

BOREHOLE DATA REPRESENTATION BY CYCLOGRAM: A CASE STUDY FROM POLONNARUWA AREA, SRI LANKA.

SANJEEWA P.K. MALAVIARACHCHI ^{1*} AND H.A. DHARMAGUNAWARDHANE ²

¹ *Institute for the study of Earth's interior, Okayama University at Misasa, Yamada 827, Misasa, Tottori 682-0193, Japan (email: smalavilk@yahoo.com)*

² *Department of Geology, Faculty of Science, University of Peradeniya, Sri Lanka.*

ABSTRACT

Cyclogram mapping is a technique representing well strata logs that depict penetrating lithologies of the boreholes together with other hydrogeologic parameters. The cyclogram method for mapping borehole data is apparently the only method available for showing locations of boreholes, three dimensional illustrations of penetrated strata and the presentation of technical and hydrogeologic data on a single map. Consequently, the cyclogram map is a base map of well records which is essential for proper interpretation of groundwater conditions in an area. According to the results of this study, we conclude that the cyclogram method can be successfully used to establish a groundwater database in Sri Lanka.

INTRODUCTION

The aim of a borehole map is the presentation of the hydrogeological conditions, useful aquifers and characterization of groundwater resources, their dynamics and quality. Such maps give also necessary information on groundwater to local administration and helps programming the hydrogeological investigations carried for planning purposes. Information from individual boreholes could be processed to generate a borehole map in order to obtain an overall picture of geological and hydrogeological conditions of a given area. Hence, mapping of boreholes illustrate strata logs and other relevant borehole data in such a way that the type of aquifer, lithological composition of penetrated strata, boundary conditions as well as aquifer hydraulic parameters can easily be understood. Therefore, well

(borehole) records provide a source of data for construction of different (hydrogeological) maps and graphs. The map showing location of boreholes, composition of penetrated strata and other borehole data is a base map of well records and is essential for the proper interpretation of groundwater conditions in an area. In addition, such maps play a key role in groundwater modeling and management (Arnold et al., 2000; De Lange, 1996).

There are many ways of graphical representation of well records. Vertical and horizontal extent of penetrated strata is usually illustrated in cross sections or three dimensional diagrams (block, panel diagrams etc.). However, above diagrams have a drawback because whenever new information from a borehole is gathered, the diagrams have to be redrawn and

reinterpreted. Furthermore, when a large number of boreholes are to be presented, many diagrams are needed and the presentation becomes confusing. By using the cyclogram mapping technique, the above mentioned disadvantages can be avoided. In essence, Cyclogram mapping, first introduced by Anderson (1973) is a technique to represent well strata logs that depicts penetrating lithologies of boreholes together with other hydrogeologic parameters such as well yield, ground water level, chemical data etc., more simple and easy-to-understand form. In this paper we present a successful attempt for application of this technique in a crystalline hard rock terrain in Sri Lanka.

Study Area

A large number of water supply boreholes have been drilled in many parts of Sri Lanka. Majority of them are located in the Central and North-central, Province (DANIDA, 1991) and have been drilled during the implementation of rural water supply and sanitation programs of the National Water Supply and Drainage Board of Sri Lanka. The study area falls within the Polonnaruwa district and covers the entire Polonnaruwa 1:50,000 topographic sheet of the Geological Survey Department. Climatically, the study area falls within the dry zone of Sri Lanka, where the mean annual rainfall is less than 1900 mm (NAS, 1988).

Major rock types of the study area could be categorized based on their field occurrence (Vitanage, 1959; Cooray, 1967) and the observation of samples from the boreholes (Dharmagunawardhana, 1994) as charnockite, granitic gneiss, granulitic

gneiss, biotite gneiss, calc gneiss, quartzite and marble. Jointing is well developed in all rock types with the majority of them trending east-west and north-south. Tectonic lineaments (Vitanage, 1959; 1968) that can be identified in the area are classified into three groups, based on their lateral extent (Dharmagunawardhana, 1994).

