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ONE OF THE MAIN NEOTECTONIC STRUCTURES IN THE NW CENTRAL ANATOLIA: BEYPAZARI BLIND THRUST ZONE AND RELATED FAULT-PROPAGATION FOLDS

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ABSTRACT

This paper suggests that the structure known as "Beypazarı flexure / monocline" in the Turkish geology literature should be named as "Beypazarı fault-propagation folds". Beypazarı, Kilci and Başören blind thrusts together with Erenler back thrust constitute the Beypazarı Blind Thrust Zone which is an active neotectonic structure as indicated by earthquake activity. NW-SE contraction created by the interaction between the North Anatolian Fault Zone, the Kırıkkale-Erbaa Fault Zone and the Eskişehir Fault Zone produced the Eldivan-Elmadağ Pinched Crustal Wedge, the Abdüsselam Pinched Crustal Wedge and the Beypazarı Blind Thrust Zone. These structures take up the internal deformation of the Anatolian Plate.

1. Introduction

Beypazarı flexure (Rondot, 1956; Kalafatçıoğlu and Uysallı, 1964; Kavuşan, 1993*a*), later known as Beypazarı monocline (Yağmurlu et al., 1988; Demirci, 2000) is one of the important structures in NW central Anatolia. The region between Beypazarı and Çayırhan were mainly investigated by geochemistry oriented studies due to lignite, trona and geothermal resources (Helvacı et al., 1981; Özpeker et al., 1991; Suner, 1993; Kavuşan, 1993*b*; Karadenizli 1995; Orti et al., 2002; Özçelik, 2002; Özgüm et al., 2003; Özçelik and Altınsoy, 2005; Diker et al., 2006; Şener, 2007; Garcia-Veigas et al., 2013; Bechtel et al., 2014; Pehlivanlı et al., 2014). During trona mining, the problems about rock mechanics and hydrogeology were also investigated (Aksoy et al., 2006; Apaydın, 2010). Structural geology / tectonics oriented studies, however, are very limited (Yağmurlu et al., 1988; İnci, 1991; Kavuşan, 1993*a*; Demirci, 2000).

Yağmurlu et al. (1988) suggested that the Beypazarı-Çayırhan Neogene basin was initiated in Early Miocene under extensional tectonic regime. After Pliocene the basin deformed under NW-SE contraction that is created by the interaction between the right lateral North Anatolian Fault and the Eskişehir Fault. This NW-SE contraction produces the NE-SW trending thrust faults, folding axes and monoclines that most prominent one is named as the Beypazarı-Çayırhan monocline.

Kavuşan (1993*a*), however, proposed that in every stage of the Beypazarı-Çayırhan basin, NW-SE contraction was operational. It is noted that the effect of fractures is fading towards the young strata and turns to folding. Demirci (2000) determined three different regional tectonic phases, E-W contraction, N-S contraction and final extension. It is also noted that the final extension is not observed around Beypazarı (Demirci, 2000, p.142).

Esat and Seyitoğlu (2010), Esat (2011), Esat et al. (2016) and Esat et al. (2017) suggested that the NW-SE contractional tectonic regime is developed in the triangle-like area between the North Anatolian Fault Zone, the Eskişehir Fault Zone and the Kırıkkale-Erbaa Fault Zone (Figure 1). Due to the interaction of these fault zones, the Eldivan-Elmadağ Pinched Crustal Wedge (EPCW) is developed and mapped in detail (Seyitoğlu et al., 2000; 2009). Abdüsselam Pinched Crustal Wedge (APCW) is recognized more

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recently (Esat, 2011; Esat et al., 2017). The third structure observed in the triangle-like area is the Beypazarı Blind Thrust Zone (BBTZ) which is the subject of this paper (Figure 1).

2. The Stratigraphy of Beypazarı-Çayırhan Neogene Basin

According to Helvacı (2010) who updated previous studies with new data, Late Cenozoic stratigraphy starts with Paleocene Kızılçay Group having red conglomerates and claystones. Unconformably overlain Çoraklar formation having lower and upper lignite layers is composed of volcanoclastic conglomerates, sandstones, siltstones and mudstones. Overlying Hırka formation contains mudstone, claystone, bituminous shale, trona, grey shale, calcareous shale, dolomitic limestone, siltstone, intraformational conglomerate and tuff. The tuff in the Hırka formation has been dated (K-Ar) as 21.5 ± 0.9 Ma (Early Miocene). Hırka formation interfingers with Akpınar formation having alternation of siliceous limestone, chert, tuff, claystone and mudstone. Conformably overlain Çayırhan formation is composed of greenish claystone, mudstone, marl and sandstone layers. Mudcracks and salt crystals are observed to be common. Bozbelen formation is made up of reddish conglomerate, sandstone and mudstone. Kirmir formation, having green claystone with gypsum layers and bedded gypsum, laterally and vertically pass into Bozbelen formation and Sarıyer Limestone which are white, thick-bedded micritic limestone. Teke volcanics interfinger with Beypazarı sequence (Helvacı, 2010) (Figure 2).

3. Fault-Propagation Folding

It would be useful to give a brief summary about fault-propagation folding before presenting the field observations in the Beypazarı area. There are two

