Khmer Stone Sculptures: A Collection Seen from a Material Point of View

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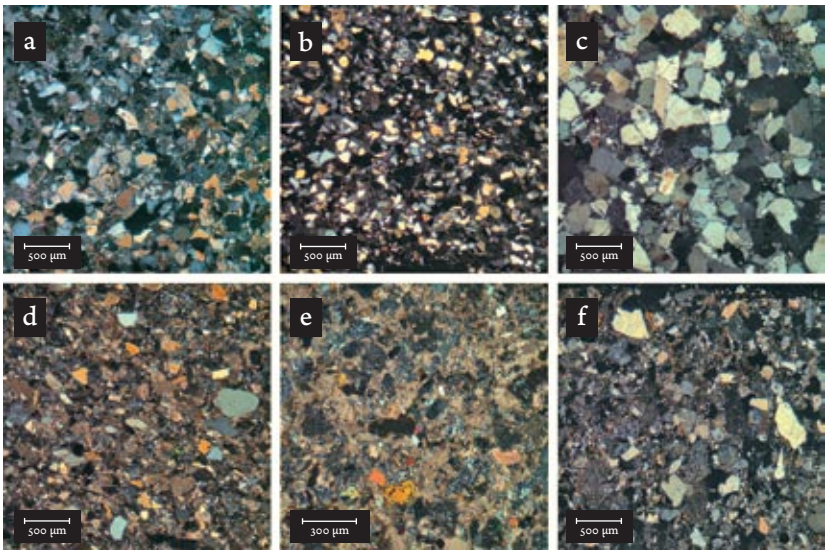
Petrographic analysis can unveil essential clues for reconstructing the function and provenance of stone artifacts and the techniques used to create them. This analytical tool can be especially helpful for integrating and enriching iconographic and stylistic considerations of Khmer sculpture and architecture.[31] Toward that end, the Department of Scientific Research at the Metropolitan, in collaboration with John Guy, curator in the Department of Asian Art, has undertaken a petrographic study of Khmer sculptural production of the pre-Angkor (ca. sixth to ninth century) and Angkor (ca. tenth to thirteenth century) periods that will be of help to specialists who are investigating the context and provenance of Khmer stone sculptures from different perspectives.

The substantial collection of Khmer art at the Metropolitan comprises pre-Angkor and Angkor freestanding sculptures and architectural elements from Thailand and Vietnam as well as Cambodia. Like the works gathered in Phnom Penh at the National Museum of Cambodia and in Paris at the Musée Guimet, these objects not only illustrate the birth and evolution of the different Khmer styles, but they also record the changes in the sculptural artistic medium through time and across geographic areas. Fifty-four Khmer sculptures from the Museum's collection have been analyzed to date, together with samples from sculptures from the National Museum of Cambodia and other museums. Under memorandums of understanding signed between the Metropolitan Museum and the National Museum of Cambodia, and with the Authority for the Protection and Management of Angkor and the Region of Siem Reap (APSARA) of Cambodia, new sculpture and quarry samples have recently been added to this study, the aim of which is to provide a comprehensive database of Khmer stone materials that has the potential to develop even further with future contributions from scientists at other museums that have holdings of Khmer sculpture.

In their primary studies of the sandstones of Angkor Wat, Edmond Saurin (in 1954) and Jean Delvert (in 1963) raised cardinal questions about the geological sources of Khmer stone materials. After almost two decades of civil strife in the region, scientific studies of sculptural media resumed in the early 1980s. In 1998 a Japanese research team led by Etsudo Uchida published a study of the stone building materials of Angkor monuments. Pierre Baptiste and his coauthors included sculptural stones in their survey of the Musée Guimet collection in 2001, as did Janet Douglas in the study of twenty-nine sculptures from the National Museum of Cambodia published in 2004 and 2007. Qualitative petrographic descriptions of Cambodian stone sculptures can be found as an appendix in some monographs and museum catalogues. All these studies, though they use different classification systems, describe the same three main types of sandstone: feldspathic arenite, quartz arenite, and graywacke.

