First results on the direct detection of groundwater by seismoelectric effect—A field experiment

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The successful application of conventional geophysical methods in exploring for groundwater and in solving hydrogeological problems has resulted in the refinement of the geophysical techniques used, as well as in the adoption of hitherto unused but known geophysical techniques for groundwater exploration. All these methods use the variation in a physical parameter as the guide for groundwater prospecting. Groundwater exploration by geophysical methods is still being commonly carried out by employing either electrical or seismic techniques. The advent of computer aided analysis of electrical field data facilitates the interpretation of subsurface geoelectrical parameters to desired accuracies. Under favourable conditions using seismic methods it is now possible to record water table associated signals. Induced polarization, VLF and other EM techniques are being used increasingly in exploring for groundwater.

The desirability of locating groundwater directly is obvious but such an approach so far has eluded success. As all the geophysical techniques that are being practised so far have failed in this direction it would be worthwhile to adopt new but known physical phenomena/parameters, and develop geophysical techniques based on them. The seismoelectric effect of earth materials appears to hold good promise in this respect.

The seismoelectric effect may be defined as the development of a potential difference between two adjacent points in a liquid-bearing solid when an elastic wave passes through it (Parkhomenko 1968; Kondrashev 1970). It is dependent on electrokinetic processes in wet rocks. It consists of flow potentials resulting from the development of an electrical double layer at the solid-liquid interface. Since the seismoelectric effect is dependent on the water saturation properties of rocks, it is believed that a groundwater prospecting method can be developed based on the seismoelectric measurements.

A field experiment to record seismoelectric signals was conducted by the author near the village of Delden in the Netherlands. Elastic waves were generated by a hammer source with the resultant electric signal being picked up by two brass electrodes and recorded on an EG & G Geometrics ES-1210 signal enhancement seismograph. That is, in place of a geophone two electrodes were used as signal detectors. The profile layout adopted is shown in Fig. 1. Six of the 12 channels on the instrument were used for recording seismoelectric signals, and the remaining six channels were used for seismic data collection. Experiments were conducted by placing electrodes parallel and perpendicular to the profile. Electrode separation was 2 m.

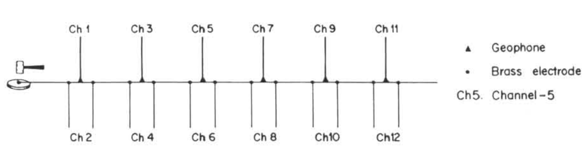

Fig 1 Profile layout.

The seismoelectric signal recorded on a seismogram of 50 ms length is shown in Fig. 2. The signal appears at 3 ms and is present for a total duration of 7.5 ms. The character of the signal recorded on seismogram of 200 ms length is shown in Fig. 3. Besides the above mentioned signal, a second distinct seismoelectric signal appears at 60 ms and is present for a duration of 20 ms. A seismogram obtained for a record length of 1 s (Fig. 4) shows the signals discussed above as well as the noise character in the area.

It would be interesting to correlate the seismoelectric signals with the results of other geophysical surveys obtained at this