- a) regional lineaments, more than 10 km long and visible on LANDSAT imagery
- b) Medium scale lineaments, less than 10 km long and visible on LANDSAT imagery
- c) Small scale lineaments less than 5 km long and visible on aerial photographs

Average orientation of regional lineaments is in the direction of north-east to south-west and medium scale lineaments show a prominent direction of north-west to south-east while the small scale lineaments are in approximately east-west (Vitanage, 1959, 1968; Dharmagunawardhana, 1994).

What Is A 'Cyclogram'?

The log of penetrated strata as obtained from the driller is usually presented in the form of a cross section. To facilitate understanding of the cyclogram form for presentation of well records, the transformation of borehole's cross section log into cyclogram is illustrated in the figure 1. By transferring the lithologic log's cross section into a cyclogram, the third dimension (depth) is added to a two dimensional co-ordinate system without projecting into space, as is usually performed in other mapping techniques (Anderson, 1973; Haman, 1980).

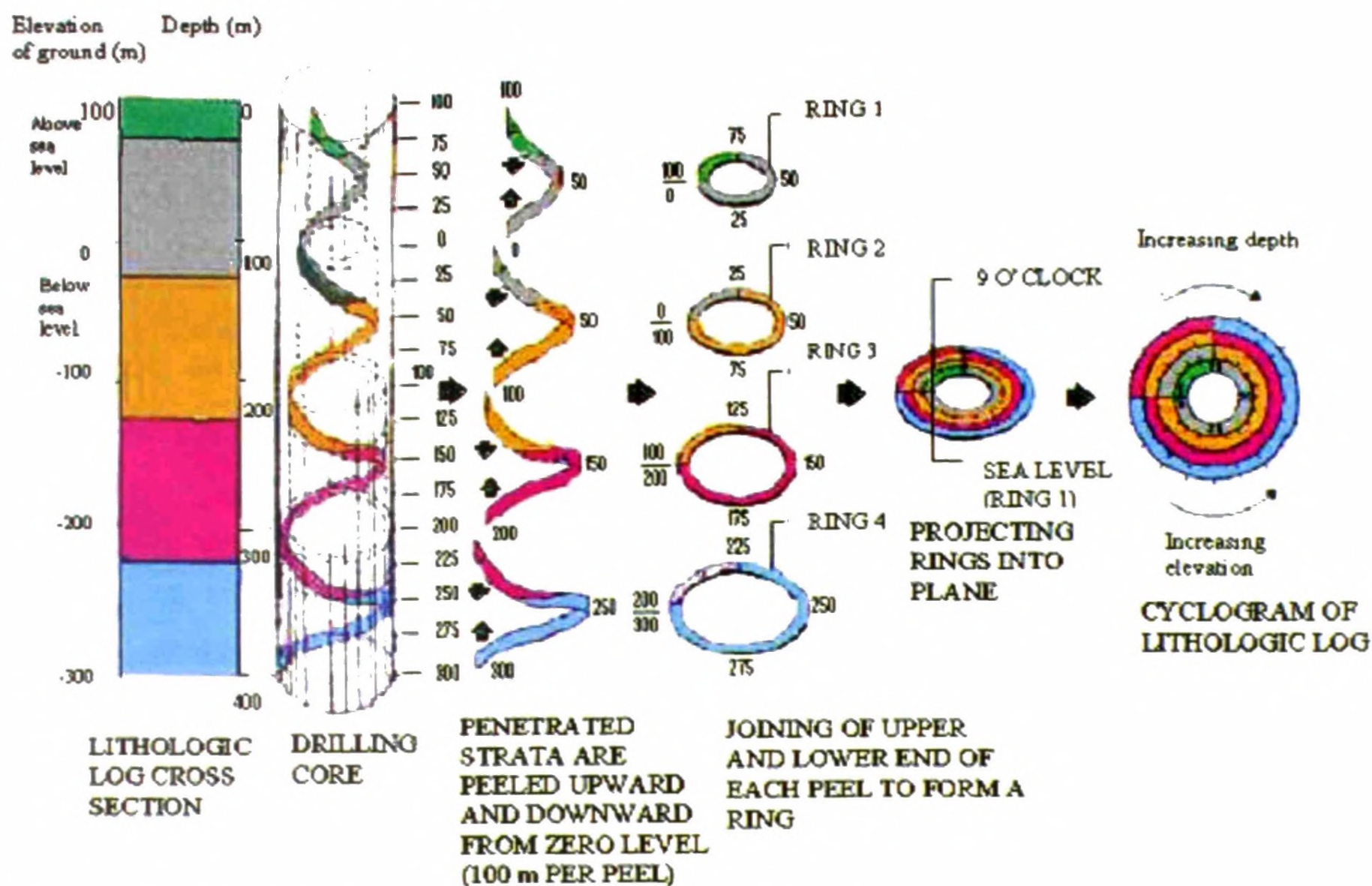


Fig: 1. Transformation of lithologic log in to cyclogram (Haman, 1980)

