Deep seismic reflection data from the Curnamona Province, South Australia: crustal architecture and tectonic implications

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SUMMARY

In 2003 and 2004, PIRSA, pmd**CRC and Geoscience Australia, in conjunction with ANSIR, acquired ~200 line km of deep seismic reflection data along an east-west transect across the Curnamona Province in South Australia. At the eastern end of the seismic transect, the crust is divided into several horizontal “bands” of differing reflectivity. In the middle part of the seismic transect, there is a distinctive bland zone within the middle to lower crust. Its significance is unknown but in terms of its origin, it could result from reduced acoustic impedance contrasts due to partial melting, metasomatism, or be a zone of high fluid flow that has homogeneously altered a large part of the crust. It is interesting to note that similar bland zones have been noted on seismic sections in the Olympic Dam and Kalgoorlie regions. In the western part of the seismic section, the Moho is not as well defined, but appears to be undulating and slightly deeper than the eastern half.

In the eastern part of the seismic transect, there is an upper crustal thrust belt that sits on a “decollement” defined by strong reflectivity at 2-3 sec TWT. This can be tracked across the seismic section to the Neoproterozoic basin. This high level thrust belt propagated westwards with the amount of displacement dying out to the west and being converted into broad wavelength folds in the near surface. This is consistent with observed fold trends - if the north-south folds on the Benagerie Ridge are F3, then F3 trends can be regarded as arcuate in both Olary and Broken Hill Domains. Northwest-verging F3 folds in outcrops of the Willyama Supergroup would then be consistent with west-directed thrusting in the seismic transect.

At the western end of the seismic transect the crust is weakly to moderately reflective beneath a near surface triangle zone consisting of a west-directed thrust duplex. This has affected Neoproterozoic rocks and hence is inferred to be a result of Delamerian age deformation.

A possible crustal boundary has been recognised as a series of shallowly east-dipping surfaces in the deep seismic underneath the Neoproterozoic-Cambrian sediments up to 9 km thick overlies basement, and passes west into the even thicker, and more highly deformed, cover of the same age in the Flinders Ranges. This deformation is inferred to be Delamerian in age. Much of the crust beneath this succession is highly reflective, but it is not as obviously partitioned into subhorizontal layers as the eastern end of the line. A shallowly east-dipping surface is potentially the boundary between two different types of crust, one underlying Willyama Supergroup, and the other at depth beneath the Flinders Ranges.

Key words: Curnamona Province, deep reflection seismic, Neoproterozoic, Cambrian, Delamerian.

INTRODUCTION

The eastern part of the transect has a well defined Moho at ~13 s TWT (~40 km depth) with a strongly reflective crust above a non-reflective upper mantle. In the western half of the seismic section, the Moho is not as well defined, but appears to be undulating and slightly deeper than the eastern half.

In the eastern part of the seismic transect, there is an upper crustal thrust belt that sits on a “decollement” defined by strong reflectivity at 2-3 sec TWT. This can be tracked across the seismic section to the Neoproterozoic basin. This high level thrust belt propagated westwards with the amount of displacement dying out to the west and being converted into broad wavelength folds in the near surface. This is consistent with observed fold trends - if the north-south folds on the Benagerie Ridge are F3, then F3 trends can be regarded as arcuate in both Olary and Broken Hill Domains. Northwest-verging F3 folds in outcrops of the Willyama Supergroup would then be consistent with west-directed thrusting in the seismic transect.

At the western end of the seismic transect the crust is weakly to moderately reflective beneath a near surface triangle zone consisting of a west-directed thrust duplex. This has affected Neoproterozoic rocks and hence is inferred to be a result of Delamerian age deformation.

A possible crustal boundary has been recognised as a series of shallowly east-dipping surfaces in the deep seismic underneath the Neoproterozoic-Cambrian cover at the western end of the line. The structures separate lower crust of very different character. In the east, this boundary may also represent the western limit of Willyama Supergroup and its underlying crust. In the west, one possibility is that this boundary could mark the eastern limit of the ancient (late Archaean to Palaeoproterozoic) crust of the Gawler Craton extending east beyond the craton boundary at the Torrens Hinge Zone.

IMPLICATIONS FOR MINERALISATION

The Kalkaroo prospect, located about 4 km to the north of the seismic line, appears to sit on second order synthetic faults associated with hanging wall anticlines above a bounding
east-dipping fault at depth. The fault beneath the anticline could have been the conduit for fluids moving from the deep crust to upper crustal levels where they could have migrated into favourable depositional sites associated with second order structures.

We have interpreted major crustal scale structures that cut to the Moho on the deep seismic section. We are now asking whether these structures are important conduits for transporting fluids from the deep crust and/or mantle to the upper crust? If so, do favourable depositional sites exist in the hanging wall in the upper crust?

CONCLUSIONS

- The Moho is at ~40 km depth, but is slightly undulating in the west.
- The crust in the eastern part is partitioned into several subhorizontal layers. The Willyama Supergroup is possibly confined to being above a decollement at ~ 6 km, with thin-skinned deformation in the upper crust.
- There is a bland zone in central part of section (cf Gawler and Yilgarn cratons).
- The lower crust in the west has a very different reflectivity pattern to that in the east.
- A Neoproterozoic-Cambrian basin up to 9 km thick occurs in the western part of the seismic transect, and severe Delamerian deformation has affected the region at the western end of the transect.
- A possible suture zone between two different types of lower crust has been imaged, with the crust in the west being overthrust by sub-Curnamona crust in the east.
- This suture zone (low angle structures) could potentially be a conduit for fluids to migrate from the deep crust and upper mantle.