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NABATEAN TOMBS ORIENTATION BY REMOTE SENSING: PROVISIONAL RESULTS

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ABSTRACT

Thirty two rock cut tombs are studied, from Petra in Jordan) and Madaa'in Saleh (Hegra) in northern Saudi Arabia. Satellite images were used from Google Earth and its accessory facilities on compass and slope evaluation. Some comparison of orientations were made with in situ compass and total station reading. There is not an apparent predominate orientation, even though striking directions are found (due south, mostly western, some eastern) which at any rate are related to sunrise, sunset and sun's orbit, at solar stands (equinoctial, solstitial) when sun light could enter tombs' entrance of the magnificent sculptured facades. Tombs are rather made by wealthy chiefs and officers, and any definite conclusion on deliberate orientation is without a strong argument. Google earth positions compared to *in situ* measurements present an error of c.2°.

KEYWORDS: Nabateans, tombs, Hellenistic, astronomy, orientation, azimuth, sunrise, sunset, hegra, petra, google maps, Madaa'in Saleh, architecture

1. INTRODUCTION

Nabataeans appeared in the Jordanian, Transjordanian to northern Saudi Arabian area as pastoral nomads as so many other Arabian tribes (Bedouins) have done through the millennia till contemporary era (Mustafa et al, 2014). They had connections with Mesopotamia, while Alexander the Great's officer

Hieronymus of Cardia wrote of the Nabataeans as having an ascetic life with harsh laws. They were also known for their incredible familiarity with the desert and their ability to fade into it to evade enemy tribes. Their system of hidden cisterns dug deep in the interior provided water for their livestock and their people (Fig.1).



Figure 1. Nabatean tombs and sites in the wider near/middle east region studied in present work

The Nabatean tombs practices and inscriptions and the different symbols engraved on the red sandstone cliffs tomb facades has been a matter of research (Alzoubi & Al Qudrah 2015) and contain indications concerning the Nabataean habits pertinent to tombs and dead body protection, as well as, the role of religious and civil authorities in this regard (Wenning, 2001; Al-Otaibi, 2011, 2013, 2015),

The Nabataeans (1 c. BC to 2nd c. AD), were highly creative in their adaptation of the Greco-Roman construction techniques. Based on their specific natural resources and architectural elements, the Nabataeans developed their own techniques in rock-cut architecture (Haddad, 2015) and the tomb façades reflect the great skills of the masons of their time.

Impressive Nabatean tombs at Petra, Jordan, has been suggested to have a series of solstitial and equinoctial alignments which might have lately helped its selection as the cathedral of the city (Belmonte et al., 2013).

At Khirbet Tannur the Nabataean temple unearthed artifacts have contributed to our knowledge of the art and religion of the ancient Nabataeans. Of

the most intriguing items found at this site was a Nabataean zodiac, which has been dated to the first quarter of the 2nd c. AD

The zodiacal circle in the Nabataean zodiac found at Khirbet Tannur is supported by a winged niké (victory), and surrounded by a mural-crowned tyche (luck, fortune).

The symbols of the Nabataean zodiac conform to their Roman and Hellenistic counterparts but they are enlivened with original touches of artistic creativity. However, by far the most significant difference in the Nabataean zodiac is the arrangement of the order of the houses within the zodiacal circle. The Nabataean zodiac found at Khirbet Tannur is extraordinary in its two opposite and completely separate halves- aries to virgo and pisces to libra. Both halves start and culminate at spring and autumn equinoxes. Some archeologists think that this denotes the existence of two New Year celebrations, one in the spring and the other in the fall, and this might help explain why there were two great festivals at Petra each year (Fig.2).

