SOFIA UNIVERSITY
ST. KLIMENT OHRIDSKI

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Modeling of seismicity and recognition of earthquake-prone areas in the Bulgarian region – seismic nodes

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METHODOLOGY

Pattern recognition algorithm Cora-3 was used to identify seismogenic nodes prone to M5+ and M6+ events.

Nodes: specific structures that are formed around the intersections of the fault zones.

Nodes are characterized by geological-geophysical parameters given as a vector.

Earthquakes with magnitude M≥ 5 and M≥6 are selected from the Bulgarian historical and instrumental catalogues to "train" the pattern recognition algorithm.

MORPHOSTRUCTURAL ZONATION

The nodes are defined using the morphostructural zonation (MZ) method based on the geomorphologic and tectonic information.

MZ combined and analysed:

- **topography maps;**
- **tectonic maps;**
- **geological maps;**
- **satellite images.**

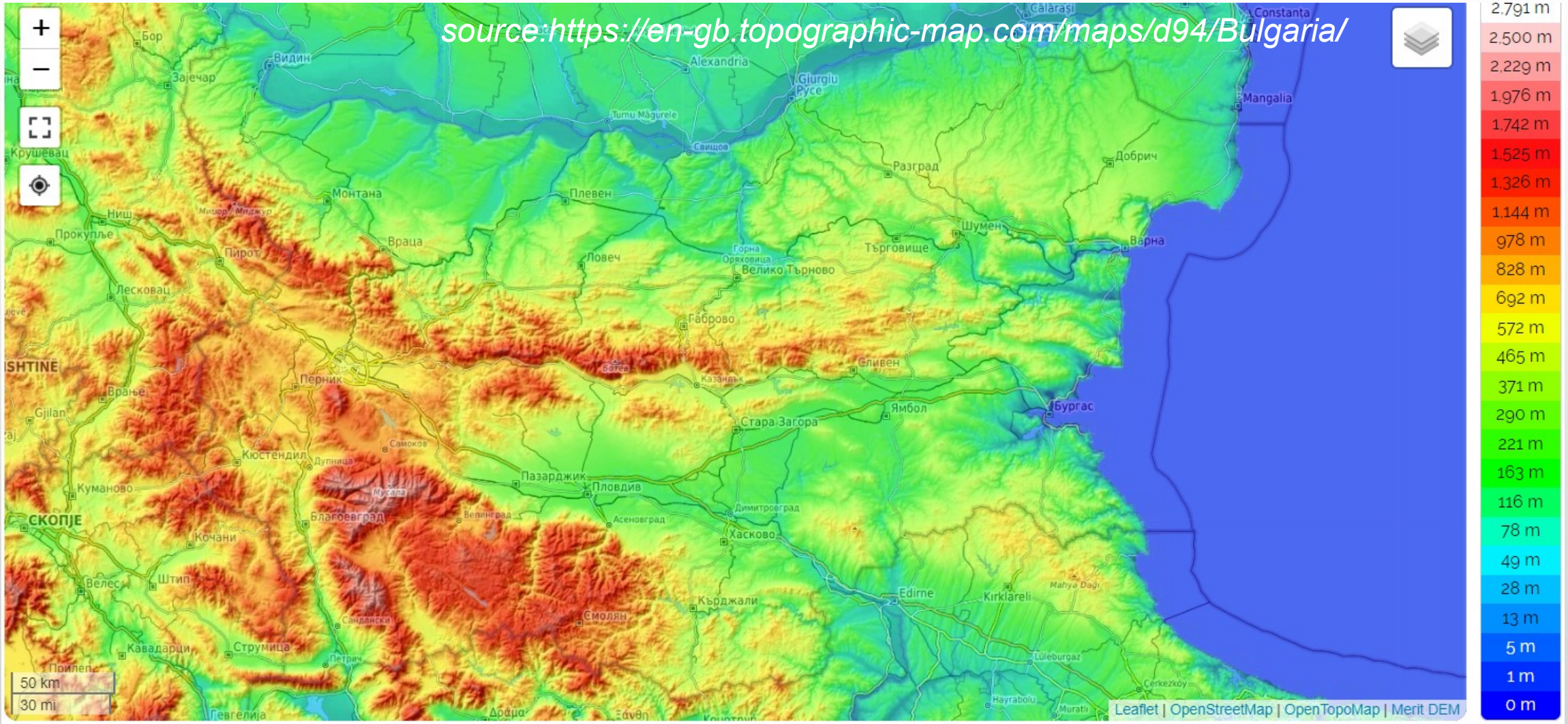
MZ morphostructures:

✓ **blocks with different ranks;**

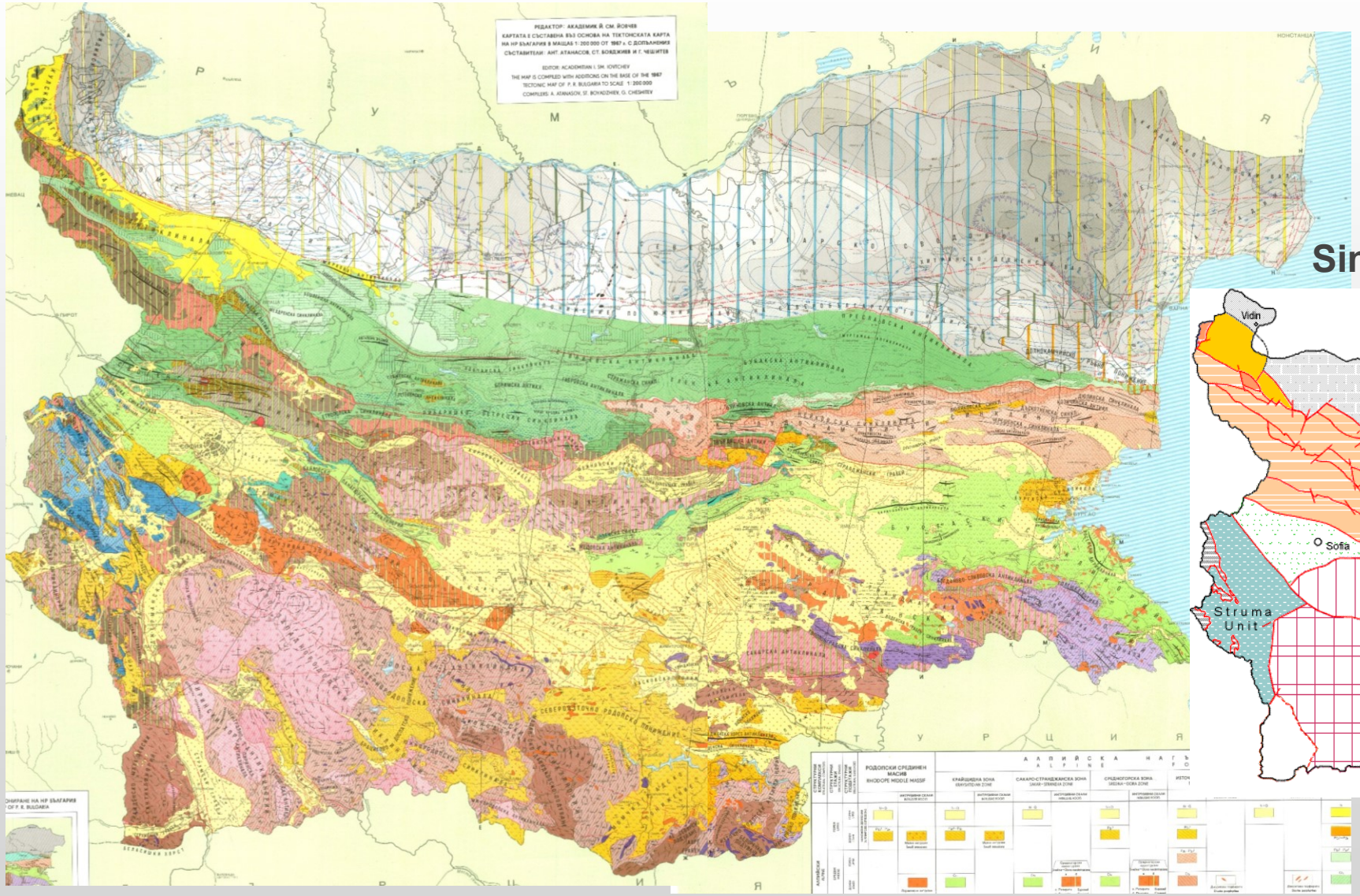
✓ **block's boundary zones – lineaments;**

