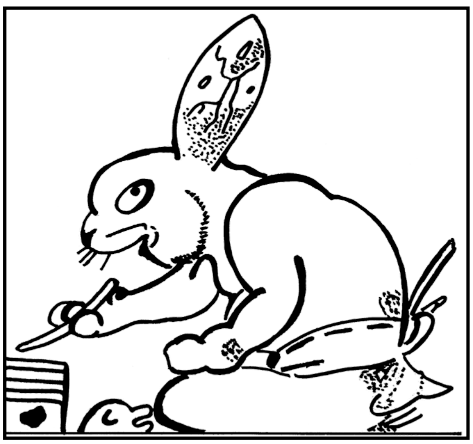
Ancient Engineering:

Selective Ceramic Processing in the Middle Balsas Region of Guerrero, Mexico

Jennifer Meanwell



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Chapter 1: Introduction: Problem Statement, Theoretical Underpinnings, and the Ecology of the Middle Balsas Region.

Pottery is a common, usually locally made product that was and is important to the daily lives of many people, because pots are used for the storage or transport of materials and for food preparation, among other functions. Archaeologists often use pottery vessels and sherds in their research, because sherds are durable and are made in various styles that frequently can be identified as indicative of a particular region, culture, and/or time period (whether or not these categories were important to ancient peoples). Studies of pottery typologies and manufacturing methods can offer archaeologists a window into how ancient peoples utilized locally available raw materials to produce functional objects that were particularly suited for certain tasks.

In this introduction, I explain the specific research goals of my project and offer a brief overview of the methods used. I also explain the historical precedents for and the theoretical underpinnings of my research. Next, I provide details on the geography, resources and climate of the Middle Balsas region, which is the geographical focus of the research. I also discuss the documentary evidence for resources that were available to ancient peoples in the Middle Balsas region and that are no longer exploited today. Finally, I provide an overview of the format of the entire publication.

1.1 Problem Statement and Research Goals

Problem Statement

My research focuses on identifying and detailing the pottery production technology developed and used in the Middle Balsas region of Guerrero, Mexico (see Figure 1.1). I chose to investigate pottery production because previous researchers, regardless of the geographic location of their studies, have obtained intriguing results that require further investigation through integration of techniques and concepts from anthropology, archaeology, and materials science. Specifically, how frequently potters changed their production techniques to influence the materials properties of the finished vessel remains an unanswered question.

Several researchers have shown through laboratory studies of samples made using ancient techniques (*e.g.,* Schiffer 1990; Bronitsky and Hamer 1986; Kilikoglou *et al.* 1998) that potters *can* influence the materials properties and behavior of finished pottery vessels by changing certain aspects of production. For example, potters can mix different non-plastic materials (temper) into the raw clays to influence the thermal shock resistance of a vessel (Bronitsky and Hamer 1986; Tite *et al.* 2001) or to change its strength or toughness (Kilikoglou *et al.* 1998). Potters also can change the permeability of the clay walls through burnishing or painting, which affects the vessel's ability to boil water (Schiffer 1990). Various researchers have suggested that potters in North America took advantage of these property differences when producing cooking vessels that needed to be resistant to thermal shock (Bronitsky 1984; Bronitsky and Hamer 1986; Budak 1991). One study of Mesoamerican pottery suggests that potters at La Quemada used a wider range of non-plastic inclusion sizes when making their cooking vessels (as opposed to bowls, which were made with a narrow range of inclusion sizes), possibly for functional reasons (Devereux 1996). Finally, a study of pottery production in India suggests that different clay sources and processing methods were used to make pots intended for distinct functions (Mahias 1993). It is still unclear, however, whether potters from many regions and from many time periods were tailoring their production methods to take advantage of these possible variations in mechanical and physical properties of the materials they used.

Figure 1.1: The location of the state of Guerrero within Mexico and the location of the Middle Balsas Region within the state of Guerrero.

The Middle Balsas Region and Site Selection

As mentioned previously, I am studying pottery production within the Middle Balsas region. The Middle Balsas region lies adjacent to the location of many ancient state-level societies within Mesoamerica, including Teotihuacán (200 BC-AD 650) and the Mexica (AD 1250-1520) to the north, the Purépecha (AD 1200-1520) to the northwest, and the Zapotecs (500 BC-AD 1520) and Mixtecs (AD 1000-1520) to the southeast. Based on documentary evidence, the Middle Balsas region is thought to have been a border area between the Aztec (Mexica) and Tarascan (Purépecha) Empires during the Late Postclassic period (AD 1350-1520: see Silverstein 2000, 2002; Hernández 1994, 1996; Pollard and Smith 2003). The extent of contact between the Middle Balsas region and its neighbors has not been established, but it is likely that the Middle Balsas interacted with surrounding societies in some fashion (imported vessels were reported by Paradis 1974 and Silverstein 2000).

I chose this area because practically no systematic archaeological investigation has focused on the Middle Balsas (see Chapter 2 for a few exceptions). Thus my research will not only add to a general understanding of how ancient peoples produced and used pottery vessels, but it will also provide a pottery sequence for the Middle Balsas throughout the Classic period (AD 200-800), which currently does not exist. The pottery sequence can then be used by other archaeologists investigating any aspect of the Middle Balsas region.

I focused my investigations on three major sites within the Middle Balsas region: La Quesería, Itzímbaro and Mexiquito (see Figures 1.1 and 1.2). The Middle Balsas is a circumscribed and homogeneous ecological zone. I describe its resources and characteristics in more detail in section 1.3. When selecting the specific sites for my research, the consistent ecology of the Middle Balsas region allowed me to eliminate most environmental factors as sources of variation among the sites. I selected La Quesería, Itzímbaro and Mexiquito because they all appeared to be of similar scale, which was larger than most other sites in the region. This eliminated site size as an additional variable. Based on the results of limited previous research (Hosler 1999a; Meanwell 2001), these three sites all appear to have been occupied during an overlapping period of time extending at least from AD 400 to 900. This time span has not been the focus of investigation for any other researchers working in the Middle Balsas region.

