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# Land Division and Water Management in the West of the Roman Empire<sup>1</sup>

*Anna Willi*

## Abstract

- This article investigates the connection between Roman land division as an instance of deliberate shaping of the landscape, and the management of soil moisture (drainage/irrigation). Predominantly archaeological evidence shows that the Roman government provided for optimized land use at the foundation of colonies by orientating the division grid in an ideal way. The land surveyors' ability to assess an area's topography and hydrology were instrumental in this process. The fact that the relation of the orientation of the division grids and hydrology is not discussed in the *Corpus Agrimensorum Romanorum* can be explained through the characteristics of the evidence.
- Im vorliegenden Artikel wird der Zusammenhang von römischer Landparzellierung als ein Mittel der bewussten Gestaltung von Landschaft und von Kontrolle der Bodenfeuchtigkeit durch Be- und Entwässerung untersucht. Insbesondere archäologische Quellen zeigen, dass die optimale Nutzung des Landes durch die römische Regierung schon bei der Gründung von Siedlungen durch eine ideale Ausrichtung des Katasters angelegt wurde. Die Fähigkeiten der Feldmesser, die topographische und hydrologische Situation einzuschätzen spielten dabei eine wichtige Rolle. Dass der Zusammenhang von Katasterausrichtung und Hydrologie im *Corpus Agrimensorum Romanorum* dennoch nicht thematisiert wird, lässt sich durch die Eigenschaften der Quellen erklären.

## 1. Introduction

Soil moisture has a big influence on cultivation and yield. Too much as well as too little can be fatal, depending on the climate, quality of soil, and the crops. The control of soil moisture through drainage and irrigation has, therefore, from early times been recognized as an important part of successful agriculture. An even distribution of soil moisture is fostered by an appropriate topographical situation and benefits from the respective infra-

<sup>1</sup> The preliminary work for this article was carried out during a stay at the University of Oxford funded by the Swiss National Foundation (SNF). I would like to thank the SNF for their financial support, and Nicholas Purcell, Anne Kolb, and Francisco Beltrán Lloris for their helpful suggestions and support. For their help with the English version of this article I would like to thank Sam Allen and Varun Ramraj.

structure. It is therefore closely linked to the landscape, which raises the question to what extent soil moisture control was taken into account when a settlement and its rural environment were planned and shaped deliberately. An example of such deliberate shaping of landscape in the Roman empire is the land division (*centuriatio/limitatio*) that took place when new colonies were founded or plots were assigned *viritim*. It had a great impact on the landscape, shaping it through the regularity of the implemented cadasters, and entailing deforestation and other means of land reclamation.

This article investigates the connection between land division and the control of soil moisture using written and archaeological evidence, with a focus on the west of the Roman empire. To this end a closer analysis of the orientation of the division grids (4) and of the hydraulic infrastructure within them (5) shall be carried out, after a short introduction to Roman land division (2) and to the evidence at our disposal (3).

## 2. Roman Land Division

Roman land division and assignation goes back to the 4<sup>th</sup> century BC, starting with the expansion of Roman power during the Latin and Samnite wars, and saw another heyday during the civil wars of the late republic when a great number of veterans required land.<sup>2</sup> During the empire the assignation of land to groups of individuals became less common, but *viritane* assignment went on until the end of the Flavian period, up to which a number of *municipia* were given the status of colonies.<sup>3</sup>

Land division was initiated by the Roman authorities: it was motioned by the senate and decreed by the people during the republic, and later by the emperor. For its implementation a commission of magistrates was assigned. The shaping of the landscape through division grids thus involved decisions made by the Roman administration. Its analysis can potentially show on what level the Roman authorities interfered and to what extent agricultural success was taken into consideration for their decisions. During the republic the usual procedure was for the senate to decree the foundation of a colony or *viritane* assignment by issuing an agrarian law. The tribune would then bring the matter before the people and the *praetor urbanus* or the *consul* would preside over the *comitium* in which a commission of magistrates was elected,<sup>4</sup> *IIIviri* in the case of colonies, and *Xviri* in the case

<sup>2</sup> For the history of Roman colonization older works such as VITTINGHOFF 1951, SALMON 1969, and KEPPIE 1983 still provide a good starting point, also see more recently LAFFI 2003 for an overview.

<sup>3</sup> Which also resulted in (new) land division, see e.g. Hyg. Grom. C 142,14–16 (for the *Corpus Agrimensorum Romanorum* the edition by CAMPBELL 2000 (abbreviated as C) will be used, indicating the page and lines within this volume. For texts not comprised in his edition, BLUME/LACHMANN/RUDORFF 1848 (L) is cited).

<sup>4</sup> See e.g. Liv. 34,53,1, cf. 37,47,2; 39,55,5f.; 40,43,1 etc. The procedures and steps leading up to the foundation of a colony are described by GARGOLA 1995, 51–70 for the middle republic. For the procedure of settlement during the late republic see KEPPIE 1983, 87–100, on the commissions see GARGOLA 1995, 58–63.

of viritane assignments.<sup>5</sup> During the late republic military commanders used their power to settle the veterans.<sup>6</sup> The basic procedure seems to have remained similar during the empire, but the emperor now replaced the senate as the decreeing authority.<sup>7</sup> Most of the tasks coming along with the establishment of a colony and land division lay with the commission, including the choice of the exact area where the settlement was to be founded, the definition of the territory's boundaries,<sup>8</sup> the religious rituals required in the procedure of the foundation, e.g. the auspices leading up to the division of the land,<sup>9</sup> and the division and assignation of the land itself.<sup>10</sup> Certain modalities could be set out in the agrarian laws prescribing the number of settlers or the lot size for certain *agri*,<sup>11</sup> other regulations were written down in the municipal charters.<sup>12</sup> Laws could moreover prescribe some general regulations of the land use stipulating e.g. that the former status of land, – sacred, public, destined for a public road or aqueduct –, had to be preserved,<sup>13</sup> or prescribing the width of the boundaries (*limites*).<sup>14</sup>

For the actual implementation of the division, many different tasks had to be dealt with on location: the division grid had to be defined, measured and marked, which means that the *limites* had to be outlined in the territory and defined through roads, ditches, and boundary stones. Even though we have very little information about the exact procedure it seems clear that the commissioners must have had help and charged workers with these tasks, some of who must have had special skills or been specialists, for example

<sup>5</sup> For the *Xviri* see e.g. Liv. 31,4,1–3; 31,49,5; 42,4,3f., for the *IIIviri* see e.g. Liv. 9,28,8; 10,21,9; 31,49,6; 32,29,4; 34,45,2; 34,53,2; 37,46,10f. See on viritane assignments GARGOLA 1995, 102–113. From the late republic onwards the commissions varied in terms of size.

<sup>6</sup> See KEPPIE 1983, 87f. and *passim*.

<sup>7</sup> See GARGOLA 1995, 179–184.

<sup>8</sup> See e.g. Hyg. Grom. C 158,11f.: *adsignare agrum secundum legem divi Augusti eatenus debebimus, qua falx et arater exierit, nisi ex hoc conditor aliquid immutaverit*; cf. C 160,6f.

<sup>9</sup> For the religious rituals see GARGOLA 1995, 41–50 and GARGOLA 2004.

<sup>10</sup> E.g. Liv. 21,25,3; see GARGOLA 1995, 87–89.

<sup>11</sup> See e.g. the motion by the tribune Atilius, naming the number of thirty families for each of five new colonies (Vulturnum, Liternum, Puteoli, Salernum, Buxentum: Liv. 33,29,3).

<sup>12</sup> See e.g. Sic. Flacc. C 130,38–132,6 stressing their importance for establishing the area under the settlement's jurisdiction. The *Lex Ursonensis* grants the inviolability of the boundaries (CIL I<sup>2</sup> 594, § 104).

<sup>13</sup> The land surveyors in their writings refer to e.g. *auctores divisionis* as issuing such laws, but without making it entirely clear who they meant by this. Sic. Flacc. C 124,6f.: *auctores divisionis assignationisque leges quasdam colonis describunt*. Also see Hyginus C 86,33f.: *illud autem observandum, quod semper auctores divisionum sanxerunt*.

<sup>14</sup> Hyg. C 76,1–8: *limites lege late patere debent secundum constitutionem, qui agros dividi iusserint. non quia modus ullus ex mensura limitibus adscribitur: solum lex observari debet. maximus decumanus et cardo plus patere debent sive ped. XXX, sive ped. XV, sive ped. XII, sive quot volet cuius auctoritate fit. ceteri autem limites, qui subruncivi appellantur, patere debent ped. VIII*. A *Lex Mamilia* established the width for minor boundaries (e.g. Hyg. Grom. C 136,6f., cf. *Commentum* C 60,14f. and Agenn. Urb. C 22,32–24,4). Also see a *lex agris limitandis metiundis* of uncertain but possibly early imperial date in Lib. Col. C 166,19–26, establishing the width of *cardines* and *decumani* for foundations in the *provincia Tuscia*.

land surveyors. In the case of a new land division it must have been the surveyors' job to trace the division grid in the landscape, using their measuring tools and expertise to draw parallel lines and to integrate hills, rivers and other obstacles into the grid. Surveyors are mentioned in inscriptions and literary texts as *agrimensores*, *mensores agrarii* and the like. Often we learn little more than their designation from these texts, but we also find them involved in the measuring of land division grids and the settlement of boundary disputes.<sup>15</sup> In general we know very little about the position and tasks of the *agrimensores*. As professionals they only appear in the early empire,<sup>16</sup> when we find them as members of the imperial *familia* as well as – presumably – free-born, commissioned by magistrates or the emperor as well as by private parties.<sup>17</sup> For the long duration of their activity during the republic we lack written evidence,<sup>18</sup> so we do not know who the surveyors involved

<sup>15</sup> The term *agrimensor* came into use during the imperial time, other/earlier denominations were *finitor* and *mentor*, in the later empire *gromaticus*. For the attestations and terminology see the respective entries in the usual dictionaries as well as reference books such as RE (s.v. *agrimensores*, *gromatici*, *mentor*); DE RUGGIERO (s.v. *agrimensor*); or DS (s.v. *agrimensor*, *mentor*). See about the attestations of surveyors and their interpretation furthermore CLASSEN 1994 and CAMPBELL 2000, xlv–liii, revising the accounts of DILKE 1971, 35–43 and HINRICHS 1974, 167–170.

