15. Aims, significance and expected outcomes

Central Australia preserves an intriguing record of late Proterozoic to Phanerozoic intraplate deformation associated with the formation of the Petermann and Alice Springs Orogens (Wells et al., 1970; Forman, 1971; Tessyier, 1985; Lindsay & Korsch, 1991; Shaw et al., 1991). These orogens involve Palaeoproterozoic and Mesoproterozoic metamorphic basement complexes and Neoproterozoic to early Phanerozoic sedimentary successions of the Amadeus Basin (Fig. 1). It is important to realise that the Amadeus Basin is a structural remnant of a formerly more extensive intracratonic basin (the 'Centralian Superbasin') that covered the bounding basement complexes to the north and south, with the preservation of the basin restricted to those regions which suffered little Phanerozoic deformation (Walter et al., 1995). The sequences within the Amadeus Basin thicken towards depocentres located at or beyond the present margins of the basins (Fig. 2). The fact that these orogens have apparently formed far from active plate margins has received considerable attention largely focused on the structural architecture (eg. Tessyier, 1985; Korsch & Lindsay, 1989; Goleby et al., 1989; Lambeck, 1991; Shaw et al., 1991) and on the controls on the long wavelength expression of the deformation (eg. Lambeck, 1983; Stephenson & Cloetingh, 1991). Until recently, there has been little attempt to understand the factors responsible for the variations in the distribution of and style of this intraplate deformation, and the relationship between Centralian Superbasin development and its subsequent reactivation.

Two recent studies have proposed that the location and style of intraplate deformation in central Australia has been influenced by the character of the overlying basin. Firstly, Braun & Shaw (1998) have argued that systematic variations in the style of structures along the length of the Alice Springs Orogeny may reflect variations in geotherm induced by variations in thickness of the overlying basin. In the second study, Sandiford & Hand (submitted - see Appendix 1 for abstract) postulated that the locus of intraplate deformation mirrors spatial and temporal variations in the thickness of basin sediments, reflecting a lithospheric rheology that is sensitive to small changes in lithospheric thermal structure resulting from basin development.

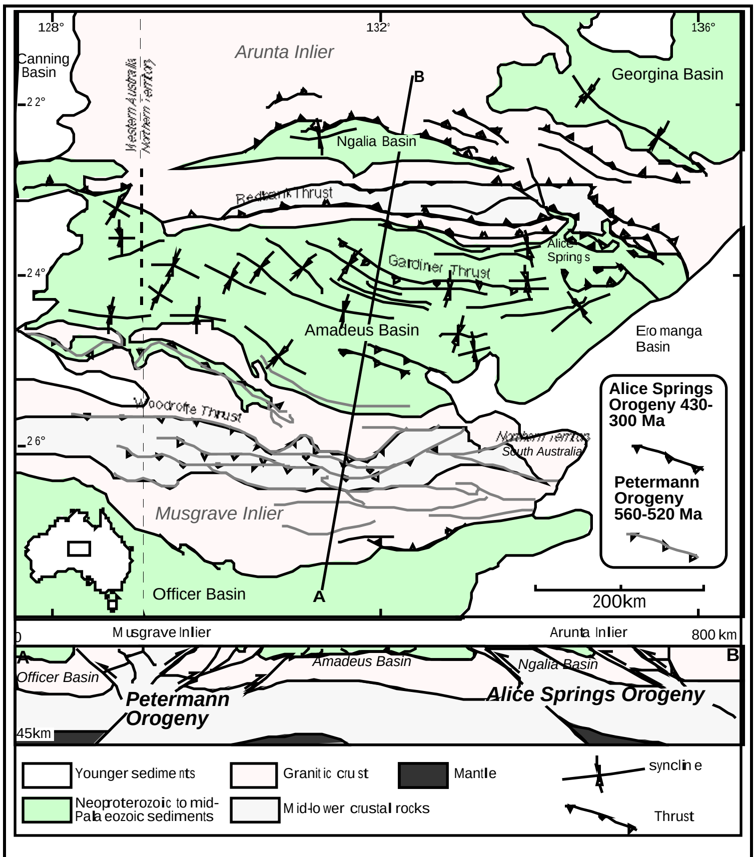

Fig 1. Geology of the central Australia, showing distribution of Alice Springs and Petermann Orogen structures, and relicts of the Centralian Superbasin' .

