Blurring the Boundaries: Integrating Techniques of Land Surveying on the Qing’s Mongolian Frontier*

Mario Camas

[Mario Camas is Assistant Professor of History at the University of Macau. He is the author of Companions in Geography: East-West Collaboration in the Mapping of Qing China (c. 1685-1735) (Leiden/Boston: Brill, 2017). His current research focuses on early Sino-European contacts and exchanges in cartography. Contact: mariocams@umac.mo]

** **

Abstract: This article focuses on the role of spatial dynamics in effectuating the integration of two different sets of land surveying techniques. During the later stages of the Qing-Zunghar wars of the 1690s, the Kangxi emperor (r. 1661-1722) repeatedly asked French Jesuit missionaries, who had been sent to China in 1685 under the patronage of the French King Louis XIV, to join his imperial campaigns targeting the Khalkha-Mongolian borderlands. In the shadow of these imperial journeys, missionaries systematically determined latitudes with Paris-made instruments while Qing officials measured road distances all along the way with graduated ropes. A next step in the evolution of imperial cartographic practice came after the Qing-Zunghar wars had come to an end, when an all-out effort was launched by the emperor to integrate the newly conquered Khalkha Mongols and their lands into the Qing polity. As part of the effort, missionaries were asked to produce a map of the new frontier by integrating European and East Asian practices, which led to the discovery of a technical incompatibility. In 1702, the problem was solved by the precise measurement of the terrestrial degree and, immediately after, the restandardization of the Qing’s most basic unit of length, the chi 尺. Thus, I argue that the turn of the eighteenth century saw the crystallization of a new or hybrid Qing cartographic practice, driven by the need to explore the new Khalkha frontier. More concretely, I show how selected techniques as developed by the French

---

* In the first place, I would like to express my gratitude to Wu Huiyi and Alexander Statman for the inspiring exchanges and cooperation that led to this publication. I also continue to be greatly indebted to Nicolas Standaert and Catherine Jami for their help in repeatedly reading and commenting on my work, including the drafts of this article.
Academy of Sciences were gradually absorbed into a pre-existing framework of Qing land surveying, a process that was shaped and facilitated by exchanges in via throughout the vast Mongolian frontier.

When scholars study the circulation of scientific knowledge between Western Europe and East Asia in the seventeenth and eighteenth centuries, they typically subscribe to a framework in which ‘Europe’ is placed in opposition to ‘China’, as a conceptual dichotomy that forms the basis of their inquiries. As a result, the actual locus and spatial context of scientific exchanges between ‘Europe’ and ‘China’ is seldom specified or problematized, while Jesuit missionaries to China are often seen as the sole facilitators of these exchanges by virtue of their exceptional mobility between the two ends of the Eurasian continent. One notable example of the continued prevalence of this conceptual dichotomy appears in scholarship on the Kangxi-era Qing atlas, known in Chinese as the *Huangyu quanlan tu* 皇輿全覽圖, which was produced by order of the emperor and with the assistance of Jesuit missionaries.

Nearly all scholarship dealing with the atlas is implicitly or explicitly concerned with the question of whether it constitutes a Chinese or a European product, or, alternatively, which characteristics of the mapping project behind this atlas, be it technical or representational, can be defined as essentially Chinese or European in nature. Even when the idea of shared authorship is promoted, the argument centers on the balance between the two cultural blocs in terms of their contribution to the mapping project and resulting atlas. In contrast, this paper shows that the mapping project and resulting atlas were in part the outcome of a complex and multi-directional circulation of land surveying techniques across Eurasia, which, when put in context, cannot be untangled into a series of singular ‘European’ and ‘Chinese’ elements. To make my point, I will focus on the role of the Qing’s Mongolian frontier in effectuating the integration of two different sets of land surveying techniques, one as developed in Paris, the other as practiced in Beijing.

The circulation of knowledge with regard to surveying techniques and cartographic practices between East Asia and Western Europe at the turn of the eighteenth century was rooted in a convergence of interests of several key actors. First, in the second half of the seventeenth century, the French Académie royale des sciences, supported by the French crown, was looking for ways to gain more knowledge of the shape and size of the Earth, and thus to increase French prestige. Second, the Jesuits in China hoped that a

---

1Smith (2012); Elman (2005); Yee (1994), esp. 177-85; Foss (1988); Needham (1959); Fuchs (1943). More recent scholarship has studied the atlas in the context of Qing rule, thereby steering the discussion away from the framework of China versus Europe. Hostetler (2001).
continued involvement in the sciences at the imperial palace in Beijing would lead to greater court protection of their religious mission in the Chinese provinces, especially since the Kangxi emperor had signaled that he wished to employ more experts in mathematics and astronomy. And third, the emperor himself actively pursued techniques of empire building, in which cartography played an essential role. As a result of the converging interests of these actors, a group of French Jesuit missionaries were appointed correspondents of the French Académie and were sent to Asia in 1685, where they strove to advance their mission with the help of their knowledge of mathematics and its many practical applications, including ‘practical geometry’ and thus the art of land surveying. In other words, even though the events reconstructed in this essay mostly took place on the fringes of empire, they in part resulted from the active involvement of two centers of power.

