Potential Interactions between Climate and Prehistoric Populations in Southern Morocco: Insights from Archaeological and Paleoclimatic Evidence

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Abstract. Southern Morocco contains a rich archaeological record: engraving, painted rocks, and funerary monuments. This pre-historic and proto-historical heritage offers valuable information about the environmental context of pre-historic settlements. However, the Southern Moroccan archaeological record suffers from dating scarcity and hence, the difficulty in establishing a reliable chronology. Most archaeological sites date from 7000 to 1000 years BP and are marked by a transition period from a humid to dry climate during the late Holocene. The relatively drier conditions likely resulted in adopting a new lifestyle characterized by cattle ranching, agriculture, and animal domestication. Holocene's enormous climatic oscillations significantly influenced the development of human settlements in the region. The concentration of archaeological archives confirms the existence of sufficient water supply in an area today semi-desertic. Therefore, the sedentarization and the development of well-stylized rock art, in addition to the grouping of funerary monuments or tumuli with complex geometry, mark the wet and rainy periods. Meanwhile, unstable communities and long-distances migration are often the features that characterize the long dry periods.

Key words: Southern Morocco, archaeological record, rock art, tumulus, paleoclimate.

1. Introduction

Climatic variations have left their mark on various supports, such as carbonate concretions in caves and waterfalls, sedimentary deposits in lakes and terraces along ancient rivers. During the Holocene, which marks significant periods of prehistory, protohistory, and history, Southern Morocco went through different climatic periods. These periods are challenging to identify. The content of the numerous archaeological sites (engravings, paintings, and tumuli) illustrates the changes that human societies and animals have undergone in the natural environment and provides useful information to describe the main climatic periods (MANNING & TIMPSON 2014). This region also contains archives and information related to climate change, recorded in speleothems (stalagmites in the many caves in the region). To characterize the potential interactions between climate and human populations during the Holocene, we use the available archaeological evidence of Southern Morocco (rock art and funerary monuments) and the paleoclimatic data obtained from isotopic data ($\delta^{18}O$) recorded on the stalagmites in the caves within the area (AIT BRAHIM et al. 2017; 2019a; 2019b; SHA et al. 2019).

Based on the description of the region's archaeological heritage, through the characterization of different figures and monuments, the climatic change indices of the Holocene have allowed us to understand the climatic environment in which the prehistoric populations lived. Our approach is based on the description of the archeological heritage in the area to identify and characterize the different figures and monuments. After that, and because of the absence of absolute dating, we adopted a relative classification of the various inventoried

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art traces intending to make a chronology of the historical heritage and discuss its evolution along the covered period.

2. Description of the archaeological heritage in southern Morocco

The study focuses on Southern Morocco, represented by the Draa valley, the Jbel Saghro, and the Sahara (Tan-Tan, Smara and Awserd regions) (Fig. 1), the Anti-Atlas mountain. These pre-Saharan and Saharan regions knew a space heterogeneity occupied by the pre-historic human population and a complex topography from north to south. The archaeological heritage (e.g., engravings, cut stones, rock paintings, rock shelters, and various funerary monuments) is varied and abundant. Many caves content some archeological traces and speleothems.

a. Rock Engravings

Several sites of rock engravings are observed in the pre-Saharan region, along the large wadis and their tributaries (Figs. 1 and 2), which means that Man needs to express his knowledge and beliefs through these engravings (BERAAOUZ 2010).

Most rock engravings are made according to the Tazina style (PICHLER & RODRIGUE 2003; FALESCHINI 1998, GAUTHIER & GAUTHIER 1995). The engravings are polished and represent mainly animals, not exclusively wild since domestic cattle are engraved. Their presentation is often fanciful, with extremities exaggeratedly extended.

In the High Atlas, the main sites of Oukaimeden, Yagour, Azibn'Ikkis, and Jbel Rat are well known for the diversity of metal weapons, horsemen, and oxen representations (RODRIGUE 1999; HOARAU & EWAGUE 2008). However, the themes differ according to the sites. In the valley of Dades Wadi, discs and several Libyco-Berber inscriptions represent the engravings (PICHLER & RODRIGUE 2000). The Ouneine rock carving sites (CATTIN 2013) illustrate the same content as the Atlas sites with daggers, shields, horse hunting scenes, and chariots.

Some bovids engravings are well-preserved in the upstream part of the Massa Wadi, the right bank. Within the Jbel Tizelmi plateau and in the reliefs overhanging Aglou (Lgaada and Boutarigt), south of Tiznit, the engravings mainly depict riders (horsemen), a dromedary figure, and hunting and battle scenes (BRAVIN 2009). In Taouz, the three sites are best known for their hundreds of engraved chariots and diverse wildlife (GAUTHIER & GAUTHIER 2015). The Saghro region is rich in archaeological sites. The most important are those in Aït Ouazik, with a hundred engravings in "Tazina style" deep polished lines, Ikhf n'Ouaroun, and Tazarine (LHOTE 1982; MUZZOLINI 1989; PICHLER & RODRIGUE 2003). The Nkob station includes Libyco-Berber style engravings with several geometric representations, rider figures (horsemen), and animal representations. In Foum Chenna, Tibaskoutine, and Assif Wirgane…, the Draa Valley exhibits some exceptionally diverse engravings in fauna and Libyco-Berber inscriptions (PICHLER & RODRIGUE 2003).

From Foum Zguid to Foum El Hassane, several sites are present. These sites are located mainly both along the major tributaries of the Draa valley and Jbel Bani. For instance, we find Kebch, Mrimina, Wadis, Tissint, Akka, Tamanart, and south of Aït Ouabelli. Tiggane, Meskaou Wadis, Tiouaziouine, Imgradn'Tayali and Metgourine, Tahouast, Imin'Tart, Moumersal, and Ighir N'Ighnain are the main sites in the Tata region (RODRIGUE 2002).

In the Ighrem region (Ouaremdaz, Imaredn, Had Walkadi), the engravings represent cups, signs, domestic animals, Lybico-Berber letters, and daggers. In Tleta Tagmoute (Imaoun), there are several sites with domestic bovids, Libyco-Berber inscriptions, wild animals, and chariots (SIMONEAU 1977; SEARIGHT 1999; PICHLER 1999, 2000a).

