# Reassessing the Mesolithic/Neolithic 'gap' in Southeast European cave sequences

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ABSTRACT – Radiocarbon sequences from some northern Mediterranean cave sites show a temporal gap between Mesolithic and Neolithic occupations. Some authors regard this as a regional phenomenon and have sought to explain it in terms of a general population decline in the late Mesolithic, which facilitated the replacement of indigenous foragers by immigrant farmers. New evidence from the rockshelter site of Mala Triglavca, in Slovenia, leads us to question this view. The results of AMS radiocarbon dating of samples recovered in excavations in the 1980s and associated soil/sediment analyses reveal evidence of substantial postdepositional disturbance of the cave sediments by human agency and geomorphological processes, which have created 'temporal gaps' and 'inversions' in the radiocarbon sequence and secondary deposits with residual finds.

IZVLEČEK – Zaporedja <sup>14</sup>C datumov iz nekaterih jamskih najdišč severnega Sredozemlja kažejo časovno vrzel med mezolitsko in neolitsko poselitvijo. Nekateri avtorji to vrzel razumejo kot regionalni pojav in ga razlagajo z zmanjšanjem mezolitskih populacij, kar naj bi olajšalo zamenjavo domorodnih lovcev-nabiralcev s kmetovalskimi prišleki. Novi dokazi iz spodmola Mala Triglavca to hipotezo spodbijajo. Rezultati neposrednega AMS <sup>14</sup>C datiranja vzorcev izkopavanj v 80. letih in sedimentne analize so pokazali na možne postdepozicijske spremembe depozitov, ki so ustvarile časovne vrzeli in inverzije v sekvenci <sup>14</sup>C datumov in sekundarne depozite z rezidualnimi najdbami.

KEY WORDS - Mesolithic, Neolithic, cave sequences, radiocarbon dating, Mala Triglavca

#### Introduction

It is often assumed that Mesolithic-Neolithic continuity or discontinuity of settlement relates to the processes involved in the transition to farming, and can be recognized and read directly in the depositional sequences of archaeological sites and their associated artefact assemblages. This view derives from the conceptual conversion of geological into cultural stratigraphy and the acceptance of lineal radiocarbon sequences as representing sequential accumulations of deposits through anthropogenic activities. Lineal series of radiocarbon dates from individual sites tend to be interpreted as a direct record of habitation, with any discontinuity being seen as a gap in occupation and, by extension, in local or even regional Mesolithic-Neolithic cultural trajectories. Thus the neolithization of southeast Europe, and the Adriatic basin in particular, has become instrumentalised by 'comparative stratigraphy' that links Anatolia (Çatal Höyük, Suberde and Beldiba) with the Peloponnese and southern Balkans (Franchthi, Argissa, Sesklo, Vlush, and Drenovac) and the Adriatic (Škarin Samograd) (*Parzinger 1993.53, 65–78, 190, 254*). Recently, attention has focused on cave deposits, with several authors arguing for well-defined breaks between the Mesolithic and Neolithic. In this paper, we discuss the evidence from the rockshelter site of Mala Triglavca, in Slovenia, which has a critical bearing on the issue.

# Continuity or gap?

Mark Pluciennik (1997) noted a hiatus of several centuries to a millennium or more between Mesolithic and Neolithic occupations in radiocarbon sequences from northern Mediterranean sites. Rather than accepting the gap as real, Pluciennik used it to highlight a number of conceptual issues relating to the transition to farming. The gap was seen as symptomatic of the periodization of the archaeological record into Mesolithic and Neolithic and the treatment of the Neolithic as radically different from the Mesolithic. He proposed several possible explanations for the phenomenon, ranging from taphonomic and methodological problems connected with archaeological visibility, to changes in settlement pattern.

However, the evidence of discontinuous occupations of individual sites was translated into regional cultural or demographic phenomena. Based on two well-studied sites with clear evidence of the gap, Theopetra (Karkanas 1999; 2001) and Franchthi (Farrand 2000; 2003), Laurens Thissen suggested there was "a stratigraphic discontinuity between the Latest (or Final) Mesolithic and the onset of the Neolithic both in Thessaly (at Theopetra) and in Southern Greece at Franchthi" (Thissen 2005.35). Others maintain that the gap is a wider regional phenomenon, using it to argue for radical change between the Mesolithic and the Neolithic. Biagi and Spataro (2001) reviewed the radiocarbon dates from selected cave sites in the central Mediterranean, and found evidence of a hiatus between the latest Mesolithic and earliest Neolithic occupations in every case. From this, it was suggested that the late Mesolithic (Castelnovian) was a period of population decline, with the hunter-gatherers disappearing altogether soon after the arrival of farming. This in turn was seen as evidence that neolithization of the circum-Adriatic region had proceeded largely by 'demic diffusion' (Biagi and Starnini 1999.12; Biagi 2003. 148-150).

In this paper we argue that the interpretation of the gap in terms of a widespread demographic decline of hunter-gatherers is problematic. There could be a number of different, and quite complex, processes behind the phenomenon, unconnected with demographic trends. In some cases a gap may simply be a function of 'sampling bias', caused by too few dated samples and/or inconsistent stratigraphic or spatial sampling. Cave excavations in the region are typically small in scale (sondages), which means that our interpretations are invariably based on only a very small sample of the deposits. A lack of proper stratigraphic control in excavations has often compounded the problem.

