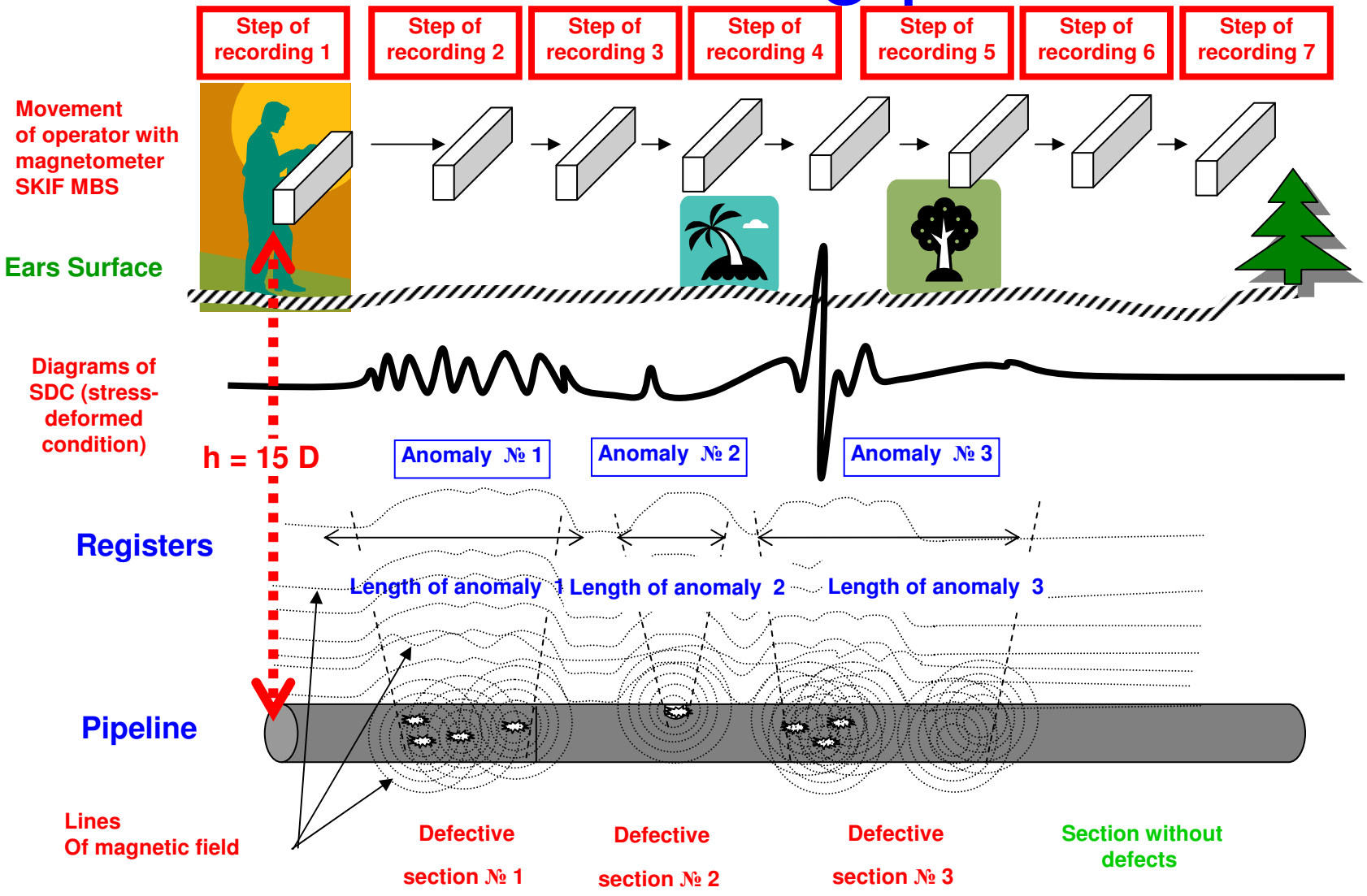
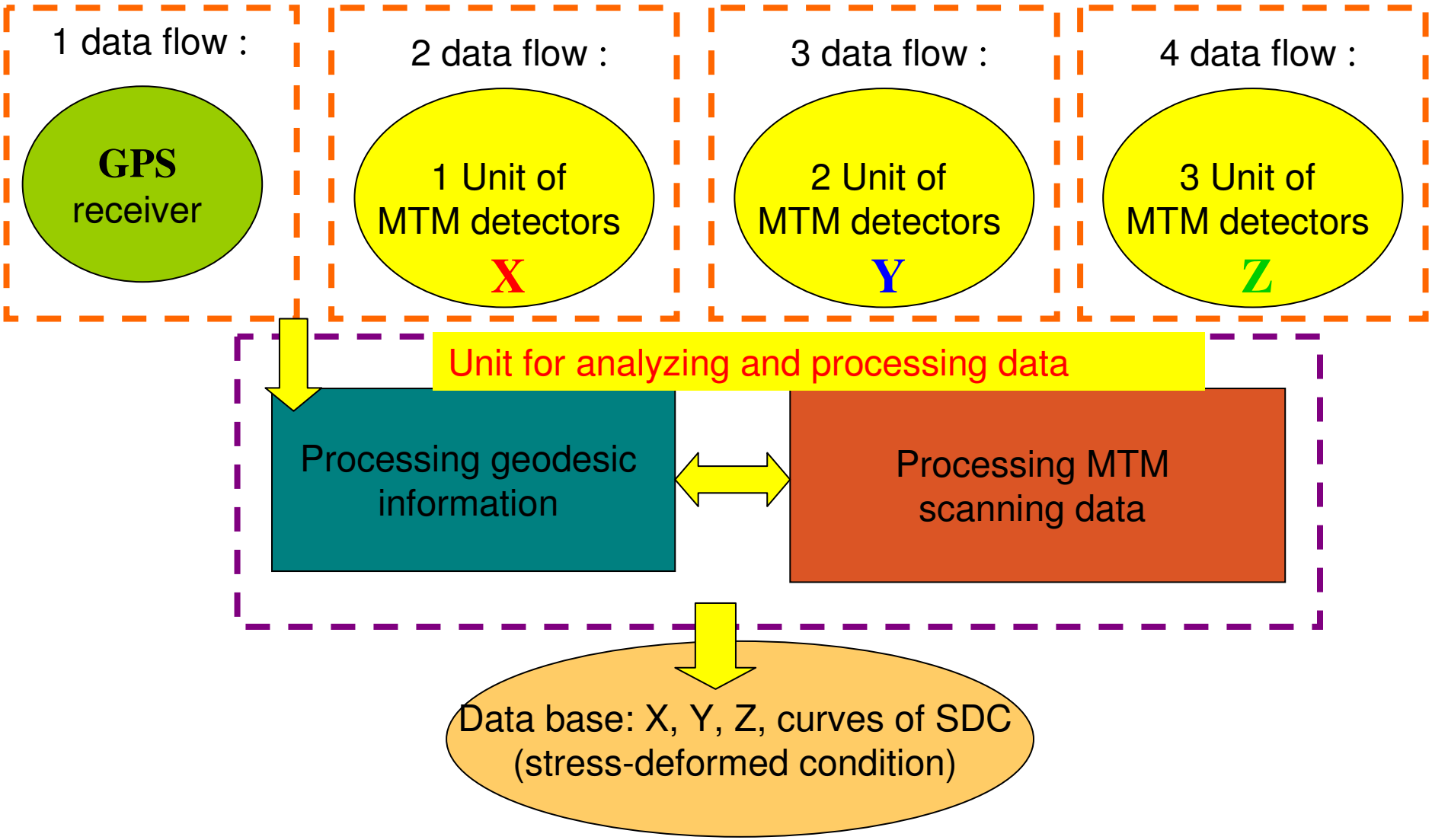
OOO R&D CENTRE “TRANSKOR-K”, RUSSIA

