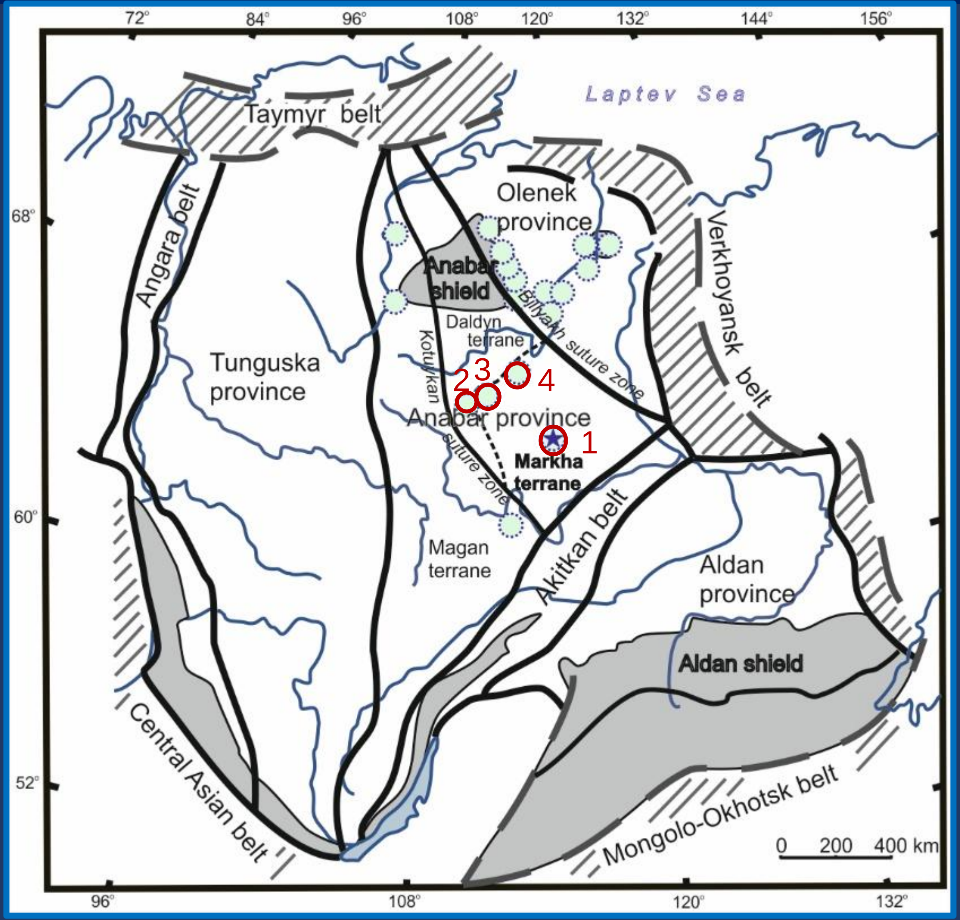
Petrochronology of the lower crust of the Anabar province of the Siberian craton

Marina Koreshkova [1]*, Hilary Downes [2], Ekaterina Akimova [1],
Maria Stifeeva [3], Irena Peytcheva [4], Dimitrina Dimitrova [4], Lubomira Macheva [5],
Aleksandr Larionov [6], Sergey Sergeev [6], Gleb Lisovski [7], Oleg Safonov [7]

[1] St Petersburg State University, St Petersburg, Russia, m.koreshkova@spbu.ru
[2] Birkbeck, University of London, UK
3 Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, St Petersburg, Russia
4 Geological Institute “Strashimir Dimitrov”, Bulgarian Academy of Sciences, Sofia, Bulgaria
5 Institute of Mineralogy and Crystallography “Acad. Ivan Kostov”, Bulgarian Academy of Sciences, Sofia, Bulgaria
6 Isotope Research Centre, A.P. Karpinsky Russian Geological Research Institute, St Petersburg, Russia
7 Korzhinskii Institute of Experimental Mineralogy, Moscow, Russia

Geological background

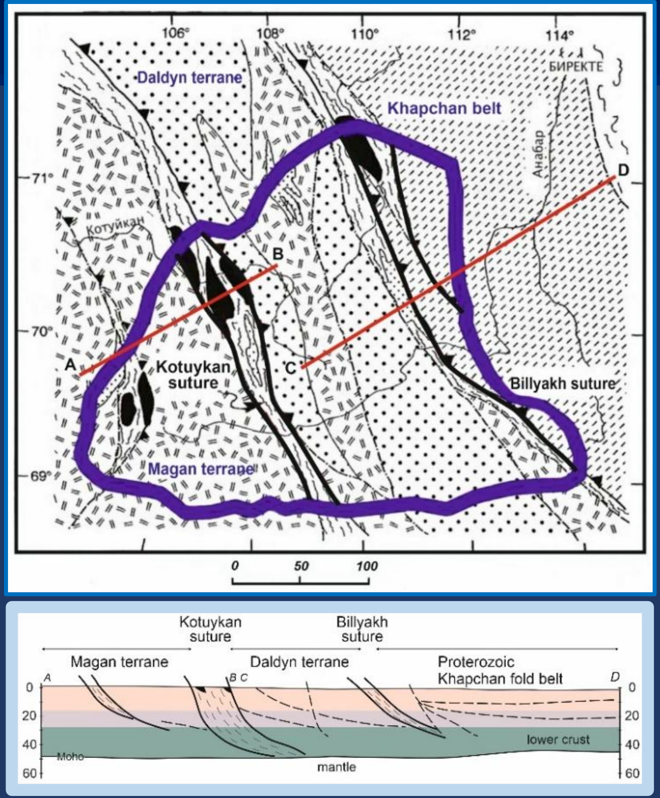


Tectonic division of the Siberian craton

(after Rosen et al. 2006; Gladkochub et al. 2006)

Marked kimberlite fields:
1 – Nakyn (Nurbinskaya), 2 – Alakit (Komsomolskaya),
3 – Daldyn (Udachnaya), 4 – Muna (Zapolyarnaya)

Donskaya 2020; Moreira et al. 2023 and previous works



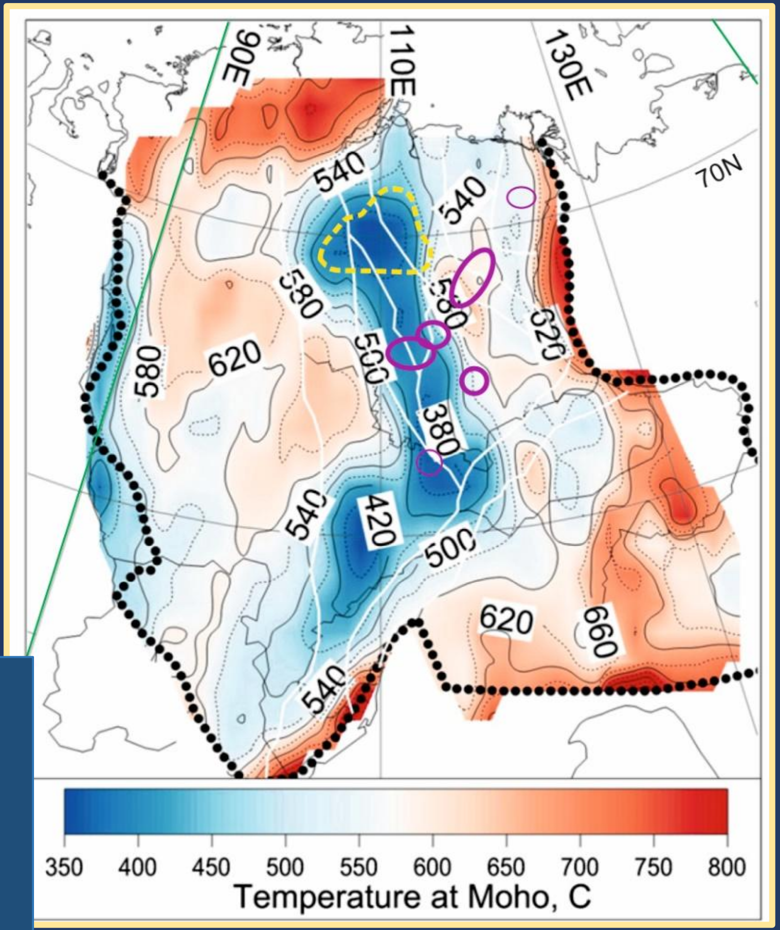
Geological sketch map of the Anabar shield and a section along lines A-B and C-D

(after Rosen et al. 2006)

3.8-2.7 Ga – magmatic rocks
~2.6 Ga – metamorphism

1.99-1.90 Ga - metamorphism
2.1-2.0 Ga – I-type granites
2.00-1.87 Ga – S-type granites
1.88-1.84 Ga – post-collisional granites

At present:
42-50 km thick crust
16-18 km thick lower crust
T at the Moho 500-540 °C



Cherepanova and Artemieva (2015)

Lower crustal xenoliths from the Alakit, Daldyn and Muna fields

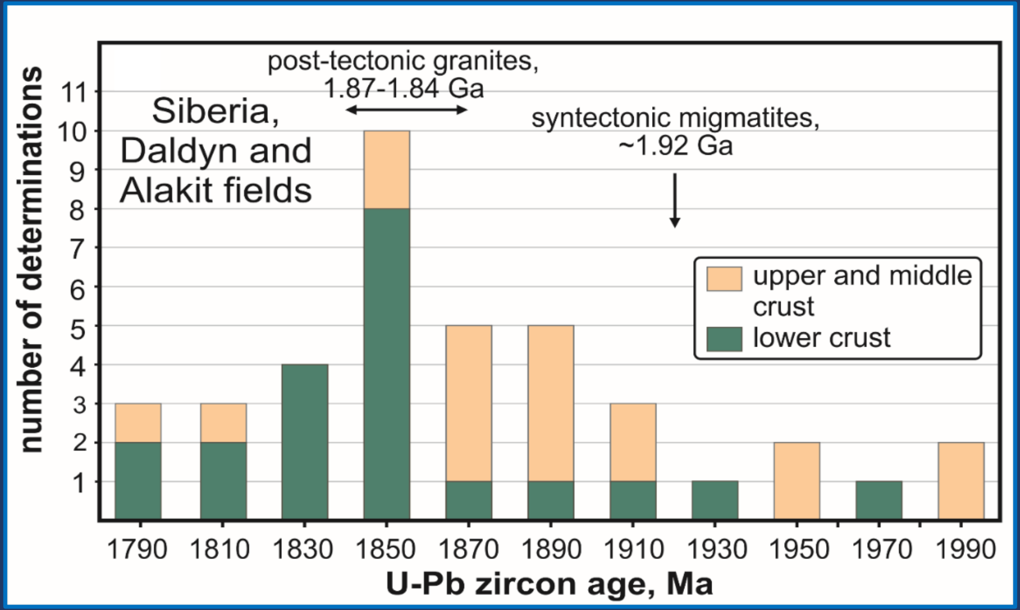
Grt-granulites:
almandine, Na-Al-diopside, oligoclase-andesine