Immediately after the arrival of the French Jesuits in Beijing in 1688, those who were allowed to stay at court quickly became involved in land surveying on the remote Qing frontiers. The very year of their arrival, for example, the Kangxi emperor asked Jean-François Gerbillon (1654-1707), one of the five French Jesuits known as ‘the King’s Mathematicians’ sent to China in 1685 by the French King Louis XIV, to take part in a Qing diplomatic mission that was to negotiate border relations with Russia. In 1686, Russian expansion in Siberia had led to fierce clashes with Qing troops, and it was this immediate threat to his northern frontier that led the Kangxi emperor to agree to the negotiations. Their result came in 1689 with the Treaty of Nerchinsk, which was accompanied by an exchange of maps between the Russians and the Qing. On the part of the missionaries, who themselves saw their involvement at Nerchinsk as an excellent opportunity to learn more about the overland routes from Western Europe to East Asia, Gerbillon recorded latitudes and distances all the way from Beijing to Nerchinsk, and, once there, determined the precise location of Nerchinsk

---

2 Jami (2012), 190-5.

3 For a full exposition on exactly how these two imperial centers were connected with regard to the mapping project under discussion, see Cams (2017), 20-85.

4 In 1688, an imperial delegation was sent to Selinginsk, close to the shores of Lake Baikal, but it returned to Beijing after violent clashes between the Khalkha and the Zunghar Mongols had blocked their way. The delegation set out again in 1689, this time heading directly north to Nerchinsk, thus avoiding Khalkha lands. Gerbillon’s edited accounts of both journeys can be found in du Halde (1735), 4: 87-251. It appears that Gerbillon was chosen for his expertise in observational practices, whereas the other European missionary present at the negotiations, Tomas Pereira (1645-1708), was chosen for his linguistic skills. See de Thomaz de Bossierre (1994), 41.

5 Perdue (2010), 350.
on the basis of repeated and more stationary observations. All of these data were undoubtedly used during the negotiations and Gerbillon even drew his own map, which does not appear to have survived.6 With this, the imperially commissioned journey to Nerchinsk constituted a first small step in the Qing court appropriating, at least to some level, European observational practices for the purpose of frontier management.

In the 1690s, further instability on the Qing’s Mongolian frontier led to the full integration of selected techniques, as developed by the French Academy of Sciences, into the Qing court’s inherited practice of land surveying. In what follows, I will discuss this evolution in three steps. First, I look at the Zunghar-Qing wars of the early to mid-1690s, and the Qing imperial excursions and military campaigns that were organized in their wake. During each of these imperial outings, which both involved travel in the (Outer-)Mongolian frontier region and beyond, the emperor personally ordered Jean-François Gerbillon to determine latitudes with Paris-made instruments, while Qing officials measured road distances with graduated ropes, a practice dating back to Han times.7 In a second step, I will focus on a preliminary survey of Khalkha lands conducted in late 1698, resulting from the integration of these lands into Qing territories following the Zunghar defeat of 1697. Here, missionaries continued to determine latitudes with Paris-made instruments, whereas longitudes were estimated on the basis of measured road distances. With these data, a map of Khalkha territories was produced that revealed a technical incompatibility resulting from the combination of different practices. In last step, finally, I show how a solution to this problem was found in the measurement of one degree of latitude in 1702, and the subsequent re-standardization of Qing’s most basic unit of length. It marked the full integration of divergent practices into a new Qing cartographic practice, the technical basis for the comprehensive land surveys of 1708-1717, and thus for the Kangxi-era atlas known as the Huangyu quanlan tu.

---

6 De Thomaz de Bossierre (1994), 40. Another map that includes information gathered during the Nerchinsk negotiations was drawn by Antoine Thomas. A copy of this map reached Rome as early as 1692 and is now kept there in the Archivum Romanum Societatis Jesu (hereafter ARSI), while other copies are kept in various European libraries and archives. For the full story behind this map, see Roque de Oliveira (2012); Lo Sardo (2003). However, as a member of the French Jesuit mission trained to adhere to the standards of the Académie, Gerbillon explicitly distanced himself from Thomas as far as mapmaking was concerned. See du Halde (1735), 4: 244.

