STUDYING THE HISTORY OF INDONESIAN ASTRONOMY: FUTURE PROSPECTS AND POSSIBILITIES

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Abstract: In this paper I identify a number of research topics relating to Indonesian astronomical history that I feel are of international importance. Through these studies, Indonesia can make a valuable contribution to international history of astronomy.

I also will discuss the role of SEAAN's new Working Group on Astronomical History and Heritage, and the value of the *Journal of Astronomical History and Heritage* and proceedings of the ICOA conferences as outlets for papers about Indonesian astronomical history. Finally, I mention chapters about Indonesia that will appear in a forthcoming book on the early development of astrophysics in Asia.

Keywords: rice cultivation astronomy, temple alignments, de Houtman, 1868 and 1871 total solar eclipses; 1874 transit of Venus, *orang asli* astronomy, Macassan astronomy, Indonesian tektites, Bosscha Observatory variable star studies, SEAAN, *Journal of Astronomical History and Heritage*, ICOA-10, *The Emergence of Astrophysics in Asia*

1 INTRODUCTION

If we follow the lead of the International Astronomical Union we see that History of Astronomy covers many different niche areas, including ethnoastronomy, archaeoastronomy, 'Applied Historical Astronomy' and even the history of meteoritics. Some of these niche areas relate to Indonesia and its astronomical history and heritage.

In this paper[1] I will identify a number of research topics relating to Indonesian astronomical history that are of international importance. These include: *orang asli* astronomy, temple alignments, de Houtman and his star map, the 1868 and 1871 total solar eclipses, the 1874 transit of Venus, the history of Indonesian tektite and meteorite studies, and early variable star research at Bosscha Observatory and Riverview Observatory (in Australia).

2 INDONESIAN RESEARCH TOPICS

2.1 Astronomy and Lowland Wet Rice Cultivation

Hidayat (2011; see also Daldjoeni and Hidayat 1987) has published several very interesting papers in English on the astronomy associated with low-land wet rice cultivation in Central Java, and emphasized the importance of *pranotomangsa*. But how typical is this astronomical knowledge base of other parts of Java, let alone other islands within the Indonesian archipelago (cf. Ammarell, 1991)? Furthermore, Islam is the predominant religion in Indonesia, but most of those living in rural Bali are Hindus while many of those in rural Manado are Christians. Have these different religions imprinted themselves on the astronomical systems in these two localized regions of Indonesia?

Here we have an opportunity to carry out a succession of localised studies of the astronomical systems associated with low-land wet rice (*padi*) cultivation, by selecting, for example, from the various locations indicated by the red dots in Figure 1. Such studies are ideal small-scale projects for university students. Meanwhile, it is heartening to know that Sawitar (2015) has already examined the astronomical system of Balinese farmers, and Hose (1905) has examined rice-farming in Kalimantan, which are excellent steps in the right direction. I particularly look forward to reading a full account of Sawitar's study when he publishes it.

Lowland wet rice cultivation is found throughout Southeas Asia. In reference to Figure 1 and the black dots shown there, how do the various Indonesian astronomical systems compare and contrast with those found in rural Philippines (where Christianity is the principal religion), Malaysia (where Islam predominates) and Vietnam, Cambodia, Thailand and Myanmar (which are Buddhist countries)? Some comparative data already exist: Ammarell (1988; 2008) and Maass (1924) have published on the 'Indo-Malaysian archipelago', while Jaafar et al. (2015) recently studied the astronomical and ecological systems associated with rice cultivation in north-western Malaysia.

2.2 Temple Alignments

Central Java in particular it is well endowed with Hindu and Buddhist *candi*, and we can assume that most (if not all) of these had astronomical associations. Irma Hariawang and her collaborators (2011) have already written about the orientation of the eastern gateway at Borobudur (Figure 2), and other Javanese temples warrant similar analysis. Meanwhile, in India and Thailand for instance, Kameswara Rao and Thakur (2011) and Komonjinda (2010) have respectively examined the interior illumination of Hindu temples at different critical times of the year, while Stencil et al. (1976) have written about the astronomical parameters of Angkor Wat in Cambodia. Javanese *candi* also could be subjected to similar scrutiny.

Figure 1: Lowland wet rice astronomical systems in Indonesia and Southeast Asia (map modifications: Wayne Orchiston).

