

New absolute paleointensity results from ~250 Ma Kuznetsk basalts.

Weak versus strong geomagnetic field at the P-T boundary.

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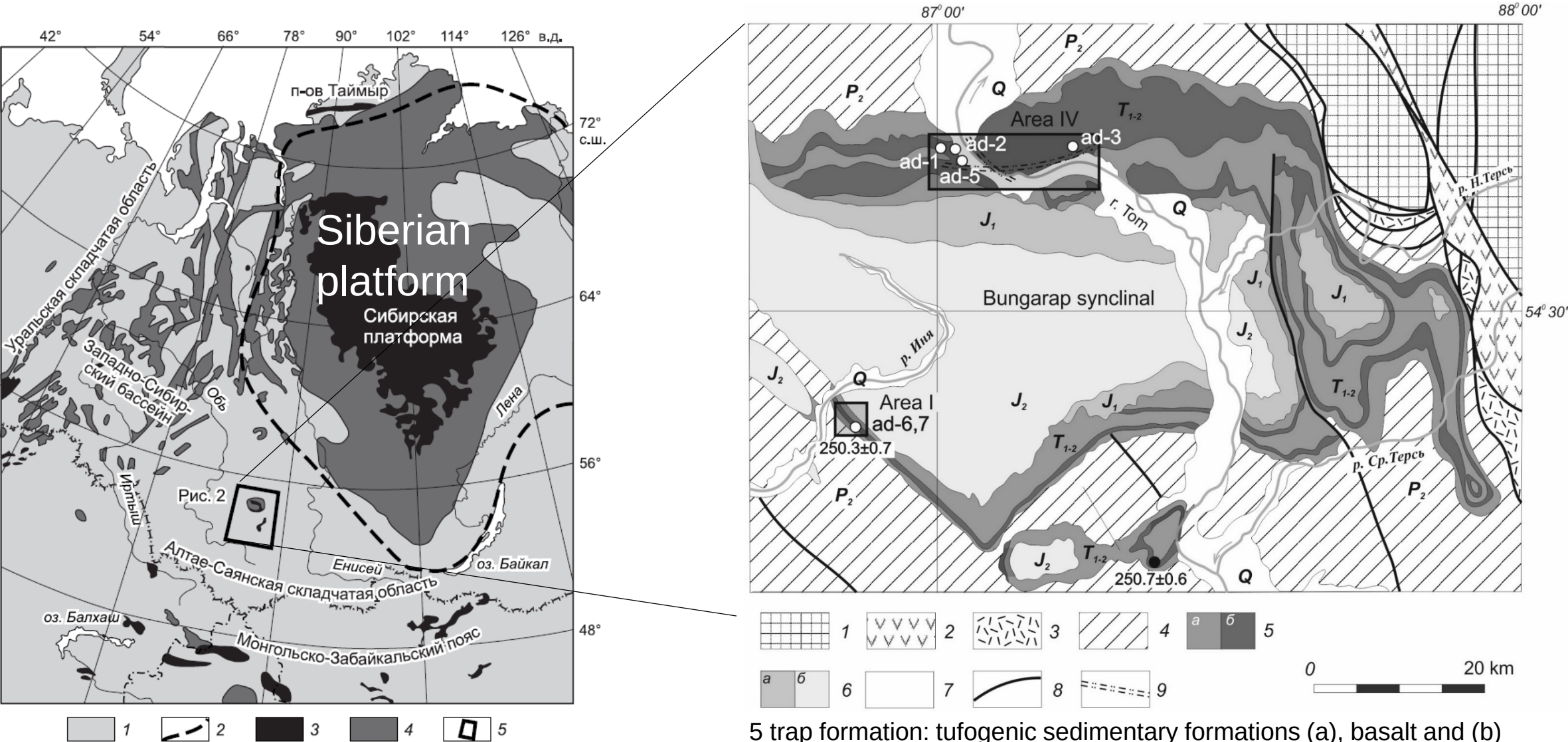
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Introduction

The paleointensity of the Siberian trap province (~250 Ma) were measured by a number of authors. Low values of the paleo-field obtained in the works [Solodovnikov, 1994; Hueneman et al., 2004; Shcherbakova et al., 2005, 2015] confirm the hypothesis Mesozoic Dipole Low. However, a high estimate of paleointensity for this particular period was also obtained [Blanco et al., 2012]. We hope to shed light on the current discussion about Siberian traps by studying their southwest part, namely the Kuznetsk basin.

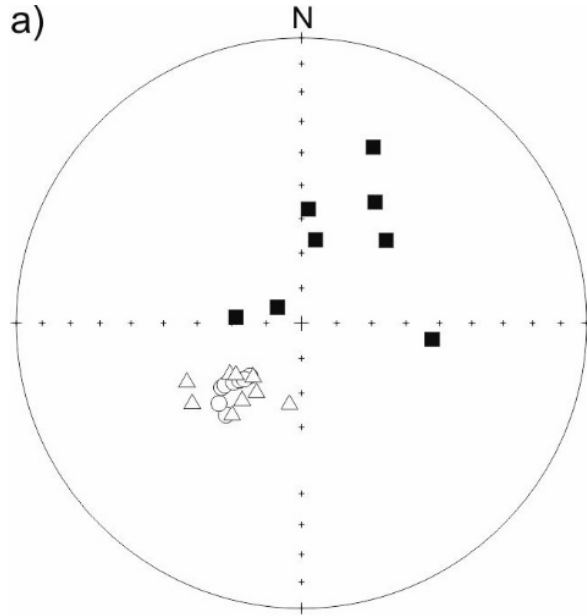
The paleodirections obtained for the Kuznetsk basin [Kazansky et al., 2005] are consistent with those of Siberia. In the continuation of this work, paleointensity studies were performed for samples of the same sites. According to the types of Arai-Nagata diagrams and magnetic properties, samples from areas IV and I were divided into **groups A and B**. Ar / Ar age dating [Reichow et al., 2009] is plotted on a map for two points of the region under study.



