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Fossil findings from the Sıcak Çermik fissure ridge-type travertines and possible hominid tracks, Sivas, Central Turkey

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ABSTRACT

Sıcak Çermik (Sivas) is an important geothermal and recent travertine formation area in Central Anatolia. The majority of travertines found in the region comprise fissure-ridge type travertines according to morphological classification. At the location called Tepe Çermik within the travertine area, fill containing fossil bone fragments of *Equus sp.*, Bovidae and other abundant animals formed within the fracture axis of a N–S striking fissure-ridge travertine developed under control of tectonic forces. The finds of these fossils in fissure-ridge travertines linked to tectonic forces indicates formation of a unique fossil environment created under the control of these forces. The Accelerator Mass Spectrometry Radiocarbon Dating analyses of fossils from the study area determined the fills were older than 43,000 years. The U/Th age of a sample from the most recently-formed banded travertine in the axis of the fracture was identified as $278,540 \pm 18,436$ years. As a result, the ages of fossils found within this fill are thought to be between 43,000 and $278,540 \pm 18,436$ years old. The high amount of perissodactyla and artiodactyla fossils found within fill in the axis of the fissure-ridge travertine probably indicates the presence of hominids who chose the region for hunting or settlement. The *Equus sp.* and Bovidae fossil samples found in the axis of the fracture indicate that in the dry and cold glacial period the paleogeography in a large portion of Anatolia comprised desert-like steppe.

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Sivas Sıcak Çermik;
travertine; Bovidae; *Equus sp.*

1. Introduction

Travertine and tufa are CaCO_3 compounds deposited by both chemical and biochemical routes in hot or cold water springs and are rock types intensely studied in different disciplines of the earth sciences. From the end of the 1800's to the present, travertines and tufas have been investigated with different aims and methods including chemistry of waters forming travertines, mineralogy and petrography of travertines, and geochemical and sedimentological properties (Barnes, 1965; Barnes & O'Neil, 1971; Bencini, Duchi, & Martini, 1977; Buccino, D'argenio, & Ferri, 1978; Chafetz & Butler, 1980; Chafetz & Folk, 1984; Feth & Barnes, 1979; Folk, Chafetz, & Tiezzi, 1985; Ford & Pedley, 1992; Friedman, 1970; Gonfiantini, Panichi, & Tangiorgi, 1968; Hayden, 1872; Heimann & Sass, 1989; Jacobson & Usdowski, 1975; Julia, 1983; Jones, 1925; Leeman, Doe, & Whelan, 1977; Love & Chafetz, 1988; Pentecost, 2005; Russell, 1882; Weed, 1890). After the 1960's studies related to active tectonics and morphological properties of travertines are noteworthy (Altunel, 1994, 1996; Altunel & Hancock 1993a, 1993b, 1996; Barnes, Irwin, & White, 1978; Brogi & Capezzuoli, 2009; Brogi, Capezzuoli, Alçiçek, & Gandin, 2014; Brogi et al.,

2016; Çakır, 1999; Çolak Erol, Özkul, Aksoy, Kele, & Ghaleb, 2015; De Filippis, Anzalone, et al., 2013; De Filippis & Billi, 2012; De Filippis, Faccenna, et al., 2013; De Filippis et al., 2012; Hancock, Chalmers, Altunel, & Çakır, 1999; Mesci, 2012; Mesci, Gürsoy, & Tatar, 2008; Pazzaglia et al., 2013; Scholl, 1960; Temiz & Eikenberg, 2011).

Within travertines, abundant fossilized remains of plants, leaves and a variety of organisms living near the depositional environment are observed (Pentecost, 2005). Apart from these fossils that are not very important in terms of geology and anthropology due to having young ages and not carrying characteristic fossil qualities, Kappelman et al. (2008) discovered a *Homo Erectus* skull fossil in a travertine quarry in Denizli (Kocabaş). Lebatard et al. (2014) identified that this skull was located in layered travertine in the Kocabaş travertine quarry and according to cosmogenic nuclide concentration and paleomagnetic measurement analysis was from 1.1 My to 1.3 My old. This finding is very important in terms of the correlation between travertines and fossilization.

In addition to being an important tool used to define geologic time in earth sciences, fossils provide important information about the habitats of organisms and their

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evolution from the past to the present day. Fossils providing information related to the habitats of vertebrates/invertebrates and single-celled/multi-celled organisms display a large amount of species and diversity within organic and clastic sedimentary rocks stretching from the past to the present. As the chemical/biochemical processes that cause travertine deposition do not provide a very appropriate environment for living organisms, apart from some algal and bacterial plant remains the relative fossil content is so low as to be non-existent. As a result, finds of vertebrate/mammalian fossils within travertines deposited by chemical processes gain importance in terms of understanding the depositional environments of these rocks, their chronological development and the paleogeography of the period when these fossils were living organisms. During normal development of travertines, there are no suitable environments for the fossilization of living things except for bacteria, algae and plant residues. Especially when these organisms increase to larger sizes, fossilization is impossible, e.g., for vertebrates. As the banded travertine sedimentation continues along the fracture axis, there is no space except for a few millimeters of opening that allows the geothermal water to rise to the surface. So fossils cannot form. The formation of fossils along an axis of a fracture that continues to open despite the cessation of hydrothermal activity is unique both in the geological literature and the studied region. For this reason, the fossil finds in Sıcak Çermik fissure-ridge type travertines are very important, especially in terms of structural geology, paleontology and anthropology.

This study was completed on bone fossils found in fill in the fissure axis of a fissure-ridge type travertine in Sıcak Çermik (Sivas/Turkey) travertine field. The aim was to identify the fossil species, determine their ages and interpret the paleogeography and climatic characteristics of the period using these fossil remains. An additional aim was to reveal the relationship between fossilization in the fissure ridge-type travertines and travertine deposition.

2. Regional geology and Sıcak Çermik travertines

Sıcak Çermik geothermal and travertine region is located 31 km west of Sivas (Figure 1). The region includes 16 travertine areas on a nearly N40°E strike located in rock units with ages ranging from Paleozoic to Miocene (Figure 1). The basement of the travertine field within the Sivas basin is formed by the Paleozoic Akdağmadeni metamorphics. Above these are Eocene volcanics and volcanoclastic units. Oligocene evaporitic rocks commonly found in the region are covered in general by Miocene continental clastics (Figure 1). These evaporitic rocks extending in a SE to NW direction are called the Sivas Backthrust (Poisson et al., 1996) and are located

above younger rocks along a NE-SW trend. Rocks of an ophiolitic melange, the product of the closure of the northern branch of Neotethys with final emplacement in the Upper Cretaceous, bound the basin with a nearly east-west orientation in a thrust belt emplaced from north to south (Central Anatolian Thrust Belt) (Figure 1).

