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SAFEGUARD AND VALORIZATION OF QANATS SITUATED IN THE PROVINCE OF SHAHROOD (IRAN) ¹

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Summary: The term qanat commonly refers to ancient underground hydraulic systems for the transport of water in desert areas to satisfy human needs as well as irrigation. In particular in the province of Shahrood (Iran) situated in the northern area of the Kavir desert these underground channels are very frequent and their structure characterize many present and past land settlements. Although qanats are still fully functional because of proper periodical maintenance, in some cases deterioration events take place mostly due to the loss of opographical information. These circumstances mainly occur to qanats composed of many interconnected parts and to the portions which are located further from their outlets. A research project is under way to reconfigure and reconsider sites taking into account functional, cultural and touristic topics.

- Geographical overview and geohydrological characteristics

The province of Shahrood is an extensive territory of the region of Semnan. The latter is situated in eastern Iran, between the northern margin of the Dasht-E-Kavir and the eastern Alborz Mountains. The province of Shahrood is one of the most interesting areas for the study of qanats both for their ancient dating and wide-spreading and for the deep interaction with the local population, in fact qanats still represent an important economy source and water supply. Currently three structures are to be considered among many other units identified: a) Shahrood; b) Beyarjomand; c) Torud.

a) The qanat of Shahrood, integrated by four shafts located at the terminal part and created from the beginning of 1990, is used to supply the city with more than 130.000 inhabitants and satisfies the needs of one third of the population. The hydraulic work develops horizontally for approximately 25 km, with a distance between the highest and lowest points of 385 m and with a 1.5% gradient. It develops roughly parallel to a watercourse with supercritical/ephemeral flow and it is functional over the past 50 years. Of the original hydraulic system only the two upper branches remain, Mojen (3,5 km) and Tash (2 km), because at 4,5 km to their merging downstream the system has been substituted by a modern pipeline in order to preserve the quality and quantity of water adduced. The location of the Shahrood qanat, consists of a degraded flood plain extending from west to south-east. This is bordered by the peaks of Mount Shavar (3945 m) to the north-north west and of Mount Tapal (2815 m) to the south. These peaks are part of the aforementioned Alborz Mountain range. The final section of the plain presents clear evidence of various abandoned qanats, which appear to have been built in different periods to drain water from the eastern and southern buttresses of Mount Tapal and Mount Shahvar respectively. This latter range presents Ordovician schist and sandstone, Silurian basalt, Devonian and Carboniferous schist, sandstone and limestone, Permo Triassic limestone and Eocene volcanic deposits. This is the main groundwater recharge area. In fact, these peaks block the damp currents from the Caspian Sea, promoting precipitation. The Tapal Mountain range consists of Jurassic schist and sandstone, Jurassic-Cretaceous limestone and Eocene limestone and tuff. This area contains clear evidence of karst phenomena and it would appear that this is the main recharge area for the alluvial groundwater used by qanat. The average water flow capacity of

¹ The project study is enacted by an Agreement edited among the Earth Sciences Department of the Technological University of Shahrood, the Environmental Sciences Department of the University of Aquila and the Chemical Methodologies Institute of CNR, Rome. A particular thanks to the Dean of the University of Shahrood, Prof. Ali Moradzadeh, to Dr. Ali Younesian, General Director of the University of Shahrood and to the Eng. Mahmud Matin who has encouraged with his dedication the start up of this project.

this qanat is approximately 120 L/s, the hydrological rate of flow is quite stable during the whole year with $\pm 10\%$ oscillations. Flow capacity largest values are registered in Spring, the smallest values are registered at the end of January. In the last years a negative trend has been observed in water availability equivalent to 40% decrease of water flow capacity. This showing deficit situation has determined the choice to create 4 shafts to satisfy the increasing summer water needs.



The qanats in the territory of Shahrood (Photo by E. Burri and A. Ferrari)

b) Beyarjomand qanat is situated approximately at 90 km SE from Shahrood and it is exclusively used for farming activities. It has been built no longer than two centuries ago. The qanat develops for approximately 10 km and it is subdivided in five branches, with a larger gradient than the one that usually characterises this typical underground hydraulic system. This qanat communicates with 190 wells. The primary wells reach depths with a variation ranging from 60 to 120 m and water flow capacity is 40–50 L/s (45 L/s measured on 01/16/2009). Along its route there were 3 watermills, the remains of one of these structures are still well-visible. The peculiar characteristic of this qanat is the presence of two galleries parallel to the two principle branches, which were dug to carry out maintenance functions and 3 barrages to use when necessary to store water and temporarily to interrupt water flow in order to operate maintenance². The chemical and physical parameters obtained during the monitoring campaign in January 2009 highlight a 18,5° C water temperature at the qanat outlet, a 7,9 pH and 800 mS/cm Electrical conductivity (these values are similar to those reported in the descriptive report). First surveys confirm water captation at different temperatures (ranging from 17,4 to 21,3 ° C). The qanat develops in conoid, eluvialcolluvial and alluvial deposits which are situated at the base of carbonate and sandstone mountain peaks (Cretaceo-Eocene age) situated at NE. Its branches follow the runoff flows occurring in the plain. The presumable refurbishing area is constituted of detritus deposits and of the near mountain range.

