

*International workshop on Paleoseismology, Active Tectonics and
Archaeoseismology*

Following the historical traces of the 1909 Lambesc earthquake



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Following the historical traces of the 1909 Lambesc earthquake

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Field trip guide - 26 & 30 sept. 2022

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- Geological aspects: Yann Klinger, Laurent Bollinger, Magali Rizza
- Historical and archaeoseismicity aspects: Georgia Poursoulis, Arnaud Montabert
- Support: Les Amis du Patrimoine de Rognes, Maison du Tourisme de Lambesc, Maison du tourisme de Rognes, Maison du tourisme de Saint-Cannat.

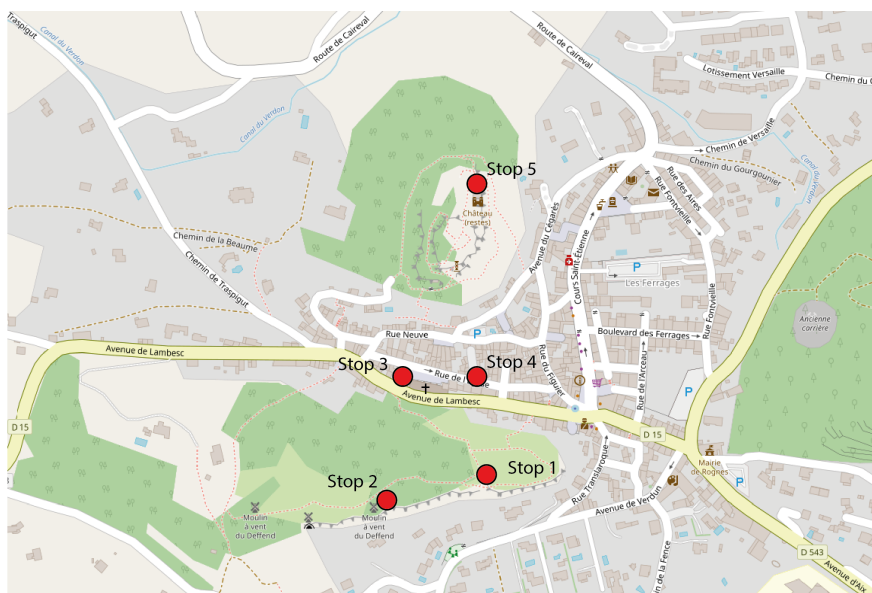
Cover photos:

- Saint Martin district in Rognes after the earthquake of June 11, 1909. Courtesy to Bureau d'évaluation des risques sismiques pour la sûreté des installations (IRSN/BERSSIN).
- View from the Défens district, before the 1909 earthquake (Courtesy "Les amis du Patrimoine de Rognes").
- View from the Défens district, June 25, 2022 (Courtesy Arnaud Montabert).

Program & Itinerary

MONDAY 26/09/2022 & FRIDAY 30/09/2022

08:00	<i>Departure from Mallemort</i>
08:30-11:00	PART 1 : TRACES OF THE 1909 EARTHQUAKE
08:30-09:00	Stop 1: View on Rognes from the Défens district
09:00-09:30	Stop 2: The damage windmill of the Défens district
09:30-10:00	Stop 3: Round table with "Les Amis du Patrimoine de Rognes"
10:00-11:00	Stop 4: Repairs & seismic resilience
11:00-12:15	PART 2 : Stop 5 - GEOLOGICAL PANORAMA AND INTRODUCTION OF THE HISTORICAL SEISMIC CONTEXT IN SOUTH PROVENCE
12:15-13:30	LUNCH
14:00-18:00	PART 3 : PALEOSEISMOLOGY
14:00-15:30	Stop 6: Chemin de la Fauchonne - Presentation of the paleoseismology work around Collavery, Ganay and la Fauchonne
15:30-18:00	Château Du Seuil - View on the Trévaresse range and visit of the fault escarpment
18:45	<i>Arrival to Mallemort</i>



Foreword

In the framework of the International Workshop on Paleoseismology, Active Tectonics, and Archaeoseismology, the members of the Organizing Committee have proposed a field trip to Rognes as one of the most damaged villages by the 1909 earthquake. This field trip and the guidebook has been prepared based on a field survey carried out by Georgia Poursoulis, Arnaud Montabert, Magali Rizza, and Stéphane Baize from June 23 to June 25, 2022. This preliminary field trip made it possible to contact local associations that provided key information for the creation of this trip. We want to thank "Les Amis du Patrimoine de Rognes" and tourism offices, "Maison du Tourisme de Lambesc," "Maison du Tourisme de Rognes," and "Maison du Tourisme de Saint-Cannat."

Through the case of Rognes, this document proposes a synthesis of the 1909 earthquake from the bibliography and the field campaign.

Introduction

On June 11, 1909, around 9:15 pm, France's last and most deadly earthquake took place. This earthquake occurred north of the Bouches-du-Rhône, 20 km northwest of Aix-en-Provence. It was felt in Perpignan, Nîmes, Montpellier and Avignon and caused 46 deaths and at least 250 injuries.

Extensive damage

Many villages, such as Vernègues, Pelissanes, Rognes, Lambesc, Puy-Sainte-Réparate, Venelles, and Salon-de-Provence were devastated. Although the earthquake caused death, the number of destroyed houses suggests that the human toll could have been higher. Fortunately, many people were outside during the main shock and not in their homes. According to a Rogne's resident:

"If the earthquake [...] had occurred an hour later, when everyone would have gone home, all the inhabitants of the village or almost all of them would have been buried under the rubble."



(a) Lambesc (Source: planet-terre.ens-lyon.fr)



(b) Saint-Cannat (Source: tourism offices of Saint-Cannat)



(c) Salon-de-Provence (Source: tourism offices of Saint-Cannat)



(d) Rognes (Source: Les Amis du Patrimoine de Rognes)

Figure 1: Postcards created from photographs of damage in the devastated villages.

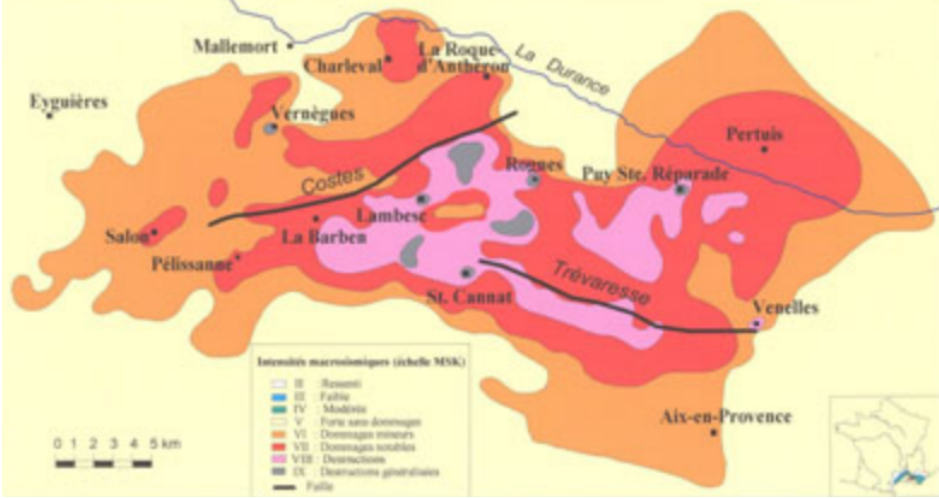


Figure 2: Distribution of the damage and location of the Trévaresse fault ([1]).

