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Afriques

Débats, méthodes et terrains d'histoire

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The case study of Sijilmasa (Morocco)

L'hydraulique oasienne contemporaine : une fenêtre sur la sociologie du peuplement des villes sahariennes médiévales. L'exemple de Sijilmassa (Maroc)

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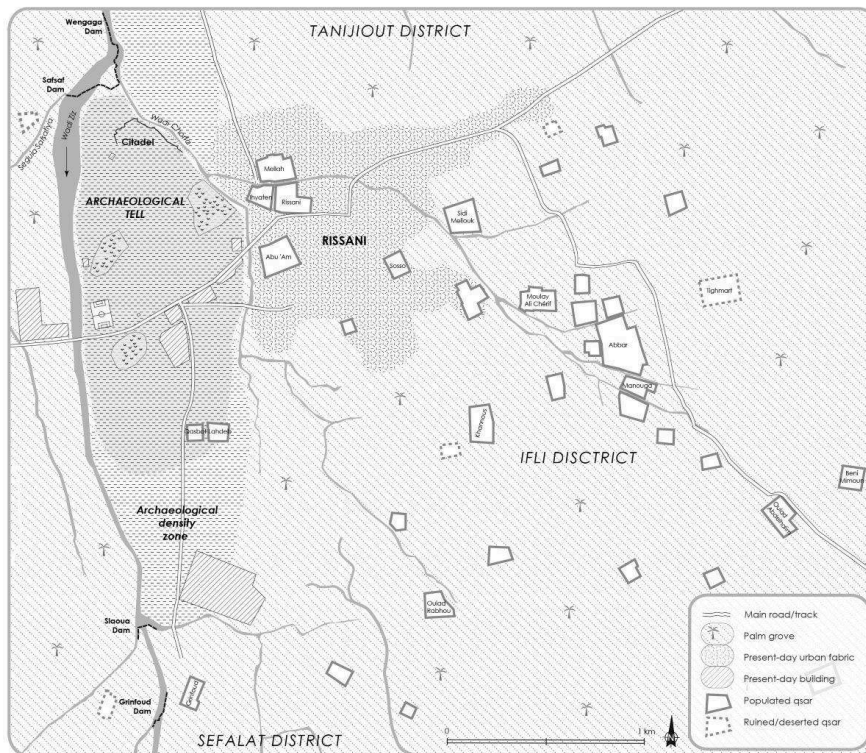
Chloé Capel

Introduction: Overcoming the difficulties of an archaeological investigation based on excavation

- 1 Sijilmasa is the large medieval oasis city located on the borders of present-day Algeria and Morocco (Tafilalt province, Morocco) that is today unanimously considered by historians as the most important caravan city of northern Sahara for the 9th–14th-century period. The broad outline of its political and economic history is known to this day thanks to a dozen textual references collected in medieval Arabic written sources that have now been extensively analyzed by several generations of historians.¹ The archaeological site is a large *tell*, located in the heart of the Tafilalt palm grove in the Saharan plain of the same name, surrounded by dozens of satellite sites, most of which have yet to be identified. Two major archaeological missions followed one another, first in the 1990s,² then in the 2010s;³ however, despite these long-term, rigorously conducted, and widely published excavation campaigns, the materiality of this major site of medieval Saharan history remains poorly documented, because only an infinitesimal portion of the site has been explored to date. Of the main archaeological site of nearly 380 ha—of which 130 ha represent the heart of the urban fabric (Figure 1)—barely 700 sq. m have thus far been extensively excavated. As a consequence, if the

curtain is beginning to be raised on the architectural patterns, on the typology of artifacts, on the chronology and temporalities of the site's development, many other fields and topics remain under-documented—such as the overall morphology of the city, the spatial frames and dynamics of urbanization, the demographic and social organization of the settlement, the artistic traditions of the site, the health status of the populations, and the relation of the town to the surrounding oasis and desert environment.

Figure 1. Map of the archaeological site of Sijilmasa and the contemporary city of Rissani



Chloé Capel

- 2 In the absence of long-term and extensive excavations, which require broad technical skills, material resources, and funding commensurate with the exceptional size of this site, it is necessary to implement alternative modes of archaeological investigation in order to circumvent these obstacles and continue to expand our knowledge of this major site in African and Mediterranean history. This strategy was followed in the framework of a PhD project entirely dedicated to the history and archaeology of Sijilmasa⁴ and where a cross-disciplinary investigation, combining environmental archaeology and hydrosociology, was tested. The first aim of this investigation, based on the observation of the current irrigation networks of Sijilmasa palm grove, was to explain the modes and systems of water exploitation of this oasis, to reconstruct the conditions of their implementation, to ascertain their antiquity, and to evaluate their evolution over time—in a word: to historicize access to water in this region. The second objective was to cross-check these elements of hydraulic history with the contributions of Political Ecology, developed by sociologists and geographers who highlight the close relationship that exists in contemporary societies between political and social stakes and environment-shaping, particularly in water landscapes.⁵

Investigation methods: At the crossroads of the hydraulic archaeology of medievalists and the social hydrology of geographers

- 3 Recently—that is, since the mid-2000s—the term ‘hydrosociology’, or ‘social hydrology’, has been largely adopted in the field of Political Ecology, notably following the clear definition⁶ given by the British geographer E. Swyngedouw (Manchester University) based on previous thoughts and current paradigmatic dynamics related to contemporary water management studies.⁷ In fact, this concept of social hydrology has been progressively built up throughout the world over the last fifty years, mainly among anthropologists. One of the pioneers, as early as the 1950s, was the German-American sinologist Karl Wittfogel, who conducted a political—and autocratic—reading of the great hydraulic laying out of the planet, from ancient Mesopotamia to the Stalinist USSR.⁸ Even though the conclusions of his work have been questioned for a long time, his theory of the existence of a close interdependence between political structures, water resource management, and hydraulic technologies has been widely adopted and, since the 1960s, considerably amended by a multiplication of case studies throughout the world.⁹
- 4 In North Africa, the cultural and environmental framework for our analysis, many geographers and to a lesser extent anthropologists have been studying, for about a century, the procedures, techniques, and social organization of contemporary irrigation in these arid or desert surroundings. Globally, geographers and agronomists have mainly addressed the environmental (hydrological resources), technical (irrigation amenities), agricultural (crop spectra and cycles), and land use planning (plot morphology) issues of hydraulic practices.¹⁰ Alongside this abundant literature, anthropologists and specialists in Islamic law have also taken up the topic of irrigation but have been focusing more on the social issues (rules and rights of use, sharing of the resource, water ownership, conflicts and arbitration) of water management.¹¹ At the crossroads of these two approaches, only a few researchers working on contemporary worlds have explicitly considered the impact of social organizations on the terms of water use and on the shaping of hydraulic landscapes, as well as the co-evolution of social patterns and hydraulic patterns—that is, two key concepts of hydrosociology.¹² For the western Maghreb region, one of these leading theorists of social hydrology was Paul Pascon (1932–1985). A native of Morocco, trained in biology and sociology, he was entrusted by the Moroccan administration with various sociological survey missions, notably at the Office National d’Irrigation (ONI) between 1964 and 1966 (i.e. in the midst of post-colonial restructuring). This position offered him the opportunity to study in depth not only the hydraulic but also the social organizations of the Marrakech plain (the Haouz Plain)—and to multiply there social experiments that today would be qualified as development initiatives. This extensive fieldwork in the Haouz of Marrakech—an arid alluvial plain intensively irrigated for at least a millennium—would give its name to the masterwork that, 15 years later, he drew from his PhD in history.¹³ His academic thesis is dedicated to the question of the social organization of the region and to its transformations faced with the successive assertion of the sultanian central state, of local chieftaincies, and of capitalist colonization.¹⁴ This broad historical survey, which combines sociology, geography, and hydrology, is based on an original reading

scale that locates the issues of water management at the heart of the analysis and leads to a global and diachronic perspective on the foundation, antagonisms, and transformations of this Moroccan society, seen through its irrigation uses. In this book, Paul Pascon demonstrates that the diversity of hydraulic uses and techniques of the Haouz Plain reflects the various social and political organizations that followed each other in this area. In other words, water management, whether it is collective or individual, concerted or imposed, fair or unequal, says a lot about the social frame and effective political powers of this region of Morocco, from colonial to contemporary times.¹⁵ Pascon has thus done pioneering work in renewing the study of hydraulic systems, which were until then mainly considered as technical objects, only for the domain of engineers. By introducing human sciences here, he defined irrigation systems as elements of human geography.¹⁶ Furthermore, he is even among the first to define this field of research, as he named it the “psychosociology of irrigation”.¹⁷ Since the 1970s, this social and political approach to hydraulic practices has become a separate part of the social sciences, until it became, in the 21st century, a full field of research under the now widely accepted name of ‘hydrosociology’.

- 5 Hydraulics has also been a major topic among historians and archaeologists, especially among specialists in ancient Roman society, which has remained particularly famous in history for its water engineering. Thus, not surprisingly, the main archaeological studies on Saharan hydraulics have concerned settlements from Antiquity, sometimes building bridges with contemporary oasis practices for the purpose of ethno-archaeological restitution.¹⁸ On the contrary, in the field of medieval or modern hydraulics, Saharan studies are still rare.¹⁹ As a consequence, it is thanks to works and advances led in other geographical areas that hydraulic archaeology came to be a fully fledged research field. Thus, in the course of the 1980s, in Spain, a movement of theorizing the discipline emerged among historians who were involved in the topic of agricultural landscape evolution of the Iberian Peninsula with the arrival of Islam. Miguel Barceló (Universitat Autònoma de Barcelona, Spain), in particular—but also Pierre Guichard (Université Lyon Lumière, France), Helena Kirchner (Universitat Autònoma de Barcelona), and André Bazzana (CNRS, France)—defined methods of investigation, created conceptual tools of analysis, and developed theoretical models, which allowed researchers to considerably rationalize the approach of the archaeologists.²⁰ As an example, and because the present paper is based on this concept, the theorization of what archaeologists now call ‘hydraulic permanence’ represents a fundamental contribution to the understanding of ancient and current hydraulic landscapes. This ‘hydraulic permanence’ is the process according to which an efficient hydraulic system is perpetually maintained in position over decades and even centuries as long as its purpose does not disappear, while being rebuilt on multiple occasions and according to different techniques to extend its existence. This phenomenon leads to and explains the accumulation of hydraulic ruins from different periods in the same place and the frequent appearance of archaeological hydraulic palimpsests in contemporary agricultural landscapes, which allows one to go back in time by reading ancient, even disappeared, hydraulic practices.²¹ Moreover, some archaeologists of this Iberian generation made great steps forward in the historicization of hydraulic systems by taking over the theories from social hydrology to apply them to archaeological remains. Among them, Patrice Cressier (CNRS, France), who is active on both shores of the Mediterranean—that is to say, between Morocco and Spain—was aware of the Moroccan work of Paul Pascon and exploited it as a

reading grid of North African artifacts. In this way, more than just understanding ancient systems from a technical and chronological point of view, he proposed to reveal the social and political systems linked to these ancient modes of water management.²² A window was thus opened on the population organizations that usually constitute a field difficult to grasp, in particular within societies without writing.

