FINAL
Archaeological Assessment of Lithophones of Great Sand Dunes National Park and Preserve and the San Luis Valley, Colorado

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VOLUME 1 OF 2: TEXT AND APPENDIX A

1944

1952

Dedicated to the memory of:

Robert Milton Armagast (1914-2005)
Julie Woodring Armagast (1920-2005)
David Woodring Armagast (1950-2016)

To my parents, Bob and Judy Armagast, who taught me from a young age to love music, history, archaeology, and nature. They always supported and encouraged me in my career as an archaeologist to never be afraid of asking hard questions, to think outside of the box, and enjoy searching for answers to the many mysteries of the past. To my brother, David Armagast, who also loved music, history, archaeology, photography, and the outdoors, and was so interested in the concept of lithophones. I miss all of you and I thank you for being an important part of my life!

ACKNOWLEDGMENTS

Many thanks are extended to the Friends of the Dunes, especially Lucy Adams, and also Lynne Young and the other dedicated members, for their support of this project. Fred Bunch, Lisa Carrico, Andrew Valdez, and Phyllis Bovin of Great Sand Dunes National Park and Preserve (GRSA) also deserve special thanks for their support of this research. Fred Bunch, Resource Manager, deserves special gratitude for his unending support for cultural resources at the park and in the San Luis Valley (SLV) over many decades.

I also would like to extend my appreciation to a number of other individuals and colleagues who have supported this work in a variety of ways, such as lending artifacts and sharing their knowledge of archaeology of the San Luis Valley: Louise Colville, Rio Grande County Museum; Angie Krall and Marcy Reiser, Rio Grande National Forest; Lowell Evans, Marvin Goad, and Brian Fredericks, Bureau of Land Management; Dr. Adrienne Anderson, retired National Park Service; Bridget Ambler, Canyons of the Ancients National Monument & Anasazi Heritage Center; Carol Beam, Boulder County Parks and Open Space; Ronald Brooks, School of Music, University of Northern Colorado; and colleagues Kelly Pool, Jon Horn, Dr. William Butler, Dr. Charlie Haecker, Dr. Emily Brown, Greg Williams, and David Killam; Martorano family members (Sal, Megan and Andrea); Jim Avery and Zachery Bergen; and local SLV residents Ken Frye, Lyn Bogle, Candye Dawson, Bob and Judy Bunker, Brian Blasi, Kevin DesPlanques, Jo Crow Bowers, David Montgomery, Jeff Shook, and Barbara Kruse.

Finally, this project would not have been possible without the financial support of the History Colorado State Historical Fund (SHF), and the efforts of the SHF staff, especially Katie Arntzen. Also, the support of the History Colorado Office of Archaeology and Historic Preservation staff, including Holly Norton, Kevin Black (retired), Todd McMahon, Chris Johnston, Sheila Goff, and Mary Sullivan is appreciated.

LIST OF ACRONYMS

BP	Before Present
CCPA	Colorado Council of Professional Archaeologists
cm	centimeters
FCR	Fire-cracked rock
FTIR	Fourier-Transform Infrared Spectroscopy
gm	gram
GRSA	Great Sand Dunes National Park and Preserve
Hz	hertz
lb	Pound
M.Y.	million years ago
NPS	National Park Service
oz	ounce
PRI	PaleoResearch Institute
SHF	State Historical Fund
SLV	San Luis Valley
USGS	United States Geological Survey

ABSTRACT

A new class of prehistoric artifacts called portable *lithophones* has been identified from Great Sand Dunes National Park and Preserve and in private collections from the San Luis Valley (SLV) Colorado. "Litho" is Greek for stone and "phone" means sound; a lithophone is a musical instrument consisting of a purposely-selected rock (often formally-shaped) that is tapped or rubbed with friction to produce musical notes. Portable and stationary lithophones have been utilized in ancient and modern cultures around the world, including Europe, the Far East, Africa, the South Seas, and South America. Only a few portable lithophones have been formally recognized in North America and none have been previously documented in Colorado.

Many of the artifacts from the SLV were originally thought to have functioned as utilitarian ground stone artifacts such as manos, pestles, and digging tools; however, testing has verified their acoustical properties. A sample of 22 lithophones was analyzed for the Friends of the Dunes as part of State Historical Fund Archaeological Assessment Grant # 2016-AS-006. The acoustical properties (notes played and sound qualities) and physical characteristics of the lithophones (diameter, length, width, shape, usewear, manufacturing technique, and potential material type), have been documented. The sample lithophones produce sounds similar to striking a marimba, xylophone, glass crystal or metal bell when tapped or rubbed with friction. These artifacts exhibit dual sound planes (produce two notes), and some produce multiple notes. It is believed that other potential lithophones could exist in archaeological contexts or in museum collections but may not have been recognized for their acoustical properties. Recommendations for future research regarding this unique artifact type are included in this report.

Music in the soul can be heard by the universe.
Lao Tzu

Music is a higher revelation than all wisdom and philosophy.
Ludwig van Beethoven

Music is a moral law. It gives soul to the universe, wings to the mind, flight to the imagination, and charm and gaiety to life and to everything.
Plato

I think music in itself is healing. It's an explosive expression of humanity. It's something we are all touched by. No matter what culture we're from, everyone loves music.
Billy Joel

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- 3 - A list and brief description of lithophones from around the world; http://www.lithophones.com/index.php?id=2, (accessed 12/5/2017)

Separately Bound (Volume 2):
Appendix B: Detailed physical descriptions and photographs of each lithophone

Appendix C: XRF analysis results (PaleoResearch Institute)

Appendix D: Acoustical properties descriptions and photographs of each lithophone

On Jump Drive:
Appendix E: Electronic files of the acoustical analysis of the sample artifacts including videos and photographs (plus all text files and Appendices A-D)

INTRODUCTION

PROJECT BACKGROUND

Many years ago, a number of very interesting and unique artifacts were identified in the Great Sand Dunes National Park and Preserve (Great Sand Dunes) museum collections and in private collections throughout the SLV, Colorado (Figure 1). The artifacts are long, carefully shaped, and made from stone. Some have been referred to in writing or labeled in museum collections or displays as pestles, roller manos, digging tools, hide-working tools, or simply ground stone.

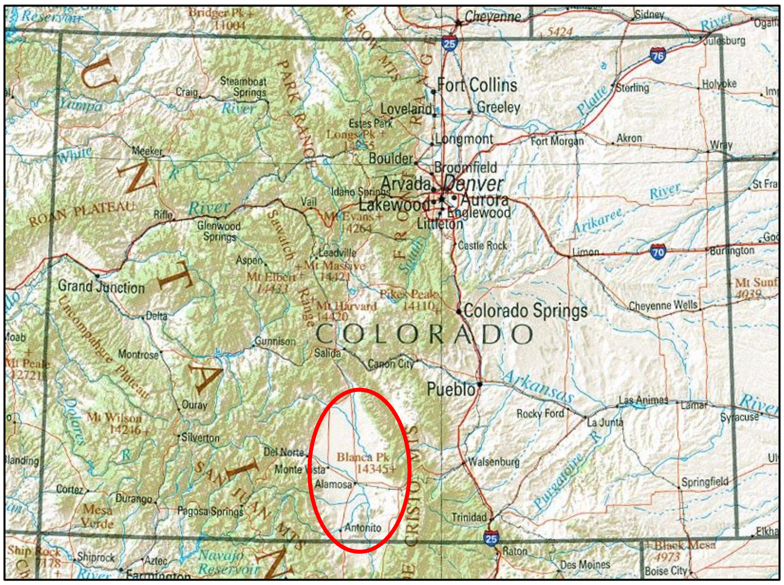


Figure 1. Map of Colorado showing the location of the SLV.

Two very cursory studies of these artifacts were conducted in 2005 and 2008 because it was thought that some may have been used as pestles or other grinding types of tools (Rhodes 2005 and Dominguez 2008). Pestles are tools that were utilized to pulverize, grind and crush a variety of materials. Some pestles were utilized to crush or pound substances using the weight of the pestle, and others were likely used in circular or reciprocal movements (Adams 2014:143-145). Pestles could have been used on a flattened stone or in a stone basin/mortar. Other pestles may have been used in wooden mortars. After examination of the sample artifacts, it was not clear why many of them did not exhibit significant use-wear similar to those known to have been utilized as pestles (Adams 2014:143-147). Also problematic was why some specimens were so long, heavy, and very carefully-shaped for a simple utilitarian purpose. As a result of these unanswered questions, the function of this unusual artifact class remained unclear and the artifacts were placed back in the museum collections.

The possible function of some of these ground stone artifacts remained a mystery until very recently when a colleague, Mr. David Killam, shared a Youtube video with Ms. Martorano that described the work of a French researcher, Erik Gonthier who works at the Museum of Man in Paris, France. Gonthier's research on long, cylindrical, stone artifacts collected from Africa by French soldiers in the early 1900s confirmed that certain specimens had acoustical properties (Gonthier 2005, 2009, and 2012; Gonthier, Gonthier and Zivcovic 2010; Gonthier and Quang Hai 2011). Gonthier determined that these acoustically-active artifacts were very likely utilized as portable **lithophones**, a musical instrument consisting of purposely-shaped rock artifacts that are struck to produce musical notes (Figure 2).

Figure 2. Erik Gonthier playing lithophones from Africa at the Museum of Man, Paris.
https://i.pinimg.com/originals/9f/f4/a0/9ff4a022ca54a0083b8bee4f9613df0f.jpg

A more recent article introducing the concept of lithophones in North America, entitled "A Possible New Class of Prehistoric Musical Instruments from New England: Portable Cylindrical Lithophones," was published by Duncan Caldwell in the journal *American Antiquity* (Caldwell 2013). Caldwell identified two lithophones from New England and discussed their characteristics in comparison to others previously identified by Gonthier. Caldwell suggested that these lithophones could be a new class of artifacts in North America. He also included a list of five physical criteria for recognizing potential portable lithophones: 1) diameter between 4 and 8 centimeters (cm); 2) lengths between 35 and 80 cm, 3) dimensions 4.5 times longer than they are wide; 4) few, if any, signs of being used for vertical grinding or pounding; and 5) the use of such acoustically-active stones as chlorite-schists and schist-actinolites (Caldwell 2013:526).

Caldwell (2013:523) indicated that the lithophones were likely associated with prestige or rituals and were not utilitarian due to their scarcity in comparison to other functional types of artifacts. He stated that only a few potential portable cylindrical lithophones have been identified in North America including the two he describes in New England, one lithophone from Arizona, and a possible one from New Mexico. Some of the cylindrical lithophones from the New England area may be up to several thousand years old, perhaps as old as 8,000 years before present (Caldwell 2013:530).

The lithophone characteristics identified by Gonthier and Caldwell, as well as those found around the world (Appendix A and http://www.lithophones.com/index.php?id=2), were compared to some of the stone artifacts from the Great Sand Dunes and SLV. The findings suggested that at least some of the SLV artifacts may have had a function other than as utilitarian grinding stones. To test this idea, three of the Great Sand Dunes cylindrical stone artifacts were set up on foam blocks and examined for acoustical properties in a similar manner to that conducted by Gonthier. A short video of the sounds produced by the three artifacts in the Great Sand Dunes collection was recorded on an iPhone. The three artifacts that were tested yielded acoustical properties similar to a marimba sound, and they yielded two sound planes (two notes), as described in Caldwell (2013:529). Two additional artifacts on loan from private individuals were also tested. These two artifacts had definite acoustical properties (ringing) and each played two different notes. The results of the initial testing suggested that other lithophones likely exist in the Great Sand Dunes museum and local private collections.

HISTORY COLORADO STATE HISTORICAL FUND GRANT

The Friends of the Dunes was founded in 1989 as a non-profit citizen's support group for Great Sand Dunes National Park and Preserve. In cooperation with the National Park Service, the Friends provide a forum for citizen involvement in planning decisions, focus public interest on issues and need, and provide volunteer and financial aid for projects beyond the scope of the park's budget. The Friends of the Dunes has benefited the park and its visitors in many different ways: provided balloon-tired wheel chairs for handicapped visitors; supported and managed archaeological and scientific research grants; and supported the Junior Ranger Program, the Ambassadors for Wilderness, and various Park cultural activities/programs.

In 2016, the Friends of the Dunes, Inc. sponsored and received an Archaeological Assessment Grant from History Colorado, Colorado State Historical Fund (SHF) to study the potential lithophones from the SLV. The SHF grant project number is 2016-AS-006. This final report is Deliverable No. 8 and summarizes the work conducted on the lithophones under the SHF grant.

PROJECT GOALS AND PERSONNEL

RESEARCH CONTEXT AND IMPORTANCE OF THE PROJECT

Although lithophones are documented and were utilized in ancient cultures around the world, only a few have been formally documented in all of North America, and no lithophones are described in the archaeological literature in Colorado. Based on previous research on lithophones from Africa and New England (Caldwell 2013), identification and study of additional lithophones is important to expand our current knowledge of prehistoric musical instruments and rituals in the New World. Archaeologists are aware of the multiple uses of stone tools for utilitarian purposes, but the use of these cylindrical stone artifacts for a function that is not simply utilitarian is unique. How, when, and why these artifacts were made and utilized, and why there appear to be so many of them in the San Luis Valley are some of the major research questions yet to be answered. An assessment of the lithophones in the collections at Great Sand Dunes and from private collectors in the SLV has the potential to begin to address these research goals and questions.

The results of this archaeological assessment grant will be an important contribution to our knowledge of how Great Sand Dunes and the surrounding SLV were utilized in prehistoric times, and especially how native peoples utilized their environment for more than just simple survival. This information about a rare and basically unknown type of ancient musical instrument in Colorado, portable lithophones, will be important for sharing with other archaeologists, scientific researchers, and interpreters throughout Colorado as well as all of North America.

GRANT PROJECT PERSONNEL

Lucy Adams, the President of the Friends of the Dunes, is the SHF Grant Recipient/Program Director. **Lynne Young**, is the treasurer of the Friends of the Dunes.

Marilyn Martorano, RPA, Principal Archaeologist of Martorano Consultants LLC, served as the principal investigator for this project. She has over 40 years of experience in cultural resource management and holds an MA in Anthropology from Colorado State University. Ms. Martorano has extensive prior cultural resource experience in the SLV with historic and prehistoric resources. She is the principal author of the prehistoric context for the SLV, Rio Grande Basin, *Colorado Prehistory, A Context for the Rio Grande Basin* (1999). Ms. Martorano has conducted major archaeological research at Great Sand Dunes National Park and Preserve for over 35 years and has documented and evaluated prehistoric and historic sites dating from the Paleoindian to the recent historic period, including Culturally Modified Trees (CMTs), campsites, trails (Old Spanish National Historic Trail), wickiups, stone structures, historic homesteads and townsites, and mining-related resources. She has also intensively researched early Hispano archaeology of the area, an effort with Front Range Research Associates, Inc., which resulted in the listing of the Teofilo and Pedro Trujillo Homesteads as a National Historic Landmark.

Ms. Martorano planned and directed the grant project and conducted the archaeological archival research, collected the lithophone samples, documented and analyzed the physical properties of the potential lithophones, and prepared the archaeological report. She worked closely with Mr. Reid who conducted the music-related investigations.

Jason Reid, percussion instructor, arranger, and composer, served as the project's specialized consultant/analyst. Mr. Reid is currently the Director of Percussion at Silver Creek High School in Longmont and is also the front ensemble Captain Head of the Colorado World Class Division Rise Percussion ensemble. His past experience includes percussion instruction with the Colorado Blue Knights World Percussion Ensemble, the University of Northern Colorado, and Wheat Ridge High School. Mr. Reid has extensive past experience performing, teaching, composing and arranging percussion music. His specialty area of expertise is with front ensemble or pit instruments including marimbas, xylophones, vibraphone, bells, cymbals, keyboard/synthesizer, and various drums. A number of these instruments are similar in general form and sound to lithophones, and Mr. Reid's expertise was vital to the musical analysis of the potential lithophones.

Mr. Reid conducted the lithophone music-specific background archival research, the musical lab evaluations of each lithophone sample artifact, and provided the musical documentation and interpretations for the archaeological report.

PROJECT TASKS AND METHODOLOGY

The following tasks and methodology were defined in the SHF grant:

TASK 1 ARCHIVAL RESEARCH AND LITHOPHONE COLLECTION

- Conduct archival research to gather relevant existing archaeological and musical data on lithophones from North America and around the world.
- Conduct an inventory of current Great Sand Dunes curated and non-curated collections containing ground stone that could be lithophones. Potential lithophones will be selected for testing of their acoustical qualities. Those specimens found to be acoustically-active will be loaned for further analysis. The San Luis Valley Field Office/BLM has also offered to lend a probable lithophone for analysis. Local SLV collectors will be contacted to determine if potential lithophones exist in their respective collections. If acoustically-active specimens are identified from private collections and were found from the general vicinity of the Great Sand Dunes and the SLV, permission will be requested of those collectors to test the artifacts for acoustical properties and to loan their artifacts for use in this study.
- Select a collection of 10 or more acoustically-active artifacts for the archaeological assessment laboratory description and musical analysis.

TASK 2 LAB AND MUSICAL ANALYSIS OF THE LITHOPHONES

- All potential lithophones specimens will be described, photographed, measured, and weighed. The lithic raw material types of each sample will be identified and compared with known lithophones.
- Formal testing of the potential lithophones for acoustical qualities as described in Caldwell (2013:529) will be conducted on each sample artifact. The sounds produced by the acoustical specimens will be analyzed using iAnalyzer Lite software as per Caldwell (2013:529), or a

similar musical software that analyzes musical sounds (decibels, hertz, note). A video of the sound(s) of each acoustically-active artifact will be recorded using professional quality recording equipment. This musical analysis on the acoustically-active specimens will be performed by a percussion specialist, Mr. Jason Reid.

- A macroscopic analysis will be conducted on the acoustically-active artifacts to determine possible manufacturing techniques, as well as potential use-wear from percussors, or from other functional uses such as grinding or pounding.

TASK 3 REPORT PREPARATION

- Prepare an archaeological assessment report that includes the results of the archival research, summarizes the results of the lithophone musical and archaeological analysis, offers recommendations for future studies, and includes suggestions for interpretation of the lithophones to the general public. The final submittals to SHF will include the hard copy report, all digital files including those from iAnalyzer Lite or other musical software, photographs, and video/audio recordings.

LITHOPHONE BACKGROUND DATA

DEFINITION OF LITHOPHONES

Litho is Greek for the word "stone" and *Phone* means "sound" so a lithophone is a musical instrument consisting of a purposely-selected rock (often formally-shaped) that is tapped, struck, or rubbed with friction to produce musical notes.

DATE RANGE OF KNOWN LITHOPHONES

Some documented lithophones in Vietnam (bifacially worked slabs played like a xylophone) are 5,000 to 6,000 years old (Caldwell 2013:522). All of the kiva bells (discussed more in depth below) from the Rio Grande Valley in the southwestern U.S., are associated with pueblos dated to post A.D. 1300 (Brown 2014:65).

PHYSICAL CHARACTERISTICS OF LITHOPHONES FROM AROUND THE WORLD

Lithophones are documented from numerous cultures around the world. A website focused on gathering data on multiple types of lithophones; http://www.lithophones.com/index.php?id=2 lists over 40 countries and contains photographs of lithophones from Europe, the Far East, Africa, the South Seas, and North and South America. Note: this list is not comprehensive and sometimes an entry is the result of a single reference to a use of stone in music-making. It does, however, give an indication of how widely rocks and stones have been and are used in the music of different cultures around the world. Examples of information on this website are included below and the entire list is included in Appendix A:

ANGOLA - The Chokwe people use stone handbells called *sango*.

ARGENTINA - In Santa Rosa de Tastil, in Argentina there is a special quartz from which lithophones have been made locally. "Tastil" apparently mean "rock that sounds." An example of the lithophones can be found in the local museum.

AUSTRIA - In the early 19th century Franz Weber built an instrument from alabaster which he called the *Lithokymbalon*.

AZERBAIJAN - The caves of Gobustan (Kobustan/Qobustan) contain ancient rock drawings which include depictions of dancing. There is also a rock which emits a deep resonating sound when struck, known as *gaval-dashy* (apparently it means "tambourine stone") and it is popularly thought that the dancing took place to the accompaniment of the sound of the stone.

BOLIVIA - The people of Northern Potosî in Bolivia apparently used ringing stones whose sound was held by them to be manifestations of the presence of the devil, *Supay*, trapped within them.

BORNEO - The Sea Dayak people in Borneo have used stone chimes which they refer to as *kromo*.

CHAD - Small stones are used in the rattle known as *Yondo* which comprises a pipe, normally made of metal.

CHINA - There are many examples of suspended stone chime bars in China. Original examples found in archaeological finds are made of marble, though later ones tend to have been principally made from jade. They were generally used for ceremonial purposes. Some of these date back thousands of years. The *bian ch'ing* or *bian'qing* is typically made up of a set of sixteen or thirty-two L-shaped tuned slabs, which are suspended in a large frame and struck on their long side with wooden mallets or padded sticks.

COLOMBIA - The Murui Muinane people from the region of La Chorrera have long traded in locally quarried granite. A large slab of this granite they appropriated for use as a gong which they have traditionally used to communicate across distances and for rituals.

ECUADOR - The National Museum possesses a lithophone, though details are hard to come by.

ENGLAND - In the eighteenth century, rocks found on the river bed in Skiddaw in the Lake District were found to possess a particularly sonorous quality. Peter Crosthwaite, who had opened his own museum in Keswick assembled a set of musical stones in 1785, some of which were already in perfect tune, the rest he tuned himself by chipping away at the stone. They can now be seen in Keswick Museum & Art Gallery.

TYPES OF LITHOPHONES

Caldwell (2013:521-522) describes two basic types of lithophones:

- Stationary
- Portable

STATIONARY LITHOPHONES

Various types of stationary lithophones include:

- Natural stalagmitic drapery
- Adulterated ridges and stalactites
- Stationary rock faces
- Natural but positioned stationary lithophones
- Manufactured stationary columnar lithophones

1) <u>Stalactites and stalagmites</u> - Natural stalactite drapery lithophones were played in many parts of the world including Europe, Mexico, and Java (Caldwell 2013:521). Adulterated ridges and stalactites are rock features that have been shortened to produce a particular tone when struck by a mallet. These types of lithophones have been reported in Upper Paleolithic art caves in Europe and also in Africa. Figures 3 and 4 show stalactites being played in Africa and in the U.S.

Figure 3. Stalagtites/lithophones in South Africa. Photo from a video that illustrates stalactites that ring when struck. They are in Tito Bustillo cave. It is part of the Cave of Altamira and Paleolithic Cave Art of Northern Spain world heritage site. https://www.youtube.com/watch?v=KdaRXu-PhZI, accessed 4/24/2018.

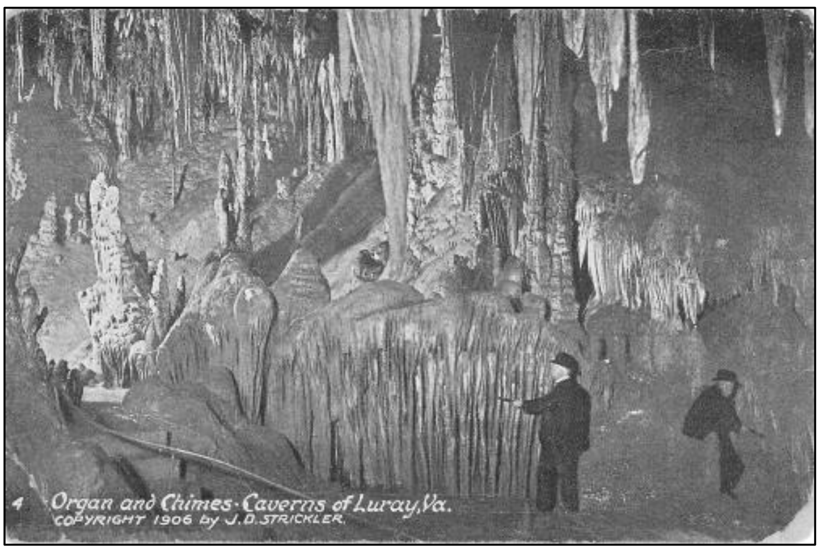


Figure 4. "Organ and Chimes," caverns of Luray, Virginia, ca. 1906. https://upload.wikimedia.org/wikipedia/commons/2/23/Organ_and_Chimes_-_Caverns_of_Luray_Va_1906_postcard.png, accessed 4/24/2018.

2) Stationary rock faces/natural rock gongs - These lithophones, referred to as rock gongs, sounding stones, or ringing rocks, are large rock/boulders found in various parts of the world, especially Africa, and also in the U.S. Examples of stationary rock gongs are shown in Figures 5 and 6. The rock gong found in Tanzania and shown in Figure 5 is described as follows:

> The well-documented rock gong shown below is to be found in Moru Koppies in Tanzania's Serengeti national park. Unlike some rock gongs which are part of a larger rock formation, this one is free-standing. The cup-marks, resulting from years of being struck, are clearly visible and cover every side. How it has been used is not certain though it may have played a part in Maasai culture. There are many other examples of ringing rocks to be found in Tanzania, some of which may have been utilised in ancestral and rainmaking ceremonies [http://www.lithophones.com/index.php?id=2].

Figure 5. Stationary rock gong from Tanzania http://www.lithophones.com/index.php?id=2, accessed 4/22/2018.

Figure 6. Stationary lithophone in Matapos, Africa. https://africageographic.com/wp-content/uploads/2015/12/ringing-rocks-in-Matopos.jpg, accessed 4/22/2018.

Two locations with ringing rocks/stationary lithophones in the U.S. include:

- Pennsylvania (Ringing Rocks Park); Figure 7.
- Montana (The Ringing Rocks – BLM land); Figure 8.

These locations exhibit large boulder fields with rocks that ring when tapped with rock hammers or other hard tools.

Figure 7. Ringing Rocks Park, Bucks County, Pennsylvania. http://troop72campspirit.org/wp-content/gallery/lost-river-caverns-ringing-rocks-2015/lost_river_caverns_ringing_rocks_2015_0008.JPG and https://media-cdn.tripadvisor.com/media/photo-s/01/44/7a/b2/upper-black-eddy.jpg, accessed 4/20/2018.

Figure 8. Ringing Rocks, Montana. https://c1.staticflickr.com/1/642/20143129853_f3b3d09f58_b.jpg and https://i.ytimg.com/vi/kyS-6P0Qa9Q/maxresdefault.jpg, accessed 4/24/2018.

3) Natural but positioned, stationary boulders and rocks – An example of these lithophones includes a natural but positioned boulder that is played in Azerbaijan and shown in Figure 9. Note how the rock is positioned on its probable acoustical nodes so that the sound is not muffled.

Figure 9. Natural, but positioned boulder lithophone in Azerbaijan (photo courtesy of Martha Lahana).

4) Manufactured stationary columns **-** Examples include columns of sonorous granite utilized in a temple in India and a limestone column in the Lao Cathedral, France (Caldwell 2013:521).

PORTABLE LITHOPHONES

Portable lithophones are also found around the world and include:

- Natural rocks that were suspended
- Manufactured suspended lithophones
- Long bifaces and stone slabs
- Stone cylinders

1) Natural rocks that were suspended - An example are sonorous rocks that were hung from a branch in Ethiopia and struck like gongs (Caldwell 2013:522). Natural rocks that were suspended vertically and played in Ecuador are shown in Figure 10. Other natural rocks were suspended and played horizontally in Ethiopia are shown in Figures 11 and 12. Another type of suspended natural rock lithophone are Bellstones found on Kauai and on other Hawaiian Islands (Figure 13). The Bellstones were reportedly utilized by ancient Hawaiian cultures in birthing ceremonies; the bells were rung at birthing sites to announce royal family births http://www.thegardenisland.com/2018/03/28/hawaii-news/bellstone-believed-missing-is-at-kauai-museum/, accessed 4/20/2018.

Figure 10. Example of natural rocks that were suspended vertically and played in Ecuador, Colección Museo de Culturas Indígenas - Cuenca, Ecuador 2007
http://juancampoverdeq.net/_Media/museo-c-aborigenes-2-2_hr.jpeg, accessed 4/20/2018.

Figure 11. Horizontally-suspended natural rocks that were played as chimes in Ethiopia: "*The use of stone bells, known as dowel has been adapted for Christian use in the Coptic church and can be heard, for example, at one of the monasteries on an island in the middle of Lake Tana. They hang from a rope and are apparently used functionally, as, for example, a dinner gong.*"
http://www.lithophones.com/index.php?id=2, accessed 4/20/2018.

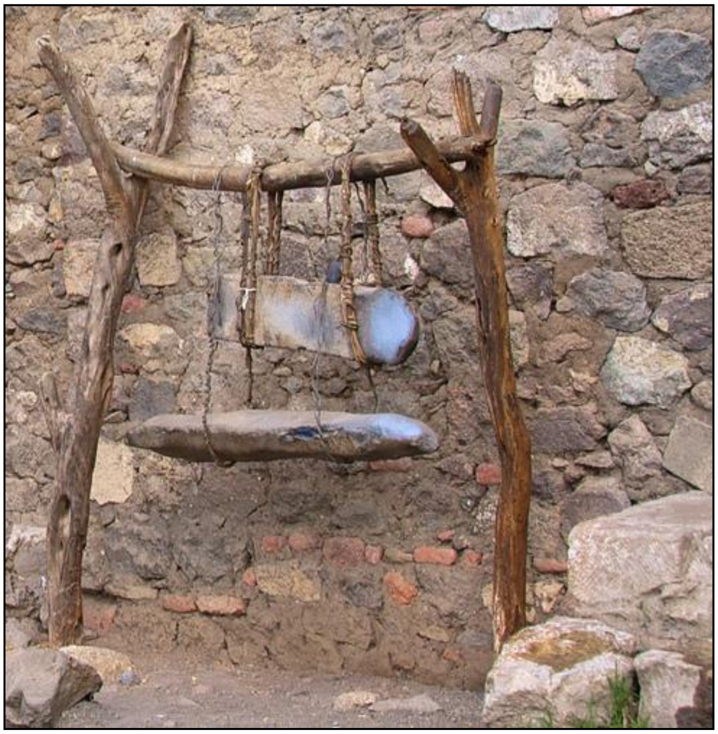
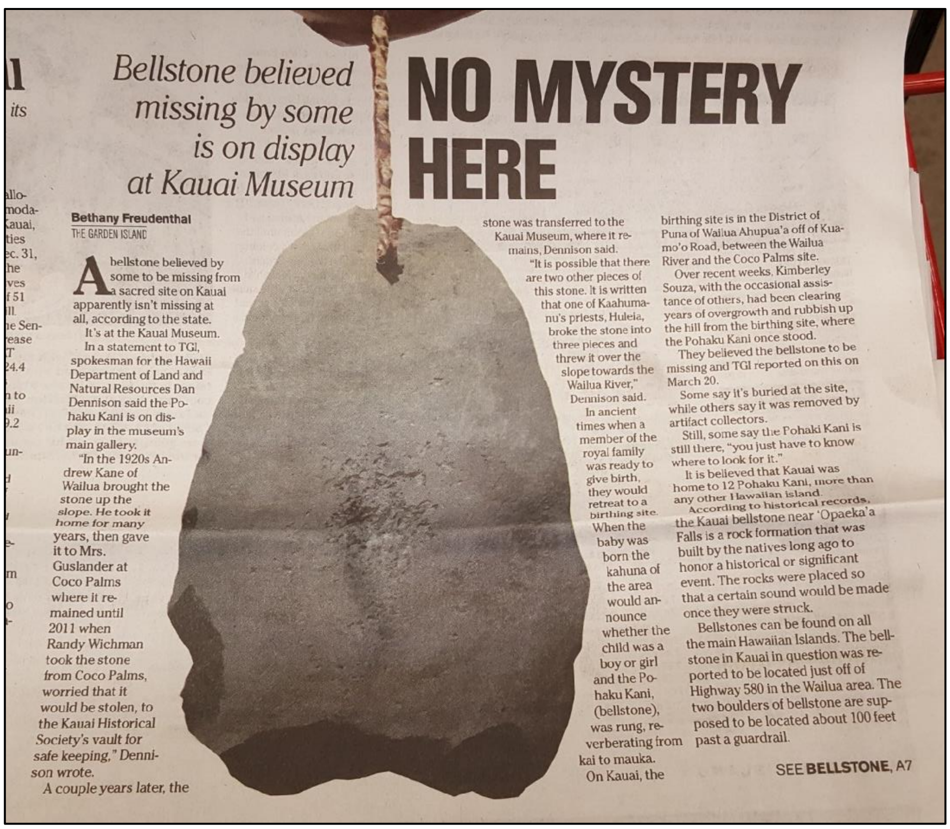


Figure 12. Ethiopian horizontally-suspended natural rock lithophones, http://www.lithophones.com/index.php?id=7, accessed 4/20/2018.



Bellstone believed missing by some is on display at Kauai Museum

NO MYSTERY HERE

Bethany Freudenthal
THE GARDEN ISLAND

A bellstone believed by some to be missing from a sacred site on Kauai apparently isn't missing at all, according to the state.

It's at the Kauai Museum.

In a statement to TGI, spokesman for the Hawaii Department of Land and Natural Resources Dan Dennison said the Pohaku Kani is on display in the museum's main gallery.

"In the 1920s Andrew Kane of Wailua brought the stone up the slope. He took it home for many years, then gave it to Mrs. Guslander at Coco Palms where it remained until 2011 when Randy Wichman took the stone from Coco Palms, worried that it would be stolen, to the Kauai Historical Society's vault for safe keeping," Dennison wrote.

A couple years later, the stone was transferred to the Kauai Museum, where it remains, Dennison said.

"It is possible that there are two other pieces of this stone. It is written that one of Kaahumanu's priests, Huleia, broke the stone into three pieces and threw it over the slope towards the Wailua River," Dennison said.

In ancient times when a member of the royal family was ready to give birth, they would retreat to a birthing site. When the baby was born the kahuna of the area would announce whether the child was a boy or girl and the Pohaku Kani, (bellstone), was rung, reverberating from kai to mauka.

On Kauai, the birthing site is in the District of Puna of Wailua Ahupua'a off of Kuamo'o Road, between the Wailua River and the Coco Palms site.

Over recent weeks, Kimberley Souza, with the occasional assistance of others, had been clearing years of overgrowth and rubbish up the hill from the birthing site, where the Pohaku Kani once stood.

They believed the bellstone to be missing and TGI reported on this on March 20.

Some say it's buried at the site, while others say it was removed by artifact collectors.

Still, some say the Pohaki Kani is still there, "you just have to know where to look for it."

It is believed that Kauai was home to 12 Pohaku Kani, more than any other Hawaiian island.

According to historical records, the Kauai bellstone near 'Opaeka'a Falls is a rock formation that was built by the natives long ago to honor a historical or significant event. The rocks were placed so that a certain sound would be made once they were struck.

Bellstones can be found on all the main Hawaiian Islands. The bellstone in Kauai in question was reported to be located just off of Highway 580 in the Wailua area. The two boulders of bellstone are supposed to be located about 100 feet past a guardrail.

SEE **BELLSTONE**, A7

Figure 13. Suspended Bellstone from Kauai, http://www.thegardenisland.com/2018/03/28/hawaii-news/bellstone-believed-missing-is-at-kauai-museum/, accessed 4/20/2018.

2) Manufactured suspended lithophones - Suspended manufactured lithophones are generally shaped and polished. They can be suspended horizontally or vertically. Examples include stone chimes from China, Vietnam, and Korea (Figures 14 and 15). In the United States, kiva bells, which are lithophones associated with Puebloan cultures, have been found in the Upper Rio Grande Valley (Brown 2009 and 2014), but are only minimally modified and some were not modified and are more similar to the category of "natural rocks that were suspended." The Mayans also suspended schist or greenstone celts from their belts with Olivera shells (Caldwell 2013:522).

