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TL dates for the Middle Paleolithic site of Combe-Capelle Bas, France

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Abstract

The Middle Paleolithic site of Combe-Capelle Bas, France, is known primarily from the excavations of Ami in the early part of the last century and more recently from the excavations of Dibble and Lenoir. Up to now, the only dates available for the site were based on geologic and paleoclimatic data. Most recently, Texier and Bertran suggest that the formation of the principal Mousterian deposits date to prior to OIS 6 and likely represent OIS 8 or even 10. The results of TL dating of burnt flints from these same deposits (Levels I-1D, I-1E, and I-2B), reported here, contradict this finding. They indicate an age of between 37 to 60 ka with six of the seven flints falling between 50–60 ka. This date fits well with Mousterian sites previously dated in this region of France.

Keywords: Combe-Capelle Bas; Middle Paleolithic; Mousterian; TL dating

1. Background

Combe-Capelle is a set of four Paleolithic sites (the Plateau de Ruffet, Roc de Combe-Capelle, Abri Peyrony, and Combe-Capelle Bas) located in the Couze Valley, a tributary of the Dordogne, in southwest France (Fig. 1). The first of these is located on the plateau overlooking the valley. The second two are set against an exposed cliff face just under the plateau. The last of these, Combe-Capelle Bas, is located along the slope from the plateau to the modern valley floor. Its full extent is unknown; at the base of the slope it is covered by more recent alluvium and it extends to at least midway up the slope.

Combe-Capelle Bas was discovered in the late 19th century and excavated on multiple occasions soon thereafter. The most substantial excavations, however, were conducted by Henri-Marc Ami from 1926 until his death in 1931. Ami started at the base of the hill and excavated a large trench (35 × 2.5–10 m) as he worked his way up hill. Following his death, Ami's excavations were finished and the collections published by Peyrony [28,29] and later Bourgon [4]. The exact nature of the stone tool industries from Ami's excavations were subject to some debate. The top of the sequence was attributed to the MTA, but while Peyrony and Bourgon saw a stratigraphic progression from Quina to Ferrassie Mousterian below this, Mellars [19] saw it as entirely Quina Mousterian. In Mellars's view, therefore, it no longer conflicted with the general pattern he had identified in southwest France of Ferrassie Mousterian always proceeding Quina Mousterian.

With regard to the date of the deposits, based on the geology and the relatively limited fauna, Peyrony [28],

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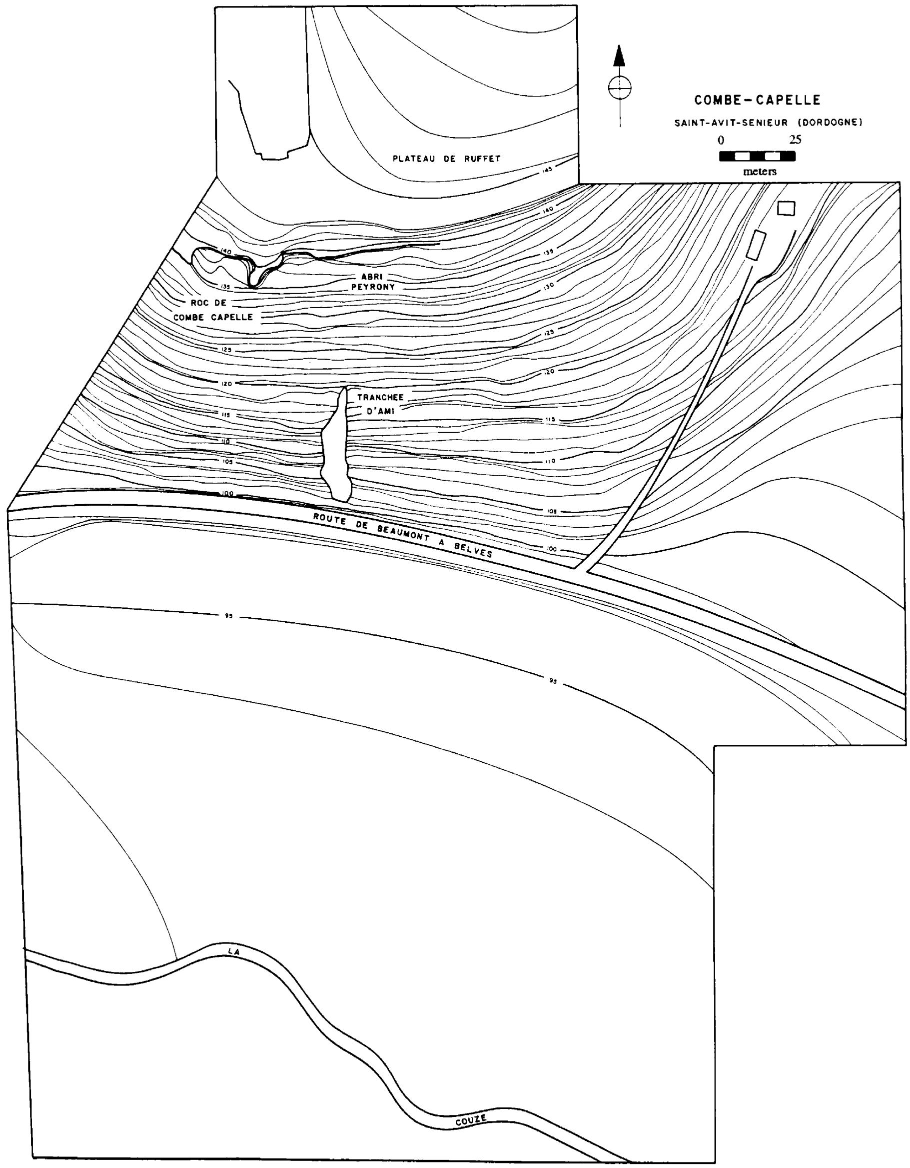

