A magmatic model for the origin of large salt formations

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Large formations of rock salt are found on every continent around the world. Oil and gas are often associated with salt deposits, which can rise kilometers above the top of the main underground salt body. These salt deposits are commonly referred to as "evaporites" because they are considered to have been formed by the evaporation of sea water. The evaporite model requires the evaporation of hundreds of kilometers of depth of seawater, a process that would require vast periods of time, far longer than the biblical timescale. Consequently evaporites have been used as an argument against young-earth geology. However, there are major problems with the evaporite model such that it is totally inadequate to explain the thickness, volume, structure and purity of salt deposits. A more feasible model regards salt deposits as the product of igneous halite magma. Such magmas melt at geologic temperatures, flow readily, and account for the association of salt deposits with reserves of coal, oil and gas. A modern analogy of such magmas, although considerably smaller in scale, can be found at the Ol Doinyo Lengay volcano in the north of Tanzania within the Great Rift Valley. With the magmatic model large salt formations are emplaced rapidly by igneous processes, a mechanism that is consistent with the biblical timescale and a young earth.

Salt formations worldwide

Rock salt formations are found all over the world on every continent. They extend deep underground. Some well-known deposits such as the Permian Zechstein deposit in Europe, the Jurassic Gulf Coast deposit in the Americas and the Miocene Red Sea and Persian Gulf deposits in the Middle East have salt pillars which rise nearly 4 km above the top of the main salt body. Oil and gas are often found under such salt deposits.

The salt structures are composed mainly of sodium chloride (NaCl up to 96%) with some other salts like potassium chloride (KCl) and magnesium chloride ($MgCl_2$) present. These accessory salts are mainly found deposited in thin horizontal layers within the inner cores of the massive formations,[1] and not at the edges.

The common explanation for the genesis of these rock-salt deposits is that the salt was evaporated from sea water, hence the name evaporites. The evaporite model requires the evaporation of immense depths of seawater, a process that would require vast periods of time, far longer than the biblical timescale. Consequently evaporites have been used as an argument against the biblical timescale and the young-earth.

The basic idea was developed by Ochsenius in the late 1800s and is called the "barrier theory". He developed this idea from estimates of the salt that evaporated in the Caspian Sea in 1877.[2] His theory describes how salty seawater floods over a sandbank into a large shallow enclosed area. The confined area behind the sandbank gets heated by the sun causing the seawater to evaporate and deposit the salt. The shallow sea must be located in an area of high sunlight where evaporation is greater than the rainfall.

Since the 1960s, and until recently, many geologists were convinced that "evaporates" formed in a tidal-flat environment.[3] But for salt deposits with thicknesses as much as 10 km the process of flooding and evaporation would have to be repeated tens of thousands of times. Nowadays, this solar evaporitic origin is highly contentious.[4,5] Hydrothermal water evaporation has been proposed as a mechanism, but it fails to explain the huge size of the massifs. Therefore the marine origin is still taught to students and presented to visitors of salt mines.

However, the evaporation theory has major problems dealing with large salt formations:

1. To form a deposit only 1 km thick would require seawater 60 km deep to be evaporated.[6]
2. The salt formations show negligible contamination with sand, contradicting the evaporation model which requires a sandbank in combination with consistently dry weather over a long period of time. This process would introduce a lot of sand into the salt evaporation enclosures.
3. The salt formations exhibit negligible contamination with marine fossils, contrary to what would be expected with seawater constantly flooding into the evaporation area and the enormous amount of seawater involved.
4. The evaporation areas need to be in regions of high sunlight and low rainfall if the seawater is to evaporate. However, the distribution of salt deposits globally contradicts the idea that all of these areas were once near the equator for the required time to achieve such a result.

Igneous origin of salt formations

James Hutton had a different view on the origin of salt formations. He identified concentric circles in a salt mine in Cheshire (UK) in 1774 and concluded: "It is in vain to look, in the operations of solution and evaporation, for that which nothing but perfect fluidity of fusion can explain."[7]

Such an igneous origin for the formation of salt deposits explains the evidence well:

1. The temperature required to melt salt and create a salt "magma" are well within the range of magmatic temperatures for silica magmas, which are common in the stratigraphic record. Melting temperatures for typical salts found in salt deposits are given in table 1.
2. Molten NaCl flows easily like water (viscosity of NaCl at 850°C is 1.29 MPa.s;[2] viscosity of water at 20°C is 1.00 MPa.s), so a salt magma will flood into the lowest areas.[8] Because of its density it will displace any water and cause it to boil. The boiling water will create the typical accessory deposits around salt formations like anhydrite ($CaSO_4$) and calcite ($CaCO_3$).[9] The next eruption will cover these anhydrite and calcite deposits and again flow into the water and cause it to boil. This process can repeat many times. In addition, the surrounding sea water can be a source for the marine fossils occasionally found within the salt layers. Of course, most marine fossils (algae and zooplankton) will be found within the anhydrite and calcite deposits.
3. It is well known that silica magmas can produce layered igneous intrusions. Likewise, the crystallization and cooling of the salt "magma" after emplacement will cause segregation of the different salts into layers within the core of the deposit, as found in the formations. Note that the low viscosity of the haline magma will facilitate the loss of heat by convection, which will cause the NaCl to solidify first while the salts with a lower melting point will follow later. Sometimes this crystallization process is interrupted by new pulses of magmatic salt intrusion.
4. The Great Rift Valley is a 6,000-km-long geographic trough formed as the result of a parting of the continental crust from northern Syria in southwest Asia through the Dead Sea and the Red Sea into central Mozambique in East Africa, as shown in figure 1. Several volcanoes are active within this rift valley which also hosts several salt massifs such as the Dead Sea and the Danakil formations, which are 10 km and 5 km thick respectively. Given the location of these massifs it seems obvious that these have a volcanic origin.[10]
5. Although the origin of the salt magma is not known at this stage, it must have originated from deep inside the crust of the earth. For a modern analogy of magmatic salt formation we can look at the Ol Doinyo Lengay volcano in the north of Tanzania within the Great Rift Valley.[8] The unusual black natrocarbonatite lavas from this volcano erupt at a relatively low temperature (~510ºC) and are much more fluid than silicate lavas.
6. The surface of the molten salt flow will quickly solidify upon contact with water, forming an impervious crust. Organisms and vegetation deposited in the valleys (or under the water) that are overrun by the flow of salt magma will, in the absence of oxygen, be transformed into coal, oil and gas. The impervious salt layer can form a gas tight enclosure able to store the gases and liquids generated. Organic material contained within the nearby lime and anhydride may also transform into coal, oil and gas, but at lower temperatures and more slowly. The magmatic origin of these salt formations explains the connection between the salt deposits found around the globe and the associated coal, oil and gas reserves.

Table 1. Melting and boiling temperatures of the layers in the salt formations (from ref. 11). ND = Not determined.

Minerals found in salt formations		Melting point (°C)	Boiling temperature (°C)
Halite	NaCl	801	1461
Sylvite	KCl	776	1500
Magnesium salt	$MgCl_2$	714	1412
Carnallite	$KMgCl_3.6H_2O$	117	ND
Bischofite	$MgCl_2.6H_2O$	ND	ND

Diagenesis of salt after original deposition

As the solid formations cool, the contraction of the deposit will create stresses and faults. In addition, the salt deposits are easily deformed by tectonic movements in the surrounding country rock. Indeed, the higher the temperature of the salt, the less resistance it has against creep.

The salt deposit in the Danakil Desert shows another form of diagenesis. The surface of this desert is 120 m below sea level, which means the salt formation is subject to groundwater pressure that creates a flow through faults and tears in the 5-km-thick formation. The interaction between the groundwater and the salt deposit emerges from the surface as hot hydrothermal salty brine.

Conclusion

The huge salt deposits found around the globe are not the result of the evaporation of seawater over long periods of time. Rather, the deposits were emplaced as a molten magma at temperatures above 800°C. The evaporite model requires much more time than is available for the biblical timescale. However, the idea that the deposits were formed by the evaporation of hundreds of kilometers of depth of seawater is totally inadequate to explain the thickness, volume, structure and purity of salt deposits. On the other hand, the model that has the deposits resulting from the generation of large volumes of molten salt "magma" explains the evidence. Furthermore, with the magmatic model the large salt formations are emplaced rapidly by igneous processes, a mechanism that is consistent with the biblical timescale and a young earth.