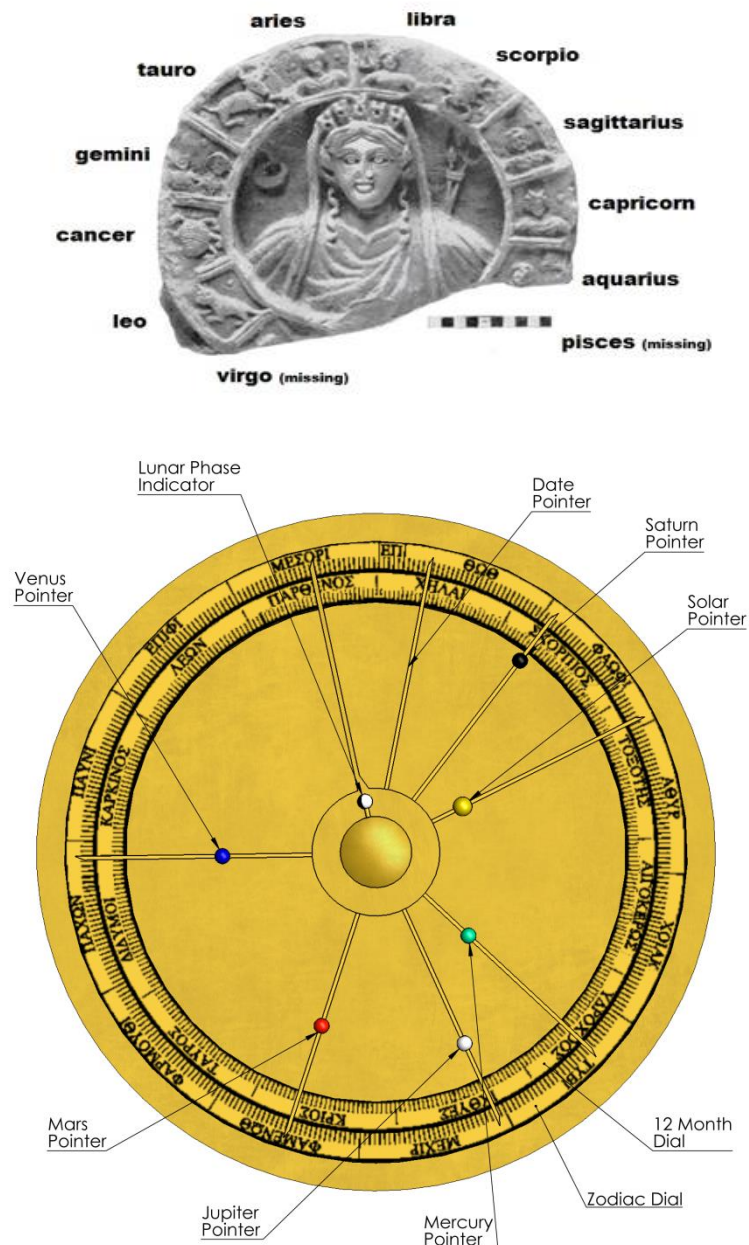


Figure 2. Upper: The zodiac symbols with half clockwise and half counter-clockwise, centered by Allat, the female goddess of fertility. Lower: The Cosmos on the front of the Antikythera Mechanism reconstruction with clockwise zodiac in Greek and Egyptian, second century B.C. (©2011 Tony Freeth, Images First Ltd. All rights reserved. <http://dlib.nyu.edu/awdl/isaw/isaw-papers/4/>)

The sky was a substantial element on Nabataean religion that is anticipated to reveal new data concerning their cultic worship as derived from the sky-scape, a usual practice with other earlier people (Liritzis & Castro, 2013; Castro et al., 2015).

Mada'in Saleh (ancient name Hegra), not far from present nearby town of al-Ula (22 km), was known as al-Hijr, or Hegra, by the Nabataean people who carved its magnificent tombs into the golden colors of Quweira sandstone outcrops. The delicate details on the entrance portals and the smooth surfaces of

its hundrend and more tomb façades reflect the great skills of the masons of their time. The splendor of the natural setting here must have reminded the Nabataeans of their capital, Petra, hewn into the rosey sandstone cliffs to the north in modern-day Jordan. It is no wonder that they chose this very spot to build their second city, Hegra, about 500 km southern to Petra. Both, Hegra and Petra are included in the UNESCO heritage list of protected sites.

Here we present the first preliminary results of our project AEGEANS2EAST regarding cultural in-

terconnections starting with the investigation of any significance of deliberate orientation of Nabatean tombs' from Saudi Arabia and Jordan, to celestial bodies in particular the sun.

2. SITES, MEASUREMENTS AND RESULTS

Thirty two monuments are studied, two Nabatean tombs, namely Al Khazn and Obeliskj tombs and

one temple at Ad Deir, from Petra, Jordan, and twenty nine tombs in Mada'in Saleh region, Saudi Arabia, three of which in some detail derive from the site Al Khuraymat (Fig.1). We applied remote sensing techniques making use of the Google Earth maps. The tombs from google maps start to appear around the rocks in the desert in any side of the rocks without any preference (Fig.3).



Figure 3. Aerial view of tombs 4, 5 and 6. Rock cut entrances just seen as openings around the promontory-like rocks.

A view of a closer up of the Tomb 6 in Madaa'in Saleh shows clearer the virtual façade and the context of the rock (Fig.4). Any little misplacement of

virtual cover does not alter the consensus of the alignment trend.