In the Guelmim region, on the Noun Wadi and the EçÇayyad Wadi banks, the engravings are dominated by animal representations (wild fauna and domestic cattle), broadly linked to the Neolithic (BOKBOT et al. 2007).

At the engraving sites in the Noun Wadi basin, the dating of tests decorated with an antelope provided an uncalibrated radiocarbon age of 2790 ± 105 BP (GRÉBÉNART 1975).

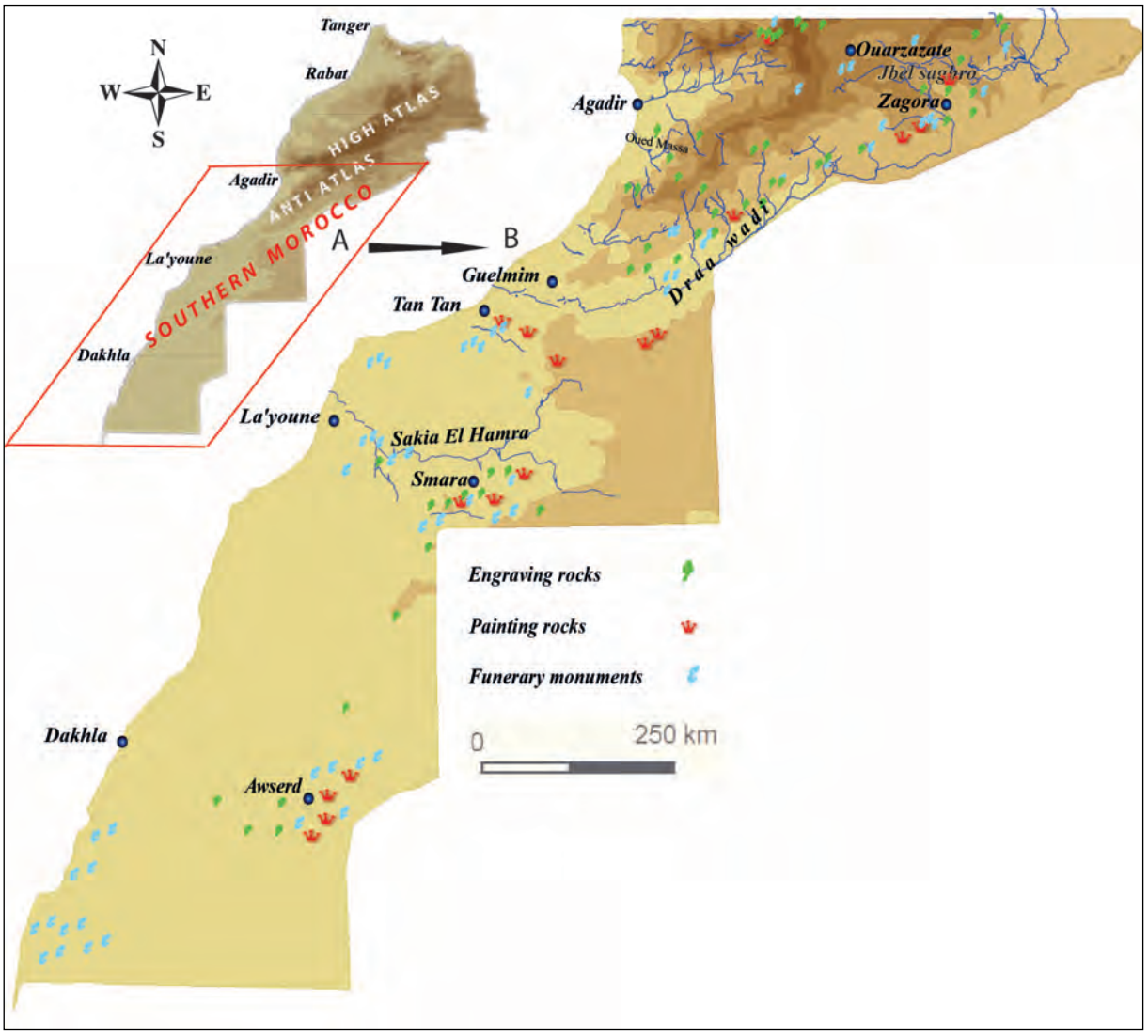

Figure 1. A- Location of the study area; B- Distribution of the main engraving rocks, painting rocks, and pre-Islamic funerary monuments in southern Morocco.

However, the presence of metallic weapons, chariots, and signs figurations, pleads in favor of art continuity until the Libyco-Berber period (SALIH & HECKENDORF 2002).

There are about a thousand engraved figures on the engraved slab of Azrou Klane located between Guelmim and Tan Tan. The oldest ones are Bovidian engravings belonging to the Libyco-Berber period represented by armed horsemen, involved in combat and hunting scenes (GRAFF 2016). The recent and contemporary engravings are numerous, such as a sailboat or a Bedouin tent.

In the Kerdous area, the main engraving sites are those of Ukas (the richest in wildlife), Tafraout (Tazeka, Jbel Mqorn, Ait Ben Said, Tagenza), and Ait Baha. In Assa Zag, at the entrance to the Ksar-Assa, a slab bear engraving of bovids, ostriches, quadrupeds, and a dromedary. Several cattle representations have been discovered at the Zag Wadi site (EWAGUE, 2018).

The Seguia el Hamra basin counts several rock sites (ALMAGRO BASCH 1944; 1946; MATEU 1948). The important ones are in the Smara area (Ras Lentareg, Mecaitab Wells, El Farsia, El AsleinBukart, Açli Bu Kerch, and Lumat de Asli). It is where we found many wild animal engravings (rhinos, elephants, giraffes, antelopes, bovines, and ostriches), geometric and anthropomorphic shapes, weapons and chariots, and Libyco-Berber inscriptions (RODRIGUE 2010). The Laghchiwat site, in the Seguia el Hamra area, includes several thousand

engravings, with a high proportion of giraffes. The Lajwad and Daraa Elquelba sites are in the vicinity of Awserd. Other notable localities are between Smara and Awserd.