Specific Research Goals

I have two overarching research objectives: establishing a chronology of the Middle Balsas and detailing the region's pottery production methods. I posit that pottery intended for different functions was often deliberately made and/or decorated in ways that were chosen to make the vessels more appropriate for their intended functions. More specifically, in this study I determine whether any of the pottery production patterns I identify in the region are linked to specific constraints imposed by the materials during the process of pottery manufacture. For example, I will show whether variables such as vessel shape and wall thickness correlate with the clay types and processing techniques determined during thin section analysis[1] of the ancient sherds. Additionally, I identify certain production behaviors that are characteristic of the entire region and that can be used as markers of this local tradition. My specific research agenda is four-fold: 1) to identify how pottery was being made at these three sites; 2) to investigate any material constraints that affected why pottery was made in the ways I determined; 3) to establish whether manufacturing methods varied through time or among the three sites; and 4) to clarify the chronology of site occupation and to provide a ceramic sequence for this region.

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1 Thin section analysis, which is also known as petrography, is a standard technique used in geology and archaeology to identify minerals and clay textures using a polarizing microscope. The technique is described in more detail in Chapter 3 and Chapter 5.

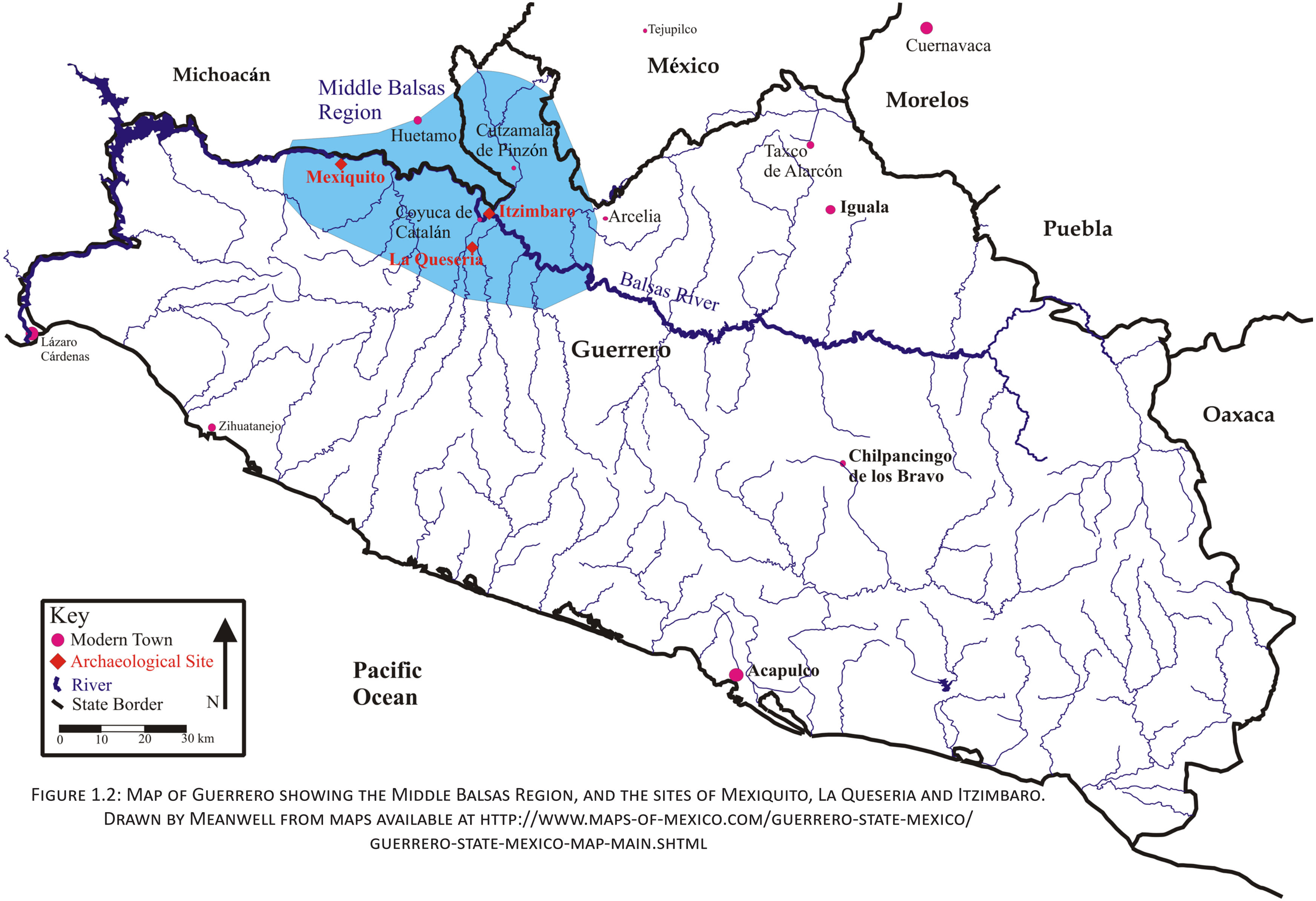

Figure 1.2: Map of Guerrero showing the Middle Balsas Region, and the sites of Mexiquito, La Queseria and Itzimbaro. Drawn by Meanwell from maps available at http://www.maps-of-mexico.com/guerrero-state-mexico/guerrero-state-mexico-map-main.shtml

Methods Overview

To accomplish these goals, I utilized a variety of methods both in the field and in the laboratory. In the field, I mapped the mounds and other architecture, performed surface collections, and excavated test pits at the three sites to collect pottery, radiocarbon samples, and other cultural materials. I also collected samples of clays from the region to compare with clays that form the fabrics of the ancient sherds. In the laboratory, I identified the vessel shapes and wares that are characteristic of the Middle Balsas region. I examined specific examples of these shape classes through thin section analysis (petrography) to determine some details of the manufacturing process and to identify the clay fabrics used for each vessel. I made two sets of small test briquettes from the local clay samples I collected. One set of briquettes was thin sectioned and compared with the ancient sherds to identify possible clay sources used in ancient times. These thin sections also helped determine which clays could be used as analogues for the ancient sherds in experiments designed to test the properties of clays, specifically their fracture strength. The second set of test briquettes was subjected to three-point bend tests to measure the transverse rupture strength (TRS) of the various clays containing different volume fractions of sand temper. Finally, I analyzed carbon samples collected during excavation to determine the chronology of various stratigraphic levels found during the excavation.

Although this work focuses most heavily on pottery manufacturing technology, evidence from the analysis of other materials including architecture, figurines, and obsidian, will be discussed briefly. The data from these materials help create a more complete picture of the chronology and particular features of the Middle Balsas culture and its interactions with neighboring groups.

