HSK1, HEMA2 ve 13 no.lu su örnekleri As, B, Li, Ni, Pb ve Si açısından diğer su örneklerine göre daha zengin olup (EK2), bu minör elementler volkanik bir kökene işaret ederler. Bu suların çatlaklı andezit akiferinden geldiği göz önüne alındığında bu beklenen bir sonuçtur.

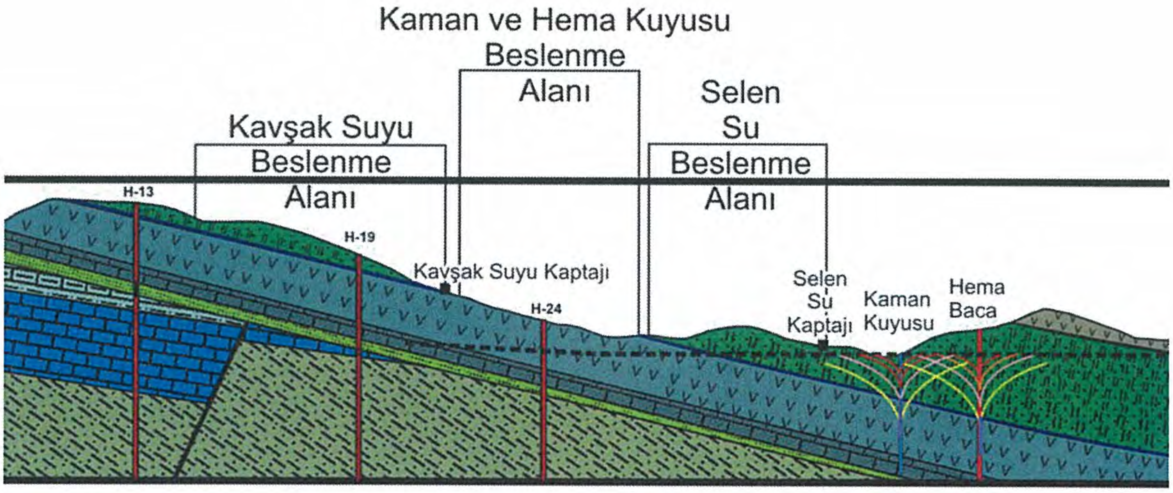
Analizi yapılan sularda HSK1 ve HEMA2 örneklerinde arsenik (As) konsantrasyonlarının içme sularında izin verilen değer olan 10 ppb (µg/L) biraz üzerinde olduğu görülmektedir. HSK1 için As konsantrasyonu 10.3 ppb, HEMA2 için As konsantrasyonu ise 12.5 ppb'dir. 13 no.lu su örneğinin As konsantrasyonu ise 7.8 ppb'dir. Yeraltı su çekimi yapılan HSK1 ve 13 no.lu (Kaman Köyü içme suyu kuyusu) kuyularında kritik olan As konsantrasyonunun periyodik olarak incelenmesinde ve 10 ppb üzerine çıktığı durumlarda ise içme suyu olarak kullanılmasının yasaklanmasında fayda vardır. Kaman Köyü içme suyu kuyusu As konsantrasyonu, Kavşak Suyu'ndan 6.5 kat ve şehir şebeke suyundan 7.8 kat fazladır. Tek dönem kimyasal analiz sonucu ile suların içilebilirliği konusunda karar vermek yerine, mevsimsel olarak analizler yapılarak bir karara varmak gerekir. Eğer bu kuyularda As konsantrasyonları içme suyu olarak kullanımını etkileyecekse, bunları koruma altına alma gereği de ortadan kalkabilir. Ayrıca bu kuyuların suları pH açısından içilebilirlik konusunda sınır değer 9.5 değerine de çok yakındır.

Sular sıcaklıkları açısından incelendiğinde, nispeten derin dolaşımlı olan HSK1, HEMA2 ve 13 no.lu su örneklerinin su sıcaklıklarının 16.1-16.5 °C arası, diğer suların ise 4.7-12.9 °C arası olduğu görülmektedir.
Sonuç olarak HSK1, HEMA2 ve 13 no.lu su örnekleri gerek kimyasal-fiziksel gerekse hidrojeolojik-hidrolojik açıdan bölgedeki diğer tüm sulardan ayrı karakterdedir.

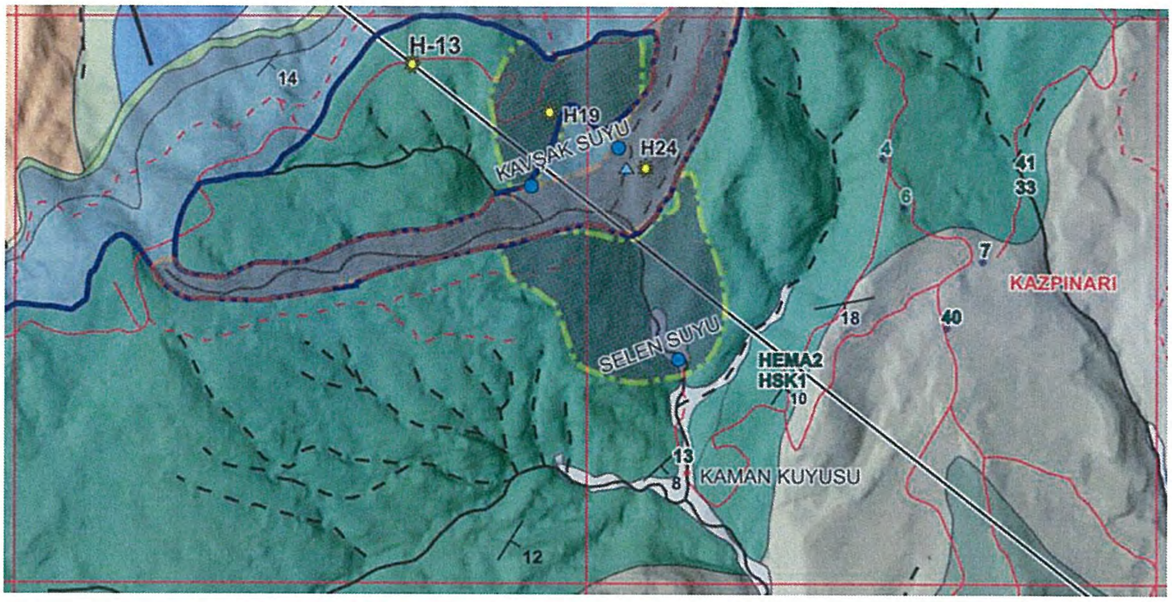
3.5.6. HEMA2 Havalandırma Kuyusu ile Yakınındaki Yeraltı Suyu İşletme Kuyusunun Kavşak Suyu, Selen Suyu ve Kaman Köyü İçme Suyu Kuyusu ile Etkileşiminin İrdelenmesi

Önceki bölümlerde açıklanan hidrojeolojik ve kimyasal veriler sonucunda HEMA'ya ait havalandırma kuyusu (HEMA2), bunun yakınındaki yine HEMA'ya ait olan su kuyusu (HSK1) ve Kaman İçme Suyu kuyusu (bu çalışmada 13 no.lu su noktası, DSİ 665 no.lu kuyu) aynı basınçlı akiferden

(Üst Kretase – Santoniyen yaşlı Andezit-Aglomera) su almaktadırlar (Şekil 22). Üzerinde yer alan geçirimsiz nitelikteki marn nedeniyle akifer basınçlı karakterdedir. Hidrolik açıdan birbiri ile bağlantılı olan bu kuyular, kimyasal açıdan da aynı karakterdedirler. Dolayısıyla bu kuyulardan herhangi birinden yapılacak su çekimi diğer kuyuları etkileyebilir. Ancak, her kuyunun etrafında su çekim miktarı [Q], akiferin hidrolik özellikleri (transmissibilite[T], depolama katsayısı[S]) ve zamanın [t] fonksiyonu olarak bir düşüm konisi oluşur. Bu değerlerin bilinmesi durumunda çekim yapan herhangi bir kuyunun düşüm konisinin yarıçapının diğer bir kuyunun düşüm konisine ulaşıp onu etkileyip etkilemeyeceği, etkileyecekse ne zaman ne kadar etkileyeceği hesaplanabilir. Akiferin hidrolik katsayılarının, pompaj kuyusu yanına açılacak bir gözlem kuyusu ile ölçüm yapılarak hesaplanması gerekir. Bu türde bir test yapılmadan yukarıdaki sorulara net yanıt vermek mümkün değildir.



Şekil 22. Kavşak Suyu, Selen Suyu, HEMA2, HSK1 ve 13 no.lu Kaman İçme Suyu Kuyusu arasındaki jeolojik-hidrojeolojik ilişki ve beslenme alanları (lejant, ölçek vb için bkz EK1)



Şekil 23. Kavşak Suyu, Selen Suyu ve 13 no.lu Kaman İçme Suyu Kuyusu beslenme alanlarını gösteren harita (lejant, ölçek vb için bkz EK1)

Kavşak Suyu'nun akiferi Üst Kretase- Kampaniyen yaşlı Tüf, Kumtaşı, Silttaşı ve Kireçtaşı'ndan oluşan birimdir (Şekil 22). Alttaki andezit akiferi ile üstündeki tüf akiferi aradaki geçirimsiz marn ile birbirinden ayrılmaktadır. Bu birim içerisinde yağış suyu bu birimin çatlakları arasında hareket etmektedir. Çok sığ dolaşımı olan yeraltı suyu, akifer içerisinde hidrojeolojik açıdan çok kısa bir süre (bir kaç ay) akifer içerisinde hareket etmektedir. Yağışlardan hızlı bir şekilde etkilenmekte ve yağışlı zamanlarda bulanmaktadır.

Hidrolik açıdan birbiri ile bağlantısı olmayan bu iki akifer, kimyasal-fiziksel açıdan da oldukça farklıdır. Alttaki andezit akiferinde ve onun altındaki daha yaşlı birimlerde yapılacak herhangi bir faaliyet (su çekimi, sondaj, madencilik) bu su kaynağını etkilemeyecektir. DSİ kuyu verilerine göre son 25 yılda basınçlı akiferde (andezit) oluşan piezometrik seviyenin +205 kotundan +110 kotuna azalması Kavşak Suyunu etkilememiştir. Ancak, bu su kaynağının üzerindeki kotlardaki tüf içerisinde Şekil 22'de Kavşak Suyu beslenme alanı olarak belirtilen bölge ve Şekil 23'de sarı renkli kesikli çizgi ile belirtilen alan içerisinde yapılacak faaliyetler, Kavşak Suyu'nu debi ve kalite açısından etkileyebilir. Selen Suyu için de belirtilen alanlarda benzer durum geçerlidir.

KAYNAKLAR

Akartuna M (1953). Çaycuma-Devrek-Yenice-Kozcağız bölgesinin jeolojisi. MTA Rap no:2059

Albers JP, Kalafatçıoğlu A (1969). Bartın-Amasra earthquake, Turkey, Sept. 3, 1968. USGS Proje raporu (IR) TU-5.

Alptekin Ö, Nabelek JL, Toksöz MN (1986). Source mechanism of the Bartın earthquake of September 3, 1968 in northwesternTurkey: Evidence for active thrust faulting at the southern Black Sea margin. Tectonophysics, 122, 73-88.

