International Conference on Rapid Sea Level Change: a Caspian Perspective 2005

Edited by

S. B. Kroonenberg

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International Conference on Rapid Sea Level Change: a Caspian Perspective

Joint Meeting of IGCP 81, IGCP 440, ICSU

Organised by

UNESCO, IUGS, (The International Union of Geological Sciences)
ICSU (International Union of Sciences)

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The University of Guilan, INCO, (Iranian Nation Center for Oceanography)
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ABSTRACTS

INTERNATIONAL CONFERENCE ON RAPID SEA LEVEL CHANGE- A CASPIAN PERSPECTIVE

Preface

Dear Participants,

Welcome to our international conference on rapid sea-level change. While concern about sea-level rise is global, our host country the Islamic Republic of Iran and the neighbouring Caspian countries have a concern of their own. Here, Caspian sea level rose a hundred times as fast as in the world's oceans. Whereas oceanic sea level rose 13 centimetres during the whole twentieth century, the Caspian sea rose 13 centimetres each year in the period between 1977 and 1995. Caspian coasts had to cope with a sudden sea-level rise of three metres in twenty years.

Therefore, when looking for a place for an international conference on sea-level change in the framework of the UNESCO-IGCP 490 project The role of Holocene environmental catastrophes in human history and the Dark Nature programme of ICSU on Rapid natural change and human responses the Caspian is a logical choice. In the recent past the Caspian countries have already experienced what we fear could happen to us in the near future elsewhere in the world. They can tell us what happened along the coasts, how people reacted to these events, and what lessons they have learnt from that. We all can benefit from their experience. The conference lines up with the third annual meeting of the UNESCO-IGCP 481 programme Dating Caspian Sea-Level Change that addresses these problems more specifically.

The aim of this meeting is to bring together scientists working on global sea-level change, rapid sea/lake level change, not only in the Caspian but also in other closed basins, to discuss the origin of sea and lake level change, its steering mechanisms, its synchronicity (or not) with global climate change and tectonic processes, its consequences for environment and coastal management, its impact on human society and human responses.

We are very grateful that the University of Guilan has offered to host this conference in Rasht, near the Caspian shore, and only a few kilometres away from the town of Ramsar, where the International Wetlands Convention was signed in 1971. We wish you a successful meeting.

The organising committee

Salomon Kroonenberg, Delft University of Technology, the Netherlands
Suzanne Leroy, Brunel University, London, UK
Nader Nariman-zadeh, The University of Guilan at Rasht, Iran
Hamid Alizadeh Lahijani, Iranian National Centre for Oceanography, Tehran
Behrooz Abtahi, Tarbiat Modarres University, Tehran, Iran
M. Hamedi, Razieh Lak, Geological Survey of Iran, Tehran

Sponsors
The organisation of this conference has been possible owing to the financial support of the following:
IGCP 481 Dating Caspian Sea Level Change (2003-2007)
IGCP 490 The role of Holocene environmental catastrophes in human history (2003-2007)
ICSU DARK NATURE - Rapid Natural Change And Human Responses (2004-2005)
INQUA
Shell
The University of Guilan, Rasht, Iran
Iranian National Centre for Oceanography, Tehran, Iran
Tarbiat Modarres University, Tehran, Iran.

Objectives of the sponsoring programmes

UNESCO- IUGS IGCP project 481 Dating Caspian Sea Level Change

(coordinators: Salomon Kroonenberg, NL, Suzanne Leroy, UK)

The Caspian Sea is a laboratory for sea level change. Between 1929 and 1977 Caspian sea level fell three metres, and between 1977 and 1995 it rose again by 3 metres at a rate of 13 cm a year, a hundred times faster than sea-level rise in the oceans during the 20th century. Rapid sea level change is a major environmental problem for coastal habitats and human activities in all Caspian countries. Drowning Caspian shores show in an accelerated way what would happen along oceanic shores at global sea-level rise due to climatic warming. Caspian sea level change is forced by global processes such as the North Atlantic Oscillation, solar forcing, deglaciation and tectonics. Past Caspian sea level offers a yardstick for past precipitation changes and therefore of past changes in global climate. The IGCP project CASPAGE (Dating Caspian Sea Level Change) aims to establish a precise Caspian sea-level curve for the recent geological past. This can help us in understanding the pace of global change in the northern hemisphere in the past, and to improve prediction of future Caspian sea-level change and its environmental consequences. The project aims to

- exchange knowledge and assemble all existing age data in a data base and discuss their quality
- consider existing cored and other sampled material for additional dating, including inter-laboratory comparison
- consider new sites for coring, sampling and dating in the Caspian region and Volga drainage basin
- establish a new Caspian sea level curve in four time scales: historic, Last Glacial and Holocene, Pleistocene and Pliocene.
- use CSL curve for validating existing Global Circulation Models.

Previous meetings took place in Moscow and Astrakhan, Russia (2003), Baku, Azerbaijan, 2004. Future meetings are scheduled in Kazakhstan (2006) and Turkmenistan (2007), see website www.caspage.citg.tudelft.nl.

UNESCO-IUGS IGCP 490 project "The role of Holocene environmental catastrophes in human history" (coordinator: Prof. Suzanne Leroy, UK)

The project focuses on the inter-disciplinary investigation of Holocene geological catastrophes, which are of importance for civilisations and ecosystems. The project is concerned with environmental events since the beginning of the Holocene (the last 11,500 calendar years) excluding therefore the influence of the glacial-interglacial cycles. Three timescales will be considered:
- the Holocene when major natural hazards are mostly known from sedimentary records.
- the last 5-4000 years for which we have written documents.
- the last couple of centuries with instrumental records.

Importantly, the project will examine how quickly ecosystems and civilisations are able to recover from catastrophic events.
With the growing recognition that major natural events can have abrupt global impacts, this project is a timely opportunity to assess the sensitivity of modern society to extreme natural threats. This project will involve not only the geoscience community, but also biologists, archaeologists, historians, meteorologists and astrophysicists.
The main structural questions to be answered in the Mauritania meeting are
• Chronology of Changes in the broad theme of Climatic, Ecological and Health Catastrophes
• Causes and mechanisms of past environmental catastrophes / rapid changes
• Impacts on past civilisations and ecosystems
• Mechanisms of recovery
Website www.brunel.ac.uk/depts/geo/igcp490/igcp490home.html

INTERNATIONAL COUNCIL FOR SCIENCE (ICSU)
"DARK NATURE - RAPID NATURAL CHANGE AND HUMAN RESPONSES
(coordinator: Suzanne Leroy, UK)

This is a new ICSU-funded project for 2004 and 2005, awarded to a consortium of organizations headed by IUGS (International Geological Sciences through its GEOINDICATOR Initiative), and including IGU, IAG, IUGG, INQUA, IGBP The project is under the scientific direction of Prof. Suzanne Leroy.
There is no doubt that human actions are forcing major changes to climate, landscapes and the environment. Contemporary discourse holds that environmental havoc is chiefly caused by humans and that if only we could manage our impacts on water, air, climate, the oceans and biodiversity, nature would be in fine balance, providing a benevolent ecosphere. However, despite the widespread influence of human actions, nature is also capable of rapid and dramatic change. Throughout our planet's geological history, its capacity for abrupt environmental change has provided the background and, commonly, the drivers for evolution.
Such natural (i.e. non-human) actions have shaped landscapes and coastal systems the physical (abiotic) environment through its interference lake and sea levels, river channels and sediment load, slope failures stability, ground subsidence, frozen ground activity and desertification.
Here, we refer to the potential for the natural environment to inflict harmful damage as 'dark nature', and highlight that these actions can occur on timescales of concern to society - that is, over a period of 100 years or less. Such 'rapid' environmental disturbances to ecosystems and communities include not only instantaneous catastrophes and, but also that affect ecosystems and people, but also slow-onset, more pervasive changes to the environment, including such as climate change.
Two fundamental issues underpin our project:
1) In reducing harmful human impacts on the environment, to what extent can we disentangle the results of human actions from those due to natural processes?

2) In striving for sustainability, how can the consequences of non-equilibrium natural change best be acknowledged by, and accommodated within, environmental and ecosystem management and policy? Previous meetings took place in Mauritania, Argentina, Canada and Mozambique.
Websites ICSU Dark Nature: www.brunel.ac.uk/depts/ges/ICSU-DN/ICSU-DN.htm or www.mun.ca/canqua/ICSU-DN/

Abstracts

SEA LEVEL CHANGE IN THE U.S. GULF COAST REGION

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The Gulf Coast Region of the United States includes five Gulf Coast States (Texas, Mississippi, Louisiana, Alabama, and Florida) that abut the Gulf of Mexico. The Gulf itself has a surface area of 630,000 square miles, and a watershed area in the United States of 1.81 million square miles. This region is one of the nation's largest ecological systems and is closely linked to a significant portion of the nation's economy. Energy, fisheries, agriculture and tourism rank among the most significant sectors of the Gulf Coast region's economy. The Gulf has five of the nation's top ten fishing ports. Gulf ports handle one half of the nation's import-export tonnage and the Gulf produces 72% of the nation's offshore petroleum production. The Gulf Coast Region relies on many natural resources to fuel important sectors of its economy. Global changes can have profound impacts on the economy and the quality of life for millions of people living in the Gulf Coast region. This report reviews the nature of global environmental change, and addresses the potential health and environmental impacts that may occur in the Gulf Coast region of the United States as consequences of various environmental alterations resulting from global change.

Over the past decades, scientific research has greatly advanced the knowledge and understanding of global environmental change. Research supported by the U. S. Global Research Program (USGRP) and international institutions such as the World Bank and the United Nations Environment Program have demonstrated that human activities exert powerful influences on environmental change on global, regional and local scales (Keeling et al. 1996; Santer et al. 1996). Recent findings by the Intergovernmental Panel on Climate Change (IPCC, 1997) indicate that human activities are increasing the atmospheric concentrations of carbon dioxide and other greenhouse gases (nitrous oxide,methane, chlorofluorocarbons, partially halogenated fluorocarbons, and ozone) which alter radiative balances, and tend to warm the surface of the atmosphere, and in some regions, of aerosols that tend to cool the atmosphere. It is important to note that aerosols do not remain in the atmosphere for long periods and global emissions of their precursors are not projected to increase substantially as compared to the effects of greenhouse gases that are long lived. These changes in greenhouse gases and aerosols constitute key factors in the global and regional changes in temperature, precipitation and other climate variables, resulting in global changes in soil moisture, an increase in global mean sea level, and prospects for more severe extreme high temperature events, floods and droughts in some places. In the United States and elsewhere in the industrialized world, energy use contributes to global warming more than any other human activity. This because most of our energy comes from carbon-based fossil fuels (coal, oil, and natural gas). Fossil fuels provide energy for a variety of purposes, including transporting goods and people, manufacturing products, heating and cooling buildings, lighting spaces, and cooking foods. Each year U.S. energy use releases more than 5.5 billion tons of carbon dioxide into the atmosphere.

Present CO2 concentrations in the atmosphere are 130% of pre-industrial levels. The surface temperature this century is warmer than any other century since at least 1400 A.D. The temperature has increased by about 0.5 - 1.1 F over the last century and is projected to rise another 2 - 6.5 F by the year 2100. The last two decades have been the warmest in this century. Sea level has risen about 4 to l0 inches and is projected to rise another 6 - 38 inches by the year 2100. Mountain glaciers have retreated worldwide this century.

As greenhouse gases continue to accumulate in the atmosphere, it is expected that an increase in rainfall amount and a consequent increase in river flooding will occur. Recent floods in the Gulf Coast areas (1993, 1997) are examples of such events, and indicate the high sensitivity of flood occurrence to changing climate. Because of its unique location adjacent to the Gulf of

Mexico, the Gulf Coast region of the United States is particularly vulnerable to various environmental alterations resulting from climate change.

CASPIAN SEA SURFACE TEMPERATURE MAPPING USING MODIS INFRARED SATELLITE IMAGES

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Sea surface temperature is one of the parameters that can be evaluated related to Rapid Sea level changes.This study presents application of the Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) thermal infrared bands for Sea Surface Temperature (SST) retrieval. SST of Caspian sea was calculated from Terra-MODIS 1km resolution images.

Sea Surface Temperature (SST) map specifies the water temperature in the homogeneously mixed surface layer. The SST is a fundamental parameter for monitoring of ocean dynamics. SST maps allow to detect eddies and fronts, upwelling events or mixing of riverine and sea water and may thus be used for a multitude of applications.

Water temperatures at the ocean surface are constantly changing. These changes affect—and are influenced by—weather and climate worldwide. By studying satellite measurements of sea-surface temperatures, scientists are learning to detect and predict recurring weather patterns such as El Niño events, which can cause devastating droughts and floods around the world.

The SST of clear-sky pixels in MODIS scenes is retrieved from brightness temperatures in bands 31 and 32 with the generalized split-window algorithm. The coefficient used in the split window algorithm are given by two methods:1)Radiosonde based 2)ECMWF model that both of them used in study.

In order to validate the SST product in clear-sky conditions so that SST is not mixed with cloud-top temperature cloudy pixels removed.

SST is defined by the radiation emitted by the sea surface observed by MODIS at instant viewing angles. Instant MODIS TIR data collected at one viewing angle do not contain information at other viewing angle due to weak scattering of the TIR signals in the clear-sky atmosphere. Also sensor zenith angles used in split window algorithm for reduction of errors.

PALAEO AMU DARYA AND PALAEO UZBOY DISCHARGE INFLUENCE ON CASPIAN SEA LEVEL AND BIODIVERSITY

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Palaeo Amu Darya and Palaeo Uzboy discharge made significant influence both on Caspian Sea level and its biodiversity. Some scientists belive that all arctic immigrants came to the Caspian Sea via Palaeo Uzboy from the Palaeo Aral Sea that had connection to Arctic basin (hypotheses by Grosswald). Palaeo Amu Darya direct discharge to the Caspian Sea also contibuted with freshwater immigrants from the East.

During deglaciation, millennia before A.D., water flux from Aral to Caspian Sea was high, perhaps as high as 100 km3 per year or more. Aral received much more water in summer, was able to accumulate to a higher height, the flow through Uzboy to Caspian was more continuous and perhaps permanent, with high floods in summer; Uzboy may have at such times a large flow of 2000 m3/sec, at last for two or three months; that would represent between 10 and 15 km3 for two months, perhaps 25 for the whole year. The 2000 m3/sec represent the maximum quantity of water the geometry of upper Uzboy is able to carry especially in the Igdy narrows, and not withstanding lateral floods in solonchaks in western Zaunguz.

It does not seem that Amu's contribution to Caspian exceeded 20 km3/y. Problem is how much underground seepage.

The hypothesis of a complete deviation of the Amu flow to the Caspian leads to some hydraulical impossibilities: problems for the Sary Kamysh exutory to convey thousands of m2/sec during the summer floods towards the present north-western Zaunguz solonchaks without any evidence of strong mechanical erosion, and for those to absorb more than a few tens of km3 through evaporation and percolation. It is an impossibility too for the geometry of the bed of Uzboy east of Kaplankir hill to convey more than, say, 10 km3 per year: problems of the "bolt" at Igdy and surroundings, which would imply flooding the canyon to heights which have let no trace of river erosion. It appears reasonable to consider that Amu Darya could not really carry to the Sary Kamysh an original flow of more than 15 to 20 km3 per year, due to the insufficient section of Daryalik and Daudan Daryas, at a time when irrigation specialists estimate the total water input to Aral of Amu Darya to be about 60-70 km3/y and even more. A big part of Amu water should have run east of the Uzboy, and dissipate in the Zaunguz desert. It seems that an inescapable conclusion is not a negligible part of he Amu flow went on running in the south eastern basin of Aral, feeding more or less regularly a big sebkha the contour of which has been determined earlier by Rubanov

REACTION OF COASTAL NATURAL-SOCIAL SYSTEM TO CHANGE OF CASPIAN SEA LEVEL

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The shore of Caspian sea is the most complicated nature-social system which has developed in during millenniums of its development by man. In the given zone there are close communications between river, sea and social factors. In river basins of Caspian sea powerful streams of substance (water, deposits, chemical substances, biological substances, heat) are formed. Sizes of these streams constantly vary, that in conditions rapid sea level change is capable to lead to dangerous processes.
The special set of dangerous processes is characteristic for river deltas. It includes the consequences connected with change of water inflow to the sea. Increase in inflow means not only possible rising of sea level, but also relative increase of water levels in deltoid water-branches, strengthening of water filtration processes to underground horizons and increase of background level of subsoil waters. Simultaneously the number of water branches increases, intensity of washout of coast and surfaces of bottom raises. In conditions of increase in duration and depth of area flooding during maximal runoff intensity of sediments accumulation increases on a surface of deltoid plain that changes efficiency of land tenure, increases rates of polluting substances accumulation in superficial soil layer, in vegetative tissues. Simultaneously the probability of occurrence of such dangerous process as penetration into delta of salt waters (wedge of salty waters) decreases or length of wedge decreases. With other things being equal increase of water content of deltoid water branches is accompanied by decrease in range and heights of positive setup increases of water level. Reduction of water inflow to deltas and sea leads to opposite changes of dangerous processes. In these conditions it is probable drying off of water offtake, infringement of

navigation safety, reliability of irrigational constructions work, becoming steppe of territories, increase in range of positive setup distribution, wedge of salty waters, etc.
Development of territories hydroecological safety theory (THST) with reference to a problem of an estimation of coastal nature-social system functioning of Caspian sea in conditions of fast change of its level has shown, that presence of ecological and economic damages in rivers mouths is characterized by modular parameter considering contribution of river, sea, hydro-morphological factors in probability and size of specified damages. The given parameter is calculated for all basic rivers of the Caspian basin.
Researches are carried out at financial support of RFFR Grants (03-05-64306 and 04-05-08037

CLIMATICALLY FORCED CASPIAN SEA LEVEL CHANGES AS IT RECORDED IN PLIOCENE-PLEISTOCENE SUCCESSIONS

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The Caspian Sea, the largest land locked basin in the world, isolated from ParaTethys at the end of Messinian. Since that time sedimentation there took place under conditions of isolated basin temporarily connected with Black Sea in Upper Pliocene (Akchagyl).

The complex, integrated studies using multiple geology and analytical tools - sedimentology, sequence-, bio-, chemostratigraphy, isotope and trace elements geochemistry and palynology demonstrated a close correlation between climatic variations, high - frequency Caspian Sea level changes and facies variability in Pliocene-Pleistocene.

Data on O, C isotope composition of ostracods shell carbonate as well as Ca/Mg, Sr/Ba ratios therein testify to significant climate and basin salinity changes through out the Pliocene-Pleistocene. and provided us by unique opportunity for characterizations of short-term climatic cyclicity in Early Pliocene, which was the major lake-level control. The biogeochemical data have been also confirmed by data on Sr isotopes in bedded and disseminated gypsum separated from Productive Series sediments. Generally, the Caspian Sea low stands correspond to intervals of rise in temperature recorded in fossils; shells oxygen isotopes and trace elements composition. It was accompanied by facial shifts to more proximal environment. In Lower Pliocene (Productive Series) such dramatic depositional setting changes led to progradation of paleorivers; deltas and development in Apsheron peninsula and Baku archipelago the braided fluvial system of PaleoVolga river in such stratigraphic intervals as Productive Series PreKirmaki, Post

Kirmaki sand, Kirmaki Suites which are the major production units in the South Caspian oil-gas bearing basin.
The Sea level rise was followed by retrogradation of the delta and facial shifts to deltaic-lacustrine environment (the best example is Kirmaki Suite of the Productive Series). Sedimentation during these stages has been strongly affected by changes in sediment load and discharge governed, probably, climate variations in the catchment area.
In Pleistocene succession the Caspian Sea level fluctuations were recorded as depositional environment changes within shoreface - offshore facial zones. The full depositional cycles of a high order with low and high stands are clearly identified within 30 meters thick succession.
The applied multi-component approach to study of sedimentary response to climate changes in the Caspian Sea demonstrated the strong influence of climatically driven rapid fluctuations of this closed basin level on stratigraphic architecture of the Pliocene-Pleistocene succession.

DYNAMIC SHORELINE RESPONSIBLE FOR OLIGO-MIOCENE RELATIVE SEA-LEVEL CHANGES OF SOUTH PARA-TETHYS (CASPIAN SEA)

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Broad exposures of Oligo-Miocene deposits (known as Zivah Formation) in NW Iran (Moghan Area) provide significant opportunity for relative sea level change study of South Para-Tethys in this part of the basin. The formation as most susceptible reservoir in NW Iran is comprised of lenticular rudaceous rocks, sandstones, argillaceous rocks, and thin layers of coal and calcareous mudstones. Comprehensive study of lithology, geometry, sedimentary structures, palaeocurrent pattern, fossil content, and stratal surfaces led to determination of 18 major lithofacies in the formation. Petrofacies analysis of the formation is carried out by detailed description of texture, composition and diagenetic features, using petrographic techniques. In this regard 13 major petrofacies are discriminated and well described. Combination of results from lithofacies and petrofacies analysis of the formation led to identification of constituent facies and facies associations. Fluvial dominated deltas wondering on the shelf of South Para-Tethys are considered as depositional environment of the facies and facies associations. Detailed sedimentological logs of the formation are constructed for three major parts of the studied area (east, center, and west). Study of facies ordering in the sedimentological logs resulted in determination of three types of sedimentary cycles. The cycles are classified in to small, medium, and large scale on the basis of their total thickness, constituent facies, and coarsening/fining up nature. The small scale cycles are divided in to three major groups (A, B, and C) based on their constituent facies, stratal surfaces and processes responsible for their development. Those of medium scale in to two groups (M1, M2) mainly based on sediment supply to

accommodation development ratio (S/A) during their development. The large scale cycles remain similar throughout the studied area. Relative sea-level changes of the basin from lower Oligocene to Mid-Miocene (deposition of the Zivah Formation) are discussed, using sedimentological characteristics of the cycles. Based on the sedimentological characteristics of the cycles, their constituent facies, and S/A ratio major controls on their development are discussed, while comparing with world wide sea level curve (Eustasy). Structural deformation of the basin margin and bordering faults activities are considered as major controls for development of small and medium scale cycles, whereas eustasy is considered as major control for development of large scale cycles. Considering numerous small and medium scale cycles, active shoreline seems to be the main cause for relative sea-level changes during lower Oligocene to middle Miocene.

