Studying wear marks with multiscale surface metrology

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Abstract

The interpretation of microwear found on stone tools is mainly based on qualitative description of surface alterations, the unavoidable subjectivity of this method is problematic. Quantitative methods to characterize surface alteration on stone tools, can avoid some of the subjectivity Recently metrology and tribology have been the focus of few studies and yielded promising results. This work provides a critical review of new theoretical principles for a quantitative study of wear marks, discovering strong correlations and confident discriminations with topographies, which could identify tool uses (e.g. Stemp et al. 2009 & 2017) and even rank characteristics of tool users.
Four commonalities of experimental works that successfully discriminated and correlated topographic measurements are reviewed (Brown et al. 2018): characterization of appropriate geometric properties, at the appropriate scales, using appropriate statistical analyses, and measuring with sufficient resolution.

According to Archard (1953), scratch depth and shape are functions of abrasive particle shape and spacing, force and hardness. Therefore, force variation and associated scratch depths, relate to users. Shape and spacing factors of scratches depend on abrasive particles native to the workpiece, and could include wear debris from the tool. The later might be distinguished by larger and more angular scratches. Scraping and chopping motions should cause scratches perpendicular to the cutting edge. Slicing or sawing should leave scratches

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parallel to the edge.

Traditional height parameters lack spatial information and are unable to distinguish the shape, spacing or direction of the scratches. Relative lengths change with scale, are sensitive to inclinations on the surface, and can therefore be appropriate for the geometric and scale criteria (Brown et al. 2018). The statistical treatment should test discrimination, e.g., F-test, and compare discrimination parameters, e.g., mean square ratios, at many different scales. This multiscale discrimination should cover the scale range available in the measurement, from the sampling interval (pixel size) to the dimensions of the field of view, in the attempt to find the scales where the confidence in discrimination is the strongest.

Archard, 1953. Contact and Rubbing of Flat Surface. J. Appl. Phis. 24 (8): 981–988.

Brown et al., 2018. Multiscale analyses and characterizations of surface topographies, in review, to be published in 2018.

Stemp et al., 2009. Quantification and discrimination of lithic use-wear: surface profile measurements and length-scale fractal analysis, Archaeom, 51: 366-82.

Stemp et al., 2017. Testing Area-Scale Fractal Complexity (Asfc) and Laser Scanning Confocal Microscopy (LSCM) to Document and Discriminate Microwear on Experimental Quartzite Scrapers. Archaeom. In press.

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