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Interconnected vowel shifts in Tocharian

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Abstract

The present article sets two goals: (i) to investigate the inner-Tocharian evolution of the Proto-Indo-European vowel system in light of the general principles of vowel shifts; (ii) to examine not only how the Proto-Indo-European vowel system led to the Proto-Tocharian (PT) vowel system, but also how the latter system further evolved in the attested Tocharian languages. As for (i), I argue the Pre-Proto-Tocharian vowel shifts to have been triggered by two fundamental changes, namely, the fronting of Pre-PT */ɔ/ to */ɛ/ and the assimilation of Pre-PT */iu̯/ to */uu̯/. As for (ii), I argue that, in Tocharian B, the central vowels /a, ə/ (< PT */a, ə/) developed the higher allophones [ə, ɨ] when unstressed. In Tocharian A, instead, the PT vowel system underwent a chain shift, whose trigger was the monophthongization of the PT diphthongs */ɛi̯, ai̯, ʔ ɔi̯/ and */ɛu̯, au̯/.

Keywords

Tocharian – vowels – vowel systems – vowel shifts – chain shifts

Introductory remarks

The reconstruction of the Proto-Tocharian (PT) vowel system has been treated in detail in two recent papers, namely, Peyrot (2019, especially 81–83) and Warries (2022, especially 188–206). While building on the insightful results of these papers, the present article sets two goals: (i) to investigate the inner-Tocharian evolution of the Proto-Indo-European (PIE) vowel system in light of the general principles of vowel shifts;[1] (ii) to examine not only how the PIE vowel system led to the PT vowel system, but also how the latter system further evolved in the attested Tocharian languages, namely, Tocharian A (TA) and Tocharian B (TB).

The paper is structured as follows. After a brief description of the vowel system that Tocharian inherited from PIE (section § 1), section § 2 is concerned with the reconstruction of the PT vowel system. I first review the vowel systems that have been previously reconstructed for PT (§ 2.1), then discuss some debated issues concerning the PT vowels (§ 2.2), and finally propose my own PT reconstruction (§ 2.3). In section § 3, I try to bridge the gap between Pre-Proto-Tocharian (Pre-PT) and PT. After having reviewed the literature on this topic (§ 3.1), I present a four-step scenario (§ 3.2) that explains how the Pre-PT vowel system set up in § 1 developed into the PT vowel system reconstructed in § 2. This paves the way for section § 4, which deals with the further evolution of the PT vowel system in TB (§ 4.1) and TA (§ 4.2); there, I discuss the synchronic vowel systems of both languages and show how they can be derived from the vowel system of PT. Section § 5 contains a summary and conclusion.

1 Point of departure: The Pre-Proto-Tocharian vowel system

This section lays out the vowel system that Pre-PT inherited from PIE. In particular, the starting point of my analysis is the Pre-PT vowel system that arose after the PIE laryngeals had undergone loss or "vocalization" in most positions, specifically:

– PIE *Ch_xC > Pre-PT *CaC;
– PIE *$V_{[\text{-high}]}h_x.C$ > Pre-PT *$\bar{V}_{[\text{-high}]}.C$;
– PIE *$C\mathring{R}.h_xV$ > Pre-PT *$C\text{ə}R.h_xV$ > *$C\text{ə}.RV$ (§ 3.2.1.i below);

1 See Labov (1994: 113–291).

– PIE *$C\underset{\circ}{R}h_x.C$ > Pre-PT *$C\partial Rh_x.C$ > *$C\partial R.C$;[2]
– PIE *h_xCV- > Pre-PT *CV-;
– PIE *$h_1\underset{\circ}{R}C$- > Pre-PT *$\underset{\circ}{R}C$-;
– PIE *$h_{2/3}\underset{\circ}{R}C$- > Pre-PT *$aRC$-;[3]
– PIE *-$Uh_{2/3}$(-) > Pre-PT *-$\underset{\circ}{U}a$(-).[4]

My reconstruction of the Pre-PT vowel system at this chronological stage is characterized by the following two assumptions. First, I assume that the Pre-PT long and short vowels had approximately the same quality, and specifically that the long and short mid vowels occupied a mid-low position in the vowel space, i.e., */ɛ̄, ɔ̄/ and */ɛ, ɔ/. On the one hand, this assumption may seem to run against the typological tendency according to which mid vowels are usually mid-high if long but mid-low if short.[5] However, vowel systems with only mid-low long and short vowels do exist. For instance, in the Ancient Greek "Strict Doric" dialects (e.g., Laconian) the short mid-low vowels /ɛ, ɔ/ < PIE *e, *o (spelled ⟨ε, ο⟩) yielded the long mid-low vowels /ɛ̄, ɔ̄/ (spelled ⟨η, ω⟩) as the result of the first compensatory lengthening and of vowel contractions. In these dialects, the new long mid-low vowels /ɛ̄, ɔ̄/ merged with the continuants of (Late) PIE *$ē$, *$ō$.[6] Since the inherited diphthongs /ɛi̯, ɔu̯/ had not yet been monophthongized to /ē, ō/ at this stage,[7] the result was precisely a vowel system with only long and short mid-low vowels, namely, /ɛ̄, ɔ̄/ and /ɛ, ɔ/.

Second, I adopt an "intercalated" representation of the short and long vowel subsystems, in which the short vowels make up the non-peripheral subsystem, whereas the long vowels (and diphthongs) constitute the peripheral subsystem.[8] The association of vowel length with peripherality is more common typologically than the reverse and is robustly documented in modern language varieties.[9]

Accordingly, the starting point of my analysis is the Pre-PT vowel system shown in Figure 1. It is important to remark that Figure 1 refers exclusively to an early stage of Pre-PT and does not imply that these vowels had the same phonetic value already in (Nuclear) PIE. More generally, it is also worth stressing

2 See Hackstein (1995: 29).
3 See Hackstein 1998.
4 See, e.g., Pinault (1997: 219–221).
5 See Maddieson (1984: 129–130); Allen (1987: 23).
6 See Lejeune (1972: 233); Rix (1992: 50, 53, 56); Miller (2014: 183[92], 196); Cassio (2016: 20, 25, 38).
7 See Lejeune (1972: 229–230, 233); Rix (1992: 46–47, 48–49).
8 On peripherality in vowel systems, see Crothers (1978: 100); Lindau (1978: 556–558); Lass (1984: 94–95); Maddieson (1984: 123–124); Allen (1987: 22); Labov (1994: 172–173, 177, 226; 2010: 145–149).
9 See Labov (1994: 230, 245).

that our understanding of the phonetic features of segments in reconstructed inventories is only approximative.

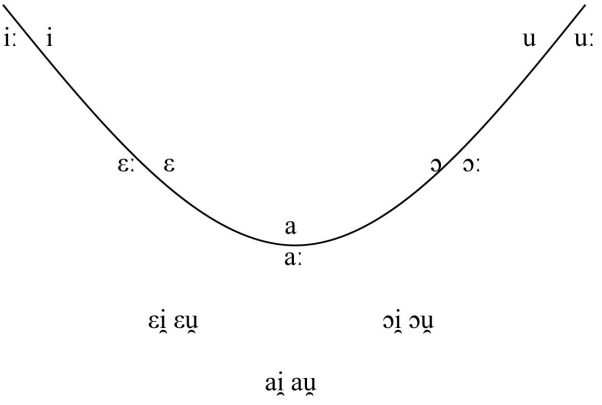

FIGURE 1
The Pre-PT vowel system after the loss and/or "vocalization" of laryngeals in most positions

2 Reconstructing the Proto-Tocharian vowel system

The present section addresses the reconstruction of the PT vowel phonemes: § 2.1 reviews previous reconstructions of the PT vowel system; § 2.2 discusses some debated issues concerning the PT vowels; § 2.3 presents my own reconstruction of the PT vowel system.

2.1 *Previous reconstructions*

2.1.1 Adams (1978: 450)

i		u
e	ă	o
æ	ā	ɔ

2.1.2 Jasanoff (1978: 33)

i	ɨ	u
e		o
	a	

A PT vowel system of this sort is also assumed by Peyrot (2019: 82), who notates /ɨ/ as /ə/. Peyrot (2019: 83) further argues that a back mid-high vowel **o̧* arose through /u/-umlaut at a later stage of PT.

2.1.3 Ringe

Ringe (1987: 121):

i u
o_2
ə
e ë o
a

Ringe (1996: 167, see also p. 131):

i /əi̯/ ə u /əu̯/
ẹ ọ
e ë o
a

2.1.4 Pinault (2008: 420–422)

i ɨ u
o
ɛ ɔ
a

ɛi̯ ɛu̯
ai̯ au̯

2.1.5 Warries (2022: 195 et *passim*)

əi̯~i əu̯~u
ə
e o
a å

2.1.6 Weiss (2022: 136)

i /əi̯/ u /əu̯/
ə o
æ å
a

2.2 *Discussion*

In the present section, I discuss some points of debate concerning the PT vowel system (§ 2.2.1–2.2.6). The main results of the discussion are summarized in § 2.2.7 (Table 1). They lay the foundation for the reconstruction of the PT vowel system presented in the next section (§ 2.3).

2.2.1 PT **œ*

The PT vowel traditionally notated as **œ* (< PIE **o*) has been argued by Ringe (1996: 90) to be 'some sort of nonfront unround mid vowel,' which he notated as */ë/.[10] In contrast, most scholars pleaded for an interpretation of PT **œ* as */ɛ/ (front mid-low unrounded).[11] In the following, I will adopt the latter view. Note further that the reconstruction of a front mid-low phoneme PT */ɛ/ is made likely by the existence of a back mid-low counterpart PT */ɔ/ (< (Late) PIE **ā*), which is traditionally notated as **å*.[12]

2.2.2 PT **e*

Alongside the central phoneme PT */ë/ (< PIE **o*), Ringe (1990: 223–226; 1996: 91–92, 132)[13] proposed reconstructing a front mid-low phoneme going back to (Late) PIE **ē*, which he notated as PT */e/. According to Ringe, PT */ë/ would have become TB *e*, TA *a*, as in TB *keme*, TA *kam* 'tooth'. In contrast, PT */e/ would have become (i) TB *e*, TA *o* next to non-palatalized **p* and **m* (cf. TB *ñem*, TA *ñom* 'name' and obl. sg. m. TB *ṣeme*, TA *ṣom* 'one') but (ii) TB *e*, TA *a* otherwise (cf. TB *meñe*, TA *mañ* 'moon').[14] Nonetheless, this hypothesis finds a counterexample in TA *cmol* (: TB *camel*) 'birth'. According to Ringe, TA *o* can, in fact, only go back to PT */e/ (< (Late) PIE **ē*), which would have palatalized a preceding consonant. If this had happened, however, a putative PT */tʲə**mʲe**l/ ought to have led to TA *ˣc**mal*** rather than to TA ***cmol***, in the same way as a putative PT */**mʲe**nʲe/ yielded TA ***mañ***. Therefore, I prefer to follow the traditional view and reconstruct only one phoneme PT */ɛ/ (front mid-low unrounded), which resulted from the merger of (i) PIE **o* and (ii) (Late) PIE **ē*.[15]

10 See also Ringe (1990: 223).

11 See Jasanoff (1978: 32–33); Pinault (2008: 420–421); Hackstein (2017: 1309); Warries (2022: 202); and further Meier & Peyrot (2017: 19); Peyrot (2019: 82). But note that Jasanoff himself (1978: 33[18–19]) does not exclude the possibility that PT **œ* was actually */ʌ/, with which he notates a central mid unrounded vowel.

12 See Recasens & Espinosa (2009: 242): '[ɛ] occurs in 83% of the world's languages endowed with [ɔ].'

13 See also Kim (1999: 127–128 with n. 44).

14 See especially Ringe (1990: 226).

15 See Jasanoff (1978: 30, 32–33); Pinault (2008: 420); Peyrot (2013: 395); (2019: 82); Warries (2022: 195); Weiss (2022: 134).