± quartz, pargasite, enstatite (hypersthene), scapolite

apatite, sulfides, zircon, ilmenite ± rutile

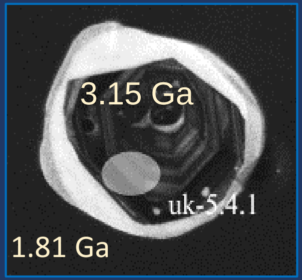
magmatic Zrn
3.2-2.7 Ga

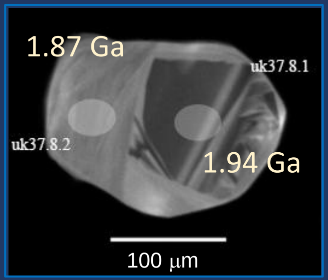
metamorphic Zrn
2.17-1.66 Ga



Koreshkova and Downes, 2021

Age, Ga	≥2.04	1.98-1.94	1.93-1.90	1.87-1.84	1.83-1.76	1.6-1.4	≤1.1
LC	Grt-granulite	Grt-granulites	Grt-granulite	Grt-granulites	Grt-granulite	Grt-granulite	
	U-Pb Zrn	U-Pb Zrn	U-Pb Zrn	Zrn equilibrated with garnet	U-Pb Zrn	U-Pb Zrn	
				750-830^{o}C 0.9-1.2 Gpa			
				U-Pb Zrn		Grt-granulite	Grt-granulites
						U-Pb Rutile	U-Pb Rutile
						U-Pb Apatite	U-Pb Apatite
MC-UC		Grt-Bt-gneiss	Grt-Bt-gneisses,	Grt-Bt-gneiss, amphibolite,	Grt-Bt-gneiss		
		U-Pb Zrn	granulite	felsic granulites	U-Pb Zrn		
			U-Pb Zrn	U-Pb Zrn			
				Grt-Bt-gneisses	amphibolite,		
				Sm-Nd isochrons	metatonalite		
					U-Pb Apatite		





Data from Apen et al. (2022), Koreshkova and Downes (2021), Shatsky et al. (2016), Shatsky et al. (2019), Moyen et al. (2017), Rosen et al. (2006)

Crustal xenoliths from the Nakyn field

Nurbinskaya diatreme

<u>Felsic xenoliths</u>

- Grt-gneisses
- Grt-Bt-schists
- Grt-granulites
- Crn-Ky-Grt-granofels

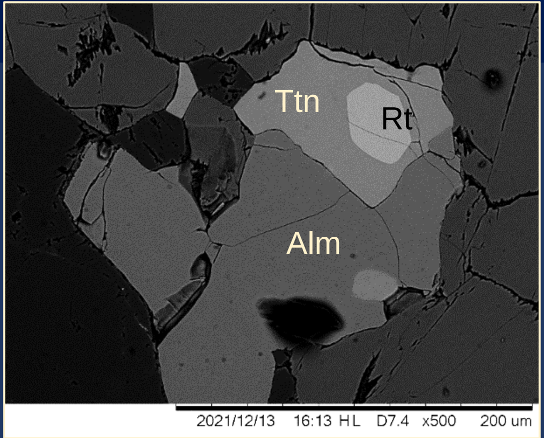
<u>Mafic xenoliths</u>

- amphibolites
- Grt-granulites
- garnetites

Grt-granulites:
almandine, Na-Al-diopside, oligoclase-andesine

± quartz, pargasite, enstatite (hypersthene), scapolite

apatite, sulfides, zircon, ilmenite, rutile, ± **titanite**

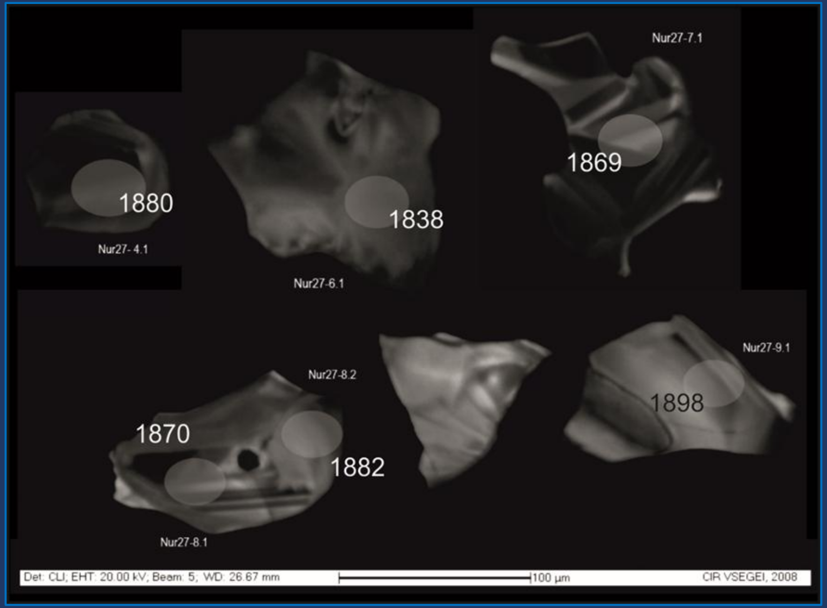


Ttn
U-Pb dates
1850 and
1785 Ma

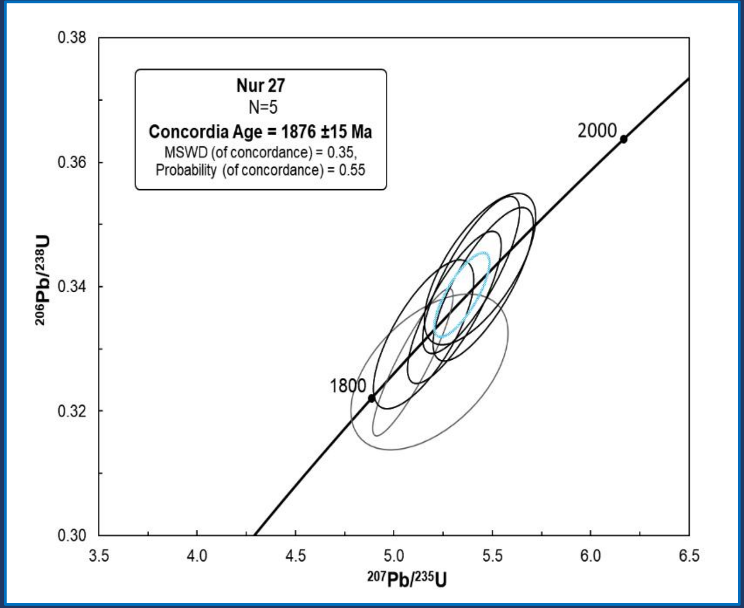
metamorphic Zrn 1.88 Ga

magmatic Zrn
2.9-2.8 Ga

Shatsky et al., 2022



CL images of zircons from Grt-granulite Nur27.
Spot numbers and $^{207}Pb/^{206}Pb$ ages (Ma) are shown.



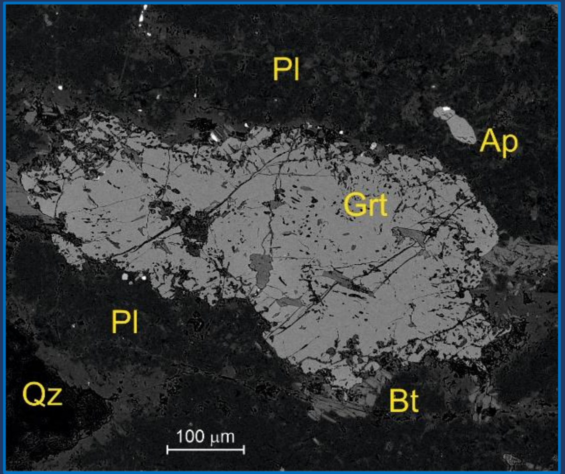
U-Pb Concordia diagram for zircon from Grt-granulite Nur27.
Data-point uncertainty ellipses are 2σ. Decay constants uncertainties are included.

Koreshkova and Downes, 2021; Koreshkova et al., 2024

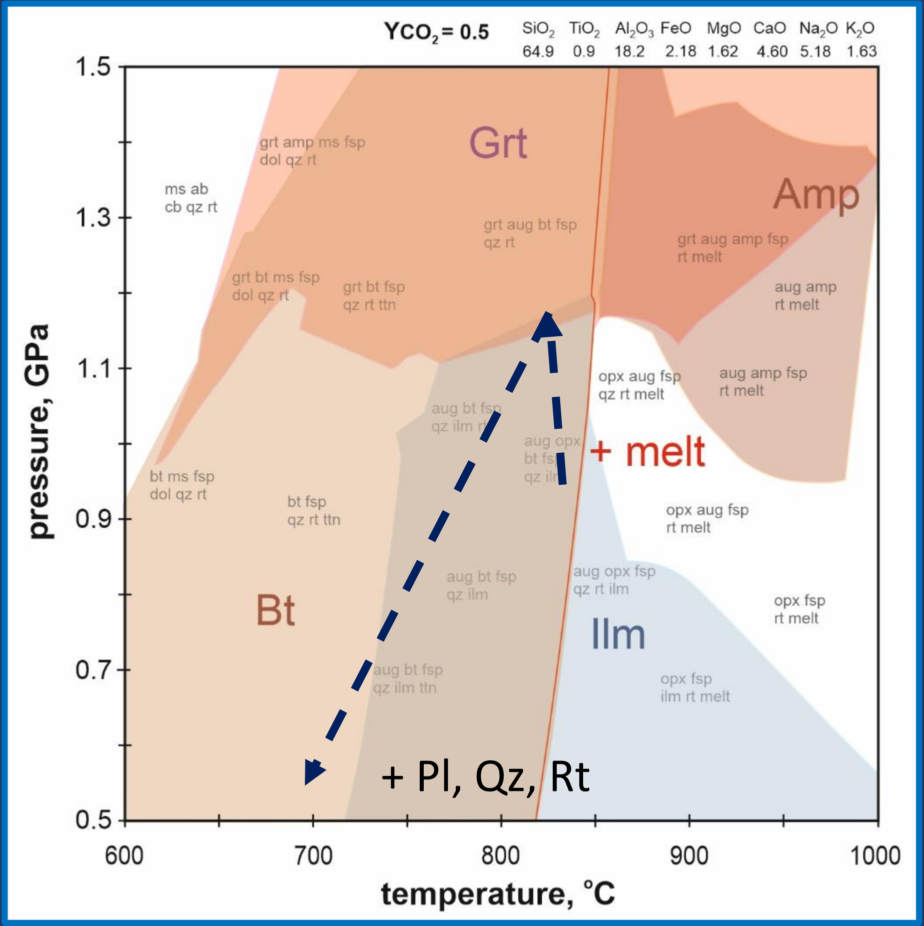
Crustal xenoliths from the Nakyn field: Grt-gneisses

Grt, vol.%	0.5
Amph	3
Bt	7
Kfs	2.7
Pl	67
Qtz	19
Ap	0.3
Ilm	0.5
Rt	x
Aln	x
Zrn	x

Gneisses are rich in plagioclase. Bulk rock composition is similar to granodiorite or tonalite.

