There is no scientific basis for the Aryan Invasion Theory

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The evidences that scientists, with background in physical sciences, must consider in order to form a professional opinion on the Aryan Invasion Theory (AIT) are examined. These evidences are from astronomy, mathematics and metallurgy. The criteria for scientists to support AIT are proposed as four questions that must be addressed satisfactorily. On these grounds, we establish that there is no scientific basis for AIT.

Nineteenth century European scholars proposed the Aryan Invasion Theory (AIT) based on the close similarities between Sanskrit and European languages[1–3]. The oldest text, *Ṛg Veda*, was dated to about 1500 BC. Later Vedic texts, *Saṃhitas* and *Brāhmaṇas*, were accordingly dated to 1000–800 BC. AIT has always been controversial and many scholars from the 19th century onwards have opposed it[1–3]. AIT continues to be dominant among Western Sanskrit scholars and others who rely on their authority. No evidence has been found in the last 150 years for any invasion. According to Klostermaier[1] (p. 21) 'The AIT is based purely on linguistic conjectures which are unsubstantiated.' To overcome the lack of evidence for an invasion, the Aryan Migration Theory (AMT), with similar dates, has been proposed.

Most archaeologists[1–5] do not support AIT. Based on geological and remote sensing studies[6–9], scholars have identified evidences for a river in northwest India that dried before 1500 BC with the River Saraswati mentioned in Vedic texts and thereby contradicted AIT. Genetic studies mostly do not support AIT[10,11]. Evidence on horse remains contested[2,12,13].

Scientists have interpreted astronomical references in Vedic texts to high chronology that oppose AIT since 1890s. We have recently presented a comprehensive analysis of the references in the *Saṃhitas* and *Brāhmaṇas* and shown[14] that they consistently lead to dates around 3000 BC. We have also examined the interpretations of Western Sanskrit scholars of the same references and showed that they give dates ranging from 3000 BC to 800 BC to AD 1200. They corroborate Klostermaier's[1] (p. 25) view that 'Traditionally trained philologists, that is, grammarians, are generally not able to understand technical language and the scientific information contained in the texts they study.' Importantly, they have been unaware of their correct interpretation of verses on *ekāṣṭaka* in *Taittirīya Saṃhita* (TS) and *Pañcaviṃśa Brāhmaṇa* (PB) to 3000 BC for the last 80 years. That is, for the first time we have shown that the Western Sanskrit scholars who proposed AIT have contradicted it themselves.

The conclusions in ref. 14 have severe implications for the few scientists, with expertise in astronomy, who support AIT. Their support is no longer tenable with Sanskrit scholars themselves interpreting some references to 3000 BC.

In this note, we consider a broader view of the evidences to establish the criteria, which are based on physical sciences, necessary to form a professional opinion on AIT. Such criteria need to consider evidences from astronomy, mathematics and metallurgy.

Evidences from astronomy

Astronomical references in Saṃhita and Brāhmaṇa texts

The key astronomical references in the *Saṃhita* and *Brāhmaṇa* texts consistently lead to 3000 BC (ref. 14). Six references – Pūrva Phalguṇi full moon marking new year, Kṛttikā on true east, Rohiṇī marking equinox, *Kauśītaki Brāhmaṇa* (KB) verse KB 19.3, the origin of *Mahāśivarātri* and verses on *ekāṣṭaka* – have been dated to 3000 BC. The last three are independent references to three different days all of which point to the new year beginning at winter solstice after *amānta* Māgha new moon (3000 BC), making it a robust conclusion. It is virtually impossible to reinterpret the above references to 800 BC. Importantly, some references have always (i.e. for more than 150 years) been considered to be contemporary, and not ancient memories, by all scholars, including Western Sanskrit scholars. For these reasons, astronomical references disprove AIT. Hence, there can be no scientific basis in support of AIT unless these references are consistently interpreted to 800 BC.

Calendrical schemes in the Vedic period

Both, TS and *Śatapatha Brāhmaṇa* (SB) have two luni-solar calendrical schemes. In the early period, SB 4.3.1.14–19, SB 8.2–8.7, TS 4.4.11, etc. lunar months were named Tapas, Tapasya (Śiśira *ṛtu*), Madhu, Mādhava (Vasanta *ṛtu*), etc. and ended on full moon. In the later period, in KB 19.3 and SB 11.1.1.7, lunar months were named after *nakṣatras*, e.g. Phālguṇa, Chaitra (Śiśira *ṛtu*), etc. and ended on new moon. They are discussed in detail in ref. 14.

