EARTH UPPER CRUST REGIME OF STRESSES INFERRED FROM BOREHOLE MEASUREMENTS ON THE ROMANIAN TERRITORY

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Le régime du stress de la croûte supérieure terrestre mis en évidence par les mesures diagraphiques sur le territoire de la Roumanie. Les études géodynamiques basées sur les enregistrements diagraphiques dans les puits de forage ont connu un remarquable intérêt depuis 1997 avec les recherches menées par l'Institut de Géodynamique de l'Académie Roumaine. Dans ce contexte, le présent article se propose d'exposer les mesures et les interprétations diagraphiques permettant d'établir le régime actuel de contraintes accomplies lors d'un grand nombre de sondages dans le territoire de la Roumanie. Ont été retenues au final, les évaluations faites pour 130 forages différents qui peuvent s'intégrer dans lesdites normes A, B, C, D, E du "World Stress Map (WSM) Quality Ranking-Scheme". Les orientations (azimuts) des contraintes horizontales maximales et minimales ont été déterminées en analysant l'ovalisation du trou de forage (breakout method) enregistré à l'aide des diagraphies pendagemétriques. La plupart des outils pendagemétriques combinés, mis en service sur le territoire de la Roumanie par Western Atlas (Diplog) et Schlumberger (SHDT et BGT) comportent un microdiamétreur à quatre bras couplés par paires jusqu'à 20 "et, au besoin, 30" par adjonction de rallonges, donnant deux courbes de diamètres indépendants mesurés dans deux plans perpendiculaires. Un intégrateur de volume du trou, placé dans l'outil du fond, offre la possibilité de déterminer les zones fracturées, cavées et ovalisée en liaison avec les phénomènes tectoniques du stress. Les orientations de la contrainte horizontale maximale et minimale pour chacun des quatre compartiments géologiques/ regions (Transylvanie, Olténie, Moldavie et Valachie) qui partagent la Roumanie ont été calculées et présentées en forme tabulaire et graphique.

Key words: borehole, breakouts, stress map, Romania.

1. INTRODUCTION

Until recently the geodynamic information related to the present day-stresses acting within the Romanian terrestrial upper crust was enough scarce and the little data provided by the previous published papers (Neguț *et al.*, 1994; Zugrăvescu, Polonic, Negoiță, 1999) have not been included in the World Stress Map (Fuchs *et al.*, 1999).

That is why in the last ten years period the research programs concerning the stress studies undertaken by the Romanian Academy – Geodynamic Institute chose topics aiming to clear up the multiple geodynamic processes taking place under the Romanian territory.

It is valuable to mention among other things the fact that Romania represents an intensively geological explored region for hydrocarbon resources, in which a lot of oil and gas deposits have been discovered and exploited during the last century. More than fifty thousands wells, drilled in the above mentioned territory, investigated geologically and geophysically its entire sedimentary fill from the ground surface to 7 km depth.

For this reason the stress-research study of Geodynamic Institute was entirely based on the countless recordings of borehole geophysicalyl measurements existing in the archives of oil and gas companies, so that it was achieved without any extra-cost.

2. BOREHOLE GEOPHYSICAL DATA-PROCESSING METHOD

Thus being the favourable circumstances, the available well log suites coming from 150 exploration boreholes – whose bottom holes-depth were less than four kilometres – have been selected, collected and finally processed. All these selected boreholes have been completely geophysically investigated in open

hole conditions with Schlumberger and Western Atlas equipments including always the Stratigraphic High-Resolution Dipmeter Tool (SHDT) manufactured by Schlumberger or the Dipmeter Tool manufactured by Western Atlas. The data processing of field recordings was performed according to the Schlumberger instructions (Schlumberger, 1982, 1989, 1996). The interpretation methods devised in the Geodynamic Institute were based on the "breakout technique", both of them being finally coupled in such way to comply with the requests of the World Stress Map. In this context, it is necessary to mention that special rules were assessed in order to ascertain the causes of breakouts (initiation and enlargements) on the basis of well wall stability and the pressure differential existing between the drilling mud and the fluid filling the rock pore space.

