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Regiochemical Control of the Ring Opening of 1,2-Epoxides by Means of Chelating Processes.9. Synthesis and Ring Opening Reactions of cis- and trans-Oxides Derived from 3-(Benzyloxymethyl)cyclopentene and Methyl 2-Cyclopenten-1-carboxylate[1]

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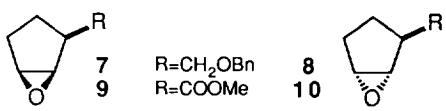
Abstract : The regiochemical outcome of the ring opening of 1,2-epoxides through chelation processes assisted by metal ions, was verified in the oxirane systems derived from cyclopentene bearing a polar functionality (CH_2OBn or COOMe) in a homoallylic relationship to the oxirane ring. The cis/trans diastereoisomeric epoxide pairs **7-8** and **9-10** derived from 3-(benzyloxymethyl)cyclopentene and methyl 2-cyclopenten-1-carboxylate, respectively, were prepared and some of their opening reactions were studied. The regioselectivity observed turned out to depend on the opening reaction protocol (standard or metal-assisted), suggesting the efficacious incursion, under the appropriate conditions, of chelate bidentate species in the opening process.

Interest in the regiochemical outcome of the ring opening reactions of 1,2-epoxides has till now been directed mostly toward functionalized typically aliphatic non-cyclic[2] or cyclic substrates derived from the cyclohexane system (epoxides **1-6**),[3] bearing a heterofunctionality in an allylic or homoallylic relationship to the oxirane ring. In some cases, a decidedly interesting control of the regioselectivity was obtained by means of different (non chelating or chelating) reaction conditions.[2,3] Much less is known about the regiochemical behavior of the corresponding 1,2-epoxides derived from the cyclopentane system. We have now

1 R_1=OBn or CH_2OBn; R_2=H **2**
3 R_1=H; R_2=CH_2OBn **4**
5 R_1=H; R_2=COOMe **6**



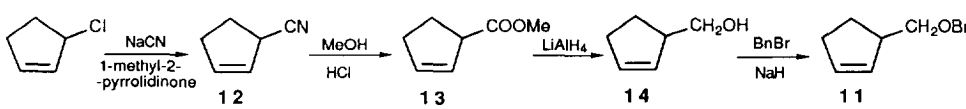
7 R=CH_2OBn **8**
9 R=COOMe **10**

conducted an examination of the regiochemical behavior of some functionalized derivatives of the cyclopentene oxide, in order to check how different opening procedures[1-3] were able to control the regioselectivity in these

systems. As a consequence, the diastereoisomeric epoxides cis **7** and trans **8**, structurally related to the previously studied cyclohexene oxide derivatives (epoxides **3** and **4**),[3a] with the heterofunctionality (OBn) in a homoallylic relationship to the oxirane ring, were prepared and some of their opening reactions were studied. In order to evaluate the effects of a heterofunctionality different from the ether group, also the epoxy esters cis **9** and trans **10**, homologs of the previously examined epoxy esters **5** and **6**,[4] were synthesized and analogously studied.

The olefin **11**, the precursor of the epoxides cis **7** and trans **8**, was prepared by benzylation of the known alcohol **14**,[5] which was prepared by Hanack's procedure,[5d] which we considered more convenient. Following this procedure, the S_N2 nucleophilic substitution with NaCN in 1-methyl-2-pyrrolidinone of the 3-chlorocyclopentene[6] afforded the unsaturated nitrile **12**, which was hydrolyzed with MeOH in the presence of gaseous HCl to give the methyl ester **13**. $LiAlH_4$ reduction of **13** gave the desired alcohol **14** (Scheme 1). Both epoxides cis **7** and **9** were synthesized in a highly stereoselective fashion by means of Sharpless'

Scheme 1

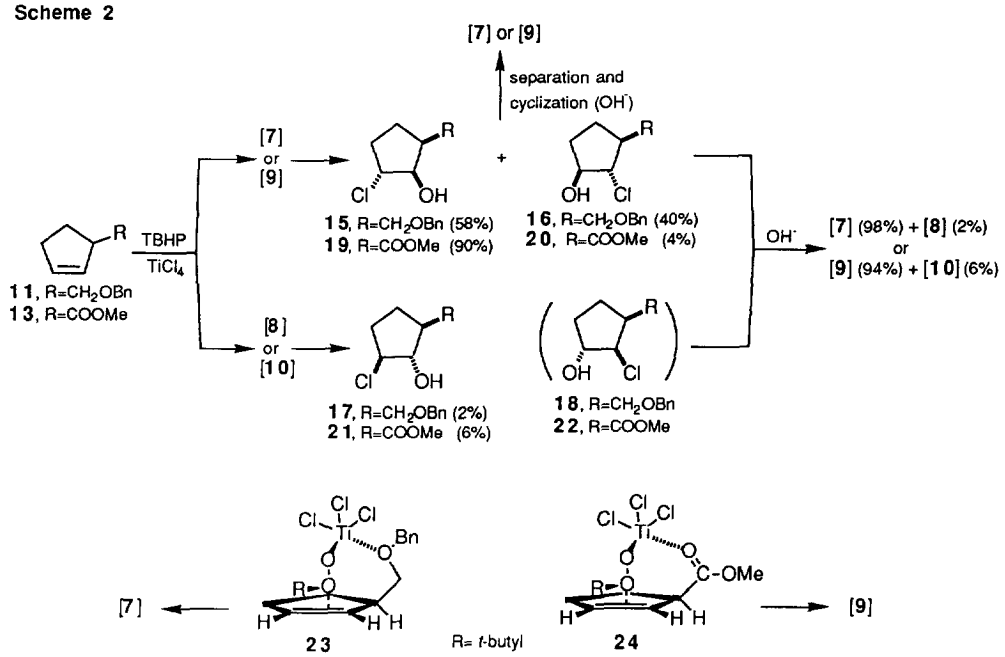


chlorohydroxylation reaction[7] on olefins **11** and **13**, respectively: the reaction of **11** with *t*-butylhydroperoxide (TBHP) in the presence of $TiCl_4$ afforded a mixture of chlorohydrins **15** (58%), **16** (40%) and **17** (2%) (chlorohydrin **18** was not present, Scheme 2).The direct base-catalyzed cyclization of this mixture afforded a 98:2 mixture of the corresponding epoxides cis **7** and trans **8**. However, the cis epoxide **7** could not be separated, by chromatographic techniques, from the albeit small amount of the trans epoxide **8** present in the reaction mixture. As a consequence, in order to obtain pure epoxide **7**, chlorohydrins **15** and **16** were separated from chlorohydrin **17** by flash chromatography, and then cyclized under basic conditions to give pure epoxide **7**. Sharpless' chlorohydroxylation reaction carried out on olefin **13** afforded a crude reaction product consisting of a 90:4:6 mixture of the chlorohydrins **19**, **20**, and **21** (the chlorohydrin **22** was not present) which were cyclized under basic conditions (aqueous NaOH in THF/H_2O) to give a 94:6 mixture of the corresponding epoxides cis **9** and trans **10**. From this mixture, the pure cis epoxide **9** was obtained by flash chromatography (Scheme 2).

Even if slightly stereoselective (cis **7**: trans **8** ratio=27:73), the *m*-CPBA oxidation of olefin **11** could not be used for the synthesis of the trans epoxide **8**, due to the above-mentioned chromatographic separation difficulties between epoxides **7** and **8**. As a consequence, for the synthesis of the trans epoxide **8** we had to proceed in a way similar to the one used for the synthesis of the cis epoxide **7**: the reaction of olefin **11** with *N*-bromosuccinimide (NBS) in aqueous THF afforded a mixture of the bromohydrins **26** (13%), **27** (13%), and **28** (74%) (bromohydrin **25** was not present) which, if directly cyclized under basic conditions, afforded a mixture of epoxides cis **7** and trans **8** in a 13:87 ratio. In order to obtain pure trans epoxide **8**, the bromohydrins **27** and **28** were separated from the crude reaction product, and then cyclized under basic conditions to give pure trans epoxide **8** (Scheme 3).

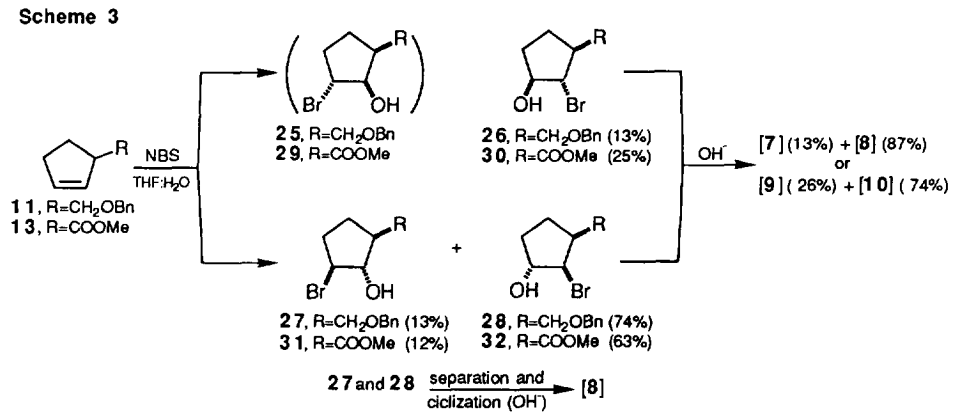
Oxidation with *m*-CPBA of the unsaturated ester **13** gave a 57:43 mixture of the two diastereoisomeric

Scheme 2



epoxides cis **9** and trans **10**, which were separated by flash chromatography. Also in this case, for the synthesis of the trans epoxide **10**, it was possible to use a more diastereoselective process (Scheme 3): the reaction of olefin **13** with NBS in THF/H_2O afforded a mixture of bromohydrins **30** (25%), **31** (12%) and **32** (63%) (bromohydrin **29** was not present) which were cyclized under basic conditions (aqueous NaOH) to give a 26:74 mixture of the corresponding epoxides cis **9** and trans **10**, separable by flash chromatography.

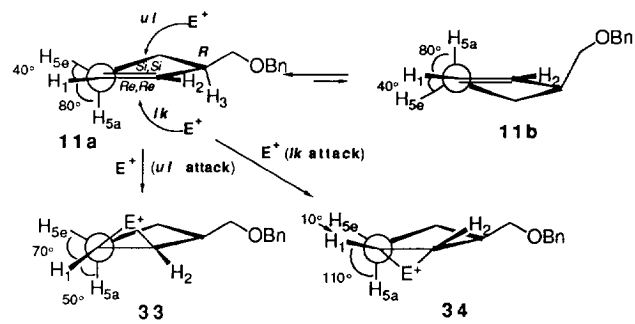
Scheme 3



The high diastereoselectivity observed in Sharpless' chlorohydroxylation of olefins **11** and **13** is in agreement with a previously reported mechanism[3a,3d,7] which implies an initial coordination of the oxidant with the oxygen of the benzyloxy group, in the case of **11**, or with the oxygen of the carbonyl group in the case of **13**: in this situation, the syn attack of the oxidant on the olefinic double bond to give, as reaction intermediates, the corresponding cis epoxide **7** (from **11**) and **9** (from **13**) is highly favored, as shown in structures **23** and **24** (Scheme 2). In the case of the reaction of **11**, the attack of Cl^- on the reaction intermediate, the epoxide cis **7**, is surprisingly not selective,[3a,3d] and both chlorohydrins **15** and **16** are consistently obtained. On the contrary, in the reaction of **13**, the chlorohydrin **19** is largely the main reaction product, as to be reasonably expected on the basis of the chelation-controlled opening of the cis epoxide **9**, the actual reaction intermediate (see below).[3a,3d,7]

The complementary diastereoselectivity observed in the reaction of olefin **11** both with aqueous NBS, followed by base-catalyzed cyclization (Scheme 3), and in the *m*-CPBA oxidation (**7**/**8** ratio=13/87 and 27/73, respectively) is due to a preferential "unlike" (*ul*) attack of the electrophile (Br^+ and peracid, respectively) on the double bond of **11**, reasonably reacting in its more stable conformation **11a** with the substituent

