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MINERALOGICAL STUDIES ON GUATEMALAN JADE

(With Four Plates)

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INTRODUCTION

Wherever the stone called jade was known to early cultures it was used extensively in the shaping of celts and similar artifacts. In the more advanced civilizations it was also used in objects of ceremony and adornment. The characteristics of the material that probably appealed particularly to the ancient artisan were the toughness of the stone, which permitted him better to exercise his artistic inclinations, and the capacity of the mineral to receive and retain a high and lustrous polish.

The earliest recognized use of jade was by the inhabitants of the neolithic lake dwellings of Europe. Among the forms of jade used as celts during thoses early times are jadeite, nephrite, and chloromelanite, minerals known to occur at a number of localities in that region but sufficiently rare to entail a special knowledge of the stone to enable the artisan to seek it out.

The use of jade in the form of ceremonial celts was widespread in the islands of the Pacific. The occurrence of jade in New Zealand was first reported to the voyager Captain Cook. This form of nephrite jade was called *poonamu* by the Maori aborigines and, in addition to celts, was used by them for ceremonial war clubs and small figurines. Rough nephrite and celts are also known from New Guinea, and celts from New Caledonia, Fiji, and other islands of Oceania.

Jade was widely used in China. The earliest objects are those of the Shang Dynasty (fourteenth to twelfth centuries, B.C.), but the

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[2] Dr. Foshag died in Washington, D. C., on May 21, 1956.

high artistic development of its elaboration presupposes a long period of previous development, probably reaching back into neolithic times. The sources of the earliest jades are unknown but were probably localities in China now forgotten or exhausted. Nephrite jade from Turkestan made its appearance in abundance during the Han Dynasty (206 B.C.-A.D. 220) and continues in use to this day. Jadeite jade from Burma did not come into use in China until the latter part of the eighteenth century.

In America simple nephrite jade celts were found in use by the aborigines of the Amazon River by the explorers of the early sixteenth century, and rough nephrite has been found in Bahía, Brazil. Simple nephrite tools were used by the Indians of the Pacific Northwest and Alaska, who obtained the raw material from the Frasier and other rivers of British Columbia.

Finally there was the widespread and varied use of jade by the indigenous culture of Mesoamerica, in an area extending from Guanajuato, Mexico, to Panamá.

The use of jade by ancient and modern Chinese is widely recognized, owing largely to the fact, perhaps, that this material continues in use to the present day and remains a common article of sale in the stock of many jewelers. As a consequence, people are quite familiar with this material and understand something of its nature and even of the mysticism that surrounds its use. An erroneous notion that jade is known *only* from China is widespread. It is less well known that jade was known and extensively used by the early indigenous cultures of Mesoamerica and that this indigenous American jade is equal in quality and comparable in the artistic merit of workmanship to the finest Asiatic product. The term "jade" is, in fact, of Spanish origin and referred to the American material long before the Asiatic material was known to the Western world.

Our knowledge of Chinese jades is comprehensive, not only for the abundance of material available for study, but also because of the very early accounts of its use and the details of the mysticism associated with it found in early Chinese works. Laufer (1912, p. 8) mentions works in Chinese as early as A.D. 1092. The *Ku yu t'u p'u,* "Illustrated Description of Ancient Jades," was published in 1176, and *Ku yu t'u,* "Ancient Jades Illustrated," by Chu Têh-jun, in A.D. 1341. A huge bibliography has since grown up about this subject, including not only archeological, ethnological, and art studies, but researches in the mineralogy, petrology, and geology of the material.

In contrast to this, the writings relating to American jade are comparatively few. These consist of rather casual mention of jade by the early chroniclers of the Conquest of Mexico (Cortés, Díaz del Castillo, the Anonymous Conqueror, Sahagún, Motilinía, Tezozomoc, and Torquemada) and a few mineralogical studies on archeological jade. The latter have been far too few to fully characterize the mineralogical range of the so-called jades.

Since the earliest known American jades show an extraordinarily high artistic merit, being, in fact, superior in this respect to later American jades, it presupposes a long and ancient artistic development during a civilization or culture of which we are now totally ignorant. When these missing chapters in the history of the indigenous Central American cultures are eventually revealed, it will more than likely be found that the development of the art of jade carving will not only parallel that of China, but be essentially contemporaneous with it. It is already apparent that the artistic zenith in jade carving during the Chou Dynasty of China is contemporaneous with the apogee of hard-stone carving attained by the "Olmecs" about the same time. This does not imply that the two arts are connected in origin and development, but that, by a curious coincidence, the two had their beginnings at about the same time, although differing in design and probably in significance, but comparable in technique and merit.

It is unfortunate that outstanding examples of hard-stone carvings of the early indigenous American cultures do not have a wider representation among the important museums of the world; otherwise their very high artistic merits, gaged even by modern standards, would be widely recognized. The finest of the early examples have a strength and simplicity of line and form not exceeded by any other culture. One need only examine a few of the portrait heads of "Totonacan" or "Olmecan" origin to recognize in them the highest elements of artistic expression. Their simple stylization produces an effect that is, to many students of this type of art, more exciting and exhilarating than the naturalistic forms developed by the Greeks. Like all similar arts, however, the period of early pure art was followed by a period of decadence, in which intricacies and frivolities of design were introduced and naturalistic tendencies became more evident, although some designs of pure line and concept persisted even into Aztec time.

With the final conquest of the indigenous races of Central America by the Spanish and the supplanting of the indigenous cultures and arts by Europeanized forms, the use and knowledge of jade very rapidly disappeared. The sources of supply of jade were soon lost, if they were not already depleted before the arrival of the Spaniards. With this loss of an advanced indigenous art, the folklore associated with it also largely disappeared. So thoroughly was the appreciation of jade eradicated from the indigenous mind that knowledge of the material, its art, and its folklore apparently disappeared from a region where but a a few years previously it was held in the highest esteem —a jewel appropriate to the kings and the gods.

The present study of the mineralogical nature of Mesoamerican jade is based upon the extensive collections of the Instituto de Antropología e Historia de Guatemala. Included in this material are the collections obtained by the Division of Historical Research of the Carnegie Institution of Washington made during their extensive excavations at Kaminaljuyú, Nebaj, San Agustín Acasaguastlán, and Uaxactún. Also included is the Rossbach collection, at Chichicastenango, under the direction of the Instituto. The study was supplemented by an examination of the important Nottebohm and Robles collections.

Mineralogical determinations were made by means of the petrographic microscope using the technique of determining optical properties by the use of immersion liquids. This technique was supplemented by an occasional examination by means of X-ray diffraction patterns. Both of these methods proved to be easy and precise for the identification of the jade minerals.

The program of study was proposed and supervised by Lic. Hugo Cerezo Dardón, Director of the Instituto, whose constant interest and assistance made the study possible. Sr. Antonio Tejeda Fonseca, chief of the section of Museología, similarly cooperated in all ways to expedite the study. Dr. Stephen Borhegyi, then of the staff of the Instituto, permitted me to share his enthusiasm for the treasures of the museum's collections.

Dr. Alfred V. Kidder, chief of the Division of Historical Research of the Carnegie Institution of Washington, was my constant mentor during this study. It would be difficult, at this point, to recognize how much that is contained in this report, and which I now claim for my own, was not actually imbibed from his vast knowledge of Mesoamerican jade. Similarly, Robert Smith and Edward Shook have guided my footsteps along the paths of archeological mineralogy.

I am greatly indebted to Sr. Carl Heinrich Nottebohm, of Guatemala City, and Sr. Vitorines Robles, of Quetzaltenango, for their pleasant reception and their permission to study the interesting jades of their collections.

HISTORY OF THE USE OF JADE

The Spanish explorers first encountered jade during the Crijalva expedition along the coast of Yucatán (1518), as mentioned by Bernal Díaz del Castillo (1632, vol. 1, p. 47). Describing the Indian settlements at the mouth of the Río Grijalva, he wrote:

> Moreover, we wished to give them some of the things we had brought with us. As they understood what was said to them, four of the canoes came near with about thirty Indians in them, and we showed them strings of green beads and small mirrors and blue cut glass beads, and as soon as they saw them they assumed a more friendly manner, for they thought they were *chalchihuites* which they value greatly.

And again (p. 52), in writing of Montezuma's interest in the arrival of the Spaniards, he stated:

> All this news had been brought to him painted on a cloth made of hennequen which is like linen, and as he knew that we were coasting along toward his provinces he sent orders to his governors that if we arrived in their neighborhood with our ships that they should barter gold for our beads, especially the green beads, which are something like their chalchihuites, which they value as highly as emeralds.

An indication of the great value placed by the Aztecs on jade is expressed by Montezuma's words to Cortés upon the presentation of several of these stones in tribute: "I will also give you some very valuable stones, which you will send to him in my name; they are chalchihuites and are not to be given to any one else but only to him, your great Prince. Each stone is worth two loads of gold." (Vol. 2, pp. 136-137.)

There is little specific mention of the use of jade among the Maya in the early Spanish chroniclers, although these people must have known of this material. Some of the regions contiguous to the Mayan area paid tribute in jade to the Aztec conquerors, as, for instance, Kolotlán, Maxtlán, and Tehuantepec (Tezozomoc, 1614, p. 539). In their campaigns of conquest the Aztecs under Montezuma reached as far as Honduras and Nicaragua. In these excursions they passed through Guatemala, collecting tribute; "y pasando adelante, llegaron a la Vera Paz, haciendo estas, y otras cosas semajantes. Y de esta Tierras, les tributaran después Oro, y Plumas Verdes, y otras cosas, que la Tierra daba, y producía, y Piedras, asi de Esmeraldas, como Turquesas, de mucho valor y estima; . . ." (Torquemada, 1613, lib. 2d, cap. 41.)

"Certain precious stones" are mentioned by Gaspar Antonio Chi (1581, p. 231) as being used as money by the natives of Yucatán.

In early colonial times the knowledge of jade persisted as far south as San Salvador, for García de Palacio (1576, *in* Squier, 1860, pp. 51-52) mentions "unos Chalchibites" being found on an island in a lake near Coatán, not far from Santa Ana.

It appears, however, that the Maya made little use of jade at the time of the Spanish Conquest. This apparent lack of appreciation of a stone so highly prized during the classic periods was probably a result of the general decline of the Mayan cultures after the collapse of the Second Empire.

Many of the arts practiced by the Aztecs were acquired by them from the remnants of an earlier culture inhabiting the Valley of Mexico, the culture of a people referred to in the chronicles as Tolteca. The Aztecs attributed to their predecessors many cultural virtues including the development of the lapidary art. Torquemada (1613, lib. la, cap. 14, p. 37) stated, "y dicen de ellos que trageron el Maíz, Algodón, y las demás Semillas, y Legumbres, que ai en esta Tierra; y que fueron grandes Artifices de labrar Oro, y Piedras preciosas, y otras muchos curiosidades." And Sahagún (1530, lib. 10, cap. 29): "Ellos mismos (Las Toltecas) por su gran conocimiento hallaron y descubrieron las piedras preciosas, y las usacron ellos primero, como son las esmeraldas y turquesa fina y piedra azul fina, y todo género de piedras precíosas."

Information on earlier uses of jade depends entirely upon archeological investigations. Such studies have revealed a much wider use of this material. The Maya, during both Early and Middle Classic periods, not only used it freely but were highly skilled in the artistic elaboration of this refractory stone. No finer examples of Mayan-style artistry are known than the magnificant specimens from Nebaj and Kaminaljuyú. Zapotecan and Mixtecan jadework have equally high merit as collections from Monte Albán will show.

Finally, jade has been found in Pre-Classic sites in both Guatemala and Mexico. The discoveries of Shook at Finca Arizona (1945) and of Shook and Kidder at Kaminaljuyú (1952) indicate that the cult of jade was already well established, sources of supply for fine stone readily at hand, and the involved techniques of its lapidary elaboration developed. And if the mysterious "Olmec" culture was contemporary with the "Archaic" or Pre-Classic cultures as discoveries at Tlatilco, Mexico, indicate, the artistic elaboration of jade reached its apogee at a very early period. This Olmec art is so advanced that centuries of development by perhaps still unknown cultures must be postulated to explain its attainment.

Chronological dating, based upon the rate of decay of carbon 14, now indicates that the earliest known use of jade in Mesoamerica dates back to about 1500 B.C. (Libby, 1952, p. 90). Its use by the indigenous cultures of Mesoamerica continued to about A.D. 1600. Monardes in his "Historia Medicinal" (1569) wrote that jades were then no longer readily obtainable, since they had been largely bought up from the caciques and nobles for export to Europe as "piedras de ijada." It then remained in vogue as an ornamental and ceremonial stone among the cultures of Mesoamerica for more than 3,000 years.

NOMENCLATURE

There are no references to jade in mineralogical or pharmacological literature before the discovery of America. Undoubtedly our knowledge of this mineral began with the opening of the New World. The Portuguese explorers of Brazil found a green stone, which they called *amazonstone,* in use among the natives. This term is now restricted to a green variety of microcline, a member of the feldspar group of minerals. Another stone of grayish-green or dark-green color was also encountered, chiefly in the form of celts. This mineral is a variety of actinolite or tremolite, members of the amphibole group of minerals, and is now called *nephrite.*

The Spanish conquerors of Mexico found a precious green stone, somewhat similar in appearance to the two Brazilian stones, being used and highly prized by the Aztecs and other indigenous people of Mesoamerica. The Aztecs called this *chalchihuitl.*

The early Spanish chroniclers frequently referred to the fine green stone from Mexico as emerald. This is not surprising since they knew only the inferior emeralds from Austria and Egypt, which the finest Mesoamerican jade surpassed in color, for the superlatively fine emeralds from Colombia were as yet unknown to them. The very high esteem in which the Aztecs and other indigenous tribes held this stone undoubtedly fostered this error. To the early chroniclers "chalchihuitl" meant "emerald." Thus Torquemada (1613, vol. 2, cap. 45, p. 521), in describing the preparation of the corpse of deceased nobles prior to cremation says, "poníanle en la boca una Piedra fina de esmeralda que los Indios llam chalchihuitl"; Tezozomoc (1598, pp. 375, 434) refers to "esmeraldas y otras muchos generos de piedras chalchihuitl," etc.

The Aztecs, too, had their particular terminology for jade and its varieties. Generically, it was known to them as *chalchihuitl.*

Molina (1585) defines *chalchihuitl* as "esmeralda basta." According to Mena (1927, p. 7) the word "chalchihuitl" is derived from the Nahuatl *xalxihuitl* (*xalli,* sand or jewel; *xihuitl,* herb or herb colored).

Molina also defines *xalli* as a certain arenaceous stone (cierta piedra arenisca), a characterization that might apply to a distinctly granular rock. The term probably means herb-green stone.

Sahagún (1530, lib. 11, cap. 8, p. 3) describes various categories of this stone, as follows:

Quetzalitztli: "son precious de mucho valor, llámanse asi porque *quetzalli* quere decir pluma muy verde, y *etztli* piedra de navaja, la qual es muy pulida y sin mancha ninguna, y estas dos cosas tiene la buena esmeralda que es muy verde, no tiene mancha, y muy pulida y transparente es resplandeciente." It is unlikely that this stone is truly emerald, for no emeralds have yet been found in the Mesoamerican region, either naturally or in archeological sites. The stone referred to is probably the finest quality of emerald-green jade, similar to the Chinese *fei-tsui* or imperial jade. Such fine green and almost transparent jade is found rarely in small objects, usually of Olmec origin. A small pendant of this quality stone is in the Nottebohm collection.

Quetzalchalchihuitl: "es muy verde y tiene manera de chalchihuitl; dícese así porque es muy verde y tiene mancha ninguna, y son transparentes y muy verdes, las que no son tales tienen razas y manchas, y rayas mezceladao!"

Except for the quality of transparency mentioned by Sahagún for quetzalitzli, this description suggests the fine, green, uniformly colored jade that is found among Olmec pieces. No important pieces of this quality stone have, as yet, been encountered in Guatemalan collections.

Chalchihuites: "Son verdes y no transparentes, mezcladas de blanco; úsanlas mucho los principales, trayéndola, en las muñecas, atándolas en hilo y aquello es señal de que as persona noble el que la tral; a los *macequales* no les era lecito traela."

This stone is undoubtedly the common jade of green and white color, such as is found so abundantly at Kaminaljuyú.

Tlilayotic: "Es del género de los chalchihuites, tiene mezcela de negro y verde." Leon (1938, vol. 3, 353) renders this term as malachite, but it is doubtful that this translation is correct. The native lapidary would hardly associate the soft malachite with the hard and tough *chalchihuitl*. Etymologically the word is derived from the Nahuatl *tliltic* (black) and *ayotic* (adjectival form of *ayotl*, gourd), that is to say "dark-green gourd color." This suggests the finer qualities of the jade mineral chloromelanite, as exemplified in the earplug from Uaxactún (3619)[3] of bottle-green color, or some of the forms

[3] These numbers refer to the catalog numbers of the collection of the Instituto de Antropología e Historia de Guatemala.

of diopside-jadeite like the curious serpent-head from Uaxactún (3307) of forest-green color.

Iztacchalchihuitl: "Algunas de estas piedras entre blanco tienan unas vetas verdes o de azul claro, tienen también otros colores entrepuestos con lo blanco, y todas estas piedras tienen virtud contra las enfermedades."

Sahagún (1530, lib. 11, cap. 8, p. 4) classes this stone as jasper. Its etymology (*iztac,* white—*chalchihuitl*) and its description suggest the white forms of jade with little green coloration, such as one finds in the Kaminaljuyú collections. It may also refer to those mixtures of jadeite and albite in which the albite predominates (jadeitic albite).