<sup>16</sup> The emergence of a literary genre concerned with tasks of surveyors in the Flavian period allows us to assume that during the late republic and the early principate land surveying had become a profession which was fully developed by the time of Domitian and Trajan. It is shown by respective passages in *Codex Theodosianus* and *Notitia Dignitatum* that the *mensores'* was an officially institutionalized profession at the end of the 3<sup>rd</sup> century AD. They attest an office presided by a *primicerius* (Not. dign. or. 11,12; Cod. Theod. 6,34,1, also cf. *Theodosii et Valentiniani constitutiones* L 273,15–17). It is not always clear what kind of *mentor* is meant.

<sup>17</sup> Surveyor sent by the governor to settle a dispute: Dig. 10,1,8,pr f. (Ulpianus); by the emperor: CIL X 8038 (Corsica); surveyor employed by one of the parties in dispute: Dig. 10,1,4,1 (Paulus). Imperial *familia*: Carthage: CIL VIII 12637 (*mentor agrarius*, imperial slave). 12639 (*agrimensor*, imperial freedman). 12912 (*mentor agrarius*, imperial slave). 12913 (*mentor agrarius*, imperial slave). 24690 (*mentor agrarius*, imperial slave); Djebel Cheidi/Thugga: CIL VIII 25988 comprises 15 *cippi*, on 25988,02b.07b and 12b is inscribed *Civit(at)is Thugg(ensis) / t(erm)ini p(ositi) per Tiberino / Aug(usti) l(iberto) praeposito / me(n)sorum*. Assignment by the emperor could temporarily bestow *immunitas* on *geometrae* (Dig. 27,1,22 (Scaevola)). Military surveyors could be appointed for works in the civil area as well (C 246,32–48, Ardea, and see the big centuriation system in Africa Proconsularis, established by the *legio III Aug.*: CIL VIII 22786, esp. f and k).

<sup>18</sup> The evidence for the republic is literary, and scarce. The allusion in the prologue of Plautus' *Poenulus* (Poen. 48f.: *eius* (sc. *argumenti*) *nunc regiones, limites, confinia determinabo: ei rei ego finitor factus sum*) implies that by the first half of the 2<sup>nd</sup> century BC the audience knew what a *finitor* was (see on this passage e.g. GARGOLA 2004, 140–144 with further reading). It has often been assumed that the profession of the surveyor originated in the context of castrametation, i.e. from the army, as a skill of centurions (Caes. Gall. 2,17: *exploratores centurionesque praemittit qui locum castris idoneum deligant*), see e.g. HINRICHS 1974, 81–84. Also see the *peritus metator* Saxa (Cic. Phil. 11,12; 14,10) who seems to have been a professional *castrametator* before being made tribune of the people by Caesar, but see CLASSEN 1994, 164–166. And see Cicero's speech against the people's tribune Servilius Rullus, who had motioned the appointment of *Xviri* for the assignment of land to peasants in Italy in 63 BC. The speech attests that Rullus had requested 200 equestrian *finitores* for his commission (Cic. leg. agr. 2,32 cf. 2,34. 45. 53), but what would have been their exact tasks is unclear. See e.g. NICOLET 1970.

in the establishment of the republican division grids were and whether they were brought along from Rome or hired on location.

The grids consisted of boundaries (*limites/cardines* and *decumani*), often roads dividing the territory into big squares or rectangles, which were then again divided into the individual lots, resulting in the measured and divided area, called *pertica*.<sup>19</sup> The use and purpose of this rigid structure was manifold. It allowed for a kind of ancient zoning of the territory<sup>20</sup> and facilitated the administration of property and the management of tax collection. For this purpose the cadaster was documented in a map, the *forma*, of which a copy was kept in Rome.<sup>21</sup> At the same time the grid provided the basis for the infrastructure within the territory. This is most evident for the roads constituting the grid, ensuring accessibility<sup>22</sup> and easier use of the land.<sup>23</sup>

The connection to hydraulic infrastructure is less obvious at first, but, for example, it was sensible to have channels and aqueducts run on boundaries, since this way they did not interfere with the individual properties.<sup>24</sup> In what follows, the connection of the

<sup>19</sup> The most commonly known type of Roman land division is established by drawing the roads in regular intervals at a distance of 20 *actus* (ca. 710 m), thus resulting in squares of 20 × 20 *actus*. These squares are called *centuriae* because they supposedly originally comprised one hundred lots (*herediae*) of two *iugera* each. Two *iugera* is very little and in fact the size of the allotted lands attested is considerably bigger in the late republic and in imperial times, usually around a third of one *centuria* or  $66\frac{2}{3}$  *iugera* (e.g. Hyg. Grom. C 156,25–29). For an overview of the attested lot sizes see CAMPBELL 2000, 339–341 adn. 30. However, the grids could take different shapes, varying the size of the *centuriae*, e.g. to 15 × 15 *actus*, or being based on rectangles rather than squares. For the varieties of grids known, see CHOUQUER/CLAVEL-LÉVÊQUE/FAVORY 1982, 851–858. The rectangular form of land division (*strigatio/scammatio*) has been thought to be the more ancient way because of Frontinus calling it *more antiquo* (C 2,10f.), but it is more likely that it was used in territory not adequate for the division into squares (HINRICHS 1974, 23–48 and cf. e.g. CAMPBELL 1996, 85f.), and the two forms could be combined.

<sup>20</sup> A surveyed territory would comprise assigned land, sacred land or public land, land divided by a limitation grid (*pertica*), and unallotted land within the territory but outside of the *pertica* (*ager arcifinius* or *arcifinalis*). Pieces of land, which did not comprise entire *centuria* or left over inside of it, were called *subseciva*. See e.g. the description of the *agrorum qualitas* by Frontinus (C 2,1–4,2).

<sup>21</sup> The authors in the *CAR* name wood, bronze and parchment as materials used for the *forma*, see e.g. Sic. Flacc. C 120,22–32; Hyg. Grom. C 158,26–34. On the *forma* see furthermore NICOLET 1988, 163–179; MOATTI 1993, esp. 31–48, 88–97; in short CAMPBELL 1996, 88–90; CHOUQUER/FAVORY 2001, 45–49. Whether the fragmentarily preserved marble and bronze maps are actual examples of official *formae* is unclear, see below note 25.

<sup>22</sup> See e.g. Sic. Flacc. C 118,36f; 120,7f.; Hyg. Gromat. C 136,10f.

<sup>23</sup> Traditionally it was thought that the installation of the grid implied a homogenous exploitation of the centuriated area. This idea has recently been put into perspective by PALET/ORENGO, who describe the results of a thorough archaeomorphological analysis of the centuriated landscape around Tarraco. Palynological analyses show that within one grid the cultivation could vary significantly and that intensive exploitation must have centered around the *villae* (PALET/ORENGO 2010, 150f. and PALET/ORENGO 2011, 394f.).

<sup>24</sup> Cf. the Augustan regulation about the – n.b. intraurban – distribution of the water of the Venafrum aqueduct, allowing to install tubes only along public roads or *limites*: CIL X 4842 l. 43–47: *dum ne*

cadasters and hydraulic infrastructure shall be examined in terms of their orientation in relation to topography and hydrology, and of the position of infrastructure within the divided territory. First, however, we must consider the evidence available to us.

### 3. The Evidence

Apart from historiographical evidence on colonization in general, inscribed boundary stones, and a few fragmentarily preserved maps,<sup>25</sup> two main groups of evidence provide information on the practice of Roman land survey and land division: archaeological remains of land division grids, and the *Corpus Agrimensorum Romanorum* (CAR), which contains the writings of the land surveyors. Both groups are unique and valuable sources of information but problematic in terms of origin and transmission. They therefore require great caution when used as evidence.

The CAR was in its first version probably composed in the 5<sup>th</sup> century AD, and additions seem to have been made up to the 7<sup>th</sup> or 8<sup>th</sup> century.<sup>26</sup> It contains excerpts of texts concerned with the work of land surveyors, varying in their chronological origin as well as in textual genre and in length. The CAR addresses various topics related to the surveyors' work, and it seems that the compilers of the *Corpus* aimed at providing a comprehensive instruction of trainee land surveyors, even if this was not necessarily the initial goal of the authors of the excerpted texts.<sup>27</sup> An emphasis was put on legal questions such as the status of land, and on disputes (*controversiae*) for example over boundaries, for the settlement of which the surveyors' help was necessary.