7 Paris had become a center for instrument production after the establishment of the French Académie. Cams (2017), 22-29.
1. The Anti-Zunghar Campaigns: Combining Techniques of Land Surveying

The 1690s saw the full integration of Khalkha lands into Qing territory, the result of both Qing territorial ambitions and efforts by the Khalkha to defend themselves, by recognizing Qing suzerainty, against the Zunghar, with whom they had been in violent conflict for a number of years. After the initial defeat of the Zunghar in 1690 by the Qing, the Zunghar leader Galdan Boshugtu Khan (1644-1697) quickly rebuilt alliances, with the Dalai Lama in Tibet among others, and moved eastwards again in the mid-1690s. Against this background, the Kangxi emperor led a number of imperial tours and military campaigns to counter Galdan’s ambitions, all concentrating on the stabilization of the Khalkha frontier. Jesuit missionaries were ordered to take part in each of these imperial outings organized in the years leading up to the final integration of Khalkha territory and peoples, which was accomplished with the death of Galdan in 1697. The role of the missionaries was mostly to answer any questions the emperor had on subjects ranging from geography to meteorology and astronomy, and to determine positions along the roads into and leading back from Khalkha territories.

A first such journey took place from May to June 1691, when the emperor himself set out for Lake Dolon, on the edge of the Mongolian steppe some 300 kilometers directly north of Beijing. There, three Khalkha khans, having fled to Qing territory, pledged their allegiance on May 29th 1691, and were subsequently absorbed into the Qing polity. Gerbillon and Joachim Bouvet (1656-1730), both French Jesuits and correspondents of the Paris Académie, were ordered to join the emperor on this journey. On May 10th, after having completed their first day of travel from the capital, they were called on to help review the emperor’s knowledge of practical geometry. The emperor asked Gerbillon to determine the difference with Beijing in polar altitude, and to explain which corrections ought to be made when calculating the meridian shadow. Next, on May 13th, when passing Gubeikou 古北口, a gate in the Great Wall, Gerbillon observed the altitude of the sun at noon “with a semi-circle of the Duke of Maine which I had offered to the emperor, who set great value on it…” After completing his observations, Gerbillon had to carefully explain to the emperor his

---

8 Perdue (2005), 174-208.
9 Gerbillon’s account of this journey was edited and inserted into du Halde (1735), 4: 252-88.
10 “avec le demi cercle de Monseigneur le Duc du Maine, dont j’ai fait présent à l’Empereur, qui en fait très grand cas…” De Thomaz de Bossierre (1994), 44; du Halde (1735), 4: 253-5.
calculations for determining latitude. From his diaries, it is clear that the number of \textit{li} traveled by the imperial party was recorded by Qing officials on a day to day basis and communicated to Gerbillon. By the time they returned to the capital from Lake Dolon, Gerbillon was ordered to continue to assist the emperor with his study of geometry. Thus, both during and after the journey, the emperor intended to personally understand and supervise the newly introduced observational practices, some of which Gerbillon had already demonstrated during the Nerchinsk negotiations.

Years after the imperial journey to Lake Dolon, Gerbillon and Antoine Thomas (1644-1709), a Jesuit from Namur working at the Qing court’s Astronomical Bureau, were ordered to join the emperor on three separate campaigns. The first, launched during the spring of 1696, was a large scale military campaign against the Zunghar, led by the emperor himself. The Qing armies were victorious, but after the battle, which took place in today’s central Mongolia, Galdan managed to escape to the Altai Mountains with only a few men. In the wake of this military expedition, and in order to prevent Galdan from gaining support among the OEds Mongols or escaping to Tibet, the emperor undertook two more campaigns, respectively travelling to Hohhot and Ningxia.\footnote{Du Halde (1735), 4: 304-55.} In all three instances, the emperor ordered two distinct cartographic practices to be conducted simultaneously: on the one hand, Gerbillon would continue his role as expert observer, determining positions \textit{vis-à-vis} Beijing in terms of latitude with Paris-made instruments, and according to the observational standards set by the French Academy of Sciences; on the other hand, Qing officials whose identities remain unknown to us were ordered to determine distances in \textit{li} by ‘straightening out’ or geometrically correcting road measurements, which were taken with ropes all along the way according to a practice dating back to Han times.\footnote{Yee (1994), 110-3.}

During the 1696 campaign against Galdan, for example, at the border between Qing and Khalkha lands, Gerbillon determined the army’s position \textit{vis-à-vis} Beijing by measuring the altitude of the pole. At the same time, the route from the gates of the Great Wall to the border had also been measured by rope. A few days later, on May 13\textsuperscript{th} 1696, the emperor appears to have compared both techniques, as recorded in his collected writings, the \textit{Shengzu ren Huangdi yuzhi wenji 聖祖仁皇帝御製文集} (1732):

\begin{quote}
The road from Dushikou to the border, measured with a rope, is 800 \textit{li} long, which is shorter when compared to the number of days measured by earlier travellers. The road from Beijing to Dushikou is very short, roughly calculated no more than 423 \textit{li}. The heir apparent can
\end{quote}
send someone to measure it by rope. At the border post, instruments were used to observe the altitude of the pole, it was 5 degrees higher than in Beijing. Measured like this, the distance in li is 1250.13