Arni P (1941). Amasra taşkömür havzasının jeolojisi ve kıymeti hakkında rapor. MTA Rap no:1266

Egemen R, Pekmezciler S (1945). Amasra taşkömür teşekkülü hakkında jeolojik rapor. MTA Rap no:1686

Gibbs RJ (1970). Mechanisms controlling world water chemistry. Science 170, p.1088-1090

Ketin İ, Abdüsselamoğlu Ş (1969). Bartın depreminin etkileri. Türkiye Jeoloji Kurumu Bülteni, cilt 12, sayı 1-2, 66-76.

Kuşçu İ, Parke JR, White RS, McKenzie D, Anderson GA., Minshull A,

Görür N, Şengör AMC (2004). Amasra açıklarında (GB Karadeniz) aktif kütle kayması ve bunun bölgesel tektonik hareketlerle ilişkisi MTA Dergisi 128, 27-47.

McKenzie D, McKenzie D (1984). Active tectonics of the Alpine - Himalayan belt between western Turkey and Pakistan. Geophysical Journal of the Royal Astronomical Society, 77, 185-264.

McKenzie D (1972). Active tectonics of the Mediterranean region. Geophysical Journal of the Astronomical Society, 30, 109-185.

MGS Proje (2009). TC Ulaştırma Bakanlığı Bolu Ulaştırma Bölge Md, Amasra Limanı Yolcu İskelesi ve Küçük Tekne Yanaşma Yeri, Nihai ÇED Raporu, 103s.

Şengör AMC, Büyükaşıkoğlu S, Canıtez N (1983). Neotectonics of the Pontides: implications for the "incompatible" structures along the North Anatolian fault. Journal of Structural Geology, 5, 211-216.

TC Bartın Valiliği (2006). Bartın İli Çevre Durum Raporu, 260s.

TC Bartın Valiliği (2008). Bartın İli Su Kaynakları Yönetim Stratejisi, 64s.

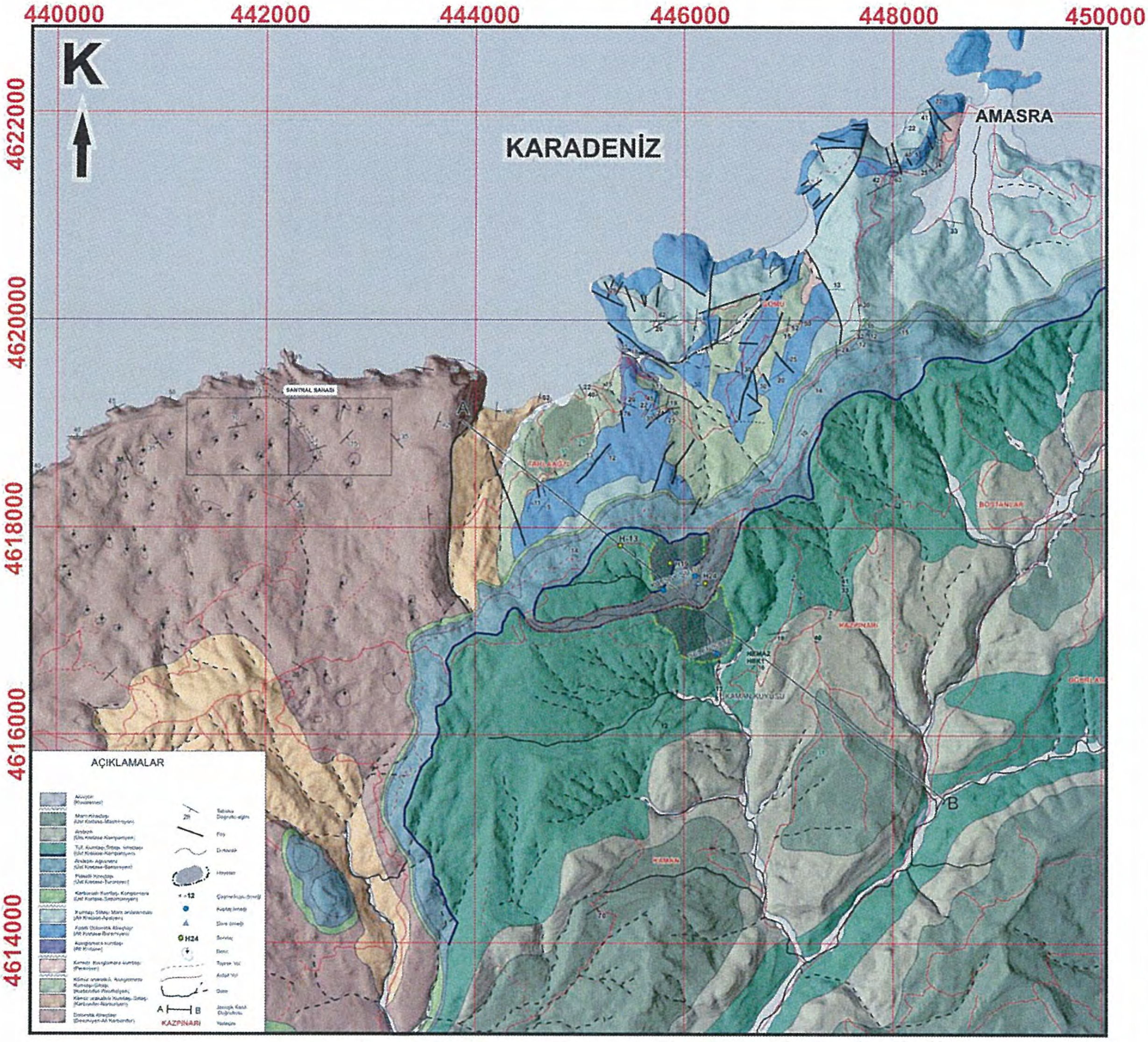
TC Bartın Valiliği (2011). 2010 yılı Bartın İli Çevre Durum Raporu, 230s

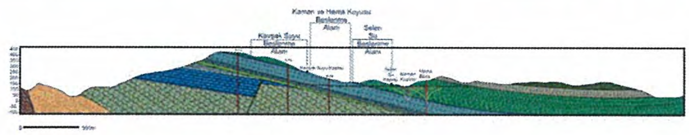
TMMOB (2008). Bartın-Amasra Termik Santral Raporu, 112s.

Tokay M (1954/55). Filyos Çayı Ağzı- Amasra- Bartın- Kozcağız- Çaycuma Bölgesinin Jeolojisi. MTA 46/47, 58-74.

Weeding H (1969). 3 Eylül 1968 de vukua gelen Bartın-Amasra yersarsıntısı MTA Dergisi 71, 135-140

EK 1 - AMASRA GÜNEYBATISININ JEOLOJİ HARİTASI





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Receiving Lab:	Turkey-Ankara
Received:	January 02, 2012
Report Date:	January 27, 2012
Page:	1 of 2

CERTIFICATE OF ANALYSIS ANK12000005.1

CLIENT JOB INFORMATION

Project:	NONE GIVEN
Shipment ID:	
P.O. Number	
Number of Samples:	10

SAMPLE DISPOSAL

DISP-PLP Dispose of Pulp After 90 days

Acme does not accept responsibility for samples left at the laboratory after 90 days without prior written instructions for sample storage or return.

SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

Method Code	Number of Samples	Code Description	Test Wgt (g)	Report Status	Lab
No Prep	10	Sorting of samples on arrival and labeling			ANK
Split Solution	10	Analysis sample split/packet			ANK
2C	10	Water analysis by ICP-MS. Solutions >0.1% TDS run by IC	1	Completed	VAN

ADDITIONAL COMMENTS

Invoice To: Envis Cevre Enerji Sistemleri Arastirma - Gelisti
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	Analyte	Dilution	Ag	Al	As	Au	B	Ba	Be	Bi	Br	Ca	Cd	Ce	Cl	Co	Cr	Cs	Cu	Dy	Er
	Unit		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	1	0.05	1	0.5	0.05	5	0.05	0.05	0.05	5	0.05	0.05	0.01	1	0.02	0.5	0.01	0.1	0.01	0.01
HEM1	Water	1	<0.05	71	10.3	<0.05	202	2.34	<0.05	<0.05	24	3.55	<0.05	0.04	5	<0.02	5.9	0.02	0.4	<0.01	<0.01
HEM2	Water	1	<0.05	547	1.2	0.10	7	18.21	<0.05	<0.05	33	7.43	<0.05	0.37	6	0.07	1.9	0.02	0.8	0.06	0.03
HEM3	Water	1	<0.05	1319	0.6	0.09	6	27.81	0.08	<0.05	23	8.21	<0.05	0.90	5	0.22	2.0	0.05	2.2	0.10	0.07
HEM4	Water	1	<0.05	127	12.5	<0.05	237	3.24	<0.05	<0.05	21	3.52	<0.05	0.03	6	0.05	6.8	0.87	0.5	<0.01	<0.01
HEM5	Water	1	<0.05	2	1.0	<0.05	80	33.16	<0.05	<0.05	21	88.05	<0.05	<0.01	5	<0.02	8.5	<0.01	1.5	<0.01	<0.01
HEM6	Water	1	<0.05	4488	1.8	0.06	9	33.81	<0.05	<0.05	28	8.27	<0.05	1.98	6	0.38	3.7	0.16	4.2	0.15	0.08
HEM7	Water	1	<0.05	448	7.8	<0.05	89	1.68	<0.05	<0.05	32	6.07	<0.05	0.23	7	0.07	6.4	0.03	1.5	0.02	0.02
HEM8	Water	1	<0.05	25	0.7	<0.05	10	38.94	<0.05	<0.05	20	93.55	<0.05	<0.01	5	0.03	7.1	<0.01	5.3	<0.01	<0.01
HEM9	Water	1	<0.05	397	1.9	<0.05	34	17.68	0.05	<0.05	17	42.83	<0.05	0.17	8	0.09	6.3	0.02	2.0	0.02	0.02
HEM10	Water	1	<0.05	1356	1.5	<0.05	22	13.68	<0.05	<0.05	29	18.19	<0.05	0.75	7	0.25	4.4	0.08	2.4	0.07	0.04

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	Analyte	Eu	Fe	Ga	Gd	Ge	Hf	Hg	Ho	In	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	0.01	10	0.05	0.01	0.05	0.02	0.1	0.01	0.01	0.05	0.01	0.1	0.01	0.05	0.05	0.1	50	0.01	0.01	0.2
HEM1	Water	<0.01	39	0.06	<0.01	0.46	<0.02	<0.1	<0.01	<0.01	0.40	0.02	11.6	<0.01	0.50	5.28	10.8	68350	0.03	0.01	2.4
HEM2	Water	<0.01	283	0.13	0.06	<0.05	<0.02	<0.1	0.01	<0.01	2.06	0.22	1.1	<0.01	1.87	1.72	0.6	6991	0.06	0.31	0.3
HEM3	Water	0.02	841	0.29	0.13	<0.05	0.05	<0.1	0.02	<0.01	2.03	0.53	0.7	0.01	2.66	8.92	0.1	4562	0.09	0.61	1.1
HEM4	Water	<0.01	32	0.24	<0.01	0.61	<0.02	<0.1	<0.01	<0.01	14.11	0.02	23.1	<0.01	0.46	1.34	11.0	70180	0.01	<0.01	0.4
HEM5	Water	<0.01	<10	<0.05	<0.01	<0.05	<0.02	<0.1	<0.01	<0.01	0.90	<0.01	5.1	<0.01	12.75	0.77	0.6	14098	<0.01	<0.01	<0.2
HEM6	Water	0.04	2429	0.94	0.16	0.10	0.13	<0.1	0.04	<0.01	1.84	0.91	1.8	0.02	1.65	15.59	0.3	5669	0.26	0.94	1.0
HEM7	Water	<0.01	266	0.11	<0.01	0.24	<0.02	<0.1	<0.01	<0.01	0.45	0.07	8.6	<0.01	1.31	4.17	7.2	71097	0.04	0.08	0.3
HEM8	Water	<0.01	<10	<0.05	<0.01	<0.05	<0.02	<0.1	<0.01	<0.01	1.34	0.02	2.3	<0.01	1.67	0.66	0.2	4803	0.01	0.01	<0.2
HEM9	Water	<0.01	206	0.07	0.02	<0.05	<0.02	<0.1	<0.01	<0.01	1.20	0.06	1.2	<0.01	4.06	2.17	0.6	16509	0.03	0.08	<0.2
HEM10	Water	0.02	801	0.28	0.07	<0.05	0.04	<0.1	0.01	<0.01	1.75	0.28	2.3	<0.01	3.33	9.14	1.8	19606	0.11	0.29	4.0

