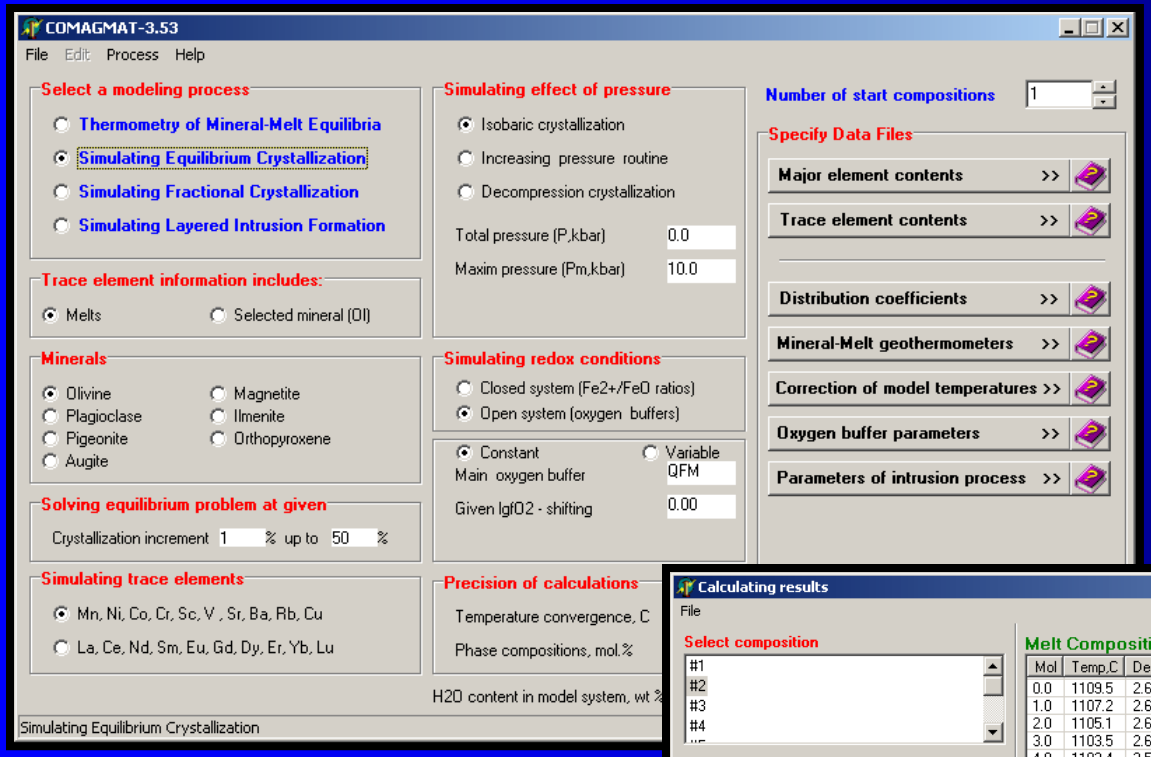
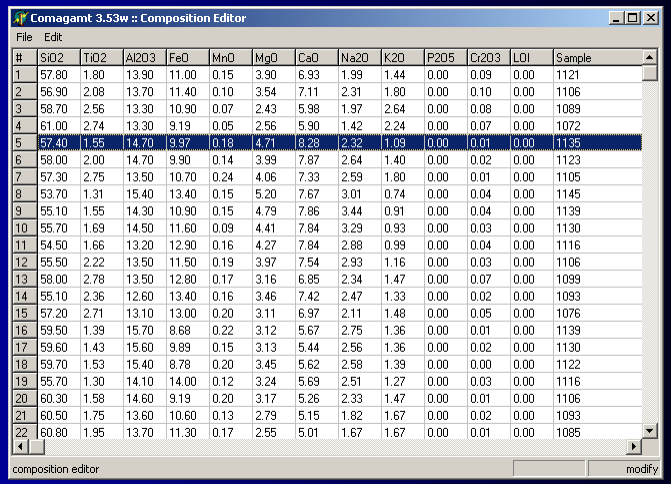
ПРИМЕРЫ ИСПОЛЬЗОВАНИЯ МОДЕЛИ КОМАГМАТ

