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The Takalik Abaj Monumental Stone Sculpture Project: High Definition Digital Documentation and Analysis

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INTRODUCTION

“The function and meanings of these stone monuments have changed through time and will continue to do so…” (Schieber de Lavarreda and Orrego Corzo 2010:178)

“Stone sculptures for the Middle and Late Preclassic periods are frequently smashed, broken, defaced, and dislocated from their original context…Another troublesome fact is that Preclassic sculptures are generally under-reported, understudied, and/or poorly illustrated” (Clark, et al. 2010:5)

The archaeological site of Takalik Abaj lies on the Pacific piedmont of Guatemala (Figure 1), and over a century of sporadic archaeological investigations has primarily focused on the site’s monumental stone carvings. The attention placed on the stone sculpture is understandable. Takalik Abaj¹ is a K’iche’ Maya term for “standing stones,” and is descriptive of the extensive collection of carved stones at the site. Three hundred and twenty six stone monuments have been registered at the site, with 124 noted as carved (Schieber de Lavarreda 2006:29; Schieber de Lavarreda and Orrego Corzo 2010:177). This assemblage is considered one of the most eclectic in all of Mesoamerica and an important component of the corpus of Mesoamerican stone sculpture.

The carved monuments at Takalik Abaj contain an evolutionary record of changing social complexity, political interaction, and ideological practices. This assemblage constitutes the portrayal of a dynamic developmental sequence that began in the Middle Formative period with symbolic elements and evolved into elite ideological expressions of rulership, power, and authority. The process culminated with the appearance of initial glyphic inscriptions and early Long Count dates that were foundational in the development of the later, Classic period Maya script. Various hypotheses, many based solely on the interpretation of sculptural style, have been formulated to explain numerous aspects of the site’s presence and significance. Yet, collectively, this unique communicative record has not been documented or published in a coordinated, comprehensive manner. Those objects that have been recorded, however, are not necessarily amenable to detailed analytical study (see Graham 1989:232).

Because of the potential interpretive value of the carved stone monuments to Mesoamerican researchers, the “Takalik Abaj Monumental Stone Sculpture Project” has an objective to promote and facilitate independent and collaborative research into Middle Formative (c. 800 to 100 BC) and proto-Classic period (c. 100 BC to AD 300) iconography and epigraphy. The project has

¹ Tak'alik Ab'aj' means "standing stone" in the contemporary K'iche' language. It was initially named Abaj Takalik by the American archaeologist Suzanna Miles using Spanish word order. This term, however, was grammatically incorrect in K'iche'; the Guatemalan government has now officially corrected this to Tak'alik Ab'aj'. The ancient name of the site remains unknown.
produced the most accurate and complete visual, spatial, and historical documentation of the Takalik Abaj stone sculptures currently possible using “best available technologies” (United Nations 2005). In order to better understand ancient cognitive systems and interpret their communicative practices, we are making those records readily available to the international research community for purposes of preservation, analysis, and interpretation. A series of non-contact, non-destructive, state-of-the-art technologies were used to produce three-dimensional and two-dimensional imaging and spatial datasets that are incorporated into expressly prepared databases where they can be interactively examined, analyzed, and compared in readily accessible virtual environments.

The perception and interpretation of archaeological materials is maximized if they are available for repeated examination over significant periods of time (Weber and Malone 2011). This durational capacity permits the objects to be analyzed by multiple experts from various disciplines, and also allows new and developing analytical techniques to be employed. Preservation, on-going analysis, and sharing with other researchers are essential factors when unique or remote material or objects that contain particular symbolic significance, such as those at Takalik Abaj, are being examined. Therefore, the success of this project can only be measured by its longevity, usefulness, and effectiveness as a reference and resource tool for researchers. In order to promote and facilitate the project’s success, the databases are intended to be dynamic, living documents that can be updated, improved, and expanded as new discoveries are made and other pertinent material and information become available to investigators. This goal will only be achieved through the cooperation, sharing, and understanding of international archaeological professionals.
The generated datasets permit researchers, students, and others the opportunity to view and analyze the archaeological landscape at Takalik Abaj from a variety of perspectives and at multiple scales in order to better understand the activities of its ancient inhabitants. In addition to the carved monuments, the project captured contextual features (e.g., architecture and terrain) whenever possible in order to provide a greater understanding of the object’s relationship to the built and natural environment. Numerous cartographic compilations and projections have been made at local site and regional levels to more accurately appreciate the site’s physical setting.

This report reviews the history of archaeological investigation at Takalik Abaj and the evolution and development of this project from the initial, on-site testing of the data collection technologies in 2006 (Doering, et al. 2006) that led to the field project conducted in 2010 and the associated data processing techniques. We also demonstrate how the data sets have been assembled, processed, and protected as they are prepared for dissemination. Examples are provided to show how the data can be viewed and analyzed by international researchers, scholars, students, and teachers on World Wide Web platforms that are accessible via the Internet. We also explain the rationale for our approach to the presentation of data, and how spatial and imaging technologies have been transferred to our Guatemalan collaborators to ensure the continuation of data collection into the future.

BACKGROUND AND PREVIOUS INVESTIGATIONS AT TAKALIK ABAJ

The archaeological site of Takalik Abaj is located in the municipality of Al Asintal, Department of Retalhuleu, in southwest Guatemala, approximately 40 kilometers north of the Pacific Ocean and 45 kilometers east of the present-day boundary with Chiapas, Mexico. The initial occupation of the settlement is said to have occurred at some point during the Early Formative period. Archaeologists have indicated that at some point in the Middle Formative period (c. 900 to 400 BC) the site gained recognition as a socioeconomic and political center (Demarest 1989:316; Graham 1981:165; Guernsey 2006:6; Parsons 1988:8; Pool 2007:224; Popenoe de Hatch, et al. 2000). In all probability, construction of public architecture began by the Middle Formative period (Crasborn Chavarría and Marroquín 2006; Schieber de Lavarreda 1994a, b), but little else is known about the site’s size and sociopolitical organization at that time (Love 2007:288).

Takalik Abaj first gained attention as an archaeological site in an 1888 report by German researcher Gustav Brühl. He initiated what would become a century-long discussion about its assemblage of carved stone monuments. Since then, the site and its sculptures have been the subject of intermittent investigations. Linguist Karl Sapper (1894) visited the site a few years after Brühl and provided a brief description of Stela 1 (Figure 2). Later, Max Vollmberg (1932), a German artist visited the site circa 1913, and commented on several monuments and produced a sketch Stela 1. According to Graham et al. (1978:87), Vollmberg’s trip was the incentive for a visit to the site by Walter Lehmann (1926), who was the first to recognize the relative antiquity of the Takalik Abaj sculpture.
Lehmann’s early temporal assignment of the carvings ran counter to the ideas of some scholars at the time, however. One of these dissenters was J. Eric Thompson, who argued against the early date (Thompson 1941). To prove his point, he visited the site in 1942 with the intention of properly dating the stone carving. In his commentary that was meant to illuminate these sculptures and their previously dubious chronology, Thompson (1942, 1943) failed to recognize that the monument that he identified as Stela 2, and the one Lehmann designated as "Piedra Schlubach" (Lehmann 1926:176) were, in fact, the same object. Ironically, it was this very monument whose temporal placement Thompson was questioning. This misidentification is an early example of inadequate recording of monuments.

In the 1960s, Susanna Miles (1965a) visited the site and published articles on Monuments 3 and 6. She was followed by Edwin Shook (1971 ), and Lee Parsons (1986; 1988) who added diverse commentaries on portions of the site’s collection of sculpture. Takalik Abaj received its first long-term concerted investigation from 1976 to 1980, when excavations and surveys of the site were directed by John Graham of the University of California at Berkeley (Graham 1977, 1978, 1979, 1981, 1989, 1992; Graham and Benson 2005; Graham et al. 1978). Graham’s summary-type articles deal almost exclusively with the sculptural record as observed from an art history perspective, the academic study of the historical development and stylistic contexts of art objects.

