Best Fit for Locations and Events

Author(s): Jerry D. Grover, Jr.
Source: *Geology of the Book of Mormon*
Published: Vineyard, UT: n.p., 2014
Page(s): 155–190

Chapter 12

Best Fits for Locations and Events

When attempting to recreate an historic hazard event that may have had multiple hazard causes or combinations of causes, an appropriate approach is to apply probabilities for each possible cause. By selecting the most probable cause of each event and applying the premise that the simplest explanation is preferable, one can arrive at what is called a "best fit" cause for each event. A best fit analysis and determination does not mean that there are no other explanations, just that the best fit is the most probable. For example, one could argue that an asteroid strike or an alien attack could account for the description of events in 3rd Nephi, but most reasonable persons would be dismissive of these causes because they have an extremely low probability. In the case of the 3rd Nephi events, there are some best fit probability criteria that will be applied where applicable to arrive at a best fit determination for each of the geographical areas and cities to determine the causes of destruction:

1. Any cause must be consistent with all actual accounts given by those who witnessed the event (or was reported to them). In this case, prophetic visions and divine declarations are considered to be part of this classification.
2. A major earthquake, a major volcanic eruption, and a major hurricane are considered to be equally probable, as all these events are considered rare with typical reoccurrence on the order of hundreds of years.
3. A severe local storm is more probable than an early hurricane.
4. A volcanic event is the most probable natural event (indeed the only) to generate mists and vapors of darkness.
5. Since it has been scientifically established in prior chapters that a volcano and earthquake are needed to account for the witnessed events then:
    a) One fault system of earthquakes is more probable than two fault systems of earthquakes.
    b) A local storm is more probable than a volcanic eruption.
    c) One volcano erupting is more probable than multiple volcanoes erupting.
    d) The volcano being located on the earthquake fault system is more likely than it being located elsewhere.
    e) Multiple, related simultaneous earthquakes are more probable than multiple simultaneous volcanoes erupting.

It is important to note that the witnesses and individuals involved in the 3rd Nephi destruction were not analyzing, interpreting, and classifying the event and all its different geological causes and results, they were just experiencing a large natural disaster. They would not be differentiating the volcano, the earthquake, the thunder, or the sinking of cities on the basis of geologic source. It would have all been one big event to them and for the most part was described as such. As a result, there is inevitably going to be some ambiguity in ferreting out each distinctive geologic event as well as the distinctive damage associated with each, as they were all happening at the same time and some in the same area. Some of the damage is definitely cumulative so the effect of any one individual hazard may be difficult to quantify.

"All the face of the land" Events

As has been previously discussed, the descriptive term "all the face of the land" or similar language typically is encompassed in a specific area such as the land northward or the land southward. Other times it indicates something widespread over Book of Mormon lands, including both the land northward and southward. Similarly, the descriptive term "whole earth" is also used, implying both the land northward and the land southward. The only phenomena mentioned that clearly imply effects over both the land northward and southward are (1) quakings, (2) mist or vapor of darkness, and (3) thunderings.

There is a bit of interpretation as to whether rending or fracturing of the earth would be considered to encompass both the land northward and the land southward. First Nephi 12:4 indicated that the "earth" "rent the rocks" and that the "plains of the earth" were "broken up." First Nephi 19:11 indicated that there was an "opening of the earth" without specific geographic reference. Helaman 14:21–22 indicates that "the rocks" "upon the face of the earth" "shall be broken up," and that the rocks "shall ever after be found in seams and in cracks, and in broken fragments upon the face of the whole earth, yea, both above the earth and beneath." The witnesses in 3rd Nephi indicated that there was a "more great and terrible destruction in the land northward" where "the whole face of the land was changed" in part by the "great quaking" (3 Nephi 8:12). Third Nephi 8:18 seems to be still talking about the land northward when it indicates that "the rocks were rent in twain" and were "broken up upon the face of the whole earth" and were "found in broken fragments" and "in seams and in cracks, upon all the face of the land." As a preface to the brief description of destruction in the land southward, 3rd Nephi 8:6 talks of the terrible thunder "insomuch that it did shake the whole earth as if it was about to divide asunder" implying perhaps that the earthquake did not actually divide the earth in the land southward.

Thus, the regional earthquake clearly involved both the lands northward and southward, due to the reference to the "whole earth" quaking. Clearly the plains area was broken up. The Veracruz fault segment extends some distance into the land southward in the coastal plains area. Movement along the Veracruz segment of the fault is definitely the best fit for the primary earthquake event. There clearly may have been additional movement along the Polochic/Motagua segment of the regional strike-slip fault system, especially considering the fact that the city of Jerusalem in the southern portion of the land southward experienced damage that may be potentially explained by an earthquake. A secondary movement of lesser intensity along the Polochic/Motagua segment would also appear to be included in the best fit scenario.

The mists or vapors of darkness are described as being widespread. The only realistic explanation for this phenomenon is a volcanic ash/tephra cloud disseminated as a result of a volcanic eruption. Occasionally during the initial moments of earthquakes, dust can be generated from shaken buildings or by brief release of sometimes pungent soil gases, but these have never been observed in modern earthquakes to last more than a few hours, and the same is indicated for pre-modern earthquakes by historic anecdote (Wolff et al., 1849, 344–46). Earthquake dust has not been observed to inhibit ignition. Volcanic ash distribution has been historically documented to inhibit combustion and last for days at a time (Kowallis, 1997, 152–53). As discussed in chapter 5, there were certain natural events that continued for three days, and these descriptions are indicative of an ongoing volcanic eruption.

The 1793 San Martín volcanic eruption is a recent example that shows that with an extensive dispersion of ash most if not all of the Book of Mormon lands could have been subject to the effects of volcanic ash. The description of events in the land northward indicate that the volcano erupted in the land northward, with the best fit candidate being the San Martín volcano, with a secondary best fit being Pico de Orizaba. Popocatépetl cannot be completely ruled out even though it seems to be located too far north to produce an ash cloud that would have dispersion in the land southward. As ash cloud distribution is highly dependent on local winds and meteorology it cannot be completely ruled out. Popocatépetl is also located at such a distance that it may be difficult to satisfy the requirement that the sounds of thunder and tumultuous noises described in the Book of Mormon could be heard in the land southward.

Great thunderings were also referred to and described as “shaking the whole earth.” The best fit for this event is the sounds of subterranean and surface phreatomagmatic explosions, which occurred as part of the volcanic eruption. While most volcanoes can exhibit phreatomagmatic explosions, the San Martín volcano is favorably situated (with extremely high rainfall levels and significant ground and surface water) and known for these types of explosions. Again the best fit for this phenomenon is an eruption of the San Martín volcano.

Finally, it is worth noting that the “storm” mentioned in 3rd Nephi does not have an associated geographical description, so cannot be assumed to cover “all the land.”

Land Northward Events

All of the events described as occurring in the land northward are explained by a volcanic eruption and effects of the San Martín volcano or secondarily by the Pico de Orizaba volcano and by a large earthquake along the Veracruz fault system, with the associated earthquake effects including subsidence, landslides, and debris flows.

Whirlwinds are also associated with destruction in the land northward. There have been reports of occasional isolated tornadoes in the Isthmus of Tehuantepec, but the best fit for the whirlwinds referred to in the Book of Mormon seems to be whirlwinds associated with volcanic eruptions, with a secondary possibility being tornadoes spawned by a hurricane.

Destructive whirlwinds that destroy buildings and take people and livestock are common in volcanic eruptions and have been reported in the 1815 Tambora eruption, the 1883 Krakatoa eruption, the 1766 Mayon eruption, the 1947 Hekla eruption, the 1963 Surtsey eruption, and the 1973 Eldfeld eruption (Kowallis, 1997).

Figures 62 and 63 are examples of volcanic whirlwinds although the ones pictured are not that powerful.

Figure 62. Whirlwinds formed following a pyroclastic flow from the eruption of the Sinabung, Indonesia, volcano on January 24, 2014 (courtesy Photovolcanica, 2014)

Figure 63. Waterspout whirlwinds formed from the eruption of Kilauea, Hawaii, volcano in 2008

As a secondary possibility, tornados are common features of hurricanes after landfall. Hurricanes actually produce conditions amenable to tornado genesis. As hurricanes make landfall, storm forces begin to decay, and wind speeds near the land surface fall off more quickly than wind speeds at higher altitudes due to friction at the ground level. This vertical gradient in wind forces, as well as extreme changes in wind direction that occur throughout such a widespread storm system as a hurricane produce the wind shear necessary for tornado formation.

Tornadoes are favorably formed in the front-right quadrant of a Northern Hemisphere hurricane that has hit land. A hurricane moving south and hitting the Isthmus from the north or northeast would place the front-right quadrant of the hurricane in the land northward, which is consistent with the Book of Mormon placement of whirlwinds.

Land Southward Events

There are no specific effects in addition to the effects already ascribed to "all the face of the land."

City of Zarahemla

The city of Zarahemla took fire according to 3rd Nephi. The Sorenson Model has identified the city of Zarehemla as the archaeological site Santa Rosa in Chiapas, Mexico. The most likely methods for Zarahemla to take fire and have the kind of accelerated burning required to kill a lot of inhabitants are lightening- or earthquake-induced ignition from existing human sources of fire in conjunction with high winds. A volcanic ignition does not seem likely, as the location is more than 100 km from the Tacaná volcano and more than 170 km from the El Chichón volcano. Since the mist or vapor of darkness in the form of a volcanic ash cloud repressed fire, it can also be reasonably postulated that the burning of Zarahemla probably occurred very early in the disaster, probably within the first three hours.

For an earthquake-assisted ignition, Santa Rosa, based on the intensity equations and intensity calculations in chapter 10, would sit in an earthquake intensity zone of 4 to 5 because it lies within 120 km of the edge of the zone of intensity at level 7 (see figure 64).

