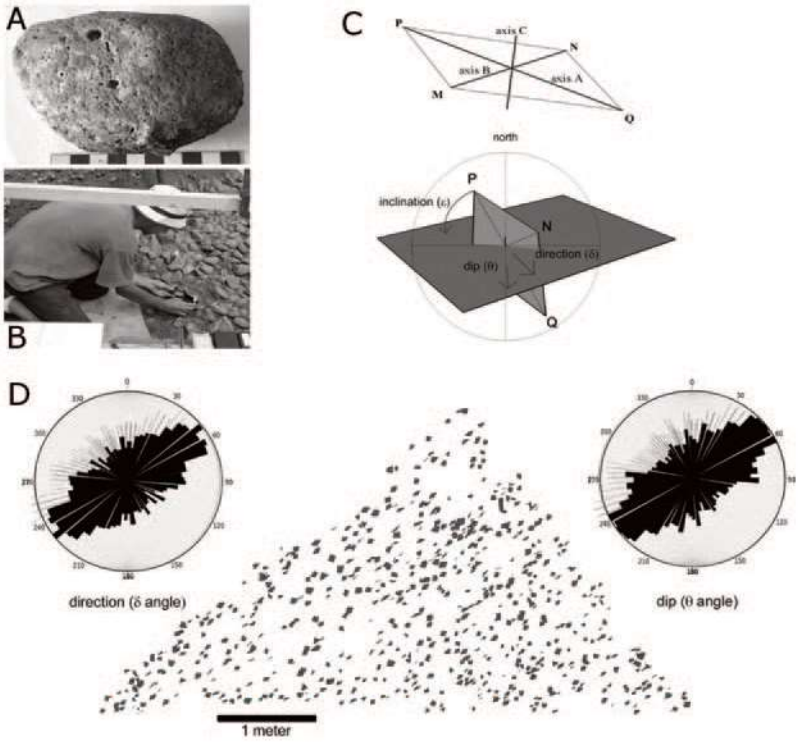

Fig. 4. Gardolo di Mezzo (Trento). A. One of the cobble belonging to the surface of US 169. B. Field survey of cobble direction, dip and inclination by compass. C. Schematization of the cobble as a quadrilateral with major axis a, between points P and Q, and intermediate axis b, between points M and N.C. With parameters taken into account for describing the fabric of quadrilateral P-Q-M-N, with respect to the horizontal. D. The area at Garm 2 (2009) where the cobbles of stratigraphic US 167 and 169=294 were surveyed. Rose-charts showing the orientation of angles δ (azimuth of major axis a) and θ (azimuth of fall line). Both parameters indicate that the area was ploughed following the direction N55°–60°E.

length of 7.75 cm, 5.70 cm and 3.94 cm being the means for the median (*b*) and minor axes (*c*) (Fig. 4).

For data processing, each pebble was graphically reproduced as a quadrilateral item having the two axes along its diagonals. Using a total station, the x, y and z spatial coordinates of the 4 vertices of the quadrilateral were recorded. Specifically, the points of the major axis (*a*) were called P and Q and those of the intermediate axis (*b*) M and N.

This idea of fabric used in this work corresponds to the position of the plane passing through the *a* and *b* axes in space. Their position may be described using three angles: direction (δ: horizontal angle of the major axis *a* with respect to the geographical north); dip (θ: azimuth of the fall line of the plane *ab* with respect to the geographical north); and inclination (ε: angle between the plane *ab* and the horizontal plane). Similar studies of the archaeological fabric applied to the orientation of artefacts tend to consider only the position of the major axis (Lenoble, Bertran 2004; McPherron 2005; Benito-Calvo *et al.* 2009).

The study presented here involved four main phases.

The first phase of the work was performed at the Gardolo di Mezzo site and included the excavation of two test areas in the cobbled surface (US 169), recording the position of each pebble embedded within the colluvial layer covering the cobbled surface (US 167). A total number of 3737 pebbles was surveyed, with a surface area of 20 m^2.

