The ZSM-48 Family

1. The Periodic Building Units (PerBU1 and **PerBU2)** in the ZSM-48 family equal the layers shown in Figure 1b and 1c. The layers are built from tubular pores of rolled-up honeycomb-like sheets of fused T6-rings with T10-ring windows as shown in Figure 1a.

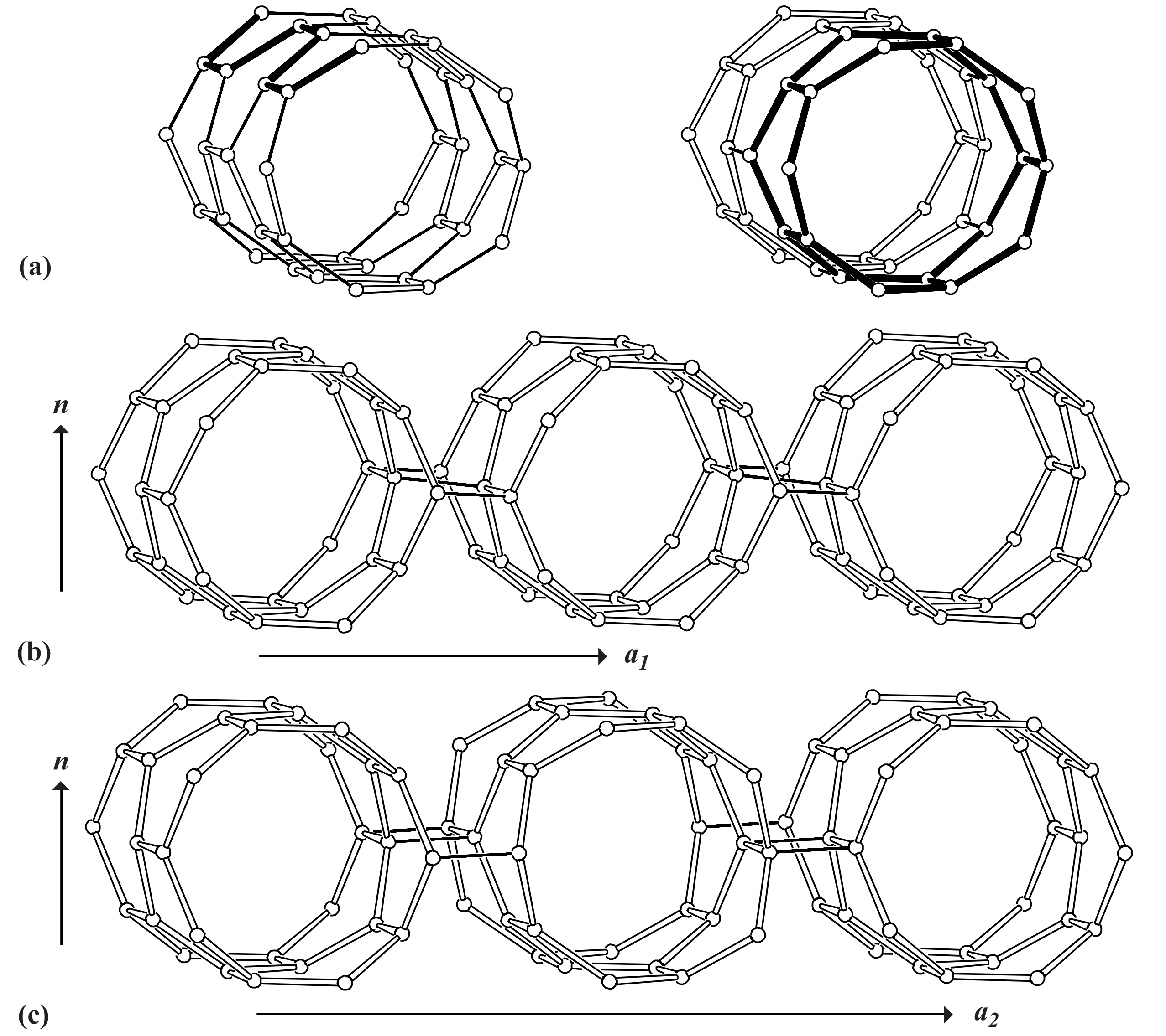


Figure 1: Tubular pore with T10-ring window (a) constructed from five crankshaft chains (left) or from T6-ring bands each consisting of 20 T atoms (right); PerBU1 (b) and PerBU2 (c) of the ZSM-48 family of zeolite frameworks seen in perspective view perpendicular to the plane normal ***n*** and along the pore axis ***b***

Tubular pores (Fig.1a), related by pure translations along $\boldsymbol{a_1}$, are connected through single crankshaft chains into PerBU1 (Fig.1b). Tubular pores, related by pure transaltions along $\boldsymbol{a_2}$ accompanied by a shift of ½***b*** along the pore axis, are connected through T4-rings into PerBU2 (Fig.1c).
[Compare the PerBU's in ZSM-48 with those in the **SSZ-31** and **UTD-1** families].

2. Type of Faulting: 1-dimensional stacking disorder of the PerBU's along the plane normal $\boldsymbol{n}$.

3. The Layer Symmetry: the plane space group of PerBU1 is P 2/b 2_1/m (2/m) and of PerBU2 is C 2/m 2/m (2/m).

4. Connectivity Pattern of the PerBU's:

The stacking of PerBU's along $\boldsymbol{n}$ requires a lateral shift of the PerBU's along $\boldsymbol{a}$ (and $\boldsymbol{b}$). It is convenient to describe the stacking sequence of the PerBU's along $\boldsymbol{n}$ using the same coordinate system in both PerBU's. Therefore the unit cell length along the $\boldsymbol{a}$ axis is taken equal to $2|\boldsymbol{a}_1|$ in PerBU1 and equal to $|\boldsymbol{a}_2|$ in PerBU2. For both PerBU's the lateral shifts along $\boldsymbol{a}$ are then given as $\pm{}^{1}/_{6}\,\boldsymbol{a}$. Direct neighbouring PerBUs can be stacked along $\boldsymbol{n}$ in several ways. The lateral shift of the top layer along $\boldsymbol{a}$ and $\boldsymbol{b}$ is:

