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Abstract:

Iran, located between the Arabian plate in the south and Eurasia in the north, suffers a stress of 20 mm/y which such stress, in addition to plastic deformations,especially in the Zagros region, caused many earthquakes along the Zagros highlands in the south-southwest,Alborz in the north, as well as Kopet-Dag and Caucasus mountains in the east and west of the Caspian. Many researchers have studied young tectonic activities in Alborz in past years (e.g. Ambrasys and Allen 2004 & 2003; Berberian, 1983; melville 1982; Tchalencko, 1974). These studies provide the first structural model of historical evolution, young geodynamics and geometry in the mechanism of fundamental faults in this mountain range.Alborz mountain range is a complex structural belt affected by various tectonic events from Precambrian to Quaternary with structural zones of the Southern Caspian in the north and central Iran in the south (Nazari, 2006; Alavi 1996; and Berberian, 1981). Alborz Young deformations indicate the appearance of transpressional deformations with a left-lateral shear in the direction and parallel to the pull-push structures of Alborz or east-west direction.

ISBN: 978-622-5858-42-8

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Young Deformations and Geodynamics of North Central Alborz, Caspian Faults and North Alborz

UCCGHA 004

2023

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سرشناسه	:	نظری، حمید، ۱۳۴۶- Nazari, Hamid, 1968-
عنوان و نام پدیدآور	:	Young deformations and geodynamics of north central Alborz, Caspian faults and north Alborz [Book]/ authors Hamid Nazari, Morteza Talebian and Manouchehr Ghorashi; employer Research Institute for Earth Sciences; advisor Geological Survey of Iran & Gilan Crisis Management Organization; supervisor Hamid Nazari; with cooperation UNESCO Chair on Coastal Geo-Hazard Analysis; summarized and translated into English Manouchehr Ghorashi.
مشخصات نشر	:	تهران: نشرخزه، ۱۴۰۲= ۲۰۲۳م.
مشخصات ظاهری	:	۳۶ص.: مصور؛ ۱۴ × ۲۱ سم.
شابک	:	978-622-5858-42-8
وضعیت فهرست نویسی	:	فیپا
یادداشت	:	زبان: انگلیسی.
یادداشت	:	عنوان به فارسی: دگرشکلی جوان و ژئودینامیک لبه شمالی البرز مرکزی، گسله‌های خزر و شمال البرز.
آوانویسی عنوان	:	یانگ دیفرمیشن...
موضوع	:	گسله‌ها -- ایران -- کوه البرز
موضوع	:	Faults (Geology) -- Iran -- Alborz Mountains
موضوع	:	ژئودینامیک -- ایران
موضوع	:	Geodynamics -- Iran
موضوع	:	زمین‌شناسی
موضوع	:	Geology
شناسه افزوده	:	طالبیان، مرتضی، ۱۳۴۴
شناسه افزوده	:	Talebian, Morteza,1965-
شناسه افزوده	:	قرشی، منوچهر، ۱۳۲۰-
شناسه افزوده	:	Ghorashi, Manouchehr- 1941
شناسه افزوده	:	یونسکو. کرسی مخاطرات زمین شناختی ساحلی
شناسه افزوده	:	UNESCO Chair on Coastal Geo-Hazard Analysis
شناسه افزوده	:	سازمان زمین‌شناسی و اکتشافات معدنی کشور- استانداری گیلان. اداره کل مدیریت بحران
شناسه افزوده	:	Geological Survey of Iran- Gilan Crisis Management Organization
رده بندی کنگره	:	QE۶۰۶/۵/ن۶ی۲ ۱۴۰۲
رده بندی دیویی	:	۵۵۱/۸۷۲۰۹۵۵۸۲۶۲
شماره کتابشناسی ملی	:	۹۳۶۷۸۹۷

Young Deformations and Geodynamics of North Central Alborz, Caspian Faults and North Alborz

Author: Hamid Nazari

نشر خزه

اطلاعات گزارش

عنوان: دگرشکلی جوان و ژئودینامیک لبه شمالی البرز مرکزی، گسله های خزر و شمال البرز

