

“Strategic considerations for geospatial collection development from Greek Academic Libraries in an open access era: GIS users point of view”

Ifigenia Vardakosta^{1,2}, Sarantos Kapidakis¹

¹Laboratory on Digital Libraries and Electronic Publishing, Department of Archive, Library and Museum Sciences, Faculty of Information Science and Informatics Ionian University, Ioannou Theotoki 72, Corfu 49100, Greece, Email: {ifigenia, sarantos} @ionio.gr

²Harokopio University. Library and Information Centre, El.Venzelou 70,176-71, Kallithea, Athens, Greece, Email: ifigenia@hua.gr, tel: +302109549170, fax:+302109560161

Abstract

Today, that the access in a wide variety of data and services is possible more than ever, GIS patrons need libraries' further focus on them in order to meet their increasingly diverse education/research needs. Patrons are the core element in an organization that provides services therefore our research approached the Greek GIS users. Excluding some surveys for GIS technology in public sector organizations there have never carried out any survey of this type for geospatial collections and GIS services; hence this study provides the basis for future research in academic libraries and information services. The challenge in conducting this research was how to access such a diverse group and how to extract an understanding for their work. To achieve the aforementioned goal we used a three phase based methodology. The first phase aimed to determine the implementation of GIS technology in an academic environment and in informational organizations. We conducted a qualitative study by addressing four experienced GIS scientists (faculty and researchers). For this goal to be accomplished the interview was based on a controlled questionnaire that was used as a research tool. The questionnaire was focused on issues that American Research Libraries (ARL) and National Library of Australia consider as strategic considerations for establishing GIS services. Thus, the questionnaire involved issues concerning policies, staffing, costs, infrastructure, data/metadata, services, users, user education and evaluation. At the second phase a research in the websites of Greek academic libraries was conducted in order to identify whether academic libraries have developed geospatial collections and GIS services fulfilling their users' informational needs.

As from the above two phases, the key findings that emerged were a) the need for geographical/geospatial information and b) the lack of academic libraries to deliver geospatial collections and GIS services to their patrons; the third's phase aim was the “mapping” of GIS user's opinion regarding the current situation in Greek libraries. More particularly, the objective was to capture their point of view about topics related to the use of libraries, the geospatial collections, GIS services and the open access. While the first two phases of our research will be presented briefly, results of this last research phase will be illustrated in detail in this paper. The electronic questionnaire was chosen as a research tool. It was circulated via e-mail in order to be answered when it is convenient for the respondents. We collected 304 completed questionnaires which represent a wide variety of GIS users (faculty, students, researchers etc). Since this study is the first one that

focuses on GIS users and their opinion regarding geospatial collections in libraries, we consider the number of questionnaires capable of drawing conclusions. Results indicate user's expectations for constant expansion of library's role and provided services in order to use more efficiently the spatial data covering their informational needs.

The paper emphasizes in potentially valuable information since it will demonstrate the findings of the above research. Furthermore, issues regarding policies, open access, co operations and strategies will be discussed extensively.

Keywords: *libraries, geospatial collections, user surveys, collection development, open access*

1. Introduction

Geospatial data play an increasingly important role in natural resources management, economy, health, politics, agriculture, conservation, science-based projects and are generally associated with man's everyday life. Geospatial data are also included in the enormous amount of data produced in different fields or "Big Data" as they are called. Quantitatively, geospatial data are important since they represent almost the 80 percent of public sector information and the economic and political decisions globally involve direct or indirect geographic information. The technological revolution did not leave the geospatial applications unaffected which have matured tremendously nowadays, emerging from specialty tools to become broadly used across numerous disciplines. Libraries which are the main organizations for collecting, preserving and providing access to a comprehensive record of information, have adjust to the current information climate in order to support the educational and informational needs of their users. The upcoming years, two major changes in information environment offer opportunities and challenges for libraries to provide geospatial collections and GIS services: a) the computing landscape and b) the "Big Data era". In many universities in western countries the library has served its community as a central resource allowing students and faculty across academic departments' access to GIS resources (Vardakosta and Kapidakis 2011).

The paper describes a three phase study regarding geographical information in Greek libraries. We will present the first two phases of the study in summary while focus will be given in the third. Therefore, we will present in detail the research regarding the perceptions of GIS users in Greece about libraries and their services in order to fulfill their educational and research needs.

2. Literature review

ALA's (American Library Association) Guidelines for Information Services §1.7 argues that "*The library should survey and assess the information needs of its community and create local information products to fulfill those needs not met by existing materials*". Several studies have been conducted over the years about user needs identification (Devadason and Lingam 1996; Marchionini et al 2003; Harris 2008).

Academic library staff and managers need to better understand what influences users' judgment of service quality, what is expected from specific services, and what improvements in service design and delivery are effective.

They need to understand their users not merely as recipients of services offered, but as partners in the development and implementation of services to make higher education and research experiences more successful from the customer's perspective (Nitecki 1996, p.188).

After the implementation of ARL GIS Literacy Project, literacy related to GIS in libraries increased. Lots of universities as they recognize the growing user interest in GIS accommodate this demand by providing services and collection development policies (Boston et al 1998; Sweetkind-Singer and Williams 2001; Howser and Callahan 2004 ; Houser 2006). Researchers and professionals in GIS referred not only in the technological infrastructure needed for its use but also in how GIS instructions are being provided to patrons (Kinikin and Hench 2005; Kinikin and Hench 2005a; March 2011). For Abbott and Argentati (1995) the library's decision to provide GIS technology and related services will bring many challenges and learning opportunities but factors that will need evaluation include the diverse needs of the campus or user community. As those professionals indicate "in order to understand the needs of research level GIS users, it is helpful to build relationships and engage in ongoing communication with the users. Florance (2006) in his work points out "*that the selectors should take into consideration the scale most appropriate to the needs of their patrons*" because "*the users of GIS are not necessarily part of the same user community as users of printed geographical information*".

The last two decades Greek libraries made tremendous development in infrastructure and services level. Several studies have been conducted over the years about users needs identification (Papachristopoulos e.a, 2008; Vardakosta and Avramidou 2008; Vardakosta and Tsubrakakou 2008) but none of them referred to the geospatial data and geographic information. This is the gap that our research intends to contribute.

3. Motivation for research

The recent years in Greece an enormous change occurred regarding the availability of geospatial data and an increased number of public sector organizations are becoming familiar with the "open access" culture. While some significant efforts like geodata.gov.gr have been emerged, thus, these advancements have left untouched the Greek academic libraries that seem to have remained in "the paper map era". Today, that the access in a wide variety of data and services is possible, more than ever, GIS patrons need libraries to recognize their increasingly diverse educational/research requirements and deliver the appropriate for them collections and services. The recognition and the identification of users needs are necessary conditions for the implementation of any kind of collection in a library. Patrons are the core element in an organization that provides services and that's why our research approached the Greek GIS users. Excluding some surveys for GIS technology in public's sector organizations (Karnavou 2002) there has not been carried out a survey of this type for geospatial collections and GIS services in Greek academic libraries so, this study provides the basis for research development in academic libraries and information services.

This paper is the result of an ongoing research to Greek scientific community dealing with geographic information and its dissemination. Our goal is to use the current research's results in order to formulate those proposals and policies that a library can adopt for developing geographical collections.

4. Previous Research

Objectives of the overall research

As mentioned above the paper aims to present the results of the last phase of an overall research regarding the geographic information in Greek libraries and information organizations. This research involved the capturing of GIS users' opinion for the services that libraries and information centers provide about geospatial information. Various scientific tools were used for conducting the research such as interview questionnaire in focus group for the first phase, website research and content analysis for the second one and a questionnaire for the third phase of our research.

We will briefly analyze the previous researches in order to make the concept of the research fully understood by the reader. We chose to describe in some detail the previous two phases of the research prior to the step by step description of the current study's results.

Phase I : What do experts sustain about GIS implementation in Greece

Objectives

The overall goal of the study was to determine how institutions/libraries have implemented GIS focusing on the areas of policies, hardware/software, staffing, costs, monetary support, user education and evaluation. We conducted a qualitative study by addressing four experienced GIS scientists (faculty and researchers). For this goal to be accomplished the interview was based on a controlled questionnaire that was used as a research tool.

The questionnaire was carried out, based on surveys that were investigating the implementation of GIS in academic libraries (Kinikin and Hench 2005 ; Kinikin and Hench, 2005a ; Gabaldon and Repplinger 2006), Australia's National Library Position associated with GIS implementation (O'Connor 1996); the strong recommendations of other librarians (French, 2001 ; Sweetkind-Singer and Williams 2001 ; Houser 2006 ; Todd 2008) and finally American Research Library GIS Literacy's Project, guidelines (ARL 1999). Furthermore, we collected information from several papers referring to existing geographical digital collections using GIS just to determine if the requirements of their development were alike (Abbott and Argentati 1995; Pfander and Carlock 2004; Hyland 2006) and we finally added questions mainly regarding the aspects of policies they followed, metadata and evaluation of the project. As it is mentioned above the survey instrument was a questionnaire consisting of 13 conditional sections, 27 questions, grouped by topic and in a way that matches the respondents perceptions of the relationship between the concerned issues: 1) General information : this section contained 6 questions that profiled the respondents (e.g. gender, discipline, education, organization/library, years of working experience and years of working in the specific organization) 2) GIS and library/organization: year that GIS developed and reasons that led to this decision, 3) Policies for collection development through a GIS system, 4) Staff (number, educational background), 5) Costs (number, financial source), 6) Hardware (variety of facilities), 7) Software

(name, access), 8) Data (source), 9) Metadata (use and kind), 10) Services provided, 11) Users, 12) User Education, 13) Evaluation of the project (See Appendix 1).

Results

According to our survey results, researchers and scholars in Greece were familiar with GIS since '90s while in universities this kind of technology appeared in the early 2000. They used an established development *policy* and investigate the format of data they were willing to use. The majority of the participants investigated their *user needs*, the necessary *budget*, limitations in the *use of data* and obtained the *technology* needed while the *staff* that was necessary for the project was partially ensured. Each institute used a different number of *staff* to get involved with the project (1-2, 3-4 and 4-5), while half of them were part time employees and the other half were full time employees. Their knowledge level was very high thanks to their expertise in GIS. Responses about *costs* of the whole project range from 3.000 euros to 1.000.000 euros for all units of the institutions and the funds come mainly from European Union or research programmes. In questions regarding the *hardware* that was used to support GIS services respondents indicated the use of computers, printers, scanners, digitizers, GPS units and Plotters. They all used a proprietary well known *software* (ArcView) operated on Windows platforms while two of the respondents indicated that the *data* required by the system were acquired, either donated by state agencies, or they originated from institutional research while the other two GIS scientists indicated that the data derived only from institutional research.

