

# *Ulughbek and his Observatory in Samarkand*



by Heather Hobden  
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Ulughbek and his Observatory in Samarkand.

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## Introduction

The Observatory built by Ulughbek in Samarkand in 1428, was unsurpassed in the world.

Ulughbek and his parents had established Samarkand, Bukhara and Herat as leading centres of learning and culture.

This part of the world, might have been a very different place if Ulughbek had not been assassinated in 1449, by religious extremists.

Ulughbek's observatory was razed to the ground.

But his work on astronomy survived.

*For as Ulughbek said:*

*"Religion disperses like a fog,  
kingdoms perish,  
but the works of scholars  
remain for an eternity."*

## Ulughbek and his Observatory in Samarkand

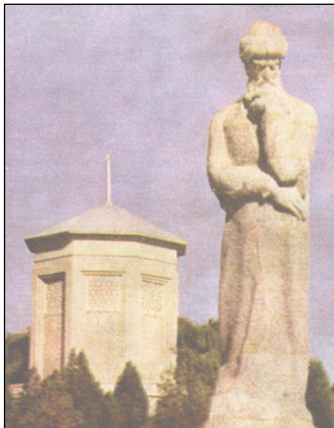
by Heather Hobden

Galileo was not the first astronomer to suffer from conflict with conservative religious authorities. In this book we see how Ulughbek, the Emir of Samarkand was assassinated because of his work as an astronomer and his observatory destroyed. But his work survived. For as Ulughbek said:

“Religion disperses like a fog,

kingdoms perish,

but the works of scholars remain for an eternity”.



These words are quoted on the marble plaque of his memorial constructed on the excavated observatory site in 1970, by sculptor Mukhtar Mussabaev, and architects Phillip Grishenko and Georgi Godlin.





## The Observatory of Ulughbek

In Samarkand, one of the many historic sites that tourists must visit, is the Observatory of Ulughbek. It is not the most impressive of Samarkand's monuments, for very little remains. But in the



long and turbulent history of Samarkand stretching back to the time the Neanderthals lived here and including such famous conquering war heroes as Alexander the Great, Chinghiz Khan and Temur (Tamburlaine in Marlow's play); Temur's grandson, Ulughbek the Astronomer is the ruler of Samarkand most remembered with national pride.

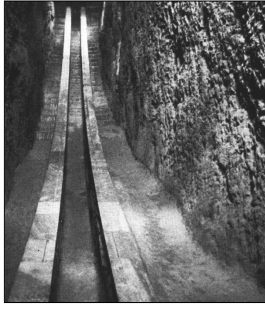
The observatory itself is situated on a hill outside the city walls. The hill is not very high, but from the top a view is to be had stretching a long way - northwards over the desert and steppe, and southwards to the white peaks of the Pamir mountains.

It is not possible today to see the sky over Samarkand as Ulughbek would have seen it. Although many of the houses near the observatory are still in a traditional style with mud walls and thatched flat roofs, little changed from Ulughbek's time, the streets in his city did not have the benefit of sodium lighting.

The observatory must have been an impressive sight when it was newly built, but by the 19<sup>th</sup> century not a trace remained.

In 1908 the observatory buildings were excavated by a Russian archaeologist, V. L. Vyatkin. For Vyatkin the excavation of the observatory was his life's work, to the extent that he was buried here - his tomb is right in the centre of the site.

The excavations revealed the circular plan of the observatory. From descriptions of it, it is known that the building was originally three stories high.



The building was bisected down the middle on the north-south axis by an enormous altitude quadrant - an estimated 63 metres along its edge and with a radius of 40.212 metres. The lower part of this instrument survived to be excavated by Vyatkin, for it was cut into the solid rock of the hill.

This part of the quadrant, which visitors can see today, is 10 metres in height. It forms a narrow trench cut into the rock. The curved floor has steps for ease of access, cut each side of two parallel lines of bricks laid upon alabaster, forming a central trench.(see illustration). The two arcs thus formed are covered with marble plates 10-12 cm. thick. Both arcs are marked out to correspond with minutes and seconds for the measurements. The western arc also carries Arabic numerals.

A number of attempts have been made to reconstruct this impressive instrument and calculate how it was operated. One Russian paper suggests it was not a quadrant but a sextant, operated with mirrors.