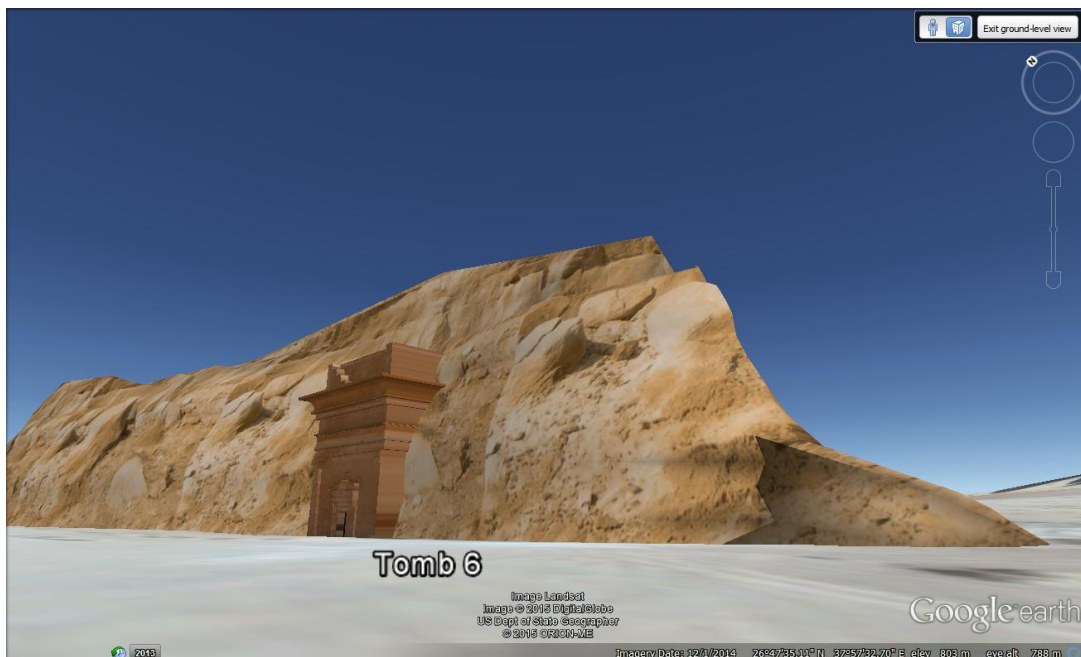


Figure 4. View of Tomb 6 at Madaa'in Saleh having western orientation

Another evaluation of the real and virtual facades is shown for the Khuraymat tomb (Fig.5).

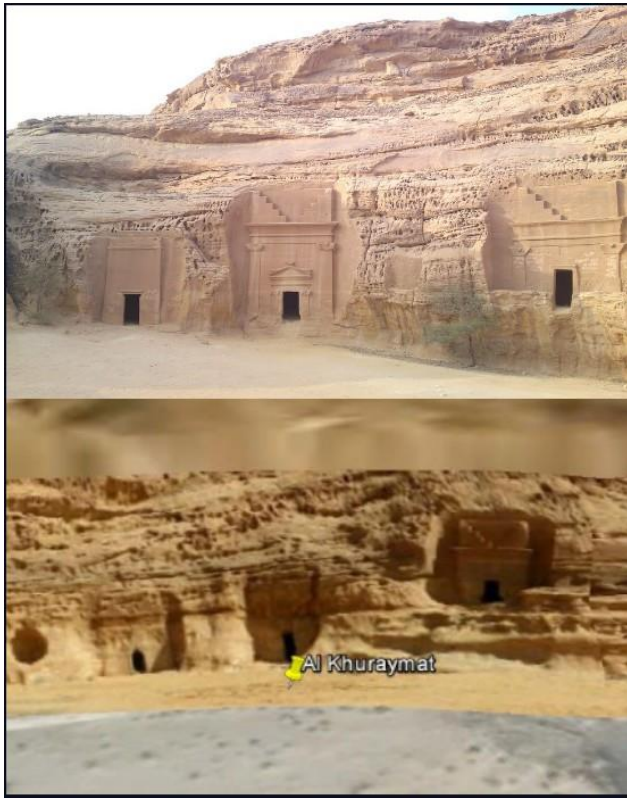


Figure 5 Al Khuraymat tomb in real (upper) and virtual (lower) versions.

Observing the locations of the tombs around a rock it is obvious the alignment yet towards a wide arc of the east to west horizon of low near zero angular altitude, due to the low altitude of adjacent scattered rocks.