As the strongest event of recent French history, the event immediately became the object of intense investigations with some pioneering works of Angot ([2], [3], [4]), Lemoine ([5]), Lallemand ([6]), and Spiess ([7]). The detailed analysis of the damage and its distribution illustrated in Fig. 2 allows to estimate a maximum intensity of VIII-IX between Lambesc and Saint-Cannat.

Seismological information

At that time, recording stations were still rare in Europe (early instrumental period). However, the 1909 earthquake was recorded by more than 30 stations within a radius of 2,000 km. Eleven seismograms of sufficient quality have allowed to reconstruct the characteristics of this earthquake (magnitude 6.0, geometry, and rupture mechanism on the fault).

From the existing seismograms, the magnitude of this earthquake has been estimated at 6.2 ([9], [10]) or 6.3 [11]¹. Levret et al. [12] proposed a lower magnitude (5.5) based on macroseismic data. Finally, eleven seismograms of sufficient quality allowed Baroux et al [8] to reconstruct the characteristics of this earthquake. The reappraisal of the seismological data yielded M_w 5.7–6.1 (6.0 preferred) and M_s 6.0, consistent with the magnitude from intensity data (M_e 5.8) and with constraints derived from modeling of coseismic elevation changes [8]. The hypocenter was shallow, 2–5 km [9], ~10 km [12]. These works allowed to identify the Trévaresse fault as the origin of the earthquake (Fig.4).

¹Surface wave magnitudes based on one or a few recordings.

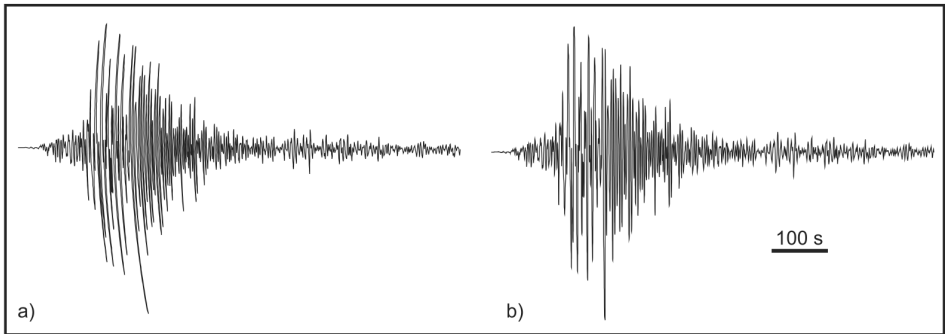


Figure 3: An example of an original historical seismogram recorded at Strasbourg; (a) before processing, (b) digitized and corrected. From Baroux et al [8].

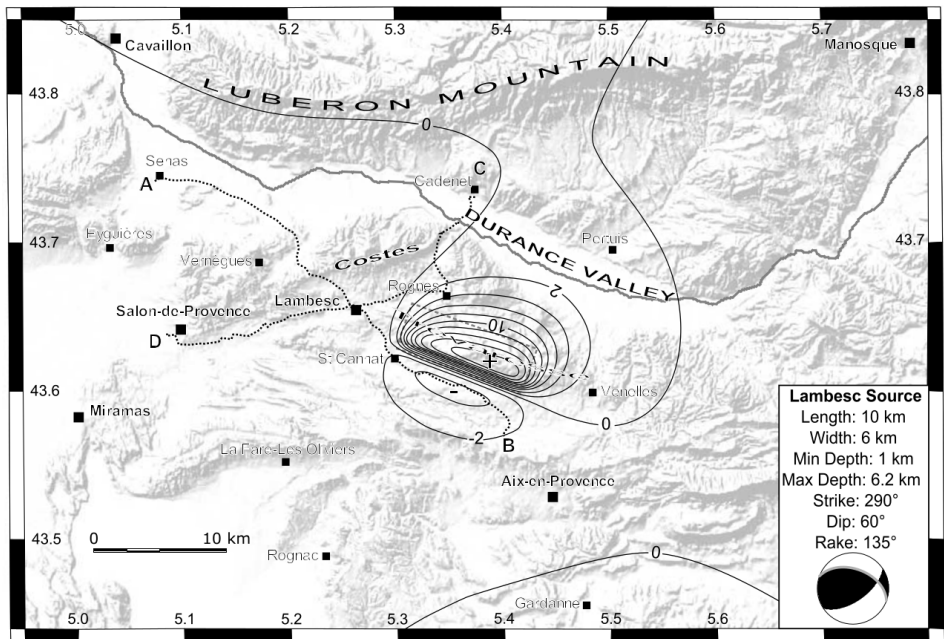


Figure 4: Map of coseismic elevation changes (solid lines) expected to result from slip along the model fault obtained from macroseismic and seismographic analyses and from geological constraints. From Baroux et al [8].

Along the Trévaresse fault

Several trenches intersecting the Trévaresse fault (Fig. 5) helped to establish the geological history of this fault ([13], [14]).

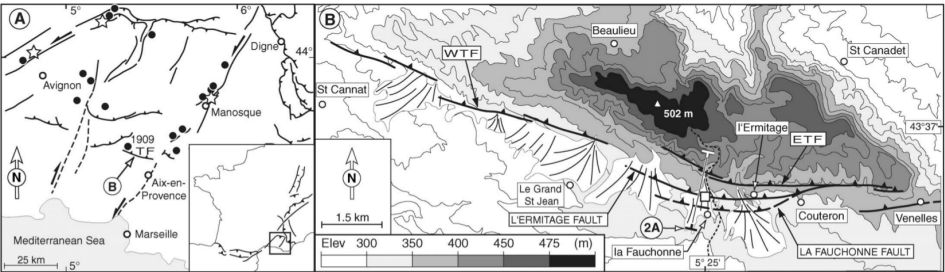


Figure 5: Figure from [14]. A: Structural map of western Provence showing $M \geq 4$ historical earthquakes (black dots; Levret et al. [12]) and sites of documented paleoseismicity. TF—Trévaresse fault. B: Map of Trévaresse ridge anticline and its piedmont showing Trévaresse reverse fault system and T2 alluvial fans. WTF, ETF—western and eastern segments of main Trévaresse reverse fault, respectively; T1 fan terraces are not shown due to their small size; thick dashed line—la Fauconne Creek.

These studies have shown that other earthquakes equivalent to that of Lambesc but much older (for several thousand years) had already occurred on this fault (Fig. 6).