- 6 This method was applied to a Saharan oasis case study: the palm grove of Tafilalt, closely associated with the history of the caravan city of Sijilmasa, which has now disappeared. The analysis of the sub-contemporary hydraulic system of Tafilalt revealed that its implementation was the result of a significant transformation of irrigation methods over time, from the origins of Sijilmasa to the present day. This system consists of three main elements: garden and domestic wells (about a thousand in 1950) that exploit local groundwater; sets of several dozen *khettâra*-s (also called *foggara*-s in other Saharan regions)—that is, underground tunnels that mainly tap the aquifers of the surrounding mountainous foothills to drain them to the outskirts of the palm grove; and the surface *sequia*-s (open channels) connected to the Wadi Ziz (the wadi that runs across the entire palm grove), which exploit surface water, particularly at the time of spring and autumn swellings. The study of these different systems has led to the historicization and dating of their use, which seems to be divided into three major hydraulic phases; moreover, these three phases correspond to three distinct hydraulic practices that themselves most likely reflect three different modes of social organization that have succeeded each other over time.²³ The chronological division is as follows: medieval period (9th–14th centuries); post-medieval period (15th–16th centuries); and modern period (17th–19th centuries).

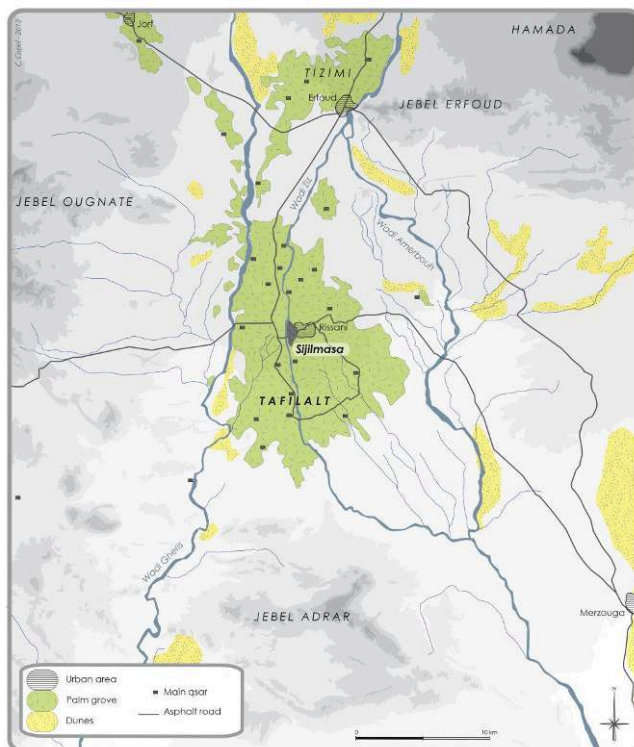
Sijilmasa, an oasis city “overlooking the waters”:²⁴ Hydraulic requirements of a desert city

- 7 Since its first references in medieval Arabic sources, all historians and geographers agree that Sijilmasa developed in a hostile and bleak desert context. However, in the works of Ibn Hawqal and al-Bakrî—the two medieval authors with the best information on the city, the former having himself visited it during the 10th century, and the latter having used first-hand accounts a century later—this negative image of the Tafilalt environment is counterbalanced by the description of the wealthy hydraulic context of the site.²⁵ These two authors agree in locating Sijilmasa on the banks of a particularly generous wadi, which they do not name, however—and nor do most ancient authors, with the exception of al-Ya’qubî (9th century), who was the first to mention the toponym of Wadî Zîz, and then, much later, al-Dimashqî (14th century) and Leo Africanus (16th century).²⁶ Ibn Hawqal also accurately describes the specific rate of flow of this wadi, which bursts its banks annually like the Nile River and then largely floods the entire region of Sijilmasa, creating exceptional conditions for the development of agriculture. Not surprisingly in a desert context, water and water management are thus key parameters for understanding the history of Sijilmasa.
- 8 The archaeological study of the entire region bears out and clarifies this initial perception. Indeed, if the city of Sijilmasa—settled in a sedimentary basin located on the northern fringe of the Sahara—was able to develop in the middle of a desert environment, it was primarily due to the rise of its oasis, where dense irrigated agriculture was implemented. The palm grove of Tafilalt, which still exists today, first

led to ensure the food autonomy of the region but also, and above all, to make Sijilmasa a supply stopover on Saharan routes that could not be overlooked, thanks to its surplus production and its obvious large size.²⁷ Although this aspect has been underestimated for a long time by historical research, it is indeed probably because of its agricultural value and of its enormous production capacity, both in foodstuffs (dates, cereals) and in fodder for pack animals, that Tafilalt owes its overwhelming position as a caravan crossroads and its longevity as such throughout the medieval period.²⁸ As a result, a large proportion of the inhabitants of Tafilalt, including those living in the urban area of Sijilmasa, must have been involved in agricultural activities, which may have led to Sijilmasa being characterized more as an agro-city than as a caravan city.

- 9 Now, in this desert context, this major agricultural hub only owes its existence to the implementation of a dense and massive irrigation system and to expert water management; these are primarily based on the exploitation of surface resources provided by the Ziz and the Gheris wadis that run cross the Tafilalt plain, where the palm grove of the same name is nestled (Figure 2). But of these two wadis, it is in fact the Ziz—and more specially its arm known as the ‘Filali’ (*‘of Tafilalt’*) Ziz alongside of Sijilmasa—that has been mainly exploited since medieval times; indeed, its morphological characteristics are quite different from those of the wadi Gheris and make it particularly suitable for agricultural use. And if this wadi is so well adapted to the needs of agriculture, it is in fact because the Filali Ziz is an anthropic construction—in other words, it is a canal.²⁹

Figure 2. Map of Tafilalt today



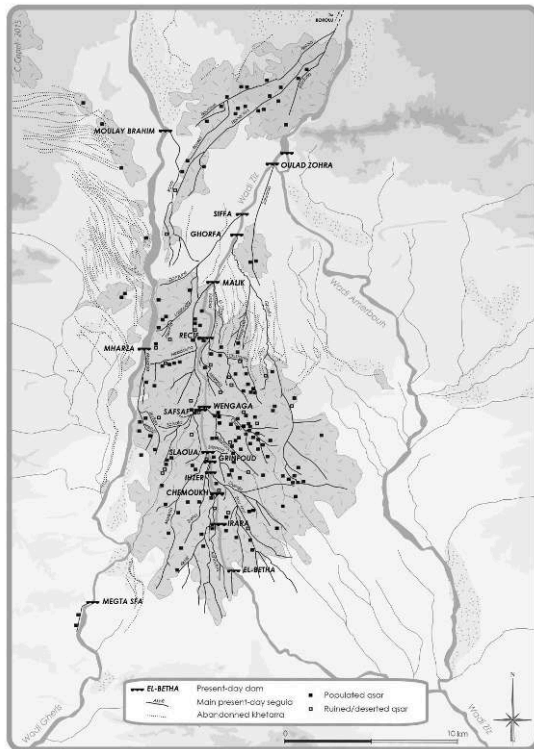
The map shows the main wadis of the region: the (Filali) Ziz, which flows through the heart of the palm grove; the Gheris, which limits the latter to the west; and the Amerbouh, which runs along the eastern edge of the Tafilalt plain.

Chloé Capel

Irrigation and hydraulic practices in medieval Sijilmasa (9th–14th c.): Common good, collective management, and settlement unity

- 10 In Saharan contexts, oases are anthropic constructions intended to ensure the food subsistence of the desert populations. Thus, the main purpose of a canal is agricultural irrigation—and, in fact, as medieval texts and sub-contemporary practices show, the role of the Filali Ziz is mainly related to this agricultural perspective. The Ziz is thus nothing more than an irrigation *seguia*, but with the proportions of a river (45 km long and 20–30 m wide). This unusual size of the hydraulic layout has led here to the implementation an original irrigation technique—likely unique in North Africa—which consists in flooding the plots of cultivation by a massive and widespread water submersion up to 1 m high. Thus, twice a year, during the two annual natural floods of Wadi Ziz, the Tafilalt palm grove is completely submerged under nutritive water and converts into a patchwork of countless basins, limited by high earthen embankments.³⁰ This method is close to flood irrigation management used on the banks of the Nile and the Senegal rivers. Then, after evaporation and deposition of nutritious silt on the plots, the latter were cultivated thanks to plant species with a fast maturation cycle (about 3 months) that did not require further irrigation before harvest time.³¹ Still in use until the end of the 1960s, this widespread flood irrigation system was documented in the 1950s and echoes the descriptions in ancient texts that rightly compare the Ziz Valley and the Nile Valley. This irrigation technique has now disappeared with the construction of the Hassan al-Dhâkil dam, 100 km upstream from Sijilmasa, which came into operation in 1973 and now protects the lower Ziz Valley from its massive (and sometimes destructive) floods and replaces them with a moderate but regular water supply, which allows for year-round irrigation similar to that adopted in all other Moroccan palm groves.
- 11 Despite its replacement fifty years ago by water supply systems directly connected to the Hassan ad-Dâkhil dam, the ancient irrigation network of the Tafilalt oasis has been largely preserved in the present-day Filalian landscape, mainly because the contemporary system makes use of a large part of this ancient network—which was perfectly well thought out and adapted to the site's organization—by joining up with it. It is thus possible to map the network of the main *seguia*-s that were in use in modern times in Tafilalt and thus to retrieve a global irrigation organization scheme for the Alawite period.³² According to this pre-colonial system, the Filali Ziz included 13 diversion dams, spread out along its course (Figure 3).

