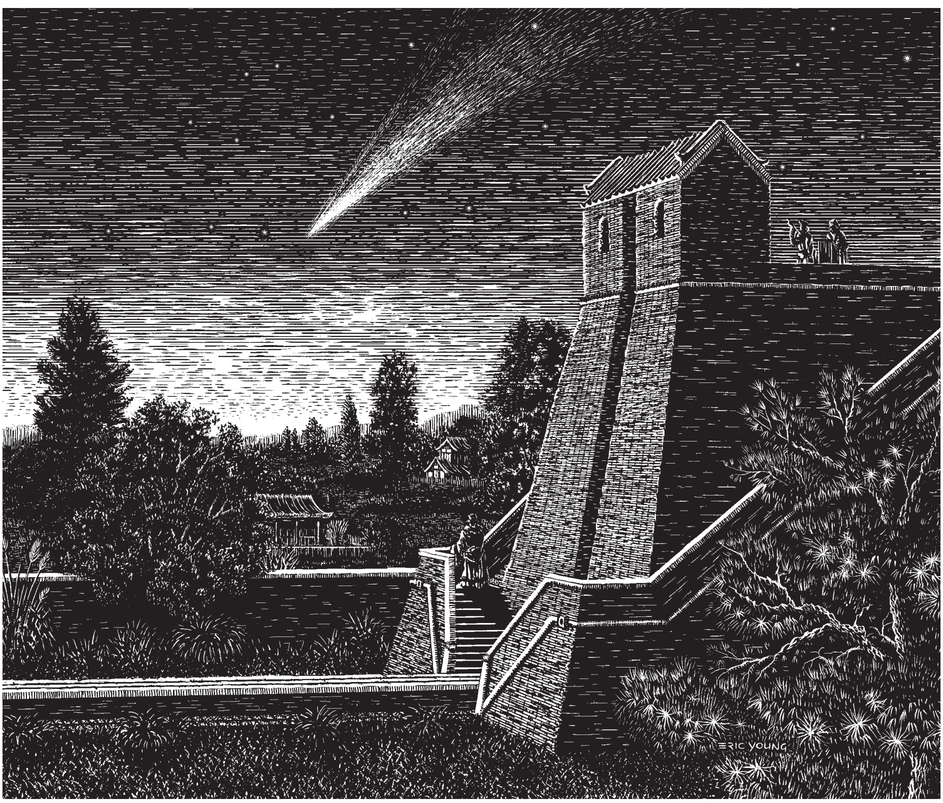
Cometography

A Catalog of Comets

volume 1: Ancient–1799

Gary W. Kronk



CAMBRIDGE
UNIVERSITY PRESS

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK http://www.cup.cam.ac.uk
40 West 20th Street, New York, NY 10011-4211, USA http://www.cup.org
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

First published 1999

Printed in the United States of America

Typeface Palatino 9.5/13 *System* QuarkXpress [BA]

A catalog record for this book is available from
the British Library.

Library of Congress Cataloging-in-Publication Data

Kronk, Gary W.
Cometography / a catalog of comets / Gary W. Kronk.
p. cm.
ISBN 0-521-58504-X (v. 1)
1. Comets – Catalogs. I. Title
QB722.K75 1999
523.6 – dc21 98-38683
CIP

ISBN 0 521 58504 X (hardback)

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Introduction

Comets have fascinated people for centuries. Their images have been found carved onto rock walls in North America and on islands in the Pacific. They were discussed in some of the earliest Chinese histories. They were written about in the chronicles of hundreds of European monasteries during medieval times.

There was never a shortage of theories concerning comets. The scientific minds of ancient Greece presented numerous theories during the 6th, 5th, and 4th centuries bc. These ranged from the idea of Pythagoras that there was only one comet and that it was a planet moving in a circular orbit that could only be seen on rare occasions, to the idea of Aristotle that a comet was gas that rose up from Earth and ignited in the upper atmosphere. The superstitious minds of the rest of the world believed comets were signs of calamity or change that only appeared during times of war and famine. Comets were also blamed for the deaths of great leaders; for example it was believed that the comet of 54 was responsible for the death of the Roman emperor Claudius Caesar.

The evolution in understanding during the period covered by volume one of *Cometography* makes it an interesting one. Among scientists, the theory of Aristotle remained the accepted theory of comet formation until challenges were made during the mid-15th century. Yet it was not until the Great Comet of 1577 that Aristotle's theory was laid to rest by the most learned men of the time, when the majority of astronomers became convinced that comets lay far outside the orbit of the moon. Interestingly, among non-scientists, the idea of comets representing signs of calamity or change continued beyond the years covered by this volume.

Perhaps one of the biggest breakthroughs in the understanding of comets came in the early 17th century when Johannes Kepler published his three laws of planetary motion. During the latter half of the same century, Isaac Newton demonstrated how these could be used to determine the orbit of a comet, and, as the 18th century began, Edmond Halley published the first catalog of comet orbits. This catalog gave parabolic orbits for 24 comets seen from 1337 to 1698. Amidst those were three very similar orbits for comets seen in 1531, 1607, and 1682. Halley surmised that these were the same comet which returned at regular intervals. He eventually predicted that the comet would return in 1758, which it did, and it became the first recognized periodic comet. Halley was honored by having the comet named after him.

The computation of comet orbits allowed an even greater understanding of comets. It enabled astronomers to begin understanding how comets changed with respect to their distances from the sun and Earth. By the latter half of the 18th century, the accounts of many astronomers were beginning to reflect this understanding, with respect to changes in brightness, coma diameter, and tail lengths.

Another major breakthrough came with the invention of the telescope. The vast majority of comets discussed in volume one were observed exclusively with the naked eye. With the telescope not even being used for astronomical observations until 1607, the first telescopic comet observations were not made until 1618, and the first telescopic comet discovery did not come until 1680.

Comet catalogs of the past

Although the first comet catalogs were produced over 2000 years ago, many were works of astrology rather than astronomy. By the 16th century some books addressing the study of comets began including brief details of previous comets.

Perhaps the first great researcher of comets was Nicholaas Struyck. His 1740 book *Inleiding tot de Algemeene Geographie, Benevens Eenige Sterrekundige en andere Verhandelingen* included some of the first well-researched accounts of comets. His follow-up book *Vervolg van de Beschryving der Staartsterren* was published in 1753 and greatly expanded our knowledge of the well-observed comets seen up to the time of its publication.