Due to perceived similarities in subject matter, even across great distances, much rock art has been ascribed to pastors and hunter engravers, who have shared a set of cultural references. The large engraving sites illustrate the succession of wildlife representations, with firstly wild and secondary domestic. Libyco-Berber inscriptions and metallic weapons represent the most recent engravings.

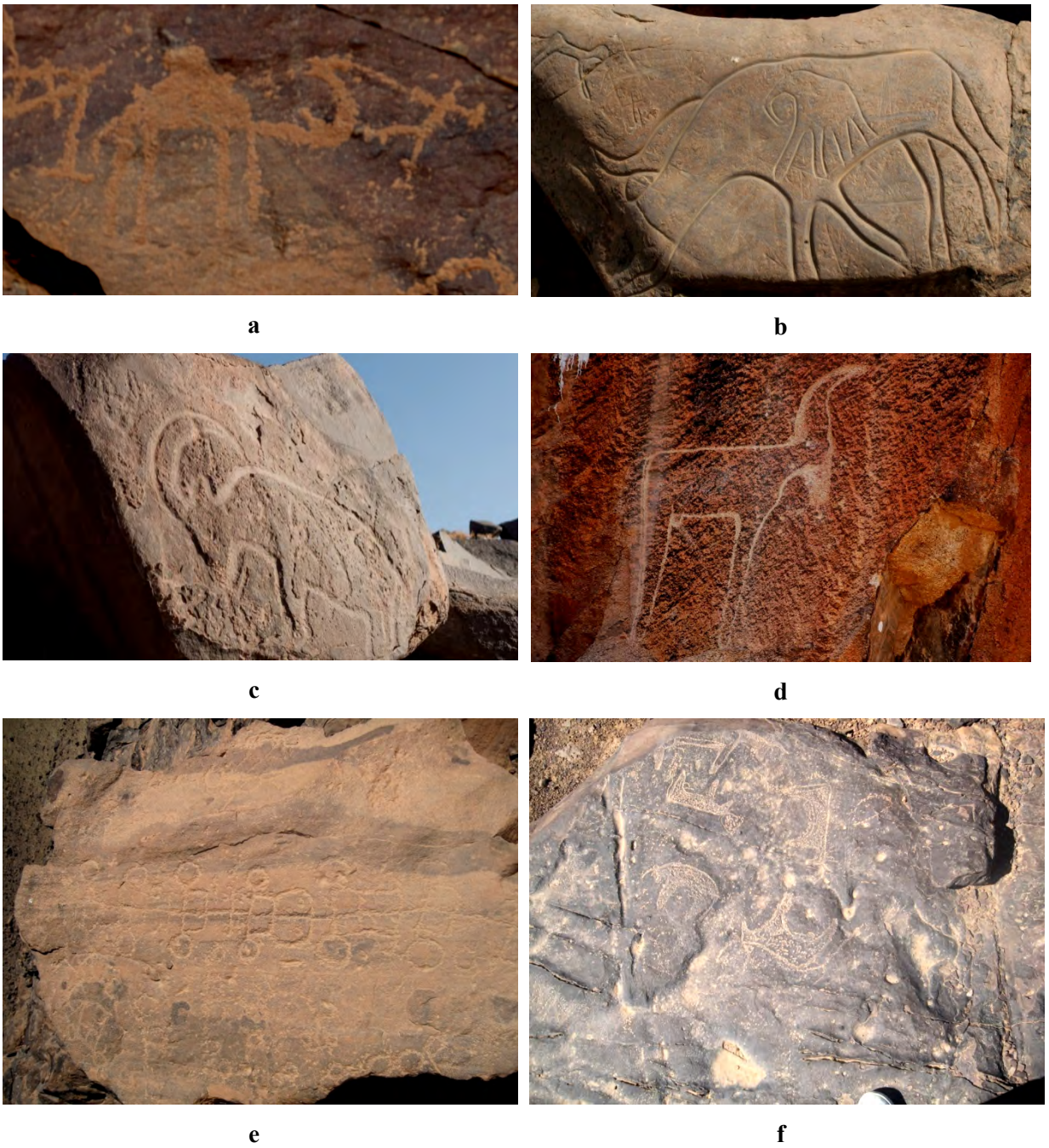

Figure 2. Selection of representations of engraving rocks: **a.** Dromedary held by an anthropomorphic shape (Amtoudi), **b**. Elephant inside a rhino (Ait Ouaaziz), **c**. Mouflon with curved horns (Tata), **d**. Bovid executed by a pecked technique on pink granite (Tazka, Tafraout), **e**. Alignment of seven chariots (Taouz) ,and **f**. Herd of cattle (Taouz).

b. Rock Paintings

The paintings found in caves and rock shelters (HECKENDORF & SALIH 1999) represent the life of Neolithic men and the surrounding fauna. There are few painting sites. The main ones are Aouin, Asguer, Oued Asleg, Jebel Aousnir, Oued Guelb, and Oued n'Thati (Fig. 1). Several compositions include spatial activities, such as dancing, hunting, and animal pictures (Fig. 3). The pigments used are often red, more rarely black or white. The patterns drawn in red, consisting of oval shapes with red dots, are observed in the rock shelters and some caves (such as the Zir Lbâaïr cave) around the Zaouia Sidi Abd En Nebi (HECKENDORF & SALIH 1999). On the edge of the Youmkat Assif tributary (Oukas site), the painted shelter shows a mounted bovine and an armed anthropomorphic painted in white.

In Tata province, there are about thirty rock shelters with cave paintings of different sizes and themes. These painted works probably date from the end of the 3rd millennium to the 1st millennium BC (SEARIGHT & MARTINET 2001).

At the level of the Laouinat shelter, located to the south-east of Tan-Tan, there is a representation of several small anthropomorphic shapes, three chariots similar to those engraved everywhere in southern Morocco, a varied fauna (sheep, bovines, antelope, ostrich, giraffe, and a ridden donkey) (SEARIGHT & MARTINET 2001). The Tifariti paintings in Saguiet el-Hamra, located about a hundred kilometers further south, show similar representations. Some painting sites from Asleg Wadi (MASY 2004) and another in Bou Dheir (BROOKS et al. 2003) depict a wild bestiary, often with large dimensions (up to 140 cm), and a remarkable ancient buffalo.