In any case, Mesolithic settlement patterns should not be interpreted in a reductionist manner. A Mesolithic settlement pattern is not just a distribution of points in space, to be studied in isolation without reference to the wider context. Rather, it is a remnant of wider economic, demographic and social structures. The long-term reproduction - social and demographic – of such structures is reflected in a stable settlement system. In this perspective the Mesolithic record becomes a densely or loosely connected network spanning large areas (Wobst 1974; Chapman 1990). Hunter-gatherer settlement patterns and associated structures are dynamic and flexible, and this is another factor that potentially can affect the occupational sequences of individual sites. Thus 'gaps' in the radiocarbon sequence of a particular site do not necessarily reflect demographic breaks and depopulations, but equally could be the result of factors such as altered mobility patterns or site use.

Moreover, other evidence argues against the idea that the transition to farming in the region relates to demic diffusion of immigrant farmers and the demographic extinction of the indigenous hunter-gatherers. The European genetic landscape was reshaped recently by the identification of subclades I1a, I1b\*, 11b2, and 11c of I Y chromosomes. Haplogroup I is the only autochthonous haplogroup that is almost entirely restricted to the European continent where it shows frequency peaks in two areas, Scandinavia and southeast Europe (Semino et al. 2000.1155-1159; Rootsi et al. 2004.129-134; 2006). The I1b\* subclade reaches maximum frequencies in southeast Europe including the Balkan peninsula, suggesting strong Mesolithic-Neolithic demographic continuity in the region (Barać et al. 2003).

It should also be noted that in some sites the existence of a gap is by no means certain, because the 2-sigma calibrated age ranges of the radiocarbon dates for the latest Mesolithic and earliest Neolithic occupations overlap. This is the case, for example, at Sidari on Corfu (*Sordinas 1969*), Konispol in Albania (*Russell 1998; Schuldenrein 1998*), Odmut in Montenegro, (*Srejović 1974; Kozłowski et al. 1994*), and Vela Spila in Croatia (*Čečuk and Radić 2005*). However, considering the circum-Adriatic region as a whole, it is noticeable that there are significantly fewer radiocarbon dates for the period 6600–6000 cal BC compared to the six centuries immediately before or after; this requires explanation, but it is beyond the scope of the present paper, except to observe that this period contained two key events, one climatic (the '8.2 ka event') and the other cultural (the spread of agriculture through the Balkan and Italian peninsulas), which probably impacted significantly on demography, settlement pattern, and the use of caves and rockshelters (*e.g. Bonsall et al.* 2002; Weninger et al. 2006; Budja 2007).

Mlekuž (2005) and Forenbaher and Miracle (2005; 2006) considered the evidence from the northern Adriatic in some detail. They acknowledged that the individual <sup>14</sup>C sequences from cave and rockshelter sites on the Triestine karst and in Istria (e.g. Benussi/ Pejca na Sedlu, Edera/Stenašca, and Pupićina) show a temporal gap between the latest Mesolithic and earliest Neolithic occupations. However, they observed that the gap varied in duration and was not synchronous among the sites, that the latest date for a Mesolithic context at Benussi is similar to the earliest dates for 'Neolithic' contexts at Edera (layer 3a), Podmol pri Kastelcu (layer 13), and Pupićina in Istria, and that there are still a number of sites with undated Late Mesolithic-Early Neolithic sequences. From this they concluded that, in spite of the existence of temporal gaps in individual sites, there was no reason to assume a general hiatus in settlement across the region as a whole. Rather, it was suggested that the lack of radiocarbon evidence and hence the existence of gaps at individual sites could reflect complex economic and social processes occurring in the region at the time, either pioneer colonization of farmers and subsequent interactions with indigenous populations in the hinterland (Forenbaher and Miracle 2006) or internal transformations of Mesolithic groups (*Mlekuž 2005*).

Current distributions of Mesolithic sites have been distorted by sea level rise during the early- to mid-Holocene, and the Mesolithic settlement pattern is biased in favour of upland caves throughout the Dinarides, while there is a selective field survey bias in favour of lowland, open-air Neolithic sites (*Chapman 1994*). The dated archaeological record for the Mesolithic-Neolithic transition is thus an obviously biased sample, based mainly on cave stratigraphies (*cf.* Biagi and Spataro's [2001] sample, which consists of caves only).

Caves are sediment traps in which archaeological deposits can accumulate over long periods of time. This characteristic has made them invaluable for recording long-term patterns of social and demographic processes. However, as geoarchaeological and taphonomic studies have accumulated, it has become increasingly apparent that the interpretation of the archaeological record from these contexts is often problematic.

