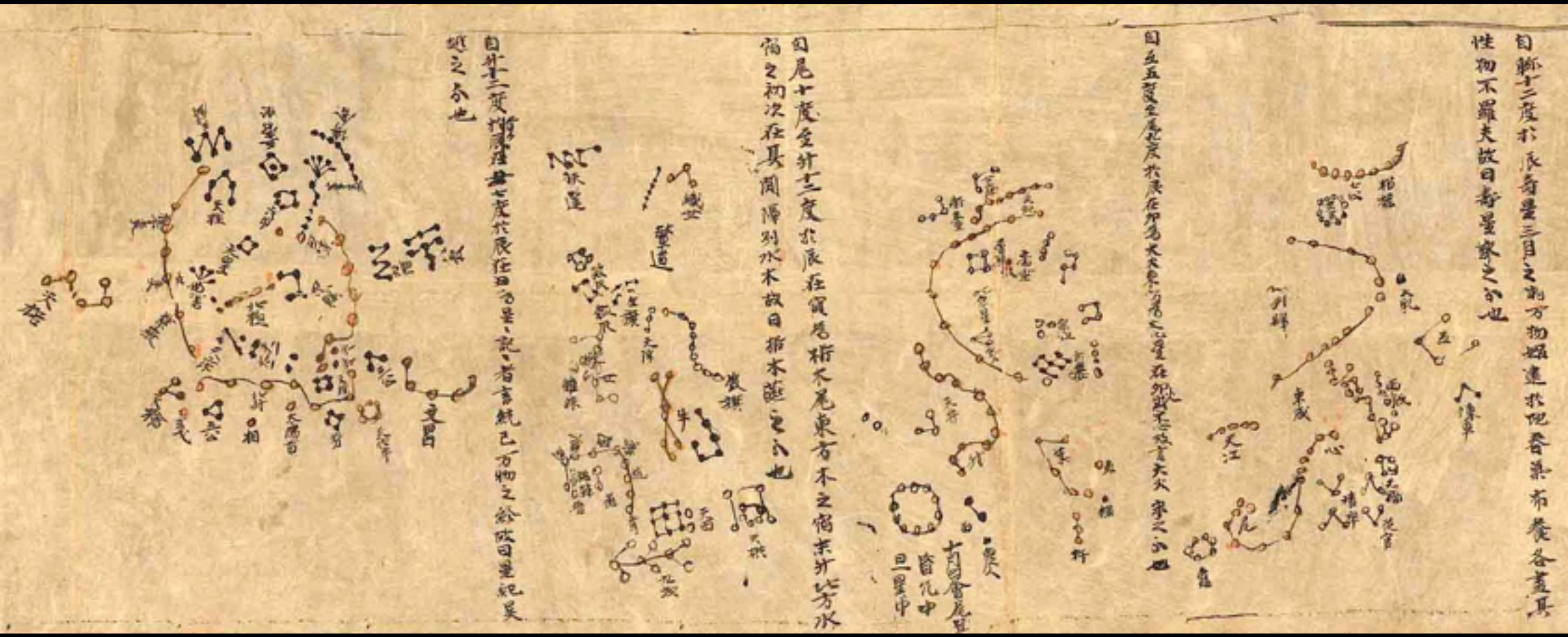
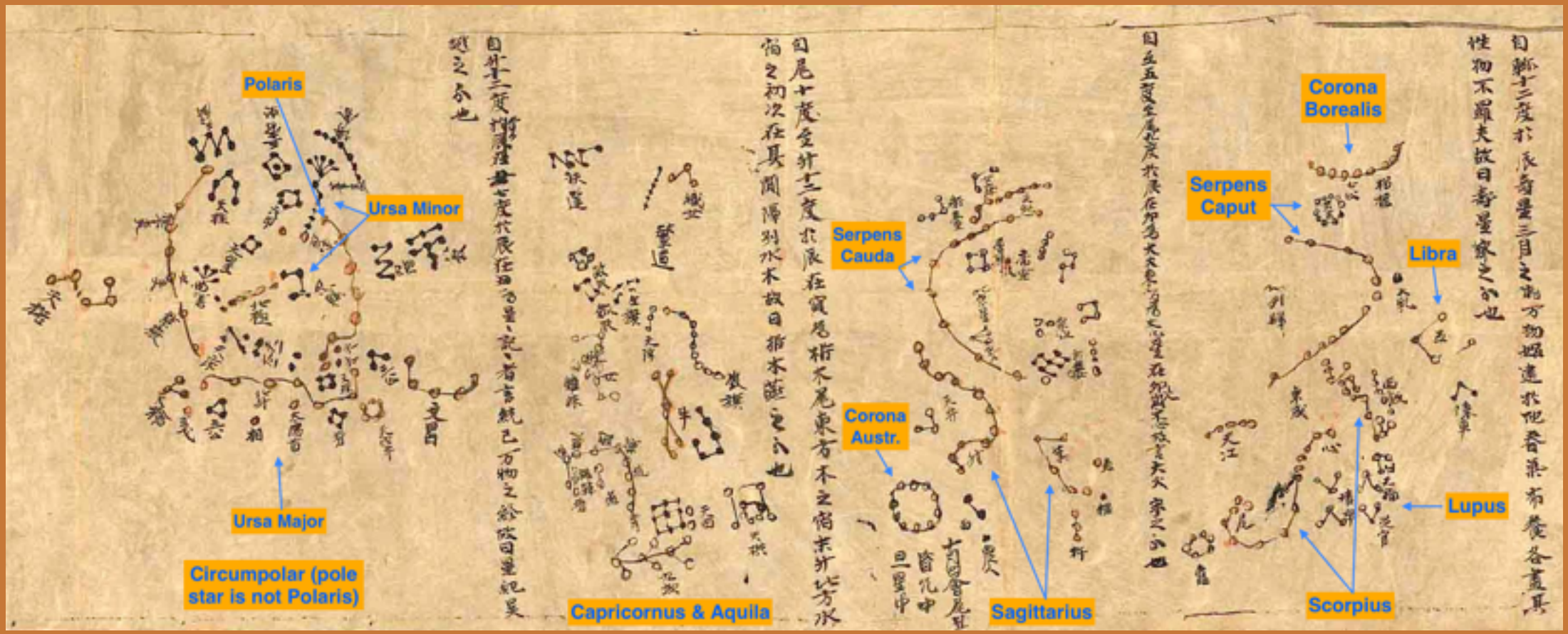
The World's Oldest Sky Atlas



Dunhuang Star Chart, Early T'ang dynasty, c. 648–683

Douglas Bullis

Mapping before Mercator: Astronomy's first azimuthal star chart



The Dunhuang Chart has no equivalent in the Babylonian or Western European cartographic traditions. It was found at the westernmost outpost of the Chinese Empire, a region influenced by quite diverse cultures such as the Tibetan form of Taran (Tantric) Buddhism, Scythian animism, and Chinese ancestor veneration. The Sinkiang and Taklaman regions were only loosely dominated by the Chinese Empire and hence much more culturally eclectic than the Middle Kingdom between the Yangtze and Yellow Rivers to the east.

Even so, the Dunhuang Chart's constellations and geometric positioning reflected the Middle Kingdom's astronomical conventions. Scholars consider it a syncretic document that amalgamated information from diverse origins into an early form of scientific perspective that also served for divination.

Lost for a Thousand Years

The Dunhuang Chart is the oldest known graphical star atlas from any civilisation. It is also the only Chinese celestial map known prior to 1100 ACE. Not a trace of its many copies produced at the time has ever been found. Though drawn between 648–683, at some point between 950 and 1000 ACE it was sealed in a secret chamber in a cave hewn by hand from a high stone escarpment, along with 40,000 other manuscripts and records — including a copy of the world's first known book printed with movable characters (story below). Until it was discovered by accident in 1903 and finally analysed by scholars in 1953, knowledge of the Chinese civilisation's thinking about the heavenly bodies existed only in a few rudimentary drawings and written accounts that date as far back as the Time of the Warring States (476 –221 BCE).

The ancient records led scholars to conclude that astronomy for the Chinese in those distant days had its uses as a divinational tool, but in later times as trade increased came to be regarded more as a navigational aid. The Chinese did not base their understanding of the heavens on the Ecliptic or fanciful chimerical beings like Capricornus, Sagittarius, or Pisces which harboured some invisible force that could modulate the fates of humans. The positions of the planets did not loom especially large in their cosmology. (Nor did the Milky Way; it was never depicted on any of the pre-modern charts.)

The Chinese celestial sphere was equatorial. In the larger scheme of annual cycles, the Equator was demarked by twelve 'Jupiter Stations', locations in the sky where Jupiter would reside for one year. Jupiter's orbital cycle is 11.89 years. The Chinese sky had 365.25 degrees instead of 360; one degree for each day.

The Dunhuang Chart has been reliably dated to between 649-684. The quality of its calligraphy marks it as a second-quality probably locally produced copy of an Imperial original which would have been lodged in the Court Astronomer's Office in the capital of the Tang Emperor in Chang'an (today's Xi'an). The plotting is accurate to within four degrees. The Chinese bureaucracy was much keener on faith to actuality than faith to deity. The Chart demonstrates a sophisticated attention to precise position three centuries before a similar level of sophistication appeared in the star charts in the *Book of Fixed Stars* by Abd. Rahman al-Sufi in 964, eight centuries before the sky atlas of Ulugh Beg of Samarkand in 1436 and the first pictorial star map in the West, the Vienna Chart of 1440.

For such a valuable trove of knowledge, the Dunhuang Chart was found in an unlikely location: in cave originally excavated at the western limit of the central Chinese Empire during the early T'ang Dynasty (609 – 983). Dunhuang was a key crossroads town during the heyday of the Silk Road era. As the westbound terminus of the Silk Road that linked Imperial China to India, Arabia, Europe, and Russia, it was a major source of revenue for the Imperial government. The peoples of the Eastern Mediterranean, Levant, Baltics, Russia, Persia, Central Asia, and India hungered for luxury goods. In exchange they much to export themselves: timber, gems, silver and gold coins, ingots of lead and flasks of mercury, medicaments, and inevitably, slaves.

