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# LOTS OF PLUMBING, LITTLE *PLUMBUM*. THE LEAD PIPING IN NOVAE REVISITED ON THE OCCASION OF A NEW FIND FROM SECTOR 12

**Abstract:** In 2016, the remains of a lead pipeline in the form of two fistulae still linked together with a mortar sleeve were found at Sector 12 in Novae. This contribution discusses the use of lead piping in Novae in general and the water supply at Sector 12 in particular. The chemical analysis and context of the finds allow for considerations regarding the features of the legionary fortress in Flavian times.

**Keywords:** Novae, *legio I Italica*, Roman military water supply, lead piping, *fistulae*

## Introduction

Strolling through Pompeii, even the untrained eye will spot lead piping sticking out at every corner: in the streets, in the houses, in the museum. Looking at the aqueducts of Novae[1] in turn, a legionary fortress in the province of Moesia Inferior located on the Danube in northern Bulgaria, not far from modern Svištov, once home for the *legio I Italica*,[2] one can easily discern a discrepancy in the remains: in virtually every fieldwork section, there are sewage/drainage canals, but there are far fewer conduits identified as supplying fresh water. There are several reasons for this, a major one being the fact that potential wooden conduits[3] would have decayed, while lead and terracotta[4] pipelines were easier to remove than canals dug into the ground (which in turn could quickly be refilled) and the lead — like any other metal — could be harvested and reused. Thus from the entire legionary camp and civil town we have a grand total of little more than 20 lead pipes or fragments thereof,[5] as well as some lead sheets for tightening conducts.[6] Novae is no exception in this regard, even though there exist Roman army forts with at least some intact lead conduits.[7] Apart from the archaeological context a given conduit is attributed to, the lead used for

[1] For an introduction to the topic of water supply in Novae with further literature, see Lemke 2018b.
[2] Research at Novae, Sector 12, is kindly supported by the National Science Centre (Narodowe Centrum Nauki), within the project: "Novae. Obóz legionowy i miasto późnoantyczne — kontynuacja badań. Baraki I kohorty legionu VIII *Augusta* i legionu I Italskiego", 2018/31/B/HS3/02593. Novae is being investigated since the 1960s, for further literature, see Sarnowski *et alii* 2012.
[3] Attested for instance in Germania: Jacobi 1934, pp. 52–53.
[4] Lemke 2021.
[5] Cf. Recław 2003. It is conceivable that a piece or two were discovered by colleagues and not (yet) published. See also Stefanov 1930–1931 and Biernacka-Lubańska 1997, p. 17, for the theory, that one of the two aqueducts supplying water from the area of modern Svištov over a length of *ca.* 6 km was entirely made of lead and included an elaborate reservoir.
[6] Biernacka-Lubańska 1997, p. 11.
[7] Stephens 1985.

piping and the mortar used in masonry canals can be analyzed on their own and provide useful information on the conduit and its chronology, especially when there are no stamps or inscriptions connected to the given object.

## Sector 12

Since 2011, fieldwork is underway at Sector 12 in Novae [Fig. 1],[8] and the recent discoveries there gave the impulse for this paper. After almost a decade, the main task is still to establish the nature of the principal structure of the late first and second century. The *praetorium*, which should be expected East, West or South of the *principia* is an attractive candidate,[9] not only because of the layout of the courtyard-centered edifice, but also because the areas West and South of the *principia* are occupied by the second-century *thermae*[10] and the *via decumana*[11] respectively. The alternative

