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STRAINED AND UNSTRAINED QUARTZ IN THE CAMBRIAN OBSERVATORY HILL BEDS IN MURNAROO NO. 1 - A MEANS OF SUBSURFACE CORRELATION IN THE OFFICER BASIN

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STRAINED AND UNSTRAINED QUARTZ IN THE CAMBRIAN OBSERVATORY HILL BEDS IN MURNAROO NO. 1. A MEANS OF SUBSURFACE CORRELATION IN THE OFFICER BASIN

ABSTRACT

Following the production of a credible and internally consistent correlation between the wells SMD 5001 and 5002 by the use of strained and unstrained quartz, the method was extended to a third well, Murnaroo No. 1. Stratigraphic subdivisions were suggested which transcended local lithological variations. Credibility and internal consistency were maintained but the method still requires verification and calibration against an objective method such as magnetostratigraphy.

INTRODUCTION

In a sedimentary sequence which lacks both fossils and widespread marker horizons, such as pyroclastics or glauconite beds, subsurface correlation from borehole intersections is normally attempted by use of facies changes. This method is usually adequate in deep water successions but is generally unreliable in the relatively shallow water sedimentation of the inland Australian basins which are currently of major economic significance as hosts for oil and gas. In this type of depositional environment, facies changes tend to be rapid, local and diachronous.

An earlier study (DME Report Book 84/83) tested several petrographic features of sediments in two cored wells, SMD 5001 and 5002, 85 km apart in the Officer Basin as the possible basis of stratigraphic correlation between the wells. The sequence investigated was the Cambrian Observatory Hill Beds, sedimented in water shallow enough to have deposited evaporite minerals at least in one horizon. Populations of on the one hand, well-rounded grains and, on the other hand, sharply angular grains suggested that recycling of detritus added complexity to that already present in depositional environments which varied rapidly in time and space.

As was expected lithological changes such as grain size or texture variation were not consistent enough to provide a basis for correlation. Variation in the mineralogy of framework grains, other than the dominant quartz, such as microcline, plagioclase, micas, chlorite and amphibole, were apparently of only local significance.

Expectations that the heavy mineral content of the sediments might be effective in correlation were not realised. Sandstones with heavy mineral bands and laminations occurred at several points in the two sequences but no rational correlation could be constructed on this basis. The heavy minerals were largely opaque but included zircon and tourmaline in various proportions. The very high degree of rounding of the heavy minerals suggests that recycling may have affected them many times and that their current stratigraphic position may be the result of the destruction in one drainage channel of a small part of an earlier sediment which may itself have been the product of a similar process.

Matrix mineralogy varies within a single thin section and much of it is of secondary replacement origin. Micas, clays, carbonates, limonite and silica are represented but are the result of local sedimentary, diagenetic and replacement processes. Some of the silica and carbonate replacement is probably the product of duricrust formation. Dissolution by pore fluids has removed enough matrix, and occasionally framework, to give some sediments a high porosity.

Lithic fragments consist largely of quartzite, chalcedony and occasional granitoids. The quartzites and granitoids provide respectively useful evidence of metamorphic and magmatic sources of detritus but, since lithic fragments are only identifiable in the coarser grained rocks, they are not widespread enough to be used in correlation between boreholes. The chalcedonic silica may be derived from sedimentary chert or from the matrix of earlier sandstones.

One petrographic feature which is observable readily in transmitted light and from which a correlation may be constructed is the relative proportions of strained to unstrained quartz. The rationale behind this method is that quartz grains which display an undulose extinction are exhibiting the strain inherited from a metamorphic origin. Grains in which a sharp extinction demonstrates the absence of strain are then assumed to be of magmatic origin since hydrothermal quartz is unlikely to be abundant enough to constitute the major framework of a sediment. Changes in the proportion of strained to unstrained quartz throughout a sedimentary sequence is seen as reflecting changes in the terrain being eroded to form the sediment. These changes may be due to lateral shifts in the courses of major drainage channels, to vertical changes as different levels of terrain are exposed or possibly to changes in climate in which the major erosion moves with the prevailing wind from one side of the drainage basin to the other. It would be unusual for such changes to result in only one type of rock being stripped. Most changes are proportional, not mutually exclusive.

