Hessdalen
Database Analysis

By Torbjørn Aamodt

Oslo, Norway 26.11.2017 - T.Aamodt
This Analysis

Background information behind this analysis are taken from Hessdalen.org

Theories and study sources are listed in Appendix A

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This is Hessdalen lights

Hessdalen is a small valley in the central part of Norway. At the end of 1981 through 1984, residents of the Valley became concerned and alarmed about strange, unexplained lights that appeared at many locations throughout the Valley. Hundreds of lights were observed. At the peak of activity there were about 20 reports a week.

Lights are still being observed in the Hessdalen Valley, but their frequency has decreased. An automatic measurement station was put up in Hessdalen in August 1998. In 2017, lights are still being reported.

So what are the lights?

Many thinks the lights are PLASMA. The fourth state of matter. The three common states are: Solids, Liquids and gas. When continuous very high pressure and temperature is added to gas, the positive atoms and the electrons will separate from being bounded to each other and exist as free particles in a gaseous cloud. Being free electrons, the plasma will easily lead electric charges, and light up. Lightnings is a good example of Plasma state.
Hessdalen database

Database goal

The primary goal of the database is to capture the whole picture that all observations create, and not to go into detail in each single observation. With this approach, the data strengthen itself by giving clearer patterns.

Data Source

All the data used in the database has its origin from the www.Hessdalen.org webpage where many observations through the years have been reported. All observations that have specified location in some degree have been used.

Database assumptions

The information located in each observation report can be very good, but also minimal, when it comes to location of the observed light/object. Also local naming, time, shape, colors, path and distance can give uncertainties to defining the observation in the database. The database use Certainty and Uncertainty on observations with coordinates. Certain location can still have some uncertainty to it, but are placed in the correct area. An example could be a light observed above Rognefjell. Here you can place the observation within some km², giving some Uncertainty, but Certainty of the area.
Database columns

The columns in the database are created based on the content of the reports, but also for further use in other workflows or analysis. UTM 32 N coordinates are given. Weather and temperature are rarely given in the reports. This information is therefore retrieved from the weather station at Røros close by where it is possible to search weather/temperature by date, going back several years.

Object form and shape are sometimes given in creative wording, and therefore, the creative words are given a more suitable shape definition.

Observer column is included to link the observation. In some reports, the observer has been affected by the object, mentally or physically. Mostly mentally – emotional. One case with a watch stopping is included. Also a case where the person became paralyzed is included (the Portal-case).

Database list:

- Observation number
- Observation route
- UTM coordinate
- Excel map coordinate
- Time
- Location of observation
- Certainty
- Weather
- Temperature
- Object form/shape
- Subform
- Colours
- Observer(s)
- Physical/Mentally affected
- Comments
At the start of making this database, I used a map overlooking Hessdalen, and placed this in a 100 X by 100 Y coordinate system. Simple. Today, a software where you can plot universal coordinates would be better. But it was sufficient for my task (UTM coordinates are included in the database).

Going through all reported observations, I found 130 observations that could give a nearly exact location on the map. Other observations are disregarded. Using the 130 observation points raging from 1996 to 2015 (Year 2007, 2008 and 2009 are missing), I created a map pinpointing each observation. Also year 1976 and 1983 are included. This gives a good picture of where the observations are likely to occur. But this is also the part of the Hessdalen where most people are, and also this «dominant area» are close to Ålen. So having most observation here can be influenced by this fact.
Database Observed routes (Database version 2)

Route database has now been included. In the same coordinate system type as All observations, 100 X by 100 Y coordinate system. Each arrow has its own cordinates, and observer position has its own coordinate. Colors are given to give certainty to routes and observer location (see page 6 for definition). Black is quite certain, while blue color could deviate in X or Y direction, but has quite certain origin and end. Green color is very uncertain. The arrow describes the path of the observation, described in the report from the observer. Not all observations have the details to make this, only the most certain observations are put here. Ex. Observations that has a direction to it, but not the origin are not included. Difficult to set an arrow without the origin (where the observer first saw the observation).
Hessdalen database

Observation certainty

**Certain observation, black color:**

Observations that state clear location like «...over the top of Finnsåhøgda» or «...went over the church» are certain observation where I can place the observation quite correctly within few meters, and give a route of the light that can be plotted. 99 of the 130 observations are certain and can give an exact point. Of the 99, only 47 can give a certain path of the observation.

