National Argon Map: an AuScope initiative

Data Acquisition Project Proposal

This form should be completed and returned to Geoff Fraser (Geoff.Fraser@ga.gov.au) for consideration by the National Argon Map Oversight Panel

Project Proponent

Name: Kasia Sobczak
Affiliation and position: The UQ Centre for Natural Gas (UQ-CNG), Research Officer
Collaborators: Dr Andrew La Croix (University of Waikato, NZ) Prof Joan Esterle (UQ) A/Prof Phil Hayes (UQ) Dr Heinz-Gerd Holl (UQ) Carbon Transport and Storage Company (CTSCo) Funding body: Australian National Low Emissions Coal Research & Development (ANLEC R&D)
Project Title: Detrital origin and depositional history of the Precipice Sandstone: implications for CO_2 reservoir continuity
Geographic Region: Eastern Australia (Queensland)
Geological Province or Tectonic Unit: North-eastern Surat Basin

How will these samples benefit the National Argon Map?
Provide a succinct answer to this question, see the suggestions in the Guidelines and Criteria on the next page.

Samples: All proposed samples come from Australia and are non-confidential.

Impact. The new $^{40}Ar/^{39}Ar$ data will make a valuable contribution to geographic data coverage of the NAM, as the Surat Basin is under-represented in the Ar-Ar database. Additionally, the majority of the datasets within the NAM are igneous cooling or metamorphic ages, with very few detrital datasets. Therefore, detrital Ar-Ar ages from sedimentary rocks will provide unique information on sedimentary provenance, maximum depositional ages, crystallisation and cooling history of the sediment sources, and insights into the post-depositional history of the dated sedimentary units. Particularly the provenance of the Surat Basin sedimentary succession remains poorly understood, and Ar-Ar dating of detrital mica will be a valuable technique to complement planned U-Pb zircon dating in constraining sediment sourcing.

Feasibility and sample material. The presence of mica within the medium- to coarse-grained sandstones of the Precipice Sandstone and Evergreen Formation has been noted in several studies (e.g., Exon, 1976; Ciesiolka, 2019). Therefore, muscovite grains suitable for Ar-Ar dating are expected to be found within the sandstones targeted for sampling. The time frame of the project has been discussed with Dr Marnie Forster and is considered realistic within the NAM initiative. We expect to access and sample the drill core in January-February 2021.

Brief Project Description:
Approximately 500 word maximum. Include what geological process/problem will be addressed, and how new $^{40}Ar/^{39}Ar$ data from the specific samples to be dated will contribute. Please include reference

to pre-existing geochronological constraints, if any exist. Please include a simple location map which showing the spatial distribution of samples in their geological context (with scale).

The project focuses on the Lower Jurassic Precipice Sandstone in the southern Surat Basin as a target reservoir for CO_2 storage. Understanding of the geological evolution of the formation is still developing, and the purpose of this project is to gain in-depth knowledge of reservoir and seal rock characteristics and variability to assess whether CO_2 sequestration will be effective and safe.

To date, most studies of the Precipice Sandstone have focussed on the northern part of the basin due to availability of data. However, the southern Surat Basin has recently been identified as a priority area for CO_2 storage exploration and development. It remains uncertain if geological and petrophysical knowledge gained from studies of the northern region are equally applicable to the south. As concluded by previous ANLEC and UQ-CNG studies (Bianchi et al., 2018; La Croix et al., 2019; 2020; Wang et al., 2019) based on palaeothickness maps, the Precipice Sandstone may represent a composite sedimentary system fed by multiple source terranes depositing sediment into two depocentres – one in the north and one in the south. If this hypothesis is correct, the data from the northern sub-basin may be of limited application to modelling reservoir properties in the southern sub-basin.

Existing published data on the provenance of the Precipice Sandstone are minimal. This project will address the information gap through integrating geochronology with sedimentological and petrophysical analyses of the sandstone facies comprising the Precipice Sandstone in 4 to 5 cored wells located in the southern and northern parts of the formation extent (Fig. 1). One of the target wells is West Moonie 1, newly completed by CTSCo. Sampling will be extended to the basal part of the overlying Evergreen Formation seal, as the Evergreen Formation contains regionally persistent marker horizons used for correlation, as well as interpretation of provenance and depositional environments.

U-Pb zircon dating by both LA-ICP-MS and CA-TIMS techniques will be the main method used to constrain depositional ages, accumulation rates, sediment source types and specific source regions. Ar-Ar dating of detrital mica will be performed on the same sandstone samples as a complementary technique to the high-temperature U-Pb detrital zircon dating. This multi-dating approach has the potential to provide further resolution on sediment sourcing and constrain the cooling and exhumation history of the source terranes that may not be recorded by zircon dating alone (e.g., Carrapa, 2010; Haines et al., 2004). Furthermore, micas are considerably less resistant to mechanical weathering and thermal resetting than zircon and less likely to survive more than one sedimentary cycle, thus providing information on a more immediate sediment source terrane than is the case for zircon (Sobczak, 2019). Data from the hypothesised northern and southern depocentres in the basin will be compared to identify any north-south variations and trends and determine implications for the reservoir properties. The new geochronology data will build on previous isotopic dating by Ciesiolka (2019).

