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A snapshot on some everyday actions of a Middle Pleistocene hominin: the Trackway B at the Devil's Trails palaeontological site (Tora e Piccilli, Caserta, Central Italy)

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Summary - *´ is report aims to give notice of and provide a more detailed dataset and detailed remarks on what can be considered a one-of-a-kind hominin fossil walking pattern: Trackway B of the Foresta ichnological site (Tora e Piccilli, Caserta, Central Italy). Although the site is known since 2003, only recently has the study been performed by means of the newest photogrammetric and experimental techniques of collection, analysis and interpretation of ichnological data. ´ e results obtained enable us to depict an astonishing movie printed in rock, describing some body features and common moments of the everyday movements of a hominin who lived about 350 ka. In particular, some up-to-now absolutely unique fossil prints of body parts of a Pleistocene hominin (calf, ankle, and gluteus), which have simply been mentioned in the ichnological fossil record, are here quantitatively described for the ÿ rst time. ´ e data coming from this research will provide scientists with new valuable elements thus far undetected anywhere else in the world.*

Keywords - *Human ichnology, Fossil footprints, Roccamonÿ na volcano, Morphometric analysis, Homo heidelbergensis.*

Introduction

An increasingly multidisciplinary approach and the development of increasingly precise and detailed surveys and techniques of data analysis are giving a decisive contribution to the knowledge of the appearance, cultural level and environments of our ancestors who lived in prehistoric times. In this joint effort, human paleo-ichnology also gives a precious contribution due to its power to record the fossil frames of some movements "frozen" in the rock. These movements, like in a modern crime scene investigation, can be very often contextualized in space and time with great precision, often giving important behavioral information.

Unfortunately, human fossil footprints are very rare and preserved only on soft rocks at high risk of preservation (Bennett *et al.*, 2013). Fossil human footprints currently known in the world are always preserved on subplanar or slightly inclined surfaces, with the only exception of the Foresta site (Tora e Piccilli, Central Italy) (Bennett & Morse, 2014; Panarello, 2016). Here human fossil footprints, traditionally known as "Devil's Trails", previously tentatively attributed to *Homo heidelbergensis* (Panarello *et al.*, 2017), but actually not yet precisely attributable to a specific human species (Panarello *et al.*, 2020 and references therein), are preserved on a strongly steep slope of Brown Leucitic Tuff (BLT) which is located on the North-Eastern slope of the Roccamonfina volcano (Mietto *et al.*, 2003; Avanzini *et al.*, 2008; Scaillet *et al.*, 2008; Santello, 2010; Panarello, 2016; Panarello *et al.*, 2017) (Fig. 1). The trampled surface has been $^{40}Ar/^{39}Ar$ radiometrically dated at 349±3 ka (Scaillet *et al.*, 2008; Santello, 2010) (Fig. 2a).

The strong inclination of this trampled slope enables scientists to elaborate dynamic models of human gait, that are not possible elsewhere so far (e.g. Saborit *et al.*, 2019).

An extended preliminary report of the fossil footprints and trackways of the "Devil's Trails" palaeontological site was published by Avanzini *et al.* (2008). Among the ichnological evidence

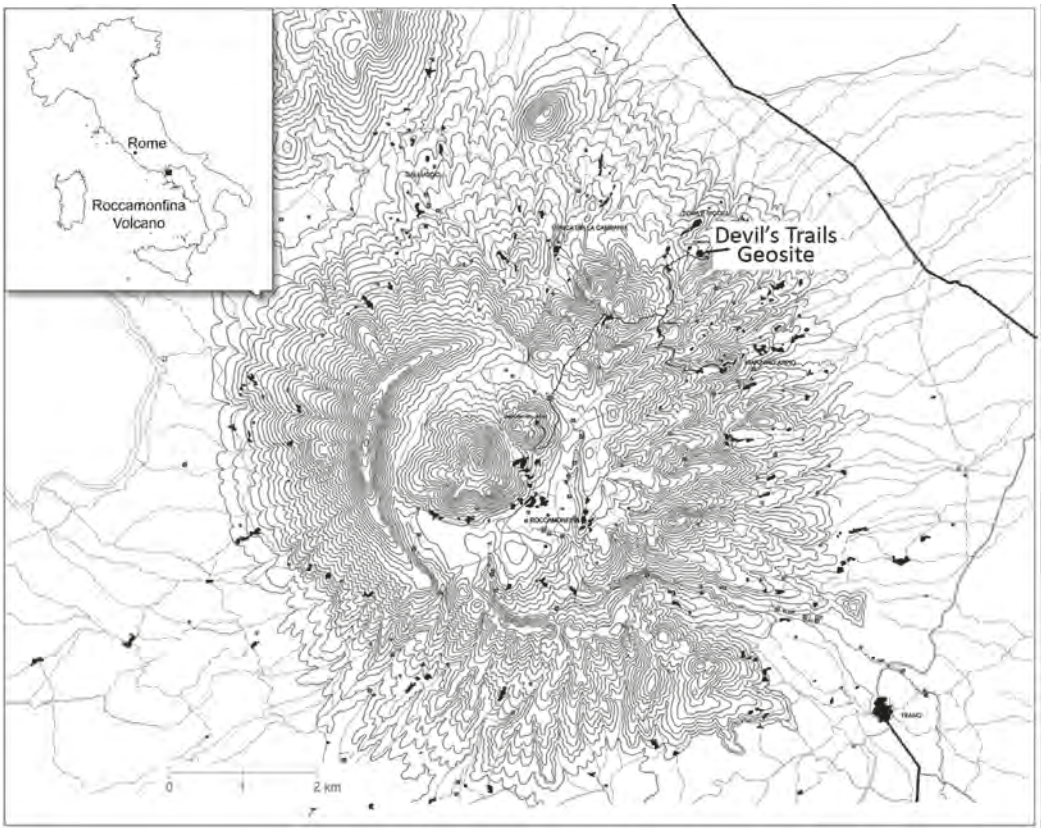

Fig. 1 - Geolocalization of the “Devil’s Trails” palaeontological site.

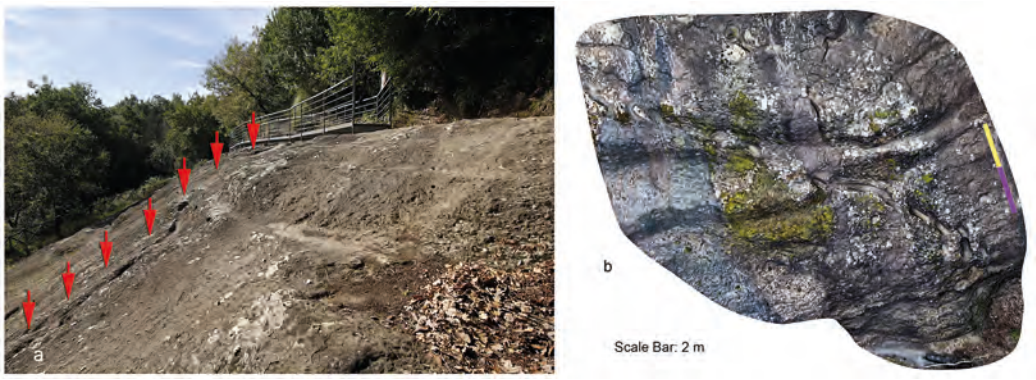

Fig. 2 – Foresta (Tora e Piccilli), “Devil’s Trails” Palaeontological site: view from the East of the tuff-slope along which Trackway B runs (the direction is indicated by red arrows) (a); Southern oblique view of Trackway B (3D generated Photo) (b). The colour version of this figure is available at the JASs website.