*ea aqua, quae ita distributa discripta deve qua ita decretum erit, aliter quam fistulis plumbeis dumtaxat ab rivo pedes L ducatur; neve eae fistulae aut rivos nisi sub terra, quae terra itineris viae publicae limitisve erit, ponantur conlocentur; neve ea aqua per locum privatum invito eo, cuius is locus erit, ducatur.* The same inscription stresses that aqueducts can not be led across private property without the proprietor's consent.

<sup>25</sup> See the bronze fragment from Verona (AE 2000, 620) with CAVALIERI-MANASSÉ 2000 and CAVALIERI-MANASSÉ 2004; the bronze fragment from Spanish Lacimurga (AE 1990, 529) with e.g. SÁEZ 1990; the bronze inscription from Spanish Ilici/Elche (AE 1999, 960) with e.g. OLESTI/MAYER 2001; for the numerous marble fragments from Orange (Arausio) the work by PIGANOL 1962 is still essential.

<sup>26</sup> For the CAR, its composition, authors and dates see the accounts and commentaries of e.g. CAMPBELL 2000, xxvii–xliv; CHOUQUER/FAVORY 2001, 17–29, 43f.; TONEATTO 2010. Lists of the contents of the CAR are given by DILKE 1971, 227–230; CRANACH 1996, 23–26 and CAMPBELL 2000, 450f. For the manuscript tradition and text history see BLUME/LACHMANN/RUDORFF 1848 vol. 2, 1–78; DILKE 1971, 126–132; TONEATTO 1983; CRANACH 1996, 28–31; CAMPBELL 2000, xx–xxvi.

<sup>27</sup> CRANACH 1996, 125–127 concludes that among the authors in THULIN's Edition of 1913 only Hyginus Gromaticus intended to write a manual for land surveyors – albeit as a theorist rather than an expert, in this CRANACH follows DILKE 1971, 130 –, whereas Frontinus and the older Hyginus were more concerned with legal questions. Whilst this conclusion is intelligible it does not so much affect our interpretation of the CAR as an entity and the aims for which it was composed.

One of the problems with the *CAR* is the difficulty of dating the texts contained in it. The core of the *Corpus*, however, consists of excerpts from a group of treatises, which can be dated back to the end of the 1<sup>st</sup> or the beginning of the 2<sup>nd</sup> century AD. As far as we can tell, these treatises mark the beginning of the tradition of writings on land survey, and the emergence of this literary genre has plausibly been related to the background of Vespasian's financial reforms, which also included the revindication of land that had been seized over the years, and therefore also involved land surveying.<sup>28</sup> Later texts include, amongst other things, excerpts from the *Codex Theodosianus*, meticulous descriptions of different kinds of boundary stones, and the *Libri Coloniarum*: a list and description of settlements of various status and their territories in Italy, depicting the situation of the middle or second half of the 4<sup>th</sup> century AD but seemingly based on documents of Augustan times. Apart from the difficulty of precisely dating the original texts, another problem is that we know next to nothing about the individual authors and their motivation to compose the works.<sup>29</sup> Some of them, however, prove themselves to be professional *agrimensores* with practical field experience, and some confidently write of a *professio nostra*.<sup>30</sup>

The dating also represents one of the biggest problems with archaeological evidence. The structure of ancient cadasters is today preserved in landscape features such as field boundaries, roads, ditches and walls, and – in regions where irrigation and/or drainage are still of importance today –, also in medieval and modern canals.<sup>31</sup> The grid structures are best visible from the air. From the middle of the 20<sup>th</sup> century onwards an inflationary identification of Roman division grids by means of aerial photography and maps took place,<sup>32</sup> many of which later turned out to be medieval, modern, or no remains of division grids at all. More recent studies demand, and provide, so called archaeomorphological

<sup>28</sup> See below note 52.

<sup>29</sup> If Frontinus, the author of one of the main treatises, was indeed the illustrious *consul* and *curator aquarum* of Nerva (PIR<sup>2</sup> I 322), his text is probably the earliest treatise on land survey known to us, but it is not easy to imagine a position within his well-known career in which he could have had a reason to compose it.

<sup>30</sup> *Professio nostra*: Sic. Flacc. C 102,4; Hyg. Grom. C 160,27. Cf. passages referring to personal experience such as Hyginus C 88,22: *quod plerisque locis inveni* (Dalmatia, Narbonensis, Hispania); 88,24f.: *ego autem quotiens egeram mensuram*; 88,33: *quod in provincia Cyrenensium comperi*; 96,4: *constabit tamen rem magis esse iuris quam nostris operis*; 96,29f.: *namque hoc comperi in Samnio*. A professional background can be assumed for most of the authors. CHOUQUER/FAVORY 2001, 37–39 not entirely convincingly distinguish “administrateurs” with a high social background, (e.g. senatorial: Frontinus), “juristes” (Ps.-Agennius), and “techniciens de la mesure et de l’arpentage, les *gromatici* en sens strict” (Siculus Flaccus and Hyginus). The composers of the late antique lists of boundary markers seem to have been high-rank officials, see PEYRAS 2008, xii–xiii.

<sup>31</sup> E.g. around Spanish Zaragoza, where such channels can be found in documents from the 15<sup>th</sup> century, see ARIÑO 1990, 72f., cf. ARIÑO/MARTÍN/NAVARRO 1998, 12.

<sup>32</sup> See e.g. BRADFORD 1957, esp. 155–216 with examples from North Italy, Croatia, North Africa and France. Another pioneer of aerial archaeology is R. CHEVALLIER, see e.g. CHEVALLIER 1964, for the cadastres esp. 128–138.

analyses including scientific analyses and, most importantly, surveys on the ground and excavation.<sup>33</sup> Such investigations have shown that the manifestations visible today do not always replace Roman ones, but were sometimes installed later, using the then visible remains of the Roman grid as a guideline.<sup>34</sup> The general position and orientation of the grids are, therefore, often the only conspicuously Roman traits about them.

#### 4. The Orientation of the Land Division Grid

The orientation of the cadasters in relation to topography matters because, for example, drainage along the roads is facilitated when they follow the slope. It seems plausible that the decision about the exact arrangement and orientation of the land division grid was taken on location, but we know very little about the course of events that led to the final decision about the grid's orientation. There is evidence suggesting that at an early stage the commissioners, or one of them, were directly involved in the measuring and dividing of the land, or in any case present during the works in certain cases,<sup>35</sup> but it is difficult to reconstruct the procedure and to determine the exact role and competences of those involved at any given time.

In the *CAR* only two authors discuss the layout of the grid to some extent, namely Frontinus and Hyginus Gromaticus.<sup>36</sup> According to them, the textbook orientation for a centuriation grid is to draw the *decumani* strictly east-west and the *cardines* north-south, after a tradition deriving from the *disciplina etrusca*.<sup>37</sup> However, they talk of the procedure as already having taken place and its discussion seems somewhat theoretical. The only passage giving some insight into the procedure itself is by Hyginus Gromaticus, when he frets about those surveyors who did not stick to the ideal orientation, but e.g. followed the actual sunrise and sunset:<sup>38</sup>

<sup>33</sup> See for a description of the archaeomorphological method (applied to the hinterland of Tarraco) PALET/ORENGO 2010 and PALET/ORENGO 2011, esp. 386–389.

<sup>34</sup> See e.g. the example of cadastre B at Orange (Bollène, “les Bartras”: CHOUQUER 2008, 869–871; BRIGAND 2012, 239–241 with further reading in the notes), or DI COCCO 2008 for Bologna. For the divisions within *centuriae*, the *limites intercisivi*, this problem had already been pointed out by BRADFORD 1957, 168f.

<sup>35</sup> See e.g. Liv. 21,25,5; 31,4,2. GARGOLA 1995, 90–95 and 185–188, stressing the resemblances of the *augur's* and the surveyor's actions suggests that both roles were at first unified in, or closely related to, the magistrate's person, since the *auguri* were magistrates themselves, also see GARGOLA 2004, 137.

<sup>36</sup> Frontin. C 8–12; Hyg. Grom. C 148,26–150,26.

<sup>37</sup> Frontin. (referring to Varro) C 8,23–33; 10,27f.; Hyg. Grom. C 134,6–19; cf. 136,13–17; 148,26–150,2; 152,18–21. Cf. Sic. Flacc. C 118,35–120,6.

<sup>38</sup> Hyg. Grom. C 136,18–22.

*Multi ignorantes mundi rationem solem sunt secuti, hoc est ortum et occasum (...). quid ergo? posita auspicaliter groma, ipso forte conditore praesente, proximum vero ortum comprehenderunt, et in utramque partem limites emiserunt, quibus kardo in horam sextam non convenerit.*

“Many (sc. surveyors), being ignorant of the principles of the universe, have followed the sun, that is sunrise and sunset (...). So what happened? After the *groma* had been positioned as when taking the auspices, perhaps in the presence of the founder himself, they determined the next sunrise, and established the *limites* in both directions, but the *kardo* did not coincide with the sixth hour (i.e. due south).”