1.2 Theoretical Underpinnings and Pottery Production Studies

The types of pottery production choices I am studying are always made from a range of technically feasible options, given the materials available. These choices may be made for practical reasons (to keep the pot from cracking when placed over a fire), for cultural reasons (to make the pot appropriate for use in a specific ritual), or both. This guiding theoretical statement for my research was developed using theories elaborated by a number of scholars who have studied ancient technologies. Several schools of thought on production and ancient technology have contributed to this study, including the anthropology of technology, analytical studies of pottery including experimental replication, and ceramic ecology.

The Anthropology of Technology and the Materials Approach

The theoretical framework behind my Middle Balsas pottery investigation derives primarily from the anthropology of technology and what has been called the ‘materials approach.’ Researchers using the materials approach, as defined by Heather Lechtman, consider the fact that ‘manufacturing an object always involves accommodation between the properties of the material from which the object is made and the object’s design’ (Lechtman 1999: 223). Materials properties are invariant and universal, but human practitioners choose certain properties from among viable technical alternatives when producing objects (Hosler 1986, 1994: 4; Lechtman 1999). Therefore, in order to study how ancient societies produced their tools and other objects, it is vital to analyze in detail the properties of the materials they utilized and their production techniques.

The history of the materials approach can be traced to the pioneering work of Cyril Stanley Smith (1965, 1971, 1973, 1977). He was the first researcher to apply analyses and techniques from materials science to the study of ancient production methods, especially metallurgy. Cyril Smith was a metallurgist and an historian of metallurgy, but he did not carry out his studies from an anthropological perspective.

In the 1970s and 1980s, Heather Lechtman, a student of Cyril Smith, pioneered the integration of anthropological archaeology with materials science, which is concerned with materials properties (Lechtman 1977, 1984a, 1984b; Lechtman and Steinberg 1973). Lechtman's 1977 article was the initial programmatic statement on technological style. She sees technologies as 'totally integrated systems that manifest cultural choices and values' (Lechtman and Steinberg 1973; Lechtman 1977: 3). Therefore, by studying in detail the properties and production methods of various types of objects, a set of characteristic behaviors or ideas is revealed, which represent the technological style of a particular culture. Lechtman compared production techniques of Andean metallurgy and textiles to develop her ideas concerning the technological styles characteristic of Andean cultures (Lechtman 1977).

Dorothy Hosler, a student of C. S. Smith and Lechtman, used the idea of technological style and operationalized it by examining the relationships between artifact design and function based on concepts drawn from materials and mechanical engineering. For example, she used finite element analysis to examine the functionality of two different west Mexican tweezer designs, determining that one of them required the properties of bronze alloys to realize the design and to function successfully (Hosler 1986: 120-209; 1994: 66-73, 145-152). Dewan and Hosler (2008) used MATLAB to model the material properties and behaviors of the variety of materials used to construct ancient Ecuadorian sailing rafts. They determined the limitations of raft size, mast height, sail dimensions, and cargo capacity through these models to evaluate whether, in prehistoric times, these craft could have sailed from Ecuador to west Mexico and back. The issue of maritime voyages between Ecuador and west Mexico is a primary concern in New World archaeology, because metal working technologies were introduced from northern South America to western Mexico, likely via a maritime route (Hosler 1986: 560-567, 1988a, 1994: 99-105). The Dewan and Hosler (2008) research provides direct evidence that vessels of dimensions they determined could have made the long, ocean-going, round-trip voyages successfully.

Hosler emphasized the importance of fundamental limitations and possibilities provided by materials properties (1986, 1994:3-6). This requires identifying the range of technical possibilities allowed by the properties of the specific materials, then identifying where people choose from technically feasible alternatives (Hosler 1986, 1994: 4). As Hosler states:

> 'I can determine *where* aspects of this particular ancient "human fabric" are visible in the selection of raw materials and processing methods and in decisions about object design. This is possible because I can distinguish between those characteristics of the technology that result from technical *choices*, which reflect and express values, interests, and other social variables, and those arising from technical *requirements* imposed by the material's inherent physical and mechanical properties.' (Hosler 1994:3- italics are original)

The significant outcome of this approach was Hosler's establishment of the archaeological chronology for the development of west Mexican metallurgical technology based solely on the engineering design characteristics of the metal artifacts (Hosler 1988b). The design of objects made from bronze alloys during Period 2 of the technology (AD 600 to 1200/1300) could not have been achieved in copper, the metal that characterized Period 1 (AD 1200/1300 to 1520) (Hosler 1994: 134-139).

The materials approach as it is now applied developed mainly using the concepts established by Lechtman (see especially 1977, 1994, 1996a, 1996b, 1999) and Hosler (see especially 1986, 1988a, 1994, 1995, 1996). This approach has been used successfully by Lechtman and Hosler's students and colleagues for a variety of different materials, including metals, polymers, and pottery (*e.g.,* Childs 1986; Devereux 1996; Dewan and Hosler 2008; Meanwell 2001; Reitzel 2007; Tarkanian 2003). The recent article by Dewan and Hosler (2008) mentioned above effectively demonstrates the utility of the materials approach for research questions concerning the use of a specific technology. Other researchers had experimented with balsa raft voyages (Haslett 2006; Heyerdahl 1955), but did not closely simulate the Ecuadorian raft's probable sail design (Dewan and Hosler 2008). Furthermore, Dewan and Hosler (2008) were able to show that certain dimensions of the rafts' centerboards and masts were required to provide safe sailing conditions, and they also demonstrated that a voyage from Ecuador to Mexico and back is feasible. The novelty and strength of the conclusions required consideration of how the materials available affected the design and function of the vessel.

David Braun (1983), in his article 'Pots as Tools,' was the first to articulate a version of the materials approach specifically for pottery. He suggests that because pots are used for different functions, they must also have materials properties that differ according to their function (Braun 1983). Other researchers have expanded on this idea by studying specific materials properties and how they affect pottery functionality (see section 1.2.2).

Beginning in the 1970s, a group of French ethnographers investigating the interactions between society and the production of material culture developed a subtly different model of artifact production known as the *chaîne opératoire* (Leroi-Gourhan 1964, 1965; Lemonnier 1976). This model argues that during the production of any object, choices are made at each step that affect and place limitations on the finished product. These scholars link processing techniques and steps to cultural considerations of the 'correct way' to form material objects, although they do not address the fundamental question of limitations due to inherent material *properties,* which is centrally important to the materials approach.