Errors in Google earth compass tools computations with regard to in situ readings for azimuth and angular altitude is $\pm 1-2$ degrees. Results are given in Table 1.

The measurements of orientation have been conducted by means of remote sensing for its geographical position (φ , λ), azimuth (Az) and angular altitude of skyline (AAS). For the geographical coordinates and AAS, Google Earth and its different applications for altitude calculation and compass tools were applied. In Google Earth images the linear curve is drawn traced from the vertical to the facades straight line extrapolated to the furthest horizon point (Fig.6). Using the application for slope calculation one can see the relief of the landscape in front of the temple and following the straight line created the highest point of the horizon is computed (Fig.7). The application also provides the slope percentage and altitude which allows the calculation of the AAS. On the other hand the compass tool (Fig.7), is applied for the calculation of the Az of the monuments; hence the next step is using both of them with the appropriate astronomical software i.e. stellarium 12 and starry night (Liritzis and Castro, 2013; Castro et al., 2015).



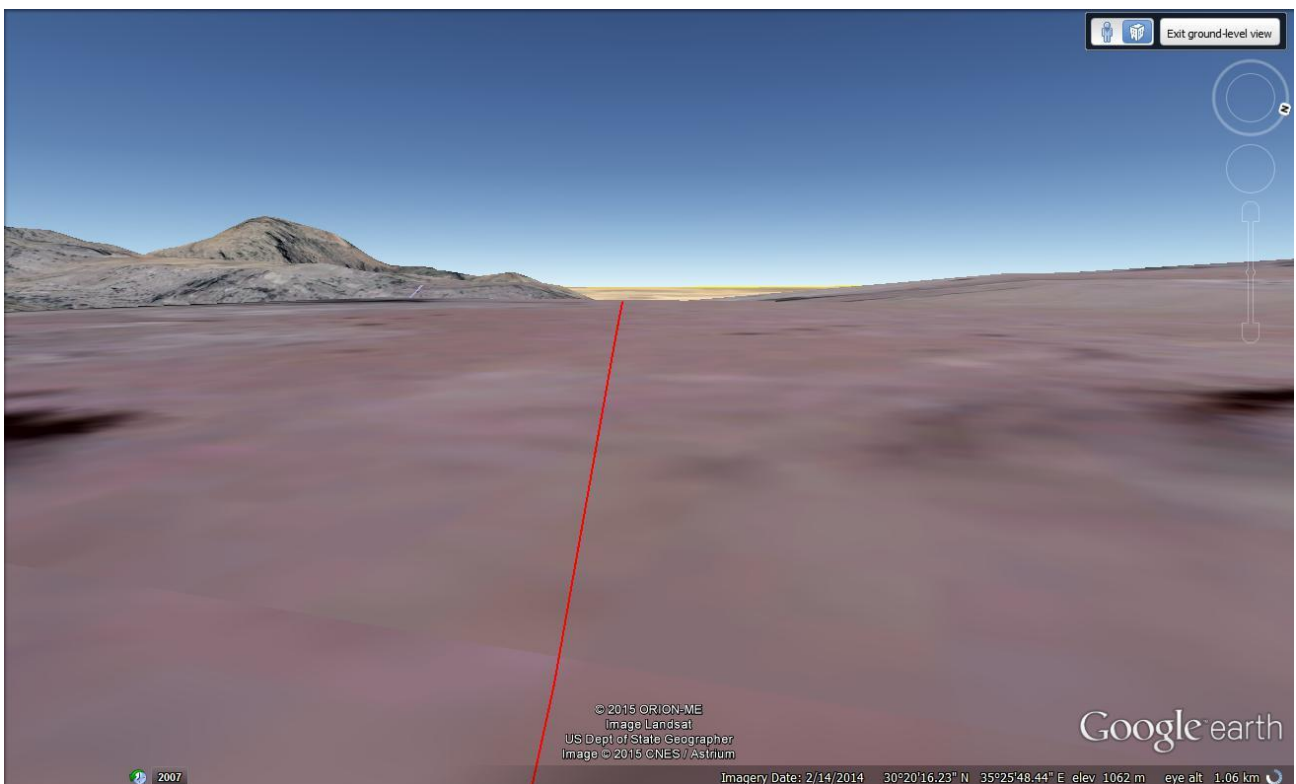
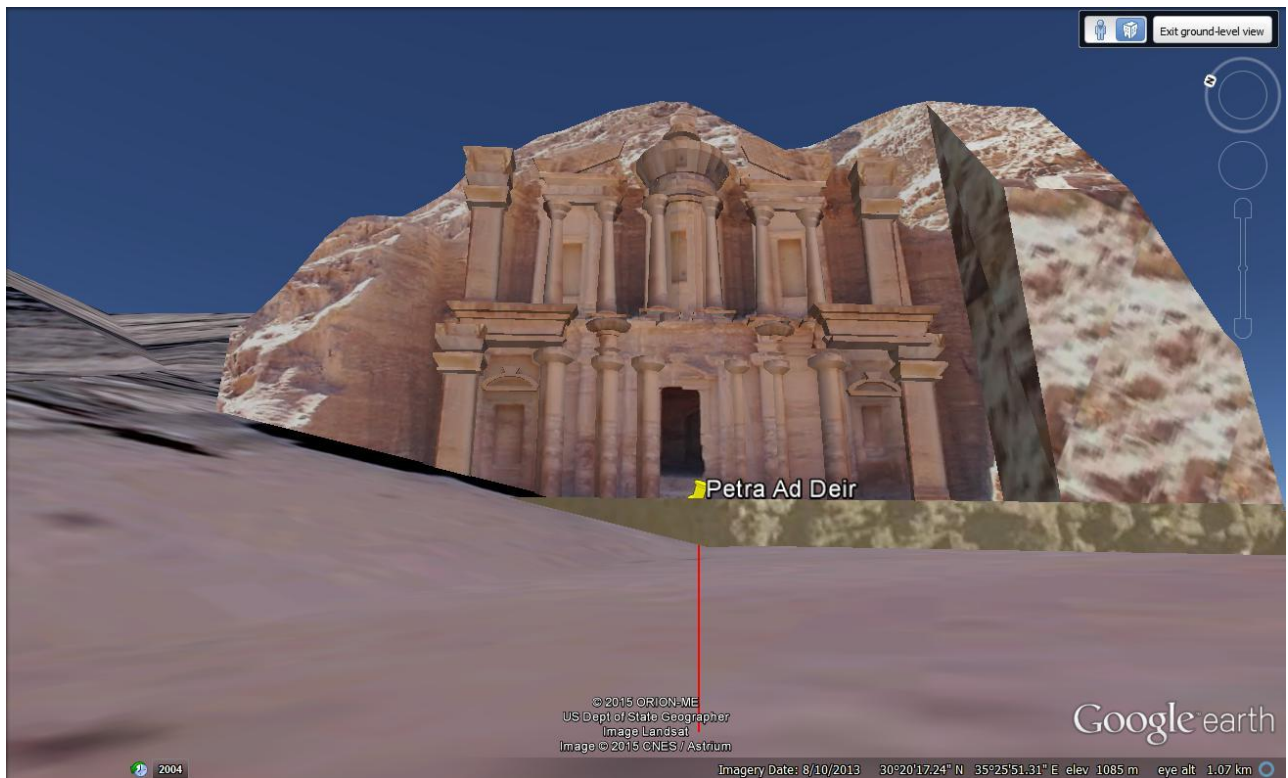


