DISTRIBUTION AND ABUNDANCE OF DARWIN IMPACT GLASS. K.T. Howard[1] and P.W. Haines[1]
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Introduction: Since its first discovery in 'soils' near Mt Darwin, western Tasmania, Australia, impact glass has been reported across an area of about 400 km^2 [1,2]. Across much of this area Darwin glass appears to be patchily distributed and its distribution is poorly defined. We have improved the constraints on the dimensions of the strewn field and estimated the abundance of glass.

Stratigraphic setting of Darwin glass: Across the strewn field the glass is intimately associated with quartzite gravels. The gravels are residual deposits formed largely from the *in situ* weathering of quartz veins in country rocks. Transport of the quartz fragments, especially in flat areas has largely been vertical. Glasses recovered from these gravels show fine surface sculpting and delicate primary morphologies that further suggest both the glass and therefore the gravels have not undergone significant lateral movement or spent time entrained in fluvial transport. As residual deposits the nature of the glass bearing gravel horizons is strongly influenced by elevation and topography.

Slopes and flat ground between ~230–500 m: On steep and gentle slopes and flat lying ground between approximately 230 and 500 m elevation the glass bearing quartz gravel lies beneath a layer of soil and peat. Immediately below the peat are the largest quartz fragments and glass in a matrix of fine quartz sand that extends to the contact of the highly weathered bedrock. Glass is rare in the fine sand below the larger quartz fragments. The peat layer varies in thickness but is typically around 20 cm thick and free of glass fragments. Below the peat the thickness of the glass bearing gravel horizon ranges from a few centimetres to several metres. On low and mid slopes the gravel horizon is consistently around 30 cm thick. The thickest gravel horizons tend to be on gentle and flat lying ground at lower altitudes.

Peaks >500 m: Peat is absent on hills and on mountain summits in the strewn field and the gravel horizon is also either absent or confined to isolated free quartz fragments and rare Darwin glass sitting directly on weathered bedrock. Previous workers assumed that early Holocene ice accumulation and transport had removed Darwin glass from slopes above 500 m.

Valley floors < 220 m: On valley floors in the strewn field the gravel horizon and Darwin glass are not exposed - buried under peat and valley filling sediments - or have been incorporated in extensive deposits of re-worked glacial moraine. Rare fragments of glass have been found sitting atop of valley fill sediments on the crater floor and these have been moved down slope.

Dimensions of the strewn field: Figure 1 shows all sites where *in situ* Darwin glass has been found (solid circles). The map is a composite of sites discovered and or studied in detail here and those reported in previous works. Verified anecdotal reports of glass finds are also included. Attention was focused on delineating the outer limits of glass occurrences in all directions. Sites where residual gravels were searched and found to be glass free are indicated (Fig. 1, x's) and these are sites that are interpreted to define the approximate limits of the strewn field (Fig 1, solid line). The southern and eastern limits of the field are least well defined and further access in these directions is difficult. Glass is likely to be found further south but to the east residual deposits are very rare and no glass is found. The suspected source crater sits at the apparent eastern limit of the field. This asymmetry in the distribution of glass noted by [2] is interpreted to reflect the preservation of glass only and not its primary post impact distribution. The asymmetry is derived from the presence of Engineer Range. These mountains (Fig. 1, triangles) are drained on either side by major rivers that have transported away glass eroded from the slopes. The glass distribution relative to the suspected crater is more equal in the remaining directions and covers and area of over 410 km^2.

The abundance of Darwin glass: At 8 sites surrounding the suspected crater and defining an area of 10 x 5 km controlled excavations have been conducted in order to estimate the abundance of glass present. A controlled excavation refers to an archaeological style dig where a known volume of material is sieved and searched for recovered glass. At each site 0.03 m^3 (10 standard prospectors' pans) of glass bearing gravel was sieved through 1 and 0.5 cm mesh sieves. Where possible the material was excavated from a standard sized area usually around 1 m^2 however, dense vegetation with complex root systems and steep rugged terrain often prevents this control. All visible glass was recovered from the sieves and a ground sheet placed below sieving operations searched for fine glass fragments. Recovered glass fragments were weighed and results normalised to kg/m^3. The determined glass abundance ranges from 47 to 0.3 kg/m^3 across the study area. The maximum value is reached in a thick residual gravel deposit some 2 km from the suspected crater. At the remaining sites measured abundances are more consistent and there is a general trend of decreasing glass abundance away from the crater. Outside of this 50 km^2 study area the abundance of glass in gravels is too low, or distribution too patchy, or access too poor for glass to be recovered in controlled conditions. Here glass is only recovered by fossicking without consideration of the volume of material or area searched and the abundance of glass is difficult to quantify.