مجری: پژوهشکده علوم زمین

مشاور: سازمان زمین شناسی و اکتشافات معدنی کشور و سازمان مدیریت بحران گیلان

زبان مرجع: فارسی

خروجی: گزارش، نقشه، مقاله، داده های الکترونیکی

ناظر علمی: حمید نظری

نویسندگان: حمید نظری، مرتضی طالبیان و منوچهر قرشی

رئیس کرسی یونسکو در مخاطرات زمین شناختی ساحلی: حمید نظری

مسئول شورای اجرایی: راضیه لک

خلاصه‌نویسی و ترجمه به انگلیسی: منوچهر قرشی

خلاصه شده از: طرح مخاطرات زمین شناسی دریایی حوضه جنوب کاسپین

ناشر: نشر خزه

با همکاری کرسی یونسکو در مخاطرات زمین شناختی ساحلی

چاپ اول: ۱۴۰۲

شمارگان: ۵۰ نسخه

صفحات: ۳۶

شابک: ۹۷۸-۶۲۲-۵۸۵۸-۴۲-۸

khazepub@gmail.com

Report Information

Title: Young Deformations and Geodynamics of North Central Alborz, Caspian Faults and North Alborz

Employer: Research Institute for Earth Sciences

Advisor: Geological Survey of Iran & Gilan Crisis Management Organization

Original language: Persian

Output: Report, Map, Paper, Digital Meta Data

Supervisor: Hamid Nazari

Authors: Hamid Nazari, Morteza Talebian and Manouchehr Ghorashi

Chairholder in the UNESCO Chair on Coastal Geo-Hazard Analysis: Hamid Nazari

Head of the Executive Council: Razyeh Lak

Summarized and translated into English: Manouchehr Ghorashi

Summarized after: Geohazard South Caspian Carpet (GSCC)

Publisher: Khazeh Publication

with cooperation UNESCO Chair on Coastal Geo-Hazard Analysis

First Edition: 2023

Edition number: 50

Page: 36

Shabak: 8-42-5858-622-978

khazepub@gmail.com

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Iran, located between the Arabian plate in the south and Eurasia in the north, suffers a stress of 20 mm/y which such stress, in addition to plastic deformations, especially in the Zagros region, caused many earthquakes along the Zagros highlands in the south-southwest, Alborz in the north, as well as Kopet-Dag and Caucasus mountains in the east and west of the Caspian.

Many researchers have studied young tectonic activities in Alborz in past years (e.g. Ambrasys and Allen 2004 & 2003; Berberian, 1983; Melville 1982; Tchalencko, 1974). These studies provide the first structural model of historical evolution, young geodynamics and geometry in the mechanism of major faults in this mountain range. Alborz mountain range is a complex structural belt affected by various tectonic events from Precambrian to Quaternary with structural zones of the Southern Caspian in the north and central Iran in the south (Nazari, 2006; Alavi 1996; and Berberian, 1981).

Alborz Young deformations indicate the appearance of transpressional deformations with a left-lateral shear in the direction and parallel to the pull-push structures of Alborz or east-west direction, (Nazari, 2006; Allen et al., 2003 and Jackson et al., 2002).

Introduction

Various interpretations of the structure of Alborz have been presented. Alavi (1996), based on his research in the eastern part of Alborz in the Binalood Mountains (south of Kopet-Dag), considered Alborz to be a complex structure of the Antiformal stack type. Before him, Stocklin (1974) and after him Allen et al. (2003), Guest et al. (2006), Nazari (2006) and Shahidi (2008) considered the structure of Alborz, at least in the central part, to be a rose structure.

The Southern Caspian, which is bounded in the south by the Alborz structural zone, in the west by the Talesh heights, and in the east by the Kopet-Dag structural zone, is limited at its southern and western edges by a compressive fault system, and in the southeast by a left-lateral strike-slip fault. The northern boundary of the Southern Caspian crust is marked in the east by the Kopet-Dag faults (Ashgabat), in the middle of the sea by the Apsheron, and in the west by the Caucasus fault on the border of the Greater Caucasus and Eurasia (Jackson et al., 2002). Based on this structural pattern, heights around the Caspian Basin such as Alborz and Talesh have been pushed over this thick oceanic crust on a compressive fault system, and the southern Caspian crust has been pushed under the Talesh and Apsheron in the west and northwest (Nazari, 2015) (Figure 1).

