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Geochemical and Mineralogical Analyses of Basalt Fragments from the Neolithic Settlement of Sumaki Höyük (Batman, Turkey) to Determine the Source Area

Sumaki Höyük (Batman, Türkiye) Neolitik Yerleşiminde Kullanılan Bazalt Parçalarının Jeokimyasal ve Mineralojik Analizlerle Kaynak Alanının Belirlenmesi

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Abstract: This study aims to determine the provenance of grinding stone tools unearthed from the Neolithic phases of Sumaki Höyük settlement using a portable Energy Dispersive X-ray Fluorescence Spectrometer (P-EDXRF) and X-ray Diffraction spectrometer (XRD). Sumaki Höyük is located in the Lower Garzan Basin of Batman province, Turkey. The settlement is dated to 9084±57 - 8123±50 cal BP. Grinding stone tools in this settlement are usually made of basalt. Albeit at low amounts, limestone was also used in the production of grinding stones. The Lower Garzan Basin, located to the east of Diyarbakır Basin, is surrounded by Mount Kıradağı to the west-southwest and Mount Raman to the south, the Garzan Anticlinal and Kentalan Anticlinal to the north-northeast. The basalt flow occurred in the Quaternary period. Samples collected from different parts of the Neolithic phase of Sumaki Höyük and the Kıradağı basalt flows were analysed using P-EDXRF to determine their chemical composition. The same samples were also analysed using XRD to determine their mineral composition. P-EDXRF and XRD analyses reveal that the samples from Sumaki Höyük and Kıradağı are in good accordance with each other. It is therefore understood that the basalt stone tools used in the settlement were taken from the Kıradağı basalts.

Keywords: Basalt, geoarcheology, Neolithic, Sumaki Höyük, Upper Mesopotamia.

Öz: *Bu çalışma, Sumaki Höyük yerleşmesinin Neolitik evrelerinde kullanılmış olan öğütme taşı aletlerin kaynağını (kaynak kayasını) portatif Enerji Dağıtıcı X-ışını Floresans Spektrometresi (P-EDXRF) ve X-Işını Kırınım Spektrometresi (XRD) kullanarak belirlemesini amaçlamaktadır. Kalibre edilmiş* C_{14} *yaşı GÖ 9084±57 ile 8123±50 yılları arası tarihlendirilen Sumaki Höyük, Batman ili sınırları içerisinde, Aşağı Garzan Havzası'nda yer almaktadır. Bu yerleşmede bulunan öğütme taşları, genellikle bazalttan yapılmakta olup az miktarda da olsa kireçtaşları da kullanılmıştır. Bazalttan yapılan öğütme taşlarının çoğu ikincil kullanım olarak mimari yapıların duvar örgülerinde kullanılmıştır. Diyarbakır Havzası'nın doğusunda yer alan Aşağı Garzan Havzası, batı-güneybatıda Kıradağ ve güneyde Raman Dağı, kuzey-kuzeydoğuda Garzan Antiklinali ve Kentalan Antiklinali ile çevrilidir. Çalışma sahasındaki bazaltlar Kuvaterner'de akma şeklinde bulundukları bölgeye yerleşmişlerdir. Sumaki Höyük'ün Neolitik evreleri ile Kıradağı ile Karacadağ bazalt akıntıları alınan numunelerin kimyasal bileşimlerini karşılaştırmak amacıyla P-EDXRF, mineral bilişimlerini ortaya koymak ve karşılatırmak için de XRD analiz yöntemleri kullanılmıştır. Bu analiz yöntemleri sonucuna göre Sumaki Höyük ve Kıradağı'ndan alınan örnekler*

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birbiriyle iyi uyum göstermektedir. Dolayısıyla Neolitik dönem mimari yapı elamanı olarak kullanılan bazalt taş aletlerin Kıradağı bazaltlarından alındığı açık bir şekilde ortaya konmuştur.

Anahtar Kelimeler: *Bazalt, jeoarkeoloji, Neolitik, Sumaki Höyük, Yukarı Mezopotamya.*

INTRODUCTION

Sumaki Höyük is in the northern portion of the Lower Garzan Valley, nearly 2.5 km east of Garzan Stream and 2.7 km north of Mount Kıradağı (Figure 1). The settlement was founded on slightly sloping ground in a southwest-northeast direction on an erosion surface with an elevation of 700-710 meters. According to excavation data between the years of 2007 – 2014 (Erim-Özdoğan and Sarıaltun, 2018), the settlement was bordered by seasonal streams or tributaries with marshy areas to the north and south; and it had the character of a settlement situated on southeast-northwest oriented natural terraces. The dimensions of the settlement, positioned on a mountain-plain transition zone or "hilly flanks" (Braidwood, 1982), are approximately 160 m from north to south and 140 m from east to west with its deepest fill being nearly 2.4 meters.

Sumaki Höyük was mainly occupied during the early Pottery Neolithic, although it had a phase with FPPNB (Final Pre-Pottery Neolithic B) features. The Neolithic settlement has been dated to between 9084±57 to 8123±50 cal BP and was divided into seven phases. (Sarıaltun, 2019). The seven phases each display a different character, not only in settlement pattern but also in the pottery and other assemblages. While phases N7, N3 and N1 are temporary campsites with pottery, Phase N6 is a permanent settlement without pottery, mainly with features resembling LPPNB (late Pre-Pottery Neolithic B), whereas during Phase N5 the settlement seems to have been occupied by both sedentary and mobile people using a small amount of pottery. Phase N4 has a permanent character, although not of long-term because of frequent flood and torrent events. Phase N2 is an intensively occupied temporary campsite with some parts that appear to display relatively permanent features. Although Phase N1 is a temporary campsite, it displays a different culture with a different pottery tradition from phases N7 and N3.

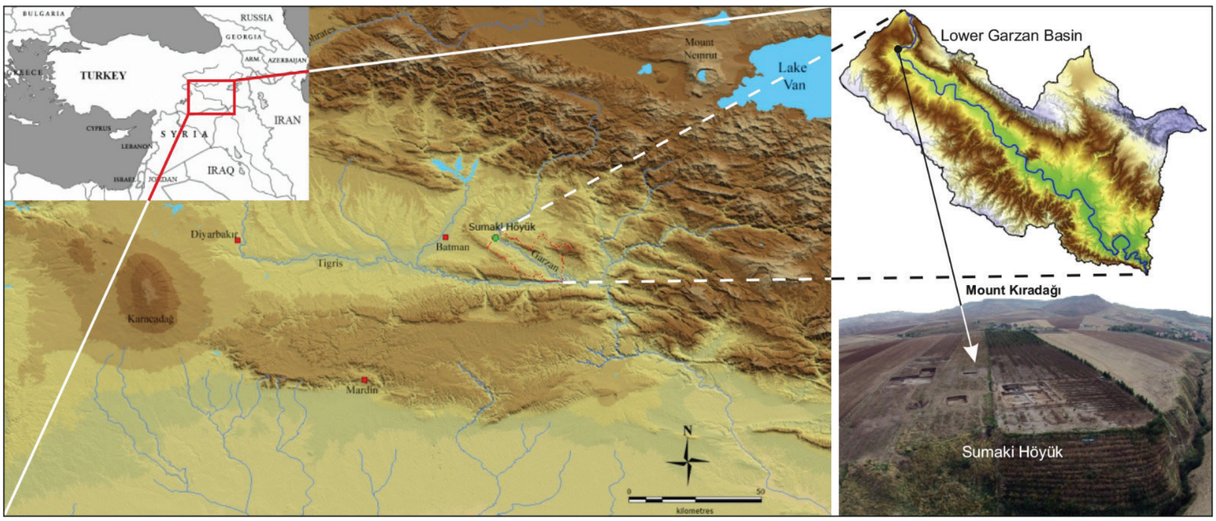

Figure 1. Map of study area showing location of Sumaki Höyük.
Şekil 1. *Sumaki Höyük'ün konumu ve çalışma alanını gösterir harita.*

The Kıradağı basalt flow 2.7 km south of the settlement played an important role in the life span of Sumaki Höyük settlement not only for the supply of basalt and production of Early Mineral Tempered Ware but also by affecting the settlement in terms of landslides and soil flow processes. The Kıradağı basalt flow lies above the Upper Miocene aged claystone, mudstone, sandstone, and conglomerates of the Şelmo Formation.

CASE STUDY: EVIDENCE of BASALT FRAGMENT SOURCES

Archaeometric research often uses analytical methods to determine the raw materials used to produce different artefacts (Antonelli et al., 2014; Baklouti et al., 2015; Eren et al., 2014). Most studies have aimed at revealing the reasons, importance, and analytical meaning of raw material exploitation of past societies (Caricola et al., 2020; Delage and Webb, 2020; Wilson, 2007). In general, the physical properties of the material used in the past have been determined; in some studies, they were investigated with the support of ethnoarchaeological data (Lemonnier, 1986; Whittaker et al., 2009). The focus of all these inferences was to shed light on the complex social dynamics of raw material use.

This study used several perspectives to interpret the choice of basalt as a raw material and deals with three theoretical views. The first of these is the physical landscape perspective; the second covers the functionalist approach, and thirdly are sociocultural implications in the context of the landscape archaeology of Upper Mesopotamia. Sumaki Höyük, a well-documented Neolithic site in the context of the theoretical approaches presented above, is an example of a case study focusing on determining the raw material source of the stone tools and the basalt stone used in the settlement's architecture (Figure 2).