Melt Volume: By estimating the average thickness of the gravel deposits across the 50 km^2 study area the volume of ejected melt can be approximated. Most of the survey area is covered with peat above the glass bearing gravel horizon that is consistently around 30 cm thick. In contrast at other locations several metres of glass bearing gravel exists and on peaks the horizon is typically less than 1 cm thick. After accounting for thin gravel cover on peaks, a conservative estimate of the average thickness of the glass bearing gravel horizon in the study area is taken to be 15 cm. Excluding the most abundant site (47 kg/m^3) the average abundance of glass in the gravel deposits across the survey region is 3.4 kg/m^3. Therefore, in this 50 km^2 area it can be estimated that there is approximately 25 500 tonnes of glass. Assuming a SG of 2 this represents a melt volume of 11100 m^3 or 0.00001 km^3. Errors in estimating the average thickness of the gravel horizon strongly influence melt volume determinations but these estimates of the gravel horizon thickness and the abundance of glass in the horizon are both conservative. As the survey area represents only 1/8th of the strewn field the estimated melt volume herein is considered to be very much a minimum estimate.

Discussion: at 1.2 km in diameter Darwin Crater is at the lower limit of scaling equations that model melt production. Based on the equation of [3] approximately 0.0012 km^3 of melt can be expected to be produced during excavation of a 1.2 km diameter crater. Of this around 1% - 3% of fully melted material (0.00001 km^3 or 12000 m^3) is expected to be ejected further than a few crater radii [3,4,5]. This agrees well with the measured minimum estimate of the volume of glass in the study area (0.00001 km^3). If the remaining >350 km^2 of the strewn field is considered modelled estimates of ejected melt volume are significantly too small. For other studied craters and especially those in sedimentary rocks modelled melt volumes generally far exceed measured volumes [3,6]. This indicates that relative to the size of the suspected source crater this is the most abundant ejected impact glass on Earth! In fact the volume of ejected melt at Darwin Crater is more abundant than is observed at much larger complex craters. Zamanshin Crater (13 km diameter) is more than 10 times larger than Darwin but here it is estimated by [7,8] that there is less than 100 tonnes of ejected glass – orders of magnitude less than is observed in the Darwin glass strewn field and importantly both glasses are of almost the same age. At similar sized simple craters such as Meteor or in small crater fields like Henbury far less glass has been found and all of this has come from closer to the crater than at Darwin [6,9]. This is despite these craters being on easily searched, flat desert planes in contrast to the mountainous rainforest of the Darwin glass strewn field. Acid groundwater ideal for the preservation of glass exists across the study area. However, this high abundance of Darwin glass seems unlikely to relate to preservation only and rather is interpreted to reflect more efficient than expected production of ejected melt during the impact event. The distribution of the glass that extends over a distance of more than 20 crater radii also exceeds modelled expectations and field observations of impact glass distribution [4,9]. This range is typical of the distribution of tektites from large impact events but the bulk of Darwin glass has a morphological and chemical character more commonly associated with *proximal* impact glasses.

Implications: My observations indicate that the crater structure is almost completely lacking in glass and this would support the findings of [3,5] that in smaller impacts a lesser volume of melt is produced but a greater proportion (all?) of this melt is ejected. The crater is in metasedimentary rocks and as such these data also appear to support the notion that the high volatile content of sedimentary rocks results in the unusually wide dispersion of melt [6]. This is contrary to recent observations at large craters in sedimentary rocks by [9] and may reflect differences in the cratering mechanics between small simple and larger complex craters. Alternatively there may be a larger undiscovered source and observed trends in the variation in glass are coincidental only - current work is aimed at determining the structur… nd its relationship to Darwin glass.

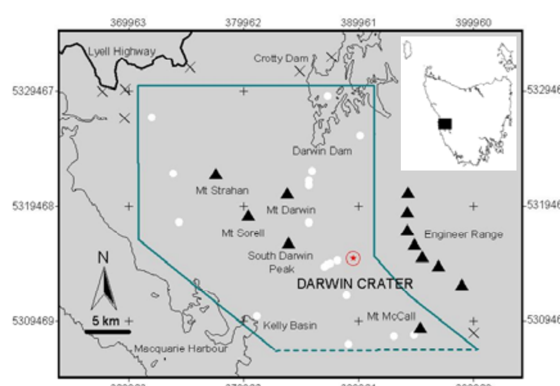

Fig. 1.

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