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BREAD FOR ALL

DOUBLE-CHAMBERED BAKING OVENS IN CASTLES

OF THE MILITARY ORDERS

JEAN MESQUI, MAXIME GOEPP, LISA YEHUDA*

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Feeding the inhabitants of the large castles of the military orders in the Near East is still an open question, since not many of them have been thoroughly excavated, or if so, they still await further research and publication. Within an array of complex structures comprising those castles, a particular type of installation is the focus of this article: double-chambered baking ovens. Their function and operation has never been exhaustively researched, and they are only briefly mentioned in a small number of publications. 1 This paper thus aims at presenting an in-depth introduction of four ovens found at Crac des Chevalier (Syria), Le Chastellet, Belvoir and Apollonia-Arsur (Israel). It includes the results of surveys in the form of detailed drawings and descriptions, and beyond that, it strives to offer interpretations concerning the functions of the various parts of the ovens and their operation during the complex process of baking.

LE CRAC DES CHEVALIERS (QAL'AT AL-HOŞN, SYRIA)

The double chambered oven at Le Crac des Chevaliers, discovered in 1928 by Paul Deschamps and François Anus while removing the rubbish that had accumulated during the Ottoman occupation in the long-vaulted halls of the castle, is certainly the most extensively published among these large ovens. First published by Deschamps, 2 it was investigated again by Biller 3 and shortly after by Meyer 4 in the 2000s.

The oven (Fig. 1-3) is rectangular, measuring c.7m in width and up to 7.6m in length. Since the ashlar of the southern façade have been removed, it is difficult to establish its precise dimensions without excavation. Its height might have been c.4m from the

floor of the lower chamber, and 3.4m from the floor of the room serving the upper chamber. Traces of the upper course of stones are still visible at the base of the window in the hall's western wall face. The entire installation was built of limestone ashlar, secondary to the walls and the vaults.

The northern façade of the oven is particularly well preserved. Built transversally to the hall, it was placed between a northern

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1 - For a general overview, see Adrian J. Boas, *Archaeology of the Military Orders* (New York, 2006), 162-163, 197-199 and Adrian J. Boas, *Domestic Setting* (Leiden, 2010), 130. Other references below, with the descriptions of the installations and the further discussion.

2 - Paul Deschamps, *Les Châteaux des Croisés en Terre Sainte. Le Crac des Chevaliers* (Paris, 1934), 269-274.

3 - Thomas Biller, M. Letitia Boscardin, Daniel Burger, G. Ulrich Grossmann, Hans Heinrich Haffner, *Der Crac des Chevaliers* (Regensburg, 2006), 344-346.

4 - John Zimmer, Werner Meyer, Letizia Boscardin, *Krak des Chevaliers in Syrien* (Braubach, 2011), 73-77, 323 (also in French *Krak des Chevaliers en Syrie*, 2013, with the same pagination).

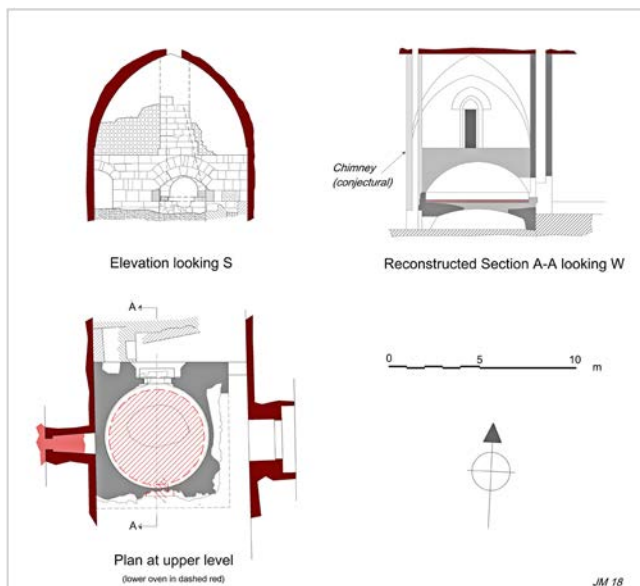


Fig. 1. Le Crac des Chevaliers (Qal'at al-Hosn, Syria). Plan, elevation and section (dr. JM 2018 from a photogrammetry based on photos Iconem 2017).



Fig. 2 (to the left). *Le Crac des Chevaliers* (Qal'at al-Hosn, Syria). View of the southern side of the oven (Yves Ubelmann 2017).

Fig. 3 (to the right). *Le Crac des Chevaliers* (Qal'at al-Hosn, Syria). Photogrammetric view from the north ; one can see at the bottom the hole to the lower oven (dr. JM 2018 from a photogrammetry based on photos Iconem 2017).

room, from which the upper chamber was accessible and a southern room, from which the lower chamber could be reached. A door in the northern façade gave access to a corridor which linked both rooms and was itself accessible through the main eastern door. The lower part of the façade was built in ashlars as far as the height of the oven; above it, only the chimney was dressed in ashlars, and the two sides were executed in field stones.

The oven comprised two superposed chambers. The lower chamber was entirely built of bricks and is fairly well preserved, except for a big hole through the centre of its vault and severe damage done to its south face by the removal of the ashlars. The chamber was circular, with a diameter of 4.9m; the vault has a quasi-elliptical profile. The opening, which was below the level of the general floor of the halls, was roughly 0.9m wide, and 0.7m high. It was preceded by an ashlar built arch, c. 1.4m wide and 1m high. In its present state, this opening does not show any remains of a chimney over it; however, in his section drawing, François Anus presents an opening in the vault which is now blocked, but can still be distinguished.⁵

The upper chamber is circular and centered above the lower one. Its diameter is 5.5m. The floor, up to 15cm thick, was built with a mix of mortar and stone fragments. Above it was a course of vertical basalt slabs, 37cm high, forming the perimeter of the chamber. Unfortunately, its vault has been almost entirely robbed. Only one or two courses of flat brick tiles constituting the springer of the vault are preserved in some places. The height can be estimated to c.2m at maximum.⁶

The opening of the upper chamber shows a complex construction. It features an outer opening comprising a large segmental arch (2.35m) with chamfered angles. Its vault is pierced by the chimney that allows the smoke to escape during the firing period. The inner opening of the chamber shows dimensions of 1.45m width and c.1m height. It possesses a basaltic threshold, slightly protruding to the north. In a phase when the furnace was no longer used, the segmental arch was transformed into a fireplace; stones were placed vertically to block the inner opening of the furnace, and a lintel (now disappeared) was added in front of the arch.⁷

The sounding made by Meyer and his team in the 2000s has made it possible to recognise table like structures to the northwest, abutting the oven and the western wall of the hall; nevertheless, their poor state of preservation makes an interpretation difficult.

So far, there has been a number of proposed interpretations of this double-chambered oven. According to Deschamps and Anus, the upper chamber was used as a domed baking oven.⁹ Concerning the lower chamber, they suggested that it was used as chamber where the raw bread loaves were put to ferment and rise. They argued that no fire was lit in this lower chamber, instead it was heated entirely by the fire in the upper chamber.¹⁰

5 - Deschamps, *Les Châteaux des Croisés*, 270, Fig. 57.

6 - Meyer, *Krak des Chevaliers in Syrien*, 74, proposes a height of at least 2.5 m. However, such a dimension would have meant that the oven would have blocked the western window, which is contradictory with the archaeological evidence.

7 - Meyer, *Krak des Chevaliers in Syrien*, 73-77, suggests that the vertical slabs still visible, forming the first course of the back wall of the new fireplace, were part of a stair allowing servants to enter the upper furnace; this interpretation is not founded on any evidence, and only justified by the belief that the upper chamber was a meat smoking chamber.

