USING ASTRONOMY FOR DATING

ECLIPSES IN ANTIQUITY

Around the time you receive this issue of *Ancient History Magazine*, it will be close to the 2600th anniversary of a famous battle between the Lydians and the Medes on the banks of the Halys River in what is now Central Turkey. We know the date because the fight happened on the same day as a rare astronomical event. Astronomy, it turns out, can be a great help for historians who want to date events in the distant past.

By Rob van Gent

To understand and make sense of ancient history, it is important to know as exactly as possible when notable events happened. Although lists of dates and years may seem boring to many, they form the chronological foundation on which history is built. In this way historical events (births, deaths, wars, campaigns, treaties, etc.) can be arranged in a logical and consistent sequence.

The Leiden scholar Joseph Justus Scaliger (1540-1609) was one of the pioneers of a specialized field of research that is now known as "astronomical chronology". This involves the study of ancient texts, calendars, and chronology, and uses astronomical observations occasionally mentioned in ancient sources to calibrate, refine, or correct existing chronological schemes. In this way historians can cite exact years (sometimes even to the precise day and month) for many events in ancient history. Others methods, such as radiocarbon dating (see *AHM* 3) and dendro-

CALENDAR DATES IN ANCIENT HISTORY

Calendar dates in ancient history are usually expressed as dates in the Roman calendar, even for events which obviously predate the origin of the Roman calendar. Such dates are known as proleptic Julian calendar dates and are based on a calendar which is identical with the calendar promulgated by Julius Caesar in 45 BC, i.e. based on a common year of 365 days with an intercalary day inserted in February once in every four years. Also note that, for BC years, astronomers often prefer to count them in the astronomical sense, with a "year zero". For example: AD 1 = astronomical +1, 1 BC = 0, 2 BC = -1, and so on.

Thales was considered one of the "seven sages", the seven men who represented the beginning of Greek philosophy. Fantasy portraits of these sages were very popular; this one, from the second or third century AD, is from Suweydie near Baalbek, and can be seen in Lebanon's National Museum in Beirut.

THE INCONSTANT ROTATION OF THE EARTH

When astronomers compute ancient astronomical events such as lunar and solar eclipses, they have to account for the fact that in ancient times the Earth rotated slightly faster than it now does. Although the difference in rotation speed is very small (the increase in the length of the solar day is about 2 milliseconds per century), the gradual slow-down of the Earth's rotation has a cumulative effect, which in ancient times adds up to several hours. The difference between Dynamical Time (the timescale on which modern astronomical calculations are based) and Universal Time (based on the actual rotation of the Earth) is known as ΔT.

At the beginning of the Christian era, ΔT was nearly three hours. 2600 years ago, its value is estimated to have been around five hours. If this difference is neglected, the computed path of totality for a solar eclipse around the time of Thales will, because the earth is rotating, be displaced about 75 degrees too far to the west.

Our knowledge of ΔT in the past is based on a small group of precisely dated solar eclipses recorded by astronomers from exactly known locations.

chronology (tree-ring counts), are less precise and have an often sizable margin of error.

How astronomy can date history

Historical records often mention natural phenomena such as earthquakes, floods, volcanic eruptions, famines, and halos, and astronomical phenomena such as eclipses (lunar or solar), comets, meteors, large sunspots, and planetary configurations. Of the latter phenomena, lunar and solar eclipses and planetary configurations are the most interesting, as modern astronomical tables (and software) allow astronomers to precisely compute the positions of the sun, the moon, and the planets for distant epochs in the past. When these can be matched with an ancient record, they thus date the record to the exact day, month, and year.

Of course, such records must provide sufficient details so that a historian can confidently link them to astronomical events. Not every darkening of the sun or the moon is necessarily a report of a solar or a lunar eclipse (it could also have a meteorological or even an allegorical explanation) and in some cases we can be quite sure that no eclipse actually happened.

The Halys River. The exact location of the battle between the Lydians and Medes is not known.

When an eclipse is not an eclipse

A notable example of an allegorical eclipse report is the darkening of the sun recorded in the gospels as having occurred during the crucifixion of Jesus Christ around AD 30. Early Christian writers already knew that this could not have been a true solar eclipse, because the crucifixion took place shortly after the Jewish Passover feast, which by definition occurs near a full moon date, while a solar eclipse can only occur at a new moon. However, according to a text dating from the late fifth or early sixth century, this was a "supernatural" solar eclipse during which the moon was observed to briefly depart from its natural orbit, eclipse the sun, and then return again to its former position (Ps.-Dionysius the Areopagite, *Letters* 7.2).