Magnetic Tomography method for inspecting pipelines (MTM)

MTM scanning process



Scheme of complex processing MTM data of underground (sub-water) object

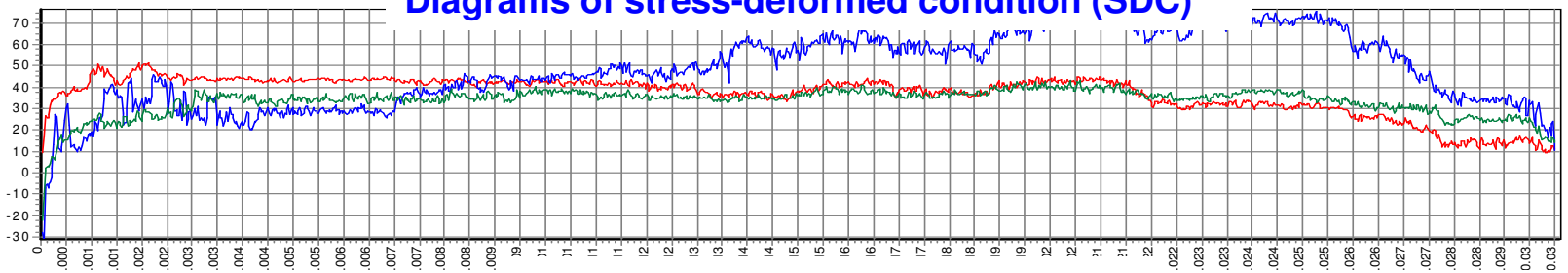


SDC diagrams

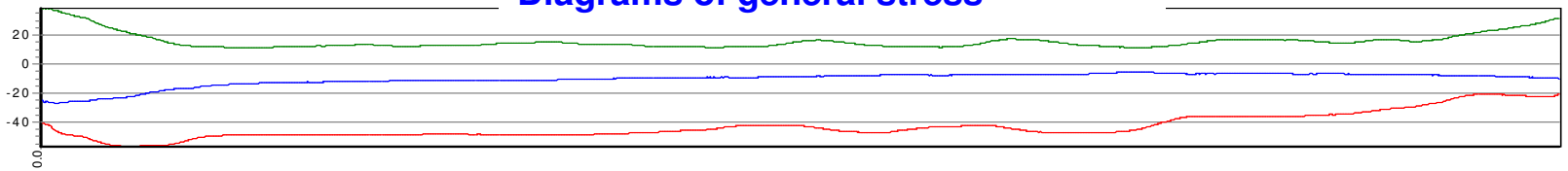
05.04.2006

Object name, direction of inspection – according a product flow

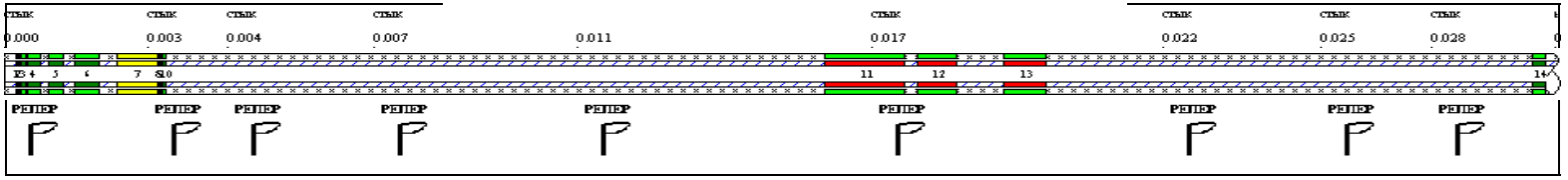
Diagrams of stress-deformed condition (SDC)