**Observation, blue color:**

These are observations that either has a clear point of origin or end. Either we do not know from where they came, but clear point where it ended, or we have a clear point from from where they came but not ended. It could be like «...Two lights in north, they came together when going over Finnsåhøgda».

**Uncertain observation, green color:**

This is very uncertain. «The light was see in the direction of...». In these cases you have a direction, but not where, distance or height in that direction. These observations are not included on the map.
Red «fat» lines marking typical paths for several lights. These red lines will give an overall picture of how the lights generally move in the Hessdalen valley. Red lines are called «highways» in the report.

Circles: Magnetic anomaly from the anomaly map.

Yellow circles with cross: Copper mines.
Hessdalen database

Database – Main routes

This picture is the most powerful of them all and give a good picture of the main paths – highways – of the lights and objects. These «highways» are then used further in the analysis. The black dotted lines on the end of the red lines (on the right picture) are speculations of origin or end. Whether these are typical routes of the lights and objects that are seen in Hessdalen can be discussed, but this is only a visual conclusion created from all path observations, an overall picture.

Keeping the Hessdalen «highways» (red lines) will make it easier to use this information combined with other data.

Again here I use simple approaches, by overlapping data on different data maps. Ex. Aeromagnetic anomalies from NGU.
Here is where the surprise comes. In the magnetic anomaly map (downloaded from NGU.no) the light/object «highways» are matching impressively with the magnetic anomalies, indicating that the observations are travelling from one anomaly to another.

This also explains why most observations are in the north of Hessdalen, because the anomalies are mainly in this area.

Earlier in the study it was unclear why some lights were travelling across Ålen to the other side of the valley, outside Hessdalen. But there is a big and strong magnetic anomaly at Litj mountain which could explain that connection.
Looking further south than Hessdalen we find a strong anomaly north of Røros. Some observations are explained to come from south of Hessdalen and also going south. A connection to the big anomaly north of Røros could explain that connection.

Magnetic anomaly maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no/side/aeromagnetiske-anomalikart
Database – Temperature vs Observation

Analyse to find if there is a typical temperature or temperature range which has to be in place to fulfill a criteria for the light phenomena to occur – the conclusion is: Temperature do not have a triggering effect as a general to seeing Hessdalen lights. Observations are seen on the whole temperature scale. The average temperature from all 130 observations is 0.06 degC. Temperatures are however mainly from the Røros weather station, which is the nearest weather station.

Later in the report, the temperature will be linked to shapes to see if there is any trend. Temperatures in the Database which are blue are all from the station in Røros (nearest). This means that the temperature could be different in Hessdalen, but assume it is close to the Røros temperatures.
Database – Observations per month

These are all the observations in the database sorted per month. It looks like spring and summer has a downside, but then in August there is general boost in observations. Then autumn and winter tend to have the same possibilities for observations. During the last 20 years, October to March have summed up just above 10 observations per month, except January which have a boost in observations.
Number of reported observations per year is decreasing. Whether this reflects a decrease in Hessdalen «lights» in general is speculation, but there is a clear trend. So far in 2015 there has been 4 reported observations (one not included in Database because of insufficient info).
Analysis - Occurance

Database – Observation time curve

Figure above show cumulative observations from 1995 to 2015, giving a slope and average observations per time unit.

Setting a slope curve to the graph, one can see quite stable reported observations per year. From 1996 to 2000 there were average 12 reported observations per year. From 2001 to 2004 there were reported in average 7.5 observations per year. Then from 2010 to 2015 there were reported in average 5 observations per year. Decreasing trend.
Database – Triangular observations

Colors in the Observations database show the different colors of the light(s) that was observed during the observation of the light(s).

Filtering out all observations that were defined triangular. These observations have reported certain colors. Also looking at the temperature at these given observations. Triangular Obs. seem to occur in cooler temperature. From 0 and colder. Most Triangular shaped observations has been in the warmer colors. Basically in the orange color area with neighbouring red and yellow.

