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ELECTRICAL CHARGES ASSOCIATED WITH SKY DARKENING AND THE TURIN SHROUD

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ABSTRACT

Sky darkness was considered as a real phenomena occurring during the Holy Crucifixion. In fact, it was evaluated as a process that occurred with the strong earthquake described by Synoptic Gospels at the time of Christ's death. The considered models suggested that sky darkness was due to atmospheric phenomena of dense cloud formation. As reported in recent works, such phenomena can be explained by the presence of air ionisation near the ground, which is able to modulate condensation nuclei at cloud altitudes. The presence of air ionisation also during aftershock periods, after strong earthquakes, suggested the Shroud could have been exposed to such ionisation. A question was raised regarding the action of such ions on the shroud touching a corpse, if it was able to accelerate the image formation.

INTRODUCTION

The Dead Sea fault is the most impressive tectonic feature in the Middle East. It is a plate boundary separating the Arabian plate and the Sinai sub-plate (Garfunkel, 1981), extending from the Red Sea in the south to the Taurus Mountains in the north has been active since the Miocene (Ben and Menahem *et al*., 1976; Kagan *et al*., 2011) with movement continuing today. Different types of paleoseismic evidence along the Dead Sea Transform show that large earthquakes have occurred in the past tens of thousands of years, (Ferry *et al*., 2007). Recently appears that the segmentation of Dead Sea fault system would lead mainly to moderate magnitude earthquakes with ML = 5.5-6.5 (Karcz, 2004). Arie (1967) suggested magnitude-frequency and magnitude-intensity relationships log N = 4.9 − 0.8 M and M = 0.5 I_{max} + 1.8, with a recurrence interval of about 40 years for M = 6 and 220 years for M = 7. Use of historic catalogue database permitted to calculate a uniform b = 0.86, and a values of 3.35 for the Mediterranean offshore zone, with M_{max} = 7.2 every 2600 years; a = 3.1 for the Israel inland segment of the fault system, with M_{max} = 7.3 every 1500 years; and a = 3.75 for the Syrian segment, with M_{max} = 8 every 1400 years (Ben and Menahem, 1979; 1991).

Different documents in literature attest to the occurrence of disastrous earthquakes in the ''Old Jerusalem'' of 33 A.D., during Christ's death (Mallet, 1853; Rigg, 1941; Prigent, 1978). Even if, a historical reanalisis enphasised that the earthquakes at the Crucifixion and Resurrection may not correspond to the occurrence of an actual earthquake (Ambraseys, 2005). The ''Old Jerusalem'' earthquake is classified as an average devastating seismic event that destroyed the City of Nisaea and the port of Megara located at west of the Isthmus of Corinth (Mallet, 1853). The Authors accept the occurrence of the Resurrection earthquake, to which they assign the severity of a catastrophic event, characterized by a local magnitude M = 8.2.

As well, another earthquake that took place in Bithynia, during the same period, that should have had an even greater magnitude (Ambraseys, 2005). Based on a detailed analysis of paleoearthquakes along the major active faults in the Earth's crust, some studies evidence their spatial and temporal distributions, as well as their regional recurrent behaviour (Min *et al*., 2000). Specifically, several earthquakes, in 1927, 1293, 1202/1212, 749, 551, 419, and 33 A.D. and 31 and mid-2nd century B.C., were recorded in three stratigraphic sections (Kagan *et al*., 2011).

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A few scientists, like for example Humphreys and Waddington (1985), think that Jesus Christ was already dead at 3 PM on Friday, April 3rd 33 A.D., because during this day there was a lunar eclipse in Jerusalem and this event occurred between 26 A.D. and 36 A.D., during the 10 years Pontius Pilate was the Roman procurator of Judea. They think that the citation "the moon turned to blood after the crucifixion took place" in Gospel narrations can indicate a lunar eclipse. But they don't consider the red moon as a phenomenon seldom associated with a strong earthquake, as occurred during Christ's death.

Instead, if we remember Chapter 3, verses 1-3 of Luke's Gospel, with a Hebraic modality of year counting, we have the beginning of Saint John's preaching on 28 A. D., on the 15th year of Tiberius Caesar's Empire; his Empire begins on 14 A. D., so 14 + 15 – 1 = 28. On this year Jesus Christ begun his preaching and his first Passover during his preaching. His third Passover (on the day of his Crucifixion) occurred on Friday, April 7, 30 A.D., the day before Passover on Saturday. Moreover, in the Acts of the Apostles, chapter 2, verses 15-21, the Author, perhaps Luke, relates about Peter's speech to Israel people about the events of the "last days", with red moon and earthquakes, with dreadful natural phenomena, the same that occurred during Jesus Christ's death. Based on these data, a discussion of several documents is caried out in order to obtain more information on such seismic events. Comparisons between Gospel, Apocryphal and Pagan historical writers and recent historical reports of strong earthquakes were carried out with respect to the darkness of the sky. Some models are discussed regarding the causes of darkness. Finally, a hypothetical consequence on shroud Image formation is offered.