References:

Bianchi, V., Zhou, F., Pistellato, D., Martin, M., Boccardo, S., & Esterle, J. (2018). Mapping a coastal transition in braided systems: an example from the Precipice Sandstone, Surat Basin. Australian Journal of Earth Sciences, 65(4), 483-502.
Carrapa, B. (2010). Resolving tectonic problems by dating detrital minerals. Geology, 38(2), 191-192.
Ciesiolka, R. (2019). Detrital zircon provenance of the Precipice Sandstone, Surat Basin, Queensland. Unpublished Honours Thesis, The University of Queensland.

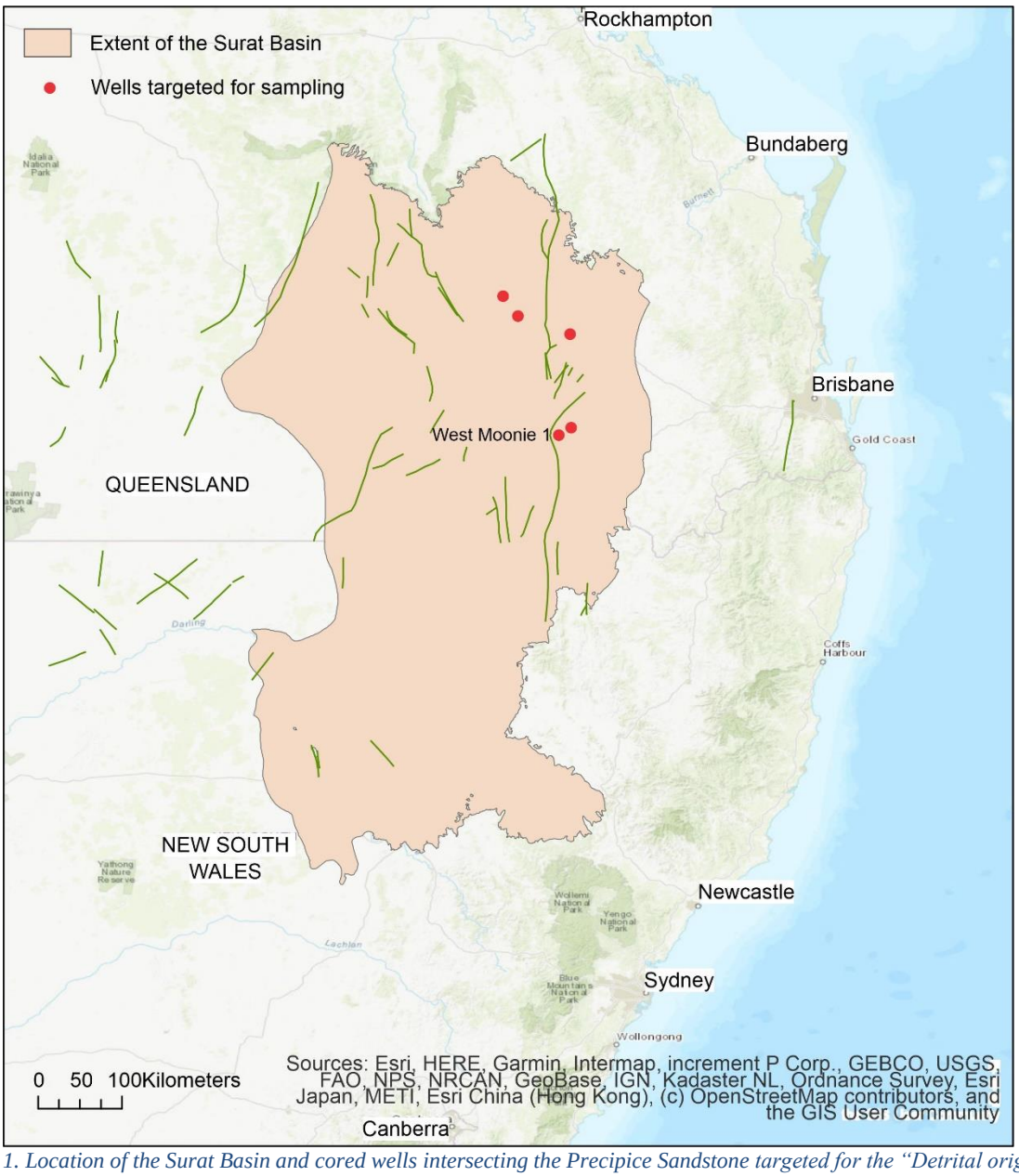

Figure 1. Location of the Surat Basin and cored wells intersecting the Precipice Sandstone targeted for the "Detrital origin and depositional history of the Precipice Sandstone: implications for CO2 reservoir continuity" project.

Exon, N. F. (1976). Geology of the Surat Basin in Queensland. Bureau of Mineral Resources, Geology, and Geophysics Bulletin 166.

