

## EVOLUTION OF EARLY WRITING IN INDIA

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The evolution of the earliest writing in India is sketched in light of the new finds in archaeology and the discovery of the R̥gvedic astronomical code. Main arguments in the derivation of Brāhmī from the writing of the Harappans are reviewed. The development of the zero sign is also traced.

### I

The Indus-Sarasvatī cultural tradition represents the beginnings of the Indian civilization. This tradition has been traced back to about 7000 B.C. in remains that have been uncovered in Mehrgarh and other sites.<sup>1</sup> Its first urban phase was during the Harappan period of 2600-1900 B.C. The writing used in this phase has hitherto been called the Indus writing, but it appears that it should be properly named the Sarasvatī writing<sup>2</sup>, because most of the settlements in this period were along the Saravatī river and because the Indian tradition associates Sarasvatī with learning and literacy in its earliest phase. Goddesses have symbolized later scripts as well as in Brāhmī and Śāradā.

It is now believed that the capture of Śutudrī (Satluj) and Yamunā, the two main tributaries of the Sarasvatī river, by Indus and Gaṅgā around 1900 B.C. led to the desiccation of Sarasvatī and collapse of the Harappan urban phase. The focus of the civilization started moving east and south. The Indus-Sarasvatī tradition continued in a state of decline until a second urbanization began in the Gaṅgā-Yamunā valley around 900 B.C. The earliest surviving records of this culture are in Brāhmī script. This second urbanization is generally seen at the end of the Painted Gray Ware (PGW) phase and with the use of the Northern Black Polished Ware (NBP) pottery.<sup>3</sup> Late Harappan was partially contemporary with the PGW phase so that we see a continuous series of cultural developments linking the two early urbanizations of India.

The Brāhmī script as seen in the earliest surviving records was systematic, reflecting the theories of Indian grammarians.<sup>4</sup> Literary evidence as well as signs on early punch-marked coins suggests that writing in India during the second urbanization goes back much before the middle of the first millennium B.C. The punch-marked coins<sup>5</sup> use a Harappan weight standard. The coins appear to have been originally issued as silver blanks by traders and their weights were checked by traders who put their own marks

on the coins. By the sixth century B.C. the kings began putting their own issuing marks on the coins. These pictorial marks were generally representative of the meaning of the king's name. Pran Nath and Fabri noted the striking similarities in the iconography of the Harappan seals and the punch-marked coins<sup>6</sup>.

Another script used in Mauryan India was called Kharoṣṭhī (Ass-lip). Used mainly in Northwest India and Central Asia for a few centuries, Kharoṣṭhī was derived from the Aramaic script and adapted to the sounds of Indo-Aryan under the apparent influence of Brāhmī. Like Aramaic it was written from right to left. Its name appears to play on the cursive nature of its character. Kharoṣṭhī characters have been seen as far as in Bāli<sup>7</sup>.

The evolution of writing in India after Brāhmī is well understood and needs no recounting. But it may be noted that all the modern scripts of India for Indo-Aryan as well as Dravidian languages, and the scripts of Sri Lanka, Tibet, Southeast Asia, including the original scripts of Philippines and Indonesia, are derived from Brāhmī. Furthermore, Indian numerals, whose evolution is tied up with that of Brāhmī, have now been universally adopted. Therefore the story of the development of Brāhmī is of considerable interest.

The recent discovery of the astronomical code on the basis of the Ṛgveda<sup>8</sup> also raises important questions regarding writing in ancient India. Even the most conservative estimates date the Ṛgveda to the second millennium B.C. although the fact of the drying up of the Sarasvatī, the major river of the Ṛgvedic era, around 1900 B.C. indicates that the Ṛgveda was probably completed in the third millennium B.C. In any case the existence of an intricate astronomical code suggests that the earliest Vedic phase was characterized by knowledge of writing. The continuity in the Vedic tradition then suggests that writing was not forgotten in the second millennium B.C.

The paper presents an overview of the connections between Sarasvatī ad Brāhmī in the light of the new archaeological discoveries. Recently published analysis, that may not be easily accessible to the readers of this journal, is summarized.

## II

We begin with a brief review of the Indus-Sarasvati tradition. According to a recent estimate nearly two-third of more than 2500 settlements of this tradition have been found along the Sarasvati river and a majority of the remaining one-third of the sites have been found in Gujarat and Uttar Pradesh; the Indus valley proper has less than 100 sites<sup>9</sup>. The Sarasvatī valleys were the heartland of this tradition and it appears that the Indus region belonged to the periphery.