On the weather side, most observations occur during cloudy or partly cloudy days. Triangle observations occur only in cloudy weather.
Analysis - Shape

Database – Cigar observations

Filtering out all observations that were defined cigar shaped.

There are reported 7 cigar shaped objects. Three of them have been described identical: Cigar shape, white, but dark in the middle. Two of them in 2002, and one in 2010. All three in 14-18 degC range. July to September. Cloudy. Two of them over Rognefjellet (Rogne mountain).
Database – Objects with Hauling movement

Filtering out all observations that were defined with hauling movement.

Some objects move in a jerky way, they move – haul – move – haul – etc. This particular movement was mostly seen on objects observed in the 90’s (96-98). Except one in 2005. Mostly yellow to red color.
Database – Light observations: Flashing

Filtering out all observations that were defined flashing lights.

The most common observation is the «Light», sometimes it is observed in a distance, so it is hard to tell color of light or shape. It becomes «Light». Other times the object is very bright so it is hard to see the shape. Mostly it is a white color. In the Database, all (except one) of the the light that was described as flashing, were observed on the west side of Hessdalen.
Analysis - Shape

Temperature at the given observation

<table>
<thead>
<tr>
<th>Weather</th>
<th>Temperature</th>
<th>Object form described</th>
<th>SubForm more details</th>
<th>Colour</th>
</tr>
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<tbody>
<tr>
<td>Foggy</td>
<td>0</td>
<td>Sphere/Orb</td>
<td>Light from sphere</td>
<td></td>
</tr>
<tr>
<td>Partly cloudy</td>
<td>-6</td>
<td>Sphere/Orb</td>
<td>Light treads under</td>
<td></td>
</tr>
<tr>
<td>Clear sky</td>
<td>10</td>
<td>Sphere/Orb</td>
<td>Blue and gull side</td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>3</td>
<td>Sphere/Orb</td>
<td>Yellow with red</td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>-3</td>
<td>Sphere/Orb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear sky</td>
<td>-20</td>
<td>Sphere/Orb</td>
<td>Size as the moon</td>
<td></td>
</tr>
<tr>
<td>Clear sky</td>
<td>-17</td>
<td>Sphere/Orb</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>-1</td>
<td>Sphere/Orb</td>
<td>Moved arc shaped</td>
<td></td>
</tr>
<tr>
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<td>20</td>
<td>Sphere/Orb</td>
<td>Stood still</td>
<td></td>
</tr>
<tr>
<td>Partly cloudy</td>
<td>5</td>
<td>Sphere/Orb</td>
<td>Moved arc shaped</td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>-20</td>
<td>Sphere/Orb</td>
<td>Tail, fast</td>
<td></td>
</tr>
<tr>
<td>Clear sky</td>
<td>8</td>
<td>Sphere/Orb</td>
<td>Shrank, unshrank</td>
<td></td>
</tr>
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<td>12</td>
<td>Sphere/Orb</td>
<td>Rotating</td>
<td></td>
</tr>
<tr>
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<td>-16</td>
<td>Sphere/Orb</td>
<td>Went vertical up</td>
<td></td>
</tr>
<tr>
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<td>-9</td>
<td>Sphere/Orb</td>
<td>Rotating</td>
<td></td>
</tr>
<tr>
<td>No weather data</td>
<td>9</td>
<td>Sphere/Orb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear sky</td>
<td>-16</td>
<td>Sphere/Orb</td>
<td>Christmas tree</td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>8</td>
<td>Sphere/Orb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>-12</td>
<td>Sphere/Orb</td>
<td>Tail</td>
<td></td>
</tr>
<tr>
<td>Partly cloudy</td>
<td>-10</td>
<td>Sphere/Orb</td>
<td>Rotating</td>
<td></td>
</tr>
<tr>
<td>Partly cloudy</td>
<td>-21</td>
<td>Sphere/Orb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Database – Sphere/Orb observations

Filtering out all observations that were defined as Orbs/Sphere.