Ulughbek copied the basic design of his observatory from the observatory of Maraghah in Iran, built in 1239 under the directorship of Nasir al-Din al Tusi, and sponsored by Hulagu Khan, grandson of Chinghiz Khan. Hulagu was known as the Ilkhan in Iran - hence the star tables produced at Maraghah were called the Ilkhan tables.

Very large instruments enabled more accurate calibration. Many such large instruments were made for observatories in the Far East during the Middle-Ages and eventually in Europe - Tycho Brahe's observatory had a large mural quadrant built into the main building similar in design to that of Ulughbek's observatory.

A display of the instruments that might have been used in Ulughbek's observatory together with an outline of the history of astronomy before Ulughbek, is in the museum on the site. This is a round building constructed in 1970, and was



designed to resemble the original observatory building. It is very much smaller and very much plainer too. The original observatory was once covered in sparkling coloured tiles. In the museum you can see copies of Ulughbek's star tables which were translated from the original Farsi (Iranian) into Arabic, Latin, French and English.

## The Life of Ulughbek

Ulughbek's real name was Muhammed Targui. He was born on the 22<sup>nd</sup> March 1394, in the town of Sultania in Azerbaijan. His grandfather, Temur the Conqueror, was on a military campaign there at the time, and on hearing the news of the successful birth of a grandson, he was so pleased that he spared the lives of the defenders of a mountain fortress who had attempted to resist him.

Temur was not normally noted for a merciful and humanitarian disposition, and Ulughbek's early years were spent with his parents following Temur's army on their trail of massacre and conquest, to Armenia, Afghanistan, India and China. On this last campaign, on 18<sup>th</sup> February 1405, Temur died.

The death of Temur was followed by war and chaos as separate members of his family struggled for power. In 1409, Ulughbek's father, Shah-Rukh, Temur's youngest son, emerged victorious. He made his capital city at Herat, (in West Afghanistan) and handed Samarkand and the surrounding territory (approximating the country now called Uzbekistan) to his eldest son Ulughbek to govern.

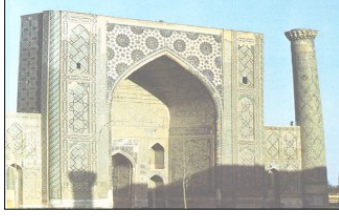
Ulughbek was then 15 years old and had been married five years to a Mongol princess descended from Chinghiz Khan. The husbands of princesses descended from Chinghiz Khan were given the title of "Gurogani" (or Kurokhan) which is how Ulughbek's star tables came to be called the "Zidzhi-Gurogani" (lit. Son-in-Law's Stars).

Ulughbek's parents were cultured people; patrons of the arts and sciences. Ulughbek had inherited from his mother, Gawhar-Shad, a love of learning. Gawhar-Shad founded mosques and a madrassah (a college) at Herat. Education for women was not encouraged, indeed it was considered indecent. Gawhar-Shad got 200 women students into her college by cunning. She took the girls with her as her escorting ladies on a royal visit. During the visit one of the girls was discovered with a student in his room. Gawhar-Shad thereupon insisted that all the students should be married immediately to each of her young ladies to save their reputations and avoid any such future incidents.

Thus education for women became for a short time respectable. On the madrassah Ulughbek found in 1417 in Bukhara, is inscribed



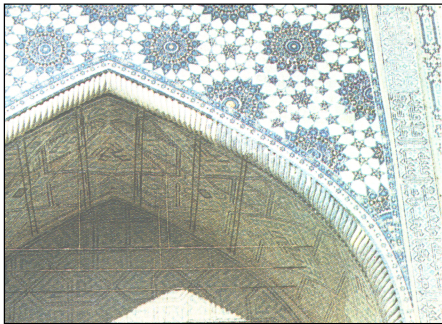
“It is the duty of every Muslim man and woman to acquire knowledge”.



Ulughbek also founded the madrassah in Samarkand, which stands on one side of the Registan, the central square in Samarkand. The other buildings were added later.

The Registan in the centre of Samarkand is one of the most beautiful historic city centres in the world. The facades of the buildings which are still being carefully restored, are covered in sparkling mosaics of coloured tiles. Over the front of the Ulughbek madrassah the tiles are arranged in a pattern of stars.