Xiuhtomoltetl: "Es como chalchihuitl verde y blanco mezclado; es hermosa; Traen esta piedra de hacia *Guatimala* y de *Xoconochoo;* no se hace por acá, hacen de ella cuentas para poner en las muñecas."

Molina defines *xiuhtomolli* as "turquesa, piedra preciosa."

Sahagún (lib. 10, cap. 29, p. 4) also mentions "chalchihuites fingidos" used by the common people to whom the use of jade was denied. This material may have been any one of the lesser stones found in archeological deposits and which show the poorer qualities of workmanship—metadiorite, serpentine, or muscovite.

Monardes (1569) refers to this stone as *piedra de yjada* and appears to have been the first to use this term in print:

> The other stone, which is called piedra de yjada and which appears to be the finest kind of emerald-plasma, tends toward green with a mixture of white, the deepest greens are the best. These are worn in various forms, as the Indians have worn them from ancient times, some like fish, others like bird heads, others like the beak of parrots, also others like round spheres, all perforated for the Indians were accustomed to carry them because of their effect in pains of the side or in the stomach, for which they are supposed to have wonderful effects.

Early writers in Latin (Hernandes, 1615; Clutius, 1627; Bartholinus, 1628; de Laet, 1647, etc.) translated the term "piedra de ijada" into its Latin equivalent "lapis nephriticus." In the French translation of the term it became *pierre l'ejade* or, simply, jade (Buffon, 1749).

To which mineral, the Brazilian or the Mexican, was first ascribed the virtue of alleviating pains in the loins or the kidneys cannot be determined. The Aztecs, as far as the record shows, did not impute any such property to chalchihuitl. A statement by Wittich (1589) that "one can buy such stones for kidney-stones from the Portuguese of Antwerp for sufficient money" suggests that their source was in some Portuguese colony.

Camillus Leonardus (1502), writing immediately before the discovery of Mexico, makes no mention of either name, although he describes about 200 stones used in medicine, including two, *cogolites* and *lyncis,* given as specifics for diseases of the bladder and kidney stones.

In the mid-seventeenth century the nephritic stone of the Orient became known in Europe, while the Mexican stone was soon forgotten, probably because examples of Mexican jade became rare. Within 50 years after the Spanish Conquest of that region Monardes (1569) reported that the stones were rare since they had already been bought up from those caciques and nobles who possessed them. The name "jade" was then transferred from the original Mexican stone to the oriental material to such an extent that some later writers denied the occurrence of true jade in America.

The mineralogical name nephrite was first applied to lapis nephriticus (pierre nephritique) by Werner (1780), but it remained for Damour (1846), investigating the jade of "India," to demonstrate its true mineralogical affinities as a compact variety of the amphibole minerals tremolite and actinolite. In a later study Damour (1863) found that a second mineral, a silicate of aluminum and sodium, was also included in the material called jade. This new mineral species he named *jadeite.* It was not until 1881 that chemical analyses by Damour showed that the Mexican stone was also jadeite. Thus, in a curiously indirect manner, the "piedra de yjada" of the Spaniards became associated with the modern mineralogical species name jadeite.

A list of early Spanish chroniclers and others who referred to jade is given below:

1519	Cortés (inventory): piedras verdes.
1519	Cortés (Merced): chalchihuitl (apocryphal ?).
1530	Pedro Mártir: piedras verdes, esmeralda.
1530	Sahagún: piedra verde preciosa, chalchihuitl, chalchihuites (pl.), quetzalitztli, quetzalchalchihuitl, tlilayotic, esmeralda.
1541	Motolinía: chalchihuitl.
1552	Martín de la Cruz and Juannes Badianus (Badianus MS.): smaragdus, yztacquetzalletztli, quetzalytztli.
1554	López de Cómara: esmeralda.
1565	Monardes: piedra de yjada.
1571	Molina: chalchihuitl.
1576	Garcia de Palacio: chalchibites, chalchivites, piedra de yjada.
1580	Francisco de Casteñada: chalchihuites.
1585	Durán: piedra verde rica.
1590	Acosta: esmeralda, piedra de hyjada.
1598	Tezozomoc: esmeralda, chalchihuitl.
1601–1615	Herrera y Tordesillas: piedra verde rica, chalchibite, chalchihuitl, esmeralda, piedra de yjada.

1609	Boetius de Boodt: osiada, kalsbee, kalssuwyn, siadre.
1612	Vásquez de Espinosa: piedra de ijada.
1613	Torquemada: esmeralda, chalchihuites, piedra verde.
1615	Hernández (Ximenes): lapis nephriticus, ytlibayotea-quetzalitztli.
1632	Díaz del Castillo: chalchihuites.
1644	Boetius de Boodt (French edition): pierre nephritique.
1647	Joannis de Laet: lapido nephritico, iztli-ayotli, quetzal itztli.
1732–1735	Zedler: jade, pierre nephritique, griestein.
1788	Werner: nephrite.
1865	Damour: jadeite.

A mineral closely related to jadeite occupies a mineralogical position intermediate between it and its pyroxene congener, diopside, a silicate of calcium and magnesium. It is appropriately called *diopside-jadeite* to indicate its relationship to these two mineral species. Washington (1922a, pp. 321, 325) proposed the additional names *tuxtlite* and *mayaite* for this mineral, an unjustifiable redundancy of names.

Another closely related mineral has a chemical composition intermediate between jadeite and acmite, a sodium iron silicate, the iron analogue of jadeite, or between jadeite, acmite, and diopside. Because of its characteristic dark-green color it has been named *chloromelanite* (Damour, 1865).

For convenience we may append here the definitions for the mineralogical forms of jade.

Jadeite: A mineral species of the pyroxene group of minerals, essentially a silicate of sodium and aluminum.

Diopside-jadeite: A mineral species of the pyroxene group of minerals, intermediate between jadeite and diopside, essentially a silicate of sodium, calcium, magnesium, and aluminum.

Chloromelanite: A mineral species of the pyroxene group of minerals, intermediate between jadeite and acmite, or jadeite, acmite, and diopside, essentially a silicate of sodium, calcium, magnesium, iron, and aluminum.

Nephrite: A compact variety of the minerals tremolite (calcium magnesium silicate) or actinolite (calcium magnesium iron silicate), mineralogical species of the amphibole group of minerals.

GEOLOGICAL OCCURRENCE

Jadeite has not been found in place in Guatemala [4] or in other parts of Mesoamerica, although there can be no doubt that the archeological material is of an indigenous origin, for it has distinctive characteris-

[4] Since this has been written, fine jadeite of a lichen-green color has been found in situ near Manzanal, Guatemala, by Robert Leslie, Guatemala City.

tics that distinguish it from jades from other sources. Some clue as to its source can be obtained from a mineralogical study of the artifacts and a comparison of this jade with other jadeite occurrences.

In localities where jadeite has been found in situ, it is always closely associated with serpentine rocks and accompanied by the mineral albite in a pure and distinctive form. Thus, at Tawmaw and other nearby localities in Burma, the source of oriental jade, the jadeite forms segregation veins in serpentine. The veins have an outer zone of green chlorite schist and black amphibolite. Immediately adjacent to the jadeite bodies is an enveloping shell of albite that grades successively into jadeitic albite and albitic jadeite to the central mass of relatively pure jadeite (Chibber, 1934, pp. 26-77). Other occurrences of jadeite in Japan (Kawano, 1939; Iwao, 1953) and California (Yoder and Chesterman, 1951) are similarly associated with serpentine and albite. The mineralogical nature of the Guatemala jadeite is exactly similar to the jades of these localities. Particularly significant is the close association of pure albite with the jadeite and the chemical composition of the jadeite, indicating that the geological environment of Guatemala jade is very similar to these other jadeite occurrences. About Tawmaw, and in California, too, glaucophane schist, chlorite schist, and actinolite-zoisite granulite are found in close association with the jadeite-bearing rocks. These same rock types are found among the stone artifacts included in Mesoamerican collections.

Since the characteristic association of jadeite in all the known occurrences is with serpentine bodies intrusive into crystalline rocks, one can reasonably expect that any Mesoamerican occurrence would be similarly situated. Serpentine is an uncommon rock, not widely distributed. Any Mesoamerican area of serpentine, therefore, is a possible source of jadeite.

A small area of serpentine, in part a laminated form called antigorite schist, is known near Tehuitzingo, state of Puebla, Mexico. This occurrence forms a ridge extending from Tlachinola to Tecolutla and Atopoatitlán. The associated crystalline rocks are quartzite, mica schist, and hornblende schist. A cursory exploration of this small area by the writer did not reveal jadeite or any evidence of primitive mining. Some of the serpentine, however, has a distinctive antigoritic character, entirely similar to the antigorite of many Olmec figurines. At the foot of this serpentine ridge is a group of small ancient mounds indicating that the locality was known to an early indigenous population.

A few small occurrences of serpentine are shown near Chimalapa, in southern Chiapas, on Sapper's geological map of Guatemala (Sap-

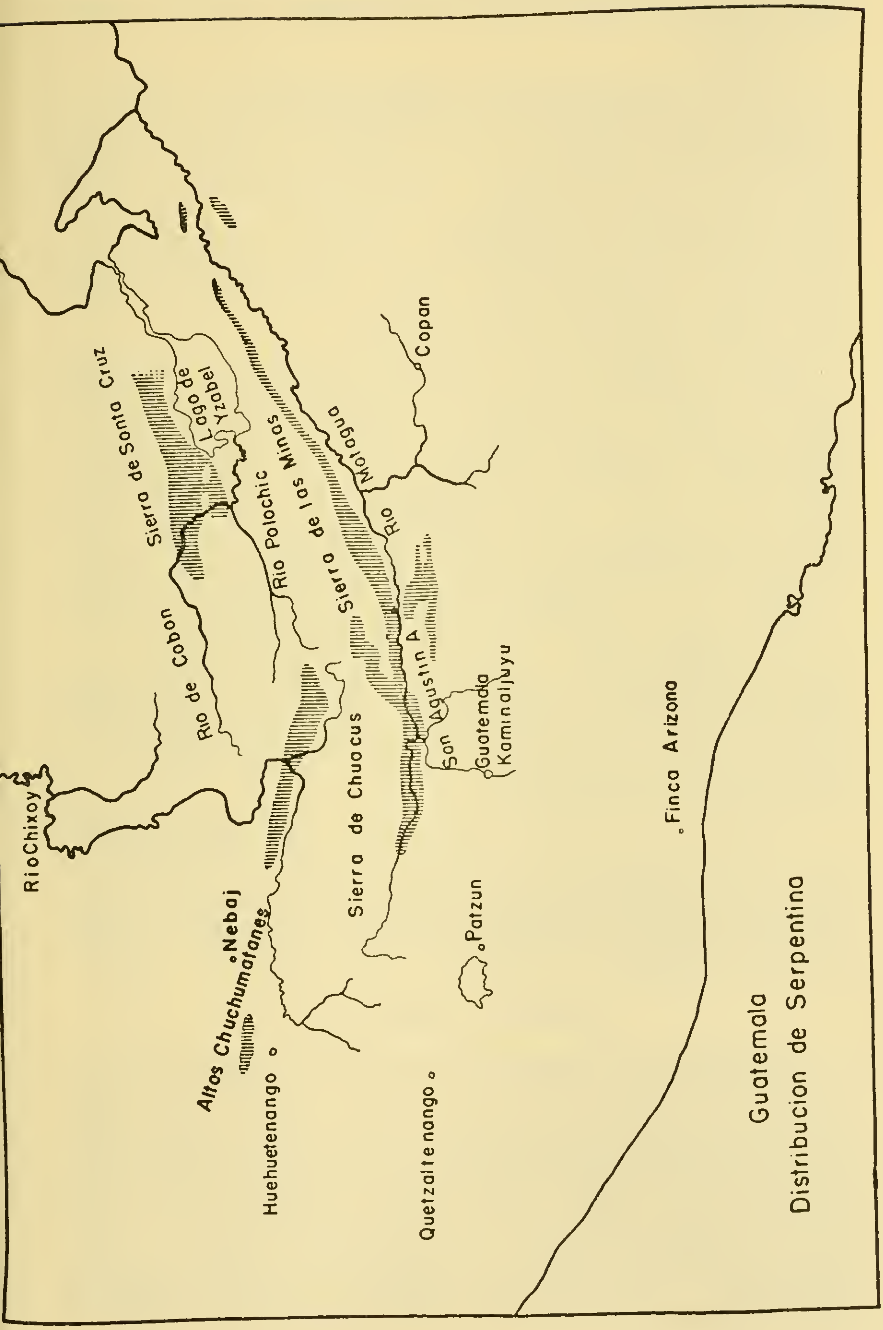

Fig. 1.—Map of Guatemala, showing distribution of serpentine. (After Sapper.)

per, 1937), but nothing is known of the details of the petrology of these masses.

The important occurrences of serpentine are within the confines of Guatemala. A belt of this rock extends along the north slope of the Motagua Valley, including the south slopes of the Sierra de Chuacús and Sierra de las Minas, and a contiguous mass south of the Rio Motagua and east of Sanarate. A second zone lies along the Río Negro, extending from Zacapulas to Santa Rosa, and a third area is found along the western shore of Lake Yzabal, from Estor to Cahabón. These areas are shown on figure 1. There is, finally, a small area exposed on the coast of Guanaja Island.

Pieces of unworked jade recovered by archeological explorations have been in the form of water-worn pebbles. Many of the worked pieces, too, show distinct evidences of having an original pebble or cobble shape. In general, the pieces show only moderate abrasion, indicating that they were not transported far from their original source by the streams. Such unworked pebbles of jade have been recovered in archeological excavations at Kaminaljuyú, San Agustín Acasaguastlán, and Quiriguá. Partially worked pieces of jade or workshop material are not uncommon in Guatemalan sites.

The favorable geology for jade in the Sierra de Chuacús and Sierra de las Minas, as well as the concentration of unworked and partially worked jade materials in sites along and contiguous to the Motagua River Valley, suggests this area as a source of some, if not all, of the Mesoamerican jade.

The beds of the streams draining from these serpentine areas should be carefully examined for pebbles and cobbles of jade. Following such jade pebbles, when encountered, upstream should lead to the actual outcropping of the mineral. Jade pebbles, when wetted, should resemble the polished artifacts in both color and luster.

CHEMICAL PROPERTIES

The mineral jadeite, the principal component of Guatemalan jades, is a sodium aluminum silicate, whose chemical composition is represented by the formula $NaAlSi_2O_6$. As a member of the pyroxene group of minerals the composition of jadeite can be modified by the addition of the molecules of other members of this group, with which the jadeite molecule can mix in any proportion. The commonly associated molecules are those of diopside, $CaMgSi_2O_6$ and acmite $NaFeSi_2O_6$. When mixed with diopside the variety of jadeite is called *diopside-jadeite* or *tuxtlite;* and when mixed with acmite, or diopside and acmite, the variety is called *chloromelanite*. Jadeite and its two varieties, diopside-jadeite and chloromelanite, are found among the jades of Guatemala.

A number of chemical analyses of Mesoamerican jades have been published in scientific literature, but all of them previously reported have been made on samples in which the jadeite was mixed or contaminated with accessory minerals, chiefly albite in varying proportions. The analyses given by Washington (1922a, p. 322) are, for example, mixtures of this kind. Calculations of the composition of the jade mineral contained in such samples can lead to erroneous results or interpretation, particularly where the percentage of the contaminant is high. To best understand the mineralogical nature of jade, and to allow a ready and accurate comparison between specimens, it is desirable to first separate the jade mineral in pure form. This can be accomplished by the use of heavy liquids and electromagnetic separators. The analysis of the pure mineral is more diagnostic and gives a more accurate basis for comparison of the jades with each other. The analyses given below were made upon samples of the purified mineral. Their purity was checked by examining the powder prepared for analysis under the petrographic microscope.

From the material available for analysis, five samples were selected. These cover satisfactorily the range in variation shown by Guatemalan jade. The results of the chemical analyses are given in table 1. For comparison an analysis of Asiatic (Burma) jade and of European chloromelanite are included, as well as the composition of the theoretically pure jadeite and diopside-jadeite (equal proportions of the two molecules).

It is common practice in mineralogy to calculate the chemical composition of a mineral in terms of theoretical pure mineral molecules of the components of a complex series such as pyroxene. These interpretations frequently serve to simplify the comparison of various members of a family. This has been done for the analyses above and the results are shown in table 2.

From a study of the analyses and the molecular composition of the jadeites given in tables 1 and 2 it is apparent that there are three distinct mineralogical varieties included in Guatemalan jades: (1) jadeite with a limited content of diopside (about 10 percent—Nos. 3, 4, 5); (2) diopside-jadeite with a chemical composition almost exactly halfway between its component and members (jadeite 50 percent, diopside 50 percent—Nos. 6, 7), and (3) chloromelanite, or acmitic jadeite (No. 8).