In order to determine precisely the Qing-Khalkha border and the progress of the army in relation to Beijing, the emperor here compares the two different cartographic practices. First, he notes that the road from Dushikou 獨石口 to the border, measured with ropes, is 800 li; knowing that the distance between Beijing and Dushikou is 423 li, this implies that the distance from Beijing to the border is 1223 li. Next, he reports the difference in altitude of the pole observed with instruments to be 5°. Given that Qing astronomical treatises at the time asserted that one degree of latitude was equal to 250 li on the ground, the distance is calculated to be 1250 li (5x250 li).14 The emperor here appears to demonstrate the near-compatibility, as he understood it, of both methods. However, the road traveled was not perfectly north-south oriented, so that the comparison is flawed. In any case, this position constituted the intersection of the main route connecting Qing lands and the Mongolian heartland with the Qing-Khalkha border at the time, which is explicitly mentioned in the excerpt quoted above as well as in Gerbillon’s diaries. Throughout the 1696 military campaign, Gerbillon and Thomas determined their positions again and again by observing the altitude of the pole star at night or that of the sun at noon, the latter being the most precise method available for determining latitude at the time.

In October 1696, the emperor ordered Gerbillon and Thomas to again join his retinue, this time for his campaign to the Ordos region, located just south of the Khalkha frontier. The route passed through Hohhot, one of the gateways into Khalkha lands and an important center for Qing-Khalkha trade. The purpose of the campaign was to prevent Galdan from forging an alliance with the Ordos Mongols and thus from escaping to Tibet.15
Gerbillon mentions the latitudes of some of the places he passed through, but does not provide much detail regarding his observations. After a Zunghar envoy met with the emperor near the Yellow River to negotiate the submission of the now isolated Zunghar leader, the emperor suddenly decided to return to the capital.  

Immediately after he reached Beijing, in mid-January 1697, a third campaign was launched, the last one designed to curb Zunghar ambitions targeting the Qing’s Mongolian frontier. Plans were made to travel all the way to Ningxia 宁夏 and from there to push a final military expedition into the Altai Mountains, where Galdan had set up camp. Thus, on February 26th, the emperor set out with his armies, again ordering Gerbillon to travel along with him. As before, Gerbillon determined latitudes, and mentions the amount of li 距離 travelled together with the general direction of the compass on an almost day to day basis. When the imperial party finally arrived at Ningxia in mid-April 1697, the emperor occupied himself with the logistics of sending his armies out into the desert. Around that time, on April 21st, Gerbillon and Thomas observed a solar eclipse with Thomas’ quadrant of more than one French pied (c. 32.5 cm) in radius. Thomas notes that the emperor himself also took part in these observations, using instruments “so that it could be admired by the princes and magnates who had gathered.”

All this is confirmed separately by an account left by Antoine Gaubil (1689-1759), a French Jesuit missionary who wrote from Beijing several decades later on the basis of notes and diaries kept at the French residence. The observation of the eclipse was also recorded in the Shengzu ren Huangdi yuzhi wenji:  

*After my arrival, We have used instruments to observe the pole, which, compared to the capital, stands 1°25′ lower. From east to west the difference is 2150 li. Today, Thomas calculated with [his] methods that the solar eclipse would describe 9°46″, whereas on the day of the eclipse we measured 9°30-something", and it didn’t get dark enough to see the stars. Seen from Ningxia, the capital is slightly north of due east.*

---

16 Perdue (2005), 197.
17 Gerbillon’s account of this journey was edited and inserted in du Halde (1735), 4: 356-84.
18 Perdue (2005), 198-203.
20 Cordier (1915), 533; de Thomaz de Bosserire (1994), 79.
21 “朕至此以儀器測量北極，較京師低一度二十分，東西相去二千一百五十里。今安多以法推算，言日食九分四十六秒，日食之日晴明測驗之，食九分三十幾秒，
Whereas the previous excerpt speaks of the position from the capital in
terms of the supposedly north-south oriented distance in *li* or altitude of
the pole, this one mentions the position of Ningxia in terms of east-west
distance in *li*. Gaubil would later state that, with the help of Gerbillon, the
latitude of Ningxia was observed at 38°35′, whereas the corrected road
distance in combination with data from the eclipse allowed the city’s
longitude to be estimated to between 10°20′ and 10°25′ west of the capital.
Here, an estimate for longitude is explicitly mentioned, and linked to the
calculated road distance from the capital. This is an indication that selected
‘Parisian’ observational techniques were slowly being incorporated into, or
married to, surveying practices of the Qing court. It should be noted that
this new combined practice did not set out base lines for precise
triangulation, as was practiced by the Académie in France, but rather used
the inherited technique of geometrically correcting rope-measured road
distances as a basis for roughly determining longitude. This is confirmed
by extant missionary sources, which claim that longitudes were merely
estimated, whereas latitudes were determined with a much higher degree
of precision.22