The next great catalog was the two-volume work *Cometographie ou Traité Historique et Théorique des Cometes*, written by Alexander Guy Pingré during 1783 and 1784. This work became the benchmark for all future comet catalogs. Pingré researched every comet that had ever been reported, beginning with reports of comets as early as 2349 bc and continuing up to the time of publication. Pingré's sources included scientific books and articles of his time, as well as classics of Roman and Greek literature, European monastic histories, and the astrological and astronomical papers and books that began being published from the 14th century. Although Pingré tried to determine which were likely comets and which were not, his work suffered from something he had no control over – his sources of Chinese observations were not extremely reliable. Considering the importance of the Chinese observations up to the 15th and 16th centuries, this somewhat degraded the value of Pingré's work over time. Despite these flaws, Pingré's work still includes something no other catalog includes during the next 200 years – details of the lesser observed comets for which orbits could never be included.

The two latest catalogs of comets have been published during the last 40 years. Sergey Konstantinovich Vsekhsvyatskij published *Physical Characteristics of Comets* in 1958. Vsekhsvyatskij was a pioneer in the study of comet brightness behavior and he provided a chapter covering this topic at the beginning of the catalog. The catalog itself included only those comets for which orbits had been computed. Pingré was a primary source for the early comets and some of the Chinese errors made it into this book. Although it provided a good source of information for each comet, it concentrated heavily on the observations of certain observers, especially during the 20th century, and much interesting information was left out. The book was originally published only in Russian. An English version became available in 1964, but suffered from numerous errors, which degraded its value. The second comet catalog to come along in recent times was *Comets: A Descriptive Catalog*, which was written by the same author as this book in 1984. The primary problem with this book was that size constraints limited the text to covering only those comets for which orbits had been computed, although a few especially interesting objects, such as the comet of 1106 were included. The text had the benefit of an article written by Ho Peng Yoke, which appeared in *Vistas in Astronomy* during 1962. This article provided numerous translations of Chinese, Japanese, and Korean observed comets. My 1984 book provided detailed accounts of comets through the early 1980s.

The goal of Cometography

The purpose of the *Cometography* series is to provide a comprehensive collection of the physical appearances of every observed comet. Great pains have been taken to search through the sources providing the most comprehensive discussions of comets. For the first volume, every effort was made to consult the original sources and even find new sources, especially for the comets seen during medieval times. Several hundred monastic histories were consulted, as well as every Roman and Greek text I could acquire. Ho Peng Yoke's work was used as the primary source for Chinese, Japanese, and Korean observations, although the corrections suggested by Ichiro Hasegawa in a 1980 paper published in *Vistas in Astronomy* were applied. In addition, Hasegawa was consulted on several occasions during 1997 to help me iron out conflicts that remained among some of the Asian observations.

I tried to weed out the comets which may not have been real. For this purpose, the most suspicious objects were placed in Appendix 1. Unfortunately, for the ancient and medieval comets, there will still remain objects which might be considered uncertain in the main portion of this catalog. One way to help the reader was devised by Dr. Brian G. Marsden a few years back, and that was the creation of the "X/" comet category, which was a way of designating comets that were probably real, but for which orbits could not be calculated. Through various consultations with Marsden, I determined the criteria to be used for the ancient and medieval comets, and assigned several comets within volume one this new designation.

For the cometary apparitions for which orbits had been computed, I have included much additional information. Details of each comet's closest approach to Earth, greatest and smallest elongations from the sun, and the extreme northern and southern declinations are included. All of these influence a comet's brightness, as well as an observer's ability to see it with respect to twilight or the horizon. In addition, I have included the dates when the moon was full, since this can influence comet observations as well.

Another item added for these well-observed comets is absolute magnitude determinations. Magnitude estimates were not made with any real degree of accuracy at any time for the comets in volume one. Therefore, these absolute magnitudes are rough values primarily derived from educated guesses of each comet's brightness when first and last seen, with factors such as altitude being taken into consideration. Although I determined absolute magnitudes for most of the well-observed comets in volume one, I discovered early on that Vsekhsvyatskij's determinations for these comets were about as good as the ones that I made. I therefore decided to use Vsekhsvyatskij's absolute magnitudes throughout volume one. My own determinations are used for comets whose orbits have been determined since Vsekhsvyatskij's time, for all of the apparitions of Halley's Comet, and for the comets for which there was a notable difference from what Vsekhsvyatskij had determined.

The oldest comet

One of the first problems I had to deal with was to establish the first comet to be listed in the catalog. Pingré (1783) began his catalog with the "Deluge comet" of –2349, which had been suggested by William Whiston during the 18th century, and an apparent Chinese comet from –2296. F. Baldet (1950) began his catalog with a Chinese account of a comet seen in –2315. Meanwhile, Ho Peng Yoke began his catalog with a Chinese account of a comet seen in the 14th century bc. Interestingly, Pingré and Baldet list 12 comets with dates older than the first listed by Ho Peng Yoke.

Correspondence with Hasegawa, Herman Hunger, and F. Richard Steavenson during the last few years brought some interesting details to light concerning these very ancient comets. Many of the oldest comets have very uncertain dates because historians have not accurately dated historical events with which the comets were associated. In some cases the date discrepancy amounts to over 100 years. In many cases, historians are not absolutely positive the objects referred to were really comets at all. Since the purpose of *Cometography* is to supply accurate information to future researchers, such objects would prove virtually useless. It would be impossible to try to link a periodic comet to them because of the date discrepancies, and, of equal importance, details of a location in the sky were rarely provided.

For the reasons stated above, I have chosen to begin the catalog with a Babylonian comet seen in –674. Its details were reported in stone by two separate Babylonian scholars of ancient times. In addition, a month and date are available and a location of "visible in the path of the stars of Anu" was specified, although historians have not yet worked out which group of stars this may refer to.

Halley's Comet

One very prominent comet in this volume is Halley's Comet, more appropriately known as 1P/Halley. This volume reports 27 apparitions of Halley's comet. Although astronomers such as Halley, J. K. Burckhardt, J. R. Hind, J. Holetschek, P. H. Cowell, and A. C. D. Crommelin contributed much in identifying the previous apparitions of this comet, recent investigations into the mechanisms of cometary motion and the orbital history of this comet have helped to better establish the actual month and day of the perihelion passages. To prevent needless repetition within volume one, I offer the following details to keep in mind when reading the various accounts of Halley's Comet.