Geographical Setting

The study area with the coordinates of 53° 24′ 7" East and 36 ° 40′ 42" North is located five kilometers west of Behshahr and two kilometers northwest of Rostam Kola in Mazandaran province. Rostam Kola is a small town in the central part of Behshahr city and is located 10 km from Neka to Behshahr road. Rostam Kola, located on the Sari-Behshahr highway, is 40 km from Sari and about 8 km from Behshahr. Gohar-tappeh is ecologically located between a narrow fertile strip between the Caspian Sea in the north and the slopes of the Alborz Mountains in the south. This area is a short distance from the beach and Alborz heights are less than one kilometer south of it (Nazari, 2015).

Research Aim

In order to study, in detail, the activity of the Caspian Fault and in fact its progressive branches to the north and to determine the number of events, magnitude and return period of earthquakes caused by the activity of these fault branches, archeoseismological studies were carried out near Behshahr (Gohar-tappeh site) in Mazandaran province, which will be described in the following. Finding out the time, place and magnitude of earthquakes in the direct results of archeoseismological research is of great importance for seismologists and archaeologists. From a seismological point of view, these characteristics are necessary to estimate the seismic risk and determine the return period of earthquakes.

Archeoseismology also helps to complete the list of historical earthquakes by providing new historical data. It is clear that increasing awareness of seismic history leads to reducing uncertainties in seismic hazard estimation, which is very important. Archeologically, finding reasons such as the cessation of living in an area, the sudden migration of tribes and nations from a land, and finding an explanation for the evidence in the ancient ruins, are all among the cases that are answered in archeoseismological research. Gohar-tappeh, due to its vast historical background and its location within the activity range of the active Caspian Fault, has revealed the need for archeoseismological studies (Nazari, 2015).

Methods

In this regard, the results of paleoseismology and to further study the structures in the region, geophysical data such as geoelectric and GPR profiles were used. In addition to data obtained from GIS, satellite images, aerial photographs and digital models are provided (Nazari, 2015) (Figure 2).

Discussion

Gohar-tappeh is one of the prehistoric settlements of Iran, which was formed during the Copper and Stone Age. The location of this area between the ancient valleys and caves of Gomishan, Hotu and Kamarband has doubled its importance. Archeological studies indicate that the area is 7,000 years old and reveal the

Bronze Age (third millennium) to the Iron Age I (mid-second millennium BC). Also, based on the study in the stratigraphic boreholes in Gohar-tappeh, this region dates back to the Copper and Stone (Chalcolithic), Bronze and Iron Ages, which specifies many works including pottery, architecture, decorative and war tools. Based on preliminary studies and movable and immovable cultural data obtained from the layers excavated in Gohar-tappeh, it be can said that the settlement began from the late Neolithic period? (Probably Chalcolithic) in this large ancient site and continued into the Bronze and Iron Ages. Also, in the eastern part of Gohar-tappeh, very few artifacts from the Parthian period have been identified. According to archeologists, humans who lived in the ancient caves of Mazandaran, such as Gomishan Cave, Hotu Cave and Kamarband Cave, after leaving the cave, gradually caused the emergence of Gohar-tappeh. This is a man-made hill; That is, over time, the inhabitants have come to higher places with the disappearance of previous places. Due to water sources, forests, sea, caves, sources of stone artifacts and favorable conditions of the region along with oth er existing potentials, Gohar-tappeh gradually took the path of development and, in the Bronze Age, became a large city with an area of 50 hectares. Therefore, in the Neolithic era, the village's way of life was settled and in the Bronze Age, it was considered and urbanized. Probably, until the Middle Bronze Age, the residential space and burial place were in one place. But in the Late Bronze Age, both the size of the city was reduced and the cemetery was moved out of the residential area. Between the Bronze and Iron Ages, this area became uninhabited for about 200 years, and in the Iron Age, the cemetery was moved out of the residential area and a sloping site was chosen to prevent water intrusion (Nazari, 2015).