The study of a rock with a petrographic microscope requires that a small fragment of material be mounted on a glass slide and polished down to the thickness of about 30 micrometers (thirty thousandths of a millimeter). Such preparation allows scientists to recognize each single mineral or assemblage of minerals that makes up the stone. So as to minimize the physical intrusion on works of art, sample



50 · White arrows indicate areas on sculpture from which fragmentary samples were taken.

51 · Micrographs showing the overall composition and texture of (a) feldspathic arenite; (b and c) fine and medium quartz arenite; (d and e) litho-feldspathic graywacke with different calcite content; and (f) litho-feldspathic graywacke rich in volcanic rock fragments

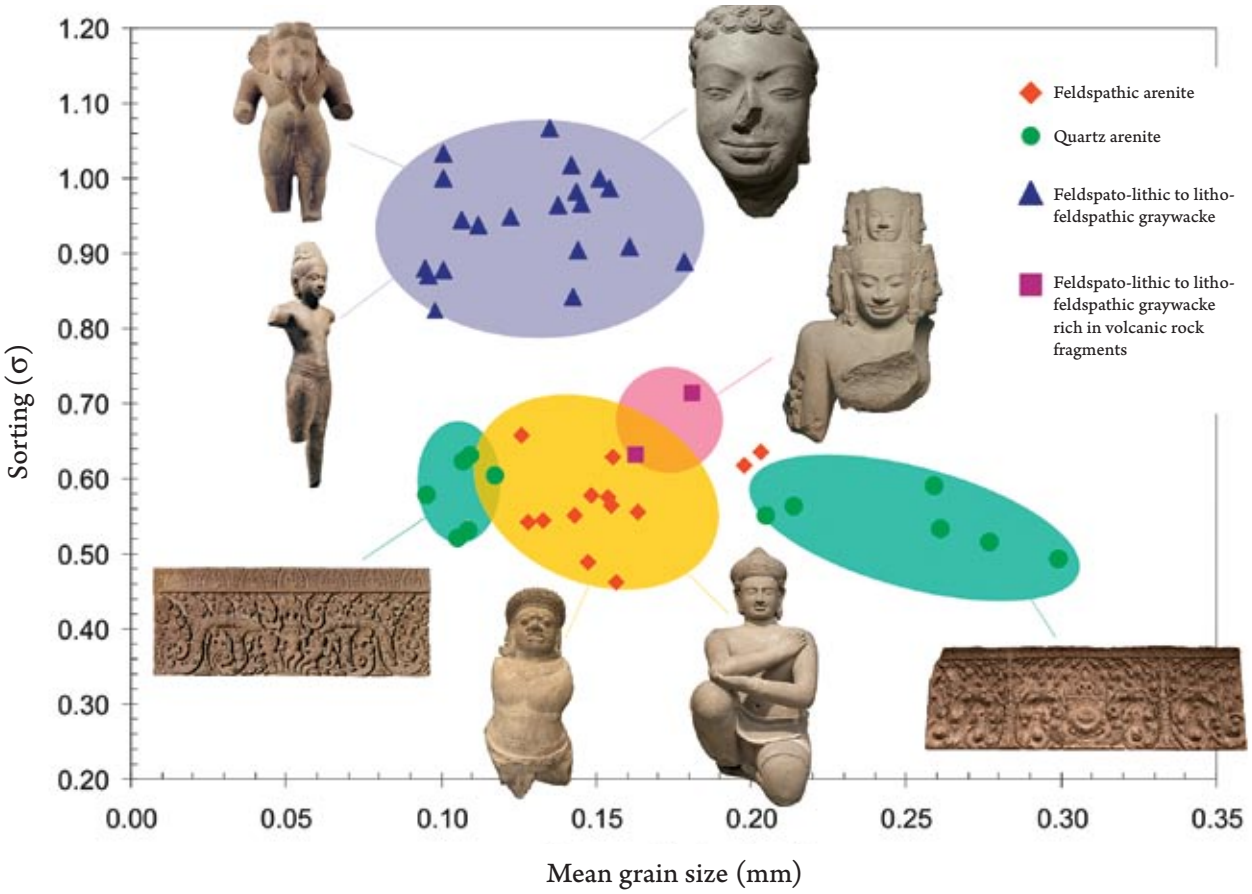
fragments are chiseled from areas already affected by previous breaks or losses, generally located at the backs of arm or leg joints or on the bottom edges of architectural elements (see fig. 50). When possible, such samples include both the exposed surface and the fresh stone interior so that the weathering of the sculpture can also be assessed. With the aim of describing and unambiguously classifying each sample of rock, the maximum number of detrital grains that make up the framework of the stone in each thin section were counted and each grain classified and measured by means of a micrometric eyepiece using a polarized light microscope. All the analyzed stone samples from the Khmer collection at the Metropolitan are sandstones, clastic (fragmental) sedimentary rocks composed of a framework of sand-size grains of older rock (clasts) set in a silty or clayey matrix and united by a cementing material.