This tradition was characterized in its earliest phase by cultivation and animal husbandry. Cattle pastoralism was an extremely important component of the economy and by 5500 B.C. domesticated cattle were central to food production. The evolution

of the culture in the Indus-Sarasvatī region has been divided into four broad eras<sup>10</sup>. The first is the *early era* (c. 6500-5000 B.C.) that is characterized by an absence of ceramics. The next is the *regionalization era* (5000-2600 B.C.) where distinct artifact styles (including ceramics) develop regionally. The third is the *integration era* (2600-1300 B.C.) where we see pronounced cultural homogeneity and the development of urban centres. The fourth era is that of *localization* (1900-1300 B.C.) where characteristic patterns from the integration era are seen to be blended with regional ceramic styles.

Amongst the many factors at the basis of the evolution of the tradition, changes in farming has been considered to be quite important. According to Richard Meadow<sup>11</sup>.

Two distinct agricultural revolutions can be identified for the northwestern region of South Asia during the pre- and protohistoric period. The first involved the establishment by the sixth millennium B.C. of a farming complex based principally on the *rabi* (winter sown, spring harvested) crops of wheat and barley... The second saw the addition by the early second millennium B.C. of *kharif* (summer sown, fall harvested) cereals including sorghum, various millets, and rice.

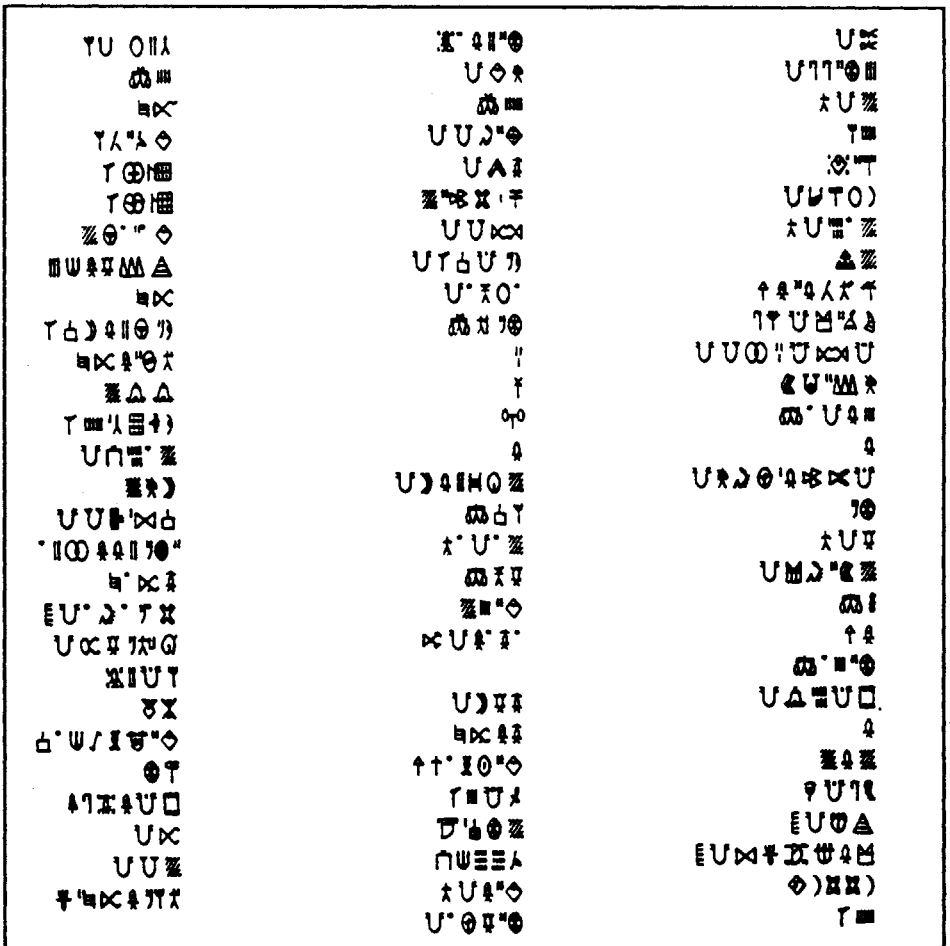
In the arid and semi-arid areas buildings were made out of mud bricks and fired bricks and stone but it is likely that wood structures were used in regions where wood was easily available. There was public architecture as in plazas, streets, public buildings, wells, drains, and tanks. Pottery was mass produced by using wheels and sometimes by molds. Painted decorations used a variety of geometric, animal and floral motifs which are still popular in India. A network of long distance trade existed. Turquoise from central Asia, lapis lazuli from northern Afghanistan, and shells from the coast of the Arabian sea have been found at Mehrgarh.

