

ANIMAL TRACTION AND THE TRANSFORMATION OF EUROPE

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The domestication of sheep, goats and cattle by the first farmers of the Fertile Crescent of western Asia, some ten thousand years ago, had unexpected consequences. Originally intended simply to secure for sedentary cereal-cultivators a captive meat supply and a convenient source of materials such as sinew and horn, domesticated livestock came to provide novel services to human populations in life as well as in death. At first, these products and services were simple: their dung fertilised the crop-gardens and their hair provided a coarse fibre; their strength and weight could be used to carry loads or to thresh the cereals--"the ox [who] treadeth out the corn" (Deuteronomy 25, 4). By the time of the appearance of the first cities, however, some six thousand years ago, the contribution of domestic livestock had considerably broadened and these animals now provided wool, milk and motive power. Clothing and diet had become more elaborate, and the power of the ox was applied to pulling the plough and the cart--the first machines for cultivating the soil or carrying its products. By this time, too, further species of plants and animals had been domesticated at various points around the Fertile Crescent: the tree-crops, rich in sugars or oils (date, vine, olive), and animals such as the donkey, horse and camel which were domesticated for transport. Donkeys, and later horses, came to be used as draught animals as well as pack animals, and more sophisticated wheeled vehicles came to be developed--especially for warfare. This growing complexity in husbandry and technology went hand in hand with a growing complexity in human relationships and the organisation of material production. Since neither ploughs nor wheeled vehicles are of much use without animal motive power and an effective way of harnessing it, and since they are relatively expensive in resources, the invention of the plough and the wheel must be considered both in the context of animal husbandry and management, and in the social and economic context of evolving human institutions.

The first evidence both for the plough and the wheel appears in the fourth millennium BC,¹ in societies which, although contemporary, were of very different kinds. It occurs at much the same time in Europe, among neolithic farmers still using the simple varieties of crops and livestock, as in Mesopotamia, where cities supported a diversified economy and a sophisticated lifestyle. This immediately raises the question of origins, and the circumstances in which the innovation arose. Since archaeological indications of these practices are usually rather rare, and occur only in specific conditions, it is not

¹1. All dates quoted in dendro-calibrated radiocarbon years BC.

possible to identify the time and place of their appearance simply by pointing to the oldest dated examples; a convincing historical reconstruction requires both a through source-criticism of the various kinds of evidence, and a sociological assessment of the most probable context for such innovations. A consideration of these questions is essential in judging whether such innovations appeared independently in several places, or spread from a single source--and such judgements are inevitably affected by considerations of general plausibility or even by national pride.² The beginnings of animal traction are thus part of a wider question about the nature of technological change in the societies which followed the beginning of farming, and in particular about the various secondary uses of livestock--the emergent properties of animal domestication--which made animals increasingly important in human economies. The question of precisely when any of these various new uses of domestic animals first came about is not easy to answer, however, since the evidence for them is largely indirect. A plentiful pictorial record began, along with writing, at the beginning of city life; but this provides only a *terminus ante quem*, a time by which they were already in existence. Direct archaeological evidence--of textile fragments, milk-residues, or traces of traction--are usually rare and require specialist expertise to identify. Less direct indications, such as the ages at which animals were slaughtered (young for meat, older if live-products were used) are laborious to obtain and ambiguous to interpret, and we are far from having the quality of data which is necessary to give a clear picture by this method.³ for milk or wool may be evident from mortality-curves derived from relatively small samples, this is not so for the necessarily rather small numbers of draught oxen; and castration--itself hard to demonstrate osteologically--is not unique to draught animals.

The answer is thus unusually dependent on theoretical expectations, to provide a coherent reconstruction from fragmentary evidence.⁴ If it is expected that

²Two major contrasting visions of change are the "evolutionary" view, which assumes gradual change and mostly autonomous local development, and the "historical" view, which envisages rapid change and interaction over long distances.

³I have not dealt with the osteological evidence in this paper, because it is less diagnostic for traction than for other secondary uses such as milk- or wool-production. In the first place, as Laszlo Bartosiewicz has shown (this volume), it is rare that pathologies give unambiguous evidence of traction; secondly, while specialised large-scale animal-keeping

⁴For instance Ursula Tegtmeier, in her very useful monograph on late-neolithic and bronze-age plough-marks (Tegtmeier 1993), defends the proposition (initially made by Lüning 1980, and investigated in experimental work by Lüning and Meurers-Balke 1981) that ploughs were known since the first spread of farming to Europe, on the grounds (1) that cereal-cultivation was already an old practice, with standardised techniques, (2) that the LBK spread very quickly, implying an effective cultivation-system, (3) that wheat and barley were everywhere cultivated with the plough in recent times, and hoe-cultivation or spade-cultivation were used with other cereals or root-crops, and (4) that plough-cultivation would be necessary to feed the densely-packed LBK settlement-clusters on the Aldenhovener Platte (Tegtmeier 1993, 4-5). None of these is compelling: (1) and (2) imply no particular cultivation-method, (3) is simply a misplaced uniformitarianism, giving no possibility for the past to be different from the ethnographic present, and (4) uses medieval figures for cereal yields, and under-estimates the productivity of intensive gardening which is the alternative (and more plausible) model for LBK farming.

such secondary uses as milking and wool-production would appear as soon as new breeds of livestock which were capable of yielding quantities of these body-products became available (for the primitive breeds produced little milk, and early sheep were hairy, not woolly), then these substances may have been used as early as eight thousand years ago--at least in certain parts of the Fertile Crescent, where farming had a long history. (In the same way, cattle must surely have been used to carry loads, and to tread grain, soon after they were domesticated.) If, on the other hand, one could only imagine these practices becoming generally adopted as part of specialist regimes of livestock-raising, it may have required the large-scale economies of urban communities before activities such as regular wool-production, cheesemaking, beer- or winemaking, or the extensive employment of livestock as draught animals, came into existence. Both expectations may have elements of truth: the use of wool, milk, or tree-crops may have remained small-scale local practices for a long time, before being taken up on a large scale for commodity-production in urban economies, and spreading along their supply-routes to neighbouring regions. Nor need the same pattern fit all these innovations: the changes leading to a woolly fleece in sheep depended on specific genetic changes, while better milk production depends on plane of nutrition as well as genetic characteristics--so that milking may have begun over a relatively large area of western Asia and Europe, perhaps earlier in those places where forage was plentiful.⁵ By analogy with these other practices, the use of cattle as draught animals might have taken place in several stages during the period from 8000 to 4000 BC, beginning with localised and *ad hoc* uses, before their more specialised use in pulling the plough and wheel became widespread in the fourth millennium BC--the pattern which is increasingly being demonstrated by archaeology. This paper discusses the empirical evidence for this development, before proposing a historical reconstruction and suggesting the economic and ecological factors involved.

What are we looking for, and how would we recognise it?

So far in this discussion, the phrases "animal traction" and "draught animal" have been used with reference to the plough and wheeled vehicles. This is a shorthand description of a rather specific technological complex, originally involving (with only rare exceptions) the use of bovids (cattle) and usually castrated males (oxen). Donkeys (or crosses between donkeys and horses or onagers) came to be used in the third millennium in Mesopotamia in groups of four for pulling military vehicles with solid wheels, and by the second millennium pairs of horses were used to pull specialised, light, spoke-wheeled vehicles for fighting--the chariot. These later uses were modifications of a

⁵ Milking was practised around the Lac de Chalain by 4000 BC, as it was in Britain (Regert *et al.* 1999; Copley *et al.* 2003).

basic design for a traction system, in use by the fourth millennium BC, based on *paired draught*, using a *draught-pole* and a *yoke*, and optimally pulled by castrated adult male cattle. (Horses were not used for heavier work until the invention of the horse-collar and shafts in Han China and their spread to the west in the middle ages.) An effective form of paired draught was the breakthrough which provided commodified animal power. This *traction complex*--which was both a harnessing technology and a system of livestock management--was unique, in that it was the root of all traditions of using draught animals, and was introduced to eastern Asia in the second millennium BC in the form of the chariot, and to the Americas by the Spanish--there being no indigenous system of animal traction in the New World.⁶ This unity and historical rarity--the global uniqueness of the traction complex--is worth emphasising, since it suggests that "parallel development" is an unlikely model: whether the size of the originating area was large or small, developments within it must have been historically related.⁷

The central importance of the draught-pole traction complex does not preclude other forms of animal traction, either as precursors or in use contemporaneously. These other usages mostly involve the use of a single animal. The two principal modes of attachment are a flexible link by traces (leather or fibre ropes),⁸ or by a system of two poles lashed together or joined by a strap across the back of the animal. The evidence of ethnology shows great diversity in such practices in recent times, since it reflects both primitive, *ad hoc* methods of use (simply using a pole to distribute the weight in carrying a load, for instance, and letting it drag across the ground if necessary), but also the use of more sophisticated and recently-developed modes of harness for equids, such as the horse-collar. Simple modes of employment, suitable for bovids, may well reach back in time to the early phases of their domestication; but in the absence of advanced harnessing systems (of the kind developed for equids) their range of uses would have been limited, before the development of the yoke and draught-pole. While evolutionary ethnographers (eg Peake 1933; Berg 1935; Haudricourt 1948; Haudricourt and Delamarre 1955; Haudricout 1988) produced speculative sequences of load-bearing machines, these have often mixed together elements of ancient, primitive usage with features of more

⁶The Eskimo dog-sled is of Old World origin, and is an adaptation of horse-harness: the horse-drawn travois of the Plains Indians is no older than the re-introduction of the horse to North America--by the Spaniards. There was, nevertheless, a knowledge of the wheel which was considered a sacred symbol of the sun and the calendar, and miniature vehicles in the form of animals were made of clay (Ekholm 1946; Borhegyi 1970). The absence of practical wheeled transport reflects the lack of traction animals.

⁷Childe (1951) was particularly impressed by the tripartite disc-wheel as a technological solution unlikely to be invented independently.

⁸An Uruk-period cylinder-seal in the British Museum shows two men apparently attaching a knotted rope, with two looped ends, to the horns of an ox (reproduced in Sherratt 1997, 155).

recent origin (like paired shafts, requiring something like a horse-collar), and so are anachronistic. The proposed reasons for developing such a load-bearing system, such as the transport of hay, may also be misleading since this is a relatively late and specialised feature of farming systems.⁹ Such ethnographic speculation--while useful in enlarging the imagination--needs to be controlled by archaeological evidence (cf. Putschke 1971).