Figure 2: Candi Borobudur (en.wikipedia.org).

This raises the issue of the somewhat later, architecturally-distinct Hindu temples in Bali (e.g. see Figure 3). What astronomical associations and orientations occur there? This would make an interesting archaeoastronomical study, and the broad topic of Indonesian temple alignments, illumination and astronomical symbolism offers an ideal opportunity for astronomers to work closely with Drs Bambang Budi Utomo and his staff from the Pusat Penelitian Arkeologi Nasional.

2.3 de Houtman and his Star Map

Frederik de Houtman (1571–1627; Figure 4) was a Dutchman who between 1595 and 1599 made two voyages to the Dutch East Indies (as Indonesia was then known), and plotted stars visible in the southern sky. Subsequently, he was imprisoned in Aceh, and was able to make further astronomical observations. In 1603 he published his southern star catalog as an appendix to a dictionary of local languages. Hidayat (2000: 46) records how

> The catalogue of stars published by Frederick de Houtman in 1603 provided the basis for the renaming of many of the southern constellations. In a publication that was brought to the attention of European astronomers, de Houtman listed 303 stars in the southern sky and provided names for the major constellations.

In 1917 the distinguished British amateur astronomer, Edward Ball Knobel (1841–1930, Figure 5; F.W.D., 1931) published a paper on de Houtman and his star catalog in *Monthly Notices of the Royal Astronomical* Society (Knobel, 1917), but since then no-one has made an in-depth study of this important astronomer and his pioneering star catalog (though see Dekker, 1987).

Here is an exciting project for an Indonesian astronomer: the relevant records are in Holland patiently awaiting your attention!

2.4 The 1868 and 1871 Total Solar Eclipses

The 1868 total solar eclipse was visible across India and Siam (Thailand), and was a watershed event in astronomical history as it revealed the chemical composition of prominences, the chromosphere and the solar corona, and led —eventually—to the discovery of a new element, helium (see Launay, 2012; Nath, 2013; Orchiston et al., 2017). Note that the path of totality of this eclipse also passed over Kalimantan and Sulawesi (Figure 6, and the surveyor and astronomer Dr Jean Abraham Chrétien Oudemans (1827–1906) published two different report on this eclipse, in German, in *Astronomische Nachrichten* (Oudemans, 1869a; 1869b).

The 1868 eclipse was followed just three years later by another total solar eclipse that offered astronomers a further opportunity to investigate the structure and elemental compo-

Figure 3: The Taman Ayun temple in Bali (www. balitourismboard. org/temples.html).

Figure 4: Frederik de Houtman (jv.wikipedia. org).

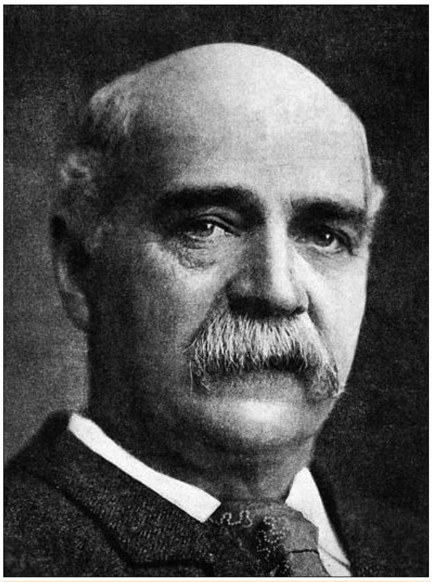

Figure 5: E.B. Knobel (en.wikipedia.org).

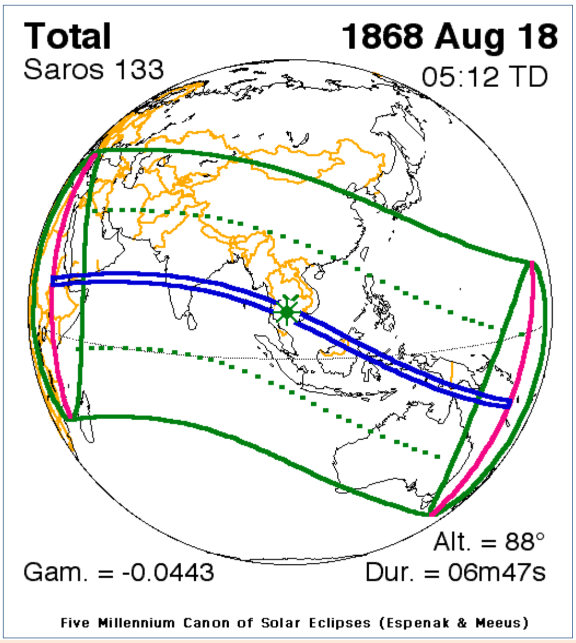

Figure 6: The path of totality of the total solar eclipse of 1868 (after Espenak and Meeus, 2006).