MATERIALS AND METHODS

Gospel and Apocryphal writers on darkness and earthquakes

Only Synoptic Gospels mention darkness and/or earthquake. Mark in chapter 15, verse 33, says in Coptic language and Esichian version: "Καὶ γενομένής ὥρας ἕκτης σκότος ἐγένετο ἐφ'ὅλην τὴν γῆν ἕως ὥρας ἐνάτης" (Merk *et al*., 1984). This means: "About midday, hora sexta in Latin version, darkness came in the whole world, until three o' clock in the afternoon" (Nestle *et al*., 1986). In verse 38 Mark says that the Temple's curtain was torn in two, from top to bottom, but he does not speaks about an earthquake. It must be remarked as the word is σκότος, darkness, and not τοῦ ἡλιου ἐκλιπές, sun eclipse or sun light enfeeblement. Then, in chapter 16, verse 2 he says that Maria of Magdala, Maria of Jacob and Salomé went to the Sepulchre just after sunrise. The words of this verse are frequently translated from Greek as "sunrise" or "in the early morning", but this detail is very important if we consider Eusebius of Caesarea's version of Mark's Gospel (CEI, 1971); in this version it can be read that after sunrise, after a seismic shock, at nine o'clock, darkness occurred suddenly in the whole world, Angels, bright thanks to God's shining light, descended from heaven, then they (Angels) ascended to heaven with Him (Christ) and a continuous light followed.

The three women were able to approach the Sepulchre. This narration of an Author, who also writes Chronica, gives a fanciful tone to the Gospel, thanks to references about Angels. In chapter 27, verse 45, Matthew (Merk *et al*., 1984) also cites darkness, but in verse 51 he adds that the Temple curtain was torn in two, the ground shook, rocks were broken, graves opened and corpses rose again. In chapter 28, verse 2 (Nestle *et al*., 1986), on the morning of Christ's Resurrection, Matthew speaks about a violent earthquake. In chapter 23, verse 44 Luke (Merk *et al*., 1984) describes darkness, σκότος, lasting three hours until the sun grew faint. In verse 45 cites he says that the Temple curtain was torn in two. The event was seldom represented by the iconography of atmospheric phenomena, see for example in Figure 1 the Pala Chigi in Sant'Agostino Church of Siena, by Perugino, 1502. Luke does not mention earthquakes or darkness in the morning after Saturday.

Saint John never cites darkness or earthquakes

It is interesting to add some reflection about the Acts of the Apostles, chapter 2, verses 15-21 (Merk *et al*., 1984): the Author, perhaps Luke, relates one of Peter's speeches to people of Israel about the events of the "last days". Peter says to the people that men who are relating the extraordinarily events during which happened during the Passion, Death and Resurrection of Christ are not drunk, they are telling about real events, as the prophet Joel had forewarned. Joel's prophecy (CEI, 1971), cited in Acts of Apostles, speaks about the sun growing faint and the moon turning the colour of blood. In chapter 3, verses 1-5, Joel also speaks about earthquakes and stars not shining. This can account for the black or dark colour of the sky, often cited in later Historical Chronicles. Perhaps the people of Israel had already lived through these events in ancient times.

Moreover, the text of a musical antiphony "Terra tremuit et quievit" (Rost, 1820) sung in Jerusalem, see Figure 2, perhaps already since the II century A.D., during the Holy Week, contains the idea of a seismic swarm after Christ's death. This antiphony, sung before the Psalmus 75, is an ancient structure of antiphony, certainly before the IV century, because it was sung by all people as a refrain, while the Psalmus was sung by a soloist. Then in IV century the antiphony was sung by two alternating chorus. Giovanni Crisostomo, bishop of Costantinopoli and important Christian author of the end of IV century, says that the ancient antiphonies report "sublime verities" and Historical facts, so the antiphony "Terra tremuit" cites historical events. The Responsorium "Tenebrae factae sunt", sung between the V and the VI "Lectiones" during the "Parasceve day", was sung by a soloist and the chorus alternately. It cites the Gospel darkness. The "Responsoria" are the most ancient liturgical songs. The Gospel citations in the "Responsoria" are the most ancient forms of Christian liturgical drama about historical events of Christ's life. The Responsorium "Angelus Domini descendit de coelo" cites the big stone in front of the Sepulcre, upsetted by an Angel in the morning of the Resurrection.