At the Geodynamic Institute, the stress study was based on the linear, isotropic poroelastic stress-strain theory assuming the strain plane orthogonal to the borehole axis. With these terms the ellipsoid of stresses was defined by giving the directions of its three axes and the corresponding stress magnitudes S_1, S_2, S_3, known as principal stresses. Generally, within depositional basins, whether tectonically inactive or undergoing extension, the maximum stress (S_1) is represented by the geostatic load/ overburden, both intermediate stress (S_2) and least stress (S_3) being located in the horizontal plane. The combination of extensional and strike slip regimes existing in the many Romanian sedimentary basins supported our assumption to consider that the principal stress is oriented vertically ($S_1 = S_v$), the greater horizontal stress as being ($S_2 = S_H$) and finally, the least horizontal stress to be ($S_3 = S_h$). The least horizontal stress was expressed as a fraction of the geostatic load (S_1) using a variable coefficient whose value was calculated on the basis of Poisson's Ratio. Both, rock elastic parameters Poisson's Ratio and Young's modulus have been derived in our study from wave velocities and bulk volume densities recorded by Schlumberger and Atlas field equipments.

Objective reasons of Geodynamic Institute activity imposed a presentation of final results under the following two forms.

The first form, seen in Figure 1, is a graphical presentation in which all maximum stress component orientations were plotted on a regional map as long line bars indicating in the middle of bar the geographical co-ordinates of borehole site.

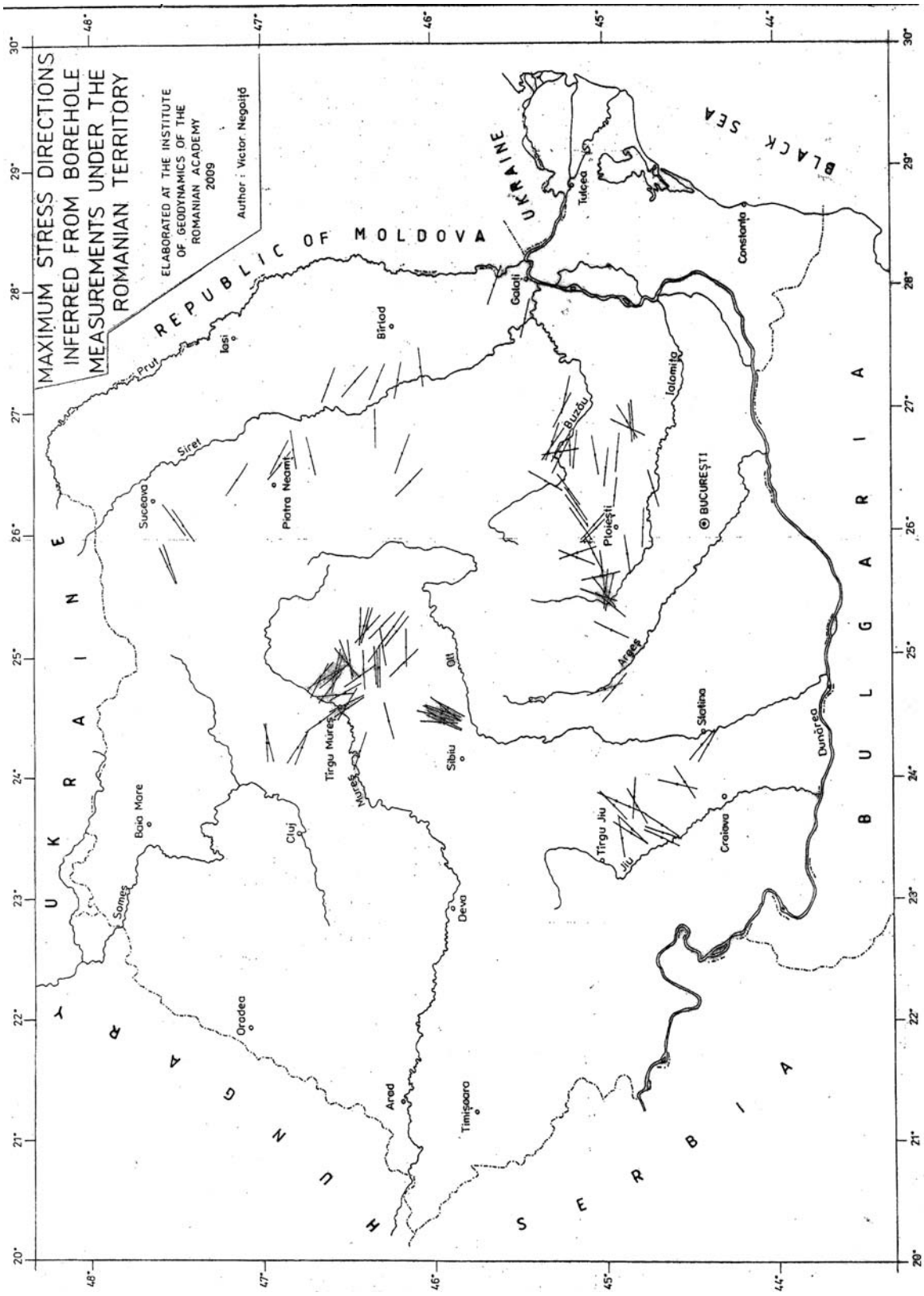
The following form of presentation, seen in Table 1, is a so-called "stress file" prepared and stored in the Stress Data Bank of the Geodynamic Institute. This stress file includes a lot of information concerning: well geographical co-ordinates, borehole intervals with continuous SHDT/Dipmeter measurements, the type of other recorded well logging measurements, lithology of geological formations passed through, boundaries between them on the basis of geological age, physical and chemical characteristics of drilling mud, borehole deviation, pressure and bottom hole maximum temperature, etc.