The most recent and extensive work at the site has been conducted by the Takalik Abaj National Project under the direction of Guatemalan archaeologists Miguel Orrego Corzo and Christa Schieber de Lavarreda. They and their staff have initiated an exceptional program of conservation and preservation of the site, its monuments, and architecture (Lavarreda and Corzo 2003; Orrego Corzo and Lavarreda 2001, 2002, 2003). During their tenure at the site, exploratory research has uncovered a series of new monumental sculptures that further illustrate the significance of the Preclassic sociopolitical activities that occurred at the site. In 2004, they uncovered “one of the earliest royal Maya graves” on Structure 7 (Tarpy 2004:66), and in March 2008, they discovered Altar 48, which contained early iconographic elements of rulership and an incipient glyphic text. Then, in June 2008, they uncovered Monuments 215 and 217 that, together with Stelae 53 and 61, form a large 2.3 m high, enigmatic standing figure carrying a smaller personage on its back (Persson 2008). Archaeological exploration of the site and discovery of its stone monuments has been hampered by a number of obstacles. Architectural features and stone sculptures are distributed across an area greater than six square kilometers of challenging landscape, and more than eighty percent of the archaeological site lies on five privately owned fincas or farms. Previously, some of these properties have not been accessible to investigators. This current project is grateful to have received permission from all private finca owners to have access to conduct survey and documentation.
In addition, Takalik Abaj surface visibility is generally very poor for various reasons. Deep deposits of volcanic ash from a 1902 eruption of nearby Santa María Volcano (Figure 3) further disguise an already uneven natural terrain. The ability to discern the surface is significantly diminished by dense natural tropical vegetation (Brühl 1888; Busby and Johnson 1978; Graham et al. 1978; Thompson 1943). The topography of the site has also been modified by long-term commercial agricultural practices (e.g., coffee, sugarcane, bananas, rubber, and pineapples). Figure 4 illustrates how the regional terrain appeared in the late 1800s at the finca “Las Nubes,” in San Francisco Zapotitlán, Suchitepéquez, about 20 km east of Takalik Abaj. Figures 5 and 6 illustrate conditions today.
Figure 3. High dynamic range (HDR) image of the Santa Maria Volcano taken from the summit of Structure 32 at Takalik Abaj (photograph by Joseph Gamble)

Figure 4. Photograph by Eadweard Muybridge of the coffee mill at the finca “Las Nubes,” San Francisco Zapotitlán, Suchitepéquez, in 1875, from the Stanford University Special Collections. Note the topography and dense vegetation that obscures surface visibility.
Figure 5. Photograph of ground cover and rubber production at Takalik Abaj

Figure 6. Example of landscape visibility difficulties encountered in recognizing and locating stone monuments at Takalik Abaj.
FACTORS IN THE DOCUMENTATION AND ANALYSIS OF TAKALIK ABAJ STONE MONUMENTS

Since their initial discovery in the 1880s, the stone sculptures have sustained injury, deterioration, and loss due to natural (i.e., physical and biological weathering) and anthropogenic actions (i.e., looting and defacement) (see Doering and Collins 2008; Ismail 2004; Kahl and Berg 2006). These degenerative processes have reduced the ability to “see” the carved content and detail for purposes of analysis. Additionally, many of the stone monuments at Takalik Abaj are no longer located in their original context, a setting that is crucial to understanding and interpretation of ancient cultures (Clark, et al. 2010). Numerous pieces have been moved and re-set across the site both in ancient and historical times. An ancient example is a series of carved stone objects were uncovered in front of Structure 3, a platform constructed in the Classic period. One monument, Altar 12, is said to have been carved in the Late Formative period based on its early Maya style, while Monument 23 is assigned to the Middle Formative period, but was subsequently recarved (Sharer and Traxler 2006:239). This type of redistribution or resetting of monuments from various time periods has further obscured or confused the chronological record. Contemporary movement of numerous monuments is also disruptive to research. For example, Stelae 1 and 4 have been relocated, and their original places of deposition are not known, and Monument 7 has been removed from the site.

Due to the loss of original context, the dating of most stone monuments at Takalik Abaj is based on stylistic comparisons (Sharer and Traxler 2006:239). Much has been written about Takalik Abaj’s Olmec phenomenon (Graham 1982; Graham 1979, 1981, 1989, 1992; Graham and Benson 2005; Popenoe de Hatch 2006; Schieber de Lavarreda 2006; Tarpy 2004) and the Late Formative period appearance of Maya-like stone sculptures that include hieroglyphic inscriptions and dates in the Long Count calendar format (Coe 1957; Graham 1979; Graham, et al. 1978). Many questions persist, however, regarding the temporal attribution and symbolic or ideological meaning of the sculpture at Takalik Abaj. Addressing these questions is made more difficult by the site’s need for secure chronometric dating. At Takalik Abaj, these temporal impediments are magnified because the topography has been significantly altered by millennia of human and natural activity. In places the landscape has been literally transformed, and during their life history, many of the monumental stone sculpture have been damaged, mutilated, recarved, reset, and reused.

The richness and diversity of the monumental stone carvings at Takalik Abaj is exceptional in Mesoamerica, but the ability to extract reliable information from them has remained problematic. Formative period sculptures have not been sufficiently recorded to permit critical iconographic and epigraphic analysis and the meager visual record and lack of adequate documentation has been lamented, as illustrated in the report’s opening quotation by Clark, Guernsey, and Arroyo. Michael Coe (1957) has also decried the omissions, insufficient photography, and the subjective recording of the sculpture. Graham (1989:242) rued that “the frequent problems of poor photographs at unsatisfactory angles, inappropriate or inadequate
lighting, failure to clean monuments to reveal detail...[in]attention to the formal properties of the sculpture...result in misconceptions, and hinders or even precludes serious study.”

Even with the acknowledged importance of the Takalik Abaj sculptural corpus, a number of issues have restricted a comprehensive and in-depth analysis of the sculpted evidence. Traditional documentation techniques, such as photography and drawing, have significant visual and analytical limitations, and replication techniques that require contact with the object usually create more problems than they solve over the long term. Technical issue can reduce the level of accuracy, measurability, and content in all these methods. For example, an artist’s drawing is essentially based on their personal response to object and level of artistic skill. The resulting image may be influenced by the surrounding environment, lighting, and the complexity of the object’s geometry.

Photographic techniques have been the most common methods used to record stone sculptures and exceptional results have been achieved. Nevertheless, its use as a stand-alone method presents fundamental problems of spatial control and the introduction of parallax, the visual displacement of an object caused by the position or angle from which the image was acquired (Collins and Doering 2006; Price 1996). This type of spatial distortion causes a progressively increasing dimensional error when used for analysis or the production of drawings from photographs. Graham (1989:242–243), noted that such inconsistencies can result in misconceptions or hinder interpretation.

Many Formative period sculpted artworks were intended to be seen in-the-round. The carving of scenes often extend around a piece’s corners or sides, and continues to the top and bottom of a piece (e.g., La Venta’s colossal heads, Monument 77, Altars 4, 5, and 7; Kaminaljuyú Altars 9 and 10; Takalik Abaj Stela 5, Monuments 15, 117, and 172). In standard methods of documentation, such as photography and line drawing, the positioning of the piece may preclude the ability to view significant portions of the object. The inability to observe the entire piece prevents researchers from conceptually visualizing the piece in its entirety, and realizing the actual extent of the areas of carving and re-carving. Evidence relating to modification, mutilation, and re-cycling can be omitted simply because of the complexity and geometry of pieces.

Inherent in these traditional techniques of recording are also problems and limitations imposed by the subjective nature of the procedures. Decisions as to what are important, what is recorded, and what is not exposed are some of the intentional and unintentional biases that are introduced into conventional documentation methods. An individual recorder may deem certain elements as outstanding or important, and may record those elements at the expense of others that they consider unimportant. In reality, however, the unrecorded portions may be vital to the analysis and interpretation of the artifact (see Collins and Doering 2006, 2009; Doering and Collins 2010a, b). Drawings made from photographs or rubbings introduce a second level of subjectivity. Well aware of these interpretive dangers, Graham (1989:243) stated that “our apprehension of [Preclassic] art has also suffered greatly” through “distortions in repeatedly republished
drawings” that result in erroneous observations. The photography and art work are usually individualized procedures and, as such, a degree of subjective interpretation will be inherent in the results (Wickstead 2009).

Issues that extend beyond the recording of monuments can also inhibit analysis and interpretation. Throughout much of Mesoamerican research, conclusions and interpretations have been influenced directly or indirectly from a tendency to classify and label monuments, artifacts, or features based on subjective observations that may have been made without satisfactory archaeological support. Grove’s (1973) demonstration that Southern Gulf Lowland Olmec “altars” were in fact thrones is a case in point, and this change in terminology substantially altered the monuments fundamental meaning and interpretation. The addition of hyperbole that identifies discoveries as the latest and greatest, the best, the first, the largest, or the most important, continually prejudice attempts at impartial analysis.