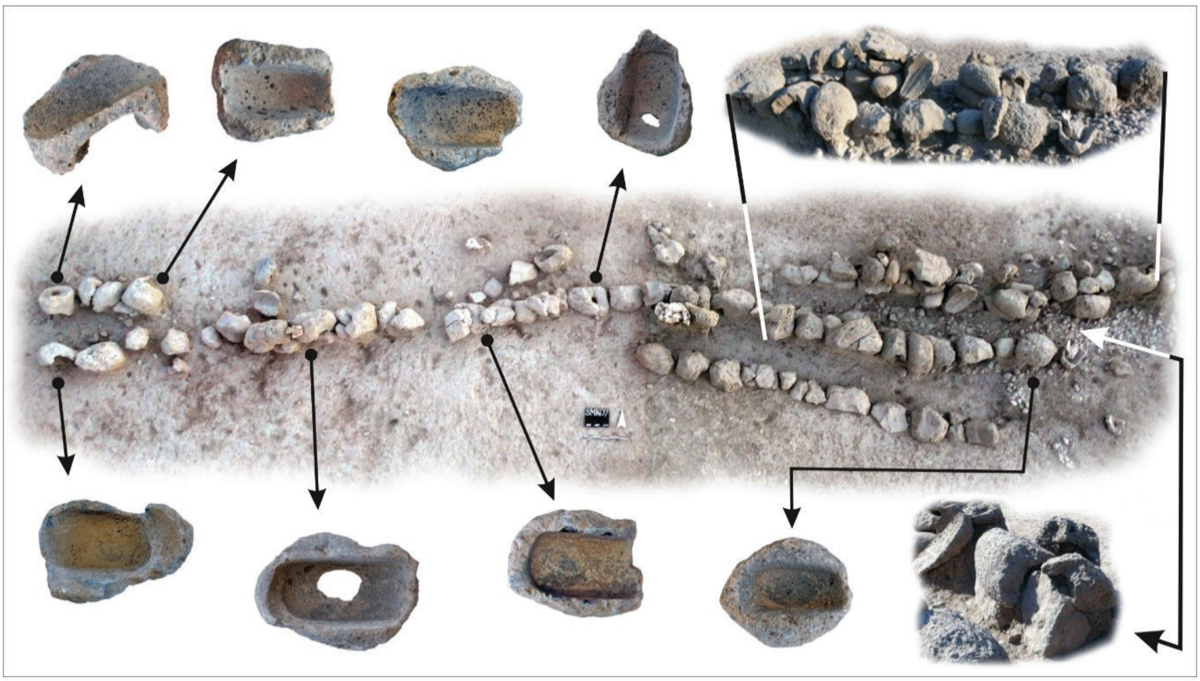

Figure 2: Basalt fragments in secondary use from Sumaki Höyük.

Şekil 2. *Sumaki Höyük'te bazalt numunelerinin ikincil kullanımları.*

Due to the workable stone material in these perspectives, a significant source is represented of both the artefactual and architectural elements of archaeological settlements (Figure 3). In Sumaki Höyük, ground stone tools made of basalt with a similar petrographic structure have been obtained. Basalt was used especially for grinding slabs and hand stones as well as in the temper of early Neolithic pottery. This accords with previous interpretations that local volcanic material was intensively used at Sumaki Höyük.

Spatial and Environmental Setting

The southern part of Southeast Anatolia lies on the northern portion of the Arabian Platform, while the north is located on the Anatolian Peninsula. The suture zone of the Taurus orogenic belt, located between these two continental plates, is comprised of a very different geological structure and units (Yeşilova and Helvacı, 2011). As regards the geological evolution of the study area the Germav Formation was formed in Paleocene in very deep marine facies represented by clay-silt and marl sediments (Güngör-Yeşilova, 2012; Yeşilova, 2012).

Due to a calm marine environment in Eocene, the very thick and dense Midyat Lime-stones (Hoya Formation) were deposited. Towards the end of Eocene and at the beginning of Oligocene, there appears to be a gap in sedimentation due to marine regression. This is the main reason for the partially continental character of the Eocene sediments.

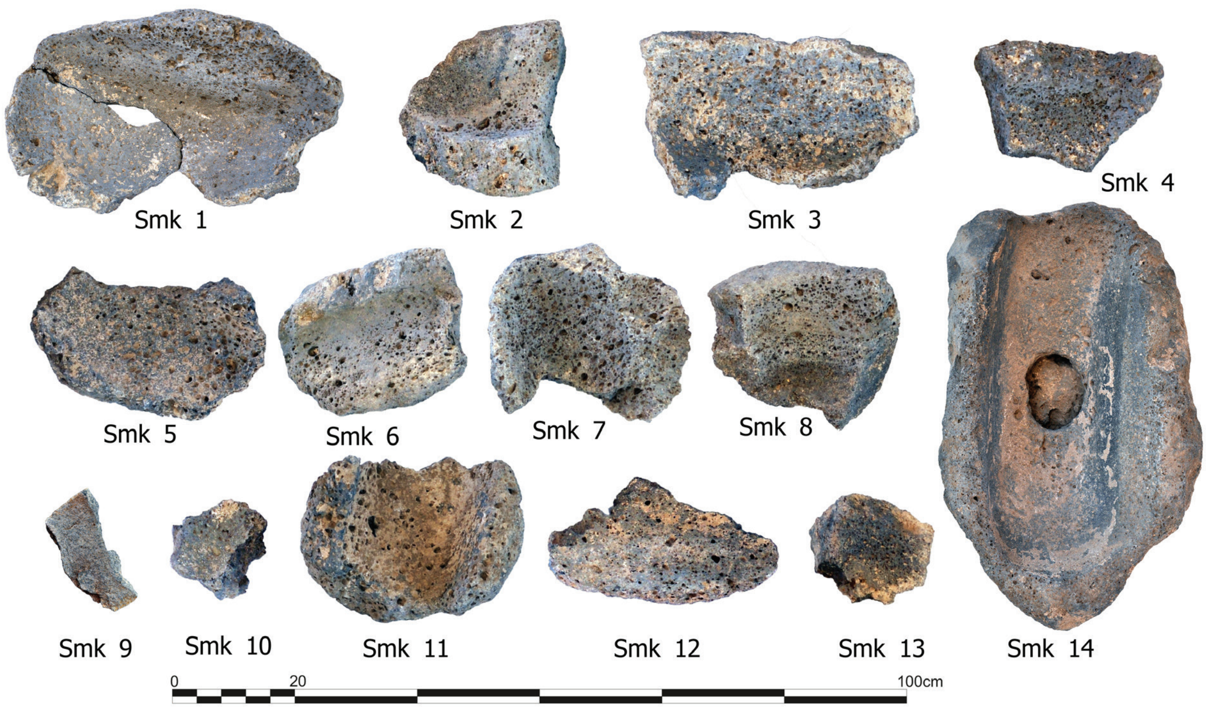

Figure 3. Selected basalt fragments from Sumaki Höyük.
Şekil 3. *Sumaki Höyük'ten seçilmiş bazalt örnekleri.*

As a result of this continental environment at the beginning of Oligocene, sedimentation did not continue at the same rate, and there is a stratigraphic gap in Lower Miocene. These Lower Miocene sediments, which are not seen in geological sections of the Lower Garzan Basin, can be seen on the northern slopes of the Tigris River. As we approach Upper Miocene, the marine environment became significantly shallower and lagoon areas were formed, as seen mainly in gypsum formations. Thus, together with fluvial sedimentation in the continental environment, the clay-conglomerate sediments of the Şelmo Formation were deposited (Altınlı, 1966; Yılmaz and Duran, 1997). This geological unit has the broadest outcrop in our study area. The clay-conglomerate sequences of the Middle-Upper Miocene are beneath the Kıradağı basalt flow (Figure 4), (Gaziulusoy-Yıldızel, 2008; Güngör-Yeşilova, 2012; Sunkar and Tonbul, 2012). Above the Şelmo Formation, there are occasional Kıradağı basalt flows.

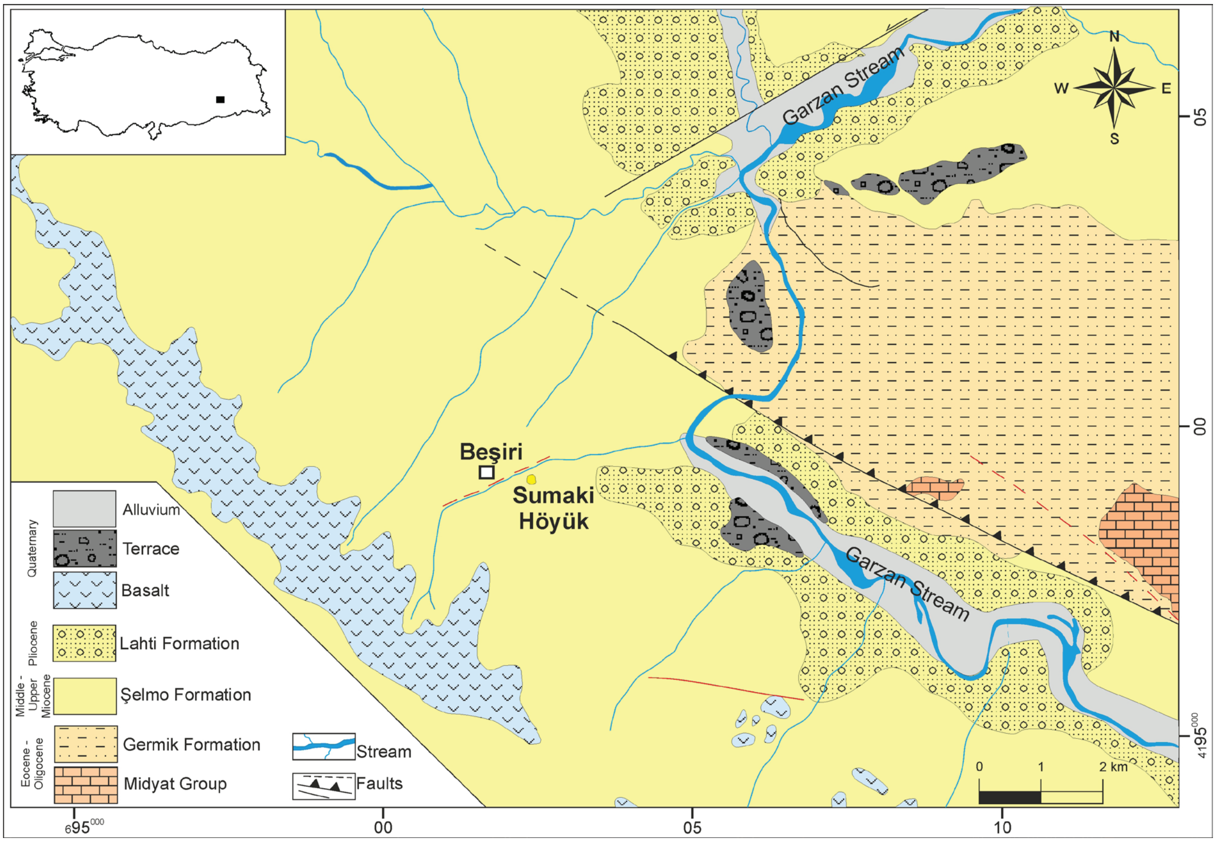

Figure 4. Geological map of Sumaki Höyük and surrounding area and location of Mount Kıradağı (Modified from Şenel, 2007; Yeşilova and Helvacı, 2011; Yeşilova, 2012).

