Project Cofinanced
by European Union

GEOTHERMAL ENERGY

MACEDONIA

ENERSUPPLY

ENergy **E**fficiency and **R**enewables – **SUP**porting **P**olicies in **L**ocal level for **E**nerg**Y**

1. INTRODUTION

1.1. Geography

High percentage of the Republic of Macedonia is mountainous. Macedonia is a landlocked country that is geographically clearly defined by a central valley formed by the Vardar River and framed along its borders by mountain ranges. Macedonia's terrain is mostly rugged, located between the Sar and Osogovo mountains, which frame the valley of the Vardar river.

The Republic of Macedonia also has scenic mountains. They belong to two different ranges: Dinarska and Rodopska. The Dinarska range is the oldest with subsequent erosion; the Rodopska range is younger offering rugged, alpine scenery. The scenery in Macedonia offers rocky mountains and green, rolling hills covered with conifer forests and lined with countless freshwater streams and rivers.

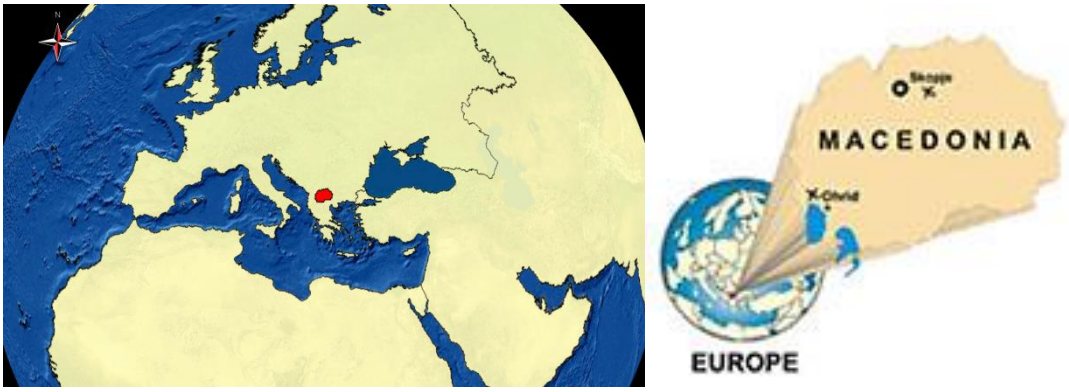

Figura 1: location of Macedonia

The total territory of Republic of Macedonia comes to **25,713 sq. km**, of which 25,236 sq. km are land, while 477 sq. km are water surface. The lowest point is Vardar River (44 m) near Gevgelija, and the highest point is Golem Korab peak (2,764 m) in the north-western part of Macedonia.

Macedonia has **766** km of boundaries, of which: **151** km with Albania; **148** km with Bulgaria; **246** km with Greece and **221** km with Serbia.

2. Methodology

2.1. Phase 1. Realization of the topographic map, Digital elevation model (DEM).

Import DEM from the site http://www.gdem.aster.ersdac.or.jp/ ; log into the site; select the "Search" on the left column to search for the tile corresponding the area to be processed; choose the tile you need and to download . Obtained the DEM is imported into the GIS and can be process, by an interpolation of the shares of DEM, is realized topographic map.

