The pictures from Lac Chauvet

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with the contribution of Gilles Munsch, Francine Cordier, Patrice Seray and Raymond Piccoli

in partnership with the French 3AF / Sigma2 Commission

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On July 18th 1952 near Lac Chauvet (Puy–de–Dôme, France), at 6:10 PM (17:10 GMT), André Frégnale, a geologist in his thirties with a keen interest in all techniques, took four photographs (identified as LC_3, LC_4, LC_5 and LC_6 hereafter), two of which are very sharp, showing a "UFO" in the sky. According to the witness, the four pictures were shot over a total duration of 25 seconds (even though he also mentioned 50 seconds during a later interview), at approximately regular intervals, with the UFO moving noiselessly in a straight line from west to east. A moderate wind was blowing from the west or north-west. The object seemed to have a circular base. A brief summary of the event (in French) can be read here.

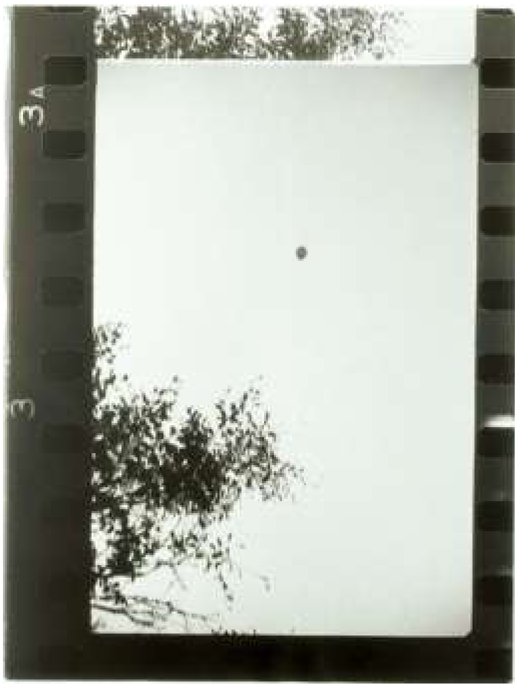
These four remarkable photographs, which had sunk rapidly into oblivion after having been extensively published in the press, were the subject in 1994 of a thorough analysis by the astronomer Pierre Guérin, published, in particular in the French journal *Lumières dans la nuit* (n° 316), then in the American *Journal of Scientific Exploration* (Vol.8, n° 4, pp. 447–469), available here.

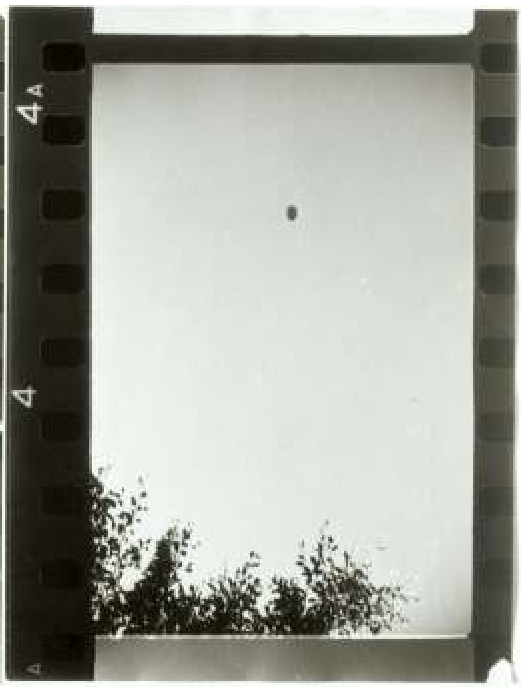
This work was completed in 2004 by Laurent Guérin (Pierre's son), who carried out an extensive geometric study, available (in French) here.

Another original and interesting study of this case was presented in 2015 by Michaël Vaillant, available (in French) here.

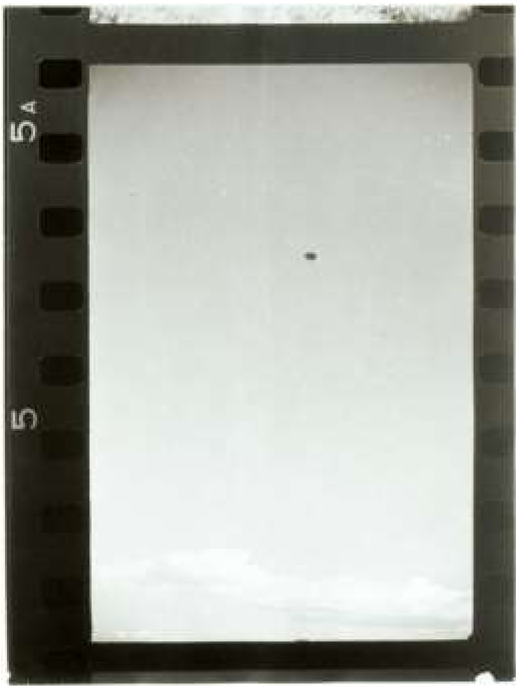
In July 2015, four experienced field investigators, Antoine Cousyn, Gilles Munsch, Francine Cordier and Patrice Seray (who all officially collaborate with GEIPAN) organized a mission and spent a few days on the actual site. With the help from Raymond Piccoli, who provided them with pictures taken on the site on July 16th 2008, they managed later to locate very precisely Mr. Frégnale's position during his sighting. They acquired and used on site the same camera model as Mr. Frégnale in order to experiment various hypothesis.

The four following images derive from paper prints of the original negatives, produced very carefully by Pierre Guérin for his study. An accurate scanning of those prints was performed later by Alain Delmon.





(LC_3) **(LC_4)**

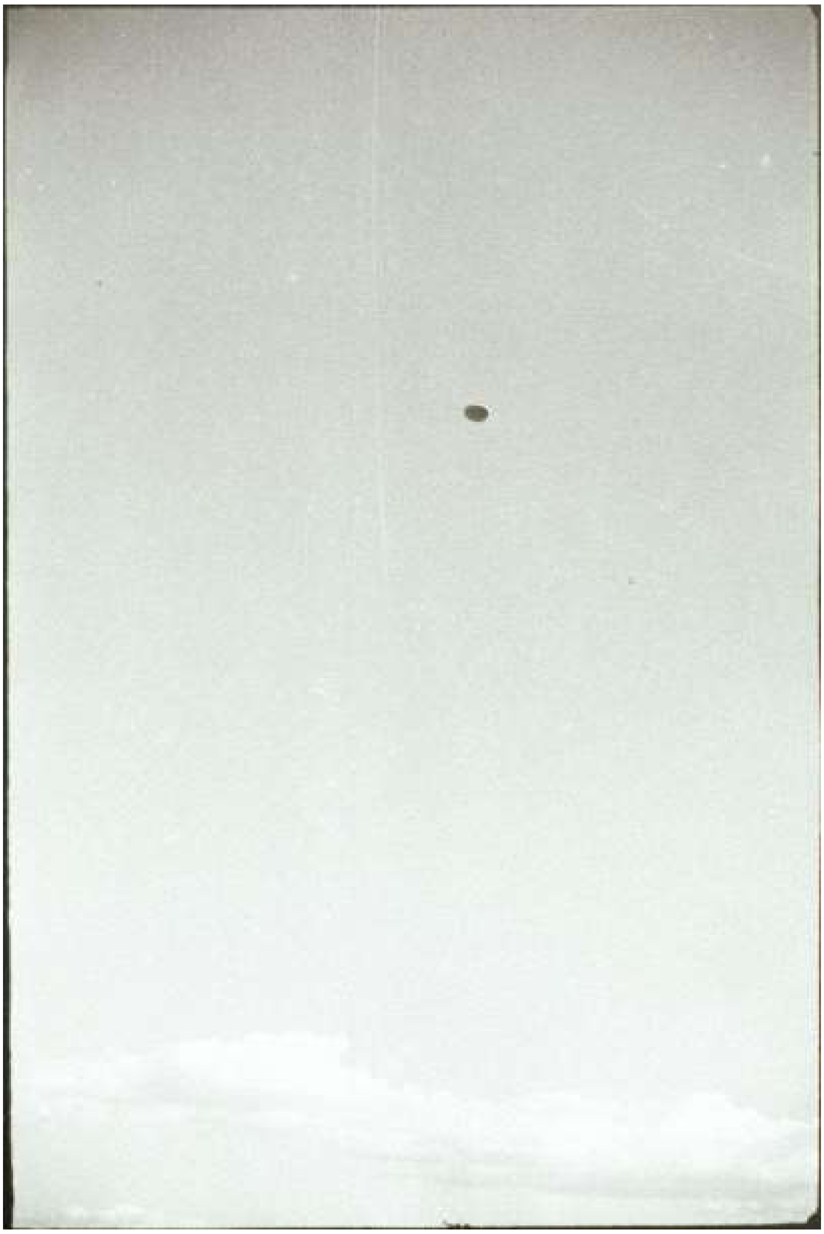


(LC_5) **(LC_6)**

The four following working images were extracted, matching as well as possible the original 24x36 format original, after application of a 90° rotation to the last two, so as to restore them to the horizontal.

LC$_3$ (1222 x 810 pixels)

LC$_4$ (1216 x 807 pixels)

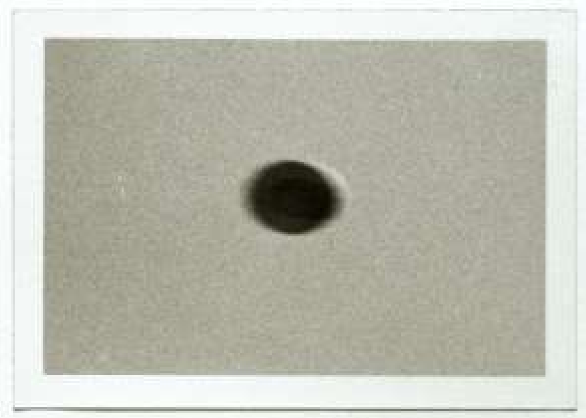


LC$_5$ (816 x 1222 pixels)

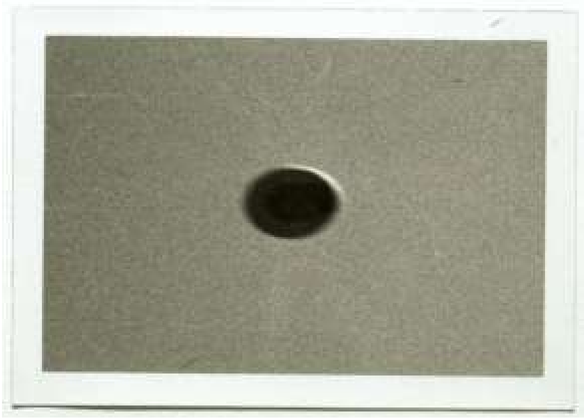
LC_6 (815 x 1223 pixels)

In addition, four other images were available: enlargements of the UFO respectively extracted from the four same images and hereafter named G_3, G_4, G_5 and G_6. These were obtained by Alain Delmon through scanning photographic enlargements of the original photographs that had been produced earlier by Pierre Guérin.

However, it was decided, for geometric mensuration, not to use images G_3, G_4, G_5 and G_6 but to stick to the earliest available set of data: LC_3, LC_4, LC_5 and LC_6.

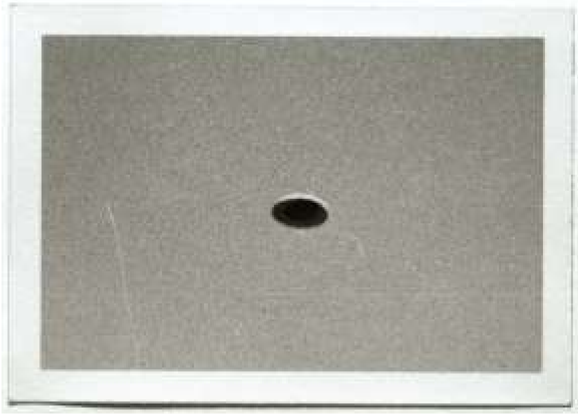


G$_3$ (1377 x 987 pixels)



G$_4$ (1371 x 981 pixels)

G$_5$ (1362 x 975 pixels)



G$_6$ (1352 x 972 pixels)

Finally, a Pathé movie (available here in French) was produced when a reconstruction of the case was organized on the site, a week after the alleged sighting, by journalists from the "La Montagne" newspaper. In the beginning of the movie, Mr. Frégnale (in the foreground, holding a photograph) indicated where he stood, near the tree visible in LC_3 and LC_4, and in which direction he had been shooting. Under his control, a journalist, using a long stick, indicated the elevation of his line of sight. Several frames were extracted from this film to produce the mosaiced image used in this report:

The aim of this paper is certainly not to contradict all conclusions of previous studies. It is specifically focused on the use of a modern interactive tool for a quick pragmatic assessment of this type of dossier. As concerns underlying mathematics and physics, nothing differs from what was found in the past, but an original geometric approach was made possible by the accurate results of the on-site mission.

According to previous investigators, Mr. Frégnale's pictures are genuine (i.e. a *real unknown remote* UFO was effectively photographed). Pierre Guérin, for his part, after his photometric analysis, concluded that the object was located at least at 60 meters from the camera, and that its diameter was at least 1 meter.

Certain other conclusions, based upon hypotheses related to supposed "classic characteristics of UFOs", were left aside…

Camera and settings

Camera model:	Zeiss Ikon Ikonta 35 (522/24)
Lens:	Zeiss Opton Tessar 2,8 – 45 mm (focal length 45 mm)
Shutter:	Compur–Rapid
Yellow filter in front of the lens:	Wratten 15
Film:	Kodak 35 mm Panatomic–X
Dimensions of the negative:	24mm x 36mm
Focal length:	45 mm
Exposure time:	1/250 s or 1/500 s (see further analysis)
Aperture:	unknown (see further analysis)

A description of the camera is available here and of the shutter here. The detailed manual can be read here.

DEPTH-OF-FIELD TABLE

DIAPHRAGM

Distance	2.8	3.5/4.0	5.6	8	11	16	22
∞	48'-∞	33'6''-∞	24'-∞	16'9''-∞	12'3''-∞	8'6''-∞	6'3''-∞
30'	19'9''-104''	16'9''-1540'	13'9''-∞	11'3''-∞	8'10''-∞	6'10''-∞	5'3''-∞
20'	14'1''-33'2''	12'5''-47'3''	10'10''-107	9'2''-∞	7'6''-∞	6'1''-∞	4'9''-∞
15'	12'3''-25'	11'2''-32'	9'9''-51'	8'6''-540'	7'3''-∞	5'9''-∞	4'7''-∞
10'	8'2''-12'1''	7'5''-13'9''	7'2''-18'4''	6'3''-22'11''	5'7''-46'3''	4'8''-∞	4' -∞
6'	5'9''- 7'6''	5'7''-8'	4'7''- 8'2''	4'1''- 9'10''	3'8''-12'9''	3'1''-25'7''	3'2''-∞
5'	4'6''- 5'5''	4'4''- 5'9''	4'1½''-6'1''	3'10½''-6'11''	3'7''-7'10''	3'3''-10'10''	2'10''-20'8''
4'	3'8''- 4'4''	3'7''- 4'1''	3'6''- 4'8''	3'3''- 4'11''	3'1''-5'7''	2'9''- 6'11''	2'4''- 9'1''
3'	2'10''- 3'2''	2'8''- 3'3''	2'7''- 3'6''	2'6''- 3'8''	2'4''-4'	2'2''- 4'9''	1'11''- 6'1''

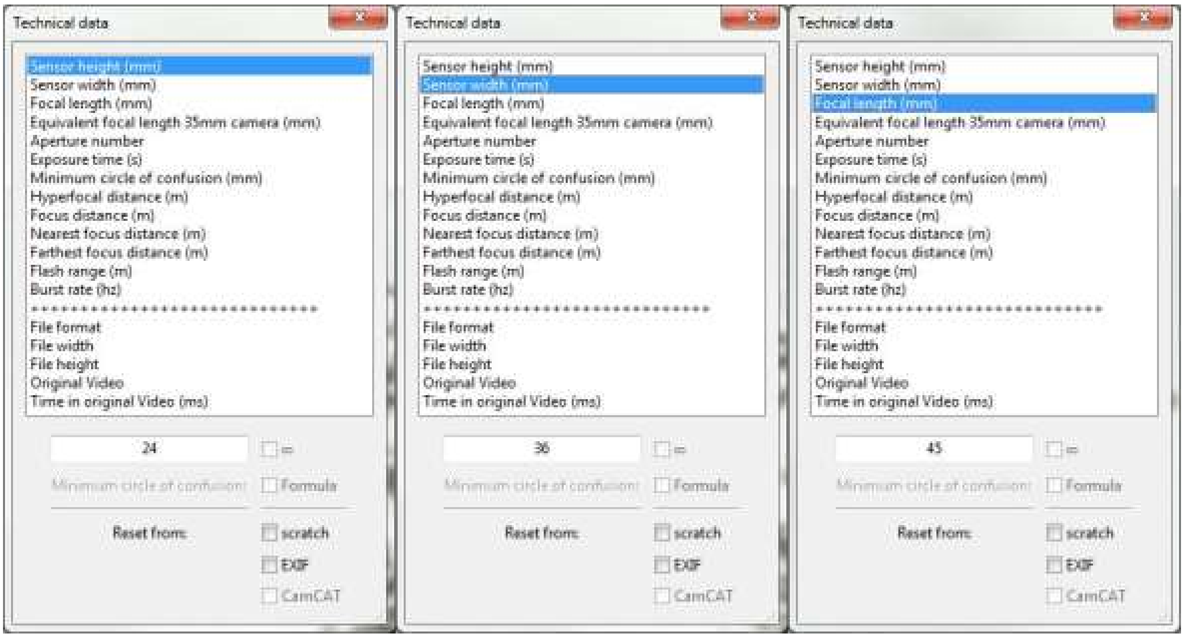
Important: A series of trials *(see Annex)* with this model established that, for an experienced photographer, the minimum elapsed time between 2 successive shots was, approximately: **5 s.**

Data preparation

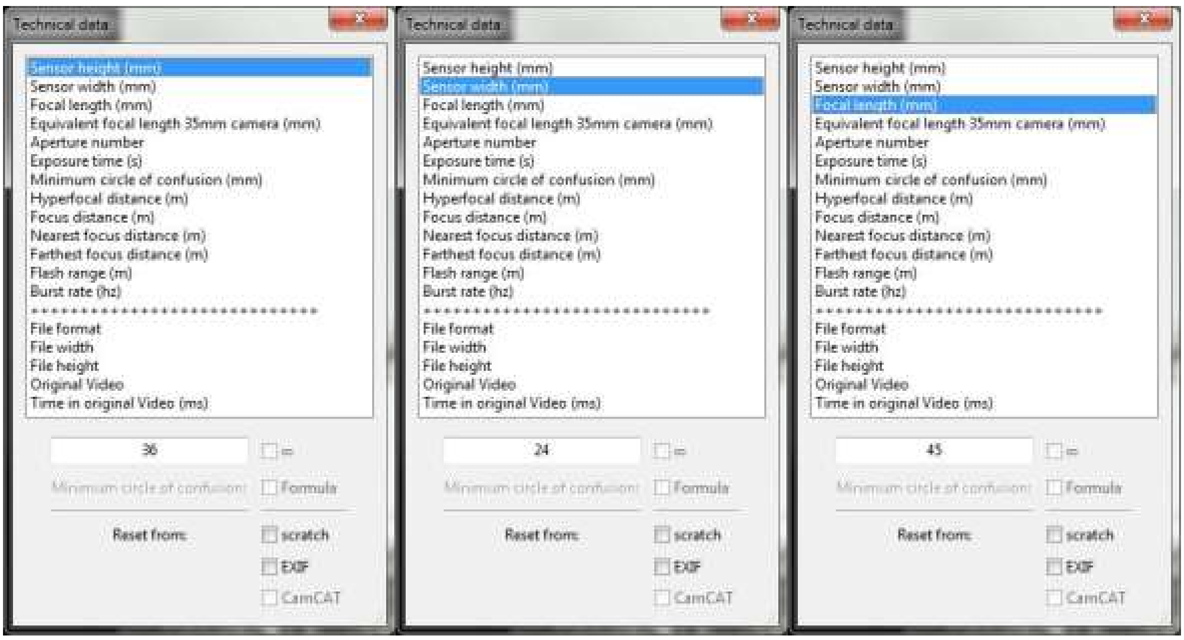
Initially, pictures **LC_3**, **LC_4**, **LC_5**, and **LC_6** were loaded into the dedicated software tool ***IPACO***, then the *Camera/Technical data* function was used to introduce the values of settings that are required for angular measurements.

The sensor's dimensions were known (24 mm x 36 mm), as well as the focal length (45 mm).

For LC_3 and LC_4 (landscape format photos):



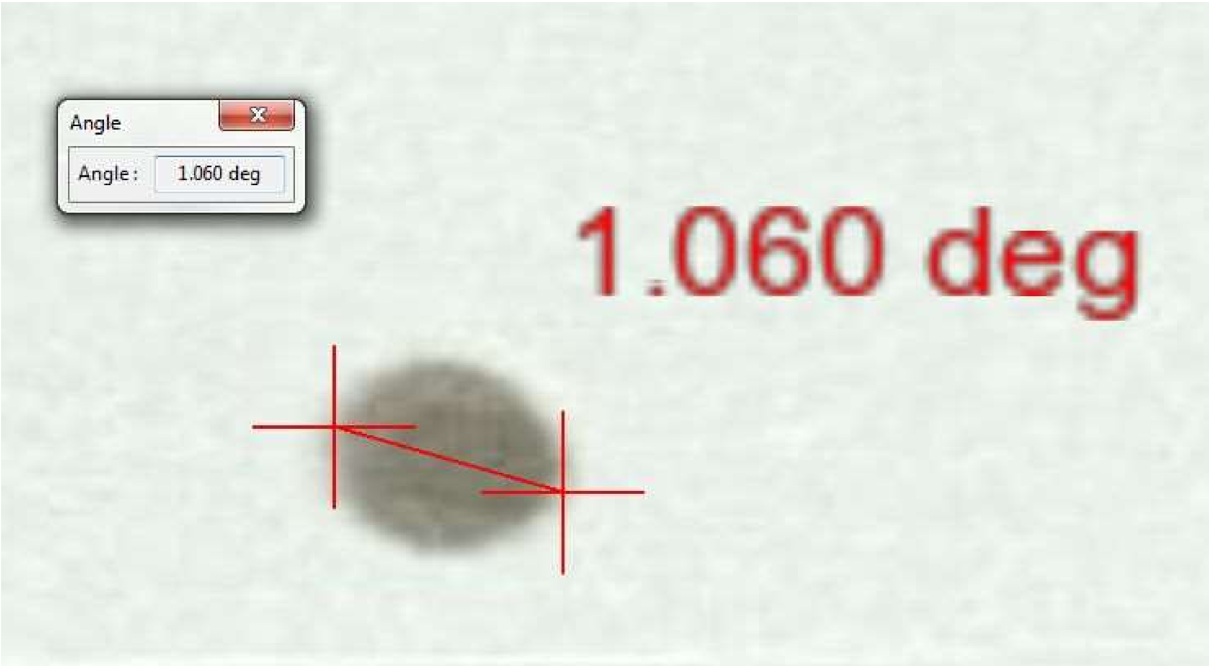
For LC_5 and LC_6 (portrait format photos):



Geometric study

Angular size of the UFO

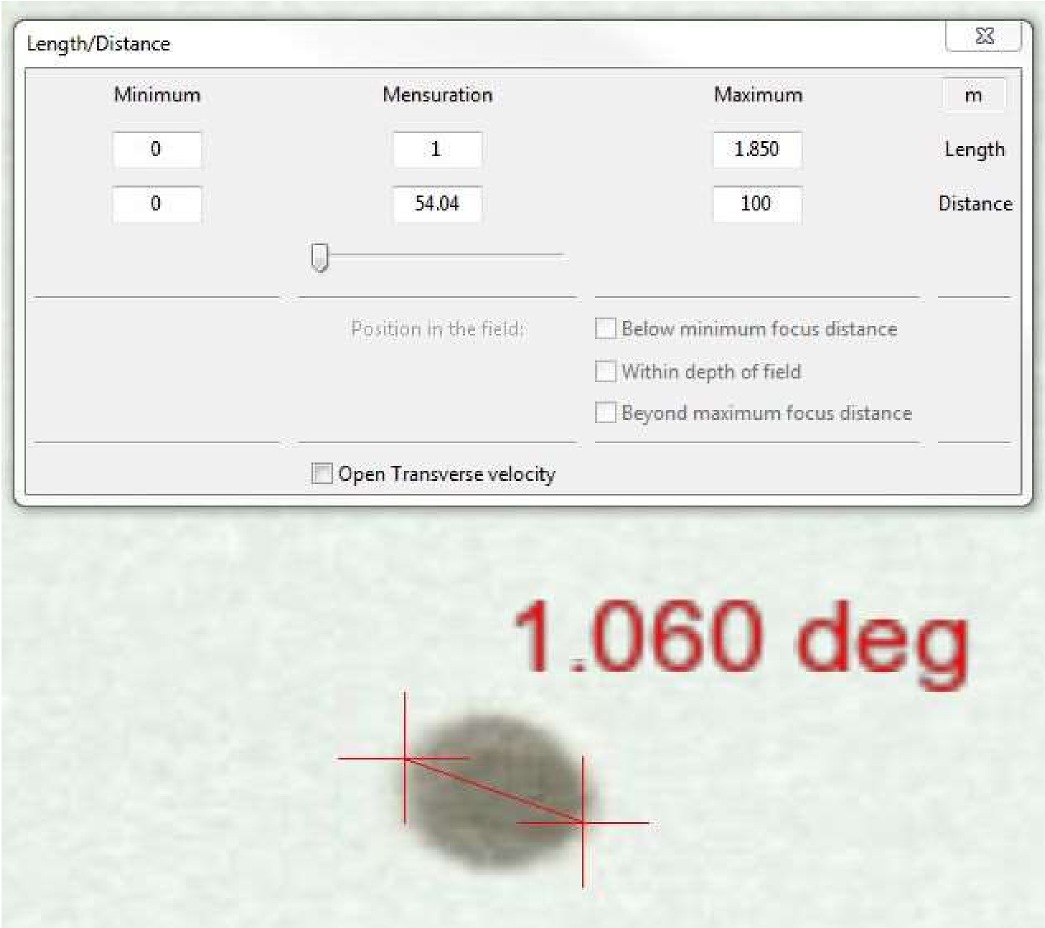
For each of the four images **LC_3**, **LC_4**, **LC_5** and **LC_6**, IPACO's *Angle* function was used in order to interactively measure the angle subtended by the diameter of the UFO's circular base:



Actually, several series of measurements were performed, using different screens, so as to take into account the interactive aspect of this operation. The following median results were retained for the angular size of the UFO's base:

On **LC_3**	:	1.06°
On **LC_4**	:	1.08°
On **LC_5**	:	0.93°
On **LC_6**	:	0.67°

On each of the four images, IPACO's *Length Distance* function was then used to measure the ratio between the UFO's diameter and its distance from the camera:



On **LC3**, one may notice, as shown above, that:

- if the UFO's distance from the camera was 100 m, its diameter was 1.85 m
- if the UFO's diameter was 1 m, its distance from the camera was 54.04 m

The following table gives, for different possible values of the UFO's diameter **Ø**, the respective values of the distance between the UFO and the camera in the four pictures:

Ø (m)	**LC3**	**LC4**	**LC5**	**LC6**
0.1	5.4 m	5.3 m	6.2 m	8.6 m
1	54 m	53 m	62 m	86 m
10	540 m	531 m	616 m	855 m
100	5404 m	5305 m	6161 m	8552 m

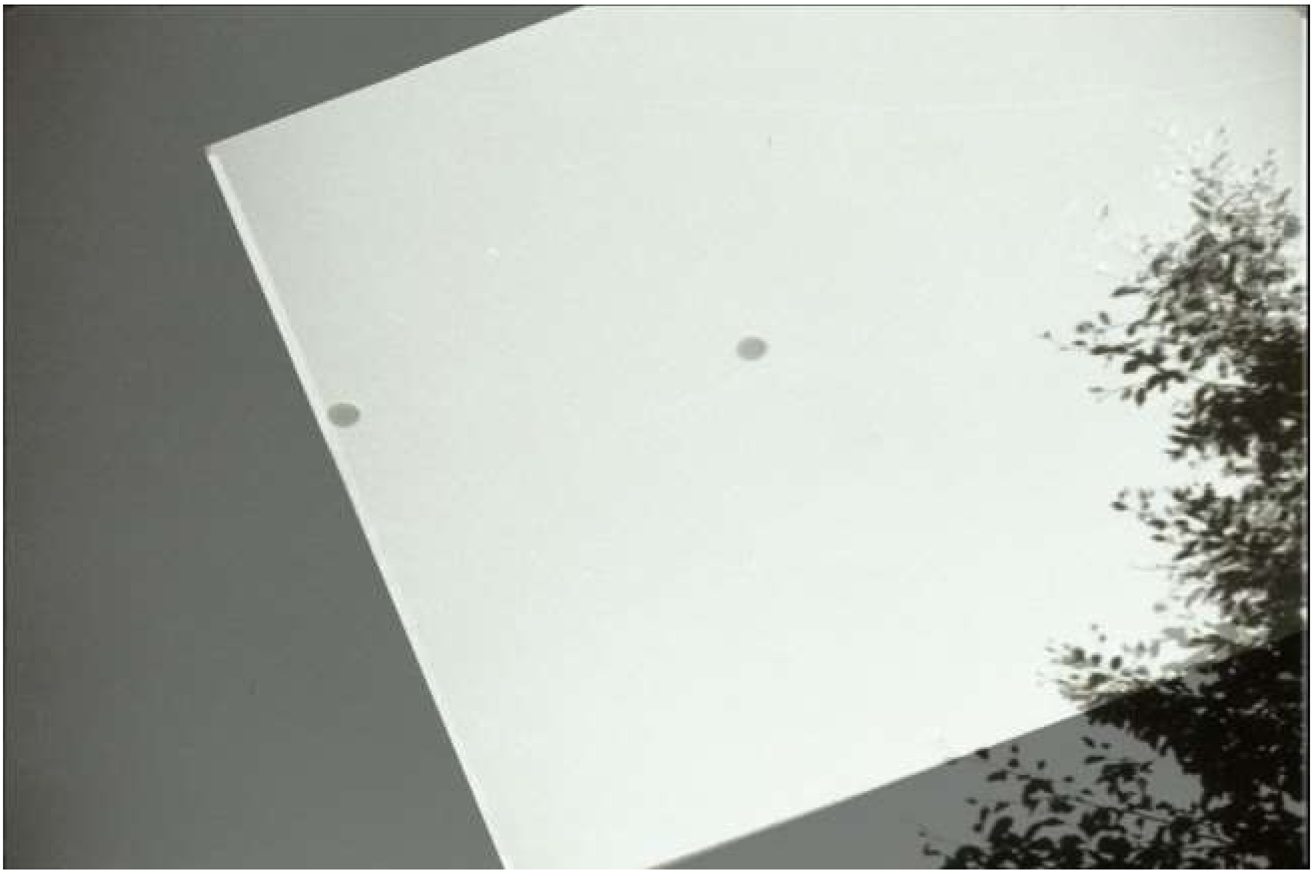
(Table 1)

It was therefore possible to establish the relative UFO–camera distance variations between the four photos. If this distance was equal to **d** on **LC3**, its respective values in the four photos were:

In **LC3** : d
In **LC4** : 0.98 d
In **LC5** : 1.14 d
In **LC6** : 1.58 d

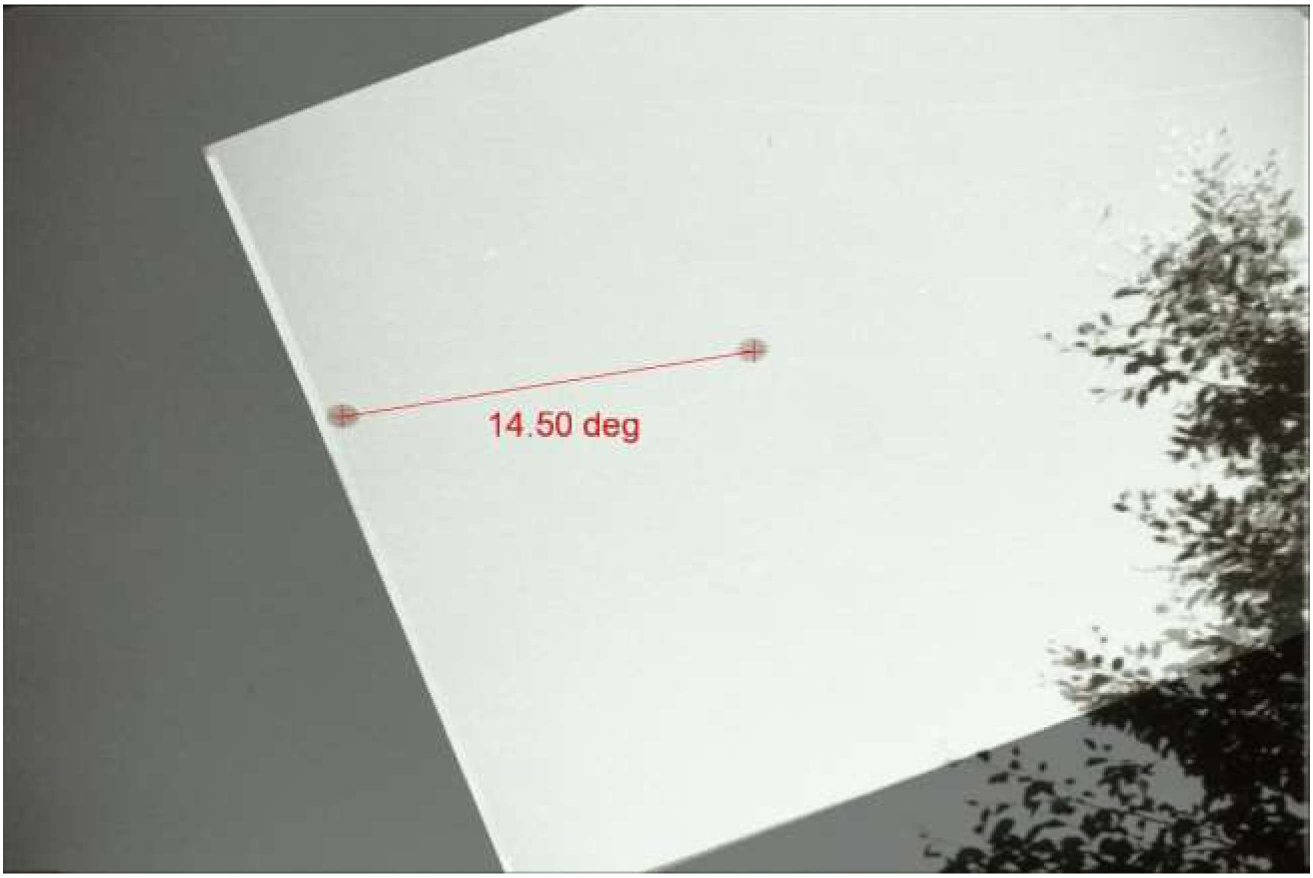
Angular displacement of the UFO between LC3 and LC4

On the first two images **LC_3** and **LC_4**, the same leaves are visible. IPACO's *3 points registration* function enabled the empirical registration of the two images through a linear geometric transformation based on three control points, providing then a composite image **LC_{3+4}** from the summation of the two registered images.



LC3+4 (1218 x 806 pixels)

After assignment to this mixed image of the same technical parameters as to images **LC₃** and **LC₄**, the *Angle* function provided the angular displacement covered by the UFO against the camera between the two shots:



Taking into account the empirical aspect of this registration, as well as the various uncertainties, a series of measurements was performed, with different choices for the three control points (same leaves identified on both photos). The results spread from 14.2° to 14.8°, and the following mean value was retained for the angular shift **a** between **LC₃** and **LC₄**:

a = 14.5°

Measurements inferred from the species of the trees

Trees are clearly visible on images LC_3, LC_4 and LC_6. A forest inventory of the Puy–de–Dôme French department, produced by the French IGN (National Geographic Institute), showed that in the early fifties, exclusively beeches were growing in this area, near Lac Chauvet, at an altitude of around 1200 m. A careful examination of the photographs confirmed this information *(see pictures below)*.

Beech Beech seen in **LC4**

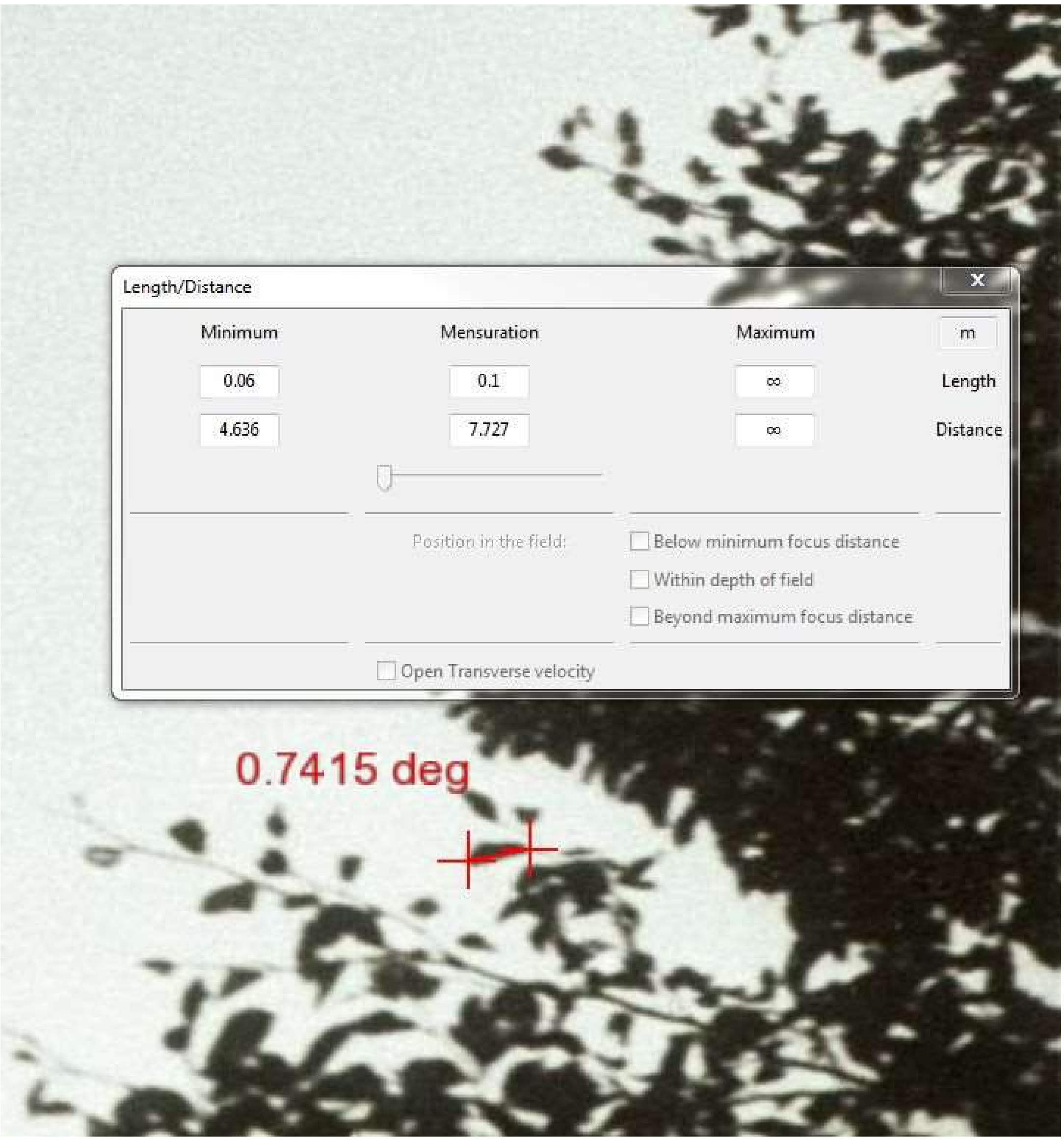
It is known that the mature leaves of a standard beech have a length of between 6 cm and 10 cm.

