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Uranium series dating of Great Artesian Basin travertine deposits: Implications for palaeohydrogeology and palaeoclimate

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ABSTRACT

Travertine deposits precipitated by groundwater discharging from the Great Artesian Basin (GAB) are widespread in central Australia and have the potential to provide a record of palaeohydrogeology and palaeoclimate. The GAB is one of the largest artesian basins in the world and a relationship between travertine deposits and recharge sites has potential importance regarding the time and position of past climate events, given that the travertines growth forms from precipitation discharge. We sampled numerous travertine sites in the southwest section of the GAB as a first approach to test this relationship. U-series dating of the travertine deposits reveal that spring discharge has likely been episodic for the last several hundred thousand years. Spring travertine deposition occurred episodically around 465 ± 50 ka, 370 ± 20 ka, 335 ± 15 ka, 285–240 ka, 185 ± 10 ka, 160–150 ka, 110–100 ka and during the past 30 ka. The periodicity of travertine ages observed with simultaneous deposition at multiple locations, argues for regional palaeohydrologic controls. Comparison of the travertine deposit ages with climate proxies in Australia shows that elevated travertine deposition rates are synchronous with wet periods in both central and southern Australia. Due to the large size of the GAB and that the recharge zones extend over multiple climatic regions of Australia, the times of travertine deposition are interpreted to represent times of high rainfall regionally. This study shows that the travertine deposits of central Australia provide a datable archive of past climate and hydrogeology of importance for understanding the groundwater evolution of the Great Artesian Basin, and that further more comprehensive studies are warranted.

1. Introduction

Comprehensive knowledge on the timing of past higher rainfall periods is essential for the validation of palaeoclimate and groundwater models, which require temporal and spatial resolution of climate data (Fitzsimmons et al., 2013; Reeves et al., 2013). There is still a need for detailed palaeoclimate records in arid and semi-arid central Australia (Fitzsimmons et al., 2013; Hesse et al., 2004; Turney et al., 2006). Travertine deposits that resulted from groundwater discharge from the Great Artesian Basin (GAB) are widespread in central Australia (Habermehl, 1980; Habermehl, 1982) and have the unique potential to provide information on past long-term effective rainfall periods for vast areas of the landscape in central Australia during the Quaternary.

Travertine deposits (also referred to as tufa) have been successfully used to investigate palaeohydrogeology and palaeoclimate (Andrews, 2006; Clark and Fontes, 1990; Crossey and Karlstrom, 2012; Drysdale et al., 2002; Faccenna et al., 2008; Frank et al., 2000; Kele et al., 2009; Martín-Algarra et al., 2003; Minissale et al., 2002; Pentecost, 1995; Priewisch et al., 2014; Sierralta et al., 2010; Szabo et al., 1994; Zentmyer et al., 2008). Travertine is a groundwater discharge deposit composed predominantly of calcium carbonate. Travertine is compositionally similar to most dripstone and flowstone speleothems, however travertine derived paleoclimate records require interpretations that differ from those derived from speleothems. Speleothem climate records are most commonly constructed from stable isotope variations (i.e., $\delta^{18}O$), which are assumed to reflect the climate at the time of deposition because of relatively fast downward infiltration of water from the surface to the cave (Ayliffe et al., 1998; Gascoyne, 1992;