ROLE OF GORGAN HISTORICAL WALL ON MEASURING CASPIAN SEA LEVEL CHANGES

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Gorgan historical wall is a historical structure in southeast of Caspian Sea near the Gomishan City in golestan province of IRAN. Firooz established this wall that called qizil – yilan (Red Snake) and qizil –alang (Red wall) 1550 years ago and exactly 700 years after the Great Wall of China. Length of this wall is about 175 kilometer from north of gomishan to pishkamar altitudes in the east of golestan province .Now the wall destroyed and only the foundation of wall remained.

It seems that the wall must be continued until the sea and even inside the sea for protecting people from attacks of northern enemies. Evidences show that the wall continued until 5.6 kilometer of north east Safa- eishan village. In this location red surface color such as a marker of wall disappears and mixture of sea sand and bivalve take place of them. Field works and experiments show the last point of this wall is in 37/07/310 and 54/05/199 coordinates .This location is 5 kilometer far from today sea level. With dating bricks and analyzing geophysical data we can get more details of sea level that has changed in this location.

SEDIMENTOLOGY OF ANZALI WETLAND SUBBASIN WITH REFERENCE TO RECENT CASPIAN SEA LEVEL CHANGES

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Anzali wetland is a depression located to the southeastern of Caspian Sea at present, roughly estimated 150 km2. Currently are the wetland involves foursubbasines. Eastern(Sheijan), central (Hendkhale) , western (Abkenar) and Siahcheshm. Among them only Sheijan and central subbasin have connection with C.S. Waters run off more than 11 rivers are collected in the wetland before reaching Caspian Sea. In this research, in order to study sediments of the wetland floor, 60-70 cm cores were taken from all of the subbasines. Considering a sedimentation rate of 2 mm /year sediments obtained from the cores could record more than 200 years of sedimentary history of the basin. Results show: 1- Coarsening of sediments from west to east due to depth decrease. 2- Organic content of the samples show an average of 10-15% which increases westward and decrease with depth. 3-In samples obtained from eastern subbasin at least 2 distinct horizons with a upper sandy with an average thickness of 20cm and lower mudy part with an average thickness of 15 cm, occasionally with sand lenses. 4- A marine shell rich horizon (Gasteropodes and plecipodes of Holocene ranging between .5 mm to 5 cm in size, distributed in a fine sandy matrix) are seen in samples obtained from sheijan subbasin. 5- Sand-mud alternation and shell rich horizons in eastern subbasin can be regard as an evidence of long and short-term fluctuation of Caspian Sea level changes.

THE CASPIAN SEA LEVEL VARIABILITY FROM THE ATMOSPHERIC MODELLING POINT OF VIEW

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Simulating the atmosphere with models have mostly the final goal of predicting the future. There are now several atmosphere-ocean model simulations (scenario runs with increased greenhouse gases) for the 21st century available and some results for the Caspian Sea
will be shown. However, first one has to understand the processes involved and to investigate the realism of these processes in model simulations to know the credability the scenario runs.

The Caspian Sea level (CSL)is governed by the river discharge, mainly the Volga river, and the precipitation minus evaporation over the Caspian Sea. The latter is hardly observed and it is fortunate that the variation of the CSL can be mostly explained by the variation of the Volga River discharge, which is well documented. Therefore also the investigations of model results will concentrate on the Volga River discharge. Atmospheric models forced with observed sea surface temperatures (SST) are able to reproduce some of the variability of the Volga River discharge, suggesting that this variability is due to some oceanic foring. The most prominent variability of the ocean is the El Nino/Southern Oscillation (ENSO) and it can be shown that the ENSO has an impact on the CSL variability. More warm ENSO events (El Nino) lead to enhanced Volga river discharge and by that to an increase of the CSL. Coming to the scenario runs, which are just being investigated, one finds a permanent enhanced El Nino signature which on its own would suggest enhanced Volga River discharge and on top of that there is a symmetric enhanced precipitation north of 50N connected to an enhanced Hadley/Ferrel circulation. Increased greenhouse gases lead, however, also to increased surface temperatures which could over the Caspian Sea lead to enhanced evaporation. One finds as well decreased precipitation over the Caspian Sea itself. Both latter points would counteract the increased CSL due to the enhanced Volga river discharge. In the present MPI coupled atmosphere-ocean model the SST of the Caspian Sea is calculated by a simple lake model which does not represent a thermocline nor salinity. Improvements in this respect are in progress.

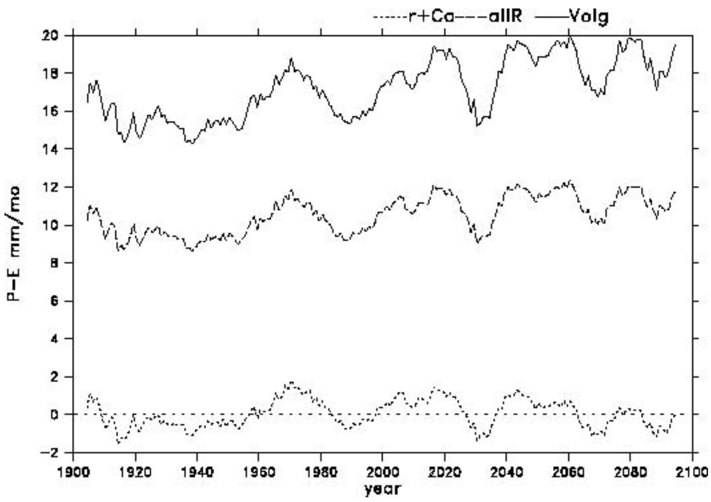

Fig 1.

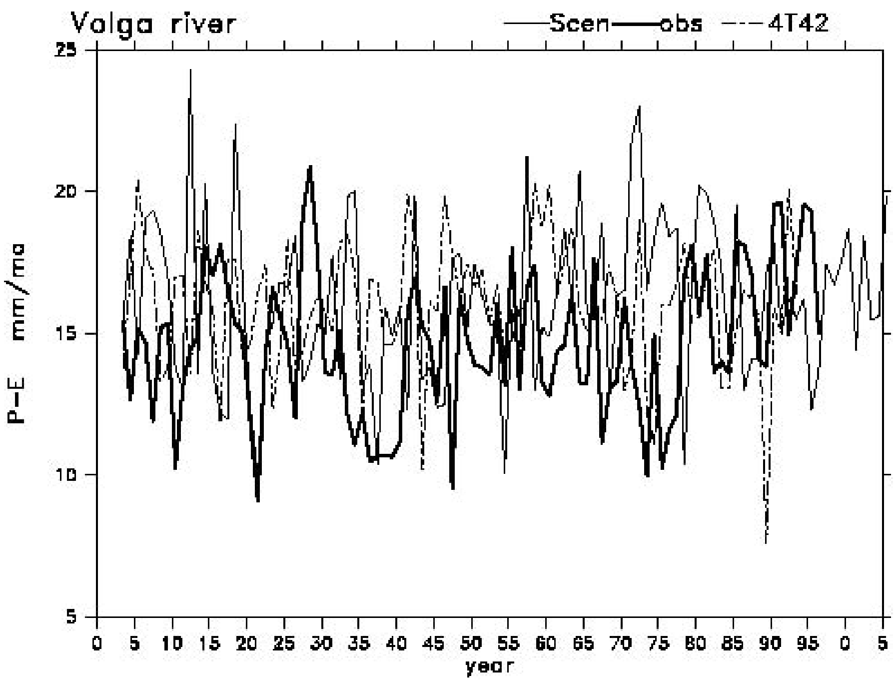
Volga river
Scen
obs
4T42
P–E mm/ma
year
25
20
15
10
5
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 0 5

Fig. 2

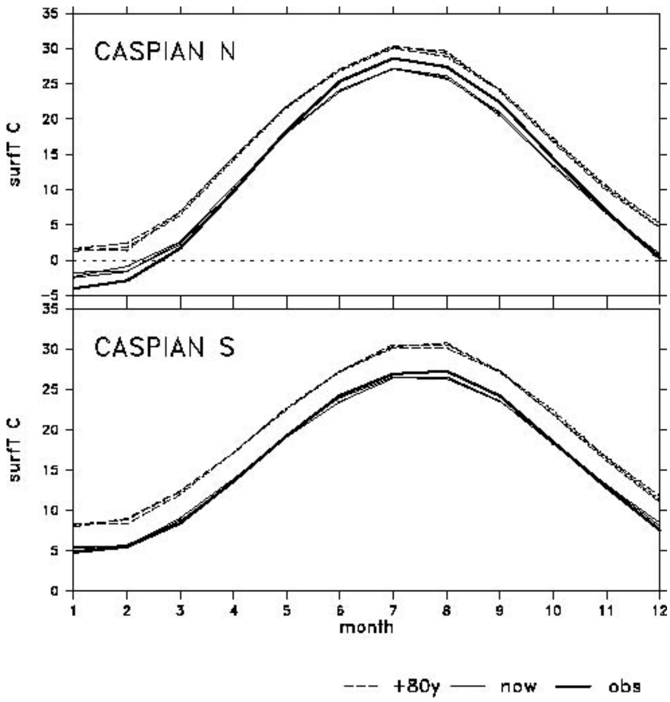

Fig 3.

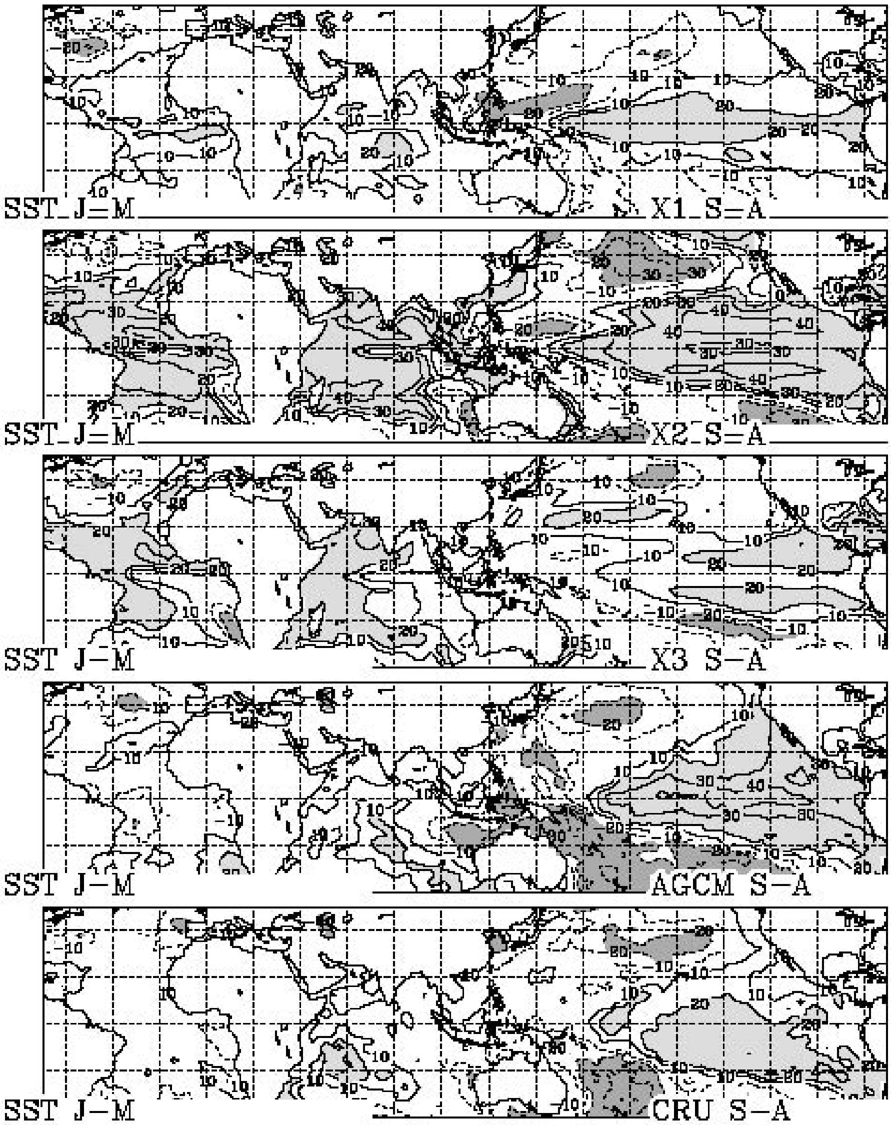

Fig. 4

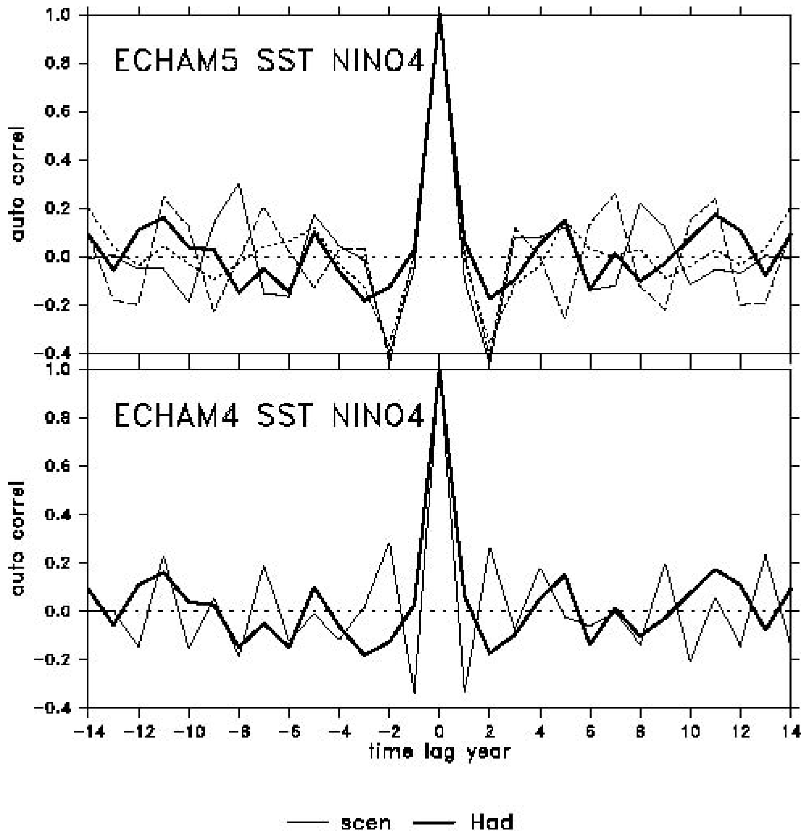
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Fig 5.

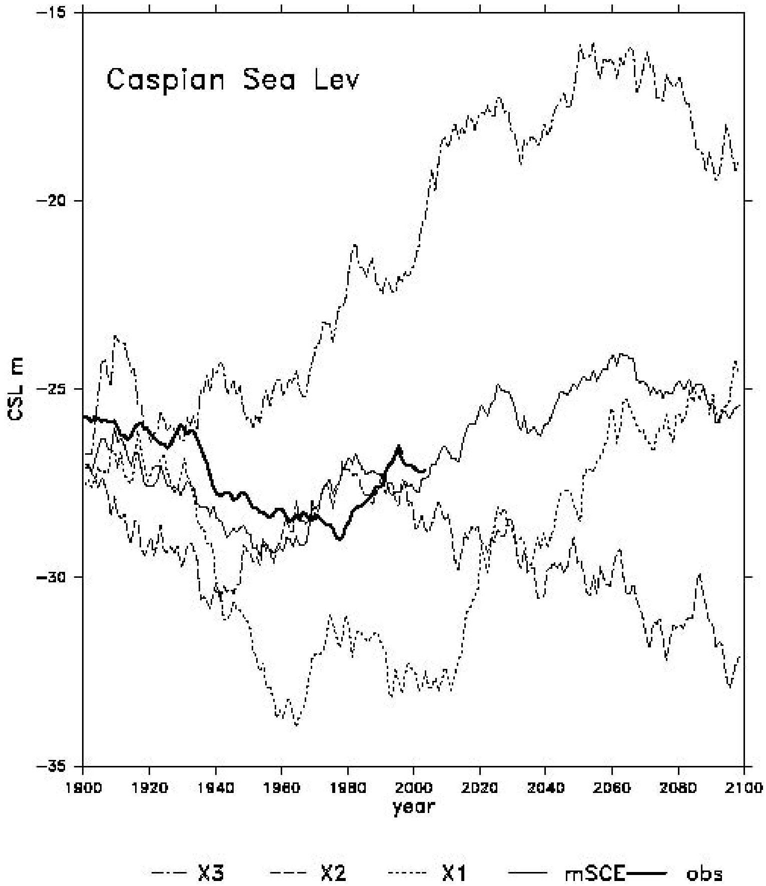
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Fig 6

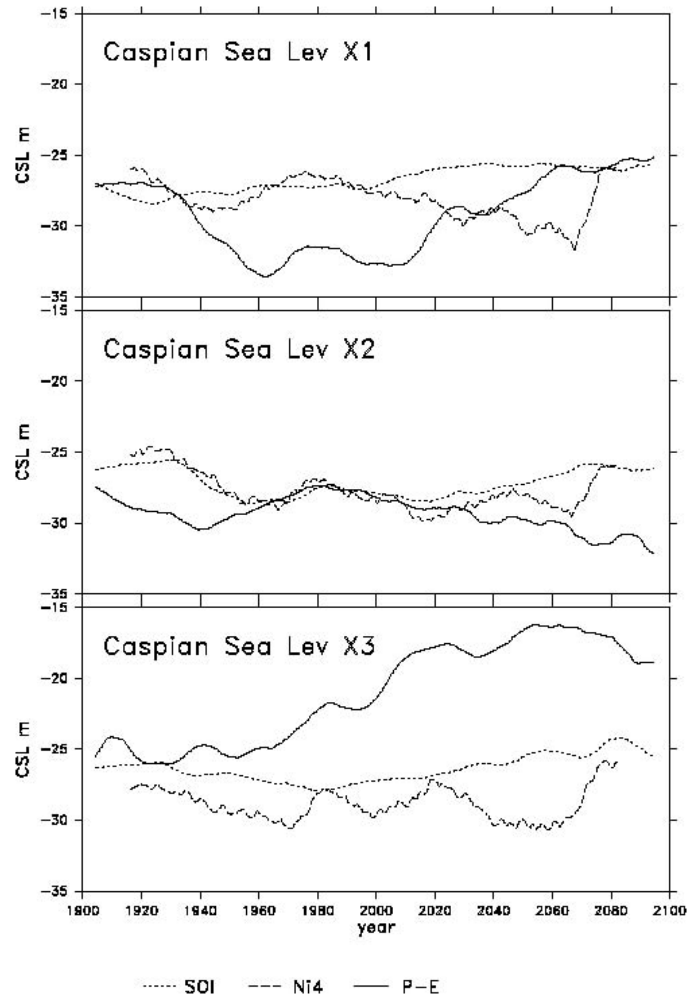
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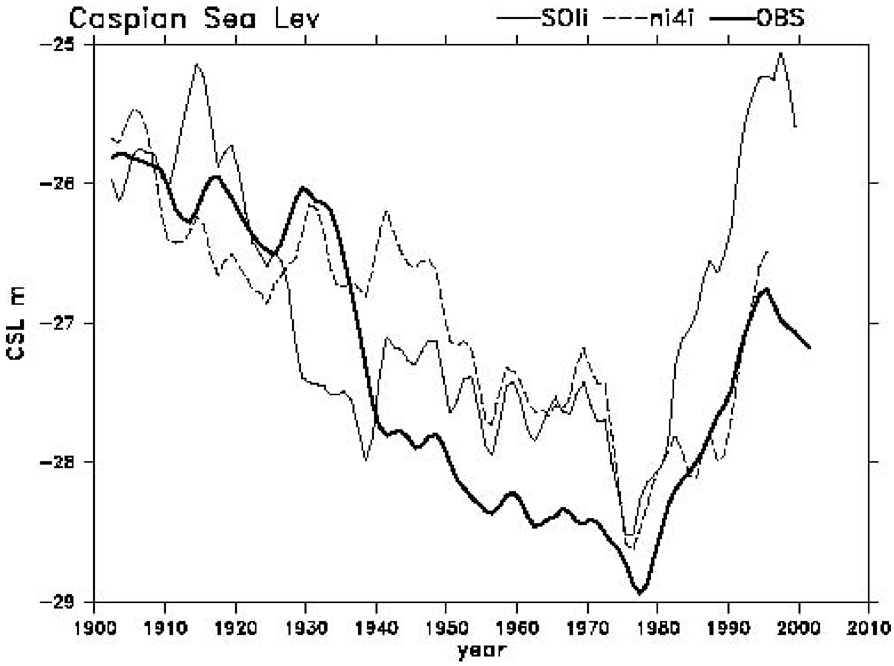
Fig 7.