An older scheme is mentioned in *Taittirīya Brāhmaṇa* TB 3.10 on *Sāvitra-cayana*[15,16] with month names Aruṇa, Aruṇaraja, etc. and a year of three seasons (Agni, Sūrya and Chandramā *ṛtu*). Abhyankar[15] has given several evidences that this scheme was prevalent in the Ṛg Vedic period. We provide additional evidences in support of this conclusion, though not his date which is not relevant to the discussion. TB 3.10 (TB 3.10.9) refers to *Ṛg Veda* RV 1.164 (ref. 16) and both refer to a year of three seasons. In contrast, *Saṃhita* and *Brāhmaṇa* texts refer to a year of 5/6 seasons with names Śiśira, Vasanta, etc. and not Agni, Sūrya, etc. TB 3.10.11 attributes *Sāvitra-cayana* to Bharadvāja in the past tense clearly implying that the ritual and the calendrical scheme are both ancient memories in TB.

Thus, from *Ṛg Veda* to *Vedāṅga Jyotiṣa* (VJ) four calendars were successively prevalent in the Vedic period. The names of the first two months of the year changed from (1) Aruṇa, Aruṇaraja (RV) to (2) Tapas, Tapasya (early *Brāhmaṇas*) to (3) Phālguṇa, Chaitra (late *Brāhmaṇas*) to (4) Māgha, Phālguṇa (VJ). The current calendar has been in vogue for 1700 years. The VJ calendar was in

vogue for more than 1000 years. It is hardly believable that four calendars were successively prevalent over a span of 800–1000 years, as implied by AIT.

Correlation of the Indus Valley and the Brāhmaṇa period on astronomical grounds

According to Bryant[2] (p. 252).

'The Indian National Science Academy (INSA) of New Delhi, for example, published a History of Astronomy in India in 1985, wherein the Indus Valley and the *Brāhmana* period are correlated.'

The additional evidences presented below show that the correlation in the INSA book[17] is entirely justified.

Śiva worship in the Harappan civilization is well attested. Chakrabarti[18] states 'That *Śiva* was worshipped in this civilisation is proved not merely by the phallus-shaped stone objects found at Mohenjodaro and Dholavira but also by the find of an indisputedly *Śivalinga* set in a Yonipatta at Kalibangan.' Sanskrit scholars believe that *Śaivism* originated in the *Brāhmaṇa* period. We have shown[14] that *Mahāśivarātri* originated in the *Brāhmaṇa* period and leads to 3000 BC on several grounds. This clearly supports the correlation of the two periods.

Starting with Dikshit[19] in 1895, many scholars have interpreted SB 2.1.2.3 to mean that Kṛttikā was on true east leading to 3000 BC. We have independently confirmed[14] Dikshit's conclusions on SB 2.1.2.3 from verses on *Agnicayana* in TS (Figure 1). The importance of the cardinal directions in Harappa has been highlighted by several scholars[20–23]. This directly correlates the two periods, especially as Dikshit[19] pointed out that the description in SB 2.1.2.3 is in the present tense and contemporary.

However, some scholars who support AIT suggest that *Brāhmaṇa* texts contain memories of observations made in the Harappan period. Parpola states 'Many things point to a Harappan origin of the *nakṣatra* calendar'[20], referring to the *nakṣatra* lists in the *Saṃhitas* and *Brāhmaṇas*[22]. Chattopadhyaya[23] (p. 259) suggests that Kṛttikā was observed to be on true east in Harappa and 'somehow' (which highlights the weakness of the suggestion) made its way into the *Brāhmaṇa* texts (SB 2.1.2.3). These suggestions have several deficiencies and are incorrect as seen below. See also sec. 6 of ref. 14.