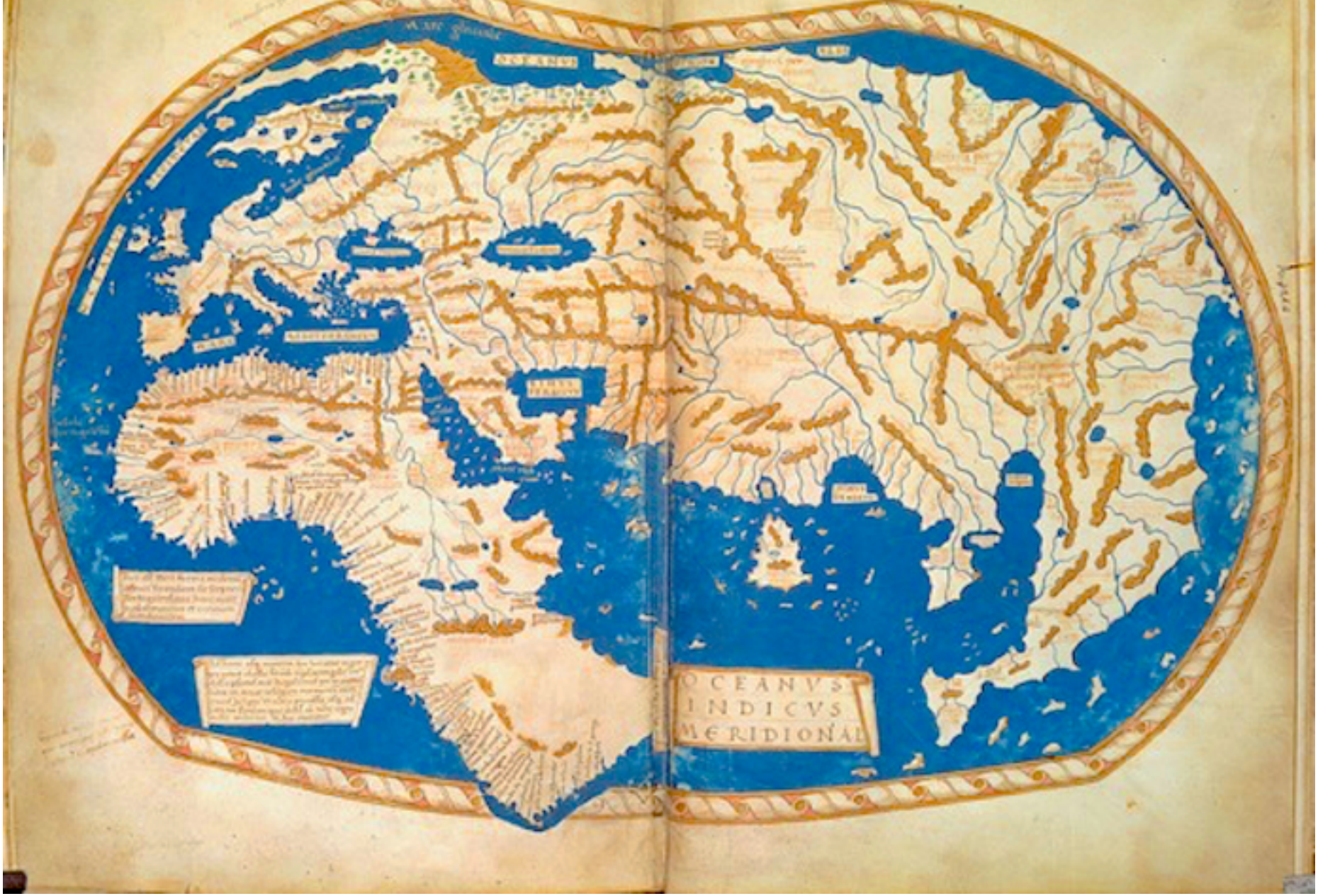
The Dunhuang map and its probable replicas were as vital to the Silk Trade as GPS is to us today. It was originally prepared to help Chinese military officers and Imperial officials to navigate the featureless, hostile terrain of the Western Kingdom. But when

merchant caravan leaders saw a copy they immediately spotted it as the most important thing they could add to their navigational repertoire.

The chart was of the heavens, not the earth. To travellers, only the night sky could point to the true way. Once past the last Dunhuang border stockade the caravan guides had to navigate the Gobi desert, Mongol steppeland, Taklaman Desert, Tarim Basin, and the Tian Shan and Pamir mountain ranges, before the hills of Samarkand finally loomed from the arid heat's mirages. While today's picture-perfect tourist publicity gives the impression that desert skies are perfect every day, the caravaners who walked the vast waterless land knew horizons to be indistinct, hazy, roiling with shimmer, phantomed by mirages. By day the heat filled eyes with delusions, tongues thickened, lips cracked, voices rasped. By night the wind ceased and the sky filled with stars. Year after year, from time out of mind in the past, those stars were in the same place they were last year. Stars were the only thing the eyes could trust.

Being a chart made primarily for military and administrative use, the Dunhuang Chart distilled centuries of information produced by an astronomical tradition firmly grounded in a mandate for accuracy. To varying degrees the lands the caravans served welcomed new ideas if the ideas were productive ones. Along with the silks came styles in garment design such as multiple layers of complimentary colours and complex surface design based on nature shapes (e.g., butterflies, chrysanthemums). The full cultural fusion came when the beauty of the garment became valued as a

Tang Imperial official traveling with bodyguards. The yellow parasol was a signal that he was under Imperial orders. More than an honorarium, the parasol also warned bandits that it would not be wise to to rob this particular traveller.



The Silk Road linking China and the West had been used sporadically from the era of Emperor Wu (141–87 BCE) but developed into the legendary trade route we think of today starting in 639 when Hou Junji (d. 643) defeated the Turkic tribes of the Tarim Basin. The Road alternated between prosperity and neglect for centuries depending on the authority exerted by the prevailing Chinese (sometimes Tibetan) dynasties. Map from c.1489–90 by Henricus Martellus Germanus, Florence.

statement that could translate into other aesthetic forms such as gold and gemstone jewellery. The notion that form follows taste displaced form follows function.

Persians loved China's many types of ceramics and silver work. Going the other way, the Chinese cheerily adapted the Persian interior decor ideas such as stools, chairs, and the Mesopotamian idea of the *divan* (bank seat along a wall) — certainly an improvement on sitting cross-legged on woven floor mats infested with lice and mites. From the sometimes Persian satrapy of Afghanistan came the most iridescent, lush blue the earth has ever made, lapis lazuli. Durable under heat, easily powdered, emollient in oils, dazzling in the sun yet scarcely less lustrous in the darkened boudoir, lapis was the foundation blue supporting every taste from Chinese cloisonné to eye shadow in Rome to ornaments fit for a queen.

The pre- and then post-Islamic world traded huge quantities wood products, metal ware, linen and wool cloth for Chinese silks, lacquer wares, and porcelain. In return the culture-loving Chinese, especially in the Imperial capital of Chang'an, embraced musical ideas and instruments from foreign regions. The melodious flute quickly found favour in court circles, banishing the shrieking whistle to the rumbustious village festivals. The Kucha tribes in the Tarim Basin, recently conquered from restive Turkic nomad tribes, exported small lacquered drums eastward, as did India its cymbals. In the Chang'an court there were nine musical ensembles representing music from throughout Asia.

Samarkand dirham (897–902 from the Vale of York Viking hoard, Durham, England.

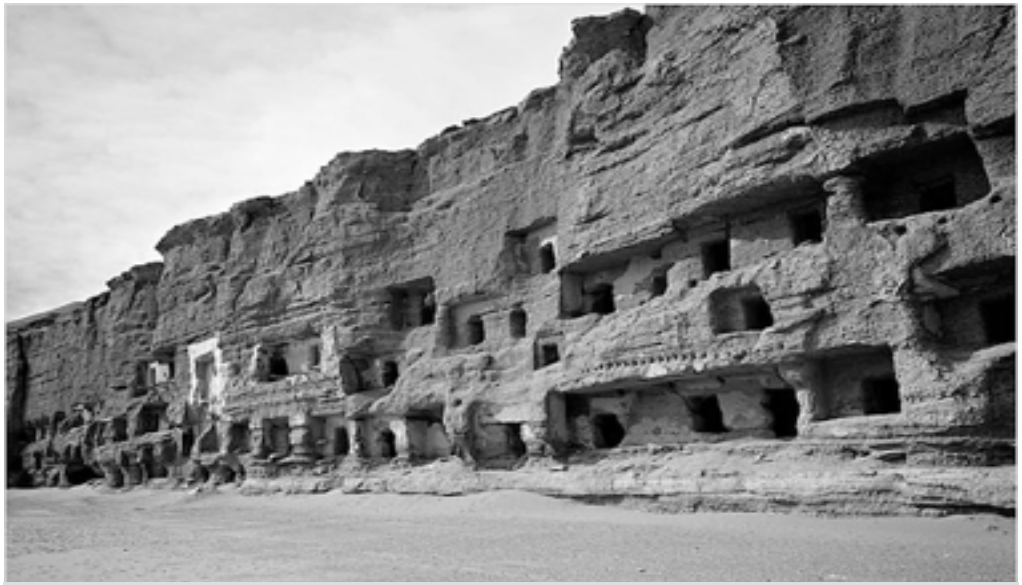
Even the Norse got into the act. Samarkand was the southern entrepôt for the Viking-controlled Volga trade to Russia and the Baltics. In a Viking treasure trove buried in 10th century England and now named the Vale of York Hoard, was a silver dirham bearing the mint marque of Isma'il I, 892-907 of Samarkand.

The only alternative trade route to the West at that time was the Silk Sea around the Malacca Straits, India/Zeylan (Sri Lanka), Hormuz, Aden, and finally the ports at the upper end of the Red Sea. In a time when helmsmen had to 'coast' or sail within sight of land, piracy was impossible to control. For impoverished sea villagers across a span of 4,000 maritime leagues, snaring merchant vessels proved a much easier catch than netting fish. Some pirate communities on the southwest coast of India grew so acculturated to the merchant raider life that they boarded their victims' ships, offloaded the goods while the pirate leader enjoyed tea with the ship captain, then bade their 'guests' farewell with, 'Do visit us again on your next voyage'. *(Ibn Battuta, Rihlah* ['Travels'], c.1353.)

Dunhuang is surrounded by arid plains and watered by only a modest river. It was a vulnerable choke point that required a large military presence to maintain Imperial control. The soldiers had to safeguard very long roads, so their garrisons could only stretch so far. To caravaners heading west, the last Chinese barracks they passed was their last safety net. They defended themselves by traveling in large numbers and employing local mercenaries. A constant worry of

caravan leaders was whose side the mercenaries were on.

Like any trade centre, Dunhuang experienced a wide variety of cultures, religions, social customs, trade practices. Faces and languages from all the world might be seen and heard there. Today Dunhuang does not loom large in the litany of romantic names – Kashgar, Samarkand, Merv, Khotan – conjured by tourist agencies advertising the 'Silk Road'. But for a thousand years Dunhuang was no less vital to the economic heartbeat of the world it served. This last outpost of *pax sinica* jutting into a volatile, nomadic world boasted no land to till, no grass to graze, no minerals to mine, wildlife more sinew than meat, howling winters, searing summers, scanty rain. Flowers probably did not grace many households. Dunhuang existed for for one reason only: goods. China vanished from the eastern horizon as merchants and their goods traipsed westward, and welcomed those same merchants trekking now eastward in turn (after settling the matter of the customs fees, of course).