(a): $-{}^{1}/_{6}\,\boldsymbol{a}$ and zero; denoted as $(-{}^{1}/_{6}, 0)$; **(b):** ${}^{1}/_{6}\,\boldsymbol{a}$ and zero; denoted as $({}^{1}/_{6}, 0)$;
(c): $-{}^{1}/_{6}\,\boldsymbol{a}$ and ${}^{1}/_{2}\,\boldsymbol{b}$; denoted as $(-{}^{1}/_{6}, {}^{1}/_{2})$; **(d):** ${}^{1}/_{6}\,\boldsymbol{a}$ and ${}^{1}/_{2}\,\boldsymbol{b}$; denoted as $({}^{1}/_{6}, {}^{1}/_{2})$.
In Figure 2 the connection modes **(a)** and **(c)** between PerBU1's, and the connection modes **(b)** and **(d)** between PerBU2's are depicted.

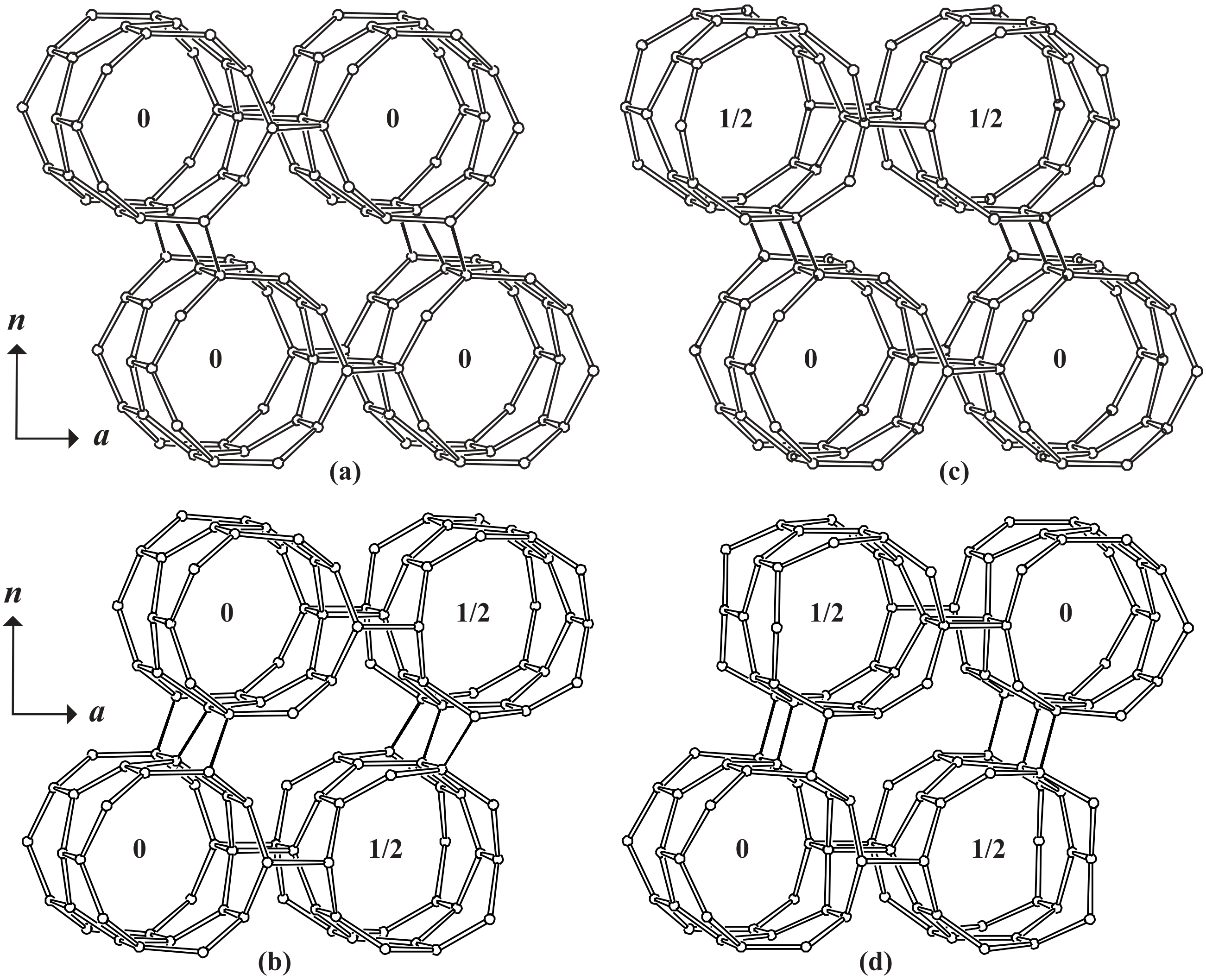


Figure 2: Perspective view along the pore axis $\boldsymbol{b}$ of the connection modes **(a-d)** in the ZSM-48 family of zeolites. The PerBU's are connected through crankshaft chains or T4-rings depending on whether the shift along $\boldsymbol{b}$ between direct neighbouring pores is zero or ${}^{1}/_{2}\boldsymbol{b}$, respectively

Once the distribution of the lateral shifts between the PerBU's along $\boldsymbol{n}$ is known, the three-dimensional structure is defined.

5. The Simplest Ordered End-Members in the ZSM-48 family of zeolites are shown in Figure 3 and Table 1. The gaps between the pores are filled by T-T dimer units. None of the end-members has been observed as pure single crystal material so far.