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	Analyte	P	Pb	Pd	Pr	Pt	Rb	Re	Rh	Ru	S	Sb	Sc	Se	Si	Sm	Sn	Sr	Ta	Tb	Te
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	10	0.1	0.2	0.01	0.01	0.01	0.01	0.01	0.05	1	0.05	1	0.5	40	0.02	0.05	0.01	0.02	0.01	0.05
HEM1	Water	<10	1.3	<0.2	<0.01	<0.01	0.79	<0.01	<0.01	<0.05	3	0.16	3	<0.5	15118	<0.02	<0.05	18.42	<0.02	<0.01	<0.05
HEM2	Water	110	0.3	<0.2	0.07	<0.01	1.35	<0.01	<0.01	<0.05	2	0.09	2	<0.5	10956	0.06	<0.05	63.88	<0.02	<0.01	<0.05
HEM3	Water	31	0.9	<0.2	0.12	<0.01	4.03	<0.01	<0.01	<0.05	3	0.10	2	<0.5	8379	0.12	0.05	59.14	<0.02	0.02	<0.05
HEM4	Water	<10	0.5	<0.2	<0.01	<0.01	44.42	0.01	<0.01	<0.05	7	0.52	3	0.6	15338	<0.02	<0.05	64.74	<0.02	<0.01	<0.05
HEM5	Water	<10	<0.1	<0.2	<0.01	<0.01	0.54	<0.01	<0.01	<0.05	6	0.14	2	<0.5	6929	<0.02	<0.05	214.6	<0.02	<0.01	<0.05
HEM6	Water	134	1.6	<0.2	0.24	<0.01	3.36	<0.01	<0.01	0.06	3	0.18	3	<0.5	14580	0.17	0.12	64.28	0.02	0.03	<0.05
HEM7	Water	27	0.4	<0.2	0.02	<0.01	0.75	0.01	<0.01	<0.05	3	0.07	3	<0.5	16322	<0.02	0.07	31.43	<0.02	<0.01	<0.05
HEM8	Water	22	0.1	<0.2	<0.01	<0.01	3.02	<0.01	<0.01	<0.05	4	0.14	1	0.6	6769	<0.02	<0.05	280.8	<0.02	<0.01	<0.05
HEM9	Water	69	0.2	<0.2	0.02	<0.01	1.22	<0.01	<0.01	<0.05	4	0.15	2	<0.5	11488	0.02	<0.05	153.2	<0.02	<0.01	<0.05
HEM10	Water	20	0.6	<0.2	0.07	<0.01	2.89	<0.01	<0.01	<0.05	7	0.23	3	1.1	13162	0.07	<0.05	83.86	<0.02	<0.01	<0.05

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	Analyte	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	0.05	10	0.01	0.01	0.02	0.2	0.02	0.01	0.01	0.5	0.02
HEM1	Water	0.05	<10	<0.01	<0.01	0.02	2.4	0.47	0.06	<0.01	7.9	0.11
HEM2	Water	0.10	20	<0.01	<0.01	0.04	2.9	<0.02	0.39	0.04	1.7	0.49
HEM3	Water	0.26	55	0.01	0.01	0.06	3.2	0.02	0.68	0.09	4.6	1.64
HEM4	Water	<0.05	<10	<0.01	<0.01	0.04	7.0	0.84	0.03	<0.01	1.7	0.09
HEM5	Water	<0.05	<10	<0.01	<0.01	0.45	2.6	<0.02	<0.01	<0.01	<0.5	0.02
HEM6	Water	0.46	156	0.01	0.01	0.14	10.0	0.07	0.93	0.13	5.2	4.63
HEM7	Water	0.06	21	<0.01	<0.01	0.04	2.0	0.20	0.09	0.02	10.4	0.52
HEM8	Water	<0.05	<10	<0.01	<0.01	0.32	0.4	<0.02	0.03	<0.01	32.1	0.13
HEM9	Water	<0.05	16	<0.01	<0.01	0.15	4.2	<0.02	0.13	0.02	1.0	0.52
HEM10	Water	0.15	55	<0.01	<0.01	0.15	7.0	0.06	0.41	0.04	2.1	1.47

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Client: **I.T.U Insaat Fakultesi**
Cevre Muhendisligi Bolumu
Ayazaga Kampusu
Istanbul Turkiye

Project: NONE GIVEN
Report Date: January 27, 2012

QUALITY CONTROL REPORT ANK12000005.1

	Method	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C
	Analyte	Dilution	Ag	Al	As	Au	B	Ba	Be	Bi	Br	Ca	Cd	Ce	Cl	Co	Cr	Cs	Cu	Dy	Er
	Unit		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	1	0.05	1	0.5	0.05	5	0.05	0.05	0.05	5	0.05	0.05	0.01	1	0.02	0.5	0.01	0.1	0.01	0.01
Reference Materials																					
STD TMDA-70	Standard	1	11.00	453	44.7	<0.05	20	332.1	14.77	10.54	56	21.71	155.6	0.01	34	277.1	368.0	<0.01	392.0	<0.01	<0.01
STD TMDA-70 Expected			10.9	415	40.7			309	15.2	13.5			145			285	389		399		
BLK	Blank	1	<0.05	<1	<0.5	<0.05	<5	<0.05	<0.05	<0.05	<5	<0.05	<0.05	<0.01	<1	<0.02	<0.5	<0.01	<0.1	<0.01	<0.01
BLK	Blank	1	<0.05	<1	<0.5	<0.05	<5	<0.05	<0.05	<0.05	<5	<0.05	<0.05	<0.01	<1	<0.02	<0.5	<0.01	<0.1	<0.01	<0.01

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	Analyte	Eu	Fe	Ga	Gd	Ge	Hf	Hg	Ho	In	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	0.01	10	0.05	0.01	0.05	0.02	0.1	0.01	0.01	0.05	0.01	0.1	0.01	0.05	0.05	0.1	50	0.01	0.01	0.2
Reference Materials																					
STD TMDA-70	Standard	<0.01	376	0.07	<0.01	<0.05	<0.02	<0.1	<0.01	<0.01	0.95	<0.01	21.0	<0.01	5.40	307.9	274.1	8473	<0.01	<0.01	327.5
STD TMDA-70 Expected			369										21.8			302	258				328
BLK	Blank	<0.01	<10	<0.05	<0.01	<0.05	<0.02	<0.1	<0.01	<0.01	<0.05	<0.01	<0.1	<0.01	<0.05	<0.05	<0.1	<50	<0.01	<0.01	<0.2
BLK	Blank	<0.01	<10	<0.05	<0.01	<0.05	<0.02	<0.1	<0.01	<0.01	<0.05	<0.01	<0.1	<0.01	<0.05	<0.05	<0.1	<50	<0.01	<0.01	<0.2

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	Method	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C
	Analyte	P	Pb	Pd	Pr	Pt	Rb	Re	Rh	Ru	S	Sb	Sc	Se	Si	Sm	Sn	Sr	Ta	Tb	Te
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	10	0.1	0.2	0.01	0.01	0.01	0.01	0.01	0.05	1	0.05	1	0.5	40	0.02	0.05	0.01	0.02	0.01	0.05
Reference Materials																					
STD TMDA-70	Standard	<10	448.1	<0.2	<0.01	<0.01	0.64	0.01	0.02	<0.05	7	23.00	<1	24.0	381	<0.02	19.09	453.8	<0.02	<0.01	<0.05
STD TMDA-70 Expected			444									21.7		25.9			19.6	442			
BLK	Blank	<10	<0.1	<0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1	<0.05	<1	<0.5	<40	<0.02	<0.05	<0.01	<0.02	<0.01	<0.05
BLK	Blank	<10	<0.1	<0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1	<0.05	<1	<0.5	<40	<0.02	<0.05	<0.01	<0.02	<0.01	<0.05

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	Method	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C	2C
	Analyte	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
	Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	MDL	0.05	10	0.01	0.01	0.02	0.2	0.02	0.01	0.01	0.5	0.02
Reference Materials												
STD TMDA-70	Standard	<0.05	<10	21.06	<0.01	56.55	298.4	0.07	0.01	<0.01	470.1	<0.02
STD TMDA-70 Expected				20.1		55.9	312				480	
BLK	Blank	<0.05	<10	<0.01	<0.01	<0.02	<0.2	<0.02	<0.01	<0.01	<0.5	<0.02
BLK	Blank	<0.05	<10	<0.01	<0.01	<0.02	<0.2	<0.02	<0.01	<0.01	<0.5	<0.02

English Version

1. INTRODUCTION

This study aims to scientifically document whether the thermal power plants planned to be constructed by HEMA ELECTRIC PRODUCTION COMPANY and WESTERN BLACK SEA ELECTRIC PRODUCTION COMPANY between the city of Bartın and the town of Amasra will have any environmental effect which is measurable/identifiable or way below the acceptable level of risk. In the possible surrounding area of influence, the current situation of the

(i) surface water springs
(ii) ground water springs

will be identified in regards to their usage and characteristics. Research and development, and scientific and technical services will be provided by ENVIS Environment and Energy Systems Research and Development Compnay. The study has been started according to the protocol signed by the two parties on 28 November 2011.

This report has been prepared based on in-situ observations in Amasra and its southwest area during the periods 2-4 December 2011 and 9-11 December 2011, and on the evaluation of current literature. During this study, observations and measurements were conducted to outline the geological and hydrogeological structures of the southwest area of Amasra.

In summary, this project aims to investigate the geological and hydrogeological characteristics of the area covering Tarlaağzı, Kazpınarı, Bostanlar, Kaman village and its surrounding, together with the area laying on the west of Tarlaağzı village which includes Tekke Cape – Poyraz Cape area; and to outline the ground water interferences, if any, between Kavuşak (Kavşak), Selen water springs and Kaman well with HEMA-2 ventilation shaft and the water well of HEMA.

2. INTRODUCTION TO THE WORKSITE

The worksite, being within the borders of the city of Bartın, between Bartın and Amasra accommodation units, including the coastal area between Amasra and Tekke Cape, encompasses a 5x10 km area towards south. The worksite comprises the town of Amasra, Tarlaağzı, Gömü, Kazpınarı, Bostanlar and Kaman Bay (Figure 1).

The areas defined above are to the north of Zonguldak E28c1 map section of the 1:25,000 scale topographic map section.