Under the Mercalli Intensity scale, a 4 or 5 is described as follows:

> IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
>
> V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

It would appear that a regional earthquake along the Veracruz fault may have been enough to overturn candles or other such elements of fire to start the spread of fire. As has been previously mentioned, there is always the possibility of large sympathetic earthquakes along faults near Zarahemla, but that would not be necessary to explain the damage to Zarahemla.

Figure 64. Santa Rosa/Zarahemla distance in relation to the 7 Mercalli intensity zone of a large earthquake along the Veracruz fault segment

The best fit explanation for the destruction in Zarahemla is ignition caused by either lightening or earthquake induced upset of ignition sources with the presence of high winds from a large local storm.

City of Moroni

Moroni was "caused to be sunk in the depths of the sea" with the inhabitants being drowned. In the context, the term "sink" or "sunk" is assumed to be literal in that the actual elevation of the city changed, especially given Jesus Christ's declaration that it sunk. Since the city of Moroni was on the ocean, a change in elevation is obvious once covered by the sea.

The Sorenson model placed the city of Moroni along the north shore of the Mecoacon Lagoon (aka Mecoaca Lagoon), at approximately latitude/longitude 18° 25' 55" N 93° 09' 28" W. This location can obviously only be approximate as the city itself is sunk either into the lagoon or into the ocean.

There may be concurrent events that could cause a flood of sea water to overcome the city, such as a tsunami or storm surge, and cause the drowning of the inhabitants, but unless these events cause subsidence, an additional or alternate hazard must be considered. Beach erosion can occur in a tsunami or a hurricane storm surge, and would typically not be considered significant enough to wash away an entire city, however these types of events might be extensive enough to wash away a city configured to run along a beachfront (we really don't know what size the city of Moroni was;

Sorenson has pointed out that some 'cities' in this area are really just military outposts). The amount of erosion from a tsunami depends somewhat on the topography of the land, but definitely is related to the force of the wave. Seventy-foot tsunamis in the Kuril Islands off the east coast of Russia, following a magnitude 8.3 earthquake on November 15, 2006, and an 8.1 quake on January 13, 2007, caused a loss of 200 cubic meters of sediment per meter of width because of tsunami-induced erosion (University of Washington, 2009). Putting this in a hypothetical situation, assuming that the tsunami erosion was 2 meters deep, that erosion would extend back from the shore 100 meters. If the city was configured running along the length of the beach than 100 meters of it could have washed away with the remaining elevation being 2 meters lower than it was previously.

However, the location of the city is proposed to be on a barrier island or spit between the lagoon and the ocean, so the erosion behavior in this situation can be much different. As the river that fed the lagoon in the 3rd Nephi time frame no longer is present, plus the fact that coastline morphology is constantly changing, an exact geological configuration of the barrier island of the lagoon as it existed 2000 years ago is not known.

A tsunami would be a possibility either by movement on the Veracruz fault, part of which is under water in the Gulf of Mexico, or by a pyroclastic flow or lahar that entered the Gulf of Mexico adjacent to the San Martín volcano. In addition, a tsunami risk has been identified in the southern Gulf of Mexico from submarine landslides, which an earthquake may also have triggered (Brink et al., 2009).

Figure 65. Barrier Island breach with new inlet created (Valvo et al., 2005)

A storm surge or a tsunami can completely remove barrier beach areas. If a storm surge fully inundates a barrier island or spit, currents flowing across the area can create a breach or inlet. Waves and surge from the 2003 landfall of Hurricane Isabel created a breach in excess of 500 meters (see figure 65) in the Cape Hatteras National Seashore. This event was not considered remarkable and is typical of what happens to other coastal areas. The elevation at Cape Hatteras of the inlet breach area went from 9 meters above sea level to 1–2 meters below sea level, so this type of event would clearly meet the change in elevation criteria for the city of Moroni to be "sunk." In the case of the city of Moroni, the breach effect would have been compounded because water washing into the lagoon from a tsunami or storm surge would also need to exit back into the ocean causing additional erosion of material as massive amounts of water flowed back through the breach.

Moroni itself does not sit within the anticipated area of direct earthquake subsidence but is located in an area of soils susceptible to earthquake amplification of 1.6 points on the Mercalli intensity scale. Being 43 kilometers from the intensity level 8 area (see figure 66) would put it in the intensity level 7 area and by addition of the amplification factor would be 8.6. Because of the susceptible soils, liquefaction could also be a contributing factor to the subsidence. Liquefaction can account for a drop in elevation as it can turn soils essentially into a flowable fluid, which can cause large portions of coastal beach to collapse into the ocean.

Figure 66. Distance from Moroni to level 8 intensity area

The disappearance of a city into the ocean caused by a large earthquake and subsequent liquefaction is not farfetched. In 1692 the pirate port city of Port Royal in Jamaica was hit by a large earthquake. The city was built on a large spit of sand, the sand being saturated with water close to sea level. On June 7, 1692, the devastating earthquake hit the city causing liquefaction of the sand, which caused it to flow out into Kingston Harbor. Most of its northern section fell into the sea (and with it many of the town's houses and other buildings). In addition, the island lost many of its forts. Fort Charles survived, but Forts James and Carlisle sank into the sea. Fort Rupert became a large region of water, and great damage was done to an area known as Morgan's Line. A map showing the extent the Port Royal sank into the sea has been created by a contributor to Wikipedia (see figure 67) based on the historical locations and the currently existing submarine surviving portion of Port Royal (which still exists under 12 meters of water and is a popular diving location).

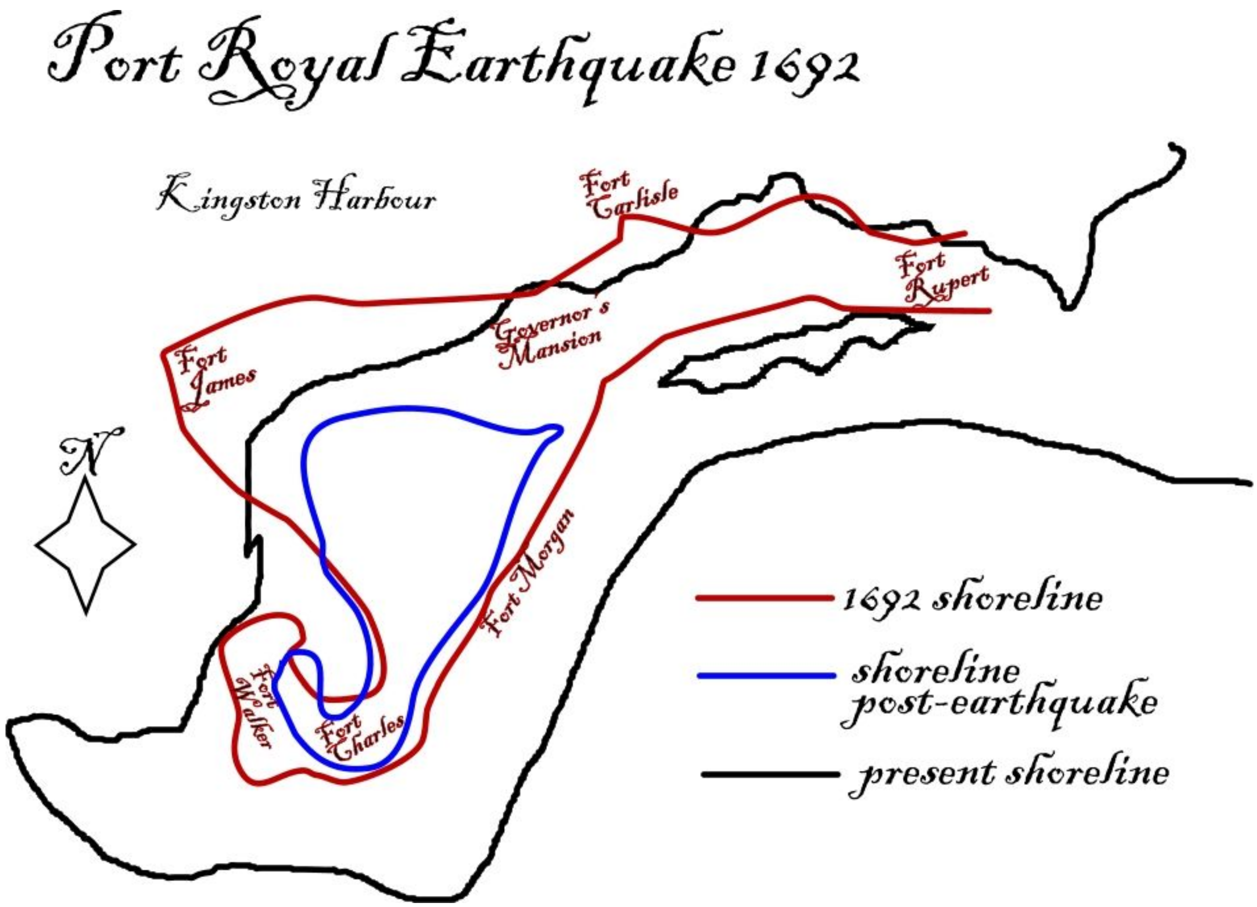


Figure 67. Portions of the city of Port Royal, Jamaica, that sank into the ocean

An examination of recent earthquake data also shows that there are some shallow and intermediate depth earthquakes within 30 kilometers of the proposed city of Moroni, so it is possible there may be an unmapped fault that might also have triggered subsidence in the area.

A best fit explanation for the destruction of the city of Moroni would be a combination of earthquake damage and liquefaction and the impact of one or multiple tsunamis triggered by submarine earthquake movement of the Veracruz fault, a Gulf of Mexico submarine landslide, or volcanic deposition impact into the Gulf from the San Martín volcano. Secondary possibilities would be the impact of a hurricane landfall and a local earthquake on a currently unidentified fault trace. The location specified for the city of Moroni under the Sorenson model is a reasonable fit for the known geology and hydrology.