Caspian Sea Lev
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1990
2000
2010
year

Fig 8.

FORMATION OF KARA BOGAZ BAY UNDER THE INFLUENCE OF CASPIAN SEA LEVEL CHANGE

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In the Caspian ecosystem the Karabogaz bay plays an important role. These two components are in a continuous interaction. When there is a hydraulic link between them, the bay is one of the outflow parts of the water balance of the Caspian Sea. In its turn, depending upon the position of sea level, the bay may be open or completely dry out, as appears clearly from the paleogeographical record.

Furthermore, at high Caspian sea level, terraces are formed on the steeper shores and clayey sediments are deposited on the bay bottom, whereas at low levels the connection between the sea and the bay is interrupted and the water in the bay evaporates completely, and salt layers are being deposited.

Recently borings have shown the presence of four salt layers on top of clayey deposits. The lowermost clay layer is underlain by Oligocene mudstones. Consequently by determining the age of the bottom sediments of the bay, the position of Caspian Sea Level since Post-Khvalyn times to modern times can be established accurately.

GEOMORPHOLOGICAL ANALYSIS RELATED TO THE AGE OF THE CASPIAN SEA KHVALINIAN TRANSGRESSION

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The Early Khvalinian transgression reached the elevations of 48-50 m. The Late Khvalinian transgression did not exceed 0-3 m. Although Khvalinian sediments yield numerous datings, the chronology of geological events remains controversial. The published data on the sampling sites and age estimations of the Early and Late Khvalinian deposits have been analyzed. All samples (60) that yield the Early Khvalinian age estimations were obtained within the elevation range between –18 and 10-15 meters. Their radiocarbon datings reveal comparatively young age of 9 to 20 ka (only several samples appeared to be older aging back to 30 ka). Most investigators consider these age estimations to be too young and suggest the Early Khvalinian stage to be as old as 50-70 ka.

Sampling sites of the Late Khvalinian deposits range from –21 to 0 meters. Moreover, their age estimations are similar to those of the Early Khvalinian ones. Thus, the Early and Late Khvalinian beds in the Northern Near Caspian Sea Region are hardly distinguishable not only in age but in their spatial position.

Mollusk shells were collected from sand interlayers within lagoon chocolate clays. The clays are considered as Early Khvalinian in age, therefore some investigators assume the same age for the shells. However, we suppose the chocolate clays to represent a succession of lagoon-transgressive terraces formed during different age intervals. The terraces form a series of steps descending towards the shore.

Thus, the age estimation of the Early Khvalinian transgression of 11-20 ka rather corresponds to its final stage than to its maximum. Since the age of the high Early Khvalinian terraces (48-50 m) is much older, the transgression maximum should have occurred 70-50 ka.

THE MODERN CONDITION OF KARA-BOGAS-GOL BAY AND ITS INFLUENCE ON CHANGE OF THE LEVEL OF CASPIAN SEA IN SECOND HALF OF XX CENTURY

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At the modern stage, during the period of the intensive development of a national economy, the multitude of water ecosystems is exposed to the influence of anthropogenic factors. The most of this influence was reflected on the unique hypersaline ecosystem, located in eastern part of Caspian Sea - Kara-Bogaz-Gol bay. Its waters are characterized by the presence of the highly saturated salts. In 1983, as a result of damming the Kara-Bogaz-Gol bay with a non-overflow dam, the inflow of water from the sea to the bay had been stopped (Frolov, 1999). The underlying reason for that was the sharp decline of the Caspian Sea level and the following reduction of spawning grounds for species. It had led to the full drying of a bay and of the part of a canal for 13 years. The ecological imbalance in the region was observed. The quality of the brines, used in the chemical industry, was deteriorated. And, what is the most important, the loss of unique biological diversity of the bay, and the Caspian as the whole, took a place.
After the destruction of the dam in 1992, there was rebirth of the bay. The pouring streams of the sea water had started to bring a huge mass of the Caspian organisms (algae). The formation of the new ecological system began. The mass development of algae and rather low salinity have led to development of the brine shrimp of artemia and to the accumulation of commercial resources of cysts.
Necessary to note that shortage of the primary research on algoflora of the bay does not allow comparing the modern data. In total, at the present moment there are about 80 species and subspecies of algae from 4 divisions (Bacillariophyta, Cyanobacteria, Chlorophyta and Dinoflagellata) exist in the bay,

the most from which have the Caspian origin. Their detection in conditions of the high salinity has allowed not only to expand their spectrum of halobs, but also to reveal the whole net of morphological and structural changes. All this promoted to occurrence of new local populations in the bay. Only a small percentage of species is adapted to dwelling in such difficult ecological conditions.

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PRESENT-DAY SEA LEVEL RISE: OBSERVATIONS AND CAUSES

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Historical tide gauges data suggest that during the 20th century, the global mean sea level has been rising by 1.8 +/- 0.3 mm/yr. Satellite altimetry observations available since the early 1990s indicates a rate of rise approaching 3 mm/yr for the past twelve years. Satellite altimetry also reveals high regional variability in the rates of sea level change, with some regions exhibiting 10 times the mean global rate. On time scales ranging from years to decades, global mean sea level change results from ocean volume change caused by temperature and salinity variations (thermosteric contribution) and ocean mass change resulting from water exchange with continental reservoirs, mountain glaciers and ice sheets (eustatic contribution). In this presentation, we discuss the various and numerous new developments that took place since the IPCC Third Assessment Report publication in 2001, as well as the most recent status of the sea level rise topic, in particular the most recent numbers of observed sea level rise and climate-related contributions. Recently published global ocean temperature data allows us to quantitatively estimate the thermal expansion contribution to present-day sea level rise. We find that for the past 50 years, thermal expansion accounts for 0.4 mm/yr sea level rise, i.e., 25% of the observed rate. For the recent years (the 1990s), it accounts for 60%of the observed rate (1.6 mm/yr of 3 mm/yr). For both periods, there is a 1.4 mm/yr residual that needs to be attributed to water mass exchange with the continents and the ice caps. Recent estimates of mountain glaciers and ice sheet (Greenland and Antarctica) melting indicates a 'eustatic' contribution to sea level rise of 1 mm/yr for the 1990s. Concerning the regional variability of sea level trends, we show that it mainly results from thermal expansion. We also discuss new perspectives

expected from the recently launched JASON and GRACE missions for precisely measuring global sea level change (with JASON), and determining land water and ice mass contributions (with GRACE) and thermal expansion (by combining JASON and GRACE data, as well as using in situ hydrographic data from the ARGO international project). Finally we briefly discuss sea level projections for the next few decades based on climate models.

LAKE LEVEL MONITORING BASED ON SATELLITE ALTIMETRY

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Accurate and continuous monitoring of lakes and inlands seas are available since 1991 thanks to the recent missions of satellite altimetry (Topex-Poseidon, GFO, Jason-1 and Envisat). Global processing of the data of these satellites could provide temporal and spatial times series of lakes surface height from 1993 to 2004 on the whole Earth with a sub-decimeter precision. The Legos laboratory is involved in this field of analysis since many years. The response of water level to regional hydrology is particularly marked for lakes and inland seas of semi-arid regions. Altimetry data can provide invaluable source of information in hydrology sciences, but in-situ data (rivers runoff, temperature, or precipitation) are still strongly needed to study the evolution of water mass balance of each lakes. Moreover, sea level variations that result from variation of hydrological parameters such as river discharge, precipitation and evaporation, are very sensitive indicators of regional climate variations.
The Legos laboratory is involved in this field of analysis since many years. Traditionally lake level variations (that are usually in continental areas) have been measured at regular 10-days intervals with Topex / Poseidon mission, GFO and ENVISAT are also of a big interest due to their higher spatial resolution than the Topex / Poseidon or Jason satellites. GFO data are available since January 2000, Envisat since 2003. Special focus on the Central Asian lakes and Caspian Sea will be presented, in particular what kind of hydrological informations can be deduced from a combination of in-situ and altimetry data.

CASPIAN SEA LEVEL RISE, IMPACTS – CHALLENGES – RESPONSES (PROPOSAL OF A JOINT INTERDISCIPLINARY AND INTERNATIONAL RESEARCH PROJECT)

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The presentation is not a scientific contribution per se, but the outline of a proposed research project on the impacts of the rapid sea level change in Circum-Caspian regions and countries. Focussing on political and socio-economic aspects of the consequences of the rapid sea level rise, it will be suggested to form an international network of researchers who will be dealing with specific impacts of the phenomenon. In line with strategies of international global change programs (IGBP / IHDP especially), the impacts of the Caspian sea level rise on

> agriculture – rural/urban settlements – tourism – oil industry – fishery – industrial waste and deposits

shall be the focus of the suggested research. Ultimate goal of this endeavour shall be a comparative analysis of coping and mitigating strategies in the border states of the Caspian Sea as well as the development of joint and coordinated strategies to tackle unavoidable environmental problems.

The presentation will outline concrete research strategies, time schedules as well as organizational and financial aspects of this proposed research scheme.

THE GEOLOGIC AND MORPHOTECTONIC INFLUENCE ON THE GENERAL FLUCTUATION OF CASPIAN SEA WITH SPECIAL REGARDS TO THE GOLF OF GHARA BOGHAZ GOL

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Caspian Sea one of the largest lakes in the world has been under taken a remarkable variation and diversifying from geologic and morphotectonic point of view since Precambrian till present time. Also the above mentioned sea as a tectonic lake is predominantly distinguished from its surrounding lakes such as Aral Sea, Van, Sevan, and Uremia ones.

The southern depression of Caspian Sea is due to subsidence resulting of tectonic events in Precambrian till Miocene, which gave rise to the uplifting of Talish mountain range and Northern Alborz Mountains. The north part of Caspian sea is the result of Cenozoic folding and continental uplifting till Plio-Quarternary age. In the western part, the subcomplex of northern Caucasus geosyncline consisted of carbonate facies together with volcanic episodes of Jurassic to Paleogene age and also the sediments of Triassic to Jurassic one having clear exposure accompanied with Paleogen-Neogene series which underlying the Quaternary deposits. In the southern parts of Caspian Sea the relevant Precambrian Gorgan schist stretching till Masal and Shanderman with other Metamorphic series underlying the Paleozoic volcanic rocks as well.

As a general statement, in Precambrian the afor mentioned basin was belonging to Gondwana land consisting of metamorphic sediments in form of small depression. In final stage it could separate from Gondwana to move towards Urasia land under taken the subsequent tectonic evolution and finally due to morphologic configuration of the Tethys sea. The Caspian depression has been formed as present stage. The mentioned depression has been dislocated by a series of normal faults as well as thrust and over thrust ones which could morphotectonicaly represent the Caspian sea as a grabben shape sloping to the southern part of the fault structures in the parallel displacement trending generally NW-SE which have devided the above mentioned depression in two parts of shallow depth and deep one. The configuration of Ghara Boghaz Gol is due to grabben displacement which is surrounded by two normal faults trending NW-SE. the fluctuation of sea level in the area of grabben depression conspicuously depends on the fault system drainage, which could provide a great deal of underground water volume being drained by pressure circulation from the bottom of the Caspian sea floor.

THE IMPACT OF GROUND WATER HYDROLOGICAL BALANCE ON THE FLUCTUATION OF THE CASPIAN SEA LEVEL DUE TO TECTONIC AGENTS IN RELATIONSHIP WITH URMIA, VAN AND SEVAN LAKES

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During the meteorological cycle especially in the northern hemisphere and rapid as gradually variation of the wind velocity with remarkable temperature increase , the permanent icy covered catchment area of the Volga rivers would start to melting due to climatological changes. It is obvious that the drainage channels and rivers are not so much enough to evacuate all the surfacial volume of the whole water circulation.

In fact a great portion of the water circulation would penetrate into the fracture zones and faulting systems especially along the NW-SE fault trends which having a major role in drainage of underground water discharge and periodically direct positive fluctuation of the Caspian Sea. It could be emphesised that the Sevan lake situated in the marginal northern flounce of the Zangezur massive uplifts which are separated by normal and thrust fault systems from Kurinski ion wich in turn is separated from Caucasian massives and high reliefs which this later one being separated by strike strip faults with trending NW-SE in general remarks.

The Urmia lake and sublatitudinal Van lake are located in the southern flank of the minor Caucasus range which also are limited by faulting and fracturing interaction with Caspian Sea .As far as the Caspian Sea was connected to Black Sea in late Cenozoic and Plio-Quaternary age, the waters of two above mentioned Seas could cover a major part of Urmia , Van and Sevan lakes in one hand and the connection of the Caspian and Black Sea was practically possible with Mediterranean Sea on the other hand.

Then in final stage the regression of Thetys happened and the afar mentioned lakes revealed as single ones. However the connection with Caspian Sea entitled as Mother Lake with surrounding minor ones which are still active. According to diagrams and monographs submitted in the present paper representing the fluctuation of the Caspian Sea periodically had a direct impact on the minor lakes, the observation stations showed after a certain period not so much long represented the fluctuation of Urmia lake as well as Van and Sevan ones up to 20 to 50 Cm especially in 1994 to 1998, which are impacted by fault systems and underground drainage following the Caspian Sea upcoming.

RECENT ENVIRONMENTAL CHANGE IN WETLAND LAKES

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Recent history of environmental changes in wetland lakes can be readily revealed by the application of sediment coring and palaeolimnological techniques. For human induced changes (hydrological modifications, pollution and climate disturbance)the past 100-200 years is usually of most significance. Using sediment core results from North African lakes and lagoons, this period is represented from between about 20 to well over 100 cm of sediment accumulation, depending on the rate sediment accumulation. Within these recent sediments (dated using lead and caesium isotope analysis) both micro- and macrofossils records demonstrated that major changes in water quality had occurred at many sites, mainly as a result of changes in the avaiability of freshwater. The North African work was funded through the European Union and some of the aims and techniques are well suited to tackling issues confronting the Anzeli National Park wetland lakes. Furthermore and on a longer timescale,it is suggested that sediment records of water level changes in the shallow Anzali wetland region could provide complimentary evidence about water level changes in the main Caspian basin

ANALYSIS OF FLUCTUATIONS OF THE SEA LEVEL IN THE CASPIAN SEA

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In the present investigations the features of daily, seasonally and annually variability of the sea level of the Caspian Sea using spectral analysis and wavelet analysis and are studied. Three deferent data set included hourly data, daily average and yearly average are used. The analysis of annual values show essential interannual variability of sea level of the Caspian Sea. In addition it is demonstrated, that the interannual tendency has a non-linear character. Continuous wavelet analysis has revealed features of short period variability of sea level. The contribution of, annual and seasonal cycles to common variability of sea level varies from one year to another. The analysis of the wavelet spectrograms had allowed us to indicate possible mechanisms of reallocating energy between oscillations of different scales.

ENVIRONMENTAL CATASTROPHES IN THE SOUTH OF RUSSIA AND CASPIAN SEA DYNAMICS IN THE SECOND HALF OF THE HOLOCENE

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We investigated paleosols buried under natural deposits alongside of the Ergeni Upland within the Kalmyk Republic (South of Russia). The study area extends for 260 km from the north to the south. Buried dark-colored soils were observed in 23 sites. Radiocarbon analysis of humus of buried soils and surface deposits is performed for 16 pits, and more than 50 radiocarbon dates were obtained. Caspian Sea is at the south-east of the Ergeni Upland and strong winds from the sea usual for this area.

The sites with buried dark-colored soils are found in different geomorphological positions; from bottoms of dry valleys and balkas (wide flat-bottomed gullies) to plain watersheds. The number of buried soils within a single site varies from one to three. All paleosols are covered by deposits of different thickness (from 25 to 150 cm) and texture: from loesslike loams and coarse sand to stony colluvium. The genesis of these deposits is also diverse; alluvial, colluvial, colluvial-eolian, and eolian prevail.

The radiocarbon ages of the uppermost 5 cm of the humus horizon of paleosols in different parts of Ergeni are comparable, i.e., those soils functioned at the same time and were buried simultaneously irrespective to their topographic position. Phases of pedogenesis identified by us are as follows: about 4000 BP; 3500 BP, 2000 BP, 1700 BP, 1000 BP, and 500-600 BP. The intervals between these phases are characterized by intensive salt continental deposit accumulation.

The results obtained demonstrate that the modern soil cover on the most part of the Ergeni Upland is young; the relief is dynamic.

Periods of soil formation and landscape stability alternate with phases of deposit accumulation and surface instability. The second half of the Holocene comprises several cycles of soil formation/deposit accumulation.

It was revealed that periods of landscape stability characterized by the formation of paleosols coincide with the phases of the Caspian Sea regression (low level), and the periods of deposit accumulation and unstable pedogenesis fall on the transgressions (high level). Increasing areas of salt soils and degradation of pure steppe vegetation also accompany high level of the sea. Thus, Caspian Sea high level cause erosion and desertification processes and finally – environmental catastrophe.

These materials concur with historic and archeological data on the development of the Northwest Caspian Area. The region was populated most densely within the periods of sea regressions. People inhabited and used the Kalmyk steppe during the phases of landscape stability which coincided with the sea regressions and abandoned it at times of intensive change of the relief, which coincided with the sea transgressions.

HOLOCENE ENVIRONMENTAL CHANGES IN UPPER VOLGA BASIN: MULTIDISCIPLINARY APPROACH TO STUDY

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Upper Volga outwash plain with a dense lake-river network and vast peatbogs is the greatest part of Upper Volga basin. The Post-Glacial environmental evolution and the human history of this region are closely related to the dynamics of hydrological regimes of fluviolacustrine or river systems. However reconstructing fluvial histories in the low gradient river systems with similar fine mineral matter transport is problematic. The multidisciplinary approach provides the opportunity to relate local palaeolandscapes properties and cultural behaviour with basin-scale fluvial events.
Three archaeological excavations, selected peat profiles and soil-sedimentary sections in Dubna Lowland (south part of Upper Volga basin) were studied, and data obtained were synchronised with published data on palaeoevents and hydrological changes within Upper Volga drainage basin.
Detailed study of macrofossils and ecological grouping of aquatic and terrestrial biota was used for reconstruction of fluvial activity and subaerial conditions. Algae and mollusks assemblages showed changes in water depth, temperature, chemical properties and discharge rates for each defined environment period. Subaerial conditions recorded in palaeosoils properties (organic horizons, morphology of cracks, cutans, mineralogy and others) were reconstructed, and these data were supported by sequences of cultural layers from Early Mesolithic up to Bronze Age. Several palaeosurfaces were reconstructed, and palaeochannels and other fluvial forms of relief were described for defined stages of environmental development.
According combined data the alternation of periods of waterlogging and subaerial development was established, and qualitative characteristic of each stage was made.

The Late-Glacial development of area was closely related to drying the periglacial lakes, high discharge and deep erosion with including pollen from the Devonian deposits into fluviolacustrine outwash.

Not later 10 300 BP (cal. BP 12350-12006) human occupation of dried area and successive planation of fluvial relief began.

Start of essential humidisation and waterlogging is supposed to be around 6000 BP (cal. 6851-6735 BP). Mesolithic settlements and cemeteries along lakeshores and riverbanks were flooded. This period was interrupted by relatively dry conditions, comfortable for human life (14C data range is 5840 – 5580 - 5350 BP).

Successive wetting, bogging and accumulation of peat and clay sapropel are marked for long period from 4590 BP (cal. 5320 – 5098 BP) up to 2600 BP. Around 2600 BP (cal. 2782 – 2483 BP) total flooding interrupted subaerial development of area. According macrofossil analysis the water is supposed to be cold and oxygen-rich.

1900 BP (cal.1925 – 1720 BP) is marked by shrinkage of water body and flooding-drying regime. Not later 730 BP (cal. 679 – 652 BP) or 640 BP (cal. 658-550 BP) wide-scale bogging and fen peat accumulation began. Macrofossils show gradual changes of carbonated waters by iron-rich slow moving waters during Holocene.

Essential palaeoenvironmental changes in Dubna Lowland are comparable with Holocene palaeoevents within Upper Volga discharge basin.

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CATASTROPHIC LANDSLIDES IN THE WEST CAUCASUS: DAMAGES AND POTENTIAL BENEFITS

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It is well known that such rapid geological process as landsliding seriously damages or even ruins the social and economical life in many mountain regions, particularly in the humid agricultural areas. Our research in the West Caucasus, Mountain Adjaria (Georgia) allows to conclude about dual impact of landslides: land sliding simultaneously acts as both a destructive factor and a mechanism of renewing mountain ecosystems, land resources and settling areas.

The Mountain Adjaria is a densely populated ancient (settlements are known from Bronze age) agricultural region bordering on Turkey, with steep slopes and absolute altitudes 400-2200 m a.s.l. Landslides, both shallow soil creep and giant geological slumps, are the characteristic features of area due to geological peculiarities and climate conditions. They periodically destroy settlements, agricultural lands and human life, and result in depopulation of mountain region. More than five thousand people migrated from damaged gorges in 1989 only. However the most significant damage of landsliding is the irreversible loss of the fine earth that is the strategic natural resource for human habitat, agriculture, forestry, etc. in mountains. Comparative analyzes of fine earth amount slumping in the rivers in the different parts of the West Caucasus was carried out.

In spite of evident multiple destructive effect of landslides their role in the life of mountain region is much more complex. Stabilized great slump forms new element of mountain topography - terrace-like body with relatively flat surface. Such slump body contains a great volume of dispersed mineral matter including fine earth, and turns into potential resource for new ecosystems and use by men.

The latter is vitally important for region with limited and strongly eroded agricultural lands.