Over time, these designation biases become engrained in the literature and are perpetuated within the discipline by the propensity of subsequent writers to accept previous interpretations without question. McCafferty and McCafferty (1994:143) demonstrated the dangers in these types of pronouncements and pointed out “the necessity of periodic reevaluations of accepted wisdom that may have been developed under theoretical paradigms that minimized cultural diversity.” Substantial changes in theoretical perspectives have occurred from the late 19th through the early 21st century, the time that these intermittent exploratory projects were conducted at Takalik Abaj. Shifts in methodological approaches have also contributed to an inconsistency in the integration of data (see Binford 1965; Childe 1925; Flannery 1968; Hodder 1991; Willey and Phillips 1958).

**PROJECT DEVELOPMENT**

The current project was conceived of and designed by Travis Doering and Lori Collins of the University of South Florida’s Alliance for Integrated Spatial Technologies in an attempt to overcome many of the issues raised above. The project was made possible through cooperation and collaboration with Miguel Orrego Corzo, Administrative Coordinator, and Christa Schieber de Lavarreda, Scientific Coordinator, of Guatemala’s Takalik Abaj National Project. The work was conducted with permission from the Institute of Anthropology and History of Guatemala (Instituto de Antropología e Historia de Guatemala) and the Ministry of Culture and Sport (Ministerio de Cultura y Deportes).

The initial steps toward the development of this project began in March, 2006, when Doering and Collins conducted a technology field test at the direction of John Clark, who was then the Director of the New World Archaeological Foundation (NWAF) at Brigham Young University (BYU). The purpose of the test was to determine the effectiveness of close-range, three-dimensional (3D) laser scanning for the documentation and recording of Mesoamerican carved stone monuments in the field at Takalik Abaj and museum environment at the National Museum.
of Archaeology and Ethnography in Guatemala City. Claudia Monzón, was the Director of the Museo Nacional de Arqueología y Etnología de Guatemala, and along with the directors of the Takalik Abaj National Project, all were instrumental in our ability to conduct this innovative test.

The BYU project required the 3D laser scanning of Monument 1 and Stela 5 at the Guatemalan archaeological site of Takalik Abaj and Kaminaljuyu Monuments 2 and 65, and Stela 10 located in the National Museum of Anthropology and Ethnography in Guatemala City. In addition to the specified pieces, Monuments 64, 11, and 8 at Takalik Abaj were also scanned and documented upon request of Orrego Corzo and Schieber de Lavarreda. Differentially corrected mapping-grade Global Positioning Systems were used during the field portion of this project at Takalik Abaj. The implementation of this technology allowed the real-world location of the scanned objects to be determined and demonstrated the applicability of integrating a variety of survey technologies. Several other areas and features were spatially recorded, and mapping products depicting site positions were processed and delivered to the directors of the Takalik Abaj Project along with the final technical report. During the 2006 field work at Takalik Abaj, Doering and Collins discussed the potential for an expanded, more inclusive project with Orrego Corzo and Schieber de Lavarreda.

In June, 2008, a new stone sculpture, Altar 48, was uncovered at Takalik Abaj, and the project directors invited Doering and Collins to document and scan the new find along with Monument 8 and Altar 30. During this time, further plans regarding a major project at Takalik Abaj were conducted with the site’s directors, and based on these discussions and their endorsement, a preliminary proposal was written and submitted, along with supplementary documents and a letter of support from Orrego Corzo and Schieber de Lavarreda, to the office of the Directorate General of Cultural and Natural Patrimony, where it was accepted and approved by Erick M. Ponciano, Director of the Guatemalan Institute of Anthropology and History.

Upon acceptance from Guatemalan authorities, a proposal for funding was submitted to the United States’ National Science Foundation. The proposal was peer-reviewed, received exceptional ratings, and was approved. Logistical and planning coordination with Project Directors Orrego Corzo and Schieber de Lavarreda allowed on-going field work to begin in January, 2010. This report, and attendant documents and data files, represent the meeting of requirements and completion of the project as identified in the “Carta de Entendiento entre la Direccion General del Patrimonio Cultural y Natural de Ministerio de Cultura y Deportes y Los Doctores Travis Doering y Lori Collins” for the project period of January, 2010 to March, 2011.

**PROJECT DESIGN**

The research design of the Takalik Abaj Monumental Stone Sculpture Project is intended to overcome a number of other obstacles in the recording, examination, and interpretation of the epigraphic and iconographic content described above. Much of the Takalik Abaj sculpture contains extensive political and historical narratives; therefore, the clarity and perception of
sculpted details on these monuments are crucial to their interpretation. There are also different monument forms and carving styles present that have been suggested as distinctively Olmec, Izapan, or Maya (Graham 1981, 1989). Some monuments display evidence of re-carving, intentional modification, and recycling. The highly accurate two and three-dimensional data will be used into the future to discern differences in forms and carving styles, as well as assess the sequence of production and reuse.

The primary method of documentation is through the use of close-range and mid-range three-dimensional laser scanners that provide the most appropriate level of detail and intensity for each monument. For example, an un-carved or non-narrative monolith was recorded with a mid-range scanner with a resolution of 0.6 mm to capture morphological and gross surface detail (Collins and Doering 2008a, b). Narrative scenes and scripts were captured with a close-range scanner that provides the highest resolution and accuracy possible (~50 microns). In many cases, the exceptional density of three-dimensional spatial data acquired permit objects to be analyzed, measured, and evaluated more effectively and precisely than if the analysts were in the field or had the physical object in their presence (Doering and Collins 2007, 2008; Doering, Collins and Perreault 2006).

Processed scan data allows in-depth, comprehensive examinations of the stone and its sculpture to be conducted in a virtual computer environment. The objects can be rotated 360° and viewed in true three-dimensions. The light source can be maneuvered to observe and accentuate the object and its carved detail from any angle, sub-millimeter measurements can be made of any portion of the piece directly on the computer screen, and numerous visualization techniques can be used to enhance and clarify detail. Cross-section and profile analysis and Surface Elevation Modeling techniques, expressly developed by Collins for investigation of carved stone monuments, also aid in examining stone reuse, recycling, and modification processes (Doering and Collins, 2010a).

Minimally, the technology provides the finest archival documentation possible for museum or collection registration, heritage preservation planning and management, public presentations, and educational applications. The benefits to long-term research and analysis, however, are exceptional. Perhaps the most exciting capability of three-dimensional scanning is its ability to capture data that can be used to rescue or resurrect sculpted details that, through wear, erosion, or other causes, have not previously been known or discernable (Doering and Collins, 2010a). Additionally, the life history of use, re-use, and recycling of the stone can be deduced from the data. New perspectives and considerations of the sculpture are provided by the ability to electronically manipulate, visualize, and measure the object. Evidence of tool marks, wear, grooving, etching, and abrading that, heretofore, may not have been visible to researchers can be analyzed and enhanced through the electronic cross-sectioning of the piece.

Other high-definition spatial documentation techniques were also employed. A terrestrial laser scanning survey (TLS) was performed in areas having high sculpture content that was related to
architectural structure portions of the site. In these areas (e.g., plazas and terraces), terrestrial LiDAR using a mid-range laser scanner was used to capture site and terrain details to +/- 3mm accuracy. These point clouds consisting of millions of X, Y, and Z coordinates were processed for use in the improvement of digital terrain modeling and contour map development. The resultant data will be useful in having site specific elevation and terrain data for several of the park areas and incorporate into the developed GIS mapping products.

In addition to multiple-range optical laser scanning, a differential correction mapping-grade Global Positioning Systems (GPS), featuring sub-meter accuracy, was used to map the present location of all documented monuments, related architectural structures, and archaeological and natural features. This recording of spatial location will assist in the long-term management and continued documentation of sculpture. It will allow for the recognition and examination of patterns that relate to contents, types, quantities, and locations of sculptures including their contextual settings and architectural relationships. As well, multiple types of progressive, high-resolution, digital photography provide additional levels of documentation for research and analysis. These multiple levels of detail are brought together in a database format that will enable the continuation of spatial and attribute data collection in a consistent recording platform (Collins and Doering 2006; Collins and Weisman 2005).

This National Science Foundation funded project is a synergetic effort involving an international team of archaeologists and researchers. The plan of work consisted of four primary components: 1) the recording and documentation of stone monuments from the site of Takalik Abaj using a variety of spatial and conventional techniques, 2) the processing and preparation of that data, 3) an evaluation of the results and their capability to improve iconographic and epigraphic analysis, and 4) the preparation and dissemination of the project results to the world-wide research community through web-based platforms for the purpose of long-term analysis and interpretation.