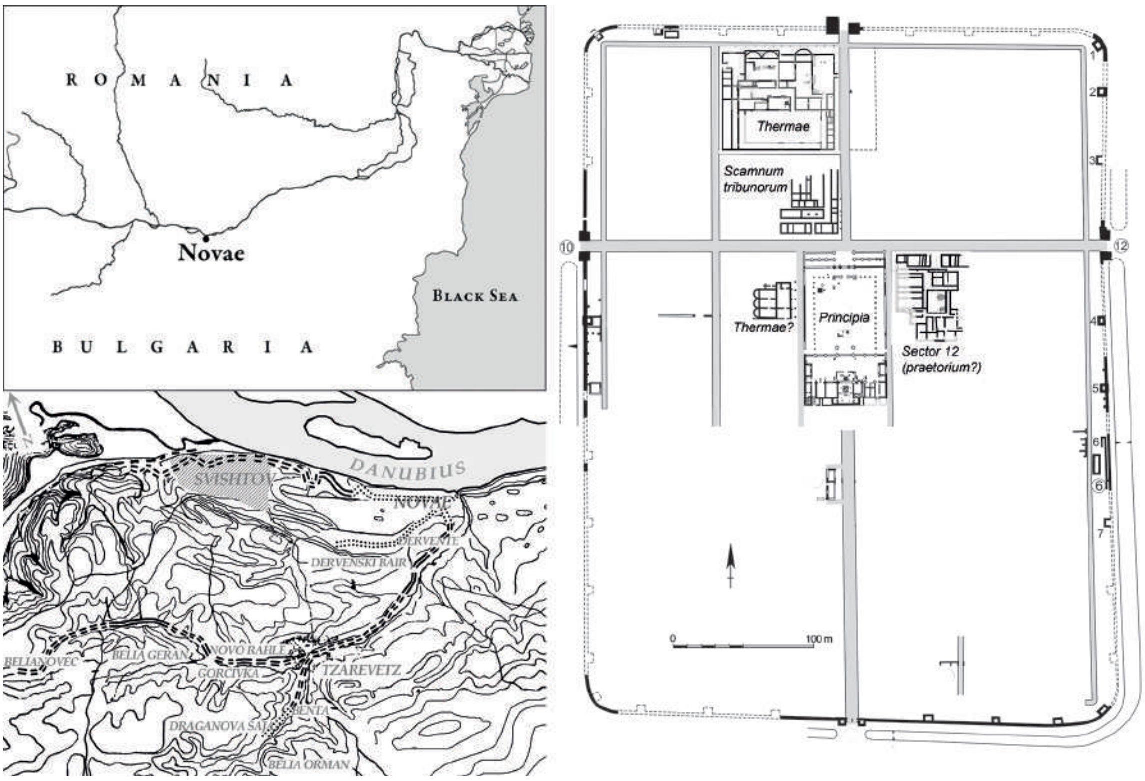


Fig. 1. Novae. Left: general location and aqueducts (compiled by M. Różycka).
Right: the legionary fort in Flavian times (slightly diachronic sketch plan, compiled by M. Lemke based on earlier plans made by J. Kaniszewski, T. Sarnowski, L. Kovalevskaâ, P. Zakrzewski, A. Biernacki, P. Dyczek, M. Lemke, B. Wojciechowski)

[8] For the given campaigns and further reading on Novae, see Lemke 2011; 2012; 2013; 2014; 2015; 2015–2016a; 2015–2016b.

[9] Lemke 2015–2016b, p. 337.

[10] Biernacki *et alii* 2016.

[11] Sarnowski *et alii* 2005, pp. 145–149. In spite of uncovering the *via decumana*, Sarnowski proposed the “not fully convincing conjecture” that the *praetorium* was located south of the *principia*, based on a contextless senatorial inscription (*ibidem*, p. 148).

idea of stone barracks with a centurion's house located at Sector 12 has also been proposed.[12] As mysterious as the building still may be, it has provided lots of useful information already, and there is no doubt the system of aqueducts and sewage channels visible here is quite intricate [Fig. 2].

The layout of these conduits is interesting not only because of its complexity, but also for the visible rearrangements undertaken during the late first / early second century. Along the western edge of the excavation area, adjacent to the eastern wall of the *principia*, runs directly from the south to the north a large canal without traces of a covering, possibly designed for rain-water, while the main sewage canal for the legionary building in Flavian times — whatever it was — runs closer to the current eastern edge, also precisely on a north-south axis. There is also a third smaller canal meandering southeast-northwest across a significant portion of the sector, draining water from a small basin added later to the courtyard of the edifice.