We do know that a large solar eclipse was visible from Jerusalem on 24 November AD 29, when 91% of the solar disk was obscured during the eclipse maximum. It is thus likely that we may be dealing here with a conflation of two separate events which occurred around the same time in Jerusalem: a large solar eclipse and the trial and execution of a Jewish religious leader, which was remembered much later as happening on the same day.

Such cases are not uncommon. The Greek researcher Herodotus of Halicarnassus (c. 484 – 425 BC) mentions a solar eclipse when the Persian king Xerxes launched his Greek expedition from Sardes (*Histories* 7.37). His departure can reliably be dated to the spring of 480 BC, but the eclipse was actually half a year later, on 2 October 480.

The eclipse of Thales

Of the numerous eclipses mentioned in classical sources, perhaps the "eclipse of Thales" is the most famous. Our earliest source is, again, Herodotus, who in his *Histories* linked it to a battle fought between the Lydians and the Medes:

> *There was war between the Lydians and the Medes for five years; each won many victories over the other, and once they fought a battle by night. They were still warring with equal success, when it chanced, at an encounter which happened in the sixth year, that during the battle the day was suddenly turned to night. Thales of Miletus had foretold this loss of daylight to the Ionians, fixing it within the year in which the change did indeed happen. So when the Lydians and Medes saw the day turned to night they ceased from fighting, and both were the more zealous to make peace.*
>
> — (*Histories* 1.74; tr. A.D. Godley).

The site of the battle is not known with any certainty, but many historians, citing the *History of Alexander* by Roman historian Quintus Curtius Rufus (4.11.5), believe that it must have been near the Halys River in Anatolia (the Kızılırmak in Central Turkey), which may have formed the natural boundary between Lydia and Media.

The report in Herodotus does not give enough information to identify this apparently total solar eclipse with confidence, but in his *Natural History*, Roman author Pliny the Elder adds the following data:

> *Thales of Miletus, who in the fourth year of the 48th Olympiad foretold the eclipse of the sun that occurred in the reign of Alyattes, in the 170th year after the foundation of Rome.*
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> — (*Natural History* 2.53; tr. H. Rackam)

From Pliny's testimony, the eclipse can be dated to the year 584 or 585 BC, and modern astronomical tables indeed confirm that there was a very notable solar eclipse visible from Anatolia in the late afternoon of 28 May 585. No other solar eclipse around that time agrees as well with the known facts.

According to Herodotus and Pliny, the eclipse was predicted by the Greek philosopher Thales of Miletus (c. 624 – c. 546), but it is uncertain how he accomplished this. Some have claimed that he may have been familiar with the *saros* or the *exeligmos* eclipse cycle (periods of 18 or 54 years after which eclipses repeat under nearly identical circumstances) but we have no evidence that these eclipse cycles were already known in time of Thales.

Perhaps Thales was just lucky in his prediction, but his fame as an astronomer and mathematician would prove to be long-lasting. It is therefore perhaps ironic that he also became the prototype of the "absent-minded scholar" who, as he was walking one night and looking upwards at the stars, fell into a well (Plato, *Theaetetus* 174a). **AHM**

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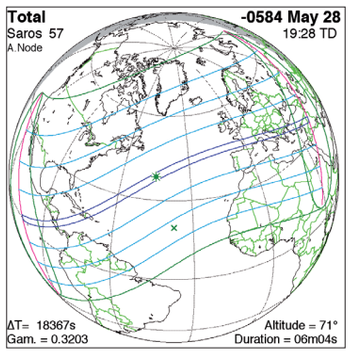
FURTHER READING

A well-known book on ancient time-keeping is Elias J. Bickerman, *Chronology of the Ancient World* (1980²). There's more at http://tiny-url.com/AHM4-Egypt.



Region of visibility of the solar eclipse of 28 May 585 BC, according to the computations of Fred Espenak. It can be inferred from this diagram that the path of totality started in Central America, and after crossing the Atlantic Ocean, passed through southern Europe and the western part of modern Turkey, ending at sunset in Mesopotamia.