THE RECORDING AND DOCUMENTATION OF STONE MONUMENTS: METHODS

The corpus of stone monuments has been recorded using a combination of close-range and mid-range three-dimensional laser scanners, mapping-grade GPS, and high-resolution photography and other imaging techniques. Specialized imagery and photographic techniques such as Reflectance Transformation Images (RTI), high dynamic range imaging (HDRI), panoramic photos, and nighttime light-raking photographic techniques were used in conjunction with the other forms of documentation. Many of these same technologies were also used to capture data at the landscape and terrain level. These combinations of technologies, referred to collectively as High Definition Digital Documentation Survey (H3D), were employed to collect scales of information that ranged from the artifact, monument and feature, to the site-level and landscape area.
Three-Dimensional Laser Scanning

Three-dimensional scanning can substantially lessen, if not eliminate, most of the difficulties and restrictions including much of the subjectivity inherent in other methods of documentation. As with any technology, this method of recording does have specific applications and limitations. Nevertheless, in the majority of cases, three-dimensional scanning is considerably more rapid and acquires more robust and accurate data than any other method of documentation currently available.

Monuments that exhibited areas of faint carving or where the highest resolution was warranted, a Konica-Minolta VIVID 9i Laser Digitizer was utilized. This machine is a close-range, triangulation 3D scanner that has an accuracy of .05mm at a range of 0.6 m to 0.9 m, less than the diameter of a human hair (Konica-Minolta 2007). This unit excels at high-precision three-dimensional measurement and is capable of a fast processing speed for rapid and straightforward merging and editing of large amounts of measurement data. The choice of the VIVID 9i was also due to its proven ability to produce exceptional results in a variety of locales (e.g., labs, bodegas, museums, and archaeological sites including Takalik Abaj) and under a range of physical and climatic conditions (Doering and Collins 2007, 2008, 2010a; Doering, et al. 2006). Figure 7 contains a static scan images processed from the VIVID 9i data. Although the image illustrates the fineness and precision of the scan data, this image is a two-dimensional representations of the three-dimensional data.

Monuments were also captured in their entirety using another form of phase-shift, close range 3D scanner. The Surphaser 25HSX scanner, provided by Direct Dimensions, Inc. of Maryland, was utilized for both its speed and accuracy, enabling the capture of even the most complex monuments and geometry at a sub-millimeter level of detail. The Surphaser was employed on a number of the larger and more complicated shaped monuments, and was found especially useful for capturing context and monuments that were in relation to one another such as stelae and altars (Figure 8).

The Surphaser3D laser scanner was included as part of the project to record monuments selected by the Takalik Abaj Projecto Nacional archaeologists and AIST archaeologists as important monuments for analysis in their totality and not just their carved surfaces. These analyses of the scan data are assisting in the understanding of reuse and recycling of monuments through time, and in discerning different episodes of carving activities. The Surphaser scanner has the benefit of being a sub-millimeter accuracy scanner (<0.3 mm), but is able to scan at a rate of up to 1 million points per second at a distance up to 5 meters. This high speed and accuracy allows complete capture of objects in much less time. For example, Monument 1 from Takalik Abaj was scanned in its entirety in approximately 50 minutes. The Surphaser was also chosen because of its ability to easily work in outdoor environments and its portability (Figure 9).
Figure 7. Screen capture showing 3D laser scan of a section of Takalik Abaj Stela 1, using the Minolta 9i 3D digitizer.

Figure 8. Screen capture showing 3D laser scan of the entirety of Takalik Abaj Stela 1 and Altar 1, using the Surphaser laser scanner.
Figure 9. Typical set-up for the Surphaser laser scanner is shown during the documentation of Takalik Abaj Stela 2. An operator positions the scanner and runs the software from the connected laptop computer.

For monuments that were un-carved or considered to be non-narrative pieces, a FARO LS 880 3D laser scanner was used for documentation. This scanner uses a phase shift technology, with the ability to rapidly acquire large areas and objects in three dimensions, with an accuracy of +/- 3mm (Figure 10). The proficiency of the FARO LS scanner has been demonstrated on a number of projects by the authors, and can be combined with Nikon true color panoramic images. Used on architecture and terrain applications, the FARO scanner offers a realistic 3D documentation
Figure 10. Screen captures showing FARO 3D scan survey of Takalik Abaj Stela 18 (above). These data can be isolated (middle) and exported to allow for 3D modeling of the piece (below).
of the site, and can be used to produce detailed visualizations, contour and terrain models, and Computer Aided Design (CAD) drawings of select features and monuments with a high degree of accuracy (Figures 11-14) (Collins and Doering 2008a, b). Computerized visualizations of the resultant data produced by the three classes and ranges of scanners used on this project will allow iconographers, epigraphers, and other researchers to study the sculptures at a high level of detail on their office, lab or home computer monitor. This analysis can be as thorough and meticulous as if the object were physically present. The 3D models are viewable in true three-dimensions, and are able to be maneuvered a full 360 degrees. The software’s virtual light source can be adjusted to any angle to bring out or enhance desired detail, and accurate on-screen measurements can be made anywhere on the object’s surface.

Figure 11. Screen capture showing the registered point cloud from the 3D documentation of Takalik Abaj Structure 12, using the FARO laser scanner. Note that the black circular areas are the multiple station setups from which the individual scans were taken. These were then merged together to produce this area view.
Figure 12. Example of digital terrain model (DTM) produced from the point cloud data from the FARO laser scanner 3D documentation of Structure 12 on Terrace 2 in the Central Group at Takalik Abaj.
Figure 13. CAD drawing produced from the point cloud data of the 3D documentation using the FARO laser scanner of Takalik Abaj Structure 12.
Figure 14. Example of software processing of a digital terrain model (DTM). These models were produced from the point cloud data derived from the FARO laser scanning survey. This 3D documentation of Takalik Abaj shows Terrace 2 and 3 plaza areas (above), with Structure 6, located within this area, shown in higher resolution with terrain contouring.
Imaging and Photographic Techniques

All monuments that we documented as part of this project were recorded with high-resolution photography using a variety of types of equipment, lighting techniques, and software applications. The directors of the Takalik Abaj National Archaeological Project cleared impediments (e.g., ground cover, vegetation, soil, etc.) where possible from around monuments ahead of the documentation, to improve access and level of detail obtainable. There were a few non-narrative pieces whose locations were not amenable to scanning and were photographed as a primary means of documentation. An added benefit to the collection of digital images is that photographs can be used to drape over the three-dimensional data to provide true color models, especially useful for visualizing and examining carved characteristics with three-dimensional detail (Doering and Collins, 2010a).

Light raking photography, a beneficial standard technique in monument documentation was used to enhance subtle and abraded carved surface details on monuments at the Finca San Isidro and at the site of Takalik Abaj. This technique was used in part to document Stela 4, Stela 2, and Stela 1, as well as Monuments 40, 8, 67, 31, and 11 (Figure 15). Light raking photography was combined with laser scanning and standard photography to provide a more accurate and complete record. Used alone, images captured using light raking can introduce parallax distortion and are often taken from limited perspectives. Traditional techniques of recording monuments thus include various levels of subjectivity that, intentionally or unintentionally, lead to incomplete or erroneous interpretation (see Schele and Miller 1986:22).

Another type of photographic imaging technique employed on this H3D project is Reflectance Transformation Imaging (RTI) that was used on carved stone surface detail areas. This imaging technique uses variable light positions in more than 50 still photographic images. The multiple images are processed to create a Polynomial Texture Mapping (PTM) file that can be viewed to reveal fine details. A unified interactive viewing experience is possible using a freely available open-source computer program where the operator can control and rake light from a variety of angles to reveal minute surface features (Figure 16). RTI was used at Takalik Abaj on Altar 30 for the front carved surface of the piece, and on Stela 5 to provide a detailed view of the carvings on the sides of the monument. Additionally, Stelae 3, 41, and 42, now located at the National Museum of Archaeology and Ethnology (MUNAE) in Guatemala City, were also recorded using the RTI technique (Figure 17).

Panoramic Images were made of several plaza areas and vistas, and were used to visualize larger areas in a contiguous manner (Figure 18). These panoramic images are also useful for web site applications and serve as another way to represent the landscape and terrain details. Linking the panoramic images to known locations in a GIS web platform can enable viewers to ‘virtually’ visit the site and its surroundings (Figure 19).
Figure 15. Light raking photography was used to document Monument 8 (left) and Monument 67 (right) from Takalik Abaj increasing the ability to see faint carved elements as well as the effects of abrasion and surface wear.