Fig. 1. Topographic map of the Combe-Capelle sites (from [8]). Combe-Capelle Bas is at the base of the hill where Ami excavated a lengthy trench (Tranchee d'Ami). Elevations are meters above sea level.

pp. 419–420, [29], pp. 255–256 and Bourgon [4, p. 129] correlated Combe-Capelle Bas with the lower shelter of Le Moustier which was thought to date to the Würm and also contains MTA assemblages. Later Breuil (Breuil and Lantier [5], p. 120) placed the middle slope deposits of Combe-Capelle Bas in the Riss. Still later, in the context of his thesis, Texier [31] studied samples from these same deposits and concluded that they dated to Würm I (but see below).

In 1988 two of us [8] began a four year project to re-excavate the site. The goal of this project was to obtain new collections that could help clarify the nature of the industries and, thereby, re-examine the possible contradiction to Mellars's Ferrassie to Quina pattern. At the same time, these excavations attempted to address the formation of the deposits and also their date. The results of these excavations and the interpretation of the site formation processes have been published ([8]; see also [10,30]) as has the complete data set [11]. This, however, is the first time the dates have been published.

The new excavations sampled Ami's trench in three places (Fig. 2), labeled Sectors I, II and III. Sector I is at the base of Ami's trench and has the deepest sequence. It consisted of two excavation units labeled Unit A1 and A2. Sector II is further upslope at approximately the broadest point in Ami's trench. It was excavated according to the traditional French grid of meter squares. Lastly, Sector III was located on the eastern side of Ami's trench near its upslope limit. This sector