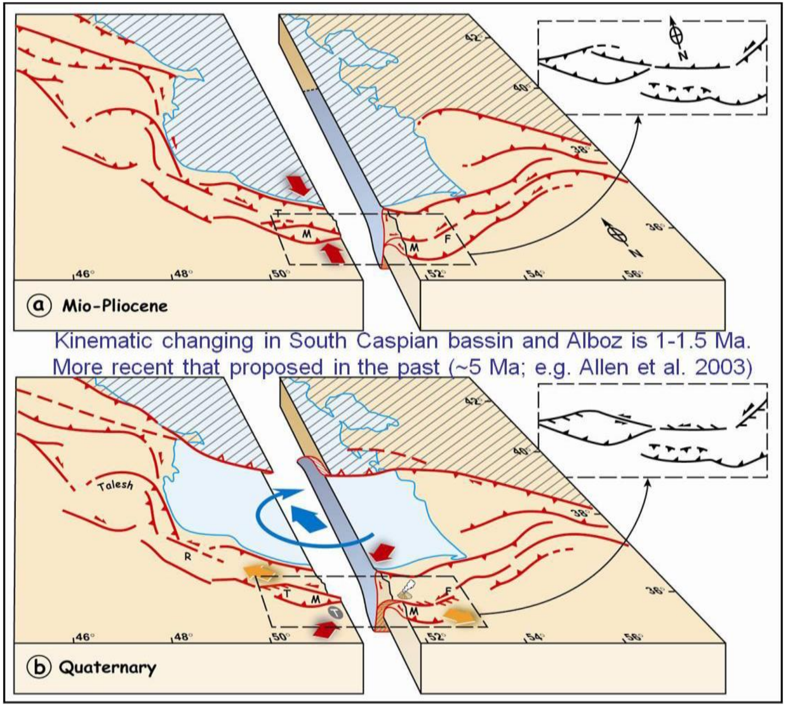

Figure 1: (a) The geodynamic pattern of the Southern Caspian Basin and the structural relationship with the Alborz area during the Miocene indicate the presence of left-lateral shear-compression systems in the eastern part of the central Alborz and right shear-compression fault systems in the western part of the central Alborz (Nazari, 2006; Ritz et al., 2006). (b) The young geodynamic pattern of the Southern Caspian and Alborz, which is based on the idea of the clockwise rotation of the Southern Caspian crust and the formation of a left shear system in the interior of the central Alborz.

The stepped shape of this hill is the first thing that attracts the attention of every viewer. According to experts, each floor is a sign of a period of time. The lower we go, the older the place gets. In archeoseismological studies, the effects of fault vibration including fracture of the building, sloping wall, rotation of building elements, lateral curvature, breaking and falling of walls, vertical rotation of objects (tombstones, columns, monuments) and crushing of corners of blocks in the result of the concentration are among the archaeoseismic evidence (Galadini et al., 2006), as examples of these effects have been observed in the trench wall at the prehistoric site of Gohar-tappeh. The effects of the earthquake observed at the prehistoric site of Gohar-tappeh are the collapse and tilting of the units. Gohar-tappeh is a man-made hill, as the units observed at the Gohar-tappeh site are cultural layers made by the ancient people of Gohar-tappeh; As a result, all of these units are expected to be horizontal. However, in part of the study area, the strata are diagonally as debris, while the upper and lower units are horizontal. This could be a sign of an ancient earthquake that occurred in this area, which caused the horizontal units to tilt. In part of the wall of this museum, the effects of faulting and displacement of cultural layers have been observed, which indicate the occurrence of earthquakes in this site (Nazari, 2015).

Gohar-tappeh is located about 20 km south of the Caspian Sea and less than one kilometer from the Alborz Mountains. The hill starts in the south with a scarp and less than two hundred meters away there is a water well on a scarp. Due to the tectonic structure observed in the region, it is expected that a branch of the Caspian Fault has advanced towards the coast and under the hill. With the formation of this fault branch, a back-thrust with a slope to the north has been created in the southern part of the hill.

Geoelectric profiles indicate structures such as thrust with a slope to the south in the northern part of the hill and another thrust fault with a slope to the north with two conjugate faults in the southern part. Thus, it is possible to imagine a branch of the Caspian Fault that has advanced under the hill. In the hanging wall, this thrust has been eroded due to extension and has caused the appearance of the hill to be double-arched, and the existence of faults, sometimes sloping to the north and sometimes sloping to the south, will not be far from expectation. And there is a back-thrust in the southern part of the hill. Under these conditions, the faults observed in the third geoelectric profile can be considered as pop-up structure; Because between two active thrust faults (Caspian Fault) and active back-thrust, the existence of pop-up structure is more common. In GPR data, due to its sensitivity to saline water, the penetration depth is reduced, but the displacements shown in these images are exactly the same as the escarpments and displacements visible in the area (Nazari, 2015).