City of Moronihah

The Sorenson model and Book of Mormon text does not geographically locate the city of Moronihah except that it is in the land southward. The destruction of the city was characterized that "the earth was carried up" upon the city, and that in "the place of the city there became a great mountain." There is no mention of the city sinking, so any hazard scenario would have to assume that the city was buried close to its pre-disaster elevation.

Sorenson opines that the city should be located in the area of the east sea because that is where Moronihah operated as a military leader. This area is a bit problematic in relation to the description of the 3rd Nephi destruction as the land is relatively flat, thus making the "earth carried up" and "became a great mountain" description inconsistent with the hazard types possible in a flat area.

Significant deposition of sediments from a flooded river or a natural dam break might be a possibility if the flood deposition occurred over a significant time period, as dam break overflow deposits can exceed 10 meters in depth, however the deeper deposits generally fill areas of lower elevation and would thus not be considered "carried up." Generally flood-caused deposition is determined by the duration of the extreme flow and the steepness of the slope of the channel, which steepness would not be present in the flat east sea area (Costa, 1988). In addition, while river flooding, tsunami, and hurricane storm surge can "carry up" silt and rock deposits, they have not been observed to create deposits that most would describe as a "great mountain" but are typically in the form of river bars and widespread floodplain sediment deposits, with maximum deposits not exceeding a few meters in elevation.

The area along the Isthmus east sea does fall within a known petroleum and gas basin, so it seems the only possibility that might meet the requirements in the flat terrain is a mud volcano. A mud volcano is caused by areas of underground natural gas overpressure that undergo a pressure explosion, releasing mud to the surface, sometime in large amounts. The mud produced by mud volcanoes is most typically formed as hot water, which has been heated deep below the earth's surface and begins to mix and blend with various subterranean mineral deposits, thus creating a mud slurry. This material is then forced upwards through a geological fault or fissure due to certain local underground pressure imbalances.

Given time, mud volcanoes can become quite large. The largest mud volcano structure, Indonesia's Lusi, which started erupting in 2006, is 10 kilometers in diameter and reaches 700 meters in height.

Significantly sized mud volcanoes can occur within the time frame of the 3rd Nephi disaster (less than three days, probably quicker to account for the high mortality rate). On September 24, 2013, a major strike-slip earthquake rattled western Pakistan, killing at least 350 people and leaving more than 100,000 homeless. The 7.7 magnitude quake struck the Baluchistan province of northwestern Pakistan. Amidst the destruction, a new island was created offshore in the Paddi Zirr (West Bay) near Gwadar, Pakistan (see figure 68). This mud volcano was approximately 100 meters high from its base of the sea floor with a base in excess of 600 meters wide.

Submarine mud volcanoes are a common occurrence in the northern Gulf of Mexico, but none have been reported near the Isthmus. Since a mud volcano adjacent to the east sea would have to occur in conjunction with a large earthquake, it is possible that an historical mud volcano could have occurred in this area. In a sub-tropical climate with heavy rainfall, a mud volcano deposit would not last very long and would be eroded away, so there would be little possibility of locating any remaining mud volcano deposits.

Since there is no geographical placement of the city of Moronihah within the Sorenson model it does not absolutely require that the city of Moronihah be located along the east sea. The hazard description given in the Book of Mormon text better fits a mass movement landslide in a valley setting, specifically a mass movement that pushes up a large ‘mountain’ of material on the opposite side of the valley or ridge. There are two scenarios where this might occur, one would be a large debris avalanche from a volcanic eruption that runs up and and even over areas of topographic relief such as a ridge, an event that occurred during the 1980 eruption of Mount St. Helens (Daniels, 1982, 154); the other would be a large landslide that can occur in valleys with a particular type of geology, often triggered by an earthquake.

Figure 68. Pakistani Mud Volcano formed by 2013 earthquake (NASA, 2014)

Since Moronihah is located in the land southward, there are a few volcanoes (see chapter 3) that were active during the 3rd Nephi period that might be attributed to the destruction of the City of Moronihah, however, there is no direct indication of a volcanic eruption in the land southward in the 3rd Nephi narrative. Rather than a volcanic debris avalanche or pyroclastic flow, one Book of Mormon commentator has suggested that the great mountain might have been a monogenetic volcano (Gardner, 2007, 304), which is a volcano that erupts once and forms from the ground up, with the classic example of the volcano Parícutin that came out of a Mexican farm field (see figure 25). However, all monogenetic volcanoes in the land southward were formed and inactive long before Book of Mormon times.

While there are multiple possibilities, a tentative best fit for the city of Moronihah, and the most probable scenario, is a large landslide that creates a mountain against or because of the opposite valley wall. On November 4, 2007, along the Grijalva River in the state of Chiapas, Mexico, occurred one of the largest landslides ever known. This landslide, known as Juan del Grijalva landslide, destroyed the town of the same name, creating a water and mud wave 50 m high that destroyed the Juan del Grijalva town, killing 20 people and moving 55 million cubic meters of rock and debris down slope to completely block the Grijalva River. According to records from the last century, the Juan del Grijalva landslide represents one of the largest mass movements of earth recorded.

Figure 69. Great Mountain left by the 2007 Juan del Grijalva landslide into the Grijalva River (Reuters, 2007)

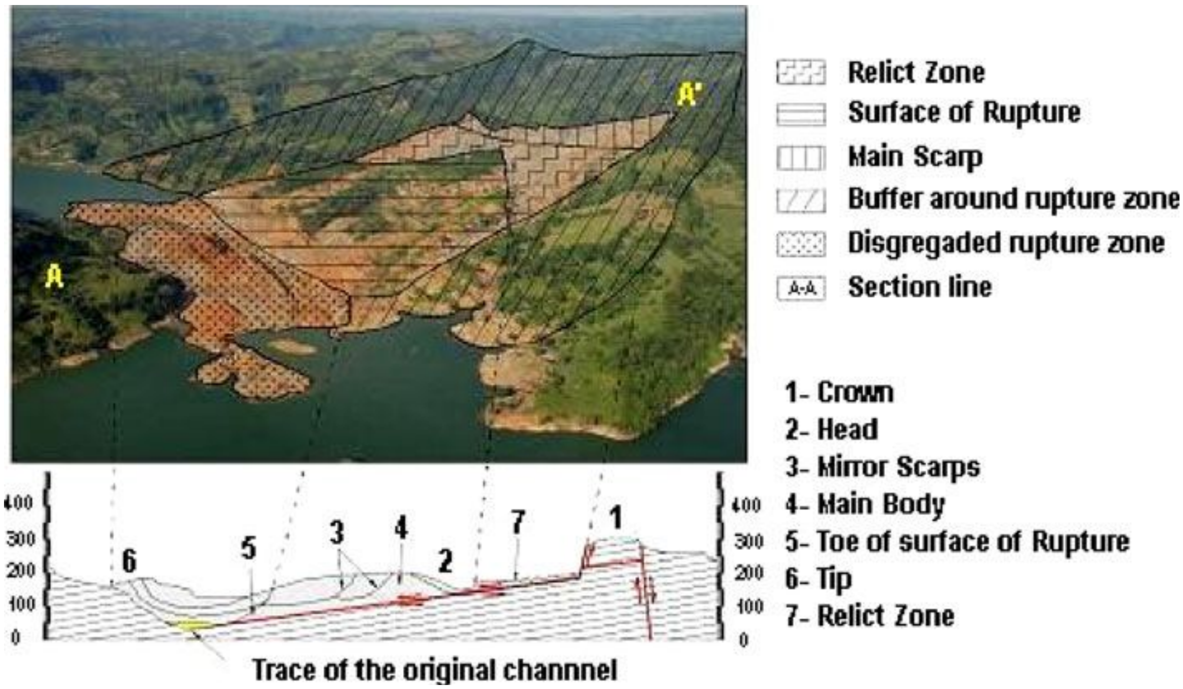


Figure 70. Diagram and cross section of the 2007 Grijalva River landslide showing the burial of the original channel (Serrano et al., 2011)

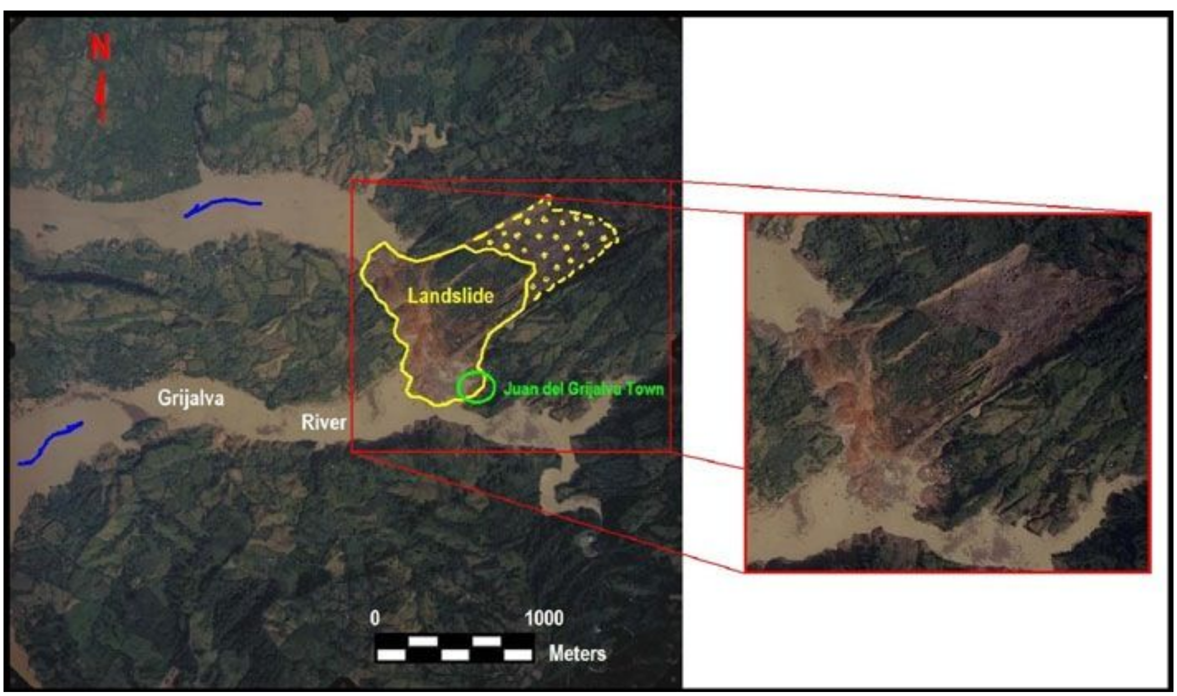


Figure 71. Aerial view of 2007 Grijalva River landslide showing location of the Juan del Grijalva Town (Serrano et al., 2011)

