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A Study of the Cultural and Geological Environment of the Magic Mountain Site in Golden, Colorado

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The results of these analyses indicate the habitation and migratory pattern of the Magic Mountain site was a periodic, but consistent, proximal visitation schedule within a migration pattern where people would inhabit the site during the fall and/or spring every year until resources were depleted. Following the depletion of the resources, the people who inhabited the Magic Mountain site moved to either the plains or the mountains to follow animal herds and to find water sources.

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Acknowledgments

I would like to thank Lawrence B. Conyers for giving access to this project, guiding me through my academic experience, and for reading way too many drafts of this thesis. I would also like to thank Bonnie Clark for acting as an amazing second advisor and for helping me into the Cultural Resource Management realm. Thank you to the University of Denver, the College of Arts, Humanities, and Social Sciences, and to the Anthropology department.

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Finally, I would like to dedicate this thesis to my grandmother, Maryann Neider, who passed away before I could finish this, but heard all about it during our time together.

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Chapter 1: Introduction

The Magic Mountain archaeological site is located in the foothills of the Rocky Mountains in Apex Park of Golden, Colorado (Figure 1.1). Now surrounded by residential neighborhoods, this site is located adjacent to a hogback outcrop of Mesozoic sandstone along Apex Gulch near Table Mountain (Trimble 1993).

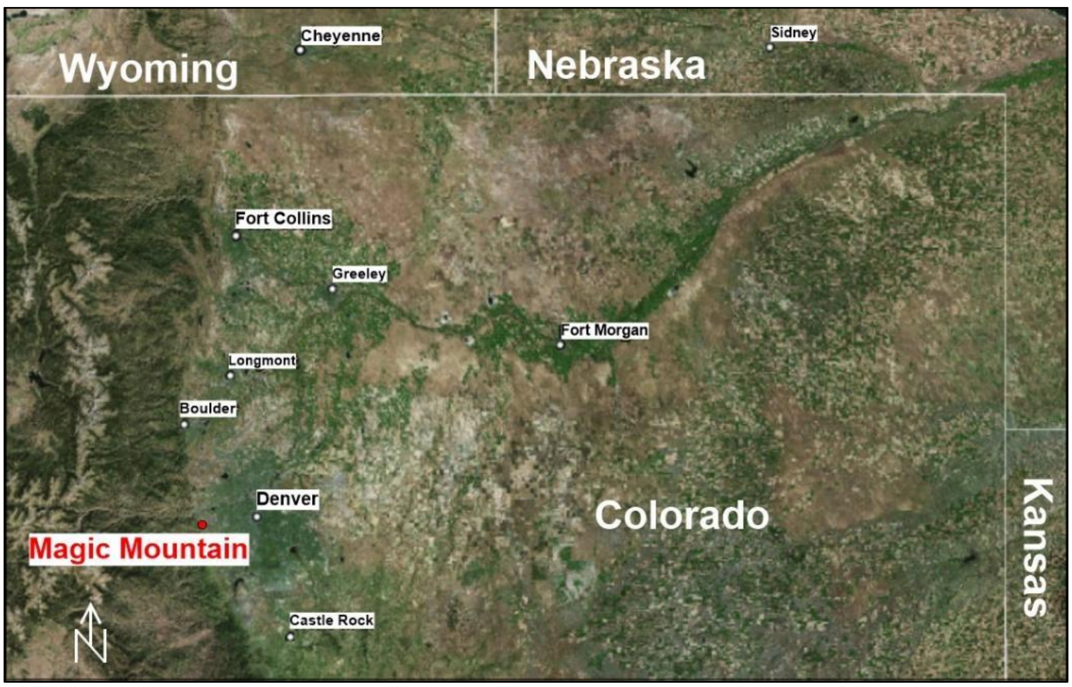


Figure 1.1: Partial map of Colorado with the Magic Mountain site.

The Magic Mountain site was used by migrating groups of hunter-gatherer people during the Late Archaic and Early Ceramic periods until 1000 CE, when habitation ceased (Koons et al 2021). During these periods, this area featured an agreeable and relatively temperate environment in the spring and fall, making it ideal for human habitation. As the seasons changed throughout the year, prehistoric people would have likely moved between the plains, foothills, and mountains in search of resources (Benedict 1992). As the Magic Mountain site was located directly adjacent to these areas, people would have had easy access to edible fruits (i.e.- raspberries) and seeds (i.e.- sunflower), access to water from the perennially flowing Apex Gulch; and access to animal herds that were migrating through the area or grazing nearby.

The Magic Mountain site was one of the first well-documented sites in Colorado that covers such a broad time span so completely (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997). The site was first excavated by Cynthia Irwin-Williams with Harvard University in the 1950s (delineated in orange in Figure 1.2) and later by Centennial Archaeology, LLC in the 1990s (delineated in blue in Figure 1.2). The first set of excavations provided data that gave the site a reputation for being archaeologically fruitful (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997). The Irwin-Williams stone tool artifact assemblage has since been used as a diagnostic collection, which is an artifact collection exhibiting specific characteristics. This designation, called the Magic Mountain Chronology, has been used as a comparative collection for many other nearby sites and is known for its abundant and time-transgressive lithic artifacts (Cassells 1997).

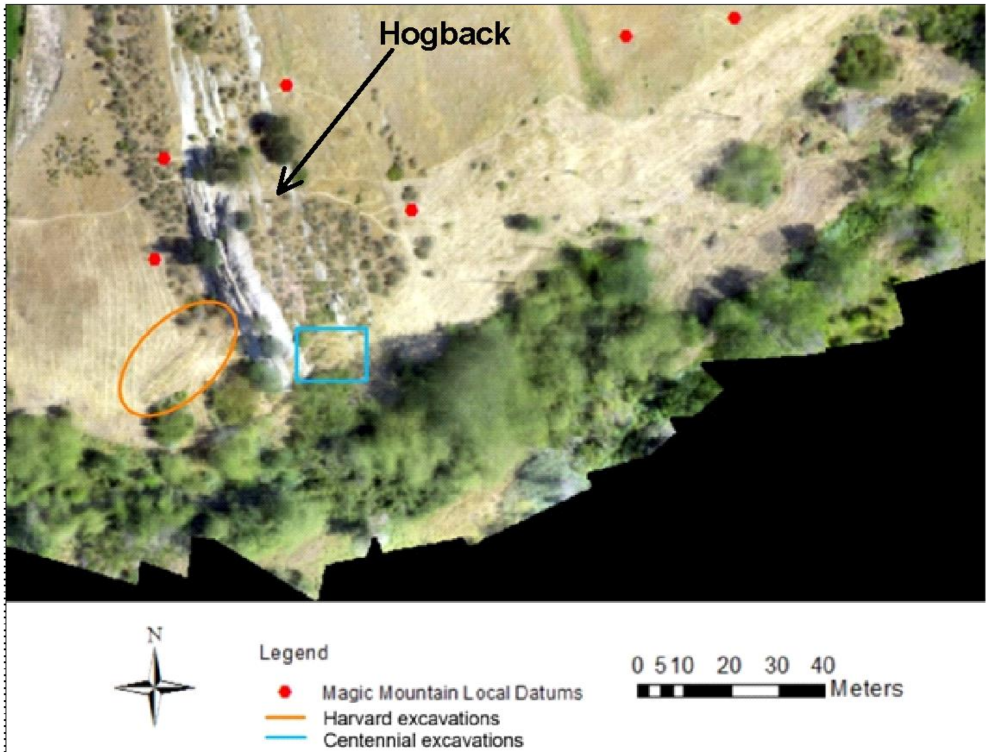


Figure 1.2: A site map of Magic Mountain that includes the datums placed by PCRG and the locations of previous excavations.

Most recently, the Denver Museum of Nature and Science (DMNS) teamed with the PaleoCultural Research Group (PCRG) to create a public archaeology project that excavated the Magic Mountain site in 2017 (DMNS and PCRG 2017 and 2018). Prior to the start of excavations, geophysical remote sensing data was collected in 2016. During this investigation, Lawrence Conyers (University of Denver) and I collected ground-penetrating radar (GPR) to map anthropogenic and geologic features. Ken Kvamme (University of Arkansas) collected magnetometry data to map positive magnetic features. The anthropogenic features that were located and studied with both geophysical datasets were revealed to be hearths during the excavations. The hearths visible within the geophysical imagery were numerous. Upon initial examination, the hearths were evident within the magnetometry data, but sometimes not apparent within the GPR. This is because there was a high number of features that were made of small clumps of stones that had burned. These features showed up as positive magnetic features in the magnetometry.

The purpose of the DMNS and PCRG 2016 to 2017 remote sensing and excavation sessions at the Magic Mountain site were to collect additional data to further evaluate the prehistoric environment and utilization pattern of the site (DMNS and PCRG 2017 and 2018). I also collected more geophysical data after the excavations took place, between 2016 and 2018, and utilized the results of the 2017 excavation, for my own research.

The aim of my research, and this thesis, is to contextualize the Late Archaic and Early Ceramic period habitation patterns of the Magic Mountain site within wider theories of proposed human migration patterns in Colorado (Benedict 1992). I propose the habitation and migratory pattern of the Magic Mountain site was a periodic, but consistent, proximal visitation schedule within a migration pattern where people would inhabit the site during the fall and/or spring every year until resources were depleted. I was able to complete this task using various methods, including ground-penetrating radar, magnetometry, geophysical mapping, and lithic and geological analyses. Each of these analyses help answer specific questions about the landscape and how it was used by people during these prehistoric times. Geophysical methods were used to map geological deposits as well as anthropogenic features. Data from this analysis confirms the Magic Mountain site was consistently utilized during both the Archaic and Early Ceramic periods. GIS modeling was used to study the solar radiation and hill shade found at the site. Modeling results indicate the site was utilized primarily during the spring and fall, and not the winter or summer. Finally, a lithic analysis was used to study raw material types, to evaluate the migratory pattern of the site, and tool diversity, to analyze how the site was utilized. Data from these analyses suggest populations who inhabited the site likely utilized the site on a short-term basis and migrated within a more proximal 30-mile range.

For my research, I surveyed large areas of the Magic Mountain site east of the hogback using geophysics and then synthesized these data into images for interpretation. I began collecting GPR data east of the hogback in the fall of 2016. Ground-penetrating radar data are collected using an antenna that emits electromagnetic waves, which reflect off different interfaces beneath the ground surface (Conyers 2013). This shows various subsurface features that include compacted surfaces, stones, and human disturbances, as well as the sediment and soil units that formed or were deposited. At the Magic Mountain site, these data were processed into reflection profiles and amplitude maps that showed where these disturbances are located as well as their depths (Figure 1.3).

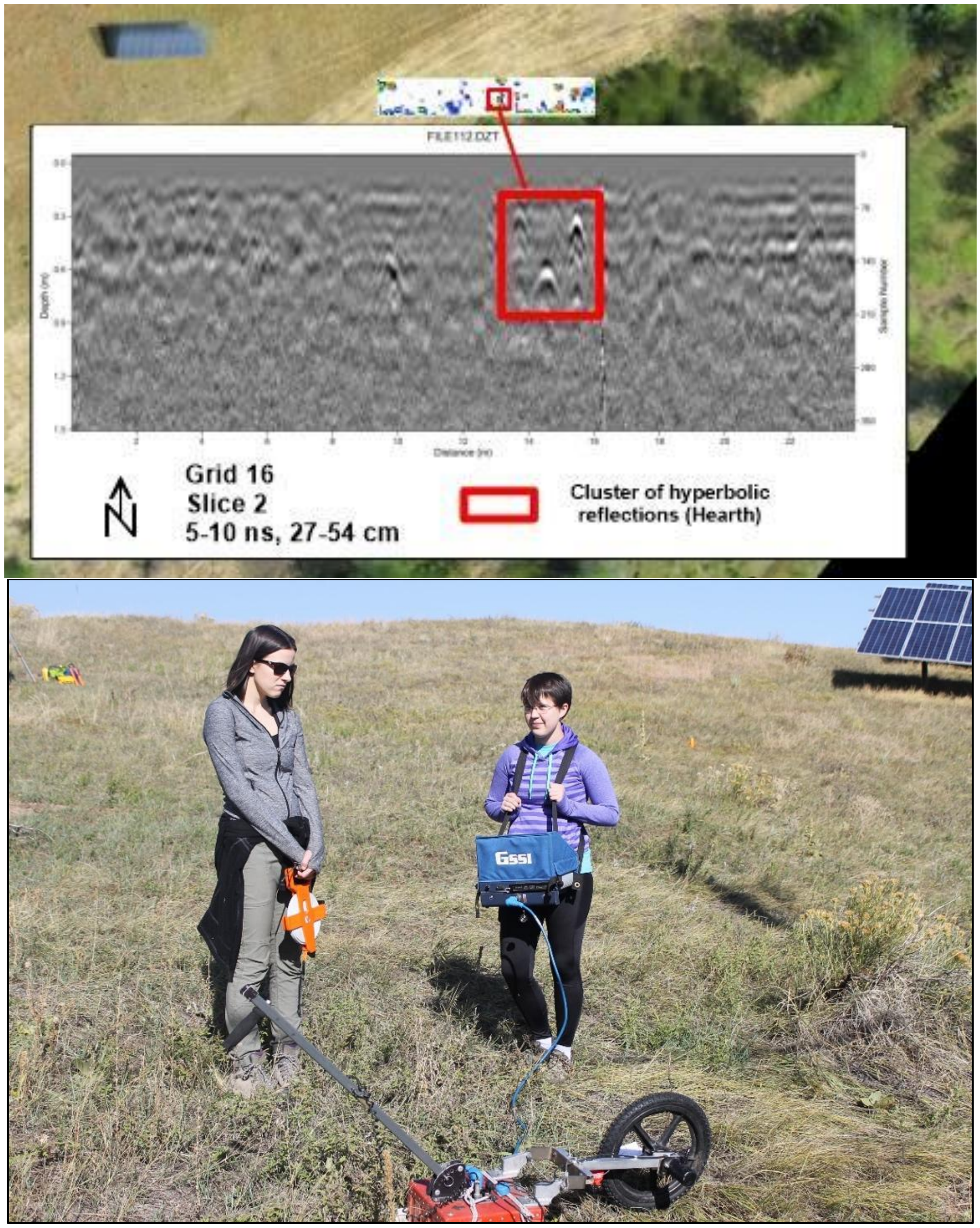


Figure 1.3: The top image is an example of a hearth with its location on the amplitude map (above) and what it looks like in the GPR reflection profile (below). The bottom photo was taken during GPR collection from September 2017.

Images of the areas where data collection took place are shown in Figure 1.4. The area where Ken Kvamme collected magnetometry data in 2017 is found in the top image, with the hearth features marked by red triangles. The geophysical data that I collected (both GPR and magnetometry) is outlined in red in the bottom image of Figure 1.4.

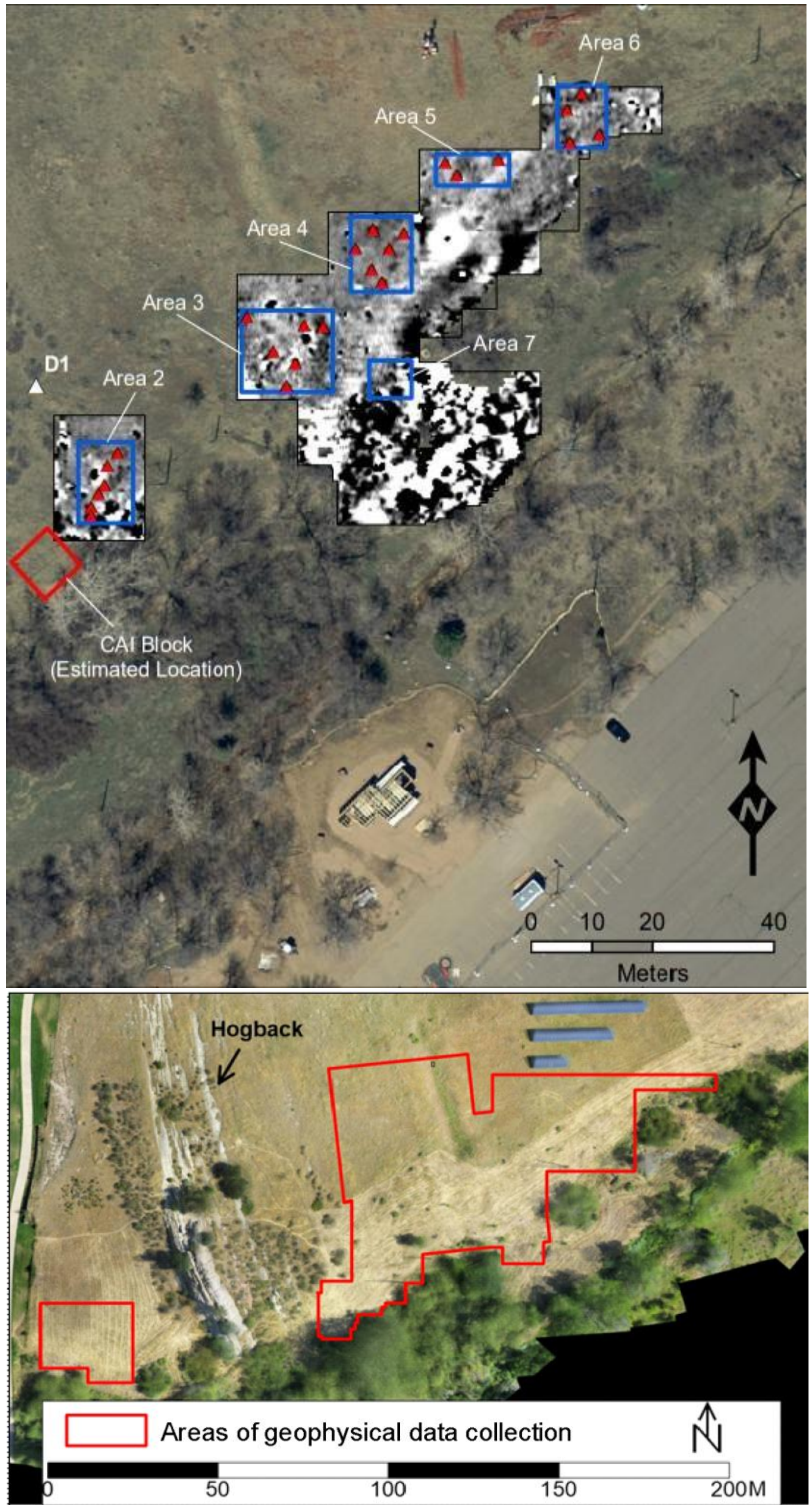


Figure 1.4: Map of the areas of geophysical data collection. The top image is the Kvamme dataset with the marked hearths and the bottom image is my data collection area. The top image is courtesy of PCRG and DMNS research design (2017)

While conducting my research at the Magic Mountain site, I also collected my own dataset of magnetometry (Figure 1.5). Magnetometry is a different geophysical method from GPR because it measures variations in the earth's magnetic field caused by the composition of materials in the shallow subsurface (Kvamme 2006a; Kvamme 2006b). This is possible because every rock and sediment has remnant magnetism or differences in magnetic susceptibility, which subtly modifies the magnetic field (Fassbinder 2015). In the case of Magic Mountain, these variations in the field were caused by hearths, where people burned the ground and the stones. When the hearths were used, they became magnetized and then retained thermoremanent magnetism, which aligns magnetic materials in the ground with the earth's magnetic field as the fire cools. The burning of the hearths also transforms minerals into ferrimagnetic minerals, which changes the magnetic susceptibility of the hearth. In archaeology, the positive magnetic readings, which indicate burning, show up in maps as a contrast to the natural background magnetism.

Figure 1.5: Photo of magnetometry data collection with author. Courtesy of Maeve Herrick.

With the integration of magnetometry and GPR at the Magic Mountain site, I was also able to map large geological features that were later dated to the Late Archaic and Early Ceramic time periods (Mitchell 2021). The GPR images showed larger features, such as the fluvial channels and other geological materials like cumulic A soil horizons. A cumulic A soil horizon occurs when organic-rich layers form as sediment is brought into this area and accumulates with the organic matter (Waters 1992). At the Magic Mountain site, this process formed a thick organic-rich sediment located downslope on the eastern side of the hogback. The GPR image in Figure 1.6 shows evidence of two river channels, located in the same area but at different depths. These two river channels are important because it shows that Apex Gulch was perennially flowing during the prehistoric times, making it a reusable resource worth visiting during migrations.

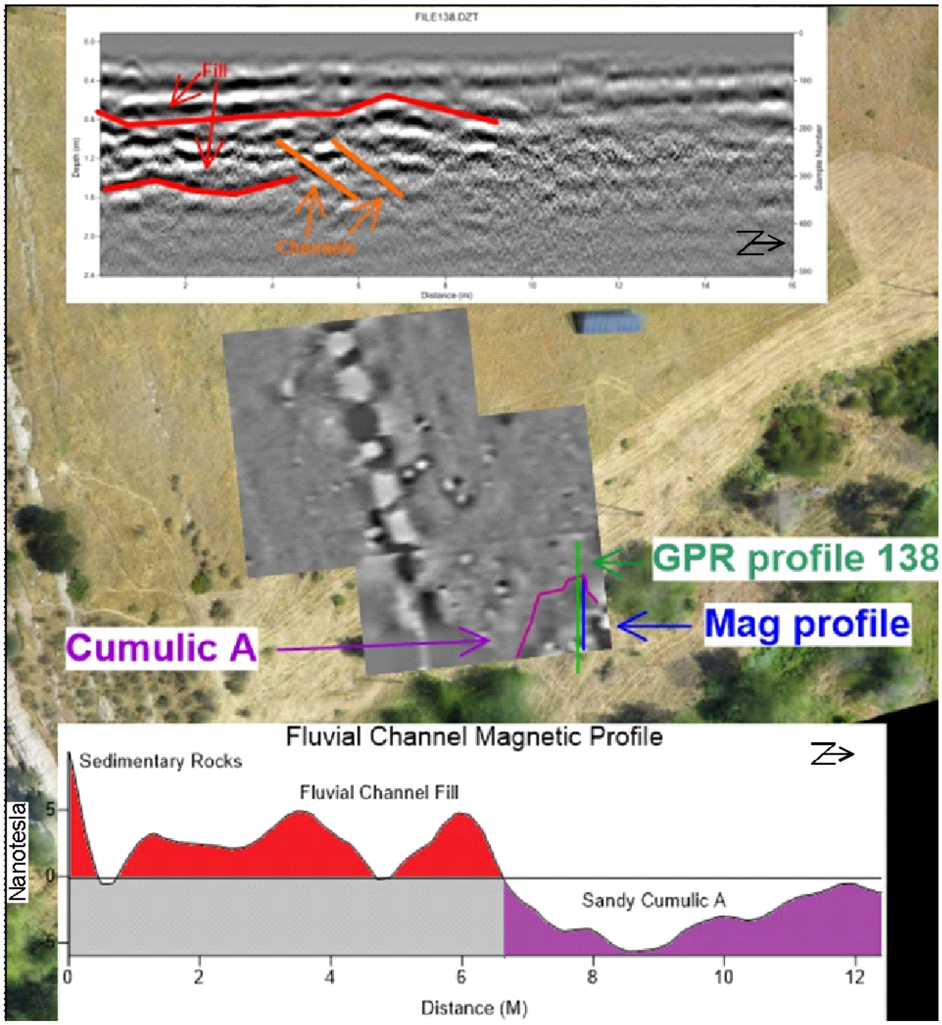


Figure 1.6: The integration of GPR and magnetometry to map the Apex Gulch channels.

The integration of magnetometry and GPR is evident in Figure 1.6, where both were used to find the Apex Gulch channels. The GPR reflection profile showed that Apex Gulch had a series of cut-and-fill sediment sequences, which is when a fluvial channel cuts through the landscape while washing in sediment that fills up the previous channel (Waters 1992). The magnetometry showed the location of a cumulic A soil horizon that filled in the area to the north of the channel (outlined in purple). This area would have been part of the floodplain, or a low-lying area where fluvial sediments would have accumulated over time (Waters 1992). The floodplain is some of the hearth features and artifacts were located during excavations.

The sedimentary rocks that were deposited in Apex Gulch have a small percentage of magnetic materials (Magnetite), which make the channels appear positively magnetic. The cumulic A soil horizon appeared negatively magnetic compared to the Apex Gulch channels. The cumulic A soil horizon is negatively magnetic because it has a lower amount of magnetite than the rocks (Jones 2018). Alternatively, the cumulic A soil horizon is less magnetic than the surrounding soils. This is likely because this area was where humans occupied, which causes magnetic organic materials to build up.

Mapping these large geological features, discovered with GPR, was possible because we profiled every excavation unit to study the soils and sediments that could be directly compared to the GPR (Waters 1992). This allowed for a determination of depositional and erosional changes over time, which is important because it shows how the site formed and how humans settled on the landscape. This documentation showed when the river was flowing swiftly and depositing sediment, when it incised downward and removed previously deposited soils and sediments, and other times when the landscape was stable and soils were forming. The integration of these three methods, GPR, magnetometry, and soil profiling/analysis, is important because it defined periods of landscape change or stability that occurred during the human occupation.

Once I had the site mapped using an integration of geophysics with the excavation information, I created maps using Geographic information System (GIS) models that showed sun exposure across the site's ground surface. I created these models using raster data, which is a digital image where each pixel denotes an elevation (Figure 1.7). The two GIS models that I created were used to study solar radiation and hill shade. These models were calibrated to assign values to each pixel to replicate the sun exposure at the Magic Mountain site. The models showed that the site has a high heat index and a lack of shade, making the location disagreeable during warmer months of the year. In other words, temperatures during the warmer months would be extremely hot with little reprieve from sun exposure. This contrasts with the fall or spring the weather is more temperate because the azimuth of the sun is lower, making the temperatures lower. Lower temperatures and more shade would have made the environment more comfortable and would have given ideal conditions for habitation.

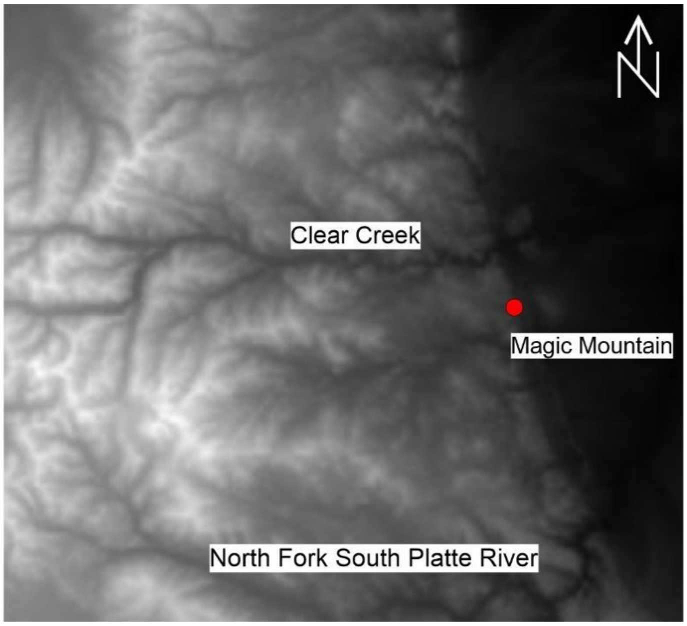


Figure 1.7: Example of raster data with the estimated location of the Magic Mountain site. Raster data is courtesy of USGS.

Finally, I was one of four interns for DMNS to do the lithic analysis on the stone tools and flakes recovered from the excavations. During this time, we completed mass flake, individual flake, and tool analyses. These analyses showed the frequency of material types, the stages of stone tool reduction, and the use of the tools at the site. I was given permission by Michele Koons, co-principal investigator from DMNS, to discuss the lithic data for my thesis. In that analysis, I studied the frequency of raw material types within the overall assemblage and studied the tool diversity at the site.

I studied the frequency of material types by comparing the raw material percentages between 2017 and 2018. These analyses showed that the material types were diverse and of local origin. This indicates that people preferred using lithic resources close by, rather than bringing stone materials along with they travel. This supports the idea that the people were moving between the plains, the foothills, and the mountains locally rather than as part of a larger, more extensive migration pattern (Benedict 1992).

Studying the tool diversity at the site required a more complex mathematical equation that is used commonly in biology to study animal species diversity within a designated area (Andrefsky 1998). This equation is called the evenness index and it calculates how many types of tools are evident within the artifact assemblage on a scale of 1.0 to 0.0. With the evenness index, 1.0 indicates that every tool is present with equal representation and 0.0 means that more tools are represented than others. Although many different types of tools are represented at the Magic Mountain site, the evenness index calculation was closer to the 0.0 end of the scale. This means that certain tools categories are more highly represented than others. At the Magic Mountain site, unpatterned flake tools are the most highly represented tool. While the site shows representation of many of the tasks through the types of tools discovered, the unpatterned flake tool implies that this tool was used once or twice quickly before being discarded (Todd 2022). Unpatterned flake tools, or informal tools, are common when lower quality materials are located close-by and are in abundance (Andrefsky 1994). I hypothesize that the quick utilization of flake tools is likely an indicator that the Magic Mountain site was inhabited to exploit the immediate environment until the seasons changed and people had to migrate to find other resources.

I integrated these methods (magnetometry, GPR, lithic analysis, soil profiling and GIS models) to specifically test a variety of hypotheses about site habitation and migratory patterns of prehistoric people in Colorado. There are several theoretical frameworks that I used to help explain the Magic Mountain site in relation to the data I recovered. The main hypothesis is that the site would have been revisited over long periods of time, which is referred to as persistent places (Schlanger 1992). This theory proposes that sites occupied or revisited on multiple incidences over a long period of time follow certain characteristics that establish it as a place of importance. Those might be visitation for specific activities or for obtaining resources. In the case of the Magic Mountain site, the high number of hearths and artifacts within the area, as well as the proximity to exploitable resources like the lithic material types, support this theory at the site.

Another way to look at human adaptation to the environment is to apply the forager-collector model by Lewis Binford (1980), which discusses site functions for hunting and gathering people, and frequency of site use over time. Binford explained that hunter-gatherer societies fall along a spectrum of within the forager-collector model with how people procure resources. Foragers travel throughout the landscape in search of resources, constantly finding new areas to inhabit until the weather changes and they move elsewhere to obtain other materials. This occurs often as they move over the course of the year to different areas. In contrast with collectors, there was a base camp that people inhabit and then return to it after resources are procured elsewhere. These two models show differences in the way people moved and exploited resources.

In the case of Magic Mountain, people showed a tendency toward foraging where they likely exploited nearby resources until they became scarce when the season changed. They would then move on to other areas. Although many different tools are represented in the artifact assemblage, unpatterned flake tools are the most common. This is likely due to the seasonality of the site and indicates short term occupations over a long period of time rather than the people inhabiting Magic Mountain as a sedentary place. The number of different tools suggests that the site was used for a myriad of tasks rather than specific tasks for short term use, which would be evident at a collector site.

