Relative sea-level changes throughout the last 6000 years on the Taman Peninsula (Black Sea, Azov Sea, Russia): a geoarchaeological study

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The Taman peninsula is geologically attached to the western end of the Caucasus. It was the site of a Greek settlement as early as the 6th century BC. Our geoarchaeological methodology combines geomorphological, archaeological and paleoenvironmental (sedimentology, carbon datings on sea-shells) data in order to reconstruct the evolution of the coastline. After the peak of the last post-glacial transgression, a main island and four islets were located between Crimea and the Taman peninsula. The alluviation of the Kouban river then filled the space and is the origin of the island’s attachment to the mainland. At the time of the Greek colonisation the process was not over. The present sea level appears regionally to be the highest level ever reached on the peninsula over the last 6000 years. It seems that for the Anapa area and the Tchouchtchka Spit area it is possible to propose a sea-level curve characterised by a slow, continuous rise during the past 6000 years. On the Taman peninsula itself, the sedimentary record of this slow ascent has been disturbed by a heavy tectonic subsidence. On at least two areas on the peninsula, we have identified this neo-tectonic subsidence effect, linked to the effect of the activity of mud volcanoes. In spite of this very active neotectonics, our data confirm the possibility for a period of downturn in seawater during the so-called « Phanagorian Regression » from the end of the 2nd millennium BP up to the 1st millennium AD.

Introduction

The Taman peninsula, situated to the south of Russia, is limited to the west by the Kerch Strait, called Bosporus Cimmerius in Antiquity, to the north by the Sea of Azov, the Palus Maeotis of Antiquity, to the south by the pontus euxines, the current Black Sea, and to the East by the present Kouban delta and the vast marshy deltaic plain of the Pre-Kouban (Fig. 1). The geoarchaeological study of the Taman peninsula and the Kouban delta is the result of a partnership between the Russian Academy of Sciences, the Moscow Archaeological Institute, the Moscow State University, the French School of Archaeology in Athens, the French CNRS and the French Ministry of Foreign Affairs. The results presented here have been obtained within the frame of the Franco/Russian archaeological survey of the Taman Peninsula, directed by Christel Müller and Youri Gorlov (Fouache et al. 2000).

According to the results of studies carried out over the last thirty years, it seems that the Holocene transgression in the Black Sea, which starts later than the global ocean evolution around 7500 BP (Ryan, Pitman 1998), was characterised by a succession of rapid sea-level fluctuations (Pirazzoli, 1991; Ismailov et al. 1989). Those fluctuations (Fig. 2) have been related mostly to climatic changes during the Holocene and the possible distortion due to the neo-tectonics factor has been neglected. The new data we obtained by drilling on the Taman peninsula confirm (Fig. 1) the
importance of the neo-tectonics effect (Fouache et al. 2004). It is also obvious that the Kouban river, by deposit of alluviations, is at the origin of the junction of islands to the mainland, but the main object of our study was to propose a paleogeographical reconstruction of the peninsula around 6th century BC.

The historical importance of the area during Antiquity

The period we are interested in is that of the Greek colonization in the 6th century BC. It amounted to the founding of essentially Milesian colonies such as Hermonasa, Phanagoria, Kepoi and Patrasys to name but the most important ones. From 480 BC, these cities came under the dominion of the kingdom of the Arkheanaktides of which the capital was probably Panticapaeum, the modern-day Kerch. It is the formation of the kingdom called Bosporus, of which the most famous monarch was Leukón 1st of the Spartocides dynasty who kept up dynamic commercial relations with Athens in the 4th century BC and expanded his realm at the expense of the indigenous tribes of the Asian area, the Sindes and the Meotes. The prosperity of Bosporus ended with the intervention of Mithradates Eupatôr at the end of the second and the beginning of the first century BC. In 10 AD, with the accession of King Aspourgos, the kingdom of Bosporus became a trading partner with Rome for the following four centuries.

The necessity of a geoarchaeological approach

The reconstruction of the paleogeography of the peninsula during the time of the Greek colonization could not have been carried out without a close collaboration between archaeologists and geographers. The mobility of the landscape was illustrated by ancient texts as well as by the existence of submerged vestiges under the waters of the Taman Gulf. The archaeologist had three questions for the geographer.

