systems tend to extreme seasonal and annual discharge variability with peak discharges frequently reaching more than 50 times those of the average flows.

In a meta-data analysis Benito et al. (2015) identified 6 region-wide flooding events in the Eastern Mediterranean between 7.8 and 0.6 ka BP, with 4 extreme events found in rivers in Greece at 7.8-7.2 ka BP, 1.9/2.0-1.6 ka BP, 0.9-0.6 ka BP and 0.3-0.1 ka BP. The studies in Greece were mostly carried out in small steepland/montain catchments or alluvial plains on the Peloponnese (fe Canzelmann et al. 2004; Fuchs and Wagner, 2005; Heymann et al., 2013; Knitter et al., 2019; Pavlides et al., 2004; Seguin et al., 2019) or Crete (fe Booth, 2010; Macklin et al. 2010; Maas et al. 1998). In CentralGreece very little information exists about major flooding events and their causes prior to 0.9 ka BP.

Information on major flooding events is of utmost importance when trying to identify settlement sites or permanent transport routes during previous times. Man-made structures such as temples, settlements or bridge-heads will be placed at sites, which are secure from high flooding events. Another important prerequisite for the placement of settlements is a secure water supply through natural sources (high ground water table, perennial water courses, lakes) and/or through the construction of reservoirs and irrigation schemes. Therefore, information on major flooding events and their response in the fluvial system can give important clues to the settlement history of an area.

2 Research Goal

In this exploratory research, the changes in the fluvial system in Kephissos Valley shall be investigated with the following goals:

- Identification of the diachroneous changes in the Kephissos River course
- Identification of potential settlement sites and/or bridgeheads along the Kephissos River
- Identification of potential water sources for settlement sites
- Identification of the major flooding events in the Kephissos Valley from 3.2-1.4 ka BP
- Correlation of the results with regard to major climate changes in the Eastern Mediterranean

3 The Research Area

Kephissos Valley lies in Eastern Lokris in the south-central part of mainland Greece at 38°35' to 38°40' N and 22°37' to 22°50'E. With an area of about 1500 km² this valley was an important agricultural and transit area during antiquity, when this region belonged to ancient Phokis.

Kephissos Valley is framed by the Parnassos Montains in the SW and the Kallidromon Mountains in the NE. The NE flank of the Parnassos Mountains consists primarily of middle Jurassic to Cretaceous limestones and dolomites, with interbedded bauxitic horizons. The SW flank of Kallidromon consists mainly of Tertiary to Jurassic limestones and Eocene to Upper Cretaceous flysch. The flanks of Parnassos and Kallidromon are steeply inclined towards the valley floor with deeply incised creeks. In several areas (fe N of Elatia and at Tithorea) long talus slopes extend into the valley, where quaternary sediments are inclined towards the position of Kephissos River. Relatively flat planes exist only at the eastern end of Kephissos Valley (Institute of Geology and Subsurface Research, 1962 & 1967; Papathanassione 2011, Pope 2000).

Thus, Kephissos valley is a typical karst region with periodically and episodically running surface waters. Even the main river Kephissos is usually dry during the summer months. During intense rainfalls (as experienced during hurricane "Ianos" from 18-20.9.2020), the surface waters respond very quickly with the potential for mayor flooding events.

Fig. 1a, b: The during summer usually dry river bed of Kephissos river at the bridge to Modi before (17.9.2020) and after hurricane "Iasos" (20.9.2020)

During the Late Bronze Age to Late Antiquity, the Kephissos Valley was an important transit area between Eastern Lokris and Böotia, which is signified by several major events: In 480 BC, Xerxes moved towards Athens through the Kephissos Valley and reportedly destroyed all settlements in this previously rich valley. Phillip II also brought his troops through the Kephissos Valley and was finally beaten at Chaironeia in 338 BC. Between 197-194 BC, Titus Q. Flaminius stationed his winter camp in Elateia after proclaiming the independence of Greece. From all accounts, the Kephissos Valley must have been an important area during the late Bronze Age to Late Antiquity. Particularly due to the work of Sporn (2017, 2018, 2019) and Sporn and Laufer (2019) more and more information on individual sites (temples, settlements) is appearing. However, very little is still known about land use, settlement distribution and settlement history of the Kephissos Valley.