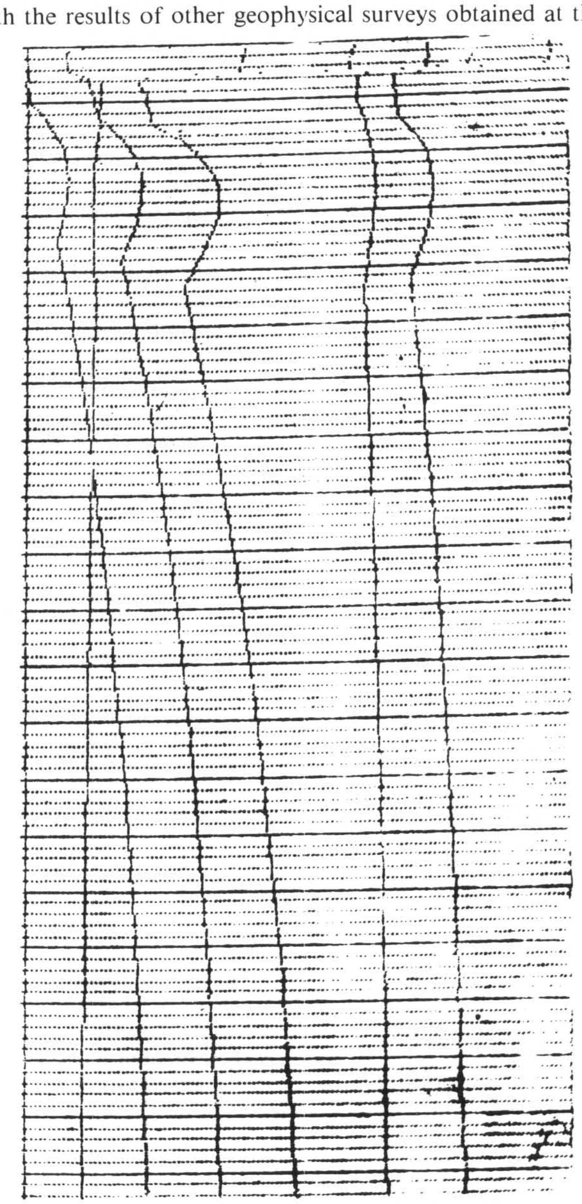

Fig 2 Seismoelectric record of 50 ms length: time line interval =0.5 ms.

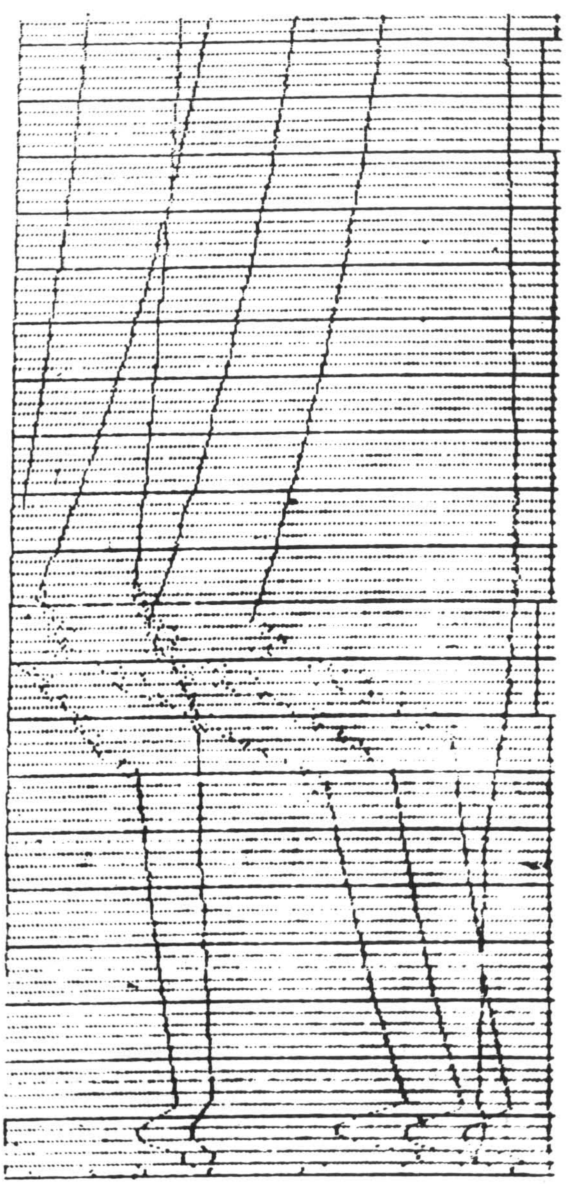

Fig 3 Seismoelectric record of 200 ms length: time line interval =2.0 ms.

