TOCHARIAN VOWELS : A NEW HISTORICAL PERSPECTIVE

Géraldine Legendre

0. Prologue*

Among the numerous languages of the Indo-European family, the Tocharian languages[1], usually referred to as Tocharian A and B, stand alone as a separate branch[2] : in many respects Tocharian morphology is extremely archaic, sharing many features with conservative Indo-European languages such as Hittite, Sanskrit and Greek. Tocharian phonology, on the contrary, is innovative and unusual in the Indo-European family : Tocharian, the easternmost Indo-European family attested, occupies a position apart in the centum/satem classification ; like other centum languages, it has stops for the Proto-Indo-European (PIE) palatals but it has no labio-velars, just like satem languages[3]. The other remarkable feature of its consonantal system is the generalization of palatalization, producing two series of consonantal phonemes, palatal and non-palatal[4]. This development is rare in the Indo-European family and found only in Slavic, Old Irish and Lithuanian.

Yet, it is in its vocalic system that Tocharian diverges the most from the rest of the Indo-European family : it has undergone considerable reduction, eliminated all long vowels, monophthongized all diphthongs (in Tocharian A) and developed three central vowels, usually represented as ä-a-ā, on a decreasing scale of height, the phonetic quality of which remains a matter of controversy. With its three central vocalic phonemes, Tocharian is quite unusual in the Indo-European family and among the languages of the world.[5]

There is more to Tocharian phonology than just unusual segments. It exhibits sound changes in its vocalic system, which are not found elsewhere in Indo-European languages : PIE short vowels of different height and frontness, *i, *e, *u merged to a single new Tocharian (A and B) central vowel ä of undetermined height. PIE short *o merged with long *e: to give Tocharian short e, a merger which involved not only quality but also quantity. These two are only the most striking cases among numerous vowel shifts which occurred during the history of the Tocharian languages and which have remained for the most part unexplained by phonologists.

Since its discovery around the turn of this century, Tocharian has remained the domain of Indo-Europeanists ; they have produced descriptive

grammars, including remarks on the phonology. My main source here is Krause and Thomas (1960), which is considered by most as the reliable source on Tocharian[6]. Their work is a descriptive grammar with extensive discussion, including a lot of data, of the development of Tocharian vowels. Schmalstieg (1973) and Penney (1976) have devoted their work to reconstructing intermediate stages in the development of Tocharian vowels ; I will discuss their analyses and compare them to mine. Martinet (1975) gives a structuralist analysis of one merger in Tocharian, PIE *i, *e, *u to Tocharian ä.

The purpose of this paper is to offer a comprehensive and unified account of the historical development of the Tocharian vowel systems. I will, in particular, appeal to modern theories, i.e. structuralism and its newest interpretations, natural phonology (Donegan, 1978), particle phonology (Schane, 1982) to motivate and explain those vowel shifts within the existing system.

The structure of the paper will be as follows. In section 1, I give an overview of the Tocharian vocalic system and state the theoretical issues which it raises. In section 2, I propose a new reconstruction for both Tocharian A and B and discuss intermediate stages. In section 3, I show how particle phonology and its new way of looking at the internal structure of vowels sheds light precisely on the most unusual mergers which took place during the evolution of Tocharian.

1. The Tocharian vocalic system : its theoretical import

The synchronic Tocharian system is usually agreed upon as being the following[7] :

Tocharian A	Tocharian B
i̯ e ä a ā o u̯	i̯ e ä a ā o u̯ ai̯ au̯

The vocalic systems of Tocharian A and B are remarkably alike, if one omits the complete disappearance of PIE diphthongs in A. Yet, some PIE segments have different reflexes in Tocharian A and B. For example

PIE *o, *e: > A a B e

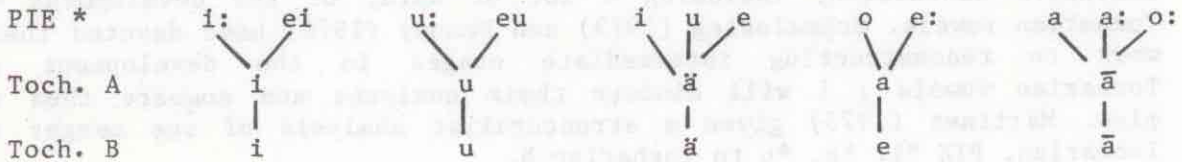
Obviously, the two languages took different routes to arrive at similar systems. Taking as a starting point the PIE vowel system which is generally agreed upon

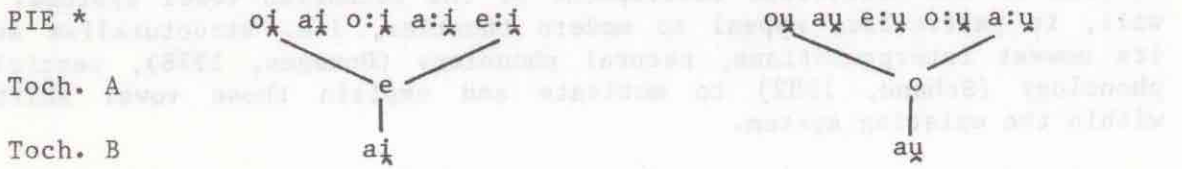
PIE vowels and diphthongs

i e a o u i: e: a: o: u:

ei̯ oi̯ ai̯ eu̯ ou̯ au̯ e:i̯ a:i̯ o:i̯ e:u̯ o:u̯ a:u̯

We can represent the Tocharian reflexes as follows





Except for the change from PIE *i, u, e to Tocharian ä, which is still controversial among Indo-Europeanists working on Tocharian today[8], all other vowels are now considered to be the regular reflexes of PIE vowels in Tocharian.

Comparing the synchronic system of Tocharian B with the historical fact, one immediately notices a discrepancy : short a and o are part of the vocalic inventory of B but are not reflexes of PIE segments. Where do they come from ? I will address this question shortly.

The systems of Tocharian A and B have been represented according to spelling conventions rather than phonetic quality. This is especially true for the vowels ä-a-ā: some have claimed that ä is phonetically a schwa [ə] (Pedersen, 1941) ; for others, it is a vowel of uncertain quality, possibly palatal, comparable to Slavic [ъ] (Van Windekens, 1976). As far as ā is concerned, Penney (1976) argues that it is not a long vowel, rather it is a "maximally open vowel", which I interpret as phonetic [a]. The quality of Tocharian a is surprisingly never mentioned in the literature, it appears that Indo-Europeanists have equated its spelling with its phonetic quality. This represents a problem for Penney, who should have discussed all three central vowels, not just the ones which look 'strange'. If indeed ä is either [ə] or [ɨ] , and ā is the lowest central vowel, them a must be a vowel in between ; Tocharian, then, has three central vowels, which makes it unusual among the Indo-European languages and the languages of the world. I will come back to the Tocharian central vowels in a short while.

While the above two questions, i.e. the origin of Tocharian B a, o and the phonetic quality of ä-a-ā are of primary concern for so-called Tocharianists, other questions of a wider theoretical scope must be asked with respect to the rather unusual shifts :

1) PIE *i, a short front vowel merged with its back counterpart *u. No such merger is exemplified in any other well-known IE subgroup. Donegan (1978) does not even give any similar development in her rather large inventory of natural vocalic processes.

2) PIE *e, a short front mid vowel merged with *i and *u to give Tocharian ä. Although a merger of e and i is not uncommon in the languages of the world, a merger singling out i,e,u is unheard of and its result, ä remains unexplained in theoretical terms.

3) The asymmetry of the Tocharian system, resulting from *e merging with *i and *u, is striking : why didn't *o merge along with the other three ?

4) Any theory purporting to explain Tocharian vowel shifts will have to account for a merger that involves not only vowel quality but also vowel quantity as in

*o, *e: > B e

As puzzling as this merger may look, it is uncontroversial and well documented in the literature.

5) The PIE short diphthongs *ei and *eu merged with *i: and *u:, respectively. Although ei > i: represents a rather common process attested in many languages, it remains to be explained why in a system like that of Tocharian, those two diphthongs were singled out, in particular, why *eu, a diphthong consisting of a front vowel and a labial glide, i.e. an unstable diphthong in Donegan's terms, merged with a long, therefore stable, back vowel *u:. Recall that all other diphthongs, short as well as long, merged to give two short diphthongs ai and au.

In the remaining sections of this paper I hope to give convincing answers to the questions I have just raised and thus show that an understanding of the Tocharian vowel shifts contributes to the understanding of how vocalic systems evolve in the course of time.

