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Geohistory Analysis of the Tabas Block (Abdoughi-Parvadeh Basins) as Seen from the Late Triassic through Early Cretaceous Subsidence Curves

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Abstract

The study area is situated in the Middle part of the Tabas Block. It contains outcrops of rocks that formed along longitudinal faults in Early Cimmerian orogenic phase. The basin subsided along these faults from the Late Triassic to Early Cretaceous, which include two sedimentary cycles. A sedimentary cycle, related to Upper Triassic to Bajocian is known as Shemshak group. Another sedimentary cycle, related to Bathonian to Upper Jurassic, is known as MAGU group. The Cretaceous rock units include red coarse-grained sandstone, at the base changing upward into red gypsifferous marl, rudist limestone and conglomerate, which deposited in a shallow marine environment. Subsidence analysis is applied to geologically disconnected objects in a manner that departs from its traditional use in basin analysis. However, as it introduces quantified data on the behavior of the crust in response to tectonics, it was shown to be an efficient tool in sorting out the major events amongst various local evidences for crustal instability. Based on the subsidence curves plotted for tectonic domain of the Tabas Block , the major obtained results include: - subsidence curves shown a relatively high subsidence rate in the Upper Triassic to the Middle Cretaceous, that coupled with rifting environment in this time; - this rifting was rapidly ceased in the Late Cretaceous to form Aulacogen(Failed Rift) and caused to generate oceanic crust and overriding of Sabzevar-Nain-Baft Ophiolites in this time; - subsidence rate in this part of Tabas Block was increasing towards the west and the north.

Keywords: Tabas block; Geohistory analysis; Subsidence curves; Abdoughi-parvadeh basins

Introduction

Structurally, the Abdoughi-Parvadeh Basins are located in the Middle part of the Tabas Block (Fig. 1). The Tabas Block is bounded to the east by Nayband right-lateral strike slip fault and to the west by the Kalmard-Kuhbanan right-lateral strike slip fault, Alavi [1]. The general trend of folds and faults in the east of the study area is E-W (095-100), while to the west is N-S, (Fig. 2). The E-W folds (Fault related Folds) developed as a result of movement on the E-W faults, which are branches of the great Nayband Fault.

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Structural elements of the study area formed in a simple shear system, which was strongly oblique-convergent, Naimi Ghassabiyan [2]. The geohistory analysis presented in this paper is based on data collected from wells and observations along the outcrop in this area. Our study was designed to integrate tectonic, stratigraphic and petrographic information generated from this part of the Tabas Block. In this paper, we discuss the construction and interpretations of geohistory of the Tabas Block. Summarize the depositional, total subsidence rate and tectonic subsidence rate from Late Triassic through Early Cretaceous and impression with coal-bearing unit to the geohistory of this basin.

1. Stratigraphy

The Upper Triassic to Cretaceous stratigraphy of the Abdoughii-parvadeh basins are represented by two major groups of rocks (megasequences I, II) that are defined based on their tectono-sedimentary features. Each group consists of a number of litostatigraphic units. In this section, we present a brief and general description of these units from the oldest to the youngest.

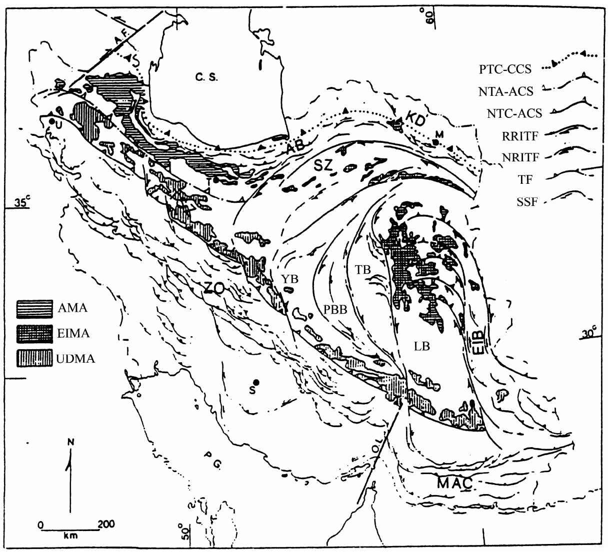

Figure 1. Generalized tectonic map of Iran [1]. Abbreviations: AB-Alborz belt; A.F.- Aras fault; AMA. Alborz magmatic assemblage; C.S. -Caspian sea; EIB-East Iran belt; EIMA-East Iran magmatic assemblage; KD-Kopeh Dagh; L.B-Lut block; M- Mashhad; MAC-Makran accretionary complex; NTA-ACS- Neo-Tethyan arc-arccollisional suture; NTC-ACS- Neo-Tethyancontinent-arc collisional suture; NRITF-Nonrotational -related, intracontinental transfer fault; O.L- Oman line; PBB-Posht-Badam block; P.G.-Persian Gulf: PTC.CCS-Paleo-Tethyan continent collisional suture; RRITF-Rotational-related intracontinental transfer fault; S-Shiraz; SZ-Sabzevar zone; SSF-Strike slip fault; T-Tehran; TB-Tabas block; TF-Thrust fault; TSZ-Tabriz-Saveh zone; U- Urumieh; UDMA-Urumieh-Dokhtar magmatic assemblage; YB- Yazd block; ZO- Zagros orogen.

1.1. Upper Triassic to Middle Jurassic (Bajocian) Foreland Deposits

The first group (megasequence I) comprises the Upper Triassic to Middle Jurassic which essentially composed of shale and sandstone with some indication coal. This megasequence was deposited in continental lagoonal basin is known as "Shemshak megasequence ". The lowest unit (Nayband Formation) of this group is the carbonate to clastic rocks, consists of sandstone, shale, siltstone and sandy limestone with coal. This unit is overlain with an unconformity contact by Shemshak Formation (Late Triassic to Early Jurassic), which comprises alternating thick and thin-bedded, poorly sorted, gray quartz arenite and immature, ammonite bearing greywacke inter-bedded with fissile shale, siltstone with coal. This unit is overlain by oolitic

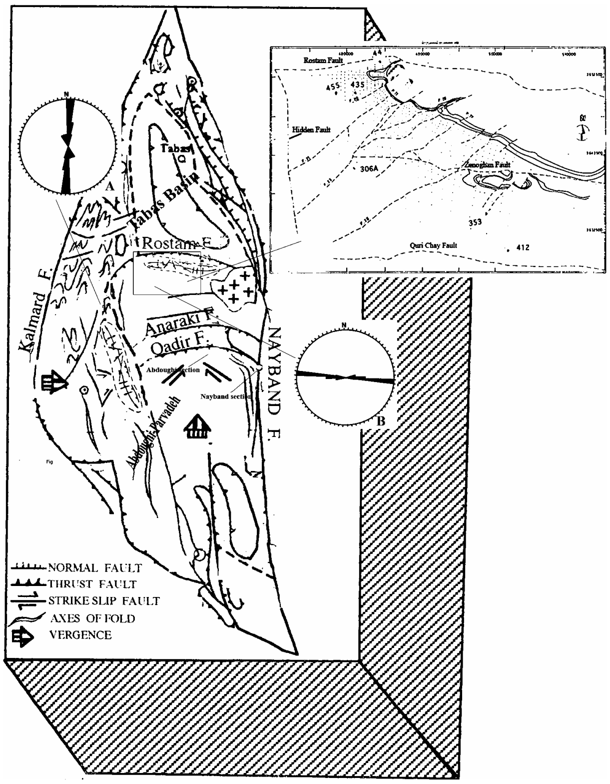

Figure 2. Location of Stratigraphic sections and Wells in study area.Rose diagram of fold Axes in West (A) and East (B) of study Area [2].

limestone (Badamu Formation) with sharp contact. This formation passes upward with a gradational contact of clastic rocks such as coarse-grain sandstone to conglomerate and alternation of sandstone and shale (Hojedk Formation).Sedimentary characteristics of this megasequence (Shemshak megasequence), strongly suggest that these rocks have formed in a foreland basin in front of the tectonic active, blocks uplifted during The Early through Middle Cimmerian Orogenic phases, Naimi Ghassabiyan [2].