8 - Meyer, *Krak des Chevaliers in Syrien*, 74 Fig. 3.46, 76 Fig. 3.49.

9 - Deschamps, *Les Châteaux des Croisés*, 270, 272-273.

10 - *Ibidem*.

Alternatively, according to Biller and his team, the lower chamber was the furnace, the upper one being the baking chamber, but they gave no precise interpretation for the *raison d'être* of the big chimney of the baking chamber.¹¹ Boas identified the installation as a baking installation, but offers no interpretation for its double chambers.¹² Finally, Meyer and his team interpret the lower chamber as a domed baking oven. Since they exclude the existence of a chimney, they consider that there was not a lot of smoke produced during the firing. The upper chamber would have been a chamber to smoke meat, particularly pork meat, thus the chimney would have been justified by the smokes produced during the smoking process.¹³ All these authors consider the oven as secondary, i.e. posterior to the construction of the envelope and of the halls (1170 onwards).

11 - Biller, *Der Crac des Chevaliers*, 346.

12 - Boas, *Archaeology*, 162.

13 - Meyer, *Krak des Chevaliers in Syrien*, 75.

14 - See Boas, *Archaeology of the Military Orders*, 258-259, with bibliography.

15 - Excavations took place during the 1990s and early 2000's under the auspices of the Hebrew University of Jerusalem under the leadership of Prof. Ronnie Ellenblum.

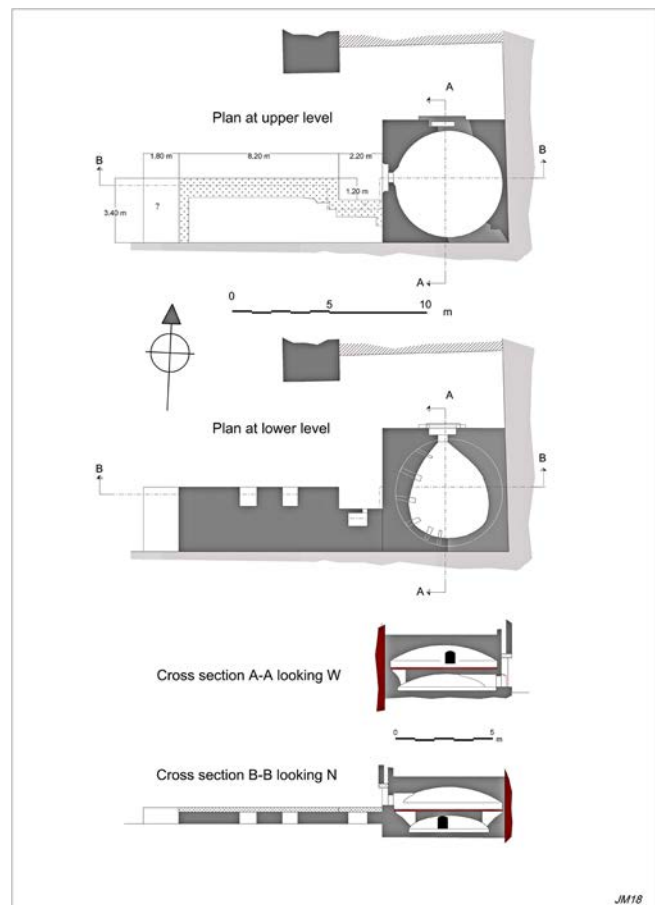
LE CHASTELLET DU GUÉ DE JACOB (*VADUM JACOB*/ATERET/BAYT AL-AHZAN, ISRAEL)

The never-finished fortress of Le Chastellet du Gué de Jacob (at Jacob's Ford), nowadays better known as Vadum Jacob, is certainly an unicum. It is a "mummified" site with an unfinished building, whose construction started in October 1178. Already in August 1179, three days after being taken by Saladin, it was deserted. Its southeastern wing yields the remains of an oven which Boas considers in his book as "almost identical to the oven at Crac des Chevaliers."¹⁴ This oven and the structures that adjoin it (Fig.2, see also Fig.8) have not yet been published.¹⁵

The structure of the oven with its two chambers is still recognisable but in a worrying state of disrepair (fig. 4-7). In its present state, without further excavations, the photogrammetry nevertheless allows to identify the structures dimensions. It is a square building of 6.3m side length, abutting the walls of the southeast corner of the fortress. It is preserved to a height of 2.9m from the ground (floor level of the lower chamber), and probably was only one or two courses higher at maximum. It is built of big limestone ashlar, most of them with bosses and marginal drafting. The lower chamber was pear-shaped in plan, measuring 4.9 m north-south and 4m east-west. This chamber was accessible from the northern side of the installation. The preserved springer on the western side of the aperture shows that it was rectangular or slightly arched (0.5 m width, c. 0.6m height) and discharged by a segmental arch. The chamber comprises a first course of vertical slabs (c. 40cm height) forming the perimeter. Above it was the vault itself, c.0.9m high and built in limestone. It is not entirely clear if the lower chamber possessed a chimney; nevertheless, its opening is built in a small recess and at a height of 1.80m, two basalt stones protrude one on each side of the recess, suggesting that there was probably a corbeled smoke hood rising above it.

The upper chamber of the oven is heavily destroyed however, some parts of the circumference of a circular chamber still remain. Its diameter was probably c. 5.5m. Here, like at Le Crac des Chevaliers, the floor of the oven was made of a mix of mortar and small stones. The design of this chamber was very much like the lower one: the vault was executed in stone, and segmental in form. One can estimate its height at 1.2m. The chamber was accessible through a rectangular or slightly arched and 0.5m wide opening, in a 30cm deep recess with chamfered edges located on the western side of the installation. One might imagine that above this recess there was a corbelled smoke

Fig. 4 - Le Chastellet - Vadum Jacob (Israel). Reconstructed plan and sections (JM 2018).



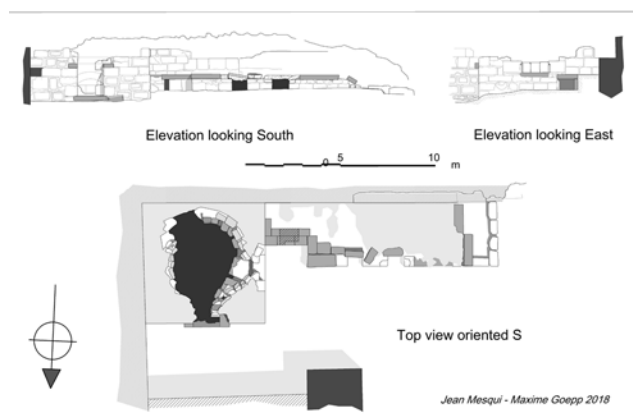


Fig. 5. *Le Chastellet - Vadum Jacob (Israel). Plan and sections in the present state of the ruins (dr JM 2018 from a photogrammetry based on photos MG 2018)*

Fig. 6. *Le Chastellet - Vadum Jacob (Israel). Internal view of the lower oven's vault, with four vertical slots (Maxime Goepp 2018).*



hood leading to the flue. The opening showed a threshold made of a basalt stone. The opening of the upper chamber was at a height of 0.95m above the western floor level, which was in turn 0.45m higher than the floor level of the northern side in front of the threshold of the lower chamber.