Şekil 4. *Sumaki Höyük ve çevresinin jeoloji haritası ile Kıradağı'nın konumu (Şenel, 2007; Yeşilova ve Helvacı, 2011; Yeşilova, 2012'den değiştirilmiştir).*

Quaternary Volcanism, Raw Materials Availability and Volcanic Segment of the Lower Garzan Basin

The main volcanism in the region is basalt flows emerging from large tectonic faults formed due to the collision between the Arabian Platform and the Anatolian Peninsula (Ardos, 1996; Tolun, 1962). In the area south of the Bitlis suture zone, outcrops of young volcanic rocks are observed (Şaroğlu and Emre, 1987). A product of north-south compression, the volcanism in southeast Anatolia which formed the Karacadağ volcanics began in Upper Miocene and probably continued through later historical periods. The Karacadağ volcanics, formed as plateau basalts, are generally young from northwest to southeast and the basalt flows spread over the surrounding area (Şaroğlu and Emre, 1987; Tolun, 1962).

The basalt flow associated with the Karacadağ volcanics (Figure 5) has been investigated under the names of Kıradağı Formation (Yeşilova and Helvacı, 2011) and Karacadağ Basalt (Tuna, 1973). However, some associate it with Nemrut volcanism (Gürcüoğlu and Turhan, 1992). According to these studies, due to the lack of a broad distribution of thin-regular basalt flow over the Şelmo Formation, and as no topographical link has been found with the Karacadağ basalt flows, the basalt is more associated with volcanism in the north and the Kıradağı Basalt is defined as part of the "Nemrut volcanic" (Şimşek, 1979; Yeşilova and Helvacı, 2011). The Kıradağı basalt lies above the Upper Miocene aged Şelmo Formation and the Pliocene-aged Lahti Formation (Yılmaz and Duran, 1997). As a result, this basalt flow has been dated to the Upper Pliocene-Pleistocene (Yeşilova and Helvacı, 2011). According to Ardos (1996), in the Siirt region both in Pliocene and at the beginning of Pleistocene, lava flows formed along fractures linked to tectonism and spread throughout the surroundings, covering the lower layers. The upper layers of this basalt flow were exposed to greater physical fragmentation, and those sections facing the surface have especially been revealed.

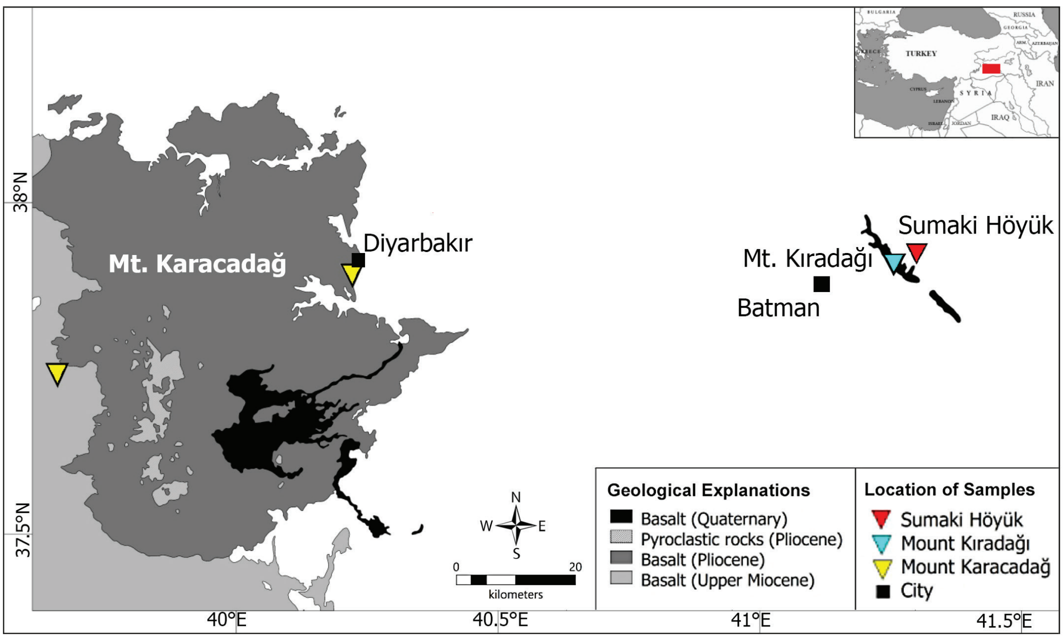

Figure 5. Map showing volcanic unit distribution around study area and sites where basalt samples were taken (modified from Tarhan, 2002 and Turhan et al., 2002).

Şekil 5. *Çalışma alanı çevresindeki volkanik birimlerin dağılımı ve bazalt örneklerinin alındığı yerleri gösterir harita (Tarhan, 2002 ve Turhan vd., 2002'den değiştirilmiştir).*

The Kıradağı basalt, overlying the Şelmo Formation between the Batman depression and the Lower Garzan Basin at an elevation of 950 m, covers an area of nearly 25 km². The approximate thickness of the unit is 20 meters. It is understood from visible sections along the Siirt-Batman Road that the basalt flows accumulated in thick-layered flows in different periods. During the basalt flows, the beige-coloured clay deposits belonging to the underlying Şelmo Formation were partially burnt and form an apparent contact between the two geological units with pink or grey characteristics. In broad flat areas, the peaks of Kuş Tepe (928 m) and Gevirbükü Tepe (1010 m) overlie the Kıradağı volcanism, although they are not very distinct (Sunkar and Tonbul, 2012).

MATERIALS and METHODS

In this study, 14 samples were taken from grinding tools made of basalt unearthed at Sumaki Höyük (Smk) site during archaeological excavations of the Neolithic phase. These grinding tools had been employed in their re-used state and were found especially in the N3-N1 stone rows, on the pillar edges, or in the stone pavement under the hearth. To com-pare the raw materials, 13 basalt samples were taken from Mt. Kıradağı (Kr) located 2.7 km from the archaeological site, and 4 basalt samples from Mt. Karacadağ (Ka), which is at least 70 km from Sumaki Höyük (Figure 5).

Energy-dispersive X-ray fluorescence analysis (XRF) is one of the methods used for elemental analyses in all kinds of samples such as liquids, solids, and powder (Friedman et al., 1999). Many rocks have a highly variable mineral composition (Schackley, 2011), hence qualitative and quantitative analyses of elements can be performed by XRF (Mantler and Schreiner, 2000). Qualitative analyses are used to determine the elements in samples while quantitative analyses determine the per-centage of ingredients in samples. X-ray fluorescence analyses were performed to support the elemental analyses. The chemical composition of solid specimens taken from the structure walls of Sumaki Höyük was conducted with a handheld energy dispersive X-ray fluorescence (P-EDXRF) device and an Olympus Innov X Delta Premium model analyser. The apparatus was equipped with a silicon-drift detector (SDD) and as an excitation source a Rh target X-ray tube. The Geochem mode of P-EDXRF was used for analysis and in this mode 40 KV and 10 KV rays were used for determination of the elements (V, Cr, Fe, Co, Ni, Cu, Zn, Pt, W, Hg, As, Se, Au, Br, Pb, Bi, Rb, Sr, Y, Zr, Th, Nb, Mo, Ag, Cd, Sn, Sb, Mg, Al, Si, P, S, K, Ca, Ti, Mn, U, LE) with a 140-second counting for each analysis. These analyses were performed at Batman University, Department of Archaeometry.

An essential method complementing the P-EDXRF and XRD analyses, which identifies and describes the minerals contained in solid samples according to their crystal structures (Shrivastava, 2009). By using this method, all minerals in the sample can be identified by patent assignment. Information on the number of minerals also becomes available. In short, the environmental conditions during the deposition process of a sample can be understood utilizing XRD analysis (Schreiner et al., 2004). The specified minerals and their related elements were interpreted in our study. For the XRD analyses, a Philips X'Pert Pro device was utilized at the Izmir Institute of Technology, Centre for Materials Research.

Use of XRF and other archaeometric techniques to determine the provenance of stone is common in scientific research. J. A. Harell studied twenty-three ancient Egyptian lime-stone quarries in the Nile Valley to obtain provenance indicators that differentiated each stone. Si, Al, Ca, Mg, Na, K, Fe, Ti and P were determined using the XRF method and twenty-eight samples were examined using thin-section petrography (Harrell, 1992). Moreover, Wenner and Herz studied quarries and archaeological samples to determine the provenance material source of archaeological samples by using petrographic and isotope analyses (Waelkens et al., 1992).

XRD and P-EDXRF analyses were performed to access geochemical data for all samples from Sumaki Höyük to determine the mineral composition and to understand the elements' diversity. Data on elemental diversity was obtained by examining 31 samples from both the settlement and source areas by P-EDXRF analyses; while 15 of the same samples were examined by XRD analyses and their mineral composition was determined. 14 basalt samples selected for P-EDXRF analyses were taken from Sumaki Höyük settlement, 13 from Mount Kıradağı and 4 from Mount Karacadağ (Figure 5). In addition, all data were classified by cluster analyses. Potential source locations were thus revealed by comparing the basalt samples found at Sumaki Höyük with the source areas.