Changes such as these are significant enough to affect the major part of the sedimentation in the basin. Quartz is such an overwhelmingly abundant constituent of the sediments that it provides an almost constant factor which transcends minor local variations in the parameters controlling sedimentation. The higher the quartz content of a sediment, the more reliable it is as a correlative characteristic. However, within fairly broad limits, the relative proportions of strained and unstrained quartz may be a reliable basis for correlation regardless of lithological variation. The possibility of broad correlation passing through local facies changes is of considerable potential value in Australian inland sedimentary basins.

The method is subject to several uncertainties. The initial identification of strained and unstrained quality is arbitrary and subjective in that a large range of extinction angles are often observable not only between all the quartz grains in a sediment but even in different parts of one grain. The observer's estimate of relative proportions of strained and unstrained quartz is necessarily subjective. Point counting techniques are still subject to this type of uncertainty as the decision as to what constitutes a strained grain is not avoided by mechanical counting.

Further uncertainty is introduced in fine grained sediments by the presence of microcline in which twin members consist of irregular patches rather than regular cross-hatching. Identification of fine grains is not always possible. Even grains correctly identified as quartz may be misleading since quartz derived from chalcedonic silica often displays an undulose extinction inherited from its original amorphous crystal lattice in the absence of any external strain.

Finally, both strain and fracturing may be imposed on a sediment by the process of making thin sections, regardless of the origin of the detritus.

Despite the manifest shortcomings of the method and the uncertainties implicit in the underlying rationale, it was possible to suggest a correlation for the successions in the wells SMD 5001 and 5002 which appeared both credible and internally consistent. Estimation of the proportions of strained and unstrained quartz is carried out here for another sequence of Observatory Hill Beds intersected in Murnaroo No. 1. 87.5 km northeast of SMD 5002.

PETROGRAPHY

The specimens are listed below with estimates of strained and unstrained quartz, with brief petrographic notes and with suggested stratigraphic subdivisions based on changes from dominantly magmatic to dominantly metamorphic source areas. Ratios of quartz types are the averages of two or, in certain specimens up to four, estimates obtained after an interval of at least a day and without reference to earlier estimates. In many specimens the two estimates repeated exactly but in specimens for which estimation was subject to uncertainty consecutive estimates varied widely. In a few specimens subject to massive carbonate replacement no reliable estimates could be obtained.

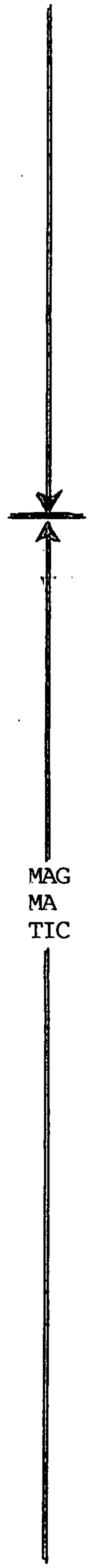
SAMPLE NO/ THIN SECTION NO	DEPTH (m)	LITHOLOGY	QUARTZ: STRAINED/ UNSTRAINED	SOURCE AREA METAM/ MAGMATIC
P36/77 C17716	623.08	Fine grained, massive quartz sandstone. Chalcedonic lithic grains. Little matrix. Few opaque grains.	4:6	
P35/77 C17715	610.81	Fine grained quartz sandstone. Heavy mineral laminations, rich in opaques, frequent in parts. Abundant plagioclase.	3:7	
P34/77 C17714	604.46	Fine quartz sandstone with coarse, rounded quartzite grains. Microcline and plagio-clase.	5:5	
P33/77 C17713	599.21	Fine quartz sandstone with abundant opaques, zircon, tourmaline. Some microcline.	5:5	
P32/77 C17712	586.18	Fine quartz sandstone with fine heavy mineral laminations.	3:7	
P31/77 C17711	565.25	Fine quartz sandstone with heavy mineral laminations at 85° to well.	2:8	MAG MA TIC
P30/77 C17710	540.08	Abundant opaques, zircon, tourmaline. Lamination now sub parallel to well.	4:6	
P29/77 C17709	530.33	Same lithology. Laminations irregular but close to perpen-dicular to well. Microcline.	3:7	
P28/77 C17708	526.00	Same lithology. Regular laminations of opaques and tourmaline.	3:7	
P27/77 C17707	516.29	Fine, even grained close packed quartz sandstone Sparse, thin laminations of opaque minerals. Very rare zircon and tourmaline.	3:7	