A very peculiar feature appears in the vault of the lower chamber. It features six vertical slots, 10 to 20cm wide, arranged radially along the periphery of the lower vault (Fig. 6). They rise from a height of 10cm above the lowermost circumference of the vault and widen towards the top where they reach and pierce the bottom of the upper chamber. Unfortunately, their inner profile is not known, but one can reconstruct them as shown in Fig. 4 (Cross sections). These slots were covered at their tops by flat thin stones (or tiles) in order to hinder a direct connection between the lower and the upper chamber.

Along the southern wall of the “bakery”, abutting the oven on its western side, is a long range of so-called “benches”, at least 10.40m long, 3.40m wide and 0.83 m high. This raised flat area of 32m² is bordered by long basaltic slabs. On its eastern part, beneath the opening of the upper chamber of the oven, there is a recess of 2.2x1.2m. Under these “benches”, three small niches open into the masonry. One of them is in the northern face of the recess, with an opening only 25cm wide, giving access to a chamber 1m long and 0.70m wide. The two other are simple boxes of 0.5m depth, and 0.8 to 0.9m width.

Boas has interpreted the double-chambered installation as a baking oven, but he does not give an explanation about the double chamber. Ellenblum and his scientific team consider this installation to be a cooking oven and dub the area around it “the kitchen”.¹⁶ Archaeologists have yet to offer a scientific interpretation for the benches alongside the installation. Biller considered the niches as “Herde”, i.e. stoves,¹⁷ but the dimensions of the niches compared to the width of the basaltic borders make such an interpretation unsustainable.

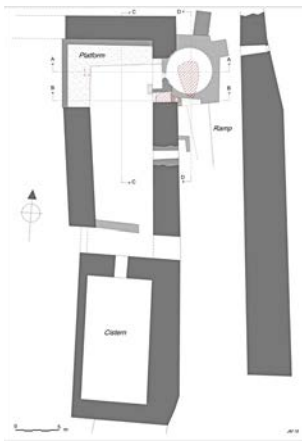
16 - Yael Segal, Shmuel Marco, Ronnie Ellenblum, “Intensity and direction of the geomagnetic field on 24 August 1179 measured at Vadum Jacob (Ateret) Crusader fortress, northern Israel”, *Israel Journal of Earth Sciences*, 52 (2004), 203-208.

17 - Thomas Biller, *Templerburgen* (Darmstadt, 2014), p.97.

Fig. 7. *Le Chastellet - Vadum Jacob (Israel). View of the possible bakery's complex from the North (Maxime Goepp 2018)*



BELVOIR (COQUET/KOKHAV HA-YARDEN/KAWKAB AL-HAWĀ, ISRAEL)



Meir Ben Dov originally excavated the fortress of Belvoir in the 1960s,¹⁸ and now a French-Israeli archaeological team are investigating it anew. In the meantime, looking for samples of big ovens, we have photogrammetrically surveyed an area located in the northeast corner of the fortress, comprising a trapezoidal room and an oven external to it (Figs. 8-12).¹⁹

At the northeastern internal corner of the external range of vaulted “endless halls”, two structures have been constructed: one of them, to the south, is a big cistern; the other one further north is a trapezoid room measuring roughly 19m in length and 6.5m in width (internal measurements). The western wall of the room was built at the same time as the walls of the external range of vaults. In

this period of primary building, a large, 7.4m wide arch was reserved in the western wall, facing a smaller arched opening 4.75m wide in the western wall of the “endless halls”. The vaulted room was open to the south, where it faced the opening of the cistern.

Outside of the trapezoidal room to the northeast, yet still inside the eastern vaulted range, a big oven was built (c.7.8 x 6.4m). It comprised a pear-shaped furnace whose floor was approximately 0.70m below the floor of the trapezoidal room; the dimensions of this chamber can be determined by the inferior courses of brick tiles that have been preserved (3.7m in length for 2.3m in maximum width). The opening of the chamber is on the south side. Its eastern jamb is preserved and enables us to determine the width of the opening (c. 0.70m). This opening was built in a trapezoidal recess accessible via a ramp from the south.

18 - Meir Ben-Dov, “The Excavations at the Crusader Fortress of Kokhav-Hayarden (Belvoir)”, *Qadmoniot: A Journal for the Antiquities of Eretz-Israel and Bible Lands*, 1(5) (1969), 22-27 (Hebrew).

19 - Surveying has been done by Maxime Goepp in January 2018, after the 2017 excavation campaign.

Fig. 8 (to the left) - Belvoir (Kochav HaYarden, Israel). Reconstructed plan of the bakery (supposed) and of the cistern (dr. JM 2018).

Fig. 9 (below, to the left) - Belvoir (Kochav HaYarden, Israel). Plan of the bakery (supposed) and of the cistern (dr. JM 2018).

Fig. 10 - (below, to the right) - Belvoir (Kochav HaYarden, Israel). Reconstructed sections of the bakery (supposed) (dr. JM 2018).

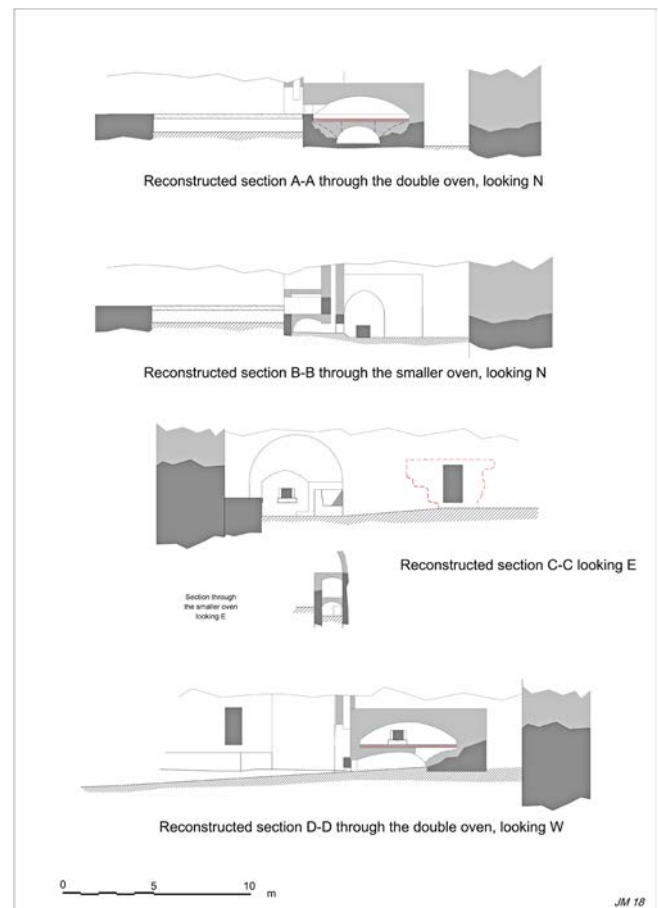
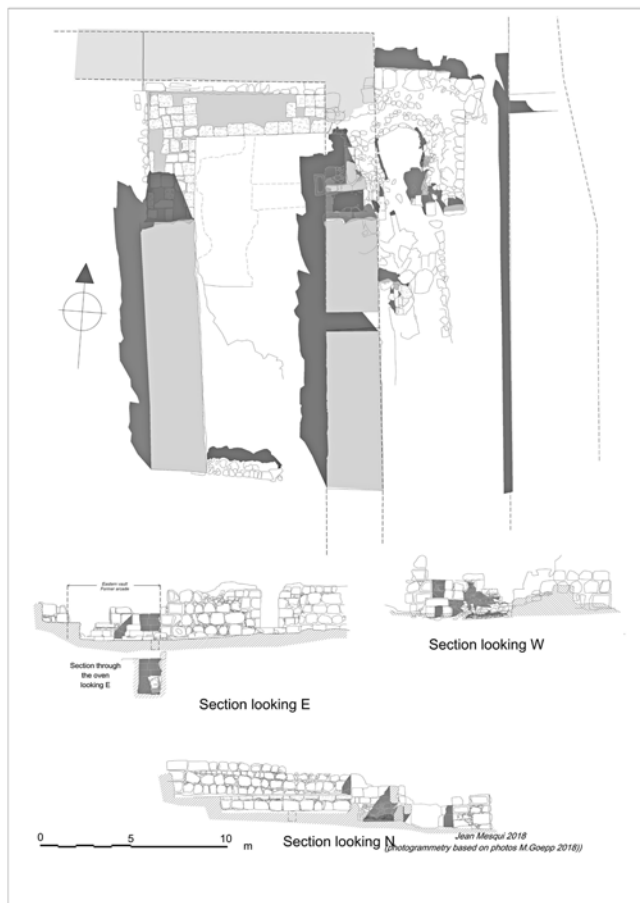