✓ **boundary zone intersections – nodes.**

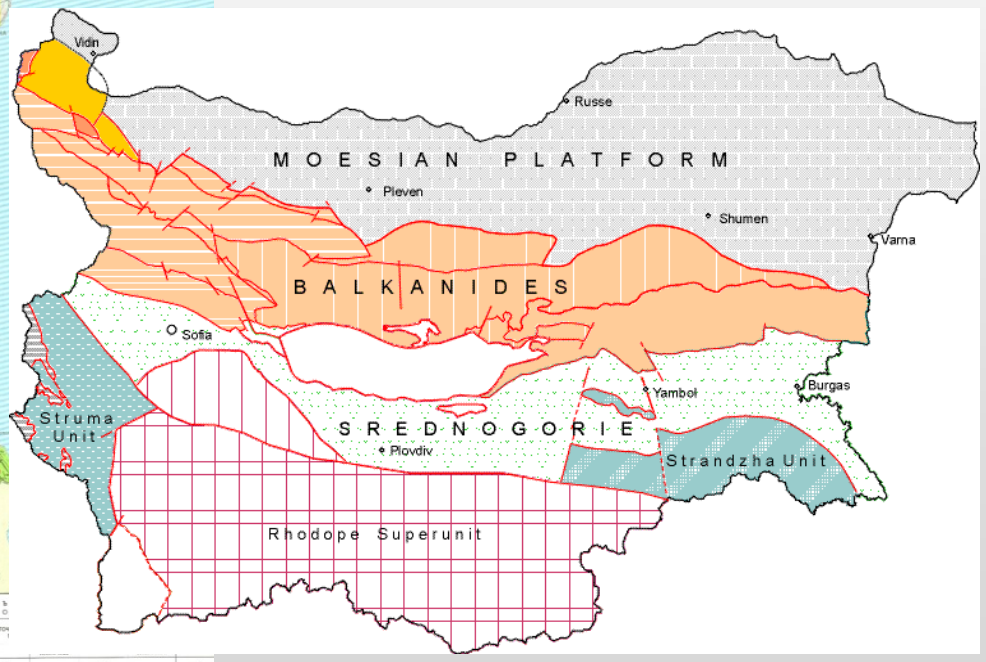
Topography map of Bulgaria



Tectonic maps of Bulgaria

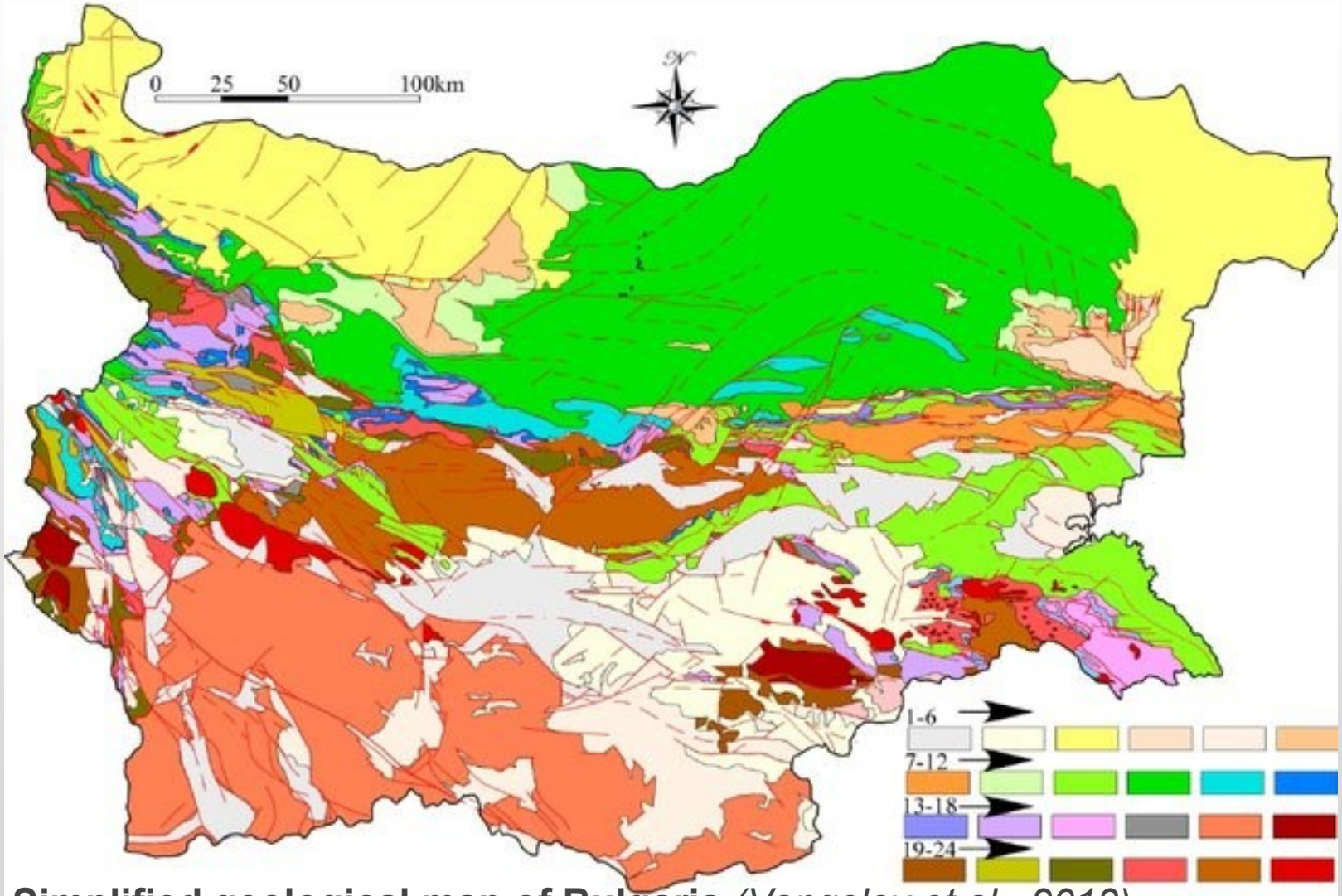


Simplified tectonic map of Bulgaria

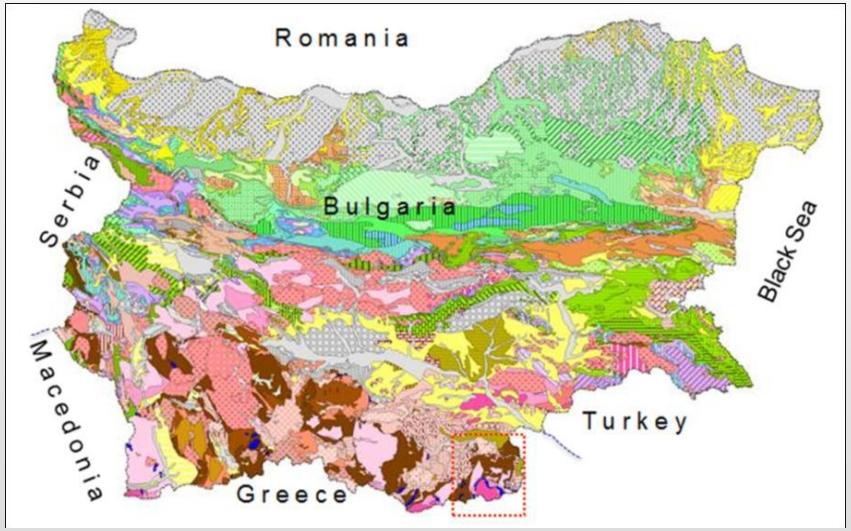


Geofond of Bulgarian Ministry of Energy

Geological maps of Bulgaria

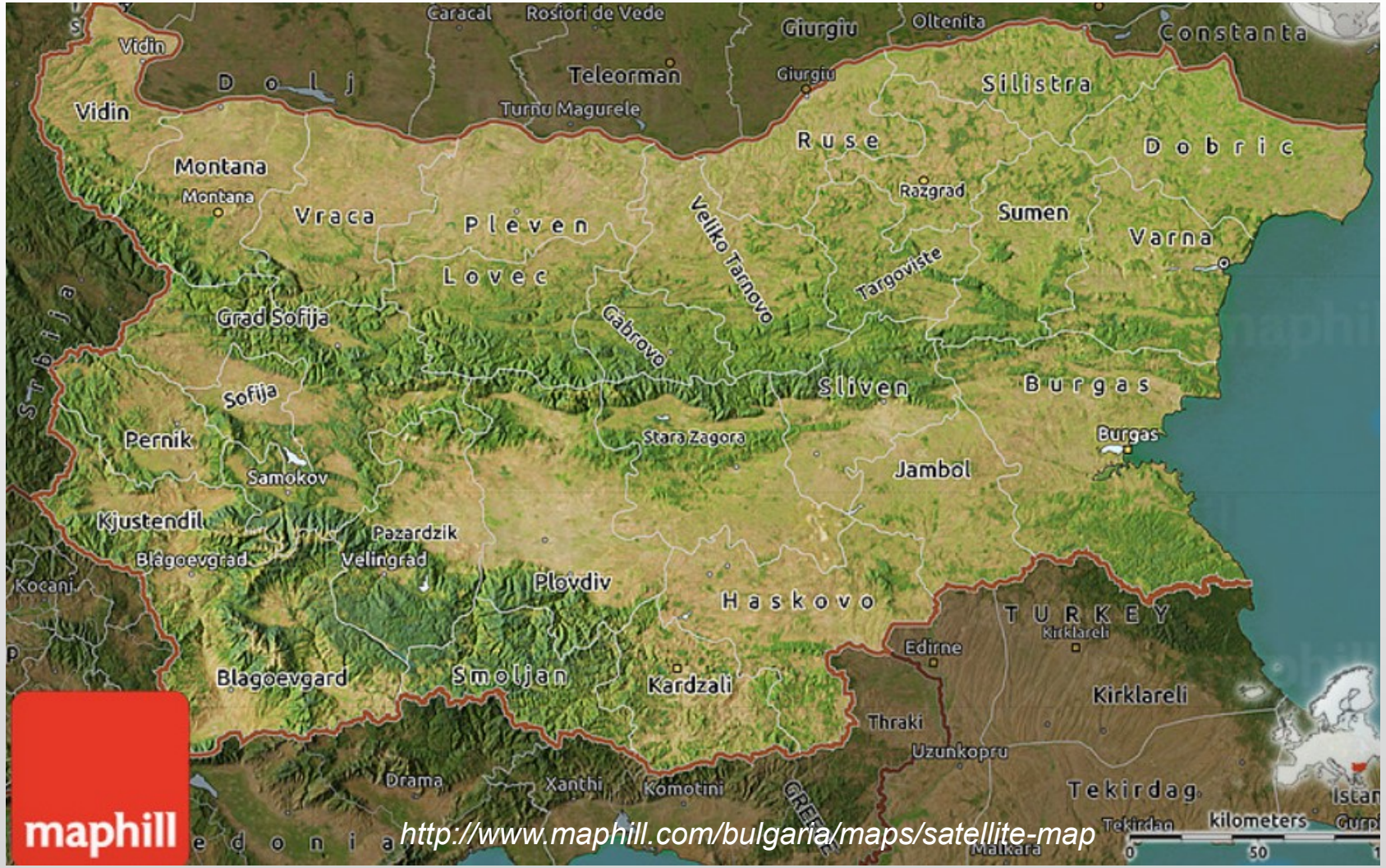


Simplified geological map of Bulgaria *(Vangelov et al., 2013)*