The hypothesis that the distribution and style of intraplate deformation in central Australia may be influenced by the thickness, distribution and composition of the overlying sediment is important because it provides a logical link between the thermal consequences of basin formation and subsequent basin inversion. Because the mechanical impact of basin development is sensitive to the thermal properties of both the basin-fill and the underlying basement (Fig. 3), as well as the basin-forming mechanism (Sandiford, submitted - see Appendix 1 for abstract), an understanding of these links potentially provides profound insights into the rehology of the lithosphere.

This project seeks to evaluate the thermal and mechanical consequences of the development of the ‘Centralian Superbasin’, focussing on its impact on the distribution and style of deformation during the Alice Springs Orogeny. The Alice Springs Orogeny was specifcally chosen for several reasons:

- It is a world class example of thick-skinned basin inversion whose fundamental mechanics are an outstanding geodynamic problem (e.g. Braun & Shaw, 1998);
- Sedimentary sequences in the northeastern Amadeus Basin, and parts of the southern Georgina Basin are well exposed, allowing characterisation of basin architectures and of thermal properties;
- Deformation was apparently localised along the general axis of a long wavelength, long lived depocenter in the Centralian Superbasin (Sandiford & Hand, submitted);
- The orogen contains basement lithologies from a wide range of crustal levels, thus providing information on the vertical and lateral variations in the thermal properties of the central Australian crust;
- A significant body of thermochronologic, thermobarometric and structural data exists defining regional variations in the link between denudation (basin inversion), thermal regimes and structural style (e.g. Shaw et al., 1992; Dunlap & Teyssier, 1995; Cartwright et al., submitted).

The project will evaluate stratigraphic and sedimentological constraints on the architecture of, as well as the physical mechanisms responsible for subsidence within, critical parts of the 'Centralian Superbasin’. In particular, emphasis will be placed on the southern Georgina Basin which bounds the Alice Springs Orogeny to the north, and which by comparsion to the northern Amadeus Basin is less well known. Thermal property data (thermal conductivity & heat production) for the basin forming sequences, and the underlying basement, will be collected in order to assess the thermal impact of basin formation, with the mechanical consequences of basin formation assessed using numerical computational techniques based on a thin viscous sheet finite element algorithm (eg. Houseman & England, 1986). Models for the thermal impact of basin formation will be assessed by comparing predicted thermal regimes with estimates of metamorphic conditons derived from thermobarometry and thermochronology of Alice Springs structures in the Arunta Inlier.

This project is aimed at testing fundamental hypotheses relating to controls on intraplate deformation, and in-as-much-as such controls provide important constraints on models of lithospheric strength, the outcomes of this project should be of fundamental significance to the international earth science community. Since the project directly addresses the relationship between basin development and the long-term mechanical strength of the lithosphere, it relates to the general phenomena of ‘basin inversion’. The inversion of sedimentary basins is of considerable interest, in part because of the important economic significance played by ‘inverted’ structures in petroleum generation and trapping, and the results of this project should therefore have wide-ranging application.

16. Research plan, methods, techniques and proposed timing

The Centralian Superbasin: As recognised by a number of previous workers (eg., Lambeck 1984; Shaw et al., 1991; Walter & Gorter, 1994) central Australian intraplate orogeny must be seen in the broader context of the development of the ‘Centralian Superbasin’, a widespread Neoproterozoic - Phanerozoic basin that covered most of the central parts of the continent. There is broad consensus that both the Petermann Ranges Orogeny and the Alice Springs Orogeny were initiated beneath this basin, with the exhumation of the basement from beneath the basins, resulting in the fragmentation of the ‘Centralian Superbasin’ into a series of structural remnants comprising the Officer, Amadeus, Ngalia and Georgina Basins (Fig. 1).