The site selected for paleoseismological research is a trench excavated by the Cultural Heritage Organization at the prehistoric site of Gohar-tappeh. Gohar-tappeh is located in the northwest of the historical city of Behshahr (Mazandaran) and near the two ancient caves of Hotu and Kamarband. The length of this trench is about 50 meters and has been dug in a north-south direction in the form of a step, so the depth of the trench varies along its length. The trench is roofed at 36° 407 ´ 47.5" North and 53° 24 ´ 04.6" East (Nazari, 2015).

In this project, two paleoseismic logs have been prepared from the western wall of the trench with a scale of 1:20. The first log, 12 meters long, was prepared from the southern part of the trench. Following the paleoseismic survey, another three meters of the northernmost part of the western wall of the trench along the previously prepared log were examined, and the paleoseismic log was prepared along with its reconstruction (Nazari, 2015).

By comparing the two paleoseismic logs prepared from the wall according to the same units, the number of seismic events specified in the second log (log B) can be considered the same as the seismic events identified in the first log (log A). Considering the evidence of seismic events in Log B and similar units of both logs, it can be inferred that the first event in Log B coincided with the first event in Log A and that one seismic event was the cause. The second event in Log B is distinct from the events specified in Log A and occurred between two events I and II in Log A. As a result of a single seismic event, seismic evidence is observed in each log (Nazari, 2015).

Thus, during paleoseismological surveys along the western wall of the trench, five distinct seismic events have been identified. Finally, the total displacement values and magnitude of paleoearthquakes have been estimated using the magnitude relation of Wells & Coppersmith (1994).

The magnitude of each event is estimated using the maximum actual displacement and the assumption of causal faulting in the vertical mechanism (normal or reverse). Hence, the magnitude of the five Paleoearthquakes identified on a branch of the Caspian Fault in the trench of the Gohar-tappeh site has been estimated about 5.6-0.7 on the MW scale in the period of 7000 to 1800 years ago (according to the data of the Cultural Heritage and Tourism Organization of Mazandaran province). According to the period determined based on archeological studies, the detected events in the study area occurred between 7000-1800 years ago. Thus, the return period of earthquakes can be calculated by assuming a homogeneous distribution of events. The mean return period is obtained by dividing the number obtained by the difference between the age of the first and last event and the interval of the events.

As a result, according to calculations, the return period on average seismic events is about 1300 years. Carbon 14 age determination tests are performed to determine the exact age of events from different stratigraphic units and at the upper and lower boundary of each seismic event. By presenting the results, a more accurate return period of the earthquakes can be predicted (Nazari, 2015).

Figure 2: Geophysical section of GPR from the scarp observed in the Kaldeh region, red arrows indicate anomaly resulting from the faulting with increasing cumulative vertical displacement at depth. The image shows the field survey method performed in GPR geophysical studies (Nazari et al, 2013).

Results

The Caspian Basin with the maximum depth of 960 meters across both south and west corners is limited to the Caspian and Astara active fault systems.

The Caspian Fault as the largest active fault system in the northern slope of Alborz, which is considered as a progressive fault compression structure and has its roots to the north in the northern Alborz fault plane, is one of the most important linear sources of earthquakes in the southern coastal part of the Caspian Sea.

This fault system according to the geographical setting, geometry and mechanism is considered as a linear source of earthquakes such as: Gorgan-Gonbad Kavous 874 AD (Ms = 6.0, Io = VII), 1498 AD and 1809 AD, Gorgan 1944 AD (Mb = 5.2, Io-VII) and Gorgan 952 AD (Mb = 4.7), Sangchal 1967AD (Ms = 6.8), Farsinach 1970 AD (Mb = 5.0), Babol Kenar 1971 AD (M = 5.2), Aliabad Katoul 1999 AD (Mb = 5.3), Gorgan 2004 AD (Mw = 5.6), Firoozabad Kojoor 2004 AD (Mw = 6.2) and Gorgan 2005 AD (Mw = 5.3)(Ambrasys and Mckenzie, 1972; Berberian and Yeats, 1999 & 2001; Tatar et al.; Melville, 1982).

The scattered earth tremors such as earthquakes recorded in the north of Anzali (05 Feb. 2012) are also evidence of the activity of progressive branches of the youngest fault system in the sea floor (Nazari, 2015).