RESULTS and DISCUSSION

The natural basalt used in construction of the early phases (N7 to N4) of Sumaki Höyük structures functioned as supporting material. A small amount of the basalt fragments found were reused. In the later phases (N3 to N1), it was proven that most stones in the structures had been used for grinding purposes in earlier phases.

Provenance of basalts can be determined by major (Mg, Si, C, Ti, Fe, P) and minor element (Cr, Zr and Nb) comparison (Greenough et al., 2001). We compared the major elements of objects from Sumaki Höyük basalts with Mount Kıradağı and Mount Karacadağ basalts in terms of their major elements (Table 1, Figure 6). The Mg of the three areas differ from each other, the Si results from the three areas are very close to each other, and the P analyses results of Sumaki Höyük (1.18%) and Mount Kıradağı (0.96%) are similar but differ (0.25%) from the Karacadağ basalt. Besides this, the K (0.92%) and Ti (1.91%) results of Sumaki Höyük nearly overlap with Mount Kıradağı (K 0.98% and Ti 1.86%) but are far from the basalt analyses results from Mount Karacadağ (K 0.53% and Ti 1.64%).

Table 1: Major element compositions of basalt samples from Sumaki Höyük, Mt. Karacadağ and Mt. Kıradağ.

Çizelge 1. *Sumaki Höyük, Karacadağ ve Kıradağ'dan alınan bazalt örneklerinin ana element bileşimleri.*

Samples	SiO_2	CaO	Fe_2O_3	Al_2O_3	TiO_2	MgO
Smk 1	36.458	20.468	19.966	13.560	3.533	1.875
Smk 2	43.253	12.851	18.676	16.228	3.047	1.911
Smk 3	39.591	18.161	18.956	13.947	3.187	3.173
Smk 4	38.063	11.949	22.469	16.558	3.814	1.491
Smk 5	44.436	11.762	18.327	15.567	2.896	2.397
Smk 6	42.902	11.902	19.439	15.574	3.189	2.286
Smk 7	42.135	11.516	20.244	15.870	3.749	2.947
Smk 8	42.788	12.195	19.520	16.125	2.889	2.196
Smk 9	48.517	ND*	22.383	18.397	3.478	2.454
Smk 10	42.153	14.022	18.635	15.880	3.055	2.123
Smk 11	41.220	11.097	21.508	15.526	3.450	2.505
Smk 12	44.971	7.522	20.781	17.423	3.189	2.244
Smk 13	43.274	8.218	21.706	16.456	3.688	2.476
Smk 14	41.701	9.639	22.078	16.631	3.366	3.178
Kr 1	43.949	8.533	20.029	18.619	2.981	1.733
Kr 2	43.096	10.358	21.348	15.318	3.478	1.882
Kr 3	34.579	24.849	19.024	15.477	2.984	ND*
Kr 4	42.324	6.444	22.433	20.093	3.154	2.121
Kr 5	43.052	10.309	23.825	15.418	3.368	ND*
Kr 6	41.851	10.384	23.655	14.164	4.010	1.846
Kr 7	40.753	10.449	23.385	16.012	3.546	2.205
Kr 8	40.522	8.912	24.269	17.490	3.650	1.909
Kr 9	43.852	10.346	19.800	16.489	3.273	1.328
Kr 10	42.701	11.017	20.616	15.626	3.488	2.148
Kr 11	42.206	11.752	20.536	15.973	3.162	2.006
Kr 12	41.127	11.393	23.951	15.216	3.915	ND*
Kr 13	40.423	12.356	21.830	16.043	3.407	2.400
Ka 1	41.640	11.031	21.441	18.528	2.856	3.727
Ka 2	41.852	10.422	21.679	17.561	2.848	3.910
Ka 3	41.834	10.215	21.088	18.941	3.193	2.826
Ka 4	44.165	13.362	16.354	17.294	3.060	2.076

* ND: Not detected - *tespit edilemeyen*

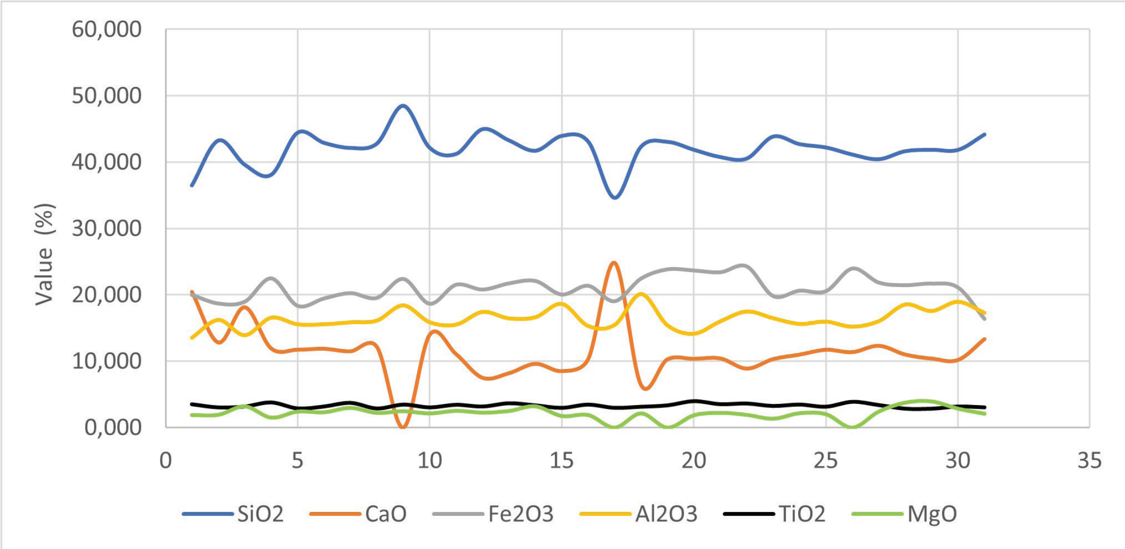

Figure 6. Comparative graph of major element results of basalt samples from Sumaki Höyük, Mt. Karacadağ and Mt. Kıradağ.

***Şekil 6**. Sumaki Höyük, Karacadağ ve Kıradağ'dan alınan bazalt örneklerinin ana element sonuçlarının karşılaştırmalı grafiği.*

Minor element (Cr, Zr, Nb) results, which can be useful for determining the provenance of the basalts of Sumaki Höyük compared to Mount Kıradağı and Mount Karacadağ, support the major element results. While Cr was not detected in Sumaki Höyük and Mount Kıradağı samples, it was found to be 0.0089% in the Karacadağ basalt samples (Table 2). Although Zr was 0.02% in and Kıradağı basalts it was 0.01% in the Karacadağ basalts. Nb contents of Sumaki Höyük, Mt. Kıradağı and Mt. Karacadağ similar to each other (Table 2).

The stones identified in Sumaki Höyük Neolithic settlement, arranged in rows by the occupants, were nearly all basalt. Within the study area, basalt units are found on Mt. Kıradağı, 2.7 km south-southwest in a beeline from Sumaki Höyük and the basalt sources of Mt. Karacadağ is about 70 km to the east from this site. Basalt fragments taken from Sumaki Höyük and the basalt raw samples from Mt. Kıradağı and also Mt. Karacadağ source areas have been examined for mineralogical and chemical compositions. Cluster analysis were performed using the SPSS 17.0. While these samples were divided into seven groups in the classification made by considering all elements (Figure 6), four groups were determined to examine minor elements (Figure 7). In both groupings, it is understood that one sample came from a different source. Minor element investigation gave more accurate and consistent results and is more compatible with settlement dynamics.

Table 2. Minor element compositions of basalt samples from Sumaki Höyük, Mt. Karacadağ and Mt. Kıradağ

Çizelge 2. *Sumaki Höyük, Karacadağ ve Kıradağ'dan alınan bazalt örneklerinin eser element bileşimleri.*