Figure 1: Examination area map for spotting the locations

3. GEOLOGY AND HYDROGEOLOGY

3.1. Previous studies

In the area, in addition to the geological studies on coal mining search (Amasra Hardcoal Project), many archived *General Directorate of Mineral Researc and Exploration* (MTA) reports exist (Arni, 1941; Egemen and Pekmezciler, 1945; Tokay,1954/55; Akartuna, 1953).

3.2. Local Geology

In the area between Bartın and Amasra, there are Paleozoic (Lower Devonian-Permian), Mesozoic (Cretaceous), Tertiary (Paleocene-Lutetian) and Quaternary formations. Paleozoic is observed in the north, Cretaceous is in the north and southeast, Tertiary is in the southwest on the surface (Figure 2).

In the area, Paleozoic-aged units begin with Devonian-aged red-colored siltstones and they have quartzite over them (Göktepe and Yılanlı-Kokaksu formations). Then, over these units, there are fosiliferous limestones, limestone-dolomitic limestone (Visean, Lower Carboniferous), coal-intercalated clay-layered sandstone-siltstone-shale (Namurain A-B-C; Alacaağzı Stratum; Westfalian; Kozlu Stage; Kozlu Formation), and conglomerate-schist-sandstone-clay (Westfalian B-C-D; Karadon Stage; Karadon Formation). Karadon Stage, which is about 50 meters thick, has red-green -colored sandstone over it (Permian; Çakraz Formation). Units that contain coal seams are covered with Permian and Cretaceous-aged units in the east and Cretaceous-aged units in the west (Tokay, 1954/55).

In the area, Mesozoic Lower and Upper Cretaceous-aged (Barremian, Aptian, Albian, Cenomanian, Turonian, Coniacian, Santonian ve Kampanian) units are observed.

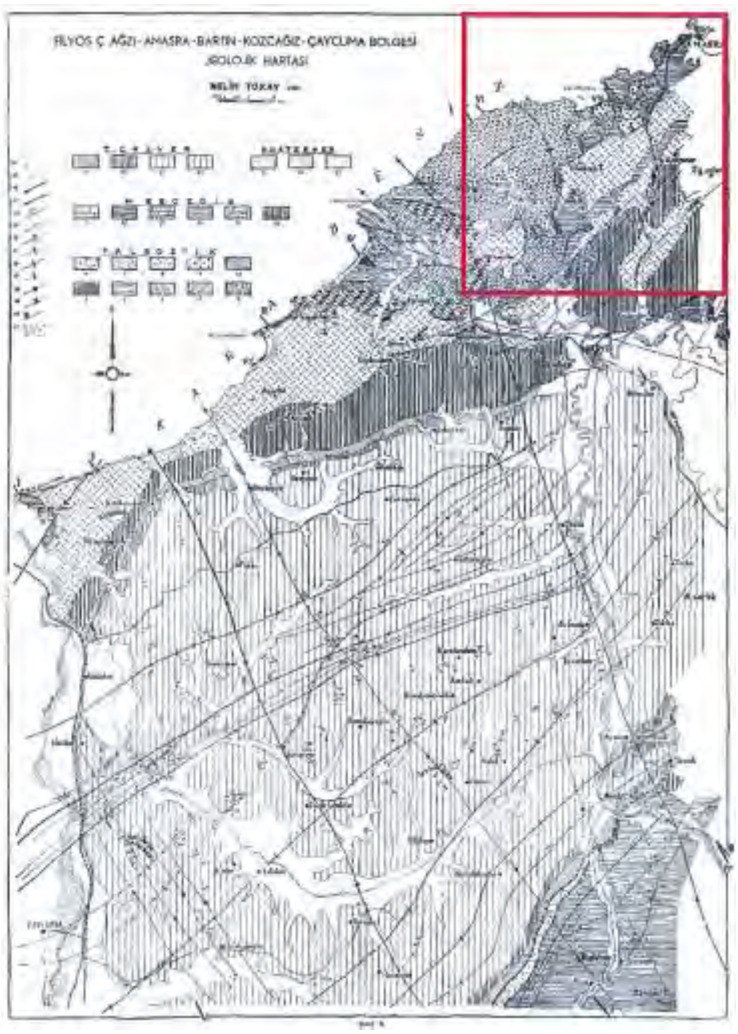


Figure 2: The Geological Map of the Region (Tokay, 1954/55) (The worksite is identified with the red borders.)

In the west, Masezoic-aged units come transgressively directly onto Paleozoic. It starts with base conglomerate (5-15 m), upon it rests carbonated sandstones and limestones (100 m) (Barremian-Aptian; Gömü Formation). Upon these rest Ammonite fossiliferous sandstone-sandy marl-sandy limestone, and in the upper levels (Asker water area) rest crystallised sandy limestones (Albian-Cenomanian; Kilimli and Cemaller – Asker water formations). Its thickness is around 0-160 m. In the southwest Amasra, over these units rest white and pink-colored thin-layered series of marl-limestone (Turonian; Başköy Formation). Around Tarlaağzı area it rests directly on Paleozoic and this unit is usually found under a mass of andesite (Tokay, 1954/55).

Upper Cretaceous-aged volcanic rocks contain andesite, basalt, agglomerate and tuff (Figure 2 and 3). Within this unit exist marl, limestone and tuffite which contain volcanic materials. On the Amasra-Bartın route, near Asker water area, andesite, agglomerate and tuff rest on sedimentary rocks. Sediments here are observed as sandstone, sandy marl and marl which contain volcanic materials. In the east and northwest Meşelik Hill especially agglomerate and tuff predominate. On the other hand, in the Kavşak water area, andesites predominate (Coniacian, Santonian, Kampanian; Dinlence, İkse and Kazpınar formations). Towards southwest, these andesites become thin-layered marls with tuff and volcanic elements (Tokay, 1954/55).

Near Kazpınar Village, marl-limestone-sandstone layers rest between andesites at the bottom and Tertiary formations at the top (Maastrichtian; Alaplı formation). Tertiary, following the marl-limestone series, is observed as pebbly limestone and marl. Paleocene-aged units, with a short gradual transition, become sandy-clayed flysch and marl (Yahyalar and Çaycuma formations). As quaternary-aged, alluvium, beach sediments and sand dunes are observed (Tokay, 1954/55).

3.3. Worksite and the Geology of the Surrounding Area

Paleozoic: The field planned as the Hema Thermal Power Plant construction site is composed of Visean-aged (Lower Carboniferaus) gray-black-colored, sporadical, dolomitic limestone. Other carboniferaus units in the field are Namurian-aged silt and shales stratigraphically located above the limestone, and above them Vestfalian-aged carbonous deposits. Above these units rest multicolored Permian sanstone and mudstone. Above these units, with angular discordance, there are Lower Cretaceous-aged clayed limestone and sparitic limestone stack. At the base of this series, pebbly mudstone and conglomerate formed from the basis are irregularly observed. Above the limestone lay Aptian-aged marl shale sandstone sequence. Above these units and Paleozoic series are Turonian-aged limestones and following them volcanic series, with angular discordance (Attachment 1 Geology Map).

The thickness of the Visean-aged limestone layers range from 30-40 cm to 7-12 m. Limestones are fossiliferous and sporadically contain chert nodules and lenses inside the layers. In the east of the worksite, in Kirazlıtarla Bay, between the Visean-aged limestones Namurian-aged silt and mudstones is limited by a normal fault (Figure 3A and 3B, Attachment 1 Geology Map).

Figure 3 A: The normal fault that forms the Karatarla Cape (facing south) B: The north sloping limestone layers between the Poyraz Cape and Delikli Cape

Dolomitic limestones are made up of close to perpendicular and south sloping layers in the water side of the west of Kirazlıtarla Bay. Starting from Delikliburun, because of the syncline lying from southwest to northwest, layers turn towards northeast (Att.1 Geology Map). Instead, from Delikliburun to the west, all the layers are north sloping by approximately 40 to 60 degrees (Figure-3B). If the slopes on the shore are inside the worksite, they exhibit a structure with undulations. At the worksite, the geology map is created based on the qualitative field model (Att.1 Geology Map). In the upper area, any trace of an active fault morphology is not observed. Only the plane of the normal fault starting from Karatarla Cape lying to south can be observed clearly on the qualitative field model (Att.1 Geology Map).

In the area which includes Tarlaağzı and Gömü villages, there are Carboniferous-aged terrestrial deposit formations. It is observed that from the east to the west the stack gets younger (Att.1 Geology Map). Carboniferous stacks are best observed on the road leading to Tarlaağzı fisherman's shelter and in the west of Kirazlıtarla Bay. Between the Dolomitic limestones and deposit stack lay a normal fault (Att.1 Geology Map, Figure 4). Probably, the stack in the west of the fault that developed in the contact between the two units is sandstone-shale sequence. The layers of the stack in the area known as being Namurian-aged are 40-45 degrees east sloping. Inside the stack along the coast, base structures, cross-layering and canal structures are observed.

Figure 4: The position of the carboniferous stack to the east of Tarlaağzı village

Above the Namurian units are deposits known as the Westfalian series made up of pebble stone, mudstone, sandstone and siltstone (Tokay, 1954/55). In the lower parts of the stack inside the worksite (Westfalian-A) alluminium-rich clay called schieferton are worked on in the west of Tarlaağzı port (Att.1 Geology Map). In this section of the stack, between the gradational transitive sandstones and mudstones, sparsely pebbled levels are found (Figure 5). The typical characteristic of the shales is concresive disintegration.

The characteristic of the Westfalan B-C-D series is being carbonous. The dominating units of the stack which is about 400 m thick are the middle coarse sandstones, thin middle layered dark gray-colored siltstones and sandstones deposited in the context of a river. In the sections of the stack in the Tarlaağzı village that contains conglomerate lenses, the predominating units are the pebbly sandstone levels. In the upper sections small scale drift structures, in the sections that contain coal levels schieferton levels, conglomeratic sandstone pebble stone intercalations along the coast in the east of the port give outcrop (Figure 6).

Figure 5: The look of Westfalian-A series from the west of the Kirazlıtarla port

Figure 6: Conglomerate intercalated sandstones that belong to the Westfalian series on the east of the Kirazlıtarla port

Towards the upper sections thin-layered clayed limestones are followed by shales. These sections can be observed, though a little, on the road that leads to Gömü village.

At the worksite, the top section of the Paleozoic stack is followed by the Permian-aged multicolored sandstone shale stack (Şekil 7). In the stream bed from the east of Kirazlıtarla Bay to the Gömü village, stack can ben observed. In the sandstones with layers that have similar thickness, sedimentary structures are less. Sandstones are red, but thin-grained thick-layered shales are green and yellow-colored, middle layered.

Figure 7: Multicolored sandstones that belong to the Permian series in the stream bed located to the west of Kirazlıtarla port

Mesozoic: Above the Paleozoic stack at the worksite, Cretaceous-aged two packets lie in angular discordance. There is angular discordance between the two packets. Lower Cretaceous-aged stack is considered as two different packets. These are lower series composed of marl-limestone and upper series composed of shale-sandstone and marl. Carbonated section and the lowest section of the stack that is predominated by middle-thick layered limestone start with the conglomerate that is derived from the base. Over these sections whose thickness sporadically reach a few meters come carbonated sandstones and towards the top come sparitic limestones. The area in which this series is best observed is the east coast of Kirazlıyayla Bay and the coastline located in the north of Gömü village (Figure 8).