Many schemes of sandstone classification exist, and none of them are universally accepted by all scientists. For the purposes of this review, we have adopted the schemes proposed by F. J. Pettijohn (1954) and by P. Gazzi (1966) and W. R. Dickinson (1970). Pettijohn divided sandstones into two texturally different classes: those with less than 15% of matrix, called arenites, and those with more than 15% of matrix, called wackes. Although this scheme has been criticized, it seems to be the most workable for the samples studied at the Metropolitan, and it allows a sharp visualization of the works of art. Using Pettijohn's criteria, more than half the objects in the Museum's collection are carved from arenites, and the rest are graywackes, a term used in this circumstance

in its general sense of dark gray, immature sandstone with significant matrix content. By using the Gazzi-Dickinson classification it is possible to further detail the nature of the stones present in the collection on the basis of the detrital grain composition. Some 90% of the studied pieces are carved from two types of arenites and two graywackes.

The first type of arenite present in the collection is feldspathic arenite, or sandstone where feldspar is an important detrital constituent that, together with quartz, makes up about 90% of the rock.[32] This sandstone is characterized by a yellowish gray color and a granular texture (see figs. 57, 58). It is usually easy to distinguish the natural bedding, or stratification, of the stone, especially when the surface of the sculpture suffered more or less intense weathering. Examination of the stone under the petrographic microscope (fig. 51a) shows a framework of fine, slightly rounded to angular grains—mostly mono-, poly-, and microcrystalline quartz and alkali feldspar—that are moderately well sorted (varied in size) and cemented by clay minerals, with a preponderance of chlorite. The rock fragments that make up 10% or less of the total framework are mostly chert, quartzite, micaceous schist, and phyllite (metamorphic rocks); intermediate to acid volcanoclasts (volcanic rocks); and subordinate siltstone and shale (sedimentary rocks).

The second arenite is classified as quartz arenite, or arenite with more than 75% quartz. This sandstone often exhibits a light reddish or pinkish gray color (caused by the diffuse film of hematite coating the grains and interstices) and a compact, crisp surface appearance (see figs. 59–61). Microscopically, it can be described as having very fine to medium moderately well sorted grains composed mostly of slightly



52 · The Metropolitan Museum of Art's collection of Khmer sculpture classified according to the textural and compositional characters of the stone material, showing examples of sculpture carved from each type of stone

53 · Head of a Buddha. Angkor Borei, Cambodia, second half of 6th century. Feldspato-lithic graywacke, h. 24 in. (61 cm). The Metropolitan Museum of Art, Gift of Doris Wiener, 2005 (2005.512)

54 · Standing Ganesha. Cambodia, pre-Angkor period, Prasat Andet style, second half of 7th century. Litho-feldspathic graywacke, h. 17¼ in. (43.8 cm). The Metropolitan Museum of Art, Rogers, Louis V. Bell and Fletcher Funds, 1982 (1982.220.7)