The *nakṣatra* lists and SB 2.1.2.3 belong to the period when the second calendrical scheme was in vogue[14]. This scheme had month names Tapas, Tapasya, etc. and its new year is described in KB 5.1 and SB 6.2.2.18. As shown in ref. 14, KB 5.1 and SB 6.2.2.18 lead to 3000 BC. The suggestion that the *nakṣatra* lists and SB 2.1.2.3 are Harappan memories in Vedic texts is an incomplete picture because the second calendrical scheme also leads to 3000 BC. No Sanskrit scholar in more than 150 years has suggested that KB 5.1 and SB 6.2.2.18 are ancient memories. Since the new year marker and the calendrical scheme are central to any period, it follows that the *nakṣatra* lists and SB 2.1.2.3 are contemporary references in Vedic texts. This supports the correlation of the two periods mentioned above.

Many scholars (including Parpola and Chattopadhyaya) have suggested that *Agnicayana* is of Harappan origin and was later incorporated into Vedic texts. See ref. 23 (pp. 130–145) for an extended discussion. Much of this suggestion relies on the extensive use of bricks in *Agnicayana*, which were also extensively used in Harappan culture. Bricks are absent in the *Ṛg Veda*.

(Although not the main issue, we mention that *Sāvitra-cayana*, TB 3.10, used gold bricks ('small pieces of gold')[16] or anointed pebbles. Gold was known since *Ṛg Veda*. TB 3.10.11 attributes *Sāvitra-cayana* to Bharadvāja[16], supposedly taught by Indra (both prominent in RV), in the past tense, clearly implying it and the calendrical scheme are ancient memories in TB. The *nakṣatras* are conspicuously absent in *Sāvitra-cayana* implying that they were not yet prominent. It is difficult to justify using pebbles instead of fired bricks (when available) and be considered greatly prestigious to be attributed to Indra and Bharadvāja. *Prima facie*, *Sāvitra-cayana* appears to be a precursor to *Agnicayana* and must be considered in any discussion on the latter's origins. It raises doubts on the above proposal.)

As shown in ref. 14, verses on *Agnicayana* in TS refer to Kṛttikā as Heaven. However, these references are only incidental to *Agnicayana*, a ritual meant to carry the patron to Heaven, which was along true east (illustrated in Figure 1). In 800 BC, Kṛttikā would rise 12° or 24 sun-diameters from true east and be nowhere near 'Heaven'. There would be no

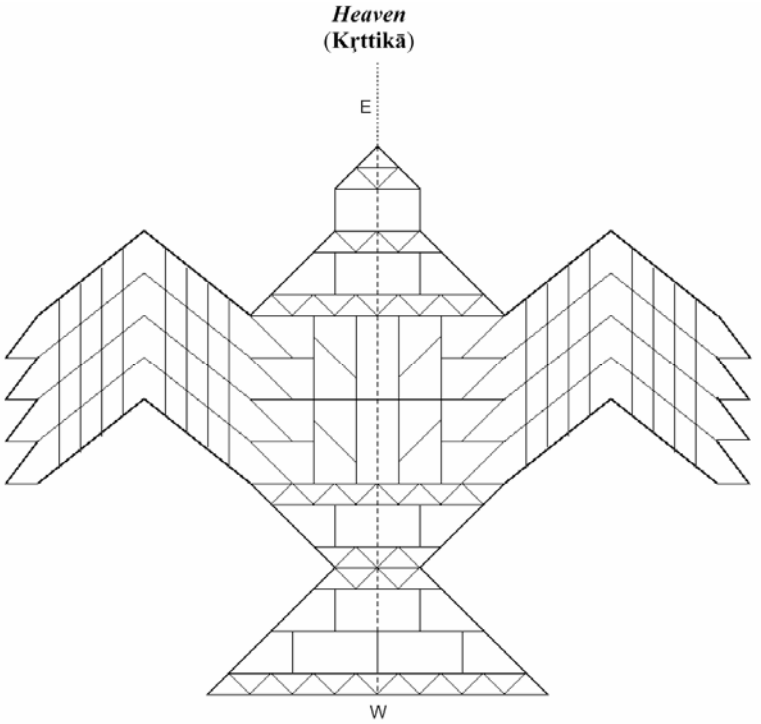

Figure 1. Schematic representation of the bird-shaped *Agnicayana* altar. *Kṛttikā* represented Heaven or was on true east in *Taittirīya Saṃhita* and leads to 3000 BC (ref. 14).

justification to refer to Kṛttikā as Heaven in 800 BC, that too in the present tense, especially since, as is well known, *Agnicayana* was obsessed with precision *in all aspects*[14]. It would be completely incongruous to suggest that precision was of essence in all aspects of *Agnicayana* except one, where a most glaring and obvious inaccuracy was disregarded. Thus, *Agnicayana* is contemporary to Vedic texts, contrary to the above proposal and thus, correlates the two periods.