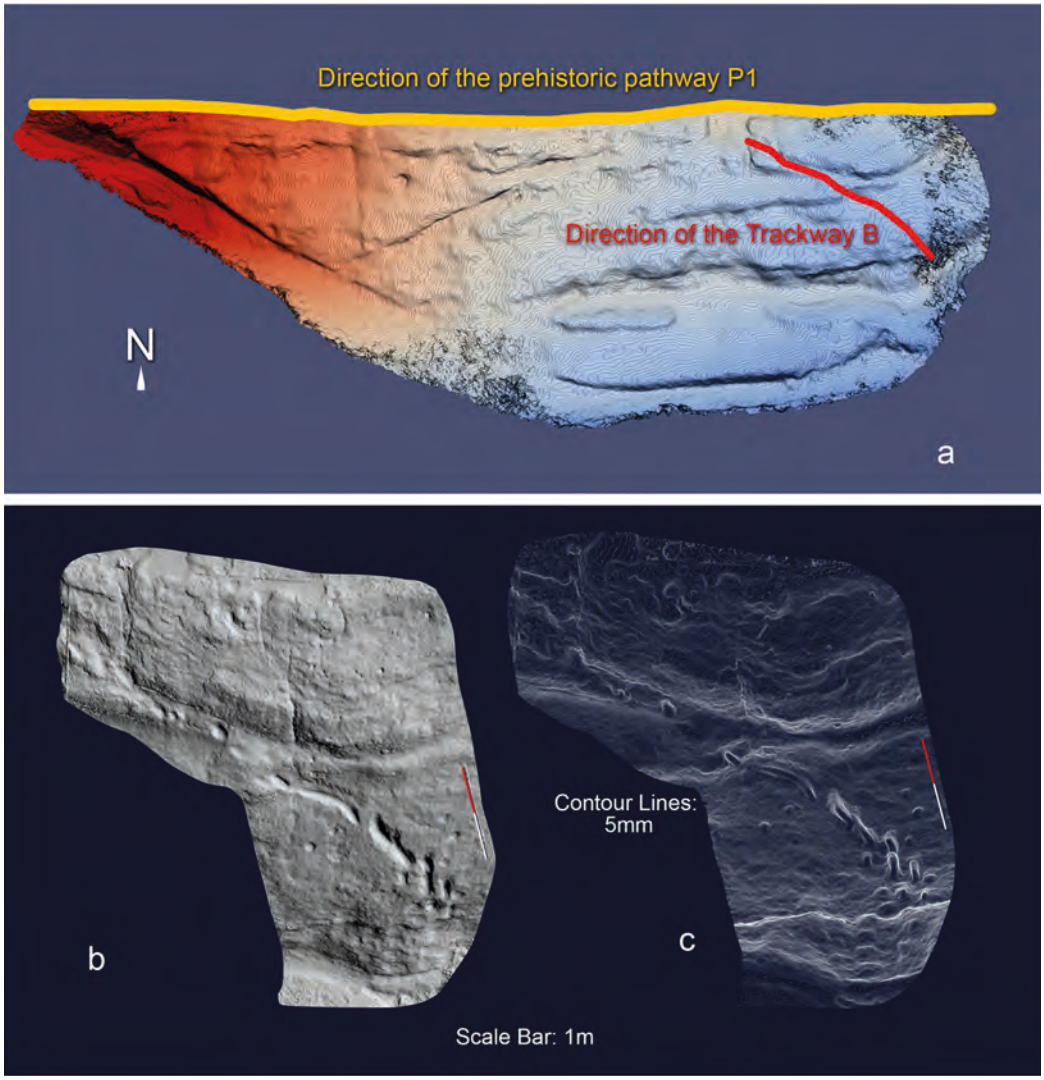

Fig. 3 - 3D generated block surface of the "Devil's Trails" Palaeontological site: Aerial Southern view of the entire slope [the direction of the prehistoric pathway is marked in yellow from which Trackway B branches off; the direction of Trackway B is marked in red] (a); Zenithal flat view of the SE area with Trackway B (scale bar= 1m) (b); Contour lines 5 mm (c). The colour version of this figure is available at the JASs website.

described in this report the so-called "Trackway B" soon seemed to be particularly interesting (Figs. 2b, 3, 4), because it preserved some uncommon and never previously observed footprints and gait pattern. These footprints were first interpreted as the prints left by a hominin during a long slide while walking in a quite straight and diagonal descending direction toward South-East. New analyses led by the scientific team of Paolo Mietto (University of Padua) and carried out by means of the most recent and reliable photogrammetric 3D modelling techniques provided new valuable

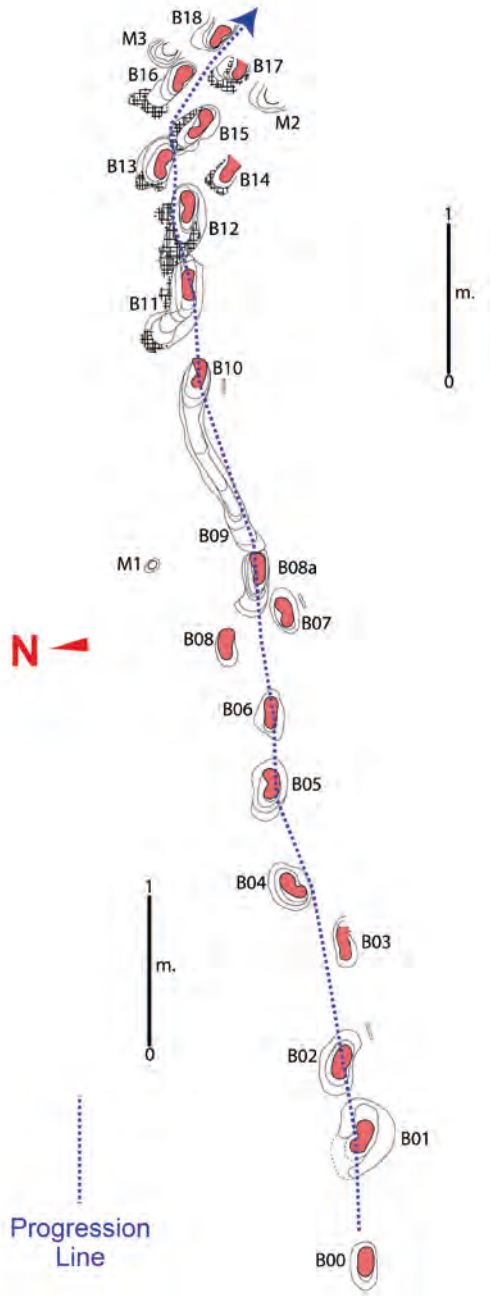

Fig. 4 - Sketch of the general course of Trackway B from its beginning to the verge of the drop of slope with the progression-line (blue dotted line). The colour version of this figure is available at the JASs website.

evidence. These data confirm the first hypotheses and allow a thorough description for the first time of the fossil prints of some human body parts which are elsewhere unknown so far (Mietto *et al.*, 2003; Avanzini *et al.*, 2008; Panarello *et al.*, 2018, 2020 and references therein).

Methods

All scientific evidence has been georeferenced with a Garmin Etrex 10 (accuracy ±3 m) and totally photographed by Canon EOS 550D, Canon PowerShot G9 and Sony NEX 6 cameras. Then all the pictures have been processed with Agisoft Photoscan Pro and detailed 3D models of the general surface and of each structure have been created following the procedures of Mallison & Wings (2014). Each model has been scaled on the basis of a metallic scale-bar. Finally, in respect of the latest scientific protocols (Falkingham *et al.*, 2018) and according to the procedure of Belvedere *et al.* (2013) some detailed contour maps and high-resolution depth maps have been created through Kitware Paraview. Each parameter of the figured models is shown in Table 1 according to the method of Lockley *et al.* (2015). The 3D models elaborated for this report are also used in other ongoing research, so their open files will only be made available on specific request. For measurements of lengths and inclinations the following instruments have been used: GemRed digital inclinometer with spirit levels (length: 400 mm; resolution: 0.1; range: 4x90° (0-360°); objective measured error ±0.6°); TACKLife Digital Inclinometer Mini Digital Protractor, mod. MDP02 (accuracy ±0.3°; resolution: 0.1; range: 4x90° [0-360°]).

Dimensional conventions

Since best preserved part of the footprints is almost always the heel-strike zone, the most proximal point of the impression (pt) was chosen as the default anatomical landmark for measuring gait parameters.

After a careful analysis of the most common and reliable procedures of footprint and

Tab. 1 - Parameters of the photogrammetric models of Trackway B.

FIGURED MODEL	NUMBER OF IMAGES	CAMERA MODEL	IMAGE RESOLUTION	FOCAL LENGTH (mm)	ERROR (pix)	RESOLUTION (m/pix)
Pista B_Noted_ Model 1	626	SONY Nex 6	3568 x 2368	16-31	0.426435	0.00525032
B01, B02	35	Canon EOS 550D	5184 x 3456	18-50	0.527276	0.000619118
B03	9	Canon EOS 550D	5184 x 3456	18-50	0.679806	0.000435948
B04	37	Canon EOS 550D	5184 x 3456	18-80	0.590223	0.00125273
B05	37	Canon EOS 550D	5184 x 3456	18-80	0.590223	0.00129012
B06	37	Canon EOS 550D	5184 x 3456	18-80	0.590223	0.0013047
B07	10	Canon P.Shot G9	4000 x 3000	7,4	0.594738	0.000454072
B08	8	Canon P.Shot G9	4000 x 3000	7,4	0.5175	0.000475237
B08a	9	Canon P.Shot G9	4000 x 3000	7,4	0.601952	0.000493607
B09	64	Canon EOS 550D	5184 x 3456	18-50	0.782356	0.00224265
B10	12	Canon P.Shot G9	4000 x 3000	7,4	0.632863	0.000420919
B11	9	Canon EOS 550D	5184 x 3456	18-20	0.532489	0.00151803
B12	14	Canon EOS 550D	5184 x 3456	18-20	0.620247	0.00109675
B13	11	Canon EOS 550D	5184 x 3456	18-35	0.66541	0.000753941
B14	11	Canon EOS 550D	5184 x 3456	18-20	0.731453	0.000823891
B15	26	Canon EOS 550D	5184 x 3456	18	1.18854	0.000886502
B16	15	Canon EOS 550D	5184 x 3456	18	1.2366	0.000994559
B17	10	Canon EOS 550D	5184 x 3456	18	0.693155	0.000844289
B18	18	Canon EOS 550D	5184 x 3456	18-70	0.64841	0.000864548
B19 (M2)	16	SONY Nex 6	3568 x 2368	16-31	0.53134	0.00269135
B20 (M3)	13	SONY Nex 6	3568 x 2368	16-34	0.685573	0.00236362
B21	8	Canon EOS 550D	5184 x 3456	18	0.617731	0.000474161
B22	8	Canon EOS 550D	5184 x 3456	18	0.580521	0.000346739

gait analysis, a series of dimensional conventions has been created and shown in Table 2 and Figure 5. They seem to be the most reliable and the most objectively applicable in the case of the tracks preserved along the "Devil's Trails" Trackway B.

