Integrated geophysical methods used for groundwater studies in the Polda and Murray Basins

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Introduction

Vertical electrical sounding (VES) and potential field methods, magnetic and gravity, have long proved useful in solving groundwater problems. Seismic methods have also been used, but are generally too expensive for practical surveys. In recent years, the TEM method has filled a gap in the geophysical armoury, extending the effective range of electrical methods to the 50–400 m depth range. We present examples of the joint use of VES and TEM methods in the Murray and Polda Basins.

The Murray Basin

GEOLOGY

Basement (Adelaide Geosyncline) outcrops in the Mount Lofty Ranges, but is overlain by up to 250 m of sediments in the survey area. Within these sediments are the major sources of groundwater within the Murray Basin—the upper, Murray Group, aquifer system and the lower Renmark Beds. The latter is a confined aquifer system and is less continuous than the Murray Group because of interruptions from basement highs. Groundwater in both aquifers is highly saline (6000–10 000 mg/l).

SURVEY OBJECTIVE

An important aspect of water quality in the Murray River relates to the movement of saline groundwater into the river system. A preliminary study indicated that saline groundwater in the Swan Reach–Mannum area was inhibited in its flow towards the Murray River. While basement highs were known to exist in this area, the details of such highs, and their effect on the saline aquifers, was less clear.

Geophysical work was planned to detail basement contours and to determine the continuity of saline groundwater over the area.

SURVEY METHOD

Electrical resistivity methods were chosen for this work because such methods can not only map basement depth, but also directly detect groundwater, particularly when saline. Moreover, they are sensitive to variations in salinity—an important aspect in this case.

Two complimentary techniques were used, vertical electrical sounding (VES) and transient electromagnetic (TEM). Both methods utilize variations in ground resistivity to detect geological (or hydrogeological) changes. As will be shown, they are complimentary; firstly, because VES gives greater detail in the shallow range and TEM is more effective for deeper zones; and secondly, because VES is more sensitive to resistive horizons whereas TEM responds mainly to conductive layers.

DISCUSSION OF RESULTS

Initial test work was done in the Sedan–Swan Reach area (Figs 1, 2) because this area was thought to have a shallow base-

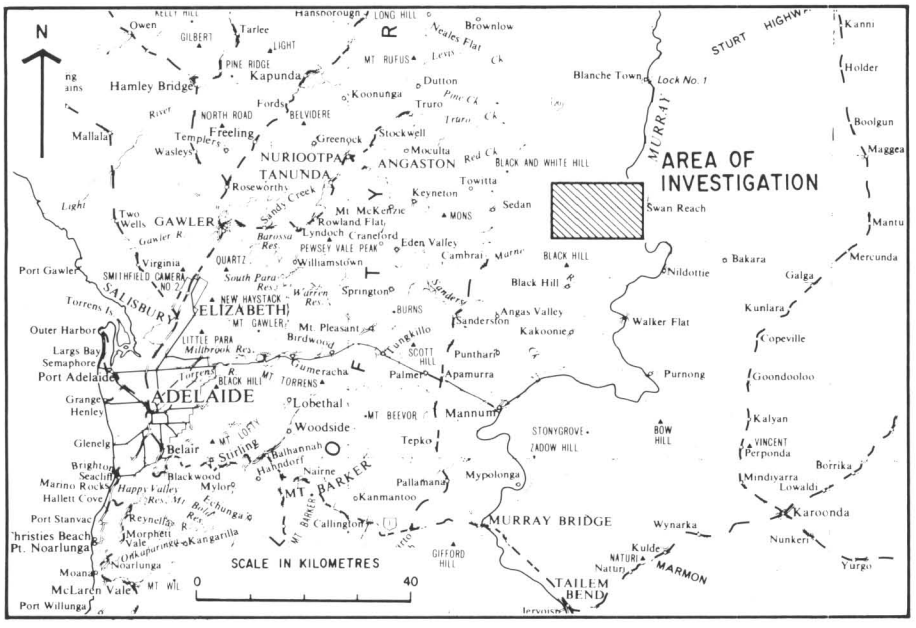


Fig 1 Location map.

ment ridge extending north from Black Hill, where basement outcrops. Two electrically logged bores, 13 km apart, provide controls for interpretation purposes.

