Analyzing the Invisible

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Syntactic Interpretation of Archaeological Remains through Geophysical Prospection

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Abstract
Although space syntax analysis (SSA) has been applied to archaeological contexts for over 20 years, such studies have exploited this potentially valuable tool to analyze and compare only well defined and fully excavated architectural space. It is the prohibitive expense and considerable effort required to properly uncover buried architecture at large urban sites that limits the practicality of SSA for the archaeologist. Presently, the increasing use of geophysical survey techniques in archaeological investigations has created powerful yet underdeveloped methodological avenues for the analysis of large scale urban sites. Primarily used as a prospection technique to guide subsequent excavation, the improved quality and diversity of available geophysical instrumentation is such that clearer definition of buried architectural remains is now becoming possible. The following paper explores the potential of a combined methodology that follows geophysical survey with space syntax analysis of those structural elements that can be detected and visualized. To illustrate the proposed method, the results of a geophysical survey of a residential sector at the pre-Colombian city of Tiwanaku, Bolivia will be presented. This will be followed by a discussion of how SSA could be employed in its analysis. Although this paper is merely a conceptual starting point in the design of a new analytical system, this method has the potential to change the scale to which space syntax can be applied to the archaeological study of early urbanism.

1. Introduction

Increasingly applied to archaeological contexts, the following study joins a growing body of scholarship that attempts to retroactively apply the tools and concepts of space syntax analysis (SSA) and its variants (Hillier and Hanson 1984; Hillier 1996). With initial and continuing exploitation in diverse areas of the Old World (Banning 1996; Banning and Byrd 1989; Bonanno et al. 1990; Cutting 2003; Fairclough 1992; Foster 1989; Laurence 1994; Plimpton and Hassan 1987; Smith, A.T. 1996; Perdikogianni 2003; Thaler 2005), New World archaeology has risen to adopt similar methodologies seeing increasing application in areas ranging from the Canadian Arctic (Dawson 2002), Mesoamerica (Hopkins 1987; Hohmann-Vogrin 2005; Robb 2007), and South America (Moore 1992,1996) with particularly strong emphasis in the American Southwest (Bradley 1992, 1993; Bustard 1996,1997; Cooper 1995, 1997; Potter 1998, Shapiro 1997, 1999; Van Dyke 1999).

The obvious and numerous limitations of analyzing ruinous and incomplete architecture of any context is only further hampered in the New World by the ideological, aesthetic and symbolic disconnect that Western academics inherently face in contemplating the ancient built environment of the Americas. To do so is to "run the risk of forcing the interpretive enterprise beyond the limits of credulity, [as] there is an almost insuperable cognitive gap between the archaic, agrarian mind and the mind of the industrial world: they inhabit and are engaged by separate realities". (Kolata, 1993, 95). Although this basic inadequacy is reiterated in some capacity by nearly every archaeological study exploiting SSA, there comes a point when the absolute value of these methods as a tool to consider past social organization must be seriously questioned and perhaps abandoned.

The present paper will make such a critical consideration as informed by a case study at Tiwanaku, Bolivia, discussing the seemingly insurmountable limitations in analyzing architectural and social organization on the urban scale in both completely and partially excavated ancient cities. With relatively minimal broad excavation at Tiwanaku and thus an almost non-existent appreciation of the overall urban organization of the site, the basic requirement of SSA to have definitive and distinct spatial information about architecture is entirely lacking. As will be discussed, the present study attempts to address this issue through the use of geophysical prospection techniques to define the now invisible ancient built environment. This paper will hope to initiate a dialogue on the development of a considerably different and new variant of SSA that would be more appropriate to the quasi-quantitative but largely interpretive field of prehistoric New World archaeology.

2. Site Discussion

Located at the altitude of 3810 masl in the northern Bolivian altiplano near the shores of Lake Titicaca, Tiwanaku was the urban capital of an important pre-Incan Andean state whose power and influence extended from northern Chile and coastal Peru to the eastern lowlands of Bolivia from AD 600 to 1100. While early archaeological excavations at Tiwanaku (Ponce 1972) focused mostly on the temples and palaces located in the site's central monumental district, more recent studies have turned to investigate the residential periphery, an area measuring 6.5km2 once thought to be uninhabited (Fig.1A). Housing a projected population between 15000 and 20000 (Kolata 2003: 5), the urban and sub-urban population of Tiwanaku are thought to have been grouped into highly organized walled neighborhood compounds or barrios that were physically and symbolically separated from the civic and ritual core. Kolata (2004) argues that these residential areas were organized such that socio-economic status of barrio inhabitants decreased the further it was located from the ceremonial core. These distinct residential units contain collections of smaller domestic structures organized around private patios and have been considered to represent a heterarchical or "horizontal" urban organization which groups inhabitants along kinship and ritual lines (Janusek 2003, 2004). Excavations within a number of barrios across the site have shown evidence of craft specialization while others seemingly maintained ties with distinct ethnic groups from the eastern lowlands (Couture 2003; Couture and Sampeck 2003; Escalante 2003; Janusek 2003; Rivera 2003). With the suspected grid-like urban plan of the residential sectors at Tiwanaku buried beneath the current ground surface, our sense of the scale of this city is lost as is our understanding of the degree of homogeneity or variation between barrio structures and their inhabitants, with the ephemeral nature of construction materials and depositional processes obscuring our understanding of the true monumentality of the site.