²The agriculture area that was initially irrigated by this qanat was called Deh Sar Khuche, after a catastrophic flash flood the population moved in a nearby area called Kharab Deh. At last, always owing to calamitous events the population moved in the current area.



An ancient mill near Bearjomand (Photo by E. Burri and A. Ferrari)

c) Torud is a village of 2000 inhabitants, which is situated approximately at 110 km south from Shahrood and lays out in the Kavir desert. The ancient part of the human settlement has been destroyed by an earthquake on 02/12/1953, (a 6.4 magnitude earthquake; epicentre 40 km south from the site) which has caused 970 victims. The outlet of the qanat is inside the village and is used only for shared services as irrigation and lavatory, since water drinking needs take place by means of wells. The qanat should be 8-10 km long, running north to south. In the upper part there are two draining channels, the more western one should have a greater flow capacity. The water flow capacity, measured on 01/17/2009, is approximately 52 L/s at the outlet of the channel. The peculiar characteristic of the water is the high temperature, measuring 24,5° C. The ground water that represents the qanat's main recharge area is located in the eluvial-colluvial deposits of the plain situated north of the human settlement. This ground water is probably furnished by rainwash, by water runoff and by the mountain range percolation of igneous origin located in the northern part of the plain. The presence of lithotypes (Eocene-Oligocene tuff and lava) and important tectonic lineaments can induce water temperature to increase. Marls and sandstones (Oligocenic-Miocenic age), which are disposed widthways to the direction of the drainage plain (NNW-SSE), emerge at south of inhabited Torud, in direction WSW-ENE.



The oasis of Torud in the Kavir desert (Photo by E. Burri and A. Ferrari)

Survey on radon gas

According to present knowledge no studies have been performed on indoor radon in the area concerning Shahrood but the problem of radon in some regions of Iran is meaningful as revealed by the recent monitoring study conducted in the Province of Ramsar (north-west area of Iran) which has highlighted several areas with concentration levels up to 3700 Bq/m³. E-Perm electrets with a SST configuration (electret short term installed in a short term chamber) have been used to measure the radon concentration in water. These E-Perm electrets have been put in the chamber for radon in water measurement produced by MI.AM. srl and the results have been read by the SPER-1 Electret's voltage reader previously calibrated and tested. The results obtained in five radon in water tests performed are reported below.

- Shahrood qanat: water sample was collected at the end of the underground pipeline which connects the former qanat to the city. Radon Concentration = 5,79 Bq/l
- Beyarjomand qanat: water sample was collected from one of the shafts of the qanat branch running parallel to the main road entering the village. Radon Concentration = 9,49 Bq/l
- Beyarjomand qanat: water sample was collected from one of the shafts of one of the two branches (water temperature aprox. 22° C) flowing into the perpendicular branch to the main road entering in the village. Radon Concentration = 13,69 Bq/l
- Torud qanat - water sample was collected at the end of the qanat course, when it arises in a construction situated under a funeral monument. Radon Concentration = 0,96 Bq/l (data given by the average of the two values found, as the measurement was taken double)

These first results obtained from the monitoring campaign carried out in January 2009 are really encouraging, as the values are largely inferior to the World average and the concentration of radioactivity in water does not represent any hazard for the population. In particular the qanat value obtained in Shahrood is very comforting as the water of that qanat provides people's houses with drinking water.

Valorization and safeguard related to Cultural Heritages

The study of qanats in northeastern Iran has gone beyond their hydrogeological and physical characteristics. In fact their configuration allowed human settlement and influenced social rules, cultural activities and the economy of water agriculture exploitation, through a tight relationship between mankind and environment. The interest in this precious subterranean aqueduct is still alive and topical and this is highlighted by a complex and continuous maintenance activity which make qanats reliable and long-lasting. This upkeep activity, onerous and often hazardous, is aimed to re-enable underground pipes, but does not take into account the historical complexity of social and economic relationships and the value of accessory works. These additional features loose their function besides presenting structural deterioration. The research investigation starts with a general, topographical and structural reconnaissance of manufactures even with the collaboration of those who contributed to their functional restoration. At the end of this phase, the further steps were to locate the exact positions of the shafts by GPS, to prepare the photographic documentation and to fill out a form which also includes additional features. The next phase is the survey of artifacts still existent such as mills which receive their motive power from the underground channel system. All this information is completed by accomplishing dating tests on the artifacts. So a proper radiography of the qanat is obtained, with the aim to introduce it in a diversified and complex cultural circuit for a complete valorization of the area, of its handicraft and traditional agriculture.