Another related theory proposed by Benedict (1992), explained that prehistoric people migrated between hunting camps in the mountains during the summer to base camps in the plains during the winter. The Magic Mountain site, which would have been a stopping location in the foothills, would have been inhabited during the spring and/or the fall and therefore this seasonality falls within the forager model of Binford (1980). This is evident through the GIS models that showed that the site would have had ideal temperature conditions during these seasons. The *Up-Down System* is therefore a local extension of the Lewis Binford model.

These theories help frame the evidence from the recent excavations in 2017 and 2018 that suggest the site likely a series of occupations, during the Late Archaic and Early Ceramic time periods. The GPR, magnetometry, and soil profiling showed that the site has a high number of hearths during a time when the Apex Gulch was freely flowing. The GIS showed that the ideal time for habitation was during the fall and/or spring because of the temperate weather. Finally, the lithic analysis showed that the site had a high number of informal tools and a high diversity of local raw material types. These findings suggest that the Magic Mountain site had a periodic but consistent visitation schedule within a migration pattern where people would inhabit the site during the fall and/or spring every year. These seasons were an excellent time for people to collect important natural resources in the area like water, animal herds, foodstuffs, and lithic raw materials. The site was likely an important place to the prehistoric peoples as they navigated the landscape in search of resources during their migrations.

Chapter 2: Geological Background

Geological Background of the Region

The Magic Mountain site (Figure 2.1) is situated in the foothills of the Rocky Mountain Front Range near Golden, Colorado (Kalasz and Shields 1997, 20). Currently located in Jefferson County, this site is within the South Platte River drainage basin and is on the border of the High Plains and the Rocky Mountains (Kalasz and Shields 1997, 20). This area has been formally called the Colorado Piedmont and has been the subject of human occupation since prehistoric times.

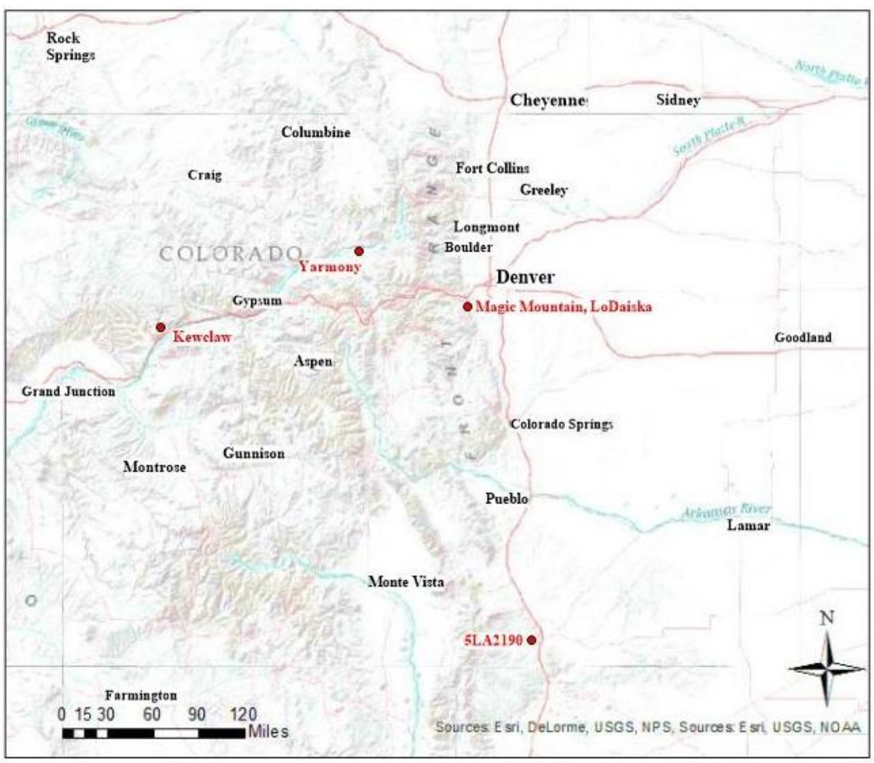


Figure 2.1: A base map of the state of Colorado that shows the extent and location of the Front Range within the state as well as important archaeological sites (red).

The Rocky Mountains are the result of a major vertical uplift called the Colorado Orogeny (Madole 1987, 213, Trimble et al. 1993, 4). The Colorado Orogeny occurred over a period of 300 million years and was the result of the North American Plate colliding with the Pacific plate (Cassells 1997, 16). The tectonic plate movement caused the earth's crust to break and fold, resulting in the formation of the Rocky Mountains (Cassells 1997, 16).

The foothill landforms, where the Magic Mountain site is located, are comprised of the Paleozoic and Mesozoic sedimentary formations (Kalasz and Shields 1997, 20). This means that the bedrock at the Magic Mountain site is of the Paleozoic era and is a part of the Lyons Formation from the Permian age (Kalasz and Shields 1997, 20; Trimble et al. 1993 12-13). This formation is sandstone, which is comprised of a compressed well-sorted fine-grained sand that is yellowish grey in color (Kalasz and Shields 1997, 21). Overall, the foothills and plains are comprised of sedimentary rocks that are formed by broken or dissolved pieces of rock that hardened and bound together over time (Chronic and Williams 2002, 9; Trimble et al. 1993, 9). Alternatively, the mountains are made of metamorphic rocks, formed from older rocks that have been altered by a chemical or physical action, and igneous rocks, which form from molten rock material during the Precambrian Era (Chronic and Williams 2002, 9).

There are various geological formations that have led to the development of the landscapes in and around the Magic Mountain site. This begins with the Paleozoic Era (Figure 2.2), which is subdivided further into geologic ages (Trimble et al. 1993, 10-13). The Paleozoic Era was punctuated with erosional events because of the Rocky Mountain uplift that occurred around two billion years ago during the Precambrian age. This area then became a seaway, forming around 600 million years ago. Sediments accumulated on the seafloor and later formed the sandstone, limestone, and shale layers present in the geologic record as bedrock. These layers uplifted and eroded away around 300 million years ago. The Fountain Formation was then formed from Precambrian sediments of various clasts sizes that came from the mountains by way of streams.

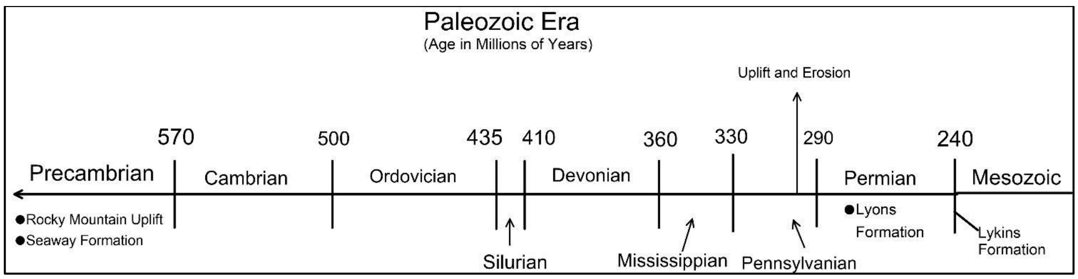


Figure 2.2: Timeline of the Paleozoic Era.

Over the next two million years, the seas advanced and retreated at least twice. During the Permian Period (Figure 2.2), the sea advanced and deposited large amounts of sand that became the Lyons Sandstone (Trimble et al. 1993, 11). As the sea floor deepened, lime and mud accumulated at the bottom and formed the limestone and shale comprising the Lykins Formation. The upper parts of the Lykins Formation were deposited after the sea retreated east, leaving a dry plain punctuated with small lakes. Sand and silts of the Lykins Formation were deposited from winds and streams during the Triassic Period in the Mesozoic Era (Figure 2.3). This was followed by the Jurassic Period, where many of the early stratigraphic layers were not preserved (Trimble et al. 1993, 11). The layers of the late Jurassic Period were preserved and became the Ralston Creek and the Morrison Formations by sediments that were deposited when the area was a swampy lowland.

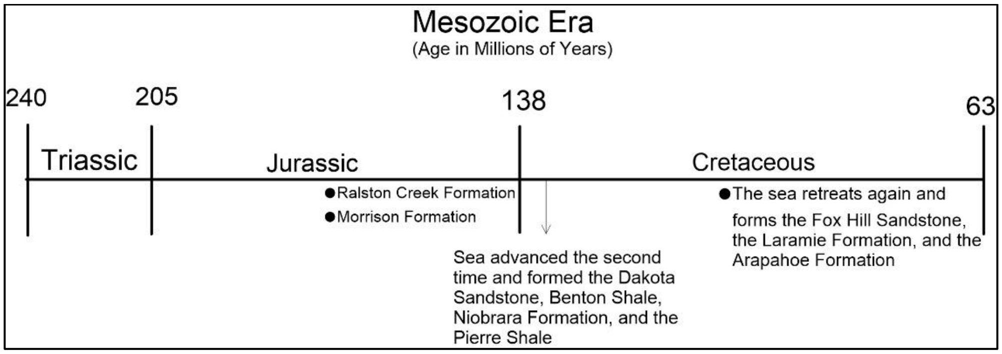


Figure 2.3: Timeline of the Mesozoic Era.

The sea advanced for the second time in the Cretaceous Period in the Mesozoic Era (Figure 2.3) around 135 million years ago (Trimble et al. 1993, 11 and 14). The advancing shore, again, deposited the sands that later formed the Dakota Sandstone. The sea floor then accumulated lime sediments and muds that formed the Benton Shale, Niobrara Formation, and the Pierre Shale. The sea withdrew for the second time in the later part of the Cretaceous Period, which formed the Fox Hill Sandstone, the Laramie Formation, and the Arapahoe Formation. Around 70 million years ago in the Tertiary Period, the speed of the Rocky Mountain uplift increased, which caused the stratigraphic layers to bend vertically (Trimble et al. 1993, 15). Volcanos somewhere to the west erupted and caused lava to flow through the fissures in the Rockies that were created during the uplift. The lava, along with volcanic ash, debris, and mud, comprised the Denver Formation.

The two major geologic formations that should be noted on the Magic Mountain site are the hogback, a ridge with steeply sloping sides, and the nearby gulch (Figure 2.4). During the last major uplift when the stratigraphic layers were up-turned to a near vertical position, the older stratigraphic layers settled to the west while the newer layers settled on the east (Fenneman 1931, 32; Trimble et al. 1993, 8). This formed the hogbacks that are located throughout the foothills of the Front Range. The softer layers eventually eroded from this process and left behind the harder layers like the Dakota Sandstone. This sandstone is cretaceous in age and is also responsible for Dinosaur Ridge, a nearby geological site with visible dinosaur prints (Fenneman 1931, 32; Kalasz and Shields 1997, 20). Apex gulch, which is a narrow ravine, flows through the site as an intermittent drainage system (Irwin-Williams and Irwin 1960, 31; Kalasz and Shields 1997, 21). This flows down from the Rocky Mountains, around the hogback, and drains to the east of the site. Gulches are characteristic of the foothills because they act as drainage from the mountains. This gulch, however, was rerouted during the construction of the Heritage Square amusement park, which is located just southwest of the site (Kalasz and Shields 1997).

Figure 2.4: Image of the hogback at the Magic Mountain site.

Other landforms that are nearby include Green Mountain, North Table Mountain, and South Table Mountain. Green Mountain is important in relation to Magic Mountain because it is thought to be a quarry area for the various lithic raw materials found at the site (Kalasz and Shields 1997, 20). This mountain is described as a high mesa located between U.S. Highway 6 and Alameda Parkway and it is capped by a conglomerate of gravel that was deposited by a stream (Kalasz and Shields 1997, 20; Trimble et al. 1993, 7). This gravel deposit then naturally cemented on top of an older volcanic flow that is known as the Denver Formation. The Denver Formation is the bedrock that underlies much of the area (Kalasz and Shields 1997, 20; Madole 1987, 213-214; Trimble et al. 1993, 7).

North and South Table Mountain were partially formed from these lava flows (Trimble et al. 1993, 8). Like its name, both Table Mountains have a flat top characteristic of mesas. At one point, these landforms were one continuous formation, but Clear Creek cut a channel between them, which gives the formation its structure today. It is hypothesized that the lava came from fissures that are located near the Ralston Reservoir in Golden.

Geological Background of the Site

The Magic Mountain site is part of a late Quaternary alluvial fan, and it was hypothesized by J. Hiram Smith and Glenn Scott that it was dominated by stream sediments that were deposited during this time (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997, 21). An alluvial fan is formed when streams and rivers flow from mountains and carry sediments to the lowlands (Waters 1992, 154). These wedge-like fans form as sediments build up over time. Alluvial fans are a common geologic formation in the foothills because water from the Rocky Mountains flows down into the plains. During this process, the water separates into smaller and smaller streams based on the topography of the area (Fenneman 1931, 12; Irwin-Williams and Irwin 1966, 31).

There are six deposits that are present in the area that Smith and Scott discuss in the technical report written by Irwin-Williams and Irwin (1966; Kalasz and Shields 1997, 21-23). There are three Pleistocene deposits that are named Verdos, Slocum, and Broadway and there are also three Holocene units named Pre-Piney Creek (>5,780 B.P.), Piney Creek (3,500 B.P. to 1850 B.P), and Post-Piney Creek (1,900 to 120 B.P). The archaeological artifacts discovered during the previous excavations were found in the Holocene deposits at the site.

All these deposits are also associated with key paleoclimatic trends that have affected site formation processes over time. The transition from the Pleistocene to the Holocene happened between 10,000 to 12,000 years ago and most notably changed the environment from a forest/savanna-like environment to a grassland (Kalasz and Shields 1997, 25). Many animal species went extinct during this time. This was followed by the Altithermal (7500-5000 B.P.) and finally the post-Altithermal (5,000 B.P. to present) (Benedict 1979, 1; Kalasz and Shields 1997, 25). It is hypothesized that there was a cool and moist period from 5,000 to 3,000 B.P. which led to a drought from 1000 B.P. to 400 B.P. A cooling period then occurred that is now known as the 'Little Ice Age' and led to wet conditions from 400 to 100 B.P. (Kalasz and Shields 1997, 25).

This site is currently found in a dry, semi-arid climate, which experiences a daily variation in temperature (Kalasz and Shields 1997, 25). This type of climate is caused by the westerly winds coming from the Pacific, which encounter the Rocky Mountains. The air is then uplifted, cooled, and produces rainfall in the high country. This causes the air to become dry and settle in the Great Plains on the east side of the Rockies (Osterkamp 1987, 196). The flow of air coming from the west is strongest during the winter months, which causes dryness and low precipitation during this time (Kalasz and Shields 1997, 25; Osterkamp 1987, 196; Stone 1999, 7). However, during the summer months, winds from the south begin to dominate, creating an influx of warm air and increasing precipitation.

Chapter 3: Cultural Background

Cultural Background of the Region

There are cultural stages that are present within the Front Range/High Plains region of the United States. These include the Paleoindian stage, the Archaic stage, and the Ceramic stage (Kalasz and Shields 1997, 37). There may also be a Pre-Paleoindian stage but there has not been evidence of this found at the Magic Mountain site in prior excavations.

Paleoindian Stage

The Paleoindian stage is broken up into the Clovis Period (11,500 B.P. to 11,000 B.P.), the Folsom Period (10,800 B.P. to 10,200 B.P.), and the Plano Period (10,200 B.P-7,000 B.P.) (Kalasz and Shields 1997, 37-39). Altogether, the Paleoindian stage is characterized by the decline of megafauna that lived on the High Plains and is associated with sites that are typically associated with single-kill events and occupation camps of a short duration. Later in the stage during the Plano Period, there is evidence of highly organized social societies. This includes complex plans of large animal kills and utilization of plant resources. Overall, this period is characterized by nomadic people, who followed large game and megafauna across the landscape (Cassells 1997, 95).

Archaic Stage

The Archaic stage is dated between 7,500 B.P. to 1,800 B.P. (Frison 1991, 80; Kalasz and Shields 1997, 39). This stage has been broken down into Early (7,500 to

5,000 B.P.), Middle (5,000 B.P. to 3,500 B.P), and Late Archaic (3,500 B.P- 1800 B.P.) periods and is marked by changes in climate (Kalasz and Shields 1997, 40-41). Over time, the climate became more arid which led to a decrease in forested areas on the High Plains and a loss of the larger megafauna (Cassells 1997, 95; Kalasz and Shields 1997, 39; Stone 1999, 15). Technology overall during this stage became more complex with evidence of diversity in tool use shown in the archaeological record (Cassells 1997, 96; Gilmore et al. 1999, 91; Kalasz and Shields 1997, 40). This change in technology is exhibited by the switch from larger lanceolate and stemmed points made during the Paleoindian Stage to smaller, notched points. These changes in tool types suggest a change in the type and size of animal that was hunted (Cassells 1997, 96; Frison 1991, 79; Gilmore et al. 1999, 92; Guthrie et al. 1984, 22). Overall, the Archaic lithic technology tends to lack the same quality of finish as the Paleoindian artifacts because these artifacts are much larger and more refined (Guthrie et al. 1984, 34).

Evidence shows that the diet of the prehistoric people was changing. This is based on the decrease in the amount of animal kill sites and the increase in grinding stones, which would have been used to exploit plant resources (Cassells 1997, 95; Frison 1991, 89; Gilmore et al. 1999, 91; Kalasz and Shields 1997, 40-41). The Early Archaic Period dates to around the same time as the Altithermal, which was hotter and drier (Benedict 1979; Guthrie et al. 1984, 23; Kalasz and Shields 1997, 40). Sites found in this period are characterized by rock shelters, campsites, and lithic technology made from local materials (Kalasz and Shields 1997, 40). Rock shelters were excellent habitation structures for this time because they were cool during the hotter months and warmer during the cooler months. They also provided protection from the elements (Cassells 1997, 99). Open sites, which were typically associated with one occupational episode like a hunting camp, were also popular during this time (Cassells 1997, 99). Campsites during the Archaic stage are typically found near lakes or streams, on smooth, well-drained ground, and are sheltered from the westerly winds (Benedict 1992, 8). These types of sites change during the Middle Archaic.

The Middle Archaic Period saw the close of the Altithermal (Kalasz and Shields 1997, 40). The people during this time period seemed to live a mobile hunter-gatherer lifestyle. This is evident through temporary shelters and a wide range of resource procurement including various plant and animal species within the archaeological record.

Finally, the Late Archaic Period has no extensive cultural changes that are noticeable within the archaeological record except for a step toward more regional divisions within the lithic technology (Kalasz and Shields 1997,40). Group cooperation, which shows social complexity, is evident though large animal hunting and procurement (Cassells 1997, 96; Kalasz and Shields 1997, 41). It was hypothesized by Irwin-Williams and Irwin that Magic Mountain would have been ideal for a campsite because there was an adequate supply of water coming from Apex Gulch, good vantage points for hunting, and the use of hogbacks for shelter (1966, 31). There are several types of architecture that are found during this time period, which include surface mud-and-stick buildings, timber lodges, pit houses, and surface masonry buildings (Gilmore et al. 1999, 100). Some evidence of habitation structures was found at the Magic Mountain site during the excavations in the 1990s including a stone wall and an indoor hearth (Kalasz and Shields 1997).

There are several sites during this time period that exhibit similar architecture to that found at the Magic Mountain Site. An example of this is the architecture at the Yarmony Pit House, located in Middle Park by the Colorado River, where there were large slab-lined cists, a shallow floor depression, hearths found, and in situ ground stone found within the structure (Cassells 1997, 102, Figure 2.1). This evidence was interpreted to be a dwelling place during the winter months because of the evidence of food storage. A shallow basin-like structure with a mano and metate was found in situ at the Magic Mountain site during the 2017 season.

Other architectural examples are found at the Kewclaw site, which is in the Colorado River Valley. The Kewclaw site is a pit house that measured 4.5 meters in diameter and was 65 centimeters deep (Cassells 1997, 104, Figure 2.1). There was a superstructure constructed from waddle and daub and within structure, there was an indoor hearth covered by sandstone slabs. This suggests a year-round occupation because the structure would keep out the elements while the hearth provided warmth. The excavations from the 1990s at Magic Mountain revealed a stone wall and minimal evidence of a wattle-and-daub superstructure (Kalasz and Shields 1997, 285). This type of construction may have been used all year because of the ability to retain heat in the cold months (Cassells 1997, 105). Finally, the site named 5LA2190, located west of Trinidad, had a shallow oblong basin with an external hearth found on the eastern side of the structure (Cassells 1997, 110, Figure 2.1).

Typically, habitation structures are associated with specific factors for the selection of that location, which include good vantage points, floral and faunal resources, as well as nearby water sources (Guthrie et al. 1984, 34). These factors are integral for activities associated with prehistoric peoples like hunting and gathering. This would influence the people's decision about where they lived and for how long they stayed in that location because daily activities are dependent on these resources.

Pit houses are common during the Archaic Period as a type of settlement pattern in the foothills-mountain area (Frison 1991, 83). These structures are perfect for colder climates and are typically accompanied by fire pits, storage pits, and grinding stones (Frison 1991, 84). Very common structures that would accompany the architecture includes the food preparation pits (Frison 1991, 89). Grinding stones and fire pits have been found at Magic Mountain (Kalasz and Shields 1997).

Ceramic Stage

The Ceramic Stage is dated to 1,800 B.P to 200 B.P. This is broken down into Early (1,800 B.P to 1,000 B.P.), Middle (1000 B.P. 10 500 B.P.), and Late Ceramic Periods (500 B.P. to 200 B.P.) (Kalasz and Shields 1997, 42-47). The Ceramics stage shows major changes in cultural patterns in comparison to the Archaic stage. It is thought that this stage in Colorado has Plains-Woodland influences, which has been hypothesized to be seen at Magic Mountain (Irwin-Williams and Irwin 1966). It is thought that as the Plains-Woodland people migrated, they brought along their cultural traits. It is hypothesized that the migration originated in Southeast and then spread to the Northeast and the West (Cassells 1997, 191).

Sedentary lifestyles and horticulture are characteristic of the Plains-Woodland tradition, though this is not necessarily seen at the Magic Mountain site (Guthrie et al. 1984, 42). This includes economic patterns, changes in artifact complexes, and demographics of the population but most notably, the introduction of ceramics (Cassells 1997, 192; Kalasz and Shields 1997, 41). One of the major artifact complexes that is evident during this Stage is the use of the bow and arrow, the development of ceramics, and semi-permanent-to-permanent architecture (Kalasz and Shields 1997, 41). This stage goes by many names including the Formative stage, The Ceramic stage, Plains-Woodland, and the late-prehistoric stage. Even though these terms are defined differently, this stage in Colorado seems to be a combination of them although the Plains-Woodland term is not normally used. This is because "Plains-Woodland" is a cultural tradition that originated in the eastern parts of North America and the term could not be substantiated based on the known artifact assemblages within Colorado (Gilmore et al. 1999, 177).

The Early Ceramic Period is marked by longer occupation periods at sites with cultural components of the Late Archaic Period intermixed (Gilmore et al. 1999, 179). According to the archaeological record, the amount of architecture increases in frequency during this time period but there is still no indication of villages like on the Plains. Types of sites and architecture for the Early Ceramic Period include open lithic sites, open camps, open architectural sites, sheltered camps, sheltered architectural sites, quarries, game drives, isolated finds, and a combination of any or all the above (Gilmore et al. 1999, 182).

There are four sub-classifications of habitation structures during the Early Ceramic Period. These include rock shelters, lean-to walls, shallow pit structures, stone rings, and sub-rectangular stone wall structures (Gilmore et al. 1999, 240). Architecture at the Magic Mountain site was found during the excavations in the 1990s that potentially fits into the Early Ceramic Period. Feature 9 found during the excavations at the site was hypothesized to be a compacted floor with a potential rock wall scatter (Gilmore et al. 1999, 243; Kalasz and Shields 1997). Underneath Feature 9, Feature 11 is a semi-circular arrangement of boulders and cobbles deposited on the Lyons Formation bedrock on the southside of the hogback. A small piece of daub was found in the same area, which suggests a wattle and daub construction for the structure. However, no postholes were found that would suggest a superstructure, which would have been common during the Late Archaic/Early Ceramic Period (Kalasz and Shields 1997, 287).

The Middle Ceramic Period is evident by wattle-and daub construction, bone and lithic tools, ceramics, horticulture (maize-beans-squash), and hunting and gathering (Kalasz and Shields 1997, 45). The Middle Ceramic Period is similar to the Early Ceramic Period, but there are fewer Middle Ceramic sites evident in the archaeological record (Gilmore et al. 1999, 245). This may be because these sites were in areas where the land was geologically unstable, so the sites were buried and/or destroyed.

Finally, the Late Ceramic Period, or the Protohistoric Period, is represented by the direct contact of the Indians and populations of European decent (Kalasz and Shields 1997, 41). It is likely that all the time periods mentioned are disturbed at Magic Mountain because of the extensive looting that occurred at the site in the past during the late 1800s-early 1900s.

Theoretical Frameworks: Theory of the Plains and Mountains

There are multiple theoretical frameworks which apply to the Magic Mountain site that help explain the site function and larger migration patterns. The framework occurring on the largest scale is the idea of persistent places, which was first explained by Sarah Schlanger in 1992. Schlanger produced the theory of persistent places by studying Puebloan sites in Dolores, Colorado. This theory suggests that an area is occupied or revisited on multiple occurrences throughout time in a region that has a long occupation period (Schlanger 1992; 95). These places, because it is a place that people tend to frequent, are inscribed with a deeper meaning for the people occupying the area.

There are certain characteristics that the site should have to be considered a persistent place. The first characteristic is that the site must have a significant quality or qualities that would cause people to revisit the site for specific activities (Schlanger 1997, 97; Moore and Thompson 2012, 268; Shaw et al. 2016, 1439). An example of this would include landscapes where animals were found for hunting or an area with a nearby lake for fishing. The second characteristic is that the site must have features that people would return to use. This includes storage features, hearths, and shelters. These features add to the built landscape and allow for structured everyday activities to take place on site. Finally, the last characteristic is that although the re-occupation of the site may be independent from the cultural features, there is a dependency on cultural materials such as exploitable resources. For example, people will always need food and water and are therefore dependent on finding these resources.

The main idea of persistent places is that these areas are never completely abandoned because people return to the area for more short-term purposes (Schlanger 1992; Moore and Thompson 2012, 12). Also, not only is there evidence of built environments to show persistence but there are smaller material items that are left behind by people regardless of topography or climatic-driven changes (Shaw et al 2016, 1440). The built environment and the artifacts both add to the archaeological record.

The theory of persistent places was also applied to prehistoric sites in the Eastern United States (Moore and Thompson 2012, 274). Moore and Thompson examine the idea of persistent places in relation to the prehistoric people who lived in the uplands in the middle Green River Region of Kentucky. These people would make their way from the uplands to the wet bottomlands for fishing and hunting. More specifically, Moore and Thompson discuss the idea of 'dwelling' which implies not only the relationships between and within populations, but the relationship that those people have to the environment (Moore and Thompson 2012, 276).

Shaw et al. (2016, 1446) adds to the idea of persistent places as well by using the theoretical framework in a more geological fashion to study Neanderthal occupations on the island of Jersey in the United Kingdom. The article is presented in a manner where they discuss each important geologic layer, which can be used in a comparable way at the Magic Mountain site.

The Magic Mountain site is likely a persistent place because of multiple characteristics. Not only are there multiple periodic occupations in a relatively stable environment, but the site is centrally located in the foothills of the Rocky Mountains. This would indicate that the people using the site could easily access both the plains and the mountains within a day or two if any environment becomes too stressful. The site is also an apt hunting area because it is near water. The geological and artefactual context from the site can also help discuss the idea of Magic Mountain as a persistent place through the analysis of raw material and lithic technology.

Another theoretical framework relevant to Magic Mountain is discussed by Lewis Binford. Binford discusses the idea of hunter-gatherers with foraging-collecting characteristics (Andrefsky 1998, 198; Binford 1980). A hunter-gatherer lifestyle is defined as people who survive by hunting, fishing, and harvesting wild plants. Although this has been a common thought within archaeology, Binford proposes the idea that hunter-gatherers can be further broken down into a spectrum that extends between foraging characteristics and collecting characteristics. On one end of the spectrum, foragers are likely to stay close to their residential base so this would mean that they would collect food daily (known as residential mobility). On the other end of the spectrum, the collectors were more likely to form 'task groups' to complete necessary activities for survival because these groups need to travel farther for resources (known as logistical mobility).

The forager-collector model is linked to the theory of persistent places because Binford discusses the fact that people have to migrate to find resources depending on the season (Binford 1980). In terms of Magic Mountain, people would have returned to the site, perhaps annually, to procure resources, making it a persistent place. The forager-collector model is studied through lithics by understanding that different material types and tools are found at the different types of sites. For example, generalized but diverse tools are found at foraging residential camps because groups of people stayed for longer periods of time and completed many of the necessary daily tasks at camp (Andrefsky 1998, 201-202). This is compared to the less diverse but specialized tools found at collectors' sites that reflect the specific task performed at the location.

The theory of persistent places and the forager-collector model is linked to a theory created by a Colorado archaeologist, James Benedict. This theory defines the 'seasonal transhumance systems' occurring throughout the Front Range and explains site usage through this lens (Benedict 1992, 11-12). Benedict discusses the *Up-Down System*, which inferred that people followed a seasonal migration pattern of moving between high-altitude and low-altitude areas. During the move, prehistoric people migrated from the hunting camps used during the summer in the mountains to the base camps along the east side of the Front Range foothills area during the winter. This system is thought to be utilized by the Mount Albion Complex people from the Early Archaic Period, evidence of which is said to be found at the Magic Mountain site. The migration of people corresponded with the migrations of large herbivores, which would move to lower altitudes during winter before snow fills the mountains (Benedict 1992, 3).

James Benedict also discussed the idea for the *Rotary System*, which is similar to the *Up-Down System* except that people during the Ceramic Period travelled a greater distance throughout Colorado (Benedict 1992, 12). In this *Rotary System*, there are winter base camps in the foothills/hogback region and hunting camps in the mountains. More specifically, the people were thought to move between the foothills in the winter, to North Park in the spring/early summer, into Middle Park during the late summer/early autumn, and then back to the foothills in the late autumn/winter (Benedict 1992, 13). This system, however, shows greater diversity in lithic raw materials as well as more sites located through what is thought to be migration areas. Some artifacts found to explain this system include corner-notched points, preforms, cord-pressed pottery, and pressure-flaked bifacial knives (Benedict 1992, 12). Both the *Up-Down System* and the *Rotary System* were used to help explain the multiple occupation periods previously found at the Magic Mountain site.