An important topic which has to be considered in the discussion of Mesolithic-Neolithic continuity is the evidence of sedimentary hiatuses or erosional surfaces between Neolithic and Mesolithic layers. Well-documented examples have been reported from Franchthi Cave (Farrand 1993; 2000; 2003) and Theopetra Cave (Karkanas 1999; 2001) in Greece, and linked to climate change (Karkanas 2001). They have been noted also at many sites on the northern Adriatic karst, including Edera, Caterina, Azzura, Zingari and Lonza (Boschian and Montagnari Kokelj 2000). In Grotta Azzura intact Mesolithic layers were found in a test trench in the front of the cave; the test trench inside the cave contained only traces of Castelnovian layers (Cremonesi et al. 1984). In the Pupićina Cave the Middle Neolithic strata are deposited directly on an early Mesolithic surface, which was compacted through trampling (Miracle and Fo*renbaher 2006*). While climate change may have been a contributory factor, these erosional surfaces and sedimentary hiatuses may largely reflect intensive anthropogenic modifications of the cave interiors, which happened at least once, at the beginning of the Neolithic, destroying evidence of late Mesolithic occupation. Reworking of older deposits appears to have been a primary process in the formation of the Neolithic layers in Edera (Boschian and Montagnari Kokelj 2000). This discontinuity also marks a completely different use of caves: from gatherings of people in the Mesolithic, to animal shelters or sheep pens in the Neolithic, which is a well-known pattern in caves and rockshelters throughout the Mediterranean (Brochier et al. 1992; see also Boschian and Montagnari Kokelj 2000). This could explain the presence of Late Mesolithic Castelnovian microliths in Neolithic deposits in the Triestine karst caves (Montagnari Kokelj 1993) and the presence of anomalous radiocarbon dates and inversions in radiocarbon sequences.

# Mala Triglavca case study

Mala Triglavca ( $45^{\circ}40^{\circ}$  N,  $13^{\circ}58^{\circ}$  E) is a rockshelter site on the Dinaric Karst of southwestern Slovenia, 15 km from the northern Adriatic coast (Fig. 1). The rockshelter opens in the side of minor doline, its north-facing entrance lying at *c*. 435m above sea level. It was formed in the bedded rudist limestone and is a remnant of the ancient cave system of the river Reka (Fig. 2).

Mala Triglavca was first described by France Leben on the basis of excavations undertaken between 1979 and 1985 (*Leben 1988*). Leben excavated the deposits in the western half of the rockshelter to a depth of *c*. 4 m below the cave floor. Excavation and recording were based on a grid of 2m squares, and the deposits removed in horizontal units (spits) of up to 20cm thickness. No sieving or flotation was undertaken. Though never fully published, Leben's excavation showed the site to have a rich archaeological inventory (see *Leben 1988; Turk and Turk 2004*) and a long occupation sequence extending back to the early stages of the Mesolithic at least.

Following site reconnaissance in the summer of 2001, new excavations were started in 2002 as a joint venture between the universities of Ljubljana and Edinburgh, with the parallel aims of clarifying the results of Leben's excavation and establishing a benchmark archaeological sequence for the local region.

Here we provide a description of the deposits within the rockshelter and discuss the results of AMS radiocarbon dating of animal bones and bone artifacts from Leben's excavation. We also highlight problems connected with the conversion of stratigraphic sequences into cultural and periodic sequences.

# Cave soils and sediments

Leben described the cave sediments in a paper written several years after his excavation (*Leben 1988*). The paper records 5 stratigraphic layers but these are

not easy to relate to the layers shown in the published diagram (*Leben 1988.Fig. 9*). That diagram shows the sequence of deposits between the entrance and the back wall of the cave. The position of the section line in relation to Leben's excavation grid is shown in Figure 4. In the central part of the cave, Leben's field drawing appears to show 7 main layers, which we have labelled I-VII in Figure 3. It is not entirely clear how these correspond with the 5 layers described in his 1988 paper, but we suggest the correlation shown in Table 1.

The lowermost layer (VII = 5) was described by Leben (1988) as "auto-

chthonous red clay with rubble". Archaeologically sterile, it was interpreted as Pleistocene in age. The overlying layers were attributed by Leben to the Holocene. Leben's (*1988*) lithological descriptions are incomplete, and the accounts in his field notes give little further information. The distinctions between layers III–VI appear to have been based mainly on small differences in colour and stoniness. Horizontal ash lenses occurred throughout this part of the sequence.

He noted lateral changes in the composition of the sediments. Thus he describes the deposits at the cave entrance as a "*unified layer of compact red/ brown clayey soil with rubble and stones*" and notes that the deposits at the rear of the cave are more stony with occasional pockets of dark soil. According to the field drawing, layer boundaries became uncertain in the rear half of cave, but occasional stone lines are shown which could relate to palaeosurfaces.

In his 1988 paper Leben simplified this part of sequence into 2 layers (3 and 4) based mainly on archaeological content. Layer 4 (VI in Fig. 3) was assigned to the Mesolithic based on the presence of microliths and an absence of pottery. This layer also contained bone artefacts (including mattocks and piercers) and fragmentary remains of wild animals (mainly deer). Layer 3 contained Neolithic pottery as well as stone and bone tools. The faunal assemblage from this layer was dominated by the bones of wild animals, but approximately one-third were those of domesticated animals including cattle, sheep, goats, and dog. At the upper boundary of layer 3, Leben (1988) reported finding Eneolithic and EBA pottery.



Fig. 1. Mala Triglavca location map.



Fig. 2. Mala Triglavca.

Layers 1 and 2 (I-II) at the top of the sequence were described in Leben's field notes as consisting of "rubble and humus", with layer 2 reported as having a greater stone content. Pottery recovered from these layers was interpreted as belonging to various periods from LBA to modern.

In 2001, as a preliminary to the current series of excavations in Mala Triglavca, the section corresponding to the S wall of Leben's trench – which was 2– 3m east of Leben's main axial section – was examined and recorded after cleaning. However, the lowermost layer encountered by Leben had been obscured by debris fall and was not re-examined at that time. Detailed description of the cave deposits was confined to the central portion of the exposed face, between the 92 and 94m grid lines, although observations on the deposits at the rear of the cave and toward the entrance were also made.

