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TRACING THE TRAJECTORY OF SCIENCE AND TECHNOLOGY IN MUGHAL INDIA

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Abstract:

It is interesting to look at a very fascinating period of Indian history in the medieval times viz the Mughal rule and to trace the trajectory of the growth of science and technology during the Mughal period of Indian history. During the Mughal rule of India, science and technology developed mainly due to the interests of Emperors and Sultans, particularly in astronomy, agriculture, engineering, architecture and medicine. A number of encyclopaedias and dictionaries were penned. Initially dictionaries were needed as new ideas were being developed as a result of interaction between Sanskrit and other languages. During the later period of Mughal rule, new ideas were accepted from European science and technology.

This paper attempts to examine the growth of science and technology during the Mughal period in areas such as Astronomy, Alchemy, and Waterworks. The Mughal Emperors (1526-1858) took a keen interest in the development ofastronomy. They patronized astronomers in their royal courts. The works thus producedwere mainly *zije*s (astronomical tables) and calendars. The Mughals had great technological achievements in the manufacture of military materials such Damascus steel for sword blades, Cannon foundries which created temperatures as high as 2400 degree Fahrenheit, Volley guns which had multiple gun barrels, and metal cylinder Rockets used particularly by Emperor Akbar against war elephants. The Mughals had made great advances in the field of metallurgy.

Introduction

During the Mughal rule of India, science & technology developed mainly due to the interests of Emperors and Sultans, particularly in astronomy, agriculture, engineering,architecture and medicine. A number of encyclopaedias and dictionaries were penned.Initially dictionaries were needed as new ideas were being developed as a result ofinteraction between Sanskrit and other languages. During the later period of Mughal rule,new ideas were accepted from European science and technology.[1]

Akbar ordered AbulFazl to translatefrom Arabic into Persian *HayatulHaiwan*, the celebrated zoological dictionary,compendium of folklore, and popular medicine, authored by Musa al-Damiri (d1406).Faizi paraphrased the first two *puranas*into Persian verse. Father Monserrate presented to Akbar an *Atlas* sent to him by Archbishop of Goa. He hadwritten in his travelogue that he had seen Akbar working on machines and givinginstructions on how to make new machines.[2]

Shaikh Abu al-Faizibn Mubarak – pen name Faizi (1547-95) was a poet laureate ofEmperor Akbar. At the suggestion of Akbar, Faizi translated BhaskarAcarya's (1114-60)Sanskrit work on mathematics *Lilavati*into Persian in 1587; containing theorems ofarithmetic and algebra. The translation was so popular that AtaullahRashdiLahoritranslated BhaskarAcarya other books on algebra and measurement. Faizi, a prodigiousauthor of 100 books, translated few mathematical problems from Latin into Persian also.The famous book covering the administration of Emperor Akbar, *Ain – e- Akbari* writtenby AbulFazlAllamiibn Mubarak (d.1602), described West and Central Asianastronomy.

Emperor Noor al-Din Salim Jahangir (d.1627) continued the patronage of translationsfrom Sanskrit into Persian as well as of Hindu scholars who wrote on Hindu law, sciencesand

[1] Science in India during the Muslim Rule, ZakariaVirk, Kingston, Canada
[2]http://www.columbia.edu/itc/mealac/pritchett/00generallinks/txt_monserrate_akbar.html#letters

lexicography. Jahangir was an excellent writer and loved nature. He recorded variousdetails of flora and fauna from all over India. He was not only curious, but a scientificobserver of minute details of species. A number of his observations are detailed in hisautobiography *Tuzk-e-Jahangiri.*