Figure 6. Upper: Petra Ad Deir, Middle: same in virtual representation, Lower: extrapolation of middle for AAS of 0 degrees.

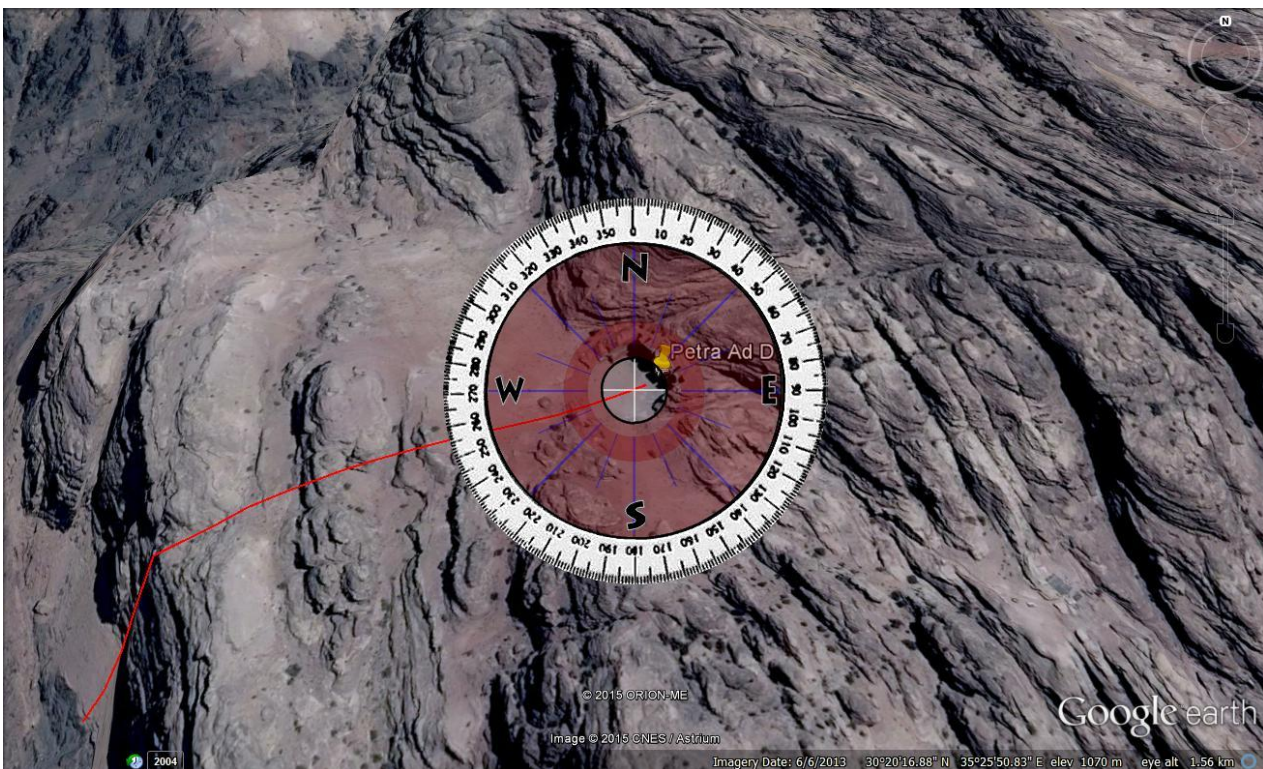


Figure 7. Upper: Ad Deir Petra with slope and compass application tools of google earth. The red line starts from the temples entrance towards left side clear horizon, followed by precipice. The elevation analysis below the image shows the same tracing line and must be read from left (Al Deir) to right. Lower: compass positioned N-S by Google with red linear curve extrapolation from temple entrance to the clear horizon on the left, followed by precipice, and marking the Az as a clockwise angle of 234°

Table 1 Comparative orientation measurements from Jordan (Petra) & Saudi Arabia (Madaa'in Saleh or Hegra) monuments.

	Monument Name	Monument type	Lat. & Long. (φ/λ)		Az ($^{\circ}$)	Orientation	H angular altitude ($^{\circ}$).
Jordan Petra	Petra Al Khazne, 1 st c. AD	Royal tomb	30°20'N 35°27'E	In situ (Belmonte et al., 2013)	65	E sunrise summer solstice	17.50
			30°19'20,50"N 35°27'05,62"E	Remote sensing	65	E sunrise summer solstice	19.30
	Petra Ad Deir, 1 st c. AD	Temple	---	In situ (Belmonte et al., 2013)	234 exterior 237,5 interior	W sunset winter solstice	8.50 exterior 7 interior
			30°20'16"N 35°25'52"E	Remote sensing	240	W sunset winter solstice	0
	Petra Obelisk Tomb,	Tomb	30°19'16,72"N 35°27'48,42"E	Remote sensing	310	W summer & equinox sunsets	7.40
Saudi Arabia Madaa'in Saleh	Tomb 1	Tomb	26°47'14,32"N 37°57'35,76"E	Remote sensing	180	S winter & equinox sunsets	0
	Tomb 2	Tomb	26°47'23,48"N 37°57'35,76"E	Remote sensing	180	S winter & equinox sunsets	0
	Tomb 3 Al Khuraymat, 1 st c. AD	Tomb	26°46'49,82"N 37°56'29,90"E	Remote sensing	185	S winter & equinox sunsets	0,90
	Tomb 4	Tomb	26°47'32,96"N 37°57'21,24"E	Remote sensing	130	SE winter & equinox sunsets	0
	Tomb 5	Tomb	26°47'33,33"N 37°57'26,07"E	Remote sensing	150	SE winter & equinox sunsets	0
	Tomb 6	Tomb	26°47'37,15"N 37°57'33,09"E	Remote sensing	270	W winter solstice sunset	2.50

Their orientation relate to solstitial to equinoctial sunrise and sunsets for azimuths ranged from due east, around west and southern directions. Paradise (2015) also reports orientations in the during sunrises and sunsets for Petra without quoting actual readings.

