HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24-N1
WELL NAME/DEPTH: Sun Unark L-24-69-40-134-30/2731.34 m.

INDURATION: excellent.
COLOUR: light grey (carbonate cement is white).
SEDIMENTARY STRUCTURES: planar laminated and cross-bedded, bedding plane parting along coal films.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 62

%gravel size: 0

%sand size: 52

%silt size: 10

%clay size: 0

Cement %: 35% sparry carbonate fills pores and in part replaces grains, especially along margins, 1% pyrite (including the framboidal variety) lines pores, trace quartz overgrowths.

Porosity %: 2

Modal Size: 0.13 mm.

Sorting: 16%/84% diameter ratio=
250 micrometres/ 65 micrometres = 3.8

Verbal Sorting Scale: moderately sorted.

GRAIN SIZE NAME: silty fine sandstone.

COMPOSITION: 15% monocrystalline quartz grains, 3% polycrystalline quartz grains, 20% chert clasts, 10% phylloid clasts, 2% alkali feldspar grains, trace plagioclase grains (in part altered to chlorite and replaced by carbonate), 3% coal clasts and films, trace unaltered glauconite pellets (some of which show good evidence of compaction), trace muscovite flakes (partly altered to carbonate and clays). Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): carbonate cemented coal- and glauconite-bearing silty fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: The presence of unaltered glauconite pellets suggests a marine origin, even though coal grains and films are also in the rock. Minor pressure solution is evident for siliceous grains and mechanical compaction was moderate, as is apparent from ductile grains that are squeezed

between more competent grains. The sparry carbonate fills pores as cement (about 20-25%) and also partially replaces grains, especially at their margins (about 10-15%). This suggests that the porosity was reduced to about 20 to 25% when the carbonate entered the sample, probably at a burial depth of 1 to 2 Km. There are excellent examples of rhomb-shaped carbonate indentations of grains and complete carbonate rhombs are present within grains (especially chert). The carbonate may be dolomite because it was neither etched nor stained red by the alizarin red solution.

THIN SECTION MODAL AND GRAIN SIZE ANALYSIS

Sample I.D.: Unal24-N1

	No of Points	Percentage of Components	Percentages of Detrital Components
Detrital Components			
Monocrystalline Quartz	73	24.33	35.27
Polycrystalline Quartz	24	8.00	11.59
Clear Chert	43	14.33	20.77
Black Chert	11	3.67	5.31
Alkali Feldspar	18	6.00	8.70
Plagioclase	1	0.33	0.48
Phylloid Clasts	22	7.33	10.63
Volcanic Clasts	2	0.67	0.97
Chlorite	2	0.67	0.97
Mica	7	2.33	3.38
Siltstone Clasts	0	0.00	0.00
Coal	2	0.67	0.97
Unidentified (too small)	0	0.00	0.00
Other Clasts	2	0.67	0.97
Cements			
Kaolinite	0	0.00	
Carbonate	93	31.00	
Other	0	0.00	
Porosity			
Intergranular/ Moldic	0	0.00	

Intragranular	0	0.00

Plucked Grains=9

Total number of points counted minus plucked grains= 300

GRAIN SIZE ANALYSIS

Sample I.D.: UnaL24-N1

Class Interval (phi)	No. Freq of Max Apparent Grain Dimension	Percentage Frequency	Cumulative Percentage Frequency
1.0 to 0.5	1	0.5	0.5
1.5 to 1.0	3	1.5	2.0
2.0 to 1.5	16	8.0	10.0
2.5 to 2.0	59	29.5	39.5
3.0 to 2.5	61	30.5	70.0
3.5 to 3.0	41	20.5	90.5
4.0 to 3.5	8	4.0	94.5
4.5 to 4.0	6	3.0	97.5
5.0 to 4.5	4	2.0	99.5
5.5 to 5.0	0	0.0	99.5
6.0 to 5.5	0	0.0	99.5
6.5 to 6.0	1	0.5	100.0

GRAPHIC GRAIN SIZE CUMULATIVE PERCENTILES IN PHI (MICROMETRE) UNITS OF SELECTED DETRITAL COMPONENTS

Sample I.D.: UnaL24-N1

Percentiles	Phi Values	Micrometres
1	1.23	426
5	1.78	291
16	2.14	227

25	2.31	202
50	2.69	155 (fine sand size)
75	3.12	115
84	3.31	101
95	4.06	60

$$\text{Graphic Sorting (Inman)} = \frac{\text{Phi(84)} - \text{Phi(16)}}{2} = 0.59$$

Verbal Sorting Scale= moderately sorted

Total Number of Grains Measured= 200

Note: Quantitative and qualitative grain size estimates are in good agreement. Thin section modal analysis, however, suggests more monocrystalline quartz (24 rather than 15%), polycrystalline quartz (8 instead of 3%) and alkali feldspar (6 compared to 2%) than was estimated qualitatively.

ELECTRON MICROPROBE CARBONATE ANALYSES

SAMPLE I.D.: UNAL24-N1.
WELL NAME/DEPTH: UNARK L-24/2731.34 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): CC1.1, CC1.2, CC1.3 and CC1.4 are analyses of dolomite in different areas of the thin section.

	CC1.1	CC1.2	CC1.3	CC1.4	AVERAGE
OXIDE WEIGHT PERCENT					
MGO	10.66	10.25	10.61	11.24	10.69
FEO	11.10	11.84	11.35	10.34	11.16
MNO	.23	.15	.09	.19	.16
CAO	33.04	32.92	33.59	33.65	33.30
TOTAL	55.03	55.16	55.64	55.42	55.31

ATOMIC PROPORTIONS (FORMULA, BASIS 2 OXYGENS)

MG	.523	.505	.515	.544	.522
FE	.305	.327	.309	.281	.305
MN	.006	.004	.003	.005	.005
CA	1.165	1.165	1.173	1.170	1.168
TOTAL	1.999	2.001	2.000	2.000	2.000

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24-N2
WELL NAME/DEPTH: Sun Unark L24-69-40-134-30/2731.92 m

INDURATION: excellent when dry, moderate after immersion in water for 1 hour.
COLOUR: light grey with dark grey laminae.
SEDIMENTARY STRUCTURES: planar lamination is defined by concentrations of carbonaceous films.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 76

%gravel size: 0

%sand size: 66

%silt size: 5

%clay size: 5

Cement %: 5% kaolinite(?), 15% sparry carbonate, 1% pore-lining pyrite (including framboids), trace quartz overgrowths.

Porosity %: 3

Modal Size: 0.20 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 80 micrometres = 3.5

Verbal Sorting Scale: moderately sorted.