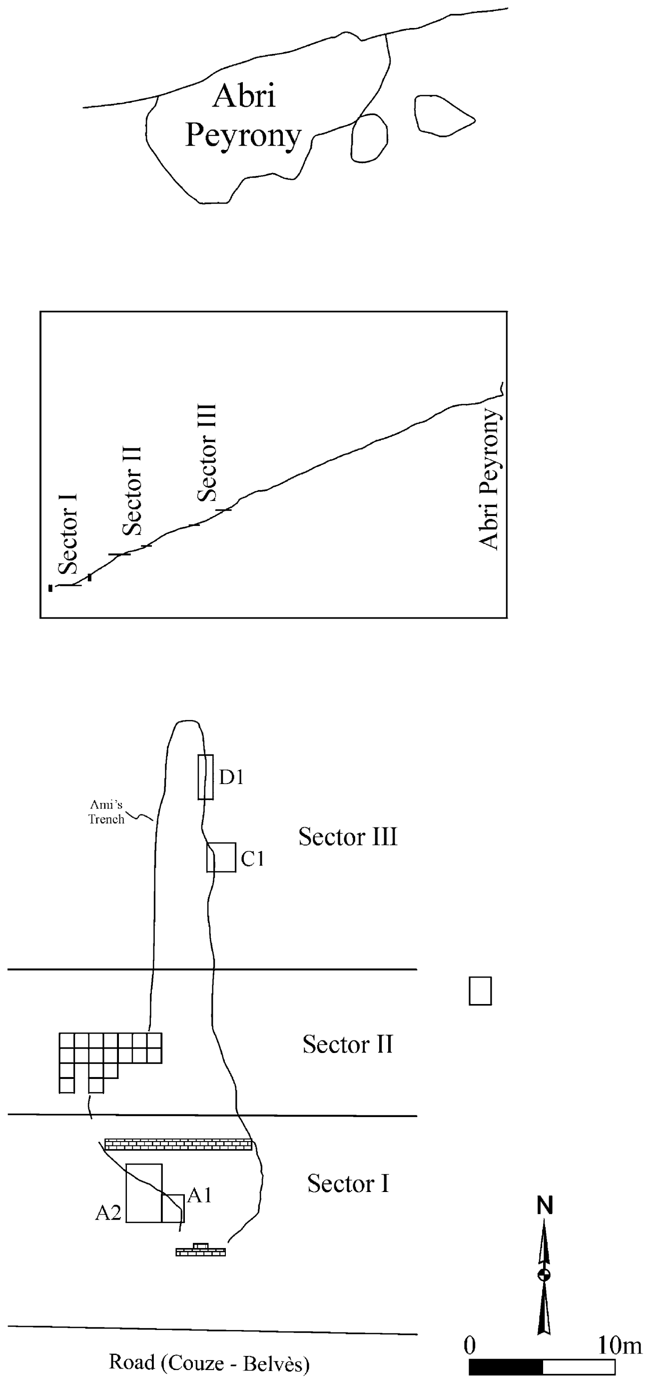

Fig. 2. Plan view of Combe-Capelle showing Ami's trench and Dibble/Lenoir units. The inset shows a south–north profile of the hillside from the base of the slope to the Abri Peyrony at the base of the plateau.

was tested with two units labeled C1 and D1. The positioning of these sectors allowed for the full sampling of Ami's sequence.

With regard to the formation of these deposits, sedimentological analysis [3], magnetic susceptibility analysis [12], artifact orientation and density analysis [15], and analysis of the artifact typology and technology [7] all suggest that each sector has its own depositional history and must be treated separately. This finding is in direct contradiction to the stratigraphy as described by Ami. Aside from the MTA which occurred only near the top of the trench, Ami saw a more or less continuous depositional sequence along the length of the trench. On the other hand, there is considerable disagreement as to the exact nature of the deposition. We have argued [6,9, p. 319] that while it is clear, particularly from the artifact orientation results, that the artifacts have moved, the movement was limited enough that the levels of each sector nevertheless show clear internally consistent and distinct chronological patterning and, therefore, retain significant integrity with regard to behavioral interpretations. Conversely, Bertran and Texier [3] argue that the deposits are the result of the mass movement of materials from the top of the hill to the bottom primarily through solifluction and debris flow. In effect, they postulate that a Mousterian site was once located where the site of Abri Peyrony is today at the base of the plateau or perhaps located on the top of the plateau where the Plateau de Ruffet rests. This site, or at least its Mousterian artifacts, was then transported down slope to create the site of Combe-Capelle Bas. Thus with regard to the behavioral value of the industries, they (Bertran and Texier [3], p. 191) conclude that "interpretations based on [the industries] should be viewed with caution".