The Indus-Sarasvatī tradition consists of several overlapping cultures and styles that probably represent different ethnic groups. The integration era, which is the richest period of this tradition, is named Harappan after the site where the first excavations were made in 1921. Soon after the famous site at Mohenjo-Daro in Sindh was excavated. Since then thousands of other sites have been discovered. These include major sites at Dholavira, Ganweriwala, Kalibangan, Lothal and Rakhigarhi. The Harappan world covered an area of about a million square kilometers that stretches from the Himalayas in the north to the Tāpti river in the south, and from the Indus river valleys in the west to the plains of the Gaṅgā and Yamunā rivers in the east. Indus and Sarasvatī valleys, Kutch and parts of Saurāṣṭra were the focus of the early and mature Harappan settlements whereas the upper course of Satluj, trans-Yamunā region of Uttar Pradesh, and Saurāṣṭra were the focus of the post-Harappan settlements.

Ceremonial structures that appear to be fire-altars have been found in Lothal and Kalibangan<sup>12</sup>. The brick-lined fire pit has five layers of brick just like a Vedic altar. Dhavalikar and Atre have argued that a fire temple with an altar is to be found in the remains of Mohenjo-Daro as well<sup>13</sup>.

III

The surviving records of the writing of the Harappans are mainly carving on seals, small pieces of soft stone, and copper tablets (Fig. 1). The total number of inscribed objects is around 4200, but many of these are duplicates<sup>14</sup>. The number of different signs used is close to 400, but these include the various numeral signs as well as the conjuncts of the more basic signs. Most texts are very brief, the average length being 5 signs, and the longest text, on a three-sided 'amulet', is 26 signs long. The longest inscription on a single side is 17 signs, in three lines, on a seal. The primary purpose of the seals was perhaps to mark ownership and the copper tablets may have served as amulets. A large number of seal impressions on clay have also survived. These are likely to have served as tags which were attached to bales of goods, for the



Sarasvati texts from Lothal (Gujarat) and Kalibangan (Rajasthan)

Fig. 1. Harappan texts

reverse sides often show traces of packing materials. The impressions of the seals are likely to have served as signatures. The pictorial motifs that accompany the writing include the humped bull, buffalo, elephant, tiger, rhino, crocodile, antelope, fish, tortoise, and so on. Geometric designs include the *svastika*, spoked wheel, and a circle with a dot.

The Harappan seals have been recovered in Mesopotamia from the 24th century B.C. onwards while Persian Gulf seals have been found in the Harappan port of Lothal. Inlands the Harappans moved their goods using wheeled carts, camels, and boats. They used strikingly accurate weights in a series that is preserved in later Indian weights. The same unique series is also found on the island of Bahrein in the Persian Gulf, suggesting this might have been their colony. Some of the weights are so tiny that they could have been used by jewellers to weigh gold, others are so big that they must have been hoisted by ropes. Their products would have included fine pottery wares, jewelry, copper and bronze vessels, and woven cotton goods. The variety and extent of this trade indicates that credit-keeping and calculations were very important to the Harappans.

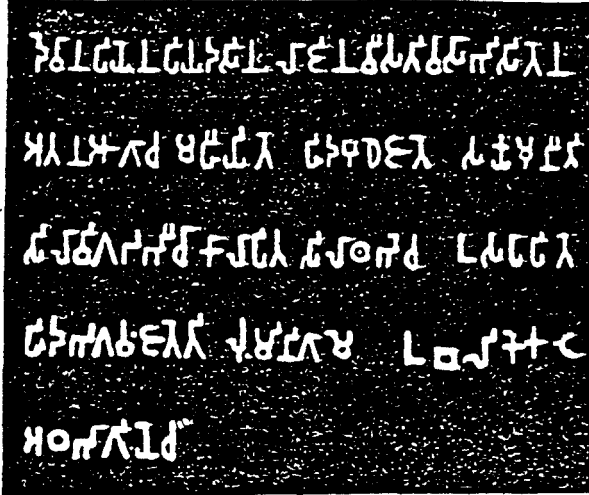
The seals of the historical period also carry brief texts<sup>15</sup>. Most of the legends represents the possessive case as in '(seal) of X'. There are cases where no case-ending is used, or where the ending is nominative as in religious formulae. The impressions from these seals, like the earlier seals of the Harappan period, were used to authenticate records, or to serve as signatures.