However, during the on–site mission, it was observed that, at this altitude, the leaves of the beeches were shorter than the expected average value of 8 cm.

A mean value of **6.5 cm** was therefore retained, allowing some useful parameters of the scene to be assessed.

Assessment of the distance from the camera to the trees

The distance between the camera and the observed beeches, in images LC_3, LC_4 (beech named "$Tree_{3\text{-}4}$" hereafter) and LC_6 (beech named "$Tree_6$" hereafter) respectively, could be assessed through IPACO's *Length/Distance* function, as follows:



Leaf of the beech $Tree_{3\text{-}4}$ in LC_4

The length of several leaves were measured this way on each of the images LC_3, LC_4 and LC_6, leading to the following median results for the distance from the camera to the beech as a function of the length of leaves:

Leaf's length	Distance in LC_3	Distance in LC_4	Distance in LC_6
6	5.2 m	5.0 m	8.7 m
6.5	**5.6 m**	**5.4 m**	**9.4 m**
8	7.0 m	6.6 m	11.6 m

(Table 2)

Position of the photographer

A close examination of the four images showed that the photographer had probably not shot all of the pictures in a standing position (high), since some of them were obviously taken in a kneeling position (low: nearer the ground).

LC_3-LC_4:

In the beginning of the Pathé movie, Mr. Frégnale was said to be exactly in the same position as one week before, when he had actually shot his first pictures.

Since he appeared kneeling in the movie, it was considered that his actual shooting position for the two first pictures was low.

LC_5:

At the end of the Pathé movie, Mr. Frégnale was shown taking pictures of a balloon, supposedly exactly under the original conditions. In this sequence, he was standing and holding his camera in "portrait format" (which did correspond to LC_5 and LC_6, the two other pictures LC_3 and LC_4 having been taken in "landscape format").

The picture he held in his hand in the movie, in order to compare it with that of a balloon, was precisely LC_5.

For this reason, it was considered that LC_5 had been shot in a high position.

LC_6:

A close examination of the grass in the foreground of picture LC_6 gave a strong impression of closeness, quite identical to that in the beginning of the Pathé movie, and clearly different from pictures shot later on site by members of the investigation team who were standing. The Pathé cameraman was definitely kneeling, like Mr. Frégnale, which explained the impression of the closeness of the grass in the movie.

For this reason, it was considered that LC_6 had been shot in a low position.

In order to assign figures it was assumed, on the basis of a standard male human size of 1.70 m, that the camera's two possible heights were:

- Standing position (high) : 1.60 m (LC_5)
- Kneeling position (low) : 1.00 m (LC_3, LC_4 and LC_6)

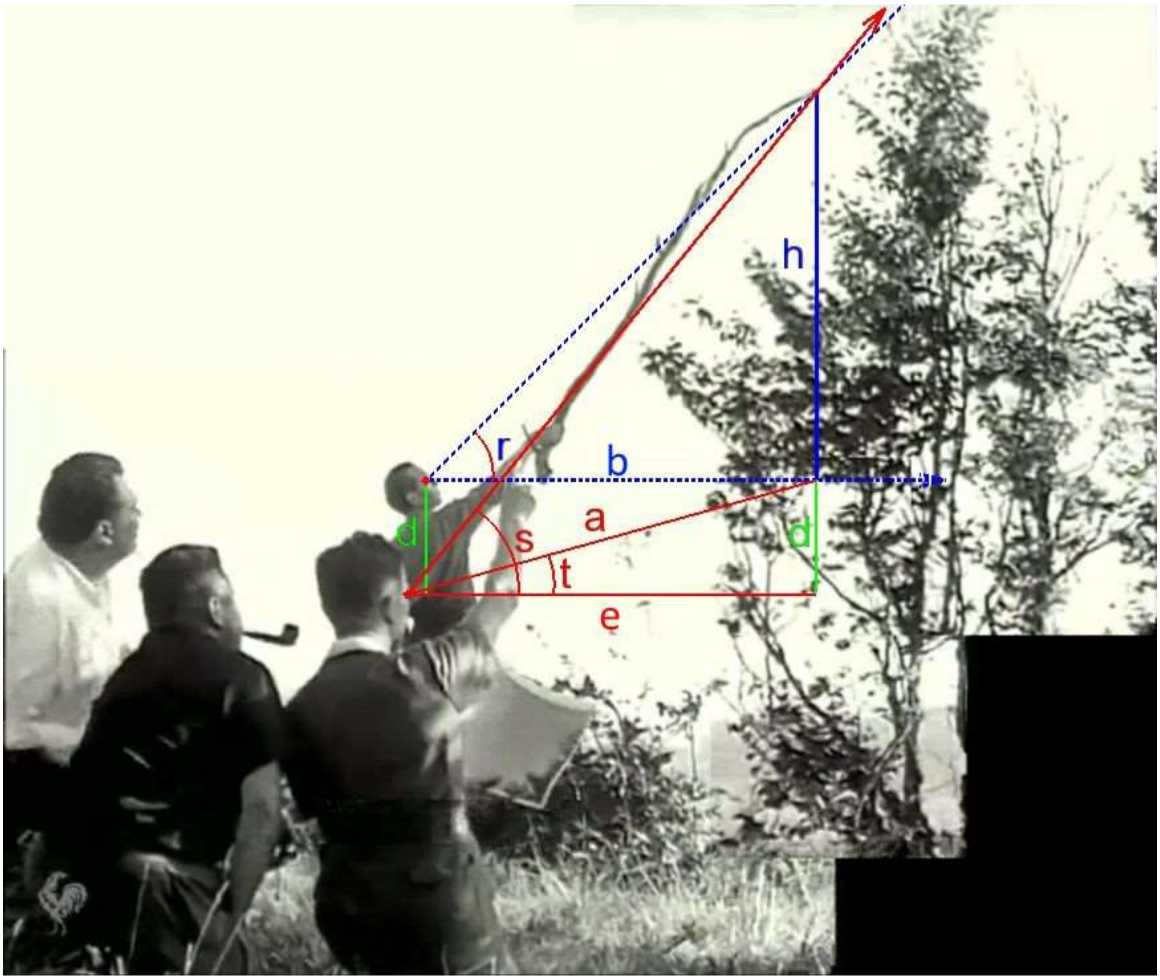
However, several series of computations were carried out with different combinations of these positions, which proved that this parameter had a very limited impact on the final results.

Elevation of the UFO

In LC_3

Considering the above–referenced *(p.6)* mosaiced image extracted from the Pathé movie, we could assess the UFO's elevation angle α on the basis of the following assumptions and of the following sketch:

- The witness Mr. Frégnale (the man on the right in the foreground) was kneeling in the very place from which LC_3 was shot, giving indications to the assistant who held a stick.
- The stick's end gave the UFO's direction as seen from the witness, at the time of LC_3.
- The assistant's arm and the stick he was holding were in a vertical plane V perpendicular to the Pathé camera's line of sight, therefore quasi–perpendicular to the vertical plane containing the respective heads of the witness and of the same assistant.
- This assistant's arm (from shoulder to the end of fingers) had a standard length for a man: 65 cm.
- The height difference **d** between the respective heads of the assistant (standing) and Mr. Frégnale (kneeling), i.e. between high and low positions (*see above*), was equal to 60 cm.



We measured the angle **r** on the image:

$r = 45°$

Thus:

$b = h$

In the vertical plane V, we could infer from the arm's length the value of **b**:

$b = h = 2.0$ m

The distance **a** from the witness to the middle of $Tree_{3\text{–}4}$ in LC_3 had already been assessed *(see Table 2)*:

$a = 5.6$ m

The elevation angle **s** was computed as follows:

$t = \arcsin (d / a)$
$e = a \cos (t)$
$s = \arctan [(h + d) / e]$

$s = \arctan \{(h + d) / a \cos [\arcsin (d / a)]\}$

UFO's elevation from the camera in LC_3 = **25°**

In LC_6

In order to assess the elevation angle of the UFO seen from the camera in image LC_6 (the only one, out of the four, for which it was directly possible), the tree on the left was considered, since this was certainly the $Tree_6$ beech. The goal was to determine, in the vertical plane containing the UFO and the camera, a point in the horizontal plane of the camera (height **h**), then to measure the elevation angle between this point and the UFO.

The camera's height **h** was taken to be equal to that of the above-defined "low position" (kneeling position):

$h = 1$ m

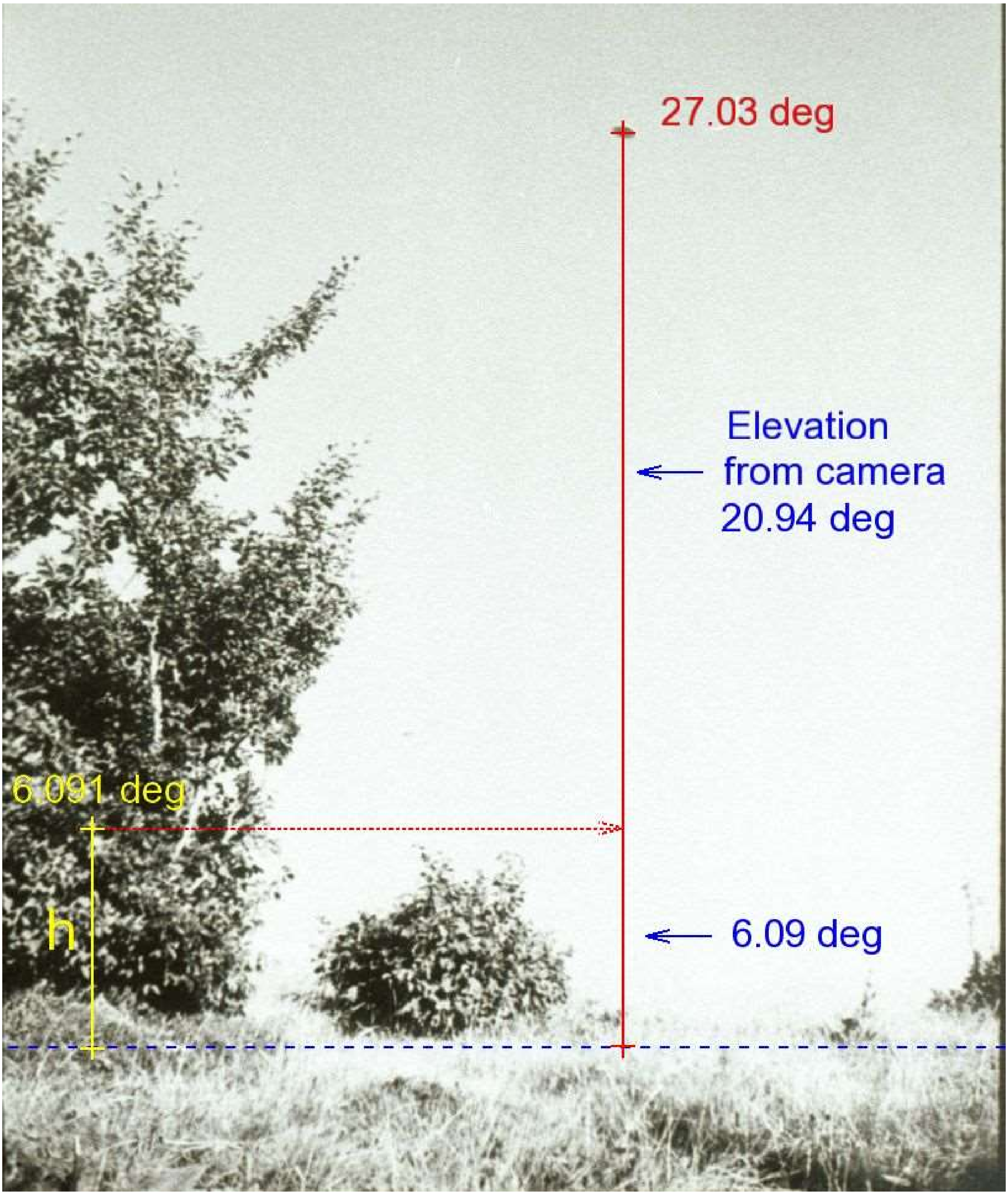
Considering the leaves' length of 6.5 cm and the derived distance of 9.4 m between the camera and the tree *(Table 2)*, the angular height corresponding to the altitude **h** of the camera reported on the tree could be computed:

$2 \arctan [(1/2) / 9.4] = 6.09°$

leading to the following assessment:

UFO's elevation from the camera in LC_6 = 27.03 – 6.09 **= 20.9°**

as illustrated by the following screen capture from IPACO:

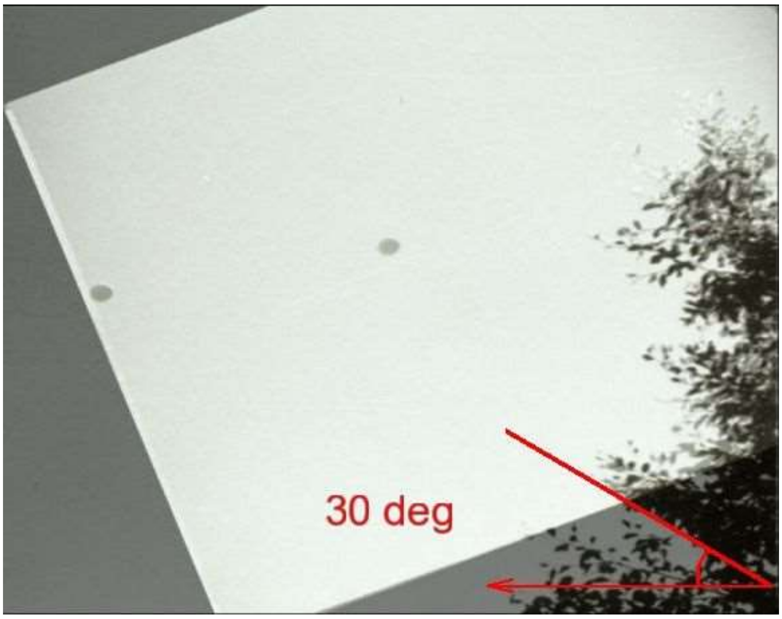

27.03 deg
Elevation
from camera
20.94 deg
6.091 deg
h
6.09 deg

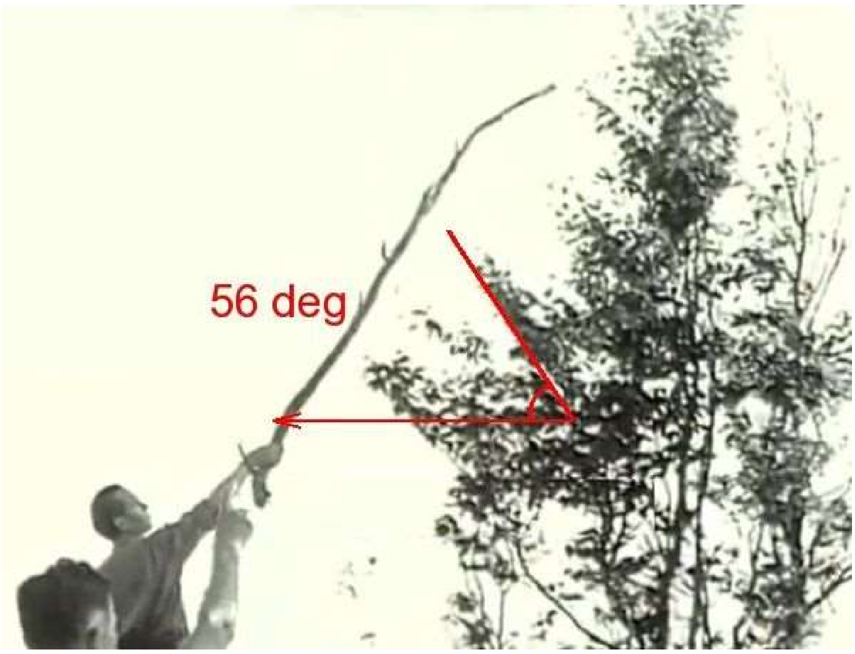
Respective tilt angles of the photographs

LC_{3+4}

The only available point of comparison with LC_{3+4} was the extracted image from the Pathé movie, showing the same tree, photographed from nearly the same location.

Assuming that this picture was horizontal, a given well–contrasted branch was identified, approximately orthogonal to the line of sight, in both this extracted image and the composite LC_{3+4} image:





From the two measured angles, we inferred the tilt angle of LC_{3+4}:

Tilt angle = 56 – 30 = **+26°**

LC_5

The only reference in this image is the stratified cumulus observed at the bottom. The lower side of such a cloud being normally horizontal, we could assess a reasonable value for the tilt angle of LC_5:

Tilt angle = **–3°**

LC_6

Previous investigators tried to demonstrate that LC_6 had to be tilted by an angle, the value of which varied inside a wide range, either clockwise or anticlockwise.

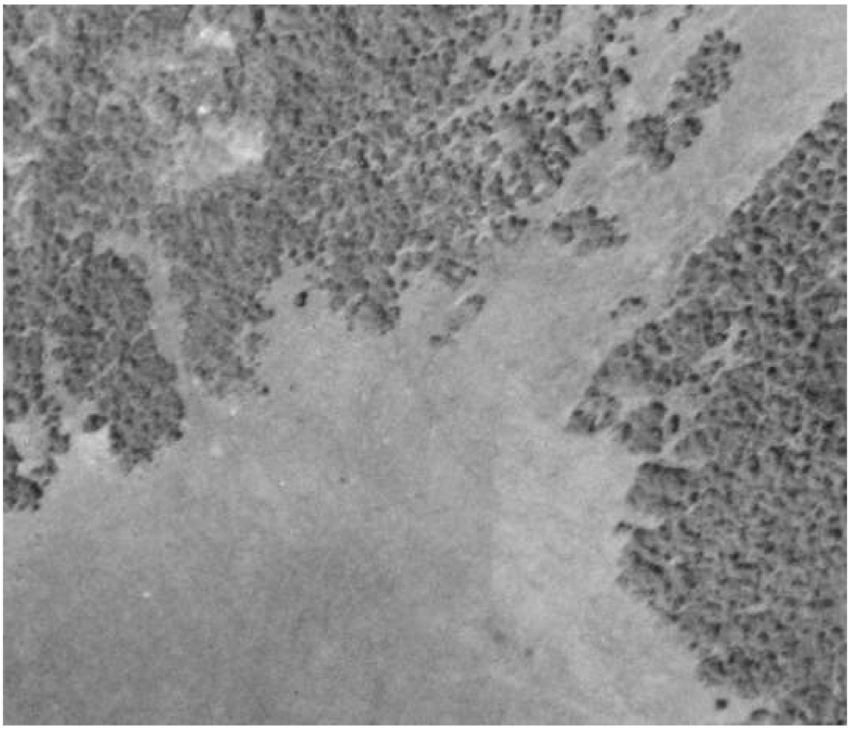
We preferred to stick to our initial impression that this photograph was approximately horizontal, which seemed normal from a professional photographer in front of such a landscape:

Tilt angle = **0°**

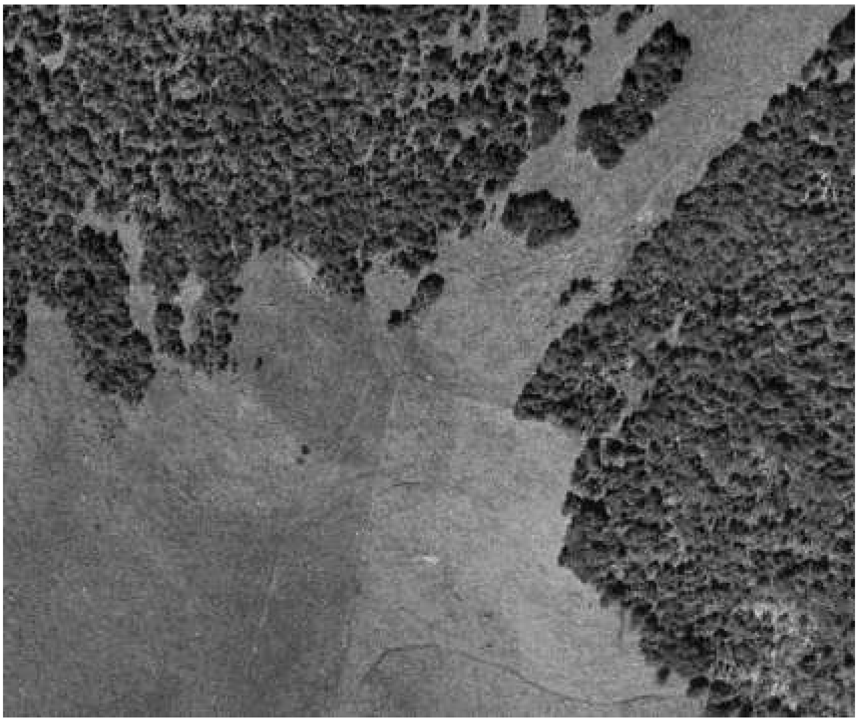
Layout of the sighting

All details about the on-site investigations that led to an accurate localization of the sighting are provided in the *Annex*.

Three aerial photographs from IGN (French National Geographic Institute), respectively dated 1955, 1968 and 2009, were used to display the area concerned:



1955



1968

2009

The third image is the most accurate, enabling later computations. It was obtained through the *Géoportail* website. The three images are properly oriented north to the top.

It was immediately noticed that a significant portion of the trees had been cleared between 1968 and 2009.

Several remarkable features of the scene were easily recognized and used as references in several pictures *(see Annex from p.112)*:

– The "Piccoli rock": this is the biggest rock in the whole area, visible on the three IGN pictures as well as on the Pathé movie, photographed by Raymond Piccoli in July 2008 and by the on–site investigation team in July 2015 *(see Annex p.102)*.

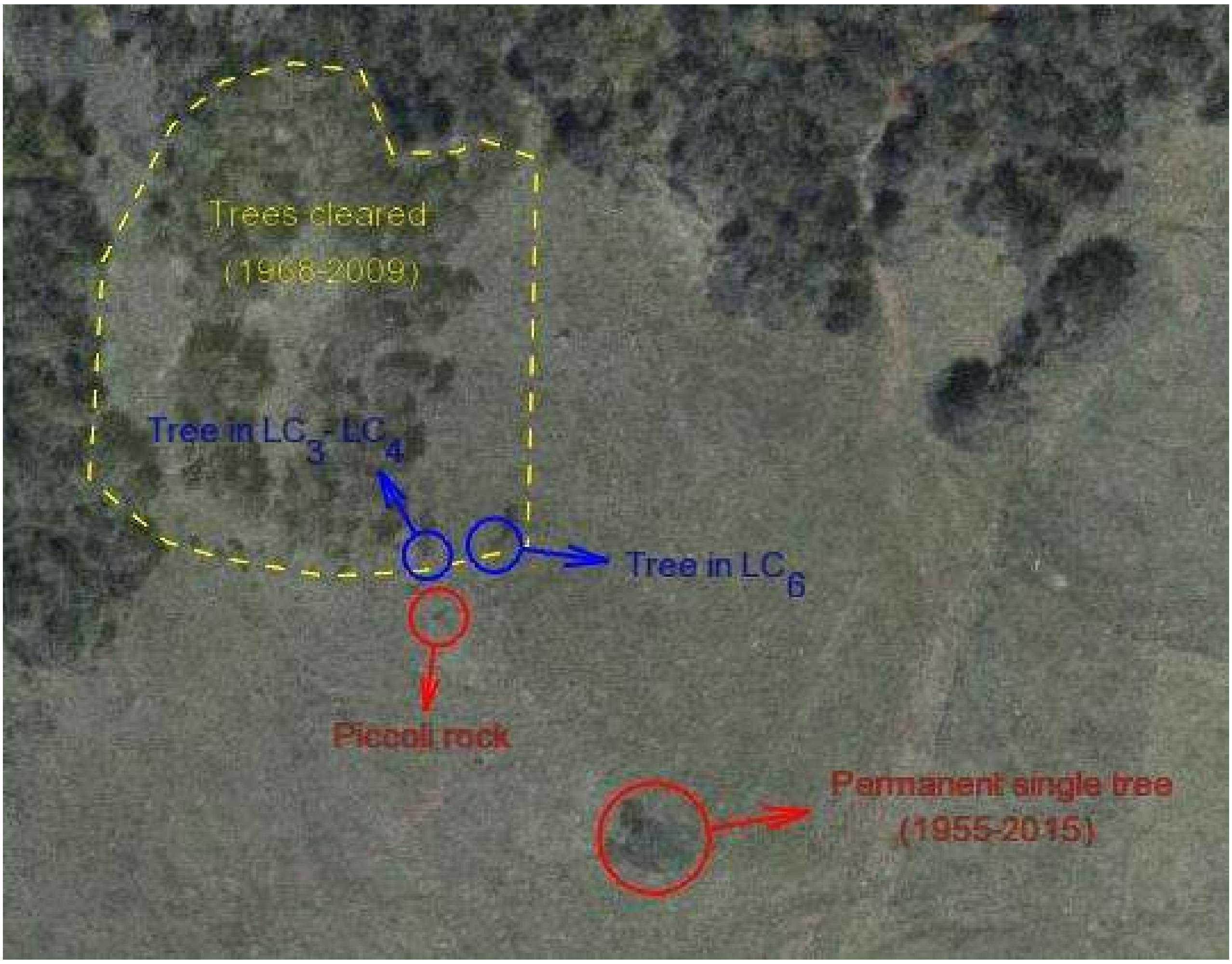
– A permanent single tree, which obviously has not changed since 1955.

– The $Tree_{3-4}$ beech displayed in LC_3 and LC_4, visible on IGN pictures dated 1955 and 1968, as well as on the Pathé movie.

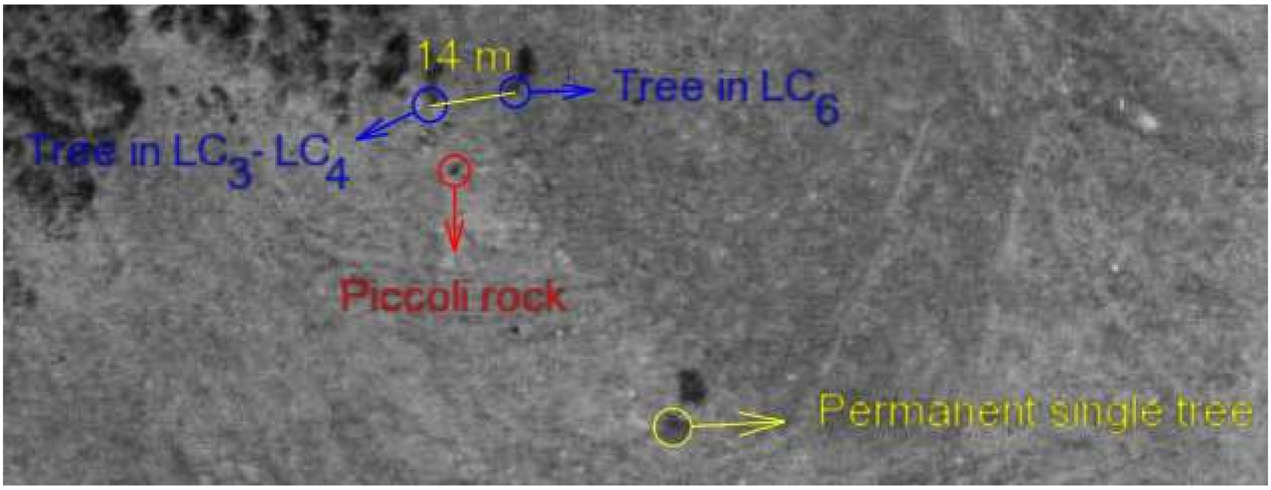
– The $Tree_6$ beech displayed in LC_6, visible on IGN pictures dated 1955 and 1968.

In order to enable mensuration, the two IGN pictures dated 1968 and 2009 were registered through IPACO. Then, using the *Géoportail* standard facilities with the 2009 picture, we could measure the distance between $Tree_{3-4}$ and $Tree_6$ on the 1968 picture.

This two–step process was illustrated as follows:



Registration (1968 + 2009)



Mensuration

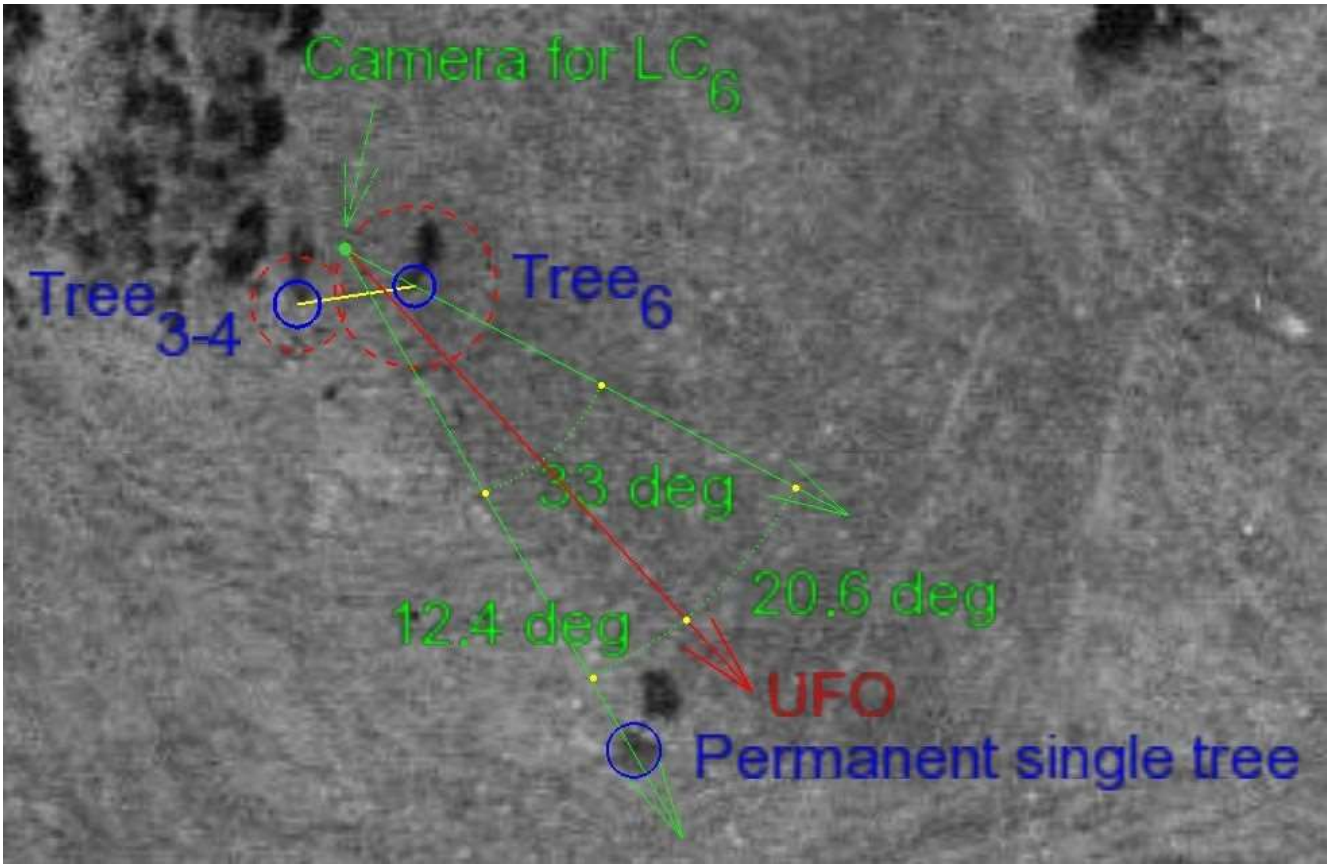
Distance $Tree_{3-4}$–$Tree_6$ **≈ 14 m**

After closer examination of picture LC_6, it appeared that, besides $Tree_6$ on the left side, what looked like a bush in the bottom right corner could, in fact, only be the top of the "permanent single tree". The angular distance between this tree and $Tree_6$ could therefore be assessed in LC_6.

LC_6

This assessment of the angular distance of 33° could only be approximate, however it was established later that the corresponding induced uncertainty had a very limited impact on final results.

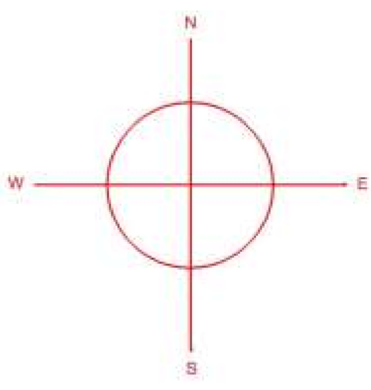
This angle value was used with the 1968 picture in order to determine the camera's position when picture LC_6 was shot.



The camera's position associated with LC_6 was located as being somewhere on the circumference of the right red dotted circle *(see sketch above)*, which indicates its already computed distance from $Tree_6$ (9.4 m: *see Table 2, p.16*). The point of this circle that complied with the condition of a 33° angle between the permanent single tree and $Tree_6$, as seen from the camera, was indicated in green ("Camera for LC_6").

The camera's position associated with LC_3 was located somewhere on the circumference of the left red dotted circle (see sketch above), which indicates its mean computed distance from $Tree_{3-4}$ (5.5 m). A three–step elimination process enabled us to reduce the possible parts of this circle that did comply with environmental constraints.

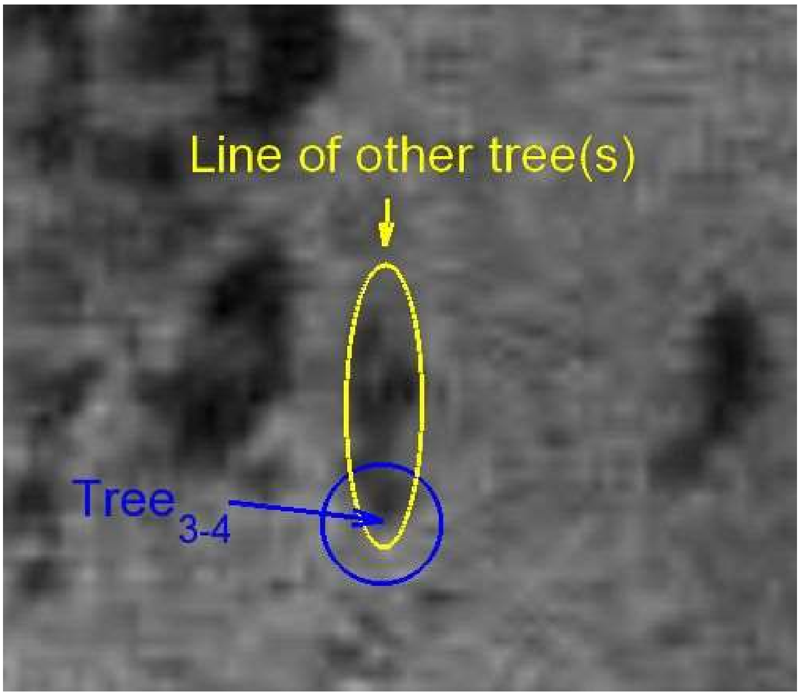
The initial open range of solutions was the whole circle:



Step 1

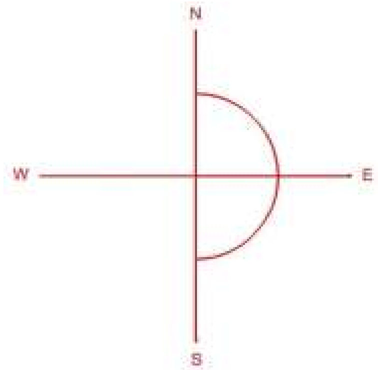
As shown in the Pathé movie, there was at least one more tree next to Tree$_{3-4}$:

This (these) tree(s) was (were) located on a line from Tree$_{3-4}$ to the North, as can be seen in the IGN 1968 picture:



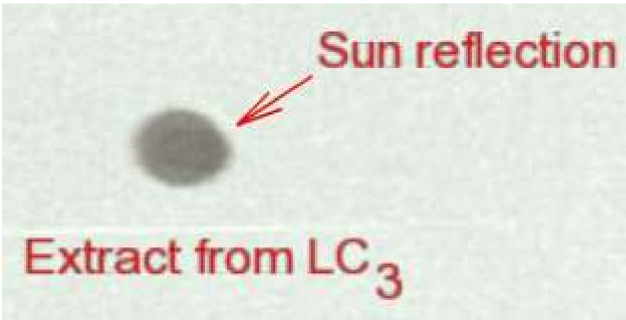
Bearing in mind that, in LC$_3$, Tree$_{3-4}$ is visible on the right side of the picture, the camera's line of sight could only be toward West (azimuth between 180° and 360°). Otherwise, the other tree(s) would have been visible in LC$_3$.