Bertran and Texier ([3], pp. 188–189) also give an assessment of the age of the deposits in each sector based on geological analysis. They argue that the slope deposits of both Sectors I and II are interstratified with alluvial deposits (our Level II-4 from Sector II and Level I-2 from Sector I) that indicate that the Couze river must have been at that level at that time. Moreover, they maintain that given that these alluvial deposits are more than 10 m above the current Couze floodplain, a significant phase of downcutting occurred between then and now. Based on their understanding of stream deposits in the Aquitaine and more specifically with terraces in the Dordogne and Isle valleys, they suggest that the majority of the slope deposits of Sectors I and II likely date prior to OIS 6 (130–188 kya) and likely represent OIS 8 (244–300 kya) or even 10 (337–363 kya). The upper part of Sector II they assign to OIS 6 given the presence of a pre-Würmian permafrost. Thus Sector I deposits predate some and possibly all of the Sector II deposits. As for Sector III at the top of Ami's trench, Texier and Bertran see two stratigraphic units. The lower unit is perhaps related to the OIS 8–10 deposits elsewhere on the slope though they entertain the possibility that they could be still older. They place the upper unit, with Ami's MTA industries, in the last glacial. Of course, given their model of re-deposition, these ages must be taken as minimum estimates since it would

Table 1
Reference numbers and find locations of the flints collected for dating. The coordinates are relative to the site datum

Laboratory reference no.	Unit-ID	Level	XYZ coordinates
CC10	A2-3766	I-1D	1014.608, 1003.862, 1.754
CC9	A2-2874	I-1D	1014.953, 1003.344, 1.94
CC2	A1-560	I-1D	1015.725, 1002.312, 2.512
CC6	A1-629	I-1D	1015.93, 1002.328, 2.568
CC7	A1-773	I-1D	1015.906, 1002.092, 2.666
CC8	A2-2497	I-1E	1013.834, 1004.355, 1.536
CC3	A1-1124	I-2B	1015.599, 1002.403, 3.624

presumably take some time for the site and its artifacts to be transported downslope after having been formed originally further up. This would make Combe-Capelle Bas one of the older Mousterian sites in France.

2. Thermoluminescence dating

In addition to the geological estimation of the age of Combe-Capelle Bas, absolute dating techniques were also attempted. Due to various logistical factors, dates could be obtained only for Sector I. The results, presented in the following section, conflict with the geological age estimation.

2.1. Methods and materials

Flints in archeological strata act as dosimeters for the natural radiation received from internal and environmental sources during the burial time. When a flint is heated to a sufficiently high temperature (ca. 450 °C) the effects of prior irradiation are erased and after cooling it begins storing the radiation energy received since the last heating [35]. If the annual radiation dose received by such a flint can be determined, the thermoluminescence (TL) measurement of the total accumulated dose (paleodose) makes it possible to estimate how long ago a hearth, for example, into which the flint had fallen was abandoned. The thermoluminescence method is particularly useful for dating Middle Paleolithic sites beyond the range of radiocarbon method and has in the past provided age-estimates for several important Mousterian sites in Europe and the Near East [25,27,36,39].

The burnt flint specimens discussed in this article were collected during the Dibble and Lenoir excavations at Combe-Capelle Bas from Levels I-1D to I-2B of Sector I (excavation Units A1 and A2). Among the ten flints selected for TL analysis, only seven were sufficiently heated to be datable. Of these, five specimens came from Level I-1D and one sample each from Levels I-1E and I-2B, respectively (Table 1). The flint find locations are indicated on the section presented in Fig. 3. The industries of these three levels are technologically and typologically very similar and best classified as Typical Mousterian, rich in notched tools. In terms of their deposition, however, the levels differ. While Bertran and Texier [3, pp. 182–183] attribute most of the levels at Combe-Capelle Bas to slope deposition, the top of the sequence (Bed I-1) in Sector I is marked by interstratified fluvial deposits oriented perpendicular to the slope and parallel to the valley. These levels appear as channel fills with some local sorting of sediments. Thus while Levels I-1E and I-2B are attributable to slope deposits, Level I-1D is a result of fluvial deposition.