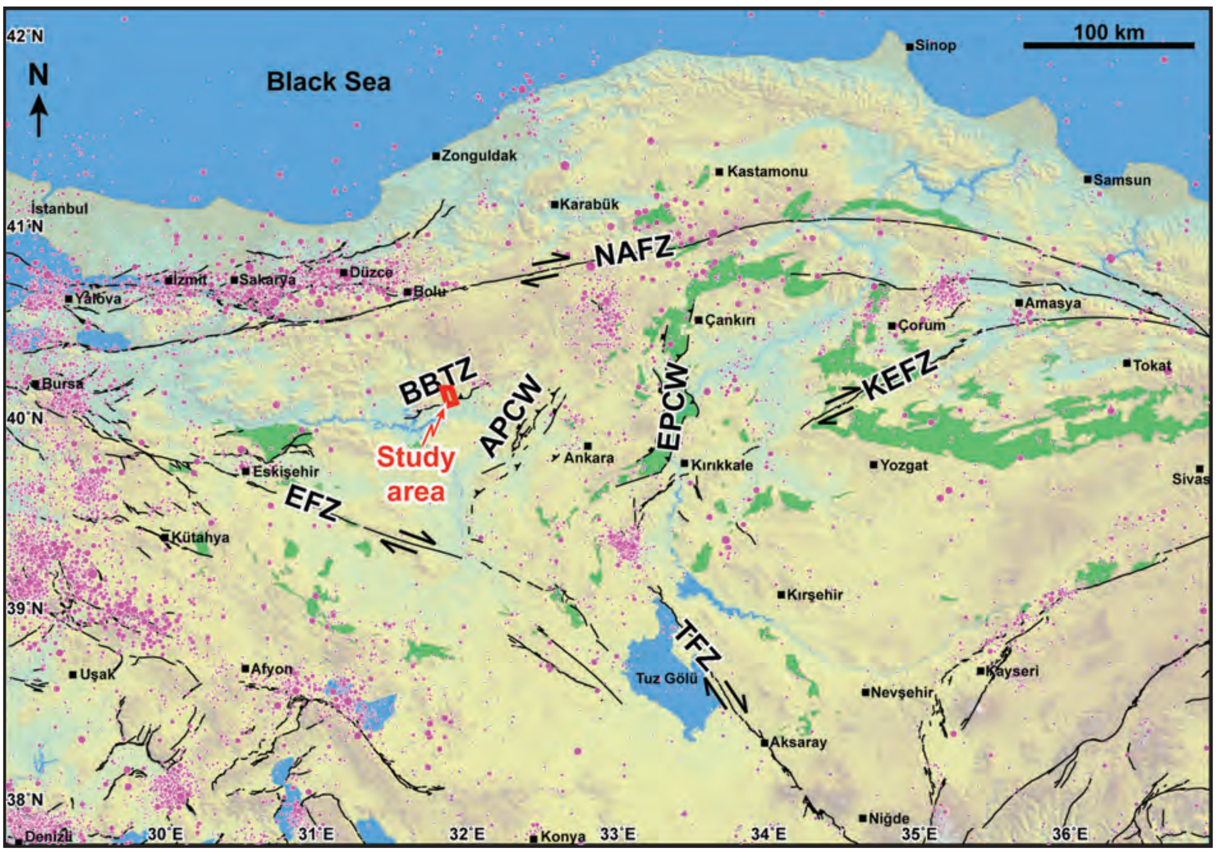

Figure 1- Main neotectonic elements of NW central Anatolia and seismicity. NAFZ: North Anatolian Fault Zone; BBTZ: Beypazarı Blind Thrust Zone; APCW: Abdüsselam Pinched Crustal Wedge; EPCW: Eldivan-Elmadağ Pinched Crustal Wedge; KEFZ: Kırıkkale-Erbaa Fault Zone; EFZ: Eskişehir Fault Zone; TFZ: Tuzgölü Fault Zone. Fault lines adapted from Emre et al., (2013), Seyitoğlu et al., (2000; 2009; 2015), Özsayın and Dirik (2007; 2011), Esat and Seyitoğlu (2010), Esat (2011), Esat et al., (2014; 2016). Pink circles represent the earthquakes from 1900 to 2013 with magnitude 3 or greater (Data was taken from B.U. Kandilli Observatory and Earthquake Research Institute). Green areas show the ophiolitic mélange rocks of the suture zone.

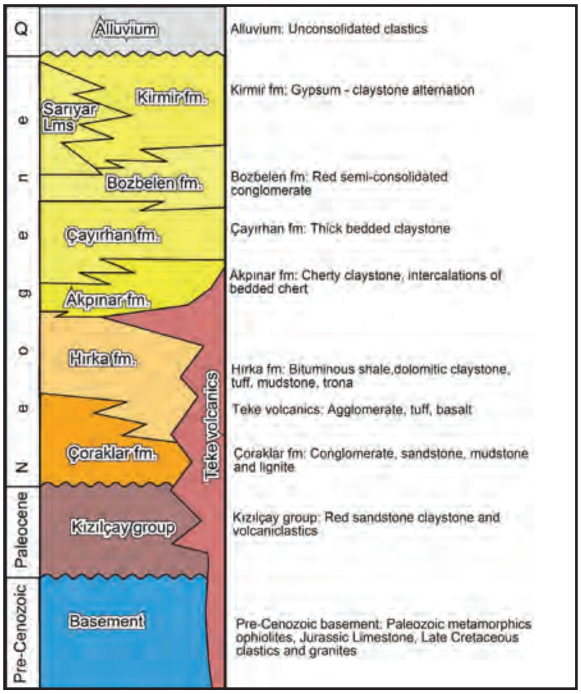

Figure 2- Stratigraphy of the Beypazarı-Çayırhan basin with no scale (Helvacı, 2010).

fault-related folding mechanisms in the thrust belts; (1) fault-bend folding: It develops in response to ramp-flat geometry of the thrust surface (Suppe, 1983) and (2) fault-propagation folding: which develops on the tip of a blind thrust where shortening is transferred to the folding (Suppe, 1985; Mitra, 1990; Suppe and Medwedeff, 1990). In the fault-bend folding, the forelimb has low dip angle compared to the fault-propagating folds with the highly dipping forelimb angle which is sometime even overturned (Calamita et al., 2012). Three models has been proposed for the fault-propagating folds in a fold-thrust belt (Jabbour et al., 2012). In the self-similar model, it is accepted that there is no rotation on the forelimb during folding. Fold geometry would be unchanged while anticline is growing. The interlimb angle remains constant (Suppe, 1985). In the time variant model, forelimb is rotated and the angle between limbs is not consistent (Mitra 1990). In the trishear model, fold developed gradually within the triangle zone on a tip of thrust fault (Erslev, 1991; Hardy and Ford, 1997; Allmendinger, 1998) (Figure 3).

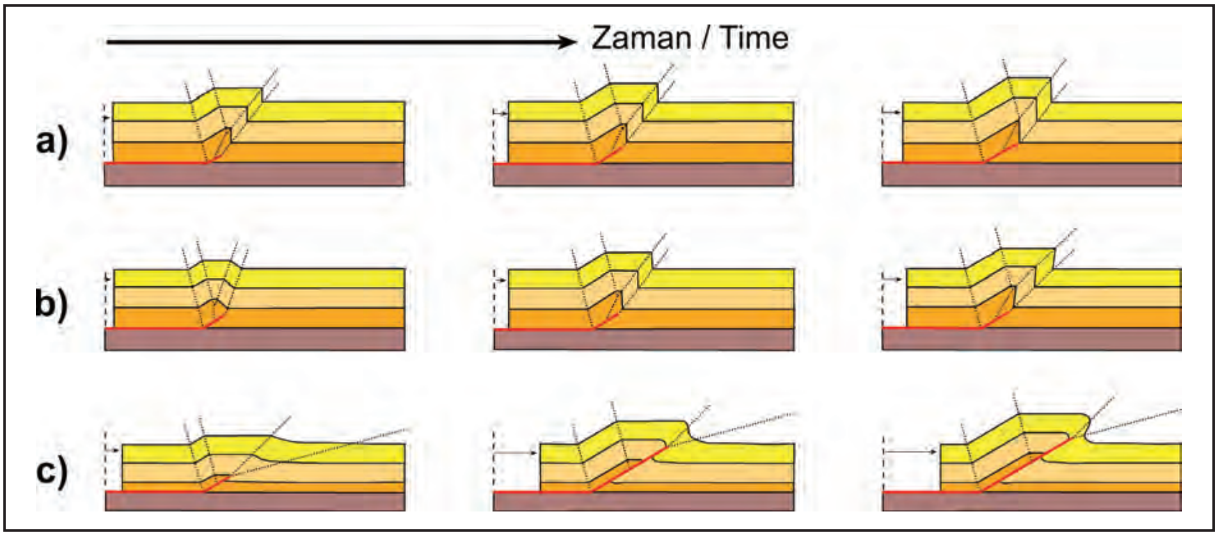

Figure 3- Three models of fault-propagation fold (Jabbour et al., 2012).