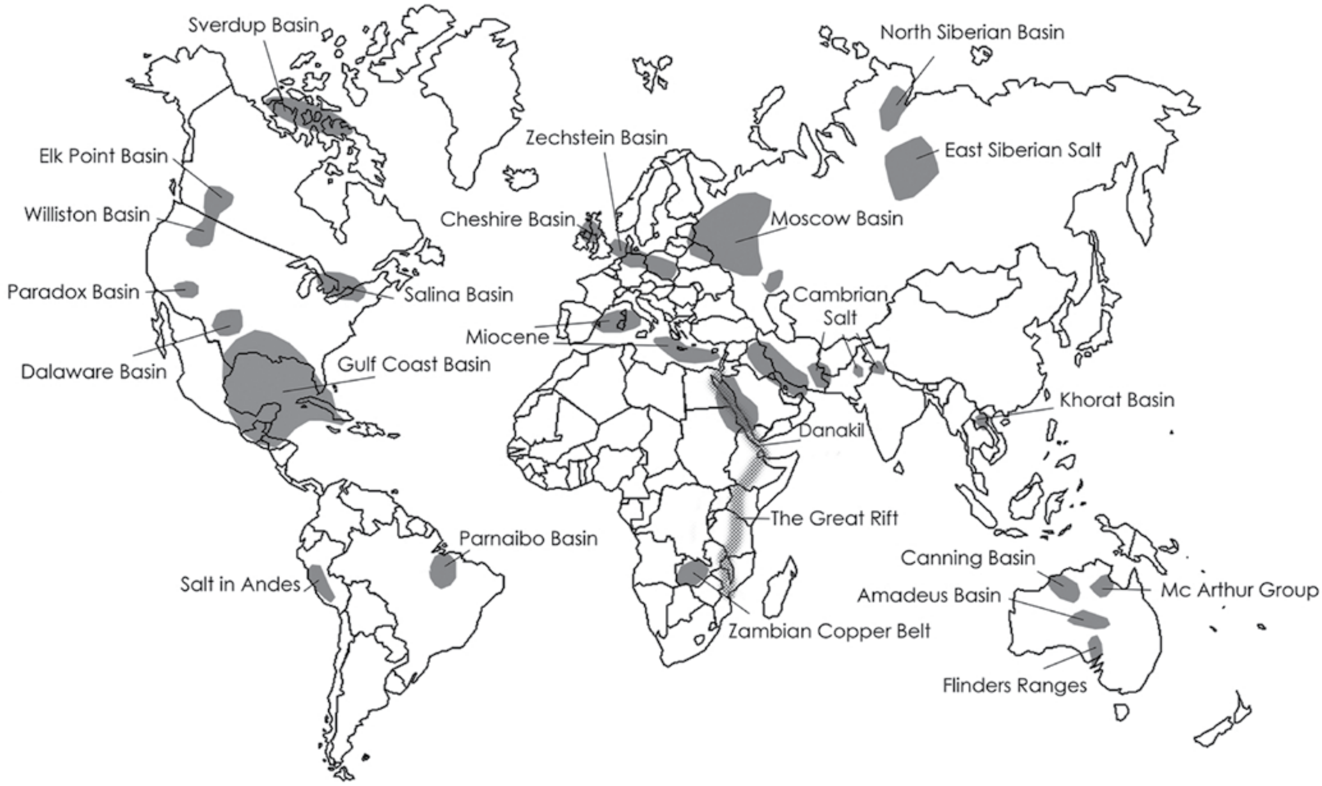

Figure 1. The major salt formations of the world (from ref. 9) together with the location of the Great Rift Valley in Africa.

References

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5. Evaporites could form without evaporation (Talk.Origins), <creationwiki.org/Evaporites_could_form_without_evaporation_(Talk.Origins)>; accessed 16 September 2009.
6. Given the current salt content of sea water (3.5 % by weight) and a specific gravity of NaCl (2,162 kg/m3). See *Ullman's Encyclopedia of Technical Chemistry*, ref. 2, p. 180.
7. James Hutton, *Theory of the Earth*, 1788, The Geological Society Publishing House, Bath, UK, p. 29, 1997.
8. The name of this unique volcano means "Mountain of God" in the local language, and is still active. It produces natrocarbonatite lava, which is rich in the rare sodium and potassium carbonate minerals, nyerereite ($Na_2Ca(CO_3)_2$) and gregoryite ($Na_2K_2Ca(CO_3)$). The origin of the lava is unknown. The volume of lava is relatively small compared with the volume of haline magma that formed the huge salt deposits around the world.
9. Warren, J.K., *Evaporites—Sediments, Resources and Hydrocarbons*, Springer, Dordrecht, The Netherlands, p. 44, 2006.
10. The destruction of Sodom and Gomorrah in Genesis 19:23–28 could be interpreted as an eyewitness report of a salt eruption. The events described in Genesis were insufficient to produce a 10 km deep salt deposit, but this occurrence may have been something like an aftershock or an expansion of the Great Rift in a northern direction.
11. *Ullman's*, ref. 2, p. 180.

Stef Heerema received a Bachelor of aircraft engineering in the Netherlands. He was involved in the installation of a salt bath for heat treatment as well as being a sales representative for steam installations. Later he was posted to the UK with Urenco (uranium enrichment). With his consultancy, he investigated the feasibility of new salt mine. He lectures on the topic of salt formations and has written a book, *The Revolution Theory*, which shows that the salt pillars around the world can be explained by the interaction of a melted salt magma with the waters of the worldwide Flood.