GENESIS OF A TERRESTRIAL SINGLE LAYER EJECTA DEPOSIT: THE STAC FADA MEMBER (STOER GROUP, MESOPROTEROZOIC, NW SCOTLAND).

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Introduction: Impact ejecta deposits on Earth, as exemplified by those associated with the Nördlinger Ries crater, invariably are of the Double Layer Ejecta (DLE) type in which shallow-sourced, unshocked, erosive-based lithic breccia is overlain by a more deeply sourced melt-rich breccia unit, or suevite. In contrast the Stac Fada Member, a 4-12 m thick impact ejecta deposit within the Stoer Group (Mesoproterozoic, ~1.2 Ga) of north-west Scotland [1], differs from typical DLEs in several respects and appears to represent a Single Layer Ejecta (SLE) deposit that is perhaps analogous to those that are dominant on Mars.

The Stac Fada Member is dominated by a largely unshocked muddy sand matrix containing larger melt clasts. Accretionary lapilli are common in the upper part of the Stac Fada Member at more proximal locations and angular lithic blocks occur widely across the surface immediately beneath the Stac Fada Member. The latter are interpreted as spallation ejecta rather than being equivalent to the lithic breccia of DLE deposits. Various features suggest that the Stac Fada Member was generated through mixing of shocked and unshocked impact products. The matrix is felsic, composed of a poorly sorted mix of quartz, feldspar and lithic grains, while the melt clasts are mafic in composition, comparable with basalt or gabbro, yet contain abundant corroded felsic inclusions. Melt clasts comprise ~20% by volume, compared with >80% in the Ries suevite and <1% in Ries lithic breccia; shocked quartz abundance is only a tenth that of Ries suevite; and emplacement temperature was ~200^{o}C, compared with >600^{o}C for Ries suevite and <50^{o}C for Ries lithic breccia. The sandy matrix of the Stac Fada Member is dominated by sand-sized particles (<2mm) with <1% pebble-grade (>1cm) clasts, whereas the Ries lithic breccia has a much broader particle size distribution extending to metre-scale or larger blocks. Melt clasts in the Stac Fada Member are matrix-supported and significantly larger than matrix clasts (cm vs. mm). The melt-matrix ratio (~1:4) remains consistent both along the outcrop (~50km) and vertically through the unit, indicating that mixing of components occurred prior to emplacement and involved minimal subsequent entrainment of sediment from the pre-impact surface.

Modeling of large impacts indicates that lithic breccias are sourced from shallow target layers while melt is sourced from deeper levels as crater excavation progresses [2]. Most terrestrial targets comprise lithified strata and/or crystalline rocks and the impact generates a wide size distribution of shallow-sourced fragments, from dust to tens of metres or more across. All but the smallest lithic clasts quickly fall out of the ejecta plume before significant volumes of melt are ejected from deeper parts of the transient crater. Consequently in DLE deposits the shallow-sourced lithic breccia and deeper-sourced melt-rich breccia form discrete, temporally separated units.

Features of the Stac Fada Member described above suggest that it was generated by impact into a target analogous with the immediately pre-impact Stoer Group, with hundreds of metres of unlithified, water-saturated, fluvial or shallow marine clastics interspersed with Lewisian (Archaean) gneiss inliers, although the melt clasts suggest a more mafic composition for the deeper target rocks. An initial plume of fine, unshocked, shallow target material remained suspended in the hot turbulent ejecta plume long enough to be joined by more deeply sourced impact melt. Fluidity of the melt within the turbulent plume is demonstrated by the abundance of felsic grains that the melt clasts contain. Thorough mixing of shocked and unshocked ejecta accounts for its relatively low temperature and the sparsity of melt clasts and shocked quartz grains compared with Ries suevite. A similar mechanism can perhaps be envisaged for SLE deposits on Mars, where sediments are only weakly cemented.

References: References: [1] Simms, M.J. 2015. *Proceedings of the Geologists' Association* 126: 742-761. [2] Artemieva, N.A. et al. 2013. *Meteoritics & Planetary Science*, 48: 590-627.