4. Field Observations

In the north of Beypazarı town, along the İnözü valley, detailed geological mapping demonstrates that so called Beypazarı - Çayırhan or Beypazarı Monocline is a fault-propagating fold related to blind thrusting (Figure 4). In the geological map of northern Beypazarı, the dark yellow, well lithified, easily distinguished volcanoclastic unit is particularly chosen to show overall structure of the area. The volcanoclastic unit is composed of poorly sorted lava blocks in tuff matrix and also contains sand size volcanic material. The unit is competent and well bedded. The upper and lower part of the volcanoclastic unit is made up of white marl, claystone, siliceous limestone and tuff. According to the previous description of the formations (Helvacı, 2010; Apaydın, 2010) it can be said that the volcanoclastic unit overlies the Hırka formation (Figure 4).

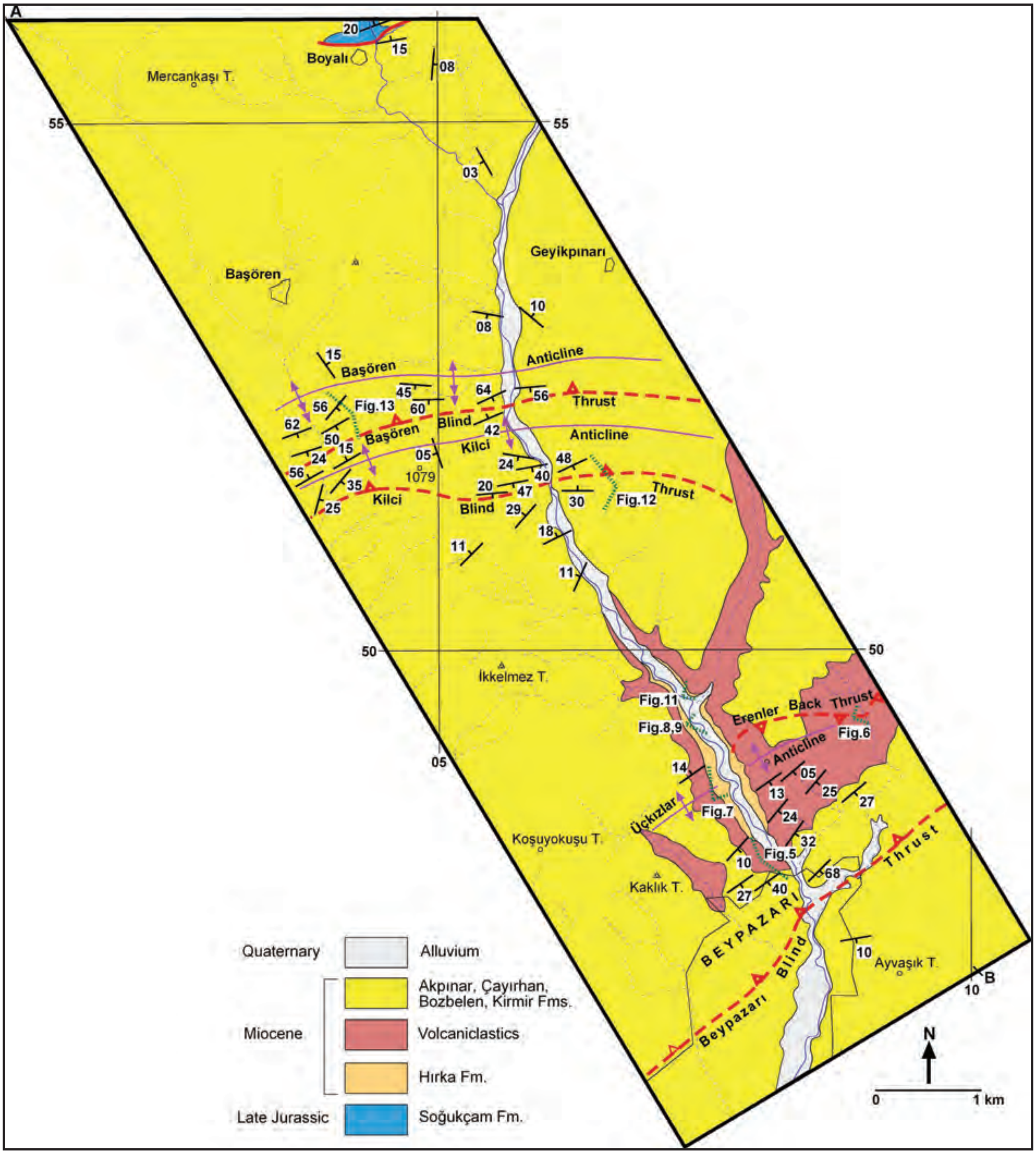

Figure 4- Detailed geological map of the NW Beypazarı.

In the Beypazarı town, Neogene sequence is inclined up to 70° towards SE, but this inclination gradually becomes less (30°) towards north and reach 10° around Üçkızlar Tepe (Figures 4 and 5). In the north of Üçkızlar Tepe, beds are dipping 15° NW. These observations show that the structure reported previously as Beypazarı monocline in the literature is an asymmetric anticline. There is no horizontal limb of fold to interpret the structure as monocline. We propose the formation of asymmetric anticline is related to a fault propagation system, which can be observed clearly on the western slope of the Erenler Tepe (Figure 6), where the hanging wall moved towards NW on the SE dipping fault surface as indicated by drag folds. The continuation of this fault towards WNW can be traced on the eastern slopes of the road located in the İnözü valley as at least three semi-parallel SE dipping fault surfaces (Figure 7).

Figure 5- a) Panoramic view of the Üçkızlar anticline in the SE of İnözü valley and (b) location of the Beypazarı blind fault. For location see figure 4.

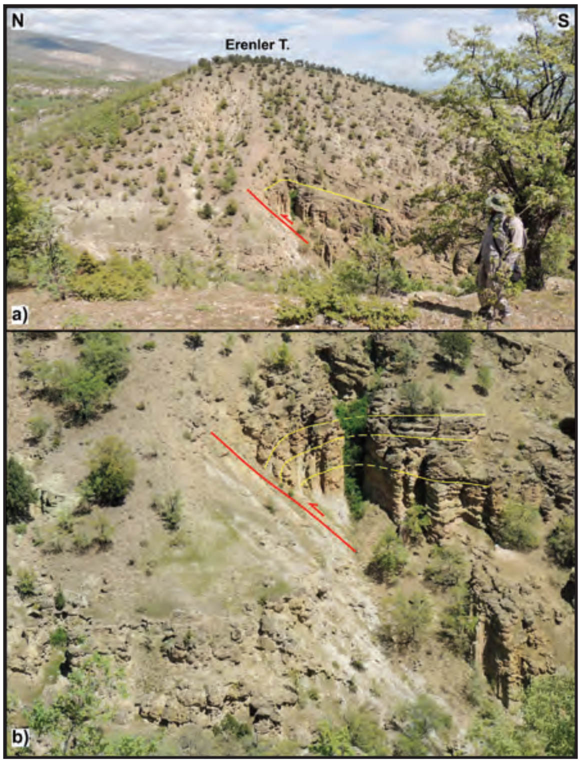

Figure 6- a) The effect of the Erenler back-thrust on volcanoclastic unit. b) detail view of drag folds. For photo locations see figure 4.