Расслоенные интрузивы и вулканические серии

WINDOWS ВЕРСИЯ МОДЕЛИ КОМАГМАТ

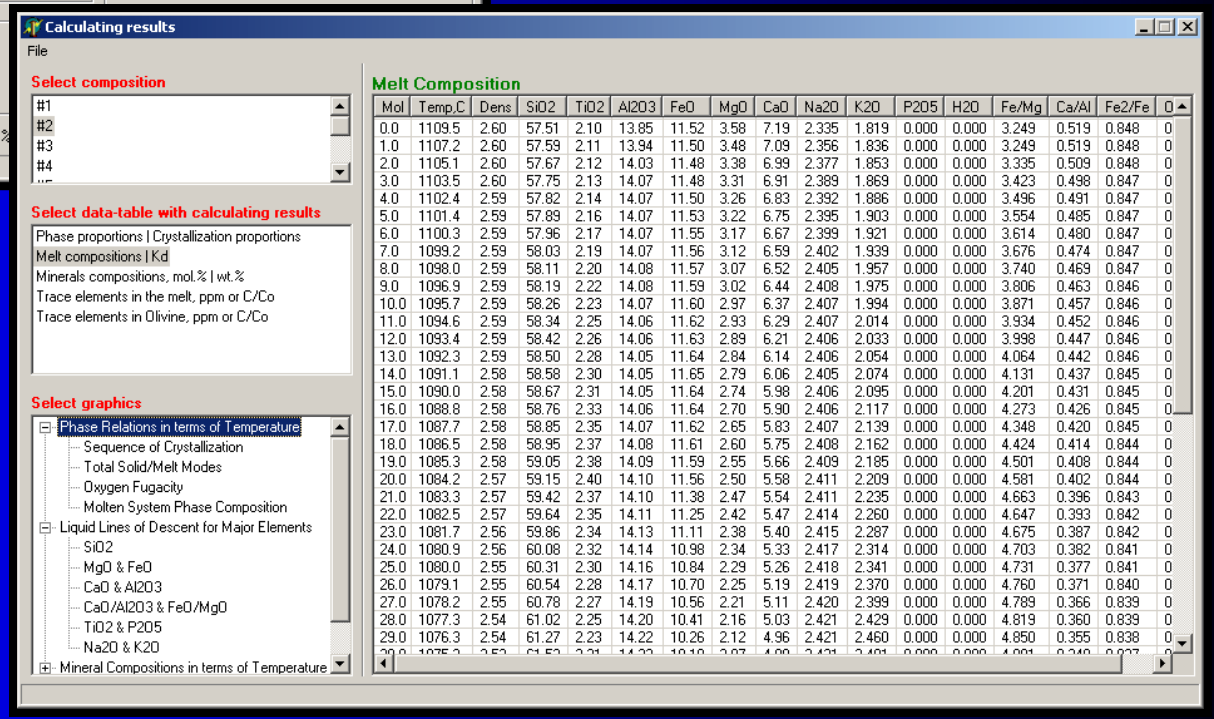




#	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Sample
1	57.80	1.80	13.90	11.00	0.15	3.90	6.93	1.99	1.44	0.00	0.09	0.00	1121
2	56.90	2.08	13.70	11.40	0.10	3.54	7.11	2.31	1.80	0.00	0.10	0.00	1106
3	58.70	2.56	13.30	10.90	0.07	2.43	5.98	1.97	2.64	0.00	0.08	0.00	1089
4	61.00	2.74	13.30	9.19	0.05	2.56	5.90	1.42	2.24	0.00	0.07	0.00	1072
5	57.40	1.55	14.70	9.97	0.18	4.71	8.28	2.32	1.09	0.00	0.01	0.00	1135
6	58.00	2.00	14.70	9.90	0.14	3.99	7.87	2.64	1.40	0.00	0.02	0.00	1123
7	57.30	2.75	13.50	10.70	0.24	4.06	7.33	2.59	1.80	0.00	0.01	0.00	1105
8	53.70	1.31	15.40	13.40	0.15	5.20	7.67	3.01	0.74	0.00	0.04	0.00	1145
9	55.10	1.55	14.30	10.90	0.15	4.79	7.86	3.44	0.91	0.00	0.04	0.00	1139
10	55.70	1.69	14.50	11.60	0.09	4.41	7.84	3.29	0.93	0.00	0.03	0.00	1130
11	54.50	1.66	13.20	12.90	0.16	4.27	7.84	2.88	0.99	0.00	0.04	0.00	1116
12	55.50	2.22	13.50	11.50	0.19	3.97	7.54	2.93	1.16	0.00	0.03	0.00	1106
13	58.00	2.78	13.50	12.80	0.17	3.16	6.85	2.34	1.47	0.00	0.07	0.00	1099
14	55.10	2.36	12.60	13.40	0.16	3.46	7.42	2.47	1.33	0.00	0.02	0.00	1093
15	57.20	2.71	13.10	13.00	0.20	3.11	6.97	2.11	1.48	0.00	0.05	0.00	1076
16	59.50	1.39	15.70	8.68	0.22	3.12	5.67	2.75	1.36	0.00	0.01	0.00	1139
17	59.60	1.43	15.60	9.89	0.15	3.13	5.44	2.56	1.36	0.00	0.02	0.00	1130
18	59.70	1.53	15.40	8.78	0.20	3.45	5.62	2.58	1.39	0.00	0.00	0.00	1122
19	55.70	1.30	14.10	14.00	0.12	3.24	5.69	2.51	1.27	0.00	0.03	0.00	1116
20	60.30	1.58	14.60	9.19	0.20	3.17	5.26	2.33	1.47	0.00	0.01	0.00	1106
21	60.50	1.75	13.60	10.60	0.13	2.79	5.15	1.82	1.67	0.00	0.02	0.00	1093
22	60.80	1.95	13.70	11.30	0.17	2.55	5.01	1.67	1.67	0.00	0.01	0.00	1085

Исходные составы

Инициализация параметров



Mol	Temp,C	Dens	SiO2	TiO2	Al2O3	FeO	MgO	CaO	Na2O	K2O	P2O5	H2O	Fe/Mg	Ca/Al	Fe2/Fe	O
0.0	1109.5	2.60	57.51	2.10	13.85	11.52	3.58	7.19	2.335	1.819	0.000	0.000	3.249	0.519	0.848	0
1.0	1107.2	2.60	57.59	2.11	13.94	11.50	3.48	7.09	2.356	1.836	0.000	0.000	3.249	0.519	0.848	0
2.0	1105.1	2.60	57.67	2.12	14.03	11.48	3.38	6.99	2.377	1.853	0.000	0.000	3.335	0.509	0.848	0
3.0	1103.5	2.60	57.75	2.13	14.07	11.48	3.31	6.91	2.389	1.869	0.000	0.000	3.423	0.498	0.847	0
4.0	1102.4	2.59	57.82	2.14	14.07	11.50	3.26	6.83	2.392	1.886	0.000	0.000	3.496	0.491	0.847	0
5.0	1101.4	2.59	57.89	2.16	14.07	11.53	3.22	6.75	2.395	1.903	0.000	0.000	3.554	0.485	0.847	0
6.0	1100.3	2.59	57.96	2.17	14.07	11.55	3.17	6.67	2.399	1.921	0.000	0.000	3.614	0.480	0.847	0
7.0	1099.2	2.59	58.03	2.19	14.07	11.56	3.12	6.59	2.402	1.939	0.000	0.000	3.676	0.474	0.847	0
8.0	1098.0	2.59	58.11	2.20	14.08	11.57	3.07	6.52	2.405	1.957	0.000	0.000	3.740	0.469	0.847	0
9.0	1096.9	2.59	58.19	2.22	14.08	11.59	3.02	6.44	2.408	1.975	0.000	0.000	3.806	0.463	0.846	0
10.0	1095.7	2.59	58.26	2.23	14.07	11.60	2.97	6.37	2.407	1.994	0.000	0.000	3.871	0.457	0.846	0
11.0	1094.6	2.59	58.34	2.25	14.06	11.62	2.93	6.29	2.407	2.014	0.000	0.000	3.934	0.452	0.846	0
12.0	1093.4	2.59	58.42	2.26	14.06	11.63	2.89	6.21	2.406	2.033	0.000	0.000	3.998	0.447	0.846	0
13.0	1092.3	2.59	58.50	2.28	14.05	11.64	2.84	6.14	2.406	2.054	0.000	0.000	4.064	0.442	0.846	0
14.0	1091.1	2.58	58.58	2.30	14.05	11.65	2.79	6.06	2.405	2.074	0.000	0.000	4.131	0.437	0.845	0
15.0	1090.0	2.58	58.67	2.31	14.05	11.64	2.74	5.98	2.406	2.095	0.000	0.000	4.201	0.431	0.845	0
16.0	1088.8	2.58	58.76	2.33	14.06	11.64	2.70	5.90	2.406	2.117	0.000	0.000	4.273	0.426	0.845	0
17.0	1087.7	2.58	58.85	2.35	14.07	11.62	2.65	5.83	2.407	2.139	0.000	0.000	4.348	0.420	0.845	0
18.0	1086.5	2.58	58.95	2.37	14.08	11.61	2.60	5.75	2.408	2.162	0.000	0.000	4.424	0.414	0.844	0
19.0	1085.3	2.58	59.05	2.38	14.09	11.59	2.55	5.66	2.409	2.185	0.000	0.000	4.501	0.408	0.844	0
20.0	1084.2	2.57	59.15	2.40	14.10	11.56	2.50	5.58	2.411	2.209	0.000	0.000	4.581	0.402	0.844	0
21.0	1083.3	2.57	59.42	2.37	14.10	11.38	2.47	5.54	2.411	2.235	0.000	0.000	4.663	0.396	0.843	0
22.0	1082.5	2.57	59.64	2.35	14.11	11.25	2.42	5.47	2.414	2.260	0.000	0.000	4.647	0.393	0.842	0
23.0	1081.7	2.56	59.86	2.34	14.13	11.11	2.38	5.40	2.415	2.287	0.000	0.000	4.675	0.387	0.842	0
24.0	1080.9	2.56	60.08	2.32	14.14	10.98	2.34	5.33	2.417	2.314	0.000	0.000	4.703	0.382	0.841	0
25.0	1080.0	2.55	60.31	2.30	14.16	10.84	2.29	5.26	2.418	2.341	0.000	0.000	4.731	0.377	0.841	0
26.0	1079.1	2.55	60.54	2.28	14.17	10.70	2.25	5.19	2.419	2.370	0.000	0.000	4.760	0.371	0.840	0
27.0	1078.2	2.55	60.78	2.27	14.19	10.56	2.21	5.11	2.420	2.399	0.000	0.000	4.789	0.366	0.839	0
28.0	1077.3	2.54	61.02	2.25	14.20	10.41	2.16	5.03	2.421	2.429	0.000	0.000	4.819	0.360	0.839	0
29.0	1076.3	2.54	61.27	2.23	14.22	10.26	2.12	4.96	2.421	2.460	0.000	0.000	4.850	0.355	0.838	0

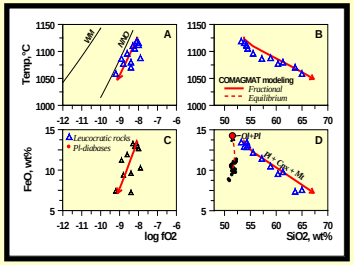
Результаты расчетов

SOME PETROLOGICAL APPLICATIONS

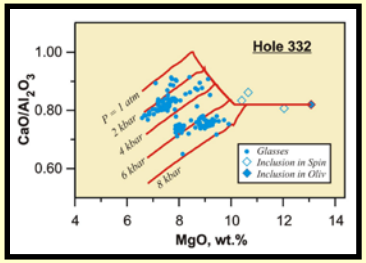
- ✓ **Geochemical thermometry of marginal rocks from the Skaergaard intrusion**

UT-04: *Ol* (1443°C) → *Aug* (1233°C) → *Pl* (1174°C),
UT-08: *Pl* (1332°C) → *Ol* (1231°C) → *Aug* (1164°C),
EC-10: *Ol* (1385°C) → *Aug* (1199°C) → *Pl* (1187°C),
MEO-18: *Pl* + *Ol* (1248 °C) → *Aug* (1161°C),
KT-47: *Ol* (1346°C) → *Pl* (1191°C) → *Aug* (1189°C),
*EG*4507: *Pl* (1242°C) → *Ol* (1225°C) → *Aug* (1163°C).