Other three types of information were also established and reported to in the "stress data file": the azimuth of maximum horizontal – principal stress, the azimuth of least horizontal – principal stress and the magnitude of the above mentioned stresses.

Since our field data stress study was provided by the open-hole geophysical measurements performed during the drilling period of the hydrocarbon-producing wells, we have been constrained to present the distribution of the stress orientations within the Romanian territory in a closed relation to the framework of geological activity of hydrocarbon industry.

3. RESULTS OF STRESS DETERMINATIONS IN ROMANIA

The first work broaching the stress problem on the Romanian territory was undertaken by Neguţ *et al.* (1994) into the framework of the PANCARDI project for European Scientific Cooperation. Using the software offered by Karlsruhe University in that cooperation between the above-mentioned university and Bucharest University, a number of 15 stress determinations have been reported and published.


MAXIMUM STRESS DIRECTIONS INFERRED FROM BOREHOLE MEASUREMENTS UNDER THE ROMANIAN TERRITORY
ELABORATED AT THE INSTITUTE OF GEODYNAMICS OF THE ROMANIAN ACADEMY
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REPUBLIC OF MOLDOVA
UKRAINE
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Târgu Jiu
Jiu
Craiova
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46°
47°
48°

Fig. 1

Table 1

1.	Geological structure	MALINI
2.	Well number	321
3.	Latitude/Longitude	47°22'/26°05'
4.	Recording equipment	DIPMETER TOOL
5.	Equipment produced by	WESTERN ATLAS
6.	Recording date	1999/31/10
7.	Recorded interval	2241-1140 = 1101m
8.	Different logs recorded	DFL – BHC – GR
		MLL – ML – CAL
		CDL – CN – DIPMETER
9.	Bit size	8 1/2"
10.	Density of drilling mud	1,31 g/cm^3
11.	Bottom hole temperature	63°C (22 hours since last mud circulation)
12.	Borehole maximum deviation	less than 1.5°
13.	Age of geological formations	SARMATIAN and BADENIAN
14.	Rocks lithology	sand, shale, sandstone, anhydrite
15.	Quality rank	B
16.	Total of breakouts	420 m
17.	Standard deviation	9%
18.	Horizontal maximum stress azimuth	53°
19.	Horizontal minimum stress azimuth	143°
20.	County	SUCEAVA

Therefore, the present work does not represent a "première" for Romania, especially because some other works have also been previously published (Zugrăvescu *et al*., 2000 and Negoiță *et al.*, 2007), but what is worthy of remark is the fact that it incorporates, for the first time in our country, a number of 130 determinations related to the present-day stresses.

All the data presented in this work are in whole agreement with the statutes of "Quality Ranking" established by Müller (1993) for World Stress Map (WSM) and consequently may be used careless.

Stress determinations results of this work are synthetically presented in two shapes:

1. The graphical shape exhibits a Romanian map indicating the maximum stress directions on the entire territory.

2. The synopsis tables (as Tables 2 and 3) indicating the essential stress information for each location situated on the Romanian territory.

Table 2 presents in an alphabetical order the well number and the geological structure according to the Petroleum Industry Nomenclature, location site and its county, as well as the geographical coordinates (latitude and longitude).

Table 3 includes in alphabetical order the well number and its site, the stress directions for maximum and minimum horizontal components, the rank quality determination according to the World Stress Map rules and the apparatus/ equipment type used during the field measurements.

