Revealing the original purpose engineered Qanat- Karez- Falaj salt leaching system compared to the Sabkha salt leaching and recovery today

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Abstract:

Academic estimates cite the principle use of Qanat/Karez water to have been for domestic irrigation purposes, however, the human engineering effort required for building these ancient Qanat systems was clearly so great that other, far more valuable options were the motivation for such a wondrous endeavor, consistently matched and compared to the Pyramids or the Great Wall of China.

The surface crust of an inland Sabkha basin typically is made up of layers of different salts that have re-crystalized and settled or precipitated during the evaporation process of controlled QANAT system flood waters. Leached Salts dissolve quickly in a desert endorheic basin, and over a short intensely hot period, the process of re-crystallizing the salts can produce purer and more concentrated, layered playa cakes. The various dissolved salts leached out of the underlying layers in the vast desert basin flats, are intermittently precipitated back on to the basin surface, one after the other.

The original ancient engineered design of the Qanat and its multiple aligned bore-holes was to control basin flooding without destroying the basin salt mirror playa or causing erosion. The Qanat systems are very ancient and have been in operation for thousands of years. It has been indicated that the first systems to have been built were in the high deserts of Persia and that they were utilized for copper mining wastewater streams to irrigate localized domestic agriculture. Although the ancient references to mining are vague, the existing huge quantity of Qanat systems and their very long tunnels up to 50km for watering the Sabkha salt playa deposits indicate another type of mining, that of the extraction and leaching of salts, particularly sodium chloride. The water was primarily needed to extract salt, rather than for simple domestic irrigation. They were built during certain periods when coastal salt evaporation pans were globally inundated, and salt was catastrophically in short supply.

Key words
Sabkha, sea-level, leaching, qanat, explosives, monopoly

More than 150,000 Qanat Karez sweet water distribution systems, including more than 200,000 kilometers of tunnels enabled, and are to be found, in most of the desert communities of Central Asia. As the operation of these systems is run inefficiently, enormous quantities of water are always being lost. The original objective of the Qanat Karez was to supply water to the arid Sabkha basins where salt deposits were leached as a result of *dissolution, evaporation and re-crystallisation*. In Arabic, Sabkha means: A flat coastal plain with a top soil salt crust also known as Salars. The surface and sub-soil of many Central Asian inland desert Sabkha basins *may also be made up of diapirs* of flat salt mirror geology.During the seasonally hot periods of the evaporation stage of the Qanat controlled 'surge system, ' salts dissolve rapidly driving the process of re-crystallizing and precipitation of purer salts and more concentrated layered playa cakes, including microbial mat. The Qanat mountain watershed systems were engineered to regulate the shallow flooding of the endorheic basin without destroying the salt mirror playa and without causing erosion. By 700 CE, the Shiia Jafari had completely reorganized the oasis management of most of the Qanat systems in the Central Asian deserts. As a result, they then controlled the major part of salt production, together with its technology, along the Middle Eastern section of the Silk Road, and were then supplying most of Europe with salt.

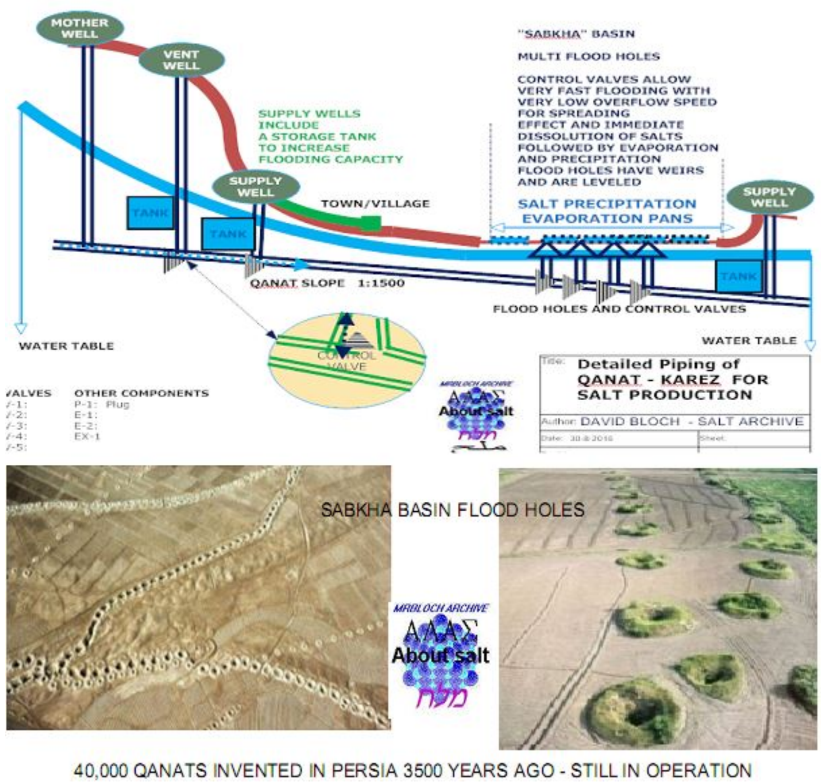

Fig 1 : Ancient QANAT design to supply watershed streams to Sabkha endorheic basins