In the base contact of the limestones in this area, there are Permian-aged sandstones. The fact that the limestones are sloping towards the contact shows that there is no angular discordance of this contact. Probably limestones on the discordance plane were mobilized during the tectonic events (Lower Cretaceous). The contact being close to horizontal shows that this is paleo-landslide. Shales located in the upper sections are best observed in the Gömü village area. Between the shales whose thickness ranges between 20-40 cm, sparse limestone levels and sandstones with varying thickness are observed. These sections that have layers with quite various directions, with the lower limestones, despite being gradational transitive, are separated from the limestones by many small-scaled fault-like contacts. The upper sections of the Lower Cretaceous stack are best observed in the roadcuts between Amasra and Kuşkayası and hillsides in the east of Amasra. Above the Lower Cretaceous stack come Senomanian-aged carbonated sandstones with angular discordance. This stack is about 20-60 meters thick. Gray-white-colored formation on the road between Amasra-Asker water cover both Lower Cretaceous and Paleozoic stack with angular discordance. On the new Bartın-Amasra road, the unit can be seen all along the way (Figure 9).

Figure 8: The look of Lower Cretaceous-aged limestones on the cape that is on the left of Tarlaağzı port. (The yellow line shows the paleo-landslide contact of the Paleozoic stack with the limestones)

Figure 9: On the new Amasra-Bartın road Upper Cretaceous-aged carbonated sandstones

On the old Bartın-Amasra road, over the carbonated sandstones come Turonian-aged pink-colored pelagic and micritic limestones. Their layer thickness is around 10-15 cm (Figure 10). They are transitive with the Coniacian-Santonian-aged volcanic series. This transition can be seen in the roadcuts on the new Amasra-Bartın road.

Figure 10: On the new Amasra-Bartın road Upper Cretaceous-aged pink micritic limestones

In a large area of the worksite, the predominating units are volcanic and volcanogenic sediments. These are products linked to volcanisms developed in the area during Late Cretaceous and have different facies. These have emerged and/or deposited in the field during the period from Coniacian to Kampanian. This series, on the Tortonian-aged limestones, is represented by two lava levels and between them thin-grained level made up of sandstone-shale sequence. It begins in the lower sections with andesitic lava. Lava, with pillow structure and product of underwater volcanisms, sporadically contain carbonated thin lenses. At the worksite, on the road from Asker water to Bartın and on the new Amasra-Bartın road, this volcanic series is present with all of its characteristics. Between andesites, agglomerates and tuffs can be observed (Figure 11).

Figure 11: On the new Amasra-Bartın road, in the Upper Cretaceous-aged volcanic series, thick-layered andesites and tuffs

Over this volcanic series, there is a thin level of 5-10 meters that contains marl-limestone-shale. Tuff-sandstone-shale stack that rests over this level can be seen in Kazpınarı village and in all the valleys starting from the south of the mountain ridge that leads to Airforce radar. From Kazpınarı to the place in which Hema ventilation shaft is located, the upper sections of the stack have open outcrops all along the way (Figure 12).

Figure 12: Sandstone-Shale sequence on the roadcuts between Kazpınarı-Hema Well

On the ridge in which the Hema well is located, a second andesite level gives outcrop. Kampanian-aged andesites indicate the structure of the water; their thickness is between 4-15 meters; and they are interbedded with tuff. Andesites with vertical cracks have dark green and brown alterations. The thickness of the stack is about 100 meters. Over this stack, compatable with it, come with gradual transition the the fossiliferous series composed of tuff and limestone sequence. At the worksite, in the south of the Bostanlar village and on the hills located in the south of the new Amasra-Bartın road, this Maastrichtian-aged series gives outcrop. All of the hills with flat tops located in the south of Kaman and Kazpınarı are made up of this unit.

3.4. Structural Geology and Seismicity

At the worksite, convolutions seen in the dolomitic limestones are closed convolutions and two different convolution axes collide with one another. Because of this, the locations and forms of the faults and convolutions which are developed as a result of the first deformation are deformed during the second deformation stage. Some of the faults developed within the limestones are formed between the layers. These faults between the thick and sound layers can be distinguished by crushed and breccia zones. These crushed zones are the fundamental dissolution points. Paleozoic sediment stack has many small-scale faults within itself. Almost all of these faults are compatible with Cretaceous-aged fault pattern. Early Cretaceous-aged events in the region show a fast faulting and tension regime. In the east of Kirazlıyayla Bay, domino-type normal faults same age as the sedimentation within the limestones point to this regime. Another important structural element is paleo-landslides that have large-scale close to horizontal dislocation plane, created by early Cretaceous tension tectonics that took place in the region (Figure 8). Particularly the faults that seem tectonically incompatible in the area stretching to the sea located in the north of Kuşkayası (Att.1 Geology Map) probably indicate a complication in the region created by a large-scale landslide. Between the limestones that cover the area as Kadırga Cape and Permian-aged multicolored units, in the contact, crushed clayed levels between the base pebble stones may possibly be pointing to a paleo-landslide detachment (stripping). Faults observed inside the Cenomanian-aged sandstones and Turolian-aged limestones are less compared with the Carboniferaus and Lower Cretaceous stack observed under this stack, and they have normal characteristics with approximate direction of northwest-southeast. These faults whose range do not go beyond a few meters can be seen in the roadcuts on the Hema Well road and the new Amasra-Bartın road (Figure 11, 13). On the other hand, Tarlaağzı village rests completely on a young landslide developed on a Carboniferaus series. Complicated layers of the formation in this region and various slopes are products of this landslide. Lower Cretaceous limestones, on the hill that is located in the north of the village, have the characteristic of blocks placed in a landslide flow. In the sections of the village that are located in the south hillsides, in the construction bases, mixed unit blocks that arrived with landslide are present together.

Figure 13: Normal faults in the roadcuts behind the Hema Well

The only knowledge in this century about the seismicity around Amasra is a 6.6 magnitude earthquake that took place on 3 Septemer 1968 at 10.20 in the morning. This moderate-magnitude earthquake caused serious destruction to villages around Bartın and Amasra. According to official numbers, 29 people died and 231 were injured because of the earthquake. The earthquake was felt in the cities that are located between Ankara, Samsun and Istanbul. The epicenter of the earthquake is about 10 km away from Amasra (Figure 14). After the major shock M 4-4.6 magnitude ten aftershocks happened. Right after the earthquake Ketin and Abdüsselamoğlu (1969) who went there for investigation thought that according to the destruction distribution on the land, the epicenter was around Akpınar-Kirlik. Around Amasra area, after the Bartın earthquake, 7 M≥4 earthquakes happened (Table 1).

Ketin and Abdüsselamoğlu's (1969) observations done in the area after the earthquake did not show any surface fracture. Researchers who observed that the coastline between Amasra and Çakraz raised 40-50 cm, concluded that the coast ramp represented a fault plane. In addition, researchers reported that on the Çakraz beach the sea first withdrew then came back and there was damage to a hotel on the coast. It is understood that this sea movement is a typical tsunami. Moreover, in the Amasra bay, the wave raised 1 meter and threw the boats onto the land; the first wave from the coast to the land came in for about 100 meters and the second one for about 160 meters (Wedding, 1969). Kuşçu et al. (2004), in their deep seismic work, mapped a 20 km wide landslide in the seismic sections off Amasra (Figure x). Researchers say that this landslide is Pliocene-aged. What is interesting is that, according to Bartın earthquake epicenter and isoseismal map, the area of this landslide is opposite to the most affected land area, and this shows the relation between the region's earthquake and underwater landslides.

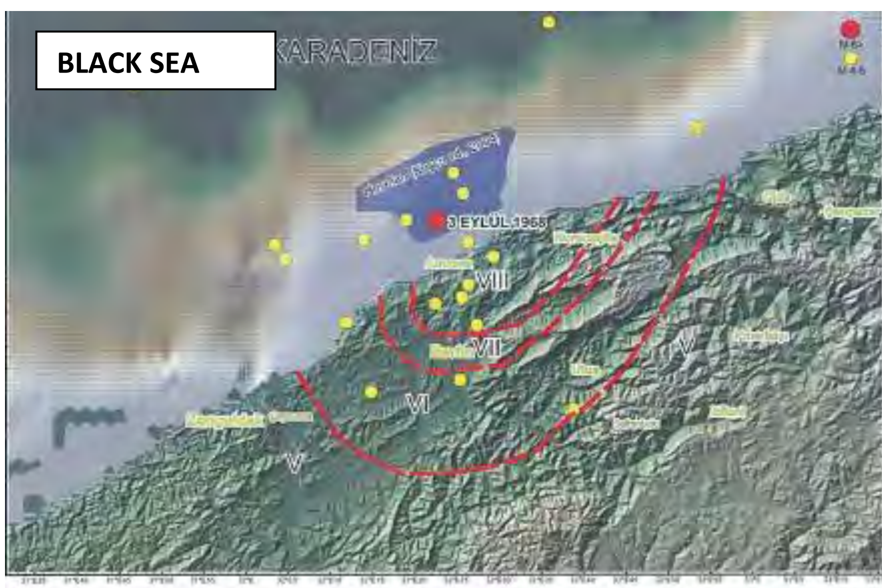


Figure 14: Seismic activity map of Bartın-Amasra and the surrounding (Data: KOERİ)
Isoseismal map (Alptekin et al. 1986) Underwater landslide (Kuşçu et al. 2004)

Those who worked in the region following Bartın earthquake prepared various isoseismal maps (Albers and Kalafatçıoğu, 1969; Ketin and Abdüsselamoğu, 1969). As shown on the prepared maps, according to the Mercalli scale, the epicentral magnitude of the earthquake was 8 (Figure 14). All the analysis conducted for Bartın earthquake point to a strike-slip faulting with reverse faulting (McKenzie, 1972; Jackson and McKenzie, 1984). On the other hand, in the ISC bulletin, using the short period P wave first motions, Şengör et al. (1983) suggested that there was a strike-slip faulting. Alptekin et al. (1986) investigated the short and long period seismograms and suggested that Bartın earthquake was the result of reverse faulting. Analysis of reverse faulting and reverse faulting with strike-slip conducted by researchers are compatible with the rise of shore level observed in Amasra (Ketin and Abdüsselamoğlu, 1969).

Along the Black sea high shores, thrust faults with different ages from Cretaceous to today are identified. There is limited data on which of these faults are active today. Quaternary-aged terraces located in Sinop point to an ongoing activity about the way Black sea high shores are formed.

Table 1. Earthquakes that happened in the last 100 years near Amasra (Source: KOERI)

Date	Time (GMT)	Latitude	Longitude	Depth (km)	Magnitude
20.04.2006	14:10	41.72	32.45	3	4.1
26.05.1990	12:41	42.10	32.60	10	4.0
14.02.1983	07:28	41.95	32.89	33	4.1
18.02.1976	23:07	41.88	32.42	3	4.4
04.07.1972	06:17	41.70	32.44	0	4.0
20.09.1971	10:57	41.58	32.44	0	4.2
20.09.1971	08:02	41.54	32.66	0	4.0
25.02.1969	13:43	41.56	32.27	31	4.3
10.01.1969	16:33	41.66	32.47	18	4.5
28.09.1968	03:25	41.75	32.10	38	4.1
10.09.1968	01:48	41.69	32.39	33	4.1
09.09.1968	11:49	41.66	32.22	33	4.2
03.09.1968	21:08	41.77	32.08	55	4.2
03.09.1968	14:09	41.81	32.33	14	4.3
03.09.1968	12:22	41.78	32.45	33	4.2
03.09.1968	10:56	41.76	32.50	11	4.3
03.09.1968	09:13	41.78	32.25	33	4.4
03.09.1968	**08:19**	**41.81**	**32.39**	**5**	**6.5**

Bartın earthquake is so far the only earhtquake which shows the rise of shore level in the instrumental period. When the facts that the periods of the earthquakes happening in the thrust faults range from 400 to 20000 years and that the parallel thrusts are being mapped on the field are taken into consideration, the number of unknowns about the earthquake risk in the areas in which thrust faults are located increases. In this context, because of the 3 September 1968 earthquake, according to the risk map prepared by the earthquake research department, the city of Bartın has 1 degree earthquake risk (Figure 15).

