"Saltman" a New Archaeological Discovery: Scientific Investigation and Conservation

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KEY WORDS: the saltman, mummification, ^{14}C, dna, chehrabad, zanjan, ctscan

Abstract

The conservation and scientific investigation of organic materials in general and ancient human remains in particular have always been a topic of immense interest to scholars. The so called "Iceman" is one example which has attracted both general the public and experts worldwide since its discovery in 1991. The discovery of the Saltman in Iran in 1994, in a remarkable condition of preservation, is another example of this. The remains were found in a salt mine located in the village of Hamzehloo, near Zanjan. After the initial investigation by archaeologist, all the finds were transferred to Research Center for Conservation of Cultural Relics for scientific investigation and preservation. All the remains were subjected to Carbon-14 dating, radiographic examinations, computer tomography, texture examinations, genetic research, chemical, biological and physical examinations of the hair, trace element analysis, technological and compositional examinations and lastly conservation of all the remains.

INTRODUCTION

In the winter of 1993, in the village of Hamzeloo, located in the western part of Zanjan province, the miners working in one of the SALT mines of the area unexpectedly came across a half-body with long hair and beard. Upon receiving the news, the Zanjan Cultural Heritage Center began investigations in the region in February 1993 which resulted in the discovery of a foreleg inside a leather foot, three knives, shorts, a silver object called an ear cleaner, a sling, parts of a leather rope, a grindstone, pieces of earthenware, broken bones and a few pieces of cloth. The above findings were transferred to the Research Center for Conservation of Cultural Relics for scientific studies. The discovered mummy was called the Saltman after the place of its discovery.

Geographic position of the mine

The mentioned salt-mine is located under hilly elevations facing Chehrabad River, one kilometer away from southern part of Hamzeloo village. This village is situated at 45 degrees and 50 minutes longitude east from Greenwich, and 37 degrees and 5 minutes latitude north from the equator. This village is situated 65 kilometers to the west of the city of Zanjan.

Introducing the Saltman and objects related to it

The SALTMAN: the natural mummification of the SALTMAN includes the head and his left foreleg. The head which has got long hair and beard also includes a part of the shoulder and clavicle. Except for the eyebrows which are dark brown, and parts of beard which are yellow, the rest of the hair is white and also curly. The right part of the face is damaged and a part of his skin with other excess material is gathered above the eye. The left part of the face and the ears are almost undamaged. The left ear has an earring like a golden ring (Fig. 1).

Fig. 1 - Head of the Saltman.

The objects related to the SALTMAN:
1-Three knives: these iron knives have handles made of horn. The blades, partially corroded are connected to the handles with rivets. One of the knives is inside a leather sheath which with the leather hook connected to it would be hung from the belt. There is also a part on the sheath for keeping the silver object called an ear cleaner (Fig. 2).

Fig. 2 - Some of the Saltman's artifacts: Knives,silver object (ear cleaner) in the leather sheath and woven rope.

2-Ear cleaner: this object is made of silver and its length is 8.5 cm. One end is like a small spoon and the other end has a sharp point. The middle part or handle is spiral.

3-Shorts: the shorts are part of the SALTMAN's clothing and the tissue is mainly plain. Their length is 35 cm and there is some ornamental margin, 15 mm wide, near the edge of the legs like «which include blue, green, red, and brown colors. Some parts of the shorts are torn and stained but on the whole the filaments are strong and flexible enough (Fig. 3).

Fig. 3 - The Saltman's shorts that had been stained and torn but strong and flexible.

4-Boot: the boot which contains the Saltman's foreleg is made of leather and its color is light brown. Its thickness is 2.5 mm, its height is 48 cm and the length of its sole is 28 cm. It is made up of four parts: the first part is related to the foreleg which covers the surface of the foot (above the big toe) to above the knee. The second part covers the toes in the form of a V.
The third part is U-shaped and it covers the heel; it starts from the arch and ends at the other side. Finally the fourth part is the sole of the boot. The needle-work on the back and the inside is very delicate (Fig. 4).

Fig. 4. - The boot which contain the Saltman's foreleg.