- In 1972, Tao Kiang published a paper examining the previous apparitions of Halley's Comet. The purpose of the work was both to calculate the degree of perturbations upon the orbit of the comet over the previous 28 revolutions and to derive probable perihelion dates based upon the visual observations.
- In 1978, Y. C. Chang conducted an intensive mathematical survey into the previous orbits of 1P / Halley. Since nongravitational forces were ignored, the accuracy of this study's results has been questioned by several astronomers, as some of the resulting perihelion dates deviate by weeks, months, and even years from computations which take nongravitational forces into account.
- Donald K. Yeomans and Kiang (1981) numerically integrated the orbital motion of comet Halley based upon the 1607, 1682, and 1759 returns, and applied any needed corrections using the "unusually accurate observed perihelion passage times in 837, 374, and 141." In addition, "small empirical corrections were made to the computed perihelion passage time in 837 and to the osculating orbital eccentricity in ad 800." They integrated the motion of this comet over the period between 1404 bc and ad 1910.
- Werner Landgraf (1986) integrated the motion of the comet for the period between 467 bc and ad 2580, based on 160 observations and normal places obtained during the comet's apparitions between 1607 and 1985, and the effects of nongravitational forces. He pointed out that the perihelion time of the 837 apparition was decreased by 0.05 day before continuing to assess the previous perihelion dates.
- G. Sitarski (1988) utilized 300 of the best positional observations obtained from 1835 to 1987, and 25 perihelion times derived from visual observations by Kiang for ad 1835 to 87 bc, and integrated the comet's motion backwards.

I spent much time compiling ephemerides from the orbits of the Yeomans–Kiang, Landgraf, and Sitarski. Although they all fit quite well for the majority of the apparitions, the oldest apparitions, from ad 66 back to 240 bc, seemed to favor the orbits of Yeomans and Kiang in terms of consistently representing the comet's appearance near specific stars and its passage from the morning to the evening sky.

Dates and calendar systems

My goal for the entire four-volume *Cometography* series is to provide consistent dating. This goal was certainly challenged during the writing of volume one, as so many different cultures had their own calendar systems. There was the Julian calendar, Gregorian calendar, Chinese calendar, Jewish calendar, Roman calendar, Greek calendar, Latin calendar, Byzantine calendar, Armenian calendar, Aztec calendar, Islamic calendar, and French Revolutionary calendar.

To give the reader a sense of what all of this amounts to, consider the following:

- The Chinese calendar is based on lunar months, so that the first day coincides with the day of new moon. The Japanese calendar system is similar to that of China; however, at one time, they began each day at 03:00.
- The Latin calendar used a system of 12 months, but broke each month down into segments called Kalendas, Nonas, and Idus. These Latin dates coincided with the Julian calendar which began in 45 bc.
- The Julian calendar established most of the rules used in today's calendar, like the modern 12 months and 7 days a week, as well as leap years every fourth year. The problem, however, was the Julian year was 11 minutes and 14 seconds longer than the solar year, so that by 1582, the celebrated date of the vernal equinox occurred 10 days later than the actual event. Many European countries adopted the Gregorian calendar at that time, but there were stragglers. Most notable were: Great Britain, which adopted the new calendar in September 1752, the Soviet Union, which adopted it in 1918, and Greece, which adopted it in 1923.

Ultimately, I have taken great care to convert all dates to universal time. Dates representing the local time of an observation have occasionally been maintained, but only if it helped get a particular point across. I have made sure the dates representing local time were marked accordingly.

Sources of research and names

I have worked to bring the size of this volume down to a minimum. One way to do this was by condensing repetitive sources. For instance, Ho Peng Yoke's 1962 work was used frequently throughout the book. Instead of including "Ho Peng Yoke, *Vistas in Astronomy*, **5** (1962)" for the majority of the comets, I have chosen to list it simply as "Ho Peng Yoke (1962)." All abbreviations are listed in Appendices 2 and 3.

Another feature I tried to bring to *Cometography* is the recognition of the full names of the people who provided the details for the comets. In some instances, however, the names would become cumbersome to read over and over. As an example, consider that Andrew Claude de la Cherois Crommelin, Heinrich Wilhelm Matthäus Olbers, and Pierre François André Méchain appear quite often. What I have opted to do is reduced these names to the first initials and last name throughout this volume and include the full names in the person index.

Conclusion

This is only the first volume of *Cometography*. Three additional volumes will appear over the next few years. *Cometography* will ultimately cover the apparition of every comet seen through the year 1999.

This first volume was perhaps the greatest challenge. As indicated above, every care has been taken to acquire information from the original and most contemporary sources. Hopefully this has raised *Cometography* to a level of accuracy never achieved by any other comet catalog.

In recent years, astronomers have used powerful computers to analyze the past orbital motion of the known periodic comets. Comets such as Swift–Tuttle, d'Arrest, and others have been linked with comets seen from a few decades to over two millennia earlier. It is hoped this collection will be a useful, time-saving tool for astronomers researching comets of the past.

Catalog of Comets

–674 During a search through Babylonian stone tablets at the British Museum, Hermann Hunger identified two references to a comet reported to an Assyrian king. Babylonian scholar Bel-le'i wrote the first and stated, "If a comet becomes visible in the path of the stars of Anu: there will be a fall of Elam in battle." Babylonian scholar Asaredu the Younger wrote the second. Unfortunately, this tablet is damaged and although it seems to provide similar details, the text is not easy to read. Hunger said other observations contained in the tablets indicate the comet was probably seen in –674 October.

full moon: October 13
sources: *Astrological Reports to Assyrian Kings*. Edited by Hermann Hunger, Helsinki: Helsinki University Press (1992), pp. 194, 256; personal correspondence from Herman Hunger (1995).

–632 The Chinese text *Lun Hêng Chiao Shih* (80) is the only record of this comet. It says that when Duke Wen-Kung of Chin State was preparing for battle at Ch'eng Pu with the state of Ch'u, a "broom star" appeared at Ch'u [ε, ζ, η, λ, ν, τ, υ, χ, 26, and SAO 77354 in Auriga], with a tail pointing toward the Ch'u State.

source: Ho Peng Yoke (1962), p. 141.

–612 This was the first comet reported in more than one Chinese historical text. Ho Peng Yoke (1962) gives seven sources, the oldest being the *Ch'un Ch'iu* (–480). The texts said a "broom star" entered Pei-Tou [the Big Dipper] sometime during the month of –612 August 4 to September 2. The *Ch'un Ch'iu* says, "Then as a broom sweeps away what is old to give place to something new, a comet is supposed to presage changes." The year is based on modern dating of the Chinese calendar. A few older sources give different dates. In 1865, James Legge said the comet was seen in –611, but J. Williams (1871) and Wen Shion Tsu (1934) said it was seen in –610.

