

Early observation of the a

David M Willis, José M Vaquero and F Richard Stephenson cast a critical eye over evidence of auroral observations in 17th-century Chile.

The Chilean Jesuit Juan Ignacio Molina SJ presented evidence for the occurrence of a large auroral display in 1640, which was allegedly seen every night in the Araucanía region of Chile from the beginning of February to the end of April. The relevant evidence was presented briefly in a book on the natural history of Chile published in 1782, almost one-and-a-half centuries after the original observation. Our search through the chronicles of Chilean history recorded in both Spanish and Latin-American literature has uncovered copies of the original publications by two earlier Jesuits, Alonso de Ovalle SJ and Diego de Rosales SJ, which describe a “battle in the sky” and a “volcanic eruption”. The available historical evidence is interpreted scientifically in terms of the coincidence of two separate optical phenomena over a period of three months (February–April). These two phenomena can be explained in terms of essentially continuous optical emission resulting from the volcanic eruption and more variable optical emission resulting from intermittent auroral displays associated with intense recurrent geomagnetic activity.

Some confusion and uncertainty surrounds the earliest datable observation of the aurora australis (or “southern lights”). The lack of precise information on this question is both surprising and unsatisfactory in the sense that a convincing case can be made for the earliest datable observation of the aurora borealis (or “northern lights”) being in the 6th century BC (Silverman 1998, Siscoe *et al.* 2002, Stephenson and Willis 2002, Stephenson *et al.* 2004, Silverman 2006). A number of authors have stated that the first reliable observation of the aurora australis occurred on the night of 17 February 1773, during the second voyage of Captain James Cook to Australia (e.g. Chapman 1957, Uberoi 2000, Bone 2007), whereas the aurora was, in fact, seen almost two-and-a-half years earlier during the first voyage to Australia (Eather 1980). Indeed, the earliest known *conjugate* sightings of the aurora occurred on the night of 16 September 1770, during Cook’s first voyage to Australia (Willis *et al.* 1996). Observations of the aurora australis on that night were recorded in the journals of (Sir) Joseph Banks (Beaglehole 1962) and Sydney Parkinson (1773), written on board *HMS Endeavour*, while sightings of the aurora borealis on the same night were described in Chinese provincial histories

from Hebei and Shandong Provinces (Yau *et al.* 1995). However, de Mairan (1733, 1754 and 1770) appears to have been the first European to draw proper scientific attention to the probable existence of aurorae in the southern hemisphere. He based his conclusion on observations made by the celebrated mariner and scientist Antonio de Ulloa, who witnessed a perceptible illumination that resembled the polar lights seen in the northern hemisphere while rounding Cape Horn in March and April of 1745 (Angot 1896, Eather 1980, Schröder 1984).

In his classic book *Majestic Lights: The Aurora in Science, History, and the Arts*, Eather (1980) notes that an aurora was reported in Chile as early as AD 1640. Although Eather cites the book by Angot (1896), entitled *The Aurora Borealis*, this merely contains an assertion that polar aurorae were seen in Chile as early as AD 1640 and does not provide any bibliographic references to support such a statement. However, in his monograph *Das Polarlicht*, Fritz (1881) quotes an earlier book by Molina on the natural history of Chile, the original of which is written in Italian (Molina 1782). Likewise, a catalogue of early observations of the “southern lights” (*Das Südlicht*), which was published in two parts (in German) by Boller (1898), cites the same book by Molina, albeit via the German translation of this work (Molina 1786). Molina (1782) notes specifically that the aurora australis was seen only rarely in Chile. He further states: “In 1640 a very large one appeared, which, according to the historians (or writers) of the time, could be seen every night from the beginning of February to the end of April.” Finding the original sources that justify the rather vague reference to “the historians of the time” has presented the authors with an intriguing bibliographical and historical challenge.

Juan Ignacio Molina SJ

The Chilean Jesuit Juan Ignacio Molina SJ (1740–1829; Giovanni Ignazio Molina in Italian), a naturalist and historian, is noted for his scholarly studies and writings on the natural and civil history of Chile (Ronan 2002) (figure 2). Molina was educated at the Jesuit colleges at Talca, Concepción and Santiago in Chile, but he was forced to leave the country (in 1768), following the expulsion of the Jesuit Order from the Spanish Empire as a result of a decree issued



by Charles III of Spain in 1767. On arriving in Spain and then travelling through Europe, Molina first settled in Imola (then a city in the northern reaches of the Papal States), where he was ordained to the priesthood in 1769. He moved to the nearby prestigious university city of Bologna in 1774, where he lived as a diocesan priest – known as Abate (Abbot) Molina – writing his natural and civil histories of Chile and lecturing on various topics.