The *chaîne opératoire* approach has been used to study various classes of material culture, including house shapes, clothing types, and hunting methods in modern Papua New Guinea (Lemonnier 1986, 1990), pottery production (Mahias 1993; van der Leeuw 1993), Neolithic adoption of various pottery, bone, and stone tools (Pétrequin 1993), and modern technology including guns, factories, and transportation systems (Govoroff 1993; Pfaffenberger 1993; Latour 1993). As noted above, however, these researchers do not consider whether materials properties have an effect on production or object design. For example, in her study of pottery production in India, Mahias (1993) assumes that the clays available in all regions have approximately the same material properties, and she does not ask the question of whether varying clay types could have influenced the production methods. Mahias notes that a specific temper type is used only in one geologic area, but she goes on to say that this should not be given much weight in the discussion, because multiple solutions to materials issues are possible (Mahias 1993: 164-165). Mahias does not seek an explicit evaluation of the possible materials limitations imposed by that certain clay type, assuming instead that the clay type available to the potters had little effect on their production methods.

Over the last decade, there have been many theoretical articles written on how materials analysis in archaeology and anthropology can provide insights into the cultures under study (*e.g.* Schiffer 2001; Sillar and Tite 2000; Jones 2004; Ingold 1990, 2007a; Prown 1996; Dobres 1999, 2000; Dobres and Robb 2005; Dobres and Hoffman 1999; Pollard and Bray 2007; Roux 2003; Lechtman 1999). In these articles, the authors discuss various theoretical positions, but most do not provide examples of how they would use their theoretical approach to analyze an archaeological assemblage. An additional set of discussion articles was published recently in *Archaeological Dialogues* (Ingold 2007a, b; Tilley 2007; Knappett 2007; Miller 2007; Nilsson 2007). In these, Ingold (2007a) advocates for more research that explicitly evaluates materials properties. He also suggests that too much emphasis is placed on theoretical dialogues over concepts such as 'materiality' and not enough emphasis is placed on the actual artifacts. The other authors argue that analyses of materials are helpful only when properly placed into a cultural and archaeological context.

Many archaeologists of all theoretical persuasions now use a variety of materials and other physical analyses routinely and profitably to answer a specific set of research questions. Most frequently, these questions address artifact provenience or material systems characterization. Provenience studies, while not the main focus of this research, are crucial to understanding ancient interaction and exchange networks (*e.g*., Fargher 2007; Martineau *et al.* 2007; Tiedemann and Jakes 2006; Abbott and Schaller 1991; Day *et al.* 1999; Rattray and Harbottle 1992). Many materials characterization studies do not consider social factors heavily in their analyses, but generally provide valuable information about the functional possibilities achievable during artifact production (Tite 1987, 1989, 1999; Tite *et al.* 2001; Schiffer 1990; Kilikoglou *et al.* 1998; Vekinis and Kilikoglou 1998; Beck 2002).

I, and other scholars who follow the materials approach, would argue that materials analyses can be used to answer a much broader set of research questions than simply provenience or materials characterization. The materials approach not only asks where or how an object was made, but also considers *why* it was made in a specific manner, and can identify culturally-influenced decisions in the production process.

My research agenda was designed primarily from the theory governing the 'materials approach' as developed and used by Lechtman and Hosler (Lechtman 1977, 1984a, 1984b, 1991, 1993, 1994, 1996a, 1996b, 1999, 2007; Hosler 1986, 1988a, 1998b, 1990, 1994, 1995, 1996, 1999b; Hosler *et al.* 1990; Hosler and Macfarlane 1996). In addition to the materials properties of finished pottery, I consider the limitations and constraints that are placed on pottery production during selected manufacturing steps, including clay selection, tempering, and firing. The importance of studying production techniques and sequences is explicitly developed in the materials approach and is also considered in the concept of the *chaîne opératoire*.

I also analyze a broader set of materials properties in my work than that evaluated previously by most experimental archaeologists (*e.g.,* Schiffer 1990; Kilikoglou *et al.* 1998; Tite *et al.* 2001; Vekinis and Kilikoglou 1998; Schiffer and Skibo 1989). I argue that a thorough understanding of ancient pottery production can be developed only through multiple analyses of ancient sherds, including petrographic, chemical, physical, mechanical, or radiographic techniques, to determine how they were produced (this is discussed in more detail below). This must be followed by experimental replication of ancient pottery production methods using appropriate clays. Finally, a characterization of the materials properties of the experimental product will offer data on the physical limitations (if any) that would have affected production. It is not sufficient to focus exclusively on either the properties or the processing of materials when evaluating pottery production. The information gained by investigating both of those topics can be used to determine how people interacted with their environment to make pottery (see the discussion of ceramic ecology). A determination of the properties of the raw materials and finished products sets limits on what it is physically possible to produce, while an identification of the processing methods can highlight specific culturally inspired choices made by the potters.

My research integrates a thorough understanding of the specific material (the materials properties and processing techniques of the specific clay, water, and temper mixture) with a concern for the social aspects of pottery production.

Replication and Laboratory Analyses of Pottery

The analytical techniques (petrography, ethnographic studies, and experimental replication) I utilize have a long history of use in archaeology. Anna Shepard, who worked primarily in the Southwestern United States and Mesoamerica, did some of the earliest research into pottery production (Shepard 1936, 1940, 1948). Shepard focused primarily on clay source identification via analysis with binocular microscopes and petrographic thin sections, but also investigated stylistic patterns (Shepard 1948, 1964, 1965). Shepard was the first person to introduce the technique of petrography to archaeological research (Shepard 1936).

Beginning primarily in the 1980s, researchers began investigating the functional properties of pottery through experimental replication. David Braun (1983) linked various pottery production changes, including different temper types and variable wall thicknesses, to the introduction and consumption of maize in the Midwestern United States during the Woodland period. Gordon Bronitsky (1984; Bronitsky and Hamer 1986) suggested on the basis of replica testing that shell tempered pottery may be more thermal shock resistant than sand tempered pottery, and that shell temper was preferred in cooking pot production. The theme of sand versus shell temper reoccurs in the archaeological literature, with Michael Budak's study on this topic (Budak 1991). Michael Schiffer and James Skibo also designed a variety of replication experiments to determine how properties, such as porosity, could affect functionality (Schiffer 1990; Skibo *et al*. 1989), and they investigated durability and wear marks in pottery as possible signals of ancient function (Schiffer and Skibo 1989).