55 · Standing Shiva. Cambodia or Vietnam, pre-Angkor period, Prasat Andet style, late 7th–early 8th century. Litho-feldspathic graywacke, h. 24 in. (61 cm). The Metropolitan Museum of Art, Rogers Fund, 1987 (1987.17)

rounded to angular mono- and microcrystalline quartz cemented by kaolinite (fig. 51b, c).[33]

Graywacke sandstones are distinguished by their dark grayish to dark greenish color, remarkable compaction, and, in some cases, highly polished finish (see figs. 53–55, 62). The graywackes in the Museum study are compact, fine-grained, and immature sandstones with a variable content of quartz, feldspar, and lithic fragments. They are mostly of two types, which have compositions varying from feldspato-lithic to litho-feldspathic and which differ as to the type and the relative abundance of rock fragments in the framework grains.

The framework of the most common graywacke is poorly sorted and slightly variable in composition (fig. 51d, e). Quartz is present as slightly rounded to very angular mono- and polycrystalline grains, chert, and quartzite grains, which together form more than half the total volume of the rock. Feldspar grains are alkali feldspar and plagioclase, and vary from 20 to 40% of the entire framework.[34] The content of rock fragments in the framework varies and reflects a metamorphic-volcanic provenance for the sandstone.[35] The matrix is composed of a fine-grained clay-sized assemblage of chlorite and illite, with subordinate calcite, quartz, iron oxides, and heavy minerals.[36] Calcite is present as interstitial cement, together with chlorite, and can vary noticeably in abundance.

The framework of the second type of graywacke is generally coarser, with a relatively high proportion of feldspar grains and rock fragments (fig. 51f). Quartz never exceeds 30% of the total framework. The matrix is abundant and rich in small feldspar laths (thin, narrow,

56 · The sandstone outcrop near Koh Ker known as Ang Khna, where evidence of quarrying of massive monoliths can still be seen. The quarry subsequently became a sacred place when the vertical surfaces were carved with deities and friezes, possibly by hermits.

57 · Kneeling male attendant. Cambodia, Angkor period, Khmer style of Koh Ker, ca. 921–45. Feldspathic arenite, h. 30¼ in. (76.8 cm). The Metropolitan Museum of Art, body: Gift of Douglas Latchford, in honor of Martin Lerner, 1992 (1992.390.2); head: Gift of Raymond G. Handley and Milla Louise Handley, 1989 (1989.100)

58 · Guardian deity. Cambodia, Angkor period, Khmer style of Koh Ker, ca. 921–45. Feldspathic arenite, h. 38¾ in. (98.5 cm). The Metropolitan Museum of Art, Gift of Doris and Harry Rubin, in memory of Ralph Konheim, 1987 (1987.308)

59 · Lintel with carved figures. Cambodia, Angkor period, Khmer style of Koh Ker, ca. 921–45. Quartz arenite, 20¼ x 49 in. (51.4 x 124.5 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.96.6)

60 · Lintel with Shiva on Nandi. Cambodia, Angkor period, Khmer style of the Baphuon, 11th century. Quartz arenite, 23½ x 54 in. (59.7 x 137.2 cm). The Metropolitan Museum of Art, Gift of The Kronos Collections, 1996 (1996.473)

61 · Lintel with a mask of Kala. Cambodia or Thailand, Angkor period, Khmer style of the Baphuon, ca. first quarter of 11th century. Quartz arenite, 23 x 67 in. (58.4 x 170.2 cm). The Metropolitan Museum of Art, Gift of R. Hatfield Ellsworth, in honor of Florence and Herbert Irving, 1994 (1994.94)

elongated plagioclase crystals). Among the accessory minerals, hornblende is the most common and characteristic. The most distinctive feature of this graywacke is the abundance of igneous intermediate to basic brittle volcanic rock fragments (up to 90% of the total rock fragments), which easily break down into pseudomatrix (matrix formed by the mechanical compaction and squeezing of soft clasts, or fragments, in the framework). The relatively fresh volcanic grains suggest that the sediment was not transported very far after it eroded from preeminently volcanic rocks.

