MAZ

MAZ.1 Zeolite framework type and topology

The framework type code is named after the mineral **MAZ**zite, $Mg_{2.5}K_2Ca_{1.5} \cdot Al_{10}Si_{26}O_{72} \cdot 30H_2O$ [98Coo1], first found at Mont Semiol, France, and described by Galli [74Gal1, 75Gal1]. The framework is isostructural with the synthetic zeolites ZSM-4 [67Mob1, 88Sch1] and zeolite Ω [68Uni1, 2003Mar1], thus representing the rare case where the synthetic compounds are known before the natural counterparts are found. An initial structure determination of zeolite Ω [69Bar1] in space group $P\,6/m\,m\,m$ is wrong [74Gal2] and not listed here. The framework structure (Fig. MAZ.1.1) can be described as being built from *maz* ($4^6 4^3 5^6 12^2$) units forming the 12-ring channels (**mzz** units, Fig. MAZ.1.3) parallel **c**, crosslinked by *gme* ($4^6 4^3 6^2 8^3$) and *kaj* ($5^2 8^2 8^1$) units as shown in Fig. MAZ.1.2.

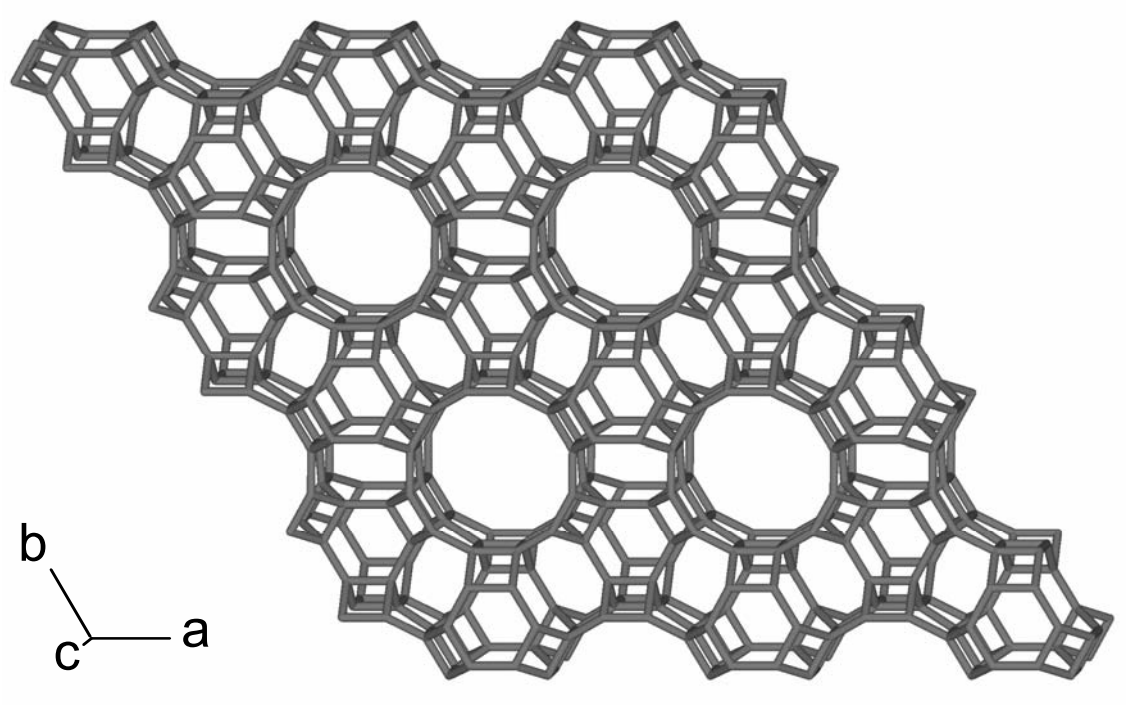
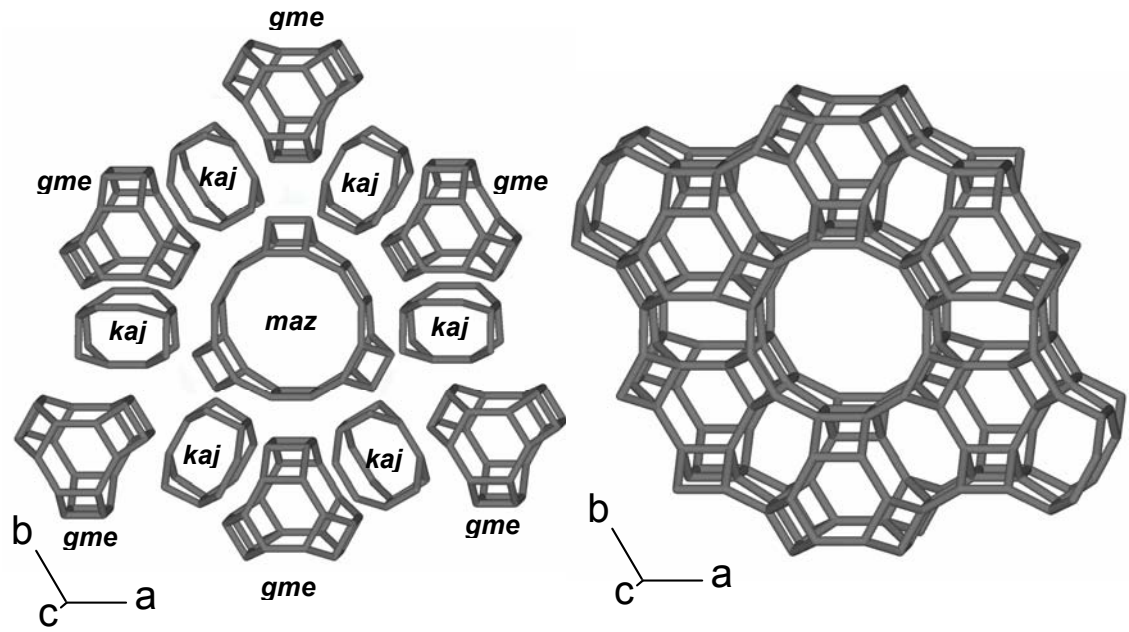