#### IV

Each letter in Brāhmī represent a consonant combined with *a*. Combinations with other vowels are represented by the use of distinctive marks which modify the basic sign (Fig. 2). Two consonants together were expressed by placing the signs for the two, one on top of another. This process of combination makes the total number of distinctive Brāhmī signs to be 330 for the 33 consonants alone, without considering the conjuncts. It is not surprising, therefore, that Sarasvatī has about 400 signs, and many of these signs are modified in exactly the same regular manner as in Brāhmī.

Based on morphological considerations, the Brāhmī signs can be divided into two groups<sup>16</sup>: the primary signs and the secondary or the derived signs (Fig. 3). These primary Brāhmī signs look closest to the Sarasvatī signs. Many of the Brāhmī signs are the first syllables of familiar objects: thus *g*, *ch*, *m*, *ś*, *h* appear to have been derived from the representations of *giri* (hill), *chatra* (umbrella), *matsya* (fish), *śara* (arrow), and *hasta* (hand).

An analysis of Sarasvatī and Brāhmī reveals connections between the two scripts that cannot be explained as arising out of chance.<sup>17</sup> One sees that the most frequent letters of Sarasvatī and Brāhmī look almost identical and besides they are in the same order of frequency (Fig. 4). One does encounter a change in the orientation of the



**Aśoka's Lumbinī Pillar Inscription, 249 B.C.**

- (Line 1) De-vā-na-pi-ye-na Pi-ya-da-si-na lā-ji-na vī-sa-ti va-sā-bhi-si-te-na  
 (2) a-ta-na ā-gā-ca ma-hī-yi-te hi-da Bu-dhe jā-te Sa-kya-mu-nī ū,  
 (3) si-lā-vi-ga-da bhī-cā kā-lā-pi-ta, si-lā-ṭha-bhe ca u-sa-pā-pi-te.  
 (4) Hi-da bha-ga-vaṃ jā-te ti Lum-mi-ni-gā-me u-ba-li-ke ka-te,  
 (5) a-ṭha bhā-gi-ye ca.

*Text Sanskritized*

- (1) Devānāmpriyeṇa Priyadarśinā rājñā vimśati varṣābhiṣikṭena  
 (2) ātmanā āgāya mahīyitam iha Buddhaḥ jātaḥ Śākyamuniḥ iti,  
 (3) silā vikṛtabhiṭṭā kāritā, silā stambhaḥ ca utsarpitah.  
 (4) Iha bhagavān jātaḥ iti Lumbinī-grāmaḥ udbalikah kṛtaḥ,  
 (5) āṣṭa-bhāgikah ca.

*Translation*

Priyadarśī, Dear to the Gods, (when) crowned twenty years, himself came and worshipped (here), because Buddha, the Śākyamuni, was born here; he had a railing made of stone built, and a stone pillar was erected. Because the Blessed One was born here, Lumbinī village is made free of taxes and the payment of an eighth share (of produce).

Fig. 2. Aśhoka's Lumbinī Pillar Inscription, 249 B.C.

<i>Letters derived from Sarasvatī</i>	<i>Secondary or evolved letters:</i>
<b>Vowels</b>	<b>Vowels</b>
> a, ∙ i, L u, ▷ e, ▷ ai	* ā, ∙ i, E ū, 7 o, 7 au, * am
<b>Consonants</b>	<b>Consonants</b>
+ k, ^ g, W gh	3 kh, □ ñ.
∅ c, E j, F jh	⊕ ch, 7 n.
C t, r d	○ th, ⊕ dh, I n
^ l, 7 d, ⊥ n	○ th, D dh.
U p, □ b, 8 m	∩ ph, 7 bh.
∩ y, { r, J L, □ v	
↑ s, 7 s, 7 h	∩ s

Fig. 3. Evolution of Brāhmī letters

signs. But such modification can also be seen in the evolution of Brāhmī to the later Nāgarī, where many signs have been turned sideways or upside-down.