The first question concerns the peninsula itself: was it a peninsula, an island or separate islands during the 6th century BC? We know...
that the Greek cities of Asian Bosporus were under the control of a sort of administrator, described in the document of the High Empire and called the “Island Official” (with the word island in the singular). We can also find, in other literary texts, many allusions to this island or to these islands where cities were built, without being able to describe exactly their perimeter based on these sources alone. Such is the case with Strabo, Pomponius Mela, Denys of Alexandria and Ammien Marcellin.

The second question is closely linked to the first. Strabo and Pomponius Mela described
the former river Hypanis or Coracanda or even Antikeites in a confused way. Where should we place the ancient course of this river, which has at least two branches if these authors are to be believed?

The last question concerns the relative variations of sea level and therefore the contours of the peninsula, which goes with the problem of the number of islands.

**Methodology**

For this study we have designed a geomorphological map and then we have drilled six boreholes (Fig. 1) on the peninsula down to
Relative sea/level changes through the last 6000 years

12 meters deep: one in the Kouban delta (S1), one on the Burgaz Spit (S2), one on the Tchouchtchka Spit (S3) and three on the Anapa Spit (S4, S5 and S6). We have also used the archival material collected in the end of the 1960s by E.N. Nevesky (1967) for the Russian Shirshof Institute of Oceanology. This material was kindly given to us by Professor L.A. Nevesky and concerns the Gulf of Taman (S7, S8 and S9). Due to practical reasons, we had to collect samples on the field and to determine the stratigraphy and lithology on the spot.

To reconstruct the relative sea-level fluctuations, it was not possible to use archaeological indicators except for determination of a global submersion since Late Antiquity (Abramov 1999, Nikonov 1994, Blavatsky 1985). We have been unable to find precise archaeological indicators, such as jetties and fishponds, on the peninsula, and the method proposed by Flemming (1979) or Pirazzoli (1979) and used by us in Turkey (Fouache et al. 1999) and Croatia (Fouache et al. 2002b), was impossible to enforce here. So we concentrated on identification of shell assemblages, characteristic of thanatocenose fauna accumulated at a medium sea level, that reflect an average position of sea-level with an error margin of +/- 1 m.

Extracted shell material has been determined and paleo-environmentally interpreted (Kaplin et al. 2001) by T. Yanina at the Geographical Faculty of Moscow State University (Tab. 1). Classical radiocarbon dating on these shells was performed at the Geological Institute of the Russian Academy of Sciences and at the Geographical Faculty of Moscow State University. A calibration was carried out, following Stuiver and Braziunas (1993), taking into account the sea water reservoir effect.

Geological setting

The formations of which the Taman peninsula is made are found on the other side of the Kerch Strait in the Crimea. These formations are made up of Miocene and Pliocene rocks, essentially clay, sands and very occasionally limestone (Touzla Cape or Aclileion Cape). These rocks were deposited on the bottom of the sea, in the position of a retro-arc basin which stretched from the north to the Viennese Carpathians to the present Black Sea. The Alpine orogenesis, through its compressive tectonics, provoked the emergence of these rocks and their folding along the antclinal and synclinal WSW/ENE axes and the group of NNE/SSW faults (Chnioukov et al. 1981). The current relief of the Taman peninsula is the result of the evolution of folded ridges in the open air since the end of Pliocene. The folded ridges have been levelled (Blagovolin 1962: Blagovolin, Pobedonostsev 1973), which explains the extension of plateaux eroded into cliffs. Since as early as the end of the Pliocene, along the antclinal axes, diapirism has caused alignments of mud volcanoes (Chnioukov et al. 1981), giving birth to eruptive cones, the largest of which are over 100 m high and occupy the highest point of the topography.