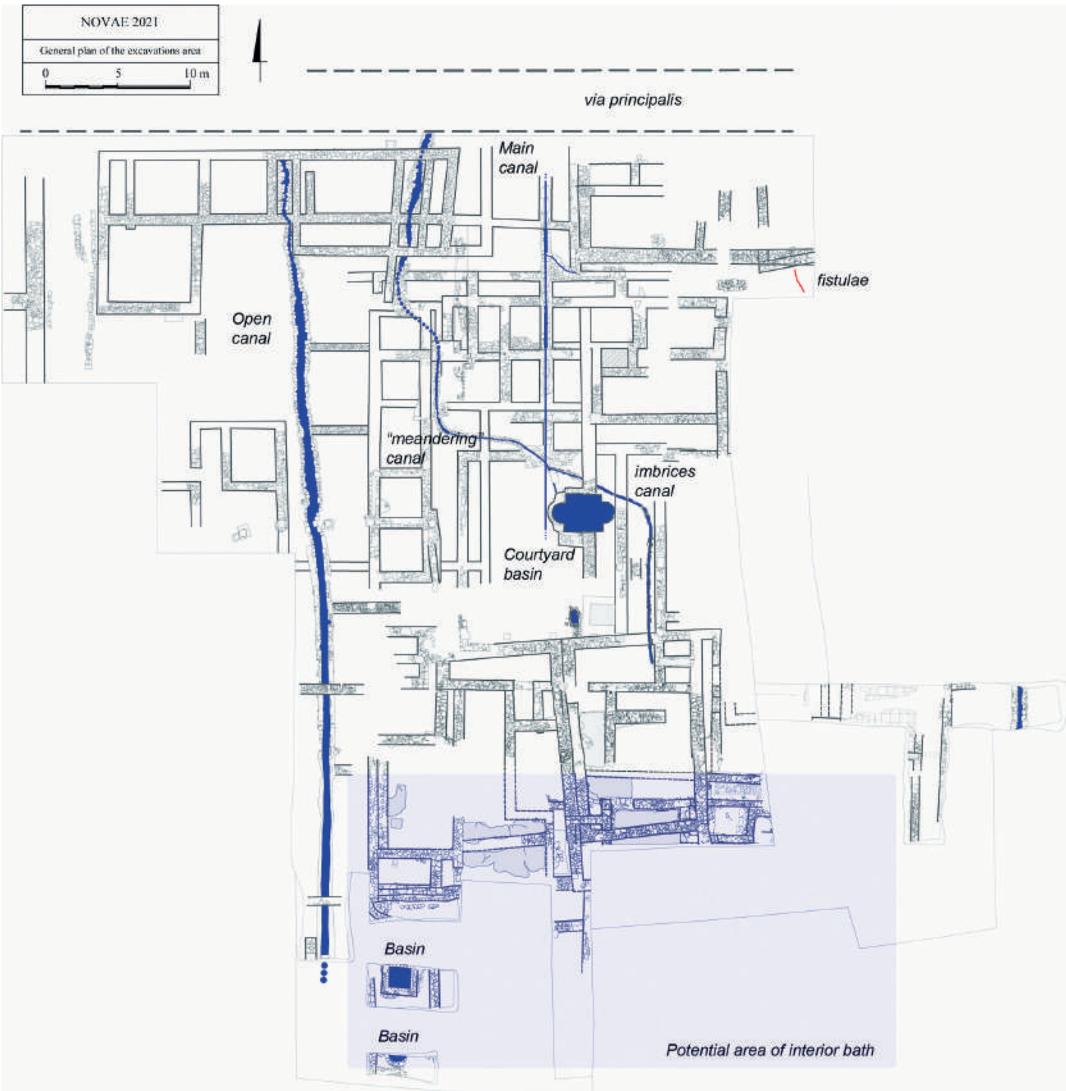


Fig. 2. Sector 12 and its system of aqueducts. The potential extent of the internal bath, the courtyard basin and the various conduits have been marked in blue in a diachronic fashion, the finding spot of the fistulae in red (compiled by B. Wojciechowski, M. Lemke)

[12] Dyczek 2018.

The main sewage channel passes under several walls. It was solidly built, consisting of medium-sized stones and bricks, which had been dug into the loess soil and were held together by white hydraulic mortar.[13] The last layer of the side walls, underneath the covering stones, consists of a row of flat tiles. The covers are big stone slabs while the bottom comprised *tegulae*. The depth measures *ca.* 0.6 m, the internal width 0.2 m, while the entire construction is 0.6 m wide. Towards the northern end of the trench, an additional tributary channel of similar build directed its waters into this drain, while at the southern edge of the excavated area a ceramic pipeline made of linked *imbrices* set in virgin soil and feeding into the main channel was discovered. The latter, somewhat unusual conduit must have been built in Flavian times, too, before the creation of the small courtyard pool which rendered the main canal obsolete (at least the stretch of it uncovered at Sector 12).