Also apocryphal Literature (A, 1930) cites darkness and earthquakes, as it is possible to read in Gospel of Peter, Gospel of Nicodemus and two reports to Tiberius by Pontius Pilate, dated in the fourth century. In the Gospel of Peter the darkness covers Judaea and lightning occurred until night. In the Gospel of Nicodemus darkness is a solar eclipse. In the two fourth century Pontius Pilate's reports to Tiberius, is very interesting to point out a citation about the moon's unusual colour:

"the darkness started at the sixth hour and covered the whole world. The following evening the full moon looked as if covered with blood for the entire night" (Sordi, 1983). The first one, titled Anaphora of Pontius Pilate about Our Lord Jesus Christ sent to Cesar Augustus (and/or Tiberius Cesar). Graeca recensio "A (and/or B)", for a citation about moon anomalous color: "the darkness had started at the sixth hour, covered the whole world, during the subsequent evening the full moon resembled blood for the entire night (note also that Orion in recensio B is unusually

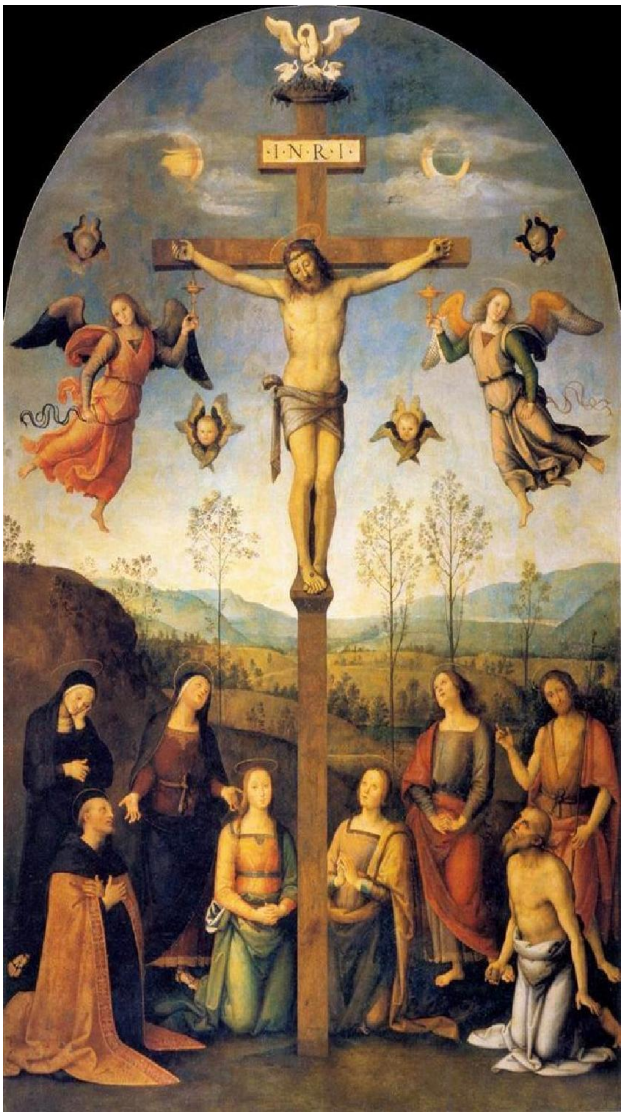

Figure 1. The Perugino's Pala Chigi, Sant'Agostino Church in Siena, 1502

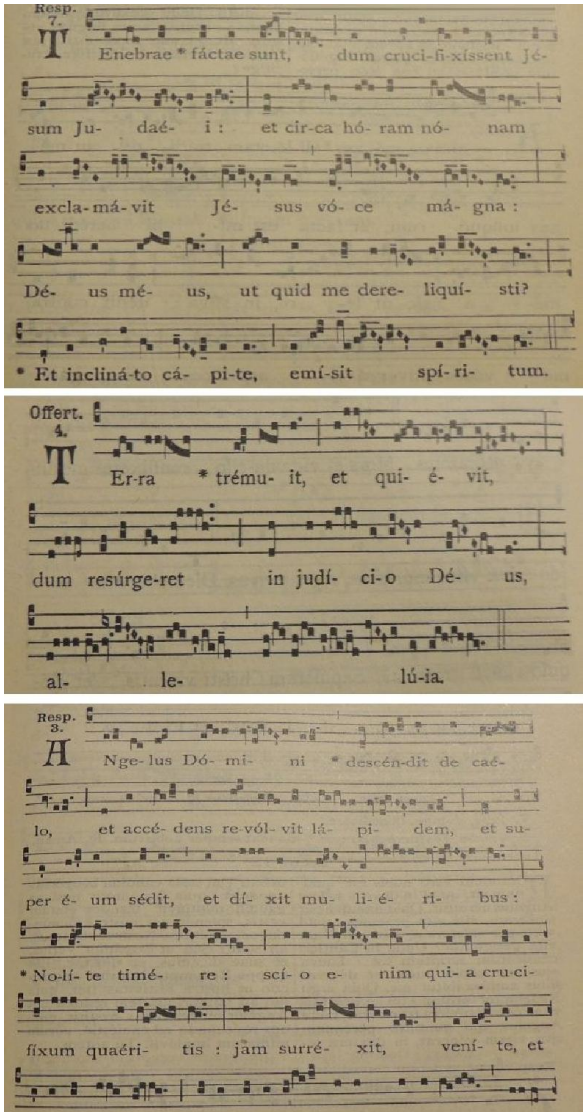

Figure 2. The antiphony, Responsoria and Himni (I-II century)

mentioned) (Craveri, 1969). In the second one, titled A letter (also: Letter from Pilate to Tiberius Emperor), where "Pilate" talking about darkness and earthquake in "lower Egypt, as cause o death of Jewish wise Baltassar in Antiochia." A further question concerns the correctness of the translation Luke 23, 45. In fact, most of the manuscripts of late antiquity and of the Byzantine period say that "the sun was darkened" (ἐσκοτίσθη/eskotisthe) instead of "the sun light failed" (τοῦ ἡλίου ἐκλιπόντος/ ἐκλείποντος/tou heliou eklipontos/ ekleipontos).

Pagan Historical Writings about Darkness and Earthquakes

Thallos (Rigg, 1941) is the first pagan author who cites the darkness during Christ's agony, but we do not know anything about him, where he was born, when he wrote his Chronicle, written in Greek. It can be deduced something about him from Sextus Julius Africanus's Chronographia, thanks to a copy of Georgius Sincellus (Prigent, 1978), a byzantine historian of IX century, who, in Ecloga chronographica, repors Africanus's extract about Thallos. Is not possible to know if Thallos mentioned by Africano is the same cited by Flavius Josephus, a certain Thallos Samareus, living in Rome in the first century, but the word is really "allos", "other". If the two are the same person, perhaps Chronicle was written after 50 A.D. Africanus reports that Thallos, in the third book of his Chronicle, says that a terrible darkness came in the whole world, rocks were broken by a terrible earthquakes and a large area of Judea was destroyed, but he defines this darkness as a sun eclipse.