Figure 16. Altar 30 was documented using Reflectance Transformation Imaging (RTI) and is shown here as a finalized polynomial texture map (PTM) file that is observed using an open-source freely available viewer. This software allows users to change the lighting using the circle or bars to the right of the image to reveal surface details.
Figure 17. Stela 3 shown in the PTM viewer with specular enhancement (above) to bring out fine surface details such as the texture drawn on the personage’s shoes, and shown using the digital light raking feature (below). Takalik Abaj Stela 3 is currently curated at the MUNAE in Guatemala City.
Figure 18. Panoramic image of Terrace 1 at Takalik Abaj

Figure 19. Example from the developing Takalik Abaj interactive website, allowing viewers to virtually visit locations depicted on the map and see features in higher resolution detail

High Dynamic Range Imaging (HDRI) is a photographic technique that uses multiple light exposures through a process of bracketing in digital photography. Images are rendered in the software and the lighting effects offer additional realism with illumination and reflections often enhanced. This technique was used on several landscape vistas and as a photographic documentation procedure on Takalik Abaj Monument 1 (Figure 20).
High resolution imagery acquisition was used for sculpture, monuments, and architecture as a primary form of documentation and this imagery provides another line of recording and inquiry for research (Figure 21). We utilized digital photography with control for lighting and color using coded scale bars for reference (Figure 22). This type of imaging adds to the corpus of materials collected and serves as a primary reference and visualization tool. These images can act as a stand-alone documentation method or can be integrated with a variety of other visualization techniques such as photo texturing of scan data, or for use with software applications that allow for web browsing at higher resolution (Figure 23).
Figure 21. AIST photographer Joseph Gamble works with his Guatemalan colleagues to photo document Takalik Abaj Monument 48.

Figure 22. This photograph demonstrates how control for elements of color, lighting, and scale were accomplished for the digital imaging of Takalik Abaj Monument 48.
Figure 23. Example of website application that allows for a high resolution examination using a zooming tool to observe surface detail of photographed monuments. Shown here is an example from the carved top of Takalik Abaj Monument 48.

Global Positioning System (GPS) Survey and Takalik Abaj Geographic Information Systems (GIS)

Our GPS survey of Takalik Abaj used a Differential Global Positioning System (DGPS) to provide sub-meter locational accuracy of all monuments, architectural, and other archaeological features. Differential correction techniques enhanced the quality of location data gathered and was performed both real-time and in post-processing of the data collected. The GPS data was used in combination with other forms of documentation to provide researchers and site managers with the ability to store, retrieve, visualize, and interpret the spatial locations and conditional details of the monuments collected. From these GPS data, a site-specific Geographic Information Systems (GIS) database for Takalik Abaj was developed. This GIS contains point and line features that were collected across the site, including private property portions to the north and south of the park. These data include linear features such as terrace and structure boundaries, roads, and paths. Point data were also collected at over 292 known monument and feature locations. These data were combined in the GIS with Digital Elevation Model data from the National Elevation Datasets that were derived from the Shuttle Radar Topography Mission (SRTM) and provided by the United States Geological Survey (USGS). Also included in the GIS were major roads, hydrographic features, municipalities, and contour intervals (Figure 24).
Figure 24. Sample GIS map showing GPS positions documented as part of the project survey along with newly acquired contour terrain details from the Shuttle Radar Topography Mission (SRTM) data.
Photographs of artifacts and features are used along with the locational position in the developing GIS and provide documentation of viewable contextual details that are beneficial for the management and understanding of the site (Figure 25). The base map previously produced by the Takalik Abaj Project archaeologists and cartographers has been georeferenced using the newly acquired GPS and scan data. The map is now able to be viewed in the GIS with spatial scale, measurements, and attribute information. This integration of photographs, historical base maps, and verified GPS locations are brought together for future web GIS applications and to establish a geodatabase that provides valuable information and spatial understanding of the site for managers and researchers alike. Additionally, specific terrain details derived from modeling of the FARO scan data was exported to an XYZ format that was brought into the GIS geodatabase for high resolution elevation modeling (Figure 26). These highly accurate terrain details along with the real-world GPS positional data are being used to rectify previous mapping done at the site that was based on more arbitrary referencing and spatial positioning. Results from this initial terrain modeling show that both the University of California Berkley mapping from the 1970s and the more recent work undertaken by the Takalik Abaj National Project include deviations in positional accuracy. (Figures 27 and 28). The GPS, terrestrial laser scanning surveys, and GIS geodatabase are long-term foundational aspects of the on-going collaboration between USF and the Takalik Abaj National Project. Collected data has been provided to the site managers, and training in software and GPS data collection has been conducted (Figure 29). Instrumentation has been supplied to the Guatemalan project directors and will remain on site. This equipment and technology transfer ensures the continuation of data entry and maintenance that will allow newly discovered areas, locations, and monuments to be included in the GIS, and for the Takalik Abaj personnel to continue to work with USF and manage spatial aspects of the site.

Figure 25. Example of how photographs are being linked to spatial locations as part of the GIS geodatabase development for future project web applications
Figure 26. Data brought into the site geodatabase include digitized features from the GPS survey, terrain and contours from the laser scanning survey and GPS positions of monuments. High resolution aerial imagery for the site area extent has also been acquired and included as part of the expandable GIS.
Figure 27. The base map for our spatial terrain data used in this example is the University of California Berkley map produced from survey work at the site in the 1970s. Substantial deviations in orientation and in the location of structures are noted when compared to the digital elevation model from terrestrial laser scanning. Despite using georeferencing techniques (fitting the base map to the terrain data in the GIS), spatial drift and errors are noted. Our current GPS and terrestrial laser scanning survey data are being used to more accurately visualize the site’s landscape and spatial dimensions.
Figure 28. The base map for our spatial terrain data used in this example is the Takalik Abaj National Project map from recent work at the site. Substantial inaccuracies in orientation and in the location of structures are noted when compared to the digital elevation model derived from terrestrial laser scanning. Although georeferencing techniques were used (fitting the base map to the terrain data in the GIS), spatial drift and deviations are noted. Our current GPS and terrestrial laser scanning survey data are being used to more accurately visualize the site’s landscape and spatial dimensions.
SURVEY RESULTS: THE PROCESSING AND PREPARATION OF THE SCAN DATA

The scan data collected in the field was processed by the University of South Florida’s Alliance for Integrated Spatial Technologies Computer Lab, which contains computers with adequate size and memory to handle the large data sets that are created in the 3D documentation of the monuments. The processed data yielded 3D models of the monuments that are opened or imported into a computer viewing environment to examine carved details and other aspects of modification such as evidence of use and re-use. Cross-sectional views, slices, and exact dimensional measurements (e.g., radius, height, and other metrological dimensions) of the monument can be made in freely available viewers, and these viewers allow for the examination of sculpture surfaces and even consideration of the piece in the round (Figure 30). Other sophisticated studies can be performed using a variety of 3D software renderers and analytic tools. These examinations include Surface Elevation Modeling (SEM) and 3D surface comparisons (Figure 31). Use of SEM analysis can lessen subjectivity in the interpretation of carved areas on monuments, and has been demonstrated as a useful tool for epigraphic and iconographic analysis (Doering and Collins 2010b; Doering, et al. 2006).

Three-dimensional software programs used in the AIST model development include Geomagic Studio versions 10, 11, and 12, and FARO Scene v. 4.5-4.7 that were used to document archaeological features, terrain and landscape mapping, and various monuments (Figures 32 - 33). Models created have been exported to a number of generic formats including .stl and .xyz ASCII data for archiving and have been stored in native file formats for viewing and sharing with...
the aforementioned software packages. Models of artifacts, features, landscapes, and terrains are also derived from a mix of 2D and 3D software applications such as Kubit, Pointools, Cyclone, AutoCAD, ArcGIS, Surfer, and Terramodeler. These softwares allow for different perspectives and derivatives of the data to be observed and considered, with screenshots and viewable files such as videos (.wmv and .avi) produced for further dissemination and electronic sharing via Web and computer applications. When all the data formats are integrated together, such as the high resolution digital photography and contextual and environmental details obtained from mid-range scanning, the sculptured pieces can be remotely analyzed to include a variety of scalar details, important to researchers and managers alike.