1.2. Middle Jurassic (Bathonian) to Cretaceous Epicontinental Shelf Succession

The second group (megasequence II), unconformably overlying the first group (megasequence I), includes succession of shallow-water and marine carbonates such as the parvadeh, Bagamshah, Pectenid Limestone, Nar, Magu Gypsum and Garu stratigraphic units, that is known as "Magu megasequence". The lowest tectono-stratigraphic unit of this group, consists of Middle Bathonian limestone (the Parvadeh Fm.), which an unconformity contact is overlain by Hojedk Formation, which comprises sandstone, siltstone with coaly argillite upward is overlain by gray green shale and marl, inter-calations of Limestone, siltstone and sandstone, (Bagh-amshah Fm.). These rocks are overlain by argillaceous limestone, intercalations of marl and abundant pecte-nides (Pectenid Limestone Fm.). The upper part of the succession such as thick bedded to massive limestone, green marl and gypsum in middle part (Nar Fm.). The youngest sedimentary of Jurassic in Abdoughi Basin, consists of very thin-bedded limestone and gypsum (Magu Gypsum). This megasequence has the characteristics of a continental shelf and epicontinental which have formed in a shallow marine environment that progressively overlaying previous foreland basin.

1.3. Cretaceous Shallow Marine Succession

The Cretaceous rock units include red coarse-grained sandstone, pebbly sandstone at the base changing into arenaceous limestone, red gypsifferous marl, rudist limestone and conglomerate towards top. This sequence was deposited in a shallow marine environment.

1.4. Cenozoic Sediments

The Cenozoic sediments on The Tabas Block consists of marl, gypsifferous marl with Upper Miocene in age the Posht-e-Badam area is predominantly thick-bedded Neogene sediments, while in the Abdoughi area it predominantly consists of Quaternary sediments.

2. Geohistory Analysis

The goal of geohistory analysis is to produce a graphical representation of the vertical movement of a stratigraphic horizon in a sedimentary basin as an indicator of subsidence and uplift history in the basin since the horizon was deposited, Haq *et al.* [3]. Several types of stratigraphic data are needed to do a geohistory of subsidence analysis. These data include a stratigraphic column showing the present-day thickness of the stratigraphic units, type of lithologies, ages of horizons, and estimated paleowater depths. Other types of data that are useful, although not necessary, are porosity information for the units and thermal information, if your goal is to determine thermal history of the basin. In addition, there are several assumption and uncertainties that are built into this analysis. Most of these problems can be overcome if thick stratigraphic sections of relatively shallow-water deposits are used and only long-term, large-scale changes are studied.

2.1. Construction of Geohistory Diagrams Method

Establishing a subsidence curve initially requires that the concerned stratigraphic section is well measured, and well calibrated to the biostratigraphic scale. The biostratigraphic ages must be converted into numerical ages; we use the updated version of International union of Geological sciences (2004) for this conversion. Secondly it requires an estimate of the bathymetry of the various sedimentary facies and a restitution of their thickness prior to compaction, which depends on both the type of sediment and the covering by the younger sediments. The total subsidence is corrected for eustatic sea-level fluctuations; we used for this purpose (Fig. 3) the post - Paleozoic first order sea-level curve from Haq *et al.* [3]. At last, since we are interested in the tectonic part of the subsidence, the loading effect of the sediments is subtracted. We used computation procedures of Van Hinte [4], Sclater *et al.* [5], and Angevine *et al.* [6] involving the following sediment compaction equations to calculate decompacted sediment thicknesses (Table 1).

$$\phi_n = \phi_o \exp(-cz) \qquad \text{(1) from Haq } et\ al. \text{ [3]}$$

where ϕ_n = porosity of the unit, ϕ_o = original porosity, c = constant for each lithology, and z = present depth.

$$T_o = \frac{(1-\phi_n)T_n}{1-\phi_o} \qquad \text{(2) from Haq } et\ al. \text{ [3]}$$

where T_o= original thickness, ϕ_n = porosity of the unit, ϕ_o = original porosity and T_n= present-day thickness.

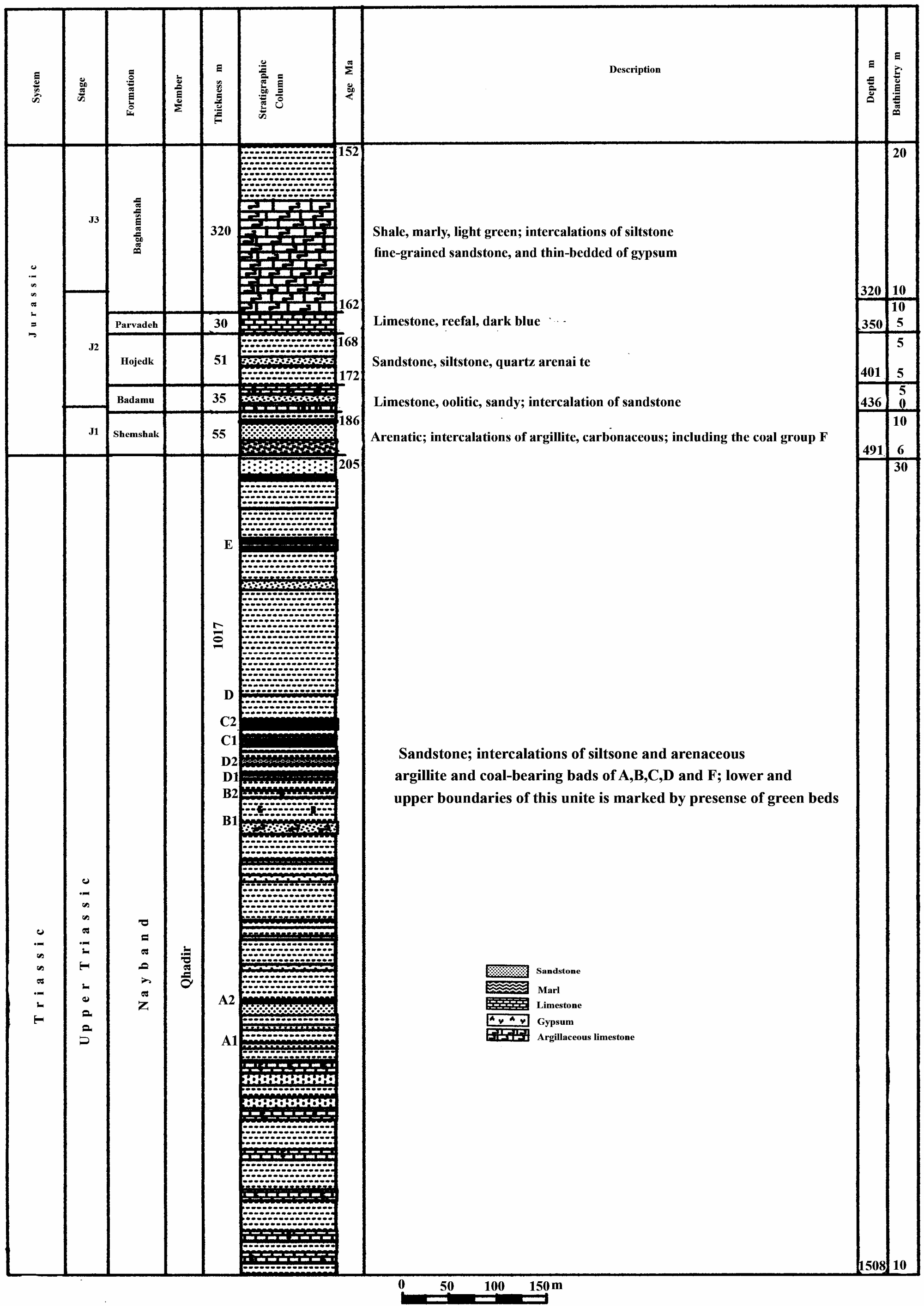

Figure 3a. Stratigraphic section of Abdoughi.