Samples	Minor elements (ppm)																	
	P	K	V	Cr	Mn	Ni	Cu	Zn	As	Br	Rb	Sr	Y	Zr	Nb	Mo	Pt	Au	Pb
Smk 1	1.3275	0.6716	0.0251	ND	0.1549	0.0001	0.0054	0.0096	0.0006	0.0001	0.002	0.0414	0.0048	0.0235	0.0025	0.0009	0.0023	0.0008	0.0007
Smk 2	1.1399	0.9427	0.0379	ND	0.1805	0.0001	0.005	0.0103	ND	0.0001	0.0026	0.046	0.0059	0.0258	0.0032	0.0007	0.0024	ND	0.0009
Smk 3	0.5649	0.894	0.0277	ND	0.1335	0.0001	0.0053	0.0106	0.0004	0.0001	0.0029	0.0382	0.0046	0.0232	0.0031	0.0006	0.0022	0.0007	0.0018
Smk 4	2.1741	0.7416	0.0281	ND	0.1843	0.0001	0.0053	0.0121	0.0025	ND	0.002	0.0387	0.0056	0.0248	0.0027	0.0007	0.002	0.0009	0.0006
Smk 5	1.3411	1.1496	0.0314	ND	0.1494	0.0001	0.0052	0.0104	ND	0.0001	0.0027	0.0467	0.0059	0.0255	0.0033	0.0008	0.0027	0.0006	0.0012
Smk 6	1.5061	0.9491	0.0306	ND	0.1752	0.0001	0.006	0.0097	ND	0.0001	0.0022	0.0451	0.0053	0.0258	0.0031	0.0008	0.0025	0.0007	0.0013
Smk 7	0.7199	1.0362	0.027	ND	0.1411	0.0001	0.0063	0.0113	0.0013	0.0001	0.003	0.0417	0.005	0.0255	0.0034	0.0009	0.0026	0.0005	0.0021
Smk 8	1.2291	0.8901	0.0458	ND	0.1743	0.0001	0.0054	0.0103	0.0004	ND	0.0026	0.0447	0.0055	0.0266	0.0033	0.001	0.0021	0.0005	0.0011
Smk 9	1.2347	1.1151	0.0393	ND	0.273	0.0001	0.0058	0.0118	ND	0.0001	0.003	0.0507	0.0063	0.0293	0.0034	0.0009	0.0027	0.0007	0.0011
Smk 10	1.1283	0.9867	0.0381	ND	0.1814	0.0001	0.0047	0.01	ND	ND	0.0026	0.0445	0.0058	0.025	0.0031	0.0007	0.0021	0.0005	0.0009
Smk 11	1.3259	0.8175	0.0339	ND	0.2844	0.0001	0.0062	0.0116	ND	0.0001	0.002	0.0436	0.0065	0.0275	0.0036	0.0012	0.0026	0.0005	0.001
Smk 12	0.8301	1.0967	0.0365	ND	0.1979	0.0001	0.0066	0.011	ND	ND	0.003	0.0394	0.0053	0.0261	0.0033	0.0012	0.0024	ND	0.0007
Smk 13	1.1248	0.9336	0.0258	ND	0.1942	0.0001	0.0058	0.011	ND	0.0001	0.0029	0.0439	0.0049	0.0241	0.0035	0.0015	0.0023	0.0005	0.0009
Smk 14	0.9049	0.7179	0.0267	ND	0.1854	0.0001	0.0054	0.0114	ND	0.0001	0.002	0.0368	0.006	0.0265	0.0033	0.0009	0.0022	ND	0.0006
Kr 1	1.098	1.0099	0.0341	ND	0.2098	0.0001	0.0067	0.0103	0.0005	ND	0.0026	0.0378	0.0061	0.0276	0.0036	0.0013	0.0028	0.0005	0.0007
Kr 2	1.1945	1.0769	0.0353	ND	0.1881	0.0001	0.0053	0.0118	0.0006	ND	0.0025	0.0424	0.0062	0.0265	0.0032	0.001	0.0023	0.0006	0.0009
Kr 3	0.6791	0.6701	0.0366	ND	0.1644	0.0001	0.0045	0.0093	ND	0.0001	0.002	0.0314	0.0051	0.0238	0.0031	0.0013	0.0022	0.0006	0.0008
Kr 4	0.6444	1.0242	0.024	ND	0.1958	0.0001	0.0051	0.0122	0.0005	0.0001	0.0025	0.0257	0.0052	0.0288	0.0039	0.0011	0.0026	ND	0.001
Kr 5	0.6442	0.9305	0.0259	ND	0.146	0.0001	0.0065	0.0096	0.0007	ND	0.0027	0.0395	0.0054	0.0274	0.0044	0.0022	0.0028	0.0008	ND
Kr 6	1.0413	0.7919	0.0273	ND	0.2121	0.0001	0.0064	0.0119	ND	0.0001	0.0031	0.0432	0.0053	0.0253	0.003	0.0012	0.0025	0.0006	0.0007
Kr 7	0.9056	0.7509	0.0206	ND	0.1916	0.0001	0.006	0.0119	ND	0.0001	0.0019	0.0375	0.006	0.0268	0.0038	0.0015	0.0024	0.0006	0.0006
Kr 8	0.7568	0.6283	0.0343	ND	0.248	0.0001	0.0068	0.0124	0.0004	0.0001	0.0019	0.0389	0.0058	0.0276	0.0035	0.0013	0.0026	ND	0.0008
Kr 9	1.1709	1.2999	0.0423	ND	0.162	0.0001	0.0046	0.0097	0.0003	0.0001	0.0028	0.0435	0.0058	0.0252	0.0032	0.0012	0.0029	0.0007	0.0006
Kr 10	1.202	1.0712	0.028	ND	0.2004	0.0001	0.0048	0.0117	ND	0.0001	0.0025	0.0424	0.006	0.0261	0.0034	0.001	0.0026	0.0007	0.0012
Kr 11	1.2043	0.8664	0.0317	ND	0.2397	0.0001	0.0052	0.0109	ND	0.0001	0.0019	0.0436	0.0058	0.0264	0.0034	0.0011	0.0023	0.0007	0.0009
Kr 12	1.0432	0.831	0.0296	ND	0.2168	0.0001	0.0065	0.0122	ND	0.0001	0.002	0.0439	0.0062	0.0273	0.0039	0.0017	0.0026	0.0006	0.0011
Kr 13	0.8995	0.7411	0.0225	ND	0.2069	0.0001	0.0042	0.0116	ND	0.0001	0.002	0.0391	0.0055	0.0271	0.0035	0.0012	0.0024	0.0005	0.0005
Ka 1	0.1279	0.0189	ND	0.0075	0.1606	0.0103	0.0116	0.0124	ND	ND	0.0007	0.0532	0.0023	0.0168	0.0037	0.001	0.0021	0.0004	0.0007
Ka 2	0.2469	0.4773	0.0143	0.0103	0.1188	0.0172	0.0165	0.0104	ND	0.0001	0.0008	0.0596	0.002	0.0151	0.004	0.0012	0.0022	0.0007	ND
Ka 3	0.1771	0.5166	0.0342	ND	0.2108	0.0139	0.0166	0.0094	ND	ND	0.001	0.0617	0.0022	0.0154	0.0041	0.0011	0.0025	ND	ND
Ka 4	0.4836	1.1457	0.0252	ND	0.1009	0.0042	0.0081	0.0072	ND	ND	0.0018	0.0719	0.0025	0.0182	0.005	0.002	0.0024	ND	0.0006

* ND: Not detected - *tespit edilemeyen*

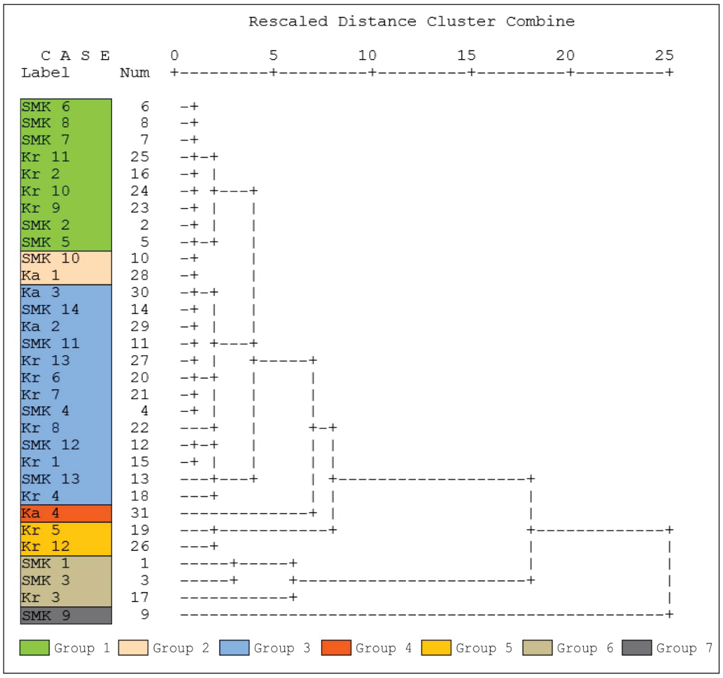

Figure 7. Dendrogram comparing and clustering basalt samples according to all elements of P-EDXRF analyses.

Şekil 7. *P-EDXRF analizlerinde elde edilen tüm elementlerin verilerine göre bazalt numunelerini karşılaştırma ve sınıflandırma dendrogramı.*

The fourteen samples from Sumaki Höyük form 7 different groups. The first group forms a cluster with five basalt samples from Sumaki Höyük (Smk 2, Smk 5, Smk 6, Smk 7 and Smk 8) that can be grouped with four Mount Kıradağı sample (Kr 2, Kr 9, Kr 10 and Kr 11). As a source, the similarity between the Mount Kıradağı basalt, very close to the study area, and Sumaki Höyük basalt fragments was already predicted. Therefore, we obtained analytical evidence of the expected result. In Group 2, only one sample from Sumaki Höyük (Smk 10) formed a group with Mount Karacadağ (Ka 1). Group 3 includes two samples (Smk 11 and Smk 14) that constitute a group with the Mount Karacadağ basalt (Ka 2, Ka 3) samples and three (Smk 4, Smk 12, Smk 13) Sumaki Höyük samples make another internal group with Mount Kıradağı (Kr 1, Kr 4, Kr 6, Kr 7, Kr 8 and Kr 13). Group 4 includes only one sample (Ka 4) taken from the distant location of Mount Karacadağ (Şanlıurfa-Siverek) while the other samples (Ka 1, Ka 2 and Ka 3) come from the Diyarbakır part of Karacadağ basalt. Group 5 includes two samples from Mount Kıradağı that are dissimilar with Sumaki Höyük archaeological samples. Group 6 includes two Sumaki Höyük samples (Smk 1 and Smk 3) that make a group with one Mount Kıradağı (Kr 3) sample. The last group is Group 7, where the basalt at Sumaki Höyük exhibits no resemblance to the basalt formations of the Kıradağı and Karacadağ mountains (Figure 7). The Group 7 sample (Smk 9) may have been imported from another culture that used a different basalt source not analysed in this research.

To summarize, while 10 samples from Sumaki Höyük make groups with Mount Kıradağı, three samples can be grouped with Mount Karacadağ, and one sample makes a group with neither of them. It is not very accurate to establish this relationship with single examples. However, it should not be ignored that this relationship analyses error in classification analyses may also occur. While there is a basalt source area very close (2.5 km), transporting basalt blocks weighing 55-60 kg from a distance of about 70 km is not only possible, but it is a very difficult task considering the period. Despite this proposition, the fact that the Neolithic communities of Sumaki Höyük were quite active in some periods may indicate the existence of different groups supplying materials from different sources at different periods.

The fourteen samples from Sumaki Höyük form 4 different groups. The first group forms a cluster with nine basalt samples from Sumaki Höyük (Smk 1, 2, 5, 6, 8, 9, 10, 11) that can be grouped with four Mount Kıradağı samples (Kr 1, 2, 9 and 10). As a source, the similarity between the Mount Kıradağı basalt, very close to the study area, and Sumaki Höyük basalt fragments was already predicted, and the major elements dendrogram mostly support same results. Therefore, we obtained analytical evidence of the expected result. In Group 2, four samples from Sumaki Höyük (Smk 3, 7, 12, 14) formed a group with nine samples of Mount Kıradağı (Kr 3, 4, 5, 6, 7, 8, 12 and 13) and one sample from Mount Karacadağ (Ka 4). Group 3 includes only three samples from Mount Karacadağ (Ka 1-3). Group 4 includes just one sample from Sumaki Höyük (Smk 4). This sample was probably brought and used from a different source area than Kırdağı and Karacadağ basalt (Figure 8).