Mogao Caves today, unvisited except for tourists, who don't generally stay for the night. *Courtesy British Library.*

Half a day's journey to the south of the city rose an escarpment of conglomerate and layered sandstone named Mogao. It was well suited to the needs of monks and others who sought refuge from the world in the calm of meditation. The earliest records of the Mogao escarpment being used as a refuge for meditation trace to the fourth century, but only after the arrival of Tibetan Buddhism introduced by Śāntarakṣita (725–788) did the earliest monks of Tibetan Buddhism excavate the caves on a large scale.

Caves loomed large in Buddhist iconography from the time of the Buddha himself, who recommended that monks make use of the long Subcontinent rainy season (June – September) to stay in one place so as to meditate more intensely. The generations of wordspinners who gradually transformed the simple life and precepts of the Buddha into the complex fantasia of the *Pali Canon* today did so knowing that abstruse theory had much less appeal to everyday folk than stories about winsome infant prodigies. The storytellers dispensed with the dirty nappies in favour of the tale that the baby Buddha's first seven steps blossomed into lotus ponds. Over time a folksy parallel canon for the common folk evolved alongside theologic speculations by saffron-robed hagiographers. Eventually some 547 morality tales cum fireside fairy-tales became codified into the *Jataka Tales*. These purport to be accounts from the Buddha's previous incarnations before achieving Enlightenment under a pipal tree. Few literary forms rival fantasy when it comes to durability.

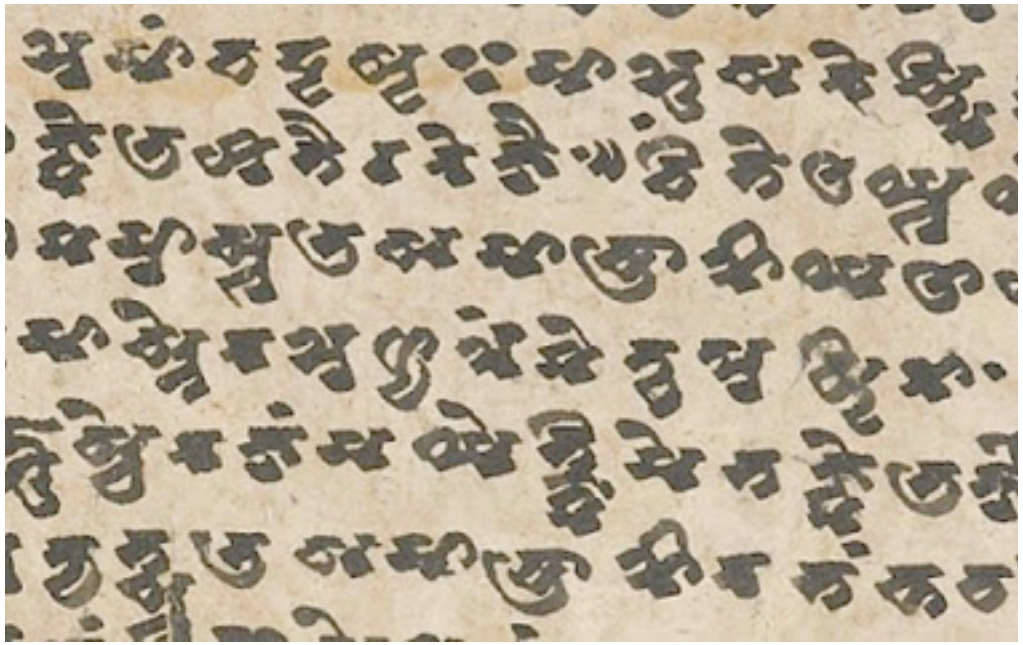
From the beginning the Buddhist expression of devotion via physical mass manifested primarily in colossal statues. Worship using the temple as a seat of identity never developed large imposing architecture the way it did in other cultures. There are many more gigantic statues of the Buddha as a human presence than gigantic temples to commemorate his godly absence. These statues of Buddha and his faithful cousin Ananda are carved into the Mogao escarpment near the midpoint of the cave complex. Similar examples exist in Polonnaruwa, Sri Lanka, China, Japan, and the Bamiyan statues in former Ghandara (now Afghanistan). The oversized earlobes harken back to the Buddha's days as a privileged princeling named Gotama Siddatta. Extended earlobes were a fashion statement of extravagant wealth since the earrings of wealthy young men were huge solid gold ear pendants. Note the size of the visitors in the bottom right corner.

Over a span of 1,000 years starting about the year 360, the Mogao monks gradually excavated a total of over 750 caves to take up residence in them. Over time the complex evolved from a retreat for meditation into a huge monastic community. The Tibetan Buddhist culture that prevailed in the Mogao Caves was monolithic, unilingual, theocratic, cohesive. The culture that evolved in nearby Dunhuang caravansary town was multicultural, multilingual, cosmopolitan, secular. Walk the streets of Dunhuang today and beneath the Bank of China branch (the only English words in view), there are ATMs (modern-day gate sentinels) doing their duty in ten languages and six scripts. Passersby have skin hues, eye shapes, languages, religious amulets, jewellery, adornments, hats, and everyday garb that might

Cave #16 where a hidden chamber (entrance visible at right) was discovered, containing 40,000 manuscripts dating from before 1000.

hail from anywhere within a radius spanning coastal China to Turkey.

The Mogao ensemble came to be known as the 'Caves of the Thousand Buddhas'. Wikipedia provides a spirited and hopefully reliable reading of the Caves' complex evolution. Most of the caves were residences. Some were devoted to devotional observance; these were effusively decorated with statuary and murals. Fresco was the only means to smooth over the rough, porous stone of the escarpment. Since the caves were not protected from the environment, even in the extremely dry climate the plaster would eventually encrust with



A manuscript from the Gilgit-Baltistan region of Pakistan was one of the 40,000 found at Dunhuang when the Library Cave was discovered in 1903. Overland travellers would encounter numerous unintelligible scripts and languages as they traversed cultural boundaries. A sort of *lingua caravansis* pidgin argot is known to have been used but was never written down.

moulds. Periodic touch-ups unwittingly recorded for posterity the stylistic differences in the way individuals applied the plaster, juxtaposed colour schemes, varied the strokes. For more egregious deterioration the monks would scrape away the old plaster and start anew. Inadvertently they left behind scrape marks and gouges. Such subtleties give Buddhist history the same personal stamp that maker's marks provide on Romanesque pillars and the facial features carved into stone by itinerant Lombardy stone carvers.

Monastic complexes, be they caves or cells, need oversight, and oversight needs records. The monks imported the many manuscripts of the *Abhidhamma* or 'Three Baskets of Wisdom' comprising the Pali Canon. Among them were a number of pamphlets listing the 247 *Vinaya* rules prescribing the daily lives of the monks. The records, writings, manuscripts, and even early printed material were mostly written in Tibetan, though some were in Chinese, Hindi, Turkic, Gilgit.

One of the Chinese documents was the world's earliest dated complete printed book. It was produced using what we would call movable type. The Chinese had invented a variant using fixed-character calligraphic blocks five centuries before Gutenberg.

As befitting its contents, the Library Cave was elaborately decorated. In archaeology circles it is known as Cave 17. About the year 1000, Cave 17 was sealed behind a wall of carefully disguised stonework. Inside was the community's entire inventory of over 40,000-manuscripts and monastic records. The monks filled the cave with their treasures and concealed it so successfully that it wasn't discovered for a thousand years. Not one word survives to say why they did it.

The end of the Tang Dynasty was an unsettled time in Chinese

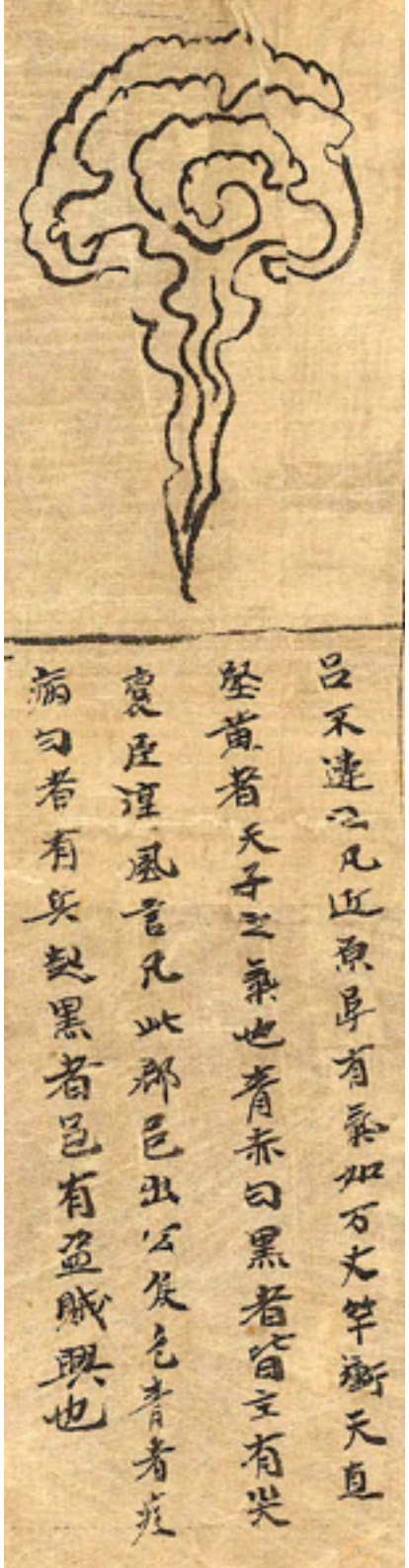
history. Warlords predated and peasants revolted, spilling vast amounts of blood and treasure. In the people's mind the Tang emperors had lost the Mandate of Heaven.

Dunhuang was administered by Tibetan rule between 670 and 780, a time in which there were numerous instances of social unrest amounting to revolt throughout western China. Whatever transpired in the Dunhuang locality around the year 1000 is not clear, but for the monks to abruptly seal off every written record of their existence, their looming fate must have been dreadful, immanent, and certain.

The only account of social disorder in China that might have reached as far as Dunhuang occurred at the end of the Tang dynasty. A diary by an Islamic traveler named Abdul Zeyd al Hassan recorded, 'During the Huang Chao rebellion near the end of Tang Dynasty, 120,000 Muslims, Jews, Christians and Parsees in Guangfu [Gansu] on business were killed'. Neither the New nor Old Tang History mentions this event, though they do record that Huang Chao sacked the Imperial capital Chang'an in the 970s.

The Mogao monks had taken their precautions all too well: the caves are known to have been occupied until the Mongol Khanates, but there are no records of the secret trove the monks had hidden away.

Ironically, in their haste to preserve every remnant of their culture, the Dunhuang monks had included the only existing copy of the one document that in its time would have all but guaranteed that one day the treasures of



Beware, mates, under that one there be rains of thieves and robbers.