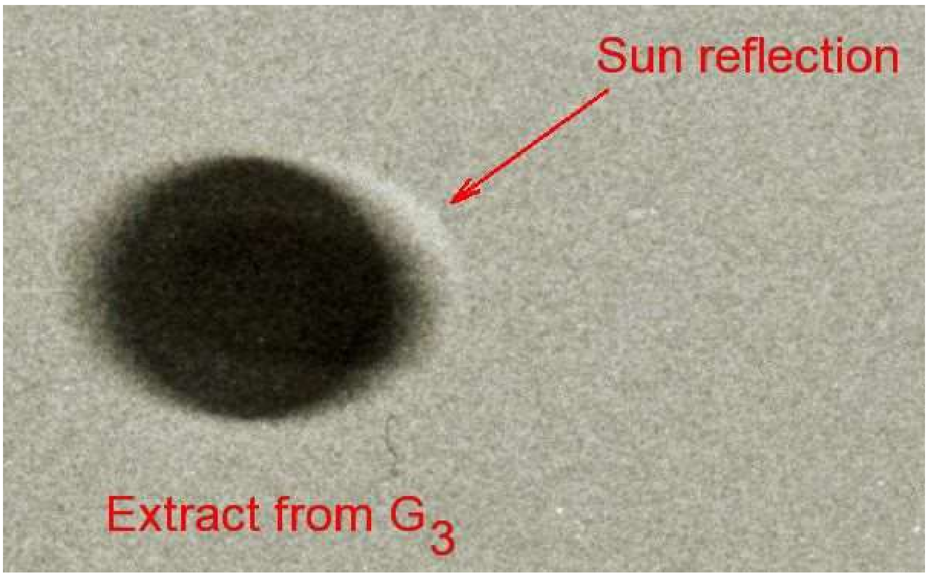
At this point, the remaining range of possible solutions was:



Step 2

At the time of the sighting (1952:07:18 17:10 GMT), the azimuth of the Sun was in the west. From the reflection of the Sun on the right side of the UFO in picture LC$_3$, we could infer that the UFO's line of sight from the camera could only be toward South (azimuth between 90° and 270°).





The azimuth angle difference between the UFO and $Tree_{3-4}$ in LC_3 could be measured:

LC_3

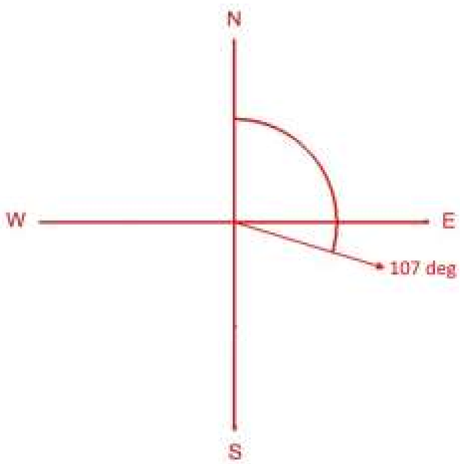
From this we could infer the possible azimuth range for $Tree_{3-4}$'s line of sight corresponding to the above–mentioned azimuth range for the UFO's line of sight between 90° and 270°:

from	:	90 + 17 = 107°
to	:	270 + 17 = 287°

The camera's position on the circle could only correspond to an angle between:

107 – 180 = –73°   and   287 – 180 = 107°

At this point, the remaining range of possible solutions was:



Step 3

The exact coordinates of the Sun at the time of the sighting could be obtained through Stellarium:

Azimuth of the Sun : 277.56°

Elevation of the Sun : 22.46°

It had already been established (*see p.19*) that in LC_3, the UFO's elevation was equal to 25°. Therefore, if the azimuth range of this picture had comprised the Sun's azimuth, then the Sun would have been clearly seen in this picture.

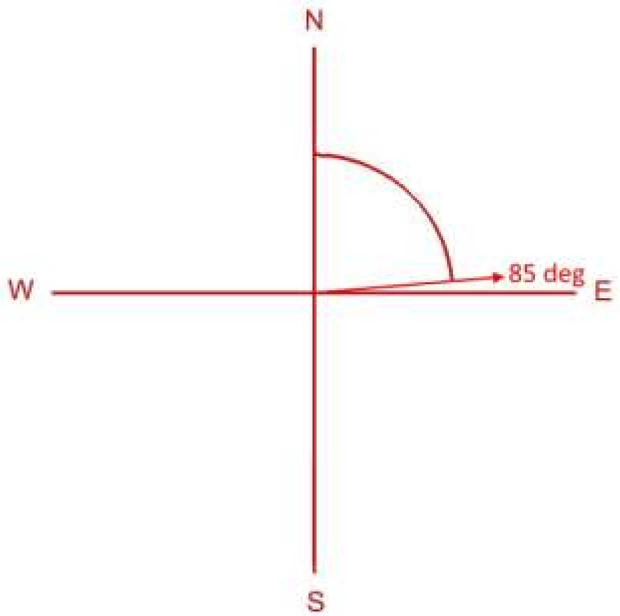
This meant that the azimuth of the right side of the LC_3 picture was necessarily less than 277.56°, and therefore that the tree's azimuth in LC_3 was necessarily less than the same value minus the azimuth distance between the respective lines of sight of $Tree_{3-4}$ and of the right side of LC_3 *(see sketch p.30)*:

$$277.56 - 12.41 \approx 265°$$

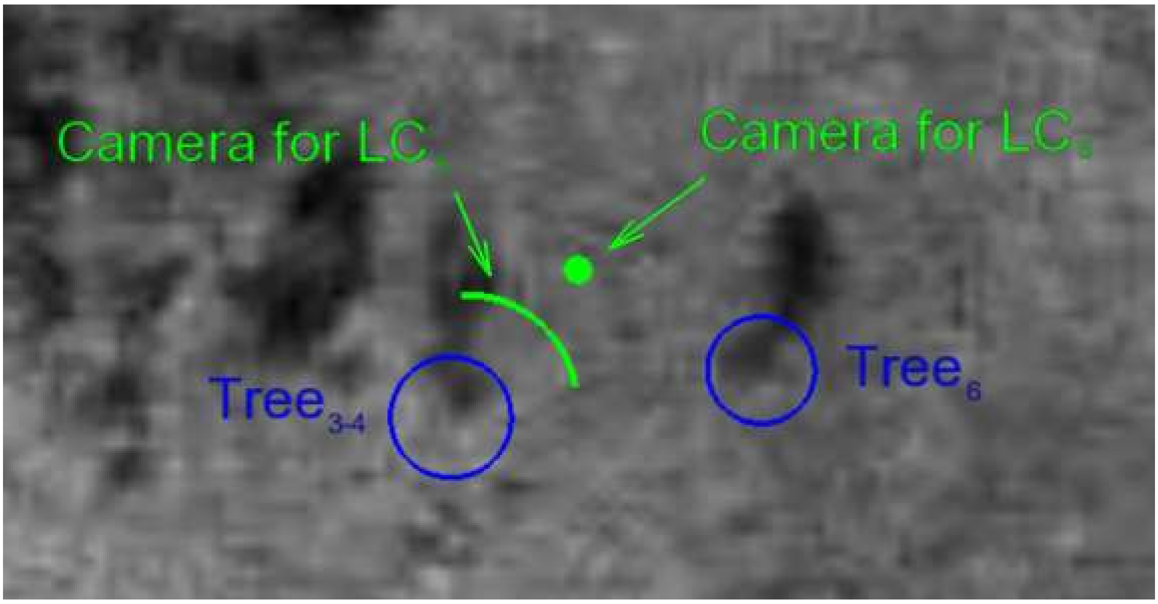
The camera's position on the circle could only correspond to an angle less than:

$$265 - 180 = 85°$$

In the end, the remaining range of solutions was:



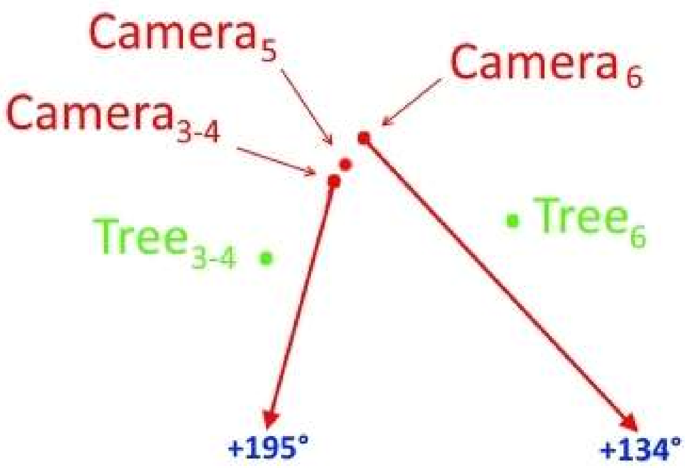
The conclusions about the layout of the sighting can be illustrated as follows:



In order to make further computations possible, without introducing significant errors, the following was assumed concerning the successive positions of the camera, projected on a horizontal plane:

- LC_3 : the camera's position $Camera_3$ was in the middle of the previously defined arc of a circle of 85°
- LC_4 : $Camera_4$ was about identical to $Camera_3$
- LC_5 : $Camera_5$ was one third of the way from $Camera_4$ to $Camera_6$ (roughly proportional to the assessed elapsed times between successive shots)
- LC_6 : $Camera_6$ had been determined previously

Taking into account the known differences in azimuth between the UFO and the reference trees in each of the pictures, we could easily derive the azimuth angles of the respective UFO's lines of sight in pictures LC_3 and LC_6, as displayed below in projection on a horizontal plane:



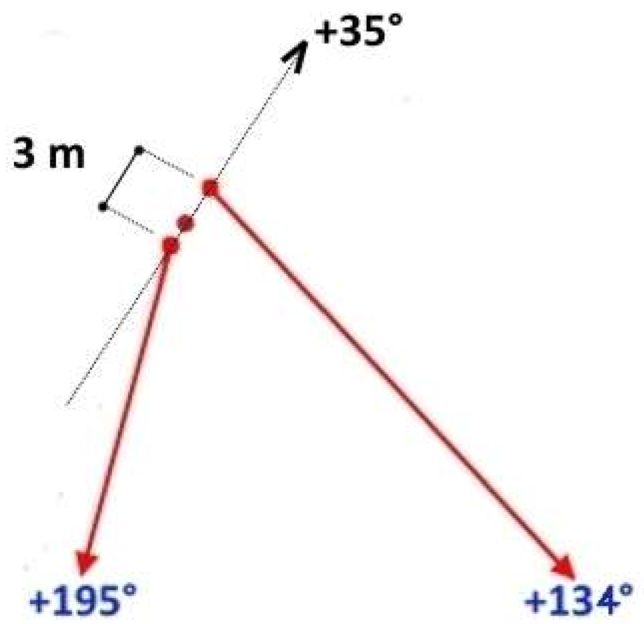
The horizontal distances between the three successive positions of the camera, as well as the azimuth of their alignment, could then be measured:

Horizontal distance Camera$_{3-4}$–Camera$_6$ **≈ 3m**

Horizontal distance Camera$_{3-4}$–Camera$_5$ **≈ 1 m**

Horizontal distance Camera$_5$–Camera$_6$ **≈ 2 m**

Azimuth of vector Camera$_{3-4}$–Camera$_6$ **≈ 35°**



Mosaicing the four images for a straight trajectory

Angular shift of the UFO during the whole sequence

At this point, some assumptions were required in order to go any further.

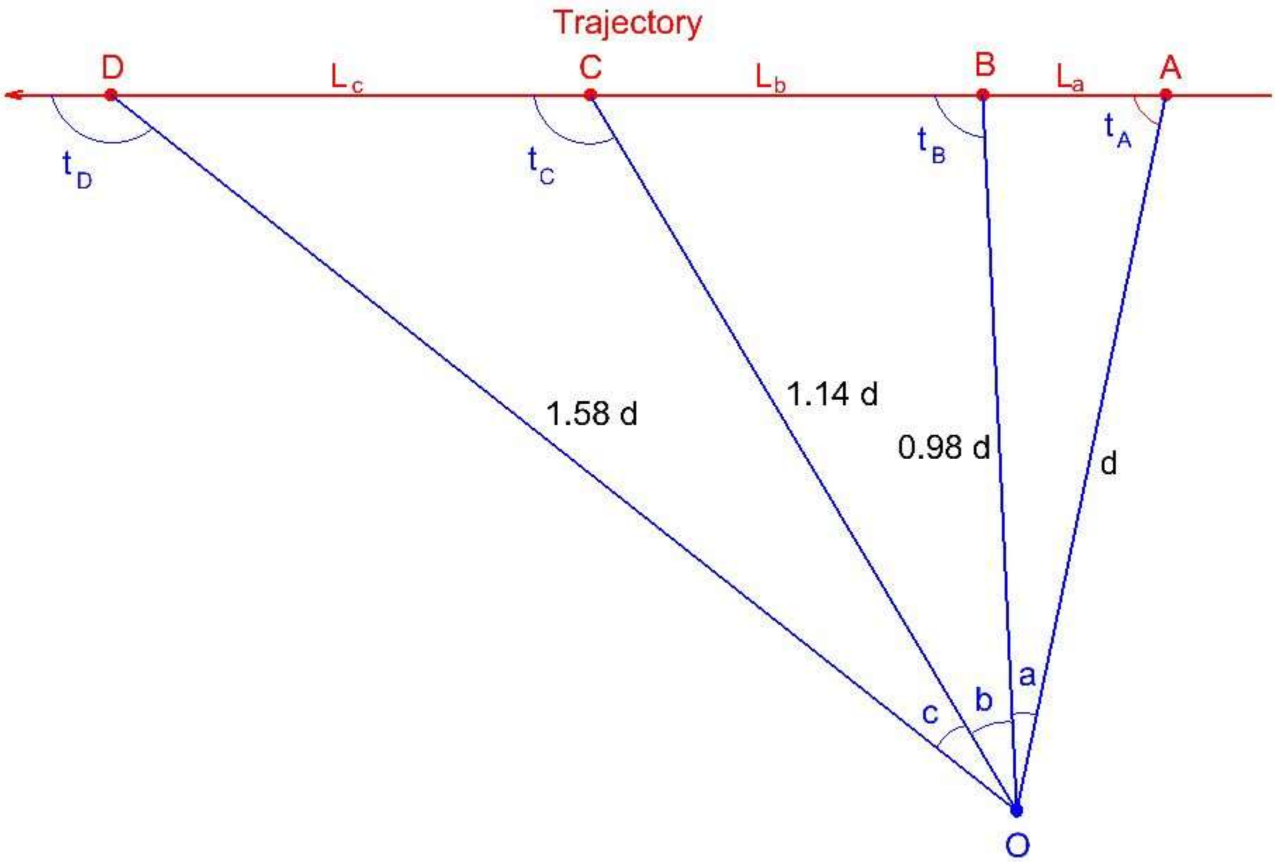
Assumption 1: the UFO was remote *(more than 30 meters from the camera)* ***and moved along a straight line*** *(according to the witness)*

The UFO being far enough from the camera, the camera's position could be considered fixed during the whole event, for geometric computations.

On the basis of the previously mentioned parameters, it was possible to reconstruct, but for a homothetic transformation, the scene's geometry in the plane defined by the camera's position and the straight trajectory of the UFO.

Significant points were respectively named as follows:

O	:	Position (assumed fixed) of the camera in the 3–D space
A	:	Position of the UFO in the 3–D space at the time of shot **LC_3**
B	:	Position of the UFO in the 3–D space at the time of shot **LC_4**
C	:	Position of the UFO in the 3–D space at the time of shot **LC_5**
D	:	Position of the UFO in the 3–D space at the time of shot **LC_6**



The following calculations enabled determination of angles **t_A**, **t_B**, **t_C**, **t_D** and **a**, **b**, **c**, as well as lengths **L_a**, **L_b**, **L_c**, expressed as a function of **d**.

The **a** angle had already been measured: **a** = 14.5°

The application of the generalized Pythagoras theorem to the triangle OAB allowed the following successive calculations to be performed:

$$\mathbf{L_a} = \sqrt{[d^2 + (0.98\ d)^2 - 2 \times d \times 0.98\ d \times \cos(14.5°)]} \quad = 0.2507\ \mathbf{d}$$

and:

$$\mathbf{t_A} = \arccos \{[L_a^2 + d^2 - (0{,}98\ d)^2] / [2\ d \times L_a]\} \quad = 78.210°$$

$$\mathbf{t_B} = a + t_A = 92.71°$$

The same theorem was successively applied to triangles OBC and OCD, leading to the following set of results:

$\mathbf{t_A}$ = 78.21°	**a** = 14.50°	$\mathbf{L_a}$ = 0.2507 d
$\mathbf{t_B}$ = 92.71°	**b** = 28.12°	$\mathbf{L_b}$ = 0.5379 d
$\mathbf{t_C}$ = 120.8°	**c** = 20.89°	$\mathbf{L_c}$ = 0.6560 d

At last, the angle $\mathbf{t_D}$ was directly derived from **c** and $\mathbf{t_C}$:

$$\mathbf{t_D} = 141.7°$$

At this point, one could consider a second assumption, so as to estimate the timing of the four shots:

Assumption 2: the UFO was moving at a constant speed, during a total duration of 25 s *(according to the witness)*

Derived timing:

Between LC_3 and LC_4	:	4.3 s
Between LC_4 and LC_5	:	9.3 s
Between LC_5 and LC_6	:	11.4 s
Total	:	25 s

This did not quite match with what the witness had reported (regular intervals).

Representation of a straight trajectory by a mosaic

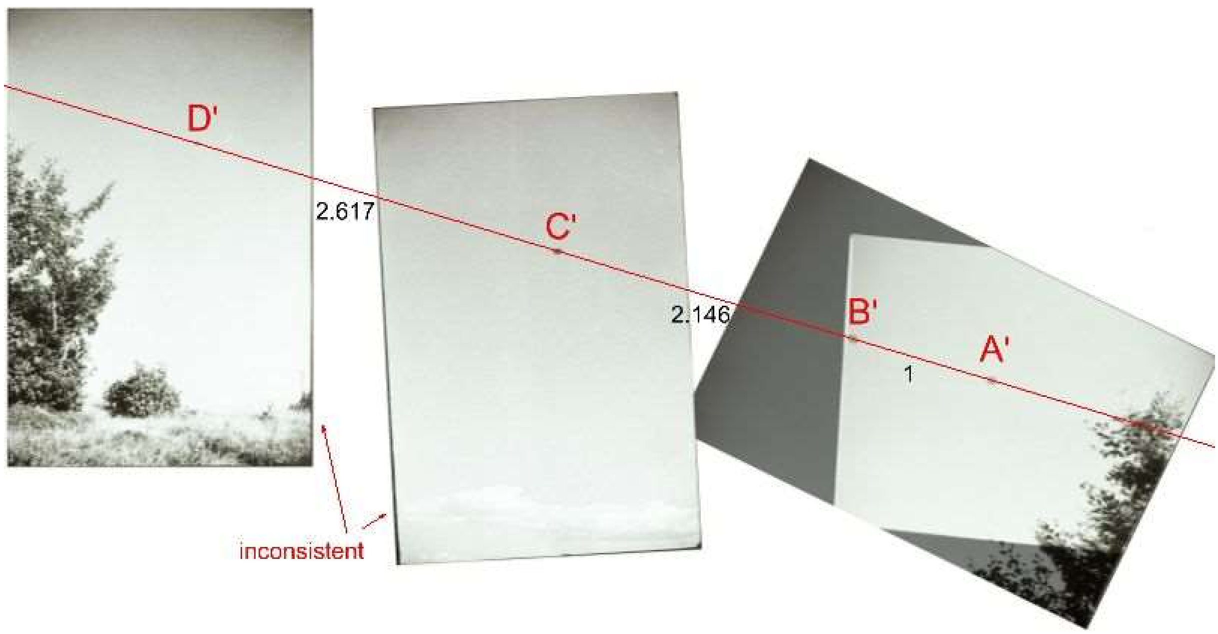
Had the four photos contained common elements of the landscape, then it would have been possible to register them, as has been done for LC_3 and LC_4, then to build a mosaic, on which it could have been checked whether the four successive positions of the UFO were actually in a straight line, at distances according to the proportions between $\mathbf{L_a}$, $\mathbf{L_b}$ and $\mathbf{L_c}$.

This was not the case. However, one could reasonably assume that registration operations would only consist, for each image, of a translation and a rotation (the witness had not moved significantly), as could be checked while registering LC_3 and LC_4.

In other words, starting from the composite image **LC_{3+4}** resulting from the registration of **LC_3** and **LC_4**, showing the two first positions of the UFO separated by the distance **L_a**, it was possible to locate images **LC_5** and **LC_6** in translation, in the form of a mosaic, taking into account the respective positions of the center of the UFO along the straight trajectory described in the diagram above, as well as the tilt angle applied to each image, as explained in a previous section.

The mosaic is equivalent to a virtual single wide–angle ideal photograph ("pinhole" type) supposedly built in a vertical plane parallel to the vertical plane of the trajectory. In the plane of the mosaic, the successive locations of the projection of the UFO's center were named A′, B′, C′ and D′. The lengths of segments A′B′, B′C′ and C′D′ in the image were respectively proportional to the lengths of segments AB, BC and CD in the 3–D space:

$$B'C'/A'B' = L_b/L_a = 2.146$$
$$C'D'/A'B' = L_c/L_a = 2.617$$



<u>Note</u>: Such a simple mosaic could not pretend to be totally realistic, since only relative positions of points A′, B′, C′ and D′ were correct. Each of the individual pictures had been created in a particular (focal) plane, not parallel to the mosaic's plane, and should have undergone a particular transform (mainly a 3–D rotation around the UFO's position) before being projected on the mosaic's plane, so as to produce a more realistic sketch.

At this point it became clear that this problem had <u>no solution</u>, because whatever the additional rotation to be applied to LC_5 and LC_6, the landscapes in the lower parts of LC_5 and LC_6 appeared definitely inconsistent in this mosaic.

This implied that <u>Assumption 1</u>, required for the sake of calculations, was <u>not</u> correct, in spite of the testimony (without eliminating necessarily the witness's good faith):

The trajectory could not be remote and along a straight line.

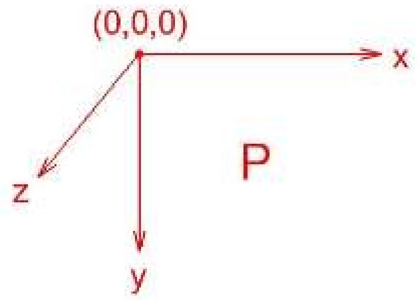
Obviously, the real trajectory was somewhat curved downwards. Then the most natural simple model consisted of an arc of a parabola with a vertical axis (accurate model in the case of a passive object thrown in the air), since the wind's impact could be considered as negligible.

Mosaicing the four images for a parabolic trajectory

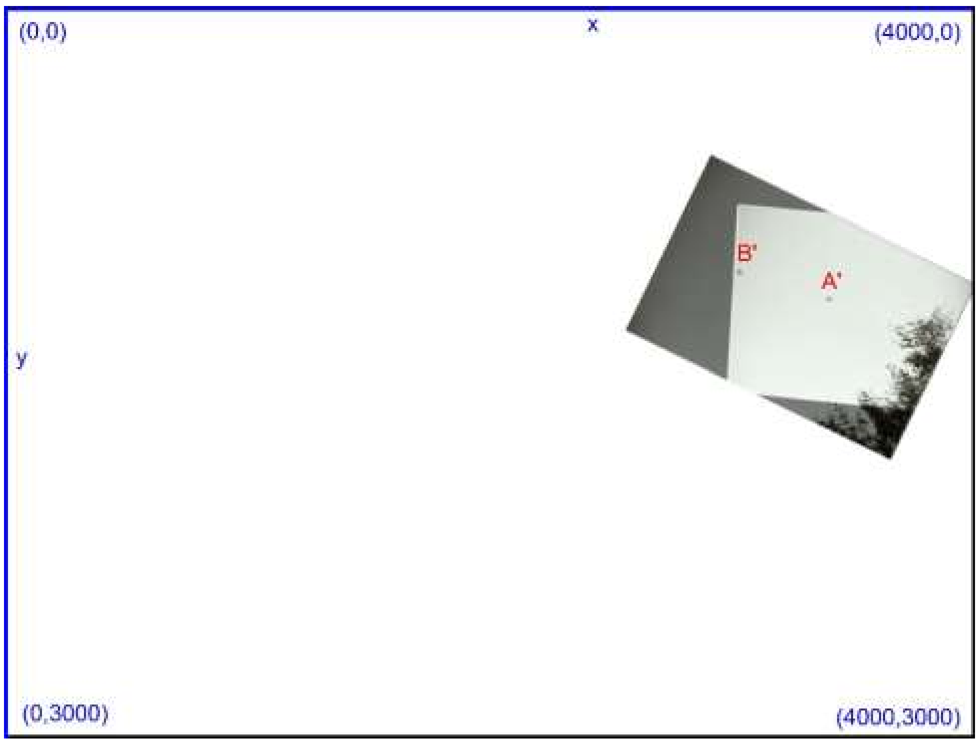
The problem was now to determine a parabolic trajectory that complied with all known constraints, including being consistent with the landscape.

A 3–D frame of reference (x,y,z) was chosen, where the P vertical plane of the parabolic trajectory was defined by:

$$z = 0$$



The reference LC_{3+4} image was arbitrarily positioned on a grid (x,y coordinates), with the 26° tilt angle computed above:



The goal was then to determine the coordinates of the four successive positions of the UFO's center (A, B, C, D), and the four successive positions of the camera (O_A, O_B, O_C, O_D):

A $(x_A,y_A,0)$, B $(x_B,y_B,0)$, C$(x_C,y_C,0)$, D $(x_D,y_D,0)$,
O_A (x_{OA},y_{OA},z_{OA}) , O_B (x_{OB},y_{OB},z_{OB}), O_C (x_{OC},y_{OC},z_{OC}), O_D (x_{OD},y_{OD},z_{OD})

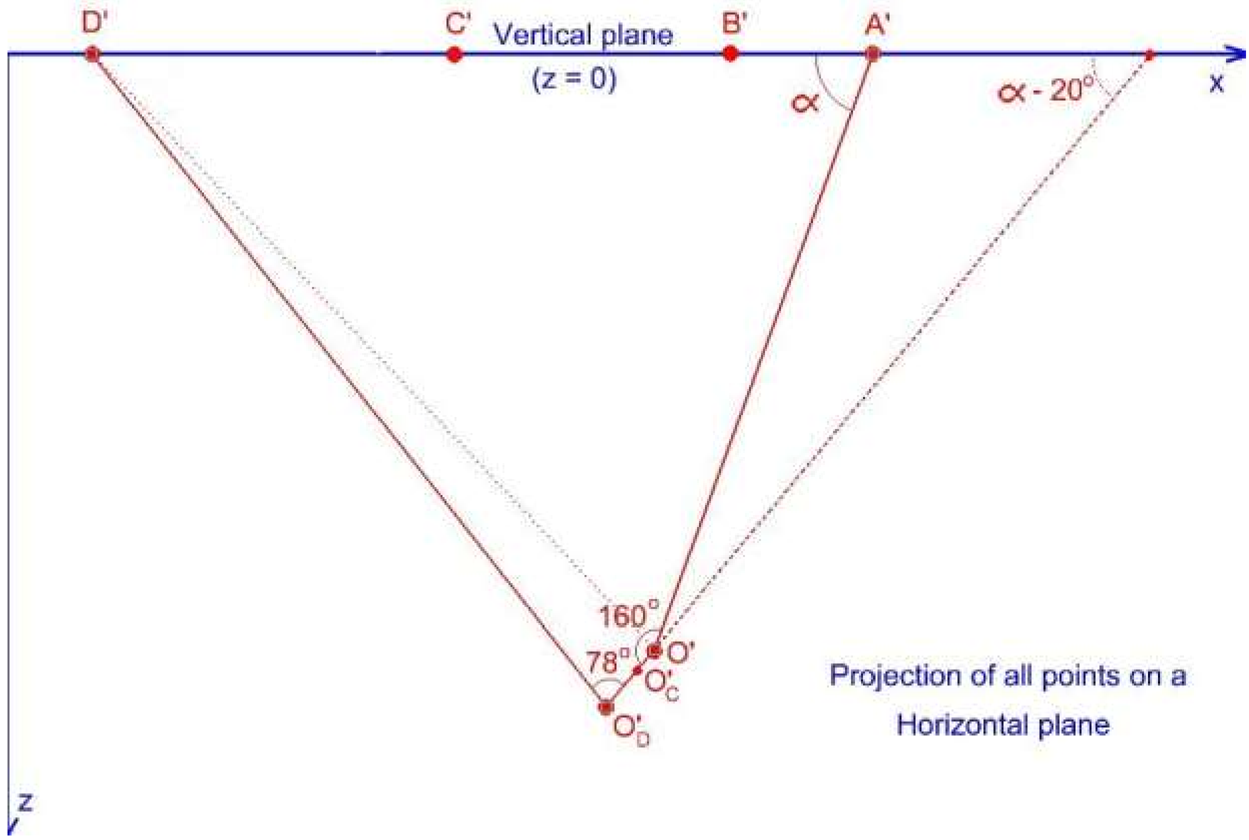
On the following basis:

- O_A and O_B were assumed identical *(see above)* and named O (x_O,y_O,z_O)
- O, O_C and O_D were assumed to be on a straight line, O_C being at one third of the way from O to O_D (*see above*)
- The camera's height was assumed to have the same value y_O for LC_3, LC_4 and LC_6 (low position), and to be larger by δ_y for LC_5 (high position),

it was chosen to take the initial camera's location O as the reference, with the following relations, where δ_x, δ_y and δ_z characterize the camera's translation between the shots of LC_4 and LC_5:

$x_{OA} = x_O$	$x_{OB} = x_O$	$x_{OC} = x_O - \delta_x$	$x_{OD} = x_O - 3\delta_x$
$y_{OA} = y_O$	$y_{OB} = y_O$	$y_{OC} = y_O - \delta_y$	$y_{OD} = y_O$
$z_{OA} = z_O$	$z_{OB} = z_O$	$z_{OC} = z_O + \delta_z$	$z_{OD} = z_O + 3\delta_z$

From the sketch presented above *(see p.33)* was derived the one below, in the frame of reference:



The angle α was unknown and the angle between the x axis and the alignment of successive positions of the camera (O-O_C-O_D) was equal to (α - 20°).

The camera's translation between shots could then be represented in the form "length + angle":

$$\delta_x = \delta \cos(\alpha - 20°)$$
$$\delta_z = \delta \sin(\alpha - 20°)$$

The parabola's equation being:

$$y = a\,x^2 + b\,x + c$$

the following constraints had to be fulfilled:

- Each of the four points A, B, C, D was located on this parabolic trajectory:

(1) $y_A = ax_A^2 + bx_A + c$

(2) $y_B = ax_B^2 + bx_B + c$

(3) $y_C = ax_C^2 + bx_C + c$

(4) $y_D = ax_D^2 + bx_D + c$

- The ratios between distances AB, O_AA, O_BB, O_CC and O_DD were already known (*see p.11*):

(5) $[(x_B - x_A)^2 + (y_B - y_A)^2] / [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2] = 0.2506604^2$

(6) $[(x_B - x_O)^2 + (y_B - y_O)^2 + z_O^2] / [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2] = 0.98^2$

(7) $\{[x_C - x_O + \delta \cos(\alpha\text{-}20°)]^2 + (y_C - y_O + \delta_y)^2 + [z_O + \delta \sin(\alpha\text{-}20°)]^2\} / [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2] = 1.14^2$

(8) $\{[x_D - x_O + 3\delta \cos(\alpha\text{-}20°)]^2 + (y_D - y_O)^2 + [z_O + 3\delta \sin(\alpha\text{-}20°)]^2\} / [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2] = 1.58^2$

- The elevation of the UFO, seen from the camera, had been measured in LC_3 (25°):

$$(y_A - y_{OA})^2 / [(x_A - x_{OA})^2 + (y_A - y_{OA})^2 + z_{OA}^2] = (\sin 25°)^2$$

(9) $(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2 = 5.59891\,(y_A - y_O)^2$
(with $y_A < y_O$)

- The elevation of the UFO, seen from the camera, had been measured in LC_6 (20.9°):

$$(y_D - y_{OD})^2 / [(x_D - x_{OD})^2 + (y_D - y_{OD})^2 + z_{OD}^2] = (\sin 20.9°)^2$$

(10) $[x_D - x_O + 3\delta \cos(\alpha\text{-}20°)]^2 + (y_D - y_O)^2 + [z_O + 3\delta \sin(\alpha\text{-}20°)]^2 = 7.82916\,(y_D - y_O)^2$
(with $y_D < y_O$)

- In projection on a horizontal plane, the angle between the straight line representing the camera's translation between the shots ($O'–O_C'–O_D'$) and the UFO's line of sight $O_D'D'$ had been assessed *(see p.35)*:

$$\langle O'O_D'D' \rangle \approx 180 - (137 - 35) = 78°$$

Using the generalized Pythagoras theorem in the projection $O'O_D'D'$ of the triangle OO_DD on a horizontal plane:

$$O'D'^2 = O_D'O'^2 + O_D'D'^2 - 2O_D'O'\ O_D'D' \cos(78°)$$

(11) $$3\delta^2 - (x_O - x_D)\,\delta \cos(\alpha\text{-}20°) + z_O\,\delta \sin(\alpha\text{-}20°) -$$
$$\delta \cos(78°)\,\sqrt{[(x_O - 3\delta \cos(\alpha\text{-}20°) - x_D)^2 + (z_O + 3\delta \sin(\alpha\text{-}20°))^2]} = 0$$

- α could be computed using the generalized Pythagoras theorem in the projection $O'A'B'$ of the triangle OAB on a horizontal plane:

$$O'B'^2 = A'B'^2 + A'O'^2 - 2\,A'B'\,A'O' \cos\alpha$$

(12) $$(x_O - x_B)^2 - (x_A - x_B)^2 - (x_O - x_A)^2 + 2\cos\alpha\,(x_A - x_B)\sqrt{[(x_O - x_A)^2 + z_O^2]} = 0$$

- An intermediate parameter was chosen in order to define the parabola. This was the abscissa x_M of its maximum:

(13) $$x_M = -b / 2a \qquad \text{with } x_M < (x_A + x_B) / 2 \text{ (top convexity)}$$

- From *Table 1 (p.11)*, the ratio between the UFO's distance OA from the camera in LC_3 and the UFO's diameter Ø was inferred:

$$OA = 54.04\ Ø$$

Knowing that δ = 1 m, the value of δ in the reference frame's unit could be expressed thus:

$$\delta = OA / (54.04\ Ø)$$

(14) $$\delta = \sqrt{[(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2]} / (54.04\ Ø)$$

- Knowing that δ_y = 0.6 m, the value of δ_y in the reference frame's unit could also be expressed:

(15) $$\delta_y = 0.6\ \delta$$

The following values could be directly measured on the graph:

x_A = 3400
y_A = 1200
x_B = 3032
y_B = 1090

The 15 following unknowns had then to be derived from the 15 above equations *(1)* to *(15):*

Ø
x_O, y_O, z_O, x_C, y_C, x_D, y_D
δ, δ_y, α
a, b, c, x_M

Resolution of the 15 equations:

(1) => 3400^2 a + 3400 b + c = 1200
11560000 a + 3400 b + c = 1200

(2) => 3032^2 a + 3032 b + c = 1090
9193024 a + 3032 b + c = 1090

(13) => $2\ x_M\ a + b = 0$
$b = -2\ x_M\ a$

(1)–(2) => (11560000 – 9193024) a + (3400 – 3032) b = 1200 – 1090

with (13) => $2366976\ a + 368\ (-2x_M\ a) = 110$

(15) $\mathbf{a = 0.149457 / (3216 - x_M)}$

(16) $\mathbf{b = -0.298913\ x_M / (3216 - x_M)}$

(2) => c = 1090 – 9193024 a – 3032 b
(17) $\mathbf{c = (2131483 - 183.696\ x_M) / (3216 - x_M)}$

(5) => $(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2 = [(x_B - x_A)^2 + (y_B - y_A)^2] / 0.25066^2$

– (9) => $5.59891\ (y_A - y_O)^2 = [(x_B - x_A)^2 + (y_B - y_A)^2] / 0.25066^2$

(18) $\mathbf{y_O = 1847.58}$ $(y_O > y_A)$

(8) => $(x_D - x_O + 3\delta \cos(\alpha\text{-}20°))^2 + (y_D - y_O)^2 + [z_O + 3\delta \sin(\alpha\text{-}20°)]^2 = 1.58^2\ [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2]$

– (10) => $1.58^2\ [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2] = 7.829156\ (y_D - y_O)^2$

with (5) => $(y_D - y_O)^2 = 0.318859\ [(x_B - x_A)^2 + (y_B - y_A)^2] / 0.25066^2$

(19) $\mathbf{y_D = 982.323}$ $(y_O > y_D)$

(4) => $x_D = \{-b \pm \sqrt{[\,b^2 - 4a*(c - y_D)]}\} / 2\ a$

$x_D = x_M \pm \sqrt{[x_M^2 - 6.69091 * (798.628\ x_M - 1027670)]}$
$x_M^2 - 6.69091 * (798.628\ x_M - 1027670) - (x_D - x_M)^2 = 0$

(20) $\mathbf{x_M = (6876044 - x_D^2) / (5343.55 - 2\ x_D)}$

(5) => $(368^2 + 110^2) / [(3400 - x_O)^2 + (1200 - y_O)^2 + z_O^2] = 0.250660^2$
(21) $\mathbf{z_O = \sqrt{(-x_O^2 + 6800\ x_O - 9631398)}}$ *$(z_O > 0)$*

(6) => $(3032 - x_O)^2 + (1090 - y_O)^2 + z_O^2 = 0.9604\ [(3400 - x_O)^2 + (1200 - y_O)^2 + z_O^2]$
$z_O^2 = -x_O^2 - 11785.9\ x_O + 43889535$

with (21) => $-x_O^2 + 6800\ x_O - 9631398 = -\ x_O^2 - 11785.9\ x_O + 43889535$
$18585.9\ x_O = 53520932$

(22) $\mathbf{x_O = 2879.66}$

(21) => $z_O = \sqrt{(-\ 2879.66^2 + 19581680 - 9631398)}$

(23) $\mathbf{z_O = 1287.57}$

(12) => $(3032 - 2916.57)^2 - (3400 - 3032)^2 - (3400 - 2916.57)^2$
$+ 2\cos\alpha\ (3400 - 3032)\ \sqrt{[(3400 - 2916.57)^2 + 1356.32^2]} = 0$

(24) $\mathbf{\alpha = 70.3827°}$

(11) => $3\delta^2 - (2916.57 - x_D)\ \delta\cos(50.3827) + 1356.32\ \delta\sin(50.3827)$
$- 0.207912\ \delta\ \sqrt{[(2916.57 - 3\delta\cos(50.3827) - x_D)^2 +}$
$\overline{(1356.32 + 3\delta\sin(50.3827))^2]} = 0$

$x_D^2 + 2\ (5.03683\ \delta - 1083.16)\ x_D + 23.6969\ \delta^2 - 12874.9\ \delta + 597032 = 0$

This equation of the second degree had 2 solutions for x_D, only one of which (the larger one) proved to lead to a solution of the whole problem:

(25) $\mathbf{x_D = 1083.16 - 5.03683\ \delta + \sqrt{[(5.03683\ \delta - 1083.16)^2 - 23.6969\ \delta^2 + 12874.9\ \delta - 597032]}}$

(14) => $\delta = \sqrt{[(3400 - 2916.57)^2 + (1200 - 1847.58)^2 + 1356.32^2]}\ /\ (54.04\ Ø)$

(26) $\mathbf{\delta = 28.355\ /\ Ø}$ *(Ø in meters)*

(7) => $[x_C - x_O + \delta\cos(\alpha\text{-}20°)]^2 + (y_C - y_O)^2 + [z_O + \delta\sin(\alpha\text{-}20°)]^2 = 1.14^2\ [(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2]$

with (3) => $(x_C + 0.637657\ \delta - 2916.57)^2 + [(ax_C^2 + bx_C + c) - 1724.08]^2$
$+ (1356.32 + 0.770321\ \delta)^2 - 3051413 = 0$

(27) $\mathbf{(x_C + 0.637657\ \delta - 2916.57)^2 + [ax_C^2 + bx_C + c - 1724.08]^2 + (1356.32 + 0.770321\ \delta)^2 - 3051413 = 0}$

Computation sequence for a given value of **Ø**:

(18) => $\mathbf{y_O = 1847.58}$

(22) => $\mathbf{x_O = 2879.66}$

(23) => $\mathbf{z_O = 1287.57}$

(19) => $\mathbf{y_D = 982.323}$

(24) => $\alpha = \mathbf{70.3827°}$

(26) => **Ø => δ**

(15) => $\boldsymbol{\delta \Rightarrow \delta_y}$

(25) => $\boldsymbol{\delta \Rightarrow x_D}$

(20) => $\mathbf{x_D \Rightarrow x_M}$

(15) => $\mathbf{x_M \Rightarrow a}$

(16) => $\mathbf{x_M \Rightarrow b}$

(17) => $\mathbf{x_M \Rightarrow c}$

(27) => $\boldsymbol{\delta, \delta_y, a, b, c \Rightarrow x_C}$

(3) => $\mathbf{x_C \Rightarrow y_C}$

The following results were obtained:

- For a given value of Ø (diameter of the UFO's base, expressed in meters), the set of 15 equations produced a solution, corresponding to a given vertical parabola and to given positions of points C and D (UFO) and of points O_C and O_D (camera) in the 3–D space, the positions of points A and B (UFO) and of point O (camera) remaining constant.