Other work has been carried out to determine identifiable and characteristic changes based on firing temperature (*e.g.*, Rice 1987: 80-110; Feathers 1991; Feathers et al. 2003; Tite 1969; Buxeda i Garrigós *et al.* 2001) and to determine firing method and extent. More recently, researchers in Greece have systematically documented changes in the mechanical properties of clays prepared with differing amounts of temper in modern replicas they have made of ancient ceramics (Tite *et al.* 2001; Vekinis and Kilikoglou 1998; Kilikoglou *et al.* 1998). More recently, Kilikoglou and Vekinis (2002) have experimented with finite element analysis as a technique for determining how a specific pottery design will fail. As Kilikoglou and Vekinis are aware, the vessel form[2] can affect the functionality of a certain design. Appendages, such as feet, must be able to support the weight of the vessel and its contents, and the aperture of a vessel neck can make it more convenient in specific applications. The shape of an entire vessel may be designed for a particular application, such as Mediterranean pointed-base amphorae that were tapered to allow dense packing aboard ships (Twede 2002).

Michael Tite (1999) has written a comprehensive summary of research carried out on pottery using methods of the physical sciences. All of these studies, while narrowly focused, are beginning to evaluate which materials properties may have been manipulated by ancient potters in various regions.

A number of scholars working at the Center for Materials Research in Archaeology and Ethnology housed at MIT have analyzed various aspects of pottery production and use using the techniques of materials analysis (Childs 1986; Little 1989; González 1993; Strazicich 1995; Devereux 1996; Meanwell 2001; Reitzel 2007). Mary Hopkins (1996) studied the production of cooking pots from Teotihuacán, in central Mexico. Her analysis focused on how the pots were made (including clay sources), but did not consider how different intended functions might have affected production, as she analyzed cooking pots exclusively. Robin Devereux (1996) investigated how temper size affected functionality in pottery from La Quemada. She determined that a larger range of temper sizes was used in cooking pots than in bowls, and experimentally determined that the larger temper sizes enhanced the thermal shock resistance of the clay vessels. Although her conclusions are qualified, she suggests those temper choices were intentional. All of these studies offer tantalizing glimpses of some of the individual materials properties that can be affected by changes in processing, and I used their results in determining the range of properties I would investigate in this research.

Ceramic Ecology and Ethnography of Pottery Production

An additional group of scholars who influenced my work on pottery production follows what is known as the ceramic ecology and systems approach, which means they look at pottery production within the context of the local environment and available materials (Matson 1965; Arnold 1975). Some researchers

2 Throughout this work I use the word form to refer to the overall shape of a vessel. I also use the phrase 'formal types' to refer to the different shape classes that I identified.

have clarified production details based on the locally available materials and determined consumption and exchange patterns in a small geographical area (*e.g.*, Fry 1980; Langdon and Robertshaw 1985; Rands and Bishop 1980). Dean Arnold (1985) correlated a large number of ethnographic and archaeological studies to look for universal behaviors as related to pottery production. He determined that most potters do not travel far (fewer than 7 km) to obtain their raw materials, except in the exceptional cases where the transport mechanism or rarity of the resource requires or allows longer distance travel (Arnold 1985: 39-50).

A number of recent ethnographic studies of pottery production have investigated some of the standard hypotheses used during archaeological investigation. Bill Sillar (1997) documented a pottery system in highland Bolivia and Peru in which the potters brought clay from their home village to other locations where the pots were actually produced. This pattern is directly opposite from Arnold's (1985) results. Other ethnographic investigations, particularly of modern Kalinga potters in the Philippines, have considered a number of relevant topics, including how political control influences access to clay resources (Neupert 2000), how differing amounts of specialization by potters affect the clay composition (Stark *et al*. 2000), how modern people decide which pottery vessel to purchase (Longacre *et al.* 2000), and whether full-time potters produce vessels that are more standardized in size and shape than part-time potters (Longacre 1999; Deal 1998:31-37; Arnold 2000). Additionally, Dorothy Hosler studied how social categories affected pottery production techniques in the Andean community of Las Ánimas (Hosler 1996).

Mesoamerican Pottery Production Studies

My research is unusual in Mesoamerican pottery production studies, both because I use petrographic analysis, a technique not common to the study of archaeological ceramics, and because I study pottery production unrelated to state-level society. Previous petrographic analyses of Mesoamerican ceramics have focused mainly on pottery production around major sites or on major trade wares including Teotihuacán/Thin Orange ware (Hopkins 1995), Monte Albán (Fargher 2007; Feinman *et al*. 1989; Shepard 1967), the Maya area (Kepecs 1998; Jones 1984, 1986; Rands and Bishop 1980, López 1989), and plumbate ware (Shepard 1948b). These studies fall into two types of investigation: either a determination of the source area for a trade ware or specific ware type (see Shepard 1948b; Fargher 2007; Rands and Bishop 1980; Strazicich 1998; Rattray and Harbottle 1992) or an attempt to determine the level of specialization in pottery production (Kepecs 1998; Jones 1984, 1986; Feinman *et al*. 1989). Studies that attempt to discover the extent to which vessel function had an effect on production techniques are rare (see however Devereux 1996; Meanwell 2001; Reitzel 2007).

My work provides data on pottery chronology, provenience, the level of specialization present in pottery production, and the possible effect of vessel form and function on production techniques among a group of related sites in the Middle Balsas region. Such a comprehensive study, which combines four major features of pottery production, is the first of its kind. Although the methods and theories I employ have been utilized previously by other researchers, this is the first project to use materials analysis of a broad range of pottery vessel types from a wide geographical area to answer anthropological questions, specifically whether potters usually optimize the materials properties of their vessels for various functions.