Basalts: 3 - surface, 4 - plutonic; Buslov et al., 2010

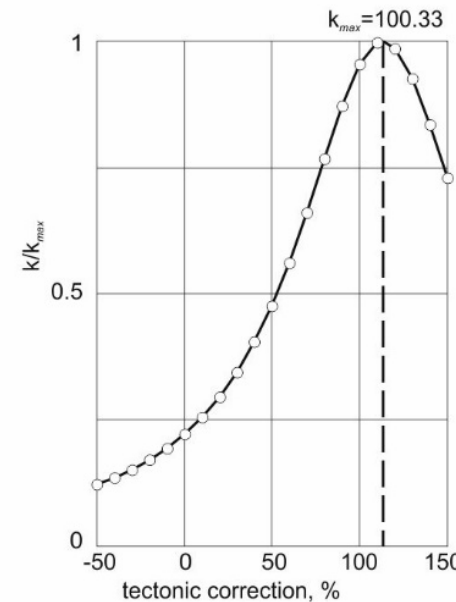
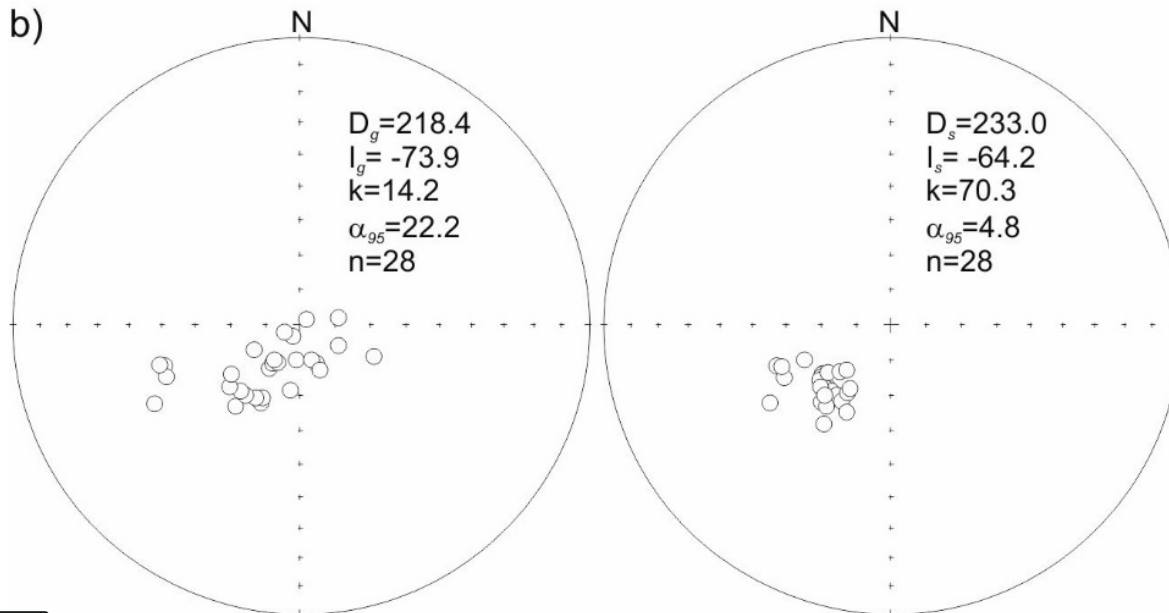
Kazansky et al., 2005

Tests of baked contact (a) and fold (b) are positive for the test object [Kazansky et al., 2005] .

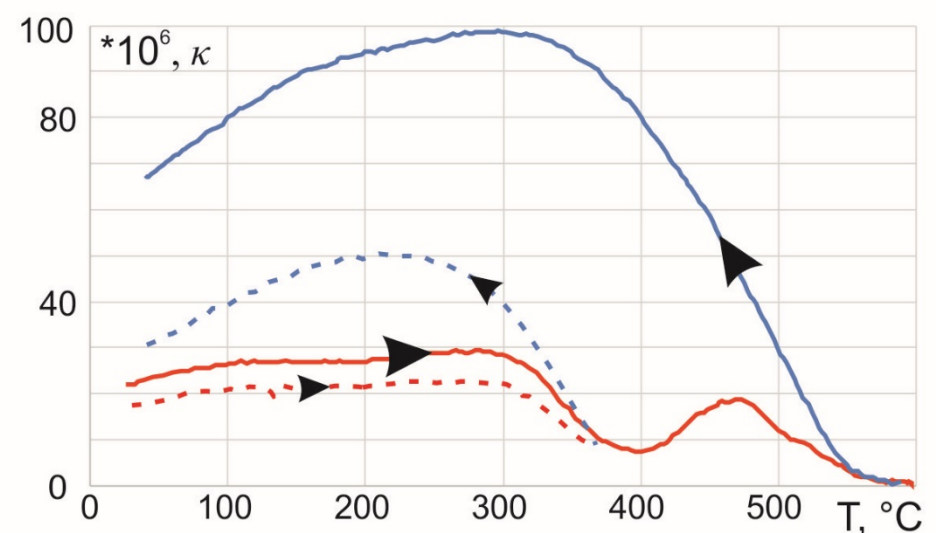
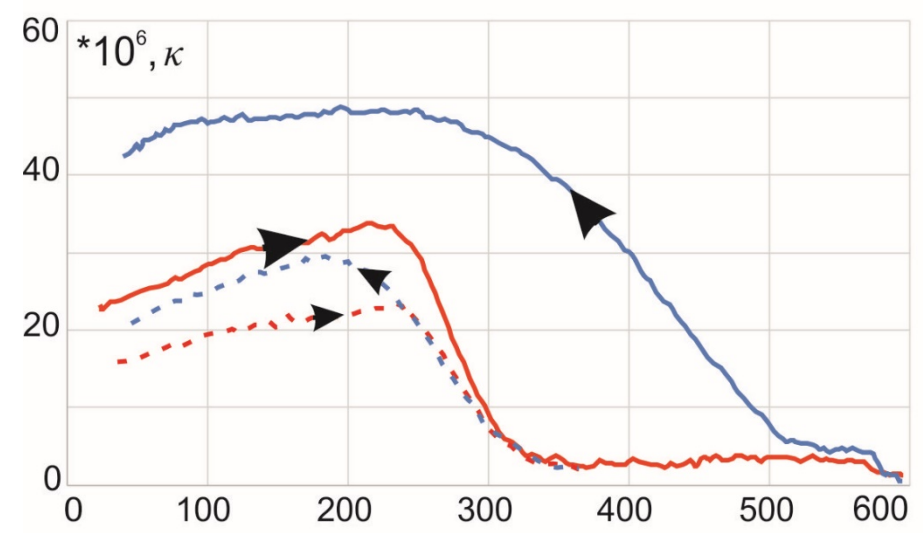
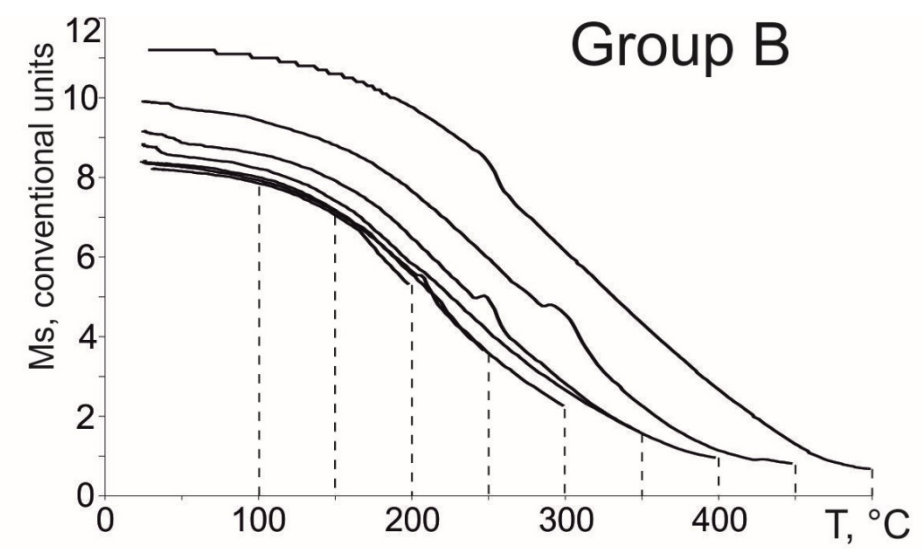
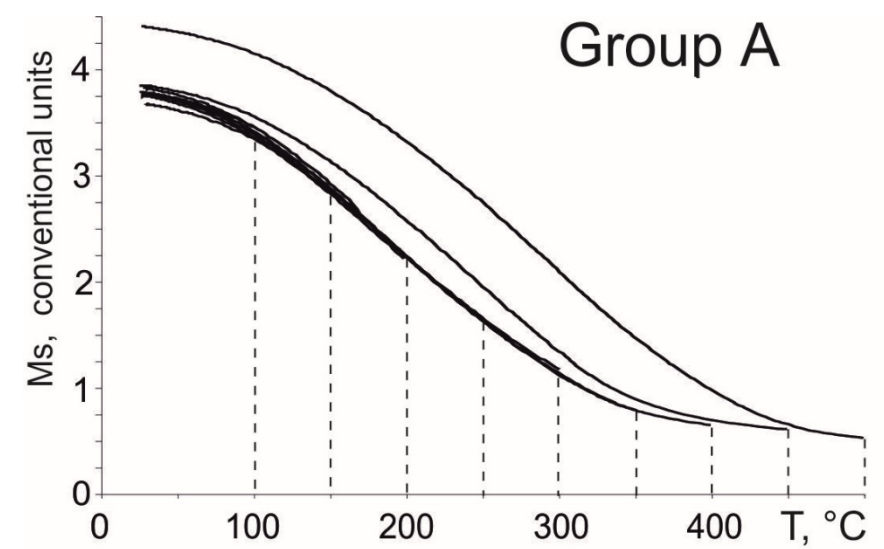


