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Herausgeber Harald Meller, Helge Wolfgang Arz, Reinhard Jung und Roberto Risch

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Anhang/Appendix

Society and environment in Southern France from the 3rd millennium BC to the beginning of the 2nd millennium BC: 2200 BC a tipping point?

Laurent Carozza, Jean-François Berger, Albane Burens, and Cyril Marcigny

Zusammenfassung

Gesellschaft und Umwelt in Südfrankreich vom 3. Jt. v. Chr. bis zum frühen 2. Jt. v. Chr.: 2200 v. Chr. als Wendepunkt?

Im vorliegenden Beitrag wird das Schwergewicht auf den Einfluss der Umweltveränderungen (»4,2 ka BP Ereignis«) auf prähistorische Gesellschaften vom Neolithikum bis zur frühen Bronzezeit gelegt. Eine kurze Trockenperiode um 2200 v. Chr. im mediterranen Raum fiel möglicherweise mit der Bildung des mediterranen Klimas unter dem Einfluss des orbitalen Antriebs zusammen. Gleichzeitig ereigneten sich tiefgreifende Veränderungen in der innertropischen Konvergenzzone, die sich im Speläothem der Dongge-Höhle, China, festmachen lassen.

Ausgewählte Studien haben gezeigt, dass sich um 2300–2200 v. Chr. in Südfrankreich, zum Beispiel im Rhonetal, ein entscheidender Wechsel im Siedlungsmuster fassen lässt. Nach einer Phase der Siedlungskonzentration entlang der Flüsse nahm die Anzahl der Siedlungen in einer Periode von sehr hohen Sedimenteinträge, Trockenheit und Brandereignissen im Flachland wesentlich ab.

Interessanterweise brach die Kupfererzgewinnung in Cabrières, Dep. Hérault, Frankreich, die um 3200 v. Chr. eingesetzt hatte, um 2300–2200 v. Chr. ab. Gleichzeitig war es aufgrund der Umweltveränderungen nun möglich, alpines Kupfer abzubauen, was sich auch in Saint-Véran, Dep. Hautes-Alpes, Frankreich, nachweisen lässt. Tatsächlich ermöglichte der Gletscherrückgang die Kupfererzgewinnung zwischen 2150 v. Chr. und 1650 v. Chr. sogar in sehr hohen Lagen oberhalb von 2400 m. ü. NN (Les Rousses, Oisan, Isère).

Die Resultate der hier vorgestellten Untersuchungen belegen eine zunehmende menschliche Präsenz in den Bergregionen, insbesondere in den Pyrenäen. Im Baskenland lässt sich die Nutzung moderater Höhenlagen (mäßig bergige Vorgebirgsregionen) anhand von nur zeitweise benutzten Behausungen (Weidewirtschaft) nachweisen. In Westfrankreich können die Daten allerdings auch anders interpretiert werden: Dort scheint die steigende Anzahl von Bauernhöfen und Parzellen für eine Intensivierung der menschlichen Besiedlung zu sprechen.

Diese neue Art der Verwaltung der Landschaft und der Agrar- und Weidewirtschaft lag zweifellos in den Händen einer Elite, die sich um 2200–2100 v. Chr. neu herausbildete. Diese gehobene Schicht beerdigte ihre Toten unter großen Hügeln in der Bretagne oder in Wessex und lässt sich gut in die Gesellschaften des 3. Jts. v. Chr. einfügen. Sie übernahm die Symbolsprache der Glockenbechergemeinschaften, allerdings unter Verwendung von luxuriösen und exotischen Materialien (ohne jedoch die Funktion der Artefakte zu erweitern).

Der Zeitraum von 2300–2100 v. Chr. entspricht einer globalen ökologischen Übergangsphase zu Beginn des späten

Summary

The purpose of this paper is to focus on the impact of environmental changes (so-called 4.2 ka BP extreme event) on ancient societies, from the recent Neolithic to the Early Bronze Age. A short period of drought in the Mediterranean around 2200 BC may correspond with the establishment of the Mediterranean climate under orbital forcing. In the same period, major switches in the Intertropical Convergence Zone are recorded in the speleothem of the Dongge cave, China.

A series of studies have established that in the south of France, for instance in the Rhône valley, an important change occurred in the human settlement system around 2300–2200 BC. In lowland areas, after a maximal concentration, the number of settlements decreased significantly along the river systems during a period of very high hydrosedimentary discharges, dryness, and fire activity.

It is interesting to note that the exploitation of copper ore resources, which had begun in Cabrières, dep. Hérault, France, around 3200 BC ceased around 2300–2200 BC. At the same time, the environmental changes allowed for an exploitation of alpine copper, as seen in Saint-Véran, dep. Hautes-Alpes, France. Indeed, from 2150–1650 BC, the glacial retreat permitted the exploitation of copper ore resources at very high altitudes of above 2400 m a.s.l. (Les Rousses, Oisan, Isère).

The findings presented in this paper have revealed a growth in human pressure in mountain areas, specifically in the Pyrenees. The exploitation of intermediate areas (from foothills to moderately mountainous regions) in the Basque Country took the form of temporary habitations (pastoralism). Others might argue that the data from Western France contradicts this pattern: the increase in the number of farms and land parcels attests to an intensification of the human settlement system.

This new kind of management of the landscape and agropastoral areas was undoubtedly under the control of a new elite that emerged around 2200–2100 BC. They buried their dead under large mounds, such as those found in Armorique or Wessex, and followed practices not out of keeping with the societies of the 3rd millennium BC, integrating into their symbolic language a reinterpretation of the set of artefacts characteristic of the Bell Beaker communities, albeit using more luxurious and exotic materials (without any further functional value).

The period between 2300 BC and 2100 BC corresponds to a global environmental threshold phase in the south-north atmospheric circulation at the beginning of the Late Holocene, caused by an orbital forcing. In the same period, the effects of millennial-scale Rapid Climate Change (RCC) lasting two to three centuries (around the 4.2 ka BP event) are recorded in the lakes, fluvial and soil systems of Western

Holozäns, die geprägt war von einer Verschiebung der atmosphärischen Zirkulation von Süden nach Norden aufgrund des orbitalen Antriebs. Gleichzeitig fand in den folgenden zwei bis drei Jahrhunderten (im Zeitraum des 4,2 ka BP Ereignisses) ein abrupter Klimawandel statt, dessen Auswirkungen sich in den Seen, Flüssen und Böden Westeuropas ablesen lassen. Die sozio-ökonomischen Veränderungen führten womöglich eine Reorganisation auf regionaler Ebene herbei, nicht aber einen globalen Zusammenbruch.

Europe. The socio-economic modifications introduced may have resulted in a spatial reorganisation at a regional level, but not in a global collapse.

Introduction

This paper deals with the impact of environmental changes on ancient societies in the south of France, from the Late Neolithic period to the Early Bronze Age; that is to say, around the so-called 4.2 ka BP extreme event. This period may correspond with the establishment of the Mediterranean climate under orbital forcing at the Mid- to Late Holocene transition[1]. The purpose of this paper is to introduce the chronology of change over time from a socio-environmental angle. We attempt to juxtapose climato-environmental data with ancient social dynamics, as reconstructed from archaeological excavations, which have established that in the south of France (e.g. the Rhône valley) an important change occurred in the human settlement system around 2300–2200 BC (Berger et al. 2000; Berger et al. 2007). Our contribution focuses on three main issues: 1. a presentation of the latest findings on climato-environmental change in the course of the 3rd millennium BC and the 2nd millennium BC; 2. an overview of the correlation between environmental and social dynamics in selected, well-documented regions of Southern France; 3. a discussion of the role of cli-

Fig. 1 Location of the key areas selected for their wide range of reliable data showing tipping points.

Abb. 1 *Die wichtigsten Gebiete mit umfangreichen und verlässlichen Datenserien, in denen sich Wendepunkte abzeichnen.*

1 Jalut et al. 1997; Jalut et al. 2000; Magny et al. 2009; Magny et al. 2013; Wanner et al. 2008.

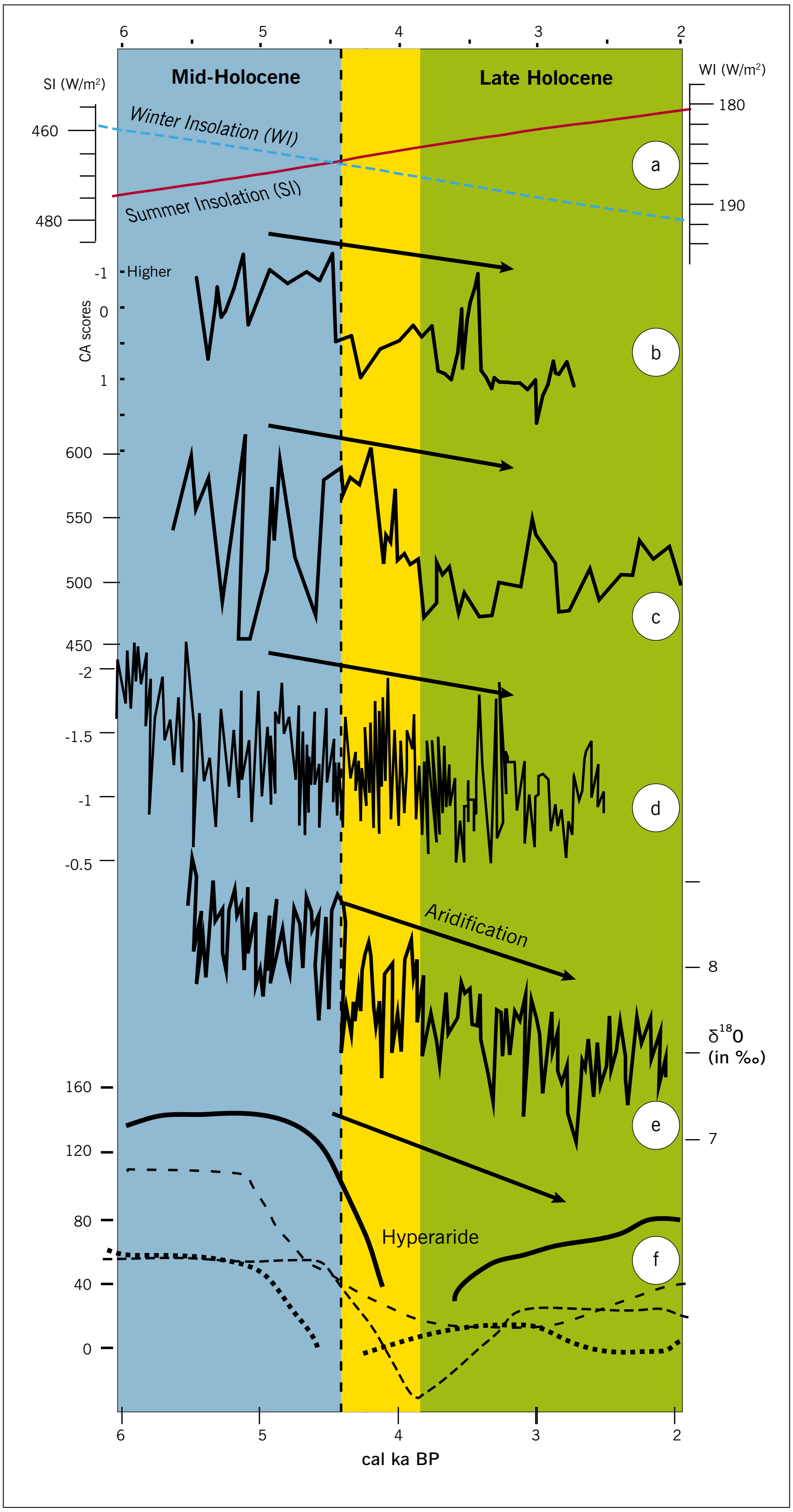


Fig. 2a–f A general evolution under orbital forcing at the Mid- to Late Holocene transition: a Insolation 40°N; b lake-level fluctuations at Preola, Sicily; c Soreq cave speleothem, Israel, in mm/yr; d Qunf cave speleothem-Q5, $\delta^{18}O$ (in ‰ VPDB); e Dongge cave speleothem, China, monsoon activity; f lake levels (in m) fluctuations in African tropics.

***Abb. 2a–f** Die allgemeine Entwicklung unter orbitalem Einfluss am Übergang vom mittleren zum späten Holozän: a Sonneneinstrahlung 40°N; b Seespiegelschwankungen in Preola, Sizilien; c Speläothem in der Soreq-Höhle, Israel, in mm/Jahr; d Q5 Speläothem in der Qunf-Höhle, $\delta^{18}O$ (in ‰ VPDB); e Speläothem in der Dongge-Höhle, China, Monsunaktivität; f Seespiegelschwankungen (in m) in den afrikanischen Tropen.*

mate in the exploitation of copper resources, which had begun in France around 3200 BC. Finally, we propose to determine the respective roles of the climate and of social dynamics in the changes that occur at the transitional period between the 4th millennium BC and the 3rd millennium BC.

Methodology

Some researchers (archaeologists as well as environmentalists and climatologists; e.g. Magny et al. 2012; Magny et al. 2013; Pétrequin 2005; Jallot 2011) consider that the 4.2 ka BP event forms an actual socio-environmental tipping point. Others adopt a less extreme and more moderate viewpoint

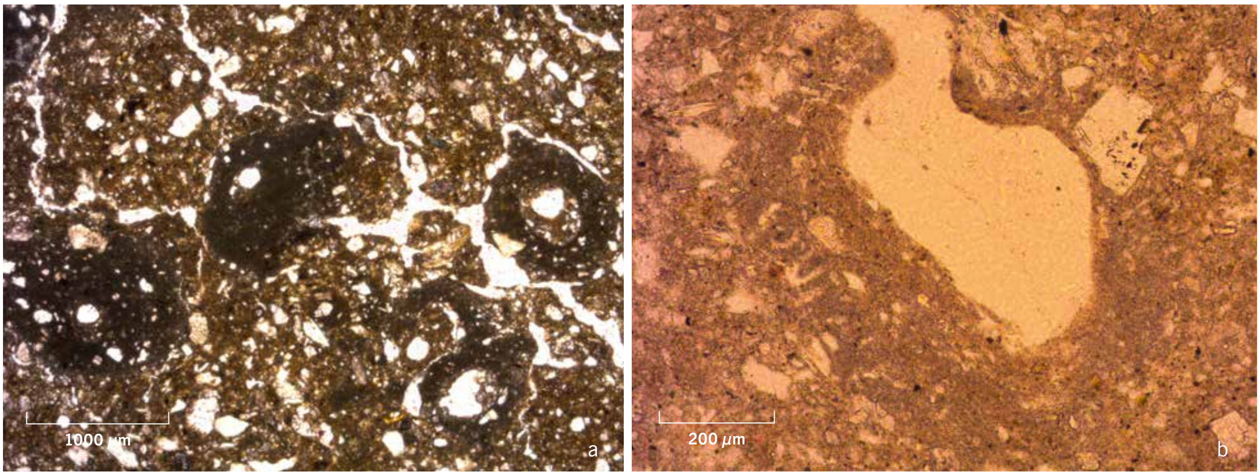


Fig. 3a–b The soil dynamic of the mid-Rhône valley's floodplains around 4.2 ka BP. a Cumulic fluviosoil of the Tricastin plain with high micro-agregation development, well cemented calcium carbonate ($CaCO_3$) nodules in a dark humic soil matrix, rich in micro-charcoals (around 2500–2300 BC; Mondragon-Les Juilleras, structure S1-F3; natural light). b Secondary $CaCO_3$ accumulations in the soil matrix (hypocoatings) with juxtaposition of few oriented coarse to fine silty flood coatings in a soil micro-porosity (La Motte-du-Rhône-La Prades/Log4-12; natural light).

Abb. 3a–b *Bodendynamik in den Flussauen des mittleren Rhonetals um 4,2 ka BP. a Ein kumulischer Fluviosol im Tricastin mit hohen Mikroaggregatsveränderungen und verfestigten Kalziumkarbonat-Knöllchen ($CaCO_3$) in einer dunkel-humosen, mit zahlreichen Mikroholzkohlen durchsetzten Erdmatrix (um 2500–2300 v. Chr.; Mondragon-Les Juilleras, Stuktur S1-F3; natürliches Licht). b Sekundäre Anreicherungen von $CaCO_3$ in der Erdmatrix (Kalk-Überzüge) und im Gegensatz dazu wenige orientierte, grobe bis feine schluffige Überschwemmungsbeläge in mikroporöser Erde (La Motte-du-Rhône-La Prades/Log4-12; natürliches Licht).*

in which the part played by climate is moderated and considered together with several other factors (e. g. Lemercier 2012). The reconstructions presented here take up a non-dogmatic position in terms of climatic and socio-cultural determinism. M. Magny's recent work has shown that there was a short period of drought in the Mediterranean around 2200 BC (Magny et al. 2009; Magny et al. 2012). This period may correspond with the establishment of the Mediterranean climate under orbital forcing.