PT */ɛ/ normally yielded TB *e*, TA *a*, as in TB *keme*, TA *kam* 'tooth' or TB *meñe*, TA *mañ* 'moon'. In the prehistory of TA, however, a sporadic tendency to round what should have become TA *a* into *o* arose in several environments, e.g.:
– / #_*P*, cf. TA *omäl* (: TB *emalle*) 'hot';
– / #_*ŋkw*, cf. TA *oṅk* (: TB *eṅkwe*) 'man';
– / #*C*^{j}_*m*, cf. TA *ñom* (: TB *ñem*) 'name' and obl.sg.m. TA *ṣom* (: TB *ṣeme*) 'one';
– / $m_{[\text{-initial}]}$_*l*, cf. TA *cmol* (: TB *camel*) 'birth' vs. TA *malañ* (: TB *meli*) 'nose'.[16]
The sporadic nature of this phenomenon is evident from cases like TA ***por****at* (: TB *peret*) 'ax' ← Iran. **paraću-* vs. TA ***par****äṃ* (: TB *perne*) 'glory' ← Iran. **farnah-*.[17]

2.2.3 PT **ä*

According to Jasanoff (1978: 30–31),[18] the PT vowel traditionally notated as **ä* (< PIE **i*, **e*, **u*) corresponds to a phoneme /ɨ/ (central high unrounded) rather than /ə/ (central mid unrounded), for the following two reasons: (i) TAB *ä* is rounded to a high vowel [u] (not to a mid vowel [o] / [ɔ]) in a labial environment, e.g., TA *yuk* (: TB *yakwe*) 'horse'; (ii) TAB *ä* is palatalized to a high vowel [i] (not to a mid vowel [e] / [ɛ]) in a palatal environment, e.g., TB *ciñcare* 'dear'.

Nevertheless, these arguments do not rule out the possibility of regarding PT **ä* as /ə/ rather than /ɨ/. In Albanian, for instance, the mid vowel /ə/ can become the high vowel /u/ in a labial environment (e.g., OAlb. (*ë*)*m-bëlón* > Alb. *m-bulón* 'cover'),[19] and the PAlb. mid-low vowel */ɛ/ became the high vowel */i/ before a palatalized consonant.[20] Accordingly, I prefer to analyze PT **ä* as a central mid unrounded phoneme */ə/. This view also seems to be shared by Adams (1978: 450), Jasanoff (2015: 90), and Weiss (2022: 124–125, 136), and may be supported by the fact that reconstructing a phoneme */ɨ/ for PT would make it more difficult to account for the synchronic vowel system of TB (as I will argue in more detail in § 4.1.1.2 below).

Finally, PT **ä* also continues the epenthetic vowel that arose from the PIE syllabic resonants. However, this observation is not particularly helpful for determining the phonetic nature of PT **ä*. According to Lombardi (2002), epenthetic vowels crosslinguistically depend on what vowels are or are not phonemically

16 See *in nuce* Jasanoff (1978: 33–34) and further Ringe (1987: 113–114); Hilmarsson (1991: 13, 130, 192–193); Pinault (2008: 451–452).
17 See Kim (1999: 127–129) and Pinault (2008: 393), respectively. See further Bernard (2025: 38–43, 43–45) (with gloss of TB *perne*, TA *paräṃ* as 'fortune, good fortune').
18 Followed by Winter (1993: 205; 1998: 157–158); Ringe (1996: xxii, 99); Pinault (2008: 420, 421); Hackstein (2017: 1304, 1309); Peyrot (2019: 82); Warries (2022: 175, 198, 199). Less explicit is Malzahn (2010: 2–3): 'central vowel **ä*.'
19 See *DPEWA* s.v. *mbulon*.
20 See Schumacher & Matzinger (2013: 219–220).

contrastive in the system: specifically, [ɨ] is epenthetic if present in the system, [ə] is epenthetic if it is present and [ɨ] is not, whereas [i] is to be expected if neither [ɨ] nor [ə] is part of the system. Apparently, Pre-PT does not fit into this typology: although no central high or mid vowel was part of the system when *[R̥] developed to **äR* at an early Pre-PT stage (§ 3.2.1.i below), the epenthetic vowel cannot have been Pre-PT *[i], since it did not palatalize preceding consonants (cf., e.g., PIE acc. sg. **ḱu̯ón-m̥* > obl. sg. TB *kweṃ*, TA *koṃ* 'dog').

2.2.4 PT */əi̯, əu̯/

Building on Adams (1978: 447), most scholars assumed that the PIE diphthongs **ei̯*, **eu̯* (> pre-palatalizing TAB *i*, *u*) yielded the PT monophthongs *[i, u] on the surface but remained diphthongal at the underlying level—i.e., PT */əi̯, əu̯/.[21] In contrast, other scholars argued the monophthongization process to have been fully completed (also underlyingly) already in PT and thus reconstructed the high vowels */i, u/$_{[+pal.]}$ for the latter stage.[22]

In line with the former hypothesis, in the following I will assume that PT had the central diphthongs */əi̯, əu̯/. A compelling reason supporting this assumption is that PIE **-ei̯* in absolute final position yielded *-i* in both Tocharian languages. This development is best evidenced by the gen. sg. ending TAB *-i*, which typically occurs in relationship terms (e.g., TB *pātr-i*, TA *pācr-i* 'of the father') and most likely goes back to the athematic dat. sg. ending PIE **-ei̯*.[23] Another potential example is the infinitive ending TAB *-tsi*, which has been claimed to continue Late PIE **-ti̯-ei̯* (i.e., the dat. sg. of *ti*-stem abstracts) or **-dʰi̯ei̯* (i.e., a recharacterized variant of the infinitive ending PIE **-dʰi̯eh₁*).[24] Had PIE **-ei̯* become */-i/ already in PT, it would be hard to explain why PT */-i/ did not undergo apocope in TA.[25] Therefore, it is preferable to assume that PIE **-ei̯* first developed to PT */-əi̯/$_{[+pal.]}$ and then monophthongized to /-i/ independently in the prehistory of TB and TA—in the latter branch, though, only after the apocope of final vowels had run its course.

If this was the fate of PIE **ei̯* in absolute final position, it is conceivable that its development in internal position was identical. Moreover, I surmise that the corresponding diphthong **eu̯* developed along a parallel path in Tochar-

21 See Ringe (1996: xxii, 135) (though cautious at the end of § 53), 136; Hackstein (2017: 1315); Weiss (2022: xxviii); and further Warries (2022: 198–199).

22 See Pinault (2008: 422); Peyrot (2019: 82); and further Warries (2022: 190, 192).

23 See Pinault (2008: 443, 489); Weiss (2022: 137).

24 See Ringe (1996: 79) and Garnier & Pinault (2020: 367–370), respectively.

25 Unless (as Ronald Kim kindly reminds me) one is willing to assume that in TA—like, e.g., in Proto-Germanic—only non-high vowels underwent apocope.

ian, namely, PIE *$e\underset{\cdot}{u}$ > PT */ə$\underset{\cdot}{u}$/$_{[+pal.]}$ > (i) Pre-TB */ə$\underset{\cdot}{u}$/ > TB /u/$_{[+pal.]}$, (ii) Pre-TA */ə$\underset{\cdot}{u}$/ > TA /u/$_{[+pal.]}$.

2.2.5 PT *$\underset{\cdot}{e}$

Ringe (1990: 236[57]; 1996: 81–86) proposed the reconstruction of a front mid-high phoneme PT */ẹ/ (= IPA [e]), which would have developed—through an intermediate stage Pre-PT */ē/—from the unstressed word-final diphthong PIE *-*oi̯* in polysyllabic words.[26] PT */ẹ/ would have yielded TB *-i*, TA *-e*, as in the nom. pl. m. TB *ratr-i*, TA *rätr-e* 'red' < PT */rətr$^{(j)}$ẹ/ < PIE *$h_1rud^hr\acute{o}i̯$. Moreover, its ancestor Pre-PT */ē/ would have triggered palatalization of (at least some) preceding consonants, as shown by presumed relic forms like nom. pl. TB *kokaly-i* 'chariots' (~ obl. pl. *kokaleṃ*, nom. sg. *kokale*).

Although this scenario may seem convincing, Del Tomba (2020, especially 23–26, 28–30) correctly addressed the following difficulties. First, a PT monophthong */ẹ/ would be expected to undergo apocope in TA, cf. *mutatis mutandis* § 2.2.4 on the development of PIE *$e\underset{\cdot}{i}$ and *$e\underset{\cdot}{u}$. Second, the assumption that the Pre-PT ancestor of PT */ẹ/—namely, */ē/—had a palatalizing effect on preceding consonants meets with several counterexamples: cf. the nom.pl. forms TB *mel-i* 'nose' (~ obl.pl. *meleṃ*; *plurale tantum*) or TB *ṣal-i* 'mountains' (~ obl. pl. *ṣaleṃ*, nom. sg. *ṣale*) as well as the type of TB *rek-i*, TA *rak-e* 'word', TB *lek-i*, TA *lak-e* 'bed', etc., whose stem-final consonants exhibit no trace of palatalization. Arguing the stem-final palatalization to have been analogically undone in the nom. pl. TB *meli*, *ṣali*, etc. (thus Ringe 1996: 82, 144) is unattractive, since in the Tocharian nominal system there are many nom.pl. forms with palatalized stem-final consonants—e.g., (i) the adjectives with nom. pl. m. in TB °*lyi*, TA °*lye* (~ nom. sg. m. TB °*lle*, TA °*l*) and TB °*cci* (~ nom. sg. m. °*tte*) or (ii) the substantives of class V.2 with nom. pl. °*Cʲ-i* ~ obl. pl. °*C-äṃ*/*s* (type TB *lyś-i* ~ *lyak-äṃ*, TA *lyś-i* ~ *lyk-äs** 'thieves'). Accordingly, a palatalized nom. pl. like TB *kokalyi* 'chariots' is best analyzed as an innovation rather than as an archaism. As argued by Del Tomba (2020: 25–26), TB *kokalyi* most likely shows a 'secondary (i.e., Tocharian B) palatalization of *-l-* caused by the nom. pl. *-i*.'

Alternatively, Pinault (2008: 443, 512) proposed that PIE *-*oi̯* developed first to PT *-*œy* and then underwent weakening to *-*äy*, which would have been the source of TB *-i*, TA *-e*.[27] On the one hand, this hypothesis is attractive, as reconstructing a diphthong for PT neatly accounts for the absence of apocope in TA. On the other hand, however, no parallels for the monophthongization of PT *-*äy* > TA *-e* are known.

26 So also Klingenschmitt (1994: 389); Kim (2000: 38; 2018: 64–65, 70–71); Hackstein (2017: 1315).

27 See also Adams (1990: 69–70); Peyrot (2019: 82–83).

Therefore, following Del Tomba (2020: 31–32), I assume that PIE *-*oi̯* regularly became non-palatalizing */-ɛi̯/ (= *-*œy*) in PT and was inherited as such in the Tocharian languages. In TA, PT */-ɛi̯/ expectedly monophthongized to *-e*. In TB, instead, unstressed word-final */-ɛi̯/ underwent weakening to */-əi̯/ (> TB *-i*) in polysyllabic words and thus fell together—except for the lack of preceding palatalization—with the outcome of PIE **ei̯* (§ 2.2.4).

2.2.6 PT *ϱ and *$\tilde{o}$

In agreement with most scholars (§ 2.1), I reconstruct a back mid-high vowel PT */o/. This phoneme has two main sources.

The first source is the phonemicization of the outputs of /u/-umlaut. After Pre-PT */i, ɛ, u/ (< PIE **i*, **e*, **u*) merged as */ə/, the back allophones of the Pre-PT descendants of (Late) PIE **o* and **ē* in the context /_.C_0*u* became phonemic and ultimately resulted in PT */o/, traditionally notated as *ϱ. The latter is continued as *o* in both TA and TB.

Following Pinault (2008: 421–422, 431–433, with notation *$\tilde{o}$),[28] I assume that the second source of the phoneme PT */o/ was the nom. sg. of PIE words whose stem ended in *°*on-* or *°*ont-*. The nom. sg. of these words can be reconstructed in two ways: either as (i) PIE *°*ōn* (< *°*on-s*) and *°*ōnt* (<< *°*ont-s*), with (regular and analogical) application of Szemerényi's Law; or as (ii) PIE *°*ōn-s* and *°*ōnt-s*, with analogical reintroduction of the nom. sg. ending *-*s* after the application of Szemerényi's Law. Despite the fact that (Late) PIE **ō* normally yields PT */a/ > TB *a* ~ *ā*, TA *ā*, the PIE sequences under discussion led to a different result in the Tocharian languages. In TB, one finds word-final *-o*. Further, as shown in (1), if the word contains a root vowel going back to (i) PIE *-*eu̯-*, (ii) PIE *(-)*u-*, (iii) PIE *#(h_1)*R̥-*, or (iv) PIE *-*o-*, this vowel undergoes umlaut to TB *-o-*. Remarkably, if the root vowel goes back to PIE *-*R̥-* (except when preceded by *#h_1), no umlaut took place, as shown in (1.v).[29] In TA, the word-final reflex is not visible due to the regular apocope in this language, but the umlaut conditions of the root vowel are the same as in TB. In TA as well, the result of the umlaut process is *-o-*; see the examples in (1).