The general features of the geological structure of the Taman peninsula are defined by its layout in the area of contact between the folded structure of the Caucasus and mountainous Crimea. According to geological data (Chniukov et al. 1981, Andreev et al. 1981, Peklo et al. 1981, Naumenko 1977), this area includes several tectonic zones (Fig. 3). The northern Taman zone (IIa, Fig. 3) is linked with the uplifting movement of Crimea’s mega-anticlinorium. The Anapa prominence (II, Fig. 3) is in the same type of uplifting context due to the proximity of the Caucasus. Between these two areas, the Kerch-Taman inter-periclinal trough is located (III, Fig. 3).

Tectonic faults are superimposed on this general feature (Plachotny et al. 1989). On the basis of geophysical, geological and geomorphological data, the Taman area comprises several blocks limited by a number of local and regional faults (Fig. 4) of sublatitudinal and submeridional directions. Three principal blocks can be observed from west to east: the Kerch/Gdanovsky, the Vishestebleevsky and the Djiginsky areas.
### Tab. 1: Radiocarbon datings from the Taman Peninsula.

<table>
<thead>
<tr>
<th>No/Depth (m)</th>
<th>Index</th>
<th>Material</th>
<th>Calibrated Age (Yrs Cal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 (11 - 11.5)</td>
<td>GIN-9942</td>
<td>Peat</td>
<td>4884 BC</td>
</tr>
<tr>
<td>S2 (3.2 - 3.5)</td>
<td>GIN-9934</td>
<td>Ostrea edulis, Cerastoderma glaucum, Chlamys glabra</td>
<td>1310 AD</td>
</tr>
<tr>
<td>S2 (3.6 - 3.8)</td>
<td>GIN-9935</td>
<td>Ostrea edulis, Chione gallina, Cerastoderma glaucum</td>
<td>1287 AD</td>
</tr>
<tr>
<td>S2 (7.8 - 8.0)</td>
<td>GIN-9939</td>
<td>Cerastoderma glaucum</td>
<td>605 AD</td>
</tr>
<tr>
<td>S2 (8.1 - 8.2)</td>
<td>GIN-9938</td>
<td>Cerastoderma glaucum</td>
<td>317 BC</td>
</tr>
<tr>
<td>S2 (10 - 10.3)</td>
<td>GIN-9937</td>
<td>Cerastoderma glaucum</td>
<td>767 BC</td>
</tr>
<tr>
<td>S3 (2.8 - 3.0)</td>
<td>MGU-1504</td>
<td>Cerastoderma glaucum, Chione gallina, Solen vagina</td>
<td>1380 AD</td>
</tr>
<tr>
<td>S3 (4.2 - 4.5)</td>
<td>MGU-1520</td>
<td>Cerastoderma glaucum, Cardium exiguum, Chione gallina, Loripes lacteus, Divaricella divaricata, Myella bidentata, Paphia discrepans, Gastrana fragilis, Abra alba, Ostrea edulis, Mytilus galloprovincialis</td>
<td>945 BC</td>
</tr>
<tr>
<td>S3 (7.7 - 8.0)</td>
<td>MGU 1502</td>