The landslide went through the river, burying the river and whatever was on the riverbank on either side of the river, leaving what could clearly be described as a “great mountain” (see figure 69). The original bed of the river was buried in 100 plus meters of material (see figure 70). The town of Juan del Grijalva was actually along the margin of the landslide but still was destroyed and lives were lost (see figure 71).

In most areas where these types of large landslides have occurred, they are reoccurrences of prior landslides along the same plane of slip. Essentially, once these landslides occur, the river backs up against the landslide material forming a lake until it overtops the landslide material. Once it overtops, it creates a new channel, generally following the alignment of the previous channel. Over time, the toe of the landslide is eroded away. Once the landslide toe material has eroded away, the resistance to slip for the rest of the landslide is removed, allowing for another reoccurrence of the landslide.

It is likely that the Juan del Grijalva landslide is one of these situations, and might be a good candidate location for the landslide that destroyed Moronihah. The landslide area is within the 3rd Nephi regional earthquake Mercalli Intensity level 8 zone, and as previously noted, this is the zone where large landslides are expected to be triggered (see figure 72). While not in the exact area opined by Sorenson as the location of Moronihah, it (or a different landslide further down the Grijalva River valley) would be closer than a volcanic eruption landslide might be.

Figure 72. Location of the 2007 Grijalva River landslide in relation to hypothetical 3rd Nephi earthquake Mercalli Intensity level 8 zone

The best fit for the destruction of Moronihah is a large landslide in a river valley within the intensity level 8 zone of the regional earthquake, with secondary possibilities being a mud volcano or volcanic debris avalanche.

City of Jerusalem

The city of Jerusalem has been identified in the Sorenson model as being on the south shoreline of Lake Atitlán (figure 73), with the identification of the recently discovered submerged city of Samabaj being a prime candidate. There are actually a few potential interpretations of the Book of Mormon text with regards to the demise of the city of Jerusalem. The first is that the waters were caused to "come up in the stead thereof" as limiting the method of demise to the description given in 3rd Nephi 9:7, which is the most common interpretation and the one that Sorenson prefers.

Figure 73. View of the south shoreline of Lake Atitlán, Guatemala (courtesy of wikipediacommons.org)

One reason to believe that there may be additional geologic events going on here is that 4th Nephi 1:9 later states that "there were many cities which had been sunk and waters came up in the stead thereof," indicating that the city of Jerusalem may have in fact physically sunk in addition to the waters coming up, if it was indeed one of the cities referred to in 4th Nephi.

In another interpretation, one which would add the additional events of sinking and burial to the demise of the city of Jerusalem, it has been suggested (Ainsworth, undated) that verses 6 and 7 need to be read together, since the punctuation was not part of the original Book of Mormon translation, and in order to square with the language of 4th Nephi.

The text of the Book of Mormon can be interpreted to say that Jerusalem was sunk and buried with water coming up in the stead thereof when reading verses 6 and 7 in 3rd Nephi 9. The current verses are as follows:

> 6. And behold, the city of Gilgal have I caused to be sunk, and the inhabitants thereof to be buried up in the depths of the earth;
>
> 7. Yea, and the city of Onihah and the inhabitants thereof, and the city of Mocum and the inhabitants thereof, and the city of Jerusalem and the inhabitants thereof; and waters have I caused to come up in the stead thereof, to hide their wickedness and abominations from before my face, that the blood of the prophets and the saints shall not come up any more unto me against them.

Ainsworth argues:

> These verses are divided in a very unusual way. Verse 6 is essentially a fragment of a sentence, ending in a semi-colon (;), not a period. Verse 7 then continues the sentence of verse 6, with *"Yea, and the city of Onihah and the inhabitants thereof…"*
>
> …[T]he use of the term *"Yea, and …"* in the Book of Mormon and it appears 280 times. In 123 cases, this term appears in the middle of a sentence, following the semi-colon (;) of the previous sentence—continuing with the same trend of thought, in the same paragraph.
>
> In 83 cases the term *"Yea, and …"* appears at the beginning of a paragraph, but in only five of these cases, does the previous paragraph end with a semi-colon (;), as in 3 Nephi 9:6-7. Put another way, in addition to 3 Nephi 9:6–7, there are only four other places where one verse ends with a semi-colon, to be followed by the next verse beginning with *"Yea, and…"*
>
> In these other four cases, the second verse, the one beginning with "*Yea, and…*" is a continuation of the thought of the preceding verse—which ends in a semi-colon. (See Mosiah 18:9, Alma 9:22, Alma 13:22, and Helaman 8:9.)
>
> … [I]n my opinion 3 Nephi 9:6-7 should be read as one paragraph, not two, with verse 7 simply being a continuation of what is being described in verse 6.
>
> Here are the two verses as I think they should appear, providing more clarity to what is being described in these two verses:
>
> 3 Nephi 9:6–7 (combined). And behold, the city of Gilgal have I caused to be sunk, and the inhabitants thereof to be buried up in the depths of the earth; yea, and the city of Onihah and the inhabitants thereof, and the city of Mocum and the inhabitants thereof, and the city of Jerusalem and the inhabitants therefore; and waters have I caused to come in the stead thereof, to hide their wickedness and abominations from before my face, that the blood of the prophets and the saints shall not come up any more unto me against them.
>
> Reading the two paragraphs this way changes the meaning of the verses dramatically. Now the event being described is one of four cities sinking into the earth, and then waters filling up the area where these cities once stood.

> Reading the verses this way allows the last comment of verse seven, (… to hide their wickedness …) to apply to all four cities, rather than just three, which makes more sense to me.

Notably, although not mentioned by Ainsworth, there is no mention of the inhabitants “drowning” as was used to describe what happened to the inhabitants of the city of Moroni. The reading of the verses to include sinking and burial as well as inundation would be consistent when considering 4th Nephi 1:9 with regards to sinking, however it would be inconsistent in that 4th Nephi 1:9 does not include burial.

Because of the variability in possible textual interpretations, it will be necessary to look at the best fit analysis using three scenarios with regards to the city of Jerusalem in light of its location in the Sorenson model and others as being on the south shore of Lake Atitlán:

1. The city did not change elevation, but Lake Atitlán raised a sufficient level to cover the city
2. The city sunk, with the potential that the level of Lake Atitlán was also simultaneously raised
3. The city was sunk, buried, and inundated by water in the vicinity of Lake Atitlán

Since the exact elevation of the city and the lake in the first century AD is not exactly known, it will be necessary to make the assumption that the city was adjacent to the shore of the lake on relatively flat land. For purposes of this analysis, the assumption is that a 10 meter rise in the elevation of the lake (or drop in the elevation of the city) would be sufficient to meet the description that the waters have come up “in the stead thereof.”

Scenario 1: Rise in the elevation of Lake Atitlán without subsidence of the city

The only identifiable methods for raising the level of Lake Atitlán are:

- Change in the hydrological regime by decreasing outflow and/or increasing inflow to the lake
- Introduction of material into the lake sufficient to raise the elevation of the lake or a change in the lake bottom geometry

Scenario 2: Rise in the elevation of Lake Atitlán and/or subsidence of the city

In this scenario the identifiable methods are:

- Change in the hydrological regime by decreasing outflow and/or increasing inflow to the lake
- Introduction of material into the lake sufficient to raise the elevation of the Lake or a change in the lake bottom geometry
- Subsidence of a portion of the lake

Scenario 3: Rise in the elevation of Lake Atitlán and/or subsidence of the city with burial of the city

In this scenario the identifiable methods are:

- Change in the hydrological regime by decreasing outflow and/or increasing inflow to the lake
- Introduction of material into the lake sufficient to raise the elevation of the lake or a change in the lake bottom geometry
- Subsidence of a portion of the lake

- Burial by volcanic deposition or landslide

Hydrology of Lake Atitlán

Lake Atitlán is a lake in the Guatemala highlands. It is scientifically classified as endorheic, which means there is no surface outfall. Water leaves the lake through a presumed system of subterranean fractures and/or permeable deposits. Thus, while the inflow to the lake is quite variable depending on weather conditions and especially the occasional hurricane that crosses the region, the outflow remains constant. In consequence, the lake level is quite variable; during extended dry periods the lake level falls and during periods of higher than average rainfall the lake level can rise. The lake is also fed by two rivers, Rio Quiscab and Rio Panajachel.

Atitlán is recognized to be the deepest lake in Central America with maximum depth about 340 m (1,120 ft). The current surface area of the lake is approximately 123 km^2, with around 24 cubic km of water. The lake is shaped by deep escarpments that surround it and by three volcanoes on its southern flank. The lake basin is volcanic in origin, filling an enormous caldera formed in an eruption 84,000 years ago. A caldera is a large volcanic crater formed by an explosion and collapse of the central part of a volcano.