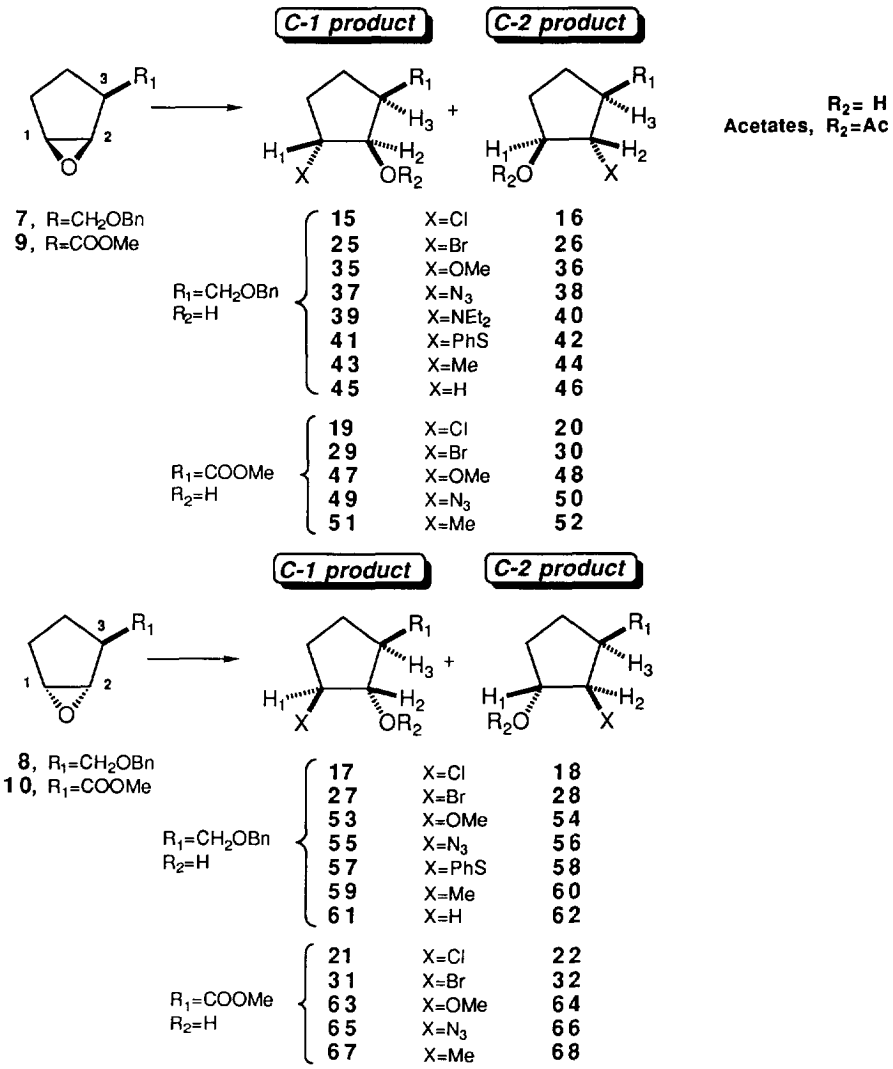
Scheme 4



(CH_2OBn) in a pseudoequatorial position (Scheme 4, where only one enantiomer of **11** is shown). In our opinion, this selectivity is due not only to the steric effect exerted by the pseudoaxial hydrogens H_3 and H_{5a} on the approacing electrophile (E^+), as previously invoked in order to rationalize the quite similar results obtained in the corresponding reactions of 3-methylcyclopentene,[8] but also to the different content of torsional strain derived from the two alternative types of electrophilic approach ["like" (*lk*) and "unlike" (*ul*), Scheme 4]. As it can be seen from an examination of the molecular models, only in the case of the electrophilic attack on the *Re,Re* face of **11a** (*lk* attack) is a clear increase in the torsional strain obtained, with the H_1 and H_{5e} protons becoming almost eclipsed (structure **34**, Scheme 4). On the contrary, the electrophilic attack on the *Si,Si* face of **11a** (*ul* attack) does not provoke any particular modification of the torsional strain of the system, as shown in structure **33** (Scheme 4). Similar explanations can be invoked in order to explain the fairly similar results from olefin **13**.

The epoxides cis **7** and **9** and trans **8** and **10** were subjected to several ring-opening reactions with nucleophiles (Cl^-, MeOH, N_3^-, $NHEt_2$, PhSH, CH_3^-, H^-, Scheme 5), both under standard, non-chelating, conditions (reaction carried out under classic acidic proton catalysis or without any catalysis) and under

Scheme 5



conditions which had proved to indicate the incursion of chelate species in the opening process (reaction carried out in the presence of a metal salt).[1-3] The results obtained are shown in Tables 1 and 2. Determination of the relative amounts of regioisomeric addition products (*C-1* and *C-2 products*)[9] in the opening reactions of epoxides **7**-**10** was accomplished by GC analysis of the crude reaction mixture and/or by ^{1}H NMR analysis of the acetylated crude reaction product.

The regiochemical results of the opening reactions of the cis epoxide **7** largely depend on the nucleophile used and on the opening reaction conditions. Methanolysis, azidolysis and the addition of Cl^- and PhSH carried out under standard conditions are only poorly regioselective, affording the corresponding opening

Table 1. Regioselectivity of the Ring Opening Reactions of the cis Epoxides 7 and 9 Under Standard and Chelating Conditions.

entry	epoxide	reagents	solvent	reaction time and temperature	*C-1 product*		*C-2 product*		yield %
1	**7**	HCl	$CHCl_3$	10 min (r.t.)	58	**15**	**16**	42	96
2	**7**	$TiCl_4$	CH_2Cl_2	30 min (-78°C)	88			12	91
3	**7**	HBr	$CHCl_3$	10 min (r.t.)	70	**25**	**26**	30	95
4	**7**	$MeOH/H_2SO_4$	MeOH	30 min (r.t.)	70	**35**	**36**	30	97
5	**7**	MeONa	MeOH	4 days (r.t.)	62			38	91
6	**7**	$MeOH/LiClO_4$ 10M	MeOH	18 h (80°C)	90			10	90
7	**7**	NaN_3/NH_4Cl	$MeOH:H_2O$	18 h (80°C)	59	**37**	**38**	41	97
8	**7**	$NaN_3/LiClO_4$ 2.5 M	MeCN	18 h (80°C)	72			28	94
9	**7**	$NaN_3/Mg(ClO_4)_2$ 5M	MeCN	18 h (80°C)	95			5	85
10	**7**	$NaN_3/Zn(OTf)_2$ 0.5M	MeCN	18 h (80°C)	97			3	80
11	**7**	LiN_3	MeCN	18 h (80°C)	83			17	93
12	**7**	$NHEt_2$	EtOH	10 days (80°C)	22	**39**	**40**	78	48
13	**7**	$NHEt_2/LiClO_4$ 2.5 M	MeCN	18 h (80°C)	63			37	92
14	**7**	$PhSH/NEt_3$	MeOH	18 h (r.t.)	55	**41**	**42**	45	95
15	**7**	$PhSH/LiClO_4$	MeCN	18 h (80°C)	73			27	97
16	**7**	Me_2CuLi	Et_2O	3 h (-15 - 0°C)	30	**43**	**44**	70	99
17	**7**	$Al(Me)_3$	pentane	48 h (r.t.)	92			8	92
18	**7**	$Al(Me)_3$/crown	pentane	7 days (r.t.)	no reaction				83
19	**7**	$LiAlH_4$	pentane	2 h (r.t.)	80	**45**	**46**	20	97
20	**7**	$LiAlH_4$/crown	pentane	5 h (r.t.) and	67			33	81
21	**9**	HCl	$CHCl_3$	10 min (r.t.)	85	**19**	**20**	15	96
22	**9**	$TiCl_4$	CH_2Cl_2	30 min (-78°C)	98			2	91
23	**9**	HBr	$CHCl_3$	10 min (r.t.)	87	**29**	**30**	13	95
24	**9**	$MeOH/H_2SO_4$	MeOH	30 min (r.t.)	87	**47**	**48**	13	97
25	**9**	$MeOH/LiClO_4$ 10M	MeOH	48 h (80°C)	97			3	90
26	**9**	NaN_3/NH_4Cl	$MeOH:H_2O$	60 h (80°C)	93	**49**	**50**	7	96
27	**9**	$NaN_3/LiClO_4$ 2.5 M	MeCN	18 h (80°C)	85			15	93
28	**9**	$NaN_3/Mg(ClO_4)_2$ 3 M	MeCN	18 h (80°C)	95			5	96
29	**9**	Me_2CuLi	Et_2O	3 h (-15 - 0°C)	76	**51**	**52**	24	95
30	**9**	$Al(Me)_3$	pentane	18 h (r.t.)	97			3	90

products in a *C-1/C-2 product* ratio varying from almost 55:45 (azidolysis and Cl^- and PhSH addition) to 70:30 (methanolysis) (entries 1, 4, 5, 7 and 14, Table 1). These results are largely different from those previously obtained in the corresponding reactions of the cyclohexane homolog, the epoxide cis **3** in which a large preference (86-92%) for nucleophilic attack on C(1) was observed in the same operating conditions.[3a] Evidently, the absence in the cyclopentane derivative **7** of all those conformational effects which typically characterize the opening behavior of the cyclohexene oxide derivatives, makes the two oxirane carbons of **7** almost equivalent and as a consequence they are almost indifferently attacked by the nucleophile. However, the slight preference for the C-1 selectivity can be reasonably attributed to the inductive electron-withdrawing effect of the substituent (CH_2OBn). In this situation, an exception is given by the aminolysis reaction of **7** with $NHEt_2$ in refluxing EtOH, where a more appreciable and, interestingly, reversed regioselectivity (*C-1/C-2 product* ratio = 22:78, entry 12, Table 1) was observed. Even if previously observed also in other oxirane systems,[10] this different regiochemical behavior of the aminolysis reaction is not easy to rationalize. A tentative explanation could be given by admitting a coordination process between the attacking nucleophile ($NHEt_2$) and the oxygen of the CH_2OBn functionality of epoxide **7**, reasonably reacting in its more stable conformation **7a** (see below), as shown in structure **69**, Scheme 6: in these conditions, the nucleophilic attack on the C(2) oxirane carbon closer to the OBn functionality appears to be favored and the *C-2 product* is preferentially obtained, as experimentally observed.

The increase in C-1 regioselectivity generally observed in the opening reactions of the cis epoxide **7** carried out in the presence of a metal salt (Table 1) can be rationalized by admitting the incursion of bidentate-chelate structures of type **72** and **73** (Scheme 6). In these conditions, the initial complexation (structures **70** and **71**) of the metal ion with the oxygen of the CH_2OBn group of epoxide **7**, reacting in either conformation **7a** or **7b**, is followed by an entropically favored further coordination of the metal with the close, geometrically approachable oxirane oxygen to give the corresponding bidentate chelate structures **72** and **73**, respectively. The nucleophilic attack on structures **72** and **73** will be directed at the C(1) oxirane carbon as a consequence of all those stereoelectronic factors implied in the chelation-controlled ring opening of these systems:[1-3,11] only the nucleophilic attack on the C(1) oxirane carbon of **72** and **73** makes the oxygen lone pair arising from the breaking of the oxirane C(1)-O bond develop favorably outside the remaining six-membered ring M^+-O-C(2)-C(3)-CH_2-O. A much less favored situation would develop in the case of a nucleophilic attack on the C(2) oxirane carbon of **72** and **73**, because of the development of the oxygen lone pair inside the remaining seven-membered ring M^+-O-C(1)-C(2)-C(3)-CH_2-O.[1-3,11]

The high C-1 selectivity observed in the opening reactions of epoxide **7** with organometallic reagents such as $AlMe_3$ and $LiAlH_4$ (entries 17 and 19, Table 1), under standard conditions may reasonably be attributed to the incursion of chelate-bidentate structures such as **72** and **73** by means of the metal present in the reagent itself (lithium or aluminum). However, the observed C-1 selectivity can be reduced, at least in the case of the reaction with $LiAlH_4$, by carring out the same reaction in the presence of a crown ether. In these conditions, the metal-sequestering ability of the crown ether reduces the reaction pathway which leads, via structures **72** and **73**, to *C-1 products*, thus increasing the amounts of *C-2 products* (entry 20, Table 1). As for the methyl transfer reaction, a partial regiochemical inversion is obtained when Me_2CuLi is used instead of $AlMe_3$, as the methylating agent. Evidently in this case, the diethyl ether, used as a necessary solvent for the formation of the reagent (Me_2CuLi) effectively prevents (like a crown ether) the formation of the above-mentioned chelate-bidentate species **72** and **73**, thus determining a substantial reduction in the C-1 selectivity.

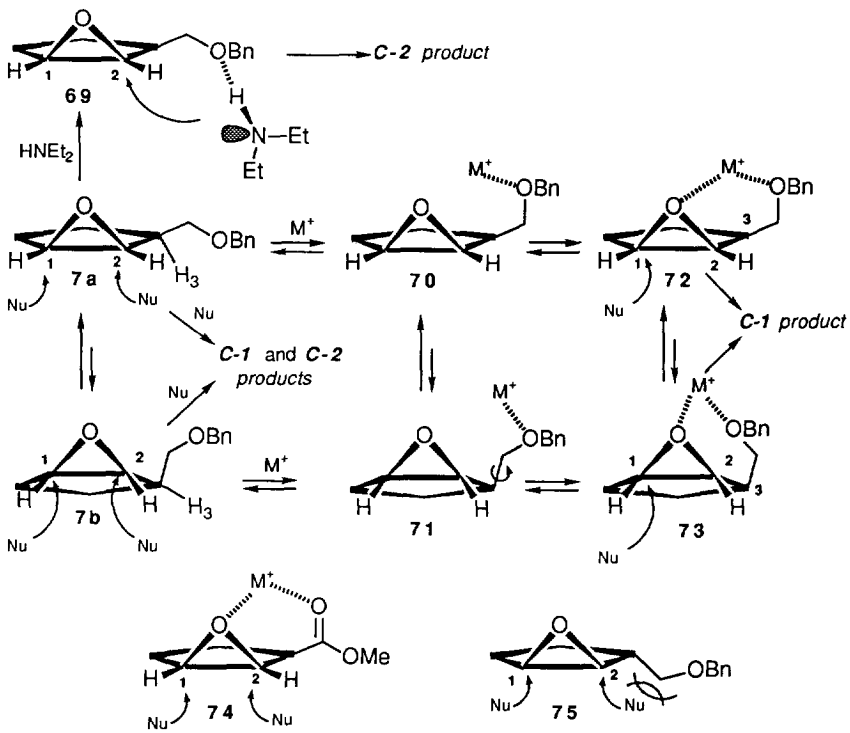
Table 2. Regioselectivity of the Ring Opening Reactions of the trans Epoxides 8 and 10 Under Standard and Chelating Conditions.