Fig. 11 (to the left) - Belvoir (Kochav HaYarden, Israel). View of the oven from the east. To the left, external opening of the small furnace; in front, the remains of the lower chamber of the oven; in an ellipse, the internal opening of the upper chamber. Behind, the tables to store the loaves (Maxime Goepp 2018)

Fig. 12 - Belvoir (Kochav HaYarden, Israel). View of the bakery (supposed) from the south. At the rear, the benches (Maxime Goepp 2018)

20 - Ben Dov, "The Excavations...", 25-26. Benjamin Z. Kedar, *Frankish Bathhouses in Communicating the Middle Ages. Essays in Honor of Sophia Menache* eds. I. Shagrir, B.Z. Kedar and M. Balard (New York 2018), 123 with notes 36 and 37.

21 - Balázs Major, "Bathing in the Medieval Latin East. A recently Discovered 13th Century Bath-house in al-Marqab Citadel (Syria)", *Hungarian Archaeology*. E-journal, 2013 (Winter), 1-6. (<http://www.hungarianarchaeology.hu>). Gergely Buzás, Balázs Major, "Crusader and Mamluk Hammām-s in al-Marqab", Marie-Françoise Boussac, Sylvie Denon, Thibaud Fournet et Bérangère Redon, ed., *25 siècles de bain collectif en Orient. Proche-Orient, Égypte et péninsule Arabique*, (Le Caire, 2014), II, 553-572 [Institut français d'archéologie orientale, Études urbaines 9, 2014].

22 - Meir Ben Dov, "Belvoir. Crusader's Fortress near Beit She'an", *Sal'it. Bulletin of the Society for the Protection of Nature and the Nature Reserves Authority in Israel*, 1, 4, 163-167, here 167 [our gratitude to Tzvi Shacham for referring us to this article]. Thomas Biller, "Die Johannerburg Belvoir am Jordan. Zum frühen Burgenbau der Ritterorden im Heiligen Land", *Architectura*, 19/2 (1989), 105-136, here 115.

The western face of the oven blocked the former arched opening to the northeast of the trapezoidal room. One can recognize here the southern jamb of a rectangular opening, whose threshold, placed at a height of 0.93m is a basaltic stone slightly protruding. Looking at this threshold from the side of the oven on the east, one can easily recognize the section of an ancient floor just below it. This very evidence points to the existence of the upper chamber of a double-chambered oven. Unfortunately, we can only estimate its dimensions, and propose that it was similar to the one of Le Chastellet with a diameter of c.5m. That would fit with the external dimensions of the oven. The only restriction that could be made is the fact that this circular oven would have cut the northern reveal of the pre-existing opening (Fig. 9). However, no trace of this angle remains. It has to be noted that in his article (1969, Meir Ben Dov indicated that "at the circumference of the oven were pipes made of clay to disperse the hot steam"; they are no longer to be seen, but could remind of the flues present at the circumference of Vadum Jacob's oven.

A broad stone bench or shelf is set around the northern and northwestern parts of the room. Its surface is made of rectangular lime stone slabs, bordered at the sides by large slabs of basalt and built against the southern wall of the northern range of "endless halls. One niche (0.6m wide, 0.9m deep) was found under the benches. Those "benches" are strikingly similar to those found at Le Chastellet, and their surface area, which measures 31.5m², matches that of Le Chastellet at 32m²; the heights are also similar (0.8m at Le Chastellet, 0.9 m at Belvoir).

To the south of the upper furnace opening, a small two-level oven was integrated into the blocking of the arched opening. A well-preserved opening to the firing chamber forming the lower level can be observed close to the opening of the big oven's furnace (Fig.9), while of the furnace itself, only the first courses of flat brick tiles are still intact. They determine an irregular half-elliptical plan (2 x 1.1 m), since to the south the oven abuts the side of the arch. Probably since the destruction of the fortress, its opening has been blocked by a large stone after the removal of the vault. Behind its lintel was a vertical flue. This firing chamber was evidently intended to heat a segmental vaulted upper chamber, which was accessible from the trapezoidal room itself (Fig. 10).

Finally, it has to be noted that a passage led through the eastern wall of the western vaulted range, secondary to the building of it, as it is shown by the insertion in the masonry. It allowed a direct passage from the vaulted range to the trapezoidal room. But it seems that this corridor was also constructed to lead from the room to a small rectangular space built against the wall.

The initial interpretation proposed by Ben Dov for this installation was to see them as part of a bath house.²⁰ Yet, no indicative installations such as pipes, water basins and conducts, as can be seen for example in the bathhouse at Margat/al-Marqab castle (Syria),²¹ were found at Belvoir, and the "benches" are not sufficient proof for a bathhouse. Ben Dov himself changed his views in 1972, expressing that the furnace was intended for industrial house and not for a bath; Biller, in his article about Belvoir, proposed to see ta forge for blacksmiths, but there is no direct evidence archaeological evidence²².

ARSUR (APOLLONIA-ARSUF, ISRAEL)

The castle of Arsur was thoroughly excavated during the 1990s.²³ Next to one of the most complete kitchens of middle eastern castles, two structures which apparently served as ovens were found (Fig.13-16). The first one, externally pentagonal, is a circular furnace measuring 3.50m in diameter and 1.30m high, located immediately east of the kitchen. It was built against the northeast corner of the courtyard of the castle. Its opening is located at present day ground level, probably slightly higher than what it was during medieval times (0.40 to 0.50m judging from the stairs leading to the kitchen). Its location, blocking more than half of the large arch giving access to the northern range of vaults, shows clearly that it was built in a secondary phase to these vaults.

Separated from this first oven by the internal wall of the vaulted circuit is a trapezoid structure (5.6 x 5.9m in maximal dimensions), occupying the full width of the eastern vaulted range, close to the northeastern tower's apse. The proportion of bricks and brick tiles preserved in the current structure show without any doubt that the structure was used as oven. A careful examination allows one to make a cautious reconstruction of its structure.

A circular range of slightly protruding slabs encircles a paved floor (internal diameter 3.5m) whose centre is occupied by an antique column shaft pierced by a circular hole at its centre. To the south, the circle of slabs opens to reach an opening inserted into the southern wall (Fig.14, 16).²⁴ The opening still possesses its eastern jamb, as well as the first voussoir of a segmental arch which hid a vertical chimney placed over the opening.

Above the floor was a vault built probably with limestone voussoirs, which are almost fully removed; but it is clear that the circular range of protruding slabs was the first layer of the vault.