Various astronomers have suggested this comet was an earlier appearance of some more contemporary comet. J. Riem (1896) suggested the year and location were evidence that this comet might have been a previous apparition of comet C/1881 K1. Several astronomers, beginning with Johann

Holetschek (1897), have suggested this might be a previous appearance of 1P / Halley. This latter link is an unlikely one, as modern investigations into the motion of this comet, indicate the perihelion date was probably within the period –619 to –615.

full moon: August 19
sources: *Ch'un Ch'iu* (–480), p. 266; *Tso chuan* (–300), p. 267; *Chu shu chi nien* (–294), p. 164; A. G. Pingré (1783), pp. 254, 573; J. Williams (1871), p. 1; J. Riem, *AN*, **142** (1896 Dec. 22), pp. 137–40; J. Holetschek, *AN*, **143** (1897 Apr. 7), p. 116; G. F. Chambers (1909), p. 242; Wen Shion Tsu, *PA*, **42** (1934 Apr.), p. 192; Ho Peng Yoke (1962), p. 142; *CAA*, **3** (1979), pp. 123, 129–30; I. Hasegawa (1979), p. 262; I. Hasegawa (1980), p. 63; D. K. Yeomans and T. Kiang (1981), p. 643; J. L. Brady (1982), p. 210; G. Sitarski (1988), p. 263; *JHA*, **23** (1992), pp. 48–9.

–524 No fewer than five Chinese historical texts report this object, the oldest being the *Ch'un Ch'iu* (–480). The texts said a "sparkling star" appeared either at or to the west of Ta-Chhen [α Scorpii] during the winter of –524. It then traveled eastward to the Milky Way. The year is given incorrectly as –530 by J. Williams (1871) and –523 in 1872 by James Legge.

sources: *Ch'un Ch'iu* (–480), p. 667; *Tso chuan* (–300), p. 668; A. G. Pingré (1783), pp. 254–5, 573; J. Williams (1871), p. 1; Ho Peng Yoke (1962), p. 142; *JHA*, **23** (1992), p. 49.

–481 The *Ch'un Ch'iu* (–480) is the oldest source to report this object. It says a "sparkling star" was seen in the east sometime during the month of –481 September 26 to October 24. J. Williams (1871) erroneously dates this account as –501 December.

full moon: October 9
sources: *Ch'un Ch'iu* (–480), p. 831; A. G. Pingré (1783), pp. 255, 573–4; J. Williams (1871), p. 1; Ho Peng Yoke (1962), p. 142; *JHA*, **23** (1992), p. 49.

–480 This object was reported among the final pages of the chronological history contained within the *Ch'un Ch'iu* (–480). The text says a "sparkling star" was seen, but no further details are given. The account's placement among other dated, chronologically listed events would imply it was seen in the winter. The *Han shu* (100) simply says a "broom star" was seen in winter.

sources: *Ch'un Ch'iu* (–480), p. 838; *Han shu* (100), p. (142); Ho Peng Yoke (1962), p. 142; *JHA*, **23** (1992), p. 49.

–479 The Roman scholar Pliny the Elder wrote in the year 77 that a comet of the Cerastes type (shaped like a crescent moon) appeared when the Greeks fought the final battle at Salamis. Historians agree the naval battle in the strait between Salamis and the Grecian mainland was won by Themistocles (an Athenian statesman) over Xerxes I (King of Persia) in –479.

sources: *Natural History* (77), book 2, pp. 232–3; A. G. Pingré (1783), p. 255; R. F. Rodgers (1952), p. 177; A. A. Barrett (1978), p. 86.

–466 This comet marks the first time the Chinese and Europeans reported a comet within the same year. Unfortunately, since each culture gave only the year, it can only be conjectured that the objects were one and the same.

The oldest reports of this event come from Greece. The philosopher Anaxagoras, who could have been a contemporary of the event, wrote during the 5th century BC. He said that a body of extraordinary grandeur was observed for 75 days prior to the fall of the great meteorite of –466. The philosopher Aristotle wrote *Meteorologica* around –329, and noted, "when the stone fell from the sky at Aegospotami . . . a comet happened to appear at the same time in the west."

The only ancient Chinese text to report a comet in –466 is the *Shih chi* (–90). The account describes the object as a "broom star," but gives no additional details.

The Romans also wrote of this comet, but not until about 500 years later. The accounts were obviously taken from the earlier Greek texts. The philosopher Lucius Annaeus Seneca wrote *Quaestiones Naturales* around 63 and the scholar Pliny the Elder wrote *Natural History* around 77. Both writers said the comet was seen by Anaxagoras, with Seneca stating the comet was "a large and unusual light of the size of a great Beam [that] shone for many days."

This comet is especially interesting in that it appeared at about the time expected for 1P/Halley. P. H. Cowell and A. C. D. Crommelin (1908) were the first to suggest that this may have been a previous apparition of 1P/Halley, but they concluded "the identity cannot become more than a vague conjecture." Other astronomers making the same suggestion included Wen Shion Tsu (1934), Yu-Che Chang (1979), and I. Hasegawa (1979). Chang suggested the account was improperly dated and should have been –465.

As 1P/Halley approached and passed perihelion during 1986, several astronomers computed its orbit back to and even through the 5th century BC apparition. D. K. Yeomans and T. Kiang (1981) determined the perihelion date as –465 July 18.24, J. L. Brady (1982) determined it as –467 July 16.55, Werner Landgraf (1986) computed it as –465 July 17.90, and G. Sitarski (1988) computed it as –466 December 2.01. As can be seen, the data regarding this comet as identical to 1P/Halley are not conclusive.

sources: *Meteorologica* (–329), book 1, p. 55; *Quaestiones Naturales* (63), book 7, pp. 236–7; *Natural History* (77), book 2, pp. 284–5; A. G. Pingré (1783), pp. 255–8, 574; J. Williams (1871), p. 2; *Observatory*, **68** (Supplement 1908), p. 668; *PA*, **42** (1934 Apr.), p. 192; *JBAA*, **58** (1948), p. 181; Ho Peng Yoke (1962), p. 142, A. A. Barrett (1978), p. 86; *CAA*, **3** (1979), pp. 123, 129; I. Hasegawa (1979), p. 262; D. K. Yeomans and T. Kiang (1981), p. 643; J. L. Brady (1982), p. 210; Landgraf (1986), p. 258; G. Sitarski (1988), p. 263.

−425 The Greek philosopher Aristotle wrote around −329 and said "when Euclees, son of Molon, was archon of Athens, there was a comet toward the north in the month of Gamelion [sometime during January and February] around the time of the winter solstice."

sources: *Meteorologica* (−329), book 1, p. 45; A. G. Pingré (1783), p. 259; A. A. Barrett (1978), p. 86.

−371 It has frequently been conjectured that this comet might have been a member of the sungrazing family of comets. The account is unusual in that it is a surprisingly complete description of the comet's motion and size.