Figure 3. Map of the sub-contemporary irrigation network of Tafilat, indicating the location of water intakes and the routes of the main *segua*-s operated during the Alawite period



Chloé Capel

- 12 The first observation is that the majority (11 of 13) of these dams—still preserved as ruins today—gave rise to a single *segua*, which alternately irrigated the right and left banks of the Ziz. The system thus adopted an overall herringbone pattern. Moreover, the water intakes were generally spaced out so that the *segua*-s did not extend downstream from the latitude of the zones watered by the next dam. This rigorous organization of the agricultural zone, made up of independent irrigated territories, led to the coexistence of non-competitive hydraulic units. This kind of hydraulic organization is very similar to that of the Haouz of Marrakech, studied by Paul Pascon.³³ Despite different local forms, the common morphological characteristics of these two systems must be related to the “tribal”³⁴ structuring of societies. And according to Pascon, they may physically reflect a fair plot allotment between neighbors, associated with equivalent water exploitation rights and based on the number and variety of social groups composing the full population of the oasis.³⁵
- 13 This system could be ancient and date back to medieval times. Indeed, this is how the set of fossilized *segua*-s has been interpreted that shaped the agricultural land of the Saharan medieval town of Tâmdult (Morocco), now abandoned. At the foot of the urban archaeological site, whose main occupation seems to date back to the 12th century, Patrice Cressier (CNRS, France) and Ricardo González Villaescusa (Université de Nice, France) have identified a series of four to six large and parallel *segua*-s that creates a mesh of narrow but very elongated strips of land. This orthonormal pattern has no apparent technical or topographical reason here and is therefore more likely to be due to social factors. In fact, it defines agrarian units that are hydraulically independent of each other and do not compete with each other. This ensures an equitable supply of

water and plots and thus thwarts possible conflicts between the populations forming the urban community of Tâmdult.³⁶ Similarly, in the case of Tafilalt as in that of Haouz, the water intakes follow one another, spaced out so as not to compete with each other. In addition, each dam gives birth to only one *seguia*, once again in order to limit any supply conflict. As a consequence, the agrarian territories are hydraulically independent so as not to take advantage of undue resources. In the same way, the upstream territories are generally better watered but also smaller—as they are limited in their extension by the existence of their neighbors—than the downstream lands, which can extend and in fact are generally much larger, but which benefit from less dampness and therefore experience a lower yield. In this way, the people implement a collective system of water management that considers the resource—the Wadi Ziz—as a common good and is based on a fair and collective supply in order to make possible the coexistence of several (and possibly antagonistic) social groups in a horizontal organization of forces. Now, because of the general stability (permanence) of hydraulic systems over time that has been demonstrated by archaeological research,³⁷ this balanced and egalitarian pattern of the Filalian network in modern times could date back to medieval times and thus be an indicator of the organization of the medieval territory of Sijilmasa.³⁸

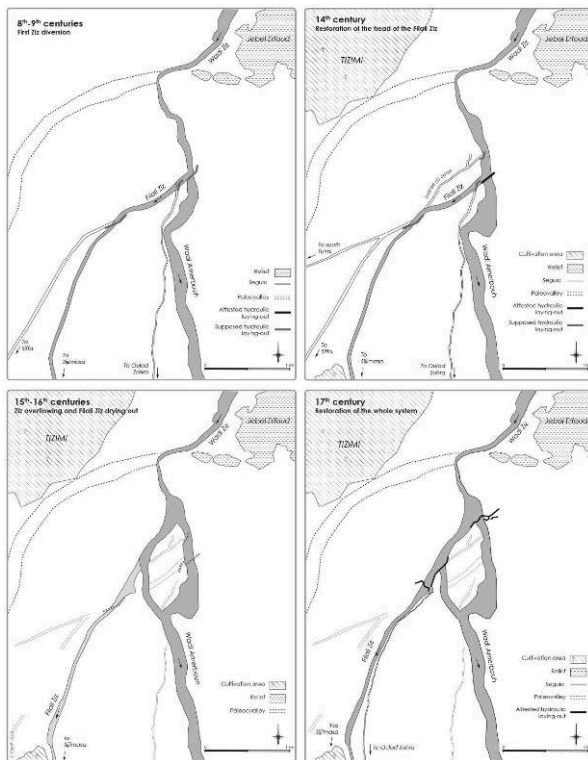
- 14 The digging of the Filali Ziz must have taken place from the time of the founding of Sijilmasa, notably because the city has been settled on its banks.³⁹ However, it will probably remain impossible to determine whether this decision—which means the launch of a massive investment in agriculture and thus the planning of a deep change in the local subsistence economy—was made by the political leaders (the Midrarid emirs, 772–976) of that time alone, or whether it was the result of a broader collective initiative involving tribal chiefs, pastoral communities, religious representatives, or even landowners. In any case, this process of agricultural colonization sheds light on the Midrarid chronology and on the origins of the city of Sijilmasa, as reported by al-Bakrî. Indeed, in this text, al-Yasa', the fourth ruler of Sijilmasa (790–824) is reported to have conducted a tribal allotment of the city after he ordered the town to be walled. The re-reading of these few sentences leads us to understand this decision not only as an allotment of the urban districts of Sijilmasa following the founding of the city, as has been usually proposed by historians, but also as an 'allotment' (or a subdivision) of water resources—that is, as the definition of the egalitarian system of the Filali Ziz irrigation network. This fair planning of the territory would also fit quite well with the historical vulgate drawn from the text of al-Bakrî, which claims that the founding of Sijilmasa was driven by the principles of the Kharejite doctrine, supposed to be of an egalitarian social conception.
- 15 The cross-checking of these textual and historical elements leads us to reconsider the origin of Sijilmasa and, in particular, the organization of its settlement during its first centuries of existence. As mentioned previously, the digging of the Ziz—which must be contemporaneous with the founding of the city⁴⁰—and the concomitant design of the secondary irrigation network convey the notion of a collective mode of water management where the hydraulic resource is considered as a common good and a shared capital. This original consensus about water management indicates a strong social agreement between all the actors involved in this project. It thus means that the Sijilmasa of the early Middle Ages developed as a single political entity, mostly united, in spite of very likely internal conflicts. In other words, Sijilmasa must have considered itself as a societal unit, as it formed a single settlement and agreed that it shared and

managed collectively a finite territory (i.e. the palm grove), and as it created the possibilities of an integrating agglomeration of people in the form of an agro-city. This feeling of a collective belonging undoubtedly prevailed over internal dissensions for many centuries, despite the turmoil of history (e.g. refuge for political dissidents, independence splits), despite external struggles for influence over the region (e.g. the successive Fatimid, Umayyad, Almoravid, Almohad, and Abdelwadid conquests), and despite demographic and social difficulties (e.g. Almohad purges, destructive floods, the Black Death).

Irrigation and hydraulic practices in post-medieval Sijilmasa (15th-16th centuries): Individualization of resources, competitive management, and atomization of the settlement

- 16 If, in the course of the 20th century, the Filali Ziz was still used as the main lifeline for the development of Tafilalt, the archaeological survey revealed that this wadi had not always held the same role nor held the same weight in the hydraulic history of the region.
- 17 The study of the area of the head of the Ziz canal, located 20 km upstream from Sijilmasa and near the present city of Erfoud, showed that, later than the 14th century, ⁴¹ a violent flood utterly diverted the course of the natural wadi. About 1 km upstream from the Filali Ziz diversion dam, the river turned away from its course and bypassed the original hydraulic system to return directly to its natural bed (called Amerbouh in this sector), depriving the irrigation canal—and by extension the entire palm grove—of its water. This event was undoubtedly experienced as a disaster, calling into question the survival of the inhabitants of Sijilmasa and therefore making it necessary to rebuild hydraulic diversion structures to keep the canal viable. These facilities were relocated about 800 m south of the original dam, to a site that was maintained and rebuilt until the 1950s, when the last renovations were carried out before the Hassan ad-Dâkhil dam was put into operation (Figure 4).

Figure 4. Diachronic plan of the head sector of Filali Ziz showing the evolution of hydraulic developments over the centuries

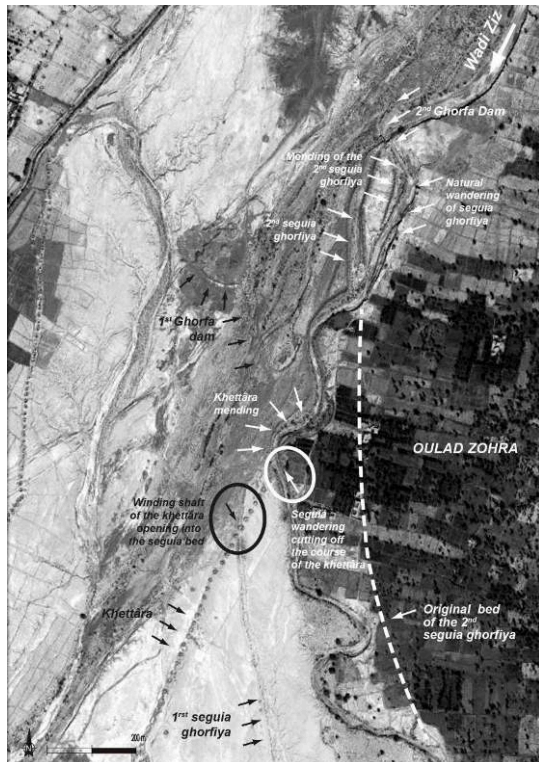


Chloé Capel

- 18 Now, some evidence indicates that this reconstruction may not have been immediate and that several years, or even several decades, may have preceded the re-watering of the artificial channel. This thesis is suggested by the existence in Tafilalt of a spectacular hydraulic layout: the *khettâra*-s (underground drainage galleries). Their large number (about 90), their density, and their great extent (some measure about 20 km, for a total of about 300 km of galleries)⁴² make it a set among the most spectacular in Morocco, comparable to the largest Iranian systems.⁴³ However, to this day, these structures have remained poorly studied and very uncertainly dated. Emile Gauthier believes that they were introduced in the early Middle Ages by the Miknâsa tribe (the founders of Sijilmasa), who brought Roman technology with them on their migration south.⁴⁴ According to Henri Goblot, the Almoravids (the founders of Marrakech in the 11th century) must be credited with their construction, as they are reputed to have provided their own capital with a vast network of water supply through underground drains;⁴⁵ and James Miller and Dale Lightfoot associate their implementation with the Merinid period.⁴⁶ In addition to not being based on any textual or archaeological evidence,⁴⁷ these hypotheses remain weak because they assume that the entire network was built in one piece, on a single occasion, and there is no evidence to support this notion. Only the geologist Jean Margat, with the help of oral memory, suggests a more careful hypothesis by staggering these constructions between the 16th and 18th centuries.⁴⁸
- 19 Scattered throughout the plain, the *khettâra*-s (or *foggara*-s) of Tafilalt can be divided into several groups but are mainly designed to drain water from the water tables located at the foot of the nearby last reliefs of the Anti-Atlas range to the direction of

small oases skirting the western edge of the palm grove of Sijilmasa. But one of these groups of galleries is different from the previous ones since it was built on the left (east) bank of the Ziz canal, in the northern half of the Tafilalt palm grove, in order to catch the lower flow of the wadi and to direct it towards the cultivated areas of the inner oasis. Careful observation of the layout of these *khettâra*-s and their intersection with other hydraulic facilities—which are numerous in this area—allows us to define a relative chronology of these structures, fully summarized in the sector of the Ghorfa dam, located at the northern limit of the palm grove (Figure 5).