(a) The directions of the TRM of the sedimentary rocks in the baked zone (triangles) are not statistically different from the ChRM of basalts (circles), but it differs significantly from the direction of unbaked rocks (squares).

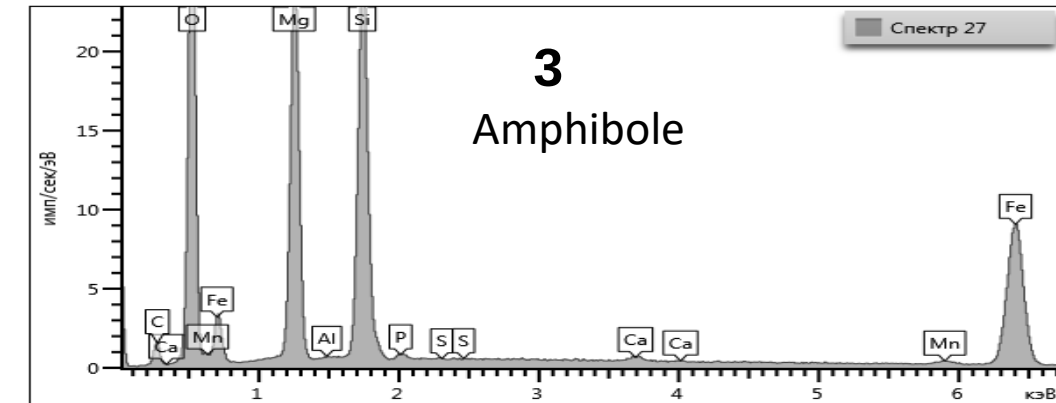
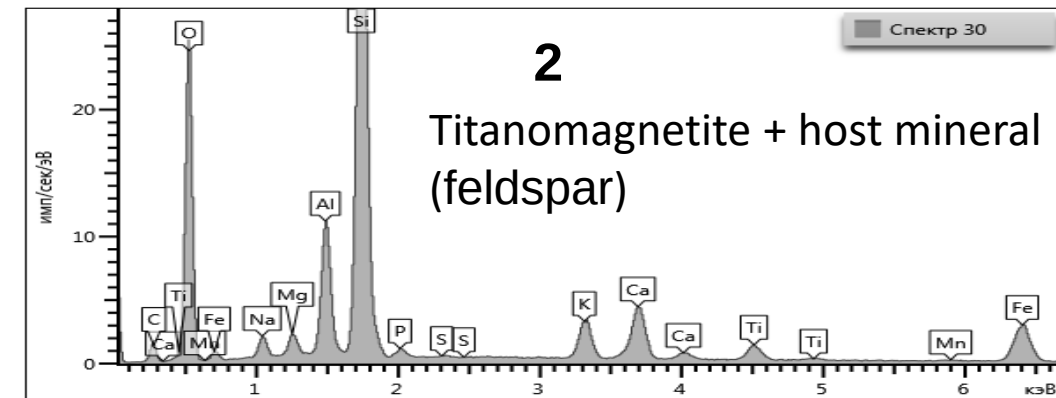
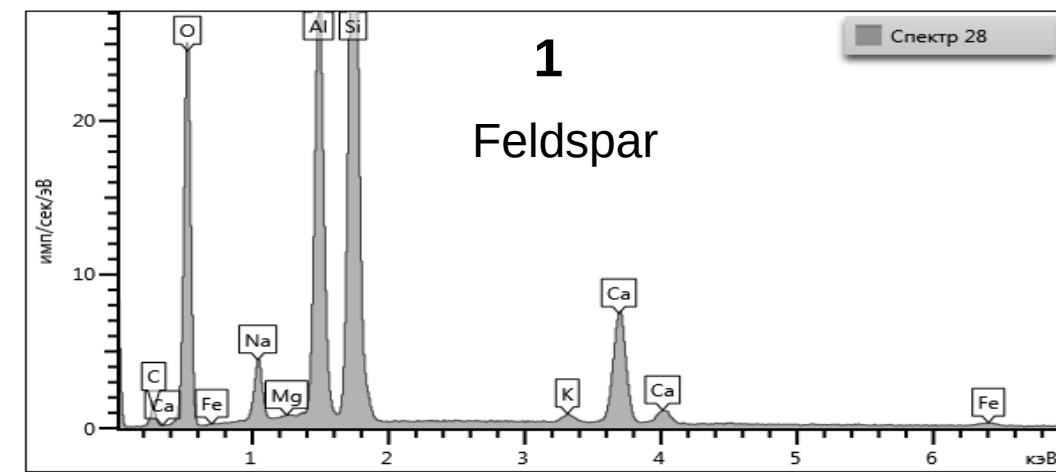
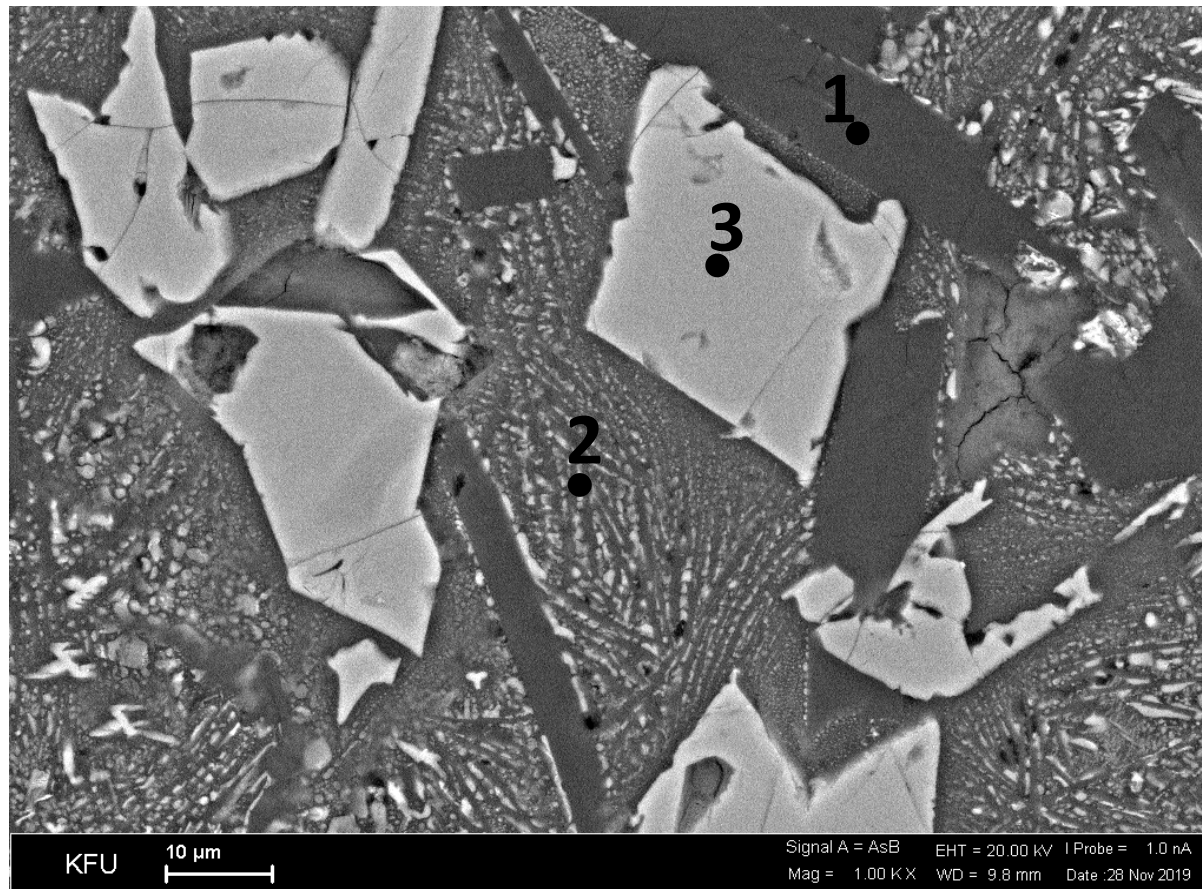
(b) The cumulative distribution of the middle directions of stable ChRM in the stratigraphic coordinate system (right stereogram) is significantly higher than in the geographical (left) one.