5-Other textiles: among the findings there are some pieces of cloth which are parts of the Saltman's clothing. They are made of wool and have plain geometric patterns with red and brown colors. There are also two pieces of woven rope which are 21 cm in length and made of wool. They are the same color as the shorts. 6-In addition to the above findings, there are also three pieces of leather rope which together are 169 cm long and 2 cm wide; a piece of stone from the sedimentary type measuring 5.3 x 5 x 10 cm; a piece of stone with a piece of rope around it; pieces of earthenware which do not represent the overall shape of any dish, they are dark gray, hand made and relatively delicate There is also one walnut.

A-Scientific studies methods and results

Dating: dating of the above collection has been done through Mass Spectroscopy method (AMS) at Oxford University on the samples of bones and filaments of cloth. Based on the acquired results the date is estimated to be about 1700 years ago (Fig. 5).
X-Ray Radiography: x-ray radiography and its related modern scientific techniques, fluoroscopy and computer tomography (CT), are known as useful and non-destructive methods in studying mummies. The information attained from these methods include traces of damage before and after death or mummification, the method of mummifying and techniques used, determining gender, recognizing age through comparison with radiological standards, etc. The results of the three dimensional C-T-Scan of the Saltman's half body and his boot show the damages like the break in the skull in the right eye (fig. 6), displacement and (Fig. 6) (Fig. 7) prolapse of the lower jaw (fig. 7), the soft tissue of the sole and the curvature of the toes, the thickness of the boot's sole (fig. 8), the position and deviation of the brain tissue toward left and forehead (the position of the head during burial) (Fig. 8).

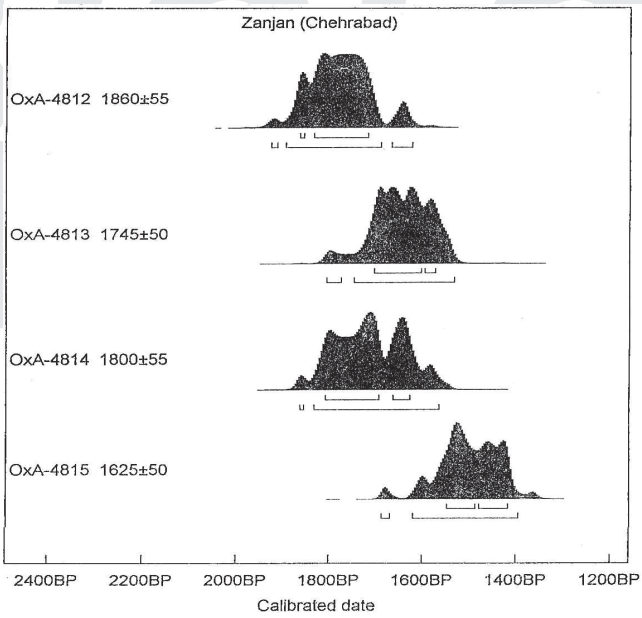

Fig. 5 - Calibrated date of the Saltman's bone and fiber samples.

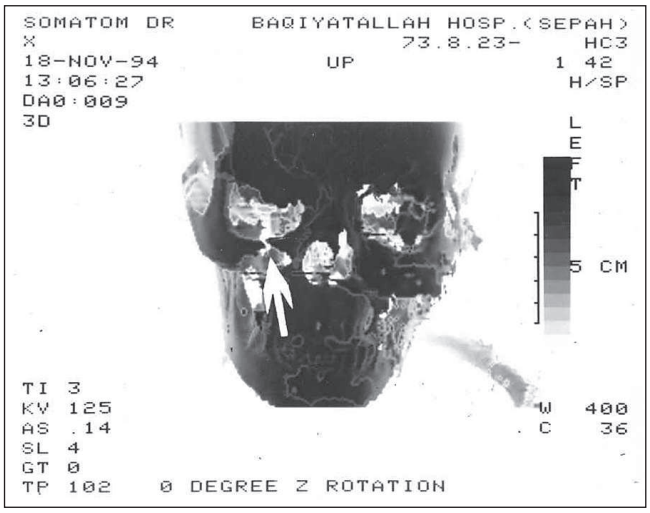

Fig. 6 - 3D CT scan of the Saltman, fracture in the skull in right eye.

