Sound of Stones

The Music Archaeology of Chime Stones in Ancient China

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Chapter 1
Introduction

This book focuses on researching the chime stone (qing 磬), *a percussion instrument carved from stone that originated in ancient China. In antiquity, people regarded the chime stone as an important musical instrument because its presence indicated the wealth and status of the tomb owners. In the late Neolithic Age, people discovered the differences between each type of stone and their sound qualities. Chime stone manufacture focused on the timbre of the natural stone, as opposed to both materials and sounding based selection in later periods, which formed a part of making a perfect and delicate chime stone. In the earlier period the chime stone was only a musical instrument for producing rhythmic sound, but as time went by, chime stones gradually became melodic instruments and were played with string, wind, and other percussion instruments in ensemble.*

The book is divided into 10 chapters. Chapter 1 provides a comprehensive view of existing research, sets out the aims of the present research alongside material sources and methodology, elaborates the theoretical framework of the book, and clarifies terminology in both English and Chinese. A summary of the main chime stone finds of the Yellow River and the Yangtze River valley areas, together with geographical features of these distributions, is provided in Chapter 2. Chapters 3 to 8 contain an in-depth discussion of the chime stones unearthed from those regions, including classification and typology, shape, manufacture, assemblage and performance of the chime stones as well as the detailed tone measurement and analysis. Chapter 9 examines the acoustic properties of chime stones. Chapter 10 looks at the use and function of chime stones, which includes the role of chime stones in ancient ensembles, cultural context, use in ritual music, and the symbolic meaning of chime stones in ancient China

1.1 The Significance of Studying Chime Stones

Chime stones and bronze chime bells were two of the most important musical instruments in the royal court of ancient China. Ownership indicated high political and social rank or status; usually they were the property of kings and aristocrats. They therefore symbolized wealth and power. Both bronze bells and chime stones were important components of the *Jin Shi zhi Yue* ("metal and stone music") in pre-imperial China, a kind of ritual music symbolizing high-ranking status in the ancient elite societies. Like chime bells, chime stones were not only musical instruments, but also served as ritual objects. Both chime stones and chime bells are equally components of an ancient social hierarchy.

Despite their similarity in symbolic importance, scholars have concentrated more on researching chime bells than chime stones. One reason is that chime bells are more

plentiful and better preserved in the archaeological record and many of them are carved with inscriptions. Due to the brittleness of the material, many chime stones have relatively poor preservation, and the integrity of chime stone sets is less than that of the bronze bells. Additionally, only a few inscriptions on chime stones have been found so far. It is likely that this is the main reason that researchers have focused their studies primarily on chime bells rather than chime stones.

Nevertheless, chime stones were usually played alongside chime bells in ritual and ceremonial events as one of the main components of "metal and stone music". In the last twenty years or so, Chinese archaeological excavations have discovered a large number of musical instruments, including chime stones and bronze bells. In particular, the new finds contain a number of complete sets of chime stones, when previous finds had only included individual or partial sets. For instance, sets of chime stones from the late Western Zhou (1046-771 BCE) and Western Han (202 BCE-8 CE) have been unearthed from tombs in recent years, so such archaeological sources can be used to carry out comprehensive analysis and discussion.

The goal of the present research is to provide a historical perspective on the development of the shape and manufacture of chime stones, including materials, design, tools, techniques, as well as pitch and tuning, and furthermore to research the acoustic properties and musical capabilities of both singly used chime stones and sets of chime stones. It is also crucial to study their combinations, tone series and scales taking into account the different archaeological sites and historical periods. Through tone measurement,[1] the acoustic properties of chime stones will be examined. Whereas previous researchers have often focused only on identifying a single pitch, this project also explores sound spectrum, timbre and ensemble. It provides new important information on musical practice in ancient China. Finally, the chime stones in different archaeological contexts and the application of chime stones, their use and function in the ancient royal court, their role and characteristics in ensemble, as well as their significance in the context of the system of ritual and music in ancient China are explored.