While the outflow remains constant under normal conditions, because the outflow is subterranean, the outflow can be affected by geologic events, specifically earthquakes. In 1976 an earthquake caused a drop of the lake level by 5 meters in a month (Medrano, 2011).

The question related to hydrology involving 3rd Nephi events is whether the hydrology could generate a rise in lake levels enough to cover a city in less than 3 days. In order to perform these types of analysis, it is necessary to determine the volume of water needed to raise the lake sufficient to cover a level city presumably located at or near the water line. It is assumed that 3 meters of water would be sufficient to cover a level city located on the water line. We know that the water line in Book of Mormon times was at least 17 meters below the current average water line based on the known depth of the submerged city of Samabaj (Medrano, 2011). The current surface area of 123 km^2 would not exist at that time; using bathymetric diagrams of the lake, it is estimated that the surface area in those times would be in the neighborhood of 110 km^2. Using these figures, it would require .33 km^3 of water to be added to the lake in a 3-day period of time in order to inundate a city.

Severe historic hurricanes have generated up to 1.9 meters of precipitation during the hurricane event. The catchment area of the Lake Atitlán is 548 km^2 so assuming that the base flow of the river and outfall seepage are in steady state, and that all of the rainfall made it to the lake in a 3-day hurricane period (which is not realistically scientifically going to happen, even in a situation where soils were previously supersaturated, or in the alternative, completely impermeable soils) than the lake could theoretically rise 10 meters in height, more than exceeding the 3 meters needed for submersion of a city.

However, in order to determine what the actual increase in level might be, additional hydrological studies would need to be completed, but it remains a possibility.

Geology Related to Submersion of the City of Jerusalem

An extensive geologic study of the lake was conducted in 1979 (Newhall et al., 1987). The study identified and reached these conclusions (among others):

- There is a probable landslide deposit at the foot of a large landslide scarp that was overlain by 10-15 m of sediment, and thus occurred at least 1,000 and probably several thousand years ago.
- Lava flows from the adjacent Tolimán volcano and its parasitic vent, Cerro de Oro, have occurred within a few (1-2?) thousand years.
- Seismic reflection profiles showed at least 175 m of flat-lying, undisturbed sediments, the result of at least 17,500 years and probably 35,000 year or more of sedimentation. No source vents for either the caldera-forming or subsequent eruptions were identified within these profiles. No resurgent doming or regional faulting is apparent within the same 175 m of sediments in the reflection profiles.

No regional faulting was detected within the sediments at the bottom of the lake during the 1979 study, however gas present in lake sediments made the seismic readings incomplete and inconclusive in determining faulting in the bedrock under the sediments. The study did not evaluate adjacent surface faults. There are local caldera related faults around the lake that may have had past activity, but additional mapping and research will be needed to determine time and amount of movement, if any (Newhall, 1987). Additional research would need to be completed as to the amount of landslide material and/or lava that may have entered the lake during those events to determine what the resulting rise in lake levels might be.

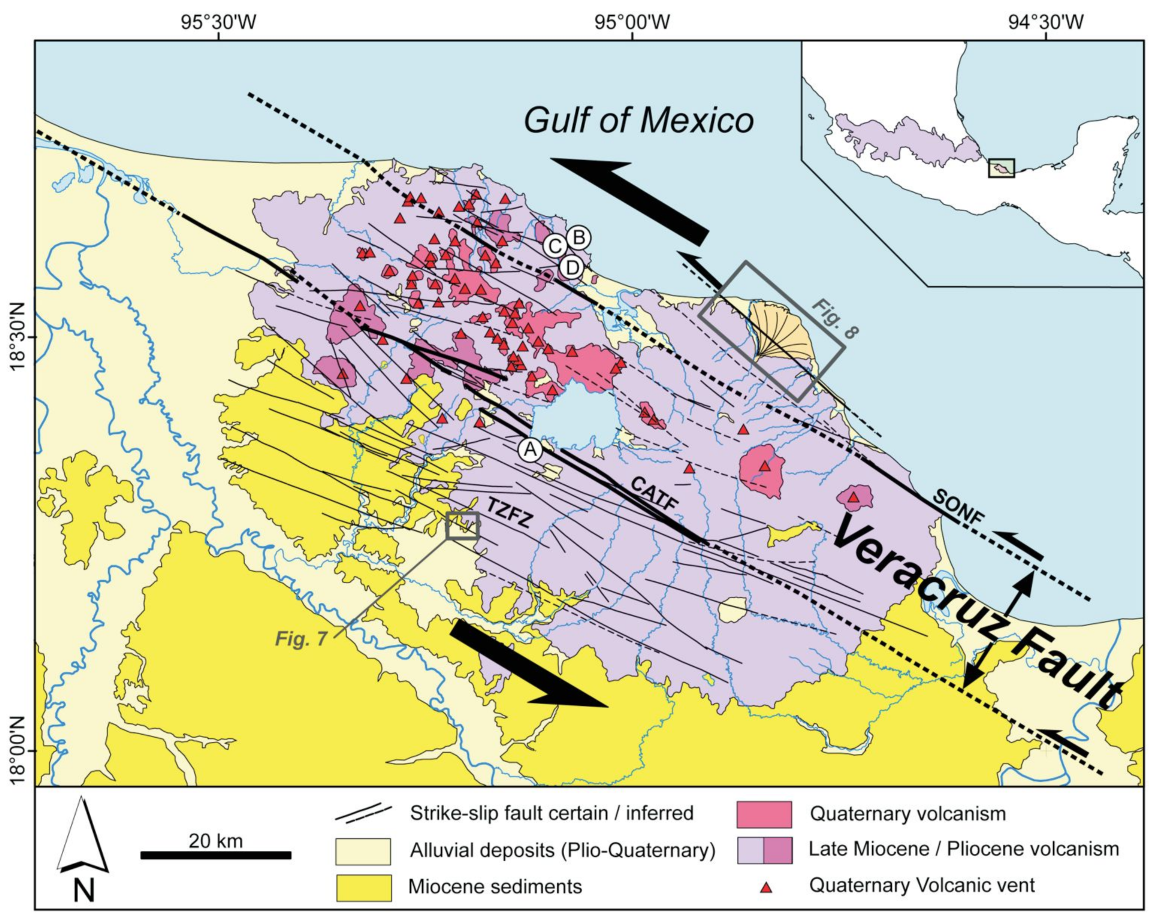
At this point, there is really no scenario that can be ruled out with regards to the city of Jerusalem as there is simply more data to be found and research that needs to be done. Rising water with or without subsidence and with or without burial are all possible. Sorenson's preference for Samabaj as the city of Jerusalem would rule out burial, since the only apparent burial on the site is post submersion lake sediments. Samabaj apparently has some topographic relief so might involve a higher rise in lake levels to be inundated. Since it is not known whether the volcanic activity or the landslide event happened during the correct time frame, any best fit scenario determination at this point would be premature.

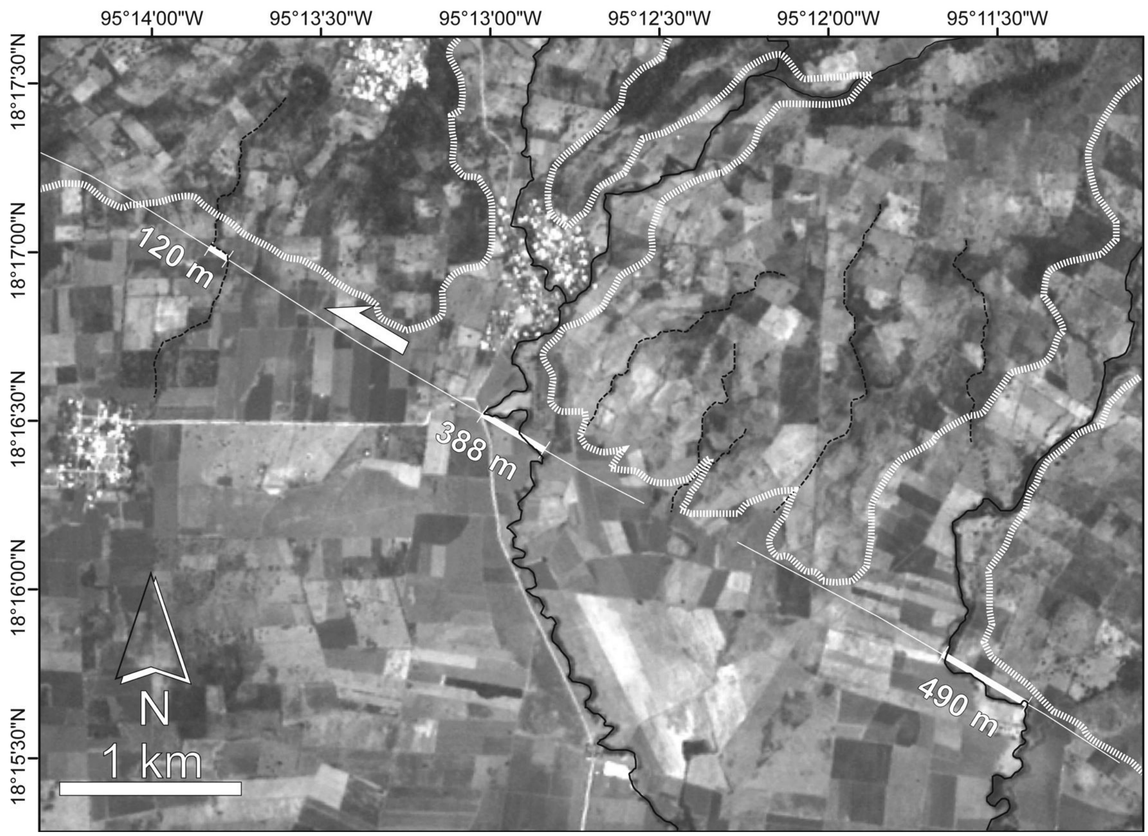
Cities of Onihah and Mocum

The discussion involving the cities of Onihah and Mocum is identical to that of the city of Jerusalem except that these two cities do not have any geographical placement in the Sorenson model, although they may also be located somewhere on the shoreline of Lake Atitlán.