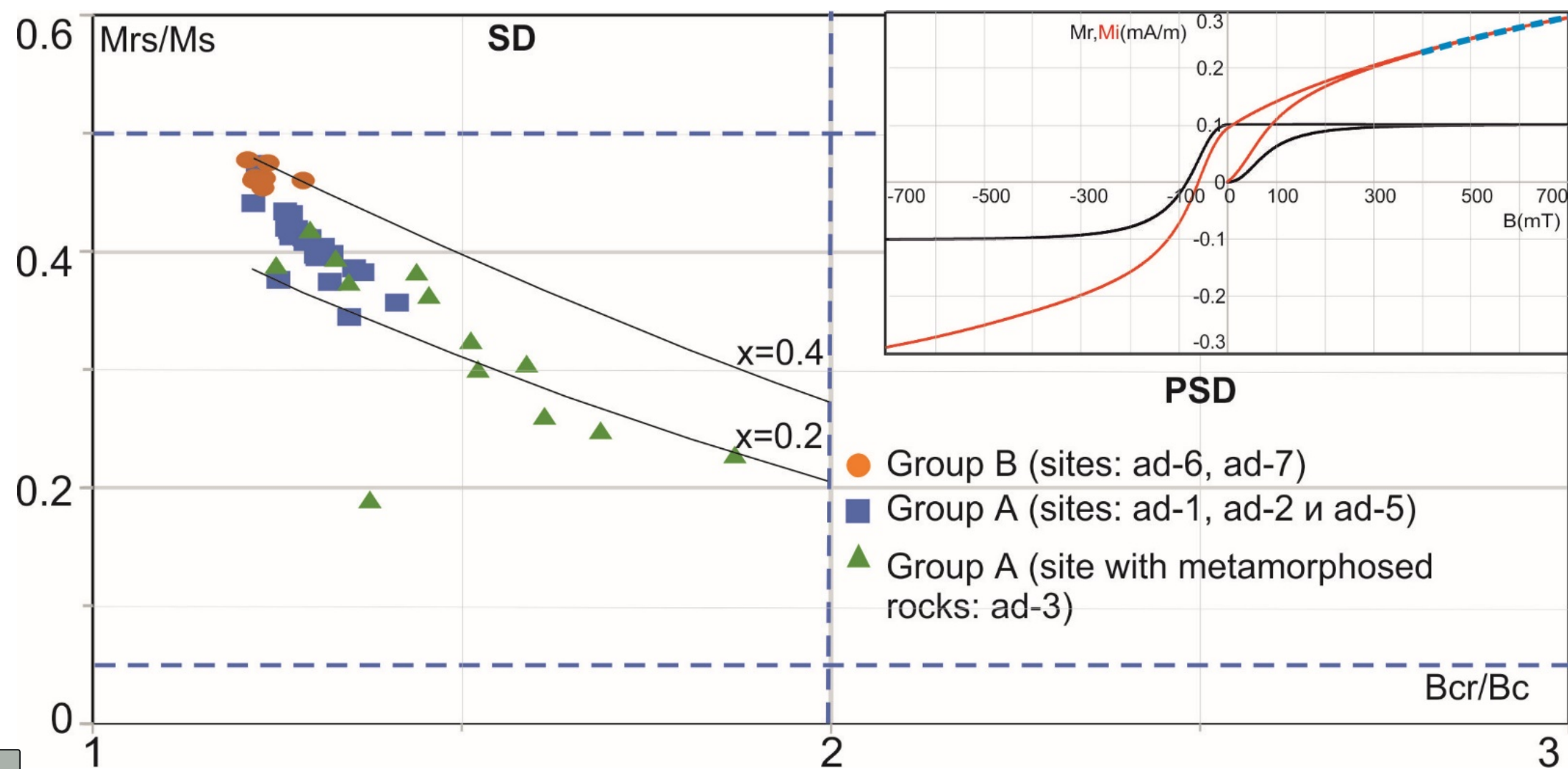
The main mineral carrier of the remanent magnetization is titanomagnetite with Curie temperatures of ≈ 300 and 360 °C for most samples of the **groups A and B**. The **group B** is also characterized by the presence of a peak in the temperature range $450\text{--}500$ °C, which, as we assume, corresponds to a magnetic mineral formation during experiments. The changes visible on the saturation magnetization graphs occur when temperatures of 450 and 400 °C are reached for **groups A and B**



