CHARACTERISTICS OF THE AUGUST 7, 2002 RECURRING HESSDALEN LIGHT DETERMINED BY VIDEO AND TRIANGULATION

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ABSTRACT The nature and position of a recurring light observed on August 6 and 7, 2002, south of the Aspåskjolen viewing area (the vista) in the Hessdalen Valley, Norway, has been the subject of controversy. One observer, Leone[1], maintained that the light was a vehicle headlight while another observer, Teodorani[2], claimed the light was other than a vehicle. A recent review of a videotape taken during the August 7, 2002 sighting, shows that both observers were correct. Two lights occurred within 19 seconds of each other near the same azimuth but clearly at different locations. Vehicle headlights appeared first, which Leone correctly identified with his telescope. Seconds later, the recurring light appeared to the west of the headlights. Apparently, while Leone viewed the first headlights through the telescope, Teodorani photographed and obtained a spectrum of the second light. Guided by the telescopic observation, Leone proposed that Teodorani's light was a vehicle on a country road where headlights briefly flashed towards the Aspåskjolen vista.

This paper questions whether the light was a vehicle on a road. The position of a similar light was determined by triangulation on August 15, 2002. In agreement with Leone's bearing estimate of 185 degrees, the light occurred at a bearing of 184.7 degrees magnetic from GPS determined coordinates of an observation camera at Aspåskjolen. Indeed, two roads do cross this bearing. However, a second bearing taken from an observation site on Heggsethødga hill indicated the light appeared south of the Heggsethødga observer. By triangulation, the distance of the light was estimated to be about, 8.3 km (5.2 miles) south of Aspåskjolen and 3.9 km (2.4 miles) south of the Heggsethødga observer. This position confirms other calculations that the light is too distant for the first and closest proposed road, and falls short of the 10.7-11.9 km distance to the second road proposed by Leone[1]. The estimated position by triangulation lies south of the schoolhouse on the flank of Skarvan Hill. Additional data and alternative hypotheses are presented which may provide insights regarding the location and nature of this controversial light.

Keywords: Hessdalen Phenomenon, light, earthlight, triangulation, instrumentation, spectrum

BACKGROUND

During the summer of 2002, researchers from Norway, Italy, and the United States converged in the Hessdalen Valley, Norway. A recurring light that had been observed in prior years was again observed and recorded by several investigators. The light appeared south of the Aspåskjolen vista area seemingly over Heggsethødga, a nearby hill to the south. The light tended to recur at approximately 22:50 CET (local time) (20:50 UTC)[1] on several nights between August 4 and August 15, 2002. To the unaided eye, the light appeared, as a single bright yellowish-white flashing orb lasting several seconds. Visually, the location and timing appeared similar each night. One observer on his first mission to the Hessdalen Valley using a

telescope saw a double light in the direction where the recurring light tended to appear. This observer concluded that the recurring light was vehicle headlights[2]. Although no roads or structures could be seen with the unaided eye at the exact location the light appeared, calculations were later made that indicated the light's azimuth was similar to those of two small private roads in the valley. Another observer who had researched the Hessdalen lights in previous years, photographed the recurring light and presumably its and spectrum at the same time the first observer was looking through the telescope. The second observer maintained the light was not a vehicle headlight. However, he also later speculated the spectrum of the light had some characteristics of an artificial light. [3]

During the 2002 expedition, this author carried out observations most evenings alongside the Italian teams and in cooperation with the Norwegian team. This author ran a digital video camera ran nearly continuously for the purpose of recording optical events, comments, and sounds using the videotape sound track as an accurate time stamped recording device. The video tape soundtrack also recorded two-way radio transmissions between this author and Project Hessdalen Leader, Erling Strand, who was at the automated monitoring station at the time of the August 7, 2002 sighting.

Later, on the evening of August 15, 2002, the last evening of Teodorani's 2002-research expedition, an impromptu decision was made to attempt to identify the location of the recurring light by triangulation from the Aspåskjolen vista site. Heggsethødga hill was chosen because the light might appear overhead. The decision was made just before sunset, and a few km of travel was required to reach Heggsethødga hill where it was thought the light occurred. This author, guided by a local Hessdalen Valley resident, drove as far as possible along an unpaved road that ended part the way up the hilltop. Delays were encountered, and it was near nightfall when they arrived at the end of the hillside road-parking site. Not enough light remained to hike to the top of the hill. Due to the waning light, this author hastily assembled equipment into a backpack and set out climbing the hill alone. She discontinued hiking before reaching the hilltop to set up the instruments in the remaining light. Drs. Massimo Teodorani and Gloria Nobili remained at the Aspåskjolen vista site with cameras[2]. Communications were maintained by two-way FRS radios.

MATERIALS AND METHODS

This author brought a portable monitoring station with her from the United States which contained the following instrumentation: Anticipating the need for triangulation, she brought two-way FRS radios and a pair of KVH Datascopes, (electronic digital compasses, accurate to ± 0.2 degrees), and a magnetic compass as backup. She also brought a Garmin Etrex Vista WAAS enabled GPS. Additional equipment included a Sony TRV 340 Hi8 Digital video camera and tripod, an Aware Electronics RM-90 gamma radiation monitor, which connects to a HP200LX computer to record gamma radiation levels, a WR3, VLF radio receiver with a 54-inch whip antenna. Also included was a Nikon FE 35mm camera with and 80-200 zoom lens, diffraction grating, and tripod. Additional equipment included an Alpha Lab Natural ULF tri-field meter with recording capability that interfaced with a Sony VAIO Laptop computer. An Edmund Scientific diffraction grating was included in the equipment but did not produce spectra adequately.

This equipment was deployed nearly nightly at the Aspåskjolen vista. Observations were first made at the eastern waypoint "Vista3". Because the presence of onlookers and their cars disturbed the instruments, and headlights disturbed observer's night vision, the observation spot was moved westward and eventually to an area near "Camera 1" (Table 2). After approximately two or three nights until August 15, 2002, observations were made near Camera 1 from a consistent spot marked by a vertical pole.

The triangulation was done in the following manner: The position of Teodorani and Nobili's cameras (Camera1) at the vista site was determined using the Garmin Etrex Vista WAAS enabled GPS. The accuracy with WAAS enabled is < 3m and without is < 16m. WAAS may not operate in Europe so the functional accuracy may be < 16m. Coordinates and bearings were observed as magnetic values (magnetic declination was 0° 52' or 0.87° at Camera1 on August 15, 2002)[4]. The coordinates of the cameras were recorded using decimal degrees, to five decimal places. Teodorani was equipped with film cameras, and spectral gratings described elsewhere[5]. This author loaned Teodorani and Nobili a KVH Datascope. This instrument was used to take the bearing of the light. This author also provided Motorola FRS two-way radios for communication.

After ascending part way up the hill, this author took a waypoint of her position (Hillside) with the same Garmin Etrex Vista GPS used to establish the Camera1 position on Aspåskjolen. Coordinates and altitudes of the two observation locations are listed in table 2. At the Hillside position, the following instruments were deployed: The Sony TRV 340 Hi-8 digital video camera was placed on a tripod facing southwards. It was set to "nightshot" mode to increase visual light and infrared sensitivity. The radiation data from the RM90 gamma detector were averaged every ten seconds and recorded on the HP200LX palmtop. The VLF signals were recorded intermittently on the sound track of the video tape by attaching the earphone output of the WR3 to a splitter that fed into the Sony TRV 340 microphone jack. This author finds the audio track of a camcorder is superior to a tape recorder because each video frame and accompanying sound track is time and date stamped to the nearest 29th of a second. The video camera ran continuously throughout the observation period. Voice recordings of all radio transmissions were made on the time stamped audio channel of the video camera through a microphone headset also attached to the camera through other side of the splitter that fed into the TRV 340 microphone input.

At the time of the 2002 expedition, the only Norwegian map/software this author was aware of in the US was Garmin Worldmap that was installed on her computer and GPS. Worldmap is a very low-resolution map that covers the US, Europe and elsewhere. It proved inadequate for accurately calculating triangulation results. After more than two years passed this author became aware of the availability of a more accurate digitized Garmin map and software that was purchased in Norway. The analysis used in this document is the digitized map set: 1:50,000 for Garmin GPS, N50 CD10 Trondheim. Garmin Mapsource version 6.11.3 was used to plot location coordinates. and determine some altitudes. The Garmin software allows only whole degree azimuths to be plotted. It was unable to accurately define the triangulation. Iconico Screen Protractor V 3.4 software was used to project azimuths on the Garmin Trondheim map. The digitized map was set for 0.87° E magnetic declination (the value for Hessdalen on August 15, 2002) and graphical solutions used magnetic bearings.

RESULTS AND OBSERVATIONS

VIDEO OBSERVATION OF LIGHTS

Two of the light observations will be discussed here; first, the recurring light photographed on August 7, 2002, then the triangulation of what was presumably the recurring light on August 15, 2002. A videotape recorded August 7, 2002 was recently reviewed. It clarifies the sequence of events that occurred during that night's observations (Table 1). Vehicle headlights appeared first at 21:00:56 UT, in the same general direction as the recurring light later occurred, and within Leone's first error estimate of 185 ±5 degrees. Leone states; *"A few seconds after each sighting this author measured the phenomenon's azimuth by pointing a compass at the exact spot where the light showed itself: 185° (+/– 5°)."* [1]. In a later paper Leone strongly asserts that Teodorani [6](2003 p2) was incorrect when Teodorani said that [Leone], *". . .saw once a car, together with all of us (and to us this occurred routinely many times) and also evaluated probably correctly the distance of it, but the real phenomenon is not situated where the inexperienced author claims"*. This author speculates that when the vehicle headlights appeared in what was thought to be along the correct azimuth, that Leone appropriately trained his telescope on the only observable light at the time; the vehicle headlights. Once trained, it would be unlikely the telescope would pick up the background in the dark, and with limited angular perspective, only the vehicle headlights would be visible. Leone correctly drew the conclusion that *he* had observed vehicle headlights and evidently said so to the other observers. During the sighting, this author repeated verbally on the digital video camera sound track that vehicle headlights were seen.