Using equations (1) and (2), the thickness of the units at successive stages in burial can be restored (Table 1). Tables 1 show how the table is set up for the back stripping and decompaction units for wells Abdoughi, 455 and 412.

We used the local isostatic balance method to compute tectonic subsidence because we could assign realistic values to required parameters (Table 2). Our current state of knowledge about crustal conditions in the Abdoughi-parvadeh areas is inadequate to

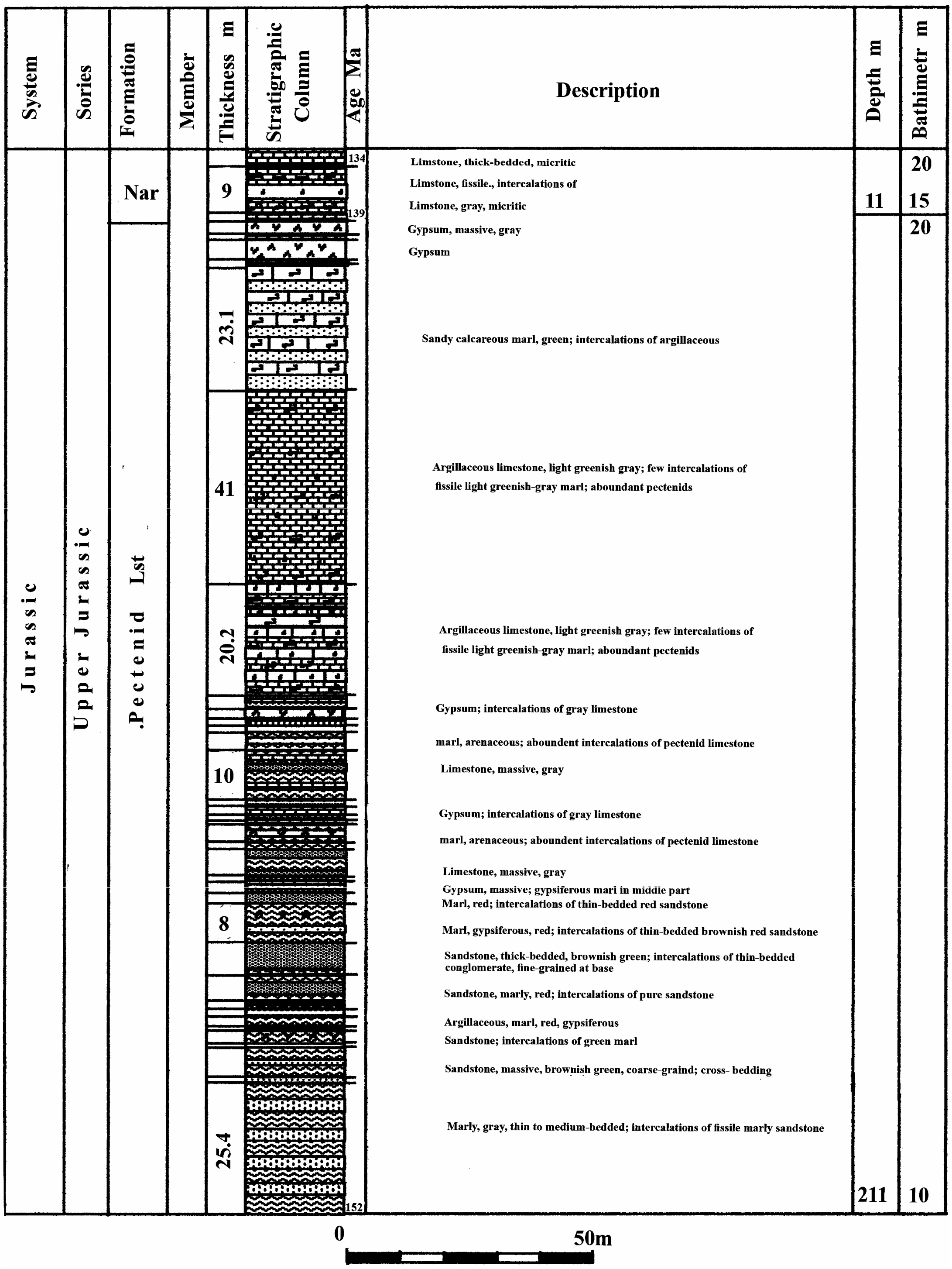

Figure 3b. Countinued.

confidently assign values to parameters used in the more realistic regional flexural analysis method described by Angevine *et al.* [6]. The following two equations were used to compute tectonic subsidence:

$$P_S = \frac{\sum^{i} \left[\phi_i Pw + (1-\phi_i) Pg\right] Ti}{S} \tag{3}$$

from Angevine *et al.* [6]

Table 1. Backstripping and Decompacted Units for Wells Abdoughi, 455. 412 For more explanation see the text

units	n	P	P	P	bg	bg	pa	h	h	h	bd	sh	sh	Ny	NY	NY	
n	11.5 0.43	=T =Φ			Initial Thickness T= Thickness Φ= POROSIT												
P	114 0.45	114.6 0.45			Present Thickness												
P	11 0.15	11 0.15	11 6.15		Restored Thickness **Abdoughi Section**												
P	75 0.47	75.2 0.47	77.4 0.49	77.6 0.49													
bg	100 0.57	100.7 0.57	109.2 0.6	110.1 0.61	117.4 0.69												
bg	220 0.38	220.7 0.38	228.9 0.4	229.4 0.41	236 0.42	247.9 0.45											
pa	30 0.34	30.1 0.34	30.9 0.36	31 0.36	31.6 0.37	32.8 0.39	36.1 0.45										
h	15 0.42	15 0.42	15.3 0.43	15.3 0.43	15.6 0.44	15.9 0.45	16.9 0.49	17 0.49									
h	15 0.47	15.1 0.47	15.8 0.5	15.8 0.43	16.4 0.51	17.4 0.54	20.6 0.61	21.2 0.62	21.5 0.69								
h	21 0.42	21 0.42	21.4 0.43	21.4 0.43	21.5 0.43	21.8 0.44	22.2 0.45	23.7 0.48	23.8 0.49	24 0.49							
bd	35 0.32	35.1 0.32	36 0.34	36.1 0.34	36.7 0.34	37.9 0.38	41.3 0.43	41.9 0.44	42.2 0.44	42.6 0.44	49.1 0.45						
sh	44 0.44	44.2 0.44	46.8 0.48	47 0.48	49 0.5	53 0.54	67.2 0.63	70.2 0.65	71.7 0.66	73.9 0.67	76.5 0.68	81.8 0.7					
sh	11 0.41	11 0.41	11.2 0.42	11.2 0.42	11.4 0.43	11.6 0.44	12.2 0.46	12.3 0.47	12.3 0.47	12.4 0.47	12.4 0.47	12.5 0.48	12.8 0.49				
Ny	760 0.44	763.2 0.44	792.7 0.46	795.6 0.46	817.6 0.48	857.7 0.5	975.8 0.65	996.6 0.57	1007 0.58	1020 0.58	1036 0.59	1066 0.6	1137 0.63	1150 0.63			
Ny	106 0.2	106.1 0.2	107 0.21	107.1 0.21	107.7 0.22	108.6 0.22	110.4 0.24	110.6 0.24	110.7 0.24	110.8 0.24	110.9 0.24	111.1 0.24	111.2 0.24	111.2 0.24	153.4 0.45		
Ny	150 0.32	150.6 0.32	151.8 0.33	151.9 0.33	152.6 0.33	153.8 0.34	156 0.34	156.2 0.35	156.3 0.35	156.4 0.35	156.5 0.35	156.7 0.35	156.9 0.35	156.9 0.35	192.9 0.47	200.4 0.49	
TRJ	1714.5	1713.6	1655.3	1650	1613	1558.7	1459.9	1449.8	1445.4	1440.2	1435.1	1427.4	1418.8	1418.6	346.3	200.4	**0**