P26/77 C17706	503.54	Fine quartz sandstone with some interstitial mica/clay. Microcline. Few irregular laminations of opaques, zircon and tourmaline.	4:6	
P25/77 C17705	469.53	Fine quartz sandstone with some thin laminations of opaques, zircon and rare tourmaline.	5:5	
P24/77 C17704	488.23	Medium grained quartz sandstone with laminations of opaques, zircon and rare tourmaline. Patchers of interstitial dolomite.	6:4	
P23/77 C17703	481.12	Fine sandstone with a little clay matrix and a few patches of interstitial dolomite. Scattered opaque grains and zircon	6:4	
P22/77 C17702	475.27	Medium quartz sandstone Little matrix, opaques and tourmaline.	6:4	
P21/77 C17701	469.18	Medium grained well sorted quartz sandstone with little matrix and interstitial dolomite.	7:3	
P20/77 C17700	424.00	Well sorted medium quartz sandstone. Well rounded grains, some of quartzite. Interstitial dolomite in patches.	8:2	
P19/77 C17699	419.00	Fine quartz sandstone, more angular grains. Little matrix, microcline and zircon.	7:3	
P17/77 C17697	396.15	Coarser, rounded quartz and quartzite grains. Very little matrix.	9:1	MET AM OR PHIC
P16/77 C17696	381.80	Laminated feldspathic siltstone. Quartz, microcline, mica clay.	7:3	
P15/77 C17695	377.04	Matrix-rich poorly sorted quartz sandstone with rare zircons and chert grains.	8:2	

P647/76 C17694B	345.00	Highly feldspathic quartz sandstone with clay matrix and some chert fragments.	8:2
P647/76 C17694A	345.00	Same lithology. Quartz grains often fractured.	8:2
P646/76 C17693	333.56	Coarse quartz sandstone with quartzite fragments and no matrix.	9:1
P645/76 C17692	332.34	Coarse quartz sandstone composed of rounded quartzite fragments in a fine quartz matrix.	9:1
P644/76 C17691	325.52	Medium grained quartz - microcline sandstone with some quartzite lithic fragments.	6:4
P643/76 C17690	321.01	Poorly sorted quartz - microcline sandstone with some quartzite clasts and a little plagioclase.	7:3
P642/76 C17689	317.11	Poorly sorted quartz - microcline sandstone with patches of inter-stitial calcite and rare, scattered plagioclase, fine grained silica, opaques, zircon and tourmaline.	6:4
P965/77 39226	309.95	Major facies change to ferruginous mudstone with extremley fine grained quartz.	8:2
P964/77 39225	280.00	Laminated, ferruginous micaceous siltstone.	7:3
P963/77 39224	264.95	Same lithology with coarser quartz and patches of dolomite.	6:4
5339RS35 C2889	256.10	Same lithology with pods of fine feldspathic quartz sandstone with dolomite.	6:4
P962/77 39223	249.93	Same lithology with scattered fine quartz grains.	6:4