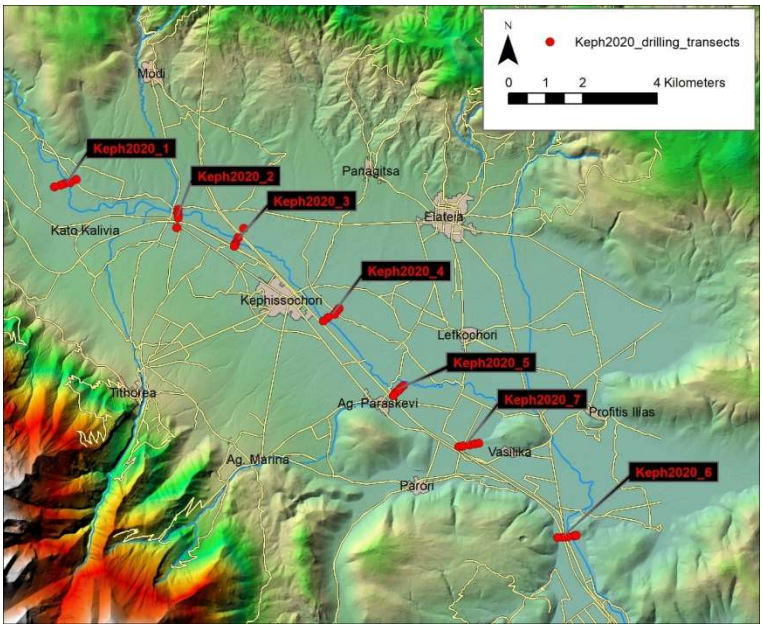
4 The fluvial system

Kephissos River is situated in the central part of Greece. With a length of 60 km and a drainage area of about 2420 km² it is the largest river in Central Greece. Its springs are located in the valley of Pindos river, where several headwater creeks are originated. Creek Kanianatis joins creek Aghorianitis just north of the confluence of Aghorianitis and Apostolia north of Polidroso. The spring region is located in an area dominated by limestone of Tertiary to Jurrassic age and its sedimentary derivatives. Due to the rapid infiltration in this karst region, these spring creeks only run periodically today. The main flow seems to come from the springs of Kephissos close to the ruins of Aghia Eloussa church close near Polidroso with a regular discharge of 0.3-3 m³/s, where already in antiquity a spring cult of the river-god Kephissos had developed.

After leaving the spring region in Eastern Lokris, Kephissos River breaks through a barrier of hard limestones of Jurassic age north of Polidhrosos, bevor entering the Kephissos valley. There it runs between the Parnassos Mountains und the Kallidromon Mountains before it leaves Kephissos Valley through a narrow valley. In antiquity, Kephissos drained into Kopais Lake, but since its drainage during the 19. Century, Kephissos was redirected towards Lake Yliki, where its waters are used for irrigation. Thus, Kephissos River does not drain into the sea.

In the Kephissos Valley, the river can be divided in 5 distinct sections: After the confluence of the spring creeks N of Polidroso , Kephissos river runs through a deeply incised gorge which reaches a depth of up to 100 m (1). North of Kato Kalivia it leaves the gorge and runs through a small flood plain with a partially braided course (2). At the confluence of small creeks from Modi and Tithorea lies an antique town at the location Paliothiva, where the river is confined to one bed again. From here, the river runs fairly straight towards Aghia Paraskevi (3), where it turns abruptly towards the east (4). At Parapotamioi the river passes through a narrow valley (5) leading towards Boeotia.