entry	epoxide	reagents	solvent	reaction time and temperature	*C-1 product*		*C-2 product*		yield %
1	**8**	HCl	$CHCl_3$	10 min (r.t.)	>99	**17**	**18**	<1	96
2	**8**	$TiCl_4$	CH_2Cl_2	30 min (-78°C)	>99			<1	91
3	**8**	HBr	$CHCl_3$	15 min (r.t.)	>99	**27**	**28**	<1	93
4	**8**	$MeOH/H_2SO_4$	MeOH	30 min (r.t.)	>99	**53**	**54**	<1	97
5	**8**	$MeOH/LiClO_4$ 10M	MeOH	18 h (80°C)	>99			<1	90
6	**8**	NaN_3/NH_4Cl	MeOH:H_2O 8:1	18 h (80°C)	>99	**55**	**56**	<1	97
7	**8**	$NaN_3/LiClO_4$ 2.5 M	MeCN	18 h (80°C)	>99			<1	94
8	**8**	$PhSH/NEt_3$	MeOH	18 h (r.t.)	>99	**57**	**58**	<1	95
9	**8**	$PhSH/LiClO_4$	MeCN	18 h (80°C)	>99			<1	97
10	**8**	Me_2CuLi	Et_2O	5 h (-15 - 0°C)		no	reaction		99
11	**8**	$Al(Me)_3$	pentane	48 h (r.t.)	>99	**59**	**60**	<1	92
12	**8**	$Al(Me)_3$/crown	pentane	7 days (r.t.)		no	reaction		83
13	**8**	$LiAlH_4$	pentane	2 h (r.t.)	86	**61**	**62**	14	97
14	**8**	$LiAlH_4$/crown	pentane	5 h (r.t.) and 5 h refluxing		no	reaction		81
15	**10**	HCl	$CHCl_3$	15 min (r.t.)	92	**21**	**22**	8	96
16	**10**	$TiCl_4$	CH_2Cl_2	30 min (-78°C)	>99			<1	91
17	**10**	HBr	$CHCl_3$	15 min (r.t.)	95	**31**	**32**	5	95
18	**10**	$MeOH/H_2SO_4$	MeOH	30 min (r.t.)	>99	**63**	**64**	<1	97
19	**10**	$MeOH/LiClO_4$ 10M	MeOH	48 h (80°C)	>99			<1	90
20	**10**	NaN_3/NH_4Cl	MeOH:H_2O 8:1	60 h (80°C)	>99	**65**	**66**	<1	96
21	**10**	$NaN_3/LiClO_4$ 2.5 M	MeCN	18 h (80°C)	>99			<1	93
22	**10**	Me_2CuLi	Et_2O	3 h (-15 - 0°C)	80[a]	**67**	**68**	20[a]	95
23	**10**	$AlMe_3$	pentane	48 h (r.t.)	complex		mixture		95

[a] Methyl 3-hydroxy-1-cyclopentencarboxylate (**76**) is the main reaction product (64%).

It is, however, not easy to explain the C-2 selectivity so far obtained, unless we admit a directing effect of the OBn functionality as tentatively hypothesized for the aminolysis reaction (see above).

Scheme 6



The high C-1 selectivity (85-93%, Table 1) observed in all the opening reactions examined of the cis epoxide **9** under standard conditions can reasonably be attributed to the strong electron-withdrawing inductive effect of the methoxycarbonyl substituent (COOMe), which makes the nucleophilic attack on the further C(1) oxirane carbon more favored. When the same reactions were repeated in the presence of a metal salt (chelating conditions), a constant, significant further increase in C-1 selectivity was observed to the point that an almost complete C-1 regioselectivity was obtained, in some cases (entries 22, 25, 28 and 30, Table 1). Also in this case, the present results can be attributed to the intervention of intermediate chelate-bidentate species, such as **74**, of the same type as previously admitted for the cis epoxide **7** (Scheme 6).[1-3,11,12]

The corresponding reactions of the trans epoxides **8** and **10** turned out to be completely C-1 regioselective, independently of the reaction conditions (Table 2). This is reasonable considering that in **8** and **10**, for strictly structural reasons, no chelate-bidentate structures are possible in any standard or metal-assisted opening reaction conditions, and the regiochemical outcome is determined, in this case, both by the inductive electron-withdrawing and steric effect of the homoallylic *O*-functionality (CH_2OBn or COOMe) which prevent nucleophilc attack on the C(2) oxirane carbon as shown for the epoxide **8** in structure **75** (Scheme 6).

Structures, Configurations, and Conformations

The structures and the relative configurations of the epoxides cis **7** and **9** and trans **8** and **10** were firmly established by their method of preparation. In particular, the highly diastereoselective synthesis of epoxides cis **7** and **9** by Sharpless' chlorohydroxylation reaction[7] on the corresponding olefins **11** and **13**, respectively, followed by base-catalyzed cyclization of the chlorohydrins obtained, unequivocally assign to **7** and **9** a cis relationship between the oxirane ring and the functionalized substituent.[3a,3d,7] In the case of the cis epoxide **7**, a further confirmation of its structure could be obtained by its LAH reduction reaction: the alcohols **45** and **46** obtained in this reaction, show the presence in their IR spectrum in dilute CCl_4 of a characteristic OH···O interaction at 3526 and 3479 cm^{-1}, respectively (Table 3), which is possible only when a cis 1,3- or a 1,4-relationship is present between the interacting groups such as the hydroxyl and the benzyloxy group.[13]

The conformational equilibrium in epoxides **7-10** cannot easily be determined by ^1H NMR studies as largely done in the case of the corresponding cyclohexane derivatives.[1,3,4,10] However, a preference for the envelope conformation **a**, with the large substituent (CH_2OBn or COOMe) pseudoequatorial, can be reasonably admitted (Scheme 6, where, for simplicity, only the epoxide **7** is shown).[14]

The structures and configurations of the *C-1* and *C-2 products* obtained as regioisomeric pairs in the opening reactions of epoxides **7-10** were unequivocally determined by simple considerations based on the configuration of the starting epoxide, the complete anti stereoselectivity commonly observed in the opening reactions of aliphatic and cycloaliphatic epoxides under the conditions used,[1-4,10] an examination of their ^1H NMR spectra (protons H_1, H_2 and H_3, Scheme 5 and Table 3), and by the use of appropriate double resonance experiments carried out, when necessary, on their monoacetyl derivatives. The IR spectra in the 3μ range in dilute CCl_4 solution[13] of the opening products (Scheme 5) show four characteristic kinds of behavior (Table 3). Bearing in mind that *i*) the OH and X groups in the *C-1* and *C-2 products* are always in a 1,2-trans relationship, *ii*) in the cyclopentane system, such a relationship does not allow the formation of any hydrogen bond between the two groups,[13a] and, as a consequence, *iii*) any hydrogen bond present in the IR spectra of these compounds is to be attributed to an interaction between the OH and the CH_2OBn or COOMe group, it follows that the IR spectra of all the opening products (Table 3), can be nicely correlated with one of the four possible regioisomeric structures, thus confirming them. The four different situations are summarized in Scheme 7, where, for simplicity, only the *C-1* and *C-2 products* from the epoxides cis **7** and trans **8** are shown:[15]

a) *C-1 products* from the cis epoxides **7** and **9**: the presence of an intense band at 3502-3535 cm^{-1} (3483-3487 cm^{-1} in the case of the haloderivatives) characteristic of a cis 1,3 OH···O interaction, possible in both the conformations **A** and **B**.

b) *C-2 products* from the cis epoxides **7** and **9**: the presence of an intense band at 3454-3481 cm^{-1} due to a cis 1,4 OH···O interaction possible only in the conformation **C**. An intense free OH band, reasonably due to the presence of the conformation **D**, is also present.

c) *C-1 products* from the trans epoxides **8** and **10**: the presence of an intense band at 3566-3574 cm^{-1} characteristic of a trans 1,3 OH···O interaction possible in the conformation **E**. This interaction is correctly less strong than the 1,3-cis OH···O interaction (see above, point *a*), as a consequence of the larger distance between the two interacting groups (OH and OBn or COOMe), as clearly shown by a simple examination of

Table 3. Spectroscopic Data for Compounds 15-67.[a]

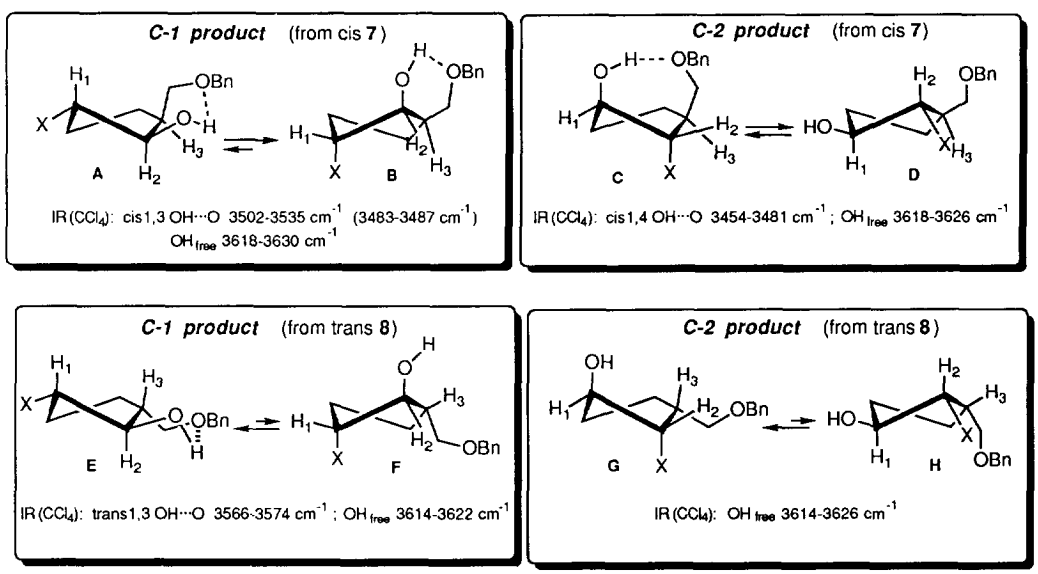
	^{1}H NMR δ			IR (CCl_4) (OH stretching), cm^{-1}		
compd	H_1 ($W_{1/2}$,Hz)[b,c]	H_2 ($W_{1/2}$,Hz)[b,c]	H_3 ($W_{1/2}$,Hz)[d,e]	1,3 OH···O	1,4 OH···O	free OH
15	4.04 (10.1)[b,f]	4.16 (11.5)[c,g]	2.52 [d,g]	3487[o]		3620[p]
16	4.08 (13.0)[c,g]	3.81 (13.3)[b,h]	2.31 [d,g]		3462[o,q]	3609[o]
17	3.95 (23.0)[b,g]	3.48 (21.4)[c,h]	*j*	3572[q]		3614[o]
19	4.22 (12.0)[b,g]	4.40 (9.6)[c,h]	3.38 (16.2)[e,i]	3514[o,q]		3618[o]
20	*j*	*j*	3.06 (19.4)[e,g]		3466[q]	3607[o]
21	3.95 (17.6)[b,k]	4.30 (16.0)[c,l]	2.70 (24.0)[e,k]	3520[q]		3614[o]
25	4.15 (13.3)[b,g]	4.37 (11.9)[c,g]	2.67 [d,g]	3483[o]		3622[p]
26	4.25 (17.9)[c,k]	3.93 (13.5)[b,l]	2.50 [d,g]		3454[o,q]	3603[o]
27	*j*	*j*	2.29 [d,g]	3572[r]		3614[o]
28	4.39 (6.0)[c,m]	4.28 (9.0)[b,m]	2.25 [d,g]			3614[o]
29	4.27 (10.4)[b,g]	4.51 (7.7)[c,h]	3.37 (20.7)[e,i]	3483[o]		3616[p]
31	3.96 (15.2)[b,k]	4.39 (15.0)[c,l]	2.67 (19.0)[e,i]	3520[q]		3614[o]
32	4.54 (12.8)[c,g]	4.30 (9.6)[b,m]	3.51 (22.4)[e,i]			3614[o]
35	*j*	4.11 (9.5)[c,h]	2.26 [d,g]	3512[o]		3626[p]
36	4.02 (11.0)[c,g]	3.36 (8.8)[b,g]	2.10 [d,g]		3474[o,q]	3626[o]
37	3.73 (13.0)[b,g]	4.05 (13.0)[c,h]	2.29 [d,g]	3502[o]		3620[p]
38	3.95 (18.0)[c,g]	*j*	2.09 [d,g]		3460[o,q]	3624[o]
41	3.49 (13.6)[b,i]	4.12 (10.8)[c,g]	2.45 [d,g]	3502[o]		3618[p]
42	4.05 (13.0)[c,g]	3.30 (11.4)[b,g]	*j*		3474[o,q]	3618[o]
43	*j*	3.74 (12.7)[c,h]	2.24 [d,g]	3535[o]		3626[p]
44	3.64 (15.0)[c,h]	*j*	*j*		3481[o,q]	3626[o]
45		4.28 (10.9)[c,g]	2.04 [d,g]	3526[o]		3630[p]
46	4.15 (12.0)[c,g]		2.26 [d,g]		3479[o,q]	3626[o]
47	3.70 (12.5)[b,g]	4.30 (7.5)[c,h]	2.95 (25.0)[e,i]	3514[o]		3614[p]
48	4.13 (14.7)[c,g]	3.84 (10.0)[b,l]	2.78 (17.5)[e,g]		3466[o,q]	3614[o]
49	3.88 (14.5)[b,f]	4.16 (10.1)[c,h]	2.92 (23.1)[e,i]	3502[o]		3618[p]
51	*j*	3.86 (14.0)[c,g]	2.82 (16.3)[e,g]	3533[o,q]		3614[p]
52	3.70 (15.0)[c,g]	*j*	2.32 (17.3)[e,g]		3504[o,q]	3626[o]
53	*j*	3.84 (15.5)[c,h]	*j*	3566[o]		3618[o]
55	*j*	*j*	*j*	3572[o]		3622[o]
57	*j*	3.75 (17.0)[c,l]	*j*	3572[o]		3612[o]
59	*j*	3.57 (16.5)[c,h]	2.00 [d,g]	3574[o]		3614[p]
61		3.99 (20.0)[c,k]	2.08 [d,g]	3570[o]		3622[o]
62	4.36 (12.0)[c,n]		2.52 [d,g]			3626[o]
63	3.62 (21.2)[b,g]	4.20 (18.0)[c,h]	2.70 (26.0)[e,g]	3537[p,q]		3618[o]
65	3.77 (25.0)[b,g]	4.20 (17.0)[c,l]	2.76 (20.6)[e,g]			3618[o]
67	*j*	3.72 (24.0)[c,g]	2.69 (21.3)[e,g]	3535[p,q]		3614[o]

