WATER QUALITY IN THE CAVES OF THE NULLARBOR PLAIN

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As part of the great international expedition to the Nullarbor in 1980, water samples were collected from all the "deep" caves, nine of which have lakes, although not all lakes were sampled (Table 1). Samples were also collected from Nurina Cave (N–46) on the Roe Plains. Previous sampling within the Eucla Basin had been restricted to bores (Lockhart Jack, 1930; Ward, 1946), to "one-off" samples in caves (King 1959), to more intensive efforts in one or more caves (Jennings 1961, Anderson 1964, Hill and Rouse 1966) and to the efforts of Lowry (1970) in both bores and caves. None of the studies cited above allowed any inferences to be drawn about the cave lakes themselves or their relationships to the regional aquifer they expose, although some suggestions are raised by Lowry's paper.

Samples were taken at the surface and at depth using sampling apparatus developed on the Nullarbor utilising the resources of a number of rubbish tips. Temperatures and pH were taken for most samples at the time of sampling. Samples were stored in "Whirlpaks" at ambient temperatures until analysis in Canberra. The following analyses were carried out in the laboratory:

pH	'Radiometer' meter as part of HCO_3^- determination
Electrolytic conductivity	'Philips' conductivity bridge
Total dissolved solids	Evaporation and weighing
Cl^-	'EEL' chloride meter
$HCO_3^- + CO_3^{2-}$	H_2SO_4 titration to pH 4.2 endpoint
SO_4^{2-}	'Hach' kit colorimetric determination
Na^+	Atomic absorption spectrometer
K^+	Atomic absorption spectrometer
Ca^{2+}	Atomic absorption spectrometer
Mg^{2+}	Atomic absorption spectrometer

There was some replication of samples and analyses including some replication for Ca^{2+} and Mg^{2+} by EDTA titration.

The results followed closely the results of the authors cited above where comparison is possible. Disappointingly the cations Ca^{2+}, Mg^{2+} and especially Na^+, but not K^+, were overestimated and Cl^- was underestimated for reasons currently (1983) being investigated. The ionic balances are thus very poor and ionic ratios cannot usefully be calculated. For this reason only a very general discussion of the results can be attempted until further samples and analyses are available. Full results are not presented here but are available from A.P. Spate on request.

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Stratified sampling with depth was carried out to more fully investigate the many reports of fresh water "creams" floating on the more saline water beneath. In spite of the good rains over much of the Nullarbor prior to our visit, evidence for increase in total dissolved solids or individual ions with depth was only evident in Moonera Tank Cave (N–53, ephemeral lake) and in Koonalda Cave (N–4, both lakes). This latter cave had not been subject to the rains and was in fact in light drought. Some decrease in HCO_3^- with depth was noted in White and South Lakes in Mullamullang Cave (N–37), in Winbirra Cave (N–45) and in both the lakes sampled in Koonalda Cave. This ion increased with depth in other caves, quite markedly in the case of Murra–el–elevyn (N–47) and Moonera Tank Cave. Lewis (pers. comm.) reports that divers commonly encounter very abrupt density changes in the lakes within Nullarbor caves.

In spite of the problems with ionic balances referred to above it would appear that there are differences between groups of deep caves. The Murra–el–elevyn, Pannikin Plain (N–49), Tommy Grahams (N–56) and Cocklebiddy (N–48) group are high in dissolved solids as is Koonalda compared to Weebubbie (N–2), Winbirra and Warbla (N–1) which are higher than Mullamullang. This lends support to the view that the deep caves are conduits draining the Bunda Plateau and the Eucla Basin as a whole. Different catchment sizes and makeup of incoming waters around the margins might explain the differences in the water chemistries of the cave system.

Interestingly, the water temperature data, and to a lesser extent pH, provides contrary evidence to the concentration data with, for example, wide variations noticeable between

Table 1. Location of samples.

Cave	No. of Samples	Sampled to depth (m)	Surface pH	Surface Temp°C	Comments
Murra–el–elevyn	3	2.0	7.48	17.0	smallish lake
Pannikin Plain	3	2.0	7.70	21.0	smallish lake
Tommy Grahams	3	2.0	7.63	22.0	small lake
Cocklebiddy	3	1.5	7.60	16.5	very large lake
Moonera Tank	2	1.0	7.65	18.0	ephemeral lake
Mullamullang					
White Lake	4	4.2	7.20	18.0	small lake
South Lake	3	2.0	7.30	16.0	very small lake
Weebubbie	7	10.0	7.48	19.5	large lake
Winbirra	2	1.2	7.48	24.0	small lake
Warbla	1	0.05	7.08	nd	small lake
Koonalda					
3rd Lake N. Passage	3	2.0	7.28	16.9	large lake
2nd Lake W. Passage	3	2.0	7.63	14.6	moderate lake
Nurina	1	0.05	7.78	17.5	very small lake, not a "deep" cave

caves (Cocklebiddy. Pannikin Plain, Tommy Grahams and Murra–el–elevyn; see Table 1) and within caves (Mullamullang and Koonalda; two lakes in each cave, see Anderson, 1964). The fascinating, and unfortunately unpublished, velocity determinations of Rauleigh Webb seem to add a third dimension to this paradox.

One might expect that the groundwaters beneath such a uniform lithology and topography might themselves be relatively uniform. The differences reported here in chemistry and temperature plus the density changes and thermoclines reported by Lewis make further investigation of the Nullarbor Tertiary limestone aquifer of more than academic interest. Lowry (1970) reports that in his Region 3 of the Eucla Basin bore water data indicates higher total dissolved solids between caves than in them or nearby; is this "contamination" from surface runoff diluting total dissolved solids in cave waters or is the more slowly moving groundwater within the rock mass more concentrated? Clearly there are many more questions to be answered in this most enigmatic of karsts.

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