These analyses suggest that there are at least three centers of pro-

TABLE 1.—*Analyses of jadeite*

	1	2	3	4	5	6	7	8	9	10
SiO_2	59.4	59.51	59.35	58.12	58.26	56.28	55.50	57.50	57.39	54.03
TiO_2		0.01	0.18	0.31	0.04	0.03	none		0.44	0.54
Al_2O_3	25.2	24.31	22.18	20.32	22.23	12.18	12.33	12.10	18.93	11.54
Cr_2O_3		0.01		0.01	none	none	none		none	none
Fe_2O_3		0.35	1.15	2.49	0.71	0.85	1.41		4.45	5.62
FeO		0.03	0.32	0.77	0.21	1.28	1.33		0.81	4.09
MnO		0.01	0.01	0.07	0.03	0.13	0.05		0.09	0.05
MgO		0.58	1.77	2.16	2.18	9.02	8.72	9.60	1.92	5.13
CaO		0.77	2.57	3.13	3.72	12.60	12.76	13.40	2.74	11.82
Na_2O	15.4	14.37	12.20	12.43	11.91	6.32	6.94	7.40	12.46	6.81
K_2O		0.02	0.20	0.10	0.40	0.11	0.25		0.11	0.20
H_2O		0.06	0.20	0.16	0.44	1.00	0.30		0.54	0.29
		100.03	100.15	100.07	100.13	99.80	99.59		99.88	100.12
Sp. Gr.			3.356	3.355	3.246	3.196	3.270		3.289	

1. Jadeite; theoretical composition.
2. Jadeite; Burma. E. Zies, analyst, *in* Yoder (1950, p. 229).
3. "Blue-Jade," Mexico. Joseph Fahey, analyst.
4. Jadeite, from large pea-green-colored celt, Guatemala. Joseph Fahey, analyst.
5. Jadeite, from boulder (No. 2078) tomb, Kaminaljuyú, Guatemala. Joseph Fahey, analyst.
6. Diopside-jadeite, rough fragment. Kaminaljuyú, Guatemala. Joseph Fahey, analyst.
7. Diopside-jadeite (tuxtlite), Tuxtla statuette, Mexico. H. S. Washington (1922b, p. 5).
8. Diopside-jadeite; theoretical for $NaAlSi_2O_6$, $CaMgSi_2O_6$.
9. Chloromelanite, from grayish-green celt, Guatemala. Joseph Fahey, analyst.
10. Chloromelanite, Vanelsvdalen, Norway. L. Thomassen, analyst, in Eskola (1921, p. 32).

venience for Guatemalan jade, not necessarily, however, widely separated. The three jadeites Nos. 3, 4, and 5 are remarkably similar to each other in chemical composition, considering their differences in physical appearances, and are, perhaps, derived originally from a circumscribed area. The black jades, or chloromelanite, are a ferrian or acmitic variety of the jadeitic jade and closely related to it. The compositions of the diopside-jadeite (tuxtlite) of the Tuxtla statuette and of the fragment from some workshop material from Kaminaljuyú are so similar that it seems almost certain that their ultimate source was the same.

TABLE 2.—*Molecular composition of jadeites*

1	2	3	4	5	6	7	8	9
Jadeite	96½	89	89	84	45	45	77	38
Acmite		1		2	2	2	12	16
Diopside	1½	10	12	12	49	49	11	42
Others	2		1	2	4	4		

1. Varieties.
2. Jadeite; Burma.
3. Blue jade; Mexico.
4. Jadeite, pea green; Guatemala.
5. Jadeite, Kaminaljuyú boulder; Guatemala.
6. Diopside-jadeite; Kaminaljuyú, Guatemala.
7. Diopside-jadeite; Tuxtla, Mexico.
8. Chloromelanite; Guatemala.
9. Chloromelanite; Norway.

A comparison of these molecular compositions also shows clearly an appreciable difference in composition between the Burmese jadeite (96½ percent jadeite, 1½ percent diopside) and Mesoamerican jadeite (89 percent jadeite, 10-12 percent diopside). It would also be of interest to point out that there is no equivalent of diopside-jadeite among oriental or any other jade, and that the Mesoamerican chloromelanites differ very appreciably from European chloromelanites. The jadeite of recently discovered occurrences in California show, in turn, appreciable differences in chemical composition from the Mesoamerican materials.

OPTICAL PROPERTIES

Even to a person with only a moderate familiarity with the uses of a petrographic microscope, the identification of jade by optical methods is rapid and easy. To one with experience in petrographic techniques a great deal of useful information can be obtained through the use of this instrument. A minute fragment, or a small amount of powder scraped from a broken edge or a rough corner yields enough material for the necessary observations. A rapid and approximate determination of the mean index of refraction (n) of the mineral not only distinguishes jade from other similar materials but also allows the separation of jade into its more specific minerals—jadeite, diopside-jadeite, or chloromelanite.

The mean index of refraction can be determined most easily by comparing the index of refraction of the mineral with that of a liquid of known index. This method is known as the immersion method.[5]

Many minerals (the optically biaxial group) have three distinct indices of refraction, corresponding to the three principle directions in the crystal lattice of the substance. In the jade minerals the lowest index (α) and the highest index (γ) are easily determined. The intermediate index (β) is more difficult to determine. Fortunately no great accuracy in the determination of the indices of refraction is required to distinguish the jade minerals from others with which it is likely to be confused. A determination of the mean index (n) suffices to distinguish jadeite and its congeners from other minerals used in the indigenous cultures of Mesoamerica.

To determine the mean index of a refraction of a mineral it is necessary only to crush a small fragment on a glass microscope slide, place a drop of appropriate liquid on the crushed mineral, cover with a cover glass, and observe the grains under the petrographic microscope, using inclined illumination and a moderate magnification. The simplest device to obtain inclined illumination is to introduce the tip of the finger below the condenser of the microscope. This operation casts a shadow over a part of the visible field of the microscope. If the index of refraction of the immersion liquid matches that of the mineral, one edge of the mineral grain appears red, the opposite edge blue.

The indices of refraction for jadeite of known composition from Mesoamerica and jadeite from Burma introduced for comparison are given in table 3.

The variations in the indices of refraction show that the value increases with an increase in the diopside content of the mineral; that is, in the change from jadeite to diopside-jadeite. Unfortunately this change is rather strongly modified by an increase in the iron content of the mineral, as is usual in all minerals where iron is a variable constituent. This is particularly clearly the case in chloromelanite, where a high acmite content raises the indices of refraction to the highest in the jadeite group.

[5] The procedure is described in Larsen, Esper S., and Berman, Harry, The microscopic determination of the non-opaque minerals. U. S. Geol. Surv. Bull. 848, 1934.

The values show, however, that a jade with a mean index of refraction ranging from 1.66 to 1.67 is jadeite, one of 1.68 is either diopside-jadeite or chloromelanite. These latter two can be easily distinguished, under the petrographic microscope, by their birefringence. Diopside-jadeite shows bright interference colors—yellow, green, red—between crossed nicols, while chloromelanite shows birefringence colors in gray, or even of an anomalous blue to brown color change.

From table 5, which gives the optical properties of other minerals used by the early indigenous artisan, and with which jadeite might be confused, it is apparent that the mean index of refraction of jadeite,

TABLE 3.—*Indices of refraction—jadeite composition*

	η	α	γ	*jd.*	*Ac.*	*Di.*	*Others*	*Name* *
1	1.66	1.654	1.667	96		2	2	Jadeite
2	1.66	1.655	1.673	84	2	12	2	Jadeite
3	1.66	1.658	1.672	89	1	10		Jadeite
4	1.67	1.663	1.679	81	1	12	6	Jadeite
5	1.68	1.666	1.688	44½	2½	47	2	Diopside-jadeite
6	1.68	1.668	1.688	45	2	49	4	Diopside-jadeite
7	1.68	1.674	1.690	77	12	11		Chloromelanite

* jd. = jadeite, Ac. = Acmite, Di. = diopside.
1. Jadeite. Burma.
2. Large block, white, mottled pale green, Type III jade. Analysis No. 2. Kaminaljuyú (No. 2078).
3. "Blue-jade," fragment, greenish gray, Type II jade. Analysis No. 3. Mexico.
4. Large celt, pea green. Analysis No. 1. Guatemala.
5. Tuxtla statuette, pale greenish gray. Proc. U. S. Nat. Mus., vol. 60, No. 2409, p. 4, 1922.
6. Fragment, pea green. Analysis No. 5. Kaminaljuyú (B 158).
7. Celt, grayish green. Analysis No. 4. Quetzaltenango.

diopside-jadeite, and chloromelanite are so appreciably different from other minerals likely to be confused with them that a rapid determination of this property should serve to positively differentiate them from all other minerals. In actual practice it was found that a glance at a few grains immersed in an appropriate liquid served to distinguish jadeite and its congeners from other jadelike minerals. The only caution required is to assure that the minute fragment detached for examination is not a grain of albite, a mineral frequently intermixed with jadeite. In the case of jadeitic albite, where a small amount of jadeite is intermixed with albite, the whole field of the microscope slide should be scanned to find the few scattered grains of jadeite that may be present.

More precise determinations of the indices of refraction would yield information from which a reasonably accurate estimate of the chemical composition of the jadeite could be deduced, but such determinations require a more detailed knowledge of the optical properties of minerals and a more refined technique than an archeologist is likely to acquire. Such determination, however, should eventually prove very useful to the archeologist when correlations of the various types of jadeite are required.

Examination by X-rays.—Wherever the appropriate X-ray equipment is available the identification of jade by this means is definite and rapid. The identification depends upon the characteristic pattern of lines that each crystalline mineral yields by the diffraction of a narrow beam of X-rays upon a photographic film. This method has

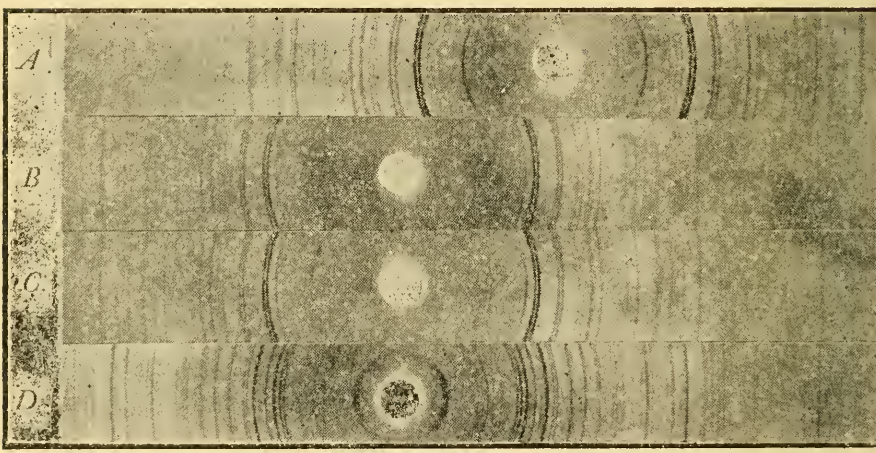

FIG. 2.—X-ray diffraction patterns of jadeite, diopside-jadeite, chloromelanite, and nephrite.

the advantage that a minute amount of powder scraped from a broken edge or from a perforated hole suffices to produce the characteristic pattern of lines of the mineral. The only precaution that must be taken is that the powder be derived from the jadeite itself and not from some extraneous small pocket of albite or other associated mineral. The easiest method for identification is to compare the photographed diffraction lines with a standard pattern of jadeite, diopside-jadeite, or chloromelanite. Closely related minerals, or the congeners of a single mineral series such as the three jade minerals, will have very closely similar patterns of lines, so that they are easily recognizable as related substances. Usually a slight shift in the disposition of the lines is apparent in the patterns of closely related minerals, so that their relationship is easily established and yet their differences are apparent. In figure 2 the X-ray patterns for jadeite, diopside-jadeite, and chloromelanite are shown, together with one of nephrite.

The differences between the jade minerals are readily apparent, while the similarities of the jadeite series are obvious.

JADE TYPES

While the jades of Guatemala show many differing aspects and characteristics, a few distinct types, particularly among the more important objects, are apparent. The finest pieces of raw material were reserved for important objects, but small, stained or otherwise imperfect material was not rejected but found a ready use in lesser objects. Many nondescript and generally unclassifiable varieties are found among the minor objects, such as beads and small crude ornaments.

Seven readily recognizable physical varieties sufficiently characteristic to lend themselves to ready identification were encountered in the collections. In some cases the type was represented by numerous examples, in others specimens were rare but were encountered in collections from widespread localities.

Type I. Jadeite.—One of the most distinctive types, and the variety popularly associated with the term "jade." Color, various shades of apple, grass, or emerald green, frequently mottled white, grayish green, or ash gray. Luster vitreous to pearly. Translucent (rare), semitranslucent to opaque. Fine to medium granular, distinct, although not always apparent on highly polished surfaces. Sometimes a mosaic pattern of grains is distinct.

The usual quality of this type is fine apple green in color, mottled white or gray, and semitranslucent. It is scarcely distinguishable from the green Burmese jade common in our present gem market. The finest quality has a uniform body texture, is translucent and of a rich emerald-green color (Nottebohm collection) and is comparable to the so-called imperial or *Fei-t'sui* jade of China and, like it, is very rare.

Frequently associated minerals with this type of jade are albite in white, sugary-grained nests, and muscovite in rich green plates. The latter frequently appear in the polished surface as apple-green rods.

The abundant jade of Kaminaljuyú, of this type, was used as ornaments, pendants, earplugs, beads, and other forms. Found in Pre-Classic, Early Classic, and Late Classic sites.

Type II. Jadeite.—The so-called "blue" or "Olmec" jade. Color varies from pearl gray through various shades of pallid, greenish gray (mineral gray, gnaphalium gray, tea green, pea green, etc.) to slate, olive, or dark ivy green. Its principal diagnostic characteristics, other than its color, are a textureless body, pearly luster on its polished surface, and chalcedony-like diaphaneity through the edges, or, in the finer quality of the mineral, through the entire stone. A frequent feature is a curdy mottling, or lighter ghostlike patches within the body of the stone. This type of jade, not uncommon in Mexico, Nicaragua, and Costa Rica, has so far seldom been encountered in Guatemala. A small figurine from Kaminaljuyú (3046) is a beautiful example of this stone. Small celts of fine stone are in the Robles and Nottebohm collections. It is a pure jadeite, without accessory minerals. Found in Pre-Classic and Early Classic sites.

Type III. Jadeite.—Color white to pale yellow green, Oural green or light fluorite green. Translucent. Luster vitreous to waxy. Two subtypes may be recognized: (a) granularity distinct to sharp, sometimes in a sharp and distinct pattern of mosaic, coarse angular grains; (b) granularity indistinct on polished surface, the luster on the polished surface waxy. A specimen of rough jade of this type from Manzanal, Motagua Valley, shows the main mass to be of type III (b) with indistinct mosaic grain structure on the polished face, but with well-defined mosaic structure of the weathered surface, and as a zone about the mass, apparently due to exposure and weathering. This type is commonly seen in plaques with Mayan-type faces carved in low relief, particularly from sites in the Quiché. Fine examples are in the Rossbach collection and have been figured by Lothrop (1936, e.g., figs. 58a, 59a, b). Associated minerals are rare and inconspicuous; it sometimes contains a little albite, or sparse spangles of mica. Found in Early Classic and Late Classic sites.

Type IV. Albitic jadeite.—Color dense white or pale ash gray mottled with Hay's green, zinc green, dull yellow green, or sage green. Distinctly granular to structureless on polished surface. Opaque. Luster pearly. Usually as beads (Kaminaljuyú, 3053), sometimes as disks or earplugs (Uaxactún, 4683). Albite usually abundant and intimately mixed with the jadeite. Found in Early Classic and Late Classic sites.

Type V. Diopside-jadeite.—Color, various shades of dark green, Cossack green, Civette green, stone green, leaf green, etc. Structure distinctly granular, prismatic, the prismatic grains usually reticulated, sometimes radiating. Sometimes traversed by fine spider-web cracks (Kaminaljuyú, 3022). Often discolored on the surface to a dark smoky grayish green. Abundant as round or tubular beads and similar minor objects, particularly in collections from the Quiché (Nebaj, 4802). Some small carved pendants are also of this material. Found in Early Classic sites.

Type VI. Jadeite.—Color light gray and green, including tea green, pea green to sage green, and storm gray. Granular, short prismatic to equigranular, distinct. Color and structure uniform. Found as large, well-shaped celts. It contains no apparent accessory minerals.

Type VII. Chloromelanite.—This ferruginous variety of jade is commonly found in Guatemala in the form of celts, although very few examples have been recovered in controlled excavations. Its color is very dark green, dull black to dusky dull green, rarely lighter in color than Russian green. An indistinct mottling is frequently apparent. The dark-green color is often evident only in shallow cracks in the stone. Other dark-colored rocks such as diorite or diabase may be confused with this mineral, but of 269 black celts in the collections of the Instituto de Antropología e Historia de Guatemala examined, 225 of them, or 83 percent, were made of chloromelanite.

Apparently the objects of chloromelanite were of utilitarian nature, celts of various shapes (Kaminaljuyú, 3197; Uaxactún, 483, etc.), chisels, reamers, etc. Some of these tools are shown in plate 2, figure 1. It is interesting to note that chloromelanite celts are still used by Guatemalan potters to polish the pottery before burning. Potters in Chinantla state that they search for these polishing celts in the surrounding hills.

Rarely are objects of high merit carved from this stone. Outstanding exceptions, however, are a "Totonacan" ceremonial celt, carved in the form of a turkey's head (2216), a fine example of artistic carving; an earplug from Uaxactún (3619) in a flawless piece of deepest green material; a monkey figure, simply but effectively carved, with a curious cartouche-like inscription on its base. Several elaborately carved celts in several collections appear to be simple chloromelanite celts with later fraudulent carving.

Chloromelanite has been found in Pre-Classic, Early Classic, and Late Classic sites. Celts in this material are represented in the collections of the Instituto de Antropología e Historia de Guatemala from Chukmuk, Chutex-Tiox, Guatemala (Roosevelt Hospital), Kaminaljuyú, Los Cerritos, Nebaj, San Agustín Acasaguastlán, San Andrés Sajcabajá, Uaxactún, Xa-pom, Zacaleu, and Zacualpa.

It should not be supposed that these jade types are unrelated or from distinct proveniences. Types I and III show frequent gradations into each other (Nebaj, 4753), and less typical examples of types I and V cannot always be readily distinguished. Borderline examples of VI and VII can be found, but are rare.