Initial observations showed that the cave deposits had been extensively modified by soil forming processes, including biotic disturbance and soil structure development. Therefore, it was decided to adopt a pedological (as opposed to sedimentological) approach to the description of the section, using internationally accepted methods described in Hodgson (1976). This recognizes layers as soil horizons, but does differentiate lithologically distinct layers through the use of numerical prefixes (Tab. 1, Fig. 5). Soil pH was measured on soil samples collected from the main horizons recognized. This was done using a pH meter with combined electrode on soil suspensions with a soil:distilled water ratio of 2:5 (Avery and *Bascomb 1982*). Calcium carbonate content was estimated by the dilute hydrochloric acid field test using the criteria defined by Hodgson (*1976*).

Starting from the cave floor, we distinguished seven horizons/layers. Broadly, these correspond to layers I-VI in Figure 3 (Leben's [*1988*] layers 1–4).

Table 1 shows that the materials have similar texture (particle size distribution) and reaction throughout, being a calcareous loam with average pH in the range 8.0–8.5. All horizons other than 6Bk show strong evidence of organic matter incorporation giving dark colours and clear evidence of biotic struc-

ture development, hence the granular structure observed throughout. These properties, together with the low porosity and packing density observed in all horizons other than 6Bk, indicate biotic disturbance of the cave sediments and their transformation into mull humus typical of soil surface horizons (Babel 1975; Duchaufour 1982). Living plant roots extend through all horizons, but are most abundant in the first three (Ah, 2AB, 3AB), including both fibrous and woody tree roots. These originate mainly from forest trees growing outside the cave. Rooting effects, including organic matter addition from dead roots, together with mixing by soil-ingesting invertebrates, are the main processes that have altered the sediments forming granular structured soil material.

The lithological differences between the soil horizons relate mainly to the frequency of stones and boulders, and the occurrence of extremely calcareous horizontal lenses. The latter occur throughout the 2AB, 3AB and 4AB horizons. In the main, these features correspond to the 'ash lenses' described by Leben. They are paler coloured and friable bodies up to 8cm thick and 40cm across in the section described. The strong concentration of CaCO<sub>3</sub> in these lenses, indicated by a very strong reaction with dilute HCl and high pH, suggests that if these are ash lenses, then some recalcification has occurred. At present it is difficult to estimate the contribution of dissolved calcium percolating through the developing soil horizons, which may have an external source, for example, calcium dissolved from the cave roof rather than from the cave sediments.

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A. PRE	SENT STUDY	B. Leben's study (Leben 1988, and field documentation)			
Laver			Layer (field		
Layer	Description	(Leben 1088)	cf. Fig. 2)	Description	
Ah	0–10/36cm.Very dark greyish brown (10YR 3/2), very calcareous loam;	1		Up to 30cm thick layer of rubble	
	pH 8.45; many very small and small angular, (tabular to equant form)			and humus; many roots.	
	limestone stones; strongly developed medium to fine granular bioti-				
	cally-derived soil structure; many medium and coarse woody roots;				
	common to many fine fibrous roots proliferate in some areas; sharp				
2AB	10/26–68/84cm Same colour texture soil structure root frequency	2		Laver of cave humus with angular	
2710	as the overlying Ah horizon: $pH 8.45$ : stones increase abruptly to	-		rubble, with many larger stones	
	extremely abundant very large and large angular (tabular to equant			(collapsed cave ceiling). It varies	
	form) limestone stones, some with subrounded elements on one side;			in thickness from 20-30cm (in the	
	this horizon becomes much thicker near the back wall of cave;			central partof the cave) to up to	
	occasional paler coloured greyish brown (10YR 5/2) to light brown			120cm (near the southern and	
	(10YR 6/3) extremely calcareous, friable, horizontally-aligned lensoid			western cave wall, whereat this	
	bodies 2–3cm thick and 20-30cm long; clear irregular lower boundary.			depth loose black soil with stones	
	edge smoothed and subrounded indicates solution weathering and			lavers 1 and 2 is not clear	
	rockfall from the cave roof, which is most likely due to frost weathering.				
3AB	68/84–160/170cm. Same colour, and texture as 2AB; pH 8.20;	3	III–IV	'Horizon 3a' Black, humose, loose	
-	strongly developed fine granular to fine subangular blocky biotically-			deposit with less rubble than layer	
	derived soil structure; far fewer stones; woody roots still common as			2. Contains many features: ash	
	above, but the frequency of fibrous roots decreases to common;			lenses and patches of burnt clay.	
	occasional faint, extremely calcareous brownish grey (10YR 5/2) to			Thickness 100–120cm. Pottery.	
	light brown (10YR 6/3) friable, horizontally-aligned lensoid bodies;				
	discontinuity in stone content indicates in washing or blowing in				
	of soil material.				
4AB	160/170–194–204cm. Same colour, texture, root frequency as 2AB;				
	pH 8.34; abundant large angular (tabular to platy form) limestone				
	stones of no particular alignment; strongly developed, biotiically-				
	derived, medium to fine granular soil structure; abrupt, irregular				
	boundary. This horizon thickens toward back wall of cave and the				
	story layer indicates a major rockfall from the cave roof				
5bAh	186-204 cm. A discontinuous buried horizon (paelosurface) of black	зb	V	'Horizon 3b' Darker sandy and	
	(7.5YR 2/0) humose, calcareous loam, pH 8.16. Less stony than 4AB			burnt soil with small rubble (or no	
	with common to many large angular (tabular to platy form) lime-			rubble). No pottery.	
	stones stones. Strongly developed medium to fine biotically-derived				
	granular structure. Common burnt and unburnt bones. Abrupt,				
	smooth boundary. The higher organic matter content of this horizon				
6Bk	could be due to addition of organic material by human agency.		VI	Black darker laver of rubble with	
ODK	(10YR 6/2) extremely calcareous horizontally-aligned lensoid body	4	VI VI	features of decomposed rubble	
	of loose to massive silt loam; stones decrease to common, i.e. fewer			and two remains of hearths.	
	stones than in 5bAh; pH 8.45; locally common small nodules of				
	CaCO3; black inclusion similar to 5bAh lens; few woody roots.				
	The less stony character, lensoid form and black inclusion of this				
	discontinuous horizon suggests a pit infill.				
7bAh	240/250-280cm (base of section). Black to very dark brown (10YR				
	and large angular limestone stones: strongly developed medium to				
	ine to medium granular biotically-derived soil structure: occasional				
	fine woody roots; common animal bones often concentrated in less				
	stony pockets suggests a midden; few snail shells; lower boundary				
	not seen;. The high frequency of animal bones agrees with Leben's				
	description of his Layer 4, regarded as Mesolithic in age. Large organic				
	matter content may relate to the decay of midden material and bones				
	nansiormed by blotic soil forming processes.	г	\/11	Autochthonous red clay ('cavo	
		5	VII	earth') with rubble. Pleistocene	
				deposit.	