Itinerary and outline

We propose to observe the impact of the 1909 earthquake through the example of Rognes. A section is dedicated to each stop. First, we will describe the extent of the damage from the Defens district. We will observe the damage still visible on the mill of the district. Then we will meet "Les Amis du Patrimoine de Rognes", who have been collecting, preserving, and transmitting the memory of Rognes for several decades. Finally, we will visit through the streets of Rognes in search of traces of damage, repairs and reinforcement.

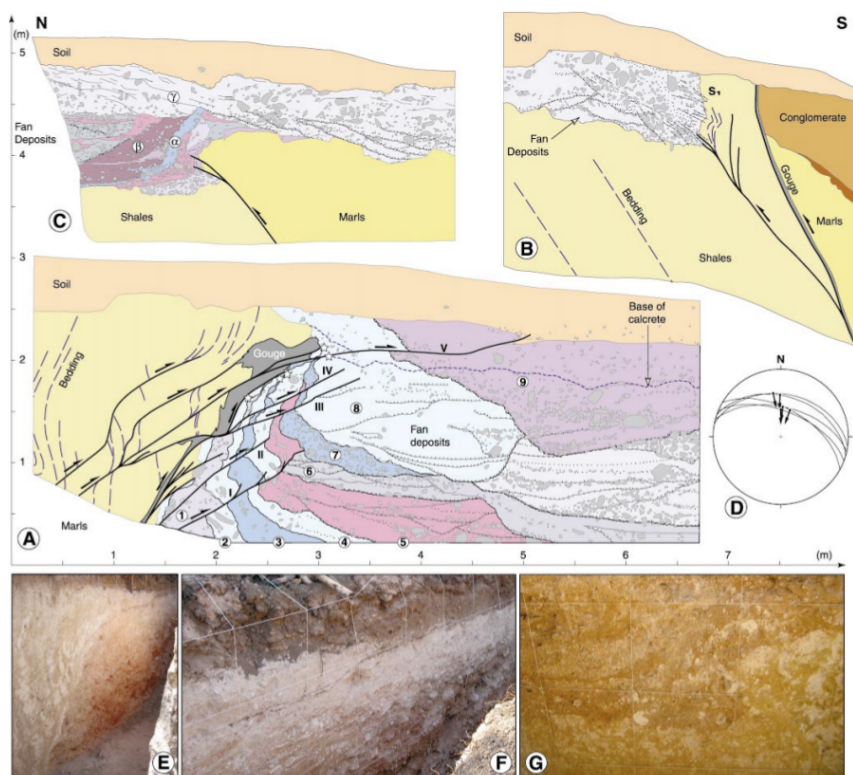


Figure 6: Figure from [14]. "A, B, and C show logs of trench located in Fig. 5. In A, I–V refer to fault splays. Sedimentary units 1–7 are colluvial wedges. Units 5 and 6 show more pronounced alluvial characters downstream. Silty-sandy unit 8 is homogeneous and shows rare channels, whereas unit 9 marks latest sedimentary discharge recognized in the trench. S 1 —cleavage. D: Coseismic striae measured on fault splays in fan material; measurements are indicated by white stars in A. E: Oblique view of l'Ermitage fault zone shown in A. F: Detail of emerging ramp of fault splay V in A showing reverse offset of calcrete duricrust and bottom of soil horizon. G: View of flexural-slip fault shown in C; grid has 50 cm mesh." [14]

Rognes in the face of the 1909 earthquake

An ancient fortified site



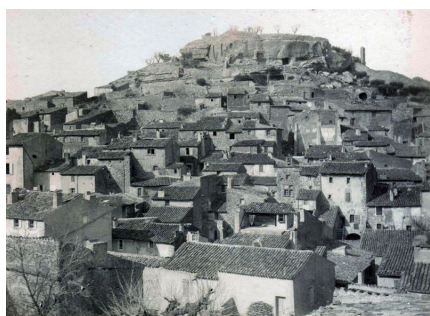
Figure 7: Historical evolution of the village of Rognes plotted on a map from 1837. Grey: district built in XI-IIth century ("castrum de ruinis"). Brown: district built in XIII-XIVth century. Blue: district built in XV-XVIth century. Pink: district built in XVII-XVIIIth century. Source: "Les Amis du Patrimoine de Rognes".

The village of Rognes has crossed the centuries. *Rongnis, Ruinis, Rognos, Rougnès, Rognes*, its name has also changed many times. The heights of Rognes were occupied during the neolithic and the Iron Age. During the Middle Ages, the "Foussa" plateau was a strategic place. The plateau is located at an altitude of more than 800 m. It was the birthplace of the village of Rognes. The "Castrum de Ruinis" was extended during the medieval period. The etymology of Rognes probably comes from the remains of previous occupations. As for "Foussa," the ancient cadastres reveal that this toponym (quite paradoxical for a summit since "Foussa" means "gap" in Provençal), will only appear in the 17th century, after the dismantling of the citadel of which only the filled-in gap remained in the classical period. In the 13th century, a still visible defensive wall embanked the Galinière and the Saint-Martin sector. The troubles of the XVIth century (wars of religion and wars of Italy) led to the eviction of a defensive wall about 800 m, seven towers, and

three doors. The fortress became a power position. In 1595, Rognes hosted the Duke of Epernon's cannons against the people of Aix rallied to Henri IV. This event led to the dismantling of the fortress between 1597 and 1600. Before the 1909 earthquake, some of the houses in Rognes date back to at least the 11th century (Fig. 7). The construction techniques used, the ageing of the materials implies an important vulnerability of the buildings.

Stop 1: damaged Rognes from the Défens district

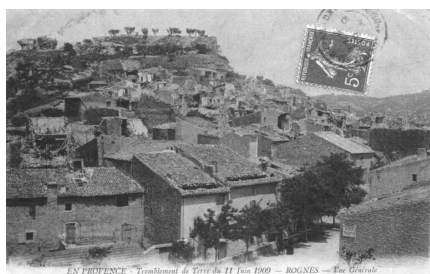
In 1909, the village of Rognes was located on the side of the Foussa (Fig. 8a). The Provençal earthquake totally destroyed the houses surrounding the summit (Fig. 8b, 8c, 8d). Only a wall from the beginning of the XVIIth century is still standing. The houses located at the foot of the hill suffered less. Today the houses built on the slopes are modern, while those at the foot are traditional.



(a) View from the Défens in 1905.



(b) View of the west district.



(c) View from the Défens.



(d) View from the Défens on the most damaged district.