FariduddinMunajjum, a court astronomer of Shah Jahan (d.1666), compiled *Zije ShahJehani.* The first section of the tables dealt with various calendars, second section dealtwith spherical astronomy, third section dealt with determination of the motions of theplanets and their positions in the sky. The Zij was translated into Sanskrit under the title*Siddhanta-Sindhu*, by Nityananda at the command of vizier Asaf Khan & completed in1635. A copy of the manuscript at Jaipur Museum once belonged to Emperor Shah Jahan,his seal is on folio 1. The Sanskrit translations consisted of 440 pages, 11 copies of thiswritten on 'jahazi' paper, 45x33 cm were distributed among the aristocrats of NorthIndia. Four copies are at Jaipur palace library. Nityananda explained the Arabic andPersian technical terms for the benefit of Hindu astronomers while giving differencesbetween islamic and Hindu astronomy. He devised new technical terms during thetranslations, which were later used in the translations Phillipe de Hire's Latin tables intoSanskrit.Malajeet was an astronomer at Shah Jahan's court. He wrote *Parsiprakasa*(1643) whichgave Arabic, Persian astronomical terms and their Sanskrit equivalents. Two Hinduscholars namely NityaNaad, andMenisvara, used Arabic, Persian and Greek works tosynthesize Islamic traditions with those of India. Mulla Mahmud Jaunpuri was a versatilescholar, expert in mathematics and astronomy. His book *ShamsayBazegha*and *ShamseyBaligha*bring out outstanding features of astronomy. Emperor Shah Jehan wanted toconstruct an observatory for MullaJaunpuri, but could not do so on account of financialconstraints on the royal treasury.

Astronomy

The Mughal Emperors (1526-1858) took a keen interest in the development ofastronomy. They patronized astronomers in their royal courts. The works thus producedwere mainly

*zije*s(astronomical tables) and calendars. Many scientific works broughtfrom outside of India like BahauddinAmuli's (1574-1621) *Khulasatul-Hasab*, andTusi's*TahrirUqlidis*and *Tahrir al-Majisti*. Attempts were made to write commentariesand translate these works. As a result the intermingling of Indian mathematical traditionwith Arabic & Persian did take place enriching the country.

The 16th and 17th centuries saw a synthesis between astronomy in medieval Islam and Indian astronomy, where Islamic observational techniques and instruments were combined with Indian mathematics techniques. While there appears to have been little concern for theoretical astronomy, Mughal astronomers continued to make advances in Observational astronomy and produced nearly a hundred Zij treatises. Humayun built a personal observatory near Delhi. Astrolabe used for astronomical observations was developed and improved upon in India.Humayun patronized astrolabe manufacturing. The astrolabe maker at his court wasAllahdabAsturlabiLahori whose sons and grandsons also made astrolabes. The instruments and observational techniques used at the Mughal observatories were mainly derived from the Islamic tradition.[3] In particular, one of the most remarkable astronomical instruments invented in Mughal India is the seamless celestial globe.

Islamic Celestial Globe, 1630 A.D. This brass globe served both as a map of the heavens, as viewed from outside the starry sphere, and as a precision tool for making astronomical calculations. Engraved on its surface are various coordinate lines, constellation figures, and Arabic inscriptions. The stars are made of embedded bits of silver. The globe is hollow and was cast in one seamless piece. It was originally set in a cradle of rings, which depicted the horizon and other astronomical circles.

The Persian-Indo polymath, FatehullahSherazi (d.1582), a scientist at the court ofEmperor Akbar (d.1605) reformed the Calendar.

[3]Sharma, VirendraNath (1995). *Sawai Jai Singh and His Astronomy*. Publ., 8–9.

Mathematics

One of the distinguished families of Punjab that made significant contributions tomathematics was Ustad Ahmad Lahori, aka Ahmad al-Mima'r, (1580-1649) the architectof TajMahal& Red Fort. One of his sons AtaullahRashedi translated BijGanitadescribing the reign of Emperor Shah Jehan. (reigned 1628–58) He also wrote *KhulasaRaaz*in Persian which dealt with arithmetic, algebra, and measurement. His other book*KhazinatulA'adad d*ealt with arithmetic, geometry of Euclid and algebra. Another sonLutfullahMuhandis wrote *RisalaKhawsA'adad*dealing with properties of numbers. Hewas also author of *SharahKhulasa al-Hisab*and his *Muntakheba*t was a translation ofPersian mathematician BahauddinAamili's*Khulasatul--Hisab*(epitome ofmathematics).