Benedict also discusses the types of sites that are typically seen in Colorado during prehistoric periods. Previous studies show that Magic Mountain was likely a campsite of some kind, which would include architecture like stone-filled roasting pits, shallow-basin hearths, and some kind of temporary shelter (Benedict 1992, 8). These campsites are located near lakes or streams, in a clearing not affected by winds or shade, is well drained, are somewhat topographically level, and have shelters protected from westerly winds. Artifacts for the sites discussed by Benedict include broken projectile points, re-sharpened tools, and tools for processing meat, hides, and wood (Benedict 1992, 8-9). There is also evidence of 'domestic' tasks performed around hearths and that tool manufacture included shaping preforms brought to the site. Shaped and striated manos and metates are evident for processing gathered plants.

The former assistant state archaeologist of Colorado, Kevin Black, also proposed the idea of the Mountain Tradition, which explains the transition from the Paleoindian to the Early Archaic Period (Black 1991). The Mountain Tradition is defined as sites that show exploitation all year by nomadic/semi-sedentary groups, which have these exploitation patterns occur over a long continuous period, and that have a separate archaeological footprint from Paleoindian in the lowland areas (Black 1991, 1). Meaning, the upland groups potentially used the mountains all year, not just on a seasonal basis. In this theory, the Magic Mountain site is used as an example to explain many of the characteristics for the Mountain Tradition even though the site is in the lowlands of the Rocky Mountains (Black 1991, 6). This means the people that utilized Magic Mountain may have used it seasonally but unlike the sites in the mountains, it was not occupied by other groups from the uplands.

Overall, the Mountain Tradition sites are located near a water source or game drive for resource procurement, there is a utilization of split cobble technology, there is a presence of microliths (tools smaller than 1 cm), there is a primary usage of local raw materials in lithic technology, there are a large number of projectile points, and there are habitation structures present (Black 1991). Although this theoretical framework is centered around the Paleoindian and Early Archaic Periods, many of the characteristics laid out match the evidence found at the Magic Mountain site during the Late Archaic/Early Ceramic Periods.

Background of the Magic Mountain Site and Previous Archaeological Work

The Apex site, now known as the Magic Mountain site, was originally named after the historic mining town of Apex that is currently located underneath the Heritage Square Amusement Park parking lot (Kalasz and Shields 1997, 7-8). The site was extensively looted during the historic times because of the rumors of a "Woodland Period cemetery" being in the area. Avocational and amateur archaeologists tried to study the site after the looting became commonplace, which led to the eventual involvement of the Colorado Museum of Natural History (now known as the Denver Museum of Nature and Science).

In the 1940s, amateur archaeologists by the name of Jack Putnam and Robert Ackerley presented the museum with the discovery of the site (Irwin-Williams and Irwin 1966, 14; Kalasz and Shields 1997, 8-9). Elizabeth and Harold Huscher, archaeologists at the museum, tested the site in 1941 and discovered a grave (Irwin-Williams 1966, 20; Kalasz and Shields 1997, 8-9). Their notes also attested to the fact that there were deep stratigraphic layers with artifacts within them. The artifacts from this excavation collection were found to be unprovenanced and had no notes or maps. The grave that was found cannot be re-located and its associated goods and/or remains have not been found within the museum collections today.

Cynthia Irwin-Williams and her brother Henry J. Irwin were conducting studies of archaeological sites in the area when they found out about the Apex (Magic Mountain) site. The siblings began studying the LoDaiska site, a rock shelter in the area but branched out to other sites within the foothills of the Rocky Mountains to better understand the different types of sites (Irwin-Williams and Irwin 1966; 1). Putnam and Ackerley notified Irwin-Williams and Irwin about the Apex site and the siblings decided to survey and test the area, with excavations beginning at the Magic Mountain site in 1959 (Irwin-Williams and Irwin 1966, 22; Kalasz and Shields 1997, 9). The siblings would go on to get their doctorates from Harvard University, with the first written report about the site being an edited version of Irwin-Williams doctoral dissertation (Kalasz and Shields 1997, 7).

Irwin-Williams and Irwin produced four research topics to study the Magic Mountain site. The first topic sought to better understand the history of the foothills because during this time, the LoDaiska site was one of the only sites studied in the area (Irwin-Williams and Irwin 1966, 16). Related to this, the second topic was to research the various technological complexes that occurred at the Magic Mountain site in relation to the known technological complexes at the LoDaiska site. The third topic aimed to understand the geological chronology and the paleobotanical evidence in comparison to the LoDaiska site rock shelter (Irwin-Williams and Irwin 1966, 17). Finally, the fourth and final topic sought to clarify the cultural characteristics of the central foothills' region.

Irwin-Williams and Irwin excavated the site using large grid block excavations (Irwin-Williams 1966, 22-26; Kalasz and Shields 1997, 10). The excavation block was separated into smaller yard-squares and oriented to magnetic north (Kalasz and Shields 1997, 10). The levels were excavated at four-inch arbitrary increments (Irwin-Williams and Irwin 1966, 24; Kalasz and Shields 1997, 10). Troweling and shoveling was used along with ¼ inch screens for sifting.

Other various methods were employed at the site, including auguring, testing, coring, and excavation with heavy equipment. The report written by Irwin-Williams and Irwin discusses five backhoe trenches that the team completed to the west of the outcrop (Irwin-Williams and Irwin 1966, 29; Kalasz and Shields 1997, 10). Soil cores were taken from the area of the grid block excavations, but no pollen was found for further analysis (Irwin-Williams and Irwin 1966, 30; Kalasz and Shields 1997, 10). It is suggested from the report that poor preservation of the samples was to blame.

However, Irwin-Williams and Irwin included J. Hiram Smith and Glenn Scott from the U.S. Geological Survey to study the stratigraphy at the site (Irwin-Williams and Irwin 1966, 31; Kalasz and Shields 1997, 9). Their report of the site stratigraphy is included in Irwin-Williams published dissertation. Although their work helped establish the geology, there are some discrepancies in the report about the depth of soil profiles completed at the site. There are seven geological units that were given the names of Zones A to G (Irwin-Williams 1966, 36; Kalasz and Shields 1997, 11). These geological units and their associated archaeological units are found in Figure 3.1.

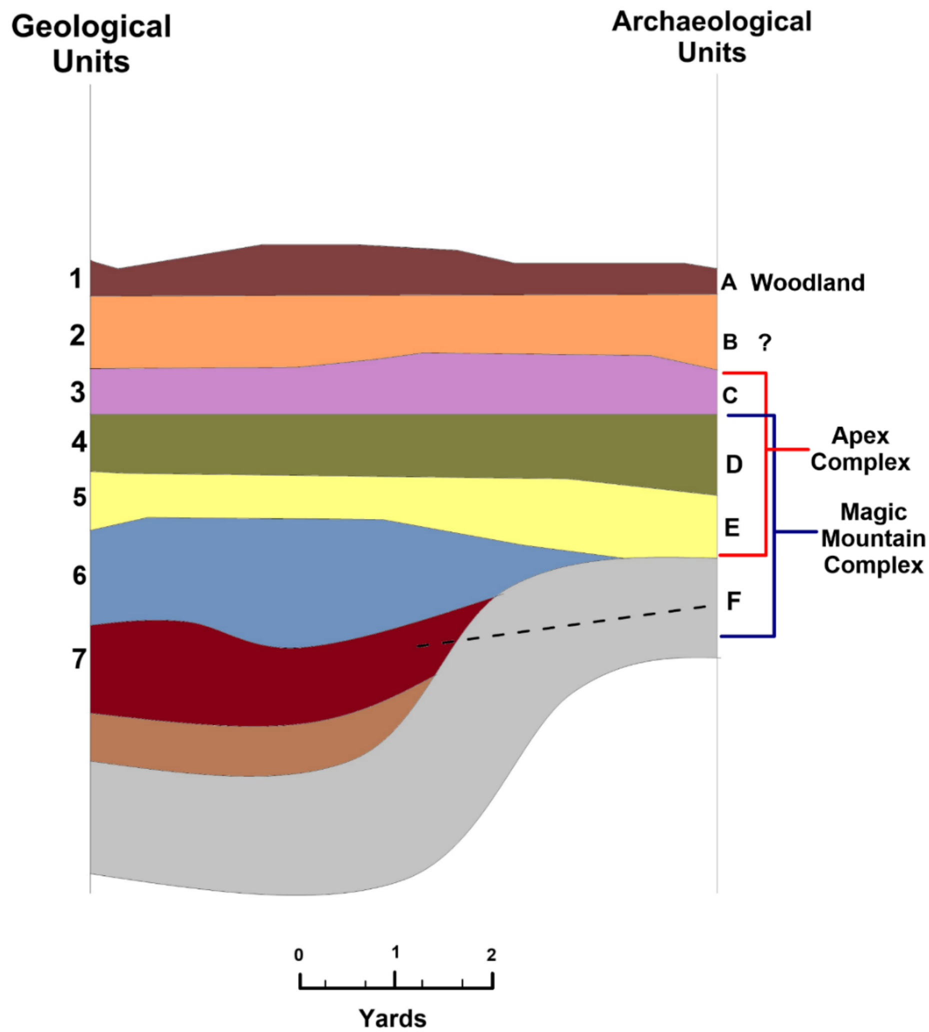


Figure 3.1: Image revised from Irwin-Williams 1966 of the stratigraphy at Magic Mountain.

Unit one (Zone A) is described as a fine-grained sand that was bounded by Unit two (Zone B), which was a fine sand and silt (Irwin-Williams and Irwin 1966, 35; Kalasz and Shields 1997, 11). Units three through five (Zone C through E) are said to represent the Pre-Piney Creek Alluvium (Irwin-Williams and Irwin 1966, 35-39; Kalasz and Shields 1997, 11). It was hypothesized that this was the level of the ground water at time of the human occupation (Kalasz and Shields 1997, 11). This alluvium is one unit, but it was written in the reports as three separate units. Unit three (Zone C) is white in color and described as chalky (Irwin William and Irwin 1966, 40; Kalasz and Shields 1997, 11). This is because of the high amount of calcium carbonate that is evident within the layer. The calcium carbonate layer was thought to be Altithermal in age because of the moist climate conditions that resulted in fluctuations of the water table (Kalasz and Shields 1997, 11-12). Unit four (D) was a yellow-ish orange color and was hypothesized to be iron staining (Irwin-Williams and Irwin 1966, 40-41; Kalasz and Shields 1997, 11). The geologists on site had speculated that this layer would have been below the water table because iron precipitated into the layer, causing the orange staining.

Unit five (E) was dark gray in color and described as sandy and silty (Irwin-Williams and Irwin 1966, 40; Kalasz and Shields 1997, 11-12). Unit six (unlabeled zone) is a deposit that consists of pebbles, cobbles, and boulders made of schist, gneiss, and pegmatite (Kalasz and Shields 1997, 12). The geologists speculated that this layer was formed from a depositional event from one single run-off event or multiple events that occurred over time. Unit seven (Zone F) showed evidence of human occupations and was fairly well-sorted and blueish-gray fine-to-loose sand (Irwin-Williams and Irwin 1966, 40; Kalasz and Shields 1997, 12). Radiocarbon dates from this layer were taken but there were discrepancies with the age dates (Irwin-Williams and Irwin 1966, 46; Kalasz and Shields 1997, 12-13).

It is assumed that the sample from unit five (E) is meant to be 4900±250 before present while unit seven (Zone F) was estimated to be 500 years of occupation during the Archaic Period from 3500 B.C. to 3000 B.C (Kalasz and Shields 1997, Figure 3.1). This is thought the be a part of the Magic Mountain Complex, which is defined as the cultural unit at the time that exhibits unique tool technology (prismatic flake tools) (Kalasz and Shields 1997, 18). Units three through five (Zones C through E) are suggested to take place between 3000 B.C. to 500 B.C., which was hypothesized to be a part of the Apex Complex. Irwin-Williams believed this complex had ties to the Southwest archaeological region of the United States, but this was not substantiated by later excavations. Finally, units one (Zone A) and two (Zone B) were dated to be from the Late Archaic Period through the Early Ceramic Period. Irwin-Williams believes that this was related to the "Woodlands Culture" (Kalasz and Shields 1997, 19). Altogether the Magic Mountain Complex, the Apex Complex, and the "Woodland Culture" all became associated with specific time periods that are used today, including the Early Archaic, the Middle/Late Archaic, and the Late Archaic/Early Ceramic Periods, respectively.

Other smaller excavations took place following the Harvard excavations. One of these included an excavation completed through Metropolitan State College (now Metro University of Denver conducted excavations), headed by Jiri Vondracek in 1974 (Kalasz and Shields 1997, 19). There were no publications from these excavations and only one box of artifacts was recovered. Minimal amounts of notes were found with no maps. The artifacts were not washed or catalogued. In 1979, the site was recorded for the Colorado Archaeological Survey, which led the Office of the State Archaeologist to nominate the site for the National Register of Historic Places.

Finally, Centennial Archaeology, LLC from Fort Collins, Colorado excavated the site in 1994 and 1996 (Kalasz and Shields 1997). These excavations further investigated some of the same questions that were raised by the Harvard excavations. This includes studying the stratigraphy, lithic analysis, and the analysis of architectural features. The aim of the research was to study the site usage and the many occupations that the Harvard excavations discussed. These artifacts are now located at the Denver Museum of Nature and Science. The only artifacts that are not located there are those from the 1959 Harvard excavations, which are in the collection at the Harvard University Peabody Museum.

In the 1990s, Centennial Archaeology, LLC continued doing research about many of the same topics as Cynthia Irwin-Williams to refine the information already known about the site. One of these topics was to test the chronology of the site, originally laid out by Irwin-Williams and her brother (Kalasz and Shields 1997, 319). The first idea Centennial Archaeology tested from Irwin-Williams' research was to study whether the anthropogenic features in Geological Zone B (a stratigraphic layer) were *in situ* and from the Late Archaic/Early Ceramic time Periods. This hypothesis was accepted because of the radiocarbon dates that archaeologists collected during the excavation season correlated to the Ceramic Period between 1700-200 B.P.

Another hypothesis Centennial included in the research design focuses on site function. The technical report suggested that there were residential base occupations at the site because of the architectural features that were found, along with the dense assemblage of faunal and lithic remains (Kalasz and Shields 1997, 322-324). This architecture found at the site suggests a somewhat sedentary lifestyle of prehistoric people utilizing the area because there was a lack of a superstructure. Although the wood made that comprised the superstructure would have decomposed over time, postholes were also not present. There was not enough data to hypothesize about seasonality occupation. Evidence that would have supported this hypothesis would have included hearths on the interior of structures as well as storage bins for winter food preservation.

Finally, the last hypothesis of note in the Centennial Archaeology technical report of Magic Mountain suggests that the site was a part of the forager-collector settlement subsistence strategy. The people would have lived a semi-sedentary lifestyle while hunting animals and gathering plants (Binford 1980, Kalasz and Shields 1997, 324-327). There was not enough evidence to suggest a lithic workshop at the site but there was extensive evidence of reworking lithic tools because of the large number of micro-flakes found. The people at the site were likely a mobile hunter-gatherer society, and the Magic Mountain site was the residential base in the foothills.

Centennial Archaeology set up one by two-meter grids on a local datum for the excavations in the 1990s. These grid blocks were excavated in 10 cm levels and the soil was screened through quarter inch screens (Kalasz and Shields 1997, 249). Besides excavation, the archaeologists also completed coring transects (Kalasz and Shields 1997, 251). The geomorphological data pointed to the fact that Pre-Piney Creek alluvium occurred from the surface to 210 cm below surface. This is thought to be units six and seven that were described in the Harvard excavations (Figure 3.1). Finally, it is hypothesized that there is a deposit of Broadway alluvium from 210 cm below surface to 422 cm below surface (Kalasz and Shields 1997, 254).

Centennial Archaeology also found chipped stone in high densities, which would suggest that people were manufacturing, using, and maintaining expedient flake tools (Kalasz and Shields 1997, 329-330). Most of the chipped stone was made of local raw materials, with a small percentage of the artifact assemblage being from non-local areas. These materials from non-local areas give evidence to the idea of seasonal migration rounds because prehistoric people would have brought the material with them as they traveled.

Chapter 4: Methods

Introduction

Various methods, including geophysics, lithic analysis, soil profiling, and GIS mapping were used to conduct research for this thesis project. Ground-penetrating radar and magnetometry were used to conduct geophysical surveys of the site to narrow down areas of interest. These areas of interest include potential anthropogenic features and geological formations that date back to the Late Archaic and Early Ceramic time periods. Following these surveys, excavations took place over two seasons to investigate the areas of archaeological and geological interest found using geophysics.

During the excavation season, soil profiles were taken of every excavation unit across site regardless of the depth. There were excavation units that were specifically designated for geological exploration that were excavated over two meters deep. By studying the soil profiles in conjunction with the geophysical data, it is possible to reconstruct the prehistoric landscape during the time when the Magic Mountain site was occupied.

Interns, including myself, completed artifact analysis at DMNS over a two-year period. This analysis included tool analysis, individual flake analysis, and mass flake analysis. I analyzed these data by studying the lithic material type and their frequencies occurring at the site. Lithic material types and their frequencies answer larger questions about resource procurement and the migration patterns of people. These data are relevant to my research because it is possible to source lithic material types. It is likely that groups travelling from further destinations to the Magic Mountain site brought exotic materials along with them. Alternatively, if the people inhabiting the site have remained local, many of the material types would be local as well.

Geographic Information System is a mapping tool used to visualize and spatially place the data derived from the geophysics, artifact analysis, and soil profiling. For example, the information obtained about lithic material types from the artifact analysis is linked to quarries throughout the area. This information is synthesized into a geospatial map that shows how far the people at Magic Mountain had to travel to collect raw lithic materials. Also included in this thesis are GIS models used to recreate the ancient environment that show sun exposure and hill shade. Geographic information system is a tool that is used to analyze the landscape by using maps to depict geological and cultural constructions of the Magic Mountain site.

The methods, which are geophysics, artifact analysis, GIS, and soil profiling, give a comprehensive view of the people who dwelled at the Magic Mountain site during the Late Archaic and Early Ceramic time periods. Overall, the geophysics and the soil profiling help archaeologists to understand how the site formed while the artifact analysis and GIS answer questions about how the people used the landscape.

Ground-Penetrating Radar

Ground-penetrating radar (GPR) is a geophysical survey method used in archaeology that allows researchers to better understand subsurface features before excavations take place (Conyers 2013). Ground-penetrating radar can give exact depths and locations of features without having to break ground surface. The GPR data acquired at Magic Mountain were collected using an SIR-3000 control unit, an antenna, and a survey wheel.

Ground-penetrating radar operates by using both the electrical and magnetic fields through electromagnetic waves to study differences in water retention levels beneath the surface of the earth (Conyers 2013, 24-27). Radar waves are generated through the use of an antenna and propagate outward. The antenna pulsates a spectrum of wavelengths through the use of an oscillating electrical current. The oscillation frequency directly correlates to the wavelength of the radar waves in that the higher the frequency, the shorter the waves that are created. Although the GPR system generates wavelengths along a spectrum in each system, different antennae generate frequencies based on their size. For example, smaller antennae generate shorter wavelengths that penetrate less deeply because they attenuate more quickly (Conyers 2013, 25-26). The opposite happens for larger antennae, which are typically used to find larger geologic features beneath the surface. The propagating radar waves are measured in hertz, which translates to cycles per second. If either of the magnetic or electrical waves are lost in some way, the waves no longer propagate and will dissipate. Radar waves can travel up to a few meters below the surface before this attenuation occurs. 270, 400, and 900 MH antennae were used in this thesis.

The 400 MHz antenna, which is the primary antenna used during this study, operates between the 200 and 800 wavelengths (Conyers 2012 25; Conyers 2013). The ground-penetrating radar system works by recording electromagnetic waves that have reflected off buried objects. An antenna on the ground surface generates waves along a spectrum of wavelengths, which then couple with the ground (Conyers 2012, 25). These waves propagate down into the ground in the shape of a cone and reflect off buried features. Once these waves are reflected off an object beneath the surface, the waves travel back to the antenna where the receiver records the two-way travel time of the wave in nanoseconds. Reflections occur within radar data at certain depths when the propagated wave's velocity changes. The only way for the wave to be recorded is if the wave travels back to the receiving antenna. The velocity of these waves can be converted to distance once the relative dielectric permittivity is calculated. The GPR system that was used for collection is annotated in Figure 4.1.

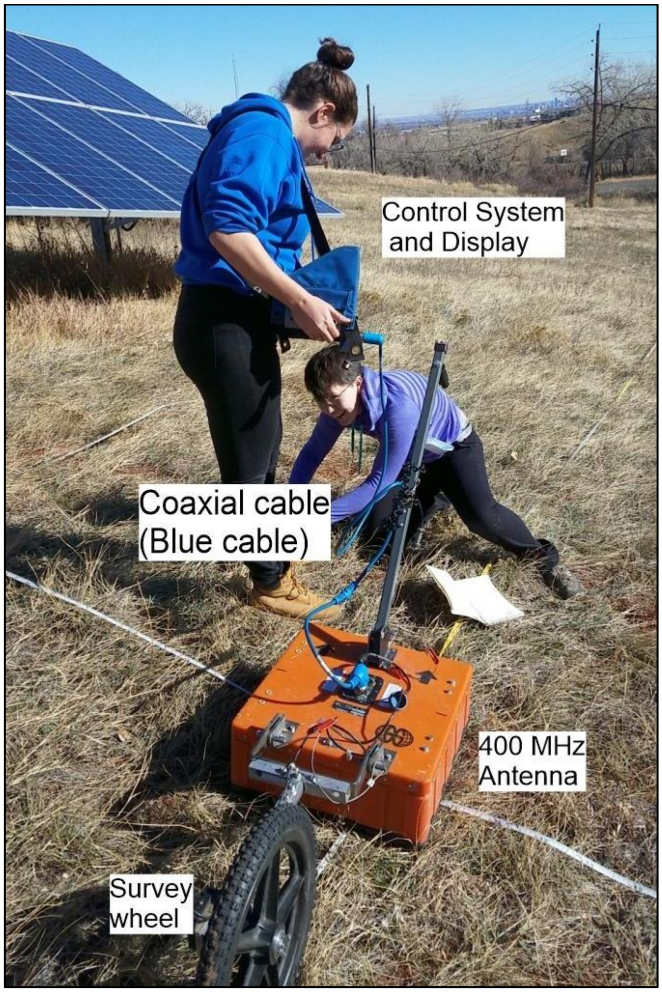


Figure 4.1. Image of collection with equipment labelled.

The relative dielectric permittivity (RDP) is a constant that takes into account both the electrical and magnetic properties of buried materials (Conyers 2013, 48; Conyers 2012, 35). The constant measures the material's ability to store charges from the electromagnetic field and then its ability to transmit that energy. This constant is used to calculate relative depths of reflections occurring beneath the surface.

Ground-penetrating radar data are collected by moving the antenna across the ground surface in transects (Conyers 2012). Typically, a grid is set up prior to collection so that the data are collected consistently at a certain designated spacing. The grids are transected in a zig-zag pattern at certain intervals of spacing. A higher frequency antenna requires a closer spacing pattern because the energy that is propagated into the ground is much more concentrated and therefore spreads out less (Conyers 2012, 28). By collecting in a grid with designated spacing, the grid can be easily processed and placed into space by using the cartesian coordinate system. Rectangular or rectilinear grids make processing easier for creating images (Conyers 2013, 38). Once images are created, these can then be added to site maps so that exact locations of the grids and the reflections within them can be noted.

A survey wheel is used to precisely calculate the distance of the transect lines, which is calibrated by walking ten meters with the equipment (Conyers 2013). The computer system notes how many revolutions per meter the wheel turned so that when the system is collecting, distance is calculated regardless of the grid size. Because GPR is a sampling technique, the survey wheel is also used by the computer system to mark when and where the waves are sent into the ground so that the locations of the reflections are recorded.

GPR Collection

A total of 16 grids were collected at the Magic Mountain site. Grids 1 through 6 were collected by Dr. Lawrence Conyers during the summer of 2016, while Grids seven through sixteen were collected by the University of Denver GPR Research Group from the Fall of 2016 to the Fall of 2017 (Table 4.1). The survey was conducted using the GSSI SIR 3000 system with 270, 400, and 900 MHz antennae.

Table 4.1: Table of the collection parameters used for GPR.

Grid Number	Antenna	Number of profiles	Time window	Regions	Grid dimensions (m)	Profile separation (m)
1	400 MHz	41	30 ns	5	1: 8x17 2: .5x 14 3: 1x 12 4: 7x 23 5:1.5x 21	.50
2	900 MHz	25	20 ns		6 x 7	.25
3	400 MHz	35	30 ns		17 x 20	.50
4	400 MHz	55	30 ns	2	1: 14 x 24 2: 13 x 20	.50
5	900 MHz	25	20 ns		5 x 6	.25
6	900 MHz	49	20 ns		10 x 12	.25
7	400 MHz	61	30 ns	2	1: 15 x 20 2: 15 x 30	.50
8	400 MHz	41	20 ns		10 x 15	.25
9	400 MHz	61	20 ns		15 x 10	.25
10	400MHz	23	50 ns		11 x 24	.50
11	270 MHz	11	50 ns		11 x 24	1
RDP Tests	400 MHz	5	20ns			
12	400 MHz	95	30ns	6	1: 20 x 45 2: 11 x 20 3: 3 x 14 4: 3 x 24 5: 3 x 17 6: 7 x 7	.50

13	400 MHz	31	25 ns		15 x 35	.50
14	400 MHz	59	25 ns		29 x 26	.50
15	400 MHz	7	35 ns		3 x 29	.50
16	400 MHz	9	35 ns		4 x 24	.50
Random	270 MHz	9	50 ns			

The area for Grid 1 was selected to re-locate the datum from the 1994/1996 excavations because it was lost over time (Figure 4.2). The area of the grid was expanded outside of the 1994/1996 excavations location to wrap around the southeast side of the hogback to search for prehistoric anthropogenic features. Because of the terrain, this grid was collected in five regions using a 400 MHz antenna at 50 cm spacing. Initial analysis revealed an area of interest in the eastern corner of Grid 1. Grid 2 was collected with a 900 MHz antenna with 25 cm spacing to study this area of interest further. This area of interest was discovered to be the makeshift dirt road that was crudely formed during the 1994/1996 centennial excavation seasons.

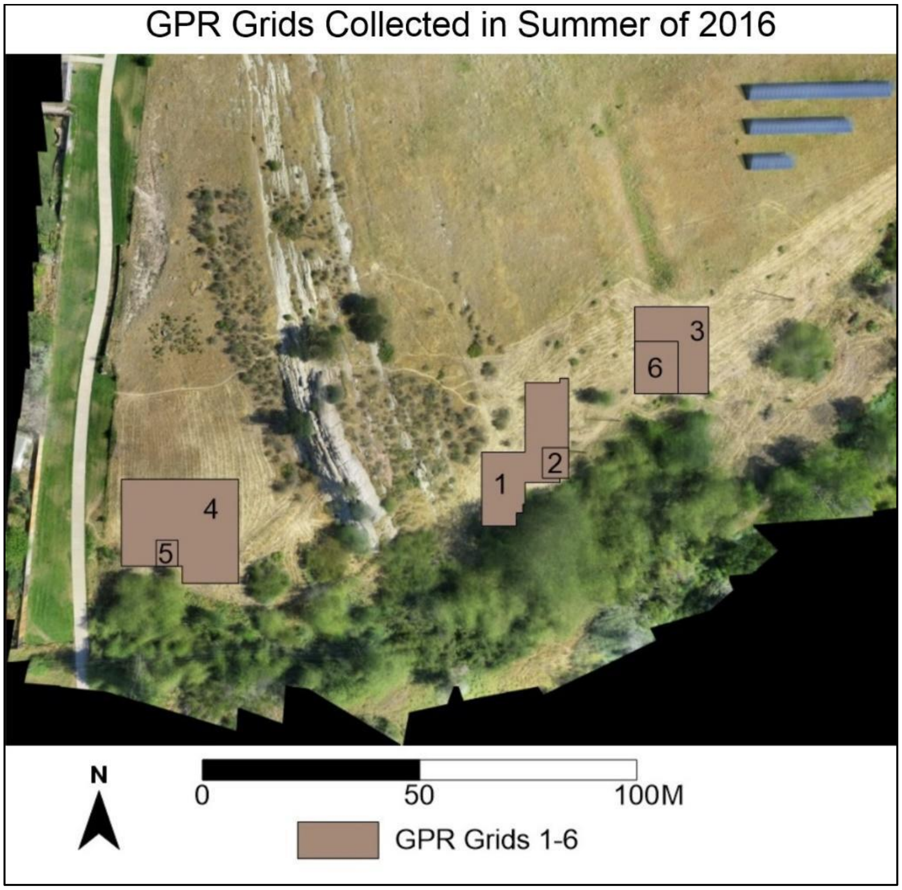


Figure 4.2: Locations of GPR grids collected by Lawrence Conyers

Grid 3 was collected at the base of the slope of the hogback, almost directly south of the large trench disturbance (Figure 4.2). This area showed strange terrain changes that looked as if they were not formed naturally. The 400 MHz antenna at 50 cm spacing was used initially. Analysis of this grid showed clusters of hyperbolic reflections as well as low-amplitude planar reflections. Grid 6 was collected in the same area with a 900 MHz antenna to acquire higher resolution data. This grid was collected at 25 cm spacing in a smaller area.

Grid 4 was collected on the west side of the hogback (Figure 4.2). The datum for the 1959 Harvard excavation was crudely described within the dissertation written by

Irwin-Williams and Irwin (1966) and was not located during recent survey work. The vague descriptions of the excavation area within the dissertation does not completely correlate with the present estimation of the excavation area. A very noticeable trench that is now covered with vegetation is evident on the present-day surface. Grid 4 was collected to find the location of those excavations as well as to look for other anthropogenic features. This was collected at 50 cm spacing while profiling in the x-direction with a 400 MHz antenna. After an initial analysis, Grid 5 was collected with a 900 MHz antenna at 25 cm spacing to provide a better picture of the reflections within the GPR images.

In the Fall of 2016, the GPR Research Group at the University of Denver collected another three grids (Figure 4.3). Region one of Grid 7 was collected within the same area as Grids 3 and 6, however region two was extended another 15 meters due east and another ten meters north. This was to look for more anthropogenic features below the present-day ground surface. These data were collected at 60 traces per meter, meaning that the features would be shown in more detail as compared to 30 traces per meter, which is the calibration standard that was used for many of the other grids. This calibration caused the planar reflections, which were subtle in Grid 3, to become more noticeable in region one of Grid 7. Because of this, Grids 8 and 9 were collected within the same area transected in both the true north and east directions with the setting of 60 traces per meter. The geologic layer could be completely mapped out in this area using GPR because of the thorough amounts of data that were collected and the resolution at which they were collected.

