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1981/54. Stable isotope investigation of groundwater at Seven Mile Beach

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Abstract

Measurement of light stable isotope ratios, δD and δO^{18}, in water from six spear bores located in exploratory auger holes in the Quaternary sediments at Seven Mile Beach confirm the extensive contribution of piped town water, used for irrigation of the Royal Hobart Golf Course, to the groundwater in the unconfined aquifer during the period of test. This water is mixed with more saline groundwater of ?slightly lighter isotopic composition derived from the confined aquifer. The water in the confined section of the aquifer, where recharge is from slow vertical leakage from temporary lagoons established on the surface clay to the north-west of the golf course, shows clear evidence of surface evaporation. The results from bores in the unconfined aquifer do not show the expected relatively heavy isotopic signature of summer rains, probably because the unusually dry summer of late 1980 made contribution from local meteoric water essentially nil.

INTRODUCTION

In 1980, Cromer (1981) conducted an extensive groundwater investigation of the Royal Hobart Golf Club and surrounding area with a view to improving the irrigation of Golf Club fairways.

Six samples of water produced during pump tests were submitted for stable isotope (δO^{18} and δD) analysis to determine whether the technique would be of value in groundwater investigations.

Two samples (WCC 28, 29) are of a saline sodium chloride groundwater (Type 1), confined in sand beneath a surface clay in the Quaternary lagoonal sediments west of the golf course. Two samples (WCC 6, 9) are typical of water derived from unconfined Quaternary marine and aeolian sediments on the golf course. This Type 3 water is thought by Cromer (1981) to be the result of mixing of Type 1 saline waters with the Type 2 waters of relatively low salinity, typical of that found in unconfined sandy coastal marine Quaternary sediments. Sample WCC 26 is a highly saline ($\sim$ 11 100 mg/*l* NaCl) groundwater from the confined aquifer adjacent to the western margin of the Quaternary sediments with the older Tertiary clay, basalt, and Permian sandstone of the Cambridge district. Sample WCC 14 is from a drill site near the northern margin of the golf course and close to the boundary between the unconfined marine sediments and the lagoonal sediments with their upper confining clay. (For locations and a description of the Holocene sediments see Cromer, 1981).

TECHNIQUES

Stable isotope techniques in groundwater investigations, particularly in mining hydrology, aquifer characterisation, and geothermal areas have been an established tool for the last 15 years in the Northern Hemisphere and New Zealand (*e.g.* International Symposium on Isotope Hydrology, UNESCO, 1978). Only one comprehensive study (Airey *et al.*, 1979 - on the Great Artesian Basin) has been made in Australia, but with the facilities now available in Hobart there has been an increasing demand for this relatively inexpensive technique as a means of 'fingerprinting' water samples. It should be mentioned that the Institute of Nuclear Science, D.S.I.R., New Zealand, has been prominent in this area for some twelve years and many

Australian geologists, including the author, have been assisted by Dr Athol Rafter (former Director, I.N.S.) and his staff during their training in the field. Tangible assistance in providing standards and assessment of data is greatly appreciated.

The techniques used for extraction of hydrogen and CO_2 for mass spectrometry are conventional, *viz.* reduction of water with U turnings at ∿ 800°C for H/D measurements (Friedman *et al.*, 1964) and equilibration of waters with CO_2 at 25°C for δO^{18} determination (Craig, 1957). A review of the range of applications of stable isotopes in geology is given by Faure (1977). The extraction systems were calibrated using International Atomic Energy Agency water standard V-SMOW and National Bureau of Standards water standards NBS1 and NBS1A, together with samples originally measured in New Zealand. A machine working standard with $\delta O^{18}_{SMOW} = -6.0^o/_{oo}$ and $\delta D_{SMOW} = -36^o/_{oo}$ was prepared from Hobart tap water. Mass spectrometry was carried out on a Micromass 602D mass spectrometer located in the Geology/ Geography building at the University of Tasmania. The assistance of R. Woolley is gratefully acknowledged.

RESULTS

The results obtained are listed below:

Table 1. STABLE ISOTOPE ANALYSIS OF GROUNDWATER, SEVEN MILE BEACH

Sample	$\delta O^{18}_{SMOW}\ ^o/_{oo}$	$\delta D_{SMOW}\ ^o/_{oo}$
WCC 6	- 6.1 ± 0.1	- 36.5 ± 1.0
WCC 9	- 6.2 "	- 37.3 "
WCC 14	- 5.9 "	- 35.0 "
WCC 26	- 6.5 "	- 43.7 "
WCC 28	- 2.7 "	- 32.9 "
WCC 29	- 3.8 "	- 38.2 "

The δO^{18} and δD values are plotted in Figure 1, which includes the meteoric water line for coastal areas in Tasmania. This was determined by analysis of samples from the Cape Grim Baseline Air Pollution Station where automatic rainfall collection facilities were made available by courtesy of the Department of Science and Technology. Monthly samples collected in 1979 were analysed by Dr G.M. Zuppi of the IAEA in Vienna and for January-October 1981 in the Hobart laboratory. The Tasmania Precipitation Line ($\delta D = 7.6\delta O^{18} + 9$) does not differ greatly from the linear relationship demonstrated worldwide by Dansgaard (1964); *i.e.* $\delta D = 8\delta O^{18} + 10$. The decrease in δO^{18} and δD values with decrease in average surface air temperatures reflects the fact that the isotope fractionation factor between the two isotopes involved increases with decreasing temperature.