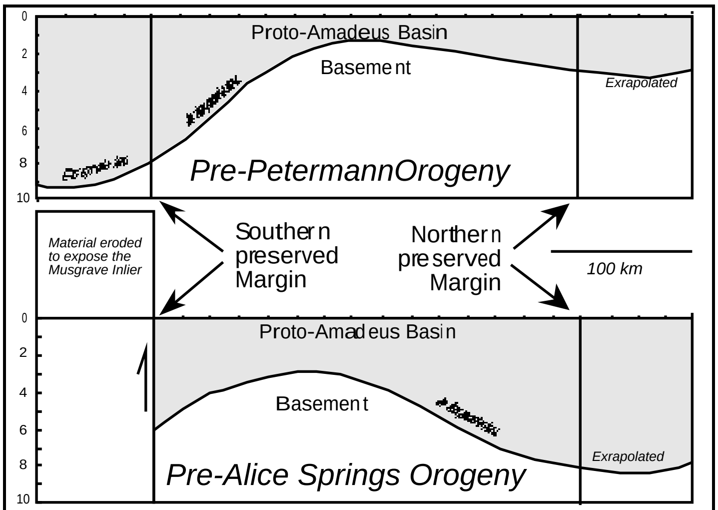

Fig. 2. Extrapolation of isopach data from the Amadeus Basin as used by Sandiford & Hand (submitted) to demonstrate thermal and mechanical effects of Centralian Superbasin formation on subsequent distribution of intraplate deformation. Note the implied dramatic shift in depocentre from the south (left) to the north (right) following the Petermann Ranges Orogeny. Although sediment close to the south margin is thick, the exposure of basemnt in the Musgrave Inlier has an overall strengthening effect on the southern margin.

The distribution of sediment in the 'Centralian Superbasin' prior to the Petermann Ranges and Alice Springs Orogenies remains poorly constrained, partly because the sediment mass has been removed from the regions of the most intense deformation. Existing data based mainly on compilations from AGSO (BMR) datasets implies long-lived and persistent depocentres near the northern and southern margins of the Amadeus Basin. Isopach maps based on a simple linear interpolation scheme show that the basin deepened towards the regions where deformation was subsequently localised (Fig 2), with the locus of deformation mimicking the locus of maximum sedimentary thicknesses at the onset of each orogenic event. Importantly, the available data **suggests** that the 'Centralian Superbasin' thickened over regions where the sediment has been subsequently removed as a consequence of deformation (Sandiford & Hand, submitted). **Clearly there is need to confirm this suggestion.** In the northern Amadeus Basin the distribution of isopacs and facies variations is relatively well understood (e.g. Wells et al., 1970; Lindsay, 1987; Lindsay & Korsch, 1991), however the data for the Georgina Basin is comparatively poorly known and provides a major limitation to understanding the interplay between basin development and intraplate deformation in this region.

Some thermal and meachnical consequences: As originally noted by Cull & Conley (1983), the unusually high heat-flows associated with the Australian Proterozoic implies that the development of intracratonic basins can potentially lead to significant heating of the underlying crust and mantle. Cull & Conley (1983) suggested temperature increases at upper mantle depths of ~ 40°C per kilometre of sediment accumulation, while Sandiford & Hand (submitted) have suggested that temperature increases of ~5-15°C/km are likely to be more appropriate to the 'Centralian Superbasin', depending on the nature of the basin forming mechanism (Fig 3). Such temperature changes can dramatically reduce lithospheric strength (Fig. 3) and Sandiford & Hand (submitted) have shown that the spatial variations in the sediment distribution on a ~ 100km lengthscale in the Centralian Superbasin could, in principle, provide corresponding variations in strain rate of up to 4 orders of magnitude, and therefore account for localised deformation in response to an in-plane stress field, firstly in the region of the Petermann Ranges during the Petermann Ranges Orogeny and then in the region of the Arunta Complex during the Alice Springs Orogeny. As illustrated by Braun & Shaw (1998), the extent of the mechanical weakening caused by basin development, will be a sensitive indicator of the the rheological structure of the lithosphere (see also Sandiford, submitted), with the form of the structures that result, likely to reflect the thermal properties (heat production and thermal conductivity) of the basin and the underlying basement. The