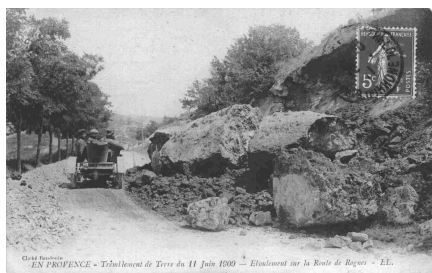
Figure 8: Postcards created from photographs of damage in the devastated Rognes. (Source: Les Amis du Patrimoine de Rognes)

Fig. 9 shows more precisely the distribution of the damage around Rognes reported on a map of 1837 (before the earthquake). The houses surrounding the "Foussa" were almost destroyed (in red). The second belt suffered significant damages (destruction of roof, in-plan mechanisms). The houses far from the "Foussa" were

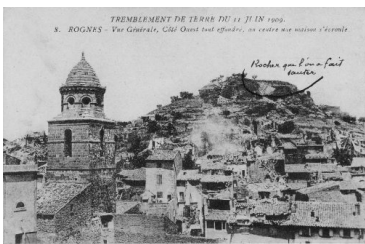
more spared (yellow).



Figure 9: Distribution of the damage during the 1909 earthquake reported on a map of 1837. Red: destroyed. Purple: highly damaged. Yellow: Slightly damage. Green: rebuilt district after the 1909 earthquake. Source: "Les Amis du Patrimoine de Rognes", archives départementales: P4 2819.



(a) Landslide along the road to Rogne.



(b) View from the Defens before the military intervention.

Figure 10: Photo of Rognes before the securing operation of the military engineers. An inscription indicates the rock that will be exploded. In the center a cloud of dust indicates a house that collapses at the moment of the photo.

The village of Rognes, the highest point of the massif de la Trévaresse, had to suffer even more significant damage due to its topographic configuration, which amplified the ground motion (topographic site effect, Fig. 11). High buildings

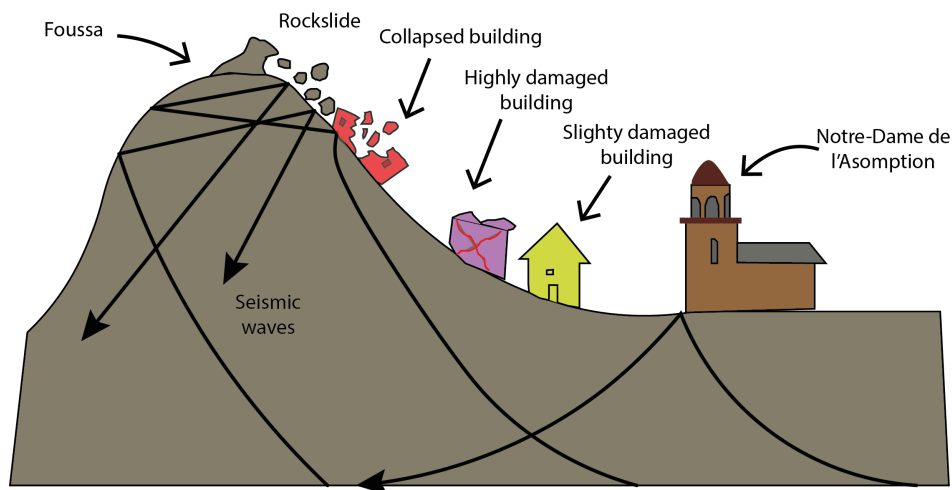


Figure 11: Illustration of the topographic site effect in Rognes highlighted by the distribution of damage.

and stone blocs broke apart (Fig. 10a). By falling on the houses below, they have significantly increased the damage. The authorities decided to remove the last rocks presenting a risk of collapse and forbid the summit's occupation to avoid exposing the population. The rockslides that you can observe today are not those caused by the earthquake but the results of the action of the military engineers to secure the site. (Fig. 10b).

The overlapping distribution of damage to the topography and the period of construction of the buildings (older buildings in the center) shows the relationship between the different factors that led to such damage (topographic site effects, vulnerability class A/B according to EMS98).

Stop 2: The windmill of the Défens district

Before going back down to the village to have a closer look at the buildings, let's observe a vestige that felt the 1909 earthquake. Many windmills were built in the area of Rognes (Fig. 12). Most of them were already abandoned at the beginning of the 20th century. We will stop in front of one of the mills of Le Défens (Fig. 13a-13b).

The damage observed is typical of the damage caused in Rognes during the earthquake. The wall of the windmill highlights in-plane failure mechanisms (Fig. 14) which is typical of the response of a cylindrical structure (strong wall cohesion).

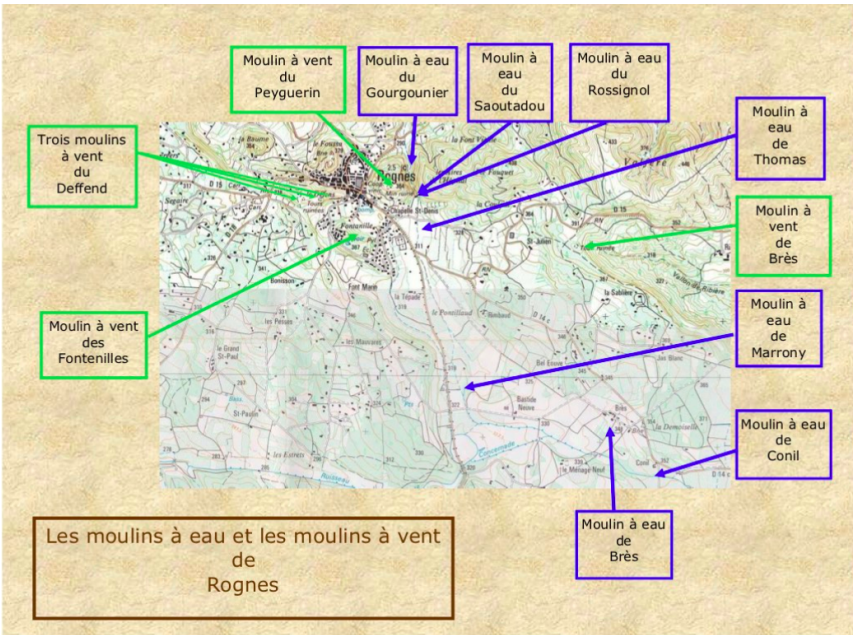


Figure 12: Location of windmills in the Rognes area.



(a) Windmill of the Defens district.



(b) Windmill of the Defens district.

Figure 13: Photos of the Défens windmill with in-plane failure mechanisms.