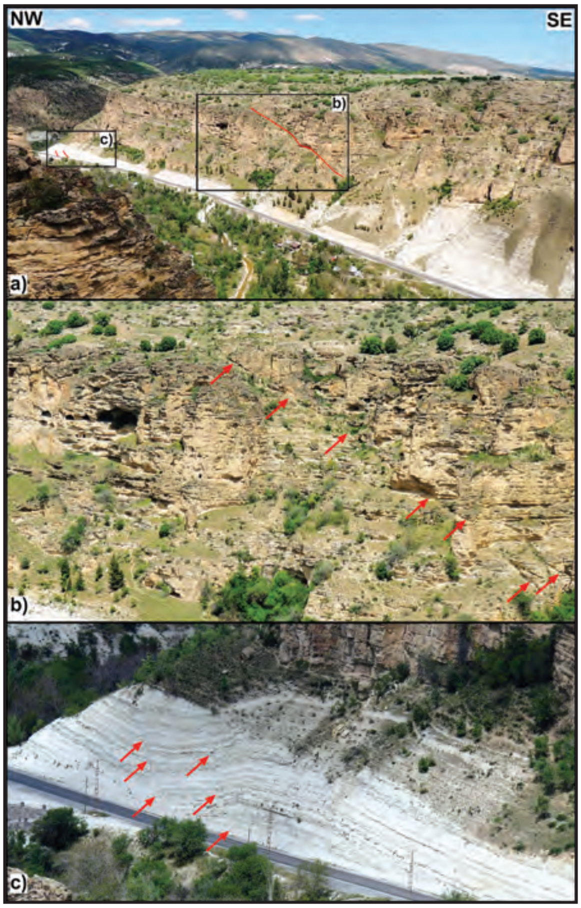

Figure 7- a) The back-thrusts in the İnözü valley. b) The continuation of the Erenler back-thrust in the İnözü valley effects the volcanoclastic unit. c) On the footwall of the Erenler back-thrust, location of semi-parallel back-thrusts. Red arrows indicate thrust surfaces. For details see figures 8 and 9, for location see figure 4.

The drag folds developed in the white marl, tuff and claystone under the volcanoclastic unit clearly indicate that hanging wall movement is towards NW (Figure 8). Upward continuation of these thrust faults cannot be observed and they were developed as blind thrusts (Figure 9). In the north of Beypazarı, main structure is an asymmetric anticline with SE vergence. For this reason, observed NW movement on the SE dipping thrust surfaces can be evaluated as back-thrusts. One can reach a conclusion that the Üçkızlar asymmetric anticline is a fault-propagation fold related to the NW dipping blind thrust (Figure 10), named as Beypazarı blind thrust. This thrust cannot be seen on the surface but its back-thrusts are clearly observed on the road cut of the İnözü valley and western slope of the Erenler Tepe as mentioned above. Therefore the term "Beypazarı monocline" should be changed to "Beypazarı fault-propagation folds" (Figure 10).

Inside the İnözü valley, around Yediler Türbesi, miniature structures of siliceous layers in the marl unit indicate that the movement is towards SE in the N70°E, 15°NW thrust system (Figure 11). These miniature structures mimic the main structure of Beypazarı blind thrust.

Further to north in the İnözü valley, near to the Beypazarı mineral water factory, Neogene sequence is folded again. There are two different anticlines following each other very closely. The smaller southern one is called Kilci anticline (Figures 10 and 12), while the northern one is named as Başören anticline and its southern limb dips more steeply relative to northern limb. These asymmetric anticlines can be traced on the valley of Alan dere, which is located on the west of the İnözü valley (Figures 10 and 13). In the Alan dere, when we closely examine steeply dipping southern limb, it can be recognized that the bedding in the inner part of the anticline has relatively higher angle than the outer part. In other words, dip values of bedding gradually decrease from inner part to outer part of the anticline (Figure 14). This demonstrates that a blind fault is responsible for the formation of the Başören asymmetrical anticline. In the deeper part, the amount of displacement on the thrust fault is higher therefore, we would expect more steep dipping at the inner part of an anticline, but near the surface, the amount of displacement on the blind thrust gradually decreases that in turn creates gentle dipping bedding towards the outer part of the anticline. In the upper section of the sedimentary sequence the effect of deformation gradually disappears. This feature demonstrates that the structures can be attributed to a fault-propagation folding (Figures 10 - 14).

In the investigated area, Beypazarı blind thrust, Erenler back thrust, Kilci blind thrust and Başören blind thrust constitute the Beypazarı Blind Thrust Zone (BBTZ) (Figure 10).

Further to north, in the Boyalı village, the basement, Jurassic-Cretaceous limestone, shows a normal faulted / overlapped relationship with the Neogene sequence. Although its primary position is altered, this relationship can be evaluated as an evidence for normal fault controlled deposition of Neogene sedimentary unit as suggested by Yağmurlu et al. (1988) (Figure 10).

5. Seismicity and Focal Mechanism Solutions

Beypazarı Blind Thrust can be followed easily from SW of Çayırhan to the NE of Beypazarı due

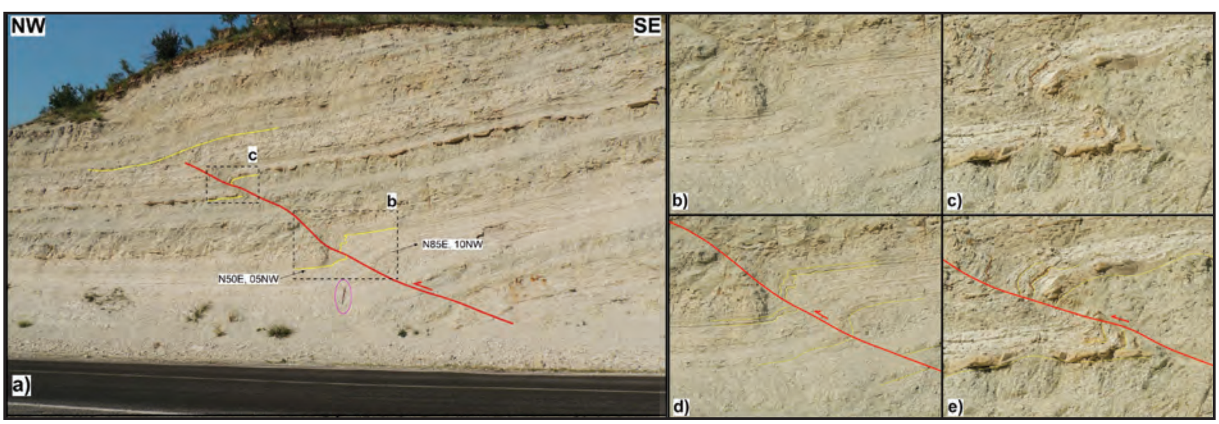

Figure 8- a) In the İnözü valley, the semi-parallel blind thrust developed on the footwall of the Erenler back-thrust. Length of pickaxe is 80 cm. b) and c) The details of drag folds on the blind back-thrusts. d) and e) interpretation of drag folds.

