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Abstract: Pore-size distribution analysis was performed on twenty-eight sediment samples from the Mallik 5L-38 research well, Northwest Territories. This study includes analysis and interpretation of pore-size distribution data obtained by mercury-injection porosimetry measurements. The purpose of this paper is to document, within the framework of the JAPEX/JNOC/GSC Mallik Gas Hydrate Research Project, results of pore-size analysis and to provide pore-structure information on the sediments.

The mercury porosity, storage, and connecting porosity values are in the ranges of 7.71–47.41%, 0.43–46.48%, and 0.61–12.9%, respectively. There are two prominent pore-size distribution modes visible related to grain-size distribution differences. There are six anomalous fine sand and silty sand samples (P2EJA-11,-17, -21, -22, -27, and -28) that have considerably higher storage porosities (30%).

Résumé : Une analyse de la distribution de la taille des pores a été effectuée pour 28 échantillons de sédiments prélevés au puits de recherche Mallik 5L-38, dans les Territoires du Nord-Ouest. Cette étude comprenait l'analyse et l'interprétation des données sur la distribution de la taille des pores obtenues par des mesures porosimétriques par injection de mercure. Le présent article a pour objet la documentation des résultats de l'analyse porosimétrique et la présentation d'information sur la structure des pores des sédiments dans le cadre du projet de recherche sur les hydrates de gaz JAPEX/JNOC/GSC Mallik.

Les valeurs de la porosité mesurée au mercure, de la porosité close et de la porosité ouverte s'établissent respectivement à l'intérieur des plages de 7,71 à 47,41 %, de 0,43 à 46,48 % et de 0,61 à 12,9 %. On a reconnu deux modes dominants de distribution de la taille des pores qui sont reliés à des différences de distribution de la taille des grains. Six échantillons anomaux de sable fin et de sable silteux (P2EJA-11,-17, -21, -22, -27 et -28) présentent des porosités closes considérablement plus élevées (30 %).

INTRODUCTION

Pore-size distribution analysis was performed on twenty-eight sediment samples from the Mallik 5L-38 research well, Northwest Territories. These samples were collected from a depth range of 908.1–1089.9 m (Table 1). This study consists of analysis and interpretation of pore-size distribution data obtained by mercury-injection porosimetry measurements. The purpose of this paper is to document the details of data that was used in more generalized papers (Katsube et al., 2005; Winters et al., 2005) for the JAPEX/JNOC/GSC Mallik Gas Hydrate Research Project.

METHOD OF INVESTIGATION

Specimens taken from each of the twenty-eight samples (as listed in Table 1) were prepared for mercury-injection porosimetry (Washburn, 1921; Rootare, 1970) tests by the AGAT Laboratories (Calgary, Alberta). At the AGAT Laboratories, each specimen was oven dried at 80ºC and then individually placed in a penetrometer assembly under vacuum. The penetrometer was then filled with mercury at a hydrostatic head of approximately 10 kPa. The volume of the mercury injected is recorded after stabilization at each pressure step up to 414 MPa (60 000 psi) at which time the mercury is assumed to have accessed connecting pores as small as 2.5–3.0 nm (Katsube and Issler, 1993). Other related parameters were also determined, using this data, such as storage porosity (ϕ_s) and connecting porosity (ϕ_c) and others as shown in the tables. Details of the determination procedures are described elsewhere (Katsube et al., 1997, 1998).

Table 1. Sample descriptions.

Sample number	Depth (m)	Lithology	Consolidation
P2EJA-11	908.1	Fine sand	Unconsolidated
P2EJA-26	910.6	Fine sand	Unconsolidated
P2EJA-16	916.2	Fine sand	Unconsolidated
P2EJA-17	919.0	Fine sand	Unconsolidated
P2EJA-21	920.8	Fine sand	Unconsolidated
P2EJA-27	925.1	Fine sand	Unconsolidated
P2EJA-7	927.4	Fine sand	Unconsolidated
P2EJA-25	933.6	Clay	Consolidated
P2EJA-4	937.5	Clay	Semiconsolidated
P2EJA-13	939.9	Clay	Consolidated
P2EJA-19	953.5	Silty sand	Semi-consolidated
P2EJA-2	955.7	Medium sand	Unconsolidated
P2EJA-20	972.1	Clay	Consolidated
P2EJA-14	973.1	Sand with organic material	Semiconsolidated
P2EJA-22	975.7	Silty sand	Unconsolidated
P2EJA-5	980.7	Fine sand	Unconsolidated
P2EJA-10	982.6	Clay	Consolidated
P2EJA-28	987.5	Fine sand	Unconsolidated
P2EJA-1	989.7	Fine sand	Unconsolidated
P2EJA-8	1 004.9	Clay	Consolidated
P2EJA-24	1 022.4	Fine sand	Unconsolidated
P2EJA-15	1 028.8	Clay	Consolidated
P2EJA-9	1 042.1	Clay	Consolidated
P2EJA-18	1 063.5	Organic shale, clayey coal	Consolidated
P2EJA-12	1 072.8	Silty sand	Consolidated
P2EJA-6	1 076.6	Fine sand	Unconsolidated
P2EJA-3	1 083.5	Clay	Semiconsolidated
P2EJA-23	1 089.9	Fine sand	Unconsolidated