Other scholars[23] (pp. 130–145) disagree with the above proposal. For example, Witzel[24] states (p. 68) that '*so far hypothetical interrelations between certain features of the Indus religion and the Śrauta ritual*', which combined with his statement 'there was no *Agnicayana* yet at the time of RV' (p. 70) implies that *Agnicayana* is contemporary to the *Saṃhita* and *Brāhmaṇa* texts. As shown in ref. 14, *Agnicayana* has an internal date of 3000 BC (Figure 1), which implies a date of 3000 BC for the *Saṃhita* period and correlates with the Harappan period. Thus, the opposing views of scholars, who otherwise support AIT, on the issue of the origin of *Agnicayana* are reconciled because the Indus Valley and the *Saṃhita–Brāhmaṇa* periods are correlated.

It is clear that scholars differ mainly on whether the references are ancient memories or contemporary. The former is an artefact of interpreting evidences within the framework of AIT. It is also sustained by a limited consideration of astronomical references where all references except SB 2.1.2.3 and the *nakṣatra* lists have been ignored.

Some astronomical references *have always (i.e. for more than 150 years) been considered to be contemporary by all scholars*. For example, Witzel[24] (p. 73) states '*In TS 7.4.8 and KB 4.4… the months are purnimanta. KB 19.2-3, however, already has amanta months…*' Clearly, it implies that the latter scheme is contemporary. No scholar in more than 150 years has suggested that KB 19.3 or verses on *ekāṣṭaka* (both of which lead to 3000 BC) are ancient memories.

It is virtually impossible to demonstrate that all astronomical references that lead to 3000 BC are ancient memories. Indeed, the descriptions of these references leave little doubt that they are contemporary (in contrast to that of the first calendrical scheme in TB 3.10). Any such attempt must *begin* with a justification, other than to salvage AIT, for changing the settled opinion (that many references are contemporary), which has never been contested. Until all astronomical references that lead to 3000 BC are convincingly shown to be ancient memories in Vedic texts, correlating the Indus and *Brāhmaṇa* periods is the most justifiable conclusion.

The correlation of the Indus and *Brāhmaṇa* periods is consistent with the views of archaeologists and geologists[1–9]. Bryant[2] (p. 160) states 'A growing number of Indian archaeologists believe that the Indus Valley civilization could have been an Indo-Aryan civilization, or, at least, the two cultures could have coexisted.' Renfrew[20] states 'It is difficult to see what is particularly non-Aryan about the Indus Valley civilization.' Geologists[6–9] have correlated the two periods by identifying evidences for a dried river in this region with Saraswati mentioned in Vedic texts.

Evidence from mathematics

The origin of mathematics has been studied by historians of mathematics from the 19th century onwards. Seidenberg[25] (p. 316) summarizes the prevailing views in 1978 as, 'To sum up the current views: The view that Classical Greece is the source of Tradition I remains the prevailing one. The source of Tradition II, it is generally held, is Old-Babylonia.' The notion of a common source had been the view of scholars for almost a century.

These conclusions were based on studies that ignored Indian mathematics. Seidenberg[25] (p. 318) states: 'I propose to show that his (van der Waerden's) theses (and Neugebauer's) cannot be maintained in their present form. The main fault in van der Waerden's analysis is that at all vital points he takes into account only Old-Babylonia and Greece: if one includes the Vedic mathematics, one will get quite a different perspective on ancient mathematics.'

While Babylonian mathematics emphasized algebra (*Tradition II*), Greek mathematics emphasized geometry (*Tradition I*). In the beginning these differentiations would not have existed and 'The main issue is the origin of geometric algebra'[25] (p. 318). Seidenberg[25] (p. 329) concluded that 'Origin of mathematics' occurred in Vedic ritual fire altars (as described in TS, SB and *Śulvasūtras*) from where it spread to Babylon and Greece.