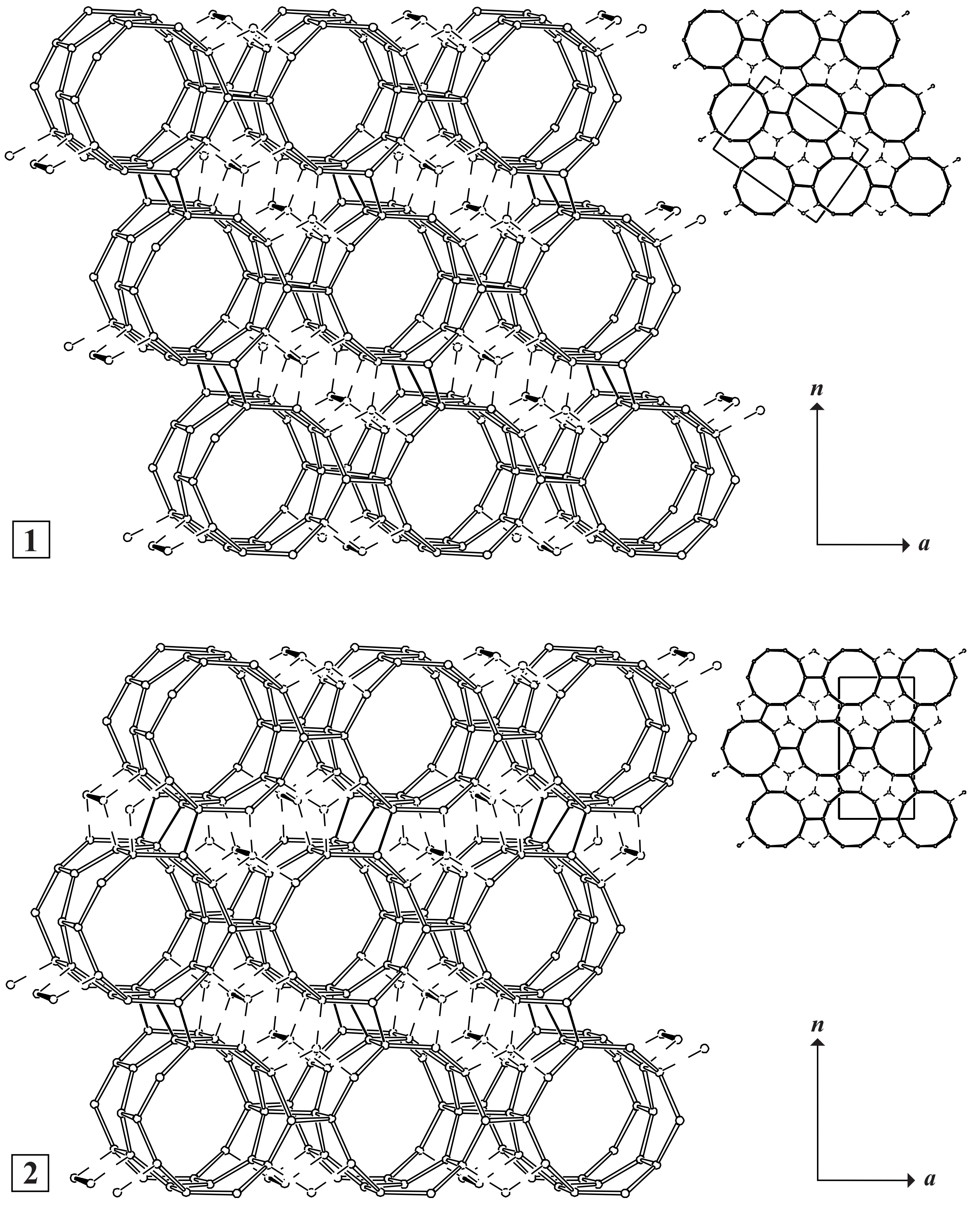
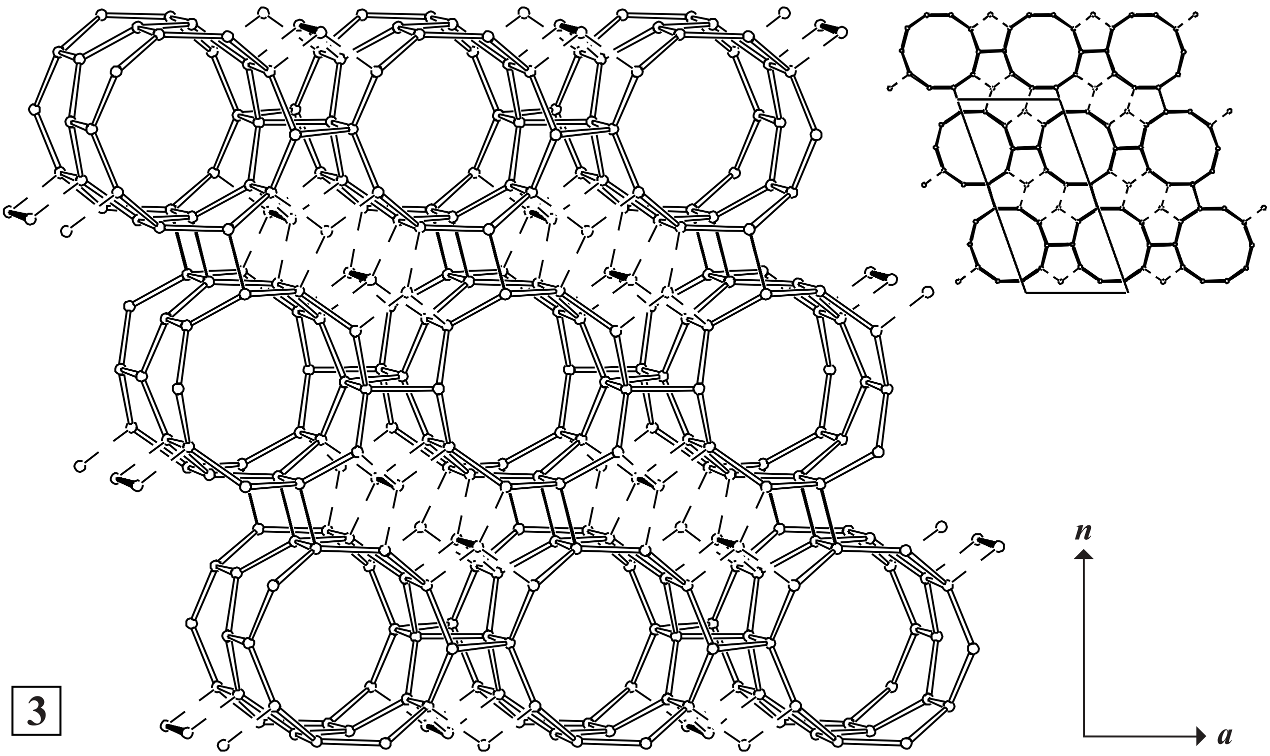