Table 2

No.	Well number	Locality	County	Latitude	Longitude
1.	4	ALȚÂNA	SIBIU	45°56'33"	24°28'47"
2.	3961	AMARU	IALOMIȚA	44°52'	26°41'
3.	721	BĂICOI	PRAHOVA	45°01'	25°48'
4.	2501	BĂLĂNEȘTI	GORJ	45°05'30"	23°25'28"
5.	301	BĂLUȘEȘTI	NEAMȚ	46°55'	25°57'
6.	302	BĂLUȘEȘTI	NEAMȚ	46°44'	26°57'
7.	3450	BĂRBĂTEȘTI	GORJ	44°55'28"	23°24'33"
8.	496	BĂRBUNCEȘTI	BUZĂU	45°17'	26°36'
9.	500	BĂRBUNCEȘTI	BUZĂU	45°15'	26°37'
10.	502	BĂRBUNCEȘTI	BUZĂU	45°16'	26°38'
11.	300	BĂRGĂOANI	NEAMȚ	46°59'	26°37'
12.	238	BERCA	BUZĂU	45°20'	26°41'
13.	314	BERCA	BUZĂU	45°20'	26°43'
14.	400	BERCA	BUZĂU	45°22'	26°48'
15.	65	BIBEȘTI	GORJ	44°45'23"	23°29'03"

No.	Well number	Locality	County	Latitude	Longitude
16.	66	BIBEŞTI	GORJ	44°25’21"	23°25’24"
17.	309	BOBOCU	BUZĂU	45°20’	27°10’
18.	70	BOGATA	MUREŞ	46°26’46"	24°07’07"
19.	526	BOLDEŞTI	PRAHOVA	45°01	26°02
20.	645	BOLDEŞTI	PRAHOVA	45°01’	26°03’
21.	2	BUDA	VRANCEA	46°08’	27°17’
22.	250	BUHUŞI	NEAMŢ	46°46’	26°41’
23.	3014	BULBUCENI	GORJ	44°20’23"	23°29’58"
24.	14	BUNEŞTI	BRAŞOV	46°07’25"	25°04’50"
25.	178	BRĂGĂREASA	IALOMIŢA	44°49’	26°53’
26.	188	BRĂGĂREASA	IALOMIŢA	44°48’	26°52’
27.	191	BRĂGĂREASA	IALOMIŢA	44°47’	26°50’
28.	195	BRĂGĂREASA	IALOMIŢA	44°45’	26°47’
29.	851	BUSTUCHINI	GORJ	45°01’29"	23°44’32"
30.	880	BUŞTENARI	PRAHOVA	45°07’	25°50’
31.	1410	BUŞTENARI	PRAHOVA	45°08’	25°47’
32.	5542	CAPĂTA	BACĂU	26°50’	46°21’
33.	350	CĂRBUNEŞTI	PRAHOVA	45°14’	26°13’
34.	3300	CIOCENI	PRAHOVA	44°55’	26°18’
35.	5	CÂRCEA	DOLJ	44°18’47"	23°54’40"
36.	14	CLOAŞTERF	MUREŞ	48°08’31"	24°56’55"
37.	215	COLIBAŞI	DÂMBOVIŢA	45°01’	25°06’
38.	216	COLIBAŞI	DÂMBOVIŢA	45°01’	25°35’
39.	2536	COLŢEŞTI	GORJ	44°50’30"	23°42’27"
40.	1	CONDURATU	PRAHOVA	44°56’	26°07
41.	175	CORUNCA	MUREŞ	46°33’36"	24°39’00"
42.	233	CORUNCA	MUREŞ	46°30’52"	24°39’46"
43.	6042	DELENI	SIBIU	46°13’42"	24°26’29"
44.	602	DRĂGĂEŞTI	DÂMBOVIŢA	44°58’	25°21’
45.	18	EREMIENI	MUREŞ	46°33’03"	24°30’18"
46.	19	EREMIENI	MUREŞ	46°32’05"	24°50’34"
47.	20	EREMIENI	MUREŞ	46°33’28"	24°49’14"
48.	22	EREMIENI	MUREŞ	46°32’45"	24°50’55"
49.	180	EREMIENI	MUREŞ	46°32’49"	24°49’43"
50.	181	EREMIENI	MUREŞ	45°53’15"	24°33’26"
51.	2	FELICENI	HARGHITA	46°13’33"	25°16’51"
52.	5	FELICENI	HARGHITA	46°11’23"	25°17’38"
53.	6	FELICENI	HARGHITA	46°15’32"	25°17’03"
54.	236	FILITELNIC	MUREŞ	46°22’15"	24°43’01"
55.	952	FRASIN	SUCEAVA	47°34’	25°47’
56.	953	FRASIN	SUCEAVA	47°33’	25°48’
57.	102	FRUMUŞIŢA	GALAŢI	45°41’	28°03’
58.	18	GHINDARI	MUREŞ	46°28’22"	24°58’02"
59.	19	GHINDARI	MUREŞ	46°28’30"	24°56’55"
60.	101	GHINDARI	MUREŞ	46°28’07"	24°57’40"
61.	21	HĂLĂNGEŞTI	GORJ	44°46’29"	23°45’59"
62.	153	HUREZANI	GORJ	44°48’23"	23°38’25"
63.	64	HURUEŞTI	VRANCEA	46°14’	27°15’
64.	700	INDEPENDENŢA	GALAŢI	45°34’	27°48’
65.	1	IZVOR BERHECI	VASLUI	46°36’	27°09’
66.	1	LIPIA	ILFOV	44°42’	26°16’
67.	10	LUPENI	HARGHITA	46°22’26"	25°15’30"
68.	11	LUPENI	HARGHITA	46°22’52"	25°15’32"
69.	13	LUPENI	HARGHITA	46°23’37"	25°15’37"