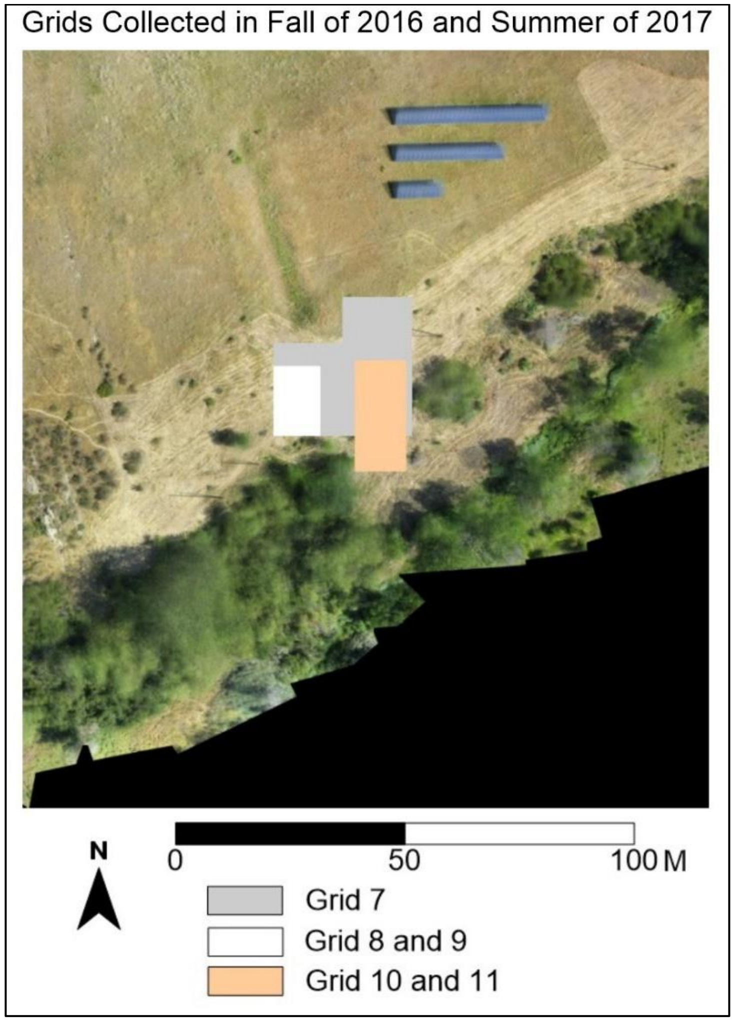


Figure 4.3: Grids collected by the DU GPR group.

Grids 10 and 11 were collected during the excavation season in the summer of 2017 (Figure 4.3). These grids were collected to better understand the geologic formations at the site. At the time, the site geoarchaeologist and the site director were researching hypotheses related to site formation. The radar data were used to initially confirm working hypotheses. Grids 12 and 13 were conducted in the Fall of 2017 and were also collected to locate geologic features. These grids were collected to better understand how the landscape changed over time by looking for eroded river channels and terraces formed by the nearby creek.

Grids 12 through 16 were collected in the Fall of 2017 and were completed to further explore for anthropogenic and geologic features (Figure 4.4). At Magic Mountain, GPR was used to map geologic features and stratigraphy. Anthropogenic features within the data that appear in specific layers also narrow down stratigraphy and the relative depths of other features. Grid 12 was profiled in the x-direction, which was transected from east to west uphill towards the hogback. More data were collected over the previous Centennial excavations.

Grid 13 was collected as an extension of region two of Grid 12 (Figure 4.4). This was transected in the y-direction, which was from south to north. During excavation season, various anthropogenic features were discovered in this area. Grid 14 was collected just east of Grid 13 and was transected from west to east. The reason for this grid was primarily geologic because of its location. Grid 15 was collected as a small sample with profiles in the north-south direction. This grid was collected in the last three meters of Grid 13. Finally Grid 16 was collected in the west-east direction and was collected to search for more anthropogenic features.

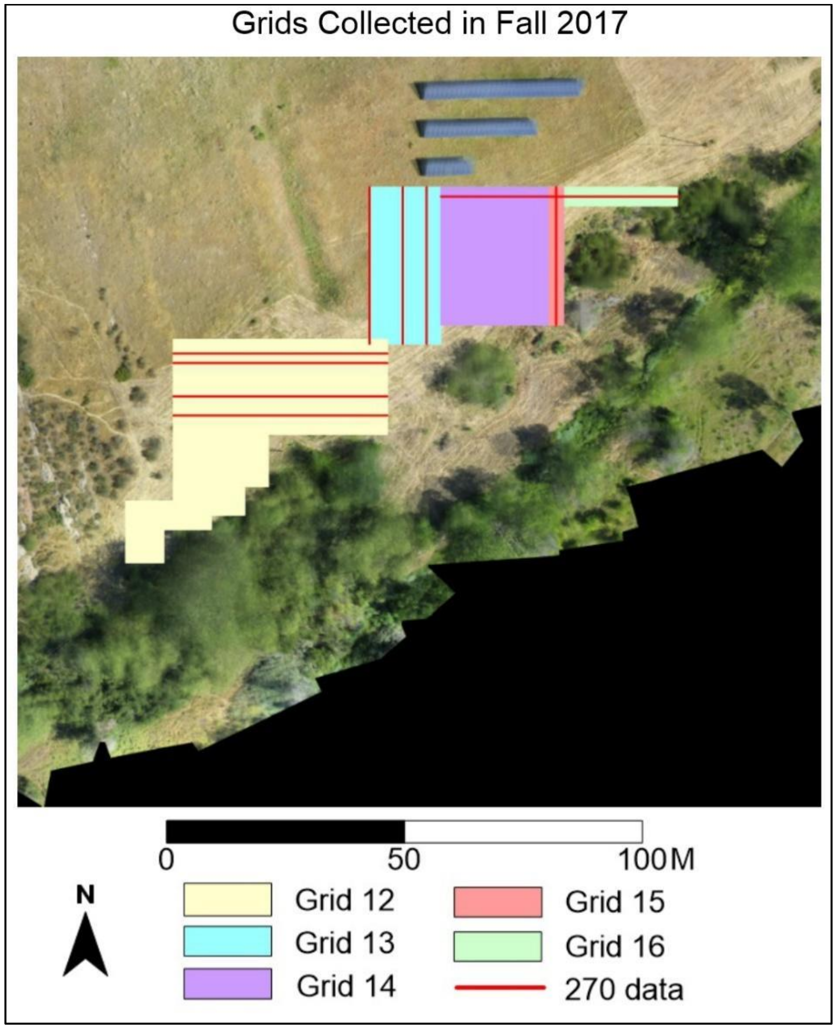


Figure 4.4: The grids collected before the 2018 season.

Nine lines of 270 MHz data were collected to map geologic features more easily. These lines were collected within grids that were already set up and were placed at specific meter marks within these grids (Figure 4.4). Preliminary data analysis of these grids showed reflections of interest. Lines of 270 MHz data were then collected over these areas of interest. One line was collected from west to east from Grid 14 through Grid 16. One profile was collected in Grid 15, three profiles were collected in Grid 13, and four profiles were collected in the region one of Grid 12.

GPR Data Processing

After the GPR data were collected, I processed them using various software programs (Conyers 2013). The programs used to process the data are *GPR Process, GPR Viewer, Surfer 12*, and *Microsoft Excel.* These programs help to convert the data into images, including amplitude slice maps and GPR profiles.

Once the data are loaded on to a computer, I used *GPR Process* to synthesize all the collected profiles. First, these files are aligned and other information, such as specific collection methods, number of regions, and number of files, is noted (Conyers 2012). With all the variables taken into account, the data are sliced. Amplitude slice maps are two-dimensional images of a three-dimensional idea. The amplitude slice maps are created by identifying the nanosecond time frame at which the data were collected. For example, a slice could portray a time interval beginning at 2 ns and ending at 4 ns, overlaying three nanoseconds worth of data on an X- and Y-coordinate plane. These time intervals in nanoseconds are used to calculate depth which translates to the Z value. Once the necessary files are created, *Surfer 12* can then be used to grid this data to create the amplitude slice map.

To completely understand these data, I examined each GPR profile individually using *GPR Viewer* (Conyers 2012). This program shows images of the GPR profile with their respective depth and length. It is here that reflections within each transected profile are viewed. This method in data processing is important at the Magic Mountain site because the planar reflections are noticeable within the GPR profiles, but not the amplitude maps. The planar reflections appeared disjointed within the data, which is from the subtle variations in water content within soils across the landscape (Conyers 2012). The disjointed planar reflections resulted in the reflections being unnoticeable within the amplitude slice maps because it was not possible to capture the entire reflection within one slice. The planar reflections analyzed within the GPR profiles were then drawn on to the amplitude slice maps to adequately convey the location of the planar reflections.

After initial analysis of each profile in *GPR Viewer*, I frequency filtered and migrated the data. Because GPR collects a spectrum of frequencies, certain wavelengths can be filtered within the data to reveal specific types of reflections (Conyers 2012). To study geological features better, higher frequencies should be filtered out whereas for smaller objects, lower frequencies should be filtered out. I frequency filtered the data to test if this would help with the attenuation that seemed to be occurring at certain depths at Magic Mountain. Initially, I started by filtering between 200 and 400 MHz, which would remove the reflections caused by smaller objects and the geologic features more easily viewable. Following frequency filtering, migration is another tool that can help with precision of location when analyzing the GPR data. Migration helps to see where the point source of the hyperbola occurs more accurately, which can give a precise depth and location of the reflection if the data is muddled within the GPR profiles. It was unnecessary to use migration in the data after it as initially analyzed because the point source of many of the reflections were easily viewable.

Magnetometry

Magnetometry is widely used as a geophysical method in archaeological survey (Kvamme 2006b). This method maps the variations within the Earth's magnetic field in the shallow subsurface. For the project, a dual sensor gradiometer was used by the DU GPR group.

Magnetometers are constructed to measure the strength of the magnetic field of the Earth, including direction of the field and its oscillation periods (Kvamme 2006b; 206). The magnetic field occurs because of the molten iron core located within the earth, which ranges in strength from 30,000 nT to 60,000 nT. (2006b; 207). Magnetic features that occur on or near the earth's surface have their own magnetic fields. This difference in values are the discontinuities that show up within the data imagery.

Magnetism can be broken up into two different forms, which are remanent magnetism and induced magnetism (Fassbinder 2015, 86). The first form, remanent magnetism, has four different processes of forming, though one of them is rare and will not be discussed. These three processes are thermoremanent magnetization (TRM), detrital remanent magnetization (DRM), and chemical remanent magnetization (CRM) (Fassbinder 2015, 87).

Thermoremanent magnetism occurs when soils, clays, and rocks that have remanent iron oxides are heated is beyond the Curie point, which is about 600 degrees Celsius (Kvamme 2006b). These substances initially have small magnetic domains that point in random directions because of the remanent iron oxides. When the soils, rocks, and clays are heated, the domains align parallel to the Earth's magnetic field and remain in place (Fassbinder 2015, 87; Kvamme 2006b; 207). Although the domains return to the original magnetization, the overall result is measurable.

The second process that forms remanent magnetism is detrital remanent magnetization, which occurs when soil containing magnetized material is deposited in standing water (Fassbinder 2015, 87). The magnetized materials orient along or parallel to the magnetic field. This is likely to occur in pits, depressions, or ditches. The third process is chemical remanent magnetization is when the critical value threshold is met for the magnetic particles. The magnetostatic forces overcome the thermal fluctuations typically found on or near the surface of the earth. The particles then align to the magnetic field of the earth through chemical/crystallization magnetic remanent magnetization. This process explains why all topsoil is magnetically enhanced in areas where cultural processes are evident (Kvamme 2006b, 217). Human occupations introduce organic materials to soils to aid in plant growth. This, in turn, aids in the growth of bacteria that produces magnetic compounds like magnetite, which raise the magnetic susceptibility of the area (Fassbinder 2015, 88).

The second form of magnetism is induced magnetism and magnetic susceptibility (Fassbinder 2015, 85-86; Kvamme 2006b, 208). Magnetic susceptibility is the ability for an object to become magnetized, which is dependent on the minerals that make up the object (Kvamme 2006b, 208). Certain minerals, which include hematite, maghemite, and magnetite are inherently magnetic. Situations like periods of wetness and dryness and fires both affect the magnetic susceptibility of the soil. Wetness and dryness effects the oxides and causes them to become more magnetic. This causes hematite to become the more magnetic maghemite. These minerals are also insoluble, which means that they are able to be moved mechanically by elements like wind or water which cause them to collect in low areas when filled in with topsoil. This includes ditches, palisades, or even anthropogenic features like postholes (Fassbinder 2015, 86; Kvamme 2006b).

Fires also cause the soils in the area to become more magnetic whether they are anthropogenic or not (Fassbinder 2015, 86; Kvamme 2006b, 208). Fires cause hematite to reduce to magnetite. Once the fired area of space is cooled, the minerals re-oxidize to maghemite which also causes magnetic susceptibility.

These natural processes can delineate human-made structures through the magnetic variations (Kvamme 2006b; 214). Some examples of this include constructions and artifacts made with fired materials, the application or removal of topsoil in structures, humans causing an increase in the magnetic minerals in topsoil, humans creating fires, and the importation of construction materials from elsewhere. These anthropogenic structures below the topsoil may also have a lower susceptibility than the soil itself. This means that there can be both positive and negative magnetic anomalies present (Fassbinder 2015).

Magnetometry Collection

Ken Kvamme from the University of Arkansas collected the original magnetometry data during the summer of 2016 and the spring of 2017. These data were collected using a single sensor Proton Procession gradiometer. The DU GPR group also spent six weekends in the Fall of 2017 collecting both GPR and magnetometry. A total of 19 magnetometry grids were collected altogether at Magic Mountain, which were a combination of both 10x10 and 20x20 grids. The GPR group used a dual sensor fluxgate magnetometer, 601 gradiometer to collect these data (Figure 4.5). The data collected by the GPR research group is the data analyzed in this thesis.

Figure 4.5: Photo of a member of the GPR Research group collecting magnetometry.

The DU GPR group calibrated the gradiometer in a magnetically quiet area at the site. During the calibration, the magnetometer is meant to warm up and acclimate to the environment while on scan mode. After the system is ‘warm,’ the sensors are oriented to the north, in our case. These sensors take measurements at both ends of the sensors where the top samples the magnetic field further from the earth’s surface while the bottom of the sensor, which is 20 centimeters from the ground, samples the magnetic field closer to the surface. The sensors then take the difference of these two samples and assign this number a place within the grid.

The grids were collected at 50 cm spacing in a zig-zag pattern at eight samples per meter. The gradiometer was oriented north, and the collection took place along that North/South axis. The earth's magnetic field is measured in nanoteslas, so this is the unit of measure that the magnetometer is designed to use. The instrument was calibrated to have a range of ± 100 nanoteslas (nT). Typically, this range is used for historic sites because of the introduction of ferrous metal. At Magic Mountain, this range was kept at ± 100 nanoteslas so that these values can be filtered out later to narrow down specific anthropogenic discontinuities within the data.

The first collection in October was meant to cover a large surface area at the site but this original composite is slightly off grid from the local datum that was used at Magic Mountain because the team lacked a stationary Brunton compass (Figure 4.6). The points for this composite were taken and synthesized into a map. These data revealed relevant site information which included some anthropogenic features as well as modern disturbances like a buried pipe running through site. This grid composite was used for the analysis in this thesis.

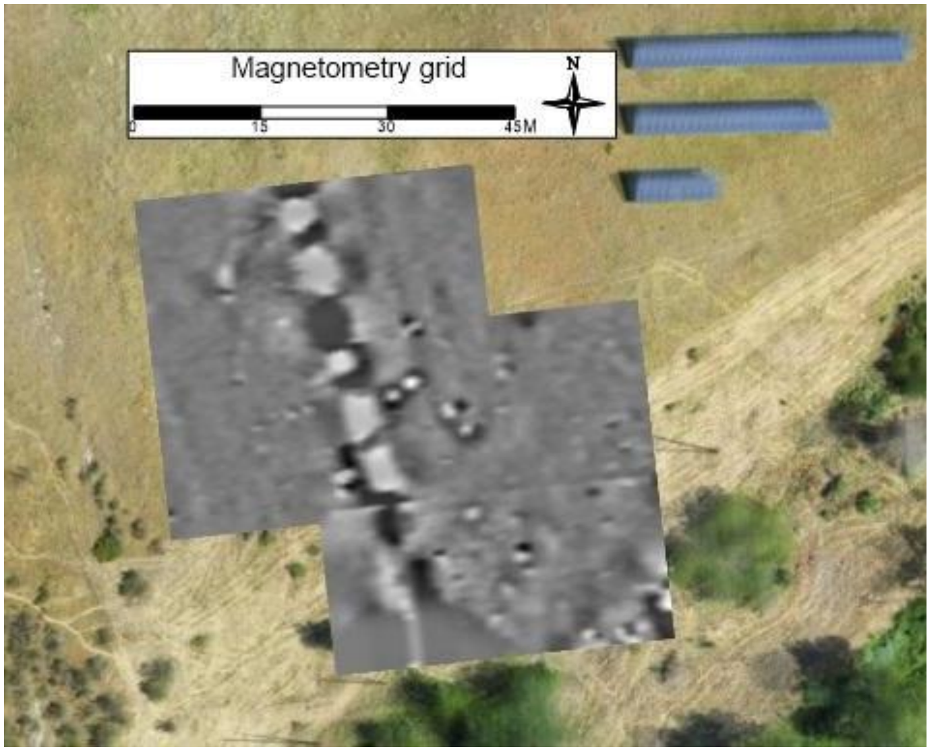


Figure 4.6: The magnetometry grids collected by the GPR group in the Fall of 2017.

The group collected the next set of five grids in November in the southwestern area of the site and a set of seven grids in the northwestern area of the site. Five 20x20 and six 10x10 meter grids were collected within a GPR grid that was previously laid out, some of which was overlapping with the Kvamme data. However, this data showed extensive errors due to the proximity of the solar panels, so it was not used.

Magnetometry Processing

I processed the magnetometry by using *Terrasurveyor* (DW Consulting 2022). This began with completing the composite grids and experimenting with various data manipulation techniques. First, I saved the raw composites and exported the *.xyz* data to ensure that the raw data were saved. In *Terrasurveyor*, this data was then manipulated by destaggering, which is to correct for the pace variation of the person who collected the data (Kvamme 2006a, 241). I also despiked the data using the mean in the software, which eliminates large differences in values that cause stark discontinuities within the data. Finally, I experimented with destriping, which takes care of heading errors and eliminates stripes that can appear in the data.

If it was necessary, I used edge matching to get rid of inconsistencies around the individual grids within the composite (Kvamme 2006a). After these processes, I exported the *.xyz* data to further manipulate it in *Microsoft Excel* and *Surfer 12*. I filtered these data in excel and interpolated using surfer. The edited images were exported and then imported into GIS where I was able to georeference them.

The magnetometry images were created using a black- white spectrum to show the different discontinuities. The black-white spectrum is used to view the more subtle details within the imagery (Kvamme 2006a, 246). This means that all discontinuities of the same kind can be easily mapped and distinguished from others.

Finally, by using *Surfer* to manipulate the composite magnetometry grids, I created magnetometry data profiles that correlate directly with locations of GPR profiles. I then compared the GPR profiles and magnetometry profiles to look for similarities in the values of the magnetic discontinuities to the visible GPR reflections. This comparison helps to understand the chemical make-up and material type of the buried anthropogenic and geologic features.

Magnetometry and Ground-penetrating Radar Analysis

Ground-penetrating radar and magnetometry are two different geophysical methods that are complementary when used in conjunction with each other (Conyers

2018, 4). Ground-penetrating radar, which records differences in water retention levels beneath the ground surface, is able to produce three-dimensional images of buried geologic and archaeological features. In comparison, magnetometry records data on the magnetic differences of buried features. Using this method, it is possible to distinguish the composition of buried features, unlike with GPR. With both methods, it is possible to map presently buried cultural landscapes along with the anthropogenic features associated with them.

For this project, analyzing ground-penetrating radar and magnetometry data in tandem gives a more comprehensive analysis into subsurface features before excavations take place. Once the data in each method were analyzed separately, I marked features of interest in both data sets. Then once I was able to georeference all the data in GIS, I began looking for anthropogenic features in both data sets that seemed to occur within the same area. I was then able to compare magnetometry data profiles that I created in *Surfer12* to the GPR profiles that would occur in the same area. The combination of these profiles helps to understand the relative depth, location, and magnetic signature of the feature in question.

The first way to study these methods in tandem is to start by visually examining geophysical maps (Conyers 2018, 7). This was completed after the data in each method was thoroughly analyzed individually. In this case, all the areas of interest were already marked by hand on the geophysical maps. Once the methods are brought together, these areas of interest were compared. The next step in the process is to compare GPR profiles to profiles created from the correlating location on the magnetometry maps. These profiles are then compared and annotated to better understand the features visible in both profiles (Conyers 2018, 16-17).

Features that are noticeable in one data set may not be noticeable in the other. For instance, hearths are more noticeable in the magnetometry data because they are a fired artifact that changes the magnetic minerals in topsoil. The hearth manifests as highly magnetic within the data. Alternatively, if water does not collect on the surface or if there are no stones present, then the hearth may not show up in the images produced from the GPR data. Conversely, there may also be features that show up within the GPR that may not be evident within the magnetometry data. Using these data sets in tandem can give a more comprehensive look at the site and its features.

Altogether, I mapped the hearths and the channels of the Apex Gulch channel system using both GPR and magnetometry in tandem. The hearths, which were fired, would have a different magnetic susceptibility than the unfired soil surrounding it. The river channels, however, were slightly more complicated to find. Apex Gulch, which would be lined by a sedimentary rock, hold a small percentage of magnetite. Magnetite is commonly found in rocks and alluvial environments (Jones 2018; Rosenblum and Brownfield 1999). The magnetite in the sedimentary rocks would appear as positive magnetic values as compared to the surrounding sediments. This is enhanced by the fact that the cumulic A has a higher sand content, which will have a lower magnetic susceptibility because there is less magnetite than in the rocks lining the channel (Jones 2018). The Apex Gulch River channels occurred during the same time as the human occupation at the site.

After each of these features are identified, their locations are marked on the geophysical maps. These maps are then digitized and geoarchaeological information can then be considered. During the excavation season, the principal investigator and the geoarchaeologist completed soil profiles in each of the excavation units. The ground-penetrating radar data conducted at the Magic Mountain site are used to recreate the soil profiles once depths in each of the soil units in each layer are assigned. Meanwhile the magnetometry conducted at the archaeological site found many of the anthropogenic features within the area.

Geoarchaeology

Geoarchaeological data was collected in conjunction with the site geoarchaeologist. Stratigraphic profiles were taken with his help and soil samples were collected, though it was unnecessary to process these because the geoarchaeologist had completed an extensive analysis. Soil profiles, which are exposed vertical layouts of soil horizons, are important for establishing age dates (Birkeland 1984, 4). First, the lithostratigraphic units, or the physical characteristics of the soil, were identified to understand the soil formation processes (Visher 1990, 629). This step is necessary to better understand the foundation material for the parent material and how it was deposited. In turn, knowledge of the depositional event can help recreate the ancient environment. A combination of geological and archaeological data help places the population found at the Magic Mountain Site within the geological record.

After the lithostratigraphic units and soils were identified, they were further broken down into horizons. Initial observations were taken at the site and soil samples were taken for further analysis. This consists of testing for calcium carbonate and clay content. By doing so, it is possible to date the stratigraphic layers. Once the stratigraphic profiles are understood, they were used in conjunction with the GPR profiles. This process can help complete geologic maps and to also map the human occupation patterns completely in a three-dimensional way.

Soils form over a long period of time, which indicates a stable landscape (Waters 1992, 40). They begin through the deposition of a sediment through an event of some kind. This sediment then begins to weather as organic materials and detritus begin to decompose on the surface. The soils begin to grow as the organic layer becomes larger and the sediments continue to weather either chemically or physically (Waters 1992, 41). Over time, other particles including calcium carbonate, clay, and iron oxides begin to precipitate down into and settle in the soil (Waters 1992, 42).

Characteristics that were noted in the soils were color, texture, presence of organic matter, bulk density, and soil moisture retention (Birkeland 1984, 12-22). Initial notes about color were taken in the field using a Munsell chart; however, more extensive notes about color can be re-established through the soil samples taken. In the case of color, chemical compounds make up the color of each soil horizon (Birkeland 1984, 12-13). Therefore, the color can be used to better understand the make-up and formation of the soil. Rolfe Mandel, the site geoarchaeologist, completed a thorough field analysis of the soils at the Magic Mountain site. He helped me complete my own soil profiles to use for my own analysis.

Geographic Information Systems

Geographic Information Systems were used to create many of the maps necessary to explain how the landscape was formed over time. Geographic information systems were the primary method for digitizing the anthropogenic features and excavation units as well as georeferencing the geophysical collection grids. A shapefile of the local datum was created so that the grids can be digitized on the local grid system. This can in turn be assigned to a larger, more widely used coordinate system.

The Magic Mountain site has a region-specific grid system created by PCRG that is linked to the UTM projection (Figure 4.7). The UTM projection is broken up into 60 zones across the world that are six degrees of longitude wide and eight degrees of latitude long (Connolly and Lake 2006, 21). The region-specific grid uses the 1983 North American datum. Mapping for the Magic Mountain site uses mostly vector data, which shows locations of important features along the landscape using points, lines, and polygons (Connolly and Lake 2006, 25).

All Areas of Excavation

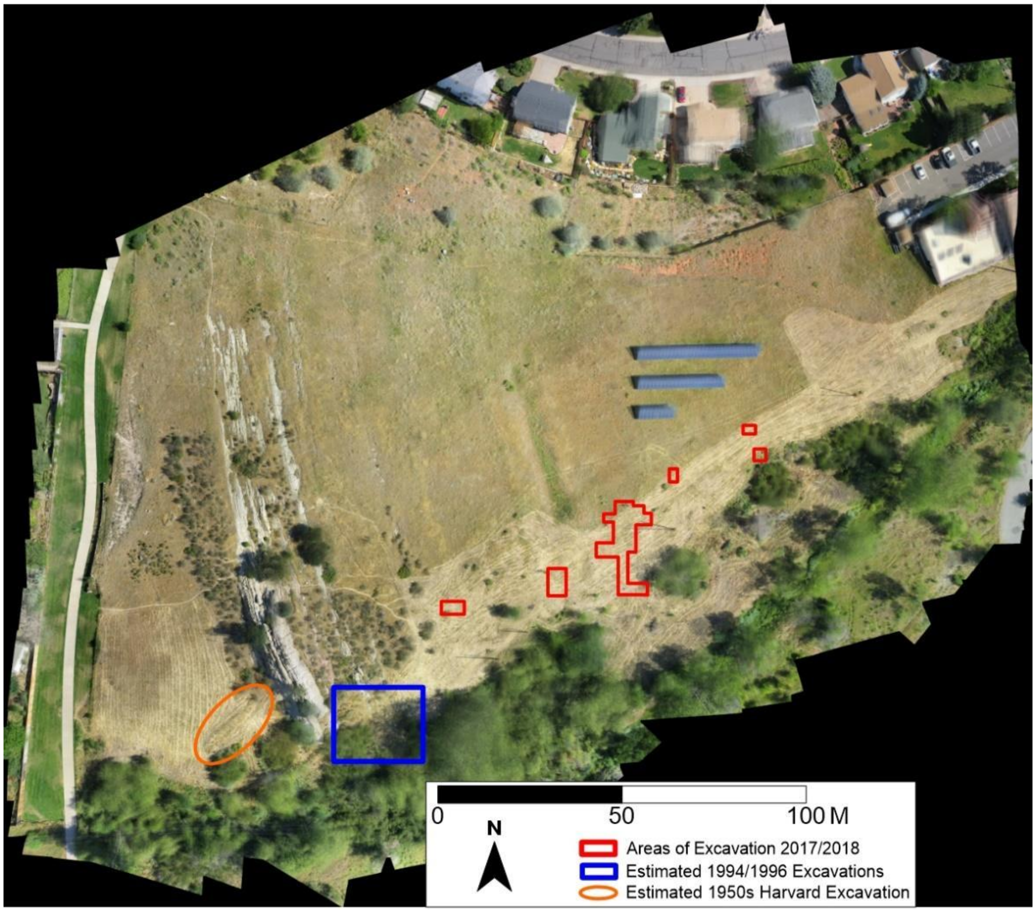


Figure 4.7. Example of GIS showing all the excavation areas.

The main GIS component in this thesis is spatial and simulation modelling. Different types of spatial analysis include hill shade and solar radiation analyses. A point was chosen at the site to complete these analyses from a specific perspective. This point was chosen from information discovered during the Centennial Excavations in the 1990s, where a potential habitation structure was discovered (Kalasz and Shields 1997). This area is highlighted in blue in Figure 4.7.

Hillshade and Solar Radiation analyses were completed in *ArcMap 10.7.1* and the results are discussed in later chapters. These analyses are helpful because they show where shade and sun exposure would be evident, respectively, using models. The models show information regarding how habitable the landscape would have been during the prehistoric times. These two types of analyses require a raster data map, found through the United State Geological Survey. Examples of the Hillshade and Solar Radiation models in GIS are shown in Figure 4.8.

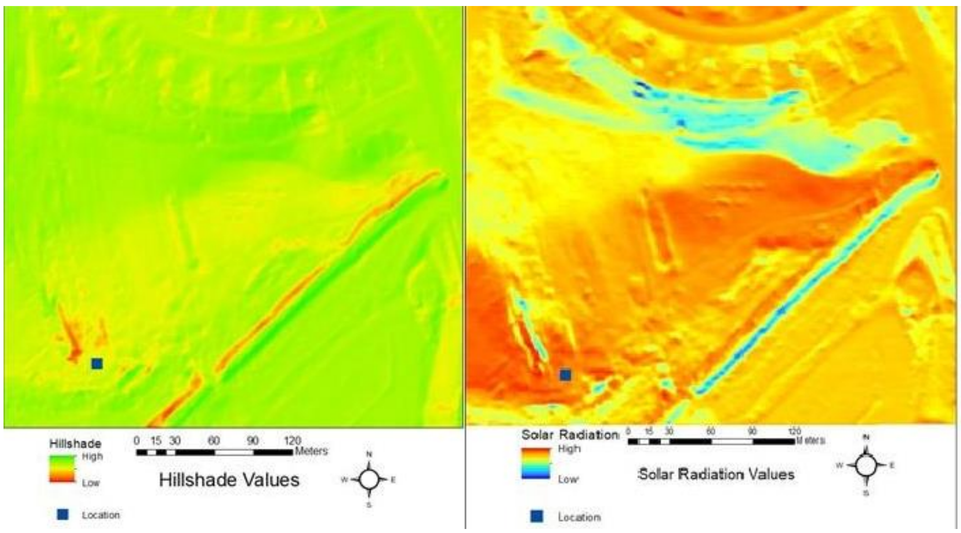


Figure 4.8: Examples of GIS models.