(1) Development of PIE words whose stem ended in *°*on-* or *°*ont-* in Tocharian

i. PIE stem **kléu̯-mon-* 'famous' > PT nom. sg. m. **klʲomo* > TB /klʲomo/ → *klyomo* 'noble', TA **klʲomo* > /klʲom/ → *klyom* 'id.';

28 See also Hilmarsson (1986: 20, 29); Ringe (1996: 10–11); Warries (2022: 189 with nn. 7–8, 191, 193).

29 See Warries (2022: 191).

ii. PIE stem *(h_x)*uKson-* > PT nom. sg. *$(\underset{\cdot}{u})$*okso* > TB *okso* 'ox', TA *$(\underset{\cdot}{u})$*okso* > *$(\underset{\cdot}{u})$*oks* > *okäs** (~ nom. pl. *ops-i*) 'id.';[30]

iii. PIE stem *$h_1 r g^w$-mon-* 'dark' > PT nom. sg. m. *ork^wmo > TB *orkmo* > (anaptyxis) /orkə́mo/ → *orkamo* 'id.', TA *orkmo* > *$orkm̥$ > *orkäm* 'id.';

iv. PIE stem *$sol(h_2)$-mon-* 'whole' > PT nom. sg. m. *solmo* >> TB *solme* 'id.';[31]

v. But: PIE stem *$\underset{\cdot}{u}l̥h_x$-ont-* > PT nom. sg. *$\underset{\cdot}{u}$əlo* (not *$^x\underset{\cdot}{u}olo$) > TB /u̯ólo/ → *walo* 'king', TA *$\underset{\cdot}{u}$əlo* > *wäl* 'id.'.

The next question to ask is thus: how did the PIE sequences *$^{\circ}\bar{o}n(-s)$ and *$^{\circ}\bar{o}nt(-s)$ lead to a phoneme PT */o/ (> TAB *o*)? In my view, the most plausible way to answer this question is (i) to start from recharacterized nom. sg. forms ending in *$^{\circ}\bar{o}n$-s* and *$^{\circ}\bar{o}nt$-s* and (ii) to assume an (originally allophonic) raising */ɔ̄/ → *[ō] in the context */_ns#*.[32] This means: PIE *$^{\circ}\bar{o}ns$ ~ *$^{\circ}\bar{o}nts$ > (/t/-loss) Pre-PT */$^{\circ}$ɔ̄ns/ → (/ɔ̄/-raising) *[$^{\circ}$ōns] > (/n/-loss in a tetramoraic final sequence) */$^{\circ}$ōs/ > (/s#/-loss) */$^{\circ}$ō/.[33] Thus, a new phoneme Pre-PT */ō/ arose. The latter yielded PT */o/ after the loss of phonemic vowel length (§ 3.2.4 below). Moreover, Pre-PT */ō/ triggered umlaut of the vowels */u/ and */ɛ/ in the preceding syllable; the details of this umlaut process will be dealt with in § 3.2.3.ii. Of course, the assumed raising Pre-PT */$^{\circ}$ɔ̄ns/ → *[$^{\circ}$ōns] must have taken place before Pre-PT */ɔ̄/ (< (Late) PIE *$\bar{o}$) had begun its descent across the vowel space to yield PT */a/. This explains why Pre-PT */ɔ̄/ in the specific environment */_ns#* escaped the usual development Pre-PT */ɔ̄/ > PT */a/.

I specified the environment of the Pre-PT raising */ɔ̄/ → *[ō] as */_ns#* because I hold that a word-final sequence Pre-PT */-ɔ̄n/ yielded PT */-an/ > TB /-aṇ/ → *-ai*. Such a development was first proposed by Winter (1987: 306) in order to

30 Though only marginally relevant here, it is worth noting that a nom. sg. TA *opäs** (instead of *okäs**) is also possible, see the discussion in Bernard (2024: 294).

31 The nom. sg. m. ending *-e* here instead of expected *-o* has been analogically transferred from the coexisting strong (i.e., thematic) paradigm, see Imberciadori (in print) s.v. B *solme*, A *salu*.

32 Notably, an (originally allophonic) raising in nasal environment would be phonetically expected for a low or mid-low vowel, see Lindau (1978: 545); Hawkins & Stevens (1985: 1574); Sampson (1999: 13, 22–23); Kostopoulos (2025). See further Phillips (1980), Allen (1987a: 64), and Filipponio (2016: 16) for parallels from Old English, Ancient Greek, and Rumanian, respectively.

33 Note that the assumption of an /n/-loss in the tetramoraic final sequence Pre-PT *[$^{\circ}$ōns] is not contradicted by the inner-Tocharian development of the thematic acc. pl. ending PIE *$^{\circ}\bar{o}ms$. The latter, in fact, soon became Pre-PT */-ɔms/ (> PT */-ɛns/ > TB *-eṃ*, TA */-ɛ^{j}ns/ > */-ɛṇs/ > */-ɛi̯s/ > *-es*) by analogy to the other thematic endings, thus acquiring a trimoraic rather than tetramoraic shape (see Kim (2012: 146, 149–150)).

account for the voc. sg. ending *-ai* of TB *klyomai* 'o noble' < Pre-PT voc. sg. */klʲɛu̯-mɔ̄n/ (~ recharacterized nom. sg. */klʲɛu̯-mɔ̄n-s/).[34] Scholars who do not accept this explanation of TB *klyomai* can alternatively assume the following scenario: PIE *°*ōn* ~ *°*ōnt* > (/t#/-loss) Pre-PT */°ɔ̄n/ > (/ɔ̄/-raising) *[°ōn] > (/n#/-loss) */°ō/, thus with an (originally allophonic) raising */ɔ̄/ → *[ō] in the context /_*n#*. In this case, it would no longer be necessary to argue that the original nom. sg. forms ending in PIE *°*ōn* (< *°*on-s*) and *°*ōnt* (<< *-*ont-s*) had been recharacterized with the ending *-*s* (see above).

2.2.7 Schematic summary

The results of the preceding discussion are summarized in Table 1.

2.3 *Proposed reconstruction of the Proto-Tocharian vowel system*

Based on the preceding discussion, I reconstruct the PT vowel system presented in Figure 2, which is in substantial agreement with the system reconstructed by Pinault and Weiss (§ 2.1.4, § 2.1.6).

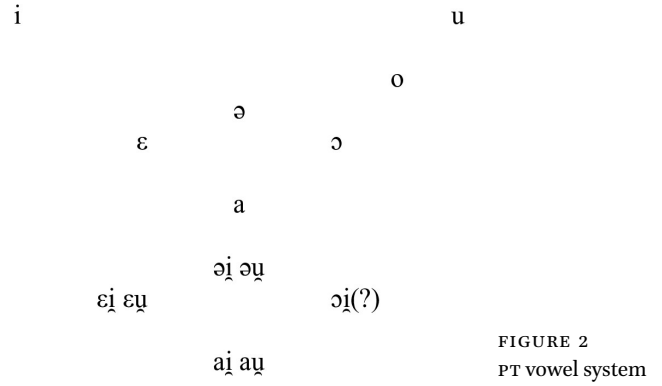

FIGURE 2
PT vowel system

The reconstruction of a PT diphthong */ɔi̯/ is disputed, as it depends on the acceptance of the *Auslautgesetz* PIE *-*s* > PT *-*i̯* in PT monosyllables—cf., e.g., nom. pl. f. PIE **téh₂-es* (> Skt. *tā́s* 'these') > Pre-PT **ta'as* > **tās* > PT **tɔs* > **tɔi̯* > TB nom. pl. f. *toy* 'these'.[35]

34 See also Imberciadori (2025).

35 See Ringe (1996: xxiii–xxiv, 59–61); Katz (1997, especially 71, 80). For skepticism concerning the reconstruction of a PT diphthong */ɔi̯/, see Pinault (2008: 422, 441–442); Del Tomba (2023: 83–84, 262–270) (on TB *toy*).

TABLE 1 List of the phonemically relevant sound changes that affected the Pre-PT vowels

1.	Pre-PT */i/ >	PT */ə/$_{[+pal.]}$ (= *^{j}*ä*)	
2.	Pre-PT */ɛ/ >	PT */ə/$_{[+pal.]}$ (= *^{j}*ä*)	
3.	Pre-PT */a/ >	PT */a/	
4.	Pre-PT */ɔ/ >	PT */ɛ/ (= **æ*)	
		PT */o/ (= **ọ*)	After the phonemicization of /u/-umlaut
		PT */o/	After the phonemicization of /ō/-umlaut
5.	Pre-PT */u/ >	PT */ə/ (= **ä*)	
		PT */o/	After the phonemicization of /ō/-umlaut
6.	Pre-PT */ī/ >	PT */i/$_{[+pal.]}$	
7.	Pre-PT */ē/ >	PT */ɛ/$_{[+pal.]}$ (= *^{j}*æ*)	
		PT */o/$_{[+pal.]}$ (= *^{j}*ọ*)	After the phonemicization of /u/-umlaut
8.	Pre-PT */ā/ >	PT */ɔ/ (= **å*)	
9.	Pre-PT */ō/ >	PT */a/	
10.	Pre-PT */-ō/ >	PT */u/[a]	
11.	Pre-PT */-ōn(t)s/ >	PT */o/ (= **õ*)	
12.	Pre-PT */ū/ >	PT */u/	
13.	Pre-PT */ɛi̯/ >	PT */əi̯/$_{[+pal.]}$	
14.	Pre-PT */ɛu̯/ >	PT */əu̯/$_{[+pal.]}$	
		PT */o/$_{[+pal.]}$	After the phonemicization of /ō/-umlaut
15.	Pre-PT */ai̯/ >	PT */ai̯/	
16.	Pre-PT */au̯/ >	PT */au̯/	
17.	Pre-PT */ɔi̯/ >	PT */ɛi̯/ (= **æy*)	
18.	Pre-PT */ɔu̯/ >	PT */ɛu̯/ (= **æw*)	
19.	Pre-PT *[R̥] >	PT */əR/ (= **äR*)	
		PT */ɛR/ (= **æR*)	In absolute initial position[b]
		PT */oR/	In absolute initial position after the phonemicization of /u/- and /ō/-umlaut

a See Ringe (1996: 89–90); Pinault (2008: 421); Kim (2018: 101–102). This change is explicitly denied by Jasanoff (2018, especially 72–74).

b See Hilmarsson (1991: 11–12); Ringe (1996: 67, 99–100); Jasanoff (2015: 96).

3 From Pre-Proto-Tocharian to Proto-Tocharian

3.1 *Proposed scenarios so far*

A discussion of how the Pre-PT vowel system developed into the PT vowel system has been most recently offered by Meier & Peyrot (2017: 18–19), Peyrot (2019: 81–83), and Warries (2022, especially 188–206).

In particular, Meier & Peyrot (2017: 18–19) and Peyrot (2019: 82) assumed the following pull chain shift: (i) first, the high vowels Pre-PT */i, u/ (< PIE **i*, *u*) turned into the central high unrounded vowel */ɨ/; (ii) afterwards, Pre-PT */ɛ/ (< PIE **e*) moved up to the front high position previously occupied by */i/ and then underwent centralization to */ɨ/; (iii) the gap vacated by */ɛ/ was filled by Pre-PT */ɔ/ (< PIE **o*), which first became a central vowel *[ɜ] (?) and finally a front vowel *[ɛ]; (iv) the monophthongization of Pre-PT */ɛi̯, ɛu̯/ provided new high vowels */i, u/. This scenario—especially (i)–(ii)—would help explain why the Pre-PT form '**mitə*' (thus Meier & Peyrot 2017: 18) 'honey' was borrowed as **mit* in Old Chinese.

With respect to the development in (i), though, one may object that no motivation is provided for why the high corner vowels */i, u/ would have first moved towards the center of the vowel space. In fact, these vowels—especially /i/—tend to be quite stable in the acoustic space, since their peripheral position guarantees the maximal / sufficient dispersion that characterizes vowel systems typologically.[36] In line with this observation is also the fact that, in Indo-European languages, /i/ and /u/ tend to remain fairly stable diachronically. Accordingly, it is unattractive (at least in my view) to assume that the centralization of Pre-PT */i, u/ took place "spontaneously" rather than within the framework of a push or pull chain shift.

For this reason, in the following, I will propose a different relative chronology, which is based (among other things) on the following assumptions: (i) when Pre-PT */i, ɛ, u/ (< PIE **i*, **e*, **u*) were still distinct and had not yet merged as */ə/, Pre-PT */ɔ/ (< PIE **o*) underwent fronting to */ɛ/ due to the acoustic overcrowding in the back of the system (§ 3.2.2.i below); (ii) the centralization of the Pre-PT high vowels */i, u/ was not a "spontaneous" process; rather, these vowels were pushed towards the center of the vowel space due to the acoustic overcrowding in the high region of the system, where the phonemic oppositions */iḭ, ī, i/ (front) and */uṵ, ū, u/ (back) had become too unstable (§ 3.2.3.iii below).