Inside the building, two stories of cloisters surround a paved courtyard with shady trees.



Ulughbek staffed his colleges with mathematicians, astronomers and philosophers, many of whom were internationally reknown for their work. Ulughbek himself was first a student then later a lecturer in his colleges.

## The Work of Ulughbek

The work which Ulughbek and his colleagues are famous for, is the building of the observatory and the production of the star catalogue and tables.

The observatory was built during the years 1428 to 1429. When it was opened, Ulughbek's proud mother arrived on a royal progress especially to view her son's work.

For the next eight years, the astronomers at Ulughbek's observatory worked on compiling the star catalogue and tables, completing this work in 1437.

Two of the astronomers had been Ulughbek's lecturers at his college: Kazi-Zada Rumi and Ghiyas-ud-Din Jamshid. When Jamshid died, his work was continued by Ulughbek and one of Ulughbek's favourite students Ali bin Muhammed Kushji.

Ulughbek used the cosmological system derived from Ptolemy's *Almagest* and modified later by the Islamic astronomers. The constellations were those in the book by al-Sufi, completed and published by his son in 1009. The most recent star tables available to Ulughbek were the Ilkhan tables published in 1261.

Ulughbek wrote a preface to his star catalogue and tables. The preface gives practical and theoretical information in four parts. The first part explains how to determine the length of years and months including those of the Chinese and Uighur calendars. The second part explains how to measure the positions of the stars. The third part is on determining the positions of the seven planets. Included in this were chapters on determining the Distance of Sun and the Moon from the Centre of the World.

Also on the Moon was the section on “The Head and Tail of the Dragon”. That is the Moon’s ascending and descending nodes, the places where the path of the Moon’s orbit crosses the plane of the ecliptic and eclipses of the Sun or Moon were likely to occur. Traditionally eclipses are caused by a dragon eating the Sun, and contemporary astronomical clocks in Europe marked this cycle with a dragon-shaped pointer.

Ulughbek shows how to predict eclipses of the Sun and the Moon. This part of the book also gives the divisions of the signs of the Zodiac - “The Twelve Celestial Houses”.

The fourth part of the book deals with the making of horoscopes. This was one of the main functions of astronomy until the invention of the telescope opened the science to the exploration of the universe. Horoscopes formed an astronomer’s main source of income.

The list of tables includes useful basic data, such as the latitudes of several major cities throughout the known world, including Spain, a large part of which was still under Islamic rule: the motions of the planets, eclipses of the moon, sine tables (trigonometry was the Islamic contribution and improvement to Ptolemy’s geometry); conjunctions of the planets and so on. Plus of course, the catalogue of stars. Some of the data was copied from past works. The constellations and magnitudes of the stars were taken from al-Sufi’s Book of Fixed Stars and some of the tables were copied from the Ilkhan tables of al-Tusi.

Ulughbek explains the formation of his star catalogue in his preface under the heading: Determination of the Places of the Fixed Stars in Longitude and Latitude:

*“Before the time of Ptolemy 1,022 fixed stars had been observed. Ptolemy has given them in a catalogue in the Almagest. The stars are distributed in six magnitudes: the largest are of the first and the smallest of the sixth magnitude. Each magnitude is divided into thirds, and in order to recognize the stars, 48 figures or constellations have been imagined, of which 21 are north of the ecliptic, 123 in the Zodiac, and 15 south of the ecliptic. The larger number of the stars are within the figures, the others are in the neighbourhood, and are designated as unformed stars of the constellation.*

*Abd-Al-Rahman-Sufi composed a treatise on the stars which all learned men have received with gratitude. Before determining by our own observations the position of these stars, we have laid them down on a sphere according to this treatise, and we have found that the greater part of them are situated differently from their appearance in the heavens. This determined us to observe them ourselves with the assistance of Divine Providence, and we have found that they were advanced from the epoch at which Sufi’s work was written, so that on giving them, according to this general observation, their absolute position, we no longer found any difference from their appearance to the eye.....*

*In our catalogue we have given the position of the stars for the beginning of the year 841 of the Hegira (1437), so that at any time we may be able to find the place of any stars on the supposition that they advance one degree in seventy solar years”.*

It can be seen from this abstract that Ulughbek’s work consisted of updating and correcting existing established data. He did not put forward any new cosmological theories. Nevertheless he upset religious fanatics.