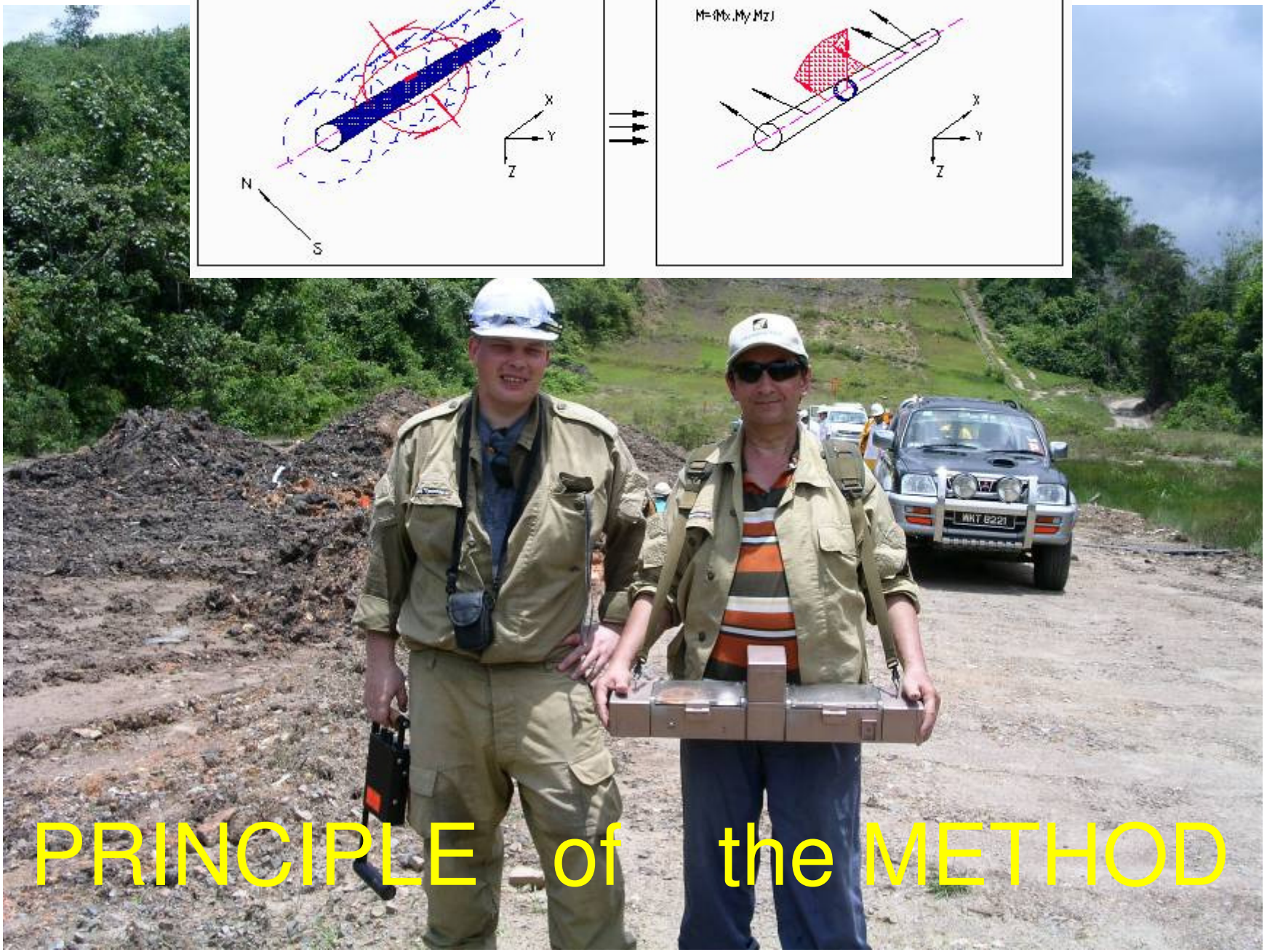
Diagrams of general stress



Pipeline situation scheme



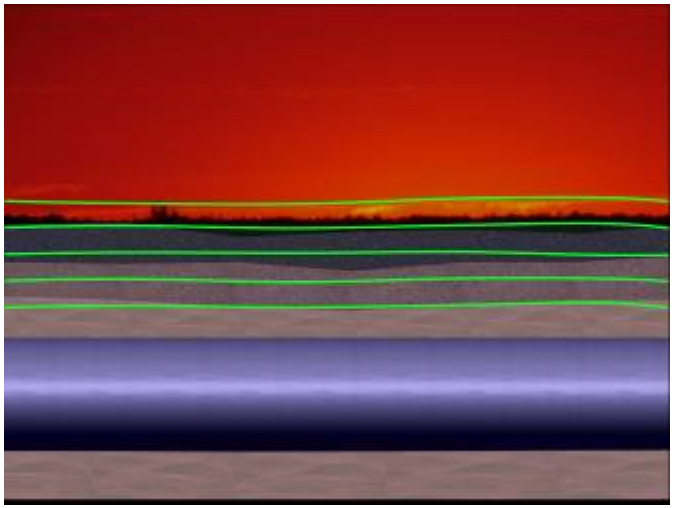
MTM data field registration



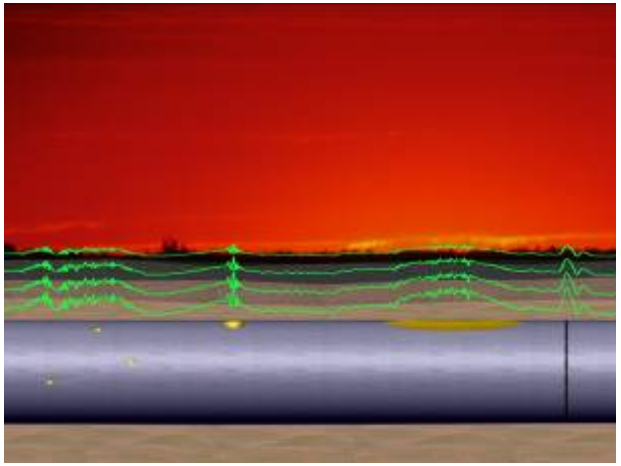
PRINCIPLE of the METHOD

Non-destructive testing works (NDT) in a pit

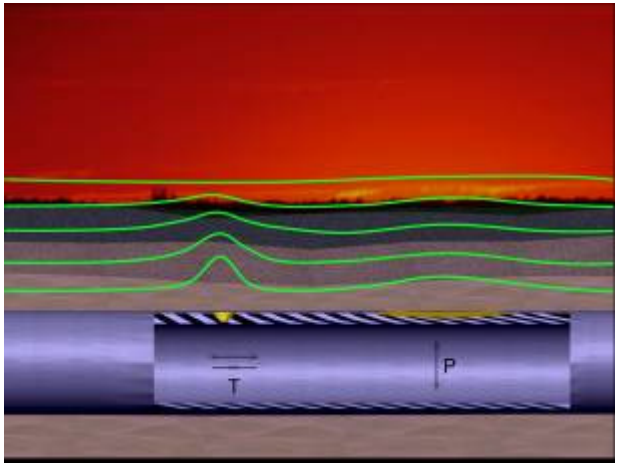
MTM data office processing



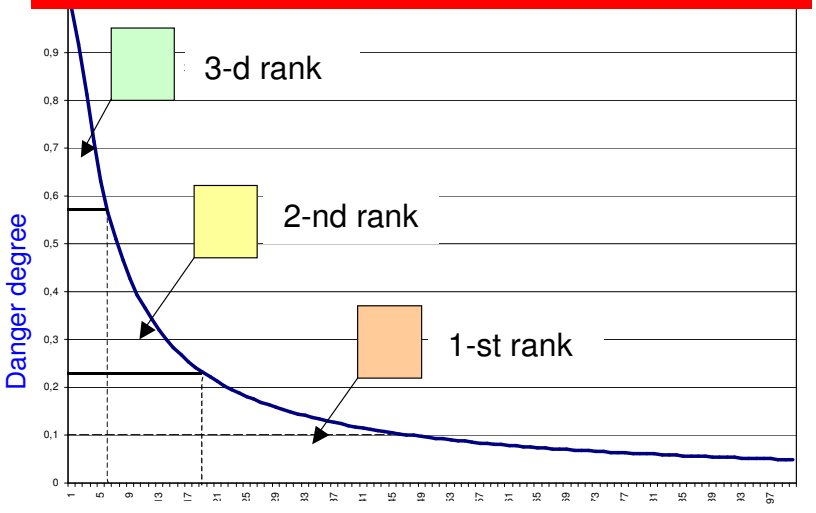
Section without SDC (stress-deformed condition) anomalies



Sections with anomalies



Diagrams of distribution of anomaly danger degree/ safe operating pressure