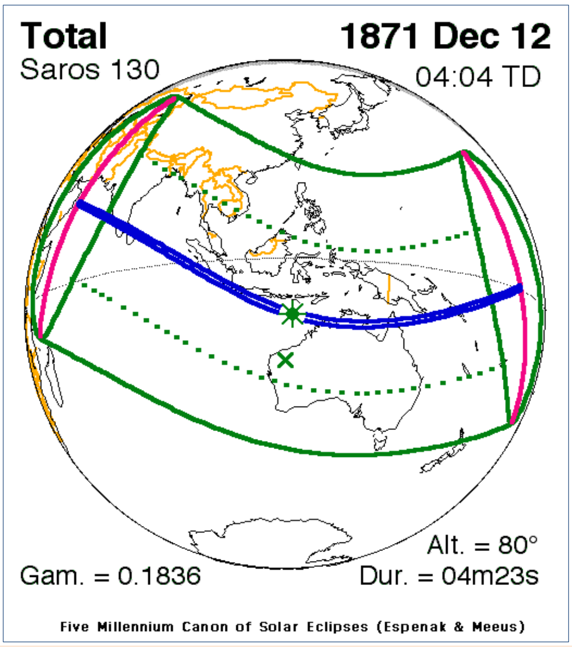

Figure 7: The path of totality of the total solar eclipse of 1871 (after Espenak and Meeus, 2006).

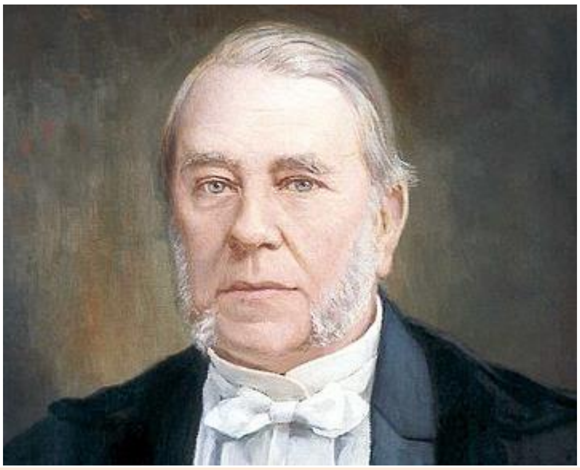

Figure 8: Dr J.A.C. Oudemans in 1898 (en.wikipedia.org).

sition of the corona, and this eclipse also was visible from India (Orchiston and Pearson, 2017) and the Dutch East Indies (see Figure 7). On this occasion the path of totality conveniently passed across Java, and Oudemans (Figure 8) was able to carry out observations and publish a long report, again in German and in *Astronomische Nachrichten* (Oudemans, 1873). Recently, Mumpuni et al. (2017) analysed Oudemans; observations of the 1868 and 1871 eclipses, and in a separate study Orchiston et al. (2018) reviewed Oudemans; overall contribution to nineteenth century Dutch East Indies astronomy.[2]

2.5 The 1874 Transit of Venus

The 1874 transit of Venus was one of the most important events in world astronomy as it offered the ideal opportunity to finally pin down the solar parallax and assign a value to the Astronomical Unit—the distance from the Earth to the Sun (see Dick et al., 1998). Consequently, a number of nations mounted expeditions to northern Asia and to the Australia-New Zealand region (Orchiston 2004) where the whole of the 7-hr transit would be visible.

Figure 9 shows that the Dutch East Indies also lay wholly within the pale blue region where the entire transit would be visible (weather permitting), and although Oudemans journeyed to Réunion to observe the event, it is reasonable to assume that other scientists with an interest in astronomy who remained on home soil would have attempted to view this once-in-a-lifetime even—and even time the ingress and egress contacts. A search, therefore, should be made in Jakarata and Bandung, and perhaps in other cities, for relevant records.