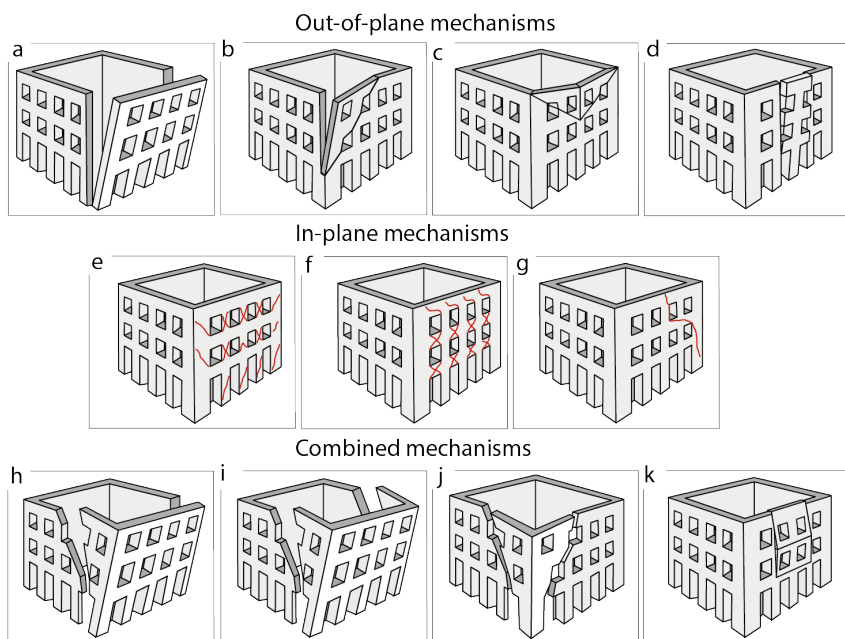


Figure 14: List of failure modes at building scale. a) Vertical overturning. b) Partial overturning. c) Horizontal arch. d) Vertical strip overturning. e) Cracks in piers. f) Cracks in spandrels g). Transverse cracks. h) Overturning with one side wing. i) Overturning with two side wings. j) Corner failure. k) Vertical arch. From [15]

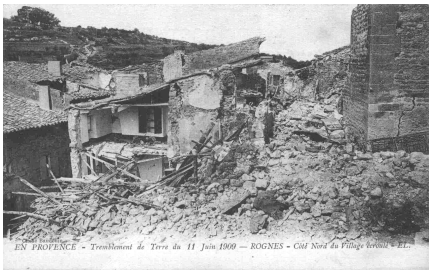
The streets of Rognes

Looking at the photographs of the damaged building, you can identify the classic mechanisms of collapse (Fig. 14). Some streets of Rognes are almost destroyed (Fig. 15a- 15b). The buildings built in the outer part of Rognes are less damaged (Fig; 15c). After the disaster, three companies of the 55th army came to help the rescuers (Fig. 15d).

Rognes after the earthquake

After the earthquake, the victims stood alone during the night. The roads were blocked, and communications were cut off (telegraph). It is only the next day that the first help arrived (about 12 hours after the earthquake). The army was mobilized on the spot (about 700 men) to help remove debris. The victims were housed in military camps (Fig. 16a), or in barracks (Fig. 16b) built quickly while waiting for the reconstruction of Rognes.

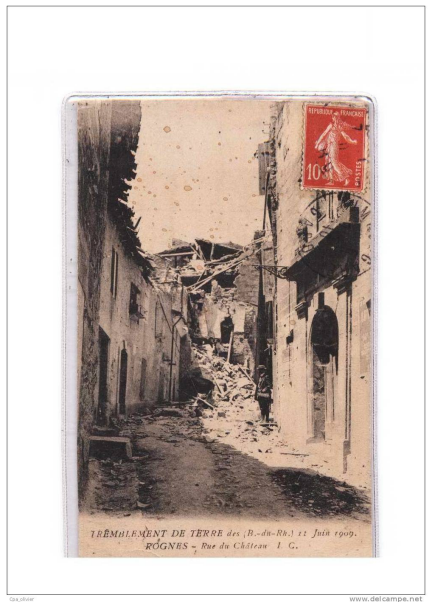
The methods of reconstruction are different from one territory to another. Rognes



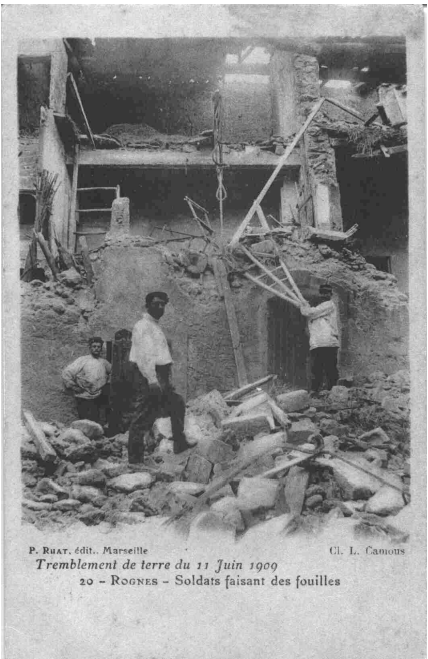
(a) Collapsed buildings in the northern district of Rognes.



(b) Collapsed buildings.

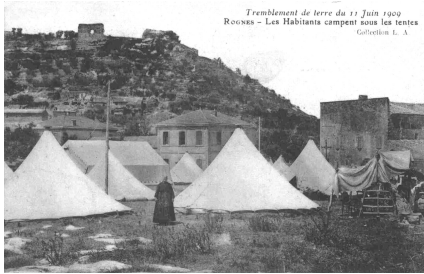


(c) "Rue du Château".



(d) Soldiers doing researches.

Figure 15: Postcards created from photographs of damage in the devastated Rognes.



(a) Camps provided by the army to shelter the victims.



(b) Barracks built while waiting for the reconstruction of Rognes

Figure 16: Accommodation for the earthquake survivors.

is an example of the identical reconstruction of districts like Saint-Cannat. In the case of Lambesc, new public roads and squares replace the destroyed districts. In the case of Vernègues, the village is rebuilt elsewhere.

Stop 3: The village of Rognes during and after the 1909 earthquake. How do people live it?²

At the time of the 1909 earthquake, there was at the village of Rognes a correspondent of the “Petit Marseillais” newspaper: Mr. Leon Poutet. Just after the first shock, he sent the first information about the event to its newspaper :

“Rognes June the 12th of 1909 at 5 AM – yesterdays earthquake destroyed a lot of houses. Many persons died. Send special editor.”[16]

After this first message, Mr. Poutet exposed day by day the events, the impressions, and the living of the affected populations at Rognes and in some other places. We will present here some elements from its papers to give you an idea of the local situation for the affected populations.

Paper of 1909 June 13 by Jean Servien special newspaper correspondent of the Petit Marseillais in Sicily and Calabria

“The earthquake in the Bouches du Rhone région. The villages of Saint-Cannat, Rognes, and Lambesc are the more affected and partially destroyed. About ten districts are affected by seismic shocks. There were about 50 dead and numerous injured. Rognes was the more affected. From the road, before arriving in the village, the disaster that affected it impresses you strongly. You see houses without a roof; landslides block the road. However, when you arrive in Rognes, the aspect of the village is very moving. We know how Rognes was built. A high hill backs the village, at the top of which olive trees take place. The village extended itself as an amphitheater until the foot of the hill. From the opposite hill, we look at the complete village, and we can see the extent of the disaster. All the houses on the hill slopes are collapsed, beheaded, or demolished. From the top to the foot of the hill, they are collapsed one on the other. It is now a dreadful mess of stones, rocks, beams, broken pieces of furniture, linen, and uprooted trees. A complete horror view. It seems that all the village collapsed from the top of the hill.” It seems like Reggio di Calabria, which reveals how strong the shock was and how the consequences are essential. If at Lambesc and Saint Cannat the number of dead is more critical, at Rognes, we can see all the extent of the disaster. [...] When the violent shock happened and collapsed the houses of the upper part and some of the low parts of the village, it was a horrible moment of terror for the population. The streets fill with people running in all directions, without any idea of the way to go or