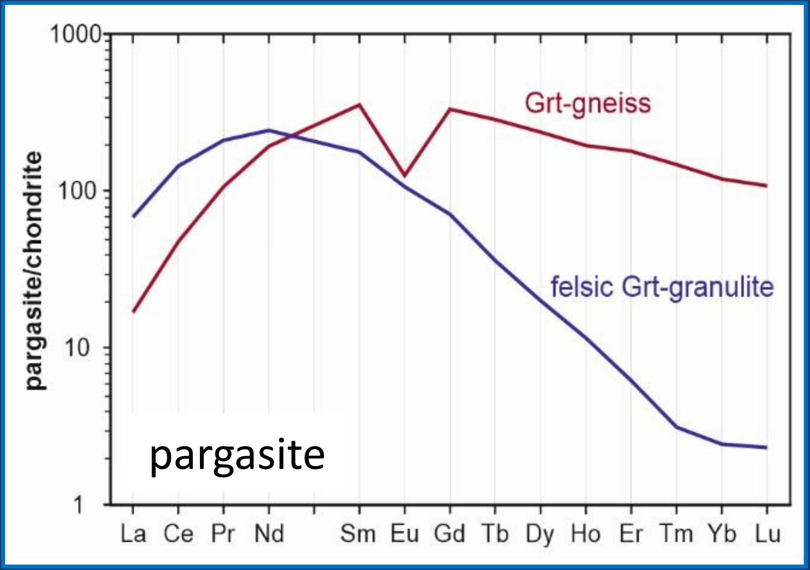


Garnet forms single grains with numerous biotite inclusions

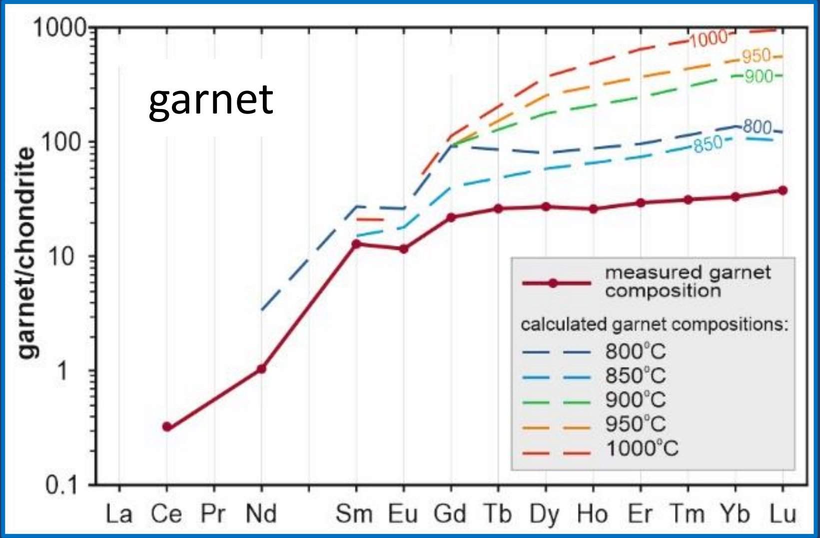


The association is not in equilibrium

Cooling and hence decompression occurred, giving Sm-Nd isochron ages of 1.83-1.76 Ga (Rosen et al., 2006)



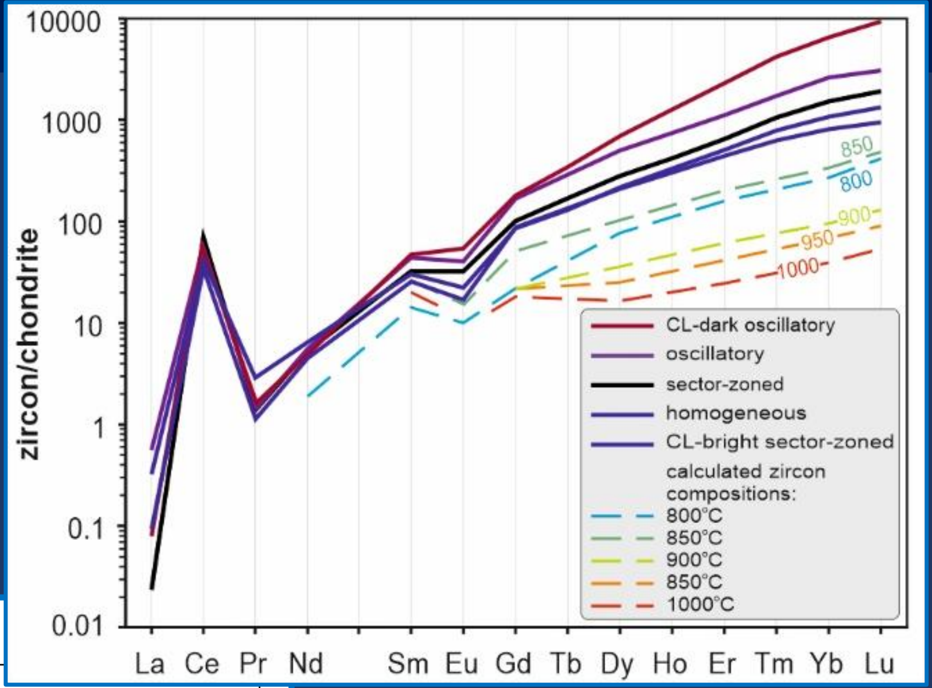
Pargasite grew in the absence of garnet



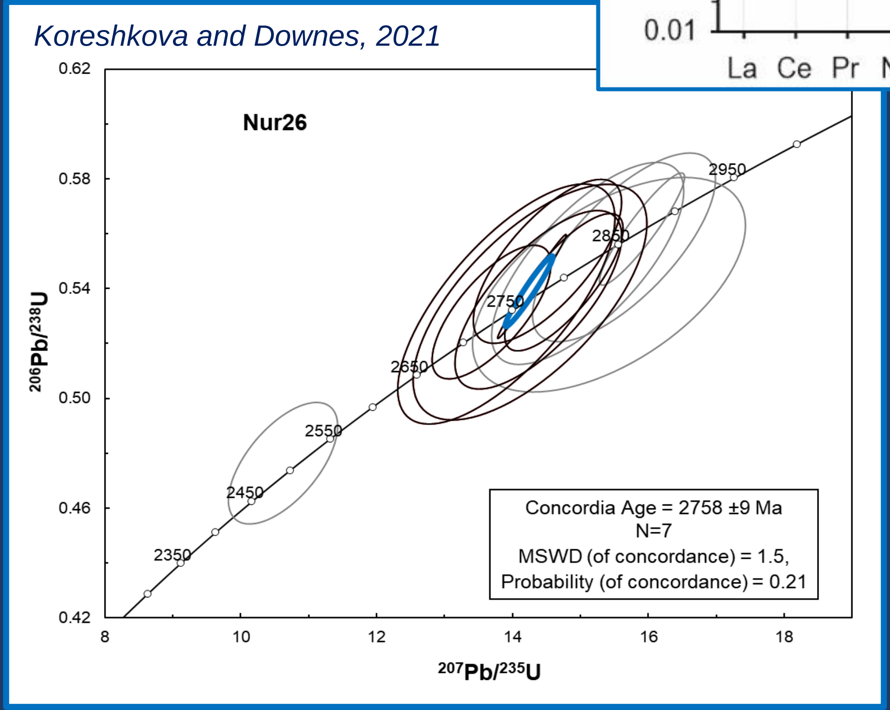
Dashed lines – calculated compositions of garnet in equilibrium with zircon

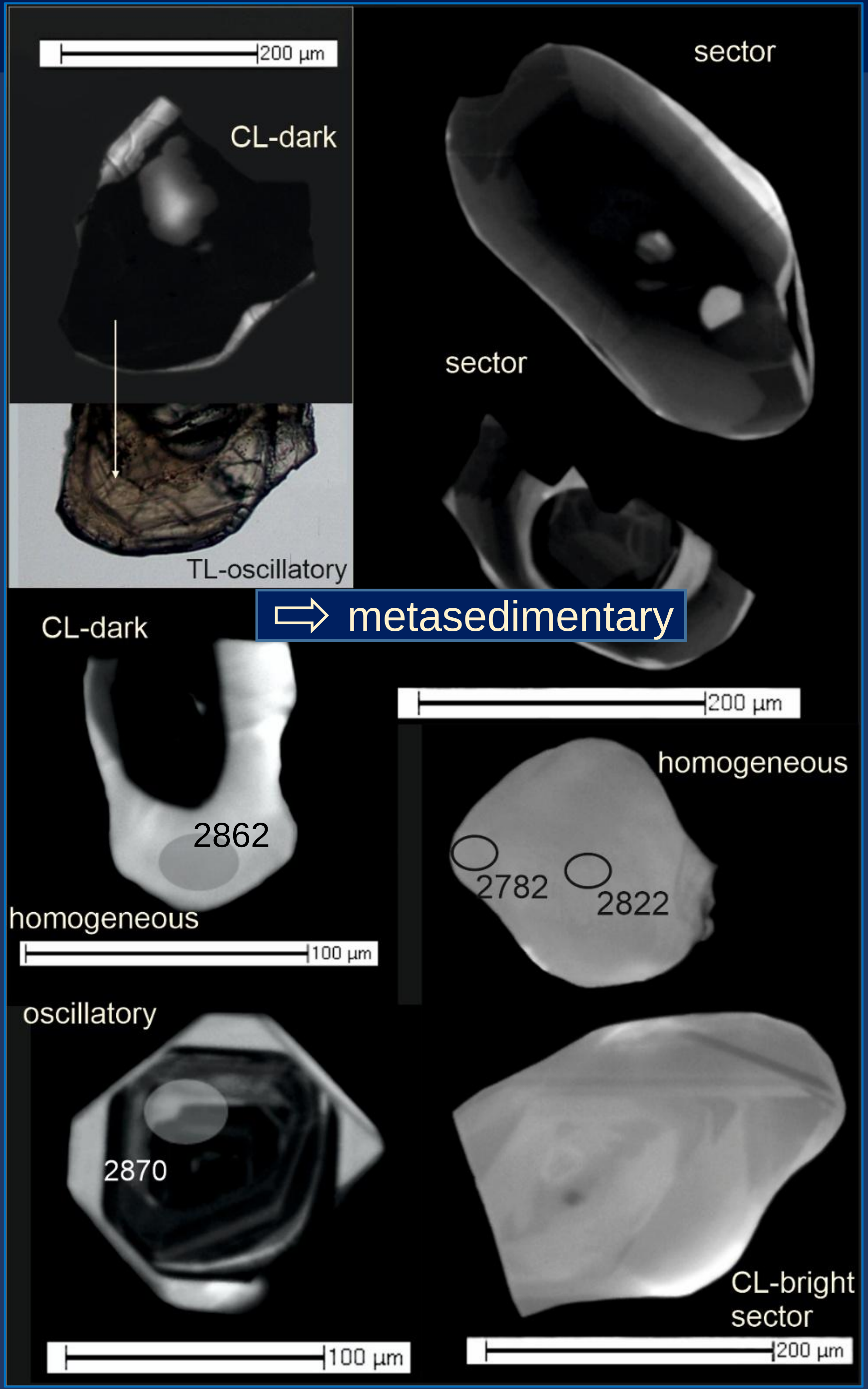
Grt-gneisses

Dashed lines – calculated compositions of zircon in equilibrium with garnet



CL-bright homogeneous zircon – 2.76 Ga



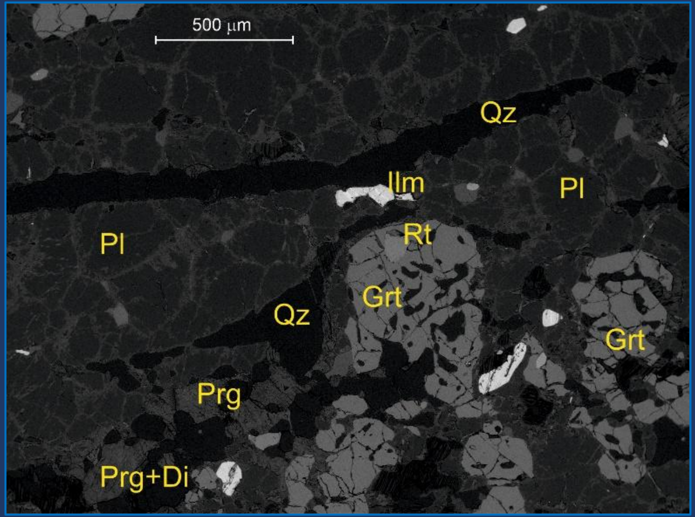


The composition and texture of zircon cores varies considerably. Therefore, the protolith was a sedimentary rock.
All grains have CL-bright homogeneous rims.