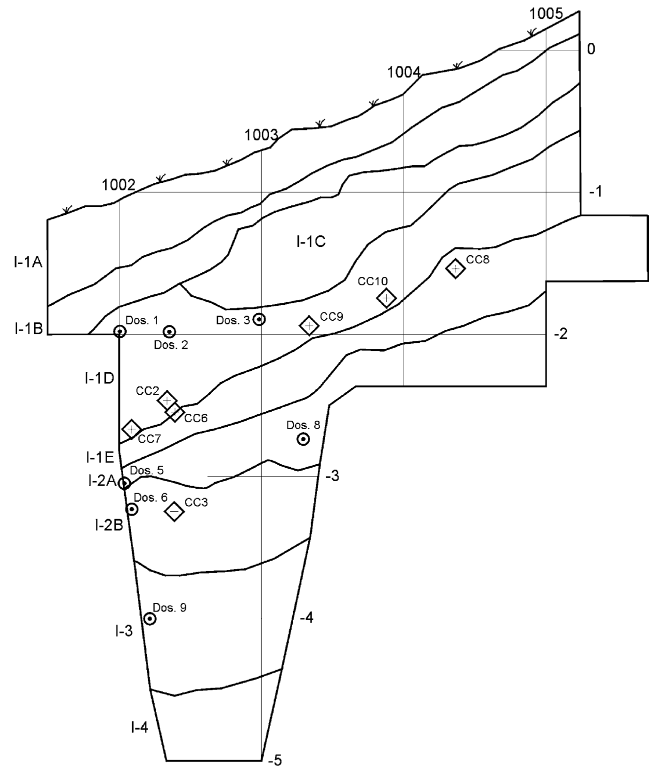

Fig. 3. West section of Units A1 and A2 with the locations of the burnt flint specimens and of the dosimeters. Elevations and the Y coordinates (across the top) are relative to the site datum.

2.2. Experimental procedure

2.2.1. Annual dose-rates measurement

In 1990, seven $CaSO_4$:Dy dosimeters were placed for one year to measure the gamma and cosmic dose-rates in Levels I-1D, 1-2A, and I-3A (see Fig. 3). The distance between each flint-find location and the nearest dosimeters usually ranged from 0.2 to 1 m.

The cosmic dose-rate received by any dosimeter (synthetic or natural) depends on the thickness of the overlying deposits. Because the upper part of the sediment filling had been removed by the excavators, the cosmic dose-rate recorded in 1990 by the dosimeters must differ somewhat from the one experienced by the

Table 2
Gamma dose-rates (with a statistical error of <3%) measured by the dosimeters planted at the relevant Combe-Capelle Bas strata

Dosimeter 1	Dosimeter 2	Dosimeter 3	Dosimeter 5	Dosimeter 6	Dosimeter 8	Dosimeter 9
I-D1 256 μGy/a	I-D1 225 μGy/a	I-D1 236 μGy/a	I-2A 255 μGy/a	I-2B 265 μGy/a	I-2A 277 μGy/a	I-3A 280 μGy/a

burnt specimens in the past. The modern cosmic dose-rates were estimated by considering the sediment thickness (from ca. 0.6 to 1 m) over each dosimeter's location and these values were subtracted from the dosimeter's record. The calculated gamma dose-rates (Table 2) showed a slight increase with depth from 226 μGy/a to 280 μGy/a but within a given level the variations did not exceed 10%. The gamma dose-rate computed for each sample was obtained by using the nearest dosimeter or the average value of the dosimeters inserted in the same level. An uncertainty of ±10% was associated with each value to account for spatial and temporal variations of the gamma dose-rate produced by radioisotopic heterogeneity and past variations of the water content of the sediment.

The mean cosmic dose-rates received by the burnt specimens in the past were estimated independently according to their pre-excavation burial depths. In Level I-1D, the samples were at a depth of ca. 1.5 m and the cosmic dose-rate deduced is 170 μGy/a; in Level I-2B, the sample was at ca. 2 m below the surface, so a cosmic dose-rate of 160 μGy/a was used. To allow for possible variations of the cosmic dose-rate provoked by the past evolution of the sedimentary fill thickness, an error of ca. ±20 μGy was associated with these values too. Such an uncertainty encompasses the range of cosmic dose-rates experienced by these levels if the burnt specimen's recorded depth deviated by about ±0.8 m from where it was in the past. The computed total external dose-rate (gamma plus cosmic) ranged from 386 to 414 μGy/a depending on the burial spot.