Description and comparison

Trackway B starts at coordinate point WGS 84 N41°19.956'-E14°01.495', at an altitude of about m. 294 (±3), and ends at coordinate point WGS 84 N41°19.954'-E14°01.498', with a difference in level (locally measured) of about 4,15 m.

The general trackway is composed of a total succession of 25 actual prints, 21 of which are footprints left by bare feet. The other fossil traces include a left handprint (TP_M1) (Panarello *et al.*, 2018), two other possible handprints (B19, B20, also called M2 and M3) and a last print which could only be interpreted as the imprint left by a right gluteus (B21). The footprints of Trackway B are entaxonic, plantigrade, longer than wide, kidney-shaped, regularly and

Tab. 2 - Dimensional conventions.

NAME	SYMBOL	DEFINITION
Central Axis	CA	The central axis of the footprint (CA) is defined by the method of Kennedy *et al.* (2003, 2005), i.e. identifying it with the bisector of the angle of the envelope cone created by the intersection of the tangents to the readable contour passing through the points of maximum lateral and medial extension, i.e. the line joining the medial metatarsal tip (mmt) with the medial calcaneal tip (mct), and the line joining the lateral metatarsal tip (lmt) with the lateral calcaneal tip (lct) (Robbins, 1985).
Base Line	BL	The baseline of a footprint (BL=Base Line) is defined by intersecting the Robbins method (1985: 67-84) with the method of Kennedy *et al.* (2003, 2005). It is the perpendicular line to the central axis of the footprint (CA) passing through its most proximal point (pt) on the contour line of the footprint.
Footprint Length	Fl	The Footprint length (Fl) is calculated along the central axis as the distance between the points of intersection between the tangents to the contour, normal to the main axis, at the most distal point of the most protruding finger anteriorly (et=extreme tip) and at the most proximal point (pt=proximal tip or “pternion”) of the detectable heel contour.
Real Footprint Length	rFl	The actual, directly measurable (rFl) - or diagonal – length of the footprint is measured as the straight distance between the most distal (et=extreme tip) and the most proximal (pt=proximal tip or “pternion”) point of the detectable contour of the footprint.
Footprint Width	Fw	The width of the footprint (Fw) is the distance between the two parallel to the central axis of the footprint (CA) passing through the most medial point (mmt) and the most lateral point (lmt) of the forefoot on the detectable contour of the footprint (see Robbins, 1985: 79-80).
Real Footprint Width	rFw	The actual, directly measurable width (rFw) of the footprint - or diagonal width - is measured as the straight line distance between the medial (mmt) and lateral (lmt) points of the forefoot on the detectable contour of the footprint (Kennedy *et al.*, 2003).
Step Length	P	The Step, or Pace (P=Pace), is the distance between two consecutive footprints (left and right). It is the distance between the line parallel to the baseline passing through a reference point of the preceding footprint and the parallel passing through the identical reference point on the following footprint (Tuttle *et al.*, 1990; Wilkinson & Menz, 1997).
Real Step Length	rP	The real Step (rP = Pace) is the straight diagonal distance between equal landmarks of two consecutive footprints (left and right).
Stride Length	L	The Stride Length (L), or simply “Stride”, or “double-step”, is the distance between two consecutive footprints left by the same foot. It is the distance between the straight line parallel to the baseline passing through a reference point of the preceding footprint, and the parallel passing through the identical reference point on the following footprint (left by the same foot) (Tuttle *et al.*, 1990; Wilkinson & Menz, 1997).

alternately patterned in such a way as to always direct the medial concavity of the plantar arch towards the progression line (Fig. 4).

Trackway B (Figs. 2, 3, 4, 11) (from the most proximal point of the footprint B00 to the most distal point of the footprint B22) is ~9,4m long and can be divided into three segments (1B, 2B and 3B). Two of these segments are fairly straight. In the central part of the trackway a long fossil slide is preserved. Named as B9, it was created by the sliding of the trackmaker’s left bare foot. The curvature of this long slide marks a clear change of direction towards SE. The angle between segments 1B and 3B is ~147° SE. The other general dimensions and characteristics of Trackway B are shown in Table 3. All the other dimensions measured according to the fixed conventions are shown in Tables 3,

Tab. 2 - continued.

NAME	SYMBOL	DEFINITION
Real Stride Length	rL	The real Stride Length (rL), which is directly measurable, is the straight diagonal distance between equal landmarks of two successive footprints left by the same foot along the same ipsilateral line.
Trackway Width	TW	The trackway width (TW) is a measure of the full width of the trackway. It should be measured in a straight line by identifying the most visible lateral protrusions through which the parallels to the stride directions pass (Leonardi, 1987; Kim *et al.*, 2008).
Pace Angle	PA	The pace angle (PA=Pace Angle) is the angle between the segments that join the same anatomical landmark of three consecutive footprints (Leonardi, 1987).
Progression Line	PL = TA	The progression line - or axis of the trackway - (TA = Trackway Axis) is built according to the scheme of Wilkinson *et al.* (1995), i.e. as follows: 1. Connect a landmark X on one footprint to the same landmark on the next footprint of the same foot to create an "ipsilateral" progression line; 2. From landmark X, draw the segment perpendicular to the contralateral progression line; 3. Measure the midpoint of all drawn perpendicular segments and merge them. The line obtained will be the line of progression (TA).
Foot Placement Angle	FPA	The angle of progression of a footprint (FPA=Foot Placement Angle) is defined as the angle between the orientation of the foot and the direction of progression (Kernozec & Ricard, 1990). Here it is convenient to consider the angle of progression of the foot as the angle formed between the central axis of the foot (CA) and the line of progression of the trackway. It has a positive value if - in the direction of gait - the central axis of the foot (or its geometric extension) diverges from the progression line and a negative value if it intercepts it.
Footprint Index	FI	Foot(print) Index (FI ="Footprint Index") is the ratio between the maximum width and the maximum length multiplied for 100 (Ashton *et al.*, 2014).
Schwartz-Clarke's Angle	SCA	Schwartz-Clarke's angle ("SCA" =Schwartz-Clarke Angle) is defined as the angle formed between the tangent of the footprint passing through the most medial points of its perimeter and the line joining the most medial point of the metatarsal zone (mmt) with the apex of the concavity of the longitudinal arch (Clarke, 1933; Śmahel, 1980; Jaworski & Aleksandrowicz, 1992; Citton *et al.*, 2018).
Footprint Area	Fa	The area which has been conventionally measured by vectorializing the surface through a geometric polyline never created with less than 40 points, such as to approximate the actual surface with a percentage that does not affect the last decimal place with respect to the chosen accuracy.

4, 5 and 6. An estimation of trackmaker's stature has been also made by using the method of Fessler *et al.* (2005). The estimation data are shown in Table 7. The preservation of the footprints is non homogeneous. To give an idea of the degree of preservation of the best footprints, two samples have been provided in Figures 6 and 7.

The movements described by the fossil footprints of Trackway B are quite uncommon and really singular.