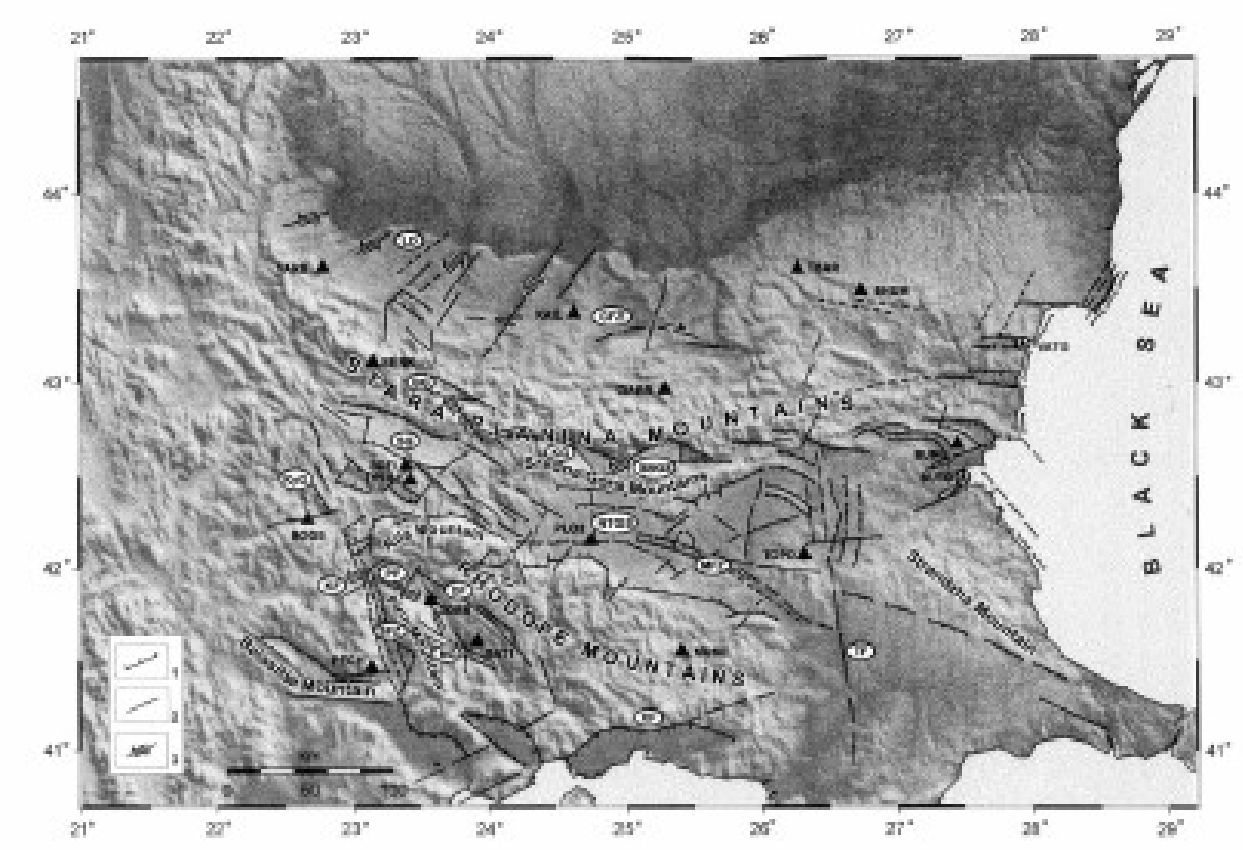


Geofond of Bulgarian Ministry of Energy

Satellite image of Bulgaria



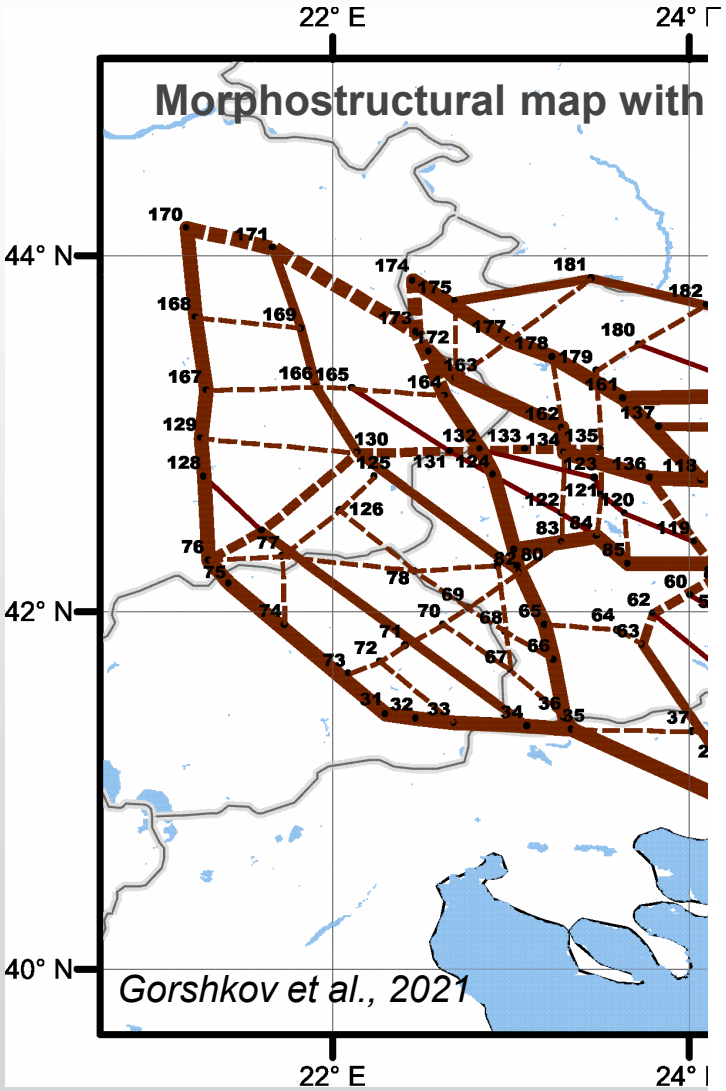
Other data for the Bulgarian territory

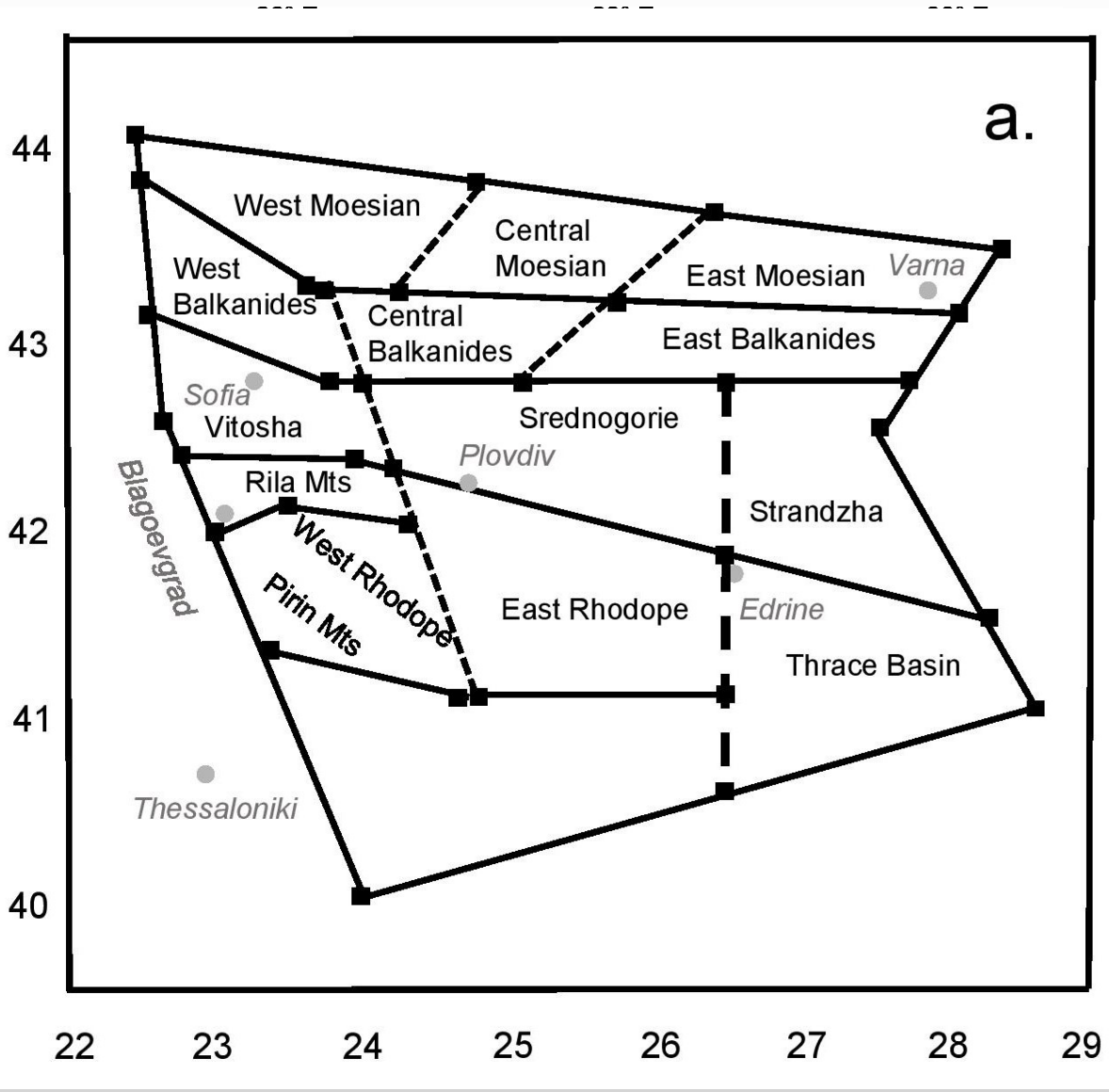


Kotzev et al. (2001)

SHARE and EFEHR projects

Morphostructural zoning map of BG region





Lands (I rank)
Megablocks (II rank)
Blocks (III rank)

Moesian:
West, Central and East

Balkanides:
West, Central and East

Srednogorie:
Vitosha,
Srednogorie, Strandzha

Rhodopes:
Rila, Pirin,
West and East
Rhodopes, Trace basin

Serbo-Macedonian:
Kraishtidi

Parameters of nodes

The nodes are defined in radius of 25 km around the intersection point:

Group I

1. Maximum altitude , Hmax
2. Minimum altitude, Hmin
3. Minimum distance l between the points with Hmax - Hmin.
4. Relief contrast, ΔH= Hmax - Hmin .
5. Measure of slope, ΔH/l.
6. Large topographic forms combination:
   a) Mauntain (m)
   b) Mountain range separated by a longitudinal valley and mountain (m/m)
   c) Mountain range and a piedmont plain (m/p)
   d) Mountain range and piedmont hills (m/pd)
   e) Mountain range, piedmont hills, and a piedmont plain (m/pd/p)
   f) Piedmont plains (p)
   g) Piedmont hills and a p. plain (pd/p)
7. The percentage of Quaternary deposits, Q.