units	bg	pa	h	h	bd	bd	sh	sh	Ny	NY	
bg	158 0.63	=T =Φ				Initial Thickness T= Thickness Φ= POROSIT					
pa	7 0.41	7.5 0.45				Present Thickness					
h	19.4 0.47	20.2 0.49	20.2 0.49			Restored Thickness Well No.455					
h	11.6 0.57	13.1 0.62	13.1 0.62	13.4 0.63							
bd	44.6 0.57	50.1 0.62	50.4 0.62	51.2 0.63	51.8 0.63						
bd	5.4 0.4	5.7 0.43	5.7 0.43	5.8 0.43	5.8 0.44	5.9 0.45					
sh	56 0.56	62.2 0.6	62.5 0.6	63.4 0.61	64.1 0.61	66.9 0.63	67.2 0.63				
sh	84 0.45	86.8 0.47	87 0.47	87.3 0.47	87.6 0.47	88.7 0.48	88.8 0.48	90.3 0.49			
NY	337 0.52	366.2 0.56	367 0.56	372 0.56	374.9 0.57	387.4 0.58	388.9 0.58	408.2 0.6	439.5 0.63		
NY	94.2 0.4	96.2 0.42	96.3 0.42	96.5 0.42	96.7 0.42	97.4 0.42	97.4 0.42	98.3 0.43	99.5 0.44	110.3 0.99	
TRi	817.2	707.8	702.9	689.7	680.9	646.2	642.4	596.9	539.1	110.3	0

units	h	h	bd	sh	sh	NY	NY	
h	34 0.49			Present Thickness				
h	38.8 0.62	39.9 0.63		Initial Thickness Restored Thickness **No.412**				
bd	20.3 0.43	20.6 0.44	20.9 0.45					
sh	27.3 0.6	28 0.61	28.9 0.62	29.5 0.63				
sh	44.6 0.47	45 0.48	45.4 0.48	45.6 0.49	46 0.49			
NY	324.7 0.58	332.1 0.59	341.7 0.6	347.1 0.61	355.3 0.62	369.3 0.63		
NY	219.8 0.43	220.9 0.43	222.2 0.44	222.9 0.44	223.9 0.44	225.4 0.44	246 0.49	
TRi	709.5	686.5	659.2	645.1	625.1	594.1	246	0

Table 2. Values to required parameters for this study

EASYSUB
A Backstripping and Decompaction Model

Name of the Well or Section: No: 306A
Region: PARVADEH
X/Y coordinates:

Modified by: Nasser-Naimi

Number of events = 16

SEDIMENT parameters

Lithology code	Lithology	ΦO Initial porosity	C ithological coefficie	P ediment grain density
1	#Limestone	0.45	0.54	2.71
2	*Sandstone	0.49	0.27	2.65
3	*Shale	0.63	0.51	2.72
4	*Chalk	0.70	0.71	2.71
5	ˆDolomite	0.31	0.22	2.86
6	Evaporite	0.15	0.10	3.00
7	*Siltestone	0.56	0.39	2.68

INPUT-DATA

Event number	Name	lithology cod	Thickness (m)	Age of the Top (Ma)	Age of the Top (Ma)	Today Erosion (m)	Bathrymetry Max (m)	Bathymetry Min (m)	Φo Initial Porosity	Φz Today Porosity	C Lithological coefficien
16	n	1	11.5	134	139	5	20	15	0.45	0.45	0.54
15	p	1	114	139	146.5	70	20	10	0.45	0.45	0.54
14	p	6	11	146.5	147	5	20	10	0.15	0.15	0.1
13	p	2	75	147	152	35	20	10	0.49	0.48	0.27
12	bg	3	100	152	155	50	20	10	0.63	0.59	0.51
11	bg	1	220	155	162	100	20	10	0.45	0.41	0.54
10	pa	1	30	162	168	15	10	5	0.45	0.37	0.54
9	h	2	15	168	169	7	5	5	0.49	0.45	0.27
8	h	3	15	169	170	7	5	5	0.63	0.54	0.51
7	h	2	21	170	172	8	5	5	0.49	0.45	0.27
6	bd	1	35	172	188	15	5	0	0.45	0.38	0.54
5	sh	4	44	186	201	20	10	6	0.7	0.55	0.71
4	sh	2	11	201	205	3	10	6	0.49	0.44	0.27
3	NY	3	760.5	205	222	200	30	15	0.63	0.52	0.51
2	NY	1	106	222	224.5	50	30	10	0.45	0.25	0.54
1	Ny	2	150.5	224.5	228	75	30	15	0.49	0.37	0.27

Where P_s = density of sediment, ϕ_i = porosity of unit, Pw = density of water, Pg = grain density (not the same as sediment density), Ti = thickness of the unit, S = thickness of uncompacted sediment.

$$Zi = S\,\frac{(Pa - Ps)}{(Pa - Pw)} + wdi \tag{4}$$

from Angevine *et al*. [6]

Where S is the thickness of uncompacted sediment column, Zi = amount of tectonic subsidence, Pa = density of the asthenosphere, Ps = density of sediment, Pw = density of water, and wdi = depth of water for unit I, Densities (P), porosities (ϕ), and lithology constants (c) that we used in these calculations are shown in (Table 2). Rock types and thickness for each stratigraphic interval were determined from analyses of Rock exposures, wells and from regional stratigraphic studies. Water depths were estimated from paleontologic data and by comparing lithofacies with analogous present-day environments (Table 3). For each section or well such as Abdoughi, 455 and 412, the various steps of the computation are shown: the calibration points that we defined on the stratigraphic column are shown by numbered crosses. The two lower curves, commonly called total subsidence curve(TS) is created due to decompaction and depict the foundering through time of the calibration point zero below sea levels and tectonic subsidence curve (TCS) is obtained after subtraction of the load effect applied to the calibration point zero by the overlaying sentiments. The two upper curves, commonly called bathymetry max.

and min. is corrected for paleobathymetry and eustatic sea level changes (Fig. 4). In Figure 5 shows the tectonic rate curve (RT) is obtained a tectonic subsidence curve (TCS) and subsidence rate curve (RS) is obtained a total subsidence curve (TS). For this study, we benefit from the wells calibrated to numbers 455, 412 and observations along the outcrop such as Abdoughi and Nayband sections, which locate in the South of Tabas Block (Fig. 2).

3. Obtained Subsidence Curves

3.1. Abdoughi Section

The Abdoughi section (Fig. 2) lies in the southern part of the Tabas Basin that is located from the other silvers of the Tabas Block by Cheshmeh Rostam Fault. More over 1719m sediments were deposited (Fig. 3) from the East to West, During the Late Triassic through Late Cretaceous. The subsidence curve (Fig. 4) starting the Late Triassic (205-228 Ma) with a relatively high subsidence rate (3.76 cm/1000y) and the end of this period, total subsidence rate was 4.47 cm/1000y and tectonic subsidence rate was 4 cm/1000y, coupled with tectonic forces of Early Cimmerian Orogenic event and sediment loading together in this time, Naimi Ghassabiyan [2].