The broader objective of this paper is to consider the progression of change from a socio-environmental angle. Here, we present a study conducted on a large scale, covering the whole of the south of France, and focusing on key areas in which a large range of available and reliable data shows tipping points: Languedoc, the Rhône valley, the south-western Pyrenees, and the French Alps (Fig. 1). These study areas, in which archaeological data has been recently augmented by rescue archaeology, encompass different types of environments (such as coasts, alluvial valleys, intermediate areas, mountains, etc.) and a high east/west gradient.

Climate changes during the 3rd millennium BC and 2th millennium BC: a short summary of the most recent research

The Mid- to Late Holocene transition

The Mid- to Late Holocene transition was mainly driven by orbital forcing, which explains seasonal and inter-hemispherical changes by a gradual decrease in summer insolation at northern latitudes (Berger/Loutre 1991). At the same time, millennial-scale rapid climatic change (RCC) events overlapped with solar/oceanic forcings (Mayewsky et al. 2004). These partly explain the cyclic variations of climate parameters that we are able to reconstruct with multi-proxy analyses.

A complex polyphased climatic oscillation occurred around 2300–1850 BC, which has been discussed since at least the beginning of the 1990s and to which a specific congress was devoted, published in the NATO ASI Series (Dalfes et al. 1997), mainly concentrating on the tropical and Mediterranean zones, and discussing different causes[2]. The climate event also affected the western Mediterranean area (Fedoroff/Courty 1995; Berger 1996; Cheddadi et al. 1998). This event seems to be characterised by two additional factors: a long-term orbital forcing leading to a summer insolation rise and a cool Neoglacial period in mid latitudes (recorded in lakes and river systems; Rimbu et al. 2003; Wanner et al. 2008; Magny et al. 2009). This long evolutionary trend contributes to an affirmation of a Mediterranean climate below latitudes 43/44° N on the one hand (discussed by Jalut et al. 1997; Jalut et al. 2000) and a dryness in the Middle East and tropical areas such as Africa, Arabia, and Asia on the other hand[3]. This period shows an abrupt decrease in levels of African tropical lakes that lasts until 1800/1700 BC (Gasse 2000; cf. the end of the green Sahara), and in the level of the Dead Sea, located in the southern part of the Middle East (Migowsky et al. 2006). This situation creates an opposite signal on the opposite shores of the western Mediterranean: dry from the centre to the south as well as humid and

2 Weiss et al. 1993; Lemcke/Sturm 1997; Bar-Matthews et al. 1998; Frumkin et al. 1991; Gasse/Campo 1994.

3 Bar-Matthews et al. 1998; Staubwasser et al. 2003; Cullen et al. 2000; Migowsky et al. 2006; Fleitmann et al. 2007; Magny et al. 2009; Magny et al. 2012.

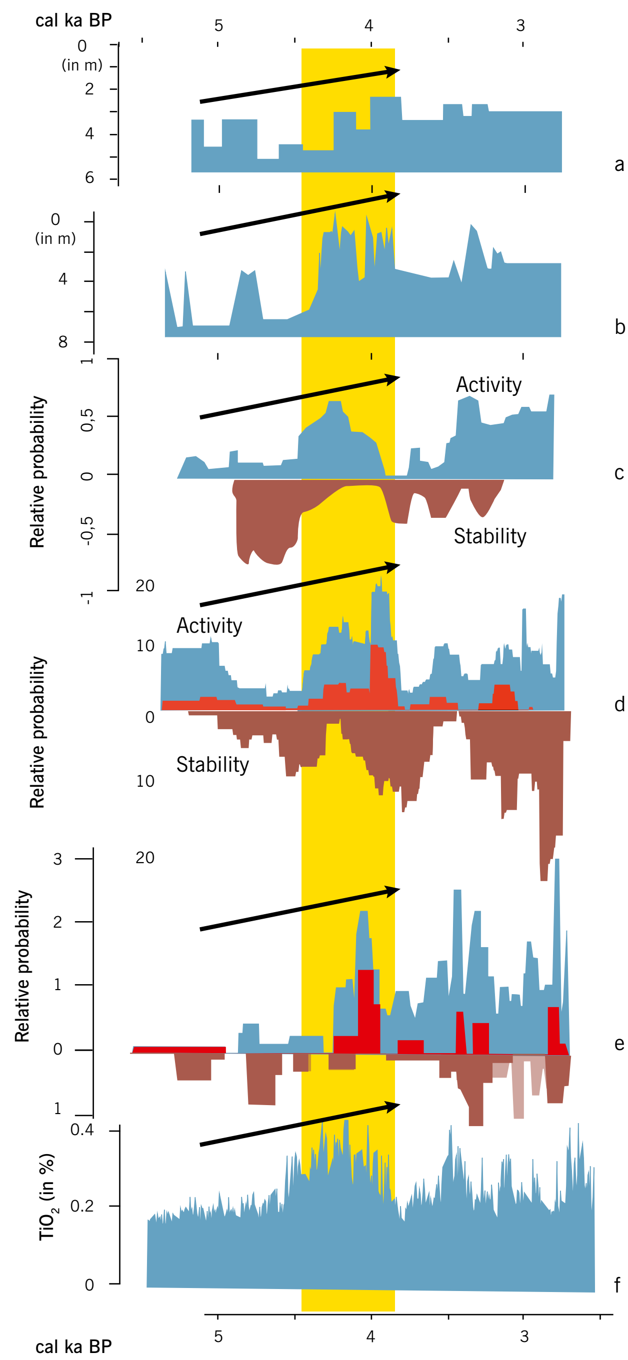


Fig. 4a–f Main Western European palaeohydrological (versus pedological) curves illustrating a threshold and a weak expression of the 4.2 ka BP event. a Lake-level fluctuations at Cerin, Jura Mountains, France; b lake-level fluctuations at Accesa, Central Italy; c rivers/slopes activity/stability, Germany; d rivers/slopes activity/stability, mid-Rhône valley; e rivers/slopes activity/stability, upper Rhône valley; f detrital Rhône sedimentation in Lake Bourget (potassium/titanium ratio; core LDB 04-1).

***Abb. 4a–f** Westeuropäische paläohydrologische (im Gegensatz zu pedologischen) Kurven mit einem Übergangsbereich und schwachen Hinweisen auf das 4,2 ka BP Ereignis. a Seespiegelschwankungen in Cerin, Juragebirge, Frankreich; b Seespiegelschwankungen in Accesa, Mittelitalien; c Flussaktivität/-stabilität und Hangaktivität/-stabilität, Deutschland; d Flussaktivität/-stabilität und Hangaktivität/-stabilität, mittleres Rhonetal; e Flussaktivität/-stabilität und Hangaktivität/-stabilität, oberes Rhonetal; f detritische Sedimente der Rhone im Bourget See (Kalium/Titan-Verhältnis; Sedimentkern LDB 04-1).*

with a contrasting hydrological regime to the north (cf. Fig. 2). Furthermore, records from tropical areas show a very high climatic variability around 2200 BC. This variability is well illustrated in the Dongge cave speleothem archive, China, with rapid and abrupt contrasting changes in the monsoon's hydrological cycle over four or five centuries (Dykoski et al. 2005) that could amplify the impact on the terrestrial ecosystems. Consequently, the southern part of France could have become a transition area, influenced by both climate zones and a high hydrological variability (Berger 2015). The numerous geoarchaeological data available for the mid-Rhône valley allow us to describe in detail the response of the river system to the change in climate. The trend towards aridity predominates from eastern Languedoc (Blanchemanche et al. 2003) to the mid-Rhône valley. Rapid infillings and a high frequency of flooding and torrential activity, apparently related to a Mediterranean-type »flash flood« function, alternating with pedogenetic activity, are indicated by: 1. a predominant trend towards incision in river systems, resulting in lower aquifers and vegetational stress (Fig. 3a; Berger 2015); 2. an increase in soil development (between flood deposits) corresponding to a succession of dark-brown, dusty, cumulic fluvisoils (Berger 2015); 3. an affluence of secondary carbonate accumulations in the

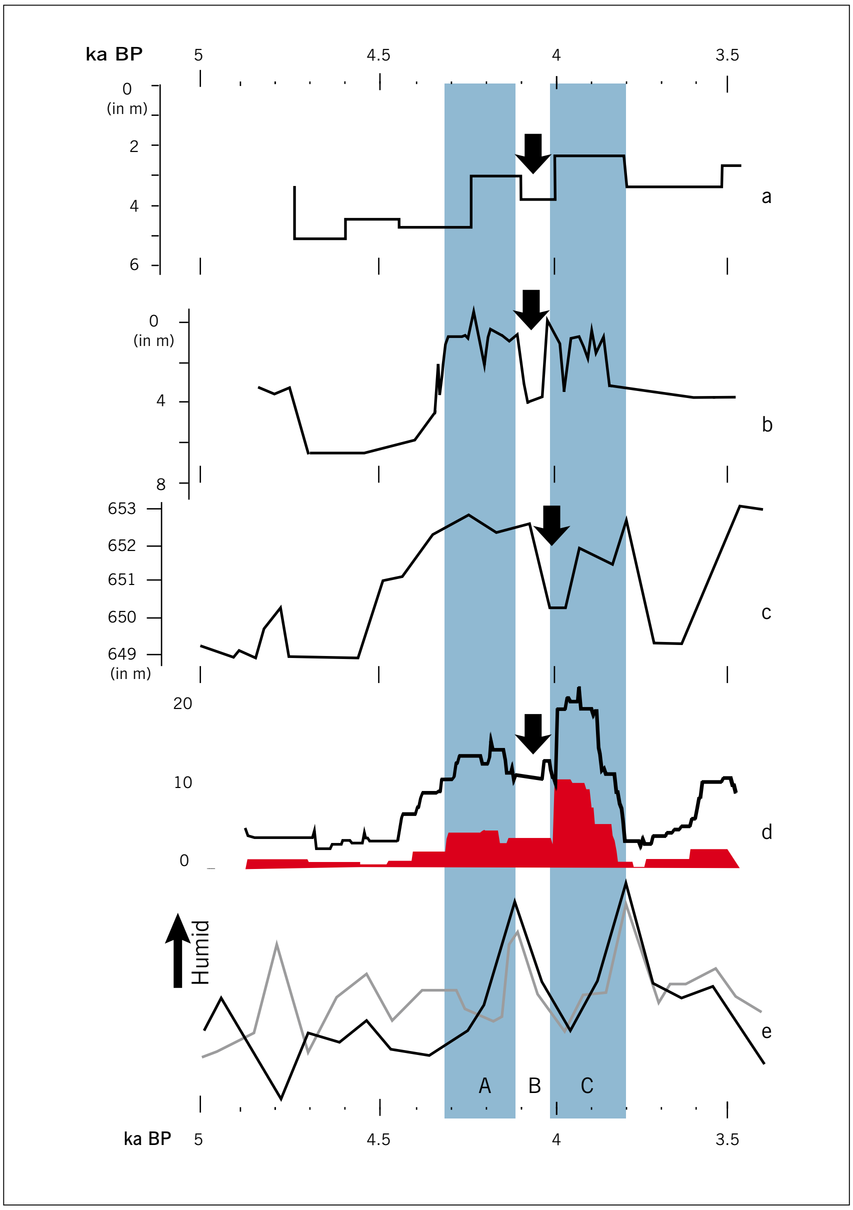


Fig. 5a–e Temporal tripartition of the 4.2 ka cal BP event. a Lake-level fluctuations at Cerin, Jura Mountains, France (45° N); b lake-level fluctuations at Accesa, Tuscany (42° N); c lake-level fluctuations at Ledro, Northern Italy (45,87° N); d cumulative probability density function (CPDF), ^{14}C series of activity of pre-alpine tributaries of the Rhône River (Drôme, dep. Vaucluse [44,5–44° N]); e Walton Moss, Northern England, plant macrofossil DHI (Dupont hydroclimatic index) BSW (bog surface wetness) reconstruction (grey), testate amoebae-inferred WTD (water table depth) reconstruction (black).

Abb. 5a–e *Zeitliche Dreiteilung des 4,2 ka cal BP Ereignisses. a Seespiegelschwankungen in Cerin, Juragebirge, Frankreich (45° N); b Seespiegelschwankungen in Accesa, Toscana (42° N); c Seespiegelschwankungen in Ledro, Norditalien (45,87° N); d kumulative Verteilungsfunktion (CPDF), ^{14}C-Datenserie aus voralpinen Zuflüssen der Rhone (Drôme, Dep. Vaucluse [44,5–44° N]); e Walton Moss, Nordengland, Rekonstruktion der Oberflächenfeuche des Moores (BSW – bog surface wetness) mit Hilfe des hydroklimatischen Index nach Dupont (DHI – Dupont hydroclimatic index) anhand von pflanzlichen Makrofossilien (grau) und der Grundwassertiefe (WTD – water table depth; schwarz) anhand des Auftretens beschalter Amöben (Testaceen).*

porosity of fluvisoils, and in the soil matrix (hypocoatings; Fig. 3b); the presence of numerous riparian forest charcoals (mainly Fraxinus) reflecting the frequency of fires (Delhon 2005; Berger et al. 2007; Delhon/Thiebault 2008); 4. isotope values showing an enrichment in $\delta^{18}O$ values in soil carbonates, reflecting rainfall predominantly of Mediterranean origin, potentially indicating a concentration of »Cévennes episodes« of torrential rain (Bonté 2006). Depending on the resolution of the different archives, a shift of between one and two centuries (between 2400 BC and 2200 BC) is observed in the date of the tipping point. Is this a function of regional shifts of climate, or is it associated with a bias in the age depth models of the different archives[4]? Whatever the case may be, the break appears very early (around 2400 BC) in Lake Preola in Sicily, in the Dongge cave, and in tropical African lakes[5].

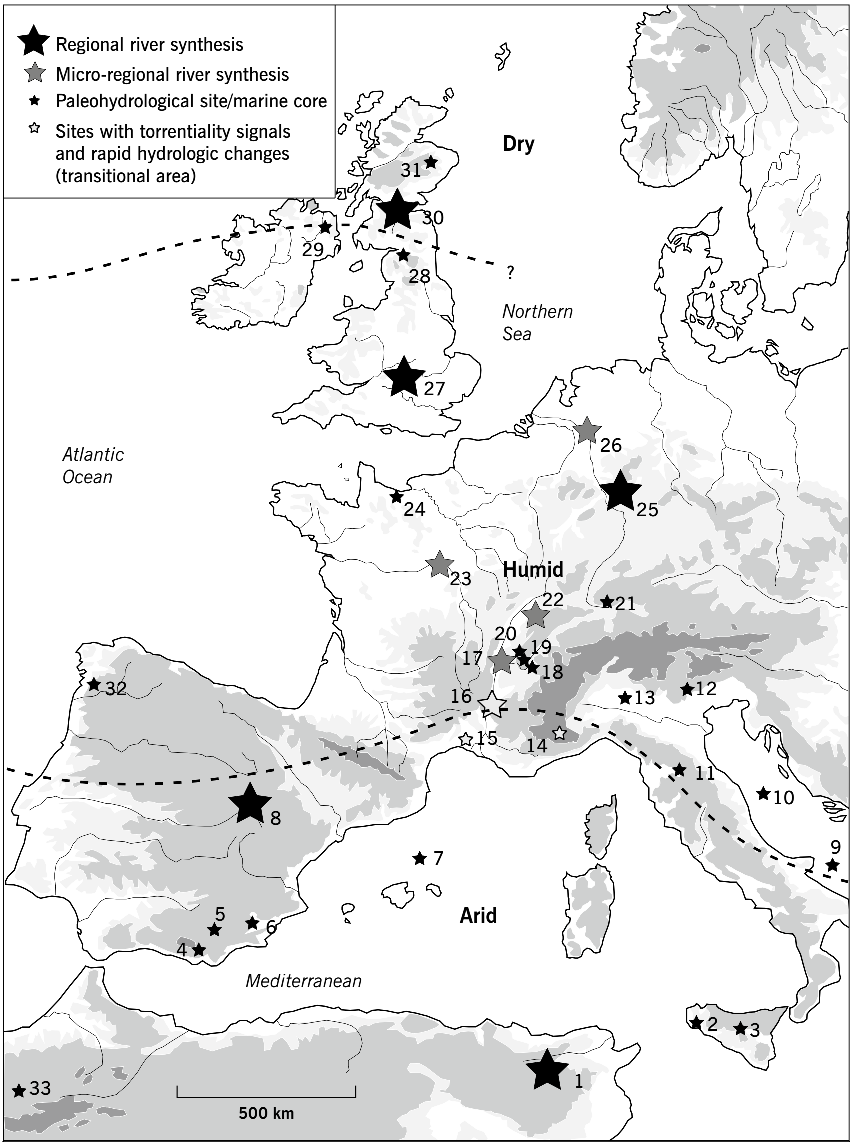
The European palaeo-hydrological systems also record an early signal, around 2450/2400 BC. At the scale of the central-western European area, a multi-centennial period of hydrological activity is identified from 2450–1900/1800 BC (Fig. 4). These hydrological changes affect Northern Italy and the lakes of the western Alps (Magny et al. 2009; Magny et al. 2012), the fluvial and colluvial domains of the whole of Germany (Hoffman et al. 2008), the western pre-alpine tributaries of the River Rhône (Berger 2015), the upper Rhône (Berger et al. 2008), Lake Bourget, due to a rise of detrital inputs from the Rhône (Arnaud et al. 2012), and Lake Constance, due to a rise of detrital inputs from the Rhine River (Wessels 1998).