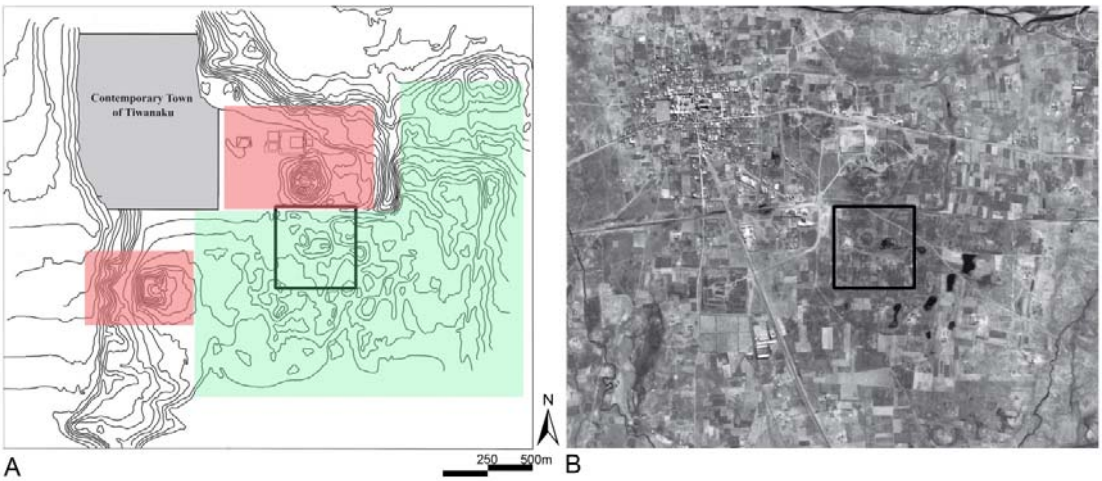

FIGURE 1A: Topographic map of Tiwanaku with monumental architecture and ancient and modern residential areas highlighted. Area bounded by the black square at centre shows the Mollo Kontu Survey area depicted in Fig. 2. (0.5m contour interval)

Residential area

Ceremonial area with monumental architecture

FIGURE 1B: Arial photograph of the same area.

Figure 1

Located approximately one kilometer south of the site's central monumental district, McGill University's Proyecto Jach'a Marka has conducted topographic and geophysical survey in conjunction with large-scale excavation of a non-elite walled barrio neighborhood and nearby cemetery known locally as Mollo Kontu (hereafter MK). Recent excavations at MK have shown that major adobe perimeter walls thought to enclose the sector are aligned to the cardinal directions tend to be built one on top of the other, suggesting great continuity in the organization of architectural and social boundaries across time (Couture 2003). While the University of Chicago's Proyecto Wila Jawira conducted preliminary excavations in residential sectors in several areas of the site, as of yet no compound has been excavated in its entirety. As such, the size, internal organization, and duration of a "typical" Tiwanaku residential compound are still unknown (Kolata 2003). It is suspected that the appearance of homogeneity imposed by Tiwanaku's rigid grid plan may be masking considerable economic and social diversity in the organization and of use of internal domestic space within and between compounds (Williams et al, 2007). With the remains of these specific structures as the primary target of my current research, I had hoped to refine our knowledge of barrio form and clarify the overall organization of this particular residential area and by extension the entire site as well. As will be discussed, the results of this study provided some indication as to the overall directionality of this ancient residential sector, but relatively spurious data about the architecture internal to these barrios and even the location of the compound boundary walls themselves.

3. Geophysical survey through magnetic gradiometry

As a non-destructive method to detect and visualize the remains of the built environment over large areas, geophysical survey in the form of magnetometry is a promising avenue of investigation which allows for a more global perspective of the spatial organization of an entire settlement. Geophysical prospection enhances our understanding of the subsurface remains at Tiwanaku sites, including house foundations, boundary walls, drainage canals, wells, and tombs. Since most of the ancient architectural remains are not visible on the surface, geophysical prospection is an important means of obtaining information about the large-scale patterns of spatial organization at the MK site. Based on magnetic properties of the archaeological features under consideration and their contrasts with the surrounding soils, one can obtain distributional information on the spatial organization of all remaining architecture but cannot clearly distinguish between distinct building phases and occupations at the ancient capital.

Magnetometers measure the strength of the magnetic field over a point on the Earth's surface. This field contains many components including underlying geology, surface materials, and natural diurnal variations and the Titicaca Basin has one of the lowest mean values on the planet — approximately 26,000 nano-teslas (nT). In efforts to remove the effect of the above components and enhance highly local sources, two separate sensors are aligned vertically with a known separation to provide a measure of gradient measured in nT/m. (Breiner 1999; Klarich and Craig 2001; Kvamme 2003; Williams et al 2007). Now widely used as an initial prospection technique to guide subsequent excavation there are a small but growing number of studies that attempt to make greater use of the potentially rich spatial data that come about through various geophysical survey techniques (Benech 2007, Neubauer 2004).