The specific technological character of paired draught using the yoke is useful both theoretically, in forming our historical expectations of how it might have originated, and methodologically, in that it allows us to pool the various kinds of evidence for traction--wheels, ploughmarks, yokes etc.--and to maximise the usefulness of the archaeological record. Both wheels and ploughs (and, of course, yokes and draught-poles) from later prehistory imply the paired draught system. Many forms of evidence are ambiguous, however, (a single "clay model wheel" may in reality be just a spindle-whorl!), and some forms can be dated more precisely than others, so that a preliminary assessment of their reliability is a necessary prelude to the analysis. First of all, it is useful to assess the reliability of different types of evidence (Table 1), which ranges from the unambiguous evidence of an actual wheel preserved in a lake-deposit or a grave-mound, to various enigmatic fragments which have been claimed as parts of ploughs. There is no time to discuss such problematic pieces individually here, save to note that whole categories of artefact have been claimed as ploughshares without convincing the archaeological community (eg the Bandkeramik stone *Schuhleistenkeil*, most plausibly interpreted as a wedge for wood-working), or that a canoe-paddle of well-known Ertebølle/Ellerbek type has been cited on more than one occasion (Chapman 1983; Vosteen 1996) in the same role! It is best to set such aberrations aside, and to deal only with more compelling evidence. Even this, however, differs in the accuracy and precision with which it can be dated (Table 2), and again can be arranged in a series of decreasing reliability, from a dendro-dated context in a lake-deposit to an attribution on typological grounds or by loose association. The two scales can then be combined in a single diagram (Figure 1), which defines a zone of reliability in its bottom, left-hand corner, and successive degrees of doubtfulness further away from this core of hard evidence. Elements from the outer (upper and right-hand) parts of the diagram may usefully supplement the core evidence in certain circumstances (for instance if there are already reasons for believing that wheeled vehicles were used, an enigmatic representation may become more believable), but ambiguous evidence should not be used on its own to establish a chronological pattern.

The evidence from different areas takes different forms. Waterlogged materials

⁹Hay-cutting on a large scale depends on use of the iron scythe.

depend not only on the presence of lakes or bogs but on the existence of lake-villages or the practice of making ritual deposits in watery places. The preservation of traces such as ploughmarks (or, much more rarely, wheel-ruts) depends on the preservation of an old, cultivated land-surface, either by rapid natural accumulation (eg sand-dunes) or more probably by the construction of an earthen mound such as a burial-monument. Moreover, recovery of these traces depends on a large body of excavations of a sophisticated kind (or at least on a network of interested amateur or professional archaeologists to record chance finds made in peat-digging). These forms of evidence thus form clusters, in areas with particular environmental characteristics and regional traditions of archaeology. Similar considerations apply to the representational evidence. Rock-art is a specific phenomenon, depending both on rock-surfaces and cultural practices; even the making of clay or metal models is a cultural expression evoked at particular times. Scenes on seals or objects represented in pictograms are specific to the early urban societies of the Fertile Crescent. It is of vital importance in assessing the relative dates of appearance in these different areas that we take such factors into account in interpreting the distribution of observations in time and space.

Interpreting the evidence

It is all the more astonishing, therefore, that the picture which emerges from these very diverse kinds of evidence should be so coherent, for there is a great accumulation of indications--of many different forms--for the occurrence of the paired-draught traction complex in the fourth millennium BC, and especially in its middle and later part. This congruence suggests that we are dealing with a phenomenon which takes the form (for whatever reason) of a horizon--a line clearly separating the periods "before" and "after", and perhaps even with a novelty which was particularly celebrated in representations because it was a recognisably new and important phenomenon rather than something which had slowly emerged over a long period. Indeed, we can go further, in asserting that there was a degree of cognitive equivalence between the two principal applications of the traction complex, the plough and the wheeled vehicle, to judge from their apposition on the rock-panel at Cemmo 2 in the Val Camonica (Berg-Osterrieth 1972; discussed by Fedele this volume; cf. Barfield and Chippindale 1997) or in syntactically comparable positions (below the belt) on the statue-menhirs of the same region,¹⁰ which suggest that they were viewed as two manifestations of the same principle--not just in an ergonomic and technological sense, but as symbols of social power. This strong association and mutually supporting evidence from many different sources suggests (1)

¹⁰Wagon (in the same style as Cemmo 2) between two opposed daggers, below the belt on the statue-menhir from Algund (Lagunda), Val Venosta, Alto Adige (conveniently reproduced in Spindler 1994, 208); plough in Val Camonica at Masso di Borni no. 1; Masso di Bagnolo no. 2, Masso di Cemmo 1; Masso di Ossimo 8 (Fossati 1994).

that claimed instances of earlier occurrences should be carefully scrutinised and--if inconclusive--now dismissed, and (2) that it may be possible to perceive chronological differences within comparable forms of evidence in different areas, so that some sense of priority and direction may be discerned, at least within the well-investigated parts of Europe.

The relevant evidence has been extensively discussed, both in this volume and elsewhere, so that it is unnecessary to do more than summarise it here. Two suggested examples of early evidence for animal traction are worth noting, however, in order to demonstrate the fragile nature of claims for paired-draught traction in Europe before the fourth millennium, and to exercise "taxonomic hygiene"--purging the record of false indications. The first are the parallel depressions beneath the long-barrow at Sarnowo (Bydgoszcz, Poland), long discussed as plough-marks but inexplicably full of charcoal. It has now been suggested (Niesiołowska 1994; *idem* 1999) that these are in fact beam-slots, with the beams burned *in situ*. In view of the fact that the associated date is a millennium older than the dozen or so examples of unambiguous ploughmarks under long-mounds in Denmark and Germany, it seems safer to reject the Sarnowo evidence as representing 5th millennium ploughing.¹¹ (A similar remark may be made concerning the oft-cited claim of 5th-millennium ploughing in Khuzestan: *** --Wright *et al.* 1980.) The other sort of evidence sometimes cited for pre-4th millennium traction are wooden objects which might be parts of ploughs or wheeled vehicles: one such, a piece of wood interpreted as a possible yoke from a late-sixth millennium Cardial-ware context at La Draga, is discussed in this volume (Tarrus-Galter and Sana Segui). Until more compelling examples are found, such early but ambiguous examples are not enough to overturn a clear pattern of association with the fourth millennium BC. As noted above, other sometimes-cited evidence is even less convincing.

Is it possible to be more specific about the date at which the traction complex appeared in Europe? The most abundant and unambiguous form of evidence for paired draught is the occurrence of plough-marks under burial-monuments in north-west Europe; and although the datings are less secure than those for dendro-dated objects in bogs, the Nordic typo-chronology is well established and forms a sequence of 1-200 year phases. Although originally divided by Montelius into an early neolithic Dolmen-period (*Dyssetid*) and a middle neolithic Passage-grave period (*Jaettestuetid*), it has recently become evident that these were preceded by a 400-year period during which long-barrows with earth-graves or enclosed timber chambers were constructed, filling the first half of the fourth millennium (3900-3500 BC) and forming EN I.¹² This was

¹¹There does, however, appear to be evidence for ploughmarks under Īupawa Barrow 15 (Jankowska 1980; Kruk and Milisauskas 1999, Figure 47,4), dating (like the Danish examples) to the mid-fourth millennium.

¹²EN I is roughly equivalent to Carl Becker's EN A and B (Oxie, Völling and Svaleklint pottery styles), EN II

followed by two centuries in which the enclosed chambers came to be built of stone, as "dolmens" (EN II), before larger chambers with access-passages became general, marking the beginning of MN around 3300 BC.¹³ There was therefore a long EN I period, before EN II began around 3500 BC: and it is this date in the middle of the millennium which is now emerging as a crucial time of change, with the introduction of enclosures and decorated pottery and the beginning of a burst of monument-building which continued into MN I and then tapered off. Faunal data from this time show a shift from pig to cattle, and pollen diagrams show the appearance of extensive grazed areas, with hazel coppice. (Information, including dates after Poul-Otto Nielsen, from accounts in Hvass and Storgaard 1993.) Evidence for ploughing begins in EN II. Four sets of ploughmarks are known from beneath¹⁴ EN II monuments (3500-3300 BC), ten from MN I and II (3300-3000 BC), with another two examples from one or the other (Thrane 1989).¹⁵ A total of 16 occurrences are therefore known for the later fourth millennium, by contrast with none in the preceding half-millennium of neolithic occupation (from which some three dozen earthen monuments--many of which have been excavated--are known, and which were capable of preserving ploughmarks). The plough thus seems to have been a basic feature of the changes introduced to southern Scandinavia shortly after 3500 BC (Figure X).

If we compare this with evidence from the north-Alpine region, there is a remarkable congruence of dates for the first occurrence of that other application of the traction-complex, the wheeled vehicle, and for equally fundamental changes in settlement and land-use. (It is again worth emphasising that conditions for preserving these kinds of evidence had long been present, in this case since c.4500 BC when lake-villages began.) The major indicators begin in the later fourth millennium, perhaps a century or so later than in Denmark.¹⁶ The most striking evidence is that of the wheels themselves,

to Becker's EN C (Fuchsberg and Virum styles).

¹³Note that other writers, eg Bakker et al. 1999, 784, cite this dating with appropriate error terms as "3650-3400 cal BC"--though that does not necessarily imply that it actually began before 3500 BC.

¹⁴The ploughmarks would have been removed by weathering if they had not been covered, so they cannot antedate the construction of the mound by many years.

¹⁵The distribution map (Thrane 1989 Figure 4) shows a concentration of EN C (=EN II) and MN Ia examples (3500-3200) in central Jutland, an expansion of MN Ib-IV examples (3200-2900) to Zealand, and a concentration of Corded Ware examples (2800-2400) in north Jutland (Djursland). Although many of the Neolithic examples listed by Thrane are on subsoil characterised as "clay", these are not the heavy morainic clays of the islands, and it would be wrong to infer that Neolithic farmers preferred clay soils. Distribution maps confirm that--where a choice was available--medium (silt-grade) soils were preferentially selected in the Neolithic, lighter (sand-grade) soils in the Corded Ware period and Bronze Age, and heavier (clay-grade) soils in the Iron Age, in the North European Plain as in Europe as a whole.