Starting from the oldest human fossil pathway up to now known (Panarello *et al.*, 2017b), which is located on the top of the slope, Trackway B runs quite regularly toward South-East (footprints B00-B05). Between the footprints B05-B06 the trackmaker's foot crosses the progression line. Then the slope becomes steeper and the trackmaker must manage a dangerous incline and a sometimes-slippery ground: a very slight footprint (B08) flanking left the footprint B07 suggest that the trackmaker was

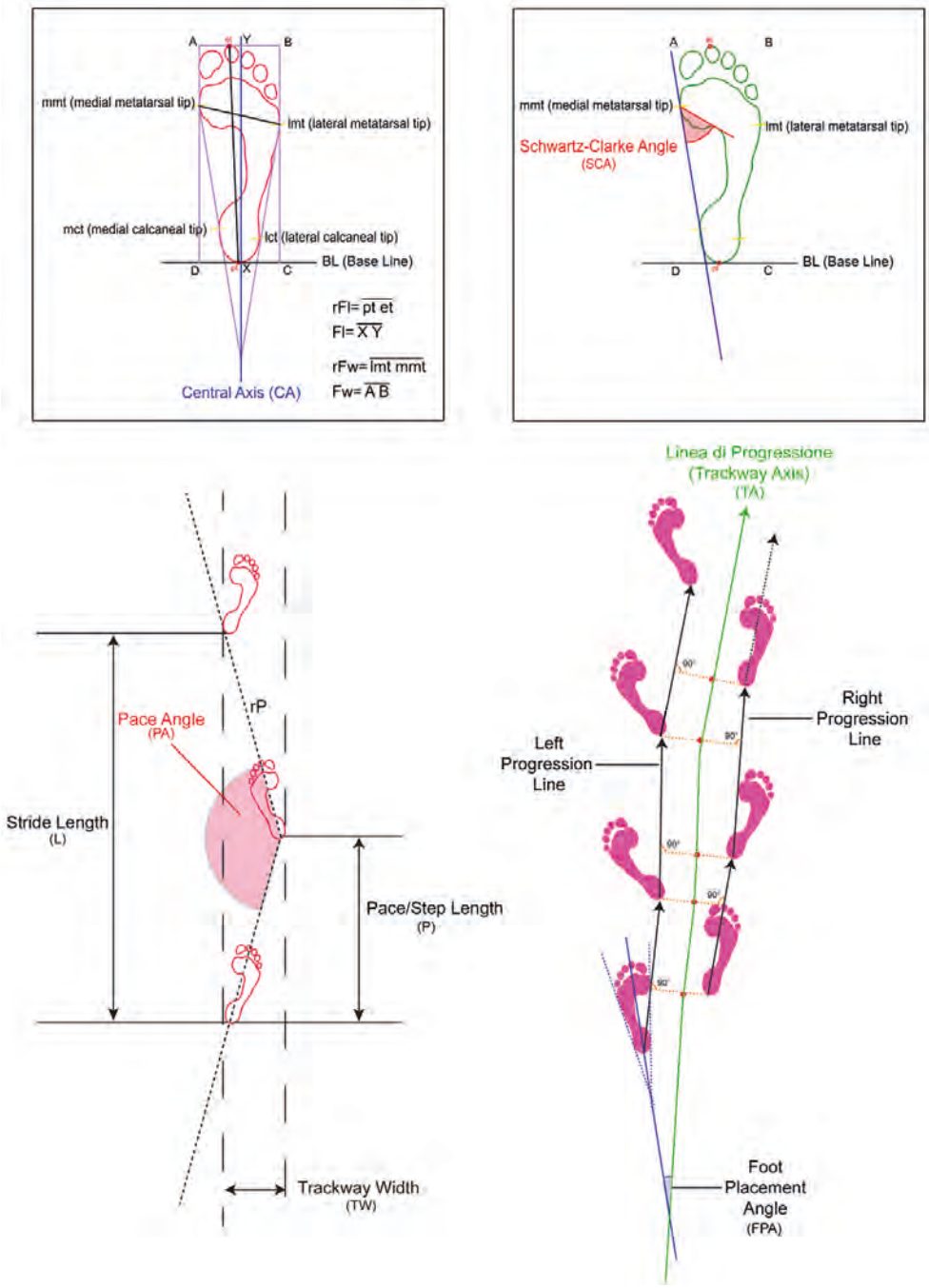

Fig. 5 - Graphical schemes of the adopted dimensional conventions (Modified from Robbins, 1985; Leonardi, 1987; Tuttle* et al.*, 1990; Kennedy* et al.*, 2003, 2005; Wilkinson* et al.*, 1995; Citton* et al.*, 2017). The colour version of this figure is available at the JASs website.

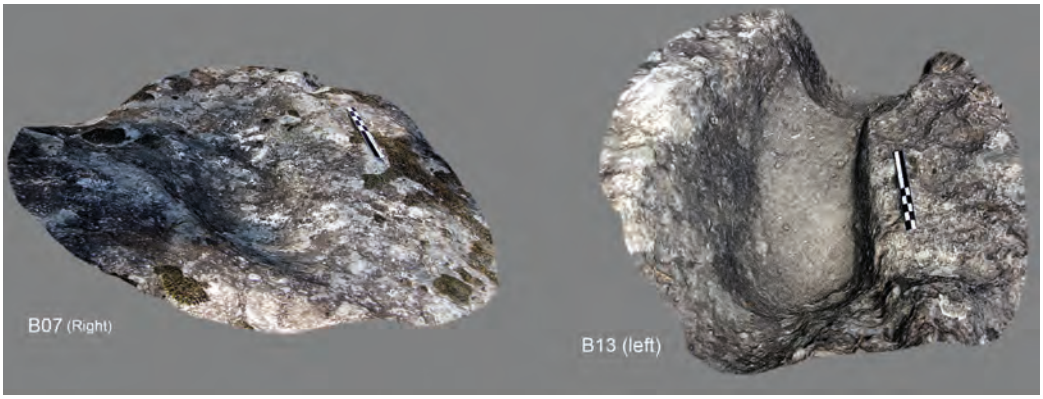

Fig. 6 - Western photographic oblique view (3D generated) of the footprints B07 and B13. The colour version of this figure is available at the JASs website.

able to stand on the right foot for a moment slightly touching the upstream slope with his left foot. After having chosen to cut the slope in an almost diagonal way, the trackmaker went on touching the ground with the right foot and sinking deeply in the soft substrate (B08a). The following step had an unexpected consequence: after having moved forward the trackmaker placed his left foot down (B09) and the ground gave way and made him slip for ~90 cm.

The complexity of this movement and of the following moments can be summarized in as follows. The trackmaker completely loses balance as a consequence of the long slide due to the subsidence of the soft and slippery ground; during this slide the trackmaker leans over onto his left flank and quickly moves forward, sinking his left hand on the side of the slope and strongly pushing it to give to the body enough impetus to regain balance (Panarello *et al.*, 2018). During this extremely dynamic movement, the trackmaker finds a secure foothold on the right foot and is thus enabled to significantly lengthen and cross the step by supporting the left foot, which creates an extremely deep footprint (B11) (Figs. 8, 9, 10; Tabs. 8, 9).

The dimensional data collected from the fossil evidence of the described movement pattern (Tab. 8, Fig. 8) appear fully compatible with those available for the human body (Picasso, 2012). Moreover, they perfectly match the dimensions of a trackmaker who is about 1,50/1,60 m tall, with a left foot about 23 cm long and with a total arm length of about 52 cm.

For a simple experimental testing of this dimensions, a re-enactment of the described movements has been done by a present-day female model (F.V.) who is 1,56 m tall, who has

Tab. 3 - General dimensions and characteristics of Trackway B.

SEGMENT	GENERAL LENGTH (m)	ORIENTATION IN THE DIRECTION OF TRAVEL	AVERAGE GENERAL INCLINATION (°)	AVERAGE GENERAL INCLINATION (%)	AVERAGE SLOPE INCLINATION (°)	AVERAGE SLOPE INCLINATION (%)
1B	5,046	104,5°E	25,00	46,6	19,30	35,01
2B	0,91	76,5°E	25,00	46,6	27,0	50,95
3B	3,482	119°SE	46,90	1.1	22,50	41,42