This case demonstrates an extensional system in the Abdoughi area. During this time more over 1000m sediments dominantly siliciclastic (upper members of Nayband Formation) was deposited. In the Early Jurassic tectonic subsidence rate rapidly decreased and was negative. This shown an uplift period in this time, but the total subsidence rate (0.15-0.28cm/ 1000y) relatively continued due to sediment loading effects. This case demonstrates a constant period in the short time. During this time, 55m sediments dominantly shale and sandstone was deposited. During Late Toarcian through Middle Bajocian (186-I72Ma) tectonic subsidence rate is negative (-0.02 cm/1000y). This shows a constant period in this time, which coupled with sediments dominantly coarse-grain sandstone and micro conglomerate in the Late Bajocian (Figs. 4-5). This basin subsided during Late Bajocian through Middle Bathonian (168-172Ma) at a relatively Medium subsidence rate, coupled with sediments sandstone, shale with coal (Hojedk Fm.). After the short time, subsidence rate decreased [total subsidence (0.6 cm/1000y) and tectonic subsidence (0.96 cm/1000y)]. In Middle Bathonian through Late Bathonian (162-168 Ma), which 30m limestone was deposited (Parvadeh Fm.), again subsidence rate increased very much [total subsidence (3.14-3.33 cm/1000y) and tectonic

Table 3. Paleobathymetry used for this study

Name Formation	Age of the Top (ma)	Age of the Base (ma)	Bathrymetry Max (m)	Bathymetry Min (m)
Nar (N fm.)	134	139	20	15
Pectenid Lim. (P Fm.)	139	152	20	10
Baghamshah (bg Fm.)	152	162	20	10
Parvadeh (Pa Fm.)	162	168	10	5
Hojedk (h Fm.)	168	172	3	0
Badamu (bd Fm.)	172	186	5	3
Shemshak (sh Fm.)	186	205	10	6
Nayband (Ny Fm.)	205	228	15	10

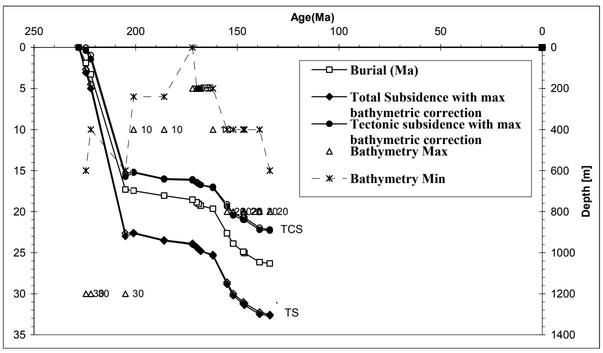

Figure 4. Subsidence curves of the Abdoughi section. For more explanation see the text.

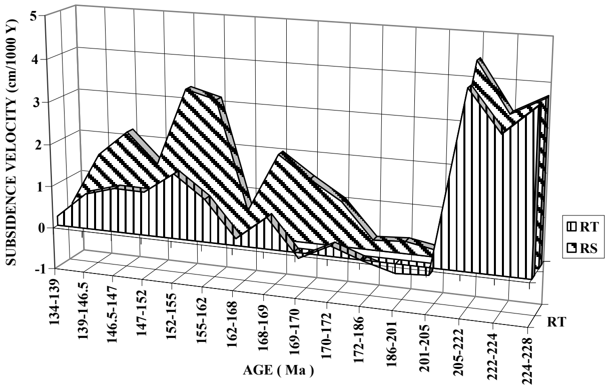

Figure 5. Subsidence rates of the Abdoughi section. Abbreviations: RS- Subsidence Rate, RT- Tectonic Subsidence Rate. For more explanation see the text.

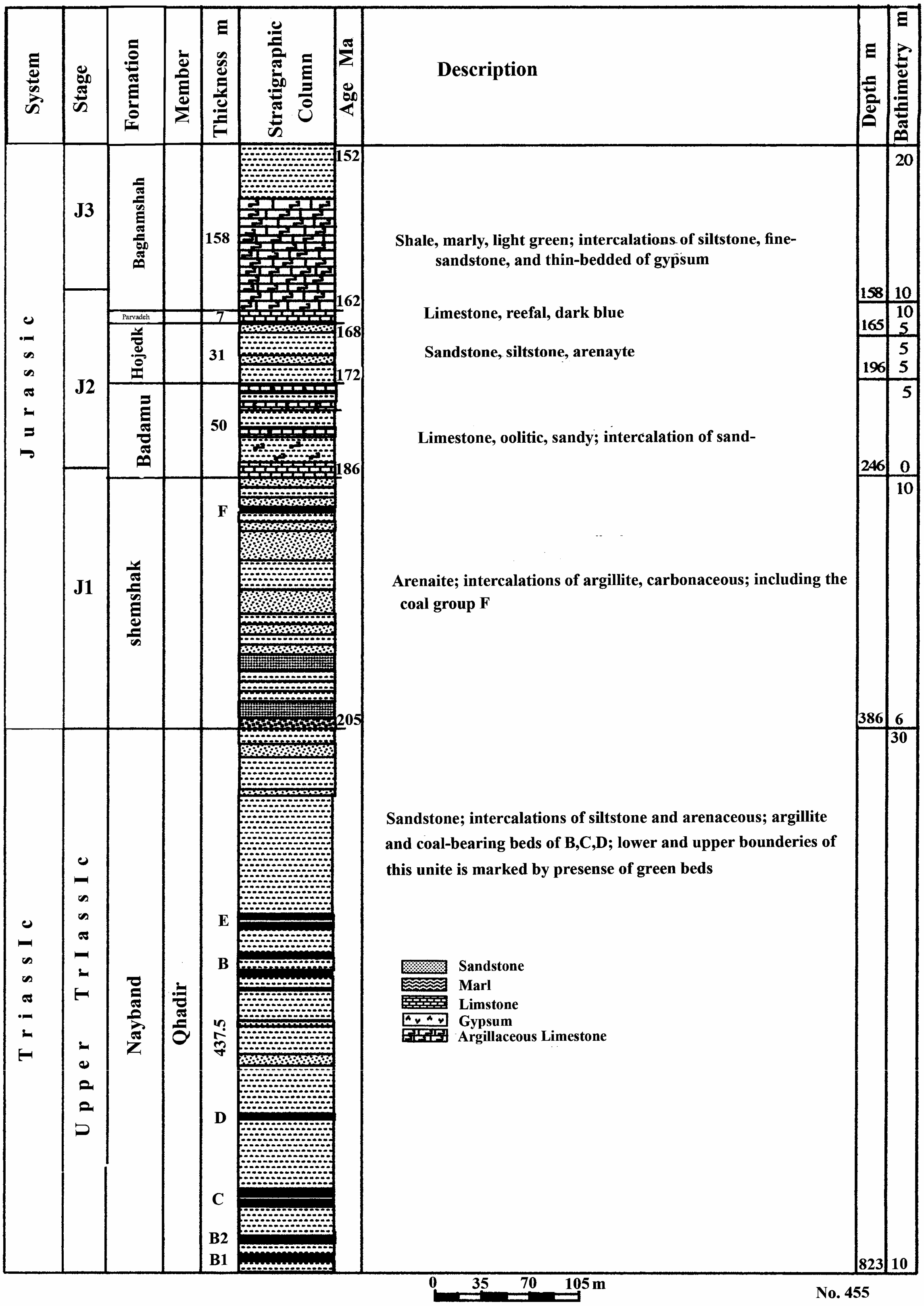

Figure 6. Stratigraphic section of Well No. 455.

subsidence (1.01-3.53 cm/1000y)]. In during late Bathonian through Callovian (152-162), more over 300m sediments dominantly marl, intercalations of sandstone, siltstone was deposited (Baghamshah Fm.), this indicates thinning of the crust of the East of Central Iran, Saidi [7]. In during Oxfordian (152Ma) through Kimmeridgian (139Ma) total subsidence rate was 1.5-1.6 cm/1000y and tectonic subsidence rate was 0.84-1.03 cm/1000y, in this time more than 200m sediments was deposited (Pectenide Limestone Fm.). During Tithonian (134-139 Ma) subsidence rate decreased very much [total subsidence rate (0.33cm/1000y) and tectonic subsidence (0.22 cm/1000y)], but the subsidence continued to Late Jurassic. During this time, 11.5m sediments dominantly carbonate was deposited (Nar Fm.), (Figs. 4-5).

In the Uppermost Jurassic, subsidence curve shown a gently negative subsidence rate coupled with an uplift period and changing of the marine environment to lagoonal-evaporite environment, during this time composed of marl and gypsum was deposited (Magu Gypsum Fm.).