Alchemy

Sake Dean Mohamed had learned much of Mughal Alchemy and understood the techniques used to produce various alkali and soaps to produce shampoo. He was also a notable writer who described the Mughal Emperor Shah Alam II and the cities of Allahabad and Delhi in rich detail and also made note of the glories of the Mughal Empire. Sake Dean Mohamed was appointed as shampooing surgeon to both Kings George IV of the United Kingdom and William IV of the United Kingdom.[4]

Medicine

One of the secretaries of Emperor Humayun Yusuf ibn Muhammad Herati wrote a book on various diseases and their remedies. Hakim Ali Gilani (1554-1609) was not only a physician but

[4]Teltscher, Kate (2000). "The Shampooing Surgeon and the Persian Prince: Two Indians in Early Nineteenth-century Britain". *Interventions: International Journal of Postcolonial Studies, 1469-929X***2** (3): 409–23.

a renowned mathematician and a scientist. He was attached to the court of Akbar who had given him the title of *Jalinoos al-Zaman*(Galen of the world). He was the only Indian physician to have written a commentary of all five volumes of *al-Qanun*. The first volume of the commentary *Jamay al-Sharahein*was published from Lucknow in 1850. Another book of his on medicine is called *MujarrabateyGilan*i (tested remedies). Emperor Jahangir believed that Akbar was poisoned by Hakim Gilani.

Muhammad Raza of Shiraz wrote a treatise *Riaz-i- Alamgiri*on medicine, food andclothing, and was dedicated to Aurangzeb. Muhammad Akbar Arzani, court physician ofAurangzeb, wrote *Tibb-i-Akbari*in 1678, which was in fact translation of Sharh -ul-Asbab. Arzani also wrote *Tajriba-i-Akbari*, based on author's own experiences.His QarabadainQadri was an extensive pharmacopeia of medicine extensively used inIndia. Imam Ghulam Hakim wrote in Persian *Elaj al-Ghura*ba (treatment of specialdiseases) which was reprinted several times during the 19th century due to its immenseusefulness.

Pharmacy

During the reign of Mughal kings of India several Qarabadains were compiled likeQarabadainShifae'ee, QarabadainZakai, QarabadainQadri and Elaj-ul-Amraz. In thesepharmacopoeias quantities of drugs in a given prescription were specified, and methodsof preparation. The court physicians supervised the preparations of royal medicine, whichwere sealed to ensure safety. Hakeem Ali Gilani was the chief physician of EmperorAkbar and used to accompany him in his travels. Hakim Gilani used to carry hispharmacy with him in these travels. He invented a kind of sweet wine for getting rid oftraveling fatigue. During the reign of Emperor Jehangir, Itr-i-Jehangiri was discovered byQueen Noor Jehan. Hakim Ain-ul-MulkShirazi composed for his royal patron emperorShah JahanAlfaz-al-Adwiyya (vocabulary of drugs). It was printed in 1793 in Calcutta,and rendered into English by Gladwin. Hakim Akbar Arzani, was a court physician ofEmperor Aurangzeb. He wrote TibbeAkbari, and Mizan al-Tibb.

Waterworks

The first Mughal Emperor Babur is known to have patronized the construction of water channels used in gardens and orchards, ablution pools for his servicemen. This tradition was continued by his grandson Akbar who built monumental waterworks in his capital at FatehpurSikri where he ordered the construction of a Dam with 13 gates.This Dam created a shallow artificial lake during the Monsoon season every year. Water was then lifted into FatehpurSikri through large mechanical devices known as the Water wheel and Sakia. Akbar's engineers brought water from the lake constantly into the city in different stages. Gravity then brought flowing water down through a complex system of channels, pools and reservoirs. However due to the shortfall of water and a brief drought FatehpurSikriwas abandoned and Akbar had to relocate his capital to Lahore.

It was due to the success of Mughal irrigations systems during the reign of the Mughal Emperor Shah Jahan that he patronized the digging of wells and build river embankments for irrigation.[5] Shah Jahan ordered the construction of two notable Canals: *Nahr-i-Faiz* and *Shah Nahr*, which drew water from the Yamuna to various irrigated fertile lands. During his reign Agra also became known as the *Waterfront garden city*, which provided wealth for its 700,000 inhabitants. Mughal Emperors were famed for their endowments to the construction irrigation systems in order to increase the amount of cultivated irrigated lands that produced higher crop yields and increased the net revenue base of the empire.

Technology

Damascus Steel

The Mughal Emperor Akbar is known to have built large foundries producing the best quality sword blades; Akbar himself is known to have preferred Damascus steel Talwar, which were considered the sharpest blades ever used in battle in South Asia.

