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Sr isotope, trace elements and oxygen isotope record in molar enamel as indicator of seasonal wooly mammoth migration in Central Europe

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Kraków Spadzista is one of the largest Gravettian (Upper Paleolithic) sites in Central Europe which was active between 24 and 22 kyr BP. During this time local woolly mammoth (Mammuthus primigenius Blum.) population was extensively exploited by Palaeolithic hunters. It is indicated by large assemblage of skeletal elements of at least 113 individuals deposited at the site. Significant amount of material is very well preserved which makes it valuable study material.
Our investigation involves molar tooth, which is characterized by thick enamel layer. This tissue has long been recognized as being most resistant to post-mortem alterations. We utilized laser ablation inductively coupled plasma mass spectrometer (LA MC ICPMS) to extract high spatial and time resolution measurements of strontium (Sr) isotopes. On that basis we determine that compositional variations is response to potential changes of migration areas, which was supported by oxygen isotope analyses and in situ trace element in conjunction with histological studies.
The studied molar tooth is well preserved which is indicated by trace elements composition (lacks enrichment in rare earth elements or actinides) with minor fractures and discolorations visible near the basal area and occlusal surface. Sr isotopic record express sinusoidal variation which we interpret as reflecting seasonal changes of migration most likely between two distinct locations (pastures). This highly consistent and very reproducible pattern is recorded in each individual plate. Estimated time of the single plate formation - 11 years, using Sr isotopic variation as seasonal marker is in excellent agreement with our histological estimates and with the previous histological studies. Thus we speculate that formation of the whole tooth to be only 1-2 yr older than single plate formation. Oxygen isotope composition conducted for several plates clearly shows cyclic changes in δ18O similar to those observed for Sr. Some local inconsistencies are most likely due to much lower time resolution of oxygen record. Nevertheless, stable isotope data strengthen our interpretation of seasonal woolly mammoth migration in Central Europe.