ANALYTICAL RESULTS

The results of the mercury-injection porosimetry tests are listed in Table 2a, b, c, d. The results are also plotted in Figures 1 and 2, in accordance with a standard format (Katsube and Issler, 1993), where one decade of pore sizes are divided into five cells of equal physical spacing. The partial porosity, ϕ_a (Fig. 1, 2; Table 2), is the porosity of each cell or the porosity contributed by each pore-size range (d), used in the pore-size distribution plots. The pore-size parameter, d_a , is the geometric mean for each cell or pore-size range in nanometres. The data for the bulk parameters derived from the pore-size distributions are listed in the lower section of the tables. They represent mercury porosity (ϕ_{Hg}), bulk density (δ_{BD}), skeletal density (δ_{SD}), pore surface area (A), residual or storage porosity (ϕ_s), residual porosity ratio (ϕ_{rr}), connecting porosity (ϕ_c), and mode of pore-size distribution (d_m) of the dry sample. The definition of these parameters can be found elsewhere (Katsube et al., 1997, 1998) and at the bottom of the tables. Following usual analytical procedures for mercury porosimetry (Katsube and Issler, 1993), two ϕ_{Hg} values are determined, one (ϕ_{Hg1}) for the pore-size range of 2.5 nm to 10 µm and another (ϕ_{Hg2}) for the pore-size range of 2.5 nm to 250 µm. This is to eliminate the instrumental error that enters into the micropore range (10–250 µm) of ϕ_{Hg2}, but is excluded in ϕ_{Hg1} (Katsube and Issler, 1993; Katsube et al., 1999). The $\phi_{Hg}1$ is used to represent ϕ_{Hg} for tight rocks with little porosity in the micropore range and ϕ_{Hg2} is used for the same purpose for rocks with larger porosities (>2.0%) in the same pore-size range since the instrumental error in that case is insignificant (Katsube and Issler, 1993). Both mercury porosities ϕ_{Hg1} and ϕ_{Hg2} were used in the ϕ_s and ϕ_c determinations. The values are listed in Table 2 as ϕ_{s1}, ϕ_{c1}, ϕ_{s2}, and ϕ_{c2}.

DISCUSSION AND CONCLUSIONS

The mercury-porosity values (ϕ_{Hg1} and ϕ_{Hg2}) are in the ranges of 0.13–20.37% and 7.71–47.41%, respectively. In this study, ϕ_{Hg2} has been used to represent the porosity characteristics in some cases since ϕ_{Hg2} is larger than ϕ_{Hg1} by more than 2.0%, for the majority of the samples. The storage porosity

Table 2a. Pore-size distribution data for different pore-size ranges, d_a, obtained by mercury porosimetry for samples obtained from the Mallik 5L-38 well, Northwest Territories.

		P2-EJA-1	P2-EJA-2	P2-EJA-3	P2-EJA-4	P2-EJA-5	P2-EJA-6	P2-EJA-7
d (nm)	d_a (nm)	ϕ_a (%)						
2.5–4.0	3.2	0.40	0.61	0.00	0.04	0.01	0.11	0.17
4.0–6.3	5.0	0.04	1.08	0.02	0.01	0.08	0.16	0.07
6.3–10	7.9	0.62	0.75	0.04	0.02	0.08	0.15	0.07
10–16	12.6	0.43	0.43	0.01	0.01	0.05	0.10	0.05
16–25	20.0	0.33	0.32	0.02	0.01	0.08	0.05	0.07
25–40	31.6	0.01	0.38	0.02	0.03	0.08	0.44	0.07
40–63	50.1	0.01	0.23	0.01	0.01	0.08	0.44	0.07
63–100	79.4	0.02	0.16	0.00	0.01	0.05	0.29	0.05
100–160	126	0.03	0.23	1.39	0.01	0.08	0.07	0.07
160–250	200	0.03	0.20	3.24	0.81	0.08	0.04	0.07
250–400	316	0.03	0.25	4.31	3.06	0.08	0.03	0.17
400–630	501	0.02	0.18	2.47	1.92	0.05	0.07	0.17
630–1 000	794	0.02	0.32	2.18	2.78	0.08	0.07	0.15
1 000–1 600	1 259	0.03	0.45	1.38	1.94	0.08	0.01	0.12
1 600–2 500	1 995	0.02	0.36	0.55	0.92	0.05	0.01	0.16
2 500–4 000	3 162	0.02	0.54	0.57	1.02	0.08	0.08	0.07
4 000–6 300	5 012	0.02	0.38	0.51	0.63	0.08	0.07	0.31
6 300–10 000	7 943	0.03	0.25	0.44	0.55	0.08	0.09	0.42
10 000–16 000	12 589	0.03	1.06	0.42	0.59	0.08	0.03	0.32
16 000–25 000	19 953	0.04	0.97	0.28	0.35	0.05	0.01	0.20
25 000– 40 000	31 623	0.04	2.67	0.44	0.45	0.08	0.02	0.33
40 000–63 000	50 119	0.10	6.21	0.38	0.43	0.08	1.94	0.42
63 000–100 000	79 433	5.20	5.94	0.28	0.31	0.02	3.91	0.46
100 000–160 000	125 893	7.40	4.34	0.20	0.25	6.17	2.33	5.21
ϕ_{Hg1}		2.11	7.11	17.19	13.79	1.23	2.28	2.33
ϕ_{Hg2}		15.02	28.30	19.17	16.16	7.71	10.54	9.27
d_{Hg}		28 280.9	11 197.5	756.6	1 411.5	36 492.8	17 231.9	23 157.8
δ_{BD}		1.484	2.258	1.978	2.043	1.229	1.463	1.359
δ_{SD}		1.734	3.149	2.434	2.425	1.327	1.631	1.493
A		5.859	9.057	1.138	0.732	1.296	2.758	2.312
ϕ_{s1}		0.34	6.12	11.59	10.83	0.07	1.92	0.58
ϕ_{c1}		1.77	0.99	5.60	2.96	1.16	0.36	1.75
ϕ_{rr1}		0.16	0.86	0.67	0.79	0.06	0.84	0.25
ϕ_{s2}		2.42	24.37	12.92	12.69	0.43	8.90	2.31
ϕ_{c2}		12.60	3.93	6.24	3.47	7.28	1.64	6.96
d_m		125 893	50 119	316	316	125 893	79 433	125 893