1.3 Description of the Middle Balsas and its Ecology

The Middle Balsas region is located in a depression formed by the Balsas River and its tributaries in the northwestern corner of Guerrero and small areas of the adjoining states of Michoacán and México (see Figures 1.1 and 1.2). Today this region falls within the area known as the '*Tierra Caliente,*' literally the 'hot lands,' where the average annual temperature (28° C) is among the highest in Mexico, and rainy season temperatures can reach at least 42º C on a regular basis (Piperno *et al*. 2007). The average altitude of the valley is about 300 m above sea level, although isolated hills exist throughout the region. The Sierra Madre del Sur mountain range is to the south, and it divides the area around the Balsas River from the Pacific coastal plain. To the north, the land rises to the Central Plateau of Mexico. The Middle Balsas region has a seasonal rainfall pattern, where heavy rains begin in late May and last until the end of October or early November for an annual total of around 1100 mm (Piperno *et al.* 2007). Rain outside of the rainy season is very rare. Although the climate is very dry outside of the rainy season, the Balsas River system provides a significant source of year-round water for the region's inhabitants.

Recent investigations into the climate history of the Iguala region just to the east of the Middle Balsas (see Figure 1.2) suggest that the climate has fluctuated mildly since the end of the Pleistocene era (around 11,000 BP) when it first approached modern conditions (Piperno *et al*. 2007). The short-term climatic fluctuations between 1800 BP and 900 BP appear to correlate to climatic events that have been linked to the collapse of Maya civilization (Piperno *et al.* 2007). Evidence suggests that during the fluctuations (Piperno *et al*. 2007) the Balsas region became drier than its current conditions. The range of plant and animal species living in the region during the time under study is therefore likely similar to those seen today, although those most dependent on rainfall may have been scarce or absent during the drier periods. Since the Balsas River is a year-round water source, it may have become even more important to people living in the area during the climatic fluctuations.

The vegetation in the Balsas depression falls into the category of *matorral espinoso caducifolío bajo,* which is translated as 'short, deciduous and spiny forest' (Moguel 2002). This category includes mainly short bushes and occasional taller trees, many of which have thorns. These species include mesquite (*Prosopis julifora*), parotas (*Enterolobium cyclocarpum*), ciríán (*Crescentia alata),* cuayulote (*Guazuma ulmifolia*), algodón silvestre (*Cochlospermum vitifolium*), and ciruelo (*Spondius purpurea*) (Moguel 2002). A variety of cactus species is also found, including the prickly pear or *nopal (Opuntia sp.)* that provides fruit and tender leaves for food. The character of the region changes dramatically from the grey and brown landscape of the dry season to the lush green of the rainy season (see Figure 1.3). Vines, flowers, and small plants appear almost as soon as the first rain of the season occurs.

Wildlife is fairly abundant, with a number of species still hunted and utilized today. The most common animals include squirrels, rabbits, frogs, scorpions, tarantulas, birds, foxes, lizards, iguanas, coyotes and a number of snake species, including rattlesnakes and coral snakes (Moguel 2002). In the hills and the Sierra Madre del Sur, deer are still found and hunted, and occasional wild pigs (*jabalí*) are also known. According to older residents of the area, deer were more common in the past, but they have been over-hunted.

In addition to water, the Balsas River provides a source of a number of riverine resources, especially fish and shellfish. Fishing for local freshwater species such as *truchas* (trout) and *mojarras* (bass) is common, and they form a significant portion of the local diet. The Balsas River also acts as a transportation route, although fewer vessels are currently found on the Balsas due to the construction of a number of dams. Before the dam construction, however, it was possible to navigate by boat from the mouth of the Balsas across most of the state of Guerrero (see Gorsuch 1966).

The Balsas depression is also rich in mineral resources. The area is dotted with a number of small copper and other mineral deposits (Hosler 1999). In fact, the only documented indigenous smelting site in Mesoamerica is located just south of the Middle Balsas region at the site of El Manchón, Guerrero (Hosler 2005). The Middle Balsas is especially known for gold deposits near the town of Placeres del Oro. Elsewhere in Guerrero, there is evidence of greenstone extraction and exportation, and greenstone of various types may be found near the Middle Balsas (Griffin 1993). Eastern Guerrero is also well known

Figure 1.3: The main pyramid (structure M-1) at La Quesería during the dry season (above) and the wet season (below).

as a source of salt from such places as Ixtapan, although there is no evidence for industrial-level salt production in the Middle Balsas Region.

Today, the agriculture of the region is mainly subsistence farming of corn, beans, chilies, and squash, herding of cattle, pigs, donkeys, or goats, and some cash-cropping of melons, *jícama*, sesame, and tomatoes. Livestock herding is especially important in the western area of the Middle Balsas near the site of Mexiquito. Many of the large fields along the Balsas River are used to produce cash crops, and often irrigation is used during the dry season to increase productivity. Many farmers still plant small plots of corn during the rainy season for their family's tortillas for the year, or to provide extra food for the livestock. Sorghum is also grown as an animal feed. A number of orchards have been planted in the area, especially mango, papaya, banana and *nánche (Byrsonima crassifolia)*.

1.4 Conquest-Era Documentary Evidence of the Middle Balsas and its Resources

A complimentary source of information about the conditions in the Middle Balsas and resources likely available and utilized by ancient peoples are the Conquest-era documents written by both indigenous and Spanish authors. A number of mainly pictorial codices detail the tribute sent from various provinces in the Aztec empire to the capital (Berdan and Anawalt 1997; Clark 1938). Presumably, the majority of the tribute consisted of local products. Another set of codices documents tribute given to Spanish landowners in the area just north of Mexiquito in the sixteenth century (Roskamp 2003). Additionally, multiple editions of a 1577 Spanish geographical survey of Michoacán known as the *Relaciones Geográficas* list the towns found in the region, their populations, and some of their notable characteristics (Paso y Troncoso 1905; Acuña 1987).

The two most relevant codices are the *Matrícula de Tributos* and the *Codex Mendoza,* both of which detail tribute sent annually to the Aztec rulers by various provinces. The *Matrícula de Tributos* appears to be a later copy of a pre-Conquest document, and it was possibly made in the period from 1522 to 1530 (León-Portilla 2003). The *Codex Mendoza* is a larger document that probably used the *Matrícula de Tributos* as a model for the middle section devoted to tribute (Castillo Farreras 2003).