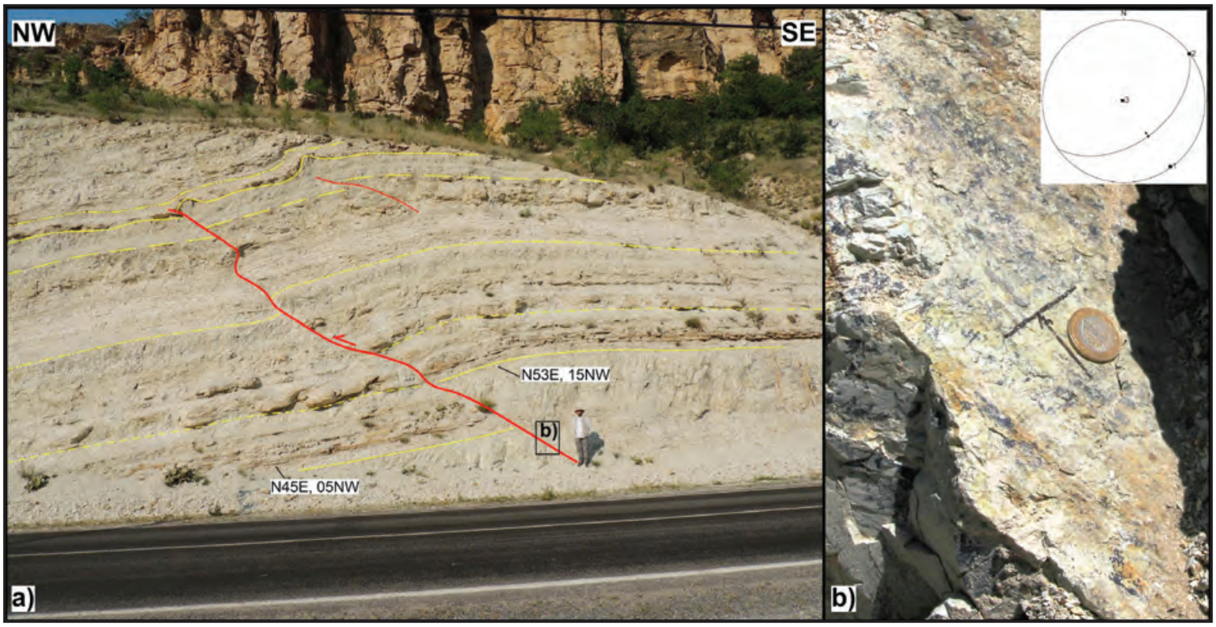

Figure 9- a) In the İnözü valley, the semi-parallel blind thrust developed on the footwall of the Erenler back-thrust. b) The fault surface and slicken lines of the thrust and their lower hemisphere stereographic projection.

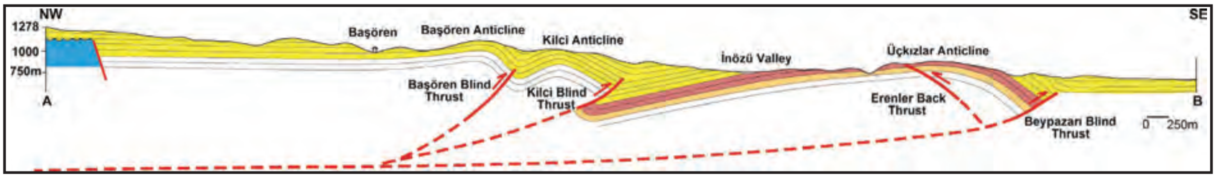

Figure 10- The geological cross section of NW Beypazarı. The position of basal thrust is interpretive. For location see figure 4.

to different dips of bedding in the sedimentary units (Figure 15a). The trending of BBTZ, which consists of the Beypazarı, Kilci and Başören blind thrusts and the Erenler back thrust, and the earthquake activity of the region overlap each other (Figure 15a). Based on the data provided by Boğaziçi University Kandilli Observatory and Earthquake Research Institute (KOERI) the earthquake activity contains seismic events having a range of magnitudes 2.5 and 4.2. The focal mechanism solutions of the events occurred between 2002-2013 (their locations and magnitudes were calculated by KOERI) are determined from P-wave first motion polarities in this study. Therefore the FPFIT algorithm (Reasenberg and Oppenheimer, 1985) based on the first motion polarity was used. The focal mechanism parameters of the events computed in this study are given in table 1.

The focal mechanisms of the recent earthquakes show that some of the seismic activity is related to thrust faulting (event no: 10, 12, 15, 16, 19, 20) (Table 1; Figure 15a). The other focal mechanism solutions indicate strike-slip faulting with both right and left lateral movements (event no: 1, 4, 5, 7, 8, 11, 13, 18). For this reason, it is interpreted that these strike-slip focal mechanism solutions may be related to the tear faulting in the thrust systems. Unmeasured strike slip fault surfaces remotely observed on the steep slopes of the İnözü valley must be related to these tear faults. The third group of focal mechanism solutions are related to normal faulting (event no: 3, 9, 17). These normal faults, semi-parallel to the thrusts are similar to the western margin of Eldivan-Elmadağ Pinched Crustal Wedge (Seyitoğlu et al., 2000; 2009) that were interpreted as compression induced normal faults (Ring and Glodny, 2010).

Result of the structural analysis of overall focal mechanism solutions is compatible with the Beypazarı Blind Thrust Zone. The strike of overall thrust surface obtained from kinematic analysis of the fault-slip data of the focal mechanism solutions is parallel to the blind thrusts shown in this paper and the principle stress direction is perpendicular to the fold axes (Figure 15b).