The internal dose-rate of each flint was calculated from its U-238, Th-232, and K-40 contents measured by neutron activation analysis at the Pierre Süe Laboratory, CEN, Saclay [14] and from its alpha-sensitivity [34]. The latter was determined by comparing the TL signals induced by alpha-rays from a Pu-238 source (flux: 2.46×10^6 alpha/cm^2/s) with those induced by beta-rays from a Sr/Y-90 source (dose-rate: 9.2 Gy/min), after the specimen had been heated for 1.5 h at 350 °C. The internal dose-rate ranged from ca. 120 to 500 μGy/a depending on the flint's radioisotopic contents and alpha sensitivity, so it could represent as little as 23% or as much as 50% of the total annual dose-rate. However, for six of the samples, the contribution of the internal dose was close to or higher than 40%, making the TL ages, on average, dependent by only 50% on variations of the external dose-rates.

2.2.2. Paleodose determination

Each flint was treated according to the procedure described by Valladas [35], and the paleodoses were determined by the additive-dose technique [26], for which a Cs-137 gamma-ray source delivering 1.48 Gy/min was used [32]. The TL signals were measured with a heating rate of 5 °C/s and detected with a Thorn EMI 9635QB photomultiplier tube through a MTO 380 nm optical filter that selected the blue component of the emission spectrum [33]. Fig. 4 shows the TL glow curves (natural and natural+artificial) of a typical Combe-Capelle Bas burnt flint (CC10) alongside the natural and regenerated linear TL growth curves. The latter was obtained after the original powder was reheated for 1.5 hr at 350 °C and artificially irradiated in order to calculate the supralinearity correction. The values of the apparent accumulated doses deduced as a function of temperature (plateau test) are given on the same figure. The paleodose was obtained by integrating the 380 °C peak from 340 °C to 400 °C, where the plateau test was satisfied [2]. In column 13 of Table 3 are listed the paleodoses of the seven samples; they ranged from 28 to 44 Gy.

3. Results

All the age-estimates and the data from which they were deduced are presented in Table 3. The ages range from about 37 to 57 ka but six of the seven flints fall into the 50–60 ka bracket. The discrepancy between the age of CC2 and those of the six other samples cannot be explained by any uncertainties in the paleodose determination of CC2. Nor can the younger age of this specimen be explained by an overestimate of its external dose: as a matter of fact, for CC2 to have an age of ca. 50 ka, its gamma dose-rate would have to be almost zero—a highly improbable event. Therefore, it is likely that CC2 is younger than the other samples and it underwent some vertical post-depositional movement.

The results obtained for the six other samples are compatible and show no noticeable variation with their burial depth (Levels I-1D to I-2B). Such agreement suggests that all six were burned within a narrow time interval and allows us to compute the mean weighted age of the individual results, with the statistical and systematic errors being treated separately. The mean age