Fig. MAZ.1.1 The framework structure of MAZ-type zeolites in the highest possible topological symmetry $P\,6_3/m\,m\,c$. View parallel [001] rotated by 10° about [100] and [120].



a Linkage of *gme* and *kaj* units around the *maz* unit.

b The assemblage shown in a) extended with additional units to show the linkage forming the 12-ring channel.

Fig. MAZ.1.2 Building scheme of the MAZ-type framework. View parallel [001] rotated by 10° about [100] and [120]. The figures are on different scales.

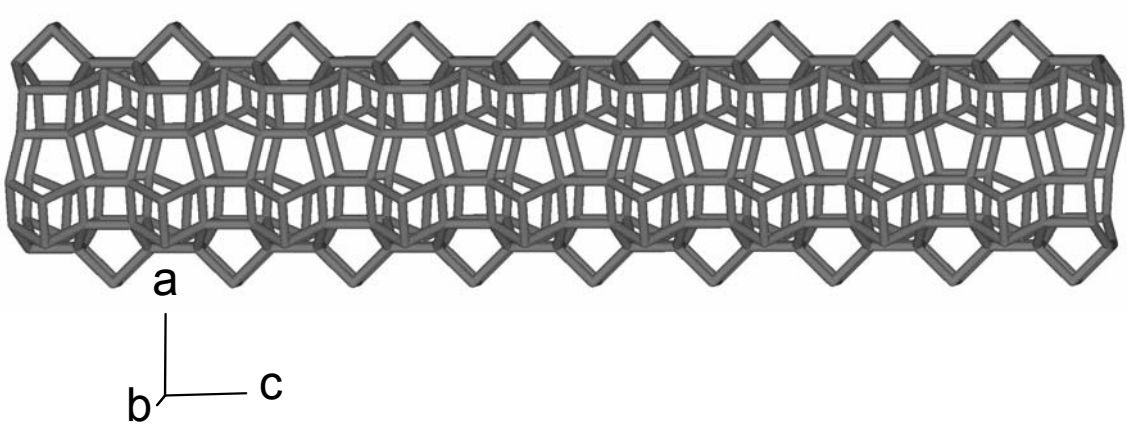


Fig. MAZ.1.3 The 12-ring channel (**mzz** unit) parallel [001] formed by an alternating sequence of *maz* units rotated by 60° according to the 6_3-axis in the center of the channel. View parallel [010] rotated by 2° about [001] and 6° about [210].