Ranks of anomalies danger

3	2	1

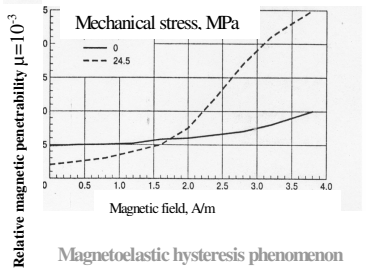
CATEGORY OF METAL CONDITION

Good	Admissible	Inadmissible

RECOMMENDATION ON ENHANCING RELIABILITY

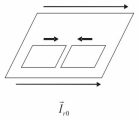
Monitoring without repair	Scheduled repair	First priority repair

Physical grounds of the method enabling the development of the magnetic tomography method



Magnetoelastic hysteresis phenomenon

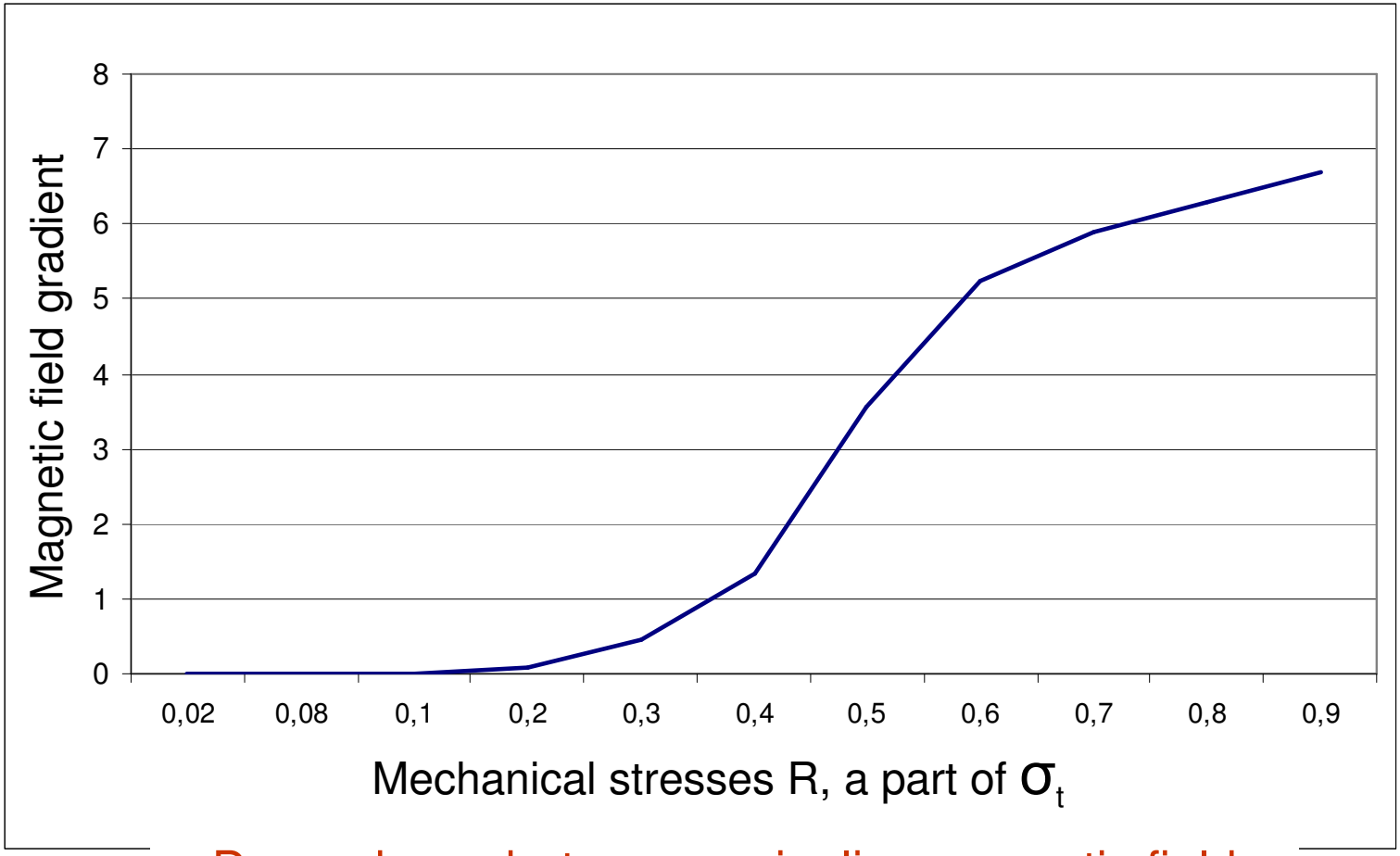
$$\Delta = \frac{\delta I_{r\sigma}}{\Delta\sigma} = \frac{k\lambda_{100}(1-N_2)I_{r\sigma}}{\frac{1}{8}\mu_0 N_1^2 I_s^2}$$