Late Miocene Derindere Member of the İncesu Formation in the Hayranlı-Halimihani area (15 km east of Sivas Sıcak Çermik area) is described and referenced according to various Miocene period faunas (Made, Güleç, & Erkman, 2013; Özkurt, Güleç, & Erkman, 2015; Kaya & Kaymakçı, 2013; Furio, Van Dam, & Kaya, 2014; Bibi & Savaş Güleç, 2008). It formed probably in a short period between 8.7 and 8.121 Ma ago and was possibly a reaction to environmental change. It belongs to the lower part of MN11 and not to MN12. The findings are discussed in the regional context and contribute to knowledge of the Anatolian fossil mammals.

When travertines are classified based on morphological properties, there are 8 travertine types including fissure-ridge travertines (Altunel, 1996). Fissure-ridge travertines provide important data related to tectonics-active tectonics based on the structural records they contain. As a result, they are related to the tectonic regime affecting the region and are used extensively in active tectonic research of these regions.

According to morphological classification, travertines in the Sıcak Çermik travertine area include 19 fissure-ridge travertines and eroded sheet-type travertine layers (Mesci et al., 2008) (Figure 2). The fissure-ridge travertines located in this area formed linked to geothermal water reaching the surface through tension and shear fractures developing as a result of compression in the region between the Central Anatolian Thrust Belt and the Sivas Backthrust (Mesci et al., 2008).

3. Fissure-ridge travertine formation

The most important factor affecting hydrothermal waters reaching the surface are planes of tectonic discontinuity like fractures and faults. There is a very close relationship between fissure-ridge travertine formations and tectonic structures. Especially in regions where extensional tectonics are dominant, fissure-ridge travertine formations are commonly observed.

Fissure-ridge travertines form due to travertine deposition by hot water rich in calcium bicarbonate emerging from a central fracture in two different forms within the fracture and at the surface. In regions where extensional tectonics dominate, water rising through the fracture systems developed in basement rocks generally deposit 'banded travertines' with different color bands linked to minerals within the water in the mainly nonporous fracture. Deposition on the generally vertical fracture walls forms symmetrically on both sides. As regional extension continues, the water rising

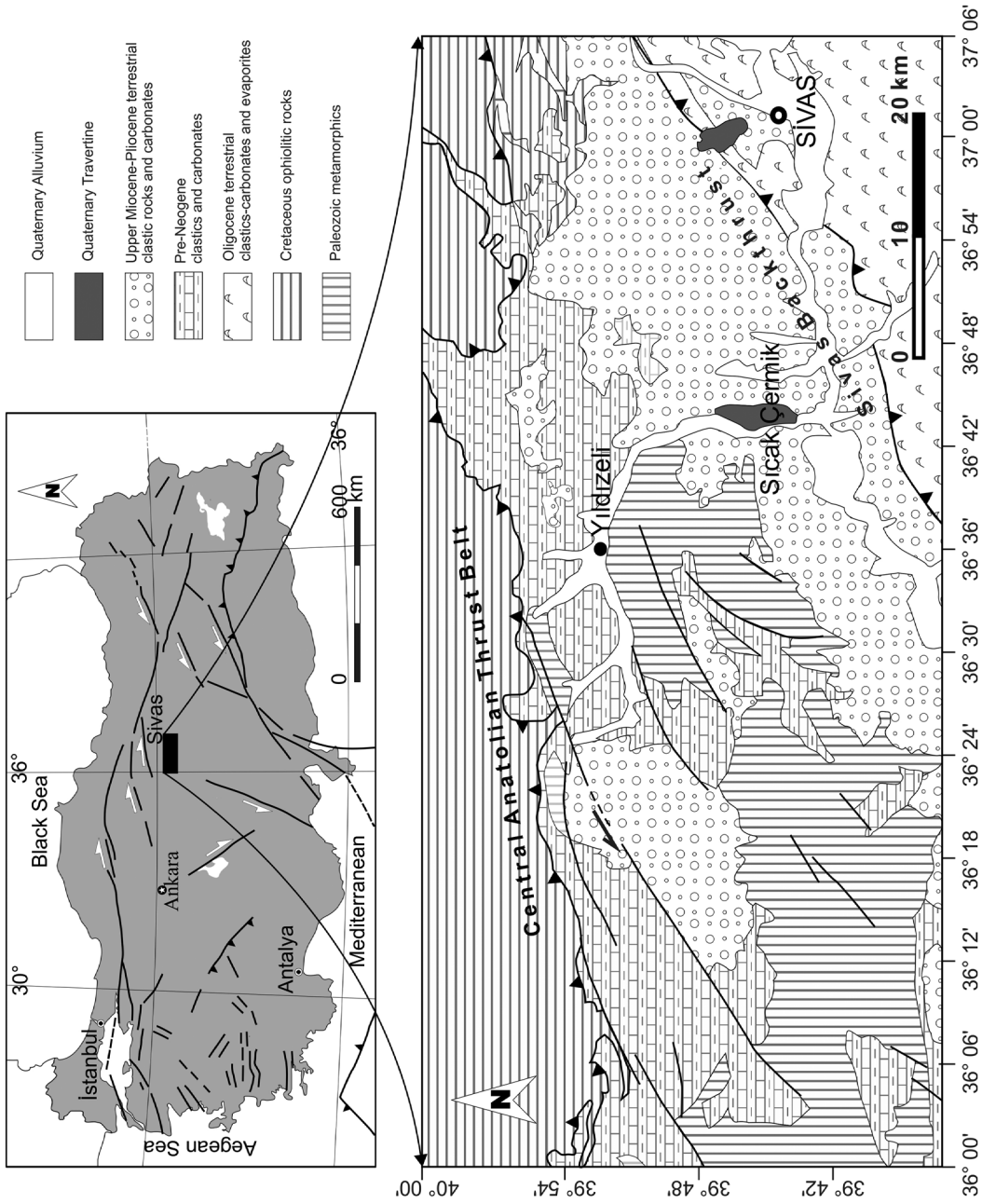


Figure 1. Location and simplified regional geologic map of the Sıcak Çermik geothermal/travertine field from Bilgiç, 2002.