Sphere/Orb observations has no trend or pattern. They are seen in many different conditions and colors, but normally they are multi-colored.
Shape vs date

- Triangular
- Cigar
- Flashing
- Sphere/Orb

Date of Observation

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Hessdalen Rock

Basalt:
- Felspat (Plagioklas): Kalium K+, Natrium Na+ og Kalsium Ca+
- Pyroksen (Augitt): Magnesium Mg2+, Jern Fe3+, Kalsium K+, Natrium Na+, Litium Li+

Gabbro:
- Felspat (Plagioklas): Kalium K+, Natrium Na+ og Kalsium Ca+
- Pyroksen (Augitt): Magnesium Mg2+, Jern Fe3+, Kalsium K+, Natrium Na+, Litium Li+
- Amfibol (Hornblende): Ca2+, Fe3+, Mg2+, Al, Si
- Olivin: Mg2+, Fe3+, Si2-O2

Glimmer: Kalium K+, Natrium Na+ og Kalsium Ca+
In the National Geographic article, Freund describe light being generated by crystals from Gabbro and Basalt being crushed just before an earthquake. In Hessdalen there are not many earthquakes documented from 1995 to 2015. Picture show most seismic activity on the coast. But the Basalt – Gabbro theory cannot be disregarded, since this is dominating a lot of the valley rock.
Observations vs. rock

Picture: Rock types above observations with path.
Database – Aeromagnetic Anomaly map

The original map used

Magnetic anomaly maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no/side/aeromagnetiske-anomalikart
Database – Gravimetric residual map

Not used

Gravimetric maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no
Light theories

• The Battery theory

• The EQL theory (EarthQuake Light)

• Lightning Balls formed of silicon, iron and calcium and in addition an element called scandium.

• Massive electric charge and that Static electricity on the mountains were whipped up by strong winds.

• Radioactivity and the decay of radon in the atmosphere. Lights are made from ‘dusty plasma’ containing ionized dust particles. Search for the presence of radon in the valley to test their idea that bubbles of the gas could erupt from the ground, pick up dust and enter the air as a glowing orb.
Battery theory

Theories about Sulphur gas being created and energized up in humid air by reaction between iron and zinc on one side of the valley and copper on the other side, with the river in the middle as an electrolyte (“The battery theory” by Jader Monari of the Institute of Radio Astronomy in Medicina, Italy

Dr Monari believes that bubbles of ionised gas are created when sulphurous fumes from the River Hesja react with the humid air of the valley. The geology also forms electromagnetic field lines in the valley, which could explain why the orbs of light move around
The Earthquake Light theory

EQL Theory - mainly seen before earthquakes

When nature stresses certain rocks, electric charges are activated, as if you switched on a battery in the Earth's crust," he says. The types of rocks that are particularly given to the phenomenon are basalts and gabbros, which have tiny defects in their crystals. When a seismic wave hits, electrical charges in the rocks may be released. In some areas, basalts and gabbros are present in vertical structures called dikes, which formed as magma cooled along vertical faults and may reach as deep as 60 miles (97 kilometers) underground. These dikes may funnel electrical charges along, the scientists wrote.

Friedemann Freund, an adjunct professor of physics at San Jose State University and a senior researcher at NASA's Ames Research Center says “sometimes earthquake lights can take many different shapes, forms, and colors”.

See link to National Geographics:

EQL theory paper

Article by Freund, Thériault, Friedemann and Derr (text copied)
"Prevalence of Earthquake Lights Associated with Rift Environments"

**Generation of the Lights:**
Our preferred model for the generation and propagation of earth currents and ensuing EQL formation is based on work by Freund *et al.* (1994, 2006, 2007, 2009), Freund (2002, 2007, 2010), and Freund and Pilorz (2012) that describes experiments stressing igneous rocks (quartz-bearing and quartz-free), limestone, marble, and others. These experiments demonstrate that electronic charge carriers are activated in the high-grade metamorphic and igneous rocks (in particular mafic and ultramafic rocks) when subjected to deviatoric stresses, turning them into semiconductors. The charge carriers derive from pre-existing defects in the matrix of the minerals, electrically inactive in their dormant state as peroxy bonds or links (i.e., $\text{O}_3\text{Si/0O/SiO}_3$), and are introduced into the matrix of minerals during cooling at high temperatures when two oxygen anions convert from their normal valence state 2$^-$ to the valence state 1$^-$, that is, $\text{O}^2$- to $\text{O}^-$. When subjected to stress, mineral grains slide along grain boundaries or dislocations sweep through, causing peroxy links to break. The $\text{O}^-$ states thus formed represent defect electrons in the oxygen anion sublattice, which turn into highly mobile electronic charge carriers, referred to as positive holes or *pholes*. These previously unrecognized charge carriers have the remarkable ability to flow out of the stressed rock volume and to move away from where they have been generated.

