Recoverable Thermal Energy for Geothermal Power Production in the Denver Basin, Lower Cretaceous Formations

Anna M. Crowell (anna.crowell@my.und.edu) and William D. Gosnold (will.gosnold@engr.und.edu)
University of North Dakota
Harold Hamm School of Geology and Geological Engineering

UND Geothermal Laboratory
The University of North Dakota

Abstract

The volumetric approach for assessing the recoverable geothermal resource of sedimentary basins, where the volume of the target resource is determined by calculating the average thickness of the formation and determining where the temperature of formation waters is within the desired range, has been applied to Lower Cretaceous age formations in the Denver Basin.

The amount of energy a binary power plant can produce is determined by several factors, such as working fluid, recovery factor, and temperature of the resource; thus, heat in place estimates were calculated for target temperature ranges, listed here in MWh; 90°C and up = 1.46×10^{12}, 100°C and up = 1.07×10^{12}, 110°C and up = 8.38×10^{11}, 120°C and up = 5.92×10^{11}, 130°C and up = 3.31×10^{11}, and 140°C and up = 8.75×10^{10}.

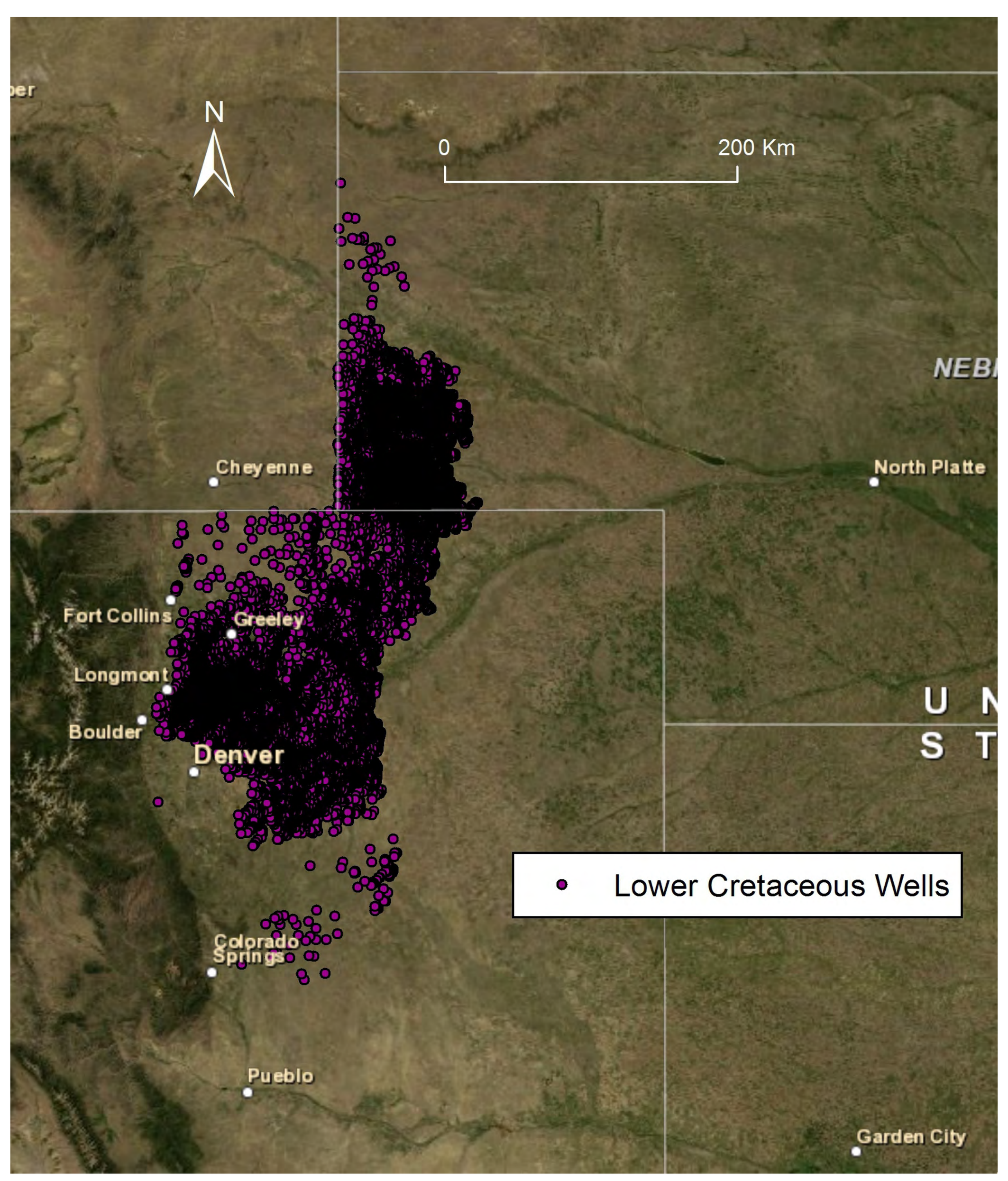

Figure 1 – Locations of oil and gas wells producing from Lower Cretaceous formations.

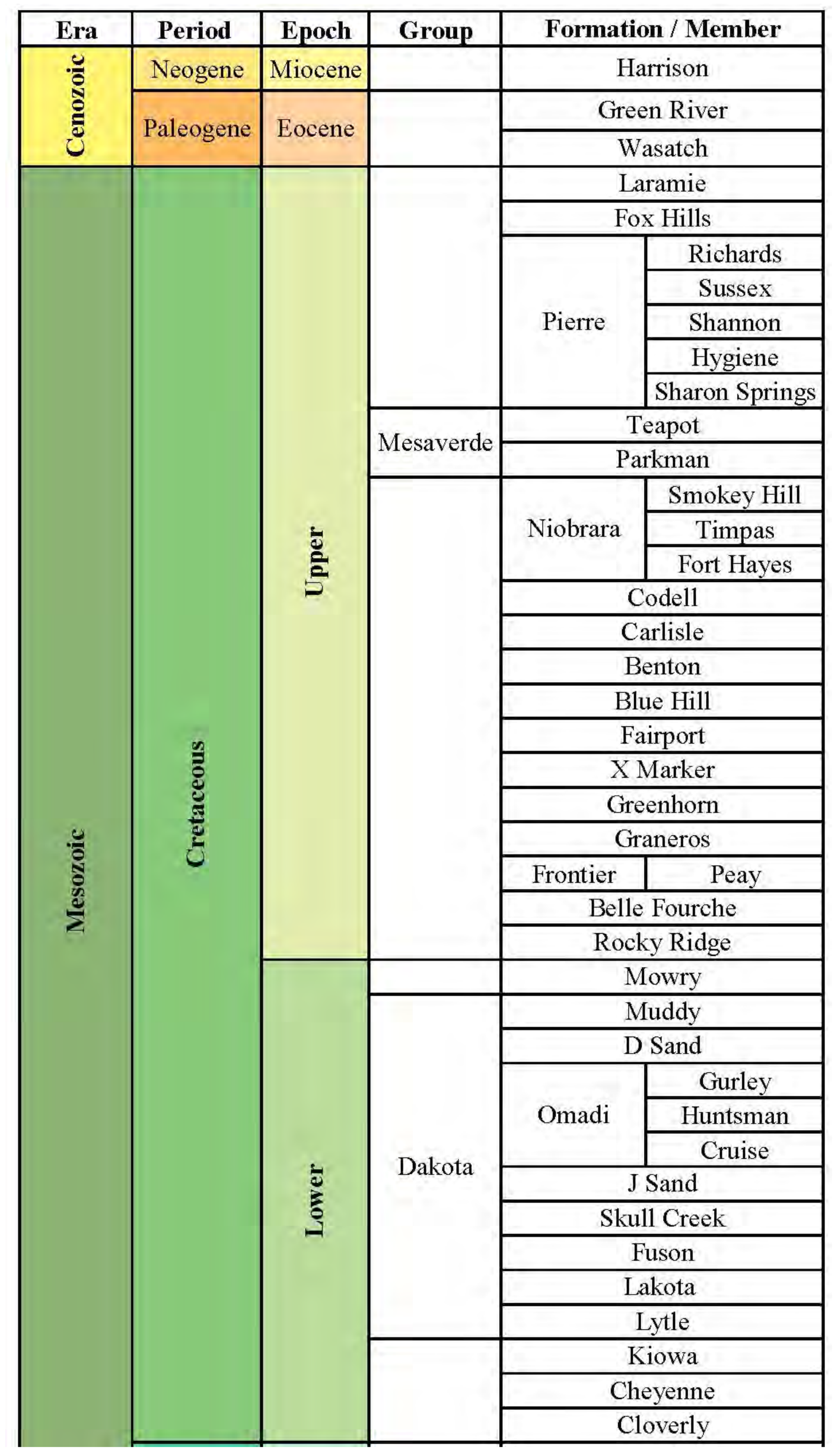

Figure 2 – Stratigraphic column showing the oil and gas producing formations used in this BHT analysis.