Figure 14. Chinese suspended L-shaped lithophones.
http://www.lithophones.com/assets/images/Historical/China_kia-cam-qing-Yuelu-Academy-China_websize.jpg, accessed 4/22/2018.

Figure 15. Suspended jade lithophones, Pyeongyeong (lithophone), Paju, Gyeonggi Province, 2009.
http://crow202.org/2011/09-jade-lithophone.jpg, accessed 4/22/2018.

3) Long bifaces and stone slabs – Lithophones of this type have been found laid sequentially from shorter to longer blades, forming stone xylophones. Some of these lithophones appear to be made of minimally-modified rock, and others are highly modified. Many have been found in Vietnam where the first group discovered contained 11 bifacially-worked upright slabs (Figure 16) which were determined to be approximately 5000 to 6,000 years old (Caldwell 2013:522). Others are suspended shaped slabs played horizontally like a xylophone and are played today (Figure 17).

Figure 16. Group of lithophones from Vietnam found *in situ.*
http://www.look4ward.co.uk/wp-content/uploads/2017/03/26-5.jpg, accessed 4/20/2018.

Figure 17. Example of shaped slab lithophones being played horizontally like a xylophone in Vietnam today, https://www.vivutravel.com/images/blog17/lithophone-vivutravel.jpg, accessed 4/20/2018.

Another type of lithophone xylophone called a *pichanchalassi*, consists of stone blades (Figure 18). They are played using two hammer-stones by Kabré boys in Togo during initiation ceremonies (Caldwell 2013:522).

Figure 18. A *pichanchalassi*, consisting of stone blades played using two hammer-stones by Kabré boys in Togo during initiation ceremonies, http://www.lithophones.com/index.php?id=7, accessed 4/20/2018.

An example of very large slab lithophones has been documented in Cambodia (Figure 19) https://decipherment.wordpress.com/2016/07/13/classic-maya-marimbas/, accessed 4/20/2018. These large slab lithophones are currently housed in the National Museum in Phnom Penh.

Figure 19. Large slab lithophones from the *National Museum*, Phnom Penh, Cambodia, https://decipherment.wordpress.com/2016/07/13/classic-maya-marimbas/, accessed 4/20/2018.

Formally-flaked bifaces that have been interpreted as lithophones have been found in several locations. In Labrador, a group of very large formally-flaked bifaces found in a cache have been interpreted as lithophones (Figure 20).

Figure 20. Bifaces cache from an Archaic site interpreted as lithophones; Forteau Point, southern Labrador, https://nlarchaeology.wordpress.com/2015/11/27/the-archaic-site-at-forteau-point-southern-labrador/, accessed 4/20/2018.

A number of very large, formally-shaped knapped stones/bifaces referred to as "macroliths" or "macroblades" have been found in various places in Belize (Figure 21) and are also thought to have been lithophones https://decipherment.wordpress.com/2016/07/13/classic-maya-marimbas/, accessed 4/20/2018.

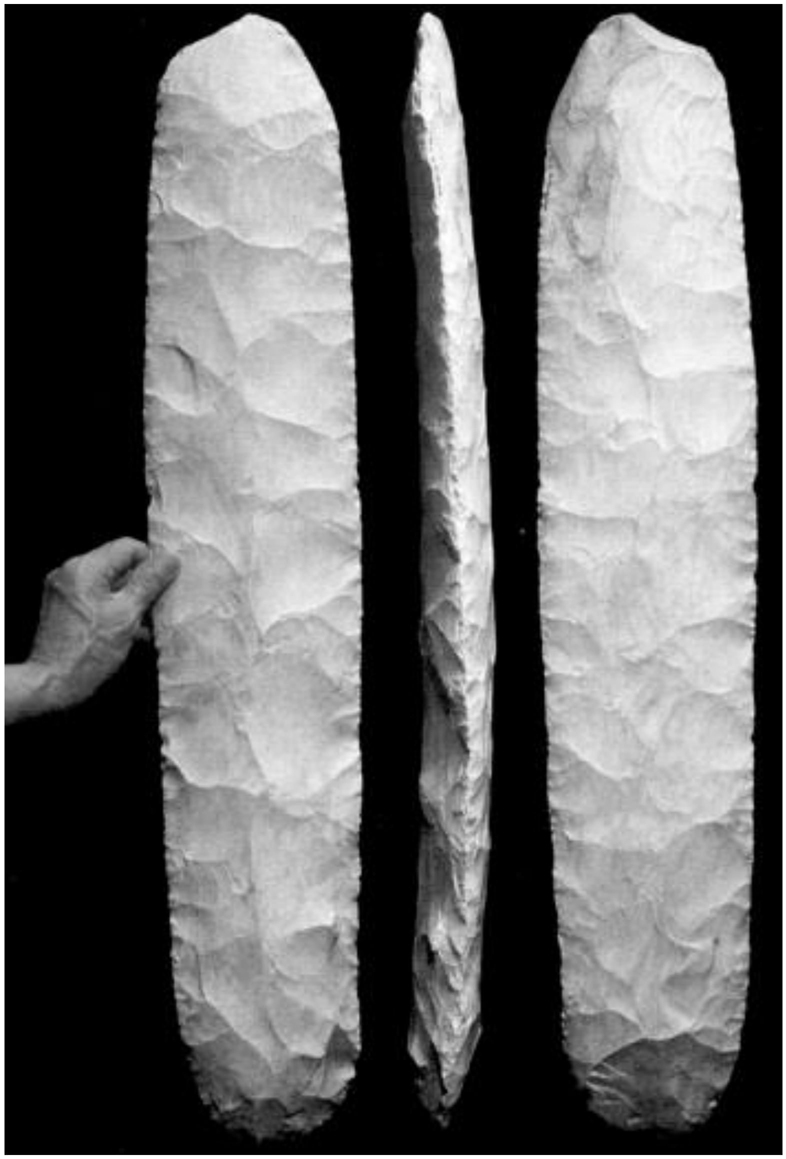


Figure 21. Examples of microblade lithophones from Belize, https://decipherment.wordpress.com/2016/07/13/classic-maya-marimbas/, accessed 4/20/2018.

4) Stone cylinders – Lithophones of this type are portable, pecked and polished, solid stone cylinders that produce clear tones when struck along the dorsal and lateral faces. As mentioned above, a number of these stone cylindrical lithophones from Africa have been intensively studied by Erik Gonthier (Figure 22) at the Museum of Man in Paris (Caldwell 2013:523).

Figure 22. Examples of solid cylindrical-shaped stone lithophones from Africa that were studied by Erik Gonthier at the Museum of Man, Paris.

Top photo: http://donsmaps.com/musicalinstruments.html

Bottom photo: https://cdn.radiofrance.fr/s3/cruiser-production/2014/04/ce429105-872a-458a-a59a-c59663450ff0/600x337_instrumentsr.jpg, accessed 4/26/2018.

PORTABLE LITHOPHONES FROM NORTH AMERICA

A few portable cylindrical lithophones similar to the artifacts from the SLV have been identified in the Eastern U.S. (Caldwell 2013); see discussion below. Unmodified or minimally-modified stones that are often notched for suspension, called kiva bells (Brown 2005, 2009 and 2014), have been found in some late period pueblos of the Southwest (see detailed discussion below); and one unnotched, highly modified, cylindrical portable lithophone (Figure 23) has been identified from northeastern Arizona (Brown 2014:65). In addition, a portable cylindrical lithophone was described and photographed by Woods Hole Oceanographic Institution, Massachusetts (Figure 24). To date; however, no portable lithophones have been previously identified in Colorado. As suggested by Caldwell (2013), portable lithophones appear to be a totally new class of artifacts for archaeologists in most of the North America.

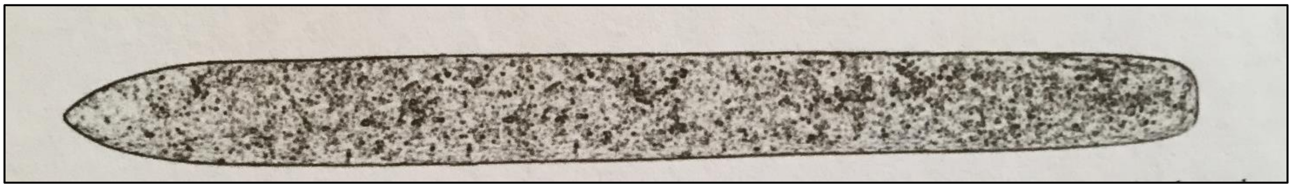


Figure 23. Drawing by Dr. Emily Brown (2014:65) of a cylindrical lithophone from northern Arizona.

Figure 24. Cylindrical portable lithophone from a collector and described by Woods Hole Oceanographic Institution, Massachusetts. https://www.whoi.edu/image-of-day/rock-on, accessed 4/26/2018.

LITHOPHONES FROM THE NORTHEASTERN U.S.

As noted above, two lithophones from New England have been described by Caldwell (2013:527). These artifacts are narrow and long (72.5 cm and 71 cm in length), cylindrical in form with a slight curvature, and are considered portable lithophones (Figure 25). They are similar to several of the artifacts from the SLV, especially samples #1, #4, and #18.

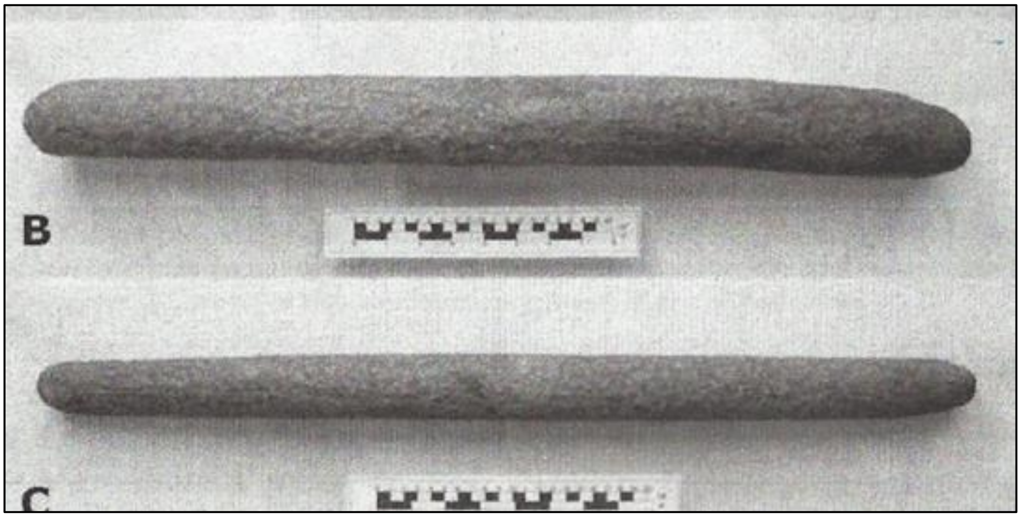


Figure 25. Two lithophones studied by Caldwell (2013:527) from New England.

LITHOPHONES FROM THE SOUTHWESTERN U.S.

As described by Dr. Emily Brown (2014:58-68), kiva bells belong to the class of instruments known as lithophones. Brown's research (2014:58-62) has indicated that all but one of the examples of portable lithophones referred to as kiva bells in the southwestern U.S. fall into the suspended natural rock portable lithophone category (Figure 26).

Figure 26. Kiva bells described by Emily Brown (2013:57).

Brown examined ethnographic accounts describing kiva bells as well as artifacts found at archaeological sites. Of the 42 artifacts she physically identified as likely kiva bells (out of 73 potential kiva bells she examined), almost all of them were unmodified stones (Table 1). Only one artifact she examined (see Figure 23), from an unknown location in Arizona, was a cylindrical rod that is similar to those described in the Sahara by Gonthier (2009) and in New England by Caldwell (2013). A very few of the kiva bells had minimal modifications that included grinding and smoothing, and a few had notches (possibly to facilitate suspension). All of the kiva bells from the Rio Grande Valley dated to post A.D. 1300 (Brown

2014:65). The most common material type for the kiva bells was basalt with other types including argillaceous limestone, phyllite, phonolite, and feldspar.

Table 1 includes a summary of the kiva bells described in the ethnographic record or from archaeological contexts and/or physically described by Brown (2005 and 2014), and those documented by Adler and Dick (1999).

Table 1. Description of example known kiva bells from pueblos in the southwestern U.S.

Location	**Description and other information including references**
Picuris Pueblo	One kiva bell and other stone rods/artifacts found in subfloor caches with other artifacts such as bone flutes, miniature pots, and other interpreted ceremonial items (Adler and Dick 1999:101-119)
San Lazaro	Brown (2014) describes three kiva bells from a private collection from this pueblo site
Taos Pueblo	Brown (2014:58) stated that Edgar Lee Hewett observed kiva bells being utilized at the Taos Pueblo in 1896
Santo Domingo	Brown (2014:58) stated that Frances Densmore observed kiva bells being utilized at this pueblo in the 1930s
Patokwa or Ka;atusekwa meaning “Place Where They Hit or Ring the Stones” (Brown 2014:58-59)	This Pueblo was built by members of the Jemez Pueblo in 1681.
Pueblo del Encierro	A kiva bell located in the Museum of Indian Arts and Culture (Brown 2014:61)
Pecos Pueblo	A phyllite kiva bell at the Pecos National Historical Park (Brown 2014:6)
Tsama	A kiva bell located in the Maxwell Museum (Brown 2005 and 2014:61)
Rainbow House/Bandelier National Monument	A kiva bell was found at Rainbow House in Bandelier National Monument and was described in the 1950s. A Cochiti Pueblo consultant stated that kiva bells were found in places where lightning had struck and that the best sounds were achieved by striking them with smaller pieces of the same type of stone (Brown 2014:59)
Gran Quivira	Several kiva bells made of gneiss, schist, limestone and petrified wood were identified (Brown 2014:64)
Sapawe Pueblo	Thirty-five kiva bells were identified; some in caches (Brown 2014: 64-65)
Other Pueblos/Sites: Pa’ako, Puye, Puaray, Kuaua, Cuyamungue, Otowi, and the Chamisal Site	A number of kiva bells were found during archaeological investigations at these pueblo sites (Brown 2014:63)

Red Font indicates currently-occupied Pueblo

Discussion and Comparison of Kiva Bells to the SLV Lithophones

As described in Brown (2005 and 2014), lithophones referred to as kiva bells from the Rio Grande Valley in New Mexico can be categorized as suspended natural rock portable lithophones. Only one of the lithophones in the SLV project sample appears to be physically similar to the kiva bells described from pueblos located in the Rio Grande Valley (Brown 2005 and 2014). Sample #9 is somewhat similar to a kiva bell from Tsama Pueblo shown in Brown’s dissertation (Brown 2005:422). The material types appear to be different from each other but the overall roughly-shaped form is similar; however, none of the SLV lithophones exhibit intentional notches for suspension.

The remainder of the described and photographed kiva bells from the Rio Grande Valley pueblo sites referenced in Brown (2005 and 2014) are basically natural, unmodified or minimally-modified stones (see Figure 26), whereas the SLV lithophones are primarily much more highly-modified and formally-shaped.

It was noted that the kiva bells described by Brown (2014) and shown in her photograph (see Figure 26), appear almost identical to natural stones found by a local SLV resident, Jeff Shook. These rocks were found by Mr. Shook in alluvial deposits in the northern part of the SLV and he called them "singing stones" based on their acoustical properties (see additional data and photographs under the discussion of potential lithic source areas for SLV lithophones in this report).

SAMPLE LITHOPHONES BACKGROUND DATA

This SHF grant examined a sample of 22 potential lithophones from the SLV. These artifacts were chosen based on their physical characteristics and on their acoustical properties that appeared similar to other described lithophones from throughout the world. For reference in this study, each artifact was assigned an artifact grant project number from 1 to 22 (Figure 27).

Figure 27. Project sample lithophones with assigned numbers. Note: the artifacts are lined up in musical order based on the primary note played. Artifacts playing the lowest to highest notes: #5, #4, #6, #17, #16, #21, #20, #1, #18, #22, #19, #7, #3, #9, #2, #13, #8, #15, #12, #10, #11, #14.

All of the artifacts studied for this grant are from the SLV with one exception. Artifact #17 was found on the Front Range of Colorado, south of Boulder Creek near Erie. This artifact was added to the analysis because at the time, it was the only potential lithophone found in Colorado outside of the SLV. The general and specific locations of each of the SLV samples are described in Table 2. The SLV artifacts include ten that were loaned from the Great Sand Dunes National Park and Preserve museum collections, one was loaned from the Rio Grande County Museum, Del Norte, Colorado; one was loaned from the Bureau of Land Management, San Luis Valley Field Office, Monte Vista, Colorado; and nine were loaned by SLV residents from private collections.

The locations where the SLV artifacts were found include the following: eight from unknown locations in the SLV; seven from the floor of the SLV in the sands, especially near springs or near old playas on the northern, western and southern edges of Great Sand Dunes National Park and Preserve; four from the pinon/juniper woodlands on the southwestern slopes of the Sangre de Cristos north of Great Sand Dunes; and two from the northern and northwestern portions of the SLV.

Basic data was recorded for each of the sample lithophones used in this study including the following, if known: current owner(s), who found the artifact, where it was found, date of the find, vertical provenience, position in ground when found, and other information (associated artifacts in the vicinity, sediments, etc.). This information was gathered from museum accession data and associated documents, and information from the private owners of the artifacts. Table 2 summarizes this basic informational data for each artifact utilized in this study.

Table 2. Lithophone grant artifact basic identification information.

Grant artifact ID #	**Current owner** **Curation and/or accession #**	**Who originally found it**	**Where found** **When found**	**Vertical provenience when found (surface or subsurface & depth)**	**If buried or partially buried, position (angle) in ground when found**	**Other Info. (artifacts in vicinity, sediments, etc.)**
1	Rio Grande County Museum #81-320-121	Unknown; part of collection donated by a local family	Unknown but likely near Del Norte or elsewhere in the SLV Unknown date	Unknown	Unknown	Unknown
2	Brian Blasi No #	Brian Blasi	SLV Unknown date	Lower Red Sands area between Big and Little Spgs.	Unknown	Unknown
3	Jo Crow Bowers No #	Found by her father	North of the Pedro Trujillo Homestead (site 5AL706) on their family ranch Unknown date	Unknown	Unknown	Unknown
4	GRSA GRSA 5100, Accession # GRSA-00409 ("standard 2-footer")	Jack Williams	Big Spring Creek (Indian Springs site 5SH181) 1938	"About six inches of it were sticking out or up vertically. I got off my horse and kicked it. Got a surprise." Williams 1996	Vertical	Many artifacts within site boundary (see site form)
5	GRSA GRSA 5106, Accession # GRSA-00409	Kevin DesPlanques	Big Springs (K. DesPlanques 8 2017: personal communication) Unknown date	Unknown	Unknown	Unknown
6	GRSA GRSA 5093, Accession # GRSA-00409 Ray Lyons "2"	Ray Lyons	SLV Unknown date	2/3 showing on surface	Unknown	Unknown

Grant artifact ID #	**Current owner** **Curation and/or accession #**	**Who originally found it**	**Where found** **When found**	**Vertical provenience when found (surface or subsurface & depth)**	**If buried or partially buried, position (angle) in ground when found**	**Other Info. (artifacts in vicinity, sediments, etc.)**
7	GRSA GRSA 5094, Accession # GRSA-00409, Ray Lyons "1"	Ray Lyons	SLV May 1960	1/5 showing on surface	Unknown	Unknown
8	GRSA GRSA 5095, Accession # GRSA-00409	Ray Lyons	SLV Unknown date	Unknown	Unknown	Unknown
9	GRSA GRSA 5091, Accession # GRSA-00406, "Pestle 3" on map, Little Springs	Ray Lyons	Little Spring (5AL10) May 1963	Surface	NA	Many artifacts (see site form)
10	GRSA GRSA 5099, Accession # GRSA-00409, Ray Lyons "97"	Ray Lyons	SLV March 1965	Unknown	Unknown	Unknown
11	GRSA GRSA 5101, Accession # GRSA-00409, Jack Williams collection "S" over "2"	Jack Williams (?)	SLV Unknown date	Unknown	Unknown	Unknown

Grant artifact ID #	Current owner Curation and/or accession #	Who originally found it	Where found When found	Vertical provenience when found (surface or subsurface & depth)	If buried or partially buried, position (angle) in ground when found	Other Info. (artifacts in vicinity, sediments, etc.)
12	GRSA GRSA 5090, Accession # GRSA-00406, "Pestle 1" on map, Little Springs	Ray Lyons?	Little Springs (5AL10) Unknown date	Unknown	Unknown	Many artifacts (see site form)
13	GRSA GRSA 5102, Accession # GRSA-00409	prob. Jack Williams collection	SLV Unknown date	Unknown	Unknown	Unknown
14	Barbara Kruse No #	Barbara Kruse	Found in potato sorting from Rd. 11 & 106 (Alamosa County) Unknown date	Unknown	Unknown	Unknown
15	BLM BLM/Monte Vista, Fish Bone Site 5AL326 FS2	Brian Fredericks	On edge of large old playa SW of Great Sand Dunes; Site 5AL326 Ca. 2015	surface	NA	This artifact was found within or immediately adjacent to a concentration of artifacts and a midden w/ charcoal. Artifacts included flakes, fire-cracked rock (FCR), ground stone, large and small animal bone, and fish bone. 14C date of 6280 to 5990 Before Present (BP); end of the early Archaic.
16	Lyn Bogle No #	Lyn Bogle	La Garita area; 1.5 miles W. of HWY 285, .25 miles south of Saguache County Road G. Approx. 1979	Completely buried; was brought to the surface when chiseling native grasslands	Unknown	9 metates, 3 manos and many points were found in that ¼ section. The artifact was located in a swale. Lyn thinks that the La Garita Creek bed may have possibly been in this location at one time; sediments were very sandy; sandy loam with gravels at about 2 feet deep; some dark river bottom clays in the area, possibly about 1 foot in depth.

Grant artifact ID #	Current owner Curation and/or accession #	Who originally found it	Where found When found	Vertical provenience when found (surface or subsurface & depth)	If buried or partially buried, position (angle) in ground when found	Other Info. (artifacts in vicinity, sediments, etc.)
17	Jim Avery No #	Jim Avery	Ca. 1 mile SE of Boulder Creek (1 mile north of Erie, CO); in a plowed field; plow likely broke it in half Unknown date	Two co-joining pieces on surface; exposed by plow	Unknown	Many manos and metates located in vicinity.
18	Candye Dawson No #	Candye Dawson	North of Saguache Creek; on the east side near the highway Ca. 2013	Unbroken end was sticking out a few inches	Nearly vertical (slightly angled)	It was located in hard pan sediments. No other artifacts visible nearby.
19	Bob Bunker No #	Bob Bunker	Pinon/Juniper woodlands north of GRSA on the SW slopes of the Sangre de Cristos on the old Baca Ranch property Ca. 1959	Surface	NA	Many artifacts in general vicinity but Archaic point styles most common in the area.
20	Bob Bunker No #	Bob Bunker	Pinon/Juniper woodlands north of GRSA on the SW slopes of the Sangre de Cristos on the old Baca Ranch property Late 1960s	Surface	NA	Many artifacts in general vicinity but Archaic point styles are most common in the area.
21	Bob Bunker No #	Bob Bunker	Pinon/Juniper woodlands north of GRSA on the SW slopes of the Sangre de Cristos on the old Baca Ranch property 2013	Surface	NA	Many artifacts in general vicinity but Archaic point styles most common in the area.

Grant artifact ID #	Current owner Curation and/or accession #	Who originally found it	Where found When found	Vertical provenience when found (surface or subsurface & depth)	If buried or partially buried, position (angle) in ground when found	Other Info. (artifacts in vicinity, sediments, etc.)
22	Bob Bunker No #	Bob Bunker	Pinon/Juniper woodlands north of GRSA on the SW slopes of the Sangre de Cristos on the old Baca Ranch property 1970s	Surface	NA	Many artifacts in general vicinity but Archaic point styles most common in the area.

CATEGORICAL TYPES OF THE SAMPLE LITHOPHONES

All of the sample artifacts are considered *portable lithophones*, as defined by Caldwell (2013:521-522). The lithophones can be further categorized as three different types of portable lithophones:

- Minimally-modified and roughly-shaped rocks
- Highly-modified rocks
- Stone cylinders

MINIMALLY-MODIFIED AND ROUGHLY-SHAPED ROCKS

Two of the sample lithophones are considered minimally-modified (#8 and #14). They both appear to be natural cobbles that have been pecked on the body surface and minimally-shaped on the ends (Figure 28). Two others, #6 and #9, are more formally-shaped overall (especially on the ends), but still retain rough shaping on the body surfaces. None of these artifacts have evidence of notches for suspension like some of the minimally-modified lithophones called kiva bells (Brown 2014). One example minimally-modified artifact, #14, is described below:

Artifact #14 (see Figure 28) is complete and is an elongated-oval shape. The cross-section is a slightly-flattened oval. The body is covered with peck marks (1 to 5 mm in size). A few small higher areas along one lateral edge exhibit polish; the remainder of the body is fairly rough with minor smoothing. An area approximately 16 cm L x 4 cm W along one lateral edge exhibits an orange-colored residue (possibly ochre), especially in the lower interstices of the deeper peck marks.

Figure 28. Artifact #14 which is a minimally-modified natural cobble.

HIGHLY-MODIFIED ROCKS

Artifacts #2, #3, #5, #7, #10, #11, #12, #15, #16, #17, #19, #20, #21, and #22 are considered very highly-modified and are ground, pecked, often polished on the body, and exhibit highly-modified ends. They are oval and/or slightly flattened in cross-section. Several of these artifacts exhibit slightly curved-shaped bodies (#2, #3, #11, #12, #15, and #19). Two example highly-modified rock artifacts, #2 and #7 are described below:

Artifact #2 (Figure 29) is complete and unevenly-shaped with one half, a flattened oval shape in cross-section and the other half is unevenly narrowing and tapering into a beveled-shape. This beveled portion of the body is more triangular in shape. The body, and extending to near the tip of both ends, is covered with various-sized peck marks, 1 to 4 mm in size. The surface of the body is ground and smoothed with a few highly-polished areas, especially on one surface. This polished area appears to be darkened, possibly suggesting that the artifact was thermally heated. There is no evidence of surface residue such as $CaCO_3$.

Figure 29. Artifact #2, example of a highly-modified rock type.

Artifact #7 (Figure 30) is complete and is a slightly-flattened oval shape in cross-section. The body is straight and is covered with numerous deep and closely-spaced peck marks, 2 to 5 mm in size, especially dense on the lateral edges of the body. On one of the flatter body surfaces, the center portions have been pecked and then ground and smoothed with some higher areas exhibiting polish. There are also some small pockets in this area that exhibit an orange-colored residue very similar to Artifact #6; this may possibly be ochre that was applied on the artifact. On the opposite flattened surface of the body, the center has been pecked but smoothed and there is also evidence of an orange-colored residue possibly applied to this surface, as well. Very small black phenocrysts (< 1 mm) are visible on both body surfaces that have been ground and smoothed.

Figure 30. Artifact #7, example of a highly-modified rock type.

STONE CYLINDERS

Artifacts #1, #4, #13 and #18 are categorized as stone cylinders. These are the most-highly modified of all of the artifacts. All of these artifacts have been carefully pecked and shaped over the entire body and are basically rounded in cross-section. Note: some of the other artifacts may appear to be cylindrical in certain photos but based on a cross-section view, they are not completely rounded. All four stone cylinder-shaped artifacts are described below:

Artifact #1 (Figure 31) is the most cylindrical over the length of artifact and is complete. It is almost straight in form and is long and narrow with the body almost completely rounded/cylindrical in cross-section, exhibiting straight parallel sides. It exhibits high polish over the entire artifact body and ends. It is the smallest in diameter (4.3 cm) of the four cylindrical artifacts. It exhibits slight tapering at both ends toward the tips. The body is covered with very small (ca. 2 mm), closely-spaced peck marks but the surface has been ground and smoothed. It exhibits polish, especially on the areas that exhibit the orange-tan colored residue coating (possibly clay mixed with $CaCO_3$) which covers approximately 2/3 of the lithophone except for one surface of the body.

Figure 31. Artifact #1, stone cylinder type.

Artifact #4 (Figure 32) is the longest of all the cylindrical specimens and other artifacts (64.5 cm in length) and exhibits a rounded cross-section over approximately 2/3 of the body. It is also very heavy (9 pounds [lb] 4.6 oz). This artifact is a slightly more-flattened oval shape from 21 cm outward from the tip to End #1. The body is also slightly curved near the end that is oval-shaped. It is the largest in maximum diameter (6.4 cm) of the four cylindrical artifacts. This artifact is covered with hundreds of small (1 to 3 mm) peck marks that are very closely-spaced. The surface of the body is heavily pecked and ground but not highly polished.

Figure 32. Artifact #4, stone cylinder type. It is the longest sample lithophone (64.5 cm in length).

Artifact #13 (Figure 33) was broken into two pieces but was conjoined with glue. It appears to be complete; however, based on the rough surface on the angled end, it may be a fragment from a longer artifact (possibly similar to Sample #4), and appears to have been rep-utilized after the original break. End #2 exhibits the steep angle (as if broken off from a longer artifact) and exhibits some evidence of utilization as a grinding tool. The body has been carefully pecked and is covered with numerous very shallow peck marks. The body exhibits grinding, smoothing and polishing on the high areas. The body is straight, cylindrical/conical in overall shape, and rounded in cross-section.

Figure 33. Artifact #13 that had been broken in half but repaired with glue. It is cylindrical in shape. Note the angle on End #2 on the left.

Artifact #18 (Figure 34) is another fragment with a steeply-angled break on End #2. The broken end exhibits very sharp edges suggesting that the break was possibly more recent, and unlike #13, this artifact does not appear to have been ground after being broken. The body is basically straight with a slight curve toward the intact end. One side of the body exhibits $CaCO_3$ residue and the surface of this side also exhibits exfoliation of some of the outer rock surface. The remainder of the body exhibits numerous peck marks and the surface of the body has been ground and smoothed and is highly polished in a few areas.

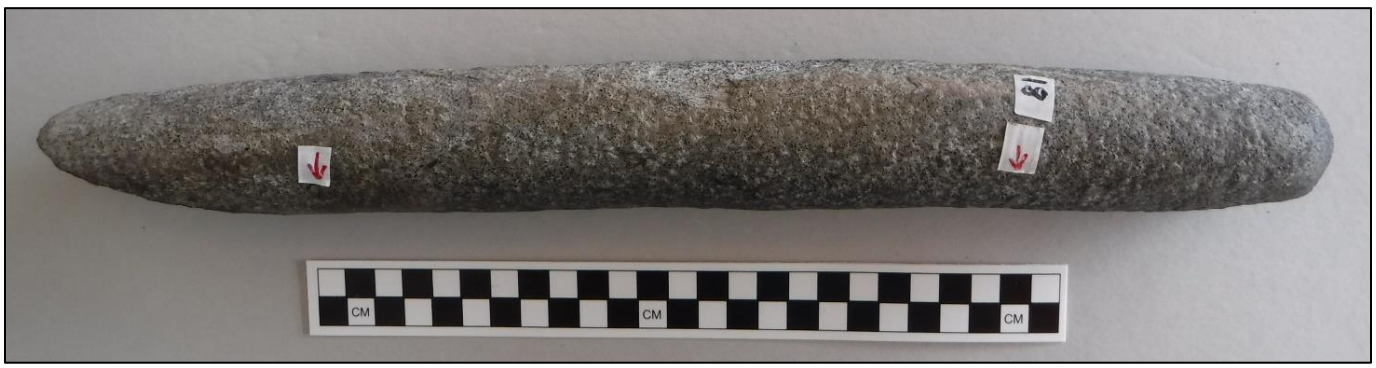


Figure 34. Artifact #18, stone cylinder type; broken on End #2 on the left.

PHYSICAL CHARACTERISTICS OF THE SAMPLE LITHOPHONES

The following physical characteristics were recorded for each of the 22 sample lithophones utilized in this analysis: completeness, weight, length, width, diameter, thickness, shape (curvature, overall, body, ends, concave or flattened areas), cross-section (End #1 and End #2), peck marks (size, numbers and placement), polish, grinding, incised marks, recent marks (artifact numbers, plow marks, scratches), residue (applied [ochre] and natural [CACO3] and natural sediments), and potential material type. One-page descriptions and detailed photos of each artifact are found in Appendix B (in separately bound Volume 2). The physical characteristics are listed in Table 3 and discussed individually. Note: potential material types are discussed separately in this report.

Lab methodology

Methodology for recording and photographing the physical characteristics included the following:

- Measurements were taken using hard and soft metric tape measures (soft tapes were more accurate for obtaining diameter, etc.).
- The weight of the artifacts was measured by using a digital scale.
- Several hand magnifiers of different strengths (up to 16x) were utilized to view and describe physical characteristics of the surface of the lithophones.

- Different lighting, both natural and man-made, were utilized when the artifacts were photographed and described. The photographs were taken with several cameras including an iphone, a Fuji Finepix XP90, and a Canon EOS Rebel T5.
- Photographs of the artifacts showing the lateral edges (curvature) were taken with a graph paper background to highlight the curvature of the body.

Table 3. Lithophone measurements and descriptive data*****

	Completeness							**Weight**		**Body curvature**		**Body shape (cross-section)**		**Body surface characteristics**							
Grant artifact ID # **Name of owner and curation info**	**Complete**	**Fragment**	**Complete/was broken & glued**	**Maximum Length (cm)**	**Maximum Width (cm)**	**Maximum Body Thickness (cm)**	**Maximum Diameter (cm)**	**Metric - grams**	**English – pounds/oz**	**Straight**	**Curved**	**Cylindrical/rounded**	**Oval and/or slightly flattened**	**Size of peck marks (mm)**	**Polish**	**Rough shaping**	**Striations**	**Smoothed/concave or flattened area on center of body**	**CACO3**	**Ochre**	**Other (plow marks, etc.)**
#1 Rio Grande County Museum, # 81-320-121	X			39.8	4.3	4.3	14.1	1361	3 lb	X		X		1-2	X				probably		orange-tan coating on 2/3
#2 Brian Blasi	X			32.0	5.4	4.6	16.0	1312	2 lb 14.3 oz		X		X	1-4	X	X		X			
#3 Jo Crow Bowers	X			31.5	6.8	3.9	18.3	1707	3 lb 12.2 oz		X		X	2-5	X	X	X	X	X		small scratches
#4 GRSA 5100, Accession # GRSA-00409, Jack Williams collection, “Standard 2-footer”	X			64.5	6.4	5.8	19.8	4213	9 lb 4.6 oz	X		X	X	1-3							
#5 GRSA 5106, Accession # GRSA-00409, Kevin DesPlanques	X			62.9	7.4	3.2	17.7	2724	6 lb 1 oz	X			X	1-4		X			X		
#6 GRSA 5093, Accession # GRSA-00409, Ray Lyons “2”	X			45.3	7.3	3.2	18.4	1701	3 lb 12 oz	X			X	2-5		X				X	
#7 GRSA 5094, Accession # GRSA-00409, Ray Lyons “1”	X			35.9	6.9	4.2	19.0	2050	4 lb 8.3 oz	X			X	2-5	X	X		X		?	