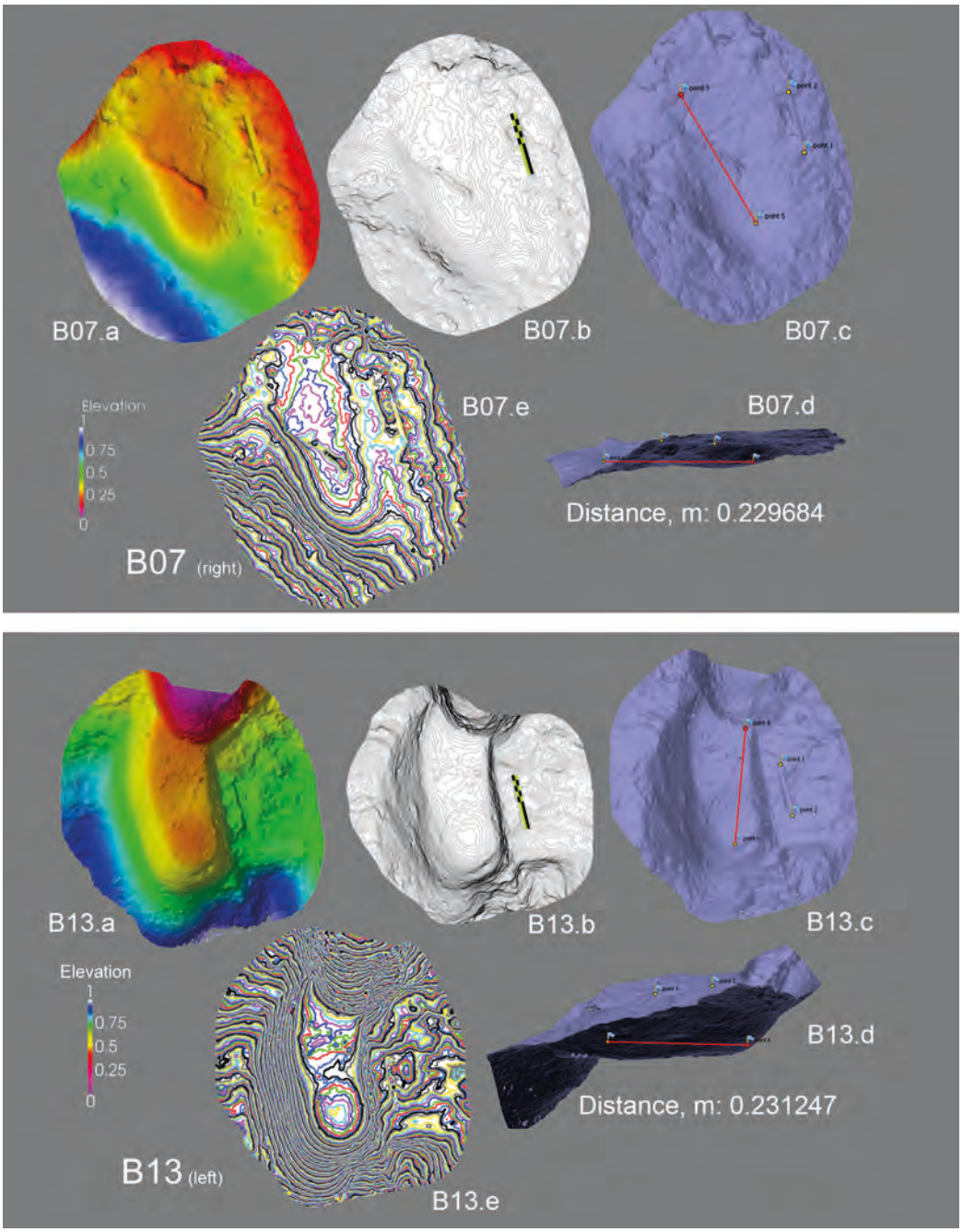

Fig. 7 - 3D generated views of two of best-preserved fossil footprints of Trackway B (scale bar: 10 cm): Zenithal depth maps (a); Zenithal contour lines 1mm (b); Zenithal flat surface with rFl landmarks marked in red (c); transverse view with rFl landmarks marked in red (d); coloured contour lines 1mm (e). The colour version of this figure is available at the JASs website.

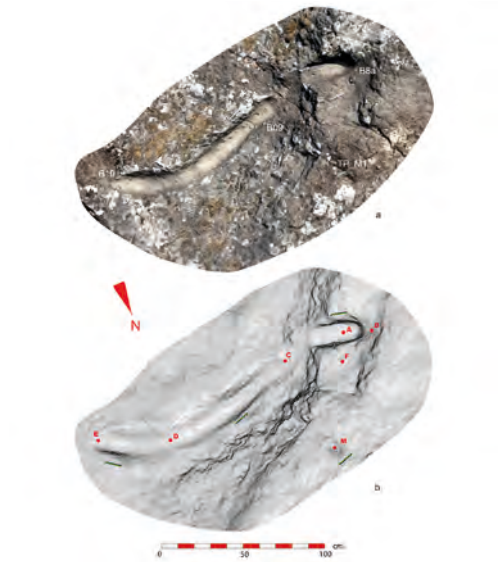

Fig. 8 – Foresta (Tora e Piccilli), "Devil's Trails" Palaeontological site: the slide zone (scale-bar: 1m; landmarks as in Table 8): Zenithal 3D generated photo (a); Contour map 1mm with landmarks marked in red (b). The colour version of this figure is available at the JASs website.

Fig. 9 - Visual summary of the experimental reenactment test on footprints B08-B10 area. The colour version of this figure is available at the JASs website.

a left foot 23 cm long and a total-arm length (achromion to stylion) of 52,5 cm. A good dimensional correspondence can be seen in the superimposed movements as shown in Figure 9 and in the distance FM=51,6858 cm (Fig. 8, Table 8), which roughly corresponds to model's arm-length.

From B11 to B13 a progressive regaining of body balance can be inferred. After the footprint B14, the direction of the trackway slightly turns South-East and the trackmaker reaches the verge of a sharp drop of the slope. Here a recent destruction of the original tuff formation makes it difficult to be completely objective in evaluating the ichnological evidence. Nevertheless, two hollows on the tuff ground which flank, respectively right and left, the last footprints of Trackway B can be reasonably interpreted only as the handprints (B19 or M2; B20 or M3) (Fig. 13) left by the trackmaker's hands on the ground to move the body forward over the verge of the drop (Fig. 11). This possibility is also endorsed by another wide print called B21 (Fig. 12) which is located immediately after the drop of the distal part of the tuff slope. It looks like a large impact zone and is clearly and easily recognizable. It is saddle-shaped and located in a right position when compared to the geometrical progression-line of Trackway B. When it was unearthed, in October 2009, it looked like the imprint of a human buttock and seemed somehow linked to Trackway B. After the complete fieldwork, the new general unearthed evidence suggested that this first impression could be correct. Actually, the dimension of the print B21 (max length: 28,5; max width: 17,9 cm) and its position between the terminal part of Trackway B and the last footprint B22 (Figs. 11, 14) (which is located in a right position at a lower altitude) strongly suggest that the interpretation of B21 as the print of a right gluteus may be the most credible. Furthermore, the measurable anthropometric data of B21 do not fall beyond the available anatomical parameters for a gluteus of a human body having limb dimensions like those measured for the trackmaker B (Fig. 8; Tabs. 4, 7, 8, 9) (http://roymech.org/Useful_Tables/Human/Human_sizes.html; Buxton, 2015).

Tab. 4 - Trackway B footprints dimensions. **Fl** = ***Footprint Length;*** **rFl** = ***Real Footprint Length;*** **Fw** = ***Footprint Width;*** **rFw** = ***Real Footprint Width;*** **FPA** = ***Foot Placement Angle‡;*** **FI** = ***Footprint Index*; rFI = Real Footprint Index; SCA = Schwartz-Clarke Angle‡; Fa = Footprint Area.***

FOOTPRINT (foot)	Fl (cm)	rFl (cm)	Fw (cm)	rFw (cm)	FPA‡ (°)	FI* (Fw÷Fl) X100 (%)	rFI (rFW÷rFL) X100 (%)	SCA‡ (°)	Fa (cm²)
B00 (left)	22.0	22.0	10.6	10.3	-9	48.2	46.8	N.M.	197
B01 (right)	22.0	22.0	10.8	11.0	33	49.1	50.0	48	194
B02 (left)	23.4	23.0	10.6	10.5	-23	45.7	45.6	N.M.	206
B03 (right)	**23.0**	**23.0**	**9.3**	**10.0**	**13**	**40.4**	**43.5**	**N.M.**	**179**
B04 (left)	21.0	21.0	9.9	10.0	32	47.1	47.6	75	152
B05 (right)	**24.1**	**23.2**	**10.7**	**10.5**	**-0.01**	**44.4**	**45.2**	**43**	**199**
B06 (left)	22.6	22.5	9.5	10.0	-10	42.0	44.4	N.M.	173
B07 (right)	**23.5**	**23.0**	**10.6**	**10.5**	**-10**	**45.1**	**45.6**	**62**	**196**
B08 (left)	22.9	22.0	11.1	11.0	-13	48.5	50.0	N.M.	201
B08a (right)	22.7	22.5	10.8	11.0	3	45.6	48.9	N.M.	181
B09** (left)	N.M.	90.1	N.M.	9.5	7	N.M.	N.M.	N.M.	N.M.
B10 (right)	20.9	21.0	10.8	10.5	33	51.7	50.0	N.M.	167
B11 (left)	**23.4**	**23.0**	**10.7**	**10.0**	**-11**	**47.7**	**43.5**	**76**	**205**
B12 (right)	**23.8**	**23.2**	**9.7**	**10.0**	**14**	**40.7**	**43.1**	**51**	**173**
B13 (left)	**23.3**	**23.1**	**10.9**	**10.5**	**-20**	**46.8**	**45.4**	**57**	**197**
B14# (right)	N.M.	N.M.	10.7	11.0#	45	N.M.	N.M.	N.M.	N.M.
B15 (right)	**23.1**	**23.1**	**10.1**	**10.6**	**25**	**43.7**	**45.9**	**47**	**162**
B16 (left)	**23.1**	**23.0**	**10.4**	**10.4**	**-4**	**45.0**	**45.2**	**N.M.**	**179**
B17 (right)	N.M.	N.M.	9.9	10.0	-4	N.M.	N.M.	N.M.	N.M.
B18 (left)	**24.0**	**23.1**	**10.6**	**10.4**	**-9**	**44.2**	**45.0**	**72**	**195**
B22 (right)	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.
General Mean	22.9	22.6	10.4	10.4	-	45.6	46.2	-	185.6
SD	0.93	0.73	0.51	0.42	-	3.0	2.31	-	16.19
Best preserved Mean	**23.5**	**23.1**	**10.3**	**10.3**	-	**44.2**	**44.7**	-	**187.2**
SD	**0.40**	**0.083**	**0.53**	**0.249**	-	**2.43**	**1.047**		**14.412**
Confidence Interval (98%)	**23.1 - 23.9**	**23.0 - 23.2**	**9.8 - 10.8**	**10.1 - 10.5**	-	**41.8 - 46.5**	**43.7 - 45.7**	-	**173.3-201.1**