During the second phase, the site stratification was physically reconstructed (using the site's original sediment) in an area measuring 6 m by 4 m, with the longest side oriented N20°E (Fig. 5). A cobbled surface was laid on a substratum of sand. The position of each individual pebble over the surface was carefully marked and documented. This cobbled surface may be considered partly as an analogue of the undisturbed stratigraphic situation documented at the Gardolo di Mezzo site, and partly as a fictitious stratification, in which each pebble was placed according to a pre-set pattern.

2056 pebbles were laid and plotted using a total station. Lastly a 20-to-30-cm-thick layer of colluvial sediment was placed on top and artificially compacted.

The third phase of the project involved making a reproduction of a wooden plough on the basis of the plough found in the Lavagnone pile-dwelling (Desenzano del Garda, Brescia) (Perini 1990b, pp. 258-261, figg. 11-13) dated to between 2048 and 2010 cal. BC using dendrochronology (De Marinis 2000, pp. 195-196; Griggs *et al.* 2007, p. 19) and referring to the oldest phase of the Polada Culture (EBA IA, Lavagnone 2)[6]. The ploughing of the experimental area was performed in June 2006,

[6] Fragments of a plough of the same type have also come from the pile-dwelling settlement of Molina di Ledro (Trento) (Perini 1990b, p. 261, fig. 11).

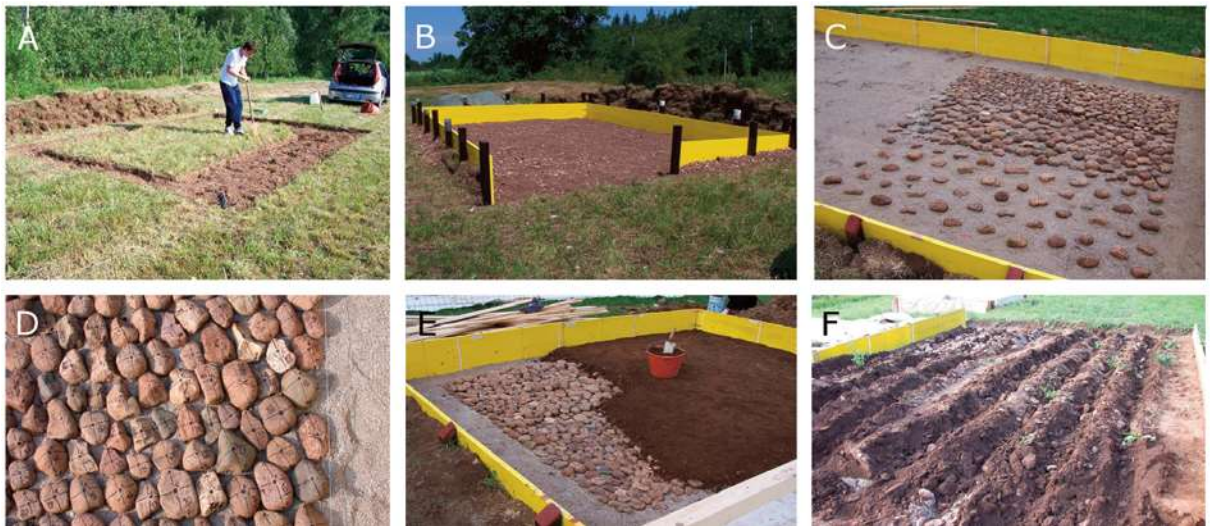

Fig. 5. Gardolo di Mezzo (Trento). The various steps undertaken at the "MARS experimental area". A. Removal of turf. B. Construction of the wooden frame. C. Deposition of the cobbles upon sand substratum, variable according to the different sectors of the area. D. Detail of the cobbles, each of them labelled by a serial number, oriented with the angles δ and θ = 0° with respect to the magnetic North. E. Accumulation of colluvial-like sediment over the cobbles. F. The experimental area after ploughing.

through bi-directional ploughing of seven furrows, which were sequentially numbered from east to west.
During the fourth and last phase of the work, excavation of the experimental area was carried out. Three test-pits were dug, covering a total surface of 7.5 m^2. Finally, the pebbles whose position was modified by ploughing (460) were recorded.

