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TRANSITION OR REPLACEMENT? RADIOCARBON DATES FROM HOHLE FELS CAVE (ALB-DONAU-KREIS / D) AND THE PASSAGE FROM AURIGNACIAN TO GRAVETTIAN

Hohle Fels (Alb-Donau-Kreis / D) is a large cave (c. 6000 m³) on the southern margin of the Ach Valley in the Swabian Jura (**fig. 1**). The cave is a key site for the Swabian Palaeolithic and yielded extensive assemblages from all Upper Palaeolithic facies present in the region, namely the Aurignacian (Conard / Bolus 2006; 2003), the Gravettian (Taller / Conard 2016; Conard / Moreau 2004; Floss / Kieselbach 2004) and the Magdalenian (Taller 2014).

The Gravettian of the site is extensive with more than 36,000 lithic artefacts and a comprehensive assemblage of organic artefacts and ornaments. The Gravettian specimens come from the three layers IIb, IIc and IIcf. Layers IId and IIe have been called »transitional« (between the Aurignacian and the Gravettian; Bolus 2010), however now the evidence points towards an Aurignacian affiliation of IIe and a Gravettian one of IId (Taller / Conard 2016). The Gravettian assemblages from Hohle Fels fit well with those from nearby sites Geißenklösterle and Brillenhöhle (both Ach Valley / Alb-Donau-Kreis / D) and contain a wealth of Gravettian lithic type-tools such as Gravette points, Microgravette points, *fléchettes* and Font-Robert points

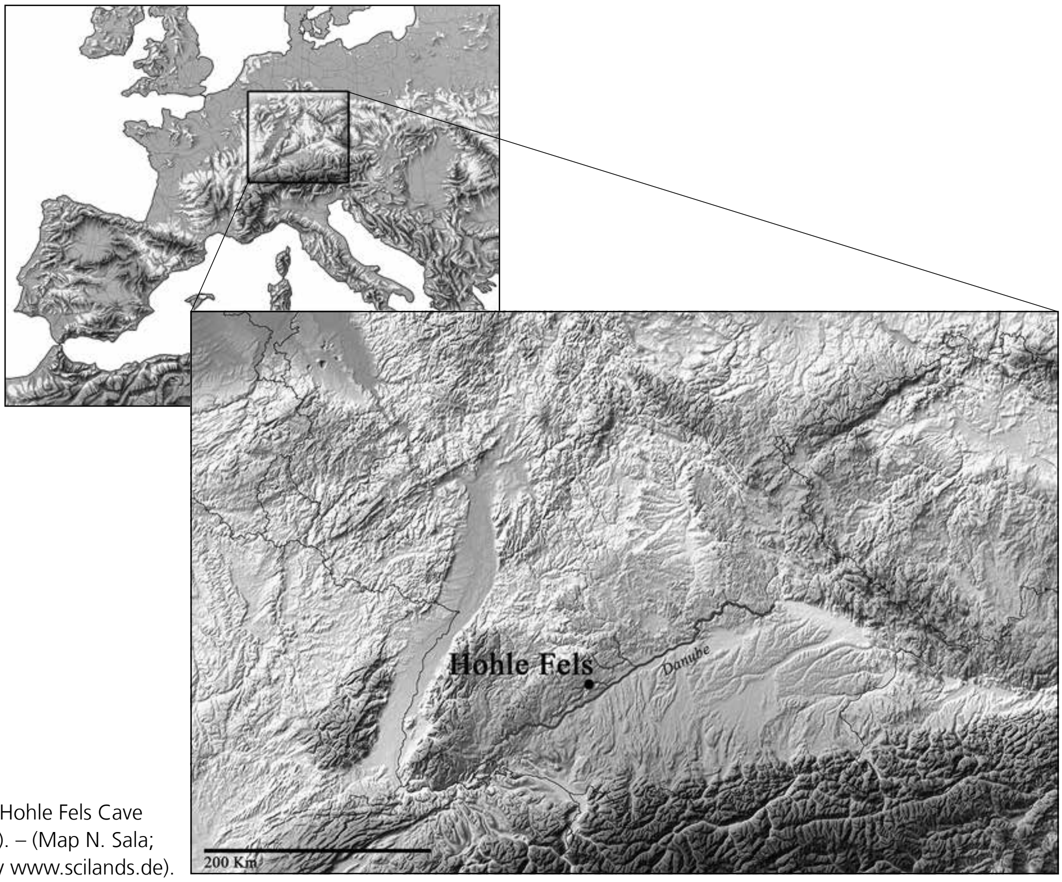

Fig. 1 Location of Hohle Fels Cave (Alb-Donau-Kreis / D). – (Map N. Sala; source map courtesy www.scilands.de).