3.2. Well No. 455

Well number of 455(Fig. 2) starting the Late Triassic and continued to Late Jurassic. During this time more than 827m sediments were deposited (Fig. 6). The subsidence curve (Figs. 7-8) in the Late Triassic shown a relatively high subsidence rate [total subsidence rate (1.9-1.98cm/1000y) and tectonic subsidence (2-1.83cm/ 1000y)], coupled with 437m sediments was deposited (upper members of the Nayband Formation). In the Early Jurassic (205-186Ma), tectonic subsidence rate (0.37-0.65cm/1000y) rapidly decreased, but the total subsidence rate (0.65-0.8cm/1000y) continued due to load of sediment effects. In this time 140m Shemshak Formation Sediments was deposited. In the Late Toarcian through Middle Bajocian (186-172Ma) the total subsidence rate was 0.03-0.34cm/1000y. During Bajocian through Middle Bathonian (172-168Ma) subsidence rate decreased [total subsidence rate (0.77-0.78cm/1000y) and tectonic subsidence rate was (0.47-0.5cm/1000y)]. In this time 31m Hojedk Formation sediments was deposited. During the Middle Bathonian through Late Bathonian (168-162 Ma) the subsidence rate was [total subsidence rate (0/24 cm/1000y) and tectonic subsidence rate (0.19 cm/1000y)], in this time 7m limestone was deposited (Parvadeh Fm.). During the Late Bathonian through Callovian (162-152Ma) basin subsided at a relatively high rate [total subsidence rate (1.68cm/1000y) and tectonic subsidence rate (1.19)], coupled with Baghamshah Formation sediment was deposited.

3.3. Well No. 412

During the Late Triassic through Late Jurassic more over 709.5m sediments were deposited (Fig. 9). In Late Triassic total subsidence rate (Figs. 10-11) was 2.33-2.37cm/1000y and tectonic subsidence rate was 2.36-2.99cm/1000y, in this time 545.5m sediment was deposited. In Early Jurassic subsidence rate decreased total subsidence rate was 0.41-0.32cm/1000y and tectonic subsidence rate was 0.6-0.18 cm/1000y, in this time 71.5m sediments were deposited..During the Late Toarcian through Middle Bajocian the tectonic subsidence rate was 0.09cm/1000y and total subsidence rate was 0.l3cm/1000y. In this time 20.3m Badamu Formation sediments was deposited. During Late Bajocian through Middle Bathonian total subsidence rate was 0.68-1.18cm/1000y (Figs. 10-11). In this time 73m sediments was deposited (Hojedk Fm.).

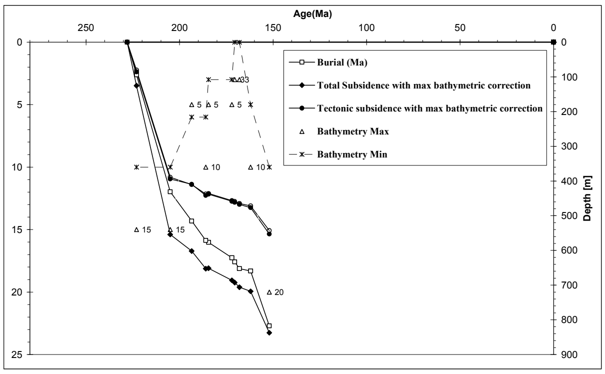

Figure 7. Subsidence curves of the Well No. 455. Same legend as Fig. 4. For more explanation see the text.

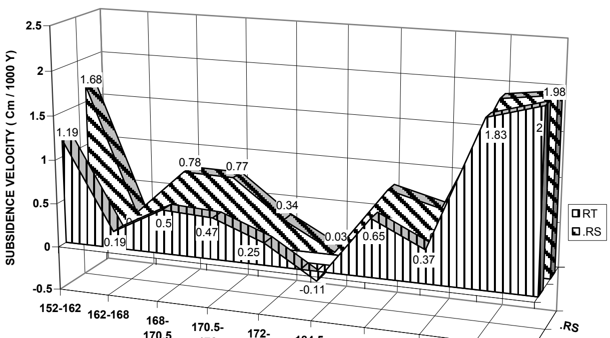

Figure 8. Subsidence rates of the Well No. 455. Abbreviations: RS- Subsidence Rate, RT-Tectonic Subsidence Rate. For more explanation see the text.

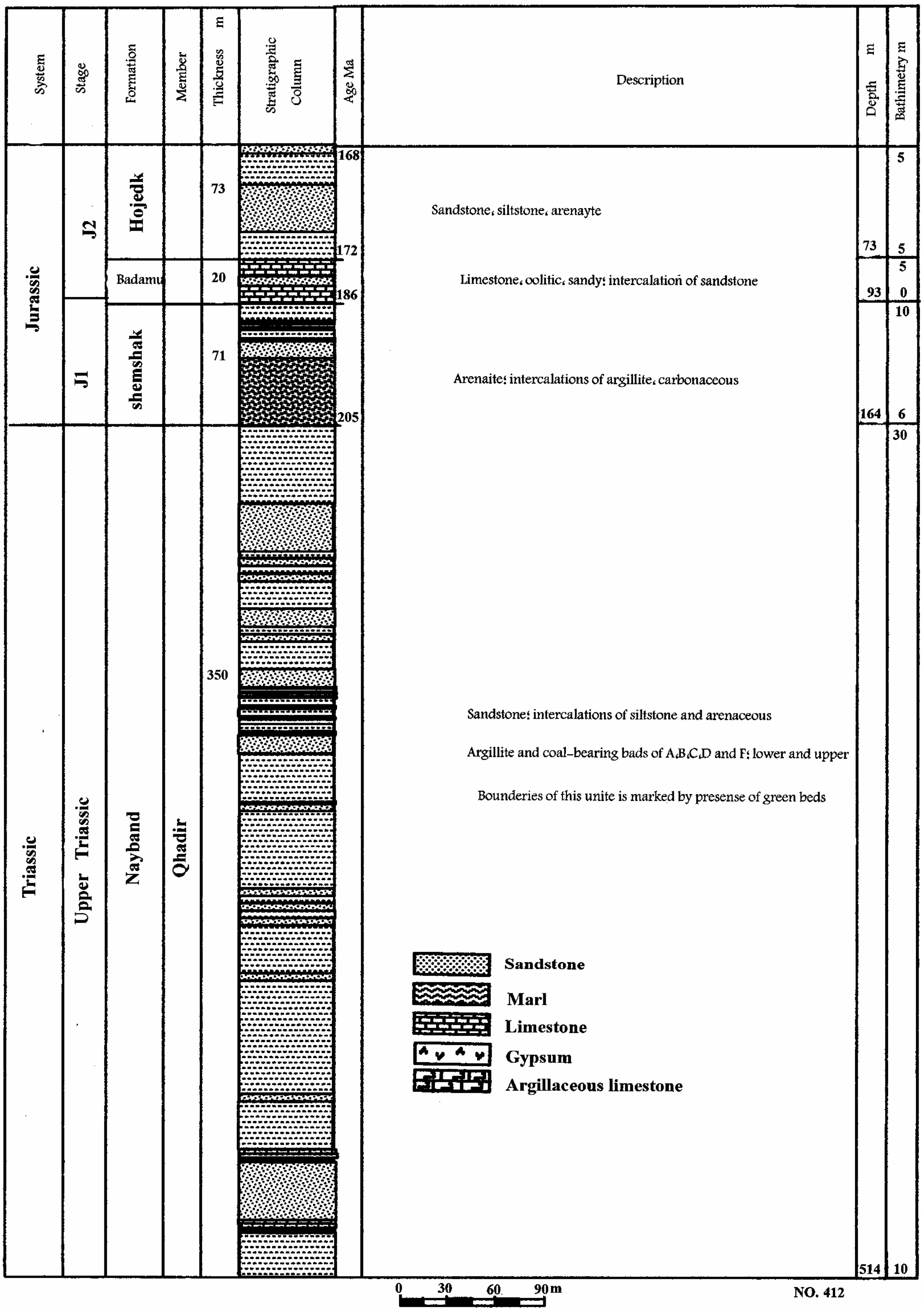

Figure 9. Stratigraphic section of Well No. 412.

