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- SECTION C -

IDENTIFYING AND TIMING THRUST DEVELOPMENT IN MULTIPLY DEFORMED TERRANES
Figure 1: Map of the Charters Towers Province (Modified after Fergusson et al., 2007) showing the major metamorphic, plutonic and sedimentary rocks of Neoproterozoic to Carboniferous age. The location of the seismic line 07GA-GC01 is shown as well as the Alex Hill Shear Zone. Rectangles show location of figures 2, 4 and 11. The inset show the location of the E-W trending Charters Towers Province (CTP) within the overall N-S trending Tasman Fold Belt System (TFBS).
**Figure 2:** Location of the samples (numbers are prefixed by rq in text) used for FIA measurements (top) and matrix foliation trends (bottom) from within the porphyroblastic portion of the Puddler Creek Formation in the Thalanga region. Map location is shown on Fig. 1.
Figure 3: Photomicrographs and line diagrams showing examples of inclusion trails preserved within cordierite (a, b) and andalusite (c, d) porphyroblasts. The cordierite is totally pinitized and the andalusite partially replaced by fine grained white micas. The different orientation of inclusion trails from core to rim suggests two stages of growth for both porphyroblastic phases. Vertical thin section. Single barbed arrow shows strike and way up. Plane polarized light.
**Section C**

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**Figure 4**: Location of the samples (numbers are prefixed by rq in text) used for FIA measurements and matrix foliation trends from within the porphyroblastic portion of the Charters Towers Metamorphics. Map location is shown on Fig. 1.
**Figure 5:** Interpreted migrated version of the deep seismic reflection line 07GA-GC01 between common depth points (CDPs) 14500 and 23000 (see Fig. 1 for location; modified after Withnall et al., 2009). The section shows a series of south dipping structures affecting the whole crust of the Charters Towers Province.
Figure 6: Concept and technique developed by Bell et al. (1995, 1998) for measuring Foliation Inflection/Intersection Axis (FIA) in porphyroblasts. (a) The observer sees an S (clockwise) or Z (anticlockwise) asymmetry when looking on either sides of the fold. (b) 3-D sketch of an inclusion trail running through a porphyroblast where the trend of the steep foliations preserved in the porphyroblast differ in orientation from core to rim to define two different FIAs: FIAs 1 and 2. The observer sees a clockwise steep to flat (referred to as H in text and tables 1 and 2) asymmetry in the core and an anticlockwise flat to steep (referred to as V in text and tables 1 and 2) asymmetry in the rim of the porphyroblast. (c) Example of inclusion trails in porphyroblasts from a single sample within five vertical differently oriented thin sections (every 30° relative to north). The FIA for both core and rim is located where the asymmetry switch occurs, between 30° and 60° for the rim and 60° and 90° for the core. This defines the FIAs in a 30° range. (d) Rose diagram for the core and rim FIAs, assuming that the FIAs are respectively located between the two more thin sections cut for each FIA trend to define them within a 10° range.
Table 1. GPS coordinates, FIA measurements and associated asymmetries and kinematic recorded for each FIA event from within the porphyroblastic samples obtained in the Thalanga region. The asymmetries are referred to as “a” for anti-clockwise and “c” for clockwise and the kinematics associated with the curvature of the foliations are referred to as “V” for a sub-vertical foliation forming event (i.e. horizontal shortening) and “H” for a sub-horizontal foliation forming event (i.e. vertical shortening or gravitational collapse).
Figure 7: Equal-area rose diagrams showing the FIA trends measured in andalusite and cordierite porphyroblasts from within rocks from the Puddler Creek Formation (Thalanga region). (a) FIA trends measured from both andalusite and cordierite porphyroblasts, five clusters of FIA trends are visible oriented at 35°, 60°, 85°, 105° and 135° all are present within cordierite porphyroblasts (b), only four which are present within andalusite porphyroblasts (c). (d) FIA succession obtained from multi-FIA samples (numbers prefixed by rq) within cordierite (C) and andalusite (A) porphyroblasts that display core (c) to rim (r) relationships and porphyroblasts growth relative timing. The succession obtained is FIA 1: 85°, FIA 2: 135°, FIA 3: 105°, FIA 4: 60° and FIA 5: 35°.
### Table 2.

GPS coordinates, FIA measurements and associated asymmetries and kinematic recorded for each FIA event from within the porphyroblastic samples obtained in the Charters Towers region. The asymmetries are referred to as “a” for anti-clockwise and “c” for clockwise and the kinematics associated with the curvature of the foliations are referred to as “V” for a sub-vertical foliation forming event (i.e. horizontal shortening) and “H” for a sub-horizontal foliation forming event (i.e. vertical shortening or gravitational collapse).
**Figure 8:** (a) Equal-area rose diagram showing the FIA trends measured in cordierite porphyroblasts within rocks from the Charters Towers Metamorphics. Four clusters of FIA trends are visible oriented at 45°, 65°, 105° and 145°. (b) FIA succession obtained from multi-FIA samples (numbers prefixed by rq) showing core (c) to rim (r) relationships within cordierite porphyroblasts (C). The succession obtained is FIA 1: 145°, FIA 2: 105°, FIA 3: 65° and FIA 4: 45°.
**Figure 9**: Photomicrograph and line diagram showing the timing relationship between cordierite and andalusite porphyroblasts. The andalusite overgrew the later high strain zone that wraps around the older cordierite. Vertical thin section. Single barbed arrow shows strike and way up. Plane polarized light.
Figure 10: Shear senses from porphyroblasts. (a) Example of the asymmetry method for a FIA trending at ~105°. The observer looks at a vertical thin section oriented at 30° (i.e. at high angle to the FIA trend) towards NW (i.e. direction parallel to the FIA trend) and records the asymmetries of inclusion trails that define this FIA. This particular case shows SSW side up and top to the NNE thrusting. (b) Cumulative frequency plot of asymmetry data for each FIA set in the Thalanga region. For FIAs 1 to 3 asymmetries were recorded looking towards W to NW, for FIAs 4 and 5 looking towards ENE and NNE. (c) Cumulative frequency plot of asymmetry data for each FIA set in the Charters Towers region. For FIAs 1 and 2 asymmetries were recorded looking towards NW and WNW, for FIAs 3 and 4 towards ENE and NE.
Figure 11: (a) Geological map of the Argentine metamorphics showing the proposed linkage between the previously mapped unconformities leading to the interpretation of a comprehensive regional structure: a window within a thrust sheet where the Precambrian metamorphics are in contact with Devonian sediments. The whole structure has been domed leading to the parallelism between foliations and bedding on either sides of the thrust. (b) Cross section showing the folded thrust sheet later normal faulted. The massive amphibolite bodies and associated mica schist / amphibolite sequence appear as intrusive parallel to the country rock foliation.