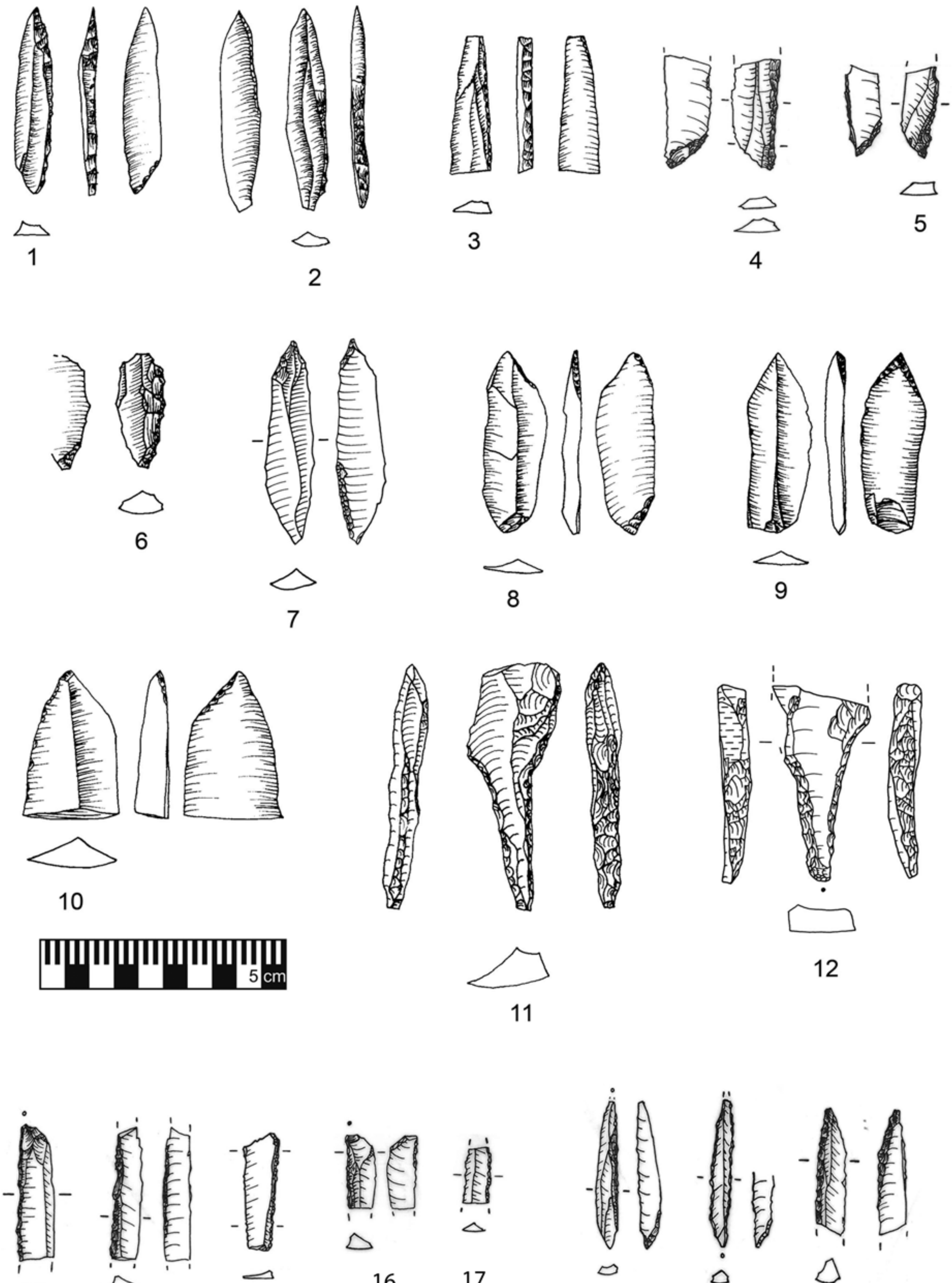

Fig. 2 Hohle Fels Cave (Alb-Donau-Kreis / D). Gravettian lithics: **1-6** Gravette points. – **7-10** *fléchettes*. – **11-12** Font-Robert points. – **13-17** backed pieces. – **18-20** Microgravette points. – (Modified after Taller / Conard 2016, figs 6-7).

(Taller/Conard 2016; **fig. 2**). A unique feature of the Ach Valley Gravettian is the fact that three out of four sites (Hohle Fels, Geißenklösterle, Brillenhöhle) are connected through inter-site refits of lithic artefacts; Hohle Fels is directly linked to Brillenhöhle as well as Geißenklösterle (Scheer 1986; 1990; Moreau 2009; Taller et al. 2019). The fourth Gravettian site in the Ach Valley is Sirgenstein (Alb-Donau-Kreis/D), and it is very likely that this station will at some point too be connected to one or several of the other locations through refits, as they have shared raw material units (Scheer 1990; Taller et al. 2019). These four sites are also the only ones with robust evidence of Gravettian occupations in the Swabian Jura (cf. Taller/Kieselbach/Conard 2019) and have accurately been characterized as being parts of an »archaeological microregion« by L. Moreau (2010, 80).

Early radiocarbon dates and typological arguments document an early Gravettian in Hohle Fels (**fig. 2**; cf. Taller/Conard 2016). Because of the early dates from both the Gravettian and Aurignacian, possible local origins of these two classic Upper Palaeolithic entities in the Swabian Jura have repeatedly been discussed (Conard 2000; 2002; Conard/Bolus 2003; Moreau 2009). L. Moreau proposed a regional development of the Gravettian out of the Swabian Aurignacian after evaluating the results of his analysis of Gravettian lithics from Geißenklösterle Cave and Brillenhöhle and contextualizing them within the Gravettian landscape on a European scale (Moreau 2009; 2010; 2012). Also, the Gravettian of Geißenklösterle yielded very old dates (Higham et al. 2012).

Hohle Fels Cave, located about 2 km southwest of Geißenklösterle is well suited to test this hypothesis. The Gravettian of the Ach Valley on the whole has been the subject of numerous investigations and publications and can be considered well studied (e.g. Schmidt 1912; Riek 1973; Hahn 1988a; 1988b; 2000; Scheer 1986; 1990; 1993; 2000; Conard 2002; Schiegl et al. 2003; Floss/Kieselbach 2004; Moreau 2009; Münzel/Conard 2004; Münzel et al. 2011; Taller/Conard 2016; Taller/Kieselbach/Conard 2019). Here, we present new AMS^{14}C dates for the Hohle Fels-Gravettian along with already existing radiocarbon ages from the site and discuss their implications for the contextualization of the assemblages. These results clarify, to what phase of the Gravettian they are affiliated and how they integrate within the Gravettian of the Swabian Jura and the Gravettian as a whole.

MATERIALS AND METHODS

Hohle Fels has been systematically excavated since J. Hahn conducted his first campaign in 1977, and after his death in 1997, N. J. Conard continued the excavations on an annual basis. During the excavation work, the sediments are water screened in order to ensure a maximum of archaeological resolution. The cave yielded Gravettian assemblages from four archaeological horizons, three of which are extensive and, according to the definition of A. Montet-White (1988) indicate occupations of »medium-sized campsites« with several thousand lithic artefacts and tools in the range of 200-1000 pieces in each layer. Horizon IId is far less substantial in terms of artefact numbers (443 pieces >1cm, 80 tools, 12 cores and 917 pieces of small debitage), which is probably due to a taphonomic reworking and transport of these Gravettian sediments. Finally, the assemblage from layer IIe, which is now considered as Aurignacian encompasses only 275 pieces >1 cm, 48 tools and six cores. On the whole, there are more than 36,000 lithic artefacts from the Hohle Fels-Gravettian.

For this study, only AMS^{14}C dates were used. All explanations regarding the sampled material, layer of origin and citation are given in **table 1**. The dates were calibrated with CalPal (quickcal2007 ver. 1.5, CalCurve: CalPal_2007_HULU, after Weninger/Jöris/Danzeglocke n.d.; Weninger/Jöris 2008; calibration: Weninger 1986). For the new dates, only artefacts were sampled, i.e., modified bones with cutmarks or other anthropogenic modifications in order to ensure an actual relationship with human activity.