The chronosequence of adaptation of former slump bodies to human occupation was studied, including first stages of forest successions and soil formation. It was shown that about 40 years is enough for using the new-formed surface as a hay land, after agricultural reclamation, and 60 years for transforming it in a tillable land and using for settling, in the given conditions of West Caucasus. The geomorphologic observation of mountain gorges showed that, at the lower parts of slopes, many settlements and cultivated lands are situated on old slumps.

Thus repeating catastrophic geological processes give start to new circles of ecosystem development, create new native habitats, new areas for agro-ecosystems and human habitations. They could be considered as a mechanism of long-term compensation of abrupt damaging processes.

Traditional ways of population adaptation to two aspects of landsliding are considered.

Researches were supported by the J. and C. MakArtur Foundation (grant № 02-73101-000-GSS).

THE LATEST PROGRADATIONAL – RETROGRADATIONAL PATTERN OF SEFIED ROUD DELTA, IN SOUTH CASPIAN SEA

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Sefid Roud River in Rasht district is one of the major and longest River Systems in south Caspian Sea.
By using technical process on different repeated Landsat data during short periods of time since 24/9/1952 (air photos) to 1/6/2000 (including data Landsat in 14/6/91 and data Landsat 1/6/2000), the following results were revealed:

1- Two major old beach ridge barriers and delta lobs are still present.

2- Several abandoned channels of Sefid Roud River indicate shifting of the main Channel to the east.

3- Width, necks and coarse grain bars of major channel have decreased by time.

4-The size of delta lobs due two joining together increased while delta channels and interdistributary bays have decreased by time.

5- Slow progradution of delta lobs involves relatively less rapid sedimentation
By time.

6- By wave action and relatively more reworking river mouth sand bar and delta platform have decreased by time.

7-General pattern of Bird-Foot delta have changed to roughly smoothed cuspate delta.

STRUCTURAL TREND AND DISTRIBUTION OF PLIO-PLEISTOCENE HORIZONS OF SEISMIC PROFILES NORTH OF ANZALI, SW CASPIAN SEA

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Eight seismic profiles north of Anzali (SW Caspian Sea) were investigated to draw time- structural contour maps. These maps are drawn based on three distinct timeline reflectors, called as South Caspian 500 (SC500), SC600 and SC700. Horizon SC500 is correlable with Surakhany unit (Upper M. Pliocene), the uppermost unit of productive series. This horizon is an erosional unconformity and shows an increase in depth in NE direction The shallower depth of these horizon in the center of the study area is due to the mud diapirism. Horzion SC600 forms a downlap surface indicative of a maximum flooding surface. This horizon is correlable with Agchagyl Fm. (U. Pliocene). Horizon SC700 (Pleistocene), is the most distinctive and the youngest studied horizon. These horizos show a similar trend to that of horizoin SC500. Most faults in the study area are normal and show NW-SE trend.

DYNAMICS FROM CASPIAN SEA LEVEL TIME SERIES.

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Available information about Caspian Sea level (CSL) dynamics is limited by short instrumental time series. Reconstruction to the past was implemented on the basis of proxy data with the help of correlation relations between CSL data and temperature in Moscow and St.-Petersburg, silt sediments data and using historical narrative information. Proxy data has low time resolution, gaps and their quality depends on correlation relations. However, correlation coefficients between temperatures and sea level strongly depend on the duration (scale) of time interval.
Historical data are usually nonequidistant, censored sample and generally need to be corrected. Thus, a reconstruction of the dynamics must be done on a basis of heterogeneous sample, and anyone obtained variant is correct only on some assumptions.

The work represents approaches to overpass of mentioned difficulties. In order to obtain the more significant coefficients of regression equation between temperature and CSL data we suggest considering of differences in dependences between CSL and temperatures on various time scales with the help of wavelet analysis. To obtain equidistant data we offer to apply method of fractal approximation. Correctness of such approximation is substantiated by scaling index estimates and by topology of the phase reconstructions of dynamics obtained by embedology methods[1]. For reduction of unknown nature noise we apply the methods of Holder regularity enhancement of time series[2]. Filling gaps of time series is implemented by means of modeling missed values by manifolds of low dimension[3]. Proposed tools allow obtaining appropriate reconstructions not only for analyzing dynamics, but for Caspian Sea level prediction.

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CLIMATE COMFORT CLASSIFICATION IN SOUTHERN COASTAL AREA OF CASPIAN SEA

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The thermal sensation and climatic comfort of a human being is mainly related to the thermal balance of the body as a whole, with the environment. The atmospheric environment has a few meteorological parameters (temperature, humidity, air movement and radiation) which determine the bioclimatic conditions of a person exposed to the environment out of doors. A complete assessment requires investigation of such further parameters such as the insolating effects of clothing, metabolic heat produced by activity, occupation, age, acclimatization to the general climatic, conditions prevailing in the region and, the air quality. There are numerous theoretical and empirical indices containing these parameters, which can more or less evaluate the bioclimatic conditions for humans.

In order to estimate the climatic comfort, we make use of climatic comfort indices. For determination and classification of climatic comfort indices in the Southern Caspian Sea Coast, we make use of weather data from the following eight synoptic stations:Astara,Anzali,Rasht,Ramsar,Noushahr,Babolsar,Ghaemshahr and Gorgan over a ten-year statistical period (1991-2000). In this direction we first make use of the statistical homogeneity test, and then the following indices are counted and classified: Effective Temperature (Discomfort Index), Relative Strain Index (RSI), Heat Index (Apparent Temperature).

GEOMORPHOLOGY OF THE NEW DELTA SEFIDRUD RIVER DURING 80 YEARS AGO AS TO THE CASPIAN SEA FLUCTUATIONS AND THE CHANGES IN ITS MOUTH FROM SPACE IMAGERY

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A survey of the maps, aerial photographes and satellite images of Sefidruds new delta occurring in the Caspian seas south coast.shows that certain fundamental morphological changes have been occurring in the delta during the 80 years ago.Rapid Caspian sea fluctuations are one of the unique particularities of Caspian sea.Althoutgh both the rise in the water level of Caspian sea during the years 1926-1978(about 3 m) and fall in the level of the sea during 1975-1995 (about 2 m)were influential in the process of its intrusion.but little or no attention has been paid toward the role of sediment budget changes and sefidruds mouth displacement in the development of the delta.The survey shows that the sefidruds new delta in influenced by the function of the waves, sea level fluctuations and the Sefidruds mouth displacement.During 1955-1964 sefidruds mouth was extended about 3.5km farther to the north west.The displacement process was occurring in the direction of east-west in the first half of the 20th century and was adversely advancing in the second half of the past century.

CASPIAN SEA LEVEL FLUCTUATION RECONSTRUCTION IN HOLOCENE EPOCH WITH BIOSTRATIGRAPHY INDICATORS

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Caspian sea as the largest lake in the world have different characteristics considering Geoscience . Infact sea level changing is the most important happening in this area. Anually fluctuation impact on arounding coastal area have serious damage and human society meet frequent destroyed phenomena .In this paper we are trying to introduce rapid sea level changing in holocen age by use biostratigraphy reasons such as : Mullasks Shell and sedimentary facies that they are showing periodic sea level changing in the caspian sea region.and along 10000 years ago we have several fluctuation as sea level rising that its latest begin about 25 years ago.finally we can conclude that caspian sea level fluctuation could continue at future similar past age and climatological effects with tectonical impact are important agents for sea level changing in the Caspian Sea region.

DATING CASPIAN SEA LEVEL CHANGE – STATE OF THE ART

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Dating Caspian Sea level change in different time scales, from decadal to millions of years, is necessary to increase understanding of sea-level fluctuations: (1) as an environmental problem in the Caspian itself, (2) as a physical model for slower sea-level changes world-wide, (3) as a component in the global climate system, and (4) as a sedimentary architectural model for oil- and gas-bearing sequences in order to improve rational and environmentally sound hydrocarbon production. Focus is on improving the record of both coastal and deep marine sequences in the Caspian.

Good progress has been made in bringing together coastal records from the various Caspian countries. Both in Russia (Dagestan), Azerbaijan and Iran there is now consensus that two major millenial highstands occurred in the last 3000 years, one at around 2600 BP, and one in the Little Ice Age. The 2600 BP highstand correlates well with the cool and moist start of the Subatlanticum recorded in large parts of Eurasia and the GISP-2 ice core from Greenland, and supposedly related to a pronounced solar minimum. Morphologically the event is recognised by the development of extensive spits along Caspian coasts, such as the Agrakhan spit in Dagestan and the Bandar-e-Anzali spit and probably also the Gorgan spit in Iran. The following deep regression, possibly down to -48 m according to new data from the offshore Kura delta in Azerbaijan, is probably related to the Warm Mediaeval Period. The last highstand took place in the Little Ice Age, probably also related to solar minima, and led to the formation of barrier complexes along the whole western Caspian coast. These data suggest that solar forcing might indeed be responsible for millennium scale changes of sea-level in the

Caspian. Few modern data are available for the eastern Caspian coasts of Kazakhstan and Turkmenistan.

Unfortunately, not much progress has been made in studying the deep marine record of the Caspian. Dating of samples from older surveys in France is still in progress, but a new geophysical and sampling cruise in the deep Caspian is urgently needed.

There is increasing support for global climatic forcing of Caspian Sea Level Change from global atmospheric circulation models (GCM's) and hydrological balance models. Furthermore also the impact of other processes on Caspian Sea Level such as tectonics, earth tides are better understood, as well as its environmental consequences in terms of biodiversity, mineralogical changes and redistribution of pollutants in coastal areas.

THE MODERN VOLGA DELTA AS AN ANALOGUE OF THE NEOGENE PRODUCTIVE SERIES, AZERBAIJAN

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The Neogene Productive Series, the main reservoir unit of the prolific hydrocarbon province in the South Caspian Basin, and the modern Volga delta in the northern Caspian Sea are deltas deposited by the same river into the same closed sea. Both deltas are low-gradient, mud-dominated, river-dominated, multichannel, ramp deltas without a shelf break, and show the impact of rapid changes in sea level, climate-driven discharge and sediment input. But there are also prominent differences.

The Productive Series forms the lowstand wedge of the most dramatic sea-level fall the Caspian has ever experienced. It consists of an up to 7 km thick succession of fluviodeltaic sediments, deposited at extremely high sedimentation rates (2-4 mm/y) by a Paleo-Volga River in the narrow, rapidly subsiding South Caspian basin between 5.5 and 3.4 Ma. Simultaneously, the Paleo-Volga carved a canyon 2000 km long and 600 m deep far upstream into the Russian plain. The proximal part of the Productive Series shows the transition from alternating sheetflood sandstones and floodplain mudstones with great lateral continuity, to finer-grained packages with common coarsening upwards facies successions, and there is evidence of repeated emergence and desiccation. A coarser grained interval reflects increasing uplift in the adjacent Caucasus. The upsection increase in mud-dominated deposition reflects a trend towards more humid climates.

The modern Volga delta is only 20 m thick and has been deposited during the last 6000 years on a wide stable continental platform at a level halfway a major Last Glacial highstand and a deep Early Holocene lowstand. It shows rapid lateral and vertical facies changes at the delta front, and is characterised by many small radial sand bodies with low connectivity, coarsening upwards levee deposits overlying clayey prodelta deposits, and fining upwards channel fills. There is evidence of frequent emergence and submergence due to rapid sea-level change. Average sedimentation rates are lower than in the Productive Series (0.7-1 mm/y in uncompacted muds).

The modern Volga delta can not be more than a partial analogue of the Productive Series for three reasons. Sedimentation in the Productive Series spanned 2Ma , but in the modern Volga delta less than 6000 years. The outcropping Productive Series sediments were deposited in a more proximal position than the sediments of the modern Volga delta front, which explains the difference in lateral continuity of the sandy successions. But above all the Paleo-Volga shed its load in a narrow, rapidly subsiding basin, while the present Volga spreads its sediment across a wide and shallow stable continental platform. The differences in basin geometry and dynamics largely explain the differences in 3-D architecture and sedimentation rates.

EVIDENCES OF THE LATE HOLOCENE SEDIMENTATION ALONG THE COAST OF SOUTHERN CASPIAN SEA, IRAN

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The South Caspian coastal area, which located in north of Iran, is characterized by high terrigenous sediment flux, different coastal slope, and high influence of wave and wave induced currents. Main part of the coast has been developed during the Holocene under changing the Caspian Sea level. Nearshore surface and core samples from marine sediments and samples from outcrops of marine terraces were used for quantitative and chemical analysis. Data from the sediment samples provide evidence of the Caspian Sea level change and pattern of sedimentation on the Iranian coast. The evidence of the late Holocene highstand found in accumulative parts which mainly seen in western and eastern of the coastal area. Shape and orientation of shoreline in these areas has an important influence on trapping of sediments which transport by longshore currents. High sedimentation rate (4- 8 mm year-1) is calculated based on 14C dating of bivalve mollusk where the rate of sedimentation on the west and eastern part of the coast (with moderate to gently slope and high reverine influx) is greater than the central part (with steep slope, direct wave approach and low sediment supply). 2m core samples where collected from depth of 20- 50 m present low organic matter silt-sandy layers with bivalve mollusks. Variations in grain size, organic matters, and carbonate content of different layers within the total sequence of the core clearly shows the sea level fluctuation. Late Holocene and modern sediments of the Iranian coast mainly characterized by sand-silt deposits with abundant of heavy minerals and low carbonate content. The content of carbonate progressively increases toward the eastern part of the coast where the fine grained materials are present. Composition of

the marine and reverine sediments demonstrate that the rivers are main source of the sediments for coastal depositions. Changing in sedimentary facies from clastic (in the west) to carbonate (in the east) indicate a change in sediment provenance from Alborz Mountain (humid climate) to Copet Dagh (arid climate) respectively.
The late Holocene sediments from the Iranian coast contain combined evidence of the last sea level fluctuations, fluvial influx and wave induced currents. These influencing factors determined the mode and pattern of clastic and carbonate sediments along the Iranian coast.

HEAVY METALS CONCENTRATION IN MODERN SEDIMENT OF SEFIDRUD DELTA

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Sefidrud Delta is the largest delta in the Iranian coast of the Caspian Sea. Catchment basin of the Sefidrud covers an area of 66000 km2, which extends over Alborz and Zagros mountains with different geological settings, climate and intensity of human activity. High population around lower Sefidrud is the main cause for susceptibility of the related environments for contamination. The Delta is comprised of fine to medium siliciclastic sands rich in heavy minerals and some phyllosilicates. Aquatic sediments in the delta in general are major sinks for heavy metals which are originated from weathering of bedrocks in the source region or derived from human activities along the river. Determination of background levels of heavy metals provides a reference level to better estimation of the relative importance of potential pollution sources. On this basis, 16 surface samples and one core were analyzed for the determination of trace metals in modern sediment of the Sefidrud Delta. Bioavailabilities of heavy metals (Cd, Pb, Cu, Ni, Cr, and Zn) were measured after leaching of the samples in cold HCL for a period of 16 hours. Heavy metals in bulk and leached sediments were determined by Atomic Absorption. Maximum concentration of heavy metals is 400 ppm for Zn in bulk sediment. Leachable portion of the heavy metals varies from zero up to 90% (for cadmium) of the bulk concentration. Little percentage of dissolved metals (Pb, Cu, Ni, Cr, and Zn) reveals that they are located in minerals structure. Differentiation between the background influence and human impact on the heavy metal concentration was done by using geoaccumulation index (comparison of the metal concentration in the surface sediments and those of cores in the same area). The geoaccumulation indices for the sediment are negligible, that indicate the role of the

source region rocks in enrichment of heavy metals. In other words, similarity of the heavy metal concentration in surface and subsurface sediments and slight solubility of the metals indicate that the main source of the metals is natural and the input of anthropogenic heavy metals via the Sefidrud River is negligible

USING REMOTE SENSING TECHNOLOGY TO MONITOR CHANGES IN COASTAL ZONE OF SOUTH CASPIAN SEA ON A CYCLE OF 14 YEARS

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A preliminary study sponsored by satellite data was initiated to determine the sedimentary environments and geomorphological aspect in the Iranian part of Caspian Sea.
The TM bands were particularly useful for much of the separability between some kind of sedimentary environment and landforms.
we classify south of Caspian Sea coastal landforms (based on Ottman,1965 Shepard,1976) with TM images. Subaerial deposition coast, prograded marine deposition coasts, coast prograded by wave or current deposition such as barrier beaches, barrier islands, barrier spits, overwash fans, coast build by organisms such as fresh water swamp coast was seen. These landforms related to structure, wave energy and weathering regimes.
Some part of its coastline advance for 14 years because of coastal emergence and progradation by deposition, or retreat because of coastal submergence and retrogradation by erosion. We show these types of coast on satellite images.
Also geomorphological changes of Sefid- Rood River and other rivers is seen. Sinuosity of Rivers in this period is decreased, so tectonic activitie in this area is increased. Extent of plain has been less. There are retrogradations of deltas within a period of 14 years because of rising sea level change.

ANALYSIS OF CLIMATE CHANGE IN CASPIAN SEA LEVEL AND FORECASTING

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in researching time change of statistical data , the general goal is detecting availability each type of specific character except accident state . for studing time series there are different goals that rae knowing and demonsration mechanism of production , prediction the future amount and optimum control asystem . in this paper , for research probably effect of climate change at caspian sea level change . thre character (homogenity , trend and jump) in sea level time seri at statistical period (1951-2003) are analyzed . homogenity test such as bartlet test , auto corrolation function , cumulative deviation and worsley's likelyhood ratio present nonhomogenity in this time seri. also Mann-Kendal and Speerman nonparametrictest and Pierson parametric test accept longterm trend at significance level 0.05 . significant deccending trend from beginig the studied period till 1977 and after it significant ascending trend until 1995 is watched . existing jump in seri is tested with Kruskal-Wallis and analysis of variance (ANOVA)test and the years with jump are detected . then , results of tests and how time seri's behavior are analyzed . in second step for finding model of changes and predicting behavior of this time seri, the auto regresive moving average (ARIMA) model is used . essential condition for runing this model are normality and being stationary of seri in average and variance . normality is tested by Kolmogrov-Smirnov and normal probability curve (p-p) test and being stationary is tested by ACF and PACF curve . with using first step difference , these conditions are satisfied . this model predict caspian sea level at 2003 with 3 cm error .

CLIMATIC FACTORS OF THE HOLOCENE CASPIAN SEA LEVEL CHANGE

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The contemporary ideas about the Caspian Sea level fluctuations are based on the structure of the Sea water balance that is determined by the climatic factors. The amplitude of the Caspian Sea level fluctuations does not exceed 4 meters during the instrumental period from the highest level (-25.2 m BS) in 1882 to the lowest level (-29.1 m BS) in 1977. Whilst the amplitude mounted to 8-10 meters during the New-Caspian transgression, and taking into the consideration the Derbent regression it was equal to 12 m.

We investigate three periods: the Holocene climatic optimum (6.2 – 5.3 KA B.P.), the warming of 1930-es and the last three decades of the 20th century, that are accompanied by the global warming and the growth of the Caspian Sea level, in order to research ranges of the Sea level fluctuations.

The peculiarity of regional climate changes has been examined for all seasons in 1990s with an extra high increase in the mean global air temperature. The temperature and precipitation anomalies have been compared for 1991-2000 and the Holocene optimum. It has been concluded that quantitative estimates of the air temperature and precipitation agree between themselves for the larger regions of Eurasia. It means that the climatic optimum of the Holocene should be used for the near future climate scenario as well as for assessment of the Caspian Sea level change.

The paleoclimatic reconstruction-maps for winter and summer air temperature and annual precipitation for global warming on 1С have been used as predicting scenarios of climate conditions in the beginning of 21 century.

Based on the heat-water balance method and scenario a hydrological model has been developed to calculate the changes in climate and hydrological parameters with the progress of global warming. This model allows to calculate changes in annual runoff and evaporation for the Caspian Sea catchment. Some additional assumptions have been made to adapt this method for scenarios of climate change.

The water balance approach and method of historical analogy (using instrumental data of the Sea water balance components) have been used for the assessment of the Caspian Sea level with global warming on 10C.

LAKE CHAD : FROM HOLOCENE MEGACHAD TO PRESENT-DAY CLIMATIC VARIABILITY

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Lake Chad lies in an endoreic basin in the center of Africa : there is no surface outflow, river and rain inputs are compensated mainly by evaporation, and by volume and area changes according both to seasonal and annual variations of the water budget. There is some geological evidence that the lake has been in the past as large as the Caspian Sea.
Based on stratigraphic, diatom and pollen analyses, the variations of the Holocene lake Megachad are presented. The recent space mission (SRTM) allowed for a detailed elevation analysis of this ancient lake. At its maximum, the area of this paleolake was 330 000 km2 with a volume of 16000 km3 and an altitude of the water level of ca 320 m. This altitude allowed for a possible outflow toward the Atlantic Ocean via the River Benue valley. For lower levels, the paleolake had no outflow to the sea and its water budget may be compared with that of the Caspian Sea.
The present shallow Lake Chad is much smaller. During the las150 years, this shallow lake has been described as Large, Normal or Small, according to its water level. The Great L. Chad, holds 25000 km2 of open waters with a limited coastal sand dune archipelago, a water surface altitude of 284 m and occasional slight overflow towards the North-East. The Small Lake Chad, is made up of different wetlands with a permanent open water area of about 1700 km2 at an altitude of circa 280 m and permanent or seasonal marshes ranging from 2000 to 14000 km2. The Normal Lake Chad has an intermediate level of 281 to 282 m, an archipelago of some 2000 dune islands, some marshy vegetation on the shores and a single body of water covering about 18000 km2 .