The cyclogram consists of number of concentric circular rings. It is decided that, each ring embraces 100m of penetrated strata. If greater detail (depth resolution) is required, the length per ring may be reduced to suit the requirement. The reference level (sea level) is selected at '9 O'clock position' in the innermost ring. Hence, the innermost ring shows counterclockwise increasing elevations from zero to 100 m above sea level. Clockwise, the elevation decreases (depth of the borehole increases) to sea level at 9 O'clock again. The elevations below sea level are indicated in the outer rings. As an example, a constructed cyclogram from this study for the borehole ME 202 of the Medirigiriya AGA division is illustrated in the figure 2.

Previous Work

Published data on previous work carried out on the use of cyclograms in Sri Lanka is not available. However, this method has been successfully utilized in sedimentary terrains in the Philippines (Haman, 1980) and Denmark (Anderson, 1973; Henrikson, 1998). Geological Surveys of Denmark and Greenland have the biggest well data archive containing data from about 250,000 boreholes plus a digital database of well records of about 208,000 wells which are interpreted using cyclograms (GEUS, 2000). Though there are no published cyclogram maps available in Sri Lanka, an attempt has been made to produce such maps of Polonnaruwa and Matale districts by the National Water Supply and Drainage board during implementation of a rural water supply and sanitation program (DANIDA, 1991).