¹⁶This apparent temporal difference may, however, be due to the greater precision of the north-Alpine sequence, which is based on dendro-dates, by comparison with that for southern Scandinavia which, although based on

discussed in detail in other papers in this volume, of which perhaps a score [20] are known from sites of the later-fourth and third millennia. While the majority are associated with Corded Ware and related cultures, the oldest (Seekirch-Stockwiesen) belongs to the late Horgen culture, at the very end of the millennium. Environmental changes (eg Schibler and Jacomet this volume) plausibly associated with more intensive forms of farming (most probably ploughing) begin at the onset of the Horgen culture itself, around 3400 BC-- associated with changes in settlement pattern and material culture (for instance spindle-whorls). These would support a date for major changes in the north-Alpine region around 3400 BC.

With this evidence in mind, it is possible to evaluate two more enigmatic finds of wooden objects from this region. The first is the piece from Arbon Bleiche 3, interpreted as a possible yoke. Although the interpretation of such wooden objects is always disputable,¹⁷ its occurrence in this horizon of change makes the identification more plausible, if still not entirely convincing (principally on account of its size). On the other hand, one possibly traction-related specimen definitely precedes this horizon, being well dated to the early fourth millennium: the fork-shaped object with bulbous tip from Reute-Schorrenried, from a context dendro-dated to the end of the 38th century BC. It has been interpreted both as the end of an A-frame travois, designed to fit on a yoke, or as an architectural element (Mainberger 2002; Königer 2002); its interpretation is critical, for the date is an accurate one and would imply paired draught in the first half of the fourth millennium BC in this area.¹⁸ The arguments against its being part of a traction-implement are that the usual design of a travois involves two poles, joined at the top (as with the Chalain 19 example: Petrequin and Arbogast this volume); that this piece does not have a sufficiently divergent angle to achieve a useful width, and that it is also unlikely to have been long enough to be useful; in short, that the head of a travois or A-frame cart would not be carved out of a single piece of wood.¹⁹ It thus seems prudent to reject it as evidence for the traction complex, leaving the most probable date as c.3400 BC, with the onset of Horgen.

large numbers of well-dated samples, does not tie the settlement evidence directly to a dendro-sequence. Since some dates will inevitably have been made on substantial timbers, already old on felling and use, a "blurring" of dates backwards in time is likely to have occurred.

¹⁷Except in the case of completely-preserved and typologically unambiguous examples such as those from Vinelz, Fiave or Petersfehn (which may be withers-yokes which fit on the neck rather than being attached to the horns, and thus have a more diagnostic shape), or that from Chalain directly associated with the travois--all of which are larger (130-170 cm) than that from Arbon Bleiche 3 (93-6 cm).

¹⁸So would an enigmatic wooden object suggested as a possible yoke from a Cortailod context at Egolzwil 4: Wyss 1983.

¹⁹The interpretation of its being an architectural element is more convincing (cf. the cartoon on the cover of Hemmenhofener Skripte 3: "Bring sofort die Stütze zurück!").

Other areas (discussed in Sherratt 1997, 1-34 & 155-248) offer evidence for the traction complex within the same broad timespan, but with less precision than Scandinavia and the circum-Alpine region. Nevertheless they offer valuable evidence both about its applications and about its distribution at this time. A particularly valuable indication of the vehicles in use is provided by the drawings of wagons, as if seen from above but with wheels *en face*, on a TRB bowl from Bronocice in Little Poland (Milisauskas and Kruk 1982). A date on bone from the pit which contained the Bronocice vessel gave a date-range of 3637-3373 BC--although this lies at the upper extreme of the seven other dates for the relevant phase, Bronocice III, which centre on 3350, and typological comparisons for this material would point to younger Boleráz which is well dated (from Arbon Bleiche 3!) to 3384-70 (discussed in Bakker *et al.* 1999). A similar date could apply to the Kráľovnica Jara TRB handle showing yoked cattle, and to the Bytyn yoked ox-figures,²⁰ which are alloys of arsenical copper (see Matuschik this volume.) It is interesting that yoked-ox figures should appear so widely at this time: in Greece a fragmentary yoked-ox figurine from Tsoungiza (Nemea) in the Peloponnese dates to the EH I/II transition, c. 3000 BC (Pullen 1992), while a complete pair of yoked oxen attached to the base of a bowl was found at Tel Farah (N) in Israel, and is attributed on typological grounds to the EBA (later fourth and third millennia). In the Carpathian basin, a box-shaped pottery container with two projecting animal-heads from Radošina in Slovakia²¹ came from a Boleráz context (3500-3300), just before the more explicit evidence of the famous Budakalasz and Szigetszentmarton wagon-models and the Alsonemedi paired-bovid²² burials, which belong to classic Baden at some time around 3300-3000 BC (Kalicz 1976; Raczky 1995). Paired-bovid burials neatly outline the area of the classic Baden culture and its contact-area in the loessic basins of the North European Plain, from the Saale-Middle Elbe region and northwards along the Elbe, through Kujavia and Little Poland to Lublin (Pollex 1999, Fig. 1 with site-list; also Jeunesse, this volume). From western central Europe, the characteristic gallery graves of Hesse, belonging to the Wartberg culture, have now been

²⁰Were they handles, too? Many bronze animal-figures (eg Greek geometric horses) originally had this function, often on wooden lids. The Bytyn ox-figures are massive and heavy, but their splayed legs would fit into a wooden base. There is no hint of any attached vehicle or plough, or even a draught-pole--in which respect they resemble the Tsoungiza and Tel Farah examples mentioned below. While their lost-wax casting technique points to an introduced technology, the existence of three such specimens in central Europe (Matuschik this volume) supports a local manufacture.

²¹Námejcová-Pavúková (1973, 300); now joined by another example from Boglarlelle Hungary (Ecsedy 1982).

²²I use this phrase, rather than "paired-ox" burials, because the domestic animals buried in such contexts are not necessarily castrates, or even male. Whether this reflects real life (a potentially damaging use of young or female animals for strenuous work), or whether trained draught-oxen were too valuable to slaughter in such circumstances, is unknown. Cows are often used as draught-animals today, eg in Portugal (Sherratt 1997, Fig. 9.3 top)--but with pneumatic tyres on metalled roads!

demonstrated to begin around 3400 and last until 3000 (Raetzl-Fabian 2002), and to this group should be ascribed the engraved stones from Lohne/Züschen (Evers 1988), and a similar example from Warburg (Günther 1990), with representations of paired draught and wheeled vehicles. After 3000 BC new types came into existence, including trapezoidal ones such as Nietleben, which are contemporary with graves of the Globular Amphora culture with their many paired-bovid burials--sometimes accompanied by discoid amber head-ornaments.²³ It is tempting to suggest that the trapezoidal shape of the chamber was intended to echo that of an A-frame cart or travois (also shown in rock-art as a trapezoid), and that these and the Globular Amphora culture cists were consciously seen as mobile homes, sometimes pulled by buried draught-animals, on the road to eternity. In an uncanny echo of this practice, seven burials in the EBA cemetery of Sarıket (the cemetery of early third-millennium Demircihüyük near Bilecik in north-west Anatolia) were in large stone cists with paired-bovid burials positioned as if pulling them (Seeher 2000).²⁴ The metaphor was clearly widespread at this time. Somewhat earlier, in the northern Caucasus, in burial 18 in Kurgan 2 of the cemetery near Starokorsunskaya,²⁵ some 25 km east of Krasnodar on the Kuban river, three wheels were found in a cist-burial belonging to the Novosvobodnaya facies of the Maikop culture, which is datable to the later fourth millennium BC (Kondrashov and Rezepkin 1988, 92-3; for Novosvobodnaya, see further below).²⁶ Meanwhile, far to the west, plough-marks under the South Street long barrow in Wessex testify to the use of animal traction in the British Isles in the later fourth millennium (Ashbee *et al.* 1979).²⁷

²³"An animal grave at Brzeźno Kujawski contained two round bone discs decorated with star motifs. Similar discs were sometimes made of clay, but most often they were made of amber ('sunbursts'), which were nearly always decorated with a cross" (Wiśniewski 1970, 199-200 incl. Figure 67). It seems that these discs may have been worn as part of the harness; their association with cattle is strengthened by their shape, which resembles a perforated disc-wheel, and they testify to the pervasive symbolism linking cattle and cosmology. In the BMW Museum at Regensburg there is *Scheibenförmiges, durchlochstes Tonobjekt* (Catalogue No. 25) from Regensburg-Harting, a disc some 6 cm in diameter with a pronounced "nave" around its central, cylindrical perforation, and four incised crosswise "spokes" or rays at cardinal points on one side, attributable to the Cham culture, which seems to be a manifestation of this idea. It may be part of a cart-model--or just a spindle-whorl (Rieckhoff-Pauli, S. 1987, *Archäologisches Museum im BMW Werk Regensburg*, Regensburg: BMW Aktiengesellschaft).

²⁴Vehicles and their oxen were also interred in Mesopotamia and Susiana in the third millennium, for instance at Ur with male burials (and a sledge with a female burial), at Kish and at Susa (Woolley 1934; Childe 1951; Littauer and Crouwel 1979). The distinctive muscular development of one individual from the Royal Cemetery at Ur led Theya Molleson to identify him as the driver of a (battle-)wagon (Molleson and Hodgson 1993).

²⁵Starokorsunskaya, not Novokorsunskaya (some 66 km distant), as erroneously mentioned in Rassamakin (1999, 151)--perhaps confused by Novosvobodnaya in the same sentence.

²⁶Rassamakin (1999, 151) reports a wooden wheel from a burial of this period at Koldyri on the Lower Don, excavated by E.I. Besspal'y, but gives no publication reference.