Compounds **18, 22, 30, 50, 54, 56, 58, 60, 64, 66** and **68** (Scheme 4) which are not present or present in an insufficient amount in the opening reactions of the corresponding epoxide, are not included. [b] CHX; [c] *CH*OH; [d] *CH*CH_2OBn; [e] *CH*COOMe (Schemes 5 and 7). [f] Quintet. [g] Multiplet [h] Doublet of doublets. [i] Doublet of doublets of doublets. [j] The signal overlaps with other signals. [k] Quartet. [l] Triplet. [m] Doublet. [n] Septet. [o] Strong band. [p] Weak band. [q] Broad band. [r] Shoulder.

the corresponding molecular models. An intense free OH band, attributable to the presence of the conformation **F** in the conformational equilibrium, is contemporarily present.

d) C-2 products from the trans epoxides **8** and **10**: the presence of only the free OH band (3614-3626 cm^{-1}). In these compounds, there is no possibility of an interaction between the two functionalities (OH and OBn or COOMe) in either of the two possible conformations **G** and **H.**

Scheme 7



As for the conformational equilibrium inside the *C-1* and *C-2 products* from the epoxides **7-10**,[15] the IR data[13] and the $W_{1/2}$ values[16] of the signal of the protons H_1, H_2 and, only in the case of the products from the epoxides **9** and **10**, H_3 (Scheme 5 and Table 3) would indicate an almost equimolar equilibrium between the two possible half-chair conformations[15] or a preference for that half-chair conformation bearing the large substituent (CH_2OBn or COOMe) in the more favored pseodoequatorial position, as shown in Scheme 7.[15,16]

EXPERIMENTAL

For general experimental procedures see ref. 3d and 11.

3-Hydroxymethylcyclopentene (14). 3-Chlorocyclopentene (17 g, 0.167 mol) was added dropwise to a stirred suspension of NaCN (34 g, 0.69 mol) in 1-methyl-2-pyrrolidinone (90 ml) and the reaction mixture was stirred for 20 h. Dilution with ether and evaporation of the washed (water) organic solution afforded a crude liquid product which was extracted with hexane. Evaporation of the washed (water) hexane extracts afforded a liquid product (10 g) consisting of practically pure **2-cyclopenten-1-carbonitrile (12)** which was directly utilized in the next reaction: IR 2237 cm^{-1} (CN); ^1H NMR ($CDCl_3$) δ 5.90-6.12 (m, 1H), 5.55-5.80 (m, 1H), 3.30-3.75 (m, 1H), 1.98-2.65 (m, 4H). Anal.Calcd for C_6H_7N: C, 77.38; H, 7.57; N, 15.03. Found: C, 77.43; H, 7.34; N, 15.29.

Anhydrous gaseous HCl was gently bubbled for 6 h in a refluxing solution of **12** (26 g, 0.28 mol) in anhydrous MeOH. After cooling, dilution with ether and evaporation of the washed (saturated aqueous $NaHCO_3$ and water) organic solution afforded a crude liquid residue which was distilled to give pure **methyl 2-cyclopenten-1-carboxylate (13)** as a liquid (19.3 g), b.p. 70°C (20 mmHg) [lit.[5d] 52°C (12 mmHg)].

A solution of ester **13** (10 g, 79 mmol) in anhydrous ether (75 ml) was added to a stirred suspension of $LiAlH_4$ (4.7 g, 119 mmol) in anhydrous ether and the reaction mixture was gently refluxed for 3 h. After cooling, water and aqueous 10% NaOH was carefully added in order to destroy the hydride excess. Evaporation of the ether solution afforded a crude liquid product essentially consisting of alcohol **14** which was purified by filtration on a silica gel column. Elution with a 9:1 hexane-ether mixture afforded pure alcohol **14** as a liquid.[5]

3-Benzyloxymethylcyclopentene (11). A stirred suspension of NaH (4.0 g of an 80% suspension in mineral oil, 0.13 mol) in anhydrous THF (120 ml) was treated at 50°C with benzyl bromide (7.6 ml, 62 mmol) and then with a solution of alcohol **14** (6.0 g, 0.061 mol) in anhydrous THF (52 ml). The reaction mixture was stirred at the same temperature for 18 h. After cooling, water was carefully added in order to destroy the excess of hydride. Dilution with ether and evaporation of the washed (water) ether extracts afforded a crude liquid product which was distilled to give pure **11** as a liquid (7.8 g), b.p. 69-71°C (0.05 mmHg); ^1H NMR ($CDCl_3$) δ 7.28-7.40 (m, 5H), 5.65-5.80 (m, 2H), 4.53 (s, 2H), 3.28-3.46 (m, 2H), 2.88-3.10 (m, 1H), 1.23-2.50 (m, 2H). Anal.Calcd for $C_{13}H_{16}O$: C, 82.93; H, 8.49. Found: C, 83.29; H, 8.11.

Chlorohydroxylation of Olefin 11. Following a previously described procedure,[3a,3d,7] the reaction of olefin **11** (2.52 g, 13.4 mmol) in CH_2Cl_2 at -78°C with 3M TBHP in 2,2,4-trimethylpentane (5.4 ml) and $TiCl_4$ (3.04 g, 16.0 mmol) in CH_2Cl_2 (10 ml) afforded a crude reaction product (3.31 g) consisting of a 58:40:2 mixture of chlorohydrins **15**, **16**, and **17** which was subjected to flash chromatography. Elution with a 75:25 mixture of hexane and AcOEt afforded pure **15** (1.40 g) and **16** (0,98 g).

***c*-2-(Benzyloxymethyl)-*t*-5-chloro-*r*-1-cyclopentanol (15)**, a liquid: IR, see Table 3; ^1H NMR ($CDCl_3$) δ 7.18-7.35 (m, 5H), 4.43 and 4.50 (ABdd, 2H, J=11.9 Hz), 4.12-4.20 (m, 1H, H_2), 4.04 (q, 1H, J=2.9 Hz, H_1), 3.64 (dd, 1H, J=9.4 and 4.4 Hz), 3.58 (dd, 1H, J=9.4 and 6.2 Hz), 2.43-2.61 (m, 1H, H_3), 2.19-2.35 (m, 1H), 1.52-1.94 (m, 3H). Anal.Calcd for $C_{13}H_{17}ClO_2$: C, 64.86; H, 7.07. Found: C, 64.97; H, 7.19. **Acetate**, a liquid: ^1H NMR ($CDCl_3$) δ 7.27-7.35 (m, 5 H), 5.24 (dd, 1H, J=5.7 and 3.0 Hz, $W_{1/2}$=10.1 Hz, H_2), 4.46-4.51 (ABdd, 2H, J=12.1 Hz), 4.17-4.26 (m, 1H, $W_{1/2}$=14.0 Hz, H_1), 3.36-3.53 (m, 2H), 2.73-2.86 (m, 1H, $W_{1/2}$=25.0 Hz, H_3), 1.98 (s, 3H), 1.18-2.38 (m, 4H). Anal.Calcd for $C_{15}H_{19}ClO_3$: C, 63.73; H, 6.73. Found: C, 63.91; H, 6.59.

***c*-3-(Benzyloxymethyl)-*t*-2-chloro-*r*-1-cyclopentanol (16)**, a liquid: IR, see Table 3; ^1H NMR ($CDCl_3$) δ 7.19-7.33 (m, 5H), 4.48 (s, 2H), 4.04-4.13 (m, 1H, H_1), 3.81 (dd, 1H, J=6.3 and 5.4 Hz, H_2),

3.41-3.54 (m, 2H), 2.26-2.37 (m, 1H, H_3), 1.56-2.10 (m, 4H). Anal.Calcd for $C_{13}H_{17}ClO_2$: C, 64.86; H, 7.07. Found: C, 64.81; H, 7.39. **Acetate**, a liquid: ^1H NMR ($CDCl_3$) δ 7.27-7.34 (m, 5H), 5.08-5.13 (m, 1H, $W_{1/2}$=11.4 Hz, H_1), 4.50 and 4.56 (ABdd, 2H, J=12.0 Hz), 4.02-4.18 (m, 1H, $W_{1/2}$=26.9 Hz, H_2), 3.46-3.61 (m, 2H), 2.05 (s, 3H), 1.18-2.30 (m, 5H). Anal.Calcd for $C_{15}H_{19}ClO_3$: C, 63.73; H, 6.73. Found: C, 63.85; H, 6.49.

Reaction of Olefin 11 with *N*-Bromosuccinimide (NBS). A solution of olefin **11** (1.64 g, 8.7 mmol) in a 9:1 THF/H_2O mixture (70 ml) was treated at r.t. with *N*-bromosuccinimide (NBS) (1.4 g, 10 mmol) and the reaction mixture was left for 18 h at the same temperature in the dark. Dilution with water and extraction with ether and evaporation of the washed (water) ether extracts afforded a crude reaction product (2.23 g), consisting of a 13:13:74 mixture of bromohydrins **26**, **27** and **28** which was subjected to flash chromatography. Elution with a 8:1.5:0.5 mixture of hexane, diisopropyl ether and 2-butanone afforded pure bromohydrins **27** (0.17 g) and **28** (1.10 g).

***t*-2-(Benzyloxymethyl)-*t*-5-bromo-*r*-1-cyclopentanol (27)**, a liquid: IR, see Table 3; ^1H NMR ($CDCl_3$) δ 7.25-7.36 (m, 5H), 4.52 (s, 2H), 3.96-4.09 (m, 2H), 3.44-3.63 (m, 2H), 2.24-2.34 (m, 1H, H_3), 1.79-2.11 (m, 3H), 1.48-1.62 (m, 1H). Anal.Calcd for $C_{13}H_{17}BrO_2$: C, 54.75; H, 6.00. Found: C, 54.51; H, 5.85. **Acetate**, a liquid: ^1H NMR ($CDCl_3$) δ 7.23-7.39 (m, 5H), 5.22 (t, 1H, J=4.7 Hz, $W_{1/2}$=11.0 Hz, H_2), 4.54 (s, 2H), 4.16 (q, 1H, J=5.4 Hz, $W_{1/2}$=17.4 Hz, H_1), 3.63 (dd, 1H, J=9.1 and 6.5 Hz), 3.53 (dd, 1H, J=9.1 and 7.0 Hz), 2.17-2.36 (m, 2H), 1.92-2.15 (m, 2H), 2.04 (s, 3H), 1.70-1.85 (m, 1H). Anal.Calcd for $C_{15}H_{19}BrO_3$: C, 55.06; H, 5.23. Found: C, 55.34; H, 5.60.

***t*-3-(Benzyloxymethyl)-*t*-2-bromo-*r*-1-cyclopentanol (28)**, a liquid: IR, see Table 3; ^1H NMR ($CDCl_3$) δ 7.25-7.48 (m, 5H), 4.49 and 4.55 (ABdd, 2H, J=11.8 Hz), 4.39 (d, 1H, J=5.8 Hz, H_1), 4.28 (d, 1H, J=4.4 Hz, H_2), 3.57 (d, 2H, J=7.2 Hz), 2.14-2.36 (m, 1H, H_3), 1.78-1.96 (m, 1H), 1.36-1.64 (m, 2H). Anal.Calcd for $C_{13}H_{17}BrO_2$: C, 54.75; H, 6.00. Found: C, 54.47; H, 5.63. **Acetate**, a liquid: ^1H NMR ($CDCl_3$) δ 7.16-7.36 (m, 5H), 5.35 (dd, 1H, J=6.6 and 1.3 Hz, $W_{1/2}$=9.3 Hz, H_1), 4.49 and 4.55 (ABdd, 2H, J=11.8 Hz), 4.42 (d, 1H, J=4.2 Hz, H_2), 3.56-3.68 (m, 2H), 2.41-2.58 (m, 1H, $W_{1/2}$=21.2 Hz, H_3), 2.00 (s, 3H), 1.16-2.10 (m, 4H). Anal.Calcd for $C_{15}H_{19}BrO_3$: C, 55.06; H, 5.23. Found: C, 55.25; H, 5.48.