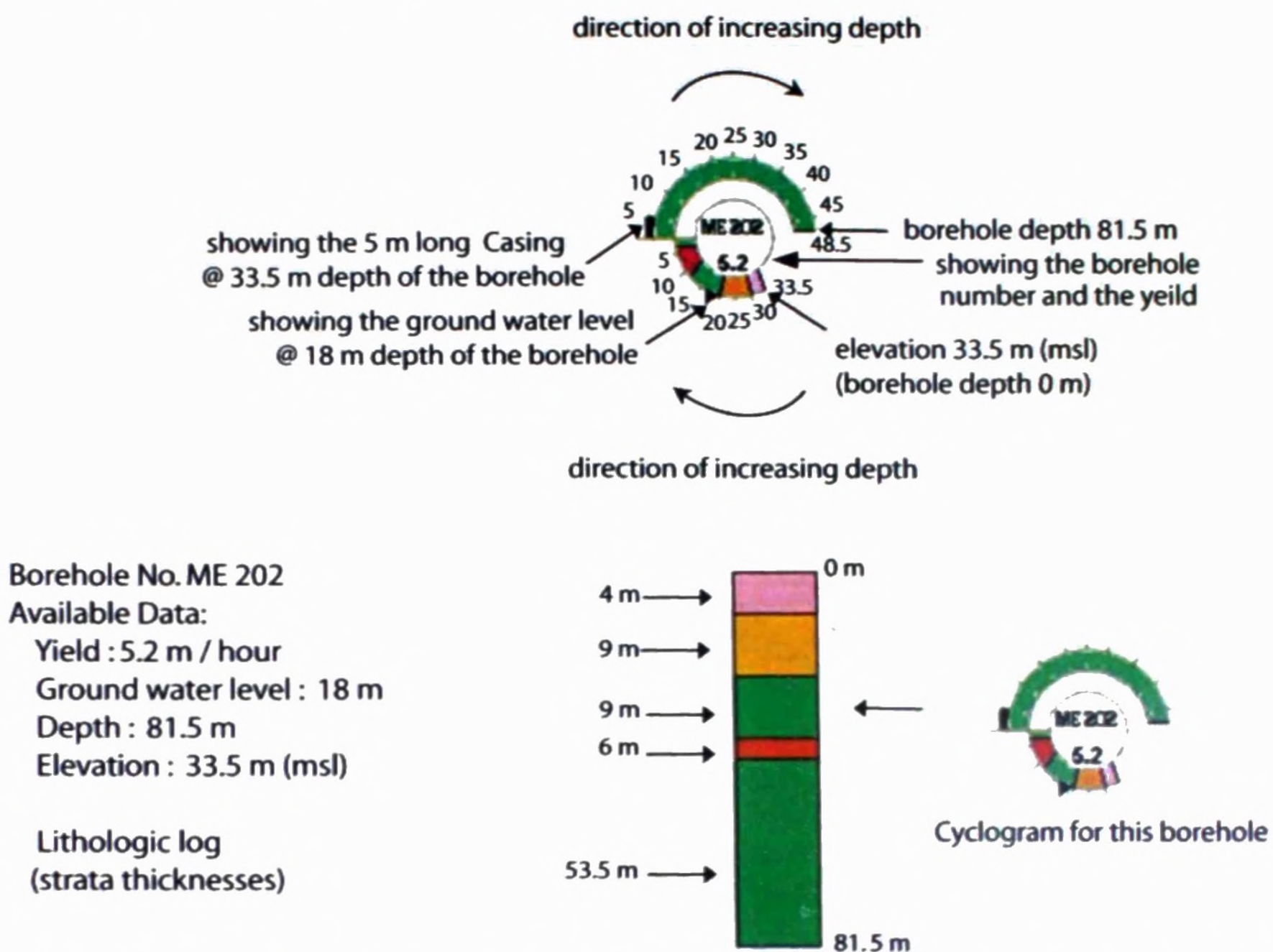


Fig: 2. Construction and the interpretation of the cyclogram of the borehole ME 202, Medirigiriya AGA division. (msl: above mean sea level).

Interpretation Of Available Data

The tube well data involved in this study were obtained from the Danish International Development Agency funded rural water supply and sanitation program of Polonnaruwa district (DANIDA, 1991). One hundred tube wells were selected for this study from five AGA divisions covering the Polonnaruwa 1:50,000 topographic sheet namely, Lankapura, Hingurakgoda, Elehera, Thamankaduwa and Medirigiriya (table 1). All the cyclograms were drawn considering mean sea level as the reference level and placing it at the 9 O'clock position in the innermost ring, following the method shown in the figure 1. To depict different lithologies at depth, corresponding sections of cyclograms were coloured. Furthermore,

parameters such as well yield, groundwater level, dimensions and intervals of casing/screening, well number etc. were indicated by symbols or digits for each cyclogram. Finally, all cyclograms were set on a map called the 'Cyclogram Map' so that all available geological and hydrogeological information are illustrated on a single layout (figure. 3).

Table 1. Details of AGA divisions and the number of wells (water supply boreholes) from each division used in this study.