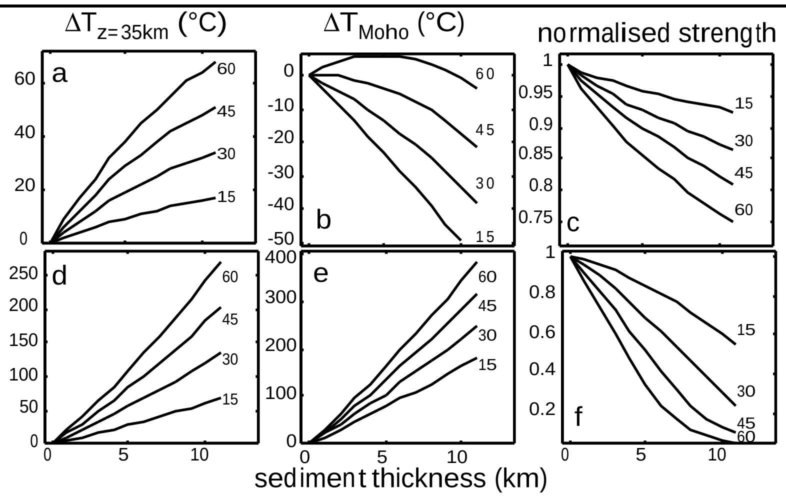

Figure 3. Long-term thermal and mechanical response to rift basin development expressed as (a) temperature changes at 35 km depth, (b) temperature changes experienced by the Moho, and (c) mechanical strength of the lithosphere normalised against the strength of the pre-rift lithosphere (after Sandiford, submitted). Contours show different crustal heat production rates (expressed in terms of the contribution to surface heat flow in mWm^{-2}). The predicted Moho temperature decline reflects general long-term shallowing due to relatively low densities of basin-fill. Note that these estimates are sensitive to the assumed thermal properties of the basin fill, and to the basin forming mechanism. For example, figures (d)-(f) show a much greater mechanical impact for a basin in which there is no signifncant deformation of the presexisting crust (such as 'eustatic', 'dymanic' and 'flexural' basins).

following points are noted concerning the potential interaction between basin development and intraplate deformation in the context of the Alice Springs Orogen:

- **The distribution of heat sources in the Arunta Inlier shows sytematic spatial variations which should impact on the style an distibution of deformation**. Figure 4 shows distrubution of heat production in the Arnta Inlier and it's relationship to the locus of maximum deundation during the Alice Springs Orogeny. Two important aspects are apparent. (1) Along the northern edge of the Ngalia Basin, and southern edge of the Georgina Basin, mean heat production in the basement is ~7 μWm^{-3}. This contrasts with significantly lower total heat production along the northern edge of the Amadeus Basin (4 μWm^{-3}). (2) Total heat production in the most deeply exhumed regions is lower than in the less exhumed areas. These two observations imply that during the ASO, crustal heat production was vertically stratified and that important regional variations existed in the relatively shallow basement. These lateral and vertical variations in heat production are likely to lead to signigicant regional variations in the thermal and mechanical consequences of basin formation.
- **The thermal and mechanical impact of basin formation will be sensitive to the basin forming mechanism.** For example, formation of 'stretch basins' results in changes in the distribution of basement heat sources, and depths to rheologically-defined compositional boundaries, in very different ways from basins developed in the absence of deformation of preexisting crust (such as 'eustatic', 'dymanic' and 'flexural' basins). Consequently, the various basin forming mechanisms should be expected to impact rather differently on the long term mechanical strength of the lithosphere (Fig 3). The 'Centralian Superbasin' is probably a composite basin with subsidence attributed to a variety of mechanisms including rift-related and, and flexural depression, operating in different places at different times (e.g. Lindsay & Korsch, 1991; Shaw et al., 1991). However, the details of basin forming mechanisms remain poorly understood, and one of