3. DISCUSSION

A first observation is that all studied tombs have not a similar orientation pattern but the three at Saudi Arabian ones. Also, there is no evidence of deliberate carvings inside the chambers and inscriptions. Tombs and graves were both collective and individual, and the historical development of tomb architecture appears to have had no observable influence on the terminology and/or intentional cardinal orientation. Thus the provisional character of present initial results only speculative can be considered until further investigation is performed.

It is however intriguing to prove that the Nabateans intentionally built their city with at least an exact position of the sun in mind.

In Petra the tombs are carved in local hills on a rocky landscape, in lieu of Saudi Arabian tombs that are in the middle of desert with flat horizon. Moreover, the difference between the tombs of Hegra and

those of Petra can't be explained by a different quality of the facades: several quite modest facades at Petra show more Hellenistic elements than some of the high qualified facades in Hegra do. Archaeological evidence shows strikingly the limits in architecture of the tombs set up to Hellenistic-Roman influence but by a strong indigenous tradition (Schmidt-Collinet, 1991).

In Petra the orientation of the two tombs is related to summer solstitial sunrise and sunset; the royal tomb at Al Khazneh realigned to solstitial sunrise may be related to sun-god Dushara and New Year celebrities (Bowers, 2006).

The three tombs at Madaa'in Saleh or Hegra (in Khuraymat) are within 2 km of the tomb we have labeled with the number 1 and have an exactly southern orientation of 180°. This orientation coincides with the onset of bright Crux, the cross constellation (alpha Crux of 0.77 apparent magnitude, compared to Vega of 0.03 and planet Venus of -4.3 and 1.98 for polar star) known for marking south, especially useful to navigators and nomadic movements. During summer solstice at sunset crux appears in front of the tombs and again at same position before sunrise of winter solstice (Fig.6).



Figure 6. a) Tomb at Khuraymat, alpha Crux of 1.25 magnitude under Centaurus (Sagittarius) before sunrise on the left of winter solstice for 50 AD. Red line is the extrapolation of the vertical to entrance towards the flat horizon Lower: the cross as seen in close up image (b)



b) The crux (cross) marking south

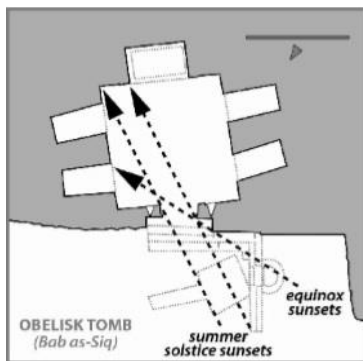


Figure 7. The Obelisk tomb plan, Petra Jordan, and the possible routes of sun light entering inside the tomb (after Paradise 2015)

During all of these days sunrays throughout the day will enter at different angles inside the tombs (Fig.7). The latter provides natural light in the chamber for various feasts, rituals related to sun-god Dushara (Bowers, 2006). Orientation of other Saudi tombs based on their virtual reconstruction in position of the real façade is approximated but if we rely on the comparison at Ad Deir and Al Khazne the virtual positioning uncertainty is ~1-2°. Investigating more tombs in Saudi Arabian tombs at Madaa'in Saleh their orientation and angular altitudes appear to vary considerably without a particular pattern (Fig. 8).