At several other locations in Novae, canals of identical build have been found,[14] hinting at an encompassing, synchronic drainage layout established in Flavian times, i.e. the construction phase of the fortress.[15] The canal was intersected when a basin unearthed in what in 2020 is the central part of the trench was built. Water from this basin, added to the courtyard of the building (which may have had another function at that point in time), was drained via a „meandering" channel with a depth of *ca.* 0.35 m. Its walls are made of large stones and a layer of bricks beneath the covering and its width gradually decreases on the excavated stretch from 25 to 12 cm (possibly to increase water pressure before reaching a latrine). Interestingly, the cover slabs are *tegulae* of *legiones I Italica* and *I Minervia pia fidelis*.[16] The bottom also consists of *tegulae*, sometimes stamped *LEG I ITAL*, but also with a number of stamps of *legio XI Claudia*.

Apparently, these new features were added at a time of reorganization within the fortress, perhaps in the early second century, when after Trajan's Dacian Wars Moesia enjoyed a period of intensive building activity. The Flavian bath had been torn down earlier and the new *thermae* were built west of the *principia*.[17] The availability of both spare material from the disassembled baths, as well as professionals specialized in building hydraulic constructions might have been taken advantage of to also construct smaller features, like this basin, which had no visible water inlet and was likely filled with rain water. A hint supporting this theory is the fact that the stamps on the base tiles of the channel, bearing stamps of the first legion, represent early, Flavian types[18] — like those used in the Flavian *thermae*. But the feature may also have been built at a later date. Either way, it seems likely that the bath was an outdoor structure on the courtyard with a hanging roof attached to the main roof but otherwise open.[19]

However, as fieldwork progresses towards the south at Sector 12, the recent discovery of a small internal bath occupying the southern wing of the principal edifice is just as important for understanding the drainage scheme here. This feature, unearthed since 2018, was oriented along an East-West axis with at least two rooms equipped with a hypocaust heating system. All rooms apparently had a floor made of hydraulic mortar. Even a bath as modest as this still generated lots of sewage water, but so far, the points where the drainage system attached to the bath have not been detected. However, it seems likely that one of the aforementioned canals running straight towards the north is a likely candidate, or even both. This leads to chronological ramifications: the covered channel was interrupted by the courtyard basin in Trajanic times or later. This would suggest that the roofed bathhouse was a feature of the building (*praetorium*?) in Flavian times.

[13] The mortar from this and several other masonry conduits has been sampled and will be published soon (Lemke, Daszkiewicz forthcoming). The analysis is possible thanks to a microgrant within the Excellence Initiative programme of the University of Warsaw (PSP 501-D356-20-0004316).

[14] Lemke 2018b; Kowal 2009; Tomas 2017.

[15] Lemke 2018a.

[16] Lemke 2014, p. 193.

[17] On the Flavian *thermae*, see Lemke 2011; Dyczek 2009. On the second-century *thermae*, see Biernacki *et alii* 2016.

[18] Duch 2012; 2019.

[19] Lemke 2015–2016a, p. 329.

After the addition of the courtyard basin, the water needed to be disposed of another way, perhaps using the open canal in the western part of the sector. Alternatively, the bathhouse could have been another exclusively "Flavian *thermae*" at Novae, albeit far smaller than the big one at Sector 4, in which case it fell out of use in Trajanic times, the space was arranged in a different manner and the legate could take a bath in fresh air on his courtyard or alternatively join his soldiers in the large bathhouse just across the *principia*.

## The lead pipes

Not far to the northeast from this private bath and quite close to the main canal of the first phase at Sector 12, a particular discovery was made in 2016: the remains of a lead pipeline in the form of two *fistulae* still linked together with a mortar sleeve/ferrule [Fig. 3]. The piping was aligned towards the north-west but not in its original position. The total length is 242 cm, making it one of the longer stretches of lead piping discovered at Novae. The single pipes measure 129 and 113 cm respectively, their walls are 4 mm thick and shaped to form a circumference of 14 cm and inner diameter of *ca.* 3 cm. The mortar sleeve/ferrule is 3 cm thick, its original length must have been around 12 cm. The lead sheets had been bent, and then hot-pressed from the top and from the side, with some flat tool [Fig. 4].