Near the great bend of the Yellow River, northeast of Ningxia, the
emperor watched his troops head into the desert on their way to the Altai
Mountains in pursuit of Galdan. The emperor and his party then returned
to the capital, following the Yellow River into the Ordos once more, only to
find out that Galdan had already died in early April, after dissension
within his ranks.23 When it had become clear that the war with the Zunghar
had come to an end, the Khalkha and their lands were set to become an
integral part of the Qing realm. However, basic surveying by Gerbillon and
others between 1691 and 1697 had for the most part only skirted the Qing-
Khalkha border (figure 1), crossing it only once during the 1696 military
campaign against Galdan. As a result, although many Khalkha had already
resettled on the Qing side of the border, the emperor launched an imperial
mission in 1698 in order to explore this new frontier and to stabilize
Khalkha lands, with the aim of putting them firmly under Qing control.

---

22 See, e.g., Cordier (1915), 529-36.
2. The 1698 Survey: Discovering a Technical Incompatibility

On May 24th 1698, a team consisting of Gerbillon, Thomas, three Qing dignitaries and a large number of officials and servants set out from Beijing, according to an account left by Thomas. The three dignitaries were not there primarily to preside over the land surveying, but rather formed an imperial commission to oversee two different meetings of Khalkha khans, which was the main objective of the journey, and a follow-up to the Lake Dolon assembly of 1691. The task of the mission was to work out in more

---

24 The routes on all images included in this article are plotted on the 1719 copperplate edition of the Qing atlas. For an overview of the different versions and editions of the *Huangyu quanlan tu*, see Fuchs (1943); Cams (2013).

25 ARSI, Jap Sin 149: 589-92; Bosmans (1926); Witek (2003). The date of departure is confirmed in de Thomaz de Bossierre (1994), 140. Gerbillon’s account of the journey was edited and inserted in du Halde (1735), 4: 385-422.
detail the integration of the Khalkha into the Qing banner system and to
discuss land control.\textsuperscript{26} In other words, the 1698 journey constituted an all-
round effort to integrate Khalkha peoples and lands into the Qing polity. In one of his letters, Gerbillon explicitly mentions that he was sent along
with Thomas not just in order to determine the positions of locations along the way, but to “make a map of the lands of the Khalkha,
[the emperor’s] new subjects”.\textsuperscript{27}

After six days of travel, the party reached Xifengkou 蔚峰口, another
gate in the Great Wall, from where they started carefully measuring road
distances with a rope of $1/3$ li in length. Besides road distances in li,
Gerbillon again meticulously notes the different compass bearings or
direction for every day of travel. He also seems to have observed latitude
nearly every day, weather permitting, by observing the altitude of the pole
star at night or the sun at midday.\textsuperscript{28} About one month into the journey,
each day covering a distance of 50 to 60 li (c. 28–33 km), they pitched their
tents at Lake Buir.\textsuperscript{29} The meeting of Khalkha leaders lasted for one week in
the vicinity of this lake, at a recorded latitude of 48°3’. The party then
traveled further, to a small lake north of the Kerülen River. Next, they
followed that river for 973 li upstream to the place where Qing troops had
decisively defeated the Zunghar armies just two years earlier.\textsuperscript{30} On August
3rd, the party arrived at the Tula River, near present day Ulan Bator. In his
account, Thomas makes reference to the Zunghar-Qing battles: “we put our
tents exactly where, in a hard battle, Galdan was defeated that very year
[1696], by one of the two armies of the emperor.”\textsuperscript{31} The party then followed
the Tula River for another 449 li until they reached the confluence with the
Orkhon River. From there, they traveled north, where another meeting
with Khalkha leaders was held between the 14th and 26th of August 1698.
During their stay, Gerbillon and Thomas talked with Russian merchants to
obtain information on Russian controlled lands to the north, and with a
young Khalkha boy in their service, who “drew a small map on the spot,
on which he marked the rivers and their courses, the towns and the villages,

\begin{flushleft}
\textsuperscript{26} Du Halde (1735), 4: 400-4. The Khalkha were absorbed into the so-called ‘jasagbanners’ of the Qing-ruled Mongol areas. These banners were headed by jasagh, a title held by Mongolian princes and descendants of Genghis Khan.
\textsuperscript{27} “pour faire la carte de pays des Kalkas, ses nouveaux suiets.” De Thomaz de Bossierrre (1994), 140.
\textsuperscript{28} De Thomaz de Bossierrre (1994), 84-92; du Halde (1735), 4: 385-422.
\textsuperscript{29} Du Halde (1735), 4: 399.
\textsuperscript{30} Cordier (1915), 541.
\textsuperscript{31} “tentoria fiximus eo in loco, ubi Caldanus anno praedicto, praelio pertinaci, ab Imperatoris altero exercitu profligatus fuit.” Bosmans (1926), 163.
\end{flushleft}
which were almost all built on the banks of one of these rivers.”