Pargasite and zircon were formed before garnet.
The appearance of garnet indicates pressure increase.
⇨ Response to Proterozoic events

Koreshkova and Downes, 2021

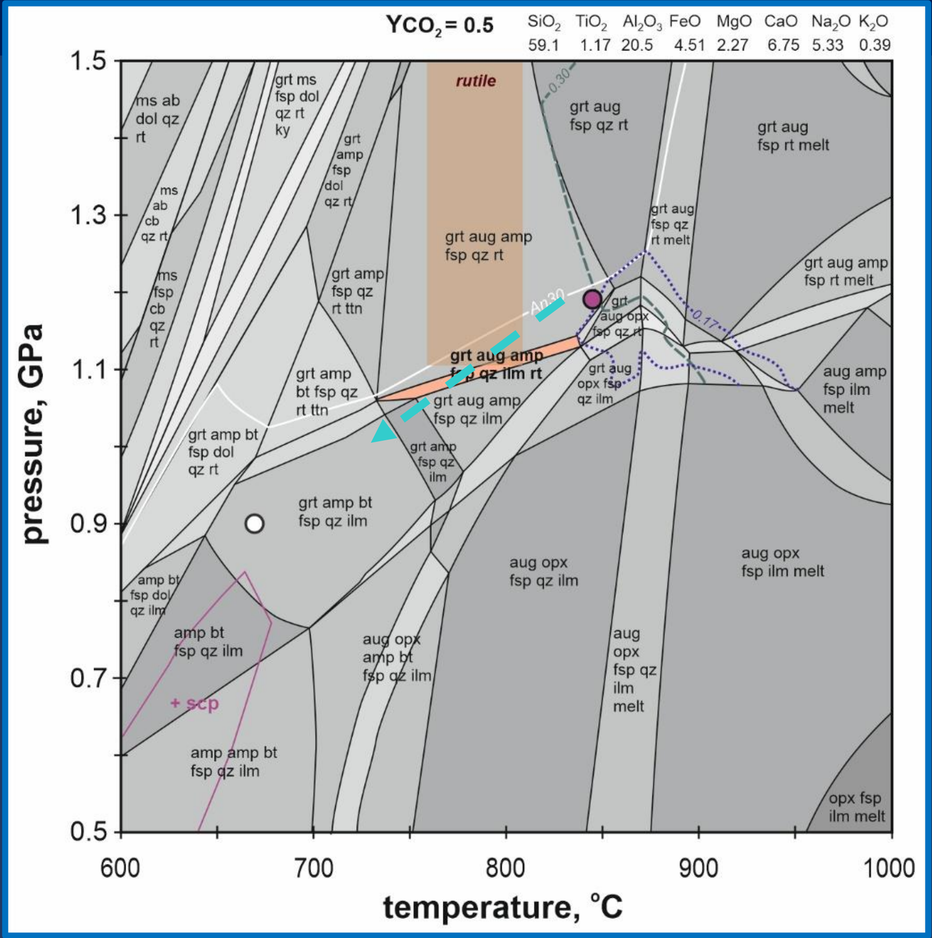
Felsic Grt-granulites: Scp-Qz-Grt-granulite



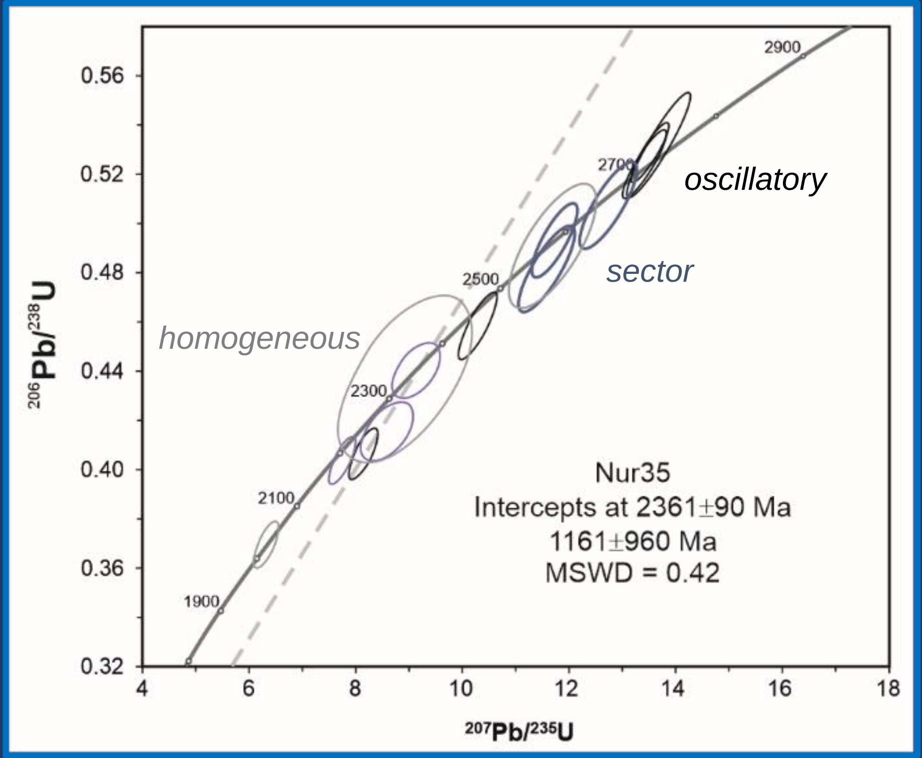
Grt, vol.%	9
Cpx	2
Amp	6.5
Pl	70
Qz	9.5
Scp	2
Ilm	0.3
Rt	0.5
Ap	0.2
Zrn	x

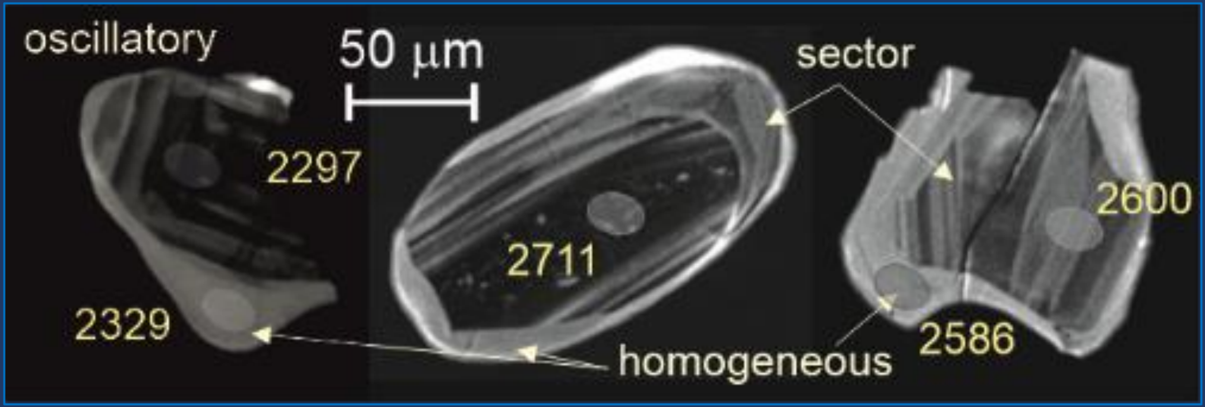
Banded Pl-rich Grt-granulite having diorite composition

850 ºC, 1.2 GPa

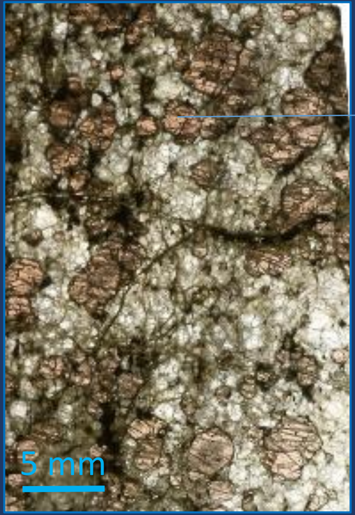


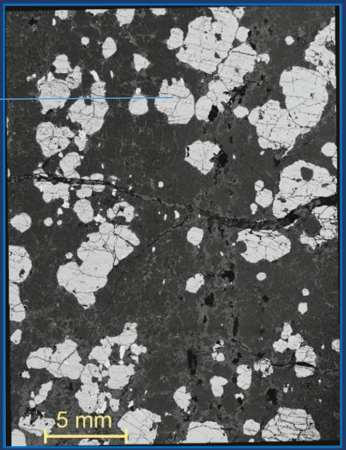
Magmatic protolith ~2.7 Ga.
Planar/sector-zoned domains ~2.6 Ga.
Homogeneous rims ~2.0-2.4 Ga.