In the raws in bold the best preserved footprints are listed, which are also the most reliable for each statistic evaluation.
N.M. = Not Measurable.

** Although B09 has been created by a left foot, it is not actually a simple footprint, but a very long slide. For this reason, for its being a substantial statistic outlier, its dimensions have not been considered in any quantitative estimation.

Not precisely measurable value.

‡ This measure is only approximate and no arithmetic mean has been calculated since each movement is too strongly conditioned by geomorphology.

Tab. 5 - Pace (Step) and Trackway Width*. P = Step; rP = Real Step; TW = Trackway Width.

FOOTPRINTS	P (cm)	rP (cm)	TW* (cm)
B00-B01	74.54	83.0	23.80
B01-B02	36.70	46.1	26.38
B02-B03	75.79	76.8	28.42
B03-B04	44.37	48.9	29.14
B04-B05	60.15	68.8	13.63
B05-B06	48.85	47.4	17.79
B06-B07	76.39	71.1	62.63
B07-B08	11.42	47.6	63.90
B08-B08a	54.56	61.1	29.71
B08a-B09	60.73	43.9	15.27
B09-B10	N.M.	112.6	12.24
B10-B11	72.50	71.8	20.17
B11-B12	70.49	59.6	30.05
B12-B13	41.01	38.6	36.20
B13-B14	17.91	46.0	75.93
B13-B15	51.53	42.8	39.48
B15-B16	**25.09**	**38.3#**	**50.78**
B16-B17	**43.61**	**47.5#**	**48.84**
B17-B18	**27.88**	**37.8#**	**46.92**
B18-B22	**N.M.**	**173.0**	**N.M.**
General mean	49.6	57.3	24.8
SD	20.4	19.3	8.5
Confidence Interval (98%)	37.3-61.9	46.1-68.5	18.48 – 31.12

- The anatomical landmark chosen for measuring step is always pt, i.e. the most proximal point of the heel.

* The sequences of footprints are underlined, in which abrupt and voluntary changes of direction take place, which significantly widen the track width at that point. For this reason these values have not been used in any consideration about Trackway B width.

* The sequences of footprints are in bold, in which the trackmaker is forced to widen more his/her legs to remain balanced, in an area where the inclination is well over 80%. Therefore, these values were not used in the counts of TW

* The pace between B18 and B22 (underlined in bold raw in the table) cannot be considered in statistical determinations because these footprints are not in continuity.

\# Value not precisely measurable.

Tab. 6 - Stride and Pace Angle. L = Stride; rL = Real Stride; PA = Pace Angle¥.

FOOTPRINTS	L (cm)	rL (cm)	PA¥ (°)
B00-B02	121.28	128.0	171
B01-B03	108.18	122.0	161
B02-B04	107.88	119.5	141
B03-B05	113.16	116.8	165
B04-B06	92.52	113.7	161
B05-B07	124.45	118.2	168
B06-B08	47.41	55.5	46
B07-B08a	32.24	40.9	36
B08-B09	113.55	100.0	142
B08a-B10	170.66	156.3	179
B09-B11	193.59	183.0	166
B10-B12	136.32	130.0	176
B11-B13	114.04	96.0	152
B12-B14	40.38	70.6	53
B12-B15	87.68	71.7	118
B13-B16	89.22	73.4	131
B15-B17	75.84	62.1	91
B16-B18	65.51	58.9	78
General mean	91.8	92.3	124.4
SD	31.6	29.9	48.2
Confidence Interval (98%)	71.2-112.4	72.8-111.7	93.05-155.7

¥ This measure is only approximate because strongly conditioned by geomorphology. The underlined values are not used in any statistical analysis, as they are strongly influenced by the long slip.

Finally, if we assume that B21 could be, on the contrary, a certain structure created by an anthropic cut of the tuff-slope to make a sort of ladder, we would find no reasonable explanation to the fact that it is very closely located (a few centimetres) near an actual carved rough stair (Fig. 11).

The last footprint of Trackway B (B22) (Figs. 11, 14) is located at the base of the difference in elevation of the slope, in an almost completely destroyed part of original tuff formation. B22 is only preserved in its most proximal part, but there

Tab. 7 - A stature estimation for Trackmaker B‡.

FOOTPRINT (position)	REAL FOOTPRINT LENGTH rFL (cm)	ESTIMATED STATURE (100XrFL)/14.7 [RATIO 14.7%] (cm)	ESTIMATED STATURE (100XrFL)/15.5 [RATIO 15.5%] (cm)	ESTIMATED STATURE (100XrFL)/15.2 [RATIO 15.2%] (cm)	ESTIMATED STATURE (100XrFL)/15.6 [RATIO 15.6%] (cm)
B00 (left)	22.0	149.6	141.9	144.7	141.0
B01 (right)	22.0	149.6	141.9	144.7	141.0
B02 (left)	23.0	156.5	148.4	151.3	147.4
B03 (right)	**23.0**	**156.5**	**148.4**	**151.3**	**147.4**
B04 (left)	21.0	142.8	135.5	138.1	134.6
B05 (right)	**23.2**	**157.8**	**150.0**	**152.6**	**148.7**
B06 (left)	22.5	153.1	145.2	148.0	144.2
B07 (right)	**23.0**	**156.5**	**148.4**	**151.3**	**147.4**
B08 (left)	22.0	149.6	141.9	144.7	141.0
B08a (right)	22.5	153.1	145.2	148.0	144.2
B09* (left)	90.1	-	-	-	-
B10 (right)	21.0	142.8	135.5	138.1	134.6
B11 (left)	**23.0**	**156.5**	**148.4**	**151.3**	**147.4**
B12 (right)	**23.2**	**157.8**	**150.0**	**152.6**	**148.7**
B13 (left)	**23.1**	**157.1**	**149.0**	**152.0**	**148.1**
B14 (right)	21.5#	146.2#	138.7#	141.4#	137.8#
B15 (right)	**23.1**	**157.1**	**149.0**	**152.0**	**148.1**
B16 (left)	**23.0**	**156.5**	**148.4**	**151.3**	**147.4**
B17 (right)	N.M.	N.M.	N.M.	N.M.	N.M.
B18 (left)	**23.1**	**157.1**	**149.0**	**152.0**	**148.1**
B22 (right)	N.M.	N.M.	N.M.	N.M.	N.M.
General Mean	22.6	153.5	145.6	148.5	144.7
SD	0.728	4.973	4.730	4.807	4.668
Best preserved Mean	**23.1**	**157.0**	**148.9**	**151.8**	**147.9**
SD	0.083	0.537	0.65	0.547	0.547
Confidence interval (98%)	**23.0-23.2**	**156.5-157.5**	**148.3-149.5**	**151.3-152.3**	**147.4-148.4**
Mean of means		**152.9**		**149.8**	
SD		**5.73**		**2.76**	
Final Mean		**151.3**			
SD		**2.19**			

The bolded footprints are the best preserved ones. They have got the power to give the most reliable statistical information.

‡ A range of ratios for the estimation of the stature is fixed according to the statistical model of Fessler *et al.* (2005).

The distal margin of footprint B14 cannot be determined with sufficient objectivity, therefore all parameters derived from its real length (rFl) have not been taken into account in the calculation of mean values and in other statistical estimates. The same footprint, moreover, appears partially altered by a recent cut even at its proximal edge.

* Footprint B09 was not used in the calculations and estimates, as it is a long slide and not a single well-defined hollow.