4. Linking geophysics and Space Syntax Analysis: Potential fraught with limitations

The use of geophysical survey and mapping as a starting point for SSA has incredible potential as it provides continuous and homogeneous documentation of settlements at a scale that is simply impossible through traditional archaeological survey and excavation. Although geophysical survey is quickly becoming standard practice in Andean archaeology, subsequent space syntax analysis of the findings has yet to have been applied anywhere in the New World with only minimal application elsewhere (Benech 2007).

With his analysis of the Hellenistic and Roman site of Doura-Europos in Syria, Benech provided the first instance of an analytic methodology that follows geophysical survey with SSA interpretation of results. With an overwhelming number of limitations inherent to my survey at MK which will be

discussed below, Benech's innovative and thorough analysis of two housing blocks was made possible through a number of crucial advantages. With a strongly orthogonal 'Hippodamian plan', the urban organization of Dura-Europos is well established and full housing blocks have been completely excavated. This wealth of comparative and complete architectural and spatial data from archaeological excavation is only further supported by the availability of classical literature and sound architectural history of the period, providing a considerably more solid foundation on which to apply SSA to geophysical results than is presently possible in the Andes. From the geophysical perspective, the magnetic environment in the Near East has a much higher mean value (nearly double at ~45,000 nT) than is found in the Bolivian altiplano, a fact which allows for much more nuanced magnetic readings and thus higher resolution magnetic maps (Breiner 1999). Despite the relatively ideal conditions at Doura-Europos, by his own admission, Benech states that "A complete study would involve taking into account all excavated and surveyed dwelling units of Doura-Europos and the layout of streets in order to obtain a concerted vision of the organization of the public and private space of the city" (Benech 2007). The following discussion of the methodology used and results of geophysical prospection at MK will further underline the overwhelming difficulty in emulating Benech's study at Tiwanaku, and by extension anywhere in the Andes.

5. Methodology and results

As mentioned, initial excavations in the Mollo Kontu "D" (MK-D) study area uncovered wall foundations whose roughly North-South orientation closely matched those of the other residential contexts at Tiwanaku. In order to clarify any and all minute surface features that could indicate the presence of buried architecture, a fine-grained topographic survey over 16 hectares of the MK study area was conducted in 2007 (highlighted in Fig. 1 A/B, Fig. 2 A). Using this topographic map as a guide, a one-hectare area surrounding the MK-D excavations was targeted for intensive magnetic survey using a Gem Systems GSM-19W Overhauser gradiometer (Fig. 2 B). The magnetic survey area was first carefully cleared of any visible metallic debris that would interfere with data collection and was then divided into 25 discrete study units each covering an area of 400 square meters. This magnetic data was collected and processed in the field using Arc GIS and further processed and refined in the laboratory as a cohesive data set.

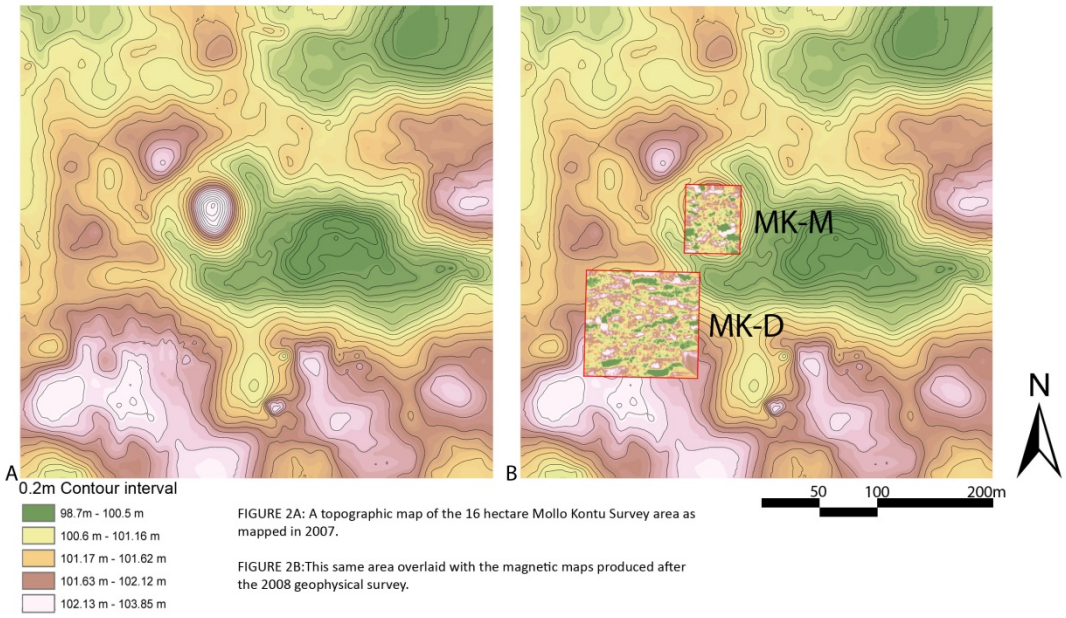

FIGURE 2A: A topographic map of the 16 hectare Mollo Kontu Survey area as mapped in 2007.

FIGURE 2B:This same area overlaid with the magnetic maps produced after the 2008 geophysical survey.