## **Opposition to Ulughbek by his son and others.**

Ulughbek's academic interests were not inherited by all his children. One son, Abd-al-Latif, had his own ideas for his future career. His grandmother Gawhar-Shad did not trust this young man - rightly as it turned out. In 1446 Abd-al-Latif was taken on a military campaign into Western Iran with his grandparents, so that his grandmother could keep her eye on him.

Just before the spring of 1447, Shah-Rukh died. Abd-al-Latif seized the opportunity for power.

He forced his grandmother to follow the litter bearing her husband's body back to Herat, on foot, wearing an ordinary linen scarf on her head and supported only by a staff held in her hand. No doubt he hoped this would finish her off too.

Gawhar-Shad not only survived this treatment she managed to regain control over her grandson's forces, in Herat.

Ten years later she was to be murdered by a great-nephew, Abu-Said. Abu-al-Latif was not the only one with ambitions on the Empire after Shah-Rukh's death.

While Ulughbek was leading his troops against rival claimants in Khorresan, Uzbeks under Abdulkhair Khan besieged Samarkand. They finally withdrew but not until after they had vandalized Ulughbek's collection of Chinese mosaics.

## **Opposition to Ulughbek by religious extremists**

Ulughbek had worse enemies than ambitious war-lords and problem children. The religious fanatics.

Men who did not like to be ruled by an academic. Men who lived by religious dogma not rational thought.

Against them Ulughbek had said:

“Religion disperses like a fog, kingdoms perish, but the works of scholars remain for an eternity”.

This angered the religious extremists. In their propaganda against Ulughbek they said “He is insane! He compares religion with fog. He says that fog is dispersed. He means the end of Islam. He says that kingdoms collapse. Indeed, his kingdom must come to an end!”

The leader of the fanatical religious extremists plotting against Ulughbek was Hodja Ubaidulla Akrrar, the head of the Sufi Nakshbendi order. Akrrar was an extreme and violent fundamentalist opposed to any deviation from his own interpretation of the dogmas of Islam. In his campaign against Ulughbek, Akrrar gained the allegiance of Ulughbek's son Abd-al-Latif who was looking for allies in his plans to wage war on his father in order to displace him.

Ulughbek like Bruno and Galileo and many other scientists was destined to become known as suffering martyrdom for his scientific beliefs against the entrenched religious conservatism - in this case of Muslim fundamentalist extremists.

There is no evidence that Ulughbek ever supported, proposed or concluded from his observations, a new cosmological system as Galileo was to do. Ulughbek's observations were made with the intention of updating earlier astronomical tables to be used in producing a more accurate calendar, and for compiling horoscopes. Ulughbek and his colleagues were not exploring the universe as in modern astronomy as this was only made possible by the invention of the telescope at the end of the 16<sup>th</sup> century, and unlike Anaxagoras in the 4<sup>th</sup> century BC, Ulughbek did not deviate from the accepted system of the universe.

The religious leaders and their followers, opposed to Ulughbek were those who disapproved of liberal ideas and liberal ways, and improved educational opportunities (including the equal education of girls and women). Much like the religious extremists of recent times – and at all times and places in history.

Pictures in the “Book of Kings” sponsored by Ulughbek's younger brother (who died at an early age in suspicious circumstances following a drunken orgy) show Ulughbek and members of his family surrounded by their court. Against a background of colourful and ornate carpets, tapestries and frescoes, courtiers are entertained by voluptuous dancing girls accompanied by musicians while pretty boys serve refreshments.

The fundamentalists banned alcohol - (but got stoned on cannabis and opium – that part of the world, especially Afghanistan is still a major producer). They considered it immoral to watch women dancing or use women as prostitutes - (but perfectly acceptable to use young boys for this purpose and Samarkand was to become notorious for its rent boys).

The fundamentalists also disapproved of the teaching and discussion of mathematics and foreign philosophies which went on in Ulughbek's colleges.