There are many aspects of jade that cannot be classified, usually among the minor objects. Many of these owe their nondescript character to an impure nature and poor quality of the stone or to surface staining. This classification, however, should prove useful in certain correlations and particularly in their origins when their provenience becomes known.

OTHER MINERALS

Other minerals having some resemblance to jade were used by the indigenous cultures of Guatemala for ornamental objects. The ancient jadeworker must have been aware of the different nature of these stones from true jade because of their differences in workability. Usually these stones were used only in minor objects in Guatemala, such as beads or small simple pendants, and usually, too, the lapidary did not expend his best efforts on these materials. Notable exceptions to this rule are the fine steatite vase from Kaminaljuyú (2718) and the muscovite figure from Uaxactún (921).

Among Mexican cultures, other stones than jade were sometimes used for important pieces. Among these one can mention fine Olmec figurines in serpentine and remarkable Aztec work in diorite, metadiorite, aplite, and rock crystal.

Actinolite.—A calcium, magnesium, iron silicate, a member of the amphibole group of minerals. When actinolite is compactly reticulated and tough it is called nephrite. The mineral found in archeological collections in Guatemala consists of a rather loose aggregate of parallel, splintery grains, is often loosely coherent and does not take a good polish, and should not be classed as nephrite. The color varies from sage green, pea green, andover green to deep grayish olive and is frequently stained. Fracture hackly, cleavage distinct, breaking into needlelike prisms. Index of refraction, 1.635. Specific gravity 2.94. Hardness, variable owing to its loosely coherent character, 3-5. Silky luster on the cleavages of the individual grains. The common type of artifact in actinolite is in the form of "button" beads (Nebaj, 4811, 4813). It has been found as beads at Chalchitán, Paraíso, and Quetzaltenango.

Albite.—This member of the feldspar group of minerals is usually white but in Guatemalan artifacts it is frequently green (tea green, dark bluish glaucous, pea green, andover green) by included jadeite or hornblende. It shows a strong tendency to absorb stain, either burial or smoke, so that it is colored superficially gray, brown, or black. Much of the albite shows a granularity resembling that of jadeite, and it is sometimes difficult to distinguish these two minerals with the unaided eye. If a small fragment is crushed between two slips of glass, albite breaks readily with a characteristic crackle, while jadeite is much tougher and resists crushing.

Albite is a common associate of jadeite. In its natural occurrence one would expect that the outer portions of jadeite bodies would be rimmed with albite and that intermediate zones would consist of varying proportions of albite and jadeite. Many fine jade pieces show nests or veinlets of albite. All degrees of mixture can be found among objects in the collections. One form is essentially albite containing dispersed jadeite. In thin section, under the microscope, the material consists of a mosaic of clear, untwinned albite grains containing scattered, etched, ragged prisms of jadeite ($n = 1.665$). Albite of similar appearance contains needles of green hornblende in place of jadeite rods. For the mixture of jadeite in albite the term *jadeitic albite* is suggested.

The most important object in jadeitic albite is the Miraflores headpiece from Mound E-III-3, Kaminaljuyú (Shook and Kidder, 1952, p. 115, fig. 81). This object, embellished with 31 pieces, shows several types of albite. The pale-green elements are of jadeitic albite, the dark-green pieces hornblendic albite.

Several other objects of jadeitic albite have been found at Kaminaljuyú, a broken celt and a broken pendant. Beads of this material are sometimes encountered in collections. It seems to have been widely used but seldom in important pieces.

It is interesting to note here the occurrence of jadeitic and hornblendic albite with jadeite at Manzanal, discovered by Robert Leslie. In general appearance and microscopic character they are exactly like the jadeitic albites found as artifacts in Guatemalan collections.

Beryl.—The only mention of beryl in use by the early indigenous populations is a reference by Antonio de Herrera (1601-1615):

> Esmaltan, engasten i labren Esmeraldas, Turquesas, i otras Piedras, i agujereaban Perlas; pero no tan bien como en Europa. Labran el Cristal, mui primamente, i hacen viriles grandes i pequeños, dentro de los quales melen Imagenes entalladas de Madera, tan pequeñas, que en el espacio de una figuran un Christo en Cruz, con San Juan, i Nuestra Señora a los lados, i la Magdalena al pie, i en la misma Madera, en la otra parte, otras figuras de manera, que en el viril hace dos haces, que si no se viese cada día, parece cosa imposible.

The Robles collection, Quetzaltenango, contains three rough pieces of beryl (aquamarine) recovered from a tomb near Salcajá. The color ranges from pale aquamarine blue to pale aquamarine green. All three pieces are broken fragments without crystal faces. This is the only reported find of archeological aquamarine in America.

Beryl has a hardness of 7½ to 8, or greater than that of quartz. The primitive lapidary would find it an extremely refractory stone to work, and it could be fashioned only with other beryl or some still harder stone.

Chlorite.—This soft mineral of dark-green color and pronounced scaly texture was not used in objects of artistic quality. It is a soft material, owing to its scaly structure, and is easily whittled into shape. Most of the *camahuiles,* or crudely carved triangular figurines, of the Quiché are of this material. Except for these *camahuiles* only a few crude beads of this mineral were found.

Glaucophane.—This mineral was found but once, as a broken celt without known locality. It is mixed with albite and chlorite. The color is black, slightly mottled pale greenish gray. The mineral is easily identified under the petrographic microscope by its pleochroism, the color changing, upon rotation of the mineral between crossed nicols, from pale buff to pale lavender or blue. The principal significance of this mineral is its geological association with jadeite, both minerals found about the peripheries of serpentine bodies.

Jasper.—Two forms of this aphanitic variety of quartz have been encountered in Guatemalan collections. One is a compact stone of green color, usually more grayish in tone than the common green shades of jade. Among the various shades of color may be mentioned bice green, deep dull yellow green, stone green, and bluish-gray green. An apple-green form, resembling chrysoprase, has been found at Uaxactún (8741). Sahagún (lib. 11, cap. 8) mentions a form of green jasper which was called xoxouhquitecpatl by the Aztecs, "Hay una manera de pedernales verdes que se llaman *xoxouhquitecpatl* (xoxouhqui = green, tecpatl = jasper) que tiran a chalchihuites; los lapidarios los llaman tecélic; porque son blandos de labrar; tienen pintas de azul claro."

A second form is chalcedonic silica impregnated with a green chloritic mineral which gives it a green color. This form is almost always associated with crystalline calcite, which weathers out, leaving the highly polished jasper in high relief in a deeply etched soft brown matrix.

Both the jasper and the jasper-calcite mixture are so distinctive that it is likely that each had a single source of origin.

Jasper is fairly widespread as minor objects but not in abundance. It has been found at Uaxactún, Kaminaljuyú, Nebaj, the Quiché, and about Quetzaltenango. A full-face figure of Quiché type in this stone is in the Nottebohm collection.

Metadiorite.—This material is a rock, rather than a mineral, and petrologically would be termed albite-zoisite-actinolite-muscovite granulite. Since, however, it is a metamorphic rock derived from diorite, a simpler designation, metadiorite, would be appropriate.

This distinctive material has peculiar significance for archeological studies since it is easily recognized and has a wide distribution in Mesoamerica. It is abundant in the form of beads and figurines in the state of Guerrero, Mexico, which seems to be the center of its dispersal, but with what culture it is associated is still unknown. It is perhaps the "chalchihuitl fingida" referred to by Sahagún as a material used by the common people, chalchihuitl being restricted to gods and nobles. This characteristic rock is also encountered in Guatemalan sites but it is rare. All sites at which extensive excavations have been carried out have yielded a few artifacts of this material, from Piedras Negras and Uaxactún in the Petén to the Pacific Coast, including Kaminaljuyú, San Agustín Acasaguastlán, Quetzaltenango, and the Quiché.

The stone is mottled green, with small areas of dark cress-green, meadow-green, or cassock-green color in a white to glaucous-green ground. When freshly broken it has a fine saccharoidal fracture, which sometimes shows the glint of small mica flakes. Its specific gravity varies from 3.07 to 3.20, depending upon the relative proportions of its various constituents. It takes a good polish, but not as well as does jade. It is frequently mistaken for and classified as jade.

In Guatemala metadiorite has been recognized only in the form of beads (Kaminaljuyú, 3072; Nebaj, 4740) or crude earplugs (Kaminaljuyú, 2501, 2502, 2503, 2543, and one in the Nottebohm collection).

Microcline, variety amazonstone.—This is one of the feldspar group of minerals which shows various colors of green or pale blue, including such hues as light blue green, lumiere blue, glaucous green, dark bluish glaucous, or light blue green, also waxy white and ash gray. Its luster is duller than that of jade. Particularly diagnostic of this mineral is a coarse, well-defined cleavage. A cross-hatched pattern of color, the result of an internal twinning of the mineral, is also diagnostic when observed.

Amazonstone is rare but fairly widespread. Its distribution and use suggest that it was prized, but rarely available. Cleavage plates, either in their natural state or polished and used as thin beads or small pendants, have been encountered. Its most common use was as small beads, often in combination with jade beads of similar size and shape (Nebaj, 4769). A crystal of characteristic natural habit was drilled for use as a pendant (Rossbach collection). A small bead of this stone was also found at Piedras Negras. It is widespread but rare in Mexico.

The Aztec *xiuitl,* which Sahagún (lib. 11, cap. 18, p. 279) describes as "turquesas bajas; estas turquesas son hendidas y manchadas, no son recias, algunas de ellas son cuadradas y otras de otras figuras," is almost certainly amazonstone. It was used in mosaics, for which its ready cleavage made it easily adaptable (Monte Albán). Cleavage flakes, perforated for stringing, have been found in Querrero. A group of natural crystals ("son cuadradas," that is, in the form of crystals), perforated for use as a pendant is in the National Museum of Mexico.

Broken natural crystals showing the crystal faces of the prism (110) and of the base (001) and the distinct cleavage are in the Rossbach collection at Chichicastenango.

The decided similarity in color of much of the amazonstone to turquoise would easily lead to a confusion of these two minerals. The irregular coloration, mentioned by Sahagún, is frequently evident in the natural mineral and is commonly observed in the Middle American material. A characteristic feature often observed in the Mesoamerican material is a cross-hatched color marking due to crystallographic twinning.

Muscovite.—This mineral, a silicate of potassium and aluminum, is an important member of the mica group. It is best known in the form of isinglass, a platy transparent mineral that can be readily split into thin plates or sheets. The variety found among the artifacts is a fine-scaly compact form called *sericite* or a fine-scaly green form known as *fuchsite*. These two forms grade into each other.

Sericite is made up of minute to small scales. Often these scales have a more or less parallel orientation so that an artifact of this material will show a silky sheen or pearly luster in certain directions. The scaly nature of the mineral may not be readily apparent on a polished surface, but can be readily recognized on a broken face. The scaly nature of the stone may also manifest itself in scattered small silvery reflections.

The color of sericite varies from light olive gray to pale yellow-green, kildare green, bice green, and similar shades. When the mineral is well compacted, it shows a waxy translucency especially when wetted. It has a hardness of 2½, and cannot be scratched with the fingernail, which will serve to distinguish it from steatite. Density 2.80-2.90. Its mean index of refraction is 1.595.

"Shoe button" beads are commonly of this mineral (Nebaj, 4767, 4783), also round beads, rondels, and simple pendant forms. Figurines or elaborate carvings in this material are seldom encountered. A notable exception is a carved figure from Uaxactún (921) described by Kidder (1947, pp. 47-48). The sides of this figure show the silky sheen of the minute orientated scales of the mineral.

Prehnite.—This mineral is a silicate of lime and alumina, sometimes found among the jades of Mexico, but not yet found in Guatemala. Its general appearance is very similar to jade type III. In color it is pale green. A common diagnostic characteristic is the presence of small metallic flakes of native copper embedded in the mineral. This metal may be oxidized on the surface of the object to green malachite. When this green crust is scraped off the metallic copper below is revealed. Another diagnostic criterion is the frequent presence of small cavities with characteristic crystals of prehnite. The mineral takes and retains a high polish. Beads are common in some parts of Mexico. Fine figurines have also been found. Although found widely distributed as worked objects, its peculiar association with native copper suggests a very limited occurrence, probably in an area of old basaltic rocks.

Serpentine.—This is a common mineral in Guatemala, making up large parts of the Sierra de Las Minas, Chuacús, and Santa Cruz. It is now extensively used in the manufacture of fraudulent antiquities to be sold to tourists at Chichicastenango and other centers. There are three principal varieties: common serpentine, antigorite, and precious serpentine, or williamsite.

Serpentine, common.—Ordinary serpentine is a rather dull, lusterless material usually of various shades of dull gray green. Some of the more pleasing colors are olive green, calla green, cedar green, ivy green, grape green, or lime green, also bone brown to black. It is structureless and shows no granularity. The stone usually takes only a poor polish. Its use is confined largely to beads and to poorly executed figurines, except in Mexico where Olmec figures of high artistic merit are found in this material. A "long-nose" is in the Nottebohm collection. Numerous beads of this mineral, from the Quiché, are in the Rossbach collection, being among the most common materials among the lesser bead forms.

Serpentine, variety antigorite.—This variety of serpentine is characterized by a distinct fissile structure. It can be split easily into thin irregular plates. Usually the objects made of this variety of serpentine are crudely done, except the fine Olmec figurines of Mexico, which are sometimes in this variety of serpentine. Antigorite, similar in all respects to that of many Olmec pieces, is found in abundance at Cerro Palón, near Tehuitzingo, state of Puebla, Mexico. Very few objects of this material have been found in Guatemala.

Three thin plates (5112), part of a large mosaic disk, show the fissile character of antigorite. Their provenience is unknown.

Serpentine, variety williamsite.—The precious variety of serpentine, williamsite, is sometimes difficult to distinguish from jade. It is, however, very rare. A cylinder, 8½ cm. long and 1½ cm. in diameter, of a somewhat grayish oil-green color, translucent and with a waxy luster, is in the Robles collection. The material of this cylinder resembles the Chinese *yu-yen* stone, a variety of serpentine much used to imitate the nephrite jade from Turkestan.

Talc, variety steatite or soapstone.—This stone can be easily identified by its softness and slippery or greasy feel. It is readily scratched by the fingernail. It is never of fine green color but shows dingy shades of gray, greenish gray, buff, brown, or red to black. It does not take a good polish. It is fairly abundant in the Quiché and many poorly worked beads are in the Rossbach collection. A finely worked vase of waxy luster and gray color is from Kaminaljuyú (2718). A few beads are in the collections from Nebaj. A string of beads from Zacualpa (1121) includes many steatite beads. Among the miscellaneous small beads from the Quiché, steatite is the most common material. A few small flares and spindle whorls in this material were found in the Rossbach collection. A string of unusually long, tubular, well-worked beads of this stone are in the Nottebohm collection.

Turquoise.—In contrast to the important use that the Aztecs and other Mexican cultures made of turquoise, especially in the form of elaborate mosaics, the almost complete absence of this mineral in the Guatemalan collections is noteworthy. The only turquoise recovered is in the form of some very small concretionary masses and small mosaic plates of a pale robin's-egg blue and cobalt green to a very pale buff color from Nebaj.

Zoisite.—A calcium aluminum silicate, an important mineral constituent of metadiorite, but also found in pure masses. Three distinct varieties were found in Guatemalan artifacts: (1) A translucent stone closely resembling jadeite of type III but showing little apparent granularity. Its color is usually mottled, Paris green and white, or Paris green and light buff. Under the petrographic microscope it appears black under crossed nicols. Index of refraction 1.725; specific gravity 3.07; hardness 5½-6½. Tough and hard to crush. It was rarely used as small pendants (Nottebohm collection), or as beads. (2) A mottled stone resembling jade of type I, but the color an opaque dense white with included areas of meadow-green pyroxene. Index of refraction 1.725; specific gravity variable. Takes only a fair polish. This form of zoisite is usually found in small irregular beads, apparently small pebbles little modified from their original shape. (3) Dense opaque greenish or bluish mineral resembling a poor grade of amazonstone, frequently containing irregular lenses of smoky-gray albite. Color mytho green to dark bluish glaucous. Index of refraction 1.705, with medium low birefringence; hardness $5\frac{1}{2}$-$6\frac{1}{2}$. Usually in the form of tubular or barrel-shaped beads.

Zoisite has been found in collections from Kaminaljuyú, Patzún, Quiché, and Quetzaltenango.

Artifacts of these minor minerals are found only in small numbers in the tombs rich in fine jade (Kaminaljuyú, Nebaj). At Uaxactún, where jade objects were scarcer and of poorer quality, the proportion of these lesser stones increased. These materials seemed to have been abundantly used in the Quiché. A lot of miscellaneous beads in the Rossbach collection (700 in 9 strands) showed the following percentages: steatite 30, serpentine 29, jade 13, tremolite 10, zoisite 5, muscovite 5, miscellaneous (chlorite, jasper, shell, microcline, unidentified) 4, marble 3, albite 1.

Very probably these minor stones will be found in all important archeological sites where comprehensive collections will be available. Their distribution, as far as they have been collected to date, is as follows:

Actinolite-tremolite: Chalchitán, Nebaj, Paraíso, Quiché, Salcajá.

Albite: Kaminaljuyú, Nebaj, Patzún, Quiché, Quetzaltenango, San Agustín Acasaguastlán, Uaxactún.

Amazonstone: Nebaj, Piedras Negras, Quetzaltenango, Quiché, Paraíso.

Jasper: Kaminaljuyú, Paraíso, Piedras Negras, San Agustín Acasaguastlán.

Metadiorite: Asunción Mitla, Kaminaljuyú, Nebaj, Patzún, Piedras Negras, Quiché, Uaxactún.

Muscovite (including fuchsite): Cadenas, Kaminaljuyú, Nebaj, Paraíso, Patzún, Quetzaltenango, Quiché, San Agustín Acasaguastlán, Zacalena, Zacualpa.