d = Pore-size range (nm).
d_a = Geometric mean pore sizes for the different pore-size ranges (nm).
d_{hg} = Geometric mean of the entire pore-size distribution (nm).
ϕ_a = Partial porosity (%).
ϕ_{Hg1} = Total porosity measured by mercury porosimetry for pore sizes up to 10 μm (%).
ϕ_{Hg2} = Total porosity measured by mercury porosimetry for pore sizes up to 250 μm (%).
δ_{BD} = Bulk density (g/mL).
δ_{SD} = Skeletal density (g/mL).
A = Surface area (m^2/g).
ϕ_1 = Storage porosity (%) calculated using ϕ_{Hg1}.
ϕ_{c1} = Connecting porosity (%) calculated using ϕ_{Hg1}.
ϕ_{rr1} = Residual or isolated porosity (%) calculated using ϕ_{Hg1}.
ϕ_{s2} = Storage porosity (%) calculated using ϕ_{Hg2}.
ϕ_{c2} = Connecting porosity (%) calculated using ϕ_{Hg2}.
d_m = Pore size of the major pore-size mode, d (nm).

Table 2b.

d_a (nm)	P2-EJA-8	P2-EJA-9	P2-EJA-10	P2-EJA-11	P2-EJA-12	P2-EJA-13	P2-EJA-14
	ϕ_a (%)						
3.2	0.60	0.02	0.13	0.01	0.00	0.17	0.02
5.0	0.05	0.02	0.10	0.00	0.06	0.04	0.08
7.9	0.02	0.10	0.06	0.00	0.11	0.04	0.04
12.6	0.02	0.04	0.07	0.00	0.06	0.03	0.04
20.0	0.08	0.06	0.10	0.00	0.29	0.06	0.05
31.6	0.26	0.68	0.12	0.08	0.04	0.10	0.73
50.1	0.03	4.48	0.27	0.14	0.04	0.07	0.05
79.4	0.02	3.74	0.81	0.16	0.04	0.04	0.05
126	2.54	5.93	2.87	0.41	0.03	0.20	0.07
200	5.25	1.65	3.35	0.58	0.15	3.04	0.06
316	4.24	0.58	3.08	0.76	0.17	3.53	0.02
501	0.54	0.25	1.62	0.56	0.40	2.53	0.05
794	0.45	0.33	1.79	0.98	0.11	3.69	0.29
1 259	0.35	0.25	0.96	1.08	0.03	0.94	0.98
1 995	0.32	0.17	0.54	0.73	0.01	0.49	0.59
3 162	0.37	0.23	0.75	1.31	0.03	0.43	1.09
5 012	0.30	0.16	0.67	1.64	0.03	0.88	1.24
7 943	0.27	0.48	0.27	2.26	0.03	0.41	1.84
12 589	0.34	0.56	0.25	3.53	4.57	0.39	2.35
19 953	0.22	0.33	0.17	6.96	2.90	0.14	1.96
31 623	0.35	0.35	0.25	13.28	2.60	0.18	4.28
50 119	0.29	0.23	0.17	2.97	2.50	0.12	6.17
79 433	0.24	0.16	0.10	2.39	1.46	0.08	4.20
125 893	0.20	0.14	0.08	1.69	1.24	0.06	3.32
ϕ_{Hg1}	15.73	19.16	17.54	10.71	1.63	16.71	7.30
ϕ_{Hg2}	17.36	20.93	18.56	41.52	16.88	17.67	29.58
d_{hg}	390.4	193.9	442.9	15 809.3	17 935.4	651.7	20 087.5
δ_{BD}	1.684	1.938	1.923	1.561	1.655	1.963	1.629
δ_{SD}	2.004	2.438	2.349	2.655	1.980	2.373	2.287
A	5.562	4.508	2.830	0.548	1.106	2.037	1.331
ϕ_{s1}	7.66	12.26	10.33	10.55	1.13	10.19	6.57
ϕ_{c1}	8.07	6.90	7.21	0.16	0.50	6.52	0.73
ϕ_{rr1}	0.49	0.64	0.59	0.99	0.69	0.61	0.90
ϕ_{s2}	8.46	13.39	10.93	40.91	11.67	10.77	26.63
ϕ_{c2}	8.90	7.35	7.63	0.61	5.21	6.89	2.95
d_m	200	126	200	31 623	12 589	794	50 119

d = Pore-size range (nm). *See* column 1 in Table 2a.
d_a = Geometric mean pore sizes for the different pore-size ranges (nm).
d_{hg} = Geometric mean of the entire pore-size distribution (nm).
ϕ_a = Partial porosity (%).
ϕ_{Hg1} = Total porosity measured by mercury porosimetry for pore sizes up to 10 μm (%).
ϕ_{Hg2} = Total porosity measured by mercury porosimetry for pore sizes up to 250 μm (%).
δ_{BD} = Bulk density (g/mL).
δ_{SD} = Skeletal density (g/mL).
A = Surface area (m^2/g).
ϕ_{s1} = Storage porosity (%) calculated using ϕ_{Hg1}.
ϕ_{c1} = Connecting porosity (%) calculated using ϕ_{Hg1}.
ϕ_{rr1} = Residual or isolated porosity (%) calculated using ϕ_{Hg1}.
ϕ_{s2} = Storage porosity (%) calculated using ϕ_{Hg2}.
ϕ_{c2} = Connecting porosity (%) calculated using ϕ_{Hg2}.
d_m = Pore size of the major pore-size mode, d (nm).