Invariably, several types of pholes are generated during stressing of rocks, characterized by different lifetimes ranging from less than a second to longer than days. As the long-lived pholes diffuse outward, they can reach the Earth’s surface. There, they form surface/subsurface charge layers, which cause locally high electric fields, often strong enough to ionize the air and even trigger corona discharges. The corona discharges are associated with the emission of visible light close to the ground and with the formation of ozone.
There is yet another aspect of the same basic process of stress activation of pholes: the highest charge carrier densities can be achieved if stresses increase so rapidly that even short-lived pholes do not have the time to recombine. This implies that, if tectonic stresses deep in the Earth’s crust increase very rapidly in any given rock volume, the number densities of pholes can reach a critical value beyond which the electronic wave functions of both the pholes and the coactivated electrons begin to overlap. This is expected to create a plasma-like state, that is, a volume of rock with a very high mobile-charge density and high conductivity. It has been suggested (St-Laurent et al., 2006) that, inside the Earth’s crust, this plasma state will become unstable and will rapidly expand outward. When such an intense charge state reaches the Earth’s surface and crosses the ground–air interface, it is expected to cause a dielectric breakdown of the air and, hence, an outburst of light. This process is suspected to be responsible for flashes of light coming out of the ground and expanding to considerable heights at the time when seismic waves from a large earthquake pass by. Those waves, especially S waves, subject the rocks to very rapid shear forces, causing mineral grains to move relative to each other, possibly even generating dislocation movements within the grains. This activates peroxy defects and creates the capability to momentarily generate high concentrations of pholes (Heraud and Lira, 2011). Igneous rocks, in particular mafic igneous rocks, have much higher concentrations of pre-existing peroxy defects than sedimentary rocks. Hence, the processes that seem to be responsible for the generation of EQL can be expected to occur preferentially in those rocks, providing a possible explanation for the often reported close association of EQL with mafic dikes and intrusions (e.g., Saguenay, Ebingen, and Pisco Peru earthquakes).

The positive hole theory can account not only for EQL but also for other pre-earthquake phenomena, such as:

- Air ionization at the ground-to-air interface.
- Changes in the electrical conductivity of the soil.
- Geo-electric and geomagnetic anomalies in the Earth’s crust.
- Ionospheric perturbations.
- Ultralow and extremely low frequency (ULF/ELF) and radio frequency (RF) emissions.
- Anomalous infrared emissions from around a future epicentral area.
- Anomalous fog/haze/cloud formation and unusual animal behavior (Derr et al., 2011).
Data Synthesis

Magnitude of Earthquakes Associated with Luminosities

EQL are generated in association with earthquakes over a wide range of magnitude from 3.6 to 9.5. It can hence be concluded that EQL may occur regardless of the earthquake magnitude, although the majority of the listed cases (i.e., 80%) were observed for events with magnitudes greater than 5.0. As already noted by Hedervari and Noszticzius (1985), our compilation also indicates that the maximum distance at which EQL are observed tends to increase with the magnitude of the event. For example, EQL have been reported for distances up to 600 km from the epicenter in the case of the New Madrid earthquake, which had a magnitude of about 8.

Distance between EQL and Earthquake Epicenter

At rare occasions, EQL have been seen as far as 600 km from any given epicenter, as our compiled list of earthquakes shows (e.g., New Madrid earthquake). More typically, EQL have been observed at distances not more than about 300 km from an epicenter. Pre-earthquake luminosities were generally seen closer to the epicenter relative to coseismic luminosities, a few at 200 km but the majority of them occurring at 150 km or less.