Lab ID	layer	material	age	±	cal BP	±2	reference
OxA-35310	IIb	modified bone	12515	55	14839	295	this publication
OxA-35245	IIb	modified bone	12605	55	14962	296	this publication
KIA 3503	IIcf	horse rib	27030	250	31769	189	Conard 2003a
GrA-43702	IIb	bear skull	27420	150	32012	172	Münzel et al. 2011
GrA-43915	IIc	bear metatarsal	27440	140	32024	172	Münzel et al. 2011
KIA 17742	IIcf	horse tibia, cutmark/impact	27690	140	32244	254	Conard 2003a
GrA 67117	IIc	modified bone	27770	150	32314	277	this publication
KIA 17744	IIcf	modified mammoth/rhino rib (tool)	27780	150	32322	278	Conard 2003a
KIA 17743	IIcf	bear vertebra with embedded silex projectile	27830	150	32359	285	Conard 2003a
Beta-161022 (H856)	IIc	bear tooth	27840	190	32375	301	Conard/Moreau 2004
GrA-43922	IIc	bear metacarpal	27850	130	32370	280	Münzel et al. 2011
KIA 17741	IIcf	modified reindeer antler	27970	140	32457	292	Conard 2003a
Beta-156094 (H145)	IId	bear tooth	28060	170	32525	306	Conard/Moreau 2004
GrA 67072	IIc	modified bone	28140	150	32579	304	this publication
Beta-156093 (H141)	IIc	bear tooth	28170	180	32605	317	Conard/Moreau 2004
Beta-161023 (H911)	IIb	bear tooth	28170	220	32612	334	Conard/Moreau 2004
GrA-43913	IIc	bear metatarsal	28200	140	32622	305	Münzel et al. 2011
GrA-43914	IIb	bear metatarsal	28330	140	32725	319	Münzel et al. 2011
Beta-156092 (H140)	IIb	bear tooth	28350	220	32756	359	Hofreiter et al. 2007
OxA-35307	IIb	modified bone	28430	300	32860	432	this publication
GrA 67065	IIc	modified bone	28540	160	32953	358	this publication
OxA-35309	IIb	modified bone	28660	300	33124	471	this publication
GrA-43912	IIc	bear metatarsal	28750	150	33255	354	Münzel et al. 2011
GrA 67070	IIcf	modified bone	28870	160	33390	345	this publication
OxA-4599	IIc	modified reindeer antler (tool)	28920	440	33349	517	Hahn 1995
OxA-5007	IIc	modified reindeer antler (tool)	29550	650	33762	568	Housley et al. 1997
KIA 8964	IIe	mammoth/rhino rib	29560	240	33884	320	Conard/Bolus 2003
GrA 67075	IIe	modified bone	29970	170	34255	169	this publication
KIA 8965	IId	reindeer antler	30010	220	34270	187	Conard/Bolus 2003
GrA-43908	IIc	bear metatarsal	30370	170	34491	164	Münzel et al. 2011
GrA 67074	IIdb	modified bone	30580	180	34703	263	this publication
KIA 16040	IIe	horse pelvis; cutmark/impact	30640	190	34795	322	Conard/Moreau 2004
GrA 67066	IIe	modified bone	30830	180	34947	353	this publication
GrA 67068	IId	modified bone	31440	190	35358	400	this publication

Tab. 1 AMS^{14}C dates from the Hohle Fels Gravettian in chronological order from young to older (calibration done with CalPal [quickcal2007 ver.1.5, CalCurve: CalPal_2007_HULU] after Weninger/Jöris/Danzeglocke n.d.; Weninger/Jöris 2008). New dates for this publication highlighted in yellow and green, further explanation in text.

RESULTS

All relevant dates hitherto obtained for the Hohle Fels-Gravettian are summarized in **table 1**. Although the vast majority of the ages more or less forms a continuum from 35 to 31 ka cal BP, there are two dates from layer IIb clearly showing a terminal Pleistocene age as would be expected from the regional Magdalenian (cf. Taller 2014). This was suspected since in the study of the lithic assemblages a considerable number of

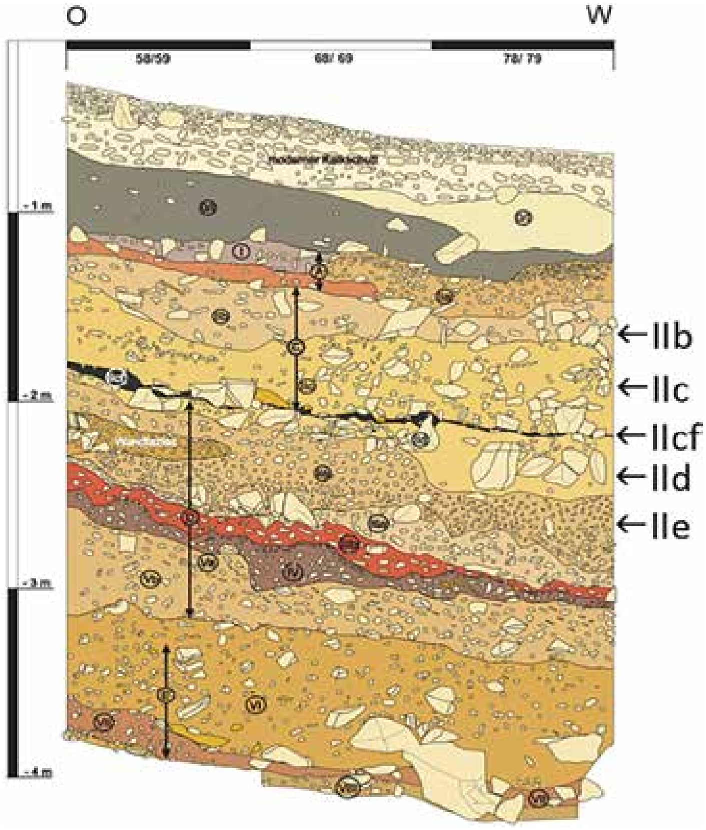

Fig. 3 Hohle Fels Cave (Alb-Donau-Kreis / D). Stratigraphy. – Relevant layers mentioned in the text indicated on the right. – (Modified after Conard / Langguth / Uerpmann 2004, fig. 1).

lithic artefacts of Magdalenian appearance in terms of both typo-technology and raw material composition was noted in layer IIb (Taller / Conard 2016). Consequently, four modified bones from the area of the excavation in question were selected for dating (**tab. 1**, highlighted in green). Two of the dates from these artefacts document an intrusion from the Magdalenian in the contact zone of both units in the northeastern part of the stratigraphy, that is, towards the entrance. The extent of the intrusion is difficult to assess since there is considerable overlap between the Gravettian and the Magdalenian in terms of lithic raw material. Moreover, the two entities are difficult to tell apart on technological grounds as well, since the goal of knapping was the production of long, narrow and straight bladelets and blades throughout both technocomplexes.

Here it is important to note that Hohle Fels experienced a major phase of erosion between the Gravettian and Magdalenian as A. Barbieri et al. (2018) have documented. This erosion, followed by the use of the cave during the Magdalenian brought the deposits from the Gravettian and Magdalenian into direct contact with each other and led to a degree of mixing in horizon IIb.

Furthermore, **table 1** includes eight new dates for the lower horizons IIc, IIcf, IId and IIe (highlighted in yellow), in order to examine the taphonomy of these layers.