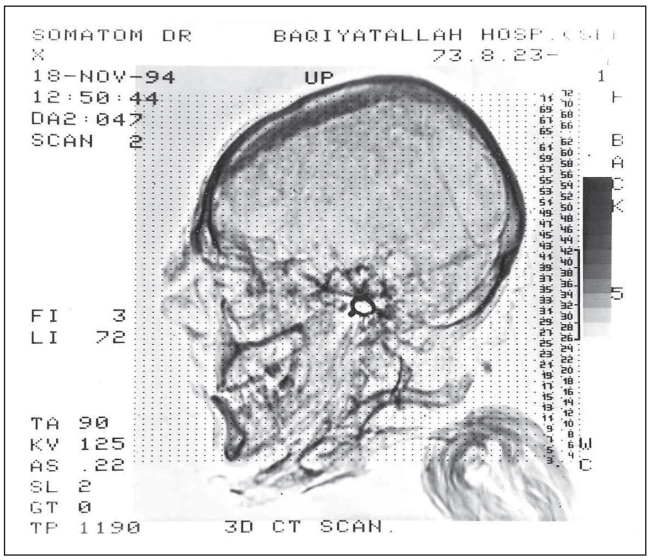

Fig. 7 - 3D ST scan, displacement and prolapsed of the lower jaw, golden ring in the Saltman's ear.

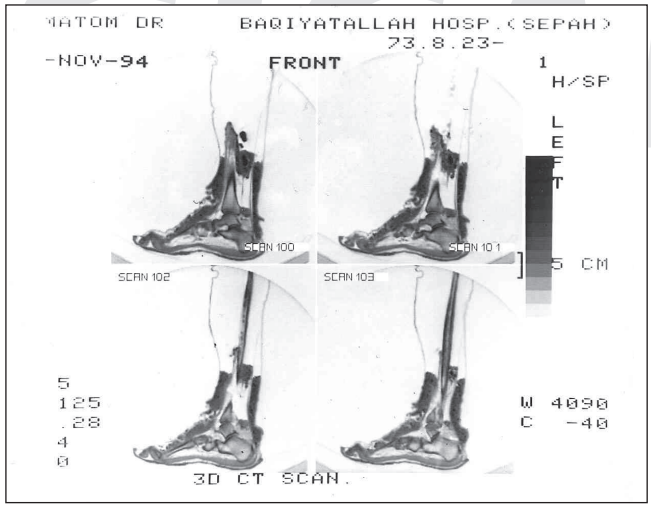

Fig. 8 - 3D CT scan, the soft tissue of the sole and the curvature of the toes in the Saltman's boot.

Pathology: through different methods of coloring and also with the use of an electron microscope it was possible to study the condition of the human body's soft tissues and the changes resulting from their mummification, proving probable diseases, the existence of micro-organisms, etc. Such information can be employed in histology and the method of keeping and preserving mummified corpses. A part of the Saltman's soft tissue was examined through Eosin-Hematoxylin coloring (E & H) method which led to the observation of traces of dermal appendages (sweat glands, hair follicles, fat glands), layers of keratinization, collagen strings and broken muscle filaments.

Genetic Studies: in old corpses, all of the biological features which can determine identity with a high certainty coefficient except DNA molecules are destroyed. The large DNA molecule which exists in a cell nucleus contains genetic regions which belong to each human being. Moreover, some types of genes are transferred from one generation to another. Thus in order to determine the identity and raciology, examining the DNA molecule when studying corpses is very important. Since different parts of the Saltman's head and foot were found separately in different times and places, it was very important to prove the two pieces belong to one body. This was confirmed through examining DNA molecules by RFLP (Restriction Fragment Length Polymorphism), PCR (Polymerase Chain Reaction) and DNA sequencing techniques from the Saltman's knee bone (No. 3, 4) and skull tissue (No. 5, 6) (Fig. 9). Dental

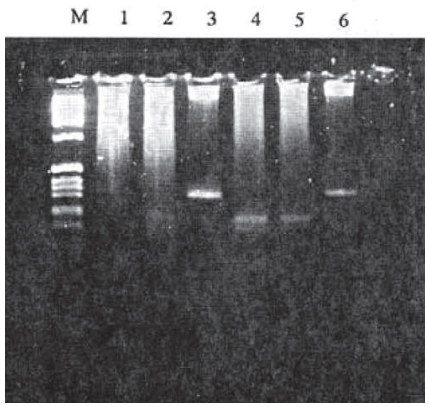

Fig. 9 - DNA finger printing: NO. 3, 4: knee bone, NO. 5, 6: skull tissue.

examinations: the condition of teeth and gums show the state of health and to some extent the type of diet. For example, hard food causes erosion of teeth and damage to people's jaws or sugars increases the rate of dental decay. Sometimes the condition of the teeth indicates the approximate age of a person. Three dimensional CT-Scan pictures and the radiology of the SALTMAN show that one of the teeth (tooth 6 in the upper jaw) is extracted and there is some decay across in teeth 5 and 6 in the upper jaw. The lower teeth are in good physical shape but because of break in the jaw in this region, the teeth are prolapsed.