The pipes likely belonged to a conduit from the late first or early second century AD and were discarded not too long afterwards, given the stratigraphic position of the pit they were deposited in and the fact they were not used as scrap metal. Most of the few *fistulae* found in Novae that could be connected to any structure at all were delivering water to a bath, so it appears likely these two pipes were part of the conduit that once provided water to the aforementioned small *thermae* some 40 m to the south.


Fig. 3. The lead fistulae upon discovery (photo by M. Lemke)

Fig. 4. Close-up of the fistulae: section, folding seam and the ferrule/sleeve (photo by P. Dyczek)

A sample from the pipes found in 2016 was examined in a laboratory, including the external surface and the internal sediment. The analysis showed that the pipe was made of high percentage lead (93.44%), with the surface slightly contaminated with silicon (2.14%), phosphorus (1.36%), clay (0.78%) and iron (0.50%), all of which probably originated from the object's deposit in the ground. Therefore, it should be assumed that the original *plumbum* share oscillated above 98%. On the other hand, the internal sediment showed, apart from the presence of lead (64.02%), significant amounts of silicon (19.63%), clay (5.85%), iron (4.54%) and phosphorus (3.89%), all elements that were probably in the flowing water and gradually deposited on the pipe,[20] an incrustation effect commonly known as sinter.[21] The analysis is generally in line with the results of previous investigations conducted on lead pipes from Novae,[22] such as a piece of piping from the *scamnum tribunorum*, dated by context to the turn of the first/second century. Apart from the contamination, a low silver and sulphur, but high copper content is characteristic. The lead used for a pipe in the *piscina* of the *frigidarium* of the Flavian baths has exactly the same characteristics.[23]

These and the other few sections of lead pipes discovered earlier in Novae are generally short. The longest ones, excavated from debris layers in *principia*, measured between 64 and 130 cm. Two sections, with a total length of 198 cm, have identical parameters: a width of 4.6–4.9 cm and a thickness of 0.8 cm. Another piece, over 70 cm long, has a larger width of 11.4 cm but in turn a wall thickness of only 0.6 cm. Another example with the same wall thickness was slightly higher: 6.4 cm. The relative thickness of the walls is a clear hint that water must have flowed under some pressure,[24] a necessity at least for the baths with their considerable requirements.

[20] The analysis was performed by Marcin Biborski, head of the Laboratory of Archaeometallurgy and Monument Conservation in Cracow. I express my gratitude to Piotr Dyczek for the possibility to publish these results here.

[21] Sinter has been found to be a valuable source of information on the relative chronology of Roman aqueducts: Schulz 1986; Sürmelihindi *et alii* 2013. Cf. Hodge 2002, pp. 227–232.

[22] Biernacka-Lubańska 1998; Dyczek 2002.

[23] Dyczek 2002, p. 274.

[24] Recław 2005, p. 44.

A pipe found near the *sacellum* of the military hospital (Sector 4), preserved to a length of 24.6 cm, had a smaller width, 3.3 cm while being also 0.6 cm thick. The parameters of pipes uncovered in the second-century baths (Sector 10) were comparable: a width from 6.5 to 7.0 cm and their walls 0.5 cm thick. However, based on the more differentiated length of the preserved sections, ranging from 20 to 107 cm, it has been suggested that they were part of the internal water system of the *thermae* and not the aqueduct that provided the water in the first place.[25] Thus by comparison the recently discovered *fistulae* fit in well, albeit being on the thin side with 0.4 cm.

## Lead in Roman aqueducts

Lead, really a by-product of the ancient silver smelting process, was produced in the Roman Empire with an estimated peak production of 80,000 metric tons per year — a truly industrial scale.[26] The metal was used in many ways, but particularly for urban plumbing. Lead was so popular in water supply for the relative ease it could be worked with and its durability, and even though the Romans had at least some idea of its poisonous effect,[27] no other material came close in terms of resisting water pressure.[28] The method of manufacturing lead pipes is recorded by Vitruvius and Frontinus. The lead was poured into sheets of a uniform length, which were bent to form a cylinder and soldered at the seam. The lead pipes could range in size from approximately 1.3 cm up to 57 cm diameter depending on the required rate of flow. The production process of lead was described in detail by M. Biernacka-Lubańska,[29] while T. Hodge pointed out that the difficult part was not so much producing a single *fistula*, but in connecting them to form a conduit, without the convenience of a mobile blowtorch.[30]