Remarkably, a similar relative chronology—i.e., Pre-PT */ɔ/ > */ɛ/ before Pre-PT */i, ɛ, u/ > */ə/—has also been assumed by Warries (2022: 191[10]) in his ingenious discussion of the (Pre-)PT vowel system. Nevertheless, Warries's scenario does not provide a systemic motivation for the centralization process Pre-PT */i, ɛ, u/ > */ə/, see especially Warries (2022: 194, 199, 205). On p. 197, Warries entertains the possibility that the development Pre-PT */i, ɛ, u/ > */ə/

36 See Martinet (1955: 62, 151, 255); Liljencrant & Lindblom (1972: 840) et *passim*; Crothers (1978: 106, 125, 133); Disner (1983: 4); Maddieson (1994: 142–143); Boë et al. (1994: 188, 199); Schwartz et al. (1997: 243); Gordon (2013: 175–176); Ladefoged & Johnson (2015: 238, 295).

may be due to Proto-Samoyed substrate influence, but he ultimately regards this hypothesis as less likely (p. 208).

Finally, as for the 'honey' word, one may retain Meier & Peyrot's (2019: 18–19) attractive proposal that the borrowing in Old Chinese happened at a Pre-PT stage. In particular, I would assume that Pre-PT */mʲɛtu/ (< PIE **méd^{h}u-*) developed first into */mʲitu/ and then into */mʲətə/ but was still realized as *[mʲitə] on the surface. In line with Meier & Peyrot (2017, especially 19), the surface form *[mʲitə] would have regularly been borrowed as **mit* in Old Chinese. If the borrowing took place before the loss of contrastive vowel length (§ 3.2.4 below), the form *[mʲitə] would have still belonged to Pre-PT. As for the assumption of a Pre-PT phonological rule */ə/ → *[i] / *mʲ_*, cf. TB *mit* 'honey' instead of expected ^{x}*mat* (Pinault 2008: 440).

3.2 *An alternative scenario*

In this section, I propose a four-step scenario that may have led from the Pre-PT vowel system reconstructed in Figure 1 (§ 1) to the PT vowel system set up in Figure 2 (§ 2.3).

3.2.1 Phase 1: Introduction of the new phonemes Pre-PT */ə/ and */ō/

i. Pre-PT */ə/

This new phoneme—which I take to be a central mid unrounded vowel (§ 2.2.3)—arose from the PIE syllabic resonants. Specifically, I assume that Pre-PT */ə/ arose at a time when the Pre-PT vowels */i, ɛ, u/ (< PIE **i*, **e*, **u*) were still distinct.[37] That Pre-PT *[R̥] > */əR/ was an early change is shown by the fact that, in the context **CR̥.h$_x$V*, the development *[R̥] > */əR/ predated the loss of laryngeals: cf. PIE **u̯l̥.h$_x$-V°* > Pre-PT **u̯əl.h$_x$V°* > **u̯ə.lV°* > PT **u̯əlo* > TB *walo*, TA *wäl* 'king'.

ii. Pre-PT */ō/

On the development Pre-PT */°ɔ̄ns/ → *[°ōns] > */°ōs/ > */°ō/ and the creation of the new phoneme Pre-PT */ō/, see § 2.2.6. Note that the new mid-high phoneme Pre-PT */ō/ lacked a front counterpart Pre-PT */ē/.

As for the introduction of the new phonemes Pre-PT */ə/ and */ō/, no relative chronology can be established. The developments described above are summarized in Figure 3a–b. The dotted lines indicate that a given phoneme did not undergo the relevant shift across the board, but only when it occurred in a specific environment (secondary phonemic split).[38]

37 See also Ringe (1996: 77–78); Warries (2022: 190).

38 On this concept, see, e.g., Hamann (2015: 249–250) (with further references).

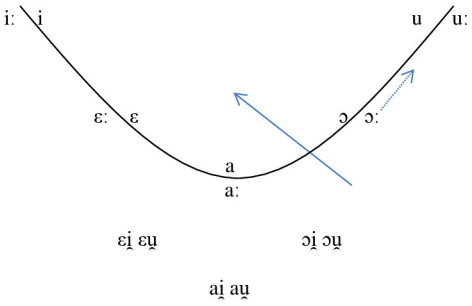

FIGURE 3A
Introduction of the new phonemes Pre-PT */ə/ and */ō/

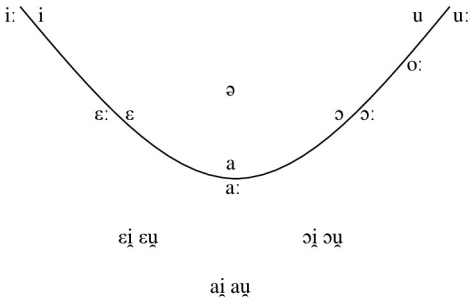

FIGURE 3B
Resulting vowel system

3.2.2 Phase 2: Fixing the overcrowding in the back region (fronting */ɔ/ > */ɛ/)

The second phase in the development of the Pre-PT vowel system was characterized by a chain shift, whose details are discussed below.

i. Pre-PT */ɔ/ > */ɛ/

I assume that the first change of this phase was the fronting of Pre-PT */ɔ/ (< PIE **o*) to */ɛ/. At first, the fronting of a non-peripheral vowel may seem to run against the third principle of vowel shifts proposed by Labov (1994: 200), according to which peripheral vowels tend to move towards the front of the vowel space whereas non-peripheral vowels tend to move towards the back. Notwithstanding this, it is well known that the acoustic vowel space is not symmetrical, and that the available space in the front region is greater than that in the back region.[39] This explains (among other things) the typological tendency according to which systems with asymmetries between the front and the back region usually have more vowels in the front than in the back.[40]

39 See Martinet (1955: 98–99); Haudricourt & Juilland (1971: 35–36); Lindblom (1986: 39–40); Allen (1987: 22); Labov (1994: 118, 256); Ladefoged & Ferrari (2012: 177).

40 See Schwartz et al. (1997: 243, 251); Boë et al. (2002: 226).

Crucially, the Pre-PT vowel system that emerged from Phase 1 (Figure 3b) had more vowels in the back than in the front. Therefore, it is likely that, at this stage, the margin of security among the back vowels Pre-PT */ū, u, ō, ɔ̄, ɔ/ was more endangered than the margin of security among the front vowels Pre-PT */ī, i, ē, ɛ/. In particular, on the mid-low axis—where the front-to-back acoustic distance is smaller than on the higher axes due to the wedge-like shape of the vowel space—the contrast */ɔ/ : */ɔ̄/ would have been most endangered. Consequently, it is conceivable that Pre-PT speakers began to push the non-peripheral vowel */ɔ/ towards the front in order to preserve its margin of security as against (relatively more) peripheral */ɔ̄/.

Here, it is important to recall that most recorded examples of vowel fronting due to acoustic overcrowding in the back region seem to involve the high vowel /u/ rather than the mid vowels /o/ or /ɔ/.[41] However, a parallel for the fronting of mid-low /ɔ/ is provided by Standard French, whose vowel system also exhibits an overcrowded back region, with four levels of height (i.e., /ɑ, ɔ, o, u/). In particular, Papakyritsis & Granese (2013: 201) report that 'many French speakers [tend] to pronounce the lower-mid back vowel /ɔ/ in a fronted manner, to the extent that it overlaps with /œ/ in both stressed and unstressed syllables.' Note, further, that in Azores Portuguese the acoustically overcrowded back region has been relieved not only through an (unconditioned) fronting /u/ > /y/, but also through a (conditioned) fronting /o/ > /ø/.[42]

ii. Pre-PT */ɛ/ > */i/

I propose that the fronting */ɔ/ > */ɛ/ triggered a push chain resulting in raising of Pre-PT */ɛ/ to */i/. Accordingly, the old phoneme Pre-PT */ɛ/ (< PIE *e) merged with Pre-PT */i/ (< PIE *i). That this merger did not lead to further shifts in the system is not particularly surprising, since /i/ often acts as a "dead end" in vowel shifts.[43]

The Pre-PT merger */ɛ/ > */i/ represents the first step in the process that ultimately led the Pre-PT short vowels */i, ɛ, u/ (< PIE *i, *e, *u) to merge as the central vowel */ə/. Moreover, the merger */ɛ/ > */i/ must have

41 See, e.g., Haudricourt & Juilland (1971: 114–120); Hock (2021: 164–165).

42 See Haudricourt & Juilland (1971: 116, 117).

43 See Labov (1994: 256–257), with reference to the *Paradebeispiel* of Koine Greek (on which see, in detail, Horrocks (2010: 160–163); Miller (2014: 43–60)). For a counterexample to this tendency, though, see Labov (2010: 141) and the New Zealand front vowel shift discussed there.

occurred after the palatalization of consonants by front vowels had run its course. Otherwise, one would not be able to explain why Pre-PT */ɛ/ and */i/ (< PIE *e and *i) show different palatalizing effects on preceding consonants.[44]

An alternative to the proposed scenario may be to invert the relative chronology of the developments in i. (fronting */ɔ/ > */ɛ/) and ii. (raising of */ɛ/ > */i/). In this case, the fronting of Pre-PT */ɔ/ could be regarded as a pull shift, which filled the gap vacated by the raising of */ɛ/.[45]

iii. Pre-PT */ɔ̄/ > */ɔ/

As for the back region, I assume that the fronting */ɔ/ > */ɛ/ triggered a pull chain that resulted in shortening of Pre-PT */ɔ̄/ (< (Late) PIE *$ō$) to */ɔ/. This process represents a shift across subsystems, with */ɔ̄/ moving from the peripheral to the non-peripheral subsystem.[46] It is important to note that, at this stage, Pre-PT */ɔ̄/ (< (Late) PIE *$ō$) had already become */ū/ (> PT */u/) in absolute final position.[47] This explains why word-final Pre-PT */-ɔ̄/ escaped the shortening to */ɔ/.

iv. Pre-PT */ā/ > */ɔ̄/

My next assumption is that the shortening */ɔ̄/ > */ɔ/ triggered a pull chain raising in the back periphery, which filled the position vacated by the old phoneme */ɔ̄/ (< (Late) PIE *$ō$). Specifically, I propose that the low central long vowel Pre-PT */ā/ (< (Late) PIE *$ā$) was raised to */ɔ̄/.

v. Pre-PT */a/ > */ā/

In turn, the peripheral raising Pre-PT */ā/ > */ɔ̄/ led to the following pull chain lowering: Pre-PT */a/ (< (Late) PIE *a) underwent lengthening to */ā/, thus entering the peripheral subsystem and taking over the place of the former long */ā/ (< (Late) PIE *$ā$).[48]

vi. Pre-PT */ɔ/ > */a/

The place vacated by the lengthening of Pre-PT */a/ to */ā/ was filled through the lowering of Pre-PT */ɔ/ (< */ɔ̄/ < (Late) PIE *$ō$, see iii. above) to */a/.

---

44 See Meier & Peyrot (2017: 18–19); Pinault (2008: 423); Weiss (2022: 157–158). For skepticism concerning the different palatalizing effects of PIE *e and *i in Tocharian, see Warries (2022: 190 fn. 9).

45 I am grateful to Ryan Sandell for having called this alternative to my attention.

46 See generally Labov (1994: 280–291).

47 See Table 1, line 10 (§ 2.2.7), with references.

48 See Labov's (1994: 280–281) 'Lower Exit Principle', according to which low non-peripheral vowels tend to become (more) peripheral.

vii. Pre-PT */ɔ̄/ > */ɔ/
Finally, I argue that the new Pre-PT */ɔ̄/ (< */ā/ < (Late) PIE *$\bar{a}$, see iv. above) left the peripheral subsystem and underwent shortening to */ɔ/, in parallel to what had happened to the old Pre-PT */ɔ̄/ (< (Late) PIE *$\bar{o}$)—see iii. above. This shift led to a vowel system with the same number of front and back vowels and thus repaired (at least partly) the acoustic overcrowding in the back region which had originally triggered the fronting */ɔ/ > */ɛ/.