Mogao would be raided. It was a copy of the star chart the caravaners used to find their way there.

Commercial wealth needs maps if it is to go anywhere, and wherever wealth goes, predators soon follow. In 7th and 8th century traversers of wilderness were little interested in sightseeing. They were concerned with surviving. Their two worst fears were disastrous weather and getting lost. The star map portion of the Dunhuang Chart was only half of the scroll's full contents. The other half was something caravaners needed as much as they needed celestial guideposts: a visual guide to weather portents. The 2.1 metre long star charts section was preceded by 1.8 metres of divinational material, including 26 drawings of cloud patterns, beneath which were interpretive captions explained the clouds' meaning.

Caravaners kept their eye out for clouds with the shapes and sizes depicted in the uranomancy section, assuming the author knew what he was talking about first hand. In reality, the Dunhuang Chart was a copy of an original made in the Imperial capital Chang-an by

Lü Buwei said that, as a general principle, when you approach a mound on a plain and there are air vapours in the shape of a staff reaching high up into the sky, straight and firm; if it is yellow, it is the colour of the Son of Heaven [the Emperor]. Blue, red, white, and black all mean the presence of tears and grief. Your servant Chunfeng [*probable author of the Dunhuang Chart*] says that as a general principle such prefectures and cities produce dukes and knights. With regard to colours, blue means deliverance from sickness, white that an army is being raised, black that robbers and thieves are increasing in the city.

scribes who likely had never left city. Why should they? Chang'an was the largest city in the world. Beyond its walls was the where the barbarians lived. The image-consulting caravaners never knew the information they were reading was worthless.

The concealed cave was discovered by accident in 1900. One of the Mogao' few residents at the time was a Chinese Daoist priest named Wang Yuanlu. He saw himself as an overseer of those caves which had been used for religious observances. Buddhists and Taoists have a long history of respecting each other's ways of thinking.

Some of the caves had been blocked by sand. As Wang went about his tidying, he cleared away the sand. On 25 June he noticed a niche in the corridor leading to a main cave appeared to have been artificially walled-off. He removed a few of the looser stones. In the dim interior beyond he saw bound sheaves and manuscripts stacked from the floor to twice his own height.

He broke away the rest of the wall and found an enormous hoard of ancient documents.

Wang took some manuscripts to show to local officials in Dunhuang, who were Chinese appointees. Since most of the manuscript in the cave were in ancient Tibetan, the Dunhuang officials expressed tepid interest but sent a few on to their superiors in Chang'an, now considerably reduced in importance to the Gansu Province administrative centre. In 1904 the governor of Gansu ordered Wang to re-seal the cave.

Wang Luanlu, the Taoist priest who discovered the concealed cave in 1903.

Word, however, got around. The Indian government wanted to learn if any of the manuscripts were in Sanskrit or Pali, and therefore part of their Buddhist cultural legacy. By chance a Hungarian born, naturalised British treasure seeker named Aurel Stein was in India, and the government asked him to visit the Dunhuang trove on their behalf.

Some writers refer to Stein as an 'archaeologist' but his collecting philosophy would be denounced by any historical society today. His methods more accurately fall into the realm of grave robbery.

When Stein visited in 1907 he was the first European visitor to see the treasure. He promptly removed and crated up about 7000 of the more promising manuscripts, paintings, and textiles and shipped them to the British Library.

Among them was a scroll of silk paper 0.04 mm thick, wrapped around a wood dowel. It was so unimposing it is surprising that he noticed it at all. One scroll contained the representation of the whole sky as it could be observed from a latitude of 34° N. It is now known as the Dunhuang Star Atlas.

The floodgates opened. The following year a French expedition under Paul Pelliot removed another several thousand manuscripts. Dunhuang was visited by a Japanese expedition under Otani Kozui in 1911, followed three years later by a Russian expedition under Sergei Oldenburg.

A curator today would be aghast. Stein had no training in even the rudimentary preservation and documentation techniques of the time. From the haste with which he broke up and shipped off other collections in Asia, he showed little concern that he was destroying what he thought he was preserving.

Most of the Dunhuang manuscripts were religious texts on Buddhism, but were written in Tibetan, a language and culture disdained by the Chinese government. In 1910, the Chinese texts were removed by the Chinese governor of Gansu and dispersed to public and private collections. The Tibetan manuscripts were scattered to England, France, Russia, China, and Japan; none were returned to Tibet.

The polar chart labelled *DB 76* is held in the Dunhuang City Museum. Stein's collection was transferred from the British Museum to the British Library collection when that establishment was inaugurated in 1972. There it was registered as Document Or.8210/S.3326. The 'S' identified it as part of the Stein trove. S.3326 did not receive much attention between 1909 and 1947, when the curator Lionel Giles' completed a catalog that listed the Atlas as '13 star-maps with explanatory text '. Giles classified it as 'Divination' (cat. no. 6974) because of the meteoromancy (cloud divination) section that preceded the star maps. Giles' descriptive manuscript of the collection was completed in 1947 but not actually published till 1957.

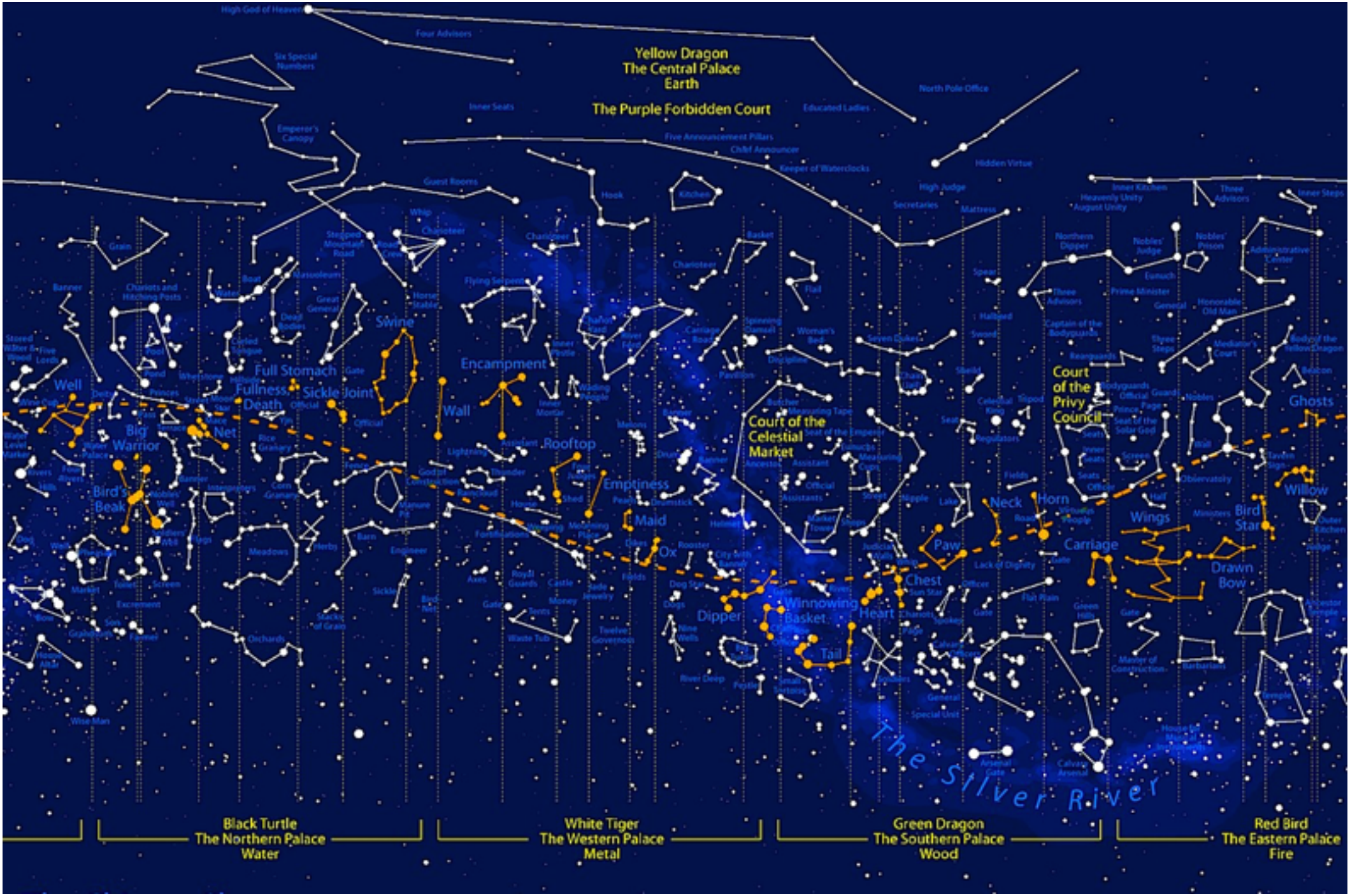
French sinologist Paul Pelliot examining Dunhuang artefacts in 1908.

Somewhat after Giles' 1947 research, probably in the early 1950s, the China antiquarians Joseph Needham and Chen Shixiang studied Stein's astronomy-related documents while researching their own monograph on Chinese astronomy, which was published in 1959. Needham estimated its provenance as 'ca. 940' in the text and captions to his reproductions of the images (his Figs 99 and 100). In a footnote on p. 264 in that volume Needham wrote that he immediately recognised the importance of the Atlas:

> I discovered this extremely interesting map in conjunction with my friend Prof. Chen Shih-Hsiang. Its probable date makes it about contemporary with the maps in the 'Book of the Fixed Stars' . (903 to 986 .)

Today the Needham Research Institute in Cambridge carries on his work.

China's Uranometria



Shadows of Forgotten Ancestors

Document Or.8210/S.3326 in the British Library is a paper scroll 3,940mm long and 244mm wide. It is backed with Kraft paper (a relic of 1950s curatorial practices), rolled loosely around an archival-quality wooden dowel treated to not stain the paper, and wrapped in a modern-era silk sheath. The Chart is a fragile document and requires the special care it is now accorded.

By the early Tang dynasty the Chinese bureaucracy had already enjoyed a millennium of Imperial blessing, social prestige, and the implied approval of Master K'ung or Confucius. Their disciplined, merit-based governance survived leadership crises, rebellions, famines, wars. The first Tang emperors intended the Silk Road to become the major trade route to the lucrative markets for Chinese products in the Levant, Byzantine empire, and Europe. In what is now Russia, the Vikings controlled trade routes from the Baltics to Samarkand.

Accounting for the wealth in cash and goods raised by import and export duties required sizeable quantities of paper and legions of scribes. Documents issued under Imperial authority at the capital of Chang'an were made of type of paper composed of a warp of thousands of pure mulberry fibres lain alongside each other the full height of the paper (avg. 24.4 cm), carefully brushed smooth, and bound by a weft of pure silk. Paper for Imperial ledgers and similar documents was produced in a standardised rectangular trim. Paper for long documents was made in scroll form and cut to the length needed for the document.