The test program comprised traversing the entire 13 km between the bores with TEM, to determine the location and general characteristics of resistivity variations. VES locations were then selected so that detailed interpretations could be done over each characteristic resistivity profile.

The test results are shown in Fig. 3. The SIROTEM time-distance plot shows low resistivity zones at either end which are clearly indicative of saline groundwater. The high resistivity zone betrays shallow basement.

The interpreted section in Fig. 3 is derived from the inversion of TEM and, where indicated, VES data. Examples of these inversions are given in Fig. 4. Separate inversions of two data sets were used rather than joint inversion. The latter is unreliable unless both data sets are seeing the same depth range.

Subsequently, extensive areas were tested using this technique of TEM reconnaissance and VES detailing. Since continuous profiles are not necessary in this environment, it was found that groups of three contiguous readings, separated by 600 m, gave adequate coverage, while allowing over 10 km of traverse to be covered each day. Spot soundings could also be done in a similar way. The method proved both effective and efficient.

Polda Basin

This area is more difficult in that the thickness of sediments within the basin is 1 km or more. Use of 400 m loop TEM

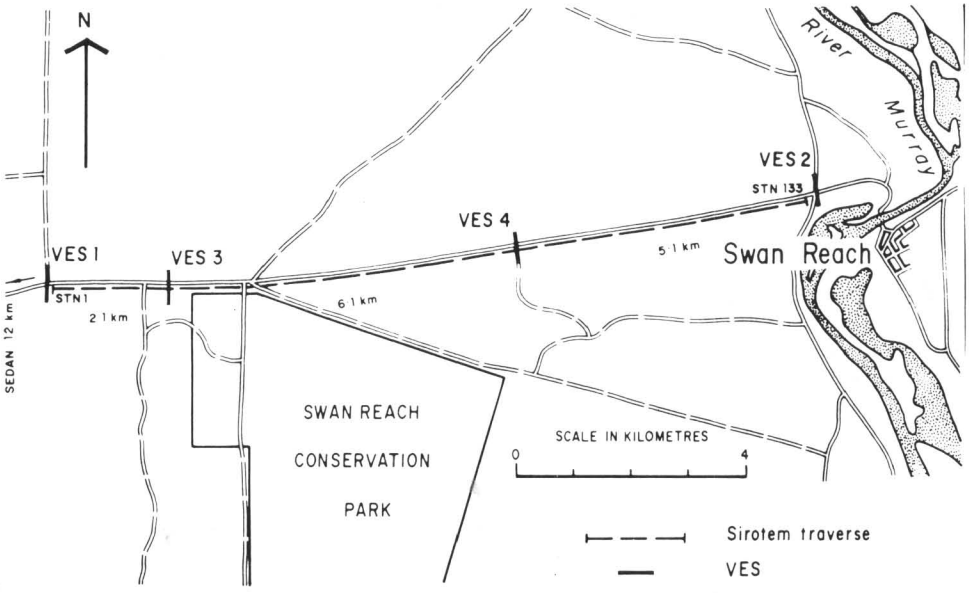


Fig 2 Location of SIROTEM traverse and VES points.