A common source for Greek and Indian geometry was first suggested[25] by Cantor in 1877 and also supported by many scholars including Seidenberg[25–27]. For the other, Seidenberg[25] (p. 329) states: 'As to the common source of Babylonian and Vedic mathematics, though at one point in the argument I used the word postulate, I now regard my thesis as proved.'

Unfortunately, at this stage, he relied on the authority of Sanskrit scholars. He states[25] (p. 324): 'Now the Sanskrit scholars do not give me a date so far back as 1700 BC. Therefore I postulate a pre-Old-Babylonian (i.e. pre-1700 BC) source for the kind of geometric rituals we see preserved in the *Śulvasūtras*, or at least for the mathematics involved in these rituals.' This was not always the case. In 1962, he stated[26] (p. 509): 'The *Rig Veda* has been dated 2000–1500 BC by Whitney, and even earlier by Jacobi.' In articles published from 1894 to 1910, Jacobi had dated Vedic texts[2] to 4000 BC on astronomical grounds. In footnote 64, Seidenberg states[26] (p. 511): 'The Babylonians of 1700 BC were way beyond the gnomon, but the Indians had it. Hence in number theory also, and not only in geometry, Pythagorean mathematics has more of an Indian than a Babylonian look.' These comments would not be made if he subscribed to AIT. In 1975, he stated[27] (p. 288): 'I have concluded that not only are the *Śulvasūtras* pre-Greek, but that even the Old-Babylonian mathematics derives from a system of practices much like those disclosed in the Indian sacred works.' As late as 1975, he was unwilling to accept AIT dates. He would not have accepted the authority of Sanskrit scholars even in 1978, if he had known that Caland's interpretation of *ekāṣṭaka* in 1931 led to 3000 BC.

Seidenberg's conclusion that Vedic mathematics is older than that of 1700 BC Babylon is confirmed now since it is clear[14] that the *Agnicayana* altar, whose mathematics he considered, leads to 3000 BC on astronomical grounds (Figure 1).

However, as seen above, the conclusions from comparative mathematics do not yield absolute dates.

Evidences from iron

Sanskrit scholars who support AIT have interpreted *kṛṣṇa*/*śyāma ayas* in Vedic

texts as smelted iron and correlated it with archaeological evidences for iron in the Iron Age, the earliest date being around 1000 BC till recently. For example, Witzel[24] (p. 67) states: 'For, the first appearance of iron, the "black metal" (*krsna*/*zyama ayas*) in S. Asia, well known to the *Brāhmaṇa* style texts, is only at c. 1200 BCE. But, iron is already found in texts much earlier than the *Brāhmaṇas* (i.e. AV, and in the YV *Saṃhitās*: MS, KS, TS; however, not yet in the RV)... To date *Brāhmaṇa* texts at 1900 BCE (see below on astronomy) is simply impossible.'

(Wizel is unaware (ref. 14) that his interpretations of astronomical references, *ekāṣṭaka* (1984) and KB 19.3 (2001), lead to 3000 BC. He had already contradicted his claim that early dates for *Brāhmaṇa* texts are 'simply impossible'.)

With regard to the issue under discussion, there are several deficiencies with this approach as discussed below.

The entire claim hinges, first, on the definitive interpretation of *kṛṣṇa*/*śyāma ayas* as smelted iron. This is far from certain. Vedic Index (VI) VI–I (pp. 31, 32) and VI–II (p. 398) highlight the tentativeness of 19th century Sanskrit scholars in interpreting *kṛṣṇa*/*śyāma ayas* as iron[28].

Recently, Bryant[2] (p. 247) states that conventional dates of AIT are justified 'provided we can be assured that the *kṛṣṇa ayas* refers to smelted iron objects and not iron ore. After all *kṛṣṇa ayas* simply means "black metal" and items made of black metal go back to the Bronze age in Harappa, whether they were smelted or not… We simply don't know'. Elsewhere[29] (p. 348) he states 'The evidence of *kṛṣṇa ayas*, iron (literally, black metal) in the *Brāhmaṇas* fails to conclude the issue since, although smelted iron does not surface in the subcontinent until the late 2nd millennium BCE, objects made of black iron ore have been discovered in Harappan sites going back to 2600 BCE. There is no way, to my knowledge, of asserting that *kṛṣṇa ayas* refers to smelted iron in the earlier texts (as it did in the later ones), rather than iron ore or even as Kazanas[30] speculates, blackened copper.'

