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Tephrochronology as a tool for precise dating and correlation of Quaternary records

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Modern geology is increasingly focused on environmental change and climate history. High temporal resolution of geological data archives is required for the use of palaeodata in model experiments predicting future changes. Linking datasets from environments ranging from ice cores and lakes to the floor of the world's oceans requires powerful dating tools. Tephra layers offer precise correlation and dating of various geological archives since they represent instantaneous events, isochrones, are rapidly deposited and often have a widespread distribution. Thus the advantages of using tephra for dating and precise correlation over large areas, terrestrial and marine, are evident. This study is motivated by this increased demand for exact dating. The aim of the study was to establish a detailed tephra stratigraphical and tephrochronological framework for the North Icelandic shelf region adding to the reliability of correlating marine, terrestrial and ice core records.

A detailed tephra stratigraphy and tephrochronological framework for the North Icelandic shelf has been established for the last 7050 cal yrs BP using marine core MD99-2275. About 60 new tephra layers, originating from Icelandic volcanic systems are revealed in the shelf sediments spanning this time period. A total of 100 tephra layers have been identified so far in core MD99-2275 spanning the last 15.000 cal yrs BP. Some 40 tephra layers in the shelf sediments have been correlated to their counterpart on land establishing a secure land-sea correlation between terrestrial tephra stratigraphy in Iceland and the marine tephra stratigraphy on the shelf. This demonstrates the potential of the tephrochronology in the North Icelandic shelf region to date and correlate past environmental changes as seen from marine, terrestrial and ice-core climate proxies. This new and detailed tephrochronological framework will significantly improve dating and land-sea correlation of palaeoclimatic records not only for the North Icelandic shelf region but possibly also elsewhere in the North Atlantic and Europe.

Other aspects of the study were to: i) evaluate the effectiveness of methods commonly used to detect tephra layers in marine environments, ii) to define the tephra layers, i.e. pinpointing the upper and lower boundaries of tephra layers with the purpose of determining the exact stratigraphical level of the time signal provided by primary tephra layers and iii) to use quantitative methods to discriminate between a primary tephra layer and reworked tephra in a marine environment. The results show that only six of the methods tested detected all investigated tephra layers, and that a primary tephra layer can be securely identified by combining results from geochemical analyses, grain morphology, mineralogical counts and grain size measurements. This multi-parameter study improves accuracy of tephra layer detection, stratigraphical placement (exact timing) of tephra layers and discrimination between primary tephra layers and reworked tephra, all of which are important factors when using tephra layers for dating and correlation of various geological archives.