Slate Islands appears to be the central uplift of a 15-20 km diameter meteorite impact crater. This conclusion is based on the presence of a submerged peripheral trough and outer rim, an unusually complex geology, shock deformation lamellae in quartz and feldspar, shatter cones, and anastomosing breccia veins containing quartz grains with deformation lamellae and shatter-coned clasts [1,2]. The shatter cones have been observed in many places around the islands but measurements of their orientation has been sparse [1] or limited to one small region on the western side of the main island [3]. Using the method of Manton [4], we have made detailed measurements of shatter cone orientations at 30 sites around the islands, most frequently along the shoreline where the exposure is generally excellent.

Shatter cones are found in almost all rock types, but are best developed in Keweenawan basalt flows, in the chilled margins of Keweenawan diabase dikes, and in Archean diorite, foliated feldspar porphyry, and felsic metavolcanics. They are non-existent, or at best, poorly developed in the more fissile, sericite-rich metavolcanics and the massive mafic metavolcanics that constitute the major part of the geology of the islands. The majority of the cones are only partially exposed when the rock was broken open, although a few nearly complete cones have been collected. The cones vary in size from a centimeter or so in length and diameter, dominantly in very fine grained rocks, to over a meter in length and diameter, observed in the coarse-grained central regions of a few thick diabase dikes. In all cases, the cone surfaces show more-or-less-linear ridges or striations that characteristically radiate from the cone apex. Measurement and plotting of the orientation of striations from a number of cones at a site yields stereographic plots, such as those of Figs. 1 and 2. These are lower hemisphere plots, with the solid symbol showing the attitude of the striation in the direction of the apex and the open symbol, in the direction away from the apex. Contrary to the suggestion of others [3], the cones tend to be similarly oriented at a given site, although at some sites the scatter in striation orientation is considerable. For most of the sites, the striation orientations form a small circle girdle, the centre of which is the cone axis. In a few cases, particularly the strongly foliated feldspar porphyry, the plotted points show a distinctly non-circular distribution which tends to be "elongated" within the foliation plane.

To provide an unbiased estimate of the attitude and geometry of the cones, a least-squares curve fitting method was used. To include the possibility of an elongation, we fitted to the data a curve specifying the variation in cone angle about the cone axis. Because we had no theoretical basis for the actual shape of the cones, we used an equation of the form: \( \mu(\theta_C, \psi_C) = \mu_0 + A \cos 2\lambda(\theta_C, \psi_C) + B \sin 2\lambda(\theta_C, \psi_C) \), where \( \mu \) is the apical half-angle, \( \mu_0 \) is the average half-angle, \( \theta_C \) and \( \psi_C \) are the trend and plunge of the cone axis, \( \lambda \) specifies the angular position around the cone axis, and \( A \) and \( B \) are constants specifying the deviations of the cone angle from the average angle. This equation is a first-order Fourier expansion which allows the average cone angle, the orientation of the cone axis, and the direction of elongation to be calculated. A more complete characterization of the cone shape requires more terms in the expansion. The non-linear curve-fitting problem was solved using an iterative Taylor's expansion method. Examples of the fitted curves are shown in Figs. 1 and 2.
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The calculated cone directions are shown in Fig. 3. The number beside each cone is the plunge of the axis, negative upward. The more reliable data are plotted as large cones. The majority of the cones point inwards and upwards. Using the most reliable data (19 sites), the best-fit intersection point was calculated and represents our first estimate of the position of the shock centre (shown as a stippled circle). The size of the circle indicates the standard error of the position. The estimated height is $1.2 \pm 0.4$ km. No structural correction for possible block rotations was made. Paleomagnetic measurements for a number of sites reveal a component of magnetization related to the shock event [5]. Using primary and secondary paleomagnetic pole positions and local geology, structural corrections were made at 11 sites [6]. The corrected position of the shock centre is shown by the hachured circle. The revised height is $1.1 \pm 0.3$ km. The shock centre is about $1.5$ km further north than earlier determined [1], a revision that will affect the estimates of shock-wave attenuation for this impact [7]. The crater depth is comparable to that of other terrestrial craters of similar size, but is less than that of similar lunar and mercurian craters [8].

Fig. 4 shows a histogram of calculated average apical angles for each site. The average angle is $86^\circ \pm 10^\circ$ (s.d.), while for the most reliable sites, it is $88^\circ \pm 7^\circ$. This angle is very close to the theoretically expected value of $90^\circ$ [9]. The data for the feldspar porphyry having the small cone angle ($65^\circ$) is that of Fig. 2. The majority of the cones are nearly circular in cross-section, most having an ellipticity less than 1.3. In only two reliable sites, both in highly foliated feldspar porphyry, the cones are definitely elliptic, with ellipticities of 1.46 and 1.51. In both cases, the plane of "flattening" of the cone lies close to the foliation plane (Fig. 2). This result suggests that the rock anisotropy has controlled not only the shape of the shatter cone, but perhaps also its orientation. These two sites are shown underlined in Fig. 3. Thus for meteorite impacts into highly anisotropic rocks, shatter cones are not expected to give a reliable indication of the shock direction.

REFERENCES
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FIG 1
Keweenawan Volcanics

FIG 2
Foliated Feldspar Porphyry

FIG 3

FIG 4

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