MAZ.2 Compounds and crystal data

Table MAZ.2.1 Chemical data.

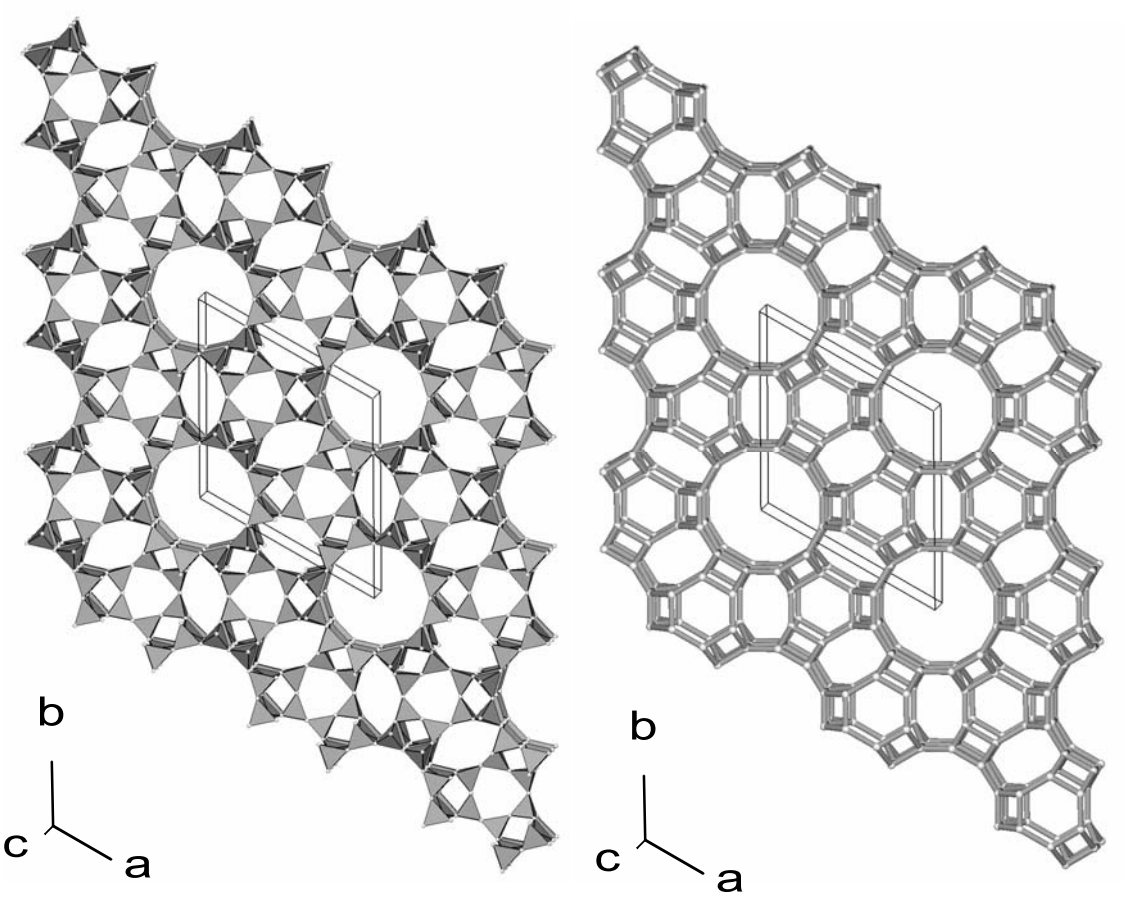
FD = framework density CE = cation exchange SR = sorbate T = temperature of thermal treatment [K]
SM = source of material TE = template TT = thermal treatment REF = reference