On the basis of this program it has been possible to identify some solutions for the following three sites:

Shahrood qanats

This hydraulic system is composed by a thick net of ancient, old and quite recent qanats and it expands almost till Mojen town. This irrigation system is of vital importance because 30% of domestic water use of Shahrood city comes from these qanats. The whole city is surrounded by the

qanat water through densely cobwebbing channels that run along the main streets which are shaded by a row of trees reminding the vital nexus which binds its existence to the essential presence of the qanat. Shahrood, by means of its accommodation facilities is definitely equipped to function as a base and reference point for several cultural routes in order to be acquainted with the qanats of the province and the landscape. Particular attention will be directed to the topographical survey of a thick qanat net located in the northern area of the city and proved only by the great quantity of abandoned shafts which have been filled with dirt. A fortified structure, which totally lapsed and others that are still partially in use, today prove an economy based even on trade.



The caravanserai of Miandash along the silk road (Photo by E. Burri and A. Ferrari)

Byāryomand qanat

This small town of about 2.300 inhabitants represents the final connection with the area of Shahrood before advancing into the Dasht-e-Kavir desert. The qanat which supplies it with water

3Samples have been taken from small pieces of pottery, encompassed in the walls of Beyarjomand mill's ruins, in order to attempt a chronological dating test. The relics are to be referred to terra-cotta fragments, which date in the VII century AD, precisely 680+/-80 AD. Obviously the date refers to the last heating at high temperature of the ceramic fragments which coincides with the ceramic workmanship, but not with the make-ready of the fragments into the mill structure. The radiocarbon analyses of straw and wood fragments provide much more recent dating, that is later than 1650 AD; straw and wood fragments are related to when they have been inserted into the structure. The site is characterised by a considerable aridity, anyhow there are rainfalls which will have required periodic interventions of consolidation. Therefore it is possible to assume that the fragments of straw and wood are non contemporary to the first production of the artefact but are due to following interventions. Other cross sections and analyses have been carried out in the Miandash caravansary, which is supplied by a net of qanats. In this case dating methodologies through thermoluminescence technique are more secure because the bricks analysed do not give rise to reuse hypotheses. The results of the analyses relating to four points of drawing concur among each other and give as a dating result 1655+/-30 AD. It has been possible to draw samples only from the external structure of the big caravansary, later dated structure compared to the main body. The analyses, conducted on December 2009, have been accomplished by Prof. Marco Martini, Director of the Department of Materials Science, University Milano-Bicocca, Italy.

has two main branches with a peculiar characteristic, one of the two branches brings quite hot water, even in Winter. The whole qanat area is surrounded by high mountains and Byāryomand landscape is favourable to create an open air qanat route-museum. For this purpose one of the ancient watermills could be restored. In the past it was activated by the qanat water which was collected in expansion chambers in order to allow the movement of the grinding gear of the mill. During qanats maintenance and cleaning operations accomplished by Afghan workers, blocks of calcite have been removed from some shafts, over 100 m deep, and brought on the surface. These blocks were obstructing the underground tunnels. With a low investment it would be possible to start an interesting hand-crafted activity to create tourist art objects and furnishings which could be put side by side with the other local activities.

Torud qanat

This oasis settlement is situated to the south of Shahrood and lays out in the Dasht-e-Kavir full desert, a little before the great Kavir salt lands. Here the meager population, approximately 2.000 inhabitants, stands severe thermal excursions and is almost totally committed to agriculture, although it could improve its economic conditions by increasing the value of cultural assets tightly connected to the presence of the qanat. First of all the qanat water spouts near the midtown, from where the water is directly distributed to the farmers through a very thick net of small channels which guarantee the necessary agriculture activity. This ancient water supply system for desert areas could be successfully considered within a cultural tourism by tracing itineraries that show the culture of water use in arid environments, the processing and conservation techniques of manufactures and the gastronomic culture. Lastly the tourist itinerary could comprise a carpet marketing inspired to local culture patterns, with methodologies, techniques, hand-woven textile fabrics and colors handed down through many generations.

The water analysis of the Torud qanat was approximately 24,5° C temperature, measured in January while the external temperature was approximately 0° C. An accurate study on this phenomenon would allow a careful evaluation for a thermal and/or geothermal exploitation at low heat content.



The qanats in the territory of Shahrood (Photo by E. Burri and A. Ferrari)

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