Table 2c.

d_a (nm)	P2-EJA-15	P2-EJA-16	P2-EJA-17	P2-EJA-18	P2-EJA-19	P2-EJA-20	P2-EJA-21
	ϕ_a (%)						
3.2	0.08	0.60	0.00	0.03	0.00	0.41	0.00
5.0	0.08	0.36	0.02	0.03	0.00	0.32	0.00
7.9	0.04	0.83	0.02	0.03	0.01	0.04	0.00
12.6	0.03	0.53	0.03	0.03	0.01	0.16	0.00
20.0	0.04	0.04	0.02	0.03	0.01	0.26	0.00
31.6	0.03	0.03	0.02	0.95	0.02	0.09	0.00
50.1	0.02	0.03	0.02	3.28	0.02	0.06	0.01
79.4	0.99	0.02	0.01	2.77	0.02	0.05	0.01
126	5.71	0.03	0.02	4.33	0.02	0.06	0.01
200	8.58	0.03	0.03	3.42	0.02	2.02	0.01
316	2.42	0.03	0.03	1.60	0.01	3.28	0.01
501	0.33	0.02	0.02	0.47	0.02	2.03	0.01
794	0.47	0.03	0.03	0.59	0.02	2.87	0.01
1 259	0.57	0.03	0.02	0.44	0.02	2.19	0.01
1 995	0.26	0.02	0.02	0.32	0.01	1.39	0.01
3 162	0.45	0.03	0.03	0.57	0.52	0.94	0.01
5 012	0.08	0.03	0.03	0.42	1.60	0.25	0.02
7 943	0.20	0.01	0.02	0.34	3.28	0.63	0.01
12 589	0.30	1.31	0.75	0.36	5.02	0.98	0.01
19 953	0.16	5.36	1.52	0.24	6.16	0.37	0.03
31 623	0.24	0.08	6.71	0.18	2.93	0.47	3.51
50 119	0.18	1.42	30.75	0.20	3.39	0.49	25.01
79 433	0.10	0.11	5.91	0.08	1.73	0.22	4.24
125 893	0.20	0.06	1.35	0.12	1.27	0.18	0.55
ϕ_{Hg1}	20.37	2.71	0.41	19.64	5.59	17.07	0.13
ϕ_{Hg2}	21.53	11.05	47.41	20.83	26.08	19.77	34.47
d_{hg}	284.8	8 104.4	48 553.2	226.3	20 850.6	897.4	53 921.2
δ_{BD}	1.968	1.323	1.519	2.022	1.583	1.955	1.432
δ_{SD}	2.503	1.477	2.824	2.544	2.121	2.428	2.154
A	2.962	10.67	0.312	3.697	0.132	4.553	0.065
ϕ_{s1}	11.47	0.47	0.40	12.48	3.36	12.20	0.12
ϕ_{c1}	8.90	2.24	0.01	7.16	2.23	4.87	0.01
ϕ_{rr1}	0.56	0.17	0.98	0.64	0.60	0.71	0.93
ϕ_{s2}	12.13	1.93	46.50	13.24	15.69	14.13	32.07
ϕ_{c2}	9.40	9.12	0.93	7.59	10.39	5.64	2.39
d_m	200	19 953	50 119	126	19 953	316	50 119

d = Pore-size range (nm). *See* column 1 in Table 2a.
d_a = Geometric mean pore sizes for the different pore-size ranges (nm).
d_{hg} = Geometric mean of the entire pore-size distribution (nm).
ϕ_a = Partial porosity (%).
ϕ_{Hg1} = Total porosity measured by mercury porosimetry for pore sizes up to 10 μm (%).
ϕ_{Hg2} = Total porosity measured by mercury porosimetry for pore sizes up to 250 μm (%).
δ_{BD} = Bulk density (g/mL).
δ_{SD} = Skeletal density (g/mL).
A = Surface area (m^2/g).
ϕ_{s1} = Storage porosity (%) calculated using ϕ_{Hg1}.
ϕ_{c1} = Connecting porosity (%) calculated using ϕ_{Hg1}.
ϕ_{rr1} = Residual or isolated porosity (%) calculated using ϕ_{Hg1}.
ϕ_{s2} = Storage porosity (%) calculated using ϕ_{Hg2}.
ϕ_{c2} = Connecting porosity (%) calculated using ϕ_{Hg2}.
d_m = Pore size of the major pore-size mode, d (nm).