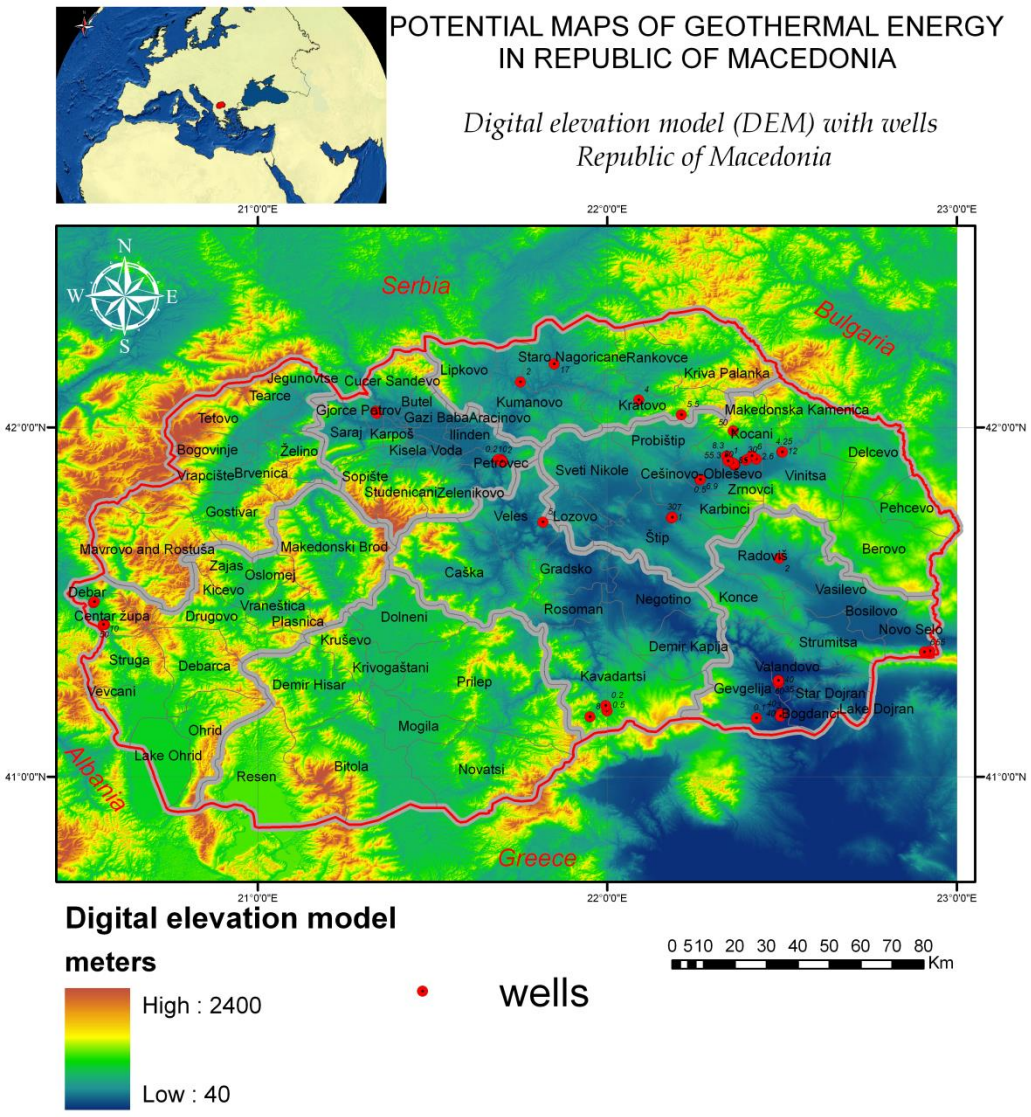

Figure 2 : DEM (Digital Elevation Model) MACEDONIA

2.2. Phase 2. Production of geo-referenced database (Geodatabase) through ArcCatalog (ESRI Corporation)

Attributes of wells

FID	Shape *	long	lat	z	temp_°C	flow_l_s	place	borehole
0	Point	527841	4654971	37	25	63	Volkovo	GTD-1(d)
1	Point	528150	4654330	31	22	22		IBSKG-3(d)
2	Point	557650	4639800	28	54.2	10	Katlanovospa	D-1(d)
3	Point	558125	4638990	25	32	4		B-1 ,B-2(d)
4	Point	558100	4639225	25	28	2		Nervnav(i)
5	Point	557850	4639500	26	38	2		Potkop(i)
6	Point	557000	4639750	27	28	0.2		Fontana(i)
7	Point	557910	4639260	23	38	1		Izvor(i)
8	Point	562100	4664460	31	31	2	Proevci	(d)
9	Point	570050	4670300	28	40	17	Strnovec	(d)
10	Point	613175	4638625	31	78	150	Podlog	EBMP-1(d)
11	Point	613095	4638775	31	77.8	80		R-3(d)
12	Point	605000	4634000	30	32	0.5	Krupishte	K-1/83(d)
13	Point	605100	4634000	29	40.6	6.9		K-2/83(d)
14	Point	618252	4640700	33	50.6	2.6	Kocansko pole	R-11(d)
15	Point	617200	4641750	34	22.4	6	Kocani	Ka-1(d)
16	Point	613000	4639000	31	79	120	Podlog	EB-4(d)
17	Point	613070	4639025	31	78	350	Podlog	EB-3(d)
18	Point	624350	4643000	35	66.4	12	Istibanja	I-5(d)
19	Point	624350	4643100	35	67	5		I-3(d)
20	Point	624475	4643025	35	56.6	4.2		I-4(d)
21	Point	612660	4649560	31	71.3	50	Trkanje	EB-2(d)
22	Point	612675	4639375	31	71.3	85		R-9(d)
23	Point	611225	4641550	35	63	8.3	Banja	B-1(d)
24	Point	611205	4641525	34	63.2	55.3		B-2(d)
25	Point	615840	4640300	34	63	30		R-1(d)
26	Point	611600	4639925	35	40	1		R-6(d)