code	chemical composition	mineral / compound name	FD	SM	CE	TE/SR	TT	T	REF
MAZ-I ***P* 6$_3$/*m m c***									
MAZ1974a01	$Ca_{1.4}K_{1.9}Mg_2 \cdot Al_{9.8}Si_{26.5}O_{72} \cdot 28H_2O$	mazzite-Mg	16.1	M	-	H_2O	-	-	74Gal2
MAZ1975a01	$Ca_{1.4}K_{2.5}Mg_{2.1}Na_{0.3} \cdot Al_{9.9}Si_{26.5}O_{72} \cdot 28H_2O$	mazzite-Mg	16.1	M	-	H_2O	-	-	75Gal1
MAZ1975b01	$Ca_{1.4}K_{2.5}Mg_{2.1}Na_{0.3} \cdot Al_{9.9}Si_{26.5}O_{72} \cdot 9H_2O$	mazzite-Mg	16.9	M	-	H_2O	D	873	75Rin1
MAZ1985a01	$Na_8 \cdot Ga_8Si_{28}O_{72}$	(Ga-mazzite)	16.7	S	Na	-	-	873	85New1
MAZ1988a01	$Na_{7.1}1.5N(CH_3)_4 \cdot Al_8Si_{28}O_{72} \cdot 27H_2O$	ZSM-4	16.5	S	-	TMA, H_2O	-	-	88Sch1
MAZ1988b01	$Si_{36}O_{72}$	-	17.1	T	-	-	-	-	88van1
MAZ2003a01	$Na_{6.6}1.8N(CH_3)_4 \cdot Al_{8.4}Si_{27..6}O_{72} \cdot 22.2H_2O$	zeolite omega	16.1	S	-	TMA, H_2O	-	-	2003Mar1
MAZ2005a01	$Na_8 \cdot Al_8Si_{28}O_{72} \cdot 30H_2O$	mazzite-Na	16.1	M	-	H_2O	-	-	2005Arl1

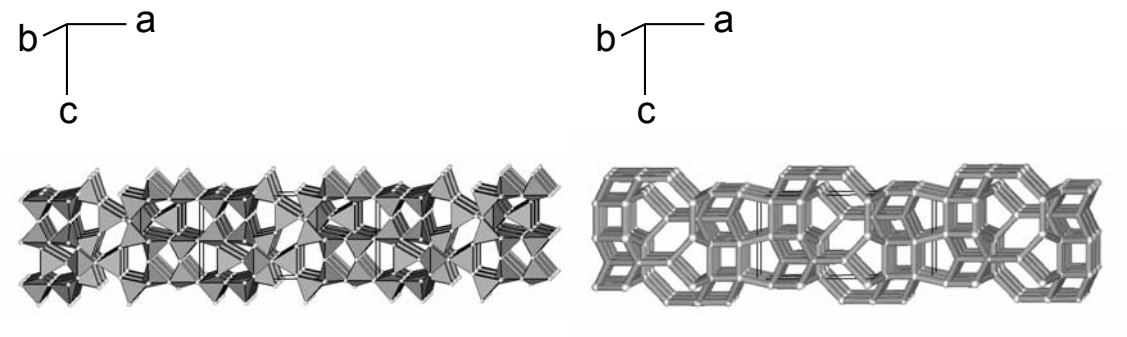
Table MAZ.2.2 Structural parameters of the MAZ-type compounds.

code	*a* [Å]	*c* [Å]	*V* [Å^3]	shift	matrix	coord. trans.	*T* [K]	reference
MAZ-I ***P* 6$_3$/*m m c***								
MAZ1974a01	18.392(8)	7.646(2)	2240	0, 0, 0	**a**, **b**, **c**	*x*, *y*, *z*	n.s.	74Gal2
MAZ1975a01	18.392(8)	7.646(2)	2240	0, 0, ½	**a**, **b**, **c**	*x*, *y*, *z*	n.s.	75Gal1
MAZ1975b01	18.007(3)	7.608(2)	2136	0, 0, 0	**a**, **b**, **c**	*x*, *y*, *z*	RT	75Rin1
MAZ1985a01	18.043(9)	7.662(2)	2160	0, 0, 0	**a**, **b**, **c**	*x*, *y*, *z*	RT	85New1
MAZ1988a01	18.1936	7.6262	2186	0, 0, 0	**a**, **b**, **c**	*x*, *y*, *z*	RT	88Sch1
MAZ1988b01	18.20	7.36	2111	0, 0, 0	**a**, **b**, **c**	*x*, *y*, *z*	-	88van1
MAZ2003a01	18.215(1)	7.6341(1)	2194	0, 0, ½	**a**, **b**, **c**	*x*, *y*, *z*	n.s.	2003Mar1
MAZ2005a01	18.2343(7)	7.6371(2)	2199	0, 0, ½	**a**, **b**, **c**	*x*, *y*, *z*	n.s.	2005Arl1

MAZ.3 Framework structure of MAZ-I compound ($P6_3/mmc$, IT #194)



a View parallel [001] rotated by 5° about [210] and [010]. **b** Skeleton model corresponding to a).



c View parallel [010] rotated by 1° about [210] and [001]. **d** Ball and stick model corresponding to c).