1.2 Terminology of the Chime Stone

Among the many percussion instruments used in musical performance, the chime stone is very interesting acoustically. According to the *Zhou Li* (The Ritual System of the Zhou; probably 3rd century BCE, see Anonymous 1980), *Ba Yin* (eight tones) was a classification system for musical instruments which divided all musical instruments into eight groups based upon their manufacturing material. These were numbered eight: metal, stone, clay, wood, bamboo, silk, leather and gourd. The chime stone belongs to the category of stone,

1 Chinese researchers generally use the term *"Ceyin"* (tone measurement) when exploring chime stones and chime bells, but in fact their tone measurements have so far been primarily focused on pitch of the instruments rather than their complete sound properties.

and it is a kind of lithophone which can be classified as a percussive idiophone within the Hornbostel-Sachs system.[2]

There is no standard terminology for describing and discussing stone-made percussion musical instruments. Currently, scholars writing in English have used the terms rock gongs, sonorous stones, ringing stones, stone bells, lithophones, chime stones, and the transliterated Chinese character *qing.* Lithophone is frequently used in the literature, but to date there is no consensus about describing different shapes of stone-made percussion musical instruments. Many scholars have concentrated on addressing lithophones. Steggerda (1944), in a related study, alleges that "stone gongs" and "ringing stones" have the same meaning and could be used interchangeably. He argues that stones can produce different pitches according to a fieldwork case study in a Maya village in the Yucatan. As he explains, the tones could not form a musical scale but chimed very nicely when struck simultaneously. In his study on Chinese lithophones, Fritz Kuttner (1990) uses "lithophone" to refer to a single stone, and "lithophones" to represent the sets of stones, whereas as we will see others use "lithophone" to represent a group of stones. M. Catherine Fagg (1994), on the other hand, uses the term "rock gong" to indicate stones that are naturally occurring and large or unmoveable, in contrast to other lithophones, which are portable and have been either artificially tuned or selected for their tonal suitability. However, according to Cajsa Lund (2009), these sorts of instruments should be named "ringing stones" as an overall term. The entry "Lithophone" in the *New Grove Dictionary of Music and Musicians* is described as "a sounding stone or series of resonant stone slabs or plaques. Lithophones occur in several forms: oblong bars suspended horizontally; vertically suspended plaques; or (as has been recently introduced) circular stone discs arranged chromatically" (Blades 2001: 886). In the entry, "stone chime" is used for describing Chinese stone-made instruments in remote antiquity, and it mentioned that the instruments "are among the most ancient and valued instruments of the Chinese" (Blades 2001: 886). The term "chime stone" is also used in Fagg's *Rock Music,* as he states, "The best known and most carefully constructed are the chime stones, common in the culture area of ancient China" (Fagg 1997: 1-2). In *Suspended Music,* Lothar von Falkenhausen uses a compound word "chimestone" to replace "chime stones" (Falkenhausen 1993).

To sum up, a lithophone generally refers to man-made stone musical instruments, like bar idiophones in Vietnam, chime stones in China and so on. A rock gong is a natural stone, often extremely heavy and not portable, in contrast to the smaller and lighter lithophones. *Qing* is a unique word which specifically refers to five-sided chime stones and their predecessors in ancient China. However, there is no uniform term to describe the entire range of musical instruments made from stone. It is useful to separate the Chinese chime stone from other stone-made instruments since it has a particular shape

2 The systematization of musical instruments was devised by Erich Moritz von Hornbostel and Curt Sachs, and first published in the *Zeitschrift für Ethnologie* in 1914 (English translation by Baines/Wachsmann 1961: 3–29). It is a systematic classification of western and non-western instruments (see Sadie/Tyrrell 2001: 75; Myers 1992: 444–461).

and tuning system. In the pinyin romanization system for Chinese, *qing* has many unrelated meanings, such as "to celebrate an event," "lightweight," and "to invite somebody somewhere." It is therefore problematic to use *qing* as the primary term for the Chinese chime stone, as it introduces some inconsistencies and confusion into the terminology relating to stone-made instruments. In this book, I adopt "chime stone" as an overall term to denote these stone-made instruments, instead of *qing* or other terms that are difficult to distinguish. The singular form of chime stone is properly described as *te qing* 特磬 ("singly used chime stone", usually of the characteristic shape and large in size), which appeared in early times, from the late Neolithic (ca. 2400 BCE) to the Western Zhou period. The plural form "chime stones" usually designates the sets of chime stones (*bian qing* 編磬), which appeared approximately in the late Shang dynasty (ca. 1260-1050 BCE) throughout the Western Zhou and Eastern Zhou (770-256 BCE) times, and extended into the Western Han period.