Table 2d.

d_a (nm)	P2-EJA-22	P2-EJA-23	P2-EJA-24	P2-EJA-25	P2-EJA-26	P2-EJA-27	P2-EJA-28
	ϕ_a (%)						
3.2	0.00	0.01	0.49	0.04	0.00	0.33	0.02
5.0	0.01	0.01	0.44	0.12	0.01	0.30	0.16
7.9	0.02	0.01	0.12	0.02	0.01	0.38	0.31
12.6	0.04	0.00	0.11	0.13	0.01	0.30	0.21
20.0	0.20	0.01	0.11	0.03	0.02	0.44	0.41
31.6	0.07	0.01	0.08	0.03	0.01	0.37	0.33
50.1	0.05	0.01	0.05	0.05	0.02	0.33	0.43
79.4	0.03	0.01	0.02	0.11	0.01	0.33	0.31
126	0.05	0.02	0.07	0.23	0.02	0.61	0.57
200	0.05	0.04	0.03	2.57	0.01	0.73	0.71
316	0.05	0.09	0.08	3.67	0.01	0.87	1.00
501	0.08	0.05	0.03	2.47	0.02	0.58	0.72
794	0.22	0.20	0.03	2.25	0.01	1.01	1.31
1 259	0.93	6.32	0.05	0.70	0.02	1.24	1.53
1 995	0.61	0.03	0.05	0.24	0.02	0.91	1.03
3 162	0.81	0.04	0.03	0.35	0.04	1.78	1.76
5 012	0.70	0.04	0.05	0.33	0.02	2.27	1.76
7 943	1.35	0.05	0.05	0.44	0.05	5.05	2.84
12 589	1.80	0.02	0.05	0.52	0.03	5.28	4.33
19 953	1.77	0.02	0.03	0.29	0.01	3.13	6.97
31 623	4.05	4.85	4.48	0.44	0.04	4.20	8.37
50 119	8.72	8.78	4.26	0.33	0.09	3.86	2.56
79 433	10.68	2.06	1.98	0.23	8.75	1.59	0.89
125 893	9.19	1.08	0.96	0.15	7.87	0.74	0.62
ϕ_{Hg1}	5.28	6.94	1.89	13.75	0.29	17.85	15.41
ϕ_{Hg2}	41.48	23.91	13.64	15.26	17.08	36.76	39.15
d_{hg}	38 993.5	17 806.4	16 995.1	694.2	83 110.2	5 980.7	7 220.1
δ_{BD}	1.552	1.714	1.479	1.479	1.792	1.749	1.641
δ_{SD}	2.622	2.241	1.706	1.706	2.140	2.770	2.697
A	0.646	0.201	6.627	2.155	0.108	6.093	3.422
ϕ_{s1}	5.20	3.64	0.42	8.71	0.07	15.97	14.07
ϕ_{c1}	0.08	3.30	1.47	5.04	0.22	1.88	1.34
ϕ_{rr1}	0.98	0.53	0.22	0.63	0.24	0.89	0.91
ϕ_{s2}	40.82	12.55	3.00	9.67	4.18	32.89	35.76
ϕ_{c2}	0.67	11.35	10.64	5.60	12.90	3.87	3.40
d_m	79 433	1 259	31 623	316	79 433	12 589	31 623

d = Pore-size range (nm). *See* column 1 in Table 2a.
d_a = Geometric mean pore sizes for the different pore-size ranges (nm).
d_{hg} = Geometric mean of the entire pore-size distribution (nm).
ϕ_a = Partial porosity (%).
ϕ_{Hg1} = Total porosity measured by mercury porosimetry for pore sizes up to 10 µm (%).
ϕ_{Hg2} = Total porosity measured by mercury porosimetry for pore sizes up to 250 µm (%).
δ_{BD} = Bulk density (g/mL).
δ_{SD} = Skeletal density (g/mL).
A = Surface area (m^2/g).
ϕ_{s1} = Storage porosity (%) calculated using ϕ_{Hg1}.
ϕ_{c1} = Connecting porosity (%) calculated using ϕ_{Hg1}.
ϕ_{rr1} = Residual or isolated porosity (%) calculated using ϕ_{Hg1}.
ϕ_{s2} = Storage porosity (%) calculated using ϕ_{Hg2}.
ϕ_{c2} = Connecting porosity (%) calculated using ϕ_{Hg2}.
d_m = Pore size of the major pore-size mode, d (nm).