V

Both Sarasvatī and Brāhmī use conjuncts where signs are combined to represent compound vowels. The core set of most frequent Sarasvatī signs seems to have survived without much change in shape into Brāhmī where it corresponds to the most frequent sounds of Sanskrit. The writing of numerals in Sarasvatī, especially the signs for 5 and 10, appears to have carried over to Brāhmī. The inscriptions appear to be proper names indicating possessions. The genitive case-ending in Sanskrit is often *sya* or *sa*, and in Prakrit the ending is generally *sa* or *ssa* and this is what we frequently see in these inscriptions (Fig. 5). This suggests that the language of the Sarasvatī inscriptions is likely to have been Prakritic. It may be noted that the sign value for the case-ending was obtained independently through frequency considerations.

The attested contacts between Sumer and Harappa turn out to be invaluable in understanding one specific inscription. Sumerian documents mention the regions of

### Sign Modification in Sarasvatī and Brāhmī

Sarasvatī (*fish sign*):

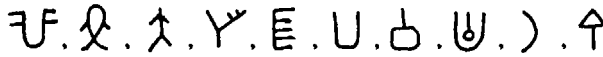


Brāhmī (*m*):



### The Ten Most Frequent Sarasvatī and Brāhmī Signs

Sarasvatī:



Brāhmī:

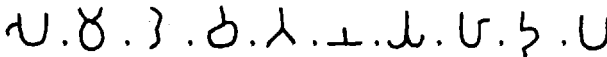


Fig. 4. The 10 most frequent Sarasvatī and Brāhmī signs

Magan, Meluhha, and Dilmun as lying to the east of their land. Dilmun is identified by most scholars to be the island of Bahrein in the Persian Gulf, Magan is taken to be the coast of Makran in Baluchistan, and Meluhha is considered to refer to the region of the Indus valley. The Sumeriologist S.N. Kramer in 1952 in a translation of a Sumerian epical story 'Enmerkar and the Lord of Aratta' found that a fourth region to the east is described as being *Bad Imin*, which if freely translated represents, 'the land of seven high places'. (This is from *bad* meaning 'city', *ia* meaning 'five', and *min* meaning 'two'.) Now the Vedic Indians called their land *Sapta Saindhava*, which Harold Bailey suggested originally meant 'the land of seven high places'. J.V. Kinnier Wilson identified a commonly occurring combination of Sarasvatī characters as representing *Bad Imin* or *Sapta Saindhava* on the basis of parallels with Sumerian writing.<sup>18</sup> I found that these very signs are read just the same using my Sarasvatī-Brāhmī theory. This provides evidence of commonality between the Harappan and the Vedic worlds. Unfortunately, the phonetic values for the most frequent Sarasvatī signs do not help us in reading most of the seals and other texts. The reason for this is that the short lengths of these texts disallows unambiguous readings.

The demonstration that Sarasvatī and Brāhmī are related and the likelihood that





in the reverse order excepting for the last two places. In other words, there existed two styles for expressing numbers that were well established: one, in formal texts where to be consistent with the structure of numerals until 99 all numbers were expressed starting with the units; second, actual writing in terms of numeral signs was in the usual place value form starting with the highest order.

The Brāhmī 10 before the advent of zero was written as a fish sign, or the sign for *m*, lying sideways. In later forms it was also written as with a single curving stroke, or with vertical stroke attached to a circle. It appears that the shape of zero was determined by the oval related to the fish sign of the Brāhmī 10. In such a representation, the zero sign clearly had the null (*śūnya*) value which explains its name. We also see how the two concepts expressed by the Indian zero, namely those of the place value and that of nothing, are likely to have become self-evident. Perhaps the simultaneous existence of the two forms of expressing numbers helped in the development of the dual concepts associated with the zero sign.

We encounter the vertical stroke attached to a circle form for 10 in the 1st and 2nd century A.D. Nasik inscriptions and in the 1st and 3rd century Āndhra and Kṣatrapa inscriptions. And the curved form is seen in the 4th century Jaggayapeta and Pallava grants.<sup>21</sup> Therefore, it is conceivable that the development of the zero sign occurred in these epochs.