The scenario presented above explains why Pre-PT */ā/ (< (Late) PIE *$\bar{a}$) and Pre-PT */ɔ̄/ (< (Late) PIE *$\bar{o}$) did not merge with each other although they moved in converging directions across the vowel space. The reason is that these Pre-PT vowels basically "passed each other by," with */ɔ̄/ falling on the non-peripheral track and */ā/ raising on the peripheral track.[49] This is probably what Ringe (1996: 93) had in mind when he claimed that Pre-PT */ɔ̄/ and */ā/ 'must somehow have developed along phonetic paths that did not cross.' However, Ringe (1996: 93) then assumed the following developments: (i) Pre-PT */ɔ̄/ > */ẽ/ (unrounded) > */ā/ > */a/ vs. (ii) Pre-PT */ā/ > */ɔ̄/ > */ɔ/ (see also p. 98). Instead, I propose: (i) Pre-PT */ɔ̄/ > */ɔ/ > */a/ and—as a consequence thereof—(ii) Pre-PT */ā/ > */ɔ̄/ > */ɔ/.[50] The developments described above are summarized in Figure 4a–b.

3.2.3 Phase 3: Fixing the overcrowding in the high region (*/i, u/ > */ə/)

This section lays out the third (and second to last) phase that characterized the development of the Pre-PT vowel system into that of PT.

i. Pre-PT */iu̯/ > */uu̯/
I surmise that the earliest change of this phase affected the high diphthong Pre-PT */iu̯/, which had arisen from Pre-PT */ɛu̯/ (< PIE *$eu̯$) through the raising */ɛ/ > */i/ discussed in § 3.2.2.ii above. Building on the insightful discussion by Warries (2022: 192, 199–200, 204), I assume that Pre-PT */iu̯/ assimilated to */uu̯/.

ii. Phonemicization of /ō/-umlaut
I further argue that, precisely after the change */iu̯/ > */uu̯/, a final segment Pre-PT */-ō/ (< */-ɔ̄n(t)s/, § 2.2.6) triggered umlaut of the preceding

49 Further examples of this phenomenon are discussed in detail by Labov (1994): see, e.g., (i) the non-merger of rising /æ/ and falling /e/ in the so-called "Northern Cities Shift" (pp. 226–227) or (ii) the height reversal (without merger) of the *meat* class and the *mate* class in various Scots and English dialects (pp. 388–390).

50 For a still different view, see Warries (2022: 194): PIE *$\bar{o}$ > PT */o/ > */a/ 'when it did not occur in word-final position.'

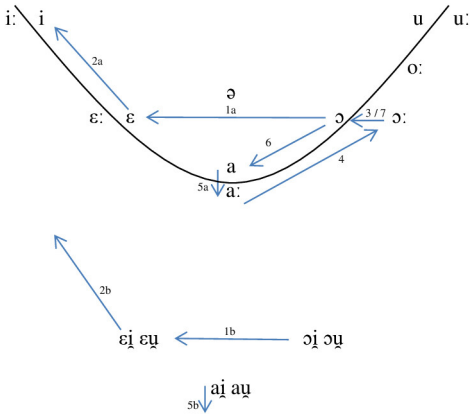

FIGURE 4A
Fixing the overcrowding in the back region

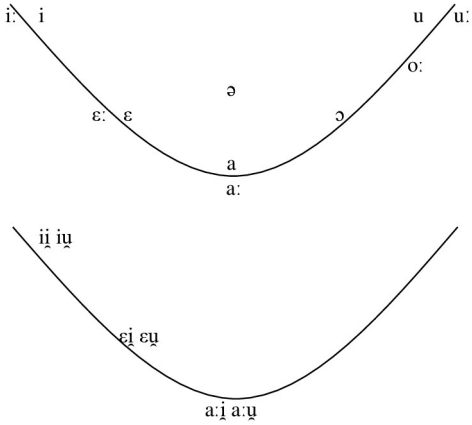

FIGURE 4B
Resulting vowel system

vowels Pre-PT */u/ and */ɛ/ to *[o]. Accordingly, (i) Pre-PT */kl̥uu̯mō/ 'noble' (< PIE **klḗu̯-mon-*) became *[kl̥ou̯mō], (ii) Pre-PT */uksō/ 'ox' (< PIE **(hₓ)uKson-*) became *[oksō],[51] (iii) Pre-PT */ɛrkʷmō/ 'dark' (< PIE **hₗrgʷ-mon-*) became *[orkʷmō], (iv) Pre-PT */sɛlmō/ 'whole' (< PIE **sol(h₂)-mon-*) became *[solmō], but (v) Pre-PT */u̯ələ̄/ 'king' (< PIE **u̯l̥hₓ-ont-*) remained *[u̯ələ̄] and did not become ˣ[u̯olō]. This umlaut process must have originally been allophonic. However, since the umlauted allomorph of the nom. sg. (m.) in most cases underwent intraparadigmatic generalization (cf. TB nom. sg. m. *klyomo*, obl. sg. m. *klyomo-ṃ*, nom. pl. m. *klyomo-ñ*, etc.), both allophones *[o] and *[ou̯] soon became phonemic due to the absence of alternations on the

51 Or, alternatively, Pre-PT */u̯uksō/ became *[u̯oksō], if the development PIE *(hₓ)u- > Pre-PT *u̯u- (> PT *u̯ə-) had already taken place—cf. PIE *h₂us- > TB *wäs-* 'dwell' and see Klingenschmitt (1994: 407 with n. 165); Kim (2000: 41 with n. 9); Hackstein (2017: 1312).

surface.[52] This means: (i) Pre-PT nom. sg. m. */ɛrkʷmō/ → *[orkʷmō] → (after the intraparadigmatic generalization) */orkʷmō/, whence a new phoneme */o/; (ii) Pre-PT nom. sg. m. */klʲuu̯mō/ → *[klʲou̯mō] → (after the intraparadigmatic generalization) */klʲou̯mō/, whence a new phoneme */ou̯/, etc. Consequently, the inner-Tocharian development of the forms discussed in (1) above (§ 2.2.6) can now be restated as in (2).

(2) (Non-)Application of the Pre-PT /ō/-umlaut

i. Nom. sg. m. Pre-PT **klɛu̯-mɔ̄n-s* > **klʲɛu̯mōns* > **klʲɛu̯mōs* > **klʲɛu̯mō* > **klʲiu̯mō* > **klʲuu̯mō* > (/ō/-umlaut) **klʲou̯mō* > **klʲoo̯mō* > **klʲōmō* > (loss of contrastive length, § 3.2.4) PT **klʲomo* > TB *klyomo*, TA *klyom* 'noble';[53]

ii. Nom. sg. Pre-PT **uksɔ̄n-s* > **uksōns* > **uksōs* > **uksō* > (/ō/-umlaut) **oksō* > (loss of contrastive length) PT **okso* > TB *okso*, TA *okäs** (or *opäs**) 'ox';

iii. Nom. sg. m. Pre-PT **r̥kʷ-mɔ̄n-s* > **ərkʷmōns* > **ərkʷmōs* > **ərkʷmō* > (*#ə*-lowering)[54] **ɛrkʷmō* > (/ō/-umlaut) **orkʷmō* > (loss of contrastive length) PT **orkʷmo* > TB *orkamo*, TA *orkäm* 'dark';

iv. Nom. sg .m. Pre-PT **sɔl-mɔ̄n-s* > **sɔlmōns* > **sɔlmōs* > **sɔlmō* > **sɛlmō* > (/ō/-umlaut) **solmō* > (loss of contrastive length) PT **solmo* >> TB *solme* 'whole';

v. But: nom. sg. Pre-PT **u̯l̥h$_x$-ɔ̄nt-s* > **u̯l̥h$_x$ɔ̄ns* > **u̯l̥h$_x$ōns* > **u̯əlh$_x$ōs* > **u̯əlōs* > **u̯əlō* > (absence of /ō/-umlaut) PT **u̯əlo* > TB *walo*, TA *wäl* 'king'.

iii. Pre-PT */i, u/ > */ə/

After the assimilation */iu̯/ > */uu̯/, the Pre-PT vowel system could no longer escape an acoustic overcrowding in the high region, since the three-way phonemic contrasts */ii̯/ : */ī/ : */i/ (front) and */uu̯/ : */ū/ : */u/ (back) would have been highly unstable.[55] One possible way to resolve this instability was to push the non-peripheral high vowels towards the center of the vowel space. I propose that this strategy was adopted by the speakers of Pre-PT. Accordingly, Pre-PT */i/ (< PIE **i*, **e*) and Pre-PT */u/ (< PIE **u*) merged with the already existing phoneme Pre-PT */ə/, which

52 Methodologically, this scenario presupposes the view that, in diachronic change, new phonemes can arise by paradigmatic leveling, i.e., by an analogical process.

53 For the assumption of a development Pre-PT **-ou̯-* > **-oo̯-* > **-ō-* > PT **-o-* (§ 3.2.4.i below), see also (Warries 2022: 200–201[17]).

54 See Table 1, line 19 (§ 2.2.7), with references.

55 See Labov (1994: 238, 245–246).

had arisen from the PIE syllabic resonants (§ 3.2.1.i). A by-product of this change was that the high diphthongs Pre-PT */iḭ, uṵ/ were also centralized to */əḭ, əṵ/. If this is correct, Tocharian would conform to the typological tendency for the phoneme /ə/ to have its diachronic source in short high vowels.[56]

Note that if one follows the traditional view according to which PT **ä* was a high vowel */ɨ/ rather than a mid vowel */ə/ (§ 2.2.3), it would be possible to argue that the Pre-PT high phonemes */i, u/ were pushed towards the center of the vowel space while keeping their original height: thus */i, u/ → */ɨ/ rather than */i, u/ → */ə/. As I will argue below (§ 4.1.1.2), however, reconstructing a phoneme */ɨ/ for PT would make it more difficult to account for the synchronic vowel system of TB, as this language most likely had only an allophone [ɨ] belonging to a central mid phoneme /ə/. Consequently, I assume that PT did not exhibit any central high phoneme */ɨ/.

According to the present scenario, the centralization */i, u/ > */ə/ represents one of the last changes that occurred before the PT stage. This relative chronology is independently confirmed by the fact that at least three loanwords demonstrably participated in this change. As for */u/ > */ə/, cf.: (i) Iran. **But* 'Buddha' → Pre-PT **put* > PT **pət* > TB /pát/ → *pat* 'stūpa';[57] (ii) Iran. **dᶻaiṇu-* → Pre-PT sg. **tˢaiṇu* ~ pl. **tˢaiṇu-a* > PT **tˢaiṇə* ~ **tˢaiṇua* > TB sg. /tˢáiṇə/* → *tsain** ~ pl. /tˢáiṇua/* → *tsainwa** 'arrow'.[58] As for */i/ > */ə/, see Iran. **Kaniṣka-* (proper name) → Pre-PT **Kaniṣkɛ* > PT **Kanəṣkɛ* > TB /Kanáṣke/ → *Kanaṣke* (B423b4 class.-late) → TA *Kanaṣke* (A49a4).[59] In contrast, later loanwords preserved their original /i/- or /u/-vowels in Tocharian: e.g., TAB *indri* 'sense organ' ← Skt. *indriya-* 'id.'.

iv. Pre-PT */ī, ū/ > */i, u/

The centralization Pre-PT */i, u/ > */ə/ triggered a pull chain resulting in shortening of the long peripheral vowels Pre-PT */ī, ū/ (< Late PIE **ī*, **ū*). These vowels entered the non-peripheral subsystem and occupied the high corner positions vacated by Pre-PT */i, u/.

v. Phonemicization of /u/-umlaut

Finally, after the merger Pre-PT */i, u/ > */ə/, the allophones *[o, ō] that belonged to the phonemes */ɛ, ɛ̄/ in the context of /u/-umlaut (i.e., /_.C_0u)

56 See Recasens (2022: 84).

57 In light of the development */u/ > */ə/, a borrowing of TB *pat* from Skt. *Buddha* is less likely, see Pinault (2024: 5–6).

58 See Warries (2022: 200, 205); Bernard (2025: 75–76).

59 See *DTTA*: 92–93; *DTB*²: 146. TAB *Kanaṣke* was kindly called to my attention by Athanaric Huard; I am also grateful to Georges-Jean Pinault for fruitful discussion of this word.