## Lead in Novae

Knowing where lead found at a given site came from is interesting, since the transport of this material in large quantities could be "ruinously expensive".[31] Dyczek suggests that in the first period of occupation, lead was brought in to Novae from a single source not far from the fortress.[32] Even though this may have been the preferable solution, it appears questionable that at a time, when due to the limitations of the local economy a large part of supplies and resources had to be imported from far away,[33] this cumbersome commodity could be harvested and pre-processed in the vicinity. It would also contrast with the data we have on the provenance of lead in Late Antiquity, when in spite of the advanced development, lead would still be imported from outside the province. At least some significant part of the lead in Novae was brought in from the mines of *metalla Triconensia* in Moesia Superior / Moesia Prima (Kosmaj in modern Serbia), as we know from the find of a lead ingot, a semi-product pending further processing.[34] This *massa plumbea*

[25] Recław 2005, p. 44.
[26] Hodge 2002, p. 156.
[27] Vitruvius recommended the use of ceramic pipes because these delivered more wholesome water than lead pipes (*De arch.* 8.6.10–11). His general recommendation was repeated by other ancient authors. Cf. Paprocki 2012.
[28] An interesting side note regarding water pressure is the consideration that the enormous Roman aqueduct bridges, as glorious as they may appear today, were built as the cheaper option as opposed to building a syphon across the slopes and bottom of a valley, since the amount of lead required to withstand the amassed water pressure and the relevant sum of money would have been exorbitant: Hodge 2002, pp. 147–157.
[29] Biernacka-Lubańska 1998.
[30] Hodge 2002.
[31] Hodge 2002, p. 156.
[32] Dyczek 2002, p. 279.
[33] Lemke 2016, p. 19.
[34] Dušanić 1989–1990; Kolendo 1986; 1994; Recław 2005, p. 42; Dyczek 2002, p. 271.

was dated on the basis of its inscriptions to the years 364–395.[35] A sample from this ingot was analyzed and compared to 88 other lead pieces of various function from Novae.[36] It turned out that all objects from the time when Novae was supplied from Upper Moesia display a homogenous profile with a predominance of copper, similar standards of silver, bismuth, sulfur and antimony.[37] Based on the data it was also suggested that in the first and early second century, the lead brought to Novae all came from a single unidentified *plumbaria*, and that the source for lead changed over the course of the second century.[38]

In spite of the general scarcity of lead piping found in Novae, there is one object that has served to highlight the capabilities of Roman hydraulic engineering overall, even though it is not preserved and the remaining description of it has to be considered semi-legendary. The object in question is the spectacular lead tank (*caput aquae*) allegedly once located at the beginning of the aqueduct supplying Novae with water from the area of modern day Svištov.[39] The "particularly striking"[40] device was notable for being shaped in an upright fashion and extremely large (7 × 1.2 × 1.2 m) for a lead tank. Unfortunately, the object was disassembled in 1915 and there is no possibility to verify the anecdotal details provided by S. Stefanov[41] that entered scientific canon since.

## Conclusion

The two fistulae from Sector 12 bring nothing fundamentally new to the discussion, although they do underline the connection between the special hydraulic requirements of Roman baths and the use of lead piping. But even with this small case study, I am very confident that in the greater scheme of things one should take for granted lots of lead piping in Novae during the operation period of the legionary fort,[42] if not on a Pompeiian scale then at least in significant amounts across the main clients of the plumbing grid: the baths for the soldiers and all smaller, private baths, mostly in the houses of high officers. As so often, in future fieldwork lies the hope of finding a larger intact portion of plumbing with more *plumbum*.

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[35] Kolendo 1994, p. 91.
[36] Dyczek 2002, p. 271.
[37] Dyczek 2002, p. 273.
[38] Dyczek 2002, pp. 274–275. Cf. Recław 2005, pp. 42–43.
[39] Biernacka-Lubańska 1997, pp. 19–22; Tsarov 2012, pp. 203–205.
[40] Hodge 2002, p. 301.
[41] Stefanov 1930–1931, pp. 270–271.
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