²⁷As an example of how even precise dates can be quoted in such a way as to be misleading, it is worth noting the following sequence. (1) The dates themselves were published (Ashbee *et al.* 1979, 264) as: BM-356 2810±130 bc; BM-357 2750±135 bc; BM-358a 2670±140 bc; BM-358b 2580±110 bc, it being noted that the first was charcoal (quite probably old wood) from the surface of the buried soil, and that the others were bones

Over a wide area, therefore, from the Alps to the Baltic and from Britain to the northern Caucasus, the first evidence for the wheel, plough and paired draught falls into the span between 3500 and 3300 BC. This reinforces the argument that claimed examples of evidence for the traction complex in Europe before 3500 BC are highly doubtful, either on grounds of their functional interpretation (whether they are, in fact, parts of ploughs or carts, or yokes, or ploughmarks), or on the accuracy of dating. By contrast, the later fourth and early third millennium offers ploughmarks from Denmark, northern Germany, Poland, the Netherlands, England, Switzerland²⁸ and Italy, models of yoked bovids from Poland and Greece, models²⁹ of wheeled vehicles from Hungary (and probably Slovakia) and actual wheels from south Germany, Switzerland and Slovenia, a travois from eastern France, and the beginning of the representational tradition of wheeled vehicles and ploughs on the southern margins of the Alps and in the North European Plain. These examples multiply during the third millennium. Nor are such innovations casual or epiphenomenal; there is evidence from many areas of a fundamental transformation in

from the ditches and antler from within the mound--implying a date around 3400 cal BC. (2) These were then cited in a popular summary as 3700-3370 cal BC (Cunliff 1993, 337, 339). (3) This dating was then cited as *first half* of the fourth millennium: "In England setzen die Belege in der 1. Hälfte des 4. Jt. während des dortigen Frühneolithikums" (Fries 1995, 20). South Street is a relatively late, "short" long-barrow, perfectly at home in the *second half* of the fourth millennium and congruent with an intelligent reading of the dates. Examples such as this could be multiplied (indeed, Fries repeats the mistake in the second half of the sentence: "ebenso im Norden in der 1. Hälfte des 3. [recte 4.] Jt." with a footnote to a long-dolmen with uncalibrated radiocarbon dates of 2760-2600 (calibrating to a range from 3500-3300, and cited by Thrane as EN C/MN I). Again, a date whose highest probability lies in the *later* fourth millennium has been quoted as *early* fourth millennium. This is a common problem with Vosteen (1996).

²⁸The example from Chur-Welschdörfli, Graubünden, Switzerland (references in Fries 1995 Cat. No. 1059, and section reproduced in her Taf. 114) is important but ambiguous: criss-cross ploughmarks were observed on a sloping surface overlying an *in situ* settlement-layer attributed to the Lutzingüetle culture, overlain by natural and cultural accumulations of later date including redeposited neolithic materials. ("I reperti ceramici, davvero modesti, sono databili con una certa difficoltà; comunque senza alcun dubbio non sono attribuibili ad un Neolitico troppo avanzato, ma piuttosto sono da considerare più antichi dei ritrovamenti relativi alla cultura di Horgen." Rageth 1989, 158.) It is overlain by further secondarily redeposited materials, nevertheless still in chronological sequence, of the early, middle and late bronze age and iron age. The ploughmarks are thus probably fourth millennium, but it is not justifiable to cite them as belonging to "die Zeit der Lutzingüetle- und der Pfynker kultur (1. Hälfte 4. Jt.)", as does Fries (1995, 20). (I point out these examples because of their importance to the dating of the earliest ploughmarks, and my criticisms in no way detract from my admiration of a very excellent and scholarly contribution by Fries, which is astonishingly comprehensive and useful.) The Chur ploughmarks are paralleled by others in the south-Alpine region: at Castaneda, also in Graubünden, and in a large exposure at St Martin de Corléans in the Valle d'Aosta, Italy (well illustrated in Mezzena 1982, Figs. 7-11)--both dating to the end of the fourth millennium and confirming the use of cross-ploughing. Claims of an earlier example, from a VBQ context from Canton di Trescore Balneario, are single deep furrows, not even parallel (Keller 1989, Fig. 85) and are presumably natural--certainly not ploughmarks.

²⁹By the final centuries of the fourth millennium, at the time of the classical Baden culture, what are plausibly interpreted as wheel-models are widespread, despite the absence of models with separate wheels, of the kind known from the Bronze Age in the Carpathian Basin (Bona 1960: examples with prominent "naves", in forms distinct from local types of spinning-whorls, have been reported from Bavaria, Franconia, Moravia, Slovakia, Hungary, Croatia, Romania and Bulgaria. The claimed earlier examples, reported by Dinu (1981), remain to be explained.

settlement patterns and cultivation practices, and hints in some areas of other contemporary innovations (wool-sheep,³⁰ 2-piece mould metal-casting,³¹ perhaps fermented drinks: Sherratt 1997). There was a major expansion of farming, and an absorption of remaining mesolithic populations in the outer parts of Europe. There is every reason to believe in a relatively sudden, widespread and revolutionary (forgive the pun!) phenomenon, spreading in (at most) a few hundred years across the entire continent of Europe, from the Mediterranean to the Baltic and from the Urals to the Atlantic. *Préhistoire événementielle!*

Patterns of contact

Can the dating and shape of this horizon be further defined? Using only the direct evidence of preserved wheels, for instance, it would be practically impossible because of their rarity and specific circumstances of preservation. If, however, the phenomenon was as event-like as I have suggested, then the patterns of cultural classification themselves (changes in taxonomic units like "cultures" or "groups") may give hints of when changes in *genre de vie* took place and the direction of contacts at the time, as we saw from southern Scandinavia and the north-Alpine region. If no clear pattern emerges, the exercise is probably best not pursued; but if the pieces begin to fit together into some sort of meaningful arrangement, then it is worth extrapolating and aligning with events elsewhere.³²

These various appearances of wheels and plough-traces do indeed correspond to a cultural horizon, whose impact is being increasingly recognised. As may have been evident from earlier discussion, the hub of these contacts was the Carpathian Basin, and it is time to summarise developments there. During the earlier fourth millennium there was a gradual breakdown of the cultural blocks which had formed the basis of previous Copper Age structure: old groups began to hybridise, and larger groupings (including the newly-integrated regions such as Scandinavia) began to form, linked by long-distance trade in copper or fine stone. At the same time, in areas like eastern Hungary and the lower Danube, where there had previously been substantial nucleated settlements, life

³⁰The first evidence for wool in central Europe is the carbonised wool from Clairvaux-les-Lacs (Clairvaux récent, c.3000-2900) (Hundt and Körber-Grohne in Pétrequin 1986, 240 and Fig. 7), and the ball of re-used linen yam with the impression of a now-vanished woollen weft, presumably wool, from the late Neolithic site of Erlenbach-Wyden, Switzerland (Ruoff 1981, 252 and Fig. 1). The question is discussed further in Sherratt (1997, 203-5).

³¹Shafthole axes cast in 2-piece moulds from arsenical copper are known from the Kuro-Arax and Maikop cultures (and perhaps more widely in eastern and central Anatolia) by 3500 BC, and became more widespread on the steppes after 3000 BC with the Pit-Grave culture, whence the form spread to south-east and east-central Europe in the early third millennium (Chernykh 1992).

³²I have discussed the dating of the Baden culture and its wider setting (Sherratt 2003) in a *Festschrift* for Nándor Kalicz, who first drew attention to the Anatolian background of this culture (Kalicz 1963).

became more mobile and in certain areas settlements moved to defensible hilltops.³³ Around the middle of the fourth millennium, however, a new culture began, which would last for the next seven centuries and set the pattern for future development--the Baden culture. It can be divided into three major phases: from c. 3500 to 3300 (Boleraz phase), 3300 to 3000 (Classical Baden phase),³⁴ 3000 to 2800 (Kostolac phase, parallel to intrusive Pit-Graves). The beginning of this new era was marked by the emergence of a very uniform culture, with a novel orientation in that it stretched between Bohemia and the Black Sea coast--hence its name, the Boleráz/Cernavoda III³⁵ complex, since it was independently defined in Slovakia and Romania before it was realised that the two groups were one and the same (Nemejcova-Pavukova 1973; Roman and Diamandi 2001). No group had previously occupied this east-west alignment (or even the two sides of the Carpathian basin, never mind the lower Danube as well), so its appearance is significant; and all the more so since it extends into the Dobrudgia and thus has access from the sea; the site of Cernavoda itself lies just below the Danube delta, where a land-route crosses low hills to link the Black Sea to the Danube corridor.³⁶

The scale of this cultural entity in its "pure" form is remarkable; but it is even more noteworthy when the area is extended to include surrounding regions on which it exercised an impact, giving it a diameter of some 1500 km. This contact-zone extends in an arc: from east to west--Little Poland, central Germany (the middle Elbe/Saale region), southern Germany and the east-Alpine foreland. Its distinctive pottery occurs on the Bodensee at Arbon Bleiche 3 (along with spindle-whorls and the yoke) at the beginning of the cultural and economic transformation which marked the beginning of the Horgen culture, though the elaborate Boleraz ceramic repertoire had little effect on the subsequent Horgen style. A more profound stylistic influence was exercised on central Germany, beginning the Salzmünde culture (Behrens 1973), and also in Little Poland where Baden influences became particularly pronounced in later TRB (Lubón). Beyond central Germany a chain of connections can be traced northwards through the Altmark, along the Elbe river to Schleswig-Holstein and Denmark where the Fuchsberg and Virum groups (EN II) developed, and also

³³Hybridisation occurred eg between Bodrogkeresztur and Salcutsa, with the formation of the Hunyadhalom complex, and late Salcutsa sites often occupy small fortified hilltops.

³⁴The classic Baden phase is marked by metal-skeuomorphic shapes (as Kalicz recognised in 1963), such as the combination of channelling, high-flung strap-handles and omphalos bases; the Boleraz phase, although equally characterised by vessels for handling liquids, has a decorative scheme based on stake-frame basketry. The Kostolac phase has a decorative scheme based in white-filled impressions, sometimes including cord-impressions, reflecting eastern influence.

³⁵The number III refers to a site, not phase in a stratigraphic sequence; and although Cernavoda I is the oldest, Cernavoda II in fact follows Cernavoda III.

³⁶Not along the river itself, but via Transylvania.

westwards into Hesse with its links to SOM gallery graves in the Paris Basin. Continuing impulses in the classical Baden period (contemporary with the Nordic earlier MN) are exemplified for instance by finds from Oldendorf II, Kr. Lüneburg, with its famous metal-skeuomorphic vessel with a strap-handle (illustrated in eg Sherratt 1997, Figure 7.3). As so often in prehistory, therefore, there seems to have been a primary axis of contacts in Europe from the Carpathian Basin, through Bohemia to central Germany and along the Elbe to Jutland.