But the above epochs do not provide a definite era for the discovery of the zero sign, since it is likely that the new usage competed with the traditional number system for centuries. In fact one would expect that inscriptions and deed plates would tend to follow the older and more commonly known style for a long time. For a parallel consider Europe where it took the Indian numerals about five centuries after their first known appearance in the Codex Vigilanus in 976 A.D. to be commonly used. Even in India the older additive system with special signs for 10, 20, 30, and so on continued to be used, alongside the place value system, for centuries.

The development of the zero sign in India was motivated by numerical calculations. This is to be contrasted from the manner in which the zero signs arose in Babylon and Mexico, where the motivation was from the areas of astronomy and calendrical calculations. The Babylonian astronomical tablets use a sexagesimal numeration system. But it is imperfectly developed being partly additive and partly place valued as within the base of 60 a decimal system is used. The Babylonian system has only three specific symbols, namely those for 1, 10, and the later symbol for 0. Unless the groups of wedge marks are separated it is always possible to miscalculate the indicated number.

The Mayans, on the other hand, used a vigesimal system but with a serious irregularity since its units were 1, 20,  $18 \times 20$ ,  $18 \times 20^2$ ,  $18 \times 20^3$ , and so on. Thus in this system the glyph representing a seashell (which is the 0) does not work as an operator, as it should in a true place value system. Furthermore, the numbers upto 20 are

additive as in the case of the Babylonian system, and therefore there exists the same possibility of ambiguity. The surviving inscriptions and codices do not write the numbers without specifying the units, which eliminates ambiguity but shows that the abstract nature of the place value number system was not fully understood. Clearly this system was also not designed for the needs of ordinary calculations. The rationale behind the Mayan system was the counting of the days of 18 months, each of 20 days.

Philipp Frank has argued persuasively<sup>22</sup> that new philosophical systems have followed fundamental advances in science and, furthermore, this philosophy is a mere generalization of the conceptual advance. One would, therefore, expect that such a process must have characterized the full development of the zero sign as well. In the second to third century A.D., Nāgārjuna founded the *Mādhyamikā* (Middle Way) school of Buddhism.<sup>23</sup> The main philosophical thesis of this school was the concept of *śūnyatā* (voidness, emptiness, or zeroness), that was taken to characterize the essence of nature. The word *śūnya* represents zero in its technical sense in the earliest Indian records. Another representation of this is the Sanskrit word *kha*, which means space, and which was written down in the Brāhmī script by a circle with a hook on top of it.

It is reasonable to suppose that the development of the zero sign provided impetus for Nāgārjuna's philosophical system. The reverse could be true, but highly unlikely because of the epigraphical evidence from the middle of the second century. The rise of a powerful philosophical school based on the power of the concept of zero, indicates that it is very probable that this epoch was when the zero sign was developed.

## VII

We now take up the question of the interregnum between the Sarasvatī and the Brāhmī writing periods. After the drying up of the Sarasvatī river around 1900 B.C. that led to the collapse of the urban Harappan civilization, the population shifted to the less arid areas of the east and the economy was transformed with concomitant changes in socio-political organization. It was during this long period that the Sarasvatī script slowly transformed into the later Brāhmī. The pottery marks in late second millennium B.C. are reminiscent of the Sarasvatī signs. It is reasonable to assume that this was the period when the logosyllabic Sarasvatī was being reorganized into a proto-Brāhmī script.

The evidence from the Vedic literature also speaks of a gradual relocation from the area of Sapta Sindhu which is practically identical to the Harappan domain. The earliest Vedas describe a society that is partly urban and partly agricultural and pastoral like the Harappan society. This may be seen most easily from the many occupations listed in Yajurveda. The Ṛgveda describes fortified towns. Ṛgvedic ritual requires construction of altars out of bricks. On the other hand, certain structures in the lowest layers of the Harappan ruins have been interpreted as fire altars. The Brāhmanas, which are appendices to the Vedas, describe the phase of slow expansion

to the east, a region that was originally densely forested. They, in turn, are followed by Āraṇyakas and Upaniṣads that capture the cultural transformation, also paralleled in the Harappan evidence, that values living in forests and small farming communities.