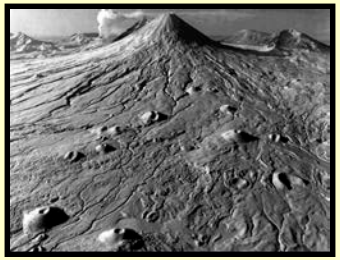
- ✓ **Modeling the formation of ferrodiorites from the Chazhma sill, Kamchatka**



- ✓ **Modeling polybaric fractionation of MORB glasses from Mid-Atlantic Ridge**



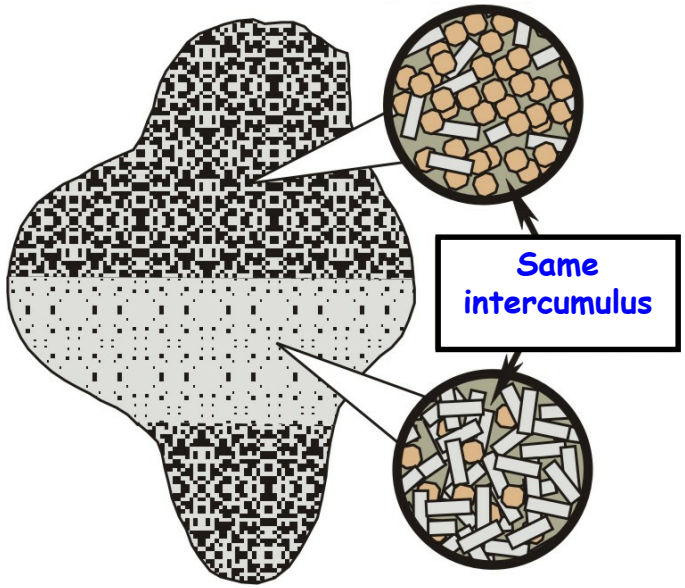
- ✓ **Modeling the generation of high-Al basalts from the Klyuchevskoy volcano, Kamchatka**



METHOD OF GEOCHEMICAL THERMOMETRY

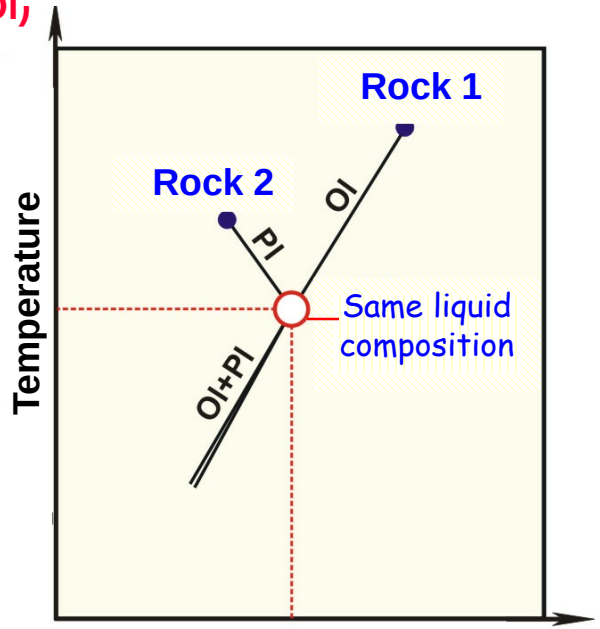
Samples of Ol-Pl cumulates

Rock 1 (enriched with Ol)



Rock 2 (enriched with Pl)

INTERSECTION OF MODELED LIQUID LINES OF DESCENT



The method was designed to extract genetic information as "recorded" in the whole chemistry of cumulus rocks, such as the temperature, inter-cumulus melt and mineral compositi-ons, and the initial modal (i.e. phase) proportions.

Method of geochemical thermometry is accomplished by means of computer modeling of the course of equilibrium crystallization for a set of rocks that assumed to have contained the same intercumulus liquid composition.

GEOCHEMICAL THERMOMETRY OF MARGINAL ROCKS
from the Skaergaard intrusion

COMPOSITIONS OF THE MARGINAL ROCKS

Compo-nents	Primitive cumulates [Hoover, 1989]					Chilled gabbro
	UT-04, *d*=2.5	UT-08, *d*=8.5	EC-10, *d*=1.0	MEO-10, *d*=3.0	KT-47, *d*=6.0	EG4507, n.d.
SiO_2	44.65	48.38	46.92	47.45	48.19	48.08
TiO_2	0.69	0.60	0.63	0.40	0.81	1.17
Al_2O_3	**4.88**	**20.91**	**9.36**	**18.32**	**11.37**	**17.22**
FeO	14.16	7.19	12.84	9.49	11.04	9.63
MnO	0.24	0.10	0.10	0.15	0.19	0.16
MgO	**23.61**	**7.06**	**17.22**	**9.83**	**14.53**	**8.62**
CaO	9.15	11.79	11.14	10.40	11.60	11.38
Na_2O	0.81	2.61	1.22	2.36	1.78	2.37
K_2O	0.03	0.17	0.04	0.06	0.13	0.25
P_2O_5	0.00	0.03	0.02	0.00	0.08	0.10

***UT*-04:** *Ol* (1443°C) → *Aug* (1233°C) → *Pl* (1174°C),
***UT*-08:** *Pl* (1332°C) → *Ol* (1231°C) → *Aug* (1164°C),
***EC*-10:** *Ol* (1385°C) → *Aug* (1199°C) → *Pl* (1187°C),
***MEO*-18:** *Pl* + *Ol* (1248 °C) → *Aug* (1161°C),
***KT*-47:** *Ol* (1346°C) → *Pl* (1191°C) → *Aug* (1189°C),
***EG*4507:** *Pl* (1242°C) → *Ol* (1225°C) → *Aug* (1163°C).

These rocks belong to the Marginal Border Series of the Skaergaard intrusion.

All of them were selected within 10 m from the intrusive contact and have no any record of parental magma fractionation.

The results indicate a wide high-temperature field of ***Ol*** for high-magnesia samples and an early crystallization of ***Pl*** for aluminum enriched compositions.

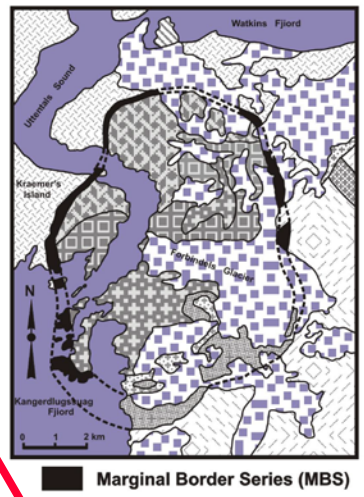
The Skaergaard intrusion

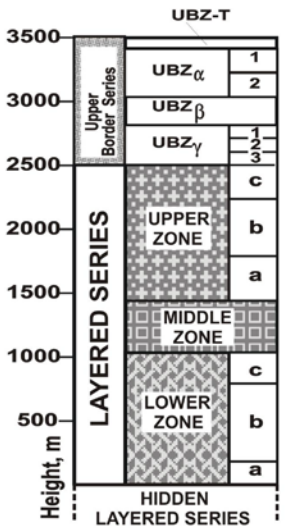
In these T-X coordinates the modeled liquid lines of descent demonstrate a closing together and intersection near 1165°C.

This intersection is consistent with the premise that the selected rocks were mechanical mixtures of cumulus crystals plus a trapped melt.

Average liquid composition representing this cluster of six evolutionary lines at 1165°C is considered to present a probable initial melt composition intrinsic to the original crystal mush from which the contact rocks have been crystallized.