<td>Cerastoderma glaucum, Mytilus galloprovincialis, Chione gallina, Solen vagina, Paphia discrepans, Cardium exiguum, Ostrea edulis, Gastrana fragilis, Abra ovata, Loripes lacteus</td>
<td>2633 BC</td>
</tr>
<tr>
<td>S3 (9.0 - 9.3)</td>
<td>MGU 1501</td>
<td>Cerastoderma glaucum, Chione gallina, Ostrea edulis, Paphia discrepans</td>
<td>3611 BC</td>
</tr>
<tr>
<td>S4 (6.7 - 7.0)</td>
<td>MGU 1575</td>
<td>Cerastoderma glaucum, Loripes lacteus, Ostrea edulis, Chione gallina, Donax sp.</td>
<td>711 AD</td>
</tr>
<tr>
<td>S4 (7.8 - 8.1)</td>
<td>MGU 1565</td>
<td>Cerastoderma glaucum, Ostrea edulis, Chione gallina, Donax sp.</td>
<td>69 BC</td>
</tr>
<tr>
<td>S4 (10 - 10.3)</td>
<td>MGU 1574</td>
<td>Cerastoderma glaucum, Abra ovata</td>
<td>918 BC</td>
</tr>
<tr>
<td>S5 (3.0 - 3.5)</td>
<td>MGU 1529</td>
<td>Cerastoderma glaucum</td>
<td>1051 AD</td>
</tr>
<tr>
<td>S5 (5.5 - 6.0)</td>
<td>MGU 1516</td>
<td>Cerastoderma glaucum</td>
<td>1399 BC</td>
</tr>
<tr>
<td>S5 (6.5 - 7.0)</td>
<td>MGU 1515</td>
<td>Cerastoderma glaucum</td>
<td>1989 BC</td>
</tr>
<tr>
<td>S6 ?</td>
<td>?</td>
<td>1570 +/- 100 ?</td>
<td></td>
</tr>
<tr>
<td>S6 ?</td>
<td>?</td>
<td>3340 +/- 80 ?</td>
<td></td>
</tr>
<tr>
<td>S7 (1.2 - 1.5)</td>
<td>MGU 1549</td>
<td>Chione gallina, Loripes lacteus, Mytilus galloprovincialis, Ostrea edulis, Cardium exiguum, Paphia discrepans, Iris irus, Tellina fabula, Gastrana fragilis, Abra ovata</td>
<td>1392 AD</td>
</tr>
<tr>
<td>S7 (1.8 - 2.0)</td>
<td>MGU 1553</td>
<td>?</td>
<td>160 AD</td>
</tr>
<tr>
<td>S8 (0.8 - 1.05)</td>
<td>MGU 1564</td>
<td>Cerastoderma glaucum, Abra ovata, Mytilaster lineatus, Loripes lacteus, Gastrana fragilis</td>
<td>1141 AD</td>
</tr>
<tr>
<td>S8 (1.9 - 2.4)</td>
<td>MGU 1548</td>
<td>Abra ovata, Cerastoderma Lacteus, Cardium exiguum</td>
<td>551 AD</td>
</tr>
<tr>
<td>S9 (1.0 - 1.15)</td>
<td>MGU 1545</td>
<td>Cerastoderma glaucum, Mytilaster lineatus, Chione gallina, Loripes lacteus, Abra ovata, Chlamys glabra, Gastrana fragilis, Nassa reticulata, Retusa trunculata, Gifrobea ventrosa, Rissoa sp., Bittium reticulatum</td>
<td>1398 AD</td>
</tr>
<tr>
<td>S9 (2.0 - 2.35)</td>
<td>MGU 1546</td>
<td>Cerastoderma glaucum, Chione gallina, Gastrana fragilis, Ostrea edulis, Cardium exiguum, Abra ovata, Nassa reticulata, Terusa trunculata, Gifrobea ventrosa, Rissoa sp., Bittium reticulatum</td>
<td>624 AD</td>
</tr>
</tbody>
</table>
Relative sea/level changes through the last 6000 years