Three of the respondents use *metadata* while one of them uses CIDOC and the other one FGDC Content Standards for Digital Geospatial Metadata. The provided services differentiated since some institutions offer GIS services accessible through internet for all users while others are offering their services after a user request. The majority claims that the digital collection based upon a GIS system was developed in order to be *used by professionals, scientists and researchers of the organization*. These findings are not surprising since the institutions designed their programs having in mind to cover their users' needs first and the external users' needs secondly. Moreover, in these organizations the staff is partially occupied which indicates the limitation of offering services, as it is mentioned above.

It is noteworthy that the necessary assistant in *user education* was given, despite that lack of full employee staff. On the contrary, according to the respondents only one of them attempted to *evaluate* the whole project. This action maybe was the result of a written obligation of the funding commission just to ensure that the whole project finally worth the budget it was given and the goals they set were achieved or it was a decision they took when establishing their collection development policy. Utilizing an assessment survey might assist institutions in shaping GIS service planning efforts.

Phase II: Do libraries provide geographical information and GIS services?

In the second phase a research in the websites of Greek academic libraries was conducted in order to identify whether academic libraries have developed geospatial collections and GIS services fulfilling their users' informational needs.

The research in the websites of Greek academic libraries was chosen intentionally as Hahn and Schmidt (2005) declare “*that library’s website could be a powerful forum for communication with users*”. Thus, a research was conducted in various Greek Higher Education Institutions for departments affiliated with geographic information and the use of GIS; those specific libraries websites were scrutinized for the existence of any geographical collection. The findings indicate that only four academic libraries offer geospatial information to their users although Greek universities sustain an efficient number of departments related to geography, geology, environmental studies etc. (Vardakosta and Kapidakis 2011).

As from the above two phases key findings that emerged were: a) the need for geographical/geospatial information and b) the lack of academic libraries to deliver geospatial collections and GIS services to their patrons; the third’s phase aim was the “mapping” GIS user’s opinion regarding the current situation in Greek libraries. Our intention was particularly to capture their opinion on issues related to the use of libraries, the geospatial collections and GIS services, and the open access. The results of this last phase research will be presented in this paper.

Phase III: What are GIS users’ opinion about libraries’ role in covering their geographical needs?

Research Question

The research question formulated for this research was “*Do Greek libraries respond in covering the informational needs of GIS users?*” For answering that, the following sub-questions were formed:

- 1) Is library use a choice for GIS users in their seeking for appropriate information?
- 2) Is the implementation of geospatial collection a necessity for Greek libraries?
- 3) Is open access an opportunity and a perspective for growth for Greek libraries?

Methodology

The electronic questionnaire was chosen as a research tool which was circulated via e-mail in order to be answered whenever was convenient for the respondents. This process yielded 325 responses that were limited to 304 most completed questionnaires which represent a variety of GIS users (faculty, students, researchers etc). Since this study is the first one that focuses on GIS users and their opinion regarding geospatial collections in libraries, we consider the number of questionnaires capable of drawing conclusions. The questionnaire comprised of 20 questions (3 open questions and 17 closed questions in which 5 of them are in likert scale) (See Appendix 2) which were designed to answer the research questions.

Once the questionnaire was developed, it was sent to three key faculty members in Harokopio University in the Department of Geography and in Department of Home Economics and Ecology for review and to one Doctoral Librarian with expertise in users surveys for review. Based on their comments the instrument was revised.

Data collection

The questionnaire was anonymous and consists of 4 sections. The first section (questions 1-5) focused on demographic data and included questions about gender, participant's educational background, working environment, discipline, and reasons for using geographical information and GIS, as to enable a deeper analysis. The second section (questions 6-12) explored the participant's use of libraries. The third section (questions 13-17) was designed in a way that permits participants to express their opinion regarding the necessity of the development of geospatial collections. By the fourth section (questions 18-19) the participants were able to answer significant questions regarding open access and libraries. Finally, there was a last (no 20) open ended question asking participants to express their opinion on what should be done for the exploitation of the geospatial data. A cover letter explaining the objectives of the research accompanied the questionnaire. Our intention was to create a sort concise questionnaire in order to increase responsiveness.

The questionnaire was promoted in print format during the 7th Panhellenic Conference of HellasGIS (May 2012) posted on the website of HellasGIS, and on the geoportal "Geothea". Due to constraints of the semester expiration and the summer holidays the response rate was low. That's why we decided to disseminate the questionnaire via e-mail to GIS users to academic institutions, research centers, public sector and private sector (companies that are engaged in GIS market) all over Greece. In January 2013 a reminder was sent to all the e-mail accounts that were used. The questionnaire's dissemination lasted till March of 2013. Technical reasons that occurred during the dissemination process (false e-mail, full e-mail account, reject message by the server etc) prevent the fully dissemination of the questionnaire.

Results

A. Participants/Demographics

In all, 304 users participated in the study; 57.1% (n=172) of whom were male and 42.9% (129) female. According their answers, 37.2% (n=112) had PhD degrees, 25.2% (n=76) a University grade, 23.9% (n=72) had master degrees, 3.3% (n=31) had a Technical Educational Institution degree and the rest 10.3% (n=31) has a different than above, educational level. 28.1% (n=84) of the participants were faculty in University, 27.42% (n=82) were students in university, 15.71 (n=47) were working in public sector, 15.05 (n=45) were working in private sector, 6.35% (n=19) were researchers in an academic institution, 4.7% (n=14) were researchers in Institution/Organization and finally 2.67% (n=8) has some other working involvement. There was an open ended question in demographic section which referred to the discipline of participant's expertise. Not all of them answered this specific question (90.13%, n=274), and for better analysis the results grouped and a breakdown is shown in Table 1.

The last question of demographic section users were asked to indicate the reason for using geographic information and GIS. As shown in Table 1, the majority of respondents 44.1% (n=131) are using geographic information for research, 38% (n=116) for educational purposes while for 29.7% (n=88) of them, GIS are part of their everyday work activity. Finally, 2.7% (n=8) indicate that they are using GIS for other purposes (for dissertations, or for several applications).

Table 1:Demographics

<i>Gender</i>	Frequencies	Percentages
Male	172	56.6
Female	129	42.4
<i>Academic qualification</i>		
PhD	112	37.2
Postgraduate diploma	86	28.3
Masters diploma	72	23.9
Other	31	10.3
<i>Professional Rank</i>		
Faculty	84	28.1
Students	82	27.42
Employees in public sector	47	15.71
Employees in private sector	45	15.05
Researchers in Academ.Inst.	19	6.35
Researchers in Res.Inst/Org	14	2.67
Other(unspecified occupation)	8	4.7
<i>Discipline</i>		
Geography	65	23.72
GIS	50	18.24
Urban Planning	26	9.48
Ecology,Ecosystems	20	7.29
Geology	22	8.02
Agronomy-Topography	18	6.56
Remote Sensing	13	4.74
Seismology	10	3.64
Engineering	11	4.01
Natural Disasters	9	3.28
Transportation	8	2.91
Migration -Demographics	8	2.91
Archaeology	7	2.55
Hydrology	7	2.55
Forestry	6	2.18
Regional Development	4	1.45
Logistics	3	1.09
International Relations	2	0.72
Public administration	2	0.72
Agriculture	1	0.36
Health	2	0.72
Military	1	0.36
History	1	0.36
Taxation	1	0.36
Tourism	1	0.36
Oceanography	1	0.36
German literature	1	0.36
Economics	1	0.36

Table 1: Demographics (Cont.)

<i>Reasons for using GIS</i>	Frequencies	Percentages
Research	131	44.1
Education	113	38
Part of everyday work activity	88	29.7
Other	8	2.7

B. Library Use

The extent of library use by the GIS experts, their opinion for their organizational abilities, and the value of their assistance in covering their educational and research needs was the goal that the second section of the questionnaire planned to achieve. Moreover, it aimed to capture their point of view for those issues that can contribute towards a geospatial collection implementation. In response to the first question the majority of the participants 82.2% (n=244) utilize the internet to cover their geospatial information needs, 62.4% (n=181) make use of research data for this purpose, 57.3% (n=168) prefer the public sector while 47.3% (n=140) are using educational data and the 28.9% (n=83) of the participants take advantage of the foreign institutions' libraries for covering these needs.

Half of the participants declare the use of a Greek library (50.2%, n=148), and the majority of them indicate that those libraries they use do not cover their needs.

The participants of the research were asked to evaluate the development of the geospatial collection in Greece using a five-step likert scale ranging from 1 (=very good) to 5 (=insufficient). According to the majority 46.7% (136) of the respondents the geospatial collection development in Greek academic libraries is defined as "insufficient" and only a small percentage of 15.8% (n=46) rates them as "very good".

GIS patrons were asked to indicate from a list possible improvements in the development of geospatial collections. The geospatial collection development policies are indicated for the vast majority of the participants, 63.9% (n=191) as the possible specific area for improvement to the direction of a geospatial collection development, while almost half of them 50.8% (n=152) believe that the organizations' administration must be committed to the development of collections and services. The cooperation with other libraries for joint collection development or purchasing data consists an improvement area for 37.8% (n=113) of the participants, while 36.8% (n=110) mentions as a key factor the enhancing of user interest. Not surprisingly, 33.3% (n=99) do not believe that Greek academic libraries respond to the collection, organization, elaboration and dissemination of the geographical information and offer value added services. A great number of respondents 32.3% (n=96) has no clear view while only 16.5% (n=49) believe that Greek libraries respond to that role (Table 2).

Table 2: Participants' Library Use

QUESTIONS	RESPONSES	PERCENTAGES
Libraries responsiveness to collect & organize geospatial data	No	33.3% (99)
Medium used for covering geospatial needs	Internet	82.2% (244)
Use of Greek Library	Yes	50.2% (148)
Geospatial needs coverage by Greek Libraries	No	53.8% (77)
Geospatial Collection Development in Greece	insufficient	46.7% (136)
Possible improvements	Policies	63.9% (191)

C. Collection Necessity

The second section of the questionnaire aimed to gather information regarding participants' perceptions for the necessity of geospatial collection development. In response to the first question of the section, the overwhelming majority of the participants 65.1% (n=194) stated that geospatial collections are essential in all libraries despite their type.

Participants were also asked to indicate their belief whether Greek libraries should collect, organize and communicate the geospatial data that their parent institution/organization creates. The vast majority of 81.9% (n=245) consider the above statement as a necessity in contrast of a small number of participants 12.4% (n=37) that expressed their neutral.

GIS experts were asked to indicate their perceptions from a list of actions that a library can follow towards geospatial collection development. The majority of the respondents 59.9% (n=179) certify the geospatial collection development policies as the main action area that a library should follow to develop a geospatial collection. This answer corresponds directly with the answer in section 2, regarding the areas of improvement towards the geospatial collection development. The 40.5% (n=121) of the participants consider that "cooperation development with other libraries for developing common practices "could contribute to the development of geospatial collections, while "the complete agreement and the administrations' support" is for the 36.5% (n=109) the main area of contribution.