Synthesis of Epoxides cis 7 and trans 8. a) A solution of chlorohydrin **15** (or **16**) (0.50 g, 2.08 mmol) in anhydrous benzene (30 ml) was treated at r.t. with *t*-BuOK (0.226 g x 2) and the reaction mixture was stirred at the same temperature for 2 h. Evaporation of the washed (water) benzene solution afforded pure **cis-1-(benzyloxymethyl)-2,3-epoxycyclopentane (7)** (0.39 g) as a liquid: ^1H NMR ($CDCl_3$) δ 7.24-7.35 (m, 5H), 4.53 and 4.58 (ABdd, 2H, J=12.0 Hz), 3.47-3.61 (m, 4H), 2.25-2.33 (m, 1H, $W_{1/2}$=18.6 Hz, H_3), 1.98-2.09 (m, 1H), 1.57-1.69 (m, 2H), 0.91-1.05 (m, 1H); ^1H NMR (C_6D_6) δ 6.77-6.94 (m, 5H), 4.01 and 4.07 (ABdd, 2H, J=12.2 Hz), 3.20 (t, 1H, J=8.7 Hz, H_1), 3.03-3.08 (m, 2H), 2.78 (d, 1H, J=2.1 Hz, H_2), 1.65-1.81 (m, 1H, $W_{1/2}$=18.8 Hz, H_3), 1.38-1.49 (m, 1H), 0.55-1.05 (m, 3H). Anal.Calcd for $C_{13}H_{16}O_2$: C, 76.44; H, 7.89. Found: C, 76.23; H, 7.93.

b) Proceeding as described above for **15**, cyclization under basic conditions (*t*-BuOK) of the crude product (0.480 g) obtained in the chlorohydroxylation reaction of olefin **11** afforded a crude product consisting of a 98:2 mixture of epoxides cis **7** and trans **8** (GC).

c) Proceeding as described above for **15**, cyclization under basic conditions (*t*-BuOK, 0.106 g x 2) of bromohydrin **28** (or **27**) (0.27 g, 0.94 mmol) in anhydrous benzene (15 ml) afforded pure **trans-1-(benzyloxymethyl)-2,3-epoxycyclopentane (8)**, as a liquid (0.110 g); ^1H NMR ($CDCl_3$) δ 7.20-7.39 (m, 5H), 4.50 and 4.58 (ABdd, 2H, J=12.0 Hz), 3.46 (s, 2H), 3.37 (d, 2H, J=0.7 Hz), 3.34 (d, 1H, J=1.5 Hz), 2.54 (q, 1H, J=7.2 Hz, $W_{1/2}$=22.0 Hz, H_3), 1.91-2.02 (m, 1H), 1.38-1.73 (m, 3H); ^1H NMR (C_6D_6) δ 6.80-6.97 (m, 5H), 3.92 (s, 2H), 3.02 (d, 1H, J=2.6 Hz, H_1), 2.86 (d, 1H, J=0.8 Hz, H_2), 2.67 (d, 2H,

J=6.5 Hz), 2.13 (q, 1H, J=6.9 Hz, $W_{1/2}$=19.0 Hz, H_3), 1.43-1.49 (m, 1H), 0.86-1.31 (m, 3H). Anal.Calcd for $C_{13}H_{16}O_2$: C, 76.44; H, 7.89. Found: C, 76.76; H, 7.71.

d) Proceeding as described above for **15**, cyclization under basic conditions of the crude reaction product of the olefin **11** with NBS (0.27 g) afforded a corresponding reaction product consisting of a 13:87 mixture of epoxide cis **7** and trans **8**.

e) A solution of olefin **11** (0.30 g, 1.60 mmol) in CH_2Cl_2 (15 ml) was treated at 0°C with 55% *m*-CPBA (0.525 g, 1.68 mmol). After 24 h at 0-5°C, usual workup afforded a crude reaction product (0.29 g) consisting of a 73:27 mixture of epoxides cis **7** and trans **8** (GC).

Synthesis of Epoxides cis 9 and trans 10. a) A solution of olefin **13** (4.0 g, 32.0 mmol) in CH_2Cl_2 was treated at 0°C under stirring with 55% *m*-CPBA (12.3 g, 36.0 mmol). After 2 h at the same temperature, the usual workup afforded a crude reaction product (4.0 g) consisting of a 57:43 mixture (GC) of epoxides cis **9** and trans **10** which was subjected to flash chromatography. Elution with an 8:2 mixture of hexane and AcOEt afforded pure epoxide cis **9** (1.93 g) and trans **10** (1.46 g).

Methyl cis-2,3-epoxy-1-cyclopentancarboxylate (9), a liquid: ^{1}H NMR ($CDCl_3$) δ 3.68 (s, 3H), 3.62 (dd, 1H, J=2.5 and 1.6 Hz, H_2), 3.43 (dd, 1H, J=2.5 and 1.2 Hz, H_1), 2.75-2.85 (m, 1H, $W_{1/2}$=21.2 Hz, H_3), 1.99-2.16 (m, 1H), 1.52-1.89 (m, 3H). Anal.Calcd for $C_7H_{10}O_3$: C, 59.15; H, 7.04. Found; C, 59.17; H, 7.22.

Methyl trans-2,3-epoxy-1-cyclopentancarboxylate (10), a liquid: ^{1}H NMR ($CDCl_3$) δ 3.64 (s, 3H), 3.58 (d, 1H, J=2.6 Hz, H_2), 3.47 (d, 1H, J=2.6 Hz, H_1), 3.05 (d, 1H, J=8.3 Hz, $W_{1/2}$= 17.0 Hz, H_3), 1.47-2.01 (m, 4H). Anal.Calcd for $C_7H_{10}O_3$: C, 59.15; H, 7.04. Found; C, 59.23; H, 7.33.

b) Proceeding as previously described,[3a,3d,7] the reaction of olefin **13** (0.504 g, 4.0 mmol) in anhydrous CH_2Cl_2 (50 ml) at -78°C with 3M TBHP in 2,2,4-trimethylpentane (1.6 ml) and $TiCl_4$ (4.8 mmol) in CH_2Cl_2 (3.5 ml) afforded a crude reaction product (0.71 g) consisting of a 90:4:6 mixture of chlorohydrins **19**, **20** and **21** (GC), which was subjected to preparative TLC (a 55:45 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense band afforded pure **methyl *t*-3-chloro-*c*-2-hydroxy-*r*-1-cyclopentancarboxylate (19)** (0.54 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.40 (dd, 1H, J=4.6 and 2.0 Hz, H_2), 4.19-4.24 (m, 1H, H_1), 3.75 (s, 3H), 3.28 (ddd, 1H, J=9.3 and 4.6 Hz, H_3), 2.43-2.60 (m, 1H), 1.88-2.29 (m, 3H). Anal.Calcd for $C_7H_{11}ClO_3$: C, 47.07; H, 6.16. Found: C, 47.11; H, 6.35. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.35 (dd, 1H, J=6.0 and 3.0 Hz, $W_{1/2}$=10.6 Hz, H_2), 4.21-4.28 (m, 1H, $W_{1/2}$=10.5 Hz, H_1), 3.67 (s, 3H), 3.38-3.52 (m, 1H, $W_{1/2}$=16.4 Hz, H_3), 2.01 (s, 3H), 1.90-2.48 (m, 4H). Anal. Calcd for $C_9H_{13}ClO_4$: C, 48.99; H, 5.90. Found: C, 48.76; H, 5.94.

A solution of chlorohydrin **19** (0.089 g, 0.50 mmol) in a 9:1 THF/H_2O mixture (10 ml) containing phenolphthalein as the indicator, was treated with 1M NaOH. When the theoretical amount of base (0.5 ml) was added (30 min), dilution with water, extraction with ether and evaporation of the washed ether extracts afforded pure cis epoxide **9** (0.060 g) (GC).

When the crude chlorohydroxylation reaction product (0.10 g) of olefin **13** (see above) was directly cyclized under base-catalyzed conditions (aqueous 1M NaOH), as above described for pure chlorohydrin **19**, a crude reaction mixture was obtained consisting of practically pure cis epoxide **9** (0.065 g) (GC).

c) Proceeding as described above for the corresponding reaction of olefin **11**, a solution of olefin **13** (0.252 g, 2.0 mmol) in a 9:1 THF/H_2O mixture (14 ml) was treated with NBS (0.39 g, 2.1 mmol) and the reaction mixture was left 18 h at r.t. in the dark. The usual workup afforded a crude reaction product (0.42 g) consisting of a 25:12:63 mixture of bromohydrins **30**, **31** and **32** (GC), which was dissolved in a 9:1 THF/H_2O mixture (30 ml) and dropwise treated with the theoretical amount of aqueous 1M NaOH (2.0 ml) in about 1h. Dilution with water and extraction with ether afforded a crude liquid reaction product (0.227 g) consisting of a 26:74 mixture of epoxides cis **9** and trans **10** (GC).

An analytical sample (0.10 g) of the above mixture of bromohydrins **30, 31,** and **32** was subjected to semipreparative TLC (a 9:1 mixture of petroleum ether and ether was used as the eluant). Extraction of the slower moving band afforded pure **methyl *c*-2-bromo-*t*-3-hydroxy-*r*-1-cyclopentancarboxylate (32)**, as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.52-4.57 (m, 1H, H_1), 4.30 (d, 1H, J=5.3 Hz, H_2), 3.74 (s, 3H), 3.51 (ddd, 1H, J=9.0 and 5.3 Hz, H_3), 1.79-2.51 (m, 4H). Anal.Calcd for $C_7H_{11}BrO_3$: C, 37.69; H, 4.97. Found: C, 37.81; H, 5.29.

Reaction of Epoxides 7-10 with HCl in $CHCl_3$. The following procedure is typical. A solution of the cis epoxide **7** (0.102 g, 0.50 mmol) in $CHCl_3$ (10 ml) was treated with 36% aqueous HCl (5.0 ml) and the reaction mixture was stirred at the same temperature for 30 min. Evaporation of the washed (saturated aqueous $NaHCO_3$ and water) organic solution afforded a crude reaction product (0.12 g) which was analyzed by GC (see Table 1).

The crude reaction product (0.115 g) from the trans epoxide **8** afforded a crude liquid product consisting of practically pure ***t*-2-(benzyloxymethyl)-*t*-5-chloro-*r*-1-cyclopentanol (17)**: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.25-7.39 (m, 5H), 4.53 (s, 2H), 3.90-4.01 (m, 1H, H_1), 3.58 (dd, 1H, J=89 and 5.7 Hz), 3.47 (dd, 1H, J=8.9 and 7.8 Hz), 3.48 (dd, 1H, J=10.7 and 6.9 Hz, H_3), 2.05-2.28 (m, 2H), 1.75-1.94 (m, 2H), 1.47-1.60 (m, 1H). Anal.Calcd for $C_{13}H_{17}ClO_2$: C, 64.86; H, 7.07. Found: C, 64.56; H, 7.30. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.18-7.28 (m, 5H), 5.02 (t, 1H, J=5.0 Hz, $W_{1/2}$=10.4 Hz, H_2), 4.44 (s, 2H), 4.03-4.11 (m, 1H, $W_{1/2}$=16.7 Hz, H_1), 3.53 (dd, 1H, J=9.0 and 6.4 Hz), 3.43 (dd, 1H,J=9.0 and 7.1 Hz), 2.07-2.20 (m, 2H), 1.97 (s, 3H), 1.65-1.96 (m, 3H). Anal.Calcd for $C_{15}H_{19}ClO_3$: C, 63.73; H, 6.73. Found: C, 63.79; H, 6.41.

The crude reaction product (0.085 g) from the cis epoxide **9** was subjected to semipreparative TLC (a 6:4 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **19**) afforded pure chlorohydrins **19** (0.060 g) and **methyl *t*-2-chloro-*c*-3-hydroxy-*r*-1-cyclopentancarboxylate (19)** (0.010 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.19-4.30 (m, 2H), 3.76 (s, 3H), 2.99-3.10 (m, 1H, H_3), 2.10-2.28 (m, 1H), 1.52-1.88 (m, 3H). Anal.Calcd for $C_7H_{11}ClO_3$: C, 47.07; H, 6.16. Found: C, 47.39; H, 6.01.

The crude reaction product (0.083 g) from the trans epoxide **10** was subjected to semipreparative TLC (a 6:4 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense band afforded pure **methyl *c*-3-chloro-*t*-2-hydroxy-*r*-1-cyclopentancarboxylate (21)** (0.070 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.30 (t, 1H, J=7.1 Hz, H_2), 3.95 (q, 1H,J=7.1 Hz, H_1), 3.67 (s, 3H), 2.69 (q, 1H, J=8.5 Hz, H_3), 2.14-2.27 (m, 1H), 1.82-2.06 (m, 3H). Anal.Calcd for $C_7H_{11}ClO_3$: C, 47.07; H, 6.16. Found: C, 47.20; H, 6.37. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.35 (t, 1H, J=4.7 Hz, $W_{1/2}$=11.6 Hz, H_2), 4.06-4.14 (m, 1H, $W_{1/2}$=17.2 Hz, H_1), 3.65 (s, 3H), 2.73-2.81 (m, 1H, $W_{1/2}$=21.5 Hz, H_3), 1.93-2.24 (m, 4H), 2.01 (s, 3H). Anal. Calcd for $C_9H_{13}ClO_4$: C, 48.99; H, 5.90. Found: C, 49.26; H, 5.71.

Reaction of Epoxides 7-10 with $TiCl_4$. General Procedure. A solution of the epoxide (0.50 mmol) in anhydrous CH_2Cl_2 (10 ml) was treated at -78°C with 1 M $TiCl_4$ in CH_2Cl_2 (0.6 ml). The reaction mixture was stirred at the same temperature for 30 min then slowly warmed to 0°C. The usual wokup afforded a crude reaction product which was analyzed by GC (Tables 1 and 2).

Reaction of Epoxides 7-10 with HBr-$CHCl_3$. The following procedure is typical. A solution of the cis epoxide **7** (0.102 g, 0.50 mmol) in $CHCl_3$ (5 ml) was treated with 48% aqueous HBr (2 ml) and the reaction mixture was stirred at r.t. for 30 min. The usual workup afforded a liquid residue (0.135 g) consisting of a 70:30 mixture of bromohydrins **25** and **26** which was subjected to semipreparative TLC (a 7:3 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **25**) afforded pure bromohydrin **25** (0.055 g) and **26** (0.024 g).