The Qanat Karez sweet water mechanism was invented some 3000 years ago. To the casual observer it is a very ancient sophisticated feat of underground engineering which could be compared to the Egyptian Pyramids and the Great Wall of China . A more technical observer will see it not only as a means of transporting water for local domestic and agricultural use in the adjacent oasis settlements, but also as a means of supplying *water* beyond, to the very arid areas and the desert flat basins. It could be assumed that the long lines of bore holes dotted along the desert floor basin were part of the settlement expansion which took place many years ago, when each plot had its own water supply. Aerial photos confirm the outline of these ancient plots and fields. [see ig 1]. However, the extremely lengthy tunnel engineering, and the bore holes which were needed to construct a Qanat system, which brought water down from the mountainous area to the extremely harsh conditions of the Asian deserts where the systems can be seen, seem to ask the question, why such colossal human investment and so much effort were spent in supplying water to these almost uninhabitable desert zones of Central Asia. The ancient Qanat Karez would not have been suitable for today's modern continuous spate irrigation which is used in *arid zone* agriculture. They were designed to provide "surge flooding" for short periods, in order to desalinate the soil of the Sabkha basin. This produced leached salts in the form of a layered microbial salt crust. [Fig. 2]

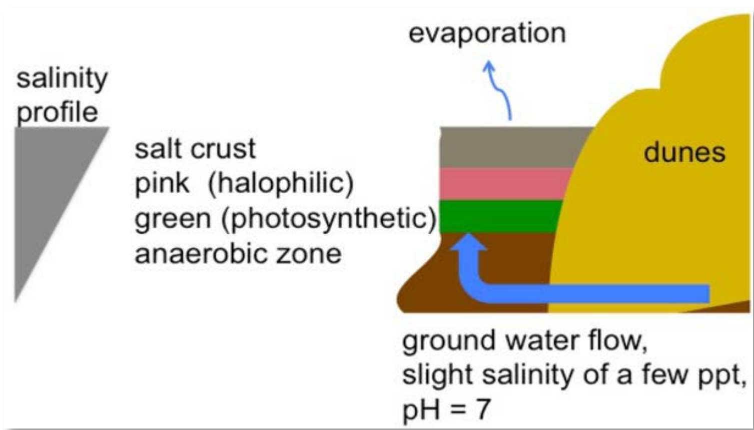

Figure 2 : Schematic formation of endorheic basin Sabkha [Salar] crusts of salts and microbial mat

As a result of the considerable rise of the ocean eustatic sea levels between the years 200 BCE and 300 CE, coastal evaporation pan sodium chloride salt was almost impossible to produce on an industrial scale, both in coastal China and Europe. The need to replace this lack of supply meant that much of the salt could only come from known inland sources such as rock mines, brine wells and saline lakes (see Fig. 6)

The estimated 70,000 ancient Qanats which still remain, are being used in Asia for desert Spate irrigation. This has caused dwindling water supplies. As a result, oasis settlements are being abandoned, due to the lack of water. Maintenance is costly, and it is difficult to understand why improvements are not being made, considering that there is so much advanced technology available. For instance, with modern materials a simple vacuum syphon system, simulating the ancient Qanat tunnels could be constructed. This would do away with the use of inefficient, dilapidated, mechanisms.

Figure 3: Forming salt crust slabs showing clear Microbial layers

Figure 5. Levering up slabs of layered salt

Figure 4. Modern Transport of salt crust slabs

The Qanat tunnel extensions which stretch beyond almost every existing settlement into the inhuman conditions of these saline deserts are evidence of an ancient industrial scale operation. However, with the coming of Islam, the control of most of the Qanat systems was taken from the vibrant, diverse communities who lived along the 'Silk Road.' These inhabitants were people of many different religions, and were much more than merely oasis dwellers. Islam bestowed a reorganized management of the water supply to the Shiia Jafari tribes.