No.	Well number	Locality	County	Latitude	Longitude
70.	14	LUPENI	HARGHITA	46°22’59"	25°15’11"
71.	25	MĂGHIRANI	MUREŞ	46°32’50"	24°54’02"
72.	250	MĂGHIRANI	MUREŞ	46°32’03"	24°54’51"
73.	398	MĂGURELE	PRAHOVA	45°08’	26°04’
74.	399	MĂGURELE	PRAHOVA	45°07’	26°04’
75.	63	MĂLDĂREŞTI	BACĂU	46°12’	27°16’
76.	30	MĂLINI	SUCEAVA	47°25’	26°09’
77.	321	MĂLINI	SUCEAVA	47°22’	26°05
78.	36	MĂRGINENI	NEAMŢ	46°53’	26°39’
79.	667	MONTEORU	BUZĂU	45°13’	26°36’
80.	320	NINEASA	BACĂU	46°08’	26°28’
81.	23	NOCRICH	SIBIU	45°54’08"	24°29’57"
82.	33	NOCRICH	SIBIU	45°54’19"	24°26’20"
83.	36	NOCRICH	SIBIU	45°53’58"	24°26’09"
84.	37	NOCRICH	SIBIU	45°54’19"	24°26’43"
85.	130	NOCRICH	SIBIU	45°54’41"	24°30’41"
86.	1	OCHENI	BACĂU	46°17’	27°14’
87.	509	OCHIURI	DÂMBOVIŢA	44°58’	25°33’
88.	765	OCHIURI	DÂMBOVIŢA	44°58’	25°31’
89.	775	OCHIURI	DÂMBOVIŢA	44°58’	25°51’
90.	2515	OCNIŢA	DÂMBOVIŢA	44°59’	25°33’
91.	2516	OCNIŢA	DÎMBOVIŢA	44°59’	25°35’
92.	53	PĂCUREŢI	PRAHOVA	45°09’	26°08’
93.	54	PĂCUREŢI	PRAHOVA	45°09’	26°09’
94.	3	PETECU	HARGHITA	46°10’25"	25°13’53"
95.	15	PETRILACA	MUREŞ	46°39’50"	24°45’52"
96.	16	PETRILACA	MUREŞ	46°36’27"	24°42’31"
97.	17	PETRILACA	MUREŞ	46°39’06"	24°46’33"
98.	18	PETRILACA	MUREŞ	46°39’33"	24°47’18"
99.	121	PETRILACA	MUREŞ	46°40’09"	24°46’40"
100.	35	PORUMBENI	HARGHITA	46°15’33"	24°05’12"
101.	36	PORUMBENI	HARGHITA	46°16’07"	25°05’02"
102.	6	POIANA SĂRATĂ	BACĂU	46°08’	26°27’
103.	431	ROŞIORU	BUZĂU	45°15’	27°10’
104.	140	SĂBED	MUREŞ	46°39’49°	24°25’27"
105.	22	SĂCEL	HARGHITA	46°17’41"	24°54’33"
106.	23	SĂCEL	HARGHITA	46°18’10"	24°55’08"
107.	25	SĂCEL	HARGHITA	46°17’05"	24°54’23"
108.	180	SĂSĂUŞ	SIBIU	46°53’01"	24°33’27"
109.	181	SĂSĂUŞ	SIBIU	46°53’15"	24°33’26"
110.	140	SĂRMĂŞEL	CLUJ	46°47’24"	24°11’34"
111.	152	SĂRMĂŞEL	CLUJ	46°48’14"	24°11’17"
112.	6004	SIBICIU	BUZĂU	45°35’	26°32’
113.	182	SÂNGEORGIU	MUREŞ	46°24’30"	24°50’07"
114.	15	SLATINA	OLT	44°28’16"	24°16’21"
115.	16	SLATINA	OLT	44°30’47"	24°15’49"
116.	175	STRUGURENI	BISTRIŢA	46°58’39"	24°14’40"
117.	176	STRUGURENI	BISTRIŢA	46°58’57"	24°13’55"
118.	28	ŞOIMUŞ	HARGHITA	46°23’12"	24°52’09"
119.	4300	ŞIRNA	PRAHOVA	44°46’	25°57"
120	400	TÂRGU MUREŞ	MUREŞ	46°31’31"	24°34’21"
121	403	TÂRGU MUREŞ	MUREŞ	46°31’07"	24°34’43"
122.	304	TÂRGU NEAMŢ	NEAMŢ	47°12’	26°30’
123.	377	TOTEA	GORJ	44°51’12"	23°32’45"