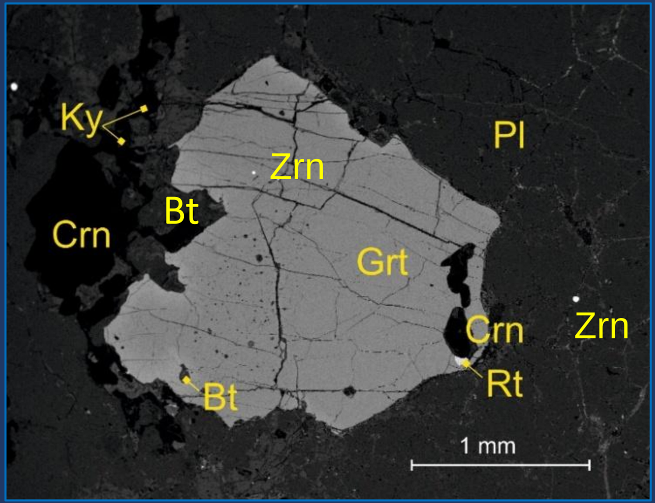




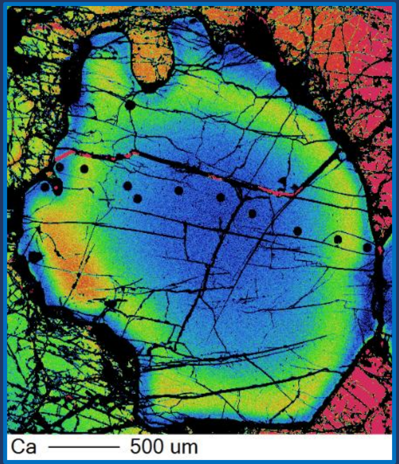
Felsic xenoliths: Crn-Ky-Grt-granofels

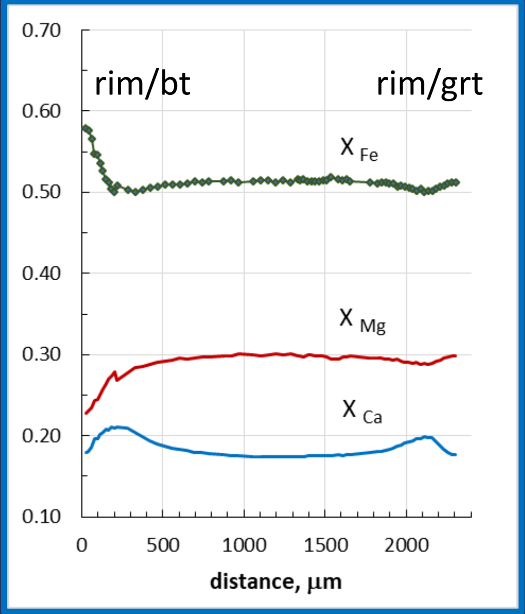




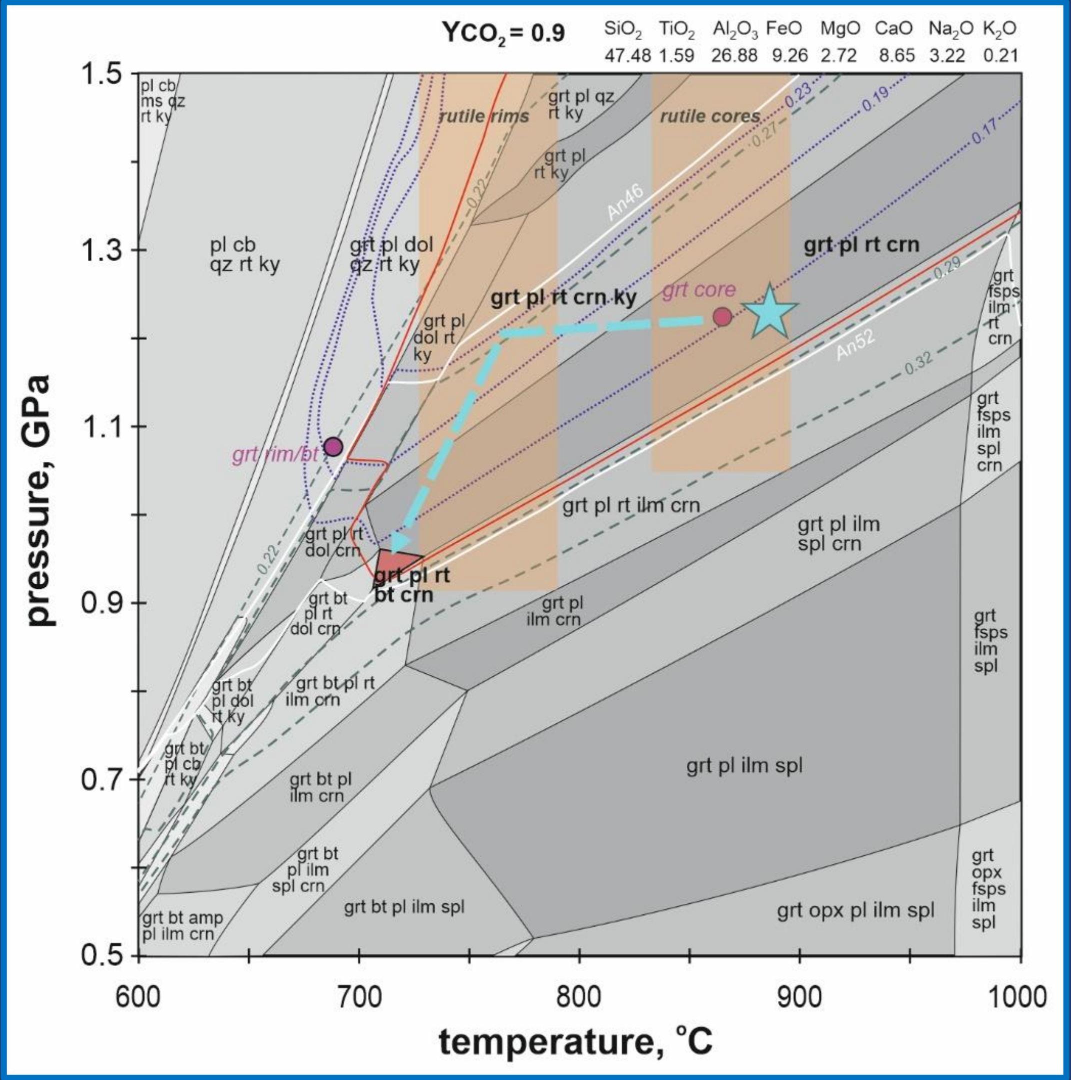


Grt, vol.%	28
Bt	1.2
Pl	67
Crn	0.9
Ky	1.7
Rt	1.1
Ap	0.09
Zrn	0.01



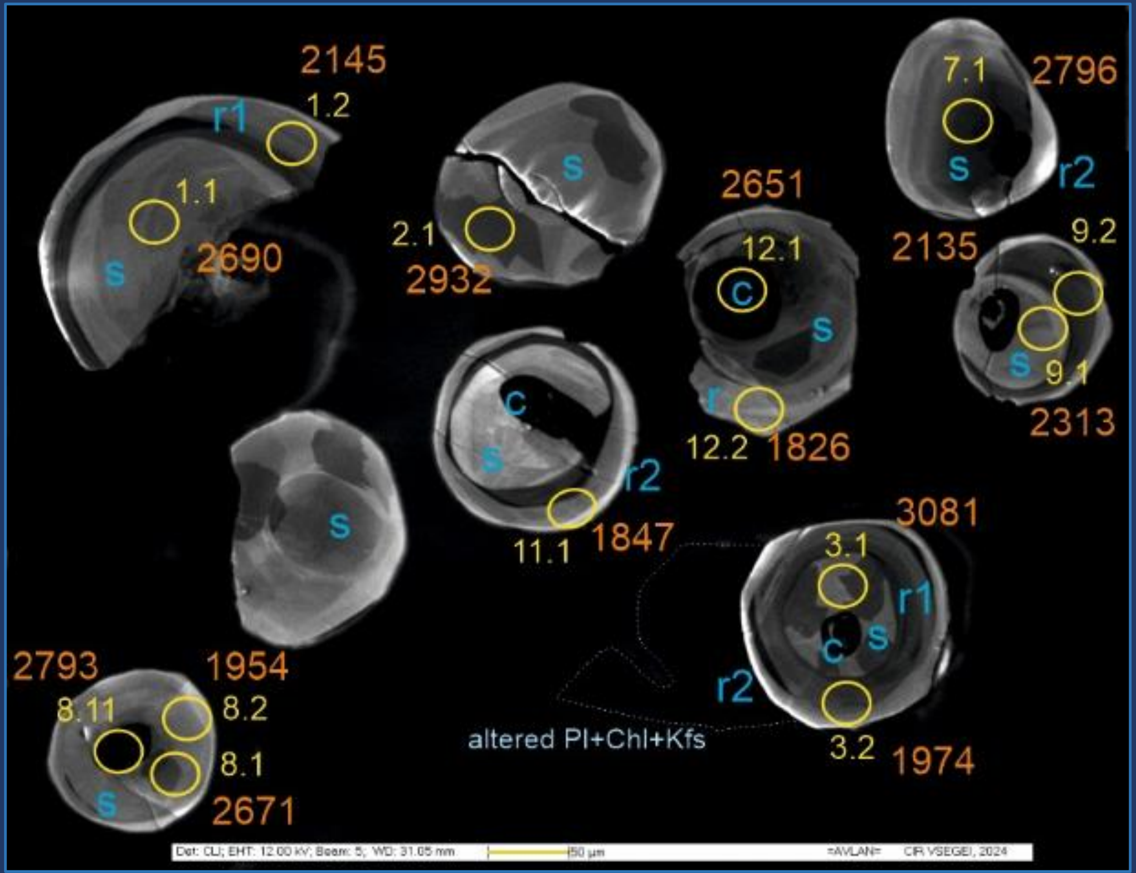


zoning in Fe and Mg was controlled by diffusion during cooling and decompression

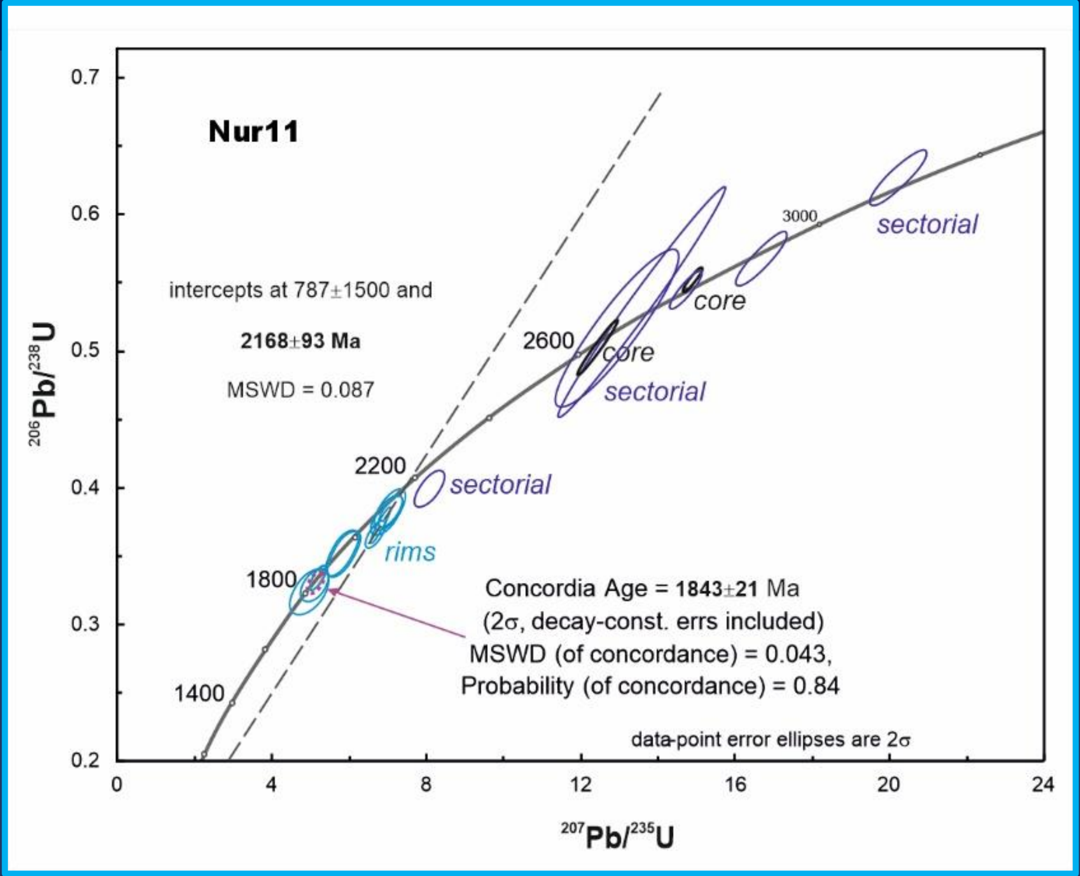


Phase equilibria modeling gave a path from 900 ºC, 1.2 GPa to 700 ºC, 0.9 GPa

Felsic Grt-granulites: Crn-Ky-Grt-granofels



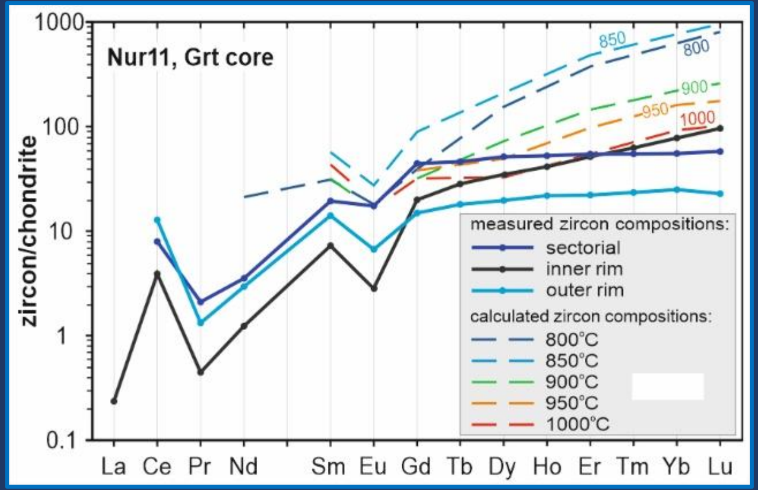
CL images of zircon from Crn-Ky-Grt-granofels Nur11 from the Nurbinskaya diatreme. Spot numbers and $^{207}Pb/^{206}Pb$ ages (Ma) are shown.

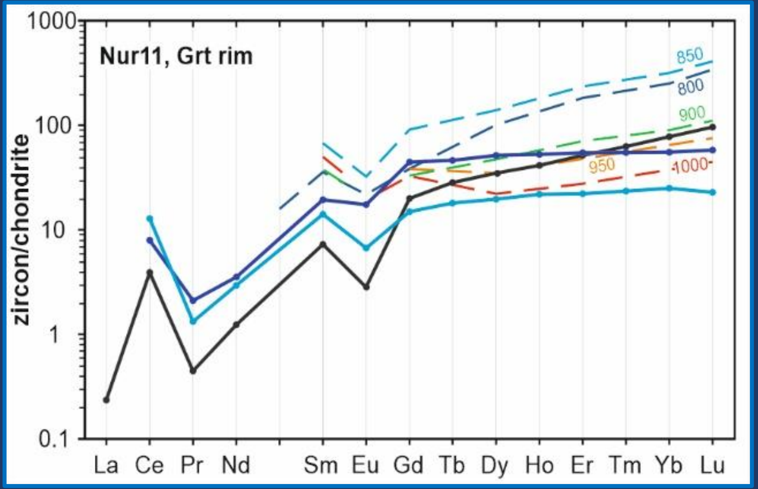