The term *qing* also leads us to another issue regarding Chinese characters. Various characters have been used to denote the chime stone; Chinese classical texts indicate this development. Different characters for *qing* occurred several times in antiquity. Initially, *shi* 石 ("stone") referred to the chime stone in classical texts. The *Shang Shu* ("Venerable Documents from Antiquity"), for instance, describes people "playing *shi* (chime stones), and dressing up as a variety of animals to dance."[3] The term *shi* also appears on a chime stone unearthed from the tomb of Fu Hao, a consort of a Shang king from approximately the thirteen century BCE, with the inscription *Renzhu ru shi* 妊竹入石 ("Renzhu sends stone as a gift"). Another example is the inscriptions engraved on the chime stones' storage box found in the tomb of Marquis Yi of the Zeng state (433 BCE, during the early Warring States period), *Gu Xi shi shi you san zaici* 姑洗十石又三才（在）此 ("This contains thirteen stones of Gu Xi"; Gu Xi is one of the Twelve *Lü* names, see Chapter 8). The term *mingqiu* 鳴球 ("sounding ball" or "ringing ball") is another name for chime stone. The *Yi Ji* 益稷 chapter of the *Shang Shu* depicts a musical scene as "Striking the sounding ball, playing the *qin* and *se* zithers" (Ruan 1980).

Another way of writing the chime stone in classical texts is the pictographic character  *qing,* which is the ancestral form of 磬. This character appeared in oracle bone inscriptions in the late Shang period (ca. 1260-1050 BCE), although there is no evidence that the character denotes the stone instrument described above. The *Zuo Zhuan* (The Commentary of Zuo, probably fourth century BCE) also mentions the *qing,* in a story of people in the Zheng state bribing someone in the Marquis of the Jin state with gifts including "two sets of chime bells, *bo*-bells and chime stones, as well as sixteen female musicians" (*Zuo Zhuan:* "Xianggong shiyinian"; for the Chinese version, see Ruan 1980: 1951).

In short, it seems that the terms *shi, mingqiu,* and *qing* are all used to depict the chime stone. They simultaneously existed in the past and could be used interchangeably. A single chime stone is also called *te qing* in an inscription on a chime stone dating to the Qing dynasty (1636-1911 CE), although we do not have evidence to conclude that the

3 Translation by the author, similarly hereafter unless otherwise indicated.

two-character phrase te qing was used before the Han dynasty. *Bian qing* refers to sets of chime stones that were frequently combined with chime bells in instrumental performance at the royal court and among various elite ranks. It seems that the terminology for chime stones was more complicated in ancient China. However, *shi* and *mingqiu* appeared earlier and were less used according to historical documents, in later times, *qing* became the standard word referring to a percussive stone musical instrument and it has survived with this meaning until today.

1.3 Previous and Recent Studies

The chime stone is mentioned many times in the *Shi Jing* ("The Book of Songs," the ancient Chinese classic of poetry, 900-700 BCE), *Shang Shu* ("Venerable Documents from Antiquity," also known as *Shu Jing,* the "Book of Documents", allegedly compiled by Confucius between 551-479 BCE), as well as in other classical poems and literature of ancient China; but there is no detailed explanation of it. During the Song dynasty (960-1279 CE), the discipline of "epigraphy" (*jin shi xue; jin* means metal, here refering to objects made of bronze, *shi* designating objects made of stone) became popular. Song dynasty epigraphy is regarded as the predecessor of Chinese archaeology, although not the archaeological study in modern meaning that we commonly know.

Chinese epigraphy mainly researched ancient bronzes and their inscriptions; only a few cases involved inscriptions on or associated with stone artefacts. With emphasis on philology and textual data, the purpose of epigraphy was to prove details of Chinese history. Writings on epigraphy from the Song and later dynasties preserved much valuable information. Some of the books created contain images of bronze objects and stone tools, and the names and contents of their inscriptions, which reflect the core of the discipline of epigraphy. For example, the chime stone uncovered from a hoard in Fufeng, Shaanxi and housed by Wangshi[4] was recorded in the book *Kaogu tu* ("Illustrations for Inquiring into Antiquity," Lü 1092); this was followed by the monograph *Lidai zhongding yiqi kuanzhi fatie* ("Assessment of Bells, Tripods, and other Ritual Vessels from Historical Times," Xue 1144), which also discussed the same chime stone. Later in Yu Xingwu's (1940) monograph *Shuangjianyi guqiwu tulu* ("*Shuangjianyi* Antique Catalog"), a chime stone excavated from Jincun near Luoyang, Henan was also cited as an example. However, the discipline of epigraphy did not conduct an in-depth study on musical instruments or music itself and failed to carry out any chronological study of bronzes and other artefacts. With the development of Chinese archaeology in late 20th century, more research has focused on different aspects of chime stones. Topics include typological study, the development of types and decoration, origin and manufacture, set combinations, scales and modes, sound experimentation and acoustic properties, inscriptions,

4 Lars Christensen argues that the Wangshi chime stone was not included in *Bogu Tu,* and discusses possible reasons in his article (Christensen 2019).

use and function, as well as social and political meaning in ritual and cultural context in ancient China.