Map & generalized section

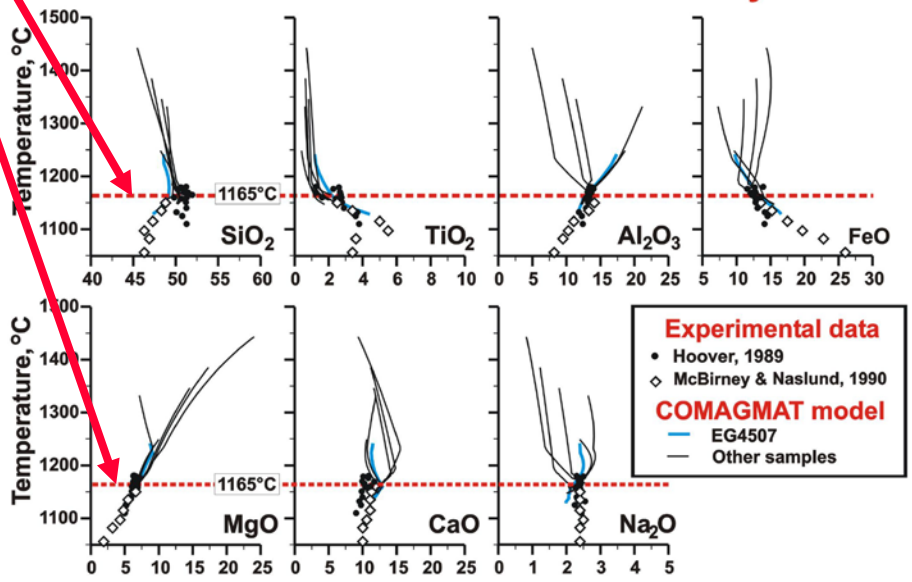




Initial Melt at 1165°C

Oxide	wt.%
SiO_2	50.01
TiO_2	1.68
Al_2O_3	12.95
FeO	13.24
MnO	0.19
MgO	6.90
CaO	12.40
Na_2O	2.37
K_2O	0.26
P_2O_5	0.15

Results of Geochemical Thermometry



Cape Kronotsky

Taking tea among layered diabases of the Chazhma sill (Eastern Kamchatka, 1982)

MODELING THE FORMATION OF FERRODIORITES
from the Chazhma sill, Kamchatka

This intrusion is composed of differentiated rocks ranging from high-Al diabases to diorites and granophyres.

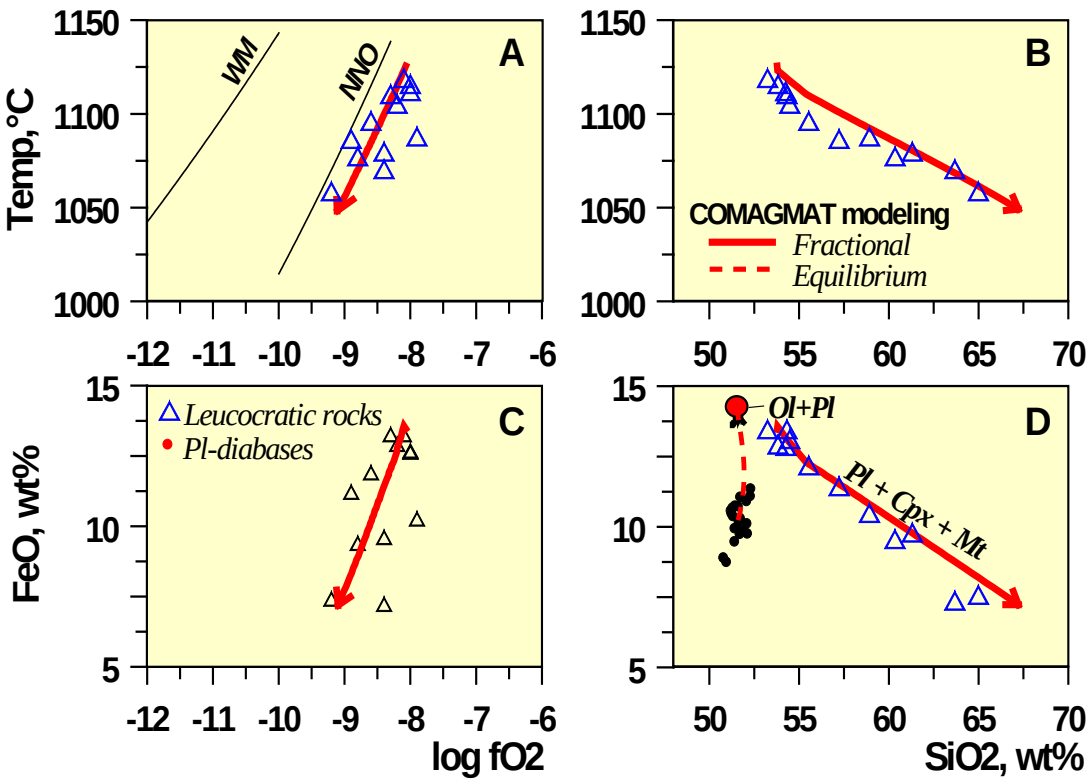
The diorites make up a large number of fine-grained leucocra-tic layers embedded between massive more dark diabases.

These observations allowed us to conclude that there were no large scale mixing between these two magmas. This leucocratic material was probably injected into the main magma body simultaneously with, or just after emplacement, as the body began to crystallize.

MODELING THE FORMATION OF FERRODIORITES
from the Chazhma sill, Kamchatka

Geochemical studies have demonstrated that the compositions of Chazhma layers display a trend of decreasing iron with increasing silica content.

The presence of Magn crystals indicates these trends were originated due to the fractionation of magnetite-bearing assemblages from same basaltic andesite parent.

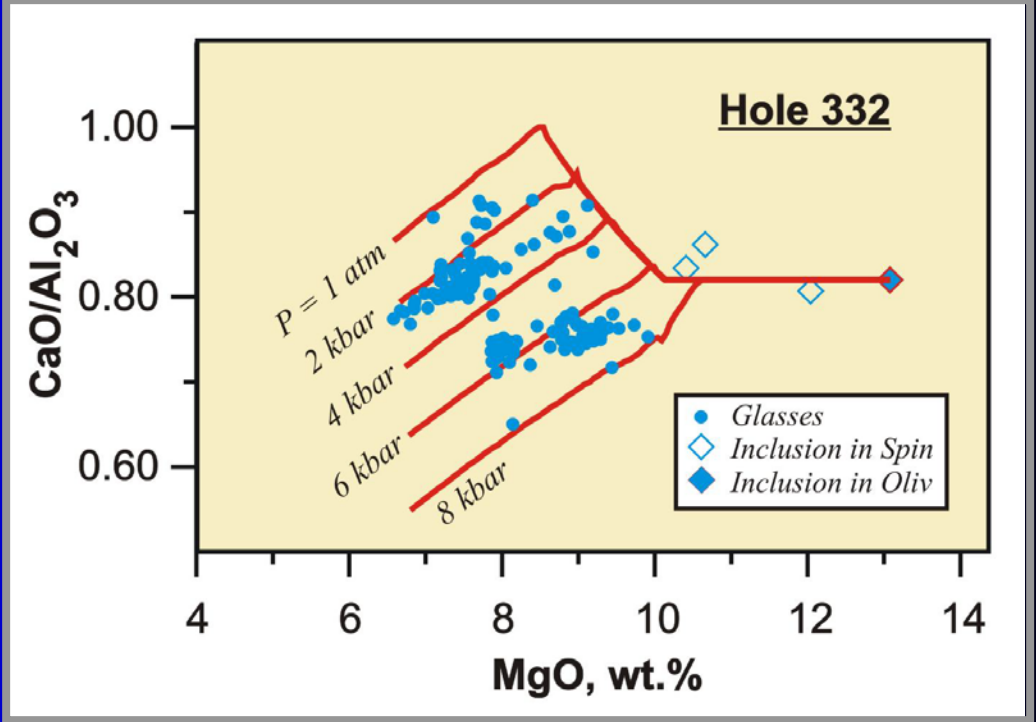


Finally, simulations near NNO buffer were carried out to accurately reproduce the iron-silica relations observed in the Chazhma suite.