Cannon Foundry

[5] "http://islam.wikia.com/wiki/Science and technology in the Mughal Empire"

During the reign of the Mughal Emperor Shah JahanJaigarh Fort, became one of the worlds most efficient Cannon foundries mainly due to the abundance of Iron ore mines in the vicinity of the fort. The Mughal cannon foundry Jaigarh Fort had a massive wind-tunnel that sucked air from the high mountains into its furnace creating temperatures as high as 2400 degrees Fahrenheit. The heated air would melt the metal. The liquid molten metal would fill a reservoir chamber and into a cannon mold in the casting pit. Most of those Mughal Cannons were massive mostly 16 ft long and had to be prepared within a single day. The Mughals also built a large ingenious mechanical device that had a precision gear system driven by four pairs of Oxen, the device was used for hollowing out the Cannon barrels.

FatehullahSheraziinvented a cannon-related machine which could cleansixteen gun barrels simultaneously, and was operated by a cow. He also developed 17barrelled cannon, fired with a matchlock.

It is believed that Mughal cannon production reached its zenith during the reign of the Mughal Emperor Aurangzeb. In fact one of the most impressive Mughal cannons is known as the Zafarbaksh, which is a very rare *composite cannon*, that required skills in both wrought Iron forge welding and Bronze casting technologies. [6]

Volley Gun

FathullahShirazi (c. 1582), a Persian polymath and mechanical engineer who worked for Akbar, developed a Volley gun. It was a military weapon designed for killing infantry. The Volley Gun had multiple gun barrels similar to hand cannons.

As opposed to the polybolos and repeating crossbows used earlier in ancient Greece and China, respectively, Shirazi's rapid-firing gun had multiple gun barrels that fired hand cannons loaded with gunpowder. The first prefabricated homes and movable structures were invented in 16th century Mughal India by Akbar the Great. These structures were reported by ArifQandahari in

[6]FathullahShirazi: Cannon, Multi-barrel Gun and Yarghu".*Indian Journal of History of Science***40** (3): 431–436. New Delhi

1579.Tipu Sultan of Mysore (1783-1799), the Nawab in the south of India, an experimenter with war rockets**,** invents iron-cased and metal-cylinder rocket artillery. He successfully used them against British East India Company forces during Anglo-Mysore Wars.

Rocket

Akbar was the first to initiate and utilize metal cylinder rockets known as *bans* particularly against War elephants, during the Battle of Sanbal.In the year 1657, the Mughal Army utilized rockets during the Siege of Bidar. Prince Aurangzeb's forces discharged rockets and grenades while scaling the walls. SidiMarjan himself was mortally wounded after a rocket struck his large gunpowder depot and after twenty-seven day's of hard fighting Bidar was captured by the victorious Mughals.

Later onward's the Mysorean rockets were upgraded versions of Mughal rockets utilized during the Siege of Jinji by the progeny of theNawab of Arcot. Hyder Ali's father Fatah Muhammad the constable at Budikote, commanded a corps consisting of 50 rocketmen (*Cushoon*) for the Nawab of Arcot. Hyder Ali realized the importance of rockets and introduced advanced versions of metal cylinder rockets. These rockets turned fortunes in favor of the Sultanate of Mysore during the Second Anglo-Mysore War particularly during the Battle of Polilur.

Metallurgy

Considered one of the most remarkable feats in metallurgy, the Seam Globe was invented in Kashmir by Ali Kashmiri ibnLuqman in 998 AH (1589-90 CE), and twenty other such globes were later produced in Lahore and Kashmir during the Mughal Empire. Before they were rediscovered in the 1980s, it was believed by modern Metallurgists to be technically impossible to produce metal globes without any Seam, even with modern technology. Another famous series of seamless celestial globes was produced using a lost-wax casting method in the Mughal Empire in 1070 AH (1659-1960 CE) by Muhammad SalihTahtawi (from Thatta, Sind) with Arabic and

Persian language inscriptions. It is considered a major feat in metallurgy. These Mughal metallurgists pioneered the method of Wax Casting[7] while producing these seamless globes.

Conclusion

For a student of history today who observes the major advances in science and technology, it is fascinating to trace the trajectory of science and technology during one of the most vibrant periods in Indian history viz the Mughal period. The Mughal Emperors were lovers of science and technology and took keen interest in their development. The technologies they used are truly awe inspiring and makes one realize that the period was second to none as far as advances in science and technology are concerned.There was a synthesis between the Indian and the Islamic tradition and this synthesis makes the history of India unique and enriching. There were translations and commentaries which ensured that knowledge was disseminated.

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