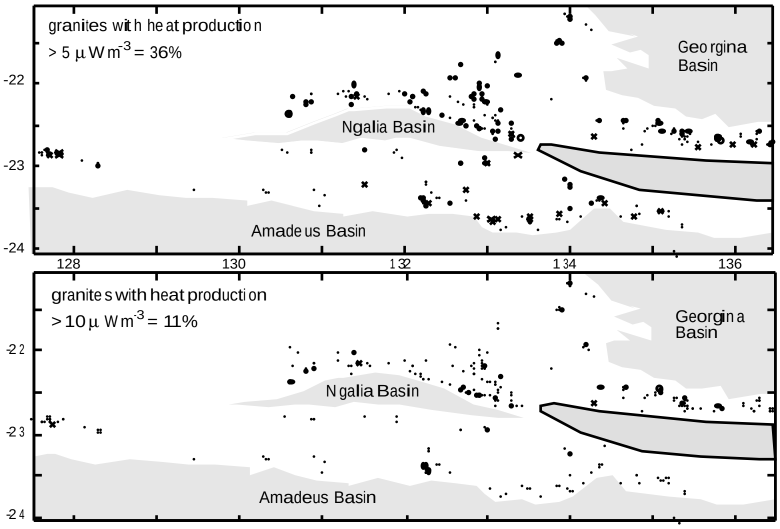

Fig. 4. The distribution of high heat production granites in the Arunta Complex, based on U-Th-K analyses from the AGSO geochemical database. Circles shows granites with heat production > 5 μWm^{-3} (upper diagram), and > 10 μWm^{-3} (lower diagram). Spots show granites with lower heat production. Rock types other than granites with high heat production are indicated by crosses. Cross hatched region shows the locus of ≥ 20km denudation during the Alice Springs Orogeny.

the aims of this proposal is to augment the existing models by incorporating new observations from the southern Georgina Basin into basin forming models.

Any discussion of the formation of the central Australian orogens must inevitably encounter the problem of the extraordinary geophysical gravity expression of these orogens. It is now well understood that this expression reflects the structural architecture developed during the Alice Springs (and Petermann Ranges) Orogeny (Goleby et al.,1989). It is less clear what sustains the anomalies, and associated structures over the past several 100 Ma (eg. Lambeck, 1983, 1991), which are clearly out of isostatic equilibrium. The implication of a relatively strong lithosphere, sufficient to sustain large gravity anomalies over long geological timescales, seems at odds with the localised nature of intraplate deformation in the earlier Palaeozoic. The notion that deformation can be localised by the thermal impact of the development of a thick basin above a relatively radiogenic basement sequence, implies that the strength of the lithosphere is very sensitive to the thermal regime. A further consequence of this notion, to be addressed in this project, is that significant lithospheric cooling and associated strengthening will be expected to accompany the removal of the basin sediments (and upper radioactive parts of the basement) during denudation (e.g. Sandiford & Hand, submitted), potentially allowing significant orogenic-scale geophysical anomalies to be ‘frozen-in’ during the terminal stages of the Alice Springs Orogeny.

The research plan: The hypotheses outlined above potentially allow profound insights into the nature of intraplate deformation and the rheological behaviour of the lithosphere in intracratonic settings. However, these hypotheses remain largely conjectural because of an inadequate knowledge of (1) the distribution of sediments within the ‘Centralian Superbasin’, (2) the basin forming mechanisms, and (3) the thermal properties of the basin and its basement. This proposal seeks to test these hypotheses by analysing

- the sedimentary thickness and associated facies distribution in the basins surrounding the Alice Springs Orogeny, with the specific aims of reconstructing the generalised distribution in areas where the sediment mass has been subsequently removed, and evaluating basin forming mechanisms,
- analysis of the thermal properties (thermal conductivity and heat production) of both the basin-fill and the underlying basement,

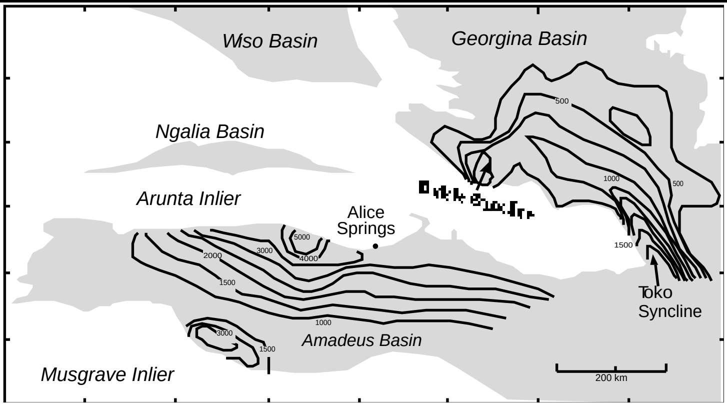

Figure 5. Generalised isopacs for the Pertaoorrta and Larapinta Groups and equivalents in the Amadeus and Georgina Basins, showing location of the Toko and Dukcie Syncline depocentres.