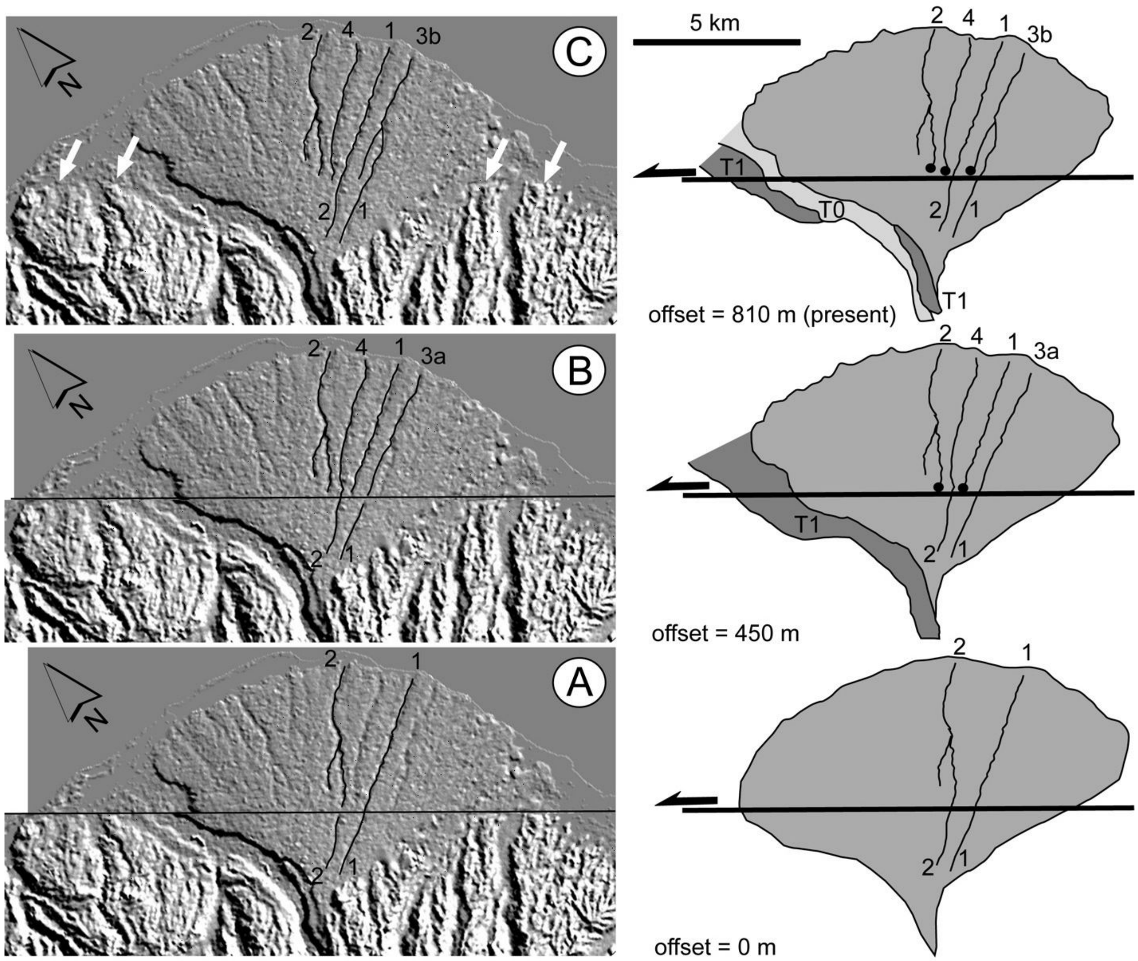
Initially, the Book of Mormon text seems to exclude by silence the possibility of these cities being located adjacent to and being inundated by the sea. The city of Moroni is specifically described as being sunk into the depths of the sea. No such language is found describing the cities of Jerusalem, Onihah, and Mocum. These cities are therefore considered to be located along a water body such as a lake, lagoon, or river, or in an area of high groundwater.

If there is no subsidence involved, the cities would obviously be located on a water body that might somehow have the water levels elevated a significant amount. For a lake, the water levels would rise with the introduction of landslide or volcanic deposits to the lake to raise its elevation. If the cities were along a river, blockage of the river by landslide (similar to the landslide description for the city of Moronihah), or the beheading of a river by later strike-slip fault movement could account for the inundation. Beheading of a river happens when the fault moves the channel of the river sideways, generally impounding the water, sometimes creating a permanent impoundment. Examples of this type of event have been documented in the area of the Tuxtla Mountains, and have probably occurred in other locations. The discussion and examples of this are included here are taken directly from Andreani et al., 2008, as a combined figure 74 (the three following images).





This is a satellite image of an area located in the southwestern part of the Los Tuxtlas volcanic field (the location designated by “Fig. 7” in the preceding image). A discrete fault trace is evidenced here by systematic left-lateral river offsets and by the sharp termination of the volcanic plateau (white dashed lines).



This is a digital elevation model of an alluvial fan in the northeastern part of the Los Tuxtlas volcanic field (the location designated as "Fig. 8" in the first image) and its possible evolution. A fault (marked by white arrows) sharply cut the volcanic deposits and an alluvial fan. Left-lateral movement along the fault is evidenced by the disposition of beheaded channels. The maximum offset obtained by restoring the channels is 810 m. A – The possible initial development stage of the alluvial fan with two main incisions. The fan was probably directly fed by the river. B – The fan is dissected on its left side by the river (deposition of the T1 alluvial terrace). The fault displacement cuts the streams on alluvial fan. The 1 and 2 beheaded lower streams are replaced by new ones (3a and 4). C – The present situation with an entrenchment of the river (T0 alluvial terrace) and a new stream displacement. The lower stream 1 is captured by the upper stream 2.

Figure 74. Combined figures and discussion of beheaded streams from lateral strike-slip movement (Andreani et al., 2008)

Inundation by a river beheading process would be expected only in the area of fracture and rupture identified by figure 61. If a river is blocked by landslide or a lake elevation is raised by landslide causing an adjacent city to be inundated, then the expected area where that might occur is identified in figure 59. If there is a river that is blocked by volcanic deposition or a lake elevation that is raised by volcanic deposition in the lake causing an adjacent city to be inundated, then the expected area where that might occur is identified in figure 76.

If subsidence causes inundation of a city that is adjacent to a lake or river, or is located in an area of high groundwater, then the expected area where that might occur is identified in figure 61. As some interpretation of the text would indicate burial, this would indicate burial by either a landslide or by volcanic deposition, indicating that this would occur in areas shown in figure 59 or figure 76 respectively.

The above listed interpretations would all be the best fit locations for Mocum and Onihah given the potentially different parameters dictated by the varying textual interpretations. A secondary best fit interpretation could also place these cities along the shoreline of Lake Atitlán if in fact the entire Lake was raised in elevation as discussed in the situation of the city of Jerusalem. If Jerusalem, Mocum, and Onihah are not the cities referred to in 4th Nephi, then the best fit analysis described here would also apply to those unnamed cities that were actually sunk.

Cities of Gadiandi, Gadiomnah, Jacob, and Gimgimno

The cities of Gadiandi, Gadiomnah, Jacob, and Gimgimno are described as being “sunk and made hills and valleys in the places thereof” with their inhabitants being “buried up in the depths of the earth.” The subsidence element places them within the area shown in figure 76. The “hills and valleys” description is quite informative as it is a perfect description of the uniquely hummocky deposits of many volcanic debris avalanches and some volcanic pyroclastic flows (see figure 75). These were not really recognized as a unique identifying landform of volcanic deposits until after the 1980 Mount Saint Helens eruption.

Figure 75. Hills and valleys (hummocks) formed by 1980 Mount St. Helens eruption debris avalanche and pyroclastic flow (USGS, 1999)

Hummocks and mounds have been identified as features in some other non-volcanic large earth landslides, but are most common in volcanic landslides and pyroclastic flows. The cities mentioned here were probably somewhat near each other, as volcanic landslides and pyroclastic flows are very directional. A typical volcanic eruption with pyroclastic flows will have one direction of eruption, sometimes two. The tectonic setting of the volcano may influence the direction of collapse and in some cases faulting may trigger collapse.

For purposes of locating the cities of Gadiandi, Gadiomnah, Jacob, and Gimgimno in reference to the "hills and valleys" method of burial, the best fit is clearly within the range of a pyroclastic flow or volcanic debris avalanche of a volcano. The best fit volcano is San Martín, because Pico de Orizaba is not within the best fit area of subsidence. As mentioned in chapter 3, the report from the 1793 eruption of San Martín indicated that the fallout was from at least 3 yards up to 6 yards thick located in a circle around the volcano with a diameter of 11.1 kilometers. Assuming that one could bury a city with a minimum of approximately 2 to 2.5 meters of material, and accounting for a potentially larger volcanic eruption than the 1793 eruption, a much greater distance than 5 km from the volcano cone would be possible for city burial.

Based on archeological excavations at Tres Zapotes (Jaime-Riverón and Pool, 2009, and Santley, 2007) and Lake Catemaco (Santley et al., 2000) that identified volcanic deposits within the time frame of 3rd Nephi, a reasonable extent of these deposits would be 26 km from the San Martín cone.