Nineteen seconds later, at 21:01:15 UT (23:01:15 CET) the sound track records excited shouts regarding another light. The video camera pans quickly to the right to a second light at a higher elevation a few degrees to the west. This second light is most likely the one captured on film by Teodorani who is more familiar with the position of roads and the expected location of the recurrent light appearance. The second light appears while the vehicle headlights are still visible. When the video camera is directed from the headlights towards the second light, it is uncertain if the headlights remained visible throughout the entire

duration of the recurring light. In this author's opinion, it is likely that Leone assumed the exclamations were related to the vehicle headlights he was observing through the telescope, and not a "new" light. The second light lasts about 12 seconds on the videotape before disappearing. The actual video clip of this sequence, which begins about 21:00:50, can be seen at: http://www.earthlights.org/hessdalen-aug7_2002.htm. (The camera time code is not available in the compressed Internet video files) Table 1 describes the key events. Figure 1 shows a good resolution video frame capture of the typical position of the recurring light taken on a different night. Figure 2 is a wide-angle video frame capture of vehicle headlights on August 7, 2002. It has been processed to show background features in the dim light... The two images can be compared to see the similar but clearly different positions of the two lights. Figure 3 shows well defined headlights in a telephoto picture. Lights of a building can be seen in the upper left corner. Figure 4 is included in this group for comparison with headlights on nearby Vårhuskjølen Road. (Figure 4 will be discussed later in the paper). When the recurring light appeared, the camera was panned rapidly in order to videotape the brief duration light. Figure 5 shows a lightened and enlarged view of the distant buildings where the vehicle headlights first appeared. Figure 6 is a telephoto video frame of the vehicle headlights to the right of the buildings.

Table 1 SEQUENCE OF EVENTS AUGUST 7, 2002 LIGHT SIGHTING

Time UT	Comments
21:00:56	Vehicle appears driving north to the right and below the house lights at near the 185 degree azimuth.
21:01:15	A second slight, the recurring light, appears over the hilltop, voices shout
21:01:27	Recurring light goes out
21:06	Leone asks if I saw or filmed two sources of light. This author replies, "I saw two lights widely separated, too far apart to be car headlights."

Figure 1 Typical view of recurring light

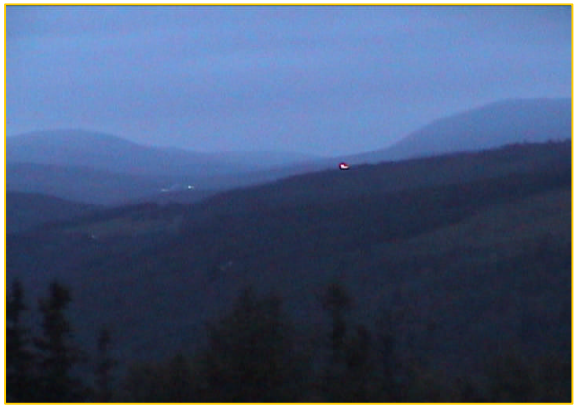


Figure 2 Vehicle headlights Aug. 7, distant view

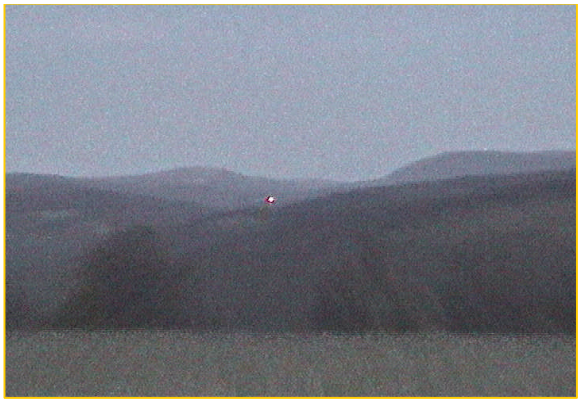


Figure 4 Headlights on Vårhuskjølen Road

Figure 3Telephoto zoom shows two headlights

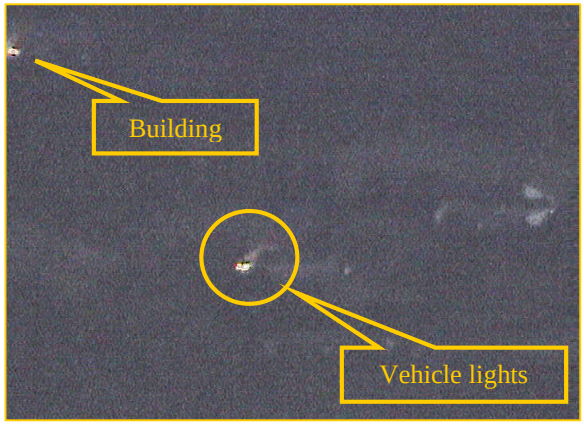


Figure 5 Lightened view of distant buildings where vehicle headlights appeared

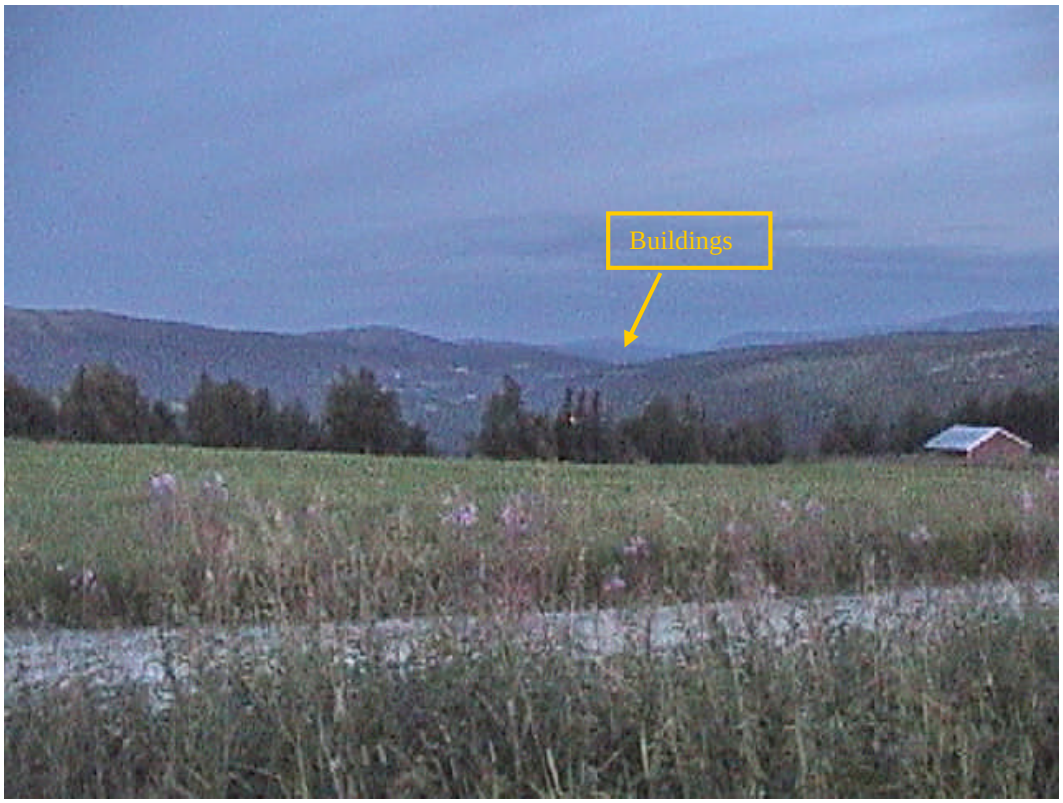


Figure 6 Telephoto of distant buildings with vehicle headlight to right ~ 10 km distance

Star

Figure 7 August 7, 2002 building, vehicle, (left) and recurring lights (streaked as camera pans).

Figure 8 Telephoto video frame capture of recurring light August 7, 2002.

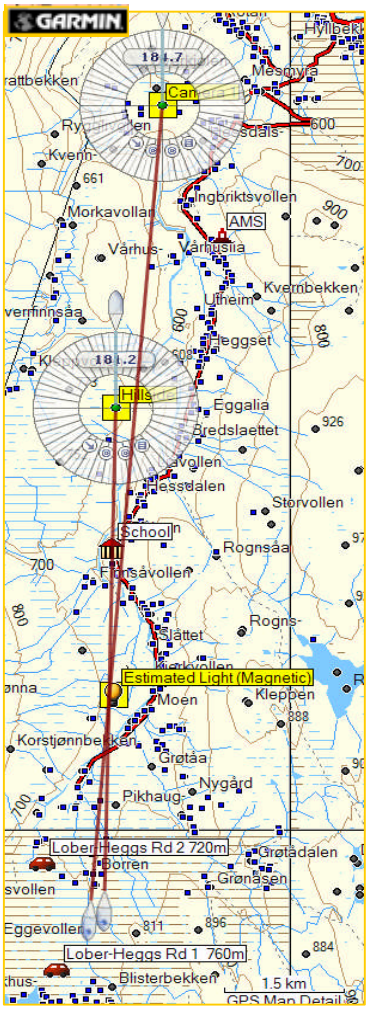
Figure 7 shows one of only two frames where all three lights appear together, the buildings, vehicle, and recurring light confirm their individual identities. The lights are streaked because the camera was rapidly panned to capture the recurring light. Figure 8 is a representative frame of the August 7 recurring light. During this sequence, Teodorani may have photographed the spectrum of this light, which on analysis

resembles vehicle headlights. The quality of the figures above is less than desirable because they are captured low-resolution video frames. Most of the photos have been processed to lighten and increase contrast so that the background is visible. No other processing has been done.