More recently, after a period of Normal to Large Lake Chad from 1954 to 1965, the water level of the Lake progressively decreased as a result of a decrease in rainfall on the basin. The annual discharge of the Chari, which provides 90% of the surface input to the lake has been respectively 39.1 109m3 for 1950-71 and 21.8 109m3 for 1972-2000 (with 2 missing years). Since 1973 the lake has entered a new, long lasting Small Chad phase, and has been split into smaller water bodies separated by sills. A major sill separates the northern basin of the lake from the southern basin which receives the inflow from R. Chari. The annual inundation in the northern basin has varied between 50 and 7000 km2 according to the flood of the R. Chari.

The transition to a Small Chad resulted in major changes in the use of its natural resources, with a failure of the large modern irrigation schemes, a development of the cultivation on the large drawndown zones or seasonnaly inundated areas, and changes in the fish communities and fisheries techniques. A more constant water level is however favoured by some populations living around the northern basin of the lake, and a transfer of water from the Congo is now under study in order to maintain a “Normal” level of the lake.

RAPID ENVIRONMENTAL CHANGES AND CIVILISATION COLLAPSE: CAN WE LEARN FROM THEM?

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In trying to measure the changes of our present environment, we use a series of monitoring schemes. However these instrumental records are often based on data ranging over the last 100-200 years only. If we want to set up preparedness measures, we need to know the full range of possible natural variability. Hence it becomes crucial to look back in time and see how rapidly, even catastrophically, the environment can change and affect societies.
J. Diamond uses five criteria to analyse the causes of societal collapse: environmental damage, climatic change, society's relations with hostile neighbours, relations with friendly societies and people's cultural response. A convergence of several of these causes will enhance the disaster extent. It seems that three factors need to be considered when analysing human recovery: the temporal scale (longer than the food storage capacity), the spatial scale (nowhere to escape) and the cultural response (freedom to innovate). We shall examine collapses such as the Norse settlements in Greenland, Easter Island, the Mayas and the Early Byzantine period.
Geo-scientists and Historians also contribute by examining together how people have responded to those changes. Some societies have collapsed, others have revived. Some societies have then gone on doing exactly the same things without learning from the experience; others have modified their behaviours and successfully adapted to changes. According to J. Diamond, a group of people may make the wrong decisions by failure 1) to anticipate the problem before the problem actually arrives; 2) to perceive a problem when it actually arrives; 3) to try to solve it; and 4) to succeed to solve it.
If we turn now to more recent examples of environmental

catastrophes, we do not seem to learn from them in most cases. In Istanbul after the Izmit 1999 earthquake and with the very high probability of an earthquake before long, the 12 million inhabitant city is still expanding and too often without the respect of anti-seismic building regulation. After the earthquake and the tsunami of the Indian Ocean in 2005, international help aims at re-estalling fishing communities and replanting fields exactly where they were. What are the mechanisms through which a society learns from the disasters of past catastrophes? Ancient societies could declare a land impure and create a myth that would keep people away. In the XXIst century, we must try to find modern solutions with politicians closely working with scientists. Maybe solutions such as the creation of nature parks and the displacement of people could be examined and would be beneficial in the long run.

NATURAL AND ANTHROPOGENIC RAPID CHANGES IN THE KARA-BOGAZ GOL OVER THE LAST TWO CENTURIES BY PALYNOLOGICAL ANALYSES

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Palynological analyses (pollen and dinocysts) of a sediment core taken in the Kara-Bogaz Gol have been used to reconstruct rapid and catastrophic environmental changes over the last two centuries (chronology based on ^{210}Pb). A natural cyclicity (65 years) of lake level changes in the Caspian Sea and in the Kara Bogaz Gol and anthropogenic factors (building of a dam separating the CS and the KBG waters) combine to induce rapid changes in lake levels of the KBG, in the salinity of its waters and in vegetation cover of its surroundings.
A problem of reworking of Tertiary dinocysts into modern deposits has been detected owing to the knowledge of the modern dinoflagellate assemblages available through a recent survey. A comparison to modern surface pollen samples from Central Asia (Anzali, Caspian Sea south and central basins, Aral Sea, Lake Balkhash, Lake Issyk-Kul and the Chinese Tien-Shan range) allows us to establish the potential reworking of at least five arboreal pollen taxa possibly by run-off and dust storms.
The impact of low lake levels on the dinocysts is marked by a lower diversity and the survival of 2 species that are typical of the KBG, the Caspian Sea species present in the KBG having disappeared. During periods of higher lake levels (AD 1871 to

1878), the lake is surrounded by a steppe-like vegetation dominated by *Artemisia*; whereas during periods of low lake levels (AD 1878 to 1913 and AD 1955-1998), the emerged shore are colonised by Chenopodiaceae. The period of AD 1913 to 1955 corresponding to decreasing lake levels has an extremely low pollen concentration and a maximum of reworking of arboreal taxa.

These environmental changes are so rapid that they are a catastrophe for the local and regional environment and society. The artificial interruption of the flow of the Caspian Sea to the Kara-Bogaz-Gol has had a negative influence on the diversity of the dinoflagellates. During the last low level period, Humans have suffered both directly (emigration, health, water resources) and indirectly (infrastructures, agriculture). Similar changes are predicted in the next decades. The Kara Bogaz Gol environmental history could be used as a showcase for the future of the Aral Sea.

CASPIAN SEA INTEGRATED COASTAL ZONE MANAGEMENT

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Caspian Sea is considered one of the most valuable aqua-systems of the world. This sea has valuable organic and inorganic sources including oil, gas and caviar. The enclosure status of this lake and its other characteristics has made it very sensitive to changes and vulnerable to hazards.
The economic, social, cultural and bio-environmental importance of this lake for its costal states on one hand and its global importance as reach course of biological variety on the other hand and also, the increasing rate of pollution and destruction of the aqua resources have made it inevitable to consider a more integral bio-environmental management system.
Our goal in this research is to introduce and discuses the national and local regulations and lows to enforce an integrated management in "Mazandaran" costal region and preservation of its environment in the light of practicing such management. Without doubt on of the most important and basic tools is the availability of appropriate national and regional lows. Searching for finding this rules in the national and regional ground and studding its sufficiency and necessity are the basic question in this research.
The research methodology is a theoretical-descriptive and comparative one by using literature and documentary review. The finding of this research show this point that also practicing such management rules finds some support in local rules and particularly, during the resent years the bio-environmental assessment rules have strengthened it, there are considerable short coming in this movement for witch, appropriate measures should be taken. The issue should receive particular consideration in micro-planning and the 5-year development plans and integral management of "Mazandaran" Sea costal region should be

classified as a sub category in the policy making of state authorities with sufficient budgeting and funding. In term of regional agreements, so far, the costal states haven't agreed on a legal system. With respect to the valuable resources in the Sea bed and under/sub bed, to reach and agreement, more time and coordination are needed. Still it seems that its easier to draw up and execute a bio-environmental protocol for environmental preservation.
Some Iranian NGO's activities for "Caspian integrated costal zone management" are included.

THE INVESTIGATIONS DIFFERENCE OF CASPIAN SEA LEVEL ON BASIC GAUGES POSTS

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Certainly, if in the same time conduct the sea level measuring in different places, then the getting dates will be distinguish among itself. It means, that in different parts of coastal zone, will be getting different sea level results. The cause of it, is the different offshore zone, the hydrological and meteorological process are influence on parts of sea, the important place here take the configuration of coastal line and topography of the present part of sea bays bottom.

The more variable and effective factors which define the rapid variation of reservoir level is the wind. The interdisposition of air stream supremacy and configuration of offshore sea line in several part of times period it seems that prevail of decreasing and increasing sanding level. The definite part here, takes the installation of gauges and seagraf. So, in time when prevails in Caspian sea the north invasion, more often and longer in summer period and more in north shoal water part of Caspian sea prevails drive away appearance, when near the Iran shores feels more. But so, one-digit accordance is observed only in those post when the shores configuration is significant removal from gauges has enough direct form. The one-direct air mase removal in bays and gulfs (Baku bay, Krasnovodsk gulf, Tub-Kargan gulf, Kuli bay, the gulf replaces on the end of Ogurchisnk island) conditions with enough duration and intensity can be the reason for the first drives with the transition in several time period in arouse or on the contrary. The appearance in its transitory conditions, but in its significant repeating, gets its reflections, the same on middle sizes of year level stand. In spite of that this appearance transitory, it find its reflection in middle years and many years middle months

meaning stand level, where the year motion is expressed from wind factors.
For level difference investigations in different posts we use the results of gauges synchronic observations, which disposed in different part of sea. Sea dates of 27 points which was chosen by us, in accord the water level instruction give to us stability results of correlations connections. From these the support was being accepted: Baku, Makhachkala, Fort-Shevchenko, Kuuli-Mayak, to them had attached the others watermeasured evedince
It was built the difference of middle years and middle mane years level from the support part of Baku and the others. We must to note, that if we compare the middle many years difference of different post level observations, enough stabilization for many years long.
Also, the compound equation of middle years and many years levels of connection by basic waterposts of Caspian sea has been introduced in that report.

Table: The middle many years difference of Csapian Sea level by the watermeasured post support net

Basic post	Investigations post	Level difference, sm		Basic post	Investigat-ions post	Level difference, sm	
		Average annual	Average monthly			Average annual	Average monthly
Baku	Astara	-20	-17	Mahackala	Izberg	-3	-3
	Lenkoran	-1	-1		Tuleniy island	+6	+5
	Neftchala	-6	-4		Kulaly island	-3	-3
	Svinoy island	-15	-13		Fort-Shevcenko	+4	+2
	Ziloy island	-5	-6	Fort-Shevcenko	Shaliga	-	+9
	Atryem island	-	-12		Kulaly island	-9	-10
	Oli stocks	-14	-12		Aktau	-4	-6
	Sumgayit	-4	-4		Bekdash	-10	-10
	Mahackala	-6	-5		Gara-Bogaz-Gol	-13	-12
	Fort-Shevcehenko	-5	-6		Guuly-Mayak	-11	-6
	Gara-Bogaz-Gol	-19	-20	Guuly-Mayak	Gara-Bogaz-Gol	-7	-8
	Krasnovodsk	-21	-20	Krasnovodsk	Gara-Bogaz-Gol	+2	+2
	Ogurcinskiy island	-13	-14		Guuly-Mayak	+6	+6
					Ogurcinskiy island	+6	+6

THE RELIEF PROJECT: LARGE EARTHQUAKE FAULTING AND IMPLICATIONS FOR THE SEISMIC HAZARD ASSESSMENT IN EUROPE, THE 1999 IZMIT-DUZCE EARTHQUAKE SEQUENCE (MW 7.3 - 7.1, TURKEY)

Meghraoui, M., D. Pantosti, S. Akyuz, S. Leroy, M. Mai, K. Atakan and the RELIEF Working Group.

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In 1999, two destructive earthquakes (Mw 7.4, Mw 7.3) with 170-km of surface faulting devastated a large region of Western Turkey. The occurrence of such large earthquakes along the North Anatolian Fault represents a unique natural laboratory and invaluable opportunity to test our present understanding of the earthquake process and refine current seismic hazard models. The RELIEF project (EC-Contract EVG1-CT-2002-00069) consists of field investigations in the earthquake-affected area as well as numerical modeling approaches to perform an integrated analysis of the seismic hazard assessment in the Marmara Sea region. To that end, we combine paleoseismology, physics of the seismic source and engineering seismology for the data collection and analysis of the Izmit-Duzce earthquake sequence.

The scope of this 3-year project comprises four main objectives: (1) Systematic geomorphologic and paleoseismological analyses (including trenching and coring of lake sediments) along each earthquake rupture-segment to document the faulting behaviour during the Holocene and late Pleistocene; (2) Finite-source inversions using multiple data sets (InSAR, GPS, seismic recordings), investigations on dynamic rupture properties, and numerical modeling of earthquake source complexity; (3) Detailed studies of site effects (including response spectra) and their relationships to earthquake ruptures; (4) Critical evaluation of previous hazard assessments, and the development of new methodologies and scenarios for the seismic hazard mitigation in the region.

ASSESSMENT OF CASPIAN SEA VULNERABILITY TO SEA LEVEL RISE BASED ON ECOLOGY

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In this project we introduce a new model for assesment of vulnerability in coastal zone with idea of topography effect, ground water and other environment parametre. this model has been drived based on geomorphology factors, slope of costal.rising of sea water,and other parametre. the amount ot this vulnerability has been detected in a cycle of 50 to 100 years in each unit of work.these units are in Land Parcel network.

NECESSITY FOR ATTENTION TO CASPIAN SEA WATER LEVEL CHANGES IN ANZALI WETLAND INTEGRATED MANAGEMENT

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Anzali wetland is a very important place in north of Iran. As its unique environmental condition, and as occurred difficulties in its ecosystem during recent years, several programs have been arranged for solving its problems. But in all of these programs, the importance of Caspian seas water level to this wetland has been ignored. But the previous literature of this wetland shows that maximum and minimum levels of Caspian Sea have different effects to this wetland such as water quality.
In this paper the importance of attention to water sea levels for succession of any Anzali wetland integrated management program has been pointed.

MODELLING OF LEVEL VARIATIONS OF THE CASPIAN SEA USING GMDH-TYPE NEURAL NETWORKS AND SINGULAR VALUE DECOMPOSITION

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Abstract:- GMDH-type neural networks (Group Method of Data Handling) are used for the modelling of the level variations of the Caspian Sea. A general-purpose software called GEVOM (http://www.guilan.ac.ir/gevom) developed by authors has been used for such numerical modelling using 70 years of annual sea level values at Port Anzali, Iran. In this way, two different approaches for structural identification of GMDH-type networks are presented. It is also demonstrated that Singular Value Decomposition (SVD) can be effectively used to find the vector of coefficients of quadratic sub-expressions embodied in such GMDH-type networks.

The data used in this work for modelling of the level fluctuations of the Caspian Sea relate to the recorded levels in years 1926 to 2003. However, in order to construct an input-output table be used by such evolutionary method for GMDH-type neural network model, 9 various inputs have been considered for possible contribution to represent the model of next year level of the Caspian sea. Such 9 inputs consist of 2 previous years of level, 2 increments of previous years of level and 5 moving average of previous years of level. Therefore, the first 2 columns of the input-output data table consist of the level of the Caspian Sea in the 1st, 2nd previous year's level of the Caspian Sea denoted by *Level*(*i-1*), *Level*(*i-2*), respectively. The next 2 columns of the input-output data table consist of increment values, denoted by *Inc_1*(*i*), *Inc_2*(*i*), which is defined as

$$Inc\_j(i)=Level(i-j)-Level(i-j-1) \quad , \qquad (1)$$

where *i* is the index of current year and *j* is the index of a particular increment. The next 5 columns of the input-output data table consist of moving average of previous years of level denoted by *MA_L_2*(*i*), *MA_L_3*(*i*), *MA_L_4(i)*, *MA_L_*5(*i*), *MA_L_10*(*i*) which is defined as

$$MA\_L\_j(i)=\sum_{k=1}^{j}\frac{Level(i-k)}{j} \quad , \qquad (2)$$

where *i* is the index of current year and *j* is the index of a particular moving average of level. Therefore, such 9-input-1-output data table has been used to obtain an optimal GMDH-type neural network for the next year modelling of the Caspian Sea's level.

SEA LEVEL CHANGES OF THE ARAL SEA DURING THE LATE HOLOCENE: CLIMATE AND/OR ANTROPOGENIC CONTROLS

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The main purpose of CLIMAN (INTAS project Aral 00-1030) is to establish the sequence of climate changes of the last few kyrs. With a multiple proxies approach recording pluvial-aridic oscillations which control sea level changes in the Aral Sea we gained a quite detailed insight into the system. The water level balance, as recorded at the shore and in the sediments of Lake Aral, enlightens the drainage balance of Amu Darya and Syr Darya Rivers. Latters are interlinked with humidity carried by the West wind drifts and the Asian monsoon to the Northern and Southern Tien Shan and the Pamir Mountains but also to irrigation activities in the river valleys. Together with climate we evaluated the history of human settlements as a reaction on the environmental changes in Central Asia.

CASPIAN SEA LEVEL STABILIZATION STRATEGY: SYNERGY OF SCIENCE, POLITICS AND TECHNOLOGY FOR CASPIAN EUSTATIC SYNDROME

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The only managerial and applicable result from the longtime researches of scientists in the context of Caspian Sea eustatic paradox is a relative confidence of politicians (decision makers) on the future endless fluctuations of the sea level by different amplitude and quasi-cycles and serious threat of coastal ecosystems and economy with critical risk. Among them, the probable hidden hazard of catastrophic fluctuation of sea level stand between -22to -29 m until 2050 and latter, is adequate to serious alarm compulsory measures of littoral states and mechanical unity of science, politics and engineering for the radical solving of this chronic problem. Doubtless ,water level management of such a sensitive and vulnerable sea with a specific and unpredictable eustasy that lead a scientific anarchy ,vagrancy of scientists and interference politicians and engineers for the compulsory defensive and offensive projects, lies on the wager of ” control strategy”. In this status the alternatives of the Game theory will be complicated in Caspian eustatic game.
At the present, in spite of several key techno-political uncertainties upon water level fluctuation knowledge and Caspian Sea region sustainable management plans, a historical opportunity come together to new challenges for professional conduction of key science ,politics and engineering synergy to acute treatment of Caspian eustatic syndrome by designing of comprehensive “control strategy” instead of Caspian Sea level stabilization as soon as possible. This strategy can be implemented by different scenarios at the optimum and littoral states mutual agreement water stand as safe status(-27.35 m as last 35 years average).In this strategy that bases on global thinking and regional acting, a two-way regulations of hydro-physical levers in the Caspian

geosystem in summiting of Volga river network and Kara- Bogaz bay wil l be operate to removal of chronic problem of sea level rapid changes, logical implementation of Caspian Sea region sustainable development plans and proving a part of ideal thoughts for sustained triple unity of science, politics and engineering in large scale and complex environmental systems management.

A LANDMARK IN MARITIME HISTORY OF INDIA – AN ANCIENT VESSEL DISCOVERY

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One of the oldest maritime states of India (Kerala) had major and minor ports flourished during different periods of history with its trade contacts with Egypt, Babylon, Persia, Greece and other countries since 1500 BC. The ancient history of Kerala is shrouded in the mists of tradition. The most popular legend is that the land crust that forms the state was raised from the depths of the ocean. The Kerala coast has been shifting westward and eastward in response to the global sea level variations. A fall in sea level shifts the coastline westward and a rise shifts the coastline eastward resulting several ancient coastlines and sand deposits corresponding to such coastlines in the marine realm westward of the present southwest Indian coastline. The formation of Vembanadu lake (Ramsar site) was a result of these processes. The Kerala coast attained its present form through a series of transgression and regression events during the Holocene period.
The evidence of a intense and recent sea level variation along the Indian coast line is gained by the discovery of the artifacts of an ancient 20-metre long vessel of the category `Pathemary' lying beneath layers of sand and mud at Thyckal (southwest coast of India). This is for the first time that an inland navigation site has been discovered in the southern Indian state. Thyckal is the country's only maritime archaeological site, which is situated in a dry land. The vessel might have got stuck in mud while it attempted to enter the inland waterways Vembanadu Lake as the old geographical maps marked the Thyckal area as sea. The well-known clam fishery, both live and dead, evidences the transformation of an originally marine environment into Vembanadu Lake. In the southern Vembanadu Lake, the shell deposits are known to occupy a depth of 2-5 m below the present

bed level. The swampy areas (Kari lands) of the south Vembanadu lake region with black peaty soil having high proportion of carbonaceous wood represent areas, which were dense mangrove forests in the past. There is the possibility that it can be a vessel used in oceans as woodborers usually found in the ocean has been found in the artifacts. "However, it appears that the vessel is of a minimum age of 500 years". The discovery became more relevant to the safety of major ports in the light of on going global climate change and sea level variation.

AN INVESTIGATION ON WATER CHEMISTRY IN TALAB-E-ANZALI ,SOUTH WEST OF CASPIAN SEA

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"In the name of God"

The recent water chemistry investigation in Anzali Wetland along barrier in Caspian Sea, up to 5 meters depths was measured in 16 localities for pH, DO, TDS, Ec, Temperature and Salinity. These measurement have been done in 1.5 meter depths. All samples have been detected by Sension 146.It is obvious that measurement have been done in situ. The average salinity ranges from 0.4 - 4.16 ppt and that be interpreted as influence of fresh water. Anzali wetland level depends to Caspian sea level.
Usually run off reduces the salinity along the cost . The following factor causes high salinity around nearly the coast and back barrier due to: 1)limited river run off 2)Shallow depth 3)Insignificant mixing and 4)wind direction. In the Anzali Wet Land pH is depend on environmental parameter such as change of temperature, DO and dissolved mineral. The average rate of pH is 8.19 and it changes between 7.60-8.69.The maximum amount is in the south west barrier which has close relation to maximum growth plants that use CO2 to produce acidity. This increase of pH will be constant through out in all summer. his phenomena can be seen every where in the Wet Lands where plants are dominant In south east of Anzali wetland increase of TDS, minerals ,Salinity and Ec can be seen because of increasing of evaporation and limitation in river run off.