GRAIN SIZE NAME: muddy fine sandstone.

COMPOSITION: 20% monocrystalline quartz grains, 5% polycrystalline quartz grains, 20% chert clasts, 15% phylloid and siltstone clasts, 2% alkali feldspar grains, 2% muscovite flakes (in part replaced by carbonate and altered to clays), 2% clasts of microcrystalline carbonate, trace microcline, trace chlorite flakes, 5% grains and films of coal, trace unaltered glauconite pellets, trace volcanic rock fragments and trace plagioclase (partly altered to clays). Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): carbonate/pyrite cemented coal- and glauconite-bearing muddy fine-grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: Unaltered glauconite pellets suggest a marine origin in spite of the presence of films and grains of coal/carbonaceous material. The sample was mechanically compacted as shown by the large proportion of deformed ductile

grains after which carbonate was precipitated. This is indicated by deformed phylloid clasts that have been almost completely replaced by sparry carbonate. The relatively small proportion of carbonate in the sample supports this idea. Sparry carbonate has replaced about 5% of the grains, mainly as partial replacements at grain margins. These replacements commonly have a characteristic rhombic shape. In addition, about 1% of the carbonate partially replaces the interior of phylloid and chert clasts and there are a few examples where deformed muscovite flakes have been almost entirely replaced by carbonate. The incidence of sparry carbonate rhombs entirely within grains, however is rare. The pore-lining pyrite was precipitated before the carbonate because carbonate cement surrounds the pyrite.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24-N3
WELL NAME/DEPTH: Sun Unark L-24-69-40-134-30/2738.93 m (8986.0 ft.).
INDURATION: excellent, either dry or immersed in water.
COLOUR: brassy brown.
SEDIMENTARY STRUCTURES: poor planar lamination/parting.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 65

%gravel size: 0

%sand size: 61

%silt size: 3

%clay size: 1?

Cement %: 30% pyrite, 2% quartz overgrowths, trace kaolinite(?).

Porosity %: 3

Modal Size: 0.2 mm.

Sorting: 16%/84% diameter ratio=
350 micrometres/ 130 micrometres = 2.7

Verbal Sorting Scale: moderately sorted.

GRAIN SIZE NAME: fine sandstone.

COMPOSITION: 25% monocrystalline quartz grains, 5% polycrystalline quartz grains, 15% chert clasts, 5% alkali feldspar grains, 10% phylloid and siltstone clasts, 1% muscovite flakes, trace plagioclase and microcline grains. Unidentified mud-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): pyrite/quartz-cemented fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: Most of the 3% porosity is moldic, having formed after pyrite cementation (the pyrite outlines the shapes of former grains). Further, the pyrite filled secondary intergranular elongate pores. The diagenetic sequence appears to be quartz cementation, secondary porosity development and finally pyrite cementation. The partial rhomb-shaped carbonate dissolution molds at grain boundaries suggest once again the former presence of carbonate as a grain-replacing mineral. The dissolution of the carbonate formed considerable porosity, which was then filled by pyrite.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N1
WELL NAME/DEPTH: Sun BVX et al. Unark
L24A-69-40-134-30/2219.24 m.
INDURATION: moderate when dry, very poor when immersed in water (disaggregates by itself in half an hour).
COLOUR: dark brown.
SEDIMENTARY STRUCTURES: planar parting, planar lamination is defined by transitional vertical grain size variation.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent % (of the sand lamina): 79

%gravel size: 0

%sand size: 54

%silt size: 15

%clay size: 10

Cement %: 5% pore-lining kaolinite, 1% pore-lining framboids of pyrite.

Porosity %: 15

Modal Size: 0.1 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 20? micrometres = 15

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: muddy very fine sandstone.

COMPOSITION (of the sandy lamina): 20% monocrystalline quartz grains, 3% polycrystalline quartz grains, 15% chert clasts, 5% microcrystalline siderite clasts, 10% muscovite flakes (in part altered to clays), 2% alkali feldspar, 4% coal films (mainly less than 100 micrometres thick but laterally continuous for centimetres) and 1% coal grains. Open cellular structure is visible in one of the coal grains, trace plagioclase (partly altered to clays), trace high birefringent/high relief minerals, trace microcline, trace unaltered glauconite pellets.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): kaolinite-cemented coal and glauconite-bearing muddy very fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: The presence of glauconite suggests a marine origin, in spite of the coaly films and grains. The porosity is distributed approximately as follows; at least 2% is secondary intergranular porosity, 1% is leached porosity

within grains, and about 12% is primary porosity between grains. Evidence for secondary intergranular porosity includes oversized and elongate pores, some of which are rhomb-shaped. The leached intragranular porosity occurs in polycrystalline quartz, chert, phylloid, alkali feldspar and plagioclase grains. Although secondary porosity is present, mechanical compaction was the dominant diagenetic process. The high proportion of ductile grains that are squeezed between the more competent ones, the small particle size with a relatively high clay and silt content and the poor sorting guarantees a very low permeability for this lithology. Pyrite framboids occur (and some are concentrated) in the oversized intergranular pores and in leached intragranular pores, suggesting a relatively late diagenetic formation. Moldic pores are more common in one of the sections which suggests that these represent grains plucked from the sample before mounting on the glass slide.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N2
WELL NAME/DEPTH: Sun BVX et al. Unark
L-24A-69-40-134-30/2955.80 m.

INDURATION: good, either when dry or immersed in water.
COLOUR: light grey with dark grey grains (carbonate cement is white).
SEDIMENTARY STRUCTURES: vague planar lamination is defined by a vertically-varying matrix content of silt and clay.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 72

%gravel size: 0

%sand size: 56

%silt size: 10

%clay size: 6

Cement %: 25% carbonate, trace quartz overgrowths, trace pore-lining framboidal pyrite, some of which occurs on the quartz overgrowths.

Porosity %: 3

Modal Size: 0.2 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 70 micrometres = 4.3

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: muddy fine sandstone.

COMPOSITION: 20% monocrystalline quartz grains, 5% polycrystalline quartz grains, 20% chert clasts, 15% phylloid and siltstone clasts, 3% alkali feldspar, 1% coal grains, trace muscovite flakes (partly replaced by carbonate), trace volcanic rock fragments, trace microcline, trace plagioclase (partly altered to clays). Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): carbonate-cemented muddy fine-grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: Sparry carbonate almost completely occludes porosity. There are good examples of grains which have been compactionally fractured with the fractures filled with carbonate. This suggests burial to moderate depths before carbonate cementation. The carbonate occurs as pore-

filling cement (about 15%) and as replacement of grain margins (about 10%) that are commonly rhomb-shaped. Some grains, such as muscovite flakes and a few chert grains are almost completely replaced. It is of some interest that the muddy lamina contains much less carbonate, which again suggests that permeability controls the distribution of carbonate. These relationships suggest, along with ductile grains that were squeezed between more competent grains and enclosed in sparry carbonate, that moderate depths of burial (perhaps 1-2 km) were achieved before carbonate cementation. A similar argument suggests a moderate amount of pressure solution before carbonate cementation. Pyrite framboids occur on quartz overgrowths in some places and are elsewhere surrounded by carbonate cement, which suggests that the order of precipitation was probably quartz, then pyrite and finally carbonate.