Africanus has not the same opinion and he specifies that during the Passover there is a full moon, incompatible with sun eclipse, so the cause of this extraordinary phenomena must be another. The same answer was given by Origene, Jerome, John Chrysostom in a polemic against those people denying the validity of the Gospels. In Acts of the Apostles, chapter 2, verses 15-21 it is just possible to understand the difficulty of accepting the Gospel version of these extraordinary events, by non eye-witnesses. But people who were present at these events, but did not believe in Christ's Resurrection, could not deny them. Whereas the Apostles interpreted them as signs from God, the non believers attempt to give a natural explanation as opposed to the one upheld by the rising Christian Church. Perhaps Thallus gave his interpretation of the darkness with the intention of contesting a supernatural one. A similar polemic was adopted by the Greek philosopher Celsus of II century. On the contrary, this polemic just at the II century shows a historical plausibility of the above mentioned events. However, remaining within the Jewish "day of the Lord", lato sensu, it is fatally heralded by earthquakes (8.8 Am; Isaiah 2:10, Jer 4:24) and eclipses of the sun (still Am Ger 8.9 and 4,

23). Elements, that seem to be acquired from contemporary pagan literature, should not come as a surprise and are also present in Judaism. Moreover, many late translations from Greek into Latin did not consider the word σκότος, darkness, but τοῦ ἡλιου ἐκλιπής, translated as "solis defectio", usually as "eclipse"; sometimes "solis defectio" was used as sun light enfeeblement, as by Minucius Felix, in his work "Octavius", IV book, when he describes British country side (Colombo, 1938). It is important, however, to point out that all writers always speak about a "solar eclipse" and none ever suggests that it might be a "lunar eclipse", even in later manuscripts.

The same problem of wrong interpretations of "darkness" in the Gospels as "eclipse of the sun" is also present in a quotation of Phlegon of Tralle, (second century), who also mentions a big earthquake in Bithinia, at the time of Christ. In a fragment attributed to Phlegon, it can be read: "serious damage due to earthquakes which also occurred among people who lived in Pontus" (Müller, 1975). Also Apollonius Grammaticus, that was Phlegon's source, reports a big earthquake at the time of Tiberius (Müller, 1975). An interesting philosopher writing before 532, probably Sirian, Pseudo-Dionysius, the Areopagites, speaks of strange phenomena regarding the moon and the sun (Dionisius, 1987).