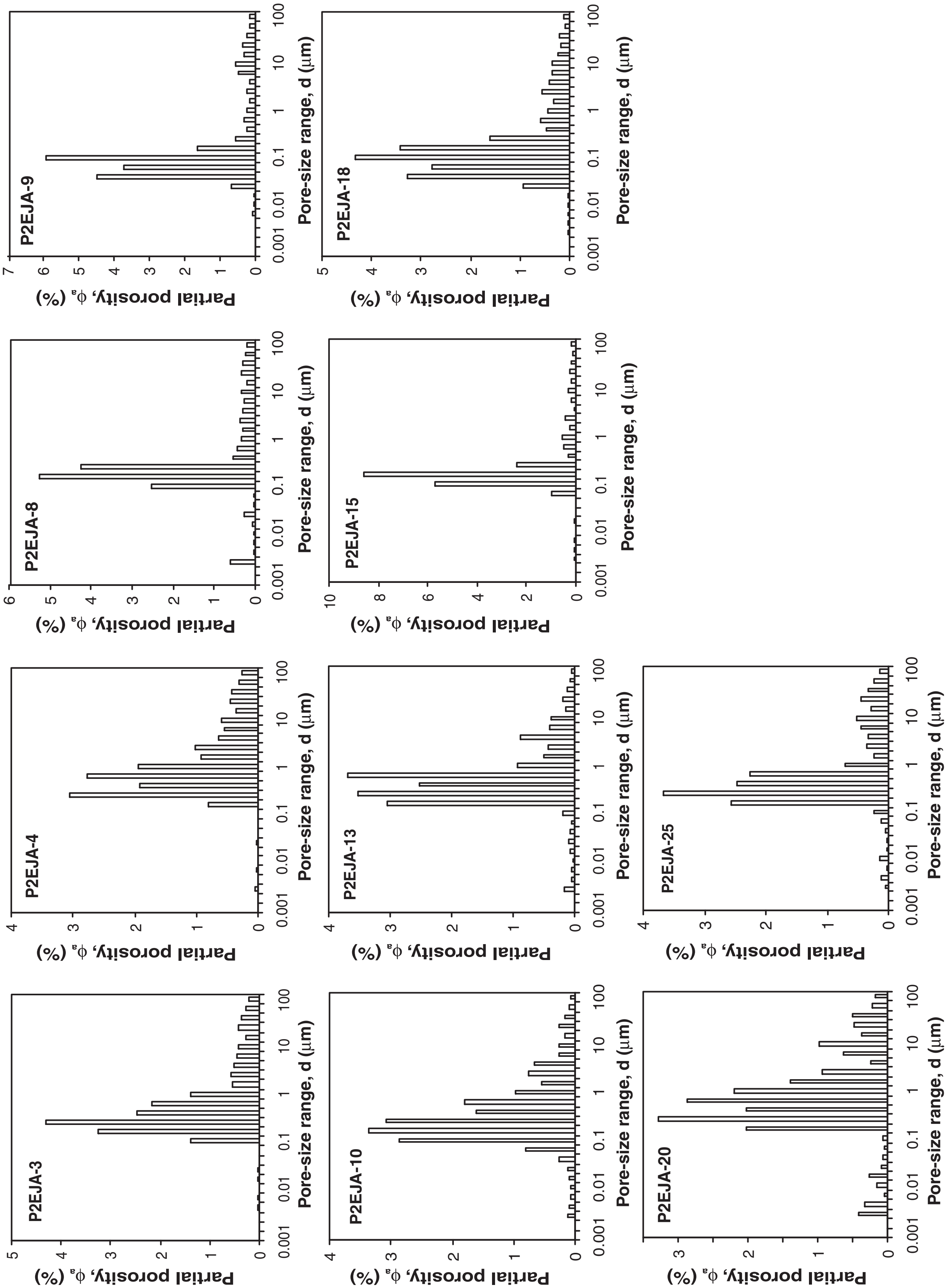

Figure 1. Pore-size distribution plots for clay samples.