U-Pb Concordia diagram for zircon from Crn-Ky-Grt-granofels Nur11 from the Nurbinskaya diatreme. Data-point uncertainty ellipses are 2σ. Decay constants uncertainties are included.

avarage values:	Th	U	Th/U	Yb_N/Gd_N	Age
CL-bright outer rim	40	42	0.97	1.69	1843±21 Ma
inner rim	169	49	3.60	3.90	~2.2 Ga
sectorial	99	86	1.16	1.23	~3.1 Ga
dark cores	72	669	0.10		

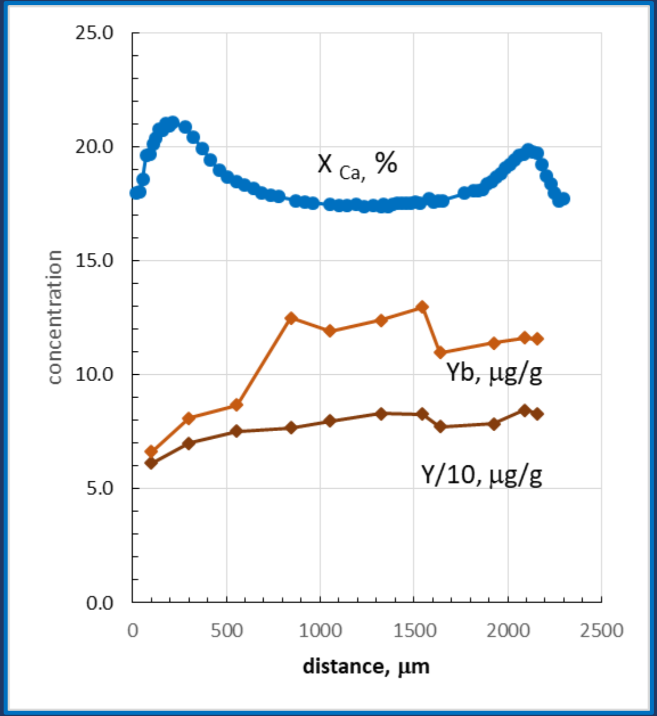
Felsic Grt-granulites: Crn-Ky-Grt-granofels

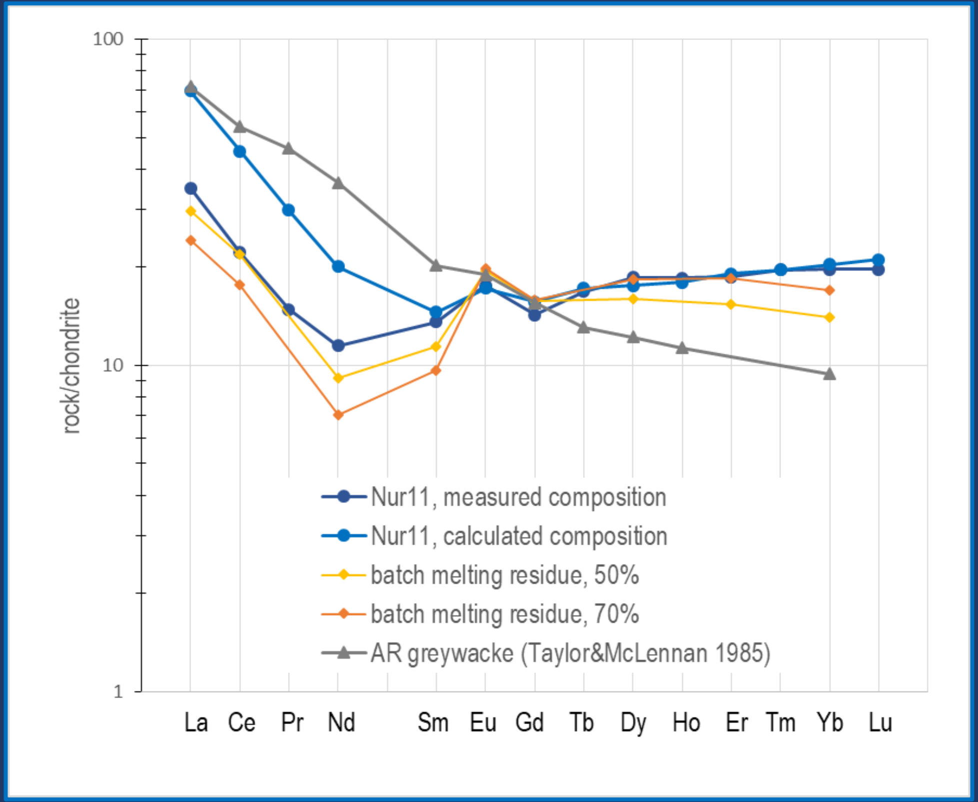




Dashed lines – calculated compositions of zircon in equilibrium with garnet

⇨ The inner rims date the association

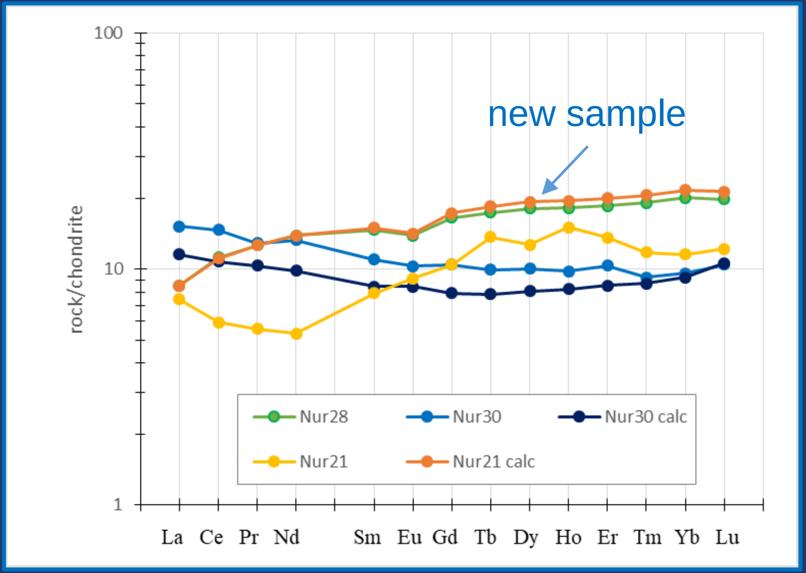




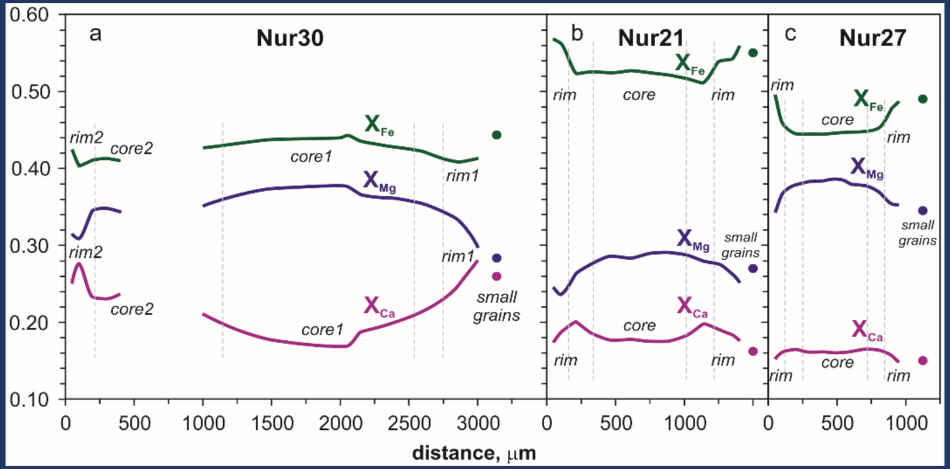
melting must have occurred before the inner rim formed

avarage values:	Th	U	Th/U	Yb_N/Gd_N	Age
CL-bright outer rim	40	42	0.97	1.69	1843±21 Ma
inner rim	169	49	3.60	3.90	~2.2 Ga
sectorial	99	86	1.16	1.23	~3.1 Ga
dark cores	72	669	0.10		