The Hillshade tool in GIS uses raster data to create a model of the hypothetical illumination of the ground surface by calculating the values of each cell. More specifically, the Hillshade analysis was completed to measure the amount of shade created by the hogback. The parameters selected for this model included an azimuth of 315 degrees (GIS default) and an altitude of 90 degrees (overhead). I chose these parameters to show the lowest amount of shade at the site because this is the most effective way of study the inhospitable characteristics of the area.

Similarly, the Solar Radiation tool in GIS uses raster data to calculate the effects of sunlight on the ground surface. The solar radiation is important to study in tandem with the hill shade because it shows the amount of sunlight the site would have received. The only parameter selected for solar radiation was to study the general area rather than at specific points. While the model shows the sunlight potential for the area, this also gives information on the heat index capabilities. The heat index is another important characteristic to study in relation to human habitation and the time of year which people used the area.

Map information was taken from *Earth Explorer*, an internet resource with downloadable maps from the United States Geological Survey, and given to me by Mark Mitchell, director of the site and director of PCRG. This spatial and simulation modelling for this thesis include elevation models to complete viewshed analysis and sun exposure of habitation structures (Connolly and Lake, 2006). This type of simulation modelling analysis helps archaeologists to study human behaviors along the landscape.

Excavation

The DMNS and PCRG excavated the Magic Mountain site from June 7th to the 25th of 2017 and again in June and July of 2018 (Figure 4.9) The directors of the excavations were Mark Mitchell (PCRG) and Michelle Koons (DMNS) and also included Amy Nelson and Chris Johnston, PCRG lab supervisors, Britni Rockwell, Jen Deats, and Talle Hogrefe, PCRG staff, graduate students from the University of Denver, the University of Oklahoma, and the University of Colorado, Denver, as well as PCRG volunteers, undergraduate students from local Colorado universities, and high school students associated with the museum. The goals of these excavations were to target and excavate the potential prehistoric features through block excavations, as well as the collection of geoarchaeological sampling and detailed stratigraphic profiles (DMNS 2017).

Figure 4.9. Excavations at Magic Mountain during the Summer 2017.

Locations of the excavations were guided by the results from the geophysical survey, specifically the magnetic monopoles and the potential feature patterns within the magnetometry and GPR data. 2 x 1-meter excavation units were placed within the area where the geophysical identifiers were estimated to be located. Once a feature of some kind was discovered, excavators opened more blocks surrounding the feature. To start, ten 2 x 1-meter excavation units were placed using a total station and mapped on to the arbitrary grid system created by PCRG. These blocks were then originally excavated as two separate 1 x 1 blocks unless instructed otherwise. The excavations unit locations are evident for both excavation seasons in Figure 4.10. Each grid block was excavated in 10-centimeter arbitrary levels because the stratigraphy at the site was unknown at the time.

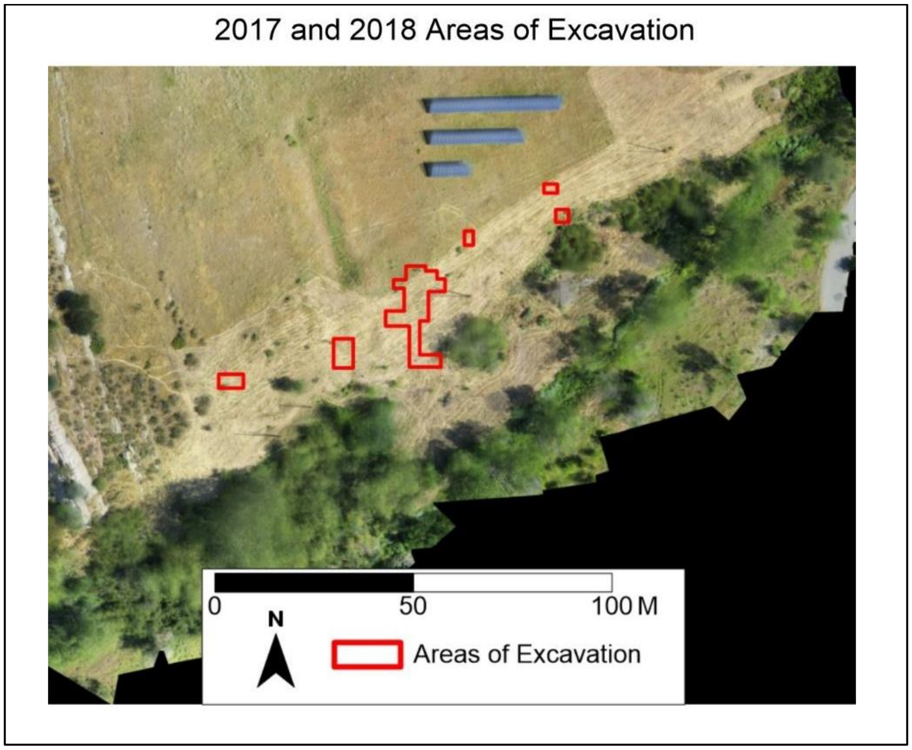


Figure 4.10: Map of the excavation units from the summer of 2017 and 2018.

Excavations began at the present-day ground surface and were dug at 10-cm arbitrary levels unless a feature was discovered, at which point it was then labeled as a feature level. The sediment from each level was sifted through either ¼” dry-screen or 1/16” wet-screens. Approximately 15 percent of the sediment was taken randomly throughout the level and was water-screened. The remaining sediment from the level was dry-screened. Artifacts that were found in the dry-screen were added to the general level bag to later be washed, sorted, and curated at DMNS. The protocol for excavating features includes taking five-liter samples of the sediment from the feature to later be studied through flotation. The rest of the sediment would be passed through a 1/8” screen. These artifacts were taken to DMNS as well.

Excavation and documentation procedures were established by PCRG. This includes pre-printed level forms that would include the coordinates of the unit and its designations, level depths, and catalog numbers of associated artifacts. The level forms also included areas for short narratives, meaning changes that were observed throughout the level of the sediments and artifacts. There was also an area on the form to describe the problems or situations associated with the level. The plan-view drawings were completed at the end of each level unless expressed otherwise. Mid-level maps were drawn if needed. Each level was photographed at the end of the level. Feature summary forms were completed for each designated feature.

A provenience- and recovery- based system was used at the site. This means that one catalog number was given for each level because the artifacts were collected in bulk. Additional catalog numbers were given for the wet-screen and if artifacts of importance were found in situ. These artifacts were then point-plotted and bagged separately. Samples taken from features were given separate catalog numbers.

Near the end of the excavation season, the geoarchaeologist was brought to the site to examine the site formations. Profiles were drawn and sediments were sampled throughout various areas of the site. Specific points were shot in using a total station and depths at the place of the profile were recorded.

Lithic analysis

I have permission from the Denver Museum of Nature and Science to work with the artifacts from Magic Mountain on my own time. I used my computer to document my findings. Specifically, I used *Microsoft Excel* to create a table to organize the data I collect from the artifacts.

The Magic Mountain site has an extensive artifact assemblage that has been the subject of inquiry since the 1950s. These assemblages are located at the Peabody Museum at Harvard (1950s excavation) and the Denver Museum of Nature and Science (1990s and recent excavations). Because of this, only the assemblages at DMNS were studied for this research.

Information from this analysis is used in this thesis and was completed by me and the other interns at the Denver Museum of Nature and Science. This includes the identification and technological attributes of the stone tools and flaking debris. Further artifact analysis for this thesis project includes collecting information on lithic type (use of the lithic), material type, and completeness of the lithic. This information was reviewed and discussed to better understand the people who lived at the site and how it was used in the past.

Laboratory analysis took place following the excavation seasons at the Denver Museum of Nature and Science. The types of analysis conducted were mass analysis, individual flake analysis, and tool analysis. Lithic analysis identifies behaviors evident in prehistoric cultures, which in turn reveals information about chronology and site function (Andrefsky 1998, 60).

Mass analysis is the study of chipped stone that does not include cores or tools (Sullivan and Rozen 1985, 755). This type of analysis is helpful because it is a method that is able to synthesize information in bulk that allows archaeologists to reconstruct prehistoric lithic technology and in turn study patterns of human behavior. This includes migration patterns, how the tools were made, what tools were present, and hunting patterns, among other characteristics. Modified stone can be classified into two separate categories, tools, and debris (Mitchell and Falk 2017, 67). A tool is an intentionally modified object that has use wear or flakes taken from it. Flakes are the debris that is left behind by this modification (Figure 4.11). Both stone tools and flakes can be studied using multiple forms of analysis.

Flake and tool raw material types were also analyzed to understand the migration patterns of the people who inhabited the Magic Mountain site. Previous excavations outlined that there were exotic raw material types that could be found in Colorado and New Mexico (Kalasz and Shields 1997). These included Troublesome Chert, Parker Petrified Wood, petrified palmwood, Flattop Chalcedony, and obsidian.

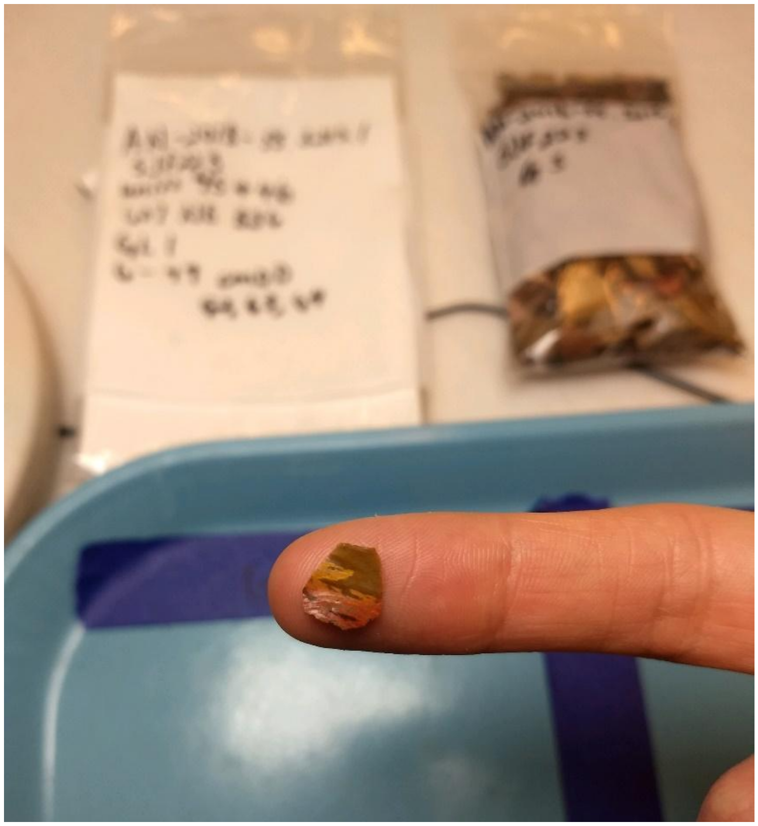


Figure 4.11. Example of flake found at Magic Mountain taken during lithic analysis.

The flakes were first sorted by category using a 4-tiered sieve system to separate them into size grade. This is important because lithic production is a reductive process, meaning that debitage pieces become progressively smaller as tools are produced and refined (Andrefsky 1998, 96). Only percussion flakes were examined in this thesis because a general analysis of tools and flakes was completed. Micro-flakes, which are flakes that were too small for the ¼”dry screens and biproducts of pressure flaking that show refinement and the refurbishing of tools, were not used in this thesis. The micro-flakes that were discovered through wet screening were taken by PCRG for analysis.

These flakes were then further separated into material type, weighed, and then counted. Specifically, the categories are size grade, material type, descriptive category (if the material can be more specifically identified, e.g., Troublesome Chert or Parker Petrified Wood), if cortex and/or heat treatment was present, weight, and the number of flakes recorded. Material type identification is especially important for determining the source location of the stone (Andrefsky 1998, 41).

After mass analysis was completed, we conducted tool analysis. During mass analysis, tools had been separated and double-checked by the members of PCRG. Altogether, information collected about the stone tools included measurements (length, width, and thickness), material type, descriptive category, tool use, and change in use-life (Andrefsky 1998). The tools were also sorted for size grade and analyzed for usage. If the tool had evidence of multiple usages (e.g.- a broken biface that was also used as a scraper), this was noted. Each tool was weighed and analyzed for material type. If a more specific material type could be assigned, that was documented as well. The measurements for the tools were taken using electronic calipers.

Finally, individual flake analysis was conducted. For this technique, every individual flake is analyzed using the image evident in Figure 4.12 (Sullivan and Rozen 1985). The flakes had previously been separated by size grade through mass analysis and were further separated into completeness categories (Figure 4.12). The flakes were redocumented for material type, including specific material types, like Troublesome chert, if applicable. (Mitchell and Falk, 2017). Measurements like length, width, and thickness were taken for complete and broken flakes. All the flakes were weighed. Finally, the flakes were analyzed for heat treatment, completeness, the platform, and its type, as well as the type of flake that it was hypothesized to be.

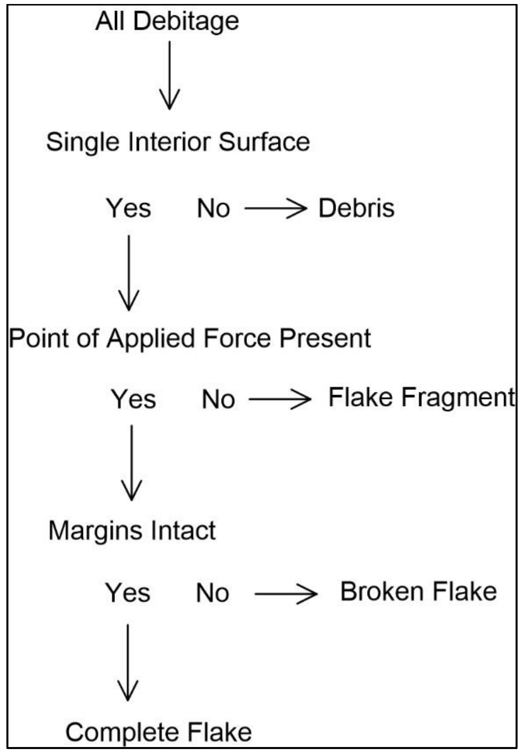


Figure 4.12: Debitage classification taken from Andrefsky (1998) and adapted from Sullivan and Rozen (1985).

The tool analysis was also completed by the interns at DMNS (me included), and the work was overseen by PCRG. The tools were classified into general categories. These included small patterned biface (arrow, points, drills, and small cutting tools), large patterned biface (dart points, hafted and unhafted biface cutting tools), unpatterned biface, patterned flake tool, unpatterned flake tool, non-bipolar core (cores and tested cobbles), bipolar core/wedge, unpatterned ground stone (abrading tools, hammerstones, and bipolar anvils), and patterned ground stone (Mitchell and Falk 2017). In this classification system, patterned tools are described as exhibiting bilateral symmetry. Conversely, unpatterned flake tools are asymmetrical and its form is determined by the original lithic blank. The patterned tools suggest that a longer time was spent crafting the final product and therefore, was likely kept for a longer period of time. The unpatterned tools suggest that these tools were manufactured and used quickly before being discarded. Examples of these tools are found in Figures 4.13- 4.15 below. These images were compiled from Kalasz and Shields (1997) and Mitchell (2022).

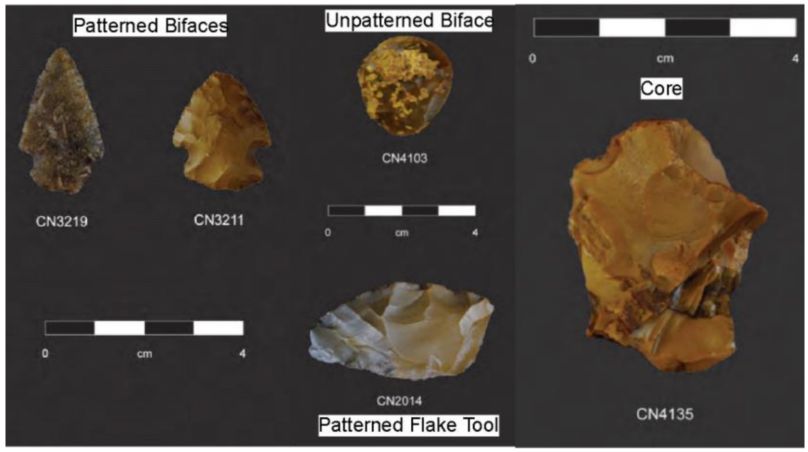


Figure 4.13: Examples of tool types from Mitchell 2022.

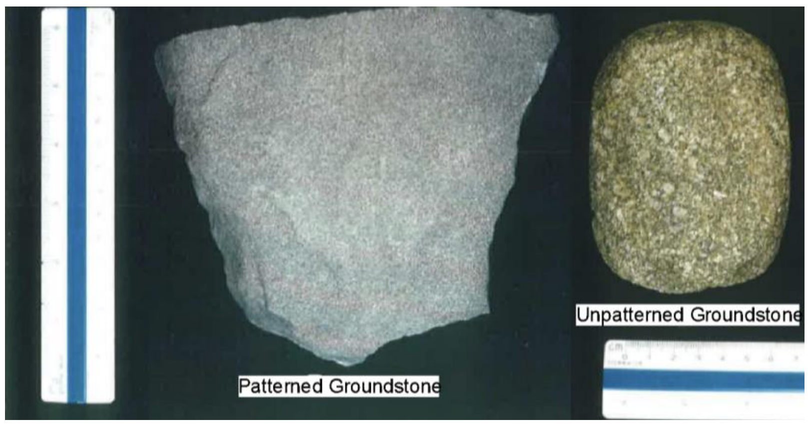


Figure 4.14: Examples of ground stone from Kalasz and Shields 1997.

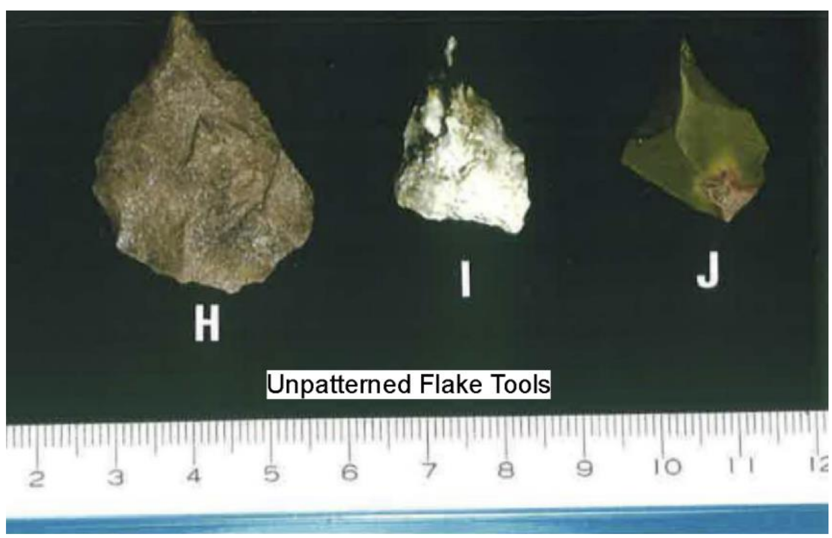


Figure 4.15 Examples of flake tools from Kalasz and Shields 1997.

Once the tools were categorized, I completed analysis regarding tool diversity to understand the make-up of these tools. I completed analysis regarding tool diversity by using the evenness index formula (Andrefsky 1998). This formula is typically used in biology to study the diversity of animal species within a given area. The evenness index equation is as follows:

$$E = \frac{\left(\frac{n_i}{n}\right)\left(log\frac{n_i}{n}\right)}{log_s}$$

With: n_i = the number of artifacts for each type

n = the number of artifacts for all types

s = the number of artifact types.

I used this formula to study the number of tools in relation to the types of tools that were present. This formula shows how diverse a collection is on a scale from 0 to 1, with zero being very diverse and one being homogenous. Tool diversity is important at the Magic Mountain Site because it answers questions regarding how the site was used during the Late Archaic and Early Ceramic time periods. The table used to calculate the evenness index is found in Appendix A.

Conclusion

Many methods are needed to comprehensively study this site. The magnetometry is useful for finding hearths and other anthropogenic features. GPR was for geologic purposes, understanding the stratigraphy at the site, and for analyzing the anthropogenic features. Lithic analysis helps with dating the stratigraphy and for answering research questions related to migration patterns. Finally, the method of excavation helps to test many of the hypotheses that are linked to the geophysical methods that are used as noninvasive prospecting tools to find potential features. All of this was synthesized using software for processing and creating images, as well as for georeferencing the information into maps.

Chapter 5: Data Analysis

This chapter describes the analysis of the findings from the data collected during the 2017-2018 excavations. These were procured using ground-penetrating radar images, magnetometry maps, stratigraphic profiles, lithic analysis, and GIS modeling. This process began with integrating the ground-penetrating radar and the magnetometry data with stratigraphic profiles to study the physical and cultural landscape. Following this analysis, the excavated materials were analyzed for raw material types and tool diversity and function. Those data were integrated with the geophysical maps to determine in what geographic and age context they were deposited. This integrated analysis answers questions regarding the site function and the migration patterns of the prehistoric peoples who resided here during millennia.

Recent studies at the Magic Mountain site revealed that there was a prehistoric river channel that flowed through site during the Archaic Period (Mandel 2022). This fluvial system produced one river terrace during a degradation event, which formed when the fluvial channel cut through the landscape and eroded away sediments. Following the formation of the river channel and the terrace, a high energy event caused the area to aggrade with sediments before a second channel cut through the area again. The second channel, which formed in the same area, brought in alluvial sediments that slowly filled the area over time starting in 1400 B.P. At the same time, the landscape was stable enough for a soil to form. The combination of alluvial sediments and soil formation caused a thick soil unit to develop on the southern side of the site, called a cumulic A soil horizon (Figure 5.1). The fluvial system was manually channelized in the historic/modern times following the construction of Heritage Square (Kalasz and Shields 1997). Soil continues to form across the site in present day.

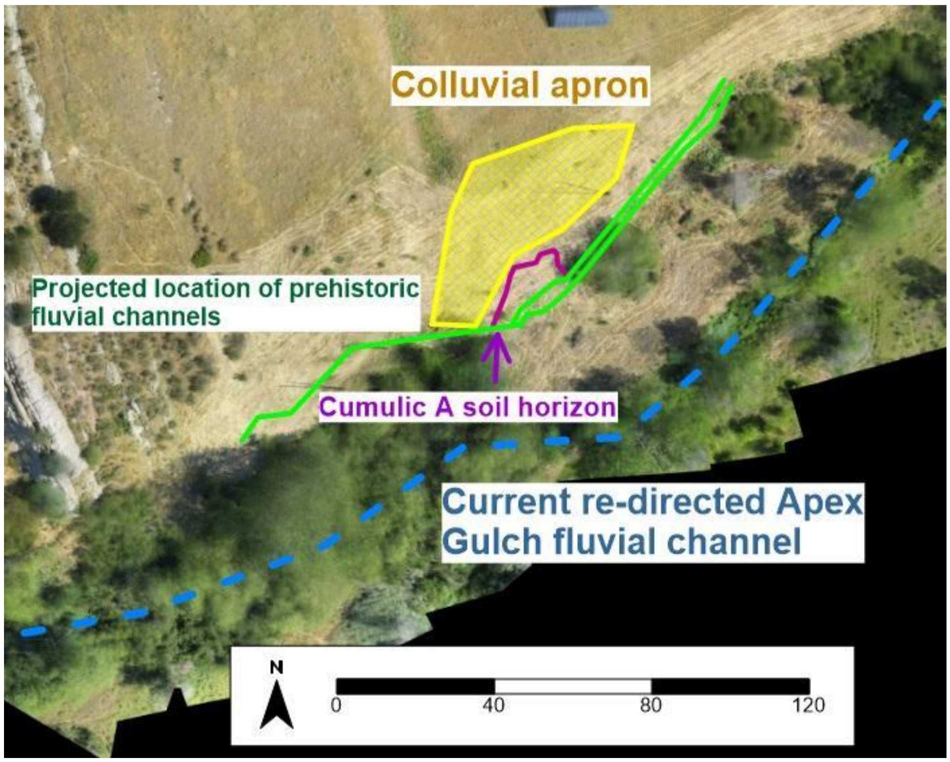


Figure 5.1: Map of the landscape features discovered at the Magic Mountain site in 2017/2018.

During the Archaic Period when the channels were forming, humans inhabited an area on the north side of Apex River system now called the colluvial apron (Figure 5.1). The colluvial apron was higher in elevation and separated from the river system by the river terrace that had formed. Following the second channel formation, people moved closer to the river system in the Early Ceramic Period, inhabiting the cumulic A soil horizon. A radiocarbon date taken at the site shows that the area was inhabited until roughly 1000 B.P. (Mitchell 2022). There is minimal archaeological evidence, two protohistoric tools, of people inhabiting the area following this date.

River Channel and Terrace

The river channel and the associated terrace are noticeable using the ground-penetrating radar and magnetometry data, which are discussed below. The Magic Mountain site is located within an alluvial environment that was constrained by bedrock outcrops to the west (Kalasz and Shields 1997). The river channel has changed elevation vertically over time rather than moving laterally across the landscape as many channels do in environments of lower elevation gradient. The current location of the Apex River channel is slightly different than in prehistoric times because it was manually channelized during the historic construction of Heritage Square (Kalasz and Shields 1997).

The ground-penetrating radar data provides three-dimensional data of the prehistoric Apex River channels that narrows down depth and location. With this method, the channel looked very clear within the GPR profiles (Figure 5.2). All the GPR profiles were then sliced into amplitude maps to provide the three-dimensional aspect. The river channels, which were difficult to capture in one slice, were mapped onto the area manually to convey their location. Figure 5.2 shows the location of the river channels within the GPR grids that were collected in 2018. Two different frequencies of data, 400 and 270 MHz, were collected within the same area. The river channels are evident in the 270 data profile in Figure 5.2.

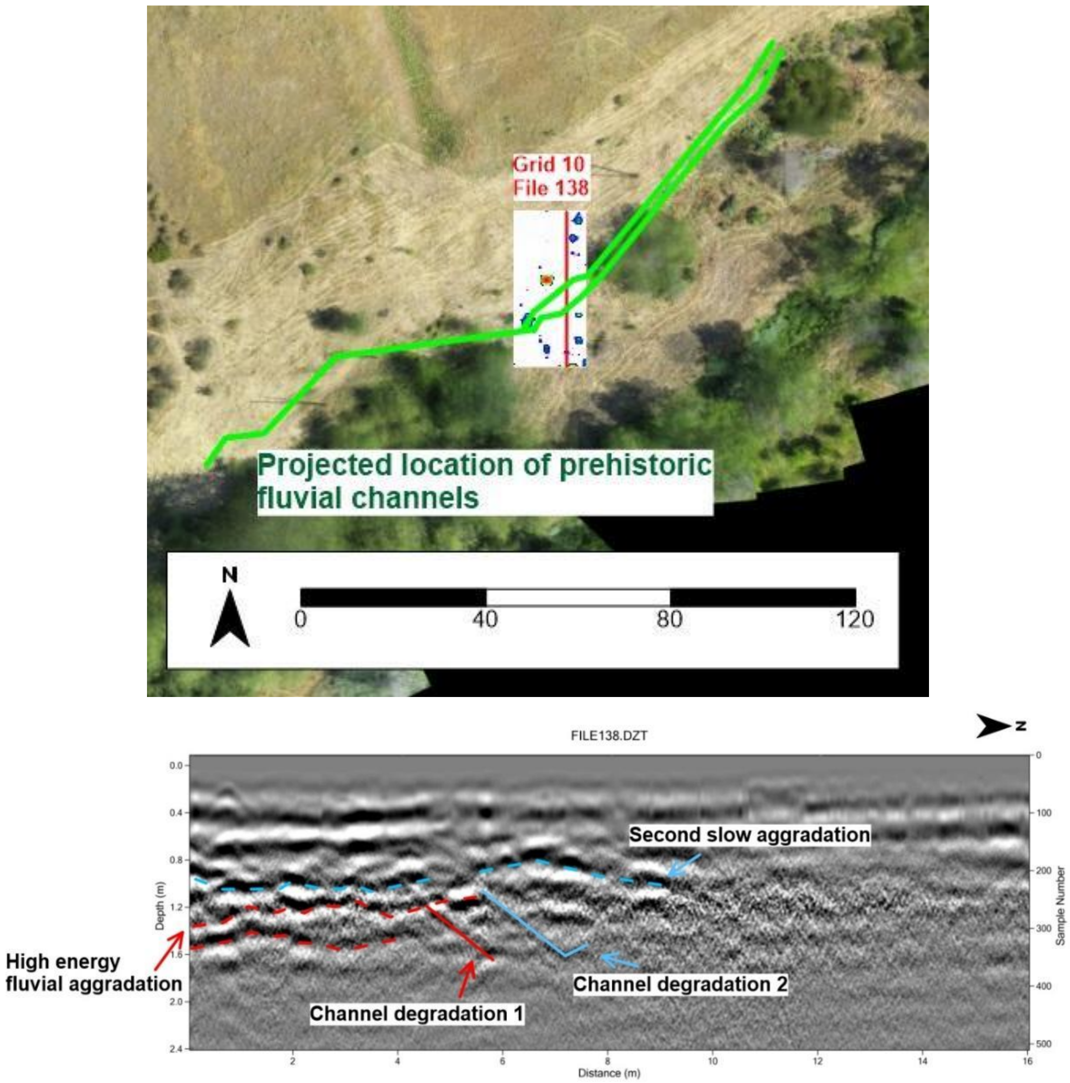


Figure 5.2: Profile showing the aggradation and degradation sequences at the site in a GPR profile (below) as well as their mapped location (above).

Figure 5.2 shows the degradation and aggradation sequences of the Apex fluvial channels. Marked in red, the channel would have degraded the sediment in the area as the fluvial channel cut through the landscape. Then a high energy event filled and covered the channel. After an unknown amount of time, the channel degraded this same area again as the channel cut through in relatively the same location. Then the second slow aggradation began filing in the channel and covering it. This second aggradation resulted in the formation of the cumulic A soil horizon to the north of the channels, which is discussed later in the chapter.

There are two other areas at the site where the Apex fluvial channel is apparent in the GPR data. These areas are on the eastern and western boundaries of where the GPR data were collected (Figure 5.3). In area 1, the two degradation-aggradation sequences are noticeable in the same location but at different depths while area 2 shows one wide river channel and a river terrace.