In this passage Hyginus accredits the choice of the orientation entirely to the surveyor, and he seems to imply that the founding magistrate did not necessarily have to be present for this event. It is problematic to generalize the procedure described by Hyginus Gromaticus,<sup>39</sup> and it is likely that the exact procedure and the roles of those involved in it varied throughout time, and probably from case to case. Based on the archaeological evidence for the three division grids around Tarraco (Tarragona, Spain) for example, J.M. PALET MARTÍNEZ and H.A. ORENGO RÓMEU have argued that the *augur*, i.e. a magistrate, defined the layout, and therefore the orientation of the grid, during the *auspicia*.<sup>40</sup> The three grids seem to have been conceived together, the *auguraculum* in the city being the starting point for the visual axes according to which the grids are oriented. The authors suggest that it was the surveyor’s task to then establish the grid orientation according to the predetermined axes following the topography and the hydrology of the terrain.<sup>41</sup> If we can not reconstruct the exact course of events, it arguably requires certain knowledge and skills to fit a division grid into any given landscape, and it seems plausible that a surveyor or someone with surveying skills would have helped and influenced the decision.<sup>42</sup>

<sup>39</sup> See, however, the staff changes in the procedure of land division described for the early principate by GARGOLA 1995, 179–184, which lead him to conclude that Hyginus Gromaticus is actually describing the situation before the mid-first century, cf. *ibid.* p. 221 note 75.

<sup>40</sup> The role of the *auspicia*, i.e. of the person performing them – a magistrate, not the surveyor –, is not entirely clear in this procedure, and so is, therefore, their impact for the orientation of the grid. GARGOLA 1995, 47f. suspects that the ritual of the *auspicia* was adjusted to the local topography, too. On the connection of augury and survey see GARGOLA 2004.

<sup>41</sup> PALET/ORENGO 2011, 397f. By making the axes e.g. the diagonal of either the square of one *centuria*, or of a rectangle formed by several *centuriae*, the surveyor would have had various possibilities of making use of the axes.

<sup>42</sup> See GARGOLA 1995, 90–95. During the principate the surveyors seem to have had some kind of supervising or intermediate position between the magistrates and the workers using the surveyors’ tools in the field. The authority responsible for the land division was usually named on the inscribed boundary stones, see Hyginus Gromaticus C 156,12; for the republic CIL XIV 4702 (Ostia, *praetor urbanus*); VI 40857 (Rome, *censores*), but inscriptions sometimes distinguish between the person in charge of decisions and the surveyor carrying out his instructions (see for a military context *Ex libro Balbi nomina lapidum finalium* C 246,33–48: *sententia dicta* by a centurion, on behalf of the emperor

The passage cited above denotes one of several reasons for which the division grids deviate from the “ideal” position. The authors also mention that some have tried to achieve the greatest possible length for the *decumani*, or wanted to distinguish the *per-tica* from another, neighbouring one.<sup>43</sup> Hydrology, however, is not mentioned as a reason for a deviating orientation. Furthermore, whilst the authors condemn such deviations in general, they admit that they do not necessarily affect the system negatively, and that the systems vary in different regions. Also, whilst the system they describe should be followed, the *per-tica* will sometimes have to be shaped according to the *locorum natura*, as Hyginus Gromaticus puts it.<sup>44</sup> The authors name natural obstacles such as mountains or the coast as examples,<sup>45</sup> but again they do not mention hydrology as a feature affecting the grid’s layout.

Judging from the preserved writings of the surveyors, then, it was not their concern to grant or facilitate the control of soil moisture: whilst their ability to evaluate the topographical situation of a given territory is evident, they do not name hydrology as a factor influencing the division grid. This is surprising when one looks at the orientation of the archaeologically preserved centuriations: the majority differ from the “ideal” orientation,<sup>46</sup> and in many cases the adopted orientation actually facilitates drainage, irrigation or both, i.e. in general an even distribution of water along the boundaries within the centuriated area.<sup>47</sup> This is also the case for the majority of the centuriation grids on the Iberian Peninsula, which shall serve as an example here. Establishing a list of known Roman centuriation grids for Roman Hispania, E. ARIÑO GIL, J.M. GURT I ESPARRAGUERA and J.M. PALET MARTÍNEZ named 28 mostly republican<sup>48</sup> grids belonging to 18 settlements, mainly in the Ebro valley and the Levante region.<sup>49</sup> The authors indicate the orientation of 26 of them in degrees. Of these, 25 deviate considerably from the ideal orientation, with the exception being Graccurreis with only 1° deviation. Twenty of them deviate by more than 10°. An obvious example is the centuriation of *Caesar Augusta* (Zaragoza) where in

Antoninus Pius, after a soldier, *ensor agrarius*, had defined the boundaries of the territory of Ardea; for a non-military context e.g. CIL VIII 8812).

<sup>43</sup> Frontin. C 10,1f. 31f.; Hyg. Grom. C 136,22–25.

<sup>44</sup> Hyg. Grom. C 144,1f.: *Hanc constituendorum limitum rationem servare debebimus, si huic postulati- oni vel locorum natura suffragabit*, cf. the *natura loci* in Sic. Flacc. C 114,35.

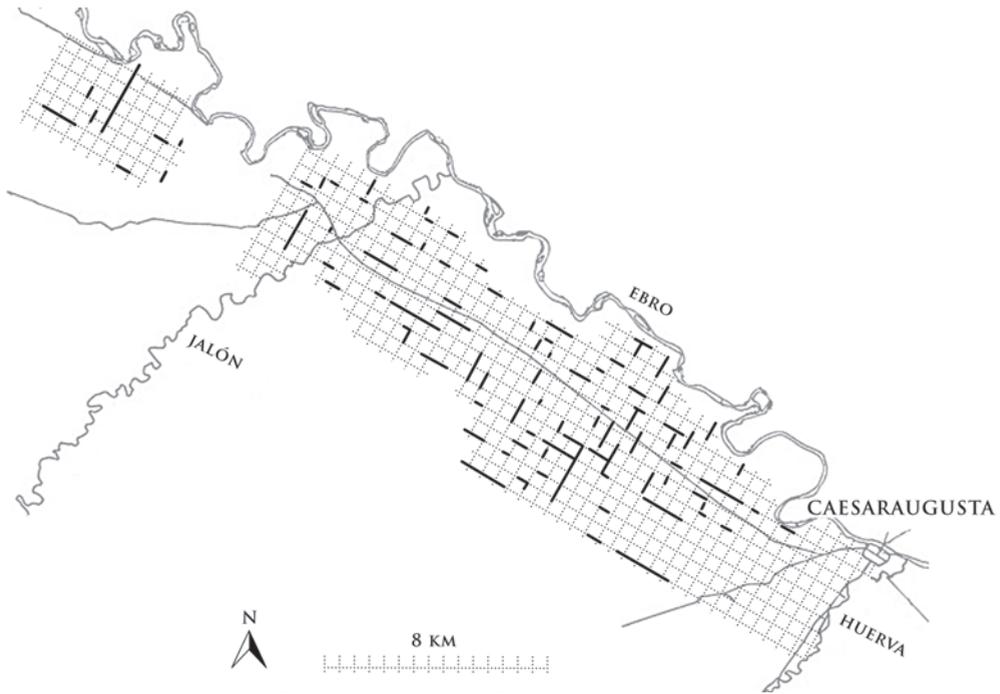
<sup>45</sup> Hyg. Grom. C 144,1–11, cf. Frontin. C 12,8–19.

<sup>46</sup> See the – however partially obsolete – list of Roman division grids all over the empire in LÓPEZ 1994, 337–387: The majority of the 163 grids for which she indicates the orientation (not always taking north as reference-point) deviate from the ideal orientation, 135 of them by more than 10°.

<sup>47</sup> In some cases the grids can also be said to be oriented according to a preexisting road which then functioned e.g. as the *decumanus maximus*. In river-valleys the roads are often parallel to the rivers, so their orientation coincides with the one convenient for drainage automatically.

<sup>48</sup> For 19 of the grids an approximate date is given, 11 of them are arguably Augustan or Caesarean-Augustan (Astigi, Barcino, Caesaraugusta I–III (II is said to be Augustan-Tiberian), Emerita Augusta, Emporiae II–III, Ilici, Tarraco III–IV). Five are dated to the 2<sup>nd</sup> century BC (Emporiae I (2<sup>nd</sup>/1<sup>st</sup> century BC), Graccurreis (179/178 BC), Palma/Pollentia (123/122 BC), Tarraco I–II (180 BC?)).

<sup>49</sup> ARIÑO/GURT/PALET 2004, 50f.



**Fig. 1** Reconstruction of the Augustan centuriation of *Caesar Augusta*. Map after ARIÑO/GURT/PALET 2004, 55 fig. 13.

all three grids the *decumani* are aligned more or less precisely with the river Ebro, fitting them into the topography perfectly, but having them deviate from Frontinus' and Hyginus Gromaticus' ideal orientation (**Fig. 1**). The situation is similar in other areas of the empire, e.g. in the Po valley and other Italian regions.<sup>50</sup> The Italian grids facilitate drainage so evidently that their analysis has led to the assumption that land amelioration including the control of soil moisture was in fact their main purpose.<sup>51</sup> This statement seems somewhat exaggerated and oblivious of the various administrative functions of centuriation grids, but it is remarkable that from archaeological evidence hydrology appears to be a feature with such a big influence on the shaping of the environment and especially on the orientation of centuriation, making it even more surprising that the surveyors never mention it

<sup>50</sup> See e.g. CHOUQUER 1987, 292; CALZOLARI 1995; BRIGAND 2007; CAMPAGNOLI/GIORGI 2009; cf. also GALSTERER 1992, 418–422. The research and literature on land division grids has grown exponentially over the past 15–20 years. A good entry-point for Italian evidence may be the volumes “Misurare la terra” (MISURARE 1984; MISURARE 1984a; MISURARE 1985; MISURARE 1985a; MISURARE 2003) and various articles in the journal *Agri centuriati*.