A question concerning the radiocarbon dates is whether we can see a diachronic trend through Gravettian layers IIcf, IIc and IIb. As is clear in **table 1** and **figure 4** that is not the case, since the dates tend to be somewhat inconsistent both in terms of the individual layers as well as throughout the complete Gravettian sequence. Indeed, layer IIcf even produced a relatively coherent series of some of the youngest dates for the Gravettian of the site. This layer consists of a small band, only 3-10 cm thick, of mainly burnt bone and is very rich in finds. Since geoarchaeological studies indicate that IIcf cannot have been reworked (Schiegl et al. 2003; Miller 2015; **fig. 3**) after its deposition, the subsequent movement of the IIc sediments contain-

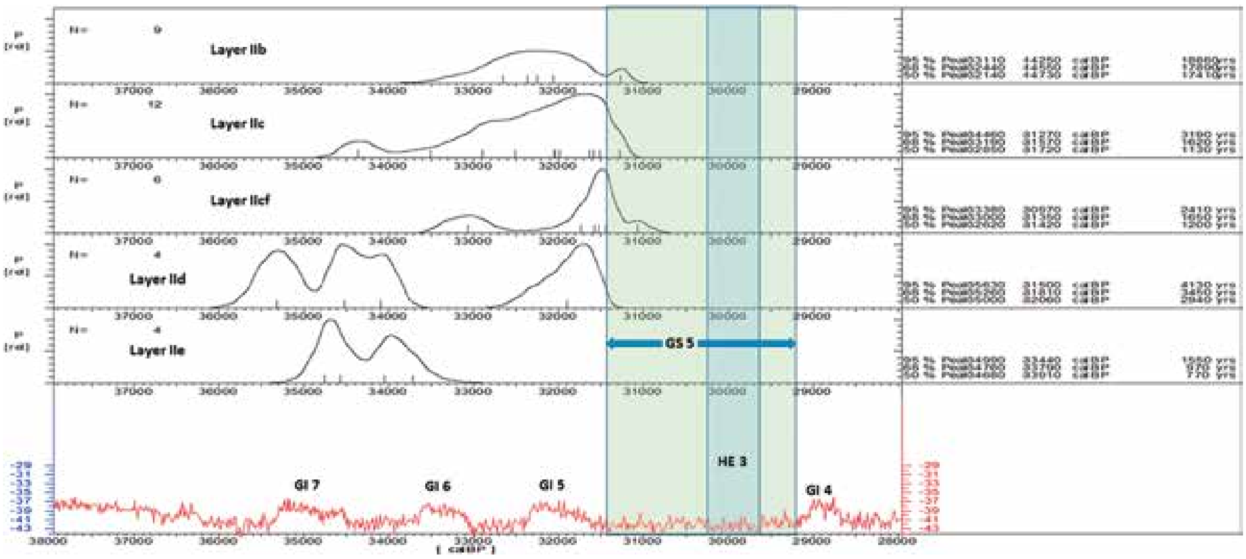

Fig. 4 Gravettian dates from Hohle Fels Cave (Alb-Donau-Kreis/D). – (All dates calibrated with CalPal [quickcal2007 ver. 1.5, CalCurve: CalPal_2007_HULU; after Weninger/Jöris/Danzeglocke n. d.]).

ing – at least partly – older settlement remains out of the cave hall could be responsible (cf. Conard/Moreau 2004). This is likely as the excavation area is situated in the corridor that links the cave hall with the entrance. In the cave hall, a cone of sediments slopes upwards towards the back of the hall, where there is an opening in the roof of the cave. There, input from the outside is and was possible and created a talus slope in the cave hall that accounts for the general direction of sediment movement from the rear of the cave towards the entrance (cf. Hahn 1988a). Concerning the interpretation of the stratigraphy, this implies that after the IIcf deposits were dumped, the IIc sediment and artefacts may have made their way out of the cave hall in an erosional event and were subsequently superimposed on IIcf. Possible agents could be soli- and/or gelifluction, as both are observable in that part of the stratigraphy (cf. Miller 2015, 109).

Another possible scenario supposes that the original location of the Gravettian living floor associated with IIcf was situated nearer to the entrance and that the waste material was subsequently dumped further inside the cave, where it was found (Schiegl et al. 2003). Based on frequent refittings of lithic fragments between layers IIc and IIcf, a possible connection of both horizons was postulated (Floss/Kieselbach 2004); recent studies confirmed this link (Taller/Kieselbach/Conard 2019). The fact, that radiocarbon dates from both horizons overlap further supports this finding (**fig. 4**).

Overall, the dates from the Gravettian and layers IId and IIe show a bimodal distribution with most of the dates accumulating around c. 32-33 ka cal BP, and 34-35 ka cal BP (**fig. 5**). It is possible that there was an early phase of an initial Gravettian settlement with ages of up to 35 ka cal BP, and then there is the bulk of dates coinciding with a slightly later but far more substantial Gravettian settlement of greater duration. Since the older dates are almost exclusively restricted to layers IId and IIe (apart from some dates from IIc), they are consistent with the stratigraphic sequence. It is problematic that both layers yielded very similar ages, as the oldest dates from these horizons of c. 35 ka cal BP are in the range of dates for the youngest Aurignacian of the site. There is thus overlap of some of the dates from the Gravettian and uppermost Aurignacian layers AHs IIe, IIIa and IIIb (Conard/Bolus 2008), which indicates a comparably short time span for the transition from the Aurignacian to the Gravettian. The seamless chronology from the late Aurignacian to the early Gravettian has been cited before as an indication that the transition must have been a relatively fast process in this region (Moreau 2009; Moreau/Jöris 2013). Since IId is of clear Gravettian affil-

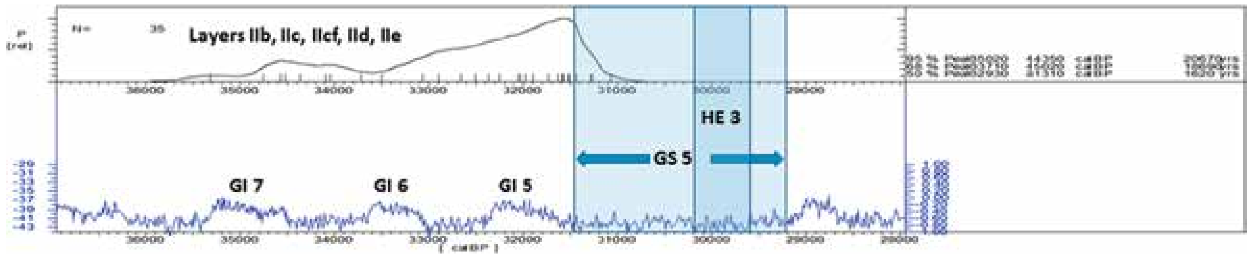

Fig. 5 Cumulative graph of dates from all layers discussed in the text plotted together. – (All dates calibrated with CalPal [quickcal2007 ver.1.5, CalCurve: CalPal_2007_HULU; after Weninger/Jöris/Danzeglocke n. d.]).

iation, the early dates for the Gravettian assemblage from this layer further support this hypothesis. It is also possible that because of sediment mixing between the Aurignacian and the Gravettian (i. e., between IIe and IId) an intrusive bone of Aurignacian origin was dated and is responsible for at least the oldest date from IId. If so, we can also assume sediment mixing as the agent behind the distribution of dates from IIe: here, the two older dates are in accordance with the upper Aurignacian of the site, whereas the two younger dates fit well within the oldest Gravettian. To conclude, even though the assemblages of IId and IIe seem to belong to Gravettian and Aurignacian respectively, the vertical relocation of single artefacts is always a possibility, even more so in the contact zones of the layers and especially in cave stratigraphies.