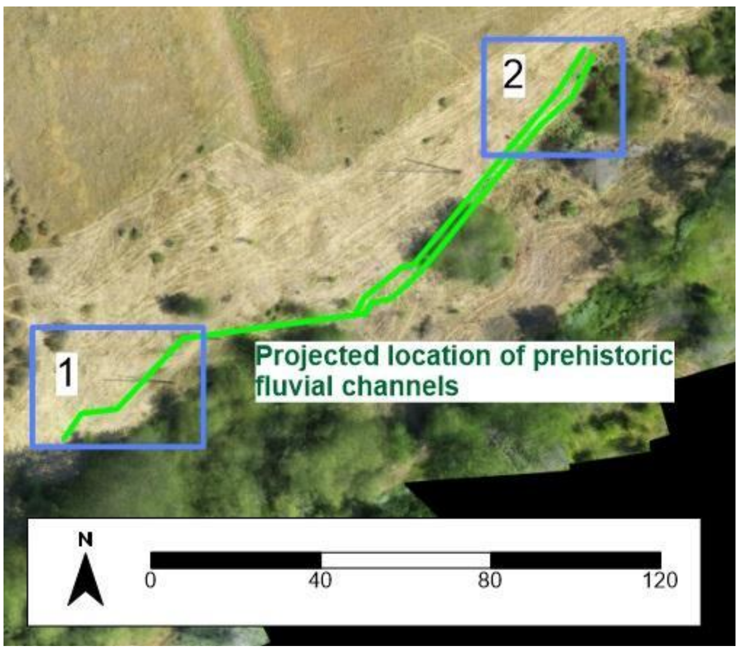


Figure 5.3: Other locations where the prehistoric river channel was found in the geophysical data.

In area 1 (Figure 5.3), there are examples of the Apex River channels that are hypothesized to be two different degradation and aggradation sequences. A GPR profile (Figure 5.4) taken from area 1 shows a lower fluvial deposit highlighted in red and is likely the first degradation-aggradation sequence. The higher fluvial deposit highlighted in blue is the second degradation-aggradation sequence. These fluvial deposits are found close to the hogback where the bedrock is much shallower, therefore these deposits are found roughly 40 cm closer to the present-day ground surface than what was discovered in GPR Grid 10.

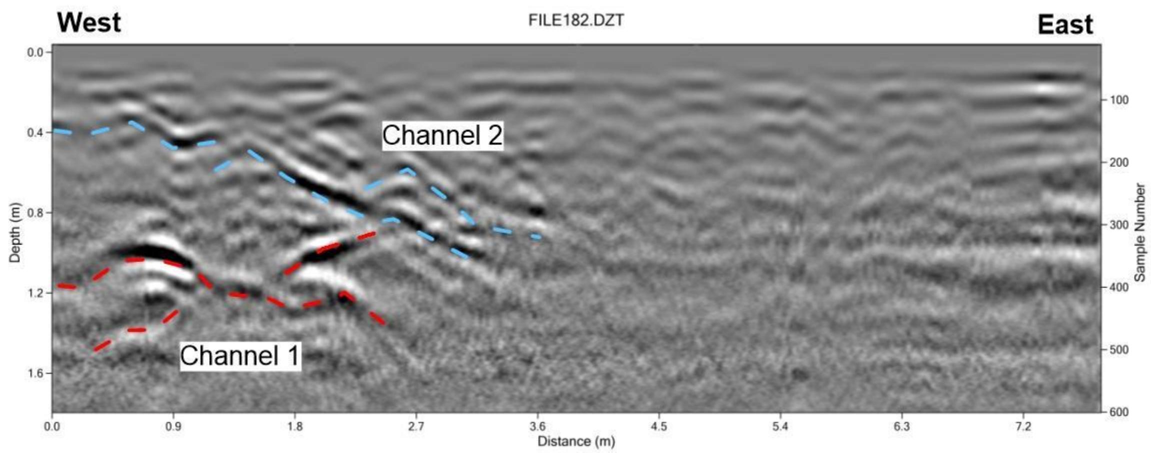


Figure 5.4: Degradation and aggradation sequences in area 1.

In area 2 (Figure 5.3), the prehistoric gulch channel to the east is noticeable within the GPR data as well. However due to issues with dense vegetation, this is the furthest extent that is mappable using geophysics. Three GPR profiles taken from this area show one wide river channel and one terrace (Figure 5.5).

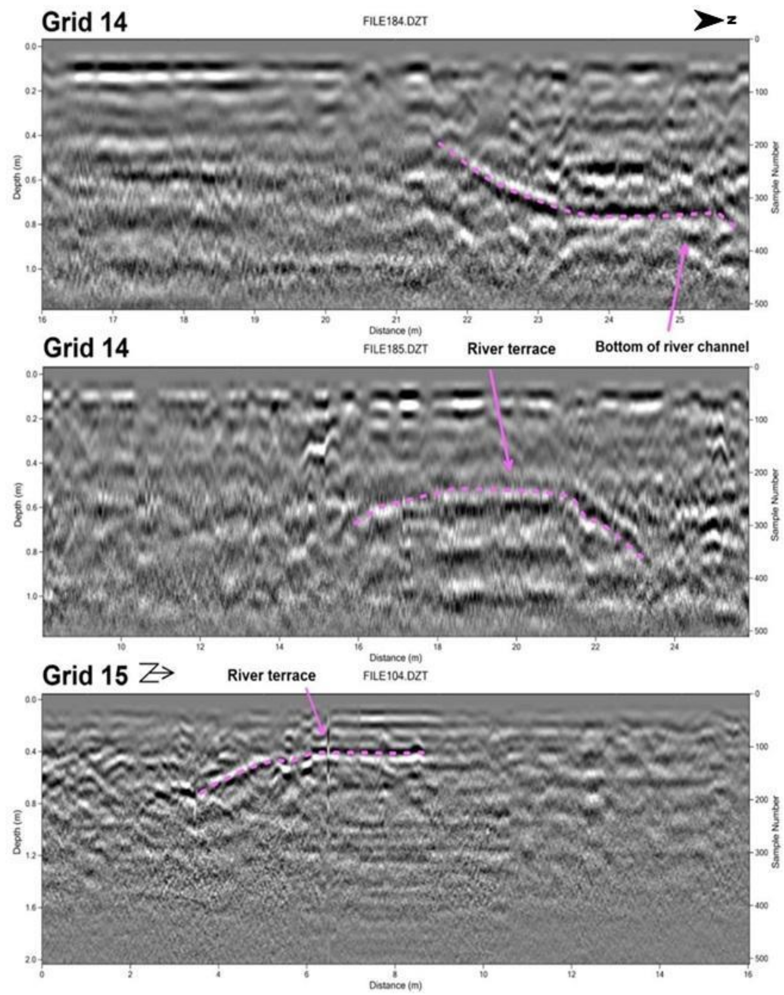


Figure 5.5: Eastern extent of prehistoric river channel with associated GPR profiles.

These profiles show low-amplitude planar reflections that are slightly sloping (Figure 5.5). The river terrace, located on the northern side of area 2, is the only area on site where it is noticeable within the GPR data. The channel, which is much wider than the other channels found across the site, is likely both channels combined. This likely occurred because there are large river cobbles found on the surface on the eastern edge of the site. Both the channels that slightly deviated from each other in the low-lying area of the site combined into one wide channel as the elevation levelled out on the eastern side of the site. This area filled in slightly over time, likely when the channel was diverted in historic/modern times (Kalasz and Shields 1997). Figure 5.6 also shows the GPR profiles of this river terrace. This river terrace is important to map because it is also an indication of the colluvial apron, which is where most of the evidence of human habitation was discovered. The river terrace had a riser and a tread that acted as protection against fluvial events by providing slightly higher ground away from the water.

GPR data collected with a 270 MHz antenna in area 2 shows an aggradation event (red), which is likely the first aggradation event that occurred at the site (Figure 5.6). Although the channel is not noticeable within the profile, the river channel would have aggraded sediment into the area. The channel would have cut through the landscape, creating the terrace that is noticeable within the profile. There was then the final aggradation event that covered the river terrace with the parent material that created the soil on the modern-day ground surface.

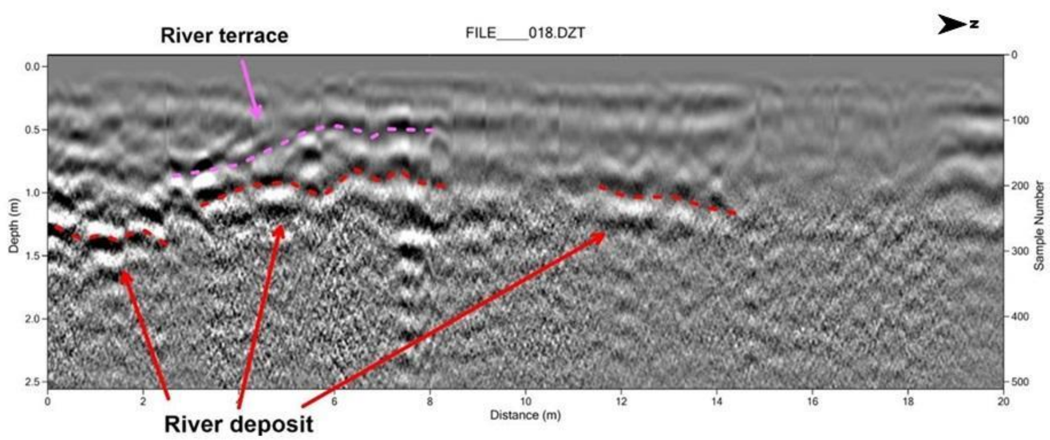


Figure 5.6: Profile of 270 data in area 2.

Overall, the projected location of the prehistoric Apex River channel begins just north of the estimated excavation unit from the Centennial Archaeology excavations in the 90s (Figure 5.7). It flowed down slope, leaving behind two degradation and aggradation sequences. These degradation and aggradation events occurred between the 6000 and 3500 B.P, though specific age dates of these events are unknown (Mandel 2022). After the channel began forming, a high energy event, or a series of high energy events, deposited sediments that would have filled in the channel causing the fluvial channel to slowly change locations over time. Then around 1400 B.P, the landscape became stable enough to begin forming the soils that exist today at the site. In the prehistoric times, this site was punctuated with landscape instability but once Heritage Square and Apex Park were built, the fluvial channel was redirected to its current location along the southern border of the site and the landscape became stable (Figure 5.7).

Figure 5.7: Landsat imagery of the greater area surrounding the site from 1985 (Courtesy of Google Earth).

Figure 5.7 shows the channelization of the Apex River system as of 1985. The Apex River channel highlighted in blue [Apex Gulch before channelization] is marked in historic topographic maps as early as 1938, which makes that the historic channel prior to the construction of Heritage Square (Netronline 2022). According to historic topographic and aerial maps, Heritage Square was built sometime after 1958 but prior to 1963. As of 1963 in historic aerials, the Apex fluvial system had been channelized. The parking lot formerly associated with Heritage Square, which is now the Apex Park trailhead, was built between 1971 and 1983. This channelization of the Apex River system is still in place present day.

Overall, the river channel helped form the prehistoric landscape, especially because there are sediment packages and landscape features that were formed as a direct result of the river system. These include the colluvial apron and the cumulic A soil horizon, where much of the cultural deposits are found. These areas are marked in Figure 5.8 and are discussed in the following sections.

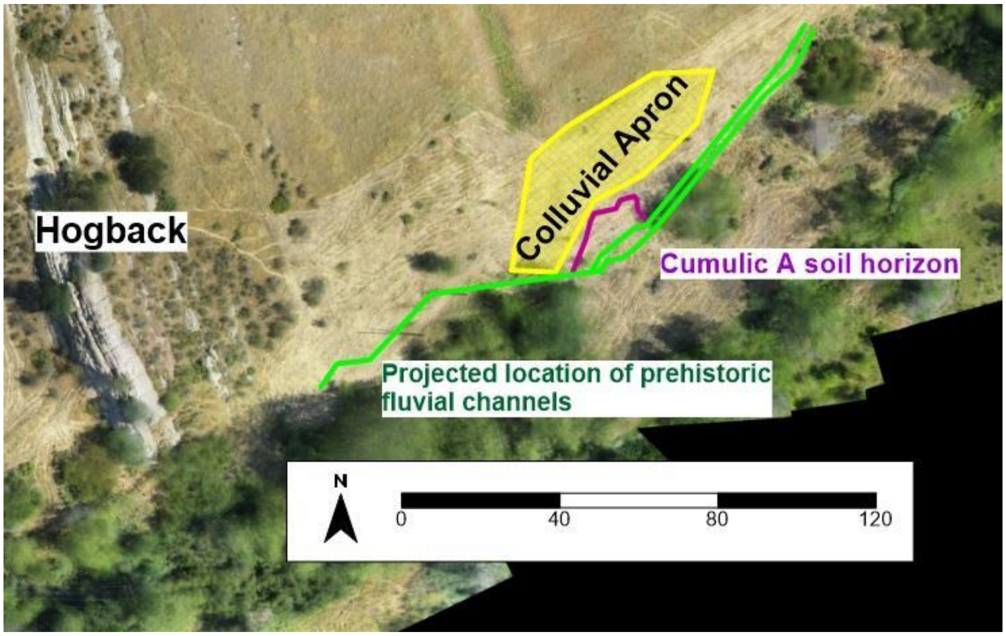


Figure 5.8: The location of the buried river channel, the cumulic A soil horizon, and the colluvial apron.

Colluvial Apron

A colluvial apron is found to the north of the river channels, downslope of the hogback (Figure 5.9). This area had most of the Archaic Period features and artifacts that were found throughout all the excavations to take place (Mandel 2022). These features and artifacts suggest that this area of the site was being used as the living space during this time period.

There were two soils found within the colluvial apron, a buried soil with a parent material of alluvium and the soil that is on the present-day ground surface that has a parent material of colluvium (Figure 5.9). The buried soil has a radiocarbon date 6340-6045 B.P., which means that it began forming before the prehistoric river channels that ran through site. Although no artifacts were found in this buried soil, it has the potential to have Early-to-Middle Archaic Period cultural deposits.

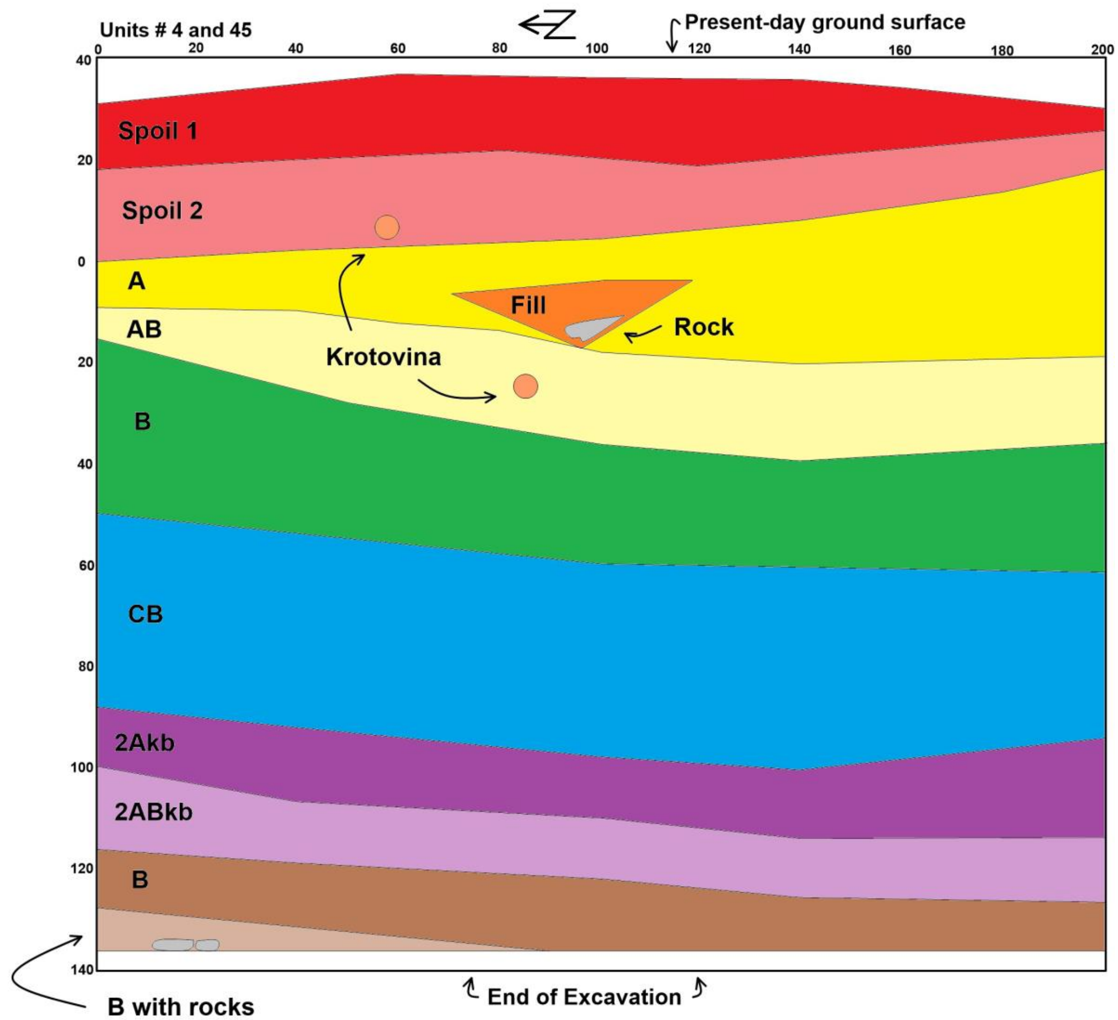


Figure 5.9: Soil profile showing the colluvial apron and krotovina (rodent burrows).

To the north of the cumulic A soil unit and the prehistoric river channels, these two soils are noticeable even though the age dates for the buried soil are 7955-7625 B.P (Mandel 2022). The difference in age dates can be explained because the A soil horizon on the north side of the site was stripped sometime before the soil was buried. The radiocarbon date was taken from the buried B horizon, which is much older than the A horizon. Therefore, it is likely the same soil even though the age dates are slightly different. This buried soil showed that there was a possibility of a Paleoindian occupation period because there was a total of 43 pieces of lithic debitage, eight of which had calcium carbonate coating. This calcium carbonate coating affirms the date and suggests that the lithic debitage was found in situ. Calcium carbonate takes a long time to precipitate through soil and coat buried objects. No stone tools were found in conjunction with this buried soil.

The soil on ground surface today began forming in the Late Archaic and Early Ceramic Periods. These prehistoric deposits were buried on the footslope and the toeslope of the colluvial apron (Mandel 2022) following the location change of the prehistoric river channels. Although many features were found during the recent excavations, there are still other features located on the colluvial apron that I discovered using geophysical methods that can be explored in future research. I hypothesize these features to be more hearths or hearth refuse.

The Magic Mountain site has an extensive number of features and material culture collection that have been discovered and documented since 1959 (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997). Prior to the Harvard excavations, the Denver Museum of Natural History (now the Denver Museum of Nature and Science) was notified of numerous burials that had been disturbed and looted. However, Cynthia Irwin-Williams and her brother Henry Irwin completed the first extensive study of the site that showed its potential for buried cultural deposits.

The Harvard excavations unearthed numerous stone tools, three burials, and six hearth features (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997). At the time, six hearths were a sparse representation compared to current findings. The Centennial excavations in the 1990s found an even more extensive lithic tool assemblage and 14 features. The descriptions of six of them sound similar to hearth features because they had charcoal staining, fire-altered rock, or some combination of both (Kalasz and Shields 1997). During the recent excavations, 15 features of this sort were discovered (Mitchell 2021). Fourteen of these features were prehistoric hearth features. This indicates that there is a total of 26 known “hearth-like” features with a potential for more to be found. More potential hearth features were mapped for future excavation using the ground-penetrating radar data collected during 2017 and 2018.

As discussed before, the hearth features found during the excavation season were previously located using magnetometry. These features were not visible with GPR as they could not be discriminated from the colluvium at the time. Following the excavation season and after receiving the locational data of the discovered features, more features were found using the GPR data. The locations of the hearth-like features were used to study what they looked like in the GPR data. More features were located for future study. The newly located features and their corresponding GPR profiles are mapped in Figure 5.10.

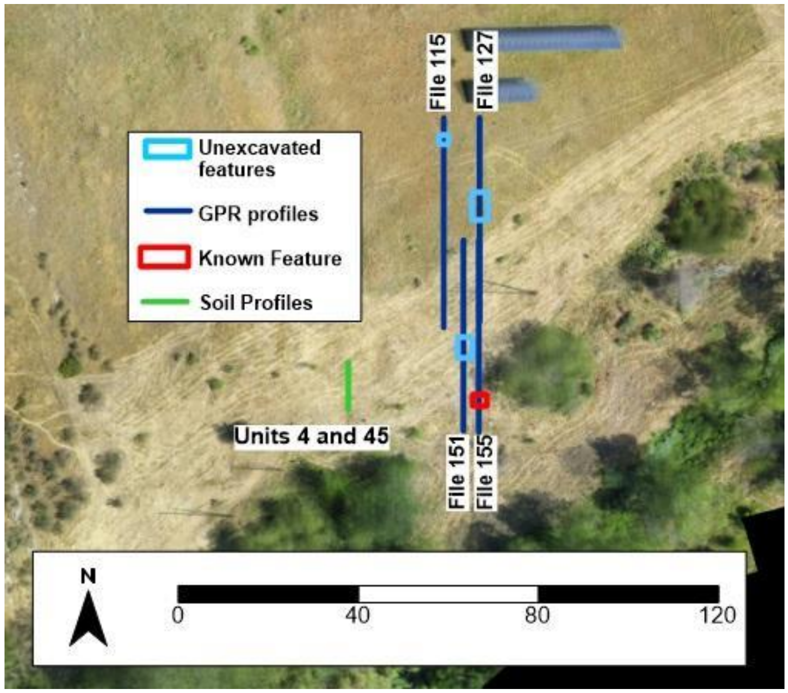


Figure 5.10: Aerial of cultural features.

An example of a feature in the GPR data that was found during the recent excavations is in Figure 5.11. File 155 shows a cluster of hyperbolic reflections that was excavated in 2017/2018. The hyperbolic reflections in File 155 are Feature 15, a small rock-filled basin (Mitchell 2021). Many of these rock-filled basins found during the recent excavations were small enough that they were only present in one GPR profile, which also meant that only one, maybe two, hyperbolic reflections were noticeable. Upon excavation, the rock-filled basins were found to be layers of fire-altered rock with some charcoal staining. These types of features were hypothesized to be hearths or hearth refuse that was part of a clean-out episode. Hearths and hearth refuse are found throughout the site and all look similarly within the GPR data.

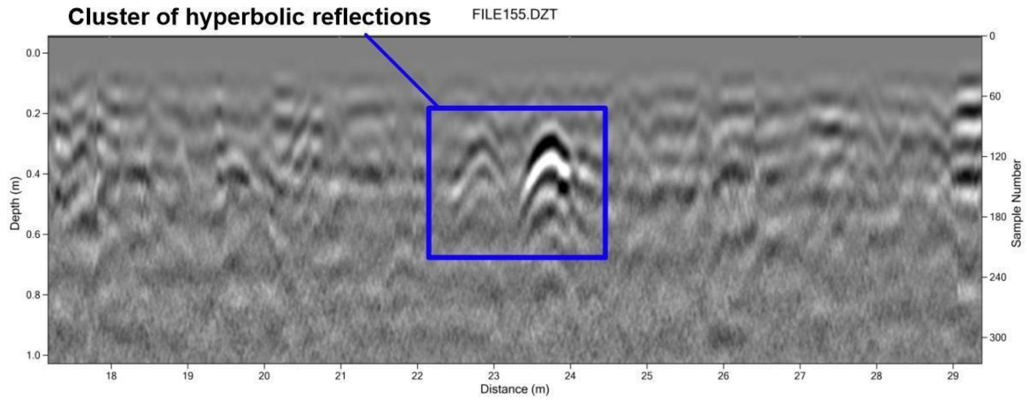


Figure 5.11: Cluster of hyperbolic reflections in the northern portion of the grid.

File 155 (Figure 5.11) shows two hyperbolic reflections, one that is low amplitude and one that is high amplitude. This is characteristic of how the features look in the GPR data at the Magic Mountain site, a few hyperbolic reflections only noticeable in one profile, because of their small size. The feature in File 155 was used as an example to find other features by looking for the same characteristics throughout the GPR data. Four other potential hearth-like features were found by using Feature 14 as an example. These areas are marked in light blue in Figures 5.10 and 5.12.

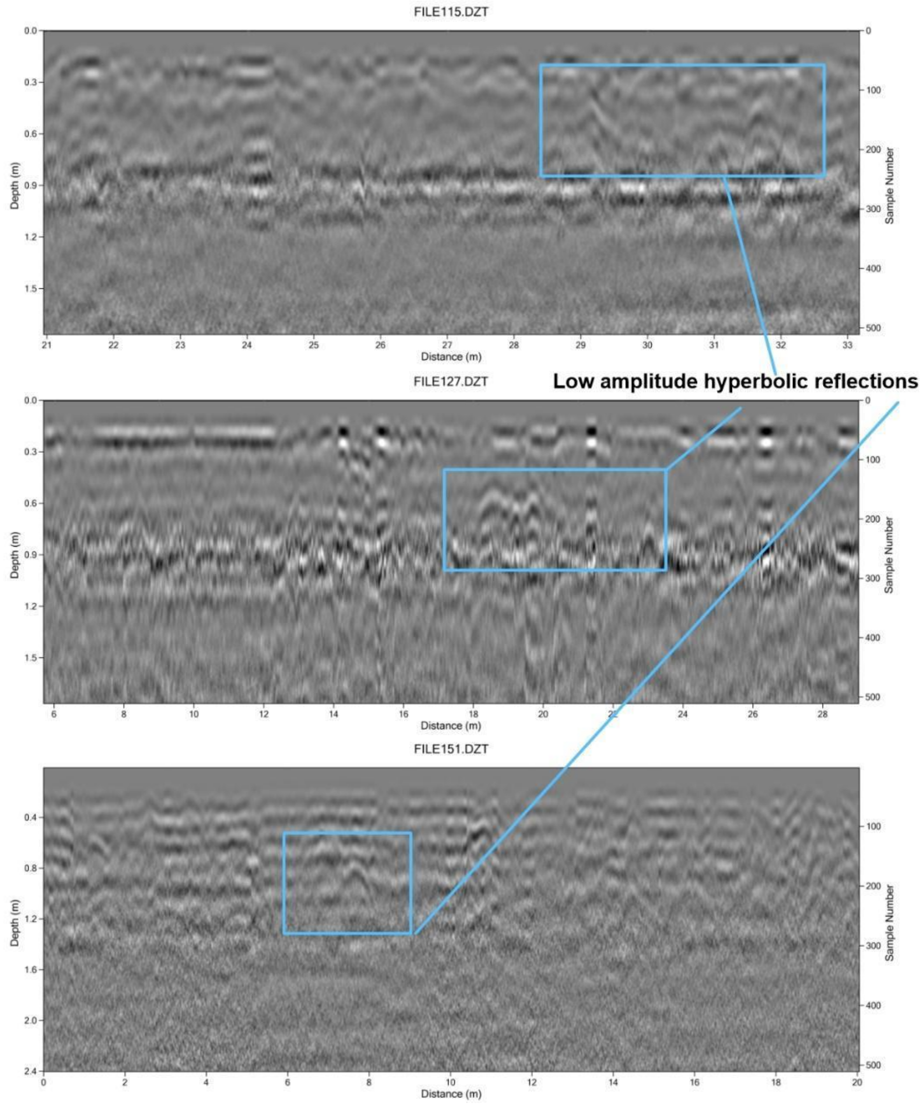


Figure 5.12: Potential anthropogenic features.

Each of these profiles show low amplitude hyperbolic reflections that are characteristic of the features that were found at the Magic Mountain site at the recent excavations. These features are likely to be hearths or hearth refuse. All of these features are located on the colluvial apron, which is where many of the excavated features were found. The colluvial apron is significant because it was the raised area that people were inhabiting as the fluvial channels were flowing through the site. This area would have been close enough to the water source for it to be utilized, but still high enough in elevation and far enough away from the channel that it would have been safe for people to camp**.**

Cumulic A Soil Horizon

Located to the north of the two prehistoric river channels and south of the colluvial apron is a cumulic A soil horizon unit. This soil horizon unit is important because there were Early Ceramic period artifacts and features found buried within the unit (Mandel 2022). The cumulic A soil horizon started to form around 1400 B.P when the landscape was more stable and after the river had cut through the site a second time.

The prehistoric location of the Apex River system and the cumulic A soil unit are both evident within the geophysical data (Figure 5.13). It is possible with ground-penetrating radar to map the prehistoric Apex channels to its exact depth, thickness, and extent. By integrating magnetometry, the cumulic A, which was not evident in the GPR, was noticeable because it has a lower magnetic susceptibility to the surrounding soils and river channels. The integration of the geophysics allows for an in-depth analysis of major landscape features, both geological and cultural. This is important because the cumulic A soil horizon and the Apex River channels existed in concurrence with the prehistoric habitation of the area.

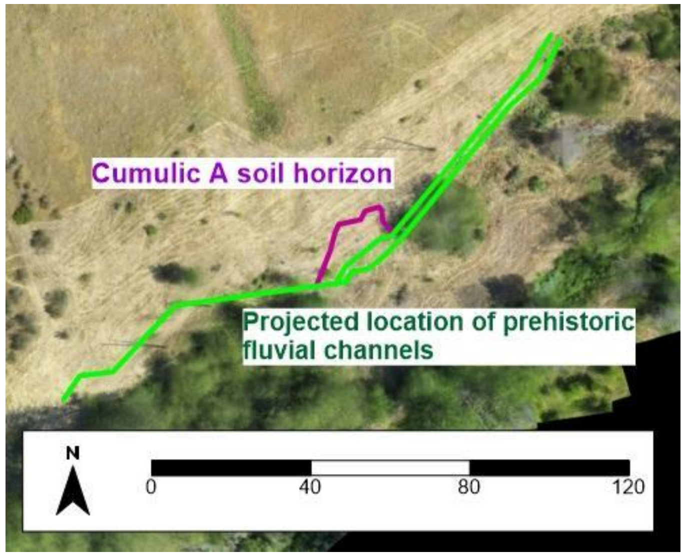


Figure 5.13: Aerial of the cumulic A and the prehistoric fluvial channels.