Serpentine: Kaminaljuyú, Nebaj, Patzún, Quetzaltenango, Quiché.

Steatite: Kaminaljuyú, Nebaj, Patzún, Quetzaltenango, Quiché, Zacualpa.

Ziosite: Kaminaljuyú, Quetzaltenango, Quiché, Patzún.

PHYSICAL PROPERTIES OF JADEITE AND JADELIKE MINERALS

The usual method of distinguishing jadeite and differentiating it from minerals of similar appearance is by the determination of certain physical properties, particularly specific gravity and hardness. There are also minor characteristics of color, luster, fracture, and texture that are frequently diagnostic. A brief familiarity with these characteristics will be a great help in recognizing the various minerals, but cannot be used as positive determinative criteria. The physical properties of these minerals are brought together in table 4.

More precise identification of the mineral species can be made by determining the mean index of refraction of the mineral. These are given in table 5.

TABLE 4.—*Identification of jadelike minerals*

Sp. gr.	*Color*	*Grain*	*Hd.*	*Use*	*Mineral*	*Remarks*
2.50-2.60	Microcline to sulfate green; methyl blue	Coarse, well-defined cleavage, sometimes in monoclinic crystals	6-6½	Beads, small ear-plugs, mosaic plates, sometimes unworked crystals used as pendants	Microcline (amazonstone)	Rather rare. Opaque
2.50-2.80	Grayish green to greenish gray, dark green to black, rarely cobalt to zinc green	Massive, without visible grain; laminated	2.5-4	Beads, pendants, figurines, mosaics	Serpentine: luster dull, frequently mottled, common serpentine; laminated, smooth feel, variety antigorite; translucent with fine texture and color, variety precious serpentine	Common. Frequently used in falsification
2.60-2.65	White, ash gray, dark to smoky gray, yellowish oil green, calla green, cedar green	Distinctly granular, sugary texture, brittle	6-6½	Beads common; figurines rare	Albite. (Green colors due to amphibole inclusions, dark gray to brown colors to staining)	Fairly common. More brittle than jade
2.60-2.65	Winter green, stone green	No apparent grain; sometimes veined white, or mixed with calcite	7	Beads, small pendants	Jasper	Rare
2.60-2.90	Oural green to Paris green, Kildare green	Distinctly granular	6-6½	Beads, pendants, figurines	Jadeitic-albite (a mixture of jadeite and albite)	Common

2.70-2.80	Gray, greenish gray, buff brown, red	No apparent grain, smooth feel. Easily scratched by fingernail	1-2	Beads, rarely pendants, vases	Talc (steatite or soapstone)	Fairly common
2.80-2.90	Gendre, Paris, olivene, Niagara or glaucous green; pearl gray. Pearly luster.	Fine to coarse scaly	2½	"Shoe-button" beads, rondels, vases (rare), figurines	Muscovite: fine scaly variety sericite, green variety fuchsite	Fairly common
2.80-3.00	Very pale green to Paris green	Coarse grained, sometimes reticulated. Small included flakes of copper common	6-6½	Beads common; figures rare	Prehnite	Not found in Guatemala
2.90-3.05	Pea green, sage green	Columnar, aggregate of rather loosely coherent needles	3-5	Elliptical beads, button beads	Actinolite	Rare
2.90-3.10	Fluorite green, bice green, Killarney green	Medium to coarse granular, reticulated prismatic	6-7	All forms, including celts	Albitic-jadeite. Mixture of albite and jadeite in about equal proportion	Common

TABLE 4.—*Identification of jadelike minerals*—continued

Sp. gr.	*Color*	*Grain*	*Hd.*	*Use*	*Mineral*	*Remarks*
3.00-3.20	Bice, forest olivene, sage and Niagara green, etain blue, speckled dark green on light ground	Granular	$5\frac{1}{2}$-$6\frac{1}{2}$	Beads, earplugs, figurines, etc.	Metadiorite	Rare in Guatemala, common in Mexico
3.00-3.35	White, oriental gray, shamrock green, grayish olive, fluorite green, white mottled green	Dense, grain not apparent	$5\frac{1}{2}$-$6\frac{1}{2}$	Small beads; small pendants rare	Zoisite: (a) translucent variety clouded green in gray or brownish ground; (b) opaque variety white mottled green	Very rare
3.10-3.35	Oural green to Killarney green, pale fluorite green to Shamrock green, white	Medium to coarse grain, mosaic grain, reticulated prismatic grain	6-$6\frac{1}{2}$	All forms including celts and mosaics	Jadeite (many variations)	Abundant
3.35-3.45	Elm green, Varleys green, blackish green	Granular indistinctly reticulated prismatic, tough	6-$6\frac{1}{2}$	Celts abundant, tools, figures; earplugs rare	Chloromelanite	Abundant

TABLE 5.—*Optical properties of jade and other minerals*

	Name	*n*	*Interference colors*	*Shape of grain*	*Remarks*
1.	Serpentine	1.500	Gray	Hackly irregular	Felted structure pronounced
2.	Microcline	1.525	Gray to yellow	Flat	Flat grains, frequently cloudy
3.	Albite	1.530	Gray to yellow	Conchoidal	Clear glassy grains
4.	Jasper	1.545	Gray to yellow	Irregular	Mosaic of minute grains
5.	Talc (steatite)	1.565	Gray	Irregular	Very soft, soapy feel
6.	Muscovite	1.595-		Flaky	Felted scaly plates
		1.600	Gray	Splintery	A mixture of 3, 6, and 12
7.	Metadiorite		Gray	Splintery	Pleochroism in blue or violet colors strong
8.	Glaucophane	1.630	Gray	Irregular	Bright red, yellow, and green interference colors
9.	Prehnite	1.630	Bright	Splintery needles	
10.	Tremolite	1.635	Bright	and rods	
11.	Jadeite	1.660	Medium	Splintery	Light gray to bright interference colors
12.	Chloromelanite	1.680	Gray	Splintery	Anomalous slate-blue and brown interference colors
13.	Zoisite	1.705	Gray to dark	Angular	Anomalous interference colors
14.	Zoisite	1.725	Black	Conchoidal	Almost isotropic

In the foregoing table the mean index is given as the average value of the lowest index (α) and the highest index (γ). The interference colors are those colors shown by crushed grains when the nicol prisms of the petrographic microscope are in crossed position. These colors are a measure of the birefringence or the difference between the lowest index of refraction (α) and the highest (γ), and have diagnostic value.

LOCAL CHARACTERISTICS

When the probably limited occurrences of jadeite in nature in Mesoamerica and the wide distribution of the material as artifacts over an extensive region are considered, the pronounced local mineralogical character of the jade collections is rather striking. Kidder, Jennings, and Shook (1946, p. 105) have already noted this variation in the kinds of jade from different Guatemalan sites. The collections from Kaminaljuyú, for example, are strikingly different from those of the Quiché. On the other hand, the wide distribution of many of the minor varieties of hard stones, apparently similarly dispersed from a single limited area, is also noteworthy. The unique metadiorite, for instance, so common as artifacts in the state of Guerrero, Mexico, has been found in almost all the Guatemalan collections. At the present time we can only call attention to this erratic distribution of jade, without indicating what vagaries of trade have brought it about.

There is no indication at present of any pronounced temporal variation in the varieties of jade. The principal types of stone have been found in Archaic or Middle Culture collections, through the Classic to materials of the historical epoch. The largest collection of Archaic (Miraflores) jade material is that recovered at Finca Arizona, and described by Shook (1945), and now in the Petrilli collection. This includes both bright-green jade (type I) and "blue" jade (type II). Jade of these two types was also found sparingly at the Archaic site at Tlatilco, Mexico. Collections of jade from Archaic sites, however, are too meager to show the possible range in all its varieties.

The possible exception to the long use of all types of jade may be the so-called "blue jade" (type II) commonly found in Olmec objects, and which may be confined to Archaic and Early Classic cultures, or if used in later cultures, may have been derived, secondarily, from Olmec sources.

Only a few examples of chloromelanite have been recovered in controlled excavations, and so its distribution cannot be satisfactorily delimited, although it appears to be abundant and widespread. This mineral has been found in Archaic or Pre-Classic sites, as well as

Early and Late Classic material, and celts of this material, recovered from archeological sites, are still used by present-day potters in Guatemala.

The minor stones seem to have a time range similar to that of jade, although the collections are too meager to completely determine their distribution. Albite, for instance, was used in Pre-Classic (Miraflores, Kaminaljuyú) Early Classic (Uaxactún) and Late Classic (Nebaj, Uaxactún).

Some of the local characteristics of the hard stones used will be given in the following notes:

Uaxactún.—Uaxactún is situated in the low, densely forested area in northern Petén. Geologically this region is a coastal plain made up of sedimentary rocks of Tertiary age, and not likely to contain deposits of jade. Extensive excavations were undertaken here by the Carnegie Institution of Washington, the results of which have been reported by Riketson and Riketson (1937). The artifacts recovered during these excavations have been described by Kidder (1947).

Considering the number of graves encountered during these excavations and the lavish offerings that they contained, the amount of jade recovered was small, and the quality of the material was poor. That a lack of appreciation of this stone was not the cause of this paucity of material is indicated by the careful re-use of material, such as the adaption of almost insignificant fragments of rich colored mineral, and of sliced beads in mosaics (447, 449). The mural painting uncovered in edifice B-XIII by the Carnegie Institution indicates a simple use of ornaments, earplugs, nose ornaments, necklaces, and belts of beads.

The jades of Uaxactún are a rather heterogenous lot, with no important pieces of fine stone. Most abundant is the pale green jadeite (type III), chiefly in the form of large and small beads, but none of the flat, carved faces commonly observed in such jade from sites in the Quiché.

Diopside-jadeite of various shades of green, such as sage green, dark ivy green and stone green, is second in quantity, and was used chiefly as very thin mosaic plates (461), or large coarse mosaic elements (8807). A curious serpent head in four articulated parts (455) is in this stone. This material was rarely used as beads.

Fine green jade (type I) was highly prized but apparently was rare. Its principal use was in mosaics (447, 449) where it is obviously reused material, salvaged from beads and earplugs, or cabachons cut from small, even tiny fragments.

The mottled ash-gray to dark grayish-green jade (type IV) has its best representation in a perforated disk (445). Several other specimens of similar material are included in the collection.

A rich chloromelanite earplug in very dark-green, finely textured material (469) is an outstanding object in this stone.

Albite is in unusually large proportion in the Uaxactún collection. In one example, a broken earplug of sea-green color (496), the workmanship is unusually good for one of the lesser stones. Jasper is represented by a fine green bead (466), some small chrysoprase green plates (8741), a poor chert pendant, and a calcitic jasper bead. Metadiorite, muscovite, and fuchsite are also represented in the collection.

A large seated idol of compact, finely scaly muscovite, Niagara green in color, is the most important object in this material now known. It has been described by Morley (1946, p. 926) as the largest known jade figure. The scaly texture of the stone is evident on the sides of the head, nose, arm, and thighs.

The predominance of pale green jade (type III), the generally poor quality of the material, and the rather heterogenous character of the jade are suggestive of material from Quiché sites.

Piedras Negras.—A small collection of stones from this site is of minor importance. It contains small objects or beads of jade (types I, III, and V), as well as jasper, metadiorite, and amazonstone.

San Agustín Acasaguastlán.—Numerous archeological sites are situated in the Motagua River Valley. This region is geologically favorable for the occurrence of jadeite since a large part of the north slope of this valley is occupied by serpentine, the important rock associated with jadeite.

The material available for study was the collection made by A. L. Smith during excavations in 1940 and described by Smith and Kidder (1943). The collection contains no outstanding jade object, although it was reported that many burials were encountered in the exploration of the site. The jades showed a wide variety including beads of fine emerald and apple-green color (type I), pale green (type III), and pea green (type V). Other material includes albite, muscovite, fuchsite, green jasper, and calcitic jasper.

The collection includes an unusually large proportion of rough and partially worked material, including a workshop lot (1762) containing 11 roughed-out beads and similar material. There is also included in the collection a stream-worn pebble of muscovite of fine color (1664), a polished earplug core (1763), and two rough partially worked pieces (1674, 1679). This large proportion of workshop material suggests that the San Agustín Acasaguastlán area was a center of a jade-working industry.

Kaminaljuyú.—Rich collections of jade have been recovered in excavations at this site in the outskirts of Guatemala City (Kidder, Jennings, and Shook, 1946; Kidder, 1949). The area lies within the volcanic ash deposits immediately associated with the volcanoes to the west, but crystalline rocks, including serpentine, are exposed only a short distance to the north.

The Kaminaljuyú jade objects are characterized by fine-quality stone and good polish. None of the other Guatemalan collections compares with the Kaminaljuyú material in its large proportion of fine stone. Particularly striking are the large numbers of objects of fine apple-green to emerald-green jadeite (type I). The pale-green jade (type III) is also better colored and more limpid than similar jade from other sites. The single example of "blue" jade (type II), a small figurine pendant (3046), is of unusualy fine quality, rare even among Olmec examples.

Fine apple-green jadeite, similar in appearance to the green jadeite from Burma, makes up one-half of the jades of the collection. The pale-green jade (type III) makes up about 20 percent of the collection. This material is vitreous in luster, and sometimes shows such a coarse and distinct granularity that it has a striking mosaic structure. The jade of type III, common in collections from the Quiché, is similar, but has a waxy rather than vitreous luster and rarely shows the distinct granularity of the Kaminaljuyú stone. This latter variety is lacking in Kaminaljuyú collections.

Jade of type IV, a dense white stone mottled with greenish-gray color is represented by six examples, the most characteristic of which is a string of 56 beads (3053), 53 of which are of this type of jade.

Of the stones other than jade, muscovite—usually the bright green form, fuchsite—is the most abundant. Two rich green vases of scaly fuchsite (4720, 4721) are, perhaps, the finest examples of this material yet found. Metadiorite is represented by six objects, four of which are crude earplugs (2501-3, 2543) of similar material. A bead is exactly similar to the metadiorite so abundant as beads in Guerrero, Mexico. A string of 16 beads (3072) contains a number of structureless zoisite beads, pale apple green in color, streaked with gray granular albite. This material, too, is abundant among beads from Guerrero.

Except for two small beads, steatite is represented only by a beautiful vase of pale greenish-gray color carved with a figure of Tlaloc, and shows traces of cinnabar powder. This is the finest example of Mesoamerican work in steatite known.

Other materials from Kaminaljuyú are serpentine, jasper, and calcite-jasper.

The jades of the Kaminaljuyú collections are distinct from other Guatemalan collections in the large proportion of high quality of both the bright-green and the pale sea-green stone, the important objects in fuchsite and steatite, and the low proportion of the lesser stones. Kidder, Jennings and Shook (1946) have called attention to the similarity of the Kaminaljuyú jade to that of Copán, Petén, and British Honduras, and its distinct quality from the Quiché stone.

Finca Arizona.—A small collection of jade was recovered from burials in mounds at Finca Arizona, on the Pacific coastal plain near San José. This collection, now in the Petrilli collection, was not seen, but the descriptions of the objects by Shook (1945) suggest definitely characteristic material of type I and type II jade. The collection is interesting in that it represents the best collection of Archaic (Miraflores) jade yet found.

Patzún-Godínez (Nottebohm collection).—The Nottebohm collection consists mainly of objects originating in the vicinity of Patzún and Godínez, situated in the volcanic area lying immediately east of Lake Atitlán. The material is undocumented except for its general provenience. No systematic excavations have been undertaken in this region. Some of the specimens in the collection may be from other areas.

The most abundantly represented jade in this collection is the pale-green variety showing little granularity on the polished surface (type III, b). Eighty-five percent of the important objects are in this type of jade. There are 11 fine examples of the Quiché type of carved face, all but 2 of which are in type III jade. The exception is carved from a jade so similar in its peculiarities to a long bead from El Sitio, in the collection of the Instituto de Antropología e Historia de Guatemala that these two pieces may well have been cut from the same rough material. Still another Quiché carved face is in calcite-jasper, the only important object in this material I have encountered. A small carved Quiché face is in porcellanous white and green zoisite.

The gray, even-grained jade (type VI) is well represented in this collection by celts and other objects. A rather crudely executed figure of a fish, 14 x 5½ cm., was obviously adapted from a pebble, with part of the original surface still evident. There is also a large, roughly tabular mass of this type of jade, essentially a rough piece, but partly shaped by pecking and grinding.

Several examples of jade type II are included, the most interesting of which is a flat peltoid pebble shaped into a celt by grinding two flat faces upon it to form the bit (pl. 3, fig. 2, *c*). A small highly polished and well-formed celt 3½ cm. long is greenish gray in color and has a translucent, evenly textured chalcedony-like body.

Chloromelanite is represented by two large celts, one with a face carved on its face (which may be recent work) and two small well-shaped and highly polished celts of tooth size. These two small "celts" and two similar ones in pale ash-gray jade in this collection appear to be unique.

Several specimens in this collection show well the association of two different types or aspects of jade in a single object, indicating that jades of different appearance need not necessarily have distinct provenience. There is, for example, a carving in pale sea-green, waxy jade (type III, b) which grades into compact gray jade (type VI).

In addition to jade, the collection contains objects in serpentine, jasper, zoisite, steatite, albite, muscovite, calcite-jasper, and metadiorite. Of particular interest among these lesser stones is a "long-nose" face in serpentine, similar to one from Nebaj (4742); a second "long-nose" in albite; and a crude earplug in metadiorite exactly similar in workmanship and material to four in the Kaminaljuyú collection (2501-3). Also unusual among collections is a string of 17 very long, well-polished steatite beads.