- implementation of numerical computations that allow incorporation of the planform variations in basin thickness and thermal properties, using a thin-viscous sheet finite element algorithm (eg. Houseman & England, 1986).

Active basin margins should be expected to be expressed in the preserved record of sedimentary facies and isopachs. As noted earlier, the general absence of indicators for such activity at the preserved margins of the various central Australian basins has lead to the notion that these basins are structural relicts of the much larger 'Centralian Superasin'. This project will focus on using facies distributions and ispoach geometries near the present-day basin margins to make inferences about the former distribution of sediment above the Arunta Inlier. Particular focus will be directed towards the Pertaoorrta and Larapinta Groups, and their equivalents in the Georgina Basin, because they show very significant long-wavelength variations in sediment thickness leading up to the development of the Alice Springs Orogeny (Fig 5). The southern Georgina basin contains important, hitherto pooorly understood, examples of 'basin inversion' during the Alice Springs Orogeny in the region in the region of the Toko and Dulcie synclines (Fig. 5, Shergold, 19__, Haines et al., 1991), **and one of the major aspects of the project is to thoroughly document the record of basin development and subseqent inversion along the sotuthern Georgina Basin,** particularly in the region of the Toko Syncline.

The central Australian region offers several unique opportunities to quantify the way in which the thermal response to basin development is modulated by the thermal properties of the basin and its underlying basement. The thermal conductivity of basin-filling sediments varies substantially with lithology (as well as diagenesis and temperature) raising the possibility that regional variations in stratigraphy could lead to significant variations in the thermal response to basin development. In order to assess the thermal impact of basin development it is therefore necessary to develop an appropriate thermal conductivity structure for the sediment pile. Because the Alice Springs Orogen has provided an oblique exposure through the basement with up to 10 km of vertical structural relief in the west (Shaw et al., 1992) and 20 km in the east (Arnold et al., 1995), it is possible in principal to construct detailed models for the depth distribution of heat production during basin formation (at least for the mid-upper crust). The construction of such heat production distribution maps, and the evaluation of spatial variations in heat production parameters, will be greatly helped by the availability of several recent radiometric surveys and AGSO's comprehensive geochemical database containing ~1100 analyses from the Arunta Complex).

*Field work:*The work program will involve both compilation of existing stratigraphic datasets as well as new field-based studies. The initial stage of the project will involve a review and compilation of existing stratigraphic data. Field work will be undertaken in the mid-parts of each of the first two years of the project (May-July), and will focus on (1) documentation of basin architetcure and subsequent inversion structures along the southern Georgina Basin and (2) establishing constraints on isopach geometries between the southern Georgina Basina nd the eastern Amadeus Basin, and (3) establishing constraints on basin forming mechanisms. Samples collected during the field work campaigns will be analysed for thermal conductivity using a divided bar apparatus at Adelaide University. Existing airborne radiometric data derived from by company (PNC) and government (AGSO and NTGS) sources will be used in conjunction with the AGSO geochemical database to estimate regional variations in the heat production character of the basement (note that some of these datasets have already been made available to the CI by the respective organisations).

Computational Methods: Computational techniques to examine the thermal and emchanical impact of basin development and subsequent inversion will be developed by the CI in conjunction with Dr Jean Braun at RSES who will work in the capacity of an associate investigator in this project. Mechanical computations will utilise the thin-viscous sheet finite element algorithms which have proved very successful in describing distributed deformation in continental interiors in other continents (eg. Houseman & England, 1986). The thin-viscous sheet model treats vertical averages of lithospheric rheology, and therefore needs explicit incorporation of thermally modulated strength variations. The thermal impact of basin development will be parameterised in terms of a depth-average strength-perturbation, with the factors that contribute to the strength variations including the thickness and thermal properties of the basin-filling sequence, the heat production contributed by the underlying basement, and the depth to strength-controlling compositional boundaries (such as the Moho) within the lithosphere. More sophisticated, coupled-thermal mechanical models, of the type employed by Braun & Shaw (1998), will be further developed to explore the role of the evolving thermal structure during ongoing denudation in order to assess the factors leading to the long-term preservation of orogenic scale gravity anomalies that characterise the central Australian region. This will require adaptation of existing numerical models to handle boundary conditions in terms of loading functions, rather than velocities as used by Braun & Shaw (1998) and many others.