The Dunhuang Chart is such a scroll. While the Emperor's original lay in the quarters of the Imperial Astrologer, 'field' copies for provincial administrators and end users were copied by individual scribes each with their hallmark calligraphy. The long scrolls were

Early Chinese silk paper was not the same as the silk cloth woven from the unspooled cocoons of *Bombyx mori* caterpillars that thrive on mulberry leaves. Instead, silk paper was made from a pulp of mulberry bark which had been pounded into fibres. The finest-grained silk papers used at the imperial court were resilient and tough even at a hairwidth thickness 0.08 mm (0.1 mm was the benchmark standard of the Chinese court scribes). A court official named Ts'ai Lun is said to have invented the method around 105 CE. Later a cheaper commercial grade was compounded out of hemp stalk fibres, old fish nets, rice, straw, even seaweed strands.

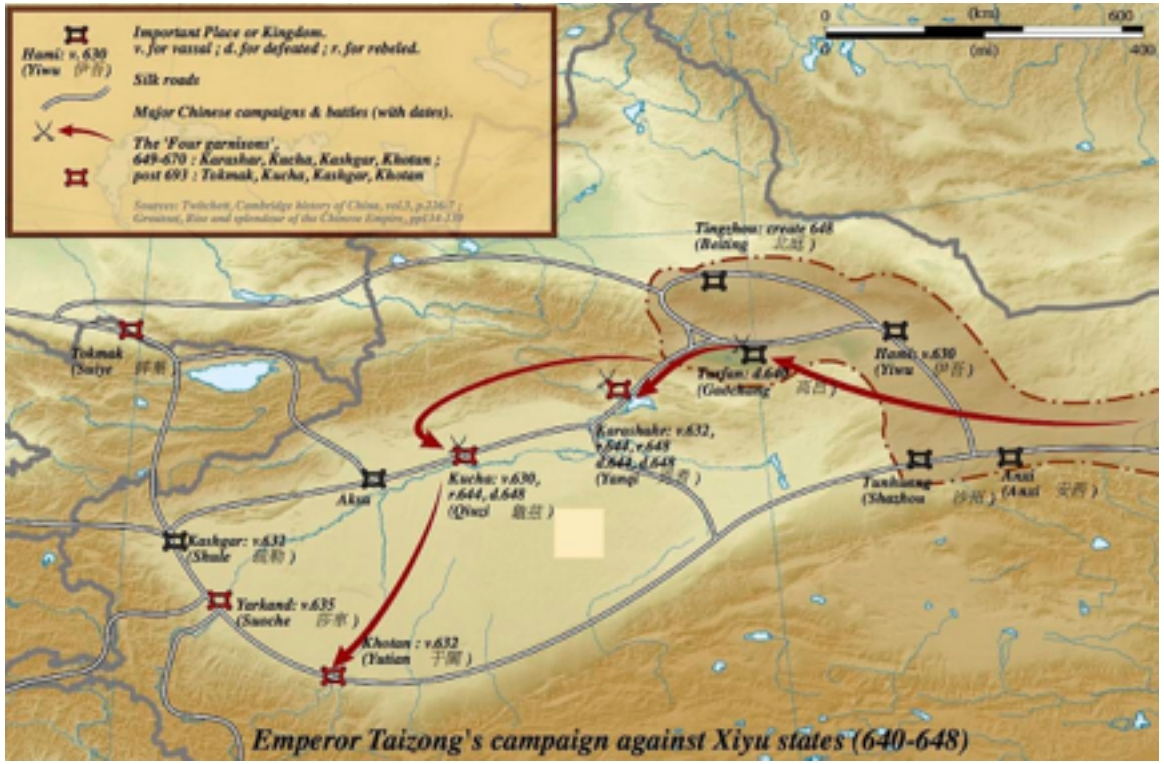
The Chinese tried desperately to contain the method's secret, but in 751 a Tang army was defeated by Ottoman Turks at the Talas River. Among the prisoners of war were paper makers. Once their hunger overcame their scruples (seldom a lengthy process), they taught their methods to Turkish artisans. By 793 paper was being produced in Baghdad. The Egyptians learned of it around 1100. The technology made its way to Cordoba via returning Muslim soldiers from the Crusades. In 1453 — the same year that Constantinople fell to the Turks and gushed its Greek scholars to Italy — paper made of tree pulp turned up in the shop of a stamper of cheap scapular medallions for the pilgrim trade who lived in Mainz on the Rhine.

Herr Gutenberg dabbled a bit in other trades. One of them was a printing press he used to make woodblock religious tracts, supplemented with the surprisingly numerous scatological comic books that served the pulp fiction readership of the time. His friends knew him as Johannes. He set his sights a bit higher and printed his way into history. While he may have switched from shabby ribaldries to the ever lucrative Bible trade, the scatty chapbook market soldiered merrily on from fair to fair in the rucksacks of itinerant hod-carriers till it was turned into high literature by one Francois Rabelais.

rolled around wood dowels and sheathed in a silk bag for ready transport. At first the intended users of field copies were military commanders who could be required to march anywhere at any time, and civil administrators who needed to navigate the sometimes trackless expanses of their jurisdictions. When compared with the fading stars at dusk the charts were easily interpreted for headings other than the setting place of the sun. The demand for caravan copies resulted in a Chang'an printing office devoted to producing copies of the Chart. Some scribes were better than others. Of their labours not a single other example remains.

Administering the Imperial Accounts consumed most paper. Paper not quite good enough for the Emperor's eyes would be diverted to provincial bureaux across the realm. Dunhuang was one of these. All goods entering or leaving the Realm for the western lands, India, and the north lands departed there.

A microfilm copy of the Chart taken in 1953 shows that the manuscript had been backed by the Kraft paper. This was standard procedure for manuscripts that had been examined by a scholar or curator and deemed of historical importance. Objects in the Stein Collection that did not attract scholarly scrutiny were left in their original condition. Many have not been reviewed since, but are stored in temperature and humidity controlled cabinets awaiting the curious scholar.



The Dunhuang Chart can be dated by internal text references to between 649 and 683. It could not have come at a better time to encourage the trans-Asian Silk Road trade. The first Tang emperor Taizong (626–649) vowed to clear the Tarim Basin of the predatory but disunited Turkic tribes which raided caravans and vanished into the Tian Shan hills. The campaign was quick, ruthless, and successful. Dunhuang is rendered 'Tunhuang' in the middle right. Note the crossed swords designating Imperial garrison barracks on the upper road. These guaranteed caravans safe passage as far as Kashgar. Samarkand was thirty or so days further on

The Chart scroll is inscribed on the recto side only; the verso is blank. Unfortunately the beginning and end sections of the scroll are missing, so the title and scribe name remain unknown. An important clue to the original author's identity appears in a citation under column 43 of the uranomancy portion of the text. It has been translated as, '. . .according to your servant Chunfeng . . .'.

Modern historians of the early Tang era (Deng and Liu, 2003; Pan, 1989) believe this refers to the astronomer Li

Chunfeng, who was the equivalent of the Astronomer Royal during the suzerainty of Emperors Taizong (personal name Li Shimin, 626–649) and Gaozong (Li Shi, 649–683).

The text is divided into two sections, divination and navigation. The sections were produced separately. There is a paper join where one ends and the other begins, but the paper itself appears identical and the calligraphic style is the same. Court scribes developed tiny quirks in the way they shaped and overlaid individual character strokes. Some have been identified by name, era, and function in the way musical score transcribers can be identified before the era of printed musical notation.

The first half of the scroll is devoted to uranomancy and meteoromancy, i.e., divination using the clouds and overall weather. The text totals 80 columns of explanatory text and 26 drawings of clouds of different shapes.

The Star Atlas follows. It is 2,100mm in length and consists of 12 vertical maps, each with descriptive text on the left, followed by one map of the circumpolar region with no text, totalling 50 text columns and 13 maps. The polar region was left without captions because the far north sky was the Purple Forbidden Court and it was taboo to utter or write an emperor's personal details.

The very last image on the scroll is a drawing of an archer in traditional garb holding a bow and arrow. The caption to his right states that he is the god of lightning. There is no explanation for the curious fact that the archer's arrow points at his own heart.

The maps

The Dunhuang Chart is a complete representation of the Chinese sky as seen from latitude 34° north. The stars and asterisms are depicted in a succession of maps covering the whole sky down to about –56° S. Some 1,464 individual stars in 283 asterisms are represented, as would be observed from the Chinese Imperial Observatory where the map was first drawn. Since Achernar and Crux are depicted on the Chart but cannot be seen from Xi'an, scholars assume that advice from officials in southern China officials was involved. The Southern Cross can be seen low on the horizon in May-June from Hainan Island. Surprisingly, the Milky Way is not shown on the Chart, and indeed is not mentioned in other old Chinese astronomy treatises.

The sky is displayed in a modified Mercator-like projection, as can be more clearly seen in a modern chart of the same sector of the sky. The projection was either a pure-equidistant or full Mercator projection for the rectangular maps, combined with an azimuthal-equidistant or stereographic projection for the circumpolar map.

Following the 'Jupiter month' tradition that gave the number twelve a significance noticed by many cultures, there are twelve hour-angle maps, ending with a north circumpolar map. The Chart is also the earliest known pictorial presentation of the traditional Chinese stellar naming system shown on the blue modern star map above. Stars are represented both isolated and grouped into asterisms. The groupings are more properly asterisms than constellations because there are no assigned boundaries. Not all of the Chinese asterisms on the Chart are identified by name. Three different colours were used to identify stars and star groups, originally assigned

by the three earlier schools of Chinese astronomy. (See '*Astronomy in Early China*' following.)

There are few mythological beings but a great many practical utilitarian objects. Orion is there, a warrior still, but Canis Major divides into The Bird, a Well (one of four wells, always a preoccupation in a caravaner's mind) and the Ghost. Lepus loses a good deal of charm when turned into The Toilet, albeit modestly shaded by The Screen. And yes, there is what you might guess below. In what is astronomy's arguably most piquant unintended irony, what lies below Excrement is the Farmer. Those dreadful office jokes about Management and Employees have been with us awhile. Presumably the artist meant the farmer's fields or simply didn't notice the implication.

Some asterisms represent conditions rather than things – Full Stomach, Wellness, Emptiness. Other identify domesticities: Stored Water & Wood, Bedroom, Grain Shed. The social roles, titles, or functions are mentioned by inference: Seat of the Solar God [Emperor] is inconspicuous beside the Court of the Privy Council attended by a retinue of Bodyguards, Officials, Seats, Rear Guards, and Advisors. This was not meant as a mordant comment on the emperor; rather, it was taboo to directly name him. In only one case in the Tang era was the emperor a her, Wu Ze tian (r. 684–705); indeed, she was the only Empress Regnant in China's entire 2,000-year dynastic history.