Figure 5. Satellite view of the Ghorfa dam sector (northern Tafilalt) where the tangle of hydraulic structures reveals a clear relative chronology of the different development phases



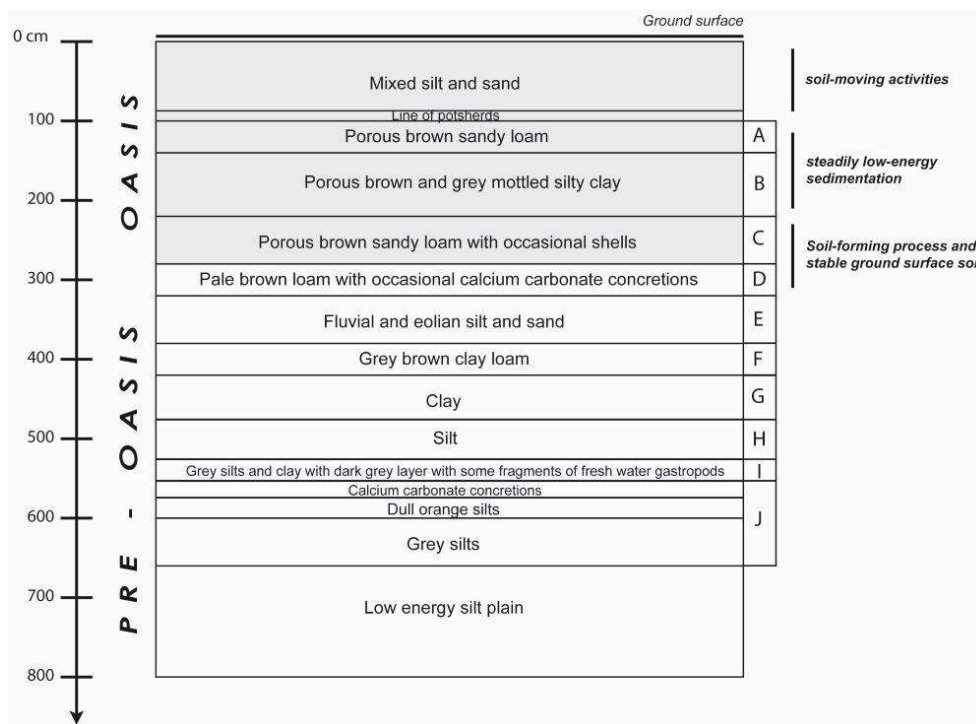
Chloé Capel, based on Google Earth

- 20 In this area, a *khettâra* was dug in the immediate vicinity of the Ghorfa dam in order to drain the water table of the Wadi Ziz; the building of this underground canal is interposed between the use of an old surface *seguia* connected to the same dam (which the *khettâra* cuts off, making it unusable), and the reconstruction of this same *seguia* (by which the same *khettâra* is cut off but not destroyed) 200 m upstream. These three successive facilities supply water to the same sector (Tanijiout district and north Ifli district), located in the heart of the oasis, but the *khettâra* does not exist independently insofar as it connects to the fossil (and original) *seguia* of Ghorfa in order, obviously, to support and increase its flow. This relative chronology thus clearly indicates that, at an early date, the surface network of *seguia*-s connected to the Filali Ziz was lacking water until it became necessary to build *khettâra*-s that were no longer connected to the surface water of the Ziz but to its underground flow. As a consequence, this indicates that the wadi was now largely dry and that some underground canals provided an opportunity for maintaining in use the old hydraulic system. The situation lasted until

the Ziz canal was fully reactivated and a network of new surface channels was established or restored.

- 21 This archaeological analysis seems to be confirmed by the pedological observations initiated in 1992 by Tony Wilkinson (University of Durham, UK) and completed by ourselves in 2013. A stratigraphic section of nearly 10 m high of the Tafilalt palm grove could be found in the riverbed of the Gheris, in a location where the river bank was deeply cut by hydrological activities.⁴⁹ Over the natural soil formations of ancient origin, which developed nearly 5 m high (strata D to J in the figure), several recent layers of anthropic origin can be identified that are over about 3 m high (strata A to C and unnumbered strata) (Figure 6).

Figure 6. Sketch diagram of Tony Wilkinson's observations about the stratigraphic section of the Wadi Gheris



The lower half of the levels (in white) belongs to natural formations, while the upper half (in grey) represents agricultural deposits

Chloé Capel, based on notes from the MAPS archives.

- 22 This anthropic series shows evidence of significant biological activity, which, in a desert environment, is characteristic of cultivated soils. Therefore, these layers consist in deposits that have been accumulated here since the creation of the Tafilalt palm grove—that is, by agricultural and irrigation activities. These bioturbated formations can be divided into three phases: the lower level (stratum C) is equivalent to a well-watered soil, endowed with a fairly dense plant cover (= significant bioturbation combined with the presence of mollusks), that only periodically floods (= multiplication of limestone concretions symbolizing frequent phases of drying) and is stable in altitude over several centuries, even a millennium (= thin deposit); the intermediate level (strata A and B) is synonymous with a constant and fast formation (= massive and regular deposits) in a constantly moist soil (= homogeneity of the sediment) occupied by dense vegetation; the upper level (without individualized numbering) is unfortunately

very disturbed owing to the recent introduction of destructive practices (deep plowing, road works, water conveyance), but its preserved base is typical of a densely cultivated soil made of regular and thick deposits, which would have been tilled by manuring (important volume of potsherds). This outstanding morphological difference between these three agricultural levels most certainly originates in the nature of the farming practices that followed one another over time: the first sequence seems to be equivalent to a phase of seasonal cultivation of the banks of the wadi, which was naturally but only periodically flooded, without any continuous irrigation; the implementation of the second sequence indicates the appearance of artificial and massive irrigation by the Wadi Ziz, with regular immobilization and spreading of flood waters that deposited large flows of alluvium in the plots; the last sequence would be an illustration of a less massive (or regular) irrigation, where nutrient supply is limited and makes the use of manuring necessary.

- 23 To sum up, this stratigraphic section reveals a broad outline of the agricultural history of the region: at an early date, before Islam, the nomadic men of Tafilalt would have developed a light and seasonal agriculture located in the narrow riverbed of the Gheris, based on the natural but short-lived flood supply; with the emergence of Sijilmasa, the Filalian society then transformed its agricultural practices to set up a large network of permanent irrigation connected to the Ziz, leading to a drastic environmental change with the birth of the oasis and the massive adoption of a sedentary and farming lifestyle by the populations; this organization was preserved until the 20th century, while undergoing quite recently a significant agricultural change with the introduction of manuring, probably in association with irrigation based on the exploitation of local groundwater instead of floodwater, which would explain the use of artificial fertilizers to compensate for the lack of alluvial nutrient supply that was previously provided by surface water.
- 24 The cross-checking of these two categories of archaeological and pedological information tends to agree with the previous hypotheses based on geomorphological observations—namely, that at some time after the 14th century, the Ziz canal suffered a severe drying up of its surface flow for a quite long duration owing to its partial or total diversion by the Wadi Amerbouh. This was followed by a period of environmental tension during which Filalian agriculture was thwarted by very unfavorable irrigation conditions, forcing farmers to renew their practices and to exploit groundwater rather than surface water. While certainly multiplying the wells in the heart of the palm grove, associated with individual drawing systems by *noria* or *pendulum*, the exploitation of underground resources of the Ziz bed was also locally implemented by the digging of *khetâra*-s, which provided an essential support to the survival of agricultural activities in Tafilalt. But all these means of water drawing introduced a major shift into water management: the latter was henceforth based on an individual and autonomous water conveyance, as the purpose of the water was no longer use for a whole agricultural district but for a single estate (= case of wells) or a small group of properties (= case of *khetâr*a-s).
- 25 Thus, at the end of the medieval period, a significant evolution in the social organization emerged: the water was no longer considered as a common good that people exploited collectively and in (forced?) dialogue, but as a resource to be individually capitalized, within a logic of privatizing a good in a context that had become competitive. This relationship with water undoubtedly reflects a similar

evolution in the Filalian society, turning to social patterns where solidarity was no longer the structuring link between the inhabitants of the palm grove, but where, with a backdrop of rivalry for water supply, competition redefined social and therefore political organizations. However, these events occurred precisely at a time—after the 14th century—when, according to the texts, Sijilmasa was experiencing a period of deep destabilization, marked by a crisis in its urban model (= city exodus),⁵⁰ by significant political disorganization (= multiplication of tribal, religious, and state arguing over control of Tafilalt),⁵¹ and by possible social weakening (= competition between tribes,⁵² plague epidemics).⁵³ Far from being unique, the cause of these troubles cannot be summed up in the difficulties identified in the water management, which are perhaps only a symptom of this crisis. But these hydraulic observations alone shed light on why Sijilmasa could not maintain itself as a coherent settlement unit, as an integrating agro-city, and as a homogeneous and indivisible urban model. The problem of water supply underlines the fact that at the end of the medieval era, Tafilalt was experiencing an increasing tendency towards internal political division, made up of family, clan, spatial, or even dogmatic rivalries that were undoubtedly reflected in the hydraulic competition. Thus, perhaps Sijilmasa and its oasis were beginning to be experienced no longer as a unified space and as a single social entity, but as a territory to be divided among several human groups with divergent interests. Thus, the rehabilitation of the Ziz, which represents a large-scale collective and planned effort, could have been permanently hindered by a lack of collective will. At the same time, the single agro-city model was breaking down, giving way to a physical spread of the population within the oasis and to a political fragmentation of its inhabitants. The city of Sijilmasa, which had become an unsustainable social model, was depopulated, while the organizational logic of the Filalian settlement was now recomposed into independent and rival units: the era of the *qsûr* was initiated.

