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THE CANAL OF XERXES IN NORTHERN GREECE: FACT OR FICTION?  
RECENT GEOPHYSICAL AND GEOARCHAEOLOGICAL INVESTIGATIONS

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Abstract: Herodotus describes how a canal was constructed in northern Greece by King Xerxes in around 480 BC to allow the Persian fleet into the Aegean in advance of its invasion of Greece. If so, this canal must have been a remarkable engineering operation for its time. This paper reports on the results of a non-invasive investigation at the supposed site of the canal on the 2 km wide isthmus of the Mount Athos peninsula. Geophysical, especially seismic survey; topographic survey and analysis of borehole sediments have played complementary roles in demonstrating that Herodotus’ account was very probably correct.

Keywords: Geophysical survey; seisms; Xerxes; canal; coring; sediment analysis; ground-penetrating radar; radiocarbon dating

Introduction

The ancient Greek historian Herodotus (Histories VII 22-4) describes how a canal was constructed in northern Greece on the orders of King Xerxes in 483-1 BC to allow the Persian fleet safe passage into the Aegean in advance of its invasion of Greece; he records that it was some 2 km long and was wide enough for two triremes to pass side by side. If this account is true, its construction must have been a remarkable engineering operation for its time. Although the canal has attracted scholarly attention over the years, no archaeological fieldwork was carried out to verify whether indeed it was a canal linked at both ends to the sea, or whether, as some have postulated, there was instead a slipway (dolikos) across the isthmus. Today the only visible remains are a depression in the central part of the isthmus.

To resolve this question, a British-Greek team has carried out over the last decade a non-invasive investigation at the supposed site of the canal which is situated on the Athos peninsula of the Chalkidiki (Fig. 1 inset). Geophysical (seismic, radar, electric and magnetic) and topographic surveys and analysis (and radiocarbon dating) of sediments from boreholes have all played important, complementary roles in the investigation in demonstrating the veracity of Herodotus’ account. The results of the project have been published with different audiences in mind: Isserlin et al (2003) have reported the project’s final stage and discussed the findings as a whole in an archaeological context, while the more technical aspects have been explored by Karastathis, Papamarinopoulos and Jones (2001) and Jones et al (2000). The present paper aims to give an overview of the project now that its current phase of fieldwork is complete, to demonstrate the role of integrated input from geophysical and topographic surveys and analysis of sediments from cores, and to consider the progress of possible future work at the canal. In our mind, two main factors justify the need for such a paper; first, the results deserve to be presented to as wide an audience as possible since the object of this investigation - the canal - is unique (not only in Greece), and furthermore it is unlikely for logistical as well as financial reasons to be excavated by conventional archaeological means at least in the near future (but see Discussion; and Isserlin et al 2003, Appendix 1); second, the project can be viewed as a case study within the context of the increasing impact that geophysical and related survey is now making in Greek and more widely in Mediterranean archaeology (Sarris and Jones 2000).
The location of the canal

The presumed course of the canal lies at the narrowest point of the Mount Athos isthmus, amid a rural landscape. Today, from the sea at its northern end it passes close to the village of Nea Roda across an area of open flat, formerly marshy land entering the central sector where the land level rises to a maximum elevation of 1.7 m above sea level, there is a pronounced depression which gives way to a stream bed that passes between two hills close to the sea at Tripti. This picture of the canal's topography is complicated by the fact that the area is one of high tectonic activity.

Sands, silts, red beds and alluvium are the main surface eolian features at the isthmus, and below them, generally but not exclusively, at a depth of at least 10 m, lie red bed sediments Syrtes 1-0. The choice of this location to construct the putative canal was a good one since not only was it at the narrowest and lowest part of the isthmus, but the sediments would have been relatively easy to dig out. To the northwest limestone and granite outcrop, and there is neiss to the south-east.

Archaeological - historical considerations

Herodotus describes not only the events that led to the construction of the canal but also how it was constructed. Having read Herodotus' account, it comes as a disappointment to find so little on the ground today that can be linked to this structure. Apart from the broad depression along the central sector, there is an apparent absence of, for example, any infrastructure that might be expected to accompany the operation of a canal, from buildings, breakwaters to harbour installations. This situation, the counter-assertion that there was instead of a canal, a slipway dike upon which ships could be drawn, takes on more credibility. Indeed, Demetrius of Skepsis wrote some three centuries later than Herodotus, claimed the canal did not traverse the whole isthmus because of the hard, rocky terrain at the southern end at Tripti. In recent times, opinions have been divided some North European travellers toreece in the 18th to early 20th century, such as Choiseul-Gouffier (1809) (see Fig. 2) followed Herodotus, while Ousin ry 1831, I 3ff believed there was a dike. Ousin views have been more divided between the two models.

The survey

The project developed a flexible and often experimental strategy, summarized in the chronological order in Table 1 that was capable of detecting and describing on the one hand a lar e, potentially deeply buried structure and on the other, building as associated with that structure. Fig. 1a, b shows the locations of most of the geophysical
### The Canal of Xerxes in Northern Greece: Fact or Fiction?

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**Table 1: The techniques used in the Xerxes Canal Project**

Surveys and boreholes; the former were generally aligned as profiles at right angles to the supposed course of the canal. Operating conditions of the survey techniques and data processing methods are given in the papers referred to in Table 1. The most informative results emerged from survey in the central sector of the isthmus.

Beginning with the electrical survey, the pseudosections from resistivity soundings displayed at the top a 1-2 m thick high resistance layer of colluvium infill, giving way to progressively lower resistance values in the thick sand/silt layer to a depth of c. 30 m. There was no indication of a canal-like structure. In the corresponding magnetic profile across the canal, the infill gave a low intensity anomaly. The magnetic anomalies detected at the northern end were interpreted as the result of modern disturbance rather than as building structures associated with the canal. The depth of penetration of the GPR survey did not exceed 10 m owing to the relatively high water table; this, coupled with the lack of dielectric permittivity contrast between the infill and the surrounding more compacted host sediments, resulted in a failure to detect a complete canal-like outline.