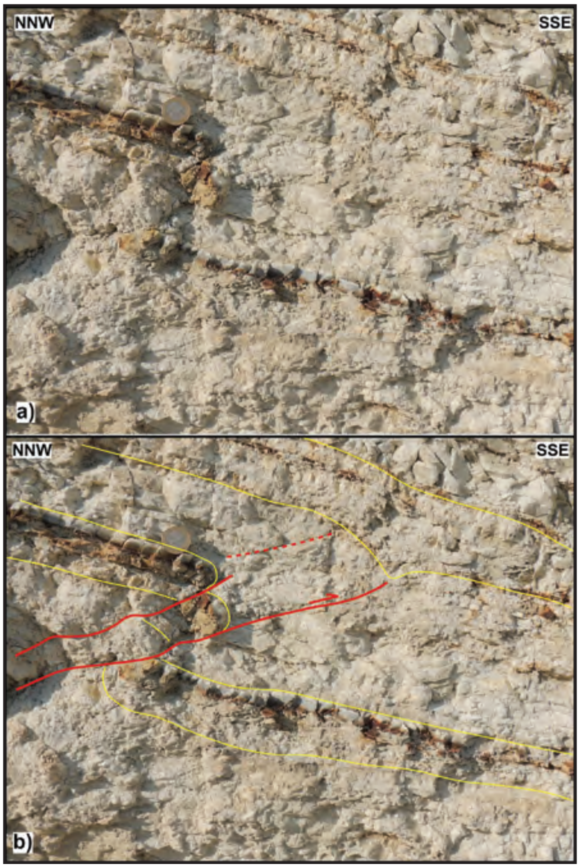

Figure 11- In the İnözü valley around Yediler türbesi, small scale blind thrusts and fault-propagation folds. This small scale structure gives a clue about large scale Beypazarı blind thrust zone. Please make a correlation for the large scale structure on figure 10.

6. Discussions

"Beypazarı Monocline" vs. "Beypazarı fault-propagation folds": Almost all definitions of a monocline mentioned nearly horizontal bedding on both sides of steeply dipping beds. These definitions indicate that previous "Beypazarı flexure or Beypazarı monocline" terminology used in the Turkish geology literature do not represent the structure in the Beypazarı town. Because detailed geological mapping presented in this paper documents that steeply dipping bedding belongs to a limb of asymmetrical anticline. The other limb is not horizontal as in the definition of monocline but dipping opposite side up to 15° (Üçkızlar anticline). This paper also documents that the Üçkızlar anticline is located between Beypazarı blind thrust and its back-thrusts. Additionally, the Kilci and Başören anticlines are recognized in this study and their relationship with the blind thrusting is demonstrated. Therefore, regional structure should be defined as "Beypazarı fault-propagation folds".

The causes of deformation: In the NW central Anatolia, recently determined Eldivan-Elmadağ Pinched Crustal Wedge (EPCW) indicate that the deformation effected Neogene units have neotectonic character and they are developed as a result of interaction between the North Anatolian Fault Zone and Kırıkkale-Erbaa Fault Zone that creates NW-SE contraction (Seyitoğlu et al., 2000; 2009). Later, a

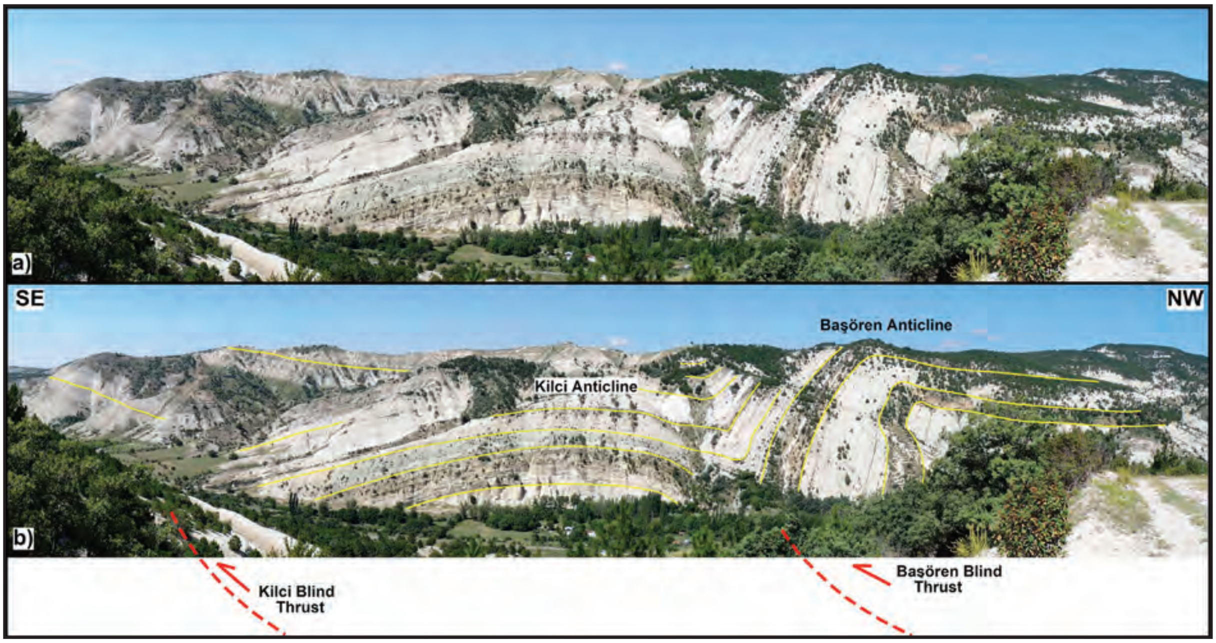

Figure 12- Panoramic photograph of Başören and Kilci anticlines in İnözü valley near to the Beypazarı mineral water factory. a) un-interpreted b) interpreted. Dipping of beds are decreasing to the up section. The position of blind thrusts are drawn by the help of small scale structures in figure 11. For location of the photo see figure 4.

Table 1- The hypocentral and focal mechanism solutions of the seismic events between Beypazarı and Çayırhan.