Studies on hair: hair, like other protective tissues (skin, horn, feather, etc), are mainly made of keratin and their firmness is the result of bridges between protein chains. Hair contains the two pigments melanin (black-brown) and feomelanin (red). Hair color includes each of the pigments in relative quantities. Oxidizing materials affect melanin and change it into a colorless compound. The elements that exist in hair in small quantities also are affected by factors like age, race, gender, geographical location of habitation, diet, and drugs. Thus the inner and outer factors of the human body affect these elements. For example the industrialization of cities plays an important role on the amount of heavy elements like lead and mercury in hair; also the amount of calcium in hair depends on the amount of calcium in the diet. The longitudinal section of hair has a scale-like structure; compared to wool, these scales cover more surfaces of each other and this is the reason for hair's softness and delicacy. The latitudinal section of hair is like a circle and an oval in straight and curly hairs respectively. The relationship between hair diameter and its medulla varies between humans and different animals. The above examinations on the Saltman's head revealed that because of oxidizing factors in the environment, the hair has become colorless and its unnatural yellowish color (more in the beard) is the result of iron compounds arising out of the head's bleeding and probably the existence of iron objects (three knives with corpse) in the place.

The identification of trace elements in hair, using ICP methods, confirms this hypothesis (Tab. 1).

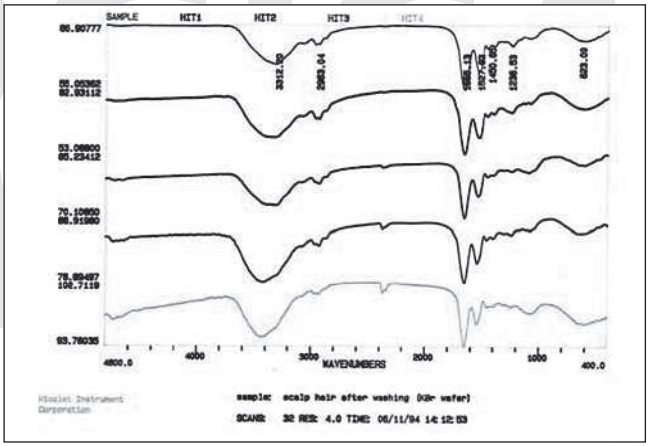

Fig. 10 - FT-IR spectrums: sample is the Saltman's hair and HIT 1-4 are new hairs.

and the segmentation of its core is also evident. Also the latitudinal section of the hair is seen in the form of an oval and the reason is the curliness of the hair. Determining blood group: blood group is one of the genetic characteristics of human beings which are transferred from one generation to another. Therefore it can be used in discovering

the relations between relatives, for example in studying the mummies of Egypt and the recognition of their relations with each other. Since the gene regions exist in nucleuses of all cells, including hair cells, the gene related to the Saltman's blood group in his hair was determined to be B. This experiment which has been done through chemical reagents indicates that these genes have kept their structure and their chemical capability, even after centuries.

B-Conservation hypothesis

The smallest productive units of a human body's tissues are cells. The main essence of a cell is made of organic materials such as proteins, nucleic acids, etc. In every cell, each of the components has different functions. One of these components is lisozomes which store enzymes.

Element (mg/Kg)	Ag	Au	Al	As	Bi	Cu	Cr	Fe	K	Na	Pb	Sn	Zn
Sample1	108	37	268	-	-	4.2	5.6	380	480	1230	17	-	196
Sample2	6.6	22.5	1270	-	47	.8	.8	687	490	595	6.6	-	53
Sample3	3.6	-	-	-	30.6	30.2	-	281.1	-	-	73.12	4.03	183.45

Sample 1 - The Saltman's hair (yellowish color), Sample2: The short's fiber , Sample 3: new hair (Bright brown).