Around that time, Gerbillon fell ill, and would not recover until his return to the capital. The party returned via a more southern route, arriving at Hohhot on October 2nd, passing the Great Wall at Zhangjiakou on the 10th, and arriving back in Beijing on October 15th. Throughout the 1698 survey of the new Khalkha frontier, road distances were measured in line with Qing practice, while Gerbillon and Thomas observed polar and solar altitudes to determine latitude, and calculated recorded road distances to estimate longitude. This time, the data was used not only to determine the position of a major city or relevant site, as had been the case during the anti-Zunghar campaigns, but in order to produce a map of a significant part of a new frontier.

On December 8th 1698, Gerbillon and Thomas presented their map of Khalkha lands to the emperor. As a result of his familiarity with the terrain, having personally led his armies in decisive battles for control over these regions only recently, and undoubtedly because the map symbolized his control of the region, Thomas notes that the emperor was greatly satisfied, and that he immediately made plans for the missionaries to continue mapping the Manchu homelands, the frontier with Korea, and the shores of the northeast the following year. But after carefully studying the map, the emperor called on Thomas to explain why the measured road distances, which included two stretches oriented almost perfectly on a north-south axis (figure 2), did not correspond with north-south distances calculated on the basis of the observed differences in latitude. Thomas states that, based on their observations and measurements in the field, the actual li was likely to be only 4/5th of the one used to make the measuring ropes.

In other words, the combination of ‘European’ and ‘East Asian’ land surveying techniques during the 1698 survey of Khalkha lands revealed some of the standards that had been used in astronomical and cartographic practice at the Qing court as faulty. As mentioned above, one terrestrial degree had been defined as equal to 250 li in astronomical treatises authored by Jesuit astronomers at the Qing court in previous decades. However, based on measurements undertaken during the 1698 journey, it had become clear that, if one considers the earth to be a perfect sphere, one

---

32 “Il nous traça même sur le champ une petite carte, où il marqua les rivières avec leurs cours, les Villes, & les Bourgades, qui sont presque toutes bâties sur le rivage de quelques-unes de ces rivières.” Du Halde (1735), 4: 417-8; de Thomaz de Bossierre (1994), 91-2. Areas around Lake Baikal on the Huangyu quanlan tu were presumably drawn with the help of this information, given that none of the later surveys reached that far north.

33 I use the words ‘European’ and ‘East Asian’ here only as a reference to the geographical regions to which these practices were confined in the period before their encounter.
degree of latitude should only consist of about 200 li. According to Thomas, the emperor now “saw that, with accurate observations, many things could be understood, namely, how many Chinese li, measured to an accuracy of one chi, were contained in one terrestrial degree.” As a result, the length of the li was redefined by imperial decree so that there were exactly 200 li in one degree of terrestrial latitude. Yet efforts to re-standardize the chi in consequence of the imperial decision were not undertaken until 1702.

Figure 2: Schematic depiction of the route followed during the 1698 survey of Khalkha territories.

34 “cum accurate observari, plurimum conducere videret, quot scilicet stadia Sinica certa ac fixa mensura uniuspedis, continenter in uno gradu terrestri” Bosmans (1926), 166.

35 The reason for this is unclear. A general preoccupation with other issues related to land control may be one possible explanation: in 1699, there were serious floods in Jiangsu province; in 1701, Kangxi gave the order to retake Dartsedo, today’s Kangding, a town on the Qing-Tibetan border.
3. The 1702 Expedition: Establishing a New Qing Cartographic Practice

For the terrestrial degree to measure precisely 200 li, as decreed by the emperor, the Qing’s most basic unit of length had to be carefully redefined. The only way to achieve this was to measure, as accurately as possible, one degree of latitude on the ground. According to Thomas, on April 24th, 1702, the emperor decreed that, at last, the terrestrial degree was to be measured in order to define the li as precisely 1/200th of that value. He wanted to have it done by the end of autumn, so that measurements would not interfere with the local harvest, and vice versa. After having found an area “flat like the sea’s surface, without even the slightest hill, and extending about 200 li” just south from Beijing near the city of Bazhou, the date of departure for the mission was fixed to November 28th.

A stone monument in a field to the east of the city was chosen as the starting point. An iron wire measuring one li was used for tracing a meridian from this point towards the south. To make sure it remained in its fixed position, every 1/3 li a marker was placed in the form of a rod that in turn was held in place by a cast-iron tripod. Personnel were positioned along the line so as to ensure that it would be kept in its right position at all times. Wherever trees stood in the way or blocked the view, they were immediately cut down by order of the local prefect, who was obliged to join the team and to assist in whatever way he could. With each li covered, two instruments ‘of good quality, equipped with two telescopes and a large magnetic needle’ were placed at both ends of the iron wire, from which the altitude of the pole was observed. Another instrument was used to survey all the rods that had already been placed, making sure that a perfectly straight line was traced. This way, li by li, a straight line was measured from just east of Bazhou to the banks of the Zhang River, near the town of Jiaohe (figure 3).