Fig. 2: Kephissos River with the proposed transects



4 Methods

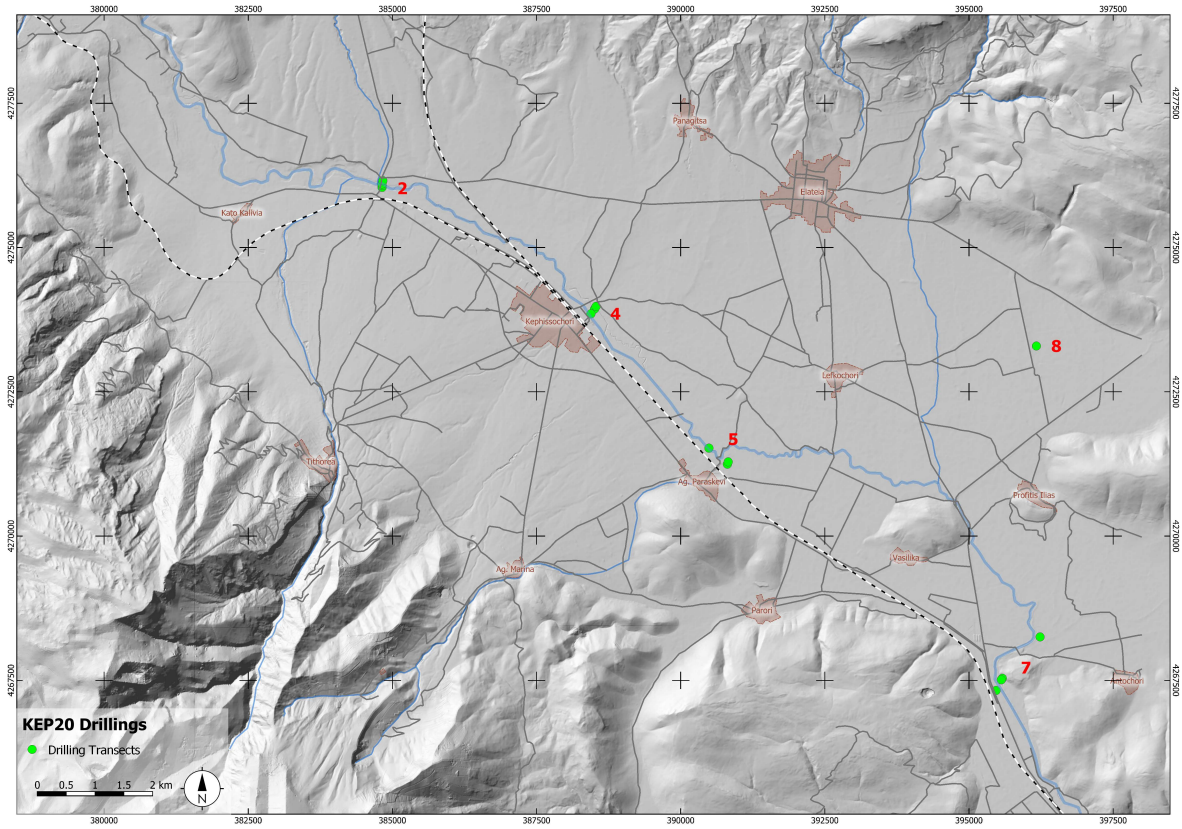
In this exploratory study, surface surveys, georadar and percussion drillings were used to analyse the diachroneous changes of the Kephissos fluvial system. Originally, it was intended to clean the banks of the Kephissos river at one location to gain a vertical profile for better understanding the fluvial sequence and to obtain samples for OSL dating. However, due to the high flooding during the Hurricane Iasos and the extremely stiff sediments, this approach had to be disregarded. Instead a vertical borehole drilled with enclosed liners was used to date the upper sequence (*see below*).

Short surface surveys of the extent and intensity of surface gravel deposits were carried out to get a better understanding of the recent flooding dynamics. At each fluvial section described above, at least one survey was carried out.