<sup>51</sup> E.g. DALL'AGLIO 1994, 17 and DALL'AGLIO 2005, 472 referring to Bologna. The authors in the CAR, if anything, stress the road network and the accessibility as the most important function of the grids, see e.g. Sic. Flacc. C 118,36f; 120,7f.; Hyg. Grom. C 136,10f.

as such in the *CAR*. This discrepancy between the written and the material evidence can possibly be explained through the evidence's different characteristics. On the one hand the *CAR* contains excerpts and one might ask whether the relevant passages were indeed written by the authors, but of no interest for, and therefore not excerpted by, the compilers of the 5<sup>th</sup> century. But the absence of this discussion might go back even further: the main texts in the *CAR*, as mentioned, were composed during or shortly after the Flavian period. By the end of the 1<sup>st</sup> century AD, however, not many new colonies were being founded, and it was more important for the surveyors to be able to deal with the existing grids than to establish new ones. This is all the more comprehensible in the context of the Flavian reforms. As is well known, Vespasian aimed at restoring the finances of the empire, which had been compromised by the turbulences preceding his reign. His actions included the revindication of seized land such as *subseciva*, entailing a lot of work for the land surveyors, who to this end had to work with boundary markers and maps that must have been hundreds of years old by that time.<sup>52</sup> This shift in the tasks of the surveyors also explains the focus on the legal problems within the *CAR*, and may furthermore explain the somewhat theoretical character of Frontinus' and Hyginus Gromaticus' discussion of grid orientation.

Even though the excerpts in the *CAR* do not address hydrology as a factor influencing the grids' layout, the fact that Frontinus and Hyginus Gromaticus emphasize that the topography, the *locorum natura*, has to be taken into account when planning a division grid hints at the evaluation of land being an important skill of the surveyors. This expertise becomes apparent in various passages in the *CAR*, supporting the assumption that the surveyors had the skills required to make a decision over the grid's layout and orientation.

The importance of topography and hydrogeography for the surveyors' work is also apparent in a passage in Siculus Flaccus' work. It is not concerned with the orientation and layout of the grid itself, but clearly with hydrology. Flaccus in his description of the categories of land, the *condiciones agrorum*, strongly advises his reader to take into account the different habits in marking boundaries that can be found in different regions. He then moves on to indicate the various kinds of boundaries and their implications. Amongst other means of boundary marking such as roads, trees, or natural *rivi*, he also describes the difficulties resulting from boundaries made of ditches.<sup>53</sup> The surveyor must take care not to mistake a drainage ditch for a boundary ditch.<sup>54</sup>

<sup>52</sup> See on this CHOUQUER/FAVORY 2001, 30–33 and 203–216; also see CRANACH 1996, 33–37, who sees Frontinus' work composed under Vespasian or Titus rather than Domitian (who gave the *subseciva* back to the Italian owners, see Hyginus C 98,22–27); and CASTILLO 1996. For the shifting interests of the authors see e.g. PEYRAS 2003. For a very short summary of the tasks and changes involved in the Flavian programme see CHOUQUER 2008, 860f.

<sup>53</sup> Sic. Flacc. C 114,3–116,6.

<sup>54</sup> Sic. Flacc. C 114,7–11.

*Ita (...) ex ipsorum locorum necessitate et ex ipsorum positione colligi debebit quae sint finales. (...) Nam quidam in extremis finibus in solo suo faciunt fossas et ex superioribus vicinisque agris defluentes aquas excipiunt, ne inferiores terrae laborent.*

“Therefore, (...), from the requirements of the sites themselves and the position of (sc. the ditches) themselves has to be decided which are boundary ditches. (...) For some people build ditches on the edge of their land and catch the water flowing down from higher and neighbouring land, in order to prevent the lower ground from being damaged.”

The danger of mistaking a drainage ditch for a boundary ditch may imply that the latter did function as drainage ditches, and apparently the individual landowners here install the ditches themselves. But the passage is particularly remarkable in illustrating the capability of the surveyors to evaluate the *necessitas loci*, in this case the hydrological situation. To carry out such evaluations must have been one of the surveyors' main tasks when establishing a land division grid. A result of this work may be visible in an inscription<sup>55</sup> from the Augustan colony Ilici, near today's Elche in Spain. It is inscribed on a bronze tablet and contains a list of 10 colonists to whom lots are assigned in a certain part of the centuriation, very much as Hyginus describes the procedure of the *sortitio* in his *De limitibus*.<sup>56</sup> In the first line the quality of the land in the respective lots is described as dry (*sicci*), which may mean drained land, or at least non-irrigated land, in turn implying irrigated lots in a different part of the system.<sup>57</sup> This task of the surveyors in fact seems quite important since it must have had further consequences e.g. in terms of financial value and taxation of the land.<sup>58</sup>

The authors of the excerpts in the CAR do not address the question of grid orientation and its connection to hydrology, and since most of the hydrologically well adjusted grids seem to have been installed during the republic, for which period we lack written evidence, we do not know who actually decided their orientation. The skills required for an appropriate layout were obviously recognized and applied for the republican cadasters, and these skills become apparent in the works of those imperial authors excerpted for the CAR, making them idiosyncratic skills of the professional surveyors.

<sup>55</sup> AE 1999, 960. The bronze tablet was found in 1996 during excavations in l'Alcudia and measures 9 × 22,5 × 0,2 cm, the letters 0,3 to 0,8 cm. See OLESTI/MAYER 2001 and OLESTI 2006. It may be dated to the second half of the 1<sup>st</sup> century BC, see on the question of dating e.g. briefly OLESTI/MAYER 2001, 114 and DÍAZ 2008, 88f.

<sup>56</sup> Hyg. C 78,5–17. On the respective passages also see CAMPBELL 1995.

<sup>57</sup> On the identification of the lands represented in the inscription see GONZÁLEZ 2007.

<sup>58</sup> The evaluation will not have had any effects on the taxes in Ilici, which according to Plin. nat. 3,19 was exempt from paying them. A study of the historic soils in the area of the cadastre B of Orange in comparison with the prices for the lots transmitted through the marble inscriptions has however shown that soil of lesser quality was let in bigger units but for less money. The lots on which drainage and deforestation was necessary were the cheapest, see FAVORY 2004.

## 5. Hydraulic Infrastructure

When we turn to the archaeological evidence of Roman division grids, ancient ditches and channels of various size and function are found in the measured areas. Sometimes these ditches and channels are found in areas without much apparent relation to the division grid itself, but sometimes on or along the Roman *limites*.<sup>59</sup> Indeed, a coincidence of boundaries and channels can be observed in very early cases, for example in the *cuniculi*-system of the latin colony Cales (334 BC).<sup>60</sup> Other examples show that aqueducts of varying size and for various purposes were installed along boundaries – *limites* or boundaries within *centuriae* – and apparently still long after the implementation of the grid. The region of Tarragona provides us with two instances that can be put in relation with two Roman *villae*. The *villa* of Mas d'en Gras is situated in one of the identified Roman cadasters in the hinterland of *Tarraco*, and a small masonry channel belonging to the villa runs parallel to its orientation.<sup>61</sup> The cadaster is thought to go back to the republican period, whilst the channel is related to the 1<sup>st</sup> century AD phase of the villa, so – if these dates are correct – this small, private channel appears to have been built well after the implementation of the land division, but was obviously aligned to the division grid.<sup>62</sup> The second example is an aqueduct bridge approximately 700 metres northwest of the Roman villa of Centcelles (Pont de les Caixes), equally in the hinterland of *Tarraco*. The bridge is medieval, but an earlier, Roman construction phase has recently been verified, and it appears to align perfectly with the *kardines* of the division grid in which it is situated.<sup>63</sup> In Roman times it may have supplied the 1<sup>st</sup>/2<sup>nd</sup> century *villa* but according to the archaeologists' estimation was most likely used for irrigation. An example of yet bigger scale may be the Sorbán-channel near Calahorra, approximately 120 km northwest of Zaragoza, where the Roman *municipium* Calagurris used to be. Again, the channel runs parallel to the *limites* of the cadaster, approximately delimiting a third of the ancient *centuria*, and probably supplying the town of Calagurris with water. Both the division grid and the channel are difficult to date,<sup>64</sup> but if the assumption is right that the cadaster is republican<sup>65</sup> and the channel was built in the 1<sup>st</sup> or 2<sup>nd</sup> century AD, then this is an example of the urban water

<sup>59</sup> E.g. in the territory of Zaragoza (Caesar Augusta), see ARIÑO/GURT/PALET 1996, 152 and 154.

<sup>60</sup> See COMPATANGELO-SOUSSIGNAN 2002, 72.