Irrigation and hydraulic practices in modern Sijilmasa (17th-19th centuries): Vertical appropriation, arbitrary management, and settlement hierarchy

- 26 While the Ziz canal underwent a period of drying up during the 15th and 16th centuries, which led to a problematic access to water and to the populations of Tafilalt renewing their hydraulic, demographic, and political organizations, one sector of the palm grove stood out from the others. This area is located immediately to the northeast and east of Sijilmasa and is now divided between two modern administrative districts, called Tanijiout (to the north) and Ifli (to the south). As mentioned above, these are precisely the only two sectors of the inner Tafilalt oasis to be irrigated by *khettâra*-s connected to the Ziz canal waterbed, leading underground water to be piped in from nearly 10 km away. If none of these *khettâra*-s is still in use today, the toponymy preserves the memory of this ancient hydraulic pattern since *ifli* is a Berber word equivalent to the *khettâra* of Moroccan Arabic (pl. *iflân*). This expression has become uncommon in most parts of northern Sahara, but it is still commonly used today in the oasis of Figuig, 300 km from Tafilalt.⁵⁴ This toponymy alone highlights the importance of the economic, environmental, and probably political role of this water supply system in the development of this area, while at the same time the rest of Tafilalt was probably to wither. Now, this region of Tafilalt is precisely the one where (as early as the 14th

century?) the Sherifian families of Sijilmasa settled,⁵⁵ which leads us to draw a correlation between the rise of this socially privileged faction of the Filalian population and the considerable work of planning and digging that meant the implementation of *khettâra*-s. The accurate date of the building of this group of *khettâra*-s is unfortunately unknown and, according to archaeological observations, may range from the 15th to the 17th century. But even with such vagueness, it remains chronologically very likely that it was indeed for the benefit of these families that the technology of *khettâra* was implemented.⁵⁶ This plan may have called up a large workforce to serve the interests of a minority and would then illustrate not only the increase of the rivalries as the consequence of the monopolization process of hydraulic resources in Tafilalt, but also the development of privileges for small groups—thus the heightening of a strong social hierarchy now visible in hydraulic practices. A similar social process has actually been documented by Gilbert Grandguillaume (EHESS, France) thanks to legal documents in the oasis of Tuat, where the Sherfian clan has been recognized as having progressively captured the social prestige of the group as well as a privileged access to water.⁵⁷

- 27 The recent hydraulic history of Tafilalt bears out this social dynamic over the past three centuries. Although some of the *khettâra*-s of Tafilalt are still in use today, their usefulness considerably decreased when the head dam of the Ziz canal was rebuilt and when massive irrigation based on flood control was restored. This event has not been accurately dated so far, but it occurred when the population of Tafilalt was able to raise a collective force to carry out these major works. However, the origin of this motivating will, which would help to date the rehabilitation work on the Ziz, has yet to be identified. The first hypothesis is to relate this event to the restoration of a community solidarity similar to the one of the early Middle Ages leading to a joint decision-making. But this hypothesis remains fragile because of the political context of the region in the modern era, which was marked by multiple territorial conflicts that the texts describe quite well. The second hypothesis consists in attributing this responsibility to the powerful networks of *zawiya*-s (Sufi brotherhoods) that were particularly strong during the 17th century, as used to be the *zawiya* of Illigh, which controlled Tafilalt between 1620 and 1640.⁵⁸ However, since Illigh's interests in the control of Tafilalt were mainly economic in nature (= trans-Saharan trade taxation), it is unlikely that this movement, originated from the far Tazerwalt (Atlantic Morocco), consented to any large-scale local investment in the field of water management, with no direct exportable benefit. A final hypothesis is to ascribe this decision to the Sherifian powers that successively had authority over Tafilalt: first the Saadians, in the second half of the 16th century, and then the Alawites, from the middle of the 17th century.
- 28 In the absence of absolute dating of the new head dam on the Filali Ziz, it remains difficult to single out one or the other of these hypotheses. But the Saadian option is quite convincing insofar as texts and archaeology have proven that under the reign of Ahmed al-Mansûr (1578–1603), the sixth sultan of the dynasty ruling over Marrakech, the Saadian power had initiated a vast program of rehabilitation of the urban center of Sijilmasa, at a time when the city was largely deserted and ruined.⁵⁹ The outlines of this ambitious reconstruction campaign are unfortunately unknown, but the building of a new great mosque on the exact location of the medieval one has been demonstrated,⁶⁰ and it would not be surprising if this major work was linked to an equally ambitious hydraulic policy of rehabilitation of the Ziz. Indeed, for anyone revitalizing the urban center, it would have been logical and necessary to ensure a permanent and reliable

water supply of the city. As for the Alawite hypothesis, it is as convincing because of the local roots of this family, which had every interest in restoring satisfactory water conditions in the palm grove that supported its political rise.

- 29 Whatever the accurate date and origin of the restoration of the hydraulic network connected to the Ziz canal, this rehabilitation is synonymous with a significant evolution in the overall design of the system. Indeed, as previously announced, the sub-contemporary irrigation network of Tafilalt includes a number of anomalies that unbalance the horizontal and egalitarian organization of its origins. The two most important of these anomalies precisely deal with the water supply to the Ifli district. The first has already been mentioned above with the Ghorfa dam. Located far upstream of Tafilalt, this dam shows the particularity of irrigating two distinct sectors located on the same left bank of the Ziz (while all the other dams are made of a single main *sequia*). The first area (Tanjiout and north Ifli) is logically located immediately downstream of the diversion, but the second one—through a second *sequia* that bypasses a large part of the oasis from the east—is in a perimeter located in the southern extension of Ifli. As a consequence, the Ghorfa dam exploits the Ziz by diverting part of the water far upstream from its final purpose without respecting the usual priority of upstream lands over downstream lands. It thus appears that the southernmost land irrigated by the Ghorfa *sequia* could be associated with a colonization process for new agricultural land for the benefit of the inhabitants (or owners) of the Tanjiout and Ifli districts, who are the ones to manage the water supply. It is difficult to shed light on the exact reasons for this agrarian extension (increase in the rural population? increase in production needs? settlement of new social groups?), but the very upstream position of the water intake suggests a political decision-making process that was vertically imposed on the population. A medieval example of the extension of an irrigated territory due to an imposed political decision has been identified (thanks to extant texts) by Tariq Madani (Université Mohamed I^{er}, Oujda, Morocco), in the region of Fez: in order to favor the tribes that had rallied to their cause, some Merinid princes (last quarter of the 13th century) proceeded to an important reorganization of the agricultural landscapes in order to reallocate plots and water rights to their supporters, especially in the form of *iqta'* (land tax concessions) and at the cost of the peasant system that had previously operated in the area. This decision by force would be the origin of century-and-a-half hydraulic conflicts among the various owners involved in this long-lasting tussle.⁶¹ A similar process could have affected the Tafilalt; and even if it is still undated, it reveals the primacy of Ifli/Tanjiout decisions over the rest of the palm grove.
- 30 The Wengaga dam is the second major anomaly that unbalances the renovated hydraulic network of the Ziz canal. Built on the outskirts of the Sijilmasa site—that is, right in the heart of the palm grove—this dam is located almost against another dam, the Safsaf dam. With its upstream position, this dam creates an astonishingly commanding relation that halts the water previously intended for the second diversion. There is therefore strong competition between the two facilities, which do not respect the usual rule of being spaced out—a spacing precisely intended to avoid any conflict interaction and to ensure the fair supply of water between neighbors (Figure 1). The Wengaga dam is the intake of the so-called Wadi Chorfa (a *sequia* also known as the Wadi Ifli), which feeds the Ifli district and thus the Sherifian district of the palm grove. In this district stand some of the oldest *qsûr* of Tafilalt, many of which were occupied in modern times by relatives of the princely family. Some of them date

back to the 17th century, as does the *q̣sar* Rissani, built by Moulay Isma'īl (1672–1727).⁶² The purpose of Wadi Ifli/Chorfa consequently suggests that its design was contemporary with the territorial development and organization of this district and that it is therefore relatively recent vis-a-vis the old history of Tafilalt. Similarly, since the Chorfa *seguia* runs across the archaeological site of Sijilmasa—passing along the northern walls of the medieval city on one side and trimming a poorly characterized sector of ruins (forming ancient suburbs?) on the other side—this observation reinforces the hypothesis that the canal was dug later, at a time when Sijilmasa was already partly abandoned. It is thus very likely that the building of the Wadi Ifli/Chorfa dates from the spread of the Sherifian clan outside of Sijilmasa and is therefore later than the 13th century and earlier than the beginning of the 17th century. This cultural, political, and spiritual context could also explain the dominant position of the dam, immediately upstream from Safsaf.

- 31 As a consequence, the introduction of these anomalies in the Ziz irrigation network highlights a double social and probably political phenomenon: while a collective and shared water supply system (= the Filali Ziz network) was rehabilitated, the Filalian society does not seem to have restored the solidarity and horizontal organization that had made water management possible at the time of the birth of Sijilmasa. Indeed, the appearance, at several points of the network, of monopolistic structures to the benefit of restricted populations and to the detriment of the whole community reveals that the system was no longer collectively managed in dialogue but imposed by a vertical authority. Thus, behind a facade of solidarity, the water resource seems to have been managed according to some privileges considered as prevalent in the Filalian society, henceforth marked by a strong social and political hierarchy. The coexistence of collective water facilities and a vertical management shows that, in the modern period, Tafilalt was undoubtedly able to restore a unitary settlement, but that the latter was riddled with numerous rivalries. The hydraulic dynamics of the modern period therefore shed light on the way the Filalian settlement was recomposed over the last few centuries: in a palm grove once again considered as a common territory, driven by the pride of belonging to the Alawite force, society restored the facade of a shared living space, where the *q̣sūr* come closer together until they even touch; but, at the same time, populations maintain irreconcilable opposition logics, illustrated by the preservation of village defensive structures (= the fortification walls of the *q̣sūr*). Despite its urban features, Tafilalt is thus no longer a city: it is a conglomeration of opposing and excluding forces.

Conclusion: Rise, decline, and transformation of Sijilmasa

- 32 The contribution of hydrosociology teaches us that the study of archaeological hydraulic structures can quite adequately reveal the general nature of the social organization of the population that adopted a particular kind of water management. It thus leads us to think about the political structuring of a former settlement (whether it reveals solidarity, rivalry, or hierarchy), especially in societies where water management is as fundamental as it is in a desert oasis. The case study of Tafilalt has clearly shown that the social organization of the palm grove evolved over time, from an interdependent and complementary community in the early Middle Ages (= urban

phase), to an individualized and autonomous groups system (= *qsûr* phase), and finally to a collective organization dominated by a vertical authority (= aggregative phase). This global ternary pattern does not exclude the occasional or local development of other social dynamics (e.g. group solidarity during the *qsûr* phase, major conflicts during the urban phase); however, the stability and inertia of hydraulic uses do not allow us to detect these circumscribed events within a long-term trend. In the case of Sijilmasa, the textual documents were nevertheless already able to provide an outline of this ternary social history. For the record, these sources place the origin of Sijilmasa in the foundation of a religious state (= an imamate) built around an egalitarian doctrine of Islam, which has now largely disappeared (= Kharijism). They then ascribe the fall of the city in the 14th century to an internal conflict between inhabitants of opposing tribes and political parties. Finally, they emphasize that the rebirth of the region was a corollary of the emergence of the Moroccan (Alawite) monarchy, at a time when the adoption of Sherifism (which appeared in the 14th century) had for some time defined new forms and categories of nobility in Moroccan society. But in addition to local historical understanding, this correlation between hydraulic history and settlement history opens up completely new perspectives for the understanding of the history of other Saharan oasis sites for which no textual sources exist. Thanks to landscape archaeology, it would thus be possible to deepen our knowledge of these desert settlements and, in particular, to evaluate their political and social histories, even though the exact location of the nomadic or sedentary domestic and power structures is lost within the contemporary palm groves that have survived their decline. Hydrosociology applied to archaeology can then open windows on disappeared and invisible societies.

BIBLIOGRAPHY

'ABD AL-RÂZIQ, M.I., 1985, *Al-khawârij fî bilâd al-Maghrib hatâ muntasaf al-qarn al-râbi' al-hijrî*, Casablanca, Maktabat al-Hurrîyah al-Hadîthah.