Figure 2

Following the completion of excavation and back-filling of MK-D, a magnetic survey was conducted over the closed units as an experimental control to test the resolution of the magnetic readings collected throughout the survey area in comparison to known architectural features (Fig.

3 A/ B). A second identical test was conducted by magnetically surveying the previously excavated Mollo Kontu Mound (MK-M) area, a small monumental structure with stone walls to the north of MK-D (Fig. 3 C/D). Considering that the soil used to back-fill the excavation areas should have nearly the exact magnetic properties of unexcavated ground, the magnetic anomalies shown as closely positioned and highly contrasting dark and light areas of the magnetic maps seem to correlate well with known architectural features when overlaid (Fig. 3 B/D). With this information about what the magnetic signature of cobblestone foundations of adobe walls should look like, hypothetical reconstruction of major compound walls and internal architecture was made based on the relative magnitude of the various anomalies (Fig. 3 B/D and Fig. 4 A/B).

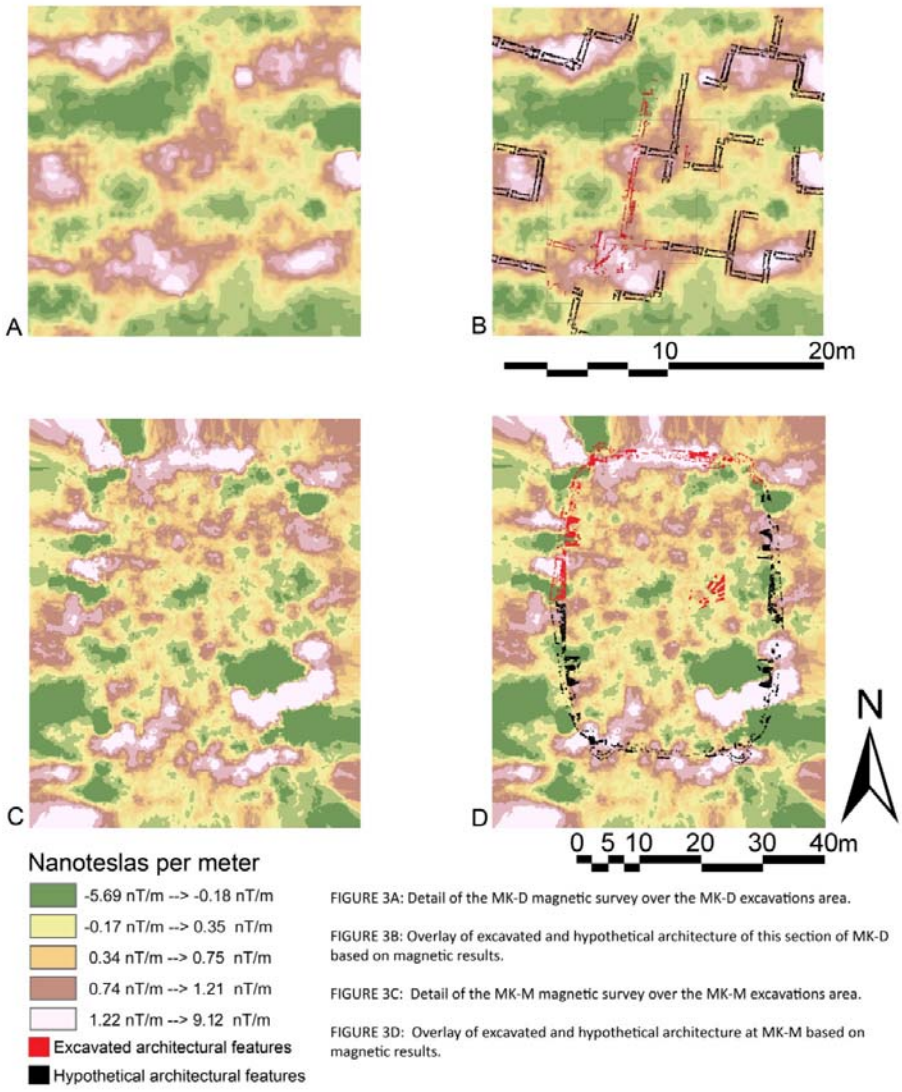

FIGURE 3A: Detail of the MK-D magnetic survey over the MK-D excavations area.

FIGURE 3B: Overlay of excavated and hypothetical architecture of this section of MK-D based on magnetic results.

FIGURE 3C: Detail of the MK-M magnetic survey over the MK-M excavations area.

FIGURE 3D: Overlay of excavated and hypothetical architecture at MK-M based on magnetic results.

Figure 3

As can easily be seen, the magnetic results in all areas are rather indistinct thus the placement of all hypothetical architecture is highly interpretive and not particularly elucidating in terms of the organization of urban space at MK-D. Figure 4 clearly illustrates the ambiguity of the results and the assumed spatial complexity of suggested architecture. Although there are nearly no distinct and recognizable discrete and repeated patterns that would suggest the presence of rooms and compounds per se, these results do suggest that there are two different overall alignments of the features, as differentiated by colour in Figure 4B. Through detailed stratigraphic excavation at MK-D, we are certain that there were at least 4 distinct phases of occupation at the site, with some partial evidence that the more recent occupations abandoned the very particular wall alignments of the earlier occupation phases, rebuilding over top of the ruined and leveled ancient city in an entirely different manner.

