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Stratigraphy and physical parameters of the Plinian phase of the Campanian Ignimbrite eruption

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GEOCHEMICAL BACKGROUND

The CI products range in composition from trachytic to trachyphonolitic (Di Girolamo 1970; Barberi et al. 1978; Civetta et al. 1997; Pappalardo et al. 2002; Fowler et al. 2007). Crystallization and differentiation processes active in the stratified magma chamber are discussed by many authors (Arienzo et al., 2009; 2011; Bohrson et al., 2006; Civetta et al., 1997; Fedele et al., 2008; Fowler et al., 2007; Pappalardo et al., 2002; 2008; Rosi and Sbrana, 1987; Signorelli et al., 1999; 2001). Abrupt changes in composition, properties and physical state in the melt (Fowler et al., 2007) or overpressure in the magma chamber (Pappalardo et al., 2008) triggered the eruption. A reconstruction of conduit dynamics during the early phase of the CI eruption is discussed by Polacci et al. (2003) on the basis of density measurements and textural investigations of the juvenile fraction. The origin of pumice clasts with different textural characteristics is ascribed to the development of conduit regions marked by different rheological behaviors.

METHODS

Grain Size and Component Analyses

Grain size analyses have been performed on bulk samples taken from each recognized layer. Graded (B and D) and thick ungraded (A and lower proximal) layers were sampled at both the base and top, and at regular intervals throughout the deposit; thin massive (C) layers and single strata of stratified unit (E and upper proximal) were sampled in the middle. Sieve analyses at 1-phi intervals were performed on the size fraction coarser than 1/16 mm. Component analyses have been performed by hand-picking in the coarse fraction (> 2 mm) and by grain-counting in the 125–1000 μm fraction.

The maximum clast size (maximum pumice, MP; maximum lithic, ML) at each location was determined in the field by measuring and averaging the long axes of five clasts collected from each layer. Multiple samples were collected, at different stratigraphic heights, within graded layers to quantify the observed grain size variations (Fig. 7).

Components were separated and weighed down to -1ϕ, while the fraction down to $+3\phi$ was analyzed using a binocular microscope and counting 500 grains for each phi interval. The statistics shown in this paper are based on the classification of several hundreds of thousands of pyroclasts.

Density Measurements

Clasts Density

We have measured the density of 5–10 pumice clasts from each layer in eight different locations at different distances and azimuth from the vent, with an aim to describe vertical and lateral variation of this parameter

Deposit Density

Densities of the different lapilli layers were calculated by pouring the weighed samples into a graduated container and tapping until a constant volume is achieved. For each sample we have measured the density of loosely packed clasts (just poured into the container), thickening packed clasts (slightly tapped into the container) and closely packed clasts (using a sieve shaker). In this way we have obtained three values for each sample corresponding to uncompacted, lightly compacted and strongly compacted deposits.

Isopachs and Isopleths

To map the distribution of PPF deposit we have measured the thickness of each layer in 49 exposures, most excavated for this study. Maximum clast sizes for pumice (MP) and lithic clasts (ML) were systematically collected for all layers. Additional measurements were taken in graded layers B and D to better represent the vertical trend of these parameters within each single bed.

Classification

To classify the sustained phase of the CI eruption, different methods were applied. Pyle's (1989) classification is based on two parameters b_c and b_t (average distance over which the thickness and the maximum clast sizes diminish by one half),

$bc = \ln 2/(k_c\sqrt{\pi})$ and $bt = \ln 2/(k_t\sqrt{\pi})$,

where k_c and k_t are respectively the slopes on a ln(maximum clast size) vs area$^{1/2}$ and ln(thickness) vs area$^{1/2}$ plots. In general, b_c values greater than 3 indicate plinian dispersal.

Jurado-Chichay and Walker (2001) proposed that the destructive potential of a plinian eruption is related to its dispersal and magnitude and is dependent upon the thickness of the fall deposit. Following Walker (1980), they assumed the area enclosed by the 1 m isopach would be a threshold marking an area within which all properties would be entirely destroyed. Cole and Scarpati (2010) suggest that load pressure is a better parameter with which define volcanic hazard related to tephra fall because it is dependent not only on thickness but also on deposit density (related to component abundances and particle packing density).