In more than a century, Sanskrit scholars have not settled on the interpretation of *kṛṣṇa*/*śyāma ayas* as smelted iron. Importantly for scientists, references to *kṛṣṇa*/*śyāma ayas* in Vedic texts do not contain any information that is amenable to metallurgical analysis. It is impossible to be certain, either on linguistic or scientific grounds, that *kṛṣṇa*/*śyāma ayas* refers to smelted iron.

The other premise in the argument for AIT is based on the earliest archaeological date for smelted iron, which was taken to be 1000–1200 BC (late second millennium BC), well after the invasion proposed around 1500 BC. Tewari[31] showed that smelted iron in the Ganga plain dates to 1800 BC. He states '…it may be concluded that knowledge of iron smelting and manufacturing of iron … was well known … and iron had been in use in the Central Ganga plain at least from early second millennium BC. The quantity and types of iron artifacts, and the level of technical advancement indicate that the introduction of iron working took place even earlier. The beginning of the use of iron has been traditionally associated with the eastward migration of the later Vedic people… *The new finds and their dates suggest that a fresh review is needed.*'

Chakrabarti[4], in an interview, responds to the question: 'Q. According to you, what is the biggest archaeological find in India in the last five years and why? A. The evidence of early iron in the Ganga plain is another example. Earlier, we used to say it began in the area around 1000 BC. Now the date is pushed back by another 800 years.'

The dates for iron have changed substantially recently with new archaeological discoveries. Even these dates can by no means be considered as settled. It is clear that they do not possess the certainty that is essential if they are to be used to date Vedic texts.

Lahiri[32] has observed that there is 'a large question mark' on the entire approach described above. She states (p. 6): 'what is now reasonably clear is the presence of chronological distinctions between the advent of iron technology and the beginning of what is described as the "Iron Age", the first distinct phase in the development of a technology capable of producing iron in the Indian subcontinent coincides with the chalcolithic cultures of the 3rd and 2nd millennium BC… this time lag between the advent of Iron and the beginning of the Iron Age has put a large question mark on any scheme which sees a simple linkage between acquisition of technological know-how involved in the process of smelting and forging Iron, and its acceptance as the primary functional metal of early societies.'

Questions that must be addressed to establish a scientific basis for AIT

Scientists must assess which evidences are more reliable – astronomical references or those to *kṛṣṇa*/*śyāma ayas*. Even before a scientific assessment is made, when a Sanskrit scholar, who supports AIT, states[29] 'The evidence of *kṛṣṇa ayas*, iron (literally, black metal) in the *Brāhmaṇas* fails to conclude the issue' the choice is clear. A professional assessment suggests the latter possibility is unacceptable as it privileges *kṛṣṇa ayas* – with no consensus in interpretation, inaccessible to scientific (metallurgical) analysis, dates that can change with archaeological discoveries and a suspect approach of linking it to the Iron Age – over multiple astronomical references that are amenable to scientific analysis and give stable dates. Clearly, the evidentiary value of astronomical references is far superior to that of *kṛṣṇa*/*śyāma ayas*.

This is consistent with the conclusion reached earlier that *there can be no scientific basis in support of AIT until astronomical references are interpreted to 800 BC*.

From the above discussions, we propose that the following questions/points must be satisfactorily addressed in order to establish the scientific basis in support of AIT.

1. Key astronomical references must be consistently interpreted to 800 BC.
2. Justification for the use of four successive calendars from *Ṛg Veda* – *Vedāṅga Jyotiṣa* (VJ) in a period of 800–1000 years.
3. Justification for interpreting *kṛṣṇa ayas* as smelted iron even as Sanskrit scholars have differed for more than a century.
4. Justification for why 'the first appearance of iron' should be used to date Vedic texts to 1000 BC when an archaeologist[31] has recently dated it to 1800 BC and states 'The new finds and their dates suggest that a fresh review is needed.' More significantly, scholars[2,29,32] have implied that this entire approach is suspect.