3.4. Nayband Section

To comparison subsidence rate in Abdoughi-- Parvadeh Basins with Nayband Basin, Nayband section has been selected, that is located to the west of the Kuh-e Nayband (Fig. 2). Bronnimann *et al.,* [9] studied lithostratigraphy and formation of the Upper Triassic Nayband Formation, kluyver *et al.,* [10] studied the explanatory text of Abdoughi Quadrangle map and Saidi [8] studied geological map and explanatory text of Abdoughi Quadrangle map. More over 11984m sediments was deposited in a variety of shallow-marine and terrestrial environments. During Early Carboniferous through Late Cretaceous (Fig. 12), the subsidence curve (Fig. 13), starting the Middle Carboniferous (335-345 Ma). During this time, sedimentary strata subsided at a relatively medium rate which shown a period of thin crustal. During the Late Carboniferous through Early Permian (283 -335Ma) again the subsidence rate decreased. During the Middle Permian the subsidence rate increased and in Late Permian (269-283Ma) was maximum subsidence rate. In the Early Triassic (241-251Ma) again accumulation rates decreased and tectonic subsidence rate was zero, which shown a constant period after the Late Permian. In the Middle Triassic, the subsidence rate increased and was maximum rate, coupled with creating a new margin in the Nayband area, Saidi [8]. During the Late Triassic (208-288Ma) over 2000m sediments fine-grain was deposited in this basin (Shemshak Formation). In Early Jurassic (186-208Ma) tectonic subsidence rate decreased and in Early Toarcian (182-186Ma) was negative, this case demonstrate a constant period and during this time more over 70m sediments dominantly carbonates was deposited (Badamu Formation). In Early Bathonian, Nayband Basin subsided at a relatively Medium subsidence rate, in this time over 750m siliciclastic sediments was deposited (Hojedk Fm.). After the short period (Early Bathonian), again basin subsided at a high subsidence rate in the Late Bathonian. During this time over 2700m sediments dominantly of marl and sandstone was deposited (Baghamshah Fm.), this indicates thinning of the crust of the East of Central Iran, Saidi [7]. In the Early Oxfordian (152Ma) subsidence rate in comparative to callovian decreased. In Late Jurassic subsidence curve shown a gently negative rate, this indicates uplifting and changing of the marine environment to continental Lagoonal Basin. During the Early Cretaceous (125-135Ma), Nayband Basin subsided at a gently Negative subsidence rate and concluded to basal conglomerate. In the Late Cretaceous again subsidence rate increased. During Barmian through Aptian, again subsidence rate decreased and in the Late Albian (96-98Ma) subsidence rate shown a highly negative rate, coupled with before period of breakup Iran block in the Late cretaceous, Saidi [7]. Due to Laramid orogenic event, the area was folded and emerged from sea water, after this event Quaternary sediments are the only that were deposited in the area.

Results and Discussion

Based on the subsidence curves plotted for tectonic domain of the Tabas Block containing Abdoughi section, wells number 455, 412 and with compare of it to Nayband section following conclusions obtained (Figs. 3-13).

- After Early Cimmerian orogenic phase, the Tabas Block Basin subsided during the Late Triassic through Early Cretaceous. Depth of the basin was reduced only for a short space due to epirogenic movements, which resulted in deposition of detrital shallow water sediments. In this time, two sedimentary cycles defined within the study area. A sedimentary cycle, related to Upper Triassic to Bajocian is known as Shemshak group, which is basically composed of shale and fossiliferous sandstone with some indication coal. This cycle was deposited in continental Lagoonal basin and includes NAYBAND, SHEMSHAK, BADAMU and ?HOJEDK Formations. Another sedimentary cycle, related to Bathonian to Upper Jurassic, is known as MAGU group, which is marl and carbonates. This cycle

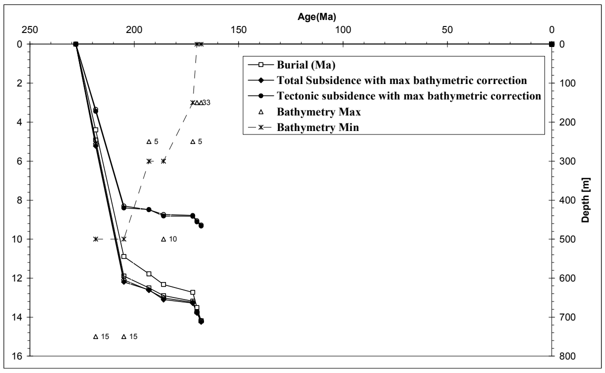

Figure 10. Subsidence curves of the Well No. 412. Same legend as Fig. 4. For more explanation see the text.

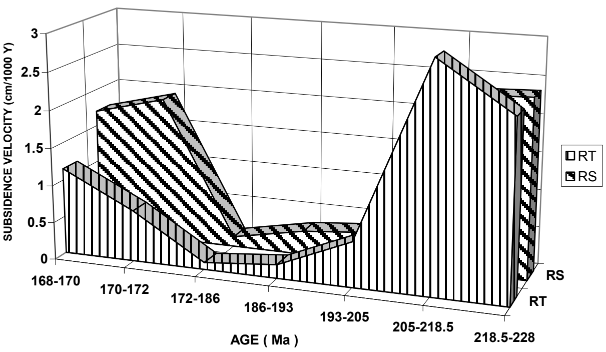

Figure 11. Subsidence rates of the Well No. 412. Abbreviations: RS- Subsidence Rate, RT-Tectonic Subsidence Rate. For more explanation see the text.

