1984/27. Distribution of clay types, halite and gypsum in early Triassic sandstones drilled near Bothwell

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Abstract

The distribution of clay types, halite and gypsum in a 245 m section of early Triassic sandstone drilled at Bothwell has been determined using XRD analysis of the core at two metre intervals. Illite plus kaolinite are dominant in the matrix of most of the sandstone, but mixed-layer illite/smectite also occurs commonly throughout the 245 m section. Chlorite is also present at two horizons. The relationship of clay, halite and gypsum distribution patterns to the occurrence of weathering zones and probable aquifers in the drill hole, provides "circumstantial" evidence that, to a significant degree, the distribution of the clays and the halite and gypsum are related to the diagenesis and weathering history of the sandstones rather than to their original depositional composition.

INTRODUCTION

During work on a project studying the factors involved in the durability of Tasmanian sandstones in building usage, it was found that the types and proportions of clays in sandstone matrices play an extremely important role in determining the durability. It was realised that it would be very useful to gain some knowledge of how clay types and proportions vary with stratigraphic position within the sandstone at a single locality. As most sandstones used for building in Tasmania are early Triassic (Upper Parmeener Super-Group) sandstones from eastern Tasmania, it was decided to sample and test a diamond-drill hole through a significant thickness of early Triassic sandstones.

During 1983, the Department of Mines drilled a deep diamond-drill hole (DDH 'THORPE') near Bothwell in the southern Central Plateau region of Tasmania. Drilling and lithological logging of the hole was supervised and performed by R.C. Donaldson and S.M. Forsyth. The upper part of the hole cored approximately 230 m of early Triassic quartz arenite before passing into a correlate of the Cygnet Coal Measures.

This hole was chosen as suitable for testing clay matrix variations with stratigraphic position as it cored a large proportion of the early Triassic sandstone and was not disrupted by faulting or igneous intrusions.

GEOLOGICAL SETTING

The hole was sited approximately three kilometres ESE of Bothwell township at EP035060. The hole was collared at 392.3 m above sea level, in an area mapped by Forsyth *et al.* (1976) as Triassic quartz sandstone (Rp). Revised mapping of the drill hole site indicates the collar occurs immediately above Rp in "micaceous mudstone and interbedded micaceous, frequently muddy, quartzose sandstone of very fine to fine grain size. Interbedded minor red beds, carbonaceous mudstone" (Rm - S.M. Forsyth, pers. comm.).

At approximately 13.5 m below the surface the hole passed into the unit mapped in the Oatlands Quadrangle as Rp, defined by Forsyth *et al.* (1976) as "quartzose sandstone of very fine to medium grain size, fining upward, with interbedded siltstone and clay pellet beds". Mudstone horizons, micaceous sandstone, occasional minor red beds, and carbonaceous mudstone also occur.

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At 234.2 m below the surface the hole passed into rock of the Cygnet Coal Measures Correlate (Pj). The hole terminated in the Lower Parmeener Super-Group at 763 m depth.

On the surface the nearest igneous intrusions (Jurassic dolerite) are over 0.5 km distant, and the nearest mapped fault is a dolerite-filled fault running north-south one kilometre to the east of the drill hole. The hole was sited in the middle of a large gravity low anomaly, which is indicative of the area being free of major igneous intrusions. There is no evidence of major faulting or igneous intrusions affecting the Triassic rocks drilled in DDH 'Thorpe'.

TESTING PROCEDURES

Small samples were taken from the core at precise two metre intervals down to a depth of 245 metres. The clay fraction in each sample was separated according to the method of Carroll (1970) and the clay types present determined by X-ray diffraction. Absolute percentages of each clay mineral within the total rock were not determined. However, a useful measure of the percentage of each clay mineral in the total clay matrix of each sample was obtained by simply comparing the heights of the main XRD peaks for each clay mineral in the given sample. This procedure is based on that of Carroll (1970) who presented a method for comparing clay percentages based on the area beneath XRD peaks. Preparation and testing of standard clay mixtures showed that this method gives results which, although only approximate, nevertheless give consistent indications of the relative proportions of the various clay minerals in a given sample.

The approximate percentages can be taken as either approximate volume or mass percentages, as the commonest clay minerals encountered (illite, kaolinite, smectite and chlorite) have variable and overlapping densities.

Clay proportions obtained in this way are not directly comparable in absolute terms between different samples, but do give useful indications of the trends in the abundance of various clays through the drill hole.

Gypsum and halite were also detected by the XRD analysis, and are included in the results. However, the solubility of these minerals means that slight variations in the preparation of samples could result in major variations in the size of their XRD peaks. Therefore, it is not possible, by XRD techniques, to determine the proportions of gypsum and halite in the samples - they are simply recorded as being present or absent.

RESULTS

The results of the testing are presented graphically in Figure 1. The lithological log prepared by S.M. Forsyth and R.C. Donaldson, and the core fracturing log prepared to a depth of 160 m by R.C. Donaldson, are also included. The significance of the fracture log is that fracture density is related to groundwater movements which, in turn, may be related to diagenetic changes influencing the mineralogy of the sandstones drilled.