***c*-2-(Benzyloxymethyl)-*t*-5-bromo-*r*-1-cyclopentanol (25)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.27-7.40 (m, 5H), 4.56 and 4.50 (ABdd, 2H, J=11.9 Hz), 4.35-4.40 (m, 1H, H_2), 4.12-4.18

(m, 1H, H_1), 3.74 (dd, 1H, J=9.4 and 4.2 Hz), 3.64 (dd, 1H, J=9.4 and 6.2 Hz), 2.61-2.72 (m, 1H, H_3), 1.56-2.56 (m, 4H). Anal.Calcd for $C_{13}H_{17}BrO_2$: C, 54.75; H, 6.00. Found: C, 54.68; H, 6.33.

***c*-3-(Benzyloxymethyl)-*t*-2-bromo-*r*-1-cyclopentanol (26)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.26-7.40 (m, 5H), 4.54 (s, 2H), 4.26 (q, 1H, J=5.6 Hz, H_1), 3.92 (t, 1H, J=5.6 Hz, H_2), 3.56 (dd, 1H, J=9.3 and 4.5 Hz), 3.50 (dd, 1H, J=9.3 and 3.9 Hz), 2.42-2.58 (m, 1H, H_3), 1.58-2.21 (m, 4H). Anal.Calcd for $C_{13}H_{17}BrO_2$: C, 54.75; H, 6.00. Found: C, 55.01; H, 5.77.

The crude reaction product from the cis epoxide **9** (0.105 g), consisting of a 87:13 mixture of bromohydrins **29** and **30** (GC), was subjected to semipreparative TLC (a 8:2 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the most intense band afforded pure **methyl *t*-3-bromo-*c*-2-hydroxy-*r*-1-cyclopentan-carboxylate (29)** (0.073 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.51 (dd, 1H, J=4.9 and 2.4 Hz, H_2), 4.22-4.33 (m, 1H, H_1), 3.74 (s, 3H), 3.37 (ddd, 1H, J=8.8 and 4.7 Hz, H_3), 2.52-2.74 (m, 1H), 2.01-2.24 (m, 3H). Anal.Calcd for $C_7H_{11}BrO_3$: C, 37.69; H, 4.97. Found: C, 37.54; H, 5.14. Due to difficulty in the chromathographic separation, bromohydryn **30** was not separated from this reaction mixture. However, its presence was firmly established by GC and ^{1}H NMR evidences.

The crude reaction product from the trans epoxide **10** (0.103 g) consisting of a 95:5 mixture of bromohydrins **31** and **32** was subjected to semipreparative TLC (an 8:2 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the most intense band afforded pure **methyl *c*-3-bromo-*t*-2-hydroxy-*r*-1-cyclopentancar-boxylate (31)**, as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.39 (t, 1H, J=7.4 Hz, H_2), 3.96 (q, 1H, J=7.4 Hz, H_1), 3.67 (s, 3H), 2.58-2.76 (m, 1H, H_3), 2.21-2.39 (m, 1H), 1.95-2.11 (m, 3H). Anal.Calcd for $C_7H_{11}BrO_3$: C, 37.69; H, 4.97. Found: C, 38.01; H, 4.89.

H^+-Catalyzed Methanolysis of Epoxides 7-10. General procedure. A solution of the cis epoxide **7** (0.102 g, 0.50 mmol) in 0.2 N H_2SO_4 in anhydrous MeOH (10 ml) was stirred at r.t. for 30 min. The usual workup afforded a crude reaction product (0.11 g) which was subjected to semipreparative TLC (a 7:3 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense bands (the faster moving band contained **35**) afforded pure methoxy alcohols **35** (0.056 g) and **36** (0.025 g).

***c*-2-(Benzyloxymethyl)-*t*-5-methoxy-*r*-1-cyclopentanol (35)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.19-7.30 (m, 5H), 4.42 and 4.49 (ABdd, 2H, J=12.0 Hz), 4.11 (dd, 1H, J=5.6 and 2.4 Hz, H_2), 3.51-3.70 (m, 3H), 3.28 (s, 3H), 2.21-2.32 (m, 1H, H_3), 1.94-2.08 (m, 1H), 1.40-1.77 (m, 3H). Anal.Calcd for $C_{14}H_{20}O_3$: C, 71.19; H, 8.47. Found: C, 71.48; H, 8.77. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.19-7.31 (m, 5H), 5.14 (dd, 1H, J=5.1 and 1.8 Hz, $W_{1/2}$=10.0 Hz, H_2), 4.45 and 4.38 (ABdd, 2H, J=12.2 Hz), 3.57-3.63 (m, 1H, $W_{1/2}$=13.0 Hz, H_1), 3.42 (dd, 1H, J=9.2 and 7.8 Hz), 3.31 (s, 3H), 3.33 (dd, 1H, J=9.2 and 6.2 Hz), 2.39-2.50 (m, 1H, $W_{1/2}$=21.7 Hz, H_3), 1.89 (s, 3H), 1.75-2.10 (m, 2H), 1.31-1.60 (m, 2H). Anal.Calcd for $C_{16}H_{22}O_4$: C, 69.06; H, 7.91. Found: C, 69.36; H, 7.62.

***c*-3-(Benzyloxymethyl)-*t*-2-methoxy-*r*-1-cyclopentanol (36)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.18-7.30 (m, 5H), 4.48 (s, 2H), 3.99-4.05 (m, 1H, H_1), 3.49 (dd, 1H, J=9.0 and 4.9 Hz), 3.42 (dd, 1H, J=9.0 and 4.6 Hz), 3.34-3.37 (m, 1H, H_2), 3.30 (s, 3H), 2.06-2.15 (m, 1H, H_3), 1.70-1.87 (m, 2H), 1.52-1.64 (m, 2H). Anal.Calcd for $C_{14}H_{20}O_3$: C, 71.19; H, 8.47. Found: C, 71.29; H, 8.33. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.26-7.37 (m, 5H), 5.01-5.07 (m, 1H, $W_{1/2}$=11.0 Hz, H_1), 4.54 (s, 2H), 3.53 (dd, 1H, J=5.0 and 3.0 Hz, $W_{1/2}$= 11.0 Hz, H_2), 3.43-3.49 (m, 2H), 3.38 (s, 3H), 2.00 (s, 3H), 1.46-2.22 (m, 5H). Anal.Calcd for $C_{16}H_{22}O_4$: C, 69.06; H, 7.91. Found: C, 69.25; H, 7.79.

The crude reaction product (0.112 g) from the trans epoxide **8** was subjected to semipreparative TLC (a 8:2 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the most intense band afforded pure ***t*-2-(benzyloxymethyl)-*t*-5-methoxy-*r*-1-cyclopentanol (53)** (0.080 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.26-7.36 (m, 5H), 4.53 (s, 2H), 3.84 (dd, 1H, J=8.1 and 5.8 Hz, H_2), 3.37-3.69 (m, 3H), 3.38 (s, 3H), 1.36-2.12 (m, 5H). Anal.Calcd for $C_{14}H_{20}O_3$: C, 71.19; H, 8.47. Found: C, 71.00; H, 8.39. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.18-7.27 (m, 5H), 4.90 (t, 1H, J=4.4 Hz, $W_{1/2}$=

10.8 Hz, H_2), 4.43 (s, 2H), 3.57-3.62 (m, 1H, $W_{1/2}$=10.8 Hz, H_1), 3.47 (dd, 1H, J=9.0 and 6.8 Hz), 3.35 (dd, 1H, J=9.0 and 7.4 Hz), 3.24 (s, 3H), 2.10-2.17 (m, 1H, $W_{1/2}$=21.7 Hz, H_3), 1.95 (s, 3H), 1.45-1.92 (m, 4H). Anal.Calcd for $C_{16}H_{22}O_4$: C, 69.06; H, 7.91. Found: C, 69.38; H, 8.18.

The crude reaction product (0.085 g) from the cis epoxide **9** was subjected to semipreparative TLC (a 6:4 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **47**) afforded pure methoxy alcohols **47** (0.060 g) and **48** (0.010 g).

Methyl *c*-2-hydroxy-*t*-3-methoxy-*r*-1-cyclopentancarboxylate (47), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.30 (dd, 1H, J=4.6 and 1.5 Hz, H_2), 3.73 (s, 3H), 3.67-3.72 (m, 1H, H_1), 3.34 (s, 3H), 2.95 (ddd, 1H, J=9.1 and 4.6 Hz, H_3), 1.94-2.27 (m, 3H), 1.55-1.71 (m, 1H). Anal.Calcd for $C_8H_{14}O_4$: C, 55.17; H, 8.05. Found: C, 55.29; H, 7.94. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.26 (dd, 1H, J=5.5 and 1.8 Hz, $W_{1/2}$=10.0 Hz, H_2), 3.51-3.70 (m, 1H, $W_{1/2}$=19.5 Hz, H_1), 3.60 (s, 3H), 3.31 (s, 3H), 3.03-3.14 (m, 1H, $W_{1/2}$=22.7 Hz, H_3), 1.95 (s, 3H), 1.53-2.17 (m, 4H). Anal.Calcd for $C_{10}H_{16}O_5$: C, 55.55; H, 7.41. Found: C, 55.73; H, 7.09.

Methyl *c*-3-hydroxy-*t*-2-methoxy-*r*-1-cyclopentancarboxylate (48), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.10-4.17 (m, 1H, H_1), 3.84 (t, 1H, J=4.3 Hz, H_2), 3.73 (s, 3H), 3.40 (s, 3H), 2.73-2.83 (m, 1H, H_3), 1.70-2.09 (m, 4H). Anal.Calcd for $C_8H_{14}O_4$: C, 55.17; H, 8.05. Found: C, 55.37; H, 8.21. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 4.97-5.02 (m, 1H, $W_{1/2}$=13.3 Hz, H_1), 4.01 (dd, 1H, J=5.1 and 3.4 Hz, $W_{1/2}$=11.7 Hz, H_2), 3.70 (s, 3H) 3.38 (s, 3H), 2.70-2.81 (m, 1H, $W_{1/2}$=21.6 Hz, H_3), 2.03 (s, 3H), 1.58-2.09 (m, 4H). Anal.Calcd for $C_{10}H_{16}O_5$: C, 55.55; H, 7.41. Found: C, 55.59; H, 7.68.

The crude reaction product from the trans epoxide **10** afforded **methyl *t*-2-hydroxy-*c*-3-methoxy-*r*-1-cyclopentancarboxylate (63)** (0.080 g), practically pure, as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.20 (dd, 1H, J=8.2 and 6.1 Hz, H_2), 3.70 (s, 3H), 3.57-3.67 (m, 1H, H_1), 3.36 (s, 3H), 2.64-2.75 (m, 1H, H_3), 1.87-2.05 (m, 3H), 1.57-1.69 (m, 1H). Anal.Calcd for $C_8H_{14}O_4$: C, 55.17; H, 8.05. Found: C, 55.44; H, 8.22. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.27 (dd, 1H, J=4.8 and 3.4 Hz, H_2), 3.51-3.69 (m, 1H, $W_{1/2}$=17.0 Hz, H_1), 3.64 (s, 3H), 3.30 (s, 3H), 2.65-2.76 (m, 1H, $W_{1/2}$=22.0 Hz, H_3), 1.73-2.10 (m, 4H), 2.00 (s, 3H). Anal.Calcd for $C_{10}H_{16}O_5$: C, 55.55; H, 7.41. Found: C, 55.34; H, 7.30.

Methanolysis of Epoxides 7-10 in the Presence of $LiClO_4$. General Procedure. The epoxide (0.25 mmol) was added to a 17 M $LiClO_4$ solution in anhydrous MeOH (1.0 ml) and the reaction mixture was stirred at 80°C for 24 h. The usual workup afforded a crude reaction product which was analyzed by GC (Tables 1 and 2).

Azidolysis of Epoxides 7-10 with NaN_3-NH_4Cl. The following procedure is typical. A solution of the cis epoxide **7** (0.110 g, 0.55 mmol) in an 8:1 MeOH/H_2O mixture (3.0 ml) was treated with NaN_3 (0.176 g, 2.7 mmol) and NH_4Cl (0.066 g, 1.24 mmol) and the resulting reaction mixture was stirred at 80°C for 18 h. The usual workup afforded a crude reaction product (0.14 g) which was subjected to semipreparative TLC (a 2:1 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **37**) afforded pure azido alcohols **37** (0.061 g) and **38** (0.035 g).

***t*-2-Azido-*c*-5-(benzyloxymethyl)-*r*-1-cyclopentanol (37)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.18-7.33 (m, 5H), 4.48 and 4.42 (ABdd, 2H, J=11.9 Hz), 4.05 (dd, 1H, J=5.9 and 3.5 Hz, H_2), 3.70-3.75 (m, 1H, H_1), 3.64 (dd, 1H, J=9.4 and 4.4 Hz), 3.54 (dd, 1H, J=9.4 and 6.5 Hz), 2.24-2.33 (m, 1H, H_3), 1.98-2.09 (m, 1H), 1.48-1.79 (m, 3H). Anal.Calcd for $C_{13}H_{17}N_3O_2$: C, 63.15; H, 6.88; N, 17.01. Found: C, 63.44; H, 6.56; N, 17.21. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.17-7.31 (m, 5H), 5.00 (dd, 1H, J=6.1 and 3.7 Hz, $W_{1/2}$=11.3 Hz, H_2), 4.43 and 4.38 (ABdd, 2H, J=12.1 Hz), 3.81-3.90 (m, 1H, $W_{1/2}$=17.2 Hz, H_1), 3.39 (dd, 1H, J=9.2 and 7.1 Hz), 3.30 (dd, 1H, J=9.2 and 5.9 Hz), 2.45-2.49 (m, 1H, $W_{1/2}$=22.5 Hz, H_3), 1.91 (s, 3H), 1.79-2.11 (m, 2H), 1.47-1.62 (m, 2H). Anal.Calcd for $C_{15}H_{19}N_3O_3$; C, 62.23; H, 6.57; N, 14.54. Found: C, 62.02; H, 6.81; N, 14.25.