6. Results

The data gathered in the field were analysed using mathematical methods, with the application of trigonometry and linear algebra formulas in order to obtain spatial parameters and angular position. Subsequently, they were processed with a computer using a SQL database (PostgreSQL), linked to a GIS software (PostGIS) (Francisci 2012).
The results obtained in the MARS experimental area made it possible to understand post-depositional modifications due to the ploughing process (fig. 6). The evidence showed it was the plough that was responsible for formation of the furrows modifying the original position of the pebbles. It was also shown that after ploughing, the pebbles could be dislocated within the furrow, along its edge or outside the furrow.
In particular, it was observed that after ploughing the pebbles:
1. underwent horizontal displacement and were mainly concentrated towards the external edges of the furrow. Horizontal displacement ranged from a few cm to 55 cm;
2. formed a linear parallel distribution pattern made up of both isolated elements and small clusters;
3. tended to be lifted, especially those at the edge of the furrow;
4. had their major axis (*a*) oriented according to the direction of the furrow (δ angle rose diagrams);
5. experienced dipping of the major plane (*ab*), which was oriented according to the direction of the furrow (θ angle rose diagrams);
6. experienced, on average, a decrease in the slope angle (ε). This parameter was not particularly significant in terms of interpretation, as the ploughing process leads to a random redistribution of this value;
7. with a flat shape tended to be re-oriented in a vertical position.
The aforementioned data were compared with data from the Garm 2 excavation sector at Gardolo di Mezzo, where 2395 cobbles in units 169–167 were plotted and surveyed in a triangular area measuring about 10 m^2.
By comparing the spatial arrangement of pebbles whose position was modified by ploughing in the experimental area and those recorded in the furrows of the colluvial cover (US 167), as well as the underlying cobbled surface (US 169=294) at Gardolo di Mezzo, it is possible to confirm the systematic correspondence of the angular direction (δ angle) and dip (θ angle) parameters.
The limited range of values in terms of dip can be attributed to the presence of a building technique which was not significantly modified by ploughing and which saw the clasts being fixed into the ground with their major axis positioned vertically.