These remains provide clear evidence of a circular chamber whose southern opening had a chimney installed between its two faces. This chamber was served by the room situated

23 - Excellent summary of the results in Israel Roll, Benjamin Arubas, "Le château d'Arzur : forteresse côtière pentagonale du type concentrique du milieu du XIII^e siècle », *Bulletin monumental*, 164-1 (2006), 67-81. Israel Roll, Hagi Yohanan, Yotam Tepper, Tamar Harpak, "Apollonia-Arsur during the Crusader Period in the Light of New Discoveries", *Qadmoniot*, 33/119 (2000), 18-31 (in Hebrew). See also Oren Tal, Israel Roll, Lisa Yehuda, Judith Bronstein, Irit Ziffer, *The Last Supper at Apollonia* (Tel Aviv, 2011).

24 - Only the southwestern part of this floor is visible at present time, but an old picture taken during the excavations shows it at full exposure (fig. 13).).

Fig. 13 - Apollonia-Arsuf, (Israel). Partially reconstructed plans and sections (dr. JM 2018 based on the photogrammetric modelisation).

Fig. 14 - Apollonia-Arsuf, (Israel). The former tow-chambered oven, from the top, in the 2000s (picture taken from Lisa Yehuda, "Cooking and Food in the Latin Kingdom of Jerusalem", *The Last Supper at Apollonia*, 80, Fig. 2).

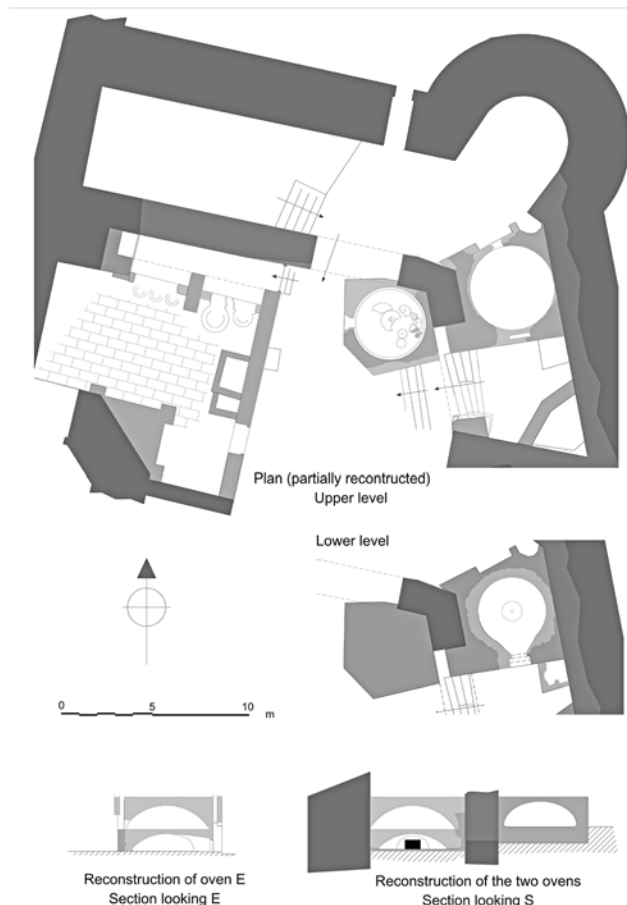




Fig. 15 - Apollonia-Arsuf. View of the kitchen, and of the baking ovens on the right in the back (Jean Mesqui 2012).

to the south, accessible by a large stair descending from the courtyard (Fig.7).

Further examination reveals the presence of two limestone voussoirs located west of the opening, at a height of 1.2 m, which form the first layer of voussoirs or springers of a second vault. One can recognise on the east side, at the same height, remnants of other limestone elements. Moreover, on one part of the perimeter one can discern a layer of flat brick tiles describing a circle of c. 4.40 m diameter, which was supposed to support the limestone springers.

Thus, it is clear that a second chamber, wider in dimensions, was located above the first one. This upper chamber was accessible from the northern room adjoining the northeastern tower. Interestingly in the northern room, the structure's northern wall possesses a rectangular recess c. 2m wide and 0.4m deep. At a height of 1.1m from the ground, there are faint remains of the eastern jamb of the former opening of the chamber. The recess was thus supposed to facilitate the installation of a chimney over the opening of the oven. Next to it, to the east, another recess, irregular in shape, has been preserved. Its use could have been to host a boiler to heat water.²⁵ One can reconstruct relatively easily the height of the lower furnace, limited by the floor of the upper to c. 0.9m. The height of the upper level can only be extrapolated (c. 1.2 to 1.3 m).

The different publications of the excavations do not refer to this structure as a double-chambered oven. The excavators have suggested, due to the presence of a manger (?) and of the central column shaft, that during a first phase this structure was a grinding mill rotated by a donkey.²⁶ During a second phase, the mill was transformed into an oven.²⁶ This interpretation seems questionable for various reasons. A column shaft with a hole at the center can be found also on the floor of the western oven, which was never

25 - The excavations records have not been investigated, thus it is still unknown to us if the floor of this recess was excavated and revealed any traces of occupation.

26 - Israel Roll, Benjamin Arubas, "Le château d'Arsur...", 78-79. Israel Roll et alii, "Apollonia-Arsuf...", 30.



Fig. 16 - Apollonia-Arsuf. Southern opening of the lower oven (Maxime Goepp 2018).

a mill. In addition, the open circle of protruding slabs and the pavement of the lower furnace belong to a uniform phase, and since the opened circle is evidently part of the furnace, one can certainly assert that the structure served from the beginning as an oven.

We can conclude that the trapezoidal structure of Arsur was a double-chambered oven, like those of the three sites described above.

THE USE OF THE UPPER CHAMBERS

All four examples of double-chambered ovens show that the upper chamber is always circular, with a diameter ranging between 4.5 and 5.5m, and a height between 1.3 and 2m (Le Crac, very conjectural) and accessible by an opening located at breast level at maximum. There is no reason to doubt that these upper chambers were baking ovens, albeit of exceptionally large dimensions in comparison to contemporary ovens in other castles.

There are some details that strengthen the argumentation in favour of the interpretation of this upper chamber as baking chamber. At Le Crac, Le Chastellet, Belvoir and (probably) at Arsur also, the opening of this chamber, or the angles of the recess in which the opening was installed, is executed with chamfered edges, in order to facilitate the use of long peels to load the baking chamber fully without leaving death angles immediately left and right behind the opening. Concerning the comfortable loading of the upper chamber, also the recess in the so-called bench right in front of the opening of the upper chamber of the oven in La Chastellet should be mentioned. Its function could have been simply to enable the person loading and unloading the oven to stand at an appropriate height in relation to the opening of the baking chamber and the benches.

Another example of a large baking oven (single chambered) was found in the castle of "Saranda Kolones" in Cyprus. It is 3.5m in diameter, with a height of approximately 1.45m (Fig.10).²⁷ Here also, the vertical edges of the opening are chamfered to make the loading with a peel easier. The presence of two donkey rotated grain mills close to the oven at Saranda illustrates the concept of *furnum and molendinum* so often cited in the medieval charters.²⁸ Interestingly, two similar grain mills can be identified at Le Crac in the western vault of the so-called Esplanade, close to the entrance of the double chambered oven vault.²⁹

The dimensions of the baking chamber are directly linked to the importance of the garrison, or to the number of people to feed. To get an idea of the magnitude of the rations, the "Encyclopedia of techniques" written during the eighteenth century, gives a good evaluation of the bread rations that could be baked in pre-industrial ovens.³⁰ The largest ovens, used by the armies, were 13x12ft (4.2x3.9m) in size, and able to bake 180 three-pound (c. 1.5 kg) loaves of bread at a time. The normal daily ration for a soldier at this period contained 1.5 pound of bread, 5 ounces of meat (c. 150g) and ½ pint of wine (c. 0.3l); cavalry men got 2 pounds of bread and one pint of wine. That means such a large oven was able to deliver 180 daily bread rations in a single batch. This can be verified simply in a drawing of an oven with 1.5 kg loaves used in the infantry commonly during the eighteenth and nineteenth century, whose size was 27 cm in diameter and 8 cm in height.³¹

Obviously, there is no indication that such rations resembled those served to the knights, sergeants and to the foot soldiers in the medieval period; in addition, they were campaign rations, and there is no indication about what was served during peaceful times when everybody was in the fortress.