Additionally in this section participants were asked to testify from a list their perception for the possible reasons that act against to the development of geospatial collections. Not surprisingly, the majority 52.2% (n=156) believes that the main restraint for this condition is the lack of policies. For the 35.5% (n=106) the main reason preventing libraries from such a collection is the high cost of geospatial data, while for the 24.1% (n=72) is assigned to libraries' administration, and for the 23.7% (n=71) is the lack of qualified staff. The "high cost of infrastructure" remains for the 21.1% (n=63) the main barrier, but for the 10% (n=30) the "lack of users interest" is the main reason that libraries do not develop geospatial collections.

In the final question of the section we asked the participants to testify their beliefs for the kind of the organization that should be responsible for the collection and dissemination of geospatial data, by rating according to the priority from a list. The "public sector (Libraries, National Documentation Centre,

Government Libraries etc)” received the overwhelming majority of 76.8% (n=229) of the answers (Table 3).

Table.3: Collection Necessity

QUESTIONS	RESPONSES	PERCENTAGES
Who should gather geospatial information	Public Sector	76.8% (229)
Geospatial Collection is a necessity for all libraries	Yes	65.1% (194)
Libraries should collect geospatial data	Yes	81.9% (245)
What a library should do for developing geospatial collections	Policies	59.9% (179)
Obstacles for geospatial collection development	Lack of policies	52.2% (156)

D. Open Access

The third section of the questionnaire was designed to collect participant’s perceptions for the open access movement and its use by libraries (Table 4). More particularly, the participants were asked to testify their opinion regarding the library’s choice to use geospatial collections in order to serve their users effectively and the vast majority of 79.8% (n=237) agrees with the statement (Fig.1). The last question of the section asked participants to declare their opinion for the availability of geospatial data only to the members of the organization that produced them and library serves. With the above statement the percentage of disagreement was vast, 64.4% (n=192). With that way, the respondents declared their belief for the free disposal of data.

Table 4: Open Access

STATEMENTS	PERCENTAGES
Libraries should use open geospatial data for providing better services	79.8% (237)
Libraries should provide geospatial data of their parent institution	64.4% (192)

What is the next priority for geospatial data?

We consider that the final open ended question would provide the opportunity to the respondents to share their deep thoughts and suggestions. In that way the questionnaire becomes an important communication channel between researchers and respondents. Thus, in the last open ended question we asked the respondents to express their opinion for the priorities that should be given in the exploitation of geospatial data.

Unfortunately, not all participants answered this open ended question 45.06% (n=137). Table 5 presents respondents’ milestones in the utilization and diffusion of geospatial data as ranked after they grouped under 5 subject categories according to their replies: “data”, “organizations”, “libraries”, “infrastructure”, “users”, “economics”.

According to their opinion the “open access to the data and their free availability at no cost” is considered as the first priority for the 20.43% (n=28) of the respondents. The “collection and organization of data” testified by 18.97% (n=26), while “policies development” mentioned by 15.32% (n=21). The “establishment of an aggregator for the management of produced geospatial data” suggested by the 8.75% (n=12), “users information” by the 8.02% (n=11) while the “quality of data” stated by 7.3% (n=10) of the respondents as the next priorities to geospatial data.

Table 5: Respondents’ perceptions for the next priorities to geospatial data

Rank	Categories	No	Percentages
Data			
1	Open access and disposal at no cost	28	20.43
2	Collection and organization of data	26	18.97
3	Policies development	21	15.32
6	Quality of data	10	7.3
10	Use of standards	6	4.37
11	Implementation of INSPIRE directive Repository for those geospatial data that are produced after public finance	5	3.64
12	that are produced after public finance	4	2.91
13	Metadata use	3	2.18
13	Determination of disposal conditions	3	2.18
Organizations			
4	Establishment of an aggregator for the management of produced geospatial data	12	8.75
7	Cooperation of public sector units the determination of that entity responsible for quality control	9	6.56
13	responsible for quality control	3	2.18
Libraries			
8	More data in libraries through the disposal of geospatial data to them	8	5.83
11	Geodatabases development by libraries	5	3.64
12	Cooperation (libraries with each other and with data producers)	4	2.91
12	Libraries’ administration interest	4	2.91
Infrastructure			
9	Development of infrastructure and use of the new technology (cloud sourcing, location based services etc)	7	5.10
Users			
5	Users information	11	8.02
13	Enhance of interest	3	2.18
13	Staff training	3	2.18
14	Teaching of related courses in school	1	0.72
Economics			
12	Public finance for data development from univ., inst, companies and for access	4	2.91

Discussion

The variety of disciplines that users are involved in, demonstrates GIS technology and data impact in today's information society despite the late involvement of Greek universities in the proliferation of new technologies related to dissemination of geographic information. GIS experts in the first phase of the research indicated the exploration of some key issues (policies, economics, staff, data, hardware, software, metadata, users, and user education) in order to implement GIS services in accordance with other researches (Deckelbaum 1997; Kinikin and Hench 2005; Kinikin and Hench 2005a).

Although GIS patrons in the third phase of our research express a strong recognition for libraries as the main organizations for collecting and disseminating the geospatial information, nevertheless, the absence of geospatial collections leads them to use internet as the primary information source as they indicated. This choice explains the fact that only half of the respondents (50.2%) use a Greek library for covering their informational needs. Their negative answer for geospatial data coverage is indicated by the “*insufficient*” identification of geospatial collection in libraries. Research data, public sector data, educational data, foreign institutions libraries' and private sector follows in users preferences as it was selected. Network-based geographical information services that utilize both wired and wireless internet to access geographical information, spatial analytical tools, and GIS services facilitate the access, processing and dissemination of geographical information and spatial analysis knowledge (Pong and Tsou 2003 p.5). The increasing popularity of the internet, has made it an integral part of our society and has changed how GIS data are accessed, shared, and manipulated.

As research results' reveal GIS patrons specify those actions that will lead libraries to fulfil their mission and expand their roles. A significant action for libraries is the development of policies. Policies indicated from the respondents as the main reason for the geospatial collection's absence. Moreover, as geospatial collections considered as a necessity in libraries despite their type, policies are also illustrated as the challenge needed for their implementation. Policies regarding the development of a digital collection mediate the creation process and maintenance of the collection within the digital library. The current information society along with the procedures of European Union or research programmes requires collection development policies to guarantee suitable resources in information organizations (e.g. RECODE project).

Another issue that the present research reveals and cannot be ignored is the relatively high percentage of participants that propose synergies as the medium that will lead to the collection development. Synergies, as researchers claim, range from commonly agreed metrics, and indicators, to the identification of subtle differences that need to be taken into account, to reform assessment strategies and policies and to facilitate collection analysis and interpretation of data (Lindauer 1998; Tsakonas and Papatheodorou 2009, p.179). The lack of administrations commitment is considered for many GIS users another important factor that acts against to geospatial collection development.

Comparing the low scores given by participants to financial contribution to the geo-collection development with the high percentage given for open access, leads to the conclusion that is considered as an opportunity to access those data they are interested in for. Special focus should be given to user's opinion about open

access. Participants consider open access as an opportunity for growth for Greek libraries since its use will provide better services. Additionally, the free availability of their parent institution geospatial data, will contribute to enhance added value services.

Research's results raise awareness among professionals in libraries and other information agencies motivating them to engage to new initiatives for the exploitation of geospatial data.

Conclusions

Using a variety of methods (focus group, website research, content analysis, questionnaire) we produced a wealth of findings related to the emergent opinion of users for libraries' response in providing geographic information and highlighted the perspectives of GIS experts in Greece for library's role in today's information society.

Although the current situation in Greek academic libraries does not fulfill their information needs regarding geospatial data and GIS services, still, according to our results, the majority of users gave them a vote of confidence since they certified libraries as the main organizations for collecting, organizing and distributing geo-information. GIS patrons' point of view clearly points out the strategic considerations libraries should take into account in order to expand their services and respond to their needs. Thus, the need for library involvement in the development of an integrated environment for access to geospatial information is clearly highlighted. The past two decades have clearly shown that libraries have the power to alter the information environment and to provide added value services to their patrons.

The above results indicate user's expectations for constant expansion of library's role and provided services in order to use effectively the spatial data covering their informational needs.

Acknowledgements

Authors wish to sincerely thank "HellasGIS" and the administrator of "Geothea" blog for their kind responsiveness to post the questionnaire to their website. Special thanks to all participants for taking time to respond this survey. Additionally, we would like to thank Alexandra Tragaki, Associate Professor in the Department of Geography at Harokopio University, Eleni Sardianou, Lecturer of Department of Home Economics and Ecology at Harokopio University and Dr. Maria Monopoli, Librarian at Bank of Greece for their helpful insights that greatly assisted the research.

BIBLIOGRAPHY

- Abbott, L.T. and Argenati, C.D. 1995. GIS: a new component of public services. *The Journal of Academic Librarianship*, 21(4), 251-256
- ARL Geographic Information System Literacy Project. 1999. <http://www.arl.org>
- Avramidou, A. and Vardakosta, I. 2008...*It is so if you think so...: Evaluation of Library's and Information Centre of Harokopio University user's education seminars*. In 17th Panhellenic Conference of Academic Libraries, Ioannina (Greece), 24-26 September <http://eprints.rclis.org/13237/>
- Boston, J., Dean, C. W., Phillips, H., and Pope, N. 1998. The public electronic library: integrating GIS resources and tools. *Library Hi Tech*, 16(3-4), 100-106.
- French, M. 2001. Creating support mechanisms for library GIS services: a perspective. *Current Studies in Librarianship*, 25(1/2), 39-48
- Deckelbaum, D. 1997. GIS in libraries: an overview of concepts and concerns. *Issues in Science and Technology Librarianship*, Winter <http://www.istl.org/99-winter/article3.html>
- Devadason, F.J. and Lingam, P.P. 1996. "A Methodology for the Identification of Information Needs of Users" 62nd IFLA General Conference - Conference Proceedings - August 25-31, <http://archive.ifla.org/IV/ifla62/62-devf.htm>
- Florance, P. 2006. GIS collection development within an academic library. *Library Trends*, 55(2), pp.222-235.
- Gabalton, C. and Replinger, J. 2006. GIS and the academic library: a survey of libraries offering GIS services in two consortia. *Issues in Science & Technology Librarianship*, 48, Fall, <http://www.istl.org/06-fall/refereed.html>
- Hahn, K. L. and Schmidt, K. 2005. "Web Communications and Collections Outreach to Faculty." *College and Research Libraries*, January pp.28-40.
- Harris, L. 2008. Library user needs analysis report http://works.bepress.com/cgi/viewcontent.cgi?article=1002&context=lindsay_harris
- Houser, R. 2006. Building a library GIS from the ground up. *Library Trends*, 55(2) 315-326
- Howser, M. and Callahan, J. 2004. Beyond Locating Data: Academic Libraries Role in Providing GIS Services. EdUC Conference Proceedings.4th Annual ESRI Education User Conference. <http://proceedings.esri.com/library/userconf/educ04/papers/pap5127.pdf>
- Hyland, N.C. 2002. GIS and data sharing in libraries: considerations for digital libraries. *INSPEL*, 36(3), 207-215
- Karnavou, E. 2002. Geospatial Data Infrastructure and GIS in modern Greece. Thessaloniki: Paratiritis [in Greek]
- Kinikin, J.N. and Hench, K. 2005. Survey of GIS implementation and use within smaller academic libraries. *Issues in Science and Technology Librarianship*, Springer <http://www.istl.org/05-spring/refereed-1.html>
- Kinikin, J.N. and Hench, K. 2005a. Follow-up survey of GIS at smaller academic libraries. *Issues in Science and Technology Librarianship*, Summer <http://www.istl.org/05-summer/article1.html>
- Lindauer, B.G. 1998. Defining and measuring the library's impact on campus wide outcomes. *College & research Libraries*, 59(6), pp.546-570
- March, G.H. 2011. Surveying Campus GIS and GPS Users to Determine Role and Level of Library Services in *Journal of Map & Geography Libraries: Advances in Geospatial Information, Collections & Archives*, 7 (2), p.154-183
- Marchionini, G., Plaisant, C. and Komlodi, A. 2003. The people in digital libraries: Multifaceted approaches to assessing needs and impact. In A.Bishop, B.Butenfield, & N.VanHouse (Eds.), *Digital library use: Social practice in design and evaluation*. Boston: MIT Press.