The oldest existing account of this comet comes from Greece, from where the philosopher Aristotle (−329) said the "great comet, which appeared about the time of the earthquake in Achaea and the tidal wave, rose in the west." He wrote, "the great comet which we mentioned before appeared during the winter in clear frosty weather in the west, in the archonship of Asteius: on the first night it was not visible as it set before the sun did, but it was visible on the second, being the least distance behind the sun that would allow it to be seen, and setting immediately. Its light stretched across a third of the sky in a great band, as it were, and so was also called a path. It rose as high as Orion's belt, and there dispersed."

Another Greek account comes from the historian Diodorus Siculus, who wrote sometime during the 1st century bc. He noted that during the 102nd Olympiad "when Alcisthenes was archon of Athens . . . there was seen in the heavens during the course of many nights a great blazing torch which was named from its shape a flaming beam." Diodorus continued, "Some of the students of nature ascribed the origin of the torch to natural causes, voicing the opinion that such apparitions occur of necessity at appointed times, and that in these matters the Chaldeans in Babylon and the other astrologers succeed in making accurate prophecies." Finally, Diodorus added these details concerning the comet's appearance. "At any rate this torch had such brilliancy, they report, and its light such strength that it cast shadows on the earth similar to those cast by the moon." This record was dated −371 / −370, but since Diodorus Siculus was not a contemporary with the event, it is probably safe to assume it is identical to Aristotle's comet. The first year of the 102nd Olympiad was in −371.

Finally, there is a further ancient text reporting this comet. It was written by the Roman historian Lucius Annaeus Seneca around 63, but, although it was written over 400 years after the comet's appearance, it quotes sources that are no longer in existence. Seneca wrote, "Callisthenes reports that a similar likeness of an extended fire appeared just before the sea covered Buris and Helice. Aristotle says that this was not a Beam but a comet. Moreover, he says that because of its excessive brightness the fire did not appear scattered but as time went on and it blazed less it recovered the usual appearance of a comet. In that fire there were many worthy things which should be noted, but nothing more so than the fact that when it flashed in the sky the sea immediately covered Buris and Helice.” Seneca added, “For Beams have an even flame, not interrupted at any point or dull but collected in the end parts like the fire Callisthenes reported was in the one which I just mentioned.”

Seneca also discussed an observation made by Ephorus. He wrote, “It is not great effort to destroy the authority of Ephorus: he is an historian. He is often deceived; he often tries to deceive. For example, the comet which was observed carefully by the eyes of all mankind because it dragged with it an event of great importance, since at its rising it sunk Helice and Buris, he says split up into two planets, a fact which no one except him reports.” Despite Seneca’s slandering of Ephorus, later historians frequently used Ephorus’ works and Polybius considered him “the most learned of ancient historical writers.”

A rough orbital calculation was obtained by A. G. Pingré (1783). He gave the year as –371 and said the comet probably passed perihelion during the winter.

T	ω	Ω (2000.0)	*i*	*q*	*e*
–371 Winter (UT)	120	302.5	<150	“very small”	1.0

sources: *Meteorologica* (–329), book 1, pp. 44–7, 55; *Historical Library* (1st century bc, book 15, pp. 88–91; *Quaestiones Naturales* (63), book 7, pp. 236–9, 260–1; A. G. Pingré (1783), pp. 259–63; G. F. Chambers (1889), pp. 512–13; A. A. Barrett (1978), p. 87.

–340/–339 The Greek philosopher Aristotle wrote around –329 that during the archonship of Nicomachus, “a comet appeared in the equinoctial circle for a few days (this one had not risen in the west), and this coincided with the storm at Corinth.” A. G. Pingré (1783) specifically gave the year as –340 and said the comet was in Leo.

sources: *Meteorologica* (–329), book 1, p. 54–7; A. G. Pingré (1783), p. 264; A. A. Barrett (1978), p. 88.

–302 The *Shih chi* (–90) provides the oldest account of this object. It says a “broom star” was seen sometime during –302.

The Parian Marble of Greece is a marble stele which records events occurring between the time of Cecrops (the legendary king of Athens) and Diognetus (archon during –263 / –262). During the archonship of Leostratus (–302 / –301) it said that a comet appeared.

sources: *Shih chi* (–90), SC1993 #2, p. 28; A. G. Pingré (1783), p. 265; J. Williams (1871), p. 2; Ho Peng Yoke (1962), p. 143; A. A. Barrett (1978), p. 88.

1P/–239 K1 (Halley) *Closest to the Earth:* –239 June 3 (0.4511 AU)
Calculated path: ARI (Disc), PER (May 22), AUR (May 29), LYN (Jun. 3), LMi–LEO (Jun. 8)

–239 This marks the first proven observation of 1P / Halley. The only ancient document to report the comet is the Chinese text *Shih chi* (–90), but the scant details indicate a movement and time period which certainly fit that expected of 1P / Halley in –239.

The text reports a "broom star" was first seen "in the east and then was seen in the north." It adds that the comet was also seen during the month of –239 May 24 to June 23 in the west. Further details are also given by the *Shih chi*, but their exact translation is open to some debate. After reporting that General Meng Ao died, Burton Watson (SC1993 #2) has said the text states, "The comet appeared in the west once more. On the sixteenth day of the month Queen Dowager Xia died." On the other hand, a translation by William H. Nienhauser, Jr (SC1994) gives the text as, "The comet appeared again in the west for sixteen days. The Queen Dowager Hsia died." Either way the comet obviously reappeared in the west.

The first identification of 1P / Halley with the comet of –239 was made by P. H. Cowell and A. C. D. Crommelin in 1908. Without the aid of the very well-observed apparition of 1910, Cowell and Crommelin determined a perihelion date of –239 May 15, which was only 10 days off from the likely true date. Additional orbital investigations conducted by astronomers during the 1970s and 1980s have confirmed the link.

The orbit calculated by D. K. Yeomans and T. Kiang (1981) is given below and indicates the following highlights for this apparition. The comet reached a minimum solar elongation of about 1° on March 31 and a maximum solar elongation of 36° on May 18. It then attained its most northerly declination of +43° (apparent) on June 4. The comet reached a minimum solar elongation of 21° on June 2 and a maximum solar elongation of 50° on June 23. This orbit also indicates the comet was probably not detected prior to the first week of May, as the solar elongation was steadily increasing from about 1° on April 1, and did not reach 30° until May 5.

The Author concludes, using the Yeomans–Kiang orbit as a guide, that the comet could not have been seen in China in the western sky until June 3.5 UT. It was probably last seen 16 days later (June 19.5 UT) confirming the translation of Nienhauser. From these two observations, it seems likely the comet was first detected in the eastern sky around mid-May.