ALAOUI, H., 1997, *Sijilmâsa wa îqlîmuha fî al-qarun al-thâmin al-hijrî*, Rabat, Ministère des Affaires islamiques.

ARRUS, R., 1985, *L'eau en Algérie : de l'impérialisme au développement, 1830-1962*, Grenoble, Presses universitaires de Grenoble.

BADUEL, P., BADUEL, A., 1980, "Les pouvoirs de l'eau dans le sud Tunisien", *Revue de l'occident musulman et de la méditerranée*, 30, p. 101-134.

AL-BAKRÎ, 1911, *Kitâb al-masâlik wa-'l-mamâlik*, 2nd edition (1st edition 1857), édition W. Mac Guckin de Slane, Alger, A. Jourdan.

AL-BAKRÎ, 1913, *Description de l'Afrique septentrionale*, 2nd edition (1st edition 1859), traduction française W. Mac Guckin de Slane, Alger, A. Jourdan.

- BALLESTEROS ARIAS, P., FERNÁNDEZ MIER, M., KIRCHNER, H., ORTEGA ORTEGA, J., QUIRÓS CASTELLO, J.A., RETAMERO, F., SITJES, E., TORRÓ, J., VIGIL ESCA LERA GUIRADO, A., 2010, "Por una arqueología agraria de las sociedades medievales hispánicas : propuesta de un protocolo de investigación", in H. KIRCHNER (dir.), *Por una arqueología agraria : perspectivas de investigación sobre espacios de cultivo en las sociedades medievales hispánicas*, Oxford, Archaeopress, p. 185-202.
- BARCELÓ, M., 1989, "El diseño de espacios irrigados en al-Andalus : un enunciado de principios generales", in *El agua en zonas áridas : Arqueología e Historia - I Coloquio de Historia y Medio Físico*, Almería, Instituto de estudios almerienses, § XV-XLVII.
- BARCELÓ, M., 1996, "La cuestión del hidrúalismo andalusí", in M. BARCELÓ, H. KIRCHNER, C. NAVARRO (dir.), *El agua que no duerme : fundamentos de la arqueología hidráulica andalusí*, Monachil, Sierra Nevada 95, p. 13-50.
- BEDOUCHA, G., 1987, *L'eau, l'amie du puissant : une communauté oasienne du sud tunisien*, Paris-Montreux, Éditions des Archives contemporaines.
- BENSAÂD, A. (éd.), 2011, *L'eau et ses enjeux au Sahara*, Paris, Karthala.
- BICHSEL, C., 2016, "Water and the (infra-)structure of political rule: A synthesis", *Water Alternatives*, 9-2, p. 356-372.
- BIREBENT, J., 1962, *Aquae Romanae : recherches d'hydraulique romaine dans l'est algérien*, Alger, Service des Antiquités.
- BRUNHES, J., 1904, *L'irrigation, ses conditions géographiques, ses modes et son organisation dans la péninsule Ibérique et dans l'Afrique du Nord, étude de géographie humaine*, Paris, Masson.
- CAPEL, C., 2016a, *Sijilmassa et le Tafilalt (VIII^e-XIV^e siècles) : éclairages sur l'histoire environnementale, économique et urbaine d'une ville médiévale des marges sahariennes*, thèse de doctorat en archéologie, ethnologie et préhistoire, université Paris 1 Panthéon-Sorbonne.
- CAPEL, C., 2016b, "Une grande hydraulique saharienne à l'époque médiévale : l'oued Ziz et Sijilmassa (Maroc)", *Mélanges de la Casa de Velázquez*, 46-1, p. 139-165.
- CAPEL, C., 2018, "Sijilmassa in the footsteps of the Aghlabids: The hypothesis of a ninth century new royal city in Tafilalt Plain (Morocco)", in G. ANDERSON, C. FENWICK, M. ROSSER-OWEN (ed.), *The Aghlabids and their neighbors: Art and material culture in 9th century North Africa*, Handbook of Oriental Studies Series 122, Leyde, Brill Academic Publishers, p. 531-550.
- CAPEL, C., 2019, "L'or africain et le paradoxe de Sijilmassa (VIII^e - XIV^e s.) : un atelier de frappe primordial, une histoire méconnue", in N. MINVIELLE-LAROUSSE, M.-C. BAILLY-MAÎTRE, G. BIANCHI (ed.), *Les métaux précieux en Méditerranée médiévale : exploitations, transformations, circulations*, Bibliothèque d'Archéologie Méditerranéenne et Africaine 27, Aix-en-Provence, Presses Universitaires de Provence, p. 243-260.
- CAPEL, C., forthcoming, *Sijilmassa, porte du Sahara. Histoire et archéologie d'une ville oasienne médiévale du sud marocain*, Rennes, Presses Universitaires de Rennes.
- CAPOT-REY, R., DAMADE, W., 1962, "Irrigation et structure agraire à Tamentit", *Travaux de l'Institut des recherches sahariennes*, 21, p. 99-119.
- COIGNET, J., 1925, "L'hydraulique agricole à l'époque romaine en Tunisie", *Tunisie agricole*, juillet, p. 76-83.
- COLIN, G., 1934, "Sidjilmâsa", *The Encyclopedia of Islam*, 1st edition, Leyde/Paris, Brill/Picard, vol. IV.

- CRESSIER, P., 2004, "Du sud au nord du Sahara : la question de Tâmdult (Maroc)", in A. BAZZANA, H. BOCOUM (ed.), *Du nord au sud du Sahara. Cinquante ans d'archéologie française en Afrique de l'Ouest et au Maghreb. Bilan et perspectives*, Paris, Sépia, p. 275-284.
- CRESSIER, P., 2006, "Géométrie des réseaux et marqueurs de territoire. L'image du partage de l'eau dans le paysage médiéval (Espagne-Maroc)", in P. CRESSIER, F. WATEAU (ed.), *Le partage de l'eau (Espagne, Portugal, Maroc), Mélanges de la Casa de Velázquez*, 36, p. 39-59.
- DASTUGUE, H., 1867, "Quelques mots au sujet de Tafilet et de Sidjilmassa", *Bulletin de la Société de Géographie*, 5th series, 13-1, p. 337-380.
- AL-DIMASHQÎ, 1866, *Cosmographie de Chems ed-Din Abou Abdallah Mohammed ed-Dimichqui*, édition A.F.M. Von Mehren, Saint-Pétersbourg, Académie impériale des sciences.
- AL-DIMASHQÎ, 1964, *Manuel de la cosmographie du Moyen-Âge*, reproduction de l'édition 1874, traduction française A.F.M. Von Mehren, Amsterdam, Meridian.
- ELDBLOM, L., 1968, *Structure foncière, organisation et structure sociale : une étude comparative sur la vie socio-économique des trois oasis libyennes de Ghat, Mourzouk, et particulièrement Ghadames*, Lund, Uniskol.
- ENGLISH, P.W., 1968, "The origin and spread of Qanats in the Old World", *Proceedings of the American Philosophical Society*, 112-3, p. 170-181.
- ERBATI, E., FAUVELLE, F.-X., MENSAN, R., 2020, *Sijilmâsa, cité islamique du Maroc médiéval. Recherches archéologiques maroco-françaises 2011-2016, Villes et sites archéologiques du Maroc (VESAM)*, 9, Rabat, INSAP.
- FOURNEL, H., 1881. *Les Berbers. Étude sur la conquête de l'Afrique par les Arabes. Tome II*, Paris, Ernest Leroux.
- GAUCKLER, P., 1897-1901, *Enquête sur les installations hydrauliques romaines en Tunisie*, Tunis, Louis Nicolas.
- GOBLOT, H., 1979, *Les qanats. Une technique d'acquisition de l'eau*, Paris, Mouton Éditeur.
- GONZÁLEZ VILLAESCUSA, R., CRESSIER, P., 2011, "Un espace agraire fossile dans le désert marocain. Une étude au croisement de l'archéologie et de l'archéogéographie", *Les Nouvelles de l'Archéologie* 125, *L'archéogéographie. Un état des lieux et de leurs dynamiques*, p. 24-31.
- GRAMAYE, J.B., 1622, *J.B. Gramaye Africae illustratae libri decem in quibus Barbaria gentesque ejus ut olim, et nunc describuntur*, Tournai, Tornaci Nerviorum.
- GRANDGUILLAUME, G., 1973, "Régime économique et structure du pouvoir : les systèmes de foggara du Touat", *Revue des Mondes Musulmans et de la Méditerranée*, 13-14, p. 437-457.
- GRANDGUILLAUME, G., 1978, "De la coutume à la loi : droit de l'eau et statut des communautés locales dans le Touat précolonial", *Peuples méditerranéens*, 2, p. 119-134.
- GUICHARD, P., LÉVI-PROVENÇAL, E., CÔTE, M., 2000, "Tâfilâlt", in *The Encyclopedia of Islam X*, Leyde, Brill, p. 82.
- HAMMOUDI, A., 1982, "Droits d'eau et société : la Vallée du Dra", *Hommes, Terre, Eaux*, 48, p. 105-118.
- HUMBERT, A., 2002, "Archéologie d'un système hydraulique. L'ancienne sucrerie d'Ouled Messaoud et le système hydraulique de la plaine du Sous", in *Eau, environnement et histoire des paysages dans le Sous, Actes du colloque de Taroudant, novembre 2000*, CR-ROM. Agadir/Nancy, Université Ibn Zohr/Université Nancy II.