Micrographs taken with SEM (Interdisciplinary Center for Analytical Microscopy of Kazan Federal University) show fine grains of titanomagnetite $\sim 1\ \mu\text{m}$ in size (point 2). Due to the fact that the minimum size of the region on which the elemental composition is revealed is larger than the grain size of titanomagnetite, the spectrum contains chemical elements characteristic of the host mineral - feldspar. Because of this, the real content of titanium is difficult to determine.

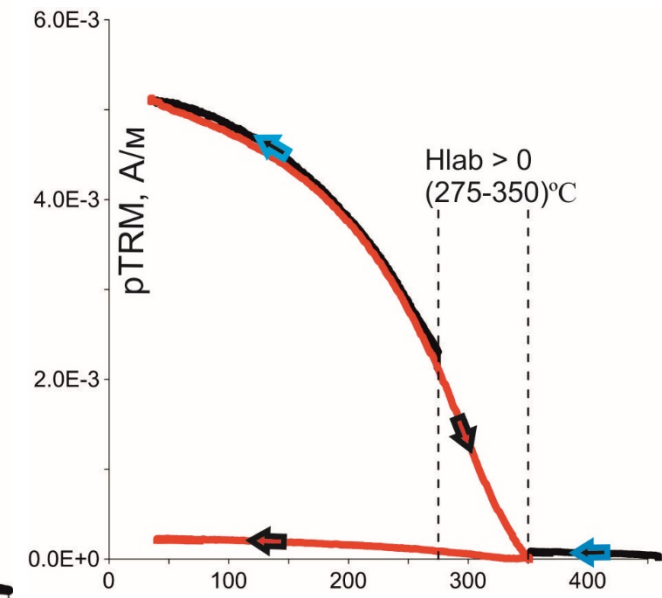
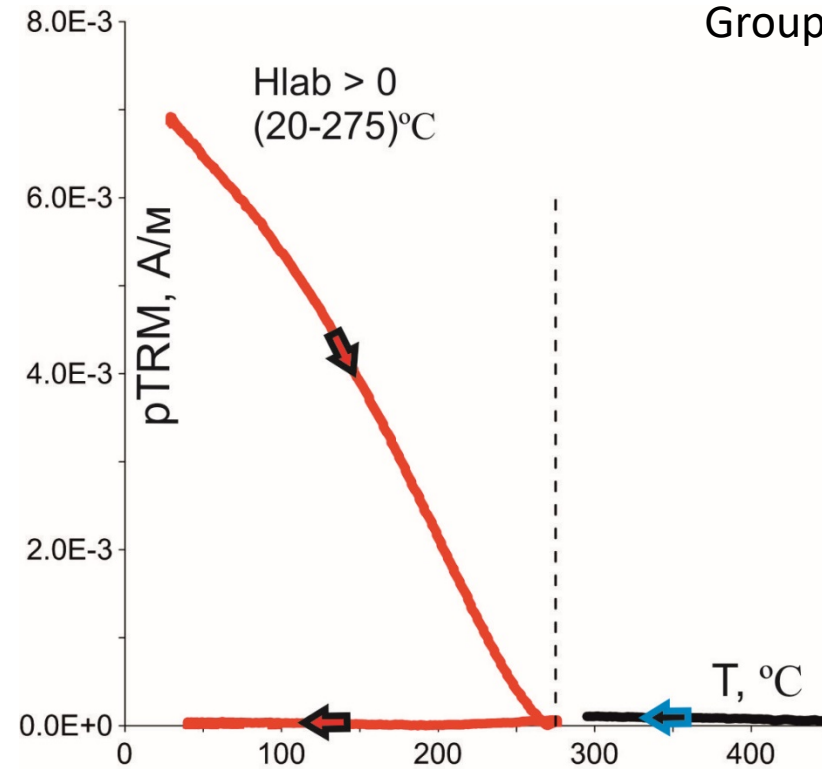
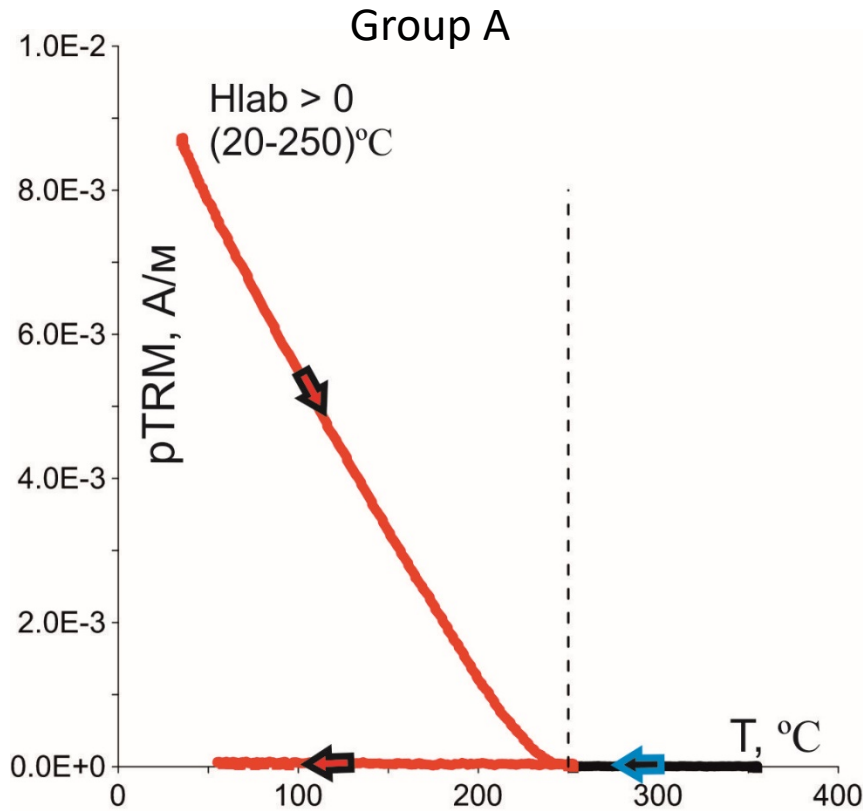