	Completeness							**Weight**		**Body curvature**		**Body shape (cross-section)**		**Body surface characteristics**							
Grant artifact ID # Name of owner and curation info	**Complete**	**Fragment**	**Complete/was broken & glued**	**Maximum Length (cm)**	**Maximum Width (cm)**	**Maximum Body Thickness (cm)**	**Maximum Diameter (cm)**	**Metric - grams**	**English – pounds/oz**	**Straight**	**Curved**	**Cylindrical/rounded**	**Oval and/or slightly flattened**	**Size of peck marks (mm)**	**Polish**	**Rough shaping**	**Striations**	**Smoothed/concave or flattened area on center of body**	**CACO3**	**Ochre**	**Other (plow marks, etc.)**
#8 GRSA 5095, Accession # GRSA-00409, Ray Lyons	X			26.5	7.1	4.3	19.3	1451	3 lb 3.2 oz		X		X	1-3		X				?	
#9 GRSA 5091, Accession # GRSA-00406, “Pestle 3” on map, Little Springs		X		27.0	5.3	2.9	14.3	774	1 lb 11.3 oz		X		X	?	X	X			X		
#10 GRSA 5099, Accession # GRSA-00409, Ray Lyons “97”		X		18.0	4.7	3.1	13.0	468	1 lb .5 oz	X			X	2-4	X	X			X		
#11 GRSA 5101, Accession # GRSA-00409, Jack Williams collection “S” over “2”		X		22.4	5.9	4.7	17.6	1128	2 lb 7.8 oz		X		X	2-3					X		
#12 GRSA 5090, Accession # GRSA-00406, “Pestle 1” on map, Little Springs	X			21.4	5.9	3.6	16.0	791	1 lb 11.9 oz		X		X	1-5						?	

Grant artifact ID # Name of owner and curation info	**Completeness**			**Maximum Length (cm)**	**Maximum Width (cm)**	**Maximum Body Thickness (cm)**	**Maximum Diameter (cm)**	**Weight**		**Body curvature**		**Body shape (cross-section)**		**Body surface characteristics**							
	Complete	**Fragment**	**Complete/was broken & glued**					**Metric - grams**	**English – pounds/oz**	**Straight**	**Curved**	**Cylindrical/rounded**	**Oval and/or slightly flattened**	**Size of peck marks (mm)**	**Polish**	**Rough shaping**	**Striations**	**Smoothed/concave or flattened area on center of body**	**CACO3**	**Ochre**	**Other (plow marks, etc.)**
#13 GRSA 5102, Accession # GRSA-00409, prob. Jack Williams collection		X		30.5	5.6	5.6	18.1	1763	3 lb 14.2 oz	X		X		1-2	X				X		Broken & glued
#14 Barbara Kruse	X			22.0	7.7	4.8	21.1	1497	3 lb 4.8 oz	X			X	1-5	X		X				
#15 BLM/Monte Vista, Fish Bone Site 5AL326 FS2		X		26.5	5.8	3.7	15.6	1037	2 lb 4.6 oz		X		X	1-5	X						sediment residue
#16 Lyn Bogle, La Garita area	X			52.0	7.7	6.0	22.6	4465	9 lb 13.5 oz	X			X	2-5	X		X		X		3 plow marks & at least 7 incised lines
#17 Jim Avery, Erie area (Front Range)			X	38.3	8.0	3.0	19.5	1616	3 lb 9 oz	X			X	2-4	X						1 plow mark & many possible incised lines
#18 Candy Dawson, N of Saguache Creek		X		40.4	4.7	4.7	15.0	1641	3 lb 9.9 oz		X	X	X	1-4	X				X		
#19 Bob Bunker1	X			29.1	6.1	3.4	15.5	1103	2 lb 6.9 oz		X		X	2-5	X				X		
#20 Bob Bunker 2 (Broken into 3 pieces & glued)			X	38.7	7.7	3.7	20.0	2007	4 lb 6.8 oz	X			X	1-5	X		X	X			
#21 Bob Bunker 3	X			40.3	7.3	4.3	20.0	2225	4 lb 14.5 oz	X			X	1-4	X		X	X			

	Completeness							**Weight**		**Body curvature**		**Body shape (cross-section)**		**Body surface characteristics**							
Grant artifact ID # **Name of owner and curation info**	**Complete**	**Fragment**	**Complete/was broken & glued**	**Maximum Length (cm)**	**Maximum Width (cm)**	**Maximum Body Thickness (cm)**	**Maximum Diameter (cm)**	**Metric - grams**	**English – pounds/oz**	**Straight**	**Curved**	**Cylindrical/rounded**	**Oval and/or slightly flattened**	**Size of peck marks (mm)**	**Polish**	**Rough shaping**	**Striations**	**Smoothed/concave or flattened area on center of body**	**CACO3**	**Ochre**	**Other (plow marks, etc.)**
#22 Bob Bunker 4	X			34.5	7.1	4.3	19.0	1908	4 lb 3.3 oz	X			X	1-5	X		X	X	X		

* See Appendix B (in Volume 2) individual descriptions for additional detailed information about the physical attributes.

PHYSICAL CHARACTERISTIC DESCRIPTIONS

Completeness - Fourteen of the artifacts are complete and unbroken (#1-8, #12, #14, #16, #19, #21, and #22), and two appear to be complete but have been broken and conjoined with glue by the collector (#17 - two pieces, and #20 - three pieces). Six additional artifacts are fragments (#9, #10, #11, #13, #15, and #18). Artifact #13 appears to be a fragment but was broken and glued (Figure 35) and #18 exhibits a sharp-angled break (Figure 36).

Figure 35. Glue visible on the center of Artifact #13 where the two pieces were conjoined.

Figure 36. Example of a fragment with an angled break at one end; Artifact #18.

Weight - The weights of the artifacts (Figure 37) range from 1 lb .5 oz/468 grams (gm) (Artifact #10) to 9 lb 13.5 oz/4465 gm (#16). Of the complete artifacts, the weight range is 1 lb 11.9 oz/791 gm (#12) to 9 lb 13.5 oz/4465 gm (#16). The average weight of the entire sample group of artifacts is 3.45 lb/1567gm.

The three heaviest artifacts, #4, #5 and #16, weigh 6 to 9+ lb each, and are also the longest. They are difficult to handle with one hand. The smaller and lighter artifacts are more easily lifted and maneuvered with one hand.

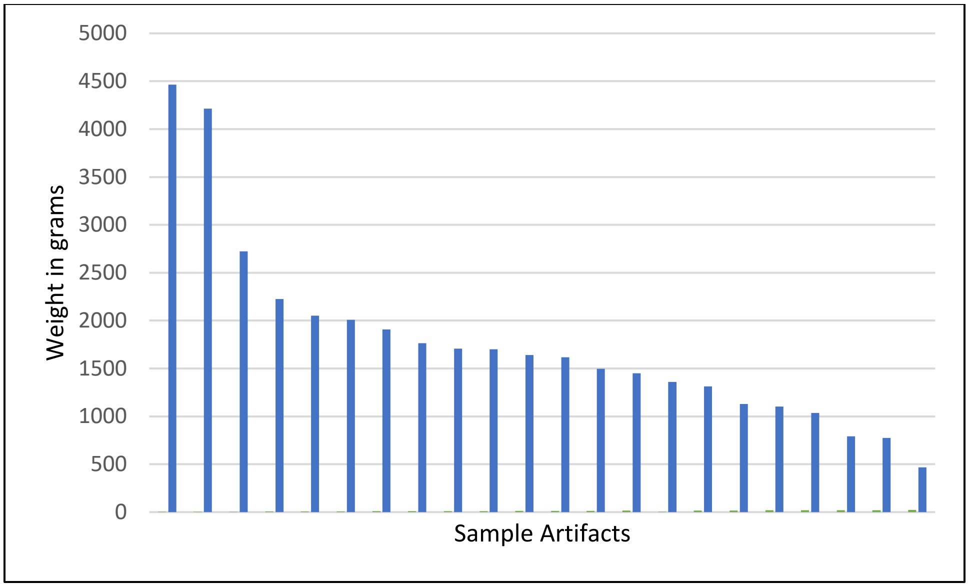


Figure 37. Weight of the sample artifacts.

Length - The sample artifacts range from 18 to 64.5 cm in length (Figure 38). The average length of all the artifacts is 35.4 cm. Of the 16 complete sample specimens (including #17 and #20 that were broken and glued but are complete), the length range was from 21.4 to 64.5 cm with an average length of 38.4 cm. Seven of these artifacts are less than 35 cm in length. Three are just slightly less than 35 cm in length (#22 is 34.5 cm, #2 is 32 cm, and #3 is 31.5 cm), and four are less than 30 cm (#19 is 29.1 cm, #8 is 26.5 cm, #14 is 22 cm, and #12 is 21.4 cm).

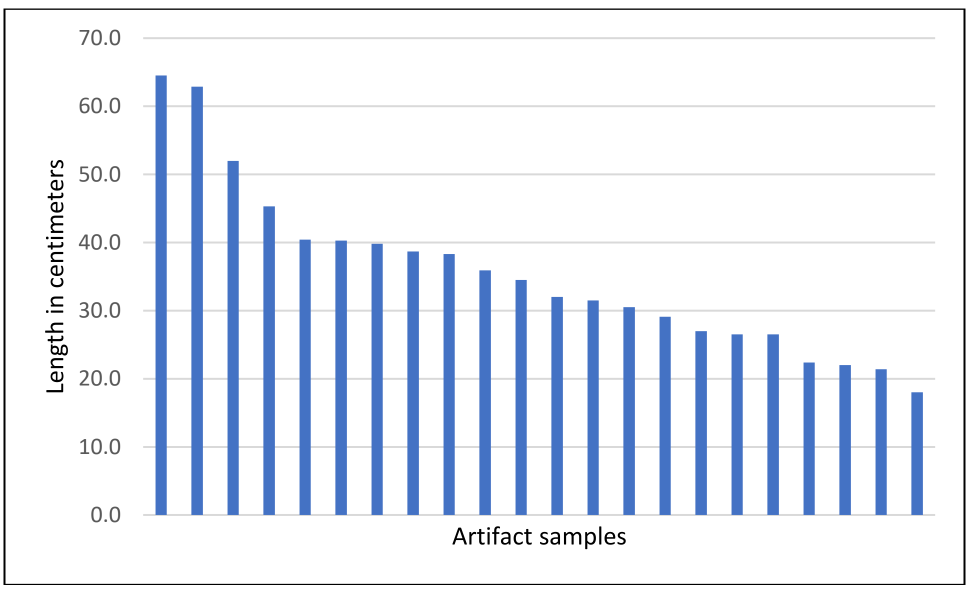


Figure 38. Length of the sample artifacts.

<u>Width</u> - The sample artifacts range in maximum width from 4.3 to 8 cm (Figure 39). The average width is 6.4 cm. The variation in width is very small, only 3.7 cm between the widest and the narrowest artifact.

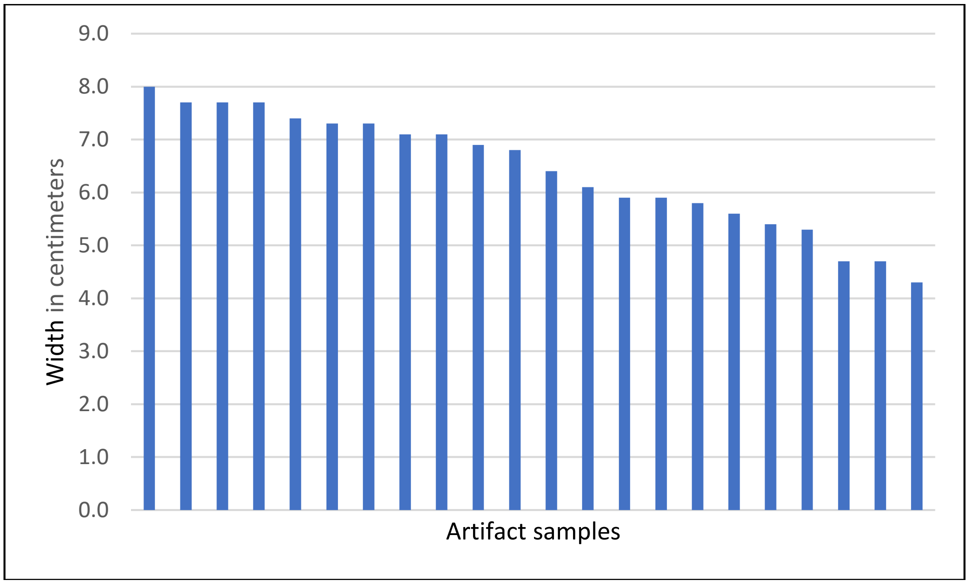


Figure 39. Width of the sample artifacts.

<u>Diameter</u> - The maximum diameter of the artifacts ranges from 13.0 to 22.6 cm with an average diameter of 17.7 cm (Figure 40). Of the 16 artifacts that appear to be complete (#1- 8, #12, #14, #16, #17, #19, #20, #21, and 22), the diameters range from 14.1 cm to 22.6 cm with an average diameter of 18.5 cm.

Of the six artifacts that are fragments (#9, #10, #11, #13, #15, and #18), the diameters range from 13.0 to 18.1 cm with an average width of 15.6 cm. The slight decrease in average diameter of the fragments is likely due to the fact that all of the fragments are end pieces; that is, the maximum diameter of most of the complete specimens was located near the mid-section of the artifact which is missing on the fragments.

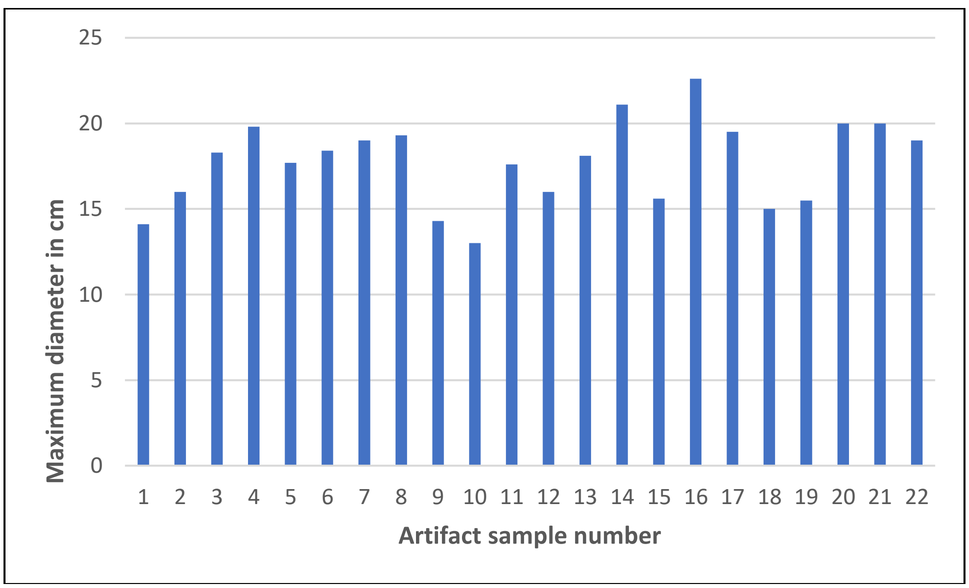


Figure 40. Diameter of the sample artifacts.

Length-to-width ratio - Based on Caldwell (2013), lithophones are generally 4.5 times longer than they are wide. This ratio affects the sound qualities and is discussed further in the section regarding the musical qualities of the lithophones and in the Summary section at the end of this document.

The average length-to-width ratio of all of the sample artifacts is 5.6 (Table 4). Five of the artifacts (23%) are less than 4.5 times longer than they are wide (#8, #10, #11, #12 and #14). The average length-to-width ratio of these five artifacts is 3.6. Of the 17 artifacts that have a width ratio 4.5 times longer than they are wide, or wider; their average length-to-width ratio is 6.2.

Table 4. Ratio of length-to-width of the sample artifacts.

Artifact sample #	Length in centimeters	Width in centimeters	Ratio of length-to-width
1	39.8	4.3	9.3
2	32.0	5.4	5.9
3	31.5	6.8	4.6
4	64.5	6.4	10.1
5	62.9	7.4	8.5
6	45.3	7.3	6.2
7	35.9	6.9	5.2
8	26.5	7.1	3.7
9	27.0	5.3	5.1
10	18.0	4.7	3.8
11	22.4	5.9	3.8
12	21.4	5.9	3.6
13	30.5	5.6	5.4
14	22.0	7.7	2.9
15	26.5	5.8	4.6
16	52.0	7.7	6.8
17	38.3	8.0	4.8
18	40.4	4.7	8.6
19	29.1	6.1	4.8
20	38.7	7.7	5.0
21	40.3	7.3	5.5
22	34.5	7.1	4.9

Thickness – The maximum thickness of the sample artifacts ranges from 2.9 to 6.0 cm (Figure 41). The thickness of each artifact was measured when it was laid on the most flattened portion, except for the cylindrical artifacts that do not have a flattened surface. The average thickness is 4.15 cm. The variation between the maximum and minimum thickness of all of the sample artifacts is small, only 3.1 cm.

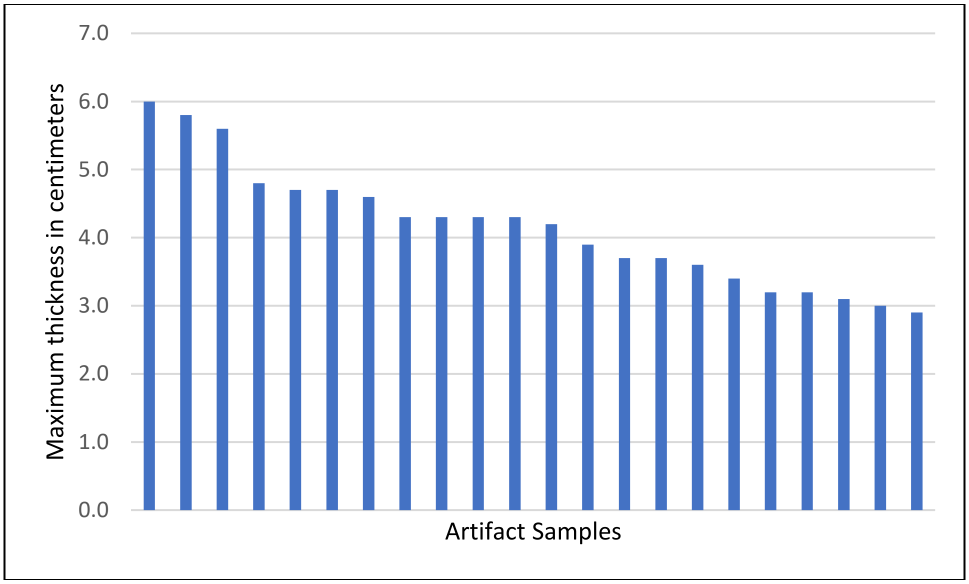


Figure 41. Thickness of the sample artifacts.

SHAPE

The shape of each artifact was described based on the curvature, cross-section, and form of the body and ends.

Curvature of the body - The overall curvature of the body of each artifact was categorized as either basically straight, curved and/or undulating. Thirteen (59%) of the artifacts have a basically straight body form (Figures 42 and 43) while nine (41%) have a visible curvature, especially when viewed on their sides (Figures 44-51). An undulating curvature was especially visible on Artifact #5 (see Figure 44).

Caldwell (2013:527) noted that the two New England cylindrical lithophones he studied also exhibited a noticeable curvature when viewed laterally, and he suggests that they may have been specifically designed with a curve to be played on a person's lap, where the curve gives them more stability. Several of the sample artifacts (#2, #3, #11, #12, #15, and #19), exhibit slightly curved-shaped bodies, especially when viewed on their lateral edges (see Figures 44-51). For the sample artifacts, it is not known if the curvature is simply a natural characteristic of the rocks or, in some cases, if a curved or undulating form was purposefully created during manufacture.

Figure 42. Artifact #1 showing a basically straight overall body form. Note: the two white marks with arrows show the acoustical node locations.

Figure 43. Lateral view of Artifact #20 showing basically straight body form.

Top view

Lateral view

Figure 44. Upper photo: Artifact #5 top view of the body. Lower photo: Artifact #5 lateral view showing overall undulating curvature.

Top view Side 1

Top view Side 2

Lateral view

Figure 45. Artifact # 6 showing both flatter top views; Side 1 exhibits a rough surface and Side 2 exhibits numerous peck marks and is more smoothed. The lateral view shows the overall curvature of the artifact and the different shapes of the ends from a side view.

Top view

Lateral view

Figure 46. Artifact #8 top and lateral views showing overall curvature.

Top view

Lateral view

Figure 47. Artifact #12: upper photo shows the rounded End #1 on the right, and the angled shape on End #2 on the left. Lateral view shows the basically straight form on the right half and the upward angled portion toward End #2 on the left.

Top view

Bottom view

Lateral view

Figure 48. Artifact #9 showing top, bottom and lateral views: the top is very rough without a $CaCO_3$ coating; the bottom view shows a heavy a $CaCO_3$ coating; and the lateral view also shows a $CaCO_3$ coating and how the artifact angles sharply upward toward the broken end.

Top and lateral view

Lateral view

Figure 49. Artifact #15 combined top and lateral view showing the rounded End #1 on the right, and the angled broken End #2 on the left. The lateral view shows the slight curvature of the body of the artifact.

Figure 50. Curvature toward End #2 (broken) on the left, Artifact #18.

Top view

Lateral view

Figure 51. Artifact #19 showing overall shape in top view (upper photo), and curvature in lateral view (bottom photo).

Cross-section shape - The cross-section shape was described as either cylindrical/rounded or oval and/or slightly flattened. This characteristic was discussed in detail in the previous section describing the three types of portable lithophones and their shapes. As noted above, only two of the artifacts, #1 and #13, are categorized as stone cylinders with a rounded cross-section on <u>both</u> ends (Figures 52), but two of the artifacts (#4 and #18), have a rounded cross-section on one end and an oval or flattened-oval cross-section on the other end (Figure 53-54). All of the other artifacts either have oval and/or flattened oval cross-sections on both ends (Figures 55-57).

Figure 52. Very rounded cross-section view of Artifact #13, End #2. This end appears to have been broken and then the edges ground/smoothed (it may be a fragment from a much longer artifact, similar to Artifact #4).

End #1 End #2

Figure 53. Example of two different cross-section shapes on a single lithophone, Artifact #4; End #1 is oval-shaped and End #2 is rounded.

End #1 End #2

Figure 54. Example of two different cross-section shapes on a single lithophone; Artifact #18. End #1 is rounded and End #2 is oval-shaped.

Figure 55. Oval cross-section of Artifact #10, End #2 (broken end). The “6” is a number marked by the collector.

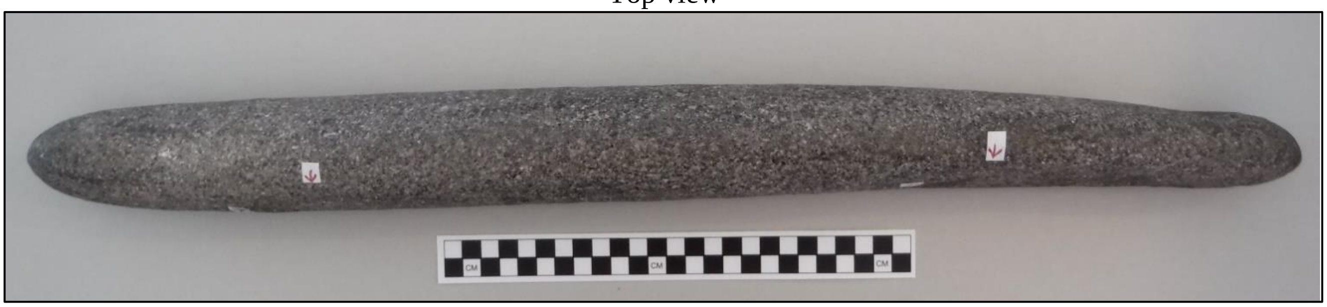
Figure 56. Flattened oval cross-section of Artifact #17, End #2.

Figure 57. Very flattened cross-section shape of Artifact #21, End #2.

Overall shape of the body and curvature - The overall shapes of the bodies of the artifacts based on the cross-section shape include cylindrical/rounded, and oval and/or slightly flattened, as discussed previously.

Tapering of the body - All of the artifacts exhibit tapering near the ends with exceptions on the broken ends of several of the fragments, for example #9, #10, #11, #13, #15, and #18. Because the actual ends appear to be missing on these fragments, the assumed tapering toward the broken ends is missing. The tapering on the complete specimens is either gradual or steep (Figures 58-59).

Top view



Lateral view

Figure 58. Artifact #4 showing tapering of the body toward End #1 on the right; not visible in the top view but very noticeable in a lateral view (bottom photo).

Figure 59. Lateral view along the length of the body of Artifact #22 showing tapering from End #1 (on the bottom of the photo) toward End #2 (on the top of the photo).

Concave or flattened areas on the body - Six artifacts (#2, #3, #7, #19, #20, #21, and #22) have a smoothed/concave or flattened area on the center of the body (Figures 60-61). This appears to be intentional; the reasons are unknown but it may be related to use of/playing of the artifact.

Figure 60. Artifact #3 showing slightly indented area in the middle of one side of the body. This area exhibits striations and scratches.

Figure 61. Artifact # 19 showing indented area on the body or the artifact. This area is deeply pecked, ground, and polished on the upper surfaces.

Rough areas - Eight of the artifacts (#2, #3, #5, #6, #7, #8, #9 and #10), exhibit some roughened areas on the body of the artifact. A rough surface is especially evident on #5, #6 and #9 (Figures 62-63). These roughened areas may be remnants of the original form of the rocks that were simply not ground smooth. This rough surface may have been intentionally left on the artifact to allow them to be more resonant if played with friction.

Figure 62. Rough surface on one side of the body of Artifact #6. Some areas exhibit peck marks but the remainder was left basically unaltered, with some evidence of grinding on the higher surfaces.

Figure 63. Rough surface on one side of the body of Artifact # 9. The edges have been roughly shaped and pecked.

SURFACE TREATMENT AND CHARACTERISTICS

The surface treatments and characteristics of the artifacts are quite varied and include polish, grinding/smoothing, incised marks, recent impacts, residue, and pecking. These treatments and characteristics were described for each artifact and photo-documented where possible.

Polish - Sixteen of the 22 artifacts exhibit evidence of polish on portions of the body and/or ends of the artifacts. One artifact, #1, exhibits polish over the majority of the entire artifact including the body and the ends. Many of the artifacts exhibit polish on the higher surfaces of the body (grains or projections) while the interstices, the spaces between the grains (Adams 2012:28), are not polished. Figure 64 shows the polish on End #1 of Artifact #21.

Figure 64. Highly polished End # 1 of Artifact #21.

Certain areas on the lithophones may have been intentionally or unintentionally polished during production of the artifact, during use, or possibly some polish may have been created during transport of the artifact. For example, the ends may have become polished if the artifact was transported vertically in a leather bag,

Grinding/smoothing - All of the sample artifacts have at least some evidence of grinding and/or smoothing, likely to shape/tune the artifact and/or could have been created during use (Figure 65). For example, evidence of grinding or smoothing may have been created if the artifact was struck or rubbed with friction with a hard percussor.

Figure 65. Artifact # 15 top view with an area that shows evidence of grinding/smoothing (darkened area on the lower left edge of the artifact).

Incised marks/lines - One of the artifacts (#16) exhibits distinct incised marks (lines) near one end. An additional artifact (#17) has several potential incised lines near End #1. Descriptions of these lines are detailed below.

On Artifact #16, there are seven distinct, separated, incised cut lines located within 13 cm of End #1 (Figure 66). These cut marks are perpendicular to the long axis of the body of the artifact. The lengths of the cut lines are: 1.46 cm, 1.1 cm, 1.32 cm, 1.03 cm, 1.07 cm, 1.59 cm and 1.68 cm; the width varies from approximately .5 to 1 mm, and they are approximately 1 mm in depth below the surface. Viewed under a hand lens, the lines are U-shaped in cross-section. Several of the cut lines are filled with $CaCO_{3,}$ suggesting that they were not recently-produced and were filled over a long period of time, likely when the artifact was located in damp sediments.

It is not known what could have produced such straight and even lines in a very, very hard material. The lines would have had to have been produced by another material that was harder than the rock itself, perhaps something like quartz crystal or another very hard material with a knife blade-like edge. It is possible that this artifact was utilized as an anvil and that the incised lines were created when another object was being cut with a very hard and sharp object.

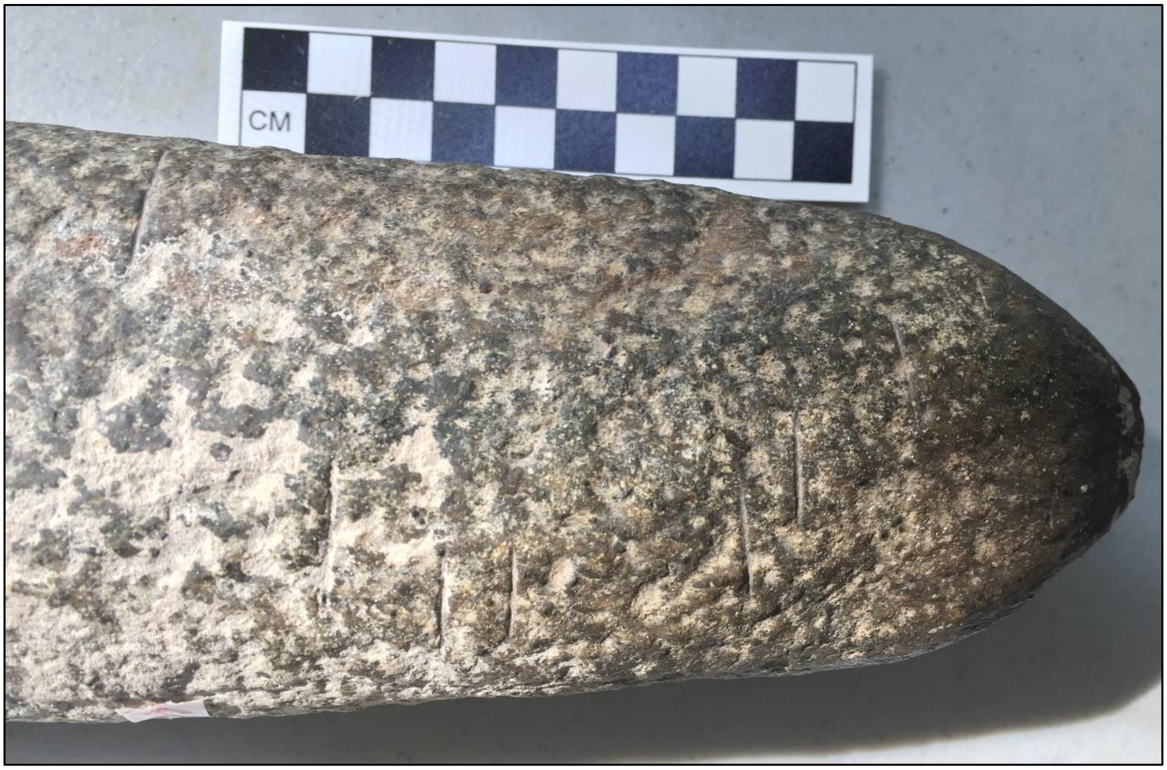


Figure 66. Artifact #16, End #1 showing incised lines. Note that several of the lines have $CaCO_3$, within the interstices.

On Artifact #17, End #1, there are four potential incised lines: 2.8 cm, 3.4 cm, 3.4 cm, and 3.5 cm in length; and 3-4 mm apart from each other (Figure 67). The lines are at a slight angle perpendicular to the long axis of the body. The end of the line closest to the tip end of the artifact is 1 cm away. Four additional similar, but less pronounced lines, are located between the more pronounced lines described above and End #1. These lines are parallel to the deeper lines. From the tip, the less-pronounced lines are 1.2 cm, 1.8 cm, 2.2 cm, and 2.8 cm in length. They are very shallow and appear to have been ground. Another probable incised line (slightly curved) crosses the ends of each of the other lines and extends along the long axis of the body near the edge for a length of 5.5 cm.

The purpose of these incised lines in not known; perhaps they are an individual's identification marks, marked certain events/years/ceremonies, or possibly were made to create a rasp-like sound if the end was played with friction. Brown (2014:62) notes that of the 42 kiva bells that she examined, 2 were decorated with an incised interlocking diamond design.

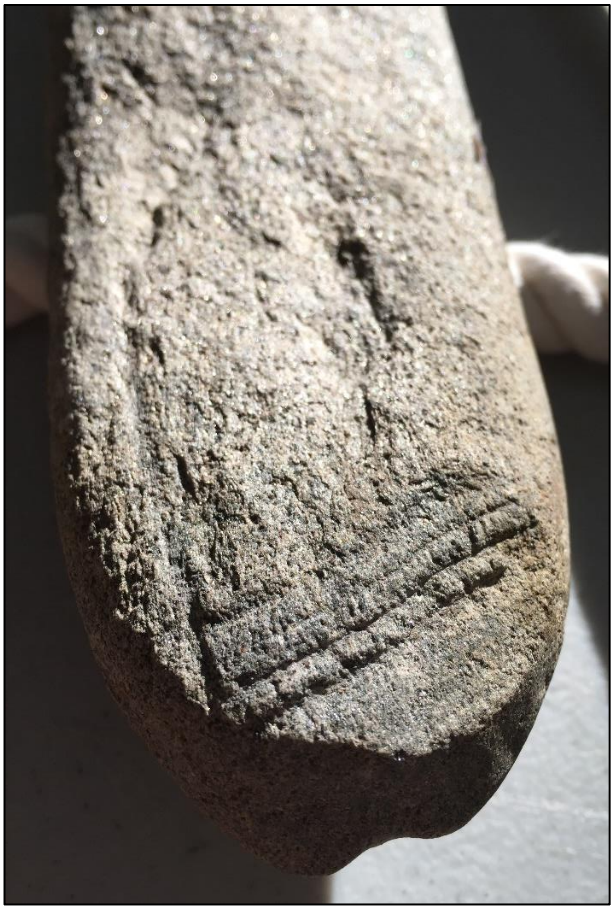


Figure 67. Two views of potential incised lines on Artifact #17 End #1.

Striations - Striations are visible with the naked eye or using a hand lens on 6 of the artifacts (#3, #14, #16, #20, #21, and #22). Some of these striations appear random and may have been produced post-collection of the artifact. Others appear in certain locations on the artifact and may have been produced during the use/playing or transporting of the lithophone. For example, Artifact #3 exhibits numerous striations in the surface of the slightly deeper/concave area on the body of the artifact (approximately 3 cm W x 10 cm L). This area exhibits numerous linear striations (Figures 68-69) ranging in length from .5 to 1.5 mm, and approximately 1 mm apart along the length of the body. There are also a very few other lines that are parallel to or at angles to the main striations. Detailed descriptions of striations on the ends of the artifacts are discussed under the section entitled "Shape and surface descriptions of the ends of the artifacts" on page 76.

Figure 68. Overview of the body on Artifact #3 showing the slightly-indented area that exhibits no peck marks. See Figure 69 below showing a close-up of this area.

Figure 69. Close-up of striations basically parallel to the length of the body on Artifact #3 in the indented area on one face visible in Figure 68. Also visible are fine, variously-angled scratches in this area.

Recent marks and impacts - A number of recently-made marks or impacts are visible on several of the artifacts and include artifact accession numbers and marks applied by collectors, marks from farm machinery, dark-colored areas from the 2005 or 2008 $CaCO_3$ analysis, and other recent-looking scratches/striations.

For example, on #16, there are three gouge marks on the body from the farm chisel that dug up the artifact (Lyn Bogle: personal communication 2016). One is on the surface of the body and the other two are close together on one of the lateral edges (Figure 70). These chisel-marks are basically tear-drop shaped and range in length from 3.5 to 4 cm, 1 to 1.5 cm in width, and up to .4 cm in depth.