TRIANGULATION

On August 15, 2002, while Teodorani and Nobili were stationed at the Aspåskjolen vista and this author was stationed at the Hillside location, the anticipated luminosity appeared at approximately the expected time, 20:52 UTC (22:52 local time). There were some unanticipated observations. This author had anticipated the luminosity would appear overhead. Instead, from the Hillside position, the object appeared to be much farther south than expected. She also noted that the light appeared just over her local horizon at such a low angle that she could not see it from a sitting position and needed to stand to observe it. The light was also smaller and dimmer than this author's recollection of her prior observations from Aspåskjolen. This author captured the light on videotape from the Hillside position. Teodorani radioed from his Camera1 position the light was bright enough he was able to photograph a spectrum. Confirmation that both observers were viewing the same luminosity was made in real-time by two-way radio. There were no other lights observed by this author in the southward direction prior to, or for the remainder of the night. After taking photographs of the spectrum of the light Teodorani determined the light's bearing was 184.7° magnetic using the KVH Datascope. He confirmed the reading using his own magnetic compass. The light appeared in a less favorable position for Adams, behind some foliage slightly hindering her ability to view it but giving a reference for sighting. Using a second KVH Datascope, Adams determined the bearing was 181.2° magnetic from her position.

Figure 9 Triangulation



TRIANGULATION CALCULATION

Initially a distance of ~ 9 km from Aspåskjolen was estimated by this author using low resolution Garmin Worldmap software, (the only map and software available to this author in 2002). Recognizing the inadequacy of the map and software for precise triangulation, this author was reluctant to publish the triangulation results until more accurate maps and software could be obtained. Years later, this author acquired a digitized map set on CD, 1:50,000 for Garmin GPS, N50 CD10 Trondheim, and Garmin Map Source 6.11.3 software became available. Although placement of coordinates (waypoints) appears accurate, even this recent release of Garmin Mapsource does not allow input of decimal degree accuracy for bearings. Triangulations attempted using this software did not compare favorably with use of either a physical protractor on several physical maps, or a digital protractor on the 1:50,000 for Garmin GPS, N50 CD10 Trondheim digitized map. Triangulations computed using a physical protractor and Iconico Screen Protractor V 3.4 software compared favorably with each other. Therefore, the Screen protractor was used to produce graphical estimates of the light position. The intersection of the two bearings of 187.4° and 181.2° was 8.3 km from "Camera1" at Aspåskjolen Vista, and 3.9 km from this author's Hillside position. The triangulation intersection occurs near N62.76612 E11.17471. These coordinates fall near the main road, FV576 that courses through the Hessdalen Valley. This location is on the flank of the Skarvan hill (where it is ~670m high), about 2 km south of the schoolhouse. Table 2 shows the position of the waypoints (observer positions) and bearings (azimuth) to the observed light of August 15, 2002. For general information, the coordinates of other significant locations in the Hessdalen Valley have been included in the table; the first observations (Vista 3), the school, and the AMS (Strand was in the AMS during the August 7, 2002 light sighting, but was not present during the triangulation).

Table 2 TRIANGULATION COORDINATES AND BEARINGS

Observers	Waypoint name	Latitude	Longitude	Altitude	Mag Bearing To light *	True Bearing to light
Adams	Hilltop	N62.80137	E11.17522	707m	181.2°	182.1°
Teodorani/Nobili	Camera1	N62.83861	E11.18674	705 m	184.7°	185.6°
Several Aug 5-7	Vista 3	N62.83866	E11.18770	699	n/a	n/a
nobody	School	N62.78419	E11.17426	621 m	up?	n/a
Strand	AMS	N62.82112	E11.20253	640 m	(193?)*	(195?)*

*Hypothetical values from AMS to estimated light position

The possibility that the recurring light occurred over a part of a hill that was 670m altitude raises questions about height of the light above the ground. The light could not have been seen if it was on the ground because Heggsethødga hill blocks line of sight from Aspåskjolen viewing area. The light would have to have been at least 20-35m above the ground to be at eye level with Aspåskjolen. Although this may appear to support the contention that the triangulation might have been inaccurate and that the only way to obtain the elevation needed is to accept Leone's hypothesis that the light may have been headlights on the higher elevation, (but far more distant) Løbergsvollen-Heggsetvollen road, other observations suggest the light may have been well above the ground. We will first discuss this possibility showing some inconsistency in altitude measurements, and second, we will examine the general hypothesis of vehicle headlights on roads showing measured bearings and distances from various observation points.

ALTITUDE VARIATION

This author found variation in altitude measurements between the GPS, Trondheim map, Google Earth, and maps used by Leone (Table 3). One must assume altitude measurements are consistent on the same map or GPS and each can be used for relative elevation calculations. However, applying altitudes from one map to another, or to GPS measurements, may produce erroneous conclusions but it may be necessary due to limited information. In particular, the GPS altitudes may not be accurate. In 2002, it is believed that the US military may have introduced purposeful errors into GPS altitudes for defense purposes, though this author understands it is no longer the case[7]. As measured by the GPS, the altitude of Camera1 and Hillside waypoints were nearly identical, 707m and 705m respectively. The Garmin Trondheim map agrees with the GPS estimating the Hillside elevation at ~710m. GPS measurements were not available from the top of Heggsethødga hill so, accepting possible measurement differences, the profile created by Nicolosi & Ricchetti[9,] in figure 10 was used to estimate the elevation of Heggsethødga hill. The hill obstructs the view to some of the southern Hessdalen valley from Camera1. The red arrow indicates the estimated position of the light over Skarvan Hill to the south of Heggsethødga hill at the estimated 8.3km distance from Camera1. The recurring light must have been at least 700-725m altitude to be seen over the hill, if indeed the triangulation is accurate and the light's location is in fact, near Skarvan hill.

Table 3 DESCREPANCY IN ALTITUDE MEASUREMENTS AT CAMERA 1

Measurement type	Meters	Feet
Garmin Vista WAAS GPS	705	2312
Garmin N50 Trondheim	690	2231
Google Earth	635	2083
Dalsbygda, 1995	690	2264

Figure 10 Elevations of 185 ° azimuth with added points of interest (Nicolosi & Ricchetti, 2003)[6]

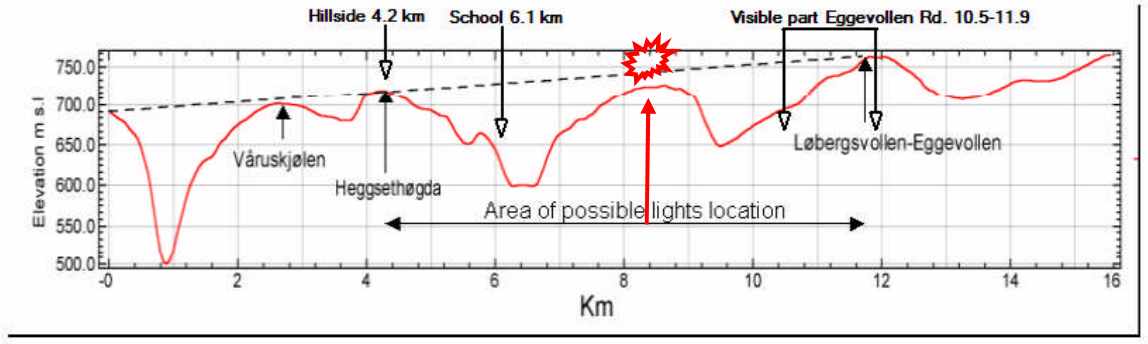


Figure 11Three turns of Vårhuskjølen road as seen from the vista. Magenta line is the 185° azimuth

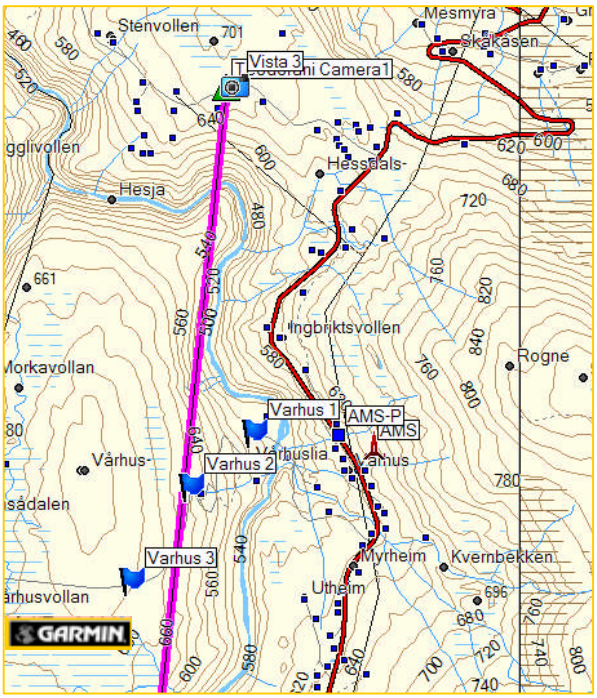
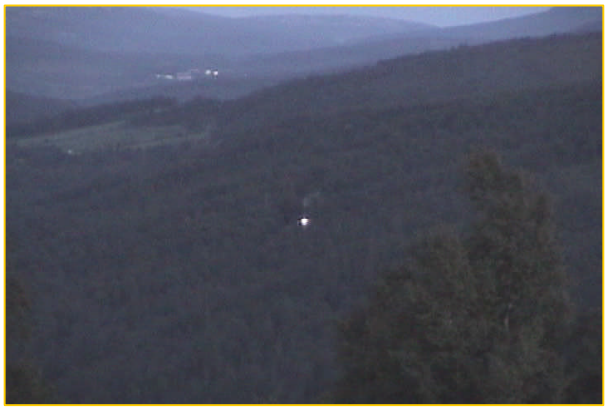