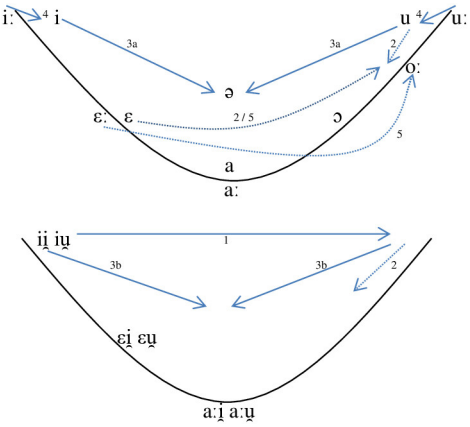

FIGURE 5A
Fixing the overcrowding in the high region

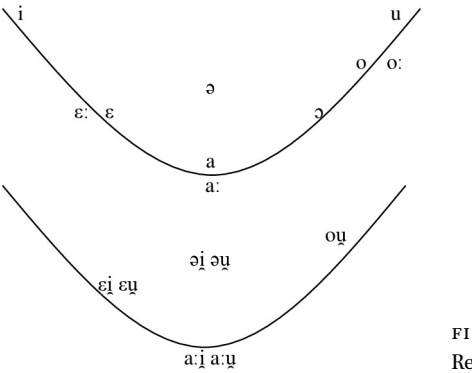

FIGURE 5B
Resulting vowel system

were phonologized as */o, ō/.[60] The new */o/ merged with the phoneme */o/ that had arisen through /ō/-umlaut (see ii. above). The new */ō/ merged with the phoneme */ō/ that had arisen from word-final */-ōn(t)s/ (see § 3.2.1.ii and § 2.2.6 above).

Similarly to what happened at the end of Phase 1 (Figure 3b), the Pre-PT vowel system that emerged from Phase 3 was unbalanced with respect to the number of front and back vowels, as it opposed three front phonemes (*/i, ē, ɛ/) to four back phonemes (*/u, ō, o, ɔ/). Furthermore, the high corners of the system were only occupied by non-peripheral vowels, namely, */i, u/. See Figure 5a–b.

60 See Warries (2022: 191).

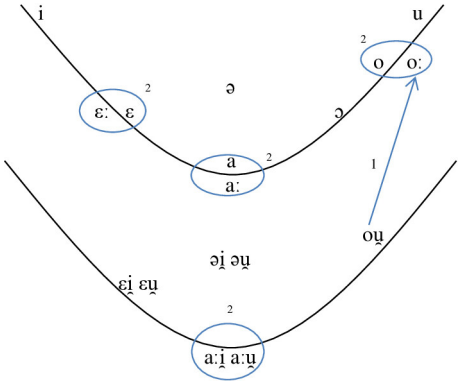

FIGURE 6A
Loss of phonemic vowel length

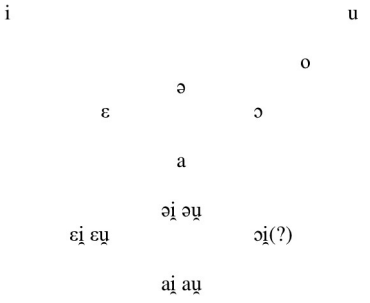

FIGURE 6B
Resulting vowel system (= Figure 2, § 2.3)

3.2.4 Phase 4: Loss of phonemic vowel length

The Pre-PT vowel system that resulted from Phase 3 (Figure 5b) led to the PT vowel system reconstructed in § 2.3 above (Figure 2) through the following two processes.

i. Pre-PT */ou̯/ > */oo̯/ > */ō/
   The marginal diphthong Pre-PT */ou̯/—which had arisen from */uu̯/ through /ō/-umlaut (§ 3.2.3.ii)—first assimilated to */oo̯/ and then contracted to */ō/, thus merging with the already existing phoneme Pre-PT */ō/.

ii. Loss of contrastive vowel length.[61]

These developments are summarized in Figure 6a–b.

61 See Ringe (1996: 124–132, especially 125, 131).

4 From Proto-Tocharian to the attested Tocharian languages

4.1 *Tocharian B*

This section deals with the evolution of the PT vowel system in TB. In § 4.1.1, I analyze the TB vowel system from a synchronic perspective. I first review the vowel inventories that have been previously assumed for TB (§ 4.1.1.1), then discuss the phonemic / phonetic value of the TB graphemes ⟨ä⟩, ⟨a⟩, and ⟨ā⟩ (§ 4.1.1.2), and finally propose a revised interpretation of the TB vowel system (§ 4.1.1.3). I then show how the latter can be derived from the vowel system of PT (§ 4.1.2).

4.1.1 The Tocharian B vowel system

4.1.1.1 *Proposed vowel inventories so far*

Adams (1978: 450):

i		u
e	ä	o
	ā	

Jasanoff (1978: 30–34, implicitly):[62]

i	ɨ	u
e	[ʌ]	o
	ʌ	
	[a]	

Winter (1998: 157):

i	ɨ	u
e		o
	a	

Pinault (2008: 415–416):

i	ɨ	u
e	[ʌ]	o
	ɑ	

62 See also Ringe (1996: xxi–xxii); Hackstein (2017: 1309).

4.1.1.2 *Discussion*

The following discussion focuses on the phonemic / phonetic interpretation of the TB graphemes ⟨ä⟩, ⟨a⟩, and ⟨ā⟩.

4.1.1.2.1. According to Sieg & Siegling (1908: 918), the *Fremdvokal* ⟨ä⟩ is phonetically a 'Svarabhakti-Vokal', i.e., [ə].[63] This view has been further pursued by Reuter (1925, especially 215–222), who analyzed ⟨ä⟩ as a pre-palatalized schwa, i.e., [ʲə].[64] Similar is the position of Krause & Thomas (*TEB* I: 39), who define ⟨ä⟩ as a 'palatal gefärbte[n] Laut von der Art des altslaw. *ъ*' (i.e., 'a palatally colored sound of the type of Old Slavic *ъ*').

Jasanoff (1978: 30, 31) was the first to develop the idea that the *Fremdvokal* ⟨ä⟩ was phonetically [ɨ], i.e., a central high unrounded vowel. Jasanoff further linked this proposal with the following two assumptions: (i) TB ⟨a⟩ was phonetically '[ʌ]' (= [ə]), i.e., a central mid unrounded vowel; (ii) TB ⟨ā⟩ was phonetically [a], i.e., a central low unrounded vowel.[65] In addition, Jasanoff (1978: 31) argued the graphic alternations TB ⟨ä⟩ ~ ⟨a⟩ and TB ⟨a⟩ ~ ⟨ā⟩ to be due to an allophonic lowering in stressed context, i.e.:

i. TB /ɨ/ → [ɨ] (= ⟨ä⟩) /_[-stress] (in a closed syllable)[66] ~ TB /ɨ/ → [ə] (= ⟨a⟩) /_[+stress];
ii. TB /ə/ → [ə] (= ⟨a⟩) /_[-stress] ~ TB /ə/ → [a] (= ⟨ā⟩) /_[+stress].[67]

Therefore, Jasanoff (1978: 30, 33–34) implicitly assumed the following developments to have taken place between PT and TB:

i. PT */ɨ/ > TB /ɨ/ (= ⟨ä⟩ ~ ⟨a⟩);
ii. PT */a/ > TB /ə/ (= ⟨a⟩ ~ ⟨ā⟩).

This leads to the reconstruction of a TB vowel system without low vowel phonemes (see also § 4.1.1.1). However, vowel systems lacking a contrastive low vowel are exceedingly rare typologically.[68] Moreover, the assumption of a development PT */a/ > TB /ə/—namely, the raising and centralization of a central low vowel—is difficult to motivate in my view, since peripheral vowels—and especially the "point" vowels /i, a, u/—usually tend to be maximally / suf-

63 See also Pedersen (1941: 12) and, most recently, Jasanoff (2015, especially 90).
64 See now also Huard (2025).
65 See also Ringe (1996: xxii); Hackstein (2017: 1304, 1309); Weiss (2022: xxiii, xxvii).
66 In an open unstressed syllable, instead, the phoneme that underlay TB ⟨ä⟩ underwent syncope on the surface.
67 See also Weiss (2022: xxvii).
68 See Disner (1983: 2; 6); ten Bosch (1986: 58); Papakyritsis & Granese (2013: 189); Martinet (1955: 151). In the UPSID segment inventory database (http://menzerath.phonetik.uni-frankfurt.de/cgi-bin/upsid_sounds.cgi, accessed 23 May 2025), only 9 (= 2%) of the languages are said to lack a contrastive low vowel.

ficiently dispersed and thus to occupy the corner regions of the acoustic space (see § 3.1 with references).

Alternatively, Winter (1998: 157) and Pinault (2008: 415–416, 438–439) argued for TB to exhibit the following two central phonemes: (i) /a/ or /ɑ/ (low unrounded), spelled ⟨ā⟩; (ii) /ɨ/ (high unrounded), spelled ⟨ä⟩. Both of these phonemes would have developed a central mid unrounded allophone spelled ⟨a⟩, which was phonetically '[ʌ]' (= [ə]) according to Pinault (2008: 415–416). Consequently, this scenario requires the assumption of the following phonological rules for TB:

i. TB /ɨ/ → [ɨ] (= ⟨ä⟩) /_[-stress] (in a closed syllable) ~ TB /ɨ/ → [ə] (= ⟨a⟩) /_[+stress];
ii. TB /a/ → [ə] (= ⟨a⟩) /_[-stress] ~ TB /a/ → [a] (= ⟨ā⟩) /_[+stress].

A variant of this hypothesis is Fellner & Koller's (2018: 83–84) proposal that the TB graphemes ⟨ä⟩, ⟨a⟩, and ⟨ā⟩ have the phonetic values [ə], [ʌ], and [a], respectively, and represent the central phonemes TB /ə/ and /a/.

The drawback of these interpretations is that they postulate opposite effects of stress on vowel quality. On the one hand, unstressed /ɨ/ or /ə/ would remain unchanged, whereas unstressed /a/ would undergo raising to [ə] (Winter, Pinault) or raising and backing to [ʌ] (Fellner & Koller). On the other hand, stressed /ɨ/ or /ə/ would undergo lowering to [ə] (Winter, Pinault) or lowering and backing to [ʌ] (Fellner & Koller), whereas stressed /a/ would remain unchanged. Certainly, a scenario in which the graphic alternations TB ⟨ä⟩ ~ ⟨a⟩ and TB ⟨a⟩ ~ ⟨ā⟩ could be accounted for in a phonetically and phonologically uniform way (see Jasanoff 1978: 31) would be preferable.

Finally, Peyrot (2008: 38–39) cautiously proposes the following analysis for the graphic alternation TB ⟨a⟩ ~ ⟨ā⟩: (i) ⟨a⟩ notates the unstressed allophone of a phoneme TB /a/ (central low), namely, [ɐ] (central raised-low); (ii) ⟨ā⟩ notates the stressed allophone of the same phoneme TB /a/, namely, [aˑ] (lower, and longer?). As for the TB vowel written as ⟨ä⟩, Peyrot (2008: 41) deems it to be /ə/ and cautiously argues it to have been shorter than the other vowels.

4.1.1.2.2. In the following, I will adopt a TB vowel system intermediate between those of Jasanoff and Winter / Pinault.

I assume that TB ⟨a⟩ was [ə] and TB ⟨ā⟩ was [a], as this finds a probative confirmation in what we know about the phonetic values of the corresponding Sanskrit signs ⟨a⟩ and ⟨ā⟩. It appears, in fact, that Skt. ⟨a⟩ rendered a central mid vowel [ə], whereas Skt. ⟨ā⟩ spelled a central low vowel [ā].[69] Since

69 See Allen (1953: 58–59 with n. 4); Jasanoff (1978: 30[11]).

vowel length was not phonemically relevant in TB, it is reasonable to argue that the phonetic difference between TB ⟨a⟩ and ⟨ā⟩ was primarily one of height, namely, [ə] vs. [a].[70]

On the other hand, I am skeptical about the phonemic interpretation of TB ⟨ä⟩ as /ɨ/. Therefore, building on Adams (1978: 450, § 4.1.1.1) and Sandell (2023: 111–113), I alternatively propose the following analysis. PT */ə/ (central mid unrounded) and PT */a/ (central low unrounded) preserved their positions in TB. This means that TB had two central phonemes /ə/ and /a/ which were realized as such in stressed position, since stress would have helped preserve the phonetic features of the underlying phonemes. In contrast, I surmise that TB /ə/ and /a/ underwent raising in unstressed position, thus yielding the allophones [ɨ] (central high unrounded) and [ə] (central mid unrounded), respectively. I.e.:

i. TB /ə/ → [ə] (= ⟨a⟩) /_[+stress] ~ TB /ə/ → [ɨ] (= ⟨ä⟩) /_[-stress] (in a closed syllable);

ii. TB /a/ → [a] (= ⟨ā⟩) /_[+stress] ~ TB /a/ → [ə] (= ⟨a⟩) /_[-stress].