Sketch on 14th cent.Catalan sea chart depicting Marco Polo's return from Asia.

The Southern Cross is the Cavalry Arsenal and α & β Centauri are the Arsenal Gate. More bucolically, the Eridanus Loop is Meadow and the string of stars north of Achernar is Orchard. Adjacent to Orchard are Farmer, Son, Grandsons, and Stacks of Grain. Prosperity is ever the dream of wishful thinking.

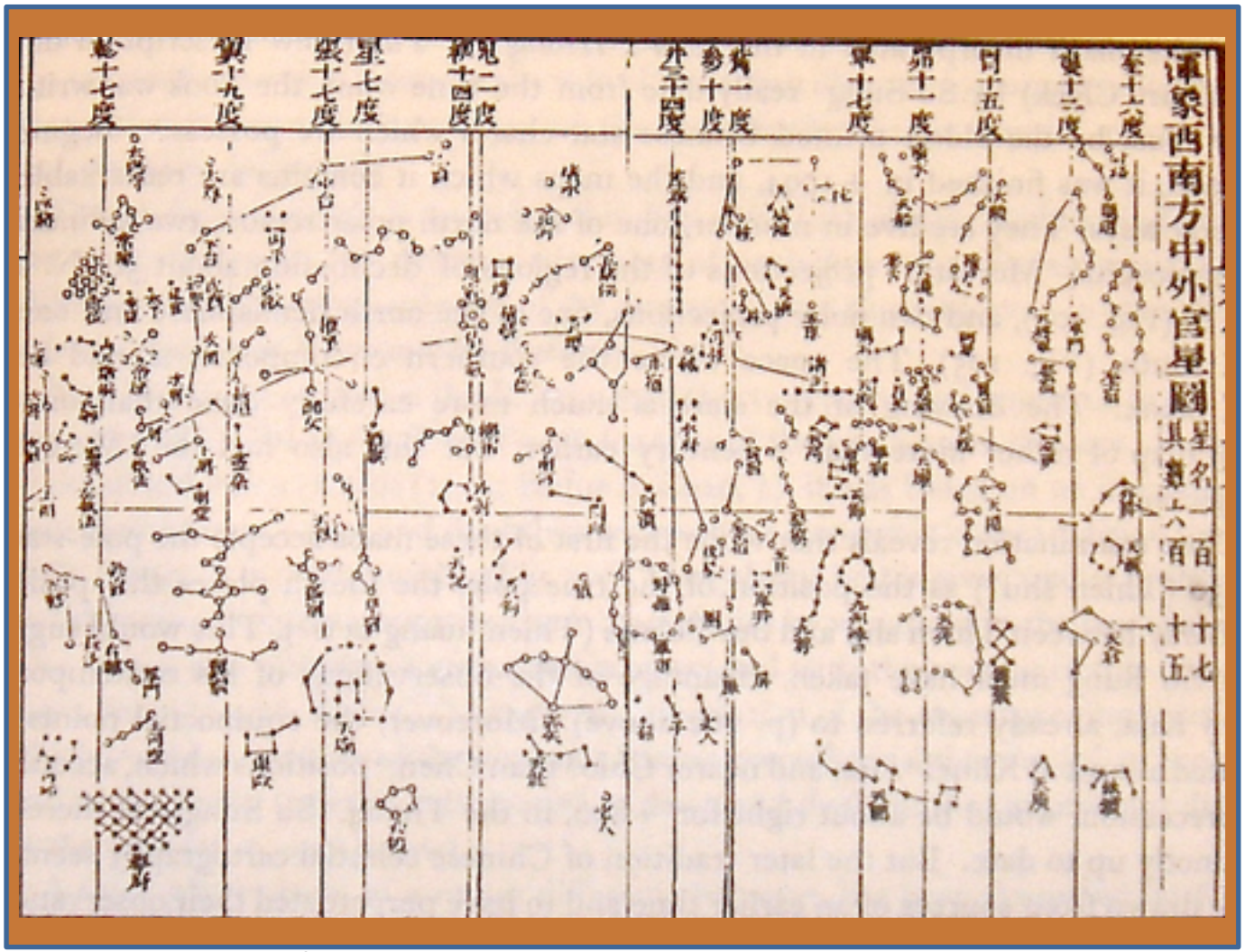
The original source data portrayed on the Chart were early Chinese lists of stars such as the third century BCE *Chen Zhuo* catalog Even then the *Chen Zhuo* was but one more update in an enormous astronomical lineage going back beyond historical records. (See following section for fuller story.) Earlier sources were the *Yueling* (not older than 240 BCE) and the *Jinshu* (unknown but redacted around 635 CE). The Dunhuang Chart was was a utilitarian summation of a long tradition of refinement. Even as the Chart was produced astronomical cartography was under review by the Tang Imperial Astronomers; the Dunhuang Chart's embrace of Mercator-like azimuthal projection was a foreshadow. The Tang astronomers' efforts resulted in a thoroughly revised cosmography called the *Kaiyuan*

Zhanjing promulgated in 729. It was a theoretical treatise that did not significantly affect traditional asterisms in the sky. At the same time the Silk Road had become less safe due to the weakening of Tang authority and Tibetan dreams of hegemony.

The Atlas has been assigned a date of 649-684. Chinese scholars suggest that it may have been drawn by Li Chunfeng around 650. The Chart's date was independently confirmed by a 2010 mathematical calculation of the Polaris position using the Chart's text and a polar planisphere. The Pole Star was not Polaris but rather Kochab (β Ursa Minoris) some 6.5° from the true pole.

Some scholars argue for a date of around 710 based on their analysis of the calligraphic style in the Chart. Since there is no front or back cover or internal evidence to the contrary, one must defer to the mathematical analysis rather than its calligraphy.

The Dunhuang Chart pretended to no scholarly loftiness. It was a handy ready reference the way *Norton's Sky Atlas* is today. The information on the star positions was portrayed using a systematic method of Mercator-like projection methods. The scale varies slightly from panel to panel but averages 4.8° / cm in R.A. (horizontal) and 5.5° / cm in declination (vertical from equator to Pole). Map to map deviations of only 1.3° to 4° from the precession-adjusted star positions for that time are impressive for a document from an early epoch and relatively small size.



The precision of the stellar positions represented in the Dunhuang Atlas was so accurate that 400 years passed before a revised chart appeared in the 11th century Song Dynasty.

Astronomy in early china

The civilisations of China, India, and Mesopotamia all created records documenting their interest in the sky and its events. Theories of correlations between the Chinese, Indian, and Mesopotamian astrological system are not always convincing, partly because of the poverty of records and partly because there was no consistent view in the three civilisations of the stars' relation to the present. The stars answered to people's divination needs and yearnings for myth, but had little political or economic value.

The earliest known Chinese attempt to explain the rotation of the sky was the *Gaitian* cosmography, in which the Emperor's parasol rotated around an axis above the flat earth. No explanation was attempted for the angle of the spin axis, except that it would be about the angle of the shaft of the Emperor's parasol as he was shielded from the morning or evening sun by the Imperial parasol-holder (a high office because the person would be in the direct proximity of the Emperor). The *Gaitan* views the cosmos as a flat earth under a round sky. There is no mention of a line of sight depth to the sky or how far the sky is from the earth. Angular measurements of stars' elevation above the horizon were interpreted using an early form of a gnomon post in the ground perhaps supplemented with an armillary sphere and *du*, the concept of the angle developed during the Zhou Dynasty.

The astronomer Zhang Heng described the sympathetic resonance between the celestial and terrestrial realms this way:

> Stars materially originated from the earth below; but their essence was perfected above. They are randomly scattered in the sky, but every one of them has its own Earthly connections. In the wilderness stars denote articles and objects; at court they denote officials; among people they denote human actions.

Western astronomy is based on the Ecliptic system and the seasonal cycles of the sun and planets through the 12 zodiacal signs. Astrologers pay scant heed to celestial events beyond the Zodiac.

Chinese astronomy did not have an ecliptic. Little importance was attached to the configuration of planetary alignments. Their system was equatorial, based on stellar rotation around the Pole Star. (Biot, 1862; de Saussure, 1930).

The sky at the Equator is divided into 28 asterisms called *xiu*. These are often translated as 'mansions' or 'lunar lodges' but the term is inspecific because they have no cartographic boundaries which would give their identity a sense of purpose in the way that zodiacal signs have a purpose (and in the thinking of astrologers, a personality). The 'hour' of a mansion is defined by the interval between the meridian passage of its designated 'lead star' and its designated trailing star (confusingly also called a 'lead' star in Chinese astrology).

The rest of the sky is divided into 255 asterisms of varying size, often in logical local groups, e.g., 'Court of the Celestial Market', 'The Purple Forbidden Court', 'Encampment', and so on. Thanks in part to the Chinese reverence for tradition and the importance of ancestry, the original Three Catalogs dating from several hundred years BCE, the Chinese constellations changed very little over time. Today they are still the basis of the Chinese astronomical tradition, in the same way the Babylonian chimerical creatures like Capricorn, Sagittarius, and Pisces are alive and well on newspaper pages today.

A similar pattern of development occurred in Mesopotamia, where the zodiac, more or less as we know it, emerged during the early first millennium BCE, many centuries after astrological prognostication began and the first asterisms were identified. Today we know the names of some seventy Sumerian constellations dating from about 2300 BCE

Surprisingly, in so human a celestial vault, there was no Euclid in early Chinese mathematics; nor was there a Milky Way in the Dunhuang sky.

There were 365.4 Chinese degrees in a Western 360° circle. The moon and planets were more often mentioned in a historical context rather than divinational one. The Emperor Xuan (r. 74–49 BCE) advised a military officer ordered to pacify the rebellious Western Qiang in the far northwest, 'The Five Planets appear in the east: China will benefit greatly if you utterly vanquish the *Man* and *Yi* barbarians.' These days military leaders prefer that planets not decide their strategies.

The moon was more prosaic. It rather tediously kept to its routine of cycling through the Chinese 28 'lodges' dutifully. It certainly had plenty of practice: the first complete lunar lodge system dates from the late fifth century BCE tomb of Marquis Yi of Zeng.

Comets were far more portentous, appearing out of nowhere as fiery oracles no one dared ignore. In the primordial battle at the dawn of Chinese civilisation between that cosmic miscreant Chi You and the Yellow Thearch, Chi You's banner was a giant comet whose fearsome approach to the earth and fragmentation into multiple 'sun-like' pieces (one thinks of Comet Shoemaker-Levi) engraved deeply into cultural memory. By Han Dynasty times Chi You's Comet was commemorated in New-Year festival reenactments of the primordial cosmic combat.

While most comets were interpreted as portents of military action, one spectacular comet so impressed Emperor Wu (r. 141–87 BCE) that he proclaimed that his reign should be called Primal Light to commemorate the the 'long star' that paid him a visit.