Magnetometry maps were created, studied, and then used in conjunction with the new locational information of the river channels to extract magnetic profiles. These profiles convey the magnetic values within the same area of the GPR profiles. The differences in magnetic values across this profile convey the make-up of the sediment packages and therefore their geological origin.

The magnetic map shown in Figure 5.14 shows a positively magnetic anomaly, the river channels, which clips the southeastern edge of the collection area (outlined in green). To the north of this feature, there is a negative anomaly that is indicative of the cumulic A soil horizon. The highly magnetic values within the area of the river channels found through using the GPR data correspond with the sedimentary rocks that were washed in through high energy fluvial events of Apex Gulch (Kalasz and Shields 1997). The cumulic A to the north, which is mainly consisting of sand and organic materials, is less magnetically enhanced.

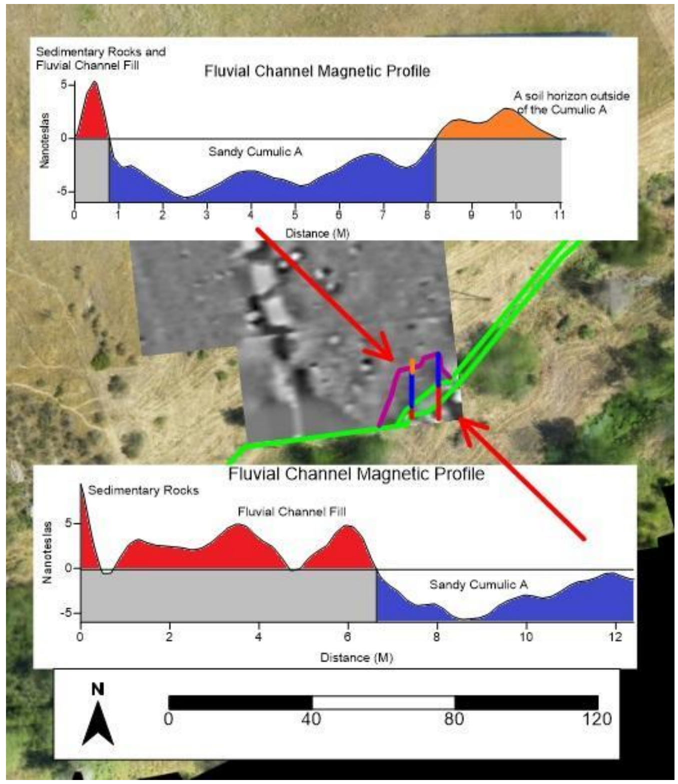


Figure 5.14: Examples of magnetic profiles with their location.

The magnetic profiles in Figure 5.14 show the magnetic values of the channel and the cumulic A. The magnetometry was used to map the extent of the cumulic A soil unit, which would have been an indication of a low-lying area where sediments settled as the soil formed (Birkeland 1984; Holliday 2004; Waters 1992; Mandel 2022). Mapped in purple in Figure 5.14, the cumulic A (purple) slowly formed to the north of where the projected prehistoric Apex River channels (green) are located. The cumulic A, which has a sandier texture brought in from alluvial flooding events, pinches out to the north before the colluvial apron (Mandel 2022). Although this A soil horizon has formed across the site, the sand content of the cumulic A soil horizon is in greater quantity in this area.

Figure 5.14 shows profiles two magnetic profiles within the area of the cumulic A soil unit. The section of the profile marked in red shows the sedimentary rocks lining the fluvial channels. The parent material at the southern edge of the site are sedimentary rocks, including gneiss and schist, which are river cobbles associated with the fluvial channel (Kalasz and Shields 1997). These river cobbles contain a mineral called magnetite, which is a magnetic material that shows up positively magnetic in the magnetometry maps. The section marked in blue in the magnetic profile is the cumulic A soil unit. The cumulic A soil unit, which is a soil unit with a higher amount of sand than the surrounding areas, shows as less magnetic in the magnetometry maps. This is because the sand has a lower amount of magnetite than the river cobbles lining the channel. The part of the profile that is marked in orange in Figure 5.14 is indicative of the soil horizon that comprises the colluvial apron. The colluvial apron is more magnetic because this area has most of the anthropogenic features and artifacts found during the excavation season. Areas where human occupations have occurred increases the magnetic enrichment of the surface soils because they introduce organic materials into the soil that causes bacteria growth that concentrate compounds like magnetite (Kvamme 2006b; Fassbinder 2015). Although the cumulic A soil horizon has some Early Ceramic features, this area was not occupied as frequently or as long as the colluvial apron. It is hypothesized that the colluvial apron was inhabited as early as 7955 B.P. whereas the cumulic A soil horizon area was not inhabited until 1400 B.P (Mandel 2022). Prior to the Early Ceramic time period, the area where the cumulic A formed showed evidence of landscape instability through the high energy events that the river produced.

Discussion of Lithic Debitage and Stone Tools

Lithic analysis is typically used for two different reasons. One reason is to identify diagnostic markers of the prehistoric culture and the other is to identify behavioral or functional markers of the culture (Andrefsky 1998, 60). At the Magic Mountain site, it was previously hypothesized that the people who used the site were part of a larger seasonal migration system where they would move between the mountains and the plains as the seasons changed and animals migrated. Due to the instability of the landscape during the Late Archaic and Early Ceramic time periods, this seasonal migration over some distance is a very likely hypothesis. However, examinations of lithic material types and tool types indicate that while populations indeed migrated, it was not to the extent prior seasonal migration arguments may suggest. Following is an examination of both lithic material types and tool diversity to demonstrate this more proximal migratory pattern.

Debitage

Irwin-Williams and Irwin indicated that the debitage collected during the Harvard excavations were mostly from local sources within a three-mile radius of the site (Irwin-Williams and Irwin 1966; Kalasz and Shields 1997). These three quarry sources included Green Mountain (cherts, agates, and petrified wood), a quartz outcrop, and a quartzite outcrop (Figure 5.15). Kalasz and Shields go more into depth about the material types with the Centennial excavations (1997). More importantly, there is a specific type of petrified wood named Parker Petrified Wood, which is found near Parker, Colorado. This type of petrified wood is very characteristic and is found within the assemblage at the Magic Mountain site.

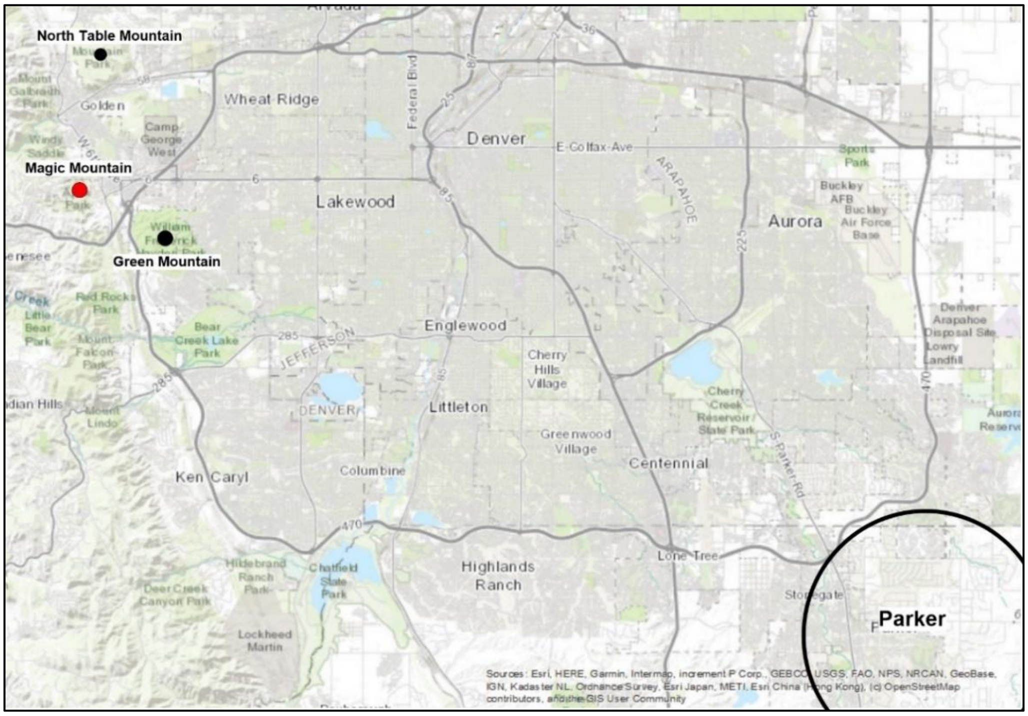


Figure 5.15: Map of main lithic sources, made from GIS maps available.

There are various material types evident within the debitage assemblage at the site. These material types include chalcedony, chert, petrified wood, quartzite, and rhyolite. Figure 5.16 shows that this assemblage is dominated by petrified wood and quartzite. Chert, chalcedony, and rhyolite make up smaller portions of the assemblage for the recent excavations. Chert in many cases can be used as an all-encompassing term for a fine-grained texture silicate rock. Others in this category would include chalcedony, flint, and Parker petrified wood. Not included in either chart are the flakes that had unassigned or unknown material types. Only about one percent of the assemblage is comprised of ‘Other,’ this includes the materials considered exotic.

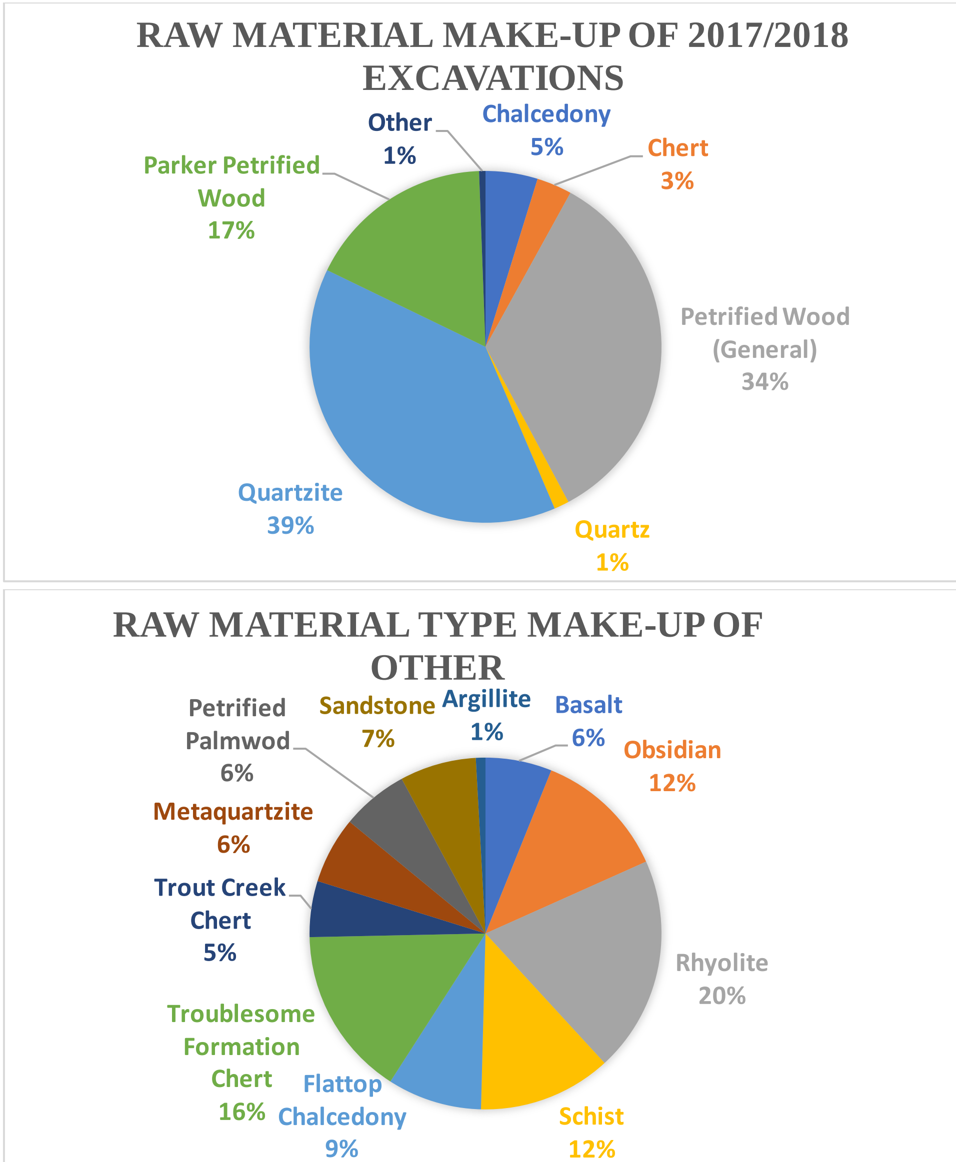


Figure 5.16: These are two graphs that shows the material type make-up of the 2017/2018 assemblage. The lower graph specifically outlines the make-up of the less frequent material types in the assemblage.

The raw material types in the upper graph of Figure 5.16 are made up of many material types found locally, including the Parker petrified wood, the quartz, and the quartzite. Making up a smaller percent of the assemblage are the materials coming from farther distances. These materials included obsidian (not sourced as of 1997 but speculated to be from New Mexico according to Kalasz and Shields 1997), Trout Creek chert, Troublesome (Kremmling) chert, and Flattop chalcedony (Kalasz and Shields 1997). Despite being a small part of the assemblage, these rarer materials from greater distances are indicative of annual rounds or even trade (Kalasz and Shields 1997).

The materials found in lower frequencies are considered exotic materials because they came from farther distances (Figure 5.17). The material that was found to be most frequent within the assemblage is Troublesome (Kremmling) chert, which is found roughly 65 miles northwest of the Magic Mountain site. Flattop chalcedony and Trout Creek chert were found in lower frequencies, and they are found northeast and south, respectively. During the annual migration, people would have brought raw materials, or tools made of those raw materials, from the mountains or the plains (Benedict 1992). However, these material types, though evident, are not prominent within the assemblage. There were three different types of petrified wood found at the site, Parker petrified wood, petrified palmwood, and petrified wood found on Green Mountain. All three parts of the petrified wood assemblage come from areas that are roughly within 30 miles from the Magic Mountain site.

Figure 5.17: Map of exotic material locations.

In the recent excavations, the Other category is made of rhyolite and Troublesome chert with schist, obsidian, and Flattop chalcedony (Figure 5.15). Some of the Troublesome chert and the Flattop chalcedony were labelled as ‘possible,’ however, they were classified and counted under their respective material type categories.

In summary, the material type assemblage consists of more proximally sourced lithic materials, with very few materials sourced from more distant locations. A more restricted seasonal movement is further highlighted by the fact that most of the material was all sourced within a 30-mile radius to the Magic Mountain site. The proximity of sourced materials illustrates two general points. The first being seasonal migration was indeed characteristic of Magic Mountain people in the Late Archaic and Early Ceramic periods. The second, and most notable, is that this migration appeared to be less distant than more generally applied seasonal migration hypotheses would imply. This phenomenon is also reflected in the analysis of stone tools.

Stone Tools

The stone tool analysis completed in this section includes a discussion of raw material types and tool diversity. Although the debitage material types are different from the stone tool material types found at the site, the proximity of the common material types remains the same. The tool diversity also indicates a more immediate exploitation of the environment around the site because there is a high number of unpatterned flake tools and unpatterned groundstone.

The raw material types for the stone tools show slightly different make-ups than the debitage that was found. The main material type of tools that was found was petrified wood while the second most frequent was sandstone in the 2017 assemblage (Figure 5.17). There was a division between the materials. The silicified stones like chalcedony, chert, petrified wood, and quartzite were made into stone tools like projectile points and bifaces. Sandstone and rhyolite made up the ground stone portion of the stone tools. This is evident in Figure 5.18. The data used in the pie graphs in this chapter were provided based on communication with the Denver Museum of Nature and Science and therefore as a courtesy the raw data is not included in the appendices.

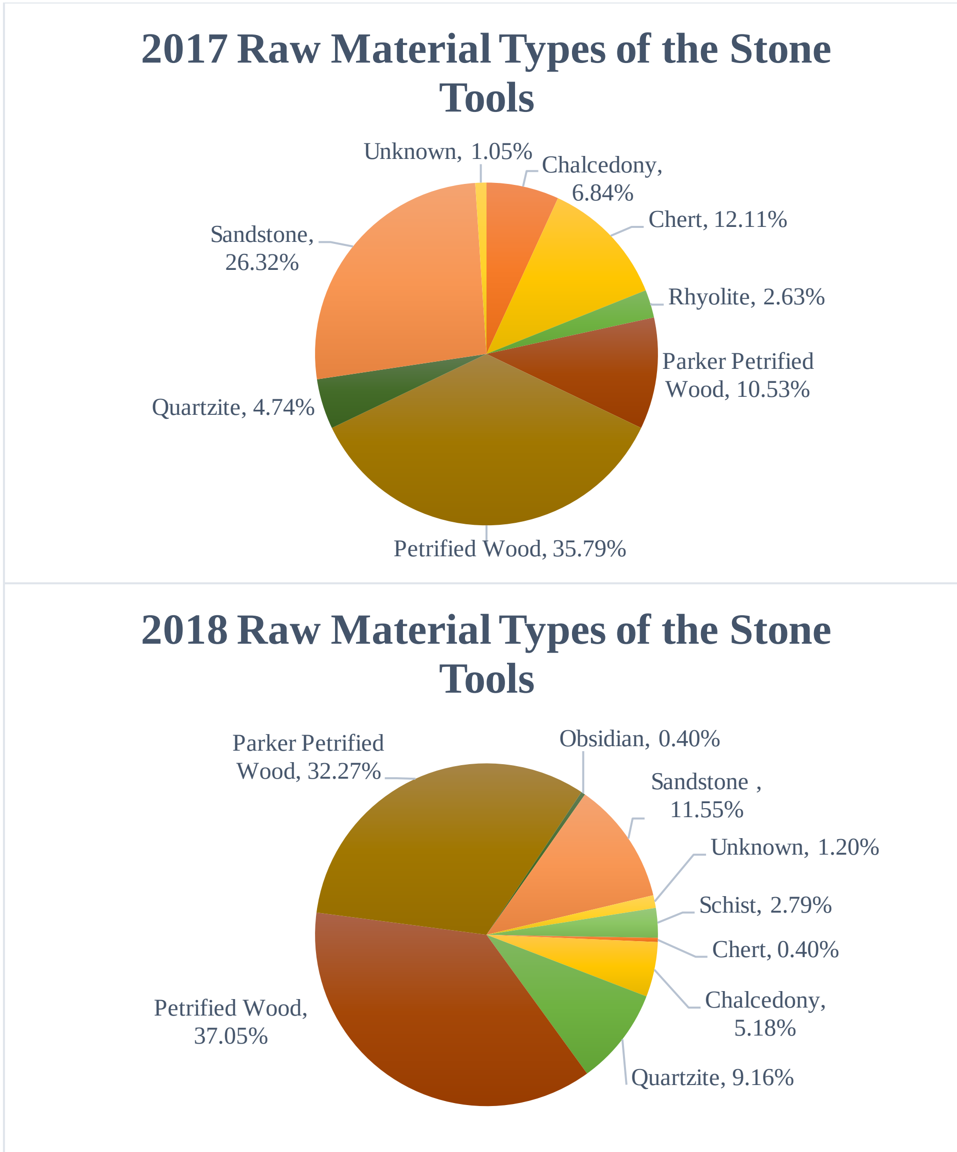
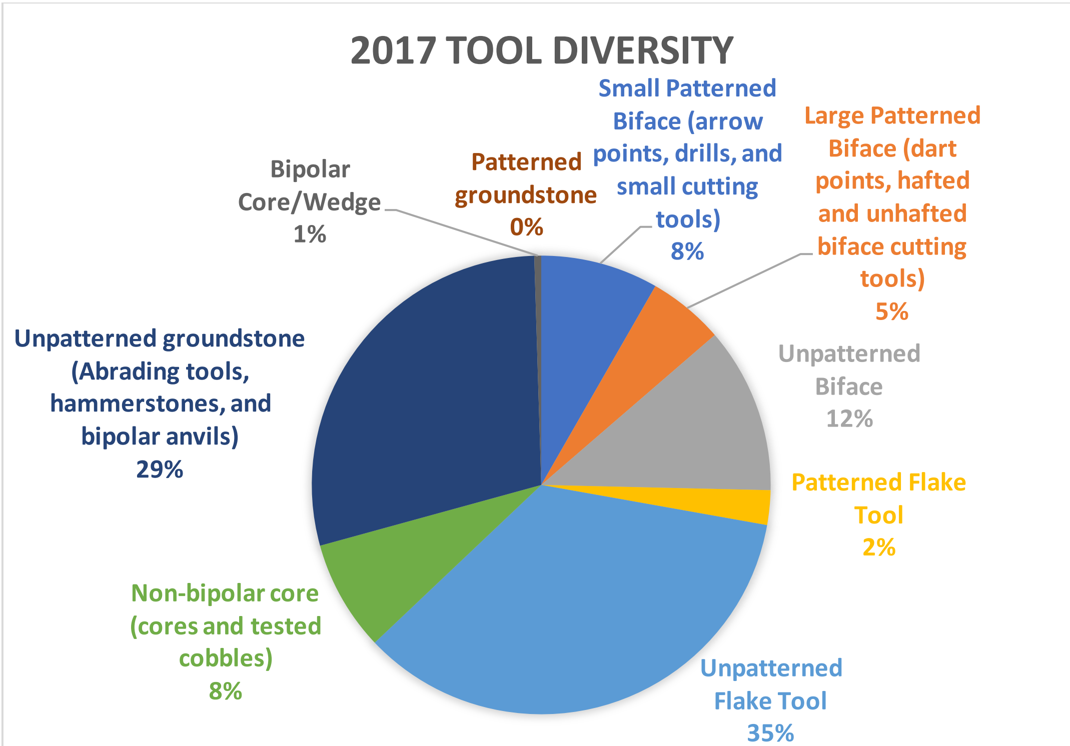


Figure 5.18: The make-up of the raw material types of stone tools.

The raw material types for the stone tools evident in the 2018 assemblage is slightly different than in the 2017 assemblage. Although the petrified wood make-up percentage is similar, there is far more Parker petrified wood and far less sandstone found when comparing the assemblages between 2017 and 2018. Although the percentage of stone tools made from raw materials found non-locally is small, there is still some indication of travel for materials like obsidian.

Studying tool diversity is important to understanding site function by applying it to the forager-collector model (Binford 1980). Base camps and residential camps would include a wide range of activities that would imply a diverse tool collection (Andrefsky 1994; Binford 1980). Alternatively, field camps are specialized sites where the tasks would be oriented to specific activities, therefore, a limited range of tools can be expected. The tool diversity at the Magic Mountain site is evident in Figure 5.19 and shows the percentage make-up of each tool type. The site was dominated by unpatterned ground stone and unpatterned flake tools. The unpatterned flake tools are considered expedient tools, which means that they were quickly utilized for a purpose and then discarded. This implies that the people used the environment for immediate exploitation.



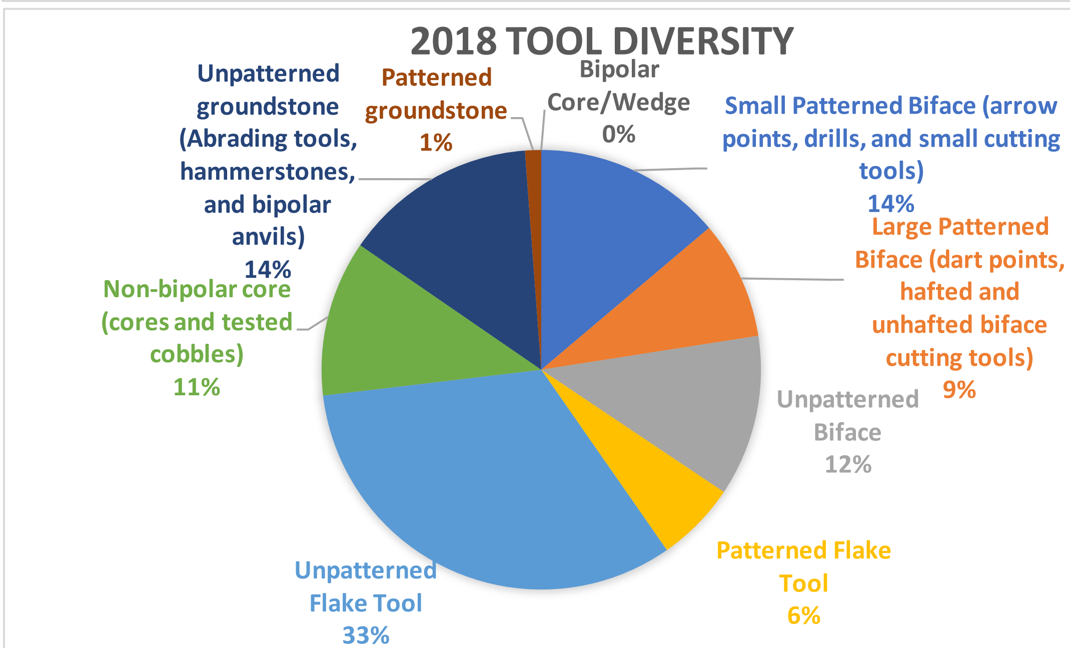


Figure 5.19: The tool diversity of both excavation seasons.

Although the percentages are similar, the tools from each season were combined and the evenness index was calculated (Andrefsky 1994). The evenness index equation is as follows:

$$E = \frac{\left(\frac{n_i}{n}\right)\left(log\,\frac{n_i}{n}\right)}{log_s}$$

With: n_i = the number of artifacts for each type

n = the number of artifacts for all types

s = the number of artifact types.

After the calculation is completed, the absolute value of the answer is taken to result in the index value. The index ranges from 1.0 to 0.0, with 1.0 meaning that all types are equally represented in the population and 0.0 meaning that more tools are represented than others (Andrefsky 1994). The evenness index for the Magic Mountain site is 0.199. This number is closer to zero and would imply that the Magic Mountain site has less tool diversity and was likely used as a place to exploit the immediate environment.

The frequency of local raw material types and the tool diversity imply that the site was used as an area for immediate exploitation. The people would then move on to another area once the environment was depleted. The raw material types at the site indicated that the people were moving on a more local level because of the high frequency of local materials present. However, people likely moved after the short-term utilization of the site, as indicated by the tool diversity. To summarize, the people at the Magic Mountain site likely used the site seasonally and then moved on once the environment was depleted. The seasonal aspects of the migration are discussed below in the GIS analysis.

GIS Analysis

Three types of GIS analysis were used to study the landscape at the Magic Mountain site in more detail. Unfortunately, the Magic Mountain site is surrounded by modern buildings and the landscape had been changed too much to convey useful information from viewshed analysis. The Hillshade and Solar Radiation analyses, however, were completed on a much smaller scale and therefore can be further analyzed.

The Hillshade and Solar Radiation analyses, which shows the amount of shade and sun exposure, respectively, was completed with a habitation point taken from the Centennial excavations in the 1990s (Figures 5.20 and 5.21). The Centennial excavations unearthed a potential habitation structure that was found near the southeast corner of the hogback. These types of analyses are important for understanding how the landscape was used during the prehistoric times. For example, studying the hill shade and the sun exposure shows how inhabitable the Magic Mountain site would be during certain times of the year.

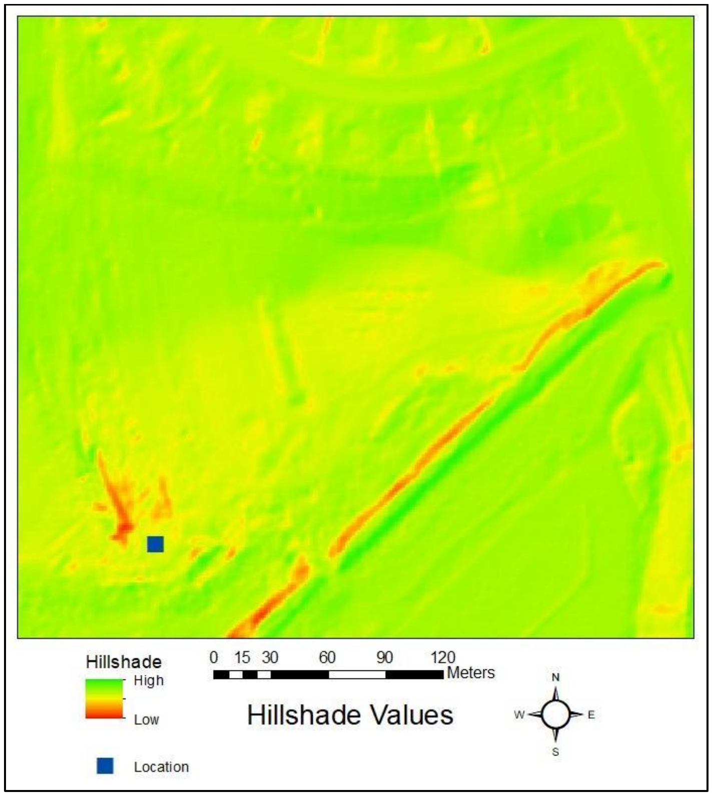


Figure 5.20: Hillshade map of Magic Mountain Site.

The Hillshade analysis shows that there are lower values, meaning more shade, at the location of the possible habitation structure (Figure 5.20). The hogback would have created shade from the sun in this area, though not an extensive amount. Previous botanical analysis completed at the magic mountain site shows that there were some trees (i.e.- firs, junipers, shrubbery) that could have been useful for shade but their density and exact proximity is unknown (Kalasz and Shields 1997). Because the area surrounding the Magic Mountain site has been modified by modern builds and the location of Apex Gulch has changed over time, the ground surface is higher in elevation by at least two meters than it would have been during the Archaic time period. This means that the hogback would likely have created more shade prior to 1400 B.P., making the site more agreeable to habitation.

The Solar Radiation analysis shows that the Magic Mountain site has medium to high solar radiation values, meaning that this area would have likely been hot during prehistoric times (Figure 5.21). With little shade and high amounts of heat, this camp would likely have been used during seasons like Fall and Spring where the temperatures would have been lower.