Because of its research importance the 1874 transit also received enormous media coverage worldwide, not just in nations involved in astronomical research (e.g. see Cottam and Orchiston, 2014), but also in those where it was used as a vehicle to promote scientific astronomy and ally fears derived from myth and superstition (e.g. see Lu and Li (2013), which specifically deals with China). Was the 1874 transit portrayed in this way in Java? A survey of local newspapers and magazines should provide the answer.

3 REGIONAL STUDIES

3.1 *Orang Asli* Astronomy

The term *orang asli* is common to Indonesia and Malaysia and refers to the original (*asli*) people (*orang*) who were thought to have occupied the Southeast region prior to the arrival of the current populations (e.g. see Aghakhanian et al., 2015; Bellwood, 2007). On the Andaman and Nicobar Islands and in isolated areas of southern Thailand, Malaysia, Indonesia and the Philippines the *orang asli* stand out physically, ecologically, culturally and linguistically from later occupants of mainland and island southeast Asia.

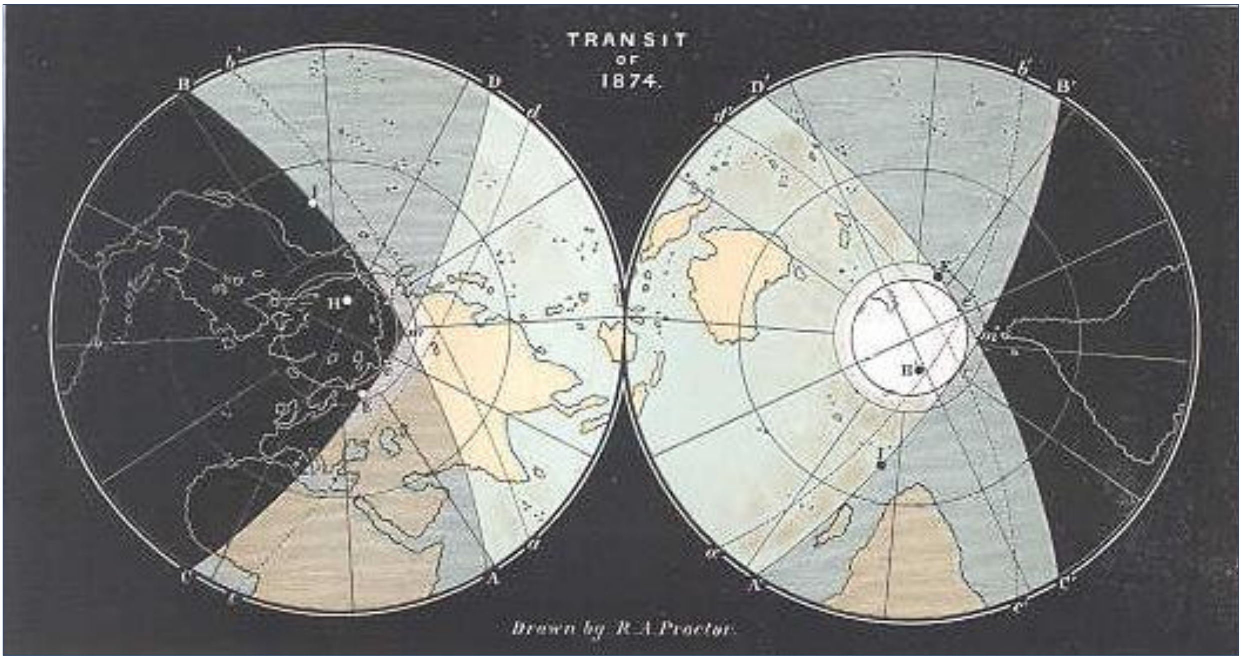

Figure 9: A map showing the visibility of the 9 December 1874 transit of Venus. The entire transit was visible, weather permitting, from the Dutch East Indies, and other nations lying within the pale blue area (after Proctor, 1874).

If the Andaman and Nicobar Islanders and the *orang asli* are indeed remnants of an ancestral relic population, as the archaeological and anthropological evidence suggests, then do their astronomical systems exhibit any 'common denominators', despite the passing of the millenia? Vahia and his collaborators (2013, 2014, 2015) recently studied the astronomical systems of what are reputed to be India's most ancient tribes, and comparative studies now need to be carried out in the Andaman and Nicobar Islands and among the *orang asli* of mainland and island southeast Asia.