T	ω	Ω (2000.0)	*i*	*q*	*e*
–239 May 25.12 (UT)	88.11	30.81	163.47	0.5854	0.9676

absolute magnitude: H_{10}=4.0 (Kronk)
full moon: May 9, June 8
sources: *Shih chi* (–90), SC1993 #2, p. 36, SC1994, p. 129; A. G. Pingré (1783), pp. 265, 575; J. Williams (1871), p. 2; G. F. Chambers (1889), p. 554; *MNRAS*, **68** (Supp. 1908), pp. 665–70; Wen Shion Tsu, *PA*, **42** (1934 Apr.), pp. 192–3; Ho Peng Yoke (1962), p. 143; *MRAS*, **76** (1972), pp. 35, 56–7; *CAA*, **3** (1979), pp. 123, 129; D. K. Yeomans and T. Kiang (1981), p. 643; J. L. Brady (1982), p. 210; *JBIS*, **38** (1985), p. 201; W. Landgraf (1986), p. 258; G. Sitarski (1988), p. 263.

–237 The only ancient source of information on this comet is the *Shih chi* (–90). It says a "broom star" was seen sometime during –237, which "possibly stretched across the heavens." This statement was discussed prior to a record listed in the fourth month, which could imply the event happened either during or before the lunar month of May 4 to June 2. The *Shih chi* later noted, "This month was frigid," and continued, "A comet appeared in the west, and again in the north, moving southwards toward the (Nan–) Tou [ζ, λ, μ, σ, τ, and ϕ Sagittarii] and lasted 80 days." This translation is similar to that by Ho Peng Yoke (1962) and I. Hasegawa (1980). Interestingly, two people have recently translated the account slightly differently. Instead of moving southwards toward Sagittarius, Burton Watson (SC1993 #2) and William H. Nienhauser, Jr (SC1994) independently said the account claimed the comet "moved southwards from the Dipper for 80 days." The "Dipper" apparently referred to Pei-Tou [the Big Dipper].

Earlier accounts do not solve the translation problem. A. G. Pingré (1783) wrote that this comet appeared in May near Sagittarius, while J. Williams (1871) said the object "was also seen in the north, to the south of Pei-Tou, for 80 days."

full moon: April 18, May 17
sources: *Shih chi* (–90), SC1993 #2, pp. 37–8 & SC1994, pp. 129–30; A. G. Pingré (1783), p. 575; J. Williams (1871), p. 2; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 143; I. Hasegawa (1980), p. 64.

X/–233 B1 This is the first comet for which accounts exist from two different cultures giving similar details about the time period of its appearance and its location in the sky.

Babylonian cuneiform tablet BM 41850 gives an account of a comet seen sometime within the 10th month of –233. According to a translation by Hermann Hunger (1996), it was detected in the "last part of the night . . . in the east." Hunger says the 10th month of –233 began on January 22 and ended on February 19.

The only ancient Chinese text to report the comet is the *Shih chi* (–90). It reports a "broom star" was seen in the east sometime during the month of –233 January 21 to February 18.

full moon: February 4
sources: *Shih chi* (–90), SC1993 #2, p. 39, SC1994, p. 132; A. G. Pingré (1783), p. 575; J. Williams (1871), p. 3; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 143; I. Hasegawa (1980), p. 64; personal correspondence from Herman Hunger (1996).

–213 The *Shih chi* (–90) is the only account of this object. It reports that a "bright star" was seen in the west sometime during –213. Interestingly, the commentary of the *Shih chi* specifically referred to this object as a "broom star".

sources: *Shih chi* (–90), SC1993 #2, p. 53, SC1994, p. 146; J. Williams (1871), p. 2; Ho Peng Yoke (1962), p. 143.

–209 Babylonian cuneiform tablet BM 45608 gives an account of a comet seen sometime within the 4th month of –209. A translation by Herman Hunger (1996) says it "appeared in the path of Ea in the region of Scorpius; it was surrounded by stars; its tail was toward the east." Hunger says the 4th month began on –209 June 23 and ended on July 21. Since Scorpius is in the evening sky during the reported time period, the comet was apparently in the evening sky. This is further confirmed by the eastward pointing tail.

full moon: July 6
sources: Personal correspondence from Herman Hunger (1996).

–171 The Chinese text *Han shu* (100) is the oldest text to report this "long-tailed star." It says the comet was seen "in the eastern quarter of the sky" sometime during –171. The *Han shu* was generally written in a chronological style and this account follows events that occurred during the spring and summer.

sources: *Han shu* (100), 4:13b; A. G. Pingré (1783), p. 266; J. Williams (1871), p. 3; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 143.

1P/–163 U1 (Halley) *Closest to the Earth:* –163 September 28 (0.1081 AU)
Calculated path: TAU or ARI (Disc), PSC (Sep. 27), AQR (Sep. 29), CAP (Oct. 3), AQL (Oct. 4), SGR (Oct. 6), SCT (Oct. 18), SGR (Nov. 1)

–163 During the 19th century and most of the 20th century astronomers searched through published records around the world, but failed to find any trace of 1P/Halley around –163. The Chinese records are the most complete and, even though they contained numerous observations of comets seen prior to –163, there is no record around the probable date of the comet's appearance. A possible explanation was offered by Homer H. Dubs (1938) when he noted, "Since eclipses are also not mentioned during this decade, it looks as though the recorders of phenomena deliberately refused to record eclipses or comets, for the good reign of Emperor Wen made them think that Heaven was sending no admonitions, hence they concluded that there were no 'visitations.'"

During 1984 August F. R. Stephenson, K. K. C. Yau, and Herman Hunger unexpectedly found references to a comet on some Babylonian tablets located in the British Museum. On Babylonian cuneiform tablet BMA 41462, they found the statement, "The comet which previously had appeared in the east in the path of Anu in the area of Pleiades and Taurus, to the west . . . and passed along in the path of Ea." A second Babylonian cuneiform tablet, BMA 41628, is more damaged than the first, but contains the statement, "of Ea in the region of Sagittarius, 1 cubit in front of Jupiter, 3 cubits high toward the north."

Stephenson *et al.* noted the Babylonian tablets contained abbreviations for star names not used until well after –400. At the same time, they knew that none of the tablets had been found to be newer than –40. Restricting their search within the range of –400 to –40, they found that tablet BMA 41462 gave the locations of the moon, Mercury, Venus, and Jupiter with respect to individual stars and constellations which indicate a date falling within the lunar month of –163 October 21 to November 19. They then examined tablet BMA 41628 and noted the positions of the moon, Mercury, Venus, and Saturn given with respect to individual stars and constellations also indicate a date within the same lunar month.

The most interesting piece of information given in the Babylonian records was that at one point the comet was situated in Sagittarius just one cubit from Jupiter. A cubit is equal to about 2.5° and Stephenson *et al.* concluded that this restricted the comet's date of perihelion to sometime between November 9 and 26. They also concluded that the probable discovery magnitude was about 4.