Historical Earthquakes Darkness of the Sky

Strong earthquakes occurring during the last centuries have been described by many authors with the aim of calculating economic damages and their effects on everyday life. Such reports also have included rural observations by witnesses, which were considered prodigious before the birth of modern science (Guidoboni, 1994) and unexplainable phenomena after (Galli, 1910). Observations have regarded morphology changes, earthquake lights, sounds, smell sensations, animal behaviour, water spring changes and atmospheric phenomena. A first summary of earthquakes where the darkness of the sky was observed is presented here:

The Haiti earthquake occurred on January 12, 2010, at 4:23 pm. It was the most powerful to strike Port-au-Prince in two centuries, having a magnitude of M = 7.0. *A witness who was in Haiti when the earthquake hit said the sky went dark just before the earthquake. People went outside to see what was going on, and that act saved their lives* (yahoo, 2010). Another atmospheric phenomena was observed after the main shock: *soil, dust and smoke smothered the city for about 12 minutes, according to witnesses* (Carroll, 2010). This phenomena was due to the collapsing of buildings and the consequential rising of dust. This phenomena, being not directly linked to atmospheric variables, has also been observed on the occasion of all strong earthquakes reported below.

L'Aquila earthquake. April the 6th, 2009 this was the strongest seismic event happening in Italy over the last thirty years, with a magnitude of M = 6.3. Around the time of the seismic swarm many instruments were working in Central Italy. People present at the time were questioned just after the main shock, and gave data on earthquake lights, gas leaks, human diseases and anomalous animal behaviour (Fidani, 2010). The questionnaire was made up of a sequence of topics, based upon observations during past historical earthquakes and written down over seven months after the main shock. Nearly all the witnesses interviewed, living in localities in places up to 40 km from the epicentre, observed a red Moon hours before the earthquake. Witnesses reported this phenomenon several days around the time of the main shock. Furthermore, witnesses living on the epicentre observed something that they called "a black Moon". They observed *a blurred Moon in a very black sky*. Some of them observed *such a black sky, that nothing else was visible around them for a few meters*, before the main shock came.

The earthquake which occurred in Colfiorito on September the 26th, 1997 was one of the strongest seismic events occurred in Italy over the last years, with a magnitude of M = 6.1. After the successful collection of information regarding the L'Aquila earthquake, a questionnaire was distributed in Umbria and Marche, in order to collect observations made by people living on the epicentre during the 1997 earthquake (Fidani, 2014). Various testimonies were collected. One of them tells of *a black cloud which covered and darkened the area around Mount Pale*, a few km from the epicentre, on the morning of September 26, about 2-3 hours before the main shock.

The earthquake, which occurred in Kanto, on September the 1st, 1923 was the deadliest earthquake in Japanese history, and at the time was the most powerful earthquake ever recorded in the area with a magnitude of M = 7.9, (Jaggar, 1923). *Although it had been raining, the air was almost instantly filled with dust, the cloud being heavy enough to cause temporary darkness immediately before the earthquake*. A photograph of the cloud suddenly appeared before the great earthquake was taken by E. Ohshima (Ikeya, 2004).

The earthquake, which occurred in Liguria, on February the 23rd, 1887 was one of the strongest seismic events ever occurred in Italy during the XIX century with a magnitude of M = 6.5. *The evening before the main shock, just before sunset, the inhabitants of Alfiano Natta observed a thickening fog which swallowed the rays of the sun* (Taramelli, 1888). *In other sites near the epicentre people told that the evening before the main shock sunlight seemed oddly pale*.

The earthquake, which occurred in Monti Albani from May the 21st to December the 6th, 1829, the Monti Albani area was struck by many shocks of moderate magnitude (Galli, 1910). *In the caves of Albano Laziale carbonic acid gas, which killed many animals, developed and many lanterns went out. In other events of the swarm the unbreathable gas was raised at the time of the shocks and remained for some time In those days. the sky was the colour of a heron so sad that in the evening it was like a thick fog. Many people had sensation of warmth in the legs at the time of the shock*.

The earthquake, which occurred in Calabria, on February the 5th, 1783 was one of the worst seismic events ever occurred in Italy in history, with a magnitude of M = 7.0 (Galli, 1910). *The main shock occurred in broad daylight and was immediately preceded by a gloomy cloud*.

