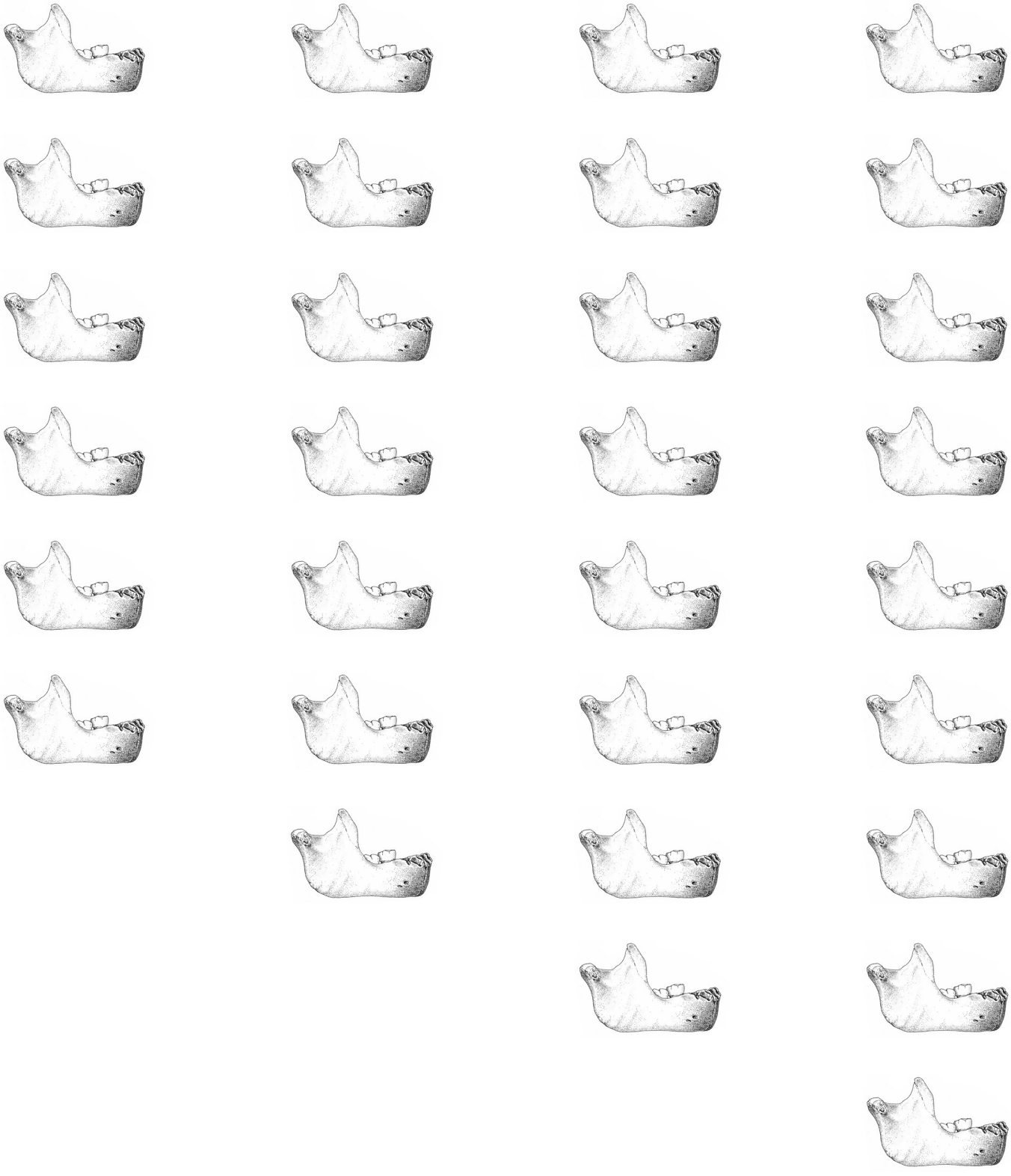

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Elemental imaging of human teeth by laser ablation ICP-TOF-MS: fast acquisition and high-resolution