Interestingly, Al Wolters (1993) suggested this comet may have played an important role in Jewish religious history. He said the third book of the *Sibylline Oracles* contained the text, "But in the west a star will shine which they call '*Cometes*,' a sign to mortals of sword, famine, and death, destruction of leaders and of great illustrious men." Wolters said most "scholars date the bulk of the book . . . to the mid-second century b.c." and he showed that "both the Seleucid and the Ptolemaic Empires saw the death or downfall of their rulers in the late months" of –163 and added that two additional rulers fell within the following two years.

Numerous investigations into the orbit of 1P / Halley were conducted during the 20th century. The first came in 1908, when P. H. Cowell and A. C. D. Crommelin determined a perihelion date of –162 May 20.5. The 1910 apparition provided the most precise observations of 1P / Halley up to that time and benefited the orbital investigations of later astronomers. T. Kiang (1972) used a combination of orbital mechanics and the original observations to determine the comet's perihelion dates back to –239. With no observations available for the –163 apparition, he computed a perihelion date of –163 October 5.5 UT. Later investigations used planetary perturbations and the effects of nongravitational forces to integrate the orbit backwards. D. K. Yeomans and Kiang (1981), Werner Landgraf (1986), and G. Sitarski (1988) computed orbits with perihelion dates ranging from –163 October 23 to November 12.

Using the Yeomans–Kiang orbit given below, the Author has determined some of the particulars of this apparition. The comet reached its most northerly declination of +13.5° on –163 September 3, and a maximum solar elongation of 178° on September 27. The comet reached a minimum solar elongation of 6° on November 24, and remained within 10° of the sun for the period November 18 to November 30.

Using the rough positions noted by Stephenson *et al.*, the Author notes that the comet was probably discovered on September 24 or 25. The comet was brightening at an average rate of about 0.3 magnitude per day at this time, which might explain why the comet was not seen earlier.

T	ω	Ω (2000.0)	i	q	e
–163 Nov. 12.57 (UT)	89.11	32.06	163.70	0.5845	0.9677

absolute magnitude: H_{10}=4.0 (Kronk)
full moon: September 4, October 3, November 2
sources: *MNRAS*, **68** (Supp. 1908), pp. 668–70; H. H. Dubs, *The History of the Former Han Dynasty*. Baltimore: Waverly Press, Inc. (1938), p. 261; *MRAS*, **76** (1972), pp. 35, 56; *CAA*, **3** (1979), p. 122; D. K. Yeomans and T. Kiang (1981), p. 643; J. L. Brady (1982), p. 210; *JBIS*, **38** (1985), p. 201; *Nature*, **314** (1985 Apr. 18), pp. 587–92; W. Landgraf (1986), p. 258; G. Sitarski (1988), p. 263; *VA*, **34** (1991), pp. 180 & 183; A. Wolters, *The Catholic Biblical Quarterly*, **55** (1993), pp. 687–97.

–162 On the Babylonian cuneiform tablet designated BMA 33850, Hermann Hunger identified two fragments of text referring to a comet seen during –162. The first text fragment indicates that on September 5 the comet was possibly 1.5° above α Corona Borealis with a tail extending to the south. On the left edge of the same tablet, Hunger (1995) noted text that “may have been added as an afterthought.” Hunger says he believes the text refers to the same comet and the same month and gives the date as September 10. The badly damaged text compares the comet’s location to α Corona Borealis and says it was seen in the first part of the night.

full moon: August 24, September 23
sources: Personal correspondence from Herman Hunger (1995, 1996).

–161 The only ancient text reporting this object is the *Han shu* (100). It says the Chinese saw a “celestial magnolia tree . . . in the southwest in the evening” on –161 February 6. The date and location imply a probable UT of February 6.5.

Wen Shion Tsu (1934) and Yu-Che Chang (1979) both suggested the actual year of the observation was –162, and that this was a previous appearance of 1P / Halley. Chang gave the perihelion date as –162 January 20. In reality, Chang did not consider the effects of nongravitational forces and his orbit was probably not very close to the truth. The computations of other astronomers who have included nongravitational forces indicate a perihelion date sometime during –163 October or November.

full moon: February 18
sources: *Han shu* (100), p. (143); *PA*, **42** (1934 Apr.), p. 193; Ho Peng Yoke (1962), p. 143; *CAA*, **3** (1979), pp. 123, 127.

X/–156 U1 Fragments of Babylonian cuneiform tablet BMA 45731 mention a comet seen on –156 October 19 and November 15. Unfortunately, no other details are available.

The *Han shu* (100) is the only ancient Chinese text to mention this object. It says a “sparkling star” was seen “in the western quarter of the sky” sometime during the lunar month of –156 October 8 to November 5. The text continues by noting that its "trunk laid straight across the Wei [ε, ζ, η, θ, ι, κ, λ, and μ Scorpii] and the Chi [γ, δ, ε, and η Sagittarii], and its end pointed to the Hsü [α Equulei and β Aquarii] and Wei [ε and θ Pegasi, and α Aquarii]." The object was over 10° long and "reached the Milky Way." It disappeared on the 16th day.

full moon: October 15
sources: *Han shu* (100), 5:1a & 27:27a; A. G. Pingré (1783), pp. 267, 575; J. Williams (1871), pp. 3–4; G. F. Chambers (1889), p. 554; H. H. Dubs, *The History of the Former Han Dynasty*. Baltimore: Waverly Press, Inc. (1938), p. 303; Ho Peng Yoke (1962), p. 144; personal correspondence from Herman Hunger (1995).

–154 The *Han shu* (100) is the only ancient account of this "broom star." It says the comet "appeared in the southwest" sometime during the month of –154 January 18 to February 15. The southwest location might indicate it was in the evening sky.

full moon: February 1
sources: *Han shu* (100), p. 5:3b; J. Williams (1871), p. 4; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 144.

–154 The *Shih chi* (–90) is the only ancient account of this object. It says a "broom star" appeared in the northeastern sky sometime during the month of –154 September 11 to October 10. The northeastern location might indicate it was in the morning sky. J. Williams (1871) wrote that this comet appeared in July, but Ho Peng Yoke (1962) noted that Williams' text was a mistranslation.

full moon: September 24
sources: *Shih chi* (–90), SC1993 #1, p. 312; J. Williams (1871), p. 4; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 144.

–153 The only ancient account of this "long–tailed star" appears in the *Shih chi* (–90). It says the comet was seen in the west sometime during the month of –153 February 6 to March 6. The western location might indicate it was in the evening sky. Chronologically, this account followed an event dated February 27, so this may indicate the comet was seen after that date.

full moon: February 19
sources: *Shih chi* (–90), SC1993 #1, p. 312; J. Williams (1871), p. 4; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 144.