The earthquake, which occurred in Cagli, on June the 3rd, 1781 was one of the strongest seismic events in Italy in the XVIII century with a magnitude of M = 6.4 (Galli, 1910). *Shortly before the shock the air became misty and the wind dropped, suddenly darkness fell in the late evening*.

The earthquake, which occurred in Rimini on April the 14th, 1672 between 9 and 10 p.m., had a magnitude of M = 5.8 (Galli, 1910). *A black cloud was observed North of Rimini before the main shock.*

An earthquake occurred in Ferrara on November the 17th, 1570 and began to be strike with many shocks, which lasted four years. The strongest shock occurred on November the 17th-18th of magnitude M = 5.6 (Bonito, 1691). *Witnesses observed that during the main shock the sky was darkened. Furthermore, black smoke was seen to come out of the cracks in rocks and the snow melted*.

Egypt earthquake. The May 13, 963 Egypt earthquake was accompanied by a violent storm, and it has been reported to create a red Sun (Guidoboni, 1994).

Pausania, in the II century A.D., wrote that *an alteration in the colour of the sun, where it turned reddish and nearly black, was a phenomenon which he interpreted as a seismic precursor*.

Seneca, 4 B.C. – 65 A.D. says that if *the darkening of the lunar disk is not succeeded by an eclipse, this is the premonitory sign of an earthquake*.

Aristotle, 384 – 322 B.C. in his theory of earthquakes says *a layer of clouds spreads and discolours and darkens the sun*.

RESULTS

Earthquake Cloud Models

Historical reports of a dimming of the Sun, red twilight glows, reddish solar halos, and dark total eclipses of the Moon indicate a high turbidity of the atmosphere (Stothers, 2002). Seldom observed in occasion of volcanic eruptions, solar darkening was supposed to have a merely meteorological origin (Stothers, 2002). A strong connection with emissions from the ground clearly appeared during the Monti Albani earthquake report. They were probably made up abundant gas which characterizes the volcanic region (Gambardella *et al*., 2004) where the earthquake occurred. Furthermore, in recent years, CO_2, CO and CH_4 gas exhalations were measured during earthquakes in many earthquake prone regions (Heinicke *et al*., 2000; Italiano *et al*., 2009; Bonfanti *et al*., 2012). All the examined cases might also caused by some kind of ground emission in the atmosphere, together with strong earthquakes (Ouzounov *et al*., 2010). Recently, stable cloud formations of particular shapes were observed from meteorological satellites in occasions of strong earthquakes (Morozova, 2012).

Two models were taken in account in which hot gases and electrical charges originated from the ground. Gas bubbles going up into the atmosphere (Levine, 1959) might have deviated the rays of the sun light because of different refraction index, see Figure 3a, and particular gases reduced the atmosphere luminescence thus causing shadows. Otherwise, humid air bubbles rose and cooled at the condensation level, forming black cumulus and shadowing the surface, see Figure 3b. However, the evaporated gases should be occurred in a very stable environment of so particular nature, respectively to produce sensible changes in refractive index, absorption of diffuse light or to produce a so rapid and intense cumulus formation so to obtain darkening as observed before earthquakes.