$$\frac{1}{2}(1+\nu)k\lambda_{100}\Delta\sigma = \frac{1}{2}(1+\nu)\left(\frac{1}{2}\mu_0 N_1 I_s \Delta I^+ + \mu_0 H_1 \Delta I^+ - \mu_0 H_\beta \Delta I^+\right)$$
$$\frac{1}{2}(1-\nu)k\lambda_{100}\Delta\sigma = \frac{1}{2}(1-\nu)\left(\frac{1}{2}\mu_0 N_1 I_s \Delta I^- + \mu_0 H_1 \Delta I^- + \mu_0 H_\beta \Delta I^-\right)$$

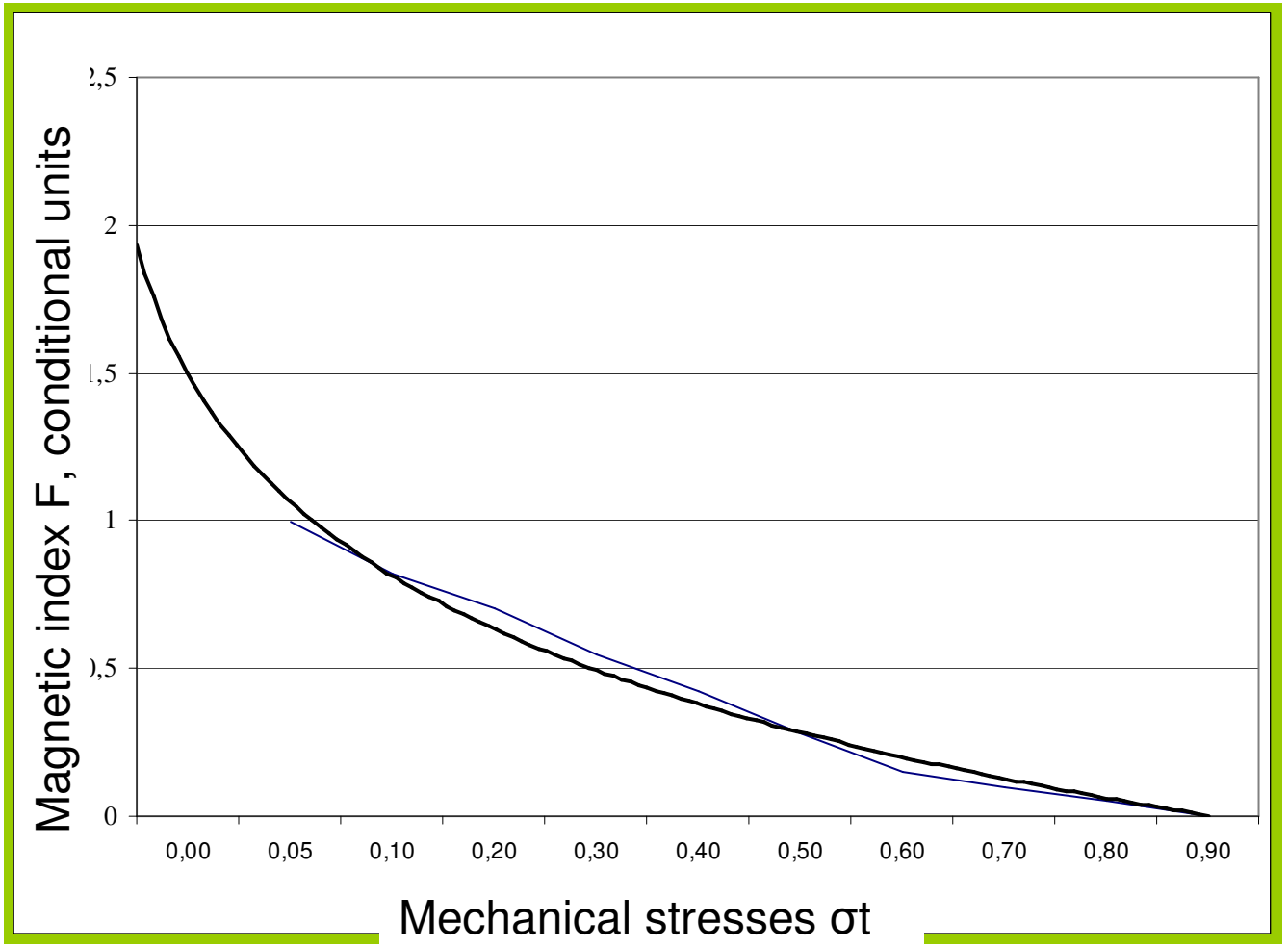
- $\frac{1}{2}(1+\nu)$ и $\frac{1}{2}(1-\nu)$ – Part of volume with magnetization oriented lengthwise vector I_{r0} and towards it, correspondingly;
- $\nu = \frac{I_{r\sigma}}{I_s}$ – Residual magnetization of magnet in adjusted condition, that is, after multi-repeated imposition of stress;
- I_s – Magnetization of saturation;
- $k\lambda_{100}\Delta\sigma$ – Change of magnetoelastic energy when stress is imposed tension σ;
- λ_{100} – Constant of magnetostriction;
- k – c Average angular coefficient;
- $\mu_0 N_1 I_s \Delta I^+$ - Change of domains magnetostatic energy;
- $\mu_0 = 4\pi 10^{-7}$ H/m
- N_1 – Demagnetizing index of inclusions (various types of defects of structure);
- $\Delta I^+, \Delta I^-$ - Complete piezomagnetic change of magnetization in the first and second volumes, correspondingly;
- $\mu_0 H_k \Delta I$ – Energy of interaction of magnitization with field, essential for interdomain boundaries to get over potential barriers, H_k – average critical field;
- $\mu_0 H_\beta \Delta I$ – Is developed owing to detention of domains at energy barriers (defects of array) and also owing to additional magnetization of matrix by inclusions having value of residual magnetization higher than matrix's.