Figure 3: Perspective drawing (left) and parallel projection along the pore axis of the unit cell in standard setting (top right) of the ordered end-members **1** and **2** (cf. Table 1) in the ZSM-48 family. T-T connections to dimer units are striped. (Fig.3 is continued on next page)



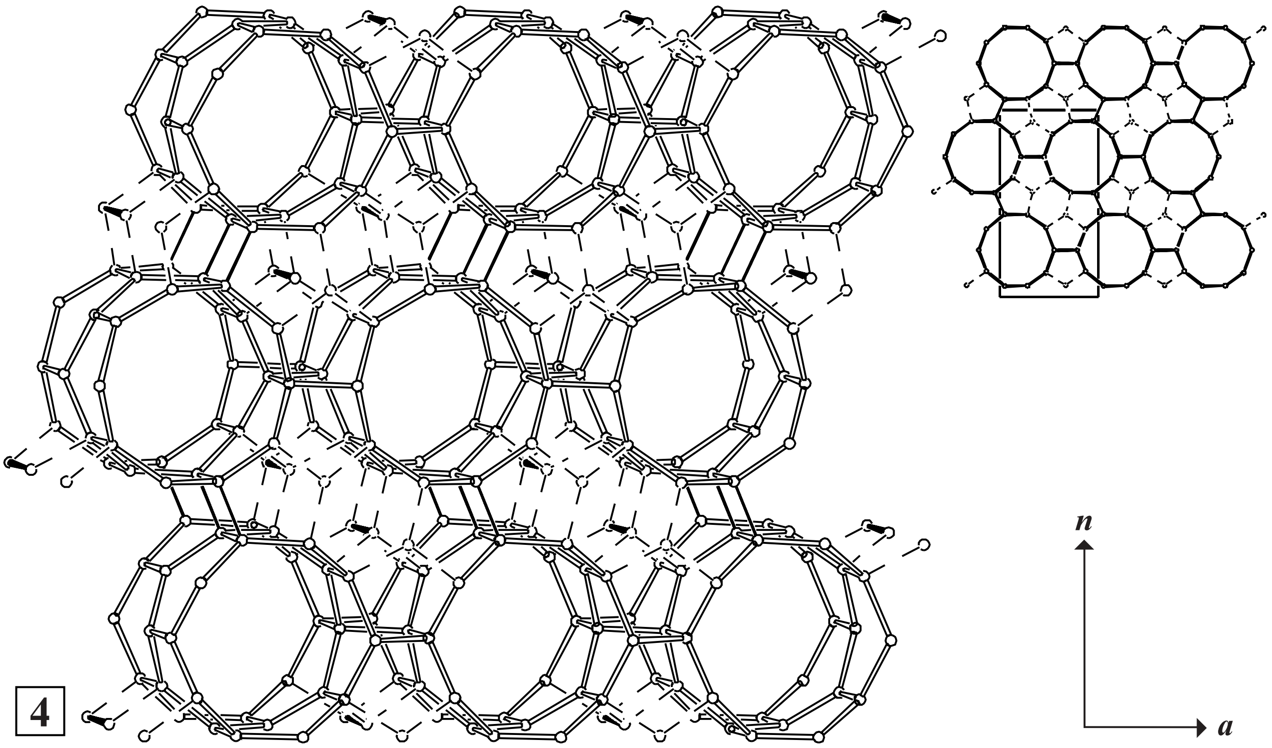
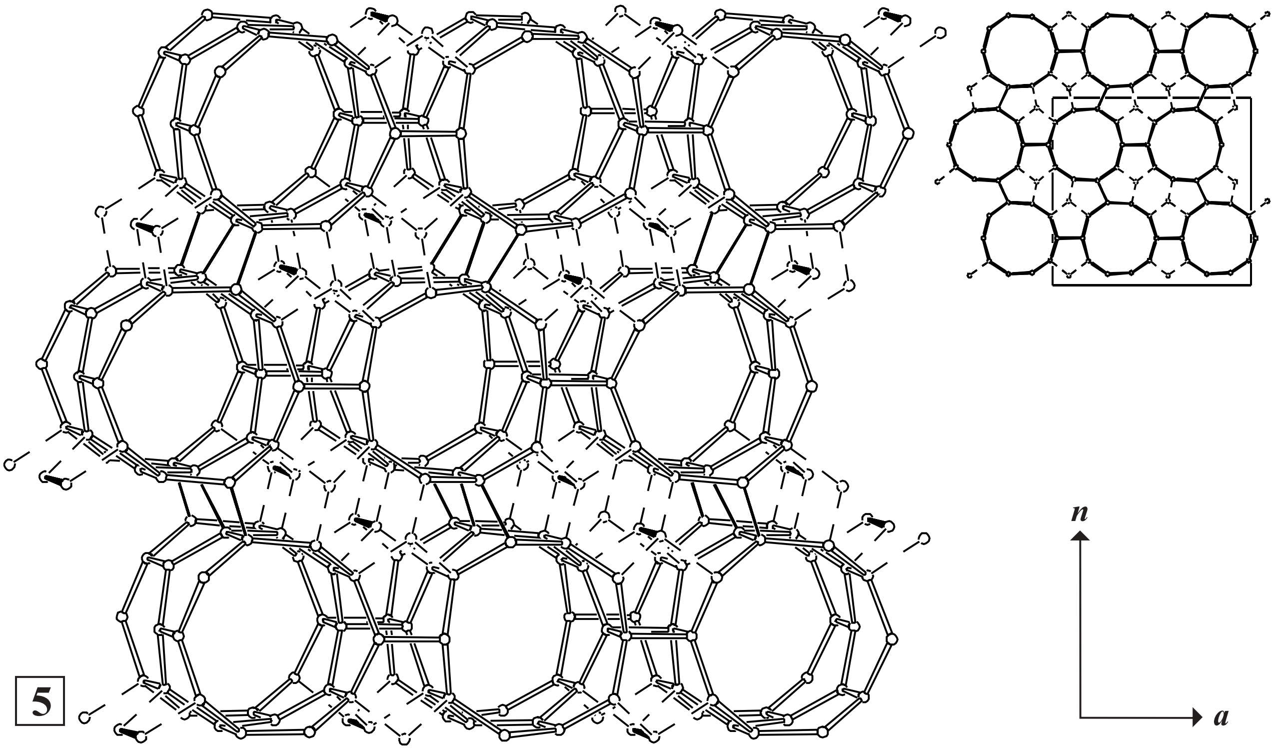