No.	Well number	Locality	County	Latitude	Longitude
124.	4544	TUTANA	ARGEŞ	45°02’22"	24°41’30"
125.	3	UNGURENI	DOLJ	44°22’20"	23°54’24"
126.	327	URZICENI	IALOMIŢA	44°42’	26°37’
127.	4811	VINTILEANCA	BUZĂU	44°58’	26°34’
128.	160	VLĂDENI	PRAHOVA	44°35’	25°45’
129.	4263	ZAMFIREŞTI	ARGEŞ	44°59’28"	24°38’30"
130.	86	ZĂTRENI	VÂLCEA	44°45’08"	23°48’32"

Table 3

No.	Well number	Locality	Stresses directions		Rank quality	Apparatus and equipments
			maximum	minimum		
1.	4	ALŢÂNA	20°	110°	B	ATLAS
2.	3961	AMARU	96°	6°	B	SCHLUMBERGER
3.	721	BĂICOI	63°	153°	B	SCHLUMBERGER
4.	2501	BĂLĂNEŞTI	43°	143°	B	SCHLUMBERGER
5.	301	BĂLUŞEŞTI	119°	29°	B	SCHLUMBERGER
6.	302	BĂLUŞEŞTI	134°	44°	B	ATLAS
7.	3450	BĂRBĂTEŞTI	83°	173°	C	ATLAS
8.	496	BĂRBUNCEŞTI	122°	32°	C	SCHLUMBERGER
9.	500	BĂRBUNCEŞTI	167°	77°	C	SCHLUMBERGER
10.	502	BĂRBUNCEŞTI	143°	53°	B	SCHLUMBERGER
11.	300	BĂRGĂOANI	88°	178°	C	SCHLUMBERGER
12.	238	BERCA	138°	48°	B	SCHLUMBERGER
13.	314	BERCA	128°	38°	B	SCHLUMBERGER
14.	400	BERCA	122°	32°	B	ATLAS
15.	65	BIBEŞTI	26°	116°	A	SCHLUMBERGER
16.	66	BIBEŞTI	31°	121°	B	SCHLUMBERGER
17.	309	BOBOCU	118°	38°	B	SCHLUMBERGER
18.	70	BOGATA	112°	22°	B	SCHLUMBERGER
19.	526	BOLDEŞTI	135°	45°	B	SCHLUMBERGER
20.	645	BOLDEŞTI	128°	38°	B	SCHLUMBERGER
21.	2	BUDA	86°	176°	B	SCHLUMBERGER
22.	250	BUHUŞI	72°	162°	A	SCHLUMBERGER
23.	3014	BULBUCENI	41°	131°	C	SCHLUMBERGER
24.	14	BUNEŞTI	96°	186°	A	SCHLUMBERGER
25.	178	BRĂGĂREASA	82°	172°	C	SCHLUMBERGER
26.	188	BRĂGĂREASA	83°	173°	D	SCHLUMBERGER
27.	191	BRĂGĂREASA	57°	147°	D	SCHLUMBERGER
28.	195	BRĂGĂREASA	76°	166°	D	SCHLUMBERGER
29.	851	BUSTUCHINI	19°	109°	B	ATLAS
30.	880	BUŞTENARI	168°	78°	C	SCHLUMBERGER
31.	1410	BUŞTENARI	53°	143°	B	SCHLUMBERGER
32.	5542	CAPĂTA	82°	172°	C	SCHLUMBERGER
33.	350	CĂRBUNEŞTI	58°	148°	B	ATLAS
34.	3300	CIOCENI	109°	19°	C	ATLAS
35.	5	CÂRCEA	37°	127°	C	SCHLUMBERGER
36.	14	CLOAŞTERF	128°	38°	C	ATLAS
37.	215	COLIBAŞI	79°	169°	B	ATLAS
38.	216	COLIBAŞI	85°	175°	C	SCHLUMBERGER
39.	2536	COLŢEŞTI	45°	135°	C	ATLAS
40.	1	CONDURATU	98°	8°	B	SCHLUMBERGER