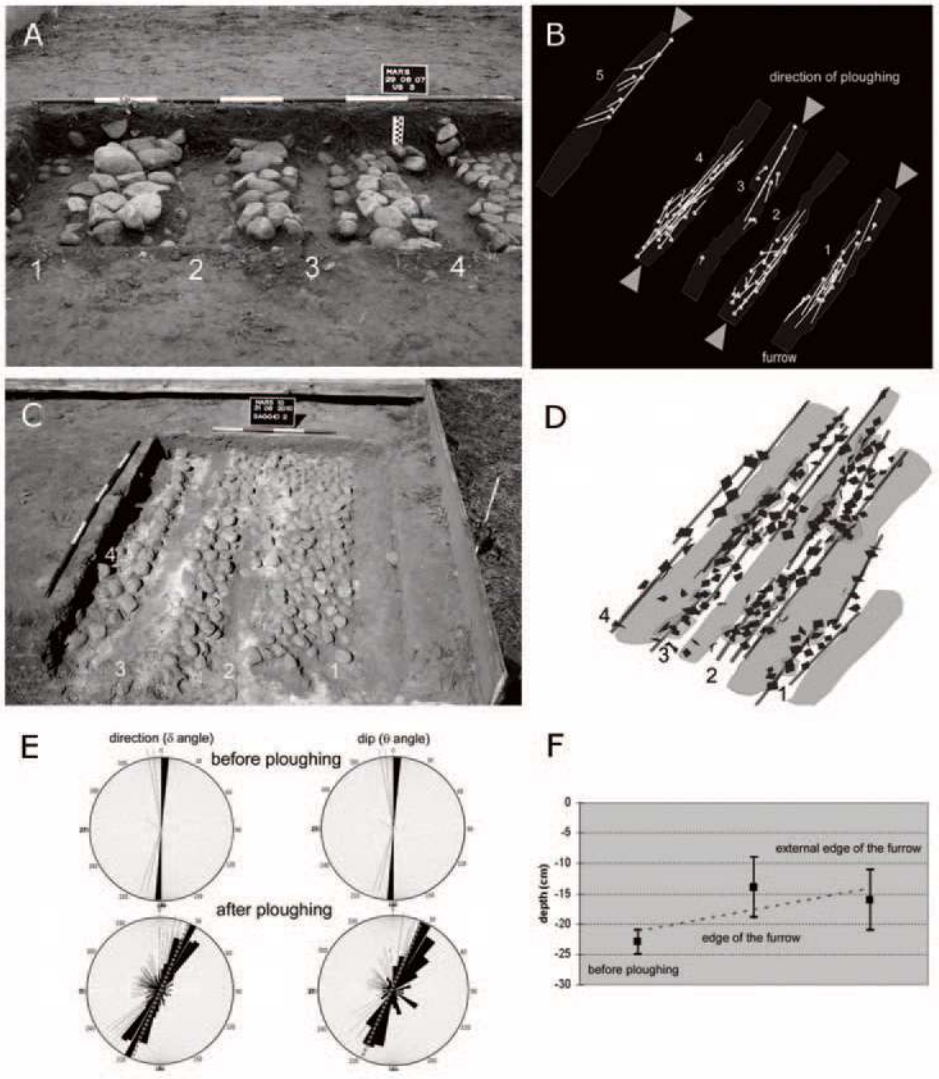

Fig. 6. Gardolo di Mezzo (Trento). A. Test excavation 1 at the "MARS experimental area" (2007). The furrows after their excavation (1-4). B. Graph showing the furrows and the displacement of cobbles after ploughing (white lines) from their original position (black circles). Arrows indicates the direction of ploughing. C. Test excavation 2 at the "MARS experimental area" (2010). Furrows after removal of the cobbles displaced by ploughing (1-4). D. Graph showing the displacement of cobbles (gray quadrilateral) along main directions (black lines). The clusters of cobbles, with the imbrications formed by ploughing are reported in light grey. E. Test excavation 2 at the MARS experimental area (2010). Rose-chart showing the change of angles δ (azimuth of major axis a) and θ (azimuth of fall line) before and after ploughing. Both parameters indicate that the cobbles change their orientation taking the same direction of the ploughing (dotted white line). F. Test excavation 2 at the MARS experimental area (2010). Vertical displacement of cobbles after ploughing. The cobbles on the edge of furrows are subjected by a larger displacement upwards.

7. Final remarks

At the Gardolo di Mezzo site, ploughing of the colluvial deposits that covered the cobbled surfaces led to alteration of the original stratification and represents a post-depositional process of anthropic origin. Similar evidence of such processes is reported in the bibliography (Limbrey 1975, Macphail *et al.* 1990, Gebhardt 1992, Lewis 2012).