Only one of the two thin sections is of good quality.

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24a-N2
WELL NAME/DEPTH: Unark L24a/2955.80 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): Pl1a.1 is an analysis of polysynthetically twinned feldspar. RF1b.1 and RF1b.2 are two analyses of what optically appears to be a volcanic rock fragment. HM2A.1 is an analysis of a light-medium green pleochroic heavy mineral. RF3A.1 is an analysis of a brown ductile phyloid clast or perhaps a volcanic rock fragment. In addition a yellowish translucent highly reflective mineral was indicated to be rutile.

	PL1A.1	RF1B.1	RF1B.2	HM2A.1	RF3A.1
OXIDE WEIGHT PERCENT					
SIO2	63.10	89.39	80.17	36.67	62.54
AL203	19.07	3.80	6.93	33.04	7.32
MGO	.00	.00	.24	6.92	.31
TIO2	.12	.23	.47	.80	.34
CR2O3	.21	.13	.16	.21	.09
MNO	.10	.00	.03	.04	.05
FEO	.27	.65	1.01	8.88	.40
ZNO	.00	.00	.02	.00	.00
NA2O	.63	.00	.00	2.59	.80
K20	14.36	1.07	2.19	.06	1.34
CAO	.28	1.37	2.82	.41	.45
P2O5	.00	.00	1.24	.00	.00
SO3	.34	.36	.00	.20	.39
TOTAL	98.48	97.00	95.28	89.82	74.03
ATOMIC PROPORTIONS (BASIS 22 ATOMS)					
SI	8.094	10.377	9.702	5.223	9.658
AL	2.884	.521	.988	5.548	1.332
MG	.000	.000	.044	1.470	.072
TI	.011	.021	.043	.086	.039
CR	.022	.012	.016	.024	.011
MN	.011	.000	.003	.005	.007
FE	.029	.063	.102	1.058	.052
ZN	.000	.000	.002	.000	.000
NA	.157	.000	.000	.717	.240
K	2.350	.159	.338	.011	.264
CA	.038	.171	.366	.063	.075
P	.000	.000	.127	.000	.000
S	.033	.031	.000	.022	.045
TOTAL	13.629	11.355	11.731	14.227	11.795

ELECTRON MICROPROBE CARBONATE ANALYSES

SAMPLE I.D.: UNAL24A-N2.
WELL NAME/DEPTH: Unark L-24a/2955.80 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): CC1C.1, CC2B.1 and CC3C.1 are analyses of dolomite in different places near the edge of grains. CC1D.1, CC2C.1, CC3B.1 and CC3B.2 are dolomite analyses in different parts of the section midway between grains.

	CC1C.1	CC2B.1	CC3C.1	CC1D.1	CC2C.1
OXIDE WEIGHT PERCENT					
MGO	9.95	10.59	11.10	10.20	11.02
FEO	10.87	8.66	9.04	10.68	8.89
MNO	.23	.23	.15	.21	.18
CAO	32.54	30.99	30.04	32.18	31.64
TOTAL	53.59	50.47	50.33	53.27	51.73
ATOMIC PROPORTIONS (FORMULA, BASIS 2 OXYGENS)					
MG	.503	.560	.586	.517	.567
FE	.308	.257	.268	.304	.257
MN	.007	.007	.005	.006	.005
CA	1.182	1.177	1.141	1.173	1.171
TOTAL	2.000	2.001	2.000	2.000	2.000

	CC3B.1	CC3B.2
OXIDE WEIGHT PERCENT		
MGO	11.97	11.43
FEO	9.59	9.54
MNO	.20	.19
CAO	31.93	31.66
TOTAL	53.69	52.82
ATOMIC PROPORTIONS (FORMULA, BASIS 2 OXYGENS)		
MG	.592	.577
FE	.266	.270
MN	.006	.005
CA	1.136	1.148
TOTAL	2.000	2.000

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N3
WELL NAME/DEPTH: Sun BVX et al. Unark
L24A-69-40-134-30/2958.18 m.

INDURATION: good when dry, disaggregates by itself in an hour after immersion in water.
COLOUR: light grey with dark grey grains, carbonate cement is white.
SEDIMENTARY STRUCTURES: planar stratification (defined by concentrations of carbonaceous material).

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 63

%gravel size: 0

%sand size: 48

%silt size: 15

%clay size: 10

Cement %: 1% pore-lining pyrite, 1% well-developed and thick quartz overgrowths, 15% carbonate.

Porosity %: 5

Modal Size: 0.17 mm.

Sorting: 16%/84% diameter ratio=
250 micrometres/ 20 micrometres = 12.5

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: muddy fine sandstone.

COMPOSITION: 15% monocrystalline quartz grains, 5% polycrystalline quartz grains, 10% chert, 20% phylloid and siltstone clasts, 2% muscovite flakes, 1% plagioclase, 1 % coal clasts, trace unaltered glauconite pellets. Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): carbonate/pyrite-cemented glauconite- and coal-bearing muddy fine-grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: A marine origin is suggested by the presence of unaltered glauconite pellets. Extreme mechanical compaction and a moderate amount of chemical compaction (pressure solution) is evident from the nature of grain contacts. Quartz overgrowths are well-developed and commonly thick, which suggests a possible relation to pressure

solution. Carbonate fills pores (about 10%) and replaces grains (5%), mainly along margins. These marginal replacements are commonly rhombic in shape. The small size of the carbonate crystals is probably related to the relatively high silt and clay content. Carbonate cementation was relatively late because the carbonate abuts against the quartz overgrowths and fills pore space much reduced by compaction. The carbonate cement also contains pyrite framboids which may indicate an uncharacteristically late time for the carbonate cementation.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N4
WELL NAME/DEPTH: Sun BVX et al. Unark
L24A-69-40-134-30/2961.01 m.

INDURATION: poor either when dry or immersed in water.
COLOUR: light brown.
SEDIMENTARY STRUCTURES: vague planar lamination is defined by varying amounts of silt- and clay-sized matrix.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 70

%gravel size: 0

%sand size: 50

%silt size: 15

%clay size: 5

Cement %: 5% kaolinite, 5% carbonate cement, trace pore-lining pyrite.