- O'Connor, M. 1996. Strategic considerations in establishing a GIS in a library.
<http://www.nla.gov.au/nla/staffpaper/mo1.html>
- Nitecki, D.A. 1996. Changing the Concept and Measure of Service Quality in Academic Libraries, *The Journal of Academic Librarianship*, 22(3) pp.181-190
- Papachristopoulos, L., Tsakonas, G. and Papatheodorou, C. 2008. Enforcement of information seeking behaviour through digital library services. In *Libraries in the Digital Age 2008*, Dubrovnik and Mljet (HR), 2-7 June
- Peng, Z-R. and Tsou, M-H. 2003. Internet GIS: distributed geographic information services for the internet and wireless networks. New Jersey: Wiley
- Pfander, J. and Carlock, D. 2004. The Arizona Electronic Atlas: a new reference and instructional tool. *Issues in Science & Technology Librarianship*, Fall, <http://www.istl.org/04-fall/article1.html>
- Sweetkind-Singer, J. and Williams, M. 2001. Supporting the Information Needs of Geographic Information Systems (GIS) Users in an Academic Library. *Science & Technology Libraries*, 21 (3-4) pp.175-190
- Todd, J.L. 2008. GIS and libraries. *Online*, 32(5), 14-18
- Tsakonas, J. and Papatheodorou, C. 2009. Evaluation of Digital Libraries: An Insight to useful Applications and Methods. Oxford: Chandos Publishing.
- Vardakosta, I. and Tsoubrakakou, A. 2008. Library's and Information Centre of Harokopio University's Services Evaluation In 17o Panhellenic Conference of Academic Libraries, Ioannina (Greece), 24-26 September [in Greek with English abstract] <http://eprints.rclis.org/13235/>
- Vardakosta, I. and Kapidakis, S. 2011. Geographical collections in Greek academic libraries: Current situation and perspectives. In International Conference on Integrated Information, Kos, September 29 - October 3 <http://eprints.rclis.org/16169/>

APPENDIX 1

QUESTIONNAIRE FOR GIS IMPLEMENTATION IN LIBRARIES/ORGANIZATIONS

1. Demographics

1. Gender:
 - Female
 - Male
2. What is the organization you are working at?
3. What is your position in the organization?
4. Education level:
5. Total years of working experience:
6. Years of working experience in the same organization:

2. GIS and Organization

7. Year that GIS implemented in your organization:
8. Report the GIS implementation purposes (*e.g. geospatial information needs of the organizations' researchers*) 1. 2. 3. 4. Other:

3. GIS Services Development Policies

9. Did library/Organization develop a policy for the provided collection in order to emerge GIS services?
 - Yes
 - No
 - I'm not sure

10. In order Library/Organization to provide GIS services:

	Yes	No	Partially
1. Investigated and identified users needs			
2. It took into account organizations budget			
3. Investigated use restrictions of various types of data			
4. Investigated resources availability			
5. Investigated data's format			
6. Obtained the necessary staff			
7. Developed a policy for the data used in a GIS			
8. Ensured the necessary technological infrastructure			

4. Staff

11. How many people in your organization are involved in GIS services?

- 1-2
- 3-4
- 4-5
- 6-
- Other ...

12. The personnel involved in the organization of GIS service is:

- Full Time employee/s in GIS (*Please specify which expertise*)
- Part Time employee/s in GIS (*Please specify which expertise*)
- Other

13. The personnel involved in GIS service's organization:

- Is/Are GIS specialist/s
- Have been trained on GIS
- Not specialized but interested in GIS

5. Economics

14. Please determine the amount of the annual available budget for Library/organization of the annual available budget for your Library /Organization:

15. Please determine the amount of money that has been spent for the development of GIS in your Organization:

16. The amount of money spent for the implementation of the system is derived from:

- The annual budget
- Research programme
- European programme
- Other (*please specify*)

6. Hardware

17. What kind of equipment do you provide to support GIS services? (*you may choose more than one answer*)

- PC's
- Printers
- Scanners
- Digitizers
- GPS units
- Plotters
- Other (*please specify*)

18. The operating system that GIS is installed on is:

- Windows
- Macintosh
- UNIX
- Other (*please specify*)

7. Software

19. The software you use for data processing is:

- Developed by us
- ArcView
- ArcGIS
- Arc Info

- MapInfo
 - Other (please specify)
20. This software is:
- Accessible only from single workstations
 - Installed on library's/Organizations' server
 - Other (*please specify*)

8. Data

21. Data entered in GIS derived from (*Please check all that applies*):
- Purchase
 - Donations
 - Internet Resources
 - Public Sector's Organizations
 - Organizations' research production
 - Other (*please specify*)

9. Metadata

22. Do you use metadata standards?
- Yes
 - No
 - Where appropriate
23. If yes, what schema? (*please specify*)

10. Level of provided service

24. Services provided by Library/Organization related to GIS include:
- Installed base system in the Library/Organization from which users can have access
 - Remote access to the system for all users
 - Remote access to the system to authorized users
 - Customized services (if requested by users)

11. Users

25. You developed this system to be used by: (*please specify scientific or other disciplines in order of priority filling in as needed e.g. geographers, archaeologists*):1...2...3...4...

12. User Education

26. The education provided for the use of GIS:
- Provided by Library/Organization through organized seminars
 - Provided by Library/Organization through electronic help
 - Provided by skilled persons not belonging to the Library/Organization
 - Education or help is not provided

13. GIS Evaluation

27. Have you carry out an evaluation study of the GIS that have been applied?
- Yes
 - No
 - I'm not sure

APPENDIX 2

QUESTIONNAIRE FOR GEOSPATIAL COLLECTIONS AND OPEN ACCESS IN GREEK LIBRARIES

A. Demographics

1. Sex:
- Female
 - Male
2. You have:
- Technological Educational Institute Grade
 - University Grade
 - Post Graduate Grade
 - PhD
 - Other (*please define*):
3. You are employed in:
- Public Sector
 - Private Sector

- University (as Faculty)
- University (as researcher)
- University (as student)
- Technological Institute (as Faculty)
- Technological Institute (as researcher)
- Technological Institute (as student)
- Research Institution/Organization
- Other (*Please define*)

4. Which is the field of your scientific specialization? Please give a brief reference:

5. For what reasons do you use GIS and data:

- Educational reasons
- Scientific reasons
- Are part of my every-day work activity
- Other (*please specify*)

B. Library Use

6. How do you cover your informational needs regarding geospatial data? (*Please prioritize*):

- Internet
- Research Data
- Educational Data
- Libraries of foreign Institutions
- Public Sector
- Private companies
- Other (*please define*)

7. Do you use any Greek library in order to cover your educational/research needs?

8. If yes, please identify the library/libraries:

9. If yes, do you believe that the library/ies you mentioned above cover your informational needs considering the digital geospatial information and the GIS services?

- Yes
- No

10. How would you evaluate the development of geospatial collection in Greece (*with 1 evaluate as "very good" and 5 as "insufficient"*).

11. In your opinion which areas should be improved in order geospatial collections to be developed?

- The planning of geospatial collection development policies
- Administration's commitment in developing collections and services
- Library's staff training
- Enhancing user's interest
- The development of synergies with the members of the parent organization
- The development of synergies with other libraries for common collections development practices or data acquisition
- Other (*please define*)

12. Do you believe that the Greek libraries respond well in collecting, organizing elaborating and spreading the geospatial information, so that they can offer services of additional value to their users?

- Yes
- No
- Maybe
- Don't know/Don't answer

C. Collection Necessity

13. Please evaluate the necessity of geospatial collections and GIS services in libraries. Identify the proposal you agree to:

- It is necessary only to libraries serving similar departments (university) or needs (institutions)
- It is necessary for all libraries regardless their kind
- It is not necessary for libraries

14. Do you believe that libraries should collect, organize and diffuse the geospatial data produced by their parent institution?

- Yes
- No
- Maybe
- Don't know/Don't answer

15. How, in your opinion, could a library contribute to the development of a geospatial collection?

- By planning geospatial collections development policies
- With the agreement and support of the administration
- By further training of the library's staff
- By strengthening patron's interest
- By developing synergies with members of the parent organization
- By developing synergies with other libraries for common collections development practices or data acquisition
- Other (*please define*)

16. In your opinion what are the reasons that inhibit the development of geospatial collections and GIS services in Greek academic libraries?

- Lack of geospatial collection development policies
- The high cost of geospatial data acquisition
- The high cost of infrastructure
- Lack of interest by libraries' administration
- Staff's lack of knowledge
- Users' lack of interest
- Other (*please define*)

17. Who in your opinion, should have the responsibility to collect geospatial data from producers and spread them with a uniform way? (*Please, prioritize*)

- Nobody, can be found sparsely on the web
- In private agencies
- Research Institutions /Organizations
- Academic Institutions
- Public Sector (National Documentation Centre, National Library, Ministries etc.)
- Other (*please define*)

D. Open Access

18. Do you believe that libraries should turn to geospatial data to better serve their users?

- Yes
- No
- Maybe
- Don't know/Don't answer

19. Do you believe that libraries should provide data only to members of their organization, even if they are not subject to legal restrictions (copyright issues)?