The ploughing process at Gardolo di Mezzo led to partial or total destruction of the lateral and vertical continuity of the stratification. This transformation was very variable and essentially depended on the relationships between two factors: the depth of ploughing, which was estimated at around 20 cm, and the sedimentation rate in the different phases of slope accumulation. In the case of a low sedimentation rate, the layer was subjected to various phases of ploughing and consequently the pebbles and the artefacts were completely uprooted and chaotically redistributed. Repeating of the process

over stable surface areas may therefore lead to complete obliteration of the original stratigraphic interfaces.
As in the case of plough-marks, ard-marks can only be preserved if ploughing took place on few occasions and the area was then abandoned or buried (see for example Hollyday 2004; Nicosia, Necco, Vanzetti 2007, p. 574; Nicosia 2010; Balista, Bovolato 2018, pp. 106-107).
At Gardolo di Mezzo, the ard-marks on the interface of the cobbled surfaces are particularly clear when the layer was only subjected to one phase of ploughing and the thickness was slightly less deep than the depth of the plough furrow.
The action of the plough is probably responsible for dispersion of the remains of a fox skeleton (*Vulpes vulpes*)[7] which was originally placed in a specially created niche on one side of the platform, dating to the most recent phase of the Early Bronze Age (EBA II)[8]. Ploughing of the colluvial deposit (US 232) resting on the skeleton caused the fox remains (98 elements) to be dragged over a 4.20 m distance.
On the basis of the documentation obtained during the archaeological research and through experimental work, it is possible to assume that the ploughing recorded at Gardolo di Mezzo took place mainly with the scope of loosening the ground in order to facilitate the laying of the cobbled surfaces. Indeed, the sandy to sandy-loam texture, as well as the firmness of the colluvial deposit, did not permit the laying of cobbles without any surface pre-treatment.
Ard-marks were also found in the settlement area, probably with the scope of preparing surfaces for settlement.
Nonetheless, as has been stated in similar contexts (Rowley-Conwy 1987; Rausing 1988; Kristiansen 1990; Mezzena 1997, pp. 90-91; Poggiani Keller 2004, p. 120; Poggiani Keller *et al.* 2018, p. 25; Ferroni *et al.* 2018, p. 165; Delcaro *et al.* 2018, p. 208), we cannot exclude the possibility that ploughing also had a super-structural significance, for example, as a practice related to preparation of the cult area.

ABSTRACT

This article presents the preliminary results of an experimental archaeology project carried out on the Bronze Age traces of ploughing of the site at Gardolo di Mezzo (Trento) in the context of two tumuli. In the cult area, several cobbled surfaces presenting ard-marks from different phases in occupation of the site have been documented. The approach adopted was based mainly on statistical processing of data from fabric analysis of the cobbles before and after ploughing.
The results of experimentation have made it possible to show that the phases involved in renovation of the cult area were preceded by ploughing of the colluvium surrounding the tumuli, and that this activity took place to prepare for the laying of cobblestones.

Questo articolo presenta i risultati preliminari di un progetto di archeologia sperimentale effettuato sulle tracce di arature dell'età del Bronzo del sito di Gardolo di Mezzo (Trento) nell'ambito di due strutture a tumulo. Nell'area di culto sono state documentate numerose superfici di acciottolato che presentano tracce di aratura nelle diverse fasi di occupazione del sito. L'approccio utilizzato è basato sull'elaborazione statistica delle modificazioni della fabric dei clasti prima e dopo l'aratura.
I risultati della sperimentazione hanno permesso di documentare che le fasi di ripristino dell'area di culto erano precedute dall'aratura del deposito colluviale circostante i tumuli e tale azione era funzionale alla posa dell'acciottolato.

KEYWORDS

Ard-marks, ploughing, fabric analysis, experimental archaeology, soil micromorphology.

Tracce d'aratura, analisi della fabric, archeologia sperimentale, micromorfologia del suolo.

[7] The archaeozoological study was carried out by Alex Fontana (Muse - Trento Science Museum), Alessandra Spinetti, Daniela Marrazzo (Osteoarch - Associazione di Ricerca e Divulgazione Osteoarcheologica) and Francesco Boschin (Università di Siena).

[8] AMS dating carried out on a fox bone sample, which provided the following radiometric measurement: (KIA-53585) 3396±16 BP corresponding to 1741-1625 cal. BC (95.4% probability).

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