By the last two centuries of the fourth millennium there seem to have been links to the east as well as the west: the Dnestr and Prut valleys connected Volhynian late TRB, via the Gordineshty group of late Tripole (CII), with late eneolithic groups in the river-valleys of the Pontic steppe area and especially those of the Zhivotilovka-Volchansk³⁷ group (Rassamakin 1996; *idem* 1999). These have burials in timber-covered pits or stone cists, and a component of dark, burnished pottery which is unlike either Tripole or steppe wares but resembles Baden-influenced TRB. These graves seem to mark a route of contacts and exchanges reaching as far as the north-west Caucasus (Dergachev and Manzura 1991), where a facies of the late Maikop culture known as the Novosvobodnaya group reproduces the cists ("dolmens") and the distinctive burnished pottery--with some remarkable echoes of western gallery graves, including the porthole entrance (*Seelenloch*) and in one case a painted scene recalling that engraved on the cist from Leuna-Gölitsch near Halle, with a bow and quiver hung on the wall (Rezepkin 1992). (This route prefigures the path of Globular Amphora culture expansion into formerly north-Tripole territory in the following century, after 3000 BC, at the same time as the Pit-Grave culture extended across the steppes and took over its southern territory.)³⁸ While these features are far from indicating a wholesale cultural transfer, they are clearly not fortuitous, and find an acceptable explanation in transmission along a long-distance "trade"-route, which is also reflected in the occurrence of Maikop arrowheads in a grave at Kosteshty in Moldavia (Dergachev 1982), and the distribution of high-arsenic daggers of Usatovo-Nerusaj type along the Dnestr (Vajsov 1993), with west Anatolian or Aegean links. These details are complicated, but symptomatic of the growing web of connections in the later fourth millennium--initially along the Danube axis from the Black Sea, and soon along the northern axis from the Carpathian Basin to Scandinavia, then, after a few centuries, laterally from north-central Europe to the Caucasus.

³⁷ Also transliterated as the Zhivotilovo-Volchanskoe group.

³⁸ Préhistoire historisante? The Globular Amphora culture expansion-pattern itself prefigures that of the Ostrogoths in the 3rd century AD, extending along the crucial trans-continental route of traffic between the Black Sea and the Baltic.

To understand how these European phenomena might fit into a wider pattern of developments, it is useful to enlarge the scale and to return to the Eurasian standpoint with which we began. The cultural contrasts of the fourth millennium BC must be envisaged in a three-dimensional way, encompassing both time and space. Farming had been established in a restricted area of the Levant by 8000 BC, and spread slowly both into Europe and towards India--often in fits and starts, as native populations initially resisted farming, and then adopted it. At the same time as the frontiers of farming were being pushed outwards, more complex forms of society came into existence within the Fertile Crescent: large communities grew up, some centred on temples with elaborate architecture, with property designated by sealings and with advanced metallurgical skills capable of lost-wax casting of arsenically alloyed copper. By 4000 BC, just as farming was being widely adopted in the southern Baltic with the emergence of the TRB culture, true cities came into existence in southern Mesopotamia. These were capable of attracting high-value materials from up to 2000 km away (lapis lazuli), and produced commodities such as textiles and liquid comestibles in bulk--the latter stored in pottery containers mass-produced on the wheel. Transactions in these commodities were recorded first by "complex tokens" (small clay models of goods such as wool-bales or jars) sealed in a clay envelope; and then, by the end of the millennium, by pictures inscribed on clay tablets--pictographic writing. For water-transport, boats equipped with sails were in use; for overland transport, donkeys were used as pack-animals. In the early centuries of the fourth millennium, attention was directed east, towards the Iranian plateau; but from some time around 3600 BC a major westward expansion began, marked by the foundation of colonies on the Euphrates bend and the extension of contacts into Anatolia (notably at Arslantepe, in the Malatya basin) and the Levant--and onwards to Egypt, where the intervention was critical in the genesis of Egyptian civilisation. (Many of these key facts have emerged only in the last three decades, as a result of rescue-excavations on sites drowned by reservoirs along the Euphrates in Syria and Turkey). This was thus a very large-scale phenomenon, whose effects (directly and unambiguously manifested, for instance, in the distribution of lapis lazuli) can be traced over an area some 3500 km in diameter.

The appearance of the traction-complex in later fourth-millennium Europe thus took place at a time of momentous events; only a few centuries after the first simple farmers appeared in Scandinavia or around the Alpine lakes, a shock-wave of new influences spread out from Mesopotamia to transform the surrounding areas. Where, within this spectrum of societies, did the traction complex first appear?

Origines: de l'aire au chariot

Our arguments have led us to the following position. The traction complex

appeared, within a few hundred years, over an astonishingly large area of western Eurasia. Its area of origin must have been much more restricted; and the combination of features is so specific that even if more than one cultural area was involved, they must have been in intimate contact. This does not, however, exclude different contributions from different areas, going towards the final package--the specialised pole-and-yoke paired draught method applied to the plough and cart. The particular characteristics of the contributing areas might have been either social or environmental--economic or ecological--and this conjunction of circumstances led to the birth of a unique zoo-technological system.

The first use of bovids as work animals, it was suggested at the beginning of this article, was in their use to tread the grain as an alternative to threshing with a stick. The characteristics of the principal cereal-crops of the world's civilisations have often had a formative influence on their technology (contrast the need to render wheat-grains into flour, leading to the development of milling technology, with its absence in rice-growing areas), and the development of threshing devices is a characteristic of Mediterranean societies: "The ear itself when reaped in some places is beaten out with threshing-sledges [*tribulis*] on a threshing-floor, in others by being trodden on by mares, and in other places threshed out with flails" (Pliny *Nat. Hist.* XVIII, lxxii, 298). The *ad hoc* use of bovids to carry loads or to drag objects attached to their horns is likely to have led to more systematic attempts to attach them to sledges--an old device pulled by human muscle-power, whose use must go back into the paleolithic. The attachment of a small, weighted sledge to an animal during the threshing would have increased its efficiency; and the addition of inset flint blades would have served in addition to chop the straw. This device, ancestor to the *tribulum*, is believed by Patricia Anderson (1999; this volume?) to have been present in the Near East and the Balkans by the sixth millennium BC.³⁹ Since a critical feature of this device is its ability to turn in a tight circle (to concentrate the grain in a heap--a property improved by the carefully slanted alignment of the inset flint blades), a flexible attachment to a single animal is desirable, and the device would thus have been secured by traces. A canopied sledge--perhaps even specifically a threshing-sledge--is shown by pictographic signs in the earliest known writing-system, that of late Uruk in the later fourth millennium BC. Such a vehicle could carry one or two people, whose weight would be advantageous in the processing. It was also an impressive manifestation of power, and its metaphorical significance is evident in Isaiah 41, 15: "Behold, I will make thee a new sharp threshing-instrument having teeth: thou shalt thresh the mountains, and beat them small, and shalt make the hills as chaff".⁴⁰ This

³⁹See also the programme and abstracts to the conference *Le traitement des récoltes: un regard sur la diversité, du Néolithique au présent*, at <http://www.cepam.cnrs.fr/Colloques/abstract2002.html>.

⁴⁰Compare the Christian symbolism of the Harrowing of Hell as another agrarian metaphor in a religious

imagery explains its association with social power (both religious and secular) in late-fourth millennium Uruk representations and in the ceremonial sledge buried in the mid-third millennium with Pu-Abi in the Royal Cemetery at Ur (Woolley 1934).

Paired draught is unlikely to have developed directly from the threshing-sledge driven in a circle, since yoking two animals makes turning difficult; the original incentive must have been something more linear: perhaps plough-furrows? A machine for making furrows would require more power--two beasts, to overcome the friction of penetrating the ground--but (while the instrument was engaged) they would only need to walk in a straight line. Although we commonly think of furrows as a means of preparing tilth, this was not necessarily their original purpose. For full preparation of the soil, either cross-ploughing was required (as indicated in north-European ploughmarks), or else secondary hoeing (as shown in Alpine rock-engravings).⁴¹ This seems insufficient motive to invent a plough *ab initio*, i.e. to create the first yoked traction technology. One circumstance which might give rise to such a need, however, is irrigation. Mesopotamian irrigation systems (unlike Egyptian ones, which used basin-irrigation) were based on dendritic canals. Much labour was expended on the construction of arterial canals; but equally important was the delivery of the water to the individual plants at the end of the system. This would have required furrows--miniature canals conducting water to rows of plants in the field. For making these, a plough would be perfect. Such a distributive system has actually been excavated, not in Mesopotamia but at late-third millennium Kalibangan in north-west India (Steensberg 1971). Early Mesopotamian representations of ploughs on seals (third millennium) often show a seeder-funnel. This would support the idea that seeds were sown only in the furrow, where water would reach them, rather than being wasted by scattering them across the whole of the field surface. Such a scenario for the beginning of the plough is speculative, but plausible and compatible with the known evidence.

What, then, of the wheel? It has long been speculated that the earliest stage might take the form of a captive roller, pegged beneath a sledge or fixed in position by a tenon. (Similar devices were created for special needs in later periods, as in the frozen burials at Pazyryk in the Altai, where they were used for moving the heavy tree-trunk coffins.) Hints of some such device are given

context. Paired draught itself (though in this case the horse and chariot) may have given rise to images of the Heavenly Twins and Dual Rulership in various Indo-European cultures, eg the Vedic Ašvins (*asva* = a pair of horses).

⁴¹However, the scenes of ploughing from Val Camonica which include with figures with hoes both show equids (donkeys) as traction-animals, and are thus first millennium BC in date: Bedolina (Capo di Ponte) and Seradina (San Rocco), Nos. 435 and 441 respectively in the catalogue of Fries (1995).

by certain Uruk pictograms, where two circular depressions are placed under the "sledge" sign, indicating a primitive vehicle with rotating components. But was it initially for carrying loads? Most transport in southern Mesopotamia was accomplished by boat, and there was little need to carry heavy loads by land. If threshing sledges were widely used, however, there would be a particular problem in making such machines in southern Mesopotamia, which is an alluvial plain without stone resources, and to which flint was an expensive import (hence the manufacture of baked clay sickles). An alternative might be to develop an all-wood device with rollers, known ethnographically and called a threshing-wain or *plostellum punicum*, perhaps the *giš-bad* ("wooden thresher") of Old Babylonian texts (Littauer and Crouwel 1990; Steinkeller 1990). A sledge-with-rollers would thus initially have been a threshing machine, though with the addition of the new draught-pole and yoke technology it had considerable potential for further development. Where did such development take place? Southern Mesopotamian colonists on the Euphrates bend carried their technologies with them (even to the extent of making baked clay sickles in an area replete with sources of stone), so that ploughs and devices with rotating rollers probably accompanied them, too. In this new setting, however, there were new transport needs and more opportunities than on the southern alluvium, for instead of a network of canals there stretched a level and largely treeless steppe. It is in circumstances such as these that one can imagine a hybridisation between the plough and the thresher, adding the yoke and draught-pole for paired traction to a simple roller-sledge, and improving the design of the rotating component to create separate wheels and axle. Go, baby, go: it must have been an exhilarating experience.