In the west coast of Southern Caspian, although there is no direct indication of the occurrence of devastating earthquakes during the last century attributed to the activity of one of the progressive branches of the

Astara fault system on the land or in the sea, but many instrumental earthquakes are recorded in the extent of the influence of this fault system. The historical earthquakes of 1709 and 1713, which destroyed the Rasht area in the 18th century, can be considered as the result of the activity of the southern branches of this fault system. Geographical proximity and direction of both Caspian mobile faults with progressive active branches isolated from each of them, which caused deformation, folding and sometimes cutting of very young sea floor deposits, along with seismic background and movement rate of <2.5 mm/y for the Caspian fault and 1.5mm/y> for the Astara fault, indicate that the recurrence of an earthquake with a magnitude of medium to large (6 <M) resulting from the re-movement of one of the active fault systems in the Southern Caspian coast or its water body is not impossible (Nazari, 2015).

South or west of the Caspian Sea as a linear source of seismicity on land and close to the water body or one of the progressive fault branches in the sea floor will cause the production and propagation of large seismic waves in the crust and then in the water column of this deep lake. Propagation of seismic waves due to the failure of rock layers at the depth of the crust and rupture and surface faulting in the land area and near such a deep basin has the ability to produce long and large waves of the Seiche type or in case of movement and rupture with displacement on one of the branches of the sea floor fault in the water body can cause the formation of Tsunami. The generation and Propagation of each of the sea waves resulting from earthquake events on the land or in the water body arising from the re-movement of the Caspian fault system or the Astara fault system due to the geometry of the basin, low relative width and accumulation of high population on the south and west coasts of the Caspian will cause high and destructive waves to hit these low shores. And due to the extent and slope of the shore compared to the geometry of the floor and the depth of the water, the possible seismic moment can form waves with a height more than 6 m in most parts and can easily crush more than 30% of the Iranian Caspian coast (Nazari, 2015) (Figure 3).

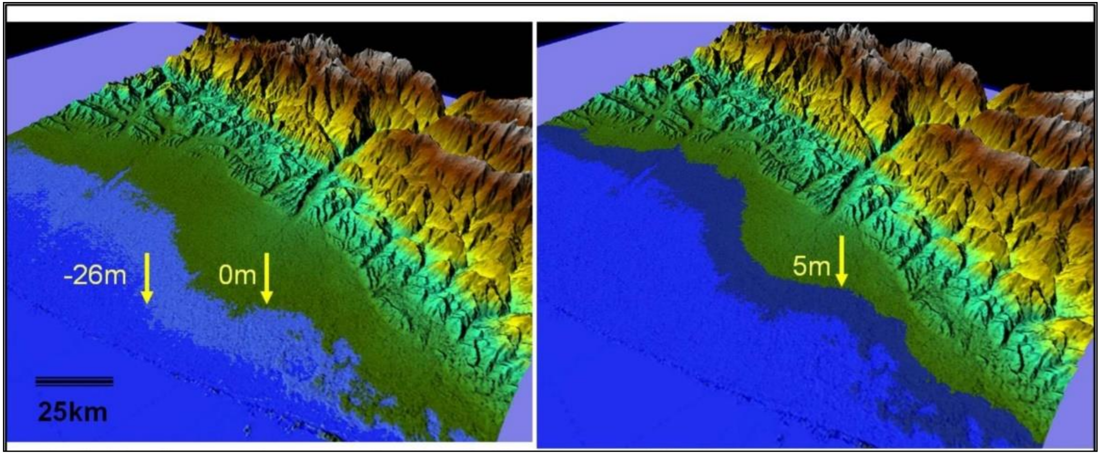

Figure 3: The waves influence zone with a height up to 5 m in the coastal zone of the Southern Caspian, yellow arrows indicate the influence line of the waves in the present-day conditions (level of 26 m) and in case of waves with a height up to 3 m (topographic level of zero meters) in figure a and waves with a height of 5 meters (level of 5 meters) in figure b and the damage zone cover is about 30% of the coastal zone of the Southern Caspian (Nazari et al, 2013).