The earliest Chinese view of the sky was that it played an essentially chrondic and calendric role, enabling humans to order events in their minds. The celestial empire was a mirror image of the Emperor's realm. Divine events in the sky presaged similar events on earth, hence the importance of comets as harbingers. One Song Dynasty court astrologer saved his neck when a comet that he didn't predict appeared in the sky. When called before the Emperor to account for his lapse, he explained that great tail of the comet was a sign that a divine wind of wisdom had blown over the earth. The Emperor was given to understand that the divine wind of wisdom had elevated him to the throne. The astrologer lived to be 71.

The *Gaitan* cosmography predates the earliest Chinese written records. It became an emblem of proper governance during the establishment of the Chinese Imperial system of centralised administration after the Warring States period (476 to 221 BCE). Chinese asterisms were first codified during the Warring States period. Astronomers who served different lords devised different systems of asterisms. The piper had to be paid somehow, and what better place to sleep than one's own astronomer-assigned lodge in the night sky? The astronomers embraced the idea of interpreting the sky as a celestial counterpart to the terrestrial state. Naming the stars to reflect the values of potentates is clue to social priorities in place at the time. Every historical record from the time of the Warring States to the present day conveys this type of correlative cosmogony.

The Chinese sense of historicism first appeared in the second century BCE with the the first chronicle of China, the *Shiji* (Historical Records). The astronomical chapters of the *Shiji* include the first stellar catalogs known anywhere. There were three distinct catalogs, each of which had its own set of asterisms and the astrological interpretations associated with them. Even as they were written the *Shiji* records were secondary sources; they copied older, now lost catalogs composed during the Warring States period.

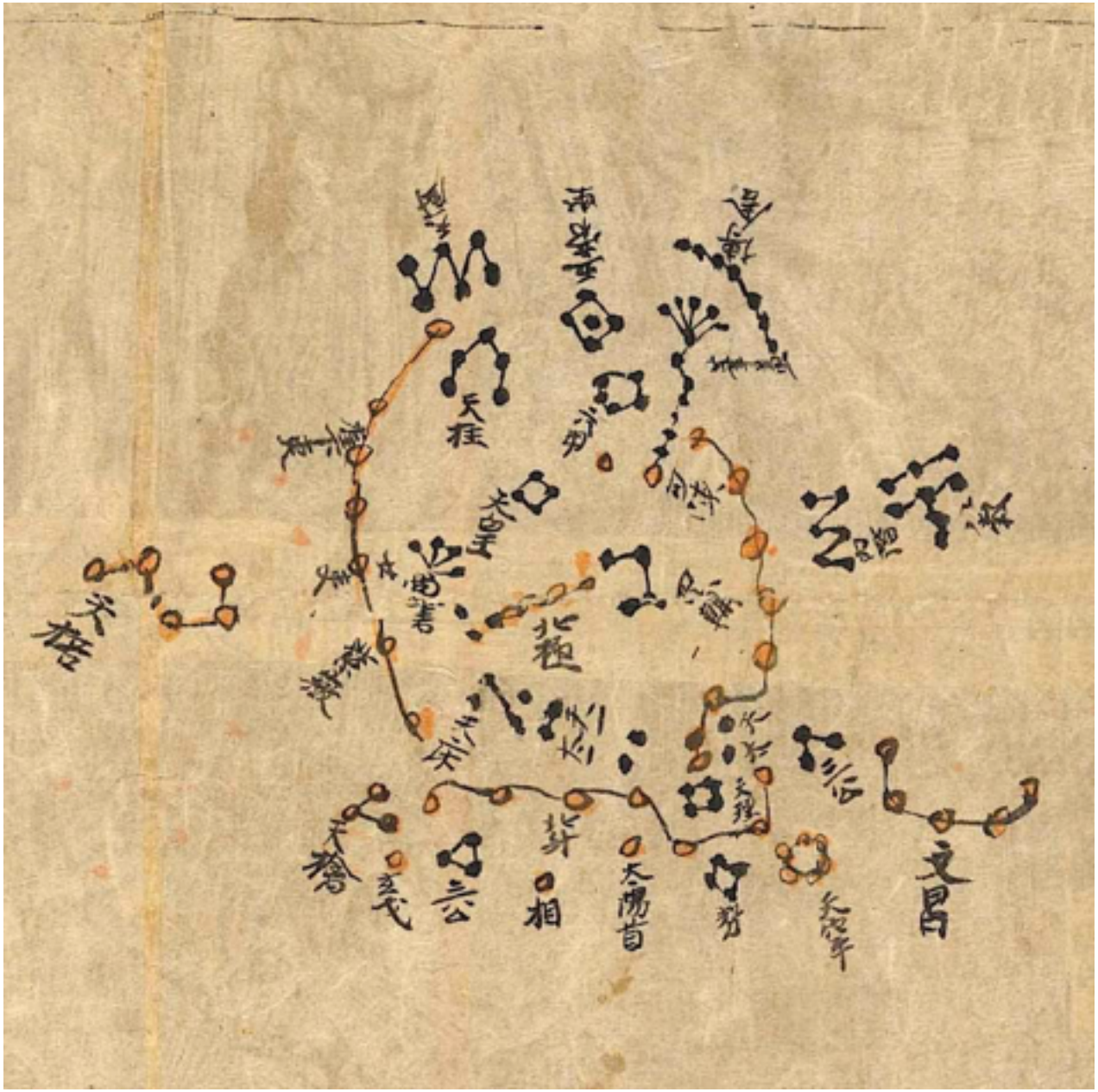
The *Three Catalogs* influence continued long after their official systematisation into the *Shiji.* Stellar configurations and nomenclature changed little thereafter, much as Western tradition was definitively shaped by Ptolemy's *Almagest* and *Tetrabiblos* compiled in the second century CE. The *Three Catalogs*' influence is felt in the the Dunhuang Chart wherein each of the twelve 'Jupiter stations' were drawn with stars in three colours. The colours represent the various asterisms handed down from star maps by China's three earliest astronomers, Shi Shen, Gan De, and Wu Xian. The naming system remained intact for eight centuries.

For all its utility the Dunhuang Chart was nonetheless long past its prime. Its basic source material was at least 600 years old because of the tradition of retaining the asterisms and astrological traditions of the Three Catalogs astronomers. The sky was understood qualitatively, in the sense that a person on a hiking trail asking for directions might be told, 'Proceed to the three rocks next to a bush, turn into the grove on the right and walk till you get to the top of a steep climb, then . . .' Hence it was that a caravan navigator might unscroll his copy of the Chart, hold it up to the night sky and in the distracting light of a flickering ember seek out Map 5, The Warrior (Orion). The navigator's task was to deduce which low hill on the horizon, at the moment invisible in the dark, would be the hill he should aim for in the morning if he wanted to head WSW for Khotan.

He would then consult his copy of the Dunhuang Chart for instructions. There he would read, '*The asterism Jiuliu* [Nine Flags, not labelled] *is SW of Yujing*' [Jade Well]. *Yujing* was a circle of ten stars representing the stone wall of a well. The text identifies *Yujing* as, '*a circle of stars close to Zi'*. '*Zi*' meant 'Son', an apt name for Rigel. Unfortunately, ν Orionis or Bellatrix lies between Yujing and Zi, and could be easily taken for it. Hence any heading deduced from assuming Bellatrix is *Zi* when *Zi* is actually Rigel would be about 8° off. Adding to the confusion, there is another *Zi* nearby: Beta Columbae. The Map 5 text describes this particular *Zi* as '*East of Zhangren*', to which the text helpfully adds, '*Zhangren and Zi should be more south of Ce than Junjing*.' *Ce* in turn is "Toilet with a Shed' and *Junjing* is 'Soldiers Well [ν Leporis]'.

About the year 725 during the reign of the Emperor Xuanzong, the Imperial astronomer Qutan Xida recognised the need for more exactitude in astronomical representation. He envisioned a complete and detailed quantitative description of the Chinese sky using positions by coordinates in Chinese degrees. His revision was promulgated four years later as *Astrological Treatise of the Kaiyuan Zhanjing* [Kaiyuan Era]. It was not a *sui generis* fresh start, as it relied on information in the astronomical chapters of the *History of the Jin* (*Jinshu*) and *History of the Sui* (*Suishu*) written by the astronomer Li Chunfeng (602 – 670). [Recall from above that Li Chunfeng had been mentioned in passing in the Uranomancy portion of the Dunhuang Chart.] Any misinformation in the Li Chunfeng Chart may have not been corrected in the Kaiyuan Zhanjing. Astronomy as a science of refined approximations has been with us a long time.

The Pole Star tells true



The circumpolar chart (#13) reveals the second-level quality of the Dunhuang Chart. The lazily lissajous connecting lines in the Big Dipper (Nobles Judge and Eunuch asterisms) would be scandalous in an Imperial Astronomer's office.

The north circumpolar map has no text. The northern part of the sky was reserved by the Mandate of Heaven to be the seat of the Emperor, his family, the court, and Minister-level officials in charge of state administration. Over time there evolved a scholarly tradition that divulging the personal name of the emperor during the time of their reign and after was a taboo. The Chinese characters for birth name of the emperor were disguised by leaving out a stroke or shaping a stroke in a non-traditional way.

The circumpolar map displays 144 stars from about +50° to +90°. Since the Pole (or pivot) Star, around which the sky seems to revolve was the most important star on the map, one would assume it to be well marked. On the map, the star is so inauspicious that it's difficult to spot which star it is. For reasons unknown, the text on the panel does not explain that the Pole Star was Kochab, not Polaris. Even then the star is not called out for special attention. A red hazy spot, not encircled in black, could be it.

Another star is red and pale, not encircled in black, and is located near 4 Ursae Minoris. It is not easily identifiable in modern terms. The Pole Star is not indicated as such on the map. It could be that red pale spot, but it would be strange that the star figuring the supreme ruler should be so inconspicuous. The type of projection used to represent the polar region gave enough information that Bidaud et al 2010 could date the map at ~650 CE.

Bidaud et al 2010 measured the chart's stellar positions using a best fit azimuthal projection (filled circles) to 700 star positions (open circles with crosses) on a contemporary map. Also shown is the measured uncertainty in the Pole position from the best fit (dotted circle) and the different positions of the Pole (open squares with crosses) at dates of about +2000 (α Ursae Minoris), –1000 (κ Draconis) and –2500 (α Draconis). the projection analysis of the circumpolar chart gives a meaningful constraint on the position of the Pole as consistent with a date of around 650.

The Dunhuang Sky Atlas is arranged in 12 individual hour-angle panels, beginning with the mansions of *Xu* and *Wei* and totalling 28 mansions in all. Vertically the hour-angle maps cover from declination about –40° to about +40°. North is up and East is to the left; right ascension (celestial longitudes) proceeds in the direction of the rising sky. The Celestial Equator and the Ecliptic are not shown, nor is the Milky Way. There is no coordinate grid although the vertical and horizontal scale is uniform all across the sky. The Chart is limited to the South by the horizon. The S declination is stretched a bit to accommodate several southern objects such as Canopus (Ch. *Laoren*), which is shown closer to the Equator than it really is. Also shown are the very southern stars, *Beiluo shimen* (α Piscis Austrinis) and *Nanmen* (a star pair in Centaurus).