No.	Well number	Locality	Stresses directions		Rank quality	Apparatus and equipments
			maximum	minimum		
41.	175	CORUNCA	171°	81°	B	ATLAS
42.	233	CORUNCA	167°	77°	C	SCHLUMBERGER
43.	6042	DELENI	72°	162°	C	SCHLUMBERGER
44.	602	DRĂGĂEȘTI	28°	118°	A	SCHLUMBERGER
45.	18	EREMIENI	135°	45°	A	SCHLUMBERGER
46.	19	EREMIENI	172°	82°	C	SCHLUMBERGER
47.	20	EREMIENI	144°	94°	C	ATLAS
48.	22	EREMIENI	171°	81°	C	ATLAS
49.	180	EREMIENI	179°	89°	C	SCHLUMBERGER
50.	181	EREMIENI	163°	73°	B	SCHLUMBERGER
51.	2	FELICENI	132°	42°	C	SCHLUMBERGER
52.	5	FELICENI	128°	38°	B	ATLAS
53.	6	FELICENI	103°	13°	B	ATLAS
54.	236	FILITELNIC	149°	59°	C	SCHLUMBERGER
55.	952	FRASIN	71°	161°	C	SCHLUMBERGER
56.	953	FRASIN	60°	150°	C	SCHLUMBERGER
57.	102	FRUMUȘIȚA	20°	110°	D	ATLAS
58.	18	GHINDARI	109°	19°	C	SCHLUMBERGER
59.	19	GHINDARI	48°	138°	B	SCHLUMBERGER
60.	101	GHINDARI	85°	175°	B	ATLAS
61.	21	HĂLĂNGEȘTI	58°	148°	C	ATLAS
62.	153	HUREZANI	22°	112°	B	SCHLUMBERGER
63.	64	HURUEȘTI	106°	16°	C	SCHLUMBERGER
64.	700	INDEPENDENȚA	116°	26°	C	ATLAS
65.	1	IZVOR BERHECI	111°	21°	B	SCHLUMBERGER
66.	1	LIPIA	85°	175°	B	SCHLUMBERGER
67.	10	LUPENI	116°	26°	B	SCHLUMBERGER
68.	11	LUPENI	114°	24°	A	SCHLUMBERGER
69.	13	LUPENI	96°	6°	B	SCHLUMBERGER
70.	14	LUPENI	121°	31°	C	SCHLUMBERGER
71.	25	MĂGHIRANI	128°	38°	B	SCHLUMBERGER
72.	250	MĂGHIRANI	108°	18°	B	SCHLUMBERGER
73.	398	MĂGURELE	55°	145°	C	SCHLUMBERGER
74.	399	MĂGURELE	60°	150°	C	ATLAS
75.	63	MĂLDĂREȘTI	145°	55°	C	SCHLUMBERGER
76.	30	MĂLINI	50°	140°	C	ATLAS
77.	321	MĂLINI	53°	143°	B	ATLAS
78.	36	MĂRGINENI	83°	173°	C	SCHLUMBERGER
79.	667	MONTEORU	109°	19	B	SCHLUMBERGER
80.	320	NINEASA	108°	18°	C	SCHLUMBERGER
81.	23	NOCRICH	21°	111°	B	SCHLUMBERGER
82.	33	NOCRICH	25°	115°	C	SCHLUMBERGER
83.	36	NOCRICH	33°	123°	C	SCHLUMBERGER
84.	37	NOCRICH	8°	98°	C	SCHLUMBERGER
85.	130	NOCRICH	19°	109°	B	SCHLUMBERGER
86.	1	OCHENI	101°	11°	B	SCHLUMBERGER
87.	509	OCHIURI	120°	30°	C	ATLAS
88.	765	OCHIURI	102°	12°	C	ATLAS
89.	775	OCHIURI	25°	115°	C	ATLAS
90.	2515	OCNIȚA	41°	131	C	ATLAS
91.	2516	OCNIȚA	56°	146°	C	ATLAS
92.	53	PĂCUREȚI	54°	144°	A	ATLAS