<sup>61</sup> JÁRREGA/SÁNCHEZ 2008, 43 with fig. 20 p. 37. The channel is 0.3 m wide and 2.25 m deep.

<sup>62</sup> A use for irrigation can not be excluded, the channel disappears in the neighbouring fields. It seems, however, very deep for this purpose, and, what is more, the groundwater is abundant in this area. From the construction method JÁRREGA and SÁNCHEZ assume that the channel discharged into a basin.

<sup>63</sup> PALET/ORENGO 2010, 143 and PALET/ORENGO 2011, 393. The path running under the bridge accordingly corresponds to the alignment of the *decumani*. REMOLÁ/ALIENDE/ROIG 2009, 195–201, 208.

<sup>64</sup> Both are named in medieval documents, and the Sorbán-channel is there referred to as an *aqueductum* as opposed to the usual *rivus* or *rego*, see ARIÑO/GURT/PALET 2004, 94–97, 107–110.

<sup>65</sup> The land division is dated to the republic only indirectly, through literary evidence. ARIÑO suggests its implementation as a means of punishment by Pompeius after the Sertorius episode (ARIÑO 1990, 130–135). The cadaster would in this case have been installed between 72 BC and the unknown date

supply system being fitted into the rural cadaster and possibly aligned with a boundary within the *centuria*.

The installation of hydraulic infrastructure was usually undertaken by individuals as in Flaccus' passage (*quidam ... in suo solo faciunt fossas*)<sup>66</sup>, or by the municipality. From municipal laws like the *Lex Tarentina*, the *Lex Ursonensis* and the *Lex Irnitana* we know that the *aediles* and/or the *duumviri* were – if authorized by a decree of the *decuriones* – allowed to build or alter channels, ditches and aqueducts, as long as this did not happen to anyone's disadvantage. To this end, it was convenient and sensible to have channels run on property boundaries,<sup>67</sup> and this custom is to a certain degree confirmed by the *CAR*. Information on the control of soil moisture is very scarce in the *CAR*. In the case of irrigation this is not surprising since the authors seem to have been writing mostly with Italy in mind, where drainage is more important.<sup>68</sup> Drainage is mentioned several times,<sup>69</sup> but usually in passages concerned with a different topic, and the mentions are rather incidental. Hydraulic infrastructure on the other hand, such as watercourses, channels and aqueducts as well as cisterns and wells, is mentioned in various instances in the excerpts and appears as an integral element of the landscape in which the surveyors move. The terminology for watercourses used in the *CAR*, however, is far from clear. It is not always possible to distinguish an artificial *rivus* from natural *rivi*, for example, and where a conduit is clearly artificial, the construction and purpose of, for example, an *aquae ductus* remains undescribed. According to their interests, the surveyors mention them when they interfere with their work, e.g. because the channels and aqueducts ran across boundaries, or were involved in boundary marking in one way or another, thus potentially giving rise to controversies, or when the surveyors had to respect the existing conduits when install-

of the endowment of the status of a *municipium* (ARIÑO/GURT/MARTÍN 1994, 314f.), but the probability of a *civitas peregrina* receiving a cataster can be questioned.

<sup>66</sup> Sic. Flacc. C 114,9f.

<sup>67</sup> See above note 24.

<sup>68</sup> Agennius Urbicus is the only one to mention irrigation explicitly, referring to the use of rainwater in Africa when discussing the *controversia de aqua pluvia arcenda* (cf. Dig. 39,3), pointing out that the circumstances for the dispute are different in Africa and in Italy (Agenn. Urb. C 20,17–21, cf. 46,4–7): *nam cum in Italia ad aquam pluviam arcendam controversia non minima concitetur, diverse in Africa ex eadem re tractatur. quom sit enim regio aridissima, nihil magis in querella habent quam siquis inhibuerit aquam pluviam in suum influere: nam et aggeres faciunt et excipiunt et continent eam, ut ibi potius consumatur quam abfluat.*

<sup>69</sup> More or less explicitly, apart from the above mentioned passage in Sic. Flacc. (C 114,3–116,6) for example in Agenn. Urb. C 46,5–9, the *Lex Mamilia* (C 216,9–12), or in Hyginus' treatise *De generibus controversiarum* (C 94,8f.). Among the instances naming infrastructure the *canabula* and *novercae* in the *Libri Coloniarum* presumably designate drainage channels, thus attesting drainage for many places in the regions of Picenum (*ager Atteiatis*: C 188,17f. cf. 190,33, *ager Hadrianus item Nursinus et Falerionensis et Pinnensis*: C 176,31 cf. 190,28 and 196,5, *ager Foronovanus*: C 194,28), the *provincia Dalmatiarum*: C 188,29, and *Valeria (ager Corfinius*: C 178,11f. For this region irrigation is attested through other literary evidence, for Sulmo/Corfinium, see Plin. nat. 17,250, cf. Ov. am. 2,16).

ing a new limitation.<sup>70</sup> In some cases they mention drainage channels and not otherwise specified *aquae ductus*, which are clearly artificial, as running on or along boundaries or directly serving as boundary markers.<sup>71</sup> Whilst the majority of these passages is to be found in the late excerpts, one very early case deserves special attention. In the CAR three paragraphs of the so called *Lex Mamilia Roscia Peducaea Alliena Fabia* are preserved, which probably dates from the Caesarean period.<sup>72</sup>

*Qui limites decumanique hac lege deducti erunt, quaecumque fossae limitiales in eo agro erunt, qui ager hac lege datus adsignatus erit, ne quis eos limites decumanosve obsaepito, (...), neve eas fossas opturato neve obsaepito, quo minus suo itinere aqua ire fluere possit.*

“Whatever boundaries and *decumani* will be laid out according to this *lex*, and whatever boundary ditches will be on the land that will be granted and allocated according to this *lex*, no one shall block those *limites* and *decumani*, (...) nor block or obstruct those ditches, so that the water is prevented from moving and flowing in its natural course.”

<sup>70</sup> Hyg. C 86,33–88,1; Sic. Flacc. C 124,6–10. From the few relevant passages in the CAR we cannot tell whether the *agrimensores* of the imperial time in these specific cases designated existing aqueducts and ditches as boundary markers or deliberately put the latter on the boundaries in order to manifest boundaries. The first procedure seems more likely for the empire since the basic infrastructure in a given territory probably already existed when the surveyors took action.

<sup>71</sup> Drainage (?) ditches run along or on boundaries in Siculus Flaccus (Sic. Flacc. C 114,3–116,5: *fossae*, also cf. certain passages in the *Corpus Iuris Civilis* such as Dig. 39,3,2,2), and aqueducts and ditches are found as boundary markers in the *De vallibus* (C 268,4: *per aquas vivas ubi terminus non possit, fossas finales et aquae ductos in fine direximus*) of uncertain date and authorship, in the late republican *Lex Mamilia* (C 216,9–12: *fossa limitalis*), and possibly in *Libri Coloniarum* C 170,11–17 for the Colonia Iunonia (*in locis quibusdam rivi finales et cavae quae ex pactione sunt designatae, hae tamen quae recturam limitum recipiunt. (...) ceterum normalis longitudo per rivorum cursus servatur*). Furthermore see the instances naming *canabula* and *novercae* as boundary markers (Lib. Col. C 176,31; 178,11f.; 188,17f. 29; 190,28. 33; 194,28; 196,5; Mago et Vegoia C 256,8). In some cases they can designate any kind of boundaries (e.g. simply *finis*: *De vallibus*; Sic. Flacc.; Agenn. Urb.; Lib. Col. C 178,11f.; 188,29; Mago and Vegoia C 256,8), in other cases the authors specifically name the *limites*, i.e. the *cardines* and the *decumani* (Lib. Col. C 170,11–17; 176,31; 188,17f.; 190,28. 33; 194,28; 196,5).

<sup>72</sup> *Lex Mamilia Roscia Peducaea Alliena Fabia* § 4, C 216,9–12. See CRAWFORD 1989, who suggests that the passage was originally a part of the *Lex Iulia* issued by Caesar in 59 (cf. Dig. 47,21,3 pr) that later found its way into the Digests and the *Lex Ursonensis*, but is not identical with the *Lex Mamilia* dictating a width of 5 feet for the boundaries, which the authors in the CAR refer to in various instances, see above note 14.

This passage thus confirms the habit to install water ditches or channels on the *limites* and *decumani*. It is, moreover, of special interest because it is repeated almost *verbatim* in the *Lex Ursonensis*, the charter of the colony Urso (Osuna, Spain).<sup>73</sup> The preserved copy of the *Lex Ursonensis* is Flavian, but the original, and the foundation of the colony, go back to Caesar or the time shortly after his death. The fact that the water flow in the boundary ditches was protected by law shows that this function of the ditches was important, and – most notably – that the control of soil moisture was already taken into account and taken care of at the beginning, when the colony was established and shaped. This last point, as seen, is confirmed by the grid's orientation, but is also supported by other evidence. One example is the dam of Muel, some 25 kilometres southwest of Zaragoza in the river Huerva. Its use for irrigation is probable, and the construction of the dam can be dated to the Augustan time, more precisely around 15 BC – shortly after the foundation of the Roman colony of Caesar Augusta.<sup>74</sup>

## 6. Conclusions

Land division is a case of deliberate shaping of the rural area, which was in effect initiated by the Roman government. At a closer look it becomes clear that this shaping was also designed to control and optimize soil moisture. This control, and thereby agricultural usability of, the rural area of Roman settlements was taken into account deliberately from the very foundation of these communities.