By reference to the drillers log and by consultation with Baroid, the manufacturers of the drilling muds used in DDH 'Thorpe', it was determined that the drilling muds used contained only organic polymers with a mineral oil carrier. Thus, the smectite and gypsum found in the drill core are real components of the sediments, and not merely contamination from drilling muds containing bentonite or gypsum.

SIGNIFICANCE OF THE RESULTS

This work is part of an ongoing investigation, and it is not appropriate at this point to attempt to present a detailed discussion of the significance of the results. However, the following points appear to have been established:

(1) Smectite occurs intermittently throughout early Triassic quartz arenites at Bothwell. In conjunction with data being obtained from quarries throughout eastern Tasmania by the author, it would appear that this pattern is typical of most early Triassic sandstones in Tasmania.

(2) The smectite usually occurs as mixed layer illite/smectite, rather than as pure smectite. This also concurs with other data from eastern Tasmania.

(3) In a number of instances, it appears that the occurrence of clays, halite and gypsum is related to groundwater movements, and thus to diagenetic rather than depositional circumstances. The clearest examples include:

   (a) An anomalous interval which appears to be related to the largest fracture zone (and largest aquifer?) in the hole, at 101 m to 107 m depth, and which also has a number of lesser fractured zones and zones logged by R.C. Donaldson as "slightly weathered" due to slight colouration. Within this interval smectite is almost totally absent in zones above and below the main fracture zone at 101-107 m; the main halite zone in the hole occurs above the major fracture zone and could be the result of halite precipitating from groundwater moving upwards from the fracture zone; and finally, whereas illite and kaolinite both occur together throughout most of the sampled part of the hole, and usually in roughly similar proportions, between 95 m and 153 m illite is a very minor component of the sandstone matrices, and kaolinite is dominant, often showing large narrow peaks on the XRD trace which indicate a well-ordered crystal structure.

   (b) The occurrence of significant gypsum in two bands at 173-187 m depth and 218-222 m depth, both of which appear to be permeable horizons enclosed above and below by less permeable lutite beds.

(4) Chlorite occurs in two zones in the hole. The first, from 5 m to 59 m depth, appears to be a surface weathering effect. The second zone, at 153 m to 173 m depth, corresponds to the thickest lutite band logged in the top 250 m of the hole, and may therefore represent the depositional composition of that bed, or result from diagenetic alteration of a bed whose depositional composition was different to the rest of the sediments sampled.

CONCLUSION

The Bothwell DDH 'Thorpe' has provided circumstantial evidence indicating that the clay, halite and gypsum composition of Tasmanian early Triassic sandstones may be related as much to diagenetic and weathering effects as to original deposition. However, further work involving detailed

examinations of the chemical interactions between the various minerals involved and the groundwater will be required before such a conclusion can be established.

REFERENCES

CARROLL, D. 1970. Clay minerals: A guide to their X-ray indentification. *Spec.Pap.geol.Soc.Amer.* 126.

FORSYTH, S.M.; ABTMAIER, B.F.; LEAMAN, D.E. 1976. Geological atlas 1:50 000 series. Zone 7 Sheet 68 (8313S). Oatlands. *Department of Mines, Tasmania.*

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CLAYS, HALITE AND GYPSUM DISTRIBUTION IN TRIASSIC SANDSTONES, BOTHWELL, DDH "THORPE"

Lithological log courtesy of S.Forsyth and R.Donaldson Fracturing and possible fissure aquifers logged to 160 metres depth by R.Donaldson

DEPTH (metres)

LITHOLOGY

Mudstone siltstone
Fine grained
Medium and coarse grained

Rm

?

Rp

FRESH ROCK

SLIGHTLY WEATHERED (–brown colouration)

INTENSELY FRACTURED ZONE (? major fissure aquifer ?)

SLIGHTLY WEATHERED

FRESH ROCK

SLIGHTLY WEATHERED

FRESH ROCK

FRACTURE ZONE

RED BEDS

ROSS SANDSTONE CORRELATE (Rp)

CYGNET COAL MEASURES CORRELATE (Pj)

ILLITE *

0 50% 100%

KAOLINITE *

0 50% 100%

NO CLAYS IN XRD

MIXED LAYER * ILLITE/SMECTITE

0 50%

Unusual type

Pure Smectite

CHLORITE *

0 50%

HALITE

0 Present

GYPSUM

0 Present

FRACTURE SPACING (metres)

0.0 0.03 0.1 0.3 1.0 3.0

Crossbeds

Plane laminations

Current Ripples

Clay Pellets

Mudstone/siltstone

Fine to medium sandstsone

Medium to coarse sandstone

Major fractures

Possible fissure aquifer

* Clay % is an approx weight and volume percentage of the total clay matrix (100 %) in the given sample; Clay percentages thus not directly comparable between different samples. Note differing scales used for certain clays