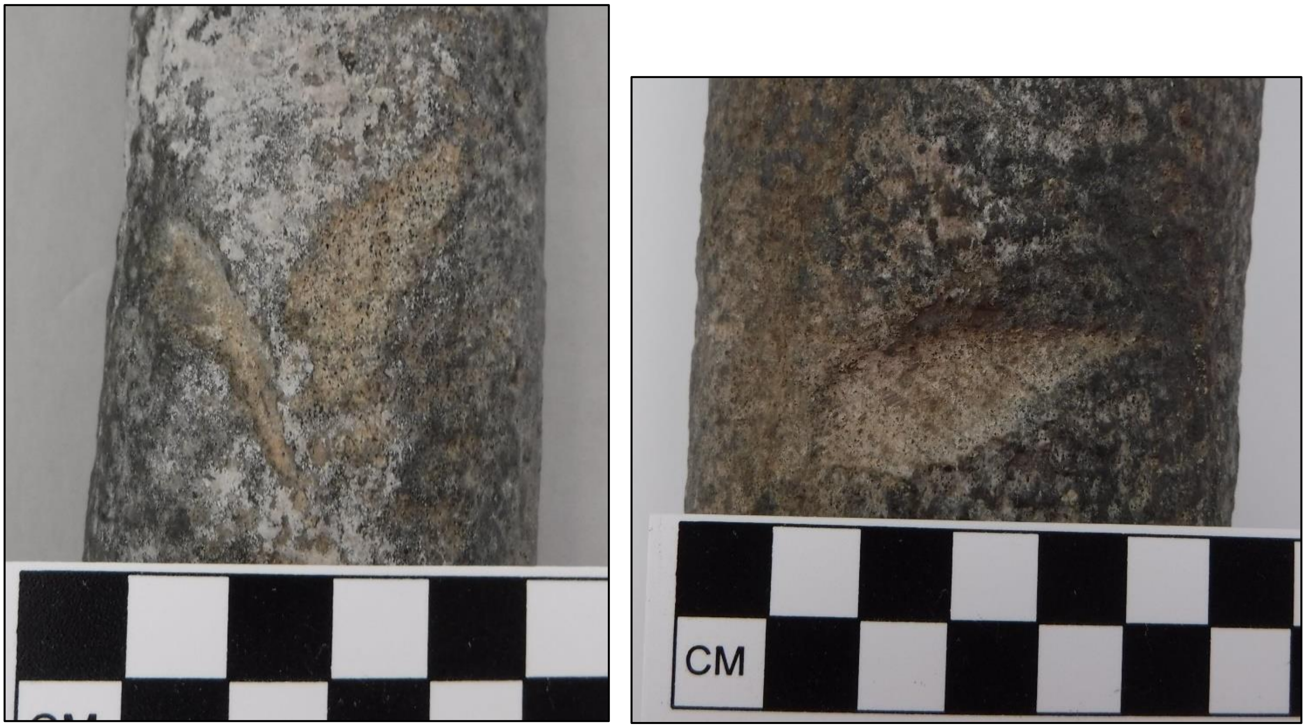


Figure 70. Recent farm chisel marks on the body of Artifact #16.

Artifact accession marks include identification numbers (usually marked in white), and numbers/marks applied by collectors such as Ray Lyons and Jack Williams (Artifact #2, #7, #8, #10, #11) that are usually marked in black (see Figure 55).

Other small random-appearing scratches may have been made in the past during use or manufacture of the artifact, or in some cases more recently during handling, transport, or storage.

Several of the sample artifacts were tested for $CaCO_3$ with drops of diluted hydrochloric acid in 2005 and/or 2008 (Rhodes 2005 and Dominguez 2008). The testing produced dark spots on the body of the surfaces of the artifacts. Exactly which artifacts were tested is not clear; however, based on a photo of sample artifacts #6 and #7 from the Rhodes (2005) PowerPoint, Slide #3, it clearly shows black smears on the body surfaces of those two artifacts. Compared to viewing the artifacts today, the smears shown in that photo appear to have faded on Artifact #6 through time, but there is still a visible black stained area on the body of Artifact #7 that could be a remnant of that testing.

Residue - Residue was visible on a number of the artifacts and includes probable applied residue (such as ochre), natural residue including $CaCO_3$, and possibly clay or other natural residue from sediments where the artifacts were found. Residue such as smearing related to use of bone, antler, wood or other soft percussors was considered when closely examining the sample artifacts, but none was definitely identified visually. However, this type of residue may possibly be specifically tested for in the future or identified with the use of a microscope or through chemical analysis.

Applied residue

The artifact most likely to have an applied residue is #6 (Figure 71). The surface of the body of this artifact (about 6 cm wide) near End #2 is rough but a number of peck marks are visible in this area. A visible reddish-orange residue is embedded in the lower interstices of this roughened area and this residue appears to be an applied pigment such as ochre. The residue is concentrated to about 5 cm from the End #2 but smaller areas exhibit pockets of residue to about 12 cm from the end. Another area with orange colorations is located from the center of this same face and extends toward End #1. The origin of this latter color is not known; it could be ochre but it also could possibly be a natural part of the stone or sediments.

Figure 71. Artifact #6, End #2 showing probable applied residue (red ochre).

Brown (2014:62) noted that of the 42 kiva bells that she examined, 5 retained red or yellow ochre in the rough areas. The likely ochre on Artifact #6 may have been applied for a purpose similar to those kiva bells, although the exact reasons for applying ochre is not known.

Natural residue

Artifacts with surface-visible natural residue that in most cases is likely a $CaCO_3$ coating, include #3, #5, #9-#11, #13, #16, #18, #19, and #22 (Figures 72-74). $CaCO_3$ is very common in the sediments of the SLV, especially near lower areas and locations that have once had surface-standing water. The $CaCO_3$ leaches out of the soils when it is saturated and then dries. There is so much white residue on the ground in certain locations in the SLV that it looks similar to snow from a distance (Martorano 2017: personal communication). If an artifact was left lying in these types of sediments over a long period of time, the $CaCO_3$ likely adhered to the surface and interstices on the artifact surfaces, and when exposed to air, remained as the hardened residue that is visible today.

Figure 72. Artifact #1, close-up view of the body of the artifact showing likely $CaCO_3$ coating possibly mixed with clay or other sediment in and between the peck marks.

Figure 73. Artifact #3 view of the body showing a thick layer of probable $CaCO_3$ in the interstices of the numerous peck marks. Note: the black smear near the end on the left is likely from previous testing for $CaCO_3$.

Figure 74. View of the center of the body of Artifact #5 showing the $CaCO_3$ on each lateral edge.

On Artifact #5, the peck marks on the surface of the body are highly visible since they are in a black rock and many are also filled with $CaCO_3$. The layer of $CaCO_3$ is very thick on both lateral edges, extending to both the top and bottom surfaces along the edges. The fact that the center of both the top and bottom surfaces are not heavily covered with $CaCO_3$ (see Figure 74) suggests that the artifact was possibly utilized or pecked after it was covered with the $CaCO_3$, or it was lying near the top of an uneven wet surface covered with large amounts of $CaCO_3$ that adhered to only parts of the lower surface of the artifact.

Artifact #16 has a gray to whitish residue coating that is visible in a few areas of the body and the lateral edge; probably $CaCO_3$. End #1 also has whitish residue in the lower areas (interstices) of the surface, and as mentioned above, there is probable $CaCO_3$ within the incised lines on this artifact.

Peck marks - Peck marks are visible on every one of the sample artifacts. They range in width from 1 to 5 mm. Some are very closely and evenly-spaced and consistent in size (Figures 75-76). Other peck marks are not regularly-spaced and vary in size, depth and placement, for example Figure 77. As mentioned previously, some of the peck marks stand out and are individually visible to the naked eye because they were made in a dark-colored rock and oftentimes are filled with white residue ($CaCO_3$).

On the lateral edge of Artifact #12, there is a cluster of peck marks and a single separated line of peck marks that is oriented perpendicular to the long axis of the body (Figure 78). The purpose of this pecking is not known unless it could possibly be related to a musical function - for example, for playing the artifact with friction.

Some of the larger artifacts are covered with many hundreds of peck marks (especially artifacts #4, #5, and #16) which exhibit peck marks on all surfaces of the body. The peck marks are most numerous on the bodies of the other artifacts, but the lateral edges of the non-cylindrical artifacts also are often heavily pecked.

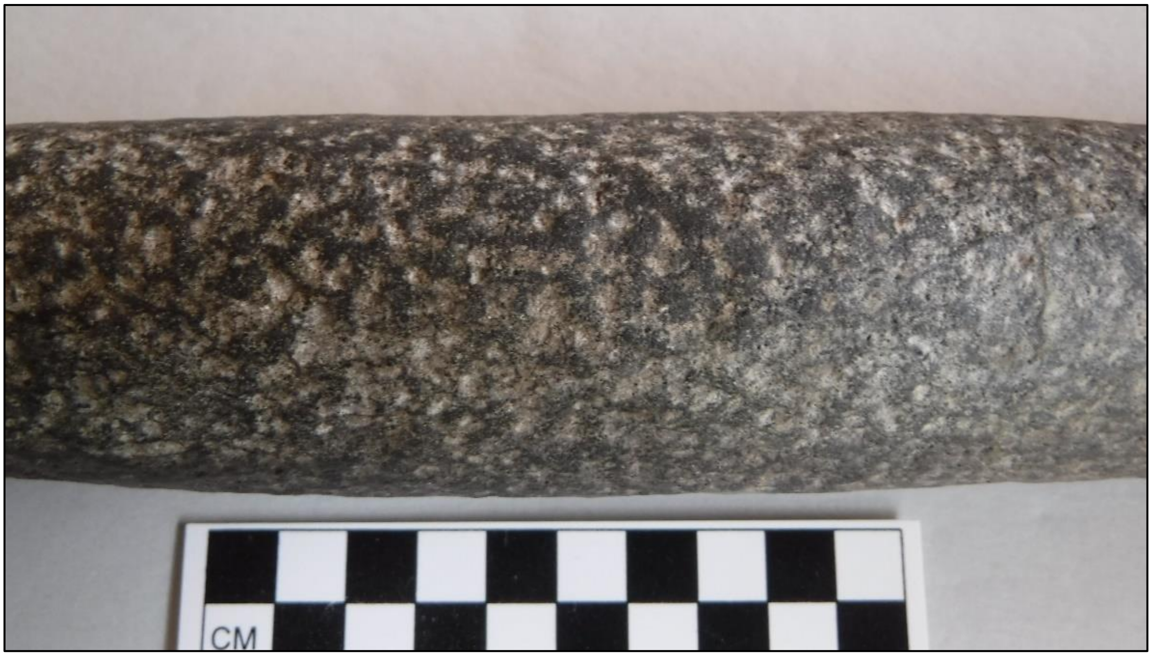


Figure 75. Close-up of the body of Artifact #2 showing the numerous, closely-spaced peck marks.

Figure 76. Close-up view of the body of Artifact #4 showing the numerous, very closely-spaced peck marks and fine, even shaping.

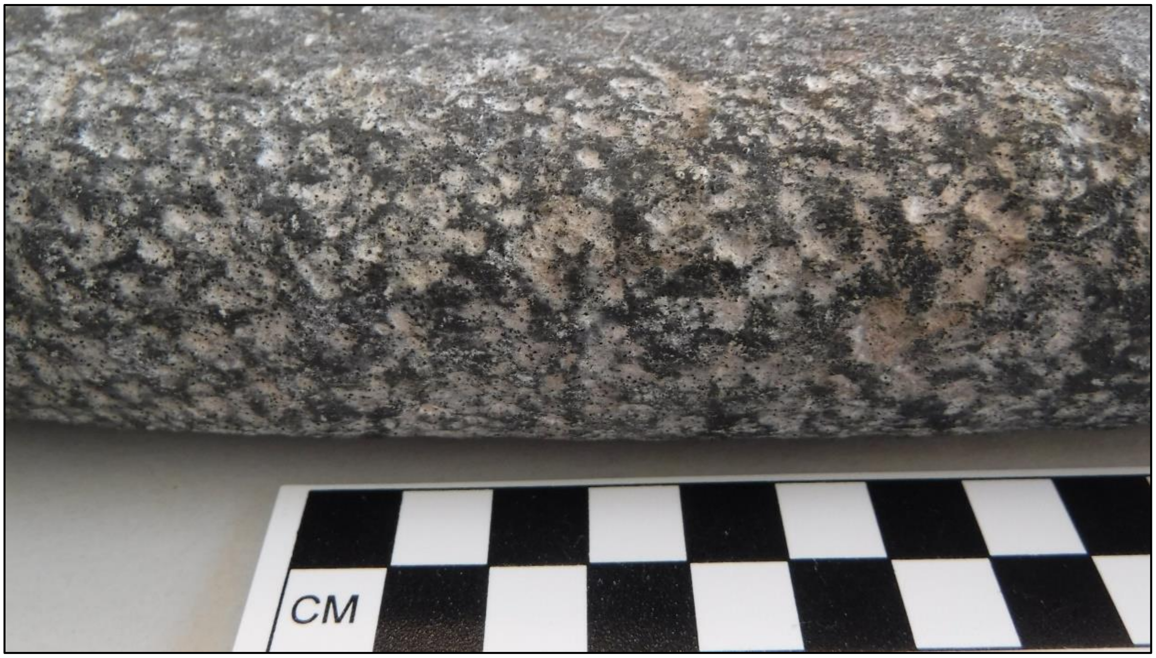


Figure 77. Artifact #7 showing heavy pecking (various-sized marks) on the lateral edge.

Figure 78. A cluster of peck marks and a single separated line of peck marks on one lateral edge of Artifact #12.

SHAPE AND SURFACE DESCRIPTIONS OF THE ENDS OF THE ARTIFACTS

The shapes and surface descriptions of the ends of the sample artifacts widely vary and are discussed below in detail (Table 5). This shaping likely has relevance regarding manufacturing techniques, methods of producing the musical sounds, and desired musical sound characteristics. The overall forms and surfaces of the ends of the sample artifacts are highly varied and complex. Very few of the artifacts exhibit two ends that are physically the same shape and/or have the same surface treatments/characteristics.

Table 5. Shape and surface descriptions of the ends of the sample artifacts.

Artifact sample #	End #1 description	End #2 Description
1	End #1 is tapered toward the tip, beginning about 5 cm from the end. The tapered area is ground, smoothed and polished, especially on the side with the orange-tan coating. The opposite side is rougher but the upper exposed higher surfaces are ground and polished. The tip of End #1 tapers to a slight rounded point.	End #2 also tapers approximately 5 cm from the tip but is wider overall than End #1. End #2 is slightly flattened at the very tip; this area is approximately 1.5 cm across. One small (3 cm x .5 cm) roughed area is located on the body 9 cm from End #1.
2	End #1 is sharply tapered into a beveled-shaped end with one edge angling 25 degrees toward the tip from 3 cm toward the body. The surface of the tip is uneven, rough and sharp in overall shape and texture. The very tip exhibits some polish. Very small (< 1 mm) shiny, polished black phenocrysts are visible scattered on the surface at the End #1.	End #2 is slightly tapered (from about 4 cm from the tip) to a gently-rounded shape. A very small area, about 1 cm long, is smoothed at the very end; the remainder of the end is roughly-shaped with additional black phenocrysts visible on the surface.
3	End #1 is slightly and gently tapered to a rounded end with a small, slightly pointed, off-center tip. The end exhibits a small rough section (1.2 cm in size) adjacent to the tip. In side view, the end is gently beveled from two sides and there is evidence of $CaCO_3$ almost to the tip.	End #2 is evenly rounded without a sharp tip and is less tapered than End #1.
4	End #1 is tapered beginning about 1.5 cm from the end and extends to a ground, rounded end with a slightly pointed tip (top view). The end is gently beveled from both sides in side view. There is no visible polish.	End #2 is similar to End #1 but is slightly more rounded and is more gently-tapered to the end.
5	End #1 gently tapers from about 5 cm out to form a v-shaped, beveled end (side view) with a slightly rounded tip (top view) about 1 cm across. The phenocrysts on the surface make the ends fell smooth.	End #2 gently tapers from about 6 cm out to form a rounded u-shaped tip (top view).
6	End #1 tapers from about 3 cm out to form a round end with a slightly pointed off-center tip. The tip is smoothed but not polished.	End #2 tapers from about 4 cm out to form a more flattened and rounded tip that is off-center and angled opposite of End #1. It is very thin at this end and is unevenly beveled at the tip in side view. End #2 has been smoothed but not polished.
7	End #1 gently tapers to a rounded tip with a very slight bulb at the tip. Phenocrysts with lines extending along the length of the body are visible from where the End #1 begins to taper to the tip (ca. 3.5 cm out).	End #2 gently tapers to a rounded tip but has no bulb. Phenocrysts with lines extending toward the tip extend from where it begins to taper, 4 cm out from the end.

Artifact sample #	**End #1 description**	**End #2 Description**
8	End #1 gently tapers to a rounded but roughened and slightly flattened end; no smoothing or polish is visible on the end.	End #2 is basically flattened but very rough; no polish or smoothing is evident
9	End #1 is tapered to a round end with flattened edges. The very tip is sharply beveled from both body faces. Very small phenocrysts (<1 mm) are visible with linear patterns following the length of the body from about 4 cm to the end.	End #2 is the broken end that exhibits a rough uneven break exposing the platy nature of the interior of the rock. No residue is visible on this end.
10	End #1 tapers gently into a rounded end that is beveled in side view.	End #2 is broken and rough with some of the higher areas showing slight smoothing. The end view depicts the platy nature of the interior of the rock, similar to Sample #9.
11	End #1 gently tapers to a rounded end with a 1 cm-wide flattened area at the tip.	End #2 appears to have been broken almost straight across the body. The surface of this break is rough with some possible light smoothing on portions of the perimeter of the end.
12	End #1 is located at the end of the curved portion; this end exhibits stepped flaking or use-wear battering on both faces leaving a ridge (ca. 3 cm across) at the tip. This ridge exhibits evidence of battering but is slightly smoothed. The flaked areas adjacent to the ridge extend toward the body approximately 1 to 1.7 cm.	End #2 tapers gently with the tip slightly rounded in shape. The very end exhibits evidence of battering. It is a roughened oval-shape 1.8 cm W x 3 cm L.
13	End #1 is gently tapered to form a rounded tip that exhibits a small flattened area on the very tip (ca. 1.2 cm L) that is smoothed.	End #2 is roughly-shaped and angled (ca. 18 degrees) with the high spots and exterior edges rounded and slightly polished.
14	End #1 gently tapers into a rounded tip with an upside-down V-shape, beveled from both sides in side view. The tip end exhibits two shallow notches but the very tip is smoothed. The lateral edges and the body exhibit blackened, smoothed and polished surfaces (some with striations) extending from up to 8 cm out from the tip. One highly polished area is nearly rounded in shape (ca. 3 cm across) and exhibits striations extending parallel to the body. One surface of this end shows probable plow or machine scar marks.	End #2 is gently tapered and ends in a more flatter-shape. An oval area (ca. 4.5 cm L x 3 cm W) around the end exhibits smoothing toward the tip end which exhibits battering in an area 1.5 cm L x 1 cm W.
15	End #1 tapers gently toward a rounded-shaped end. It is gently beveled from two directions (side view). This end is not smoothed or polished and black phenocrysts on the surface make it appear roughened.	End #2 exhibits an uneven angled break with a rough surface and edges.
16	End #1 tapers from ca. 4.5 cm of the end to form a basically rounded shape with a slightly flattened tip (ca. 1.5 cm across). The tip forms an upside-down V-shape in side view and is steeply beveled on both sides. Linear striations are visible from about 6 cm out from the end along the long axis of the body extending to the end. Similar to the body, small black phenocrysts are visible on the surface but have also been flattened and polished. The end also exhibits a darkened appearance where it tapers toward the end (ca. 5 cm from the tip).	End #2 is similar in overall shape to End #1 except that it is slightly more pointed in shape in top and side views, and the tip end (ca. 1.5 cm across) is rough rather than rounded and smoothed. A rounded lip that is polished is also located on one side of the body. The other body side of this end also exhibits linear striations ca. 4 to 5 cm from the tip. This tapered area has a darkened appearance.

Artifact sample #	End #1 description	End #2 Description
17	End #1 gently tapers to a rounded tip with one indentation in the middle. The tip, ca. 1 cm from the end, steeply tapers to a ridge at the very tip. This area exhibits smoothing but no polish. The side view of this tip is a short, steep, upside-down V-shape, beveled on both sides. On the flattened body side adjacent to End #1 are four incised lines: 2.8 cm, 3.4 cm, 3.4 cm, and 3.5 cm in length; and 3-4 mm apart from each other. The lines are at a slight angle perpendicular to the long axis of the body. The end of the line closest to the tip end of the artifact is 1 cm away. Four additional similar, but less pronounced lines, are located between the more pronounced lines described above and End #1. These lines are parallel to the deeper lines. From the tip, the less-pronounced lines are 1.2 cm, 1.8 cm, 2.2 cm, and 2.8 cm in length. They are very shallow and appear to have been ground. The purpose of these incised lines in not known; perhaps they are an individual's identification marks or possibly made to create a rasp-like sound if played with friction. Another probable incised line (not straight) crosses the ends of each of the other lines and extends along the long axis of the body near the edge for a length of 5.5 cm.	End #2 is thicker than End #1 but the tip is shaped in a similar manner to End #1 except that there is no indentation. It is also steeply beveled to the tip in side view. End #2 shows more evidence of smoothing. A probable plow mark is located on the edge near End #2. It is a gouge 1.5 cm x .6 cm.
18	End #1 tapers steeply (from about 1 cm of the end) into a cone shape with a fairly sharp point at the end. The entire end is not smoothed or polished and small black phenocrysts (similar to Sample #2) are visible on the surface making it feel rough.	End #2 is the broken end. The break is 11 cm long with a long-oval shape; angled at 30 degrees from the body. The broken end exhibits very sharp edges suggesting that the break was recent or at least was not reused/reworked.
19	End #1 tapers steeply from about 2.5 cm of the end to a slightly rounded smoothed tip. It is basically cone-shaped. The very end of the tip (.5 cm wide) has been flattened.	End #2 is similar in form to Sample #11, End #2. It is a roughly-flattened surface that exhibits some smoothing on the higher edges. It possibly represents a break from a longer artifact. Some reddish-brown sediments remain on the surface along one edge close to End #1; possibly an applied residue (?)
20	End #1 only slightly tapers as it angles and flattens into an almost squared-off angled end. The tip end is angled toward one edge and is rounded, smoothed and polished. One edge exhibits evidence of battering and is a roughened, broken area.	End #2 tapers into a more rounded end (top view) and is an angled upside-down V-shape (beveled in both directions in side view) at the tip. This end exhibits a steep angle in the opposite direction of the other end. Smoothed linear striations (parallel to the long axis of the body) are visible at the end, 1.5 cm to 10 cm out from the tip. The striations and polish are visible on the tip end and along both margins of the body but not on the two flat body surfaces.

Artifact sample #	End #1 description	End #2 Description
21	End #1 tapers steeply from approximately 2.5 cm of the end to a cone-shaped tip end. The very tip end is flattened and ca. 1 cm across. This tip is roughened but has been smoothed. Similar to Sample #20, End #2, there are linear striations parallel to the body extending from 1.5 cm near the end to over 6 cm out along the edges. Like Sample #20, End #2, the striations on #21 do not extend from the end over the flattened body surfaces. These body areas on #21 are highly polished.	End #2 is gently tapered to a rounded tip (top view) and is beveled from both directions to a ridge (side view). This end exhibits polished linear striations at the end and along the sides similar to End #1 but is a little less pronounced.
22	End #1 tapers steeply (2 cm from the end) to form a cone-shaped tip. The end is highly polished and exhibits striations parallel to the long axis of the body.	End #2 tapers gently to form a more rounded/flattened end (top view and side view). It exhibits smoothing and polish but less than End #1. It also exhibits striations parallel to the long axis of the body.

Shapes of the ends

The shapes of the ends of the sample artifacts vary considerably. They vary not only in overall shape from lithophone to lithophone, but the two ends of individual complete lithophones most often are different from each other (Figure 79). The shapes of the ends also vary depending on how they are viewed: from a top view, side/lateral view, and end view (Figures 80-81).

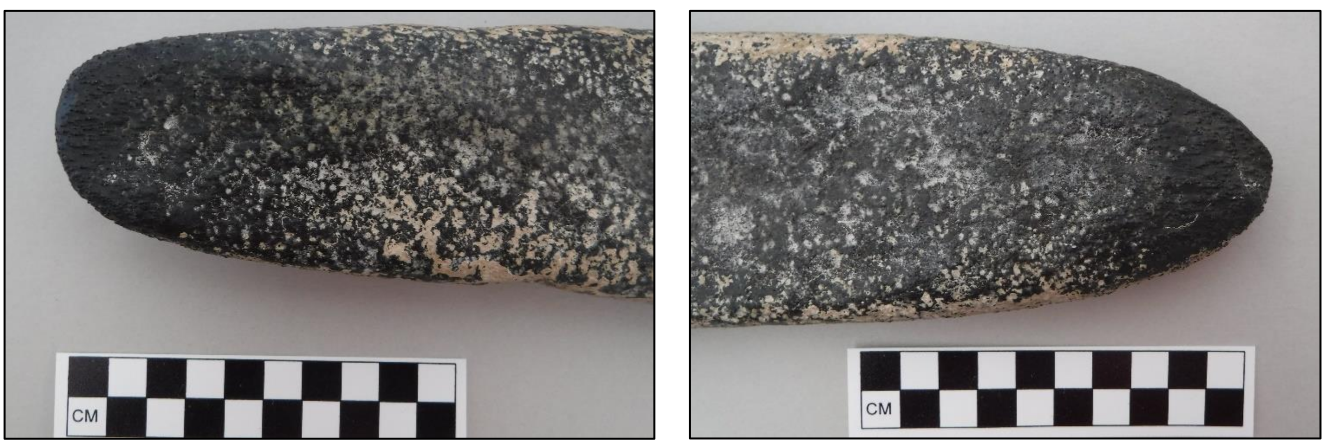
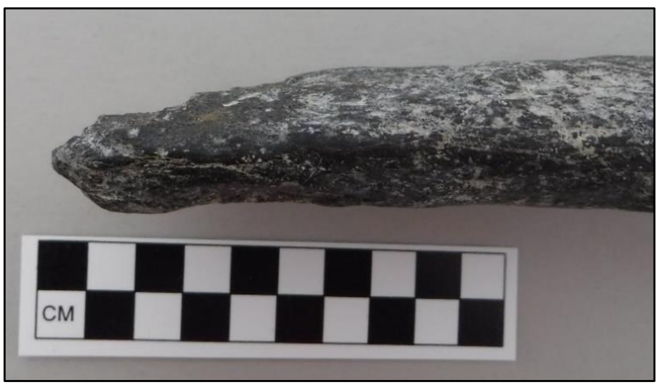


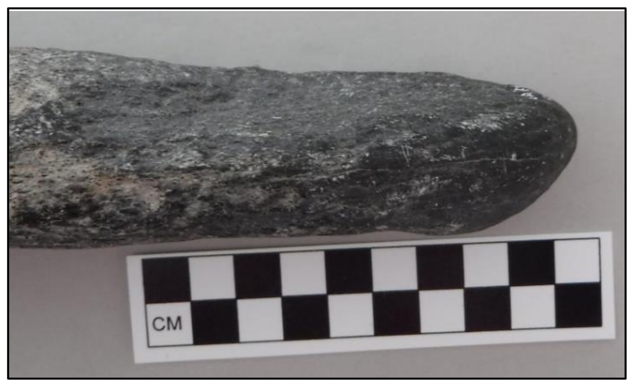
Figure 79. Artifact #5 top view of different shaped ends on a single lithophone. End #1 on the right is more pointed, and End #2 on the left is much more rounded in shape.

End #2 top view

End #1 top view



End #2 lateral view

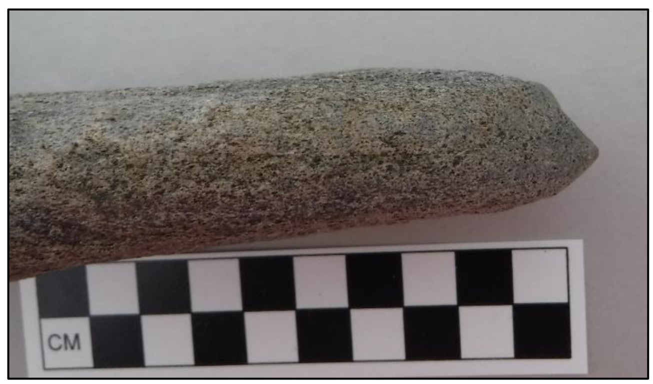


End #1 lateral view

Figure 80. Artifact # 6 showing top and lateral views of both ends. Note the different shapes of the ends.

Top view

Lateral view



Close-up lateral views of both ends

Figure 81. Artifact #17 showing top and lateral views, and close-ups of both ends showing varied shapes depending on viewpoint (top or lateral).

The shapes of the ends of the complete sample lithophones can be described with the following individual descriptive terms and are discussed in more detail below.

- Tapered
- Beveled
- Conical
- Rounded
- Pointed
- Flattened
- Bulbous
- Angled

Note: sometimes several of these descriptive terms can be applied to a single end, for example, End #1 on Artifact #11 "gently *tapers* to a *rounded end* with a very small *flattened area* at the tip."

Six of the artifacts exhibit one end with a break (End #2 of artifacts #9, #10, #11, #13, #15, #18 and potentially #19). Three of these artifacts, #9, #15 and #18 exhibit angled breaks that are rough and not ground. The additional four artifacts, #10, #11, #13, and #19 exhibit some evidence of light smoothing on the higher area and edges of the ends, suggesting they were utilized and/or ground after the artifact was broken.

Tapered - All of the complete specimens taper from the body toward the ends. Characteristics of the tapering include:

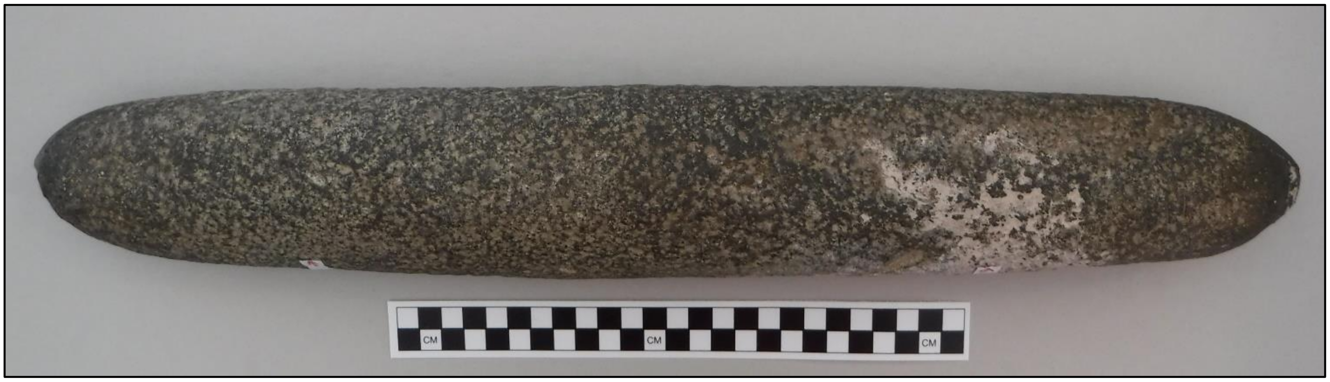
- Gentle tapering - most of the unbroken ends are gently tapered from ca. 1.5 cm to 5 cm out toward the tip.
- Steep tapering - several of the ends exhibit steep tapering within a short distance of the ends. Examples include End #1 of artifacts #18, 19, 21, and 22. These four artifacts also exhibit cone-shaped tips (see below). Artifact #2, End #1 tapers at a very sharp angle to one side (Figure 82).

Figure 82. Artifact #2 showing steep tapering toward End #1 on the right.

- Tapering to off-center tips – End #1 of Artifact #21 tapers to a slightly off-center tip. Ends #1 and #2 of Artifact #6 taper to off-center tips angled in opposite directions of each other (Figure 83).

Figure 83. Ends #1 and #2 of Artifact #6 showing tapering to off-center tips angled in opposite directions of each other.

Beveled - In side view, a large number of the artifact are also beveled towards the ends, usually from both sides (Figures 84 and 85). The following artifacts exhibit this type of beveling: #9, End #1; #14, End #1; #15, End #1; #16, End #1; #17, Ends #1 and #2; #20, End #2; and #21, End #2.



Top view

Lateral view

Figure 84. Artifact #16 overviews showing the shapes of the ends from different viewpoints. On the lateral view, note the beveled End #1 on the right; also note the slight upward curvature toward that end.

Figure 85. Beveled End #1 on Artifact #14.

Conical with a pointed tip - Other artifacts, as mentioned above, are a well-defined conical shape; End #1 of artifacts #18, #19, #21, and #22 (Figures 86-87). These artifacts have a pointed tip at the end of the cone-shaped end.

Caldwell (2013:526) noted that "Columnar lithophones also turned out to be most sonorous when their ends were conical or ogival (having a curved, pointed arch-shape), rather that flat or slightly bulbous, like the majority of pestles."

Figure 86. Conical end with a pointed tip on Artifact #18, End #1.

Figure 87. Conical End # 1 with a small slightly-flattened tip on Artifact #22.

Rounded - Many of the artifact ends are rounded (Figures 88 and 89); some with a more pointed tip end (Artifact #16, End #1), and others with a more flattened tip end that is rounded on the edges (Artifact #8, End #1; #11, End #1; #12, End #1; #13, End #1; and #16, End #1).

Figure 88. Top view of Artifact #20 showing rounded End #1.

Figure 89. Example of a more squared end that is rounded on the edges, Artifact #12, End #1.

Flattened - Other artifacts with broken ends exhibit a more flattened break at one end, for example, Artifact #11, End #2; and Artifact #19, End #2 (Figure 90). The majority of the artifacts have rounded or pointed ends. There are a few samples, that have an overall rounded or pointed end shape that exhibit a very small area on the tip that is flattened. For example, Artifact #21, End #1 exhibits a cone-shaped end with a very small, 1 cm-wide flattened area at the tip. Artifact #19, End #1 also shows a very small ground/flattened area at the tip (Figure 91)

Figure 90. Flattened End #2 of Artifact #19 showing evidence of light grinding and/or battering.

Figure 91. End #1 of Artifact #19 showing small flattened area and possible battering on the very tip.

Bulbous - Only one of the artifacts exhibits a slightly bulbous end at the tip; Artifact #7, End #1 (Figure 92).

Figure 92. Artifact #7, End #1 showing bulbous shape.

Angled - As noted above under the discussion of broken ends, three of the artifacts, #9, #15 and #18, exhibit angled breaks on one end that are rough and not ground. These artifacts do not appear to have been ground or reshaped/utilized after the break occurred.

<u>Surface descriptions/characteristics of the ends</u>

The surfaces of the ends exhibit a number of different characteristics including the following: grinding, smoothing, polish, rough areas, battering and step fractures, darkened areas, linear striations, residue, and phenocrysts.

Grinding and/or smoothing - The tapered areas of the ends often show evidence of light grinding/smoothing: Artifacts #1, End #1; #6, Ends #1 and 2; #11, End #2; #12, End #1; #13, End #1; #14, Ends #1 and 2; #17, End #1; #20, End #1; and #22, End #2.

Polish - Areas exhibiting polish are visible on a number of the ends in small areas: Artifacts #1, End #1; #2, End #1; #13, End #2; #14, End #1; #16, Ends #1 and #2; #20, Ends #1 and #2; and #22, Ends #1 and #2 (see example, Figure 64).

Rough areas - Areas that exhibit a rough surface are visible on the surfaces of the breaks and also on a few of the ends such as Artifact #3, End #1; #8, End #2; and #20, End #1.

Battering and step fractures - Battering and step fractures were not commonly observed on the ends except on a few artifacts: #12, End #2 on a small ridge at the very tip-end; #12, End #2 on the rounded end; #14, End #2 in a very small area (1.5 cm x 1 cm) at the tip; and #20, End #1 on one small edge. Figure 93 shows an example of battering on the tip.

Figure 93. Example of battering on the End #2 of Artifact #12.

Darkened areas - Darkening of the ends is visible on a number of the artifacts, especially #14, End #1, and #16, Ends #1 and 2 (Figure 94). The cause(s) of this darkening are unknown but could be related to how the artifacts were manufactured and/or utilized and/or transported. For example, if the artifacts were manufactured/shaped in a vertical position on some type of leather or other similar material, or were held with hands during shaping, the ends may have absorbed oils, etc. that darkened the rock. Or, if the artifacts were transported in a vertical position in a leather bag, the ends may also have been darkened and/or polished over time.