This whole topic lends itself to an exciting field experiment, and has the potential to encourage collaboration between anthropologists and astronomers and produce important results for Asian and Southeast Asian astronomy. While thus far very little has been published in English on the Indonesian *orang asli*, which were found in Kalimantan, potentially Indonesia has an important role to play in this research.

3.2 Astronomy and the Macassans

Another Indonesian-related project with exciting research potential and regional implications relates to the astronomy of the Macassans.

Since the mid-seventeenth century (Ganter, 2008) each year, starting in December (the wet season) groups of up to 1,000 Macassan fishermen in fleets of *praus* would voyage to northern Australia and establish coastal settlements in the western Gulf of Carpentaria, eastern Arnhem Land and the Kimberleys region (Figure 10), where they would live for the next 4–5 months, interacting with the local Aboriginal populations and even marrying Aboriginal women (see Macknight, 1976, 1986). The incentive for these trips was the sea cucumber or *trepang* (Figure 10 inset), which they harvested, boiled and then dried in the Sun and smoked. The processed *trepang* were taken back to Macassar, in southern Sulawesi, and from there shipped to China where they were a delicacy in cooking and also were viewed medicinally as a stimulant and an aphrodisiac. Because of the economic success of these early Macassan ventures other Indonesian fishermen from islands closer to Australia (see Figure 10) subsequently began to replicate the exploits of their Sulawesi compatriots.

These expeditions only ceased in 1907 when taxes and licence fees imposed by the Australian government made *trepang* fishing uneconomical, but by that time large numbers of fishermen from at least five different Indonesian islands had lived (and occasionally died) on the Australian coast (see Theden-Ringl et al., 2011), in the process learning about Australian Aboriginal culture, and at the same time drastically changing Aboriginal culture and leaving their mark on the local languages (Evans, 1992) and in rock art (Chaloupka, 1996). In addition, Aboriginal men sometimes joined these expeditions when the Indonesians returned to their home ports (Macknight, 2011).

So, if we survey the astronomical knowledge systems associated with Indonesian fishermen from these different islands (e.g. see Ammarell, 1995; 1999) will we discover that they also include elements of Aboriginal astronomy? Conversely, do any the astronomical knowledge systems of coastal northern Australia include aspects of Indonesian astronomy? Here is a fascinating ethnoastronomical project crying out for attention in both Indonesia and Australia.

Figure 10: Map showing the Gulf of Carpentaria, Arnhem Land and Kimberleys coast of Australia and Indonesian islands known to have been involved in harvesting the *trepang*. The insert shows one of these sea cucumbers (map modifications: Wayne Orchiston).

3.3 The History of Indonesian Tektite Studies

Tektites are glass-like objects that sometimes look like obsidian, or volcanic glass, so originally they were referred to as 'obsidianites'. We now know these tektites have nothing to do with volcanoes, but were formed during major meteorite impacts. They are found around the world in a limited number of 'strewn fields', most of which are associated with known meteorite craters.

By far the largest tektite strewn field is the Asian-Australian strewn field which extends from mainland Southeast Asia through to Australia (Figure 11) and is also represented by microtektites recovered during deep-sea drilling over much of the floor of the Indian Ocean (see Glass et al., 1996: Figure 1) and recently from the Trans-Antarctic Mountains in Antarctica (Howard, 2011). ^{40}A/^{39}A, and fission track dating indicates that this extensive strewn field derives from a single major meteorite impact that occurred between 770,000 and 780,000 years ago (McCall, 2001) somewhere near the Laos-Thai border (Schnetzler, 1992; Schnetzler and McHone, 1996).

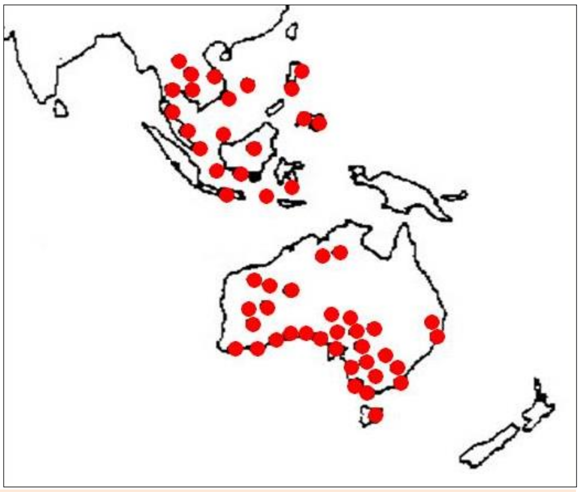

Figure 11: A map showing the general distribution of tektites belonging to the Asian-Australian strewn field (map: Wayne Orchiston).