Since there is only a comparably low number of artefacts in layer IId, a horizontal relocation of these sediments is possible. The direction of the relocation of the IId sediment as such may have been down slope out of the cave hall towards the entrance similar to the dynamics observed in layer IIc.

With ages of c. 34 ka cal BP even for the established Gravettian layers, an early Gravettian is documented in Hohle Fels, which in turn is in accordance with the early Gravettian dates from Geißenklösterle (Conard/Bolus 2003; Moreau 2009, 53; Higham et al. 2012).

RAPID PALAEOCLIMATIC FLUCTUATIONS IN LATE MIS 3 AND POSSIBLE IMPACT ON GRAVETTIAN HUNTERS

All of the dates for the Hohle Fels-Gravettian fall into late Marine Isotopic Stage (MIS) 3 (duration from 57-29 ka BP; cf. Lisiecki/Raymo 2005; Bradley 2015). The climate in MIS 3 includes the crucial parts of the early Upper Palaeolithic in Europe and was characterized by a series of episodes of sudden warmings with subsequent coolings (e. g. Dansgaard et al. 1993; Grootes et al. 1993; Mayewski et al. 1997; Rasmussen et al. 2014). The transition from the Aurignacian to the Gravettian in Hohle Fels happened at some point during or in-between Greenland Interstadials (GIs) 7 (also Denekamp Interstadial) and 6 in a more moderate climatic environment; although already before and during the Aurignacian a gradual cooling is evident in the composition of small mammal remains (Rhodes/Starkovich/Conard 2019). The Gravettian settlement itself then took place between c. 34 and 31 ka cal BP, persisting into the cooler and longer Greenland Stadial (GS) 5 (**fig. 4**). The climatic deterioration at the end of MIS 3, which ultimately led towards the Last Glacial Maximum (LGM; in MIS 2) is pronounced in GS 5 at around 30 ka cal BP with the Heinrich Event 3 (H3; cf. e. g. Bond/Lotti 1995; Hemming 2004) and most likely had a significant impact on Palaeolithic hunters in Swabia. Changing environmental conditions will affect hunter-gatherers as they might cause a shift in plant associations and in the availability of hunting prey (e. g. Kelly 1995; Binford 2001). This, in turn, may necessitate changes in hunting behaviour and, consequently, technologies and tool kits, as the cooling climate likely caused increased seasonality and thus forced Gravettian people to lead an exceedingly mobile lifestyle (e.g. Jöris/Street/Sirocko 2009). This is a possible explanation for Gravettian innovations, especially in terms of the appearance of backed lithic projectile heads (e.g. Gravette and Microgravette points), but even more so backed lithic bladelets in general as a very mobile, modular and multifunctional tool category. Although the details of this transitional process from the Aurignacian to the Gravettian are as yet unclear, backed lithics can generally be considered as parts of a highly mobile and modular technology designed for different purposes and functions (e.g. Bolus 2010; Taller et al. 2012), probably indicating a greater need for flexibility and mobility.

In Hohle Fels, the Gravettian ends at around 31 ka cal BP (**figs 4-5**), meaning that as H3 began, Gravettian people were already gone. It remains to be established whether we should expect migration or indeed local extinction as the cause (Maier/Zimmermann 2017). As A. Maier and A. Zimmermann noted, temperatures, as well as insolation, were lower during the second part of the Gravettian than ever before or after in the Upper Palaeolithic (cf. also Rasmussen et al. 2014). Even though glaciation was at its maximum during the LGM, temperatures were not as low as from 30 ka cal BP onwards (Maier/Zimmermann 2017). Interestingly, the ^{14}C dates from Geißenklösterle place the Gravettian of that site in a very similar chronological window (Moreau 2009; Higham et al. 2012), which further strengthens the connection of the Gravettian occupations of both caves along with the lithic refit between these assemblages (Taller/Kieselbach/Conard 2019), as both sites were part of the same settlement system and were occupied simultaneously.

It is striking that in more southerly regions like e.g. Southwestern France (Bosselin/Djindjian 1994; Djindjian/Bosselin 1994; Terberger 2003) or the Iberian Peninsula (e.g. Bradtmöller et al. 2012), the Gravettian outlasted not only H3 but in fact was present until c. 24 ka cal BP. In Eastern Europe, the Gravettian too persisted considerably longer than in Swabia (Reynolds et al. 2015), although the relation to the Central European Gravettian is unclear. It thus seems possible that we see the displacement of people from Central Europe southwestwards and perhaps also east in search of more agreeable conditions.

Still, H3 is recognizable in Iberia at roughly the same time (Fletcher/Sanchez Goñi 2008), but appears to have had a less severe effect on living conditions for humans. The best climatic data that we have for the Gravettian from Hohle Fels comes from the macro-botanical and palynological record of the site and indicates a colder climate and a reduced presence of wood compared to preceding phases of the settlement, including the Aurignacian and the transition to the Gravettian (Riehl et al. 2014). At the end of the Gravettian sequence, boreal indicators have completely disappeared and rodent remains indicate cooling with increasing tundra elements (Riehl et al. 2014). Here, we hypothesize a causal relationship between the climatic development at the time and the disappearance of Gravettian hunters.

DISCUSSION: GRAVETTIAN ORIGINS IN THE SWABIAN JURA?

Thus far, it is difficult to make a clear case for Gravettian origins as the result of an *in situ* development out of the Aurignacian at Hohle Fels, as hypothesized by N. J. Conard and M. Bolus (2003) and championed by L. Moreau (2009) for Geißenklösterle and Vogelherd (Lkr. Heidenheim/D). Although apparently some backed pieces are known from different Central European Aurignacian contexts (e.g. Vogelherd, Sirgenstein, Willendorf II-2 [Bez. Krems-Land/A], Breitenbach [Burgenlandkreis/D], Lommersum [Kr. Euskirchen/D], Krems-Hundssteig/A]; cf. Hahn 1977; Bolus 2012), they are typically rare and do not seem to form a coherent and recurrent class of artefacts. The fact that AH IV of Vogelherd yielded four backed pieces might well be attributed to an admixture of Aurignacian with younger, most probably Magdalenian sediments. No artefacts indicating a Gravettian occupation of Vogelherd were found yet, although some of the radiocarbon dates from the site yielded a Gravettian age (Conard/Langguth/Uerpmann 2003; Conard/Bolus 2003). Another five backed specimens from the Aurignacian of Geißenklösterle (AH II) are again interpreted by L. Moreau as indicating an *in situ* development of backed pieces, especially since all of them are made out of *Bohnerzhornstein* (pisolitic chert), a lithic raw material that is characteristic of the Aurignacian assemblage of the site (Moreau 2009). However, even in these cases, one has to bear in mind that Geißenklösterle – like Vogelherd – is a cave site and the cultural stratigraphy is especially vulnerable to taphonomic dislocation of the smaller artefacts. The site was also used heavily by cave bears (e.g. Münzel/Conard 2004), which invariably will have led to a degree of mixing. We do not mean to reject L. Moreau's views completely, but still the evidence is thin and the backed pieces from the Aurignacian layers in Vogelherd and Geißenklösterle do not represent a homogeneous tool group. These backed artefacts do not appear regularly in the Aurignacian and when they occur, their number is low. Hence, the appearance of backed lithics in these Aurignacian layers might rather be attributable to taphonomic processes or mixing of sediments. J. Hahn (1977) conceded as much when he wrote that only very few of the backed pieces from Aurignacian contexts originate from open air sites and would thus be more securely attributable as belonging to Aurignacian assemblages. Little has changed since J. Hahn published on this particular matter. In Hohle Fels, there are only two backed pieces from layer IIe (both fragmented, one made out of radiolarite) and none so far known from the Aurignacian layers *sensu stricto*.