4 See e. g. »reservoir effects« for marine cores (foraminifers) or African lakes (gasteropods), as well as »old wood effects« on micro-charcoal samples from European lakes and rivers systems.

5 Wanner et al. 2008; Magny et al. 2009; Jalut et al. 2009; Cullen et al. 2000; Staubwasser et al. 2003; Fleitmann et al. 2007; Dykoski et al. 2005; Gasse 2000; Bar-Matthews et al. 1998; Migowsky et al. 2006.

Fig. 6 Geographic tripartition (dashed line) at the scale of the western Mediterranean and Europe around 4.2 ka BP.

Abb. 6 *Geografische Dreiteilung (gestrichelte Linie) im westlichen Mittelmeerraum und in Europa um 4,2 ka BP.*



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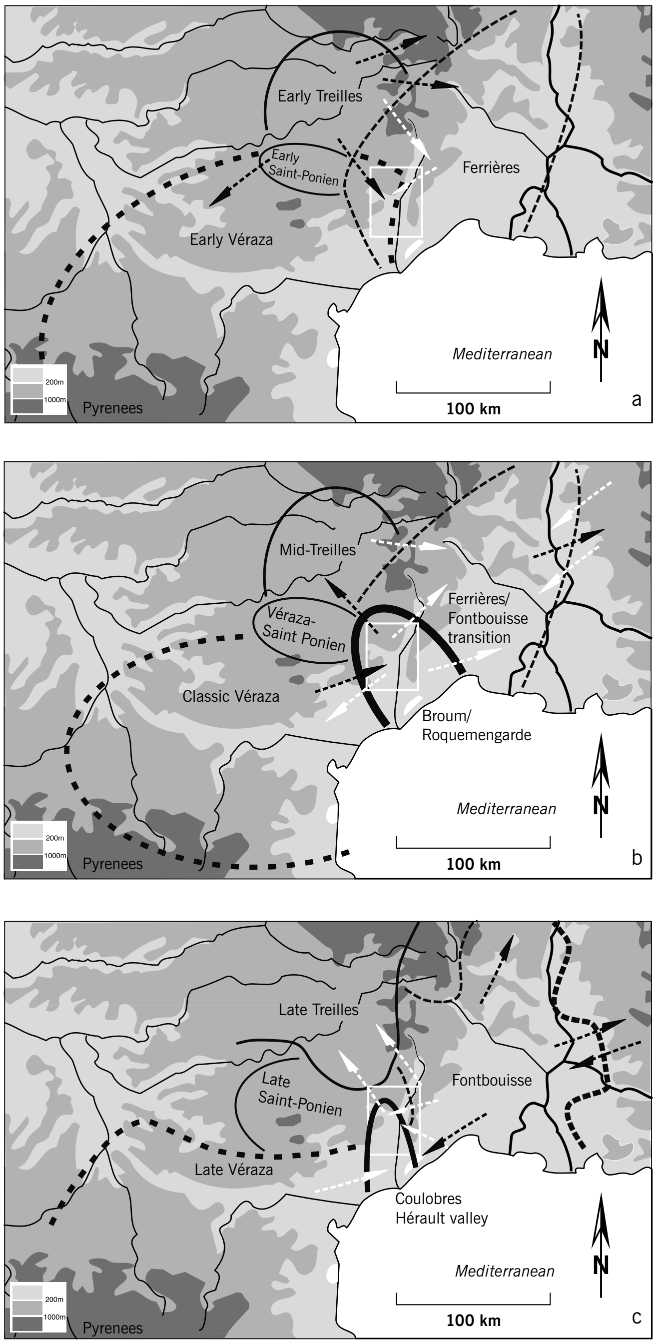
32 Growth of mires and detrital activity in north-western Spain
33 Low lake level of the lake Tigalmamine indicated by core C86.



Late Neolithic I (3400–2900 BC): At the end of the 4th millennium BC, the Hérault valley is open to influences from the Ferrières, Véraza, and Treilles cultural groups. The cultural loans are limited to striped decor. This period corresponds to the first phase of the Puech Haut occupation. The pottery from the settlement is decorated with single or multiple cords (specifically, wavy and striped cords). The range of pottery shapes evolves with the increase of low careen vessels and the emergence of firsts clay repulsed ornamentation.

Late Neolithic II (2900–2600 BC): A cultural group, very specific to the Hérault valley, appears around 2900 BC. The cultural situation in the Hérault valley stands out from the neighbouring culturals groups by virtue of a dynamic which, unlike the first phase, now displays its own identity. The diffusion of several traits towards eastern Languedoc highlights favoured links. The Hérault valley influence on the Ferrière/Fontbouisse sequence is undoubted. Such a cultural relocation usually takes place within the framework of a larger economic process.

Late Neolithic III (2600–2400 BC): Around the second half of the 3rd millenium BC, eastern Languedoc is characterised by the advancement of the Fontbouisse Culture. The Hérault left bank and parts of the coastline are henceforth reconnected to the eastern Hérault influences. There is an evolution in the ceramic style with the increase of low careen vessels, cords, and imprints. This phenomenon indicates an affirmation of the identity of this area. It is related to a regional development that sees several local groups (such as the Fontbouisse Culture) emerging.

Fig. 7a–c Geographical extension of the main Late Neolithic cultural groups in Languedoc and the Grands Causses area between the end of the 4th millennium BC and the second half of the 3rd millennium BC.

Abb. 7a–c *Geografische Verbreitung der wichtigsten spätneolithischen Gruppen im Languedoc und im Grands Causses-Gebiet vom Ende des 4. Jts. v. Chr. bis zur zweiten Hälfte des 3. Jts. v. Chr.*

The internal structure of the »4.2 ka BP event«

According to the available data for the north-west Mediterranean, it is possible to recognise a tripartite climate oscillation between 2300 BC and 1850 BC in the lake systems from Northern Italy to the north-western Alps and in the mid-Rhône River basin. This internal cyclicity of the 4.2 ka BP event was first identified and discussed by Magny et al. using a study of lake systems (Magny et al. 2009). There already has been observed a tri-partite climatic dynamic at the scale of the mid-Rhône valley, but without developing it in detail (Berger et al. 2007). The new semi-quantitative data recently obtained in the same region (using cumulative probability density function analysis of soils, alluvia, and fire events) may suggest that the main tributaries of the mid-Rhône valley effectively record a similar tripartite tendency during the same period (Berger 2015).

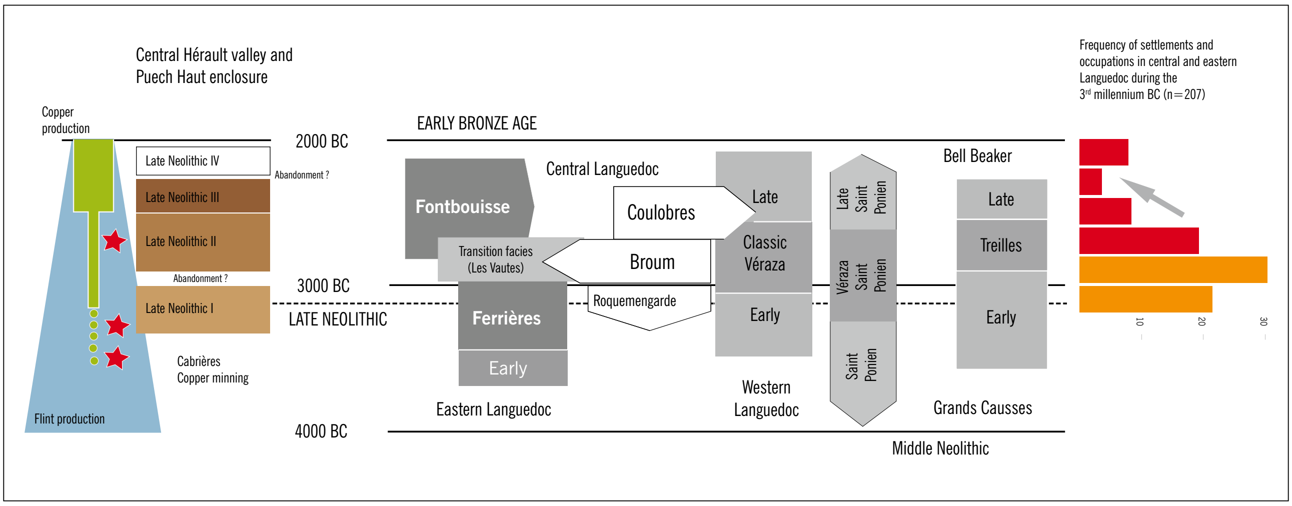


Fig. 8 Chronological diagram, dynamics of the human settlement systems, and the metallurgical production of the main cultural groups during the Late Neolithic period, in Languedoc and the Grands Causses area, between the end of the 4th millennium BC and the second part of the 3rd millennium BC. Red stars – time of main mining activity.

***Abb. 8** Chronologische Abfolge, Besiedlungsdynamik und Metallverarbeitung der wichtigsten spätneolithischen Kulturgruppen im Languedoc und im Grands Causses-Gebiet vom Ende des 4. Jts. v. Chr. bis zur zweiten Hälfte des 3. Jts. v. Chr. Rote Sterne – Zeitpunkt verstärkter Bergbauaktivität.*

When Northern Italian and Alpine lakes record high levels (phase A and phase C in Fig. 5) the Rhodanian rivers show a high hydrosedimentary activity associated with rapid channel infillings, high flood frequency and torrential activity, mainly in the alluvial fans and slope systems. When the lakes record low levels (phase B in Fig. 5), the Rhodanian rivers record entrenchments and pedogenic activity with high evapo-transpiration processes in the floodplains, generating secondary calcium carbonate accumulations and a fire activity peak (Berger 2015).

Can this whole tripartite multi-centennial period be considered as the so-called 4.2 ka BP event or only the dry median episode of 100/150 years, which was initially observed in tropical areas[6]? When comparing synchronous palaeoclimatic and environmental archives at the Western European and Mediterranean scale, we observed a zonal, latitudinal functioning during this period, characterised by a trend to aridity in the south-eastern part of the Iberian Peninsula (decreasing fluvial activity in Mediterranean watersheds, increasing fire activity in Andalusia), in Southern Italy (lower lake levels in Sicily) and in North Africa (decreasing wadi activity in Tunisia and lower levels in Lake Tigalmamine, Morocco, mid-Atlas mountains)[7]. A moister and colder climate, indicated by continental and marine data sets is recorded in northern regions above 43/44° N, from the Po river plain to the Adriatic Sea to the southern part of England in unglaciated river basins, in all sectors of the Rhine catchment area, in the mid-Loire basin, and finally, at higher altitudes, in the Jurassian and northern Alpine lakes (Fig. 6). Northern England shows a more controversial climate signal, with few climate contrasts during the 4.2 ka BP event, and the Scottish lake and peat bog records may indicate a milder and drier climate (Fig. 6). This zonal climatic functioning, formerly identified for the same macro-regional area during the 8.2 ka BP event and the Mid-Holocene period (Magny et al. 2003a; Berger/Guilaine 2009; Vannière et al. 2013), must have impacted differentially on the soil systems, water resources and crop yields at the Western European scale, requiring different social and economic responses of ancient societies at the Late Neolithic/Early Bronze Age transition.

Human settlement system and environment dynamics in Southern France

Here, we present an overview of the correlation between environmental and social dynamics in several well-documented regions of Southern France, selected for the availability and the reliability of their data: Languedoc, the Rhône valley, the south-western Pyrenees, and the French Alps.

Mediterranean coast, Gulf of Lion, and Languedoc landscape dynamics from 2800–2000 BC

Languedoc and the Gulf of Lion coastline form a hot spot of human settlement at the end of the 3rd millennium BC. An increase in rescue excavations has allowed a large range of data to be processed relating to habitation sites and land-use from 2800–2000 BC (Carozza et al. 2005). Through this study we are able to suggest a chronological cross-section, integrating, on one hand, cultural data (chrono-typology) and, on the other, economical information related to land-use from the coastal areas to foothill and mountain zones (Fig. 7).