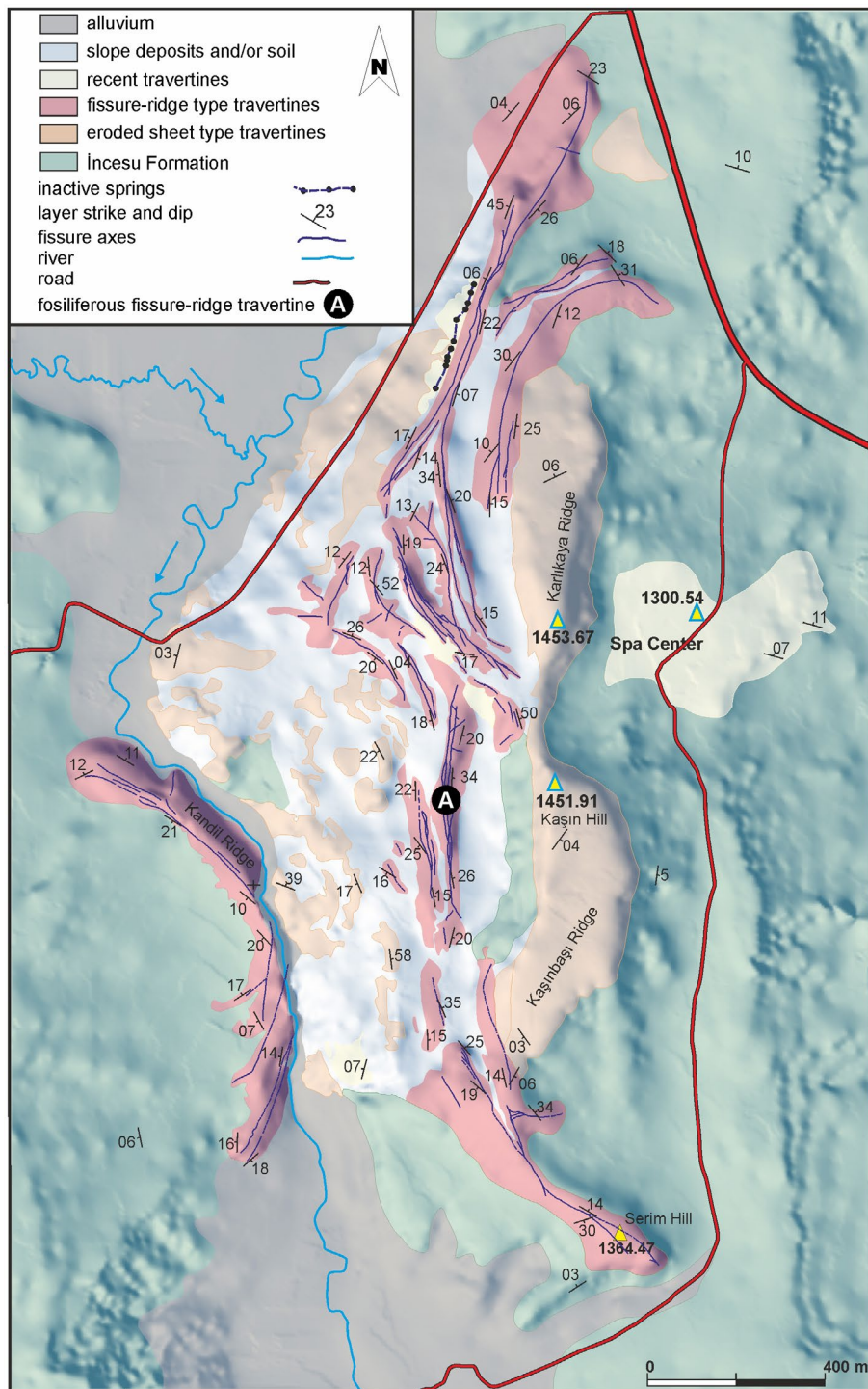


Figure 2. Geological map of the Sıcak Çermik geothermal/travertine field (Source: Author).

within the continuously-opening fracture continues to deposit travertine in parallel form on the fracture walls, assuming the fracture axis remains stable (Figure 3(b)). Due to this development, the ages of banded travertines increase as you move away from the axis of the fracture. In other words, the youngest travertine band is found at the fracture axis. When dating fissure-ridge travertines, these banded travertines are used. The most appropriate method to date travertines is the uranium/thorium (U/Th) method. With this method reliable results may be obtained for 5000 to 500,000 years

(Altunel, 1994; Çakır, 1999; Altunel & Hancock, 1993a, 1993b, 1996; Altunel, 1996; Hancock et al., 1999; Brogi et al., 2014; Mesci et al., 2008; Brogi & Capezzuoli, 2009; Temiz et al., 2009; Mesci, 2012; Çolak Erol et al., 2015; Brogi et al., 2016).

While this banded travertine deposition is continuing on the axis of the fracture, due to changes in physical properties, like evaporation of hot water, cooling and dispersion of volatile compounds, more porous layered travertines form at the surface. At this stage of deposition, carbon dioxide gas within hot water reaching

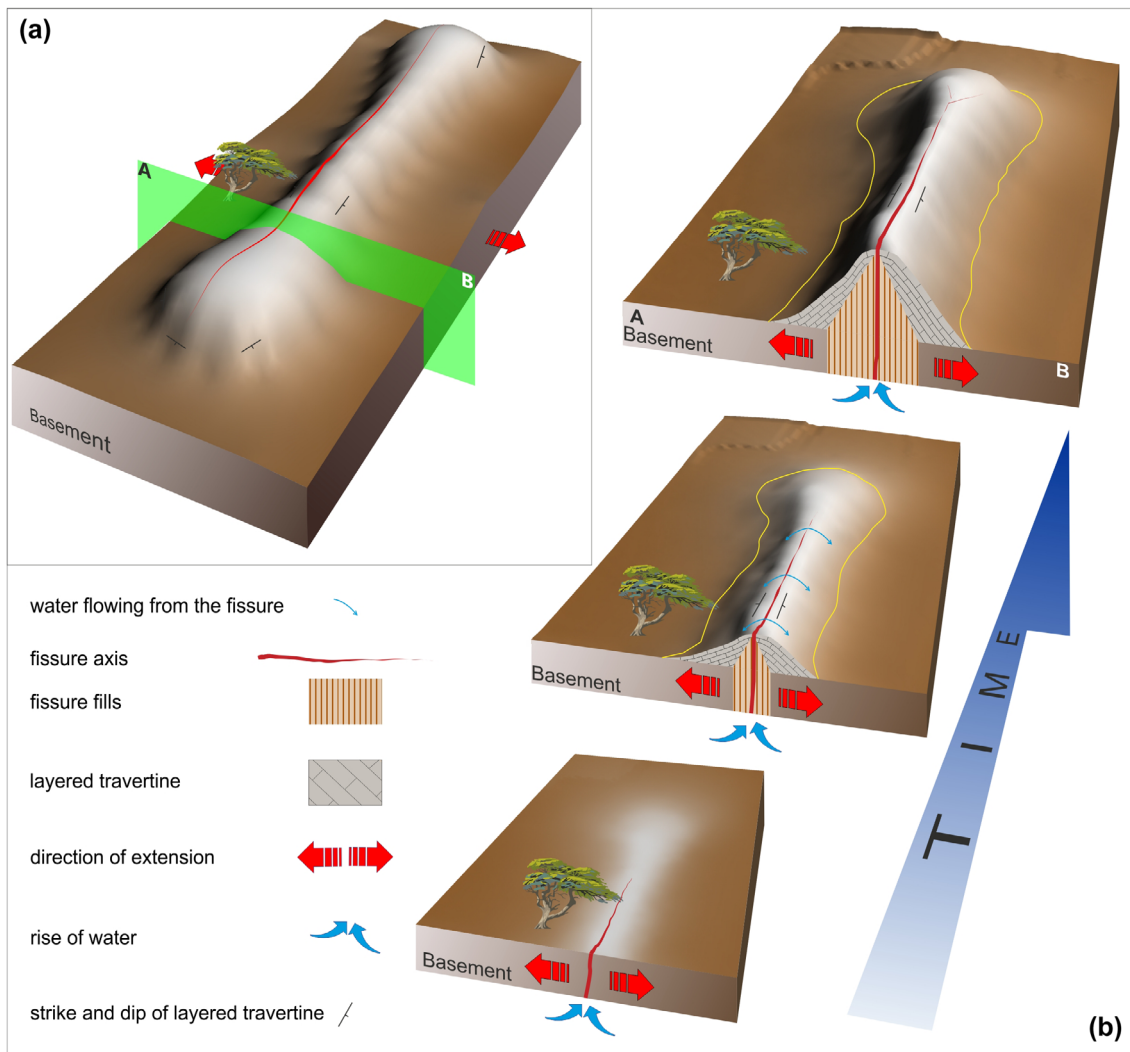


Figure 3. Block diagrams showing a fissure-ridge travertine (a) and its development stages (b) (Source: Author).

