LATERAL VARIATION IN THE STAC FADA IMPACT EJECTA DEPOSIT, NW SCOTLAND: CLUES TO CRATER LOCATION, SIZE, AND EJECTA EMPLACEMENT PROCESSES.

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The Stac Fada Member is a 4-12-metre-thick unit within the 1.2 Ga year old Stoer Group in north-west Scotland. It has an elongate (~50 km long) but narrow (<200m wide) broken outcrop, truncated by faulting and/or erosion, and is interpreted as a partial chord section through an external impact ejecta deposit [1]. It is a largely homogeneous unit composed predominantly of cm-scale devitrified melt clasts (~20-30% by volume) within a matrix of muddy sandstone containing sparse shocked quartz and reidite [1-3]. Uniquely among terrestrial ejecta deposits the Stac Fada Member appears to represent a Single Layer Ejecta (SLE) deposit, perhaps analogous to those that are dominant on Mars [4], rather than a Double Layer Ejecta (DLE) type (cf. Ries) where shallow-sourced, unshocked, erosive-based lithic breccia is overlain by a more deeply sourced melt-rich breccia, or suevite. An emplacement temperature of ~200ºC for the Stac Fada Member [1] is intermediate between that of lithic breccia (cold) and suevite (hot) and suggests mixing of cold sediment (the sandy matrix) with hot melt (the vitric clasts). Its largely non-erosive base suggests that mixing occurred before emplacement. The source crater has yet to be identified, with opinion differing radically on its location, either broadly to the west [1,3] or to the east [2], and its size, estimated variously at 13-14 km [3], 40 km [2] or even 100 km [5].

At all but one site the Stac Fada Member appears remarkably uniform both vertically and laterally. This apparent homogeneity masks subtle variations that can provide clues to crater size and location. Thickness diminishes from ~12 m in the north to ~4 m in the south. Depositional slickensides and shear surfaces, absent or indistinct in the north, become increasingly prominent at more southerly sites and suggest westward movement of a viscous flow. Vitric clasts, randomly oriented in the northern part of the outcrop, become increasingly aligned subparallel to bedding and/or shear surfaces in the southerly part of the outcrop. Spallation ejecta blocks on the surface immediately below the Stac Fada Member generally are undisturbed indicating emplacement was non-erosive [2], but abundant lithic debris in the basal part of the Stac Fada Member at the southernmost sites indicates erosive entrainment of underlying material. Elutriation pipes and authigenic feldspar pore-fillings, common in the north, become increasingly sparse southwards and are absent at the southernmost sites.

Enard Bay, just 15 km from the northernmost outcrop, seems anomalous. Accretionary lapilli are significantly larger and more abundant here than elsewhere. Elutriation pipes, seen to north and south, are absent although authigenic feldspar is pervasive as pore fillings. Across much of the site both vitric clasts and matrix appear profoundly altered and unlike what is observed at other sites. Reaction rims around vitric clasts suggest that much of the ejecta deposit here experienced significant metasomatism by high-temperature fluids.

These observations together indicate that Enard Bay probably was closest to the impact crater, with a broadly southward transition from high-temperature, fluid, non-erosive, ejecta flow to a cooler, more viscous, erosive flow over a distance of ~35 km. This is comparable to observations made at Ries and Chicxulub [6], although it differs from those examples in being a Single Layer Ejecta deposit. Crater diameter is inferred to be of the order of 15-20 km, at the lower end of previous estimates.

References:

[1] Amor, K. et al. (2008) *Geology* 36: 303–306. [2] Simms, M.J. (2015) *Proceedings of the Geologists' Association* 126:742-761. [3] Amor et al. (2019) *Journal of the Geological Society, London* 176:830–846. [4] Simms, M.J. (2016) *Meteoritics & Planetary Science* 51: A578, Abstract #6091. [5] Simms, M.J. and Ernstson, K. (2019) *Journal of the Geological Society* 176: 817-829. [6] Kenkmann, T. and Schönian, F. (2006) *Meteoritics & Planetary Science* 41:1587-1603.