Figure 12 Telephoto headlights on Vårhuskjølen road



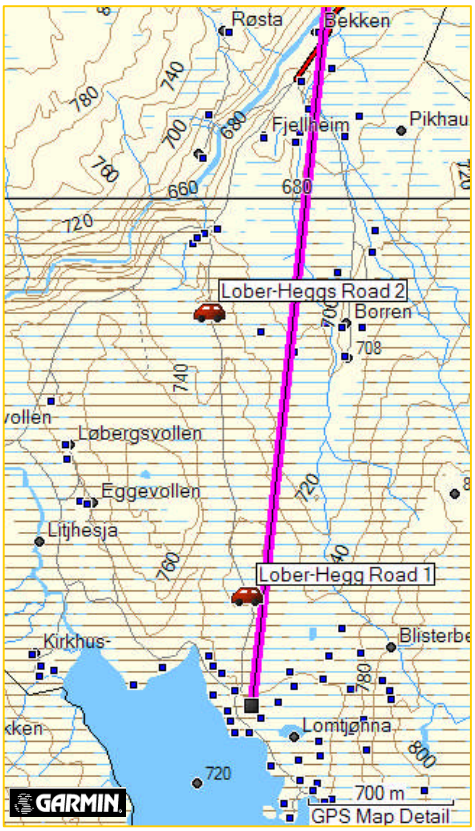
HEADLIGHT POSSIBILITIES

The possibility that the recurring light was a vehicle headlight has been thoroughly discussed in several papers by both Leone [1,4] and Teodorani[8,9]. The possibility that the recurring light was a vehicle on Vårhuskjølen the road close to Aspåskjolen on Heggsethødga hill, has been ruled out. This paper offers photographs of vehicle headlights on this road for further confirmation, and as an orientation reference to show where vehicle lights appear in the Hessdalen Valley. Lights appearing along roads can be regarded as artificial lights. Genuine Hessdalen lights most likely do not appear in these locations. A brief background of headlight possibilities on roads is summarized for readers unfamiliar with the Hessdalen Valley.

Vårhuskjølen Road: In addition to parts of the main road FV576, that courses through the Hessdalen Valley, at least two well-traveled private roads are visible from the Camera 1 position though other very small roads may exist that are not shown on the map. Vehicle headlights can be seen on certain sections of the main private roads. (Additionally, a section of FV576 is visible from the Aspåskjolen vista). All of these roads cross an 185-degree azimuth from Aspåskjolen vista. The roads were described by Leone [1] who initially proposed Vårhuskjølen road to be the source of the headlights and therefore the recurring light. Vårhuskjølen road had several turns where headlights become visible. These points are designated in table 4 as Vårhuskjølen 1, 2, and 3. Their distances were quite close to the Aspåskjolen observation point 1.9, 2.2, and 2.8 km distance. The bearings of these turns were 174°, 184°, and 190° respectively. After Leone[1] suggested this road was the location of headlights, it was ruled out as a possible source of the recurring light by

Nicolosi and Ricchetti[9] who created an elevation profile (figure 7) showing the light must have been between 4 and 12 km distance from Camera1. They showed that Vårhuskjølen road was not only too close, but the angular elevation of the light in Teodorani's photo (+0.4) and the angular elevation of Vårhuskjølen road turns (-0.3,-0.9, and -1.7) did not match. As photographic confirmation, Figure 12 shows vehicle headlights on Vårhuskjølen road. This is clearly not a match with the position of the recurring light. With greater telephoto magnification the headlights are clearly discernable. Further confirmation that this road can be ruled out, was this author's position when she triangulated the recurring light. She was south of the road, 4.2 Km south of Camera 1 at Aspåskjolen, when she observed the light south of her. This lends additional support to Nicolosi and Ricchetti[10] 's calculations the light was not on or near Vårhuskjølen road which was only 1.9-2.2 km distance from Camera1. The photograph in figure 12 may serve as a good control for the brightness of vehicle headlights at a 1.9-2.8 Km distance, and to show new observers where vehicle headlights appear.

Figure 13 Visible part of Løbergsvollen-Heggsetvollen road



Løbergsvollen-Heggsetvollen road: Leone[11] proposed vehicle headlights might be visible from a more distant road that also lies along a ~185° ± 5 azimuth from Aspåskjolen. Løbergsvollen-Heggsetvollen road runs slightly NE-SW. The section of the road that may be high enough to be visible from Aspåskjolen lies between azimuths of 186.8-188.2 degrees. Løbergsvollen-Heggsetvollen road is the southern- most extension of the main Hessdalen Valley road FV576, that climbs from the valley floor, runs past Eggevollen enroute to Hessjøen Lake and beyond. The road ascends to the top of the hill so that northbound headlights (going downhill) could be seen at waypoint Løbergsvollen-Heggsetvollen road 1, altitude ~740 m. Vehicle headlights would continue to be visible along the road until Løbergsvollen-Heggsetvollen road 2, altitude 760m, where the road descends behind an intervening hill. According to the Garmin map, the view is unobstructed between the two automobile icons, a distance of 1.3km. Intervening Heggsethødga hill is ~700m at the 185° azimuth line. However according to Nicolosi & Ricchetti's profile, the viewing distance is more restricted because according to their graph, Heggsethødga hill is higher and blocks the lower part of the view. Using the Garmin map, the flank of Skarvan hill (altitude 720m) intervenes between Camera 1 and Løbergsvollen-Heggsetvollen road blocking the view for most of the length of the road. Waypoints on Løbergsvollen-Heggsetvollen road 1 and 2 (car icons in Figure 13) defines the 1.3 km section of the road where vehicle headlights might be visible. Distances from Camera1 are 11.9 and 10.7 km (7.4-6.6 miles) respectively. Regardless of the altitude accuracy discrepancies of various maps, both methods show that some section of Løbergsvollen-Heggsetvollen road is visible from Aspåskjolen but for different distances which would affect the duration of the observed vehicle headlights.

Table 4 HESSDALEN LOCATION BEARINGS, ALTITUDES, AND DISTANCES

Location from	Location to	Distance Km	Distance mi	Altitude m	Altitude ft	Magnetic Bearing *
Camera 1	Hillside	4.2	2.6	609	2,230	188.3
Camera 1	Vårhuskjølen1	1.9	1.2	520	1,771	174.2
Camera 1	Vårhuskjølen2	2.2	1.4	640	2,099	184.5
Camera 1	Vårhuskjølen3	2.8	1.7	700	2,296	190.1
Camera 1	School	6.1	3.8	684	2,034	185.9
Camera 1	***Estimated light***	***8.3***	***5.2***	***670***	***2198***	***184.7***
Camera 1	AMS	2.1	1.3	680	2,230	157.7
Camera 1	Løber-Heggs 1	11.9	7.4	760	2,427	186.8
Camera 1	Løber-Heggs 2	10.7	6.6	720	2,362	188.2
Hillside	School	1.9	1.2	684	2,034	180.5
Hillside	AMS	2.6	1.6	680	2,230	030.0
Hillside	***Estimated light***	***3.9***	***2.4***	***670***	***2198***	***181.2***
Hillside	Løber-Heggs 1	7.7	4.8	760	2,427	185.8
Hillside	Løber-Heggs 2	6.4	4.0	720	2,362	188.9
School	AMS	4.4	2.7	680	2,230	017.6
School	Løber-Heggs 1	5.8	3.6	760	2,427	186.9
School	Løber-Heggs 2	4.5	2.8	720	2,362	190.6
Løber-Heggs 1	Løber-Heggs 2	1.2	0.9	760	2,427	352.5
Løber-Heggs 2	Løber-Heggs 1	1.2	0.9	740	2,362	172.84

*Magnetic bearings in Table 2 were determined by Datascope. Magnetic bearings in Table 4 were determined by a combination of Iconico Screen Protractor 3.4 overlaid on the Garmin Trondheim map.

ARTIFICIAL LIGHT POSSIBILITIES

The nature of the recurring light remains elusive. In addition to the position of the light, (if on a road would indicate vehicle headlights), if the position is not on a road, what is the light? The spectral analysis done by both observers supports the possibility that the light may have a man-made origin, similar to a halogen light or other artificial light spectrum. Leone [1,4.] asserts that the spectral characteristics of the light indicate an artificial origin, namely high intensity vehicle headlights. Teodorani himself noted the similarity of the spectrum he photographed to other artificial lights he had analyzed. Teodorani and Nobili even speculated in detail about the possibility that the recurring light might be an expensive prank [2.] Some additional factors might indicate a man-made origin of the light: The regularity of the time of day of the recurrence of the light (around 2050 UTC), and the similar position of the light each night suggests other than natural origin. Teodorani' proposed hoax was too expensive to be practical. This author speculates a less expensive method. A elevated light might be achieved by shining a powerful halogen light on a highly reflective helium-filled Mylar balloon or weather balloon carrying a reflective surface. Such a balloon could soar over the ground and the reflection would meet the spectral observations made by Leone and Teodorani. Additionally, radio controlled airplanes, blimps, and helicopters can carry payloads of lights or reflective surfaces. This author wishes to note the hoax scenario is a speculation, not an assertion.