Porosity %: 20

Modal Size: 0.17 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 50 micrometres = 6

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: silty fine sandstone.

COMPOSITION: 15% monocrystalline quartz grains, 5% polycrystalline quartz grains, 25% chert clasts, 15% phylloid clasts, 2% alkali feldspar, trace chlorite, trace microcline, trace high birefringent/high relief minerals, trace volcanic rock fragments, trace muscovite flakes. Unidentified silt- and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): Kaolinite/carbonate-cemented silty fine-grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: The porosity distribution is approximately as follows; 5% is moldic, 3% at least is intragranular and 12% is intergranular. A high degree of mechanical compaction and a moderate degree of pressure solution is suggested by the nature of grain contacts. Higly deformed ductile grains between competent grains and compactionally fractured grains (with fractures propagating from grain/grain

contacts) suggests burial to at least moderate depths before carbonate cementation. About half of the total porosity is of secondary origin, and most of this occurs as elongate and oversized intergranular pores. Intragranular secondary porosity was observed in chert, alkali feldspar, plagioclase and volcanic rock fragments (containing molds of plagioclase laths). The relict sparry carbonate occurs as cement and replaces grain margins as characteristic rhomb-shaped indentations. There is no doubt that the dissolution of carbonate-replaced material (including clay and silt matrix) increased the porosity and permeability. Pores of secondary origin are lined with kaolinite and pyrite which implies a relatively late diagenetic formation for these minerals. In a few places, kaolinite fills molds of secondary origin. Minor mechanical compaction after carbonate decementation is revealed by ductile grains that have been squeezed into the rhomb-shaped molds of adjacent competent grains. This conclusion is based on the assumption that these grains with rhomb-shaped molds at grain margins did not survive a previous cycle of carbonate cementation, decementation, erosion and redeposition.

Excessive grain plucking required re-impregnation of the surface with clear cyanoacrylate prior to final thinning.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N5
WELL NAME/DEPTH: Sun BVX et al. Unark
L24A-69-40-134-30/2966.36 m

INDURATION: good, either dry or immersed in water.
COLOUR: light grey with dark grey grains.
SEDIMENTARY STRUCTURES: planar lamination is defined by carbonaceous films.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 69

%gravel size: 0

%sand size: 36

%silt size: 18

%clay size: 10

Cement %: 5% kaolinite, 10% calcite (stained red with alizarin red stain), 1% pore-lining pyrite, trace quartz overgrowths.

Porosity %: 20 (the thin section was made from core plug 28, for which a porosity of 11.2% and a permeability of 0.29 millidarcies was measured).

Modal Size: 0.08 mm.

Sorting: 16%/84% diameter ratio=
150 micrometres/ 20 micrometres = 7.5

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: muddy very fine sandstone.

COMPOSITION: 15% monocrystalline quartz, 2% polycrystalline quartz grains, 10% chert grains, 20% phylloid and siltstone clasts, 5% muscovite, 5% grains and films of coal, 1% chlorite flakes, 1% alkali feldspar grains, 1% grains of finely crystalline pyrite, trace unaltered glauconite pellets, trace plagioclase grains, 1% volcanc rock fragments. Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): calcite/kaolinite-cemented glauconite- and coal-bearing muddy very fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: The presence of glauconite pellets (some of which are compactionally deformed) suggests a marine origin, in spite of the relatively large proportion of coal grains and films. Mechanical compaction was the most

important diagenetic event, as revealed by ductile grains squeezed between the more competent grains. Pressure solution was of minor importance, at least for quartz grains, judging by the relatively low proportion of non-point contacts between quartz grains. The calcite occurs as cement and commonly replaces grains at margins. The depth at which calcite cementation occurred is not apparent from textural relations, but moderate depths are suggested by the considerable mechanical compaction and relatively small amount of carbonate cement. Pore-filling kaolinite predates carbonate cementation, however, because where the alizarin red stain etched away calcite, kaolinite is revealed in incident light.

It should be noted that calcite cement is underestimated in the stained section because the alizarin red solution etched away about 5 micrometres of calcite.

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24aN5
WELL NAME/DEPTH: Unark L24a/2966.36 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): 2A.1 is an analysis of a part of a glauconite grain that has altered to an off-green colour (chlorite). 2B.1, 2B.2, 2B.3 and 2B.4 are analyses of different parts of a brown phylloid (clay-rich?) clast.

	2A.1	2B.1	2B.2	2B.3	2B.4
OXIDE WEIGHT PERCENT					
SIO2	31.57	13.15	28.94	12.75	28.46
AL203	16.56	9.62	18.15	8.94	17.73
MGO	8.60	4.89	7.21	4.69	6.37
TIO2	.07	.50	1.17	.51	1.05
CR203	.06	.00	.00	.05	.00
MNO	.25	.26	.11	.45	.02
FEO	26.83	34.22	23.81	38.18	20.75
ZNO	.11	.00	.00	.00	.00
NA2O	.14	.00	.02	.00	.00
K20	.49	.77	4.07	1.60	3.88
CAO	.68	6.26	1.36	3.34	4.39
P2O5	.00	2.25	.03	.40	2.08
SO3	.07	.00	.11	.20	.00
TOTAL	85.43	71.92	84.98	71.11	84.73

ATOMIC PROPORTIONS (FORMULA ON THE BASIS OF 32 OXYGENS)

SI	7.802	4.567	7.299	4.672	7.097
AL	4.823	3.939	5.396	3.863	5.213
MG	3.169	2.530	2.710	2.562	2.369
TI	.013	.130	.222	.139	.197
CR	.012	.000	.000	.015	.000
MN	.052	.075	.024	.141	.003
FE	5.546	9.940	5.021	11.701	4.327
ZN	.020	.000	.000	.000	.000
NA	.066	.000	.011	.000	.000
K	.155	.339	1.311	.747	1.236
CA	.181	2.330	.366	1.311	1.174
P	.000	.661	.007	.124	.440
S	.013	.000	.022	.054	.000
TOTAL	21.852	24.511	22.389	25.329	22.056

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UNAL24A-N5.
WELL NAME/DEPTH: UNARK L24A/2966.36 M.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): 3a.1 is an analysis of an apple green glauconite pellet. 3b.1 is a brownish-green altered part of the same glauconite pellet. 4a.1 is an analysis of the altered glauconite(?).