In stone, the Patzún-Godínez material shows strong affinities to general collections from the Quiché. This is especially true of the relative abundance of the pale sea-green jade (type III). In this respect the collection is similar to the jades recovered at Zacualpa.

Quiché (Rossbach collection).—The Rossbach collection was gathered together by the former parochial priest, Father Rossbach, of Chichecastenango, and is now housed in a small public museum in that town. Except for a small collection from Zacualpa the collection consists of minor objects presented to him by members of his and neighboring parishes. Presumably the specimens are derived largely from sites in the Department of Quiché.

The Quiché material, as illustrated by the material in this collection, shows a wide variety of jade, usually of poor quality, and an abundance of lesser stones. It should be considered, perhaps, not as characteristic of the materials of the area, but of the variety of stones used in minor objects.

The small objects of jade are usually of nondescript quality. Impure and discolored stone is common, and much of it appears altered and stained subsequent to working. Of the distinctive and recognizable types, the pale-green variety (type III) is most abundant. Fine apple- to emerald-green stone is rare. The collection contains many pebble-shaped pieces, crudely carved into full or profile face pendants by straight or curved line incisions, with shallow drilled indentations to represent the eyes. Numerous small earplugs, varying from flat to cupped forms, are largely in jade, but a few in jasper, albite, and fuchsite are also represented.

A great variety of beads are included in the collection. Nine strands, including about 700 individual beads, gave the following percentages of stone varieties: Steaite 31 percent; serpentine 27 percent; jade 14 percent; actinolite 10 percent; zoisite 5 percent; muscovite 2 percent; miscellaneous 7 percent. Among the miscellaneous materials are marble, jasper, calcite-jasper, metadiorite, and amazonstone.

A stone not found in other sites is a granular white marble streaked or mottled grayish green or bright green by fuchsite. Some of the larger objects in this material are undoubtedly fraudulent work but some of the small objects appear authentic.

Within the Department of Quiché are areas of serpentine rocks in which some of the jade from this area may have its origin.

Nebaj.—The Nebaj collection includes more than 100 specimens, many of them of unusual artistic merit. Among the objects are three plaques, collected by A. L. Smith and described by Smith and Kidder (1951; 4733, 4734, and 4735), outstanding objects of Mayan art. The plaque (4733; Smith and Kidder's fig. 59b) is the finest example of Mayan jade carving as yet discovered. Other striking examples of Mayan jadework are a string-cut example of jade (4760; Smith and Kidder's fig. 52f); a jade skull with inset earplugs (4764; Smith and Kidder's fig. 56); a long squarish bead 13 x 3 cm. drilled longitudinally, a remarkable example of drilling (4802; Smith and Kidder's fig. 58c).

While the jade of this collection is in general of high-quality material, few of the larger and important pieces fall within the recognized types, differing in texture and frequently in color from the commoner types I and III. I have pointed out, however, in a description of the jade types, that only a part of the material can be divided into reasonably clear-cut categories, and that much fine jade has individual physical characteristics that separate it from other jade. The variation in the varieties of jade from Nebaj is in contrast with Kaminaljuyú jade where a strong similarity of the material runs through the collection.

Lapidary techniques are quite varied, ranging from the involved techniques of the large plaques to objects ornamented with simple grooved lines and incised circles. The details are adequately described in Smith and Kidder's report.

Minor objects, in addition to those of jade, include a wide variety of materials: serpentine, muscovite, amazonstone, actinolite, steatite, metadiorite, jasper, jasper-calcite, marble, and albite.

The Early Classic material from Nebaj includes jade, types I, III, and IV, muscovite, jasper, amazonstone, rock crystal; Late Classic, jade types I, III, IV, and V, muscovite, jasper, jasper-calcite, amazonstone, albite, metadiorite, and serpentine. Differences in this list are probably due to the larger number of Late than Early Classic pieces.

It is interesting to note that the single "long-nose" figure (4742) is of a light, fine-grained serpentine, as are most of the few other "long-nose" faces known.

Zacualpa.—In the Rossbach collection at Chichicastenango are a number of specimens that can be identified as some of the material described by Lothrop (1936) from Zacualpa. These pieces are carvings characteristic of this area and which Lothrop has classified as Oaxacan, Pipil, and Quiché styles of decoration.

Fine green stones, like the jade of Kaminaljuyú, are absent in this small collection. The pale-green stone without distinct granularity (type III, b), which is not represented in the Kaminaljuyú jades, is the common type.

Zoisite, actinolite, muscovite, and steatite have been found at Zacualpa as beads. A string of beads (1121) contains 34 beads of jadeite, 57 of zoisite, 63 of steatite, and 14 of muscovite.

Quetzaltenango Valley (Robles collection).—Of the major pieces in the Robles collection, most of which came from the vicinity of Quetzaltenango, the jades are, for the most part, types not distinctly classifiable. Of the 99 major pieces, 25 percent belong to the pale-green granular jade (type III, a), 12 percent to the nongranular pale-green jade (type III, b), 6 percent to the gray celt jade (type VI), and 2 percent "blue" jade (type II). Fifty-two percent of the specimens cannot be readily assigned to any type of jade. Also included among the stone objects, chiefly as beads, are steatite (38 pieces), jasper (27), serpentine (23), zoisite (21), albite (9), amazonstone (5), and miscellaneous (13).

Three small broken fragments of aquamarine, pale blue to pale green in color, are the only examples of this mineral found in Guatemalan collections.

In the large percentage of pale-green jade (type III) and the large proportion of miscellaneous stones among the minor objects, this collection has strong similarities to the collections from the Quiché. The number of pieces of celt jade (type VI) suggests the collections from Patzún-Godínez.

Among the noteworthy examples of stone is a cylindrical rod of precious serpentine 8½ cm. long. This serpentine resembles the finest quality of the Chinese "yu yen" stone, a fine green, evenly textured serpentine. A monkey head in black chloromelanite, 4 cm. high and 4½ cm. across, well carved in simple design and with a curious cartouche-like inscription on its base, is one of the few well-carved figures in this type of jade. Among examples in type VI jade are two carved pendants. This type of jade is usually restricted to long, narrow well-made celts. It is probable that these pendants are late fraudulent carvings made from early celts.

Paraíso.—A small collection of 21 pieces came from Paraíso and are in the Robles collection. It contains jades of miscellaneous aspect, including objects in jade types I and III. Also included are beads or minor objects of actinolite, amazonstone, calcite-jasper, and muscovite. This small lot is similar to the materials common in the Quiché material.

Zacaleu.—A small collection of minor objects from Zacaleu consists of small beads of green jade (type I) and pale-green jade (type III). Serpentine, fuchsite, and metadiorite are also included. The few minor specimens in the collection show a strong affinity to the Kaminaljuyú jades in mineral character.

LAPIDARY TECHNIQUES

The Mesoamerican lapidary was an artisan of the highest skill, well acquainted with the virtues of the various stones with which he had to deal. Sahagún (1530, lib. 10, cap. 7) has given us the attributes of the lapidary:

> El lapidario está bien enseñado y examinado en su oficio, buen conocedor de piedras, las cuales para labrarlas quítales la raza, córtales y las junta, o pega con otras sutilmente con el betún, para hacer obra de mosaico.
>
> El buen lapidario artificiosamente labra y inventa labores, sutilmente esculpiendo y puliendo muy bien las piedras con sus instrumentos que usa en su oficio.
>
> El mal lapidario suele ser torpe o bronco, no sabe pulir sin que echar a perder las piedras, labrándolas atolondronadas o desiguales, o quebrándolas, o haciéndolas pedazos.

Seler (1890) has reproduced and translated a portion of Sahagún's original Nahuatl text relating to the art of the lapidary as practiced by the Aztecs at the time of the Spanish conquest, and now preserved in the archives of the Academy of History, Madrid. His rendition is not always clear as to the lapidary techniques employed. I present here a new translation in which the interpretations are more in conformity with lapidary practices and principles. Definitions were taken from the dictionary of Molina (1585) and grammatical construction from the grammars of Molina (1585) and Garibay (1940). The Nahuatl text can be found in Seler, and in Saville (1922).

1. The master lapidary (1)[6] cuts rock crystal, amethyst, *chalchihuitl* [common jade] (2), and quetzalitztli [fine jade] (3) with an abrasive (4) and hard copper.
2. And he scrapes it with a trimmed flint (5).
3. And he perforates it and drills it with a small metal tube (6).
4. Then he carefully smooths it, polishes it, gives it luster (7) and so prepares it.
5. He polishes it (8) in [or with] wood (9) so that it shines.
6. Or the lapidary polishes it with bamboo (9) and so prepares it.
7. And in the same manner the amethyst is prepared.
8. First he breaks it into pieces (10) and trims it with [a] copper [instrument] because he works only the good red material.
9. To prepare it in this manner it is not necessary to break it with [a] copper [instrument].
10. And then he grinds it and smooths it and makes it shine, and polishes it with wood, using the polisher with which they clean and prepare it.
11. And the stone called *eztecpatl* (11) [bloodstone] is very hard and is not easily cut with the abrasive.
12. And it is broken by striking with a stone.
13. Also the flawed stone which is no good is thrown away (12) and is not polished.
14. They select and seek only the good [stone], the good [stone] they polish, the blood-colored [stone] and the well-spotted [stone, i.e., the bloodstone].
15. It is ground then upon a very hard stone (13) that comes from the country of the Matlatzincatl.
16. It is good for this purpose for the bloodstone is as hard as the stone and they grind each other.
17. Then it is smoothed with abrasive and polished with emery (14).
18. And then it is prepared and polished with bamboo.
19. And in this manner they make it sparkle and give it the brilliance of the sun.
20. And that [stone] called vitzitziltecpatl [hummingbird stone, opal] (15) resembles that bird.
21. When finished it is as if painted, white and green and like fire, similar to a star and like a rainbow.

[6] Numbers in parentheses refer to notes following this section.

22. It is ground and polished only with sand.
23. And that [stone] called *xiuhtomolli* [turquoise] is not hard, emery is not used to grind it or to smooth it or to polish it, but worked with bamboo it is made to shine like the sun and to reflect light.
24. And the *teoxihuitl* [precious turquoise] is not very hard.
25. In the same manner it is polished and cleaned with fine sand, and the good [stone] is given the brilliance of the sun with a turquoise polisher.

NOTES

(1) *"Tlateque tulteca," "tlatecque tulteca."* The Aztecs attributed to the Toltecs a mastery of many of the arts. "Y dicen de ellos, que trageron el Maíz, Algodón, y las demás Semillas, Legumbres, que ai en esta Tierra; y que fueron grandes Artifices, de labrar Oro, y Piedras preciosas, y otras muchas curiosidades" (Torquemada, 1613, lib. 1ª, cap. 14.). For this reason master craftsmen or artists were referred to as "tulteca"; "Eran poco Guerreros, y más dados al Arte de Labrar Piedras (que esto quiere decidr Tulteca, como ya hemos dicho), que á otro Arte alguno."

(2) *"Chalchihuitl," "esmeralda baja"* (Molina); "son verdes y no transparentes, mezcladas de blanco" (Sahagún); ordinary jade.

(3) *"Quetzalitztli," "esmeralda"* (Molina); "las esmeraldas que se llamen quetzalitztli" (Sahagún, lib. 11, cap. 8); fine jade.

(4) *"Teoxalli," "teuxalli"* = esmeril (Molina); "los Lapidarios cortaban, y labraban las Piedras preciosas, con cierta arena, que ellos sabían, aunque aora la cortan con Esmeril, y hacían de ellas las figuras, que querian" (Torquemada, 1613, pt. 2D., lib. 13, cap. 34). "El Esmeril se hace en las provincias de *Anáhuac* y *Tototepec,* son unas pedrezuelas pequeñuelas; unas son coloradas y otras, etc., y los lapidarios las muelen, y con la arena limpian y pulen las piedras preciosas. Una manera de margagita que sale del metal, cuando se lavan después de molidos; otra manera de margagita negra que se hace en muchos partes; otra manera de esmeril de pedernales molidos, son unos pedernales o piedras recias que se hacen hacia *Huaxtepec,* en los arroyos, traídas por acá, muélenlas y con aquellas debastan las piedras preciosas, para después purificarlas con el otro esmeril arriba dicho" (Sahagún, libro 11, cap. 10).

(5) *"Tecpatl tlatetzotzontli"* = "pedernal martillado" (Molina); probably a jasper tool fashioned by flaking.

(6) *"Tepuztlacopintli"* = "cañuto de estaño horador piedras preciosas" (Molina, *vide cañuto*). The use of metal tubes for drilling may have been a Spanish introduction. It is unlikely that the Aztecs used the metal tin extensively. "Antes que viniesen los españoles a esta tierra nadie se curaba de la plata, ni del plomo; buscaban solamente el oro en los arroyos . . . ." (Sahagún). Lothrop (1952, p. 14) describes an ornamented disk of tin from the *cenote* of Chichén-Itzá. Holmes (1897) describes the leg bone of a large bird used as a drill in a Mexican travertine ("onyx") object from Chalco, Mexico. Hollow bamboo rods, used in conjunction with an abrasive, would serve well for perforating.

(7) *"Temetzuia."* Molina defines this term as "pegar o soldar con plomo." Seler translates it "to give a matt finish." It probably signifies "to give a leadlike luster." Jade, when well polished, has a pearly luster that may be compared to that of lead. This metal was probably unknown to the Aztecs before the advent of the Spaniards (see note 6).

(8) *"Pepetlaca, tonameyotia, tlanextia, cuecueyoca."* All have the same connotation—to sparkle, to glitter. Their combined use here, and in other passages, is an example of the redundancy of terms commonly used by the Aztecs.

(9) *"Ytech quahuitl," "anozo quetzalótatl."* A hard wood or bamboo, used with an abrasive, is an efficient means of polishing stones, and yields a surface showing the characteristic features of the indigenous polish. "El que vende espejos es de los lapidarios, porque también corta sutilmente piedras del espejo, y las raspa con el instrumento que llaman *teuxalli,* y las asierra con un betún hecho de estiercol de murciélegos, y púlelos en unas cañas macizas que se llaman quetzalótatl" (Sahagún, lib. 10, cap. 24). "El que vende piedras preciosas, o es lapidario, es de esta propiedad, que sabe labrar sutilmente las piedras preciosas y pulirlas para hacer relucir, y algunas las pule con la caña maciza que llam *métatl;* y algunas lima, y algunas adelgaza" (Sahagún, lib. 10, cap. 16).

(10) *"Molena,"* etc., "amollentar la tierra" (Molina). "Cuando los que conocen las piedras hallan alguna piedra preciosa dentro de ella, primeramente la quiebran, y sacan la piedra preciosa de donde está, y luego la debastan, y después la raspan, y después la limpian para que resplandeza, y después la esmeran sobre una caña mazica" (Sahagún, lib. 11, cap. 8).

(11) *"Eztecpatl"*; *eztli* = sangre, *tecpatl* = pedernal; *eztetl* = piedra de sangre (Molina). Varieties of jasper, including bloodstone in the form of pendants or the so-called "pulidores" have been found in the Valley of Mexico and other localities.

(12) *"Itepetlayo"; tepeua* = "echar algo por el suelo" (Molina), that is, to discard. "Las piedras preciosas no se hallan asi como están ahora, en poder de los que las tienen, o que las venden, asi hermosas y pulidas y resplandecientes, más antes se crían en unas piedras toscas que no tienen ninguna apariencia ni hermosura, que están por esos campos, o en los pueblos; las traen de acá, para allá, y otras tales piedras muchas veces tienen dentro de sí piedras preciosas, no grandes sino pequeñitos; algunas las tienen en el medio, otras en las orillas o en las costados" (Sahagún, lib. 11, cap. 8).

(13) *"Ytech tetl cenca tlaquauac"* = "junta a una piedra muy dura." Sahagún (lib. 10, cap. 8) defines *teuxalli* as an instrument for grinding gems, "las raspa con el instrumento que llam teuxalli." Molina calls this stone *teuxalli,* "piedra arenisca como molejón parar amorar herramienta." Two stone objects, one in the collection of the Instituto de Antropología e Historia de Guatemala and one in the Robles collection, are grooved in such a manner as to suggest their use in grinding stones in the manner here indicated. Drucker (1952, p. 146) describes saws of a gritty stone from La Venta.

(14) *"Ezmellil"* = esmeril. The use of esmeril was probably introduced by the Spanish, for no deposits of this nature are known in Mesoamerica. "Los Lapidarios cortaban y labraban las Piedras preciosas, con cierta arena,

que ellos sabían, aunque aora la cortan con Esmeril, y hacien de ellos las figuras que querian (Torquemada, 1613, pt. 2D, lib. 13, cap. 34).

(15) *"Vitzitziltecpatl,"* "hummingbird jasper." Seler apparently confuses this stone with *huitzitziltetl.* Sahagún says of the latter, "hállase esta piedra a las orillas de la mar entre la Arena." Its occurrence suggests the operculum of a conch. The description of *vitzitziltecpatl* suggests precious opal. This stone occurs in several places in Mexico and has been encountered in some archeological sites.

Undoubtedly the lapidary techniques used by the Aztecs, and described by Sahagún were derived from, and were essentially the same as, those used by earlier cultures, but they had undergone some changes with time. Copper instruments were a late introduction, for this metal appears to have been unknown to the earliest cultures. Bird bones or bamboo stems were probably the forerunner of the copper tube. The use of emery was a very late introduction by the Spaniards as noted by Torquemada.

Essentially the lapidary process of the Aztecs was carried out somewhat in the following manner:

The raw material was not always suitable for lapidary use, but frequently was broken, trimmed, and the suitable material selected, the worthless stone being rejected. The selected material was shaped with a trimmed hard stone, or rubbed down into shape upon a selected hard stone suitable for this purpose. It was ground, smoothed, and then polished, using either wood or bamboo and an appropriate abrasive.