Figure 3 (Continued): Perspective drawing (left) and parallel projection along the pore axis of the unit cell in standard setting (top right) of the ordered end-members **3** and **4** (cf. Table 1) in the ZSM-48 family. T-T connections to dimer units are striped. (Fig.3 is continued on next page)



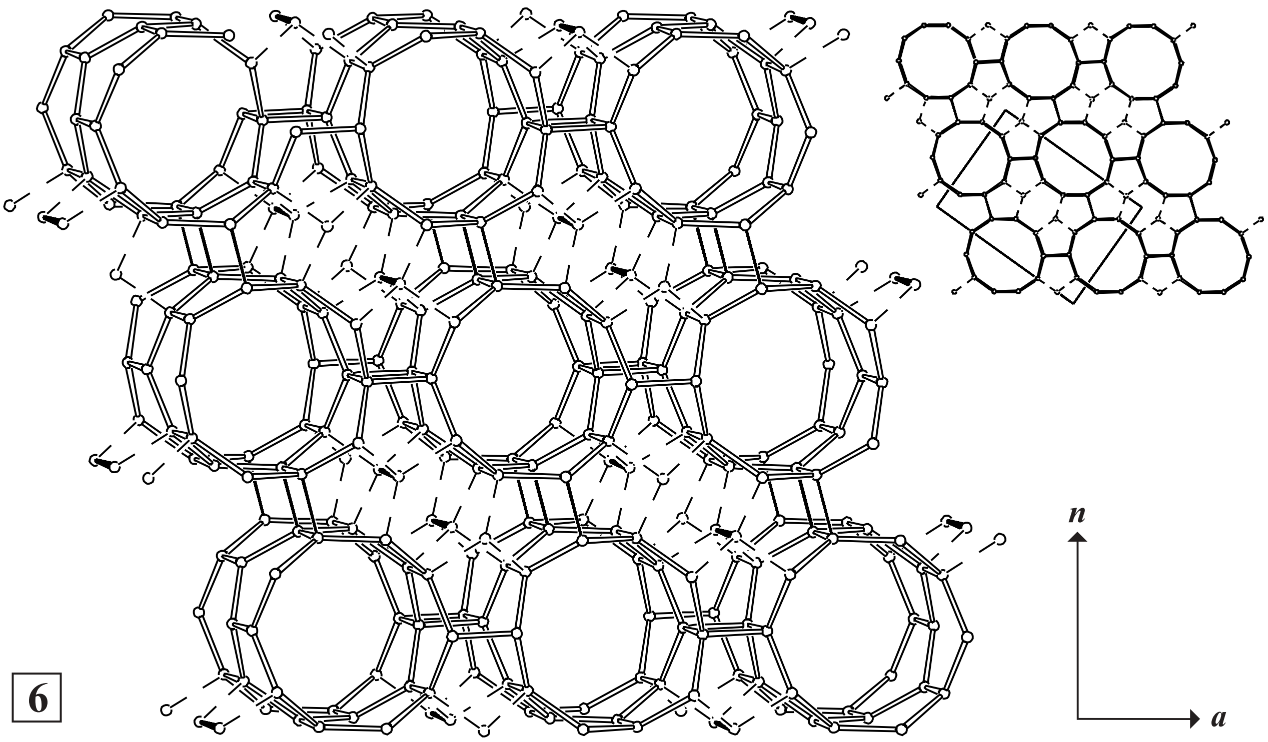


Figure 3 (Continued): Perspective drawing (left) and parallel projection along the pore axis of the unit cell in standard setting (top right) of the ordered end-members **5** and **6** (cf. Table 1) in the ZSM-48 family. T-T connections to dimer units are striped. (Fig.3 is continued on next page)