Figure 30. 3D model produced from scan data of Takalik Abaj Stela 2 showing multiple views of the monument
Figure 31. Surface Elevation Model (above) shows elevation and relief details of the carved surface. It was produced from the scan data of Takalik Abaj Monument 48 (below).
Figure 32. Static views of FARO LS mid-range scan data of a portion of Takalik Abaj Terrace 1. The data allow for terrain and architectural analysis within the point cloud. Shown here are screen captures in the FARO Scene software demonstrating metrological dimension examination and feature extraction (above) and three dimensional modeling and visualization of features (below).
ANALYSES OF THE DOCUMENTATION TECHNIQUES OF THE STONE MONUMENTS

Embedded on sculpted monuments are messages that articulated political ideologies and cosmological themes that formed a shared language of rulership and power within Mesoamerican communication spheres (Guernsey 2006). The Takalik Abaj Monumental Stone Sculpture Project is instrumental in developing new ways of studying ancient sculptures and their contextual landscapes. Traditionally, epigraphers and iconographers, people who study writing and symbols, used photographs and hand lighting techniques to try to tease out information on the stone so that it could be drawn by hand and studied. Conventional recording and analysis of carved stone monuments in Mesoamerica has, until recently, largely consisted of rubbings, sketches, tracings, and photo documentation from which two-dimensional line-drawings of surface details and carving are rendered. For purposes of replication, molds and casts were produced. Photographic techniques used to record information in the field included controlled lighting that caused shadows to be cast in order to enhance faint details and reveal contours carved in the stone. These shadows may, at the same time, conceal or obscure other detail critical to the observation and interpretation of the piece. Nevertheless, this technique has proven helpful in many cases, but it is time-consuming, laborious, and can introduce problems of spatial control and parallax, the apparent visual displacement of an object caused by a change in the position from which the image was made. This type of spatial distortion can introduce progressively increasing error when used to create line drawings.
Three-dimensional laser scanning, combined with high resolution photo documentation is now providing a more accurate and comprehensive tool for assessment and has the additional benefit of lessening the subjectivity inherent in conventional recording of stone sculpture. 3D scanning techniques provide the most objective and precise visualization of sculpted elements presently possible for comprehensive epigraphic and iconographic research (Doering and Collins 2010b; Price 1996). These methods allow an examination of symbols and icons in meaningful ways, such as accurate comparative analysis of styles and their social connotation. The resulting data can also permit the ‘life history’ of the stone to be visualized and deduced. The use, reuse, and recycling of the artifact can be examined and interpreted within the cultural process from its extraction to deposition (Doering and Collins 2010b).

Terrestrial laser scanning is non-contact and non-destructive. As the scanner works, it rapidly captures the surface geometry of an object with extreme accuracy and precision. Using specially designed software, 3D objects can then be viewed virtually as they are in reality. With computer extraction and enhancement tools, as well as digital lighting, a complete study and analysis of the object can be performed remote from the piece or site. Object size can range from small, hand-held artifacts to large stelae and carved stone monuments, stucco friezes, painted and incised rock faces, and even entire landscapes. The choice of scanner and software used is dependent upon the scale and detail of analysis desired by the researcher. Three-dimensional scans produce highly accurate and extremely dense data sets that can be used for a number of purposes and applications (Collins and Doering 2006, 2009).

In the study of carved stone and other artistic or communicative mediums (e.g., stucco, shell, wood, clay, and greenstone) in Mesoamerica, many obstacles, both natural and human-induced, have confounded researchers. From the subtlety of the carvings themselves, to natural factors such as erosion of surface texture, to lichen and fungus obscuring problems, to vandalism and looting. All of these factors cause a loss of archaeological visibility. Three-dimensional scanning as part of the documentation workflow is enabling not only detailed iconographic and epigraphic study, but allows the piece to be preserved and recorded completely. Data collected can be utilized by sophisticated 3D printers and milling machines that can replicate objects using the exact dimensional and surface information collected, without the need for using molds and casts that damage and weaken the stone and cause surface loss.

At Takalik Abaj, several of the monuments are imperiled. Their surface loss since the time of excavation is noticeable in its photographic documentation. Acceleration of deterioration comes from air pollutants and acid rain and other atmospheric contaminants (Varotsos 2009). Plant growth and lichens are another area of concern, as they adhere to the surface and can remove texture when they are removed, and also cause a diminished archaeological visibility (Figure 34). Laser scanning can overcome many of these surface degradation impacts, and can provide a snapshot in time of the monument’s current condition and allow a fine-scale analysis of surface detail (Figure 35). These analyses can provide new information or change previous interpretations and renderings (Figure 36).
Figure 34. Takalik Abaj Monument 64 is an example of a carved monument that is covered in lichen growth that diminishes the archaeological visibility of the piece. This monument was documented with standard photography, GPS, and short-range laser scanning.

Figure 35. Three dimensional model productions in Geomagic 3D software, shows the fine and abraded carved surface details that are not readily visible on the in situ piece.
Figure 36. Previous drawings (top) of monuments can be reviewed and adjusted using the scan data for comparison, such as the SEM of Takalik Abaj Monument 64 (bottom), illustrates differences in spatial positioning, size, depth, and detail.
Some researchers have focused on “finessing more details from old stones,” and have called for more accurate ways of getting at those faint carvings (Clark 1999:24). We suggest that a workflow for documentation should include high resolution imaging procedures (e.g. light raking, RTI, and HDRI), three-dimensional laser scanning at an appropriate scale and resolution, and GPS locational survey to provide for management and spatial context understanding for in-situ objects. Because there are multiple distance ranges, levels of accuracies, resolutions, and limitations among three-dimensional scanners, the appropriate tool that will address the specific research question at hand needs to be carefully considered. For example, if interest is in the carved elements and surface details, a short range scanner is more appropriate than a mid or long range scanner, which is more useful for capturing landscape and general terrain information. Attempts at three-dimensional documentation have been made using inappropriate scalar tools, with variable results often not able to be used to answer specific questions relating to iconography and epigraphic content. Figure 37 demonstrates the different data densities between short and longer-range scanning.

Figure 37. Point cloud data from two types of laser scanning surveys documenting the same piece. Takalik Abaj Stela 5 was recorded as part of a longer-range scanning survey (left) that captured all of the associated structure and plaza architectural areas. The same piece was also recorded using short-range 3D laser scanning (right) with emphasis on surface detail.

The physical capabilities as well as the limitations of the scanner and the conditions under which it is expected to operate also need to be studied. Factors regarding how to power the unit and protect it from outages and surges can be significant. For remote or outdoor applications, the
ability of the unit to operate properly under varying, sometimes extreme, climatic and environmental conditions have to be addressed. For example, some scanners require highly controlled laboratory conditions, lighting, or temperature may not be a good choice for working in jungles, tropical environments, or typical archaeological field conditions. Logistical and personnel considerations are dependent upon the apparatus and ancillary equipment necessary and are as important to the success of the project as determining if the scanner model will provide the accuracy and resolution necessary to fulfill the research requirements.

Utilizing the proper scale of analysis and following the proposed workflow for documentation that includes photography and GPS spatial recording, a number of monumental sculptures and carvings from Takalik Abaj are yielding new information for researchers. One such example is Stela 2, a monument that has been the subject of numerous documentation surveys. Previous archaeological inquiry concerning the piece has included light raking photography, molds and rubbings of the piece, and several iterations of line drawings, descriptions, and interpretations (see Coe 1957; Graham, et al. 1978:89-91; Sharer 2000:467; Sharer and Traxler 2006:248; Orrego Corzo and Schieber de Lavarreda 2001; Wolley Schwarz 2001).

As part of our H3D workflow, we documented Stela 2 using a number of techniques to assist in the virtual preservation of the piece in its current condition. This record included aspects of it archaeological context, spatial relativity, and meaning. Light raking photography was utilized to capture faint and eroded details and to cause shadows to be cast to reveal contours carved in the piece (Figure 38). Stela 2 is located in situ at a location just north of the National Park on Finca San Isidro property. The piece has been reburied and uncovered several times in its archaeological history; therefore, having an accurate spatial record of its location was also important to the present survey. This spatial location can be used for management of the resources and in research and in consideration of the larger landscape questions at Takalik Abaj.