To this end, I am making certain theoretical assumptions about phonological systems, which I now wish to make explicit : Following the structuralist tradition, as put forward by Martinet (1964), vocalic systems should be viewed globally as functional systems which "struggle" to maintain their symmetry : the total system defines a vocalic space within which phonemes are affected by various forces, from within and without, thus provoking 'chain' reactions. One of the most striking consequences may be the creation of a 'case vide' or empty slot in the system whenever a vowel gets 'pushed away'. This empty slot, in turn, strives to be filled up, allowing the system to restore its global balance and symmetry.

Haudricourt and Juilland (1970) stress that the tendency for vocalic systems to reduce the number of their back phonemes is due to the asymmetry of the vocal apparatus, a position that Donegan (1978) takes in her study of natural vocalic processes, or, in her words, "palatality is somehow stronger than labiality" (p. 102). This is undoubtedly true in Tocharian where palatalization has pervaded both the vocalic and the consonantal systems.

Following Donegan, I further claim that the "basic fortition processes which affect vocalic elements in diphthongs are identical with those that affect simple vowels" (p. 113) ; in short, that diphthongs do not behave like two moras ; rather they behave like a sequence of V + V : fortition processes may affect any of the two vowel-like segments and a change in one may, in turn, affect the other segment. We will see shortly that such a position allows for a unified analysis of short vowels and diphthongs in Tocharian.

Finally I will appeal to assumptions made by particle phonology, as recently developed by Schane (1982, personal communication), in particular his notion of tension between opposite tonalities, i.e. palatal vs. labial, which causes segments to dissimilate ; a presentation of particle phonology will precede my discussion of the Tocharian shifts in those terms in section 3.

I will now turn to the analysis of the development of the Tocharian vowels. In section 2, I propose a different reconstruction from those of Schmalstieg (1973) and Penney (1976), including a plausible chronology of the individual changes and their motivation.

2. The historical development of Tocharian vowels

Most Indo-Europeanists dealing with the Tocharian languages have stopped short of explaining anything concerning Tocharian phonology, and phonologists have left the domain virtually untouched[9]. To my knowledge, there exist only two reconstructions of the vocalic systems by Indo-Europeanists, Schmalstieg (1973) and Penney (1976). I will now give a short account of their contribution.

2.1 Previous analyses

Schmalstieg (1973)

Schmalstieg reconstructs two Proto-Tocharian (PT) stages : PT 1 is the result of PIE *a: merging with *o: to a: His PT 2 is reached after the following changes took place :

1) PIE *e > PT ä, "an overly short vowel, like the Slavic jers"

2) PIE *o,e: > PT e : "when PIE *e left its position in the vowel triangle, *o and *e: moved in to fill up that space". To account for the existence of synchronic o in B, Schmalstieg claims that the merger was not complete. Also, PT a: "tended to move into the position of o" as length was lost[10].

Schmalstieg's Proto-Tocharian 2 stage is a quadrangular system, which he claims to be the last stage common to Tocharian A and B :

i ä u
e a o

Proto-Tocharian 2 gave Tocharian B directly, under the influence of stress, whereby

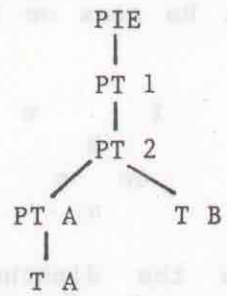
ä > a
a > a:
i > i:

Schmalstieg thus claims that there is an asymmetry between i/i:, a true length contrast re-established by stress[11] and u/u: which reflects only "the arbitrariness of the scribe". This distinction is quite unconvincing.

Proto-Tocharian 2 did not give Tocharian A directly : it went through a Proto-Tocharian A stage, where all diphthongs monophthongized. It further underwent an incomplete process which he calls umlaut : in the environment of a "preceding palatalized (soft) consonant and a following unpalatalized (hard) consonant" (sic!)[12] :

stressed ä > u
stressed a > o

His global reconstruction is a follows



His final vocalic systems are identical for Tocharian A and B

i,i: u,u:
e ä o
a,a:

Schmalstieg reconstructs three long vowels, i: and a: as a result of stress and u: for no reason at all : his reconstruction should be ŭ, an indication of scribal fancy. The result is an asymmetrical system that looks rather dubious. Furthermore, his assumption behind

PT 2 > PT A > A

is that A developed a stress pattern, which he does not make explicit, which in turn triggered an umlauting process. Accent or stress in Tocharian A remains a matter of controversy today : there is no clear pattern that can be extracted. Assuming it 'en passant' to make a change work is, I think, another dubious practice. Finally, Schmalstieg does not discuss PIE *i,u > ä, probably because he uses Van Windekens as his primary source of information. Two independant critical reviews, Gippert (1979) and Winter (1981) have convinced me that his Phonétique du Tokharien (1976) is less than reliable.

Penney (1976)

Penney is aware of Van Windekens' shortcomings and goes back to earlier sources. I agree with his individual changes but not with his account of PIE *o,e: > A a, B e.

He claims that "from the correspondance A a, B e it is clear that IE *o was unrounded in Proto-Tocharian" and reconstructs a PT *oe which he cites as Cowgill's reconstruction (1967) ; he adds that this *oe "could be umlauted to a according to rules that differ slightly for each dialect".

One problem with his analysis is that he does not specify what kind of vowel oe is supposed to represent : if it is a front mid rounded vowel like French [oe], then he must postulate a rounding process that changes his supposed back unrounded PT *o. Penney does not discuss the mechanism of his alleged change. Another problem is that he claims to be using Cowgill's reconstruction of oe. But what Cowgill reconstructs in his 1967 paper is not oe but ae! Is this simply a typographic error on the part of Penney or his convention for ae ? We don't know. Finally, Penney talks about an umlauting process which he does not make explicit either. So far, his analysis is shaky. He goes on to postulate the following PT stage

i u
ä
oe o + ai̯, au̯
a

In Tocharian A, when the diphthongs monophthongized, o was "reinforced" whereas the new vowel e "caused some readjustment" : oe was lowered to a, which in turn caused original a to become the more open ā.

In Tocharian B, "the system of pure vowels was altered as a result of the emergence of a new triad ä-a-ā, where, before the effects of the accent were felt, only an opposition ä-a existed". It caused oe to be raised to e. Both languages ended up with the same vowel system :

Tocharian A/B

ī ū
e ä o
a
ā

Penney's reconstruction is the following

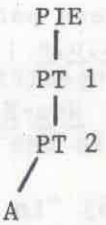
PIE
|
PT
/ \
A B

Although Penney's data are correct and most of his analysis plausible, his treatment of PIE *o > PT *oe > A a, B e is dubious.

Both analyses, though, fail to provide any conclusive explanation that would link all the changes together. Motivations behind their described shifts are not made explicit, neither are their theoretical assumptions[13].

2.2. A new analysis of Tocharian vowel shifts

Using basically the same data as Penney's I have come up with a different analysis, which is, I think, well motivated. Starting with a plausible reconstruction, I propose the following



It differs from Schmalstieg's and Penney's reconstructions in several respects : first, the two Tocharian languages were but one language up to a recent date ; second, B is the most conservative of the two languages and can be reconstructed as the second Proto-Tocharian stage.

From this it follows that my treatment of stress is different : I will shortly explain why I believe that stress developed at a very early stage and is common to both Tocharian A and B. Finally, Tocharian A is more innovative than B ; it developed further, very likely under Indo-Iranian influence.

Before discussing each step in detail, I wish to discuss the stress pattern exemplified in the central triad ä-a-ā of Tocharian B.

2.2.1 Stress and central vowels

Both languages exhibit considerable vocalic reduction, since all long PIE vowels have shortened and short PIE *i,u,e have merged to a central vowel ä. Tocharian A exhibits the most vocalic reduction since all PIE diphthongs have monophthongized - in B, they merged to give optimal diphthongs ai and au. This development, plus the fact that Tocharian A underwent systematic apocope of final vowels, which are retained in B, suggests that Tocharian A is the most innovative of the Tocharian languages.

Tocharian B shows evidence of a stress pattern in the central vowel system, where a is found only in alternation with ä and ā, as follows[14]

Stress pattern in B

stressed	unstressed
ā	a
a	ä

The three central vowels alternate in Tocharian B, under what is believed to have been "un accent d'intensité très fort" (Van Windekens, 1941). This is the only clue to Tocharian accent we have. This taken in isolation, suggests that Tocharian B has only two central vocalic phonemes ; yet, recall that Tocharian ä is also the reflex of PIE short *i,u,e. This is why Tocharian A and B have always been considered to have three central phonemes.