That the Vedic people were literate is indicated partially by a reference to the mark of eight that occurs in the Ṛgveda itself. Aitareya Āraṇyaka, of the period of forest dwelling, has a clear reference to how a pupil should do his writing. Several Upaniṣads describe different aspects of the alphabet.

## VIII

The connection between Sarasvatī and Brāhmī is just one more piece of evidence that suggests that the Indus-Sarasvatī tradition was Indo-Aryan and Vedic. It is generally accepted that the Indo-Aryans were present in India during the Harappan phase. But the literary evidence from the Vedic texts with its astronomical time-markers forces one to accept that the tradition must have been Vedic. Although not enough thought has been given to such a conclusion in the West, it does not contradict the different proposals by Gimbutas,<sup>24</sup> T.V. Gamkrelidze and V.V. Ivanov,<sup>25</sup> Colin Renfrew<sup>26</sup>, and Mallory<sup>27</sup> that posit a dispersal of the Indo-European languages at different periods ranging from the 4th to the 7th millennium B.C. It also agrees with the analysis of the literary evidence that indicates an unbroken tradition going back to several millennia B.C.<sup>28</sup> One might posit that the Indo-Aryans spread outside of the original Sapta Saindhava area with the spread of farming. This makes the mechanism of their expansion similar to the one that has been recently suggested for the spread of the Indo-Europeans into Europe.<sup>29</sup>

The relationship between Sarasvatī and Brāhmī is one more piece of evidence that interlocks with other similar evidence from archaeology and literature linking the Harappan and Gaṅgā civilizations. It opens up a new direction for a further study of the Sarasvatī script. The beginnings of the Sarasvatī script remain shrouded in mystery. Might these beginnings have had any connections with the writing of the Sumerians is a tantalizing question.

## REFERENCES

1. Jarrige, J.F. and Meadow, R.H., Antecedents of Civilization in the Indus Valley, *Scientific American*, 243(2), 122-133, 1980.  
 Possehl, G.L. (ed.), *Harappan Civilization—A Contemporary Perspective*. Aris & Phillips, Warminster, U.K., 1982.  
 Kenoyer, J.M. (ed.), *Old Problems and New Perspectives in the Archaeology of South Asia*, Wisconsin Archaeological Reports, Madison, 1989.  
 Rao, S.R., *Dawn and Devolution of the Indus Civilization*. New Delhi: Aditya Prakashan, 1991.  
 Nayak, B.U. and Ghosh, N.C. (ed.), *New Trends in Indian Art and Civilization*. New Delhi: Aditya Prakashan, 1992.  
 Kak, S.C., The Indus tradition and the Indo-Aryan, *Mankind Quarterly*, 32, 195-213, 1992.
2. Kak, S.C., The structure of the Ṛgveda, *Indian Journal of the History of Science*, 28, 71-79, 1993.