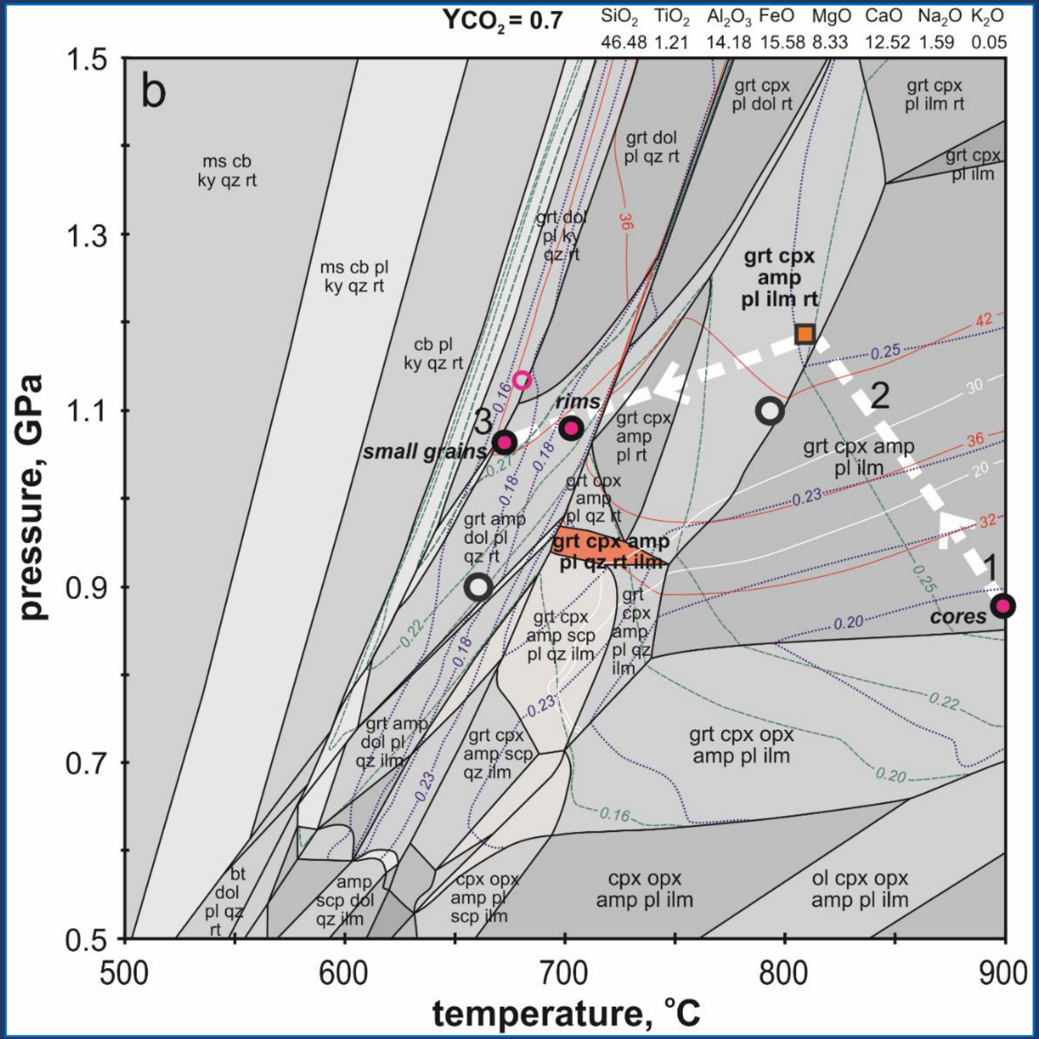
Crustal xenoliths from the Nakyn field: Mafic Grt-granulites



Comparison of observed and calculated REE patterns in granulite xenoliths from the Nurbinskaya diatreme. Values are normalized to chondrite CI (Sun and McDonough 1989)



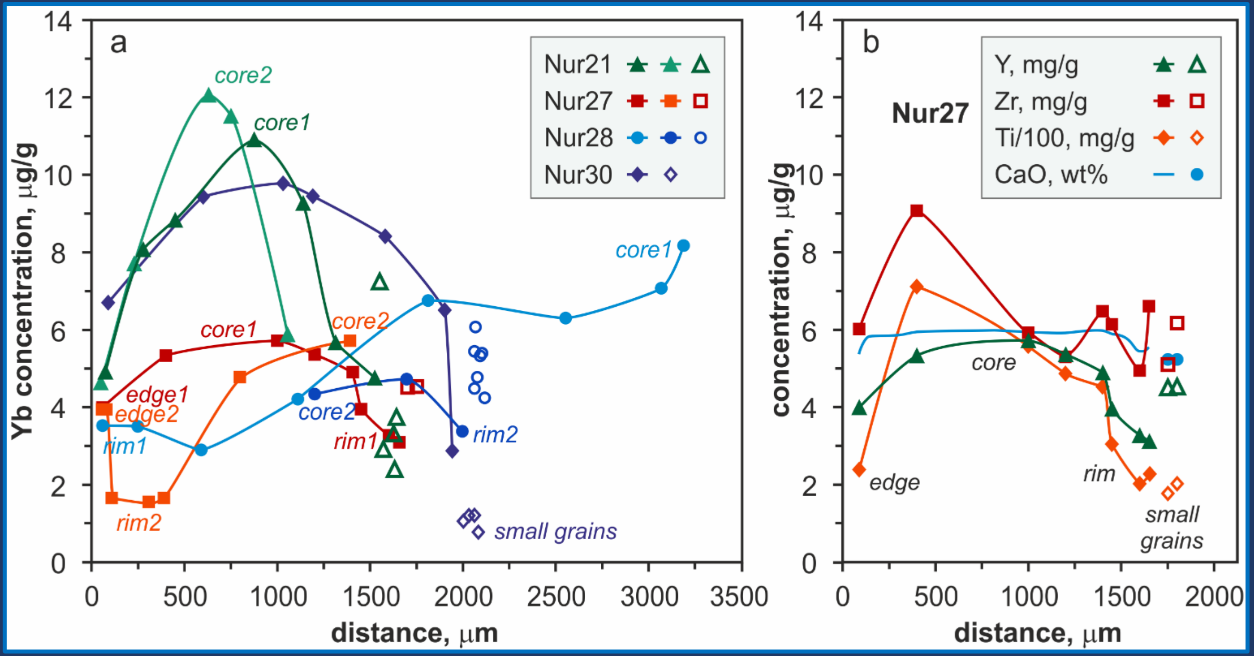
Variations in XCa, XMg and XFe along traverses across garnet grains from xenoliths from the Nurbinskaya diatreme.



Phase equilibria modeling results for calculated composition of Grt-granulite Nur21 from the Nurbinskaya diatreme.

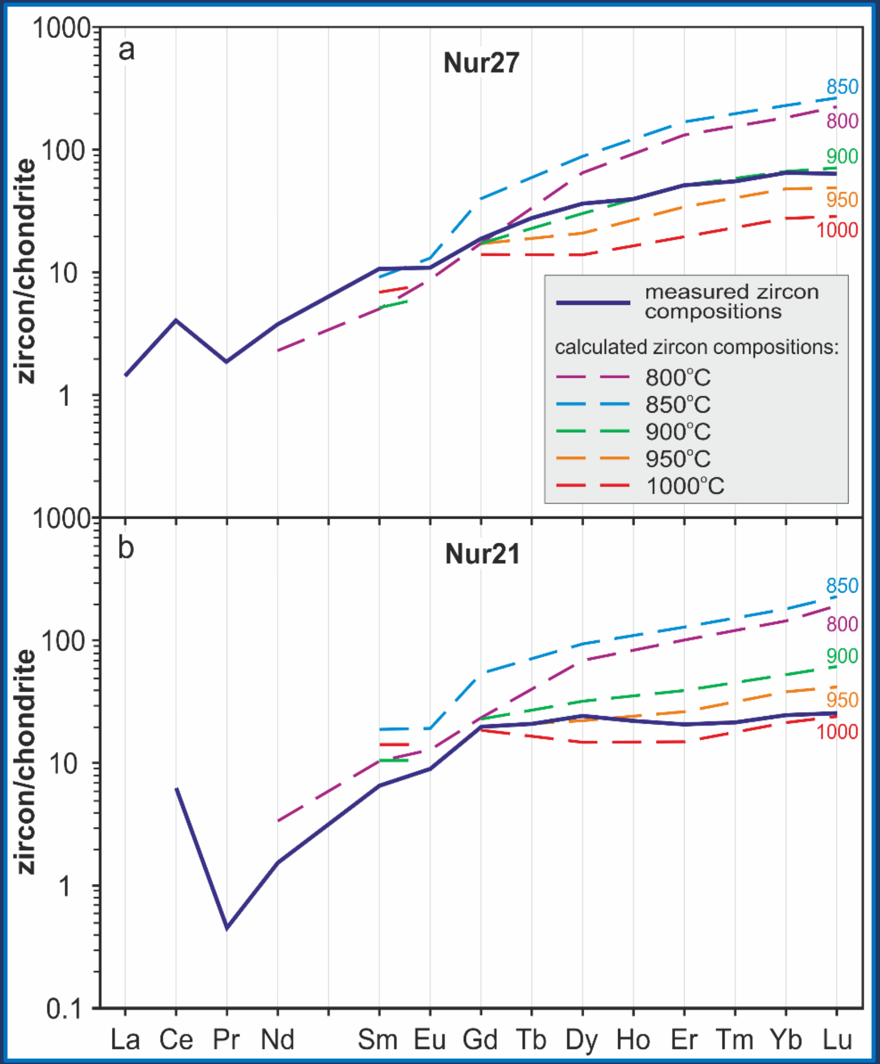
Koreshkova et al., 2024

Crustal xenoliths from the Nakyn field: Mafic Grt-granulites



Variations in trace element concentrations along traverses across garnet grains from mafic xenoliths from the Nurbinskaya diatreme.