It is quite unclear whether Tocharian A had a similar accent, in particular because it does not exhibit corresponding alternations. My claim here is that the above stress pattern developed very early, because of its role in the merging of *i,u,e ; in Tocharian A the pattern became obscured by later developments, specific to A, such as PT *e > a.

Coming back to the triad ä-a-ā, I wish to give evidence that Tocharian ā is not a long vowel in the sense of PIE long a: :

- As pointed out by Penney (1976) "in Indian alphabets of this period ā represents a maximally open vowel rather than necessarily a long one, and the same may hold for the Tocharian script, which is a variant of the North-West Indian Brāhmī script".
- There is furthermore ample evidence that Tocharian ā is a reflex of both PIE long and short *a :

PIE * aḱ-	A āk	B āke	'end'
Lat. sal	A sāle		'salt'
Gr. ἄργυ-ρος	A ārki	B ārkwi	'white'
Lat. māter	A mācar	B mācer	'mother'
PIE *tāgi̯ (o)-	A tāççi		'chief'
Lat. nāre	B nāsk-, nask-		'to swim'

To account for PIE *a > Tocharian long a: one would have to claim that short PIE *a is the only vowel which became long in Tocharian. Note that the word 'to swim' has two spellings, ā and a. Such doublets are common in Tocharian and not limited to ā/a ; I will shortly discuss ī/i and ū/u doublets. Their existence is explained in the literature by referring to inconsistency on the part of the scribes. I will give another explanation when I discuss various stages in the development of Tocharian.

- A final argument is provided by borrowings : as pointed out earlier, Tocharian was in close geographical contact with Ancient Uighur, the Turkic language of the region, which borrowed quite a few items of vocabulary from Tocharian A, in particular religious terms. The result which concerns us here is that whenever a word with ā was borrowed into Turkic, it shows up as short a and not long a: ; yet Turkic is a language with contrastive vocalic length :

from Poppe, Introduction to Altaic Linguistics

Turkic	čadik 'tale about Buddha'	Toch. A	ǰātak
	dyan 'meditation'		dhyāṃ
	kinari 'legendary creature'		kinnare
	kšan 'moment'		kṣaṇa
	nirvan 'nirvana'		nervāṃ
	madar 'sea monster'		mātār

As to the quality of the three central Tocharian vowels, my position is that it is impossible to know what the true phonetic value of those vowels was. Yet, we can and must make claims as to their functional value within the Tocharian system. Having acknowledged the existence of three central vowels, the highest being ä, the lowest ā and an intermediate one on a scale of height a, I propose now a phonetic counterpart for each of them :

ä [ɨ]
a [ʌ]
ā [a]

This representation only means that ä functions as the highest central vowel in the Tocharian vowel system, that a and ā function respectively as ʌ and a.

2.2.2. Proto-Tocharian 1

Reconstructing one or more Proto stages is equivalent to claiming a plausible chronology, the evidence for which can come only from within, from the interaction between changes. If one can prove that a given change must have occurred before another one because of its consequences for the whole system, then the reconstruction becomes plausible. The Proto-Tocharian stage 1 that I posit is the result of changes which require partial ordering. The steps are the following :

1 - PIE *a:, o: > PT *a:
2 - PIE *o > PT *o:
3 - PIE *oi, ou > PT *o:i, o:u
4 - PIE *i, e, u > PT *ä (= ɨ)
5 - PIE *ei > PT *i:
*eu > PT *u:
6 - Loss of length

I will now discuss each of these steps in detail.

1. PIE *a:, o: > PT *a:

This shift is uncontroversial and Schmalstieg also posits it as his first development : the reason is that the original merger of PIE *a: and o: is an old Indo-European trend attested in Germanic, Lithuanian and Slavic. While Germanic and Lithuanian exemplify a merger to o:, Slavic and Tocharian show a merger to a:. According to Donegan (1978) "the property of sonority, to which vowel height most closely corresponds, seems to be a more basic property of vowels than its timbre" (p. 29) and long vowels are more susceptible to Lowering than their short counterparts. In those terms, a: is more sonorant than o:, which is also long. These two factors explain what Donegan would call a 'natural' change.

Proto-Tocharian a: merges with PIE *a later, when length is lost everywhere, and ends up as ā in stressed position and a in unstressed position in B, as ā in A.

I claim that the merger of PIE *a: and *o: occurred first because it conditioned change 2 which is turn conditioned changes 3 and 4.

2. PIE *o > PT *o:

When PIE *o: merged with *a: it left PIE short *o in a quite unstable position : in a system with contrastive length it was the only short vowel. My claim is that in order to restore the balance, *o became longer to fill up the space. This would explain why it did not merge with PIE *u even though *i and *e did to PT ä.

In Donegan's terms this is a typical strengthening process : the more sonorant a vowel is, the more susceptible to lengthening it is. In section 3 I will show that particle phonology analyses this change in terms of conservation of particles, a direct correlate of step 1.

3. PIE *oi̯, ou̯ > PT *o:i̯, o:u̯

Recall my assumption that each half of a diphthong behaves like a single vowel. I postulate this change as one example of this principle at work in Tocharian : it explains why the short diphthongs *oi̯, *ou̯ did not merge respectively with *ei̯, *eu̯, which were singled out for a different fate. Actually step 3 is a subset of step 2 on the basis of my assumption that diphthongs behave like a sequence of VV. I give it here as a separate step for the sake of clear exposition only.

4. PIE *i, e, u > PT *ä [15]

Steps 4 and 5 are quite intricate and their chronology with respect to one another is not firmly established. I present the shift from *i, e, *u to ä first because it makes the understanding of *ei̯ > i: and *eu̯ > u:, easier even though they might have been simultaneous.

There is a lot of evidence in Tocharian for establishing a shift from PIE *i, *e, *u to Proto-Tocharian ä and it is necessary to consider the phenomenon in initial position and medial position.

It has been observed by many Tocharianists that in initial position the reflexes are not *ä but i̯ä and u̯ä as in

PIE *ekwo	B yakwe	'horse'
PIE *uĝh-s-	A wäks	'to be worried'

This diphthongization process, which is general in initial position, is analyzed by Martinet as "dégagement d'une prothèse", palatal for front vowels and labial for u :

PIE *i	>	Tocharian	i̯ä
*e			i̯ä
*u			u̯ä

Among Indo-European languages, Slavic exhibits a similar development, though limited to PIE *e in initial position. What is remarkable in Tocharian is that the occurrence of the prothetic element is not limited to initial position : it is also found in medial position, where it is absorbed by the preceding consonant :

PIE *li-mn	A lyäm	B lyam	'lake'
PIE *onqel-	A añcäl		'bow'
PIE *dheghw-	AB tsäk-		'to burn'

In Tocharian ly, c, ts are palatal phonemes, the result of widespread palatalization observed but unexplained by Tocharianists. Martinet (1975) gives an enlightening solution to the palatalization mystery as he claims that the merger of *i, *e, *u to *i̯ä, *u̯ä at the Proto-Tocharian level is the source of palatalization of the environment by 'infection' or "transfer de certains traits vocaliques sur la consonne précédente", a process already attested in Slavic and Old Irish.

The Old Irish case is quite relevant here : Donegan points out that labialization of a preceding consonant is very rare, in contrast to palatalization, and that in Old Irish labialization occurred before u, never before o. This is precisely the case in Tocharian where o never behaves like u. She concludes that palatalization and labialization seem to be favored in the environment of less sonorant vowels. Then, why did *e go along with *i and *u ?

Before answering this question, I wish to sum up the discussion of PIE *i, *e, *u > PT ä : although *i,e,u surface as ä in Tocharian, in medial position, the merger involved an intermediate step, which can be represented as follows

PIE *i > i̯ɨ > ɨ
*u > u̯ɨ > ɨ
*e > i̯ʌ > ɨ

Again, the prothetic segment is absorbed by the preceding consonant in medial position ; in initial position it shows up as a glide, as expected.