- Yes
- No
- Maybe
- Don't know/Don't answer

20. In your opinion which is the next priority for utilization/spread of geospatial data?

Σύγχρονες διεργασίες ιζηματογένεσης στο υποθαλάσσιο τμήμα του δέλτα του ποταμού Πηνειού (Θεσσαλίας)

Γαζής Ι-Ζ.¹, Λαζογιάννης Κ.^{1,2}, Χασιώτης Θ.¹, Βελεγράκης Α.¹ και Πούλος Σ.²

¹ Τμήμα Επιστημών της Θάλασσας, Πανεπιστήμιο Αιγαίου, Λόφος Πανεπιστημίου, Μυτιλήνη 81100, Λέσβος, hasiotis@marine.aegean.gr

² Τμήμα Γεωλογίας & Γεωπεριβάλλοντος, ΕΚΠΑ, Πανεπιστημιούπολη, Ζωγράφου 15784, Αθήνα

Abstract

Piniος river (Thessaly) discharge at the outer part of Thermaikos plateau forming an extensive deltaic plain. Even if many studies have been performed for the subaerial part of the delta, the submarine part has been only occasionally studied during surveys of the wider Thermaikos Gulf. This paper summarizes the modern sedimentation processes of the subaqueous part of the delta down to ~70m water depth. High resolution data were acquired using a multibeam and a 3.5 kHz subbottom profiler along ~215 km of navigation lines. Positioning was by a DGPS. The morphology of the delta is smooth with slopes reaching the ~12 % along the delta slope between the 15 and 35 m depth. The seismic stratigraphy is described by two seismic sequences. The upper sequence corresponds mainly to fine-grained sediments deposited during the Holocene highstand (mid-late Holocene), having a considerable thickness shallower than the 35m and wedging out at greater depths. The lower sequence is related to sediments deposited during the Late Pleistocene – Holocene transgression and seems to be coarser and/or more compacted relatively to the overburden. The acoustic basement has an uneven morphology, it is rarely traced and corresponds to the pre-transgression subaerial surface at about 120-130 m depth. At the northern part older deltaic plain and foreset deposits were recognized. These sediments seem to be eroded due to wave and near-bed current action, respectively. Alternations of the river mouth and distributary channels southern than the modern mouth, had as a consequence smaller amounts of sediment deposition to the north, prone to the erosion action caused by local hydrodynamics. The subbottom sediments are characterized by the widespread occurrence of gases, especially at the central and southern parts of the delta, having as a result numerous acoustic anomalies (turbid zones, gas plumes, enhanced reflectors etc). Their presence in combination with the unconsolidated sediment nature have caused deformational features like small successive rotated blocks and dewatering structures, which are covered by a thin veneer of recent sediments. The lower seismic sequence is intersected by a big number of channels in different stratigraphic levels, implying to intense sedimentation processes during the last transgression phase. Smaller channels are occasionally observed also in the upper seismic sequence. Modern channels at the shallow waters of the deltaic plain were not detected, probably due to the rapid sediment re-distribution from the wave action. At the southern part of the delta NW-SE synthetic normal faults were found to displace the sedimentary layers of the lower seismic sequence.

Λέξεις Κλειδιά

Δέλτα Πηνειού, Ολόκαινο, γεωφυσική διασκόπηση, αέριοι υδρογονάνθρακες, κανάλια, ρήγματα

Keywords

Piniος delta, Holocene, geophysical prospecting, gas, channels, faults

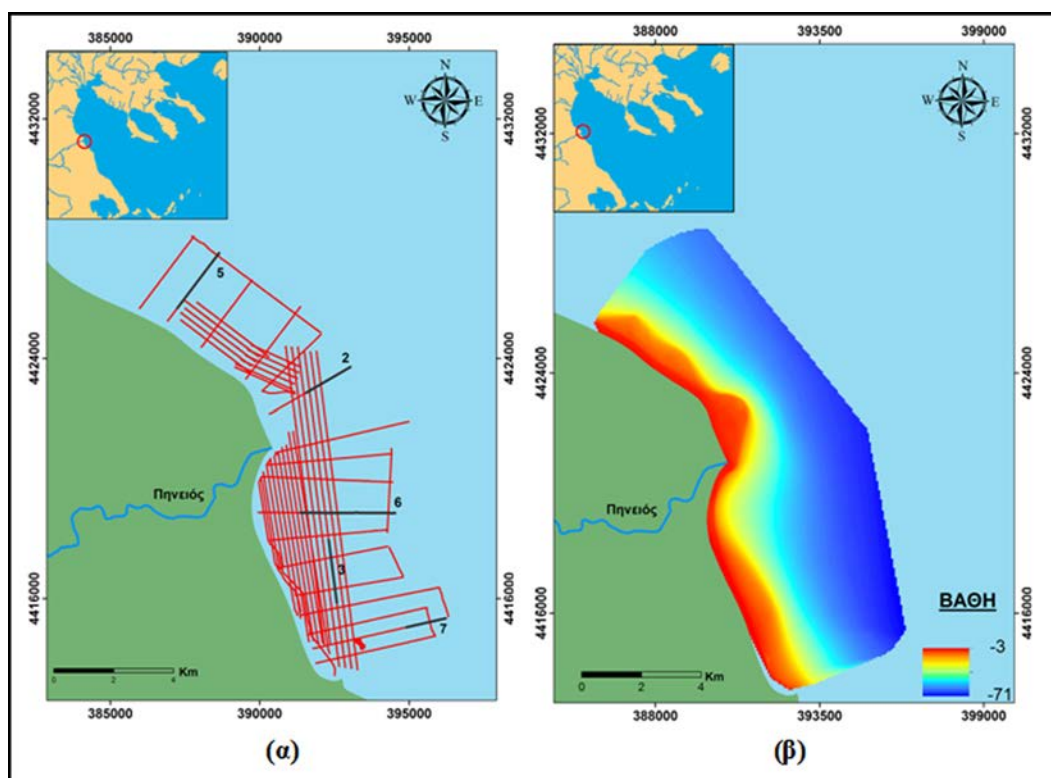
Εισαγωγή

Ο ποταμός Πηνειός (Θεσσαλίας) εκβάλλει στο δυτικό τμήμα του εξωτερικού πλατώ του Θερμαϊκού κόλπου σχηματίζοντας ένα εκτεταμένο δελταϊκό πεδίο έκτασης ~70 km² με μήκος δελταϊκής γραμμής περί τα 20km. Σύμφωνα με το σύστημα ταξινόμησης του Galloway (1975) κατατάσσεται στα κυματικά δέλτα καθώς η μέση ετήσια μηνιαία ένταση της κυματικής δράσης στις δελταϊκές ακτές είναι της τάξης των 70-1454 w/m², με κύματα μεγάλου αναπτόγματος (Poulos et al. 2000), ενώ αντίθετα το παλιρροιακό εύρος της περιοχής είναι σχετικά μικρό (μ.ο. 20 cm) (Kombiadou et al., 2012). Αν και το χερσαίο τμήμα του

δέλτα έχει αποτελέσει αντικείμενο συστηματικής μελέτης από πολλούς ερευνητές (π.χ. Karymbalis and Gaki-Papanastassiou, 2008; Gaki-Papanastassiou et al., 2010), το υποθαλάσσιο τμήμα έχει περιστασιακά ερευνηθεί στο πλαίσιο μελετών του ευρύτερου Θερμαϊκού κόλπου (π.χ. Lykousis et al., 2005; Karageorgis et al., 2005a, b). Στην εργασία αυτή μελετώνται οι σύγχρονες διεργασίες ιζηματογένεσης όπως αποτυπώθηκαν σε μια αναλυτική έρευνα υψηλής διακριτικότητας στο υποθαλάσσιο δελταϊκό πρίσμα και μέχρι βάθους περίπου 70 m.

Μεθοδολογία

Η συλλογή των γεωφυσικών δεδομένων πραγματοποιήθηκε με ένα πολυδεσμικό ηχοβολιστή τύπου GeoAcoustics και με έναν τομογράφο υποδομής πυθμένα 3.5 kHz ORE / Geopulse υψηλής διακριτικής ικανότητας. Ο προσδιορισμός της θέσης του σκάφους πραγματοποιούνταν με διαφορικό δορυφορικό σύστημα (DGPS) της TRIMBLE. Για την πλοήγηση του σκάφους και το σχεδιασμό των πορειών ηχοβολισμού χρησιμοποιήθηκε το σύστημα HYPACK. Η έκταση του πυθμένα που σαρώθηκε ήταν περίπου 26.5 km² κατά μήκος ~ 215 km γραμμών πλοήγησης (Εικ. 1α). Για την επεξεργασία των γεωφυσικών δεδομένων χρησιμοποιήθηκε το λογισμικό SonarWiz Map, ενώ τα ψηφιακά βαθυμετρικά αρχεία και η παραγωγή όλων των χαρτών έγινε μέσω του λογισμικού ArcGis 10.1.

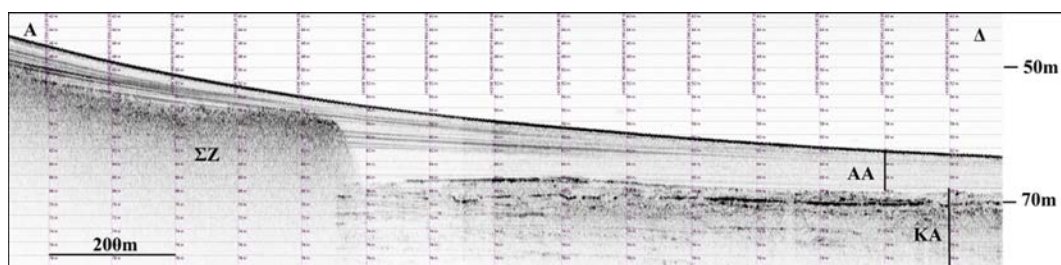


Εικόνα 1: (α) Χάρτης πορειών γεωφυσικής διασκόπησης και θέσεις τομογραφιών που παρουσιάζονται στο κείμενο και (β) βαθυμετρικός χάρτης της υποθαλάσσιας περιοχής του δέλτα του Πηνειού.

Αποτελέσματα και Συζήτηση

Η μορφολογία του υποθαλάσσιου τμήματος είναι ομαλή με κλίσεις που κυμαίνονται από 1 έως 12 % (Εικ. 1β). Η δελταϊκή πλατφόρμα εξαπλώνεται έως τα ~15 m βάθος, περιορισμένη σημαντικά στο βόρειο τμήμα του δέλτα λόγω της μειωμένης πλέον τροφοδοσίας ιζημάτων (παλαιοεκβολή) και της έντονης κυματικής αλλά και ρευματικής δράσης στην περιοχή (π.χ. Zervakis et al. 2005). Αντίθετα, εκτείνεται σε μεγάλη απόσταση (~800 m) μπροστά από τη σημερινή κύρια εκβολή. Το δελταϊκό μέτωπο βρίσκεται μεταξύ των ισοβαθών των 15 και 35 m όπου και αναπτύσσονται και οι υψηλότερες κλίσεις. Τέλος, η προδελταϊκή περιοχή φτάνει στα ~ 70 m με ασήμαντες κλίσεις.