Measurements of hysteresis loop parameters of the studied samples fell in the region between the SD and PSD and almost all lie between the $\text{Fe}_{3-x}\text{Ti}_x\text{O}_4$ titanomagnetite curves obtained by [Day et al., 1977]. The parameters M_s and B_s were determined after approximation in the range of 400-700 mT of the induction loop according to the equation $M_i = aB - b/B + c$, where aB is the paramagnetic component, b / B is introduced because the loop did not reach saturation, c is M_s .



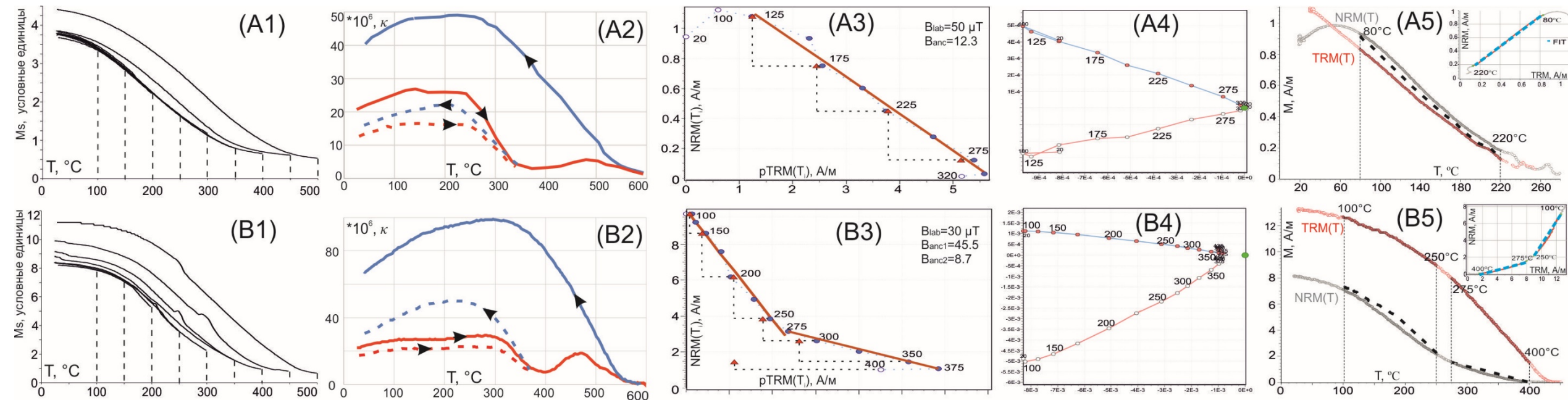
The presence of tails of partial thermoremanent magnetizations (pTRMs) was verified as follows. In a fully demagnetized sample, pTRM was created in the temperature range (T_1 , T_2). Then, after cooling to room temperature, the sample was again heated to temperature T_2 and again cooled to room temperature. In the event of a loss in the manner of more than 95% of the induced pTRM, the law of independence is confirmed.

In our case, for the samples of both groups of the pTRM, the one created in the interval (20-250 °C) and (20-275 °C) is completely lost after repeated heating to temperatures of 250, 275 °C. For group B, the pTRM in the interval (275-350 °C) although has a remainder "tail" but it is less than 5% of the full pTRM, that confirm law of independence.