  Coordinates of the fixed points in the reference frame:

  A (3400, 1200, 0)
  B (3032, 1090, 0)
  O (2880, 1848, 1288)

  Coordinates of the other points for 10 particular values of Ø, together with the conversion of 1 meter into the reference units:

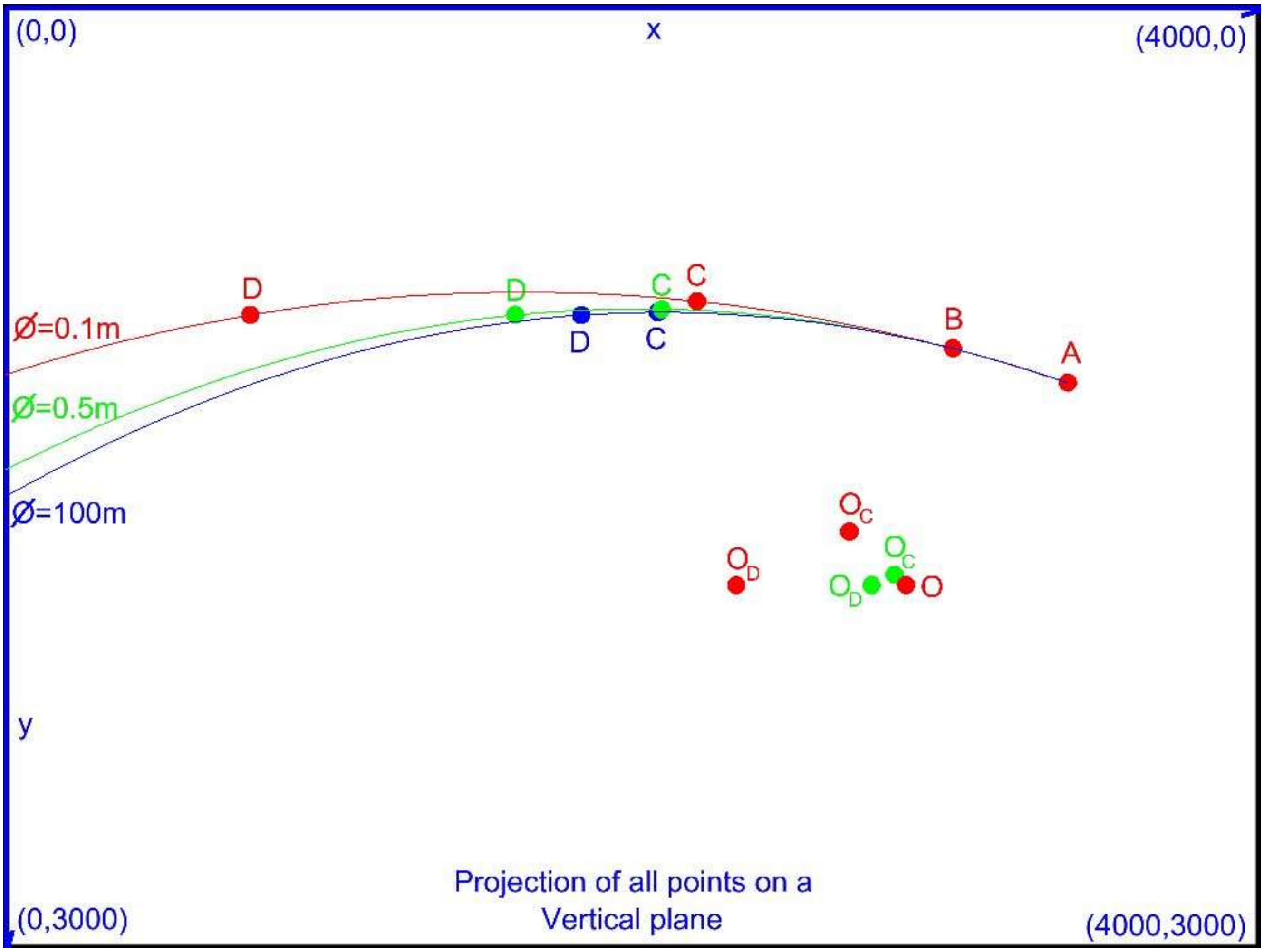
Ø	x_C	y_C	x_D	y_D	z_D	x_{OC}	y_{OC}	z_{OC}	x_{OD}	y_{OD}	z_{OD}	1 m
0,1	2212	938	781	982	0	2699	1677	1506	2337	1848	1943	283,6
0,2	2126	950	1312	982	0	2789	1763	1397	2608	1848	1615	141,8
0,5	2098	963	1630	982	0	2843	1814	1331	2771	1848	1419	56,7
1	2091	968	1736	982	0	2862	1831	1309	2825	1848	1353	28,4
2	2088	971	1789	982	0	2871	1839	1298	2853	1848	1320	14,2
5	2087	973	1821	982	0	2876	1844	1292	2869	1848	1301	5,7
10	2087	973	1832	982	0	2878	1846	1290	2874	1848	1294	2,8
20	2086	973	1837	982	0	2879	1847	1289	2877	1848	1291	1,4
50	2086	973	1840	982	0	2879	1847	1288	2879	1848	1289	0,6
100	2086	973	1841	982	0	2879	1847	1288	2879	1848	1288	0,3

(Table 3)

  It was noticeable that for values of the UFO's size Ø larger than several meters, the geometric configuration varied very little, the reason being that the impact of the operator's small movement between the shots (δ + 2δ = 3 m) was then negligible.

- The following graph displays, in projection on a vertical plane, the configuration of all relevant points for 3 different values of Ø:

  Ø = 0.1 m in red
  Ø = 0.5 m in green
  Ø = 100 m in blue



- Key geometric parameters could then be computed "a posteriori" from the set of coordinates presented above *(see Table 3)*.

  The following table gives the results, as functions of ϕ, for the following parameters:

  - Elevation of the UFO's line of sight seen from the camera in the four successive pictures: θ_A, θ_B, θ_C, θ_D
  - UFO's azimuth shifts seen from the camera between the successive shots: ϕ_{AB}, ϕ_{BC}, ϕ_{CD}
  - UFO's total azimuth shift seen from the camera between the first and the last shot: ϕ_{AD}
  - Actual distance between the UFO and the camera when each picture was shot: OA, OB, O_CC, O_DD
  - Relative increase of the distance between the UFO and the camera: OB/OA, O_CC/OA, O_DD/OA

Ø	θ_A°	θ_B°	θ_C°	θ_D°	ϕ_{AB}°	ϕ_{BC}°	ϕ_{CD}°	ϕ_{AD}°	OA (m)	OB (m)	O_CC (m)	O_DD (m)	OB/OA	O_CC/OA	O_DD/OA
0,1	25,0	26,5	25,0	19,2	15,3	24,7	20,8	60,7	5,4	5,3	6,2	9,3	0,98	1,14	1,72
0,2	25,0	26,5	27,7	22,7	15,3	32,1	13,4	60,8	10,8	10,6	12,3	15,8	0,98	1,14	1,46
0,5	25,0	26,5	29,2	25,4	15,3	36,0	9,6	60,8	27,0	26,5	30,8	35,5	0,98	1,14	1,32
1	25,0	26,5	29,6	26,5	15,3	37,2	8,4	60,8	54,0	53,0	61,6	68,4	0,98	1,14	1,27
2	25,0	26,5	29,8	27,0	15,3	37,8	7,8	60,9	108	106	123	134	0,98	1,14	1,24
5	25,0	26,5	29,9	27,4	15,3	38,2	7,4	60,9	270	265	308	332	0,98	1,14	1,23
10	25,0	26,5	30,0	27,5	15,3	38,3	7,3	60,9	540	530	616	661	0,98	1,14	1,22
20	25,0	26,5	30,0	27,6	15,3	38,3	7,3	60,9	1081	1059	1232	1319	0,98	1,14	1,22
50	25,0	26,5	30,0	27,6	15,3	38,4	7,2	60,9	2702	2648	3081	3294	0,98	1,14	1,22
100	25,0	26,5	30,0	27,6	15,3	38,4	7,2	60,9	5404	5296	6161	6585	0,98	1,14	1,22

(Table 4)

The angles and distances were computed as follows:

$$\boldsymbol{\theta_A} = \arctan \{(y_O - y_A) / \sqrt{[(x_O - x_A)^2 + z_O^2]}\}$$
$$\boldsymbol{\theta_B} = \arctan \{(y_O - y_B) / \sqrt{[(x_O - x_B)^2 + z_O^2]}\}$$
$$\boldsymbol{\theta_C} = \arctan \{(y_{OC} - y_C) / \sqrt{[(x_{OC} - x_C)^2 + z_{OC}^2]}\}$$
$$\boldsymbol{\theta_D} = \arctan \{(y_O - y_D) / \sqrt{[(x_{OD} - x_D)^2 + z_{OD}^2]}\}$$

$$\boldsymbol{\phi_{AB}} = \arctan [(x_A - x_O) / z_O] + \arctan [(x_O - x_B) / z_O]$$
$$\boldsymbol{\phi_{BC}} = \arctan [(x_B - x_O) / z_O] + \arctan [(x_{OC} - x_C) / z_{OC}]$$
$$\boldsymbol{\phi_{CD}} = \arctan [(x_C - x_{OC}) / z_{OC}] + \arctan [(x_D - x_{OD}) / z_{OD}]$$
$$\boldsymbol{\phi_{AD}} = \arctan [(x_A - x_O) / z_O] + \arctan [(x_{OD} - x_D) / z_{OD}]$$

$$OA = (\boldsymbol{Ø} / 28.355) \sqrt{[(x_A - x_O)^2 + (y_A - y_O)^2 + z_O^2]}$$
$$OB = (\boldsymbol{Ø} / 28.355) \sqrt{[(x_B - x_O)^2 + (y_B - y_O)^2 + z_O^2]}$$
$$OC = (\boldsymbol{Ø} / 28.355) \sqrt{[(x_C - x_{OC})^2 + (y_C - y_O)^2 + z_{OC}^2]}$$
$$OD = (\boldsymbol{Ø} / 28.355) \sqrt{[(x_D - x_{OD})^2 + (y_D - y_O)^2 + z_{OD}^2]}$$

A close examination of this table provided the following information:

- All fixed figures related to points O, A and B (θ_A, θ_B, ϕ_{AB}, OB/OA) were exactly as expected
- Figures related to point C, varying with Ø, did not pose any problem (no contradiction with any previous mensuration or computation)
- Figures relative to point D (yellow columns of the table) were varying with Ø, and only matched previous measured or computed values for <u>one particular value of Ø</u> (see *Table 1 p.11* for OA and O_DD, *p.19* for $\boldsymbol{\theta_D}$).

This <u>final unique solution of the set of 15 equations</u> could then be described as follows:

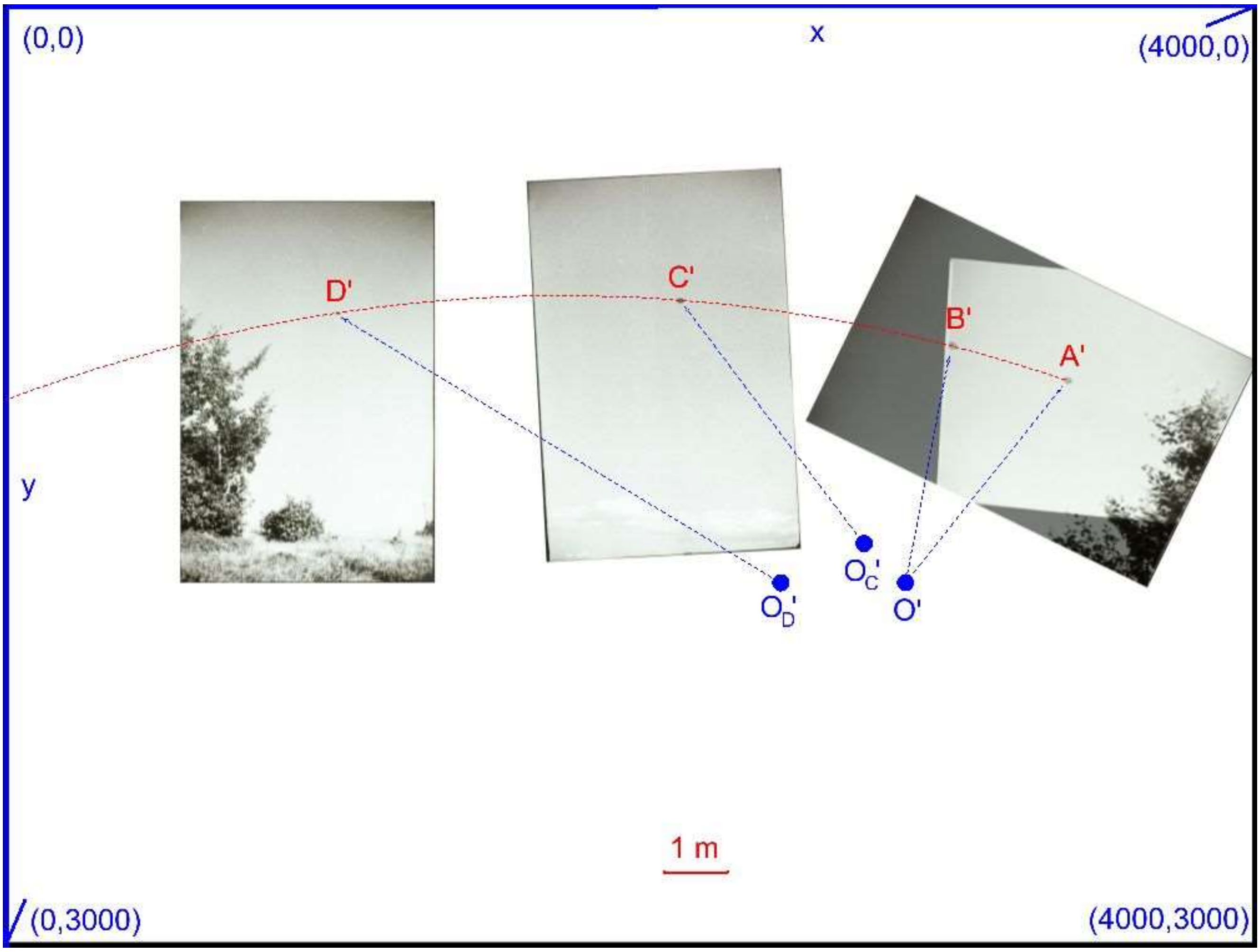
Ø	θ_A°	θ_B°	θ_C°	θ_D°	ϕ_{AB}°	ϕ_{BC}°	ϕ_{CD}°	ϕ_{AD}°	OA (m)	OB (m)	O_CC (m)	O_DD (m)	OB/OA	O_CC/OA	O_DD/OA
0,136	25,0	26,5	26,5	20,9	15.3	28,8	16,6	60,7	7,3	7,2	8,4	11,6	0,98	1,14	1,58

the main result of this geometric study being that:

The UFO's diameter was in the order of 14 cm.

The following mosaic, which illustrates the unique solution of the trajectography problem, is equivalent to a virtual single wide–angle ideal photograph ("pinhole" type) supposedly built in a vertical plane parallel to the vertical plane of the trajectory. In the plane of the mosaic, the successive locations of the image of the UFO's center were named A', B', C' and D'. The lengths of segments A'B', B'C' and C'D' in the image were respectively proportional to the lengths of segments AB, BC and CD in the 3–D space.

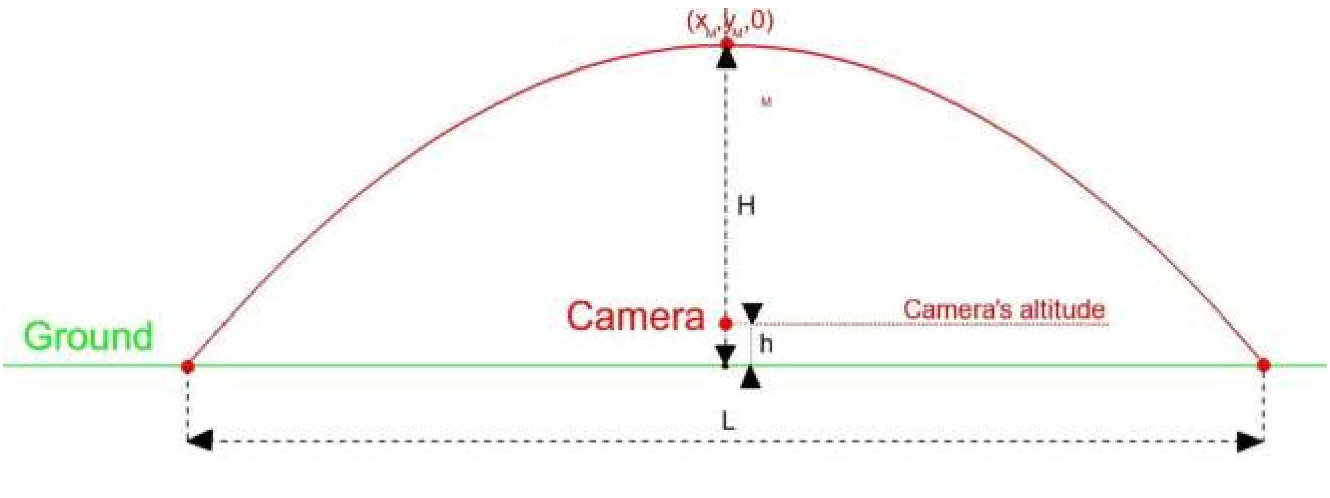
The most likely representation of the UFO's parabolic trajectory in a vertical plane (z = 0), also including the projections O', O_C', O_D' on this plane of the camera's successive positions, was as follows:



Note: Such a simple mosaic could not pretend to be totally realistic, since only relative positions of points A', B', C' and D' were correct. Each of the individual pictures had been created in a particular (focal) plane, not parallel to the mosaic's plane, and should have undergone a particular transform (mainly a 3–D rotation around the UFO's position) before being projected on the mosaic's plane, so as to produce a more realistic sketch.

Considering therefore the above–referenced arc of a parabola as the representation of the UFO's trajectory, it was then straightforward to assess the corresponding top height H and the ground–to–ground distance L of this arc of a parabola, in units of the 3–D reference frame and in meters.

It was necessary to take into account the camera's reference altitude **h** (low position of the photographer), expressed in the 3–D reference frame's unit.



In these units, the parabola was defined, in the plane z = 0, by:

$$y = a\,x^2 + b\,x + c$$
$$a = 0.149457 / (3216 - x_M)$$
$$b = -0.298913\,x_M / (3216 - x_M)$$
$$c = (2131483 - 183.696\,x_M) / (3216 - x_M)$$

For Ø = 0.136 we could easily compute the abscissa of the parabola's maximum:

$$x_M = 1785.29$$
⇨ $$a = 0.000104463$$
$$b = -0.372996$$
$$c = 1260.59$$

The value of the camera's y coordinate being known ($y_O = 1724.08$), the equation to be solved and its 2 solutions were:

$$a\,x^2 + b\,x + c = y_O + h$$

$$x_1 = 1785 - \sqrt{(8806440 + 9572.77\,h)}$$
$$x_2 = 1785 + \sqrt{(8806440 + 9572.77\,h)}$$

leading to the following total distance L (in the 3–D reference frame's unit):

$$L = x_2 - x_1$$
$$L = 2\sqrt{(8806440 + 9572.77\,h)}\ \textit{units}$$

The top height H (minimum y) of the parabola could be computed as follows:

$$H = y_O - (a\,x_M^2 + b\,x_M + c) + h$$
$$H = (1300.83 + h)\ \textit{units}$$

As already mentioned, a standard "human" value of **1 m** was assigned to the camera's height h (kneeling position).

The conversion ratio between reference *units* and meters was the following, for Ø = 0.136:

1 m = 28.355 / Ø = 208.5 *units*

Thus:

L = 31.53 m

H = 5.412 m

The final rounded results were the following:

UFO's diameter	**:**	**Ø ≈ 14 cm**
Trajectory	**:**	**arc of a vertical parabola**
Ground to ground covered distance	**:**	**L ≈ 32 m**
Maximum height above the ground	**:**	**H ≈ 5.4 m**

(Table 5)

Consequently, this geometric study's conclusions reject the witness' explanations of a large remote object, looking instead for an explanation of clay pigeons or similar.

Even though on-site measurements, as well as simplifications in the modeling process, may have induced some errors, the resulting overall uncertainty may reasonably not be considered as larger than **30%**, which infers the following limits:

9.5 cm < Ø < 18 cm

22 m < L < 41 m

3.8 m < H < 7 m

<u>Note</u>: The elements of the scene of which the assessed localization was most uncertain were points C and O_C. However, the above computations of key angles and sizes <u>did not depend at all</u> on the coordinates of those two points.

In other words, the geometric study presented above only relied on pictures LC_3, LC_4 and LC_6. The picture LC_5, which did not contain any useful geometric information about the scene, was only approximately localized a posteriori, once the parabolic trajectory had already been established.

Radiometric study

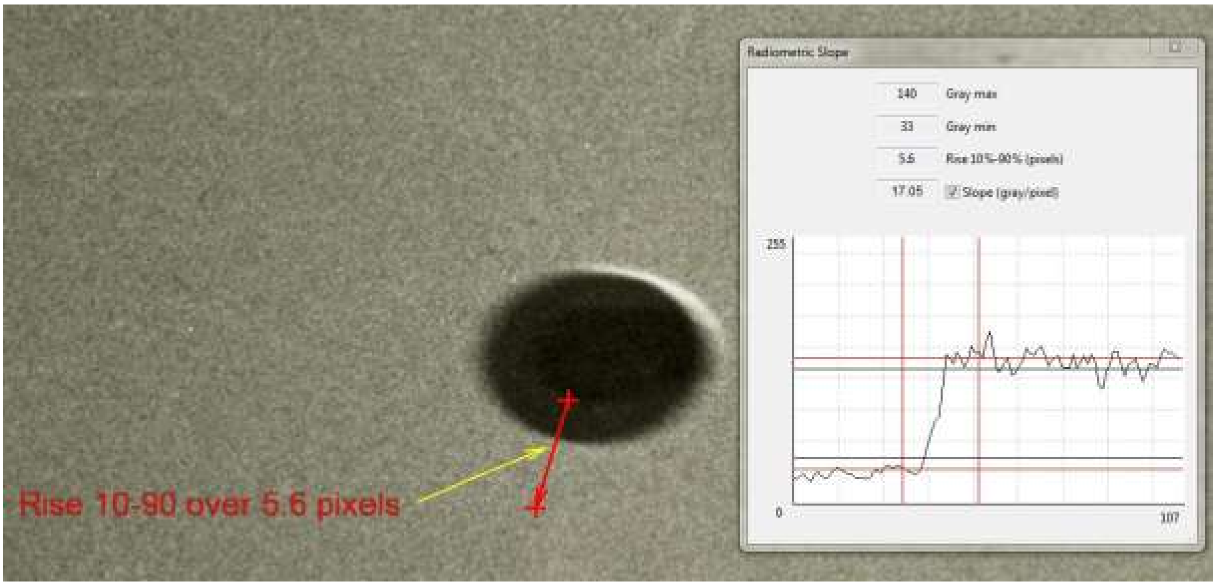
The radiometric part of this analysis, carried out independently from the geometric part, was focused on the assessment of "distance from the camera versus depth–of–field", taking into account the only things that could be seen on the four pictures: a cloud, beeches and the UFO.

The *Radiometric Slope* function of IPACO was used to quantify the sharpness of the cloud, of leaves and of the UFO in each of the pictures. For a given contour, the principle consisted in measuring, along a straight line perpendicular to this contour, the number of pixels which separate, on the radiometric slope, the 10% point from the 90% point.

Each measurement was done 20 times, producing a reliable median value, on each of the 8 images available: LC_3, LC_4, LC_5, LC_6, G_3, G_4, G_5, and G_6.

On pictures LC_3 and LC_4, where a motion blur appeared on the UFO's contour along the axis of the trajectory, two series of measurements were performed: one along this axis ("motion blur"), and the other one along a perpendicular axis ("no motion blur").

IPACO's tool's operation is illustrated as follows:



The final results of the whole set of measurements are presented in the *Table 6* below, where each figure is the median value out of a series of at least 20 operations.

Contour of	Image	**Sharpness index** (pixels)
Cloud	LC_5	2.2
Beech leaves	LC_3 "no motion blur"	2.9
	LC_3 "motion blur"	4.5
	LC_4 "no motion blur"	2.5
	LC_4 "motion blur"	3.4
	LC_6	2.6
UFO	LC_3 "no motion blur"	2.7
	LC_3 "motion blur"	4.8
	LC_4 "no motion blur"	2.3
	LC_4 "motion blur"	3.6
	LC_5	2.9
	LC_6	2.7
	G_3 "no motion blur"	6.7
	G_3 "motion blur"	31.8
	G_4 "no motion blur"	6.6
	G_4 "motion blur"	20.0
	G_5	6.8
	G_6	6.7

(Table 6)

Referring to the LC_3, LC_4, LC_5, LC_6 images, the smallest "sharpness index" value was 2.2 pixels for the cloud, the contours of which appeared very sharp in LC_5. Taking into consideration an uncertainty of about 1 pixel, it was admitted that all objects with a "sharpness index" lower than 3 pixels, which did appear sharp on the images, were located inside the depth–of–field. This proved to be the case for the UFO in the four pictures and for all leaves in LC_3, LC_4 and LC_6 .

The "Depth–of–field table" edited by the manufacturer of the camera *(see p.8)* is reproduced in the *Table 7.0* hereunder. Such a table indicates the minimum and maximum distances for which objects appear sharp on a photograph, as a function of the "aperture" and "focal distance" settings of the camera. In this table:

- possible "aperture" settings are mentioned in the upper line
- possible "focal distance" settings are mentioned in the left column
- all distances have been converted into meters

Settings	**2.8**	**3.5/4.0**	**5.6**	**8**	**11**	**16**	**22**
∞	14.6 m –> ∞	10.2 m –> ∞	7.3 m –> ∞	5.1 m –> ∞	3.7 m –> ∞	2.6 m –> ∞	1.9 m –> ∞
9,14 m	6.0 m –> 31.7 m	5.1 m –> 409 m	4.2 m –> ∞	3.4 m –> ∞	2.7 m –> ∞	2.1 m –> ∞	1.6 m –> ∞
6,10 m	4.3 m –> 20.2 m	3.8 m –> 14,4 m	3.3 m –> 32,6 m	2.8 m –> ∞	2.3 m –> ∞	1.9 m –> ∞	1.4 m –> ∞
4,57 m	3.7 m –> 7.6 m	3.4 m –> 9.8 m	3.0 m –> 15.5 m	2.6 m –> 165 m	2.2 m –> ∞	1.8 m –> ∞	1.4 m –> ∞
3,05 m	2.5 m –> 3.7 m	2.3 m –> 4.2 m	2.2 m –> 5.6 m	1.9 m –> 7.0 m	1.7 m –> 14.1 m	1.4 m –> ∞	1.2 m –> ∞
1,83 m	1.8 m –> 2.3 m	1.7 m –> 2.4 m	1.4 m –> 2.5 m	1.2 m –> 3.0 m	1.1 m –> 3.9 m	1.0 m –> 7.8 m	1.0 m –> ∞
1,52 m	1.4 m –> 1.7 m	1.3 m –> 1.8 m	1.3 m –> 1.9 m	1.2 m –> 2.1 m	1.1 m –> 2.4 m	0.9 m –> 3.3 m	0.9 m –> 6.3 m
1,22 m	1.1 m –> 1.3 m	1.1 m –> 1.2 m	1.1 m –> 1.4 m	1.0 m –> 1.5 m	0.9 m –> 1.7 m	0.8 m –> 2.1 m	0.7 m –> 2.8 m
0,91 m	0.9 m –> 1.0 m	0.8 m –> 1.0 m	0.8 m –> 1.1 m	0.8 m –> 1.1 m	0.7 m –> 1.2 m	0.7 m –> 1.4 m	0.6 m –> 1.9 m

(Table 7.0)

Sharpness of the cloud

The contours of the cloud in LC_5 were extremely sharp (index of 2.2 pixels, the minimum value altogether). This indicated that this cloud was clearly inside the depth–of–field.

On the other hand, this cloud was obviously farther than 500 m away from the camera:

Higher limit of the depth of field > 500 m

This eliminated a large part of the possible settings of *Table 7.0*, as illustrated below:

Settings	2.8	3.5/4.0	5.6	8	11	16	22
∞	14.6 m –> ∞	10.2 m –> ∞	7.3 m –> ∞	5.1 m –> ∞	3.7 m –> ∞	2.6 m –> ∞	1.9 m –> ∞
9.14 m	6.0 m –> 31.7 m	5.1 m –> 409 m	4.2 m –> ∞	3.4 m –> ∞	2.7 m –> ∞	2.1 m –> ∞	1.6 m –> ∞
6.10 m	4.3 m –> 20.2 m	3.8 m –> 14,4 m	3.3 m –> 32,6 m	2.8 m –> ∞	2.3 m –> ∞	1.9 m –> ∞	1.4 m –> ∞
4.57 m	3.7 m –> 7.6 m	3.4 m –> 9.8 m	3.0 m –> 15.5 m	2.6 m –> 165 m	2.2 m –> ∞	1.8 m –> ∞	1.4 m –> ∞
3,05 m	2.5 m –> 3.7 m	2.3 m –> 4.2 m	2.2 m –> 5.6 m	1.9 m –> 7.0 m	1.7 m –> 14.1 m	1.4 m –> ∞	1.2 m –> ∞
1.83 m	1.8 m –> 2.3 m	1.7 m –> 2.4 m	1.4 m –> 2.5 m	1.2 m –> 3.0 m	1.1 m –> 3.9 m	1.0 m –> 7.8 m	1.0 m –> ∞
1.52 m	1.4 m –> 1.7 m	1.3 m –> 1.8 m	1.3 m –> 1.9 m	1.2 m –> 2.1 m	1.1 m –> 2.4 m	0.9 m –> 3.3 m	0.9 m –> 6.3 m
1.22 m	1.1 m –> 1.3 m	1.1 m –> 1.2 m	1.1 m –> 1.4 m	1.0 m –> 1.5 m	0.9 m –> 1.7 m	0.8 m –> 2.1 m	0.7 m –> 2.8 m
0.91 m	0.9 m –> 1.0 m	0.8 m –> 1.0 m	0.8 m –> 1.1 m	0.8 m –> 1.1 m	0.7 m –> 1.2 m	0.7 m –> 1.4 m	0.6 m –> 1.9 m

(Table 7.1)

Sharpness of the leaves

Referring to *Table 6 (p.51),* we knew that all leaves were inside the depth of field in the four pictures ("no motion blur" sharpness index < 3), inferring that the shortest distance between the camera and leaves (5.4 m) was inside the depth of field:

Lower limit of the depth of field ≤ 5.4 m

This allowed the elimination of another set of possibilities from *Table 7.1*:

Settings	2.8	3.5/4.0	5.6	8	11	16	22
∞	14.6 m –> ∞	10.2 m –> ∞	7.3 m –> ∞	5.1 m –> ∞	3.7 m –> ∞	2.6 m –> ∞	1.9 m –> ∞
9.14 m	6.0 m –> 31.7 m	5.1 m –> 409 m	4.2 m –> ∞	3.4 m –> ∞	2.7 m –> ∞	2.1 m –> ∞	1.6 m –> ∞
6.10 m	4.3 m –> 20.2 m	3.8 m –> 14,4 m	3.3 m –> 32,6 m	2.8 m –> ∞	2.3 m –> ∞	1.9 m –> ∞	1.4 m –> ∞
4.57 m	3.7 m –> 7.6 m	3.4 m –> 9.8 m	3.0 m –> 15.5 m	2.6 m –> 165 m	2.2 m –> ∞	1.8 m –> ∞	1.4 m –> ∞
3.05 m	2.5 m –> 3.7 m	2.3 m –> 4.2 m	2.2 m –> 5.6 m	1.9 m –> 7.0 m	1.7 m –> 14.1 m	1.4 m –> ∞	1.2 m –> ∞
1.83 m	1.8 m –> 2.3 m	1.7 m –> 2.4 m	1.4 m –> 2.5 m	1.2 m –> 3.0 m	1.1 m –> 3.9 m	1.0 m –> 7.8 m	1.0 m –> ∞
1.52 m	1.4 m –> 1.7 m	1.3 m –> 1.8 m	1.3 m –> 1.9 m	1.2 m –> 2.1 m	1.1 m –> 2.4 m	0.9 m –> 3.3 m	0.9 m –> 6.3 m
1.22 m	1.1 m –> 1.3 m	1.1 m –> 1.2 m	1.1 m –> 1.4 m	1.0 m –> 1.5 m	0.9 m –> 1.7 m	0.8 m –> 2.1 m	0.7 m –> 2.8 m
0.91 m	0.9 m –> 1.0 m	0.8 m –> 1.0 m	0.8 m –> 1.1 m	0.8 m –> 1.1 m	0.7 m –> 1.2 m	0.7 m –> 1.4 m	0.6 m –> 1.9 m

(Table 7.2)

Considering a normal practice of photography, the most likely settings were those in the left part of the remaining opened possibilities, in particular:

- **Aperture** : **5.6** or **8**
- **Focal length** : **9.14** or **∞**

Sharpness of the UFO

Minimum size

The UFO's sharpness index, disregarding its "motion blur" sides, was between 2.3 and 2.9, which meant that it was all the time within the depth of field, i.e. at a distance from the camera larger than or equal to the hyperfocal.

The UFO's diameter's minimum possible size depended on the actual settings, the most restrictive case being that of the highest possible value of the hyperfocal (5.1 m: yellow case in *Table 7.2*).

In that case the UFO's minimum size could be directly derived from *Table 1 (see p.11)*, referring to picture LC_4, where the UFO was at its shortest distance from the camera:

Ø ≥ 0.096 m

Motion blur *(Step 1)*

Considering the motion blur on images LC_3 and LC_4, if it could be assumed that the camera was perfectly fixed during each shot, with an effective exposure time of 1/250 s (or 1/500 s), IPACO's *Transverse velocity/Distance* function could be used to assess the transverse speed of the UFO, respectively in LC_3 and LC_4. This hypothesis of a fixed camera was assumed true for this first step.