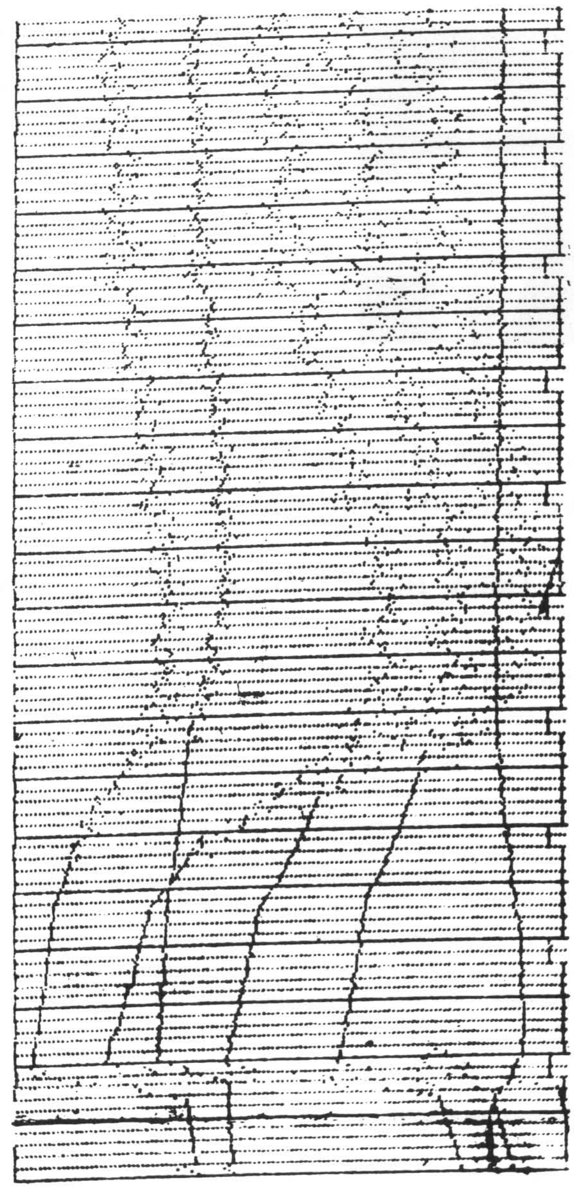

Fig 4 Seismoelectric record of 1 s length: time line interval = 10 ms.

location. The shallow refraction surveys indicated a two layer subsurface with $V_1 = 660$ m/s, $V_2 = 1620$ m/s and thickness of the first layer $d_1 = 2.1$ m. The vertical electrical sounding conducted indicated a four layer subsurface as listed below: $\rho_1 = 650\ \Omega$ m, $h_1 = 2.5$ m: $\rho_2 = 150\ \Omega$ m, $h_2 = 650$ m: $\rho_3 = 13\ \Omega$ m, $h_3 = 100$ m and $\rho_4 = 400\ \Omega$ m. The refraction surveys failed to give information regarding deeper layers despite the large shot detector separations. The seismoelectric signal present at 3 ms appears to originate at a depth of approximately 2 m if we assume a velocity of 660 m/s as the average velocity of the elastic wave (based on seismic data) up to the solid-liquid interface. The depth of origin of the seismoelectric signal coincides approximately with the depth of the water table in this area. However, a direct correlation of the seismoelectric signal appearing at 60 ms with other geophysical results is not obvious.

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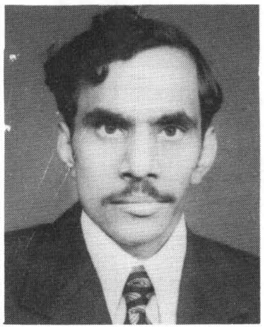
References

Parkhomenko E. I. (1968), *Electrification Phenomena in Rocks*, Nauka, Moscow (in Russian) (translated into English in 1971).