How does this Just-So⁴² story match up with fact and theory? First, the observations and the source-criticism. There is, of course, a marked absence of the kinds of evidence which so assist the inquiry in Europe: bog-finds and ploughmarks (though there is no reason why the latter should not be found in future excavations). There is a particular shortage of evidence of all kinds in the earlier fourth millennium, the Early Uruk period, since few sites except Susa have had their deposits of this period excavated. These deficits are to some extent remedied by the appearance of a pictorial record (pictograms, scenes on seals, wall-paintings), though our sample of all these is biased towards the Late Uruk period in the later fourth millennium. It would be reasonable to suppose, however, that the agrarian system of which they were part (at least on specialised, capital-intensive temple estates) had come into existence early on in the Uruk period, as part of the process of urbanisation. Pictograms show that in southern Mesopotamia (Uruk) in the later fourth and

⁴²The term comes from a book by Rudyard Kipling, including such masterpieces as "How the elephant got its trunk", etc.

Elam (Susa) in the later fourth and very early third millennia, a plough with two stilts (handles) and a composite draught-pole was in existence, and that (at least in the former) there was also the sledge and perhaps the *plostellum*. Three representations (one on a plaque, two known through seal-impressions) give more details of the sledge, and all show it in a ritual or ceremonial scene with a figure sitting under a canopy behind the driver (Littauer and Crouwel 1990). In each of these, only a single draught-animal is shown; only in one case (a sealing from Arslantepe VIA, ie late Uruk) is an attachment clearly shown, and since this passes on the outside of the animal it must represent traces rather than a draught-pole. The first direct representation of paired draught occurs in a wall-painting at Arslantepe on the eastern wall of corridor A796 alongside Temple B, in an artificial rectilinear style which--interesting in itself--is clearly derived from representations on textiles (Frangipane 1997, Figs. 15 and 16).⁴³ Temple B has a dendro-date of 3374 BC.⁴⁴ Arslantepe has also yielded a perforated clay disc interpreted as a model wheel, and this interpretation is strengthened by an unfinished stone example (both similar to examples from the contemporary Kuro-Arax culture in the Transcaucasus) from Jebel Aruda, an Uruk colony on the Euphrates bend (Bakker *et al.* 1999).⁴⁵ If these discs do indeed represent wheels, then they are evidence for a fixed axle and independently-rotating wheels⁴⁶--a considerably more sophisticated vehicle than the *plostellum* or even the fixed-wheel cart, and thus signifying the emergence of a manoeuvrable vehicle potentially resembling those shown in the Bronocice drawing or the Budakalasz model. This evidence is thus congruent with a southern Mesopotamian origin for the draught-pole traction complex, and a

⁴³It is worth quoting the excavator's description of this important scene *in extenso*:

The painting, in red and black... depicted a narrative scene with a repetition of some decorative/symbolic elements found in the other paintings. The part that has been restored so far has revealed two figures of stylised bulls [or oxen] ... which seem to be pulling what appears to be a monumental cart driven by a coachman... On the bulls' horns are attached the reins which end in a ring held by the coachman, while a standing rod ending in a T-shape and standing between the two bulls might represent a kind of standard [or a schematic rendering of the draught-pole? AS]... The scene, which continues northwards, might be even more complex, but the elements that have been uncovered so far are very similar to the depiction of the transport of an eminent personage on a sledge car covered by a canopy, which is found on a glyptic seal, particular in the context of Arslantepe's glyptic, which was impressed on three sealings in room A 206. This seal repeats the iconographic elements of an Uruk seal interpreted as a ritual threshing scene, emphasising the ideological reference by the Arslantepe elites to images of power expressed in a Mesopotamian environment." (Frangipane 1997, 64-5).

The whole scene is clearly part of the visual rhetoric of power.

⁴⁴The Arslantepe date is an average of seven wiggle-matched dendro-samples: see <http://www.arts.cornell.edu/dendro/acta/fig6.htm>.

⁴⁵No models of the vehicles themselves are so far known from the fourth millennium in the Near East, and the only model of a yoked pair is that from Tel Farah (N) in Israel (late fourth or more probably third millennium).

⁴⁶ A round hole implies free rotation about a fixed axle, with the wheel held in place by a linch-pin; a square hole implies that a rotating axle was mortised to the wheel (see diagram in Sherratt (1997, Fig 9.2).

north Mesopotamian/Syrian/east Anatolian/Transcaucasian origin for the full development of the wheel.

These pieces of evidence from the Fertile Crescent are directly contemporary with the Boleraz impact and the beginning of Horgen in the north-Alpine region, but potentially a century later than the earliest reliable evidence of plough and cart from northern Europe. It would be naive, however, to read this difference as reflecting an origin of the traction complex in Schleswig-Holstein and its almost immediate transfer to Sumer;⁴⁷ rather it reflects the different kinds of evidence in each area, and the relatively late appearance during the fourth millennium of a pictographic script. If the use of ploughs and threshing-sledges began on temple estates (as seems likely, since the use of draught animals is expensive in Near Eastern environments, and implies some concentration of capital to support specialised production methods),⁴⁸ then such systems are likely to have come into use at the onset of urbanisation, early in the millennium. Contacts with the Caucasus and the western wing of the Fertile Crescent began in the Middle Uruk period around 3600 BC (Rothman 1901; Postgate 2002), which provides a context for the initial dispersal of the traction complex, and just sufficient time for a very rapid transmission along the main axis of contacts across temperate Europe--either (or both) along the Danube from the Black Sea, or through the Caucasus and the Ukraine. (Why this transfer was so rapid, and which route was used, will be considered in the following section.)

⁴⁷In the manner that R. Braungart in 1912 pointed to the Walle ard as evidence that the *Indogermanen* had carried plough-cultivation to the Mediterranean! (Cited in Tegtmeier 1993, 4).

⁴⁸A Sumerian poem, the contest of the hoe and the plough, makes precisely this point. The whole text is available electronically at:

<http://www.gatewaystobabylon.com/myths/texts/disputations/hoevsplough.html>

and is worth reading for its immediacy across four millennia. The hoe starts the fight: "Plough, you draw furrows--what does your furrowing matter to me?" The plough replies haughtily: "The king takes hold of my handles, and harnesses my oxen to the yoke. All the great high-ranking persons walk at my side. All the lands gaze at me in great admiration. The people watch me in joy..." But the simpler hoe thinks the plough is too complicated: "When you come out to the field after me, your single furrow gives you pleasure. When you put your head to work and get entangled in roots and thorns, your tooth breaks. Once your tooth is fixed, you cannot hold on to your tooth. Your farmer calls you 'This plough is done for'. Carpenters have to be hired again for you.... A whole workshop of artisans surrounds you... Your work is slight but your behaviour is grand. My time of duty is twelve months, but your effective time is four months and your time of absence is eight months--you are gone for twice as long as you are present." And so on--like a conversation between a VW beetle owner and a BMW owner. The plough is a capital-intensive investment. Paul Halstead (1995) has calculated that in Mediterranean environments specialist draught animals can only be maintained on a production-unit of 5 ha or more, like the Turkish *çiftlik* (*çift*="a pair" [of oxen]). The plough is most unlikely, therefore, to have a long prehistory. This point was grasped long ago by E.C. Curwen: "We must not imagine that the use of the plough is as ancient as agriculture itself. On the contrary, it was a comparatively late invention... The earliest evidence we have of the plough comes from Mesopotamian cylinder-seals and Egyptian paintings going back to rather before 3000 BC... This evidence suggests that the plough, like the wheeled vehicle, may have been a product of the industrial movement of that era. In fact, it is probably not too much to say that the plough made industrial food production and the rise of urban culture possible" (Curwen 1953, 57 and 64).

In summary, therefore, it can be suggested that the use of cattle for draught purposes probably began some eight thousand years ago (a millennium or so after their initial domestication), but that specialised uses involving the traction complex only began some six thousand years ago, in the context of early urbanisation. This specialised usage had two aspects: a technological one to do with attachment and harnessing, to which the novel solution was the pole and yoke; and a livestock-rearing one which was the maintenance of expensive specialist draught animals--oxen--which took time to train and had to be grain-fed during the ploughing season.⁴⁹ Such combinations of expertise and value in a visually impressive performance of applied strength became natural symbols of power and prestige (hence their frequent depiction in ceremonial contexts), and this demonstrative aspect was at times as important as their practical advantage.

Dispersal

By contrast with these speculative reconstructions of the evolution of traction-devices in the Near East, Europe presents an abundance of evidence--at least for wheeled vehicles. Moreover these show a variety of forms, raising the question of whether the differences are due to functional specificity or cultural tradition. (The question is complicated by the fact that they are usually found in fragments; that is why the practice of interring complete vehicles, in the Caucasus and on the steppes, is so useful: Piggott 1968; *idem* 1983.) Two major sets of differences are evident: that between two-wheelers and four-wheelers, and that between rotating axles (fixed to the wheels) and axles fixed to the body of the vehicle (about which the wheels rotate).⁵⁰ Since it is difficult to turn four-wheel vehicles if the wheels do not rotate independently, and four-wheelers almost inevitably therefore have fixed axles, it is probable--even though not provable on present evidence--that these differences correspond to two fundamental categories of vehicle (and might even be associated with further contrasts, such as horn-yoke versus withers-yoke, though there is no necessity for this).⁵¹ The four-wheelers certainly imply more sophisticated

⁴⁹A text from the archive of Lugalanda of Lagash (c.2400 BC) records that draught-oxen were fed a quantity of barley during the ploughing-season that was equal to the amount used as seed-corn (Nissen *et al.* 1993, 63 and 68). The training of such a draught animal took about three years, during which there was effectively no return on the investment. Using a draught animal both for ploughing/sowing and threshing was an effective way of using its working life, as was using it at other times for general transport: this is one reason why the traction-complex spread as a package.

⁵⁰A further contrast is in the use of external battens to secure bi- or tripartite wheels, *versus* the use of internal dowels: the former are known only from the circum-Alpine examples with rotating axles, which in some (and perhaps all) cases belonged to two-wheeled carts.