MODELING POLYBARIC FRACTIONATION OF MORB GLASSES

The tholeiitic compositions form two evident clusters that could indicate of two different tholeiitic magmas fractionating Cpx at a depth.

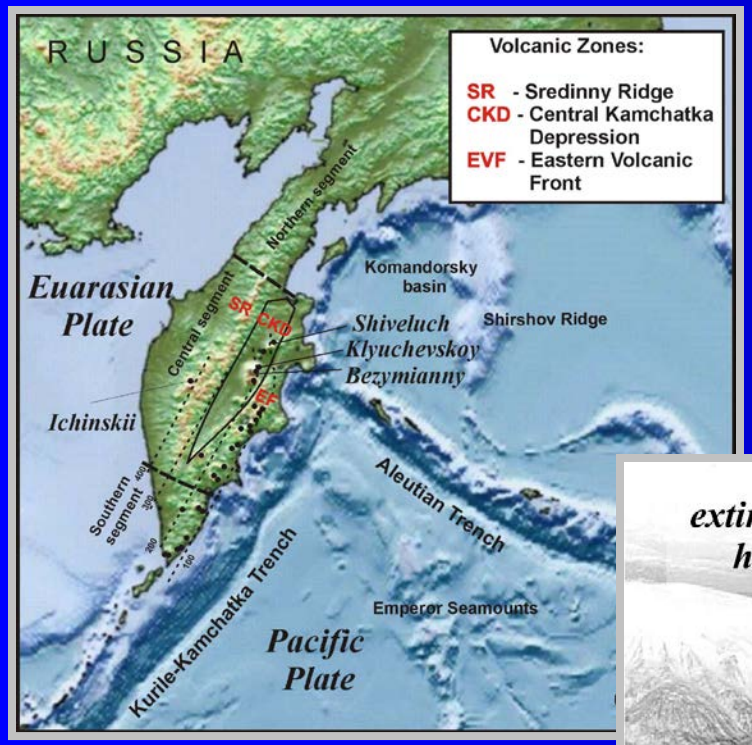
In attempt to understand this diversity, we carried out a set of polybaric calculations simulating fractionation at low to elevated pressures for a proposed high-magnesia parental basalt.



The results evidence for the diversity of tholeiitic glasses has been derived from same precursor, with these two compositional groups being different in the depth of the fractionation process.

A part of these melts has been originated near 6 kbars, whereas the majority of the glasses indicate of low pressures crystallization at the depth of 2-3 kbars.

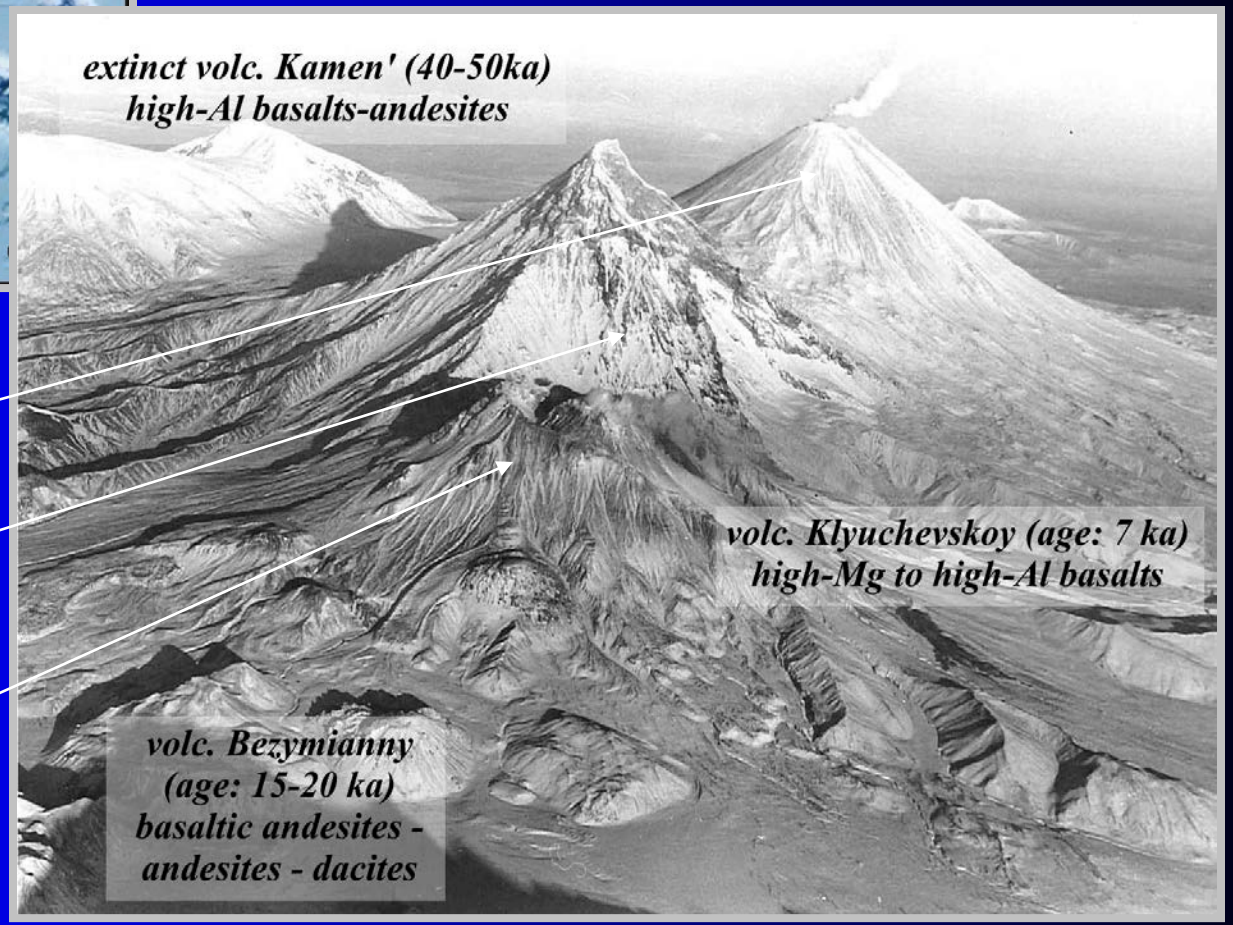
KLYUCHEVSKOY'S GROUP OF VOLCANOES (Kamchatka, Russia)