AGA division	Number of wells selected
Lankapura	25
Hingurakgoda	16
Elehera	10
Thamankaduwa	30
Medirigiriya	19
Total	100

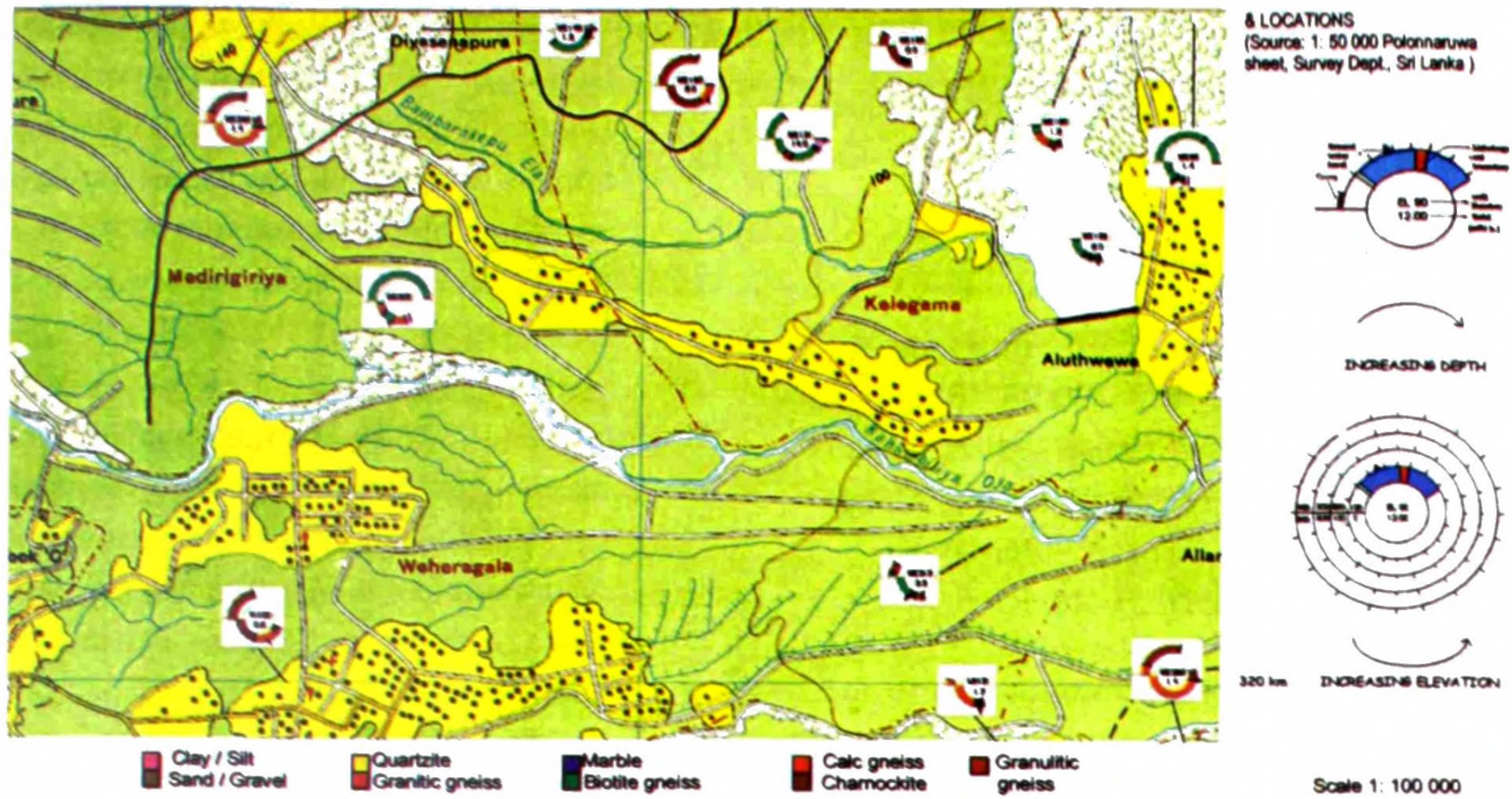


Fig: 3. The cyclogram map showing borehole records and locations. Cyclograms are plotted on the 1:50,000 scale topographic sheet of Polonnaruwa, Survey Department of Sri Lanka.