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17. Relevance of applicant skills

The applicant has a strong research record in field of continental geodynamics, with his work emphasising the complex interactions between thermal and mechanical response of the lithosphere. A collaboration between the CI and Dr. Randy Richardson and David Coblentz (then at University of Arizona) in the early to mid 90's, provided much of the impetus for his current interest in intraplate deformation, with the current proposal motivated by recent studies into the causes and consequences of anomalous heat production in the Australian Proterozoic crust (Sandiford & Hand, 1998; Sandiford et al, submitted).

18. Role of Chief Investigator & other participants

This project involves a number of distinct 'streams', including (1) detailed stratigraphic analysis of sequences in the 'Centralian Superbasin' ', (2) compilation of thermal properties database relevant to the central Australain superbasin and its basement, and (3) thermal-mechanical modelling of lihospheric-scale deformation. The CI will be responsible for overseeing the project and implementing thermal and mechanical modelling undertaken during the project, he will also be responsible for development of heat production model distributions based on existing AGSO geochemical datasets and airborne radiometric survey work supplied by NTGS. The thin viscous sheet model will be developed in conjunction with Dr Jean Braun at RSES who will act in the capacity as a associate investigator. Stratigraphic analysi, feidl work and collection of samples for thermal conductivity analysis will be undertaken by the appointed SRA (see section 20).

19. Explanatory statement of track record

See relevant comments in section 17.

20. Justification of budget

Personnel: This project seeks funding for an experienced field geologist with expertyise in stratigraphy, sedimentology and structral geology. The appointee repsonsible for (1) documenting basin architecture and inversion structures in the southern Georgina Basin, (2) stratigraphic and sedimentological analysis of 'Centralian Superbasin' focussing on reconstructing isopach geometries in the region of the Alice Springs Orogeny, and (3) for elucidating the stratigraphic signals of basin subsidence mechanisms. The nominated candidate for this position is Dr Peter Haines, who has a wealth of experience in both central Australia, having worked for the Nothern Territory Geological Survey (NTGS) on both Amadeus Basin and Georgina Basin stratigraphy (see brief c.v. below). Importantly, his work with the NTGS has provided a major contribution to our understanding of basin development in the southern Geoirgina Basin (Haines et al., 1991). Dr Haines is currently involved in a ARC collaborative research grant due to finish in 1998. Because of his experience, and current appointment level, funding is requested at SRA level equivalent to ARF level B4. Part-time research assistance (2 day/week) during the mid-two years of the project is requested to prepare samples for, and run, thermal conductivity measurements, to digitise isopach data, and help in the prepration of geological maps under the direction of the SRA.

Equipment: Funds for a personnel computer for the SRA are requested.

Maintenance: Maintenance is requested to cover incidental costs associated with field work (aerial photographs, maps, sample bags etc) estimated to be ~$100 p.a. and for preparation of samples for thermal conductivity analysis. Airborne radiometric data will be processed using the industry standard software package Intrepid for which the current academic license fee is $2000 pa. Drafting support (charged at departmental rate of $20/hour) will be required in the later parts of the project to enable publication quality preparation of geological maps, stratigraphic columns. Thin sections fro standard sedimentary petrological work are quoted at the departmental rate of $20/section.

Travel. Travel and support funds are requested so that the RE can undertake field work (4WD support at 40c/km and camping allowance of $35/day), accompanied in part by both the CI and AI. The development of the numerical methods in this program will involve close collaboration with Dr Jean Braun at ANU RSES, and funds are requested to enable the CI to visit ANU to facilitate in this collaboration. A request is made to enable the RA to the Geological Society of America conference during the third year of this project. While not essential for the progress of the research, this will provide an important opportunity to present the results of this study in an international forum and, more importantly, provide an important career development experience for the RA, for which no other sources of funds are likely to be available.