27	Point	647225	4583900	25	68	55	Bansko	B-1(d)
28	Point	647160	4583500	27	73	6		Izvor(i)
29	Point	625530	4559875	65	47.2	40	Negorci	NB-3(d)
30	Point	625600	4559750	64	53.2	40		NB-4(d)
31	Point	625410	4559100	65	32	3		B-1(d)
32	Point	624812	4570375	56	45.1	7.2	Smokvica	Sied6(d)
33	Point	624800	4570340	57	56.7	60		Sied1(d)
34	Point	624775	4569650	57	48.1	5.2		Sied2(d)
35	Point	624815	4570250	57	56.1	35		Sied4(d)
36	Point	624780	4570400	57	64	40		Sied5(d)
37	Point	598552	4621825	30	59	1	Stip	Ldzi(i)
38	Point	598360	4621700	28	57	7		Kezovica(d)
39	Point	598630	4621850	26	32	30		B-4(d)
40	Point	583760	4560225	74	28	0.5	Kozuf	Toplidol(i)
41	Point	579743	4558275	88	22	8		Toplik(i)
42	Point	583450	4561875	72	21	0.2		Mrezicko(i)
43	Point	619650	4558425	22	23	0.1		Gornicet(i)
44	Point	590143	4659035	44	31	4	Kratovo	Povisica(d)
45	Point	600300	4654510	33	28	5.5		Dobrevo(d)
46	Point	567810	4620025	28	21	5	Veles	sabotav(d)
47	Point	624308	4609287	34	26	2	Raklesh	Dupn(d)
48	Point	460100	4593667	16	25	2	Dojran	Toplec(i)
49	Point	460100	4593667	24	20.5	10		Deribas(d)
50	Point	462588	4593667	75	40.5	50		Baniste(d)
51	Point	462587	4593667	40	48.5	10	Debar	Kosovrasti(d)

Figura 3: Attributes of wells

2.3. Phase 3. Interpolation of Geo-database data (eg. Temperature, heat flow, etc…)

The type of interpolation is a function of data distribution in terms of geography and the physical process of study. The name of the interpolation used for create geothermal maps of Macedonia is: IDW INTERPOLATION.