As Figure 11 indicates, tektites are known from Indonesia, and their typical chemical composition is shown in Table 1. The first Indonesian tektite described was from Pelaihari (Kalimantan) in 1836, followed by 'Billitonites' from the island of Bilitung, recovered during tin-mining operations, but they also have been recovered from several other sites in Kalimantan, from Natuna and Gourd Islands, from Java and from Flores. Those from Java, sometimes referred to as 'Javanites', are mainly from Sangiran, and in the course of researching *Homo erectus* ('Java Man') geologists recovered more than 10,000 specimens (von Koenigswald, 1960). Despite certain problems (see Orchiston and Seisser, 1982), these Sangiran tektites have even been used to try and date *Homo erectus* (Ninkovich and Burkle, 1978; von Koenigsvald, 1968).

Indonesian tektite studies have been carried out mainly by geologists and little has been published by astronomers, even though tektite studies are an important part of meteoritics (which is about meteorites, tektites, meteorite craters and the impact cratering processes).

Given the recent interest shown in the Asian-

Table 1: The mean chemical composition of tektites from Java (adapted from McCall, 2001: Table 2.4).

Element	SiO_2	Al_2O	Fe_2O_3	FeO	MgO	CaO	Na_2O	Ka_2O	TiO_2
%	72.32	11.68	0.85	4.81	2.75	2.89	1.78	2.35	0.75

Australian tektites (e.g. see Howard, 2011 and references therein), now is a good time to survey the relevant literature and produce a research paper documenting the history of tektite studies in Indonesia. This will not only be a valuable contribution to the history of astronomy but undoubtedly also will be appreciated by geologists, geochemists and other scientists involved in tektite studies.

3.4 Bosscha Observatory Variable Star Studies

Thanks to the 1901 total solar eclipse, Indonesia was able to make a valuable contribution to solar physics (see Pearson and Orchiston, 2017), but astrophysics only emerged in Indonesia during the 1920s with the founding of the Bosscha Observatory at Lembang, on the southern slopes of a volcano and at an altitude of ~1300 m (Voûte, 1933: A14). The initial suite of instruments there included a twin Zeiss refractor with an aperture of 64 cm; a 37-cm Schmidt refractor; the Bamberg Astrographic Refractor; a Secretan 16-cm refractor; a Zeiss 13-cm refractor; a Zeiss 11-cm comet-seeker and an assortment of astrocameras. From the start, these were mainly devoted to variable star studies (see Hidayat, 2000).

The founding Director of the Bosscha Observatory was Joan George Erardus Gijsbertus Voûte (1879–1963; Figure 12; O'Connell, 1964), and one of his friends was the Jesuit astronomer Father Edward Francis Pigot (1858–1929; Figure 13; Drake, 1988), who had set up the Riverview Observatory in Sydney (Australia) in 1907. Initially Riverview Observatory was devoted to seismology and meteorology, but when it acquired an equatorially-mounted 17.8-cm (7-in) refractor in 1922 Pigot was motivated to initiate an astronomical research program. While returning from the Pan-Pacific Science Congress in Tokyo in 1926 he visited Bosscha Observatory and after discussions with Voûte decided that Riverview also would investigate variable stars, using photographic photometry. Unfortunately Pigot died before this plan could be actioned, and it was left to his successor, Fr William O'Leary, to bring it to fruition. In order to achieve this, Bosscha Observatory kindly donated what was referred to as the 'Voûte Telescope', which comprised

> … two separate astrocameras, and a 10-cm guide scope, the latter being mounted within the polar axis Northumberland style (this is simply a variant of the English equatorial mounting). For the remaining years of the 1930's, through the 40's and into the early 50's O'Leary and O'Connell (the next director) … succeeded in discovering hundreds of new [variable] stars … Some of these were written up in the *Riverview College Observatory Publications*, which began in 1935. Through this work Riverview Observatory achieved an international reputation … (Orchiston, 1985: 72–73).