Tab. 1. Characteristics of soils and sediments in Mala Triglavca rockshelter: a) present study; b) Leben's study.

At a depth of 186cm, a much darker humose layer was encountered (5bAh). This was black (7.5YR2/0) in colour, and is interpreted as a buried surface with a larger organic carbon content, possibly with finely divided charcoal. The colour suggests the addition of organic material by human agency. This layer also contained common burned and unburned bone fragments.

In one place in the central part of the section, this dark layer rested directly on lighter greyish, extremely calcareous material, which took the form of a lenticular body c. 115cm long and 40-50cm thick (6Bk). This very porous but massive material compressed easily and was non-sticky, indicating a high carbonate or ash content. In places, firmer and denser areas coincided with the presence of small nodules of calcium carbonate. It also contained black, humose inclusions similar in composition to the 5bAh horizon. The much less stony character of this feature suggests some kind of pit infill. The other pedological features indicate solution of calcium derived from the ash and/or limestone fragments and re-precipitation of secondary calcium carbonate as intercalary crystals or nodules. Although the black colour of this horizon might suggest finely divided charcoal, no other evidence of burning in the form of larger charcoal fragments or burned stones was recorded.

Toward the base of the section, at approximately 240cm, another black to very dark brown humose horizon was recorded (7bAh). This was also interpreted as a buried surface. As with the overlying horizons, this was a very calcareous loam, and contained abundant medium and large angular limestone stones. Bones were also common, concentrated in less stony pockets, together with a few landsnail shells.

The variability in stone content throughout the section can in part be attributed to rockfalls from the roof and walls of the cave, most probably due to frost shattering. In the 2AB horizon stones were very large and extremely abundant, consisting of angular limestone, but with subrounded elements on one side. This juxtaposition of form can be attributed to solution weathering on the cave roof, thus proving the origin of this stony material. This is further proven by the thickening of this extremely stony layer towards the rear wall of the rockshelter where stones are tabular or platy with a distinct horizontal alignment indicating a recent fall from the roof with little disturbance of horizontal bedding.

In parts of the underlying horizons, stone lines were apparent. In the 3AB horizon at 106cm an alignment of medium to large angular stones may also represent a minor rockfall from the cave roof, or an arti-



Fig. 3. Leben's main axial section drawing with position of samples for radiocarbon dating (Tab. 2).

ficial stone pavement. However, much of the 3AB horizon was much less stony than the overlying or underlying horizons.

Generally, the variation in frequency of stones in the different horizons could relate to variations in the intensity of rockfalls, inwashing or wind deposition of stoneless sediment, or indeed, preferential removal of stones by human agency. The horizons recognized in the central part of the section became difficult to trace toward the rear of the rockshelter. The more chaotic arrangement of stones and boulders and subhorizontal alignment along what appear in some cases to be shear planes, suggests that disturbance through rotational slumping of the materials has occurred. This was confirmed in 2006, after several seasons of excavation, when pottery from different periods (Middle Neolithic/

Vlaška culture and Eneolithic/Ljubljana culture) was found on either side of a distinct shear plane. Moreover, the horizontal alignment of the recent rockfall described earlier is nowhere seen in these lower layers to the rear of the rockshelter. Possible explanations include slumping of super-saturated cave sediments after overloading by rainwater running into the cave, and movements triggered by seismic activity. There is a significant slope leading into the rockshelter and the amount of surface water which runs in during storms can be high. Solution weathering at the rear of the cave may periodically have destabilized the adjacent deposits, facilitating movement.