17 - John Rosser, "Excavations at Saranda Kolones, Paphos, Cyprus, 1981-1983," *Dumbarton Oaks Papers*, 39 (1985), 81-97. The excavator proposed to see here an oven for baths, but Adrian Boas has reestablished the correct interpretation as baking oven (Boas, *Archaeology of the Military Orders*, 162). The attribution of the castle to the Hospitallers (1191-1204) made by Rosser has been contested by James Petre, "Back to Baffes. 'A Castle in Cyprus attributed to the Hospital?' revisited", in Jochen Schenke, Mike Carr, ed., *The Military Orders. 6.1. Culture and Conflict in the Mediterranean World* (London, 2017), 115-122. See also James Petre, *Crusader Castles of Cyprus/ The Fortifications of Cyprus under the Lusignans. 1191-1489* (Nicosia, 2012), 313-357. The oven was probably built by the Lusignans early in the thirteenth century.

28 - Joshua Prawer, *Crusader Institutions*. (Oxford, 1980), 134; Adrian Boas, 1999. *Crusader Archaeology: The Material Culture of the Latin East*, (London, 1999), 77; Benjamin Z. Kedar, «Frankish bathhouses», 132-3.

29 - Jean Mesqui, Maxime Goepp, *Le Crac des chevaliers. Histoire et architecture* (Paris, 2019), 390-391.

30 - For instance, see M. Dupré d'Aulnay, *Traité général des subsistances militaires...* (Paris, 1744). M.Malouin, *Description et détails des arts du Meunier...* (Paris, 1767), 305-321. Louis-Félix de Keralio, *Encyclopédie méthodique des arts militaires*, I (Paris, 1784), 708-712.

31 - Terry Crowdy, "Napoleon's Infantry Handbook" (Barnsley, 2015), § 192.

Fig. 17 - Saranda Kolones (Cyprus). Panoramic view of the bakery, showing the oven, and at each side, the tables for the loaves (Maxime Goepp 2008)



32 - *Recueil des Historiens des Croisades, Historiens orientaux*, IV, 206-207.

33 - The excavators have proposed to consider the present floor of the single-chambered oven as a secondary floor, built in a phase where the oven was transformed in a storage. Nevertheless, without further evidence, this assumption seems questionable.

34 - M. Malouin, *Description...*, 312; Mieczysław Grabowski, "Backhäuser und Backöfen in Lübeck", in *Küche, Kochen, Ernährung: Archäologie, Bauforschung, Naturwissenschaften*, ed. Ulrich Klein, Michaela Jansen, Matthias Untermann, *Mitteilungen der Deutschen Gesellschaft für Archäologie des Mittelalters und der Neuzeit*, 19, (Paderborn, 2007), 128-136 (online <http://journals.ub.uni-heidelberg.de/index.php/mitt-dgmn/article/viewFile/17697/11510>) [here 134].

35 - In French, these flues were called "éventouses" or commonly "houras".

Nevertheless, let us take the example of Le Chastellet, where the oven was built to provide for the armed garrison as well as the small army of workers – diggers, masons, carpenters and their valets, who were constructing the fortress. The Muslim chronicler Abū Sāma, writing on the basis of Saladin's secretary's Fāḍil letters, indicates that there were 80 knights, with their servants, and 15 officers each commanding 50 men, which would be 925 men.³² All the defenders were killed, and 700 prisoners taken and led to Damascus. Even if these numbers are exaggerated, there were probably more than 500 people in and around the fortress during the eight months it existed.

Considering the above, one can understand why such big ovens were necessary: at least two or three baking batches per day would have been sufficient to provide the bread needed by such high numbers of inhabitants. The case of Arsur, a single-chambered oven and a double-chambered one operating at the same time, shows what considerable amounts of bread were necessary during the four years of Hospitaller occupation.³³

It is important to note, at least for two installations (in the castles of Arsur and Belvoir), the presence of boilers next to the upper furnace opening. They were used for heating the water necessary to knead the dough, as we will see below.

THE USE OF THE LOWER CHAMBERS

Bread baking requires lasting temperatures around 200 to 230 degrees Celsius emitting evenly from the stones and/or bricks of the floor, as well as from the dome of the oven's baking chamber. In order to reach that condition the oven needed to be preheated. For this purpose, wood was stacked in the oven's baking chamber and lit. This fire needed to be constantly fed, and it took around 2 to 3 hours, depending on the fuel material, until the stones and bricks of the chamber's floor and dome were thoroughly heated and evenly re-emitted a temperature suitable for baking bread.³⁴ The main goal of the preheating phase is to obtain an even temperature in all parts of the furnace. The larger the area, the more this condition is difficult to reach. Therefore, one recommendation in the baking theories of the eighteenth century was to insert some form of flues, or

vertical channels in the periphery of the vault, to let oxygen enter the chamber during the firing phase and help it to burn. These openings were blocked afterwards during the baking phase.³⁵ Apparently, this was the solution in the case of the single-chambered oven at Saranda Kolones (fig. 18). Looking at the oven at Le Chastellet and its curious vertical slots or conducts pierced through the vault of the lower chamber, it can be assumed that they were used to transmit the heat of the smaller lower chamber to those peripheral parts of the floor of the upper chamber that did not sit right above the area of the lower one (Fig. 6).

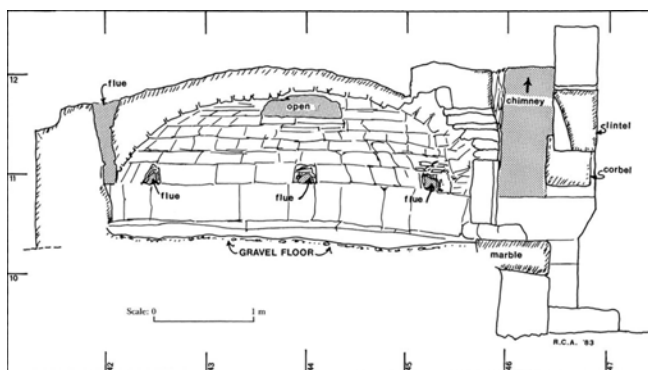


Fig. 18 - Saranda Kolones (Cyprus). Section through the oven (from Rosser, «Excavations...»).

Most likely the function of the lower chamber was to provide a constant heat supply for the upper chamber after the initial heating was completed and the ash was removed. The reason was obviously to allow a fast rotation of baking batches, and to avoid long phases of reheating the upper chamber in between the rounds of baking. Thus, after the first heating of the day which was done in the upper chamber, the ash was removed, while a permanent fire in the lower chamber ensured stable temperatures in the upper chamber.