Coming back to the question as to why *e merged with *i, a plausible answer is that stress had already started to operate in the following manner :[16]

Recall the alternations that appear under stress in the central vowel series :

Stressed	Unstressed
a	ä
ā	a

So, we have a type of step-wise pattern whereby a stressed vowel moves down one step on the scale. Sonority being the vocalic quality par excellence, it is of course the more sonorant or lower vowels that we expect to appear in a stressed position and this is nicely illustrated here, in Tocharian. Using the phonetic references given earlier the above pattern can be reformulated as follows :

Stressed	Unstressed
ʌ	ɨ
a	ʌ

Now, suppose that stress had started to affect the system of high PIE vowels *i and *u, already developed into ɨ in Proto-Tocharian. The result was two different reflexes, depending on stressed or unstressed position :

*i > iɨ > ɨ < [ɨ] - stress / [ʌ] + stress

*u > uɨ > ɨ < [ɨ] - stress / [ʌ] + stress

If, at the same time, PIE *e was moving centrally to a vowel of the same height :

*e > iʌ > [ʌ] everywhere

then, it follows that the two developments clashed and merger was inevitable between the reflex of *i in stressed position and that of *e. I suggest further that the reflex of *e, having merged in stressed position, merged with ɨ in unstressed position, by analogy. Recall that stress also affected the lowest central vowel as follows :

PIE * o:, a:, a > a < [ʌ] - stress / [a] + stress

In this solution I am making use of an independantly established stress pattern. What is new is that I am claiming that it developed at a very early stage and thus radically changed the fate of PIE vowels in Tocharian. Everyone agrees that the vocalic system of Tocharian is radically different from that of PIE, in short that it is considerably reduced. There must have been a strong force behind this change, a force which can plausibly be equated with that of an emerging stress pattern.

As for the merger of *i and *u, Normier, 1980, gives evidence for a similar development in an Iranian language, East Ossetic, where Proto-Ossetic *i and *u gave East Ossetic ɨ (and West Ossetic i and u).

Yet, Tocharian is even more remarkable than shown so far ; the secondary palatalization described above in turn palatalized the vowel : this is Martinet's solution to the frequently noted umlauting of palatal ä > i and labial ä > u :

PIE	*medhu	B mit	'honey'
	*penkwe	B pis	'5'
	*wento	B yente	'wind'

It is plausible to reconstruct several steps as follows :

*medhu > *myät > *myet > *myit > mit
*wento > *wyänte > *yänte > yente

Note that the development *myet > *myit > mit involves two processes that I will discuss under step 5, i.e. palatalization and consonantal depalatalization.

The process of palatalization by a palatalized consonant is further attested in Tocharian by the existence of doublets like

A cäñcär/ciñcär	B cäñcare/ciñcare	'lovely'
	B cimpim/cämpim	'I wish I could'
A ñäs	B ñiś/ñäś	'I'
	B śitkai/śätkai	'very'
	B yikṣye/yäkṣiye	'flour'

These doublets are not reflecting "scribal fancy" as often claimed in the literature ; they are strong evidence of two stages, before umlauting took place and afterwards (recall that c indicates [č] and ś [tš]). As Krause-Thomas (1960) point out, the appearance of i in accented syllables in B is good evidence that a developed from ä under accent, that ä is indeed the original vocalism.

5. PIE *ei̯ > PT *i:
*eu̯ *u:

This development is another case in Tocharian where each half of a diphthong behaves like a single vowel. Furthermore the first half *e behaves like the single vowel *e[17] :

*e > i̯ [i̯] - stress
∧ [∧] + stress
absorbed

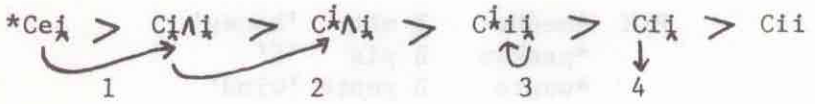
I will discuss *ei̯ > i: and *eu̯ > u: separately since their development involves somewhat different phenomena. Consider first *ei̯ > *i: :

PIE *mei̯n- AB onmiṃ 'to repent'

All the sources consulted do not discuss the reflex of *ei̯ in both stressed and unstressed position. Considering that on- is a prefix in

Tocharian it is reasonable to assume that stress falls on the last syllable, i.e. on i.

So, the development from *ei̯ to PT *i: can be represented as follows (where C stands for consonant):



This complex development involves the following steps :

1 - *e > *i̯∧ in stressed position, before the original i̯ glide

2 - *Ci̯ > *Cˇ the prothetic glide palatalizes the preceding consonant

3 - *Cˇ∧iˇ > *Cˇiiˇ the stressed vowel [∧] is palatalized by the following i̯ glide : phonetically [∧] cannot resist palatalization when it is preceded and followed by a palatal element, the sequence being almost unpronounceable.

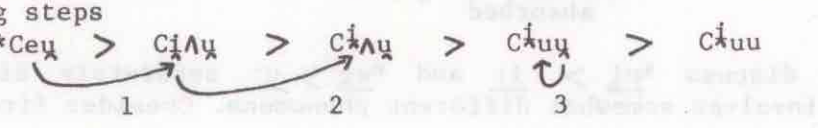
4 - *Cˇ > C the palatalized consonant is depalatalized in front of the high front vowel i : this process of consonant depalatalization in a palatal environment is fairly common and attested in another Indo-European language, Rumanian, which by the way, is the only other IE language with three central vowels (Schane, 1971 and personal communication).

The result of this development is a sequence ii, equivalent to long i:. It then merges with PIE *i: and is later shortened when length is lost across the board.

Turning now to *eu̯ > u:, we note an interesting contrast : the preceding consonant always shows up as a palatal

PIE *leu̯qo	B lyu̯ke	'light'
*gheu̯r	A çur-	'to worry'
*seu̯r	A ṣurāṃ	'semen'

The development from *eu̯ > u: is similar to that of *ei̯ > i:, except for one missing step, depalatalization, which is precisely what should be missing if the explanation we gave for *ei̯ > i: is correct. Consider the following steps



1 - *e > *i̯∧ before the original u̯ glide

2 - *Ci̯ > *Cˇ the prothetic glide palatalizes the preceding consonant ; it is absorbed by the consonant.

3 - *C$^{i}_{\ast}$∧u > C$^{i}_{\ast}$u$_{\underline{u}}$ the vowel [∧] is labialized by the following u̲ glide. The preceding consonant retains its palatalization because it is in a labial environment.

The sequence uu, equivalent to a long vowel u: is later shortened to Tocharian u.

Our assumption that diphthongs are equivalent to a sequence of VV and undergo the same processes as single vowels in a given system allows for a strikingly simple answer to the mystery as to why the short PIE *ei̯ and *eu̯ diphthongs were singled out to merge with the long PIE vowels, *i: and *u:, respectively. It is interesting to note that Tocharian is not the only case in Indo-European where such a behavior can be recognized : Smith (1984) argues for a palatalization process in diphthongs in Common Slavic.

6. Loss of length

As a result of the previous discussion, Proto-Tocharian had reached a stage where it can be represented as follows

i: ɨ u:	e:i̯,o:i̯,a:i̯,ai̯
e: ∧ o	e:u̯,o:u̯,a:u̯,au̯
a	

This is a system where length has ceased to be functionally contrastive, except for the diphthongs a:i̯/ai̯ and a:u̯/au̯ ; consequently, it was lost across the board. The existence of doublets, exhibiting alternations i/i: and u/u: such as

pilenta/pi̯le	'wound'	
dvip/dvīp	'island'	Skr. dvīpa
lyuke/lyūke	'light'	
lyutar/lyūtar	'more'	

have erroneously and unjustly been attributed to some kind of inconsistency on the part of the scribes. Rather, this practice attests to a stage where length might still show up phonetically under some circumstances but is no longer contrastive in the Proto-Tocharian language.

Proto-Tocharian 1

At this point I reconstruct a stage (1) in Proto-Tocharian because I believe that loss of length marked a turning point in the development of the language :

i ɨ u	ei̯ eu̯
e ∧ o	ai̯ au̯
a	oi̯ ou̯

What is striking about this system is that it is very symmetrical. Yet, it was to be disrupted again by the highly unusual merger of PT *e, o to e.

2.2.3. Proto-Tocharian 2 (= Tocharian B)

The common Proto-Tocharian language underwent two further shifts before reaching its stage 2.

7. PT *e, o > e

This merger is undoubtedly of the rarest kind and surprisingly it has never been the subject of controversy among Tocharianists : this shows that their primary concern was to describe the sound changes (and there is a large corpus of data that attests to the regular nature of this change) and not to explain them. Recall that it involves both a change in quantity and quality :

PIE *e:, *o > e

A long mid front vowel merged with a short back vowel of the same height to give a short front vowel. The change in quantity does not pose a problem, once it is established that PIE short *o underwent lengthening as a result of the merger of PIE *a: with *o: (step 2), and that it underwent shortening as a result of across-the-board loss of length (step 6) :

PIE *e:,o > *e:,o: > *e,o > e

Why a change in quality, especially, why would o become a front vowel e ? I will now discuss a number of factors which, I believe, have contributed to this shift.