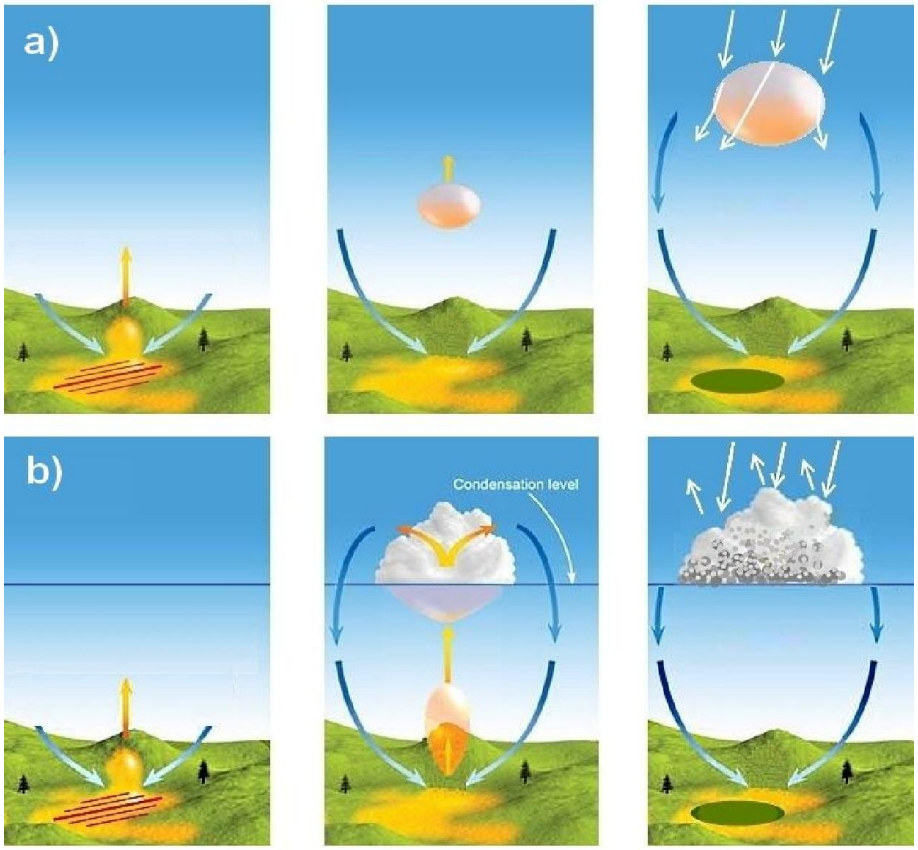

Figure 3. Two models of solar darkening due to vertical fluid migration which produces light refraction a); and light reflection b)

Examining the differences in refractive index of CO_2, CO, CH_4 and other observed gases during earthquakes (Heinicke *et al*., 2000; Italiano *et al*., 2009; Bonfanti *et al*., 2012) with respect to the air refractive index, see Table 1, very small values were found to be of 2 10^{-4}, also for pure gases.

Table 1. The refraction indexes of several natural gases

Gas	(0 °C, 760 mmHg)	Refraction Index
	Air	1.000293
	N_2	1.000297
	O_2	1.000272
	Ar	1.000281
	CO_2	1.000448
	CO	1.000350
	Ne	1.000066
	He	1.000036
	CH_4	1.000444
	H_2	1.000139
	Water vapour	1.002490

Being so, the refraction produced by index variations due to the presence of abundant similar gases separated by air in atmosphere do not produce any significant light ray deviation. Given that pressure and temperature variation were recorded in some strong earthquake events (Tronin *et al*., 2004), the influence of gas density variations on refraction was taken in account using the Gladstone-Dale relation (Gladstone *et al*., 1864)

$$\sim 0.022\ \rho/\rho o\ [\ \%\ ]. \quad (1)$$

The calculated density variations which corresponds to the measured pressure variations of 100 mBar were of the order of few mg/cm^3, producing few percent contribution. In analogy, the influence in temperature of few degrees so as was observed during strong earthquakes (Genzano *et al*., 2009) is able to produce refraction variations evaluated in

$$\sim 283/(273+T)\ [\ \%\ ], \quad (2)$$

which still calculated few percent contribution. Moreover, the reflection occurring above the bubble due to these differences in refraction indexes can be calculated by

$$|(n1-n2)/(n1+n2)|, \quad (3)$$

and is always a very small value. The total contribution of sun light depletion due to these four effects should be of few percent not being able to explain the observed darkening. Finally, Rayleight diffusion of the light is responsible for the sky illumination in all the directions different from the Sun position, therefore no significant light depletion being possible by a small divergence of sun light. Thus, the sky darkening reported in the Bible seems to be not explainable by a refraction phenomena. Then, the condensation of humidity emitted by ground was taken in account. Cumulus clouds form from hot invisible air bubbles detaching themselves from the surface rise and cool to the condensation level, see Figure 3b. Hot air bubbles can generate tornado-type clouds in ascending the atmosphere. Such clouds were photographed over the epicentre zone of the Kobe earthquake (Teramoto *et al*., 2000). However, a major problem is that mixing processes in the naturally variable lower atmosphere seem likely to disturb such ascending gas motions (Harrison *et al*., 2014). Historical reports suggested the presence of electrical activity around the epicentre, early before the occurrence of strong earthquakes (Fidani, 2005). Large and sudden changes in atmospheric ion concentrations have been observed at Kobe 8 days before the 1995 earthquake, M = 7.3, in Japan (Satsutani, 1996).

Tributsch (1978) supposed that charged aerosols were being emitted from the fault zone and could explain the formation of both clouds and fog in air with less than 100% humidity. Ikeya and Takaki (1996) calculated that an electric field gradient collects dust, smoke and vapour, making their condensation easier. As a result, charged aerosol may be generated by an intense electric field and become nuclei leading to fogs and clouds. A model was recently proposed to overcame the major difficulty with the ion-induced nucleation (Harrison *et al*., 2014), which is that condensation of water droplets on ions requires extreme levels of water super-saturation. Coupling between surface air and clouds could occur via the global electric circuit, where enhanced ionization in the lower atmosphere will increase the vertical electrical current flow always present in fair weather. Following the Authors, vertical current flow through the horizontal edge of a layer cloud in semi-fair weather, generate charges at the horizontal cloud–air boundary influencing, in some cases, the evaporation–condensation of drops. Confirmations of nucleation using optimised gas mixtures were experimentally observed (Harrison *et al*., 2003) and long-range cloud dissipation was apparent in a satellite image of the Chernobyl reactor plume due to enhanced ionisation from radioactivity (Brandi *et al*., 1987). Being so, more intense and black clouds maybe formed during earthquake occurrence due to the presence of charged ion in the lower atmosphere.