Figure 94. Darkened area at End #1 of Artifact #16.

Linear striations - Linear striations are visible on a few of the ends. Artifact #14, End #1 exhibits striations parallel to the long axis of the body; #16, End #2 exhibits striations 4 to 5 cm out from the tip; #20, End #2 shows striations parallel to the long axis of the body near and at the end; #21, Ends #1 and 2 exhibit striations parallel to the long axis of the body near and at the ends; and #22, Ends #1 and #2 exhibit striations in similar locations to Artifact #21. Figure 95 shows an example of the striations. It is not known if these striations are the result of use/playing or perhaps were created during manufacture/shaping of the artifact.

Figure 95. Striations extending parallel to the body from the tip of End #1, Artifact #16. Also note a few visible phenocrysts on the surface of the end.

Residue (applied and natural) – Residues, both applied and natural, exist on a few of the ends and were described above under the general discussions of residue on the body of the artifacts.

Phenocrysts - Black phenocrysts are visible with the naked eye on a number of the ends, especially in the tapered areas and toward the tips: Artifact #2, Ends #1 and #2; #5, End #1; #7, Ends # 1 and 2; #9, End #1; #15, End #1; and #16, End #1; and #18, End #1. Figures 96-97 shows examples of these phenocrysts; also see Figure 95 above.

Figure 96. Artifact #7, End #1 showing visible phenocrysts.

Figure 97. Artifact #15 showing visible phenocrysts on the angled portion of the End #1.

MATERIAL TYPES

Certain material types appear to be key to quality acoustical properties of lithophones (Caldwell 2013:524). He notes that "…lithophones were made of homogeneous rocks whose consistency was especially coherent since discontinuities interrupt the propagation of sound waves through the artifact." The lithophones identified and studied by Erik Gonthier from Africa (Caldwell 2013:523) were made primarily of chlorite-schists and schist-actinolites, with dolomitic limestone, amphibolites, quartizites, and smectites also represented. The two lithophones that Caldwell identified from New England were made of two different material types: a porous siltstone and a chloritoid schist (Caldwell 2013:528); and also produced slightly different acoustical tones, likely due to the different material densities. The most common material type of kiva bells studied by Dr. Emily Brown (2014) was basalt with other types included argillaceous limestone, phyllite, phonolite, and feldspar.

Based on a visual comparison, the material types of the sample artifacts utilized in this study appear similar to each other in some cases and highly varied in others. All of the artifacts exhibit what appears to be very dense materials and they are heavy for their size. The materials types have been generally described by geologist Andrew Valdez, NPS, and Dr. Richard Madole, emeritus United States Geological survey (USGS) geomorphologist, as basalts, andesite, granite and schist. A sample of the artifacts was also examined by Dr. Nigel Kelly and Dr. Richard Wendlandt of the Colorado School of Mines in Golden, Colorado in 2008 (Dominguez 2008).

In general, most of materials were identified by Dr. Nigel Kelly and Dr. Richard Wendlandt as possible low temperature metamorphics (<650º C); as schists with varying amounts of foliation (Dominguez 2008). Associated rocks included mica schist, chlorite, hornfels, and amphiboles, commonly bearing magnetite; harder mineral inclusions are staurolite, garnet, and andalusite.

It was noted by several of these professionals that freshly-broken surfaces were not available on any of the artifacts to facilitate proper visual identification of the material types. Therefore, the resulting identifications, for example, basalts, granites, schists, and andesites, are considered less precise than might otherwise be possible if fresh breaks were available. For that reason, material types were not assigned to each lithophone.

Detailed XRF chemical element analysis of each lithophone was also conducted by Dr. Linda Scott Cummings, Paleoresearch Institute (PRI), on July 13, 2017 at the PRI laboratory in Golden, Colorado (Figures 98 and 99). Ms. Martorano transported all the sample grant project lithophones to the lab and they were examined and analyzed by PRI staff utilizing a portable XRF instrument.

XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. XRF is a non-destructive analysis that results in a breakdown of the chemical elements making up a stone. The detailed results of this XRF analysis on the sample lithophones are included in Appendix C (in separately bound Volume 2), and Figure 100 depicts a summary of the results by element. This figure summarizes the combined averages by chemical element of three points sampled on each lithophone (at both ends and at a center point).

Although XRF analysis is much more precise than descriptions based on visual analysis, determining what the results of this analysis means regarding our understanding of lithophones is not clear. As visible on the graph (see Figure 100), the XRF results indicate very low or basically zero values for each element except for SI (silicon), AL (Aluminum), FE (iron), K (potassium), and CA (calcium). Silicon has a value nearly three times higher than the next highest value (aluminum). The value of iron was just slightly less than aluminum, and potassium and calcium were the next highest values after iron. All the other values were very, very low (<1).

Determining the meaning of these chemical element values as they relate to acoustical properties and actual materials types of lithophones is beyond the scope of this assessment grant. Hopefully, future work can use this data to help evaluate how the chemical elements and materials types of known lithophones can be used to answer questions regarding acoustical properties of different rock types and sources.

Figure 98. Linda Scott Cummings, PRI, and her assistant taking initial XRF readings to determine the chemical make-up of the lithophones.

Figure 99. Robert Varney, palynologist and paleoecologist for PRI, taking additional XRF readings to determine the chemical make-up of the lithophones.

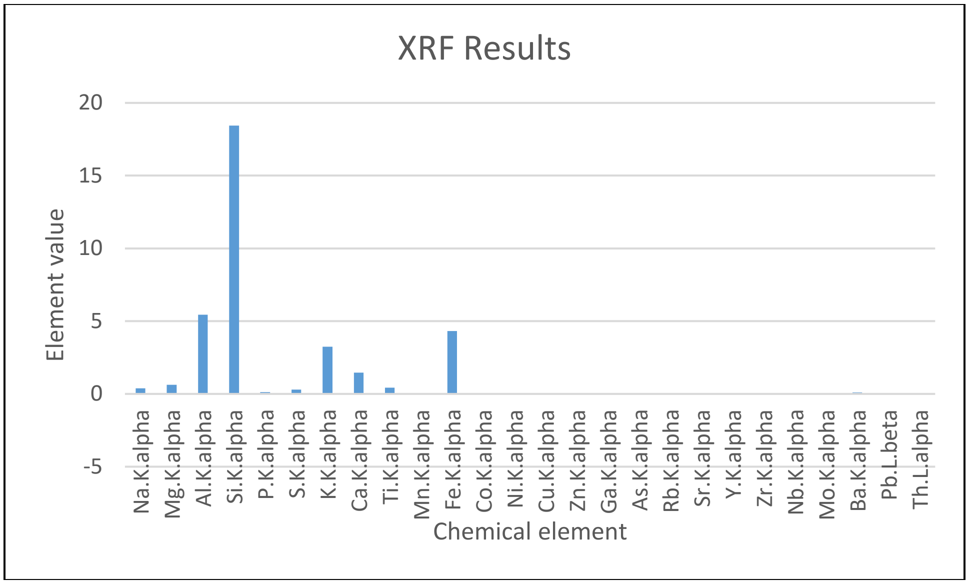


Figure 100. XRF chemical element values results based on the average readings at three points on each artifact (both ends and at a center point).

POTENTIAL LITHIC SOURCE AREAS FOR SAN LUIS VALLEY LITHOPHONES

This is a future project to determine the lithic source areas for the lithophones found at Great Sand Dunes and in the SLV, but a few potential ideas about sources that could have been utilized are discussed below:

- <u>Columnar volcanic rocks</u> from the western side of the SLV (Figure 101) or other similar types of rocks could possibly have been lithic sources for the SLV lithophones. A few representative samples of volcanic columnar rocks from this portion of the SLV are about 1½ to 2 feet long and have acoustical properties when tapped even though they are unmodified. It is possible that prehistoric peoples may have obtained similar rocks and played them either unmodified or may have formally-modified them.

Figure 101. Volcanic columnar rocks from the northwestern edge of the SLV.

- Rocks located in alluvial deposits from the northern portion of the SLV near Villa Grove (Figure 102) were found by a local resident, Jeff Shook. He noticed when he was digging holes in the alluvial gravels that certain rocks would hit each other and make musical sounds. Mr. Shook didn't know about lithophones but called these his **"**singing stones**"** and has collected a number of them for over the past 35 years.

  It is thought that prehistoric peoples could have also collected stones such as these and either created modified lithophones or utilized them unmodified, similar to kiva bells.

Figure 102. "Singing stones" found in alluvial deposits near Villa Grove (photo courtesy of Jeff Shook).

- For the specimens identified as schist in Dominguez (2008), three general areas in the vicinity of the Great Sand Dunes were identified as potential sources. A very likely source is a formation southeast of Blanca Peak, "Biotitic Schist, Gneiss, and Migmatite; … derived principally from sedimentary rocks" (Tweto 1979: Formation Xb). Another lies to the southeast of Blanca Peak and to the east of Great Sand Dunes, "Felsic and Hornblendic Gneiss; … either separate or interlayered" (Tweto 1979: Formation Xfh). A third lies to the east and northeast of Great Sand Dunes, "Granitic Rocks of 1700 Million Years Ago (M.Y.) Age Group" (Tweto 1979: Formation Xg).

DISCUSSION OF POTENTIAL GATHERING AND QUARRYING METHODS FOR LITHOPHONES

The toolstone sources utilized and methodology for obtaining toolstone for lithophones in the SLV and elsewhere in the western U.S. have not been determined. The lithophones studied for this project include both minimally-modified and extensively-modified rocks. The original geological context for these rocks is not known although potential sources were identified in the above discussion. Perhaps many of these rocks were obtained as individual natural stones, similar to those described as Kiva Bells (Brown 2014) and shown in Figure 26, but some of them could have also been formally quarried.

If rocks for lithophones were formally-quarried, exactly what extraction process was utilized is not known. It is possible that the process that has been documented to quarry and manufacture manos and metates in traditional ways by descendants of ancient civilizations in southern Mexico and Central America (Searcy 2011:50) may provide some clues to prehistoric lithophone stone tool quarrying and manufacturing methodology used to make formally-shaped lithophones.

In traditional Mayan cultures in Guatemala, metate/mano manufacturers called *metateros*, were observed by Searcy (2011) and the processes utilized to quarry and manufacture the manos and metates were documented in detail. The manos that Searcy documented are very similar in form to many of the lithophones. For example, they are made of volcanic stone and range in length from 23 to 27 cm in length x 5.6 to 5.9 cm in width. The manos were created from smaller stones or boulders found on the surface and roughed out (with squared edges) at the quarry area. Theses mano preforms were then transported to a separate work area where they were shaped into the final form using several different sizes of metal tools hafted onto wooden handles (Searcy 2011:50-51). A finished mano could be produced within about an hour by a skilled *metatero* (Searcy 2011:50-51).

One of the more interesting aspects of the process of making manos and metates by the Maya was how they determined if the stone had flaws. The *metatero* would test potential boulders for a number of important qualities (i.e., color and vesicular density) and included the testing for flaws by tapping specimens lightly and listening to the “ring” of the rock (Searcy 2011:36, 56-57). For example, one *metatero* tapped on four mano preforms with a piece of stone and the one mano with a perceived resonance that was different from others, was determined to have flaws (Searcy 2011:56-57). These flawed stone artifacts would not be sold at market since some consumers apparently also tested prospective purchases using this same technique.

This methodology of testing for flawed stone could also have possibly been utilized during lithophone stone selection, especially since the stones for lithophones were assumed to have been selected primarily for sound production. It is also assumed that the testing of resonance at the point of extraction or collection of potential lithophones would have likely been a very important part of the process.

ACOUSTICAL ANALYSIS

HOW DO LITHOPHONES MAKE SOUNDS?

The sound travels through a lithophone as sound waves when they are tapped or rubbed with friction. The way the sound travels is based on the physics of sound waves and how sound travels through various materials (Caldwell 2013):

- The sound waves travel in two sinusoidal curves that cross each other twice (Figure 103).

- Where the sound waves cross, shown by the yellow arrows in Figure 103 are called the **acoustical nodes or dull zones** and these are the only two spots where they can be held, suspended or laid on a rope or other material without muffling the sound.

- It is the **same concept as a modern marimba**; the photo in Figure 104 shows that the marimba pieces are also attached at the nodes/dull zones.

- The lithophones generally produce the best sounds when tapped between the acoustical nodes and the ends of the artifact or in the middle of the two acoustical nodes. If tapped on either of the acoustical nodes, the sound is muffled, or if the artifact is laid on a flat surface or held or laid anywhere except on the node locations, the sound will also be muffled.

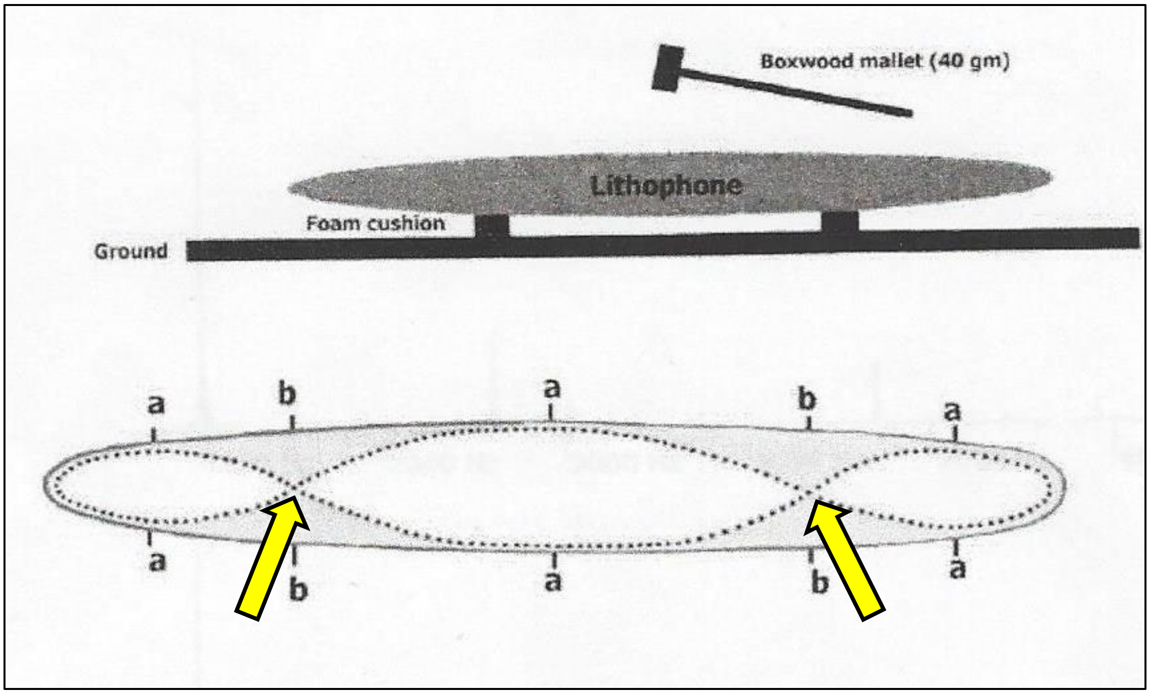


Figure 103. How sound waves travel in two sinusoidal curves through a lithophone (from Caldwell 2013:524). The two points depicted by the yellow arrows show where the waves cross and are called acoustical nodes.

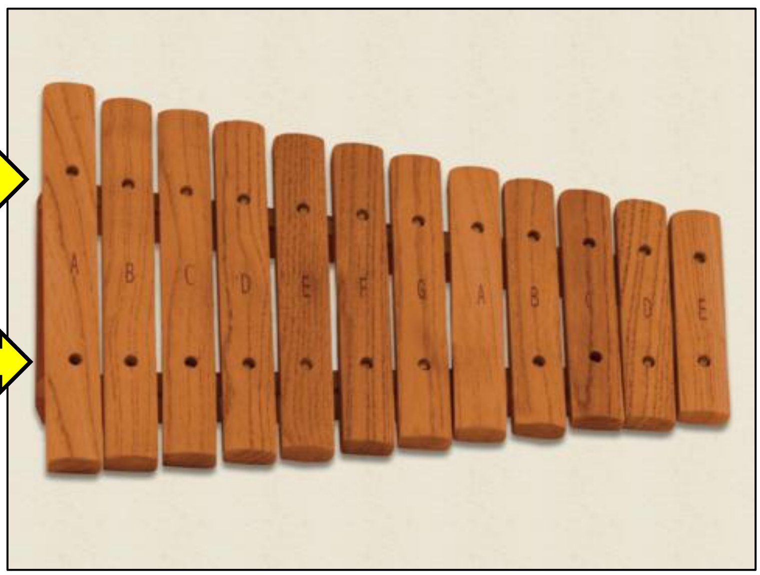


Figure 104. Acoustical node locations where the wooden pieces are attached to a modern marimba.

Not all rocks produce musical sounds – it depends on the type of rock and density of the material as well as the shape, length and width (Caldwell 2013):

- For example, rocks like sandstone do **not** produce musical notes because the material is not dense enough, but others like basalt, schist, granite, gneiss, and petrified wood can produce musical sounds. According to Caldwell 2013 and Brown 2014, the following materials can produce good acoustical sounds: Schists (chlorite-schists, schist-actinolites), basalt (including Jemez, New Mexico basalt), phyllite, gneiss, limestone (argillaceous, dolomitic), petrified wood, phonolite, feldspar, amphibolites, quartzites, and smectites. Note: also see discussion of Materials Types above.

- Artifacts with ends that are broken off or shaped straight across or are slightly bulbous at the ends (like many pestles) do not make good acoustical sounds.
- Most lithophones produce the best sounds if they are at least 4.5 times longer than they are wide (Caldwell 2013:526), assuming they are whole and not broken.

A detailed discussion and comparison of these described characteristics of lithophones and the sample lithophones studied for this grant project are included in the Summary section at the end of this document.

Portable lithophones were/are played in a variety of positions:

- Horizontally like a xylophone (Figure 105)
- Suspended or horizontally or vertically (Figure 106)
- Played upright, usually being held by 1 or 2 hands (Figure 107) or could have been played across the lap, the legs or ankles (Figures 108 and 109)

Figure 105. Lithophones being played horizontally like a xylophone.

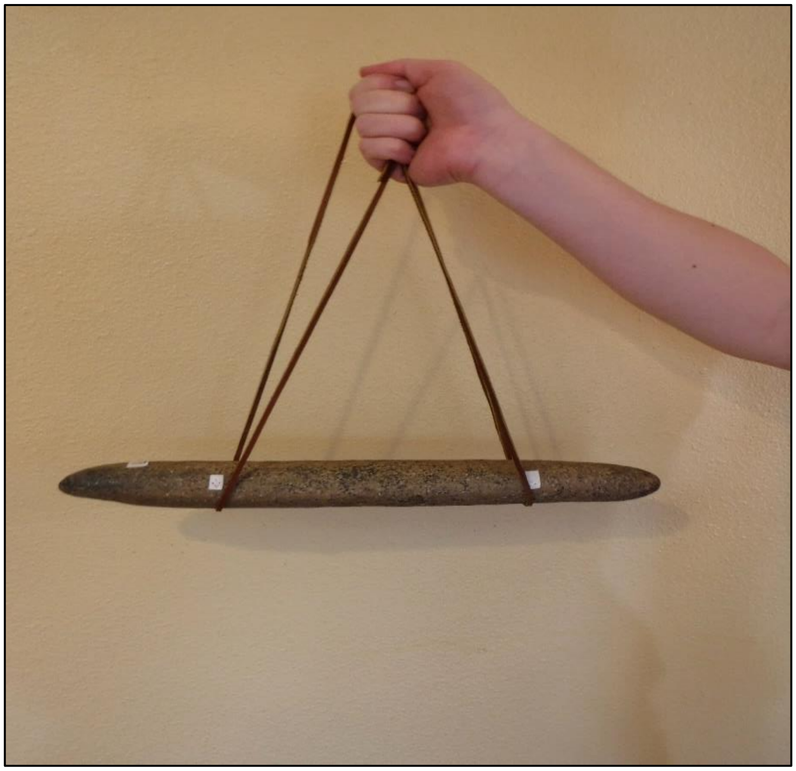


Figure 106. Lithophone #1 suspended for playing horizontally. It is suspended by leather on the two acoustical nodes (dull zones).

Figure 107. Playing lithophone #1 vertically by holding it at the point of the upper acoustical node (dull zone).

Figure 108. Lithophone #4 being played across the lap. The legs are touching the lithophone on the acoustical nodes or dull zones

Figure 109. Lithophone #4 being played across the ankles, touching only on the two acoustical nodes.

Methods potentially utilized to play the lithophones in different positions

- Percussion (striking with a hard or soft percussor/mallet)
- Friction (rubbing with a hard or soft percussor/mallet)

Rough areas - As noted above, several artifacts, (#5, #6, and #9), exhibit roughened areas on the body of the artifact. These roughened areas may be remnants of the original form of the rocks that were simply not ground down; however, it may have been intentional to leave these roughened areas to allow the artifacts to be more resonant if played with friction.

For example, a rasp is a percussion instrument consisting of a serrated surface that is rubbed or stroked with a percussor such as a stick (Figure 110). A rasp has intentional raised lines or ridges that allow for certain sounds to be produced. The roughened areas on artifacts #5, #6 and #9, and the incised lines on #17 may have been played with friction similar to a rasp.

Figure 110. Ute bear dance rasp. https://fcmdsc.files.wordpress.com/2009/09/ute-bear-dance-rasp.jpg?w=500&h=200, accessed 1 26 2018

POTENTIAL MALLETS UTILIZED IN PREHISTORIC/HISTORIC TIMES

Different types of mallets or percussors were likely utilized on lithophones in prehistoric or historic times based on ethnographic evidence and artifact analysis. Evidence suggested by Caldwell (2013:531) indicates that percussors could have been made of various natural materials that would have been available in the past including wood, bone, antler, and stone. He notes that repeated striking of a lithophone with any of these types of percussors would likely leave evidence of its use, either as residue or physical alterations in the stone.

Brown (2014:58) notes that ethnographic evidence for Puebloan kiva bells indicates that percussors were made of stone, similar to the material of the lithophones. Brown describes visible usewear/scarring on the kiva bells that she attributes primarily to use of stone percussors (Brown 2014:62). She suggests that other types of percussors, such as antler, bone, and wood, may have also been utilized on the kiva bells. Brown observed striations and/or polished areas that would have likely developed when friction rather than percussion was used to cause the stone to vibrate and emit sounds. Some of the kiva bells had evidence of both scarring and polish.

Caldwell (2013:531) notes that previous studies have shown that antler and bone leave dark smeared markings on rock when used repeatedly, and that these markings may be identifiable on certain artifacts that have not been altered (washed, etc.) after collection. Also, striking by harder materials, such as stone, can leave what were described as “the consistent appearance of either small, densely clustered conical fractures or multiple small, densely clustered areas of polish…” (Caldwell 2013:531). Caldwell suggests that polish and scratches and may be the result of more stroking-types of impacts, likely similar to those that Brown (2014:62) suggests may have been produced from rubbing/friction rather than striking.

As noted above under the description of physical characteristics of the sample lithophones, residue such as smearing related to use of bone, antler, wood or other soft percussors was not identified visually on the sample artifacts. On Artifact #4, near End #1, side 1 (see Figure 58, top view photo, right end of the artifact), there is a darkened area that could possibly be evidence of some type of soft percussor, but it is has not been verified. One reason that there was not clear surface-visible evidence of potential use of percussors made of materials like antler, bone or wood on the sample artifacts may be related to the fact that the majority of these artifacts were found on the surface and likely had been subjected to weathering (and especially sand-blasting) for many years. It is also possible that this evidence from percussors is not visible with the naked eye or with hand lenses and could possibly be tested for in the future with the use of a microscope or with other types of analysis like Fourier-Transform Infrared Spectroscopy (FTIR).

The majority of the sample artifacts exhibited peck marks, polish and/or smoothing on most of the body surfaces. These physical characteristics could have been the result of the use of various types of percussors and/or result from manufacture and shaping of the artifact; however, a determination of the sources of these physical characteristics was not clear during this investigation.

ACOUSTICAL ANALYSIS METHODOLOGY

To obtain the best sound from the lithophones, they needed to be suspended or raised above a flat surface like a table. Caldwell (2013:525 and 529) suggested either suspending or placing them on small foam cushions before tapping each one.

For playing the sample artifacts, several methods were tested including placing the lithophones on foam blocks, on jute ropes, and on pieces of wood that had thin strips of foam window insulation attached (Figures 111-114). The jute ropes originally utilized were discarded when it was determined that chemicals in the rope material were leaving dark marks on the rocks. The best and easiest method to play the lithophones was determined to be laying the artifacts on two pure cotton ropes (with no added chemicals).

Figure 111. Laying out the lithophones on a jute rope.

Figure 112. Laying out the lithophones on small strips of foam (for insulating windows) attached to small pieces of wood.

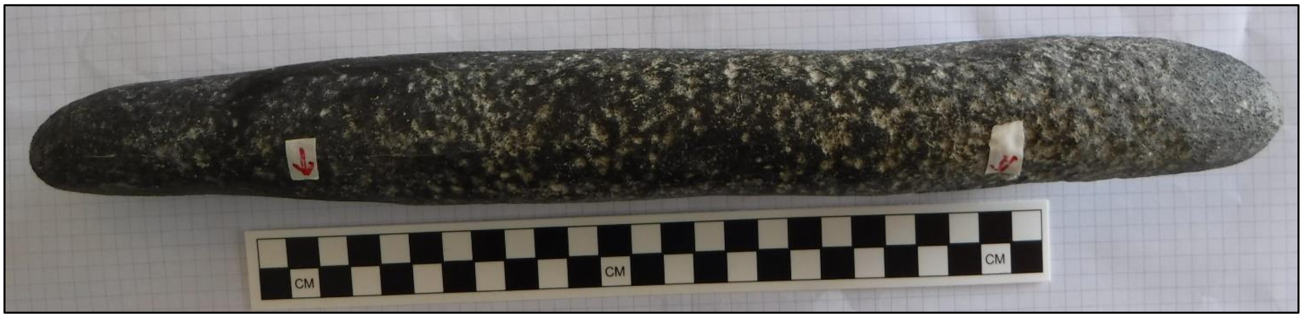
Figure 113. Using foam block to raise the lithophones from the surface.

Figure 114. The lithophones laid on natural cotton ropes during the acoustical analysis.

<u>Acoustical Nodes</u>

1) The two acoustical node locations or dull/dead zones were first marked on the artifact by ear (listening to the sounds played along the length of each sample to determine where the sound was muffled), and then by actually measuring the distance of approximately 25% of the length of each lithophone from each end, based on Caldwell (2013:524). Figure 115 shows the marked node locations on several artifacts.

Artifact #1



Artifact #7 lateral view

Figure 115. Example artifacts with acoustical node locations marked with red arrows.

2) The node locations were also double-checked on some of the flatter lithophones by utilizing the "salt method" which involves pouring salt along the body surfaces and tapping on the lithophones. When tapped repeatedly, the salt crystals lie flat, and split up to travel to both nodes, lining up perpendicular to the long axis of the artifact. The salt is displaced from the vibrating areas and collects along the nodal lines perpendicular to the length of the lithophone.

   Figure 116 shows a progression of photos depicting this "salt method" to determine the locations of acoustical nodes/dull zones on Artifact #3. The artifact was tapped repeatedly for approximately five minutes to move the salt from the long axis of the artifact to the two acoustical node locations (see lower photos in Figure 116).

   The "salt method" is used on musical instruments like a glockenspiel to determine the node locations (Campbell and Greated 1994:434-435). The glockenspiel is one of the simplest of tuned percussion instruments consisting of a set of rectangular cross-section metal bars supported horizontally on a frame. The bar is supported on two narrow strips of felt which touch it only very close to the nodal points. Theoretically, according to Campbell and Greated (1994), the nodal points are at 22.4% of the length of the bar from each end, but it can vary slightly depending on the drilling of holes for attachment and the changes made to the size made during tuning.

Salt sprinkled along the lithophone and beginning of tapping it repeatedly.

Notice how the salt is beginning to separate and migrate toward the nodes.

Further separation of the salt toward the nodes.

Final view showing the salt concentrated at the two nodes

Figure 116. Utilizing the "salt method" to depict how the vibrations produced when playing a lithophone move the salt crystals along the length of the lithophone to the acoustical node locations. The yellow arrows show the locations of the nodes as determined by ear on the lower photo.

Table 6 includes the acoustical node locations as determined by ear and by measuring approximately 25% from each end of the lithophone. As visible on the table, the acoustical node was fairly easy to identify by ear.

Table 6. Hz, weight, length, width, thickness and location of the acoustical nodes on each sample lithophone.

Grant Artifact ID #	Hz (primary)	Hz (secondary)	Weight (grams)	Length (max. cm)	Width (max. cm)	Thickness (max. cm)	Node distance (cm) from ends by ear	% of total length as gauged by ear	Distance of node at 25% from end (cm)	Comments
1	1661	1600	1361	39.8	4.3	4.3	10.0	25%	9.95	
2	2635	2850	1312	32.0	5.4	4.6	8.0	25%	8	
3	2100	2101	1707	31.5	6.8	3.9	8.2	26%	7.875	
4	751	419	4213	64.5	6.4	5.8	16.1	25%	16.125	
5	235	1170	2724	62.9	7.4	3.2	15.7	25%	15.725	vibrates the entire artifact when tapped; vibrations can be felt with fingers almost touching artifact
6	947	377	1701	45.3	7.3	3.2	11.2	25%	11.325	
7	2103	1048	2050	35.9	6.9	4.2	8.9	25%	8.975	
8	3168	4989	1451	26.5	7.1	4.3	6.8	26%	6.625	
9	2424	2432	774	27.0	5.3	2.9	6.5	24%	6.75	fragment
10	4472	1502	468	18.0	4.7	3.1	4.5	25%	4.5	small fragment
11	4783	5665	1128	22.4	5.9	4.7	5.6	25%	5.6	fragment
12	4457	4458	791	21.4	5.9	3.6	5.1	24%	5.35	
13	3101	3122	1763	30.5	5.6	5.6	7.6	25%	7.625	prob. fragment; broken into 2 pieces & glued
14	6191	8786	1497	22.0	7.7	4.8	5.5	25%	5.5	

Grant Artifact ID #	Hz (primary)	Hz (secondary)	Weight (grams)	Length (max. cm)	Width (max. cm)	Thickness (max. cm)	Node distance (cm) from ends by ear	% of total length as gauged by ear	Distance of node at 25% from end (cm)	Comments
15	3292	1648	1037	26.5	5.8	3.7	6.6	25%	6.625	fragment
16	1389	1792	4465	52.0	7.7	6.0	13.0	25%	13	
17	376	2841	1616	38.3	8.0	3.0	9.5	25%	9.575	broken into 2 pieces & glued
18	875	1845	1641	40.4	4.7	4.7	10.0	25%	10.1	fragment
19	1988	498	1103	29.1	6.1	3.4	7.2	25%	7.275	
20	720	720	2007	38.7	7.7	3.7	9.6	25%	9.675	Broken into 3 pieces and glued
21	1410	282	2225	40.3	7.3	4.3	10.0	25%	10.075	
22	1865	3082	1908	34.5	7.1	4.3	8.6	25%	8.625	

Different methods for playing the sample artifacts were attempted to test the sound qualities of each method:

- Holding the artifact vertically at the uppermost acoustical node (see Figure 107)
- Laying the artifacts on their two acoustical nodes on ropes, on foam blocks, or on the window foam insulation strips attached to the pieces of wood (see Figures 111-114)
- Suspending the artifact vertically with a piece of leather by the upper node (when suspended vertically, the upper node is the node closest to the top end of the lithophone); or suspending the artifact horizontally at both acoustical nodes (see Figure 106)
- Playing the artifact across a person's lap/legs or ankles (see Figures 108 and 109)

Different types of percussors were also tested to determine the difference in sound qualities (Figures 117-119):

- Modern mallets made of various materials including plastic and synthetic composites
- Rock (elongated pebbles of similar material to the lithophones)
- Bone (baked and natural, weathered animal bone)
- Antler (deer)
- Wood (various types and hardness including modern wooden drumsticks made hickory and a mallet made of boxwood)

Figure 117. Mallets made of natural materials used to play on the sample lithophones; left to right: rock, bone and antler.

Figure 118. Drumstick and mallet made of wood; top – hickory drumstick used as a mallet, and bottom – boxwood mallet.

Figure 119. Modern mallets made of plastic and composite materials.

MUSICAL SOUNDS PRODUCED BY THE SAMPLE LITHOPHONES

One of the grant tasks was to conduct an acoustical analysis of each lithophone using software that identifies and records the sound qualities. Several apps, including iAnalyzer Lite, Pitch Analyzer, and Tonal Energy Tuner, were utilized to document the sounds of each lithophone, and the Pitch Analyzer and Tonal Energy Tuner apps were found to be the easiest to use and most accurate.

The Pitch Analyzer app (v5.0, 2017) was used to record and document the following information: musical note, the cents above or below the standard pitch of each note, octave, and frequency or Hertz (Hz). For example, the primary note of Artifact #1 is $G\#_6/Ab_6$ -0.14 cents. The G#/Ab is the note played, the "$_6$" indicates the octave (the higher the number, the higher the octave), and the "cents" is a musical unit of measurement indicating how high above or below the standard pitch is for that particular note.

The Hz or frequency of the note is indicated numerically. Hz is the standard unit of measurement used for measuring frequency (https://techterms.com/definition/hertz accessed 5/20/2018). Hz was named after Heinrich Rudolf Hertz, the first person to provide conclusive evidence or proof of the existence of Electromagnetic Waves (Reid 2018: personal communication). Hz is a unit of frequency that is defined as One Cycle Per Second. Hz are commonly expressed in multiples: kilohertz (10^3 Hz, kHz), megahertz (10^6 Hz, MHz), gigahertz (10^9 Hz, GHz), and terahertz (10^{12} Hz, THz).

Since frequency is measured in cycles per second, one Hz equals one cycle per second (https://techterms.com/definition/hertz accessed 5/20/2018). Hz is commonly used to measure wave frequencies, such as sound waves, light waves, and radio waves. Sound waves close to 20 Hz have a low pitch and are called "bass" frequencies. Sound waves above 5,000 Hz have a high pitch and are called "treble" frequencies.

In music, the application of Hz has to do with vibration (Reid 2018: personal communication). Sound travels in a longitudinal wave, which is an oscillation of pressure. We perceive frequency of sound waves as pitch. Each note corresponds to a particular frequency which is measured in Hz. The average adult ear is able to perceive frequencies ranging from 20 Hz to 16,000 Hz.

While examining the individual notes played by each lithophone and the inconsistencies between pitches and frequencies, it is important to consider the wide range of musical tuning practices known as Temperament. The depth of this topic (musical tunings) is very complex. The information about temperament given here is to help provide a basic context and definition to what is outlined in the musical analysis of the lithophones.

Temperament is a tuning system that defines, compares, adjusts and compromises the pure intervals of "Just Intonation" to meet musical requirements. The tempering of tones is the process of altering the size of an interval by making it narrower or wider than pure. Most modern Western musical instruments are tuned in the Equal Temperament system. Equal Temperament is a musical system of tuning in which the frequency interval between every pair of adjacent notes has the same ratio.

Other "general" temperament systems include:

- **Pythagorean Tuning (6th Century B.C. - Pythagoras) -** A system of musical tuning in which the frequency ratios of all intervals are based on the ratio 3:2.
- **Meantone Temperament (16th Century Renaissance - Pietro Aron) -** A tuning system, obtained by slightly compromising the fifths in order to improve the thirds.
- **Well Temperament (20th Century - a.k.a. Good/Circular Temperament) -** A type of tempered tuning described in 20th-century music theory. The term is modeled on the German word *wohltemperiert*.
- **Schismatic Temperament -** A musical tuning system that results from tempering the schisma of 32805:32768 to a unison.