Calculation of serviceability parameters



Dependence between a pipeline magnetic field density and mechanical stresses

$$F = -0{,}6245 \ln(\sigma) + 1{,}5$$



Dependence between complex magnetic index F and mechanical stresses in a pipeline

Magnetic field density in H or Ам$^{-1}$	10^{-9}
Range of an object wall thickness	Starting with 2.8 mm
Limits regarding pipelines diameters D	56 ≤ D ≥ 1420 mm и >
Rate of MTM-inspection	2-5 m/s
Maximum pressure	Not limited
Minimum pressure for gas pipelines	0,02 MPa
Minimum radius of turning (bend)	Not limited
Internal minimum diameter	Not limited
Dimensions	200×200×750 mm
Weight of the tool	4,7 kg
Length of an inspected section, minimum	40 m
Volume of registration along lengthways an object	100 %
Admissible deviation from the axis of an underground object	Not more than 3 D
Admissible distance between the magnetometer and a pipeline (deviation from axis, depth of bedding)	20 D
Step of scanning (registration and data recording by detectors), maximum	0,25 m
Error in determining longitudinal coordinate of anomaly	± 1,5 m
Error in determining angular coordinate of anomaly	20^{o}

MTM Report

Register of revealed MTM anomalies

Coordinates of anomaly, m

Type of fixation

GPS-coordinates: latitude, longitude

№ anomaly

Metal condition: good (3); admissible (2); inadmissible (1)

Integral index F, conditional units

Angular coordinate of anomaly, hour

Beginning, end , Length of anomaly

Distance from the preceding fixation (-) to the next fixation (+)

Prognosis of anomaly type

Safe operating pressure, MPa, Tsaf

Free accident operation term, years, at Tsaf

Rank of anomaly

№		
1)	1	НЕДОПУСТИМОЕ
	2	ДОПУСТИМОЕ
	3	ХОРОШЕЕ
2)	Дефекты* и ** идентифицируются как дефекты типа "ТЯЖЕ коррозии	
3)	Потери металла	
	Трещиноподобные дефекты	
	Изменение геометрии	
	Нарушение сплошности	
	Дефекты сварных соединений	
	Аномалии НДС	

Notes:

Recommendation on enhancing reliability of a pipeline section

Section for the first priority repair (1)

Section for the scheduled repair (2)

Section without repair - monitoring (3)

Types of anomalies:

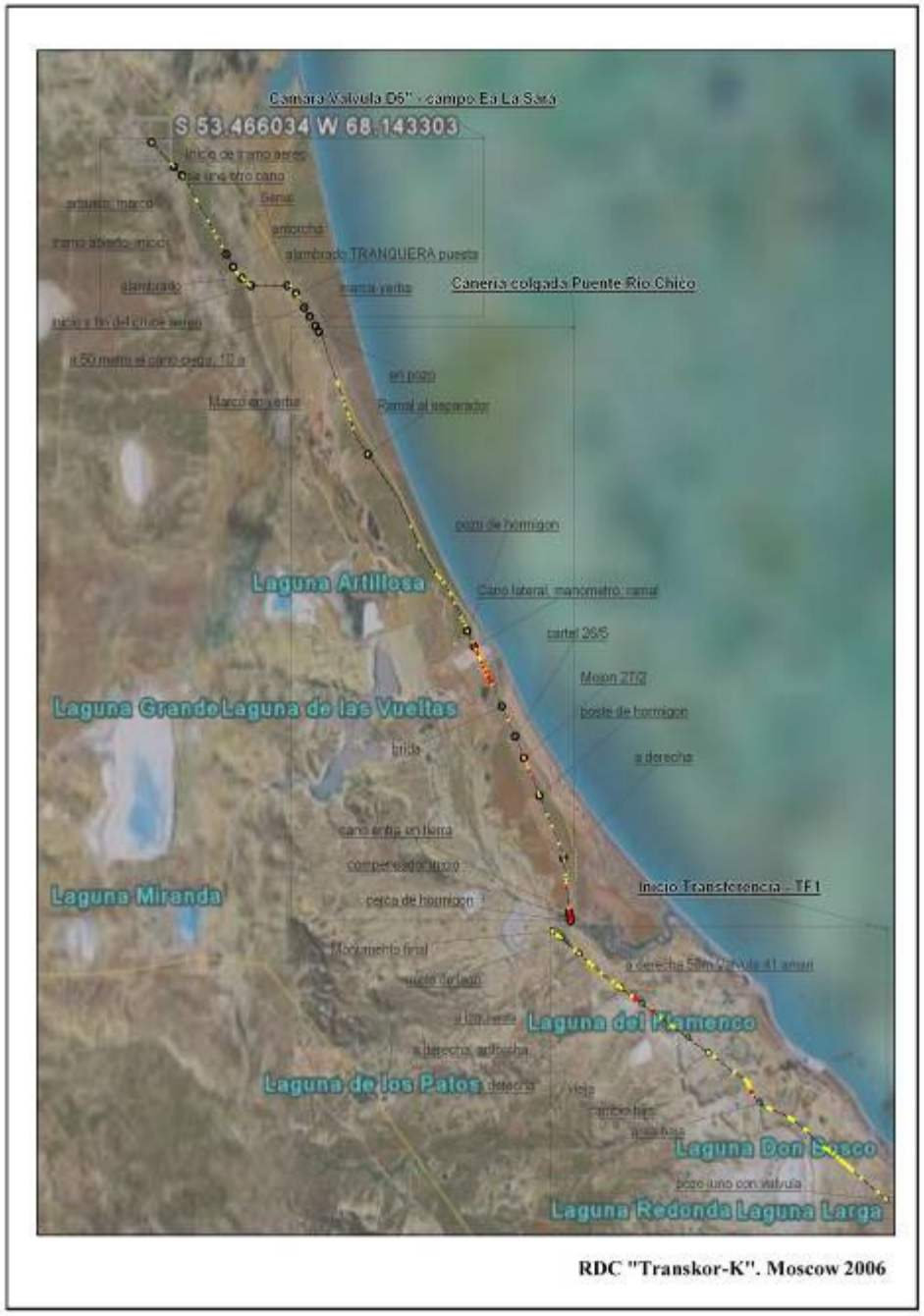
Metal loss

Crack-like defects

Geometry change

Weld joint defects

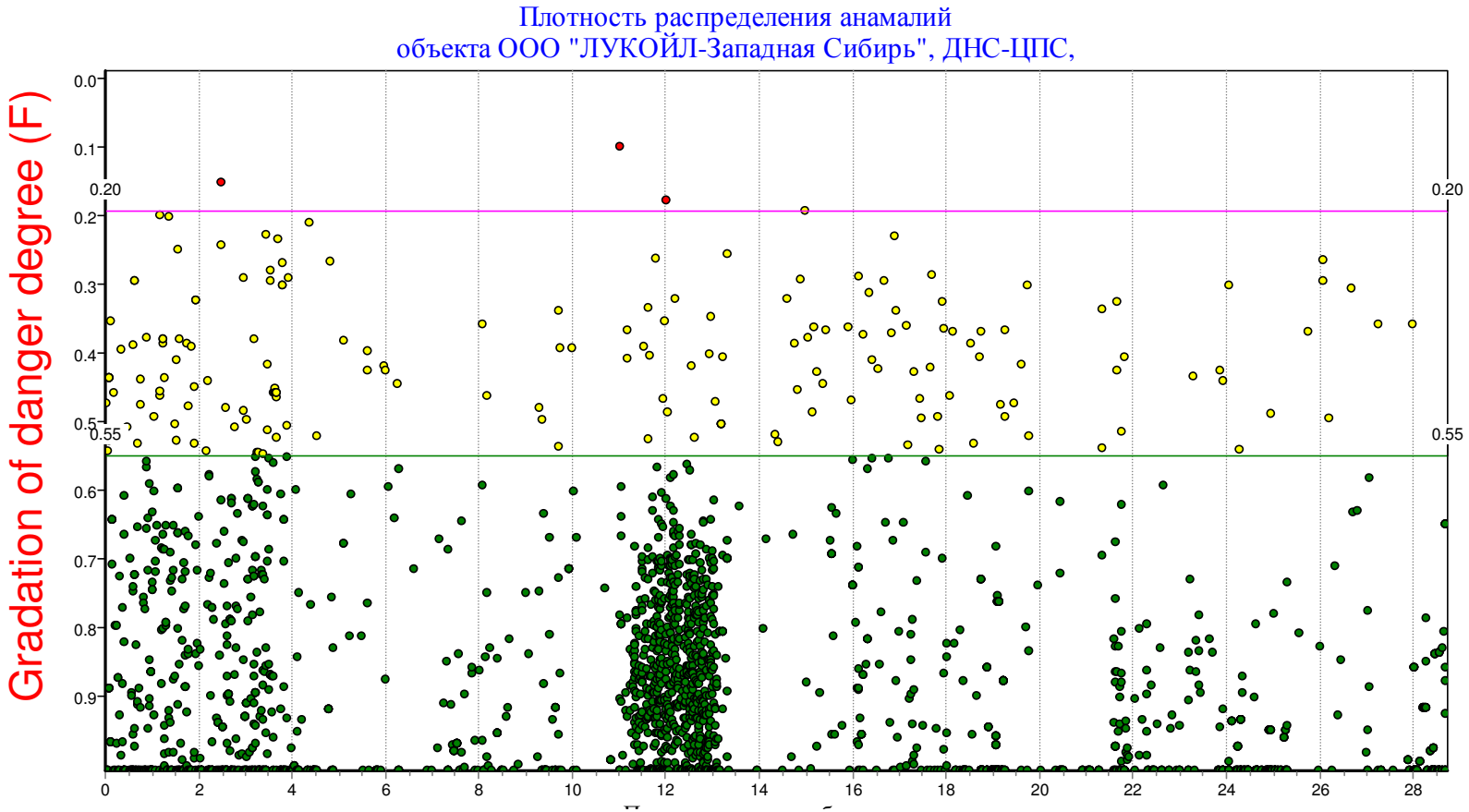
SDC (stress-deformed condition) anomalies