Considering the quick transition from the Aurignacian to the Gravettian, the early dates raise important questions. Regarding lithic technology, we see a clear difference in blank production between the Aurignacian and Gravettian of Hohle Fels. The Aurignacian is characterized by bladelet production on small bladelet cores, carinated and nosed endscrapers, as well as carinated, busked and other burin-cores, whereas (the often thick) blades are produced on unidirectional parallel blade cores (Bataille/Conard 2018). In contrast to that, during the Gravettian of Hohle Fels, the operational chain of the blade and bladelet production forms a continuum or was carried out parallel and mostly took place on the same cores. The knappers aimed to produce long, straight and narrow blanks; as was observed by L. Moreau (2009) for the Gravettian of Geißenklösterle. In addition, the technology and typology of organic tools and jewellery differ markedly between both technocomplexes (Conard 2003b; Münzel et al. 2016). In the Aurignacian, ivory and antler were used for the manufacture of projectile points; in the Gravettian, these spearheads were made from mammoth and/or rhino rib bones (Barth 2007; Münzel et al. 2016). The Aurignacian of Swabia is famous for the earliest figurative art and musical instruments (e.g. Conard 2003a; 2009; Conard/Malina/Münzel 2009; Conard/Malina 2014), whereas from the local Gravettian only a phallus-like hammerstone (Conard/Kieselbach 2006) and one engraving of an indeterminable animal on a reindeer antler adze are known (e.g. Scheer 1994; Barth 2007); both these finds originate from Hohle Fels Cave.

In terms of lithic raw materials, however, there is a discernible degree of continuity from the Aurignacian throughout layers IIe, IId and IIcf, and only in IIc and IIb does the picture change with a more diverse assortment of raw materials. The Hohle Fels- Aurignacian lithic assemblages are characterized by the dominance of mostly grey Jurassic chert (usually more than 80%), followed by often reddish or brown-grey *Bohnerzhornstein* (up to 20%; cf. Bataille/Conard 2018; pers. comm. G. Bataille). Other lithic raw materials are rare or absent. Layers IIe, IId and IIcf are similar in that Jurassic chert also dominates the spectrum of lithic raw materials, although even more clearly with over 90% of all pieces. *Bohnerzhornstein*, as well as radiolarite, are rare in these layers with percentages of 5% or lower, and other raw materials are not present in significant quantities (always below 0.2%; Taller/Conard 2016). The assemblage of layer IIcf is not really usable for this argument since it represents a dump containing the remains of a knapping episode of local grey Jurassic chert (Schiegl et al. 2003; Floss/Kieselbach 2004; Taller/Conard 2016). Furthermore, a connection between layers IIcf and IIc was demonstrated through repeated lithic refittings (Floss/Kieselbach 2004;

Taller/Kieselbach/Conard 2019), so that in the phase of occupation in question radiolarite seems to have been in use after all. In this context, it is also important to note the incomplete nature of the IIe and IId assemblages (Taller/Conard 2016). The key difference between the Aurignacian and the Gravettian in terms of lithic raw materials is the virtual absence of radiolarite in the Aurignacian and its importance in the Gravettian of IIc and IIb. L. Moreau (2009) suggested a greater need for fine-grained lithic raw materials for the sophisticated blank and tool production in the Gravettian as a causal factor for the emergence of radiolarite in these layers. An alternative hypothesis suggests that the lack of radiolarite in the Middle Palaeolithic and the Aurignacian in Swabia might be based on reduced accessibility of this raw material due to denser vegetation or »an environmental geomorphological change« (Hahn 2000, 254) before the Gravettian (Hahn 2000; Çep 2000).

We thus do see changes as well as continuity on different levels and in different areas. Based on the evidence from Hohle Fels, two options are plausible:

1. We are dealing with newly arriving immigrants who carry Gravettian technologies and follow new land use patterns. If so, where did they come from, where – and why – did their material culture originate?
2. We are dealing with a changing local society that developed new hunting strategies and technologies and was expanding their range in order to enhance their ability to subsist in a changing environment.

The first hypothesis bears the problem that some of the dates from Hohle Fels are among the oldest for a fully developed Gravettian, and that it is unclear where the origins of these industries could lie. In terms of palaeogenetics, an arrival of new groups of people carrying Gravettian technologies and traditions might or might not have happened (e.g. Soares et al. 2010). Contacts into other regions are indicated by lithic raw materials from e.g. the Upper Rhine region, c. 200km as the crow flies in a southwestern direction from Hohle Fels, as well as the distribution of ivory teardrop-shaped pendants (sometimes also made of schist and other minerals; Scheer 1985). This connectedness has been postulated before for the Swabian Gravettian by L. Moreau (2009, 220), who stated that the Ach Valley has to be viewed as part of a supraregional social and economic network.

There is thus far no discernible hiatus in the settlement between the Aurignacian and the Gravettian in Swabia and the dates of both technocomplexes overlap, which tends to support the second hypothesis. To a certain degree, both proposals are not entirely mutually exclusive if we allow for the possibility of an influx of people with different technologies and ideas into an already populated area. In that case, it would still need to be determined where the incoming people would come from and why they would have made their way here. M. O'Farrell (2003) and L. Moreau (2009) have proposed a change in hunting technology and strategy from the Aurignacian to the Gravettian before. M. O'Farrell also stated that while indirectly the most likely causal factor might have been climatic deterioration, the direct reason for the visible changes in technology is as yet unclear and may be subtle (O'Farrell 2003, 134).