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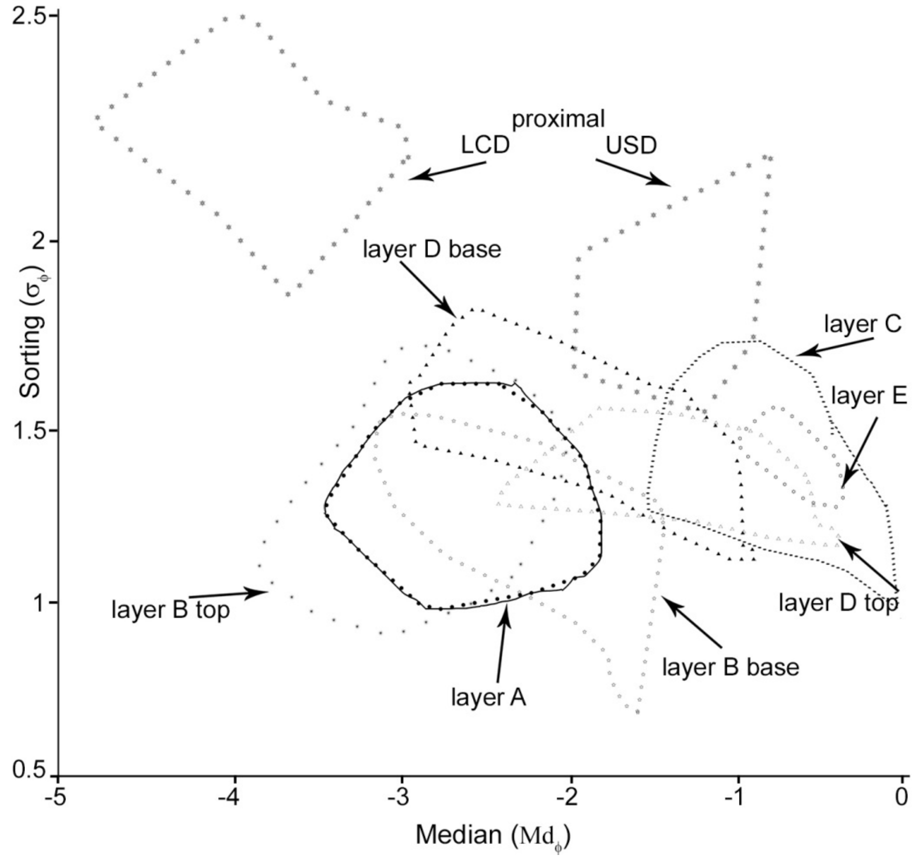

Figure DR1. Grain size parameters for CI fall layers in proximal and medial deposits.