6 Magny et al. 2009; Weiss et al. 1993; Staubwasser et al. 2003; Cullen et al. 2000.

7 For references concerning the content of this paragraph see figure 6.

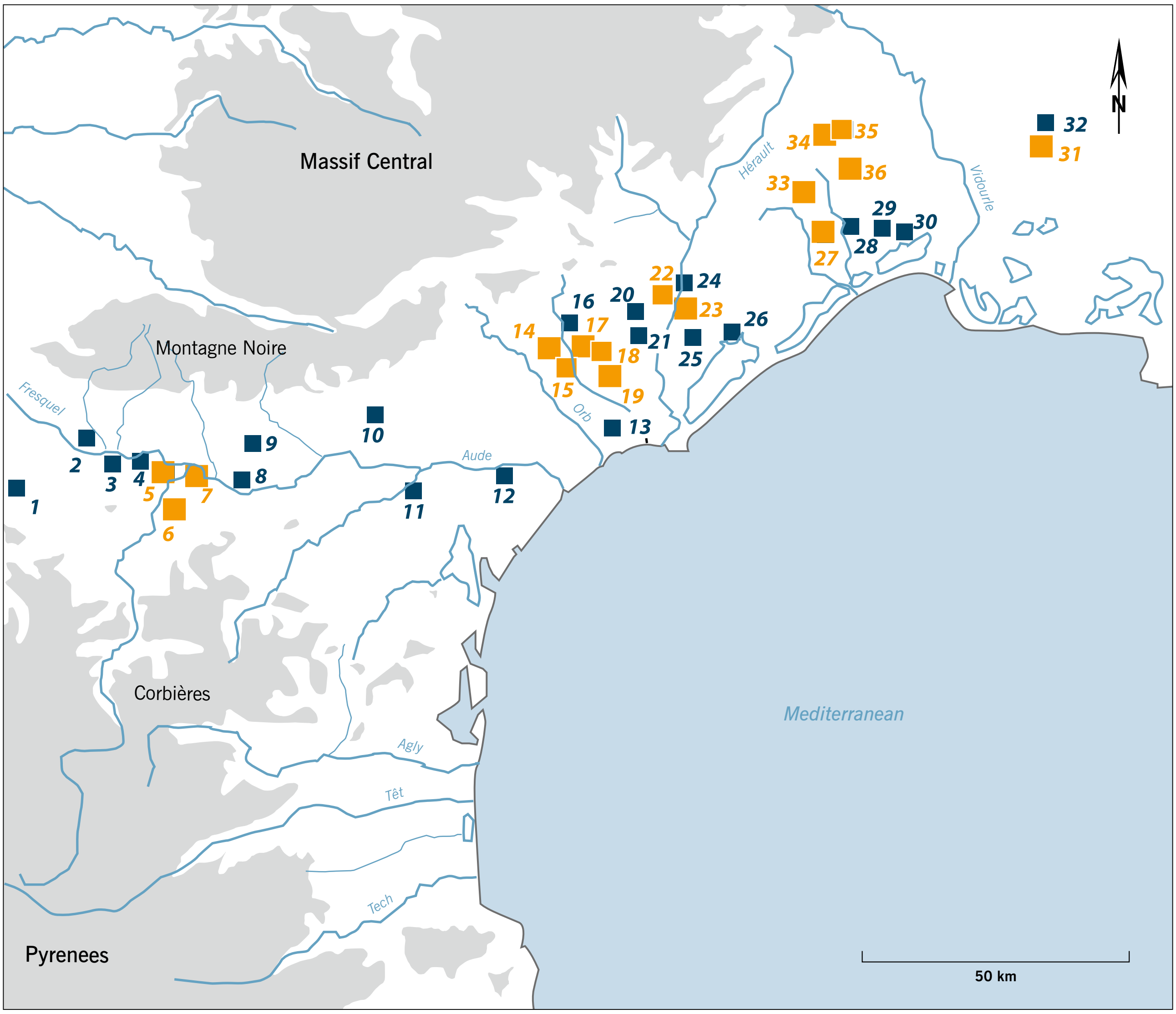


Fig. 9 Map of the main Late Neolithic fortified settlements and enclosures in western and eastern Languedoc (orange – sites cited in the text; blue – sites not cited in the text). 1 L'Agréable à Villassavary, dep. Aude; 2 Rocreuse à Saint-Martin-le Vieil, dep. Aude; 3 Poste-Vieille à Pezens, dep. Aude; 4 Saint-Antoine à Caux-Sauzens, dep. Aude; 5 Rivoire à Pennautier, dep. Aude; 6 Carsac-Mayrevieille, dep. Aude; 7 Roc d'En Gabit, dep. Aude; 8 Le Mourral à Trèbes, dep. Aude; 9 La Serre à Laure-Minervois, dep. Aude; 10 La Careirasse à Mailhac, dep. Aude; 11 Médor à Ornaisons, dep. Aude; 12 La Moulinasse à Salles-D'aude, dep. Aude; 13 Les Mourguettes à Portiragnes, dep. Hérault; 14 Le Grand Bosc à Lieuran, dep. Hérault; 15 Le Peiras de l'Hermitage à Servian, dep. Hérault; 16 La Grande Pèpre à Servian, dep. Hérault; 17 Le Croix-de-Fer à Espondeilhan, dep. Hérault; 18 La Croix-Vieille à Espondeilhan, dep. Hérault; 19 Campagne à Abeilhan, dep. Hérault; 20 Fontachère à Caux, dep. Hérault; 21 L'Estagnol à Tourbes, dep. Hérault; 22 Puech Haut à Paulhan, dep. Hérault; 23 Roquemengarde à Saint-Pons-de-Mauchiens, dep. Hérault; 24 Les Hermes à Bélarga, dep. Hérault; 25 Montagnac, dep. Hérault; 26 Pech Badieu, dep. Hérault; 27 Richemont à Montpellier, dep. Hérault; 28 Richter stade à Montpellier, dep. Hérault; 29 La Capoulière à Montpellier, dep. Hérault; 30 Font de Mauguio à Mauguio, dep. Hérault; 31 Moulin-Villard à Caissargues, dep. Gard; 32 Vignolles à Nîmes, dep. Gard; 33 Boussargues à Argelliers, dep. Hérault; 34 La Tailladette à Rouet, dep. Hérault; 35 Campmau à Rouet, dep. Hérault; 36 Le Lébous à Saint-Mathieu-de-Tréviers, dep. Hérault.

***Abb. 9** Verbreitungskarte der wichtigsten spätneolithischen befestigten Siedlungen und sonstigen Befestigungsanlagen im westlichen und östlichen Languedoc. 1 L'Agréable à Villassavary, Dep. Aude; 2 Rocreuse à Saint-Martin-le Vieil, Dep. Aude; 3 Poste-Vieille à Pezens, Dep. Aude; 4 Saint-Antoine à Caux-Sauzens, Dep. Aude; 5 Rivoire à Pennautier, Dep. Aude; 6 Carsac-Mayrevieille, Dep. Aude; 7 Roc d'En Gabit, Dep. Aude; 8 Le Mourral à Trèbes, Dep. Aude; 9 La Serre à Laure-Minervois, Dep. Aude; 10 La Careirasse à Mailhac, Dep. Aude; 11 Médor à Ornaisons, Dep. Aude; 12 La Moulinasse à Salles-D'aude, Dep. Aude; 13 Les Mourguettes à Portiragnes, Dep. Hérault; 14 Le Grand Bosc à Lieuran, Dep. Hérault; 15 Le Peiras de l'Hermitage à Servian, Dep. Hérault; 16 La Grande Pèpre à Servian, Dep. Hérault; 17 Le Croix-de-Fer à Espondeilhan, Dep. Hérault; 18 La Croix-Vieille à Espondeilhan, Dep. Hérault; 19 Campagne à Abeilhan, Dep. Hérault; 20 Fontachère à Caux, Dep. Hérault; 21 L'Estagnol à Tourbes, Dep. Hérault; 22 Puech Haut à Paulhan, Dep. Hérault; 23 Roquemengarde à Saint-Pons-de-Mauchiens, Dep. Hérault; 24 Les Hermes à Bélarga, Dep. Hérault; 25 Montagnac, Dep. Hérault; 26 Pech Badieu, Dep. Hérault; 27 Richemont à Montpellier, Dep. Hérault; 28 Richter stade à Montpellier, Dep. Hérault; 29 La Capoulière à Montpellier, Dep. Hérault; 30 Font de Mauguio à Mauguio, Dep. Hérault; 31 Moulin-Villard à Caissargues, Dep. Gard; 32 Vignolles à Nîmes, Dep. Gard; 33 Boussargues à Argelliers, Dep. Hérault; 34 La Tailladette à Rouet, Dep. Hérault; 35 Campmau à Rouet, Dep. Hérault; 36 Le Lébous à Saint-Mathieu-de-Tréviers, Dep. Hérault.*

Languedoc

The chrono-cultural sequence derived from this data is characterised by four main steps. The first and the second steps correspond to the Late Neolithic, the third to the emergence of the Fontbouisse Culture and the appearance of Bell Beaker artefacts (around 2500–2400 BC), and the fourth to the development of the Epi-Campaniforme »barbed wire ware« facies (Vital et al. 2012; Lemercier 2012). Multiple lines of evidence indicate that the beginning of the Early Bronze Age dates to around 2200 BC. In Languedoc, a denser human settlement system has already been shown and suggests a probable population growth (Carozza et al. 2005). The frequency curve of the number of human occupations sheds light on an important increase around 2600 BC, followed by a very sharp decrease around 2400/2300 BC (Fig. 8). This collapse affects every type of region: coastline, hinterland, garrigue karst plateau. Cumulative radiocarbon dates for the Fontbouisse Culture allow an analysis of the cumulative probability density function (CPDF) to be generated, showing an optimum of occupation around 2500 BC (Jallot 2003; Guilaine/Escallon 2003). Archaeological and cultural data clearly show a decrease of the number of settlements. The process of change seems to take place around 2400/2300 BC. But do we necessarily need to talk about a demographic crisis? During the Late Neolithic III and IV, archaeological records shed light on an important variability in the shape of habitations and also a wide selection of environmental conditions. The most significant evidence is the increase in large enclosed settlements in plains and coastal areas (Fig. 9–10). This phenomenon emerges during the Late Neolithic II (2800 BC) and ends around 2400–2300 BC. Some rescue excavations suggest that, in the plains, sites are characterised by different types of enclosures. Usually, a primary enclosure is augmented by extensions, while some areas are fenced. These sites appear in alluvial valleys, sometimes near channels, between 2800 BC and 2200 BC.

Abandonment in the plains around 2200 BC

A sharp decrease in the number of sites and the density of human occupation occurs from 2200 BC onwards in the plains, for example along the coastlines. From then onwards, settlements are characterised by pits and isolated structures that deliver very poor archaeological material, with barbed wire ware ceramics. One of the main drawbacks is the lack of habitation floor-plans but a few settlements have delivered isolated burials (isolated graves, pit graves, and stone cists). The number of Early Bronze Age settlements is very low in spite of large scale rescue excavations and surveys. None occur from 1800–1600 BC.

The garrigue area: complementary settlements

In scrublands and karstic areas, the chronology of Late Neolithic settlement abandonment is also a key issue. Here, archaeological investigations have shed light on more than eighty open or fortified sites and enclosures occupied from the second part of the 3rd millennium BC. These complementary sites are characterised by an economic system that exploits diversified ecosystems. A decrease in the number of settlements is seen around 2350–2250 BC (Fig. 8), followed by Early Bronze Age barbed wire ware re-occupations on the top of the collapse levels of stone architecture, for example at Rocher du Causse, dep. Hérault. In scrublands, a probable gap is observed around 2300–2200 BC. The archaeological rescue excavation conducted in the village of Langlade-Vignaud 3, dep. Gard, has provided new data concerning the Late Neolithic to Early Bronze Age transition (Hayden et al. 2011). This dry-stone habitat witnessed five architectural development steps. Steps 1–3 belong to the Fontbouisse Culture; the archaeological occupation levels yielded material which is typical of this culture. The first contacts with Bell Beakers are also attested during this occupation. The partial abandonment of the settlement observed during phase 4 is characterised by the forming of dumps inside the collapsed houses. Finally, an ultimate re-occupation takes place inside the houses. The associated material is related to the Bell Beaker period, in a »Rhodano-Provençal« style. Radiocarbon dates as well as typology data show that the occupation ended and the abandonment of the settlement may have taken place around 2300–2200 BC.

On a regional scale, all the available evidence suggests that, from the Late Neolithic to the Early Bronze Age, the Languedoc and Gulf of Lion regions are characterised by a social-ecological transition and a close relationship between economic development and environmental changes. At this stage of our study, we are able to develop a regional model.

Firstly, the period between 2600–2500 BC seems to be characterised by a rapid growth of population – associated with the appearance of enclosures, linked to an important new type of territorial control –, the exploitation of natural resources, economic specialisation, and the development of a symbolically interconnected territory. This phase was followed by a period of consolidation (2500–2300 BC) corresponding to an important segmentation of space, in which we observe the establishment of connections with new influences (such as Bell Beakers) and the development of specialisation strategies, e. g. in metallurgy. The consequence of this rapid growth was an increase in social vulnerability and a low resilience of the socio-ecological system. Next, an environmental and climate forcing (aridification) has been dated to 2300–2100 BC. The accumulative effect of socio-economic and environmental changes produced a break and a disconnection in local networks.

Lastly, there has been identified a period of reorganisation around 2100–1900 BC. The Early Bronze Age period might be perceived as an attempt to revitalise the ancient network (Epi-Campaniforme, Early Bronze Age 1), through the reoccupation of many habitation sites.

The mid-Rhône valley flood plains and the 4.2 ka BP RCC event

On a multi-centennial scale, the high-resolution palaeohydrological reconstructions in the mid-Rhône valley area reveal a rapid succession of rivers functioning between 2400 BC and 1900 BC. Long mechanical trenches across the pre-alpine river valleys (Mediterranean TGV [Train à Grande Vitesse] rescue archaeology operations) show contrasting changes in the hydrological cycle, with a succession of river incisions and infillings on a multi-centennial scale. These changes had a high impact on floodplains and riverbanks with Bell Beaker settlements that densified during this period (Berger 2015). The pedological and hydromorphological indicators discussed above show a progressive flood aggradation that contributes to the burying of black floodplain soils, a succession of rapid dry/wet episodes (flash flood type, cumulative fluvial soils rich in calcium carbonate [$CaCO_3$]) and a regional decrease in moisture availability, which probably forced the Neolithic communities to move closer to the riverbeds. But the repetition

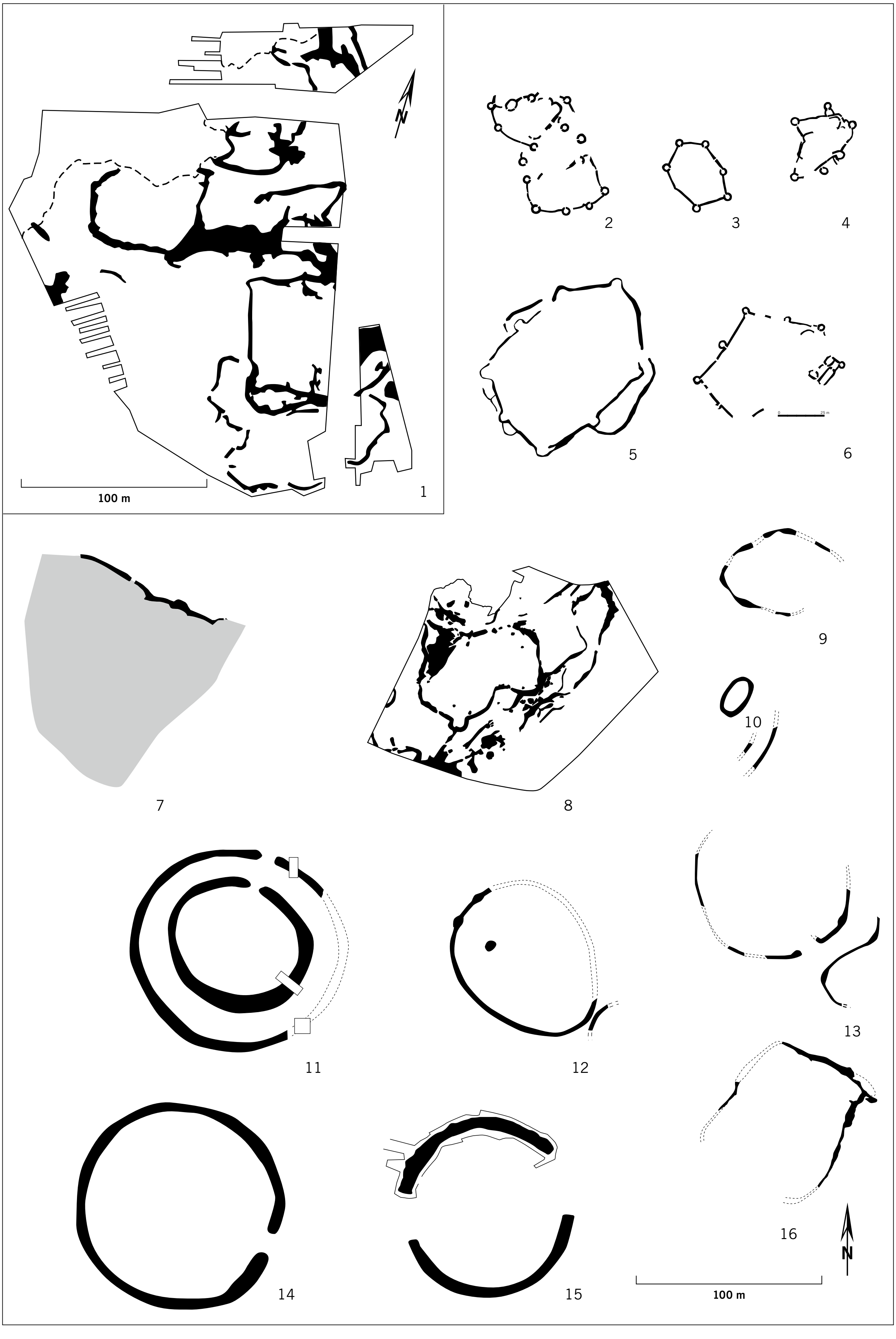

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Fig. 10 (left page) The main enclosures and fortified settlements at the end of the Neolithic period in eastern and western Languedoc: 1 Caissargues, dep. Gard; 2 Tailladettes, dep. Hérault; 3 Boussargues, dep. Hérault; 4 Campmau, dep. Hérault; 5 Puech Haut, dep. Hérault; 6 Le Lébous, dep. Hérault; 7 Roquemengarde, dep. Hérault; 8 Richemont, dep. Hérault; 9 La Croix de Fer, dep. Hérault; 10 Campagne, dep. Hérault; 11 Carsac, dep. Aude; 12 Le pierras de l'Hermitage, dep. Hérault; 13 Le Grand Bosc, dep. Hérault; 14 Rivoire, dep. Aude; 15 Roc d'En Gabit, dep. Aude; 16 La Croix-Vieille, dep. Hérault. The enclosures no. 2, 3, 4, and 6 were built with dry-stone walls.

***Abb. 10 (linke Seite)** Die wichtigsten Befestigungsanlagen und befestigten Siedlungen am Ende des Neolithikums im östlichen und westlichen Languedoc. 1 Caissargues, Dep. Gard; 2 Tailladettes, Dep. Hérault; 3 Boussargues, Dep. Hérault; 4 Campmau, Dep. Hérault; 5 Puech Haut, Dep. Hérault; 6 Le Lébous, Dep. Hérault; 7 Roquemengarde, Dep. Hérault; 8 Richemont, Dep. Hérault; 9 La Croix de Fer, Dep. Hérault; 10 Campagne, Dep. Hérault; 11 Carsac, Dep. Aude; 12 Le pierras de l'Hermitage, Dep. Hérault; 13 Le Grand Bosc, Dep. Hérault; 14 Rivoire, Dep. Aude; 15 Roc d'En Gabit, Dep. Aude; 16 La Croix-Vieille, Dep. Hérault. Die Anlagen 2, 3, 4 und 6 waren in Trockenmauerbauweise errichtet.*

of hydrological extremes weakened the occupation of the valley bottoms and compromised the sustainability of socio-environmental systems (Berger et al. 2007; Berger 2015).