Although no female figurines have been found in sites of the Swabian Gravettian, they are a key element of the Gravettian art and symbolism (e.g. Mussi/Cinq-Mars/Bolduc 2000). Even though we do not see any clear connection between the Aurignacian and Gravettian of Hohle Fels, we have to keep in mind that the oldest of these artefacts were discovered in Aurignacian layer Va/Vb in Hohle Fels (Conard 2009; Conard/Malina 2014). The female figurines from Hohle Fels share many characteristics with the widespread later Gravettian depictions such as the pronounced emphasis on sexual attributes and the little attention to the head, face, arms and legs (Conard 2009). This similarity suggests a possible connection between the Hohle Fels-Aurignacian and the Gravettian (cf. Gaudzinski-Windheuser/Jöris 2015).

Another, more secular link between both technocomplexes concerns the procurement of lithic raw materials. As stated above, the composition of lithic raw materials in the assemblages of layers IIcf, IId and IIe shows little divergence from the pattern in Aurignacian layers IIIa, IIIb and IV (pers. comm. G. Bataille; Bataille/Conard

2018), so that in terms of raw material provisioning we observe a degree of continuity from the Aurignacian to at least the lower layers of the Gravettian. This circumstance has previously been proposed as a possible argument for a transitional role of the lower Gravettian in Hohle Fels (Jöris et al. 2010). Moreover, this pattern of continuity in raw material use across the boundary from the Aurignacian to the Gravettian was also observed in Geißenklösterle (Moreau 2009, 219; Conard/Moreau 2004, 40; Bolus 2010). However, keeping in mind the apparent connection between layers IIcf and IIc and the consequential weakening of the argument of continuity in raw material procurement beyond horizon IId, we have to concede that in spite of all this, there is little direct evidence for an *in situ* development of the Gravettian in Swabia.

CONCLUSION

Both the composition of the assemblages and some of the ^{14}C dates document an early age for the Gravettian in Swabia. The turnover from the Aurignacian to the Gravettian was swift, given that there must only have been a short time of transition in Swabia in general and in Hohle Fels in particular. This is evident in the overlap of dates between the final Aurignacian and the lower Gravettian and places the transition between 35 and 34 ka cal BP; by 34 ka cal BP the Gravettian is established, while the main phase of the Gravettian occupation dates from 33 to 31 ka cal BP. The fact that occupations from three out of four Gravettian sites in the Ach Valley, all situated within a radius of only a few kilometres, are connected through inter-site lithic refits, together with the radiocarbon dates point towards a comprehensive, contemporaneous settlement of this archaeological region during the Gravettian.

If changes in technology and tool kit became necessary because of the rapidly changing climate after 35 ka cal BP (cf. Conard/Bolus 2003, 363), the response of hunter-gatherers to this requirement came quickly. This probably catalysed the evolution of the Gravettian technocomplex and lead to an expansion of the territory which its makers occupied.

This view fits the general model of a Central European origin of the Gravettian (e.g. Moreau 2009; 2010), since Hohle Fels integrates well chronologically and techno-typologically along with other sites situated in the Danube region such as Geißenklösterle, the Bavarian Weinberghöhlen (Mauern, Lkr. Neuburg-Schrobenhausen/D) and Willendorf II/5 in Lower Austria and is an integral part of the earliest group of Gravettian sites in Europe. Other Central European sites with early Gravettian dates lie in Moravia (Kozłowski 2015; Svoboda et al. 2015), Southern Poland (Valde-Nowak/Nadachowski/Madeyska 2003; Wisniewski et al. 2015) and maybe Slovakia (Kaminská 2016).

However, concerning the discussion on Gravettian origins, one should bear in mind that there are Gravettian sites in other European regions with similarly early ages such as in Cantabria (Bradtmöller et al. 2012), which makes identifying a single original region of the Gravettian difficult and unlikely. In any case, the existence of comprehensive social networks between Gravettian populations in Europe is indicated; by the increased presence of non-local lithic raw materials in the assemblages as well as the fact that sometimes marine molluscs are present in sites several hundred kilometres from the sea (e.g. Hahn 1969; Floss 1994; Svoboda 1994; Alvarez Fernández 2001). Ivory teardrop-shaped pendants were widespread in Europe during the Gravettian, strengthening the hypothesis of shared ideas among these Upper Palaeolithic populations (Scheer 1985; Vercoutère/Wolf 2017). These social and economic networks would also allow for comparably quick diffusion of ideas and technological innovations across Europe (e.g. Moreau 2009).

Going back to the model proposed by N. J. Conard, K. Langguth and H.-P. Uerpmann (2004; cf. **fig. 5**), with regard to possible Gravettian origins in Hohle Fels we argue for a combination of models 2 and possibly 4; i.e., a comparably fast endogenous evolution with the added possibility of immigration or input from other

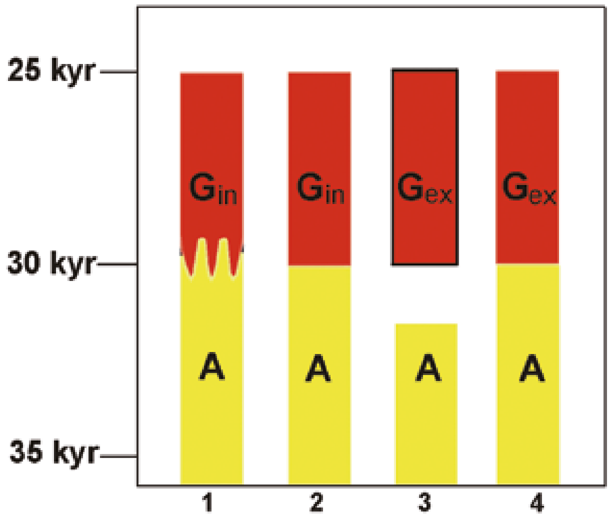

Fig. 6 Possible scenarios for the genesis of the Gravettian in Swabia (ages given in non-calibrated radiocarbon years): **1** gradual, endogenous formation. – **2** fast endogenous formation. – **3** immigration of Gravettian people after hiatus. – **4** immigration of Gravettian people without hiatus. – (After Conard/Morau 2004, fig. 12).

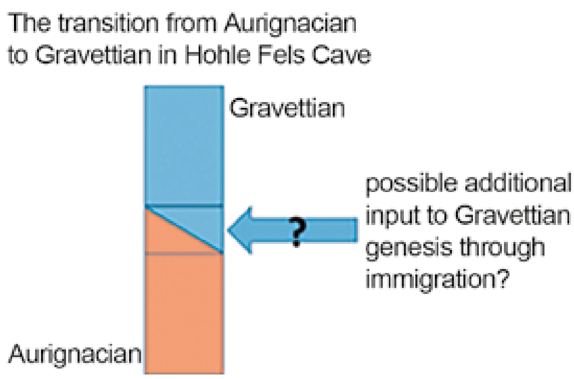

Fig. 7 Hypothetic model for the beginning of the Gravettian in Hohle Fels (Alb-Donau-Kreis/D) and more generally in the Upper Danube region. – (Illustration A. Taller).

regions catalysing the transformation towards the Gravettian (cf. fig. 6, above) as the most probable scenario. However, this does not mean to imply that Hohle Fels, or the Swabian sites, are the sole place of origin for the Gravettian. There is also the possibility that an arrival of Gravettian people brought innovations to Swabia after the emergence of the technocomplex elsewhere and replaced the regional Aurignacian without any archaeologically discernible hiatus in settlement activity (model 4 after Conard/Langguth/Uerpmann 2004). The question of transition vs. replacement that we introduced in the title of this paper can thus not yet be answered satisfactorily, and even a combination of both possibilities is conceivable.