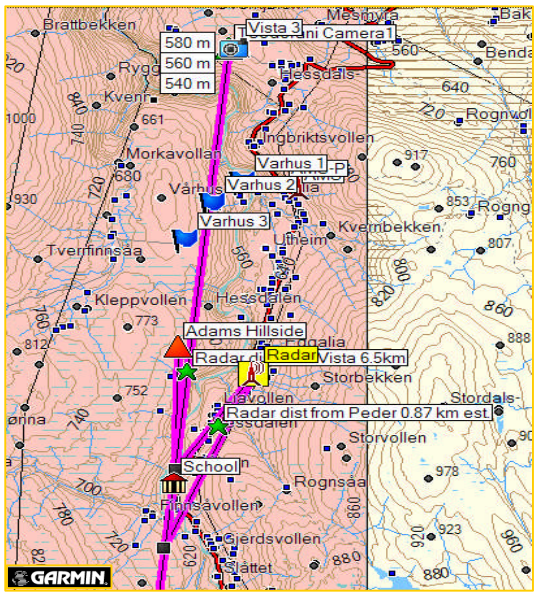
GENUINE LIGHT POSSIBILITIES

RADAR

On the other hand, anomalies and data in the vicinity of the schoolhouse may support natural causes other than pranks. The schoolhouse is ~2 km north of the triangulated recurring light position. First, although comprehensive radar investigation was not done, some radar data may show anomalous echoes north of the schoolhouse about 3 km north of the estimated light position. Radar echoes are in the hypothesis testing stage and are not confirmed indicators of the Hessdalen phenomenon at this time. However, the findings of Montebugnoli's pulsed radar are intriguing. They suggest possible anomalous radar echoes in the vicinity

< 1.5km) of the school.[12] Montebugnoli found an echo 4.5 km south of Aspåskjolen vista (presumably along the 185-degree azimuth that runs down the center of the valley and crosses the school). Another radar sighting was done from Peder's farmhouse. Sporadic echoes were detected 7/8 km and 13/15 km from the farm in the direction of the school. This author was present at the time of the radar investigations at Peder's farmhouse. She recorded the GPS position (N62.79776 E11.19219) of the radar and took

Figure 14 Green stars are radar echoes near school red triangle Adams location



bearings of Montebugnoli's description of the azimuths between which the echoes occurred (201-214 degrees). These azimuths are shown in Figure 12 originating at the "radar" site at Peder's farmhouse (yellow antenna icon) continuing until they intersect the 185-degree azimuth from Aspåskjolen vista. The two azimuths sit astride the schoolhouse. The echo locations are represented by green stars. The echoes are in the direction of the school less than one km away. If a focus of activity exists, one might surmise it might cover an area of a few km. These echoes north of the school may warrant more detailed investigation of the entire vicinity especially the area 2 km to the south.

SCHOOL LIGHT SIGHTINGS

Another observation that supports the possibility that valid phenomenon may occur in the vicinity of the schoolhouse was a student sighting. This author was present at the schoolhouse during the 2004 Østfold College science camp. Students on both Mt. Finnsåhøgda and Rogne reported a sighting by two-way radio. Near the same time, students outside of the schoolhouse reported seeing flashes overhead. This author took cameras outside and observed for an hour but no further lights were seen or recorded. This author however was looking northward, the southern view where the triangulation was calculated, was blocked by the school itself. There may have been additional sightings over the years of which this author is unaware. It would be interesting to seek historical reports of sightings in the vicinity of the school to further evaluate the possibility of activity.

MIRAGES

The character of the light during the triangulation seemed anomalous. Both observers simultaneously saw a light to the south and confirmed it by two-way radio. The more distant observer 8.3 km away on Aspåskjolen vista reported the light to be bright and large. The closer observer, 3.9 km away, observed a small light of medium brightness. This suggests that meteorological effects need to be examined. Although direct view of vehicle headlights on roads from Aspåskjolen vista has been questioned, the possibility of superior mirages or reflections from distant vehicle headlights or even airplane lights remains unexplored. Superior Mirages may reflect very distant lights over the horizon. They occur because an inversion layer of cold dense air creates a boundary layer under warmer air above. Inversion layers are likely in the Hessdalen Valley from cold dense air that flows at night down the Hesja river channels displacing warmer air as it flows along the river's course. Changes in the temperature and therefore dew point can be visualized by the frequent fogs that settle over the river in the evening. The river runs very close to the road from the schoolhouse southward to the end of road FV576. It runs past the triangulated position that is just 310m west of the river. This position along the river might be situated such

Figure 15 Colors of recurring light

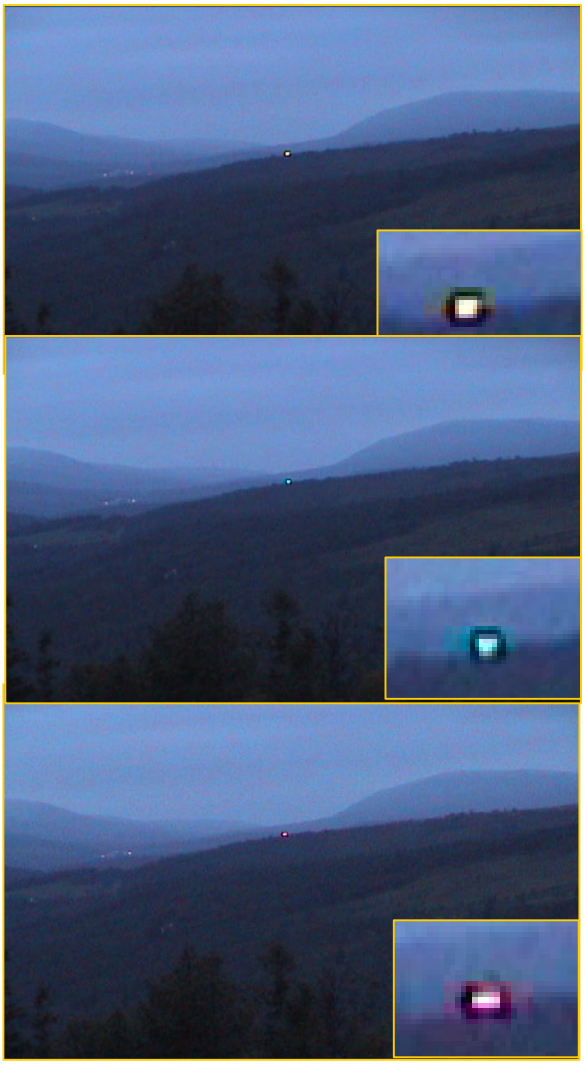


Figure 16 Teodorani and Nobili's spectrum [2]

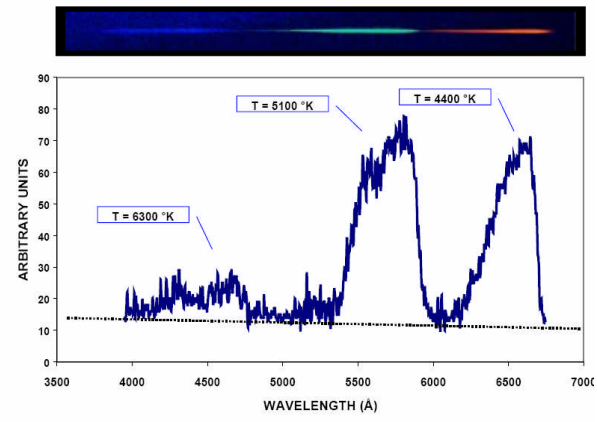


Figure 7. Spectrum of a Hessdalen light-phenomenon obtained with a ROS grating in connection with a Praktica BX-20 reflex camera equipped with a 270 mm lens. The dotted line indicates the level of noise. The three peaks are indicated with the relative temperatures which are derived from the Wien law. The wavelength range in which the spectrum is detected responds to the sensitivity curve of a Kodak Ektachrome 100 film [12], which was used to take the spectrum.

that distant vehicle headlights could be reflected at that location. One candidate could be traffic on parts of Løbergsvollen-Heggsetvollen road that are blocked from view from Aspåskjolen. To test this hypothesis in the fall of 2004, this author acquired meteorological data in the vicinity of the schoolhouse. Data were recorded every ten minutes for nearly a month from four weather stations. These stations were positioned at various altitudes between the riverbank up to the level of the schoolhouse. These data have yet to be analyzed for temperature gradients. Positive findings would not negate the Hessdalen Phenomenon, but may explain some lights that recur at certain locations.

EMPIRICAL OBSERVATIONS

Teodorani and Leone both analyzed the spectrum of the light taken from a still film camera. The analysts assumed that the light was a single source and that the emissions did not vary and had constant color temperature peaks. The video recording by this author (on a different but typical night) shows that the light might vary in intensity, shape, and shift spectrally. In the video, the recurring light rapidly changes color, intensity, and shape from frame to frame (1/29th second) (figure 15). This corresponds to the well-known visual descriptions of the "blinking light". Teodorani's spectral photos using a film camera are apparently the summation of these color changes over several seconds of exposure. These video frames raise the question whether the spectral shifts are caused by atmospheric dispersion, or whether the video camera accurately recorded spectral, intensity, and shape changes inherent to the light. (Note that the building lights to the lower left of the light do not seem to change color and shape, but they may not be of sufficient intensity).