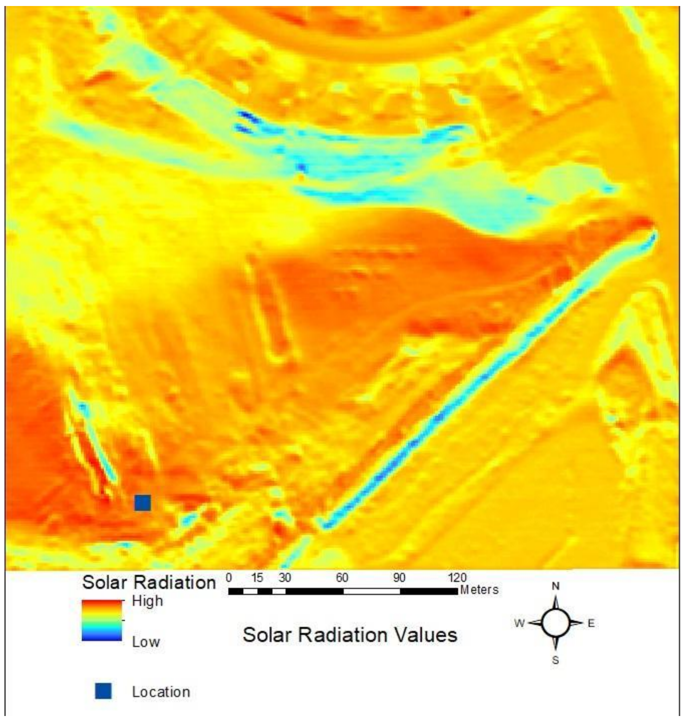


Figure 5.21: Solar Radiation model of Magic Mountain.

Summary

Altogether, there are two Apex River channels, a colluvial apron, and a cumulic A soil horizon located at the Magic Mountain site. Prior to the river channels forming, the site showed evidence of stability because of the buried soil horizon that would have existed between 7955-6045 B.P. Between 6000 and 3500 B.P., one channel cut through the landscape across the site, a high energy event caused that channel to fill, and another channel formed at a slightly higher elevation. As the river channels cut through the landscape, the colluvial apron became the place of habitation for the people who utilized the Magic Mountain site. This is shown through the numerous cultural features found during the recent excavations. Then around 1400 B.P, the landscape became stable enough to begin forming the soils that exist today at the site. The cumulic A soil horizon, which began forming around the same time, indicates that the landscape was stable while the Apex River lightly flowed. Because of the flow of the river was less tumultuous, the people likely moved closer to the stream. Many of the Early Ceramic features and artifacts were found within the cumulic A soil horizon.

The geology of the Magic Mountain site shows that the people likely visited periodically over a long period of time rather than occupying the area consistently. The anthropogenic features found at the site were hearths, which is not an indication of long-term habitation. However, the raw material types of the lithic assemblage indicate that much of the raw materials were sourced locally. The tool diversity indicates that the primary tools used were unpatterned ground stone and unpatterned flake tools. Unpatterned tools indicate at they were used quickly and likely for a short period of time before they became refuse. This suggests that the people exploited the immediate environment and then moved on to other areas when the resources diminished.

The GIS data suggests that the site would have had excellent conditions for habitation during the spring or fall. The hill shade and solar radiation analysis shows that the landscape itself did not create a large amount of shade for people to utilize and that the site would have been too hot to inhabit during the summer. The river would have been great to utilize in the fall and spring because of snow melt from the mountains.

Therefore, I hypothesize that the Magic Mountain site was used annually as a seasonal open camp likely utilized in a migration pattern between the plains and mountains when the temperatures were lower.

Chapter 6: Interpretations

Introduction

The landscape features, anthropogenic features, and the artifacts found at the Magic Mountain site were analyzed and interpreted to better understand how the people interacted with the landscape. Answering larger questions regarding site usage and seasonal migration patterns of peoples within the area.

A combination of theories about hunter-gatherers, forager-collector models, persistent places, and seasonal migration rounds helps explain the people who inhabited the Magic Mountain site, on both a site specific and a region-specific scale, and are explored below. I propose the habitation and migratory pattern of the Late Archaic and Early Ceramic period at the Magic Mountain site was periodic, but consistent, proximal visitation schedule within a migration pattern where people would inhabit the site during the fall and/or spring every year until resources were depleted.

Summary of Findings

The aim of this thesis was to study the prehistoric landscape at the site to better understand the people inhabiting the area during the Late Archaic and Early Ceramic time periods. I hypothesized that the site was a camp used during the fall/spring as part of an annual migration that took place between the mountains and plains. More specifically, this site was revisited over a long period of time because the environment had an abundance of resources and a stream that was constantly flowing. Overall, the geophysical data showed that there was the Apex Gulch River channel that likely had one-to-two high energy flow events, which caused the channel to change slightly over time. Around the time of these high energy events, people inhabited the colluvial apron, which would have been a high ground compared to the level of the channel. After the high energy events, the flow of the river channel tended to be lighter. This is evident through the cumulic A soil horizon, which formed because sediments slowly accumulated as soils began to form. The artifacts and radiocarbon dates taken from the site show that it was mainly inhabited during the Late Archaic and Early Ceramic time periods, which is around the time the cumulic A soil horizon was forming.

I suggest the Magic Mountain site would have been inhabited during the fall/spring because these would have been times when the environment was more temperate. The GIS models of hill shade and solar radiation show that the temperatures would have been extremely hot during the summer. The hogback casts little shade, making the area completely reliant on vegetation shade, which is not ideal during the hotter months. This landscape analysis shows that the site was likely a steppingstone between the plains and the mountains during the annual migrations hypothesized to take place.

Artifacts found at the site shows that unpatterned tools were extremely common, suggesting that these tools were used once or twice and then discarded. This may be the case because the site had local quarries that are located nearby. A high number of the lithic debitage flakes and the tools found at the site were made from these local raw materials. These materials include local quartzites and Parker petrified wood. Very little exotic materials were found during excavation and included materials like obsidian and Kremmling chert. These findings suggest that the people were using the local materials rather than bringing them from much farther away. So, while the lack of habitation structures suggests that the site was likely an open camp utilized only during the spring and/or fall, the materials suggest that the migration pattern likely was not as geographically large as previously thought.

Altogether, there are multiple theoretical frameworks that help explain these findings that were uncovered during recent excavations. These include the *Up-Down System* from Benedict (1992), the forager collector model from Binford 1980, and the theory of persistent places from Schlanger (1992).

Discussion of Migrations, Mobility, and Site Function

Benedict discussed the Magic Mountain site as part of a larger annual prehistoric migration system where people would come to exploit resources and then leave once these resources were depleted (Benedict 1992). The first *Up-Down System* suggested that prehistoric peoples migrated between high-altitude and low-altitude areas, where they migrated from mountain hunting camps in the summer to Front Range winter base camps. This corresponds with the migration of large herbivores. Alternatively, there is also the *Rotary System* where the populations travelled larger geographical distances throughout Colorado. This system runs from the foothills in the winter to North Park in the spring to Middle Park in the summer, and then back to the foothills. This system, in theory, would show more diversity in the raw material types seen at sites within the migration pattern because these materials were carried along and were sourced from farther away places.

However, a larger percentage of raw material types found during the recent excavations were considered local materials for the area, indicating a more geographically restricted migration pattern.

It is important to discuss the raw lithic materials in conjunction with Benedict's theoretical framework. A small percentage of exotic materials make-up the raw material lithic assemblage at the Magic Mountain site. Many of the materials found can be located to modern day Parker, Colorado (Parker Petrified Wood), Green Mountain, and North Table Mountain (Kalasz and Shields 1997). According to Binford (1980) and Benedict (1992), in theory, a highly mobile group of people would likely have a diverse raw material type assemblage because these materials would be brought along as people migrated. Although there is a diverse amount of material types in the Magic Mountain assemblage, there is a high amount of local materials present.

The fact that the lithic raw material types are local is an interesting data set for this thesis. While the site shows signs of utilization over a long period of time, the geophysics suggests that this habitation was not continuous. Although they were found at the site, exotic raw materials were found in less than one percent of the recent assemblage, indicating a small amount of far travel or trade. In this case, the materials are dominated by Parker Petrified Wood, which is roughly 30-miles away from the Magic Mountain site. Benedict's theory of the *Up- Down* System, where people move between high altitudes and low altitudes, seems more highly likely. The fact that there are some exotic materials in the assemblage suggests that there is some movement or migration of people during the Late Archaic and Early Ceramic time periods.

The tool diversity at the site was studied using the evenness index, discussed by Andrefsky (1998). On a scale of zero to one, with zero being homogenous and one being highly diverse, the evenness index for the site scored a 0.199, meaning that the site is on the less diverse end of the scale. Although there were a large number of types of tools represented, unpatterned tools were more prominent within the assemblage. This correlates with the theoretical framework that was discussed by Binford in the Forager-Collector model (1980). The Forager-Collector model is a spectrum, and it has been discussed that the sites prehistoric people inhabit will not firmly fall on either end of the spectrum. The Magic Mountain site has characteristics of both foraging and collecting. The site has a low tool diversity, meaning unpatterned tools have a higher frequency, but many different types of tools are still represented. Although a low tool diversity suggests that the site was used on the collecting end of the spectrum, the tools that are highly represented are unpatterned. With the collecting model, these tools would be highly refined and used for specific purposes. The unpatterned tools suggest a certain level of expediency, where the tools were used quickly and then discarded. This characteristic aligns more along the foraging end of the spectrum. Altogether the site was used for a full range of activities until the resources in the area were depleted, then the people would have moved on to other areas, suggesting a forager technique.

Binford's theory of the forager-collector model helps explain the site function of Magic Mountain and its place among the greater prehistoric peoples. The site does not exhibit many aspects of sedentism in the recent excavation seasons. The Centennial Archaeology excavations suggested that the Magic Mountain site exhibits a lower level of sedentism and emulates more of a forager society rather than a collector society (Kalasz and Shields 1997). These excavations unearthed a pithouse structure, where size and complexity directly correlate with sedentism. At Magic Mountain, the small size and the massive rock wall segment suggested that this was more of a short-term shelter. This is compounded by the fact that there are no storage cysts and the hearth features do not exhibit a high degree of manufacture. It is hypothesized that the longer a group of people inhabit an area, the more prevalent storage cysts become for the storage of goods. The same thinking applies to hearth features that may have a higher degree of manufacture, meaning more construction integrity. This degree of sedentism is still hypothesized for the recent excavations because only hearth structures were found.

It was hypothesized that the Magic Mountain site was closer to the forager end of the spectrum rather than the collector (Kalasz and Shields 1997). This is because the forager system is more highly mobile, with the main residential base being the place where subsistence, manufacturing, processing, and maintenance activities are completed (Binford 1980; Kalasz and Shields 1997). Unpatterned tools are more prevalent than others and there is also a low frequency of exotic materials. Although these findings fall more on the collector end of the spectrum, there is still evidence of annual habitation and migration through the lack of manufactured features, the use of expedient tools, and the raw materials coming from within a 30-mile radius.

Discussion of Persistent Places

The recent excavations also warrant new theoretical frameworks to be discussed in relation to this site. This includes the idea of persistent places, as originally described by Sarah Schlanger in 1992. Schlanger explains that persistent places are when a site is occupied or revisited multiple times in a region that has long occupation periods (Schlanger 1992). These sites have characteristics that include a significant quality/s that would deserve revisitation for specific activities, features that people would return to use, and a dependence on nearby cultural materials or exploitable resources (Schlanger 1992; Moore and Thompson 2021; Shaw et al 2016). Examples of this would include revisiting landscapes where there was fruitful hunting and fishing previously and places where food or cultural materials were stored for later use.

With persistent places, sites may not be continuously inhabited but are also not abandoned because people may return to the area for a short-term purpose (Schlanger 1992; Moore and Thompson 2021). It is also not necessary for a place to be part of a built environment, Schlanger explains that small material culture artifacts, lithics for example, can be included as well. This is relevant to the Magic Mountain site because there is a substantial number of lithic artifacts but no features part of the built environment that would qualify.

For the recent excavations, the geophysical research conducted at the site is extremely important to help clarify previous findings at the site including the geological environment and the anthropogenic habitations. Understanding the geological environment at the site gives information on the reason the environment was a desirable place to live and how sustainable the living habits were of prehistoric peoples.

As a reiteration from Chapter 4, a recreation of the geological environment is important to the analysis of the prehistoric peoples that inhabited Magic Mountain. The alluvial fan where the site is located shows cyclic energy events through the differences deposition and location of sediments. This suggests that the environment would have been a relatively unstable landscape in the sense that its stability was unpredictable and erratic (Kalasz and Shields 1997). McFaul's explanation insinuates that although water energy events are happening frequently, these events affect areas differently and with different severities. This means that the Magic Mountain site, although affected by fluvial energy events occasionally and of varying degrees of severity, was not affected by every event located within the site. This would allow soils to form to a certain degree.

To summarize the findings within the geophysical data, soils began forming at the site 6340-6045 B.P, forming the colluvial apron that people inhabited during the Archaic period. During the Archaic and Early Ceramic periods, the Apex River system flowed through site and created at least two river channels because of degradation and aggradation events. During the Early Ceramic period, the Apex River system became more stable and formed a cumulic A soil horizon.

The Apex River system, which runs through the site, likely had high energy events that carried in river cobbles and other sediments that would cause cut-and -fill sequences across the landscape within the site boundary. The cyclic nature of the river system is also what likely caused the soils to form, which shows stability of the landscape (Kalasz and Shields 1997). The washing away and depositing of sediments during these times would make it less likely for people to utilize this area. However, during the times of stability, people utilized this area.

Sometime prior to 1400 B.P., the first noticeable gulch channel began forming through the site. There was a fill sequence that began around 1400 B.P. which formed the cumulic A soil horizon in the prehistoric floodplain. It was during this process that the other gulch channel that is located less than a meter north of the previous began forming as part of the braided river system (Kalasz and Shields 1997; Waters 1992). It was during this time that humans utilized this area of the Magic Mountain site, which is evident through the discovery of anthropogenic features. The gulch channels brought in sediments from upstream and were deposited to the east in the downslope area of the site. This is what formed the prehistoric floodplain, as shown through the cumulic A formation. The Apex Gulch River channel finally moved to its present-day location following its redirection for the construction of Heritage Square in the historic times (Kalasz and Shields 1997). From this point forward, colluvium is found as the primary energy event at the site. The stability of the landscape in conjunction with the nearby water source shows that this was an excellent place for environment utilization.

The first line of evidence that shows that the Magic Mountain site was likely part of a place that was visited occasionally, but consistently, throughout the Late Archaic and Early Ceramic time periods is the fact that the environment was stable enough to form soils but unpredictable enough to have high energy fluvial events. It is highly likely that the Magic Mountain site was utilized when possible, for example, inhabiting the site when the landscape was stable but moving on to another in the area when it was washed out. When Magic Mountain was utilized, people would inhabit the site for as long as possible before the resources were depleted, then they would migrate again elsewhere.

The Magic Mountain site would have been a place to find ample resources, especially during the Late Archaic/Early Ceramic time periods. The GIS models show that the site would have been difficult to live at during the summer months because of the high heat and lack of consistent shade. However, the snow melt during the spring would have been an ample place to find water. It is likely that the site was utilized when following herds of animals between the mountains and the plains.

In theory, this would make Magic Mountain a persistent place if it were part of a series of sites that were visited during a migration pattern. Because there is no evidence of storage cysts or lasting architecture, it is unlikely that this place was inhabited frequently or for long periods of time. There is, however, a large amount of lithic debitage and tools that are evident at the site. This can be explained by through Benedict's theory where sites were visited annually. The Magic Mountain site, being near a river system, was likely a persistent place because of the number of natural resources nearby. If this site was visited annually and the site was relatively stable throughout the Late Archaic and the Early Ceramic, then the high number of artifacts is explainable through the frequency of visitations each year. As people visited the area and completed their necessary daily tasks, artifacts like debitage would were left behind. This would mean that debitage would be deposited as the soils were forming across the site. The amount of debitage is explained by the Magic Mountain site being visited yearly over a long period of time during a migration pattern. The cumulic A soil horizon, which forms more quickly over time, resulted in a relatively even distribution of lithic debitage.

Chapter 7: Conclusion

Key Findings and Research Questions

The aim of this thesis was to study site function and larger migration patterns of the people who utilized the Magic Mountain site between the Archaic and Early Ceramic periods. Although the site has been the subject of academic inquiry since the 1950s, new remote sensing data collection methods were employed, as well as new data from recent excavations analyzed, allowing for a better understanding of the geological environment and the utilization patterns of the people from this period.

I have proposed the habitation and migratory pattern of the Magic Mountain site was a periodic, but consistent, proximal visitation schedule within a migration pattern where people would inhabit the site during the fall and/or spring every year until resources were depleted. This was primarily demonstrated using various methods, including GPR, magnetometry, geophysical mapping, and lithic and geological analyses. Each of these analyses help answer specific questions about the landscape and how it was used by people during these prehistoric times. Geophysical methods were used to map geological deposits as well as anthropogenic features. Data from this analysis confirms the Magic Mountain site was consistently utilized during both the Archaic and Early Ceramic periods. GIS modeling was used to study the solar radiation and hill shade found at the site. Modeling results indicate the site was utilized primarily during the spring and fall, and not the winter or summer. Finally, a lithic analysis was used to study raw material types, to evaluate the migratory pattern of the site, and tool diversity, to analyze how the site was utilized. Data from these analyses suggest populations who inhabited the site likely utilized the site on a short-term basis and migrated within a more proximal 30-mile range.

To research my hypothesis, I completed work to map the geological environment in its entirety to study site function and larger migration patterns. The key findings include the discovery of the prehistoric floodplain and two Apex Gulch River channels, which were found using geophysical methods. Other methods, such as lithic analysis and GIS models, were used to place the site within larger frameworks like site function and migration patterns. The geophysical methods, GPR and magnetometry, were used to study the geological environment in conjunction with the geomorphology of the site. The ground-penetrating radar showed evidence of two Apex Gulch channels that would have been part of cut-and-fill sequences during the Late Archaic/ Early Ceramic time periods. Around 1400 B.P., the first channel cut through the site and began depositing sediments at a high rate, creating a cumulic A soil horizon. Sometime later, a high energy event caused a cut-and-fill sequence that created another Apex Gulch channel. It was during these sequences that humans inhabited the site.

The ground-penetrating radar was an excellent method to map the geological environment, especially with discerning the Apex River channels. The magnetometry was used to study the anthropogenic features, all hearths, and the cumulic A soil horizon. These two methods were linked to geomorphology data that were collected during the two excavation seasons. It was possible to map the prehistoric Apex River channels and the prehistoric floodplain to their fullest extent because the of geophysical data.

The lithic analysis and the GIS models were used to study site function and larger migration patterns. The lithic analysis showed that the lithic assemblage is mainly comprised of local materials at the site, with a small percentage of exotic materials. This indicates that although the people at the Magic Mountain site spent a lot of time within a certain proximal radius, the presence of exotic materials still show larger cultural relationships through travel and trade. Although the evenness index shows that unpatterned flakes tools were in abundance, there is still a high number of different tools found at the site. This indicated that the site falls closer to the forager end of the spectrum within the forager-collector model. Binford theorized that higher tool diversity that is generalized indicates that the site was likely part of a residential camp that foraged. Although the site fell along the foraging end of the spectrum, foraging and collecting is not dichotomous.

The GIS models were used to study the characteristics that made the Magic Mountain site inhabitable. Hillshade and Solar Radiation are two models that were used in this thesis. The Hillshade modeling showed that the Magic Mountain site has a lack of shade, and the Solar Radiation model shows that the temperature would have been too high to comfortably live during the warmer months. Because during the Late Archaic and Early Ceramic time periods show that the climate was drier, an emphasis would have been placed on water and therefore, the cooler months with water flow in Apex River system would have been ideal conditions for habitation.

Contributions, Limitations, and Recommendations for Future Work

The Magic Mountain site has been a subject of intensive study since the 1950s because of its vast lithic assemblage and potential for future study. The lithic assemblage, which has been evident across all excavations that have taken place, is some of the most extensive collections that have been found in the area. Although the site has been extensively studied, the recent excavations have thoroughly excavated the site to gain a clearer picture of the prehistoric environment.

This thesis contributes to the recent studies through the addition of geophysical methods. Ground-penetrating radar and magnetometry, in conjunction with the geomorphology data, were used to rebuild the site geologically without complete ground-breaking intrusion. With these methods, I was able to map two prehistoric Apex Gulch channels and the floodplain that formed during the Late Archaic/ Early Ceramic time periods. These findings show that the Apex River system was a prominent feature along the landscape when humans inhabited the area. Minor methods that were used in this study, lithic analysis, and GIS models, helped bolster and solidify that the environment was hostile enough for humans to migrate to other places in search of more resources.

There is still more research potential for this site in the future. On the eastern side of the hogback, there are three areas of interest that were found in the GPR data that are worth exploring given the similarities to other heart/hearth refuse features. Although the Harvard excavation locations have been lost over time, it is hypothesized that this study took place on the western side of the hogback. Due to time constraints, this area was not excavated. There is ground-penetrating radar data for this area. Even though this data was collected and analyzed, it was not used in this thesis. There is a potential to add to the archaeological and geological record further upon exploration of this area. A report regarding this information can be found in Appendix B.

While this research focused on the theory of persistent places the aspect of natural resources and the environment, this theory can also be correlated with other important characteristics. In previous research, it was noted that burials were discovered and that there was a potential for architectural features. These burials and features would emphasize religious and cultural aspects that also very deeply align with the persistent places theory. These aspects would be an excellent avenue for further research.

Other than the time constraint for the excavations, another includes some of the excavation techniques that were employed. The site was excavated in 10 cm increments, rather than by stratigraphy. Although chronology data can be re-created, it is more difficult to infer data about the flakes and their material types in regards to their specific age date. The excavation technique, however, was still an excellent way to complete the data recovery because the crew was primarily comprised of students and volunteers with little experience in excavating by stratigraphy.

Another limitation in regards to the lithic analysis includes the observer effect. Two groups of four interns over the course of two years completed the lithic and tool analysis at DMNS. Trainings were given in the identification of material types and tool types, however, the interpretation of these materials could vary depending on the person completing the analysis. The tool data was thoroughly checked over by PCRG once an initial analysis was completed by the interns, so there is less chance of observer effect than with the material type observations.

The Magic Mountain site is an excellent example of a Late Archaic and Early Ceramic habitation site. There is ample material within the artifact assemblage to study and the site is easily accessible in modern times. This site still has a lot of research potential to add to the archaeological record of the Colorado Front Range.

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Appendix A

Evenness Index

Technological Class		Archaeol-ogy log		
	Expected	percent	natural log	Final
Small Patterned Biface (arrow points, drills, and small cutting tools)	52	0.113537	-2.175625	-0.02745
Large Patterned Biface (dart points, hafted and unhafted biface cutting tools)	33	0.072052	-2.630362	-0.02106
Unpatterned Biface	54	0.117904	-2.137885	-0.02801
Patterned Flake Tool	20	0.043668	-3.131137	-0.01519
Unpatterned Flake Tool	155	0.338428	-1.083444	-0.04074
Non-bipolar core (cores and tested cobbles)	45	0.098253	-2.320207	-0.02533
Unpatterned ground stone (Abrading tools, hammerstones, and bipolar anvils)	95	0.207424	-1.572992	-0.03625
Patterned ground stone	3	0.00655	-5.028257	-0.00366
Bipolar Core/Wedge	1	0.002183	-6.126869	-0.00149
				-0.19917
				0.199

Appendix B

Further analysis

Grid 4, which is west of the hogback at the site, was not initially analyzed using the GPR data. This area is likely the location of the Harvard Excavations in the 1950s. Unfortunately, due to time constraints, this area was also not studied during the 2017/2018 excavations. This data is included in the analysis of the grids that were collected by the University of Denver, GPR group.

Grid 4 GPR analysis

Grid 4 was collected by Lawrence Conyers during the summer of 2016. This was the only grid that was not analyzed in depth before the excavations took place in the summer of 2017. These data were collected on the western side of the hogback, directly north of Apex Gulch. This grid was collected to search for anthropogenic features of the Late Archaic/ Early Ceramic period (DMNS and PCRG 2017 and 2018). This grid, however, was also collected to search for the Harvard excavations that took place in 1959. The datum for these excavations were lost over time so the GPR was used to relocate the general area where the excavation units were placed (Kalasz and Shields 1997). This area to the west of the hogback was not explored during the 2017-2018 excavations because of the time constraints. It is important to analyze this grid for future study. Figure 1 displays a GPR slice of the grid that includes the important marked reflections that were evident in the GPR profiles

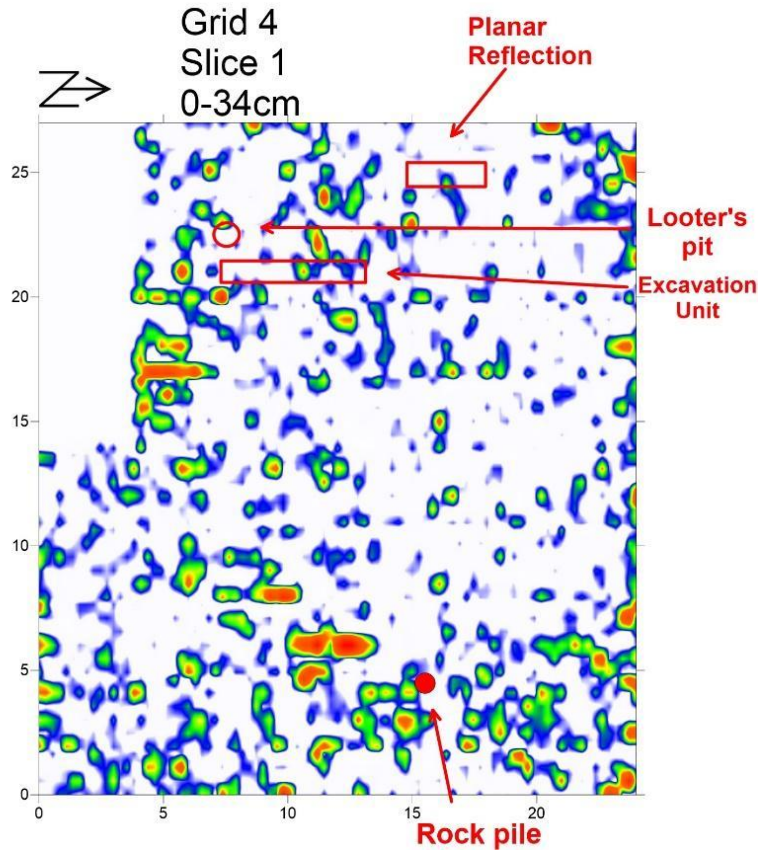

Figure 1: A GPR slice of Grid 4.

There are a few important reflections that are noticeable within the grid 4 data, which include both historic and prehistoric features. Two of the features found look to potentially be part of an excavation unit from the Harvard Excavations in 1959 with Cynthia Irwin-Williams and Henry Irwin. Along with this, there also is a looters pit located just west of the unit (Kalasz and Shields 1997). The prehistoric features include a planar reflection, which is likely a compacted surface like a buried soil horizon, and a cluster of hyperbolic reflections that is a rock pile or hearth. These two features should be studied further in the future to verify these hypotheses. The hypothesized reflections related to the Harvard excavations are marked in Figure 1.

There are prehistoric features found within the data as well. These are evident in the two profiles in Figure 2, which show a cluster of hyperbolic reflections and a planar reflection. Profile 211 shows the cluster of hyperbolic reflections are likely a rock pile or a hearth. The reflection shows such a dense cluster of hyperbolic reflections that each reflection is not discernable from another. These clusters are commonly found across site through excavation and has been either hearths or refuse from hearths (e.g.- rock piles). These features are anthropogenic and prehistoric in origin (Kalasz and Shields 1997).

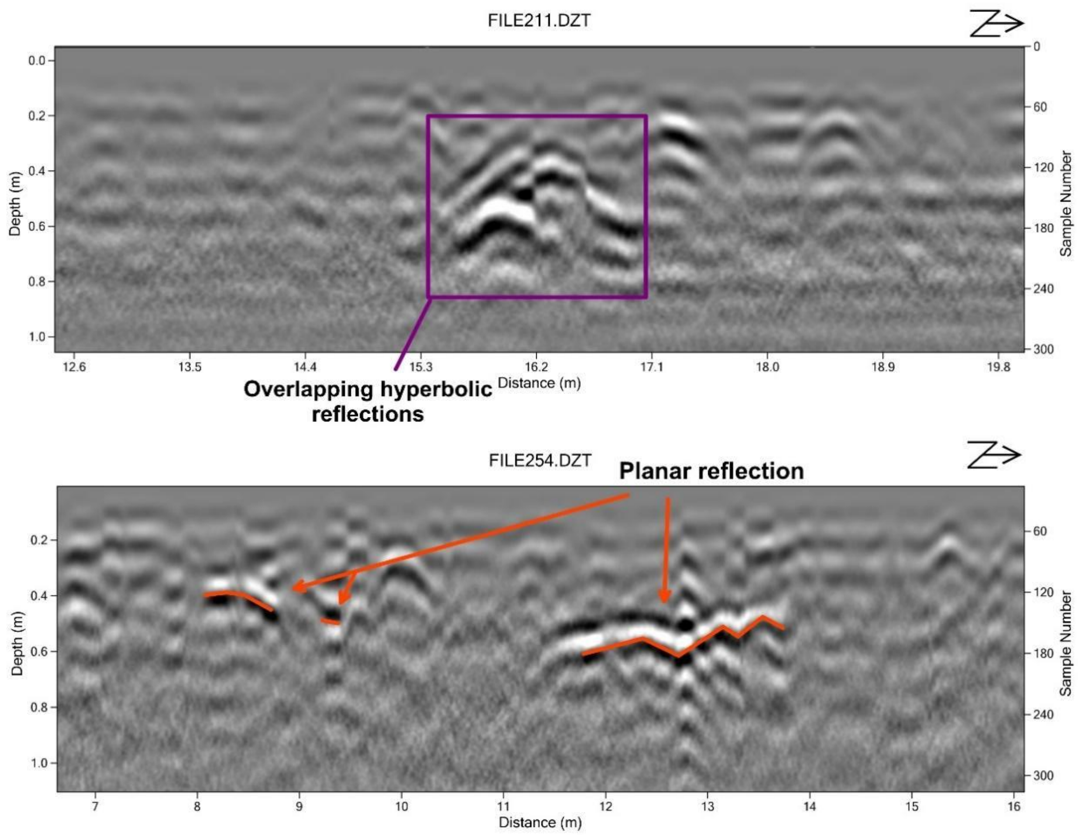

Figure 2: Examples of the prehistoric features found in grid 4.

Figure 2, profile 254 shows the planar reflection found in grid 4. This is hypothesized to be prehistoric because similar reflections have been found on the eastern side of the hogback. It is hypothesized that the planar reflections found on the east side of the hogback in Grid 7 is likely a buried A soil horizon or some other compacted surface from the late Archaic/Early Ceramic time periods because of the artifacts and hearths/rock piles that were found in the same proximity. The planar reflection in Grid 4 can also be a soil horizon or a compacted prehistoric surface.

Both prehistoric features found in Grid 4 look similarly to other features found using the geophysical data and excavations. Meanwhile the historic features related to looting and excavations also look similarly to other features found across the site. Grid 4 was analyzed to facilitate future study in this area because the 2017-2018 excavations were unable to study them.