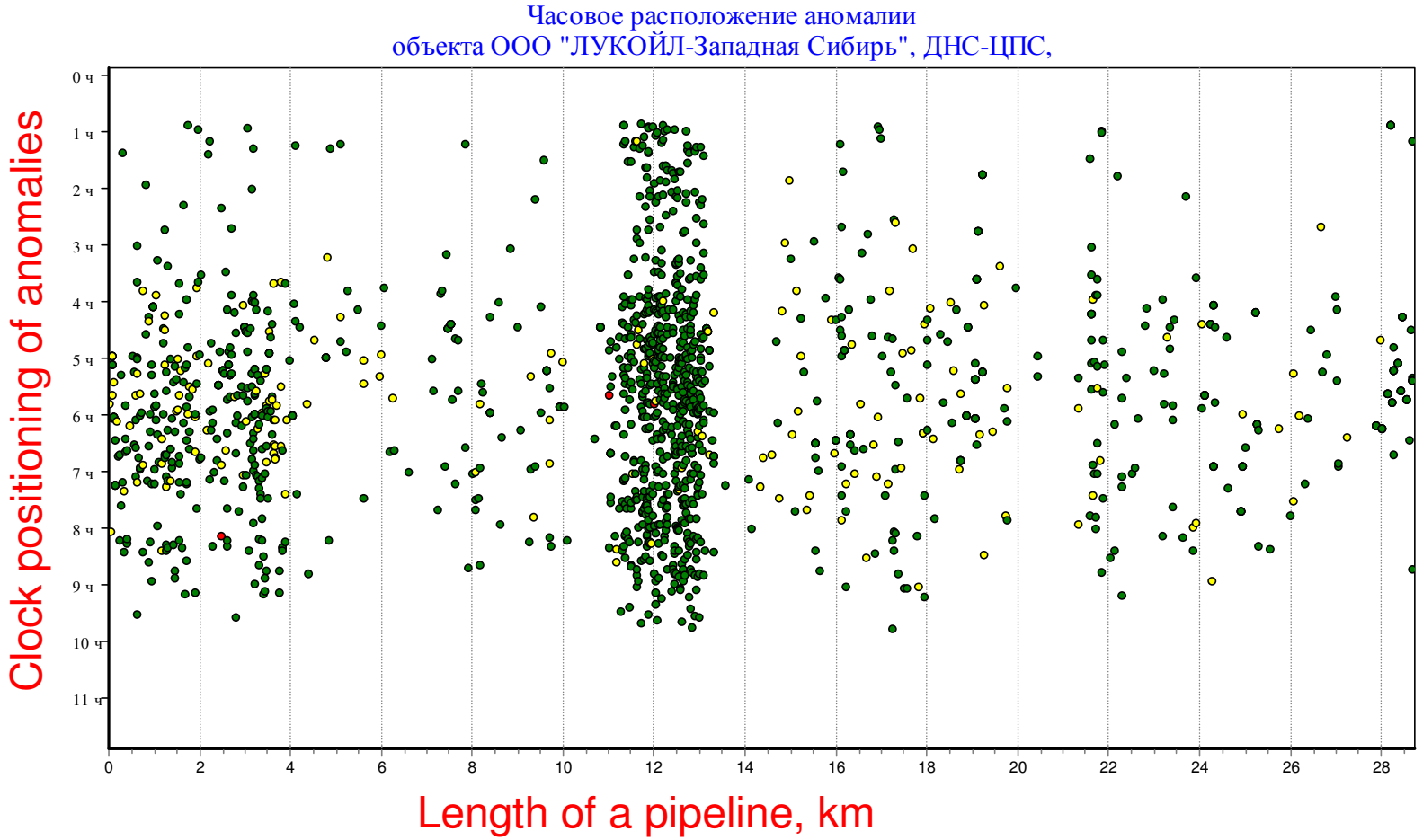
Map-scheme

with fixing an object
to topo-base
(Tierra Del Fugo,
Patagonia, Argentina)

Distribution of anomalies lengthways an object



Distribution of angular coordinates of anomalies



The following is included into the text:

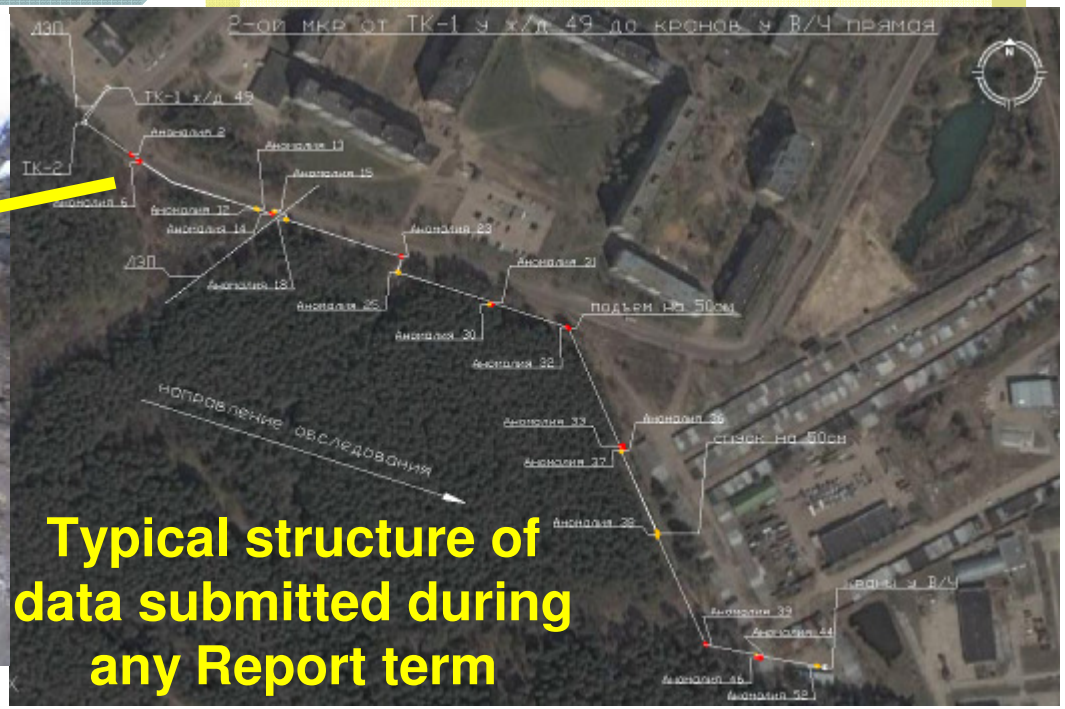
- Register
- Tables
- Photos

1. Situational, geodesic and other schemes, tables describing the MTM results;
2. Data illustrating the methodic of field and office works;
3. Data characterizing principals and peculiarities of revealing SDC anomalies of a ferro-magnetic pipeline;
4. Data relevant to the work results.

The following is included as graphic attachments:

- Maps
- Diagrams
- Schemes

1. Maps of distributing parameters of SDC anomalies of an object;
2. Situational Maps-schemes of an object; diagrams
3. Maps of geodesic positioning of an object by GPS-coordinates;
4. Schemes of comparing the inspection data with topo-base of a pipeline route.



Typical structure of data submitted during any Report term