It is important to note that when EQL were seen far away from the epicenter, as some reports for the New Madrid earthquake suggest, they seem to be always time correlated with the passing of the seismic waves. The most definite evidence comes from Lima, Peru, in which the passage of the seismic wavetrain associated with the 2007 $M_w$ 8.0 Pisco earthquake (coming from a distance of 150 km) was recorded by a seismometer on the PUCP university campus, while the EQL were recorded simultaneously by automated surveillance cameras (Heraud and Lira, 2011). In this case, it was clear that the outbursts of light did not occur during the passage of the compressional ($P$) waves but during the passage of the shear ($S$) waves. This implies a direct coupling between the crustal rocks and the very rapid, high-amplitude change in shear stress caused by the $S$ wavetrains (Gharibi et al., 2003).
Map of the Saguenay-Lake St. Jean area showing the location of the earthquakes and associated earthquake lights (EQL) that occurred within or in proximity to the Saguenay Graben during the seismic sequence of November 1988 to January 1989.

Map of the Ebingen earthquake area showing the distribution of 49 reported EQL. Note that a large number of luminosities were observed in the vicinity of the Hohenzollern and Rhine grabens. EQL were seen within a radius of 110 km from the Ebingen earthquake.
Map of the western part of the Abruzzo region of Italy, in the vicinity of L’Aquila, showing the location of various types of earthquake lights (EQL) observed prior to and during the L’Aquila earthquake of April 2009.
Simplified model of phole propagation within an intraplate rift setting pertaining to the Saguenay Graben, Quebec, Canada. The vertical scale (topographic relief) is exaggerated for clarity. +, positive holes; e’, electrons.

Simplified model of phole propagation within an interplate, orogenic tectonic setting in a subduction zone environment (i.e., Andean-type).
Hessdalen lights vs EQL

Theory and data
The very essential part of generating lights from rock, is ex. the need for mafic rock. Common mafic rock is basalt and gabbro. Hessdalen has both. When subjected to stress, mineral grains in Gabbro and Basalt slide along grain boundaries, causing peroxyl links to break, which (in short) turn into highly mobile electronic charge carriers, referred to as positive holes or pholes. If these pholes are overlapping, increasing in density, they can generate the plasma state. If plasma surface, it can generate dielectric breakdown of the air and generate spherical lights.

We have two situations to get stress in these rocks. Fault stresses and induced stress from earthquakes.

In public webpage www.jordskjelv.no you can view all earthquakes happened in Norway and around, from 1998 until today. Since EQL (EarthQuake Lights) are more common in areas with stronger magnitude earthquakes (normally magnitude 5 or more), the assumption that Hessdalen lights could be EQL, is not strong. The theory is however interesting and is worth checking out.

Earthquakes in Norway have a more common magnitude between 2 and 3, and not above 5 which have been found to dominate the appearance of EQL (80% of EQL appear with earthquakes above 5 in magnitude). EQL’s are said to appear before, during and after an Earthquake. Database from www.jordskjelv.no was checked with the Hessdalen lights dates and matches can be seen in Table EQL.1 and Figure EQL.1.

Another common occurrence is that EQL normally happen within 150 km of the Earthquake, but have been assumed happening 600 km away, but then after a high magnitude earthquake (M=8). High magnitude earthquakes are not the case for Hessdalen, and since most earthquake epicenters in Norway are between 300 km and 400 km away from Hessdalen, the EQL theory for Hessdalen is found to be - not a good match! See Figure EQL.2
Earthquakes in North Europe

Figure EQL.1
Earthquakes in the same period (± 1 day) as Hessdalen observation

<table>
<thead>
<tr>
<th>Number</th>
<th>Observation</th>
<th>Origin Time</th>
<th>Lati</th>
<th>Long</th>
<th>Depth</th>
<th>Magnitude</th>
<th>Area</th>
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<td>06.09.2014 18:56</td>
<td>60.13</td>
<td>6.562</td>
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<td>2.91</td>
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Table EQL.1  NS = Norwegian Sea (not in map), NN = Northern Norway (not in map), X = Not found, Number = In map

T.Aamodt
There are many earthquakes at the same time as the Hessdalen observations, but it is hard to conclude if there is any connection between them. The earthquake magnitude and distance does not match the EQL observations elsewhere.
Lightning database

Lightnings from 2001 to 2014 over Hessdalen. Data from Sintef.