Haines, P. W., Turner, S. P., Kelley, S. P., Wartho, J., & Sherlock, S. C. (2004). 40Ar–39Ar dating of detrital muscovite in provenance investigations: a case study from the Adelaide Rift Complex, South Australia. Earth and Planetary Science Letters, 227(3-4), 297-311.

La Croix, A. D., Harfoush, A., Rodger, I., Gonzalez, S., Undershultz, J. R., Hayes, P., & Garnett, A. (2019). Reservoir modelling notional CO2 injection into the Precipice Sandstone and Evergreen Formation in the Surat Basin, Australia. Petroleum Geoscience, 26(1), 127-140.

La Croix, A. D., He, J., Bianchi, V., Wang, J., Gonzalez, S., & Undershultz, J. R. (2020). Early Jurassic palaeoenvironments in the Surat Basin, Australia–marine incursion into eastern Gondwana. Sedimentology, 67(1), 457-485.

Sobczak, K. (2019). Investigating far-field tectonic events as drivers of provenance change in sedimentary basins. Unpublished PhD thesis, Queensland University of Technology.

Wang, J., La Croix, A. D., Gonzalez, S., He, J. & Underschultz, J. R. 2019. Sequence stratigraphic analysis of the Lower Jurassic Precipice and Evergreen Formations in the Surat Basin, Australia:

Implications for the architecture of reservoirs and seals for CO2 storage. Marine and Petroleum Geology, 102, 829–843.

Approximate number of samples proposed for $^{40}Ar/^{39}Ar$ analyses: 20-25 samples

Lithologies and minerals proposed for $^{40}Ar/^{39}Ar$ analyses: Sandstones - muscovite (main target mineral) and biotite (if present)

Do you have a preferred ^{40}Ar-^{39}Ar laboratory? (ANU, Curtin, UQ, UMelb):
If so, why you prefer this laboratory (e.g. student affiliation, ongoing relationship, sample type etc):

As the project is based at UQ Centre for Natural Gas, UQ is the preferred facility for reasons of location, as well as past and ongoing collaboration with the low-temperature geochemistry and $^{40}Ar/^{39}Ar$ geochronology laboratories at UQ. However, we are open to collaboration with other laboratories involved in the NAM, as best suited for the project.

Guidelines and Criteria

Project Proposals for funding support as part of the AuScope National Argon Map initiative will be assessed on the following criteria.
Australian: Samples must come from Australia (this may include Australian offshore regions)
Non-confidential: $^{40}Ar/^{39}Ar$ data must be made publicly-available (ie non-confidential)
Impact: to what extent new $^{40}Ar/^{39}Ar$ data from the proposed samples will contribute to geographic data coverage, or address key geological questions
Feasibility: whether the nature of the work is tractable via $^{40}Ar/^{39}Ar$ geochronology and the scale of the proposal is realistic within the time frame of the National Argon Map initiative (January 2020 – June 2021)?
Appropriate sample material: whether the proposed samples are (i) appropriate for $^{40}Ar/^{39}Ar$ analyses, and (ii) available within the time-frames of the National Argon Map initiative?

Oversight Panel
Dr Geoff Fraser, Geoscience Australia
Professor Zheng-Xiang Li,
Dr Anthony Reid, Geological Survey of South Australia
Peter Rea, MIM/Glencore
Dr Catherine Spaggiari, Geological Survey of Western Australia
Dr David Giles, MinEx CRC
Dr Marnie Forster (observer role as Project Coordinator)

Expectations
AuScope funding will cover the costs of sample irradiation and isotopic analyses.

Project Proponents will be responsible for:

- Provision of appropriate sample material. This includes mineral separation, which can be arranged at the relevant $^{40}Ar/^{39}Ar$ laboratories (in many cases this is preferred), but costs of mineral separation will be borne by the project proponent. The relevant laboratory reserves the right not to analyse material if it is deemed unsuitable for $^{40}Ar/^{39}Ar$ analysis.

- Provision of appropriate sample information. A sample submission template will be provided. Information in these sample submission sheets will form the basis of data delivery/publication, and the oversight committee or relevant laboratory reserves the right not to proceed with analyses unless and until appropriate sample details are provided. This includes description and geological context for each sample.
- Leading the preparation of reports and/or publications to deliver $^{40}Ar/^{39}Ar$ results into the public domain within the duration of the National Argon Map initiative (January 2020 – June 2021).
- Project Proponents will be expected to communicate directly with the relevant $^{40}Ar/^{39}Ar$ laboratory once a project has been accepted by the Oversight Committee, in order to clarify project expectations, arrange sample delivery, discuss results, collaborate on reporting and data delivery etc.

Participating Ar Laboratories will be responsible for:

- Providing advice to project proponents regarding suitable sample material and feasibility of proposed work
- Irradiation of sample material
- $^{40}Ar/^{39}Ar$ isotopic analyses
- Delivery of data tables, and analytical metadata to project proponents

Queries regarding possible projects as part of the National Argon Map initiative can be directed to Marnie Forster (Marnie.Forster@anu.edu.au) or Geoff Fraser (Geoff.Fraser@ga.gov.au)