Let's consider first the data ; so far the environment of a given change has always proven to be quite enlightening :

PIE *ok^{w}-	B ek	'eye'
*u̯ok^{w}-	B wek	'voice'
*gombhos	B keme	'tooth'
*dgom	B kem̨	

If one follows Krause-Thomas'idea that Tocharian k from PIE *k^{w} had retained some of its labio-velar articulation, then we can explain the shift from o to e as a result of dissimilation, a process by which segments become less similar to each other : PT * o became e when it was preceded or followed by a labial segment m or k from *k^{w}.

This analysis is confirmed by the fact that the change o>e did not occur across the board : in the environment of Tocharian k from PIE *k, o did not dissimilate. Consider

PIE *(s)qolm(o)	A koläm	B kolmai	'boat'
	A ko	B koym̨	'mouth'
*okto	A okät	B okt	'8'

When a palatal element is present, it also prevents dissimilation

PIE *koli	B kolyi	'hair'
*oldi	B olyi	'boat'
	A poñs B poñc	'all'
	AB cok	'lamp'

The dissimilation of o is correlated to other factors inherent to the development of the Tocharian languages : palatal color is much stronger than labial color in Tocharian ; recall that it invaded the consonantal system too. Furthermore, the opposition e/o-e:/o: was very strong in Indo-European as the whole system was dominated by ablaut. In languages where *o did not merge with *e, i.e. Germanic, Albanian, Lithuanian, the ablaut system was well-maintained[18]. In Tocharian and in the well- known case of Indo-Iranian[19], the ablaut system is considerably reduced, precisely because of the merger of e and o. Tocharian further parallels Indo-Iranian in that in A the final outcome of this merger is a, and may well have been influenced by it.

8. PT *a̯i, e̯i, o̯i > a̯i
*a̯u, e̯u, o̯u > a̯u

The optimization of diphthongs is well attested as a strengthening process in the languages of the world and Tocharian is but one example of the fortition process which aims at producing stable diphthongs, i.e. of maximal color, labial or palatal, and maximal sonority : Donegan (1978) equates increase of sonority with lowering and increase of labial/palatal color with raising and claims that diphthongizations are "very often step-by-step polarizations of sonority and color". Each half, the color-bearing element and the sonority-bearing element will have the tendency to increase the property which it already possesses to a high degree, a tendency which Donegan calls the "rich-get-richer principle".

Under our assumption that each half of a diphthong behaves like the corresponding vowel in Tocharian, we can postulate an intermediate step in the merger of all diphthongs :

(1) PT *e̯i, *o̯i > *e̯i PT *e̯u, *o̯u > *e̯u

(2) *e̯i, *a̯i > *a̯i *e̯u, *a̯i > a̯u

Step 1 parallels the shift motivated under 7, i.e.

PT *e, o > e

Step 2 applies the theoretical principle underlying the polarization of diphthongs I have described above. Note again the symmetry between the front and the back diphthongs.

Proto-Tocharian 2 = Tocharian B

i ɨ u
e ∧ (o) a̯i, a̯u
a

I represent o in () because of its rare occurrence in Tocharian B : in most cases as discussed earlier (step 7) it has undergone dissimilation and merged with e. Compared to my reconstructed stage (1), Proto-Tocharian (2) can be characterized as more unstable and it represents the stage at which Tocharian B is attested in the manuscripts.

The unstability of o in Tocharian B is supported by the fact that the language exhibits a late tendency towards monophthongization of the diphthongs ai and au to e and o respectively (in Tocharian A it applies across the board) and that the monophthongization to o is much more frequent than that to e :

B	aiśalle/eśalle	'to know"
	aikemar/ekasta	'you have known'
	mauko/moko	'old'
	lauke/loke	'remote'
	śaul/śol	'life'
	rautkam/rotkär	'they moved'

The existence of such doublets attests to the late chronology of this process.

In summary, o in Tocharian B has two sources : PIE *o, which did not undergo dissimilation (of o to e) and PT2 *au, which is undergoing monophthongization. Tocharian B, as exemplified in the manuscripts, appears to be a language in the process of changing, precisely to restore symmetry and balance to the global system.

2.2.4. Tocharian A

Tocharian A diverges from Proto-Tocharian 2 in that it completed some of the changes that had been initiated at that stage. It possibly did so under the influence of Indo-Iranian, with which it came into contact (Lane, 1966).
The famous Indo-Iranian merger PIE *e, a, o > I-A a finds a counterpart in Tocharian A :

9. PIE *e:, o > A a

*okʷ-	A ak	B ek	'eye'	Skr. vāk
*gombhos	A kam	B keme	'tooth'	Skr. jambha-

Hansen (1940) discusses Tocharian borrowings from Iranian and gives a few which are relevant here ; unfortunately the reconstructed PIE form is usually missing :

A	param	B perne	'honor'	Saka phārra Sogdian prn
A	patrak		'leave'	Skr. patra
A	ratäk	B retke	'army'	middle Persian ratak

Recall the intermediate steps discussed earlier :

PIE *e:, o > PT *e: , o: > *e, o > e > a

When PT2 e shifts to a, it leaves two empty slots in the vocalic triangle, those of e and o[20], ready to be filled up when the monophthongization of aj and aw applies pressure onto the entire system (step 10).

10. PT2 aj > e
aw > o

This monophthongization process again parallels that of Iranian[21]. Hansen (1940) gives only one instance of a plausible borrowing :

A metrak B maitrāk — Saka maitrai, mätrai; Partian mytr'; Middle persian metrak (?); Sogdian mērak

That A aj, aw are the regular reflexes of B e, o, respectively is attested by many examples such as[22]

B	aikare	A	ekär	'empty'
B	śaim	A	śem	'I was'
B	yapoy	A	ype	'country'
B	auñento	A	oñant	'beginning'
B	klautke	A	lotäk	'manner'

Note that steps 9 and 10 are not ordered ; they are more likely to have been simultaneous and interacting as suggested under 9.

11. Further vowel weakenings

All Tocharianists agree that the stress pattern in Tocharian A defies a straightforward account. Some alternations do occur :

ø-ä	oñkälmāñ/oñkaläm	'elephant' nominative plural
ø-a	artmār/artamār	'love'

The most interesting alternations, however, are those between Tocharian A and B

A	B			
ā	a	A āknats/āknts āñ	B aknātsa	'ignorant'
a	ā	A wāskat	B waskāte	

An extensive investigation of stress in Tocharian A is well beyond the scope of this paper. I wish to suggest though that stress in A must have had the same source as that in B but that it became 'blurred' as a result of a merger specific to A which involved the central vowel a i.e. e, o, a > a. Consequently, it may have undergone restructuring, linked with the systematic apocope of final vowels, a development noted only in Tocharian A :

A	kam	B	keme
A	śäm	B	śana

With these remarks on stress in Tocharian A I conclude my reconstruction of both Tocharian A and B and my explanations as to why the sound changes occurred the way they did.

In the remaining section of this paper I will reexamine the processes which underly these sound changes in terms of particle phonology. Because of the assumptions it makes about vowel systems, particle phonology offers an explicit formulation of the phenomena involved.

3. A particle analysis of Tocharian vowel shifts

3.1. Particle phonology

Particle phonology recognizes three primitives or elementary particles : i, u are tonality particles of palatality and labiality, respectively ; a is the aperture particle. Segments are represented as combinations of particles : front vowels contain the particle i, round vowels (back) contain the particle u and the number of a particles corresponds to vowel height. As a whole, the number of particles is a direct reflection of the complexity of a segment, thus inherently building in the idea of markedness. As for central vowels of the Tocharian kind, their representation depends on their contrastive number. In a system with three central vowels, the highest is said to be particleless and is represented as ± (a representation which does not make a claim about its true phonetic quality) ; the two lower vowels are represented as a and aa, respectively. Following is a table (from Schane, 1982) which gives particle representations of common vocalic segments :

1 - Short Vowels

[i]	i	[u]	u	[ü]	iu	[±]	±
[e]	ai	[o]	au	[ü]	aiu	[ʌ]	a
[ɛ]	aai	[ɔ]	aau	[œ]	aaiu	[a]	aa

2 - Diphthongs

[ai̯]	a	i̯	[ei̯]	ai	i̯
[au̯]	a	u̯	[ou̯]	au	u̯
[oi̯]	au	i̯	[eą̱]	ai	ą̱
[eu̯]	ai	u̯	[oą̱]	au	ą̱
[u̯e]	u̯	ai	[aǫ̱]	a	au̯

3 - Long Vowels

[i:]	i	i	[u:]	u	u	[ü:]	iu	iu	
[e:]	ai	i	[o:]	au	u	[ö:]	aiu	iu	
[ɛ:]	aai	i	[ɔ:]	aau	u	[œ:]	aaiu	iu	[a:] a a

Particle phonology diverges from standard generative phonology in the following respects : where standard generative phonology makes a sharp distinction between features and segments, particle phonology claims that particles can exemplify both particular segments and

properties of vowels[23]. Furthermore it makes the interpretation of particles context-dependent : in structuralist terms it views language-specific vocalic systems as closed systems : the particles existing in a given system are the units that undergo various changes ; certain particle sequences may lose particles because they are unstable, others may gain particles ; yet, any gain must be sanctioned in some way within the system, which strives to conserve particles. Tocharian exemplifies a number of processes which particle phonology mirrors in a beautiful and simple manner.