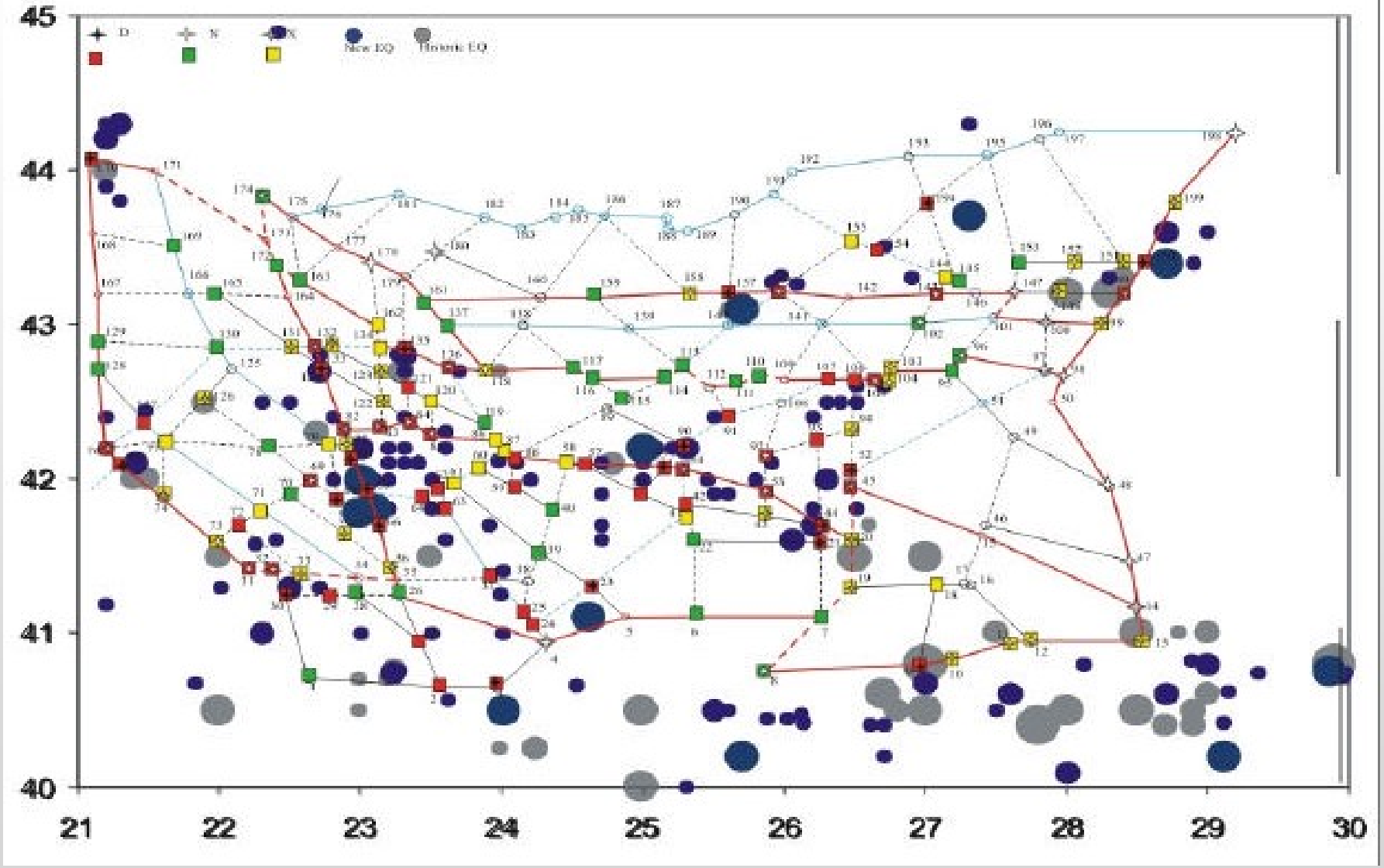
Group II

8. The highest rank of lineament in the node, RL
9. The number of lineaments in the node, nL
10. The distance from the node to the nearest intersection, rint
11. The distance from the node to the nearest I rank lineament, r1.
12. The distance from the node to the nearest II rank lineament, r2.
13. The number of faults in the node, NF.

Group III

14. Maximum Bouguer anomaly, Bmax. .
15. Minimum Bouguer anomaly, Bmin
16. Gravity “relief energy”, ΔB= Bmax – Bmin
17. Maximum geomagnetic anomaly, MAmax. .
18. Minimum geomagnetic anomaly, MAmin
19. Geomagnetic “relief energy”, ΔB= Bmax - Bmin