Molina’s first attempt to acquaint Europeans with Chile was his non-polemical work *Compendio della storia geografica, naturale, e civile del regno del Chili* (Brief Treatment of the Geographic, Natural and Civil History of the Kingdom of Chile), which was written in Italian and published anonymously in Bologna in 1776 (Ronan 2002). Subsequently, two books written in Italian under his own name, *Saggio sulla storia naturale del Chili del signor Abate Giovanni Ignazio Molina* (Monograph on the Natural History of Chile by the Abbot Giovanni Ignazio Molina) (Molina 1782) and *Saggio sulla storia civile del Chili del signor Abate Giovanni*

aurora australis: AD 1640



1: Could an aurora have provoked the description “a battle in the sky” in the 17th century? (Joshua Strang, USAF, Wikipedia)



2: Juan Ignacio Molina SJ (1740–1829).

Ignazio Molina (Monograph on the Civil History of Chile by the Abbot Giovanni Ignazio Molina) (Molina 1787), were published in Bologna. The first book, in particular, obtained a high reputation on the continent of Europe, where it was translated into German (1786), Spanish (1788), French (1789) and later into English (1808, 1809). A revised edition of the book on the natural history of Chile was also published in Bologna (Molina 1810).

Inevitably, there are some slight discrepancies between the different translations of Molina's first book on the natural history of Chile (Molina 1782). In the English translation (1809), which is a “rather free” translation (Ronan 2002) and hence sometimes imprecise, the editor states that Molina was deprived of his manuscripts and natural history collection when he was expelled from Chile but he had “the good fortune to regain by accident some time after his residence in Bologna” his more important manuscripts. However, in the preface to the second edition of his book on the natural history of Chile, Molina (1810) states:

“Luckily, at that time, I came across part of my manuscripts, which I had lost due to the haste and adventures of my travels.” Indeed, he notes further that “this part [of my manuscripts] was mutilated in many places and did not provide me with the material necessary to write a natural history of the country, and I did not omit to inform the public of this fact in the preface.”

According to Ronan (2002), Molina was relieved by the customs agents of the research materials he had carefully amassed on Chilean history and the country's flora, fauna and mineral products, which he was attempting to smuggle aboard the ship *Nuestra Señora del Rosario*. This confiscation of his materials occurred at the start of his journey from Callao, Peru, via Cape Horn to Puerto de Santa María, near Cádiz, Spain. How Molina recovered his battered and incomplete notes and papers is not clear (Ronan 2002).

In the second (revised) edition of his book on the natural history of Chile, Molina (1810) refers explicitly to the work of de Mairan (1773, 1754, 1770), Franklin (1779) and other authors

on polar aurorae, which “for a long time were believed only typical of the northern hemisphere, where they were generally called Aurora Borealis.” However, Molina mentions specifically that a similar phenomenon had been observed “towards the Antarctic by the well-known [Captain] Cook and other educated sailors” and that “unlike the others [in the northern hemisphere], these [observations] were called Aurora Australis.” As in the first edition of his book (1782), he states that aurorae “were rarely seen in Chile or in other countries near the Tropics. In 1640 a very large one appeared which, according to the historians of the time, could be seen every night from the beginning of February to the end of April.” Molina also mentions that these were, coincidentally, the very same months of the year in which Cook saw the aurora australis on his second voyage to Australia in 1773. Such comments indicate that Molina was well aware of the work of contemporary scientists. However, the statement that the Chilean aurora of 1640 was observed *every night* from the beginning of February up to the end of April (*si osservò tutte le notti dal principio di Febbrajo sino alla fine di Aprile*) seems improbable if only in terms of likely meteorological constraints (e.g. cloud cover). As in the first edition of his book (1782), Molina (1810) notes that four aurorae occurred in the 17th century for which he did not have the details. He notes further that “the inhabitants of the Archipelago of Chiloé maintain that this phenomenon was often seen in their

islands, which is not improbable because that [geographic] extremity of Chile has higher latitude [in the southern hemisphere] than the rest of the Provinces.”