Stela 2 has been interpreted as having a Cycle 7 initial series date (see Graham et. al. 1978; Thompson 1943; Proskouriakoff 1950; Coe 1957). These findings were based on the unevenly preserved iconography and glyphic content of the piece, and some of the subsequent explanations were made based on concurrence with documentation made by others and not by actually studying the piece in situ. In question, is whether surface flaking and intentional mutilation of the piece has altered the long count date carved on the piece. While measurements and surface viewing with photography, rubbings and molds have been made, the 3D data that was acquired allow for a virtual forensic analysis of the surface. Micrometer level measurements and analysis of the scaring caused by surface flaking or defacement indicate a Cycle 8 initial series date that changes the temporal placement of this piece (Figure 39-40).
Figure 38. Light raking photography was one recordation technique applied to the documentation workflow for Takalik Abaj Stela 2.
Figure 39. Three-dimensional laser scanning and modeling of Takalik Abaj Stela 2 allows for virtual light raking, metrology, and sectional analysis of the piece, demonstrating the presence of two additional ‘scar’ arc areas of consistent shape and size, where dots would have been present above the bar yielding a Cycle 8 initial series.
Figure 40. Measurements of the existing dot and the arc scars from the two removed dots show their diameter to be within sub-millimetric differences (35.274 mm, 35.213 mm, and 35.127 mm respectively).
APPROACH TO THE DATA AND ITS PRESENTATION

The purpose of the data capture and processing is to permit intensive and comprehensive analyses of the monuments that will be on-going into the future. In addition to evaluation of the styles of carving and iconographic and epigraphic content, researchers can conduct metrological surveys, examine the stone’s morphology and spatial context, and its use and reuse. We have attempted to make the presentation of the spatial data to the researcher as objective as possible. We believe that it is imperative that the investigator be able to make their examinations and reach their own interpretations and conclusions with little or no external or biasing factors. Alternatively, we realize that it is equally important to provide the examiner with the thoughts, ideas, and impressions of other researchers. The latter objective is achieved separately through additional data that is presented in text, image, and bibliographic form.

In addition to minimizing any visual subjectivity, we have also attempted to reduce any labeling or descriptive bias that is inherent in much of archaeological classification. To achieve the objectives of the project, interactive databases are designed to offer the researcher two ways of approaching the data. The first provides the viewer the opportunity to observe, consider, and analyze the monuments in an objective, unbiased manner, and includes such data as context (GPS) and high resolution imagery and terrain data. The second database directs viewers to past research and previous thoughts and interpretations of the objects through extensive bibliographic and image archives, as well as presenting the current data in several formats for visualization.

These two databases, which will be cross-promoting but use different information visualization presentation styles, are constructed and maintained as part of the on-going research evolving from the data collection portion of the project. The websites have data management plans to archive and protect the information obtained in this project, inclusive of the metadata. The University of South Florida AIST website will include a user-friendly interactive GIS interface that will allow visitors to the web portal to see where features and architecture are located, examine environmental and terrain data, and access photographic images that are linked to attribute details (Figures 41 - 42). This web portal will also have sections that showcase site level details, high resolution imagery, and 3D data from the project (Figure 43). Data will be ready for sharing and dissemination through web spatial data bases that can be easily accessed and freely available formats.
Figure 41. The AIST web portal will showcase the GPS and GIS data collected and associated metadata that provides a contextual and virtual site visitation through interactive visualization opportunities.
Figure 42. The AIST web portal will include the spatial survey data collected and associated images that will provide a contextual and virtual site visitation through interactive visualization opportunities. These data can be viewed through such freely available software as Google Earth (shown here as example) that allow for greater landscape understanding.
Figure 43. Example of the Takalik Abaj web portal format on the AIST project page showing imagery taken of Altar 12. This web portal section will contain digital images from the project (above) that can be interactively viewed and analyzed in higher resolution using a zoom feature in the software viewer (below).

The second database is part of the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI) web portal. The Takalik Abaj work has been incorporated into the Mesoamerican Three-Dimensional Imaging Project that was created by Doering and Collins in 2006 with FAMSI’s support. The intention of this portal is to share and disseminate 3D imagery of stone monuments and other artifacts from Mesoamerica and to promote and facilitate their investigation and analysis internationally (Figure 44). The FAMSI web portal format contains primary reference source information, and two and three-dimensional data, images, videos and screen captures from a variety of projects. The FAMSI database is unique in that it is a relational database, with extensive cross-connected resources, references and research. The FAMSI web portal has an international demographic and is presented in both Spanish and English, with hundreds of thousands of hits and inquiries to the site annually.
CLASSIFICATION AND DESIGNATION OF MONUMENTS IN THE DATABASES

Our efforts have been directed toward providing the researcher with the opportunity to examine the monuments and their sculpted content with a minimum of subjectivity or bias (see Doering and Collins 2010a). We use broadly accepted typological nomenclature and attempt to avoid stipulative definitions or titles that attach unsupported connotations to the meaning of the object (e.g., flyers, barrigons, swimmers, ancestors, deities, etc.). The objective of this designation approach is to allow the viewer to draw their own conclusions regarding the stone, its form, content, and context with minimal interpretive burden. Because many of the carved stones can now be visualized by researchers with clarity, detail, and comprehensiveness not previously unavailable, and in many cases can be viewed, measured, and evaluated more precisely and comprehensively than if the object was examined in situ, the examiner can make their observations independently, free of intended or unintended preconceptions.

“All classification is arbitrary” (Beaudry, et al. 1993:52). The subjective naming of an artifact, monument, or feature can distort its intended function and meaning (Beck and Jones 1989). Labeling is a critical exercise that is frequently applied without judicious attention to is tendency to bias interpretation (Hamilakis 2007). The naming or classifying of an archaeological object impose categories, and hence order, upon the object, but this act can also misrepresent the object or its use and significantly interfere with its interpretation. In other words, subjectively or
inaccurately named objects can suppress alternative thought and inadvertently restrain research designs.

An example of this type of interpretive diversion is the original categorization of a particular type of carved stone monuments found on the Southern Gulf Lowlands at the Olmec settlements of San Lorenzo, LaVenta, and El Marquesillo as “altars,” a descriptive term used in 1926 by Blom and LaFarge (1926:86-88). The usual interpretation of the term altar implies a place at which religious rites are performed or on which sacrifices are offered to the gods or ancestors. For fifty years this term guided the interpretation of carved stone monuments that were branded as altars. Grove (1973), however, demonstrated that these monuments were, in actually, thrones of Olmec rulers that carried considerable sociopolitical implications that are dissimilar to those that are associated with places of sacrifice. This rectification of terminology has substantially changed the research community’s interpretation of these monument types and, at the same time, provided a greater understanding of the hierarchical nature of Olmec rulership and its dependence on ideological power (see Doering 2007:107-111). We have worked collaboratively with the Directors of the Proyecto Nacional Takalik Abaj, to develop a metadata system of information that will be used with the FAMSI web portal database (Appendix A). This system will provide common nomenclature and descriptions for publications and other web information sharing applications that come from this project. Any descriptive terminology will be found under key words or in bibliographic references, and naming of pieces will be done in such a way that superfluous details are omitted to reduce bias in the interpretations.

The following is an explanation of the nomenclature used in the system of the labeling of the stone monuments. The labeling of Takalik Abaj monuments follows those used by Schieber de Lavarreda and Orrego Corzo (2010) that were proposed by Miles (1965b), Parsons (1986), and Graham (1982; 1979, 1981, 1989, 1992; Graham and Benson 2005; Graham, et al. 1978). The terms are described, some with additional background information to clarify the meaning or intention of the terms.

**Monument:** the term “monument” is used frequently in this database and is intended to be a general classifier that can be applied to any or all of the stone objects under discussion. It is used in reference to carved and un-carved stone objects that were believed to have been produced and erected to convey historical, ideological, or political information.

Monuments may have been used to reinforce the primacy of contemporary political power, or used to educate the populace about important events or figures from the past. Monuments vary in size, style, morphology, and context. Their social meanings are rarely fixed across time and space being frequently 'contested' by different social groups or changed according to shifting ideological standards. As Schieber de Lavarreda and Orrego Corzo (2010:178) state, “The function and meanings of these stone monuments have changed through time and will continue to do so...”
Also contributing to the complexity of meaning or interpretation is the fact that some stone monuments have been reused or recycled and may need to be considered at multiple levels (see Doering and Collins 2010b). For example, San Lorenzo Monument 53 (Colossal Head 7) was originally an Olmec table-top throne that was later recarved into a colossal head (Porter 1989). For the researcher, this act raises numerous questions: was its last materialization the most important in the stone’s life history, or what, if any, is the relationship between these two distinct types of symbolic monuments? Was the recarving an act of veneration, respectful ideological transformation, or willful obliteration?

**Stela:** free standing, upright stone slab embedded in a horizontal surface (Houston, 2001). The stone may or may not be intentionally formed or carved. Plural: stelae.

Some of the earliest stelae appeared in the Middle Formative period. Those at La Venta and other sites from this period may have been intentionally shaped to replicate the form or morphology of ceremonial jade celts. This intent or concept is supported by deciphered Maya text carved on to stelae that suggest the “precious stones” were large, monumental celts and axes (Stuart, 2010:291; see also Porter, 1992; Taube, 2000).