3. Shaffer, J.G., The Indo-Aryan invasions: cultural myth and archaeological reality, in *The People of South Asia*, edited by Lukacs, J.R., New York: Plenum, 1984.
4. Upasak, C.S., *The History and Paleography of Mauryan Brāhmī Script*, Nalanda: Nava Nalanda, 1957.
5. Mitchiner, M., *The Origins of Indian Coinage*, London: Hawkins Publications, 1973.
6. Fabri, C.L., The punch-marked coins: a survival of the India civilization. *Journal of the Royal Asiatic Society*, 307-318, 1935.  
Mainkar, V.B., Metrology in the Indus civilization. In B.B. Lal and S.P. Gupta (eds.), *Frontiers of the Indus Civilization*, New Delhi: Books and Books, 1984.
7. Ardika, I.W. and Bellwood, P., Sembiran: the beginnings of Indian contact with Bali. *Antiquity*, 65, 221-232, 1991.
8. Kak, S.C., The structure of the Ṛgveda, *op.cit.*  
Kak, S.C. The astronomy of the Vedic altars and the Ṛgveda. *Mankind Quarterly*, 33, 43-55, 1992.  
Kak, S.C. and Frawley, D., Further observations on the Rigvedic code. *Mankind Quarterly*, 33, 163-170, 1992.  
Kak, S.C., Planetary periods from the Rigvedic code. *Mankind Quarterly*, 33, 443-442, 1993.  
Kak, S.C., The astronomy of the Vedic altars. *Vistas in Astronomy*, 36, 117-140, 1993.
9. Misra, V.N., Research on the Indus civilization: a brief review, *Eastern Anthropologist*, 45, 1-19, 1992.
10. Shaffer, J.G., The Indus Valley, Baluchistan and Helmand Traditions: Neolithic through Bronze Age. In Ehrich, R. (ed.), *Chronologies in Old World Archaeology (3rd Edition)*, Chicago: University of Chicago Press, 1992.  
Shaffer, J.G. and Lichtenstein, D.A., Ethnicity and change in the Indus valley cultural tradition. In Kenoyer, *op.cit.*
11. Meadow, R.H., Continuity and change in the agriculture of the greater Indus valley. In Kenoyer, *op.cit.*
12. Thapar, B.K., *Recent Archaeological Discoveries in India*, Paris: UNESCO, 1985.
13. Dhavalikar, M.K. and Atre, S. Fire cult and human sacrifice: some Harappan rituals. in Kenoyer, *op.cit.*
14. Mahadevan, I., *The Indus Script*, Delhi: Memoirs of the Archaeological Survey of India, 1977.  
Joshi, J.P. and Parpola, A. (eds.) *Corpus of Indus Inscriptions*, Delhi: Memoirs of the Archaeological Survey of India, 1987.
15. Thaplyal, K.K., *Studies in Ancient Indian Seals*, Lucknow, 1972.
16. Upasak, *op. cit.*
17. Kak, S.C., On the decipherment of the Indus script – a preliminary study of its connection with Brāhmī, *India J. of History of Science*, 22, 51-62, 1987.  
Kak, S.C., A frequency analysis of the Indus script, *Cryptologia*, 12, 129-143, 1988.  
Kak, S.C., Indus writing, *Mankind Quarterly*, 30, 113-118, 1989.  
Kak, S.C., Indus and Brāhmī: further connections, *Cryptologia*, 14, 169-183, 1990.
18. Kinnier Wilson, J.V., *Indo-Sumerian*, Oxford, 1974. Also, Saindhavaśilā-rock salt.
19. G. Ifrah, *From One to Zero*. Viking Penguin, New York, 1985.
20. Kak, S.C., The sign for zero, *Mankind Quarterly*, 30, 199-204, 1990.
21. B. Datta and A.N. Singh, *History of Hindu Mathematics*. Asia Publishing, Bombay, 1938, 1962.
22. P. Frank, *International Encyclopedia of Unified Science*, edited by O. Neurath, R. Carnap, C. Morris. Chicago, 1938, 1955.

23. R.H. Robinson, *Early Mādhyamika in India and China*, University of Wisconsin Press, Madison, 1967.
24. Gimbutas, M., Primary and secondary homeland of the Indo-Europeans. *J. of Indo-European Studies*, 13, 185-202, 1985.
25. Gamkrelidze, T.V. and Ivanov, V.V., The ancient Near East and Indo-European question: Temporal and territorial characteristics of proto-Indo-European based on linguistic and historico-cultural data, *J. of Indo-European Studies*, 13, 3-91, 1985.  
D'iakonov, I.M., On the original home of the speakers of Indo-European, *J. of Indo-European Studies*, 13, 92-174, 1985.
26. Renfrew, C., *Archaeology and Language*, London: Jonathan Cape, 1987.
27. Mallory, J.P., *In Search of the Indo-Europeans*, New York: Thames and Hudson, 1989.
28. Tilak, B.G., *The Orion*, Pune, 1893, 1989.  
Pargiter, F.E., *Ancient Indian Historical Tradition*, Oxford University Press, London, 1922.  
Sengupta, P.C., *Ancient Indian Chronology*, University of Calcutta Press, Calcutta, 1947.  
Roy, S.B., Chronological framework of Indian protohistory — the lower limit, *Journal of the Baroda Oriental Institute*, 32, 254-274, 1983.  
Kak, S.C., On the chronology of ancient India, *Indian Journal of History of Science*, 22, 222-234, 1987.
29. Ammerman, A.J. and Cavalli-Sforza, L.L., *The Neolithic Transition and the Genomics of Populations in Europe*, Princeton University Press, 1984. Sokal, R.R., Oden, N.L., and Wilson, C., Genetic evidence for the spread of agriculture in Europe by demic diffusion, *Nature*, 351, 143-145, 1991. Kak, S.C., The Indus tradition and the Indo-Aryans, *op. cit.*