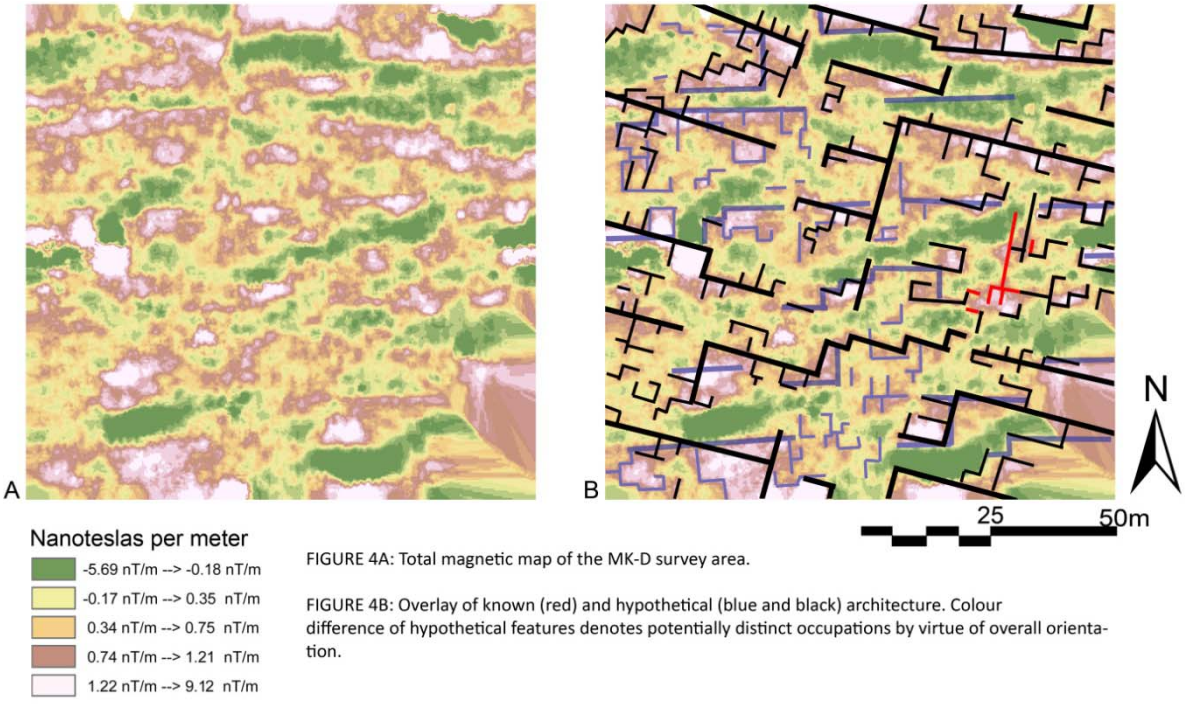

FIGURE 4A: Total magnetic map of the MK-D survey area.

FIGURE 4B: Overlay of known (red) and hypothetical (blue and black) architecture. Colour difference of hypothetical features denotes potentially distinct occupations by virtue of overall orientation.

Figure 4

Considering that the stone foundations of the earliest occupations were found at the relatively shallow depth of approximately 50cm from the present ground surface, it is entirely possible and very likely that earlier construction materials were reused by later inhabitants in the erection of new buildings. Keeping this potentially complicating factor in mind, one must also accept that the MK-D area and much of what was the residential periphery of Tiwanaku had been under intensive agricultural cultivation until the relatively recent protection by the Bolivian archaeological authorities, the Unidad Nacional de Arqueologia. With both manual and mechanical plowing easily reaching the upper archaeological contexts, it is very likely that stone alignments have been considerably disturbed and displaced throughout the study area, thereby effectively hampering any spatial interpretation through either geophysical survey or even excavation to a degree. Accepting that the entire area is likely to have been highly disturbed over time, it is not unreasonable to assume that contemporary metallic items such as broken ploughshares, tools and refuse could easily be incorporated into the soil matrix, further skewing the magnetic readings collected. Above all the final and perhaps fatal confounding limitation to this particular study comes about in above mentioned peculiar and uniquely low ambient magnetic signature of this area of the world, affecting the resolution and this spatial intelligibility.

As has been made abundantly clear, the natural and situational conditions at Mollo Kontu and Tiwanaku in general seem to emphatically resist any attempt to define a large-scale and detailed organization of the ancient city through geophysical prospection, thereby making any space syntax analysis meaningless at best and accordingly, will not be considered here. Suffice it to say that this particular archaeological case presents perhaps one of the worst-case scenarios for the application of a combined geophysical and space syntactic methodology. However, as will be discussed below, this limitation provides a unique opportunity to both critically examine the value of applying SSA to archaeology and prompts a discussion of the need for an archaeologically focused variant of SSA that makes pointed efforts to consider and address the limitations and strengths inherent to archaeology as a field to which SSA has enormous interpretive potential.