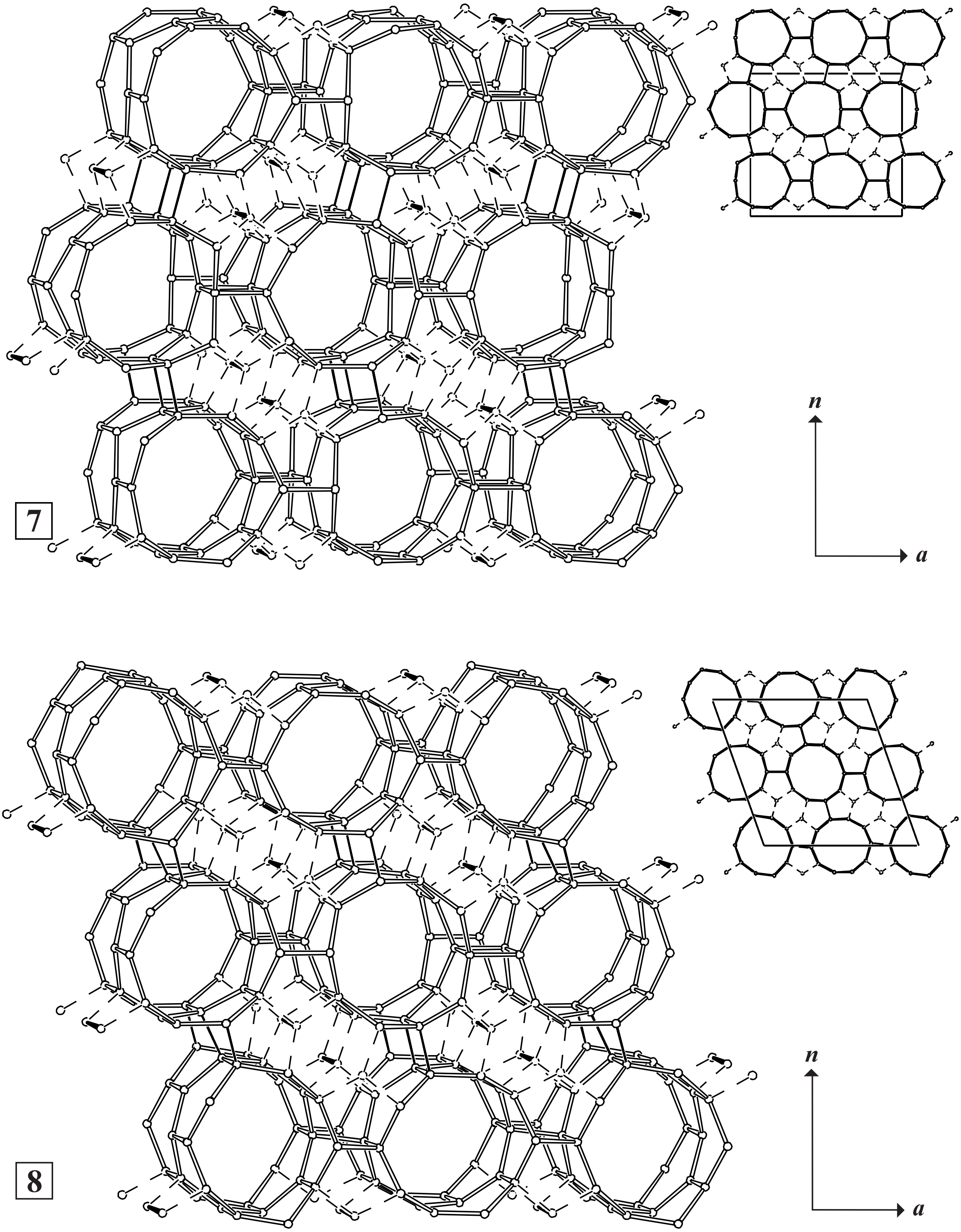


Figure 3 (Continued): Perspective drawing (left) and parallel projection along the pore axis of the unit cell in standard setting (top right) of the ordered end-members **7** and **8** (cf. Table 1) in the ZSM-48 family. T-T connections to dimer units are striped. (Fig.3 is continued on next page)

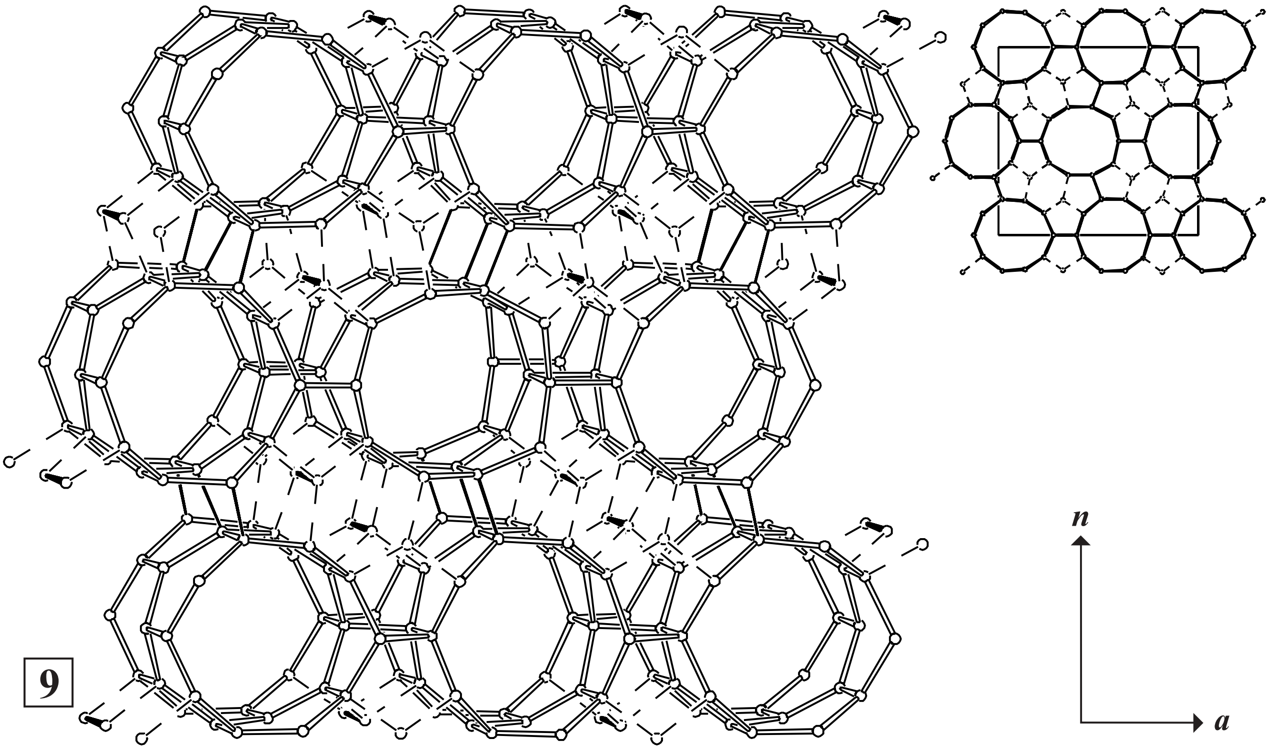


Figure 3 (Final page): Perspective drawing (left) and parallel projection along the pore axis of the unit cell in standard setting of the ordered end-member **9** (cf. Table 1) in the ZSM-48 family. T-T connections to dimer units are striped.