Without more detailed mapping of volcanic deposits, it is necessary to consider that the eruption could have gone in any direction when assigning an area where Gadiandi, Gadiomnah, Jacob, and Gimgimno might have been located. In addition, the inactive volcano south of San Martín called San Martín Pajapan volcano has a crater that opens to the east with debris avalanche deposits extending 20 km to the Gulf of Mexico and the Santa Martha Volcanic Complex adjacent to San Martín Pajapan has two craters opening to the south with debris avalanche deposits (Capra et al., 2002), so lacking any more exact mapping and dating of the debris avalanche deposits these areas must be considered as a possible areas of "hill and valley" burial as these structures also sit in the earthquake zone of subsidence. Therefore, the area identified in figure 76 would be a reasonable area where one might expect to find the cities Gadiandi, Gadiomnah, Jacob, and Gimgimno, with the likelihood that some or all of them are located near each other.

Figure 76. Zone of "hills and valleys" deposition either from volcanic eruption deposits (within 26 km of cone) or debris landslides

City of Gilgal

The city of Gilgal was sunk and covered with earth. Subsidence places the city in a best fit scenario within the level 8 Veracruz fault area identified in figure 61. In order to be covered with earth, it would have to either be in the "hills and valleys" area shown on figure 76 (even though the final cover is not described as a hill and valley, it is possible that not all of the material deposited would have formed hills and valleys) or in an area where significant adjacent slopes exist subject to landslides, typically in a valley. Given the fact that there is a reference to the valley of Gilgal in the book of Ether, the valley scenario is considered the best fit for this city. The best fit for the city of Gilgal is the area identified in chapter 10 (figure 61) within the Mercalli level 8 earthquake zone where most major earthquake-triggered landslides would be expected to occur.

Cities of Jacob-Ugath, Laman, Josh, Gad, Kishcumen

The descriptions given of the destruction of Jacob-Ugath, Laman, Josh, Gad, and Kishcumen are that they were "caused to be burned with fire"; and Jesus Christ "did cause them [the inhabitants] to be burned" and "did send down fire and destroy them." The most obvious explanation for this method of destruction is ignition of the cities by volcanic fallout. No mention is made of these cities sinking, so they may or may not have been within the zone of potential earthquake subsidence. Also this is obviously a different description than Zarahemla, which merely did "take fire." It seems pretty clear that the city and the individuals in the cities and the cities themselves were directly burned by the fire that came from the sky, not by a secondary conflagration caused by a lightning strike or an earthquake triggered event.

There are no real studies that model the maximum distance that can be covered by incendiary material from a volcanic eruption. Clearly the closer to the volcano, the higher chance there is of hotter fallout occurring. Meteorological patterns can also be influential as the cooling of volcanic material is a function of the time elapsed since ejection from the volcano. The best information for a maximum area of incendiary material probably comes from the eruption of Krakatoa where ash fallout 70–80 km from the volcano was still hot enough to burn holes in clothing and vegetation (Bryant, 2005, 233). Using the 70 km distance, the San Martín volcano area identified in figure 77 is the best fit probable area where the cities Jacob-Ugath, Laman, Josh, Gad, and Kishcumen were located, with secondary possibilities being a 70 km area around Pico de Orizaba or Popocatépetl (not shown in figure 77).

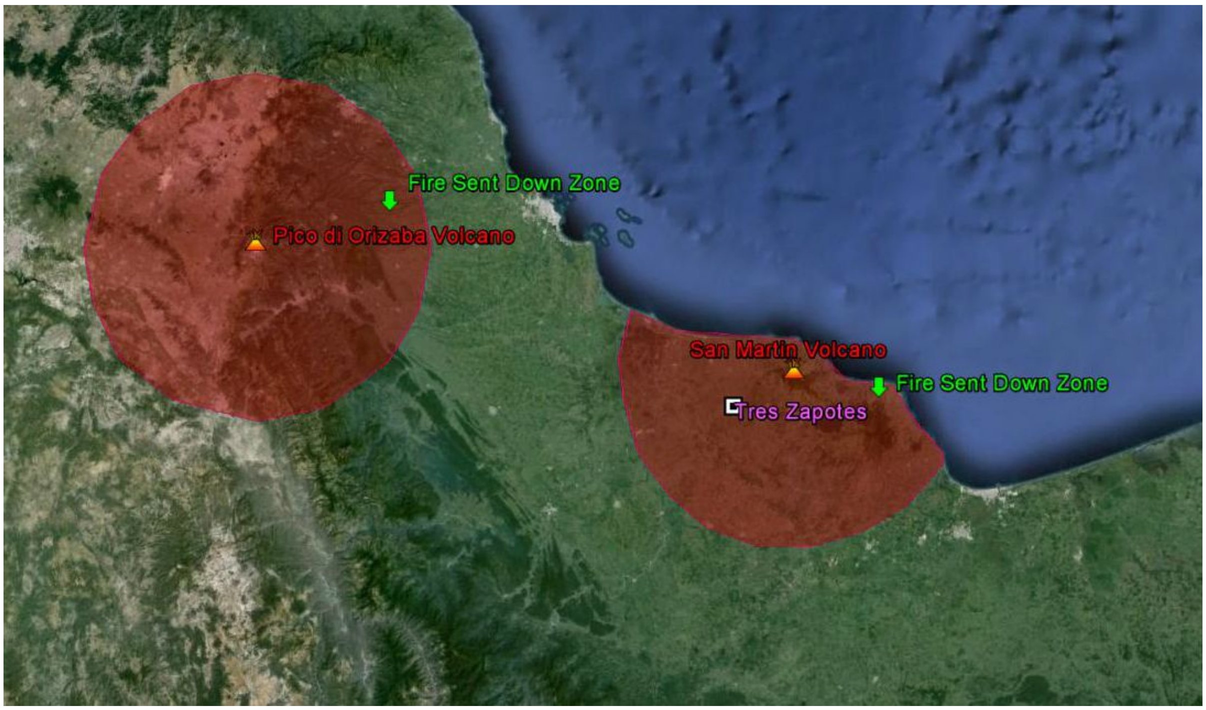


Figure 77. Zone of raining of fire for the Pico de Orizaba or San Martín volcanoes (within 70 km of the cone)

City of Bountiful

The temple in the land of Bountiful is not noteworthy because of the description of its destruction, but is noteworthy because it was apparently not destroyed as is recounted in 3rd Nephi 11:1. It was also situated in a geographic position such that the people were observing "the great and marvelous change that had taken place." The scriptures do not say what the level of damage may have been at the temple or in the land of Bountiful, but the location clearly was positioned to support a multitude of 2500 persons (3rd Nephi 17:25) who were at or near the temple, and after Jesus appeared these men, women, and children were told to return to their homes (3rd Nephi 17:3), which they later did (3rd Nephi 19:1). The locale also contained or was immediately adjacent to a much larger population than 2500 persons because overnight, just by word of mouth, an "exceedingly great number" of persons were on hand the next day (3rd Nephi 19:3). The temple was also adjacent to some type of body of water (3rd Nephi 19:10).

Houses were apparently still standing and habitable, and a large number of persons survived whatever damage had occurred (if any). The scripture does not refer to the city of Bountiful, but refers to the temple that was in the land of Bountiful. It is clear from the number of people at the temple with homes nearby that the temple was located in or immediately adjacent to a city. Although the scripture does not explicitly identify the "city" of Bountiful, it can be inferred that the temple was located at the city of Bountiful. There is some indication that on at least on one occasion, the term "land of Bountiful" and the term "city of Bountiful" were used interchangeably (Alma 53:3).

The Sorenson model identifies the city of Bountiful as being in the area of the current city of Tonalá, which is located on the west bank of the Tonalá River prior to it discharging into the Gulf of Mexico, with an approximate longitude/latitude location of 18° 12' 16" N and 94° 08' 41" W. This location does lie within the Mercalli zone 8 area, however it is located on stable bedrock consisting of conglomerate, sandstone, and siltstone formations, which may have dampened surface oscillations somewhat limiting the earthquake damage (see figure 60).

Importantly, directly across the Tonalá River is an entirely different seismic situation, as the soils and sediment are marsh deposits that are extremely susceptible to amplified ground shaking and potential liquefaction. The estimate for the amplification increase for this material, which extends for kilometers eastward and southward, is that it would add 2.4 points to the Mercalli scale, making the level 8 intensity estimated for the area a 10.4 (see figure 60). The destruction description for level 10 and 11 intensity is:

> 10. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
>
> 11. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

The identification of Bountiful located at Tonalá under the Sorenson model is directly supported by the underlying geology and the regional earthquake scenario. The indication that Bountiful exhibited a much lower level of damage than areas immediately adjacent is supported by the underlying stable rock where Bountiful is, and is also supported by the extensive damage caused by the earthquake amplification in the marsh alluvial deposits that would have occurred within sight easterly across the river for long distances east and south. This clearly squares with the people "marveling and wondering" and "were showing one with another the great and marvelous change which had taken place." No doubt some of the wonder would have been caused by seeing the relative difference in levels of destruction from one side of the river to the other.

Also, since the earthquake would be stronger (even in the stable rock) further to the south and west, this location for Bountiful would have received the lowest intensities of the earthquake anywhere north of the Veracruz fault, as it was the farthest point away from the fault before encountering soils and sediments that significantly amplify the earthquake shaking. It would have been the area of least damage in the region where people might logically gather after a large earthquake.

The Tonalá location is an absolute best fit for the city of Bountiful.

Events Without Geographic Specificity

There are a number of events in the prophecies and in 3rd Nephi that do not have geographic specificity, but they also have best fit explanations as to the geologic event that they are linked to, so in that sense are tied to geography. These events can be analyzed with best fit analysis, but for the most part they are all explained by volcanic eruption or by a regional earthquake.

Noises

The 3rd Nephi account references three types of noises: (1) terrible thunder that occurred for three hours, (2) tumultuous noises that occurred for three days, and (3) dreadful groanings that occurred for three days. The best fit for all of these is a volcanic eruption coupled with a regional earthquake and aftershocks.