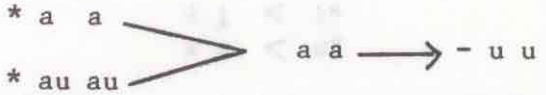
3.2. A particle analysis

3.2.1. Decay of tonality

Decay is particle phonology's way of representing neutralization as a loss of one or more particles. Recall the first merger :

PIE *a:,o: > PT *a:

In particle terms it is viewed as loss of tonality[24].



According to Donegan (1978), the lower (= more sonorant) a vowel is, the more susceptible it is to delabialize. In particle terms, the merger is favored because a: is a vowel of pure sonority and o: which contains both sonority and labial tonality will tend to lose its weaker particle, u. Note that the consequence of this merger on the remaining short *o finds a natural explanation here (step 2) : particles are conserved in that the lost u particles are gained by *o. This is reinterpreted as a gain in length :

au + u u ⟹ au u
[o] [o:]

Neutralization occurs in the diphthong series too, where

PT *ei, ai, oi > ai
*eu, au, ou > au

This was analyzed as a polarization of the palatal/labial element vs. the sonority element within the diphthongs (step 8). Particle phonology recognizes such polarizations thanks to its notions of minor tension between the particles i and u (opposite tonalities) and major tension between tonality and sonority/aperture. Maximal diphthongs [ai] a i and [au] a u, both sequences of an aperture particle and a tonality particle, mirror this major tension which gives them more stability. The process by which less stable diphthongs (= subject to less tension) optimize is again that of decay of tonality :

Note that the number of moras is retained in this neutralization process : this is simply a change from marked to unmarked segments, which does not disrupt the global system.

3.2.2. Fission and cloning

In the course of historical change, particle sequences are subject to breaking apart : this is called fission in particle phonology (diphthongization). Donegan (1978) notes that processes may create two non-identical elements out of a single vocalism as in Tocharian

PIE *i > i̯ä
*e > i̯ä
*u > u̯ä

Recall that this phenomenon was explained by Martinet as "dégagement d'une prothèse". This process is mirrored in particle fission : a vowel splits up into a rising diphthong, i.e. an up glide of the same tonality as the original vowel and a vowel which contains neither tonality nor sonority particles, which particle phonology calls particleless, represented as ±.

*i > i̯ ±
*u > u̯ ±

By calling Tocharian ä particleless, particle phonology does not make any claims as to its phonetic quality. The notation simply means that it is the highest vowel in a system that has three central vowels. It does however make a claim as to its functional importance, namely that it is a very unstable, reduced vowel that has no color whatsoever ; neither does it have any aperture. This is precisely what one can expect from a vowel which shows up in unstressed position only and in a supporting function in Tocharian A, where it is used to break up consonantal clusters which have been left strandd in final position after the loss of final vowels.

In particle phonology e is represented as a sequence of an aperture particle and the particle i, indicating its frontness (all front vowels contain the particle i, all rounded vowels have u, and all non-high vowels have the aperture particle a). In particle terms, the shift from *e to i̯ä is the result of fission.

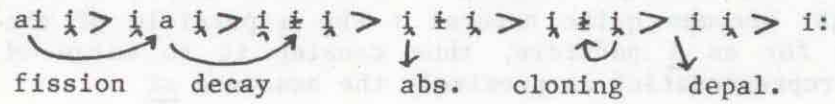
ai > i̯ a [i̯ʌ]

Recall that the prothetic glide resulting from fission was absorbed by the preceding consonant (except in initial position) and that stress caused a merger of e and i:

*u > u̯ ± ⟩ ± ⟨ ± − stress
*i > i̯ ± ⟩ ⟨ a + stress

*ai > i̯ a > a everywhere
↓
absorbed

Particle phonology views this merger as the result of particle exchange, whereby a high stressed vowel acquires an aperture particle while a mid unstressed vowel loses one. In our earlier discussion we extended our analysis of PIE *i,u,e > ä to two diphthongs which were singled out for a similar fate, i.e. *ei and *eu. Recall that their final outcome was PT *i: and *u:, respectively. Particle phonology allows for a similar development in terms of fission, decay and cloning:[25]



The first segment of the original diphthong ai, the particle representation for [e] splits up into a new diphthong (by fission) followed by decay of aperture : according to Donegan, less sonorant vowels are more likely to become even less sonorant, i.e. in the Tocharian central series

ä	±
a	a
ā	aa

the mid vowel a, which contains only one aperture particle is likely to lose it and become ±. Recall that the prothetic glide is absorbed by the preceding consonant, which in turn palatalizes the vowel : particle phonology calls this phenomenon, cloning, an assimilative process by which an off-glide is copied onto the particle representation of the other mora of the diphthong. Consonantal depalatalization follows and the result is a sequence of i i̯ equivalent to a long vowel i: which merges with PIE *i:.

We saw earlier that the change *eu > u: involved a similar process of fission but that the preceding palatalized consonant did not undergo depalatalization due to the labial environment :

When the prothetic glide was absorbed by the preceding consonant it left a sequence ± u̯ which underwent cloning, thus giving rise to a new long vowel u u = u:.

The next step in the development of Proto-Tocharian 1 is the general loss of length. In particle terms this is equivalent to decay by loss of a tonality particle. Notice that in the cas of [a:] , which is pure aperture aa a, it is one a particle which is lost in this process.

3.2.3. Mutation

Particle phonology treats dissimilation as mutation, whereby one tonality particle is exchanged for the opposite one. In dissimilations, the property which is lost in the segment which undergoes change is preserved in the environment ; in Donegan's terms, bleaching is

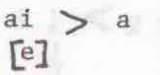
especially applicable in such an environment : vowels before or after labials are particularly susceptible to delabialization. This is precisely the case in Tocharian where PT *e, o merged to e. Particle phonology captures this kind of change thanks to its notion of tension between tonality particles : in a labialized environnement u will tend to differentiate and exchange for the particle i. Under these considerations, a merger between a back vowel and a front vowel of the same height becomes quite natural : the u particle of the vowel o is exchanged for an i particle, thus causing it to merge with e, whose particle representation is precisely the sequence ai :

With this particle solution we can avoid positing untermediary vowels such as Penney's oe, a segment which makes a claim as to its phonetic quality, for which we have no evidence in the language.

Using the particle model, I have sofar reformulated the changes which lead to the Proto-Tocharian 2 stage, which is also that of Tocharian B. Recall that Tocharian A underwent two more changes which lead to an even greater vocalic reduction, i.e. decay again and fusion (monophthongization).

3.2.4. Decay and fusion in Tocharian A

In Tocharian A e merged with a. This is a case of neutralization to a less marked segment a. In particle terms, a vowel containing pure aperture (or sonority) is less marked than a vowel which contains both tonality and aperture particles. Recall that the number of particles mirrors the complexity of a segment. Thus a change like the above e > a appears to be a quite natural process of decay of tonality :



Recall the final sound change which occurred in Tocharian A, i.e. the monophthongization of ai and au to e and o. The particle notion mirrors the relationship between ai and e on one hand, au and o on the other, and calls it fusion : the particles of the diphthong fuse into a single complex particle. In particle phonology, ai/e, au/o are merely different temporal sequences (linear vs. simultaneous) of the same particles. All and only the original particles are conserved in the fusion process :

Fusion is a highly common process : it is attested in Old French where [eu], [ue] fused to [ö] (Schane, 1982), in Old Persian (Hashemipour, 1984), in Slavic (Smith, 1984), to name only a few other cases in Indo-European.

4. Epilogue

I have examined the historical development of the Tocharian vowel system with the intent of explaining in a unified manner why the changes previously noted by Indo-Europeanists might have occurred the way they did. I have established a new reconstruction for both Tocharian A and B on the basis of what I claim to be the regular changes. I have proposed that Tocharian B is more conservative than Tocharian A, that its development corresponds to what I reconstruct as a Proto-Tocharian 2 stage. I have claimed that stress developed very early and is common to both Tocharian A and B. The fact that it cannot be clearly recovered in Tocharian A is due to a late phenomenon, specific to A, which obscured the original pattern. Much work remains to be done in this domain though.