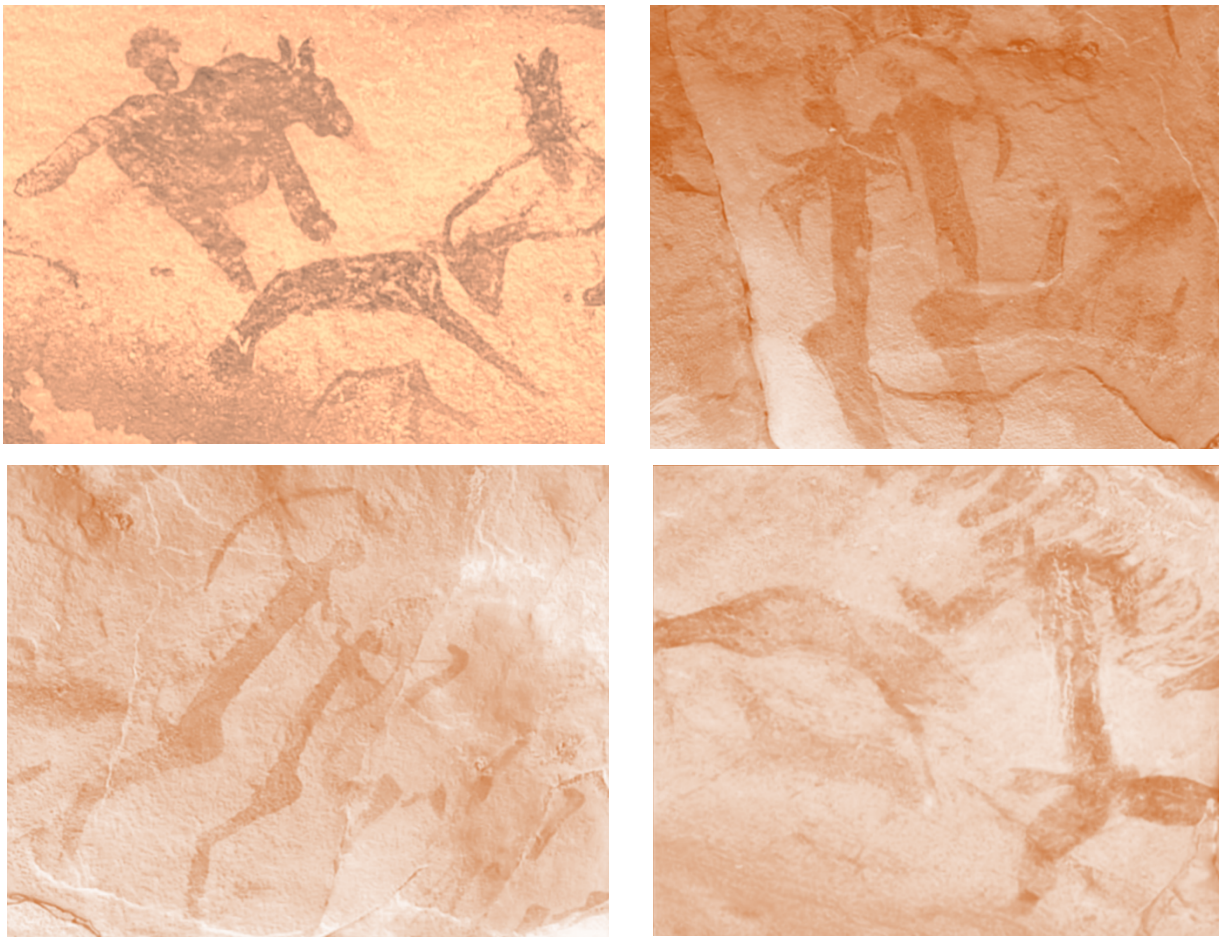

Figure 3. Rock paintings in the cave of Aouinet Azguer with inscriptions made in the flat areas. Anthropomorphs armed with bows are characterized by pronounced buttocks and broad thighs.

The cave paintings of Aouinet Azguer (Msied) are made in rock shelters located on the banks of the Azguer Wadi tributary. The painted figures, bovids, antelopes, lions, and anthropomorphic figures, are probably from different styles and periods (SEARIGHT & MARTINET 2002).

In the five painted shelters of Ifrann'Taska, the drawings are zoomorphic graphics (bovids), anthropomorphic illustrations, dotted lines, lines, geometric patterns, Libyco-Berber characters, and horsemen (HECKENDORF & SALIH 1999).

Several small caves (Cueva del Diablo, Cueva Pintada, Lajwad, Dáraa El Quelba, Legteitira) exist on the Jbel Lajwad's cliff of to the south-east of Aousserd in the Tiris desert. The main paintings are hand tracings, zoomorphic figures, quadrupeds, and Libyco-Berber characters.

The paintings of Zemmour are in several small shelters on rocky cliffs. Five pictorial styles are defined. The oldest is attributed to the Bronze Age (3800-3200 BP), as evidenced by halberds representations, and the most recent being between the 4th century BC (2400 BP) and the beginning of the Christian era, according to the presence of Libyco-Berber texts and the absence of camels. A single inscription in Arabic could represent ages after the 15th century AD. (SOLER SUBILS et al., 2005 & SOLER SUBILS 2006).

The paintings of Ifran-n-Taska (South-west of Zagora) are among the rare testimonies of non-engraved rock art in Morocco. The drawings have been made of red ochre, white, black, and yellow, on the inner sides of five shelters at the edge of a dry river (ZAMPETTI et al. 2013). The ages of these paintings are: 3794 ± 37 BP (shelter I); 4 1 00 ± 59 BP (shelter III) and 7062 ± 37 BP (shelter IV) (ZAMPETTI et al. 2013).

c. Protohistoric funerary monuments

The protohistoric funerary monuments of the pre-Islamic culture are tumuli of earth and/or stones of different shapes and sizes. The main sites of southern Morocco are in Figure 1. The most important groups are not far from pasture areas (HACHID 2000), and along the wadis: Draa, Noun, Ziz, Guir, Taouz, Chbika, Saquia El Hamra, Massa and their tributaries (SOUVILLE 1965; MILBURN 1974; BOKBOT 1991; BOKBOT 2000; BOKBOT et al. 2007; MATTINGLY et al., 2017; ABIOUI et al. 2019). There are several diverse forms of tumuli (Fig. 4). Along the Draa Wadi and its tributaries (Tazarine, Tamimoute, Tasminakhte, Oued El Myet, Tilougui, Bom Zwaguer, Mirdc, Foum Azlag, Rbat Lahjar, Tissergate, and Foum Larjam), we can distinguish simple stone lifting or in the form of spherical caps (MATTINGLY et al. 2017). The Foum Larjam site is the largest and the most spectacular burial ground in the entire Drâa valley (MEUNIÉ 1958).