#### **Radiocarbon Dating**

Samples of terrestrial mammal bone from Leben's excavation were selected for AMS <sup>14</sup>C dating, together with an additional pottery sample. The objectives were to establish the ages of the different layers, and to test the stratigraphic integrity of the sequence.

All the dated materials show evidence of anthropogenic modification, either in the form of manufacturing traces (bone tools) or fragmentation (animal bones).

Eight samples from bones of large mammals were submitted to the Poznan lab. A further 12 samples



*Fig. 4. Leben's excavation grid with density of pottery sherds per grid square.* 

were taken from individual antler and bone artefacts using high-speed steel drills, and submitted to the Oxford Radiocarbon Accelerator Unit. The samples submitted to Oxford weighed between 200mg and 620mg, while those submitted to Poznan were fragments weighing between 300mg and 1200mg. Collagen extractions were performed using each laboratory's standard procedure. The Oxford procedure included an ultrafiltration step. This usually produces collagen of improved quality (for details, see Bronk Ramsay et al. 2004; Higham et al. 2006. 556). Collagen quality and chemical integrity are assessed using the atomic ratio of carbon to nitrogen (C:N atomic ratio), the percentage of collagen extracted compared with the starting weight of bone (wt% collagen), and the carbon yield of the collagen on combustion. Problem bones may be screened on the basis of these parameters. Bone is considered acceptable if measured C:N ratios of collagen fall between 2.9 and 3.5. In addition, bone that is composed of less than 1wt% collagen is not dated. Collagen yield in five of the samples submitted to Oxford fell below this threshold value, and so only 7 of the 12 samples submitted were actually dated. One pottery sherd was submitted to the Poznan laboratory, where organic residues on the pottery were extracted and dated. The 16 radiocarbon dates obtained from the Oxford and Poznan labs are presented in Table 2.

The radiocarbon sequence documents frequent use of the cave from 8400 BP to at least 3700 BP. The dates fall into three distinct clusters (8400–7900, 7600–7200 and 6600–6000 BP) with some outliers. However, the clusters as well as the gaps in the sequence (7900–7600 BP, 7200–6600 BP) could be the result of the sampling.

A consideration of the relation between depth/stratigraphic context and age reveals some obvious inversions in the sequence. However, the inversions can be observed only in the sequence from grid squares 4 and 5 in the rear of the cave, close to the cave wall, where horizon boundaries became uncertain, evidence for rockfalls increases (Tab. 1) and the presence of shear planes was noted.

The dates from the central part of the cave (grid squares 2, 3, 6, 7), where horizons could be clearly defined, show no obvious inversions. Here, a long gap of  $1770 \ ^{14}$ C years can be observed between OxA-15139:  $6451 \pm 36$  BP) and OxA-15138:  $8225 \pm 40$  BP. The dates come from successive spits. The boundary between these spits at 3.05m depth corresponds to the boundary between Leben's horizons 3a and 3b (4AB and 5bAh, Tab. 1). According to the

excavator, the main difference between the two layers was the presence of pottery and bones of domesticated animals in layer 3a and their absence from layer 3b (*Leben 1983*).

Therefore, the gap of 1770 radiocarbon years probably corresponds to a sedimentary hiatus or erosional surface, separating Mesolithic and Neolithic deposits in the central part of the cave. The recorded morphology of the 5bAh horizon supports this feature as a paleosurface (Tab. 1). The 'missing' dates corresponding to this temporal gap (OxA-15136: 7255 ± 40 BP, Poz-14232: 7630 ± 50 BP, Poz-16341: 7950  $\pm$  50 BP) occur in the deposits at the rear of the cave, in grid squares 4 and 5. Occasional stone lines inclined upward toward the back of the cave suggest that the deposits in this part of the cave were formed in a different way from those in the central area of the cave. These deposits could be the result of movement of material from the central part of the cave due to human agency, combined with natural processes operating at the back of the cave, redepositing rockfall as scree, which was subsequently buried by finer sediment to produce inclined stonelines. Therefore, it may be suggested that at some time before 6400 BP, sediments originally deposited

Sample	Grid	Level	Lab ID	¹4C age yr B.P.	Error	δı3C	Cal yr BC age range (2σ)	Median probability of cal yr BC age range
red deer mandible	4	2.70	Poz-14232	7630	50		6591–6420	6477
large ungulate humerus	5–6	3.50-3.70	Poz-14241	8210	50		7446–7070	7226
large ungulate scapula	7	2.90-3.05	Poz-14243	5980	40		4988–4750	4869
Bos seu Bison skull	5–6	3.50-3.70	Poz-14244	8020	50		7075–6710	6932
Sus scrofa maxilla	3A	"directly above Pleistocene layer"	Poz-14245	8070	50		7180–6820	7046
red deer antler	4	2.50-2.70	Poz-16341	7950	50		7041–6691	6867
human skull	4	2.50 "above breccia deposit"	Poz-16342	5120	40		4031-3798	3893
Capra horn core	3	1.90	Poz-15343	3690	40		2198–1959	2081
pottery fragment	4	2.70-3.00	Poz-21395	6320	40		5460-5214	5301
antler, red deer ("beam chisel")	5	4.10	OxA-15134	6602	37	-20.4	5617–5485	5546
antler, red deer ("beam chisel")	4	4.05	OxA–15135	8430	45	-20.8	7582-7367	7514
antler, red deer ("beam chisel")	5–6	3.60–3.75	OxA–15136	7255	40	-21.9	6221–6034	6133
bone, large ungulate ("splinter")	4	3.70-3.90	OxA–15137	7229	38	-18.7	6211–6020	6090
bone, roe deer ("fine 1/2 point")	6	3.05-3.25	OxA–15138	8225	40	-21.1	7446–7081	7242
bone, roe deer ("tip of medium point")	7	2.90-3.05	OxA-15139	6451	36	-19.2	5481-5343	5418
bone, red deer ("fine point")	4	3.70-3.90	OxA-15223	6647	37	-19.3	5635–5511	5579