	HYPOCENTRAL SOLUTIONS													FOCAL MECHANISM SOLUTIONS									
														Plane 1			Plane 2			P-axis		T-axis	
#	Date (yyyy. mm.dd)	Time (hh:mm:ss.s)	Latitude N (°)	Longi-tude E (°)	Depth (km)	Mag.	Ns	Gap (°)	Dmn (km)	Rms (s)	Erh (km)	Erz (km)	Nfm	Strike (°)	Dip (°)	Rake (°)	Strike (°)	Dip (°)	Rake (°)	Azm (°)	Plng (°)	Azm (°)	Plng (°)
1	2002.11.27	02:06:05.66	40.2692	32.0803	12.17	3.20	13	130	77.0	0.42	2.6	0.8	11	295	75	150	33	61	17	347	9	251	32
2	2006.08.28	18:54:19.97	40.2622	32.1530	12.91	3.19	13	142	70.0	0.60	2.4	0.4	9	5	70	100	158	22	64	87	24	291	64
3	2006.12.07	22:59:21.50	40.2637	32.1140	5.00	3.14	22	60	73.0	0.48	1.2	0.4	13	350	10	-20	100	87	-99	360	48	199	41
4	2008.01.26	04:00:22.62	40.2485	32.1133	5.00	3.32	31	49	68.0	0.34	0.8	0.3	20	125	65	0	35	90	155	83	17	347	17
5	2009.01.11	01:51:40.29	40.2988	32.1360	5.00	4.00	77	51	70.0	1.05	2.0	0.9	23	85	75	140	187	52	19	141	15	39	38
6	2009.01.11	02:04:46.43	40.2500	32.1133	5.00	3.30	32	49	68.0	0.76	1.8	0.7	22	50	70	130	162	44	30	112	15	3	49
7	2009.01.11	02:21:34.95	40.2478	32.1142	5.00	3.52	45	49	68.0	0.61	1.2	0.5	16	0	90	40	270	50	180	127	27	233	27
8	2009.01.30	15:43:14.02	40.2452	32.0817	6.81	3.18	26	49	70.0	0.37	1.1	0.2	13	40	55	-10	136	82	-145	4	30	263	18
9	2009.02.09	00:06:31.69	40.2962	32.1603	9.12	3.30	15	70	69.0	0.31	1.0	0.3	8	120	65	-90	300	25	-90	30	70	210	20
10	2009.02.09	08:23:25.26	40.2542	32.1298	5.00	3.50	41	50	68.0	0.68	1.5	0.6	22	200	25	40	73	74	110	147	27	8	56
11	2009.06.09	01:56:08.45	40.1448	31.6782	5.00	3.18	32	44	55.0	0.24	0.6	0.2	13	130	80	150	226	61	12	181	13	84	28
12	2009.07.19	00:54:51.92	40.2075	32.1205	5.00	2.77	16	92	65.0	0.31	1.2	0.4	8	75	85	90	255	5	90	165	40	345	50
13	2009.07.21	19:01:25.24	40.1157	31.6732	8.05	3.07	21	80	57.0	0.47	1.5	0.3	10	180	55	-30	288	66	-141	148	44	52	7
14	2010.08.28	01:03:19.67	40.1777	31.8363	5.00	3.29	12	132	63.0	0.81	3.9	1.3	7	345	85	80	229	11	153	84	39	244	49
15	2010.11.11	23:03:27.42	40.0487	31.6355	7.70	2.97	12	125	60.0	1.08	4.9	0.9	6	160	50	110	310	44	68	236	3	135	74
16	2010.11.20	17:23:03.15	40.1820	31.7265	5.00	2.91	11	165	55.0	0.32	1.8	0.6	7	135	50	130	262	54	53	18	2	112	60
17	2010.12.02	23:01:46.32	40.1240	31.6802	9.83	2.92	13	81	56.0	0.35	1.7	0.3	6	75	30	-120	289	64	-74	228	67	7	18
18	2011.01.12	10:31:34.60	40.1482	31.7363	5.00	3.30	20	85	58.0	0.28	0.8	0.3	9	145	65	170	239	81	25	10	11	105	24
19	2011.09.20	07:34:59.26	40.3032	32.1113	8.52	3.20	27	91	72.0	0.61	1.7	0.4	18	145	55	120	280	45	54	214	6	112	65
20	2013.11.17	20:28:00.36	40.1967	32.1308	5.00	3.10	25	48	64.0	0.42	1.0	0.4	13	25	45	70	232	48	109	309	2	212	76

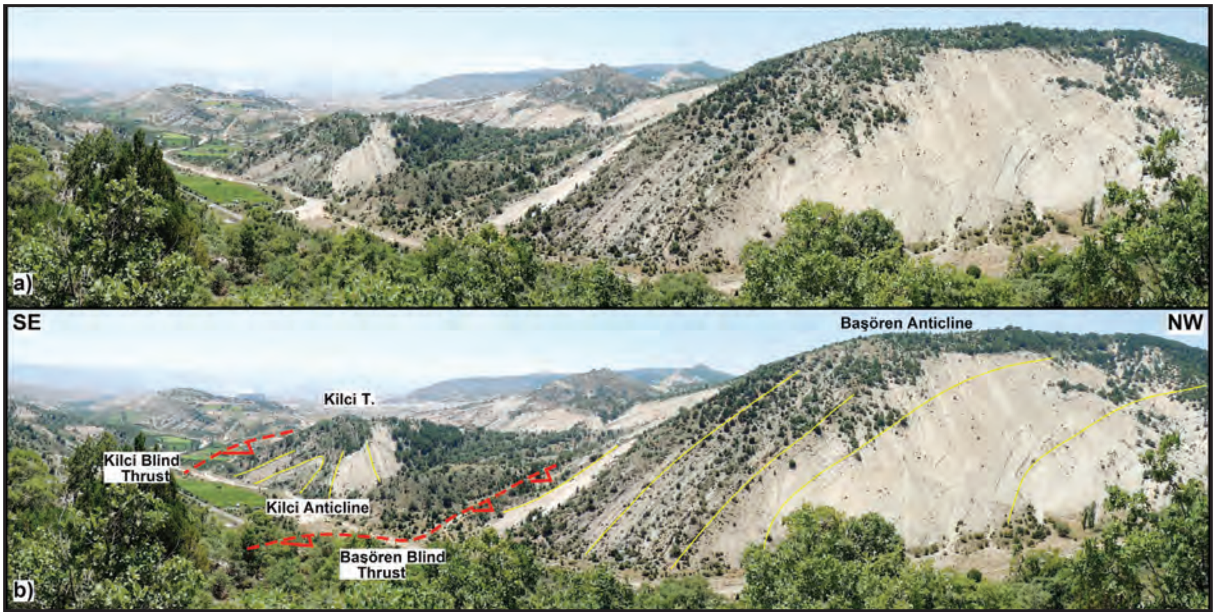

Figure 13- Panoramic photograph of Başören and Kilci anticlines at the north of Eti Soda factory in Alandere. a) un-interpreted b) interpreted. For the location of photo see figure 4.

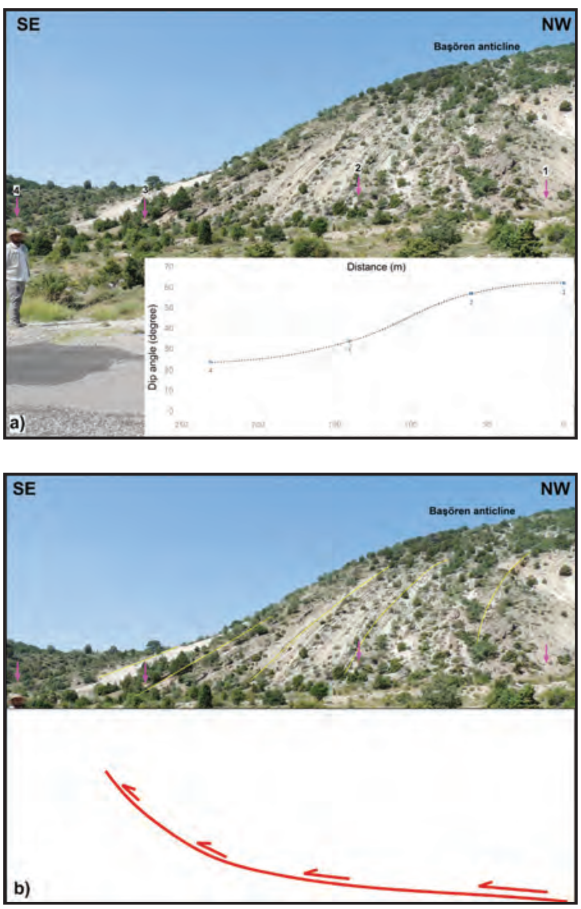

Figure 14- a) The dipping of beds is gradually decreased towards SE at the forelimb of asymmetric Başören anticline in Alan dere. b) The possible relationship between displacement differences on blind thrusting and dipping of beds. Please find that length of arrows indicates displacement differences.