ESTIMATION OF WATER RISING HAZARD RATES REGARDS TO SEA FLUCTUATION AND TOPOGRAPHY CONDITIONS IN THE MAZANDARAN COASTAL ZONES

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The Caspian Sea which, is the biggest lake in the word has about 7000 km shore line commonly with five countries. The southern part of these shorelines that are belonged to Iran lied about 813 km in length. These shorelines and coastal zones have different topography conditions that can be based on contour lines between – 22 until –30 meters based on free sea level. Due to sea fluctuation, this bands are changeable and oscillationable. During past years, the Caspian Sea has considerable water rising with destruction in people life. Because of different slop conditions, this destruction was not equal in the coastal zones.
The historical, statistical and measurements information expressing to be possible water rising by –22 meters contour line. Determination and specification of the hazard rate for each coastal zone can be help to make decision for coastal managers and regional administrators and can be classify the coastal zones based on hazard rates. Estimation of water rising hazard rates can be estimate by topography models and predictable water rising rates. This study presents the estimation investigation of the water rising hazard rates against each half-meter band water rising in the 11 coastal cities of Mazandaran province and classifies these coastal zones based on their hazard rates in the each height band. For this, the scale 1:2000 coastal zones land use maps was prepared and scanned to extract topography information. Due to not be up to date these maps, the land use information was not applicable. The coastal digital elevation model was generated using interpolating of contour lines and elevation points. The politic border of each city was extracted from Mazandaran database. For

each city, the digital elevation model was extracted based on the borders. Digital elevation models were classified to eight half-meter water rising classes. These maps show the flooded area in each city if the sea is going to coming up at each elevation. The statistical information such as area was extracted for each elevation class and city respectively. The rate of water rising hazard in each rising class was computed by dividing of the each rising class to city area. These rates express that if the Caspian Sea will be going to rise at each elevation class, what cities will have critical conditions. The results showed that in each eight half-meter class from –26 by –22 the cities of Neka, Babolsar, Neka, Babolsar, Nour, Nour, Nour and Chalous would have the most water rising respectively. Results also showed that in general the Behshar City would have critical in total bands. This study was performed only with topography parameter to estimate the water rising hazard rates for coastal zones. This study will be complete if they will be integrate by socio-economical information and land use to estimate accurately critical zones.

NORTH-WEST CASPIAN STEPPE AT THE END OF 5000 – 3000 BC: CHANGES IN THE ENVIRONMENT AND HUMAN OCCUPATION OF THE REGION

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North-west Caspian Sea steppe area was a special cultural province of the Bronze Age. Analyses of environment and spatial distribution of archaeological sites dating back to different cultures of the Bronze Age helped us working a model of climate changes and occupation of this territory during the following time interval: cal4500-2250 BC.

I: 4500-4000 calBC. During this period the climate in the area under investigation was moderately dry, and atmospheric precipitation was slightly less than the modern one (about 350 mm), mixed grass steppe vegetation predominated. Eneolithic population exploited a watershed plateau of the Yergenui Hills, riverin and lacustrine valleys. The maritime Caspian Sea steppe, the Sarpa plain and many small ecological niches of the Kuma-Manych depression were empty.

II: 4000-3650 calBC. The mild continental climate did not changed; the level of annual precipitation was 400-450 mm. New Majkop culture population penetrated the Kuma-Manych depression area and the adjacent watershed plateau from the south, i.e. the North Caucasus. All their seasonal summer routes were linked to water routes tributaries. Almost all open steppe areas were empty.

III: 3650-3450 calBC. Lacuna. The absence of any archaeological sites dating back to this period hypothetically suggests that climate deteriorated.

IV: 3450-3000 calBC. Climate conditions changed: a mild and humid climate attracted newcomers: Late Majkop culture population and Early Yamnaya culture population appeared. The occupied area gradually expanded as far as the North Yergenui Hills and Northern areas of the Caspian plain.

V: 3000-2500 calBC. Predominance of dry steppes suggests existence of more humid climatic conditions comparing to the previous period. Yamnaya culture population consolidated its positions in still empty ecological niches of the Caspian Sea region and the Sarpa plain, but did not reach maritime steppe areas of the Caspian Sea. Adjacent Black Land was also empty.

VI: 2500-2250 calBC. Climate deterioration and paleoecological disaster were characterized by extremely dry climatic conditions and desert landscape. Adaptation of the Catacomb culture steppe population to deteriorated climatic conditions in this region led to exploitation of new ecological niches, spread of the pastoral groups across the entire territory.

CHRONOLOGY OF THE HOLOCENE CASPIAN SEA-LEVEL OSCILLATIONS

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Critical analysis of the abundant traditional radiocarbon datings of the Caspian Sea Holocene deposits gave a new insight into the chronology of its sea-level oscillations during the last 10 kyr - the major regressive epoch with smaller transgressive-regressive cyclicity. It is generally considered that all datings from the coasts correspond to transgressive Caspian sea-level oscillations, while other datings record various sea-level variations. We analyzed 84 Holocene datings from the coasts and 52 ones from shelf and deep Caspian Sea deposits.

There are evident uneven groupings of datings clearly demonstrating different sea-level positions. Datings of the Holocene coastal deposits form two major groupings in the time intervals 0.5-2.4 and 3.2-3.9 ka. Less evident groupings correspond to the intervals 5.4-6.4 and 7.3-8.2 ka. Thus dated sediments are characterized by specific index-fossil assemblages of mollusks, and, therefore, have a clearly defined stratrigraphical position. Sediments dating back to 0.5-2.4 and 3.2-3.9 ka contain shells of Cerastoderma glaucum (Cardium edule) and are assigned to the New Caspian transgression. The sediments aging back to 5.4-6.4 ka are barren of C. glaucum, but contain a typical New Caspian assemblage of Didacna species (D. crassa, D. baeri, D. trigonoides), which is totally different from the typical assemblage of the older Khvalinian transgression. These beds probably correspond to the beginning of the New Caspian transgression prior to the migration of C. glaucum from the Black Sea to the Caspian Sea. However, since these beds do not contain C. glaucum and are divided from the New Caspian deposits by a 1.5-kyr long break in sedimentation, they should be assigned to the earlier Holocene transgression.

Sediments of the 7.3-8.6 ka-interval contain a typical Khvalinian assemblage of mollusks with the late Khvalinian index species Didacna praetrigonoides.

The marked groupings of datings related to the Holocene Caspian sea-level highstands are separated by the intervals deficient in datings. In the coastal zones these are the intervals 2.4-2.8, 4.0-5.0, 6.4-7.3 and 8.6-11.0 ka, which correspond to regressive epochs, when no marine sediments were accumulated on the coasts. In the shelf and deep-sea sediments these intervals have different manifestations. The intervals 4.0-4.4, 6.6.-6.9 and 8.6-9.9 ka are characterized by numerous radiocarbon datings revealing a clear shift in sediment accumulation from coastal zone to shelf and deep-sea basin that is natural for regressive epochs. Periods devoid of any radiocarbon datings are of special interest. One possible explanation is that these were the periods of deep regressions, when the Caspian Sea shelf was exposed. This might have been the case for the following time intervals: 1.0-1.2; 2.4-2.8; 4.4-5.0; 6.9-7.3; 8.2-8.6; and 7.9-11.0 ka.

The discussed transgressive-regressive rhythms of the Caspian sea-level oscillations have different correlation with classifications of the Holocene sea-level variations proposed by other investigators. Transgressive rhythm 7.3-8.2 ka corresponds to the Dagestan stage of the New Caspian Sea (Varushchenko, 1987); 5.4-6.4 ka – to the Gousany stage (Varushchenko, 1987), II (Rychagov, 1977) and III (Leont'ev, 1976) stages. The established chronology of regressive Caspian sea-level rhythms is in a good accordance with regressive stages described by S.I. Varushchenko (1987): Mangyshlak (8.6-11.0 ka), Zhelandin (6.4-7.3 ka), Makhachkala (4.0-5.0 ka), Aleksandr-Bai (2.4-2.8 ka) and Derbent (1.0-1.2 ka).

A RAPID SEA LEVEL CHANGE DURING MIS3?

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The occurrence of a significant sealevel high-stand during Marine Isotope Stage 3 (MIS3, late Pleistocene) is a very controversial topic. In fact, offshore seismic and core data from the Gulf of Mexico, peri-Antarctic coastal deposits, drill cores from the Italian Po Plain and proto-Aurignacian cultural relics from the Italian Prealps lend support to the potential existence of a sea stand reaching about - 15/18 m below present sea-level at ca 37-40 ky BP. However, such postulated relative high-stand conflicts with the widely accepted marine oxygen isotopic curves in the ocean and is not documented by coral terrace records anywhere. One major difficulty to solve this controversy stays with the potential unreliability of chronological constraints used to date these asserted MIS3 records. However, if further research will confirm the proposed chronology, the obvious implication is that this relative high stand was of short temporal duration in order not to be imprinted in the isotopic and coral records

CORRELATION OF PLEISTOCENE PALEOEVENTS IN THE PONTO-CASPIAN AREA

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Based on systematization and critical analysis of all known findings of fossil molluscan fauna from the Caspian and Black sea regions, as well as from the Manych depression, detailed schemes of the paleogeographical evolution of these areas were worked out. Correlation of the established paleoevents revealed the major paleogeographical changes to be generally synchronous (Table 1). The Early Pleistocene Bakunian transgression of the Caspian Sea corresponded to the Late Chaudian one of the Black Sea. The Middle Pleistocene Early Khazarian and Ancient Euksinian transgressions were relatively synchronous. During the Late Pleistocene, the vast interglacial Karangatian transgression of the Pontian basin correlated in time with the small Late Khazarian transgression of the Caspian Sea, while the New Euksinian basin with sea-level far below zero mark was synchronous to the vast Early Khvalinian transgression of the Caspian Sea.
Table 1. Migrations of ancient molluscan faunas as the basis for correlation of the Pleistocene paleoevents in the Ponto-Caspian area (single arrows show migrations of brackishwater Caspian species, double arrows show migrations of marine Mediterranean species).

Age	Pontian basins	Sea of Azov basins	Ancient Manych Strait: western	Ancient Manych Strait: eastern	Caspian basins
Holocene	→> Black Sea →>	Sea of Azov			New Caspian
Late Pleistocene	New Euksinian ←	←		←?	↑ ← Late Khvalinian
			←	←	↑↑ ← Early Khvalinian ↑
	→> Karangatian →>	← Karangatian →>	← →>	←	Late Khazarian (II)
			→>	←	↑↑ ← Late Khazarian (I)
Middle Pleistocene	→> Uzunlarian →>	?	←		
	↑↑ Ancient Euksinian (II) →	← Ancient Euksinian →		←	↑ ← Early Khazarian (III)

Middle Pleistocene	Ancient Euksinian (I) →	← Ancient Euksinian →	← →	← →	↑↑ ← Early Khazarian (II)
					↑↑ ← Early Khazarian (I) ↑
	→> Epi-Chaudian				Urundzhikian
Early Pleistocene	Chaudian-Bakunian ← →	← Bakunian →	→ ←	←	↑ ← Late Bakunian
	↑↑ ← Late Chaudian →				
	↑↑ Early Chaudian	← ?	← ?	← ?	↑↑ ← ? Early Bakunian

ABRUPT SEA LEVEL CHANGE AT 4200-4000 CAL. YR BP AND THE COLLAPSE OF THE ANCIENT CIVILIZATION

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The study of the annually laminated sediment from Lake Tougou-ike in Japan revealed an extreame depletion of total sulfur contents and the increase of siderite content between 4200 and 4000 cal. yr BP. This extreme reduction in total sulfur content indicate the abrupt regression of the sea level between 4200-4000 cal. yr BP.Ancient civilization begin to decline at 4200-4000 cal. yr BP in the Yangtze River Basin as well as in the Yellow River Basin, China.Almost all of the large urban centers in the Yangtze River Basin were abandoned at around 4000 cal. yr BP and the giant urban settlements disappeared abruptly at this time. A similar collapse of the Neolithic culture at 4000 cal. yr BP were also reported in the central plain of northern China, and Japan. In Japan, the middle Jomon culture fall at this time.The giant settlements at Tell Leilan in Syria, Mesopotamia were also abandoned during this period.It is highly likely that the abrupt regression of the seal level at 4200-4000 cal. yr BP linled to the major climate deterioration that swep through the Eurasian continent led to the collapse of ancien

FORECASTING CASPIAN SEA LEVEL CHANGE USING DYNAMIC REGRESSION MODELS

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In this research after introducing the transfer function models, the Dynamic Regression Models (DRM) will be presented. Then the identification of the models by prewhitening the input, the estimation of the parameters and the diagnostic checking of adequacy of the models will be discussed. One of the main problems of this kind of models is the presence of outlier's data. To overcome this problem the identification of outlier's data in the transfer function models is investigated.

Finally, using the temperature, rainfall, humidity, and wind velocity of Guilan and Mazandaran states as the repressor variables and the Fluctuation of Caspian sea level as a predictor variable, collected monthly during 1970-2004, the sea level is being predicted for year 2005.

Author Listing

Author Listing

Appendix A

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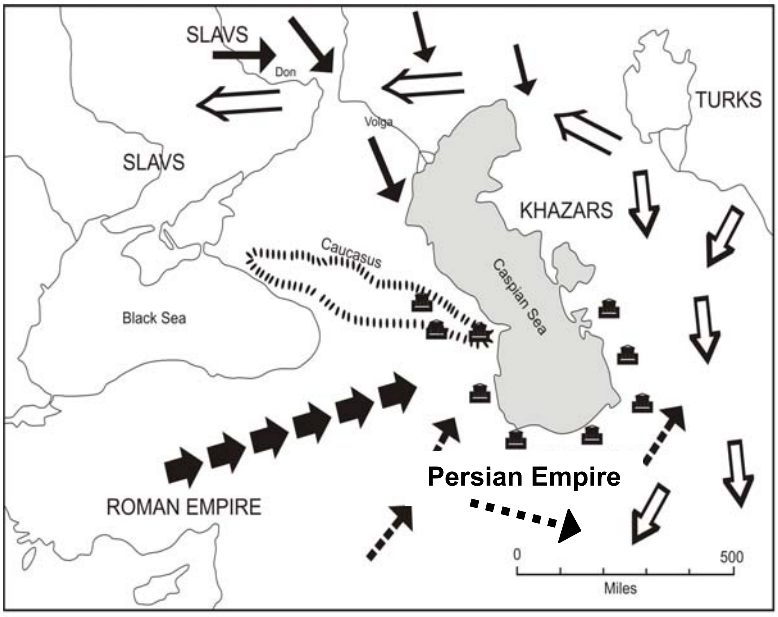
Human Arrival in the Caspian Coast

The Caspian Sea as the world largest land-locked water basin draws the attention of man from the late Pleistocene-early Holocene and the early civilizations have formed along the coast of Southern Caspian.

Important sites in the east part of the southern coast are Krasnovodsk, Ashghabad and Gorgan, as well as Behshahr, Roudbar in the south. In the western part Hashtpar and Baku are the identical points. They are located mainly above the Khavalyn Sea-level with the Paleolithic to Neolithic ages. In the human-occupation sites, plentiful amounts of animal bones can be found which most of them are currently living in the Alborz forest. After the primary civilization where straggly distributed along the Caspian coast, the Aryan tribe (the ancestor of Iranian and Indian) reached to the Southeast Caspian around the Middle Holocene. Latter in 550 BC Iranian group of the people as Persians, Kurds, Balouches and other relatives have established the Persian Empire that stretched to the coast of southern and middle Caspian. Expanding of the Roman Empire in to the Caucasian region and Huns from Altai tribes to the north Caspian, created a new scene and dividing the countries governing lands which remained unchanged for a long period of time. Khazers as another Altai group of people moved to the northern Caspian and developed their Empire to the east Europe in 750 AD. Having change Sympathy of Byzantine from Khazars to Russia as new orthodox caused conquest of Russia to the South and break up of the Kazars Empire. But Russians did not settle in the north Caspian coast in that time. They have opened the route for newly coming people from Altai as Turks and Mongols.

Dissolution of the Persian Empire from the Arabs in 600 AD and presence of Islam in the Caspian region have developed new civilization. The Turk settled between west Caspian and South Black Sea and quickly dominated the Greeks. They established political control and later captured Constantine Pole in 1453 AD and have formed Ottoman Empire. Expansion of Russia to the south through the Russian-Persian wars during 19th century divided the Caspian coast between two countries. The last major geopolitical change occurred in 1991 with dissolution of the Soviet Union, which formed newly sovereign countries. The Caspian Sea coast during the past 10000 years (Holocene) experienced settlement of different people that some of them have had great influence in the region and has their major role now as well (see figure 1). The names of the Caspian Sea and geographical names in its periphery reflect signature of the human history in the region.

More than 40 names introduced for the Caspian Sea, in which most of them derived from the Persian culture such as Qazvin (Caspian?) , Guilan, Mazandaran, Gorgan, Hirkana, Abaskun, , Khorasani, Dailam, Tabarastan, Passin, Kharazmi, Baku, Shirvan and Saraii. Some names referring the geographical features and monuments such as Darband (and Darband Wall), Baku, and Abshuran which indicate the previous Persian governance in the region.



Formation of early civilizations around the Caspian, 12000 years ago

Migration of the Aryans to the land of Iran and forming the Persian Empire, 6000 years ago

Combination of the West and East Roman Empires and extension of the new Empire to Caucasus and Caspian, 2000 years ago

Migration of Hones from the north of Caspian to east Europe, 1700 years ago; Migration of the other Altai's to the Caspian region (e.g.Khazars, 1300 years ago); Ruination of the East Roman Empire in 1453

Expansion of Islam to the Southern, Eastern and Western parts of the Caspian

Expansion of the Russian governance and ruination of the Kazars in 956 BC; Perpetual presence of the Russians started from 400 years ago

Figure 1- History of the main immigrations

The Caspian Catchments Basin

The Caspian Sea catchments basin cover an area of 3.5 km^2, which mainly located in five littoral states namely Iran, Turkmenistan, Kazakhstan, Russia and Azerbaijan, as well as small part in Turkey, Armenia and Georgia. The northern part of the basin located in high latitude forest, middle Volga steppe and Pre-Caspian deserts.

The western and southern parts of the basin situated in high Mountain area of Caucuses and Alborz respectively. The southeastern part covers Copet-Daq Mountains and whole eastern part encompasses of wide area of deserts. Rivers, which flow from northern Caspian coast (Ural, Volga, Terek and Sulak), supply about 90% of riverine water influx to the Sea. The southwestern and southern rivers (Kura and Sefidrud) are main sources of sediments to the Caspian Sea. The eastern coast has very limited water and sediment supply to the sea.

Population that settled in the Caspian catchments basin is estimated to be around 80 million (Table1), most of which living in Russia (73%), Iran (13%) and in Azerbaijan (10%). Widespread human activities in the Caspian region deeply affected its natural environment. The first pollution due to the human activities (oil exploitation) noted in the mid 19th century, before that natural oil seepage was greater than oil exploitation.

Development of industry, agriculture, fishery, marine transportation, oil exploitation and urbanization from the middle 20th century in the Caspian basin have raised the human impacts on the sea, as pollution, introducing invasion species and endangering some other species and reducing fluvial influx.

Table 1-Geographical facts of the Caspian Sea littoral countries

Country	Area of the country (Km^2)	Area located in Caspian watershed (Km^2)	Population (Million)	Population settled in Caspian watershed
Iran	1685000	185000	65	11
Turkmenistan	488100	400000	4.1	0.4
Kazakhstan	2717300	695000	17.1	0.4
Russia	17075400	1800000	148	60
Azerbaijan	86600	86600	7.6	7.6

The Caspian Sea Basin

The Caspian Sea basin with exclusion of Kara Bogaz Gol Bay is limited from north to south between 47^o 57' and 36^o 33' latitudes, and from west to east between 46^o 43' and 54^o 53' longitudes. In spite of connecting the Caspian Sea to the Black Sea and Baltic Sea through channels, which are using for transportation, the Caspian Sea is remained as enclosed basin.

Physiography

The Caspian Sea is a semi-eclipse basin oriented in N-S direction with a length of about 1200 km and width of about 400 km. The sea surface area and water volume (in –28 m) is around 360.000 km^2 and 78.000 km^3 respectively. On the basis of bottom morphology of the Caspian Sea, it can be divided into three sub-basins. The northern Caspian is rather shallow with bottom sloping gently southwards and reaching to the maximum depth of 25 m. The middle Caspian basin consists of a deep basin in center with the maximum depth of 788 m and narrow shelf in west and wide one in east. The Southern Caspian basin with the maximum depth of 1025 m has the main volume of the sea and separated from the middle basin by the Abshron sill in depth of 150 m

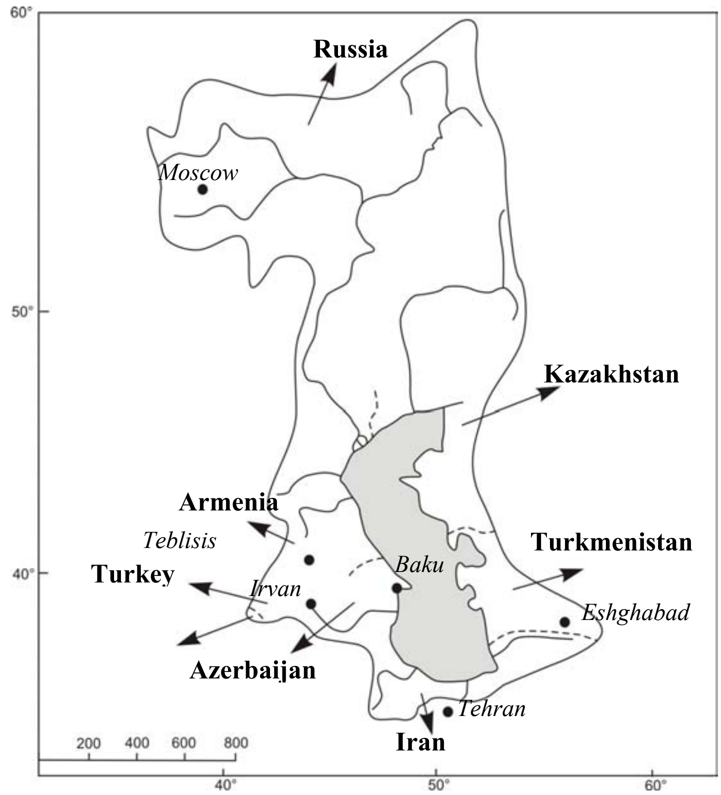


Figure 2- Sketch map of the Caspian Sea and its catchments basin.