Percussion drillings were carried out to measure the thickness and characteristics of the sedimentary sequence for a better understanding of the areal extent of fluvial processes in earlier times. Originally it was planned to carry out 7 transects of 3-5 bore hole drillings. Transect 3 had to be omitted due to the extensive anthropogenic changes made during the re-building of the railway track. Transect 6 was omitted after the surface surveys and the results from transect 5 indicated, that there was no alternate river course south of Paraskevi.

Transects 2, 4, 5 and 7 were drilled to maximum depth (up to 7 m) until it was no more possible to penetrate colluvial grus or alluvial gravel layers. At each transect, 3-4 bore hole drillings were carried out with an open Stitz drill corer with a diameter of 7 cm, which provides sufficient material for sedimentological analysis.

Fig.3: Kephissos river with actual transects



In addition, at two locations (Fig. 3: Transect 8) in slight depressions at the confluence of rivers Kephissos and Assos and at a low lying area near the Chapel of Saint Georgios, where local reports indicate some kind of surface water (pers. comm. Katja Sporn), exploratory single bore hole drillings were carried out. These sites were the only areas in Kephissos Valley, which were considered potential sites for ancient peat layers (though it was unlikely that pollen preservation would be good enough for palynological analysis)

At all transects, georadar soundings were used to find alternative river courses. The use of this method encountered two problems: Due to the repeated floodings, the surface soils along River Kephissos are of very good quality and are, therefore, mainly used for agriculture. They are also riddled with mouse holes, which disturb the radar signal considerably. However, the Georadar proved to be very useful for checking negative vegetation abnormalities, which showed distinct fluvial characteristics. Simple Google Earth satellite pictures showed potential ancient alternate river courses along or even parallel to river Kephissos. Thus, Georadar soundings were run across several of these abnormalities.

Fig. 4: Table of transect coordinates

Transect	x	y	z
Kep20-2-1	384820.900	4276043.005	166.963
Kep20-2-2	384823.062	4276076.826	166.703
Kep20-2-3	384822.578	4276103.259	165.677
Kep20-2-4	384835.224	4276159.691	168.388
Kep20-4-1	388532.561	4273981.515	149.445
Kep20-4-2	388506.518	4273935.372	149.644
Kep20-4-3	388444.065	4273852.512	149.483
Kep20-5-1	390824.692	4271287.406	138.217
Kep20-5-2	390810.566	4271247.142	138.404
Kep20-6-1	395579.578	4267536.888	123.411
Kep20-6-2	395561.224	4267510.483	123.129
Kep20-6-3	395471.051	4267326.522	123.776
Kep20-6-4	396234.160	4268253.601	124.118
Kep20-8-1	396170.235	4273294.950	127.945
Kep20-8-2	390490.704	4271525.409	139.872

7 Results and discussion

The following results are only preliminary findings, which have to be verified by subsequent studies, particularly with regard to the history of floodings between the Late Bronze Age to Late Antiquity:

The main course of the Kephissios River has not changed for a long time, possibly the entire late Holocene: There was no evidence for any earlier deviation from its todays' course, except for some obvious modern rectifications at Kefissochori/Kato Tithorea. In some areas, the river is too deeply incised to suggest any changes in the course of the river (this is also true for the incised creeks at the flanks of Parnassos and Kallidromon). In the shallower southern part, the topography of the valley with debris flows from Parnassos and Kallidromon forces the river in its present course.

Starting at section 3, the river shows the first signs of a flood plain, which extends at least to the southern end of Kephissos valley: Very stiff reddish loams were found at a depth of 1.3 m at the left side of the river (just opposite of the ancient town of Paliothiva) indicating long periods of overbank floodings with the deposition of fine material. The alluvial loams probably stem from Terra Rossae, which were eroded upstream and deposited at the sites, where the slope of the river decreased. On the right hand side, three terraces were found with no evidence of theses alluvial loams – at least the upper two terraces could be of anthropogenic origin. The reddish alluvial loams were found again at greater depth (up to 5 m) in the following transects, indicating increasing sedimentation downriver. Below the loams, massive gravel beds alternate with the fines indicating major flooding events with high flow velocities in the past.