Besides appealing to similar changes in other Indo-European languages and to universal tendencies to account for some of the changes, I have used arguments from within the Tocharian system itself and theoretical reasons to support other more unusual mergers such as PIE *i, e, u > ä and PIE *e:, o > e. Particle phonology's notions of fission and mutation offer an insightful way of looking at these shifts.

With their assumptions about the universal properties of vowels, natural phonology (Donegan) and particle phonology (Schane) help establish that nothing bizarre happened in the development of Tocharian ; rather it appears that the language made use of all its resources, striving to keep the vocalic system balanced and functional. Considered unusual among the Indo-European family, Tocharian becomes a good illustration of a complex interaction of changes which lead to considerable reduction on one side and striking symmetry on the other.

FOOTNOTES

*I am grateful to Sanford Schane, Margaret Langdon, Matthew Chen, and Mike Smith for their helpful comments and criticisms on earlier versions of this paper. All errors and omissions, of course, are my own.

[1] Documents, dating from 500 to 1000 A.D., written in a north Indian syllabary called Brāhmī, were discovered in the Chinese Turkestan (Tarim Basin) region of Central Asia around the turn of this century. Many of the texts found were translations from Buddhistic texts and often bilingual (with Sanskrit). The language was therefore rapidly deciphered and identified as belonging to the Indo-European family and given the name Tocharian because it was believed - still a matter of debate doday - to have been the language of a central Asian people referred to in classical texts as Tocharoi or Tochari. Now extinct, Tocharian exists in two clearly marked forms, called Tocharian A (also known as Tourfan or East Tocharian) and Tocharian B (also known as Kuchean or West Tocharian), and it is still controversial today whether A and B should be given the status of different languages belonging to a single family, i.e. the Tocharian family, rather than being considered, as they have been sofar, separate dialects of a single language, Tocharian.

[2] Although Tocharian A exhibits influence from Old Iranian and Tocharian B some influence from Middle Iranian and more from Indic (Sanskrit) it is not an Indo-Iranian language and is considered a separate branch of the Indo-European family tree. Although it has been convincingly established that B was the native spoken language of Kucha, the western region of the Chinese Turkestan (Lévi, 1913), it is still somewhat unclear what the origin of Tocharian A is: documents, exclusively of religious content, written in A were found only in the eastern part of the Basin, in the Karashar-Turfan region, next to manuscripts written in B. It has been argued (Lane, 1966) that at the time when the documents in dialect A were written, it had become purely a liturgical language in the monasteries of the east, with dialect B possibly used as a monastery vernacular and a non-indo-european language of the region, possibly Ancient Uighur (or Ancient Turkic) used as a vernacular outside the monasteries. The evidence comes from the extreme regularity in form and orthography of dialect A (as opposed to the extreme irregularity displayed by dialect B) and from manuscripts written in A but glossed in dialect B and in Uighur, in what has been identified as a different handwriting.

[3] Until Tocharian was discovered, the satem/centum distinction within the Indo-European family was believed to be geographical, besides phonological : all eastern languages were satem and western languages, centum. Tocharian is the easternmost IE language attested but it is centum.

[4] The Tocharian consonantal inventory is in the literature divided into a palatal and a non-palatal series :

	Stops	Fricatives	Nasals	Liquids
Nonpalatal	p t k	s	n ṅ ṃ m	r l
Palatal	c ts ś py ky tsy (B)	ṣ	ñ my (B)	ly

Remarks :
a) /ṅ/indicates[ŋ]
b) /ṃ/shows nasalization of the preceding vowel (equivalent to Sanskrit anusvāra)
c) /c/indicates [ć]
d) /ś/(also written ç) is of undetermined quality (possibly [tš́], historically it shows palatalization of IE *k or *ts)
e) /ṣ/indicates [š]

The most striking aspect of Tocharian consonants with regard to PIE however, is the elimination of the voiced stops *b, *d, *g, as well as the aspirated *bh, *dh, *gh, which have merged together with the reflexes of the plain voiceless stops *p, *t, *k into Tocharian p,t,k.

[5] Out of 317 languages compiled in the UCLA Phonological Segment Inventory Database (1981), only 15 languages are reported to have 3 central vowels with the following height distinctions : high/mid/low

(12) : Tagvy, Somali, Yay, Saek, Po-Ai, Sundanese, Cham, Sa'ban, Nambakaengo, Mixe, Ket, Kashmiri ; high/higher mid/low (2) : Thai, Lahu ; mid/raised low/low (1) : Mazahua.

6 My other sources include Pedersen (1941), Van Windekens (1941, 1976) Normier (1980). I have cross-checked many claims about so-called regular vs. exceptional reflexes. I have rejected some, kept others.

7 All sources consulted stress that ī and ǐ, ū and ŭ do not reflect a difference in length. They are said to reflect inconsistency on the scribes' part.

8 It is rejected by Van Windekens (1976), in disregard of the data.

9 Martinet (1975) proposes an interesting analysis for some of the facts, which I will discuss in the course of this paper. Unfortunately, the sources he uses are not always correct.

10 His analysis of Tocharian here is based on an analogy with Lithuanian, where "the change of *a: to o was taking place in word-final position faster than in other positions".

11 Schmalstieg does not make explicit how stress is the basis for re-establishing the length contrast : "the long vowel merely reflected the position of stress at some period or another" (p. 362).

12 According to Schmalstieg this process, incomplete in Tocharian, is similar to an umlauting process, complete in Russian.

13 M. Smith points out to me that a similar failure to adequately explain why changes occurred the way they did can be found in Shevelov's accounts of Common Slavic vowel shifts (see Smith, 1984) which are also limited to a description of the facts.

14 I am assuming here that Krause-Thomas' treatment of stress in Tocharian B is correct. Van Windekens (1976) summarizes the evidence for it: "dans le dialecte B le passage de ä à a ne s'explique qu'à partir de la position tonique de cette voyelle, et l'affaiblissement de ā à a ne s'explique qu'à partir de la position atonique de cette voyelle. Ce (double) phénomène a permis de constater que dans ce dialecte plusieurs mots (formes) dissyllabiques ont l'accent sur la première syllabe, et que plusieurs mots (formes) trisyllabiques (aussi certains mots à quatre syllabes) ont l'accent sur la deuxième syllabe" (p. 12). Winter, citing Cowgill in Lane, Studies in Honor (1967) states that "the accent of Tocharian... does not depend merely on the number of syllables in a word, but must be determined empirically for each word or category" (P. 175).

15 A number of exceptions to the merger of PIE *i,e,u to Tocharian ä are found. They include a number of doublets where i alternates with e but does not appear as ä :

A nirmit/nermit	B nermit	'artificial'	Skr. nirmita
AB nervāṃ		'nirvana'	Skr. nirvāṇa

A śiśäk	B ṣecake	'lion'	?	
A śriṣṭhi/śreṣṭhi	B śreṣṭhi		Skr. śreṣṭhī	
A tiri	B teri/tiri	'manner'	?	

These exceptions are given by Krause-Thomas (1960) who do not give etymologies for 'lion' and 'manner'. I have no explanation at this point for 'lion'. The others, of which three are direct borrowings from Sanskrit exhibit this change from i to e in a distinctive environment r. It is not unusual for a lateral like r to alter vowel quality. This represents, I think, a late development, internal to Tocharian.

Some PIE *u did not merge to ä ; this prompted Pedersen (1941) and Krause-Thomas (1960) to assume another treatment for PIE *u, whereby it is continued by AB u, with the possibility of a further lowering from u to o :

AB ruk-	'to lose weight'	= Lit. rùkti	
AB putk-	'to share'	= Lat. puto	
B pruk	'to jump'	PIE *pruñga, Russ. prýgat'	
A kukäl	B kokale	'car'	
A truñk	B troñk	'grotta'	
A nu	B no	'but'	

In borrowings from Sanskrit

A oppal	B uppāl	'loto'	Skr. utpala
A kontāl		'ring'	Skr. kuṇḍala
AB postak		'book'	Skr. pustaka

Penney (1976) discusses these exceptions, pointing out that most of them - if one excludes the borrowings - consist of ablauting verbal roots. As far as the borrowings are concerned, I have nothing to say at this point, only that they parallel the front vowel alternations i - e.