CONCLUSIONS

The cyclogram technique for mapping borehole data is apparently the only method available for showing location of boreholes, three-dimensional interpretation of penetrated strata and other technical and hydrogeologic data from wells on a single map. Consequently, the cyclogram map is a base map of well records, which is essential for proper interpretation of groundwater conditions in an area. Unlike traditional methods of illustration of borehole data, cyclograms can be easily updated with new records. Also in traditional methods, each borehole requires a separate sheet to represent its records. However, cyclograms require only a small space so that one sheet can represent records of a number of boreholes. Since cyclograms are presented on the topographic map itself, it can easily be used to find new sites for drilling wells.

In addition to that, cyclogram maps reflect the ground water level over an area and hence it enables to find the ground water flow direction too. Moreover, wide spread of cyclograms over a map enables the hydrogeologist to obtain a clear view of overall hydrogeology of the region.

ACKNOWLEDGEMENTS

Dr. Atula Senaratne, Head of the Department of Geology (2001) and all academic and non academic staff of the department of Geology, University of Peradeniya are thanked for providing the facilities and kind assistance to carry out this work. Also, Ms Sakunthala Harischandra and Asiri Harischandra are thanked for their help in computer type setting.

REFERENCES

- Anderson, L.J. (1973) Cyclogram technique for geological mapping of borehole data. Geological Survey of Denmark publication III.
- Arnold, J.G., Muttiah, R.S., Srinivasan, R. and Allen, P.M. (2000) Regional estimation of base flow and groundwater recharge in the Upper Mississippi river basin. *Journal of Hydrology* (227), 21–40.
- Cooray, P.G. (1967) *An Introduction to the Geology of Ceylon*. National Museums Publication, Colombo, Sri Lanka.
- DANIDA (1991) Well drilling and hand pump installation (January 1985-June 1991), Polonnaruwa district, Completion report, Danish International Development Agency.
- De Lange, W.J. (1996) NAGROM, a model for national groundwater management and regional and local studies. *European Water Pollution Control*, 6 (5), 63–67.
- Dharmagunawardhane, H.A. (1994) Some aspects of hydrogeology and geochemistry of crystalline rock terrains in Sri Lanka with special emphasis on Matale and Polonnaruwa. (Unpublished M.Phil thesis, University of Peradeniya, Sri Lanka).
- GEUS (2000) Well data archive, Geological Data Centre, Geological Survey of Denmark and Greenland. URL: <http://www.geus.dk/departments/quadernary-marine-geol/research/themes/well-sample-laboratory-uk.htm>
- Haman, Z. (1980) Cyclogram method for mapping of borehole / well records. In: *Establishment of Groundwater Data Banks in the Phillipines*, (B) part two, Kampsax Krüger consulting engineers, Denmark.
- Henriksen, H.J. (1998) Climate change and available groundwater resources - the national Water Resources Model for Denmark. In: Lemmelä, R., Helenius, N. (Eds.), *Proceedings of the Second International Conference on Climate and Water*, Espoo, Finland, vol. 3, 1459–1470.
- NAS (1998) *National Atlas of Sri Lanka*: Survey Department of Sri Lanka publication Colombo, Sri Lanka
- Vitanage, P.W. (1959) *Geology of the country around Polonnaruwa*. Geological Survey, Ceylon, Memoir No.1. Colombo, Sri Lanka.
- Vitanage, P.W. (1968) A study of the structural features and erosional surfaces in Ceylon. *International Geological Congress XXIII Session*, Prague (abstracts) 129 p.