DISCUSSION

Implications for the Shroud Image Formation

The arguments presented above to explain earthquake clouds can now be translated in the study on the formation of the Image on the Holy Shroud. Electric field could be useful to condense vapour in atmosphere, but it should be difficult to form inside a cavity. In fact, earth ground is usually characterized by a discrete conductivity able to dampen an electric field in a cave. Positive electric charged aerosols were supposed to produce many phenomena observed with earthquakes (Freund, 2013). Stressed rocks release electronic charge carriers known as positive holes, possibly due to peroxy links break (Freund, 2002). The positive holes are highly mobile and can flow out of the stressed sub-volume of

earthquake nucleation. When the positive holes arrive at the Earth's surface, they lead to ionization of air at the ground–air interface. Moreover, the positively ionised air concentrated in the lower level of atmosphere and particularly inside closed room like tombs.

It is impossible to known when and who entered in the cave to carry out the Shroud. However, it was necessary to fold the Shroud because of its size. Being so, if any biological substance as sweat wetted the Shroud, and it was the unique cause producing the image in a long time, the folding of the Shroud would also have lasted the biological substance on the opposite face of the Shroud contacting the wetted Shroud, therefore producing duplicates of some region of the Shroud. As it is not observed on the Turin Shroud, then this suggests that image formation occurred probably before the Shroud folding, not simply due to the contact with biological substances. Furthermore, the Man of the Shroud was bury after the strong earthquake described in the bible, not before it when the ground emissions were expected. However, in several historical cases of very strong earthquakes, electrical non-seismic phenomena were also observed after main shocks (Galli, 1910; Fidani, 2010). From the Gospels it is possible to know that other earthquakes occurred in the days following Jesus Christ's death, and a seismic swarm after Christ's death was suggested from the text of a musical antiphony.

It is possible to think therefore, that other strong aftershocks stroke the same region while Jesus Christ's body remained in the tomb, so being possibly exposed to the similarly strong ionisation phenomena. It is plausible that positive charged aerosols invaded the tomb and accumulated inside it during aftershock period after the crucifixion. Such aerosols touched the Shroud and charged it, Figure 4a. The linen which was made the Shroud is an anti static material which is able to slowly dissipate electric charges. It means that charges slowly moved in the Shroud to equilibrate electric charging. Doing so, positive charges can to attract electrons from the body skin surface which was in contact with the Shroud, see Figure4b, thus accelerating the surface skin acidification. This possibly attracted Hydrogen from the surface of the linen fibres producing dehydration and oxidation phenomena, see Figure 4c, as resulted in chemical studies of the Turin Shroud linen fibres (Schwalbe *et al*., 1982).

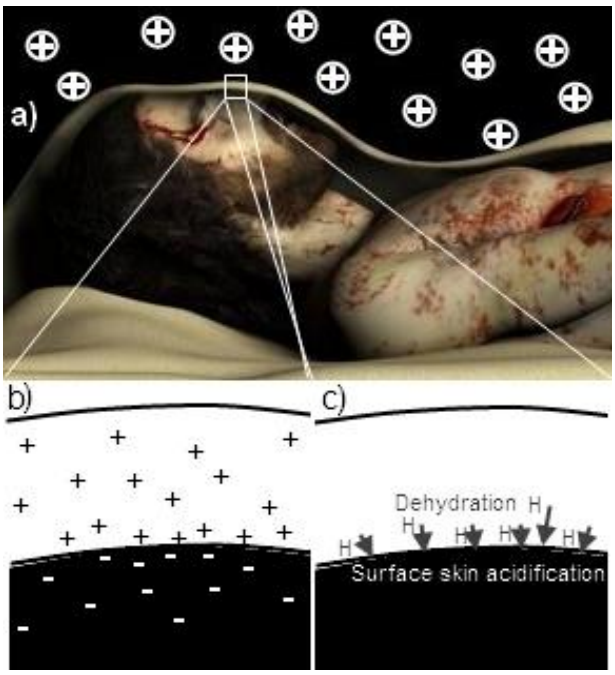

Figure 4. The process possibly caused by charged aerosols accumulated in the tomb where the Jesus Christ's body was deposed after crucifixion

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