Most Chinese scholars have concentrated their studies on tone series, scales and modes of chime stones, discussing their regularity. In order to examine the development of the tone series and investigate different possibilities of scale formation, Huang Xiangpeng (1978) conducted tone measurement to determine the tone series of chime stones. He explored the variety within chime stones' tone series, which evolved from three tones (such as *shang-jue-zhi,* which contains a minor third) to four tones *(gong-jue-zhi-yu),* and eventually reached five tones (i.e. a pentatonic scale) from the late Shang (ca. 1260-1050 BCE) to the Warring States period (475-221 BCE). His review of the development of musical scales from Neolithic to pre-Qin China also demonstrated the differences of the pentatonic scales of the ancient Chinese and ancient Greeks. In his comparison, the perfect fifth harmonic relation occupies a predominant position in the Greek scale, whereas the harmonic relationship of the minor third figured prominently in the Chinese scale. Li Chunyi, a prominent researcher of ancient Chinese music historiography and Chinese music archaeology, has conducted a great deal of research on ancient Chinese musical instruments found archaeologically. In *Zhongguo shanggu chutu yueqi zonglun* ("A Comprehensive Discussion of Unearthed Musical Instruments of Ancient China," Li 1996), Li constructed a theoretical perspective on chime stones, including a comparative study of scales and modes in order to find possible scale paradigms. Scales of chime stones will be discussed in Chapter 8 of this book. Fang Jianjun (2010a) measured the tone data on both chime bells and chime stones excavated from the Western Han tomb in Luozhuang, suggesting that the fundamental frequency becomes much clearer with chime stones tuned to higher pitches. This effect is explored in Chapter 9.

Another research area that scholars have explored is the typology of chime stones. Several types and subtypes of chime stones have been classified (Chen 1988; Li 1996; Fang 1996; Wang Zichu 2004; Wang Anchao 2005a; Zheng 2005). According to Li Chunyi, chime stones can be divided into four main types based upon the development of their shape. Following the historical development of chime stones, Fang Jianjun (1996) also produced a similar four-type classification of chime stones, according to subtle differences in the top part of the chime stones. Wang Anchao proposed a classification system of four types focused on shape and decoration (Wang 2005a). Chime stones have also been divided into three types according to their shape and acoustic properties (Zheng 2005). Wang Zichu (2004) divided the stones based on their dates, as well as their shapes and types. Other similar methods for classifying types of chime stones focus on the development of shape and profile (Gao 2004; Ren 2008).

The shape of chime stones (five sides with a curved base) has led scholars to discuss whether the instruments had an ancestor. Some have suggested that the unusual shape derived from a stone-made tool used in agricultural production (Wang/Jia 1991; Xiu/Wang 2001; Wang 2006a). Others suggest the chime stone and other objects have an evolutionary relationship. Kuttner (1953) claimed that the chime stones were connected to the Chinese *bi* disk (*pi* in the system of romanization he used), suggesting that the *bi* disk was the embryonic form of the chime stone. Suo Quanxing (2009) also argued that this

rectangular stone implement with a square-hole that was chiselled on the surface of it was the ancestor of the chime stone. Chime stone shape typology is discussed in Chapter 3.

Dating methods in the music archaeological field can be problematic. The carbon-14 dating system (Kovar 1966; Bowman 1990; Mook/van der Plicht 1999; Qiu/Zhang 1999; Qiu/Cai 2001) cannot be used to date stones themselves, but can be used to date items found in association with them, and thus the date of their burial. Cajsa Lund (2009) discussed dating ringing stones found in Sweden through observing cup marks on them. As she suggests, this method of dating also gives a broad range of dates. No matter how one dates stone-made musical instruments, the time suggested is not a single point but rather an approximate range.