Dynamic of settlement in the mid-Rhône valley (2500–2200 BC)

Researches in spatial archaeology and numerous rescue excavations identified thirty »Bell Beaker« sites in a small micro-region of c. 1000 km² (Valdaine basin and Tricastin plain; Fig. 11). Two sites in the Valdain basin and one in the middle Roubion catchment give detailed pedosedimentary and archaeological information (Roynac-le Serre, Francillon/Roubion-Pas de l'Estang et Montboucher/Jabron-Pancrace; Berger 1996; Vital et al. 1999; Berger 2015). In the Tricastin plain, data mainly come from the alluvial fans of the rivers Berre (southern Berre transect), Echaravelles (Bartras), Lauzon (Juilleras, le Chêne), and Lez (Brassières Sud)[8]. GIS analyses, made in collaboration with G. Davtian, of the spatial distribution of these Late Neolithic III sites (Berger 2015) show a clear densification in floodplains and wet basins around 2600–2300 BC (Fig. 12a) when other landscape units were partly underrepresented. The majority of these sites were quickly buried under alluvia around 2300/2200 BC (Fig. 11).

A long term development of settlements in the mid-Rhône valley

Between 2250 BC and 2100 BC, Bell Beaker sites abruptly disappeared from the mid-Rhône valley after achieving a density maximum in floodplains and wet basins. This disappearance is not due to taphonomical bias, as numerous mechanical trenches have been dug in different landscape units of the region. The disappearance occurs two centuries after the disappearance from the lake shores of the Jura, the northern Alps, the Swiss plateau, and Bavaria by the same Bell Beaker populations. The caves and rock shelters of the lower Ardèche karst do not represent a settlement alternative during this episode (Berger et al. 2007; Vital 2008). A reoccupation of floodplains is observed around 2100–2050 BC (Early Bronze Age I and a few late barbed wire ware ceramic occurrences) after a 100–150 years hiatus, according to radiocarbon chronology (Fig. 12b; Vital et al. 1999; Vital 2008). This cultural hiatus is observed at a regional scale (mid- to lower Rhône valley, Provence; Vital 2008). The re-settlement of Jurassian lake shores is also identified during the 21st century BC (Pétrequin 2005). The Early Bronze Age I settlements are most often associated with charcoal beds in the alluvia of the floodplains, indicating a clearing by fire of

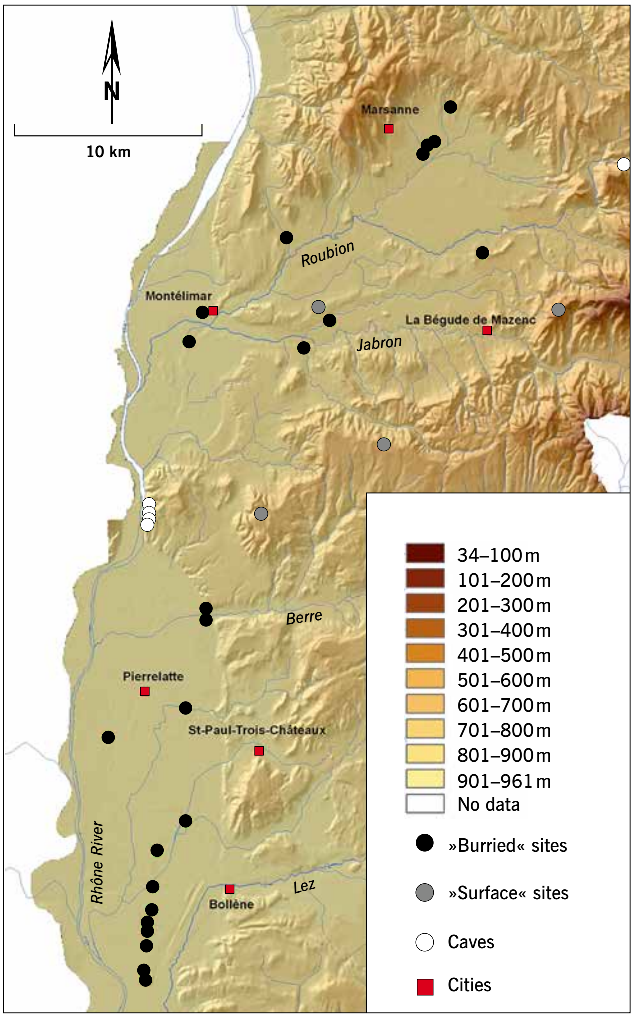

Fig. 11 Map of Late Neolithic III sites (Bell Beaker period and Fontbouisse Culture) of Valdain basin and Tricastin plain (mid-Rhône valley). The micro-regional archaeological data illustrate a predominance of buried Late Neolithic III sites.

***Abb. 11** Verbreitungskarte der Fundstellen des Spätneolithikums III (Glockenbecherperiode und Fontbouisse-Kultur) im Valdain-Becken und in der Tricastin-Ebene (mittleres Rhonetal). Die archäologischen Daten der Mikroregionen zeigen ein Übergewicht unterirdischer Bodendenkmalen an.*

8 Billaud 2002; Lemercier 2002; Margarit et al. 2002; Berger 2015.

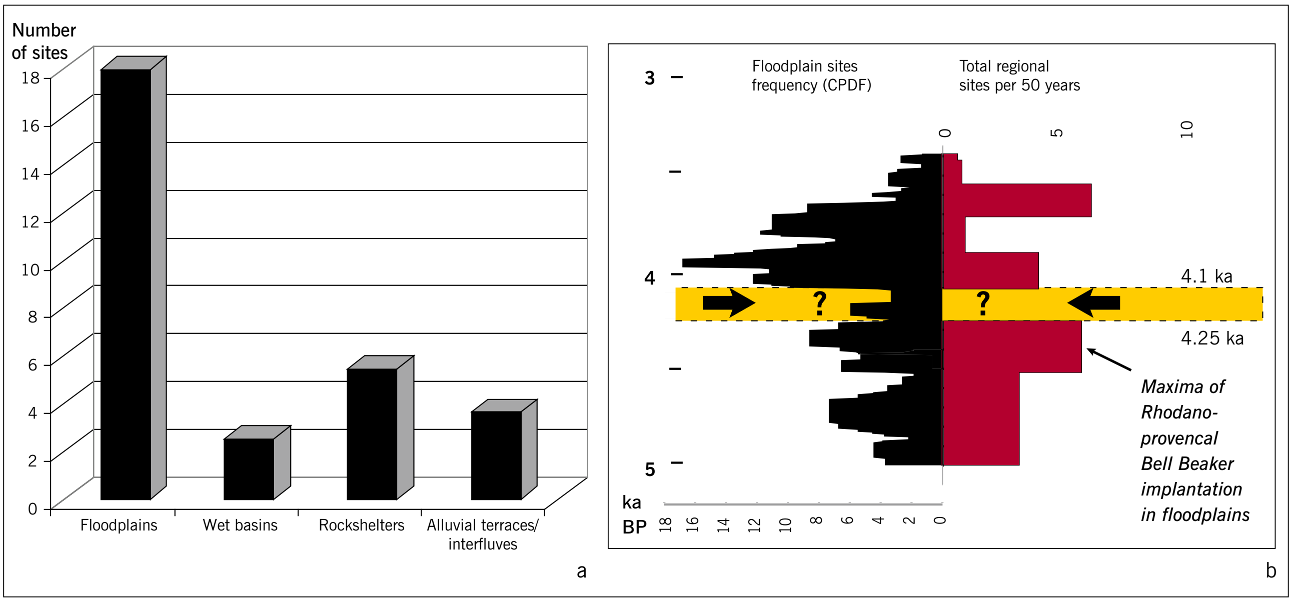

Fig. 12a–b Location of Bell Beaker and other Late Neolithic III sites of the Tricastin-Valdaine region in the main landscape units: a Strong predominance of floodplain settlements; b comparison of curves of CPDF of sites in floodplains and of total regional settlement of the mid-Rhône valley.

Abb. 12a–b Fundstellen der Glockenbecherzeit und des Spätneolithikums III in den wichtigsten Landschaftstypen der Tricastin-Valdaine-Region: a Starkes Übergewicht der Siedlungen in den Flussauen; b Vergleich der CPDF-Kurven der Fundstellen in den Flussauen and aller Siedlungen im Gebiet des mittleren Rhonetals.

the vegetation cover that was densely reinstated after the end of the Bell Beaker period.

French Pyrenees and intermediate areas

We have just seen that, in the Mediterranean region, the period between 2400 BC and 1900 BC corresponded to a period of alteration, in the course of which environmental changes played a leading role. The Pyrenees Mountains are emblematic in the treatment of this subject because they present a high east-west ecological transect. Here, palaeoecological data have allowed us to observe the rhythms of anthropisation (Fig. 13; Carozza et al. 2006). The cumulated radiocarbon datings gathered from archaeological sites reveals two periods in which human occupations decrease in mid-elevation mountains and foothills (Fig. 14). The first corresponds to the period between 2900 BC and 2500 BC

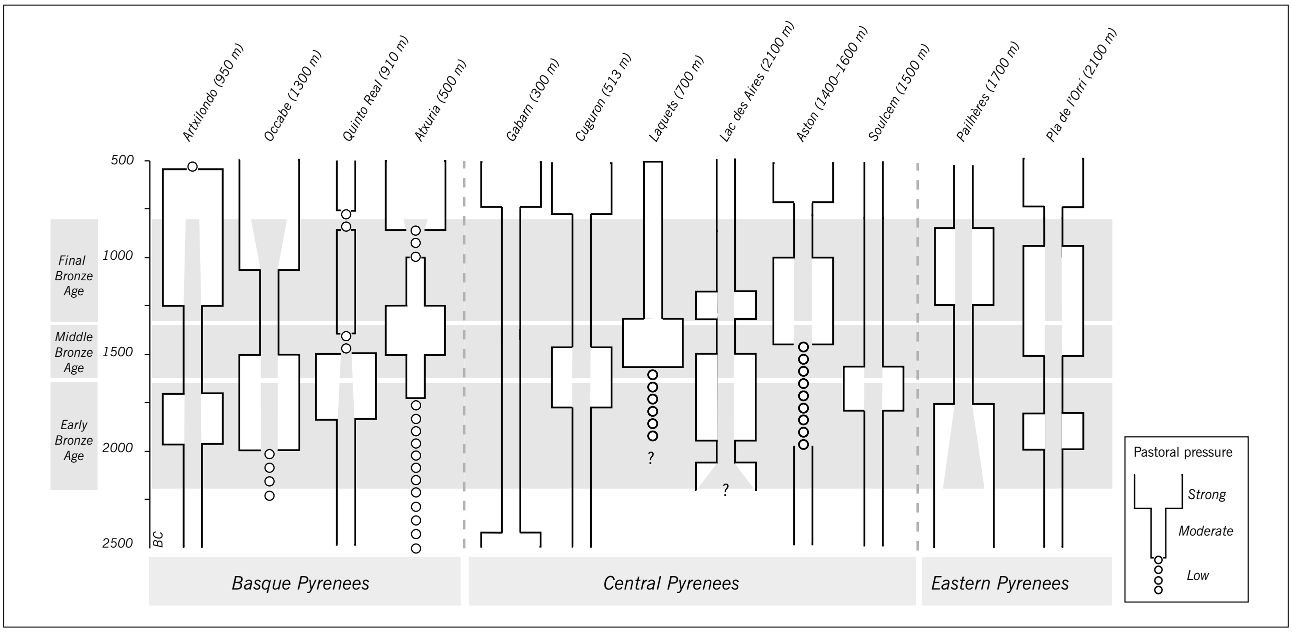

Fig. 13 Variation of the pasture pressure between the Basque Country and the eastern Pyrenees between the end of the Neolithic period and the Late Bronze Age. The pressure is estimated according to the fluctuations of the pollen indicator values that indicate pastoral activity.

Abb. 13 Unterschiedliche Weidebelastung im Baskenland und in den östlichen Pyrenäen zwischen dem Ende des Neolithikums und der Spätbronzezeit. Die Schätzwerte beruhen auf den Schwankungen der auf Weidewirtschaft hindeutenden Pollenindikatoren.

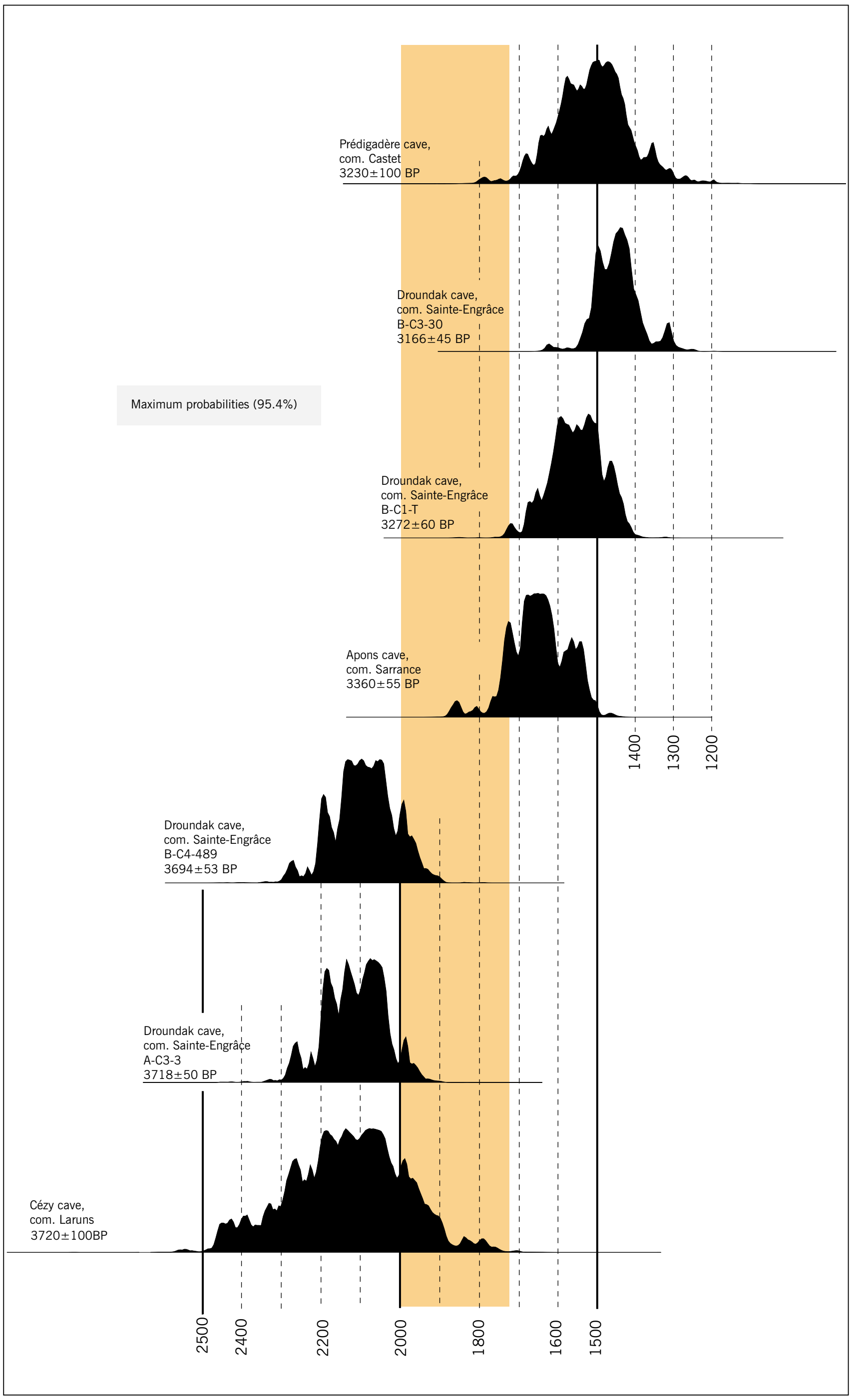

Fig. 14 Dating of burial sets from the western Ossau valley, prov. Béarn, western Pyrenees. There is a gap between 2000 BC and 1800 BC.

Abb. 14 *Datierung von Gräbern im westlichen Ossautal, Prov. Béarn, westliche Pyrenäen. Zwischen 2000 v. Chr. und 1800 v. Chr. zeichnet sich eine Lücke ab.*

(Late Neolithic) and the second to the period between 2000 BC and 1900 BC (Early Bronze Age). According to pollen markers, an increase in pastoral use emerges at the beginning of 3rd millennium BC (Carozza/Galop 2008). However, this is not a widespread phenomenon, but rather a local occurrence.