	3A.1	3B.1	4A.1
OXIDE WEIGHT PERCENT			
SIO2	54.15	8.32	53.57
AL203	14.85	3.76	25.02
MGO	4.09	1.49	2.62
TIO2	.07	.00	.27
CR203	.07	.00	.41
MNO	.00	.18	.04
FEO	12.47	4.88	5.13
ZNO	.00	.05	.00
NA2O	.00	.00	.00
K20	8.18	.00	7.64
CAO	.48	37.11	.61
P2O5	.00	.33	.00
SO3	.10	.29	.23
TOTAL	94.46	56.41	95.54

ATOMIC PROPORTIONS (FORMULA ON THE BASIS OF 32 OXYGENS)

SI	11.023	3.757	10.292
AL	3.562	2.001	5.666
MG	1.240	1.002	.752
TI	.011	.000	.038
CR	.012	.000	.063
MN	.000	.069	.007
FE	2.123	1.840	.824
ZN	.000	.018	.000
NA	.000	.000	.000
K	2.125	.000	1.873
CA	.104	17.946	.125
P	.000	.127	.000
S	.015	.097	.034
TOTAL	20.215	26.857	19.674

ELECTRON MICROPROBE DATA

SAMPLE I.D.: Unal24a-N5
WELL NAME/DEPTH: Unark L24a/2966.36 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): 4B.1 is an analysis possibly of a volcanic rock fragment, 4C.1 and 4C.2 are analyses of different areas of another volcanic rock fragment.

	4B.1	4C.1	4C.2
OXIDE WEIGHT PERCENT			
SIO2	50.32	12.93	20.04
AL203	24.88	11.60	14.89
MGO	1.82	4.06	5.56
TIO2	.59	.53	.26
CR203	.11	.00	.00
MNO	.02	.68	.65
FEO	2.45	35.21	31.17
ZNO	.01	.00	.21
NA20	.15	.08	.00
K20	4.06	.52	.07
CAO	.91	4.68	4.28
P205	.00	.38	1.58
SO3	.23	.17	.00
TOTAL	85.55	70.84	78.71

ATOMIC PROPORTIONS (FORMULA ON THE BASIS OF 32 OXYGENS)

SI	10.412	4.604	5.839
AL	6.067	4.868	5.112
MG	.562	2.153	2.416
TI	.092	.143	.057
CR	.017	.000	.000
MN	.003	.206	.160
FE	.423	10.487	7.595
ZN	.001	.000	.045
NA	.061	.058	.000
K	1.073	.237	.027
CA	.202	1.788	1.335
P	.000	.113	.390
S	.036	.046	.000
TOTAL	18.949	24.703	22.976

ELECTRON MICROPROBE CARBONATE ANALYSES

SAMPLE I.D.: UnaL24a-N5
WELL NAME/DEPTH (M): Unark L24a/2966.36 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): CC1B.1 is an analysis of carbonate cement near a grain margin. CC1C.1 is an analysis of carbonate cement midway between grains. HM1.1 is a heavy mineral.

	CC1B.1	CC1C.1	HM1.1
OXIDE WEIGHT PERCENT			
MGO	2.17	1.25	.30
FEO	2.78	2.96	56.73
MNO	.28	.23	1.72
CAO	47.76	48.78	1.38
TOTAL	52.99	53.22	60.13
ATOMIC PROPORTIONS (FORMULA ON THE BASIS OF 2 OXYGENS)			
MG	.114	.065	.018
FE	.082	.087	1.867
MN	.008	.007	.057
CA	1.796	1.841	.058
TOTAL	2.000	2.000	2.000

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N6
WELL NAME/DEPTH: Sun BVX et al. Unark L24A-69-40-134-30/2967.26 m (9735.1 ft.).

INDURATION: good, either dry or immersed in water.
COLOUR: light grey with dark grey grains.
SEDIMENTARY STRUCTURES: good bedding plane parting.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 67

%gravel size: 0

%sand size: 55

%silt size: 10

%clay size: 2?

Cement %: 2% quartz overgrowths, trace pyrite, 1% kaolinite, 20% sparry calcite, 5% spar-sized dolomite.

Porosity %: 5

Modal Size: 0.2 mm.

Sorting: 16%/84% diameter ratio=
330 micrometres/ 100 micrometres = 3.3

Verbal Sorting Scale: moderately sorted.

GRAIN SIZE NAME: silty fine sandstone.

COMPOSITION: 20% monocrystalline quartz grains, 5% polycrystalline quartz grains, 25% chert clasts, 5% phylloid and siltstone clasts, 3% alkali feldspar grains, trace microcline, plagioclase, muscovite (partly replaced by carbonate) and apatite(?)f grains. Unidentified mud-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): calcite/dolomite/quartz/kaolinite-cemented silty fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: Pressure solution was an important early porosity-reducing mechanism as evidenced by the relatively high proportion of planar and concavo-convex contacts between quartzose grains. Mechanical compaction was of lesser importance because of the low proportion of ductile phylloid grains, though these have all been squeezed between the more competent grains. In addition, a number of the brittle grains have been compactionally fractured. Both pyrite framboids and

Kaolinite booklets (or dolomite pseudomorphs of kaolinite) were observed in relief in the alizarin red S etch surface in the calcite. Some of the pyrite was precipitated in the carbonate as planar structures along rhombohedral cleavage surfaces of the carbonate. Dolomite occurs throughout the calcite as islands and as a kind of delicate network. There is no clearly defined pore-lining and pore filling relationship between the calcite and dolomite which suggests that the calcite may be partly replaced by the dolomite or perhaps the calcite is dedolomite, though it does not preferentially occur in dolomite crystal cores. The carbonate fills the fractures of compactionally fractured grains which suggests a relatively late diagenetic origin for the carbonate cement. This is supported by textural relations which suggest extensive pressure solution between quartzose grains prior to carbonate cementation.

ELECTRON MICROPROBE CARBONATE ANALYSES

SAMPLE I.D.: UnaL24A-N6
WELL NAME/DEPTH (M): Unark L24A/2967.26.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): C2b.1 is an analysis of carbonate replacing a feldspar lath in a volcanic rock fragment. C3b.1, C4e.1 and C4e.2 are analyses of carbonate cement midway between framework grains. C3c.1 and C4d.1 are analyses of carbonate cement near the edge of a framework grain. In addition, analyses also suggest the presence of zircon and tourmaline as heavy mineral grains. A brown semi-opaque rock fragment was found to be a potassium-aluminum silicate with minor titanium and iron.