As is well known, the presence or absence of stress can modify the quality of vowels in different ways. In many languages (e.g., in English, German, Catalan, etc.), stressed vowels tend to be more peripheral, whereas unstressed vowels tend to be more centralized.[71] Accordingly, one might explain the phonological rule TB /a/ → [ə] as a centralization—i.e., a movement towards the non-periphery of the vowel space—that took place in unstressed position. All the same, the phonological rule TB /ə/ → [ɨ] can be hardly analyzed as a centralization, since [ɨ] is more peripheral than [ə]. At this point, it is important to recall that some studies have reported an alternative effect of stress on vowel quality. Specifically, stressed vowels at times tend to be lower or more sonorous than unstressed ones, i.e., to display a higher F1 value and thus to maximize their contrast with the surrounding consonants (Sonority Expansion Hypothesis). As a reaction to this, unstressed vowels may become higher or less sonorous than their stressed counterparts, thus displaying a lower F1.[72] Such a sonority / height difference between stressed and unstressed position has been reported for Castilian Spanish, Mexican Spanish, and Standard Bulgarian.[73] Note fur-

70 See Weiss (2022: xxvii).

71 See, e.g., Nadeu (2012: 1396, 1398–1399; 2014: 2) (with references).

72 See Beckman et al. (1992, especially 84–85); Nadeu (2012: 1396).

73 On the Castilian Spanish mid and low vowels, see Nadeu (2014: 12 (Figure 11), 14); on Castilian and Mexican Spanish in general, see Nadeu (2012: 1397–1398) and Santiago & Mairano (2018: 456 (Figure 4)). On the Standard Bulgarian mid and low vowels, see Dokovova et

ther that, in Standard Italian, unstressed mid vowels are higher than their stressed counterparts—e.g., It. [ˈbɛne] 'well' ~ [beˈniɲːo] 'benign', [ˈnɔve] 'nine' ~ [noˈvanta] 'ninety', etc.

The TB data can therefore be accounted for in a phonetically and phonologically uniform way by assuming an allophonic decrease of sonority—i.e., a raising—of the central mid and low vowels in unstressed position. This would have the consequence that TB had no central high unrounded phoneme /ɨ/.[74]

4.1.1.2.3. Finally, there is no need to assume that the central vowel phonemes of Classical TB were different from those of Archaic TB. As is well known, in Archaic TB both phonemes /ə/ and /a/ are written without a clearly motivated distribution: TB /ə/ can be represented both as ⟨ä⟩ (= [ɨ]) and as ⟨a⟩ (= [ə]),[75] whereas TB /a/ can be notated both as ⟨a⟩ (= [ə]) and as ⟨ā⟩ (= [a]).[76] Despite this apparent randomness, Peyrot (2008: 33–37, especially 37) made a convincing case that some tendencies pointing to the distribution of Classical TB can already be identified in Archaic TB: (i) ⟨a⟩ tends to be written more frequently for unstressed /a/ and ⟨ā⟩ for stressed /a/; (ii) although ⟨a⟩ for /ə/ is rare, this spelling is mostly found in stressed position. It seems therefore logical to conclude that the phonemic oppositions were the same as in Classical TB, but that the spelling conventions for notating the allophonic alternations had not yet been standardized in Archaic TB.[77]

It is noteworthy that the spelling convention according to which TB [a] (← /a/$_{[+\text{stress}]}$) is written as ⟨ā⟩ whereas TB [ə] (← /a/$_{[-\text{stress}]}$) is written as ⟨a⟩ seems to have been standardized earlier than the convention according to which TB [ə] (← /ə/$_{[+\text{stress}]}$) is written as ⟨a⟩ whereas TB [ɨ] (← /ə/$_{[-\text{stress}]}$) is written as ⟨ä⟩.[78] As kindly pointed out to me by Ryan Sandell, this may have a reasonable explanation: since [ɨ] was purely allophonic (i.e., it was not itself contrastive), speakers of TB were less attuned to / could not perceive the distinction between [ə] and [ɨ]. In contrast, the distinction between [ə] and [a] was salient, because it had phonemic relevance.

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al. (2019: 2723 (Figure 2))—the relevance of Bulgarian to the present discussion was kindly called to my attention by Ronald Kim.

74 This is also implied by Peyrot (2008: 33–41), Fellner & Koller (2018: 83), and Weiss (2022: xxvii–xxviii), who notate the TB central phonemes as /ə/ and /a/.

75 Though the latter spelling is quite rare, see Peyrot (2008: 35).

76 In this case, the distribution of both spellings is more balanced, see Peyrot (2008: 36–37).

77 See Peyrot (2008: 38).

78 See Peyrot (2008: 39–40).

4.1.1.3 *Proposed Tocharian B vowel system*

Based on the preceding considerations, I assume that TB exhibited the vowel system presented in Figure 7. The origin of the mid vowels TB /e̯, o̯/ will be discussed in § 4.1.2.ii below.

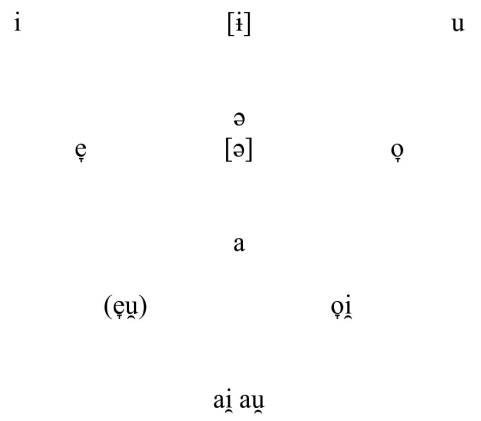

FIGURE 7
TB vowel system

The front diphthong /e̯u̯/ was phonemic only in Archaic TB. In Classical TB, it merged with the central diphthong /au̯/.[79] On the back diphthong TB /o̯i̯/, see Pinault (2008: 440–442) and Del Tomba (2023: 83–84).

4.1.2 From Proto-Tocharian to Tocharian B

This section lays out how the TB vowel system presented in Figure 7 (§ 4.1.1.3) can be derived from the PT vowel system reconstructed in Figure 2 (§ 2.3).

i. Front region

The only demonstrable changes were the following two: (i) word-finally in polysyllabic words, the unstressed diphthong PT */-ɛi̯/ underwent weakening to Pre-TB */-əi̯/ (§ 2.2.5), which then regularly developed to TB /-i/ (see iii. below); (ii) non-word-finally in polysyllabic words and in monosyllables, both diphthongs PT */ɛi̯/ and PT */ai̯/ merged as TB /ai̯/—this merger was completed before the earliest written records of TB.[80] In contrast, the parallel merger of the back diphthongs TB /e̯u̯/ and TB /au̯/ had not yet taken place in Archaic TB (§ 4.1.1.3).

On the fate of the front mid-low vowel PT */ɛ/ in TB, see ii. below.

79 See Peyrot (2008: 41–49); Pinault (2008: 416).

80 See Peyrot (2008: 49, 58–59).

ii. Back region
As for the PT opposition between */o/ (mid-high) and */ɔ/ (mid-low), it is at first sight unclear whether it was preserved in TB or rather leveled as a "pure" mid phoneme TB /o̯/. On the one hand, one may argue that the uniform writing TB ⟨o⟩ speaks in favor of the neutralization of both phonemes */o/ and */ɔ/ inherited from PT. On the other hand, cases like Italian, where /o/ and /ɔ/ are both notated as ⟨o⟩ (e.g., in ⟨notte⟩ = [ˈnɔt:e] 'night' vs. ⟨ombra⟩ = [ˈombra] 'shadow'), call for caution. Nevertheless, there seems to be evidence suggesting that a mutual approximation PT */o, ɔ/ > TB /o̯/ did in fact take place. This is shown by the fact that both the TB continuant of PT */o/ and the TB continuant of PT */ɔ/ triggered umlaut of a preceding front mid vowel TB ⟨e⟩ to ⟨o⟩.[81] This phenomenon is best accounted for under the assumption that PT */o/ and */ɔ/ had been leveled as a "pure" mid phoneme /o̯/ in the prehistory of TB and thus had the same umlauting effect on a preceding front vowel. Note, moreover, that a mutual approximation of the PT vowels */o/ and */ɔ/ is also phonetically plausible, as it would have led to a more balanced system that displayed the same number of front and back mid vowels.[82] Finally, this scenario suggests that the front mid-low vowel PT */ɛ/ had undergone raising to TB /e̯/ ("pure" mid) in order to match the height of its back counterpart TB /o̯/. Summing up: TB ⟨e⟩ = /e̯/ (< PT */ɛ/) ~ TB ⟨o⟩ = /o̯/ (< PT */o, ɔ/).

iii. Central region
The PT central phonemes */a, ə/ preserved their positions in TB and developed the higher—i.e., less sonorous—allophones [ə, ɨ] when unstressed (§ 4.1.1.2). Another important change that affected this region was the monophthongization of the central diphthongs PT */əi̯, əu̯/, which first assimilated to */ii̯, uu̯/ > */ī, ū/ and finally merged with the high corner vowels /i, u/ (§ 2.2.4).

The developments described above are summarized in Figure 8a–b.

81 This is best seen in the following TB adjectives: (i) ***omotruññe**** 'southern', whose internal ⟨o⟩ goes back to a PT */o/ which had arisen from PT */ɛ/ (< PIE **o*) after the phonemicization of /u/-umlaut (§ 3.2.3.v); (ii) TB ***oṅkrot*(*t*)*e**** (: TA *oṅkrac*) 'immortal', whose internal ⟨o⟩ goes back to PT */ɔ/ < Late PIE *$\bar{a}$ < PIE *eh_2. For a detailed discussion of these TB forms, see Imberciadori (in print) s.v. B *omotruññe** and B *oṅkrot*(*t*)*e**, A *oṅkrac*, respectively.

82 On the merger of mid-high and mid-low vowels, see Recasens & Espinosa (2009) (with focus on Catalan).

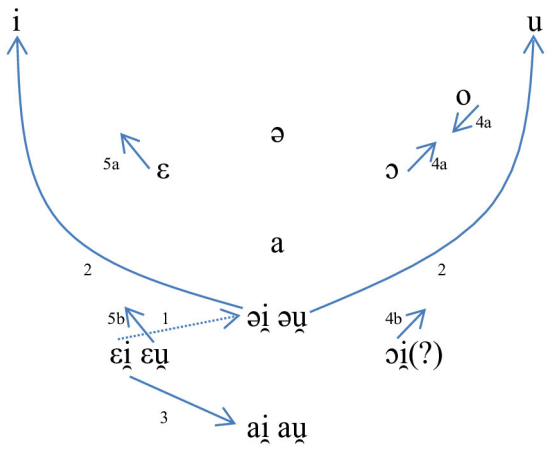

FIGURE 8A
From PT to TB

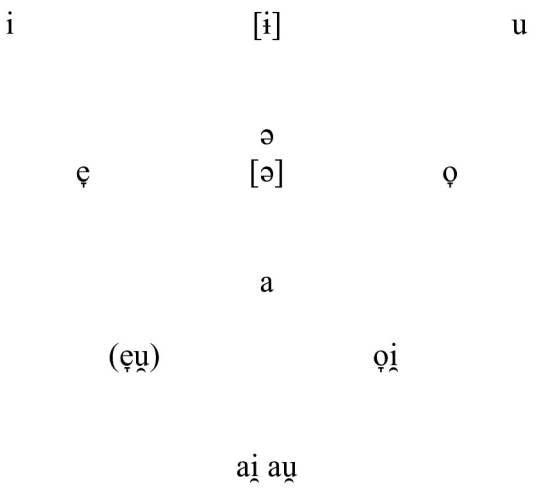

FIGURE 8B
Resulting vowel system (= Figure 7, § 4.1.1.3)

4.2 *Tocharian A*

This section deals with the evolution of the PT vowel system in TA. In § 4.2.1, I analyze the TA vowel system from a synchronic perspective. I first review the vowel inventories that have been previously assumed for TA (§ 4.2.1.1), then discuss some specific vowel phonemes of this language (§ 4.2.1.2), and finally propose a revised interpretation of the TA vowel system (§ 4.2.1.3). I then show how the latter can be derived from the vowel system of PT (§ 4.2.2).