–146 The astronomical chapter of the Chinese text *Han shu* (100) is the only ancient account of this comet to give details. It says a "broom star" was first seen on –146 May 13. The comet "appeared at night in the northwest" and "was found at the Tsui-Hsi [λ and ϕ^1 Orionis].” It was described as white and about 10° long. The account continues, “It moved away at dawn and became smaller,” eventually going out of sight after 15 days. J. Williams (1871) said this comet was seen on March 14, but Ho Peng Yoke (1962) showed that this date was erroneous. The *Shih chi* (–90), although older than the *Han shu*, gives no usable details, since it simply notes that a comet was seen.

This is a confusing account as at this time the sun was very near Tsui-Hsi. Therefore, for the comet to have been seen at night, it must have been in the same right ascension as Tsui-Hsi, but much further to the north. With a location in the northwest, it might have been in Auriga.

The Author suggests the annals of the *Han shu* may also have an account of this comet. This document claims that during –147, “In the summer, the fourth month, a comet appeared in the northwest.” This account was later copied by the Chinese text *Thung Chien Kang Mu* (1189). The fourth month of –147 was equal to the period April 29 to May 27, while the fourth month of –146 was May 16 to June 15. Ho Peng Yoke (1962) listed this account as a separate comet, but the few details available do reflect those of the –146 comet.

full moon: May 2, May 31

sources: *Shih chi* (–90), SC1993 #1, p. 314; *Han shu* (100), 5:6a; A. G. Pingré (1783), pp. 268, 576; J. Williams (1871), p. 4; G. F. Chambers (1889), p. 554; Ho Peng Yoke (1962), p. 144.

Acknowledgments

I would like to express my gratitude to those individuals who played important roles in helping me finish this first volume of *Cometography*.

Since I had no initial experience with foreign languages, I wish to express my gratitude to those who patiently helped me understand several languages well enough to do my own translations, armed with good foreign language dictionaries. All of these people were students and employees at Washington University in St. Louis, Missouri. Thanks go to Cathy Schaewe, Diane Woepke, and Nicole Strombom for their assistance with French, Brad Thone and Mike Lee for their assistance with Spanish, and Ricki Coleman for her assistance with Latin. Thanks also go to Bin Shao and Yu Shan-Ping for their clarifying translations in Chinese, a language for which I did not attempt my own translations.

Thanks go to the librarians who assisted me at Linda Hall Library (Kansas City, Missouri), Northwestern University (Evanston, Illinois), Southern Illinois University at Edwardsville, St Louis University (Missouri), and Washington University (St. Louis, Missouri). I wish especially to thank the Washington University physics librarians Betty Eickhoff (retired) and Sylvia Toombs who allowed me special privileges in checking out some materials. At Washington University's Bernard Becker Medical Library, I wish to thank Nancy Bennett, of interlibrary loan, for working to acquire everything I requested, and also Lilla Wechsler, of rare books, for discussing sources for information on medieval science and translating some of the more difficult German and Latin passages.

Thanks go to Betsy Kelly of the Bernard Becker Medical Library for letting me take virtually last-minute vacations when I needed them and for letting me use the office laser printer to print out copies of the manuscript. What a great person to work for.

Thanks go to Daniel W. E. Green (Harvard-Smithsonian Center for Astrophysics) for looking over the manuscript with a critical eye during the last couple of years.

Special thanks go to several people who helped me acquire sources. Patrick Vanouplines (Vrije Universiteit Brussel) not only shared some of his research into comet accounts in old shipping logs, but he ultimately provided me with numerous pages of Nicolaas Struyck's 1753 book *Vervolg van de Beschryving der Staartsterren*, complete with his own translation into English. Art R. T. Jonkers (Department of History, Vrije Universiteit Amsterdam and Department of Earth Sciences, University of Leeds) also provided me with comet observations from several shipping logs. Honsook Kim (Korea) completely translated pages 19a to 28b of chapter six of the 1770 edition of the *Chungbo Munhon Pigo*, thus providing me with a translation independent of Ho Peng Yoke's 1962 translations of this text. Gregory Lobdell (Seattle, Washington) sacrificed a few of his lunch hours at the University of Washington library tracking down passages I requested from the many volumes of L. A. Muratori's *Rerum Italicarum Scriptores*. Vahe G. Gurzadyan (Yerevan Physics Institute, Armenia) was kind enough to send me his translations of comet accounts in Armenian texts.

Special thanks go to Terri Ricker-McClain (Washington University) and John T. Ramsey (University of Illinois at Chicago) for their help in understanding how comets fit into ancient European and Middle Eastern cultures. Terri and I had numerous talks during the late 1980s and early 1990s. She was kind enough to lend me several books from her personal library. I had the good fortune to get to know John from e-mail discussions during 1996, 1997, and 1998. He sent me several articles dealing with ancient comets that were not available to me at local university libraries.

Special thanks go to David B. Cook (University of Chicago) for sharing his extensive research on comets and meteors reported in Muslim texts. After I spent several years trying to find help tracking down comets in these texts, David wrote to me out of the blue early in 1998. He asked if I would be interested in seeing what he had gathered and provide comments for a paper he was writing. After he found out how enthusiastic I was to see the material, he went back to the libraries and collected even more information. Although his paper will officially be published in 1999, David let me use his translations in *Cometography*, and these have greatly enhanced our knowledge of several comets seen in the past.

Special thanks go to Don Yeomans (JPL), who has so graciously sent me hard-to-find articles during the last few years to help plug holes in my own research, and who continued to encourage me along the way. He also was kind enough to send me his own unpublished orbits for 55P / Tempel-Tuttle for use in *Cometography*.

Special thanks go to Brian G. Marsden (Harvard-Smithsonian Center for Astrophysics), who has so patiently answered my many letters over the last 20 years, and whose own work writing the annual comet summaries for the *Quarterly Journal of the Royal Astronomical Society* was one of the initial inspirations for this project.

Special thanks go to my friends Kurt Sleeter, Eric Young, and Ed Cunnius for occasionally pulling me away from this very time-consuming project for a few hours of relaxation doing what we all enjoy as a group – stargazing. This was my original inspiration for my desire to learn more about comets, and it was always a nice break to sort of bring things back into perspective. Eric also provided the cover art for *Cometography*, while Ed looked over some of the sections of the manuscript and provided technical comments that proved useful.

Most of all, I wish to thank my wife, who so patiently allowed me to run around to those various libraries and spend so much time at my computers working on this project, as well as my two boys, David and Michael, who waited so patiently (and sometimes not so patiently) for Daddy to finish writing so he could spend time with them.