In spite of the primitive means to which the lapidary was restricted, he was able to achieve results of the highest merit in the elaboration of such refractory materials as jade and other hard stones. Except for the few details given us by Sahagún and Torquemada, the early techniques can only be inferred from the evidence yielded by worked and partially worked objects found at archeological sites. Collections recovered from the Motagua River Valley and vicinity appear to be exceptionally rich in unworked jade and workshop material, suggesting that this region was an important jadeworking center. Interesting workshop lots have been found at Kaminaljuyú (Kidder, Jennings and Shook, 1946), San Agustín Acasaguastlán (Smith and Kidder, 1943), and Uaxactún (Kidder, 1947).

Workshop lots in the collections of the Instituto de Antropología e Historia de Guatemala are as follows:

Kaminaljuyú (3077): Lot of small pebbles, sawed pieces, and earplug cores. The pebbles are of type III jade, and are angular with worn edges. The earplug cores are almost pure white jadeite. From Tomb I, Mound A.

Kaminaljuyú (B-158): Lot of broken pieces of jade and many small fragments, rough unfinished jade bead disks apparently salvaged from other material, crystal or quartz; rock containing plates of specular hematite, perhaps used as source of hematite for polishing rouge.

Uaxactún (8736): Rough ground pieces of jade (for mosaic); sawed beads (for mosaics like Uaxactún mosaic earplug 3294); broken beads of albite and metadiorite.

San Agustín Acasaguastlán (1762): 6 bead blanks of jade; bead blank of jasper; 3 tubular bead blanks of jade, sawed; rough pebble of jade, partly drilled; small earplug core; small jade tool; 2 roughed-out small jade pendants; 2 finished but crude jasper pendants; miscellaneous roughed-out and broken pieces; rough pebble of jasper; rough piece of chalcedony; small quartz crystal.

In addition to rough mineral pieces, a number of examples of reworked objects or of salvage material were encountered, indicating that jade of fine quality was highly prized and probably rare. Such examples are polished earplug cores (San Agustín Acasaguastlán, 1763), small earplug made from an earplug core (Kaminaljuyú, 2965), sliced jade beads used in mosaics (Uaxactún, 3293, 3294), sawed and broken beads reworked (Uaxactún, 8736).

The jadeworking techniques have been described by Kidder, Jennings, and Shook (1946, pp. 118-124) in detail. A few additional observations will be given here.

The specimens in Guatemalan collections show evidence of pecking, grinding, rasping, sawing, drilling, reaming, polishing, incising, graving, and string sawing.

Abrasives.—According to Torquemada (1613, pt. 2D, lib. 13, cap. 14), the lapidaries "cortaban y labraban las Piedras preciosas, con cietar arena, que ellos sabían." The hardness of jade, 6-7 on the scale of hardness of Mohs, requires an abrasive of equal or greater hardness to cut or polish it. Sahagún (lib. 11, cap. 10) describes the abrasive used by the Aztecs as follows:

> El esmeril se hace en las provincias de Anáhuac y Tototepec, son unas pedrezuelas pequeñuelas; unas son colorados y otras, etc., y los lapidarios las muelen, y con la arena limpian y pulen las piedras preciosas. Una manera de margagita que sale del metal, cuando se lavan después de molidos; otra manera de margagita negra que se hace en muchos partes; otra manera de arena que sale de los espejos cuando se pulen, o se labran, otra manera de esmeril de pedernales molidos, son unos pedernales o piedras recias que se hacen hacia Huaxtepec, en los arroyos, traídas por acá, muélenlas y con aquellas desbasten las piedras preciosas, para después purificarlas con el otro esmeril arriba dicho.

The red stones mentioned in the above list may be garnet (hd. $6\frac{1}{2}$-$7\frac{1}{2}$) or rouge (hd. $6\frac{1}{2}$-7). *Margagita* or pyrite has a hardness of $6\frac{1}{2}$ and was much used for mirrors. *Margagita negra* is probably specular hematite, a material found in tombs at Kaminaljuyú. This material, when finely ground, is the familiar polishing powder known as polishing rouge. Pedernal, or *piedra recia,* is quartz (hd. 7) or any hard stone which, when crushed into a fine sand or powder, would serve its purpose.

Garnet is widely used as an abrasive today, its sharp lune-shaped fracture making it particularly useful for the dressing of iron and steel objects. Hematite as rouge is also widely used as a polishing medium in present-day lapidary practice. Flint, as ground flint, tripoli, or other forms of fine-grained silica, are also useful in modern lapidary techniques. Esmeril, as such, was a Spanish introduction into Mesoamerican lapidary techniques, as stated by Torquemada.

Crushed jade itself can also be used as a cutting, grinding, and polishing medium. In this connection it is interesting to note the find of crushed jadeite in the jadeworkers' tomb at Kaminaljuyú described by Kidder, Jennings, and Shook (1946, pp. 85, 120, fig. 3a). This material, probably contained in a small sack or pouch, consists of crushed angular jadeite fragments of medium to coarse size (maximum grain size, 3 mm.) mixed with specular hematite, feldspar, quartz, augite, hornblende, olivene, muscovite, biotite, magnetite, a few grains of cinnabar, rock fragments of andesite, and mica schist. Of these minerals the feldspar, quartz, augite, hornblende, olivene, biotite, and magnetite are normal constituents of the volcanic ash that covers the region about Kaminaljuyú. The clean nature of this sand suggests that it was derived from the bottom of arroyos, or was washed free of accompanying clay and slimes. The jadeite, specular hematite, muscovite, and mica schist are foreign to the area. Cinnabar is also foreign to this area, but is probably an accidental contaminant, as it has no lapidary value, although it was frequently used as a pigment for painting jade objects. In the workshop material (B-158) broken fragments of jade were found, as well as a rock fragment containing specular hematite. Material such as this sand could serve satisfactorily for sawing, grinding, and polishing jade when used with a metal or wooden instrument.

Abrasives harder than jadeite or quartz sand, such as corundum or emery, were probably unknown to the Mesoamerican lapidaries. Beryl (hardness 8) is a useful abrasive and was known to the indigenous inhabitants of the region, but it is a rare mineral and very local in its distribution. The small fragments of this mineral in the Robles collection show no evidence of having been used either as a tool or as an abrasive.

Pecking.—The technique of pecking with a round or blunt stone tool was commonly used in the elaboration of round beads and celts. The rounded balls of jade from which earplug pairs were cut were shaped by pecking. Unfinished examples of such objects often show the percussion marks of the pecking instrument, as, for example, some of the bead blanks shown in plate 2, figure 2, and the earplug blank in plate 4, figure 1, *b*. Many celts show the percussion scars on the poll and sides, and light percussion "ghosts" below the polish of the face (pl. 3, fig. 2, *b*). This operation seems to be confined to the lesser qualities of jade and was not observed in the fine green-colored stone, where the percussion "ghosts" would detract from the beauty of the material.

A number of chloromelanite tools, some of them broken, show rounded and scarred surfaces, suggesting their use as percussion instruments. The durability and toughness of chloromelanite makes it a suitable stone for this purpose.

Pecking was also used for delineating designs upon polished surfaces, as on thick mosaic plaques. Such designs were sometimes produced by pecking since they show a rough pitting and a lack of sharpness at the edges. The features of the lines suggest, however, that the percussion was accomplished by means of a pointed instrument carefully placed and then struck with another object. In this manner better control of the design could be obtained than by simple pecking.

Grinding.—Grinding as a means of pre-forming an object in jade would, with the means available to the ancient lapidary, be a tedious and laborious process. While some objects show evidences of grinding, this technique does not appear to have been widely used. Pecking and sawing appear to have served the lapidary better. It was used, however, on rough stone where the piece already had an acceptable shape and needed only slight modification. In the process of grinding, the jade object was probably rubbed upon the stone grinder. Two flat stones with wide grooves, one in the collection of the Instituto de Antropología, the other in the Robles collection, were perhaps used as grinding stones.

Several objects in Guatemalan collections show distinct evidence of this technique. A celt in the Nottebohm collection was obviously ground from an appropriately shaped pebble (pl. 3, fig. 2, *c*). Another specimen in this collection is a large, essentially rough mass of jade (pl. 3, fig. 2, *a*), but shows abundant traces of pecking and grinding. Coarse mosaic plates were usually shaped by grinding and modified by rasping. Blanks for tubular beads were often shaped by grinding, after sawing.

Striations on the face of flat earplugs and the general flatness of the flares indicate that grinding was used in the shaping of the flare. Grinding was also used to square off the stem and to smooth the edges of the flare. Striations also suggest that the flaring type of earplug was fashioned and smoothed by grinding, after the preliminary sawing to shape, to impart a smooth surface preparatory to polishing.

Large, heavy beads were frequently ground at each end to eliminate irregular or ragged edges.

Undoubtedly, grinding was used extensively where minor modifications of shape were required in the elaboration of the design.

Rasping.—The technique of rasping is not greatly different from that of grinding, although a different tool was probably required. In the operation of rasping a comparatively narrow filelike tool was applied to the stone, the rasped surface yielding a number of small striated facets, while in grinding the object was frequently applied to the stone, yielding a single broad surface. The only objects in which rasping appears to have been used extensively are small mosaic plates, the purpose of the operation being to reduce the mosaic wafers to an appropriate thickness. The striated character of the rasped surface indicates that the tool offered a medium-grained, unpolished surface of hard stone. Such a tool may have been similar to the "texalli" of the Aztecs, defined by Molina as "piedra arenisca como molejón para amorar herramienta."

Sawing.—This technique was commonly used whereby larger pieces of jade were cut into slabs or thin wafers for further elaboration. Many of the larger plaques show the saw cuts on the back of the object. The sawing was usually accomplished first from one side, then the other, and the slab then broken, leaving a rough septum between the two cuts. In very thin waferlike sections, as for mosaic plates, the cut may continue through the stone to obviate possible breakage. The large jade boulder from Kaminaljuyú shows a number of broad saw cuts where pieces were removed for working. By applying a straightedge to some of these cuts they were found to be entirely straight or very slightly concave. Remnants of the cut groove indicate that the cutting edge of the instrument was hardly more than a millimeter thick. The three fine Nebaj plaques (4733, 4734, 4735) showed the original sawed surface on the back and the cuts are likewise entirely straight. A metal tool, as of copper, used in conjunction with crushed jade or sand would serve admirably for this purpose. Trials with the thin axlike copper objects, sometimes identified as money, were found to be efficient saws when used with abrasive, but these celtlike objects do not show the wear that such a use would undoubtedly induce. Lacking such a metal tool, a hard wood or bamboo saw would serve. Convex cuts, such as would result in string or cord sawing, were not encountered.

Sawing in this manner was a rather ancient accomplishment, for it is shown by some of the mosaic pieces from a Miraflores headdress from Kaminaljuyú.

In addition to the use in the sawing of plaques, this technique was widely used in the pre-forming of long tubular beads. Several bead blanks roughed out by sawing were encountered in the collections (pl. 3, fig. 1), and such beads as the 12-cm.-long one from Nebaj were pre-formed in this manner.

Sawing was an essential process in pre-forming both the flat and flaring types of earplugs (pl. 4, fig. 1, *b*). Sawed earplug blanks of both types are known. The cutting groove indicates a cutting edge of the saw about a millimeter in thickness.

Mosaic plates were also sawed in a similar manner. Some of these jade mosaic plates are only ½ mm. or less in thickness. A small plate from Kaminaljuyú 1 x ½ x .05 cm., consisting of a single grain of fine green jadeite and with marked cleavage cracks, shows distinct marks of sawing, and demonstrates the precision and care with which fine-quality material was treated.

Although sawing was frequently employed in the elaboration of fine ceremonial celts in "blue" jadeite in Olmec examples, this technique does not appear to have been used in the more utilitarian celts of the Guatemalan area.

Sawing techniques were also used in some of the decorative elements of figurines and pendants. Earplug flares are sometimes notched by sawing (Nebaj).

Thin mosaic plates from Uaxactún were divided by sawing. The cut indicates a sawing edge of about 1½ mm. in thickness.

Drilling.—Amazing examples of drilling are sometimes found in Mesoamerican artifacts, and a wide variety of drills were used. Small or thin objects were usually single-drilled, that is, from one side only, to yield a small conical hole. Larger objects were double-drilled, first from one side, then the other, to yield a biconical hole. Large objects were similarly drilled, the meeting of the two holes, unless reamed out, shows a thin broken septum.

Both solid and tubular drills were used. The solid drills were used chiefly for drilling beads and for the small cup-shaped depressions frequently used as elements of design, as in the corners of mouths of faces, and in headdress design (pl. 4, fig. 2, *b*). Such drills may have been jade-tipped rods, the four figures shown (pl. 1, fig. 1, *b, c, e, f*) being, perhaps, such jade points. Large blunt drills were used in larger cup-shaped depressions and in rings or ringlike beads. By using jade drill points no abrasive is required, sufficient dust being generated by the friction of the two stones to act as a satisfactory abrasive.

Some remarkable examples of drilling are found in the Guatemalan collections. The fine Nebaj plaque (4733) was drilled transversely for suspension for its entire width of 14 cm. A long bead from Nebaj was drilled for a length of 12 cm. Both objects were double-drilled, first from one side, then the other, to meet so perfectly in the middle of the stone that the join is hardly perceptible.

Hollow drills were widely used (pl. 4, fig. 1, *b, c*). The resultant core could be used for small objects. These hollow drills sometimes had a diameter of 3 cm. or more. Drill grooves in the cores indicate that the cutting edge of the tool had a thickness of about a millimeter. These hollow drills were probably of reed or bamboo (the Aztec *quetzalotatl*) or bird bones (Holmes, 1897, pp. 304-309). Sahagún mentions tubes of metal (*teputztlacopintli*), used for drilling precious stones, but these are probably a late introduction into the lapidary techniques, perhaps by the Spaniards.

In order that such drills should be effective, an abrasive must be applied to the cutting edge. For soft stone any hard-rock powder would be suitable, but for jade some hard mineral such as crushed jadeite or fine quartz sand would serve the purpose.

Large hollow drills were used principally in the elaboration of earplugs. The inner diameter of the stem was almost always prepared in this manner. In the earplug blank with its accompanying core (3068, pl. 4, fig. 1, *b*) the stone was drilled from the sawed side to the bottom of the hemispherical mass and the core tapped free. The core is slightly tapering, $1\frac{3}{4}$ cm. at the top, $2\frac{3}{8}$ cm. at the bottom. A remnant of the cutting groove at the bottom of the core indicates a cutting edge of the drill $1\frac{3}{8}$ mm. wide. The drilled hole is $2\frac{1}{4}$ cm. wide at the top, and 2 cm. wide at the bottom. An earplug from Nebaj (4782) shows further evidences of the use of large drills. The central hole was drilled first from the flat face of the earplug blank, then from the rear. A circular septum indicates where the two drill holes met. A second, and larger drill, $1\frac{3}{4}$ cm. inside diameter, was now used to drill the cylindrical stem to a length of $1\frac{1}{2}$ cm. A circular groove at the base of the stem indicates that this drill had a cutting edge 1 mm. in thickness. This earplug was completed by sawing the back of the flare by horizontal cuts, polishing the stone and reaming the throat.

Certain elaborately pierced designs may have been produced by drilling a series of contiguous holes, which could then be joined by grinding to form a flowing design. Such a technique was used by the Olmec lapidaries.

A few measurements of the dimensions of hollow drills were made upon the circular elements of designs and show a range from an inside diameter of 1 to 6.5 mm. and with a thickness of the drill from $\frac{3}{8}$ to $1\frac{1}{2}$ mm. The ratio of interior diameter to thickness of the drill walls is usually about 5-6: 1, but occasionally one varied widely from this ratio.

A drilling technique appears to have been used to produce shallow cup-shaped earplug flares (Nebaj, Uaxactún). The instrument used appears to have been a thick, blunt drill producing a shallow depression, which could then be polished. In the case of the Nebaj flares the diameter of the tool was 20 mm., and in the broken Uaxactún flare 8 mm. This technique could be classified as grinding, except that a rotating tool was probably used.

Conically pointed drills were also used to perforate beads or to drill holes in pendants for suspension, but to judge by the septa remaining in biconically drilled holes, the blunt drill was preferred.

Beads were sometimes first drilled on both sides with a blunt, solid drill to form two cup-shaped depressions, and the perforation then completed by a smaller, more cylindrical drill to yield a small hole.

Reaming.—Drilled holes were frequently smoothed by reaming. This is particularly common in the stem and throat of earplugs (Kidder, Jennings, and Shook, 1946, fig. 145, *a, b*). The flaring throat of some earplugs may well have been produced by reaming. The neatly beveled edge of the horizontally flared earplugs was certainly produced in this manner. Large beads were sometimes reamed after drilling to yield a widely tapering hole.

Several stone tools in chloromelanite, appropriate for reaming, were encountered in Guatemalan collections. Plate 1, figure 2, *e,* is almost certainly a reamer and fits well the reamed throat of some of the earplugs. Plate 1, figure 2, *a,* would also serve such a use, while figure 2, *c,* seems to be a reaming tool of general utility. It should be noted that reamers such as those illustrated are also suitable, through shape and hardness, for use as polishers.

Polishing.—The polished surfaces of Mesoamerican jades show characteristics different from those on modern lap-polished surfaces.

Under the microscope or a hand lens one can see that the eminences are polished but that the intergrain depressions are rough. The reflections from a polished surface are a pattern of brilliant spots separated by an irregular anastamosing network of dull areas. Such a surface would result from fine grinding with a hard tool. In modern polishing with a felt lap and an appropriate polishing powder, the entire surface is polished, since the soft felt penetrates the intergrain fissures to produce a smoothed and polished valley. The result is a completely polished surface with a microscopically undulating surface. In addition, the "pull" of a felt lap leaves a series of minute orientated ridges not shown by fine grinding or polishing with a hard surface. The distinctive surface features should serve to distinguish authentic Mesoamerican polishing from modern lap polishing.