Tumuli with monuments and chapels are common in Taouz. The antennae, crescent, and fly-wing tumuli are spectacular at the Garas' level hanging over the Oued Chbika (southwest of Tan-Tan). The tiered tumuli are found at Akhfnir and on the banks of the Noun Wadi. Tumuli with several branches are discovered in Awserd site. Other circular shapes with belts or antennae, heart shapes, crescent-shaped, or fly shapes, are also present in the region. The graves are either scattered or grouped in the necropolises form. Scattered graves indicate a nomadic state. Meanwhile, the necropolises form attest to the sedentary builders who practiced livestock and/or agriculture.

In Oued Chbika and Smara, funeral monuments show complex structures attesting to a significant investment in time and labor to create accurate geometric shapes and bring the appropriate construction material on site. These monuments are often associated with rock art sites and reflect the cultural and ethnic diversity of pre and protohistoric communities in the region. Their construction period is between the most remote Prehistory and the end of the Middle Ages.

Radiochronological ages of funerary monuments in southern Morocco are rare. EL GRAOUI et al. (2010) obtained an Age of 1430 ± 35 BP on a skeleton in a circular tumulus in Taghjijt. The grave traces are made up of metal objects (iron and bronze), ostrich eggs pieces, and shells.

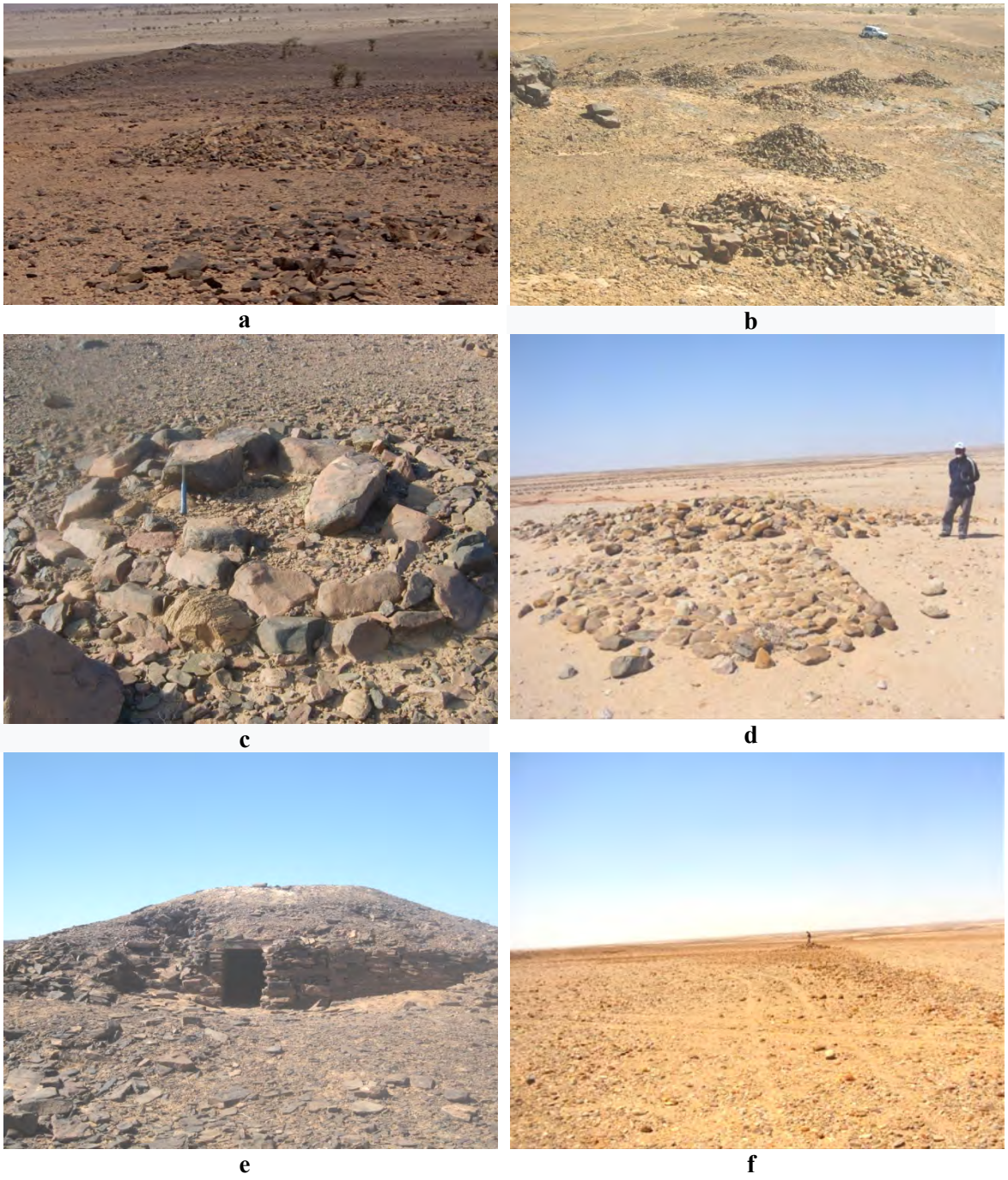

Figure 4. Examples of pre-Islamic funerary monuments: **a.** Stone cairn (Foum El Hassane), the most common structure in south Morocco, **b.** skylight tumuli of Foum Larjam necropolis, **c.** circular tumulus (Azguigh, Agdz), **d.** complex monument with short antennae (Oued Chbika), e. chapel tumulus of Taouz, and **f.** tumulus with long antennae (Oued Chbika).