6. Assessing the value of SSA to archaeology and the need for a paradigm shift

After applying qualitative access analysis techniques of SSA to the prehistoric Anatolian sites of Çatalhöyük and Hacilar, Cutting (2003) offers a pointed and very realistic set of basic guidelines for the archaeologist hoping to pursue SSA as an avenue of investigation:

1) SSA is most effectively used where inside or outside spaces are differentiated by walls and partitions rather than by screens, furnishings, changes in floor level or repeated patterns of behaviour.
2) The technique requires a minimum level of information about connected spaces both inside and outside buildings, with clear entrances, complete buildings and open spaces and complete settlements â" or at least blocks of buildings.
3) The more spaces the better — the two-roomed buildings yield less informative numerical results than the building with five or more rooms.
4) Given that the configuration of the upper storey affects the value of the ground-floor spaces, and that upper storeys seldom if ever survive archaeologically, it is important at least to know the location of the link between ground floor and upper levels.
5) It is not worth attempting to use access analysis as a quantitative technique when too much information — for example, roof-top activity and movement patterns on roof-top entrance sites — is missing. Access analysis cannot be used to create data that no longer exist within the archaeological record. (Cutting 2003, 18).

Considering this list, and the ambiguous nature of spatial data available at nearly every archaeological site the world over, it begs to ask why so many archaeologists have gravitated to SSA and its variants? Quite obviously, the overwhelming archaeological desire to catalog, typify, organize, order and thus 'understand' the ancient past seizes the opportunity to quantitatively define the social, seemingly without the contaminating influence of biased contemporary Western ideology. This is not to suggest that anyone wholeheartedly adopts the numerical output of SSA as anything more than a potentially illuminating foundation on which to lend support to interpretation. By all means, the fundamental theories from which SSA proliferates today in architectural, urban planning and sociological capacities have continuously improving and nuanced application and value. However, these innovations have left archaeologists to independently create a undeniably faulty pastiche of ideas and methods with which they then attempt to use to shoehorn incomplete and extremely complicated data sets into some semblance of an interpretation.

Only relatively recently has SSA seen a concerted effort to incorporate elements of human perception and cognition, an aspect that one would assume to be of fundamental importance to what is essentially the study of human behaviour in response to space, and the reflexive relationship between society and the spaces they design. As Bafna (2003) states: "On the whole there is still a lack of an overarching theory that proposes a systematic social effect of the visual information available to a situated observer. In the absence of such a theory, the empirical work done on behavioural effects of isovists has not reported large successes despite displaying frequent technical innovation and methodological sophistication." (Bafna 2003, 26).

The very concept of developing an overarching definition of a "systematic social effect of visual information" is perhaps closer to the mark in terms of potential archaeological application, but such a generalization would again force the archaeologist to bend temporally distant and often largely unknown ideology into an ill-fitting model based on the present. Any form of an archaeologically specific SSA system would have to rely on a ideologically and environmentally specific set of variables that could be tailored to the particular case at hand, taking cues from both artefactual evidence and ethnographic comparison as is often the case in nearly all archaeological interpretation. Such a flexible and malleable form of SSA would depart from the scientific and into the phenomenological, creating a quasi-qualitative, quasi-quantitative system of thought that if developed, could lend support to interpretation of the remains of the built environment.

Primarily, there would need to be less emphasis on connectivity of built spaces abandoning the importance of access analysis and relative 'depth' considering the enormous variability and socially specific understanding of physical and abstract concepts of boundaries, and the use of space. For instance, symbolic concepts of colour change, light quality, superposition, subterranean elements, the presence of controlled watercourses and spaces with unmarked ritual or historic meaning, are all elements that go unconsidered even with isovist and axial line analyses that take some consideration of human visual perception if nothing else. As an example of the fallibility of the equating increased 'depth' with exclusiveness and restriction through access

analysis is in the argument that perhaps it is was the ability to see into such 'deep', restricted space such as the stereotypical ritual atop the distant peak of ceremonial architecture. This could very easily have been the intention of the social architects assumed to control the urban environment.

As Cutting makes explicit in her discussion of the power of using SSA as a 'tool to think with', she proposes the use of access analysis in a non-quantitative way that "enables the internal layout of individual buildings and the relationship between groups of buildings to be studied and compared in ways that are overlooked by descriptions of room sizes, the distribution of features and the proportion of built to non-built space." Quite rightly, she continues in stating that "Where the archaeological data are sufficient about room functions, thinking in terms of access analysis can highlight repeated associations between certain activities, access and privacy" (Cutting 2003, 18). This sort of flexible and creative application is exactly how archaeologists should approach SSA, with any new archaeologically specific form of analysis that may develop in future adopting a largely non-quantitative although rational and systematic methodology that is entirely sympathetic to what is assumed about to the society being considered.

It is precisely this type of yet to be designed analytical system that research at Tiwanaku could benefit. If, through continued excavation and survey, further evidence arose that suggested that bounded residential compounds were in fact the base residential unit, then without considering the nature of the varied activities with in these domestic units, interpretations of the orientation and interconnection between these barrios in relation to the ceremonial center or natural phenomena and landmarks of the site could be made. In such a hypothetical case the use of geophysical data to determine at least the location of barrio structures and general orientation would be valuable into and of itself. So, could currently available SSA techniques be applied to this particular case study? It is not a question so much of whether SSA could be applied to this situation to draw some form of numerically supported conclusion as would be entirely possible although futile, it is a question of whether it should be applied at all in its current form? The answer is overwhelmingly negative, but there is clearly a need to create a new system dedicated to the spatial and interpretive eccentricities of archaeological contexts.