The experiments show that the change in these elements in the hair is clear than the change in its hydrocarbon structure. Measuring the infrared spectrum (FT-IR model Nicolet 510P) of the hair and the comparison with new samples of hair showed no difference (Fig. 10). Dryness of the Saltman's hair and its fragility can be the result of the humidity shortage and high

Sample: Saltman's hair, HIT1-4: new hairs (Fig. 10) amount of PH in the environment. In the microscopic image of longitudinal section of the hair, the scales are seen clearly

When a cell is damaged, in other words when it dies the lisozome wall is torn, the enzyme is freed in the cell and through a chemical reaction it causes the disintegration and digestion of the cell. Like many chemical reactions, this one also takes place in an aqueous state. Therefore one of the factors for disintegration of body cells stems from the components of the cell itself. Another factor is the existence of bacteria inside the human body and in the external environment. After the gradual predominance of death, these micro-organisms start their activity through

chemical reactions and the disintegration of the dead tissues. If such reactions are accompanied with the use of oxygen they are called fetid, and if they occur in an environment without oxygen they are called fermentative. The type of bacteria and its environmental conditions play important roles in the disintegration of a corpse. Besides the above factors which are the major ones in annihilating corpses, there are other elements that are effective in this process in other ways. The presence of fungi is one of such elements. These groups of organisms fulfill their needs through organic substances like sugars, starch, and nitrogenous organic material like proteins. Sometimes insects and their larva share the annihilation of the corpses with bacteria. Moreover corpses can be good source ofnourishment small underground vermin. The environmental conditions of growth and the survival of biological factors, as mentioned above, affect the disintegration of the corpse; and enzymes existing in the productive tissue cells were introduced which become active only in the presence of water. Therefore the omission of water and humidity from the environment causes the process of disintegration of a cell to get stopped. The bacteria also, depending on their type in a cell, have the enzymes of digestion of tissues; the presence of water is undeniable here too. In case of lack of water in the environment, the bacteria encounter a sort of loss, and their activities and production are stopped. The fungi, which are among destructive micro-organisms, also need water or humidity in the environment for their nourishment and growth. Besides water and humidity, the activity and growth of different types of bacteria and fungi depend on several other factors, for example heat, light, humidity of the materials, the depth of penetration in the materials, density of oxygen and carbon dioxide in the atmosphere and the pollution. The fungi mainly grow in an environment with the average condition of 20-23 °C, the humidity of 68% and neutral PH, but they can also tolerate well a PH between 2 and 9. The amount of water needed for biochemical activities of bacteria growth is above 90% and for fungi, 70-85%. Some bacteria and spores can live hidden for months and even years without any sign till the conditions for their growth are provided. Moreover insects and their larva which are among cold-blooded creatures are sensitive to climatic conditions; therefore their existence depends on humidity and temperature.

The conservation theor

The control of humidity is one of the important factor for conservation of dry mummies in such a way that the RH of the environment must be kept constant and appropriate level in all seasons. One of the methods for controlling humidity is the use of a material which is called a buffer. Buffers are materials which keep the humidity of the environment unchanging so that when humidity rises, the extra amount is absorbed and when it is highly reduced, through humidity loss the balance is attained. Silicagel is among this type of material. This material is used more than others because it has such characteristics as the ability of absorbing water, being chemically inactive, non-flammable, changing color in dry and humid conditions, and not needing a reagent.
Since the use of disinfectants not only may cause environmental pollution, but also may have a short term disinfection property and cause damages on the work of art itself, therefore for solving this problem in recent years new methods have been proposed like keeping the mummies in atmospheres like nitrogen, argon, or carbon dioxide. Such conditions through reducing humidity and oxygen cause the destruction of biological agents. Of course it cannot be denied that some biological agents can live hidden for a long time without any sign till the conditions for their growth is again provided. The Saltman, which is considered a dry mummies (in salty conditions), owes its stability for seventeen centuries to natural conditions which the salt mine made available when he was buried. The presence of salt, by absorbing the water of tissues and their subsequent dehydration, has prevented the activities of the body enzymes which cause the digestion of cell components; also it has prevented the growth and the activity of the bacteria and other micro-organisms. Besides the d\dehydration of the corpse, the presence of Chlorine ion (chloride) and its penetration in the tissues has also helped the preservation of the corpse with its quality of being microbicidic and disinfecting. Therefore according to the above hypothesis the most important and effective factors in preserving the Saltman has been the control of temperature and humidity.