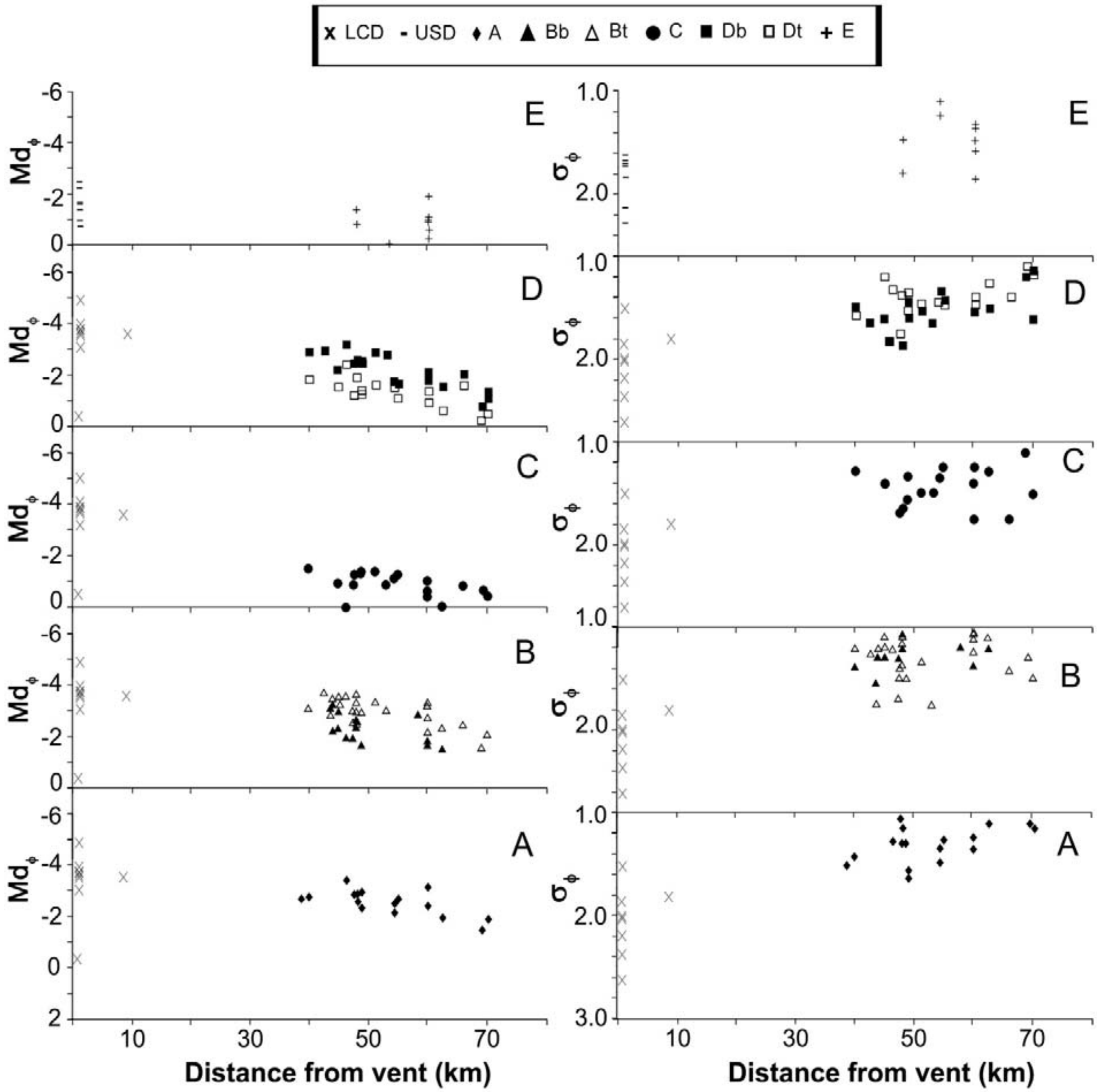

Figure DR2. Plots of median and sorting parameters of the CI fall layers A-E with increasing distance from vent. Proximal deposit: LCD (Lower Coarse lapilli Deposit), USD (Upper Stratified Deposit); medial deposit: Layers A–E. b—base (black symbol), t—top (white symbol).

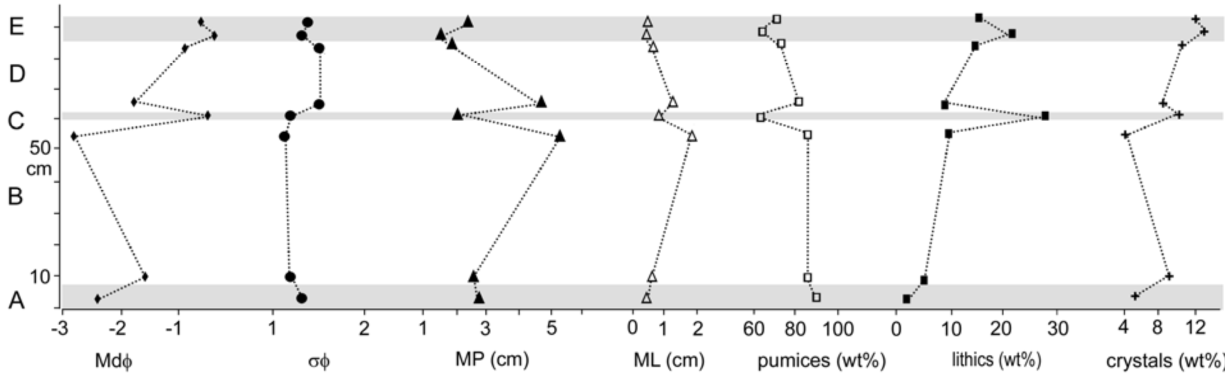

Figure DR3. Vertical variation in grain-size parameters and components in a composite section (layers A to D from Montoro and layer E from Penta). Median diameter (Md_{ϕ}); sorting (σ_{ϕ}); maximum pumice diameter (MP, average of the five largest pumice clasts); maximum lithic diameter (ML, average of the 5 largest lithic clasts); weight % of pumice clasts (pumices); weight % of lithic clasts (lithics); weight % of crystals (crystals).