Records of an aurora in Chile in 1640

Following on from the references to the “historians of the time” in the books by Molina (1782, 1787, 1810), we have searched the chronicles of Chilean history in both Spanish and Latin-American literature. Three major publications have been found that refer to the alleged Chilean aurora of 1640: (1) *Historica Relacion del Reyno de Chile* (Historical Account of the Kingdom of Chile); (2) *Varias y Curiosas Noticias del Reino de Chile* (Several and Curious News of the Kingdom of Chile); and (3) *Historia General del Reino de Chile* (General History of the Kingdom of Chile). The first publication is a book written by Alonso de Ovalle SJ (1603–1651) (figure 3), which was published about five years before his death (de Ovalle 1646). The second publication is another book written by de Ovalle (1648), which is essentially the same work with a different title. The title page of the first of these two books is shown in figure 4. The third publication is a manuscript written by Diego de Rosales SJ (1603–1677), which was published posthumously about 200 years later in three volumes (1877–1888), after being edited by the noted Chilean historian Benjamín Vicuña Mackenna (de Rosales 1877). It is clear that Molina would have been acquainted with all three major works by de Ovalle and de Rosales (Ronan 2002).

The background to the Chilean auroral observation in 1640 is the long conflict, known as the Arauco War (1536–1656), between the Spaniards and the Mapuche people who inhabited the Araucanía region of Chile. The three publications in Spanish, cited previously, discuss this long conflict in some detail. In particular, de Ovalle (1646 p302) described the two portentous signs observed by the Mapuche people in his country in early 1640. One sign was a spectacular volcanic eruption that started in February 1640. Another sign was a “battle in the sky”. The original text describing this phenomenon is:

“Vieronse en este tiempo en el aire formados dos exercitos, y esquadrones de gente armada, puestos en campo, y orden de pelea, el uno a la vanda de nuestras tierras, donde sobresalia, y se señalava un valiente Capitan en un caballo blanco, armado con todas armas, y con espada ancha en la mano desenvainada, mostrando tanto valor y gallardía, que daba alientos, y animo a todo su exercito, y le quitava al campo contrario; el qual se vio plantado a la parte de las tierras del enemigo; y acometiéndole el nuestro, le dexó desbaratado en todos los encuentros que tuvieron; representacion



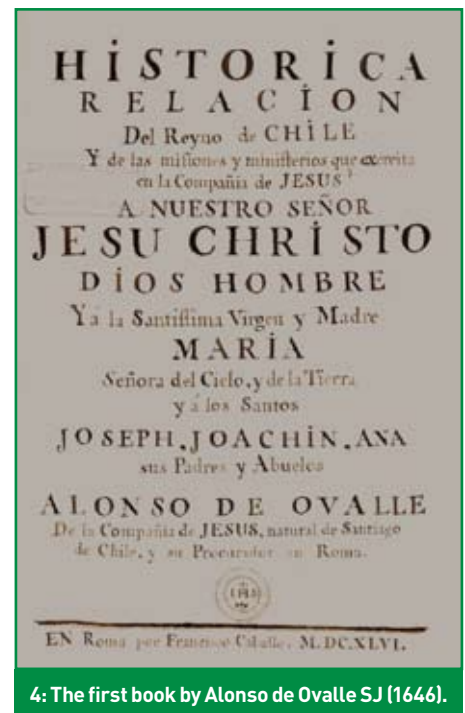
3: Alonso de Ovalle SJ (1603–1651).

que les duró por tiempo de tres meses, para que hubiese menos que dudar, particularmente en los leidos, y noticiosos de las historias Romanas, y del segundo libro de los Macabeos, donde se ven casos, y prodigios semejantes y que assi se hiziesse mas persuasible lo que afirman testigos de tanta calidad, como son entre otros, don Pedro de Sotomayor, doña Catalina de Santander, y Espinosa, y doña Mariana de Sotomayor, españoles cautivos que entonces lo eran del enemigo,” (de Ovalle 1646 p302).

This early Spanish text may be translated into English as follows:

“In these days there were seen two armies arrayed in the air and squadrons of armed men, in field formation and prepared for battle. One was at the side of our lands, and there stood out a valiant captain mounted on a white horse, fully armed and bearing a drawn broadsword in his hand. He showed such courage and gallantry that he lent keenness and encouragement to all his army, while causing dismay in the opposing camp which was arrayed on the enemy’s side of the land and which was routed in all the encounters that took place. The fighting lasted three months. To allay any doubt, similar cases and prodigies are described in the Roman histories and the second book of the Maccabees. And for greater persuasion, there are the affirmations of such exceptional witnesses as, amongst others, Don Pedro de Sotomayor, Doña Catalina de Santander y Espinosa, and Doña Mariana de Sotomayor, Spaniards who at the time were captives of the enemy,” (de Ovalle 1646 p302).