Tab. 2. AMS <sup>14</sup>C ages and associated contextual data for mammalian bone pottery samples from Leben's excavation in Mala Triglavca rockshelter. Calibration performed with CALIB 5.0.2 (Stuiver & Reimer 1993; Stuiver et al. 2005) using the IntCal04 curve (Reimer et al. 2004).

between 8200 and 6400 BP in the central part of the cave were moved toward the rear of the cave and redeposited against the cave wall. One date  $(OxA-15136: 7255 \pm 40 BP)$  is on a bone tool (red deer antler beam "chisel"), while others (Poz-14232: 7630 ± 50 BP, Poz-16341: 7950 ± 50 BP) are on fragmented animal bones and antlers (Tab. 2). Thus, in our opinion all three dates, which correspond to the hiatus in the central part of the cave, indicate human use of the cave during this period. The deposits at the rear of the cave contain large quantities of cultural material, including lithics, bone tools, pottery, and fragmented animal bones. The spatial distribution of pottery, with concentrations of pottery sherds near the cave walls (Fig. 4), suggests that movement and redeposition of material at the cave walls (possibly associated with living floor maintenance) continued after 6400 BP. A pottery fragment from grid square 4, dated to  $6320 \pm 40$  BP (Poz-2139) further supports this hypothesis.

However, there appears to have been another process that altered the positions of deposits within the cave. Three dates, Poz-2139:  $6320 \pm 40$  BP., OxA-15223:  $6647 \pm 37$  BP and OxA-15137:  $7229 \pm 38$  BP from the rear of the cave (grid squares 4 and 5) create a depth/age inversion with the dates above

them (Poz-14232: 7630 ± 50 BP, Poz-16341: 7950  $\pm$  50 BP, OxA-15136: 7255  $\pm$  40 BP). They relate to a level corresponding to Leben's Mesolithic layer 4 (equivalent to 7bAh in Table 1). This suggests that there were postdepositional processes, which led to vertical displacement of material. It seems likely that this movement is connected with the curved shear/ erosional planes discovered in 2006 (see above), most likely caused by periodic slumping of cave sediments after overloading by rainwater running into the cave. These rotational slumps (Selby 1993) were probably localized and connected with the presence of cavities or conduits penetrating the bedrock at the back of the cave, which provided a further destabilizing factor. Unfortunately, the low resolution of Leben's contextual information for the dated material does not allow us to localize those processes.

The evidence presented for disturbance of the cave sediments by soil formation, in particular bioturbation (Tab. 1), is not regarded by the present authors to have significantly affected the stratigraphic sequence of the sediments in the central parts of the cave. The finer fractions of the sediments have certainly been substantially transformed into soil materials with the form of mull humus, however, larger clasts (stones and boulders) and larger archaeologi-



Fig. 5. Section corresponding to W wall of Leben's trench, recorded in 2001.

cal objects, including those used for dating, have probably remained more or less in situ, providing lithologically distinct layers. However, smaller, undated animal bones and bone tools could indeed have been translocated by soil forming processes.

#### Pottery

Leben's layer 3 contains Neolithic and Eneolithic pottery. The assemblage is modest in size; 690 pottery fragments could be attributed to this layer. The ceramic material is very fragmented and only 29 whole vessels could be reconstructed. The assemblage was investigated for its technological and typological properties on a macroscopic level, and subsequently archaeometrical analyses of pottery samples from the site were also conducted (*Žibrat Gašparič 2004. 206–209; 2008.44–64*). The material includes some ceramic vessels that are typical of the Neolithic period in this region, including bowls ornamented with triangles, tulip shaped cups, and a rhyton fragment (Fig. 6: MT22/00, MT 24/03; *Žibrat Gašparič 2004. Fig. 2, 1–3*).

Three main groups of ceramic matrixes were identified at the macroscopic level. The group with calcium carbonate is by far the most abundant; 78.3% of all the samples from Leben's layer 3 belong to this group. The group with calcium carbonate and quartz constituted 18.9%, and the group with quartz made up only 2.7% of the total assemblage. Calcium carbonate in the form of the mineral calcite was added as temper to the clay, as shown by the mineralogical analysis of the material (*Žibrat Gašparič 2004.215– 216*).

The distribution of the pottery sherds in the cave shows distinctive patterning, with pottery concentrations in the grid squares adjacent to the cave walls, where average potsherd weight is also higher than in the grid squares in the central part of the cave (Fig 4). This evidence supports the hypothesis that material in the cave was moved and deposited, or redeposited, near the cave wall. Grid square 4, located at the back of the cave, contains most of the pottery from Leben's layer 3 (232 fragments or 33 % of the ceramic material from the layer). This material is mixed; it includes artefacts that can be securely attributed to the Neolithic and Eneolithic periods on the basis of typological characteristics. One potsherd from grid square 4 was dated by the AMS <sup>14</sup>C method. The result (Poz-21395:  $6320 \pm 40$  BP) places the potsherd firmly in the Neolithic (Žibrat Gašparič 2008.48, Fig. 4.2).