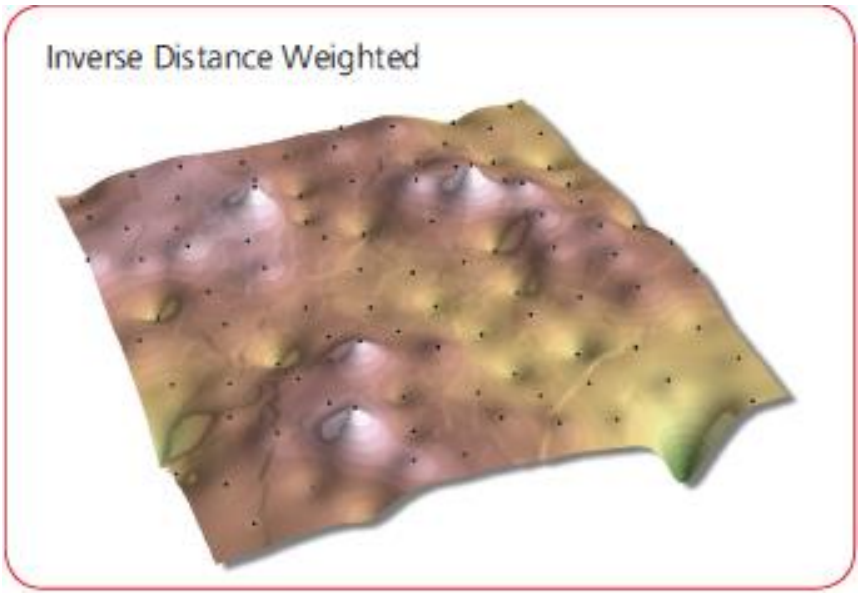

Figure 4: IDW interpolation

The IDW function should be used when the set of points is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear- weighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value.

2.4. Phase 4. Overlapping levels

With use of Geographic Information System (GIS Technology), is possible to bring together different levels of information related to area in question and to geo- referenced data.

Available data:

- Wells (location and depth)
- Flow (l/s)
- Isotherms (C°)

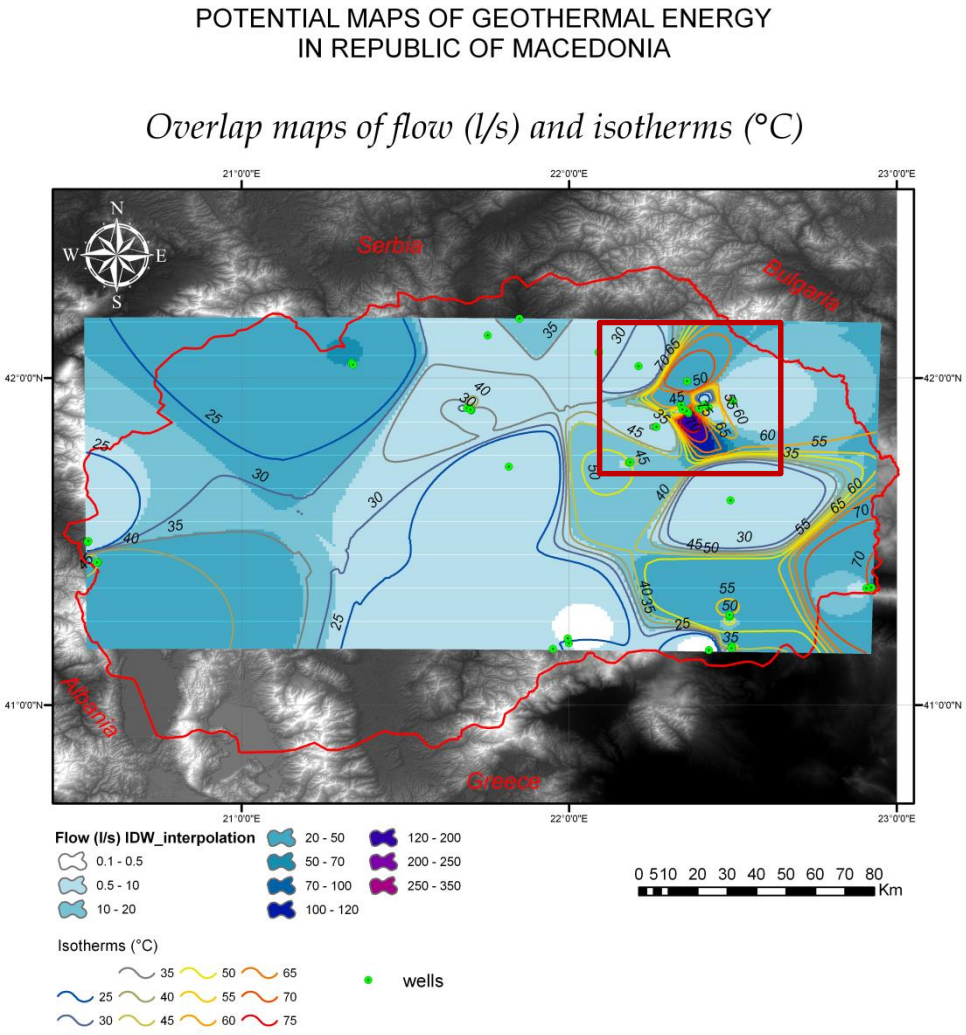

Figura 5: Overlap maps of flow (l/s) and isotherms (°C)