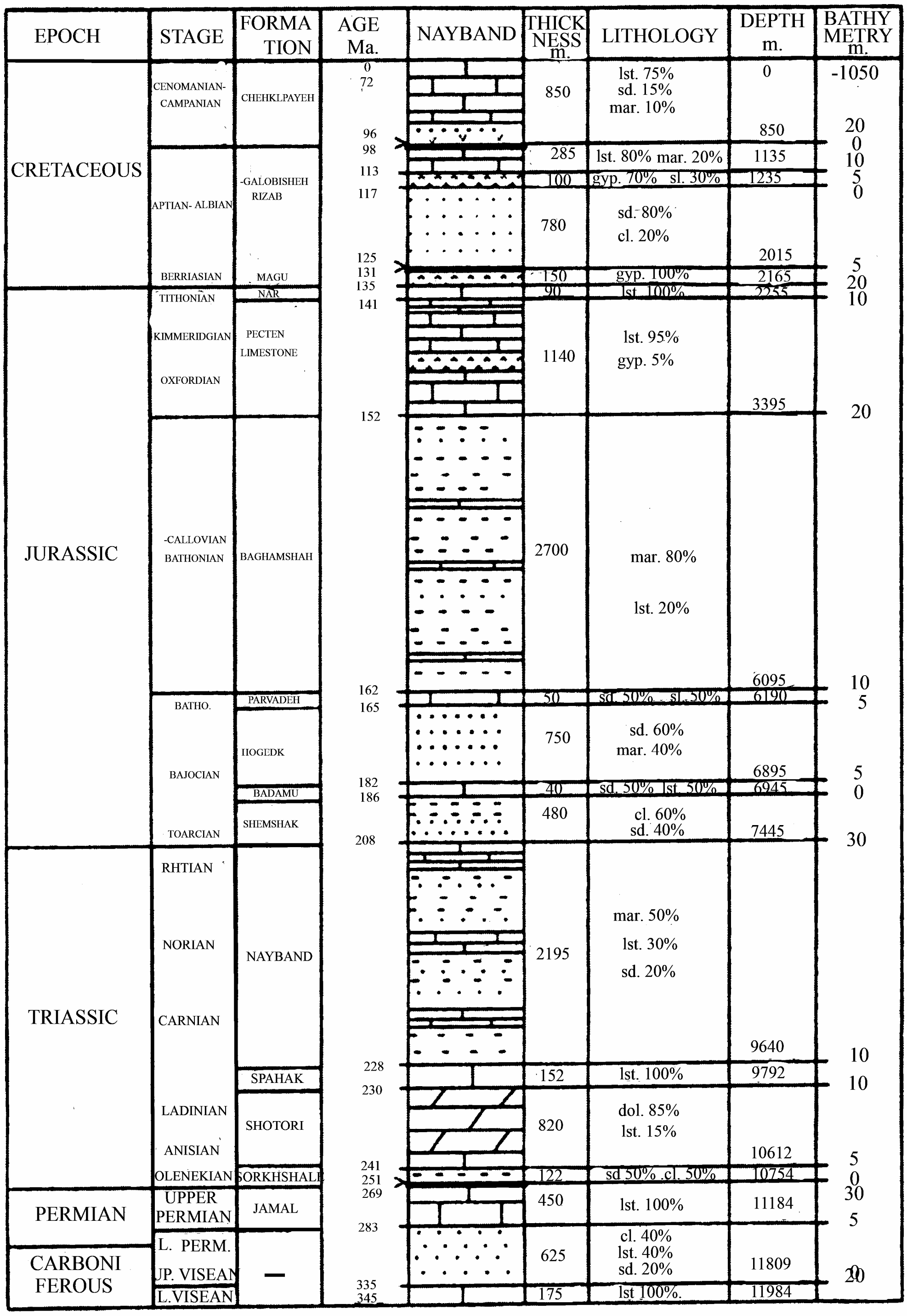

Figure 12. Stratigraphic section of the Nayband section [9].

was deposited in a shallow marine basin and includes PARVADEH, BAGHAMSHAH, PECTENIDE LIMESTONE, NAR and MAGU Formations. The Cretaceous rock units consist of red coarse-grained sandstone, pebbly sandstone at the base changing into arenaceous limestone, red gypsifferous marl, rudist limestone and conglomerate towards top. This sequence was deposited in a shallow marine environment. In the

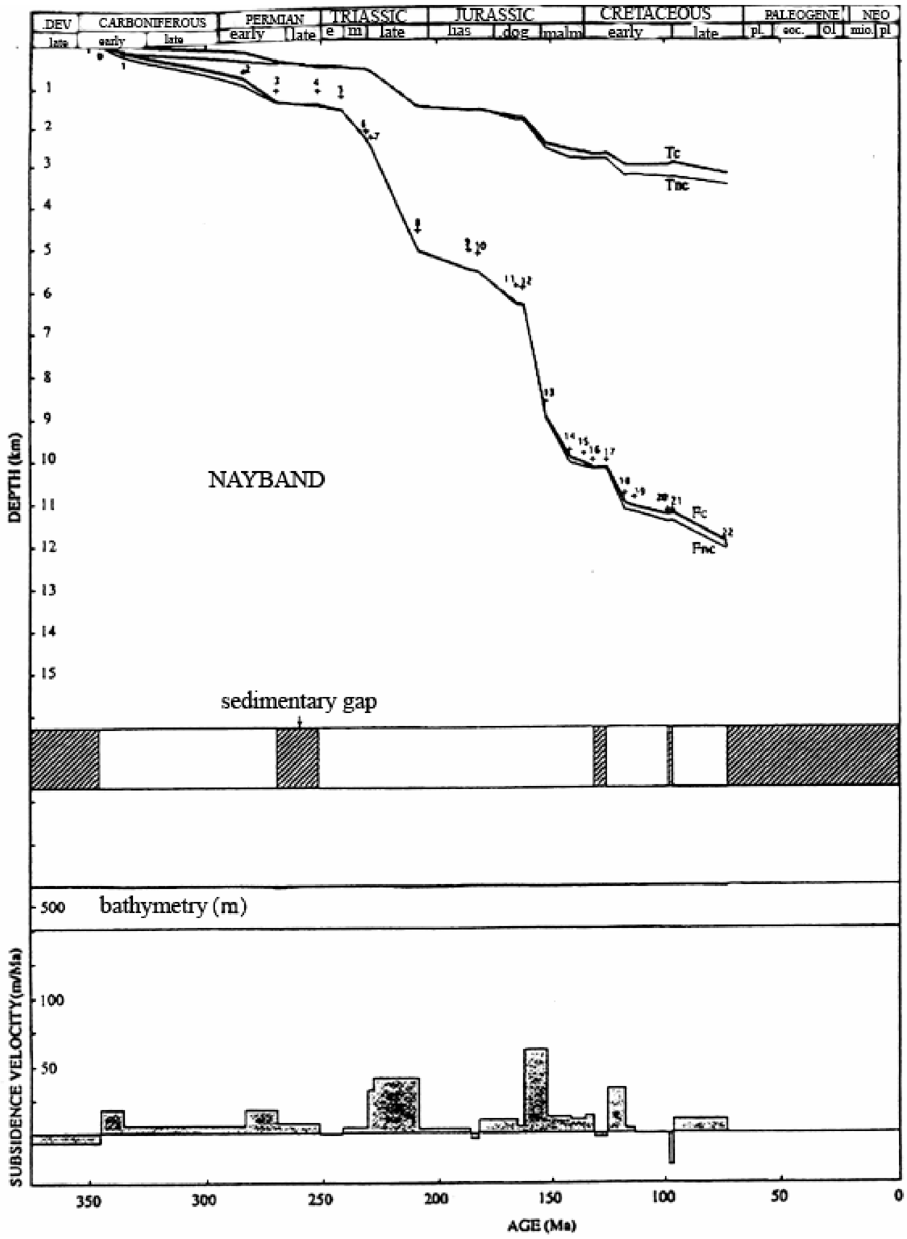

Figure 13. Subsidence curves of Nayband section. Same legend as Fig. 4. For more explanation see the text [9].

Late Cretaceous movements of Laramid orogenic phase generate a strongly convergent kinematic regime, and caused to the area was folded and emerged from seawater. After this event Quaternary sediments are the only that were deposited in this area. Dextral strike slip movement in the Nayband Fault demonstrated a convergent regime in the eastern part of area. The Nayband Fault movement caused to create E-W Faults which are branches of the great Nayband Fault and E-W Fault related Folds in this area. This is to continuing the present structural framework of the area was formed during this tectonic event. Moreover rotational movements (anticlockwise) in Tabas Block, especially in direction of the E-W Faults generated gap spacing for explosion of Neogene volcanic rocks.

- Based on the subsidence rates calculated in Abdoughi-Parvadeh sections, the Eo-Cimmerian unconformity separating Lower-Middle Triassic platform carbonates from Shemshak Group (Norian-Bajocian).

- In the Early Jurassic tectonic subsidence rate rapidly decreased and was negative. This shown an main uplift phase of the Eo-Cimmerian orogeny in this time.
- During Late Toarcian through Middle Bajocian (186-I72Ma) tectonic subsidence rate is negative. This shows a constant period in this time, which can be coupled with sediments dominantly coarse-grain sandstone and micro conglomerate at the base of the Upper Bajocian-Bathonian ?Hojedk formation or Parvadeh formation (Mid-Cimmerian unconformity).
- The Mid-Cimmerian unconformity separates the Shemshak Group from the Upper Bajocian-Upper Jurassic Magu Group.
- Based on the subsidence rates calculated in sections of Parvadeh-Abdoughi area increasing subsidence rate in Tabas Basin from the east to the west and from the South to the north.
- All of the subsidence diagrams in Tabas Block shown two stages in subsidence curve. The first stage of subsidence formed by thinning in the curst, during a lithospheric extension. The rate of this subsidence is related to primary thickness. The second stage in subsidence generated by cooling of lithosphere. In this stage the subsidence is thermal and transient. The subsidence rate is related to amount of extension and sediment loading. Therefore the total subsidence in this stage is a function of isostasy.
- The tectonic subsidence curve in the Tabas Block shown a relatively high subsidence rate in the Norian-Rhetian and in the Upper Bajocian-Upper Jurassic that coupled with rifting environment in this time. This rifting was rapidly ceased in the Late Cretaceous to form Aulacogen (Failed Rift) and caused to generate oceanic crust and overriding of Sabzevar-Nain-Baft Ophiolites.
- The Nayband Basin subsidence rate is more than Abdoughi Basin, because the Nayband Fault activity is playing a main role in the changing of the facies, thickness and subsidence rates in this basin.

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