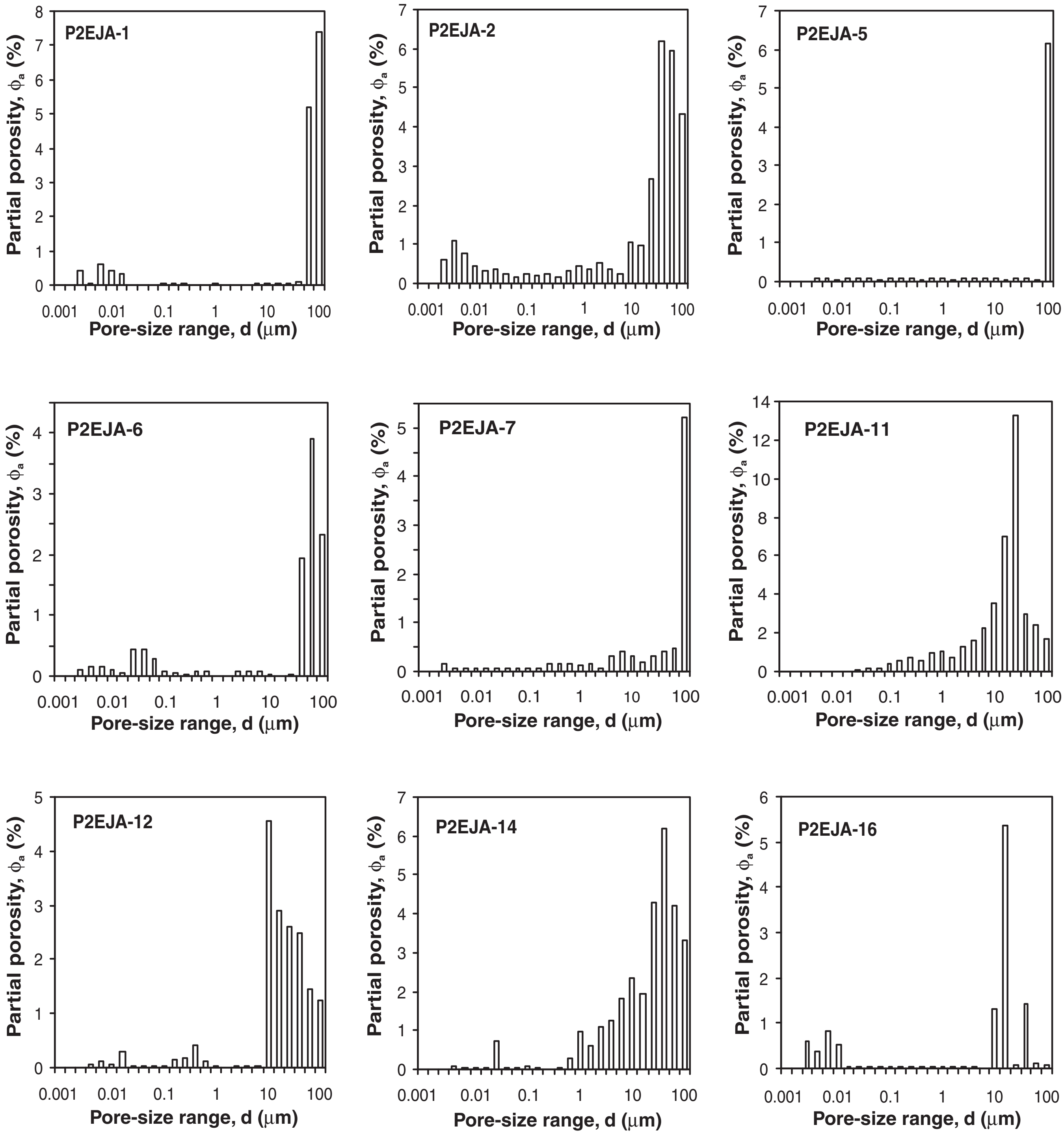

Figure 2. Pore-size distribution plots for sandy samples.

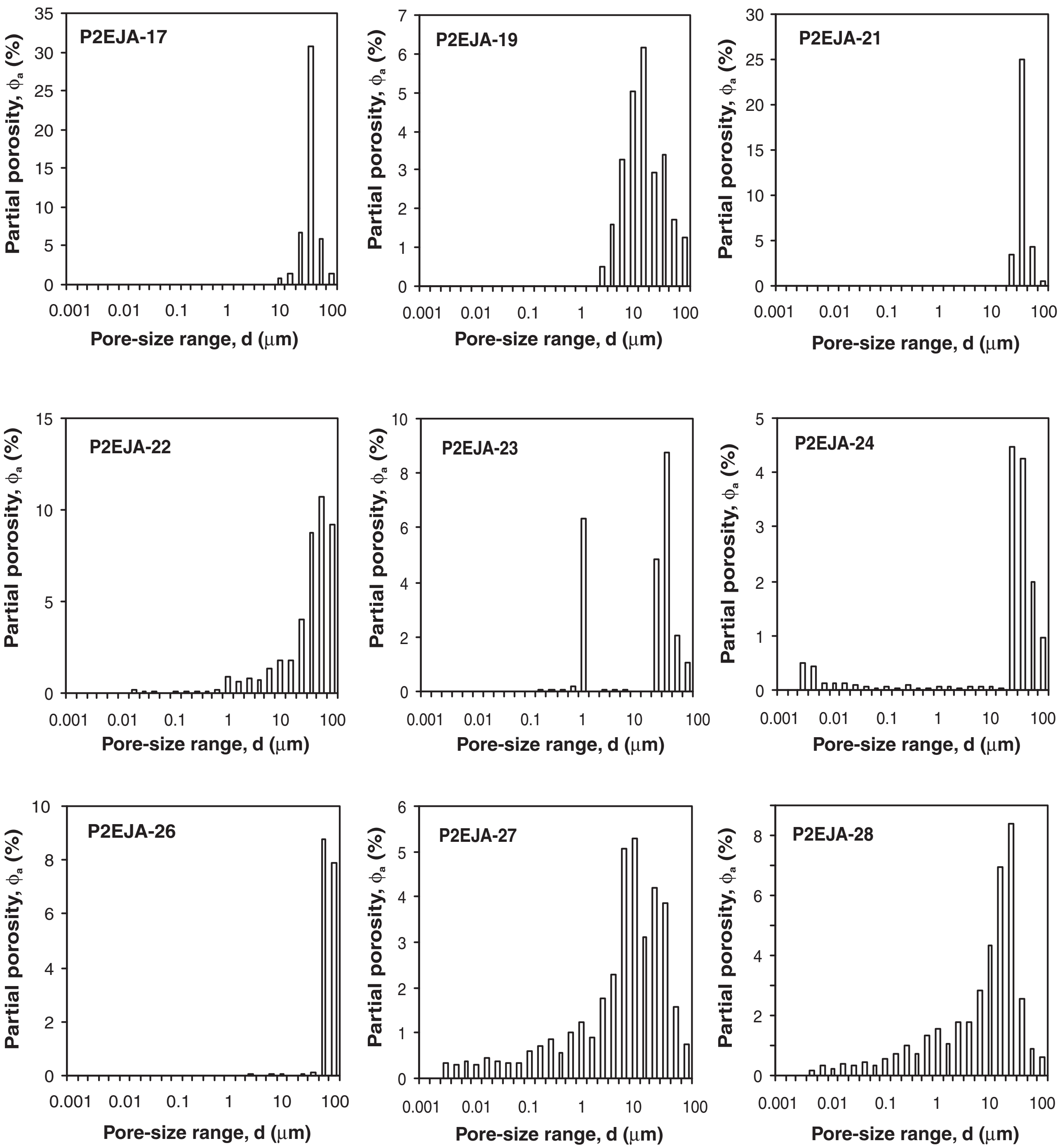

Figure 2 (cont.)