In the Tamrhalt-n-Zerzem (Oued Noun) graveyard, the funerary furniture consists of iron bracelets, iron earrings, necklaces made of copper and iron beads, tests of ostrich eggs, green rocks, seashells, and flint shards (BOKBOT et al. 2007). The most important tumulus of Foum Larjam necropolis was dated using radiocarbon: 2649 ± 28 BP, 1589 ± 30 BP, and 1344 ± 30 BP (MATTINGLY et al., 2017).

In the Saharan regions, the ages of the different types of monuments (keyhole, crescent, aligned and antennae) (MEUNIÉ 1958; GAUTHIER & GAUTHIER 2006, 2007, 2008, 2009; EL GRAOUI et al. 2010) show that the monuments keyhole (4280 to 5610 BP) and crescent (3310 to 4720

BP) are the oldest, and spread over the Lybico-Berber period. Monuments with antennas (1450 to 1870 BP) and alignment (1450 to 1870 BP) appear at the beginning of the Caballine period.

According to GAUTHIER & GAUTHIER (2009), these funerary monuments are probably the work of the same population existing there for more than 5000 years

3. Classification and chronology of rock art

The chronology of rock art is still relative due to the lack of geochronological data on rock carvings and paintings. However, several attempts have been tried for classification and chronology at local and regional scales, both locally and regionally (AUMASSIP 1993; CORNEVIN 1993). According to MORI (1970) and BARICH & GRUNERT (1991), the beginning of rock art dates to the Paleolithic end. Whereas for MUZZOLINI (1995) the oldest representations appear at the beginning of the Neolithic.

The archaeologists have defined the main periods by following stylistic criteria, analyzing the subjects represented, the superimpositions, and the patinas, and considering the succession of animal representations, first wild, then domestic. As a result, five main groups of engravings can be distinguished, based on the theme of representations.

a. Bubaline period

It is a period of the ancient buffalo (formerly called "Bubalus") and corresponding to the ancient Neolithic (7000 - 8000 years BP) (BERAAOUZ 2010). The ancient buffalo occupied the entire Northern part of the African continent during the Pleistocene. Representation of an example of *Synceruscaffer* (African buffalo) is in Smara. Four or five images are present in the banks of the Dra Wadi (RODRIGUE 2001). These images may be of ancient buffaloes. This period is closely related to the hunter-pastoral period characterized by wild animal representations (elephants, giraffes, hippos, rhinos, buffaloes, ostriches, antelopes, etc.) and the absence of domestic animal representation. The engravings of this period are sometimes associated with diverse symbols: spirals, labyrinths, and circles. SIMONEAU (1969) interpreted the engravings of cattle amid hunters as a hunter-pastoralists milieu. For the majority, this period would be before 3000 BC because from this date begins the Bovidian period. In other words, the beginning of the Neolithic in southern Morocco.

b. Bovidian period

The period of domestic cattle of the Middle Neolithic started about 6500 BP and lasted at least until around 4500 BP. The works show large herds of bovids and scenes from pastoral life (LE QUELLEC 1998; LHOTE 1989). The beef mounted in Adrar Metgourine (Akka, southern Morocco) is dated around 2000 BC (DU PUIGAUDEAU & SENONES 1964). According to (HECKENDORF 2008), the rock representations of Jbel Bani do not provide any clues of cultural changes caused by desertification linked to Neolithic cattle herding. The spatial distribution of the different engravings can be created as part of transhumance, from Saharan and pre-Saharan territories to the Atlas Mountains. In the absence of typical landmarks, the classification of rock art does not distinguish the Bubaline period (Tazina style) and the Bovidian period.

The presence of wildlife (elephants, rhinos, felines, antelopes, etc.) provides information on a climate similar to the current savannah. This relatively humid period is between the fourth and the third millennium BC (MUZZOLINI 1982). SEARIGHT (1999) dates the Bovidian from the Imaoun site, located north of Akka, to around 2000 BC. According to the author, this dating is justified by the fact that the pastures of the region continue to provide sufficient vegetation cover for the present cattle.

c. Chariot period and Caballo-Cameline period

The sites of chariot representations associated or not with humans are relatively rare. The most beautiful one is in Tamanart Wadi (Icht). The representations are sometimes associated with spear points and ornate discs (EZZIANI 2004). Chariots are engraved both in the High Atlas Mountains and in south Morocco. The chariot introduction from the Sahara into Morocco would date to around 700-600 BC (MUZZOLINI 1988) or

between 1000 and 500 BC (VERNET 1993). The schematic chariots of the Atlas could date back to the 7th / 6th centuries BC. And in this case, the term Atlas Bronze would be placed before this date and lasted until the 2nd / 3rd centuries (AUCLAIR et al. 2016). The chariots are engraved in a pastor to cattle milieu. The chariot episode in rock art, marked by the use of wheel couplings in daily life, is of great cultural significance (CAMPS 1982, 1989).

The Caballo-cameline period is subdivided into an early period of "horse" that extends from 3500 to 2000 BP and a recent period of "camel" (LHOTE 1984). In this period, the succession is domestic cattle, then horses and dromedaries. Horse engravings are rare. They are in Tamanart Wadi. Camel representations are exceedingly rare, as the dromedary would have been recently introduced in the region from the first millennium to medieval times (AUCLAIR et al. 2016). The dromedaries are introduced into Sahara since 250 ± 100 BC (MUZZOLINI 1995).

Saharan rock inscriptions, reflecting the period of chariot and horse, could be as old as the Maghreb Libyan alphabet. They could document one or rather several regional "Libyan Saharan alphabets" (HACHID 2007). The oldest Libyan inscriptions can be located between the Caballine and the Camel periods transition (PICHLER 2007). (MUZZOLINI 1995) assigning a date not earlier than the beginning of the 1st millennium BC for the ridden horse in the Saharan regions. However, the same author groups together the Libyco-Berber and horsemen who carry round shields and spears with camel engravings dated to around 200 BC in Morocco.

d. Libyco-Berber period and Metal Ages

This period is characterized by representations in the form of an alphabet that resembles Tifinagh (sites of Ouaremdaz, Ait Ouarzik, Foum Chenna, Wirgane, Tibaskoutine, etc.), which are protohistoric inscriptions, written in an old script that is difficult to decrypt (PICHLER 2000a; PICHLER & RODRIGUE 2003; PICHLER 2007). According to MONOD (1932), the "cameline" or even "equine" period largely corresponds to the "Libyco-Berber" group. The origin of this alphabet can be located between the end of the second millennium BC and the first millennium BC (HACHID 2007). The oldest inscriptions may have been dated to the 6th century BC (CAMPS 1977) and persisted in North Africa until the end of the ancient world (early 8th century) minimum. These inscriptions cover the period from protohistory to early history and even more recently (RODRIGUE 1989; RODRIGUE 1992).