Unless these questions are addressed, there is no scientific basis for AIT**.** We have not considered evidences from mathematics, even though they too cannot be used to support AIT, because the dates obtained are from relative comparisons that are necessarily less reliable than absolute dates.

Examination of the views of scholars with expertise in astronomy who support AIT

We examine the views of Pingree and Kocchar, who, to the best of our knowledge, are the only scholars who have interpreted astronomical references and also support AIT. It highlights the fact that scientists who have interpreted astronomical references overwhelmingly oppose AIT.

On KB 19.3, Hunger and Pingree[33] (p. 76) state, 'It is demonstrated in Pingree (1989) that the months here begin with new moon as in Mesopotamia', i.e. the month of Māgha *began*, not ended, with new moon. This is the worst possible scheme as, theologically[14] the moon would die on the very first day of the month. TS 7.1.4 specifically states that the new moon and the next day belong to separate half-months, whereas in his scheme they belong to the same half-month. Given that *Vaiśākha* new moon coincided with Rohini (SB 11.1.1.7), *Vaiśākha* full moon would be ~40° away from *Viśākha nakṣatra* instead of being near it. Consecration begun on *ekāṣṭaka* would not span two seasons or years despite explicit verses to this effect.

VJ refers only to *amānta* months that are absent in Mesopotamia. Pingree claimed that the 'whole system' of VJ was borrowed from Mesopotamia[34]. If Pingree is to be believed, Lagadha replaced the pre-existing Mesopotamian scheme of KB 19.3 and introduced the *amānta* scheme in VJ even as he borrowed its 'whole system' from Mesopotamia. It is clearly illogical. Since VJ has *amānta* months absent in Babylon, it should have been a pre-existing indigenous tradition. Thus, even if VJ astronomy was borrowed from Babylon (it is not), KB 19.3 would have *amānta* months and lead to 3000 BC. (Witzel's[24] view (p. 73) that verses VJ 5-6 'post-dates the establishment of the calendrical scheme with *amānta* months… KB 19.2-3, however, already has *amānta* months' is similar.)

On SB 2.1.2.3, Kṛttikās on true east, Pingree[35] states, 'unfortunately for this theory, parts of the *nakṣatras*, *Hasta*, *Viśakha*, and perhaps *Sravana* were also on the equator in 3000 BC'. This objection was already discussed in 1895 by Dikshit[19] as none of the junction stars would be on the equator, which is also confirmed by Narahari Achar[35]. Pingree has completely ignored the special status of Kṛttikā evident in TB and TS. We have confirmed[14] that Kṛttikās were on true east from verses in TS (Figure 1).

Pingree[34] did not comment on errors in observations in the *Brāhmaṇa* period. For VJ, he proposed three possibilities, of which only one is relevant here as the others involve equal ecliptic segments not found in *Brāhmaṇa* texts. He proposed, *without any scientific justification*, a 10-day error in determining solstices that would shift dates by 700 years. However, we have shown[14] that even a large error of the diameter of the sun in the observation of sunrise leads to an error of 2 days. Our considered view[14] (sec. 4.2) is that 'Readers (especially scholars who suggest large errors without substantiation) are welcome to determine winter (or summer) solstice by direct observation of sunrise (or sunset) to convince themselves that it is impossible to determine solstices to an error of more than 3 days.' As discussed in ref. 14 (sec. 4.3–sec. 5), the use of the gnomon combined with a tradition of careful observations would lead to very accurate measurements. Pingree's 10-day error estimate should be considered to be another example of his well known prejudices[36,37]. Even if accepted, it shifts dates of astronomical references from 3000 BC to 2300 BC and not to 800 BC.

Pingree's conclusions are incorrect on several counts. He did not interpret other references, KB 5.1, *ekāṣṭaka*, etc.

Kochhar[38], an astronomer, co-authored an article which dates SB 2.1.2.3 to 3000 BC. It states[38] 'the *Śatapatha Brāhmana* explicitly states that Kṛttikās rise due east… we know that the name *Mula* existed in the *Kṛttikādi* list whose origin dates back to about 3000 BC'. He supported AIT in a book[39] which, surprisingly, does not mention the above article. In the book[39], he states that SB 2.1.2.3 leads to 2300 BC 'if rigorously true' ($\lambda = 0°$), which differs from the analysis ($\delta = 0°$) in his article[38]. A clarification was clearly warranted. Importantly, there is no suggestion that SB 2.1.2.3 or the *nakṣatra* lists are ancient memories. He has not analysed other key astronomical references, KB 5.1, KB 19.3, *ekāṣṭaka*, etc.