	C2B.1	C3B.1	C3C.1	C4D.1
OXIDE WEIGHT PERCENT				
MGO	.63	.56	.47	.43
FEO	1.74	1.43	1.39	1.26
MNO	.18	.26	.20	.28
CAO	43.85	50.16	49.79	51.30
TOTAL	46.40	52.41	51.85	53.27

ATOMIC PROPORTIONS.				
FORMULA (BASIS 2 OXYGENS).				
MG	.038	.030	.025	.022
FE	.059	.043	.042	.037
MN	.006	.008	.006	.008
CA	1.897	1.919	1.927	1.932
TOTAL	2.000	2.000	2.000	1.999

	C4E.1	C4E.2
OXIDE WEIGHT PERCENT		
MGO	.67	.35
FEO	1.53	1.28
MNO	.21	.32
CAO	48.46	51.99
TOTAL	50.87	53.94

ATOMIC PROPORTIONS.		
FORMULA (BASIS 2 OXYGENS).		
MG	.037	.018
FE	.047	.037
MN	.007	.010
CA	1.910	1.935
TOTAL	2.001	2.000

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N7
WELL NAME/DEPTH: Sun BVX et al. Unark L-24A-69-40-134-30/2968.84 m.

INDURATION: good, either when dry or immersed in water.
COLOUR: light brown.
SEDIMENTARY STRUCTURES: vague planar lamination is defined by a vertically-varying matrx content of silt and clay and by rare very thin mudstone laminae.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 71

%gravel size: 0

%sand size: 46

%silt size: 15

%clay size: 10

Cement %: 5% sparry carbonate (as cement and as grain-margin replacements), 2% kaolinite, trace (about 0.1%) pore-lining pyrite, 2% quartz overgrowths.

Porosity %: 20% (the thin section was made from core plug 38, for which a porosity of 15.3% and a permeability of 39.7 millidarcies was measured).

Modal Size: 0.1 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 40 micrometres = 7.5

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: muddy very fine sandstone.

COMPOSITION (excluding 2 thin mudstone laminae): 15% monocrystalline quartz grains, 3% polycrystalline quartz grains, 20% chert clasts, 3% alkali feldspar grains, 15% phylloid and siltstone clasts, 1% muscovite flakes (partly altered to carbonate, clays or chlorite), 1% coal grains, trace plagioclase, trace high-birefringent/high relief minerals, trace volcanic rock fragments containing feldspar laths, trace chlorite flakes, trace microcline.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): carbonate/kaolinite/quartz-cemented muddy very fine-grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: The porosity distribution is

approximately as follows; 3% is moldic, at least 2% is intragranular and 15% is intergranular. A moderate degree of mechanical compaction is evidenced by compactionally deformed (and rarely broken) ductile grains. Pressure solution is also visible in the nature of quartz/quartz grain contacts. It is of interest that the outlines of some of the grain molds are defined by adjacent ductile grains that were obviously deformed prior to the dissolution of the grains. This suggests that at least some of the moldic porosity was formed after a considerable depth of burial. Rhomb-shaped molds at grain margins and relict sparry carbonate (as cement and grain margin replacement) leaves little doubt that the dissolution of carbonate-replaced material was the means by which secondary porosity was formed. Whether there was a major event in which carbonate occluded porosity or whether a more gradual step-by-step process of carbonate cementation/replacement/dissolution at different times and depths operated is not clear. Other textual relations include pyrite framboids on quartz overgrowths and within some of the relict carbonate cement. In addition, kaolinite lines and to a lesser extent, fills pores of secondary origin. Compaction after secondary porosity development was negligible.

The surface of the section was impregnated with clear cyanoacrylate (in a sealed polyethylene bag) because grain plucking was excessive in the matrix-rich zones.

THIN SECTION MODAL AND GRAIN SIZE ANALYSIS

Sample I.D.: UnaL24a-N7

	No of Points	Percentage of Components	Percentages of Detrital Components
Detrital Components			
Monocrystalline Quartz	94	31.33	35.74
Polycrystalline Quartz	22	7.33	8.37
Clear Chert	63	21.00	23.95
Black Chert	8	2.67	3.04
Alkali Feldspar	25	8.33	9.51
Plagioclase	0	0.00	0.00
Phylloid Clasts	27	9.00	10.27
Volcanic Clasts	2	0.67	0.76
Chlorite	0	0.00	0.00
Mica	5	1.67	1.90
Siltstone Clasts	0	0.00	0.00
Coal	0	0.00	0.00
Unidentified (too small)	16	5.33	6.08
Other Clasts	1	0.33	0.38
Cements			
Kaolinite	0	0.00	
Carbonate	4	1.33	
Other	3	1.00	
Porosity			
Intergranular/ Moldic	28	9.33	

Intragranular	2	0.67

Plucked Grains: 20

Total number of points counted minus plucked grains= 300

GRAIN SIZE ANALYSIS

Sample I.D.: UnaL24a-n7

Class Interval (phi)	No. Freq of Max Apparent Grain Dimen-sion	Percentage Frequency	Cumulative Percentage Frequency
1.5 to 1.0	7	3.5	3.5
2.0 to 1.5	45	22.5	26.0
2.5 to 2.0	80	40.0	66.0
3.0 to 2.5	37	18.5	84.5
3.5 to 3.0	11	5.5	90.0
4.0 to 3.5	6	3.0	93.0
4.5 to 4.0	2	1.0	94.0
5.0 to 4.5	4	2.0	96.0
5.5 to 5.0	3	1.5	97.5
6.0 to 5.5	2	1.0	98.5
6.5 to 6.0	1	0.5	99.0
7.0 to 6.5	2	1.0	100.0

GRAPHIC GRAIN SIZE CUMULATIVE PERCENTILES IN PHI (MICROMETRE) UNITS OF SELECTED DETRITAL COMPONENTS

Sample I.D.: UnaL24a-N7

Percentiles	Phi Values	Micrometres
1	-	-
5	1.57	337
16	1.85	277

25	2.00	250	
50	2.31	202	(fine sand size)
75	2.72	152	
84	2.97	128	
95	4.73	38	

$$\text{Graphic Sorting (Inman)} = \frac{\text{Phi(84)} - \text{Phi(16)}}{2} = 0.56$$

Verbal Sorting Scale= moderately sorted

Total Number of Grains Measured= 200

Note: More clay-sized material is probably present than was detected by thin section grain size analysis. This could explain the discrepancy with the qualitative estimates. Modal analysis of the thin section suggests more monocrystalline quartz (31 rather than 15%), polycrystalline quartz (7 instead of 3%), and alkali feldspar (8 compared with 3%) than was qualitatively estimated. Kaolinite, which is observed in a sample fracture surface was not detected, however by thin section analysis.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N8
WELL NAME/DEPTH: Sun BVX et al. Unark
L24A-69-40-134-30/2969.61 m.