***t*-2-Azido-*c*-3-(benzyloxymethyl)-*r*-1-cyclopentanol (38)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.18-7.30 (m, 5H), 4.48 (s, 2H), 3.91-3.99 (m, 1H, H_1), 3.35-3.51 (m, 3H), 2.04-2.10 (m, 1H, H_3), 1.54-1.88 (m, 3H), 1.14-1.22 (m, 1H). Anal.Calcd for $C_{13}H_{17}N_3O_2$: C, 63.15; H, 6.88; N, 17.01. Found: C, 63.29; H, 6.91; N, 17.33. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.22-7.31 (m, 5H), 4.84-4.93 (m, 1H, $W_{1/2}$=19.1 Hz, H_1), 4.48 (s, 2H), 3.67 (dd, 1H, J=7.9 and 5.9 Hz, $W_{1/2}$= 15.3 Hz, H_2), 3.35-3.49 (m, 2H), 1.97-2.11 (m, 2H), 1.98 (s, 3H), 1.72-1.85 (m, 1H), 1.51-1.66 (m, 2H). Anal.Calcd for $C_{15}H_{19}N_3O_3$; C, 62.23; H, 6.57; N, 14.54. Found: C, 62.28; H, 6.59; N, 14.85.

The crude reaction product (0.141 g) from the trans epoxide **8** consisted of ***t*-2-azido-*t*-5-benzyloxymethyl-*r*-1-cyclopentanol (55)**, practically pure, as a liquid: IR, see Table 3; ^{1}H NMR δ 7.25-7.39 (m, 5H), 4.52 (s, 2H), 3.35-3.87 (m, 4H), 1.93-2.23 (m, 2H), 1.72-1.90 (m, 1H), 1.52-1.72 (m, 2H). Anal.Calcd for $C_{13}H_{17}N_3O_2$: C, 63.15; H, 6.88; N, 17.01. Found: C, 63.44; H, 6.56; N, 17.21. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.19-7.35 (m, 5H), 4.92 (t, 1H, J=4.5 Hz, H_2), 4.47 (s, 2H), 3.78-3.87 (m, 1H, $W_{1/2}$=19.0 Hz, H_1), 3.31-3.53 (m, 2H), 2.14-2.27 (m, 1H, $W_{1/2}$=23.0 Hz, H_3), 2.00 (s, 3H), 1.51-2.04 (m, 4H). Anal.Calcd for $C_{15}H_{19}N_3O_3$; C, 62.23; H, 6.57; N, 14.54. Found: C, 62.41; H, 6.20; N, 14.76.

The crude reaction product (0.10 g) from the cis epoxide **9** was subjected to semipreparative TLC (a 7:3 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense band afforded pure **methyl *t*-3-azido-*c*-2-hydroxy-*r*-1-cyclopentancarboxylate (49)**, (0.075 g) as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.16 (dd, 1H, J=4.9 e 2.9 Hz, H_2), 3.88 (quintet, 1H, J=3.4 Hz, H_1), 3.67 (s, 3H), 2.92 (ddd, 1H, J=9.1 and 4.9 Hz, H_3), 2.11-2.25 (m, 1H), 1.92-2.05 (m, 2H), 1.58-1.70 (m, 1H). Anal.Calcd for $C_7H_{11}N_3O_3$: C, 45.40; H, 5.94; N, 22.71. Found: C, 45.55; H, 6.18; N, 22.48. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.17 (dd, 1H, J=6.4 and 4.2 Hz, H_2), 3.99-4.06 (m, 1H, $W_{1/2}$=13.5 Hz, H_1), 3.67 (s, 3H), 3.14-3.25 (m, 1H, $W_{1/2}$=17.3 Hz, H_3), 1.90-2.30 (m, 3H), 2.03 (s, 3H), 1.58-1.73 (m, 1H). Anal.Calcd for $C_9H_{13}N_3O_4$: C, 47.57; H, 5.73; N, 18.51. Found: C, 47.91; H, 5.68; N, 18.26.

The crude reaction product (0.096 g) from the trans epoxide **10** turned out to consist of **methyl *c*-3-azido-*t*-2-hydroxy-*r*-1-cyclopentancarboxylate (65)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 4.20 (t, 1H, J=7.9 Hz, H_2), 3.74 (s, 3H), 3.70-3.85 (m, 1H, H_1), 2.69-2.82 (m, 1H, H_3), 1.90-2.17 (m, 3H), 1.58-1.76 (m, 1H). Anal.Calcd for $C_7H_{11}N_3O_3$: C, 45.40; H, 5.94; N, 22.71. Found: C, 45.74; H, 5.80; N, 22.94. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 5.25 (t , 1H, J=5.5 Hz, $W_{1/2}$=11.9 Hz, H_2), 3.89-3.97 (m, 1H, $W_{1/2}$=17.8 Hz, H_1), 3.72 (s, 3H), 2.70-2.87 (m, 1H, $W_{1/2}$=19.4 Hz, H_3), 1.71-2.17 (m, 4H), 2.08 (s, 3H). Anal.Calcd for $C_9H_{13}N_3O_4$: C, 47.57; H, 5.73; N, 18.51. Found: C, 47.33; H, 5.98; N, 18.72.

Azidolysis of Epoxides 7-10 with NaN_3-$LiClO_4$ in CH_3CN. General Procedure. A solution of the epoxide (0.50 mmol) in anhydrous CH_3CN (2 ml) was treated with NaN_3 (0.040 g, 0.61 mmol) and $LiClO_4$ (0.53 g, 5.0 mmol) and the resulting reaction mixture was stirred at 80°C for 18 h. The usual workup afforded a crude reaction product which was analyzed by GC (Tables 1 and 2). In the case of the cis epoxide **7**, the reaction was repeated also in the presence of $Mg(ClO_4)_2$ and $Zn(OTf)_2$ to give the results shown in Table1.

Aminolysis of the cis Epoxide 7 with $NHEt_2$-EtOH. A solution of the cis epoxide **7** (0.075 g, 0.37 mmol) in anhydrous EtOH (0.6 ml) was treated with $NHEt_2$ (0.096 ml, 0.925 mmol) and the resulting reaction mixture was stirred at 80°C for 5 days. Dilution with ether and evaporation of the washed (water) organic solvent afforded a crude liquid reaction product (0.076 g, 48% yield) consisting of a mixture of the two amino alcohols **39** and **40** (^{1}H NMR), which did not separate under any TLC operating conditions, and the unreacted epoxide **7**. As a consequence the crude reaction product in anhydrous pyridine (2 ml) was treated with Ac_2O (1 ml) and the resulting reaction mixture was left at r.t. overnight. The usual workup afforded a crude reaction product consisting of the corresponding acetates **39-Ac** and **40-Ac** (^{1}H NMR) which was

subjected to semipreparative TLC (a 9:1 mixture of benzene and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **40-Ac**) afforded pure **39-Ac** (0.010 g) and **40-Ac** (0.032 g).

***c*-2-Acetoxy-*t*-3-(*N*,*N*-diethylamino)-*r*-1-benzyloxymethylcyclopen-tane (39-Ac)**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.26-7.35 (m, 5H), 5.34 (dd, 1H, *J*=7.0 and 4.1 Hz, $W_{1/2}$=12.7 Hz, H_2), 4.46 (s, 2H), 3.48 (dd, 1H, *J*=9.2 and 6.9 Hz), 3.34 (dd, 1H, *J*=9.2 and 6.7 Hz), 3.16-3.25 (m, 1H, $W_{1/2}$=12.9 Hz, H_1), 2.54-2.66 (m, 4H), 2.38-2.46 (m, 1H, $W_{1/2}$=19.2 Hz, H_3), 1.47-2.08 (m, 4H), 1.96 (s, 3H), 1.01 (t, 6H, *J*=7.1 Hz). Anal.Calcd for $C_{17}H_{24}NO_3$: C, 70.34; H, 8.27; N, 4.83. Found: C, 70.31; H, 8.51; N, 5.09.

***c*-3-Acetoxy-*t*-2-(*N*,*N*-diethylamino)-*r*-1-benzyloxymethylcyclopen-tane (40-Ac)**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.26-7.36 (m, 5H), 5.11-5.21 (m, 1H, $W_{1/2}$=17.3 Hz, H_1), 4.56 and 4.51 (ABdd, 2H, *J*=12.0 Hz), 3.60 (dd, 1H, *J*=9.0 and 4.2 Hz), 3.41 (dd, 1H, *J*=9.0 and 7.6 Hz), 3.03 (dd, 1H, *J*=8.4 and 5.6 Hz, $W_{1/2}$=15.6 Hz, H_2), 2.46-2.56 (m, 4H), 2.00-2.10 (m, 1H, $W_{1/2}$=19.3 Hz, H_3), 2.01 (s, 3H), 1.60-2.00 (m, 4H), 1.00 (t, 6H, *J*=7.1 Hz). Anal.Calcd for $C_{17}H_{24}NO_3$: C, 70.34; H, 8.27; N, 4.83. Found: C, 70.27; H, 8.40; N, 4.69.

Reaction of the cis Epoxide 7 with $NHEt_2$-$LiClO_4$ in MeCN. A solution of the cis epoxide **7** (0.075 g, 0.37 mmol) in anhydrous MeCN (1.5 ml) was treated with $NHEt_2$ (0.38 ml, 3.7 mmol) and $LiClO_4$ (0.40 g, 3.75 mmol) and the reaction mixture was stirred at 80°C for 18 h. The usual workup afforded a crude reaction product (0.091 g) presumably consisting of the two amino alcohols **39** and **40** (^{1}H NMR) which was acetylated, as usual and then analyzed by GC (Table 1).

The reaction of the cis epoxide **7** with $NHEt_2$ in MeCN was repeated also in the presence of $Mg(ClO_4)_2$ and $Zn(OTf)_2$ to give the results shown in Table 1.

Reaction of the Epoxides 7 and 8 with PhSH-NEt_3. The following procedure is typical. A solution of the cis epoxide **7** (0.102 g, 0.5 mmol) in MeOH (0.5 ml) was treated with PhSH (0.15 ml, 1.5 mmol) and NEt_3 (0.26 ml, 2.0 mmol) and the reaction mixture was stirred at r.t. for 20 h. Dilution with ether and evaporation of the washed (saturated aqueous $NaHCO_3$ and water) organic solution afforded a crude reaction product (0.150 g) which was subjected to semipreparative TLC (an 8:2 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **41**) afforded pure thioalcohols **41** (0.050 g) and **42** (0.039 g).

***c*-2-(Benzyloxymethyl)-*t*-5-phenylthio-*r*-1-cyclopentanol (41)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.07-7.34 (m, 10H), 4.47 and 4.42 (ABdd, 2H, *J*=11.9 Hz), 4.12 (m, 1H, H_2), 3.55-3.70 (m, 2H), 3.49 (ddd, 1H, *J*=8.0, 5.4 and 2.4 Hz, H_1), 2.42-2.49 (m, 1H, H_3), 1.41-1.82 (m, 4H). Anal.Calcd for $C_{19}H_{22}O_2S$: C, 72.60; H, 7.00. Found: C, 72.75; H, 6.91. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.34-7.39 (m, 2H), 7.13-7.27 (m, 8H), 5.12 (dd, 1H, *J*=5.4 and 3.0 Hz, $W_{1/2}$=10.2 Hz, H_2), 4.42 and 4.37 (ABdd, 2H, *J*=12.0 Hz), 3.55 (ddd, 1H, *J*=7.8, 4.8 and 3.0 Hz, $W_{1/2}$=16.0 Hz, H_1), 3.42 (dd, 1H, *J*=9.2 and 7.3 Hz), 3.31 (dd, 1H, *J*=9.2 and 6.4 Hz), 2.58-2.75 (m, 1H, $W_{1/2}$=20.5 Hz, H_3), 2.19-2.23 (m, 1H), 1.88-2.00 (m, 1H), 1.83 (s, 3H), 1.47-1.62 (m, 2H). Anal.Calcd for $C_{21}H_{24}O_3S$: C, 70.77; H, 6.74. Found; C, 70.95; H, 6.61.

***c*-3-(Benzyloxymethyl)-*t*-2-phenylthio-*r*-1-cyclopentanol (42)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.17-7.42 (m, 10H), 4.55 (s, 2H), 4.00-4.10 (m, 1H, H_1), 3.55 (d, 2H, *J*=4.0 Hz), 3.28-3.32 (m, 1H, H_2), 1.68-2.21 (m, 5H). Anal.Calcd for $C_{19}H_{22}O_2S$: C, 72.60; H, 7.00. Found: C, 72.82; H, 6.74. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.32-7.39 (m, 2H), 7.14-7.29 (m, 8H), 4.95-5.03 (m, 1H, $W_{1/2}$=15.7 Hz, H_1), 4.44 (s, 2H), 3.50 (dd, 1H, *J*=9.3 and 5.2 Hz), 3.43 (dd, 1H, *J*=9.3 and 3.5 Hz), 3.32 (dd, 1H, *J*=7.5 and 4.8 Hz, $W_{1/2}$=13.9 Hz, H_2), 1.95-2.12 (m, 2H), 1.83 (s, 3H), 1.54-1.70 (m, 3H). Anal.Calcd for $C_{21}H_{24}O_3S$: C, 70.77; H, 6.74. Found; C, 70.71; H, 6.47.