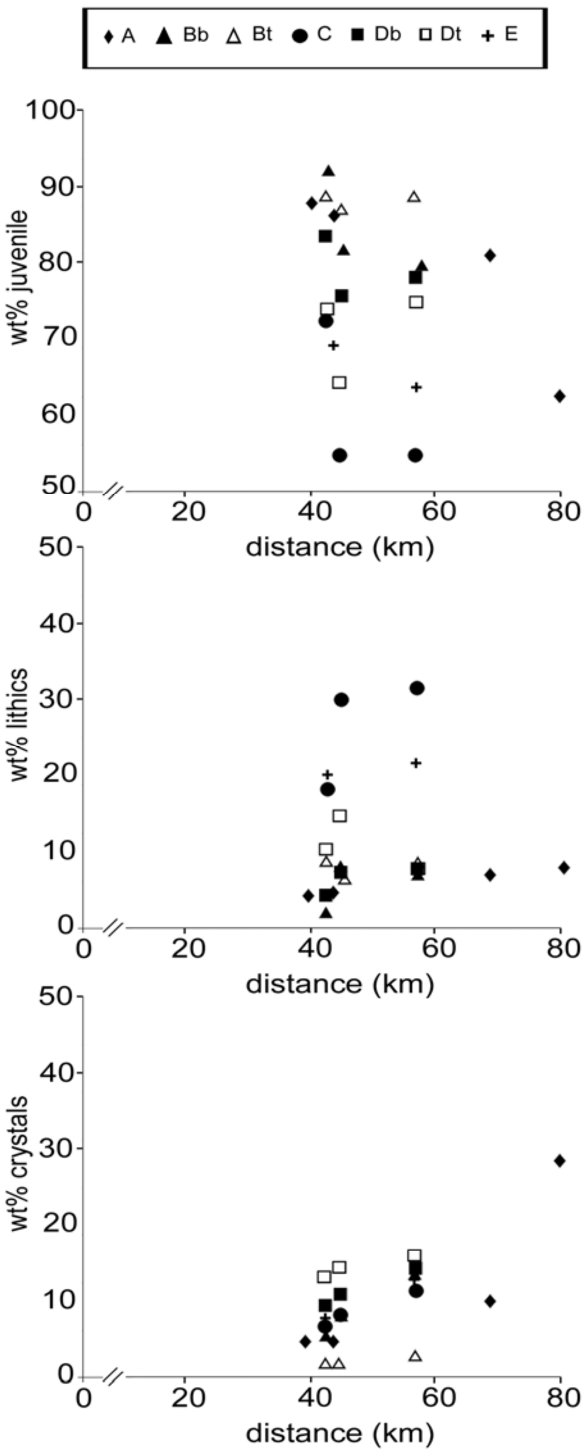

Figure DR4. Component variation with distance from vent for CI fall layers. Note the decrease in juvenile and increase in heavy components in all sampled locations. To avoid distortion of the main trend we have plotted only data from sections close to the dispersal axis of each layer.

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Figure DR5. Grainsize and componentry histograms of all samples collected in CI fall deposit. Samples are arranged for sections (located in figure 3). Black boxes indicate accidental lithic component, white and dotted boxes indicate juvenile and loose crystal components, respectively. Grey boxes represent not analyzed sizes (<1/16 mm). Pie diagrams show the relative abundance of the four components.

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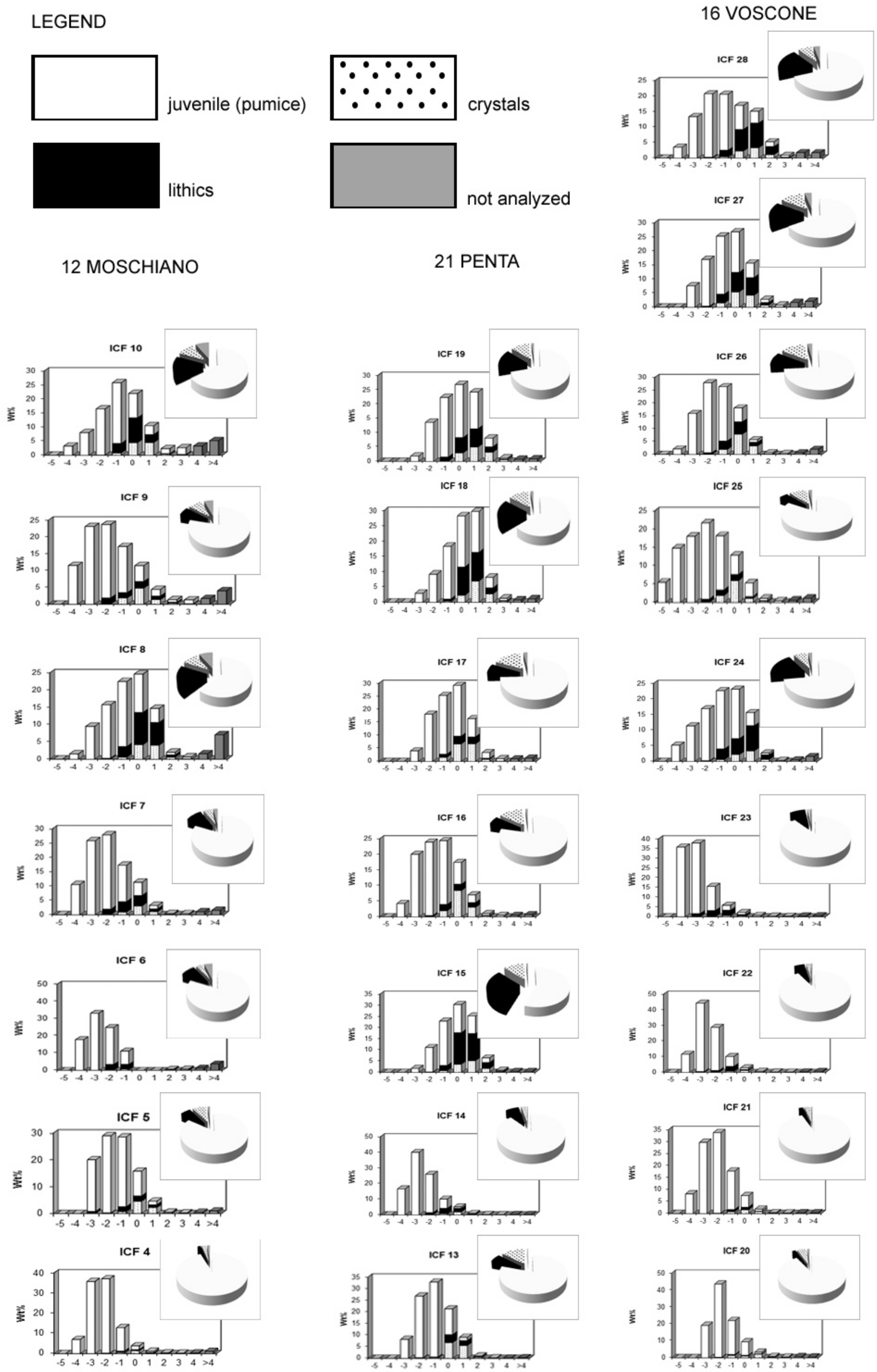