INDURATION: moderate when dry, disaggregates by itself a few minutes after immersion in water.
COLOUR: light grey with dark grey mottles.
SEDIMENTARY STRUCTURES: two (1 & 3 mm thick) mudstone laminae are interlaminated with the silty sandstone.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 69

%gravel size: 0

%sand size: 49

%silt size: 15

%clay size: 5?

Cement %: 10% mainly pore-lining kaolinite, trace pyrite framboids, 1% quartz overgrowths, trace sparry carbonate.

Porosity %: 20% (the sections were made from core plug 42, for which a porosity of 18.2% and a permeability of 20.6 millidarcies was measured).

Modal Size: 0.2 mm.

Sorting: 16%/84% diameter ratio=
300 micrometres/ 50 micrometres = 6

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME (of the silty sandstone): silty fine sandstone.

COMPOSITION (of the silty sandstone): 15% monocrystalline quartz grains, 10% polycrystalline quartz grains, 25% chert clasts, 10% phylloid and siltstone clasts, 1% plagioclase grains, 1% alkali feldspar grains, trace muscovite flakes, 1% coal clasts, trace chlorite grains, trace clasts of microcrystalline carbonate, trace microcline, trace volcanic rock fragments (with feldspar laths). Unidentified silt- and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): Kaolinite/quartz-cemented silty fine grained litharenite interlaminated with mudstone.

PETROGENESIS/ADDITIONAL INFORMATION: The porosity distribution is approximately as follows; 3% is moldic, at least 3% is

intragranular and 14% is intergranular. Over half of the intergranular porosity occurs as oversized and elongate pores of secondary origin. Rhombic molds at grain margins point to previous replacement by and later dissolution of sparry carbonate. Most of the mechanical compaction occurred prior to the development of secondary porosity, simply because the secondary pores are so well preserved. Pressure solution was also an important porosity reducing process, judging by the large proportion of planar contacts between quartzose grains. Other textural relations include pyrite framboids, both on quartz overgrowths and in oversized intergranular pores of secondary origin. Kaolinite lines and also fills pores of secondary origin, including grain molds. These relationships point to a late diagenetic origin for the kaolinite and pyrite.

Grain plucking was a problem in the mud-rich parts of the section, a problem that was minimised by impregnating the surface of the thin section with clear cyanoacrylate prior to final thinning. Staining of the epoxy was not carried out.

HAND SPECIMEN/THIN SECTION MICROSCOPE DESCRIPTION: MACKENZIE DELTA-BEAUFORT SEA SUBSURFACE CONVENTIONAL DRILL CORE SAMPLES.

SAMPLE IDENTIFICATION: UnaL24A-N9
WELL NAME/DEPTH: Sun BVX et al. Unark
L-24A-69-40-134-30/2976.31 m

INDURATION: good, either dry or immersed in water.
COLOUR: medium grey with very dark grey laminae.
SEDIMENTARY STRUCTURES: very low angle cross-stratification is defined by carbonaceous/micaceous films.

GRAIN SIZE/COMPOSITION (VOLUMETRIC ESTIMATES):
Terrigenous Constituent %: 70

%gravel size: 0

%sand size: 50

%silt size: 15

%clay size: 5?

Cement %: 25% sparry poikilotopic calcite, 1% pore-lining pyrite, 1% quartz overgrowths, 1%? kaolinite.

Porosity %: 2

Modal Size: 0.09 mm.

Sorting: 16%/84% diameter ratio=
200 micrometres/ 45 micrometres = 4.4

Verbal Sorting Scale: poorly sorted.

GRAIN SIZE NAME: silty very fine sandstone.

COMPOSITION: 15% monocrystalline quartz grains, 3% polycrystalline quartz grains, 20% chert clasts, 20% phylloid and siltstone clasts (in part replaced by calcite), 1% alkali feldspar grains, 2% muscovite flakes (many altered to carbonate and to a lesser extent chlorite and clays), 3% coal grains/films, trace unaltered glauconite pellets, trace clasts of microcrystalline dolomite, trace volcanic rock fragments (containing feldspar laths), trace plagioclase, trace high-birefringent/high-relief minerals. Unidentified silt and clay-sized material comprises the remainder.

ROCK NAME (cements, miscellaneous transported constituents, clan designation): calcite/pyrite-cemented coal and glauconite-bearing silty very fine grained litharenite.

PETROGENESIS/ADDITIONAL INFORMATION: Sparry calcite has almost occluded porosity. A clue to the timing of calcite cementation is found in grains that have been compactionally fractured. The

fractures propagate from the points of contact with adjacent grains indicating that the fractures are related to compaction. The fractures are filled with calcite cement, suggesting a considerable depth of burial prior to carbonate cementation. This is supported by a large proportion of compactionally squeezed ductile phylloid grains. Where the alizarin red staining solution has etched away calcite (to a depth of about 8 micrometres), pyrite (some of which is framboidal) and kaolinite(?) stand in relief. The sparry calcite, as in other examples, has replaced many of the grain margins (as rhomb-shaped indentations). Pore-filling calcite comprises about 20% while grain-replacing calcite comprises about 5%. To summarise, the pyrite, kaolinite and probably quartz overgrowths predate calcite cementation, which occurred at a considerable depth when primary porosity had been reduced to about 20%. The small amount of remaining porosity is distributed as isolated pores along one thin lamina and probably represents leached calcite cement, though the evidence is not conclusive.

The amount of calcite is underestimated in the stained section because the alizarin red stain etched away about 8 micrometres of calcite (compare with the unstained polished thin section).

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24a-N9
WELL NAME/DEPTH: Unark L24a/2976.31 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): RF1.1, RF1.2 and RF1.3 are analyses of different parts of the matrix of a volcanic rock fragment containing carbonate-replaced feldspar laths. HM3A.1 and HM3A.2 are analyses of different parts of a yellow-brown low-birefringent heavy mineral. In addition, a grain of rutile is suggested from analysis.