It can be assumed that the double-chambered ovens at Le Crac and Arsur were improved, as successors of those in Belvoir and Le Chastellet. In the case of Le Chastellet, the lower furnace was significantly smaller than the upper chamber showing a pear-shaped layout. In contrast to that, the lower furnaces of Le Crac and Arsur were only slightly smaller than the upper chamber and circular. This leads us to think that, first, at Belvoir, as at Le Chastellet, there were probably vertical slots to improve the heat



diffusion; later, the ovens at Le Crac and Arsur were improved by enlarging the lower heating chamber. But this second assumption presupposes that progress is linear, which is not always the case. Anyway, we know that the oven at Arsur was certainly built by the Hospitallers after they were granted the castle in 1261.³⁶

A SHORT DESCRIPTION OF BREAD MAKING

Bread could be made from a wide variety of grain: wheat, rye, barely, oat, millet and spelt, and it could be prepared in various ways: cooked, double-cooked, soaked or dried.³⁷ But when it came to bread that was baked, flour from grain that possessed the ability to rise was preferred in Europe. Until approximately 150 years ago, there was no industrial yeast, and the making of fermented bread relied solely on sourdough.³⁸ Unlike working with yeast, making sourdough bread was a lengthy process including different stages of mixing, resting, kneading and ripening, requiring almost a day's work before a loaf could be put into the oven.

During the last millennia, the preparation of a sourdough bread has not changed remarkably and can be described as follows: first, the starter or pre-ferment is mixed with flour and water, creating the leaven or pre-dough. It takes at least four, but usually around eight to twelve hours (depending on the temperature of the environment) until the yeast and lactic acid bacteria in the leaven, responsible for aroma and texture, are fully developed and can be used for preparing the final bread dough. In the second stage wheat or rye flour, water and salt are added to the leaven and are kneaded thoroughly. Then bread loaves are formed and left an additional 2-3 hours for rising. All the above described processes need to be performed in temperatures not dropping below 17 degrees and not reaching above 35 degrees to ensure a proper development of the dough. Additionally, for the same purpose, the water added to the dough needs to be warm.

CAPACITY OF OVENS AND WORKING SURFACE

The time consuming and work intensive nature of the processes of baking is further emphasized when looking at the ovens studied in this paper. The preserved baking chambers of the ovens in Le Crac des Chevaliers and Le Chastellet show a diameter of 5m, while the baking chamber of the oven in Belvoir, which is not preserved, can also be reconstructed as having a diameter of c. 5m. According to that diameter, all ovens had a floor space of almost 20sqm.

Provided with all these details about bread preparing and bread baking, it can be assumed that the only way to operate an oven of such enormous size efficiently was to operate it at full capacity. But what does full capacity mean?

If we assume that a standard bread loaf weighted, as mentioned above, 1.5kg and had a diameter of 27cm,³⁹ then approximately 180 bread loaves could be inserted into the oven during one round of baking.⁴⁰ It is reasonable to assume that in order to increase the efficiency of the baking process several such rounds of baking were done.

Fig. 19 (to the left) - The preparation of the sourdough bread, and the kneading in the 18th c. (from the *Description et détail des arts...*, pl. V)

Fig. 20 (to the right) - The baking and the storage of the bread in the 18th c. (from the *Description et détail des arts...*, pl. VII)

36 - Roll, "Le château d'Arzur", 64.

37 - James Davis, "Baking for the Common Good: a reassessment of the assize of bread in medieval England", *Economic History Review* LVII, 3 (2004): 465-502, here 471; Annette Schäuble, "Ernährungsrekonstruktion zweier mittelalterlicher Bevölkerungen aus Brandenburg anhand der Analyse stabiler Isotope" In *Küche, Kochen, Ernährung...*, 269-286, here 272-273; Rolf Reutter, "Essen und Trinken im Odenwald um 1750", In *Küche, Kochen, Ernährung...*, 291-296, here 293-294; Massimo Montanari, *Medieval Tastes: Food, Cooking, and the Table*, trans. B. Archer Brombert (New York, 2015), 61, 171.

38 - Massimo Montanari, *Medieval Tastes: Food...*, 55-57; James Davis, "Baking for the Common Good...", 473.

39 - Louis-Félix de Kéralio, *Encyclopédie...* In 13th century England the Assisa Panis et Cervisie ensured a stable selling price for a unit loaf of bread. The size of a bread loaf was henceforth subjected to the cost for a quarter of wheat and fluctuated as much in weight as prices for wheat increased or decreased (Davis, J. 2004: Baking for the Common Good..., here 479-481, 495-496). The same can be observed in late Medieval Germany (Mieczyslaw Grabowski, *Backhäuser...*).

40 - It was taken into consideration that the floor space of the oven could not be optimally used due to the hectic of the process of inserting



Fig. 21 - Belvoir. View of the opening to the upper oven (in front), and of the secondary oven (on the right). At the rear, one can recognize the lower ovens bottom (Photogrammetric view 2018).



Fig. 22 - Crac des Chevaliers. View of the table like structures at the opening of the upper oven (Iconem 2017).

Fig. 23 (below, left) - Krak de Moab (al Kerak, Jordania). Plan and section of the double-chambered oven and the adjoining room (dr. JM 2018 from photogrammetry MG)

Fig. 24 (opposite page, at the top) - Bethgibelin - Beit Guvrin (Israel). Plans of the kitchen/bakery complex (dr. JM 2019)

Fig. 25 (opposite page, at the bottom) - Bethgibelin - Beit Guvrin (Israel). Elevations and sections of the double chambered oven in the Hospitaller castle (dr. Jean Mesqui 2019).

the loaves into the baking chamber. Furthermore the space immediately left and right behind the opening of the baking chamber was “dead space”, not reachable with the peel and therefore not loaded with bread.

41 - Louis-Félix de Kéralio, *Encyclopédie...*, recommends for each large oven a trougher 3m long and 1m high.

42 - Roll, “Le château d’Arsur”, 77-78.

43 - We thank Prof. Denys Pringle for having pointed out this fine example; it allowed us to survey (using photogrammetry) the room and the installation. The oven stays in the underground vaults to the north of the fortress: an adjoining room, presented as a kitchen by the local guides, seem to have served as workshop for an unknown industrial function.

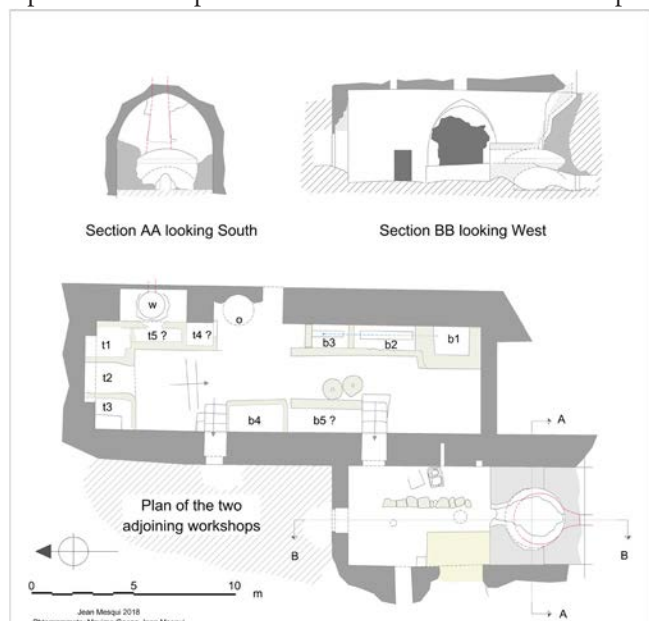
Approximately 130kg of leaven, and consequentially approximately 330kg of dough, are necessary for 180 bread loaves, which could easily be left for fermenting and kneaded in large wooden troughs.⁴¹ Concerning the forming and resting of 180 loaves of raw bread which still needed to rise for several hours, a problem occurred: Large unoccupied surface space in immediate vicinity of the oven was needed. One solution were wooden tables which could be set up within the bakery. Yet, the platforms next to the ovens in Le Chastellet and Belvoir and two tables located on each side of the oven at Saranda Kolones could have served as a permanent surface for exactly such a purpose.