Seismicity used to train the PRM CORA-3

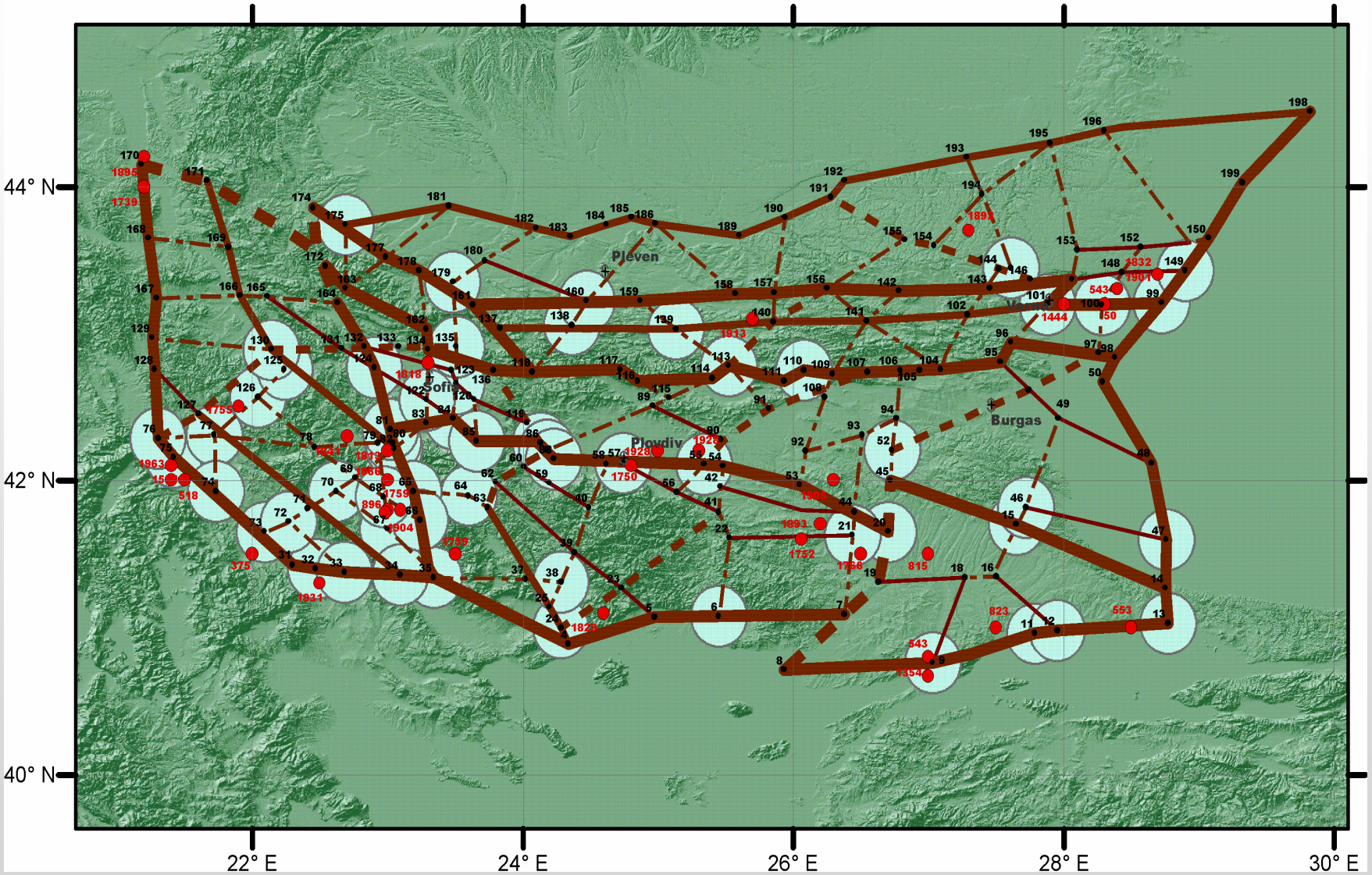


Seismicity as a teaching for pattern recognition algorithm Cora-3 194 events with M≥5 for the period from 29 D.C. to 2020 (Grigorova et al., 1976; Solakov et al., 2020)

137 nodes are capable for events with M5+

82 nodes are capable for events with M6+

Seismogenic nodes M6+



Seismogenic nodes capable of generating earthquakes M6+.

Continuous and dashed lines represent the longitudinal and transverse lineaments of I, II, and III rank.

Red dots denote epicenters of 30 earthquakes with M ≥ 6.0.

White circles mark 59 D nodes prone to M ≥ 6.0 events.

Non-circled intersections of the lineaments are N nodes.

Towns, situated within 25 km radius of certain node

Town	Inhabitants(2021)	Number of node
Sofia	1 221 172	**135**, 134, **123**, 121
Plovdiv	343 070	57, 58
Varna	332 686	**148**
Burgas	198 035	50
Russe	133 813	190, 191
Stara Zagora	124 599	91
Pleven	89 823	160, 159
Sliven	82 251	106, 107
Dobrich	79 269	**147**, 153
Shumen	72 342	**143,** 144
Yambol	63 656	106**, 94**
Pazardjik	65 671	58
Blagoevgrad	67 810	**65, 68, 80, 66**
Veliko Turnovo	65 793	**157**

Nodes:

XXX – prone for M6+

XXX – prone for M5+

XXX – not selected

CONCLUSIONS

- Morphostructural zoning and pattern recognition methodology were used and successfully tested on the seismic activity
- 59 nodes capable of generating earthquakes with magnitude M ≥ 6 have been identified on the territory of Bulgaria
- The observed seismicity (30 earthquakes with M ≥ 6) is associated with 16 of these nodes, used as a reference for the recognition of seismogenic nodes by the procedure used
- The obtained results can be used in the compilation of long-term **seismic hazard maps**, as well as be used in **non-deterministic seismic risk assessment.**

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Vangelov et al., 2013

Kotzev et al. (2001)

SHARE and EFEHR projects

Grigorova, E. and Glavtcheva, R. 1976. Seismic activity and expected K maximum within the territory of Bulgaria. Proc. Seminar of the Seismic Zoning Maps, Skopje, 27 oct. - 4 nov. 1975, UNDP/UNESCO Surv. Balk. Reg., Skopje, v. I, 206-215

Solakov et al., 2020

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THANK YOU FOR YOUR ATTENTION!