In each picture, the length of the image of the transverse displacement, covered during exposure time, was assessed as the difference between the "motion blur" index and the "no motion blur" index, corrected by a factor 10/8, so as to take into account 100% of the slope's length (IPACO's index is computed between 10% and 90% of the slope):

$$l_{TA} = (10/8)\ (4.8 - 2.7) = 2.625 \text{ pixels}$$
$$l_{TB} = (10/8)\ (3.6 - 2.3) = 1.625 \text{ pixels}$$

These values corresponded to the following angular displacements in LC_3 and LC_4:

$$<I_A> = 0.0978°$$
$$<I_B> = 0.0531°$$

Referring to *Table 4 (see p.46)* for the values in meters of OA and OB, the respective transverse displacements corresponding to the respective blurs on LC_3 and LC_4 could be computed in meters:

$$l_{TA} = 2\ OA \tan (<I_A>/2)$$
$$l_{TB} = 2\ OB \tan (<I_B>/2)$$

Which led to the following respective transverse velocities V_T, taking into account the exposure time of 1/250 s:

$$V_{TA} = 500\ OA \tan (<I_A>/2)$$
$$V_{TB} = 500\ OB \tan (<I_B>/2)$$

To assess absolute velocities V, it was necessary to divide transverse velocities by sin (<OAB>):

$$V_A = V_{TA} / \sin (<OAB>)$$
$$V_B = V_{TB} / \sin (<OAB>)$$

The value of this angle <OAB> could be derived from *Table 4 (see p.46)*, using the generalized Pythagoras theorem:

$$<OAB> = \arccos [(OA^2 + AB^2 - OB^2) / (2\ OA\ AB)]$$

The following table gave the results of calculations for 4 values of the UFO's size Ø:

Ø (m)	*units*/m	**OA** (m)	**OB** (m)	**AB** (m)	**<OAB>** (°)	**V_{TA}** (m/s)	**V_{TB}** (m/s)	**V_A** (Km/h)	**V_B** (Km/h)
0,1	284	5,40	5,30	1,35	78	2,3	1,2	8,5	4,5
1	28,4	54,0	53,0	13,5	78	23	12	85	45
10	2,84	540	530	135	78	231	123	848	451
100	0,284	5404	5296	1352	78	2306	1227	8481	4512

(Table 8)

If the exposure time was equal to 1/500 s, the velocities mentioned in this Table had to be multiplied by 2.

<u>Motion blur</u> *(Step 2)*

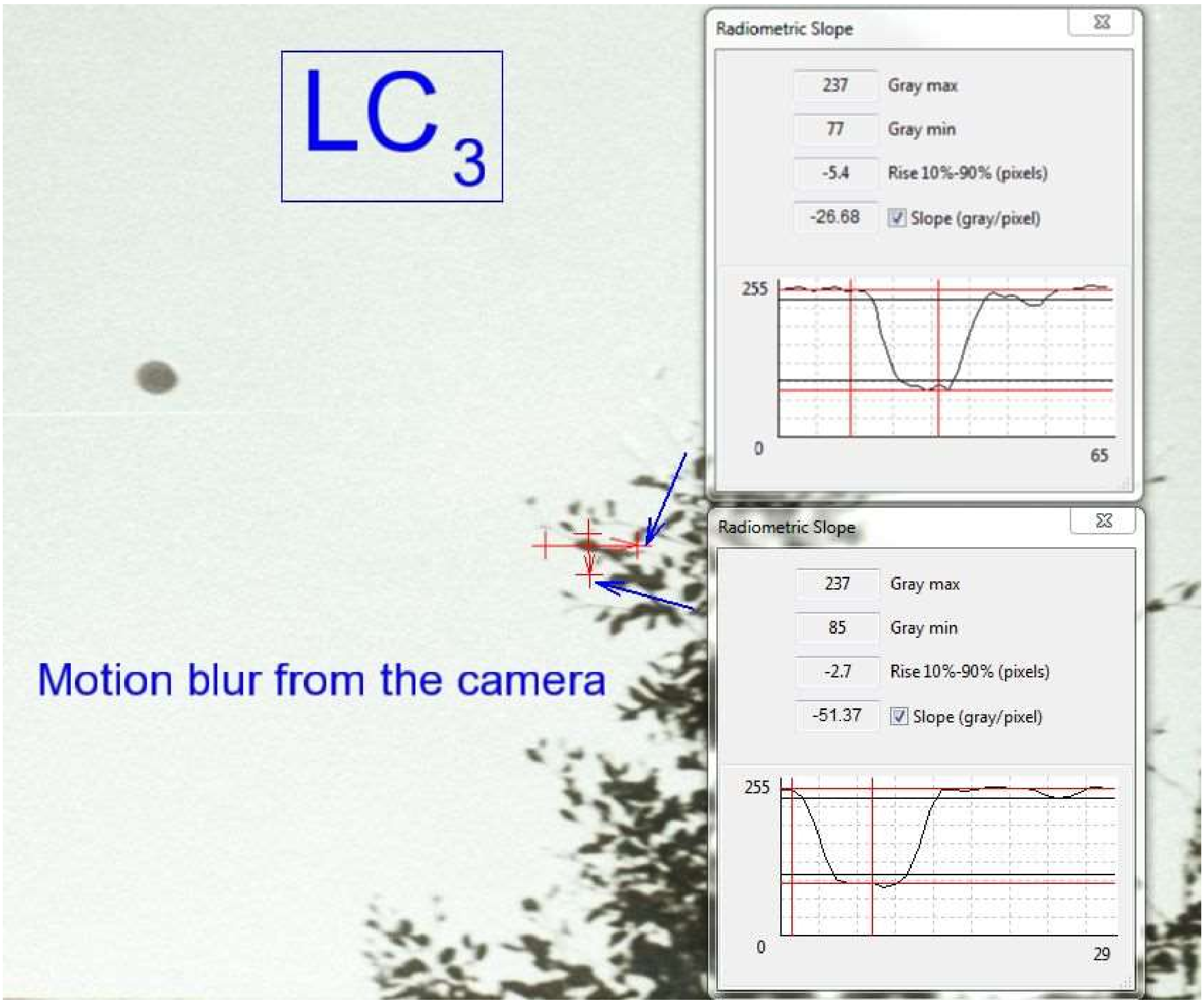
In reality, the hypothesis of a fixed camera proved unrealistic since, most probably and quite naturally, the photographer had tried to "catch and follow" the UFO's movement while shooting.

The results presented above do confirm this, considering the velocities V_A and V_B (which, strictly speaking, only reflect <u>relative</u> movements between the UFO and the camera):

$$V_B < V_A$$

This difference could be interpreted as the result of an initial erratic movement of the photographer during his first shot, followed by a better adapted movement to follow the UFO's movement during the next shots.

The movement of the camera during the first shot could be confirmed by a comparison between the sharpness of leaves in the direction of the movement and in the perpendicular direction:



On this leaf, the sharpness index' value in the direction of the UFO's movement (−5.4) is twice that in the perpendicular direction (−2.7), which is about the same proportion as for the UFO. The same result was obtained with several different leaves of this beech.

This proved that the relative movement causing the motion blur originated mainly from the camera's movement, not from the UFO's movement.

The final conclusion was that no useful information about the UFO's velocity could be extracted from the observed motion blur in LC_3 and LC_4.

Assessment of the UFO's velocity

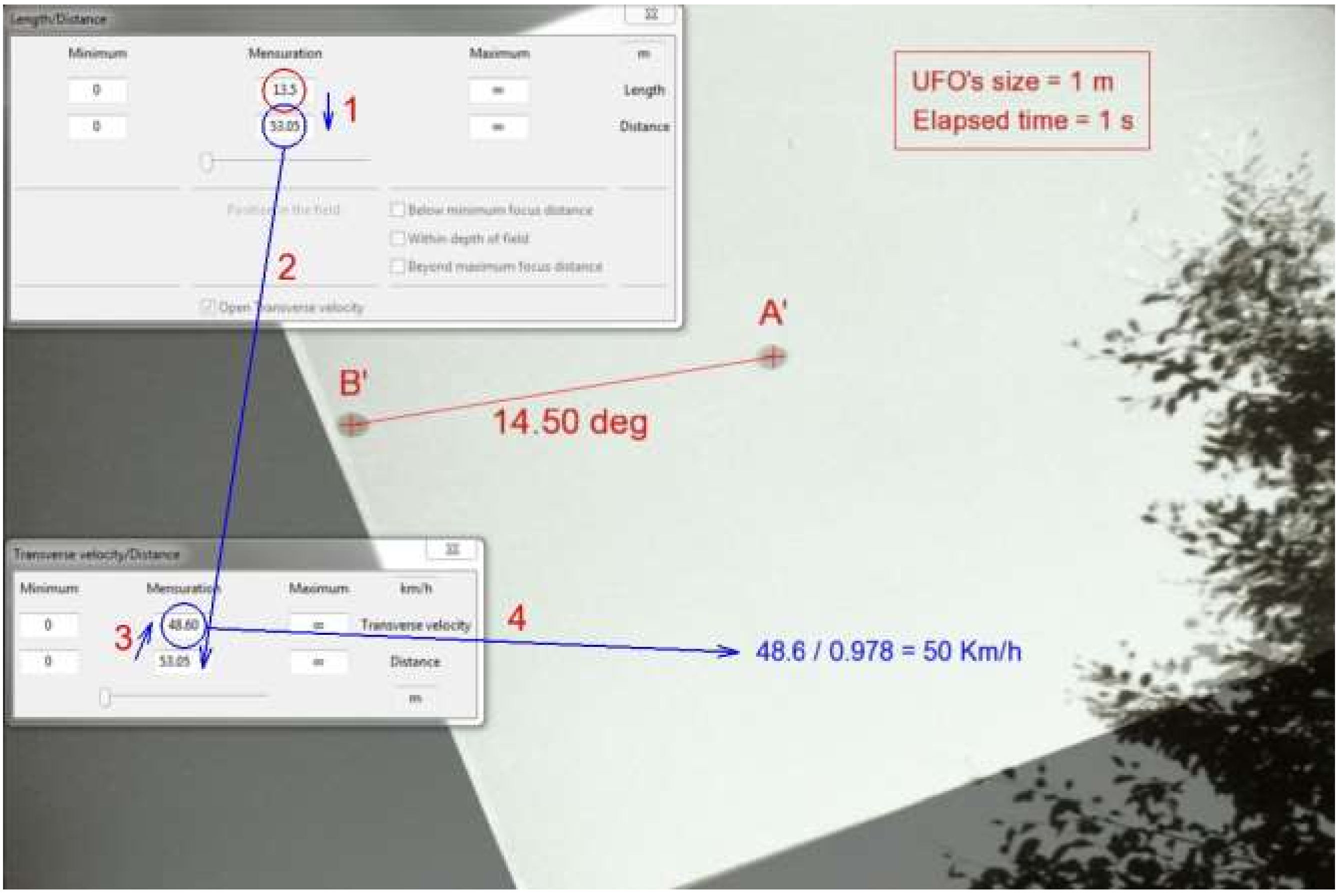
There remained only one lead available to assess the UFO's velocity, based on the composite LC_{3+4} image, assuming that the velocity was about constant between points A and B of the UFO's trajectory.

Table 8 *(see p.55)* provided the length of the OA, OB and AB segments (respective distances between the camera O and points A and B of the UFO's trajectory) and the minimum value of the UFO's velocity V in LC_3, as functions of its diameter Ø. The distance OM from the camera to the middle point M of the segment AB was also derived:

Ø (m)	**OA** (m)	**OB** (m)	**OM** (m)	**AB** (m)
0.1	5,40	5,30	5,35	1,35
1	54,0	53,0	53,5	13,5
10	540	530	535	135
100	5404	5296	5350	1352

(Table 9)

With image LC_{3+4}, it was possible to assess the UFO's mean velocity between points A and B as a function of the UFO's diameter Ø and of the elapsed time T between shots LC_3 and LC_4:



- *Table 9* provided the value of OM as a function of Ø
- The elapsed time T between shots LC_3 and LC_4 was introduced in IPACO's *Camera/Technical data* function as a "pseudo–exposure time"
- IPACO's *Length/Distance* and *Transverse velocity/Distance* functions could then be used to assess the UFO's transverse velocity V_T
- The UFO's absolute velocity V was equal to the transverse velocity V_T divided by sin (<OAB>), like in the previous paragraph.

The resulting values of V (Km/h) were the following:

V (Km/h)

T (s) **\ Ø** (m)	**0.1**	**1**	**10**	**100**
0.1	50	500	5000	50000
1	5	50	500	5000
10	0.5	5	50	500
100	0.05	0.5	5	50

This "raw" table could be refined so as to only display acceptable solutions which take into account the established limit for elapsed time T (forbidden values appear grayed out):

- Minimum elapsed time T *(see p.7)*: T ≥ 5 s

V (Km/h)

T (s) **\ Ø** (m)	**0.1**	**1**	**10**	**100**
0.1	50	500	5000	50000
1	5	50	500	5000
5	1	10	100	1000
10	0.5	5	50	500
100	0.05	0.5	5	50

(Table 10)

According to this table, if the UFO's size was in the order of one meter or less, its velocity was lower than 10 Km/h, which could only be understandable if it was a light object pushed by the wind (balloon). This hypothesis (balloon) had already been eliminated *(see Annex p.90)*.

Consequently, from this part of the analysis (ignoring the other parts), we could only infer that the UFO's size was more than 1 m, **unless the four pictures did not relate to the unique movement of a unique object (case of a fake based on several small objects thrown successively)**.

Hypothesis of a fake

Since the very beginning of this study, the possibility of a fake was taken into account. This was the main reason for organizing an on-site mission in July 2015. The *Annex* provides all details about the initial investigations concerning the case (bibliography, camera and film models, possible types of fake) and on the sequence of events during the mission.

The two most probable hypotheses retained to explain a possible fake were those of a Frisbee and of a clay pigeon. The case of a balloon had been eliminated from the beginning, as explained in the *Annex (p.90)*.

Hypothesis of one or several Frisbees

The Frisbee, invented in the USA in 1948, has only been massively introduced in France at the end of the fifties, after the Lac Chauvet event. However, a few examples may well have been brought back by some of the numerous American soldiers who were settled in France at that time. The detailed history of this sport is provided in the *Annex (p.77)*.

In the fifties, all existing Frisbees had the same characteristics:

- Diameter : 23 cm
- Weight : 115 g

A thrown Frisbee has a spinning velocity in the following range:

Minimum	: 3.3 rev/s
Average	: 6.5 rev/s
Maximum	: 10 rev/s

During the on–site mission in summer 2015, the team of investigators made a lot of launches and took many photographs, using the following equipment:

- One modern Frisbee (1991) with a 23cm diameter
- Several modern Frisbees (2015) with a 25 cm diameter
- A Zeiss Ikon Ikonta 35 camera identical to Mr. Frégnale’s
- Modern films with characteristics similar to those used at the time
- Several modern digital cameras

The bad wind conditions prevented the team from collecting useful quantitative information from Frisbees. However, from a qualitative standpoint, some pictures did resemble those from Mr. Frégnale.

The hypothesis of one or several Frisbees could therefore not be formally rejected, but the strong point against this explanation remained the fact that, in 1952 in France, those objects would have been rather difficult to find, as opposed to clay pigeons.

Hypothesis of one or several clay pigeons

Clay pigeons have been present in France for a long time, and the detailed history of this sport is provided in the *Annex (p.82)*. In 1952, they were mostly produced and sold in France by the "Manufacture Française d'Armes et de Cycles de Saint–Etienne" (usually called *Manufrance*), together with associated manual launchers.

As far as clay pigeons were concerned, at that time, the main standard characteristics were the following:

- Diameter : 10.8 cm
- Thickness : 3 cm
- Weight : 90 g

As far as launchers were concerned, the most popular model was called "Pistol Rex". It was basically portable, but it could be fastened to a fixed base. It could be equipped with 3 different springs, corresponding to 3 different ranges:

- Range: 30 m (standard), 40 m or 50 m

During the on–site mission in summer 2015, the team of investigators organized a lot of launches and took many photographs, using the following equipment:

- An American manual launcher "Western Hand Trap" (model V1500A) from the fifties
- A modern fixed automatic launcher
- Modern clay pigeons "Solognac" (11cm diameter, 2.4 cm thickness, 100 g)
- A Zeiss Ikon Ikonta 35 camera identical to Mr. Frégnale's
- Modern films having characteristics similar to those used at the time
- Several modern digital cameras

A thrown clay pigeon has a spinning velocity in the following range:

Minimum : 19 rev/s
Average : 24 rev/s
Maximum : 30 rev/s

Here is one of the photographs displayed in the *Annex*:

The same picture in black and white:

Obviously, even though the brightness of the sky differs from Mr. Frégnale's pictures, this clay pigeon looks very much like the object photographed in 1952.

As concerns trajectories, the following figures were obtained after many launches, for the ground to ground covered distance L, the maximum height above the ground H and the duration of the flight T:

	L (m)	**H** (m)	**T** (s)
Average	22	8,5	3
Maximum	40	12	4

Those figures are close to those presented at the end of the geometric study *(see Table 5)*.

One obvious conclusion is that if the series of four pictures from Mr. Frégnale shows clay pigeons, they cannot be explained by a single throw, just because the minimum time between shots is more than the maximum flight duration. Several successive throws have then been required for the fake.

On-site experiments proved that is was easy to launch several pigeons successively with each conforming to nearly the same trajectory.

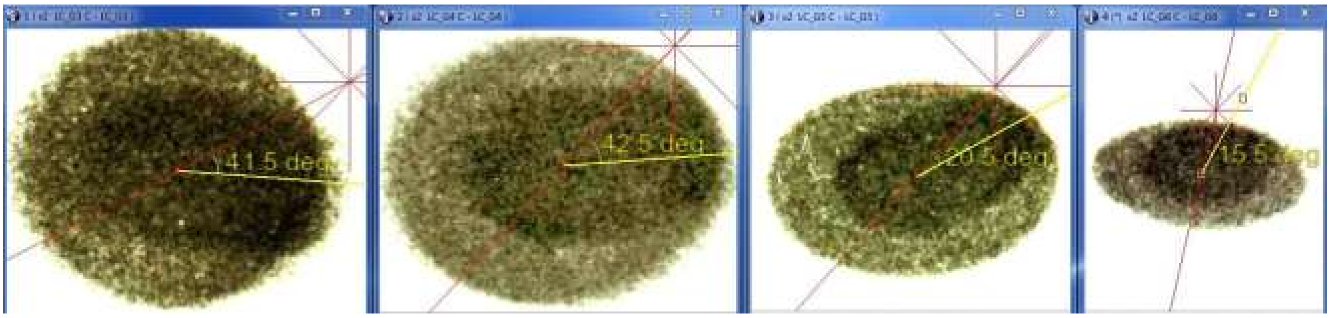
Problem of the dark spot

One particular aspect of Mr. Frégnale's pictures was the dark spot observed in the lower part of the UFO, and particularly its dissymmetrical configuration. A puzzling feature, noted by all previous investigators, was that, at first glance, the "axis" of this dark shape seemed to line up with the direction of the Sun, as well as with the direction of the UFO's movement.

Nature of the dark spot

The initial question was to determine whether the dark spot was physically linked to the UFO or whether it was just a shadow.

On each of the 4 enlarged images of the UFO (G_3, G_4, G_5 and G_6), the exact position of the maximum reflection of the Sun around the UFO was determined using, in a "diverted" way, IPACO's *Flare* function, which computes the "radiometric barycenter" of the reflection, and marks this point (which indicates precisely the Sun's direction) with an asterisk. Considering the ellipse of the UFO's base, the radius joining the center with this maximum reflection point was then compared with the "axis of symmetry" of the dark spot, as follows:



G_3 (41.5°) G_4 (42.5°) G_5 (20.5°) G_6 (15.5°)

Although the indicated angle values were approximate, they all were definitely by far different from zero, which excluded the possibility for the dark spot to be a simple shadow.

The dark spot was therefore really attached to the UFO itself.

Tentative explanation

Considering the dark spot as an integral part of the UFO, the next question was to know whether its relatively sharp contour on the four photographs was compatible with the exposure time.

To obtain an answer, a specific experiment was conducted in March 2016, as explained in the Annex (*pp.129-130*), using clay pigeons that were marked with a rectangular white painted spot, thrown manually and photographed by a modern camera with an exposure time of 1/250 s or 1/500 s.

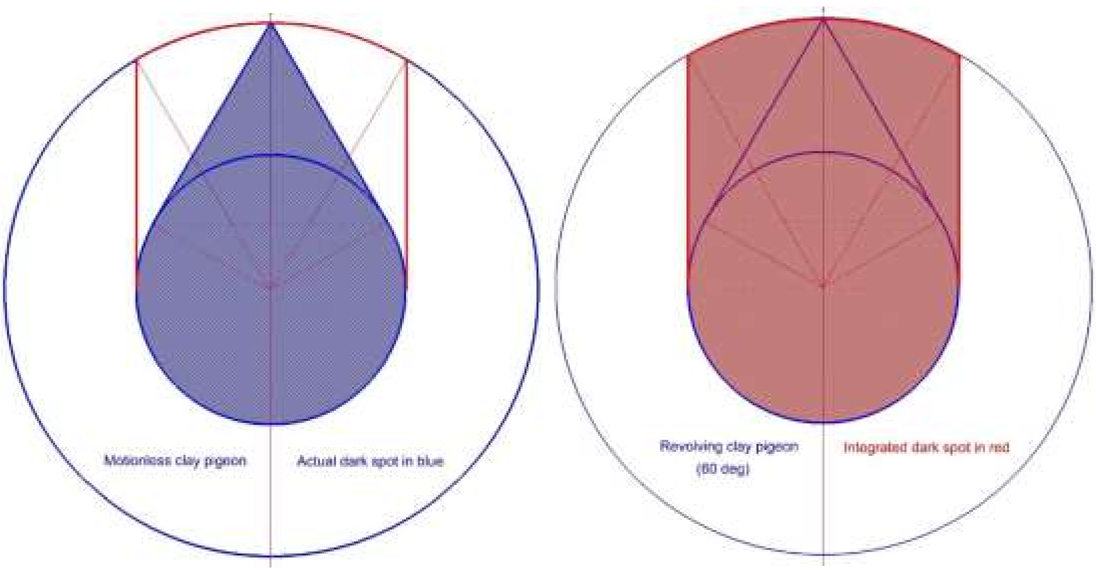
Here is one of the pictures (1/250 s), together with an enlargement of the clay pigeon:

The white rectangular spot was visible, with a sharpness comparable to that of the UFO’s dark spot. This confirmed that there was no incompatibility between the appearance of the UFO and its dark spot on one hand, and Mr. Frégnale’s shooting conditions on the other hand.

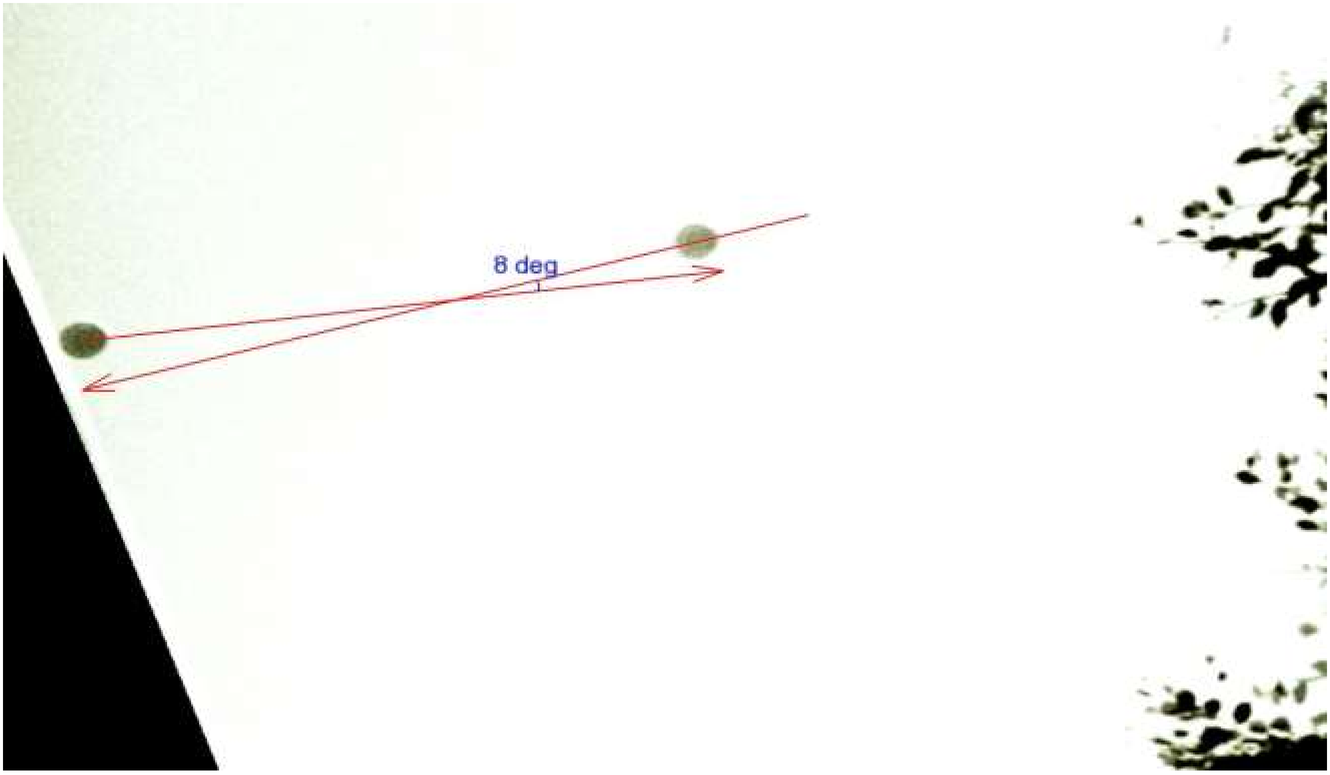
For a standard clay pigeon’s spinning velocity of 24 rev/s and an exposure time of 1/250 s, the spinning angle covered during exposure is:

$$360 \times 24 / 250 \approx 35°$$

The integration, during the exposure time, of the contrasted spot may also “bend out” its apparent shape, as qualitatively illustrated by the following sketch:



It was also interesting to try and quantify the initial impression that the dark spot's axis was in the direction of the UFO's movement. Going back to the composite picture LC_{3+4}, we could check that the dark spot's respective axes in the two positions of the UFO formed an angle of around 8° "downwards".



Although its assessed value was approximate (possible error up to ± 4°), this angle could not match at all the above-described parabolic trajectory. Indeed, if they had been along the movement's direction, the two dark spot's axes, in the two successive positions of the UFO, should have formed an angle "upwards", in accordance with the parabola's convexity.

In conclusion, the apparent alignment of the dark spot, either with the Sun or with the UFO's movement, was only approximate and in the end meaningless.

Even though the exact explanation of this dark spot could not been found, its presence does not contradict in any way the conclusions of this report.

Conclusion of the analysis

This analysis was conducted on the basis of reliable data, in terms of localization of the reported events, accurate identification of used photographic equipment, knowledge of previous studies and characterization of the witness' profile.

The geometric study enabled a rather accurate characterization of the object's parabolic trajectory to be obtained. If several objects must have been thrown successively (hoax) from the same place in the same way, this trajectory would still represent, with a limited uncertainty, the average trajectory.

The geometric study also demonstrated that the object's size was in the order of 14 cm, with an uncertainty of no more than 30%, which eliminates once and for all the hypothesis of a large object (one meter or more), and therefore proves that Mr. Frégnale's testimony was a fake.

The radiometric study enabled the possible camera's settings to be assessed. From this stemmed two useful pieces of information:

- The UFO's size was larger than 9.6 cm (from the depth of field)
- Pictures LC_3 and LC_4 could not display the same object, or at least the same throw (transverse velocity v's minimum time between two shots)

The on-site experiments with clay pigeons produced pictures very similar to those from Mr. Frégnale, and the measured heights and distances were very much in line with typical clay pigeons' trajectories.

At last, the "mysterious dark spot" on the object's base, whereas not finally explained, does not raise any technical problem, as was shown by specific experiments.

The final explanation is therefore that M. Frégnale must have thrown, using a launcher, or let throw by a companion a series of small discoid objects (diameter between 9.5 and 18 cm) , or the same object several times in a row, along the same trajectory. He was most probably using clay pigeons (diameter of 11 cm), or else maybe a variation (M. Frégnale was an excellent handyman) or even Frisbees.

The dark spot probably resulted from a coarse lick of black paint given on the center of the object's base (or objects' bases) or, conversely, from an unequal lick of white paint on the dark base' edge *(see the sketch at the bottom left of p.63)*.

The fact that this spot seems (quite approximately) lined up with the Sun and/or the object's trajectory stems from chance, unless (but nothing proves this) Mr. Frégnale had shot several series of 4 pictures so as to keep the most strange looking one.

The set of four pictures must be classified as a fake.

It is interesting to note that the results of this analysis report, which used a quite original approach, are close to those from other major studies of this case, in terms of the overall geometric layout.

In particular:

UFO's azimut	LC3	LC4	LC5	LC6
Guérin	195°	176°	142°	119°
Vaillant	192°	178°	161°	135°
IPACO	195°	180°	151°	134°

****

Annex

The idea of an on-site reconstruction naturally came in mind to the investigators and analysts as their work gradually progressed. It was at first necessary to take again everything that was said and done on the matter since 1952 (see chapter "S*ources*" at the end of the annex).

This preliminary work that consisted of readings, source and data researches, then compilation, was mainly done by ACN, assisted and supported by FLE and GQK on one hand for IPACO, and by the ground investigators FCR, PSY and GMH on the other hand (see chapter "*Credits*" at the end of the annex).

Several other investigators participated in a more or less active way to this preparation and in particular some members of the French UFO forum UFO scepticisme: NAB, DCN, MAR, FLO and SNL.

Finally, it goes without saying that without the meticulous work of the previous analysts and investigators (PGN, LGN, and ADN) and the support of XPT, MVT and RPI, nothing could have been possible.

This first section "preliminary researches" presents, in the most possible exhaustive way, the preliminary work that has been done so as to perform the on-site reconstruction that happened between July 26th and July 30th 2015, which presentation is the object of the second part of this annex.

Then, in the third part, are presented the later works to the reconstruction that were useful for the IPACO report itself.

Preliminary researches

Identification and use of the photographic equipment

Choice of the camera model

PGN-ADN-ACN-NAB-DCN-SNL

The identification of the camera was a relatively long and difficult process that was the subject of several more or less technical discussions between the various investigators, in the course of the years.

Chronologically, the first mention of the camera used was that done by PGN in 1972 and taken again by ADN in his own researches (6); Mr. Frégnale himself never directly mentioned the model he used at that time.

Then, PGN briefly mentioned, for the first time, the camera ("**Ikonta Zeiss**"), as a caption of Mr. Frégnale's photos that illustrate a non-specialized paper about UFOs in the French review "*Science et Avenir*" (1), then in 1993 in an article published in the French specialized review "*Lumières dans La Nuit*" (3) and finally in 1994, in a paper of the "*Journal of Scientific Exploration"* (4).

He specifies in these two last papers that the camera used was of the brand **Zeiss Ikonta** "*with an excellent Tessar lens (with a 45 mm focal distance) and with a central shutter of Compur or Prontor type. A slightly yellow filter Wratten 15 was used (to darken blue sky on black and white photographs). The diaphragm was likely set at 1:5.6. The displayed exposure time was 1/250 s (but likely 1/200 s, since central shutters are always too "slow" at high shutter speeds). Considering the average photographic density which varied on the negatives, the diaphragm (or the speed?) was changed between the first and second shots.*"

This description is translated later, in 2003, by ADN in his website (6). He specifies as an aside: *"From the precise indications of Pierre Guérin (kind of the body, of the lens, of the shutter ...), I think that I have found with a very little margin of error the exact camera that André Frégnale used.*

*According to me, this is a **Zeiss Icon "Contessa"** model 533/24, with a 35 mm film, produced between 1950 and 1953. (f2.8, 45 mm Tessar lens, shutter Compur Rapid X synch), "folding" type (with a folding lens)."*

Lots of discussions occurred later about the relevance of this choice, particularly with ACN, DCN, NAB, and SNL on the French forum "UFO scepticisme" (7).

From this, it appears that the Zeiss Ikon Contessa is not the only one 35 mm camera model that existed in 1952, and that it can be equipped with both a 45 mm Tessar lens and a Compur or Prontor shutter. This is also the case of the **Zeiss Ikon Ikonta** 35 mm (522/24), built from 1948 to 1953 and that can be equipped with both a 45 mm Tessar lens and a Compur-Rapid shutter, up to 1/500 (DCN). A color filter (yellow, green ...) can be attached to the lens as well.

Zeiss Ikon Ikonta 35 II (5224/524) equipped with a Novar-Anastigmat 45 mm f3.5 lens and a green filter (17)

The model equipped with the Tessar lens is rare, because of the war damage shortages caused to the German factories that produced it. It was quickly replaced by other models, such as the Novar or, later, the Xenar (13) (17).

The rare Ikonta model equipped with the Tessar lens and the Compur-Rapid shutter (11)

As concerns the Ikon Ikonta 522/524, it was gradually replaced, from 1951, by the Contina models.

Besides, in the two cameras, the loading can only be done by the receiver spool located on the left side, contrary to other more recent models where the loading is done by the right spool (SNL):

Back view of the Zeiss Ikonta 35 (522/24) (11)

Back view of the Zeiss Contessa 35 (533/24) (12)

The main element that helps to differentiate between the two camera models was the name that is word by word “**Zeiss Ikonta**” and not “**Zeiss Icon**”. Indeed, the model named "**Zeiss Ikon Contessa**" was never usually mentioned as "**Zeiss Ikonta Contessa**". At most it can be said that the sole designation "**Ikonta 35**" was only used to define the model design (14) (15).

Besides, the Ikonta does not have, in contrast to the Contessa, either rangefinder or exposure measurement, that could have been of utility to Mr. Frégnale, who was an informed photographer. Finally, the Contessa was at that time an expensive camera, more than the Ikonta (16). Mr. Frégnale, who was a modest man (6 - Chapter IV) would naturally choose the Ikonta model.

This model name "**Zeiss Ikonta**" was probably specified by Mr. Frégnale himself during a phone interview with PGN, who never met him, as far as we know.

Therefore, our choice naturally tends to this model (DCN-ACN).

Once the model is defined, ACN could buy for the on-site reconstruction the exact same camera, except for the lens which is a Xenar and not a Tessar (both f/2.8). It is a **Zeiss Ikonta 35 mm (522/24)** in perfectly working condition:

The camera used during the on-site mission

Choice of the film model
PGN-ADN-ACN-NAB-DCN-SNL-MGU

Another problem that occured for the optimal use of the camera is the choice of the film to use during the reconstruction.

Indeed, PGN explained that the film used was a Kodak "*Panatomic-X Kodak 35 mm*" (3). ADN is more precise: "*Kodak Panatomic-X (5060) FX BW (ISO 32) where 5060 is the Film Code Number and FX the Code Name*" (6 - Chapter VIII), without specifying however the source of this information.

Kodak unopened pack vintage 2 1/2" x 3 1/2" Panatomic-X cut films, ANTI HALO

This film, which was considered at that time as a "must" in photography, being absolutely unobtainable nowadays (either the production was stopped or the film is widely expired), it was necessary to find a change solution that could be acceptable, i.e. with the same technical characteristics as that of the Panatomic X.

ADN says (6 - Chapter VII): "*This film was the most accurate available at that time, and it held this record for a very long time up to the arrival firstly of the Kodak Technical Pan, then in 1987 of the T-Max 100 [...] Its revolving power incredibly high varying from 180 lpm to 200 lpm according to the sources (lpm = lines per millimeter)",* without quoting these sources.

In a technical paper (18) from Tim Vitale allowing computing the effective resolution of an image thanks to an equation that takes into account the theoretical lens resolution, the used film and the post-process, we learn that the native resolution of the Panatomic-X in 1976 was about 170 lpm.

This film had a long life span (from 1933 to 1987), and **never ceased to progress** in the course of time. In another technical paper from the same author as the previous one (which is in fact an increased edition) (20), we learn that the Panatomic-X was often evaluated as the one that had the higher resolving power in the technical data books of Kodak. This resolution was therefore evaluated as follows:

- 1939 : 55 lpm
- 1947 : 100 lpm
- 1956 : 95-115 lpm
- 1965 : 136-225 lpm
- 1976 : 170 lpm

Panatomic-X was often rated with the highest resolving power in the Kodak data books. The data on this film was followed through the Kodak books noted above:

(1) 55-lp/mm* (2794 ppi) in 1939 *Kodak Film: Data Book on Negative Materials* (15¢)
(2) 100-lp/mm* (5080 ppi) in the 1947 version of the same data book (35¢)
(3) 95-115lp/mm* (4750-5842 ppi) in 1956 *Kodak Data Book on Films* listed as "high" resolving power
(4) 136-225-lp/mm* (6908-11430 ppi) 1965 *Kodak Advanced Data Book* (50¢) listed as "very high"
(5) 170-lp/mm (MTF data) (8636 ppi) in 1976 Kodak book on *B&W Professional Films* (F-5, $5.95)
(6) NA, not listed in the 1984 version of Kodak Pub F-5

Chronological evolution of the native resolution of the Panatomic-X film

Therefore, although it is right to say that this film was probably the most highly resolved in 1952, its resolution was not between 180 and 200 lpm, but rather around **100 lpm**.

As the production of this film was stopped in 1988, we searched for a replacement solution that respects in a best possible way the technical criteria imposed by the Panatomic-X:

- Black and white film
- Low ISO
- 35 mm format
- Present resolving power: 200 lpm at contrast 1000:1 and 60 lpm at contrast 1:6
- High quality image
- Ultra-fine graininess

Two kinds of films seemed to comply with most of these criteria:

- The Ilford ***"PAN F Plus 50 ISO 35 mm B&W***" (21).
- The Fuji "***Neopan Across 100 ISO 35 mm B&W***" (22).

ACN bought respectively 5 and 3 of these films.

Identification of the trees

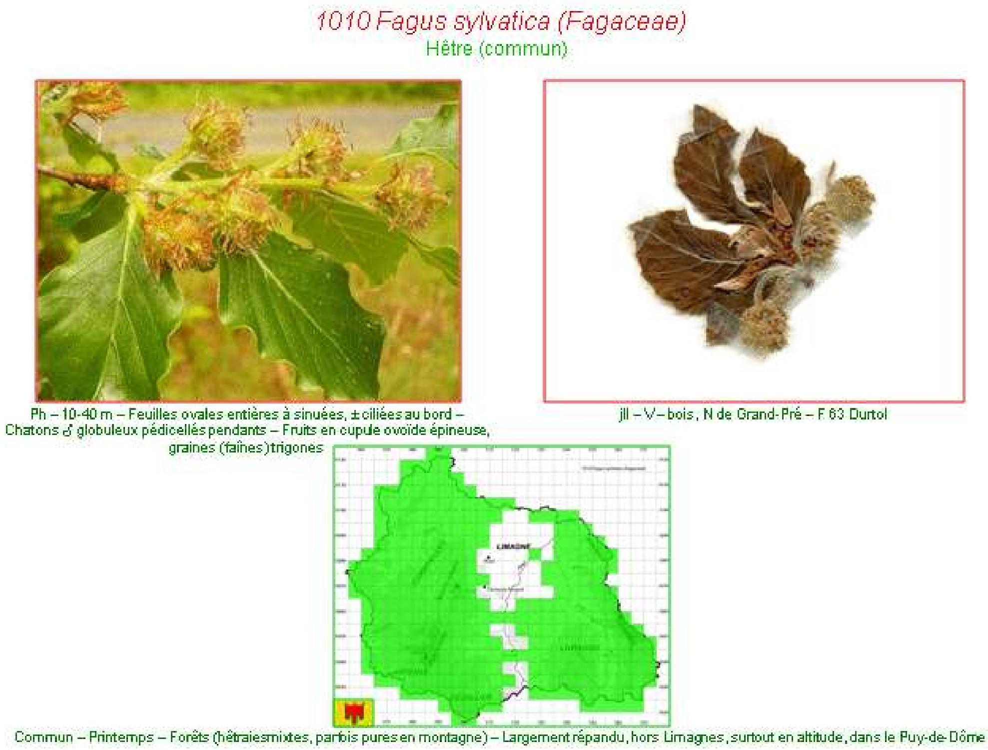
ACN-PSY

The identification of the trees visible both on Mr. Frégnale's original photos and on Pathé's movie (filmed during the first on-site reconstruction that took place on Saturday, July 26th 1952 and called hereafter "*Pathé movie*") is a main point of the case analysis.