Fig. MAZ.3.1 Projections of the MAZ-I crystal structure of mazzite, $Ca_{1.4}K_{2.5}Mg_{2.1}Na_{0.3} \cdot Al_{9.9}Si_{26.5}O_{72} \cdot 28H_2O$ (MAZ1975a01, 75Gal1).

Table MAZ.3.1 Atomic coordinates and site definitions for mazzite, $Ca_{1.4}K_{2.5}Mg_{2.1}Na_{0.3} \cdot Al_{9.9}Si_{26.5}O_{72} \cdot 28H_2O$ (MAZ1975a01, 75Gal1).

atom	*x*	*y*	*z*	B_{eq} [Å^2]	site symmetry	Wyckoff position	no. of atoms in unit cell
(Si,Al)1	0.0933(1)	0.3536(1)	0.0444(2)	1.14	1	24(l)	17.52 / 3.24
(Si,Al)2	0.4902(1)	0.1584(1)	¼	1.17	*m* . .	12(j)	8.76 / 6.48
O1	0.4352(2)	0.1114(2)	0.4279(5)	2.59	1	24(l)	24
O2	0.1614(2)	2*x*	0.0016(6)	2.21	. *m* .	12(k)	12
O3	0.1004(3)	0.3822(3)	¼	2.52	*m* . .	12(j)	12
O4	0.2741(3)	0	0	2.50	. 2 .	12(i)	12
O5	0.2589(2)	2*x*	¼	2.60	*mm*2	6(h)	6
O6	0.5751(2)	2*x*	¼	2.08	*mm*2	6(h)	6
(K,Na,Ca)1	½	0	0	3.56	. 2/*m* .	6(g)	2.52/0.3/0.18
Mg1	⅓	⅔	¼	3.25	$\bar{6}$ *m* 2	2(c)	2
Ca2	0	0	0.572(8)	23.2	3*m* .	4(e)	0.88
OW1	0.467(1)	2*x*	0.161(2)	6.4	. *m* .	12(k)	6
OW2	⅓	⅔	0.516(1)	4.3	3*m* .	4(f)	4
OW3	0.271(1)	2*x*	¼	5.4	*mm*2	6(h)	2.64
OW4	0.566(1)	0.355(1)	¾	6.9	*m* . .	12(j)	5.28
OW5	0.028(2)	0.148(1)	0.530(4)	7.7	1	24(l)	5.52
OW6	0.088(1)	2*x*	¾	21.8	*mm*2	6(h)	5.34
OW7	0.076(1)	2*x*	¼	31.2	*mm*2	6(h)	2.70

Table MAZ.3.2 Selected interatomic distances and angles for mazzite, $Ca_{1.4}K_{2.5}Mg_{2.1}Na_{0.3} \cdot Al_{9.9}Si_{26.5}O_{72} \cdot 28H_2O$ (MAZ1975a01, 75Gal1).

	T - O [Å]	T - O - T [°]		T - O [Å]	T - O - T [°]
(Si,Al)1 - O1	1.630(4)	144.6(2)	(Si,Al)2 - O6	1.642(7)	170.9(4)
(Si,Al)1 - O4	1.640(4)	136.8(3)	(Si,Al)2 - O5	1.654(4)	149.2(4)
(Si,Al)1 - O3	1.642(2)	146.4(3)	(Si,Al)2 - O1	1.657(4)	144.6(2)
(Si,Al)1 - O2	1.645(7)	138.0(3)	(Si,Al)2 - O1	1.657(4)	144.6(2)
Mean	1.639	141.5	mean	1.653	152.3

