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New developments with Schmidt-hammer exposure-age dating (SHD): Comparison of mechanical and electronic Schmidt-hammers – towards a conversion factor for Q- and R-values

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Developed as an instrument for in situ destruction-free testing of concrete hardness in construction works, the Schmidt-hammer has subsequently been introduced and applied in various fields of geomorphology and geology. In the context of investigating Late Glacial and Holocene glacier chronologies, the Schmidt-hammer has been widely used as a relative-age dating technique. Such applications have for example successfully separated moraines formed during different glacier advance periods (‘Little Ice Age’-type events). Pilot studies combined Schmidt-hammer measurements with available radiocarbon ages in order to achieve age constraints. Schmidt-hammer exposure-age dating (SHD) combining Schmidt-hammer and terrestrial cosmogenic nuclide dating (TCND) has recently been successfully applied in Norway and New Zealand. Schmidt-hammer tests have also been used to ensure the representativeness of boulders selected for TCND sampling. Especially in mountain regions with a high “geomorphological uncertainty” with the dating of Holocene moraines the inherited multi-proxy approach of SHD owns a considerable potential for reliable investigations of Late Glacial/Holocene glacier chronologies and their palaeoclimatic interpretation.

An electronic Schmidt-hammer (named SilverSchmidt) was introduced by the manufacturer of the original mechanical Schmidt-hammer (Proceq SA) a few years ago. It offers especially facilities for much easier data processing and constitutes, therefore, a major improvement and potential replacement for the mechanical Schmidt-hammer. However, its different approach to the measurement of surface hardness – based on Q-(velocity) values instead of R-(rebound) values – means that measurements from the two instruments are not easily interconvertible. Prior to any considerations of using the instruments interchangeably or replacing the mechanical Schmidt-hammer in future studies with the SilverSchmidt, comparative tests under field conditions need to be undertaken to ensure reliability.

A comparative study of the mechanical and the electronic Schmidt-hammer, both instruments were N-type models with identical impact energy of 2.207 Nm for the plunger, was performed in the west-central part of the Jotunheimen mountain range of southern Norway. The test localities on bedrock exposures of locally predominating pyroxene-granulite gneiss constitute sites of known age previously investigated by Matthews & Owen (2010). To compare both instruments and explore interconvertibility, we used two different approaches. First, resampling was carried out with the SilverSchmidt at selected localities previously sampled by Matthews & Owen (2010) with the mechanical Schmidt-hammer. Second, additional parallel sampling was conducted with both instruments with greater experimental control. For this second approach, paired samples ($n = 50$) were collected so that the plunger impacts of both instruments were set close together on the rock surface (to avoid any influence of modifications to the surface by consecutive impacts on the same spot). In order to test their performance at the higher and lower end of surface hardness, similar paired sample tests were also made on a full-metal proprietary test anvil and soft tarmac, respectively.

The application of the electronic SilverSchmidt with extensive sampling under field conditions was unproblematic. Subsequent data processing was considerably less time-consuming and more efficient than with the mechanical Schmidt-hammer. Q-values and R-values are closely related, Q-values are systematically higher than R-values by 7.70-10.25 units over most of the operational range of both instruments. Linear conversion equations indicate a conversion factor in the order of +9.6-10.1 units is applicable when converting R-values to Q-values. These estimates agree well with data obtained on the standard test anvil, which yield Q-values that are, on average, 8.54 units higher than R-values. These numerical relationships are likely to break down only on very

soft lithologies (like the tested tarmac). Given the interconvertibility of the two instruments, the SilverSchmidt is regarded as a potential replacement for the mechanical Schmidt hammer. This enables, moreover, continuity in study areas with existing R-value data archives. However, when comparing data sets of different age, adjustments must be made for any changes to the instrumental calibration value over time. Following this initial success, further testing of these conclusions in relation to different rock types and environmental conditions is advisable.

Reference:

Matthews, J.A. & Owen, G. (2010): Schmidt hammer exposure-age dating: Developing linear age-calibration curves using Holocene bedrock surfaces from the Jotunheimen-Jostedalsbreen region of southern Norway. Boreas 39: 105 – 115.