The presence of camels and horses allows placing Foum Chenna engravings in the second half of the first millennium BC (PICHLER 2000b). Libyco-Berber alphabetic signs can only date back to the 7th - 8th centuries BC (PICHLER 2007). The beginning of the Libyco-Berber period is 1000 BC in North Africa and Sahara (Aumassip) or the first millennium BC (CHENORKIAN 1988).

The representations of the metal ages are tall male figures, accompanied by daggers and halberds, especially at the High Atlas sites, in Oukaimeden and Yagour (EZZIANI 2004; AUCLAIR et al. 2016). The metal weapons representations testify to contacts between Moroccan and European territories during the Bronze Age (RODRIGUE 2010). The thousands of engravings on the plateau of Jbel Tizelmi correspond to the late period during which the abundance of rifles is related to this weapon introduction in the region.

The High Atlas weapons had a close connection with the Bronze Age of the El-Argar civilization (south-eastern Spain, 1800 to 1200 BC) (HACHID 2007). The High Atlas engravings of Bronze Age metal weapons can be subdivided into Old Bronze (local weapons and/or imported from ancient Iberian) and relatively recent Bronze (integration of Mediterranean Bronze into the Atlas world) (CHENORKIAN 1988). The Bronze Age continued in the High Atlas until the 6th-5th centuries BC (early Antiquity). The arrival of metallurgy (copper, then iron) and the horse marked the end of prehistory (VERNET 2014). The engravings and paintings that depict metallic weapons and chariots associated with horse domestication are part of the prehistoric period (GAUTHIER & GAUTHIER 2008). The Bani region is unique when it comes to metal weapons. Engravings showing weapons have been

discovered on the Adrar Metgourine site (CHENORKIAN 1988), north of Akka, and on the Tazout N'dri site, located east of Assa (SIMONEAU 1969). The iron tools, weapons, and Arabic curved dagger entered North Africa at 700-1000 BC or the end of the 7th century AD.

e. The Islamic period and Powder Age

This period is represented by metal objects, such as fibulas, swords and scissors, and Muslim tombstones oriented towards Mecca. In recent centuries, images of rifles and symbols in the shape of stars have appeared in Yagour, Tizelmi, and Tainant (AUCLAIR et al. 2016; DURIEUX 2018). They are attributed to the Powder Age and are related to the emergence of patterns marked by the appearance of firearms at the turn of the colonization age.

4. Climate variability and potential impacts on prehistoric populations

Archaeological, pre-historic, or proto-historical archives provide valuable data to better understand past climate changes. But due to the lack of accurate dating, they are hard to decrypt in southern Morocco (CLARKE et al. 2016; SEARIGHT 2013). Nevertheless, it is possible to approach climatic variability in this region during the Holocene by combining the isotopic data recorded on the speleothems taken from the Wintimdouine cave (Fig. 5f) with those on the archaeological heritage of southern Morocco (Fig.5 a to d).

In southern Morocco, the Upper Paleolithic is relatively humid. The climate is dry from 11500 to 10800 BP, with a wet period around 10500 BP. It became relatively wetter only after 10000 years BP due to the shift of the African monsoon northward. During the called "Green Sahara", the climate remained relatively wetter until about 4000 years BP. This long period has observed three short periods (centennial-scale) of relative aridity: 9400 to 9000, 8200 to 8400, and 5200 to 5000 years BP, which could have created a favorable environment for human settlements in the region.

After 3800 years BP, the climate conditions were deteriorated significantly due to the increasing aridity and some of the humidity intervals that may have lasted for several centuries. Interestingly, most of the archaeological sites were dated from 7000 to 1000 years BP. This transition period from a wet to dry climate is favorable for pastoralism and hunting. The latter part of this period is dry, and cattle ranching, agriculture, and animal domestication have been developed. Hence, adopting a new lifestyle indicates the pre-historic society's resilience against a relatively unfavorable climate.

Wild or domestic animals' presence or absence is intimately linked to climatic features, particularly in southern Morocco. Accordingly, the presence or absence of animals is generally illustrated in rock art.

Livestock farming has been replaced by highly mobile pastoralism based on sheep and goats. It involved movement in both Saharan and mountainous pasturelands, where water could be available. The areas around the Anti-Atlas oases (Draa river, Massa river, and Tata valleys) and the High Atlas Mountains (Oukaimeden, Yagour, Azibn'Ikkis, Jbel Ratand, Ouneine) would have provided certainly refuge zones for species unable to survive in increasing aridity. This period is associated with sedentarism and the greater exploitation of available natural resources. The large wadis retain some humidity which attracts the fauna of the large dry Sahara. And this would explain why we have the rapid increase of rock art representations and funerary monuments throughout these wadis and their tributaries.

We propose that rock art may significantly contribute to understanding people's concentration in Southern Morocco and their relation to climate changes during the Holocene.