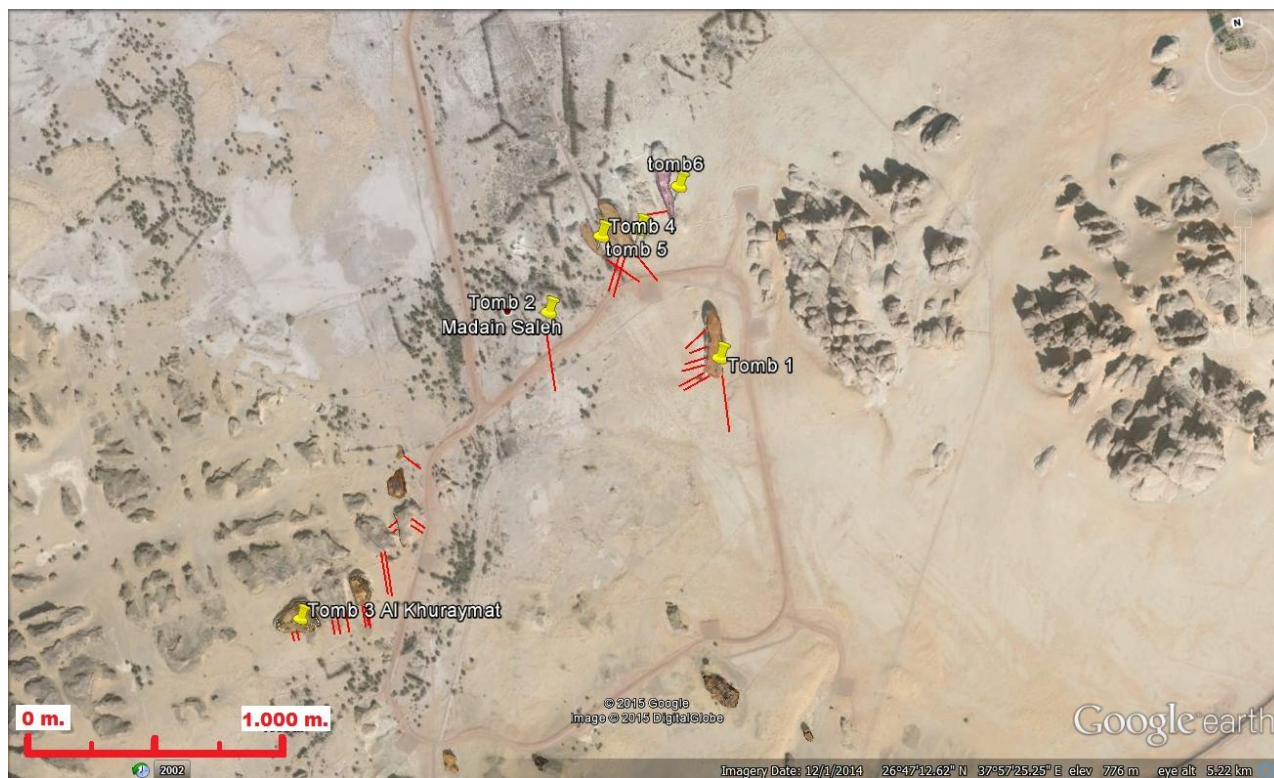


Figure 8. Distribution of all tombs at Madaa'in Saleh. (Red) Lines indicate tomb entrance direction.

Indeed, out of 29 rock cut tomb entrances in Madaa'in Saleh (including the three of Table 1), 12 tombs or ~45% align towards 180° ; 10 tombs are southwest, 5 southeast, one due east and one northwest. Regarding angular altitudes of skyline they vary between zero and $\sim 3^\circ$. For example for Tomb 6 the western façade of $Az=270^\circ$ looks at another outcrop in a distance of about 170 m and a height of 7 m, hence the angular altitude is 2.5° .

Although some temples and/or tombs may apparently appear to be deliberately chosen and carved to receive solar light inside the chamber or at conchs, altars (Paradise, 2015) the coincidental equinoxes drew at an artifact depicting the zodiac from Khirbet Tannur indicates equinoctial festivities.

The above are supported by the architectural study of Nabatean tombs by Mahdi Abdelaziz and Shafer Rababeh (2008) who concluded that: a) the Nabataeans used various names for their tombs and burial installations, b) the range of terms was related to the size and the architectural style of the tombs, c) the choice of tomb styles were themselves related to the geology and environment of the different regions within the Nabataean polity; as rock-cut, as free-standing or dug into the ground. Finally, the used limited magnificent rock cut tombs for some centuries, of the Hellenistic-Roman period, in relation to

burials of local Nabateans, imply re-use by latter generations mainly of same family tree (*Samuel*, B', κ', 14). The archaeological site Al-Hijr in Madaa'in Saleh (Hegra), apart of the 111 monumental tombs more burials exist but of non-monumental burial style (Al-Otaibi, 2013).

4. CONCLUSION

The Nabatean tombs at Petra and Madaa'in Saleh seem to have variable orientation without any consistent pattern, but rather geological and geographical reasons. Tomb architecture appears to have had no observable influence on either the terminology from inscriptions or deliberate skyscape relationship.

In particular, the illumination inside the chambers of Al Khuraymat during southern alignment occurs a little earlier of any sunset at different seasons. This may have served their needs of any possible rituals inside of the chamber. At the same time the associated crux, widely known to Mediterranean people may have served as marked point for their beliefs or nomadic movements. All orientations at Madaa'in Saleh are related to winter and equinox sunsets, but in Petra the royal tomb at Al Khazneh is related to solstitial sunrise may be related to sun-god Dushara and new year celebrations.

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