The land surveyors played a very important, if to us nearly invisible, role in this process, presumably influencing the orientation of the grid, using their skills to assess the topography and the hydrology of an area, an ability which is also evident in the *CAR*. The fact that the archaeologically evident relation of the orientation of the division grids and the hydrology is not discussed in the surveyors' writings can be explained through the characteristics of the evidence: from the republic, in which period most of the cadasters were installed, we lack written evidence, and in the empire, for which we can use the excerpts collected in the *CAR*, the surveyors had other tasks.

The *CAR* however does confirm the relation of the division grids and the installation of the hydraulic infrastructure, which is tangible in the archaeological evidence, showing that the cadaster influenced the shaping of the landscape long after its implementation.

<sup>73</sup> CIL I<sup>2</sup> 594, § 104. We lack archaeological evidence for division grids and channels for the surroundings of Urso, but as the grounds are swampy drainage seems more obvious. See ARIÑO/GURT/MARTÍN 1994, 322.

<sup>74</sup> C<sup>14</sup>-analysis indicates a date in the early empire. The more precise dating to 10–5 BC is based on inscriptions of the *legio IV Macedonica* found on the lower layers of ashlar. This legion is known to have been involved in a number of construction works in the province. See URIBE/MAGALLÓN/FANLO/MARTÍNEZ/DOMINGO/REKLAITYTE/PÉREZ 2010, 341–345 and URIBE/MAGALLÓN/FANLO 2012, 79f.

The actual implementation and installation of the infrastructure, e.g. for irrigation systems, was in most cases left to the local authorities, who seem to have been geared to the cadasters' structure even generations later. However, the Roman government provided the basis for optimal land use right at the foundation of colonies by orientating the division grid in an ideal way. This was a one-time, spatially limited intervention, but had a far-reaching impact in the long run.

## Bibliography

- ARIÑO 1990 = E. ARIÑO GIL, Catastros romanos en el convento jurídico caesaraugustano. La región aragonesa, Zaragoza 1990.
- ARIÑO/GURT/MARTÍN 1994 = E. ARIÑO GIL/J.M. GURT I ESPARRAGUERA/M.A. MARTÍN BUENO, Les cadastres romains d'Hispanie. État actuel de la recherche, in: P.N. DOUKELLIS/L.G. MENDONI (ed.), Structures rurales et sociétés antiques. Actes du colloque de Corfu (14–16 mai 1992), Paris 1994, 309–328.
- ARIÑO/GURT/PALET 1996 = E. ARIÑO GIL/J.M. GURT I ESPARRAGUERA/J.M. PALET MARTÍNEZ, Réalités archéologiques et restitution théorique des parcellaires. Analyse du problème sur quelques exemples hispaniques, in: G. CHOUQUER (ed.), Les formes du paysage 2. Archéologie des parcellaires, Paris 1996, 142–154.
- ARIÑO/GURT/PALET 2004 = E. ARIÑO GIL/J.M. GURT I ESPARRAGUERA/J.M. PALET MARTÍNEZ, El pasado presente. Arqueología de los paisajes en la Hispania romana, Salamanca 2004.
- ARIÑO/MARTÍN/NAVARRO 1998 = E. ARIÑO GIL/M.A. MARTÍN BUENO/M. NAVARRO CABALLERO, Les centuriations de Caesaraugusta, in: M. CLAVEL-LÉVÊQUE (ed.), Atlas historique des cadastres d'Europe I, Bruxelles 1998, Espagne Dossier III, p. 1–14.
- BLUME/LACHMANN/RUDORFF 1848 = F. BLUME/K. LACHMANN/A. RUDORFF, Die Schriften der römischen Feldmesser, Berlin 1848 (2 vols., reprint Hildesheim 1967).
- BRADFORD 1957 = J.S.P. BRADFORD, Ancient Landscapes, London 1957.
- BRIGAND 2007 = R. BRIGAND, Les paysages agraires de la plaine vénitienne. Hydraulique et planification entre Antiquité et Renaissance, in: Actes du colloque Medieval Europe 2007, <http://medieval-europe-paris-2007.univ-paris1.fr/R.Brigand.pdf>. [31.1.2013]
- BRIGAND 2012 = R. BRIGAND, L'étude des centuriations romaines. Acquis anciens et nouvelles perspectives, in: D. BOTEVA-BOYANOVA/L. MIHAILESCU-BIRLIBA/O. BOUNEGRU (ed.), *Pax Romana*. Kulturaustausch und Wirtschaftsbeziehungen in den Donauprovinzen des römischen Kaiserreichs. Akten der Tagung in Varna und Tulcea, 1.–7. September 2008, Kaiserslautern 2012, 235–254.
- CALZOLARI 1995 = M. CALZOLARI, Interventi di bonifica nella Padana Centrale in età romana, in: L. QUILICI (ed.), Interventi di bonifica agraria nell'Italia romana, Roma 1995, 7–16.
- CAMPAGNOLI/GIORGI 2009 = P. CAMPAGNOLI/E. GIORGI, Centuriazione e assetti agrari nelle Valli Marchigiane. Il rapporto tra persistenza e idrografia, *Agri Centuriati* 6, 2009, 299–311.
- CAMPBELL 1995 = B. CAMPBELL, Sharing out Land. Two Passages in the *Corpus Agrimensorum Romanorum*, CQ 45.2, 1995, 540–546.
- CAMPBELL 1996 = B. CAMPBELL, Shaping the Rural Environment. Surveyors in Ancient Rome, *JRS* 86, 1996, 74–99.
- CAMPBELL 2000 = B. CAMPBELL, The Writings of the Roman Land Surveyors. Introduction, Text, Translation and Commentary, London 2000.
- CASTILLO 1996 = M.J. CASTILLO PASCUAL, El nacimiento de una nueva familia de textos técnicos. La literatura gromática, *Gerión* 14, 1996, 233–249.

- CAVALIERI-MANASSÉ 2000 = G. CAVALIERI-MANASSÉ, Un documento catastale dell'agro centuriato veronese, *Athenaeum* 88.1, 2000, 5–48.
- CAVALIERI-MANASSÉ 2004 = G. CAVALIERI-MANASSÉ, Note su un catasto rurale veronese, *Index* 32, 2004, 49–81.
- CHEVALLIER 1964 = R. CHEVALLIER, *L'avion à la découverte du passé*, Paris 1964.
- CHOUQUER 1987 = G. CHOUQUER, Le tissu rural, in: G. CHOUQUER/M. CLAVEL-LÉVÊQUE/F. FAVORY/J.-P. VALLAT (ed.), *Structures agraires en Italie centro-méridionale. Cadastres et paysages ruraux*, Rome 1987, 285–314.
- CHOUQUER 2008 = G. CHOUQUER, Les transformations récentes de la centuriation. Une autre lecture de l'arpentage romain, *AnnESC* 63.4, 2008, 847–874.
- CHOUQUER/CLAVEL-LÉVÊQUE/FAVORY 1982 = G. CHOUQUER/M. CLAVEL-LÉVÊQUE/F. FAVORY, Cadastres, occupation du sol et paysages agraires antiques, *AnnESC* 37.5–6, 1982, 847–882.
- CHOUQUER/FAVORY 2001 = G. CHOUQUER/F. FAVORY, *L'arpentage romain. Histoire des textes, droit, techniques*, Paris 2001.
- CLASSEN 1994 = C.J. CLASSEN, On the Training of the *agrimensores* in Republican Rome and Related Problems. Some Preliminary Observations, *Illinois Classical Studies* 19, 1994, 161–170.
- COMPATANGELO-SOUSSIGNAN 2002 = R. COMPATANGELO-SOUSSIGNAN, I catasti della Campania settentrionale. Problemi di metodo e di datazione, in: G. FRANCIOSI (ed.), *Ager Campanus*. Atti del convegno internazionale. La storia dell'*Ager Campanus*. I problemi della *limitatio* e sua lettura attuale. Real sitio di S. Leucio, 8.-9. Giugno 2001, Napoli 2002, 67–76.
- CRANACH 1996 = PH. VON CRANACH, *Die Opuscula agrimensorum veterum und die Entstehung der kaiserzeitlichen Limitationstheorie*, Basel 1996.
- CRAWFORD 1989 = M.H. CRAWFORD, The *Lex Iulia Agraria*, *Athenaeum* n.s. 67, 1989, 179–190.
- DALL'AGLIO 1994 = P.L. DALL'AGLIO, Centuriazione e uso del territorio nella pianura emiliana, in: J. CARLSEN/P. ØRSTED/J.E. SKYDSGAARD (ed.), *Land Use in the Roman Empire*, Rome 1994, 17–25.
- DALL'AGLIO 2005 = P.L. DALL'AGLIO, Le infrastrutture territoriali. Toponomastica e centuriazione, in: G. SASSATELLI/A. DONATI (ed.), *Bologna nell'Antichità*, Bologna 2005, 453–478.
- DS = CH. DAREMBERG/E. SAGLIO (ed.), *Dictionnaire des Antiquités Grecques et Romaines*, Paris 1881–1919.
- DE RUGGIERO = E. DE RUGGIERO (ed.), *Dizionario epigrafico di antichità romane*, Roma 1895–1997.
- DI COCCO 2008 = I. DI COCCO, Aree 'apparentemente' centuriate della pianura Bolognese, *Agri Centuriati* 5, 2008, 67–75.
- DÍAZ 2008 = B. DÍAZ ARIÑO, *Epigrafía latina republicana de Hispania*, Barcelona 2008.
- DILKE 1971 = O.A.W. DILKE, *The Roman Land Surveyors. An Introduction to the Agrimensores*, Newton Abbot 1971.
- FAVORY 2004 = F. FAVORY, L'évaluation des compétences agrologiques des sols dans l'agronomie latine au Ier s. ap. J.-C. Columelle, Plinie l'Ancien et le cadastre B d'Orange, in: M. CLAVEL-LÉVÊQUE/E. HERMON (ed.), *Espaces intégrés et ressources naturelles dans l'Empire Romain*, Besançon 2004, 95–118.
- GALSTERER 1992 = H. GALSTERER, Die Kolonisation der hohen Republik und die römische Feldmessenkunst, in: O. BEHREND/S. L. CAPOGROSSI COLOGNESI (ed.), *Die römische Feldmessenkunst. Interdisziplinäre Beiträge zu ihrer Bedeutung für die Zivilisationsgeschichte Roms*, Göttingen 1992, 412–428.
- GARGOLA 1995 = D.J. GARGOLA, *Lands, Laws, & Gods. Magistrates and Ceremony in the Regulation of Public Lands in Republican Rome*, Chapel Hill/London 1995.
- GARGOLA 2004 = D.J. GARGOLA, The Ritual of Centuriation, in: C.F. KONRAD (ed.), *Augusto augurio. Rerum humanarum et divinarum commentationes in honorem Jerzy Linderski*, Stuttgart 2004, 123–150.
- GONZÁLEZ VILLAESCUSA 2007 = R. GONZÁLEZ VILLAESCUSA, Ce que la morphologie peut apporter à la connaissance de la centuriation d'*Ilici* (Elche, Espagne), *Agri Centuriati* 4, 2007, 29–42.