- IBN HAWQAL, 1938, *Surat al-ard*, édition J.H. Kramers, Leyde, Bibliotheca Geographorum Arabicorum.
- IBN HAWQAL, 1964, *Configuration de la Terre*, trad. J.H. Kramers et G. Wiet, Beyrouth/Paris, Commission internationale pour la traduction des chefs d'œuvre / Maisonneuve et Larose.
- AL-IFRÂNÎ, 1888-1889, *Nuzhat al-hâdî bi-akhbâr mulûk al-qarn al-hâdî. Histoire de la dynastie saadienne au Maroc (1511-1670)*, ed. and trad. O. Houdas, Paris, Ernest Leroux.
- JACQUES-MEUNIE, D., 1982, *Le Maroc saharien des origines à 1670*, Paris, Klincksieck.
- KABLY, M. (dir.), 2011, *Histoire du Maroc. Réactualisation et synthèse*, Rabat, Publications de l'Institut royal pour la recherche sur l'histoire du Maroc.
- AL-KHATIB, M., 1989, *Duwaylat Banî Midrâr, 140-296 H/757-908 M.*, Le Caire.
- KIRCHNER, H., NAVARRO, C., 1994, "Objetivos, métodos y práctica de la arqueología hidráulica", in *Arqueología y territorio medieval*, Jaén, Université de Jaén, p. 159-182.
- LÉON L'AFRICAIN, 1956, *Description de l'Afrique*, traduction française A. Epaulard, Paris, Adrien-Maisonneuve.
- LESSARD, J.-M., 1969, "Sijilmasa. La ville et ses relations commerciales au XI^e siècle d'après el-Bekri", *Hespéris-Tamuda*, 10, p. 5-36.
- LETHIELLEUX, J., 1948, *Le Fezzan : ses jardins, ses palmiers. Notes d'ethnographie et d'histoire*, Tunis, Bascone & Muscat.
- LEVTZION, N., 1982, "The Jews of Sijilmasa and the Saharan trade", in M. ABITBOL (ed.), *Communautés juives des marges sahariennes du Maghreb*, Jérusalem, Institut Ben-Zvi et Université hébraïque de Jérusalem, p. 253-263.
- LIGHTFOOT, D., 1996, "Moroccan Khettara: Traditional irrigation and progressive desiccation", *Geoforum*, 27-2, p. 261-273.
- LIGHTFOOT, D., MILLER, J., 1996, "Sijilmasa: The rise and fall of a walled oasis in medieval Morocco", *Annals of the Association of American Geographers*, 86-1, p. 78-101.
- LINTON, J., BUDDS, J., 2014, "The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water", *Geoforum*, 57, p. 170-180.
- MADANI, T., 2003, *L'eau dans le monde musulman médiéval. L'exemple de Fès (Maroc) et de sa région*, thèse de doctorat, Université Lyon II.
- MADANI, T., 2005, "La question du partage de l'eau entre amont et aval dans le monde rural marocain médiéval", in *Water management in medieval rural economy. Les usages de l'eau en milieu rural au Moyen Âge. Ruralia V, 27 septembre-2 octobre 2003*, Lyon, Villard-Sallet, Rhône-Alpes, France, Prague, Institute of Archaeology, p. 68-72.
- MADANI, T., 2006, "Le partage des eaux dans l'oasis de Figuig (Maroc oriental) : approche historique et archéologique", *Mélanges de la Casa de Velázquez*, 36-2, p. 61-81.
- MARÇAIS, G., 1913, *Les Arabes en Berbérie du XI^e au XIV^e siècle*, thèse de doctorat de l'université de Paris, Constantine/Paris, Braham/Ernest Leroux, 2 vol.
- MARGAT, J., 1954, "Sédimentation actuelle par épandage des eaux de crue dans les palmeraies du Tafilalt (Maroc pré-saharien)", in *Comptes-rendus de la X^e assemblée générale de l'UGGI*, Rome, Association internationale d'hydrogéologie scientifique, p. 192-193.
- MARGAT, J., 1958, "Les ressources en eau des palmeraies du Tafilalt", *Bulletin économique et social du Maroc*, 22-77, p. 5-24.

- MARGAT, J., DESTOMBES, J., HOLLARD, H., 1962, *Mémoire explicatif de la carte hydrogéologique au 1/50 000 de la plaine du Tafilalt*, Rabat, Service géologique du Maroc.
- MC CALL, D., 1961, "The traditions of the founding of Sijilmasa and Ghana", *Transactions of the Historical Society of Ghana*, 5-1, p. 3-32.
- MELLOUKI, M., 1985. *Contribution à l'étude de l'histoire des villes médiévales du Maroc : Sigilmassa des origines à 668 (H)/1269 (J.-C.)*, thèse de doctorat, Université Aix-Marseille I.
- MERCIER, E., 1867. "Sidjilmasa selon les auteurs arabes", *Revue Africaine*, 11, p. 233-242 et p. 274-284.
- MESSIER, R., 1999, "The grand mosque of Sijilmasa: The evolution of a structure from the mosque of Ibn Abd Allah to the restoration of Sidi Mohammed ben Abd Allah", in M. HAMMAM (ed.), *L'Architecture en terre en Méditerranée : histoire et perspectives. Actes du colloque international de Rabat (27-29 novembre 1996)*, Rabat, Faculté des Lettres et Sciences Humaines de l'université Mohamed V, p. 287-296.
- MESSIER, R., MILLER, J., 2015, *The last civilized place: Sijilmasa and its Sahara destiny*, Austin, University of Texas Press.
- MEZZINE, L., 1984, "Sur l'étymologie du toponyme de 'Sijilmasa'", *Hespéris-Tamuda*, 22, p. 19-25.
- MEZZINE, L., 1987, *Le Tafilalt. Contribution à l'histoire du Maroc aux XVII^e et XVIII^e siècles*, Rabat, Publications de la Faculté des Lettres et des Sciences Humaines.
- MOULIAS, D., 1927, *L'organisation hydraulique des oasis sahariennes*, Alger, Carbonel.
- AL-NASIRÎ, 1894-1895, *Kitâb al-istiqâ li-ahbâr duwal al-Maghrib al-aqṣâ*, Le Caire, al-Mu'allif, 4 vol.
- OBERTREIS, J., MOSS, T., MOLLINGA, P., BICHSEL, C., 2016, "Water, infrastructure and political rule: Introduction to the Special Issue", *Water Alternatives*, 9-2, p. 168-181.
- PASCON, P., 1975, *Le Haouz de Marrakech : histoire sociale et structures agraires*, thèse de doctorat de l'université Paris Diderot, 4 vol.
- PASCON, P., 1977, *Le Haouz de Marrakech*, Rabat, Éditions marocaines et internationales, 2 vol.
- PASCON, P., 1979, "De l'eau du ciel à l'eau de l'État : psychosociologie de l'irrigation au Maroc", *Hérodote*, 13, p. 60-78.
- PASCON, P., 1983, *Le Haouz de Marrakech*, (2nd edition), Rabat, Éditions marocaines et internationales, 2 vol.
- PELLAT, C., 1965, "al-Dilâ", in *The Encyclopedia of Islam*, Leyde, Brill, vol. II, p. 223.
- PELLAT, C., 2004, "Midrâr", in *The Encyclopedia of Islam*, édition CD-ROM (édition imprimée 1954), Leyde, Brill, vol. VI, p. 1037.
- PENET, P., 1913, *Hydraulique agricole dans la Tunisie méridionale*, Tunis, Imprimerie Rapide.
- PÉRENNES, J.J., 1993, *L'eau et les hommes au Maghreb. Contribution à une politique de l'eau en Méditerranée*, Paris, Karthala.
- POWERS, D., 2002, *Law, society and culture in the Maghrib, 1300-1500*, Cambridge, Cambridge University Press
- ROCHÉ, P., 1965, "L'irrigation et le statut juridique des eaux au Maroc (géographie humaine, droits et coutumes)", *Revue juridique et politique (Indépendance et coopération)*, 1, p. 55-120 ; 2, p. 255-284 et 4, p. 537-561.

- ROSENBERGER, B., 1977, "Population et crise au Maroc aux XVI^e et XVII^e siècle. Famines et épidémies", *Cahiers de la Méditerranée*, HS 2, p. 137-149.
- SCHROETER, D., 2000, "Tâzarwâlt", in *The Encyclopedia of Islam*, Leyde, Brill, vol. X, p. 405.
- SHAW, B.D., 1982, "Lamasba: An ancient irrigation community", *Antiquités africaines*, 18, p. 61-103.
- SWYNGEDOUW, E., 2009, "The political economy and political ecology of the hydrosocial Cycle", *Journal of Contemporary Water Research and Education*, 142, p. 56-60.
- TERRASSE, H., 1949–1950, *Histoire du Maroc des origines à l'établissement du Protectorat français*, Casablanca, Frontispice, 2 vol.
- TERRASSE, H., 1960, "Alawîs", in *The Encyclopedia of Islam*, Leyde, Brill, vol. I.
- TROUSSET, P., 1986, "Les oasis présahariennes dans l'antiquité : partage de l'eau et division du temps", *Antiquités africaines*, 22, p. 163-193.
- WILSON, A., MATTINGLY, D., 2003, "Irrigation technologies: Foggaras, wells and field systems", in D. MATTINGLY (ed.), *The archaeology of Fazzân*, vol. 1, *Synthesis*, Londres, Society for Libyan Studies, p. 234-278.
- WITTFOGEL, K., 1957, *Oriental despotism: A comparative study of total power*, New Heaven/Londres, Yale University Press/Oxford University Press.
- WRIGHT, J., 1991, "Sijilmasa, a Saharan entrepot", *Morocco: The Journal of the Society for Moroccan Studies*, 1, p. 7-19.
- AL-YA'QÛBÎ, 1892, *Kitâb al-buldân*, édition M.J De Goeje, Leyde.
- AL-YA'QÛBÎ, 1937, *Les Pays*, trad. G. Wiet, Le Caire, Institut français d'archéologie orientale.

NOTES

1. The first modern notes dedicated to Sijilmasa were written in the community of French military officers involved in the conquest of the Maghreb (H. DASTUGUE, 1867; E. MERCIER, 1867; H. FOURNEL, 1881, p. 22-24) and then by the Alawite chronicler al-Nasirî (1894–1895, I-55-58, II-101, III-142-145, 171-173, 202, 207). The first critical studies on the city, built from the cross-check of several historical sources, then issued from the circle of Orientalists of the Protectorate period, such as Georges Marçais (G. MARÇAIS, 1913, p. 224, 370, 382-384, 393-398, 564-564), Georges Colin (G. COLIN, 1934), Charles Pellat (C. PELLAT, 1954), and Henri Terrasse (H. TERRASSE, 1949–1950, I-169, 173-174, 186, 203-204, 220, II-48, 214). The major monographic studies were subsequently the work of Moroccan historians after independence, especially Larbi Mezzine (L. MEZZINE, 1984; L. MEZZINE, 1987), Mohamed Mellouki (M. MELLOUKI, 1985), Mahmud Ismâ'il 'Abd al-Râziq (M.I. 'ABD AL-RÂZIQ, 1985, p. 109-143, 210-229), Muhammad al-Khatib (M. AL-KHATIB, 1989), and Hassan Alaoui (H. ALAOUI, 1997). On the Western side, the few studies of this time focused more on the Saharan dimension of Sijilmasa than on its Maghrebian history (D. MCCALL, 1961; J.M. LESSARD, 1969; N. LEVTZION, 1982; J. WRIGHT, 1991). Within this production, we must single out the masterwork of D. Jacques-Meunié dedicated to the history of the whole Saharan regions of Morocco and in which the history of Sijilmasa is not only precisely documented but also contextualized in the regional history, thus delivering what remains one of the best historical works on the city to date (D. JACQUES-MEUNIÉ, 1982, p. 58, 62, 66-67, 153, 170, 184, 195-197, 201-207, 211, 226, 235-243, 256-258, 264-272, 283, 287-298, 335-337, 455-456, 741). Since the 1990s, Sijilmasa

has not really drawn the attention of historians, mainly because of the very small number of historical sources available on the site, which considerably hinders the renewal of analysis.