⁵¹Gandert (1964) interprets the Vinelz (mid-third millennium) example as a horn-yoke (*Nackenjoch*) and Petersfehn (late-third/early second millennium) as a neck-yoke (*Widerristjoch*). It seems likely that the relatively undifferentiated shape of the Chalain yoke indicates a horn-yoke. Horn-cores with abrasions are known from Bronocice period 5, ie parallel to classic Baden (Kruk and Milisauskas 1999, Fig. 53) and from Guhrau [present-day Góra] in Silesia, in a pit with TRB sherds.

carpentry, both in their wheels and in the attachment of a draught-pole.

On the sample currently available to us, however, it is not possible to establish a chronological priority: the Bronocice wagon-drawing is arguably older than (or at any rate as old as) the north-Alpine finds of wheels with rotating axles, but the difference is insignificant--the two types are effectively contemporaneous in the later fourth millennium. There is a slight difference in spatial distribution at this time, with Bronocice and the Hungarian wagon-models (Budakalasz and Szigetszentmarton) to the north and east of the two-wheelers and rotating axles--though by the third millennium four-wheelers are widely distributed, from Val Camonica to Denmark, and from the Netherlands to Bulgaria, in contexts such as Corded Ware, Pit-Grave or later Remedello. (The Novotitarovka culture in the Kuban, a local group of the Pit-Grave complex, has yielded numbers of notably complete and well-preserved examples of wagons from this time: Gei 2000.)⁵² The generally exclusive archaeological occurrence of the two categories, while it has some association with different cultural groups, seems more likely to be due to different landscapes and contexts of use, exaggerated by the preservation biases of different kinds of evidence. The two categories certainly persisted in contemporary use (the four-wheelers evolving as prestige vehicles, the two-wheelers retaining their primitive simplicity) down to recent times. Carts with two wheels fixed to rotating axles have been described ethnographically from Ireland to Mongolia--surviving especially amongst relatively self-sufficient communities in rugged terrain.

A visual impression of the two categories has been created as Fig X. The A-frame cart with a rotating axle (Fig X top) is a composite created from the north-Alpine wheels and a version of the Chalain travois with a simplified junction and the Arbon Bleiche 3 yoke (though the Chalain one might have been used), informed by recent Turkish ethnography (pers. obs.) and the late bronze age examples from Armenia.⁵³ The wagon with fixed axles (Fig X bottom) has a body based on the Budakalasz model⁵⁴ (a quadrangular base with matting attached to inset corner-poles), wheels like those known from Pit-Grave and Corded Ware contexts, a Y-shaped draft-pole like those from Klosterlund or several Novotitarovka sites (Gei 2000) in the Kuban region, and the Vinelz yoke

⁵²The statistics are astonishing: some 80 vehicles in graves in the Kuban region alone, and perhaps another hundred in the rest of the steppe region. The wooden remains show up as substantial stains in the dry conditions, though they are not as well preserved as the waterlogged examples from Armenia (Piggott 1968). It is nevertheless a shame that they have been recorded in so schematic a fashion, with small-scale plans and few technical drawings.

⁵³The A-frame cart from Lchashen Barrow 2 in fact has a fixed axle, mounted at the rear--a slightly sportier version!

⁵⁴The circular naves are indicative of a fixed axle and independently-rotating wheels.

(Winiger 1987, 107)--all dating to the earlier third millennium. Since the body of a four-wheel vehicle cannot maintain a constant height for the draught-pole and yoke by tilting about its single axle as a two-wheeler can, a pivoted draught-pole is desirable, and the Y-shaped design seems general--note that the Budakalasz "draught-pole" is in fact the handle of the cup.⁵⁵ The Lchashen finds show that these two types co-existed and remained largely discrete, and were even being buried in the same tomb, so that they seem to have had complementary uses (Piggott 1983, 70-8).⁵⁶ These examples suggest the long co-existence of two discrete functional types, employed in different circumstances and usually preserved under different conditions. This would argue for a relationship like that between wheeled vehicles and the plough: all of these manifestations would represent aspects of the traction-complex, and were potentially present wherever it spread, but particular applications would only have been put into practice where it was appropriate, and only preserved in the archaeological record by accident or by cultural choice. In short: these different applications are complementary, and do not represent different "traditions", spreading across Europe by different routes.

While it would be tempting, therefore, to attribute the occurrence of the two categories of wheeled vehicle in later-fourth millennium Europe to the convergence of two streams--with two-wheelers, suitable to rugged terrain, arriving from Anatolia, and four-wheelers, suitable for wide plains, arriving through the steppes from the Caucasus--this is less probable than their spread as parts of a single complex.⁵⁷ As a principal axis of contacts in the middle of the fourth millennium, a route across Anatolia--from Malatya to Cappadocia, and thence through northern Anatolia and via the Black Sea coast to the Lower

⁵⁵Although reconstructed in a nice drawing as a two-wheeler (Schovsbo 1983), the Klosterlund find is surely the draught-pole and front wheels of a four-wheeled wagon. There would thus be no need to perch a wattled superstructure precariously over the Y-junction of the pole, as shown in the drawing. The only supporting evidence for the Klosterlund reconstruction would be the Lohne/Züschen engravings, which apparently show a two-wheeler with a short, triangular body: but I wonder if this engraving, too, is not an incomplete depiction of a four-wheeler with a Y-shaped draught-pole? In at least one instance, the preserved slab seems to have a segment of the surface missing here. (The engraving as presently depicted, however, bears a striking resemblance to an open-air rock engraving at Kammenaya Mogila--"rocky mound"--an inselberg near the Sea of Azov in the Ukraine (Mihailov 1979, 45). Its date is unknown, and the wheels are rendered in plan and not *en face*, so it cannot be seen whether they are solid or spoked--for cattle-drawn chariots, of second-millennium or later date--are known from Armenian rock-art.

⁵⁶The large wagons from Lchashen are larger than fourth- and third-millennium examples, and resemble the covered wagons shown in early-second millennium Syrian clay models (Littauer and Crouwel 1974). The Lchashen examples have the interesting and distinctive characteristic that the draught-pole is replaced by an A-frame constructed like a cart-body, making them introgressive hybrids. (A similar phenomenon may be manifested in the design of the Hallstatt wagon, which seems similarly to have developed from the conjunction of two A-frames to improve the turning properties of the vehicle, by then horse-drawn.) The closest well-preserved analogy for European four-wheelers is provided by vehicles of the early third-millennium Novotitarovka culture (Gei 2000), with their Y-shaped draught-poles (up to 4m long).

⁵⁷This was the opinion of Mrs Littauer in her letter to me in 1986 (Sherratt 1997, 246 Note 3), and I am happy to acknowledge her far-sightedness.

Danube--is the most probable connection between the area of Uruk expansion and the explosive beginnings of Baden. Only further work in Turkey will make this clearer. Connections with the Caucasus via the Pontic steppes seem to be a few centuries later; and indeed, following the logic of the argument concerning cultural connections set out above, it seems as likely that knowledge of wheeled vehicles spread to the Caucasus along this route *from* central Europe, rather than that it was a second route by which they spread from the Near East *to* Europe. In either case, connections would have been established through the territory of the Tripole culture, in its final (CII) phase, and contributed to its breakup. This would explain the occurrence of wheel-models in Tripole contexts, some perhaps attached to standing animal figures rather than wagons (Gusev 1995), in the later fourth millennium BC.

Evidence for the typology of early ploughs is less plentiful, but deserves comment. European ploughs, by contrast with the forms shown in Mesopotamian and Egyptian representations,⁵⁸ had a single stilt and a less elaborate structure.⁵⁹ The earliest preserved example is that from Walle, now radiocarbon-dated to 2570-2460 BC (Lerche 1994, 204). This is a crook-ard, which has often been envisaged as being based on a hoe (or on some pre-existing device for creating furrows, the *Furchenstock*: Schulz-Klinken 1977),⁶⁰ by comparison with the bow-ard which has similarly been envisaged as based on a spade (Glob 1951, 109)--though it could equally be envisaged as being derived from a different kind of hoe (Fries 1995, 25-6).⁶¹ It looks as if the basic idea of the traction-plough was translated into a variety of forms, sometimes based on existing instruments, adapted to local soil-conditions and uses. (Wheeled vehicles, too, are likely to have manifested such local peculiarities.) The crook-ard (or the closely related sole-ard, distinguished by being made of a separate sole and draught-pole) may thus have arisen in Anatolia, or more generally around the margin of the Fertile crescent, as a

⁵⁸And the one preserved example from Dra-abu'l-Na'a (Tegymeier 1993, 20, Fig. 25).

⁵⁹For instance, lacking "ears", which were only used in Europe in Roman times, as on the Köln model (Glob 1951, Fig. 133). [Anatolische Söpflüge?].

⁶⁰ The *Furchenstock* ("furrow-stick") is the name given by some authors to an implement occasionally found preserved in circum-Alpine lake-villages, though interpreted by others as a threshing-stick. (Other wooden instruments, optimistically called "hand ploughs" but more probably digging-sticks, have been recovered from the early-third millennium Šventoji-6 waterlogged settlement in Lithuania: Rimantienė and Česnyš 1990, Figure 2) There is no way of telling its original use, though employment as a pick-like agricultural instrument or hoe is not implausible. There is no evidence whatsoever for its originally having been dragged with a rope, which may have been suggested by the analogy of devices pulled by rope in China (Leser 1931). Such humanly-dragged devices, in the specialised context of rice-cultivation in east and south-east Asia, however, are best interpreted as spinoff from the traction-complex, where water-buffaloes would otherwise take the place of cattle (in a non-milking economy) and draught-animals are thus expensive.

⁶¹The Egyptian plough, which differed in its structure from the Mesopotamian, was likewise related to the local hoe design: Breasted 1935, Fig. 27.

device more suitable outside the uniform alluvial soils of the river-valleys; it was widespread both in Mediterranean and temperate Europe, and probably also in the north-Pontic region,⁶² in the third and second millennia (Sherratt 1997 Figs. 3.2 and 6.6). Although preserved examples of bow-ards are later, and associated with the heavier and wetter soils of north-west Europe,⁶³ the north-Italian representations which are believed to date to the early third millennium (late Remedello), such as that accompanying a wagon at Cemmo 2 in the Val Camonica, seem to show an angled implement somewhat resembling a bow-ard;⁶⁴ and it may be that--as with the varieties of wheeled vehicle--different sorts of prehistoric ploughs co-existed for different purposes (cf. Reynolds 1981). On the scenario proposed here, plough and wheel would have spread together, and by the same routes. The dual application of the traction complex, to cultivation and transport, would have increased its attractiveness as a package.