Moreover, de Ovalle (1646) inserted in his



4: The first book by Alonso de Ovalle SJ (1646).

book an engraving showing the signs apparently witnessed by the Mapuche people (volcanic eruption, battle in the sky, etc); this engraving is presented in figure 5. The same verbal description of a “battle in the sky” is also included in an anonymous eight-page pamphlet in Spanish, printed in Madrid by the publisher Francisco Maroto (Anonymous 1642). This pamphlet discusses the negotiations and prodigies that led to the signing of a peace treaty between the Araucanians and the Spanish on 6 January 1641.

Scientific interpretation

As noted previously, Molina (1810) states explicitly that an auroral display was observed in Chile in 1640 and that this auroral display lasted from the beginning of February to the end of April. However, the original Spanish text quoted in the previous section merely states that the “battle in the sky” lasted three months, which does not necessarily imply that the “spectacle” was seen on every night during this interval. The Spanish publications suggest that both a “battle in the sky” and a “volcanic eruption” were observed in 1640 (Anonymous 1642, de Ovalle 1646, de Rosales 1877). Apart from presenting the quoted text on the “battle in the sky”, de Ovalle (1646) also states that “a volcano burst [erupted] and began to burn with such force that it spewed [ejected] rocky crags.” Indeed, the engraving shown in figure 5 clearly depicts both the “battle in the sky” and the “ejection of rocky crags”. It is known that the Llaima volcano (geographic co-ordinates: 38°42’S and 71°44’W) erupted in Chile in February 1640 (Casertano 1963). Since 1640 was a relatively quiet year in the long Arauco War (Molina 1787) and the peace treaty between the Araucanians and the Spanish was signed

5: An engraving showing the “battle in the air”, included in the first book by Alonso de Ovalle SJ (1646). The translation of the Latin text at the foot of this engraving may be rendered as follows: “The Indians in Chile were won over to peace and [Christian] faith by prodigies consisting of a mountain spewing fire, a river bearing along a tree and a monster, eagles seen only for the second time, and the Spanish army triumphing over their own army in the sky.”



on 6 January 1641 (de Ovalle 1646 p306), it appears highly likely that the year of the optical phenomena observed in Chilean skies was indeed 1640. Similarly, since the Llaima volcano erupted in the month of February in 1640, it seems probable that the “battle in the sky” also commenced at about the same time and continued, possibly intermittently, for approximately three months.

Several cities in the Araucanía region of Chile, namely Angol, La Imperial (now Carahue), Osorno, Valdivia and Villarrica, were mentioned in the context of the “battle in the sky” (de Ovalle 1646 p301). As an illustrative example, the geographic co-ordinates of Villarrica, situated on the western edge of the Villarrica Lake, are $39^{\circ}18'S$ and $72^{\circ}14'W$. The present-day geomagnetic (dipole) co-ordinates of Villarrica are $29^{\circ}02'S$ and $0^{\circ}24'W$ (epoch 2005), whereas the approximate geomagnetic (dipole) co-ordinates in 1640 were $33^{\circ}40'S$ and $30^{\circ}35'W$ (Jackson *et al.* 2000), although the error bars might be as high as 5° in 1640 (Jackson, private comm. 2009). Thus the geomagnetic latitudes of the places at which the Chilean aurora was observed were probably no more than a few degrees greater (i.e. more southerly) in 1640 than at the present time. Auroral displays at such low geomagnetic latitudes are usually associated with strong solar and geomagnetic activity. According to McKinnon (1987), the period between February and April in the year 1640 was close to a sunspot maximum (1639.5). However, as noted by Vaquero (2007), the determination of this particular sunspot maximum is based on far fewer actual telescopic observations of the Sun from Europe during the short interval 1638–1639 than is implied in the work of Hoyt and Schatten (1998).

Nevertheless, as cited in the catalogue of Chinese astronomical observations published (in Chinese) by Beijing Observatory (1988), five precisely dated Chinese sunspot observations were recorded around the time of this solar maximum (9 December 1638; 7 February, 16 March and 26 October 1639; and 13 April 1640). Indeed, the unaided-eye Chinese sunspot observation on 13 April 1640 occurred within the three-month interval associated with the Chilean auroral observation (1 February – 30 April). Therefore, if the spectacle implied by the expression “battle in the sky” was intermittent rather than continuous between the beginning of February and the end of April, the Chilean aurora of 1640 may have been associated with intense recurrent geomagnetic activity. Support for such an interpretation comes from the fact that the description of the spectacle witnessed by the Mapuche people refers to their army being “routed in all the encounters that took place”.