Three distinct colors were observed in the video still frames; red, blue-green, and yellow-white. Is this an artifact of the CCD or do these colors approximate Teodorani's spectral peaks (Figure 16) notwithstanding errors caused by Ektachrome film? If atmospheric dispersion can be ruled out, these data may pose new questions regarding the light's nature. They may suggest there is more complexity to the light than a constant source. Although these data are not sufficient to answer the question, they may serve as impetus to conduct further experiments such as using low lux video cameras, with a greater understanding of the spectral responses of their CCDs in combination

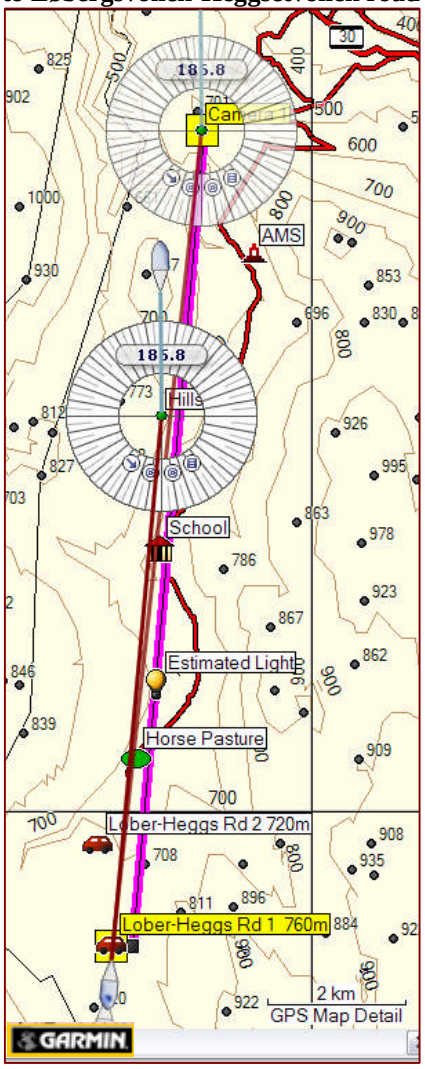
Figure 17 One of several video frames showing the light apparently below the ridge tree tops

with spectral gratings to gather more accurate data. Another noteworthy observation that supports a light near Skarvan hill is captured video frames of the recurring light. Figure 17 shows the light apparently in front of the trees on the crest of the hill. This is one of several frames that show the light in the foreground. It is unlikely that vehicle headlights on Løbergsvollen-Heggsetvollen road would shine this brightly through foreground trees.

AZIMUTH CONSIDERTIONS

If the lights were indeed on Løbergsvollen-Heggsetvollen road there would have to be substantial errors in azimuth measurements on the part of *both* triangulation observers. Figure 18 shows the 184.7 azimuth in magenta hypothetical bearings to the highest, most likely visible point on Løbergsvollen-Heggsetvollen road (brown). Løbergsvollen-Heggsetvollen road lies at an azimuth of 186.8° to 188.2° from Camera1 at Aspåskjolen, and at a bearing of 185.8° to 188.9° from the Hillside observation point. Figure 18 shows that if the light were headlights on Løbergsvollen-Heggsetvollen road the observer at Camera1 would have made an error of 2.1°-3.5° AND the observer at the Hillside position would have made an error of 4.6° to 7.7° in their azimuth measurements. Headlights on this road would probably have appeared 2° to 3.5° to the right of the light in Teodorani's photograph.

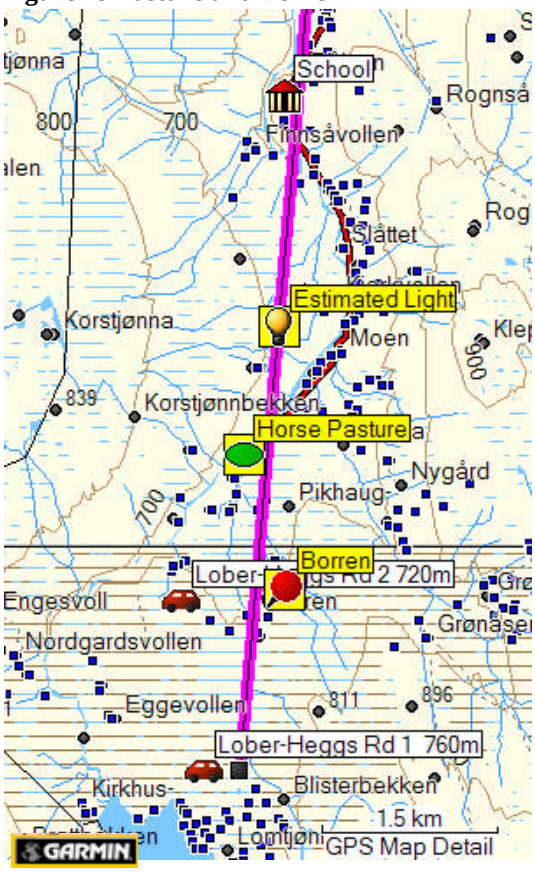
Figure 18 Hypothetical triangulation to Løbergsvollen-Heggsetvollen road



SITE OBESERVATION

The evening following the triangulation, August 18, 2002, this author drove along Road *FV576* towards the area of the preliminary light coordinates (N62.76041 E11.17239) to do an observation. These coordinates lay south of the school where road *FV576* closely follows along the course of the Hesja River. The ability to make observations at the exact coordinates was limited by the character of the road. Road *FV576* has no shoulder (space alongside) on which to park a vehicle. The first opportunity to park was at a horse pasture (Figure 19) about 500m south of the (first) estimated triangulation coordinates. Figure 20 may indicate this was the correct location. A horizontally flipped image of Teodorani's photograph from Aspåskjolen (as if viewing from the south side) of a light with a silhouette of the ridge in the background compares favorably to the perspective from the horse pasture with the exception of a stand of trees near the middle of the photo.

Figure 19 Pasture and Borren



This author arrived at the horse pasture at 19:19 UT (21:19 CET). She set up VLF, radiation, and magnetic recording equipment and a video camera. She noted there were no power lines in the vicinity. While it was still light, she videotaped various points of interest in the surroundings and noted bearings to them. At 20:45 UT, an airplane passed overhead. At 20:58 (22:58 CET) a short duration flash occurred lasting just one video frame, (less than 1/29th second). The flash occurred in a northerly direction at a bearing of ~ 015°. The flash was brighter than a star in the same field of view (figure 21). The author did not see the flash. Frequently very brief lights are not seen but they are recorded by the camera. (These brief lights *are visible*, there have been many instances where lights have been seen and noted by several members of a group, then confirmed later when the video tape is reviewed). At the same time the flash occurred, the wind suddenly increased but no velocity measurement was made. No vehicles came down the road while the video camera was running. At 21:09:55 UT (23:09 CET) a blinking light appeared over the hill at approximately 260° (estimated by video landmarks taken earlier. The duration of the light was only 8 seconds before it vanished over the ridge, and there was not enough time to take a bearing). No noise was heard. The light was slightly brighter than a star, and appeared to be blinking somewhat irregularly. Although the light was first seen towards the westerly direction (Figure 22), apparently 90° away from the estimated light's position, the direction of travel was to the northeast where the light might have intersected the estimated position along its course of travel. The motion of the light was steady, similar to an aircraft but the irregular blinking seemed atypical of an aircraft. Usually, airplanes are easily identified in video recordings because most anti-collision strobe lights flash at almost exactly one-second intervals. Therefore a light that flashes every 29 video frames is most likely an aircraft. Identifying the character of this light was more difficult because the video camera was set to nightshot I mode. In this mode ~6 video frames are added together to increase brightness in dark surroundings. Thus, it is difficult to determine the timing of the flash intervals.

Figure 20 comparisons of both sides of the hill

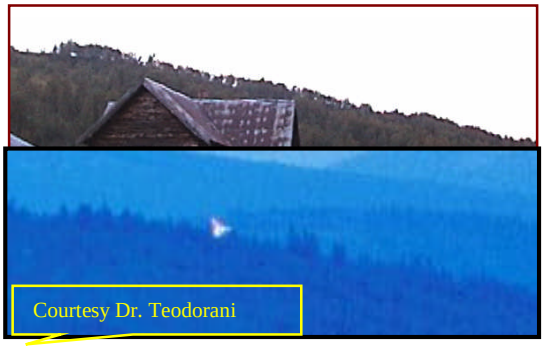
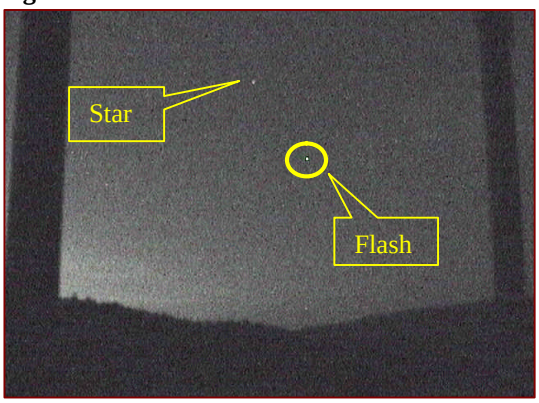


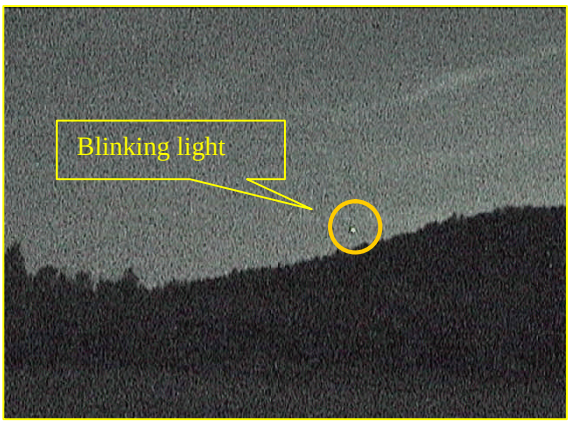
Figure 21 Short duration flash



Further analysis is necessary to determine the exact character of this light. There are several possibilities: a genuine light, an aircraft, or a coincidental unknown light unrelated to the recurring light. If it was a high altitude airplane, this raises the mirage/reflection question. A scheduled airline passing overhead on a nightly basis might explain the regularity of the recurrence of the light. An aircraft might not need to pass directly over the triangulation coordinates to be

reflected. Hessdalen is in between at least two aircraft "traffic lanes" or jetways. It is also situated at a distance from Trondheim and Røros airports where landing lights are turned off and on creating the effect of lights suddenly appearing and disappearing.[13] Additional support of the airplane possibility may be Teodorani's spectrum. His two spectral peaks may possibly lie in the range of the red and green, port and starboard lights on aircraft wing tips. It would be interesting to compare spectra of airplane wing lights and Teodorani's recurring light spectrum. Further, some of Teodorani's photos may suggest reflections of light configurations similar to aircraft. The last possibility is the observed light may have been merely coincidental and unrelated to the recurring light. This author possesses additional unanalyzed data that will be explored in a future publication.