Conservation measures during past decade

In the beginning of the custody period which refers to the end of 1993, the Saltman's halfbody was put in a case made of glass and nearly closed which contained the packages of silicagel acting similar to desiccators. For keeping the half body in a suitable standing position, a soft pillow made of ineffective materials (cotton, non-acidic, non-textured paper) was put under the right side of the head, on the bottom of the case. Such temporal conditions were kept during the study of the piece. The result of the scientific studies on the half body almost confirmed the conditions of its preservation from the environmental point of view. In the summer of 1998, and at the conclusion of an International Conference on Naturally Mummified Remains (18-24 May, 1998, IRAN, TEHRAN) The Saltamn and its related archaeological finds were transferred to the National Museum of Iran and since then the monitoring of environmental conditions of the collections has regularly been undertaken. In 2000 and in co-operation with Pastor Institute in Tehran, samplings were taken from the torso and foreleg for microbiological and fungal examinations. The results showed no fungi pollution; only in the boot and two points of the head, the existence of usual bacteria in soil: *Bacillus Coagulans* whose activities are very limited biochemically, and *Acinetobacter spp*., *Staphylococcus epidermidis*, *staphylococcus aureus* was detected. It must be noted that bacteria usually grow under high humidity conditions; therefore no biological activity will be observed

in them until the suitable conditions for their growth are provided. In 2001, in order to improve the preservation state of the collection, a special box made of plexiglass was designed and made by the Conservation Department of the National Museum which was used as a stand and a container for silicagel grains in the case containing the half body. The design was to enable the blue grains of silicagel to act as buffers controlling the humidity of the case through the arranged holes on the upper side of the box; the other aim of the design was to allow changes in color due to sudden changes in humidity to be completely observable. Also the SALTMAN's boot, which contained the foreleg and was kept inside the display case and exposed to the external environment, was transferred to the closed case containing the silicagel package. In early 2003, through adding a layer of talc, to absorb ultra violet rays, the display case and the whole collection were protected against the dangers resulting from such rays. Based on observations and and physical examinations carried out in December 2003, there was no perceptible changes in the form, color, and smell of the Saltman's half body, and for the time being no serious danger was anticipated. Figures 21 and 22 taken of the present state of this important historic piece can be compared with those of the time of its discovery (Fig. 11, 12). Undoubtedly due to great archaeological importance as well as vulnerability of this valuable collection, its state of conservation should and will continuously be monitored and controlled (Fig. 11, 12).

Fig. 11 - Present state of the Saltman.

Fig. 12 - Previous state (time of discovery) of the Saltman.

Conclusion

The archeological studies and examinations of the salt mine in Chehrabad, Zanjan, show signs mining and extraction. Also Carbon 14 dating on the Saltman's half body and his shorts indicates that this natural mummy, which is considered a dry mummy, approximately belongs to the Parthian period. The form of the hairs, earring, and clothes confirm this fact. The damages on the Saltman's head show that the Saltman had died due to an accident in the mine resulting to a sever blow to his head. According to genetic examinations, the discovered foreleg dioes indeed belong to the Saltman and non-availability of other parts of the corpse is probably due to their eradication during mining activities. The burial of the corpse near salt has resulted in complete dehydration of the tissues and consequently protection of the remains against decay which otherwise would have resulted from the disintegration of the tissues and biological activities. The mummy has been preserved for 10 years through preventive conservation. During this period and through usage of silicagel in a closed environment, thus controlling the amount of relative humidity, keeping it lower than the limit needed for the growth of biological agents, no physical or chemical interference in the mummy have been observed.

Acknowledgements

Hereby the authors wish to acknowledge with appreciation the cooperation of following scholars for their helps and supports during the course of this research: Mrs. Robab Takbiri Oskoi, C^{14} Dept., RCCCR Mrs. Fereshteh Rahimi, ICP Dept., RCCCR Mr. Alireza Bahreman, Conservation Dept., RCCCR Mrs. Mahnaz A. Gorji, Conservation Dept., National Museum of Iran Mr. Houshang Sobouti, Archaeologist, Zanjan Cultural Heritage Center Dr. Ahmad Reza Bahremand and Dr. Mohammad Reza Poorshafie Microbiology Dept., Mrs. Shahindokht Basiri, Mycology Dept., Fereidoun Mahboudi, Biotechnology Dept., Iran Pasteur Institute Dr. Jalal J. Shokouhi, CT Scan Section, Baqietollah Hospital Dr. Abbas Shakour, pathology Dept. and Dr. Masoumeh Naji, Cerology Dept., Legal Medical Organization of Iran

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