MAZ.4 Chemical composition

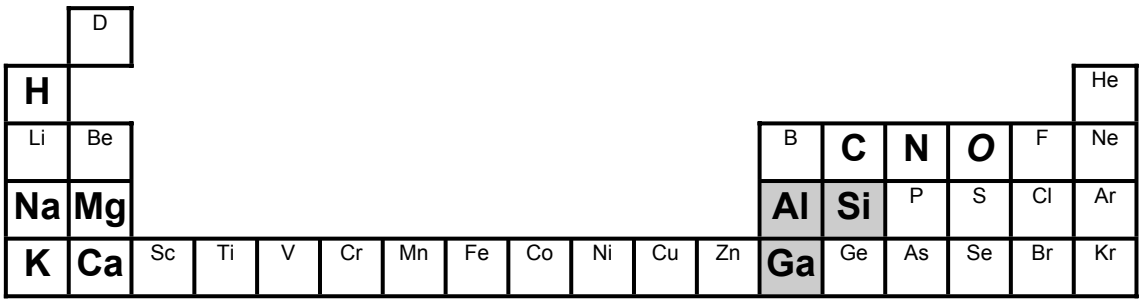


Fig. MAZ.4.1 Chemical elements (highlighted) occurring in the MAZ-type compound. Framework cations are in grey fields.

MAZ.5 Flexibility and apertures

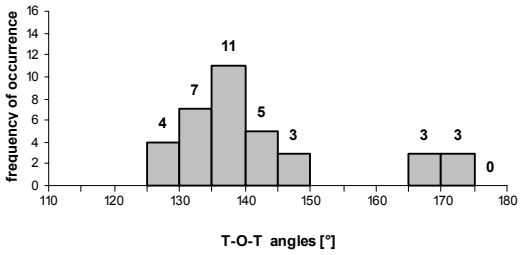


Fig. MAZ.5.1 All individual T-O-T angles from 6 experimental crystal structure determinations of MAZ-type compounds with silicoaluminate frameworks. The individual values of the angles range from 130° to 178°, with a mean value of 147°.

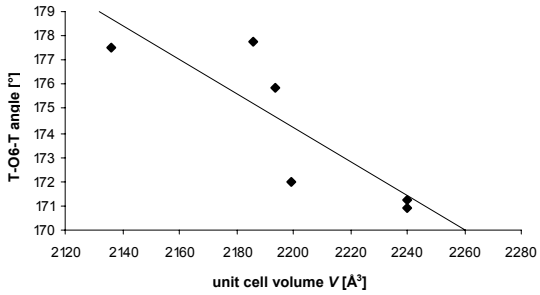


Fig. MAZ.5.2 Individual T-O6-T angles from 6 experimental crystal structure determinations of MAZ-type compounds with silicoaluminate frameworks *versus* unit cell volume V. The individual values of the angles range from 171° to 178°, with a mean value of 174°. The line is a least-squares fit to all points.

The overall spread of values of the individual T-O-T angles of MAZ-type silicoaluminates ranges from ca. 130° to 178°, with a mean value of 147°. This is clearly larger than the mean value observed in the sample of 2436 T-O-T values for silicoaluminates zeolite frameworks generally, which is 141° [95Bau1]. This larger mean value is due to the values of the T-O6-T angles which average 174° (they range from 171° to 178°). The mean for all the other T-O-T angles around oxygen atoms O1 to O5 is about 142°, that is, it is close to the overall mean. The range of these other angles is from 130° to 154° (Fig. MAZ.5.1).

Not only is the T-O6-T almost straight, but it also plays a particular role in the MAZ-type framework. As it increases in the different investigated samples their *a* and *b* unit cell constants decrease in their values and the unit cell volume decreases, while the *c* unit cell constant remains essentially unchanged, see Table MAZ.2.2. This is illustrated in Fig. MAZ.5.2 which is analogous to Figs. LTA.5.6 and FAU.5.8. In all three cases these angles antirotate [92Bau1, 92Bau2] to the other T-O-T angles in the framework. As a consequence the framework is noncollapsible as opposed to such frameworks as NAT or SOD in which all T-O-T angle corotate and the frameworks become collapsible ([95Bau1], see also the FAU and LTA chapters). Among zeolites, the only known noncollapsible frameworks known so far are FAU, KFI, LTA, MAZ, and MOR. The tetrahedral framework of feldspar is also noncollapsible [96Bau1]. The 12-ring in the MAZ framework is as wide as in the FAU-type framework and reaches almost 7.5 Å.

MAZ.6 Other information

Various catalytic properties of MAZ-type silicoaluminates have been investigated repeatedly. For references see [2003Mar1].

MAZ.7 References

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