The petrographic characterization of the stone materials sheds new light on the Khmer sculpture in The Metropolitan Museum of Art. The study reveals that it is possible to group the sculptures according to strong petrographic similarities (fig. 52). Integrating these results with stylistic considerations, which will be the subject of a future joint study with curatorial colleagues, and comparing them with other published petrographic data about stone usage in Cambodia will add to our ability to contextualize them.

Most of the pre-Angkor sculptures in the Museum, which date from the sixth to the ninth century and represent a diversity of styles and iconographies, were made from similar stone material worked with consummate skill. These early Khmer works originating from the southern provinces of Cambodia (see, for instance, figs. 53–55) are carved from feldspato-lithic to litho-feldspathic graywacke that displays a generally well preserved, dark grayish to dark greenish, sometimes highly polished surface. This sandstone was rarely used for buildings, although a similar type of stone has been found in the early sanctuary of Ta Keo, built in the late tenth to early eleventh century.[37]

The Angkor statuary in the collection, on the other hand, is mostly made from feldspathic arenite.[38] This type of stone—also called arkose, gray or green sandstone, or gray to yellowish brown sandstone—occurs extensively in architectural elements of the Angkor period,[39] and it has been also identified in most of the Angkor sculptures collected in the Musée Guimet and the National Museum of Cambodia.[40] Feldspathic arenite, which constitutes the main subhorizontal tablelands of the Lower to Middle Jurassic Age in northern Cambodia,[41] seems to have been the preferred material for statuary in the highly centralized Angkor kingdom from the tenth to the sixteenth century.[42] This sandstone forms the shallow bedrock of the region around Koh Ker (fig. 56), some sixty miles northeast of Angkor, which served as the capital of the Khmer empire for a brief time during the reigns of King Jayavarman IV and his son Harshavarman II (928–44). The bedrock could have provided an adequate supply of sandstone for the massive buildings and myriad sculptural works created in the Koh Ker style, exemplified by two male figures in the Metropolitan's collection, one a kneeling attendant, the other a guardian deity (figs. 57, 58).

Technical rather than geographic or historical motivation seems to have influenced the choice of quartz arenite as a medium. As examples dating from the early tenth to the eleventh century in the Museum's collection attest (see figs. 59–61), this particular stone appears to have been the favorite material for architectural elements, particularly those carved with intricate detail, in several different pre-Angkor and Angkor styles.[43] Quartz arenite was used as well for lintels, columns, and other Angkor architectural fragments of different periods in the Musée Guimet's collection.[44] The petrographic data collected on Angkor architecture by Uchida and his coworkers reveal that similar stone, which Uchida calls red sandstone, has been found in the finely carved architectural elements of Banteay Srei, the Angkor temple devoted to the Hindu god Shiva that was consecrated in 967, and in the pillars of the South Kleang in Angkor Thom, which also dates to the late tenth century.[45] Similar examples can be recognized in architectural elements scattered throughout various sites in northern and southern Cambodia.

62 · Bust of Hevajra. Cambodia, Angkor period, Khmer style of the Bayon, late 12th–early 13th century. Feldspato-lithic graywacke, h. 52 in. (132.1 cm). The Metropolitan Museum of Art, Fletcher Fund, 1936 (36.96.4)

The markedly immature sandstone rich in volcanic rock fragments appears to have played a specific and short-lived role in Angkor sculptural production. It was used for the sculptures in the Metropolitan that reflect the Khmer style of the Bayon (see fig. 62), the sumptuously decorated Mahayana Buddhist temple that King Jayavarman VII (r. ca. 1180–ca. 1230) built at the center of his capital at Angkor Thom. This supports Douglas and Sorensen's hypothesis that feldspato-lithic graywacke was predominantly used for sculpture created during Jayavarman VII's reign.[46]