—Terrible thunder

The "terrible thunder" occurred initially and during the first three hours of the catastrophe with the clear best fit being the initial explosive events of the volcanic eruption. Besides the noise of the explosions, upon initial eruption, volcanoes produce an initial pressure or shock wave. When Mount St. Helens erupted, the pressure wave preceded the initial blast and the blast was described as a "roaring noise" (Rosenbaum et al., 1981).

The terrible thunder was also referenced as part of the force that caused the whole face of the land northward to be changed, so by implication it was part of the volcanic eruption. Secondarily, earthquakes can also create sonic booms in some geologic settings (discussed further in chapter 13).

—Tumultuous Noises and Dreadful Groanings

"All manner of tumultuous noises" are mention as continuing, at least intermittently, for three days as well as "dreadful groanings." The range of noises that can be created by a volcanic eruption range across a broad sound spectrum from whistles, jetting, and hissing from the escape of subterranean gases to rumbles from debris avalanches to harmonious sounds that develop in lava tubes to loud explosions from ongoing eruptive release. Scientists have characterized the captivating diversity of acoustics generated from outgassing and fluid dynamic processes as a "volcanic symphony" (Garces et al., 2013, 368). This range of noise would clearly encompass the description of "tumultuous noises" and "dreadful groaning" referred to in 3rd Nephi.

As previously mentioned, the 1793 San Martín volcanic eruption produced around 400 phreatomagmatic explosions, which the inhabitants mistook as cannon fire. Ironically, even though cannon fire was clearly not a part of the Book of Mormon, when the Book of Mormon quotes Isaiah, the term "tumultuous noises" is used to describe the noise of gathering and mustering for battle.

> The noise of the multitude in the mountains like as of a great people, a tumultuous noise of the kingdoms of nations gathered together, the Lord of Hosts mustereth the hosts of the battle. 2 Nephi 23:4

The term “tumultuous noises” is used in one other place in the Book of Mormon, involving another volcanic event that is discussed in further in chapter 13.

> And it came to pass when they heard this voice, and beheld that it was not a voice of thunder, neither was it a voice of a great tumultuous noise, but behold, it was a still voice of perfect mildness, as if it had been a whisper, and it did pierce even to the very soul. Helaman 5:30

Earthquakes can also create a small variety of noises as compared to a volcano. Most earthquake seismic wave sounds are below the audible range for humans. Except for the sonic booms that can accompany earthquakes, most of the sounds associated with earthquakes are described as low rumbles or the sound of grating rocks. These sounds might better fit into the “dreadful groaning” category.

Exceeding Sharp Lightening

Without having witnessed a volcanic eruption, one might seek to explain the reference to “exceeding sharp lightening” by a severe thunderstorm, however the nature of volcanic lightning is something to behold and very clearly is the best fit based on the Book of Mormon description, with the statement that it had “never had been known in all the land” definitely not an exaggeration. Figures 78 and 79 demonstrate the nature of this lightening. Even though there is some time lapse as part of the photography, the volcanic lightening is awe-inspiring, and would truly strike fear in anyone who witnessed it.

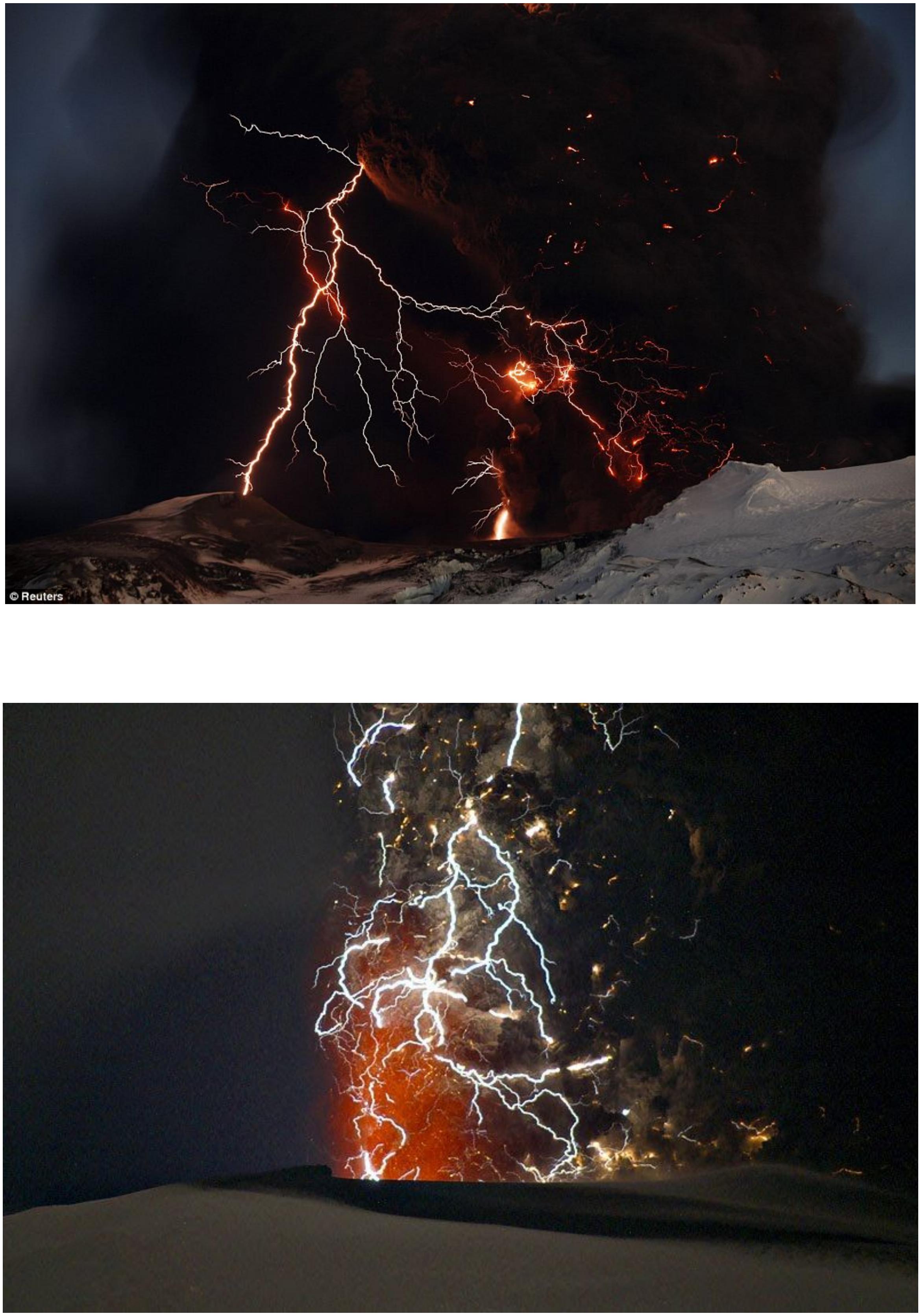


Figure 78. Volcanic lightning from the Eyjafjallajokull, Iceland, volcano, April 2010 (courtesy Reuters)

Figure 79. Volcanic lightning from the June 2011 eruption of the Cordón Caulle volcano in Chile (courtesy Negroni, 2014)

Figure 79 continued. Volcanic lightning from the June 2011 eruption of the Cordón Caulle volcano in Chile (courtesy Negroni, 2014)

Earthquake Related Events

The following events mentioned in the 3rd Nephi account can be related to a regional earthquake, but do not have any other specific geographic tie. The best fit for this occurrence is within the Mercalli intensity 8 zone shown in figure 61.

- Mountains tumbling into pieces
- Earth trembling (3-day duration, earthquake aftershocks)
- Rocks rend
- Earth rent
- Earth cleaved together
- Opening of the earth
- Face of the land changed
- Breaking up and scattering of rocks

Volcanic Eruption Related Events

The following events mentioned in the 3rd Nephi account can be related to a volcanic eruption, but do not have any other specific geographic tie. The best fit for this occurrence is a location within the “hills and valleys” area shown in figure 76.

- Mountains tumbling into pieces
- Earth trembling (3-day duration, earthquake aftershocks)
- Rocks rend
- Earth rent
- Earth cleaved together
- Opening of the earth
- Breaking up and scattering of rocks
- Opening of the earth
- Fire and smoke
- Face of the land changed

Mountains Made Low “Like unto a Valley”; Valleys Which Shall Become Mountains

The method by which valleys become mountains was previously discussed in the section on the city of Moronihah. The description of mountains made low “like unto a valley” can be explained either by (1) a volcanic debris avalanche, which involves the collapse of a volcano during eruption or of a weakened weathered volcanic deposit or by (2) a large landslide. Of particular interest is the description “like unto a valley.” The language is different than merely referring to them as a valley, because the landform being described is not quite like a normal valley. This description is quite accurate as the valleys that result from both the volcanic avalanche and a large landslide are not exactly valleys, as they have a headwall on the upper slope and the valley that forms is somewhat of a U-shape instead of a classic V-shaped riverine valley and are often referred to as landslide scarps. An example of a collapsed volcanic cone is shown in figure 80; this type of horseshoe-shaped valley landform is typical. Geographically, the best fit for this occurrence is a location within the “hills and valleys” area shown in figure 76. An example of a something “like unto a valley” formed from a landslide is shown in figure 81. The best fit for this occurrence is within the Mercalli intensity 8 zone shown in figure 61.

Figure 80. Debris avalanche scarp of White Island Volcano, New Zealand (courtesy http://wikitravel.org, 2014)

Figure 81. Landslide scarp from 1995 La Conchita, California, landslide (courtesy National Geophysical Data Center, NOAA, http://www.ngdc.noaa.gov/hazardimages/picture/show/1562)