4.2.1 The Tocharian A vowel system

4.2.1.1 *Proposed vowel inventories so far*

Adams (1978: 450):

i		u
	ä	
e		o
	a	
	ā	

Jasanoff (1978: 30–34, implicitly):[83]

i		ɨ		u
	e	ʌ	o	
		a		

Winter (1998: 157):

i		ɨ		u
	e		o	
		a		
	ē		ō	
		ā		

4.2.1.2 *Discussion*

Following Jasanoff (1978: 30, 33–34), I assume that TA had three central vowel phonemes on three different levels of height—i.e., from highest to lowest, TA /ɨ/ = ⟨ä⟩, TA /ə/ = ⟨a⟩, and TA /a/ = ⟨ā⟩. As for the phonemic status of TA /ɨ/ = ⟨ä⟩, cf. minimal pairs like TA *pat* 'or' vs. *pät* 'over, on',[84] TA [1]*pār* 'recitation' ~ [2]*pār* (a measure of volume) vs. *pär* 'arrow',[85] etc. Based on the PT vowel system reconstructed in § 2.3 (Figure 2) above, I surmise that the following developments took place between PT and TA:

i. PT *ɛ > TA ə (= ⟨a⟩);

ii. PT *ɔ > TA ə (= ⟨a⟩);

83 See also Pinault (2008: 415–416); Hackstein (2017: 1309).

84 See *DTTA*: 262, 276; Catt et al. (2022: 254–255).

85 See *DTTA*: 270–271, 278.

iii. PT */ə/ > TA /ɨ/ (= ⟨ä⟩);
iv. PT */a/ > TA /a/ (= ⟨ā⟩).

A systemic motivation for the developments in i.–iii. will be offered in § 4.2.2 below.

Ringe (1996: xx; 1998) cautiously[86] assumed the existence of an additional TA phoneme, namely, '/ŭ/ which differs from /ä/ [here notated as /ɨ/] in being rounded and from /u/ in being subject to syncope' (1996: xx). According to Ringe, TA '/ŭ/' occurred (among others) in forms like all. sg. TA $k_{u}c$-*ac* (~ obl. sg. *kuc*) 'who'. However, the assumption of an additional phoneme TA '/ŭ/' is probably unnecessary, since cases like TA *kuc* ~ $k_{u}c$-*ac* can be accounted for by positing an underlying structure TA /kʷɨc/, with monophonemic /kʷ/.[87] The TA obl. sg. /kʷɨc/ would have been realized as [kʷuc] (with allophonic rounding and backing /ɨ/ → [u] / *k*ʷ_), and this would have triggered a labial dissimilation [kʷuc] > [kuc] = ⟨kuc⟩. In an open syllable, however, where /ɨ/ was regularly syncopated on the surface, the underlying labiovelar did not undergo dissimilation before allophonic [u] and was therefore notated graphically as ⟨k_{u}⟩—i.e., TA all. sg. /kʷɨc-ac/ → [kʷcac] = ⟨k_{u}cac⟩. At any rate, scholars who are willing to accept the existence of a phoneme TA '/ŭ/' should simply regard it as the rounded counterpart of /ɨ/, namely, /ʉ/.

4.2.1.3 *Proposed Tocharian A vowel system*

Based on the preceding considerations, I assume that TA exhibited the vowel system presented in Figure 9a–b. The only difference between the two figures is the presence (Figure 9a) or absence (Figure 9b) of the back mid opposition /o/ : /ɔ/. I will discuss this point in § 4.2.2.v below.

4.2.2 From Proto-Tocharian to Tocharian A

This section examines how the TA vowel system presented in Figure 9a–b (§ 4.2.1.3) can be derived from the PT vowel system reconstructed in Figure 2 (§ 2.3). In particular, I argue that a push chain shift was responsible for the formation of the TA vowel system.

i. Monophthongizations

I assume that one of the earliest developments that affected the Pre-TA vowel system was the monophthongization of the PT diphthongs. In particular: (i) the /i̯/-diphthongs PT */ɛi̯, ai̯, ? ɔi̯/ assimilated to */ɛę/ > */ē/ > TA /ɛ/, spelled ⟨e⟩; (ii) the /u̯/-diphthongs PT */ɛu̯, au̯/ assimilated to

86 See especially Ringe (1998: 617).
87 See Kim (1999a: 142–145); Pinault (2008: 417–418).

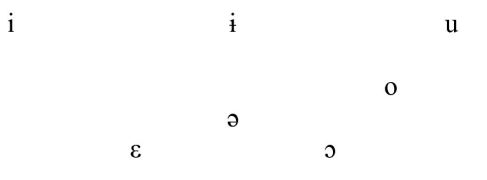

FIGURE 9A
"Maximal" TA vowel system

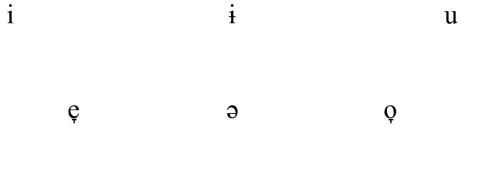

FIGURE 9B
"Minimal" TA vowel system (= Jasanoff 1978: 30–34, § 4.2.1.1)

*/ɔ̯ǫ̯/ > */ō/ > TA /ɔ/, spelled ⟨o⟩; (iii) the remaining diphthongs PT */əi̯, əu̯/ assimilated to */ii̯, uu̯/ > */ī, ū/ > TA /i, u/, spelled ⟨i, u⟩. These changes must have taken place after the Pre-TA apocope of final vowels had run its course, since the monophthongs ⟨e, o, i, u⟩ are the only vowels that can occur word-finally in TA. The monophthongization PT */əi̯, əu̯/ > TA /i, u/ took place independently of the parallel monophthongization PT */əi̯, əu̯/ > /i, u/ in TB (§ 4.1.2.iii, § 2.2.4).

ii. PT */ɛ, ɔ/ > TA /ə/
Whereas the new high monophthongs TA /i, u/ merged with the inherited high vowels */i, u/, the new mid-low monophthongs TA /ɛ, ɔ/ pushed the inherited mid-low vowels */ɛ, ɔ/ towards the center of the vowel space. There, the latter phonemes merged as a central mid vowel /ə/, which was notated as TA ⟨a⟩ in line with the phonetics of Skt. ⟨a⟩ and TB ⟨a⟩.[88]

iii. PT */ə/ > TA */ɨ/
As a consequence of the centralization PT */ɛ, ɔ/ > TA /ə/, the old central mid phoneme */ə/ was pushed towards the central high region, where it became TA /ɨ/ and was notated as ⟨ä⟩. Accordingly, TA, unlike TB, developed a three-height phonemic contrast along the central axis.

88 I follow here the *communis opinio* according to which PT */ɔ/ (in the traditional notation **å*) yielded *a* in TA (: *o* in TB)—see, e.g., Pinault (2008: 451); Hackstein (2017: 1313). A different scenario was proposed by Burlak & Itkin (2003, especially 30–33), who argue that PT */ɔ/ (notated as **o*) remained unchanged in TA in initial syllables (i.e., *o*) and yielded *a* in later syllables.

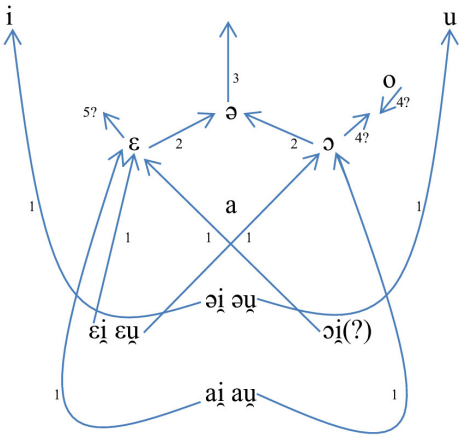

FIGURE 10A
From PT to TA

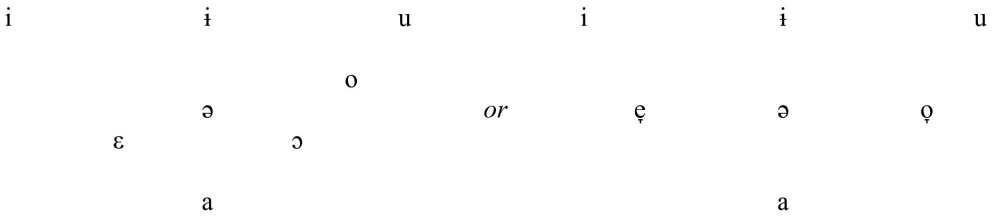

FIGURE 10B Resulting vowel system (= Figure 9a–b, § 4.2.1.3)

Those scholars who follow Ringe in positing an additional phoneme TA '/ŭ/' (§ 4.2.1.2) should further assume that Pre-TA */ɨ/ (< PT */ə/) developed a rounded allophone *[ʉ] which was phonologized as /ʉ/ in the prehistory of TA.[89]

iv. PT */a/ > TA /a/
As in TB, the central low vowel PT */a/ remained stable in TA, where it was spelled ⟨ā⟩.

v. TA /o, ɔ/ > /o̯/?
Finally, it is unclear whether the back mid vowels TA /o/ (< PT */o/) and TA /ɔ/ (< PT */ɛu̯, au̯/) had merged as a "pure" mid phoneme /o̯/ in TA and had consequently caused the front mid-low vowel TA /ɛ/ (< PT */ɛi̯, ai̯, ? ɔi̯/) to raise to /ẹ/. If this did not happen, we have to assume that the grapheme ⟨o⟩ notated both /o/ and /ɔ/ in TA (see § 4.1.2.ii above, with reference to the phonetically ambiguous value of ⟨o⟩ in Italian).
The developments described above are summarized in Figure 10a–b.

89 For a possible scenario, see Ringe (1998: 614).

5 Conclusions

In this paper, I have tried to show how the evolution of the PIE vowel system in Tocharian can be better understood by taking into account the general principles of vowel shifts. The results of the present study can be summarized as follows.

i. After the loss of PIE laryngeals in most positions, I reconstruct the following Pre-PT vowel system: */ī, i, ē, ɛ, ā, a, ɔ, ō, u, ū, ɛi̯, ɛu̯, ai̯, au̯, ɔi̯, ɔu̯/.

ii. For PT, I reconstruct the following vowel system: */i, ɛ, a, ɔ, o, u, ə, ɛi̯, ɛu̯, ai̯, au̯, ? ɔi̯, əi̯, əu̯/.

iii. I propose that the PT vowel system in ii. can be derived from the Pre-PT vowel system in i. through the assumption of the following developments.

   a. Pre-PT */ɔ/ (< PIE **o*) underwent fronting to */ɛ/ due to the acoustic overcrowding in the back of the system. This had two main consequences. First, Pre-PT */ɛ/ (< PIE **e*) was pushed towards the front high region, where it merged with Pre-PT */i/ (< PIE **i*). Second, the fronting of */ɔ/ triggered a complex pull chain shift in the back of the system: (i) Pre-PT */ō/ (< (Late) PIE **ō*) was shortened to */ɔ/ and then lowered to */a/; (ii) Pre-PT */ā/ (< (Late) PIE **ā*) was raised to */ō/ and then shortened to */ɔ/.

   b. Whereas the Pre-PT diphthong */iu̯/ (< PIE **eu̯*) at first did not undergo any further change, the other high diphthong Pre-PT */iu̯/ (< PIE **eu̯*) was assimilated to */uu̯/. This led to a system with an acoustic overcrowding in the high region, where the phonemic oppositions */iu̯/ : */ī/ : */i/ (front) and */uu̯/ : */ū/ : */u/ (back) were potentially unstable. Consequently, the non-peripheral high vowels Pre-PT */i/ (< PIE **i*, **e*) and Pre-PT */u/ (< PIE **u*) were pushed towards the center of the vowel space. There, they merged with the central vowel Pre-PT */ə/, which had arisen from the PIE syllabic resonants.

   c. Distinctive vowel length was lost.

iv. The PT vowel system then evolved in the following ways in Tocharian B and A.

   a. In TB, the back mid vowels PT */o, ɔ/ were leveled as /o̯/ (= ⟨o⟩), whereas the front mid-low vowel PT */ɛ/ was probably raised to /e̯/ and spelled ⟨e⟩. As for PT */a, ə/, they preserved their central positions and were spelled ⟨ā, a⟩. However, the central phonemes TB /a, ə/ developed higher—i.e., less sonorous—allophones when unstressed, namely, [ə] (= ⟨a⟩) and [ɨ] (= ⟨ä⟩), respectively. Accordingly, I reconstruct the following vowel system for Classical TB: /i, e̯, a, o̯, u, ə, ai̯, au̯, o̯i̯/.

b. In TA, PT */ɛ, ɔ/ became /ə/ (= ⟨a⟩), since they were pushed towards the center of the vowel space by the new mid-low vowels /ɛ, ɔ/ (= ⟨e, o⟩) that arose from the monophthongization of the PT diphthongs */ɛi̯, ai̯, ʔ ɔi̯/ and */ɛu̯, au̯/. Consequently, PT */ə/ was raised to /ɨ/ (= ⟨ä⟩). As in TB, PT */a/ led to TA /a/ (= ⟨ā⟩). Accordingly, I reconstruct the following vowel system for TA: /i, ɛ, a, ɔ, o, u, ə, ɨ/ or /i, e̯, a, o̯, u, ə, ɨ/.

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