Above all, it seems that in studying archaeological plans, both field and research archaeologists must make efforts in not only considering the space of an excavated or surveyed area, but must attempt to understand the nuanced elements of place, understanding that real people would have carried out their daily lives in and around the excavated buildings and settlements. To disregard the concept of place in the analysis of an archaeological space is to ignore the experience of the participant observer. It is though a combined consideration of how people may have interacted with each other and moved through and between public and private built and non-built space that creates a place out of a space. By quantitatively studying individual buildings or collections of buildings is to consider one tiny element of a once very dynamic place and thus work within a social vacuum that by no means could possibly reflect how society once functioned. Despite the seemingly cold quantitative gaze of SSA, the current form used by archaeologists is so rife with overly generalized value judgments as to the structure and operation of human societies both past and present, that specific custom and ideology are seldom if ever considered.

References

Bafna, S. 2003. Space Syntax: A Brief Introduction to its Logic and Analytical Techniques. *Environment and Behaviour* 35 (2003): 17-28.

Banning, E.B. 1996. “Houses, Compounds and Mansions in the Prehistoric Near East”. In *People Who Lived in big Houses: Archaeological Perspectives on Large Domestic Structures.* G. Coupland and E.B. Banning, eds. Monographs in World Archaeology 27, 165-185. Madison: Prehistory Press.

Banning, E.B., and B.F. Byrd. 1989. Alternative Approaches for Exploring Levantine Neolithic Architecture. *Paleorient* 15:154-160.

Benech, C. 2007. New Approach to the Study of City Planning and Domestic Dwellings in the Ancient Near East. *Archaeological Prospection* 14 (2007): 87-103.

Bonanno, A.T., T. Gouder, C.Malone, and S. Stoddart. 2005. “Monuments in an Island Society: The Maltese Context”. *World Archaeology* 22(2) (1990): 189-205.

Bradley, B. 1992. Excavations at Sand Canyon Pueblo. In *The sand Canyon Archaeological Project*, W.D. Lipe, ed. Occasional Paper 2, 79-91. Crow Canyon Archaeological Center, Cortez, Colorado.

Bradley, B. 1993. Planning, Growth, and Functional Differentiation at a Prehistoric Pueblo: A Case Study from SW Colorado. *Journal of Field Archaeology* 20 (1993): 23-42.

Breiner, S. 1999. *Applications Manual for Portable Magnetometers.* San Jose: Geometrics.

Bustard, W. 1996. “Space as Place: Small and Great House Spatial Organization in Chaco Canyon, New Mexico, A.D.1000-1150”. Ph.D diss., University of New Mexico, Albuquerque, 1996.

Bustard, W. 1997. Space, Evolution and Function in the Houses of Chaco Canyon. *First International Space Syntax Symposium Proceedings.* Ed. Bill Hillier. Vol. 2. London: The Bartlett School of Graduate Studies: Space Syntax Laboratory, 2 vols. 23.1-23.22.

Cooper, L. 1995. “Space Syntax of Chacoan Great Houses”. Ph.D diss., University of Arizona.

Cooper, L. 1997. Comparative Analysis of Chacoan Great Houses. *First International Space Syntax Symposium Proceedings.* Ed. Bill Hillier. Vol. 2. London: The Bartlett School of Graduate Studies: Space Syntax Laboratory, 2 vols. 22.1-22.12.

Couture, N. C. 2003. Ritual, Monumentalism, and Residence at Mollo Kontu, Tiwanaku. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 202-225. Washington: Smithsonian Institution Press.

Couture, N. C. 2003. Monumental Space, Courtly Style, and Elite Life at Tiwanaku. In *Tiwanaku: Ancestors of the Inca*, edited by Margaret Young-Sanchez, 126-149. Lincoln: Denver Art Museum and Universtiy of Nebraska Press.

Couture, N.C. and K. Sampeck. 2003. Putuni: A history of Palace Architecture at Tiwanaku. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 226-263. Washington: Smithsonian Institution Press.

Cutting, M. 2003. The Use of Spatial Analysis to Study Prehistoric Settlement Architecture. *Oxford Journal of Archaeology* 22(1) (2003) : 1-21.

Dawson, P.C. 2002. Space syntax analysis of Central Inuit snow houses. *Journal of Anthropological Archaeology* 464-480.

Escalante, J. 2003. Residential Architecture at La K'arana. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 316-326. Washington: Smithsonian Institution Press.

Fairclough, G. 1992. Meaningful Constructions – Spatial and Functional Analysis of Medieval Buildings. *Antiquity* 66(1992): 348-366.

Foster, S.M. 1989. Analysis of Spatial Patterns in Buildings (Access Analysis) as an Insight Into Social Structure: Examples from the Scottish Atlantic Iron Age. *Antiquity* 63:303-314.

Hillier B, and J, Hanson. 1984. *The Social Logic of Space*. Cambridge: Cambridge University Press.