- HINRICHS 1974 = F.T. HINRICHS, Die Geschichte der gromatischen Institutionen. Untersuchungen zu Landverteilung, Landvermessung, Bodenverwaltung und Bodenrecht im römischen Reich, Wiesbaden 1974.
- JÁRREGA/SÁNCHEZ 2008 = R. JÁRREGA DOMÍNGUEZ/E. SÁNCHEZ CAMPOY, La vil·la romana del Mas d'en Gras, Vila-seca 2008.
- KEPPIE 1983 = L. KEPPIE, Colonisation and Veteran Settlement in Italy 47–14 B.C., London 1983.
- LAFFI 2003 = U. LAFFI, La colonizzazione romana nell'età della Repubblica, in: I. BALDELLI/L. GODART/M. LIVI BACCI/R. VILLARI (ed.), Il fenomeno coloniale dall'Antichità ad oggi (Atti dei Convegni Lincei 189), Roma 2003, 37–52.
- LÓPEZ 1994 = P. LÓPEZ PAZ, La Ciudad Romana Ideal. 1. El Territorio, Santiago de Compostela 1994.
- MISURARE 1984 = R. BUSSI (ed.), Misurare la terra. Centuriazione e coloni nel mondo romano. Il caso modenese, Modena 1984.
- MISURARE 1984a = R. BUSSI (ed.), Misurare la terra. Centuriazione e coloni nel mondo romano. Il caso mantovano, Mantova 1984.
- MISURARE 1985 = R. BUSSI/V. VANDELLI (ed.), Misurare la terra. Centuriazione e coloni nel mondo romano. Città, agricoltura, commercio: materiali da Roma e dal suburbio, Modena 1985.
- MISURARE 1985a = R. BUSSI/V. VANDELLI (ed.), Misurare la terra. Centuriazioni e coloni nel mondo romano. Il caso veneto, Modena 1985.
- MISURARE 2003 = R. BUSSI (ed.), Misurare la terra. Centuriazione e coloni nel mondo romano, Modena 2003<sup>2</sup>.
- MOATTI 1993 = C. MOATTI, Archives et partage de la terre dans le monde romain (IIe siècle avant – Ier siècle après), Rome 1993.
- NICOLET 1970 = C. NICOLET, Les *finitores ex equestri loco* de la loi Servilia de 63 av. J.C., *Latomus* 29, 1970, 72–103.
- NICOLET 1988 = C. NICOLET, L'inventaire du monde. Géographie et politique aux origines de l'Empire romain, Paris 1988.
- OLESTI 2006 = O. OLESTI VILA, La *sortitio* de Ilici. Un ejemplo de la precisión agrimensoria, in: D. CONSO/A. GONZÁLES/J.-Y. GUILLAUMIN (ed.), Les vocabulaires techniques des arpenteurs romains, Actes du colloque international (Besançon 19–21 septembre 2002), Besançon 2006, 47–61.
- OLESTI/MAYER 2001 = O. OLESTI VILA/M. MAYER, La *sortitio* de Ilici. Del documento epigráfico al paisaje histórico, *DHA* 27.1, 2001, 109–130.
- PALET/ORENGO 2010 = J.M. PALET MARTÍNEZ/H.A. ORENGO ROMEU, Les centuriacions de l'ager Tarraconensis. Organització i concepcions de l'espai, in: J.M. PREVOSTI/J. GUITART (ed.), Ager Tarraconensis. Vol. 1. Aspectes històrics i marc natural, Tarragona 2010, 121–154.
- PALET/ORENGO 2011 = J.M. PALET MARTÍNEZ/H.A. ORENGO ROMEU, The Roman Centuriated Landscape. Conception, Genesis, and Development as Inferred from the Ager Tarraconensis Case, *AJA* 115.3, 2011, 383–402.
- PEYRAS 2003 = J. PEYRAS, Colonies et écrits d'arpentage du Haut-Empire, in: M. GARRIDO-HORY/A. GONZALÈS (ed.), Histoire, Espaces et Marges de l'Antiquité. Hommages à M. Clavel-Lévêque, Vol. 2, Besançon 2003, 103–155.
- PEYRAS 2008 = J. PEYRAS (ed.), Arpentage et administration publique à la fin de l'Antiquité. Les écrits des hauts fonctionnaires équestres. Textes établis, traduits et annotés par Jean Peyras, Besançon 2008.
- PIGANIOL 1962 = A. PIGANIOL, Les documents cadastraux de la colonie romaine d'Orange, Paris 1962.
- REMOLÁ/ALIENDE/ROIG 2009 = J.A. REMOLÁ/P. ALIENDE/J.F. ROIG, L'aqüeducte del pont de les Caixes i la vil·la romana de Centcelles (Constantí, Tarragonès), *Tribuna d'Arqueologia* 2008–2009, 183–207.
- SÁEZ 1990 = P. SÁEZ FERNÁNDEZ, Estudio sobre una inscripción catastral colindante con Lacimurga, *Habis* 21, 1990, 205–227.
- SALMON 1969 = E.T. SALMON, Roman Colonization under the Republic, London 1969.

- THULIN 1913 = C. THULIN, *Corpus Agrimensorum Romanorum*, Stuttgart 1971 (Editio stereotypa editionis anni MCMXIII cum addendis).
- TONEATTO 1983 = L. TONEATTO, Tradition manuscrite et éditions modernes du *Corpus Agrimensorum Romanorum*, in: M. CLAVEL-LÉVÊQUE (ed.), Cadastres et espace rural. Table ronde de Besançon, Mai 1980, Paris 1983, 21–50.
- TONEATTO 2010 = L. TONEATTO, Agrimensori e testi di agrimensura, in: P. RADICI COLACE/S.M. MEDAGLIA/L. ROSSETTI/S. SCONOCCHIA (ed.), Dizionario delle scienze e delle tecniche di Grecia e Roma, vol. I, Pisa/Roma 2010, 46–52.
- URIBE/MAGALLÓN/FANLO/MARTÍNEZ/DOMINGO/REKLAIITYTE/PÉREZ 2010 = P. URIBE AGUDO/M.Á. MAGALLÓN BOTAYA/J. FANLO LORAS/M. MARTÍNEZ BEA/R. DOMINGO MARTÍNEZ/I. REKLAIITYTE/F. PÉREZ LAMBÁN, La presa romana de Muel. Novedades de hidráulica romana en el Valle del Ebro, in: L.G. LAGÓSTENA BARRIOS/J.L. CAÑIZAR PALACIOS/L. PONS PUJOL (ed.), *Aquam perducendam curavit*. Captación, uso y administración del agua en las ciudades de la Bética y el occidente romano, Cádiz 2010, 333–345.
- URIBE/MAGALLÓN/FANLO 2012 = P. URIBE AGUDO/M.Á. MAGALLÓN BOTAYA/J. FANLO LORAS, New Evidence on Roman Water Supply in the Ebro Valley. The Roman Dam of Muel (Zaragoza, Spain), in: M. ZUCHOWSKA (ed.), *The Archaeology of Water Supply*, Oxford 2012, 75–83.
- VITTINGHOFF 1951 = F. VITTINGHOFF, *Römische Kolonisation und Bürgerrechtspolitik unter Caesar und Augustus*, Wiesbaden 1951.