Other related research includes inscriptions, decorations and metaphor relating to the chime stones. A study comparing the inscriptions of the chime stones and the drum-shaped stones (sometimes misleadingly called "stone drums") of the Qin state in the Spring and Autumn period discusses the possible dates of manufacture and the similarity of the styles of these inscriptions (Hao/Hao 2007). The decorations or inscriptions on different chime stones may draw more or less on metaphor, depending on their type of patterns, contents and archaeological contexts. The essence of both inscriptions and decorations is that they can reflect the ritual power and status of the owners (Qiu/Li 1981; Huang 1981; Li 1983; Chen 2002; Ye/Wang 2005; Wang 2006b). Inscriptions also sometimes explore the musical theories relating to the tuning system (Hubei Provincial Museum 1981; Fang/Zheng 2007a; 2007b).

In relation to the techniques used to manufacture the chime stones, the *Qingshi* ("*Qing* family") chapter of the *Kaogongji* ("The Records of Examination of Craftsmen") describes the method of tuning and also the ratios between the different dimensions of chime stones. The *Kaogongji* is a historical document that records specifications and manufacturing processes for various objects in the official handicraft industry; *qingshi* designated the craftsman who was expert at making chime stones professionally. Most historians treat the *Kaogongji* as an official record of the Qi state in northeast China during the early Warring States period (476-387 BCE), but the author is anonymous. The *qingshi* chapter provides a formula that gives a ratio for the dimensions of the chime stone during the Eastern Zhou times (770-256 BCE; see Chapter 4).

In the 1960s, Zhuang Benli (1966) conducted a research project focused on musical instruments in museum collections in Taipei, which included chime stones and clay ocarinas that had been discovered in the 1930s in Anyang, Henan and were then transferred to Taiwan before 1949. In order to explore the development of the shape and design of the Taipei collections of chime stones from the Shang (ca. 1600-1046 BCE) and Zhou dynasties, he measured four chime stones to compare them with the *Kaogongji Qingshi* text. He discovered that the actual sizes of the chime stones differed significantly from the text. Also using the formula from the *Kaogongji,* Fang Jianjun (1989c) examined nine Western Zhou (1046-771 BCE) chime stones that had been found in various geographical locations. He found that the dimensions and ratios of excavated chime stones were a little smaller than those given by the *Kaogongji Qingshi.* Chapter 4 explores the geographic locations and periods of chime stones, using both my fieldwork and existing data from past research projects.

Sun Chen (2009) attempted to find different interpretations of the formula in *Kaogongji,* and verified the text by calculating the dimensions of unearthed chime stones, and concluded that the *Kaogongji* was written in the Warring States period. Other scholars have discussed the possible date in which *Kaogongji* was written (Xuan 1993; He 2009; Sun 2009) and examined the acoustic theories the book describes (Du 1965; Wenren 1982). Wenren Jun (1982) proposed a specific explanation of the acoustic descriptions of the chime stones in light of modern acoustic theory, showing that the vibration patterns of a chime stone are equivalent to the transverse vibrations of an elastic plate.

Acoustic research on stone musical instruments has aroused much interest in recent years. For instance, Thomas Rossing and Junehee Yoo (2006) carried out acoustic research comparing Chinese chime stones and Korean *pyeongyeong.* They provide conclusions about the relationship between the vertex angle of a chime stone and its fundamental frequency. Their work is discussed in Chapter 9, which explores the wider spectra of the larger sample group of stones under study in this book.

Rupert Till (2010) conducted an acoustic analysis of a digital model of Stonehenge using software designed for architects, exploring the acoustics of a large stone monument. Aaron Watson (2013) examined the acoustics of Neolithic monuments and discussed whether the acoustic properties of these monuments were intentional or fortuitous. Apart from these studies, a significant amount of research exists on the tuning systems of chime stones in ancient China (Dai 1993; Wu 1994; Miao 1996; Feng *et al.* 1996), as part of the history of acoustics in China. Other studies (Kuttner 1990; Zhu 2010) examine the musical and physical qualities of chime stones. Kuttner proposed that the curved base of chime stones acts to improve the stone's acoustic qualities. Zhu Guowei (2010) argued that it is possible to obtain reduced overtones in the lower frequency range when a chime stone with a curved base vibrates. Both Kuttner and Zhu suggest that the curved base of some chime stones has a specific acoustic effect (see Chapter 9).