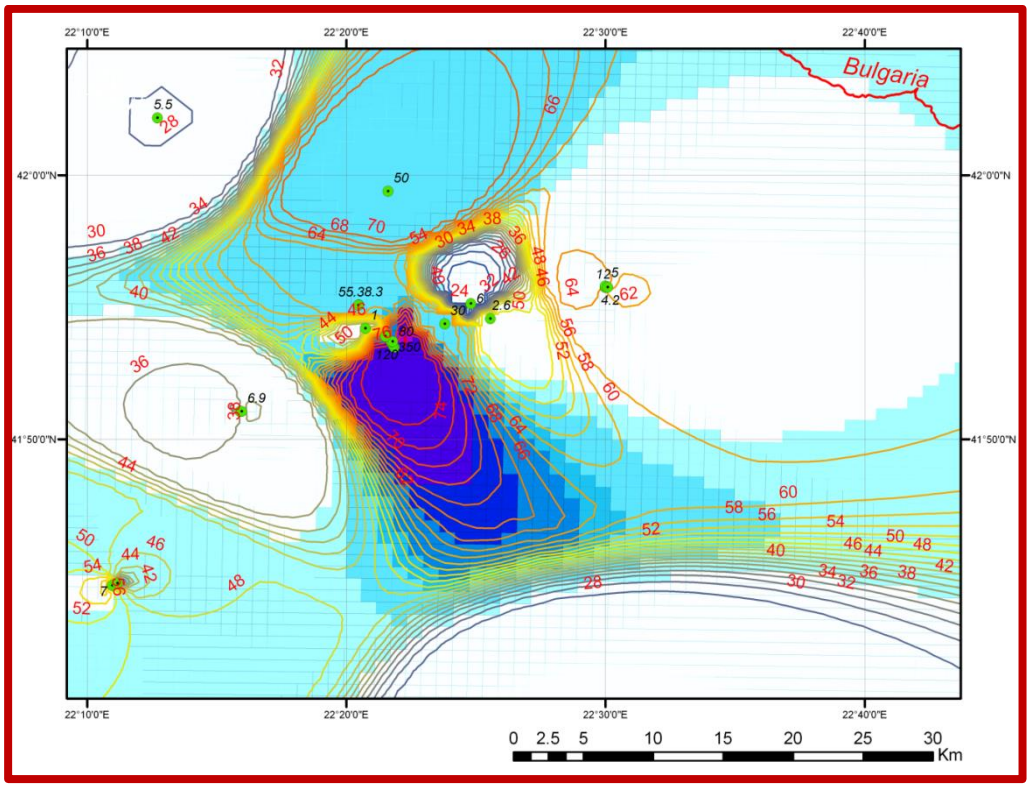

Figura 6 : Zoom of overlap maps of flow (l/s) and isotherms (°C)

Inside the red box is shown the correlation between a high water flow and high temperature of the water.

2.5. Phase 5. Results and interpretation of geological and geothermal data

Geothermal maps were made using a particular type of interpolation (IDW interpolation) that can analyze the data having the slightest margin of error, so you have an excellent graphic representation of data available.

Geothermal maps shown below, represent the temperature distribution throughout the area examined, starting from the exact data available within the wells, we interpolate the other data in the surrounding areas.