Red- 1st degree
Purple- 2nd degree
Dark yellow-3rd degree
Light yellow-4th degree
White-5th degree

City centre
Town centre
Dıstrict centre

Red line-active faults
Dashed line-road
Then as follows: Railway, River, Town borders, City borders

ANKARA EARTHQUAKE RESEARCH DEPARTMENT

Figure 15: Earthquake risk map of the city of Bartın (http://www.deprem.gov.tr/sarbis/depbolge/bartin.gif)

According to the analysis conducted by the Ministry of Public Works and Settlement

The risk of a 5.5 Magnitude earhquake (for Bartın)

is calculated as:

For a 25-year period 85.0%

For a 49-year period 97.7%

For a 73-year period 99.8%

For a 97-year period 99.9%

The risk of a 6.5 Magnitude earhquake (for Bartın)

is calcuated as:

For a 25-year period 45.6%

For a 49-year period 70.1%

For a 73-year period 83.4%

For a 97-year period 90.8%

The risk of a 7.5 Magnitude earhquake (for Bartın)

is calculated as:

For a 25-year period 18.2%

For a 49-year period 33.3%

For a 73-year period 45.0%

For a 97-year period 53.8%

(Bartın Governership, 2006).

3.5. HYDROGEOLOGY

3.5.1. Meteorological Data and Water Balance

The average of the meteorological characteristics (temperature, rainfall, sunshine duration, relative humidity and wind speed) of the town of Amasra from 1975 to 2005 are given in Table 2 (Source: Amasra Port Passenger Pier environmental impact (ÇED) report). The average temperature in the town of Amasra is 13.5 °C. The coldest months are December, January, February and March, the hottest are June, July, August and September. The annual rainfall is 996.7 mm, and 29% of the rain falls in winter months, 16% in spring, 21% in summer and 34% in autumn. Although there are seasonal differences in rainfall, in the climate of the area, every season is rainy.

The Penman method is used in order to prepare the water balance using the meteorological data. The annual potential evaporation is measured as 937.6 mm. According to the calculations done in the Table 3, of the annual rainfall of 996.7 mm 813.3 mm evaporates, the remaining 183.4 flows. This water excess is water that flows, and some of this water infiltrates into the soil and constitutes the ground water. The quantity of water that flows and has the capacity to infiltrate into the ground is approximately 18.4% of the rainfall. In the region between Bartın-Amasra in which the wind speed is low, evaporation has a much lower value, potential and actual evaporation is 473.1 mm/year, water excess is 523.6 mm/year. In this case, the amount of water that flows and has the capacity to infiltrate into the ground is approximately 52.5% of the rainfall.

Table 2. Meteorological data of the town of Amasra (1975-2005)

	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Temperature (°C)	6.3	5.8	7.3	10.8	14.8	19.4	21.8	22.0	19.1	15.4	11.5	8.2	13.5
Rainfall (mm)	104.8	67.8	66.0	51.1	43.1	66.1	63.6	81.3	99.3	119.2	114.8	119.6	996.7
Sunshine duration(hour/day)	2.55	3.42	4.50	5.30	7.17	9.05	9.95	9.35	7.68	5.57	3.65	2.57	5.9
Relative humidity(%)	69	69	71	72	76	74	75	75	71	72	68	68	72
Wind speed (m/s)	5.4	5.5	5.1	4.5	4.1	3.9	4.3	4.4	4.5	4.9	5.1	5.8	4.8

Table 3: The meteoroligical water balance prepared by the Penman Method for the town of Amasra

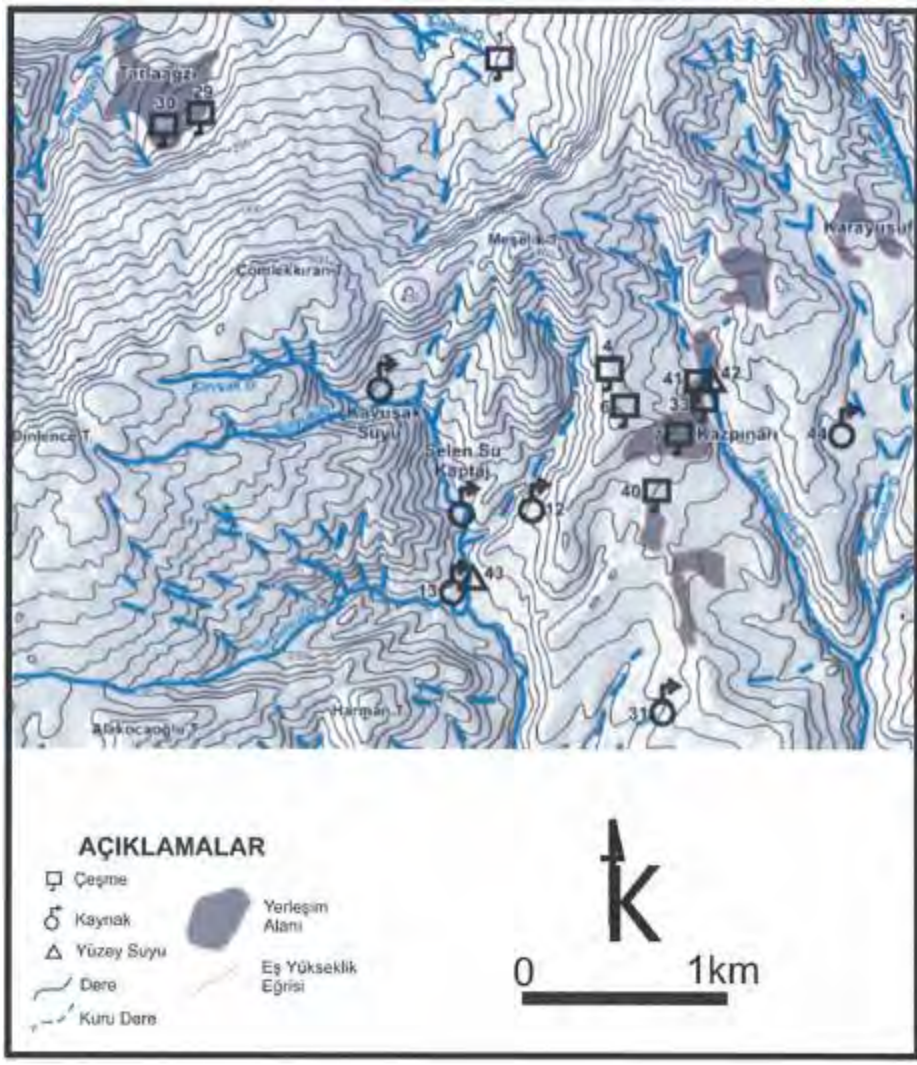
WATER BALANCE METHOD:PENMAN	WATER RESERVE CAPACITY OF SOIL (mm): 100												
RAIN STATION: AMASRA 1975-2005	MONTHS												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YILLIK
TEMP. (°C)	6.3	5.8	7.3	10.8	14.8	19.4	21.8	22.0	19.1	15.4	11.5	8.2	13.5
potential evaportranpiration (mm),EP	42.4	50.3	58.2	71.9	87.6	115.4	133.1	121.5	92.0	64.0	49.6	51.6	937.6
Rain (mm), Y	104.8	67.8	66.0	51.1	43.1	66.1	63.6	81.3	99.3	119.2	114.8	119.6	996.7
Y-EP	62.4	17.5	7.8	-20.8	-44.5	-49.3	-69.5	-40.2	7.3	55.2	65.2	68.0	59.1
Water reserve (mm)	100.0	100.0	100.0	79.2	34.7	0.0	0.0	0.0	7.3	62.5	65.2	100.0	-
Actual evaportranspirat (mm)	42.4	50.3	58.2	71.9	87.6	100.8	63.6	81.3	92.0	64.0	49.6	51.6	813.3
Deficient water (mm)	0.0	0.0	0.0	0.0	0.0	14.6	69.5	40.2	0.0	0.0	0.0	0.0	124.3
Extra water (mm)	62.4	17.5	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	33.2	183.4
Flow (mm)	47.3	32.4	20.1	10.1	5.0	2.5	1.3	0.6	0.3	0.2	31.3	32.2	183.2
Water deficit in (mm) relation to rain	57.5	35.4	45.9	41.0	38.1	63.6	62.3	80.7	99.0	119.0	83.6	87.4	813.5

3.5.2. Water points

In the area chosen as the field for the hydrogeological study, 20 water points are investigated (Figure 16). In these water points, there are 4 water wells with various depths, 12 water springs and connected to them water fountains and 3 surface water places (streams); and samples are collected from water leaking from the ventilation shaft that belongs to HEMA and from the tap water used in the town (Ulupınar spring which is about 30 km away from the town) (Table 4,5,6 and 7).

Table 4. Water points investigated between Amasra-Kazpınar, their coordinates and elevations

No	COORDINATES		Elevation (m)	Type
	X (m)	Y(m)		
HSK1	446654	4616625	190	Water well
KVS	445909	4617228	243	Kavşak water spring
KVSD	446133	4617404	313	Stream water near Kavşak water
HEMA 2	446630	4616521	181	Water leaking from HEMA ventilation shaft with $m^{3/}$hour debit
1	446468	4618850	140	Tap water from the spring
2	446691	4620025	100	Tap water
4	447015	4617331	271	Tap water from the spring
6	447074	4617150	253	Şükrü Acar fountain
7	447359	4616980	226	Tap water from the spring
13	446310	4616218	98	Kaman village well
29	444967	4618620	90	Tap-Nigar Verdi fountain
30	444820	4618531	101	Tarlaağzı water spring
31	447266	4615613	158	A person's well (caisson)
33	447489	4617201	208	A person's well (caisson)
37	446884	4620077	119	Tap water from the spring
40	447234	4616730	225	Tap water from the spring
41	447511	4617274	210	Spring water
42	447511	4617274	210	Çamaşır stream water
43	446337	4616268	101	Kaman stream water
44	448219	4616997	177	Paşa fountain
45	city tap water			Ulupınar (city tap water)



EXPLANATION

Square-Tap
Circle-Spring
Triangle-Surface water
Curved line-Stream
Dashed curved line-Dry stream

Dark patch-Settlement area
Thin curved line-Elevation slope

Figure 16: Location map of the worksite water points

Table 5. Field measurements conducted in the springs and the taps

No	Electrical conductivity (EC)	pH	Temperature (t)℃	Debit
KVS	74	7.0	10.5	2.5 l/s
1	260	8.0	9.0	-
2	330	7.4	7.2	-
4	58	6.5	8.2	-
6	61	6.7	4.7	-
7	58	6.3	7.2	2.6 l/dk
29	85	7.7	8.3	-
30	338	7.5	11.2	0.4 l/s
37	330	7.5	8.6	0.18 l/s
40	100	7.1	7.2	0.3 l/dk
41	592	7.0	12.9	0.25 l/s
44	56	6.6	6.6	2 l/s
45	540	8.0	-	500 l/s

Table 6. Field measurements conducted in the wells

No	Electrical conductivity (EC)	pH	Temperature (t)℃	Static level
HSK1	303	9.1	16.1	77
HEMA 2	348	9.2	16.5	-
13	322	8.6	16.2	0
31	430	7.4	12	1.80
33	603	7.1	12.8	1.90

Table 7. Field measurements conducted on the surface water

No	Electrical conductivity (EC)	pH	Temperature (t)℃
KVSD	65	7.3	7.3
42	280	7.9	9.2
43	180	7.9	8.1

Figure 17: Look of some of the water points investigated at the worksite

3.5.3. Ground Water Level

At the worksite, the level of ground water is measured in the 2 water wells – one shallow one widescale – (31 and 33), in the well that works as the control well for HEMA (HSK1) and Kaman village water well (13); the results are given in Table 6. In the shallow wells (Figure 17), the level of ground water is about 2 m and is very close to the surface. HSK1, 13 and HEMA 2 are piezometric water levels belonging to the fissured andesite with pressurised aquifer quality. Entry to the fissured andesite aquifer from around HEMA-2 is +20 elevation and water level rises to about +110 elevation. In this case, Kaman water well (13) creates artesian flow, and the ground water leaks out of the well by itself. A similar artesian situation is observed during the opening of the HEMA-40 well in Uğurlar village, which is located in the southeast of Kazpınarı.