In addition, there are a few European observations of the aurora borealis during the first four months of 1640, one of which apparently relates specifically to the Thirty Years War (1618–1648). The second part of the auroral catalogue published by Link (1964) includes records (in German) for the following dates: 27 January, 28 March, 12 and 14 April. One entry for January may be translated as follows: “Year 1640, on 17 January [Julian date] several fiery signs appeared during the whole night, in which shooting rays were fighting each other from morning until midnight, so that the sky was brightly illuminated,” (Lehmann 1699). Another entry, which probably refers to the same auroral display, may be translated as: “In January, in the region of Stuttgart, two warlords, one from the S, the other from the E, clashed with

each other in the air.” The record for 28 March states: “At the time [General] Banner [Banér] had to flee from Bohemia, at 02:00 LT in the night of 18 March [Julian date], an omen was seen like a battle in the sky.” The entries for 12 and 14 April merely refer to a “fiery atmospheric phenomenon” and an “evening atmospheric phenomenon” (Uranophilus 1651), which are rather dubious auroral observations.

The archaic Spanish text on the Chilean aurora of 1640 mentions explicitly that much earlier prodigies are described in the history of the Romans and the second book of the Maccabees. In Roman times, the aurora was described by Seneca in his *Naturales Quaestiones* (Natural Questions) and by Pliny the Elder in his multi-volume survey of natural phenomena entitled *Naturalis Historia* (Natural History). These observations have been discussed in detail by Stothers (1979a, 1979b) and briefly by Silverman (1998). In the second book of the Maccabees (II Maccabees chapter 5, verses 2–3), reference is made to a “battle in the sky” in the year 168 BC that lasted almost 40 days. As noted by Silverman (1998), the alleged duration of this presumed auroral display is completely unrealistic, unless the writer intended to imply that the phenomenon occurred sporadically over a 40-day interval. A similar reservation obviously applies to the Chilean aurora of 1640, which apparently lasted 90 days. However, it is argued here that the apparently long duration of the Chilean aurora can be explained in terms of intermittent auroral activity over a three-month interval, possibly associated with recurrent geomagnetic activity, which occurred in conjunction with less variable optical phenomena produced by a volcanic eruption that commenced nearer the start of this interval.

Throughout recorded history the aurora has often been described and depicted in terms of battles, blood-rain, candles, flames, fires or torches in the night sky (Stothers 1979a, Eather 1980, Silverman 1998). Indeed, there are clear conceptual similarities between the engraving shown in figure 5 and contemporary illustrations of aurorae observed in Europe, presented in the books by Eather (1980) and Brekke and Egeland (1994). Moreover, the description of auroral displays in terms of warfare is not confined to European (and Middle East) histories. For example, a clear reference to a military victory is presented in the contemporary description of an aurora sighted on 21 September 1631, as recorded in chapter 39 of the Chinese history *Qing Shigao* (Draft Qing History). The relevant text may be translated as follows:

“Tiancong reign period, 5th year, 8th month, day dingmao [4]. Ming forces came to attack Prince Ajige [Qing general 1605–1651]. There was a thick fog and no-one could be seen. Suddenly a dark blue-green vapour came rushing down from the sky

into the enemy [Ming] camp, and suddenly it was opened like a gate. Our [Qing] troops were then able to overcome them.”

Therefore, it seems likely that the reference to a “battle in the sky” in Chilean history implies one or more observations of the aurora australis between the beginning of February and the end of April in the year 1640.

Conclusion

Further evidence for a sighting of the aurora australis in Chile in 1640 has been gleaned from our search of relevant chronicles in both Spanish and Latin-American literature. Three books and a political document (in Spanish) refer to a “battle in the sky” and a “volcanic eruption”, which commenced at the beginning of February and apparently lasted until the end of April. A critical examination of all the evidence, including the important evidence in the later books (in Italian) written by the Chilean Jesuit Juan Ignacio Molina, suggests that both the aurora australis and the optical effects of a volcanic eruption were observed in Chile between the beginning of February and the end of April in 1640. Since these observations occurred close to a sunspot maximum (1639.5), it is possible that the aurora was seen intermittently during this three-month interval – perhaps in association with recurrent geomagnetic activity – whereas the optical effects of the volcano were seen continually during this time. A search of other historical documents, including accounts of sea voyages, is now being made in an attempt to find even earlier descriptions of the aurora australis. ●

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