The crude reaction product from the trans epoxide **8** (0.077 g) was subjected to semipreparative TLC (a 3:1 mixture of petholeum ether and ether was used as the eluant). Extraction of the most intense band afforded pure ***t*-2-(benzyloxymethyl)-*t*-5-phenylthio-*r*-1-cyclopentanol (57)** (0.050 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.29-7.39 (m, 2H), 7.10-7.27 (m, 8H), 4.45 (s, 2H), 3.75 (t, 1H, *J*=7.8 Hz, H_2), 3.53 (dd, 1H, *J*=8.9 and 5.6 Hz), 3.28-3.43 (m, 2H), 2.06-2.20 (m, 2H), 1.28-1.86 (m, 3H). Anal.Calcd for $C_{19}H_{22}O_2S$: C, 72.60; H, 7.00. Found: C, 72.91; H, 7.16. **Acetate**, a liquid: ^{1}H NMR ($CDCl_3$) δ 7.30-7.37 (m, 2H), 7.14-7.27 (m, 8H), 4.95 (t, 1H, *J*=6.0 Hz, H_2), 4.41 (s, 2H), 3.33-3.57 (m, 3H), 1.55-2.21 (m, 5H), 1.81 (s, 3H).Anal.Calcd for $C_{21}H_{24}O_3S$: C, 70.77; H, 6.74. Found; C, 70.99; H, 6.53.

Reaction of Epoxides 7 and 8 with PhSH-$LiClO_4$ in MeCN. General procedure. A solution of the epoxide (0.3 mmol) in anhydrous MeCN (0.6 ml) was treated with PhSH (0.048 ml, 0.45 mmol) and $LiClO_4$ (0.16 g, 1.5 mmol) and the reaction mixture was stirred for 18 h at 80°C. The usual workup afforded a crude reaction product (0.095 g) which was analyzed by ^{1}H NMR (Table 1).

Reaction of Epoxides 7-10 with Me_2CuLi. General procedure. Following a previously described procedure,[3e] the reaction of the epoxide (1.0 mmol) in anhydrous ether (5 ml) with Me_2CuLi [prepared from MeLi (3.75 ml of a 1.6 M solution in ether) and CuI (0.57 g, 3.0 mmol)] at -15°C for 30 min, then slowly warmed to 0°C (2 h), afforded a crude reaction mixture which was analyzed by GC (Tables 1 and 2).

The crude reaction product (0.21 g) from the cis epoxide **7** was subjected to semipreparative TLC (an 8:2 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **43**) afforded pure methyl alcohols **43** (0.050 g) and **44** (0.105 g).

***c*-2-(Benzyloxymethyl)-*t*-5-methyl-*r*-1-cyclopentanol (43)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.19-7.30 (m, 5H), 4.47 and 4.43 (ABdd, 2H, *J*=12.0 Hz), 3.74 (dd, 1H, *J*=6.6 and 4.8 Hz, H_2), 3.51-3.61 (m, 2H), 2.16-2.33 (m, 1H, H_3), 1.57-1.88 (m, 3H), 1.31-1.42 (m, 1H), 0.99-1.14 (m, 1H), 0.93 (d, 3H, *J*=6.6 Hz). Anal.Calcd for $C_{14}H_{20}O_2$: C, 76.36; H, 9.09. Found: C, 76.54; H, 9.17.

***c*-3-(Benzyloxymethyl)-*t*-2-methyl-*r*-1-cyclopentanol (44)**, a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.18-7.29 (m, 5H), 4.45 (s, 2H), 3.64 (dd, 1H, *J*=10.0 and 4.8 Hz, H_1), 3.40 (dd, 1H, *J*=8.9 and 4.2 Hz), 3.34 (dd, 1H, *J*=8.9 and 5.1 Hz), 1.65-1.82 (m, 3H), 1.47-1.60 (m, 2H), 0.94 (d, 3H, *J*=6.9 Hz). Anal.Calcd for $C_{14}H_{20}O_2$; C, 76.36; H, 9.09. Found: C, 76.27; H, 9.32.

The trans epoxide **8** turned out to be stable under the above-described operating conditions and was recovered completely unreacted from the reaction mixture.

The crude reaction product (0.14 g) from the cis epoxide **9** was subjected to semipreparative TLC (a 6:4 mixture of petroleum ether and ether was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **51**) afforded pure methyl alcohols **51** (0.080 g) and **52** (0.027 g).

Methyl *c*-2-hydroxy-*t*-3-methyl-*r*-1-cyclopentancarboxylate (51), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 3.82-3.90 (m, 1H, H_2), 3.65 (s, 3H), 2.77-2.88 (m, 1H, H_3), 1.85-2.03 (m, 4H), 1.08-1.21 (m, 1H), 0.93 (d, 3H, *J*=6.5 Hz). Anal.Calcd for $C_8H_{14}O_3$: C, 60.76; H, 8.86. Found: C, 60.51; H, 9.09.

Methyl *c*-3-hydroxy-*t*-2-methyl-*r*-1-cyclopentancarboxylate (52), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 3.65-3.75 (m, 1H, H_1), 3.63 (s, 3H), 2.27-2.38 (m, 1H, H_3),1.60-2.11 (m, 4H), 1.18-1.31 (m, 1H), 1.01 (d, 3H, *J*=6.9 Hz). Anal.Calcd for $C_8H_{14}O_3$: C, 60.76; H, 8.86. Found: C, 60.87; H, 8.77.

The crude reaction product (0.14 g) from the trans epoxide **10**, consisting of a 29:7:64 mixture of methyl alcohols **67** and **68** and the unsaturated ester **76** was subjected to semipreparative TLC (an 8:2 mixture of benzene and AcOEt was used as the eluant). Extraction of the two most intense bands afforded pure methyl alcohol **67** (0.044 g) and the unsaturated hydroxy ester **76** (0.075 g).

Methyl *t*-2-hydroxy-*c*-3-methyl-*r*-1-cyclopentancarboxylate (67), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 3.66-3.77 (m, 1H, H_2), 3.70 (s, 3H), 2.62-2.75 (m, 1H, H_3), 1.76-2.00 (m, 5H), 1.05 (d, 3H, *J*=6.2 Hz). Anal.Calcd for $C_8H_{14}O_3$: C, 60.76; H, 8.86. Found: C, 60.71; H, 8.99.

Methyl 3-hydroxy-1-cyclopentencarboxylate (76), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 6.72 (d, 1H, *J*=4.0 Hz), 4.96-5.02 (m, 1H), 3.77 (s, 3H), 1.70-2.75 (m, 4H). Anal.Calcd for $C_7H_{10}O_3$: C, 59.15; H, 7.04. Found: C, 59.24; H, 7.23.

The methyl alcohol **68** was not separated from the reaction mixture, but its presence was firmly established by GC and ^{1}H NMR evidences.

Reaction of Epoxides 7-10 with $AlMe_3$. The following procedure is typical. A solution of the cis epoxide **7** (0.102 g, 0.50 mmol) in anhydrous pentane (7 ml) was treated at 0°C and under nitrogen with 2M $AlMe_3$ in hexane (0.5 ml). The reaction mixture was stirred for 1 h at the same temperature, and then 48 h at r.t. Dilution with ether (30 ml) followed by careful addition of water and 5% aqueous HCl, and evaporation of the washed (saturated aqueous $NaHCO_3$ and water) ether solution afforded a crude liquid product (0.075) which was analyzed by GC (Tables 1 and 2).

The crude reaction product (0.080 g) from the trans epoxide **8** was subjected to semipreparative TLC (a 75:25 mixture of petroleum ether and ether was used as the eluant). Extraction of the most intense band afforded pure ***t*-2-(benzyloxymethyl)-*c*-5-methyl-*r*-1-cyclopentanol (59)** (0.055 g), as a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.19-7.29 (m, 5H), 4.46 (s, 2H), 3.57 (dd, 1H, *J*=8.8 and 5.3 Hz, H_2), 3.26-3.39 (m, 2H), 1.90-2.10 (m, 1H, H_3), 1.35-1.85 (m, 4H), 0.98 (d, 3H, *J*=6.2 Hz). Anal.Calcd for $C_{14}H_{20}O_2$: C, 76.36; H, 9.09. Found: C, 76.07; H, 9.15.

Reaction of Epoxides 7 and 8 with $AlMe_3$ in the presence of 12-Crown-4. The general procedure of ref.3e was followed to give the results shown in Tables 1 and 2.

Reaction of Epoxides 7 and 8 with $LiAlH_4$. The following procedure is typical. A solution of the cis epoxide **7** (0.122 g, 0.60 mmol) in anhydrous ether (or pentane) (4.0 ml) was added to a stirred suspension of $LiAlH_4$ (0.15 g) in anhydrous ether (10 ml) and the reaction mixture was stirred at r.t. for 2 h. The usual workup afforded a crude reaction product (0.062 g) which was subjected to semipreparative TLC (an 8:2 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **45**) afforded pure alcohols **45** (0.080 g) and **46** (0.020 g).

cis-2-(Benzyloxymethyl)-1-cyclopentanol (45), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.19-7.30 (m, 5H), 4.48 and 4.43 (ABdd, 2H, *J*=12.0 Hz), 4.23-4.49 (m, 1H, H_2), 3.50-3.60 (m, 2H), 1.97-2.11 (m, 1H, H_3), 1.40-1.80 (m, 6H). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.73; H, 8.74. Found: C, 75.75; H, 8.92.

cis-3-(Benzyloxymethyl)-1-cyclopentanol (46), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.16-7.33 (m, 5H), 4.47 (s, 2H), 4.11-4.19 (m, 1H, H_1), 3.40 (dd, 1H, *J*=8.9 and 4.6 Hz), 3.34 (dd, 1H, *J*=8.9 and 4.5 Hz), 2.16-2.37 (m, 1H, H_3), 1.89-2.04 (ddd, 1H, *J*=13.8, 10.1 and 5.4 Hz), 1.35-1.49 (m, 1H), 1.52-1.77 (m, 4H). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.73; H, 8.74. Found: C, 75.58; H, 8.64.

The crude reaction product (0.12 g) from the trans epoxide **8** was subjected to semipreparative TLC (a 3:1 mixture of petroleum ether and AcOEt was used as the eluant). Extraction of the two most intense bands (the faster moving band contained **61**) afforded pure alcohols **61** (0.088 g) and **62** (0.012 g).

trans-2-(Benzyloxymethyl)-1-cyclopentanol (61), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.24-7.40 (m, 5H), 4.56 and 4.50 (ABdd, 2H, *J*=12.3 Hz), 3.99 (q, 1H, *J*=6.7 Hz, H_2), 3.59 (dd, 1H, *J*=8.9 and 5.4 Hz), 3.36 (t, 1H, *J*=8.9 Hz), 2.00-2.17 (m, 1H, H_3), 1.48-1.98 (m, 5H), 1.14-1.29 (m, 1H). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.73; H, 8.74. Found: C, 75.61; H, 8.97.

trans-3-(Benzyloxymethyl)-1-cyclopentanol (62), a liquid: IR, see Table 3; ^{1}H NMR ($CDCl_3$) δ 7.26-7.37 (m, 5H), 4.52 (s, 2H), 4.36 (septet, 1H, *J*=2.6 Hz, H_1), 3.35 (d, 2H, *J*=6.7 Hz), 2.44-2.60 (m, 1H, H_3), 1.30-1.98 (m, 6H). Anal.Calcd for $C_{13}H_{18}O_2$: C, 75.73; H, 8.74. Found: C, 75.47; H, 8.55.

Reaction of Epoxides 7 and 8 with $LiAlH_4$ in the Presence of 12-Crown-4. The general procedure described in ref. 3d was followed to give the results shown in Tables 1 and 2.

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12. A similar study carried out on the cyclohexane homolog, the cis epoxide **5**, did not give any evidence of the intervention of chelate-bidentate structures in the metal-assisted ring opening reactions, due to the result of a complete C-1 selectivity, constantly observed both under standard and chelating conditions.[4]

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15. Due to the pseudorotation process, which causes complication in the use of the envelope conformation in polisubstituted cyclopentanes, we have preferred to make use in Scheme 7 of half-chair conformations in order to tentatively show the conformational equilibrium in *C-1* and *C-2 products* from the epoxides **7-10**, also considering that in substituted cyclopentanes there is little preference for any particular conformation of the cyclopentate framework itself.[14]

16. In a substituted cyclopentane system, the use of the $W_{1/2}$ values of the ^1H NMR signal of the ring protons in order to obtain informations on the pseudoaxial or pseudoequatorial nature of the protons themselves, as commonly done in the cyclohexane system,[1,3,10] might appear somewhat arbitrary.[17] However, the high $W_{1/2}$ values (16.0-23.0 Hz) observed for protons H_1, H_2 and H_3 in the *C-1 products* from the epoxides trans **8** and **10** (Scheme 5 and Table 3), which should reasonably prefer a conformation such as **E** (Scheme 7)[15] with the three substituents pseudoequatorial (H_1, H_2, and H_3 pseudoaxial), would indicate, at least in the present trisubstituted cyclopentane system (*C-1* and *C-2 products*, Scheme 5), an acceptable correlation between the pseudoaxial or pseudoequatorial nature of a proton and the high (larger than 15.0 Hz) or low $W_{1/2}$ value (below 12.0 Hz) of the corresponding ^1H NMR signal, respectively.[17]

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