Lightning data can be bought from Sintef (website in Norwegian): [http://www.sintef.no/sintef-energi/produkter-og-tjenester](http://www.sintef.no/sintef-energi/produkter-og-tjenester)
First, let's look at the energy that one lightning can bring down to the ground. A Cloud-to-Ground (CG) lightning.

According to Williams, E R, “The Electrification of Thunderstorms”, a typical lightning has a voltage of several hundred million volts. Lightning carries $10^{20}$ electrons in a fraction of a second as the process develops a peak current of 10 kA. Current and voltage multiplied gives us Effect. If peak flow is 10 kiloamps and voltage 500 million volts, then we get that a lightning strike has an effect of 5000 MW:

$$ P = I \times V = 10 \text{kA} \times 500\,000 \text{kV} = 5\,000\,000 \text{kW} = 5000 \text{MW} $$

It sounds powerful, but if we take into account the timing of it all, we can see quickly that this does not correspond to much energy. If we assume that it lasts 30 microseconds, i.e., 30 millions of a second ($30/1\,000\,000 \text{s}$), it gives us the following amount of energy:

$$ E = P \times \text{time} = 5000 \text{MW} \times 30/1\,000\,000 \text{s} = 0.15 \text{MJ} = 150\,000 \text{J} $$

150,000 joules is equal to 41.7 Wh.

Conclusion: a **10 kA lightning can power a 40W light bulb for one hour**.

This being a normal negative charged lightning (-kA), a positive charged lightning (+kA) are normally 6-10 times stronger. ([https://en.wikipedia.org/wiki/Lightning](https://en.wikipedia.org/wiki/Lightning))

Following pages will present if there is a pattern to the lightning's that hit Hessdalen.
Question is: «Where does the energy of the Hessdalen lights come from?».

There is the «Car-battery-theory» that is the resent theory, I introduce here Lightning as one theory. Now, a «Lightning + Car-Battery» theory could be feasible. How the lightning then would trigger the lights or maybe be «stored» in the ground («battery») for later occurance is another question, which I cannot answer. But a lightning database from 2001 to 2014 for Hessdalen has been aquired from Sintef and a database has been created to be used together with the observation database, which in combination can give interesting findings. Findings that are including and excluding for lightning to have a meaning in Hessdalen will be presented.
Positive and Negative Lightning

As more and more positive charge builds in the upper part of the storm and on the ground beneath the storm, more and more negative charge builds in the lower part of the cloud. When you have sufficient electrical potential, a lightning strike occurs and electrons flow. These are examples of negative lightning because electrons flow towards the positive charge.

There is another type of lightning that is far more powerful, one in which positive charge flows instead of electrons. However, instead of discharging with the negative charge at the base of the cloud, it travels outside the cloud and strikes the ground where there’s a pool of negative charge. They tend to be about 5 times more powerful and hotter than a negative strike, last about 10 times longer, strike several miles away from the storm and produce huge amounts of ELF and VLF radio waves. So instead of power up a lightbulb (40W) for 1 hour, it could power up something with 2000W for 1 hour. And that’s energy!! Positive lightnings are also said to be main cause of sprites and elves (light phenomena above clouds).

Reference:
http://www.weatherimagery.com/blog/positive-negative-lightning/
Lightning database

Tables show observations as blue color and days with lightning in the Hessdalen Area as orange color.

Looking at the lightning data from year 2001 to 2014, there is no clear pattern or connection between lightnings in Hessdalen and the observations.

Most lightnings happen in the rain season, July-Agust.
In some years there are no observations in the July-august when the lightnings are occuring the most, but straight after in the following months.

However, there are also observations in the winter months when lightnings have not been occuring for a while.