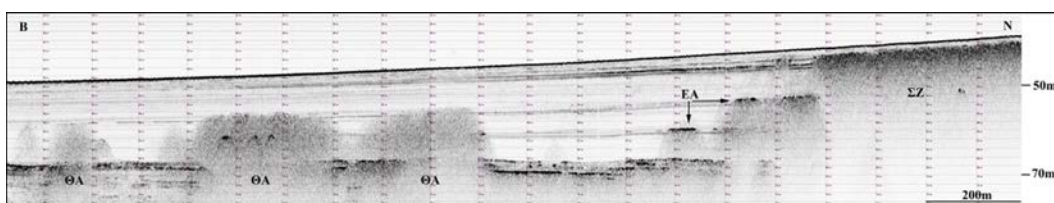
Η γενική στρωματογραφία στη ζώνη έρευνας περιγράφεται από την ύπαρξη δύο κύριων σεισμικών ακολουθιών (Εικ. 2) που επικάθονται στο ακουστικό υπόβαθρο της περιοχής. Η ανώτερη (επιφανειακή) σεισμική ακολουθία (ΑΑ) είναι ακουστικά σχεδόν διαφανής χωρίς ή με λίγες ασθενείς παράλληλες / υποπαράλληλες εσωτερικές ανακλάσεις και με μια συνεχή και σαφή επιφανειακή ανάκλαση. Τα ιζήματα της ακολουθίας αυτής αποτέθηκαν κατά τη διάρκεια της πρόσφατης υψηλής στάθμης της θάλασσας (μέσο-ανώτερο Ολόκαινο) και σχετίζονται με τις πλέον σύγχρονες λεπτόκοκκες αποθέσεις του δελταϊκού πρίσματος, οι οποίες έχουν σημαντικό πάχος πλησίον της ακτής (30 και τοπικά 35 m) και αποσφηνούνται με την αύξηση του βάθους. Οι ασθενείς εσωτερικές ανακλάσεις αντιστοιχούν σε αδρομερέστερα ιζήματα (έως αμμόδη) που αποτέθηκαν σε περιόδους πιο έντονων πλημμυρικών ροών. Η γεωμετρία των σεισμικών ανακλαστών της ΑΑ είναι πλάγια προσχωματική, υποδηλώνοντας την ύπαρξη σχετικά μεγάλης τροφοδοσίας ιζημάτων, με πολύ μικρή ή καθόλου καθίζηση της επιφάνειας απόθεσης σε περιβάλλον σταθερής στάθμης θάλασσας. Η κατώτατη σεισμική ακολουθία (ΚΑ) χαρακτηρίζεται από ημιπαρατεταμένη ανάκλαση, με παράλληλες / υποπαράλληλες, ημιπαρατεταμένες, διακοπτόμενες, ασαφείς υποεπιφανειακές ανακλάσεις, τοπικά με παρουσία υπερβολών. Η ΚΑ αντιστοιχεί σε ιζήματα που αποτέθηκαν κατά την αρχική φάση της τελευταίας επίκλυσης (ανώτερο Πλειστόκαινο – κατώτερο Ολόκαινο) και είναι περισσότερο συμπιεσμένα ή/και αδρομερέστερα σε σχέση με τα υπερκείμενα. Σύμφωνα με τους Lykousis et al. (2005) το όριο μεταξύ των ΑΑ και ΚΑ (μέγιστη πλημμυρική επιφάνεια) υπολογίστηκε στα 6000 yr BP τόσο για την ευρύτερη περιοχή του Θερμαϊκού Κόλπου, αλλά προσεγγιστικά και για τον Πηνειό, βάση πυρηνοληψιών, που πραγματοποιήθηκαν στις προδελταϊκές περιοχές του Αξιού και του Πηνειού και τοπικά διείσδυσαν μέχρι το άνω μέρος της αδρομερέστερης ΚΑ. Το ακουστικό υπόβαθρο (μη διακριτό σε όλες τις τομογραφίες) αντιστοιχεί στην ασυμφωνία της ΚΑ με το προ-επίκλυσης ανάγλυφο, τμήμα του οποίου είχε χερσεύσει μέχρι βάθους 120 - 130 m και εμφανίζει, γενικά, ανώμαλη μορφολογία και μεγάλη συμπύκνωση μη επιτρέποντας στα ηχητικά κύματα βαθύτερη διείσδυση.



Εικόνα 2: Τομογραφία 3.5kHz κατά μήκος των κύριων εκβολών του Πηνειού όπου διακρίνονται η ανώτερη σεισμική ακολουθία (ΑΑ), η κατώτερη σεισμική ακολουθία (ΚΑ) και σεισμοκονιασμένες ζώνες (ΣΖ).

Ένα από τα σημαντικότερα χαρακτηριστικά που εντοπίστηκαν στις τομογραφίες είναι η εκτεταμένη ακουστική επικάλυψη των ιζημάτων (και ιδιαίτερα της ΚΑ) λόγω έντονα σεισμοκονιασμένων περιοχών και άλλων ηχητικών ανωμαλιών (έντονοι ανακλαστήρες και σεισμοκονιασμένοι θύλακες) που οφείλονται στην ύπαρξη αέριων υδρογονανθράκων στους πόρους των ιζημάτων (Εικ. 2 και 3). Η παρουσία αέριων υδρογονανθράκων στα ιζήματα του δέλτα του Πηνειού και της ευρύτερης περιοχής του Θερμαϊκού κόλπου έχει επισημανθεί και από άλλους ερευνητές (Lykousis et al, 1981; Lykousis et al, 2009). Το πεδίο εμφάνισης των αέριων υδρογονανθράκων καταλαμβάνει μεγάλη έκταση (Εικ. 4), με τη μεγαλύτερη συγκέντρωση να είναι στο κεντρικό και νότιο τμήμα της περιοχής μελέτης, ενώ ελαττώνεται σε έκταση προς το βόρειο τμήμα. Η συνολική έκταση που καταλαμβάνουν οι αέριοι υδρογονάνθρακες είναι 18 km², ενώ η βαθυμετρική τους εξάπλωση βρίσκεται μεταξύ των ισοβαθών 25 - 40 m στο βόρειο τμήμα, 15 - 55 m κοντά στις εκβολές και 5 - 45 m στο κεντρικό και νότιο τμήμα. Όσον αφορά την κατανομή μέσα στην ιζηματογενή στήλη και εδώ τα βάθη ποικίλουν με τα αέρια να εμφανίζονται από βάθη ~38 m κάτω από την επιφάνεια του πυθμένα έως και λιγότερο από 1 m από τον βυθό. Η μελέτη των τομογραφιών δεν έδειξε την

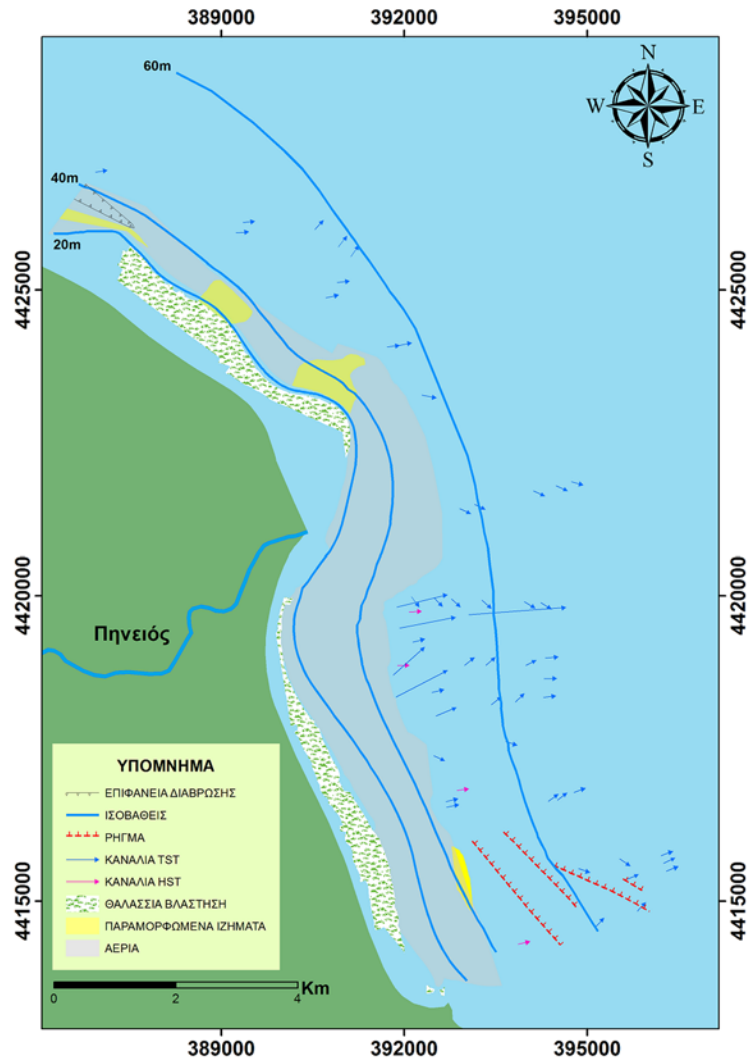
παρουσία επιφανειακών ή υποεπιφανειακών χαρακτηριστικών που σχετίζονται με την ύπαρξη αερίων (πχ κρατήρες, αναθολώσεις). Η απουσία τους πιθανώς να οφείλεται στο γεγονός ότι η πίεση που ασκείται από την υφιστάμενη συγκέντρωση αερίων δεν μπορεί να θέσει σε αιώρηση ή σε αναθολωση τα ιζήματα. Επίσης δεν καταγράφηκαν διαφυγές αερίων υδρογονανθράκων μέσα στην υδάτινη στήλη. Βέβαια, η ύπαρξη των αερίων σε μικρό βάθος κάτω από τον πυθμένα σε συνδυασμό με τη γειτνίαση της ευρύτερης περιοχής με την τεκτονικά ενεργή περιοχή της τάφρου των βόρειων Σποράδων (δυτική απόληξη της τάφρου του Βορείου Αιγαίου), δεν αποκλείει στο μέλλον την ανάπτυξη τέτοιων δομών, μετά από σεισμικά γεγονότα ικανού μεγέθους, όπως άλλωστε έχει παρατηρηθεί και σε άλλες σειсмоγενείς περιοχές της χώρας (Papatheodorou et al., 1993; Hasiotis et al., 1996). Όσον αφορά στη σύσταση των αερίων, με βάση την ευρύτερη οικο-γεωλογία της περιοχής μελέτης, πρόκειται μάλλον για βιογενούς προέλευσης.