Anthropisation of intermediate areas: the French »Pays Basque« (Basque Country) during the Early Bronze Age

An increase in human occupation clearly takes place in hills and mid-elevation mountains in the French »Pays Basque« after 2200 BC. It seems to go together with a regionalisation of cultural groups and the development of economic strategies based on the complementary interplay between resources and environment. Besides, the data show an opportunistic exploitation of copper ore resources in the Aspe valley. This period follows an important abandonment phase, dated to the Late Neolithic. Around 2500 BC, an increase in the number of sites goes together with a rise in agricultural markers (Cerealia type; cf. Carozza/Galop 2008) and a growth in paleo-fires linked to pastoral activities (Rius et al. 2011). On a more local scale, the Early Bronze Age human occupations, structured in small areas (plateau du Cézy) show a chronological discordance linked to an important gap between 1900 BC and 1800 BC, when a lack of settlements is observed. This phenomenon reveals a high mobility of the agro-pastoral systems. Finally, the results of our

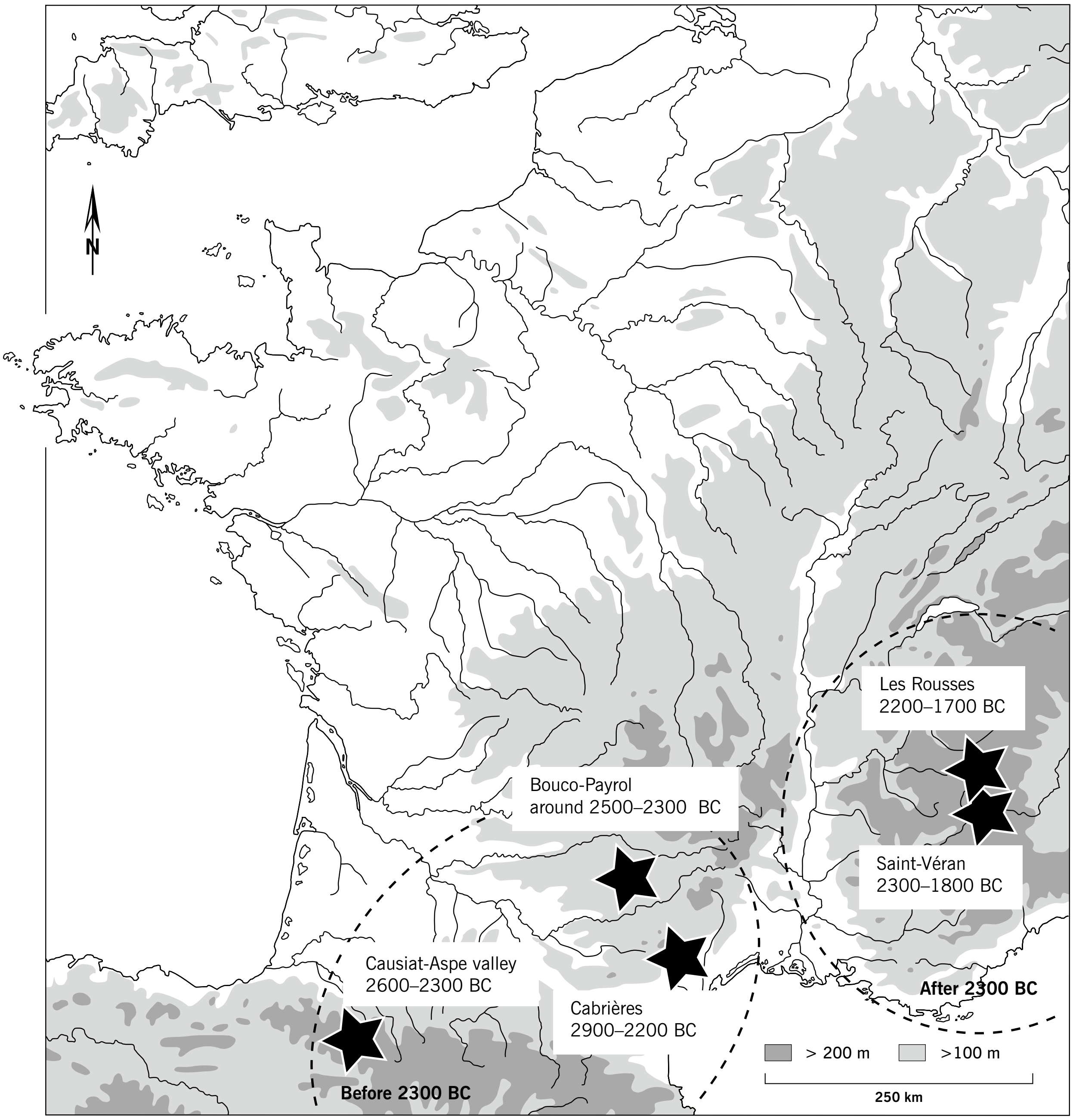

Fig. 15 Map of the main Late Neolithic and Early Bronze Age metallurgical centres (dashed lines) and mining complexes (stars) in the south of France.

Abb. 15 *Verbreitungskarte der wichtigsten spätneolithischen und frühbronzezeitlichen Metallurgiezentren (gestrichelte Linien) und Bergbaukomplexe (Sterne) im Süden Frankreichs.*

studies establish that the »4.2 ka BP event« does not seem to constitute a tipping point in the Pyrenees. Intermediate areas became attractive ecosystems for Late Neolithic and Early Bronze Age agro-pastoral communities.

Languedoc versus Alps: the role of climate in the exploitation of copper resources

It is worthwhile at this stage to consider the question of environmental changes and to understand the role of climate in social-economic patterns. Firstly, we will discuss the central Languedoc area, around the metallurgical district of Cabrières, dep. Hérault, during the Late Neolithic (Fig. 15; Ambert et al. 1998; Carozza/Mille 2007; Mille/Carozza 2009). Next, we propose to look at the modality of the copper ore exploitation in the Alps during the Early Bronze Age[9].

Metallurgical production in south-eastern France during the Late Neolithic (2900–2300 BC)

In southern France, it is well-known that first copper artefacts appeared during the Late Neolithic I (3100–2900 BC)

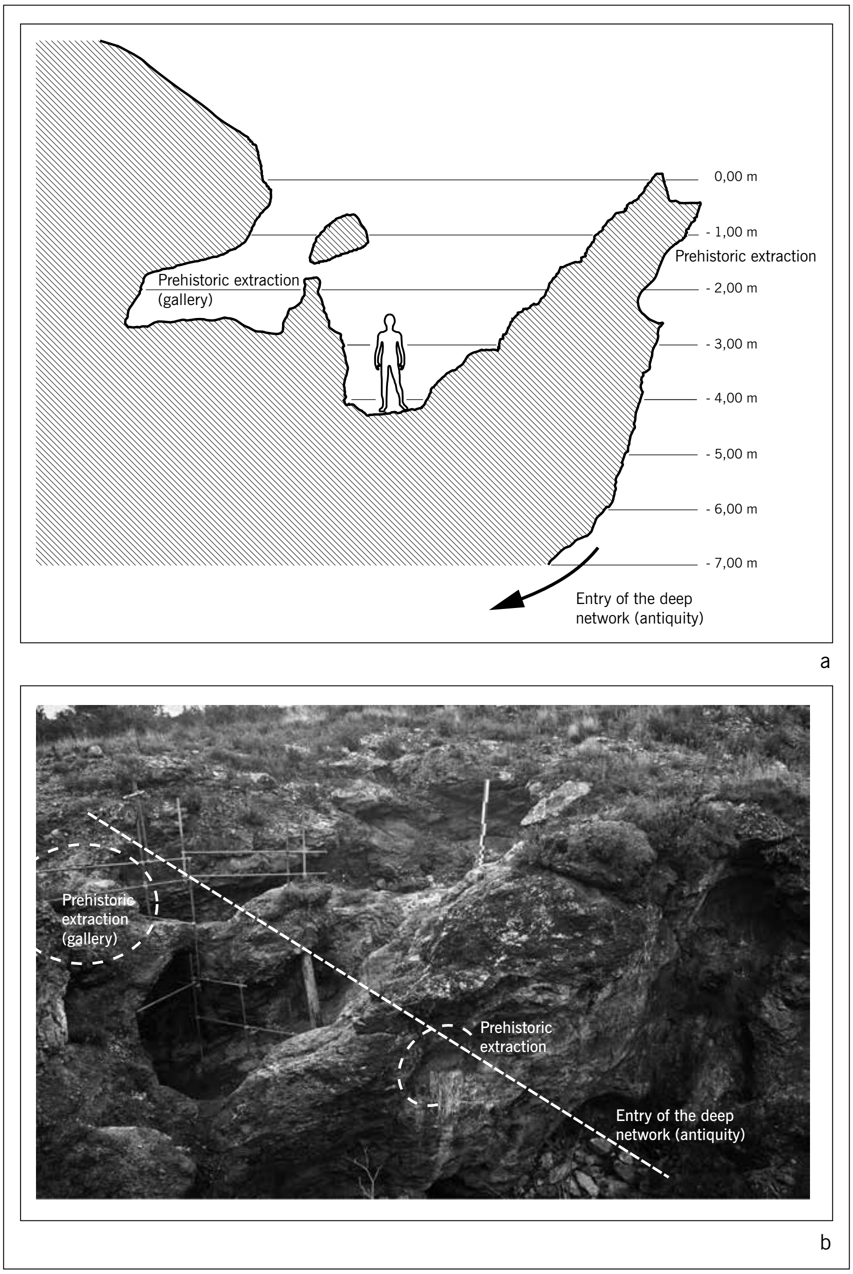

Fig. 16a–b Prehistoric ore extraction in the Pioch Farrus 4 mine at Cabrières, dep. Hérault. The rounded shapes are dated to the Late Neolithic. The extraction scheme is shown superimposed on the general view of the mine: the extraction followed the mineralised veins in open air trenches or parallel galleries.

Abb. 16a–b *Prähistorischer Erzabbau im Bergwerk Pioch Farrus 4 bei Cabrières, Dep. Hérault. Die eingekreisten Bereiche datieren in das Spätneolithikum. Das Abbauschema ist auf die Ansicht des Bergwerks projiziert: Der Abbau der Mineralienadern erfolgte im Tagebau oder in parallelen Stollen.*

in the Véraza and Epi-Ferrières communities (Carozza 2005; Carozza 2009). Several copper analyses indicate the regional source of the copper metal (Cévennes and Languedoc), revealing the exploitation of local resources and the shortness of the distribution network. We observe no occurrence of competition in the field of tool production between copper and lithic material.

Cabrières: a mining and smelting complex from 3100–2200 BC

In the central Languedoc area, the studies conducted around the metallurgical centre of Cabrières, dep. Hérault, allow an integrative approach combining metallurgy and socio-cultural dynamics during the 3rd millennium BC (Ambert et al. 2002). The site is characterised by abundant extraction and mineral processing sites, concentrated in a small perimeter (Fig. 16). Shallow mines were systematically exploited. Excavations have shed light on a metallurgy characterised by low production and a smelting process in low furnaces or crucibles, sometimes carried out in domestic areas. Radiocarbon dates obtained in mines and metallurgical areas show that the metallurgical production began around 3100 BC and ended c. 2200 BC. An optimum of probability has been observed c. 2500–2400 BC (Carozza 2005). On a local scale, a modification of the land-use and a change in the settlement type are observed, with an increase of fortified sites and enclosures around 2500 BC. In the mid-Hérault valley, a fortified habitat was established and grew up on the top of the Puech Haut hill (Paulhan, dep. Hérault) from 3200–2200 BC (Fig. 17). The transformation of the form and the status of

9 Bailly-Maître/Gonon 2008; Bourgarit et al. 2010; Carozza et al. 2010; Barge et al. 1998.

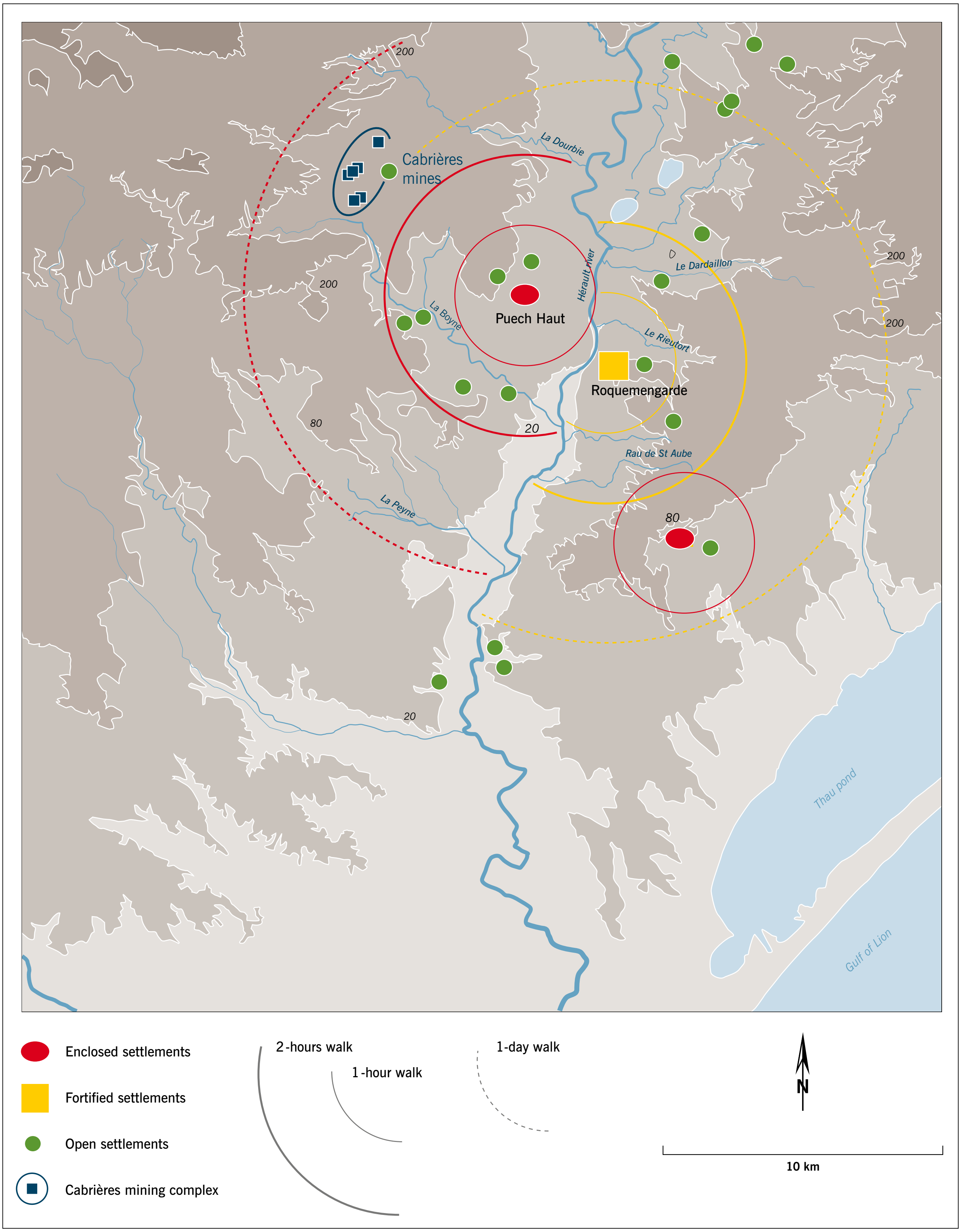

Fig. 17 Land use at the beginning of the 3rd millennium BC in the mid-Hérault valley.