Results

From the bottom to its upper part, the S1 core (Fig. 5), located in the Kouban delta, contains peat, marine semi-closed bay sediments and then deltaic sediments. Palynological analysis confirms that there was a marine environment during the Greek colonisation (Bolihovskaya et al. 2004). The radiocarbon dating obtained on the peat (5940 +/- 50 BP) shows that the maximum penetration of the sea occurred at that time. Cores S1, S2 and S6 were also studied (Bolihovskaya et al. 2004) to establish changes of vegetation (Fig. 10). The palynological results have shown that the warmest and dry conditions prevailed in the intervals 4100-3950, 3500-3300/3200, 2800-2400, 1650-1300 and 1000-900/800 yrs BP. The maxima of humidity for the studied period correspond with the chronological intervals 4500-4300 and 3950-3500 yrs BP, corresponding with the spread of forest communities. During an interval from 2500 up to 1500 BP (5th century BC - 5th century AD) the dominance of the steppe formation was interrupted by phases of wetter climate, which caused at first expansion of the wood-steppe vegetation, and then wide circulation of broad-leaved woods in the landscape.

Fig. 4. Regional pattern of tectonic structure (Kerch-Taman area)
The other cores show an alternation between sandy biodetritic sediment characteristic of beaches and mainly clayey sediments rich in shells (S2 and S3 Fig. 5, S4 Fig. 6, S5 and S6 Fig. 7, S7, S8 and S9 Fig. 8). The biggest paleogeographical change since Antiquity occurs in the gulf of Taman, where most of the city of Phanagoria is now under water (Fig. 8). Was this post-antic submersion homogenous all over the peninsula?

Following the coherence of our results, the deeper the shells, the older the radiocarbon dating, for each core we have reconstructed a local relative sea level curve (Fig. 9). Then we could distinguish two zones with a rather similar curve: at Burgaz Spit and Western Anapa Spit (S3 and S5) on the one hand, at Tchouchtchka Spit and eastern part of Anapa Spit (S2 and S4) on the other. The gulf of Taman is a transition zone between two other areas. We can also distinguish a global dis-symmetry between contemporaneous sea levels. The greatest difference is observed for ancient sea levels. For example, in 1000 BC the sea level is located around –2m below the present sea level in S5, around –4m in S3 and around –9.5m in S2 and S4. We observed for all the curves a relative sea level stabilisation between 500 BC and 500 AD.

Such differences for such a relatively small area at the scale of the Taman peninsula are undoubtedly due to unequal subsidence, itself due to the neo-tectonic effect. How can this neo-tectonic effect be explained?

**Discussion**

There is a perfect correlation between tectonic units and the three different groups we observe on relative sea level curves (Fig. 10). Burgaz Spit (S2) and Western Anapa Spit (S4) are located in two characteristic uplifting areas. The Gulf of Taman (S7, S8 and S9), Tchouchtchka Spit (S3) and the eastern part of Anapa Spit (S5 and S6) are located in a global subsiding zone. The Taman Gulf is a transition zone between two other areas. Tectonic measurements (Nikonov 1994, Nikonov et al. 1997) confirm the neo-tectonic...
Fig. 8. Cores S7, S8 and S9

Fig. 9. Relative regional sea-level fluctuations in Taman Peninsula
subidence in the central zone of the Taman peninsula. The present-day subsidence at Temrjuk in the Kouban delta nowadays is estimated between 3.5 and 4 mm/year, and the tectonic part is estimated between 2 and 3 mm/year. For the Black Sea side, south of the peninsula, the global subsidence, during the Upper Pleistocene, is estimated at 2.5 mm/year. These data confirm that the subsidence rate varies from one point to another in the peninsula.

In this context the relative stabilisation of sea curves between the 5th century BC and the 5th century AD can be considered as a consequence of a period of downturn in sea level (Bolihovskaya et al. 2004) from the end of the 2nd millenium BP up to the middle of the 1st millenium AD, during the so-called “Phanagorian Regression” and it is possible to propose a “real sea level curve” (Fig. 10).

From a general point of view, our results confirm that the neo-tectonic effect explains the rapid variations in relative sea level fluctuations on a regional scale and that this factor has been neglected in sea level changes studies around the Black Sea.

Our data confirm the models proposed by Neveseky (1958) for the position of shorelines around 9th to 5th century BC (Fig. 11). We can specify that, except for the presence of beach-barriers and spits, there were also at that time one main island and at least three islets, maybe four, surrounded by lagoons and marshy areas (Fig. 12). The junction of the islands to dry land by the Kouban river came late, during the Late Antiquity and Early Middle Ages.

**Conclusion**

The results of our analysis of regional sea level variations in different tectonic zones of the Taman peninsula confirm the differential tectonic movement during the historical times within an approximate rate of 0.5 to 1.2 mm/year. Our results confirm the necessity to take into account the tectonic impact in paleo-environmental studies and sea level reconstructions in the Black Sea for the Late Holocene.

The consequences for archaeological investigations are very important. Most coastal archaeological vestiges are underwater on the peninsula, but not at the same altitude according to their position on the peninsula. Our results highlight the interest of an underwater survey but also the interest to study environmental changes and landscape dynamics for paleogeographical studies.
Fig. 11. Possible reconstitution of sea-shore IX to V century BC (Adapted from Nevesky 1958)

Fig. 12. Geomorphological map of the Taman peninsula and the Kouban delta
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