The borders between the northern and middle Caspian and the middle and southern Caspian sub-basins are supposed as the lines between Chechen Island and Tobkaragan Cape and Zhiloy and Cooli Capes respectively. Distribution of the depth and incurred area varies relative to the sea level change. The 100 m depth occupies the largest area (62.2%) and most of water volume is found from 100-600 m depths.

Proportion of the north, south and middle parts of the Caspian sub-basins to whole area of the sea are 24.3%, 36.4% and 39.3% respectively and the proportion of the above mentioned parts in respect to water volume to the whole basin volume reach to 0.5%, 33.9% and 65.6%.

There are some islands in the Caspian Sea with approximately 2000 km^2 surface area including islands of northern (1813 km^2), middle (71 km^2) and southern Caspian (165 km^2). The largest island recognized as Chechen Island with the area of 122 km^2 which is located in western part of the north Caspian basin. The sea-level fluctuation changes physiographic parameters of the basin such as depth, surface area, water volume and the length of the shoreline. The last sea level rise increased sea surface area around 30.000 km^2 and water volume around 1000 km^3.

History of the Caspian Sea Evolution

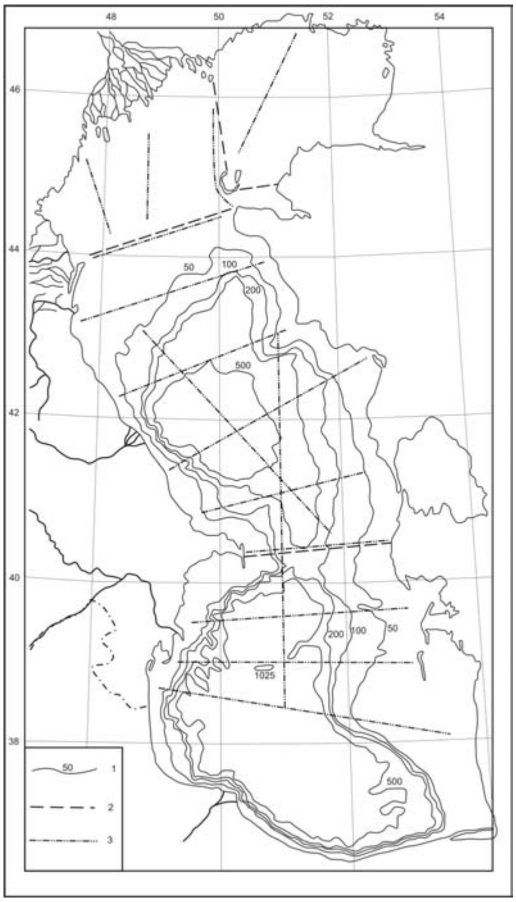
The Caspian Sea history as a land-locked water basin originated to almost 5.5 million years ago. Before that, the Caspian Sea was a part of the Parathetys Ocean which also contains the recently Black Sea, Azof Sea, and Mediterranean Sea. The orogeny in the Cenozoic separated the Caspian and Black sea from each other when the Great Caucasian Mountains uplifted between them as an island.

Continuation of Alpine orogeny in the early Pliocene and up rising of the Caucasian territory cut the connection with the Caspian and Black sea via Manich valley (between north Caucasian Mountains and southern Don River). From this time, the geological, biological and hydrological history of the Caspian Sea has been started as an enclosed basin. There are close relation between the Caspian sub-basins' morphology, geology and the history of their formation and evolution.

Geophysical studies of the Caspian basin indicated that the Earth's crust in the middle and southern parts contains sedimentary, granitic and basaltic layers (figure 4). Thickness of the crust in middle and southern Caspian reaches to 30-40km and 30-35 km respectively. The crust in the southern Caspian shows more oceanic characteristics. Thickness of sediments accumulated over crystalline basement increases in the Caspian Sea from north to south and reaches the maximum thickness of 24 km in southern Caspian Sea basin.

Water chemistry of the Caspian Sea

Study of the Caspian Sea water revealed that the main ion compositions are as follow: Cl^-, SO_4^{2-}, HCO_3^-, Na^+, K^+, Ca^{2+}, and Mg^{2+}. Comparing to the composition of the oceanic water chemistry, the Caspian Sea water composition is mostly controlled by the composition of rock units in its watershed which characterized by the low concentration of Cl^- and abundance of Carbonate, Sulfate and Calcium. The main sources of the elements for the Caspian Sea water are salt bearing ground water seepage (61%), influx from river discharge (31%) and precipitation over the sea(2%). Out taking of the elements from the Caspian Sea water is mainly controlled by carbonate sedimentation and sedimentation of evaporites in Kara Bogaz Gol Bay .



1- Depth contour line
2- Proposed line for the Northern, Middle and Southern part of the Caspian Sea
3- Oceanographical transects for collecting hydrophisical and hydrochemical parameters

Figure 3- Different parts of the Caspian Sea.

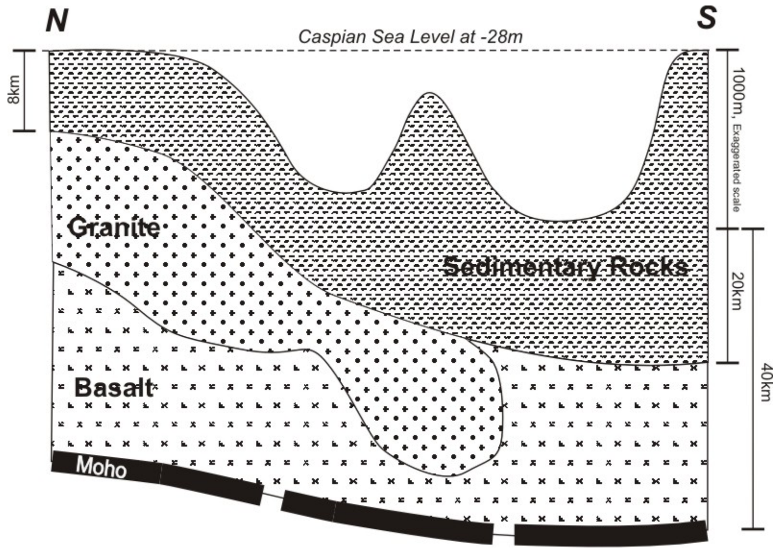


Figure 4- Structure of the Caspian Sea basement (approximate scale).

The Caspian Sea salt balance mainly depends on water out flux to the Kara Bogaz Gol Bay , the balance is positive if the Bay is closed and negative if it is open. The Caspian Sea level change in order of a few meters little influences on the salt balance. Salinity of the north Caspian Sea is very variable (1-6 ppt) and determined mainly by its riverine water supply, conversely in the middle and southern parts variation of the salinity is negligible and is around 12-13 ppt. Long-term sea level change due to Volga influx can cause considerable fluctuation of salinity in the northern Caspian Sea. Fluctuations of salinity in the middle and southern Caspian Sea are very negligible at the governing conditions.

Dissolved oxygen content in Caspian Sea water is affected by water temperature, river input, photosynthesis and sea level fluctuation. Therefore, the oxygen content is different in various seasons and different parts of the sea. In central part of the northern Caspian the distribution of the dissolved oxygen is almost homogenous. Long term measurements showed the increasing of the dissolved oxygen in Volga delta and decreasing in western part of the north Caspian. In middle and southern Caspian, higher values of the dissolved oxygen are seen in shallow coasts and delta areas due to turbulent mixing (except in highly polluted areas like Baku bay and Sumgaeet in Republic of Azerbaijan).

Due to cold water flow from northern Caspian along the western shore and warm water flow along eastern shore the dissolved oxygen content of the western shores is higher than the eastern shores (6-6.5 ppt). In deep waters of the Caspian Sea the dissolved oxygen content is decreased with depth, but even in deep areas of the Caspian Sea the relative oxygen content could be reach to 2-4 ppt due to deep water circulation.

The primary production mainly depends on availability of nutrients and their composition in the sea water which the river inflow is the main source where the groundwater precipitation has a minor role.

In Caspian Sea, from the nutrition distribution point of view, the shallow areas of the western shore, deltas, and human impacted (Baku bay, Makhachkalah shore, Kerasnovedesk bay and Fort Shevchenko) having the highest concentration of nutrients. Vertical distributions of nutrients in the deep waters of the southern and middle Caspian are affected by the deep water circulation.

Nutrients dynamics in Caspian Sea water is affected by various parameters which mainly are: seasonal fluctuations due to photosynthesis, river flux of nutrients in to the sea, production-degrading ratio in different seasons, the intensity of water and sediment exchange, winter convection and glaciations, and vertical water circulation in deep areas of the sea.

Organic materials play important role in water chemistry, energy balance and materials exchange in the basin. Phytoplankton is the main source of organic materials in the Caspian Sea and supplies over 97% of the available organic materials. River flux provides small part of the organics into the Caspian Sea, which 80% of riverine organic flux is supplied by Volga River. Role of macrophites in production organic materials in the Caspian Sea is not so significant.

In the Caspian Sea, degradation processes plays an important role regarding the balance of organic materials. Therefore, phytoplankton production and degrading processes are the main controlling factors of the organic material concentration in the Caspian Sea.

The Caspian Sea, comparing with other water bodies, has higher pH due to high alkaline inputs from river flux and also due to the sea water composition. The temporal and spatial variation in pH is affected by biochemical, physicochemical (Photosynthesis, organic materials degrading, aquatics respiration, carbonate system status, etc) and hydrological (river water composition, water dynamic, water temperature, etc) factors. The concentration of hydrogen ion in various parts of the middle and southern Caspian varies from 8.3 to 8.6 in surface area and 7.7-8 near the bottom layers according to the biochemical, physicochemical, and hydrological conditions. In northern Caspian the highest pH is seen near the Volga River mouth.

Physics of the Caspian Seawater

The Caspian Sea surface currents have different origins which the important ones include river currents, wind-induced currents, gradient and thermohlaine currents. The velocity of river currents are less than 10 cm/s where the velocity of the wind induced currents depend on wind duration and velocity which reach up to 50 cm/s. The thermohlaine currents usually have low velocity in order of a few cm/s.

The surface currents in northern Caspian with southward direction in absence of wind are river type. When wind blows, contribution of river flow is limited to delta area and in other areas wind-induced currents are dominated in the surface layer and compensatory current in opposite direction in bottom layer.

The surface current in middle and southern Caspian are cyclonic and anticyclonic types respectively. In the mean time, the general water flow heads from northwest to the south and from southeast to the north. By considering the influence of shoreline and bottom morphology, pattern of sea surface currents in different regions may vary considerably. Additionally, in coastal area, the current regime mainly depends on the wave direction approaching to the coast and wave breaking.

The Caspian Sea water vertical stratification and circulation determined mainly by vertical profile of water temperature and salinity parallel with hydro-meteorological conditions over the sea. The Sea water temperature has considerable variability regarding the temporal and spatial variation. In summer, the surface Caspian Sea water temperature in northern Caspian reaches to maximum (25° C) and in winter dropped to minimum(almost 0°C). In winter, the sea water frozen and in sever winters the freezing process might be extended in to the western parts of the middle Caspian in the vicinity of Baku. The maximum and minimum registered temperature in northern Caspian is 39.7°C and -1.9°C respectively. Due to the large volume of water in the middle and southern Caspian, the fluctuations in water temperature in middle and southern Caspian are lower. The middle Caspian water temperature is moderate in winter and is 6°C in surface water (at the depth of 40m) and 5°C at the bottom layers (600m). In summer, the water temperature in this area is varying from 24°C in the surface to 5°C in deep areas. In winter, the temperature of southern Caspian in the surface layer (at the depth of 40m) and in deepest layers (600 m) differs from 10 to 6°C. In summer these changes is varied from 27°C (in surface) to 6°C (600 m).

Caspian Sea water salinity differs in various part of the sea and the lowest (1 ppt) and highest (14ppt) salinity is seen in Volga delta and eastern coastal waters respectively. Caspian Sea surface water salinity in eastern part always is higher than northern, western and southern parts. The reason should be sought in high evaporation from Caspian eastern shores and river water influx in other parts. The water salinity in vertical profile from surface to deep layers is varied from 12.8 to 13.2 ppt. Since the water temperature and salinity is vary from surface to deep areas, the water masses with almost similar temperature-salinity and consequently the almost identical density in Caspian Sea could be separated. Accordingly, the four following water masses are separable:

1-Northern Caspian water mass

2-Middle and southern Caspian surface water mass

3-Middle Caspian deep water mass

4-Southern Caspian deep water mass

Northern Caspian enjoys of shallow water and rivers input, so bearing low salinity and high temperature fluctuations. Presence of the long sill between middle and southern Caspian(between Azerbaijan and Turkmenistan) at the depth of 150m, the middle and southern Caspian deep waters could not easily mixed and accordingly have different temperature, salinity and density. These four water masses mix stead-fast and bearing the following process:

At the beginning of warm period of the year, the river water with lower salinity and temperature travels from northwest and west Caspian to the south and in eastern shore will be headed for the north due to mass evaporation and consequently higher salinity. In cold period of the year, in the boundary between northern and middle Caspian, the relatively saline and very cold water with higher density sink down to the median layers of middle Caspian and then moved above the Abshron Sill to the median layer of southern Caspian and thereby the circulation of Caspian Sea is formed.

The wind and consequently wave regime in the Caspian Sea are affected by three main factors including general atmospheric circulations, coastal topography and local atmospheric circulations due to differences between heat transfer of land and sea. The wind in north-northwestern, northeastern and southeastern directions is dominant over the Caspian Sea.

The stormy winds are mostly abundant in middle parts of the Caspian Sea (in the northeast of Azerbaijan Republic and southeast Daghastan of Russia) that experienced 100 days with stormy winds each year. The maximum registered wave height in this area is around 12 m.

The Caspian Sea Level Fluctuation

The Caspian Sea after separation from the Black Sea in the Pliocene (around 5.5 million years ago), has shown different cycle of the sea level change in amplitude of 300 m. Average Caspian Sea level is never constant throughout the time and space. Different processes can cause a change on the Caspian Sea-level, that encompasses a broad range of time scales from a few second (as waves) to a few thousands year as geological process concern. Small time scale of the sea level change usually is reversible. Changing in atmospheric pressure, wind, wave and position of the Sun and the Moon all contribute to changing the Caspian Sea level. Seasonal fluctuation of the sea level occurs in response to the changing of river flux and sea water temperature. Long-term sea level fluctuation depends on the sea water balance (difference between river influx to the sea and evaporation over the sea surface). Geological processes as subsidence, uplifting, spreading, and sedimentation can cause a change on the Caspian Sea water volume over the long periods of time. Geological processes over the Caspian catchments basin can affect the water balance with changing watershed and river course to another basin. The factors that cause changing the Caspian Sea level can be grouped as follows;

The factors that move surface water and then change sea- level. Changing in atmospheric pressure, wind, wave, current and sun-moon position can change the Caspian Sea level in the period up to few days and magnitude of 4 m.

Steric change causes the variation in the Caspian Sea water volume without a change in water mass (variation in temperature and salinity). Variation in salinity of the main part of the Caspian Sea water (middle and southern Caspian) is very small and steric change largely depends on seasonal change of water temperature (and then expansion and contraction of water) that account on the sea level in order of 4 cm a year.

Main factors that change the Caspian basin volume are the tectonic activity and sedimentation. Horizontal marine traces with Holocene age located around the Caspian Sea reveals that the influence of tectonic activity is important in the greater time-scale. Vertical changes of tide gauge on the Caspian coast are very low and show subsidence and uplifting. Therefore tectonic activity in the Caspian basin with different geological history in its sub-basins can result increasing of the volume in one sub-basin and decreasing in another. Sedimentation over the Caspian bottom can raise the sea-level in the order of 0.1 mm/y.

Factors that change water balance. Main input elements of the Caspian Sea water balance are river influx, precipitation over the sea surface and ground water seepage. Out flux of water depends on evaporation over the sea surface and in Kara Bogaz Gol Bay . Long-term fluctuation of the Caspian Sea level largely controlled by the changes in precipitation over the catchments basin and evaporation from the sea surface which depends on circulation pattern over the Eurasia. Intense human activity in the catchments basin of Volga River from the mid 20 century decreased the sea level in the range of 1 m.

Many studies attempt to predict the Caspian Sea level on the basis of stochastic models of water balance, paleodata of sea level change, cyclicity of sea level change, and correlation between sea level change and the factors that can attribute on the elements of water balance, as atmospheric circulation, Atlantic surface water temperature, and solar activity. None of the studies predicted sea level rise of 1979 and fall in 1995. The problem is, the mechanism of controlling factors on the elements of water balance is not clearly understood.

Table 3- Main elements of the Caspian Sea water balance

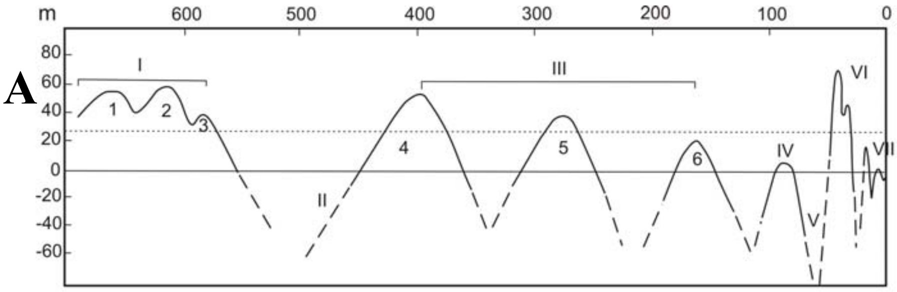
Period	**River influx km^3/y**		**Evaporation from sea surface km^3/y**	**Ground water discharge km^3/y**	**Outflow to Karabogaz bay km^3/y**	**Caspian mean sea level m**
	All Rivers	Volga Rivers				
1900-1929	332.4	250.6	389.4	5.5	21.8	-26.1
1930-1941	268.6	200.5	394.8	5.5	12.4	-27.9
1942-1969	285.4	241.2	356.4	4.0	10.6	-28.5
1970-1977	240.5	207.6	374.9	4.0	7.1	-29.1
1978-1992	308.6	263.4	348	4.5	2.4	-27.1

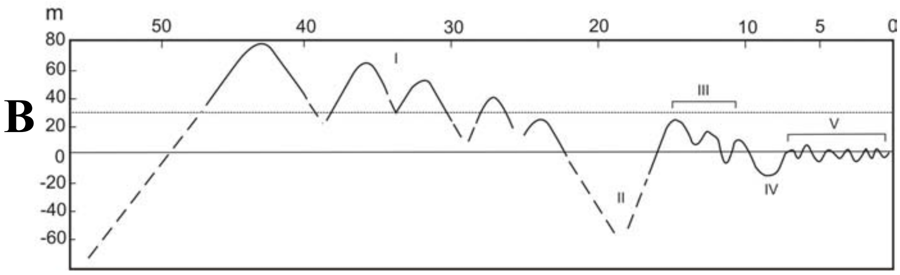
The Caspian Sea Coasts

General Characteristics

The total length of the Caspian coasts is around 4400 km, which 700km located in Russia, 600km in Azerbaijan, 815km in Iran, 650km in Turkmenistan and 1600km in Kazakhstan. Major morphological characteristics of the extensive Caspian coasts depend on geological setting of the sea and adjacent areas. The Caspian Sea level change, river fluxes and waves and wave-induced current have been developed new morphological features on the preceding geological history. The coast of north Caspian Sea with gentle slop located on the south Russian platform. Great river deltas (Ural, Volga, Terek and Sulak, see figure 7), Sand dunes and old marine terraces and river valleys are the major morphological features of the north Caspian coast. West Coast of the middle Caspian Sea characterized by moderate to steep slope profile, which consists of sandy-gravely beach to rocky shore. Small river mouths and deltas and barrier-lagoon complexes are developed on the West Coast of middle Caspian
Sea. East Coast of the middle Caspian Sea located on the Kayasan Plateau which Mangyshlak and Kinderly peninsulas, Kara Bogaz Gol Bay and old marine terraces are the prominent morphological structures. The West Coast of the South Caspian Sea comprises in particular the Kur and Lenkoran depression, which correspond to subsidence from the Pliocene.

Figure 5- Caspian Sea level fluctuation chart, based on the instrumental measurements.





(A)Peliestocene
I- Baku progression-retrogression cycle, 1=Early Baku,; 2= Upper Baku; 3= Oronjick
II- Venice retrogression
III- Early Caspian progression-retrogression cycle, 4= Paleosingil; 5= Singil; 6= Kasoozh
IV- Late Caspian progression cycle
V- Atel retrogression cycle
VI- Khvalian progression-retrogression cycle
VII- Neo-Caspi progression-retrogression cycle
(B)late Pleistocene-Holocene
I- Early Khvalian progression-retrogression cycle
II-Middle Khvalian retrogression
VI- Late Khvalian progression-retrogression cycle
IV- Mangyshlak retrogression
VI- Neo-Caspi progression-retrogression cycle

Figure 6- Caspian sea-level fluctuation through the geological time scale.