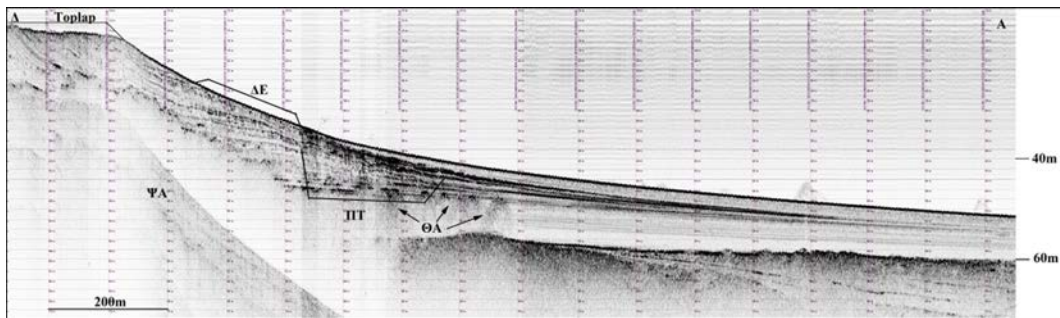
Εικόνα 3: Τομογραφία 3.5kHz όπου φαίνονται διάφορα ηχητικά φαινόμενα (SZ, EA, ΘΑ) λόγω της ύπαρξης αερίων υδρ/κών στους πόρους των ιζημάτων (SZ: σεισμοκονιασμένες ζώνες, EA: έντονοι ανακλαστήρες, ΘΑ: θύλακες αερίων).

Στο βόρειο τμήμα της ζώνης έρευνας, η ύπαρξη των αερίων σε συνδυασμό με τον υπο-στερεοποιημένο χαρακτήρα των δελταϊκών αποθέσεων οδήγησαν σε εσωτερικές παραμορφώσεις των ιζημάτων υπό τη μορφή (i) μικρών περιστροφικά ολισθόντων τεμαχών κατά μήκος μικρής έκτασης και βάθους καμπύλων επιφανειών ασυνέχειας (Εικ. 4 και 5), παρόμοιων με αυτά που αναφέρονται από τους Hasiotis et al., (2006) και Lykousis et al., (2009) σε δελταϊκά περιβάλλοντα και (ii) δομών αφυδάτωσης (dewatering structures), που τοπικά καλύπτονται από μικρού πάχους επιφανειακά αδιατάρακτα ιζήματα. Γενικά όμως, η μελέτη των τομογραφιών δεν φανέρωσε κάποιο εκτεταμένο ή μη σύγχρονο κατολισθητικό φαινόμενο, γεγονός που μοιάζει αρκετά παράδοξο αν αναλογιστεί κανείς την έντονη παρουσία αερίων υδρογονανθράκων στο μεγαλύτερο τμήμα της ζώνης έρευνας σε όλη την ιζηματογενή στήλη, αλλά και τον υποστερεοποιημένο χαρακτήρα των σύγχρονων δελταϊκών ιζημάτων, συνδυασμός που συνδέεται σχεδόν πάντα από χαμηλές τιμές διατμητικής αντοχής στους πόρους των ιζημάτων και ιζήματα επιρρεπή σε αστοχίες (Whelan et al., 1975). Βέβαια, θα πρέπει να ληφθούν υπόψη οι μικρές κλίσεις των πρηνών και η απουσία έντονης σεισμικής δραστηριότητας, ενώ επιπλέον ο Λυκούσης (1990) αναφέρει ότι οι προδελταϊκές τουλάχιστον αποθέσεις χαρακτηρίζονται γεωτεχνικά ως λίγο ευαίσθητες, με τις τιμές αστράγγιστης διατμητικής αντοχής να προσεγγίζουν τα 51 kPa σε βάθος 2.7 m κάτω από τον πυθμένα.

Στο όριο της ζώνης έρευνας στο βόρειο τμήμα του δέλτα, και σε βάθη 36 – 40 m διαπιστώθηκε αποκάλυψη υποεπιφανειακών ανακλαστήρων στον πυθμένα (Εικ. 5), γεγονός που αντιστοιχεί σε χαρακτηριστικές διαβρωσιγενείς επιφάνειες που οφείλονται μάλλον στη δράση ρευμάτων κοντά στον πυθμένα (Zervakis et al., 2005). Η στρωματογραφική σχέση toplap που εντοπίστηκε ρηχότερα (Εικ. 5) είναι αποτέλεσμα της διαβρωτικής δράσης των κυμάτων και της απουσίας σημαντικής προσφοράς σύγχρονων ιζημάτων στην περιοχή αυτή. Οι εναλλαγές της θέσης της κύριας κοίτης και των περιφερειακών καναλιών διανομής των φερτών υλικών του Πηνειού νοτιότερα από τη υφιστάμενη απόληξη του τις τελευταίες δεκαετίες είχε ως συνέπεια την απόθεση μικρότερου ποσοστού ιζημάτων στο βόρειο τμήμα, τα οποία φαίνεται να υπόκεινται σε μεγαλύτερη μεταφορά από το ισχύον υδροδυναμικό καθεστώς. Αξίζει να σημειωθεί ότι επιφανειακή διάβρωση τμημάτων του πυθμένα στο ευρύτερο πλατώ του Θερμαϊκού κόλπου έχει επίσης αναφερθεί από τους Lykousis and Chronis (1989) από τομογραφίες τύπου 3.5 kHz.



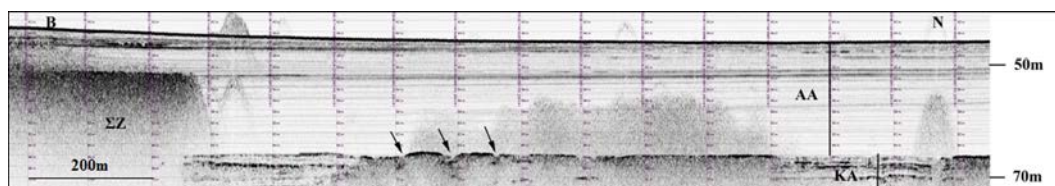
Εικόνα 4: Γεωμορφολογικός χάρτης της υποθαλάσσιας περιοχής του Δέλτα του Πηνειού.



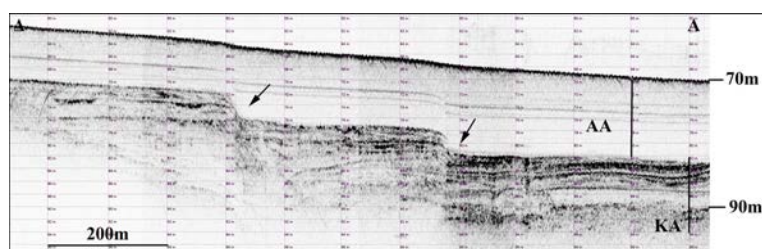
Εικόνα 5: Τομογραφία 3.5kHz από το βόρειο τμήμα του δέλτα όπου φαίνονται μικρά περιστροφικά ολισθέντα τεμάχια (ΠΤ), διαβρωσιγενείς επιφάνειες (ΔΕ) λόγω ρευμάτων και η στρωματογραφική σχέση toplar στο περιβάλλον της δελταϊκής πλατφόρμας. ΘΑ: θύλακες αερίων, ΨΑ: ψευδοανάκλαση.

Ένα από τα κύρια χαρακτηριστικά της ΚΑ είναι επίσης το πλήθος θαμμένων καναλιών που εμφανίζονται σε όλο το εύρος περιοχή έρευνας, με τη συντριπτική πλειοψηφία αυτών να καταγράφονται σε απόσταση ~2.3 km από τις εκβολές του Πηνειού (Εικ. 4 και 6). Η παρουσία τους θα μπορούσε να θεωρηθεί αναμενόμενη καθώς πριν την άνοδο της θαλάσσιας στάθμης η προδελταϊκή περιοχή αποτελούσε το παράκτιο περιβάλλον των παλαιοεκβολών, με πλήθος δελταϊκών καναλιών να διασχίζουν και να διαβρώνουν την παλαιο-δελταϊκή πλατφόρμα. Το βάθος εμφάνισής τους μέσα στην ιζηματογενή στήλη συμπίπτει με το βάθος που τείνει να εμφανίζεται η ΚΑ (>16 m), με αρκετά όμως κανάλια να εντοπίζονται ακόμη βαθύτερα. Οι

κοίτες των καναλιών έχουν βάθος που κυμαίνεται κυρίως μεταξύ 2 – 8 m, ενώ το εύρος τους ποικίλει σε μεγάλο βαθμό. Κανάλια που εμφανίζονται στο ίδιο στρωματογραφικό επίπεδο και παρουσιάζουν κοινά ακουστικά χαρακτηριστικά και διαστάσεις κατά μήκος διαδοχικών τομογραφιών εντοπίστηκαν και χαρτογραφήθηκαν στο κεντρικό τμήμα του δέλτα, με μήκος που φτάνει έως και τα 1.5 km (Εικ. 4). Επιπλέον, στο κεντρικό και νότιο τμήμα της ζώνης έρευνας εντοπίστηκε μικρός αριθμός καναλιών μέσα στην ΑΑ, 4-10 m κάτω από την επιφάνεια του πυθμένα, με εύρος και βάθος κοίτης μικρότερο από 2 και 4 m, αντίστοιχα. Αναγνωρίζονται από την τοπική ταπείνωση και ενίσχυση της ανακλαστικότητας των υποεπιφανειακών ανακλαστήρων, πάνω στους οποίους έχουν σχηματιστεί. Η μικρή αυτή ταπείνωση δεν επηρεάζει την επιφάνεια του βυθού.



Εικόνα 6: Τομογραφία 3.5kHz όπου φαίνονται η ανώτερη (AA) και η κατώτερη σεισμική ακολουθία (KA), σεισμοκονιασμένες ζώνες (SZ) και η ύπαρξη καναλιών (βέλη).



Εικόνα 7: Τομογραφία 3.5kHz από το νότιο τμήμα του δέλτα όπου φαίνεται η παρουσία δύο ίδιων μετατόπισης κανονικών ρηγμάτων (βέλη). AA: ανώτερη σεισμική ακολουθία και KA: κατώτερη σεισμική ακολουθία.