the surface and emptying perpendicular to the fracture axis disperses more quickly than within the fracture and forms sloped travertine layers perpendicular to the fracture axis on the topography (Figure 3(b)).

The geometry of fissure-ridge travertine formations on maps resembles an elongated ridge containing the main fracture on the axis (Figure 3(a)). The width of the central fracture may vary from a few centimeters to a few meters linked to the rate, continuity and duration of extension. Altunel (1994) stated that as development of the fracture works from the center towards the tips, the width of the main fracture in the center of the ridge is proportionally greater than at the tips.

The hydrothermal activity causing travertine deposition may end for a variety of reasons. If hydrothermal activity and extension of the fracture axis end together, fissure-ridge travertines gain an appearance similar to Figure 4(a), with vertical banded travertine on both sides of the fracture axis and layered travertines at the surface.

However, if hydrothermal activity ceases while extension of the fracture axis continues, there is a continuously expanding gap on the axis of the fracture. As there is

no new water release from the fracture axis, there is no deposition of banded travertines in this gap (Figure 4(b)).

This gap on the fracture axis fills over time with material derived from erosion of the travertine ridge. This fill material mainly comprises travertine pebbles and blocks, with animals living in the region dying due to falls into the gap and/or organic remains of animals eaten by meat-eaters (carnivores or human) contained within this fill (Figure 4(c)). When this fill material within the gap is cemented by geothermal water seepage, the bones of these animals may be preserved and reach the present day.

4. General characteristics of formation of fissure-ridge travertine containing fossils

Figure 2 shows the travertine types located in the Sıcak Çermik travertine field, with fossil remains of a variety of vertebrates observed in the fissure-ridge travertine shown by A. This fissure-ridge travertine extends for 1335 m along a N–S line (Figure 5). There are 2 main fissure axes parallel to each other on this ridge with a total

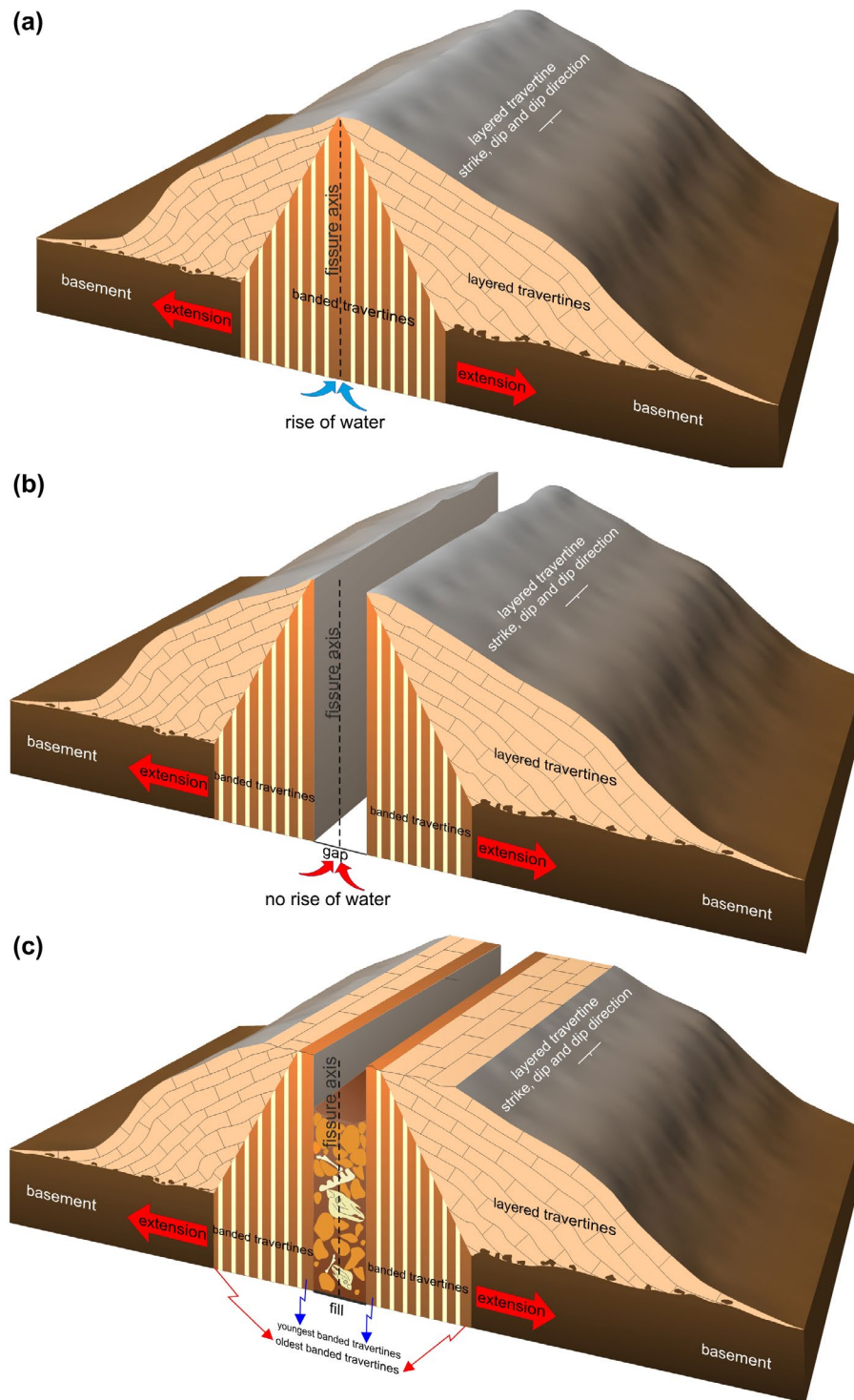


Figure 4. Three dimensional view of usual (a), gap (b) and fossiliferous fill (c) formation in a fissure-ridge type travertine (Source: Author).

length of 2053 m and banded travertine formations are observed within these.