In an effort to determine the provenance of the pottery from Mala Triglavca, clay samples were taken mostly in a 5km radius around cave, as proposed by Arnold (1985.32–34) for prehistoric sites. Samples were taken from the Mala Triglavca rockshelter, from the nearby archaeological site of Trhlovca, from local caves or denuded caves in the vicinity (*e.g.* from Divaška jama, dolina Radvanj, Lipove doline), as well as from some more distant locations on the Karst plateau (Tomaj), from Vremsko polje, and from the Slovene coastal area near the open-air Neolithic site of Sermin near Koper (*Žibrat Gašparič 2008.89–* 96).

The analyses revealed the clay samples from cave sites and the samples from Vremsko polje to have a mineralogical composition similar to the natural clay matrix of the Neolithic pottery from Mala Triglavca, from which it is inferred that the pottery was produced locally. Only the clay samples from the Slovene coastal region (e.g. from Sermin and Rižana near Koper) could not be linked to the Neolithic pottery production of Mala Triglavca, mainly because they contained calcareous molluscs (not present at Mala Triglavca) but also a lower concentration of the mineral haematite (*Žibrat Gašparič 2008.97–100*). Trace element analysis revealed similarities between the Mala Triglavca ceramic assemblage and the clays from the Divača Karst region (*i.e.* from the locations of Divaška jama, Trhlovca, dolina Radvanj and Lipove doline) and from the nearby Vremsko polje (*Zib*rat Gašparič 2004. Tab. 5; 2008.100-107. Fig. 4.32).

As part of a functional study of the pottery, 36 samples from layer 3 were analyzed for the presence of organic residues or lipids using the GC-C-IRMS me-



Fig. 6. Typical middle Neolithic bowl ornamented with triangles, from Leben's layer 3 with evidence of milk lipids (MT 22/00) and a rhyton fragment (MT 24/03).

thod. Lipids were present within the pottery fabric in 28% of the samples. Milk residues could be identified in 6 (16.7%) of the pottery samples analyzed from Mala Triglavca (*Šoberl et al. this volume*); these were detected in 3 bowls and 1 cup, one of which is a typical middle Neolithic bowl ornamented with triangles, from Leben's layer 3. (Fig. 6: MT 22/00). These results provide direct evidence of Neolithic dairying practices, and this line of research could lead to a new understanding of the function and social meaning of Neolithic pottery in the Caput Adriae region.

### Conclusions

The evidence from the current excavations and associated soil/sediment analyses at Mala Triglavca show that in the central part of the cave a well-defined stratigraphic sequence can be established, despite postdepositional modification by soil forming processes. There is, however, also evidence for postdepositional disturbance of the cave sediments by human agency and geological/geomorphological processes. Leben's description of the cave sediments assumed a straightforward stratigraphic sequence, failing to recognize the significance of postdepositional modifications. Where controls can be established, some postdepositional disturbances - for example, those resulting from soil forming processes such as bioturbation - do not significantly alter the superpositioning of larger components within sequential layers/horizons, as in the sequence described in Table 1. However, the current study has found substantial evidence for other postdepositional processes of greater magnitude including: rotational slumps and possible anthropogenic removal and transport of soil material. In places, such processes have transformed the stratigraphic sequence in Mala Triglavca rockshelter, altering original stratigraphic relationships, thus effectively creating a series of secondary deposits with residual finds.

The relatively large set of radiocarbon dates obtained on bone samples from Leben's excavation now enables some of the processes to be identified. Vertical displacement of material has created 'temporal gaps' and 'inversions' in the radiocarbon sequence. Two separate processes are indicated. One accounts for the radiocarbon gap detected in the sequence from the middle of the cave, which can be explained by late Mesolithic deposite having been removed from this area and redeposited against the rear wall of the cave – a process that was probably linked to human activity – and subsequently modified by natural processes resulting in inclined stonelines. Another postdepositional process resulted in the movement of material deeper into the cave, possibly due to rotational slumps, as evidenced by the presence of distinct shear planes. The precise nature of these anthropogenic and natural processes, and the relationship between them, is uncertain, but may be resolved through ongoing excavation of the site.

The work at Mala Triglavca underlines the fact that any stratigraphic or radiocarbon sequence may be a complex palimpsest, created and recreated through a series of interlinked processes. On the one hand, 'gaps' in the radiocarbon sequence do not necessarily represent periods of abandonment of a cave, but may reflect episodes of postdepositional disturbance and intensive modification and transformation of the cave sediments. They may also be created by having too few radiocarbon samples and by the selectivity of the sampling. Small scale excavation (typical for cave sites), failure to appreciate the effects of postdepositional processes, direct translation of series of radiocarbon dates into cultural sequences, and interpretative models that see the Neolithic as radically different from the Mesolithic, have all contributed to the creation of such gaps. The gaps detected by some researchers in the radiocarbon sequences of caves in southeast Europe around the time of the Mesolithic-Neolithic transition are perhaps symptoms of our approach toward the transition, rather than a reflection of radical cultural or demographic change associated with the displacement of Mesolithic foragers by immigrant farmers.

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