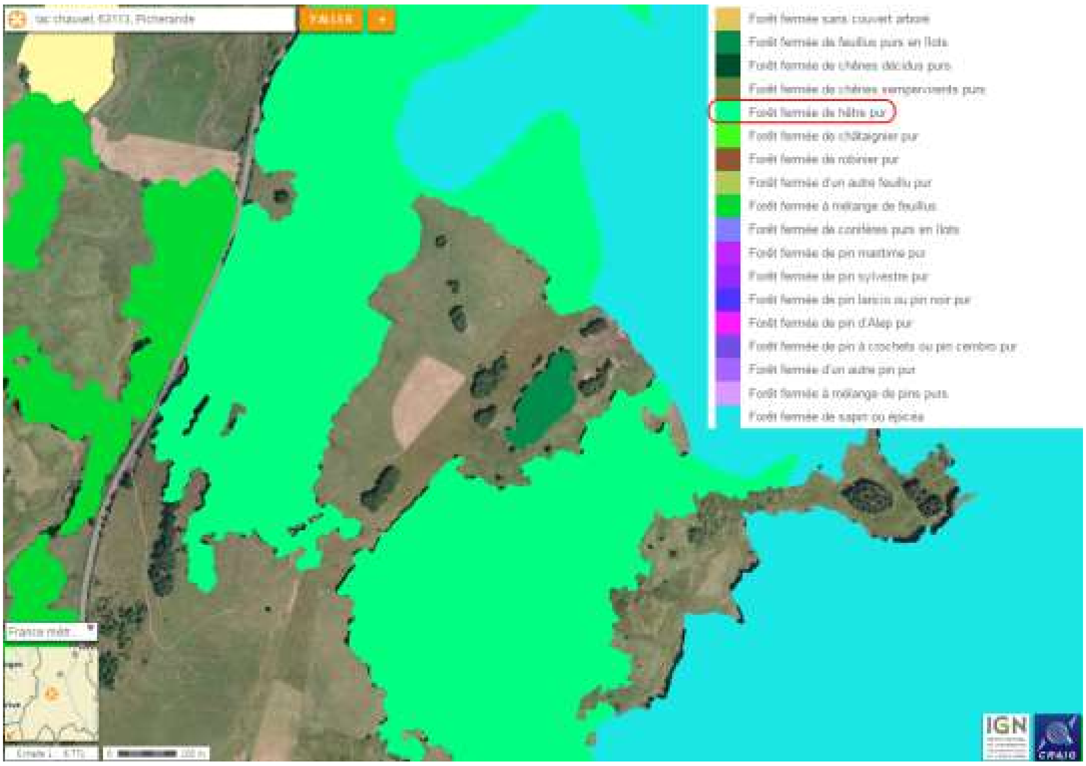
Indeed, their physical characteristics allow, especially with the help of IPACO, to do a process of geometric and radiometric measurements essential for the continuation of the study.

The first preliminary work was to determine which varieties of trees were present on the area in 1952, and if these varieties are still present nowadays. The Puy-de-Dôme department fortunately owns lots of database material constituted by botanists and available for consultation on-line (23) (24) (25).

The cross comparison of these databases with the forest data coming from the Géoportail site (26) allows, proceeding by elimination, to determine the nature of the trees visible on the photos and on the Pathé movie, and which location was rediscovered after the second on-site reconstruction in July 2015. They were juvenile beeches, already mostly present in 1952 in the area.



Combined or pure beech wood distribution in the Puy-de-Dôme department (23)



Géoportail forestry data (26)

Samples of juvenile beeches found on Internet have a very similar aspect (in "feather") to that of the trees visible on the photos and on the Pathé movie:

The main difference between plain beeches and mountain beeches (around 1200 m of elevation for Mr. Frégnale's position), lie in their more stocky aspect for the mountains' ones. Beeches observed on site are all mature, not growing any further after 50 years, their age being at least 70 years old (PSY).

The size of their leaves was measured on the site (ACN) and they have an **average length of 6.5 cm, never more than 7 cm** (10 cm for plain beeches).

It is noticeable that some of these remarkable trees were conserved on the place over time and had grown without suffering from any important modification of their "morphology" by human intervention.

LC_3/LC_4 beech in July 1952 and a similar beech photographed in July 2015 on the site

Identification of the UFO

PSY-GMH-FLE-ACN-DCN-NAB-MAR-FLO

Two main hypothesis are retained for this identification.

In the hypothesis of an unknown **rather big and distant object**, its physical and dynamical characteristics must, as far as possible, be quantified by IPACO and comply with what Mr. Frégnale said, namely:

- Azimuthally displacement around 100° (37) (5) (6).
- Straight and horizontal trajectory (1).
- Trajectory without swinging or curve (1).
- Regular and uniform linear speed (1).
- Interval time of around 8 seconds between each photo and the following one (1).

Most of these points are developed in the analysis.

In the hypothesis of a forgery perpetrated by Mr. Frégnale (therefore of a **rather small and close object photographed several times**), the idea of the use of a common manufactured object with a circular shape was submitted for the first time by various contributors, about ten years ago. PGN mentioned as well the hypothesis of a "*suspended model oscillating on an invisible thread or thrown in the air four successive times*", refuting it at the same time, as well as the idea of a photographic forgery (and in particular of a voluntary double exposure) (3).

The hypothesis of a confusion was suggested as well, as soon as in July 1952. The only object that was likely to cause such confusion at that time was a weather balloon. See about this subject the chapter "*Balloon hypothesis (confusion)"* page 88. This balloon hypothesis will stay the only one mentioned up to 2003 where the discussion on Internet (8) (9) (10) highlighted three new ideas about the possible nature of the object that could have been used:

- A Frisbee
- A clay pigeon ("*skeet*")
- A hat

These hypotheses necessarily imply that at least two persons were present: one to throw the object and the other one to take photos.

However, it was said that Mr. Frégnale, who was known for his cleverness, could have modified, built or created a delayed propulsion system (DCN) for the two first hypotheses.

This system could also have been modified by Mr. Frégnale to throw a disk-shaped object with no or low rotation (problem of the "*dark spot*").

In any case, we try for the on-site reconstruction to be as faithful as possible in the choice of the Frisbee and clay pigeon models, in comparison to what existed in 1952.

Frisbee hypothesis
A few histories...

ADN-ACN-GMH

This hypothesis collides at first glance with a historic and cultural difficulty, as stated by ADN (6 – Chapter V).

Indeed, although the Frisbee was massively produced and commercialized in the USA by the Wham-O company only in 1957, the first plastic models were sold as soon as 1948 door-to-door in south California by their two inventors (Morrison and Franscioni) and the company they created ("*Pipco*").

WHAM-O

Frisbee

Roswell, New Mexico. The "Roswell Incident" fueled our country's infatuation with UFOs, and in response, Pipco renamed their toy the Flyin' Saucer. According to written correspondence acquired by Malafronte, Morrison got some blocks of hard plastic and had a mechanic friend, who owned a lathe, turn out some models while Franscioni funded the start-up with $25,000. Using these early models, the first Flyin' Saucer molds were made sometime in 1948.

The Pipco Li'l Abner Flyin' Saucer, launched in an effort to invigorate the company, ended up being Pipco's demise.

Flyin' Saucer Pilots

Morrison and Franscioni quickly learned that after landing on a store shelf, their flying toy remained there. Like a UFO, the Flyin' Saucer had to be seen to be believed, so the entrepreneurs demonstrated it wherever they could find a crowd. Their first account was the local Woolworth's store in Glendale, California, where the two men dazzled shoppers with their remarkable skill at throwing and catching. Despite Morrison and Franscioni's proficiency, the store manager wasn't taking any chances—he had the men stand within a wire cage during the demonstration!

The sight of a sailing disk is so common today that it's hard to imagine the amazement that bystanders experienced when they first saw this new toy in use. After Morrison and Franscioni moved their demonstrations to the great outdoors, they overheard an onlooker comment that "they must be using wires to fly the thing." Quickly, the two savvy salesmen incorporated the perceived deception into their sales pitch. "The Flyin' Saucer is free," they'd say. "But the invisible wire is $1.00."

They promoted the Flyin' Saucer in California and at Daytona Beach, Florida. They even landed orders from Disneyland, but despite their continued efforts, the "World Champion Flyin' Saucer Pilots" (as they hailed themselves) could not get their toy off the ground. With sales waning, they thought the recognition of a well-known license might provide the lift they needed.

In the spring of 1950, Pipco signed an agreement with Al Capp, the creator of the comic strip *Li'l Abner*. The men evidently overstepped the limits of their agreement with Mr. Capp in packaging Li'l Abner comics with the toys, because shortly after the disks hit the streets, Pipco was hit with the cancellation of the contract and a lawsuit. Having weathered four years of development and promotional efforts with little return, this threat of litigation proved too much for Pipco; they settled with Capp for $5,000, but the damage was done.

Extract from Tim Walsh's book recounting the Frisbee's history (27)

These models were also sold to Woolworth (popular California supermarkets in the fifties) and, later, to Disneyland for 1$... which was the price of the invisible thread that allows them to fly (actually a joke of the inventors to reply to the sceptics that believed (dixit) that the object was maintained in the air by an invisible thread!).

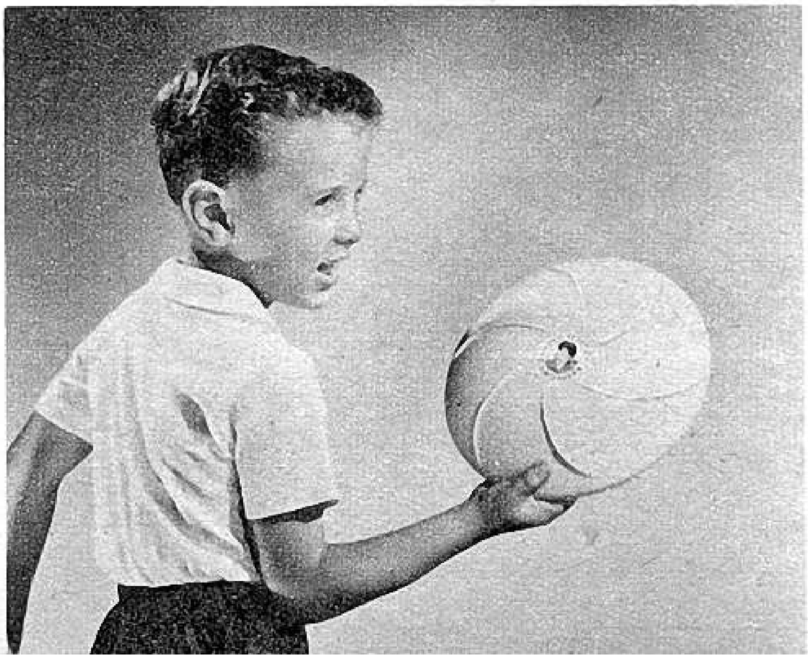
The most funny aspect in this story is that the two Californian inventors drew their inspiration from the Roswell saga to create this first plastic disk-shaped that they naturally named "*Flyin-Saucer*"! They wanted to pick up (already at that time!) on the ambient madness that prevailed in the USA around the flying saucers.

Then, at the beginning of 1950, the designer Al Capp concluded a deal with Pipco to revive the "*Flyin-Saucer*" model thanks to the comic character Li'l Abner, but it was a failure, the two inventors overstepped the deal concluded with Al Capp by offering for sale at the same time the disk and the circular-shaped illustrated card-board to stick on this disk (27).

Pipco (1950) FS 2/3 Li'l Abner's Flyin Saucer, AKA Pipco Crab, Arcuate Vanes

Li'l Abner's Flyin-Saucer, AKA Pipco Crab - 1950 (28)

Li'l Abner's Flyin' Saucer can be thrown, boom-eranged or skimmed. It's made of Lumarith plastic. Capp Enterprises, 17 East 45 Street, N.Y.C. $1



1950 advertising praising the Frisbee Li'l Abner Flyin-Saucer (29)

What we don’t know however is how many models were sold (not in masses, as the selling struggled to take off between 1948 and 1955) and if they were already exported to France at that time…

However, and even if it would be surprising that the Frisbee concept was generally known in France in 1952 (the first models “*officially*” came in the country in 1977 (32')), it can’t be formally excluded that American expatriates coming to France could bring in such models in their luggage this year or some years before.

Indeed, after WW2 and under the French IV^{e} Republic, many Americans, civilian and military, settled in France between 1948 and 1958 principally (date of the power backing of General de Gaulle and the break of the *"Americanization"* politic in France), year when France counted more than 62.000 Americans on its ground. They brought in with them their way of life, their sports and also their hobbies (30). Frisbee was already well known in 1952 in the USA and to imagine that it could have been imported this way in France at that time is not unbelievable at all.

To summarize, it is really possible that Mr. Frégnale was aware of the existence of the Frisbee as soon as July 1952 and took inspiration from it, and even was possibly able to get a model in hands.

As a Frisbee is a plastic object, it is light and easy to handle and can easily be thrown quite far away with little training. It is although sensitive to the wind.

The ancestor of the Frisbee ("Frisbie's Pies Tin") (29)

Choice of the Frisbees
ACN

Four Frisbees of different colors (red, black and white) have been brought by ACN and used. Three are of the same modern model, with a 25 cm diameter and a weight of 170 g. The fourth is a white 1991 model, with a different shape, with a 23 cm diameter and a weight of 115 g. These last characteristics are identical to those of the first Frisbees produced in the USA (the "*Li'l Abner Flyin-Saucer*" model diameter is for example 9 inches, about 23 cm). The brown Frisbee, recent model, is an advertising model from the *Snickers* brand and was brought by FCR.

The three modern Frisbees red, black and white, are semi translucent and it is possible to see the upper markings by transparency (for the red and white models), which will be useful for the speed rotation measurements.

The Frisbees used during the July 2015 on-site reconstruction

Clay pigeon hypothesis

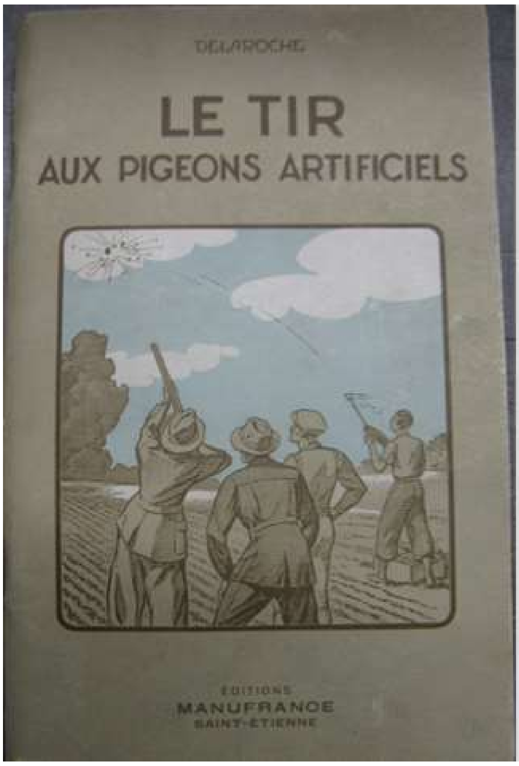
ADN-DCN-ACN-PSY-GMH

This other hypothesis involving a disc-shaped object was evoked as soon as the beginning of the 2000s on Internet (8) (9) (10), mainly because of the aspect of the clay pigeon, which disc's shape, like that of a Frisbee, is similar to that of the photographed object.

However, in contrast to Frisbees, clay pigeons and throwers had existed for a long time in France in 1952. They were mainly distributed by the *Manufacture Française d'Armes & de Cycles de Saint-Etienne* ("*Manufrance*", Loire), located 120 km away from *Lac Chauvet*.

Extract of the 1951 Manufrance catalogue

The factory even edited in 1950 a 62 pages guide that detailed the material and its use:




CHAPITRE I

LE MATÉRIEL

1° LE PISTOLET LANCE PIGEONS

Fig. 1

Afterwards, ADN disputes the hypothesis (6 – Chapter V), stating:

"Skeet machines throw clay targets of 11 cm in diameter and weighing about 100 g. Imagine the needed modifications on such a launcher to make it eject trays of 1 m in diameter!

Skeet machines eject the trays at a certain angle from the ground. For the object to have a horizontal trajectory it would need not only to change the launching angle on the machine, but also to raise it several tens of meters up (since the object, assuming that it is at most about 60 meters away from the camera, is also consequently nearly 40 meters high).

The skeet machines were rare and expensive in 1952. It is unlikely that a single individual has been able to afford such a luxury, especially for a mere hoax. It is even more unlikely that Mr. Frégnale was able to buy such a strange object without triggering the curiosity of the neighbourhood, as he was not a shooter. Besides he would need the help of one or two accomplices to handle and hoist the machine, as well as bulky equipment ... Little discreet stuff."

However, like we already noticed, manual throwers were common and easily findable at that time in *Manufrance.* We were able to find two models from this catalogue.

- The ***"Pistol Rex"***:

Present in the 1951 *Manufrance* catalogue (see illustration page 82), it could be used "*bare hands*", standing, or fixed on the ground on an adapter support ("Simplex *support*"). Easily transportable (weight: 3.7 kg) and compact (1 m long stretch out and 0.6 armed), it is however true that its price was a handicap (5700 “*old*” Francs for a mean salary *(in French)* for an employee in France in 1952 of 4404 francs) for someone as modest as Mr. Frégnale.

Pistol Rex in its box with two of its three springs (32)

It was delivered with a « normal » spring that throws the clay pigeon (110 mm of diameter) about 30 m away. On demand, it was possible to mount two other springs called “strong” and “very strong” throwing the pigeon respectively 40 m and 50 m away. There existed as well various accessories and a “regulator” that allow to give to the thrower 15 possible different orientations (in elevation and in azimuth).

The "*Pistol Rex*" built by the Saint-Etienne factory is, nowadays, a rare object, hard to find and coveted by collectors.

Pistol Rex ready for use

- The ***"Skeet-ball"***:

This model is different from the "*Pistol Rex*" as it could be directly fixed on the barrel of the gun or shot rifle, or on a removable wood handle that had a gun shape.

Even lighter than the "*Pistol Rex*" (about 1.5 kg), equally handy and compact, it threw only small clay pigeons called "*bourdons*" (60 mm of diameter).

Its price is although a handicap, like for the "*Pistol Rex*". It is present since 1952 in the Manufrance catalogue, page 52:

52 MANUFRANCE, SAINT-ÉTIENNE (Loire)

TIR AUX PIGEONS ARTIFICIELS " SKEET-BALL "

Pour l'entraînement au tir de chasse sur but mobile, à courte distance et avec des armes des calibres les plus divers.

Le " **Skeet-ball** " est un nouveau sport qui procure à celui qui le pratique une très grande rapidité de tir en même temps qu'un coup d'œil infaillible. Par un entraînement suivi, tout chasseur, tout tireur, peuvent arriver, grâce au " **Skeet-ball** ", à une maîtrise étonnante et à égaler les meilleurs fusils, aussi bien en chasse qu'au tir aux pigeons. Le projecteur " **Skeet-ball** " lance en effet ses pigeons avec une très grande vitesse initiale et leur tir exige, surtout à courte distance, des réflexes extrêmement prompts.

Le projecteur " **Skeet-ball** " a été conçu pour être fixé, en raison de son faible poids, sur le canon d'une arme à un coup : fusil ou carabine jusqu'à 17 m/m de diamètre extérieur. Dans ce cas, le tireur actionne lui-même l'appareil et peut s'entraîner seul. Il peut aussi s'adapter sur une poignée amovible en forme de pistolet et même encore se fixer par vis sur un poteau avec déclenchement par câble à la disposition du tireur, simple à réaliser.

Le tir aux pigeons " **Skeet-ball** " peut se pratiquer à des distances diverses, suivant l'arme que l'on possède.

— Entre 20 et 25 mètres, avec une arme de chasse normale du calibre 24, 20, 16 ou 12.

— Entre 15 et 20 mètres, avec une arme de calibre 12 m/m ou 14 m/m ou un fusil de chasse normal pourvu d'un tube réducteur.

— Entre 10 et 15 mètres, avec une carabine 9 m/m et des cartouches à double charge de plomb.

Il est à remarquer que la pratique de ce tir avec des armes de petits calibres permet l'emploi de cartouches peu coûteuses, ce qui est particulièrement intéressant pour celui qui s'entraîne.

Projecteur avec poignée amovible.

PIGEONS ARTIFICIELS

ACCESSOIRES POUR SKEET-BALL

Extract of the 1952 Manufrance catalogue (legal deposit 2nd quarter 1952)

Skeet-ball stretched out

We note besides that the purchase of such a thrower is not an absolute prerequisite for the trials of the photos reproduction. Indeed, trials have been done by simply throwing clay pigeons by hand, with very good results. We should also not forget that Mr. Frégnale was a gifted inventor and handyman and that he could undoubtedly build without much difficulty a similar thrower, or modify an existing one.

Choice of the manual thrower
ACN

ACN was able to find a "*Pistol Rex*" but could not unfortunately purchase it as the seller excessively increased its price at the time of the transaction.

So we pulled over an American model, also produced in the fifties, and operating on a principle a little different from the "*Pistol Rex*". Indeed, the spring is fixed, integrated into the body of the thrower, which is used as an extension of the force and the speed of the launcher arm. The size of clay the pigeons accepted by this launcher is standard, i.e. 110 mm.

"Western Hand Trap" V1500A fifties model

Choice of the pigeons
ACN-PSY

Although clay pigeons' characteristics are internationally normalized, the detail of their upper part and their colors (essentially bright on the upper part and dark on the bottom part) can vary slightly. The same applies to their diameter (from 108 to 110 mm), their height (from 24 to 30 mm) and their weight (from 90 to 110 g).

The model from the Manufrance catalogue had the following characteristics: diameter 108 mm, width 30 mm and weight 90 g.

Clay pigeon model - Manufrance 1951

Pigeons used during the trials weight exactly 100 g and have a 110 mm diameter and a 24 mm width. Their colors are orange on the upper part and brown on the bottom part:

Nowadays, there are smaller models (60 mm for the "*bourdon*", 90 mm for the "*mini*" and 98 or 98.5 mm for the "*rabbit*", intended to be launched at ground level). We know that the "*bourdon*" existed as well in 1952.

Lastly we note the existence in 1952 of plastic pigeons (called "*semi-hard*" or "*for trial*", see p.82 in the extract of the Manufrance catalogue). These pigeons were supplied with the skeet-ball. It was however impossible to find any more information about this special pigeon model.

Balloon hypothesis (confusion)
ACN-FLO

This hypothesis was firstly postulated the 25 July 1952 by "aviation experts" and was passed by the press.

Selon des experts aéronautiques

La « soucoupe volante » photographiée en France était probablement un ballon-sonde

Nous avons annoncé que le 18 juillet, à 18 heures environ, un ingénieur électricien du Puy, M. Frégnale, en excursion dans la région de Besse, prenait quatre photographies d'un « disque qui, soudain, traversa le ciel d'ouest en est ».

Ces quatre documents — que l'on peut affirmer n'avoir été nullement retouchés — ont été présentés aux experts aéronautiques français. Ceux-ci pensent que l'engin photographié n'est autre qu'un ballon. L'hypothèse est solidement renforcée, voire confirmée, par une enquête menée par « France-Soir » à la Météorologie nationale, qui lance chaque jour dans le ciel des dizaines et des dizaines de ballons-sondes.

L'ingénieur en chef de l'Air, chef de la section des engins spéciaux, M. Decker, a ainsi jugé les quatre documents photographiques :

— C'est la première fois, a-t-il dit, que l'on me présente des photographies aussi nettes de prétendues « soucoupes volantes ».

Examinant attentivement les documents, l'ingénieur en chef de l'Air poursuit :

— Cet « engin » me paraît bien petit. La netteté de son contour et le rapport de proportions entre le premier plan (des arbustes) et le « disque » permet d'établir qu'il se situe très bas, qu'il est de dimension réduite et très rapproché de l'observateur. Celui-ci estime la distance à 3000 ou 8000 mètres. Personnellement, je supprimerais un zéro à ces chiffres et je la situerais à 300, au maximum à 800 mètres.

» La tache lumineuse que l'on aperçoit très nettement sur la tranche à droite confirme l'heure de l'observation. C'est un simple coup de pinceau du soleil alors à 45° au-dessus de l'horizon et dont les rayons s'accrochent au contour ouest de « l'engin ».

» M. Frégnale affirme n'avoir rien entendu. C'est étonnant. Tout engin propulsé dans le ciel produit un « écoulement » de son. Aucun n'échappe à la règle.

» A ma connaissance, aucun appareil guidé n'a été lancé sur cette région le vendredi 18. Alors ? Il est troublant, ce disque silencieux se déplaçant à une altitude relativement basse en un vol rectiligne comme s'il était dans le vent. Il ressemble étrangement à un simple ballon. Nous avons toutes les chances que la « soucoupe volante d'Auvergne » en soit un. »

(Lire la suite en 5me page)

Feuille d'avis de Neufchatel (33)

A controversy ensued by interposed articles, particularly with the publication in the newspaper "*La Montagne*" of articles challenging the assumption (35) (36). Journalists of "*La Montagne*" had therefore investigated and organized, with Mr. Frégnale, a "*Pathé actualité*" journalist and two or three other people, an on-site reconstruction on Saturday 26 July 1952, using one or more weather balloon(s), red and white, with a diameter of 50-60 cm and about 1.20 m.

Mr. Frégnale was placed in the same location as on 18 July, he had the same camera and it was the same time (36).

Details of this reconstruction are visible on AND's website (6 - Chapter IV).

Mr. Frégnale asserted himself in this newspaper (36). "*Some say that I photographed a weather balloon [...] I worked in aviation and, therefore, I have often observed such balloons that are transparent. However, the disk I photographed is never presented to the eye but in a flattened shape in the horizontal direction. In addition, the travel speed was far too important to be that of a weather balloon pushed by the wind. In addition, weather balloons are launched in the area "Centre du Puy" and "Aulnat". The wind, that day, was northwest oriented, whereas the craft that crossed the sky was moving from west to east".*

This investigation and the results of the comparison of the photos taken by Mr. Frégnale on July 18th and July 26th were published in the newspaper on July 28th, then picked up by other newspapers, especially by "*Point de vue*" dated August 7th:

Le 18 juillet à 15 h. 30, M. André Frégnale (ci-dessus), au cours d'une excursion à environ 1.200 mètres apercevait un objet de forme oblongue qui se déplaçait rapidement à une altitude qu'il évalua à 3.000 m. M. Frégnale eut la présence d'esprit d'en prendre 4 photos successives en l'espace de 30 secondes environ. Le bruit se répandit qu'il avait photographié une soucoupe volante. Une controverse s'engagea. On prétendit que M. Frégnale n'avait pas photographié autre chose qu'un ballon-sonde. Avec le concours de techniciens, il lançait, quelques jours plus tard, un ballon-sonde dans des conditions aussi proches que possibles de celles dans lesquelles il avait photographié l'objet, et le photographiait. Ces clichés de M. André Frégnale, personne n'a voulu prendre l'initiative de les publier, au lendemain de la controverse qui s'était engagée. Nous les publions aujourd'hui en exclusivité. L'examen par des spécialistes écarte toute hypothèse de truquage.

Voici la photographie prise par M. A. Frégnale le 18 juillet (en haut) et celle d'un ballon sonde prise quelques jours plus tard (en bas). Ces deux photos prises au même endroit.

Clermont-Ferrand

Photo prise par M. Frégnale

Point de vue (38)

The comparison of the two photos in this paper, that represent the weather balloon and the UFO, is visible as well in the Pathé film:

Extract of the Pathé film with the comparison of both photos (weather balloon and UFO) taken by Mr. Frégnale at the same location and in the same conditions

The Pathé journalist stated: "*The comparison of the obtained photos clearly shows that there is no similarity between the balloon and the mysterious object*".

After this reconstruction, the balloon hypothesis was not evoked up to 1994, in the JSE paper, written by PGN (4), and in a very concise way.

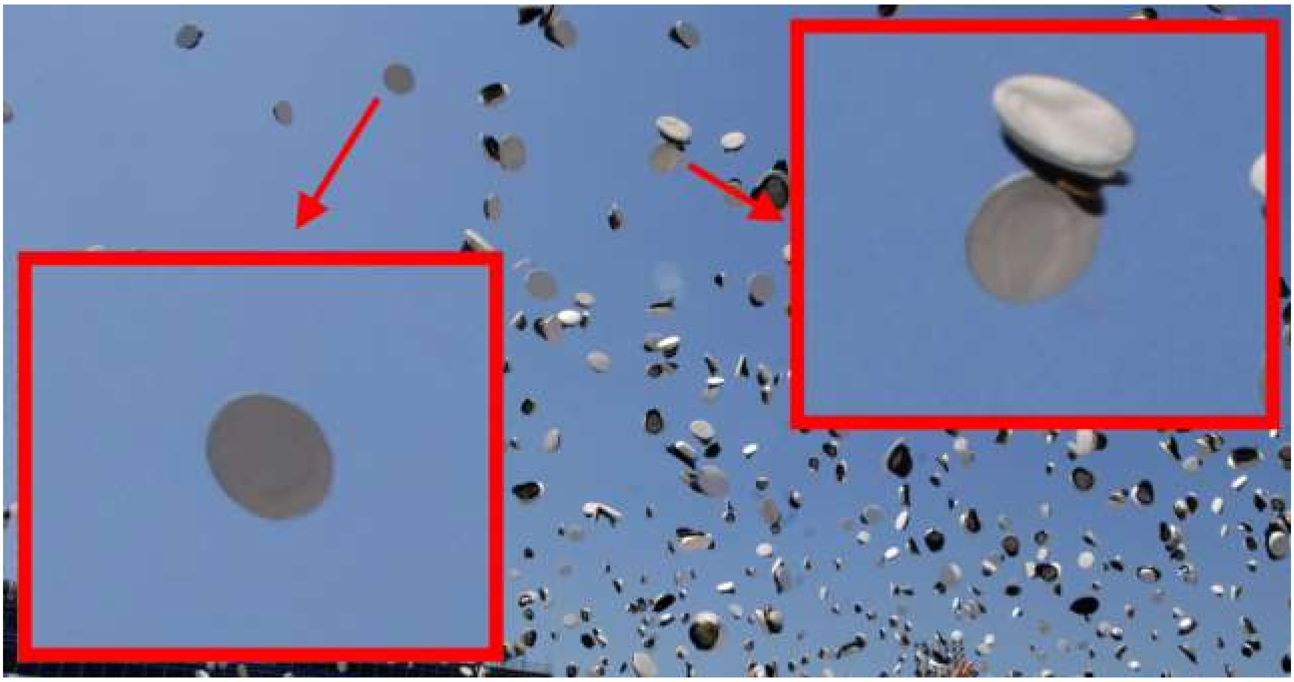
Then the hypothesis was evoked again in the Internet discussion (8) (9) (10) relative to the case right at the end of 2003, and summarized in the ADN website (6 - Chapters V and VIII).

Finally, it was the object, in 2015, of a long technical discussion about its feasibility and the possibility that such a balloon could take the appearance as seen on Mr. Frégnale's photos (7). The general consensus is that the hypothesis is not credible and therefore will not be retained for the analysis, thanks particularly to the results of the on-site reconstruction done July 26th 1952, in the closest possible conditions as on July 18th, which shows the visual differences between the balloon and the UFO.

During the on-site reconstruction in July 2015, this hypothesis could unfortunately not be tested, the wind being too strong.

Hat hypothesis
MAR

The hypothesis of a forgery made by Mr. Frégnale with the help of a hat (cap style) was evoked several times (7), in particular by MAR as soon as the 2000s.



In some aspects and in some viewing conditions, the resemblance to the UFO in Mr. Frégnale's photographs is rather gripping, including for the position and shape of the dark spot (created in the example above by the peak of the cap).

However, one might wonder whether successive shots could create a posteriori, during the negatives and prints examination, the illusion of a continuous and relatively stable displacement along a parabolic trajectory, especially during unfavourable weather conditions (wind).

Unfortunately, as for the balloon hypothesis, during the on-site reconstruction in July 2015, this could not be tested, the wind being too strong.

Precise location of the site and place of shooting

Previous investigators

ADN

One of the decisive points for the continuation of the analysis is obviously to determine the place where Mr. Frégnale was standing at in July 1952 when he took the four photos.

The case is commonly called "*the Lac Chauvet case*", although it is not exactly located on Lac Chauvet (Puy-de-Dôme department, Picherande municipality), but between 0.8 km and 1 km to the east:

General view of the area

ADN investigated about this point and found lots of information regarding Mr. Frégnale and the whole case. We can quote what he said on his website about this (6 - Chapter IV). Then, the journalist of "*La Montagne*" indicated that Mr. Frégnale "*was approximately near the Lac Chauvet*" (34) and Mr. Frégnale indicated himself the next day to the journalists that the observation took place "*between Besse and Condat*" (35).

Besides, journalists of this newspaper, the makers of "*Pathé-Journal*" and other persons came back to the exact place with Mr. Frégnale one week later, to do the above-mentioned tests (37).

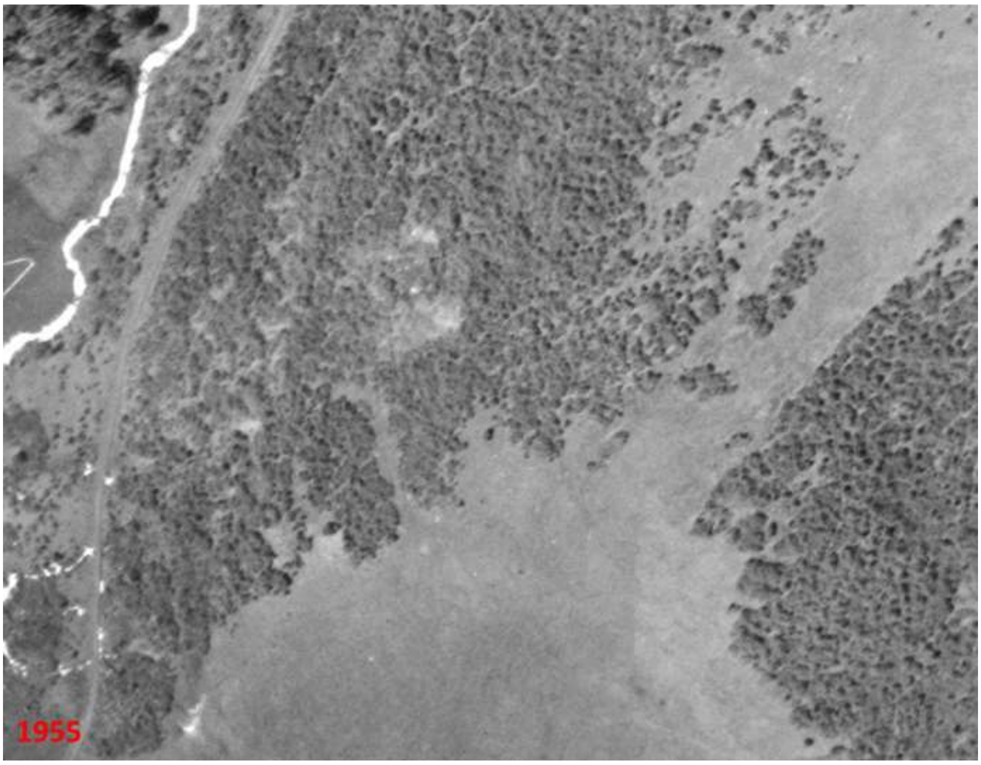
Mr. Frégnale was "*at the same place and there were the same conditions*" ("*Pathé movie*"), "*he has the same camera and it was the same hour*" (newspaper "*La Montagne*") to create the photos of the weather balloon.

As mentioned on AND's website, the short documentary film "*Pathé"* made from this reconstruction could be retrieved and exploited, which allowed, thanks to the visible landscape marks in the movie, to demarcate an area located about 1 km to the east of *Lac Chauvet* (6 - Chapter VIII):

Current investigators
ACN-DCN

A preliminary work, before the on-site reconstruction, was to try to confirm or to disprove this area as that where Mr André Frégnale could be located.