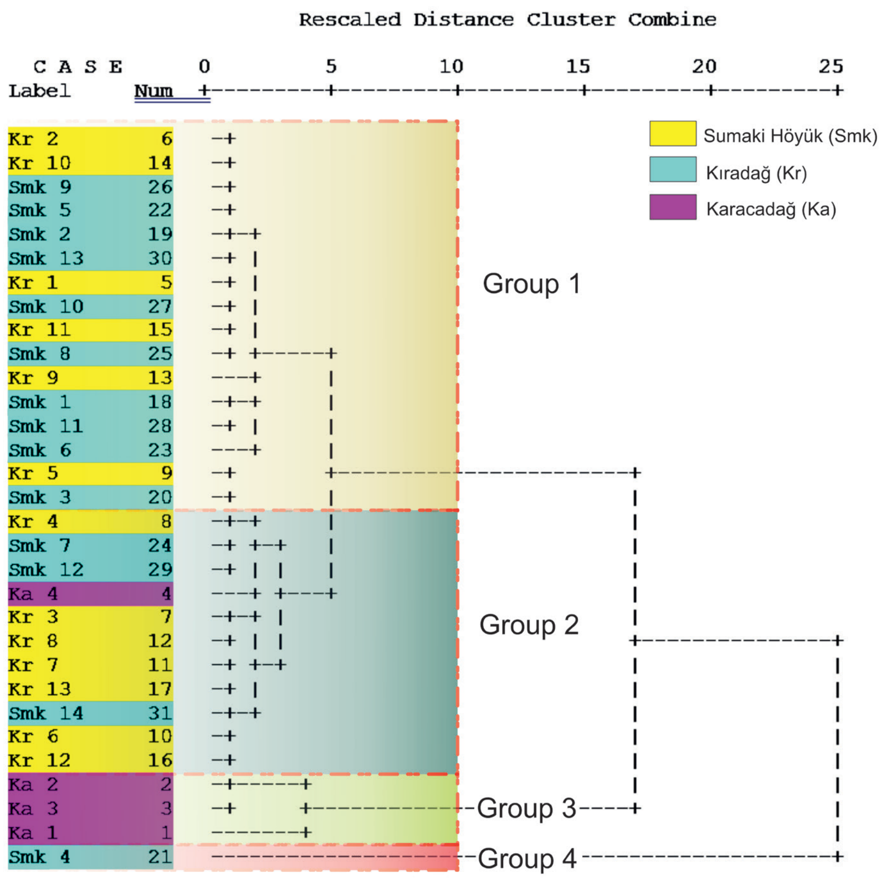

Figure 8. Dendrogram clustering basalt samples according to minor elements of P-EDXRF analyses

Şekil 8. *P-EDXRF eser element sonuçlarına göre bazalt numunelerini sınıflandırma dendrogramı*

Major and minor element dendrogram (Figure 7 and 8) results support each other in terms of Sumaki Höyük samples (except one sample) gathered from the nearest Mount Kıradağı which was expected to be because of location.

To understand the correlation of the major elements of the P-EDXRF analyses results, a binary correlation table was created using SPSS 17.0. There is a positive correlation of ,672 between Si and Al, that is, as silicon increases, aluminium also increases. Another significant is the positive correlation of ,598 between Ti and Fe and ,523 between Mg and Si. There is a negative correlation of ,598 between Ca and Fe, and ,539 between Ca and Si (Table 3)

The first habitation of the settlement is dated to 9084±57 cal BP. This earliest period is represented by Phase N7 with "temporary campsite" features; a series of post-bases or holes in different locations and hearths and fire pits that were identified in a nearly 250 m^2 area (Area B) on the natural soil. During Phase N6, which is dated to 8708±90 - 8594±49 BP, the settlement area was densely inhabited with discrete regular, partly permanent structures that were constructed by the piled earth technique without stone footings. Although the settlement appears to have a particular pattern in Phase N6, there is no planned use supporting a long-term settled lifestyle, such as the presence of public buildings, a varied external organization, architectural elements reflecting ritual traditions, and underfloor burials or burial areas.

Table 3. Correlation analyses of basalt samples from Sumaki Höyük, Mt. Kıradağı and Mt. Karacadağ

Çizelge 3. *Sumaki Höyük, Kıradağı ve Karacadağ bazalt örneklerinin korelasyon analizi.*

Correlations								
		Mg	**Al**	**Si**	**K**	**Ca**	**Ti**	**Fe**
	Pearson Correlation	1	,497**	**,523****	-,275	-,169	,055	,245
Mg	Sig. (2-tailed)		,004	,003	,134	,363	,771	,184
	N	31	31	31	31	31	31	31
	Pearson Correlation	,497**	1	**,672****	-,019	-,492**	-,060	,359*
Al	Sig. (2-tailed)	,004		,000	,920	,005	,750	,047
	N	31	31	31	31	31	31	31
	Pearson Correlation	,523**	**,672****	1	,449*		,152	,231
Si	Sig. (2-tailed)	,003	,000		,011	,002	,413	,210
	N	31	31	31	31	31	31	31
	Pearson Correlation	-,275	-,019	,449*	1	-,204	,192	-,238
K	Sig. (2-tailed)	,134	,920	,011		,272	,300	,198
	N	31	31	31	31	31	31	31
	Pearson Correlation	-,169	-,492**	**-,539****	-,204	1	-,255	**-,582****
Ca	Sig. (2-tailed)	,363	,005	,002	,272		,167	,001
	N	31	31	31	31	31	31	31
	Pearson Correlation	,055	-,060	,152	,192	-,255	1	**,598****
Ti	Sig. (2-tailed)	,771	,750	,413	,300	,167		,000
	N	31	31	31	31	31	31	31
	Pearson Correlation	,245	,359*	,231	-,238	**-,582****	,598**	1
Fe	Sig. (2-tailed)	,184	,047	,210	,198	,001	,000	
	N	31	31	31	31	31	31	31

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Briefly, having more wicker architecture with a simple internal-external area organization and use, the ‘permanent’ settlement in Phase N6 is construed to have had a shorter lifespan than other LPPNB sites.

The succeeding Phase N5 dated from 8526±60 to 8491±50 cal BP, according to the radiocarbon dating of four samples, had a similar character to the previous Phase N6. Here, structures comply with the low terraces of the topography of the period, as in Phase N6, but are more crowded. Both in building layout and construction technique, notable changes are recognized in Phase N5. Like the previous phase, this phase continues the cell building tradition along with multiroomed and double-roomed buildings.

During Phase N4, the primary reason for changes in settlement pattern and architectural traditions is clearly the forced abandonment of the settlement due to the flood/torrent episode experienced at the end of Phase N4 or shortly before Phase N5.

Following the break in occupation in Phase N4, which is dated to 8461±49 - 8436±52 cal BP, rehabitation of the settlement ended the cell building tradition. However, the construction of multi-roomed and double-roomed buildings with piled earth walls continued, and the number of temporary single-roomed short duration dwellings with reed surroundings/walls increased.

In Phase N3, dated to 8395±28 cal BP, the settlement pattern and architectural tradition of phases N6-N4 disappear. Lasting for nearly 250 years, the permanent settlement transforms into a temporary “campsite” with features partly like Phase N7. Temporary oval structures now replace the practice of permanent buildings and, according to the distribution of artefacts, there was intensive usage of open areas.

In Phase N2, the settlement pattern and spatial distribution density were recreated like phases N6 and N4. The buildings were located beside each other and built following the topography of the period. The architectural tradition of this phase is single-roomed rectangular-planned temporary buildings. Accordingly, the temporary circular structures from Phase N3 are replaced by temporary rectangular structures.

The final habitation of the Neolithic settlement, represented by Phase N1, is dated to nearly 8150 - 8100 cal BP according to comparative chronological data. The architectural tradition in this phase displays a different style to nearly all the previous phases. In this phase, stone is the dominant construction material. This occupation is represented by rows of large leftover basalt grinding stones placed in different directions, sometimes forming corners. The plentiful lime fragments observed in previous phases are virtually non-existent in the fill from this phase. Based on ethnographic examples, they are like the stone surroundings of tent dwellings in the winter quarters of the Lower Garzan Basin (Sarıaltun, 2020). As with the architecture and outdoor organization, noteworthy changes are observed in the artefact assemblage of Phase N1. Plant-tempered either plain or red-washed ware in different forms replaced the mineral-tempered dark-faced burnished hole-mouth ware. Instead of the unfired clay figurines made of bitumen-mixed clay in previous phases, very few fired clay figurines with different shapes were found. All these changes illustrate an entirely different tradition; perhaps the presence of semi-nomadic societies coming from a different region(s).

In the nomadic system, the concept of the group is linked to the line of descent, which forms the basis of social structure in eastern Anatolia, especially the southeast (Beşikçi, 1969). The Alikan tribe selects its winter quarters particularly in the steppes of the Garzan Valley - Beşiri, Kurtalan, Kozluk, Silvan, İdil, Cizre districts - and their surrounding areas. High altitude summer pastures are mainly located around Aveberdan, Kariz, Nemrut Dağ, Süphan Dağ, Düav, Çatak, Zövaser, and Lake Van. Basin seems to have developed into a port of call, probably for mobile groups, before they set off for the highlands, such as Nemrut Dağ, Süphan Dağ, and the Lake Van district. From this point of view, it is significant that the Smk 4 basalt sample (Figure 8) was found in Sumaki Höyük settlement. The groups that came to the settlement area of Sumaki Höyük during the north-south movement of the Neolithic semi-nomadic communities, along a route like the current migration route, may have brought a piece of basalt with them as a "souvenir".