Research on the vibration patterns of chime stones is also significant. Vibration models can be developed using a number of different methods (JSDTKGD 1988; Chen/Wang 1989; Yoo/Rossing 2006; Zhang/Cheng/Zhu 1997). Chinese archaeologists have conducted experimental work to calculate the key vibrating frequencies and modes and to research the vibrating properties of chime stones of various shapes. To analyse these different vibrating modes, it is necessary to find relationships between the vibrational mode frequencies and the shapes of ancient chime stones. Using FEM (Finite Element Method), the Jiangsu Dantu archaeological team has calculated the vibration characteristics and frequencies of chime stones of various shapes and sizes. Chen Tong and Wang Zhongyan carried out similar research using FEM to obtain an empirical formula for the fundamental frequency of a stone. Later, Yoo and Rossing conducted an experiment to compare the Korean *pyeongyeongs* and Chinese chime stones. They conclude that the most important parameter is the vertex angle of the chime stones, but also note that the curvature of the base may have a smaller influence. These experiments were theoretical computer studies, whereas most real chime stones have curved bottoms and are therefore far more difficult to analyse.

Another approach is to use Nearfield Acoustic Holography to simulate the vibration modes of chime stones (Zhang *et al.* 1997). Zhang Dejun, Cheng Jianzheng and Zhu

Nianqiu (1997) considered various aspects of chime stones in order to obtain a specific formula for pitch design through building different models of chime stones. Their first two experiments used the same methodology and concentrated on the fundamental frequencies and primary modes of the Chinese chime stones. Their third experiment used a parallel comparison to find similarities and differences between the Chinese chime stones and Korean *pyeongyeongs*. Nearfield Acoustic Holography was used to detect the vibrational modes present, but these methods did not take into account the curvature of the base, and the formula it provided has some deviations from computer-based experiments.

Other research on chime stones is based on computational and technological analysis. Zhang Baocheng, Xu Xuexian, Chu Meijuan and Han Liusheng (1983) used primarily computer analysis of the sonic properties of chime stones to investigate their vibration mode using spectrograms, combined with mathematical equations for calculating their frequencies. In contrast to this, Jae-hyun Ahn and Richard Dudas (2015) focused on physical model studies that relied on computational Modal software. They created a physical model that can be used in musical studies. They also constructed a framework for the use of sound synthesis for ancient chime stones. Both of these projects are based on computer models rather than actual chime stones.

Much research has been carried out on the 32-piece set of chime stones from the tomb of Marquis Yi of the Zeng state. The tomb contains a large number of musical instruments, including a sixty-five-piece assemblage of bronze bells and many other wind and string instruments. Relevant studies on the chime stones from Marquis Yi's tomb have treated the textual explanation of the inscriptions (Huang 1981; Hubei Provincial Museum 1981; Qiu/Li 1981; Li 1983; Chen 2002; Wang 2006b), the scale structure of the chime stones (Gao 1988; Wang 2005b, 2007; Liu 2014; Liu 2015), and the reconstruction of the chime stones (Tong 1981; Hubei provincial Museum/ZKYWWYS 1984; Xu/Zhang/Feng 1988; Zhang 2006). These comprehensive studies to some extent provide a reference for researching chime stones from other tombs during the Eastern Zhou period (770-256 BCE). Studies of this set of stones provide a model approach for what I discuss in Chapter 8 with regard to scales and modes in chime stones.

Although both archaeologists and musicologists have paid considerable attention to the acoustics of chime stones, their cultural significance and relationship with the ancient Chinese system of ritual and music have been largely ignored. Previous studies have paid insufficient attention to the acoustical properties, especially timbre using an analysis of partials. Scholars have highlighted the data acquired from the tone measurement of certain sets of chime stones, but there has been little widely cast fieldwork or broad analysis. Some issues need further discussion, for instance, how did ancient people create the convex pentagon-shaped chime stone, and what is the meaning of this unique shape? What is the significance of the chime stone with the arching base? What are the sound qualities and timbral characteristics of chime stones found in different regions or from different historical periods? These questions outline the persisting mystery of the chime stones, and show that it is worthy of further discussion.

1.4 Research Sources and Methodology

In order to obtain specific and reliable results, only chime stones that were uncovered archaeologically by means of scientific excavation with published formal or brief reports were studied, including only a very few specimens without documented archaeological context. References examined for the project draw on an extensive number of research articles published in scientific journals. Owing to the emergence of newly excavated finds and their studies, the research materials considered in this book are defined as published before October 2019.