Also, according to the paleoseismological studies carried out in Gohar-tappeh, Behshahr, the activity of the progressive branches of the Caspian fault can be summarized in terms of seismicity as follows: considering the morphotectonics and geophysical observations made at the prehistoric site of Gohar-tappeh, it is possible to schematically depict the modified pattern of the position of the major Caspian fault to the south and its progressive system to the north of the site. In this study, it is suggested that a branch has advanced from the east-west Caspian fault to the north and beneath the study area. At the southern edge of the hill, a back-thrust has been active. In the hanging wall of the thrust fault, due to the function of maximum extension, the erosion has a significant effect. Also, in the northern part of the hill, the tension from the impact of the thrust fault activity has caused the erosion of the northern part of the hill and the activity of farmers and their advance towards the hill has intensified the destruction of the hill. Then, paleoseismological studies were carried out on the western wall of the trench of the Gohar-tappeh site. Despite the absence of large-scale historical and instrumental earthquakes in the Caspian fault zone, the results of paleoseismological studies of the Gohar-tappeh trench show evidence of the occurrence of ancient earthquakes on the Caspian fault in the period of 1800-7000 years ago. Based on the time-stratigraphic correlation of the units and the identification of evidence of Caspian fault movement in the trench of the Gohar-tappeh site, at least five paleoearthquake events over the last 7,000 years with a magnitude of about 5/6/7 on the moment magnitude scale (Mw) have been identified. Archaeologists estimate the age of the trench floor at about 7,000 years, the upper level of the trench at about 1,800 years, and the middle part of the trench at about 3,600 years, based on stratigraphic dating. Also, in the middle part of the trench, works of several hundred years have been observed in creating units and as a result, there is no life in this part. However, in the lower parts, evidence of a high-magnitude earthquake has been observed. In this case, it is argued that the occurrence of two prehistoric earthquakes in this region has caused the disappearance or migration of people before the history of Gohar-tappeh, which is consistent with archeological studies in the region (Nazari, 2015).

References:

Aleskrov, E.; Narimanov, E.; Husseynov, B.; Jafarov, S.; Akhmedov.; O., 2004. Results of the Paleovolga deltaic sediments study within Gunashily Field. AAPG Dedberg conference Sandstone in lacustrine environments: Implications for exploration and reservoir development, Baku, Azarbaijan. AAPG Bulletin 88, no.13.

Allen, M. B., J. Jackson, et al. 2004. "Late Cenozoic reorganization of the Arabia-Eurasia collision and the comparison of short-term and long-term deformation rates." TECTONICS 23: 1-16.

Berberian, M. 1983. "The southern Caspian. Acompressional depression floored by atrapped, Modified oceanic crust." Canadians Journal of Earth sciences Vol.20, No.2: 163-183

Brunet, M. F., Korotaev, M.V., Ershov, A.V., Nikishin, A.M., 2003. The South Caspian Basin: A review of its evolution from subsidence modelling: Sedimentary Geology, v. 156, p. 119–148, doi: 10.1016/S0037-0738(02)00285-3.

Davidson, J., Hassanzadeh, J., Berzins, R., Stockli, D.F., Bashukooh, B., Turrin, B., and Pandamouz, A., 2004. The geology of Damavand volcano, Alborz Mountains, northern Iran: Geological Society of America Bulletin, v. 116, p. 16–29.

Devlin, W., Cogswell, J., Gaskins, G., Isaksen, G., Pitcher, D., Puls, D., Stanley, K., Wall, G., 1999. South Caspian Basin: young, cool, and full of promise. GSA Today 9 (7), 1 –9.

Djamour, Y., Vernant, Ph., Bayer, R., Nankali, H., Ritz, J.-F., Hinderer, J., Hatam, Y., Luck, B., Le Moigne, N., Sedighi, M., Khorrami, F., 2010. GPS and gravity constraints on continental deformation in the Alborz mountain range, Iran., Geophysical Journal International. doi: 10.1111/j.1365-246X.2010.04811.x.

Hydrometrology and Hydrochemistry of Seas, 1994. Hydrometeoizdat, v. 6 the Caspian Sea, no. 1, p. 360.

Jackson, J.; Priestley, K.; Allen, M.; Berberian, M., 2002. Active tectonics of the South Caspian Basin. Geophysic Journal International, v. 148, 214-245.

Jones, R. W.; Simmons, M. D., 1996. A review of the stratigraphy of eastern Paratethys (Oligocene-Holocene). Bull. Nat. His. Mus. (Geol. Suppl.) v. 52, 25-49.

Kazmin, V, G., and Verzhbitskii, E, V. 2011. Age and Origin of the South Caspian Basin: published in Okeanologiya, 2011, Vol. 51, No. 1, pp. 136–145.