similar Abdüsselam Pinched Crustal Wedge (APCW) is defined and it is stated that triangle-like area between the North Anatolian Fault Zone, Eskişehir Fault Zone and the Kırıkkale-Erbaa Fault Zone is under NW-SE contraction (Esat and Seyitoğlu, 2010; Esat, 2011; Esat et al., 2016; Esat et al., 2017). Inside the triangle-like area, positions of main contractional structures are different (Figure 1). EPCW, is located between Ankara and Çankırı and has a NNE-SSW trend (Seyitoğlu et al., 2009). In the west of Ankara, APCW has NE-SW trend (Esat, 2011; Esat, et al., 2017). The Beypazarı blind thrust zone (BBTZ, its details given in this paper) has ESE-WSW trend. In the NW central Anatolia, the strikes of main contractional structures gradually change from NNE to WSW, this situation must be related to a triangle-like area getting narrower towards west. It is considered that the interaction between the North Anatolian Fault and the Eskişehir Fault created deformation around Beypazarı as previously suggested by Yağmurlu et al. (1988).

The relationship between the earthquake activity and Beypazarı Blind Thrust Zone: The focal mechanism solutions presented in this paper indicate that Beypazarı Blind Thrust Zone (BBTZ) is an active structure (Figures 15a and b). There is an epicenter distribution on the SE of BBTZ. These data indicate that BBTZ is continuing towards SE with a basal thrust. As indicated by the focal mechanism solution of earthquake number 12 (Table 1; Figure 15a), the basal thrust must be shallow dipping towards NW.

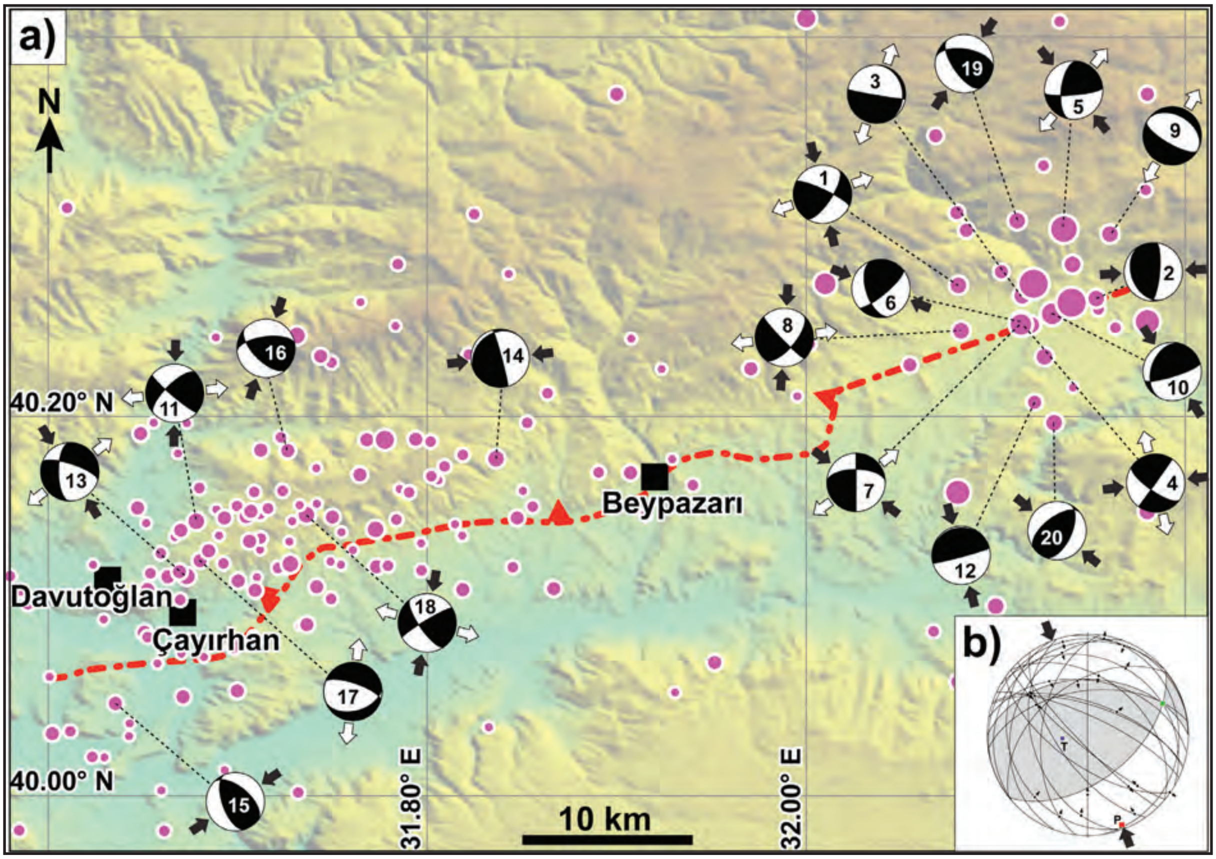

Figure 15- The focal mechanism solutions produced in this study and the seismic activity around Beypazarı . Pink circles represent the earthquakes in the instrumental period. The magnitudes vary between 2.5 and 4.2. Data was taken from Boğaziçi University Kandilli Observatory and Earthquake Research Institute. For details of the focal mechanism solutions see table 1. Red dotted line indicates Beypazarı Blind Thrust b) A structural analysis of the fault-slip data obtained from the focal mechanism solutions. P and T represent the contraction and extension axes, respectively.

The focal mechanism solutions are related to both thrust and strike-slip faulting. The lacking of dominantly right and left lateral strike-slip solutions may indicate that they are related to tear faulting. Similarly, in the NE of the study area, the main and aftershocks of 2000.08.22 Uruş earthquake (M: 4.3) provide solutions of both thrust and strike-slip faulting. Kaplan (2004) attributed these focal mechanism solutions to the NE-SW trending left lateral Uruş (Çeltikçi) fault zone, but these seismic events may well be related to Beypazarı Blind Thrust Zone and related NW-SE trending right lateral tear faulting.

7. Conclusions

The structure known as "Beypazarı flexure" or " Beypazarı monocline" in the Turkish geology literature is in fact a fault-propagation folds related to blind thrusting. For this reason, the name of "Beypazarı fault-propagation folding" is proposed in this paper. All of the blind thrusts that played a role to create this structure are named as the Beypazarı Blind Thrust Zone (BBTZ). Seismic activity and focal mechanism solutions show that BBTZ is an active neotectonic structure. BBTZ is an important element with EPCW and APCW which take up the internal deformation of Anatolian plate between NAFZ, EFZ and KEFZ (Figure 1).

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