The two Aztec provinces of Tlachco and Tepequacuilco are closest to the Middle Balsas area, and the western edge of the Tepequacuilco province is close to the eastern edge of the Middle Balsas region (see Figure 1.4). According to these documents, the Tepequacuilco province sent cotton *mantas* (a type of women's clothing), gourd bowls, corn, beans, amaranth, copal, honey, copper axes, and greenstone, among other things, to the Aztecs (Berdan and Anawalt 1997: 79). The province of Tlachco, slightly to the north, also sent *mantas*, gourd bowls, corn, and honey (Berdan and Anawalt 1997: 76). The production of *mantas* likely implies that the cotton was locally grown, although it may have been imported for processing from Morelos, for example. The greenstone and copper axes sent by the Tepequacuilco province are noteworthy; Guerrero is the only source of copper noted in the codices, and greenstone comes from a limited number of locations (Castillo Farreras and Sepúlveda y Herrera 1997: 120-122). Both copper and greenstone may have been produced in the Middle Balsas region as well.

In a more recent revision of the Aztec tribute provinces, the closest strategic (non-tribute providing) province to the Middle Balsas region is Tetellan, with the tribute provinces of Tlachco and Tepecuacuilco also nearby (Berdan *et al.* 1996: 112). Other tribute documents confirm the extensive natural products that were sent from the province of Tepecuacuilco to the Aztec empire's heartland (Berdan 1996: 130). These resources included gold, silver, copper, jade, salt, pigments, cotton, cacao, maize, white honey, mats, and chilies (Berdan 1996: 130). At least one scholar has suggested that the abundance of metal resources in the

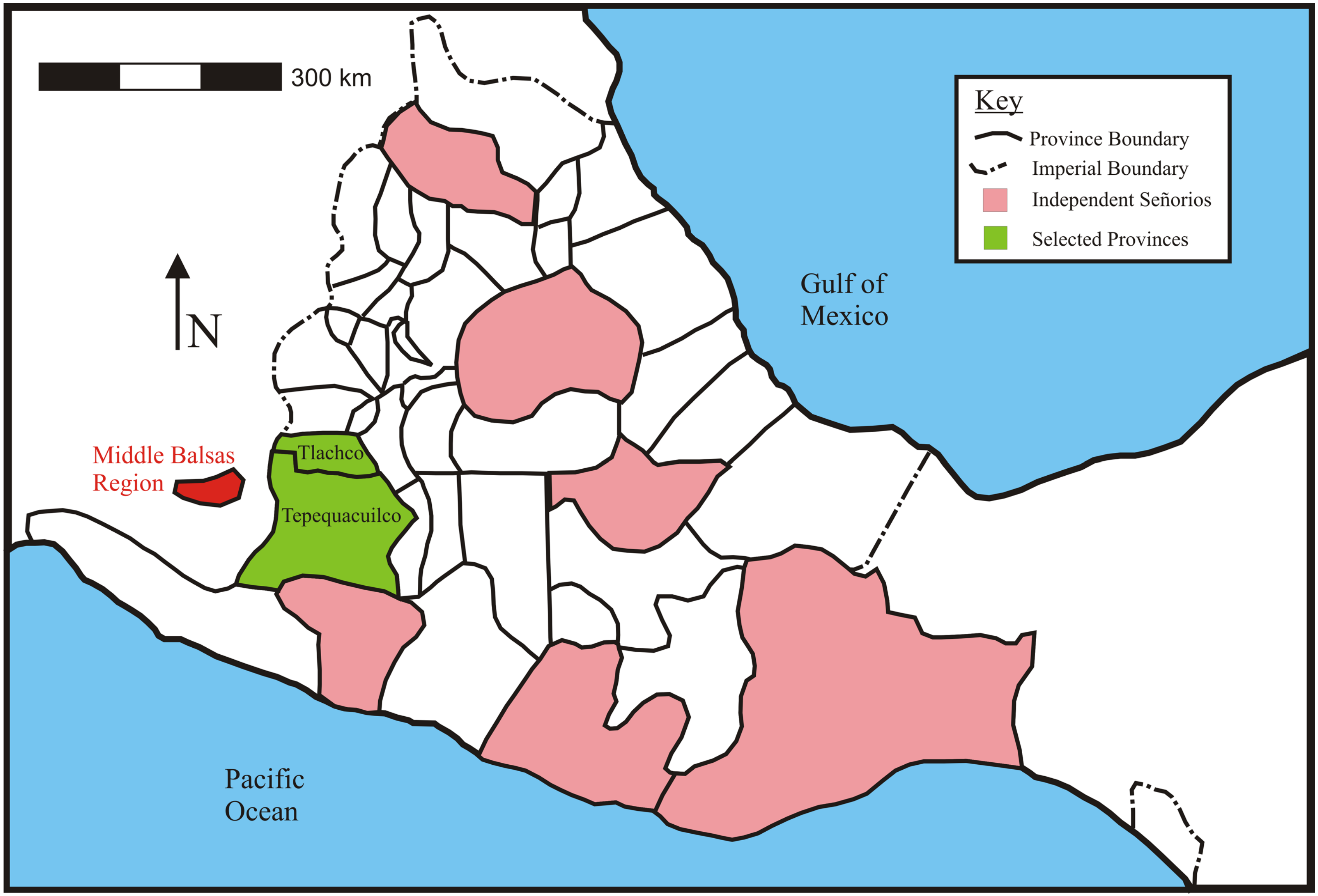

Figure 1.4: Detail of Mexico showing the provinces of the Aztec Empire and the Middle Balsas Region.

Middle Balsas region and surrounding areas may be the major reason that the Tarascans and Aztecs were in conflict over control of this area (Smith 1996: 139).

The codices of Cutzio and Huetamo (see Figure 1.5) detail the tribute and labor given to the Spanish *encomenderos* (land owners) by the local indigenous populations in the mid-sixteenth century (Roskamp 2003). According to these codices, the area was producing honey, salt, turkeys, pottery vessels, cotton clothing of various types, and dried fish (Roskamp 2003: 29-31). This information suggests that small local salt production centers were present, and that cotton was being grown and turned into usable garments in the area. The dried fish are likely a product of the Balsas river system. These products are similar to those mentioned in the Spanish documents detailed below.