How much the ancient cultures that developed their various lithophones used a specific tuning system like these is unclear. However, it is obvious that on some level, there was a methodical approach to tuning each stone (modifying length and shape, for example). In order to further this specific research and to analyze and theorize about the use of a tuning system would require a number of lithophones from a cache that contained various sizes and shapes of artifacts. Determining the notes played by a group of lithophones that were found together would provide extremely valuable information to help understand the potential scales and music that might have been played on ancient lithophones.

<u>Acoustical analysis testing and recordings</u>

The acoustical analysis testing and recordings were conducted at the School of Music, University of Northern Colorado, and also in Longmont, Colorado. Each artifact was tested for acoustical properties by positioning it horizontally on its two acoustical nodes and tapping with a composite mallet on the top surface and on the lateral surface near one end (Figure 120). Information from the Pitch Analyzer app, including notes and Hz, were recorded for each location that was tapped. The note produced on the top surface was considered the primary note, and the note produced on the lateral edges was considered the secondary note. In addition to tapping each artifact with a composite mallet, they were also tested for sound production using friction by rubbing a mallet or a small elongated pebble along the length of the artifact.

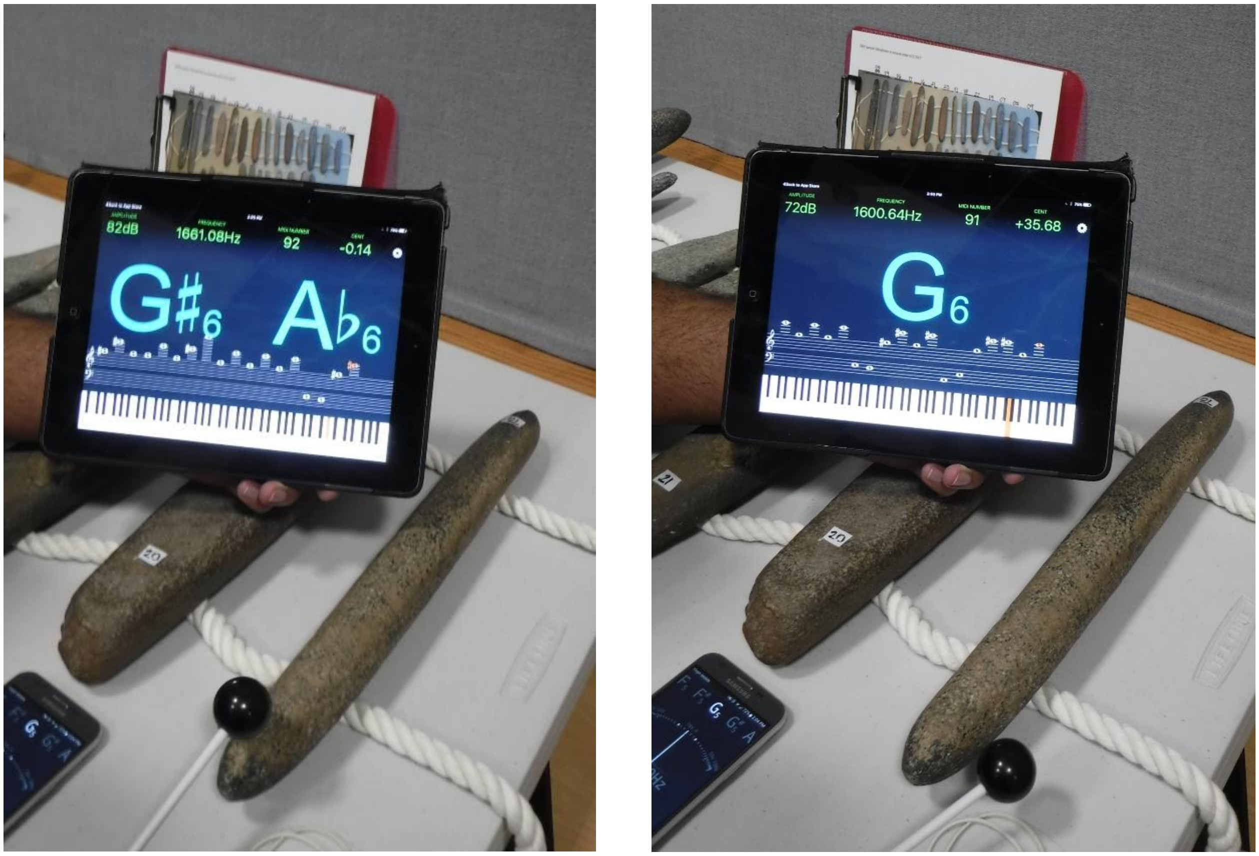


Figure 120. Method utilized to test the sample artifacts for acoustical properties. Photos show Artifact #1; on the left, testing the top surface, and on the right, testing the lateral edge. The results of the testing are shown on the Pitch Analyzer app.

Individual pages with photos showing the Pitch Analyzer app results for each lithophone are included in Appendix D (in separately bound Volume 2). Appendix E includes electronic files (videos) of each sample artifact being played, and a number of other videos showing the use of different mallets and various methods of suspending and playing the lithophones. These electronic files are on a jump drive and the list of the contents is included in Volume 2. Table 7 lists a summary of the Pitch Analyzer results including comments regarding the notes and sounds of each lithophone with tapping and friction, the primary and secondary note(s), and Hz produced by each artifact.

Table 7. Description of the lithophone sounds.

Grant Artifact ID #	**Primary Note(s)**	**Hz primary note(s)**	**Secondary Note(s)**	**Hz secondary note(s)**	**Description of primary & secondary notes** **Comments regarding the artifact and its resonance, sound qualities, etc.**
1	G#$_6$/Ab$_6$ -0.14 cents	1661	G$_6$ +35.68 cents	1600	Notes are ½ step apart; same octave. It is very resonant over all of the surface and very resonant with friction, even when just tapping or rubbing with fingers. The sound is similar to a metal bell or glass/crystal. It plays two or more notes at once/overtones over most of the body.
2	E$_7$ -1.24 cents	2635	F$_7$ +34.49 cents	2850	Notes are ½ step apart; same octave. It is highly resonant all over the surface when tapped and highly resonant with friction. The sound is similar to a xylophone/marimba. It plays some overtones on different surfaces, for example, on the angled end. The sound is piercing.
3	C$_7$ +6.27 cents	2100	C$_7$ +7.24 cents G♯$_4$/Ab$_4$ +25.32 cents G#$_7$/Ab$_7$ +18.8 cents	2101 421 3358	Two notes are the same and the same octave. Additional notes are different from the other described notes, and one is a different octave. It is highly resonant when tapped and is resonant with friction. The sound is similar to a xylophone. The sound is piercing.
4	F♯$_5$/Gb$_5$ +27.35 cents	751	G♯$_4$/Ab$_4$ +16.45 cents	419	The two notes are more than an octave apart. The center of the body plays a very pure tone; the ends play more overtones. It is very resonant with a clear, bell-like sound similar to a xylophone when tapped. It is also very resonant with friction.

Grant Artifact ID #	**Primary Note(s)**	**Hz primary note(s)**	**Secondary Note(s)**	**Hz secondary note(s)**	**Description of primary & secondary notes Comments regarding the artifact and its resonance, sound qualities, etc.**
5	A♯$_3$/Bb$_3$ +18.68 cents	235	D$_6$ +-13.02 cents A♯$_3$/Bb$_3$ +15.69 cents	1166 235	Two of the notes are the same and one is a different octave and note. It is highly resonant with a very pure tone in the center of the long axis when tapped; the ends are louder when tapped but have more of an overtone than the center. When tapped, the entire artifact vibrates and you can feel the vibrations with your fingers when they are placed near the body of the artifact. It is highly resonant with friction. The sound is similar to a xylophone. The CaCO3 on the edges may affect the resonance when the artifact is tapped in those locations.
6	F♯$_5$ Gb$_5$ +22.68 cents F♯$_4$ Gb$_4$ +33.09 cents	750 377	F♯$_4$/Gb$_4$ +36.80 cents	378	The two of the primary notes are the same but different octaves, and the secondary note is the same as one of the primary notes but a different octave from the other one. It is very resonant when tapped and is also very resonant with friction. It sounds similar to a xylophone/marimba. It plays basically the same sound on the sides, likely because it is so flattened.
7	C$_7$ +8.52 cents	2103	C$_6$ +3.58 cents	1049	It plays the same note but different octaves. It is resonant when tapped and is resonant with friction. It sounds similar to a xylophone/marimba.
8	G$_7$ +17.78 cents	3168	D♯$_8$/Eb$_8$ +3.58 cents	4989	It plays two different notes that are different octaves. It is resonant when tapped and is also resonant with friction. It sounds similar to a xylophone/marimba.

Grant Artifact ID #	Primary Note(s)	Hz primary note(s)	Secondary Note(s)	Hz secondary note(s)	Description of primary & secondary notes Comments regarding the artifact and its resonance, sound qualities, etc.
9	D♯$_7$/Eb$_7$ -45.45 cents	2424	D♯$_7$/Eb$_7$ -39.80 cents	2432	It plays the same note and same octave. Fragment. It is very resonant when tapped and highly resonant with friction. It sounds similar to a xylophone or marimba. The sound is piercing.
10	C♯$_8$/Db$_8$ +14.43 cents	4472	F♯$_6$/Gb$_6$ +26.43 cents	1503	It plays different notes and different octaves. Small fragment. It is not highly resonant when tapped likely because it is a short fragment. It has minimal to no resonance with friction. It has a high-pitched xylophone/marimba-type sound.
11	D$_8$ +30.82 cents	4783	F$_8$ +23.87 cents	5665	The notes are three half steps (or one whole step and ½ step) apart but the same octave. Fragment. It is not highly resonant when tapped and has very low resonance with friction. It sounds similar to a xylophone when tapped but the sound is dull.
12	C♯$_8$/Db$_8$ +8.62 cents	4457	C♯$_8$/Db$_8$ +9.14 cents Also plays other notes: G$_7$ -43.94 cents F♯$_8$/Gb$_8$ +47.81 cents G$_8$ -49.15 cents C♯$_5$/Db$_5$ -12.72 cents F♯$_6$/Gb$_6$ +22.92 cents	4458 3057 6086 6096 550 1450	It plays the same note and same octave and multiple additional notes and octaves. It is resonant when tapped and is a little resonant with friction. It sounds similar to a xylophone.

Grant Artifact ID #	**Primary Note(s)**	**Hz primary note(s)**	**Secondary Note(s)**	**Hz secondary note(s)**	**Description of primary & secondary notes Comments regarding the artifact and its resonance, sound qualities, etc.**
13	G_7 -19.25 cents	3101	G_7 -7.31 cents	3123	It plays the same note and the same octave. Prob. fragment; also broken into 2 pieces & glued. It is not highly resonant when tapped or with friction. It sounds similar to a xylophone/marimba but has a dull sound likely related in part to the break.
14	G_8 -22.48 cents	6191	$C\sharp_9/Db_9$ -16.28 cents	8786	It plays different notes and different octaves. It has low resonance when tapped and exhibits very minimal resonance with friction. It sounds similar to a xylophone but is a dull sound.
15	$G\sharp_7/Ab_7$ -17.49 cents Also various notes incl.: $G\sharp_6/Ab_6$ -13.56 cents	3289 1648	$G\sharp_6/Ab_6$ -13.68 cents	1648	It plays the same note but different octaves; also other notes including the same note and same octave. Fragment. Very resonant when tapped and highly resonant with friction. It sounds similar to a xylophone. The sound is piercing.
16	F_6 -9.06 cents	1390	A_6 +30.44 cents	1791	The primary notes are two whole steps apart, same octave. It is highly resonant when tapped and highly resonant with friction. The sound is similar to a xylophone and is a very clear bell-like sound.
17	$F\sharp_4/Gb_4$ + 27.86 cents	376	F_7 +29.17 cents Also plays other notes: $C\sharp_5$ Db_5 +25.14 cents G_3 -35.08 cents	2841 563 192	It plays various notes and octaves. Broken into 2 pieces & glued. It is very resonant when tapped and very resonant with friction. It sounds similar to a xylophone/marimba. The sound may be slightly dulled by the break in the middle of the artifact.

Grant Artifact ID #	**Primary Note(s)**	**Hz primary note(s)**	**Secondary Note(s)**	**Hz secondary note(s)**	**Description of primary & secondary notes Comments regarding the artifact and its resonance, sound qualities, etc.**
18	A_5 -7.97 cents	876	$A\sharp_6/Bb_6$ -18.02 cents	1845	It plays notes that are ½ step apart but different octaves. Fragment. It is not highly resonant when tapped but produces more resonance with friction. The sound may be slightly muffled due to the fact that it is a fragment and also because some of the outer surfaces of the artifact are exfoliating. It sounds more like a marimba (more wood-like and dull).
19	B_6 +11.59 cents	1989	B_4 +15.45 cents	498	It plays the same notes, two octaves apart. It is resonant when tapped and is resonant with friction. It produces a xylophone/marimba sound.
20	$F\sharp_5/Gb_5$ -45.70 cents	721	$F\sharp_5/Gb_5$ -46.05 cents	720	It plays the same note and same octave. Broken into 3 pieces & glued. It exhibits medium resonance when tapped likely due to the two breaks in the body. It is not highly resonant with friction. The sound is more wood-like (marimba) and dull, likely affected by the two breaks.
21	F_6 +16.56 cents	1410	$C\sharp_4/Db_4$ +35.29 cents	283	It plays different notes and different octaves. It is resonant when tapped and exhibits medium to high resonance with friction (the ridges perpendicular to the long axis of the body on one face may increase the resonance with friction). The sound is similar to a xylophone/marimba.
22	$A\sharp_6$/Bb6 +0.41 cents	1865	G_7 -29.84 cents Note: the side has various pitches; for example, it also plays $A\#_6/Bb_6$ -4.22 cents	3082 1860	It plays various notes and octaves. It exhibits medium resonance when tapped and is resonant with friction. It produces a xylophone/marimba-like sound.

CHARACTERISTICS OF THE SOUNDS AND NOTES PRODUCED BY THE SAMPLE LITHOPHONES

The following section describes the basic sounds produced by the lithophones:

- When tapped with a percussor, the sounds produced are similar to tapping on metal bells, glass (crystal), a wooden marimba or a metal xylophone, or a combination of these sounds.
- When played with friction, the artifact is actually being struck numerous times as the mallet hits various surfaces of the artifact. When rubbed with friction, the musical sounds produced by the sample artifacts vary from a smooth, extended-length sound to a rougher, choppy, extended-length sound, based on the smoothness or roughness of the surface of the lithophone.
- In general, the longer lithophones play a lower note while shorter ones play higher notes, similar to the high and low notes produced by a modern xylophone or marimba. When the sample artifacts are viewed in musical order from lowest note played to highest note played (see Figure 27), it is obvious that there are exceptions to this generalized statement. For example, Artifact #6 and #17 play lower notes and are significantly shorter that #16 which plays a higher note. The reasons for this difference in sounds versus length is not completely understood but it may be related to a number of characteristics such as the overall shape of the artifacts (#6 and #17 are both generally flattened oval shapes in cross-section and #16 is very rounded in cross-section), or perhaps the shape combined with other factors such as rock type, density and weight of the artifact make a difference in determining whether an artifact produces a higher or lower note.
- The sounds produced by the sample lithophones are louder (more resonant) and more musical (have more of a ring) when played with hard percussors such as a hard-composite material (like modern xylophone mallets), or a hard and dense elongated rock (not sandstone). Antler and bone also produced a similar, but not quite as resonant of a sound. The baked fresh bone worked better than a piece of highly-weathered bone. Playing the lithophones with wood like hickory or boxwood produced a somewhat softer sound, but the boxwood mallet produced good resonance. Neither of the wooden mallets resulted in producing a sound that was as resonant as harder materials like rock.
- The sound of each lithophone is muffled when played directly on one or both of the acoustical nodes with any type of percussor. The best sounds are produced near either end or near the middle point along the length of the artifact.

The 22 lithophones play a minimum of 57 notes (Figure 121). All of the lithophones produce at least two sounds, one on the top surface and one on the sides or lateral edges. The notes produced by a single lithophone vary from those that play the same note and same octave on the top and lateral surfaces, the same note but different octaves, ½ step to 2 steps apart, and those that play multiple notes and multiple octaves depending on where they are tapped. Many of the lithophones also play overtones, or a combination of notes at the same time.

When the more rounded-shaped lithophones are tapped continuously while rolling them (with both acoustical nodes lying on a rope), they generally play a clear primary note, then overtones (both the primary note and the secondary note at one time), and then a clear secondary note. This pattern is repeated as the lithophones are continuously rolled.

The notes played by the lithophones vary from those that are above the standard pitch of a note, ranging from Artifact #7, C_6 **+3.58** and Artifact #8, $D\#_8/Eb_8$ **+3.58** to Artifact #12, $F\#_8/Gb_8$ +**47.81**; and below the standard pitch of a note, ranging from Artifact #1, $G\#_6/Ab_6$ **-0.14** cents to Artifact #20, $F\#_5/Gb_5$ **-46.05**. This range of variation of pitches is likely related to temperament as discussed on page 110.

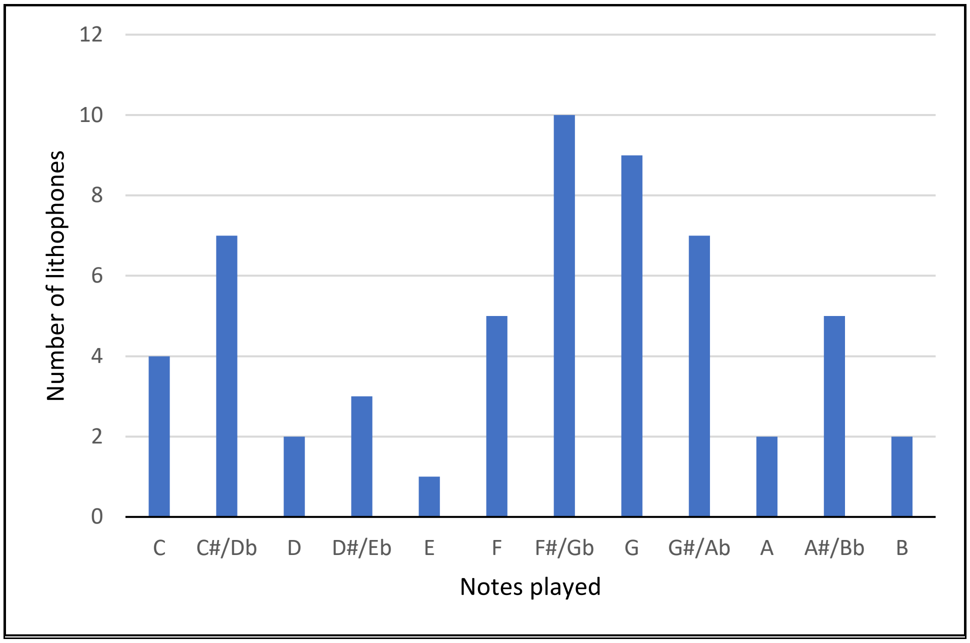


Figure 121. Notes played by the sample lithophones.

The Hz produced by the 22 sample lithophones ranged from 192 Hz on Artifact #17 (broken into three pieces and glued), to 8786 Hz on Artifact #14. Some of the lithophones that play a clear, musical sound, such as Artifact #5, have a low Hz (235) when tapped in some locations and is higher in others (1166 Hz). On Artifact #12, the recorded Hz ranged from 550-6096 Hz, depending on where it was tapped. The relevance of the Hz that is produced and the actual sound qualities of each lithophone are not known.

ACOUSTICAL INTERPRETATION

Of all of the notes produced by the sample lithophones, 56% are pentatonic (the black keys on a piano) and 44% are not (see Figure 121). Understanding the meaning of the notes produced by these artifacts is a complex topic.

A relevant presentation relating to the neuroscience within music and how it translates throughout human society is entitled *Notes and Neurons: In Search of Common Chorus*:
WSF website - http://www.worldsciencefestival.com/
Full Presentation - https://www.youtube.com/watch?v=S0kCUss0g9Q (accessed 5 19/2018)
Topics Discussed:

- Why does neuroscience want to study music?
- How does the brain fit into understanding music?
- Is music the same if you already know what to expect?
- Pitch, rhythm and timbre
- Is rhythm different across cultures?
- Comparing musical predictions across cultures
- **Bobby McFerrin demonstrates the power of the pentatonic**
- Is music a part of speech?
- Testing galvanic skin response

This presentation was taped at the World Science Festival on June 12, 2009 and includes musical performances, research overviews, and discussions by Bobby McFerrin, Daniel Levitin, Jamshed Bharucha, Lawrence Parsons, and John Schaefer (moderator). Specific to the lithophone research, it reinforces how ingrained the pentatonic scale is in virtually ALL human cultures.

Although it is not known what scales were played by the lithophones, it is likely not a coincidence that there seems to be a strong indication toward the use of pentatonic scales in the creation of lithophones. It supports the fact that pentatonic scales, in all its various forms, are the most commonly used tonal structure in the world. In fact, research shows that pentatonic scales have been encountered all over the world, for example:

- Peruvian Chicha cumbia
- Celtic Folk Music
- German Folk Music
- English Folk Music
- Croatian Folk Music
- West African Music
- American Jazz and Rock Music
- Children's Songs
- Ancient Greek
- Traditional Japanese Court Music
- Shomyo chanting
- Quenchua/Aymara tribes in South America
- Ethiopian kraar tuning
- Indonesian Gamalon tuning
- Western Impressionistic Composers (i.e. Frédéric Chopin - Etude in Gb Major, op. 10, no. 5 -"the "Black Key" etude - Major Pentatonic)

The graph in Figure 121 shows the full range of Semitones, also called a half step or a half tone. Semitones are the smallest musical interval commonly used in Western tonal music and are considered the most dissonant when sounded harmonically. Semitones are defined as the interval between two adjacent notes in a 12-tone scale. This could indicate that use of both Hemitonic (Pentatonic scales that include semitones) and Anhemitonic (Pentatonic scales that do not include Semitones) scales.

This could mean that the use and tuning of the lithophones may have been influenced by far-away cultures. However, there seems to be a commonality in the findings of C#/Db-D#/Eb-F#/Gb-G#/Ab-A#/Bb - indicating the presence of the Anhemitonic "Pentatonic" Scale (Major Pentatonic). Since the Major Pentatonic scale is the simplest and most commonly-used Pentatonic scale, it would also be conceivable that the non-pentatonic tones were accidental or lost their tonality due to environmental changes over the years. Accident or not, there seems to be the potential that there was a basic understanding of a Chromatic Scale (12 Semitones). Was there outside influence (through prehistoric cultural trade or travel/migrations, or recent European Colonization/contact) or was the tradition of making and playing lithophones in the SLV a local cultural innovation over a long period of time? These are some of the questions regarding the acoustical properties of lithophones to be investigated for future research.

DATING AND LOCATIONAL INFORMATION FOR THE SAMPLE LITHOPHONES

The majority of the lithophones studied for this project were collected without obtaining specific locational data or information about the archaeological context. Only one of the grant lithophones, Artifact #15, originates from a professionally-recorded and dated prehistoric site. It was found on a site located at the edge of a large old playa southwest of Great Sand Dunes National Park and Preserve at the Fish Bone Site, 5AL326 (Figure 122). This artifact was found within or immediately adjacent to a concentration of artifacts and a midden with charcoal. Artifacts included flakes, FCR, ground stone, large and small animal bone, and fish bone. This feature/artifact concentration was radiocarbon dated to 6280-5900 B.P.; the end of the early Archaic.

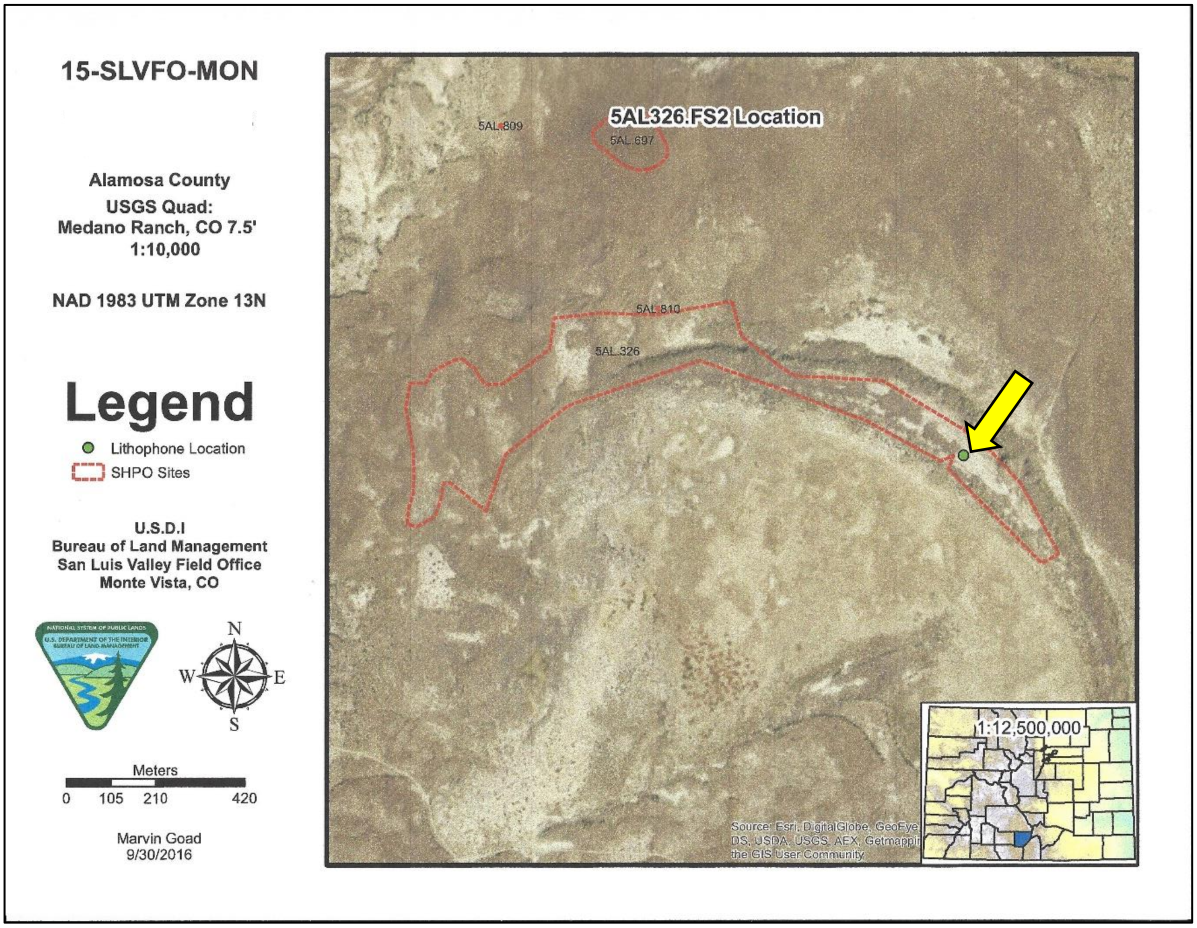


Figure 122. Location of Artifact #15 within the boundaries of 5AL326, the Fish Bone Site.

This date is many thousands of years prior to the pueblo occupations of the Southwest and the known dates of kiva bells, which primarily date to ca. post A.D. 1300 (Brown 2014:65). The date for this Fish Bone Site feature/artifact concentration where Artifact #15 (categorized as a highly-modified stone cylindrical lithophone) was found, is possibly suggestive that the more highly-modified lithophones from the SLV could significantly pre-date the described lithophones/kiva bells from the Southwest (Brown 2014), in some cases by over 5000 years.

Additional research and analysis is needed to test this hypothesis and determine if the more highly-modified lithophones and many of the other lithophones found in the SLV date to a much earlier time and are possibly related to a different cultural group or groups. The Fish Bone Site may have potential to contain additional buried dateable archaeological components, including the possibility of additional lithophones. This type of site would be important to investigate to potentially answer additional research questions about lithophones, especially regarding context and dates of use.

PUBLIC BENEFIT OF THE PROJECT

PROFESSIONAL AND PUBLIC PRESENTATIONS, DEMONSTRATIONS AND PUBLICATIONS

To help spread awareness of lithophones to professional archaeologists and the public, a number of professional and public presentations and demonstrations of the lithophones were given Ms. Martorano during the grant contract period of performance:

1) Colorado Council of Professional Archaeologist (CCPA) March 2017 (professional poster and demonstration)
2) Fort Garland, August 9, 2017 (public presentation and demonstration)
3) Great Sand Dunes National Park and Preserve Visitor Center, August 10, 2017 (public presentation and demonstration)
4) Loveland Archaeological Society, September 5, 2017 (public presentation and demonstration)
5) Loveland Stoneage Fair, September 23, 2017 (public presentation and demonstration)
6) Carol Beam, Boulder County Open Space and Mountain Parks Archaeologist, August 4, 2017 (demonstration and discussion)
7) Dr. Sally McBeth, Ph.D., Professor and Chair, Department of Anthropology, University of Northern Colorado, October 13, 2017 (demonstration and discussion)
8) CCPA Annual Meeting, March 2018 (professional paper presentation and demonstration)
9) Santa Fe National Forest Site Stewards, April 2018 (PowerPoint presentation and sound videos)
10) Boulder County Parks and Open Space, May 9, 2018 (PowerPoint presentation and demonstration)

In addition, an article written by Ms. Martorano entitled “Ancient Tones – the Lithophone,” was published in the 2017 January/February edition of the *Colorado Central Magazine*.

GREAT SAND DUNES NATIONAL PARK AND PRESERVE INTERPRETATION

As a public agency, Great Sand Dunes National Park and Preserve provides a direct opportunity to interpret the past to the general public and to cultivate awareness of cultural and historic preservation to a wide audience. With a yearly visitation of approximately 280,000 people, the park has many opportunities to reach the public (local and world-wide) through educational videos, ranger-led walks and programs, and museum exhibits.

Relating a musical concept like the playing of prehistoric stone instruments/lithophones to the public would be a new interpretive dimension that could be accomplished with almost any age group (from young children to adults) and would be a unique way to promote and convey preservation themes. Interpretation of archaeology at Great Sand Dunes is already an important part of the park’s interpretative efforts for the public, and information resulting from this assessment grant will add significant, new data for further interpreting the prehistory of Colorado, and especially the Great Sand Dunes and the SLV. Consultation with official tribal representatives to determine appropriate types of interpretations of lithophones is recommended. For example, would it be acceptable to use some of the lithophones from the park’s official collections of lithophones, or perhaps it might be more appropriate to create replicas for public display, interpretation or demonstrations.

The public has already been directly involved in the project because SLV private collectors had an opportunity to share their knowledge and artifacts for inclusion in the lithophone sample analysis. Nine of the sample grant artifacts were loaned from private collectors. Involving the local collectors was additionally a means for raising awareness in the public sector about the value of scientific study versus collecting artifacts for personal use and can hopefully assist in supporting the prevention of future unauthorized relic collection, an ongoing issue at Great Sand Dunes and in the SLV.

RECOMMENDATIONS FOR FUTURE WORK

Although a wealth of new information has been collected about these unique ground stone artifacts from the SLV, there is much still to be researched in order to fully understand how lithophones were utilized in Colorado and other nearby areas in the past. Some of the remaining research questions include the following:

- **Where did the rock used for the lithophones came from?** Are the source areas local or from surrounding or distant locations, or both? Did the source areas for rocks obtained to make lithophones vary over time? What did the natural rock look like prior to being modified for use as lithophones; was it quarried or found as naturally-occurring individual rocks? Can additional XRF data analysis be utilized to determine the potential source areas for the stone utilized to make the lithophones from the SLV and other areas?

- **If certain lithophones were made from quarried stone similar to the described methods utilized to manufacture Mayan manos and metates in Guatemala (Searcy 2011), would it be possible to find lithophone quarry sites with remaining evidence of the quarrying extraction process?** In Searcy's descriptions of mano and metate quarries, a photograph depicts grooves made in a boulder to split off pieces of stone, and potential stone quarrying waste material is visible at a currently-utilized stone mano/metate quarry (2011:40, Figure 3.1).

  Identifying potential rock outcrops that are most likely to have acoustically-active stone in areas surrounding the SLV, and then selecting and visiting easily accessible locations may help to identify potential prehistoric lithophone quarry/extraction sites.

- **Who was making and using lithophones in the SLV, Colorado, and surrounding areas?** Were the lithophone producers and users local inhabitants or outsiders who may have utilized the SLV seasonally or at other times? Did the makers and users of lithophones in the SLV change over time?

- **What role did lithophones have in the lives of the users/players and those who listened to them? Were lithophones used for ritual/ceremonial purposes or for everyday activities such as a form of communication, or a combination of both?** Did the use and purpose of the lithophones change over time? Did knowledge of using ground stone for sound become lost or perhaps was not known by certain Native American cultural groups in Colorado and other parts of North America? Could the different shapes of lithophones indicate the associated type of use, i.e., whether used ritually or for other uses? Can evidence of applied residue, such as ochre, suggest use of a lithophone for ritual or ceremonial purposes?

- **Were lithophones ever utilized as multi-purpose tools?** There are many remaining questions regarding the use of lithophones as multi-purpose tools and/or only as lithophones. Were some lithophones made and used as multi-purpose tools, or did the sometimes-visible minimal evidence of use for grinding and crushing occur at a later time? For example, does evidence of battering, striations and other physical characteristics on lithophones such as on artifacts #12, #14, and #20, suggest their use as multi-purpose tools (either during concurrent use as lithophones or later during reuse or repurposing of the artifacts); or, could those physical characteristics have possibly been produced during the manufacturing process or during transport, storage, or during use/playing as a lithophone?

- **Were there gender roles associated with the manufacture and use of lithophones similar to the Mayan traditions of manufacturing and utilizing manos and metates (Searcy 2011)?** In the Mayan areas where Searcy observed the production of manos and metates, the males quarried and manufactured the manos and metates and the females were primarily the ones who utilized those tools for grinding and food preparation. Future Native American consultation and/or analysis of lithophones found in specific archaeological contexts may help to shed light on this question.

- **What types of percussors were utilized on lithophones found in Colorado?** Did the materials utilized as percussors vary through time, for different cultural groups, and/or by geographical areas? Can evidence for the type of percussor be identified on lithophones found on the surface, or does any evidence of softer percussors (especially materials like bone, antler or wood) weather away on surface artifacts and be more likely to be identifiable on lithophones that have been retrieved from buried cultural deposits? Can evidence of the use of hard percussors be identified through microscopic analysis of the surfaces of the lithophones?

- **How long were lithophones utilized in the SLV? Was the concept of lithophones in Colorado and other places in North America a creation of outside influence or cultural innovation by local populations, or a combination of both**? What is the time range for all lithophones found in the SLV? Could lithophones have been utilized for thousands of years, for example back to Paleoindian times? Do certain types (unmodified or minimally-modified types and highly-modified cylindrical lithophones) date to different time periods or could they be affiliated with different cultural groups?

  Was the idea of lithophones introduced through migration or movement of different cultural groups or was it an ancient or more recent local invention? Or, could the tradition of using lithophones have been brought into the SLV by several cultural groups at various times, resulting in the differing physical forms of the lithophones?

  Based on the more recent forms of lithophones (ca. pre-A.D. 1300) known as kiva bells (Brown 2014), and are described as either un-modified or minimally-modified stones, could it be suggested that more formally-shaped lithophones (especially the cylindrical and other highly-modified artifacts in the study sample) are an earlier form?

  The date for the Fish Bone Site feature/artifact concentration where sample lithophone #15 (categorized as a highly-modified cylindrical lithophone) was found, significantly pre-dates the described lithophones/kiva bells from the Southwest (Brown 2014), in some cases by over 5000 years. Additional research and analysis is needed to test this hypothesis and determine if the more highly-modified lithophones and many of the other lithophones found in the SLV date to a much earlier time than kiva bells and are possibly related to a different cultural group or groups.