The vertical fissure at the northern tip of this ridge within a previously operated and later abandoned quarry continued to expand in an E-W direction after hydrothermal activity ceased. Thus there is a 40 cm wide gap in the axis of the fracture. This cavity is filled with rock pieces of varying size from pebble to blocks formed by erosion of rocks in the region from the beginning of development to the present (mainly travertine), along with soil and

organic remains. This rock-soil mixture is cemented by a very weak carbonate (travertine) cement (Figure 5).

The fill developed in this gap in a fissure-ridge travertine located in Sıcak Çermik (Sivas) contains abundant amounts of fossils. In the section not operated by the quarry and thus preserved, the physical dimensions are measured as 40 cm width, 6 m visible depth and nearly 20 m length. Fossils are obtained from sections of the fissure in the quarry and observed at the surface in fill without any excavation. When examined from this aspect, it is

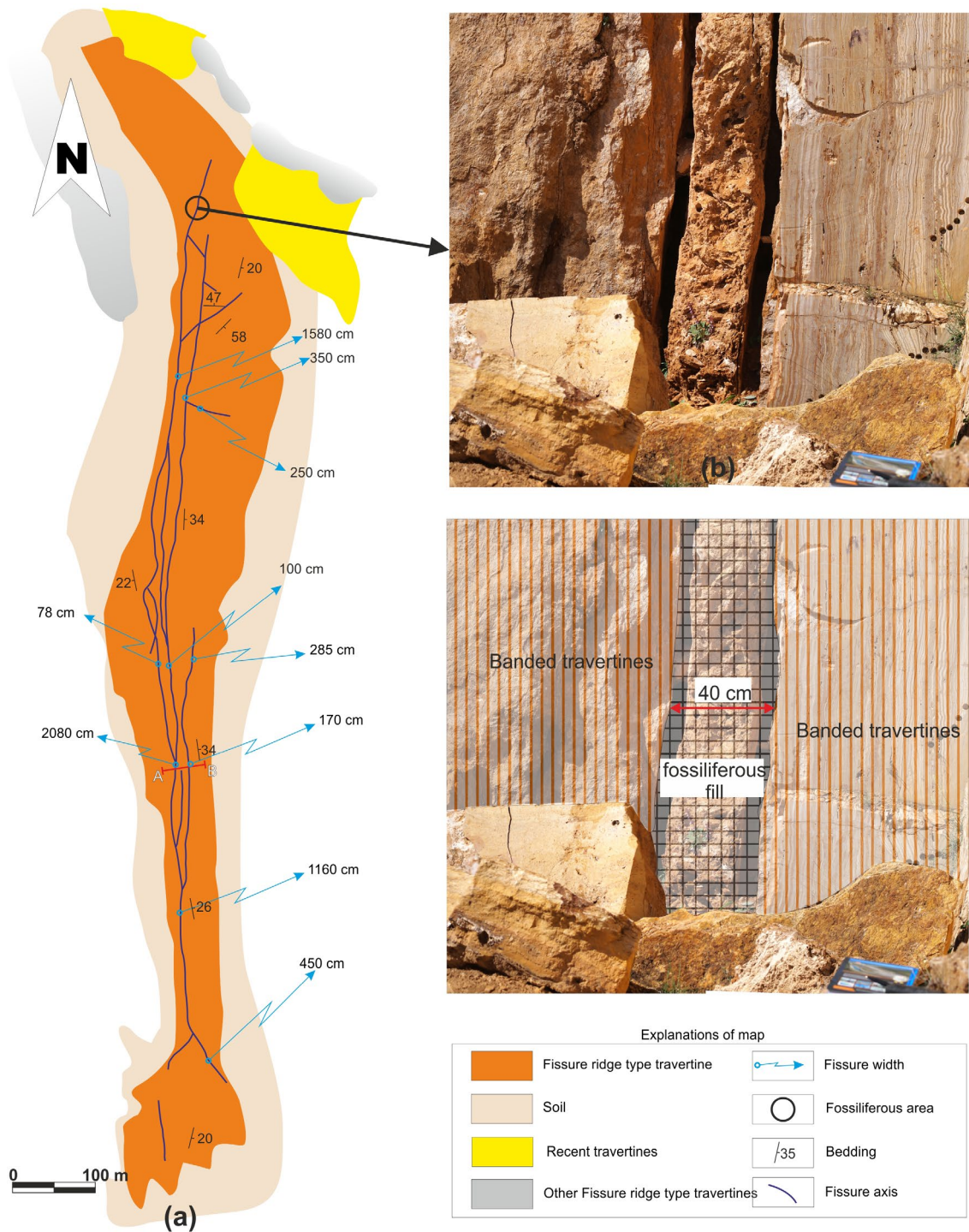


Figure 5. Map view of fissure ridge travertines with fracture fill containing fossils (a) and photograph of fill (b) (Source: Author).

Table 1. U/Th age analysis results.

| ^{238}U ppb | ^{232}Th ppb | $^{234}\text{U}/^{238}\text{U}$ | $^{230}\text{Th}/^{234}\text{U}$ | $^{230}\text{Th}/^{238}\text{U}$ | $^{230}\text{Th}/^{232}\text{Th}$ | Calculated age (ka) |
|----------------------|-----------------------|---------------------------------|----------------------------------|----------------------------------|-----------------------------------|----------------------|
| 39.599 ± 0.187 | 0.225 ± 0.003 | 1.742 ± 0.015 | 1.041 ± 0.018 | 1.813 ± 0.030 | 975.944 ± 21.215 | 278.540 ± 18.436 |

thought there are abundant amounts of fossils contained in a total of 48 m^3 or more fill material.

A sample taken from banded travertine in the fracture axis at this location was radiometrically dated at Montreal Quebec University, Canada. The age of this travertine sample was identified as $278,540 \pm 18,436$ with the

U/Th method (according to the thermal ionization mass spectrometry (TIMS) and multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS methods) (Table 1, Figure 6). Four fossil samples taken from this fill had Accelerator Mass Spectrometry Radiocarbon Dating (AMS) analyses completed by Beta Analytic Company in

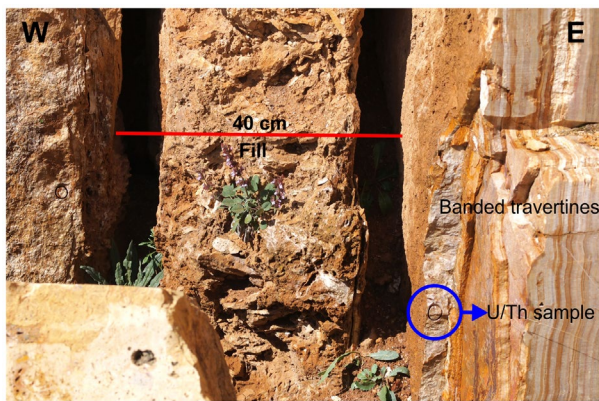


Figure 6. Appearance of samples used for U/Th age analysis (Source: Author).

Miami (USA) and no collagen was obtained from the samples (Figure 7). This shows that the samples must be older than 43,000 years.