Probably the early jade polishing was accomplished with jade polishing tools. Experiments by the writer have shown that small jade celts, such as are shown in plate 1, figure 2, *d, f,* are efficacious in polishing a properly prepared jade surface. The resultant polish shows the same characters as the authentic Mesoamerican polish. There is no evidence that a polishing powder was used other than the dust developed by the abrasion of the celt upon the jade surface being polished.

A similar polished surface can be obtained easily and quickly by polishing a smoothly ground surface with the outer surface of a bamboo rod, using an appropriate abrasive. A hard wood surface would also serve this purpose but is less efficacious than bamboo. Polished surfaces on obsidian or rock crystal produced in this manner show characters different from the polished surface of jade, because of their lack of granularity.

Incising.—A simple pattern of fine incised lines, without further modification, is sometimes found upon unimportant objects. Such incising was perhaps accomplished by edged jade tools like that shown in plate 1, figure 1, *d,* or fine jade points.

Another manner of incising was by means of tubular drills. Circular elements, as for eyes, and lune-shaped curves, made by holding the drill at an angle, as for the nose or mouth, are frequent in the Mayan heads of the Quiché region. Other decorative elements, such as representation of earplugs, circles on cheeks or foreheads of figures, or simply random circles on flat surfaces are also encountered. Deeper and more intricate graving forms the basic technique in the more elaborate carvings. This was done with abrasive tools to form a deep groove. Frequently the eyes, nose, and mouth of faces are produced by this means, as well as head bands and the delineation of the headdress.

Such incising can be accomplished with sharp-bitted celts of jadeite or chloromelanite. Finer detail can be performed with finely pointed jadeite rods, such as one from Mexico in the collections of the U. S. National Museum. Large celts, such as the one shown on plate 1, figure 2, *f*, would serve for roughing out the larger elements of some designs.

String sawing.—A specimen from Nebaj (4760) representing a turkey (?) shows large commalike elements in the design which may have been produced by string sawing. The design begins at a drilled hole and continues in a tapering commalike pattern. The cut has been polished, thereby obliterating any marks of the tool used. A flat bead from Kaminaljuyú representing a parrot's head in profile shows a single such element to delineate the bird's beak. In a small serpent figure, also from Kaminaljuyú, the long slitlike mouth is probably by the same technique. Certain straight elements, as the mouth or headband lines in effigies, may have been made by string sawing, but there are no clearly diagnostic criteria to prove this.

Superb examples of string sawing in jade, and similar to the specimen from Nebaj, from Costa Rica, are in the Bliss collection, National Gallery of Art, Washington, D. C.

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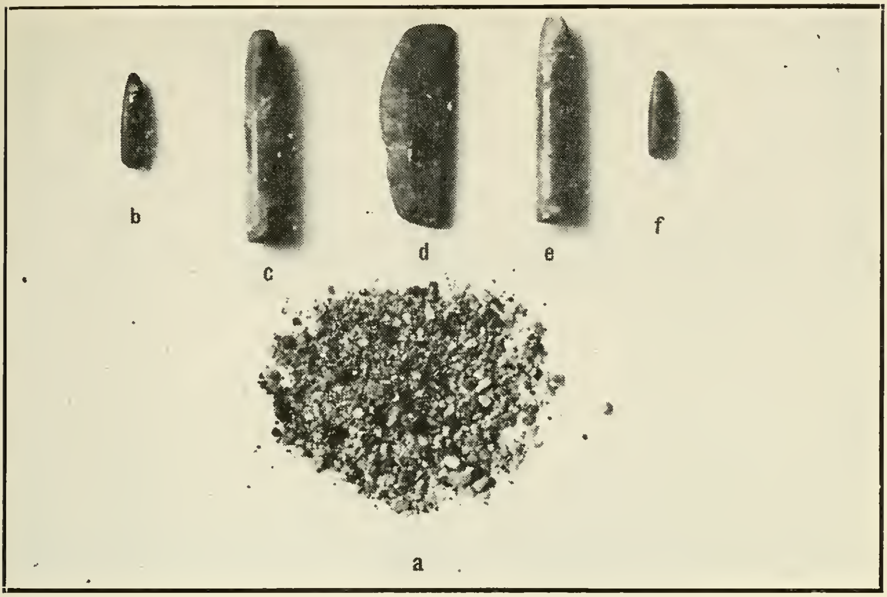
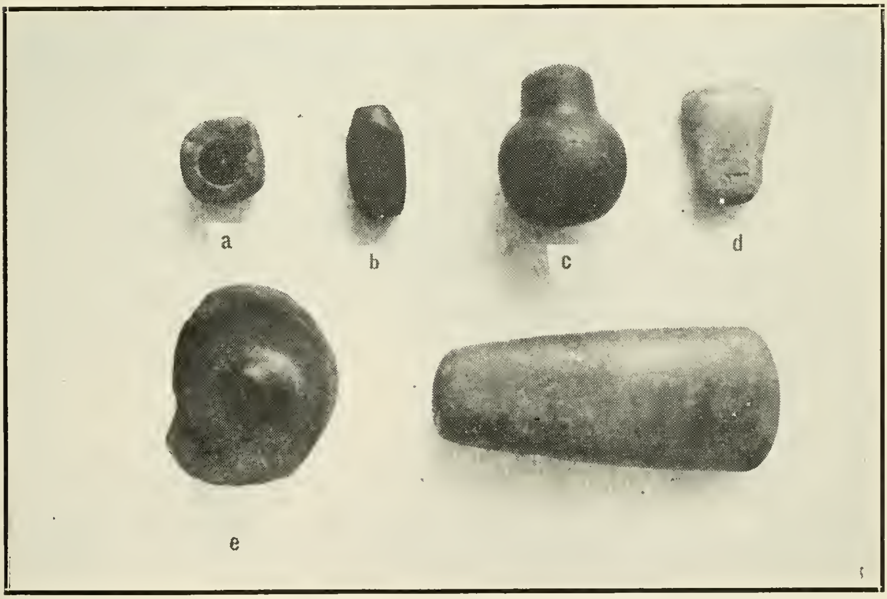
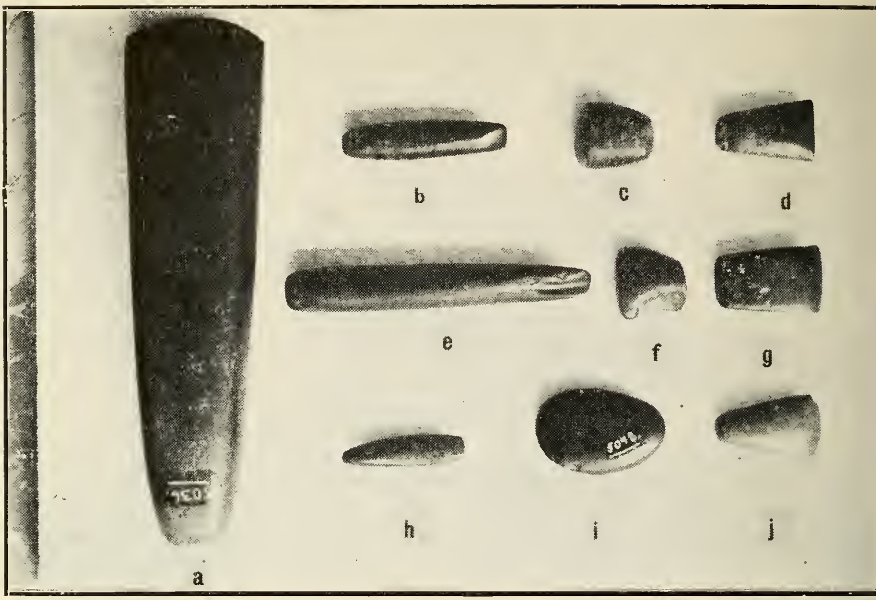
PLATES



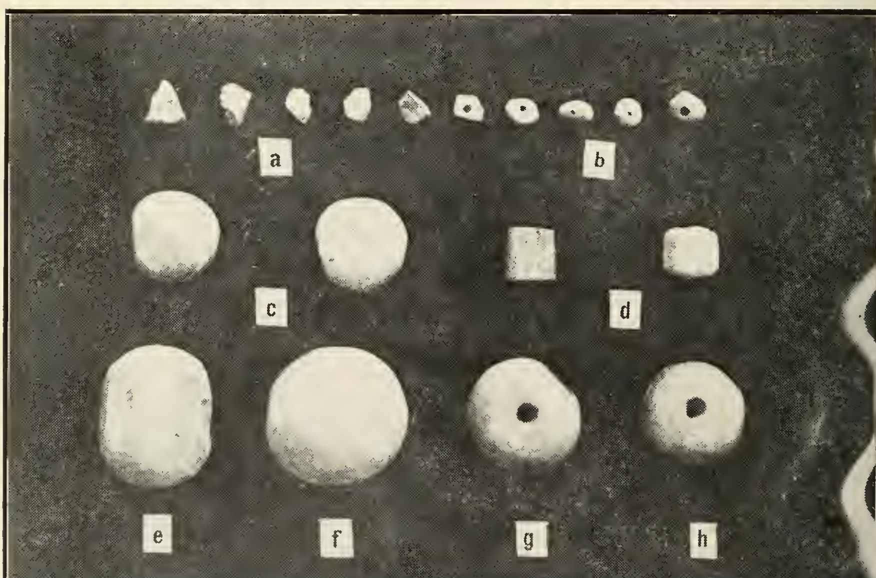
1. Jade-working tools. *a,* Crushed jadeite abrasive, Kaminaljuyú; *b, f,* jadeite drill points(?), San Agustín Acasaguastlán; *c, e,* jadeite drills(?); *d,* jadeite graver(?), San Agustín Acasaguastlán (natural size).



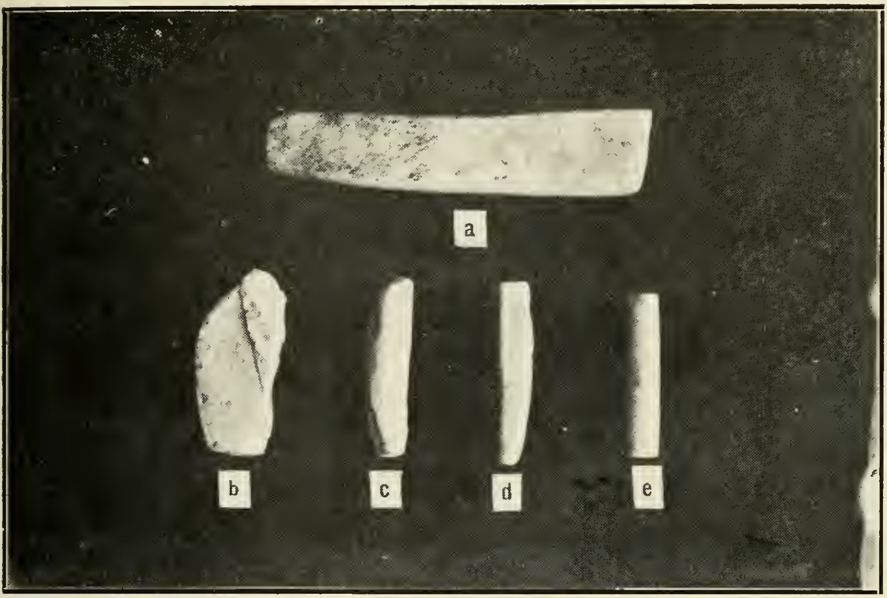
2. Jade-working tools. *a,* Jade, drilled hole with central pointed core, Nottebohm collection; *b,* chloromelanite reamer, Nottebohm collection; *c,* chloromelanite reamer and polisher(?), Nottebohm collection; *d,* jadeite polishing celt (5041); *e,* earplug reamer, Kaminaljuyú; *f,* large jadeite polishing celt (5039), 14 cm. long. (See footnote 3, p. 8, for explanation of numbers in parentheses.)



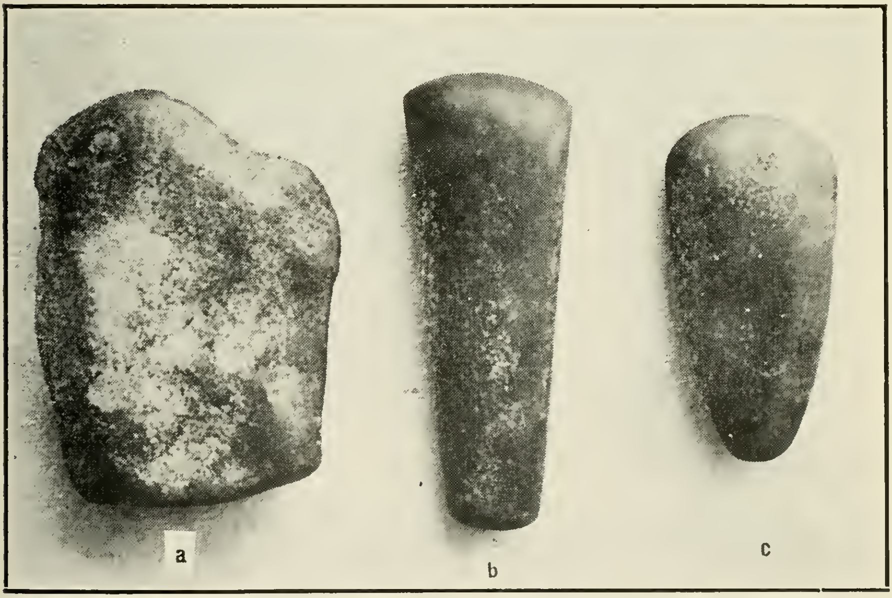
1. Chloromelanite tools, polishers, polishing celts, gravers, and percussion tools. *b, c, j*, 1458; *g*, 5041; *h*, 5042; *i*, 5048; *e*, Chichecastenango, 6594; *a, f*, no numbers. *e* is 14 cm. long.



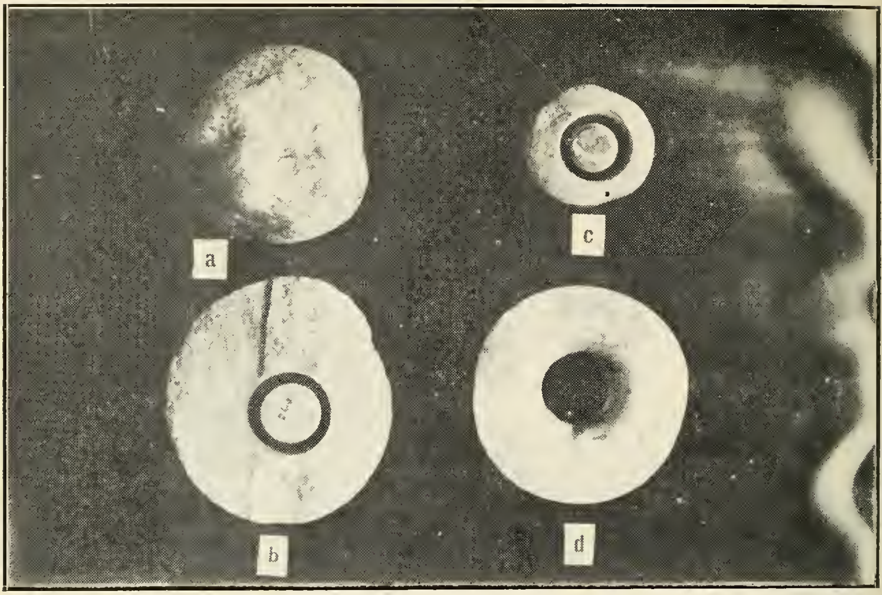
2. Jade-working techniques. *a*, Small jadeite fragments for small beads, Kaminaljuyú; *b*, small beads made from *a*; *c*, jadeite bead blanks, pecked round but not polished or drilled (3077), Kaminaljuyú; *d*, bead blanks; *e, f*, cylindrical roughed-out jadeite bead blanks (1765), San Agustín Acasaguastlán; *g*, jadeite bead, drilled but unpolished (2908), Kaminaljuyú; *h*, finished jadeite bead (2955), Kaminaljuyú. (Natural size.)



1. Jade-working techniques. *a*, Large jadeite bead (4802), 13 cm. long, made by sawing, polishing, and drilling; *b*, sawed jadeite bead blank (3077), Kaminaljuyú; *c*, sawed and shaped but not drilled jadeite bead blank (3027), Kaminaljuyú; *d*, completed jadeite bead, sawed and rounded (4745), Nebaj.



2. Jade-working techniques. *a*, Jadeite used in celts, partly shaped by pecking and grinding, Nottebohm collection; *b*, jadeite celt, like *a*; the white spots are percussion scars, the celt well polished; Nottebohm collection; *c*, a flat pebble of jadeite ground into a celt; the sides and poll are unworked pebble surface, the front and bit are shaped and polished; Nottebohm collection. The large jade block is 17 cm. maximum length.



1. Jade-working techniques. Earplugs: *a*, Jadeite pebble (3146), such as is used in the forming of earplugs; *b*, jadeite, pecked round, sawed, and drilled (3608), Kaminaljuyú; *c*, shaped and drilled block of jadeite (5116), an earplug blank(?); *d*, finished earplug of jadeite (5003). *a*, *b*, and *d* are all in the same type of jade. (About $\frac{1}{2}$ natural size.)

2. Jade-working techniques. Figurines: *a*, Water-worn pebble of jadeite; *b*, figure carved from water-worn pebble of jadeite. (About natural size.)