A calculation of the floor space available on the platform in Le Chastellet shows that between 190 and 215 bread loaves could be placed on it for rising, easily enough space for the amount that could be inserted into the oven. The platform’s height measured more than 1m and was almost the same as the opening into the baking chamber. It was thus convenient for picking up the bread loaves and inserting them into the oven without excessive lifting or bending. The process of inserting was further made easy by the recess in the platform right in front of the opening of the baking chamber. This recess enabled a person to stand at a comfortable height and distance to the opening of the baking chamber as well as to the surface of the platform and to freely maneuver the peel. All these technical conditions ensured a quick loading and unloading of the oven.

The small oven at Belvoir (fig. 21), as well as the recess located on the eastern side of the northern opening of the baking oven at Arsur, can be certainly be interpreted as heating places for a cauldron of water used during the kneading of the dough.

One could object that there are no such tables at Le Crac des Chevaliers or at Arsur. In the case of Le Crac it is important to keep in mind that to the west of the opening of the baking oven, a ruined structure has been excavated which could well have been the southern extremity of such tables (fig. 22). A complete excavation would be necessary to support this assumption.

At Arsur, the excavations have not revealed any table-like structures in the direct vicinity of the upper furnace, in the vaulted room to the north or in the apsidal room of the northeastern tower. The





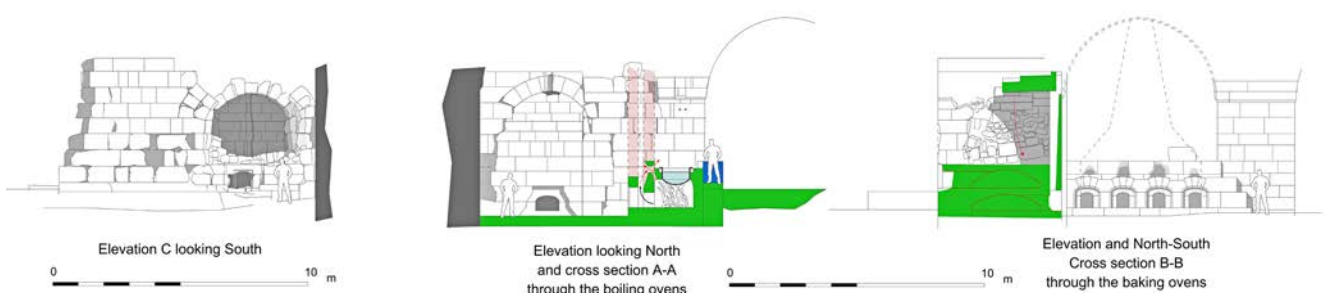
excavators interpreted the large hall situated on the west as a horse stable in a first stage, and as a refectory in the second stage (but this last proposition is only based on the presence of a rectangular pillar at the center of the room interpreted as a basis to support a wooden table)⁴². The presence of hydraulic plastering at the northeast corner of the hall casts doubt on such an interpretation. Perhaps the large room was used for other purposes, like the storage of the loaves.

DISCUSSION: DOUBLE-CHAMBERED BAKING OVENS

As of today, two-chambered ovens seem to be extremely rare in the Frankish castles of the Near East: two other examples have been recognized very recently at Le Krak de Moab/al-Kerak (Jordan) (Fig.23, 24), and at Beth Guvrin (Bethgibelin, Israel) (fig. 25).⁴³ All examples discussed here were built in large fortresses with important “professional” garrisons, as were the fortresses of the Military orders.⁴⁴

Yet, despite their presence in some of the most important castles of the Military Orders, one may wonder why the technique of the double-chambered oven was not more

⁴⁴ - Al-Kerak belonged to Renaud (Raynald) de Châtillon; but the northeastern part of the fortress was granted to the Hospitalers in a charter dated 1152 (at least the northeastern tower and the barbana between this tower and the tower of the chapel). Cartulaire general des Hospitaliers, p.160, n°207. Denys Pringle, “Hospitalier Castles and Fortifications in the Kingdom of Jerusalem, 1136-91”, forthcoming. Bethgibelin was granted to the Hospitalers by Fulk of Anjou around 1136 : see Amos Kloner and Michael Cohen, “Die Kreuzfahrer Beth Guvrin”, in *Matthias Piana, Burgen und Städte der Kreuzfahrerzeit* (Petersberg, 2008), 285-292.



45 - See a medieval illumination showing a baker loading an oven with his peel in Tacuinum Sanitatis, Milan or Pavie, c.1390-1500, Paris, BnF, nouvelle acquisition latine 1673, fol.56. Under the furnace, a fire is burning under the lower vault.

46 - Kay-Peter Suchowa, "Frühe Innovation der Backofen-Technik. Der Zweikammer-Backofen des Lübecker Aegidienhofs", *Zeitschrift für Archäologie des Mittelalters*, 35 (2007), 101-107. See also Mieczysław Grabowski, "Backhäuser und Backöfen...",

47 - It is interesting that in the 1950's a German company advertised small double-chambered ovens measuring max. 0.7x1.6m and functioning only by heating the lower furnace; however, this type never had any success, since the use of electricity solved all these questions. Klaus Freckmann, "Das Handwerk der Backofenbauer in Bell in der Osteifel", *Hausforschung und Wirtschaftsgeschichte in Rheinland-Pfalz* [Jahrbuch für Hausforschung, 41]. (Marburg 1993), 331-351.

common. In fact, this kind of oven was unknown in the technical Encyclopedias of the eighteenth century, which proves that the technique of the double oven never really caught on, except in the middle eastern fortresses of the end of the twelfth and thirteenth century.

Although some medieval and post-medieval illuminations depict domed baking ovens with a fire lit in a vault under the baking chamber, it is reasonable to assume that the painters allowed themselves some artistic freedom.⁴⁵ The artists may have turned the vault under the baking furnace commonly used for storing and drying wood into a heating chamber.

In the present stage of our investigation, only one other example of a double-chambered oven has been published. It was excavated in the Hanseatic city of Lübeck (Germany), in a Beguines convent, and dates between 1400 and 1577. It consisted of a lower furnace, rectangular (2 x 2.2m), roofed by a segmental vault, over which a circular chamber of 2.6m diameter covered by a dome was built. The interpretation of the excavator was that the lower chamber was the furnace, where the fire was permanently maintained, and that the upper chamber was the baking chamber. Thus, he considers this double-chambered oven as a link between the classical so-called "Roman" baking ovens, and the modern indirect heated ovens developed during the nineteenth and the twentieth century, where different systems allow the heat to circulate around and inside the baking chamber.

But double-chambered ovens operated in this fashion showed severe flaws. Heated only from below, the difference between the temperature of the floor and the vault area would have been too great resulting in a baking chamber with a floor so hot that it could burn the bottom of the bread and a vault area too cool to properly bake the upper part of the bread.

In the case of the four double-chambered middle-eastern ovens, it is clear that the presence of chimneys over the opening of the upper furnace indicates the burning of fires inside of it. The only reasonable reason to have additional fire-chambers below them is to keep the ovens at an even temperature during the process of baking, and to help heating the floor of the upper furnace.

Nevertheless, the rarity of the model seems to show that these ovens were too large to function properly, even with the double heating.