Tab. 8 - Slide movement measures.

SEGMENT	LENGTH (cm)
AM	75.2272
BM	75.5808
FM	51.6858
AF	23.9307
AC	43.9191
CD	86.5035
DE	48.3318
CE=CD+DE	134.8353

Landmarks description with reference to Fig. 8:
A: The most proximal point of the footprint B08a.
B: The most proximal point of the foot touchdown that created the footprint B08a.
C: The most proximal point of the foot touchdown that created the footprint/slide B09.
D: The most proximal point of the foot touchdown that created the footprint B10.
E: The most distal point of the footprint B10.
F: The highest point of the possible hip impact on the sidewall.
M: The deepest point of TP_M1 handprint.

Tab. 9 - Other dimensional data of footprint B11.

PARAMETER	CURVILINEAR LENGTH (cm)
Left Calf Max Width	22
Left Calf Mid Width	15
Left Ankle Width	10
Straight length from the top of the calf-print to the heel strike zone of the footprint	~ 36

is no doubt about its authenticity as a footprint. Its surviving part, in fact, preserves the complete touch-down area of a right foot, where the marks of the change of direction of the trackmaker's left foot during its sinking and sliding forward are clearly visible. Finally, the partial footprint B22 appears as the only smooth area within a very rough and altered surface (Fig. 14e).

The number and the characteristics of the ichnological finds worldwide and the different dimensional conventions through which they are surveyed and analyzed make it impossible to make a strict and objective comparison of the various available dataset. Every comparison could turn out to be, in fact, at best approximate if not completely unreliable. Anyway the length and width of the footprints of the trackmaker B of Foresta (Tora e Piccilli) seem perfectly match the dimensional ranges up to now available (Bonmatí *et al.*, 2010; Carretero *et al.*, 2012; Dingwall *et al.*, 2013; Pablos, 2015; Pablos *et al.*, 2017; Jungers *et al.,* 2016; McNutt *et al.*, 2018), just like the estimated average stature of ~151.3 cm made through the method of Fessler *et al.* (2005).

Discussion

Only few human ichnosites are known in the world so far, and very few of them have been dated to an age older than 150 ka (Bennett & Morse, 2014 and references therein; Panarello, 2016 and references therein; Masao *et al.*, 2017; Altamura *et al.*, 2018). The "Devil's Trails" of Foresta (Tora e Piccilli) belong to this very small group, but they are the only ones to be located on a very steep slope so far. That is why they are unique evidence of some uncommon and often instinctive movements that cannot be reconstructed elsewhere.

The icnhological actuality and the general taphonomical caracteristics of Trackway B have been already demonstrated and published (Mietto *et al.*, 2003; Avanzini *et al.*, 2008; Panarello *et al.*, 2017). However, after new studies and careful surveys some other elements of detail can be recorded. First of all, the width of

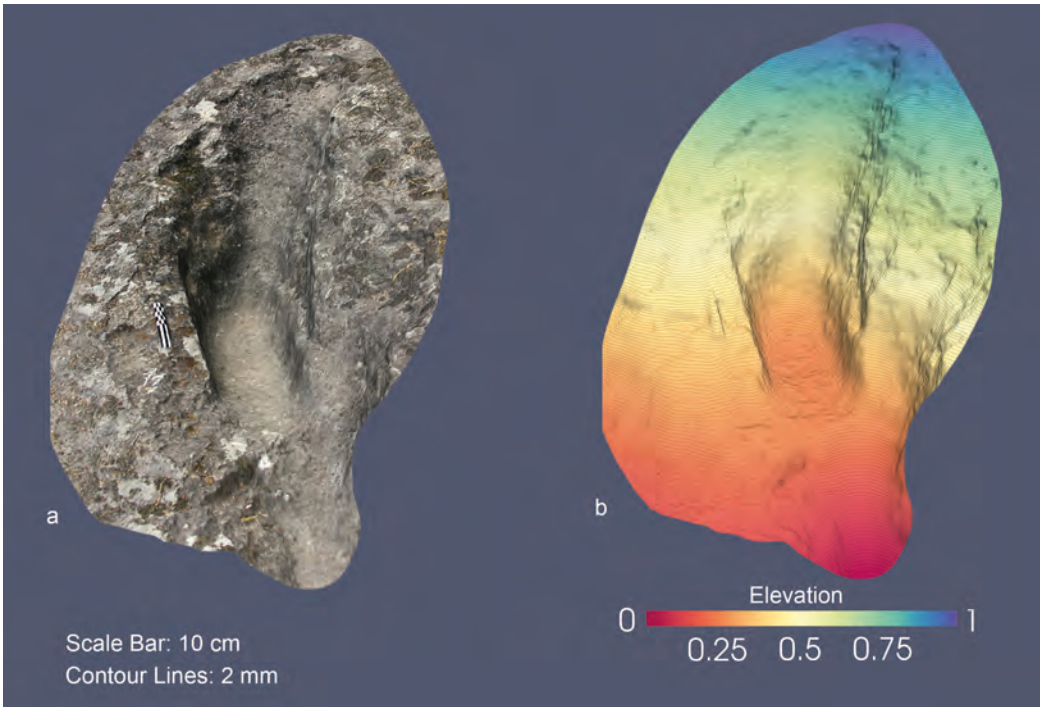

Fig. 10 - Southern frontal view of the footprint B11 (entire leg) (scale bar: 10cm): 3D-generated photo (a); contoured (2mm) depth map (b). The colour version of this figure is available at the JASs website.

Trackway B ("TW" in Table 5) that never exceeds 40 cm (Bates, 1950; Kim *et al.*, 2008), except when the trackmaker must make some unnatural movements to change direction or maintain the general body balance.

As already noted, the footprints of Trackway B are not homogeneously preserved and, in some cases, they have been partially altered also by quarrying activities that took place in historical times (Panarello *et al.*, 2017b and references therein). This happened because the quarrymen transformed the general footprint hollows into support areas for footwear in some steepest zones (Panarello, 2008, 2016 and references therein). Fortunately, the great depth of the general hollows containing the footprints has ensured that the anthropic cut almost never reaches the actual footprints that have not been damaged as a consequence. The greatest damage, on the other hand, has to be attributed to natural agents and to the uncontrollable impact on the site by visitors who do not know or cannot understand the extreme delicacy of a fossil footprint. Best preserved footprints and the data relating thereto, which are very useful for statistical and anthropometric comparisons, have been highlighted in the tables, in which the same collected data have been summarized.

The careful observation of Trackway B gait pattern (Fig. 4) shows that the first touch of the heel on the ground (both of the left and of the right foot) is always located in an advanced position if compared to the previous one, except for the footprint B11 (left foot). On the contrary, the first impact zone of this footprint is in a back position if compared to that of B10 and shows a noticeable leg lift, which is followed by a heavy left foot support, so that the foot sinks for about

Fig. 11 - Eastern photographic view of the most distal part of Trackway B (the recent carved anthropic ladder, and the footprints from B19 to B22 are marked, respectively, with dotted and continuous white lines). The colour version of this figure is available at the JASs website.

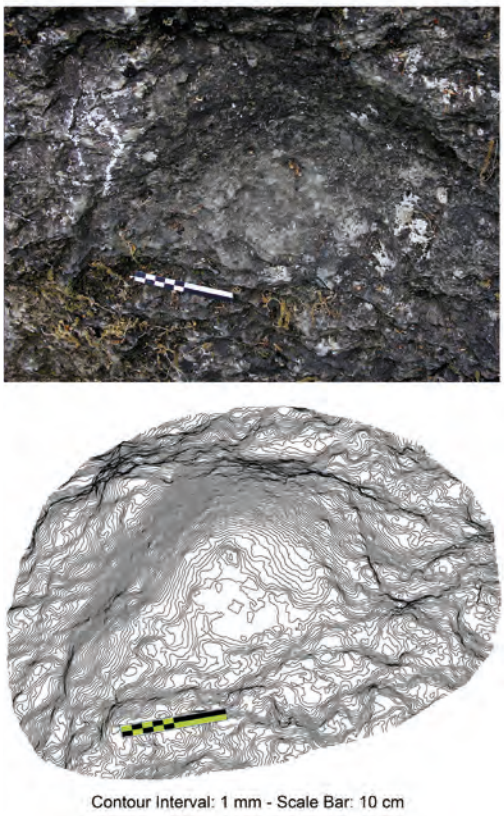

Fig. 12 - B21 (right gluteus?) (southern view, scale bar: 10cm): 3D-generated photographic view (a); contour map 1mm (b). The colour version of this figure is available at the JASs website.

36 centimeters. During this sinking, the left foot rotates toward the medial direction (i.e. toward the progression line). This quite uncommon movement gives us the possibility to measure the dimensions of the whole leg, with the calf and the ankle (Fig. 10, Tab. 9) and to be sure that the trackmaker was rapidly sliding forward when he leaned his left foot on the steep and slippery slope. Unfortunately, to date, these quantitative data are not objectively comparable to any other of this kind, because no other similar evidence is currently known.