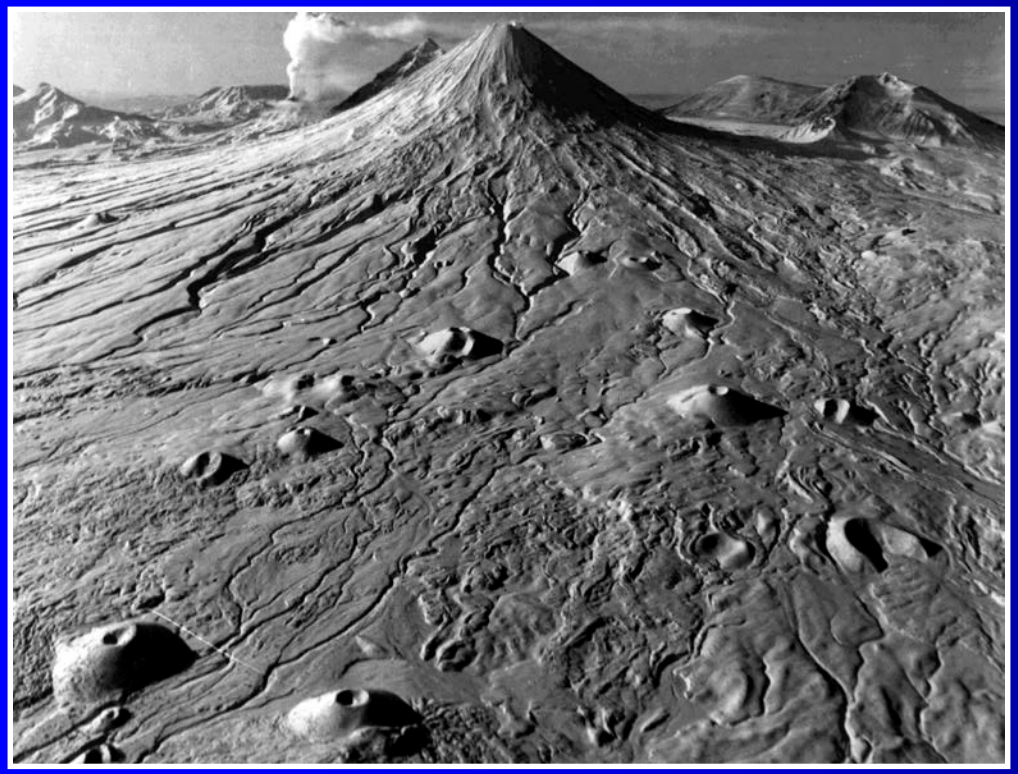
Klyuchevskoy:
basalts

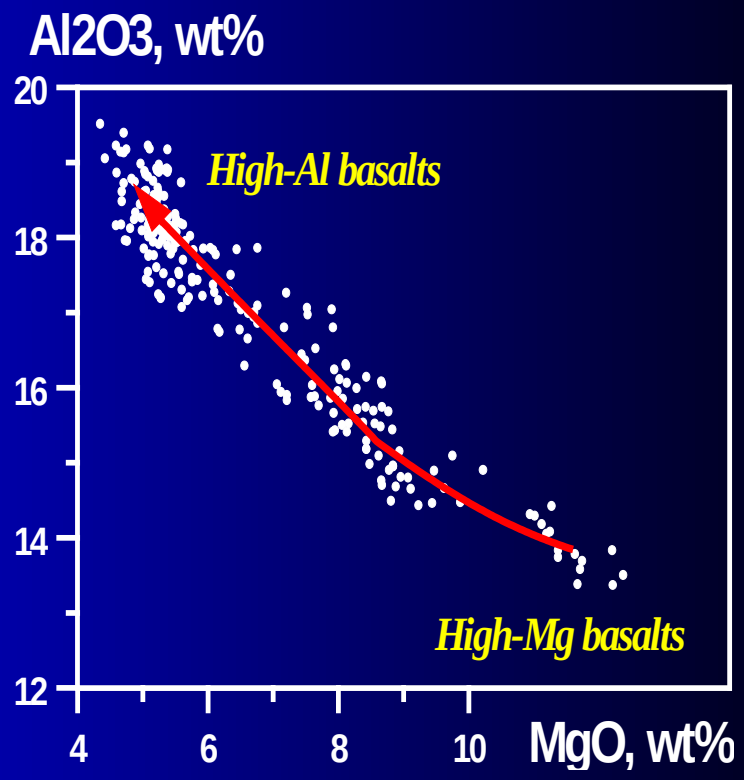
Kamen:
basaltic andesites

Bezymianny:
andesites



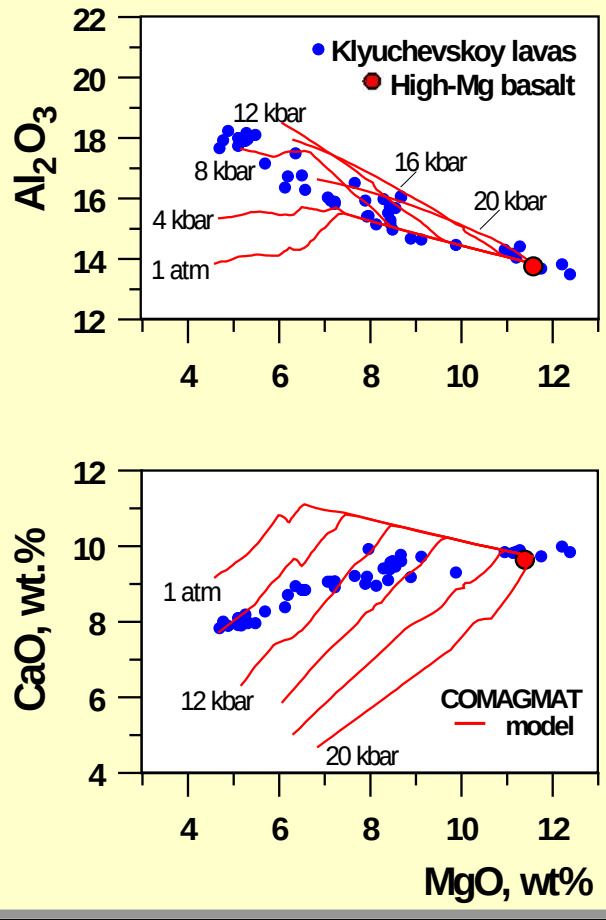
MODELING THE GENERATION OF HIGH-AL BASALTS
from the Klyuchevskoy volcano, Kamchatka





The volcanic edifice consists of numerous basalt lava sheets and pyroclastic materials, **ranging continuously from high-Mg basalts to high-Al basalts containing at least 18% Al_2O_3.** The proposed genetic link between high-magnesia and high-alumina basalts includes the removal of mafic phases, **principally olivine and augite**.

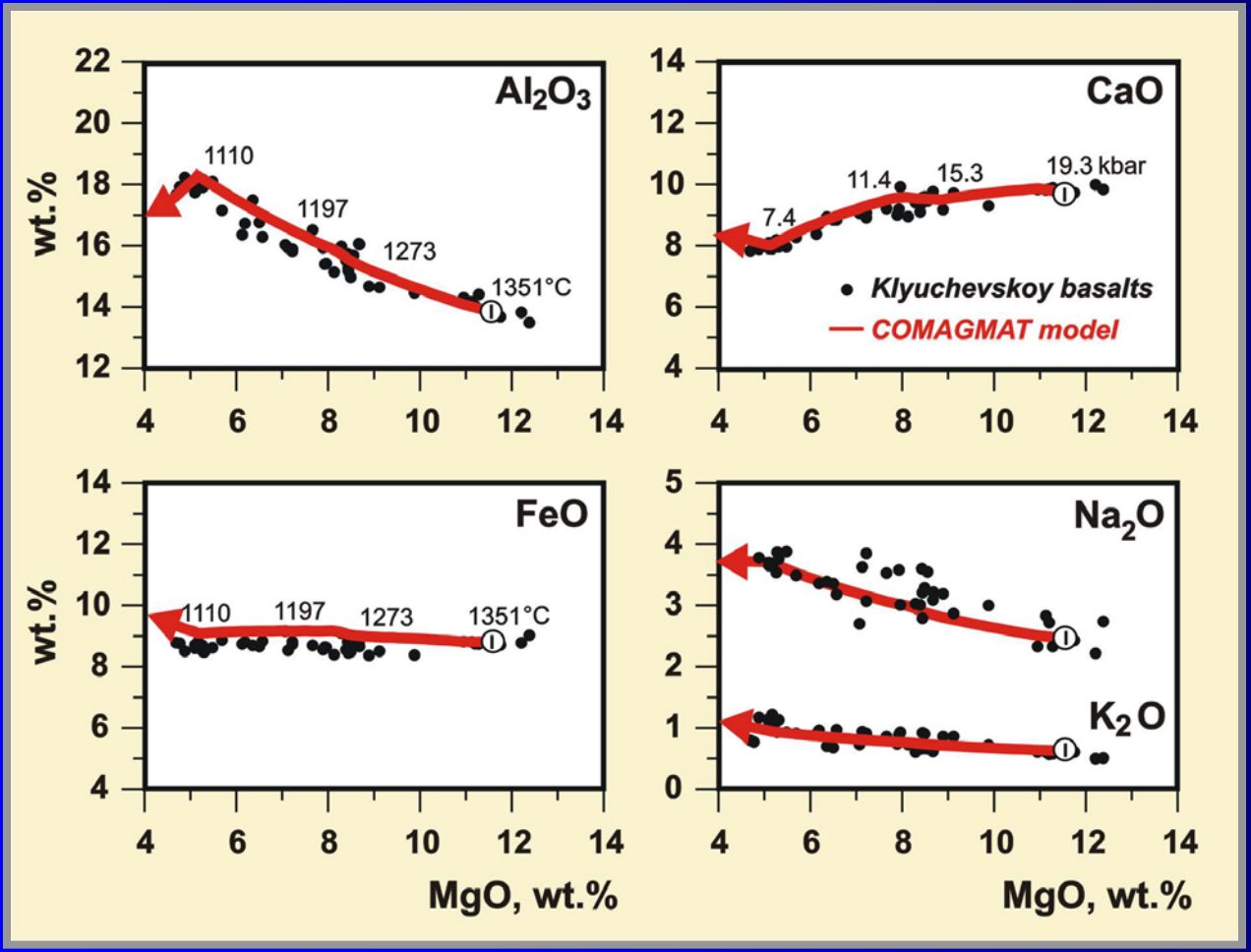
MODELING OF THE THE ISOBARIC FRACTIONATION PROCESS
at unhydrous conditions ranging from 1 atm to 20 kbars



At the pressures more than 8 kbars equilibrium crystallization of the high-magnesia parent results in the alumina enriched liquids. However, **the modeled trends do not provide an adequate match with the observed CaO-MgO trend**.