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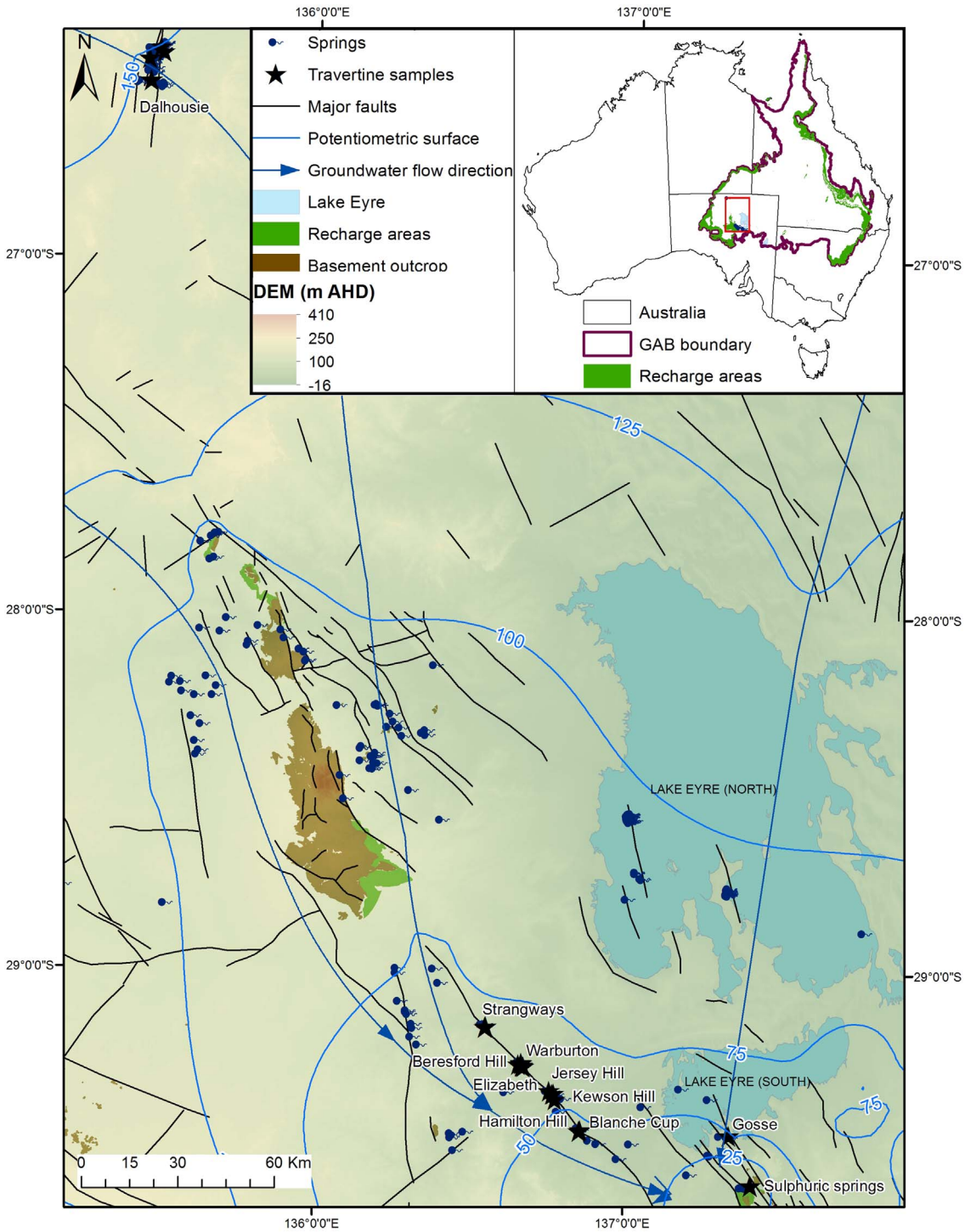

Fig. 1. Map showing spring locations with sample locations labelled. Springs are aligned to the normal faults that bound Neoproterozoic Adelaidean Geosyncline. Faults presented are compiled from a number of sources (Aldam and Kuang, 1988; Callen et al., 1995; Drexel et al., 1993; Krieg et al., 1991; Williams, 1973). Potentiometric surface and regional groundwater flow lines from Love et al. (2013) in m Australia Height Datum (AHD) recharge areas from Smerdon and Ransley (2012).

Goede et al., 1996; Quigley et al., 2010a). In contrast, the stable isotope variations recorded in spring travertine deposits are interpreted to be a result of the climate at the time of groundwater recharge (Andrews, 2006). They are also further complicated by long groundwater flow paths leading to a lag time between recharge and the time the climate signal is recorded by the travertine. In addition, mixing of groundwater from different recharge areas and flow paths within the aquifer and evaporation after groundwater discharge may alter the stable isotope climate signal in the travertine deposit. Often in studies that use travertine as proxies for understanding palaeoclimatic events, increased discharge and, hence recharge from rainfall periods are identified by an increase in the volume of carbonate being deposited (Crossey and Karlstrom, 2012; Drysdale et al., 2002; Frank et al., 2000; Hennig et al., 1983; Martín-Algarra et al., 2003; Priewisch et al., 2014; Szabo, 1990; Szabo et al., 1994; Zentmyer et al., 2008). Larger travertine growth is often interpreted to be representative of increased spring discharge from increased groundwater flow rates and hence increased recharge. Higher aquifer hydraulic heads driven by enhanced recharge during