Federico Lugli[1,2], Alessia Nava[3,4], Martin Rittner[5], Simona Arrighi[1], Federica Badino[1], Eugenio Bortolini[1], Carla Figus[1], Giulia Marciani[1], Gregorio Oxilia[1], Matteo Romandini[1], Sara Silvestrini[1], Anna Cipriani[2,6], Wolfgang Müller[7], Luca Bondioli[4], Stefano Benazzi[1,8]

1 - Department of Cultural Heritage, University of Bologna, Ravenna, Italy · 2 - Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Modena, Italy · 3 - DANTE Laboratory for the study of Diet and Ancient Technology, "Sapienza" Università di Roma, Rome, Italy · 4 - Bioarchaeology Service, Museo delle Civiltà, Rome, Italy · 5 - TOFWERK AG, Thun, Switzerland · 6 - Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA · 7 - Institute of Geosciences, Goethe-University Frankfurt, Frankfurt/Main, Germany · 8 - Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

The distribution of trace elements in the mineralized tissue of permanent and deciduous teeth is crucial in reconstructing past human behavior and ecology. Recent work demonstrated how weaning practices and diet during infancy may be unraveled investigating chronologically-resolved thin sections of human teeth [1,2]. In addition, trace element distribution in dental tissues can decipher the health status (i.e. heavy metal intoxications) of an individual and resolve post-depositional processes (i.e. fossilization. Enamel is highly resistant to diagenesis and sequentially mineralizes over several years, recording dietary input information at high time-resolution. This tissue is thus the ideal target for trace element and isotope analysis, even if the complex process of enamel secretion and mineralization can overprint the trace element signal and great attention has to be paid in selecting the regions of interest into the crown [1]. From a methodological perspective, trace elements are commonly measured in histological sections employing in-situ and imaging techniques, such as laser ablation ICP-MS [3], electron microprobe and x-ray fluorescence. We propose here a novel workflow to map trace elements in histologically-defined sections of human teeth via LA-ICP-TOF-MS imaging [4]. The icpTOF (TOFWERK AG) combines a classical ICP-MS system with a Time-of-Flight mass analyzer and is able to acquire a complete mass spectrum in 0.03-0.05 ms for each sampling point. We analyzed thin sections from two archaeological teeth (one lower first permanent molar and one lower deciduous second molar) from the Roman Imperial necropolis of Isola Sacra (II-IV century CE, Lazio, Italy), coupling a state-of-the-art ICP-TOF-MS (icpTOF2R, TOFWERK AG, Thun, Switzerland) with a Teledyne CETAC Analyte G2 193 nm excimer laser and a low dispersion, fast-washout ablation cell (Cobalt). Teeth were embedded in EpoThin (Buehler) resin and cut using a diamond blade microtome (Leica 1600), at the Museo delle Civiltà in Rome, Italy. Final sections (∼100 μm thick) were analyzed for their histomorphometric features using a polarized light microscope and chronologized counting the Retzius lines and cross striations incremental markings. Through this setup, we were able to obtain high-resolution elemental maps (pixel size ranging between 10 and 20 μm) of the dental crown and to precisely correlate chemical data with the growth patterns of the tooth. Being this technique micro-destructive for the thin section (∼<1 μm ablated in depth), it is possible to re-observe the growth patterns of the enamel after ablation and, potentially, repeat the mapping on the same thin section. The two Roman teeth showed clear Pb variation through the crown, highly correlated with enamel growth trajectories, likely related to the environmental exposure to this toxic metal during the individual's lifetime. The reliability of these results is corroborated by the evidence that Pb is almost unaffected by the maturation overprint [1]. To conclude, LA-ICP-TOF-MS can either be used as a screening tool for subsequent detailed chemical and isotope mapping of the entire section of the dental crown or as an effective tool to study weaning practices, diet, environmental exposure to toxic metals, and post-depositional elemental uptake.

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