In Middle Formative period complex societies of Southern Mesoamerica, a “Stela Cult” has been recognized as being closely linked to ideology and rulership (Newsome, 2001:686-687). Dynastic and calendrical rites centered on the erection of stelae by elite factions of the societies. The cult is believed to have originated in La Venta and spread south to the Pacific Coast where it flourished in the Late Formative period at Izapa, Kaminaljuyú, and Takalik Abaj as well as in the Maya lowland sites of Nakbé and El Mirador (Hansen, 1991; Guernsey 2006).

**Altar:** usually a raised structure on which sacrifices are offered or incense is burned in worship; an object which serves as a center of worship or ritual.

The use of the term “altar” has, in some cases, led to misidentification or misinterpretation of monuments. Matthew Stirling (1943) applied the term “altar” to large Olmec monumental sculptures that resembled “stone tables” (Grove 1973:129). In his influential paper, David Grove (1973) demonstrated that many carved stone monuments identified or classified as altars, were indeed thrones of rulers.

The pairing of a stela and an altar typically combines an erect stone stela with a low stone altar. The origin of the altar-stelae complex is unknown, but by the Late Preclassic period the pattern had become well-developed at Izapa and Takalik Abaj. “The paired stela-altar format represents a conceptually unified ideological vehicle that was used to transmit powerful messages concerning Late Preclassic rulership and the nature of its performance” (Guernsey Kappelman, 2004:100). Figure 45 below illustrates the relative positioning of the stela (Takalik Abaj Stela 18) and its associated altar (Takalik Abaj Altar 6). Possibly because of the prominence of the stela-
altar complex, especially during the Classic Maya period (Newsome, 1996), many stone monuments have been identified as altars based solely on their spatial position relative to stelae. An example of a monument identified as an altar because of its location in front of a stela, is Takalik Abaj Altar 13 (Figure 46). This carved stone lies in front of the un-carved Stela 17. It is reasonable to assume that this monument was originally carved and erected as a vertical stela. It was later broken and re-used, placed in the position of an altar relative to Stela 17 (Orrego Corzo and Schieber de Lavarreda 2001; Graham, et al. 1978). Therefore, Takalik Abaj Altar 13 has at least two identities and purposes that need to be considered.

Figure 45. Takalik Abaj Stela 18 and Altar 6, illustrating the typical positioning of these types of monuments within the altar-stela complex
Figure 46. AIST Photograph of Takalik Abaj Altar 13.
Throne: The chair or seat occupied by a ruler or king, literally a seat of power. Examples of stone thrones are frequent at Formative period sites, with changes in style, form, size, and iconographic features occurring from the Early to the Late Formative periods. Depictions of rulers seated on thrones are also known (e.g., Oxtotitlan cave, Takalik Abaj Monument 48, and Takalik Abaj Stela 5) (Figure 47). The terms altars and thrones have been used interchangeably in Mesoamerican literature for reasons discussed above.

Figure 47. AIST Photograph of Takalik Abaj Stela 5 that shows the carved image of a ruler seated on a throne.
**Reused/Recarved/Recycled:** indicates the monument has been modified in some manner and used in a manner(s) different from its original purpose or context.

**Barrigón/Potbelly:** These are terms used to describe various sculpted forms of anthropomorphic figures that generally display a rotund physical appearance (see Thompson and Valdez Jr. 2008). These personages usually have distinctive facial features, such as puffy faces and closed eyes, and they grasp their ample stomachs (e.g., Takalik Abaj Monument 40 (aka Barrigon 40) (Figure 48), Monte Alto Monument 4, San Juan Sacatepequez Monument 1). In some cases, the sculpture is only of the head of the individual (e.g., Monte Alto Monument 10, Takalik Abaj Monument 99). Guernsey (2010) has argued persuasively that the narratives depicted through these figures are not directly related to the girth of the personages, but in the iconographic details they contain. If her hypothesis is correct, then the terms barrigón and potbelly may bias a researcher’s interpretation.

![Figure 48](image)

Figure 48. AIST Photograph and laser scan 3D model of Takalik Abaj Monument (Barrigon) 40 that is today located in front of the Finca San Isidro.

**Captives:** Commonly associated with individuals who have been subdued and bound for sacrificial purposes. Specific poses, symbolic characteristics (e.g., hands tied behind the back, cropped hair, naked or minimally dressed), and submissive postures are common attributes of captives depicted in stone (see Marcus, 1974; Doering and Collins 2010b; Baudez and Matthews 1978).
Boulder Sculpture: This term is used to describe “the use of large stones in which the natural contours remain substantially recognizable and distinguishable” (Graham 1982:16), and can result in relief or in-the-round sculptures (Schieber de Lavarreda and Orrego Corzo 2010:182).

Petroglyph: Also called rock engravings, are pictogram and logogram images that have been created by removing part of a rock’s surface by incising, picking, carving, and abrading. Petroglyphs are frequently associated with unmodified rocks in their natural context.

PREPARATION AND DISSEMINATION OF PROJECT RESULTS

Primary among the platforms for dissemination are expandable web-based, electronic databases that allow for the data to be freely shared, and any new or subsequently available information can be readily added. The databases that will be used are the Alliance for Integrated Spatial Technologies web portal (http://aist.usf.edu) and the FAMSI website (www.FAMSI.org). Symposia and seminars, specific to this project, will be organized and presented at international academic and research meetings such as those of the Society for American Archaeology, the Simposio de Investigaciones Arqueológicas in Guatemala, the Southeast Conference on Mesoamerican Archaeology and Ethnohistory, and others. Journal articles are planned for appropriate peer-reviewed publications such as Ancient Mesoamerica, Latin American Antiquity, and the Journal of Field Archaeology among others. Curriculum development in areas of archaeological methods and spatial technologies at the University of South Florida will also benefit from this project. Collaborations and research between the authors and the Proyecto Nacional Takalik Abaj will be pursued, and assistance with the on-going development of documentation procedures such as GPS and GIS at the site is anticipated.

The methods used and results generated by this project will also be disseminated in the spatial technology sector. Articles will be submitted to 3D Scanning Technologies, and ISPRS Journal of Photogrammetry & Remote Sensing, and presentations will be given at the Annual SPAR Conference on 3D laser scanning and the Geomagic Convergence International Users Conference. The PIs are members of the International Council on Monuments and Sites (ICOMOS) and the international meetings can be a presentation opportunity. Collaborative efforts with Guatemalan researchers will be sustained, with the Directors of the Proyecto Nacional Takalik Abaj able to utilize all of the various prepared data, models and images derived from the project for further research, publication and dissemination.

Technology transfer to the Proyecto Nacional Takalik Abaj allows Guatemalan investigators to use the datasets and to keep track of locations, conditional assessments, and other attribute information. A laptop computer, a mobile GPS handheld processor with 1 to 3 meter accuracy, and all applicable software and training has been provided to the site’s archaeological staff. This equipment and training allows a continuation of portions of the documentation process after the current project has ended.
CONCLUDING REMARKS

A consensus of leading researchers at the 2007 Dumbarton Oaks Pre-Columbian Symposia and Colloquia, held in Antigua, Guatemala is accurately summarized by the organizers Clark, Guernsey, and Arroyo (2010:5) that a “troublesome fact is that Preclassic sculptures are generally under-reported, understudied, and/or poorly illustrated.” We believe that the Takalik Abaj Monumental Stone Sculpture Project is a major step in rectifying this situation by producing the most accurate and accessible documentation, imaging, and background material currently possible. Scholars, students, educators, and investigators around the world will have the opportunity to visualize and analyze the stone sculpture from Takalik Abaj in ways not previously possible.

The ability to share these data with researchers internationally over the long-term is crucial when unique or remote objects, such as those at Takalik Abaj, are to be examined. The capacity for the interpretation of these archaeological materials is maximized when repeated examination can be conducted over significant periods of time. The resulting project databases are designed to be dynamic, functional research tools that can be updated, improved, and expanded. In this manner, the objects can be analyzed by interdisciplinary experts, and future software developments and analytical techniques can be applied.

This project also demonstrates a successful collaboration between international researchers and agencies. The directors and staff of the Takalik Abaj National Project, Ministry of Culture and Sports and the University of South Florida’s Alliance for Integrated Spatial Technologies have worked together to produce one of the most advanced and comprehensive programs of documentation for purposes of research in Mesoamerican Studies. The research capabilities at Takalik Abaj have been enhanced and expanded significantly, and all parties involved in the project have and will continue to benefits from the work that has been conducted.

We believe the initial stages of the project have been successful and have more than met the original design. The true success of this project, however, can only be measured by its longevity, usefulness, and effectiveness as a reference and resource tool for researchers, and as an educational introduction to the archaeology of Takalik Abaj. We will continue to strive to make these objectives a reality, and continue to work with the Takalik Abaj National Project to ensure the success into the future.
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