Table 1: Stacking sequences of the PerBU's for the simplest ordered end-members in the ZSM-48 family. The end-member number refers to the framework plots **1-9** on this and previous pages. The standard setting ($\boldsymbol{a_0}$, $\boldsymbol{b_0}$ and $\boldsymbol{c_0}$) of the space group is used

End-Member	***Lateral shifts (along n) in fractions of (a, and b)*** [1]			***space group***	$\boldsymbol{a_0}$	$\boldsymbol{b_0}$ **(Å)**	$\boldsymbol{c_0}$	***ß*** **(º)**
				PerBU1				
1 [2]	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	Cmcm	14.24	20.14	8.4	-
2	$(-^{1}/_{6}, 0)$;	$(+^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	Pmmm	8.4	23.26	12.33	-
3	$(-^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;.....	C2/m	24.66	8.4	12.33	109.47
4	$(-^{1}/_{6}, ^{1}/_{2})$;	$(+^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;.....	Pmma	8.4	23.26	12.33	-
				PerBU2				
3 [3]	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	C2/m	24.66	8.4	12.33	109.47
5	$(-^{1}/_{6}, 0)$;	$(+^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	Cmcm	8.4	24.66	23.26	-
6 [4]	$(-^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;.....	Imma	8.4	14.24	20.14	-
7	$(-^{1}/_{6}, ^{1}/_{2})$;	$(+^{1}/_{6}, ^{1}/_{2})$;	$(-^{1}/_{6}, ^{1}/_{2})$;.....	Cmcm	8.4	24.66	23.26	-
				PerBU1 and PerBU2				
8	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	$P2_1/m$	24.66	8.4	24.66	109.47
9	$(-^{1}/_{6}, 0)$;	$(+^{1}/_{6}, 0)$;	$(-^{1}/_{6}, 0)$;......	Pmm2	8.4	23.26	24.66	-

[1] $\boldsymbol{a}$ = 24.66 Å (See Fig.1 and Section **4**); the pore axis $\boldsymbol{b}$ = 8.4 Å; $\boldsymbol{n}$ is parallel to $\boldsymbol{a} \times \boldsymbol{b}$.

[2] End-member **1** equals polytype 48A from Ref. 5.

[3] This end-member, built from PerBU2, is identical to end-member **3** built from PerBU1.

[4] End-member **6** equals polytype 48B from Ref. 5.

▲

6. Disordered Materials Synthesized and Characterized to Date:

ZSM-48 (1,2,3,4,5,6); EU-2 (7); ZBM-30 (8); EU-11 (9).

7. Supplementary Information

7.1 *Comparison with the SSZ-31 family:*

The Periodic Building Units (PerBU1 and PerBU2) in the SSZ-31 family equal the layers shown in Figure 4b and 4c. The layers are built from tubular pores (Fig.4a) of rolled-up honeycomb-like sheets of fused T6-rings with T12-ring windows. [Compare these PerBU's (with T12-ring windows) with the PerBU's in ZSM-48 (with T10-ring windows) and in UTD-1 (with T14-ring windows)].

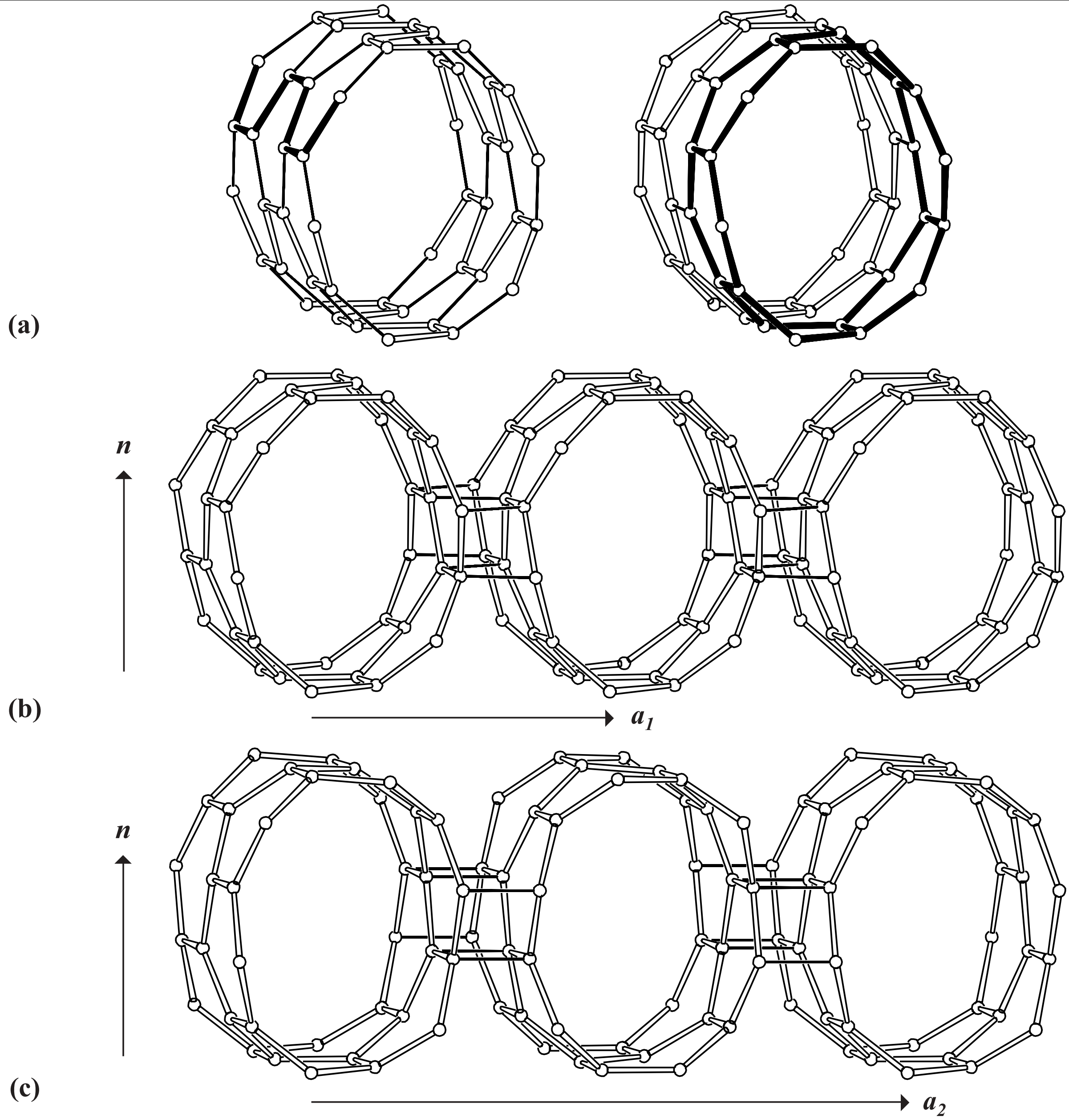


Figure 4: Tubular pore with T12-ring window (a) constructed from six crankshaft chains (left) or from T6-ring bands each consisting of 24 T atoms (right); PerBU1 (b) and PerBU2 (c) of the SSZ-31 family of zeolite frameworks seen in perspective view perpendicular to the plane normal ***n*** and along the pore axis ***b***

For more details: see the description of the **SSZ-31** family in this 'Catalog'.

