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A geochemical reevaluation of caldera-forming eruption deposits in the Upper Borrowdale Volcanic Group, English Lake District.

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Caldera-forming eruptions sequences produce a wide range of volcanogenic sedimentary deposits, from primary mesobreccia (blocks > 1m) that form from the collapse of caldera wall scarps during the eruption, to co-ignimbrite ash plumes (particles < 2mm) deposited during the waning of outflowing pyroclastic density currents, and even secondary aqueously reworked sediments deposited within caldera lakes. Understanding the temporal and special distribution of these deposits is vital to both locate and reconstruct the collapse sequence of these catastrophic events. However, research of caldera volcanoes is greatly hindered at modern examples due to subsequent burial of their own deposits.

Ordovician deposits (452 Ma) of the Borrowdale Volcanic Group (BVG) in the English Lake District are dominated by large-scale, caldera-forming deposits that have been tectonically uplifted and dissected by glacial erosion. Each of the BVG calderas have the potential to provide a wealth of knowledge regarding how calderas erupt, collapse, and continue to shape geological processes when their explosive activity ceases. However, due to intense faulting, alteration, and impersistent exposure across the Lake District, in-depth research of these calderas has been largely prevented using standard field-mapping techniques. This leaves most of the understanding for the overall nested caldera complex to be inferred.

This investigation utilizes whole-rock geochemistry as the primary method to establish correlations between potential large-scale, caldera-forming pyroclastic deposits across large distances. Once the extent of each deposit was determined, they were individually traced back to their source vents. Detailed fieldwork was then conducted to identify characteristic caldera-forming features, such as rapid thickness changes over volcanotectonic faults, and extensive intercalated mesobreccia deposits.

Geochemical analysis of immobile elements, including Nb, Th, Y, and Zr, of potential caldera-forming pyroclastic deposits has allowed for several notable correlations to be established, or disproven. Firstly, proximal outflow sheets from Langdale Caldera have been successfully correlated to pyroclastic sheets over 15 km from the caldera margin and suggest a multi-phase collapse sequence. Secondly, significant differences in the geochemistry of deposits associated with the Lincomb Tarns Formation (> 500 km^2 ignimbrite) indicates the presence numerous pyroclastic sheets, originating from two separate caldera volcanoes within the Helvellyn and

Ambleside areas. Finally, geochemical variations within the Haweswater 'caldera' infill deposit prove that sudden thickness changes, previously associated with syn-collapse volcanotectonic faulting, are the result of separate eruption events that have since between adjacently faulted.