The gait parameters of Trackway B have more meaning and are more eloquent if they are considered "step by step" rather than in their average values. The pace and the stride, in fact, are extremely irregular and strongly conditioned by the local geomorphology and by the consistency of the substrate.

Conclusions

The results of the present research have allowed researchers to draw attention to and to quantitatively describe for the first time the fossil prints of a complete leg (calf, ankle and foot) and of a probable gluteus of a Middle-Pleistocene hominin in a sub-aerial and completely free from any cultural connotation environment.

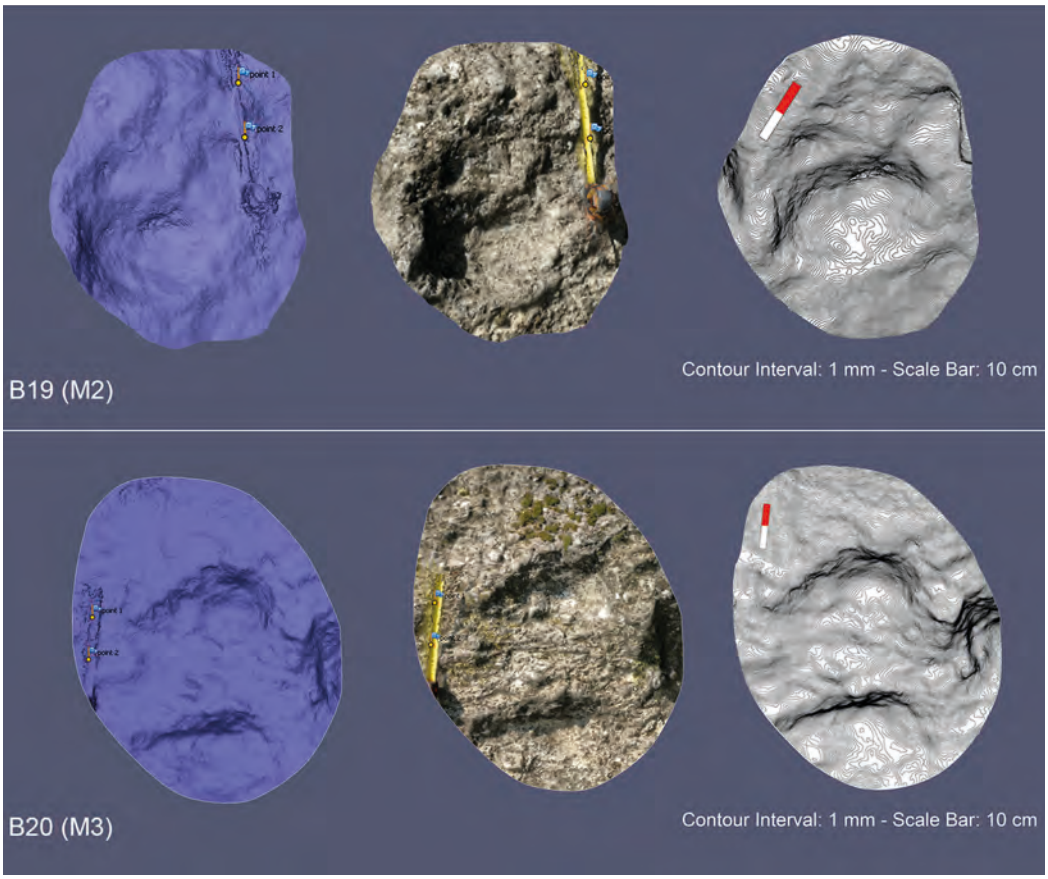

Fig. 13 - M2 (B19) and M3 (B20) 3D generated zenithal blocks (southern view, scale bar: 10cm): flat surface (a); photographic view (b); contour map 1mm (c). The colour version of this figure is available at the JASs website.

Furthermore, the 3D photogrammetric modelling and a careful and prolonged direct analysis of the trampled surface of the “Devil’s Trails” palaeontological site have permitted the compilation and the provision of a completely new, updated and reliable dataset of each ichnological evidence of the Trackway B.

Finally, new collected data have enabled researchers to confirm the actuality and to give a more detailed description of the particularly unique walking pattern of a Middle-Pleistocene hominin during his instinctive attempt to regain and/or preserve balance after a sudden and prolonged slide along a very steep and slippery slope.

If considered as “frames in sequence”, the footprints of the Trackway B are a sort of quite unique motion-picture of everyday life of a prehistoric hominin.

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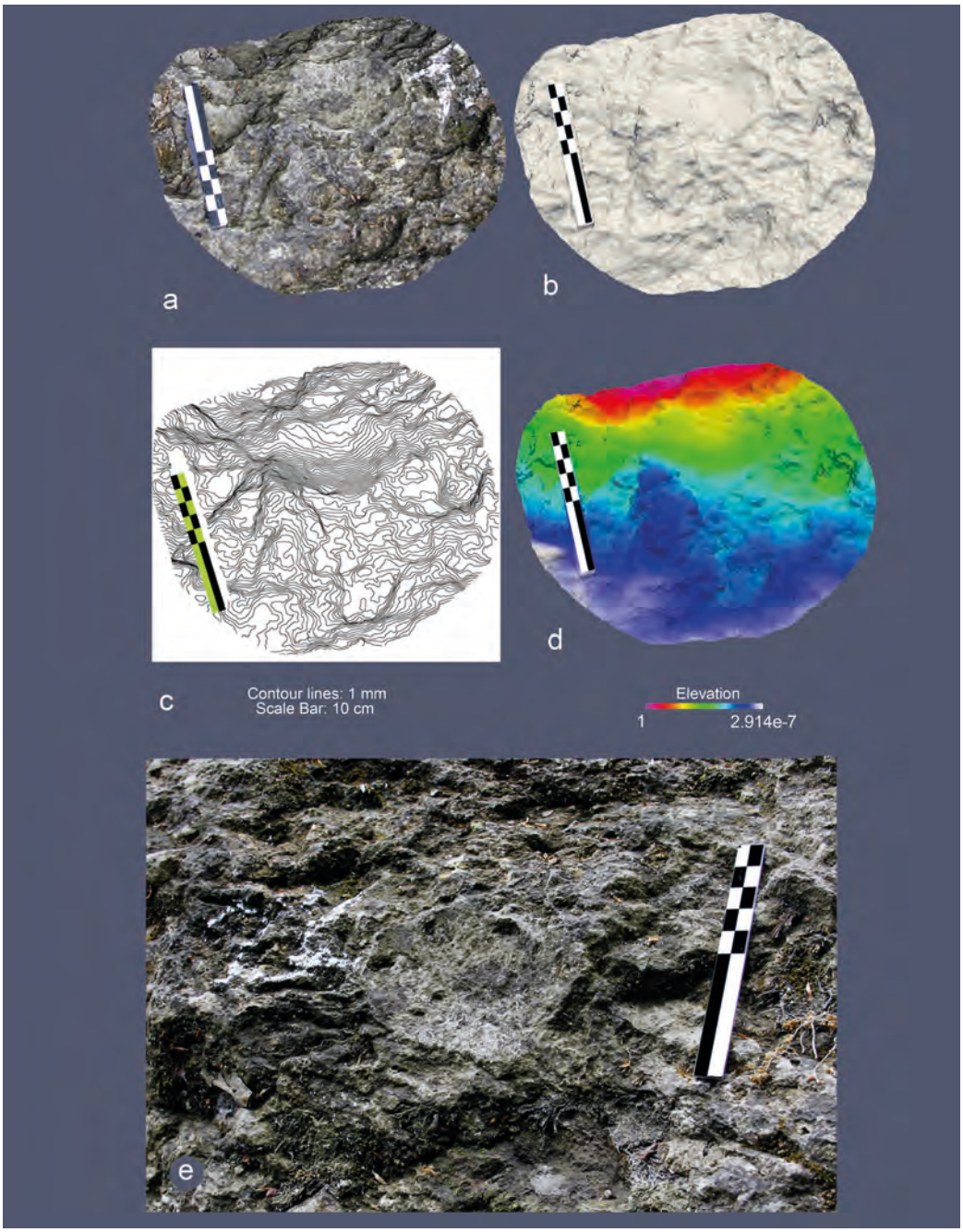

Fig. 14 – Footprint B22 (right foot heel strike zone) (scale-bar: 10cm): northern zenithal 3D-generated photo (a); flat surface (northern zenithal view) (b); contour map 1mm (northern zenithal view) (c); Depth map (northern zenithal view) (d); South-Eastern photographic view (e). The colour version of this figure is available at the JASs website.

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