POTENTIAL MAPS OF GEOTHERMAL ENERGY
IN REPUBLIC OF MACEDONIA

Map of isotherms (Temp °C) of thermal waters

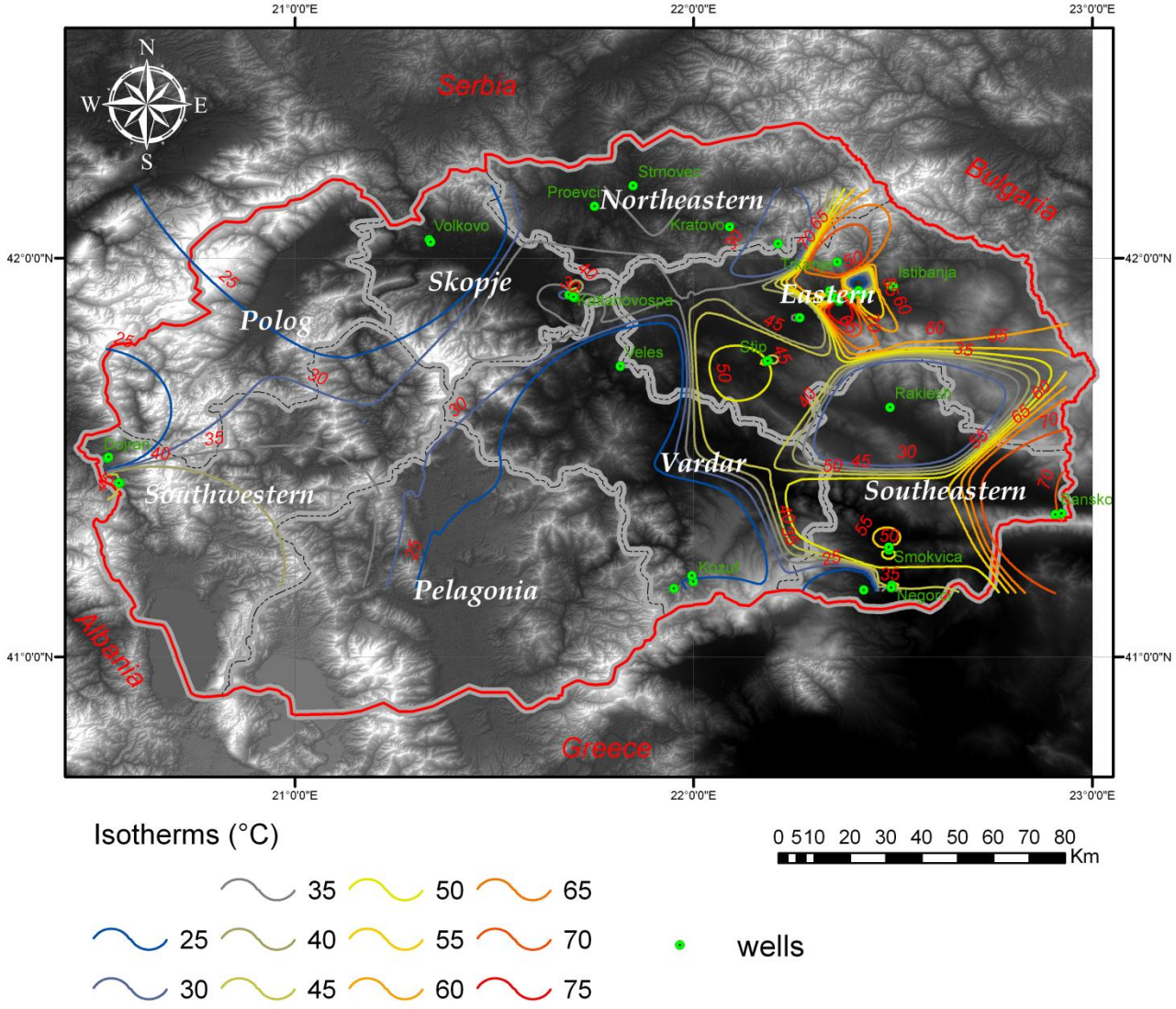

Figura 6: Map of isotherms of thermal waters

POTENTIAL MAPS OF GEOTHERMAL ENERGY
IN REPUBLIC OF MACEDONIA

Map of temperatures interpolation (Temp °C) of thermal waters