Exceptions to *e > ä are exhibited in Tocharian A, as a result of an umlauting process, specific to A

A yuk	B yakwe	PT *yäkwe	PIE *ekuos	'horse'
A tuñk	B tañkw	'love'		
A ṣuñk	B ṣañkw	'vengeance'		

As pointed out by Penney (1976), the conditioning factor is the sequence kw, which counts as a labio-velar and causes a preceding ä to be rounded to u. Krause-Thomas (1960) stress that Tocharian k had retained some labio-velar articulation. Finally it appears that ä-umlaut may yield two different results whenever the merger of two words has to be avoided :

AB yok	'drink'		PIE *e	Hit. ekuzi
A yuk	B yakwe	'horse'	PIE *ekuos	

[16] I am endebted to Sandy Schane who suggested this solution to me.

[17] I am aware of another solution for this shift, i.e. raising :

PIE *eḭ > iḭ > i:
*eṷ > iṷ > u:

Although the raising analysis is simpler, at least for *eḭ, it requires to abandon the common treatment of single vowels and diphthongs in Tocharian, a strong claim which I wish to defend.

[18] In Germanic PIE *o,a > a, in Albanian *o,a > a,ë, in Lithuanian *o,a > a.

19 In Indo-Iranian *ă̆,ŏ̆,ā̆ > ă̆. The qualitative ablaut system was completely destroyed.

20 Well, the o slot is not quite empty since some os, which did not dissimilate, survived. It is only half empty !

21 In Indo-Iranian, a similar monophthongization process resulted in long vowels e: and o: (see Hashemipour, 1984).

22 From Winter, Lexical Interchange between 'Tocharian' A and B, JAOS, 1961.

23 The tonality particles i and u stand for the vowels [i] and [u], and for the glides [i̯] and [u̯]; they represent the property of frontness and roundness, respectively ; finally they combine the two properties of length and tenseness ; the aperture particle a represents the vowel [a], the properties of openness, lowered height and laxness.

24 Long vowels have two equivalent representations as factored and unfactored complexes :

	factored	unfactored
[i:]	i i	i i
[e:]	ai i	ai ai
[u:]	u u	u u
[o:]	au u	au au

In the factored complexes all redundant particles are eliminated, except for the tonality particle. The representations are needed for different processes.

25 The alternative analysis, raising, involves assimilation to height

ai i̯ > i i̯
[ei] [i:]

Assimilation of the particle i involves discarding an aperture particle to achieve maximum tonality. This process is called droning (see Smith, 1984 for such a treatment in Common Slavic). Since this solution involves the same process as under my analysis, i.e. loss of an aperture particle, I do not think that it is superior to mine, which allows me to keep the symmetrical behavior of short vowels and diphthongs, at least as far as fission is concerned.

REFERENCES

Adams, D. Q. 1978. Ablaut and Umlaut in the Tocharian Vowel System, in JAOS, Vol 98,4, 446-450.

Baldi, P. 1983. An Introduction to the Indo-European Languages. Carbondale : Southern Illinois University Press.

Benedict, P.K. 1972. Sino-Tibetan : A conspectus. Cambridge University Press.

Benveniste, E. 1936. Tokharien et Indo-Européen. Feschrift für Hermann Hirt II. Heidelberg.

Clauson, G. 1975. The foreign elements in Early Turkish. Researches in Altaic Languages. Budapest.

Cowgill, W. Ablaut, Accent, and Umlaut in the Tocharian Subjunctive. In Studies in Historical Linguistics in Honor of George Lane. Univ. of North Carolina Studies in the Germanic Languages and Literatures. 1967. 58. 171-181.

Donegan, P.J. 1978. On the Natural Phonology of Vowels. Working Papers in Linguistics; 23. The Ohio State University. Columbus.

Gippert, J. 1979. Review of A.J. van Windekens Le Tokharien confronté avec les autres langues indo-européennes. Acta Orientalia, Munksgaard, Copenhagen.

de la Grasserie, R. 1891. Essai de Phonétique Dynamique. Maisonneuve, Paris.

Grønbech, V. 1979. Preliminary Studies in Turkic Historical Phonology. Indiana University Uralic Altaic Series. Vol. 135.

Hansen, O. 1940. Tocharish-iranische Beziehungen. Zeitschrift der Deutschen Morgenländischen Gesellschaft, Band 94. Leipzig. 139-64.

Hashemipour, M. 1984. Vowel shifts in Persian. in Linguistic Notes From La Jolla. UCSD.

Henning, W.B. Argi and the "Tokharians" Bulletin of the School of Oriental Studies. Vol. IX. 1937-39. 545-571.

Haudricourt, A. & A. Juilland. 1970. Essais pour une histoire structurale du Phonétisme Français. Mouton. The Hague.

Krause, W. 1952. Westtocharische Grammatik. Winter. Heidelberg

Krause, W. & W. Thomas. 1960. Tocharisches Elementarbuch. Winter. Heidelberg.

Lane, G. S. 1938. Problems of Tocharian Phonology. Language, 14. 20-38

Lane, G.S. 1945. The Tocharian Palatalization. Language. 21. 18-26

Lane, G.S. 1966. On the Interrelationship of the Tocharian Dialects. In Ancient Indo-European Dialects, ed. by Birnbaum & Puhvel. University of California Press.

Lane, G.S. 1967. On the significance of Tocharian for Indo-European Linguistics. In Studies in Historical Linguistics in Honor of George Lane. 76-87.

Lévi, S. 1913. Le "Tokharien B", langue de Koucha. Journal Asiatique. 2.311-380.

Lévi, S. 1933. Fragments de textes koutchéens. Paris.

Martinet, A. 1964. Economie des Changements Phonétiques. Francke. Berne

Martinet, A. 1975. Observations sur l'évolution phonologique du tokharien. In Evolution des Langues et Reconstruction, ed. by. A. Martinet. PUF. Paris.

Menges, K. 1968. The Turkic Languages and Peoples. Ural-Altaische Bibliothek. Harrassowitz. Wiesbaden.

Meillet, A. 1913. Le Tokharien. Indogermanisches Jahrbuch. 1.1-19.

Normier, R. 1980. Tocharisch nkät/nakte 'Gott'. Zeitschrift für Vergleichende Sprachforschung. Vol. 94. 251-281.

Pedersen, H. 1941. Tocharisch vom Gesichtspunkt der indoeuropäischen Sprachvergleichung. Munksgaard. Copenhagen.

Pelliot, P. Tokharien et Koutchéen. Journal Asiatique. 224. 23-106.

Penney, J.H.W. 1976. The Treatment of Indo-European Vowels in Tocharian. Transactions of the Philological Society. London. 66-91.

Poppe, N. 1960. Vergleichende Grammatik der Altaischen Sprachen. Teil 1. Porta Lingarum Orientalium. Harrassowitz. Wiesbaden.

Poppe, N. 1965. Indroduction to Altaic Linguistics. Ural-Altaische Bibliothek. Harrassowitz. Wiesbaden.

Sapir. E. 1936. Tibetan Influences on Tocharian. Language. 12. 259-271.

Reitz, T.G. The Correspondences among the Mid Vowels of Tocharian. In Studies in Historical Linguistics in Honor of George Lane. 1967. 182-185.

Schane, S.A. 1971. The phoneme revisited. Language. 47.3.

Schane, S.A. 1982. Two English Vowel Movements : a particle analysis. In Linguistics Notes from La Jolla. UCSD.

Schmalstieg, W. 1973. The Development of the Tokharian Vocalic System. Orbis. Louvain. 353-368.

Smith, M.B. 1984. Vowel Shifts in Common Slavic. In Linguistic Notes from La Jolla . UCSD.

UCLA Phonological Segment Inventory Database, 1981. UCLA Working Papers in Phonetics. 53.

Van Brock, N. 1977. Remarques sur le vocalisme du tokharien. Zeitschrift für Vergleichende Sprachforschung. 77-92.

Van Windekens, A.J. 1941. Lexique étymologique des dialectes tokhariens. No. 11. Bibliothèque du Muséon. Louvain.

Van Windekens, A.J. 1976. Le Tokharien confronté avec les autres langues indo-européennes : La Phonétique et le Vocabulaire. Centre International de dialectologie générale. Louvain.

Winter, W. 1961. Lexical Interchange between Tocharian A and B. JAOS, 81. 271-280.

Winter, W. 1965. Tocharian Evidence. In Evidence for Laryngeals, ed. by W. Winter. Mouton. The Hague.

Winter, W. 1955. A Linguistic Classification of Tocharian B Texts. JAOS 75-75. 216-225.

Winter, W. 1981. Review of Van Windekens Le Tokharien confronté avec les autres langues indo-européennes. Language. 57. 935-941.