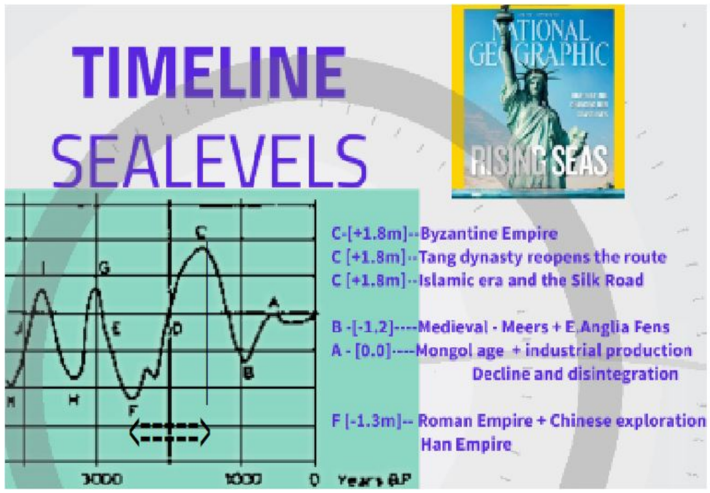

Figure 6 TIMELINE of eustatic sea levels

All of the Qanat systems in these oasis communities are Shiia, and in general, the water supply has been allocated fairly and has been well-managed. Looking closely at the saline desert basins where most of the ancient Qanat extensions were constructed, it is clear that they also supplied water to these inland Sabkhas, which simulated the typical, flat, salt mirror conditions of the coastal Sabkhas. The conclusion is that desalination of the soil was primarily important for the production of pure layered slabs of salts, and, not for domestic and agricultural needs.

This was a critical period of rising sea levels, leading to inundation of Mediterranean salt pans and 'coastal' Sabkhas. As a result, for a long period of time, the *coastal* salt pans were not operational. Thus there was much justification for the enormous investment in human terms in the construction of the Qanat systems. Historically the coastal salt fields are the only real evidence of such a previous catastrophic rise of sea level and may indicate that present day carbon research may not be on the correct track.

Vol. (L.)	% Evap.	Fe_2O_3	$CaCO_3$	$CaSO_4$	NaCl	$MgSO_4$	$MgCl_2$	NaBr	KCl
1.00	0								
0.53	47	0.003	0.064						
0.19	81		0.053	0.560					
0.14	86			0.562					
0.13	87			0.184					
0.11	89			0.160					
0.09	91			0.051	3.261	0.004	0.008		
0.06	94			0.148	9.650	0.013	0.036		
0.04	96			0.070	7.896	0.026	0.043	0.073	
0.03	97			0.014	2.624	0.017	0.013	0.036	
0.02	98				2.272	0.025	0.024	0.052	
0.016	98.4				1.404	0.538	0.027	0.062	
TOTAL		0.003	0.117	1.748	27.107	0.624	0.153	0.222	
last bittern					2.588	1.854	3.164	0.330	0.534
TDS		0.003	0.117	1.748	29.665	2.478	3.317	0.552	0.534