A possible explanation of these discrepancies is to link the formation of the observed suite with decompression fractionation of the parental high-magnesia magma containing small but significant water.

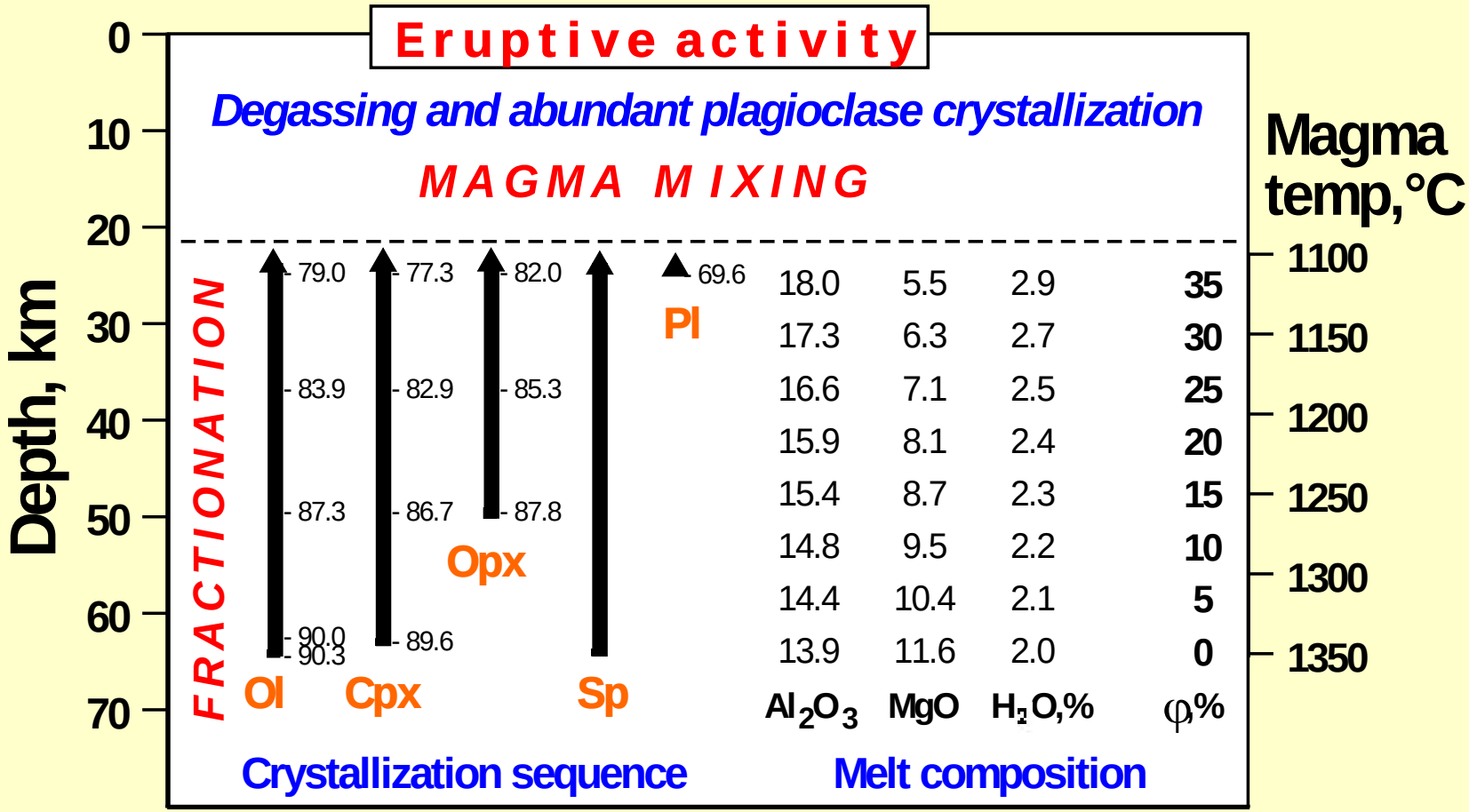
THE OPTIMAL MODEL OF THE DECOMPRESSION FRACTIONATION
for the high-Mg magma of the Klyuchevskoy volcano



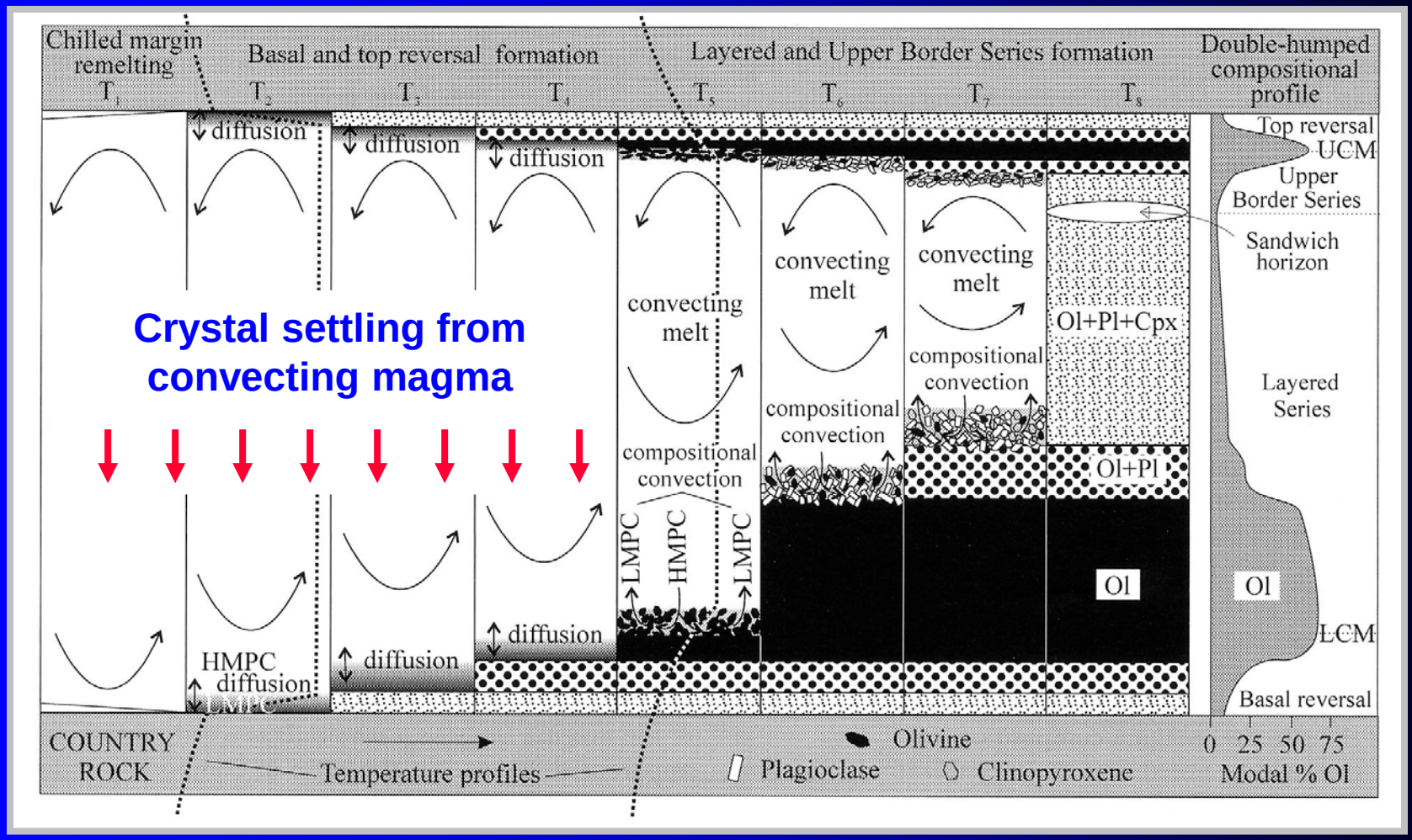
These chemical trends can be produced by **~40% fractionation** of the ***Ol-Aug-Sp-Opx*** assemblage during ascent of the magma over **the pressure range 19-7 kbars**.