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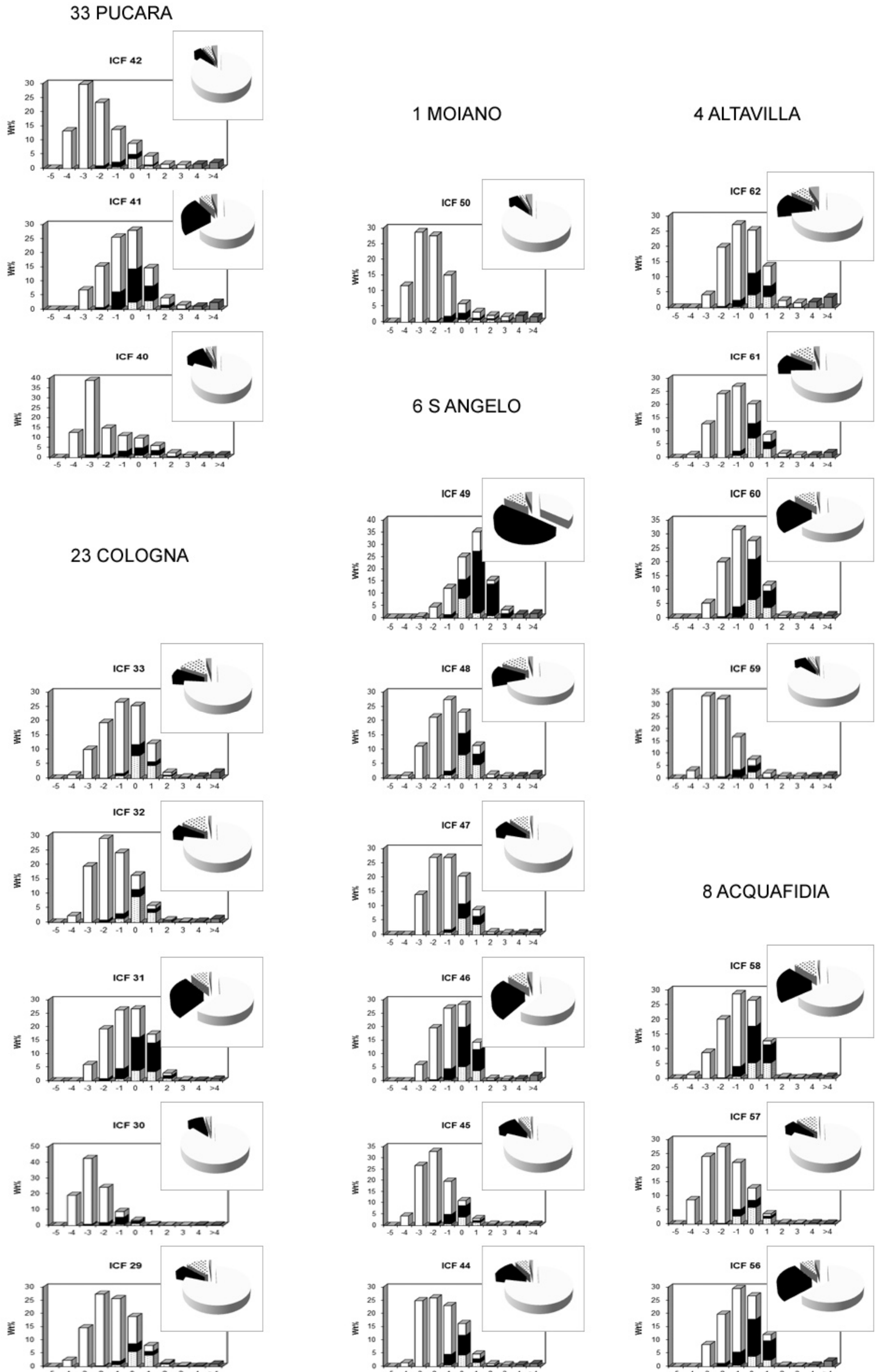