It can not be stated that lightnings has any effect on the occurance of Hessdalen observations.
Lightning database from 2010 to 2014 have marked Cloud-Cloud lightnings that can be taken out. This leaves the Cloud-to-Ground lightnings that are the most interesting lightnings for Hessdalen data analysis. If we take the number of CS-lightnings vs. Observations from the database in the same year, we get above trend. The less lightnings, the more observations. Specially, the less pos lightnings, the more observations.

This is opposite of what I was expecting. This is just an observation of the data. Difficult to prove, but I present it here anyway. Hessdalen lights are observed by people that normally tend to stay indoors when rain and lightning occur. Thats why we almost never have observations in bad weather.
Lightning database

Lightnings all Cloud-to-Ground from 2011 to 2014 over Hessdalen. Lightning data from Sintef.

All lightnings from Cloud-to-Ground (CG) from 2011 to 2014 displayed here. In 2011 Sintef replaced lightning tracker system to new and better ones. The new system could differ from Cloud-to-Ground and Cloud-to-Cloud lightnings. This is why I use only lightnings from 2011 to 2014 here.

Result of plotting all Cloud-to-Ground lightnings:
Anomalies on the west side of Hessdalen do not have lightning hits inside the anomaly area (yellow color). There is a denser lightning hit area inside the valley, and to the east side. Considering wind direction, during 5 years there is still significant increased lightning hits in the blue circle (Rogne Mountain).
Even if a lot of the lightning hit the tip of Rogne Mountain where highest point is 917 meter, this is by far the highest point in the area, both Finnsåhøgda on the west side and Stordalshøgda south of Rogne Mountain is higher.
Lightning database

Lightnings all Cloud-to-Ground from 2011 to 2014 over Hessdalen.
Lightning data from Sintef.

**Blue circle:**
Denser accumulation of lightnings

**Yellow circle:**
No lightning hits inside anomaly

Same lightnings as previous page.
Putting the map together with the lightnings and the anomalies, we clearly see that most Cloud-to-Ground lightnings hit the eastern part of Hessdalen rather than the west (inside blue circle).
If this could be explained by the theory that the eastern part of Hessdalen has a different charge than the western part is not for me to say, but there is clearly a difference on the map.
Lightning database

Lightnings with –kA (negative) from 2005 to 2014 over Hessdalen.
Lightning data from Sintef.

Negative charged lightnings are the most common lightning. Here lightnings the last 10 years. In Hessdalen they hit quite random. No lightning hit inside an anomaly around Hessdalen, except the two with red color (outside Hessdalen). How the lightnings hit inside and outside the anomalies could be coincidence. Rogne mountain seem to have a cluster of hits (blue circle).
Lightning database

Lightnings with +kA (positive) from 2005 to 2014 over Hessdalen.
Lightning data from Sintef.

**Blue circle:**
Denser accumulation of lightnings

**Yellow circle:**
No lightning hits inside anomaly

Positive charged lightnings are not happening as frequent as the negative charged lightnings. Here no lightnings have hit inside the magnetic anomalies. The positive lightnings are hitting more frequent inside the Hessdalen valley than on the mountain on each side of the Hessdalen valley (blue circle). Also the northern tip of Rogne mountain has more hits.
Hessdalen Light in Google Map?

Bright triple round lights found here on Google map.
Hessdalen light?

Map: Google Earth

Looks like three spheres together

Playing with the colors and lights in the picture. The light stand out.

LINK: https://earth.google.com/web/@62.81195936,11.09472672,1022.62207999a,489.94821342d,35y,-0h,0t,0r
Three spherical lights together above a fault close to Finnsåhøgda mountain top in Hessdalen.
Compared to other maps

No indication of light rock, sand or other items on other maps in this spot. There is snow patches on nearby mountains, but no other white patches on this one. In case, it is the last snow patch on this mountain.
Appendix A

Norwegian geology and observations:

http://www.ngu.no
http://www.hessdalen.org

Battery theory:
http://www.dailymail.co.uk/

EQL theory:
http://srl.geoscienceworld.org/content/85/1/159

Lightnings:
https://en.wikipedia.org/wiki/Lightning
http://www.weatherimagery.com/blog/positive-negative-lightning/
http://www.sintef.no/sintef-energi/produkter-og-tjenester

Eartqake:
http://www.jordskjelv.no