²After the newspaper “le Petit Marseillais” papers with the kind collaboration of the association: “Les amis du patrimoine de Rognes”

understanding of the horrifying adversity that had fallen on them. Far from all the noise, the disaster, and the cries, people run away to the lands and spend the night under the sky and rain, numbed and frozen by the rain and cold wind. [...] The rescue work started courageously in the morning when a group of habitants returned to the ruined village. Each one helps the other, giving rescue to the injured and digging up the dead from the ruined houses.”[17]

Paper of 1909 June the 18th by Jean Servien

“Visiting the area of this region affected by the disaster, the village of Rognes seems the more affected and devastated. We could find in the houses of the land preserved. The buildings along the roads stay up, and any crack is visible on their faces. The church was also preserved, but not the presbytery completely collapsed. If the low part of the village is majority preserved, the center and the upper one are badly affected. From the slope in front of the village, we can see all the extent of the disaster, a view not so terrible [...] because it seems like antique ruins, as they are disposed of artistically. We said that, but we also see the dead in their coffins taken from the ruins and move to the hospital [...] At the top of the hill where the ruined village is extended, the olive trees move with the wind giving some life to this desolation. As we climb up the hill to the olive trees, the reality of the disaster became evident to us; under the Foussa Castel, the houses are all fallen one on the other like a giant playing with its balls through the village streets and falling the houses down, or a monstrous force tilting the hill and overthrowing everything established on its slopes [...]. We understand that the ruins are recent with the scary show of the poor people trying to find in the rubble the memories of their fortune lost under the dust [...] The oldest men cry after their family houses bequeathed by their ancestors are lost forever, reduced to ruins by the disaster.”[18]

About animal's intuition by Leon Poutet

“[...] What is sure is that all the animals go away from their lives, and those who cannot escape because they are not free to do it expressed their terror by their shriek. By what secret warning does the animal know the near disaster and indicate their desire to run in the land as far as possible? [...] In the hill near Beaulieu between the first and the second shock, the birds cry to warn the danger [...]”

Those who remain by Jean Servien

“Those who remain after the disaster stand up in front of the ruins looking at Nature which continues her live, the birds singing, the sound of the wind in the trees; they stay in a mediative position without a complaint, the eyes red after the tears and insomnia, they seams amaze to be here, still in live, whereas so much others, among who children, died ? [...]”

A new visit to the affected villages: At Rognes by Armand Gerbe

“By the road from Caire to Rognes, we arrived in an area at the village entrance near the school house; we can see 12 “marabouts” tents erected around a bigger one, square shape, in the center. Here leave the survivors of the disaster. A cooking stove in cast iron is located beside, also a survivor of the disaster, where an occupant of the camp prepared the diner for all the others. The survivors who take refuge in this camp constitute a sort of community, living together as a large family. [...] The soldiers who specialized in engineering worked the clearing the collapsed part of the village. We know that the Village of Rognes is overhung by a steep hill named “Foussa.” On this hill, two large rocks are overhanging the summit, which could be dangerous for the village in case of another shock. [...]”

The Installation of the camps at Rognes from the “Petit Marseillais” by Gaspard Galy 1909 June the 23rd

“The “Petit Marseillais” newspaper collected money from its lectors and could give temporary camps to the population of Rognes. Thirty families with 140 persons could take advantage of these less insecure shelters. Fifty families are occupying temporary camps made of tents all around the village. More than 20 farms had been demolished after the earthquake, so families without shelter need care. The Mayor of Rognes hopes many houses will be repaired before winter and families can occupy their shelters in perfect security. A solution must be found for those who had utterly lost their houses or farms. The “Petit Marseillais,” after meeting with the mayor and the president of the local rescue community of Rognes, decided to build about 40 tiny houses, sufficiently comfortable for the families whose houses could not be repaired or rebuilt before the winter days. Those houses will be built in wood, as in Vernègues, with a door, windows, and a roof covered with tiles. According to the number of people, the house would have one or two bedrooms and a kitchen. With the help of the “Petit Marseillais,” the two villages of Vernègues and Rognes will be rebuilt temporarily and as well as possible. In order to complete the reconstruction work started

by the “Petit Marseillais,” Mr. Léon Poutet, local newspaper correspondent and president of the rescue community of Rognes, offered a site of 1000m² for the location of the wooden houses. On the other hand, the priest Fouque offered the village of Rognes a dismountable house large enough to give shelter to 200 persons. It measures 17m long and 8m large, and 8m high in the middle, with six doors and two iron stairs at each part, and could be divided into many flats. Twenty families ask the mayor for a flat in this large temporary house. [...]”[19]

Paper of 1909 june the 24th by Jean Servien

“In Rognes, the church and its bell tower were preserved. The bell tower suffered some superficial cracks and needed some consolidations. However, the presbytery was utterly ruined, irreparable. The front wall is detached from the lateral ones, the ceilings no longer hold, and we cannot consider repairing them. The better bias is to destroy it and build a new vicarage. If we go inside the church, we find it intact, and in the nave, a memorial mass to the earthquake victims was celebrated by the Canon of Aix. [...] At Rogne, 25 families leave now under tents, waiting for the wood houses sent by the “Petit Marseillais” to be elevated. These tiny houses are built in a fanned-out shape around a fountain in the central village, giving the impression of a small village inside the big one. [...] There is a remarkably singular fact to be mentioned in Rognes as in Aiguilles; there is a fountain with a big basin near the farm of Grand Saint-Paul. Before the disaster, the basin needs 20 days to be full of water. After the 11th of June event, it became complete in one day, but the fountain did not flow now.”[20]

Paper of the 1909 july the 7th

“A new shock happened in Rognes on the 7th of July at 10 PM. This shock was violent enough and was perceived in Rognes for 2 seconds. An indescribable panic takes hold of the inhabitants, who immediately abandon the houses and the camp shelters, running through the streets under the effects of fear. Many people from Rognes spend the night outside in the land.”

Paper of the 1909 july the 8th

“The shock that happened yesterday produced new damage, cracks on some habitable houses rendered them dangerous, and people abandoned them. Numerous support walls fell, as well as pieces of furniture. The fear of the population seems challenging to stop. The giving up of pastoral work because of the fear could be harmful to the population’s provisioning.”