***Abb. 17** Landnutzung im frühen 3. Jt. v. Chr. im mittleren Hérault-Tal.*

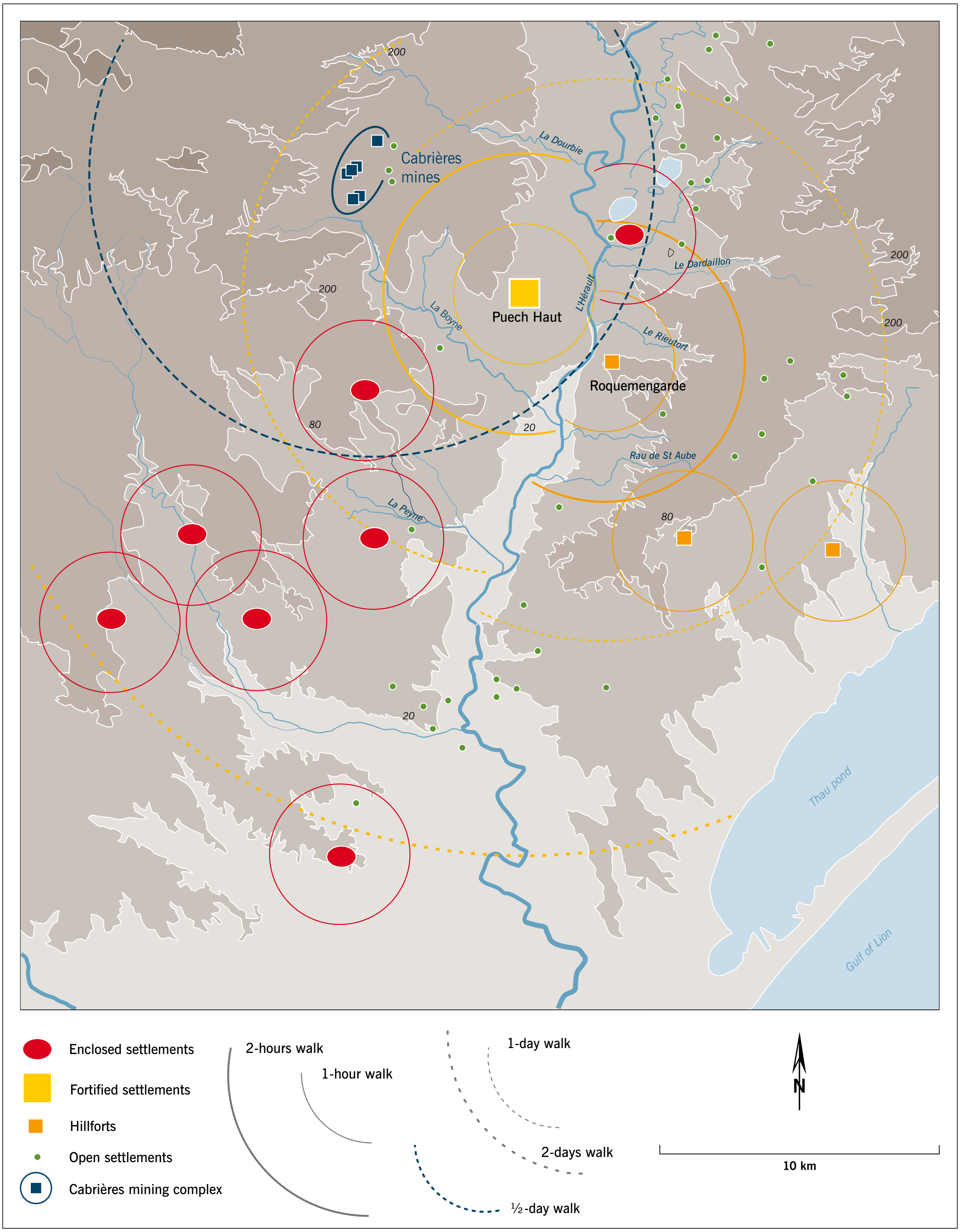

Fig. 18 Land use at the middle of the 3rd millennium BC in the mid-Hérault valley.

***Abb. 18** Landnutzung im mittleren 3. Jt. v. Chr. im mittleren Hérault-Tal.*

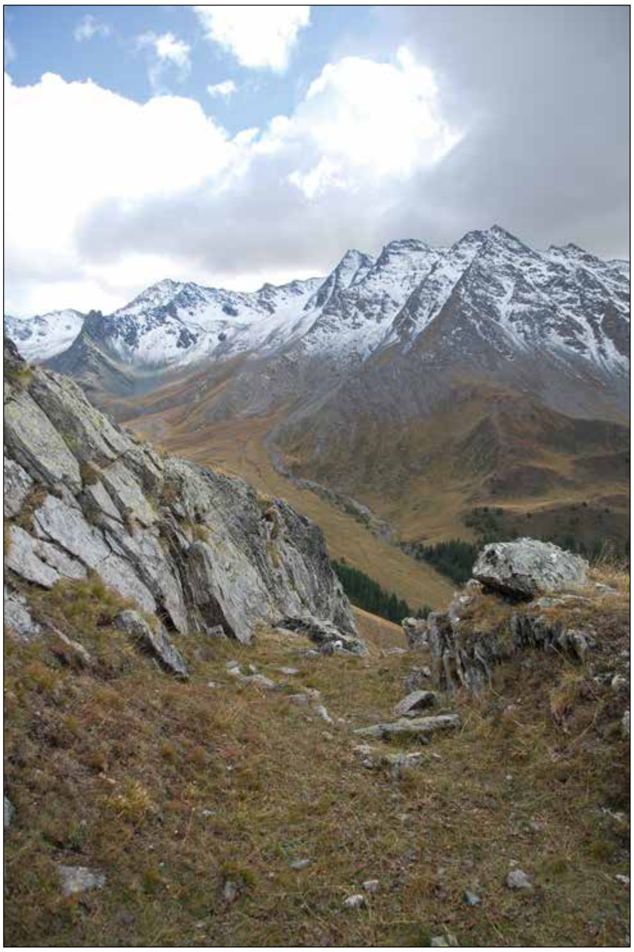

Fig. 19 View of the »Tranchée des Anciens« Early Bronze Age mine in Saint-Véran, dep. Hautes-Alpes.

Abb. 19 *Ansicht des frühbronzezeitlichen Bergwerks »Tranchée des Anciens« in Saint-Véran, Dep. Hautes-Alpes.*

this enclosure and fortified site goes together with an increase in the exploitation of copper resources. The mines of Cabrières are 5 km away from Puech Haut. Moreover, from an economical point of view, we observe at the same time an exact complementarity between agriculture and pastoralism, a pressure on the environment linked to the specialisation in animal husbandry (sheep and goat), and a peak in the exploitation of the copper mines. On a regional scale, land use reveals an increase in fortified open settlements during the first stage of the Late Neolithic period (around 2800 BC) and the establishment of a complementarity between agriculture and pastoralism. During the Late Neolithic III (2700–2500 BC) an increase of the number of the enclosures goes together with a peak in copper mining (Fig. 18). The agglomeration of population induces a pressure on the environment. The increase of grain farming and the abandonment of pig farming (in favour of sheep and goat) generated modifications in the economic structures. Around 2400–2300 BC, a gradual abandonment of sites, the disappearance of agricultural production structures, and the arrival of small human occupations (with Bell Beaker pottery) is observed. A short time later (around 2200–2150 BC), the exploitation of copper resources comes to an end. In sum, our pattern reveals a socio-environmental crisis around 2500–2200 BC, characterised by a gradual abandonment of sites and fortifications and the disappearance of agricultural production. Clearly, the previous pattern is not likely to be transposed to the whole south of France. In this regard, it is also important to investigate the situation in the southern Alps.

Mining and metallurgy in the French Alps

In the high mountain context of the French Alps, the expansion of copper exploitation started in the 24th century BC. The Saint Véran, dep. Hautes-Alpes, Early Bronze Age mining and metallurgical complex is one example of seasonal copper exploitation at high altitude (Carozza et al. 2010; Mille/Carozza 2009; Barge et al. 1998). Here, the exploitation of bornite started around 2350 BC on several mining sites set up at altitudes of 2400–2600 m a.s.l. (Fig. 19). The mining and smelting complex consists of a 60 m long and 40 m deep mineral extraction trench. Radiocarbon dates indicate a chronology of copper-ore exploitation around 2400–1900 BC, with an optimum focused on 2100 BC. The metallurgical process, which lies at the origin of a mass production in copper, is characterised by high performance, with a high ratio between copper and iron. At 1250° C, the process produced a smooth plate slag (in German: Plattenschlacke). Production has been estimated at about 2000 t of ore (bornite) during the Early Bronze Age alone, this is to say that the mining exploitation of Saint-Véran reached about 7 t of copper during a period of only four centuries. The end of the 3rd millennium BC constitutes a break in the modalities of metallic production and distribution (Fig. 20).

Les Rousses: Early Bronze Age mass exploitation of copper

The discoveries made in the Oisan rock massif, dep. Isère, by C. Bailly-Maître and J. Vital (Bailly-Maître/Gonon 2008; Vital 2009) support the idea of a rise in the exploitation of copper resources in alpine regions the during Early Bronze Age. The Early Bronze Age metallurgical site of »Les Rousses« was discovered in a high mountain area (2200–2700 m a.s.l.). Here, ores were usually formed of copper sulphide and worked by the action of fire. The intensive nature of the mining is clearly shown by the mineral extraction trench (Cavalle 4): the deep trench has exhausted the veins over a length of over 200 m. This methodical vein exploitation is quite an outstanding phenomenon and goes together with a mass exploitation of resources. The radiocarbon dates suggest that the exploitation began at the end of the 3rd millennium BC (2200 BC), when occupation disappears in the pre-alpine watershed. The exploitation may have been interrupted at the beginning of the Middle Bronze Age (17th century BC).

Exploitation of resources in high mountain regions: what about the environmental context?

We propose here to look at the environmental context of the exploitation of high mountain resources, as shown by the sedimentary record of one lake from the Vanois rock massif, near the »Les Rousses« mining district. The Lake Bramant

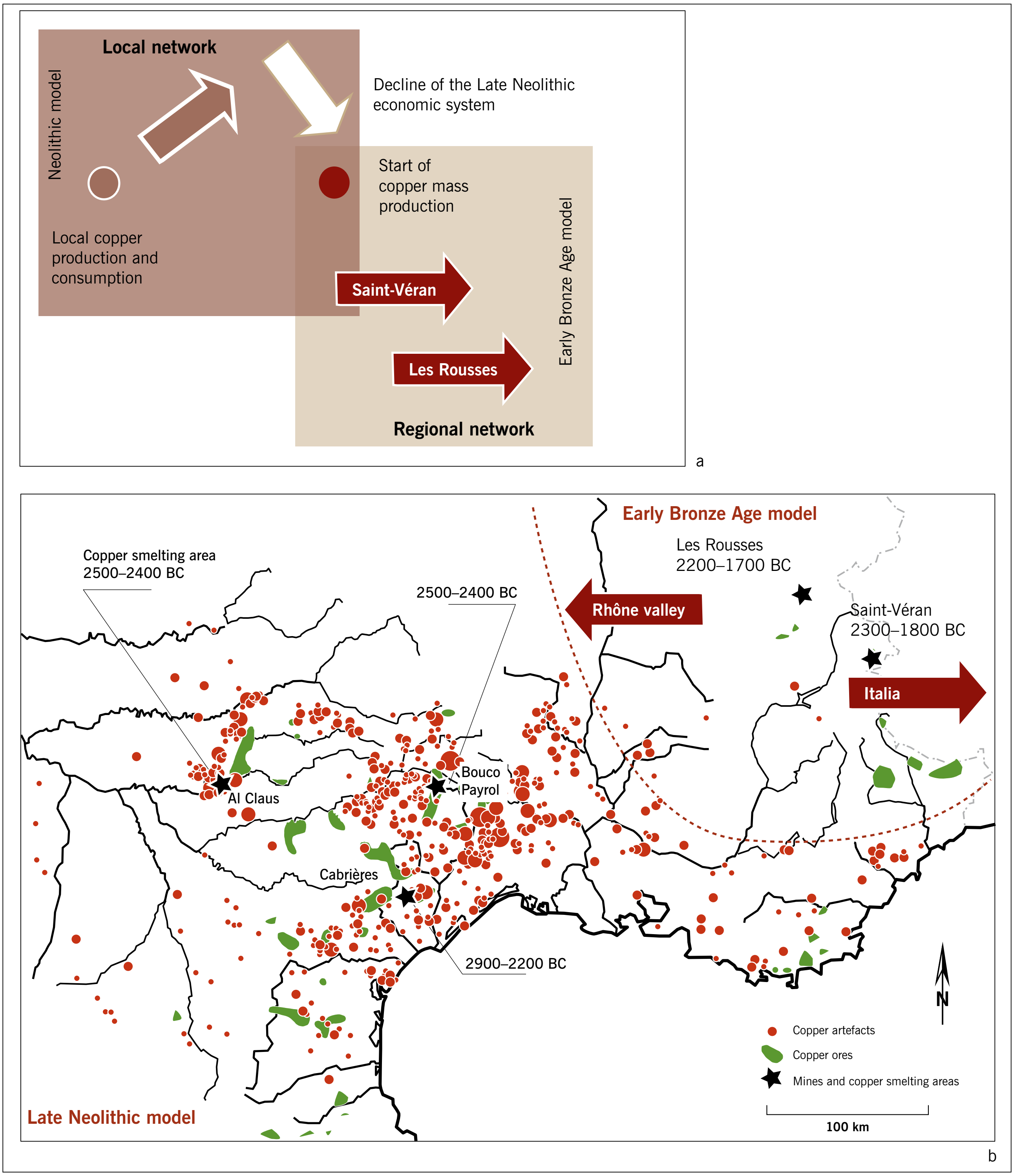

Fig. 20a–b a Chronological evolution pattern of metallurgical production modalities during the end of the Neolithic period and the beginning of the Bronze Age in the south of France. b Distribution map of the copper objects dating from the end of the Neolithic period, discovered in Languedoc and in the Grands Causses area.

***Abb. 20a–b** a Chronologische Entwicklung der Metallverarbeitung am Ende des Neolithikums und zu Beginn der Bronzezeit im Süden Frankreichs. b Verbreitungskarte von Kupferobjekten des Endneolithikums im Languedoc und im Grands Causses-Gebiet.*

sedimentary record demonstrates both environmental changes and mining activity in alpine regions (Carozza et al. 2010a). The Bramant lake sedimentation is strongly influenced by glacier fluctuations. Coring and multi-proxy studies show significant changes in sedimentation at the base of the core. Two organic-rich units dated to the Early and Late Bronze Age have been related to periods of reduced glacier activity. Two atmospheric metallic contaminants, induced by mining activity, have also been identified in the sediments.

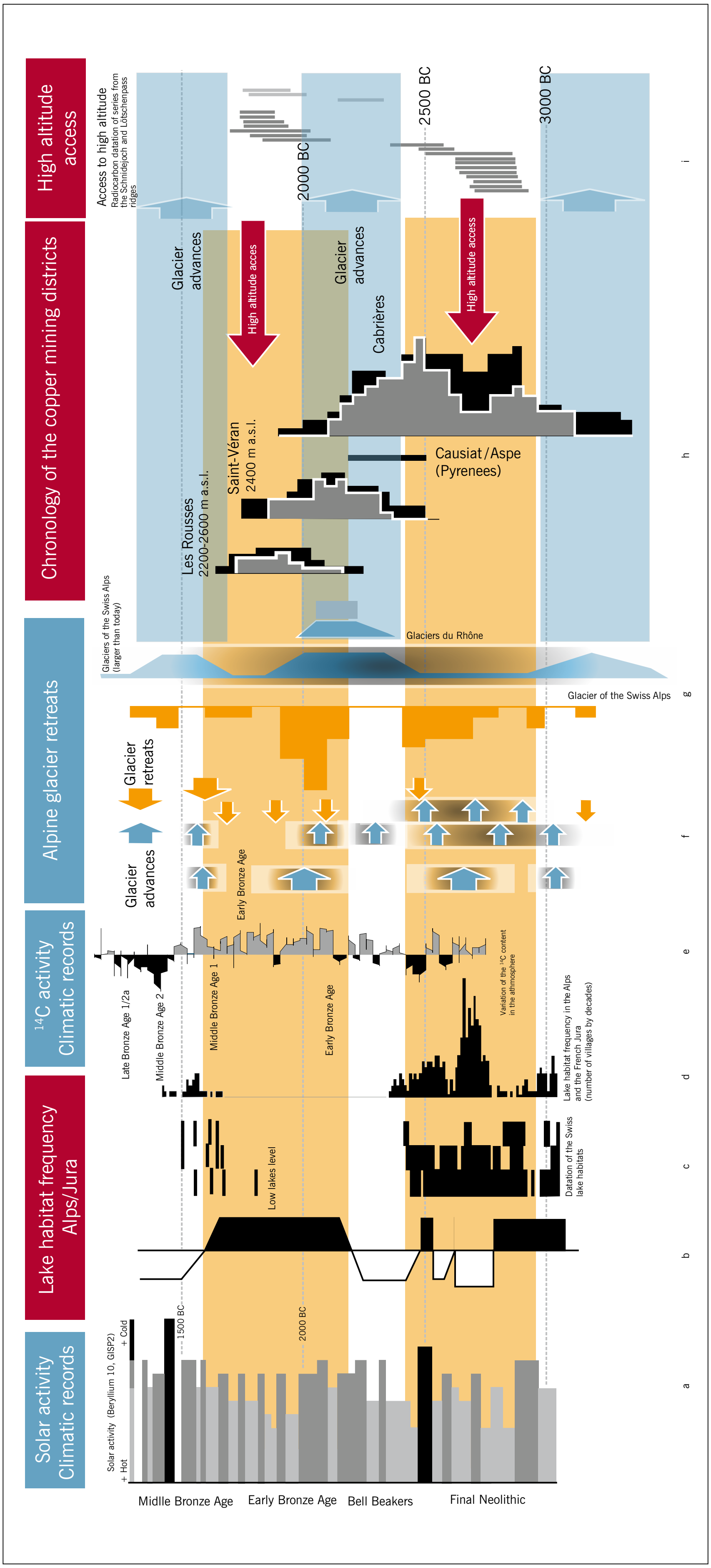

Fig. 21a–i The exploitation of copper ore resources at middle and high elevations in the Alps, and identification of the main environmental requirements.