The coast consists of several cape-bay forms in the north which mainly originated from folding structures and mud volcanoes. Kura delta in central and small river mouths and deltas in south part, and coastal barriers, cliffs and terraces are the major morphological features on the coast. Morphology of east coast of the south Caspian Sea closely associated with the behavior of the sea level change and southward longshore currents which developed a set of bars and barrier-lagoons.

South coast of the South Caspian Sea is a narrow strip that developed between Alborz Mountain and south Caspian sub-basin. The Coast mainly composed of sandy- gravely beach, river deltas of Sefidrud in west and Gorganrud in east, and barrier- lagoon complexes in accumulative areas.

Iranian Coast of the Caspian Sea

The coastline of the Caspian Sea in Iran extends over 800 kilometers including two barrier lagoons of Anzali in the west and Gorgan in the east. The Southern Caspian coastline located in three provinces: Guilan in west, Mazandaran in central and Golestan in eastern part.

The Iranian coast of the Caspian Sea encompasses coastal landforms and geomorphology as developed in the Quaternary. Many factors interplay to create the changing face of the coast that we see today. Geology, sea-level change, fluvial and marine sediment supply, wind, wave, and increasingly human activities for the past few decades are the main factors which formed the recent coastal features of the Iranian coast.

The outline of geological factors along the Iranian coast has a fundamental control on the general shape, orientation and slope of the coastal area. The Alborz mountain range with four major faults in north part bordering to the south Caspian sub-basin have determined the concave morphology of the coast. Lenkoran depression in west and Gorgan depression in east attribute to the moderate to gently slope of the coast in related areas, while nearness of the main south Caspian deep basin to the central part account for high gradient of the coast. A further influence of geology on the coast is in the provision of sediment from the catchments basin into the shoreline. Sediments are brought to the coast by 65 rivers, which flow from the north part of Alborz, except two of them, Sefidrud in west and Gorganrud in east coast began their course from Zagros and Copet-Daq mountains respectively. They annually supply around 40 million tons of sediments to the shoreline. Main portion of coarse sediments are bring to the coast by rivers, especially in central coast, where gradients are steep and coarse-grained material is readily transported by floods. The sediments that supplied to the coast are distributed by waves and wave induced currents along the shore. The waves reaching to the Iranian coast are mainly from north, northwest and northeast directions. The wave regime generally causes prevailed southward longshore current on the west and east coasts and eastward current on the south coast.

The southward longshore currents account for another source of sediments to the Iranian coast. Longshore currents have a great effect on the coastal landforms. Lagoons and bays are formed behind the barrier beaches, which developed in central Guilan, east Mazandaran and Golestan coasts. These areas also have sandy spits, which in case of Miankaleh in east coast; grow up to 60 kilometers in length (see appendix). High energies of waves and wave induced currents in comparison to the sediment supply are responsible for drift of the sediments out of the coast. They cause considerable erosion in high gradient coast of west Mazandaran which composed of coarse-grained sediments. The low gradient east shoreline does not allow the high waves to reach to the coast, and the coast mainly consists of fine-grained sediments as a consequence. Therefore the coastal marine and fluvial environments contribute on the geological background that determined the sediment distribution and morphology of the Iranian coast. The sandy beaches are dominant in Guilan and east Mazandarant coasts and gravely beaches are mostly found in west Mazandaran while the muddy coast found in Golestan. Sandy beaches, gravely beaches and muddy coasts occupy approximately 60%, 20%, and 20% of the coastline respectively.

In accumulative coasts of central Guilan and east Mazandaran onshore wind regime has developed sand dunes as high as 4-5 m with 100-500m width.

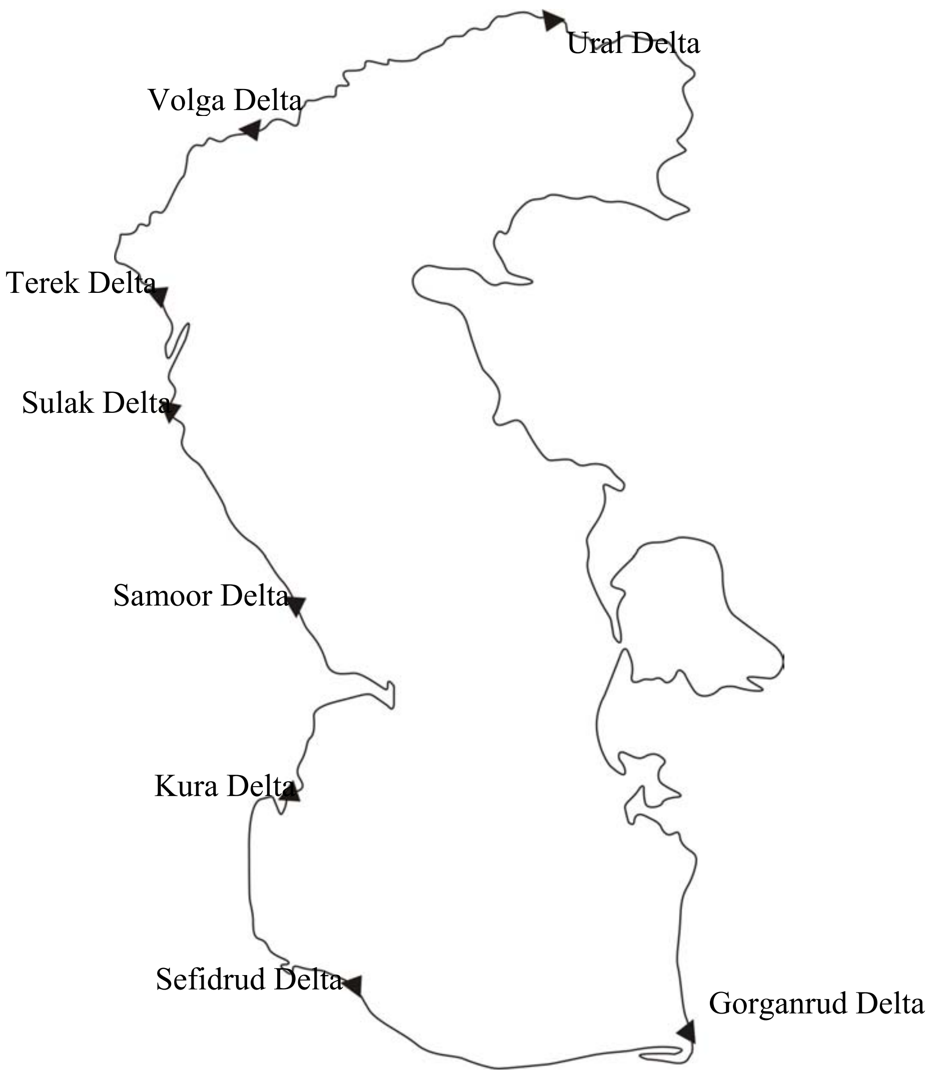


Figure 7- Caspian Sea deltas.

For the million of years the Caspian Sea and its coastal area were affected by the different natural environmental changes and were adapted with the new conditions. Estuaries, lagoons and wetlands are moved back and forth as the sea level raised or felt down and most of the coastal areas were protected by sand dunes against erosion and inundation. But the coastal systems of the Caspian Sea were highly disturbed by the human activity and the natural patterns of the coast and its adjacent features such as estuaries and wetlands were changed.

Construction of dam on the Sefidrud River including other development activities and changing the natural pattern of the river and its estuary brought many limitations and stresses into its natural system. At the time being the Sefidrud estuary is not able to adapt itself with sea level rise.

Saltwater intrusion will severely change the natural chemical condition of estuary. This will also affect the living resources of the estuary.

Pollution caused by the vast residential activities near the coast is one of the most important events, which happened due to sea level rise. By considering the natural environment of the Caspian Sea, as a closed marine body, the intruded pollutants due to sea level rise will remain in the environment for the long period of time and there is no way for the environmental adaptation in this case.

By removing sand dunes from the coast, the natural barrier against sea level rise and its subsequent inundation is disappeared and large areas of the coastal lands are subjected to inundation without any possibility for adaptation. In this case the coastal lands may adapt to the new condition, but should remember that its biophysical condition and ecosystem will change severely.

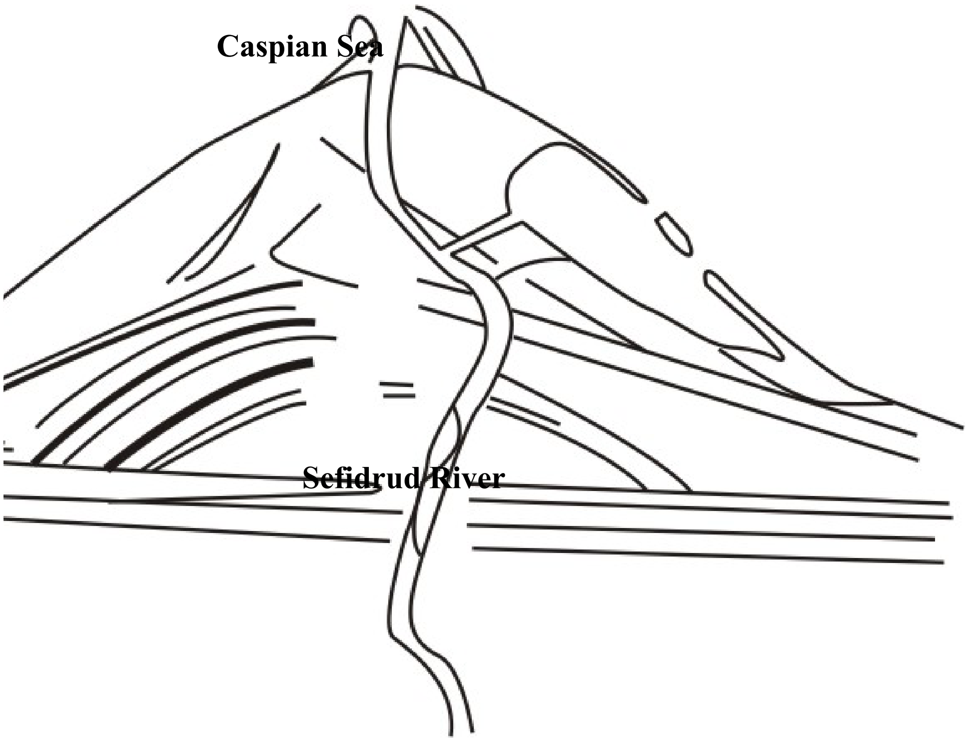


Figure 8- Morphology of the Sefidrud Delta based on the Cosmos satellite image, 1992.

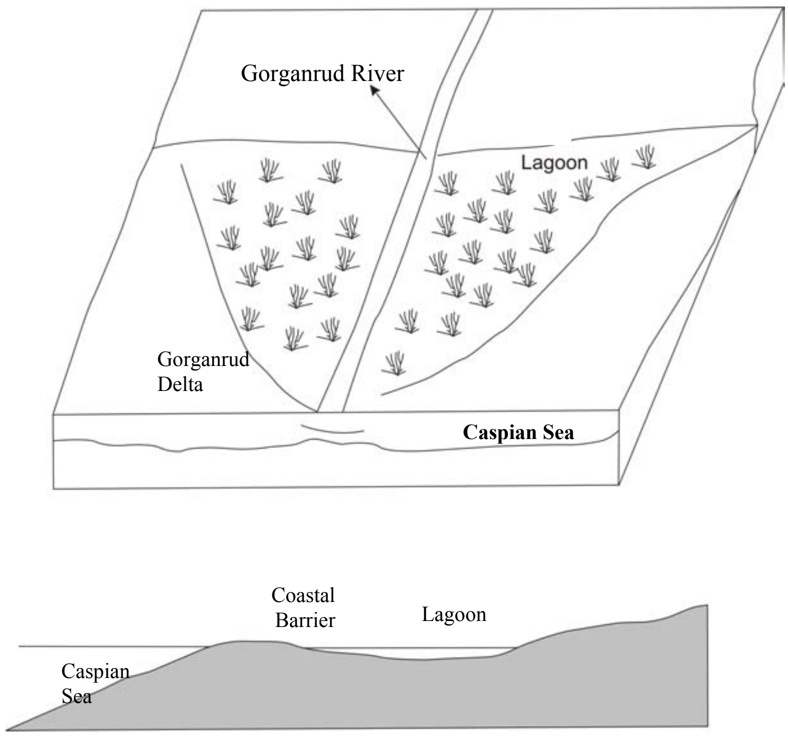


Figure 9- Gorganrud Delta

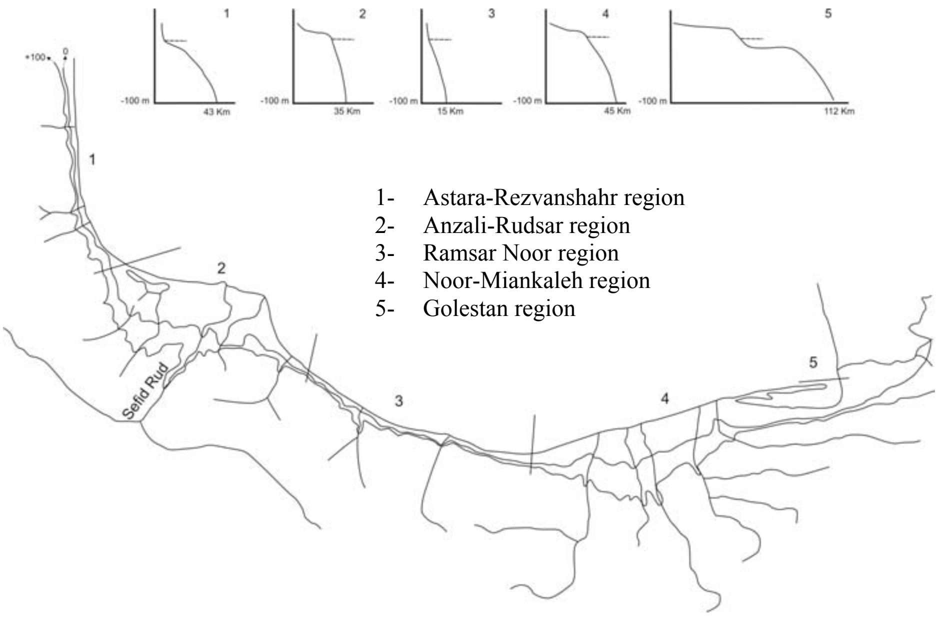
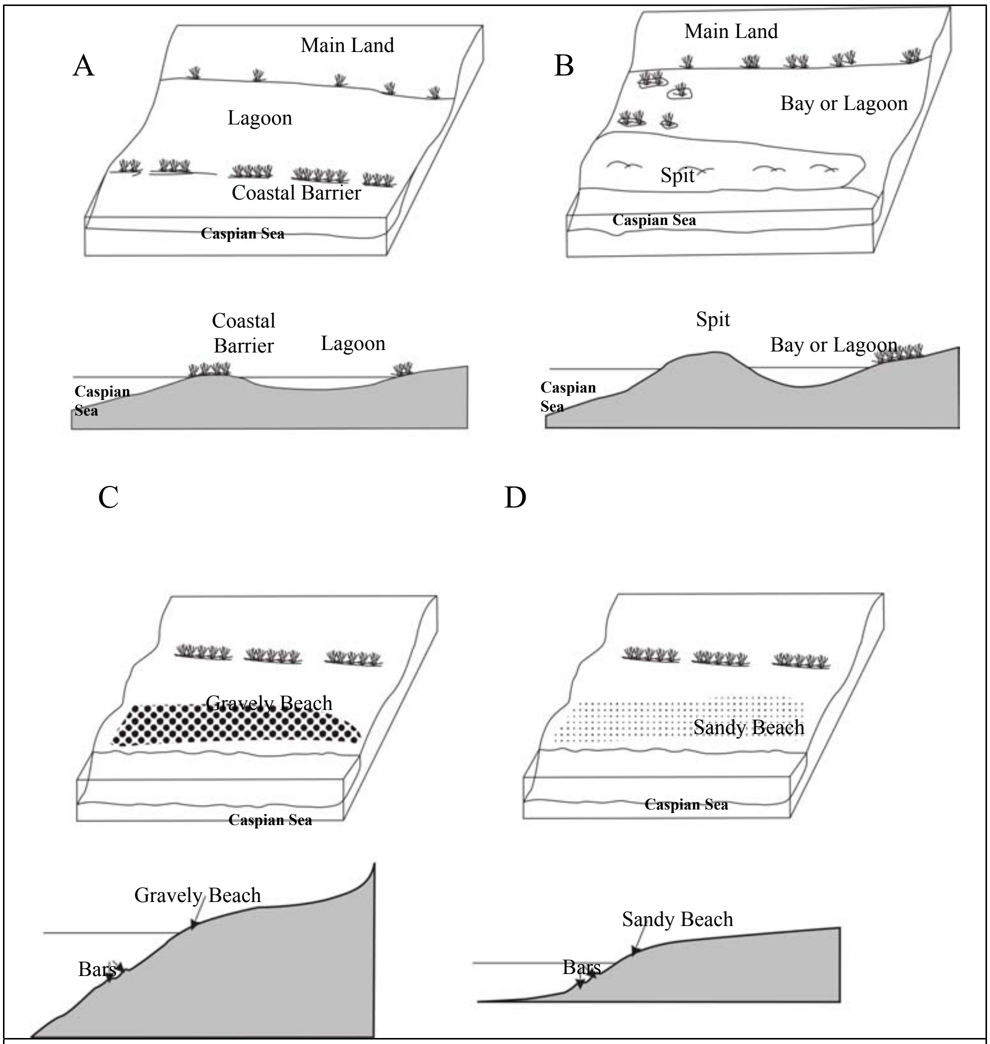


Figure 10- Classification of the Iranian coasts of the Caspian Sea and related continental shelf transects.



A- Central Gilan and East of Mazandaran
B- Gorgan coastal region and Anzali lagoon
C- West of Mazandaran
D- West of Gilan

Figure 11- Typology and relative transects of the Iranian coasts of the Caspian Sea.

Table2-South Caspian Coastal Characteristics

Specifications / Region	Gradient		Sediment	Dominant wave approach & coastal currents	Main rivers	Main geomorphologic features	Dominant coastal processes
	From shoreline to depth 10 m	Above shoreline to –20 m					
Astara- Rezvansher (West Guilan)	0.002	0.03	Siliciclastic sands	Northeast, north waves and southward long shore current	Astara, Karganrud, Lavandavil, Lisar, Dinachal	Sandy beach, small river mouths and small lagoons in vicinity of the mouths	Accumulative-erosional
Anzali- Rudsar (East Guilan)	0.007	0.005	Siliciclastic sands	North, north west waves, eastward long shore current	Sefidrud, Polrud, Langrud and Small rivers flowing to Anzaly lagoon	Spit- lagoon of Anzaly and Amirkula Great Delta of Sefidrud, Small river mouths, Sandy beach and Sand dunes, coastal lagoon due to sea level rise	Accumulative
Ramsar- Noor (West Mazandaran)	0.01	0.06	Siliciclastic coarse-grained sediments	North waves, offshore currents	Chalus, Chakrud, Safarud	Gravely beach	Erosional
Noor- Miankaleh (East Mazandaran)	0.008	0.002	Siliciclastic sands	North, north east waves, and eastward long shore current	Haraz, Talar, Babolrud, Tajan, Larim, Neka	Sandy beach, sand dunes, small river mouths, coastal lagoons due to sea level rise	Accumulative-erosional
Behshahr- Gomishan (Golestan)	0.0008	0.0008	Fine- grained sediments, Carbonate prevailing northward	North east waves, southward long shore current	Gorganrud	Muddy coast, barrier lagoon of Gorgan and Gomishan, Gorganrud delta	Accumulative

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Appendix B

Excursion Program

May 5- Anzali Region

- Excursion Briefing (30 minute)

- Travel from Rasht to Anzali and boat trip in Anzali Lagoon

- Lunch in Fishery Restaurant

- Travel from Anzali to Sangachin outcrop and coastal sand dunes and beach berms in north of Anzali.

- Travel to south Anzali Lagoon to see Old spit and Old lagoon behind it (partially in filled).

- Return to Rasht for night.

May 6- Sefidrud Region

- New Sefidrud Delta, Marine traces and lagoons in Kiashar and Zibakenar

- Marine teraces in northeast Lahijan coast, Old Sfidrud delta and semi-enclosed lagoon(Dastak, Amirabad and Amircola region)

- Lunch in Lahijan

- Travel to the east coast and to sea gravely steep slope Beach of Ramsar and Chalus

- Going to Nour for Night

May 7- East Mazandaran Coast

- Holocene Outcrop in Larim Valley, then to see sandy beach, small lagoon and sand dunes

- Behshahr Caves (Kamrband, Huto, Gohartappeh) and to sea cultural layers of the Mesolithic to Neolithic Ages.

- Lunch in Behshahr

- Holocene outcrop in Neka Valley

- Miankaleh Spit, a long wide sandy spit on the end of the southern coast

- Return to Nour

May 8- Gorgan Region

- Travel to the south coast of the Gorgan Bay, gently sloping Muddy coast

- Boat trip to the Gorgan Bay

- Gorganrud Delta

- Gomishan Muddy coast and Gomishan lagoon in east coast

- To see some Mudvalcanoes in east coast?

- Lunch in Gorgan

- Return to Nour

- *May 9*

- Return to Tehran