	RF1.1	RF1.2	RF1.3	HM3A.1	HM3A.2
OXIDE WEIGHT PERCENT					
SIO2	37.94	41.41	43.56	44.53	42.50
AL203	13.28	15.99	16.39	32.43	33.44
MGO	.52	.66	.38	6.35	6.59
TIO2	1.55	1.17	1.88	.50	.51
CR203	.06	.00	.10	.14	.22
MNO	.00	.05	.11	.03	.11
FEO	2.89	3.12	2.93	5.76	5.75
ZNO	.00	.00	.06	.00	.00
NA20	3.10	2.66	3.72	2.22	2.25
K20	3.19	3.26	3.03	.11	.07
CAO	16.94	12.59	11.67	.31	.34
P205	1.21	1.01	1.11	.00	.00
SO3	.00	.04	.00	.06	.08
TOTAL	80.68	81.96	84.94	92.44	91.86
ATOMIC PROPORTIONS (BASIS 22 ATOMS)					
SI	6.387	6.656	6.722	5.963	5.749
AL	2.636	3.029	2.980	5.118	5.331
MG	.129	.157	.087	1.267	1.328
TI	.196	.141	.218	.050	.051
CR	.008	.000	.012	.015	.024
MN	.000	.007	.014	.004	.012
FE	.406	.419	.378	.645	.651
ZN	.000	.000	.007	.000	.000
NA	1.011	.831	1.113	.576	.591
K	.685	.670	.597	.019	.011
CA	3.055	2.168	1.929	.044	.049
P	.172	.138	.145	.000	.000
S	.000	.005	.000	.006	.008
TOTAL	14.685	14.221	14.202	13.707	13.805

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24a-N9
WELL NAME/DEPTH: Unark L24a/2976.31 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): RF2B.1, RF2.B.2, RF2B.3 AND RF2B.4 are analyses possibly of a brown volcanic rock fragment. RF2C.1, RF2C.2 and RF2C.3 are analyses of a brown phylloid clast.

	RF2B.1	RF2B.2	RF2B.3	RF2B.4
OXIDE WEIGHT PERCENT				
SIO2	83.73	90.40	89.19	82.87
AL203	4.63	4.87	6.18	5.26
MGO	.00	.00	.00	.00
TIO2	.07	.50	.12	.10
CR203	.11	.05	.08	.00
MNO	.00	.05	.00	.00
FEO	.22	.23	.48	.40
ZNO	.30	.22	.92	1.00
NA20	.00	.11	.02	.00
K20	.61	.67	1.25	1.37
CAO	4.06	.43	.34	.38
P205	2.38	.00	.00	.00
SO3	.00	.74	1.36	1.80
TOTAL	96.11	98.27	99.94	94.21

ATOMIC PROPORTIONS (FORMULA, BASIS 32 OXYGENS)

SI	14.400	14.968	14.644	14.620
AL	.938	.951	1.195	1.079
MG	.000	.000	.000	.000
TI	.009	.062	.014	.013
CR	.015	.006	.011	.000
MN	.000	.006	.000	.000
FE	.032	.031	.066	.058
ZN	.038	.027	.111	.129
NA	.000	.034	.008	.000
K	.134	.141	.261	.305
CA	.749	.076	.060	.070
P	.346	.000	.000	.000
S	.000	.092	.168	.236
TOTAL	16.661	16.394	16.538	16.510

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24a-N9
WELL NAME/DEPTH: Unark L24a/2976.31 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): RF2C.1, RF2C.2 and RF2C.3 are analyses of a brown phylloid(?) grain.

	RF2C.1	RF2C.2	RF2C.3
OXIDE WEIGHT PERCENT			
SIO2	82.87	77.86	79.99
AL203	11.61	9.20	10.08
MGO	.85	.62	.79
TIO2	.32	.36	.55
CR203	.26	.20	.16
MNO	.03	.01	.11
FEO	.45	.48	.60
ZNO	.02	.01	.00
NA20	.27	.37	.64
K20	2.27	1.85	2.13
CAO	.36	.31	.31
P205	.00	.00	.00
SO3	.33	.26	.38
TOTAL	99.64	91.53	95.74
ATOMIC PROPORTIONS (BASIS 22 ATOMS)			
SI	13.842	14.112	13.929
AL	2.286	1.966	2.068
MG	.212	.168	.205
TI	.040	.049	.073
CR	.034	.029	.022
MN	.005	.001	.017
FE	.063	.072	.088
ZN	.002	.001	.000
NA	.086	.129	.215
K	.483	.428	.473
CA	.065	.060	.058
P	.000	.000	.000
S	.042	.035	.050
TOTAL	17.160	17.050	17.198

ELECTRON MICROPROBE DATA

SAMPLE I.D.: UnaL24a-N9.
WELL NAME/DEPTH: Unark L24a/2976.31 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): RF3B.1 and RF3B.2 are analyses of different parts of a semi-opaque dark brown phylloid(?) clast. GL4A.1 and GL4A.2 are analyses of 2 different areas of a glauconite grain.

	RF3B.1	RF3B.2	GL4A.1	GL4A.2
OXIDE WEIGHT PERCENT				
SIO2	64.35	63.89	54.78	54.23
AL203	11.57	8.51	19.77	19.81
MGO	.97	.71	3.21	3.22
TIO2	.66	.43	.14	.19
CR203	.14	.25	.05	.13
MNO	.04	.13	.00	.00
FEO	1.15	1.13	9.43	9.40
ZNO	.01	.03	.00	.00
NA2O	.00	.10	.41	.52
K20	1.99	1.42	6.66	6.69
CAO	6.47	11.04	.58	.63
P2O5	.31	.31	.00	.00
SO3	.14	.12	.15	.14
TOTAL	87.80	88.07	95.18	94.96

ATOMIC PROPORTIONS (BASIS 22 ATOMS)

SI	8.741	8.804	7.390	7.349
AL	1.853	1.382	3.143	3.164
MG	.196	.146	.645	.650
TI	.068	.044	.014	.020
CR	.015	.028	.006	.013
MN	.005	.015	.000	.000
FE	.131	.131	1.064	1.065
ZN	.001	.003	.000	.000
NA	.000	.027	.107	.138
K	.344	.250	1.147	1.156
CA	.941	1.630	.085	.092
P	.036	.036	.000	.000
S	.015	.012	.016	.015
TOTAL	12.346	12.508	13.617	13.662

ELECTRON MICROPROBE CARBONATE ANALYSES

SAMPLE I.D.: UnaL24a-N9
WELL NAME/DEPTH (M): Unark L24a/2976.31 m.
LEGEND FOR ANALYZED MATERIAL (COLUMN HEADINGS): CC4b.1 and CC4b.2 are analyses of calcite cement near a grain margin. CC4c.1 is an analysis of of calcite cement midway between grains.

	CC4B.1	CC4B.2	CC4C.1
OXIDE WEIGHT PERCENT			
MGO	1.78	1.87	2.18
FEO	3.09	2.91	3.17
MNO	.29	.21	.23
CAO	44.79	45.52	46.43
TOTAL	49.95	50.51	52.01

ATOMIC PROPORTIONS.			
FORMULA (BASIS 2 OXYGENS)			
MG	.099	.103	.116
FE	.097	.090	.095
MN	.009	.007	.007
CA	1.795	1.800	1.781
TOTAL	2.000	2.000	1.999