Tang astronomers probably learned what they knew about the Southern sky from court delegations that visited the region. Less than half a century after the Dunhuang Chart an expedition was dispatched to the south led by Yi Xing (683–727), a Tang astronomer assigned to remeasure the positions of many stars in the antiquated third century *Chen Zhuo* list. Yi Xing established eleven observing stations, down to latitude 17.4° near Hué in present-day Vietnam.

Jupiter Stations

Jupiter's sidereal cycle is 11.86 years. This unerringly bright planet would spend 365 x 0.988 = 360.4 days in each of China's 12 *ci* or 'Jupiter stations'. This gave Chinese astrologers a cycle on which to construct their divinational architecture, just as typical cloud shapes such as nimbus, cumulonimbus, horsetail cirrus, or herringbone stratus served up a theoretical touchstone for atmospheric divination. Landscape, landforms, geological features like cliffs and chasms; animals, plants, insects, body parts, and physical maladies each had their own complex set of symbols, rules, interpretations, and of course, listener expectations.

The maps are apparently thumbnail-and-eyeball copies of a master document, although the method of reproduction is not clear. The fineness of the original paper might have allowed the maps to be traced in grisaille from a sharp original.

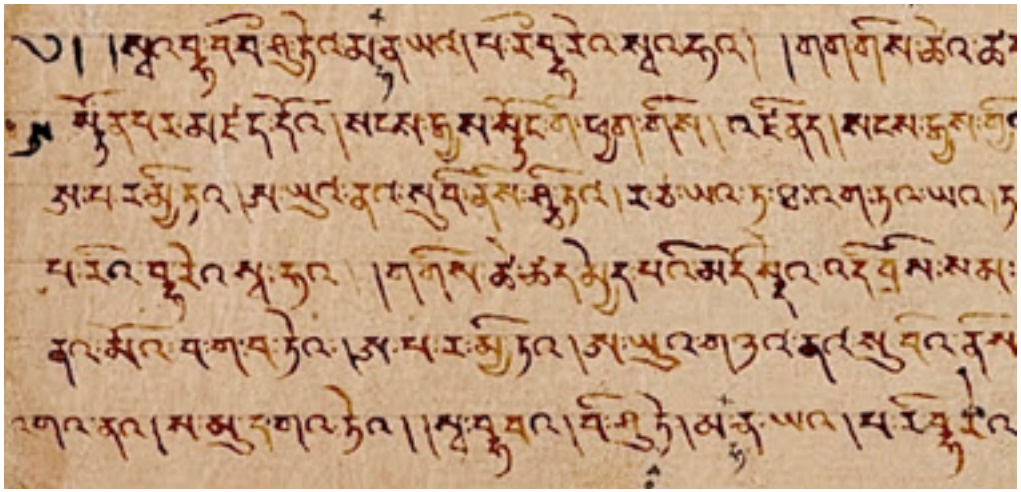
The Celestial Equator was graduated in Chinese degrees, which are defined according to the mean year duration of 365.25 days. Hence each Chinese degree was 0.9856 European degrees.

The text at the bottom of the maps, an additional text gives the major annual landmarks associated with the lunar month. Together with the number of the lunar month, one reads the position of the Sun with respect to the mansions present on the map and the culminating constellations at dusk and at dawn during the month.

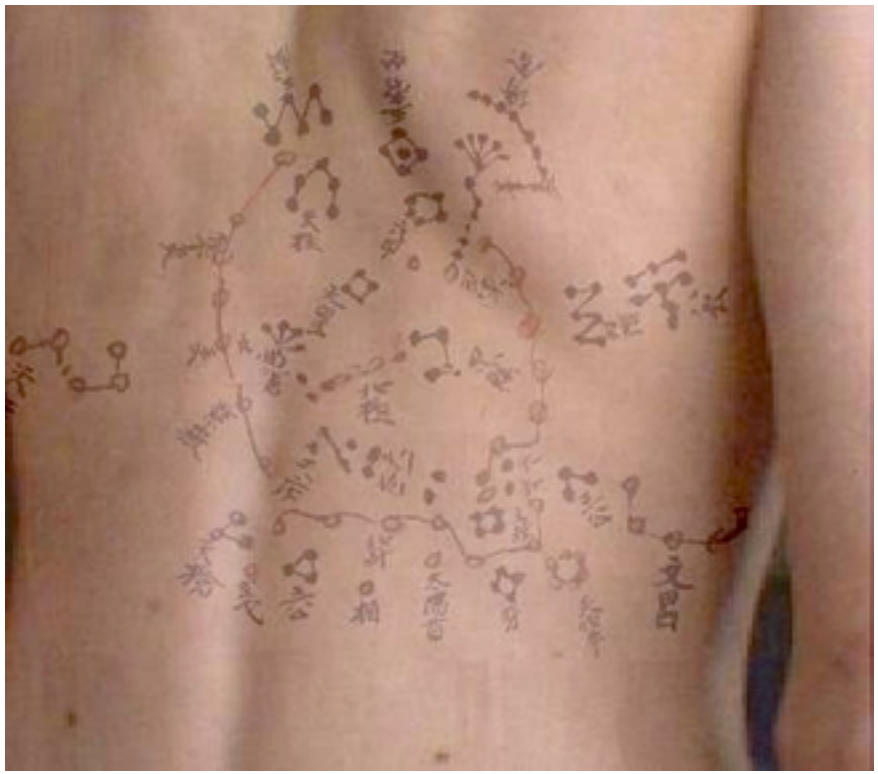
All the bright stars visible from latitude 34° N appear on the map. The faintest are visual magnitude 6.5. Chinese astronomers did not indicate visual magnitudes when drawing star atlases. The reason is simple: astronomers didn't draw the atlases. Imperial scribes did. Astronomers today must feel the same when they read what editors have done to their books.

Overall the positional accuracy of the maps is of the order of 1.5° – 4°. The layout of the rectangular maps uses similar scales from one to another, but with ±5° variation in the location of the Equator.

Now, to get to Khotan you head north by northwest . . .



Thinking could get a bit strange in an isolated monastic community in surroundings as austere and vulnerable as the Buddhist community at Dunhuang. Some monks took to writing their manuscripts in their own blood as a form of ascetic statement of their sincerity. Pigment analysis proved this script to have an iron content consistent with undiluted dried blood. Considering what the early patristic fathers did to themselves in the Sinai during the first few centuries ACE, the Dunhuang monks walked on the mild side. Blood writing was not a hasty affair. One drop could make two letters, as testified by the frequent colour changes here. Curious readers can pursue this behavioural oddity here.



Today people prefer to write with their blood the modern way.
Source: *Google Images.*

The world's oldest printed, dated book

Page from a copy of the *Diamond Sutra* found in Cave 17, Dunhuang, ink block image with separate block for Chinese text. British Library Or.8210/P.2, dated 868. *Zoomable facsimile in British Library here.*

Not so fast there, Herr Gutenberg . . .

Books have been with us since long before Gutenberg. Indeed, Gutenberg wasn't even the first to have invented moveable type, that is, individual symbols that can be assembled to make words and sentences. That honour goes to one Bi Sheng (990–1051). [See p.28] Books were any document assembled of individual sheaves of thin, flat material which contained information presented in an established sequence and bound into a single unit which could be then consulted page by page. The first printable 'paper' was made of long threads of mulberry silk combed in a uniform direction and trimmed at the edges.

The Dunhuang Star Chart was an early example but by no means the first. No earlier books made of printed pages exist, but individual leaves bound into a volume that can be open and closed go back as far as 660 BCE. Seventy-five years ago some workers in Bulgaria unearthed a 6-page set of 24-carat gold plates embossed with images and Etruscan letters, making it roughly 2680 years old today.

Other oldies but goodies exist as well: the Book of Kells was produced around 800 CE. The Cuthbert Bible has been dated to 698 (though the cover is a parvenu at a mere several hundred years). Top honours for the most well-worn book is a Jewish *Siddur* or prayer book, dating from 840. Poor Johannes Gutenberg would barely qualify for also-ran in these circles. His were not even the oldest books printed from moveable type. *Read here for more information* and some fine images of the Top Ten in the bibliophile world.

Although not the earliest example of a printed book, the Dunhuang *Diamond Sutra* is the oldest we have bearing a date. By the time it was made, block-printing had already been practised in the Far East for more than a century. The quality of the illustration at the opening of the *Diamond Sutra* shown above reveals the carver of the printing blocks to have been a man of considerable experience and skill.

It's dated in a colophon – a note printed at the end of the scroll. The note reads, 'Reverently made for universal distribution by Wang Jie on behalf of his two parents' followed by the Chinese calendar date for 11 May 868. Wang Jie did not make the book himself, but enabled (i.e., paid for) its making – a pious act by which he would have gained much merit.

It was made in seven sections, each printed from a single block. First, the text was painted on thin paper, which was pasted face-down on to a wooden block. The block carver then reversed the shapes of the characters. As many 1,000 sheets a day could be printed from the carved block.

. . . there's a chap named Bi Sheng

Four centuries before Gutenberg, the Chinese inventor Bi Sheng (990–1051 AD) created the world's first known movable type system for printing. His technique was invented between 1041 and 1048 during the Song dynasty. At that time traditional block printing — the method that produced the Dunhuang *Diamond Sutra* — was an expensive, time-consuming process. Each carved block could only be used for a specific page of a particular book. Discovering a typo in the proofs

stage was a disaster — the entire block had to be re-carved.

Bi Leng thought up the idea of making each character out of tough, durable, high-fired porcelain. He first carved individual characters in reverse form on one face of standardised cubes of feldspar-rich kaolin clay while the clay was still moist enough to carve. He was an alchemist by trade, so knew a thing or two about processing mineral earths. The cubes were then hardened by fire were so durable they could be used hundreds of times. This system lent itself to batch manufacture that could move from place to place. The individual datacubes (for so indeed they were) were converted into printing forms by gluing the characters to an iron plate that was coated with a mix of pine resin, wax, and ash. The form was then warmed till the type adhered firmly to the plate

The advantages were many — woodcut blocks would wear flat from the inherent abrasion from paper or silk sheets and become illegible. There was no way to renew them (this can be readily seen in the image of the Dunhuang *Diamond Sutra*, in which the characters on the right edges of the text block are conspicuously weak.) The system was well suited for print runs of several hundred copies —ideal for a system as bureaucratically organised as the Tang Dynasty's bureaucracy. The major drawback was the the Chinese character set in common use during Bi Sheng's time was 30,000. See *1*, *2*, *3* for more information.

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