Instead, several episodes of (natural) infilling of the depression were evident, as was the apparent asymmetry of this depression which was also detected in some of the seismic data.

Following the initial promising seismic refraction and reflection profiles in the central sector, the technique was employed at points along the whole course of the canal. The results overall were highly satisfactory generally, and also specifically owing to the lower velocity values obtained in the infill as compared to those of the host material: Fig. 2a shows clearly the profile of the canal at one position in the central sector, and the picture resulting from 2-D inverse modelling techniques on data from a series of five profiles at the northern end appears in Fig. 3. Furthermore, the direction of the canal apparent in Fig. 3 differs from that originally determined on the basis of present-day lowest ground level (Fig. 1a) such that it is now likely the canal connected with the sea at least 50 m further east (Fig. 1b: 2000 route). The combination of seismic survey and analysis of borehole cores proved to be powerful for two reasons. First, the former estimated the
discussi

Archaeo logical interpretation of the pro ect's results can be summarised succinctly: across the 2 km isthmus a canal was very likely du, its top with being c. 30 m and its base now buried some 1 m below present round level the canal would have been shallow, but more enerally apparently around 3 m deep. This description conforms fairly well to that given by Herodotus, and it harmonises with the model according to one of the early travellers, de Choiseul-Gouffier (1809), shown in Fig. 2b. At both ends, the canal connected with the sea there is no ood reason to suppose there was a diolkos at the southern end. The canal is not to have been of uniform construction, and nor does it appear to have had a lon life its main function fulfilled, it was probably not maintained and so fell into disuse rapidly. in this li it is perhaps not surprisin that no evidence was found for buildin s that could be associated with the canal's operation. no doubt such buildin s e ised, but they were temporary and have lon since disappeared. verall, although the pro ect's ambitious aims have been largely fulfilled, the quality of the results was not uniform across the isthmus that the clearest results were consistently obtained in the central sector has been frequently alluded to, in contrast first to the

depth of the base of the canal below present-day round surface in the central sector to be. 1 m, a value which coincides remarkably with the depth of the interface of the clay silt layers and the more compact red beds and sediments respectively in F1, 4 as observed in the sequence of sediments in borehole 3 H3 in F1, 1b this interface surely represents the base of the canal F1, 4. Second, the combined methods resolved the issue of the diolkos model at the southern end: not only did there seem to be no serious obstacle from shallow bedrock there that would have prevented the canal being tended all the way to the sea, but there were no indications of a diolkos anywhere. Two notable features of the core sediments taken in the central sector were the absence of marine indicators that hints that the canal's direct links with the sea were limited in duration, and the presence of indicators that the canal fell into disuse probably rapidly by side collapse cretin in places stillwater marshy environments. Finally, although in the air photo raphs of the canal beyond the central depression, it is noteworthy that among the drainage areas appearing in yellow in a ANDSAT-TM false-colour satellite image of the region is one traversin the isthmus in a direction remarkably similar to that proposed by the combined survey evidence marked 2000 route in F1, 1b.
situation around T A1-A2 in F1.1a where the modern stream bed joins the canal depression towards Tripliti, and second to what is mentioned below in the plain at the northern end.

Turnin to the methodology adopted, seismic survey was very well suited to the problem in hand, while the contribution from the other geophysical techniques was useful but less crucial. borehole coring was not only necessary in such a context but the results that this approach provided from the sediment analyses were essential. That said, the borehole coring confronted two problems; first, the nature of the sediments was such that core loss was significant in some places. Second, whereas the decision where to locate the boreholes in the central and southern sectors was relatively straightforward, the situation in the wide and plain at the northern end was different; here, the partial picture obtained from the e lectorary few cores taken had little archaeological significance. The same remarks apply to the e lectorary use of radiocarbon dates to try and date the construction of the canal. As e ected, the dates from sediments taken ust above the base of the canal at two locations in the central sector were considerably older than the likely time of construction because of the presence of older anic components in the sediments. The point is that to obtain archaeologically reliable full dates would require sediment samples for radiocarbon dating that would be too numerous to be justified in terms of cost and effort.

Looking to the future, although the project's field work as reported here is now completed, there are a number of avenues for further work. ne that has been recognised for some time is the desirability of an underwater reconnaissance of the two ends of the canal for indications of harbour installations and breakwaters, as well as for information supplementing that already obtained by apan els and ambourou lou 1 on sea level chan es. Second, the opportunity for exploiting the potential of core sediments for environmental reconstruction has not been lost; Drivaliari and Syrides (2003) have already presented their preliminary environmental findings which they publish at a later date. Netic susceptibility measurements on the cores may also be valuable D. Kontopoulos, pers. comm.). Third, having defined the course of the canal with some confidence by geophysical survey there is sufficient associated topographic data...
to make a 3-D reconstruction of the canal. This could have direct educational value, as well as enhancing the presentation of the canal to visitors to the region, especially in the event that the proposed archaeological park' at Nea Roda becomes a reality. In fourth and most provocative of all would be the excavation of a test section of the canal, as outlined by Isserlin et al. 2003: Appendix 1, probably in the central sector. This would be a very challenging but in our opinion worthwhile enterprise. Finally, we note with interest the current erian and Shipwreck Survey off Mt Athos which is a collaborative effort of the Greek phorate of Underwater Antiquities, the Canadian Archaeological Institute at Athens and the Hellenic Centre for Marine Research, hitley 2004: 4.

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