According to the XRD analyses results of the samples taken from Sumaki Höyük basalts, Kıradağı and Karacadağ basalt flows are identified with different minerals (Figure 9, 10). Witherite, Bytownite and Periclase minerals were not detected in Sumaki Höyük and Kıradağı basalt samples (Table 1 & 2) but, they were determined in Karacadağ samples. Diopside, Jadeite and Oligoclase minerals were found in the basalt samples of Sumaki Höyük and Kıradağı, however, these minerals were not found in the Karacadağ samples. Although Zeolite, Feldspar, Berlinite, Ilmenite, and Magnetite minerals were identified in the Kıradağı samples, they were not found in Sumaki Höyük and Karacadağ samples. This may be due to the limited number of samples and/or periodic formation variations in the Kıradağı basalt. Since Calcium and Albite were clearly identified in soil samples taken from Sumaki Höyük's Neolithic deposits, their presence in Sumaki Höyük basalt samples indicates that these minerals probably contaminated the grinding tools, which is noteworthy.

According to the XRD analyses, ground stone tools made of basalt with a similar petrographic structure to the Kıradağı basalt have been obtained in Sumaki Höyük (Figure 9, 10). Therefore, previous interpretations that local volcanic material was intensively used at Sumaki Höyük have been proved correct.

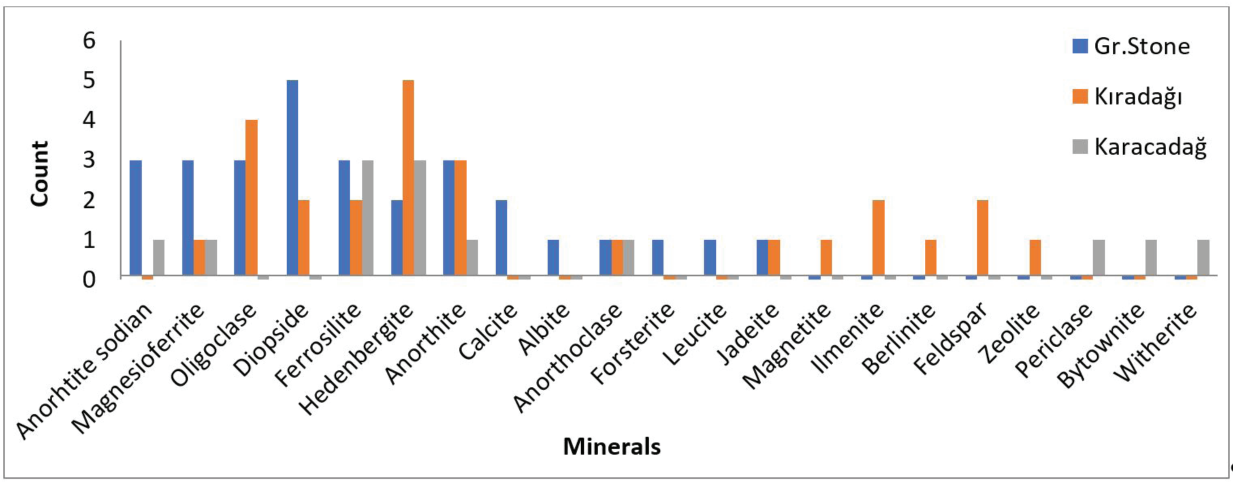

Figure 9. Comparison of basalt samples from Sumaki Höyük, Mt. Karacadağ and Mt. Kıradağ according to XRD analyses.

Şekil 9. *Sumaki Höyük, Karacadağ ve Kıradağ bazalt örneklerinin XRD analizine göre karşılaştırılması.*

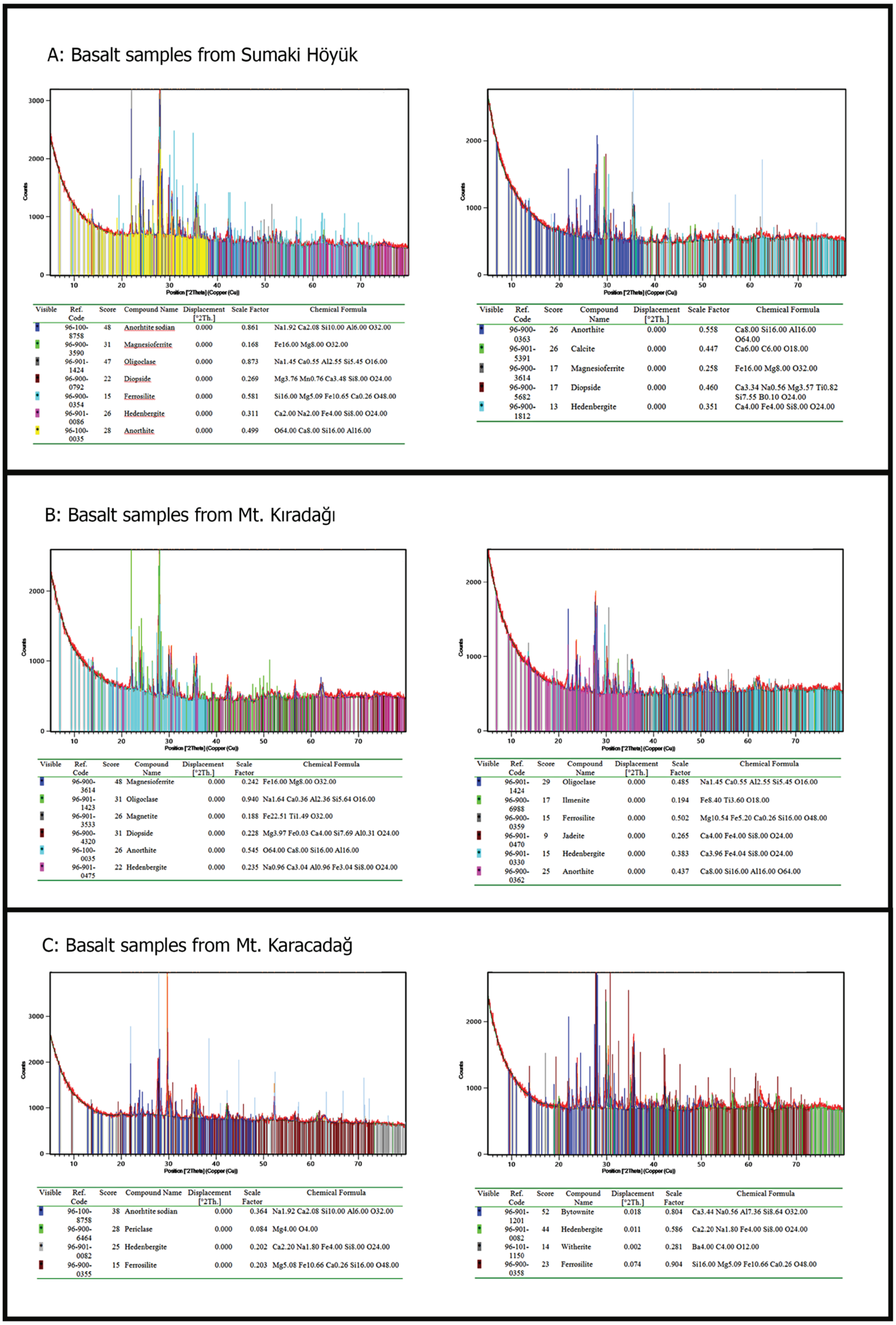

Figure 10. Measured XRD pattern from Sumaki Höyük, Mt. Kıradağı and Mt. Karacadağ.

Şekil 10. *Sumaki Höyük, Kıradağı ve Karacadağ'dan ölçülen XRD deseni.*

CONCLUSION

To determine the chemical composition, P-EDXRF was used for analysis, and XRD was used to establish the mineral content of the basalt. The main reason for this was to determine the raw material source of Sumaki Höyük grinding stone objects. P-EDXRF analyses results evaluated the source of the basalts in terms of their major elements. The major elements of Sumaki Höyük (Mg, Si, P, K, Ti and Fe) are very similar and nearly overlap with Mount Kıradağı but differ from Mount Karacadağ. Only the Si result of Sumaki Höyük is very close and there is no significant difference with the Mount Kıradağı and Mount Karacadağ basalts. According to the XRD analyses results, Diopside, Jadeite and Oligoclase were present in the basalt samples of Sumaki Höyük and Kıradağı; however, these minerals were not found in the Karacadağ samples. Witherite, Bytownite and Periclase minerals were not detected in Sumaki Höyük and Kıradağı basalt samples while they were determined in Karacadağ samples. As per the P-EDXRF results, the major and minor element composition of Sumaki Höyük objects is made of basalt from Mount Kıradağı. XRD analyses also supports the P-EDXRF results, because the XRD analyses also suggests that Sumaki Höyük basalt and Mount Kıradağı basalt have the same petrographic features.

GENİŞLETİLMİŞ ÖZET

"Sumaki Höyük (Batman, Türkiye) Neolitik Yerleşiminde Bulunan Bazalt Parçalarının Çok Perspektifli Jeokimyasal ve Mineralojik Analizi" başlıklı bu çalışmanın asıl amacı; Sumaki Höyük Neolitik yerleşmesinde farklı zamanlarda ve işlevlerde kullanılan bazalt alet ve mimari örneklerin kaynak alanının tespitine yöneliktir. Gerek yerleşmede ele geçen bazalt örnekler gerekse en yakın kaynak alanlarındaki hammadde niteliğinde bazalt kayaçların kimyasal bileşimini ve mineral içeriğini belirlemek için portatif Enerji dağılımlı X-ışını floresan analizi (P-EDXRF) ve X-Işını kırınımı (XRD) analizi yapılmış ve elde edilen veriler çeşitli analitik yöntemlerle karşılaştırmalı olarak incelenmiştir. Ulaşılan istatistik veriler ile yerleşimin tarihsel seyri karşılıklı olarak ele alınarak hem arkeolojik hem de jeoarkeolojik perspektifle yorumlanmış ve bazı önermeler yapılmıştır.