All these suggestions imply a very rapid transmission of the traction complex across long distances, and it remains to suggest why that should be so. Four aspects are important.

(1) The use of animal traction was initially an elite activity, requiring a concentration of resources and involving an assertion of power and control (over livestock and, by implication, over people). It was both expensive and symbolically important. Elites keep in touch with each other over long distances, and emulate each other; practices such as the use of paired draught would have spread from centre to centre in a series of leaps, before becoming widely adopted by the population at large.⁶⁵

(2) Long-distance trade-routes were already in existence by 4000 BC. In Europe the early fourth millennium BC was a time of proliferating contacts and the breakdown of cultural boundaries: a series of large cultural groupings

⁶²A stele of mid-third millennium date with a cultivation scene has been recovered from a *kurgan* at Simferopol in the Crimea: illustrated in Kruk and Milisauskas (1999, Figure 48).

⁶³Dated examples begin in the first millennium BC (Døstrup, Milton Loch etc: see Fig 3.2 in Sherratt 1997). A find from Pict's Knowe near Dumfries in Scotland, hailed as "Europe's oldest plough" (*British Archaeological News* NS 18 November 194), has also turned out to be Iron Age.

⁶⁴Interestingly, at the same time that representations of bow-ards are common in south-Alpine rock-art, Greek and Etruscan pictorial sources (eg painted pots) show only crook or sole ards--perhaps due to a conventionalised representation of Triptolemos. Such biases show how partial one form of evidence can be, perhaps reinforcing the methodological principal of assuming a diversity of contemporary practices. (It may be, however, that the rock-art depictions are not true bow-ards, but rather crook-ards with a steep angle to the sole, and that the difference is in the manner of their depiction!)

⁶⁵This model might be supported by the observation that wheel-diametres on the steppe generally decreased during the third millennium, from c. 70 cm at the beginning to c 50 cm later on (Hausler 1992, 179-82)--the bourgeoisification of the wagon.

appeared, named after features of their pottery and conventionally labelled in German--the TRB (*Trichterrandbecher*) complex in the North European Plain, the *Furchenstich* complex in the western Carpathian Basin and adjacent montane areas, and the *Scheibhenkelhorizont* which linked the eastern Carpathian Basin with the lower Danube. The Carpathian Basin thus lay at the centre of a web of contacts in the early fourth millennium BC, and supplied desirable materials such as copper as far north as Scandinavia.

(3) Perhaps rather obviously, cattle were already kept as domestic livestock, and exploited for their secondary products (milk); castration was probably already practised and the beasts were probably already used for carrying loads and even (with ropes) as traction animals. All that was missing was an idea--the blueprint for a machine that had gone through its "research and development" phase elsewhere, and offered itself as a fully operational package with multiple applications.

(4) The use of animal traction, especially for cultivation, was the solution to an impending crisis in European farming (Figure X). Following the introduction of hoe-cultivation and the keeping of small numbers of livestock in the early Neolithic, European populations grew continuously in the following millennia. The most fertile and easily cultivable soils were occupied first, and gradually deforested. Cultivation spread to lower-quality land, and much of the cleared land went from arable to grazing and the numbers of animals increased. Introduction of the traction complex, using animal power to cultivate the extensive cleared areas,⁶⁶ made maximum use of the available land and restored the balance between arable and pasture; a stable system of mixed farming (which sustained Europe's rise to world prominence in the next five thousand years) was the result.

The introduction of the traction-complex to Europe, therefore, was like dropping a match on dry hay: it spread like a conflagration across an entire continent. Plough and cart were complementary applications of the new technology, bringing both practical advantage to everyday affairs, as well as an element of ostentation to ceremonial and cult.

*Was there a Secondary Products Revolution?*⁶⁷

Some two decades ago, writing an article for a volume in memory of my teacher David Clarke (Sherratt 1981), I tried to answer the question which he had posed to me during my doctoral research in the Balkans about when the

⁶⁶In a sense, the ox replaced the pig as a device for turning over the soil and at the same time providing protein.

⁶⁷Some years ago it was dismissively described as "unter die Räder gekommen" (Vosteen 1996); a more rigorous examination renders this judgement premature.

plough had appeared in Europe (cf. Clarke 1979, 288). Stuart Piggott (1979) had just summarised his continuing investigation⁶⁸ of "the first waggons and carts", the subject of a classic article by Gordon Childe some 25 years before (Childe 1951); and in the same year Mary Littauer and Joost Crouwel had published their survey of the Near Eastern evidence for vehicles and riding (1979).⁶⁹ All of these writers acknowledged the close relationship between the plough and the cart, some suggesting the priority of the plough (Littauer and Crouwel 1979, 10). Reviewing the evidence, I was struck by the congruence of indications for these two items in Europe, and (on a narrower range of evidence) in the Near East. Following David Clarke's own methodology I examined the outliers, to see if they were odd; and Sarnowo seemed distinctly dubious, but all the rest seemed to line up uncannily around 3500 BC, coinciding with a major horizon of cultural change in Europe, centering on the Baden culture.⁷⁰ Since one of the characteristics of this culture was its distinctive set of drinking-vessels (including, incidentally, the Baden culture cart-models themselves), I speculated that his new interest in liquids might be connected with milk-products. Indications at about this time of the first use of wool, and of the domestication of equids (and soon also camelids) as transport animals, seemed to be more than coincidence; and so the idea was born of a second generation of innovations connected with domestic livestock--a "secondary products revolution", centered in the Fertile Crescent and impacting upon Europe just as farming itself had done four millennia previously. As in the Neolithic Revolution, different elements would have been contributed from different areas, but the complex would have spread as a package.

But what brought all these elements together in the first place, and gave them their common logic? These, and other features such as the first tree-crops, occurred as the first urban communities appeared in the Fertile Crescent. The arrival of these features in Europe at about the same time could thus have been due to spinoff from this process of urbanisation. In that case, the changes in container-shapes such as the Baden "jug and cup complex" might be more to

⁶⁸Begun with "The earliest wheeled vehicles and the Caucasian evidence" of 1968. The subject had been given particular topicality by publication of J.D. van der Waals' doctoral thesis (1964), which despite its title was a wide-ranging survey.

⁶⁹Stuart came to live near Oxford in his retirement, and both Mary and Joost were frequent visitors to the Ashmolean, where Roger Moorey was an encyclopaedic source of evidence on all aspects of Near Eastern antiquity; so I had a ready pool of advice, and must express my gratitude to all these scholars.

⁷⁰"This horizon has long been recognised as marking a major change in culture and settlement patterns. It marks the beginning of the Early Bronze Age in Transcaucasia, Anatolia, the Aegean and the Balkans; the Tripole-Usatovo transition in the Ukraine; the Baden culture in central Europe, the Middle Neolithic (Passage Grave) period in north-west Europe, and the Chalcolithic of south-west Europe. There is thus reason to believe that the introduction of of this traction complex, and perhaps other features, was of major importance in European culture-history; and that its spread to other areas may have been equally significant." (Sherratt 1981, 271-2). Prophetic words.

do with the adoption of fermented beverages (Sherratt 1987) than the beginning of milking (which could have begun some time before the other innovations (Sherratt 1983, 94).⁷¹ Rather than a chance series of innovations, this suite of new practices concerning production, consumption and transport would be related to the intensification and diversification of production and the scale of trading activity around the first cities. The idea of a "secondary products revolution" would be unnecessary, since these would all be aspects of Childe's Urban Revolution--much as the 18th-century Industrial Revolution was accompanied by an "Agricultural Revolution".⁷² This concept is an attractive one, and explains what would be otherwise a series of curious coincidences. At the core of the development would be the process of capital concentration and economies of scale manifested in the first cities and their temple estates, giving rise to the first system of commodity production (Sherratt and Sherratt 2001). This promoted hitherto localised materials such as wool⁷³ into export items, and created quantities of fermented products from fruit, grain and milk produced in specialised units (eg the "herd of Inanna" shown on seals: Frankfort 19**). Colonial expansion dispersed these consumption-habits and their supporting technologies and systems of animal management, creating fresh novelty when they encountered new environments (eg grape-wine in the mountains instead of beer and date-wine; horses and camels as transport-animals instead of donkeys on the steppes and the Persian plateau). The process was a cumulative one.

This emphasis on capital formation is why I would locate the locus of innovation in the early urban communities themselves, and--in company with Childe and Piggott--attribute the plough and wheel to Mesopotamian origins (albeit with a dialectic between southern and northern Mesopotamia). This is why I have sometimes been (inaccurately) described as a neo-diffusionist. A primary dispersal of these features through Uruk trading-colonies would have taken them to south-east Anatolia and the Trans-Caucasus, from whence they could have spread along exchange-routes into eastern and central Europe. This would explain the appearance of horses and new, larger breeds of sheep in central Europe in the later fourth millennium, in the same half-millennium as the

⁷¹"It is thus not improbable that milking was being practised in Europe by 4000 BC, or even earlier" (Sherratt 1983, 94). Current evidence, from organic residues, dates milk consumption in north-west Europe to 4000 BC (Regert *et al.* 1999; Copley *et al.* 2003); a research programme to examine systematically the evidence from earlier millennia, funded by the Leverhulme Foundation, is currently being undertaken by Richard Evershed, Sebastian Payne and Andrew Sherratt.

⁷²This is why Childe had to find a different name for the first appearance of farming, and chose the "Neolithic" Revolution.

⁷³Woolly breeds of sheep were probably limited to Iran before the fourth millennium, and spread in Uruk contexts to create what one commentator has described as "the fibre revolution" (McCorriston 1997).

plough and cart (Benecke 1994).⁷⁴ Scandinavia and the circum-Alpine area, and even the Carpathian Basin and the lower Danube, would have experienced the backwash of events taking place elsewhere. This reconstruction has a comprehensiveness and intellectual coherence which is lacking in any other reading of the evidence. If true, it means that the fourth millennium witnessed a transformation in Old World culture which is astonishing alike for its scale and speed, and for the profundity of the transformation which it caused.

N O T E S

⁷⁴Wool has now been identified from the same period in Novosvobodnaya contexts in the Caucasus (Shishlina *et al.* 2003).