Στο νότιο τμήμα της περιοχής μελέτης αναγνωρίστηκε, με βάση τον απότομο τερματισμό και τη μετατόπιση των σεισμικών ανακλάσεων, μια σειρά θαμμένων κανονικών συνθετικών ρηγμάτων γενικής διεύθυνσης ΒΔ-ΝΑ, που μετατοπίζουν τα ιζήματα της κατώτερης σεισμικής ακολουθίας, χωρίς όμως να προκαλούν και αντίστοιχη μετατόπιση στον πυθμένα (Εικ. 4 και 7). Το βάθος που εντοπίζονται είναι μεταξύ 10m έως 16m κάτω από την επιφάνεια του βυθού (64-78 m από την επιφάνεια της θάλασσας), το μήκος τους φτάνει τα 2.2 km, ενώ το άλμα τους κυμαίνεται μεταξύ 2 και 6 m. Η παρουσία κανονικών συνθετικών ρηγμάτων διεύθυνσης ΒΔ-ΝΑ τόσο στο χερσαίο τμήμα όσο και ανοιχτά του δέλτα του Πηνειού έχει προγενέστερα επισημανθεί από τους Caputo & Pavlides (1993), ενώ οι Mascle & Laure (1990) αναφέρουν την παρουσία κανονικών ρηγμάτων στην ευρύτερη περιοχή του δυτικού Θερμαϊκού.

Τέλος, σε βάθη ρηχότερα από τα ~10 m και ~20 m στο νότιο και βόρειο τμήμα της περιοχής έρευνας, αντίστοιχα, (α) η εντονότερη ανακλαστικότητα στη φωτοσκιασμένη μορφολογική απεικόνιση του πυθμένα από τον πολυδесμικό ηχοβολιστή, καθώς και (β) ο ημιπαρατεταμένος ακουστικός χαρακτήρας της επιφανειακής ανάκλασης στις τομογραφίες σε συνδυασμό με την περιορισμένη διεισδυτική του ικανότητα, οφείλονται στην παρουσία μικροανάγλυφου λόγω θαλάσσιας βλάστησης που αναπτύσσεται πάνω σε σχετικά αδρομερέστερα (αμμόδη) υλικά (Εικ. 4). Χωρικά εξαπλώνεται κατά μήκος όλης της δελταϊκής πλατφόρμας, εκτός από το τμήμα της κύριας εκβολής του ποταμού καταλαμβάνοντας συνολικά μια έκταση ~ 3.7 km².

Συμπεράσματα

Η παρούσα εργασία αποτελεί την πρώτη συστηματική προσπάθεια προσδιορισμού των σύγχρονων διεργασιών ιζηματογένεσης από δεδομένα υψηλής διακριτικής ικανότητας στο υποθαλάσσιο δέλτα του Πηνειού. Η μελέτη των γεωφυσικών δεδομένων αποκάλυψε

πλήθος σημαντικών γεωμορφολογικών στοιχείων ρίχνοντας φως στις διεργασίες ιζηματογένεσης μετά από την τελευταία παγετώδη περίοδο (Α. Πλειστόκαινο – Ολόκαινο). Από τη βυθομετρική διασκόπηση διαπιστώθηκε η ανάπτυξη των τριών τυπικών φυσιογραφικών ενοτήτων που συναντάμε στα δέλτα, δηλαδή της δελταϊκής πλατφόρμας, της καταφέρεας και της προδελταϊκής περιοχής με, γενικά, ήπιες κλίσεις (1 – 12 %) έως και βάθη 70m. Τα κυριότερα γεωμορφολογικά στοιχεία της περιοχής αποτελούν η ύπαρξη πλήθους θαμμένων καναλιών κυρίως στην κατώτερη σεισμική ακολουθία, σύγχρονες διαβρωσιγενείς επιφάνειες λόγω δράσης ρευμάτων καθώς και η παρουσία θαμμένων ρηγμάτων, τα οποία εμφανίζουν συνθετικό χαρακτήρα ως προς τα αντίστοιχα της χέρσου προς το νότιο τμήμα της ζώνης έρευνας (Caputo et al., 2004). Αποτέλεσμα της σημαντικής προσφοράς ιζημάτων πλούσιων σε οργανικό υλικό, είναι η εμφάνιση ενός εκτεταμένου πεδίου αέριων που φτάνει σε μικρό βάθος κάτω από τον πυθμένα, εμφανίζει ποικιλία ηχητικών ανωμαλιών και έχει προκαλέσει παραμορφώσεις ιζημάτων, όχι όμως κάποια σύγχρονη γεωμορφή ή κάποιο σύγχρονο εκτεταμένο κατολισθητικό γεγονός. Η απουσία ενός σύγχρονου συστήματος καναλιών διανομής στο περιβάλλον της υποθαλάσσιας πλατφόρμας πιθανόν δικαιολογείται από τη γρήγορη ανακατανομή των ιζημάτων από το επικρατών κυματικό καθεστώς.

Η γενική σεισμική στρωματογραφία καθώς και η ύπαρξη αερίων στα δελταϊκά ιζήματα είχε αποτυπωθεί και σε προγενέστερες μελέτες της ευρύτερης περιοχής του Δυτικού Θερμαϊκού Κόλπου (π.χ. Lykousis & Chronis 1989; Lykousis et al. 2005, 2009). Στην εργασία αυτή όμως αποκαλύφθηκε η έκταση και η διακύμανση της κατανομής τους κάτω από τον πυθμένα, τα φαινόμενα παραμόρφωσης που προκαλούν καθώς και άλλα σημαντικά γεωμορφολογικά στοιχεία που δεν είχαν εντοπιστεί λόγω του αποσπασματικού χαρακτήρα των προηγούμενων ερευνών.

Ευχαριστίες

Η συλλογή των δεδομένων και οι Θ.Χ. και Α.Β. χρηματοδοτήθηκαν από το πρόγραμμα ΘΑΛΗΣ-MARE (MIS: 375655) και οι Κ.Α. και Σ.Π. από το πρόγραμμα ΘΑΛΗΣ-DAPHNE (MIS: 375908) που χρηματοδοτούνται από την Ευρωπαϊκή Ένωση (Ευρωπαϊκό Κοινωνικό Ταμείο) και από Εθνικούς πόρους μέσω του Επιχειρησιακού Προγράμματος “Εκπαίδευση και Δια Βίου Μάθηση” (ΕΣΠΑ 2007-2013).

Βιβλιογραφία

- Caputo R. Helly b., Pavlides S., Papadopoulos G., 2004. Palaeoseismological investigation of the Tyrnavos Fault (Thessaly, Central Greece). *Tectonophysics* 394, 1–20.
- Caputo R. & Pavlides S., 1993. Late Cainozoic geodynamic evolution of Thessaly and surroundings (central-northern Greece). *Tectonophysics*, 223, 339-362.
- Gaki-Papanastassiou K., Karymbalis E. and Maroukian H., 2010. Recent geomorphic changes anthropogenic activities in the deltaic plain of Pinios river in central Greece. *Bulletin of the Geological Society of Greece*, 17(1) XLIII, No 1: 409-417.
- Galloway W.E., 1975. Process framework for describing the morphological and stratigraphic evolution of deltaic depositional systems. In: Broussard M.L. (Ed.): *Deltas, Models for Exploration*. Houston Geol. Soc., Houston, 87-98.
- Hasiotis T., Papatheodorou G., Kastanos N., and Ferentinos G., (1996). A pockmark field in the Patras Gulf (Greece) and its activation during the 14/7/93 seismic event. *Marine Geology*, vol. 130, pp. 333-344.
- Hasiotis T., Charalampakis M., Stefatos A., Papatheodorou G. and Ferentinos, G., 2006. Fan delta development and processes offshore a seasonal river in a seismically active region, in the NW Gulf of Corinth. *Geo-marine Letters*, vol 26(4), pp. 199-211.
- Karageorgis A.P., Kaberi H. Price N.B., Muir G.K.P., Pates J.M., Lykousis V., 2005a. Chemical composition of short sediment cores from Thermaikos Gulf (Eastern Mediterranean): Sediment accumulation rates, trawling and winnowing effects. *Continental Shelf Research* 25, 2456 –2475.

- Karageorgis A.P., Anagnostou C.L., Kaberi H., 2005b. Geochemistry and mineralogy of the NW Aegean Sea surface sediments: implications for river runoff and anthropogenic impact. *Applied Geochemistry* 20, 69–88.
- Karymbalis, E. and Gaki-Papanastassiou, K., 2008. Geomorphological study of the river deltas of Pinios, Kalamas, Evimos and Mornos. *Proceedings of the 4th Panhellenic Conference on Coastal Zones Management, Mytilene, Greece*, 86-94.
- Kombiadou K. and Krestenitis Y. N., 2012. Fine sediment transport model for river influenced microtidal shelf seas with application to the Thermaikos Gulf (NW Aegean Sea). *Continental Shelf Research* 36, 41–62.
- Lykousis V., Roussakis G., Sakellariou D., 2009: Slope failures and stability analysis of shallow water prodeltas in the active margins of Western Greece, northeastern Mediterranean Sea. *International Journal of Earth Science (Geol. Rundsch)*, 98: 807–822.
- Lykousis, V., Karageorgis, A., Chronis, G., 2005. Delta progradation and sediment fluxes since the last glacial in the Thermaikos Gulf and the Sporades Basin, NW Aegean Sea, Greece. *Mar. Geol.*, 222–223: 381–397.
- Lykousis V. and Chronis G., 1989. Mechanisms of sediment transport and deposition: Sediment sequences and accumulation during the Holocene on the Thermaikos plateau, the continental slope and basin (Sporades basin), north-western Aegean sea, Greece. *Marine Geology* 87, 15-26.
- Lykousis V., Collins M.B., Ferentinos G., 1981. Modern Sedimentation in the N.W. Aegean Sea. *Marine Geology* 43, 111-130.
- Masclé J. & Laure M., 1990. Shallow structure and recent evolution of the Aegean Sea: A synthesis based on continuous reflection profiles. *Marine Geology*, 94: 271-299.
- Papatheodorou G., Hasiotis T., Ferentinos G., 1993. Gas charged sediments in the Aegean and Ionian Seas, Greece. *Marine Geology*, 112: 171-184.
- Poulos S.E., Chronis G.Th., Collins M.B., Lykousis V., 2000. Thermaikos Gulf Coastal System, NW Aegean Sea: an overview of water/sediment fluxes in relation to air–land–ocean interactions and human activities. *Journal of Marine Systems* 25, 47–76.
- Whelan T.A., Coleman J.M. and Suhayda J.N., 1975. The geochemistry of recent Mississippi river delta sediments: gas concentration and sediment stability. *Offsh. Techn. Confer.*, Houston, Texas, paper 2342: 71-84.
- Zervakis, V., Karageorgis, A., Kontoyiannis, H., Papadopoulos, V., Lykousis, V., 2005. Hydrology, circulation and distribution of particulate matter in Thermaikos Gulf (NW Aegean Sea), during September 2001–October 2001 and February 2002. *Continental Shelf Research*, 25: 2332–2349.
- Λυκούσης Β., (1990). Προδελταϊκές αποθέσεις: Σεισμική στρωματογραφία, ιζηματολογία και ευστάθεια πρηνών. Διδακτορική Διατριβή, Παν/μιο Πατρών.