In conclusion, we propose that the transition from the Aurignacian to the Gravettian was the result of multifactorial turnovers of the palaeoenvironment which in turn had an important impact on hunter-gatherer societies all across Europe. The specific social and economic components of these dynamics remain unclear. The transition from the Aurignacian to the Gravettian is thus not easily explainable in a monocentric and/or monocausal model. The hunter-gatherer groups of Central Europe seem to have been linked in regional as well as supraregional networks. In this scenario, the idea of viewing Gravettian innovations as local reactions of these groups towards a changing environment and the associated challenges for human subsistence at the moment holds high explanatory power (cf. Kozłowski 2015). The evidence of extensive social networks in the Gravettian makes a quick distribution of useful innovations highly likely.

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Zusammenfassung / Summary / Résumé

Kontinuierliche Fortentwicklung oder Ablösung durch neue Einwanderung? ^{14}C-Datierungen aus der Hohle Fels-Höhle (Alb-Donau-Kreis / D) und der Übergang vom Aurignacien zum Gravettien

Die jungpaläolithischen Schichten des Hohle Fels (nahe Schelklingen) bieten exzellente Voraussetzungen für eine Untersuchung des Überganges vom Aurignacien zum Gravettien. Mit einem Alter von 35 000-34 000 Jahren kalibriert vor heute gehört das Gravettien der Fundstelle zu den ältesten Inventaren des Mittleren Jungpaläolithikums in Mitteleuropa. Die ebenfalls sehr alten Radiokarbondatierungen aus der benachbarten Geißenklösterle-Höhle bestätigen das hohe Alter des Gravettien auf der Schwäbischen Alb. Die Steinartefaktinventare aus dem Hohle Fels und den anderen Fundstellen der Alb in der unmittelbaren Umgebung (Geißenklösterle, Brillenhöhle) zeigen auch typologisch ein frühes Gravettien an, mit Geräten wie Gravettespitzen, Mikrogravettespitzen, Font-Robert-Spitzen und *fléchettes*. In der Stratigraphie des Hohle Fels gibt es keine erkennbare Besiedlungslücke zwischen Aurignacien und Gravettien, und die Datierungen beider Technokomplexe überlappen teilweise. In diesem Aufsatz werden neue wie bereits existente AMS ^{14}C-Datierungen der gravettienzeitlichen Schichten des Hohle Fels und ihre Implikationen für die Entwicklung des Gravettien diskutiert. Die Ergebnisse werden sowohl mit Daten zur regionalen wie europaweiten Paläoumwelt als auch mit der Fundstellenlandschaft des frühen Gravettien in Mitteleuropa mit Stationen wie den Weinberghöhlen in Bayern oder Willendorf II/5 in Niederösterreich kontextualisiert. Die Datierungen verbessern darüber hinaus auch das Verständnis der stratigraphischen Zusammenhänge der vier relevanten Fundschichten des Hohle Fels.

Transition or Replacement? Radiocarbon Dates from Hohle Fels Cave (Alb-Donau-Kreis / D) and the Passage from Aurignacian to Gravettian

The Upper Palaeolithic record of Hohle Fels Cave (Swabian Jura, near Schelklingen) provides an excellent record of the transition from the Aurignacian to the Gravettian. The Gravettian of Hohle Fels dates among the oldest Middle Upper Palaeolithic sites known with earliest ages between 35 and 34 ka cal BP. The radiocarbon dates from Geißenklösterle confirm the early age for the Swabian Gravettian. The lithic assemblages from Hohle Fels and those from other Swabian sites in the vicinity (Geißenklösterle, Brillenhöhle) indicate an early Gravettian with artefacts such as Gravette points, Microgravette points, Font-Robert points and *fléchettes*. In Hohle Fels we see no significant hiatus in the settlement, and the dates from the Upper Aurignacian and oldest Gravettian are in deed chronologically very close and do in part overlap. Here, we discuss existing as well as new AMS^{14}C radiocarbon dates from the Gravettian and their significance for the evolution of this Upper Palaeolithic entity. We then contextualise the results both with existing data on the regional and European palaeo-environment as well as the early Gravettian landscape of sites in Central Europe with occupations such as the Weinberghöhlen in Bavaria or Willendorf II/5 in Lower Austria. The dates also shed light on the relationship of the different Gravettian layers of Hohle Fels and thus contribute to understanding the stratigraphic context of these four horizons.

Développement continu ou remplacement par une nouvelle immigration?
Datations au ^{14}C du Hohle Fels (Alb-Donau-Kreis/D) et de la transition de l'Aurignacien au Gravettien
Les couches du Paléolithique supérieur du Hohle Fels (près de Schelklingen) offrent d'excellentes conditions pour étudier la transition de l'Aurignacien au Gravettien. Avec un âge de 35 000-34 000 ans calibré avant le présent, le Gravettien du Hohle Fels fait partie des plus anciens inventaires du Paléolithique moyen tardif en Europe centrale. Les datations radiocarbone très hautes de la grotte voisine de Geißenklösterle confirment l'âge élevé du Gravettien du Jura souabe. Les inventaires d'artefacts en pierre des Hohle Fels et des autres sites de découverte de l'Alb à proximité immédiate (Geißenklösterle, Brillenhöhle) montrent aussi typologiquement un Gravettien précoce, avec des appareils comme des pointes de la Gravette, des microgravettes, des pointes de la Font-Robert et des fléchettes. Dans la stratigraphie de Hohle Fels, il n'y a pas d'écart de peuplement reconnaissable entre Aurignacien et Gravettien, et la datation des deux technocomplexes se chevauche partiellement. Cet article traite de la datation au radiocarbone AMS^{14}C, nouvelle et existante, des couches gravettiens du Hohle Fels et de leurs implications pour le développement du Gravettien. Les résultats seront mis en contexte à la fois avec des données sur le paléoenvironnement régional et européen et avec le paysage gravettien précoce en Europe centrale avec des stations telles que la Weinberghöhlen en Bavière ou Willendorf II/5 en Basse Autriche. La datation améliore également la compréhension des connexions stratigraphiques des quatre couches de trouvailles pertinentes du Hohle Fels. Traduction: L. Bernard

Schlüsselwörter / Keywords / Mots clés

Baden-Württemberg / Jungpaläolithikum / Gravettien / ^{14}C-Datierung
Baden-Württemberg / Upper Palaeolithic / Gravettian / radiocarbon dating
Bade-Wurtemberg / Paléolithique supérieur / Gravettien / datation ^{14}C

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