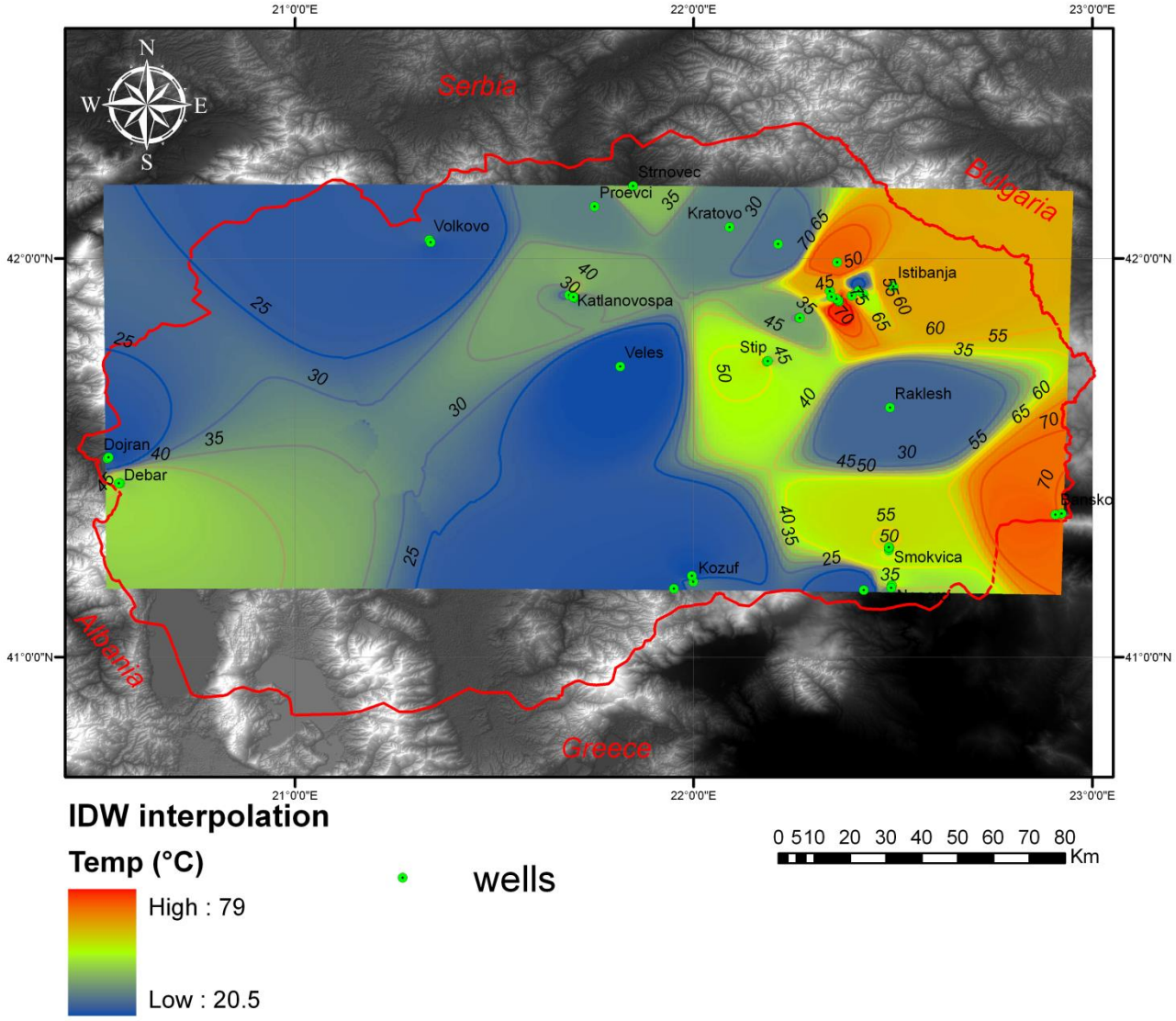

Figura 7: IDW interpolation of temperatures of thermal waters

From maps shown above, it is evident that the area most favorable from the point of view of the geothermal power, is the area east of the Macedonia. In this area temperatures of thermal waters reach 70 °C.