There is no evidence for an alternate river course south of Paraskevi, where Kephissos turns to the west with a sharp angle: The hypothesis on alternate river course from Paraskevi south of Vasilika towards the confluence of Kephissos and Boghdhanorema west of Antochori (Parapotamoi) is unlikely. No evidence for an old river bed was found in the sediments of transect 5 south of Paraskevi. Also, the old foundations of the bridge at Paraskewi support the notion, that the course of Kephissos River was stable at that river section at least since late Antiquity.

There is no evidence for ancient peat areas: Even at the most promising sites near the confluence of Kephissos and Assos and at the depression at Aghios Georgios no organic strata were found. At the confluence of Kephissos and Bogdhanorema massive layers of sands to course gravels (with fining) rather indicate a confluence fan.

In the lower part of Kephissos Valley, shallow rinnen indicate old small flood channels: Satellite images and Georadar indicate shallow (up to 1.5 m) channels, running approximately parallel to the current river course. N of Koukouli-hill at Vasilika, Georadar was used to check the satellite images. The radargrams showed shallow channel structures at a depth of 1 – 1.5 m, supporting the notion of shallow flood channels.

Fluvial history: It was not possible to decipher the fluvial history from 3.2-1.4 ka BP. Two cores were sent to the OSL laboratory in Freiburg (Dr. Fülling) to get an idea about the age of the upper two sediment layers near Paliothiva. The results should allow a first approach to the recent fluvial history of Kephissos. *However, the results will most probably not be present before the end of 2020 or January 2021!*

8 Consequences for future archaeological research

There is no evidence for an alternative river course. Therefore, potential settlement sites should be in higher locations along the present river, such as at Paliothiva. In low lying areas, where vegetation changes indicate old high flood channels, settlement sites are unlikely.

At two sites, potential bridge sites of Late Antiquity age are likely in the Kephissos valley, where further research should be carried out: a) At the current bridge between Paliothiva and the road to Modi and b) at the bridge east of Aghia Paraskevi, where next to the modern bridge an older Turkish bridge containing remnants from an obviously ancient bridge exist.

Karst springs were probably the most important water source at the distal sites during earlier times (fe Modi, Elateia). Since karst springs are notorious for their unreliability over long periods of time (discharge and even location can change abruptly), the positions of the karst springs today offer no safe information on their location and intensity during Antiquity. However, due to its location and flow intensity, the current spring at Elateia seems to be a good place for further investigation.

At the sites along the river, wells are dug in the sediments to a depth below the current river bed even today, providing a potential water source even when the river itself runs dry. It can be assumed, that this practise was also used during earlier times. In addition, cisterns would provide a source of water in the settled areas. No evidence for mayor water works, such as at the northern part of Kopais (Kontouri et al., 2013; Knauss et al. 1986) were found, but this was not the focus of this years' campaign.

9 Summary

The exploratory research to investigate the diachroneous changes in Kephissos valley was only partially successful. The results show, that there were no major changes in the Kephissos River course for a long time (possibly the entire late Holocene). They also indicate a complex and very intense flooding history of Kephissos valley. Some indications for further archaeological research with regard to settlement sites and bridgeheads were found.

However, due to hurricane Iasos and the massive gravel beds, which could not be penetrated by regular drills, the flooding history of Kephissos valley remains unclear, until the two cores have been dated. They should at least allow a first approach to the recent fluvial history of Kephissos.

Ackknowledgements

Our great thanks go to Prof. Dr. Katja Sporn, who has not only initiated the project, but has supported this research in countless ways. We also thank Hans Birk for measuring the drill sites and Stefan Biernath for his GIS applications. I thank the very competent drilling team Andre Jepsen, Larissa Werner, Jens Christopeit and Emma Hadre for their never ending energy under partially problematic conditions. I gladly acknowledge the financial support of the German Archaeological Institute (DAI).

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