2. The MAPS (Moroccan-American Project and Sijilmasa) is an ambitious Moroccan-American archaeological program directed by Ronald Messier (MTSU University, Tennessee, USA) between 1988 and 1998. Published between 1993 and 2015, 18 articles and a monograph (R. MESSIER, J. MILLER, 2015) crown this pioneer and prolific work but, perhaps because of the academic training of their authors, these archaeological productions remain on the whole very close to the problematics developed until then by historians (gold trade, political history, study of the monuments referenced in the texts...).

3. *Sijilmasa: ville, oasis, carrefour* is a Franco-Moroccan archaeological program directed by François-Xavier Fauvelle (CNRS, France) and Larbi Erbaty (INSAP, Morocco) between 2011 and 2016. Nine articles and a monograph (L. ERBATY *et al.*, 2020) have just completed this work, mainly built around the extensive excavation of approximately 250 sq. m located in the heart of the urban site. This work draws a diachronic micro-history of a neighborhood of the caravan city and precisely documents a part of the material culture of the city.

4. C. CAPEL, 2016a; C. CAPEL, forthcoming.

5. J. OBERTREIS *et al.*, 2016.

6. "Hydro-social research envisions the circulation of water as a combined physical and social process [...] insisting on the inseparability of the social and the physical in the production of particular hydro-social configurations. [...] Changes in the use, management, and socio-political organization of the water cycle and social changes co-determine each other" (E. SWYNGEDOUW, 2009, p. 56).

7. E. SWYNGEDOUW, 2009.

8. K. WITTFOGEL, 1957.

9. C. BICHSEL, 2016.

10. As emblematic examples, see J. BRUNHES, 1902; P. PENET, 1913; D. MOULIAS, 1927; J. LETHIELLEUX, 1948; R. CAPOT-REY, W. DAMADE, 1962; R. ARRUS, 1985.

11. See for example the following selection: P. ROCHE, 1965; L. ELDBLOM, 1968; G. GRANDGUILLAUME 1973; P. BADUEL, A. BADUEL, 1980; G. BEDOUCHA, 1981; A. HAMMOUDI, 1982; J.J. PÉRENNES, 1993; A. BENSÂD, 2011.

12. E. SWYNGEDOUW, 2009.

13. P. PASCON, 1974.

14. P. PASCON, 1977.

15. P. PASCON, 1983, I-84-98.

16. P. PASCON, 1983, I-84-85.

17. P. PASCON, 1979.

18. P. GAUCKLER, 1897-1901; J. COIGNET, 1925; J. BIREBENT, 1964; B.D. SHAW, 1982; P. TROUSET, 1986; A. WILSON, D. MATTINGLY, 2003.

19. T. MADANI, 2006; R. GONZÁLEZ VILLAESCUSA, P. CRESSIER, 2011.

20. M. BARCELÓ, 1989; H. KIRCHNER, C. NAVARRO, 1994; M. BARCELÓ, 1996; P. BALLESTEROS ARIAS *et al.*, 2010.

21. M. BARCELÓ, 1989, XXV.

22. P. CRESSIER, 2006.

23. Undoubtedly, there are more hydraulic phases in Tafilalt history and therefore there are certainly more subtleties in this ternary model, but these phases are not perceptible to the sole archaeological surface survey, and only excavation could possibly fill out this first proposal.

24. Likely etymological meaning of the Berber toponym Sijilmasa (L. MEZZINE, 1984, p. 24).

25. IBN HAWQAL, *Surat*, p. 99-100; IBN HAWQAL, *Configuration*, p. 97-98; AL-BAKRÎ, *Masâlik*, § 148; AL-BAKRÎ, *Description*, p. 282-283.
26. AL-YA'QÛBÎ, *Buldân*, p. 358-360; AL-YA'QÛBÎ, *Pays*, p. 225-226; AL-DIMASHQÎ, *Cosmographie*, p. 90, 238-239; AL-DIMASHQÎ, *Manuel*, p. 109, 143, 338; LÉON L'AFRICAIN, *Description*, I-425.
27. Although declining and reducing, the palm grove of Tafilalt is still today the largest oasis area of Morocco, with more than 150 sq. km of surface.
28. C. CAPEL, 2019, p. 247-253.
29. For the geomorphological, archaeological, and historical demonstration of the artificial nature of the Wadi Ziz at Sijilmasa, see C. CAPEL, 2016b.
30. The pluvionival rate of flow of the Ziz and the Gheris is marked by two major annual floods: the spring flood, fed by the snow melting from the High Atlas range, is regular, predictable, and abundant—an unusual feature in the Sahara, where surface water supplies are usually solely based on local and unpredictable rain; the autumn floods, occurring at the time of air mass movements causing the change of season, result from (often stormy) mountain rains and are characterized by a shorter duration and more intensity, while being much less predictable in time.
31. J. MARGAT, 1954, p. 192; J. MARGAT, 1958, p. 19.
32. As Tafilalt resisted French colonization until 1933 and as WWII put an end to most French laying-out projects in Morocco in the early 1940s, the impact of French hydraulic modernization was very limited in Tafilalt and mainly consisted in identically rebuilding pre-colonial structures within the short period of 1946-1956.
33. P. PASCON, 1983, I-84-98.
34. One might prefer the expression 'clanic' or 'kinship' structuring.
35. P. CRESSIER, 2006, p. 44.
36. P. CRESSIER, 2004, p. 281-282; R. GONZÁLEZ VILLAESCUSA, P. CRESSIER, 2011, p. 27-29.
37. M. BARCELÓ, 1989, XXV.
38. The overall organizational pattern of the sub-contemporary hydraulic network of Tafilalt is supposedly egalitarian but nevertheless suffers today from a number of anomalies that could call into question this interpretation. But most of these aberrations are actually the consequences of changes made to the system after it was planned; see below.
39. For a dating of Wadi Ziz, see C. CAPEL, 2016b, p. 151-155 and C. CAPEL, 2018, p. 539-541.
40. Concerning the foundation of the city of Sijilmasa and its different phases of construction, see our proposals in C. CAPEL, 2018.
41. Date of the last restoration of the original Ziz canal diversion dam, obtained by radiocarbon analysis of a (unidentified) charcoal taken from the construction mortar of the dam: 650 +/- 35 BP; i.e. a double calibrated chronological interval of 1279-1329 and 1340-1396 AD (2σ).
42. J. MARGAT *et al.*, 1962, p. 204.
43. P.W. ENGLISH, 1968, p. 177.
44. Mentioned by J. MARGAT *et al.*, 1962, p. 204.
45. H. GOBLOT, 1979, p. 153.
46. D. LIGHTFOOT, J. MILLER, 1996, p. 98; D. LIGHTFOOT, 1996, p. 266-267.
47. With the exception of D. LIGHTFOOT, 1996, p. 267.
48. J. MARGAT *et al.*, 1962, p. 204.
49. Section located at the level of the ford/bridge of the Alnif road, near the *qsar* Oulad Saidan, on the left bank of the Gheris.
50. LÉON L'AFRICAIN, *Description*, I-425-430.
51. M. KABLY, 2011, p. 300-313; D. JACQUES-MEUNIE, 1982, p. 594-596.
52. LÉON L'AFRICAIN, *Description*, I-427-431.
53. B. ROSENBERGER, 1977.

54. T. MADANI, 2005, p. 70.
55. AL-IFRANÎ, *Nuzhat*, I-292, II-484; H. TERRASSE, 1960; C. PELLAT, 1965; D. JACQUES-MEUNIE, 1982, p. 646-653; P. GUICHARD *et al.*, 2000.
56. Since it does not seem to exist in western Maghreb before the 12th century, the *khettâra* technique may have been developed mainly during the Saadian era, particularly in the context of the expansion of the Souss sugar refineries (A. HUMBERT, 2002). This chronological setting supports the dating of the Tafilalt examples, which could be substantially contemporary.
57. G. GRANDGUILLAUME, 1978, especially p. 129-131.
58. P. GUICHARD *et al.*, 2000; D. SCHROETER, 2000.
59. J.B. GRAMAYE, *Africae*, p. 188.
60. R. MESSIER, 1999, p. 289-290.
61. T. MADANI, 2003, unpaginated, II-4-B; the same law case at the same moment is described and analyzed in D. Powers, 2002, p. 95-140 but with no reference to the political/sultanian origin of the conflict (reduced just to neighboring issues and law issues).
62. H. DASTUGUE, 1867, p. 369-370.

ABSTRACTS

This paper compares two fields of analysis: on the one hand, hydrosociology, theorized by geographers and anthropologists, which conceptualizes the uses and landscapes of water as a reflection of the social organization of the group; on the other hand, hydraulic archaeology, developed by archaeologists and historians, which has demonstrated the permanence of ancient hydraulic structures in contemporary landscapes. The aim of this cross-disciplinary approach is to produce a social interpretation of the ancient irrigation systems fossilized in current agricultural plots, in order to produce a diachronic analysis of social organizations that have disappeared. The case study of this contribution deals with the medieval city of Sijilmasa (Morocco) and the Saharan oasis of Tafilalt that still surrounds the archaeological site today. This study of sub-contemporary oasis hydraulics has made it possible to historicize its development over the long term and to highlight a clear correlation between the successive implementations of different irrigation practices and the evolution of the socio-political organization of the Tafilalt population over the centuries. Corroborated by textual sources, this model could be applied in the future to other medieval Saharan oases for which no written or archaeological record remains and whose social organization is otherwise unknown.

Cet article confronte deux champs d'analyse : d'une part, l'hydrosociologie, théorisée par les géographes et les anthropologues, qui appréhende les usages et les paysages de l'eau comme un reflet de l'organisation sociale du groupe ; d'autre part, l'archéologie hydraulique, développée par les archéologues et les historiens, qui a démontré le phénomène de permanence des structures hydrauliques anciennes dans les paysages contemporains. L'objectif de cette approche croisée est de produire une lecture sociale des systèmes d'irrigation anciens fossiles préservés dans les parcelles agricoles actuelles afin d'en tirer une analyse diachronique des organisations sociales disparues. L'étude de cas présentée ici concerne la cité médiévale de Sijilmasa (Maroc) et l'oasis saharienne du Tafilalt qui entoure encore aujourd'hui son site archéologique. Cette étude de l'hydraulique oasienne subcontemporaine a permis d'historiciser son développement

sur la longue durée et de mettre en évidence une corrélation évidente entre la mise en œuvre successive de différentes pratiques d'irrigation et l'évolution de l'organisation socio-politique de la population du Tafilalt au cours des siècles. Corroboré par des sources textuelles, ce modèle pourrait être à l'avenir appliqué à d'autres oasis sahariennes médiévales pour lesquelles aucune information écrite ou archéologique n'est à ce jour connue et dont les organisations sociales restent donc inconnues.

INDEX

Mots-clés: archéologie, hydrosociologie, hydraulique, peuplement, irrigation, oasis

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AUTHOR

CHLOÉ CAPEL

Chargée de recherche CNRS, UMR 8167 Orient & Méditerranée – Équipe Islam Médiéval (France)