---

36 Bosmans (1926), 166. Note that the debate on the shape of the earth had only just begun. For mapmaking purposes, it was assumed that the earth was not flattened at the poles, and thus that every degree of latitude covered the same distance on land.

37 “instar superficii maris, sine ullis prorsus colliculis, ad 200 circiter stadia protensum.” Bosmans (1926), 167; Bernard (1935), 455-8.

38 “bene probatum, instructum duobus tubis opticis et magna acu magnetica” Bosmans (1926), 168.

39 The Zhang river is known today as Laozhang He.
Selected for the flatness and scarce vegetation of the area, the line between Bazhou and Jiaohe crossed three villages. In two of these, the low, flat roofs of the houses allowed for the uninterrupted continuation of measurements. The third village, however, at li 79, did not allow for unimpeded measurement, so that the iron wire had to be laid out parallel to the original line but one li to the east. Measurements continued from this parallel line until the team hit the shores of a sizable lake, at li 97. At this point measurements resumed one li to the west, again in perfect parallel to the original line. Finally, on December 15th, when measurements hit the banks of the Zhang River, at li 199, a gnomon (guibiao 圭表) about three meters high was erected on top of a horizontal beam marking the meridian.

Two days in a row, prince Yinzhi 胤祉 (1677-1732), the Kangxi emperor's third son, personally observed the shadow cast on the horizontal beam so as to determine the precise latitude.

Thomas, however, expressed doubts about the prince's observations in his account of the measurements. After all, with only a few days to winter solstice, the sun did not even reach a midday altitude of 30°, so that the phenomenon of refraction would make any readings of the altitude of the...
sun at midday unreliable at best. For three consecutive nights, therefore, Thomas observed the altitude of the pole star with a large quadrant, finding that it was 40°21' above the horizon. But since the Zhang River prevented the team from measuring one more li to the south, they had only measured 199 instead of the 200 li the emperor had ordered. Therefore, it was decided to travel back to the other extremity of the line, at Bazhou, to measure one more li to the north. When they arrived there, on December 21st, the same large gnomon was installed, while Thomas again observed the altitude of the pole star with a quadrant, on two consecutive nights, with a result of 41°22'30". Thomas recorded the following calculation:

<table>
<thead>
<tr>
<th>Height of the pole at the northern extremity (of 200 li)</th>
<th>41°22'30&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of the pole at the southern extremity (of 200 li)</td>
<td>40°21'00&quot;</td>
</tr>
<tr>
<td>Difference</td>
<td>1°01'30&quot;</td>
</tr>
<tr>
<td>Correction (refraction)</td>
<td>02&quot;</td>
</tr>
<tr>
<td>Corrected difference</td>
<td>1°01'32&quot;</td>
</tr>
</tbody>
</table>

Thus, with 200 li or 360,000 chi meticulously measured to cover a difference in latitude of 1°01'32", one degree of latitude should cover a distance of 351,030 chi, that is, roughly 195 li according to the old standard chi. This standard chi, or yingzaochi 營造尺, which had been used to make the one li iron wire for conducting the 1702 measurements, was cast in brass and kept at the imperial palace. Since the emperor had decreed that one terrestrial degree should measure exactly 200 li, this chi that had to be redefined was shortened to 195/200 of its former size.

---

40 Refraction occurs when the rays of the sun are bent by the earth’s atmosphere, causing an unreliable observation of the altitude of the sun above the horizon.
41 South of Paris, similar measurements had taken place in 1669-70, when Jean Picard (1620-1682) led the French Academy’s first stage in tracing a meridian through Paris by triangulating from carefully measured baselines.
42 Bosmans (1926), 168.
43 Witek (2003), note 39.
Table 1. The Qing units of length as redefined in 1702 with corresponding values in meters.\textsuperscript{44}

<table>
<thead>
<tr>
<th>Li</th>
<th>Chi</th>
<th>Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>360,000</td>
<td>c. 110,880,000</td>
</tr>
<tr>
<td>1</td>
<td>1,800</td>
<td>c. 554,400</td>
</tr>
<tr>
<td>1</td>
<td>0,308</td>
<td></td>
</tr>
</tbody>
</table>

The significance of these changes are summarized as follows in the Qing Veritable Records (Qing shilu 清實錄):

The number of degrees of the Heavens corresponds perfectly to the vastness of the Earth. When we calculate them using the chi of the Zhou era, then for one degree in the Heavens, there are 250 li on Earth. When we calculate them using the contemporary chi, then for one degree in the Heavens, we have 200 li on Earth. Since antiquity, those who drew maps did not follow the number of degrees of the Heavens in order to calculate geographical distances, so that there were many mistakes. \textsuperscript{45}

To recapitulate, finally, with the li officially defined in terms of precisely how many li there should be in a degree of terrestrial latitude, and a new standard chi defined so as to match this new li, maps could be drawn on which the observed latitudes and longitudes, or ‘heavenly’ degrees, would match the measured road distances. This event therefore constituted the final step in the formal establishment of a new Qing cartographic practice, or the full integration of selected techniques of land surveying as practiced by the French Academy of Sciences into the Qing court’s cartographic practices. This new, hybrid, cartographic practice formed the technical basis for a series of land surveys that were unprecedented in scale, timing, and personnel needed, and executed by mixed teams of European missionaries and Qing officials between 1708 and 1717. These land surveys, and the atlases that were produced as a result, constituted the largest mapping project of the early modern world, and provided the most authoritative source of cartographic data on East Asia until well into the nineteenth century.