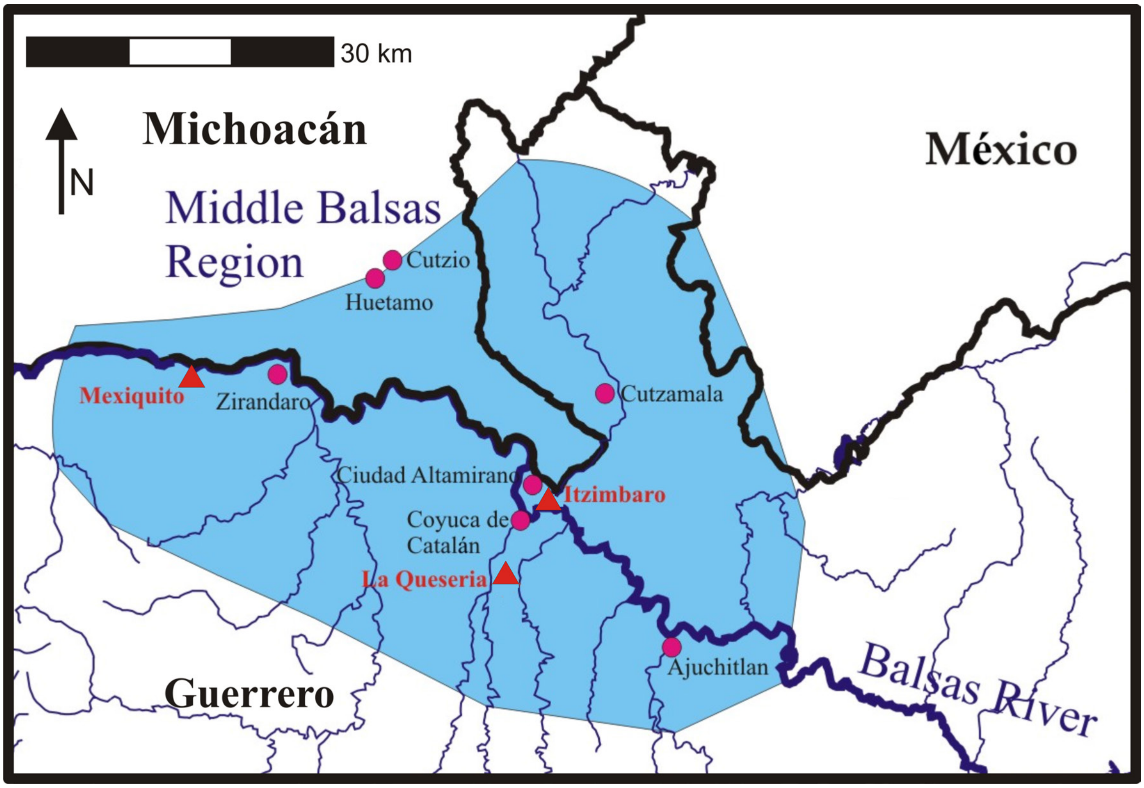

Figure 1.5: The locations of modern towns mentioned in codices and their relations to La Queseria, Itzimbaro and Mexiquito. Refer to the key in Figure 1.2 for the symbols used in this map.

The *Relaciones Geográficas de Michoacán* includes responses to a number of detailed questions about the populations, geography, and characteristics of two towns within the Middle Balsas Region (Acuña 1987). These towns are Ajuchitlán (which also includes Coyuca, Cutzamala, and Pungarabato/Ciudad Altamirano) and Zirándaro (which includes Cutzio). Figure 1.5 indicates the locations of these towns. The descriptions of both towns mention the rainy season from May to October, the extreme heat, the large number of mosquitoes, as well as the extremely fertile soils along the river (Acuña 1987:30-41, 264). Corn, beans, chilies, and squash were the staple foods of the region, and melons from Spain were being successfully grown in the area (Acuña 1987: 38-40, 264-265). River fish and a number of animals including deer, *jabalí*, iguana, and frogs are noted as sources of meat (Acuña 1987: 261). Both Ajuchitlán and Zirándaro had small salt production sources, although these only produced enough for local consumption, and salt was not traded long distances (Acuña 1987: 43, 267). Ajuchitlán is mentioned as producing cacao, and the editor believes that two different species may have been grown in the region (Acuña 1987: 42). Cotton was produced in all towns of the region along the Balsas River. Finally, the Ajuchitlán summary notes that the area was once heavily occupied, although the population had reportedly decreased by 1577 when the survey was conducted (Acuña 1987: 30).

Other documents suggest that the native population dropped from 5468 persons in 1548 to 2300 in 1579, and again to 1175 in 1603 (Gerhard 1972:136). The minimum native population was noted in 1649, when only 416 native tributaries were documented (Gerhard 1972:136). Gerhard (1972: 136) suggests that migration was the main cause for the reduction in population, although disease and an earthquake also had an effect. By 1787, the Middle Balsas Region was located within an administrative division known as Guaymeo and Sirándaro under the control of a mayor in Huetámo (Gerhard 1972: 136).

In short, the sixteenth-century documentary evidence suggests that the climate and products of the Middle Balsas region have not changed significantly over the past five hundred years, although additional agricultural products have been introduced to the area, such as cattle and mangos. The combined documentary evidence suggests that honey, corn, cotton, and beans were important agricultural products of the Middle Balsas region, as they are known from regions to the east and northwest. Greenstone and copper may have been produced in the Middle Balsas region, although there is little direct evidence for this. While these documents do seem to confirm that cotton and cacao *can* be grown in the Middle Balsas region, it does not mean that these *were* being grown there in large volumes before Spanish intervention. The *Relaciones* speak of several Spanish plants that had already been introduced into the area, and it is possible that cotton or cacao was not a common agricultural product in pre-Conquest times.

1.5 Summary of Format

This work will proceed in six additional chapters. In the second chapter, I detail previous archaeological research in the Middle Balsas region. I also describe some studies of the surrounding areas that help define the unique aspects of Middle Balsas culture. The third chapter contains the explanation of the methods and sampling strategies I employed in both the field excavations and the laboratory analyses. In the fourth chapter I present the results from the field excavations at La Quesería, Itzímbaro and Mexiquito, including the radiocarbon analyses that provide absolute dates for the stratigraphic levels discovered during excavation. The fifth chapter contains the results from the laboratory analyses, including the formal studies of pottery sherds, the petrography of ancient sherds and modern clay samples, and the mechanical testing of test briquettes. In the sixth chapter I use the petrographic results, the vessel shapes, and the chronological data to clarify the details of Middle Balsas pottery production through time. Finally, in the last chapter I set forth the general conclusions and explain their implications for pottery production studies in Mesoamerica, as well as directions for further research.