POTENTIAL MAPS OF GEOTHERMAL ENERGY
IN REPUBLIC OF MACEDONIA

Map of flow (l/s) interpolation of thermal waters

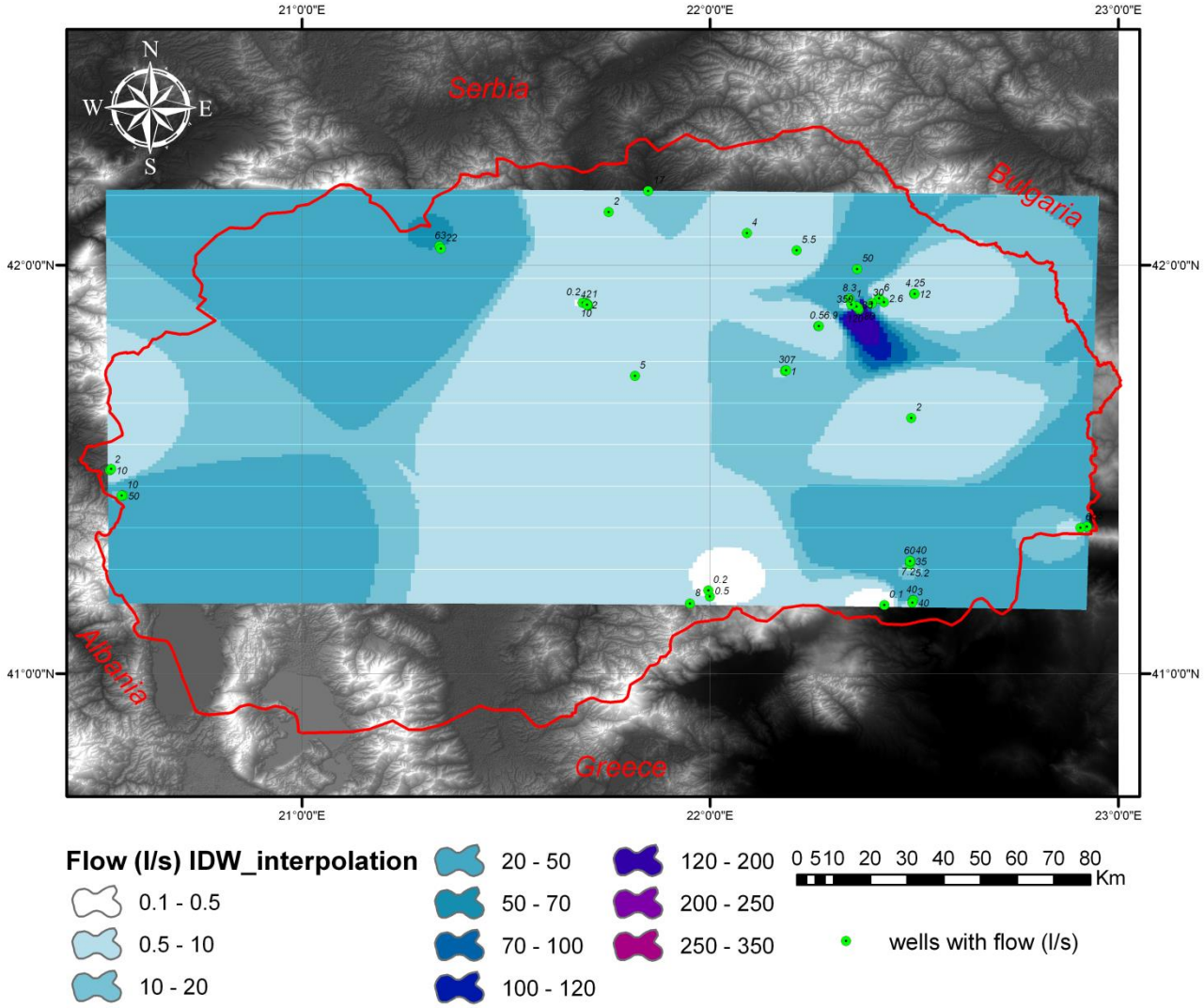

Figura 8: Flow (l/s) IDW Interpolation

3. Conclusion

The graphical representation of the geothermal maps set out above allows a direct evaluation of areas most important from the point of view of the geothermal resource.
Using the GIS program, is possible to press a button on a selected area (eg a well) and consult all the data available from the table attributes, such as temperature data at various depths.
Another peculiarity of the GIS is that allowing to continually add new information to the maps already made in order to make more precise the qualitative estimation of data.
Geothermal maps made for Macedonia are characterized by a paucity of data, they represent a qualitative estimation of geothermal energy.