MET
AM
OR
PHIC

5339RS59 C20970	229.39	Same lithology as at 249.93 m. with scattered patches of coarser quartz.	6:4
P70/77 C17793	218.39	Feldspathic quartz silt- stone with coarse to medium sandy bands.	4:6
5339RS8 C20969	216.23	Fine silty mudstone with pods of coarser quartz and disseminated dolomite.	6:4
5339RS34 C28888	215.90	Intraformational mudstone conglomerate with dolomitic and chalcedonic matrix.	5:5
P69/77 C17792	215.75	Identical lithlogy.	5:5
P961/77 39222	215.00	Weakly laminated muddy dolomite siltstone with scattered coarser quartz grains and many fine opaques.	5:5
P960/77 39221	204.97	Fine grained dolomitic mudstone with rare mica and quartz. Abundant microparticulate pyrite, often framboidal.	2:8
P959/77 39220	194.98	Massive, fine grained dolomitic mudstone with dark schlieren.	2:8
5339RS33 C28887	192.35	Massive calciferous fine grained dolomite with coarse dolomite and fibrous chalcedony in fractures and pods.	2:8
5339RS7 C20968	186.36	Fine grained, cross laminated dolomite with scattered very fine quartz.	4:6
P958/77 39219	184.95	Weakly laminated fine calciferous dolomite and magnesian limestone.	4:6
5339RS32 C28886	182.50	Intraformationally disturbed mudstone with dolomite - chalcedony matrix and fine dolomite with pyrite - coarse dolomite mineralisation.	5:5



5339RS6 C20967	182.36	Laminated to massive fine grained dolomite. Very little quartz. Microcline.	4:6	
5339RS31 C28885	180.90	Massive dolomite. Very little quartz.	3:7	MAG MA TIC
P957/77 39218	177.98	Massive dolomite. Little quartz, possibly of colloidal origin.	6:4	
P956/77 39217	172.95	Bedded dolomite. Very little non-carbonate material.	6:4	
P955/77 39216	167.90	Too few non-carbonate grains to give significant estimates.	?	
5339RS5 C20966B C20966A	161.61	Well bedded micaceous mudstone. Moderately abundant quartz. A few patches of calcite.	 4:6 4:6	
P954/77 39215	155.00	Ferruginous siltstone. Abundant mica, microcline and quartz. A little disseminated dolomite.	6:4	
P953/77 39214	149.80	Micaceous and feldspathic siltstone with patchy calcite replacement.	7:3	
P952/77 39213	139.95	Identical except for slightly coarser grain size.	7:3	MET AM OR PHIC
P951/77 39212	92.90	Mudstone with substantial dolomitic replacement in veins, patches & interstices.	8:2	
P950/77 39211B 39211A	89.92	Micaceous siltstone with scattered calcite replacement. Same lithology.	6:4 6:4	
P949/77 39210	85.02	Same lithology.	5:5	
P948/77 39209	79.95	Ferruginous mudstone with calcite and silica replacement.	6:4	

5339RS30 C28884	79.25	Intraformationally disturbed ferruginous silty mudstone with substantial chalcedonic replacement.	5:5	
P947/77 39208	74.95	Siltstone with mud flakes and substantial disseminated calcite replacement.	5:5	
5339RS29 C28883	66.00	Fine grained calciferous dolomite with mud and silt lenses and patchy chalcedonic replacement.	6:4	MET AM OR PHIC
5339RS28 C28882	65.00	Chert with intraformational disturbance. Matrix of calcite and quartz between chert fragments.	5:5	

DISCUSSION

The following subdivisions of the Observatory Hill Beds in Murnaroo No. 1 are suggested from visual estimates of strained and unstrained quartz in samples intersected between 65 m and 623 m

Interval	Dominant rock type in source terrain
65-155	Metamorphic
162-215	Magmatic
216-496	Metamorphic
496-623	Magmatic

Evidence for the subdivisions is strongest in the coarser quartz sandstones below the major facies change at 310 m. It is less reliable above this point and is particularly weak in the carbonate rocks between 168 m and 205 m in which the quartz content varies from low to virtually absent (in the specimen from 168 m).

In general the degree of strain is less reliably estimated in very fine grained quartz. The possibility that undulose extinction may be the result of a colloidal origin is raised in the samples from 66, 79, 80, 178, 182, 192 and 215 m. Chert is present in samples from 65, 345, 377 and 623 m.

Most of the specimens within one group contain quartz dominantly of the type distinguishing the group, suggesting an internal consistency in the method. It would be invaluable, however, to calibrate the method externally by an objective technique such as magnetostratigraphy.

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