These opponents had protested for years without any effect, but Abd-al-Latif was now willing to make use of all his father's opponents whatever their personal motives, to gain power. He gathered on his side the fundamentalists and also those who were dissatisfied with Ulughbek for other reasons. Many joined him just because they thought the younger man was a better military leader. Ulughbek was forced to launch a military attack against his son Abd-al-Latif, which he lost.

## Ulughbek is assassinated

Abu-al-Latif was now the Emir, but he had to get rid of his father entirely before he felt safe in his position. Amongst those he had collected round him who bore a grudge against Ulughbek was a man called Abbas who father had been executed on Ulughbek's orders. Abu-al-Latif made plans.....

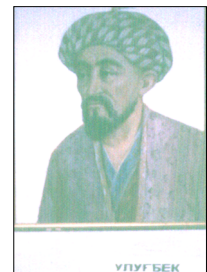
On the 27<sup>th</sup> October 1449, a cold wet day, Ulughbek left Samarkand, riding with the hadji (pilgrim to Mecca) who was appointed his companion and the few bodyguards who were left to him. They had not gone very far when a messenger overtook the group ordering them to turn to a nearby village to collect something necessary to their journey.



When Ulughbek arrived in the village he was seized by Abbas and beheaded.

His remains were buried next to the tomb of his grandfather Temur in the Gur-Emir Mausoleum.

In 1941, both these famous bodies were exhumed by archaeologists. They were able to confirm that Ulughbek had been violently beheaded. A reconstruction was made of his head by Mikhail Gerassimov, who pioneered this method of forensic archaeology.



Abd-al-Latif managed to defeat his ambitious cousin Abu-Said in the following year after Ulughbek's violent death, but was himself assassinated.

Abu-Said conquered Samarkand in 1452 and placated the Uzbek threat by giving Ulughbek's daughter Rabiga Sultan Begim, as a wife to the Uzbek Khan Abdulkhair. Abu-al-Latif's son joined his aunt and Abdulkhair to depose Abu-Said. That is how the region was taken over by the Turkic speaking Uzbeks and was to become Uzbekistan.

It was too late to save the observatory. The religious fundamentalists had organized a fanatical mob to destroy and raze the entire building of Ulughbek's great observatory - at that time the biggest and best equipped in the world. The library of 15,000 books was looted, and the scholars driven out of Samarkand. The religious leaders declared the hill on which the observatory had stood, was the burial place of "forty maidens". They built a mausoleum to these "forty maidens" on this site and turned it into a lucrative centre for pilgrimage, hoping by this means to utterly destroy the memory of Ulughbek's observatory.

## **Legacy of Ulughbek**

Ulughbek's work had not been lost to the world. Ulughbek's ex-student, later assistant, Ali-Kushji, who had been forced to flee from Samarkand took his copy of the star catalogue with him and had it published. Translations were made of the original text which was in Farsi (Iranian) into Arabic the *lingua franca* of the Islamic world.

By the end of the 15<sup>th</sup> century, Ulughbek's star catalogue and tables were used by astronomers throughout the Islamic world. The Ottoman Turkish astronomers in Istanbul were still using them in the 1580s.

In 1643, John Greaves, Savilian Professor of Astronomy at Oxford University, translated Ulughbek's work from Iranian and Arabic copies into Latin. But his work was never published. In 1655, Thomas Hyde, Librarian at the Bodleian at Oxford University, published a translation of Ulughbek's work collated from four manuscript copies.

By this time, however, the Ptolemeic system had been almost totally abandoned – following Kepler's calculations of the orbit of Mars and the discoveries made by the telescope. Ulughbek's tables had already been superseded by others, first by those of Copernicus and then by the Rudolphine tables compiled by Tycho Brahe and Kepler. Other astronomical tables soon followed as the telescope made more precise measurements possible and extended the observations.

In the 18<sup>th</sup> century the Indian Prince Jai Singh, built several observatories with gigantic instruments constructed according to Ulughbek's calculations, but these were already too out of date to be of much practical use and were little more than astronomical theme parks.

Although knowledge of Ulughbek's achievements came late to Western Europe, they did not go unrecognised. Ulughbek was accorded a place with such as Ptolemy, Copernicus, Galileo and Kepler - amongst the world's greatest astronomers.



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