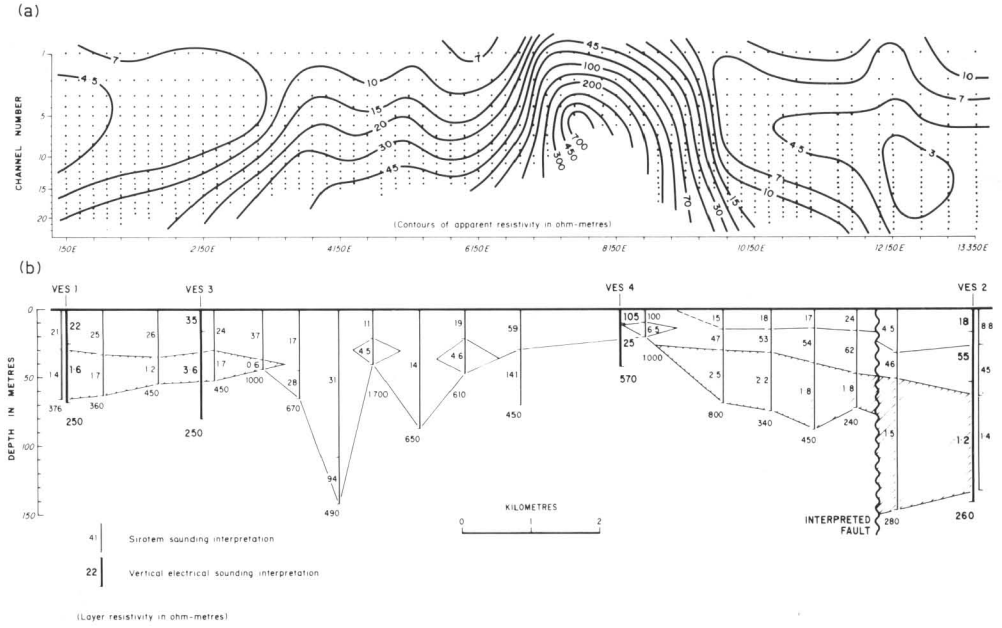
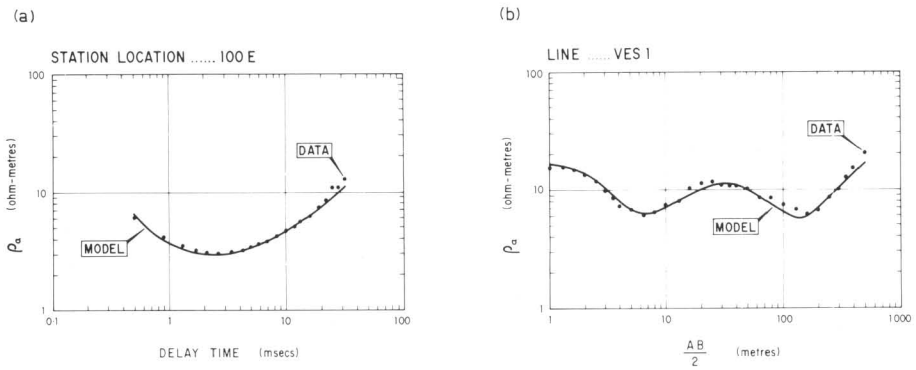


Fig 3 (a) SIROTEM time-distance plot, with (b) interpreted section.



LAYER	THICKNESS (metres)	RESISTIVITY (ohm-metres)
1	1·5 *	17 *
2	3·0 *	3·1 *
3	24 **	21
4	36 **	1·4 **
5		380

* Fixed parameter
** Influential parameter

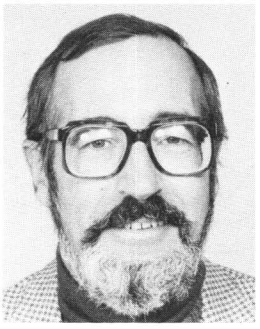
LAYER	THICKNESS (metres)	RESISTIVITY (ohm-metres)
1	1·5	17
2	3·0	3·1
3	20·0	22·0
4	43·0	1·6
5		250·0

Fig 4 (a) SIROTEM and (b) VES inversions at station 100E.

traverses was satisfactory for delineating the edges of the basin, but did not have adequate penetration in the deeper parts of the basin. Because of high conductivities, the need is not for larger loops, but for later delay times (500 ms or more) than are available on the SIROTEM instrument. AMT proved more successful.

Summary

An effective and efficient method of using TEM and VES methods for groundwater problems was developed. Mapping of basement depths and the quantitative delineation of saline aquifers were achieved.



Sandy Dodds graduated from Queen's University, Canada, in 1963 with a BSc in geological sciences. After 8 years with the contracting company Huntec Ltd in Canada and Australia, he returned to academia, receiving an MSc from Macquarie University in 1975. Since then he worked for CSIRO, the University of NSW and Geoex Pty Ltd, where he became involved with SIROTEM. Most of his work and study has been involved with electrical methods. He is now a senior geophysicist with the South Australia Dept. of Mines and Energy.

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