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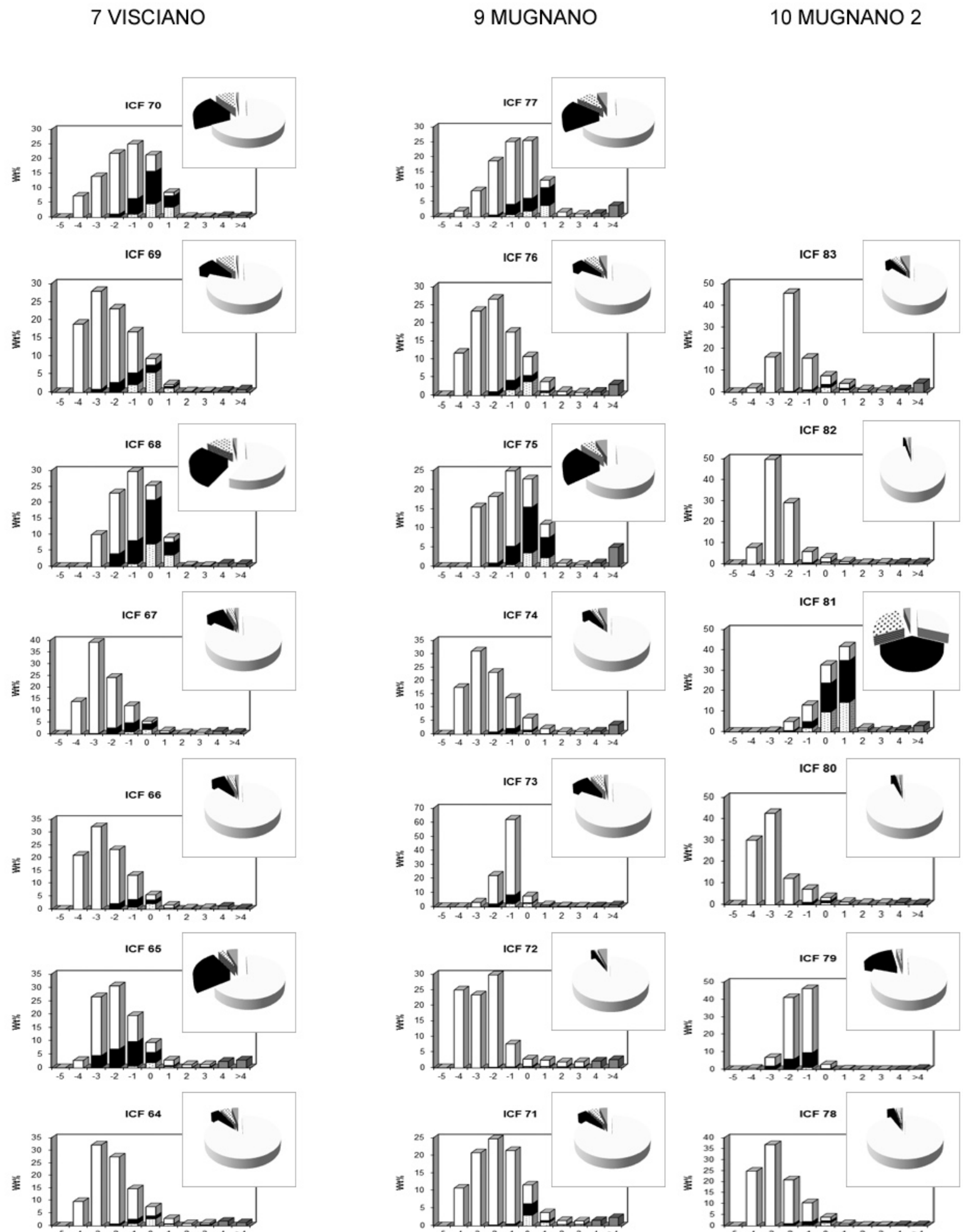