Unlike Pingree, whose (incorrect) interpretation of KB 19.3 is compatible with AIT, Kocchar's support of AIT is despite his interpreting SB 2.1.2.3 to 3000/2300 BC. This must be considered to be his personal philosophy that is in contrast to the views of most scholars[1–11] who stand by their professional conclusions, even if they contradict AIT. For example, Chakrabarti[4] states, 'Archaeology can provide continuous history'. Schaffer and Lichtenstein state (p. 17) 'the modern archaeological record for South Asia indicates a cultural history of continuity rather than the earlier 18th through 20th century scholarly interpretation of discontinuity and South Asian dependence upon Western influences'[1]. Underhill *et al.*[11] (p. 483) state that their genetic study 'would exclude any significant patrilineal gene flow from East Europe to Asia, at least since the mid-Holocene period'. The *sine qua non* for an astronomer to support AIT in a professional capacity is to demonstrate that astronomical references in Vedic texts are compatible with it.

It is clear that the support of scientists for AIT is based on incorrect interpretations of few astronomical references or in a personal capacity. Such scientists have also not considered other key astronomical references that contradict AIT. Their support for AIT has been rendered completely untenable after Sanskrit scholars' interpretation of *ekāṣṭaka* to 3000 BC from 1931 onwards. Clearly, the conclusion that there is no scientific basis for AIT stands.

Discussion

After considering evidences from astronomy, metallurgy and mathematics, it is clear that astronomical references are, by far, the most reliable evidences of the three. They consistently lead to about 3000 BC (ref. 14) and oppose AIT. Importantly, though evidences from metallurgy and mathematics are less reliable, they are not in contradiction with this date. Unlike the latter two, where (doubtful) attempts have been made to reinterpret them with the framework of AIT, astronomical references are completely incompatible with AIT. Since they are

the most reliable of the three, they confirm the conclusion reached earlier that *there can be no scientific basis in support of AIT until key astronomical references are interpreted to 800 BC.*

The astronomical evidences cannot be wished away. Jacobi had long been ignored by mainstream Western scholars[2] (p. 252), yet Seidenberg[26] in 1962 resurrected his dates reached 50–70 years earlier on astronomical grounds because they, and not AIT dates, were compatible with his conclusions. The reason he[25] modified his opinion in 1978, 'Now the Sanskrit scholars do not give me a date so far back as 1700 BC…' is no longer applicable, since it is now clear[14] that their interpretation of *ekāṣṭaka* (from 1931 onwards) leads to 3000 BC. Thus, scholars are fully justified to invoke dates from astronomical references in case their conclusions are compatible with them rather than AIT dates.

The suggestions that astronomical references are ancient Harappan memories are unsubstantiated or weakly substantiated and are incorrect. Importantly, this is based on a limited consideration of the astronomical references. Other key references, that also lead to 3000 BC, have *always* (for more than 150 years) been considered to be contemporary by all scholars, including Western Sanskrit scholars. A moment's reflection will show that it is virtually impossible to demonstrate that all references that lead to 3000 BC are ancient memories. From a scientific perspective, AIT stands disproved.

It is also important to recognize the limitations of the astronomical evidences. Any general or overarching theory (such as AIT or AMT or Out of India Theory) that dates the *Saṃhita* and *Brāhmaṇa* texts to 800 BC is incorrect. In contrast, any general theory that dates them to about 3000 BC is plausible at best. Astronomical references cannot decide between competing general theories that date the *Saṃhita–Brāhmaṇa* period to about 3000 BC and other evidences must be considered to decide their correctness. Any general theory must interpret specialized evidences to the satisfaction of specialists and not vice versa.

Conclusion

We have examined evidences from astronomy, mathematics and metallurgy, which any scientist with a background in physical sciences must consider in order to form a professional opinion on AIT. We propose the criteria – four questions that must be addressed satisfactorily – for scientists to support AIT in a professional capacity. On these grounds, we establish that there is no scientific basis for the Aryan Invasion Theory.

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