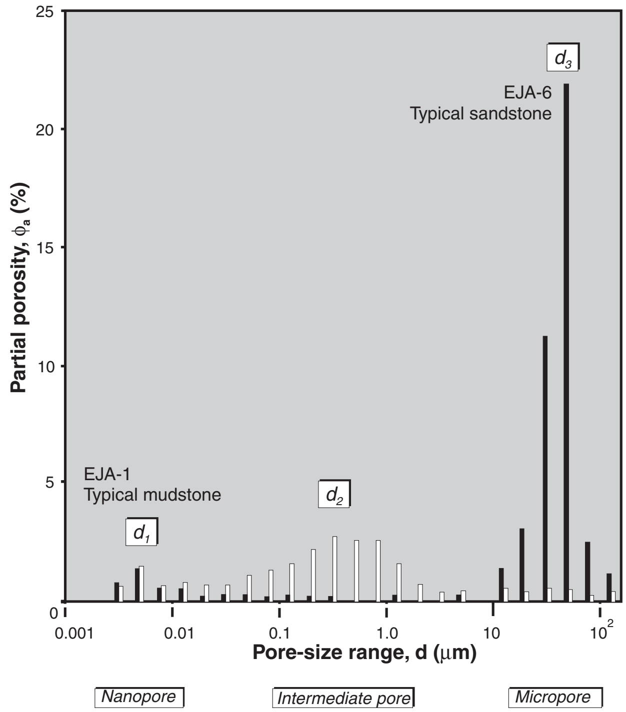

Figure 3. Typical pore-size distribution plots of sandstone and mudstone samples. The d_1, d_2 and d_3 are the modes for each of the three pore-size distribution bodies (*modified from* Katsube et al., 1999).

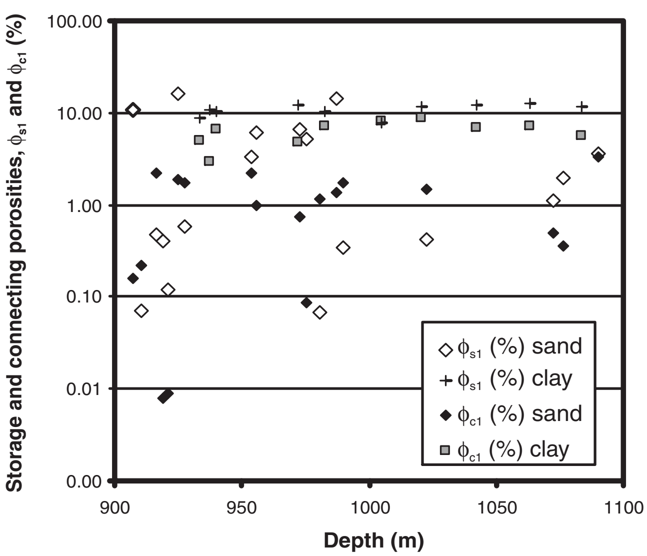

Figure 4. Storage (ϕ_{s1}) and connecting (ϕ_{c1}) porosities for sand and clay samples versus depth.

values (ϕ_{s1}, and ϕ_{s2}) are in the ranges of 0.07–15.97% and 0.43–46.48%. The connecting porosity values are in the ranges of 0.01–8.90% and 0.61–12.90% (Table 2), respectively. There are two prominent modes visible in the predominantly unimodal pore-size distribution plots, one (d_2) for the intermediate-pore-size ranges (126–1259 nm) of the clay

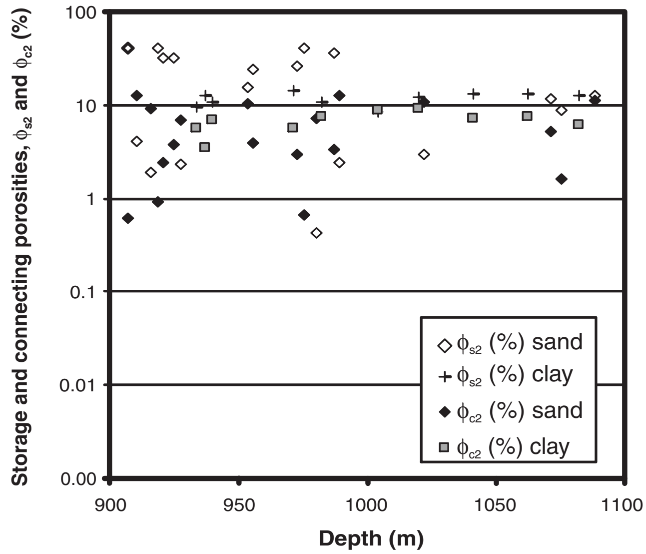

Figure 5. Storage (ϕ_{s2}) and connecting (ϕ_{c2}) porosities for sand and clay samples versus depth.

samples and another (d_3) for the micropore-size ranges (12 589–125 893 nm) of the sandy samples. These distribution patterns are similar to those typical of mudstone (Fig. 3) with similar modes of d_2 and of sandstone with similar modes of d_3 (Katsube et al., 1999). The pore-size distribution patterns can be divided into two groups based on grain size. Group I (Fig. 1) represented by 10 clay samples and Group II (Fig. 2) represented by 18 sand samples. Group I samples have nearly identical unimodal pore-size distributions with a pore-size mode (d_2) in the range of 0.1–1 μm. The Group II samples have a pore-size mode (d_3) in the range of 10–100 μm. The ϕ_{s1} values for Group I samples range from 7.66–12.48% with an average of 10.77% compared to 0.07–5.97% with an average of 3.95% for the Group II samples. There are three anomalous fine sand and silty sand samples (P2EJA-11, -27, and -28) that have considerably higher ϕ_{s1} values (10.55%, 15.97%, and 14.07% respectively, Fig. 4). The ϕ_{s2} ranges for Group I are 8.46–14.13% and for Group II are 0.43–46.48% (Fig. 5). The averages are 11.76% and 18.79%, respectively.

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