In order to meet Amasra Hardcoal Enterprises' water needs, in 1985, somewhere between Kazpınar and Military Radar Base, no. 33151 well has been opened by DSİ (general directorate of state hydrolic works) (in the Geology Map and section provided in the attachment, between H24 and Kavşak water). In this well, between 0-45 m tuff-marl, 45-103 m agglomerate-tuff-marl, 103-212 m andesitic tuff and 212-250 m marl-tuff are removed. Similary, water is collected from the pressurised aquifer within the fissured andesite, and the static level is measured as 14 m. The elevation of this well is reported as 219 m in the well log; because the water level is 14 m, it can be said that, around the time of the opening of the well, the piezometric level was around +205 m elevation. Using this information, it can be concluded that, in the well that had less elevation than Kavşak water, the drop in the ground water level by 95 m in the last 25 years (elevation of +205 down to +110) did not affect Kavşak water spring.

Other wells opened by DSİ between 1972-1979 (no.17036, 19969, 20088, 20089 and 25614) are all near the Bartın stream. Here, inside the alluvium in the 50-60 m deep wells, static levels are very close to the surface and wells that flow artesian exist.

3.5.4. Hydrogeological Characteristics of the Geological Units

Limestones detailed in the geology section that are Paleozoic-aged, thick-layered, much convoluted and sporadically dolomitic have a fissured-carstic structure (Figure 18A), and in hydrogeological terms they are very permeable (high permeability). At the worksite and on the coast of Tekke Cape-Poyraz Cape, any water points such as lakes, rivers, springs, wells etc. are not encountered. In about 300 m west of Delikli Burun area, the existence of a water spring coming from the sea level is known to the local residents (Figure 18 B). However, during field investigation, there was no water encountered at the spring point. At the water exit point located on the spring, a weak leakage was observed. Based on this information, it is clear that limestone drains the water it gets from rainfalls quickly into the sea that has the lowest elevation, so cannot accumulate the ground water. In the area, very recently (December 2011-January 2012), ground investigations showed that there was no ground water. Even though it is a very permeable unit, it cannot store the ground water, so it does not have the aquifer characteristic.

Figure 18 A: The karstic structure on the surface in the station area B: To the west of the Delikli Cape, water spring point coming out of the karstic whole

Karstification (dissolution) in limestones is the result of rainwater, which is acidic, reacting with limestone, whose chemical composition is calcium carbonat. The rainwater is acidic because it takes in carbondioxide gas from the atmosphere, so creates carbonic acid, a weak acid (pH~5.5).The rainwater dissolves by reacting with calcium carbonat during the period of change from being acidic to neutral. At the worksite, karstification has mainly occurred on the layer surfaces. In addition, in the surface and the deep, without many deep extensions, many middle-size cave formations can be observed on the coast.

However, in the field, in Sarnıç Çukuru and Sarnıçdere areas, around Karakovuz Tepe and Taşboğazı Tepe, very big and explicit sediment structures that are called doline, pothole, sinkhole etc. exist. Dolines observed during the field work are not very big on the surface and are filled with soil (Figure 19). The most important controller of the karstic characteristic of the worksite is the location of the dolomitic limestone layers. Particularly, on the seaside between Karatarla Cape and Delikli Burun, between the vertical and close-to-vertical layers, development of karstic holes is observed. Some of the caves located on the shore are sediments created by wave energy in the areas in which dissolution between layers is high (Figure 20).

Figure 19: On the field of work, the possible structure of the dolines covered with soil and the basis of a doline in the field

Figure 20: Wholes developed by the effect of the waves, because of the layering observed along the coast

In the field observations done at the worksite, many dolines are observed. 39 dolines are detected in the quantitative field model that is prepared based on the topography data in the 1/25000 map of the region; in the recommended station area, 11 dolines with a diameter between 15-55 meters are mapped (Att.1 Geology Map). Apart from these, in the station area, on the doline that is shaped by 3 interconnected pipes that are approximately in the northwest-southeast direction, and that is 300 m long and 30 m wide, agriculture is being done. During the station field study, a pothole observed while entering the field from south has a diameter of about 20-25 meters and a depth more than 20 meters, and it swallows a seasonal streamlet on which a trail rests. The topographic structure seen inside and around the station field is, rugged in its entirety, is a typical karst topography. Outside the worksite, the observations done in a quarry in the west shows that the karstic characteristics that effectively deform the surface considerably weaken 10-15 meters below the surface. It is observed that in the sections in which the layer is less sloped, the dolines are flat-sided; in the sections where the slope is larger, the dolines are lined up on a straight line and are deeper.

The sections with debris that are Paleozoic-aged are impermeable and cracked only because of the leaked surface water, they have very weak and weak aquifer characteristic.

In the Mesozoic stack Lower Cretaceous-aged limestones and sandy limestones are impermeable; and in the sparitic thick-layered limestones that are found towards the top, dissolution holes are observed in limited areas. Karst is very weak. Marl sandstone shale stack that follows these levels are impermeable and does not contain ground water. The sections of the Upper Cretaceous stack that contain ground water are micritic limestones, cracked andesites and tuffs, which are located on the Cenomanian-aged sandstones. These limited aquifers have local characteristics. For example, the very famous Kavşak water develops only from the series that is located in the north and contain tuff and loose sandstones, and from just above the thin-plated marl limestone level. Selen water spring is a similar case. Water that comes from sandstone-tuff series is distinguished from Kaman water and Hema well water by their low electrical conductivity (EC). Kaman water and Hema water completely feed from cracked and fractured andesites in the stream bed that is located in the south of Kavuşak water, and because of this, as pressurised aquifers they can rise up to 100 m elevation while Selen water can only rise up as normal spring. Similarly, Selen water feeds from the loose sand and tuff stack and the surrounding hills (Att.1 Geological Section). All the springs around Kazpınarı develop from either upper andesites or loose sandstone tuff stack.

In the pumping test conducted in the 25 m-deep well no.33151 opened by DSİ near Kavşak water, when 4 l/s debit water was withdrawn, the drawdown was 34 m. Based on this information, the specific yield of the well as 0.12 l/s/m and approximate transmissibility (T) as 20 m^2/day can be measured. Because it is known that the <u>cracked andesite aquifer</u> is about 80-100 meter-thick, the permeability (hydrolic conductivity) of 0.2 m/day can be found. An aquifer with such permeability value can be classified as a <u>weak aquifer</u>.

In the no.665 well opened by DSİ (in this study no.13 water point), at the end of the pumping test, the water reached a 79 m depth after the water withdrawal of 6 l/s debit. In this case, the specific yield of the well is 0.08 l/s/m; results similar to those of no.33151 well are obtained; in this well, cracked andesite aquifer is a weak aquifer. A well opened in Uğurlar (x: 0449659, y: 4615986) and two in Kazpınarı (x: 0447300, y: 4617800 and x: 0446601, y: 4616701) by DSİ with similar aquifer have specific debits of 0.19, 0.1875 and 0.06 l/s/m, respectively.

When the DSİ wells opened on behalf of Turkish Coal Enterprises (TKİ) are investigated, in the <u>alluviums</u> that are outside the worksite but around the Bartın stream that is inside or close to the station project domain, in the no.25614 well opened in 1979, between 33-56 m the aquifer made up of sand and pebbles has a hydrolic conductivity (K) of 15 m/day; in the no.20089 well opened in 1973, between 22-30 m the aquifer made up of silty pebbly sand has a hydrolic conductivity (K) of 3.5 m/day; in the no.20088 well and no.19969 well opened in 1974, between 31-40 m the aquifer made up of sand and pebbles has a hydrolic conductivity (K) of 270 and 900 m/day; and this is <u>good aquifer</u>. Because the top and bottom of these aquifers are restricted by an impermeable unit, <u>aquifers have a pressurised characteristic</u>.

3.5.5. Chemical Properties of Water

Some of the evaluated properties from the results of the chemical analysis of water conducted by ACME Canada (Att.2) are given in Table 8. Water sent for analysis are numbered from HEM1 to HEM10 and are indicated in paranthesis in Table 8. HSK1 HEMA Water Well water sample, leaked water from the HEMA2 ventilation shaft sample and no.13 Kaman drinking water well sample are distinguished from others by their high Na content; no.45 Ulupınar spring city tap water sample and no.31 a person's caisson well are distinguished from others by their high Ca content.

For the clarification of the chemical properties of water, in order to distinguish the cases in which water-rock interaction has taken place, a diagram proposed by Gibbs (1970) is used. In this diagram, it is shown that HSK1, HEMA2 and no.13 Kaman drinking water well, which gets water from the pressurised cracked andesite aquifer, provide water samples that have chemical properties which have developed <u>due to a long-term interaction with the rock</u>; all other water samples that were analysed (Kavşak water, all stream water, Ulupınar spring water, Paşa fountain, shallow and widescale caisson wells) develop their chemical properties due to the effects of rainwater, and the <u>water's circulation inside the rock is not long enough for reacting with the rock</u>.