7.2 *Comparison with the UTD-1 family:*

The Periodic Building Units (PerBU1 and PerBU2) in the UTD-1 family equal the layers shown in Figure 5b and 5c. The layers are built from tubular pores (Fig.5a) of rolled-up honeycomb-like sheets of fused T6-rings with T14-ring windows. [Compare these PerBU's (with T14-ring windows) with the PerBU's in ZSM-48 (with T10-ring windows) and in SSZ-31 (with T12-ring windows)].

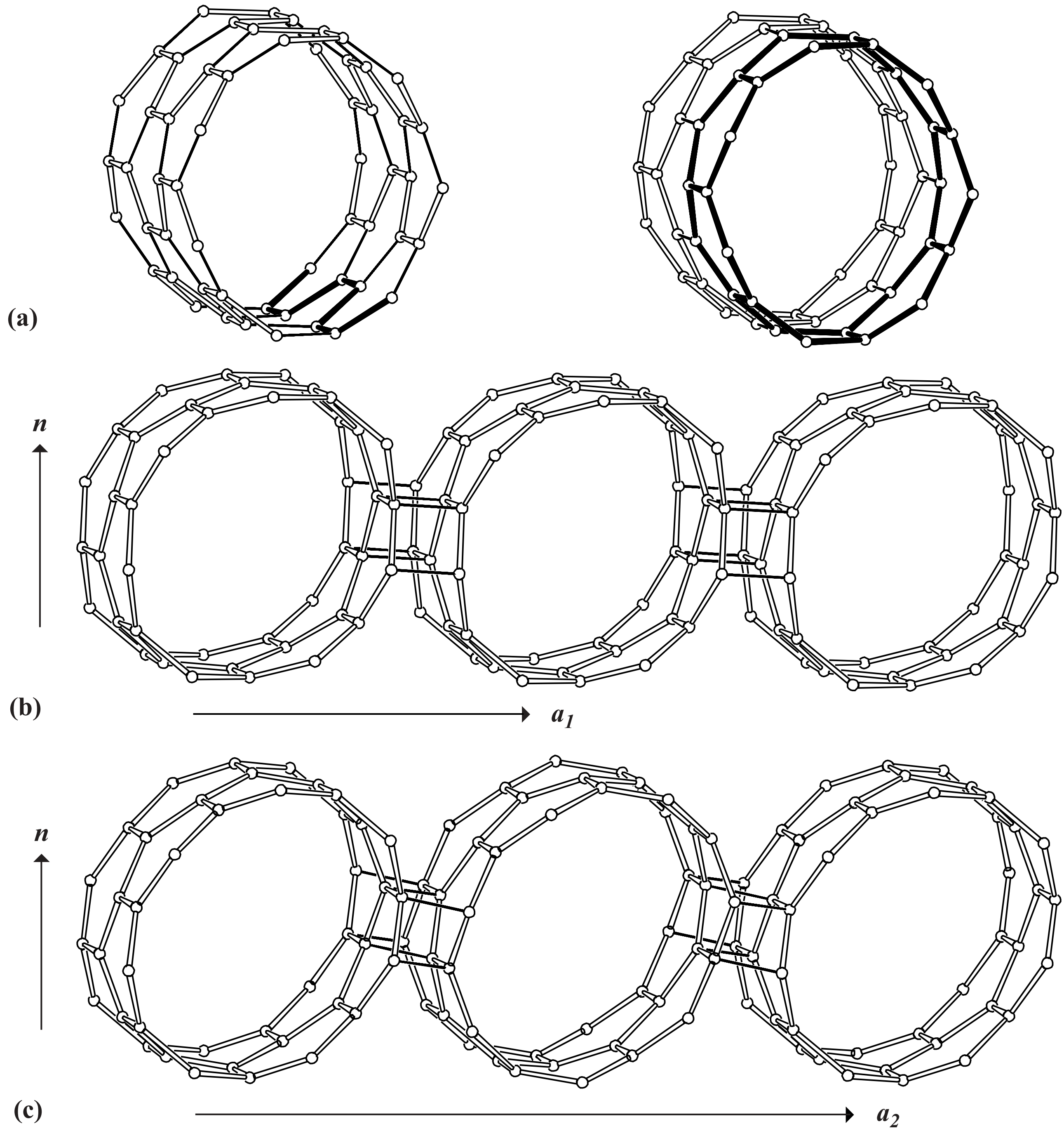


Figure 5: Tubular pore with T14-ring window (a) constructed from seven crankshaft chains (left) or from T6-ring bands each consisting of 28 T atoms (right); PerBU1 (b) and PerBU2 (c) of the UTD-1 family of zeolite frameworks seen in perspective view perpendicular to the plane normal ***n*** and along the pore axis ***b***

For more details: see the description of the **UTD-1** family in this 'Catalog'.

8. References

(1) J.L. Schlenker, F.G. Dwyer, E.E. Jenkins, W.J. Rohrbaugh and G.T. Kokotailo, Nature **294**, 340 (1981).

(2) P. Chu, US Patent 4,397,827(1981).

(3) L.D. Rollmann and E.W. Valyocsik, US Patent 4,423,021(1983).

(4) P. Chu, US Patent 4,448,675(1984).

(5) J.L. Schlenker, W.J. Rohrbaugh, P. Chu, E.W. Valyocsik and G.T. Kokotailo, Zeolites **11**, 355 (1985).

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