  Formal consultation with official tribal representatives is also recommended and may provide insight into how, when, why and where lithophones may have been manufactured and utilized in historic and prehistoric times in the SLV.

- **What is the geographical distribution of lithophones in other areas of Colorado and the western U.S.?** One of the sample artifacts, #17, was found on the Front Range of Colorado near the town of Erie. In addition, several potential lithophones have been reported by persons in eastern Colorado (Marilyn Martorano 2018: personal communication), and several interesting ground stone artifacts from sites in northern New Mexico have been loaned to Marilyn Martorano (Figure 123). These artifacts from New Mexico have not been intensively researched but they do have significant acoustical properties and warrant further investigation. The fact that the majority of these lithophones came from northern New Mexico suggests that it is likely other unidentified lithophones (in addition to kiva bells) may exist outside of Colorado and especially from locations in the Southwest such as New Mexico and Arizona.

Figure 123. Artifacts that are likely lithophones from New Mexico.

- **Were some or all of the lithophones used by hunter/gatherer groups, and if so, were lithophones cached and used repeatedly during seasonal rounds? Were groups of lithophones also cached by sedentary groups?** The fact that Artifact #4 was found in a vertical position buried deep in the sands, and Artifact #18 was also found nearly vertical, suggests they may have been cached similar to lithophones found in Northern Africa as described by Caldwell (2013:526). Caldwell noted that leaving lithophones cached in a vertical position would make them visible to anyone searching from afar. At Great Sand Dunes, Artifact #4 was found positioned vertically in the sand dunes. Due to the strong winds that blow the sand around in that area, if an artifact was left lying flat/horizontal, it would not be likely for someone to return at a later time and be able to find that artifact again since it would probably be covered up very quickly by shifting sands. It would also seem to make sense to cache a lithophone for pedestrian hunter/gatherer groups due to the weight of some of the larger lithophones such as Artifact #4, #5, and #16, which weigh between six and nine pounds each.

  Brown (2014:63-64) describes several caches of lithophones from pueblos in northern New Mexico. Caches of lithophones (or potential lithophones) have also been found in Arizona in a Mogollon pithouse and in New Mexico at the Cuyamungue Pueblo near Santa Fe (see discussion under next bullet), so there is at least some evidence of lithophone caching by sedentary groups.

- **Were lithophones found in the SLV used individually or in groups of more than one lithophone, or both?** All of the lithophones studied for this grant are assumed to have been found as single artifacts and not part of a cache; however, several of the artifacts were described to have been found near each other on the west side of Great Sand Dunes. Since these artifacts were found over a number of years, it is possible that some were originally located together and were picked up at different times as they were uncovered by shifting sands.

  Other lithophones are known to have been found together as a cache. A described cache of 23 Kiva Bells was found in Cuyamungue, New Mexico and reported in an article of the newspaper *The New*

Mexican on Wednesday, August 6, 1952 (Figure 124); http://tiwafarms.blogspot.com/2014/07/kiva-bells.html, accessed 4/3/2018.

This Blogspot also notes that ringing rocks have been found in several other locations in New Mexico including at Point of the Rocks in Colfax County (where there are deposits of Phonolite), The Jemez (west of Los Alamos) and in the Los Pinos Mountains southeast of Belen.

More information about the musical and physical characteristics of this group of Kiva Bells would add significant data to our knowledge about the notes, scales, and sounds (including temperament) that would have been produced from a set of lithophones rather than single artifacts. A description of the physical characteristics of this set of lithophones would also add very important data to our knowledge of lithophones. In addition, an associated date may be available for this cache and would be very important for comparison with other known lithophones in the southwestern U.S.

THE NEW MEXICAN

Wednesday, Aug. 6, 1952

Remarkable Cache Found At Cuyamungue

23 Kiva Bells Unearthed

Demo Leaders Predict Shutout In Solid South

Ninos de Hoy

DANCE AT THE APACHE CLUB

LENSIC STARTS TODAY

CRY OF MIGHTY ADVENTURE!

KANGA

SLADE'S DAIRY

Kool-Aid

THE SUMMERHOUSE

"I REMEMBER MAMA"

DRIVE IN CHICO THEATER

"LADY FOR A NIGHT"

U.S. Oil Output Shows Increase

El Nido

EL GANCHO INN

TOURIST TAVERN

Figure 124. A described cache of 23 Kiva Bells found in Cuyamungue, New Mexico and reported in an article of the newspaper *The New Mexican* on Wednesday, August 6, 1952; http://tiwafarms.blogspot.com/2014/07/kiva-bells.html, accessed 4/3/2018.

A cache of 12 schist, gneiss and basalt "pestles and digging tools" was found by Joe Ben Wheat in a wall niche of a Mogollen pithouse dating from ca. A.D. 100 to the late 900s at the Crooked Ridge Village site in Arizona (Wheat 1954). Some of these illustrated and described artifacts (Figure 125) appear very similar to portable lithophones previously described in the literature (Caldwell 2013), and to some of the sample artifacts studied during this project. Wheat noted that the physical characteristics of these artifacts did not seem to support the use of these artifacts as pestles or for digging (Wheat 1954:136-137). These physical characteristics support the idea that there is a possibility this cache of artifacts could have functioned as lithophones. If these artifacts still exist in a museum collection, it is suggested that they should be tested for their acoustical properties. Similar to the Cuyamungue cache, if this cache of artifacts are lithophones, it would be valuable to conduct an acoustical analysis and compare the results with other caches.

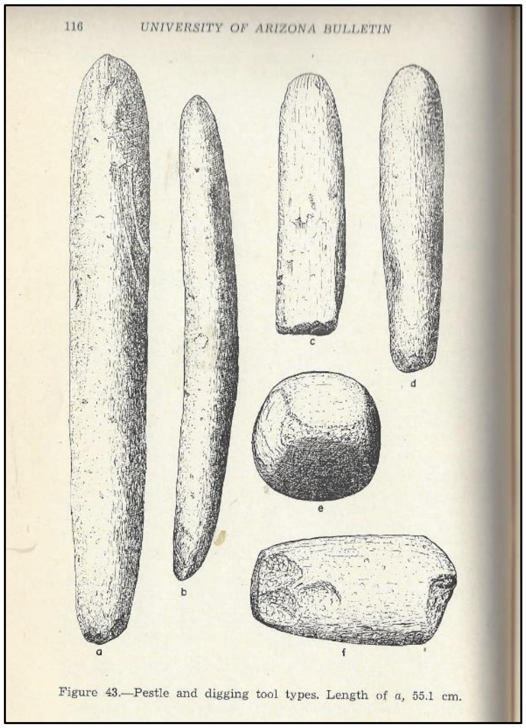


Figure 125. The four longer artifacts shown in this figure and described as possible "pestles and digging tools" were found by Joe Ben Wheat in a cache of 12 artifacts a wall niche of a Mogollon pithouse dating to ca. A.D. 100 to the late 900s at the Crooked Ridge Village site in Arizona (Wheat 1954:116). Based on their physical characteristics, they could be possible lithophones.

- **Is there any other evidence of the use of lithophones in the SLV such as depictions of lithophones on rock art?** A local artist, David Montgomery, found a rock art panel at site 5RN1 that he believes may depict the playing of lithophones (Figure 126) and perhaps there are other potential depictions of the use of lithophones that have not yet been identified.

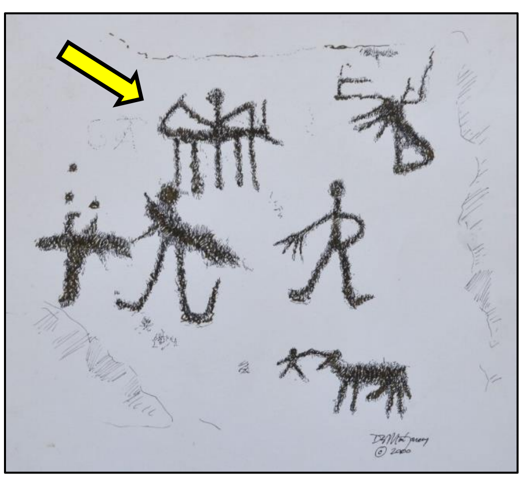


Figure 126. Drawing of a rock art panel at site 5RN1 on the western edge of the SLV that could possibly depict the playing of a group of lithophones (drawing courtesy of David Montgomery).

- **Can the use of non-destructive modern technologies like 3D modeling be utilized to help understand the physical properties and sound characteristics of known lithophones**? Due to the many variations in shape of the body and ends of a single lithophone, it is difficult to accurately describe the physical characteristics of lithophones, even by using detailed photographs. Utilizing 3D modeling would enable a more precise record of each lithophone and possibly may help to better understand and compare sound qualities with physical appearance.

- **What are the reasons for the differences in sounds compared to length, width and weight of a lithophone?** The differences in sound may be related to a number of physical characteristics such as the overall shape of the artifacts (rounded body versus generally flattened oval shapes in cross-sections, and/or shapes of the ends), or perhaps the shape combined with other factors such as rock type, density, and weight of the artifact (Caldwell 2013). Experiments to specifically test and compare sounds of lithophones with various physical characteristics may help to answer these questions.

- **The presentation discussed above relating to the neuroscience and music and how it translates throughout human society (*Notes and Neurons: In Search of Common Chorus*: Full Presentation; https://www.youtube.com/watch?v=S0kCUss0g9Q), has many relevant research topics related to musical sounds across different cultures and to the concept of music played by lithophones, especially as related to pentatonic scales.** How far back in history could these ideas apply and how does it relate to the creation and use of lithophones in North America and especially in Colorado? There are many additional specific questions related to the notes and scales produced by lithophones. For example, did the musical sounds/scales produced by different groups that made and utilized lithophones vary over time? Were stone sources for lithophones chosen to create specific notes and sounds, or were the stones chosen simply because they were resonant, and the note played was secondary in the selection process? It appears that the shape, length, and density of the stone are the major criteria regarding the acoustical properties of lithophones, so it is assumed that rocks were specifically shaped/tuned to obtain a certain pre-conceived note(s), but, as related to the previous question, could it also be possible that resonance and musical quality had a higher value for selection of raw materials for lithophone manufacture than being able to create specific notes or sounds?

As discussed above, one of the main goals of the project is to help create awareness of the alternative function of sound production for certain ground stone artifacts that have acoustical properties. Based on information obtained to date, it is likely that additional lithophones have been found by collectors or are located in archaeological collections in museums or other repositories. This has been and continues to be a major goal for lithophone research in the future. Questions related to this goal include:

- **Do other lithophones exist in the SLV or other parts of Colorado (or other geographical areas) but simply have not been correctly identified as to function?** For example, an artifact that appears to have the physical characteristics of a lithophone was observed in a local museum in the town of Saguache at the north end of the SLV (Figure 127). It is currently labeled as a "kneading stone."

  If this artifact and others described below or found in the future can be tested and determined to have acoustical properties, it may help to show a more wide-spread distribution of lithophones and provide more information about context and dating.

Figure 127. "Kneading stone" that may be a lithophone; located in a museum in Saguache, Colorado.

Another potential lithophone was found a number of years ago during site testing by Metcalf Archaeological Consultants, Inc. in northwestern Colorado at site 5MF2995 (McDonald: 2001). This artifact (Figure 128) was pointed out to the author by Kelly Pool. It was found in a grid unit southeast of Feature 1M that was radiocarbon dated to the Late Archaic, 2760± 90 BP (Beta-58881). It was described as follows:

> It is a long and relatively thin schist tool of unknown function, similar in appearance to several other tools found on this project (Figure 7). The two faces of the tool are flat and appear to be relatively unaltered. The margins and ends have been shaped by heavy grinding and pecking. One of the ends is flattened and battered. The opposite end is rounded and is somewhat polished. The tool is complete and measure 218 mm in length, 55 mm wide, and 26 mm thick. It has a mass of 625 g [McDonald 2111:14-15].

Based on its physical characteristics, this artifact may have functioned as a lithophone and is the type of artifact that will hopefully be tested for acoustical properties in the future.

Figure 128. Potential lithophone (.72) found at site 5MF2995 in northwestern Colorado.

Another likely lithophone is located in a local museum in Truth or Consequences, New Mexico (Figure 129). This specimen is displayed next to a smaller artifact that also appears to be a possible lithophone. The longer specimen, which is over four feet in length, was reportedly found associated with the mammoth skull shown on the table behind the two lithophones. There are many research questions related to this find:

- **Do other lithophones of this size exist, and who made them and when? Where did the toolstone material come from (local or distant source)? What notes would a lithophone of this length produce? Could the potential association with mammoth remains suggest a long use of lithophones over time in North America?**

Figure 129. Lithophone from New Mexico that is over four feet long and was reportedly found in association with a mammoth skull.

- **Are there other types of lithophones from archaeological contexts such as caches of large biface lithophones or stationary boulder lithophones that exist in Colorado or elsewhere?** An article published in Southwestern Lore (La Belle and Johnston 2015:1-149) contains many examples of large bifaces found in caches. While the majority of these do not appear similar to other described flaked biface lithophones found in other parts of the world (see Figures 20-21), some of the larger examples of bifaces found in Colorado, such as those from the Mahaffy Cache in Boulder County (La Belle and Johnston 2015:138-149), could potentially have acoustical properties. The fact that some biface caches have been interpreted as lithophones is at least suggestive that perhaps groups of large bifaces or even individual artifacts should be tested for acoustical properties.

- **Could other types of ground stone artifacts, such as a celt or adze, have functioned as lithophones?** Two artifacts from a private collector have been tested for acoustical properties and the sounds are very bell-like (similar to modern metal bells). Figure 130 shows two of these artifacts.

Figure 130. Two celt/adze-like artifacts from northern New Mexico that produce highly-resonant bell-like sounds.

- **In the future, if lithophones are found in archaeological contexts, it is recommended that they be carefully documented, tested for acoustical qualities, collected, and dated, if feasible, to help understand the use of these artifacts over time.** To assist in this goal, a list of recommended steps to follow to document and identify potential lithophones in the field is included in the next section, prior to the project summary. It is also recommended that potential lithophones be collected, if possible, so that additional detailed descriptive and acoustical lab analysis can be conducted. Although collection/curation space is restricted, it is suggested that lithophones would be worthy of collection since our current knowledge about them is so limited at this time.

RECOMMENDATIONS FOR FIELD AND LAB IDENTIFICATION OF POTENTIAL LITHOPHONES

Ground stone artifacts are not normally collected during archaeological field work, primarily due to the paucity of curation facility space. Ground stone artifacts are also not collected, especially from the surface, based on the pre-conceived idea that this type of artifact is usually not considered worthy to collect because they are generally thought to have no potential to provide additional data. As mentioned above, due to the general lack of knowledge about lithophones and the important data that could potentially be collected from these artifacts, it is recommended that <u>any</u> potential lithophones (from surface or subsurface contexts) be collected for further analysis and study.

To determine if an artifact has acoustical qualities in the field, or if a laboratory/museum specimen requires testing, it is suggested that the following steps be undertaken:

1) To test the artifact for acoustical properties, the first step is to locate the two acoustical nodes. The two nodes are located at points approximately 25% from each end of the artifact, so these two spots can be estimated or measured based on the length of the artifact (Figure 131).
2) To be tested, the artifact needs to be held vertically, suspended, or raised above the ground or any flat surface. It can be held vertically using minimal contact with one finger and your thumb at the uppermost node location (see Figure 107). It can also be suspended horizontally or vertically on one or both of the acoustical nodes using leather strips or sturdy string (see Figure 106). The artifact can also be laid horizontally with the two nodes on top of narrow pieces of hard foam, narrow sticks or pieces of rope (see Figure 131).
3) A hard mallet is needed to tap on the artifact. In the field, an elongated pebble made of a dense rock type (like granite, basalt, etc.) can be utilized. In the lab, an elongated pebble, piece of antler or hard bone (see Figure 117) can be used. If feasible, the best mallet for testing is a hard composite or plastic (not yarn-wrapped) xylophone-type of mallet (see Figure 119). Even though a rock mallet will produce a good sound on a lithophone, use of a composite or plastic mallet is recommended for testing, if possible, so that new usewear markings are not created on an artifact.
4) Once the acoustical node locations are identified, the artifact should be placed on ropes or held or suspended at those locations (as described above), and when an appropriate mallet is found, the next step is to tap on the top surface of the artifact (using a spring-like motion in your wrist). There are three locations to tap on to test for acoustical properties: near either end or in the middle of the two acoustical nodes (see Figure 131). You can also tap on the lateral edges in these same three locations and determine if the sound is the same, higher or lower than the top surface sounds. Do <u>not</u> tap on the acoustical node locations on either the top or lateral surfaces since the artifact is not resonant at these two points.
5) If the artifact is a potential lithophone, the sounds should be similar to tapping on a wooden marimba, a metal xylophone, glass crystal, or a metal bell. If there is no ringing or musical sound, the artifact is likely not a lithophone. Software apps, such as Pitch Analyzer and Tonal Energy Tuner, are easily-accessible and reasonably-priced tools that can be downloaded on cell phones, computers, or other devices and can be used to determine the acoustical characteristics (note, Hz, etc.) of sounds produced by potential lithophones.

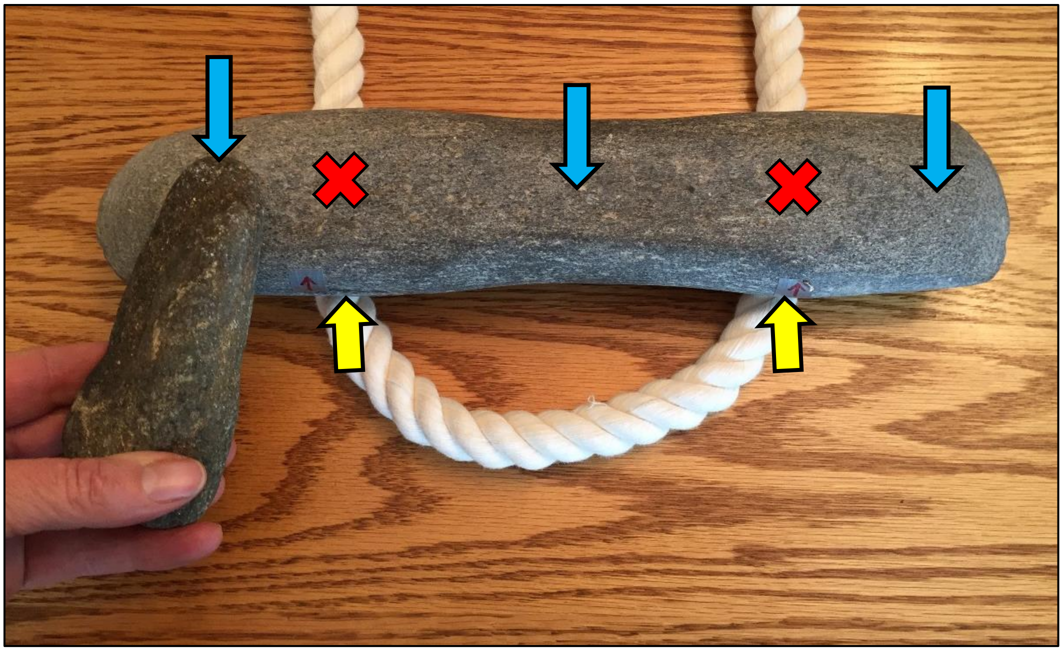


Figure 131. How to test a potential lithophone in the field or lab using a natural elongated pebble. The yellow arrows show the acoustical node/dull zone locations where the artifact should be supported above a flat surface or the ground, or where it should be held if testing in a vertical position. The red "Xs" mark the locations not to tap, and the blue arrows shows the best locations to tap the artifact to check for acoustical properties.

SUMMARY

A new class of prehistoric artifacts called portable *lithophones* has been identified from Great Sand Dunes National Park and Preserve and in private collections from the SLV, Colorado. "Litho" is Greek for stone and "phone" means sound; a lithophone is a musical instrument consisting of a purposely-selected rock (often formally-shaped) that is tapped or rubbed with friction to produce musical notes. Portable and stationary lithophones have been utilized in ancient and modern cultures around the world, including Europe, the Far East, Africa, the South Seas, and South America, but prior to this study, only a few portable lithophones have been formally recognized in North America and none have been previously documented in Colorado.

A sample of 22 lithophones was analyzed for the Friends of the Dunes as part of State Historical Fund Archaeological Assessment Grant # 2016-AS-006. Many of the artifacts utilized in this study from the SLV were originally thought to have functioned as utilitarian ground stone artifacts such as manos, pestles, and digging tools. The physical characteristics of the sample artifacts, including diameter, length, width, thickness, overall shape(s), weight, usewear, surface treatments, and possible material type, have been documented during this grant research.

After analysis of these artifacts, it appears that certain physical characteristics, such as evidence of grinding, polishing, striations, etc. should not automatically be assumed to be the result of using an artifact for a grinding-crushing type of function. In the case of lithophones, these characteristics may have more relevance to manufacturing techniques related to obtaining certain musical sounds and/or be the result of the playing of the lithophone as a musical instrument by striking/tapping or rubbing with friction.

It is not known if these sample lithophones were created for a single purpose related to producing musical sounds or perhaps were considered multi-purpose tools when created. It is also possible that these artifacts were created as lithophones by certain groups of people and then some of the artifacts may have been repurposed/utilized at a later time by other groups who may or may not have been aware of the concept of

lithophones. These different scenarios cannot be verified with the current data on this sample of artifacts, but future research, documentation, and dating of potential lithophones from *in situ* locations, may help to understand the purposes and uses of lithophones over time in Colorado and other areas of the western U.S. Future consultation with official Native American tribal representatives may also provide insight into how lithophones may have been utilized in historic and prehistoric times.

The acoustical properties (notes played and sound qualities) were also documented (described and recorded). All of the sample lithophones have acoustical properties. They each produce sounds similar to tapping on a wooden marimba, xylophone, glass crystal, or metal bell, and they exhibit dual sound planes (produce two notes), similar to other described portable lithophones (Caldwell 2013). Some of the sample lithophones appear to have more resonance and musical qualities than others. For example, the more highly-modified forms, such as those that are cylindrical, others that have been significantly shaped, and those that are complete and not fragments or broken and repaired, produce more resonant sounds that are similar to tapping modern metal bells or other modern musical instruments like marimbas or xylophones.

Caldwell (2013) described the physical and acoustical descriptions for a portable lithophone based primarily on data from Gonthier (2005). These characteristics of portable lithophones are listed in Table 8 and comments about how these characteristics are similar or different than the sample artifacts studied for this project are discussed.

Table 8. Characteristics of previously-described lithophones (Caldwell 2013) versus the sample project artifacts.

Caldwell (2013:526) descriptions of portable lithophone characteristics	**SHF Project 2016-AS-006 lithophone characteristics**
The acoustical nodes are located approximately 25% from both ends of the artifact.	This was true for all of the sample lithophones tested for this project (see Table 6 for specific data by artifact).
Columnar lithophones were most sonorous when their ends were conical or ogival rather than slightly flat or slightly bulbous like the majority of pestles. Caldwell also noted that those end shapes were not really diagnostic for columnar lithophones overall because of the range of cross-sections actually were quite varied.	This was difficult to compare on the sample artifacts for several reasons: 1) Many of the artifacts are not columnar in form. Also, some of the artifacts did have a slightly flattened end, but most of those were fragments where the flattened end was created because it had been broken (ex. Artifact #11 and #13). These artifacts were not very resonant, perhaps due to the one flattened end-shape; however, the lack of resonance may also be related to the fact that they are fragments. 2) Many of the sample artifacts exhibited ends that were different shapes from one end to the other on a single artifact. Some of these artifacts were very sonorous and others were not as sonorous. The body shapes/cross-sections on some of the sample artifacts also varied from one end to another. 3) Although several of the columnar or rounded-body complete lithophones were very sonorous (ex. Artifacts #1, #4, and #16), other fragments of a similar shape (ex. Artifact #13 and #18) were not highly resonant, but one fragment (Artifact #15) was, in fact, very resonant. This information suggests that the resonant qualities may be related more to other factors, such as the rock type/density and the overall length and shape of the artifact, rather than only the end-shapes.
<u>Length-to-width ratio</u>: Portable columnar lithophones have to be at least 4.5 times longer than their width.	<u>Length-to-width ratio</u>: The average length-to-width ratio of all of the sample artifacts is 5.6 (see Table 4). Five of the artifacts (23%) are less than 4.5 times longer than they are wide (#8, #10, #11, #12 and #14). The length-to-width ratio of these five artifacts averages 3.6. Of the 17 artifacts that have a width ratio 4.5 times longer than they are wide, or wider; their average length-to-width ratio is 6.2. In general, the longer sample lithophones have a more resonant sound than the shorter ones. Of those five artifacts with a lower width to length ratio, two are not very resonant (#10 and #11; note: these two are also fragments); two have some resonance (#12 and #14); and one (#8) is very resonant. This suggests that the width to length ratio does affect the sound of the sample lithophones, at least to some extent.

Caldwell (2013:526) descriptions of portable lithophone characteristics	**SHF Project 2016-AS-006 lithophone characteristics**
<u>Width range</u>: Caldwell noted that all of the 34 African lithophones analyzed by Gonthier had a width that ranged between 4 to 8 cm. Caldwell noted that the density of the rock material, and length were significant factors in sound production rather than width which had almost no effect on the fundamental tone.	<u>Width range:</u> The sample artifacts range in maximum width from 4.3 cm to 8 cm (see Figure 32). The average width is 6.4 cm. The variation in width is very small, only 3.7 cm between the widest and the narrowest artifact. It is clear that the sample artifacts studied for this project have the exact same range of width, between 4 and 8 cm, that has been previously described for other lithophones, e.g., Caldwell (2013).
<u>Lengths of lithophones</u>: between 35 and 80 cm	Of the 16 complete sample specimens (including #17 and #20 that were broken and glued but are complete), the length range was from 22.0 to 64.5 cm with an average length of 38.4 cm. Seven of these artifacts are less than 35 cm in length. Three are just slightly less than 35 cm in length (#22 is 34.5 cm, #2 is 32 cm, and #3 is 31.5 cm), and four are less than 30 cm (#19 is 29.1 cm, #8 is 26.5 cm, #14 is 22 cm, and #12 is 21.4 cm).
Few if any signs of being used for vertical grinding or pounding.	A few of the sample artifacts have some evidence of light grinding and/or battering on the ends (ex. Artifact #12, #14, #19 and #20) but none have end shapes or wear similar to normally-described pestles used primarily for crushing and grinding (Adams 2014:138-140). It is hypothesized that some of the sample lithophones could have been utilized as multi-purpose tools either during concurrent use as lithophones or perhaps at a separate time if an artifact was later re-used or re-purposed. Since the manufacturing technique(s) for various-shaped lithophones are not understood, future research may help to clarify what physical characteristics of lithophones may be the result of manufacture, playing, storage or caching, and/or transporting of lithophones versus uses for other purposes.
Use of acoustically active stones such as chlorite-schists and schist actinolites.	The exact material types of the sample lithophones are not definitely known but based on consultation with a variety of geologists, they appear to be basalts, andesites, granites, and schists. These types of dense rocks are similar to those described by Caldwell (2013) and (Brown 2014).

Caldwell (2013:526) descriptions of portable lithophone characteristics	SHF Project 2016-AS-006 lithophone characteristics
A feature that added to the quality of lithophones was having an oval latitudinal cross-section (across the instruments trunk) rather than a circular one.	Only two of the sample artifacts, #1 and #13, are categorized as stone cylinders with a rounded cross-section on both ends (see Figure 52), but two of the artifacts (#4 and #18), have a rounded cross-section on one end and an oval or flattened-oval cross-section on the other end (Figure 53-54). All of the other artifacts either have oval and/or flattened oval cross-sections on both ends. In total, over 85% of the lithophones have oval or flattened-oval cross-sections on both or at least on one end. Those artifacts with rounded cross-sections are generally very resonant, but some of the oval or flattened-oval artifacts are also very resonant, so this characteristic described by Caldwell (2013), does not appear to be relevant to the sample artifacts.

Dating of the sample artifacts was based on existing data and no new dates were obtained during this project. The date for the Fish Bone Site feature/artifact concentration where lithophone #15 (categorized as a highly-modified stone cylindrical lithophone) was found, is possibly suggestive that the more highly-modified lithophones from the SLV could significantly pre-date the described lithophones/kiva bells from the Southwest (Brown 2014), in some cases by over 5000 years. Additional research and analysis is needed to test this hypothesis and determine if the more highly-modified lithophones and many of the other lithophones found in the SLV date to a much earlier time and are possibly related to a different cultural group or groups.

Based on their physical characteristics and acoustical qualities, all of the sample artifacts are thought to likely have been utilized as lithophones, or at least they have physical and acoustical properties that are highly suggestive of such a function. Overall, none of the artifacts appear to have been utilized primarily for normal grinding or crushing-related functions (such as to crush and grind foodstuffs), like a regular mano or pestle. Some of the sample artifacts do have limited evidence of use for grinding, pounding, etc. but this does not appear to be the primary functional type of use or purpose (see Table 8).

Based on research from all over the world, there seems to be almost a universal knowledge and language of music throughout history. Looking at today's music, it is fascinating to be able to track the lineage of musical influence across time and distance. Finding a tonal structure in these rock artifacts that is used in virtually every corner of sophisticated civilization, is extremely eye-opening. The discovery of a tonal system (Semitones) in these lithophones, mainly the use of an extremely common tonal structure (Anhemitonic Pentatonic Scales), would serve to bridge the gap between all continents and cultures.

As noted above, there are many remaining research questions yet to be answered, but this current grant research project has shown that that considering the idea of sound as a function for ground stone and other types of stone artifacts in Colorado and other locations in the western U.S. is valid and warrants additional study.

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APPENDIX A (1)

ANNOTATED BIBLIOGRAPHY OF KEY LITHOPHONE REFERENCES

Caldwell, Duncan
2013 A Possible New Class of Prehistoric Musical Instruments from New England: Portable Cylindrical Lithophones. *American Antiquity* 78(3):520-535.

In this article on lithophones in New England and North America, Caldwell discusses the different types of lithophones:

- Stationary lithophones
- Adulterated ridges and stalactites
- Natural rock gongs on stationary rock faces
- Natural but positioned stationary lithophones
- Manufactured stationary columnar lithophones
- Portable lithophones (natural rocks that have been suspended, long bifaces and stone slabs, and stone cylinders).

Caldwell identified two lithophones from New England and discusses their characteristics in comparison to others previously identified by Erik Gonthier (lithophones from the Sahara, Africa and are curated in the Musee de L'homme, Paris). He also includes a list of five physical criteria for recognizing potential lithophones: 1) diameter between 4 and 8 cm; 2) lengths between 35 and 80 cm; 3) dimensions 4.5 times longer than they are wide; 4) few, if any, signs of being used for vertical grinding or pounding; and 5) the use of such acoustically-active stones as chlorite-schists and schist-actinolites). He includes recommendations for acoustical analysis of potential lithophones with iAnalyzer Lite software.

Caldwell also discusses the acoustical properties of portable cylindrical lithophones:

- The lithophones produce clear fundamental tones ranging from *fa*4 + 3 at around 700 HZ through *la*, around 6,500 HZ, with resonances that vary between 1 and 2.5 seconds.
- The majority of the sounds are about a quartertone different on the lateral faces from the dorsal faces, making most of the stone rods two-toned instruments.
- He also describes how the sound moves through the lithophones; the sound waves crossing themselves twice and creating two dull zones (about a quarter of the way from each end). At these two points, the stone can come into contact with another medium without breaking the integrity of the sound waves.
- Columnar lithophones were more sonorous when their ends were conical ogival rather than flat or slightly bulbous (like pestles).
- An oval cross section was also better for sound production than a circular one.
- The density of material and length also were a significant factor in sound rather than width which had almost no effect on the fundamental tone.
- Making the columnar lithophones as smooth and even as possible was likely based on a desire to obtain pure fundamental notes.

Caldwell indicates that the lithophones were likely associated with prestige or rituals and were not utilitarian due to their scarcity in comparison to other functional types of artifacts. He stated that only a few potential portable cylindrical lithophones have been identified in North America including the two he describes in New England, one lithophone from Arizona, and a possible one from New Mexico. These cylindrical lithophones may be up to several thousand years old, perhaps as old as 8,000 years before present.

Brown, Emily J.
2005 *Instruments of Power: Musical Performance in Rituals of the Ancestral Puebloans of the American Southwest.* Ph.D. dissertation, Graduate School of Arts and Sciences, Columbia University.

Emily Brown's Ph.D. dissertation includes descriptions of numerous types of musical instruments utilized in the prehistoric southwestern U.S. She includes a section entitled "The Archaeomusicology of Kiva Bells" where she describes "Kiva bells from the American Southwest as elongated stones of argillaceous limestone, basalt, phyllite, phonolite, feldspar and similar materials usually a foot or more in length."

Dates:

- She notes that the vast majority of lithophones are found in late Pueblo III and Pueblo IV sites in the Rio Grande Valley and that all known kiva bells date to after A.D. 1300.

She notes that the Patokwa Pueblo (Ka;atusekwa, one of the native words for the pueblo translates to "Place Where They Hit or Ring the Stones") or "a place where kiva bells were used…..". While this Pueblo is situated in the Jemez Mountains with easy access to Jemez basalt, kiva bells have been found at many pueblos in the vicinity of Jemez. She also notes that "….more research is needed to identify the sources of stone used for music-making."

Associated use of kiva bells:

- Dr. Brown also notes that "the available ethnographic evidence suggests that kiva bells were used primarily ceremonially, both to announce the time for men to assemble in kivas and as part of ceremonies carried out in more public settings such as those associated with the winter solstice." She states that "The few examples of kiva bells decorated with ochre reinforce a ceremonial interpretation." Also, "That none of the objects for which contextual information is known were found with burials suggests they were not individually owned."

How found:

- She also states that many times kiva bells have been found in caches with other kinds of objects (for example concretions, lightning stones and minerals)
- Even though they are found individually, they have often been found in groups (3, 5, 11 and 23)

Most of the kiva bells in her sample were not extensively culturally modified, but one specimen from northeastern Arizona was shaped into a smooth shaft with one flat and one pointed end, and exhibits two different tones when tapped. Note: This specimen is similar to several found in the SLV.

Brown, Emily J.
2014 "A Sound Like That of Bells": Lithophones in the Southwest *in* Enduring Curiosity, Generous Service; Papers in Honor of Sheila K Brewer. Edited by Emily J. Brown, Carol J. Condie, and Helen K Crotty. Papers of the Archaeological Society of New Mexico 40, Albuquerque.

In this article, Dr. Brown focuses on lithophones found in the Southwest. She notes that most of the lithophones found in the Southwest fall into the suspended natural rock portable lithophone category with the exception of the stone cylinder from Arizona (described above). She describes several early ethnographic observations of kiva bells being played the Taos Pueblo (1896 by Edgar Lee Hewett) and at Santo Domingo (1930s by Frances Densmore). Densmore noted that to make a sound, the lithophones were struck with another smaller stone. A Cochiti consultant also told a researcher in the 1950s that "Kiva bell stones were found in places where lightning had struck, and that the best tones were achieved by striking them with smaller pieces of the same type of stone…".

Dr. Brown notes that of the 73 artifacts labeled as kiva bells in collections that she sampled, only 42 clearly possessed physical characteristics of kiva bells.

Material types:

- Brown notes that sandstone did not have good acoustical properties due to its "low density and highly friable nature."
- She describes kiva bells from the American southwest as "elongated stones of argillaceous limestone, basalt, phyllite, phonolite, feldspar and similar materials usually 30 cm or more in length." She mentions that "very few kiva bells have been found outside of the Rio Grande Valley proper." Brown also mentions gneiss, schist and petrified wood being used with schist being the most common at Gran Quivira.
- Brown mentions that a much smaller type of lithophone also appears all over the southwest. These are only a few inches long and are generally referred to as "ringing stones", are almost always made from petrified wood, and are most often found in northern Arizona.