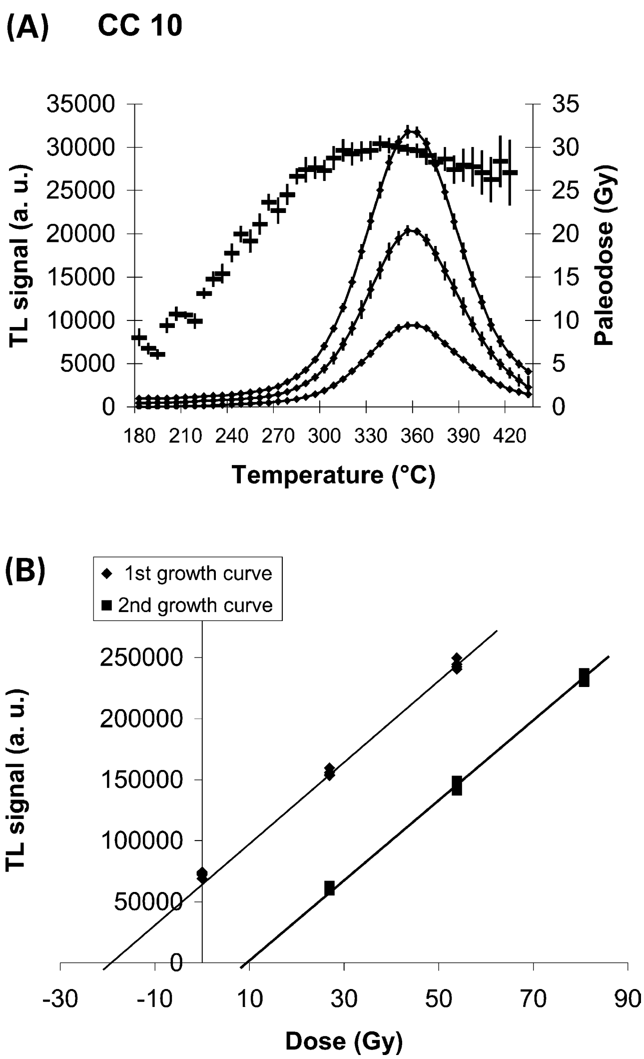

Fig. 4. A: TL glow curves of CC10: natural TL and natural plus artificial TL induced respectively by the added doses of 17 and 54 Gy. Plateau test plots computed from the linear growths of the TL signal as a function of applied dose. B: TL growth curves of CC10 obtained respectively at the first and second heatings in the TL oven.

of 51.8 ± 3.0 ka (at one sigma level) indicates that the fires in which the flints were burnt belong to the first part of OIS 3 [18].

4. Discussion

These results fit well with dates published for similar Mousterian sites in the region. They overlap with the ESR dates from the upper layers of Pech II (Layer 2–4, multiple dates approximately 54–87 kya EUM [13]) which are mostly Typical Mousterian, the TL dates from the MTA-A at the base of the lower shelter at Le Moustier (Layer G, 50.3 ± 5.5 kya and 55.8 ± 5 kya [37]; 43.0 ± 2.3 kya EUM and 47.0 ± 2.5 kya LUM [24]), and the TL dates from the Typical and MTA levels of Fonseigner (Level E–D, 50.2 ± 5.3 kya, 52.8 ± 5.5 kya, and 56.4 ± 6.8 kya [38]). Interestingly, the Combe-Capelle Bas and Le Moustier dates support the correlation that both Peyrony and Bourgon suggested for these two sites half a century ago.

Conversely, the dates are in direct conflict with Texier and Bertran's age estimations based on the site's geology [3]. Whereas they placed these deposits in OIS 8 or 10, the TL data place them squarely in OIS 3. We must point out that no error in the estimation of the experimental data (paleodose and annual dose-rates) could explain such a discrepancy. For instance, to get an age older than 200 ka, the paleodose of each sample would have to be multiplied by a factor of five or greater, a most unlikely scenario. On the other hand, no error in the external dose-rate estimation could reconcile the TL age with the presumed geological age; for instance, even if the gamma dose-rates were assumed to be insignificantly small, the TL age deduced for six of the flints would not exceed 80 ka. Though the magnitude of the difference is larger in this instance, the contradiction between the geologically derived date and the absolute dating is not surprising given prior difficulties reconciling Laville's geologically derived chronological model for the region with the frequency of climatic oscillations documented by the oxygen isotope stages and with new absolute dates from key, referential sites such as Le Moustier [16,17,20–23, p. 187].

Bertran and Texier's site formation model, which posits a massive re-deposition of material from upslope, is also predicated on deposition during a cold period. Since the burning event that set the date of the tools likely preceded their re-deposition, this would place the timing of Bertran and Texier's model very late in the Middle Paleolithic. The only cold period of similar intensity and duration to OIS 8 or 10 is OIS 2. Though OIS 3 is an interpleniglacial period, it is nevertheless characterized by rapid and fairly frequent climatic oscillations. Whether a period of sufficient cold and duration exists to account for the amount and degree of solifluction posited in their model, however, is unclear.

Additionally, the consistency of the dates is a bit surprising in the context of their re-deposition model, particularly since they posit two different depositional modes for the dated levels: fluvial and colluvial. Under circumstances of such extreme mixing, one might expect a wide range of dates and/or stratigraphic inversions, but with the exception of one sample, very similar age estimates were obtained for flints with very different dosimetric characteristics.