Thanks to the historical aerial maps (1948 and 1955) available from the French Géoportail website, we could retrieve the general area pointed out on AND's website. At first glance, it does not seem to suffer from significant modifications between these two years. Secondly, it is possible to compare this area, to a reduced scale, between this year (we chose 1955) and a recent period (2009):

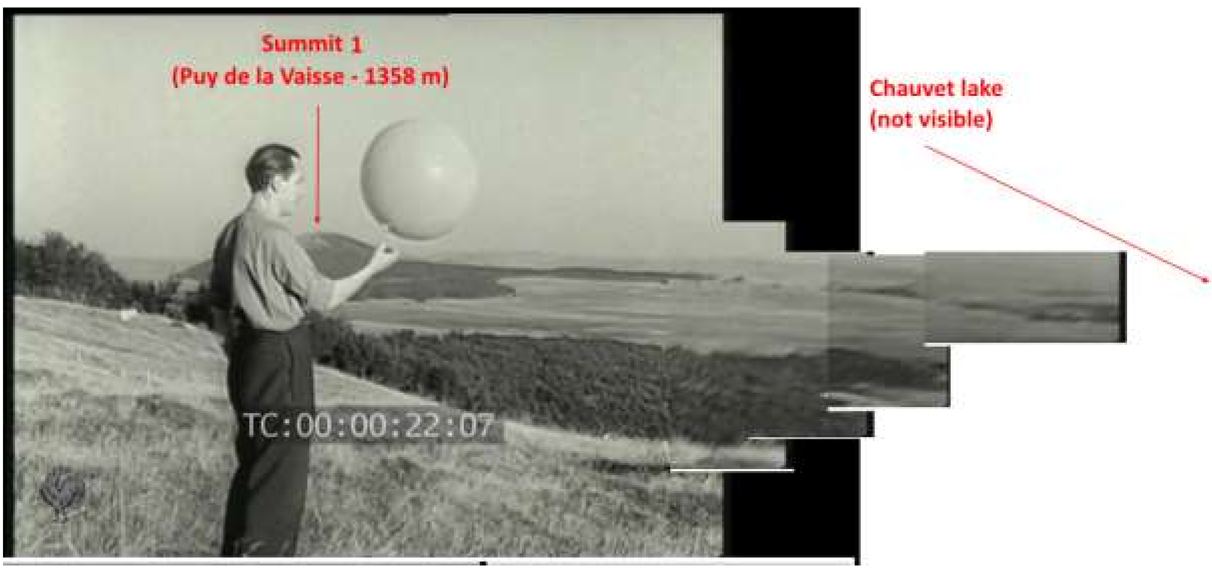


View of the area in 1955, scale 1:5000

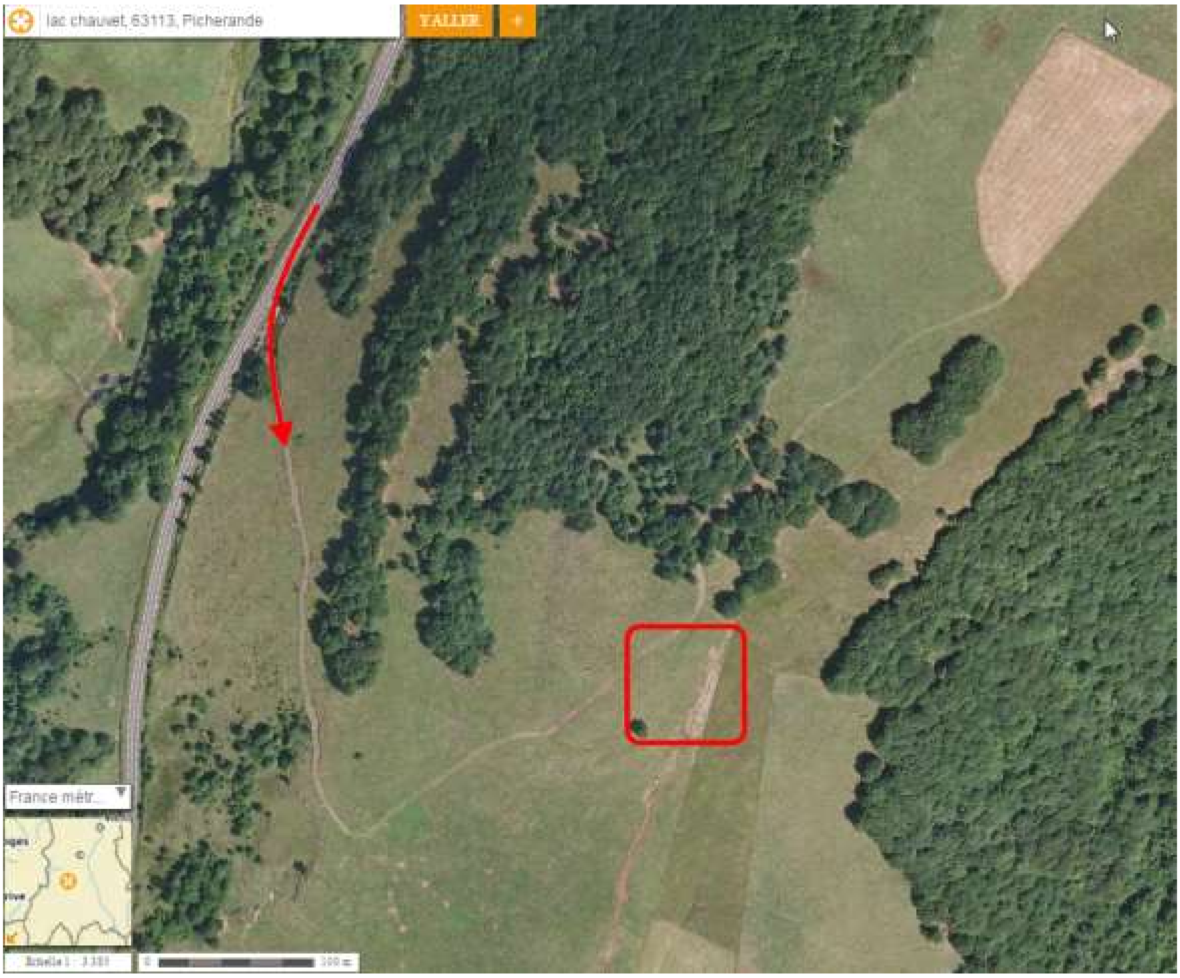
View of the area in 2009, scale 1:4265

Although the wooded area have been "*rationalized*", in the sense that lots of scattered trees have been cut, the limits of the various timbers better outlined and a large pasture (up to the north) wooded with resinous trees, their remains nonetheless lots of easily recognizable landmarks.

After having retrieved the "*Pathé movie*" from the Pathé archives website in the original version, it was possible, proceeding by cross-checking and comparison, to spot many landscape clues using various online tools (Google Earth, Maps and Streetview), to better define the area where the weather balloon launcher was during the reconstruction with the journalists a week later:



This area can be roughly delimited as follows, with the access path:



This work confirmed and quantified the accuracy of the first estimate, which enabled us to organize and prepare in a best possible way the future on-site reconstruction.

What was left therefore was to retrieve and precisely measure on the ground this area, as well as that where Mr. Frégnale was standing, and eventually to double-check it afterwards (see chapters "*On-site reconstruction - Investigations chronology - Presentation of the first three days - Research of the imaging location*" pp. 102-103 and "*Later work - Precise location of the sighting and imaging location*" pp. 110-123).

Mr. Frégnale

ADN-ACN

The general consensus is that André Frégnale was a very talented, creative, all-rounder and particularly good handyman. The 1952 newspapers described him as passionate in geology and as a "*very skilled photographer*" (34). ADN, after his meticulous investigation, describes him as follows (6 - Chapter IV):

André Frégnale

André Frégnale est né aux alentours de 1920, probablement à Chamalières ou dans une commune des environs. Il avait donc une petite trentaine d'années au moment des faits et habitait alors avec sa soeur aux Martres de Veyre, petite commune du Puy-de-Dôme. Il est unanimement décrit comme "original mais pas marginal". Il a été très difficile de trouver sa profession exacte. Les rares sites web traitant de ce cas mentionnent un "géologue" (comme d'ailleurs la presse de l'époque), ou un "ingénieur". En fait c'est vrai et faux à la fois. Faux car il semble bien que André Frégnale n'avait aucun diplôme supérieur et était un vrai autodidacte. Vrai, car c'était un homme d'une curiosité infinie, passionné de sciences, de technologie, de nature, de randonnée, de spéléologie, de kayak, d'escalade, de photographie, et de bien d'autres choses encore.

Il est décrit comme très inventif, très adroit de ses mains. Il bricolait par exemple d'astucieux petits dispositifs pour son institutrice de soeur, afin d'illustrer spectaculairement ses cours de sciences. Il a d'ailleurs enseigné quelques temps dans un lycée de Bagnols sur Cèze ; je me plais à croire que c'était la techno.

Son autre talent reconnu était la *photographie*. Il a commencé sa carrière comme reporter photographe pour un studio de Clermont Ferrand, aujourd'hui disparu. Il a notamment effectué un reportage dans le désert Algérien pour les camions Berliet (NDR : je ne sais pas pourquoi mais en écrivant ces lignes il me vient immédiatement en tête des images du film "100 000 dollars au soleil" avec Ventura, Belmondo et Blier. Vous savez, celui avec cette réplique culte "Quand les mecs de 130 kg disent certaines choses aux mecs de 60 kg, les mecs de 60 kg ont tendance à les écouter !").

Puis il a quitté ce studio et s'est mis à faire des photographies plus "artistiques", aidé en cela par une troisième passion : les longues balades dans la nature sauvage. Une anecdote à ce propos. Mme Jeanne D. se souvient d'une journée d'hiver où elle cheminait seule en pleine campagne. Tout était entièrement blanc, recouvert d'un manteau de neige vierge, silencieux et magnifique. Une vraie carte postale. Quand soudain elle fut hélée par André Frégnale qu'elle n'avait pas vu. Attiré lui aussi par la beauté du paysage, il était sorti "mitrailler" un peu. Apercevant Jeanne, il lui demanda de refaire un ou deux passages dans la neige immaculée, essayant visiblement de faire une photo "recherchée" avec la lumière d'hiver, les traces de pas de Jeanne dans la neige, les arbres au loin. Elle s'exécuta avec plaisir puis repartit.

D'ailleurs de l'avis unanime, André Frégnale avait un réel talent de photographe, et pas seulement de "technicien" de la pellicule.

Le caractère un peu fantasque, un peu excentrique d'André, transparaît encore plus lorsque l'on sait qu'il a écrit et envoyé au ministère de l'éducation nationale un petit livre proposant rien moins qu'une "réforme de l'orthographe". Et quelle réforme : trouvant les règles du Français inutilement compliquées, il proposait notamment de recourir à une orthographe simplifiée basée sur la phonétique. Par exemple le "ph" s'écrirait désormais tout simplement "f" ! D'ailleurs mettant en application ses propres recommandations il étiquetait "fotos" les diverses boîtes contenant ses tirages !

André était sportif et adepte de tous les loisirs à sensation : escalade, spéléologie, kayak, etc. Et, cerise sur le gâteau, il arrivait même à conjuguer toutes activités en même temps : longue randonnée dans une région sauvage (Sancy, Lac Chauvet), escalade pour étudier la géologie locale, photographie de ses découvertes, puis développement "perso" dans son propre labo photo ! Eclectique vous dis-je, et en avance sur son époque.

Il était aussi amoureux de sa liberté et courageux. Lors de la seconde guerre mondiale, enrôlé de force dans le STO et envoyé en Allemagne, il s'évade, vole une moto, et rentre ainsi en France, sans être jamais inquiété par la suite !

Enfin, les Frégnale (mère, frère et soeur) étaient tous catholiques, très croyants et pratiquants. André avait même été dans les scouts.

Summary of ADN's researches

This investigation was completed by the researches of ACN in 2014 and 2015.

Chronologically, the first track of Mr. Frégnale found on the Internet dates back to **1937** and is about an advertising published in the French magazine "*La pêche indépendante*" (39) (40), signed by himself and where he exposes what is probably one of his first inventions, a spinner bait:

1937 PIND 01.jpg

Nous sommes tous, naturellement, à la recherche du meilleur appât, de celui qui, pour un nombre d'heures de pêche donné, nous fournira le plus gros pourcentage d'accrochages... et de prises. Et moi aussi, tout comme vous, j'ai fait mes petites inventions, puis mes essais avec celles-ci. Vous étonnerai-je en vous disant que j'en suis... très satisfait ? Non, n'est-ce pas ? Eh bien ! pour vous remercier de votre bienveillance, je vais vous décrire mes trouvailles, libre à vous de chercher mieux, de les perfectionner encore si vous vous en sentez capables.

D'abord, ma cuiller. Elle est d'un principe nouveau, puisqu'elle est à la fois ondoyante et tournante, ce qui lui donne un très grand pouvoir attractif. Jusqu'à ce jour, en effet, les appâts étaient, à peu près tous, tournants ou ondoyants et les quelques exceptions réunissant les deux principes nécessitaient, pour se mouvoir, une récupération beaucoup plus rapide. Au contraire, ma cuiller possède la sensibilité d'une très bonne cuiller tournante et l'intensité de ses vibrations, tout en conservant l'allure naturelle si attirante de l'appât ondoyant.

Elle m'a donné des résultats surprenants. Excellente pour tous les poissons carnassiers, dans n'importe quelles eaux, elle est d'une supériorité incontestable pour la pêche du saumon en rivière rapide et pour la pêche à la traîne.

Je l'utilise en cinq tailles et en quatre teintes : argenté brillant, argenté mat, doré mat, doré mat et peint sur la face concave.

Vous la décrire serait superflu. Regarder simplement ce dessin.

André FRÉGNALE.

"La pêche indépendante" - 1937

A picture of this spinner bait (called "*Caprice*") is also present, without any comment, in an old book related to the fishing lures in France (41).

We then find his trace in various caving expeditions, especially:

- **in 1943**: Roger Brillot and André Frégnale, from the group "*Norbert Casteret*" of Clermont-Ferrand, explored the main tunnel of the Réveillon abyss (42) (43) (44) (45) up to the terminal siphon and the camp room. They performed a complete topographical mapping of this cavity (plane and cross-section). In April of this same year (46) is also explored the "*Creux de Soucy*" by the same group.

- **between 1945 and 1947** when, as a boy scout and member of the group "*Norbert Casteret*", he took part in the exploration (47) of the river and the abyss called "*Saut de la pucelle*":

Exploration du gouffre du Saut de la Pucelle (Lot)

- **1945 à 1947** Le groupe **« Norbert Casteret » (GNC)** de Clermont-Ferrand entreprend des explorations sérieuses avec **Roger Brillot** et **André Frégnale**.
  - Terminus 1945 : « La grande Marmite » (740m)
  - Terminus 1946 : « Le Troisième siphon » (842m)
  - Terminus 1947 : « La cascade du terminus GNC » (1 582m)

Ils en ressortent une première topographie et un rapport.

Pour leurs explorations, ils avaient établi un camp de base sur une petite plateforme qu'ils ont nommée « Bidon V » à 500m de l'entrée.

Si les deux premières voutes mouillantes ne présentent plus maintenant aucune difficulté, c'est parce qu'ils ont abaissé le niveau des plan d'eau à coups de burins.

Several papers were written at that time about these caving expeditions and are published in specialized annals ("*Spelunca*"...).

Then, André Frégnale produced in **1950** (48), with Jean Dallet (deceased recently - 2014), a 16 mm B&W documentary about a new school in Clermont-Ferrand:

Nos Écoles

REF. : 8940

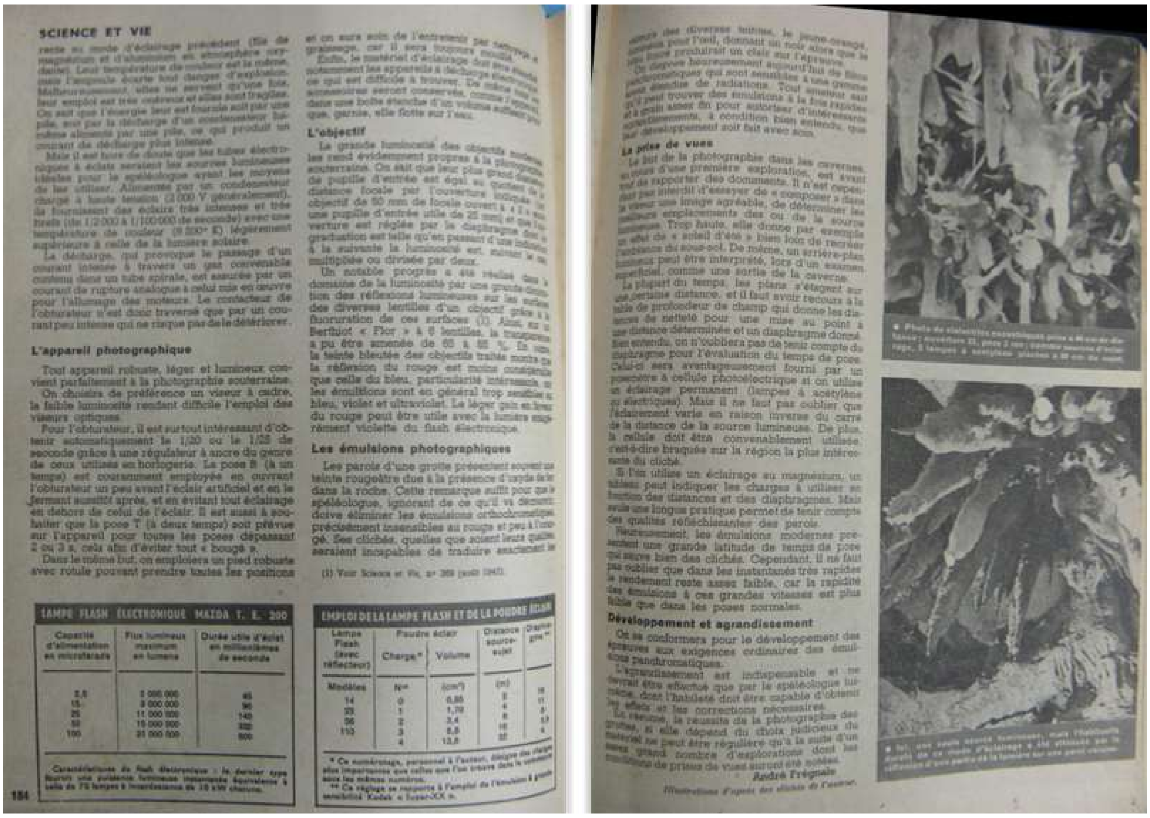
CATEGORIE : Film 16
TYPE DE FILM : Documentaire

METRAGE : 180 mètres
COULEUR : N&B
SON : Optique
LANGUE : V.F.
ETAT : Très bon état
SUPPORT : Sur noyau Kodak et en boîte métal

Documentaire de 1950 réalisé par J. Dallet et A. Frégnale.

A Clermont-Ferrand, on inaugure une nouvelle école. Enfin les petits élèves pourront jouer dans une cour de récréation, l'ancienne école n'en était pas pourvue. Les salles de classe sont spacieuses, le réfectoire digne d'une sale de restaurant, l'amphithéâtre est à présent équipé d'un projecteur de cinéma. Qu'il est bon d'avoir une salle de sport digne de ce nom.
Bref, l'école, comme le pays tout entier, se reconstruit et se modernise.

In **March 1951** is published, in the French review "*Science et Vie*", a four page paper written by Mr. Frégnale and called: "*So many problems to take underground photos!".* It's about a technical presentation of advanced methods for photographing any subject in an underground environment. The photos that illustrate this article are from Mr. Frégnale himself.



SCIENCE ET VIE

L'appareil photographique

L'objectif

Les émulsions photographiques

La prise de vues

Développement et agrandissement

André Frégnale

Science & Vie n°402 - March 1951

Then, on August 11th **1956**, is published the n°3528 of the sailing newspaper "*Le Yacht*", which cover photo is signed by André Frégnale (49):

Finally, the last trace of Mr. Frégnale dates back to **1959**, when a documentary is produced by A. Vandel and J. Dallet, to which Mr. Frégnale *may* have taken part (we have not been able to get confirmation yet), called "*Faune cavernicole*". The only known copy of this documentary in color VHS is now in the library of the University of the French West Indies and Guiana, Pointe-à-Pitre, Guadeloupe.

André Frégnale died around **1984** (4).

All this research completely confirmed Mr. Frégnale’s character, which was of a curious, inventive, smart and particularly gifted man in many areas, and especially in photography. He developed himself in his personal laboratory all his photographs (ADN).

On-site reconstruction

Chronology of the investigations

FCR-PSY-GMH-ACN-XPT

This reconstruction took place over five days, from Sunday, July 26th 2015 to Thursday, July 30th 2015.

Presentation of the first three days

Sunday 07/26/2015 with FCR and GMH: *(fair weather)*
~14h00: preliminary research of the observation location. Orientation scouting and first trials to retrieve the witness's position.

General view of the area toward south-south-east

Monday 07/27/2015 with FCR, PSY, GMH and ACN: *(variable weather)*
~15h15: the team tries to get familiar with the old camera (Zeiss Ikonta). Tests and trials show that a **minimum period of about 5 seconds** is required between two shots. This lapse of time includes, without changing any technical parameters, winding, recocking, framing and shutter release (note that PGN considered that there had been changes in parameters between the first two pictures: either the aperture or the exposure time was modified).

Installation and release trials of the modern clay pigeons thrower bought by FCR-PSY (mechanical problem solved by GMH). Presentation by ACN of the vintage (50s) manual thrower and of the skeet material that existed at that time in France (1951 Manufrance catalogue).

American thrower "Western Hand Trap", fifties


Modern mechanical thrower

Call from RPI. Meeting is scheduled the next day at 9h. He said he had previously done GPS localization on the basis of rocks and of the Pathé film.

Tuesday 07/28/2015 with FCR, PSY, GMH, ACN and XPT: *(rainy day, windy and threatening weather that got better during the day)*
Phone exchanges with ACN and XPT. Despite some hesitation (it rains at their home), the meeting is held but delayed at 9h30-10h.
09h05: we arrived at Lac Chauvet (some photos are done).
09h42: SMS from RPI that could not join us.
~ 09h40: arrival of XPT and ACN at Lac Chauvet.
~ 09h45: SMS to RPI to ask him about his GPS localisation data, without reply.
~ 10h10: arrival with ACN and XPT on the sighting place.

Research of the imaging location
FCR-PSY-GMH-ACN-XPT

This work was mainly done during Tuesday, July 28th 2015. The scouting was long and difficult, especially due to the modification of the landscape (trees have grown) over the years, the poor clues present on the original photos, and without having the GPS localization from RPI.

Nonetheless, by aligning the distant landscape marks (wooded limits, hills submit, fences position and differences in level...) we could more precise (by a couple of meters) as to the probable position of the weather balloon thrower on the Pathé film and so confirm our preliminary results:

East view, the balloon thrower had to be a little further, where the down slope intensifies to the right

ACN thinks that Mr. Frégnale's position is about 60 m higher, close to the first grove of trees, as their configuration looks like what can be seen on the photos (shadows, distances computed between the trees, presence toward north of a grassy bank, like in LC_6...).

View of the above-mentioned first grove of trees

Most of the photos taken in order to reconstruct the landscape of the original photos from Mr. Frégnale have been done from an higher position, a few meters to the right of these trees, along the fence (on the side of the trees).

The trials that concern the throws occurred from the lower position, close to the biggest fence pole and the closest tree, both visible on the above photo.

South-west view

North-east view

First clay pigeon throwing trials

They were done with the mechanical thrower, at first:

Note: west gusty wind.

~ 12h45: group photo with, from left to right, ACN, XPT, PSY, GMH, FCR and XPT's grandson.

Continuation of the throwing objects trials

~ 14h45: came back on the sighting place with ACN. Continuation of the photo trials with clay pigeons throws (with the help of the two throwers, mechanical and manual), throws of Frisbee. Unsuccessful trials with berets. Photos, videos and various measurements.

Trials with Frisbees

The trials were done by PSY with the five Frisbees brought in by ACN and FCR. The throws were done towards the North with the photographers located West of PSY's position:

The wind, still blowing in gusts from west, quickly changes the initial parabolic trajectory of the Frisbee.

Trials with clay pigeons

The trials were done with the two throwers, a modern mechanical and an American manual, from the fifties.

The mechanical thrower was attached to the ground in three points and the clay pigeons thrown toward south-south-west, almost in the direction of the three photographers (ACN-XPT-FCR), drifted away from the throw axis of about 10° to the west (see the map next page). The wind, blowing in gusts from the west and coming therefore from a perpendicular axis to the general throwing axis (north-south) change the parabolic trajectory of the pigeons. The stability is modified as well, but the inclination stays *a priori* stable in the end of the trajectory.

X: position of the photographers; L: position of the thrower

The mechanical thrower quickly proved to be difficult to use, firstly due to the force applied to the arm by the tension spring at the launch, which requires operators to regularly reattach the thrower to the ground (no ad-hoc fixing):

Secondly, the vertical inclination possibilities of the launch arm are limited, which force the pigeon not to go higher than a certain elevation, in particular on flat ground.

On the other hand, during our trials (see above sample), the photographers were located at the foot of the launcher which artificially introduced a greater down slope and a better rendering of the photos relative to the visible landscape on LC_6 (in the hypothesis that it was done toward this direction), than that if they were located on flat ground (good visibility of the background bank and potential further trees, behind the bank, not visible).

The trials with the manual thrower were far easier to do and allowed more vertical angular displacement and a greater liberty of execution, in a general way. After some trials, the time it takes to GMH to get familiar with the thrower, we could take lots of photos of the clay pigeons. On the two samples below, GMH is located outside the frame, on the right and at about a hundred meters away from the photographers:

View 35 of the film 4 taken with the Zeiss Ikonta

View 31 of the film 4 taken with the Zeiss Ikonta

Note: still a gusting wind blowing from west.

~ 17h30: XPT joined us. Viewing of the Pathé film.
~ 18h30: return to the lac Chauvet. Departure of XPT and ACN.

Presentation of the two last days

Wednesday 07/29/2015: *(Rainy night, windy and rainy weather all the daylong)*
~09h00: selection and back-up of the files.

Thursday 07/30/2015: *(Rainy night, windy and threatening weather that gets better during the day)*
~09h00: return to the observation site to do complementary measurements (elevations and azimuths).

Later work

Once the on-site reconstruction was over, a long task that consisted of cross-checking, study and thought was done. In particular, it was about to:

- check the consistency of the estimated positions of Mr. Frégnale determined on-site and by the previous investigators (RPI).
- check if the above estimations are consistent with the range of the azimuthal displacement of the UFO between LC_3 and LC_6 estimated with previous investigators (PGN, LGN and MVT) and Mr. Frégnale himself.
- obtain a range of possible measurements concerning the rotation speed, the travelled distance and the reached elevation of the Frisbee and the clay pigeons, during the trials.
- try eventually to reconstruct the whole scene as it was in 1952.

Precise localisation of the sighting and of the imaging location

ACN-PSY-FCR-GMH-RPI

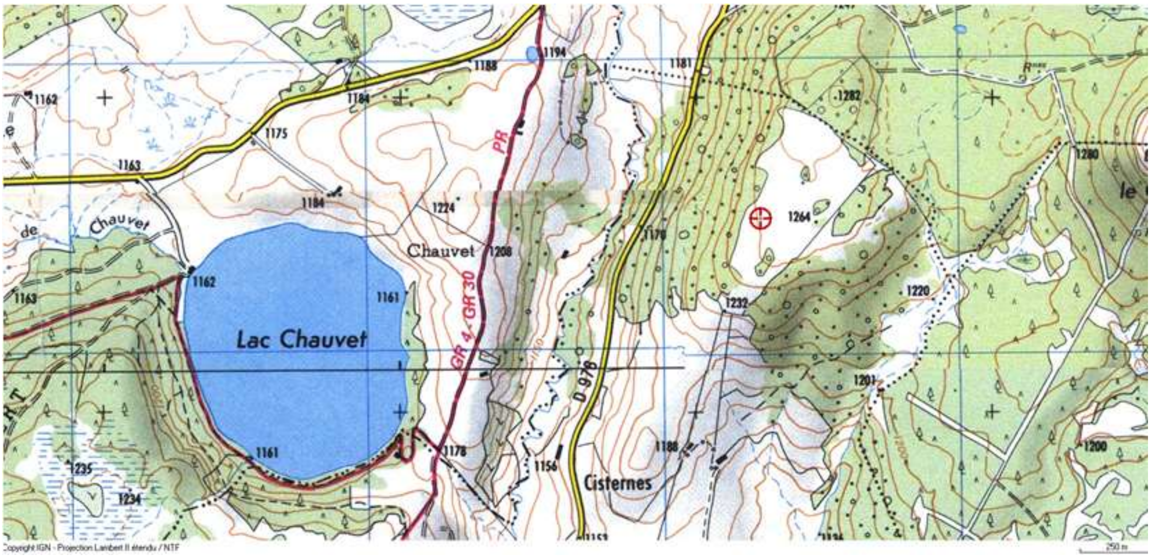
RPI data

As the GPS coordinates for the estimated position of Mr. Frégnale were not given in time by RPI when we were on the site, but later, on October 12th 2015, no check of this position could be done over there, in spite of the initial intuition of PSY, FCR and GMH about a plausible place in this area (presence of lot of rocks...) and their move to the site the first day.

RPI, to find this place (GPS coordinates: **45°27'48,8" N / 002°51'02,7" E**) that he estimated to be 300 m further to the north-north-east than the one estimated by ACN, essentially based his estimate on the presence and aspect of a rock visible on the "*Pathé movie*" which, according to him, is still present currently:

Extract of the "Pathé movie" 6th second – Mr. Frégnale is in the foreground

Photo taken by RPI that shows the above-mentioned rock plus a single tree - both will serve as reference landscape marks for the study



IGN map given by RPI that demonstrates, according to him, Mr. Frégnale's position (red target), determined from the ground references

ACN data
Preliminary research

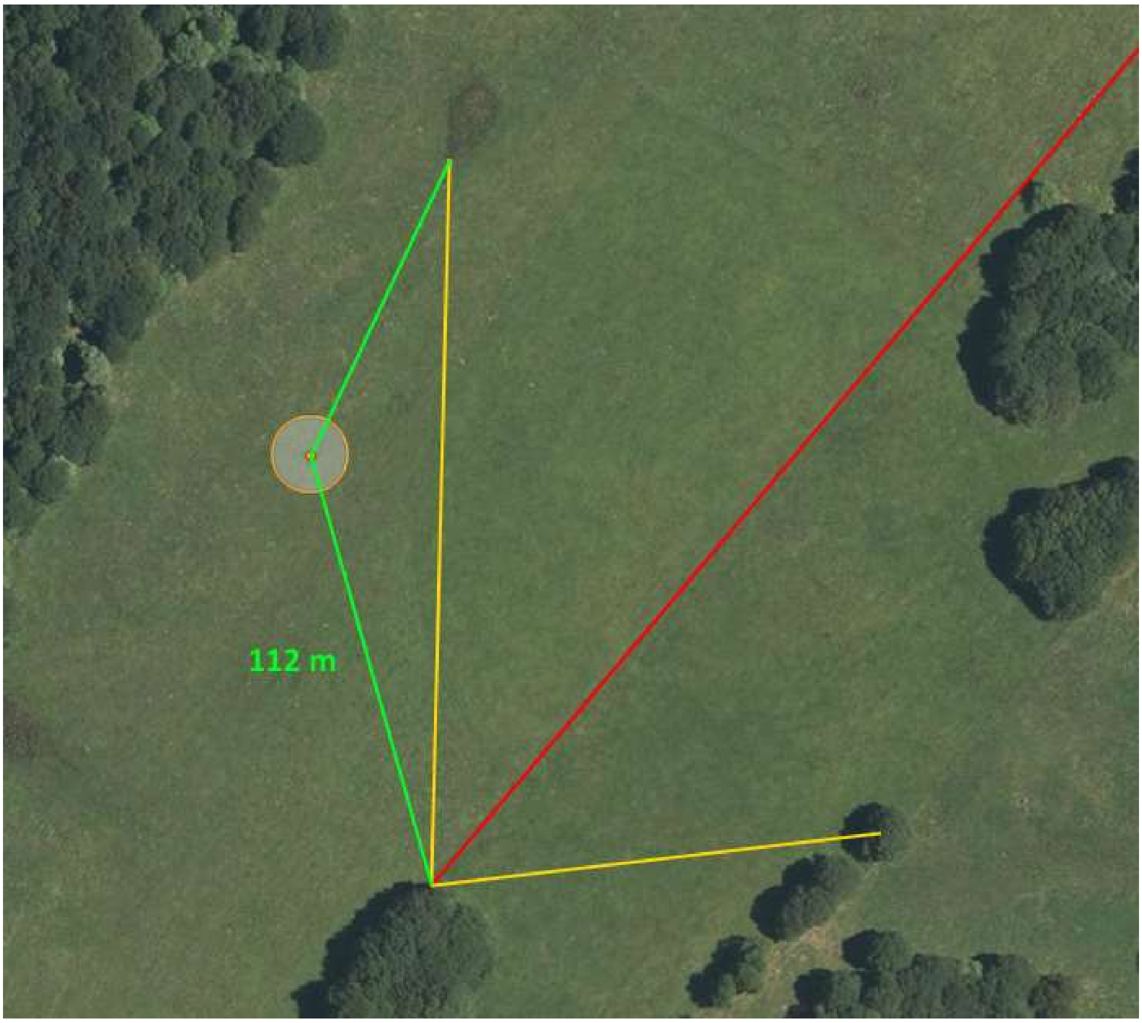
Thanks to the coordinates provided by RPI

A detailed research on the aerial photos of the area available on the Géoportail website shows that the area mentioned by RPI was cleared out from its scattered trees between 1974 and 1979.

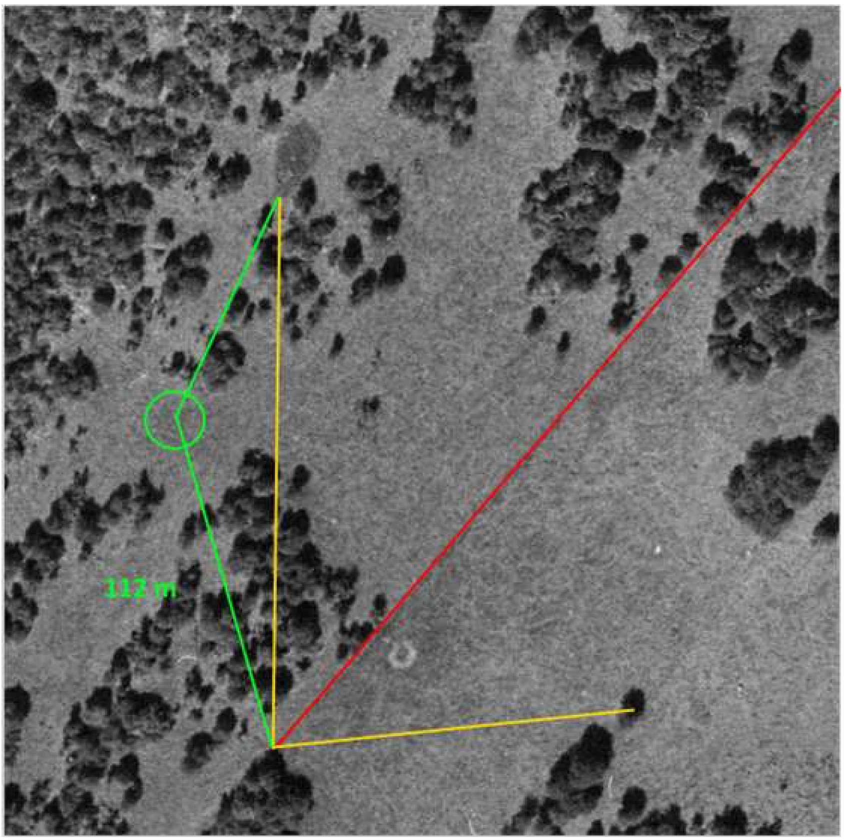
Besides, still on the Géoportail website, there are aerial photos of high quality, in black and white, dating back before 1974.

We will especially retain the photo n°5767 taken on January 1st 1968 at the 1:19454 scale, where the trees are clearly visible and unmodified since 1952.

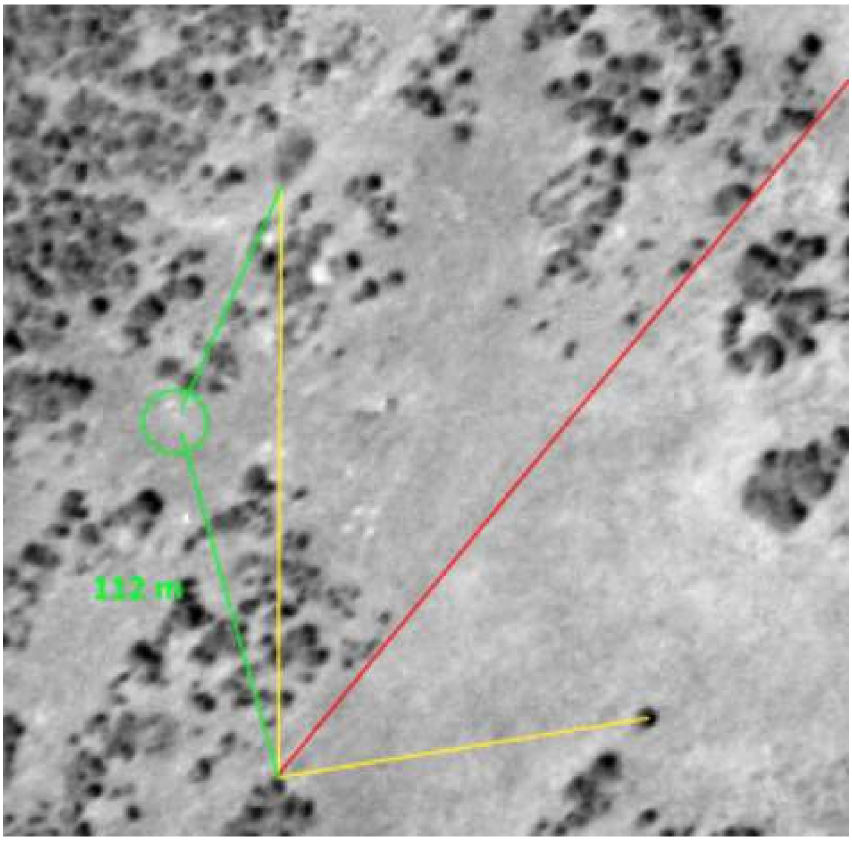
GPS coordinates provided by RPI allow us to locate the exact spot on a recent map and to mark a few notable landmarks (fences, trees, stone heaps...):



2009 aerial photo and GPS coordinates that indicate Mr. Frégnale's position according to RPI



1968 aerial photo with the same landmarks



1955 aerial photo with the same landmarks

Thanks to the "*Pathé movie*"

During the first on-site reconstruction one week after July 18th 1952, one or more weather balloon(s) have been launched. The summary of this reconstruction is in the article of the newspaper "*La Montagne*" dated July 28th 1952 (37) (6 - Chapter IV):

"We went to the same places where the photos were taken of the "flying saucers". After checking the wind direction, we proceeded to balloon releases that are employed by the meteorology [...] Mr. Frégnale was placed at the spot where, on July 18th, he took his photos. He had the same camera, it was the same time. When a balloon went into the field where he was last week, Mr. Frégnale repeated the gestures that he had made a week earlier".