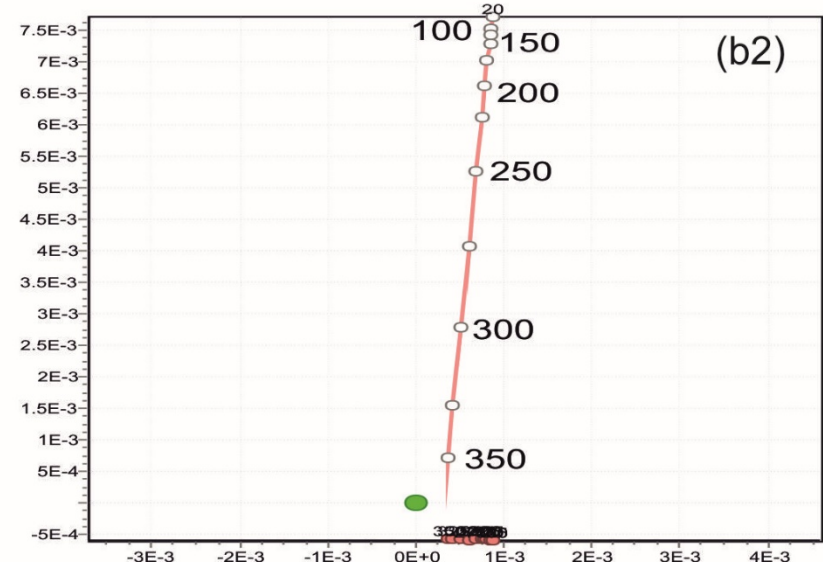
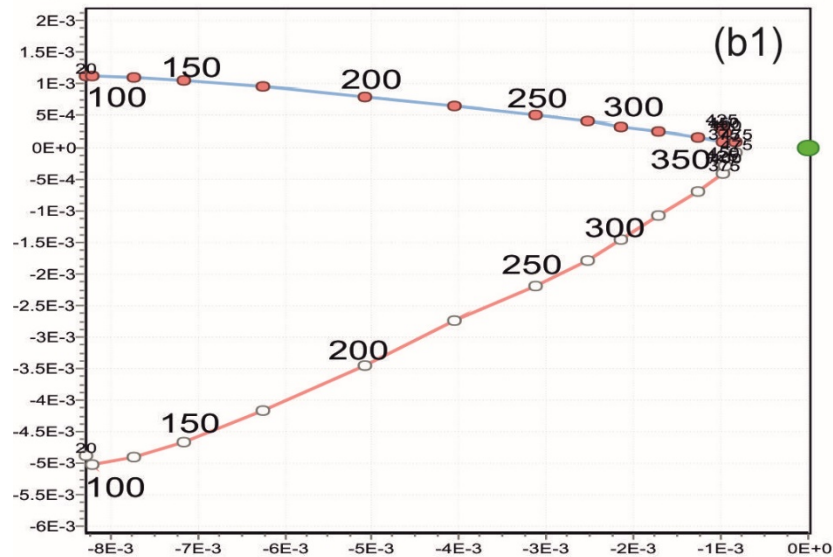
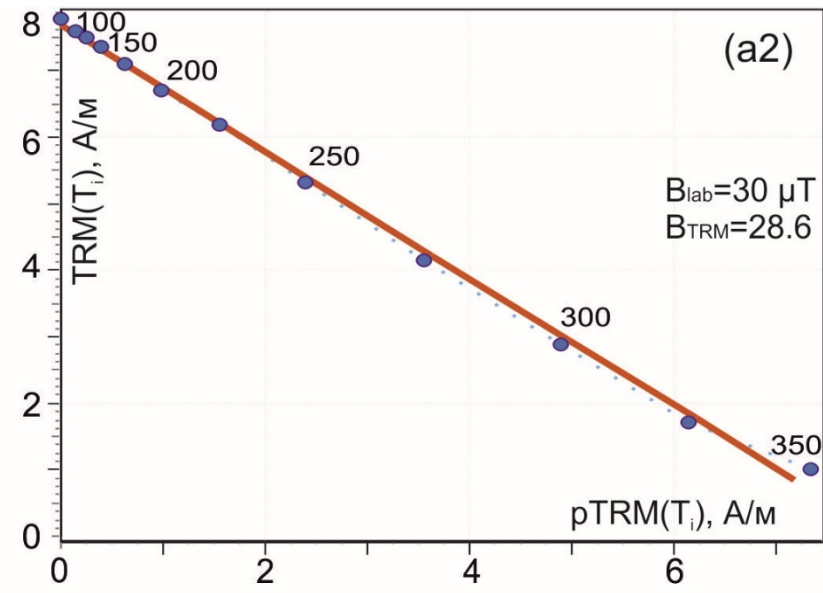
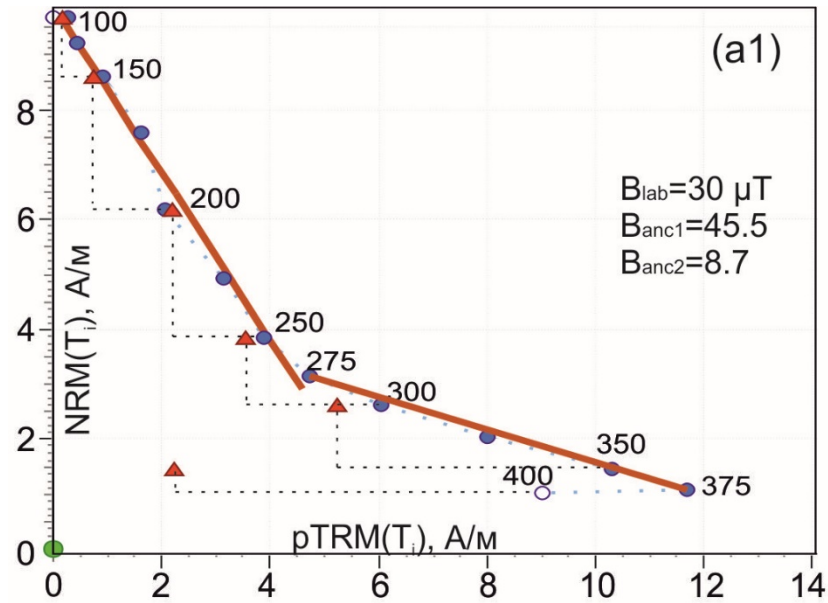
For **group A**, the typical Arai-Nagata diagram (A3) has a straight section in the range of 125-300 °C until the complete demagnetization. The determined B_{anc} for AD-49 sample is 12.3 μT with a reliability factor $q = 13.8$.

For most samples of **group B**, the Arai-Nagata diagrams have a bend, but the direction in the Zijderveld diagram remains the same (B4). The B_{anc} for AD-69 sample determined by the low-temperature interval is 45.5 μT , the factor $q = 11.8$, and by the high-temperature interval, 8.7 μT , with a factor $q = 8.1$. It should be noted that the pTRM checks are poorly matched for the high temperature interval, which is a sign of changes in the sample.

