# THE STAC FADA MEMBER, NORTHWEST SCOTLAND: AN IMPACT ORIGIN BUT WITH A TWIST.

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**Introduction:** While the British Isles lack any confirmed hypervelocity impact craters, a small number of impact deposits have been reported from southwest England [1], the Isle of Skye [2], and the northwest Scottish Highlands [3]. Of these, the Stac Fada Member of northwest Scotland, is the most spatially extensive and volumetrically extensive. The Stac Fada Member is part of the Stoer Group of the larger Torridonian Supergroup. It was historically thought to be volcanic in origin, but with interpretations varying from an ash flow deposit [4], a hot mudflow [5], to a volcanic debris flow [6, 7]. In 2008, Amor et al. [3] proposed that the Stac Fada Member was a "suevite" (i.e., an impact melt-bearing breccia) and part of the proximal ejecta blanket of an undetermined hypervelocity impact structure. These conclusions were based on the presence of shocked quartz grains, chromium isotopes and elevated platinum group metal and siderophile element abundances. Further evidence of an impact origin of this deposit came from the discovery of reidite ($ZrSiO_4$) [8]. The location of the source crater remains unknown and heavily debated. This goal of our study is to reinvestigate the impact origin of the Stac Fada Member.

**Methods:** Fieldwork was carried out to investigate the Stac Fada Member on multiple occasions from 2008 to 2016. Optical microscopy was performed on polished thin sections from 46 samples using an optical microscope combined with a four-axis universal-stage (U-stage). Quantitative analyses and investigation of micro-textures were carried out using both back-scattered electron (BSE) imagery and wavelength dispersive X-ray (WDS) techniques on a JEOL JXA-8900 L electron microprobe. Semi-automatic digital image analysis was conducted to quantify the geometry of clasts in hand samples to compare them to previously collected and published data on hand samples of other glass-bearing breccias from confirmed hypervelocity impact craters following the methods of Chanou et al. [9].

**Results and Discussion:** One of the motivations for this study was to confirm the impact origin of the Stac Fada Member. We documented 78 sets of planar deformation features (PDFs) in 48 quartz grains, which is a notably lower PDF-plane-to-grain ratio (1.63) than the 2.36 reported by Amor et al. [3]. This difference of results can be explained by Amor et al. [3] having measured only 25 quartz grains. Thus, we can confirm the presence of shock-metamorphosed and -melted material in the Stac Fada Member.

However, other properties of the Stac Fada Member are unlike any other confirmed proximal impact ejecta deposits. Most importantly, the Stac Fada Member is moderately to very well sorted, contains very few shocked mineral clasts, no shocked lithic clasts, is dominated by vitric clasts rather than lithic clasts, and possesses internal layering and grading, all properties that fundamentally differentiate this unit from all other well-documented impact melt-bearing ejecta deposits on Earth [10, 11]. Instead, these properties are most similar to the Onaping Formation of the Sudbury impact structure [12] and impact melt-bearing breccias from the Chicxulub impact structure [13].

**Conclusions:** Based on the similarity of the Stac Fada Member with the Sudbury and Chicxulub deposits, we propose that melt-fuel-coolant interactions (MFCI) – akin to what occurs during phreatomagmatic volcanic eruptions – played a fundamental role in the origin of the Stac Fada Member. We suggest that the impact was into the river systems and water-laden sandy sediments that are now preserved as the Bay of Stoer Formation, where there would have been abundant water to drive MFCI within the host crater and to transport this melt and other crater-derived material well beyond the crater rim. We thus conclude that the rocks of the Stac Fada Member are not primary impact ejecta but instead were deposited beyond the extent of the continuous ejecta blanket as high-energy ground-hugging sediment gravity flows. For details on these results and a complete discussion see Osinski et al. [14].

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