Mesci et al. (2008) determined a rate of opening of 0.0280 mm/year by dating the fossiliferous fissure-ridge type travertine. The youngest banded travertine age on the ridge was found to be 279 ka. The gap on the axis formed after 278 ka and when the width of 40 cm is considered along with an opening rate of 0.0280 mm/year, it may be concluded that the fossil fill formed over 14 ka. As a result the ages of the fossils should be older than 43 ka.

5. Faunal and climatic analysis

Fossil depositional environments provide valuable information about habitats from the past that organisms have lived in. In this context, the fossils contained in the Sicak Çermik deposits precipitated by hot water springs give valuable information about paleo-ecosystems.

Glacial periods are very influential periods that affected life in Anatolia. Significant fossil records found in the past and still to be found from this time are very important in terms of Anatolian paleobiostratigraphic, paleogeographic, paleoecological and paleochronological studies. The data obtained from the Sicak Çermik geothermal field are remarkable in terms of providing crucial data about the Pleistocene and results of the fossil analysis provide paleoecological data. During the Pleistocene period, glaciers covered a large portion of the earth's surface. The Middle Pleistocene period when the Riss and Würm glaciations occurred coincides with the period when *Homo* genus was evolving and at the end of this period, humans had spread to nearly all sections of the planet. Many paleontologists research Pleistocene fossils to understand the climate in the past. However, the Pleistocene period was not only a period when climates and temperatures changed dramatically, but was also a period when fossils were generally well preserved in abundant amounts allowing very sensitive dating. In the last glacial period, Anatolia was dominated by cold and dry climate conditions (Atalay, 2005). From

pollen analysis, it is understood that there were common conifer forests in high elevations in the surroundings during the Late Quaternary (Ocakoğlu & Akkiraz, 2016). Plants like *Quercus*, *Castanea*, Elagnaceae, Oleaceae, *Fagus*, *Salix* and Fagaceae were found in areas with lower topography. Herbaceous plant cover comprised forms of Chenopodiaceae, Asteraceae Ligulifloreae, Poaceae, Caryophyllaceae, *Artemisia* and Brassiaceae. The abundant finds of these forms indicate the climate was generally cold and dry. Isotopic data and pollen results show that hot and wet periods continued to occur in Anatolia (Ocakoğlu & Akkiraz, 2016). Undoubtedly, just as there are different climatic regions in Turkey today, there were also regional differences in the Quaternary as during the Quaternary the geographic conditions in Turkey do not appear to undergo transitions reflecting rapid change. During the Pliocene and Quaternary continental and semi-arid climatic conditions similar to today were dominant. The main morphologic models are flood-surface erosion-mud deposition in the Pliocene and fluvial-valley development-alluvial deposition in the Quaternary. However these are not clear variations, but slow and perhaps transient transitions and as a result it is possible to say there was general continuity (Kayan, 1996a). It is well known that the Quaternary period is characterized by climatic fluctuations. During cold periods (glacial times) glaciers formed at higher latitudes and on high mountains and prograded towards lower latitudes (Kayan, 1996b). In this period, glaciers covered mountains in the coastal sections of Anatolia above an elevation of 2500–2600 m, with glaciers covering mountains in Central and Eastern Anatolia above an elevation of 2700–2800 m due to the continental location (Atalay, 2005). A more general effect of the climatic changes on the landforms of Anatolia in the Quaternary was indirectly felt by means of changes to the hydrological balance. Glacial periods were cooler in Turkey even though there was no inland glaciation. Therefore surface waters in rivers and lakes increased even during periods of lesser precipitation because there was less evaporation. Besides, the climate was generally semi-arid in Turkey during the hot-dry interglacial (interpluvial) periods of the Quaternary. It is accepted that more than one fluctuation between glacial and interglacial conditions occurred in Anatolia (Kayan, 1996b). Soil formation significantly ceased during the Last Glacial Period. The basic reason for this was the dry and cold climate conditions dominating in the internal section of Anatolia. One of the most important characteristics of the Last Glacial Period is plant assemblages reflecting the climate conditions. In a general statement it may be said that due to the cold and dry climate conditions, low-elevation areas in the interior of Anatolia were covered with steppe. In high elevation areas of central Anatolia yellow pine and birch forests were common, currently forming taiga forests and belonging to the European-Siberian Plant Geography Region (Atalay, 2005). In this period, it



Figure 7. Appearance of samples taken for C^{14} age analysis (Source: Author).

is possible the genetic structure of Anatolian fauna was so diversified it cannot be compared to any other region.

Order Perissodactyla Owen, 1848

Family Equidae, Gray, 1821

Subfamily Equinae Gray, 1821

Genus Equus, Linnaeus, 1758

Equus sp.

Material: Right lower M1–M2 (Figure 8), lower right M3 (Figure 9), upper right P3–P4 (Figure 10), upper left M1–M2 (Figure 11), mandibula fragment, (Figure 12), humerus (Figure 13)

Description: Within Çermik samples (Figure 8) right lower M1–M2 caballoid horse is shown.

Caballoid horses are one of a few large mammalian lineages with clear evolutionary trend in the Pleistocene. The remains of horses are found abundantly in many important Late-Middle Pleistocene archeological and paleontological areas. Horses have the potential to

display broad distribution geographically in both hot and cold periods. These characteristics make them extremely important in terms of paleoecology (Savage, 1977; Lister, 1992). Equus is divided into two main groups characterized morphologically by enamel patterns on mandibular molar teeth and especially the form and shape of the metaconid and metastylid junction. Stenonid horses (this group is named after the typical Villafranchien representative of the group, *Equus stenonid*) are characterized by an entoflexid in the form of a V between the metaconid and metastylid. Caballoid horses (named after *E. caballus*, the domestic horse) are characterized by a U-shaped entoflexid (Boule, 1899; Hopwood, 1936; McGrew, 1944; Gromova, 1946, 1949; Dietrich, 1949; Forsten, 1988).

Caballoid or true horses are thought to have evolved from primitive stenonid horses during the Early Pleistocene (Forsten, 1988). In the early period of the Middle Pleistocene the numbers of caballoid horses increased and replaced a variety of stenonid species in



Figure 8. Lower right M1–M2 (Source: Author).



Figure 9. Lower right M3 (Source: Author).



Figure 10. Upper right P3–P4 (Source: Author).



Figure 11. Upper left M1–M2 (Source: Author).