Samples WCC 6, 9, and 14 lie on the meteoric water line and are, within error limits, indistinguishable from average Hobart tap water ($\delta O^{18}_{SMOW} = -6.0^o/_{oo}$, $\delta D_{SMOW} = -36^o/_{oo}$). These results confirm the calculation by Cromer (1981, p. 3-15) that groundwater presently constitutes only about one-third of the total irrigation water. Fresh mains water pumped into Soak 1 during the day, and used for nightly irrigation cycles, contributes greatly to the water in the unconfined aquifer in dry periods.

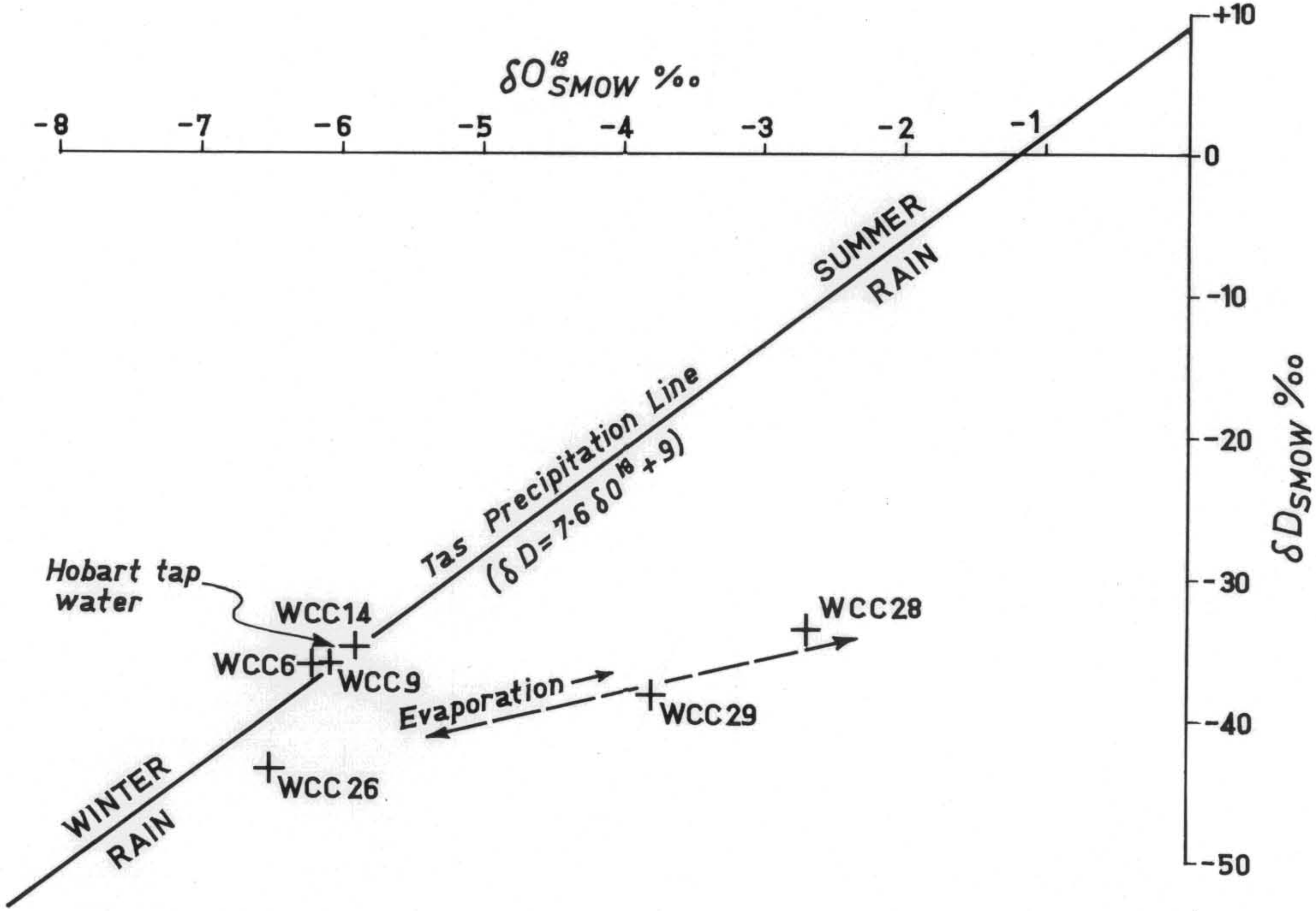

Figure 1. *Stable isotope data, groundwater samples, Seven Mile Beach.*

5 cm

Samples WCC 28 and 29 are of better quality water, contributing to the groundwater by vertical leakage from temporary lagoons after heavy rain, but showing the effects of evaporation in that they lie along a line of slope ~ 3 rather than the slope of ~ 8 predicted from equilibrium condensation from vapour. The highly saline sample WCC 26 is somewhat lighter in both δO^{18} and δD and reflects the different origin (possibly older) of this Type 1 groundwater in the confined aquifer. It is not possible to determine the age of the groundwaters without tritium or C^{14} measurements. These techniques are not currently available in Tasmania.

If the proposal to decrease the dependence of the Golf Club on mains water is accepted, then the relative amounts of groundwater derived from recharge of the aquifer can be assessed by periodic δD and δO^{18} measurements. Measurements of conductivity alone ($\equiv$ NaCl content) may be insufficient to differentiate between Type 1 and 3 waters. It would be desirable to extend this study to include Type 2 waters that should show the typical seasonal variation in δD and δO^{18} of groundwaters in unconfined aquifers. Type 2 waters in the unconfined portion of the aquifer would normally be expected to be recharged by isotopically 'heavy' summer rainfall. That this does not appear to have happened in the holes tested may be due to the very low rainfall of November-December 1980.

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