Figure 22 Blinking light lasted 8 seconds over Pasture hill



DISCUSSION

There are several possibilities for the nature, location, and mechanism of the recurring light ranging from vehicle headlights to unknown. This discussion will speculate on some of the possibilities, review some experimental techniques, and identify areas that may be of value in generating future ideas and experiments. It is important to rule out artifact lights of every kind, headlights, meteorological, and other artificial lights so that time and energy can be spent analyzing valid light phenomenon. On the other hand it is important to consider possibilities. A plausible explanation does not imply a comprehensive explanation for all phenomena. The data relating to the recurring light is still too scant to draw definitive conclusions. Multiple observations are needed.

EMBLA 2002 was Leone's first expedition to the Hessdalen Valley. Other observers who had participated in previous EMBLA missions were more familiar with the view of the terrain from Aspåskjolen vista. Even seasoned observers often have difficulty orienting themselves to unfamiliar observation sites the first few nights when there are minimal orientation cues in the darkness. It can be challenging even for observers familiar with an area to detect small differences in horizontal azimuth. It can be nearly impossible to *accurately* detect small changes in vertical elevations in the dark without aid of instrumentation. Further, it is extremely challenging even for experienced observers to determine the character of distant lights in real-time observations. It has been the experience of this author that skilled observers can mistake vehicle headlights as earthlights, and vice versa. Earthlights sometime split giving the appearance of vehicle headlights. They may not be recognized as such until they display erratic movement such as ascending straight up. The definitive answer lies in an appropriate methodology where all lights (except those on well traveled known roads), regardless of observers real-time assumptions, are photographed with multiple cameras and their character determined during later analysis. If it shines, photograph it. Tape and film are inexpensive compared to lost rare opportunities.

Field research presents challenges that are not present in laboratory or theoretical research. The environment cannot be controlled, observers must react quickly to ever changing circumstances. As opposed to laboratory research, field research has an emotional component of excitement and necessity to react quickly due to the brief duration of the lights. It is physically challenging to site a camera's telephoto lens or a telescope on a glowing object during the brief duration of a light appearance. At these times, researchers may experience adrenalin surges. It is well known that cognitive function, including memory retention, declines under presence of adrenal hormones released during periods of acute reactions or stress. Observations made under these conditions are inherently error prone and precautions and redundancy must be built into experimental protocols to guard against the possibility of error or inaccurate interpretations. This author suggests an experimental protocol she has developed to help record important information that may escape observers while their attention is focused on a light.[14]

Both Teodorani and Leone have contributed some elegant work describing their observations, but it appears that neither is entirely correct in their conclusions due to inadequate data collected at the site. From an operations point of view, if Teodorani had recorded the dates, times and azimuths of his photographs he would have been less vulnerable to criticism. On the other hand, if Leone (who performed optimally given the instrumental limitations) had been able to photograph his telescopic observations, would have had a record to compare his observation to Teodorani's photograph. Had this been done, it would have been obvious the two observers were looking at two different lights. Instead, Leone assumed they were both looking at the same light, while Teodorani was aware that was not the case. It is acknowledged that looking though the telescope was not part of Leone's mission, and that he was not prepared or equipped to take photographs. To Leone's credit, he did record the approximate time and azimuth of his observation. However, all the lights, buildings, vehicles and recurring lights, clustered within the error limits of the 185 ± 5° (or less) azimuth that Leone measured. In retrospect, a magnetic compass was not accurate enough to have discerned the small difference necessary to differentiate the positions of the various lights in this situation.

It was Leone's duty to report what he saw; vehicle headlights. However, drawing conclusions about the nature of the recurring light from a single unverifiable visual observation seems premature. Instead of exploring the reason for the discrepancy between the observations, both scientists ignored each other's communications about the light each had observed. Leone asserted that Teodorani and Nobili had ignored his admonition that the light was a vehicle headlight. On the other hand, Leone also ignored Teodorani's assertion that he [Leone] had observed a vehicle shortly before the "real" recurring light appeared. They were both correct in the interpretation of their observations. Leone observed a vehicle while Teodorani observed and photographed the recurring light, or presumably its spectrum. The error occurred when Leone assumed that Teodorani had photographed the same vehicle headlights that he [Leone] had observed. Leone then applied distance, position, and spectral calculations not to his own observed vehicle headlights, but to the light in Teodorani's photograph which he had not observed but thought he did.

Leone's starting point, was the assumption they had both observed the same light, therefore Teodorani's light was vehicle headlights. Leone's analysis began with that conclusion, which precluded examination of other possibilities. Leone contributed an exquisite review of headlight luminosity and spectra as well as the spectral sensitivity of Ektachrome film. These are excellent and valuable contributions to the knowledge base, and certainly apply to vehicle headlight observations, which are always a confounding problem in earthlight research. Leone however concludes that this review applies to Teodorani's photograph and shows correlations between Teodorani's spectrum and Halogen lights but the match though statistically significant is not exact. Does this small difference leave a margin for additional interpretations?

If the spectrum of Teodorani's light indeed does match artificial light, this again raises the question whether the recurring light was a hoax, mirage, or perhaps even an error. Another possibility that might explain a spectrum similar to an artificial light is to question the spectrum itself. Did Teodorani photograph the correct spectrum? It is characteristic of the Rainbow Optics diffraction grating that the source light and resulting spectrum are widely separated and cannot be viewed at the same time through a telephoto lens. The camera must be panned horizontally away from the light in order to photograph the spectrum that appears outside of the frame of view. This can be a confusing task when there are several lights present. (the building lights, vehicle headlights and the recurring light were all close to one another). The experimenter must make an instantaneous decision which spectrum to photograph. Might it be possible that during the necessary haste to photograph the spectrum of the brief duration light, (that occurred simultaneously with the vehicle headlights), Teodorani accidentally photographed the spectrum of the vehicle headlights instead of the recurring light? Comparing photographs of the positions of the vehicle light and recurring light it is clear that they are two different lights at different locations but horizontally displaced spectra might be confusing.

Leone hypothesizes that the light was vehicle headlights on Løbergsvollen-Heggsetvollen road. The following data indicate Løbergsvollen-Heggsetvollen road may not be the best candidate to explain the lights. First, Leone's luminosity calculations do not exactly fit the model of headlights as far as Løbergsvollen-Heggsetvollen road. They are an order of magnitude too intense[4] for the calculated distance indicating the light may be closer than 10.7-11.9 km away. Additionally, there is only a ~two° difference

between the estimated azimuth of recurring light and the most visible top portion of Løbergsvollen-Heggsetvollen road. This small arc is extremely difficult to discern visually at night, but easily measurable in photographs or in the field with a Datascope.

There are several indications that support the possibility that the triangulation results may be in the correct vicinity at Skarvan hill and that the light did not occur on Løbergsvollen-Heggsetvollen road. 1) Although the triangulated position is close to the azimuth of the Løbergsvollen-Heggsetvollen road, the triangulated position of the recurring light is about 4 km closer to the Camera1 observation site, and may be a better fit with Leone's luminosity calculations. 2) There is an azimuth discrepancy measured from the Hillside location. The azimuth of the recurring light from the Hillside position was 181.2°, the azimuth from Hillside to the Løbergsvollen-Heggsetvollen road 1(top) is quite different; 185.8°, and Løbergsvollen-Heggsetvollen road 2 (lowest) is 188.9°. If the light were on Løbergsvollen-Heggsetvollen road this implies a large measurement error of 4.6° to 7.7°, unlikely for an experienced user of an instrument with 0.2-degree accuracy. 3) Figure 20 shows the recurring light apparently in front of the trees. Vehicle headlights would be unlikely to shine through the apparently dense trees. 4) The profile of the hillside near the triangulation coordinates looking northward is similar to the flipped image of Teodorani's recurring light photo (as if viewed from the other side), suggests the author was in the correct position. 5) The appearance of a light near the anticipated time also suggest the recurring light, or its' source, may have been observed. The position of the observer was 2-4 km north of Løbergsvollen-Heggsetvollen road. 6) There were only three light observations during the entire two-hour period this author was at the site; the 20:45 UT aircraft, the 20:58 UT unseen flash, and the 21:10UT unidentified light. While it would not be prudent to draw conclusions from only one sample, this observation opens up additional possibilities about the nature of the light and suggests a new location to be explored.