The implications of these dates for Sectors II and III at Combe-Capelle Bas, which are also Typical Mousterian, are less evident. It turned out to be quite difficult to correlate the stratigraphic sequences of each sector, and as noted previously, we believe that each sector has its own depositional history (one point on which all of us seem to agree). Bertran and Texier

Table 3
Thermoluminescence age-estimates and radioactivity data for the burnt flint specimens from Combe-Capelle Bas

Sample	U	Th	K	α Sensibility	Internal dose		Gamma	External dose		Annual dose		Paleodose		Age	
	(ppm)	(ppm)	(%)	(µGy/a/10^3α)	(µGy/a)	±	Dose	(µGy/a)	±	(µGy/a)	±	Gy	±	(ky)	±
CC10	0.220	0.155	0.037	12.17	122.3	6.7	221.8	391.8	23.4	514.2	24.4	29.5	0.8	57.4	4.2
CC9	0.770	0.154	0.030	16.23	371.1	26.3	219.7	389.7	23.2	760.9	35.1	42.3	2	55.6	4.4
CC2	0.720	0.161	0.042	17.15	373	25.9	240.1	400.1	23	773.1	34.6	28.3	0.9	36.6	2.7
CC6	0.460	0.218	0.049	15.03	250.1	15.3	241.4	411.4	23.1	661.5	27.7	31.9	0.7	48.2	3.3
CC7	1.070	0.090	0.044	16.29	500.9	36.6	254.4	414.3	24	915.3	43.8	44.8	1	48.9	3.8
CC8	0.710	0.188	0.063	16.76	382.3	25.3	219.7	389.7	23.2	772.1	34.4	43.9	7.2	56.9	7.8
CC3	0.580	0.176	0.038	16.72	305.3	20.5	236.5	396.6	22.7	701.9	30.6	37.1	2.7	52.9	4.6

The U-238, Th-232, and K-40 contents of the dated specimens (columns 2 to 4) are given in ppm, ppm and % respectively. The combined statistical and systematic error of ±10% are essentially caused by uncertainties in the reference standard.

The alpha sensitivity (column 5) was determined by comparing the TL-α and TL-β signals induced by α and β particles from Pu-238 and Y/Sr-90 sources, respectively [34].

The internal dose-rate (column 6) of each flint was computed from its contents U, Th and K and from the specific dose-rates given by Adiamec and Aitken [1].

The external (column 7) dose-rates were deduced from measurements taken in the field by dosimeters.

Following Aitken's [2] recommendations the statistical and systematic errors were calculated separately for each flint. Each of the tabulated over all errors represents the mean square average of the two (column 16).

suggest that Sector II is probably later than most of Sector I and they view the upper portion of Sector III as the most recent at the site (post-Eemian). If they are correct in this relative stratigraphy, then the TL dates place most of Sectors II and the upper portion of Sector III post-50 ka. But here again, this late date is difficult to reconcile with their geological observations for Sector II [3, p. 189].

With regard to Mellars's relative chronological model of Quina following Ferrassie, it is now known that Combe-Capelle has neither variant. Rather, the Combe-Capelle industries are primarily Typical Mousterian, rich in notches and denticulates though technologically it is similar to the Quina with an emphasis on thick flake production [8]. As for the MTA, the new excavations were not able to locate this level, and it is quite likely that it comes from an area east of Ami's trench. Thus, with regard to Mellars's [23] more recent attempts to establish an absolute chronology for the Mousterian variants, the Combe-Capelle Bas dates are equivocal, particularly since Mellars views the Typical and Denticulate as not particularly chronologically sensitive and indeed questions their status as "significant or meaningful industrial or taxonomic entities" [23, p. 191]. Nevertheless, Mellars has suggested that Typical industries may cluster in OIS 5; a point not supported by Combe-Capelle Bas.

Thus the Combe-Capelle Bas dates contribute to the gradually growing database of dated Mousterian sites from southwest France. At a general level they fit well in the context of post-Eemian (the old Würm I and II) Mousterian sites, and in this regard the new TL dates are preferential to Bertran and Texier's geologically derived estimation of the site's age. It is not clear whether Bertran and Texier's model of massive post-depositional re-deposition at Combe-Capelle Bas is still a tenable alternative to our (HLD and ML) model of much more limited movement of deposits that retained their basic chronostratigraphic integrity. At a minimum, a fresh evaluation of the geological evidence for the formation of these deposits in light of the timing indicated by these relatively late dates is necessary.

Acknowledgement

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