This is consistent with the decrease in the temperature from **1350 to 1100°C**, with ~2 wt.% of H2O in the initial melt.

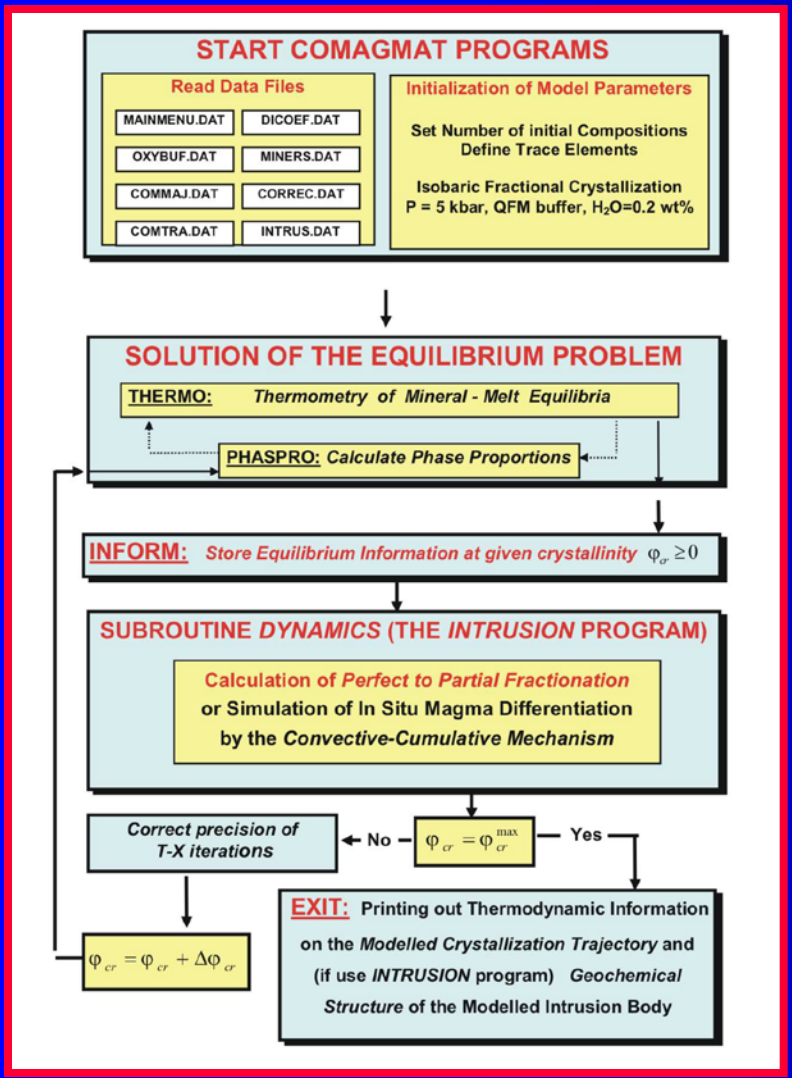
PROPOSED EVOLUTION OF THE MAGMA PLUMBING SYSTEM
for the Klyuchevskoy volcano



CONVECTIVE-CUMULATIVE MODEL SIMULATING THE FORMATION OF DIFFERENTIATED SILLS FROM THE SIBERIAN PLATFORM

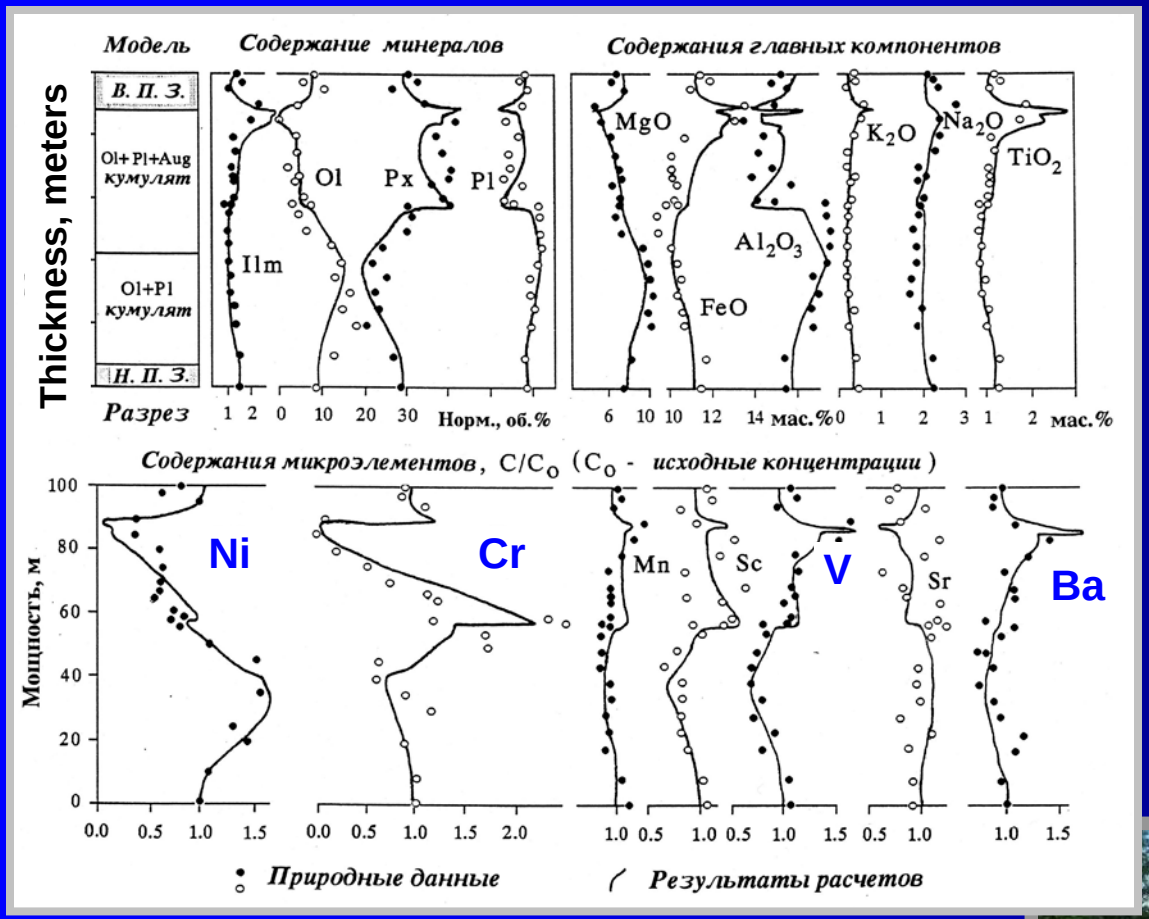


DEVELOPMENT OF "INTRUSION" PROGRAM AND FIELD STUDIES



Integration of physical constraints into the COMAGMAT model

COMPARISON OF CALCULATIONS WITH OBSERVATIONS



- Natural data for the Vavacan sill

/ Calculations

ГЛАВНЫЕ ВЫВОДЫ ЛЕКЦИИ

НЕТ НИЧЕГО ВАЖНЕЕ ПОЛЕВЫХ РАБОТ !