It would be interesting to carry out a comparative study of the variable star research programs of the Bosscha and Riverview Observatories during the period 1930–1950 to see the ways in which the Sydney programs were influenced and guided by those initiated earlier at the Lembang observatory.

4 DISCUSSION

The Southeast Asian Astronomy Network (SEAAN) is the primary 'association' of professional astronomers in the ASEAN nations and meets annually in a different city in one of the member countries. The next SEAAN conference will be held in Myanmar in December 2017, and it is planned to hold a separate meeting there of the SEAAN History and Heritage Working Group. Papers presented at this historical meeting will be combined those that were presented in Ao Nang at the 30 November–1 December 2015 meeting of the Working Group and published by Springer (see Orchiston and Vahia, 2018).

In order to reach an international audience, increasing numbers of research papers on Indonesian history of astronomy need to be published, *in English*, in reputable astronomical books and journals. The obvious choice of journals for Indonesian scholars is this Journal, which is produced by the National Astronomical Research Institute of Thailand and, amongst other topics, actively promotes research on Asian astronomical history. Undoubtedly the most useful book to publish in is the ICOA proceedings. The International Conference on Oriental Astronomy (ICOA) conferences are held every three years in a different Asian city. The next meeting, ICOA-10, will be held in Uzbekistan in 2019.

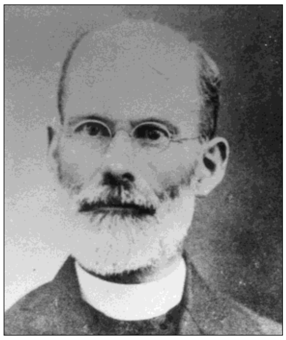

Figure 12 (left): J.G.E.G. Voûte (en.wikipedia.org).
Figure 13 (right): Father Pigot (courtesy: Riverview College Archives).

Finally, I should mention a book titled *The Emergence of Astrophysics in Asia: Opening a New Window on the Universe*, edited by Tsuko Nakaura (Japan) and myself, which will be published by Springer in 2017. This includes an Indonesian section, which begins with an overview paper by Hidayat, Malasan and Mumpuni (2017)—see Figure 14—and is followed by two case studies that detail specific research projects undertaken in the Dutch East Indies during the nineteenth century that contributed to the early international development of solar physics (Mumpuni et al., 2017; Pearson and Orchiston, 2017).

5 CONCLUDING REMARKS

In this paper we have discussed a number of research topics relating to Indonesian ethno-astronomy, ancient astronomy, positional astronomy, astrophysics and the history of meteoriticis that I believe have local or regional importance. Five of these are specific to Indonesia:

- Astronomy and lowland wet rice cultivation
- Temple alignments
- de Houtman and his star map
- The 1868 and 1871 total solar eclipses
- The 1874 transit of Venus

I also discussed five research topics where Indonesian astronomy should be studied in a regional context, namely:

- Astronomy and lowland wet rice cultivation (Indonesia and Southeast Asia)
- *Orang asli* astronomy (Indonesia and Philippines, Malaysia, Thailand, Andaman and Nicobar Islands)
- Astronomy and the Macassans (Indonesia and Australia)
- The history of Indonesian tektite studies (Indonesia, Southeast Asia, Australia)
- Bosscha Observatory variable star studies (Indonesia and Australia)

Figure 14: One of the figures included in the paper by Hidayat et al. (2017) in the forthcoming book on *The Emergence of Astrophysics in Asia* … (courtesy: Emanuel Sungging Mumpuni).

Some of these topics can be studied by individuals or small groups of collaborators and would even make excellent student projects, but major studies that examine the relationship between Indonesia and regions to the north, northwest and/or the southeast ideally call for international collaborations. Through these studies, Indonesia can make an important contribution to international history of astronomy.

6 NOTES

1. This is a revised version of a paper presented at *Seminar Astronomi Dalam Budaya Nusantara*, Universitas Ahmad Dahlan Yogyakarta, Yogyakarta, in 2015.
2. Note that these studies by Mumpuni, Orchiston and Steinicke were carried out following the Yogyakarta conference and in response to discussions that occurred during that conference.

7 ACKNOWLEDGEMENTS

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