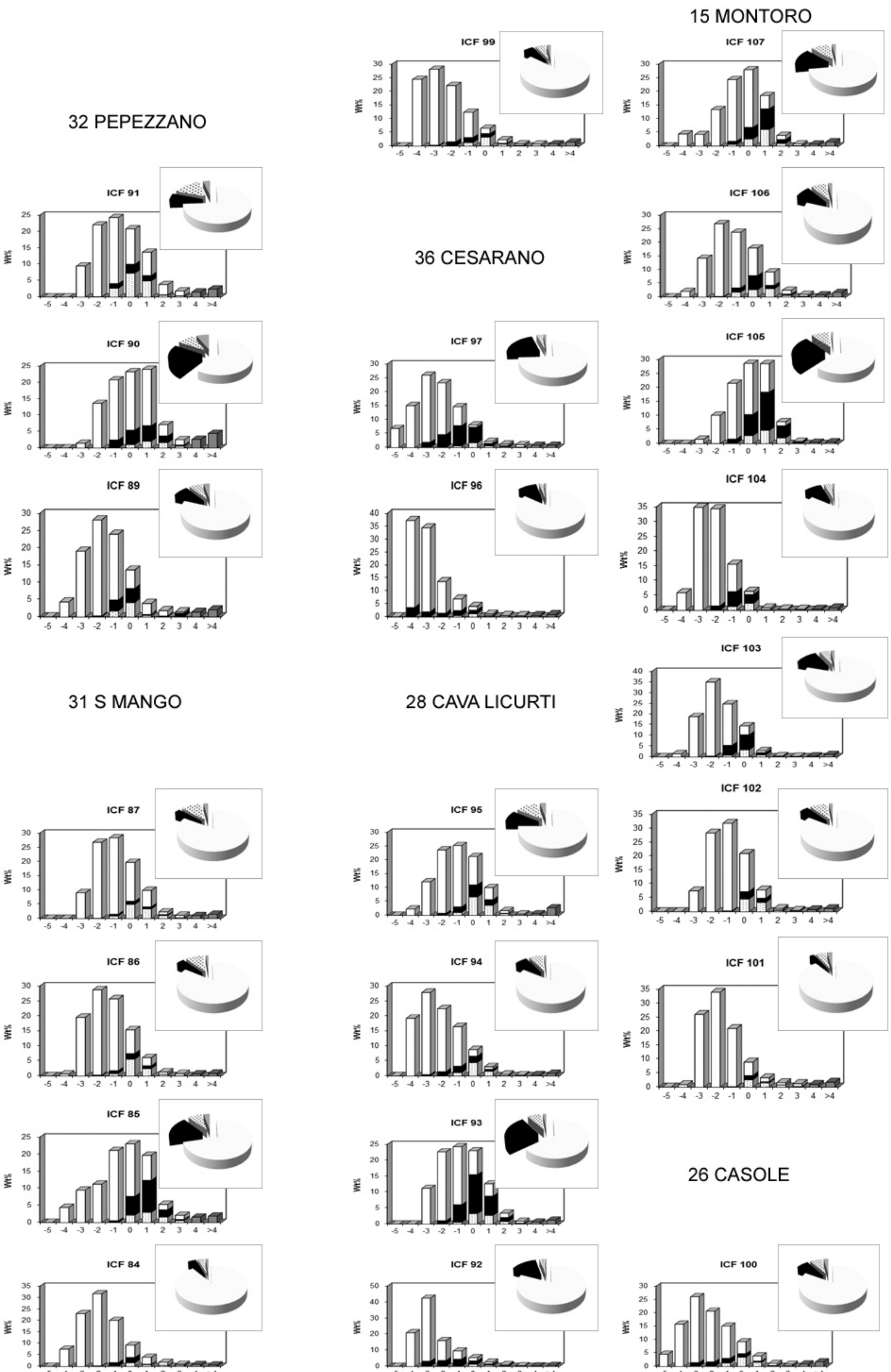
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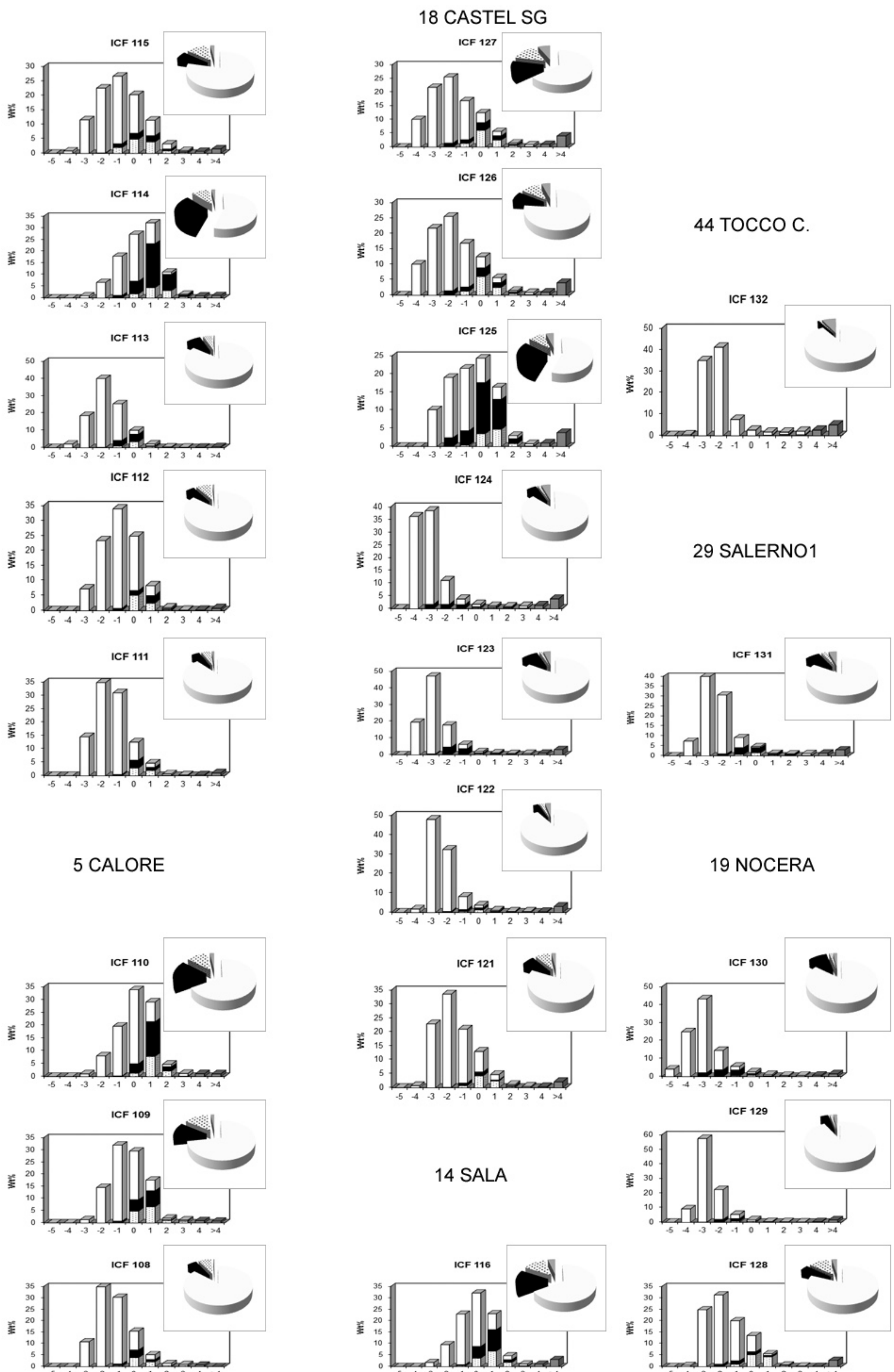