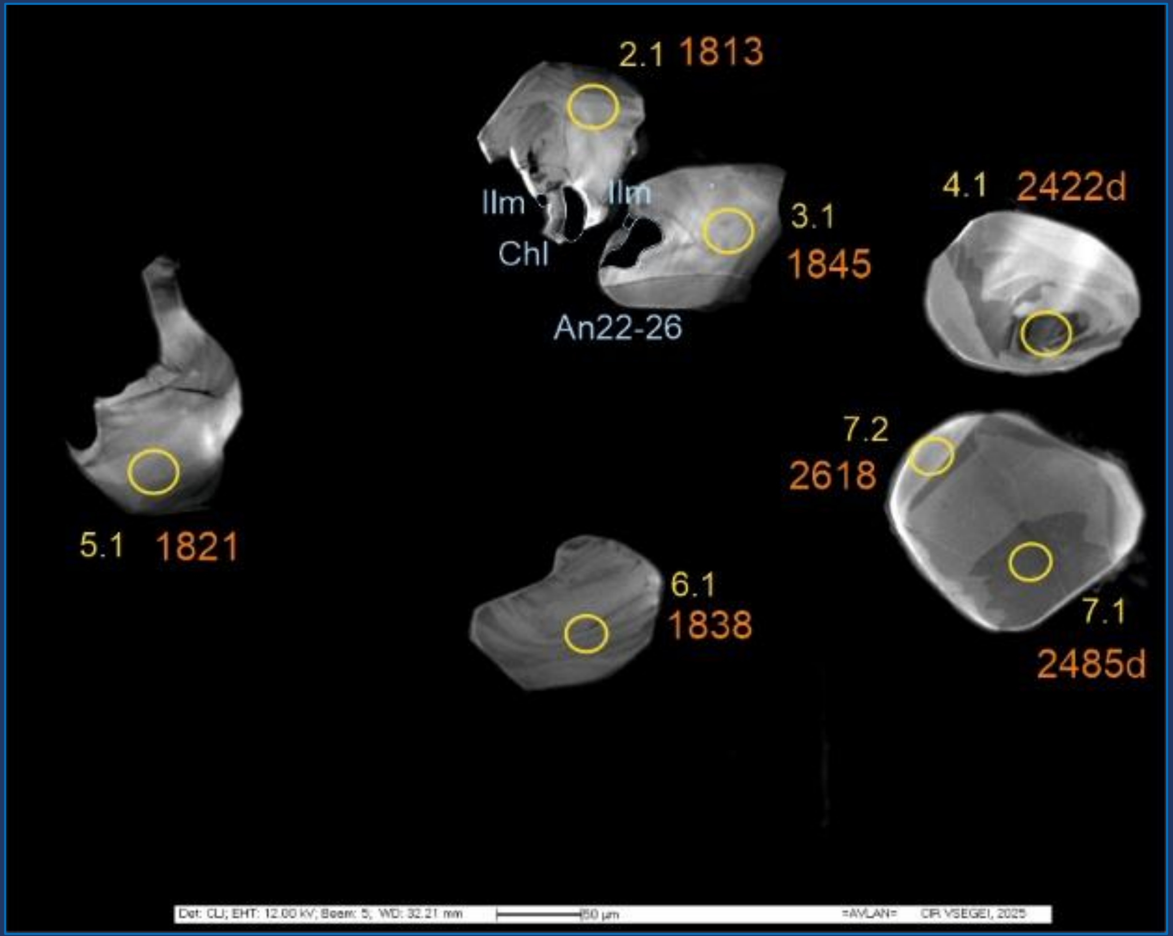
Koreshkova et al., 2024



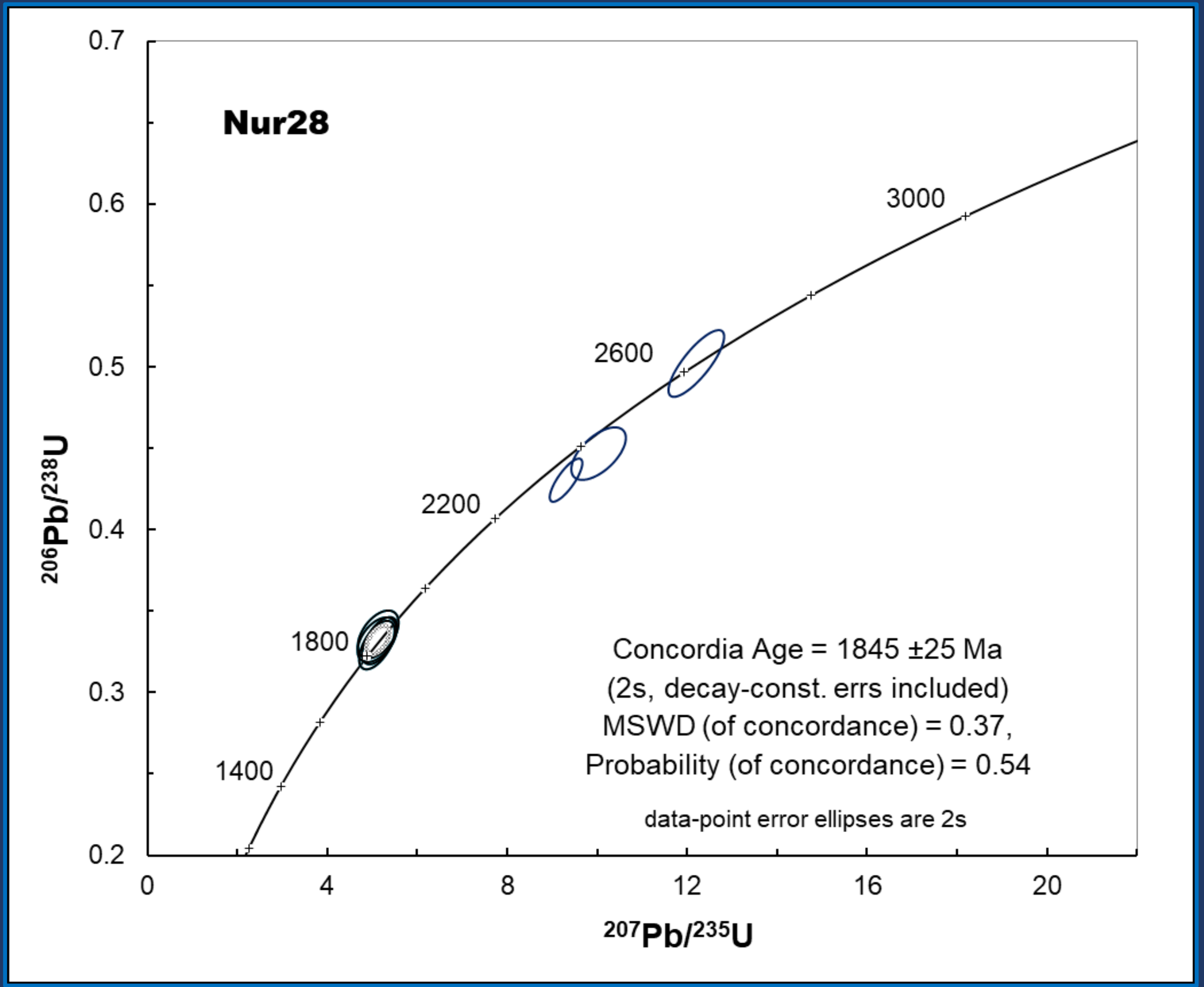
REE patterns of zircons from xenoliths from the Nurbinskaya diatreme

Dashed lines – calculated compositions of zircon in equilibrium with garnet

Crustal xenoliths from the Nakyn field: Mafic Grt-granulites



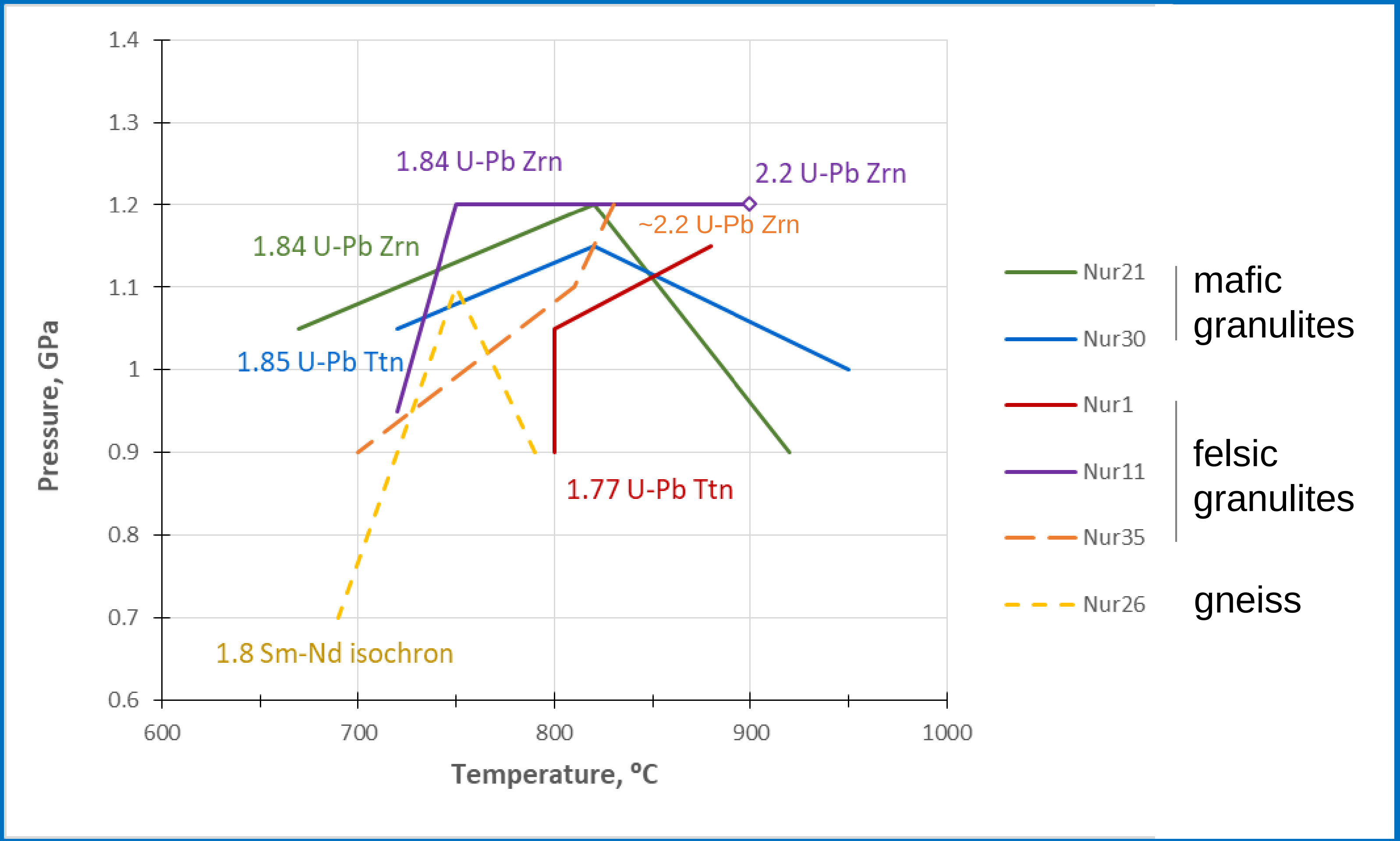
CL images of zircon from Grt-granulite Nur28 from the Nurbinskaya diatreme. Spot numbers and $^{207}Pb/^{206}Pb$ ages (Ma) are shown.



U-Pb Concordia diagram for zircon from Grt-granulite Nur28

Data-point uncertainty ellipses are 2σ. Decay constants uncertainties are included.

Crustal xenoliths from the Nakyn field: Mafic Grt-granulites



Mafic Grt-granulites, felsic Grt-granulite Nur1 and Crn-Ky-granofels have similar PT-paths

Felsic Grt-granulite Nur35 was probably exhumed by 1.88-1.84 Byr

Grt-gneiss spent a short time at lower crustal depth, which was not enough to produce an equilibrium association

conclusion

- the crust of the Anabar province was built tectonically; complexes with different thermal histories were stacked together in the Paleoproterozoic.
- The lower crust was significantly reworked during post-collisional thermal events (1.88-1.84 Ga); nevertheless, it preserved evidence of metamorphic events at 2.2-1.9 Byr, contemporaneous and preceding the amalgamation of the craton, as well as events at ~2.6 Byr.
- Archean high-grade metamorphic rocks were involved in building the lower crust of the central part of the Anabar province.

Thank you for your attention!