Hillier, B. 1996. *Space is the Machine: A configurational Theory of Architecture*. Cambridge: Cambridge University Press.

Hohmann-Vogrin, A. 2005. Space Syntax in Maya Architecture. Edited by Bill Hillier. *5th International Space Syntax Symposium,* 279-292. Delft: Bartlett School of Graduate Studies, University College London.

Hopkins, M. 1987. Network Analysis of the Plans of Some Teotihuacan Apartment Compounds. *Environment and Planning B* 14(1987):387-406.

Janusek, J. W. 2003. The Changing Face of Tiwanaku Residential Life: State and Local Identity in an Andean City. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 264-295. Washington: Smithsonian Institution Press.

Janusek, J.W. 2004. *Identity and Power in the Ancient Andes: Tiwanaku Cities through Time*. New York: Routledge.

Klarich, E and N Craig. 2001. “Geophysical Survey in the Lake Titicaca Basin: Uncovering Elite Domestic Architecture at Pucara, Peru.” Paper presented at the annual international meeting for the Society for American Archaeology. New Orleans, 2001.

Kolata, A.L. 1993. *The Tiwanaku: Portrait of and Andean Civilization.* Cambridge: Blackwell.
Kolata, A.L. 2003. The Proyecto Wila Jawira Research Program. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 3-17. Washington: Smithsonian Institution Press.
Kolata, A.L. 2003. The Flow of Cosmic Power: Religion, Ritual, and the People of Tiwanaku. In *Tiwanaku: Ancestors of the Inca*, edited by M. Young-Sanchez, 96-125. Lincoln: Denver Art Museum and Universtiy of Nebraska Press, 2003. Kvamme, K.L. Geophysical Surveys as Landscape Archaeology. *American Antiquity.* (2003): 435-457.
Laurence. R. 1994. *Roman Pompeii, Space and Society.* Routledge, London.
Moore, Jerry D. 1992. Pattern and Meaning in Prehistoric Peruvian Architecture: The Architecture of Social Control int he Chimu State. *Latin American Antiquity* 3, no. 2 (1992): 95-113.
Moore, Jerry D. 1996. *Architecture and Power in the Ancient Andes: The achaeology of public buildings.* Cambridge: Cambridge University Press.
Neubauer, W. 2004. GIS in Archaeology – the Interface between Prospection and Excavation. *Archaeological Prospection* 11(2004):159-166.
Perdikogianni, Irini. 2003. Heraklion and Chania: A study of the evolution of their spatial and functional patterns. *4th International Space Syntax Symposium.* London: Bartlett School of Graduate Studies, University College London. 19.1-19.20.
Plimpton, C.L., and F.A. Hassan. 1987. Social Space: A Determinant of House Architecture. *Environment and Planning B* 7(1987):439-449.
Ponce Sanginés, C. 1972.*Tiwanaku: Espacio, Tiempo y Cultura*. Los Amigos del Libro, La Paz.
Potter, J. 1998. The Structure of Open Space in Late Prehistoric Settlements in the Southwest. In *Migration and Reorganization: The Pueblo IV Period in the American Southwest.* edited by K.A. Spielmann, ed. Anthropological Research Papers 51,137-153. Tempe: Arizona State University.
Rivera Casanovas, C. 2003. Ch'iji Jawira: A Case of Ceramic Specialization in the Tiwanaku Urban Periphery. In *Tiwanaku and its Hinterland: Archaeology and Paleoecology of an Andean Civilization, vol. 2: Urban and Rural Archaeology*, edited by A. Kolata, 296-315. Washington: Smithsonian Institution Press.
Robb, Matthew H. 2007. The Spatial Logic of Zacula, Teotihuacan. Edited by Bill Hillier. *6th International Space Syntax Symposium.* Istanbul: Bartlett School of Graduate Studies, University College London. 062.1-062.16.
Shapiro, Jason. 1997. Fingerprints in the Landscape. Edited by Bill Hillier. *Space Syntax First International Symposium.* London: Bartlett School of Graduate Studies, University College London. 21.1-21.21.
Shapiro, Jason S. 1999. Mud, Messages, And Museum Spaces. Edited by Bill Hillier. *Space Syntax Second International Symposium.* Brasilia: Barlett School of Graduate Studies, University College London. 42.1-42.12.
Smith, A.T. 1996. Imperial Archipelago: The Making of the Urartian Landscape in Southern Transcaucasia. Ph.D dissertation, University of Arizona. UMI Dissertation Services, Ann Arbor.
Thaler, Ulrich. 2005. Narrative and Syntax: new perspectives on the Late Bronze Age palace of Pylos, Greece. *5th International Space Syntax Symposium,* 323-338*.* Delft: Bartlett School of Graduate Studies, University College London.
Van Dyke, R.M. 1999. Space Syntax Analysis at the Chacoan Outlier of Guadalupe. *American Antiquity* 64 (3)(1999): 461-473.
Williams, Patrick Ryan, Couture, Nicole C, and Deborah Blom. 2007. "Urban Structure at Tiwanaku: Geophysical Investigations in the Andean Altiplano." In *Interdisciplinary Contributions to Archaeology: Remote Sensing in Archaeology*, edited by James Wiseman and Farouk El-Baz, 423-441. New York: Springer.