No.	Well number	Locality	Stresses directions		Rank quality	Apparatus and equipments
			maximum	minimum		
93.	54	PĂCUREȚI	50°	140°	C	ATLAS
94.	3	PETECU	120°	30°	B	ATLAS
95.	15	PETRILACA	136°	46°	A	SCHLUMBERGER
96.	16	PETRILACA	137°	47°	B	ATLAS
97.	17	PETRILACA	128°	38°	B	SCHLUMBERGER
98.	18	PETRILACA	154°	64°	C	ATLAS
99.	121	PETRILACA	148°	58°	A	SCHLUMBERGER
100.	35	PORUMBENI	80°	170°	B	SCHLUMBERGER
101.	36	PORUMBENI	118°	28°	C	SCHLUMBERGER
102.	6	POIANA SĂRATĂ	136°	46°	B	SCHLUMBERGER
103.	431	ROȘIORU	106°	16°	B	SCHLUMBERGER
104.	140	SĂBED	146°	56°	A	SCHLUMBERGER
105.	22	SĂCEL	95°	5°	C	SCHLUMBERGER
106.	23	SĂCEL	88°	178°	C	SCHLUMBERGER
107.	25	SĂCEL	86°	176°	C	SCHLUMBERGER
108.	180	SĂSĂUȘ	29°	119°	B	SCHLUMBERGER
109.	181	SĂSĂUȘ	38°	128°	C	SCHLUMBERGER
110.	140	SĂRMĂȘEL	118°	28°	C	SCHLUMBERGER
111.	152	SĂRMĂȘEL	130°	40°	B	SCHLUMBERGER
112.	6004	SIBICIU	30°	120°	C	SCHLUMBERGER
113.	182	SÂNGEORGIU	146°	56°	B	SCHLUMBERGER
114.	15	SLATINA	130°	40°	C	SCHLUMBERGER
115.	16	SLATINA	126°	36°	C	ATLAS
116.	175	STRUGURENI	78°	168°	C	ATLAS
117.	176	STRUGURENI	88°	178°	C	SCHLUMBERGER
118.	28	ȘOIMUȘ	85°	175°	A	SCHLUMBERGER
119.	4300	ȘIRNA	92°	2°	C	SCHLUMBERGER
120.	400	TÂRGU MUREȘ	155°	65°	C	ATLAS
121.	403	TÂRGU MUREȘ	143°	53°	B	ATLAS
122.	304	TÂRGU NEAMȚ	129°	39°	C	ATLAS
123.	377	TOTEA	35°	125°	C	ATLAS
124.	4544	TUTANA	158°	68°	C	ATLAS
125.	3	UNGURENI	11°	101°	C	SCHLUMBERGER
126.	327	URZICENI	110°	20°	C	SCHLUMBERGER
127.	4811	VINTILEANCA	82°	172°	C	SCHLUMBERGER
128.	160	VLĂDENI	81°	171°	C	SCHLUMBERGER
129.	4263	ZAMFIREȘTI	137°	47°	B	SCHLUMBERGER
130.	86	ZĂTRENI	92°	2°	C	SCHLUMBERGER

According to the World Stress Map – Quality Ranking, each of all stress determinations is framed/integrated in one of the following five quality ranks (A, B, C, D, E) where (A) represents the best quality and (E) is the weakest one.

The framing is established on the basis of several relations in which the variables are: (1) the number of zones with distinct borehole breakouts and their length, (2) the well maximum deviation and (3) the standard deviation of stress determination.

All details in connection with various relations are incorporated and registered within the "stress file" of four regional stress studies carried out during the last five years. These regional stress studies were undertaken as follows: for Transylvania region – in 2005, for Oltenia region – in 2007, for Moldova region – in 2007, for Wallachia region – in 2008; all of them being nowadays stored in the archives of the Geodynamic Institute belonging to the Romanian Academy.

Table 4 depicts the rank quality of maximum stress directions for each on the four above-mentioned regions, as well as a total for the entire country.

Table 4

Region	Number of determinations	Rank quality				
		A	**B**	**C**	**D**	**E**
MOLDOVA	20	1 5%	7 35%	11 55%	1 5%	0 0%
MUNTENIA	40	2 5%	6 40%	19 47.5%	3 7.5%	0 0%
OLTENIA	17	1 5.9%	6 35.3%	10 58.8%	0 0%	0 0%
TRANSYLVANIA	53	7 13.2%	22 41.5%	24 45.3%	0 0%	0 0%
ROMANIA Total	130	11 8.46%	51 39.23%	64 49.23%	4 3.07%	0 0%

4. CONCLUSIONS

On the basis of borehole measurements carried out during the customary well logging operations, a stress study was undertaken by the Geodynamic Institute of the Romanian Academy.

Having this aim, the available well log suites coming from 150 boreholes were selected, collected and finally processed.

The field data processing was performed according to Schlumberger directions, the interpretation method devised in our institute was based on the "breakout technique", both of them being finally coupled in such a way to comply with the requests of the World Stress Map quality conditions.

Finally, a catalogue containing solely the best 130 determinations of horizontal component stress directions coming from the most adequate locations on the Romanian territory have been supplied. Concomitantly with the catalogue a map was prepared in order to show, in a graphical format, the distribution of stress directions in our country.

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