Kroonenberg, S. B.; Boels, F. J.; Hoogendoorn, R. M.; Overeem, I; Aliyeva, E.; Huseynov, D.; Badykova, E. M.; Svitoch, A. A.; Hinds, H.; Simmons, M. D.; 2004. Modern Caspian deltas as analogus for the productive series, Azarbaijan. AApg Hedberg conference Sandstone deposition in lacustrine environments: Implications for exploration and reservoir development, Baku, Azarbaijan. AAPG Bulletin 88, no. 13.

Lebedev, L., 1991. Oil and gas potential of the Caspian Sea. Petroleum Information Corporation, 66 p.

Mangino, S., & Priestley, K. 1998. The crustal structure of the southern Caspian region. Geophysical Journal International, 133, 630–648.

Masson, F., Anvari, M., Djamour, Y., Walpersdorf, A., Tavakoli, F., Daignieres, M., Nankali, H. & Van Gorp, S., 2007. Large-scale velocity field and strain tensor in Iran inferred from GPS measurements: new insight for the present-day deformation pattern within NE Iran, Geophys. J. Int., 170, 436–440.

Morton, A. M.; Allen, M.; Simmons, F.; Spathopoulos, J; Still, D.; Hinds, H.; Ismalzadeh, A; Kroonenberg, S.; 2003. Provenance patterns in a neotectonic basin: Pliocene and Quaternary sediment supply to the South Caspian. Basin Research, v. 15, 321-337.

Nazari, H., Ritz, J. F., Burg, J. P., Shokri, M., Haghipour, N., Mohammadi Vizheh, M., Avagyan, A., Fazeli Nashli, H. & Ensani, M. 2021. Active tectonics along the Khazar fault (Alborz, Iran). Journal of Asian Earth Sciences.

Nazari, H., Talebian, M., Ghorashi, M., 2015. Young Deformations and Geodynamics of North Central Alborz, Caspian Faults and North Alborz. Project No: 112- T- P- 99, Geohazard south Caspian Carpet (GSCC), Research Institute for Earth Sciences, page 68 (in Persian).

Neprochnov, Y.P.,1968. Structure of earth s crust of epi-continental seas:Caspian, Black and iMediterranean:Canadian Journal of Earth Scences,v.5.p.1037-1043.

Okada, Y., 1985, Surface deformation due to shear and tensile faults in a half-space, Bull. seism. Soc. Am., 75, 1135–1154.

Okada, Y., 1992, Internal deformation due to shear and tensile faults in a half-space, Bull. seism. Soc. Am., 82, 1018–1040.

Priestley, K., Baker, C., Jackson, J., 1994. Implications of earthquake focal mechanism data for the active tectonics of the South Caspian Basin and surrounding regions. Geophysical Journal International 118, 111 – 141.

Reynolds, A. D.; Simmons, M. D., Bowman, B. J.; Henton, J.; Brayshaw, A. C.; Alizadeh, A. A.; Guliyev, I. S., Suleymanova, S. F.; Ataeva, E. Z.; Mamedova, D. N.; Koshkarly, R. O.; 1998, Implications of outcrop geology for reservoirs in the Neogene productive series: Apsheron peninsula, Azarbaijan. AAPG Bull., v. 82, 25-47.

Ritz, J, F., Nazari, H., Ghassemi, A., Salamati, R., Shafei, S., Vernant, P.,2006. Active transtension inside central Alborz: A new insight into northern Iran–southern Caspian geodynamics: Geological Society of America June 2006; v. 34; no. 6; p. 477–480; doi: 10.1130/G22319.1.

Solovev, V. F.; Kulakova, L. S.; Lebedev, L. I.; Maev, E. G.; 1962. major feature of geologicalstructure in the middle, and Southern Caspy, South Geology.Complex Exped. Work, no. 7, 446-498.

Talebian, M., Ghorashi, M., Nazari, H., 2013. Seismotectonic map of the Central Alborz, Scale 1:750000, Geological Survey of Iran, http://ries.ac.ir/eqhazard/wp/Resualts. htm

Vernant, P., Nilforoushan, F., Hatzfeld, D., Abbassi, M.R., Vigny, C., Masson, F., Nankali, HMartinod, J., Ashtiani, A., Bayer, R., Tavakoli, F., Chery, J., 2004. Present-day crustal deformation and plate kinematics in the Middle East onstrained by GPS measurements in Iran and northern Oman. Geophysical J. International 157, 381–398.

Walpersdorf, A. et al., 2006. Difference in the GPS deformation pattern of north and central zagros (Iran), Geophys. J. Int., 167, 1077–1088.