TDS = total dissolved solids

Figure 7 Typical order of precipitation by gradients

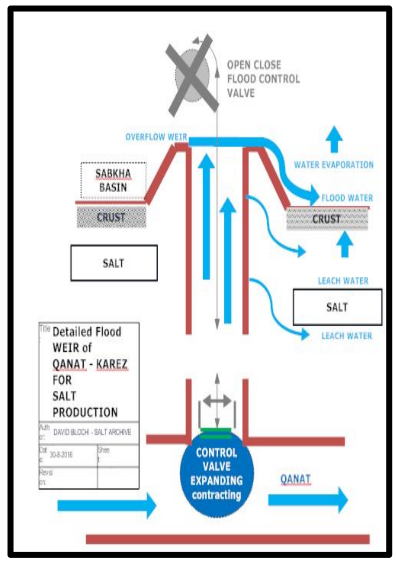

Figure 8 QANAT Surge flood boreholes and valve mechanism

The operation of a Qanat specifically for the purpose of leaching salt from a highly saline playa soil, required the careful flooding of the flat Sabkha basin fields. The porosity of the soil allowed the flood waters to dissolve the existing salts. Capillary activity caused by evaporation of concentrated brines on the Sabkha basin surface, allowed re-crystalization and precipitation according to the order of *the brine gradient concentration* on the flat floor of the basin. It was critical that there was an amount of flood water that was accurately controlled, so as to avoid erosion of the flat basin. This controlled the overflow from the long lines of Qanat boreholes. Qanat tunnels and storage systems had to be flooded seasonally, so that the amount of water would ensure 'welling up' of the water over the borehole weirs, above the water table. Valves consisting of leather buckets filled with water, were raised and lowered by a 'windlass' either to open or close the borehole apertures to the Qanat tunnel water. [fig] In this way the minimal flood depth of the Sabkha fields and the short interval in the exposure to evaporation, affected the precipitation process, resulting in the salts forming a crust. This stage in salt production would normally be carried out during the hot season, when it was critical that there were short flooding cycles, and re-crystallization and precipitation were fully controlled. This required precise pulse timing using water clocks invented for that purpose. Precipitated salts together with other organic and inorganic elements formed a microbial crust in precise layers according to the ordered physical brine concentration and cooling.[Fig] The resulting precipitated crust formed pure layers of various crystal cakes, including organic layers which are today still collected and traded by nomadic desert communities, demonstrating the simplicity of this method of leaching.

In the Great Salt desert of the Dunakil depression, such salt crusts even present under natural and random conditions without the controlled use of the engineered Qanat. Various non-marine evaporates, including sodium chloride and sulphates were very valuable. Of no less importance to another, but more sensitive trading product, were the incendiary salt layers of the Sabkha crust. Various recipes of saltpeter and other succulent nitrates were becoming critically important to power struggles between the Ottoman and Byzantine Empires, in the Mediterranean. All these minerals and others will surely become the basis of a future desert industry.

SUMMERY But to succeed, there must be a complete understanding of the operation and purpose of the Qanat system. In an effort to improve the existing Qanat systems operation, and salvage many of the desert civilisations of Central Asia that have long lost the very valuable salt trade of the 'Silk Road,' one must understand the planned, but now forgotten, flood operating regime of the Qanat, and reinstate the flooded storage and syphon surge technology that will preserve the water table. [see Figure] Blocking of the tunnels that were previously used for salt leaching, is essential in order to prevent losses and allow future closed circuit hydroponics, aeroponic agriculture and solution mining. The new 'Nur Lop' potash plant in China in the Tarim basin and its access to the huge water table is one example of what the future of mineral solution mining holds. (Fig. 10)

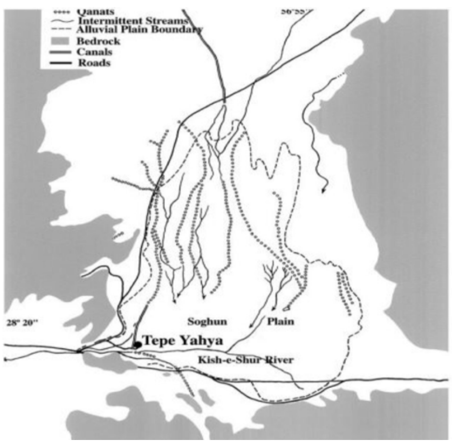

Figure 9 Typical basin QANAT borehole distribution

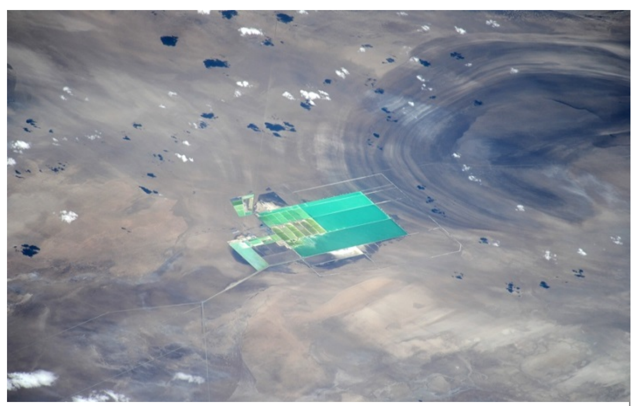

Figure 10 LOP NUR new potash plant China using underground brine sources [Qanat simulation]

For the Shiia Jafari community which may still be involved in the 'Silk Road' and salt trading monopolies, including more recently, the oil petrochemical trade, dealing with the critical and vital question of water management *could* today prevent conflict in the community and ensure survival. The future of the industrial processes necessary to leach these Sabkha basins of modern products, such as uranium will be the future of the Asian arid zones, which make up a third of the planet's dry desert surface area. Simulation of the ancient Qanat technology and the use of modern techniques and materials can thrive in an atmosphere of co-operation between the Shiia Jafari and the Sunni communities in order to extract the vital water and minerals that lie below the Tarim, Taklamakan, and Gobi desert subsoils, and make the modern New Silk Road a success.

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