Table 8. Chemical analysis results (The sample no. when the analysis was sent to ACME-Canada is indicated in paranthesis – see Att.2)

Sample No	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Si (mg/L)	Alkalinite (mmol/L)	Hardness (°Fr) Calcul.	Hardnes (°Fr) Measure
HSK1 (HEM1)	68.35	0.40	3.55	0.50	15.1	122	1.1	1.6
KVS (HEM2)	7.00	2.06	7.43	1.87	10.9	22	2.6	2.4
KVSD (HEM3)	4.56	2.03	8.21	2.66	8.4	21	3.2	2.8
HEMA2 (HEM4)	70.18	14.11	3.52	0.46	15.4	134	1.1	1.6
45 (HEM5)	14.10	0.90	88.05	12.75	6.9	220	27.3	26.2
44 (HEM6)	5.67	1.84	8.27	1.65	14.6	19	2.8	4.4
13 (HEM7)	71.10	0.45	6.07	1.31	16.3	138	2.1	2.6
31 (HEM8)	4.80	1.34	93.55	1.67	6.8	190	24.1	21.0
42 (HEM9)	16.51	1.20	42.83	4.06	11.5	112	12.4	13.4
43 (HEM10)	19.61	1.75	18.19	3.33	13.2	60	5.9	6.4

HSK1-HEMA water well; KVS-Kavşak water; KVSD-stream water; HEMA2-water leaking from the Ventilation shaft; 45-City tap water (Ulupınar); 44-Paşa fountain; 13-Kaman village well; 31-Keson a person's well; 42-Çamaşır stream; 43-Kaman stream

In addition to their high EC (Table 6), HSK1, HEMA2 and no.13 water samples are basic in terms of PH. The water samples show that they come from the same aquifer hydrogeologically, and it is observed that the water samples are of the same aquifer chemically, too. On the other hand, Kavşak water's aquifer is completely separate, and with its very short circulation, it is clear that it almost has the properties of rainwater. The fact that during rainy periods the water is blurry in the Kavşak water catchment is another indication of the fast effect of the rainwater on the spring.

It is known that the high hardness of Ulupınar water (no.45) is due to a carbonated and karstic aquifer. Another example of high hardness is no.31 (caisson well) water. In the geology map given in the Att.1, it can be seen that this well is located in the Upper Cretaceous-aged Marl-Limestone unit, and because of the carbonated rock its hardness is high.

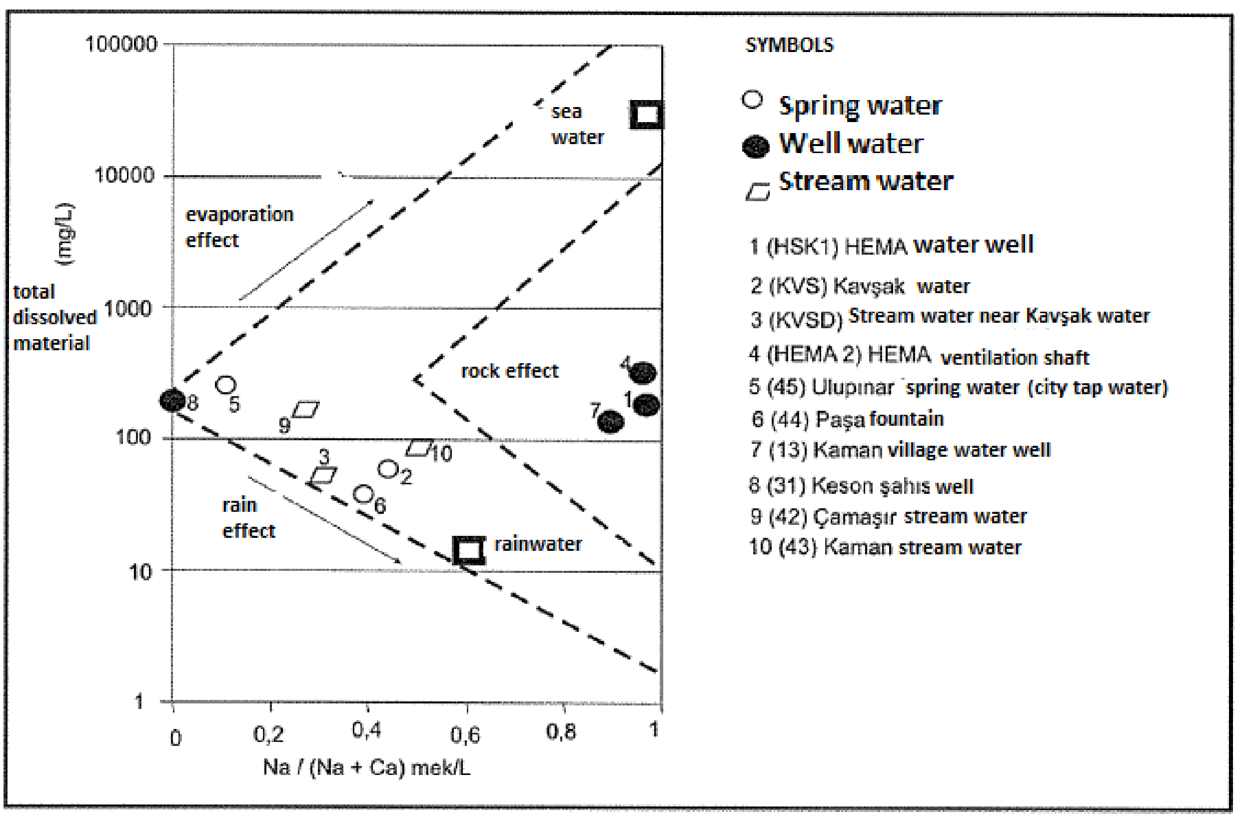


Figure 21: The change of the Na/(Na+Ca) weight ratio as a function of the total dissolved material (Gibbs, 1970)

HSK1, HEMA2 and no.13 water samples are richer compared to other water samples in terms of As, B, Li, Ni, Pb and Si (Att.2), and these minor elements are an indiciation of a volcanic origin. When the fact that these samples are taken from cracked andesite aquifers is taken into consideration, this is an expected result.

It is seen that, in the water samples from HSK1 and HEMA2 that were analysed, arsenic (As) concentrations are slightly higher than the allowed value of 10 ppb (μg/L) for drinking water. For HSK1 As concentration is 10.3 ppb, for HEMA2 As concentration is 12.5 ppb. No.13 water sample's As concentration is 7.8 ppb. HSK1 and no.13 (Kaman village drinking water well) wells, for which ground water was withdrawn, it will be helpful to evaluate the critical As concentration periodically and when it is above 10 ppb ban it from being used as drinking water. Kaman village drinking water well As concentration is 6.5 times higher than Kavşak water and 7.8 times higher than city tap water. Rather than making decisions about the drinkability of water after a single-term chemical analysis, decisions should be made after seasonal analysis. If As concentrations in these wells will affect their use for drinking, the need to protect them may disappear. Moreover, water in these wells has pH values which are very close to the drinkability limit of 9.5.

When these water samples are evaluated in terms of their temperature, HSK1, HEMA2 and no.13 water samples that have a relatively deep circulation have water temperature between 16.1-16.5 °C, and other samples are between 4.7-12.9 °C. In conclusion, HSK1, HEMA2 and no.13 water samples are distinguished from all others in the region both for their chemical-physical and hydrogeological-hydrolojical properties.

3.5.6. The Interaction of HEMA2 Ventilation Shaft and Nearby Ground Water Management Well With Kavşak water, Selen water and Kaman Village Drinking Water Well

Based on the hydrogeological and chemical data presented in the previous sections, it is concluded that HEMA's ventilation shaft well (HEMA2), close to it another water well that belongs to HEMA (HSK1) and Kaman Drinking Water well (in this study no.13 water point, DSİ no.665 well) get water from the same pressurised aquifer (Upper Cretaceous – Santonian-aged Andesite-Agglomerate) (Figure 22). Because of the impermeable marl that is above it, the aquifer is pressurised. These wells that are connected with each other hydrolically also have the same characteristics chemically. Thus, water withdrawal from any of these wells may affect other wells. However, around each well, as a function of water withdrawal amount (Q), hydrolic characteristics of the aquifer (transmissibility (T), storage coefficient (S)) and time (t), a gradient cone is formed. Given these values, whether the radius of the gradient cone of any well that withdraws reaches another well's gradient cone and affects it or not, if it does, when and how much it will be, can be measured.

Hydrolic coefficients of the aquifer have to be calculated through measuring the observation well that is opened near a pumping well. It is not possible to answer the questions above without conducting such a test.

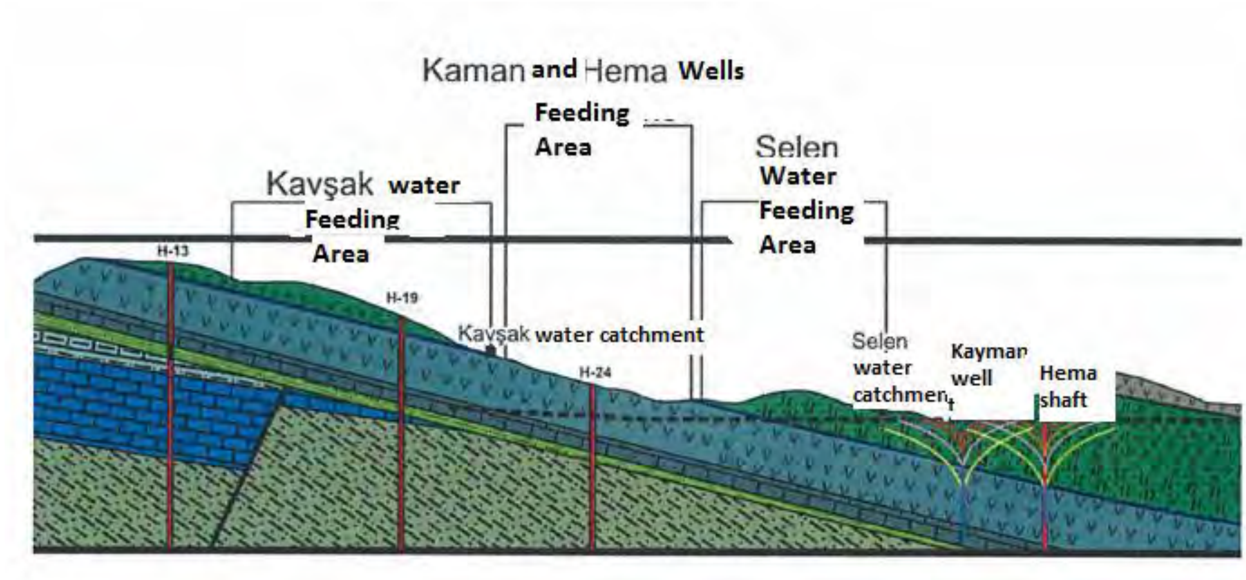


Figure 22: geological-hydrogeological relation and feeding areas between Kavşak water, Selen water, HEMA2, HSK1 and no.13 Kaman Drinking Water Well (for the legend, the scale etc. see Att.1)

Figure 23: The map indicating Kavşak water, Selen water and no.13 Kaman Drinking Water Well feeding areas (for the legend, the scale etc. see Att.1)

The aquifer of Kavşak water is the unit composed of Upper Cretaceous-Campanian-aged Tuff, Sandstone, Siltstone and Limestone (Figure 22). The andesite aquifer at the bottom and the tuff aquifer at the top are separated from each other by the impermeable marl between them. Rainwater inside this unit moves between the cracks of this unit. The ground water that has a very shallow circulation moves inside the aquifer for a hydrogeologically very short time (a few months). It is quickly affected by the rain and gets blurry in rainy periods.

These two aquifers that are not related hydrolically are also quite different chemically-physically. Any activity (water withdrawal, drilling, mining) that will be conducted in the bottom andesite aquifer and in the older units below will not affect this water spring. According to DSİ well data, the drop in the piezometric level created in the pressurised aquifer (andesite) from +205 elevation to +110 elevation in the last 25 years has not affected Kavşak water. However, activities in the region in Figure 22 indicated as the Kavşak water feeding area and in the area indicated by yellow dashed lines in Figure 23, inside the tuffs above the elevation of this water spring, can affect Kavşak water in terms of debit and quality. Same is true for Selen water in the indicated areas.