\textsuperscript{44} Based on a detailed study of different chi. Ferguson (1941). Note that Picard had estimated one degree of latitude to measure 110.46 km. \textit{Supra}.

\textsuperscript{45} 天上度數俱與地之寬大吻合，以周時之尺算之天上一度，即有地上二百五十里，以今時之尺算之天上一度，即有地上二百里。自古以來，繪圖者俱不依照天上之度數以推算地理之遠近，故差誤者多。Qing shilu: Shengzu ren huangdi shilu 清實錄: 聖祖仁皇帝實錄, juan 246.
Conclusion

The actual encounter of two different sets of land surveying techniques and their gradual integration is closely intertwined with spatial dynamics. This holds true in at least two ways. First, there is the question of the physical locus of the technical integration as facilitated by these multiple (groups of) actors. Whereas many of the cross-cultural scientific exchanges in seventeenth- and eighteenth-century Eurasia took place within well-defined spatial boundaries, in this story, the nature of land surveying and the context in which two divergent practices were explored meant that much of the encounter and integration materialized during travel. Naturally, these spatial dynamics profoundly shaped the encounter: the north-to-south routes taken by the surveyors through large swaths of scarcely populated lands, for example, allowed the early detection of incompatibility between new techniques for determining latitude and the then current assumptions with regard to the length of one degree of latitude. The solution to this problem, redefining the 里 in terms of the terrestrial degree and then the 寸 in terms of this new 里, directly facilitated the establishment of a new cartographic practice by the Qing court. In other words, the evolution described in this article was in no small measure determined by the environment in which it took place: the Qing’s vast Mongolian frontier and the roads thither.

On the other hand, there is the conceptual locus of the Jesuit missionaries often commented on in previous scholarship, where scientific exchanges like these are seen as taking place in-between ‘(Qing) China’ and ‘Europe’, with the Jesuit missionaries as the only mobile elements connecting the two blocs. Although this has proven to be a fruitful abstraction, in this case, tracing the exchange demands that we step out of the dichotomy and bring several other actors, or groups of actors, into the picture. The Manchus are an obvious choice for matters related to Qing China, but perhaps even more crucial here are the Khalkha, the Zunghar, and the Russians. After all, the emperor’s move to improve cartographic practices was directly motivated by an unstable frontier, which inspired the exploration of divergent land surveying practices. Thus, the integration of cartographic practices was shaped to a great extent by Manchu-Qing ambitions towards Khalkha territories and peoples, and took place in the shadow of clashes with the Russians and the Zunghar. In this regard it is important to note that the Jesuits were no longer the only mobile participants: Qing dignitaries, officials and, crucially, the emperor himself were the principal travelers, and played equally essential roles in bringing about the integration of land surveying practices.

These points aside, I have mainly argued that a hybrid, or new, cartographic practice was formed out of two distinct practices, the
incompatibility of which was revealed as they were both put to use simultaneously while serving the imperial purpose of incorporating a new frontier. This, in turn, dictated that the absorption of specific observational and geometrical techniques into Qing practices could not be accomplished without redefining the li and the chi. Therefore, the outcome of this scientific encounter, this new cartographic practice, cannot be said to belong to China, the Qing or its emperor, and even less so to Europe, the Jesuits, or the Paris academicians. Rather, it effectively blurred the boundaries between ‘new’ practices introduced from France and ‘old’ practices that had been inherited by the Qing court, a story that can perhaps inspire one to reflect on other long-standing boundaries and frameworks in the study of cross-cultural exchanges in history.
References

Abbreviations
ARSI: Archivum Romanum Societatis Iesu
BnF: Bibliothèque nationale de France
CCT: Chinese Christian Texts Database,
https://www.arts.kuleuven.be/sinologie/english/cct


——— (2017), Companions in Geography: East-West Collaboration in the Mapping of Qing China (c. 1685-1735), Leiden/Boston: Brill.


Jami, Catherine (2012), *The Emperor’s New Mathematics: Western Learning and Imperial Authority During the Kangxi Reign (1662-1722)*, Oxford: Oxford University Press.


Qing shilu: Shengzu ren huangdi shilu 清实录: 聖祖仁皇帝實錄, Vols. 3-6, Beijing: Zhonghua shuju (reprint 1985).