"Many documents were taken, both by Mr. Frégnale and by the photographer from "La Montagne" and the cameraman from the documentary "Pathé-Journal" [...] Mr. Frégnale wanted to demonstrate in front of several witnesses that he had largely enough time in 50 seconds to take four photos and examine the craft with binoculars. This craft, as shown by the photos and the structure of the landscape, crossed an angle of approximately 100°. Mr. Frégnale tried as much as possible to take the same photos with the same trees in the foreground and herbs".

Careful examination of the "*Pathé movie*" reveals the relevant extracts, and in particular the place from where the balloon was launched:

The cameraman was facing south-east and the balloon thrower south-south-west. His position was determined with reasonable accuracy during the on-site reconstruction in July 2015, and further specified later during complementary cross-checking work:

The journalist from "*La Montagne*" assured that the wind direction was checked before the balloons were launched; probably to be sure that they were visible from Mr. Frégnale's position after their launch from the thrower position defined above.

As ADN (6 - Chapter V) acquired from the French weather forecasting the records from July 1952 for the weather stations of Picherande and Besse, we could check the wind direction for the reconstruction day, on July 26th 1952.

18		6	23	14,5	W	md
19		6	23,5	14,75	NE	md
20		6½	27	16,75	NW	md
21	6	13	25	19	NE	f
22	0,1	11,5	25	18,25	NE	aF
23	6	14,5	24,5	19,5	NE	aF
24		9,5	22	15,75	NE	md
25		4,5	21,5	13	NE	aF
26		7	25	16	NE	aF

Weather records of Besse, 7h solar time

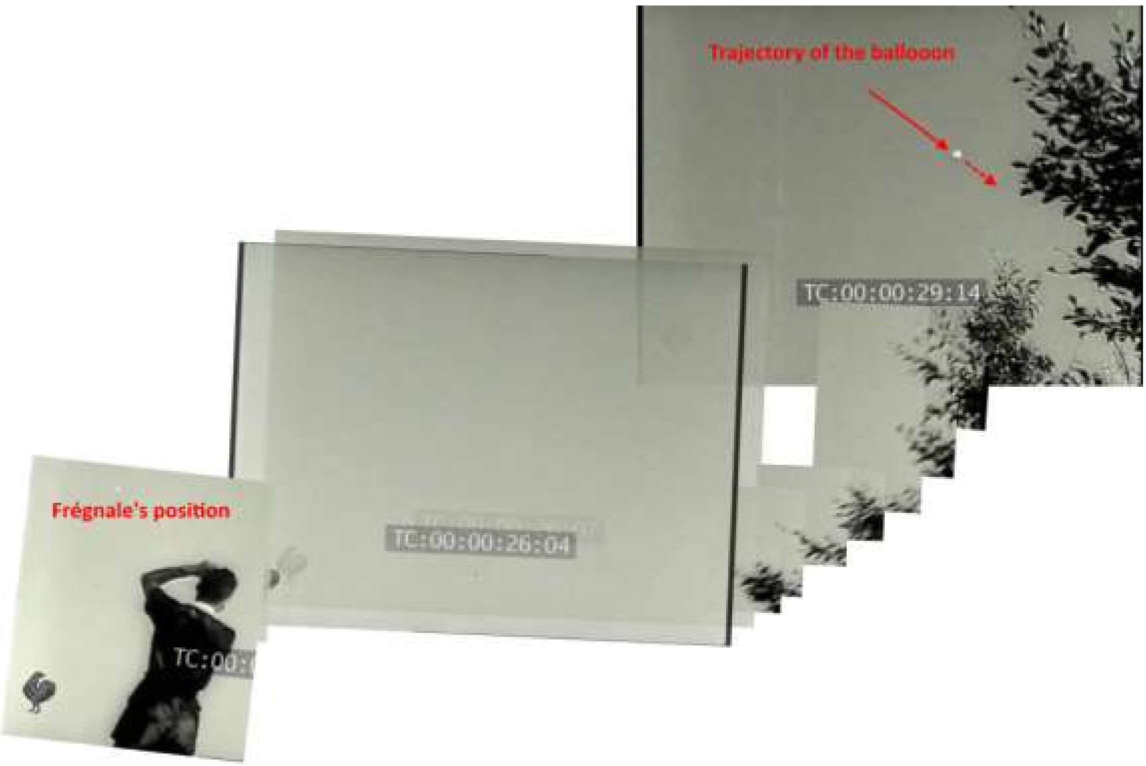
18		9	23,4	15,2	no	"
19		10,2	24,6	17,4	no	"
20		10,2	29,4	19,8	E	"
21	4,2	12,8	28,2	19,5	E	"
22		14,5	25,8	20,2	E	"
23	10	13	26	19,5	N	"
24		11,8	26	18,8	E	"
25		9	24	16,5	E	mod
26		12	28	20	E	mod

Weather records from Picherande, 7h solar time

The weather pattern was at this period from **east to north-east** and the wind's strength was moderate to relatively strong.

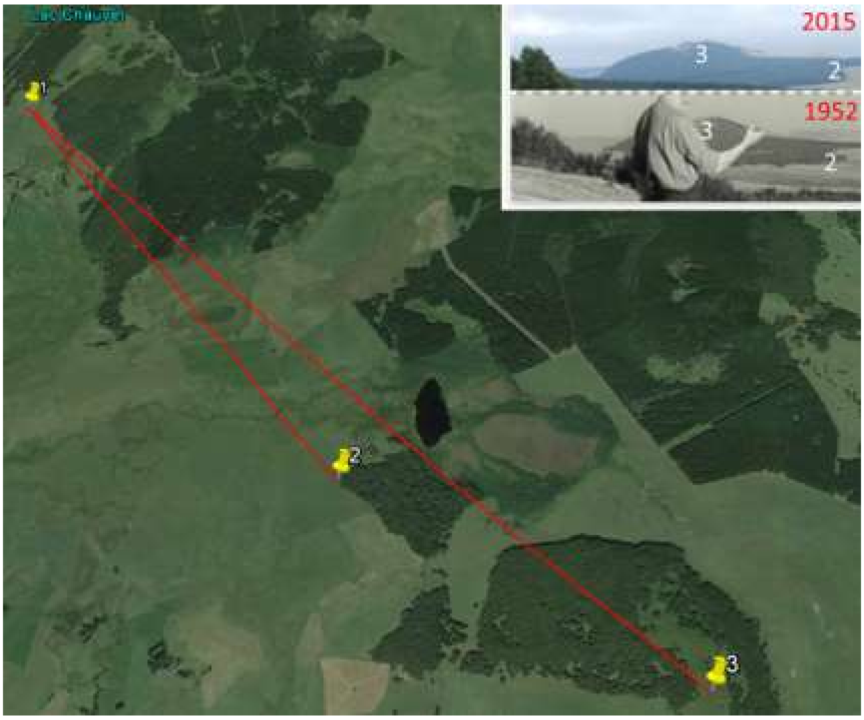
The weather balloons, once released, were heading **west or south-west**, which is confirmed by the view of the "*Pathé movie*" where the balloon is globally heading toward the same axis as that which the thrower was oriented toward.

If we take a second look at the "*Pathé movie*", at the moment when Mr. Frégnale, close to the shrub visible on LC_3 and LC_4 (and recognizable on the movie), takes photos, we can create a global mosaic with the apparent path of the balloon, moving from the left to the right:



The follow-up of our calculations and measurements imply at first that we determine the equivalent focal length 35 mm of the camera used by the cameraman from Pathé. The model of this camera being unknown, we can use IPACO’s tool *Camera/Focal Length* using landmarks with known size and distance, visible on the movie.

The "*Puy de la Vaisse*" is a hill of volcanic origin well visible from the 22th second, as well as some landscape characteristics, which have not or little changed since 1952:



These landmarks (1: thrower position; 2: clean cut in the forest at the foot of the "*Puy*"; 3: summit of the "*Puy*"), materialized in Google Earth, allow us to do angle, distance and length measurements in the focal plane of the image.

The angular separation between points 2 and 3, as observed from point 1 is of 7°.

Next step consists of determining the mean distance that separates them from the balloon thrower with this simple formula: D = (d1 + d2) /2.

d1 is the distance between the thrower and the summit of the "*Puy de la Vaisse*": 4350 m.

d2 is the distance between the thrower and the clean cut: 2700 m.

D = (4350 + 2700) /2

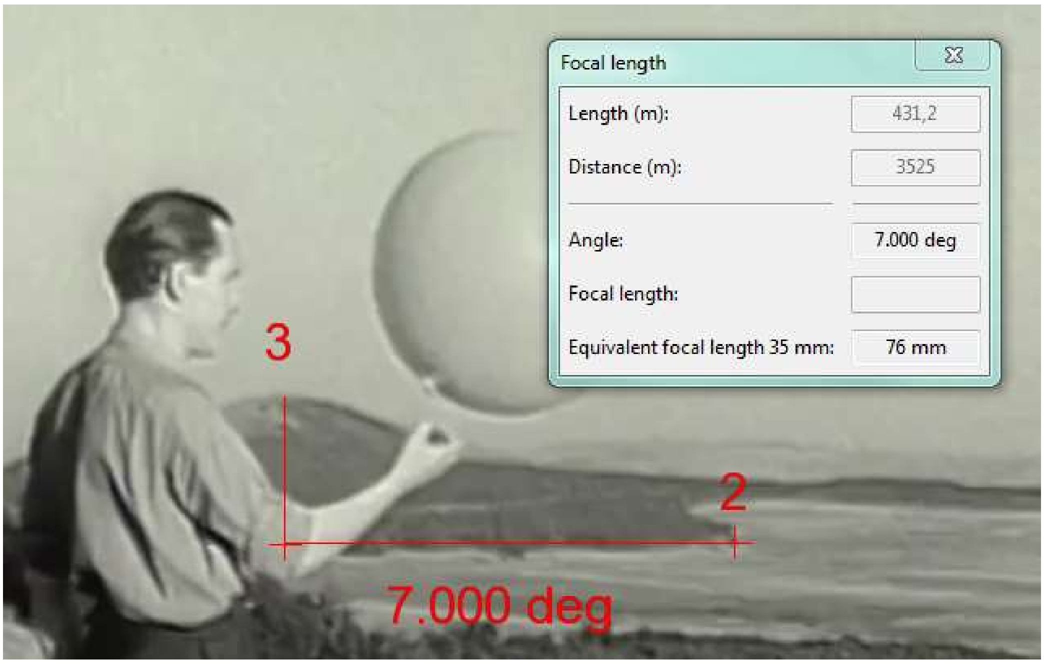
D = **3525 m.**

Then, we can determine the transversal distance that separates these two points, using the formula: L = 2 D tg (A/2).

L = 2 * 3525 * tg (7°/2)

L = **431.2 m.**

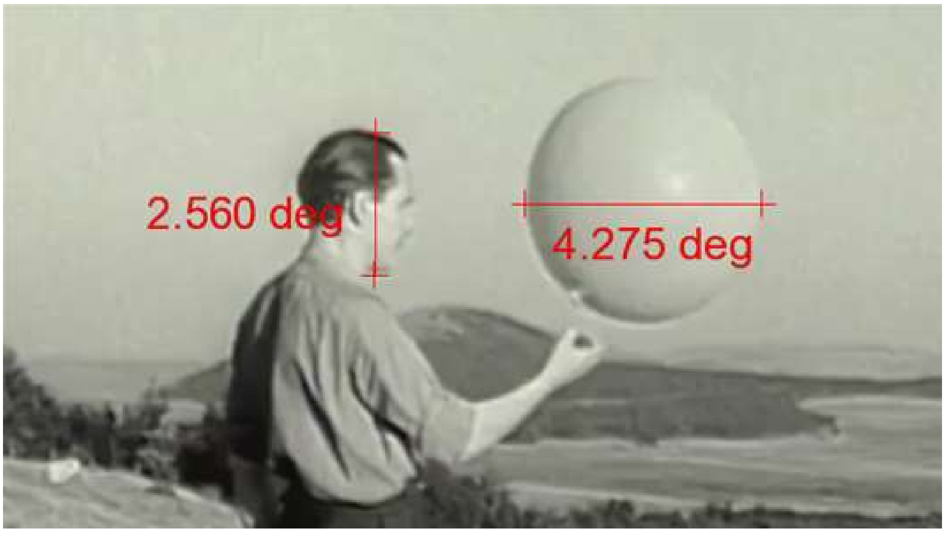
Now that we have determined these two values, we can import the captured picture into IPACO and use the tool *Camera/Focal Length*, then complete the corresponding values in the fields "*Length*" ("L") and "*Distance*" ("D"). The results are automatically displayed and they correspond to the angle that separates the two points 2 and 3 (7°, which allows to check that the calculations are correct) as well as the value of the equivalent focal length 35 mm:



The equivalent focal length 35 mm is **76 mm**.

We can then proceed to the following measurements:

- Angular size of the head of the balloon thrower
- Angular size of the balloon:



- Measurements of the head of the balloon thrower as a function of his estimated size. In a human body, the proportion of the head comparatively to the complete size is of 0.13

(50). We will take as limit sizes 1.60 m and 1.80 m, which gives for the size of the head a value **between 20.8 cm and 23.4 cm.**

- Distance estimates that separate the whole system balloon/thrower from the cameraman. Thanks to the previously determined measurement, and considering that the balloon and the thrower are on a same perpendicular plane to the camera line of sight and at the same distance, we use the IPACO tool *Length/Distance*:

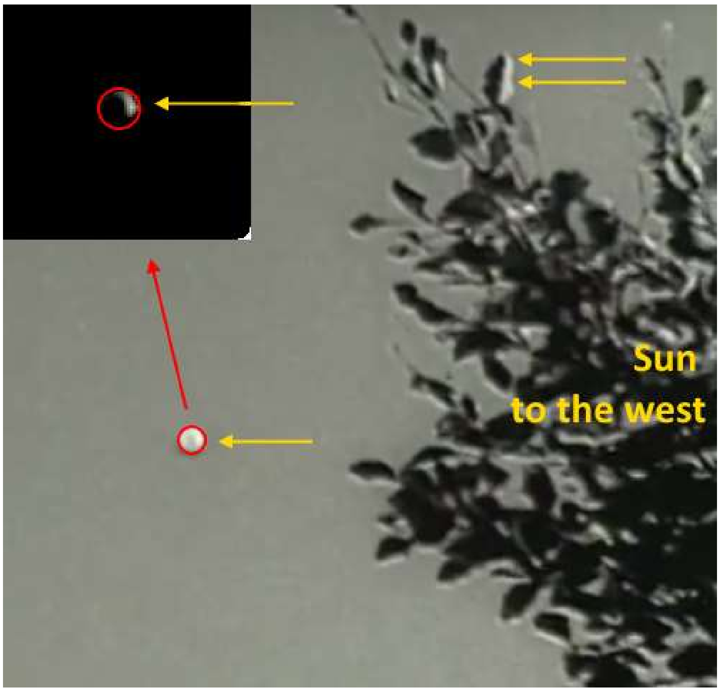
The system balloon/thrower is located at a distance from the camera **between 4.6 m and 5.2 m.**

- Estimations of possible diameters of the balloon:

Balloon's diameter is between **35 and 39 cm**. This number is to compare with that given by the journalist from "*La Montagne*" (37): "*We proceeded to balloons launches that are used by the weather services. They are of two kinds: some have a diameter between **50 and 60 cm**, the others have a diameter of about 1.2 m*".

Obviously, the balloon released on the "*Pathé movie*" does not measure 1.2 m, and 60 cm seems a little too big. We will retain however for the following all the given and computed measures.

As we saw above, Mr. Frégnale, in the "*Pathé movie*" was taking photos of the balloon when it passed in his field of view. If we examine carefully a capture of the movie with the shrub and the balloon, several clues show that the Sun was coming from the right (west): lighting of the leaves and of the balloon (exposed by a strong modification of the contrast and the luminosity):



Besides, it is possible, like for the image of the balloon when it was released, to measure with IPACO its angular size:

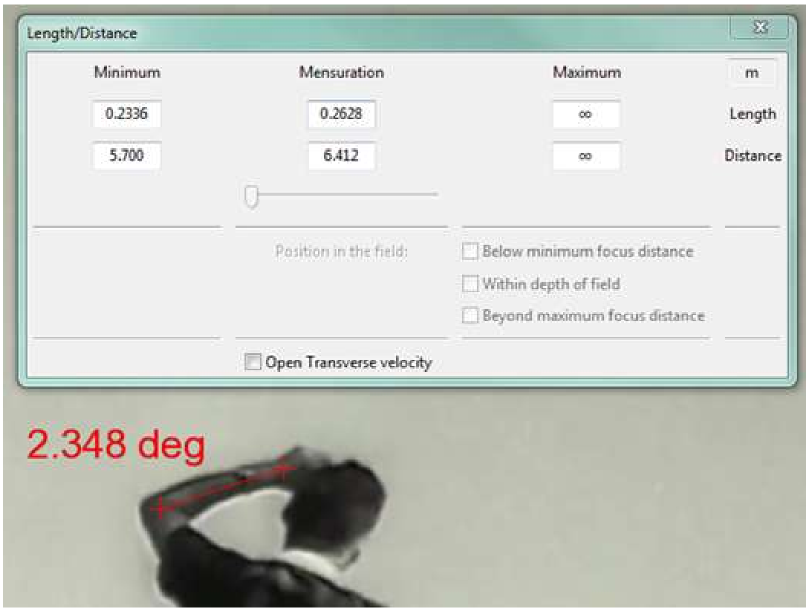
Then we open again the *Length/Distance* tool in order to compute the distance between the balloon and the cameraman at this precise moment, as a function of the various given and computed sizes for this balloon.

Results can be presented in the form of a table:

Diameter of the balloon	cm	35	39	50	60	120
Distance to the cameraman	m	35,8	39,9	51,1	61,4	122,7

The distance between the balloon and the cameraman is between 36 m and 123 m. Mr. Frégnale is supposed to be in the same place as a week earlier, so to this distance must be subtracted the one that separates him from the cameraman, while taking into account the angular deviation between the axis of the camera that aimed at Mr. Frégnale and the axis of the camera that aimed at the balloon. Measured on the mosaic page 50, this angle is of **38°**.

Using the human body proportions (50) and the image of Mr. Frégnale reproducing the photos, where his forearm is clearly visible (transverse to the camera), we can measure the distance that separates him from the cameraman:



This distance is between 5.7 m (for a size of Mr. Frégnale of 1.60 m) and 6.4 m (for a size of Mr. Frégnale of 1.80 m).

We can deduce by trigonometric calculations (cosine law) four possible solutions regarding the distance that separates Mr. Frégnale from the balloon, function of both the size of Mr. Frégnale and that of the balloon. We will retain the two extremes, which are:

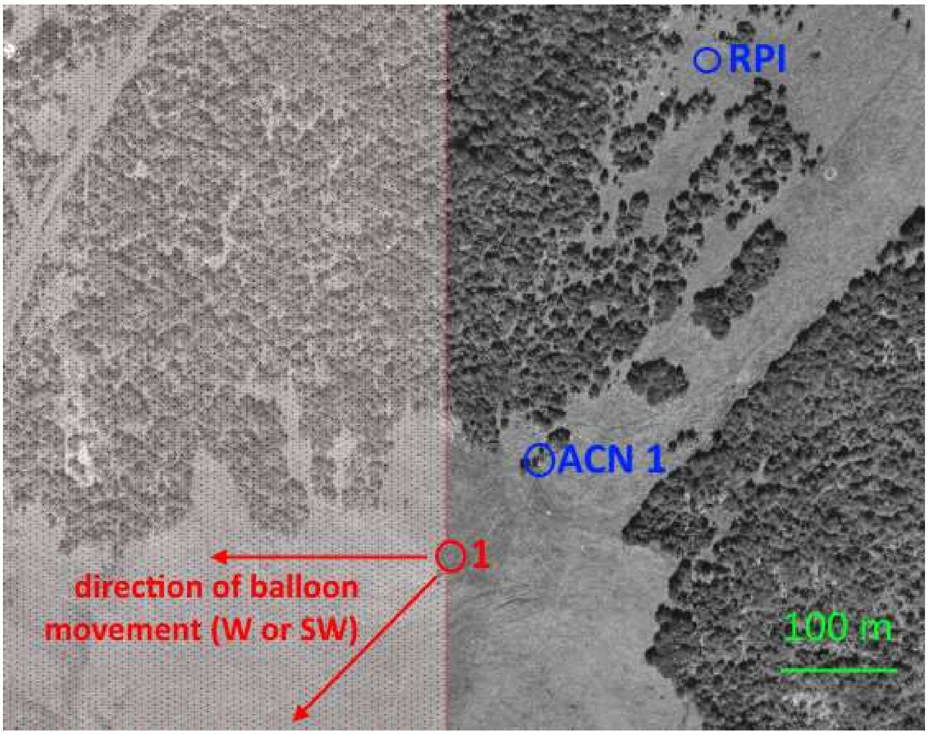
- **29.87 m** if the balloon’s size is 35 cm diameter and if Mr. Frégnale’s size is 1.80 m.
- **118.29 m** if the balloon’s size is 120 cm diameter and if Mr. Frégnale’s size is 1.60 m.

Besides, as the balloon was heading west or south-west, Mr. Frégnale and the Pathé cameraman can be located only to the right of the balloon thrower, in the wind’s direction.

The next step consists of reporting these measurements and results on a fifties map, taking into account the hypothesis regarding Mr. Frégnale's position developed until now.

Comparison of the hypotheses

The more precise aerial map is the n°5767 taken on January 1st 1968 at a 1:19454 scale (already used page 47) where the trees are clearly visible and, for the most, still present since 1952. We report on this map all the known hypothesis up to now for Mr. Frégnale's position (in blue), the data regarding the position of the balloon thrower (in red) and the scale (in green):



As can be seen, none of the two hypothesis emitted previously by ACN and RPI complies with what is visible on the "*Pathé movie*", the distances that separate these two points being too important.

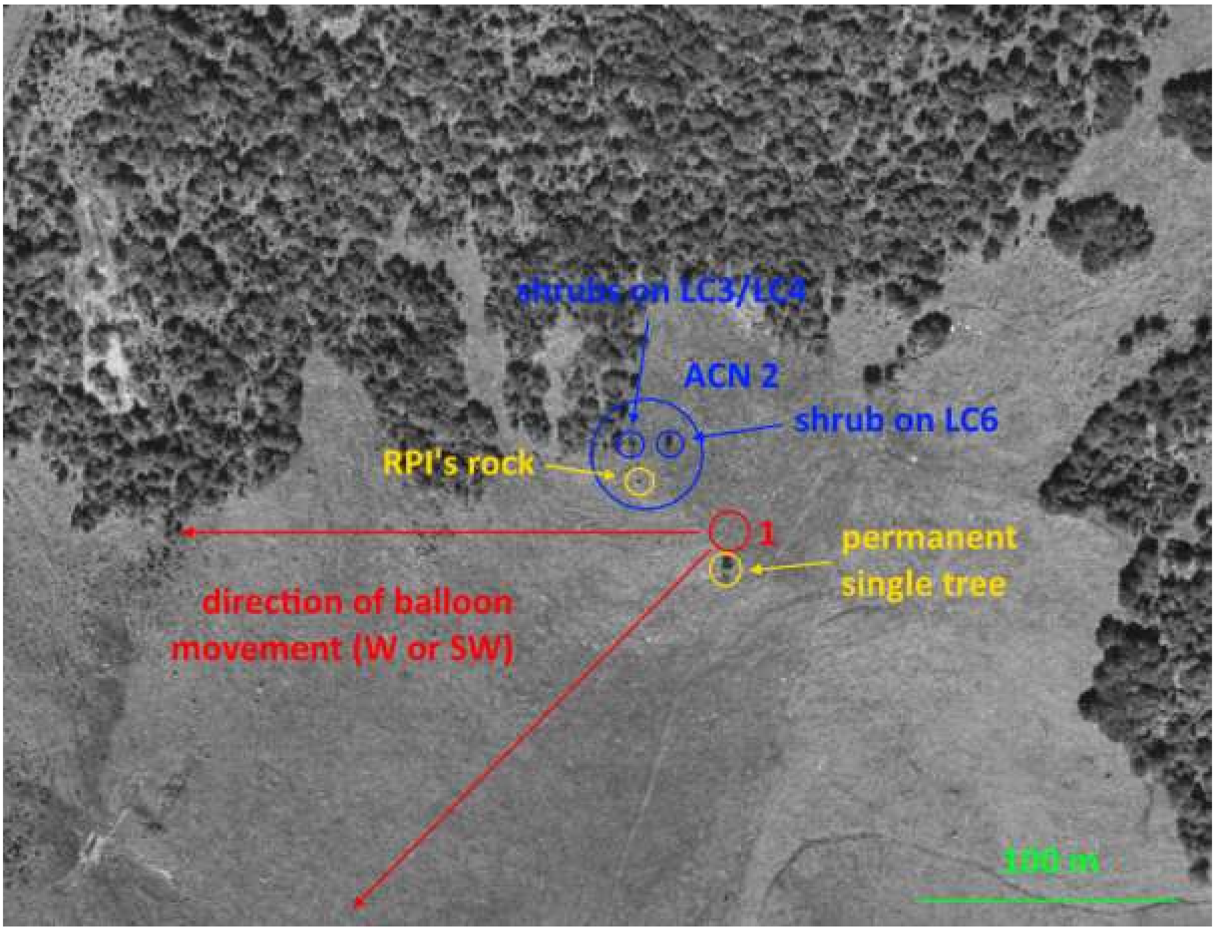
Mr. Frégnale should consequently be somewhere, to the wood border, between the north and the west of point 1 to the west end of the field.

We must take into account as well the following known parameters:

- Globally, Mr. Frégnale was facing south.
- The azimuthal displacement between the positions of the UFO should theoretically be at least 60° and at most 100° between LC_3/LC_4 and LC_6.
- There should be visible shrubs only to the right and nothing on the left on LC_3 and LC_4 with a 43.6° angle (angular width of the photos).
- As well, there should be a shrub to the left, and possibly another far away to the right, on the last photo with a 29.4° angle (angular width of LC_6).
- The distant landscape (hills...) in the background should not be visible on LC_6.

- On the "*Pathé movie*", during the reconstruction one week later around 18h30, the characters that are close to the shrubs were in the shade. Therefore, there should be other shrubs to their right.
- The distance that separates the photographer from the shrubs in LC_3 and LC_4 must be about 5.5 m for LC_3/LC_4 and 9.5 m for LC_6.

Then, we can enlarge the concerned area to examine the remaining possibilities.



Only one place seems to match with all the above defined restrictive criteria (with however an uncertainty about the visibility of the background landscape for LC_6, which depends on the value of the difference of level). Noted "*ACN 2*", it delimited a shrubs area that does not exist anymore today. It is located about 50-60 m to the north-west of the place of the thrower balloon.

We also reported (in yellow) on this map the single tree and the remarkable rock photographed by RPI in July 2008 (see page 118) and by the team of investigators in July 2015 (see p.102). These particular points were discussed in the analysis.

"*ACN 2*" is more consistent with a wind blowing from the east than with a wind blowing from the north-east, for which the weather balloon reaches more quickly the maximal possible distance that separates it from Mr. Frégnale, as defined page 55 (**118.29 m**).

The exploitation of these results for the possible trajectory calculations of the UFO is in the analysis report.

Development and use of the silver films
ACN

Development

On the whole lot of eight films bought by ACN, four were integrally used and printed in small format in the PHOTON laboratory (CNES).

Films and prints were received by ACN on October 17^{th} 2015. Out of the four films, only three were developed, the fourth one being fully overexposed (a "*Neopan Acros 100*"), after a mishandling (misplacement in the receiver spool then film ripped at the notches) during on-site reconstruction.

Use chronology

These four 36 exposure films were used as follow:

- **First film**: film used: "*Ilford PAN F Plus 50*".

  - Views 36 to 28: not used because of the winding done during the trials to get familiar with the camera.
  - Views 27 to 21: indoors trials Monday 07/27/2015 afternoon.
  - Views 20 to 10: photos in all directions Tuesday 07/28/2015 morning and afternoon.
  - Views 9 to 1: photos of the clay pigeons thrown with the mechanical thrower, Tuesday 07/28/2015 afternoon.

- **Second film**: film used: "*Neopan Acros 100*".

  - Views 36 to 13: photos of the various Frisbees.
  - Views 12 to 2: panoramic done from "*ACN 1*" position.
  - View 1: north-east view.

- **Third film**: film used: "*Neopan Acros 100*". Overexposed.

- **Fourth film**: film used: "*Ilford PAN F Plus 50*".

  - Views 36 to 19: photos of clay pigeons thrown by GMH with the manual thrower, Tuesday 07/28/2015 afternoon.
  - Views 18 to 15: photos of Frisbees thrown by PSY, from "*X*" position (see page 40), Tuesday 07/28/2015 afternoon.
  - Views 14 to 6: views of the area from "*ACN 1*"'s position.
  - View 5: the "throwers" GMH and PSY.
  - Views 4 to 1: other views of the area.

Exploitation of the results

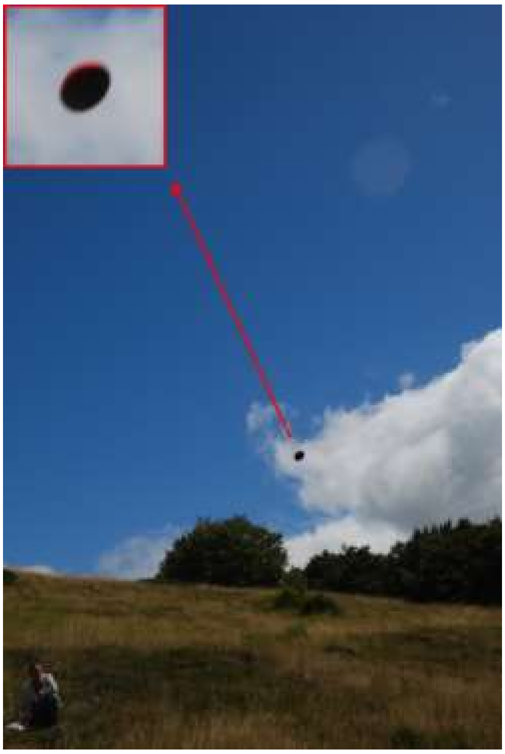
It was impossible, because of both the strong winds present on site during the reconstruction and the physical nature of the Frisbees (lightweight plastic material and larger, more sensitive to the effects of the wind), to throw Frisbees showing parabolic trajectories regular enough to be measured.

However, we achieved much better results with clay pigeons which, although a little lighter, kept in most cases during the throws a relatively constant and quantifiable trajectory. The size of the launched object is probably crucial, the surface subjected to the wind being smaller in the case of pigeons.

Visual aspect

It is noteworthy that, despite different lighting conditions and camera angles, the visual appearance of the photos of pigeons launched during the trials is very similar to that of the UFO photos from Mr. Frégnale. The following selection speaks for itself in this respect:

- **NIKON D80** - Equivalent focal length 35 mm: 48 mm; exposure time: 1/500 s; aperture: f/8; focus: ∞



- **ZEISS IKONTA** - Equivalent focal length 35 mm: 45 mm; exposure time: 1/500 s; aperture: f/5.6; focus: ∞

Technical aspect

Having spotted in the reconstruction's scene the following positions...

- location of the thrower
- location of the photographer
- location of the fall of the pigeon/Frisbee

... we were able, thanks to IPACO, to proceed with photos and videos taken on the site to obtain measurements regarding:

- the maximal elevation **H** reached by the pigeon/Frisbee
- the total length **L** in projection to the ground of the travelled distances
- the duration of the flight **T** between the throw and the ground fall of the pigeon/Frisbee

The following results, selected for the analysis, are the average and maximum values measured and/or calculated for a parabolic trajectory rather flattened covered by clay pigeons thrown with the mechanical launcher or by the Frisbees:

Pigeons	**L** (m)	**H** (m)	**T** (s)
mean	22	8,5	3
maximum	40	12	4

Table 11

Frisbees	**L** (m)	**H** (m)	**T** (s)
mean	20	3.5	2
maximum	25	5.8	4

Table 12

Finally, measurements of rotation speed **V** have been done as well. They are summarized in the two following tables:

Pigeons	**V** (tours/mn)
minimum	1135
mean	1440
maximum	1800

Table 13

Frisbees	**V** (tours/mn)
minimum	200
mean	392
maximum	600

Table 14

Extra trials

ACN-FCR-PSY-LBN

Some extra trials with clay pigeons have been performed by hand and with the manual thrower on February 29th 2016, March 5th 2016 and March 10th 2016. They were at first painted with a rectangular white mark on their underneath part. Then they were photographed with modern cameras, in order to check the following points, exploited in the analysis:

1. The general aspect of the object and its potential similarity with the UFO of Mr. Frégnale's photos.
2. Qualification and quantification of the blur of the dark spot, then comparison with the data of the UFO on LC_3 and LC_4.
3. Complementary measurements of the spinning velocity.
4. As the trials on March 10th 2015 have been done with the Sun at an angular elevation of 22°, i.e. the same as on July 18th 1952 at 18h10, and with the thrower and the photographer correctly orientated, check of the potential presence of a projected shadow on the underneath part of the object.

Photo taken with a Canon Powershot A720 IS on March 10th 2016 at 16h43 - Exposure time 1/250e

Photo taken with a Canon Powershot A720 IS on March 10th 2016 at 16h49 - Exposure time 1/500e

Credits - Sources

Credits

ACN : Antoine Cousyn ("*Elevenaugus*t")
ADN : Alain Delmon
DCN : Dominique Caudron ("*Oncle Dom*")
FCR : Francine Cordier
FLE : François Louange
FLO : "*Flo78*"
GMH : Gilles Munsch
GQK : Geoff Quick
LBN : Lucas Bleuzen
LGN : Laurent Guérin
MAR : Eric Maillot ("*Marcassite*")
MGU : Mario Groleau
MVT : Michaël Vaillant
NAB : "*Nablator*"
PGN : Pierre Guérin
PSY : Patrice Seray
RPI : Raymond Piccoli
SNL : "*Sénéchal*"
XPT : Xavier Passot

Sources

Relating to the case

1 - Pierre Guérin: "*Science et Avenir*", pp.708-709, September 1972.
2 - Review "*Inforespace*", article from J.L Vertongen, SOBEPS, n°32, pp.24-28, March 1977.
3 - Review "*Lumières dans La Nuit*", article from P. Guérin, n°316, pp.3-18, March 1993.
4 - Pierre Guérin: "*Journal of Scientific Exploration*", Vol.8 n°4, pp.447-469, 1994.
5 - Pierre Guérin: "*Les mécanismes d'une désinformation*", 2000.
6 - Alain Delmon: "*Lac Chauvet, France, 1952*". Internet website, 2003 to 2005.
7 - French forum "*UFO Scepticisme*": "*Les photographies du Lac Chauvet*".
8 - Discuss list "*Aleph*".
9 - French-speaking forum "*Les sceptiques du Québec*".
10 - Discuss list "*Francom.ovni*".

Relating to the choice of the camera model

11 - Specialized auction website "*Enchères CataWiki*".
12 - Youtube video "*Zeiss Ikon Contessa 35 - 533/24 (Operating)*".
13 - Specialized website in the Contina history "*Camera Wiki*".
14 - Specialized website in camera models "*Camerapedia*".
15 - Specialized website in camera models "*Camerapedia*" - Contessa 35 sheet.
16 - Specialized website in old cameras "*Collection appareils*" - Contessa 35 sheet.
17 - Website of the collector Ernst Giger - Zeiss Ikon

Relating to the choice of the film

18 - Tim Vitale: "*Film grain, resolution and fundamental film particles*". October 2009.
19 - Wikipedia: "*List of discontinued photographic films*".
20 - Tim Vitale: "*Estimating the resolution of historic film images: using the resolving power equation (RPE) and estimates of lens quality*". November 2009.
21 - Film Ilford - Technical sheet.
22 - Film Fuji - Technical sheet.

Relating to the identification of the trees

23 - Herbarium of the Clermont-Ferrand university - UNIVEGE. "*Flore du département du Puy-de-Dôme*", by the French botanist Jean-Louis Lamaison.
24 - Forester stock list of the Puy-de-Dôme department - IGN.
25 - Hedges of the Puy-de-Dôme department - "*Essences champêtres, choix des essences en fonction de l'altitude et du sol*".
26 - Géoportail website.

Frisbee hypothesis

27 - Tim Walsh: "*Timeless toys*". 2005.
28 - UFOpop - *Li'l Abner's Flyin Saucer.*
29 - Collection of vintage Frisbees: "*Marvin's Flying Disc Collection*".
30 - Wikipedia (French): "*Liste des bases de l'OTAN en France*".
31 - Phil Kennedy: "*Spinnin' yarns - 19 events from published Frisbee history... that never happened!*". Co-writer of the book "*Flat Flip Flies Straight, True Origins of the Frisbee*". June 2006.
31' - Flying Disc France Federation - History

Clay pigeons hypothesis

32 - French forum "*Long distance shooting*": "*Manual thrower*".

Balloon hypothesis

33 - "*Feuille d'avis de Neufchâtel*" - July 25th 1952.
34 - "*La Montagne*" - July 24th 1952.
35 - "*La Montagne*" - July 25th 1952.
36 - "*La Montagne*" - July 26th and 27th 1952.
37 - "*La Montagne*" - July 28th 1952.
38 - "*Point de vue*" - August 7th 1952.

André Frégnale

39 - Advertising published in "*La pêche indépendante*". 1937.
40 - Bernard Caminade: "*Leurres de pêche - publicités et brevets 1865-1970*".
41 - Pierre Boutaz, Jean-Yves Martin, Marc Rattez and Alain Rigazio: "*Les leurres de pêche en France de 1850 à 1950*".
42 - Wikipedia (French): "*Gouffre de Réveillon*".
43 - "*Gouffre du Réveillon, circuit Martel-cascade, Alvignac, Lot*".
44 - Francis Guichard: "*Le gouffre-goule de Réveillon*", Spéléo Dordogne, n°96 pp.34-45. 1985.
45 - Roger Brillot and André Frégnale: "*Le gouffre du Réveillon. Commune d'Alvignac (Lot). Exploration du Groupe Norbert Casteret de Clermont-Ferrand*", Spelunca, 3e set, vol.1, pp.150-153. 1946.
46 - Internet website "*Chanterkaraoke*" - Lacs Bessards.
47 - Marc Lenormand: "*Etude du gouffre du Saut de la Pucelle Rignac (Lot)*". 2012.
48 - Internet website "*BD-Cine.com*" - 16 mm film, documentary "*Nos écoles*". 1950.
49 - Review "*Le Yacht*" n°3528 on August 11th 1956.

Later work

50 - Internet website "*Corps humain - Proportions*"