Paper of the 1909 august the 9th by Gaspard Galy

“In Rognes, 20 wood houses had been built 3m by 6m long, occupied by 20 families. By 25, others still live in tents. There is also a large house in wood and iron given by the Petit Marseillais to the population as temporary shelter for other families. [...]”[21]

Paper of the 1909 september the 28th

“The Foussa of Rognes never more exist! The famous rock was destroyed yesterday at 10 AM. It had a diameter of 20m at its summit and 19m at its base, and a height of 8m with a total weight of 4 262 137 kg. The rock is located at the summit of the hill, overhanging the village. The name “Foussa” in the Provençal language was given to the hill because of the numerous cave of pits “fosses” dug in 739 AD by the populations during the Arabic invasions in order to found a more secure shelter than in the lands around. The earthquake of June 11th and the aftershocks produced the collapse of the houses on the hill, the crack of the caves, and the make the rock dangerous. For this reason, the rock of Foussa was destroyed yesterday by the soldiers of the engineering regiment. Traditionally the young couples, during their weddings, go on the plate-forme of the Foussa Rock to greet their free years. The rock is an essential part of the local and familial history.”

Evidence of the 1909 earthquake in the Rognes streets

Building archaeoseismology to track earthquake traces

Although districts have been massively rebuilt, the earthquake left traces on the walls of Rognes. These traces can be identified thanks to building archaeology³. Building archaeology is defined as the study of all the material traces that inform the design, construction, and management of a building through the vertical stratigraphic analysis of elevations ([22]). This approach can be applied at the scale of a building ([23]), and even at the scale of a whole city as recently in Pompeii ([24]), Manosque ([25]) or peruvian cities ([26]).

Traces associated to past earthquakes can be direct (cracks, collapse) or indirect (reconstruction, cracks or openings filling, retrofitting techniques). The buildings of Rognes were either completely rebuilt or repaired (unlike the mill of Défens). It is, therefore, necessary to interpret these indirect traces in order to identify the associated failure mechanism.

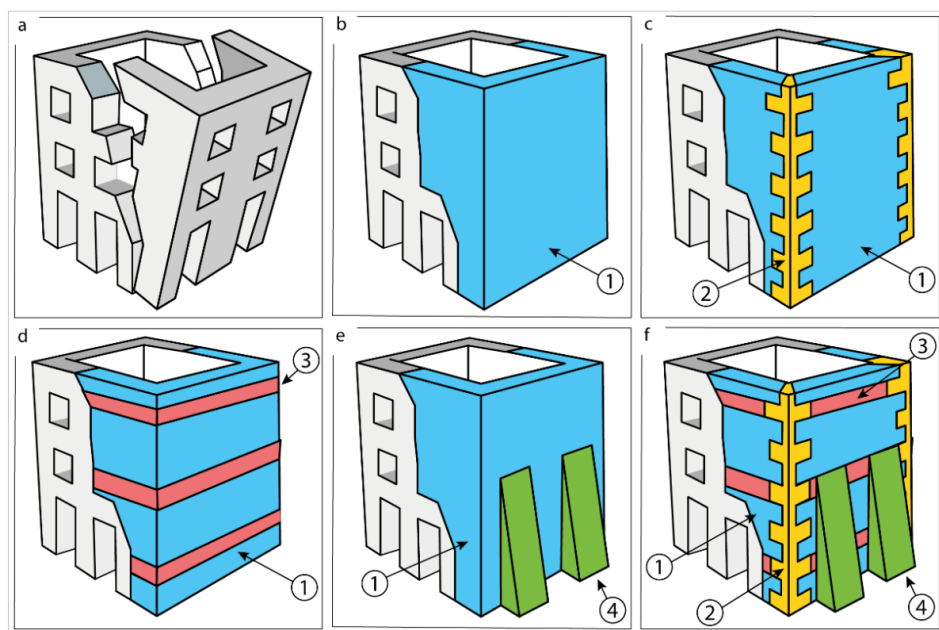


Figure 17: Repair strategies associated with overturning with two side wings (a). (b) Reconstruction strategy (element 1 in blue). (c) Corner chainage technique (element 2 in orange). (d) Brick (element 3 in red). (e) Buttresses (element 4 in green). (f) Combined repaired and reinforcement techniques.

There are many alternatives for repairing the same type of damage. Let's consider

³In the seismic context, it is referred to building archaeoseismology

an overturning with two side wings. A first reconstruction strategy is to build up the collapsed wall (Fig. 17-b). A second strategy is to add a corner chainage to the wall reconstruction to link the facade to the side walls and avoid a facade collapse (Fig. 17-c). A brick chainage can also be used to connect the building walls and reinforce the connection between the walls (Fig.17-d). Buttresses are sometimes added to prevent further tilting (Fig.17-e). Finally, all these seismic techniques can be combined (Fig. 17-f).

We present some traces that you can identify in the streets of Rognes.

Reinforcement techniques

Because of the high mass of masonry building and the low quality of mortar, the problem of high compressive forces occurs in the elements of structures built from stone. The horizontal components of the compressive forces are balanced using tie rods and anchors. These techniques allow to prevent collapse under abnormal loading in static condition, or out-of-plane mechanisms (Fig. 14) induced by seismic loading. Like most of the villages in the Trévaresses area impacted by the 1909 earthquake, you will notice the presence of many ties on the facades of the buildings⁴ (Fig. 19).



(a) Stone masonry with tie rods to link floors with the facade (Avenue de Lambesc, Rognes).



(b) Stone masonry with tie rods to link floors with the facade (Rue de l'église, Rognes).

Figure 18: Exemple of reinforcement in Rognes.

⁴The use of false ties has been identified in the region. Following the earthquake, some inhabitants installed faketic rods to receive compensation. You can distinguish them from the real ones by the absence of nuts.



Figure 19: Typology of tie rods used in Lambesc (e, f, g, h, j, k, o), Saint-Cannat (a, b, c, d, l, m, n) and Rognes (i, p, q)



(a) Filling of two openings (in blue) close to the building corners (Rue de l'église, Rognes)



(b) Filling of a previous arch and arrangement of two openings

Figure 20: Exemple of arrangement in Rognes.

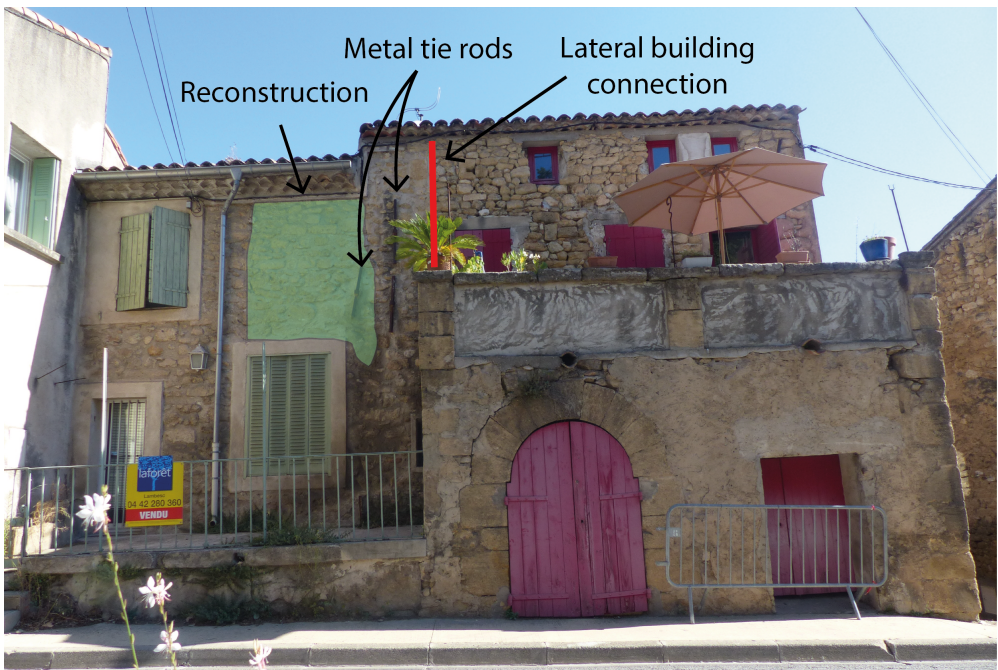


Figure 21: Reconstruction along two buildings (Avenue de Lambesc, Rognes).