Sumaki Höyük, Garzan Vadisi'nin kuzey kesiminde, Garzan Çayı'nın yaklaşık 2,5 km doğusunda yer almaktadır (Şekil 1). 2002 yılında "Ilısu Baraj Alanı Garzan Vadisi Kültür Envanteri" projesi sırasında ilk kez tespiti yapılan yerleşmenin arkeoloji kazılarına 2007 başlanmış ve 2014 yılında son verilmiştir (Erim-Özdoğan ve Sarıaltun 2018). Arkeolojik kazı ve araştırma sonuçlarına göre, söz konusu yerleşim yeri mevsimsel akarsular veya kollar tarafından sınırlandırılan ve güneydoğu-kuzeybatı doğrultusunda hafif eğimli bir yüzeyde kurulmuştur. Sumaki Höyük, asıl olarak Çanak Çömlekli Neolitik dönemde iskan edilmiş olmakla birlikte ilk iskanı FPPNB (Çanak Çömleksiz Neolitik Dönem Sonu) döneminde olup bu ilk iskan "konak alanı" niteliğindedir (Sarıaltun, 2019). Yerleşimin Neolitik dolguları kalibre edilmiş C_{14} yöntemine göre günümüzden önce 9084±57 ile 8123±50 arasında tarihlendirilmektedir (Sarıaltun, 2019). Neolitik dönem kültür dolgusu 7 evreye ayrılmaktadır. Her biri farklı bir karaktere sahip olan bu 7 evre, yalnızca yerleşim düzeni açısından değil aynı zamanda çanak çömlek, mimari ve diğer arkeolojik buluntular açısından da farklılık göstermektedir.

Kullanılan hammadde kaynaklarının kanıtlarını elde etmek için arkeometrik araştırmalarda genellikle analitik yöntemler kullanır. Bu bağlamda çoğu çalışma, geçmiş toplumların hammadde kullanımının nedenlerini, *önemini ve yönetimini anlamak için bu tür analizlerin entegre edilmesi gerektiğinden yola çıkarak araştırmalar yapmış ve bazı sonuçlara ulaşmıştır. Bu araştırma Sumaki Höyük'te Neolitik dönem topluluklarının kullandığı bazaltın kaynağını belirlemek ve yerleşimin farklı dönemlerindeki hammadde kaynaklarında değişiklikleri anlamak için analitik bir yaklaşım tercih edilmiştir. Dolayısıyla bu çalışma, Neolitik Döneme tarihlendirilen Sumaki Höyük yerleşim mimarisinde kullanılan bazalt parçalarının hammadde kaynağının belirlenmesine odaklanan bir vaka çalışmasıdır (Şekil 2). Sumaki Höyük'te bazalttan yapılmış ve işlenebilir taş malzeme (bazalt) nedeniyle, arkeolojik yerleşim yeri hem yatay hem de mimari unsurlarının önemli bir kaynağı temsil etmesi nedeniyle dikey farklılıklar açısından da değerlendirilmiştir. (Şekil 3).*

Ardos (1996) ve Tolun (1962)'a göre çalışma sahası ve yakın çevresindeki ana volkanizma, Arap Platformu ile Anadolu Yarımadası'nın çarpışması sonucu oluşan büyük tektonik faylardan çıkan bazalt akıntılarıdır. Güneydoğu Anadolu'da kuzey-güney sıkışmasının bir ürünü olan ve Karacadağ volkanitlerini oluşturan volkanizma Üst Miyosen'de başlamış ve daha sonraki tarihsel dönemlerde de devam etmiştir (Şaroğlu ve Emre, 1987; Tolun, 1962). Yüzey akıntıları şeklinde yayılan Karacadağ volkanitleri, genellikle kuzeybatıdan güneydoğuya doğru yayılmıştır. Karacadağ volkanitleri ile ilişkili bazalt akışı (Şekil 5), Kıradağı Formasyonu (Yeşilova ve Helvacı, 2011) ve Karacadağ Bazaltı (Tuna, 1973) isimleri altında incelenmiştir. Ancak Gürcüoğlu ve Turhan (1992) Nemrut Volkanizması'yla da ilişkilendirmektedir. Kıradağı bazalt akıntısının Üst Miyosen yaşlı Şelmo Formasyonu üzerinde geniş bir dağılım göstermemesi ve Karacadağ bazalt akışları ile topografik bir bağlantı bulunamaması nedeniyle daha çok kuzeydeki volkanizma ilişkilendirilmektedir. Kıradağı Bazaltı Şimşek (1979) tarafından Nemrut Volkaniti'nin bir parçası olarak tanımlanmaktadır. Çalışmaya konu olan Sumaki Höyük yakın çevresindeki Kıradağı bazaltı, Üst Miyosen yaşlı Şelmo Formasyonu ile Pliyosen yaşlı Lahti Formasyonu'nun üzerinde yer alır (Yılmaz ve Duran, 1997). Bununla birlikte bu bazalt akışı Ardos'a (1996), Yeşilova ve Helvacı (2011) tarafından; Batman çöküntüsü ile Aşağı Garzan Havzası arasında 950 m yükseklikte Şelmo Formasyonu üzerinde yer alan Kıradağı bazaltı, yaklaşık 25 km²'lik bir alanı kaplamaktadır. Birimin yaklaşık kalınlığı 20 metredir. Bazalt akıntılarının farklı dönemlerde kalın tabakalı akıntılar halinde biriktiği Siirt-Batman Yolu boyunca görülen kesitlerden anlaşılmaktadır. Bazalt akıntıları sırasında alttaki Şelmo Formasyonu'na ait bej renkli kil yatakları kısmen yanmış ve pembe veya gri karakterli iki jeolojik birim arasında belirgin bir dokanak oluşturmuştur.

Sumaki Höyük'ten elde edilen bazaltlar genellikle Kıradağı'na özgü kimyasal bileşime ve mineralojik özelliklere daha yakındır ve sınıflama analizi de bu ortaklığı net olarak sunmaktadır. Bununla birlikte, bazı istisnalar vardır. Sumaki Höyük'ün farklı kesimlerinden elde edilen bazaltların farklı kaynaklardan gelmesi, muhtemelen çeşitli zamanlarda ve farklı faaliyetlerle ilişkili olarak farklı kaynaklardan malzeme getiren farklı grupların varlığına işaret edebilir. Bu çalışma, Sumaki Höyük'ün erken Neolitik döneminde Kıradağı bazalt akışından yoğun bir şekilde yararlandığını ve daha düşük bir ihtimalle Karacadağ bazaltından da tedarik ettiğini göstermektedir. Bununla birlikte tek örnekle bu ilişkinin kurulması çok doğru değildir. Sınıflama analizindeki bu ilişki analiz hatasının da olabileceğini göz ardı etmemek gerekir. Çok yakınlarında (2,5 km) bazalt kaynak alanı varken; yaklaşık 70 km uzaklıktan 55-60 kg ağırlığındaki bazalt blokların taşınması hem olası değildir hem de dönem dikkate alındığında oldukça güç bir meşakkattir. Bu önermeye rağmen Sumaki Höyük Neolitik topluluklarının bazı dönemlerde *oldukça hareketli olduğunu gerçeği nedeniyle farklı dönemlerde farklı kaynaklardan malzeme tedarik eden farklı grupların varlığını da işaret edebilir. Aşağı Garzan Havzası, Nemrut Dağı, Süphan Dağı ve Van Gölü bölgesi gibi yaylalara çıkmadan önce bugün olduğu gibi geçmişte de hareketli yarı-göçebe gruplar için bir uğrak alanı özelliğindedir. Bu açıdan, Smk 4 bazalt örneğinin (Şekil 7) Sumaki Höyük yerleşiminde bulunmuş olması önemlidir. Neolitik yarı-göçebe toplulukların kuzey-güney hareketi sırasında Sumaki Höyük yerleşim alanına bugünkü göç yolu gibi bir yol boyunca gelen gruplar tarafından yerleşmeye taşınmış, yanlarında "hatıra" olarak bir parça bazalt getirmiş, olabilir. Alınan örneğin olası tüm ağırlığı 3 kg geçemeyecek olması da mineralojik farklıkla birlikte, taşınma olasılığını da mümkün kılan bir diğer nedendir.*

Sumaki Höyük'ün ana elementleri (Mg, Si, P, K, Ti ve Fe) Kıradağı ile çok benzer ve hemen hemen örtüşürken, Karacadağ'dan farklıdır. Sadece Sumaki Höyük'ün Si sonucu çok yakın olup, Kıradağı ve Karacadağ bazaltları ile önemli bir fark yoktur. XRD analiz sonuçlarına göre Sumaki Höyük ve Kıradağı bazalt örneklerinde diopsit, jadeit ve oligoklas; ancak bu minerallere Karacadağ örneklerinde rastlanmamıştır. Sumaki Höyük ve Kıradağı bazalt örneklerinde Viterit, bitovnit ve periklaz minerallerine rastlanmazken, Karacadağ örneklerinde ise bu mineraller tespit edilmiştir. P-EDXRF sonuçlarına göre Sumaki Höyük objelerinin major ve minor element bileşimi Kıradağı bazaltlarıyla ilişkisini kanıtlamaktadır. XRD analizi de P-EDXRF sonuçlarını önemli ölçüde destekler niteliktedir.

Bu sonuçlar, Sumaki Höyük ve benzeri diğer Neolitik yerleşimlerdeki hammadde kaynakları ve malzeme dağılımı üzerine gelecekteki çalışmalar için önemli bir temel oluşturma niteliğindedir. Ayrıca, bazalt kullanımının yerleşim stratejisi, mimari gelenek ve çanak çömlek üretim süreçleri üzerindeki etkileri ile Neolitik dönemdeki sosyal ve ekonomik ağları anlamada bu çalışma değerli bilgiler sunmaktadır. Bu interdisipliner çalışma, Sumaki Höyük'ün yerleşim stratejisini ve yapısal örüntüsü hakkında yeni perspektifler sunmakla kalmayıp, aynı zamanda kapsamlı arkeometrik incelemelerin Neolitik yerleşimlerin anlaşılmasında nasıl kullanılabileceğine dair bir model de sunmaktadır.

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