If the vehicle headlights Leone saw was not on Løbergsvollen-Heggsetvollen road, where they? The position of the headlights that Leone observed may be on an offshoot on the left (east) side of the main road FV576. The main road that runs through the Hessdalen Valley is obscured from the Camera1 viewpoint by small hills and gullies for much of its length. However, a section of the road and/or an offshoot is visible. The lights of buildings near a road are seen in many of the photographs. (Figures 5, 6, and 9). The August 7, 2002 videotape shows vehicle headlights appearing near and to the right of building lights. A valley resident has reviewed the photographs and believes the buildings are located at Borren where there are three small farms. (Figure 19) He confirmed there is a strong light at one of the farms that can be seen from the Aspåskjolen vista. Borren is 10.4 km from the Aspåskjolen vista at an altitude of ~720m. Borren lies at a bearing of 183.3° magnetic. That is well within Leone's original sighting of 185±5° azimuth, of the light he saw. The azimuth of the recurring light was 184.7°, only 1.4° difference from Borren. This small difference would be very difficult to discern at night with only a magnetic compass. It is quite possible therefore, that the headlights observed by Leone through his telescope *were from a vehicle traveling northward on a short private road between Borren and road FV576*.

CONCLUSIONS AND SUGGESTIONS

Empirical observations are the foundation of the scientific method and a keystone of hypothesis formation. Historically, many significant breakthroughs have been discovered through singular serendipitous observations. Although these singular spontaneous empirical observations are extremely important, the scientific method calls for using empirical observations to formulate an hypothesis for further testing, before conclusions are drawn and proposed as fact or theory. Observations must be repeated to test the hypothesis. Drawing conclusions from a single observation is premature.

The controversy over the nature of the light sighting would not have occurred if adequate documentation had been done by each of the two observers. Instead, conclusions were drawn from a sighting of a vehicle of unknown position, not photographically documented to provide verification of the background details (location) of the visual observation. Both researchers correctly drew conflicting conclusions, and continued to publish these conclusions supported by complex computations based on their individual observations. Teodorani calculated luminosity of the light. Teodorani's calculations were evidently based on a preliminary unpublished distance figure of 9 km that this author had communicated to him from her first

attempt at triangulation calculations using low resolution Garmin Worldmap. This distance estimate has been revised to 8.3 km (5.2 miles) this paper.

The debate whether the recurring light is headlights on Løbergsvollen-Heggsetvollen road can be solved by physical means. The visible section of Løbergsvollen-Heggsetvollen road from Camera1, as measured on the Garmin Trondheim map spans the azimuth of 186.8°-188.2° magnetic. Teodorani's measurement of the azimuth of the light using the Datascope during triangulation was very close, 184.7. It is possible that the separation falls within the combined researcher, instrument, and calculation errors. It is suggested that the definitive determination whether the location of the recurring light is on the Løbergsvollen-Heggsetvollen road is to go there. This author developed a protocol to identify vehicle headlights on a Chinati mountain road in Marfa Texas that can easily be applied to Hessdalen. A team member drove to the section of the road in question with an agreement to arrive at a certain location (the summit) at a certain time and turn the vehicle headlights off and on for identification. (Mobile phones were not available to the team at that time, and the distance 25 miles, was too far for radio communication.) Similarly, sending a team member to the high point of Løbergsvollen-Heggsetvollen road in mobile phone contact with observers at Aspåskjolen would show where, how well, and how long vehicle headlights could be seen. The car headlights can be blinked several times for positive identification and the exact azimuth can measured. The driver may also carry a GPS set on tracking mode. The driver can take a waypoint at the beginning of his journey. The recorded track will be time stamped so the exact whereabouts of the vehicle can be determined. Once the car begins descending at a known speed, observers at Aspåskjolen may photograph and videotape the descent of the car along the road. The duration that the car is visible on the road and the blinking caused by foliage can be compared to photos and videos of the recurring light. Use of this empirical technique will put the location of the headlight vs. recurring light issue to rest.

One of the factors that contributed to the controversy was the need for better equipment. While it is cost effective to do preliminary research with inexpensive equipment to determine if an area warrants further study, data collected in this manner is often of low resolution or poor quality. These data provide valuable exploratory information, but are generally inadequate for confirmation of hypotheses. If it has been determined that an area that warrants study, then it becomes more cost effective to invest in higher resolution instrumentation and more accurate data collecting devices. Considering the expense of an expedition; travel, sustenance, and lodging and time to reach a remote site, it is a good investment to be prepared with the best affordable equipment so that data will be high resolution, reliable, and yield good results. Otherwise, if data are of poor quality, there is no savings. The results may not justify the cost of the expedition.

In order to determine the exact position of a light that will enable accurate luminosity calculations, accurate instrumentation such as a precision electronic compass is necessary. Instruments such as the KVH Datascope have high accuracy and respond faster than a magnetic compass. The Datascope also has its own illumination, a benefit to nighttime observations. If a Datascope had been used to measure the azimuth of Leone's vehicle headlights instead of a magnetic compass, he would have been able to pinpoint the location of the headlights he observed. Using the magnetic compass introduced up to 5° error in the measurement.

Additionally, having enough researchers to participate in triangulation teams at different locations in the Hessdalen Valley can give definitive distance data. Strand and Hauge accomplish triangulations during science camps with student observers on the mountains on either side, overlooking the Hessdalen Valley, Mts. Finnsåhøgda, and Rogne. It is suggested that international teams also station observers elsewhere in the valley rather than all observers gathering at Aspåskjolen vista. Though desirable, it may not be necessary to station observers on Finnsåhøgda and Rogne, which require long hikes carrying instrumentation. An observer at the more easily reached AMS (Figure 8) for instance, may be of great value.

Better coordination and communication among International research teams would benefit Hessdalen Phenomenon research. Another factor that would aid the research is to coordinate timing of equipment and clocks among research teams. To understand the physics of the Hessdalen Phenomenon, it is important to know whether geophysical/environmental/experimental events occurred before, during, or after a light sighting. By setting instruments and computers accurately to a single clock standardized in UTC, data can

be accurately compared among researchers and new knowledge gained that would otherwise be unavailable. Additionally, better communication and understanding of each other's experiments would enable researchers to note observations that might be relevant to another's experiment which otherwise might be overlooked. In addition, this researcher has found that having a team member whose *only* job is to record events and take notes is a valuable asset.

Leading edge research such as field research investigating the Hessdalen Phenomenon is a learning experience as research protocols and methodologies are developed. Oversights and errors are inherent in the process. Mistakes can be valuable teachers that increase awareness and help to define the next steps. The only unacceptable blunder is to not pay attention, or purposely ignore these experiences so that the mistake is repeated another time. The light controversy cries out loudly for the necessity of improved documentation, coordination, and collaboration between members of all research teams. Time and effort spent speculating on unknowns that could have been documented such as times and azimuths of photographs, and photos to back up visual observations would have saved considerable energy speculating about data that should have been recorded. Lacking adequate documentation of the light occurrences, erroneous assumptions were made that both researchers observed the same light, which the video recording shows they were not. Both Teodorani and Leone have called for better documentation of research data. Teodorani has correctly called for photographic validation of visual observations, and Leone has correctly called for better temporal and location documentation of photographs. Indeed, better documentation and coordination is needed to elucidate the nature of the Hessdalen lights. It is hoped this example reinforces the necessity for adequate, detailed, and accurate documentation in Hessdalen field research.

In conclusion, Teodorani and Leone were both correct. The video record shows that Teodorani and Leone observed two different lights that appeared within seconds of each other and both were correct in their assumptions of what they had observed; a possible Hessdalen light, and vehicle headlights. Both authors agree the spectrum of the recurring light may have elements of an artificial light. Additional data from triangulation suggests new possibilities for the location and possibly nature of the recurring light, or at least the possibility that Hessdalen Phenomenon may occur within a few km of the horse pasture. The nature of Teodorani's recurring light remains unsolved. The primary question is whether it was indeed vehicle headlights. If the position of headlights on Løbergsvollen-Heggsetvollen road can be physically verified and shown to coincide with the photographic position of the recurring light, then the mystery is solved. If known headlights do not correspond to the light's position then further research is needed to characterize the nature and location of the recurring light. It is not known however, if the recurring light continues at this date.

The goal of this paper has been to demonstrate there may be additional possibilities for the nature of the recurring light. Artificial possibilities include vehicle headlights, a prank, or reflections of vehicles or even airplanes from a mirage. If a mirage is found to be the explanation, similar phenomenon may exist in other analogous earthlight areas for instance Trout Lake Washington, where a river runs along a narrow valley surrounded by high mountains. Trout Lake is also near airports and under jetways. Such an explanation does not invalidate the existence of the phenomenon, but it does imply that the phenomenon may be much rarer than thought. If the light is a valid Hessdalen phenomenon, and it still exists, additional areas may warrant investigation. Triangulation should be a high priority. The vicinity between the horse pasture and school may be one of several productive areas to investigate.

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ADDENDUM

This paper was written while this author was on a prolonged research expedition in Arizona away from IEA headquarters. Some references and details may have been overlooked because these data were located in California and not available at the time of this writing. In order to meet the deadline for the ICHP workshop submission, only the video recording and triangulation analysis will be published at this time. The analysis of radiation and VLF data taken at the "hilltop" site and elsewhere will be presented in later publications. The analysis presented in this paper is this author's initial effort to describe the Hessdalen light activity. There are 15+ hours of videotapes to examine that require at least 4-6 hours each to thoroughly investigate. These unviewed tapes contain data that will increase knowledge of this light. It is possible that the data may strengthen conclusions, or, the additional data may change some conclusions of this paper.

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