Figure 22: Reconstruction along the window (first floor). Metal tie rods.

Figure 23: Example of reconstruction in Rognes.

PÉRIMÈTRE DU CATACLYSME

et la trépidation a été si forte aux étages supérieurs, que des meubles dans une maison de la rue Saint-Agricol ont été renversés. Le mouvement sismique a été à peine perceptible dans la rue. On ne signale pas d'accident de personnes, mais la panique a été générale et, durant quelques minutes hommes et femmes se sont précipités hors de leur domicile, se demandant anxiétement ce qui venait de se passer.

a Saint-Ruf, un jardinier qui arrosait ses plantes et se trouvait sur une passerelle, a été surpris par la trépidation, qu'il est tombé dans une fosse sans se faire du mal. Au bar des Glaces, des bouillottes mal assujetties sur les étagères se sont cassées. A 10 heures l'animation est encore très grande dans la rue. Beaucoup de mères de familles ont grand peine à faire rentrer à la maison les fillettes enrôlées.

Vers 11 heures, le calme a commencé à renaître dans la population affolée, autant par les secousses sismiques que par le réveil des pilotes ou même fantômes corporés de groupe en groupe. Le meuble livré à une fureur enflammée et si pu me rendire compte que sur la rive droite du Rhône, à Villeneuve et sur la route de Pujau, la déstabilisation a été très violente et la secousse s'est fait ressentir à travers les rochers, coup sur coup. En ville, dans le quartier Carrière, après des remparts, principalement on se trouve la colonie italienne,

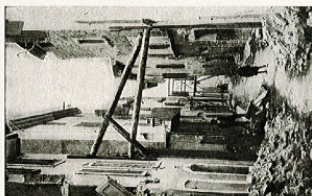


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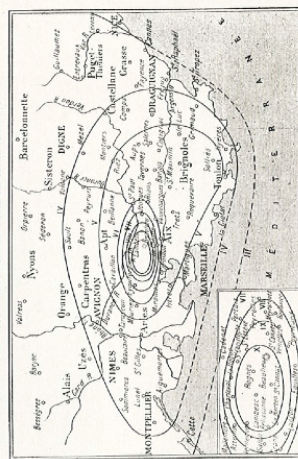
(L'Extrait du Bulletin de la Société Astronomique de France.



Phot. Neg.

Plus une de Polak-Cornet

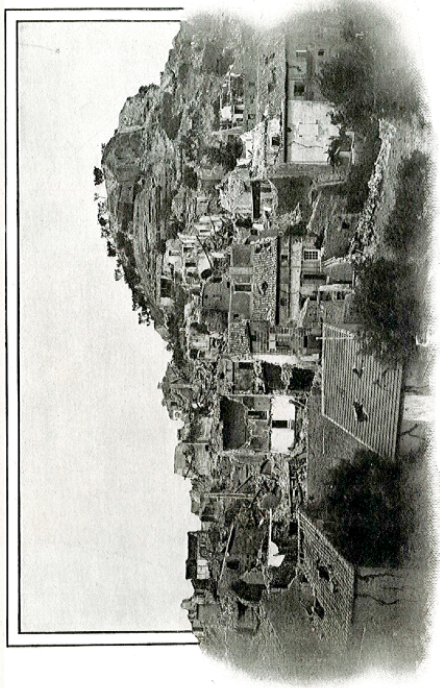
Pour se rendre exactement compte de la situation de la secousse sismique du 20 juin, M. Camille Flammarion, le savant Secrétaire général de la Société française d'Astronomie, a procédé comme il l'avait fait après le tremblement de terre des Pyrénées-Orientales, à l'observation de la position du Soleil, à l'aide de l'équatorial astronomique et de la Riviera, du 23 février 1887, c'est-à-dire en traçant les courbes d'intensités décroissantes à partir de l'épicentre. L'éminent astronome de la Société de Rossé-Forel dont la notation est la suivante :



ROGNES

Autrés cependant par l'âme de la maison, nous venions voir si, parmi ces runes amoncelées, il n'est pas de créature qui respire encore ; et au milieu de la nuit, les tristes nouvelles se colportent : un on vient de sortir un tel de dessous les débris, il vit ; dans telle rue, il y a un mort, dans telle autre une morte ; là, dans cette maison en angle, toute une famille est renfermée ; plus haut, une autre agonise ; ici, ce sont des appels désespérés ; là, plane un silence de mort. De temps en temps c'est la chute d'un toit ou d'un mur, puis le silence et l'obscurité recouvrent toute chose de leur voile et de leur mystère.

Une angoisse douloureuse nous étreint. Notre poitrine est sèche ; notre gorge, où s'est arrêtée la poussière des vieux murs qui ont failli nous écraser, notre gorge est prise d'un âcre picotement, mais la détresse morale que nous éprouvons est plus forte que la peine physique.



Phos

[illegible]

En face de nous se dresse en éventail menaçant un pigeonnier à moitié démoli, et à côté gît un amas de pierres, et tombeau d'une morte. De quel côté que se portent nos regards et notre pensée, c'est une vision d'horreur et d'épouvante !

Peu à peu le jour luit, et sembles à des apparitions fantômes, drapés dans leurs couvertures blanches, les corps dilataés par l'effroi, les lèvres agitées par un frémissement nerveux; tous courent de groupe en groupe, secoués par cette danse de Saint-Guy que le tremblement de terre leur a imprimée. Ils s'inquiètent de l'un et de l'autre : ils se demandent à voix basse si l'un d'eux n'est pas mort, si l'un d'eux n'est pas déjà descendu dans la fosse. Ils se demandent à voix basse si l'un d'eux n'est pas mort, si l'un d'eux n'est pas déjà descendu dans la fosse. Ils se demandent à voix basse si l'un d'eux n'est pas mort, si l'un d'eux n'est pas déjà descendu dans la fosse.

Et lorsque nous voulons rentrer dans nos demeures, une autre terreur nous saisit : ne s'écrouleront-elles pas sur nos têtes comme tant d'autres qui ont disparu dans la nuit ? Car l'impression dominante causée par le tremblement de

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