In this book, archaeological sources including excavation reports and inscriptions on chime stones are taken into account. The most valuable materials for this study are the musical instruments themselves, which have been found in aristocratic tombs as well as some small tombs with unknown occupants. Those archaeological sources, as Li Chunyi says, are full of authentic, accurate materials and facts (Li 1986). The data from my fieldwork provides additional information. This fieldwork covers chime stones in museum collections using original sound recordings. In addition, a number of historical documents have been consulted. Textual sources can provide details about real musical practice during ancient times that artifacts cannot. Useful texts for this purpose include classical texts such as the previously mentioned *Zhou Li* (probably 3rd century BCE) and *Shi Jing* (900-700 BCE), the *Yue Ji* ("Record of Music," completed in the Warring States period [475-221 BCE]), and the *Li Ji* ("The Book of Rites," allegedly compiled by Dai Sheng in the Western Han dynasty [202 BCE-8 CE]).

The principal methodology of this book derives from music-archaeological considerations, a multidisciplinary discipline with approaches including classification, analysis and typological study (Hickmann 2001: 848-854), as well as more contemporary approaches in archaeoacoustics and sound archaeology (Till 2014). From a diachronic and synchronic perspective, chime stones are classified into specific types and subtypes and the evolutionary development of their shape and manufacture during two thousand years from the late Neolithic Age (ca. 2400 BCE) to the Western Han dynasty (202 BCE-8 CE) is explored. Furthermore, an acoustical study of the chime stones is conducted. Within this process, tone measurements are taken and pitch data obtained, and then the combinations of the chime stones, their tone series, scales and modes, and their connection with bronze bells and other musical instruments are examined. In order to explore the pitch, timbre and frequency spectrum of chime stones archaeoacoustic techniques using computer software are adopted, uncovering the relationship between frequencies and dimensions.

The project methodology is in part derived from the theoretical framework of organology within ethnomusicology, as discussed by Mantle Hood (1971). He suggested that research on musical instruments should combine the ontology of technology with their cultural background. His "organograms" demonstrate that organological research should be sited within a comprehensive context of economy, culture, rite, symbol, and gender. Hood regarded music in its relation to society and culture, stating that ethnomusicology is "an approach […] not only in terms of itself but also in terms of its cultural context" (Hood 1969: 40). He later concluded that "music is inseparable from the cultural

context as distinct from its social context and it both affects and is affected by the context" (Hood 1971: 250). Here, Hood was following Merriam who mentioned "the study of music in culture" (Merriam 1960: 109), a point he later emphasized in his *The Anthropology of Music* (Merriam 1964: 17-36).

Lothar von Falkenhausen adds that research into ancient musical instruments such as chime bells should not only stress their type, but also their culture (Falkenhausen 1993). Indeed, excavated musical instruments cannot be defined and studied without reference to their archaeological context or archaeological culture. All these theories emphasise that we should put music into its cultural context in the course of study. Thus, it is crucial to research the chime stone based upon a system of ritual and music and combine musical research with cultural perspectives to explore the role, function and significance of the chime stone in the specific time and space of ancient China. It is important to study both the material and non-material culture of the instruments in an archaeological context, rather than to study them in isolation, as has been the approach of many previous studies. Furthermore, it is necessary to pay attention to the excavated ruins, tombs, ancient states and ethnicities that the chime stones belonged to.

Fieldwork in music archaeology uses observation, sound recording, physical measurement and tone measurement to collect a range of further data. For this study, fieldwork at the Hebi City Museum (Henan) with colleagues and students from the Tianjin Conservatory of Music has been carried out in 2013, in order to measure the chime stones and chime bells dating to the Spring and Autumn period (770-476 BCE) that were excavated from tomb M4 in Qixian Songzhuang (Henan). In 2016, the author travelled to various sites in China, including Anyang, Hebi, Xinzheng and Zhengzhou (all in Henan province), as well as Xi'an (Shaanxi), Chaoyang (Liaoning), Chifeng (Inner Mongolia), Zhangqiu and Jinan (Shandong), in order to visit museum collections of chime stones and other instruments. During this fieldwork, 107 chime stones in all were observed. Some of them were well preserved, but some had already broken, and thus it was not always able to take sound recordings and measurements. Even so, the dimensions and tone data of 65 chime stones in total were measured, in addition to the previously published data of tone measurements discussed in this book. The approach and software used for acoustic analysis are described in detail in Chapters 8 and 9.