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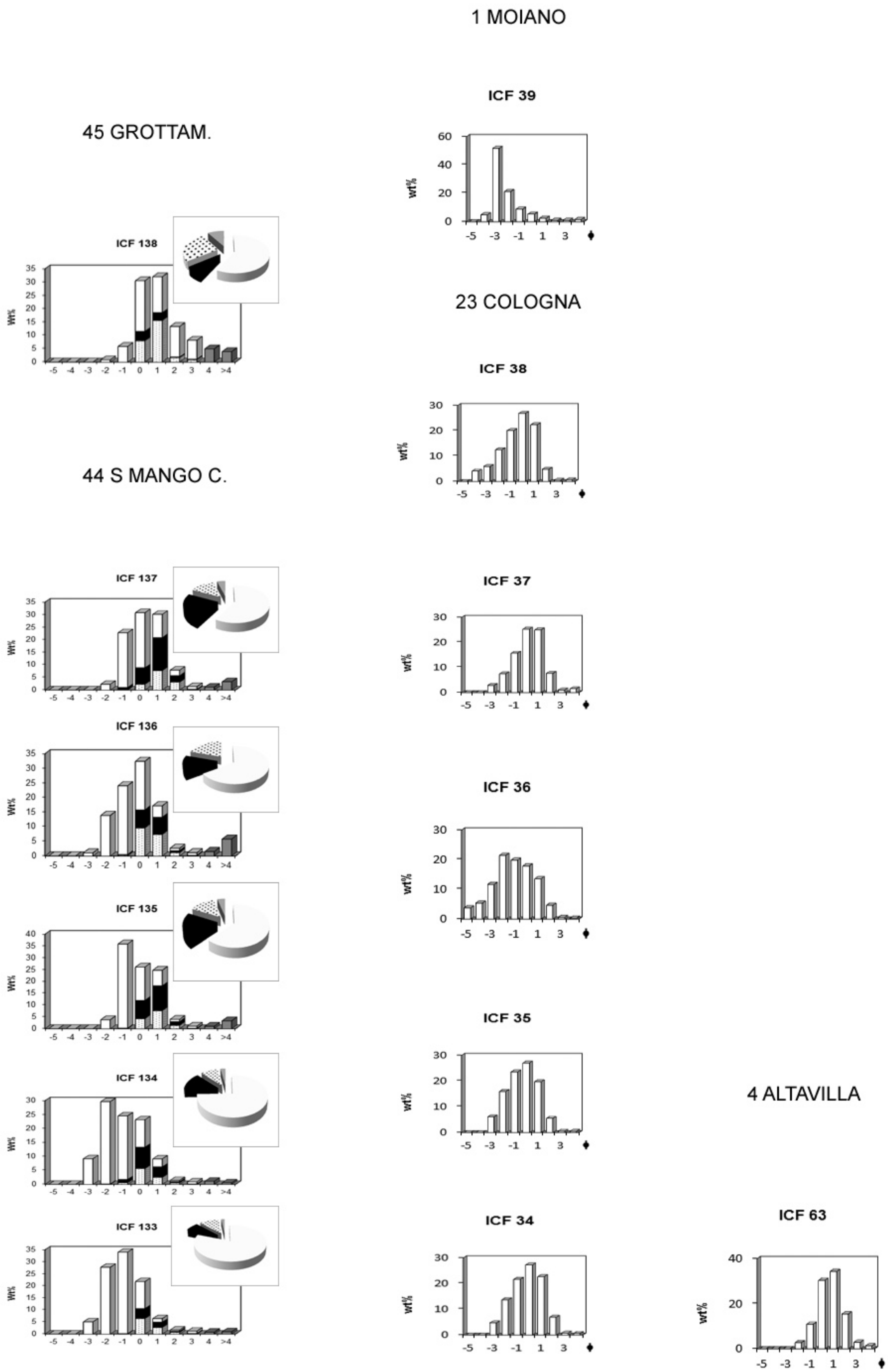
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