Kondrashev S. N. (1970), *Piezoelectric Method of Prospecting*, Nedra, Moscow (in Russian).



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Use of geophysics for the location of saline groundwater inflow to the Murray River east of Mildura

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Introduction

The River Murray forms the border between New South Wales and Victoria, and crosses South Australia on the final part of its 1600 km route to the sea. The salinity of the Murray increases downstream, as is the case with most large rivers of the world. However, such salinity variations are not smooth. Gutteridge *et al.* (1970) noted that in one particular 4.5 km stretch of the river near Mildura, 80 tonnes of salt per day were entering the Murray from an unknown source. This was particularly apparent in drought years and attributed to the influx of saline groundwater. A closer look at this area forms the subject of this paper.

Study area near Mildura

The study area is located in the Murray Basin, which covers parts of New South Wales, Victoria and South Australia (Fig. 1). The Murray Basin (an area of 300 000 km^2) contains a sequence of Tertiary deposits with a maximum known thickness of 600 m, mostly of marine origin. The basal Renmark Group contains the non-marine Warina Sand and Olney Formation and is more than 300 m thick near the south-western corner of New South Wales. This group is overlain by marine deposits of the Murray Group and the discomformably overlying Bookpurnong Beds and Parilla Sand.

Gutteridge *et al.* pinpointed the area of high saltwater inflow at Lambert Island (20 km upstream from Mildura), and showed that the maximum rate of inflow occurred during the drought period between October 1967 and April 1969. There are several mechanisms which generally contribute to salinity increases. These are:

(1) the effects of evaporation;
(2) drainage flow from installed drainage systems;
(3) the effect of the river channel itself as a drain in collecting seepage flows from irrigation systems;
(4) the entry into the river channel of regional seepage flows;

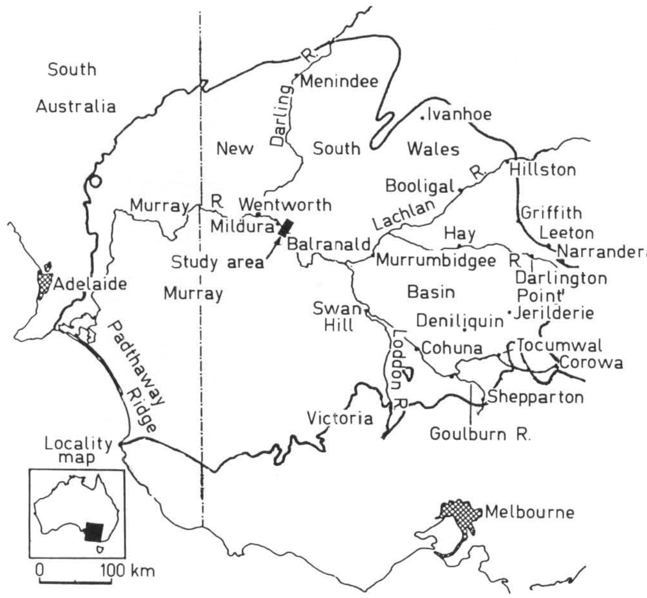

Fig 1 Location of survey area near Mildura, NSW.

(5) the weathering and partial solution of suspended matter as the river progresses to the outlet;
(6) entry into the river of surface flows as in storm drainage and natural creeks flowing through saline lands.

Figure 2 shows that during the drought year for this particular area, regional seepage flows were the main source of salt inflow. Subsequent studies by the Water Resources Commission revealed that the water table associated with the Parilla Sand in the vicinity of Lambert Island has a strong slope towards the Murray River impressed on the regional west and north-west slope. The water table and the area of salinity increase are shown in Fig. 3. It was also found that pressure heads in the deeper part of the Parilla Sand were higher than the heads in the shallower aquifers. The area in which this upward gradient occurs extends along the 4.5 km length of high