Europe (Van Asperen, 2009). The evolution of caballoid horses during the Late Pleistocene in Europe has been the topic of much research extending to the Middle

Pleistocene (Nobis, 1971; Eisenmann, 1991; Forsten, 1993). One hundred thousand years ago the dimension of limb bones reduced and from 200,000 years ago the

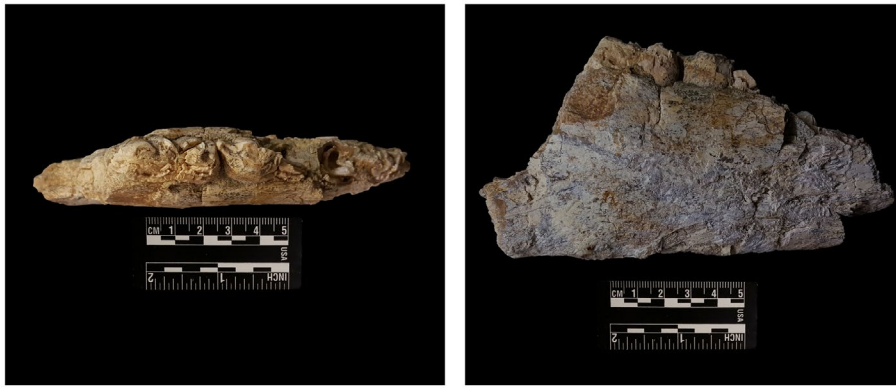


Figure 12. Mandibula piece belonging to *Equus caballus* (Source: Author).

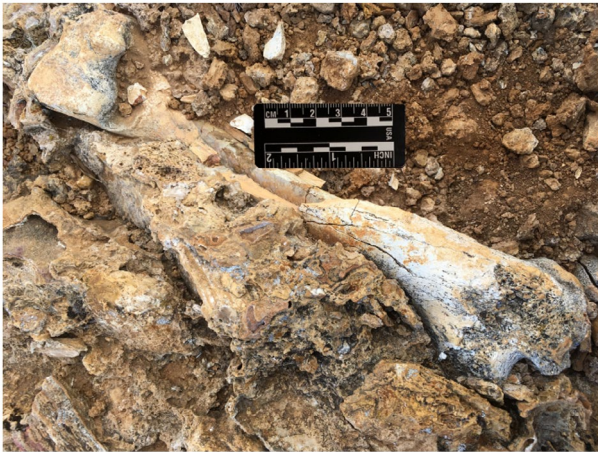


Figure 13. Humerus bond belonging to *Equus caballus* (Source: Author).



Figure 14. Lower second molar tooth belonging to deer in Cervidae family (Source: Author).

probable reduction in tooth size characterized a reduction in the size of horses occurring in the Late Pleistocene (Eisenmann, 1991). In addition to size variations, reduction in the size of latera digits, loss of flexibility of the foot and development of stretching mechanisms ensured adaptation to a cursorial lifestyle as a result of changes occurring especially in the metapodial and phalanges (Sondaar, 1968; Van Asperen, 2009). In rapidly changing Pleistocene environments, these ecophenotypic responses of size and shape fluctuations are expected and do not disrupt the evolutionary standpoint (Forsten, 1993). Research in later horse populations has shown that although the morphology of caballoid horses is relatively homogeneous, there may be differences between populations that are related to adaptation to regional conditions (Forsten, 1993; Van Asperen, 2009). *Equus caballus* does not require much description but is a species well known in the literature that successfully survived from the Middle Pleistocene to the end of the Pleistocene in Eurasia (Azzaroli, 1985a; Telegin, 1986). With different morphological types within this long time period, *Equus caballus* separated into different subspecies 300–200 thousand years ago in forested areas of Europe. In this way, some researchers have described sub-species: *E. c. alaskae* (Hay, 1913, pp. 2, 3.

Lamut, or Beringian Horse), *E. c. caballus* (Linnaeus, 1758, p. 73. Northwestern European Horse), *E. c. ferus* (Boddeart, 1785, p. 159. Tapan (gmelini Antonius, sylvestris Brinken are synonyms), *E. c. mexicanus* (Hibbard, 1955. American periglacial Horse), *E. c. mosbachensis* (Von Reichenau, 1903, p. 583. Central European Horse), *E. c. Przewalskii* (Poliakov, 1881, p. 1. Przewalskii Horse, Mongolian Wild Horse), and *E. c. pumpelli* (Duerst, 1908, p. 397. Afro-Turkic Horse).

The evolution of the horse followed a certain route in a variety of fossil samples; however it shows many branches. One of the sub-species of *Equus caballus* occurring in the Pleistocene was the ancestor of current horses. Many of these sub-species died out due to natural selection. In the first stage of horse evolution, we see that hooves, teeth and at the same time body size changed. In the dry and cold glacial period, a large portion of Anatolia was covered by desert-like steppes and soil formation ceased.

The codes are as follows (According to Payne, 1991):

OL = occlusal length, measured from the approximate centers of the mesial and distal sides, including the external cement;

Be = buccolingual length taken with one jaw of the calliper in contact with both the parastyle and mesostyle

and the other on the protocone, including the enamel but not including the cement;

Bapf = the distance the postfossette projects above the prefossette at right angles to OL (usually measured on enlarged photocopies);

LP = greatest length of protocone including enamel;

B3 = width from protoconid to metaconid at right angles to OL;

B4 = width from hypoconid to metastylid at right angles to OL;

Lnd = greatest length of double knot including enamel;

LF = greatest length of postflexid including enamel;

Bei = smallest distance between internal enamel of buccal sulcus and lingual sulcus.

Lnd = 15.22

Bei = 2.10

B3 = 15.02

B4 = 14.57

Be = 24.87

LP = 14.70

LP = 13.35

Order Artiodactyla Owen, 1848.

Family Bovidae Gray, 1821

Subfamily Bovinae Gray, 1821

Material: Lower second molar teeth

Only represented by a broken tooth (Figure 14). As a result, it is very difficult to determine species. These ruminating herbivores from the Bovidae family lived in a broad biome including savannah, tundra and forests, as understood from Sıcak Çermik samples.

6. Marks

The presence of paleolithic areas in Turkey has been known since the beginning of the 20th century. With relatively small-scale research until the 1940's and 1950's, studies have increased and continued in the last 20 years. Prof. Kılıç Kökten, the leading paleolithic researcher, excavated the significant paleolithic area of Karain Cave (Burdur) from 1946 to 1973. In addition to this study he determined tens of other paleolithic settlement areas. Since 2016, 490 paleolithic areas have been listed under the auspices of the TAY project creating a database of archeological areas in Turkey and of these only thirty-eight paleolithic settlement areas have been excavated. The most noteworthy gap in paleolithic distribution is the Central Anatolian plateau. The paleolithic period in Anatolia is very important in terms of passage from Africa to Europe and again to Asia via this route.

There are many examples of gaps developing on the fracture axis of fissure-ridge travertines observed in many areas of Anatolia like Pamukkale (Denizli) and Diyadin (Ağrı). In a total of 19 fissure-ridge travertines in the

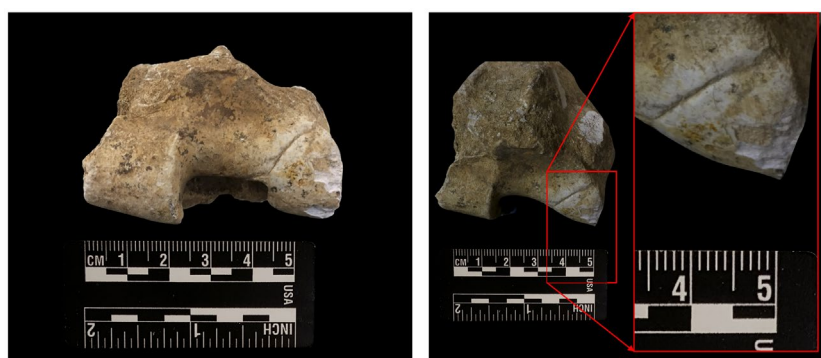


Figure 15. Mark on a tibia bone belonging to Equus (Source: Author).