Abb. 21a–i *Der Kupfererzgewinnung in mittleren und hohen Alpenlagen mit den wichtigsten ökologischen Voraussetzungen.*

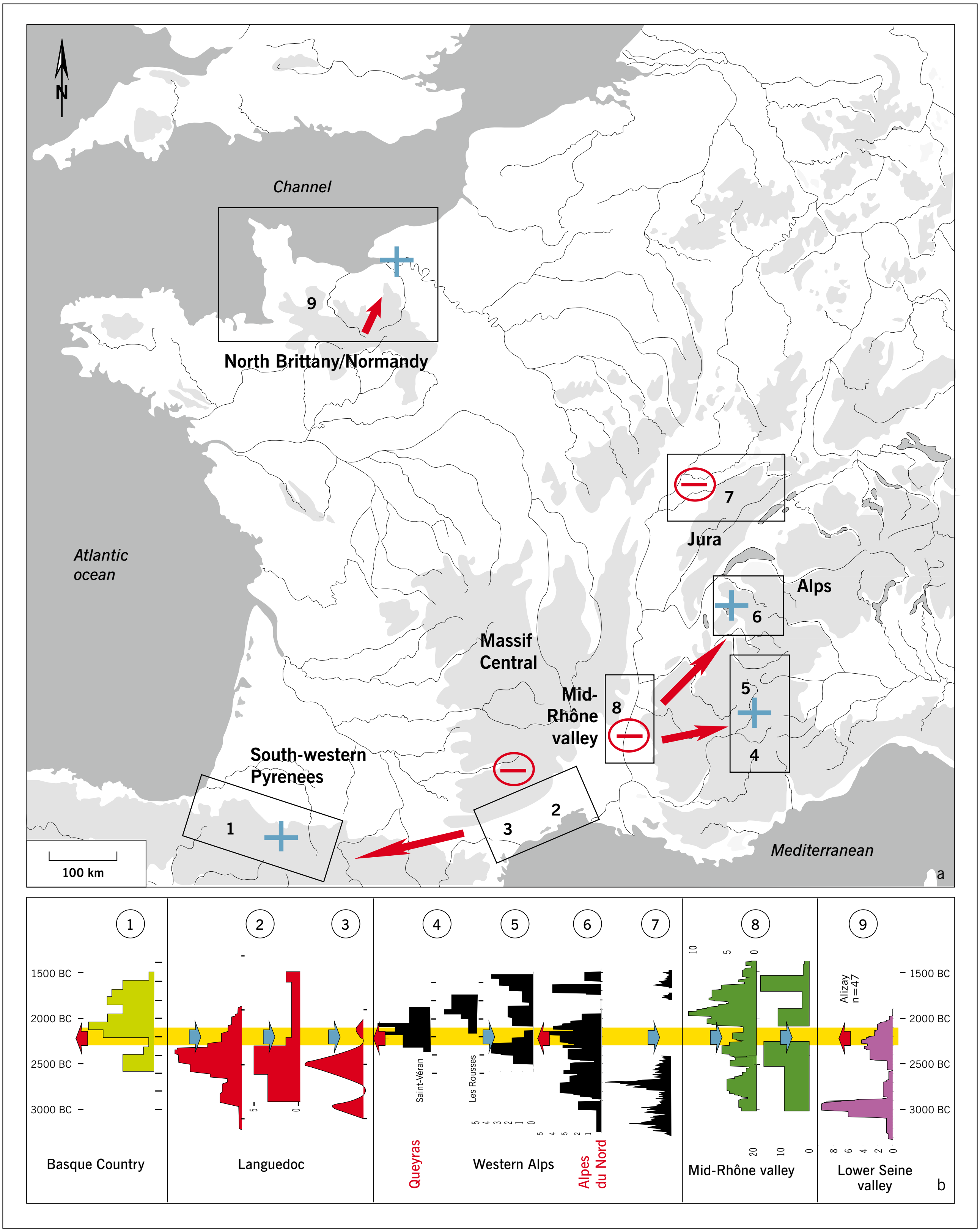

Fig. 22a–b a Map of the micro-regions documenting the Late Neolithic III to Early Bronze Age transition around 4.2 ka BP: 1 Western Pyrenees; 2 Languedoc plateau (Boussargues-Les Vautes); 3 Languedoc (Fontbouisse Culture); 4 southern Alps (Queyras, Saint-Véran); 5 central-western Alps (CPDF); 6 northern Alps (multi-source CPDF); 7 Jura/Swiss Plateau/Bavaria; 8 mid-Rhône valley; 9 Normandy (Alizay site, CPDF). Red minus signs – depopulated areas; blue plus signs – densely populated area; red arrows – direction of possible mobility of people around the 4.2 ka cal BP event. b Comparison of temporal dynamics of the same micro-regions illustrating spatial re-organisation throughout France. Blue arrows – sharp decline; red arrows – growth.

Abb. 22a–b *a Karte der Mikroregionen am Übergang von Spätneolithikum III zur frühen Bronzezeit um 4,2 ka BP: 1 Westliche Pyrenäen; 2 Languedoc Plateau (Boussargues-Les Vautes); 3 Languedoc (Fontbouisse-Kultur); 4 Südalpen (Queyras, Saint-Véran); 5 westlicher Zentralalpenraum (CPDF); 6 nördliche Alpen (multi-source CPDF); 7 Jura/Schweizer Mittelland/Bayern; 8 mittleres Rhonetal; 9 Normandie (Fundstelle Alizay, CPDF). Rote Minuszeichen – entvölkerte Gebiete; blaue Pluszeichen – dicht besiedelte Gebiete; rote Pfeile – Richtung möglicher Bevölkerungsbewegungen um das 4,2 ka cal BP Ereignis. b Ein Vergleich der zeitlichen Dynamik in denselben Mikroregionen zeigt eine räumliche Umgestaltung über ganz Frankreich an. Blaue Pfeile – starker Rückgang; rote Pfeile – Zunahme.*

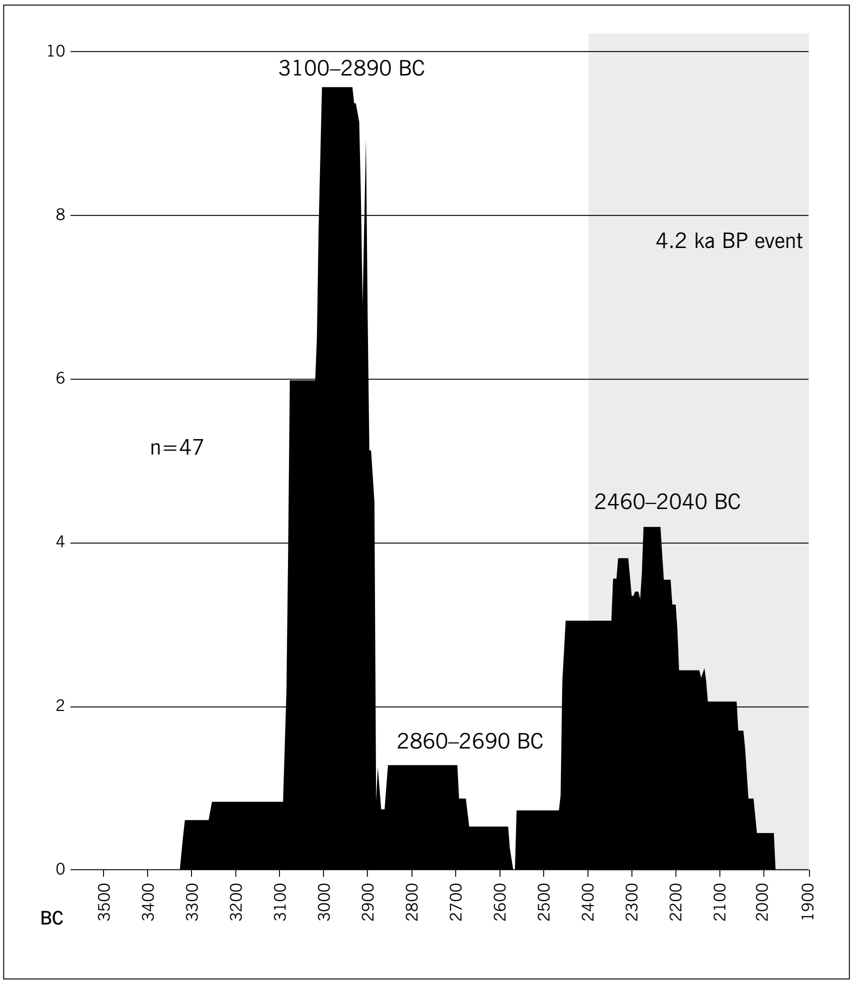

Fig. 23 CPDF curve of the Late Neolithic Alizay site (along the banks of the Seine River).

Abb. 23 *CPDF-Kurve der spätneolithischen Fundstelle Alizay (am Ufer der Seine).*

Global climate change, glacial retreat, and the exploitation of copper resources in the French Alps between 2500 BC and 1500 BC

The environmental synthesis displays long term interaction between human activities and environmental changes at high altitudes. In the Swiss Alps, the beginning of the Early Bronze Age (2200 BC) is characterised by a period of glacier advances, contemporary with the 4.2 ka BP climate event (Fig. 21). But the Bronze Age major climate change tendencies are characterised by two warm episodes. The first, occurring from around 2200–1650 BC (Early Bronze Age), allowed access to the high mountains. The second occurred during the Late Bronze Age. These two Bronze Age episodes brought about significant changes in the vegetation at around 2500 m altitude. The western Alps are obviously a major area for study in view of the spectacular development in the Rhône valley. Data converge nowadays to show that the high altitude exploitation of copper resources is closely related to the glacial retreat. This model could display a correlation between climatic changes and metallic resource exploitation in high mountain regions. This exploitation was made possible by the retreat of small glaciers after several global warming episodes.

Towards a pattern in copper resources exploitation

By combining the results of archaeological and environmental studies, it is finally possible to suggest a pattern in the evolution of copper resources exploitation in Southern France from 2500–1500 BC. At the beginning, the Late Neolithic period (3000–2500 BC) in the Alps and the Pyrenees is characterised by an exploitation of foothills resources, a low-performance metallurgical process and a local distribution network. From the Early Bronze Age onwards (thanks to the new access to high mountain resources) there can be observed a large distribution network resulting from the development of a mass-production model of copper extraction and a high performance metallurgical process.

The Middle Bronze Age (1700–1350 BC) marks a change, with the end of the exploitation of high mountain resources (due to climate change) and the move of the production centres towards the Central Alps (Austria, Northern Italy).

Conclusion: the 4.3–4.1 ka BP period

This paper presents the first results of investigations to understand the impact of environmental changes on ancient societies, from the Late Neolithic to the Early Bronze Age. The given reconstruction aims to illustrate that the 4.2 ka BP event corresponds to a long period between 2300 BC and

1850 BC, in which three distinct environmental phases can be defined. This data, already underlined by Magny et al. (2009), makes more complex the presented perception of the temporal progression of the 4.2 ka BP event and associated cultural changes at the transition from the Late Neolithic to the Early Bronze Age. In Southern France, the establishment of a Mediterranean climate and two geographical gradients (east-west/north-south) can be observed. A high demographic growth occurs during the Late Neolithic and the economical pattern is then characterised by high specialisation in economic activity and low resilience of the environment. In the Gulf of Lion and the mid-Rhône valley, the economy is more and more oriented to pastoralist activities. Sites become increasingly scarce and their size and number are sharply reduced around 2300–2200 BC. Finally a social-environmental crisis is identified around 2300–2100 BC, characterised by a general abandonment of the foothills as well as coastal and floodplain areas that were densely occupied until this period. At the same time, a hydroclimatic crisis with a high frequency of extreme events is recorded from the Rhône valley to the foothills of the southern Alps (Lake Ledro; Vannière et al. 2013) with large effects on settlement systems in the floodplains, and we observe changes in sociocultural models. The Late Neolithic economic model, based on a high specialisation (pastoralism, metallurgy) was faced with an increasing aridity causing a low environmental resilience (scarcity of water and vegetation, soil erosion, etc., exceeding the resistance thresholds and regeneration capacity of ecosystems), especially in garrigue areas, which probably crystallised social tensions (development of enclosures and fortified sites). From 2400–2300 BC, the Late Neolithic III societies experienced the cumulative effects of a growth crisis and rapid climate change which caused the breakdown of the established socio-environmental system.

Between 2200–1800 BC, the attraction of intermediate areas (Auvergne medium-high mountains), and of high mountains (Pyrenees, northern and southern Alps) causes a reorganisation of settlement around pastoral and cynegetic activities (Marguet et al. 2008; Rey et al. 2008) or mining (Bailly-Maître/Gonon 2008; Carozza et al. 2010a). The development of resource exploitation (metallurgy) in the high mountains of the Alps is well identified and dated in the Queyras and Oisans (Fig. 21). It also seems to be found at high altitude around the Mercantour lakes in the Maritime Alps (Brisset et al. 2012). Populations at this time enjoy a milder climate at high altitudes, during a long phase of Swiss glacier recession around 2900–1650 BC (Holzhauser et al. 2005; Joerin et al. 2008), which reaches a maximum between 2200 BC and 1900 BC (Joerin et al. 2006; Joerin et al. 2008). The development of ore resources exploitation at high altitude in the Alps occurs as the Mediterranean climate gradient increases. On a larger scale, the Early Bronze Age undergoes a change of polarity (relocation of demographic centres) with cultural contributions coming from Central Europe and Italy, and also from the Channel and the North Sea.

An overview of information regarding land use and the exploitation of mountain areas (mainly for mining and farming) reveals reverse dynamics around the 4.2 ka BP event and the likely reorganisation of populations in the French geographical area (Fig. 22). In the northernmost areas around the English Channel, the period corresponding to new forms of settlement (small in size as well as less fortified and monumental than during the previous period), to a specialisation of activities (hunting, fishing) along major rivers, associated with high mobility. Some large sites illustrate continuous occupation and even a greater occupation between 2400 BC and 2000 BC, in the low valley of the Seine in particular (Fig. 23). The enlargement of the spatial focal point shows that we are probably witnessing changes in the cultural polarity – towards the northern temperate zones along the Channel/North Sea and eastwards into the Alpine region/Italy and Central Europe, while the low alluvial plains and northern Mediterranean coast appear largely abandoned until the development of Early Bronze Age I villages (from 2100 BC onwards; Fig. 22).

Acknowledgements

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3 a–b J.-F. Berger
4 a after Magny et al. 2011; b after Magny et al. 2007; c after Hoffmann et al. 2008; d after Berger 2015; e after Berger et al. 2008; f after Arnaud et al. 2012
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Bislang erschienene Bände in der Reihe »Tagungsbände des Landesmuseums für Vorgeschichte Halle«

Die Reihe der Tagungsbände des Landesmuseums wurde 2008 ins Leben gerufen. Anlass dazu war die Konferenz »Luthers Lebenswelten«, die im Jahr 2007 in Halle ausgerichtet wurde. Bereits der zweite Tagungsband widmete sich mit dem Thema »Schlachtfeldarchäologie« dem Mitteldeutschen Archäologentag, der seit 2008 jährlich von Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt veranstaltet und zeitnah publiziert wird. Dem großen Anteil internationaler Autorinnen und Autoren entsprechend, erscheinen viele Beiträge dieser Reihe in englischer Sprache mit deutscher Zusammenfassung.

Mit dem bislang zuletzt erschienenen Tagungsband konnten die Vorträge und Posterpräsentationen des 6. Mitteldeutschen Archäologentags »Metalle der Macht – Frühes Gold und Silber« in zahlreichen Artikeln renommierter Forscher verschiedenster Fachdisziplinen vorgelegt werden.

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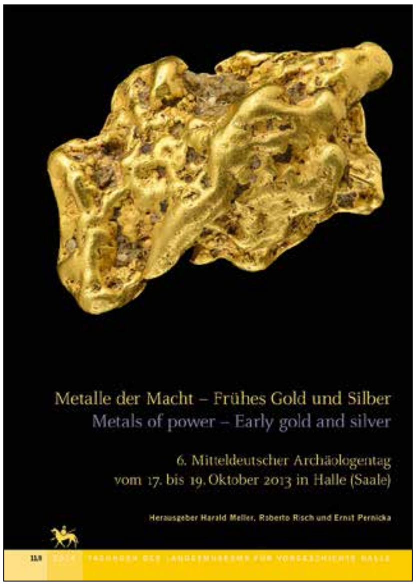

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