Shaping of the stones:

- The majority of kiva bells in her sample were unmodified stones
- Of the kiva bells that that had been culturally modified, the most common treatment was grinding and smoothing.
- A few had notches in the sides, "presumably to facilitate suspending". A few retained remnants of red or yellow ochre and two were decorated with an incised interlocking diamond pattern.
- At Gran Quivira, most of the kiva bells have an oval depression running lengthwise along the center of their faces (pecked and then polished).

Use-wear:

- She noted that "most kiva bells she examined showed scarring from being struck with another stone although she suggests that percussors of antler, bone, and wood may have also been used.
- Some exhibited striations or polish possibly from friction rather than striking
- Based on studies of percussion of flint, antler and bone on stone, use of flint resulted in clusters of conical fractures or polish
- Antler and bone left calcium/phosphorus deposits that appeared as dark smears overlaying clusters of depression in the surface of the stone.
- The effects of wooden percussors was identified as an area for future study.

Musical properties of the kiva bells:

- Some were more resonant with friction than with tapping
- Regarding sound: in one case two tones about a major third apart were clearly distinguishable; on another, a note at an interval of a fifth was prominent in the overtones in addition to the root note.
- Regarding sound and materials types, as discussed by Caldwell (2013), the most successful lithophones are those made from homogeneous rocks that are basically cylindrical in form and denser materials were more sonorous.
- Lithophones with conical or otherwise roundly tapering ends rather than flat or slightly bulbous ones sounded better
- Cross-section: more circular-shaped lithophones sounded better than oval-shaped ones (She is citing Caldwell here and I believe this is an error since Caldwell 2013 notes that oval-shaped columnar lithophones are more sonorous).
- Differences in length made more differences in sound to change the pitch than did changes in width
- In general, stones were not resonant unless the length was at least 4.5 times the width.

Adams, Jenny L.
2014 *Ground Stone Analysis, A Technological Approach*. University of Utah Press, Salt Lake City.

This book is the go-to reference on ground stone material types and analysis. It does not discuss lithophones but does have detailed information about identifying and analyzing ground stone that may be useful for documenting and describing lithophones.

One item of interest (page 147) is her discussion of a cache of 11 cylindrical pestles or pestle-like tools that were recovered from a pithouse at Crooked Ridge Village in the Point of Pines area of Arizona by Joe Ben Wheat in the 1950s:

Wheat, Joe Ben
1954 Crooked Ridge Village (Arizona W:10:15). University of Arizona Bulletin 25(3), Social Science Bulletin 24. University of Arizona Press, Tucson.

Wheat thought that these tools might have been digging sticks but noted that the usewear did not match this function. Adams suggest that they may have been used in different stages of pithouse construction. Based on the shapes (elongated, cylindrical) and material types (basalt, gneiss and schist) of these artifacts, my hypothesis is that the artifacts in this cache could be lithophones.

Prasad, M.G. and B. Rajavel
n.d. Musical Pillars and Singing Rocks. Noise and Vibration Control Laboratory, Department of Mechanical Engineering, Stevens Institute of Technology, Hoboken, New Jersey.

This article discusses the architectural elements of ancient south Hindu temples built between the 8th centuries and the 16th centuries that exhibit musical pillars which are made of solid granite. These temples exhibit two types of musical pillars: beating or tapping pillars, and blowing pillars (the sound created by air).

APPENDIX A (2)

INTERNET LINKS TO LITHOPHONE INFORMATION, SOUND CLIPS AND VIDEOS

INTERNET LINKS TO LITHOPHONE INFORMATION, SOUND CLIPS AND VIDEOS:

http://www.telegraph.co.uk/culture/music/10702186/Cavemens-rock-music-makes-a-comeback.html
Date accessed: 10/21/2016
This article about lithophones was written in 2014 and discusses lithophones located in the Musee de L'homme, Paris. These lithophones, dated to between 2500 and 8000 BC (the New Stone Age), are currently located in the Paris museum and are originally from the Sahara, Africa. Many of these lithophones were brought back to France in the 1900s by French troops stationed in the African colonies such as Algeria and the Sudan. Erik Gonthier, paleomusicologist and lithophone specialist, noted that they were originally thought to be pestles or grinders of grain, but he discovered their musical qualities in 1994 when he tapped one with a mallet.

The lithophones are carefully crafted stone rods up to 3.2 feet in length. Gonthier noted that "The instrument was the result of a "grain by grain" chipping process that could have taken as much as two years to complete." He said that "all lithophones, which can be made from types of sandstone (note: I think the term "sandstone" is an error, possibly due to translation because all other sources state that sandstone does NOT have good acoustical properties), share certain characteristics. Every instrument has two sound "planes" that can be found by tapping at 90 degree angles around its circumference." To play the lithophones, Gonthier said they would have "rested on brackets made of leather or plant fibers, or even on the musician's ankles, sitting cross-legged." He notes that music may not have been the only purpose of the lithophones, that they may have been used for other purposes such as for communication, to signal danger, etc. Gonthier noted that he believes that "there might have been a strong link between music and visual art in prehistoric caves."

The Natural History Museum of Paris allowed four percussionists from the French National Orchestra to play two concerts with 24 of the lithophones (see video links).

http://www.tinkertunes.com/lithophones
Accessed: 10/21/2016
The Tinkertunes Music Studios opened in 1995 in Traverse City, Michigan as a music teaching facility, and provides private and group lessons in piano, flute, violin, as well as numerous Early Childhood music programs. Their goal is to share the joy of making music and to provide opportunities for a musically enriching experience that will begin a lifetime of appreciation.

This article has a short discussion about the origins of lithophones and uses around the world. The author has made lithophones out of a number of materials such as pieces of granite countertop, chunks of Indiana limestone, black granite floor tile, Michigan Petoskey Stone, and even metal wrenches and bolts. The article also has short video clips of the playing of lithophones made out of various materials, and a list of relevant links to information about lithophones.

http://www.lithophones.com/index.php?id=45
Accessed: 10/21/2016
This website focuses on gathering data on multiple types of lithophones, and describes lithophones documented from numerous cultures around the world. It lists over 40 countries and contains photographs of lithophones from Europe, the Far East, Africa, the South Seas, and North and South America. The site also has musical links to different types of lithophones from around the world.

www.whoi.edu/image-of-day/rock-on
Accessed: 12/1/2016
This is a short 1-page article about a lithophone that was brought to Woods Hole Oceanographic Institute in 2012 by an amateur archaeologist. It was identified as a lithophone based on Duncan Caldwell's 2013 *American Antiquity* article (see above). The article contains a photograph of a lithophone that is similar in shape and size

(a long, rounded shaft of stone) to several found in the SLV. The photograph depicts the playing of the lithophone with another stone that is elongate and is hand-held.

www.mprnews.org/story/2007/03/16/lithophone
Accessed: 12/1/2016
This is a 1-page article referencing a Minnesota Public Radio story from 2007 about a percussionist, Heather Barringer, from a musical group call Zeitgeist, who was performing on a group of lithophones that is laid out like a xylophone. Some of these stones look similar to several of the lithophones from the SLV.

VIETNAM LITHOPHONES:
http://www.megalithic.co.uk/article.php?sid=2146412031
Accessed: 12/1 2016
This article discusses a group of 11 lithophones found in Vietnam that are believed to be 3,000 years old. They were found in a buried pit. Lithophones have been found there at several sites in the past.

http://www.vietnamtourism.com/en/index.php/news/items/2839
http://www.vietnamtourism.com/en/index.php/about/items/1889
Accessed: 12/1/2016
Several 1 page articles referencing recent and past finds of lithophones in Vietnam.

Vietnam youtube videos:
https://www.youtube.com/watch?v=VnNhjMQrneA
Accessed: 12/1/2016
Excellent video of modern stone lithophones being played xylophone style in Vietnam. They are played using two wooden mallets with the lithophones laid out horizontally and suspended on rope or ? on their dull zones, and played on top of a horizontal piece of wood.

https://www.youtube.com/watch?v=gCHno2kftVU
Accessed: 12/1/2016
Same basic video as above.

SCOTTISH LITHOPHONES AND ONE CALIFORNIA LITHOPHONE:
www.dragonprojecttrust.org/audioclips
Accessed: 12/1/2016
This article has photographs, a short description and audio clips of four lithophones:

1) **The Iona Ringing Rock lithophone is located on the island of Iona, Scotland**. It is a large boulder with an associated hammerstone in a carved-out hollow. It makes a deep ringing sound.
2) **Carn Menyn, Wales**. This site in the rock outcrops of the Carn Menyn ridge of SW Wales is the source area for Stonehenge bluestones. The sounds are muffled by the wind but it makes a higher pitched metallic ringing sound.
3) **Vision Quest Site, California.** A small boulder lithophone with a petroglyph (bird?). It is played with another rock and makes a ringing sound similar to a metal bell.
4) **Balephetrist Ringing Rock, Tiree is located on the Inner Hebridean Island of Tiree, Scotland.** This is a large (non-native stone) boulder located in an isolated beach-edge position. It is covered by over 50 cup marks, thought to be Bronze Age, and "seemingly caused by repeated striking of the rock over untold centuries." The sound is metallic.

1890 "ROCK BAND" LITHOPHONE FROM KESWICK, ENGLAND:
www.metmuseum.org/blogs/met-museum-presents-blog/2015/wild-sound#
www.swaag.org/GEOLOGY/lithophonic%20stones.htm
Accessed: 12/1/2016

These are links to articles, photographs and audio clips of early (1890s) lithophones that were used in "Rock Band" concerts by the Till family, and popular in the 1890s in England, Scotland, Europe and the U.S. The Till family reportedly played this lithophone instrument, called a "rock harmonicon or stone xylophone", in over 1000 concerts.

How played:

- The lithophones were suspended on heavy pieces of rope on their dull zones and played horizontally like a xylophone on a wooden stand. A "range of hammers and leather- and cloth-covered mallets were used to coax different timbres from the rock band."

Lithophone material types:

- gneiss and hornblende schist

Acoustical properties:

- The Till family lithophone had 22 rock bars "that produce a 3-octave diatonic scale, and originally may have included a second row of stones to enable a full chromatic scale.

ARCHAIC SITE IN LABRADOR WITH LITHOPHONE BIFACES:
https://nlarchaeology.wordpress.com/2015/11/27/the-archaic-site-at-forteau-point-southern-labrador/
Accessed: 12/1/2016
This article discusses archaeological work at an Archaic Site at Forteau Point, southern Labrador. The site contains points, knives, scrapers, adzes, a gouge, ground slate implements, 15 indeterminate fragments and a core. Material types included chert, quartzite, silicified slate and andesite. An interesting side-note in the article is a reference to 18 large bifaces (a cache of 4 large bifaces and 14 that were found in association with a large area of red ochre). They refer to the four cached bifaces as a lithophone. This cache was radiocarbon dated to 5035 ± 65 BP (see photos and excerpt from the text below):

> "To add to the idea of a ceremonial function for the site, over several years of revisits 18 large bifaces were recovered from the area ranging in size from 29 cm to 38 cm in length. Clearly, such large bifaces were not meant for hunting. Tuck 1993 states '*The four largest specimens were found in a single cache and the others in association with large patches of red ochre* . . .' Tuck speculates that these 4 bifaces formed part of a precontact 'lithophone' which would have functioned similar to a xylophone.

Forteau Point cache bifaces that form the 'lithophone'.

Forteau Point cache bifaces that form the 'lithophone' (Tuck 1993)."

NIGER, WEST AFRICA LITHOPHONE:
http://www.pick-et-boch.com/en/lithophone-prehistoric-sound-stone-from-niger-singing-stone-a6780.html
Accessed 12/1/2016

A website for a music store that sells old and new instruments. The store is located in Lyon, France. They posted photographs and a short description of a "Prehistoric Lithophone of Niger". They state that the estimated age is "approximately -4500 to -10000 years which corresponds to the Neolithic Period."

Lithophone description:

- The lithophone is 75 cm long and 6 cm diameter (it looks very similar in size and shape to several of the very long round lithophones from the SLV).

Acoustical properties:

- The sounds produced by the lithophone are "bisonore, and plays a Mi or F depending on where it is struck with a thick stick or a small hammer."

ARCHAEOACOUSTICS – THE SOUNDS OF ANCIENT PLACES:
http://www.landscape-perception.com/archaeoacoustics/
Accessed 12/1/2016
This excellent website discusses recent investigations into archaeoacoustics – the study of sound in archaeological contexts. It includes discussions, photographs, and audio clips at numerous locations including Stonehenge. Topics include art and archaeology, sound and sightlines, acoustic mapping, and visual mapping. Specific information on "ringing rocks" around the world, echoes, and how sound affects mind and body (ex. they discuss that a 110 HZ primary resonance band has been linked to stimulation of a certain electrical brain rhythm associated with a particular trance-like state).

GENERAL RINGING ROCKS REFERENCE:
https://en.wikipedia.org/wiki/Ringing_rocks
Accessed 12/1/2016
This website contains numerous links to sites like Ringing Rocks, Pennsylvania and Ringing Rocks Montana. It also contains a write-up on the geology of the ringing rocks boulder fields and why it is thought that certain individual rocks ring while others do not. One researcher has suggested that the ringing is due to internal stresses within the rocks themselves.

RINGING ROCKS, MONTANA:
Ringing Rocks Point of Interest Montana:
http://www.blm.gov/mt/st/en/fo/butte_field_office/recreation/ringing_rocks.html
Accessed 12/1/2016
This link is to the BLM and includes minimal information about the ringing rocks but does include a map and directions to the site.

https://mbmg.mtech.edu/pdf/geonews-RingingRocksMTMagazine2013.pdf
Accessed 12/1/2016
This brief magazine article is written for the general public but does have some discussion about the Ringing Rocks Montana rock formation (part of the igneous intrusive system, the Boulder Batholith) and note that the density of the rocks is above average, possibly explaining the ringing ability. It also notes that the public can climb on and "play" the rocks at this location which is within the Deerlodge National Forest and under the jurisdiction of the Bureau of Land Management.

YOUTUBE VIDEO LINKS TO RINGING ROCKS PARK, MONTANA:
Accessed: 10/21/2016
http://www.youtube.com/watch?v=V91dkxp_XhI&sns=em
"Freakin' Awesome Rock Drum Solo @ Ringing Rock State Park Montana" – a drummer playing on several ringing rocks.
http://www.youtube.com/watch?v=472PEHLpwTQ&sns=em

Windy video recording of a couple playing the rocks.

http://www.youtube.com/watch?v=kyS-6P0Qa9Q&sns=em
A video of a number of people playing the ringing rocks.

RINGING ROCKS, PENNSYLVANIA:
http://www.atlasobscura.com/places/sonorous-stones-ringing-rocks-park
Accessed: 12/2//2016
This is a very brief article with a few photos of "The Sonorous Stones at Ringing Rocks Park, Upper Black Eddy, in Pennsylvania. The article notes that the boulder field covers 7 acres and the rocks are 10 feet deep.

https://www.youtube.com/watch?v=NBfrLoBpsIQ
Accessed: 12/2//2016
This excellent video is taken in Ringing Rocks Park, Pottstown, Pennsylvania. It shows an overview of the boulder field and examples of a number of different boulders being "played" with a metal hammer. The sounds and pitches are quite varied and some sound very similar to metallic bells.

VIDEO – UNKNOWN LOCATION (In France?)
https://www.youtube.com/watch?v=a8AjkDlZrJs
Accessed: 12/1/2016
Published on Jun 17, 2015
Suivez Fabrice Bony, musicien et compositeur à la recherche de pierres sonores...
Follow composer and musician Fabrice Bony in his research of special and musical stones...
Montage et réalisation : Samantha Zaccarie.

This video shows a musician and composer in the field in 2015 rocks (location appears to be close to timberline). He is shown testing natural rocks he is choosing to use as musical stones. He tests them with a small square elongated stone.

After testing and collecting the musical stones, he takes them back to his studio, places them on long, narrow wooden square pieces of wood in xylophone fashion, and plays them. He appears to be playing them with regular wooden store-bought mallets. Very good video because it shows how the stones were chosen as well as played.

ERIK GONTHIER VIDEO LINKS/LITHOPHONES FROM THE SAHARA, AFRICA THAT ARE IN THE MUSEE DE L'HOMME, PARIS:
Best one:
https://www.youtube.com/watch?v=jEtFewAtzsU
Accessed: 12/1/2016
A short video clip showing Erik Gonthier playing a few of the lithophones he identified in the Museum of Man in Paris.

http://www.dailymotion.com/video/x1iqfxf_paleomusique-erik-gonthier_music
Accessed: 12/1/2016
Le programme pédagogique de l'Orchestre National de France - Découverte ONF - propose un concert exceptionnel au Museum national d'Histoire naturelle dans la série Musicomusée. Paléomusique: une commande pour lithophones au compositeur Philippe Fénelon, sur un texte d'Erik Gonthier, création vidéo des élèves de l'Ecole Estienne, avec les percussionnistes de l'Orchestre National de France.
Publication date : 03/21/2014
Duration : 05:25
Category : Music

This video shows Erik Gonthier in the Museum playing example lithophones that he discovered in the museum collections in Paris. These lithophones came from the Sahara and were brought back by French troops in the early 1900s. The language in the video is in French but a variety of lithophone types can be seen and heard being played.

http://www.dailymotion.com/video/x1t61ck
Accessed: 12/1/2016
This is a short video of Gonthier and others preparing to play the Saharan lithophones in a concert in Paris. They show and are practicing on a number of lithophones; language is French.

http://www.dailymotion.com/video/x1iqjp3_paleomusique-interpretation_music
Accessed: 12/1/2016
This excellent video includes a number of musicians who demonstrate playing of the lithophones identified by Gonthier. A variety of different sizes and shapes of lithophones are visible and are played. Video is in French.

http://www.dailymotion.com/video/x1os8k2_concert-a-l-age-de-pierre_tech
Accessed: 12/1/2016
Another video with Erik Gonthier explaining the lithophones (in French) and a short clip of musicians from the National Orchestra playing them. Variety of lithophone shapes and sizes are visible.

http://erikgonthier.blogspot.com/
Accessed: 12/1/2016
I translated this from French but it does not make a lot of sense and is confusing. I think that other articles and videos are much better

MODERN MUSIC PLAYED ON LITHOPHONES:
www.**youtube**.com/watch?v=jalL0Cz7uH8
Accessed: 12/1/2016
FABRICE BONY / SPIRALES EPHEMERES - Lithophone - Instants Sonores 2014
Lithophones being played with other instruments – modern music but interesting

Elias Davidsson
n.d The Icelandic Lithophone. Experimental Musical Instruments Journal, September 1998.

Davidsson discusses the "Icelandic Lithophone" which is made from natural sonorous stones collected from outside of Reykjavik.

Material types:
- basaltic, isotropic stones

Sizes:
- 15 to 20 cm in length and 6 to 15 mm in thickness

Percussor:
- after experimenting, the author recommends use of small, rather hard mallets, such as a Baltor no. 5

Sounds:
- They collected over 100 ringing stones with a range of almost three octaves.
- The stones can be struck with a mallet or an almost continuous "tenuto" sound can be obtained by stroking the surface of the stone with another stone or pebble.
- The fundamental note can be perceived with the most clarity when hit at its extremities
- Overtones, mostly inharmonic, can be obtained by hitting the stone in other locations.
- The fundamental note can be enhanced by using a softer mallet.

- Some stones provide two or three simultaneous pitches.
- Music just for the lithophones has been composed.

APPENDIX A (3)
List and brief description of lithophones from around the world;
http://www.lithophones.com/index.php?id=2, (accessed 12/5/2017)

ANGOLA
The Chokwe people use stone handbells called *sango*

ARGENTINA
In Santa Rosa de Tastil, in Argentina there is a special quartz from which lithophones have been made locally. "Tastil" apparently mean "rock that sounds". An example of the lithophones can be found in the local museum.

AUSTRIA
In the early 19th century Franz Weber built an instrument from alabaster which he called the Lithokymbalon.

AZERBAIJAN
The caves of Gobustan (Kobustan/Qobustan) contain ancient rock drawings which include depictions of dancing. There is also a rock which emits a deep resonating sound when struck, known as *gaval-dashy* (apparently it means "tambourine stone") and it is popularly thought that the dancing took place to the accompaniment of the sound of the stone.

BOLIVIA
The people of Northern Potosî in Bolivia apparently used ringing stones whose sound was apparently held by them to be manifestations of the presence of the devil, Supay, trapped within them.

BORNEO
The Sea Dayak people in Borneo have used stone chimes which they refer to as *kromo*.

CHAD
Small stones are used in the rattle known as *Yondo* which comprises a pipe, normally made of metal.

CHINA
There are many examples of suspended stone chime bars in China. Original examples found in archaeological finds are made of marble, though later ones tend to have been principally made from jade. They were generally used for ceremonial purposes. Some of these date back thousands of years. The *bian ch'ing* or *bian'qing* is typically made up of a set of sixteen or thirty-two L-shaped tuned slabs, which are suspended in a large frame and struck on their long side with wooden mallets or padded sticks. Picture below courtesy of Dr Kia C.Ng, University of Leeds.

COLOMBIA
The *Murui Muinane* people from the region of La Chorrera have long traded in locally quarried granite. A large slab of this they appropriated for use as a gong which they have traditionally used to communicate across distances and for rituals.

ECUADOR
Apparently, the National Museum possesses a lithophone, though details are hard to come by.

ENGLAND
In the eighteenth century, rocks found on the river bed in Skiddaw in the Lake District were found to possess a particularly sonorous quality. Peter Crosthwaite, who had opened his own museum in Keswick assembled a set of musical stones in 1785, some of which were already in perfect tune, the rest he tuned himself by chipping baway at the stone. They can now be seen in Keswick Museum & Art Gallery where the picture below was taken.

In the years following a number of people began to make musical instruments using the stone, known as hornfels or spotted schist, meticulously tuning them by cutting them into different length slabs and laying them horizontally. The best known, and largest, was built by Joseph Richardson - he called it the Rock Harmonicon - and he subsequently made a career out of it touring Britain and abroad giving recitals. The instrument may now be seen, and played, in Keswick Museum.

Also widely known, emanating from the same area but finding success by moving to the USA, was the Till Family Rock Band, formed by Daniel Till and his two sons, James and William. Part of their instrument can be seen in the Metropolitan Museum. New York. There are other examples of Skiddaw lithophones to be found, including one commissioned by John Ruskin which is now housed in the Ruskin Museum in Coniston. A new lithophone is currently being constructed which will be housed at Ruskin's former home, Brantwood, on the edge of Lake Coniston.

In nineteenth century Yorkshire, a man called Neddy Dick, from Keld in upper Swaledale was known for his extraordinary collection of musical instruments which included a collection of rocks which he played by striking with various implements. Many of these he obtained by scouring the bed of the River Swale. He never achieved the wider success enjoyed by the Richardsons and the Till family: a tour of the country was planned but he sadly died a few days prior to his debut.

ETHIOPIA

The use of stone bells, known as *dowel* has been adapted for Christian use in the Coptic church and can be heard, for example, at one of the monasteries on an island in the middle of Lake Tana. They hang from a rope and are apparently used functionally, as, for example, a dinner gong.

FINLAND

In the region of Karelia, on the border of Finland and Russia, rock gongs have been found close to petroglyphs or stone carvings. This suggests they were used ceremonially, probably by Saami people.

FRANCE

There are various examples of ringing stones to be found in Brittany. At Menec, near Carnac, there some standing stones known as *pierres creuses* or "hollow stones" because of their ring. It is quite possible that the sound of the stones would have been incorporated in the rituals intended for the placed stones. In Le Guildo, on the edge of the Arguenon estuary, there are some boulders which are well known locally for their propensity to ring when struck. A folklore has accumulated around them. At the cave-shrine of St Gildas near Pontivy where, up to his death in 540 AD the Welsh missionary hermit who gave it its name used a rock gong to summon his small congregation to Mass. It may be that the gong had previously been used in pagan ceremonies. It may still be seen and a couple of miles away, in the church of Bieuzy, there is another rock gong. In the Dordogne there are a number of caves which contain prehistoric paintings in close proximity to stalactites which ring when struck and which show evidence of considerable use.

In the 19^{th} Century an amateur scientist Honoré Baudre spent over thirty years seeking out suitable pieces of flint for what he termed his geological piano. He was invited to play it at various concerts and exhibitions in France and elsewhere in Europe, including several concerts in Britain. A translation of a contemporary French article about him appears elsewhere on the site under *Articles*.

GERMANY

The composer **Carl Orff** (1895(1895-07-10) – 1982) wrote for the lithophone and had one built for him by his student **Klaus Becker-Ehmck**. The instrument, which he referred to as *Steinspiel* was used in particular in his opera *Antigonae*.

GUINEA
A number of examples of ringing rocks have been documented. These appear to have been used for communication, for public announcements and as warning signals of imminent danger.

HAWAII
Before the introduction of the guitar and ukulele into Hawaiian music in the early 1880s most instruments used to accompany traditional hulas were percussive. These included pairs of stone castanets consisting of round, flat pieces of basaltic lava, played by the hula dancers. Two such pairs are to be found in the USA's National Music Museum in Vermillion, South Dakota.

ICELAND
The Icelandic composer Elias Davidsson has used and written about lithophones.
The band Sigur Rós have also used lithophones and there is a suggestion that their modern use follows an ancient tradition of lithophones to be found in the country. They are made from basaltic, isotropic stones which, as a result of climatic changes, have split into thin slices or slabs

INDIA
There are ancient examples in Orissa in southern India of rocks and boulders that emit sonorous sounds when struck which, because of their proximity to sites of rock carvings suggest that they were used musically. It is thought these date back to Neolithic, or late Stone Age times (several thousand years BC). Other sites in southern India also have evidence of early use of ringing rocks. Some, cited by Catherine Fagg in *Rock Music,* are to be found in the Gulbarga, though to what extent they were used in any significant way is unclear. There is more evidence in the work of Nicole Boivin who has investigated sites in Sangana-Kupgal, close to the town of Bellary in Karnataka. Here there are ringing rocks with clear evidence of cup-marks to suggest rhythmic playing and they are sited alongside petroglyphs, drawings incised into the rock.
From a more recent, but still ancient time there are many temples in India built with stone pillars which resonate with different pitches, turning the whole building into a musical instrument. Examples may be found in Hampi (Karnataka), Tadpatri and Lepakshi (Andhra), Madurai, Vaishnavite shrine in Tirunalveli (or Tirunelvelei), Alagar Koil, Tenkasi, Curtalam, Alwar, Tirunagari and Suchindram in Tamil Nadu.

JAPAN
Suspended chime bars can sometimes be found in Buddhist temples and are very similar to those from China. It is most common for these to be metallic but early examples were made of stone. Stone is also used in wind chimes.

JAVA
It is thought that *gamelan* gongs or *bonangs* were originally made from stone: examples have been uncovered on a number of sites in East and Central Java.

KENYA
Rock gongs are to be found in a number of places: in central Kenya, near Embu, on Mfangano Island in Lake Victoria, in Kilifi district close to the coast and elsewhere. Sometimes these have had a ritual, sacred significance, elsewhere they are put to more playful use by children.

KOREA
Like Japan, Korea adopted the Chinese form of stone chime bars for ceremonial use. In Korea these are known as *pyen kyang* and comprise sixteen L-shaped slabs suspended within a frame.

LIBERIA
There are various examples of stones being used as a simple percussive material, without being characterized by any particular qualities of pitch. The National Sound Archive of the British Library has recordings of Liberian work songs being accompanied by stones.

MALI
Apparently, the Dogon people of Mali have used lithophones. In 1966 film-makers Jean Rouch and Gilbert Rouget made a film *Batterie Dogon. Éléments pour un étude de rythmes* about their use. There are various examples of ringing rocks, some of which may have cultural significance.

MALAYSIA
Batu Gong, near Tambunan in Malaysia is apparently known for its musical rocks. They are large pieces of stone which lie on the ground and each emits a range of different tones and pitches depending on where it is struck. Groups of local people gather to play tunes on them (possibly for the benefit of passing tourists). What their past cultural significance might have been isn't clear.

MEXICO
In Oaxaca, in caves associated with the Mixtec people, there are a number of stalactites, stalagmites and columns which appear to have been used for musical purposes. These caves had particular cultural significance and were used for various rituals. In one cave in particular, Las Ruinas, there are speleothems bearing indentations and markings which suggest they were struck percussively.

MICRONESIA
In Pohnpei in the Caroline Islands there is a tradition of grinding the root of kawa, an intoxicant used widely throughout the region, using stones in a large, resonating basalt dish. The preparation turns into a musical performance as the resultant rhythms take over from the job in hand.

MONGOLIA
There is a now rarely heard Mongolian lithophone known as the *shuluun tsargel*, whose stones are suspended by cord on a frame. The CD Musique et Chants de Tradition Populaire Mongolie Grem G7511 contains a track played on an instrument made up of fourteen stones by a musician from Bayan Khongor in southern Mongolia.

NEW ZEALAND
Stones have been used in different ways in Maori music. Unusually, stone (along with bone and wood) has been used to make flutes imitating the sound of birds. In particular the stone *koauau* is used to replicate the bell-like notes of the bird known as *kokako*. Stone has also been used in making bullroarers in which “The player’s spirit travels up the cord to create the sound, which then travels on the wind to take the words and dreams of the player to the listeners of the world”

NAMIBIA
Examples of ringing rocks have been found with multiple cup-marks which suggest that they have been repeatedly pounded, most likely in a rhythmical, musical way, though the exact nature of their use no longer seems to be known.

NIGERIA
The Yoruba people have a history of using lithophones, but the best documented examples of musical stones in Nigeria are the multiple rock gongs which Bernard Fagg wrote about in the 1950s and later documented in his widow Catherine's book "Rock Music" (1997). The most notable of these are to be found at Birnin Kudu in Kano State. These rock gongs have been used for communication, ritual and recreational use. It may be that they were also used for ensemble musical performances.

PORTUGAL
The Escoural Painted Cave in Evora is similar to those in the Dordogne in France in that it combines rock paintings with stalactites which shown signs of having been repeatedly struck. This suggests evidence of rituals going back to paleolithic times.

RUSSIA
Alla Ablova of the Conservatory of Petrozavodsk in Russia is an authority on ancient lithophones discovered in various parts of the world. She has written in particular about some that appear in a number of legends and folk songs from the Karelia region of Russia and in Saami folk-tales.

SCOTLAND
There are a number of ringing stones to be found in Scotland at least some of which had ritual significance in ancient times. One of these, "Arnhill", also known as the "Ringing Stane" and the "Haddock Stone" situated near Huntly in Aberdeenshire is part of a stone circle. Others include the Johnston Stone, also in Aberdeenshire, and The Ringing Stone or Clach o'Choire on the island of Tiree in the Inner Hebrides.

SOUTH AFRICA
Catherine Fagg, in her book *Rock Music* mentions a number of ringing stones in Britstown District, in central South Africa, but she wasn't able to establish their level of significance within the community. In many parts of the world there is sometimes a reticence about talking about ringing stones, possibly because of their sacred quality, and even their whereabouts remains a local secret

SUDAN
Rock gongs are to be found on the west bank of the Nile and were also documented by Bernard Fagg. One was featured in the first of the BBC documentary series *Lost Kingdoms of Africa* and it was suggested that many other such gongs, whose use dates back to 5000 BC, have been discovered there in the Nubian desert.

SUMATRA
In Western Sumatra there are some ancient musical rocks known as *talempong batu* which can be seen in Nagari Talang Anau. From photographs they look somewhat similar to those found in Vietnam. It seems likely that they were the predecessors of the metal gongs known as *talempong* found in the same region. Quite how old they are or what social function they may have had originally is not known, though they would have almost certainly had a ceremonial use. Apparently the *talempong batu* are still considered locally to have spiritual powers and it is said that in the event of imminent disaster the stones will make strange and bizarre rumbling sounds.

SWEDEN
A granite ringing rock with cup-marks, indicating probable repeated playing, is to be found on the island of Gotland. It is reputed to have been used in ancient times as a sacrificial stone and a pagan altar.

TANZANIA
The well-documented rock gong shown below is to be found in Moru Koppies in Tanzania's Serengeti national park. Unlike some rock gongs which are part of a larger rock formation, this one is free-standing. The cup-marks, resulting from years of being struck, are clearly visible and cover every side. How it has been used is not certain though it may have played a part in Maasai culture. There are many other examples of ringing rocks to be found in Tanzania, some of which may have been utilized in ancestral and rainmaking ceremonies.

TOGO
The *Kabiyé* people, from a northern region of Togo, a small west African state which lies between Benin and Ghana, play musical stones for ceremonial and ritual purposes. The playing of music is linked strictly with agricultural seasons and these musical stones may only be played for a short period, after harvesting, between November and January. The stones, known as *pichanchalassi*, are laid on the ground, usually, it seems, in a set of five, each with a different pitch, and struck with another smaller stone. Several tracks featuring playing of the *pichanchalassi* can be heard on the Ocora CD *Togo.*

UGANDA
Along with Nigeria and Sudan, Uganda can boast of a number of natural rock gongs. These have been documented in Catherine Fagg's book *Rock Music*. It seems that these have sometimes been used ritually and their whereabouts is sometimes a local secret. More profanely they are often used by children as a play area. In 2007 the composer Nigel Osborne undertook a commission in collaboration with London Sinfonietta based on the sounds of rock gongs on the island of Lolui Island situated in Lake Victoria.

USA
VIRGINIA:
The Great Stalacpipe Organ, Luray Caverns, Shenandoah National Park.
The instrument is the creation of mathematician and Pentagon scientist Leland W. Sprinkle and was built in 1954. Playing the keyboard triggers rubber-tipped mallets, which strike stalactites in the surrounding caverns, carefully chosen for the accuracy of their pitch. The organ lays claim to being the largest musical instrument in the world. www.luraycaverns.com

MINNESOTA:
Pipestone quarry, Minnesota, mentioned by Longfellow in "The song of Hiawatha", is the source of a soft claystone carved by the Sioux into ceremonial pipes. They also created musical instruments from pipestone. This rare example of a non-percussive lithophone is to be found in the National Music Museum in Vermillion, South Dakota.


PENNSYLVANIA:
Ringing rocks are a well-known feature of the landscape near Easton. It isn't known how far these had any ancient ritual significance. Their main cultural role comes through tourism.

UZBEKISTAN
Here stone castanets known as *qayraq* / *kayrak* or "black stones", are played, two in each hand, to accompany dancing.

VENEZUELA
In the early twentieth century various archaeological digs in South America unearthed what were thought to have been examples of stone percussion. A burial cave at Niquivao in Trujillo, Venezuela contained rectangular plates of serpentine with incisions which suggested they may have been suspended for use as a type of chime or gong.

VIETNAM
Many groups of differently pitched stones have been found in Vietnam, indicating that they were being used musically thousands of years ago. The first of these were famously uncovered by a French archaeologist Georges Condominas in 1949. These stones have continued to be used by some of Vietnam's minority people such as the M'nong, most of whom live in the Central Highlands. Although not central to Vietnamese traditional music as performed today, their place is acknowledged and some musicians have built their own modern versions and continue to play them. The Vietnamese name is *dan da*. The ancient set of stones seen in the photo below were spotted in a Hanoi music shop. An article by Mike Adcock about a trip to Vietnam in search of musical stones appears in the Articles section of this site.

WALES
The Pembrokeshire village of Maenclochog in Dyfed lies south of the Preseli Hills. Its name is Welsh for ringing stone, referring to two large such stones which once graced the landscape. That is until the late eighteenth century when they were broken up for road-building in defiance of the wishes of local people. There are, it seems still other ringing stones to be found in the region, some possessing cup-marks.

ZIMBABWE
Various rock gongs and ringing stones have been documented in Zimbabwe. As elsewhere in Africa some of these appear to have been used as means of communication over long distances. Others have sacred significance, and are believed to speak the voices of the ancestors. Near Muzondo, in the region of Musombo and Chiramba, ensemble musical performances have been documented, using *mujejeje*, the Shona word for musical stones.