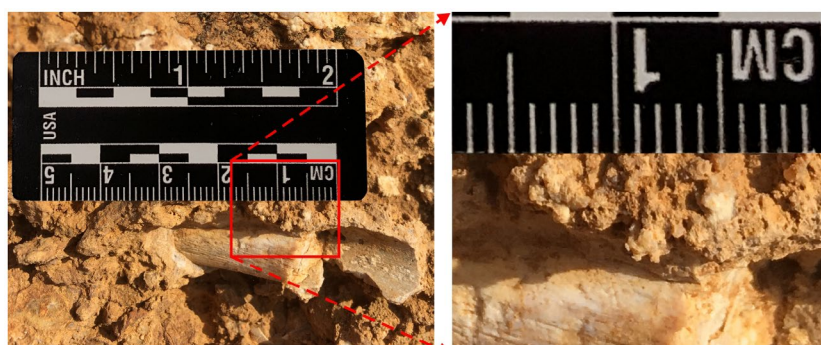


Figure 16. Marks on long bone pieces within travertine (Source: Author).

Sıcak Çermik travertine area, there are two other examples of gap and fill in the fracture axis of fissure-ridge travertines. In these two formations, there are no fossil remains encountered. This situation makes the fracture axis containing fossils even more interesting. The abundant bone pieces found shows that animals did not fall into this gap by chance. Additionally, it should not be ignored that many fragmented cranial and post cranial samples are found among the fossils obtained at this location. The most surprising thing about the fossils are the marks on some bones. This situation is probably due to anthropogenic or predatory effects. The fissure-ridge travertine axis fracture gap forms an environment for the fossils protected from external factors and movement and this leads to the consideration that these animals with marks fell and/or were thrown into this gap immediately before or after death (Figures 15 and 16). The U/Th age results show the gap in the fracture axis began to form before 278 thousand years ago, while Accelerator Mass Spectrometry Radiocarbon Dating (AMS) analysis shows that fossil traces are older than 43 thousand years. As a result these fossils must have formed between these two age dates. When the abundance of the fossils, presence of marks and possible age dates are assessed together, it may be considered that the site where the samples are found can be described as a hunting or settlement area for homo genus. No specific evidence to define anthropogenic movements has been identified up to now. However, the fact that this type of fauna has been fossilized in abundance in a constricted location suggests the existence of an archeological settlement. A more detailed study in the future will be able to clarify this situation.

7. Discussion and conclusions

Fissure-ridge travertines are geological formations frequently used in recent years for tectonic-active tectonic research due to structural data they contain. The development of these types of travertines is fully related to extensional tectonics. Geothermal water rising to the surface along fractures within the rocks cause banded travertines to form within the fracture and layered travertines to form at the surface. At the fracture axis, continuously opening with regional extension, the youngest travertine layers are formed. As a result, moving away from the fracture axis, older travertine bands are found. In some situations, due to the nature of groundwater or the transmitting fractures, geothermal flow may not be carried to the surface at a later time. In this situation if there is continuing extension, the formation of banded travertine formations in the fracture axis stops and a gap may form along the fracture axis. These gaps fill over time mainly with rock pieces of travertine pebbles and blocks and soil. This fill material may become weakly cemented over time by geothermal water leaks.

Sıcak Çermik (Sivas) geothermal and travertine field contains 19 fissure-ridge type travertine formations. Due to a quarry in the fissure-ridge travertine with N-S strike shown by A in Figure 2, surfaces were formed that cut the fracture axis in a vertical direction. This surface includes weakly cemented fill with 40 cm width and 6 meter height developed in the fracture axis. Within this fill there are abundant amounts of bone fossils together with travertine pebbles and blocks. Samples taken from bone fossils contain no collagen showing that they are older than 43,000 years as determined by Accelerator Mass Spectrometry Radiocarbon Dating (AMS) analysis. A sample from the youngest banded travertine found in the axis of the fracture immediately in contact with the fossil fill was dated to $278,540 \pm 18,436$ years with U/Th age analysis. This result shows that the gap containing the fill material in the axis of the fracture formed from $278,540 \pm 18,436$ to the present. Thus, the ages of fossils found within the fill are considered to be between 43,000 and $278,540 \pm 18,436$ years.

Horse-related fossils in the Çermik deposits are very fragmented, with many not well-preserved and no whole fossil belonging to an animal obtained making species and breed definition difficult. In spite of this, based on teeth, mandibula fragment and humerus bone *Equus sp.* and a second molar tooth of Bovidae were identified. Caballoid horses, which were abundant in Pleistocene ecosystems, have wide geographical distribution potential both in hot and cold periods. These characteristics make them very important in terms of biostratigraphy and palaeoecology. This is because animals living in large flat areas are well known from the literature as being a part of the basic hunting culture of Paleolithic humans. This is probably similar in the Sıcak Çermik finds. However, the fact that the study area is narrow and limited restricts the net findings, it only allows the utilization of fossil remains. In these times when shelter was a major problem, hot water springs are highly likely to have provided temporary or permanent shelter in these habitats. Taking into account this context, it can be seen that the Sıcak Çermik samples indicate a paleoecological approach reflecting a cold climatic period.

What makes this ridge with fossils special is that the majority of fissure-ridge travertines do not commonly contain fossil formations in the fracture axis. The abundant fossils found at this ridge in Sıcak Çermik are thought to be due to probable *hominid* activity, involving hunting or settling in the area to benefit from hot water. Though no remains supporting the presence of hominids in the area have been found yet, the cut marks on the bones, regular fractures and abundant mixed bone pieces found in a small area are prospective evidence supporting this hypothesis.

Fossils are very fragmented, with many not well-preserved and no whole fossil belonging to an animal obtained making species and breed definition difficult.

In spite of this, based on teeth, mandibula fragment and humerus bone from *Equus sp.* and a second molar tooth of Bovidae were identified.

In conclusion, Sivas Sıcak Çermik geothermal and travertine field and the fissure-ridge travertine with fossils are considered to be important for three reasons. The first reason is that the fill in the fissure-ridge travertine is linked to tectonic forces and formed a unique fossilization area developing under control of these tectonic forces. The second reason is that between 43,000 and 278,540 ± 18,436 years ago, this paleogeographical area was suitable for *Equus caballus sp.* and *Cervidae* to inhabit. The third reason is that the mixed and abundant bone pieces belonging to the fauna in this region found in a small area leads to the consideration that these animals were hunted, indicating the presence of hominids.

Disclosure statement

No potential conflict of interest was reported by the authors.

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