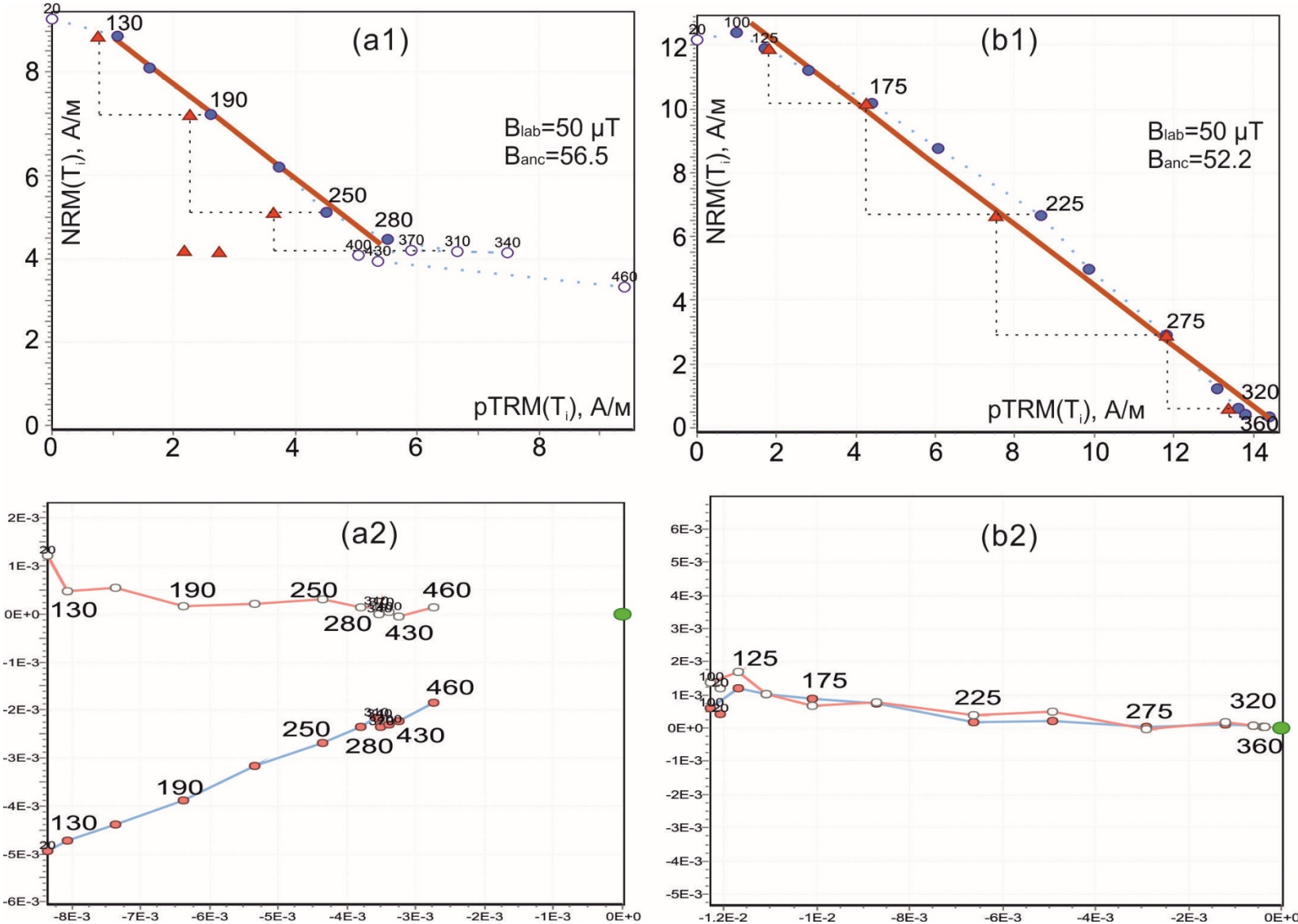


Typical graphs for **groups A and B**: (1) magnetization saturation M_s , (2) magnetic susceptibility versus temperature $k(t)$, (3) diagrams Arai-Nagata, and (4) Zijderveld, (5) thermomagnetic curves - Wilson's method.

After carrying out the Thellier-Coe experiment on a sample AD-69 of **group B** to temperatures of 400 °C (a1, b1), TRM was created on it with a field $B = 30 \mu\text{T}$. Modeling of the Thellier experiment showed the absence of a bend in the Arai-Nagata diagram (a2) and a fairly good determination of the field of $28.6 \mu\text{T}$.



The experiment was also carried out using the SQUID Magnetometer 2G Enterprises and the Thermal demagnetizer MMTDSC. Part of the experiment on AD-69 sample up to temperatures of 280 °C is no different from the same using an ORION vibromagnetometer. However, the high-temperature interval goes to the “shelf”. The acquisition of pTRM is accompanied by the absence of NRM loss to temperatures of 400 °C. We suggest that during the experiment mineralogical changes occur when temperatures above 300 °C are reached.



In group B, there are also Arai-Nagata diagrams with a rectilinear portion up to complete demagnetization, which show a high H_{anc}. Sample AD-79 (b1) B_{anc} = 52.2 μT, factor q = 24.3

Currently, additional studies are being conducted for **group B**. However, there is reason to believe that the paleo-intensity selected in the low-temperature interval (100-275) is determined correctly.

Site	Paleodirections					Paleointensity					× 10 ²² Am ² VDM (mean for site)		
	Nd	Dec°	Inc°	k	α95°	N/n	Banc μT	Banc St.err. μT	Banc St.err. %	Banc St.dev. μT	VDM	VDM St.err	VDM St.dev
Group A													
ad-1	13	212.7	-67	354.5	2.2	11/12	13.7	0.81	5.9	2.7	2.2	0.13	0.43
ad-2	7	213.2	-68.4	620.9	2.4	8/8	11.4	0.39	3.4	1.1	1.85	0.06	0.18
ad-3	11	248	-63.5	173.4	3.6	6/12	12.8	4.1	32.1	10.1	1.81	0.58	1.43
ad-5	12	233.5	-65.3	163	3.4	12/15	12.2	0.7	6.1	2.6	1.89	0.12	0.4
Group B													
ad-6	14	225.5	-64.2	360.7	2.1	13/13	42.2	1.7	4.1	6.2	6.72	0.28	0.99
ad-7	10	227.7	-70.4	379.1	2.5	10/10	44.8	2.0	4.4	6.3	7.13	0.32	1

Conclusions:

- According to the petromagnetic properties and diagrams of Arai-Nagata, the samples are divided into two **groups A** (sites 1,2,3,5) and **B** (6,7).
- The main magnetic mineral is titanomagnetite with fine grains of the order of $1 \sim \mu\text{m}$ with a Curie temperature of about 300 and 360 °C for samples of **groups A and B**.
- For samples of **group A**, changes are not characteristic up to the complete demagnetization of NRM. Arai-Nagata diagrams are straight. The average paleointensity calculated for this group is $12.6 \pm 0.7 \mu\text{T}$, and the VDM is $2.04 \pm 0.11 \times 10^{22} \text{Am}^2$.
- The Arai-Nagata diagrams of most samples of **group B** have a bend when the temperature reaches about 300 °C, but the direction in the Zijderveld diagram does not change. We assume that when this temperature is reached, chemical transformations begin to occur inside the samples, which violates the conditions of the Thellier-Coe experiment. The paleointensity determined from the low-temperature region is $43.3 \pm 1.3 \mu\text{T}$, the VDM is $6.92 \pm 0.21 \times 10^{22} \text{Am}^2$.
- In **group B**, in addition to the Arai-Nagata diagrams with bend, which make up the majority, there are also cases with a straight line until complete demagnetization at temperatures of 360 °C or more, in which Banc has similar values with calculated over the low temperature range.
- For samples of **group B**, additional studies are being conducted that will allow more reliable conclusions.

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Thank you for attention!