Short C.V.: Dr. Peter Haines

Date of birth: 22 May 1960

Education:

- 1982 Honours, Geology, University of Adelaide, Sedimentology and trace fossils of the Pacoota Sandstone, Amadeus Basin, central Australia.
- 1983-1987 Degree of Doctor of Philosophy in Geology, University of Adelaide, Late Precambrian carbonate shelf and basin sedimentation Wonoka Formation, South Australia.

Employment:

1989 - 1995 : Geologist, Northern Territory Geological Survey
1992 - 1993 : Part time lecturer in geology, NT University, Darwin NT
1995 - present: Research Associate, The University of South Australia.

Relevant Publications(full list includes19 refereed papers)

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Appendix 1: Abstracts from relevant publications in submission

Controls on the locus of Phanerozoic intraplate deformation in Central Australia

Mike Sandiford & Martin Hand, submitted to Earth and Planetary Science Letters, December,1997.

Abstract: The locus of Phanerozoic intraplate deformation in central Australia changed from the presently preserved southern margin of the Amadeus basin during the early Phanerozoic Petermann Orogeny to the northern margin in the late Phanerozoic Alice Springs Orogeny. Immediately prior to each event the thickness of the Amadeus basin sediments varied from as little as 2 km in the central parts of the basin to as much as 8 km in the vicinity of the presently preserved margins of the basin with the locus of deformation mimicking the locus of maximum sedimentary thicknesses at the onset of each orogenic event. We show that differential burial of the 'Central Australian' Proterozoic basement complexes beneath the Amadeus basin is capable of producing variations in Moho temperature of up to 80°C prior to the Petermann Orogeny and up to 150°C prior to the Alice Springs Orogeny. For a 'Brace-Goetze' model of lithospheric rheology, the variations in Moho temperature equate to variations in effective lithospheric strain rate of 3 - 7 orders of magnitude, implying that variations in thickness of the sedimentary blanket may have played a primary role in localising Phanerozoic intraplate deformation in Central Australia.

Mechanics of basin inversion

Mike Sandiford, submitted to Tectonophysics, February, 1998.

Abstract: In addition to the effects resulting from the thermal properties of the basin-fill, the long-term consequences of rifting on the thermal state of the deep crust and upper mantle reflects (1) cooling induced by the reduction in heat production in the attenuated lithosphere, and (2) heating due to the burial of this heat production beneath the basin. Provided that the heat production is largely concentrated in the upper half of the crust, these factors result in significant increases in temperature at deep crustal and upper mantle levels. Because the Moho depth is likely to be reduced in the long-term limit of an isostatically balanced basin, these same factors may lead to slight cooling or slight heating of the Moho, depending on the nature of the basin-fill. For a ‘Brace-Goetze’ model for lithospheric rheology (ie, a rheology governed by a combination of frictional sliding and power-law creep), significant long-term lithospheric weakening (up to 5% per kilometre of basin-fill) accompanies basin formation when the lower crust is relatively strong and the basin fill is characterised by appreciable heat production and low thermal conductivity. In contrast, weak lower-crustal rheologies may result in long-term lithospheric strengthening. The abundant evidence for basin-inversion in the geological record may therefore imply that heat production is strongly concentrated in the upper half of the crust and, under normal continental thermal regimes, the lower crust is strong.

21. Chief Investigator Publication list, last five years

**papers relevant to this application are marked with asterisks*

Sandiford, M., Mechanics of basin inversion, submitted to Tectonophysics

*Sandiford, M., and Hand., M., Controls on the locus of Phanerozoic intraplate deformation in central Australia, submitted to Earth and Planetary Science Letters.

Paul,E., Flottmann, T., Sandiford, M., Structural geometry of the northern Flinders Ranges in the Adelaide Fold Belt, South Australia, submitted to Australian Journal of Earth Sciences.

*Sandiford, M., Paul,E., & Flottmann, T., Sedimentary thickness variations and deformation intensity during 'basin inversion' in the Flinders Ranges, South Australia, submitted to Journal of Structural Geology.

Sandiford, M., Hand., M. and McLaren, S., High geothermal gradient metamorphism during thermal subsidence, submitted to Earth and Planetary Science Letters.

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