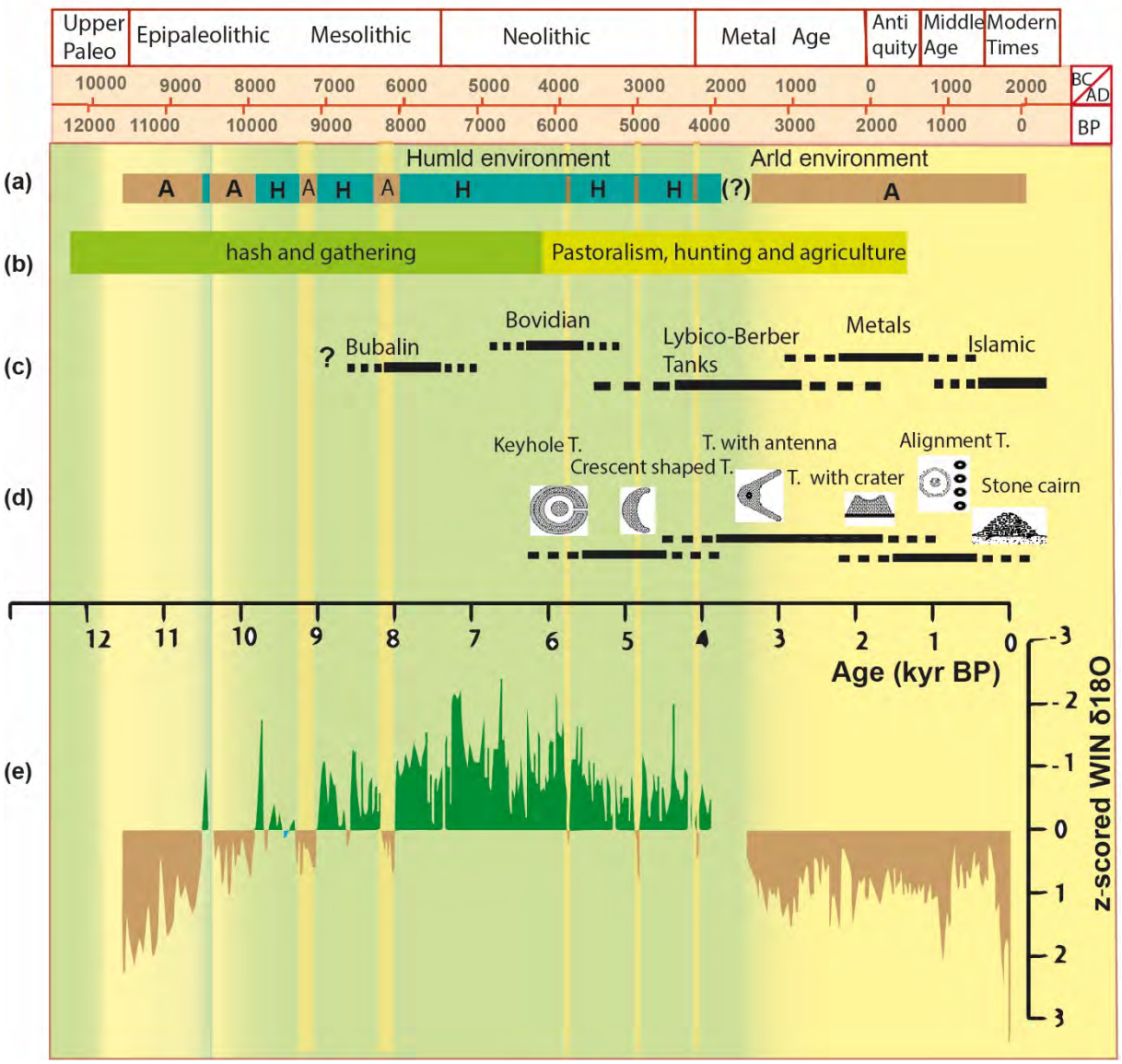

Figure 5. Holocene climate changes in the great south of Morocco as reconstructed based on the speleothem records discussed in the text; cultural changes are also reported. a. Alternating arid (A) and humid (H) periods, b. Human cultural change during Holocene times, c. Chronology of engraving rocks, d. Evolution of the shape of pre-Islamic funerary monuments (GAUTHIER & GAUTHIER 2009), and references therein] and e. Hydroclimate records in Win-Timdouine stalagmite (AIT BRAHIM et al. 2017, 2019a, 2019b, SHA et al. 2019).

5. Conclusion

This review of southern Moroccan rock art sites shows that several different modes of existence and climate variability had mainly influenced the populations and their artistic activities like painting and engraving rocks. Most of the wadis banks and their tributaries show rock art and funerary monuments, attesting to the local evolution of human occupation. From the oldest period (Bovidian) to the Caballine and Libyco-Berber periods, the figures testify to permanent human occupation in southern Morocco.

The difference in themes, style, and patination indicate that rock art is not all contemporary, plus many sites experienced several periods of occupation. In the north of the study area, the rock arts are sparse and less extended (Oued Massa, Yagour, Ounein), while the stations in the southern are substantial and variable. Additionally, in the South, the representations of abundant wild animals plead in favor of hunting in a steppe environment. While in the north, ruminants replace wild animals, show animals' domestication, and metals' use in artistic activities.

Climate change has undoubtedly played a major role in the evolution of human populations, their activities, migrations, and the future of civilizations. Indeed, the Holocene is characterized by a climate oscillating modestly on the regional scale. Nevertheless, these climatic oscillations have had a significant influence on the development of human civilization in the area, as highlighted elsewhere (ANDERSON et al. 2007; FOSTER 2012). Households concentration testifies to the existence of water points around which populations carried out their different activities. The drying up of water sources has likely caused the migration or disappearance of populations in these contexts. The dramatic climate change during the Holocene and the natural environment in which prehistoric populations lived have induced distinct cultural responses. In an arid climate, long dry periods are often characterized by unstable and conflicting societies, increased insecurity among human groups, and their migration over long distances (BROOKS 2006; ANDERSON et al. 2007; FOSTER 2012; CLARKE et al. 2016). On the other hand, during humid and rainy periods, sedentarization is dominant, and the development of well-stylized rock art, and the grouping of tumuli with complex geometries (ABIOUI et al. 2019; BERAAOUZ et al. 2014). On the boarding of palm areas, the concentration of rock art and funerary monuments attests that the geographical conditions might have remained unchanged during the last centuries.

Southern Morocco offers a wide range of rock art sites that have been identified extensively. Due to perceived similarities in the area and even across great distances, much of rock art has been attributed to hunter-gatherer painters and engravers who appear to have a shared set of cultural references. As is often the case with rock art, the accurate attribution of authorship, date, and motivation is difficult to establish. But the research on rock art in southern Morocco is still ongoing, along with the archaeological and paleoclimate records that could help better understand past human-climate interactions.

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