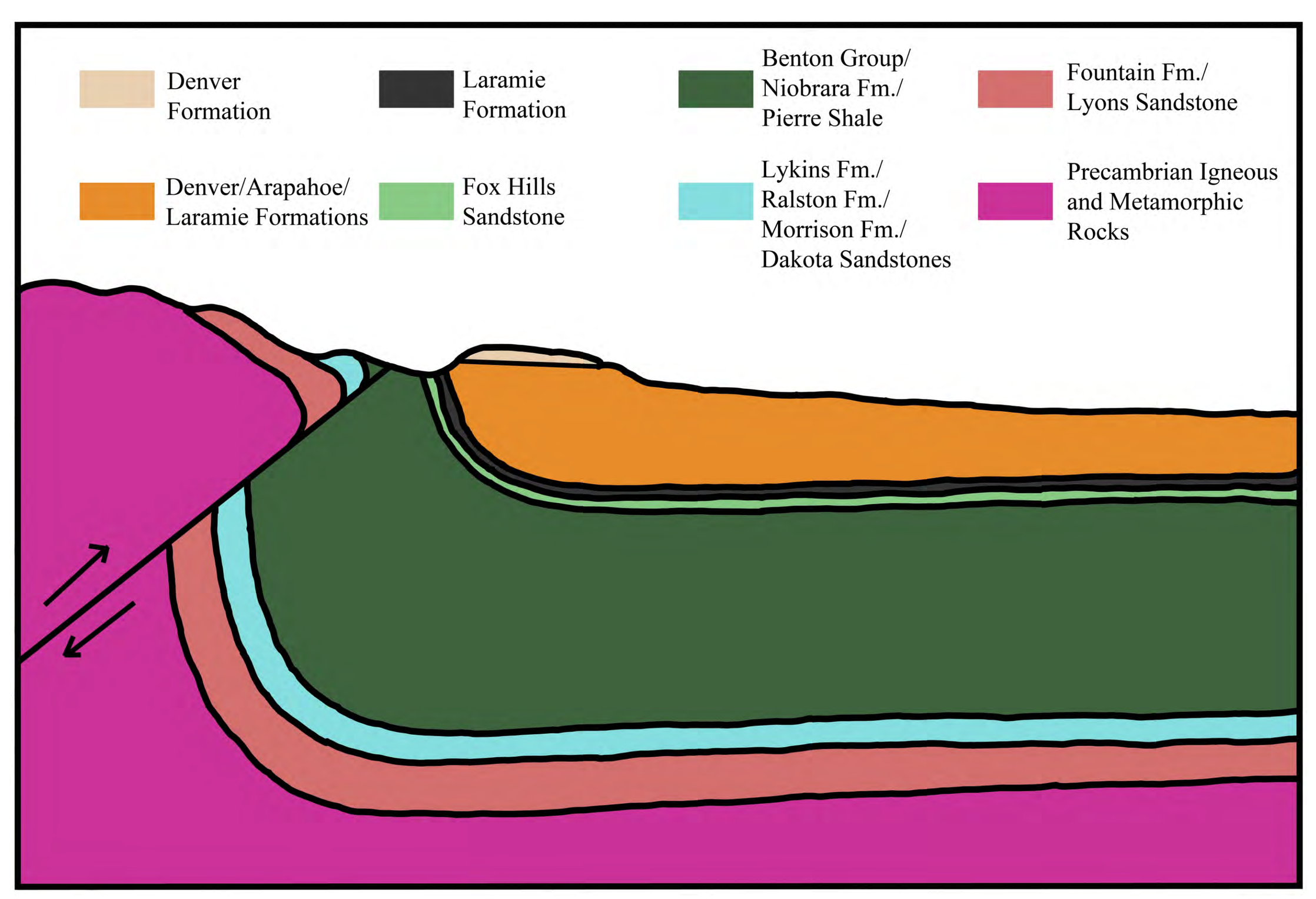

Figure 3 – Cross section of the Colorado portion of the Denver Basin, showing the Golden Fault, Colorado Piedmont, and Oil-producing sandstones of interest.

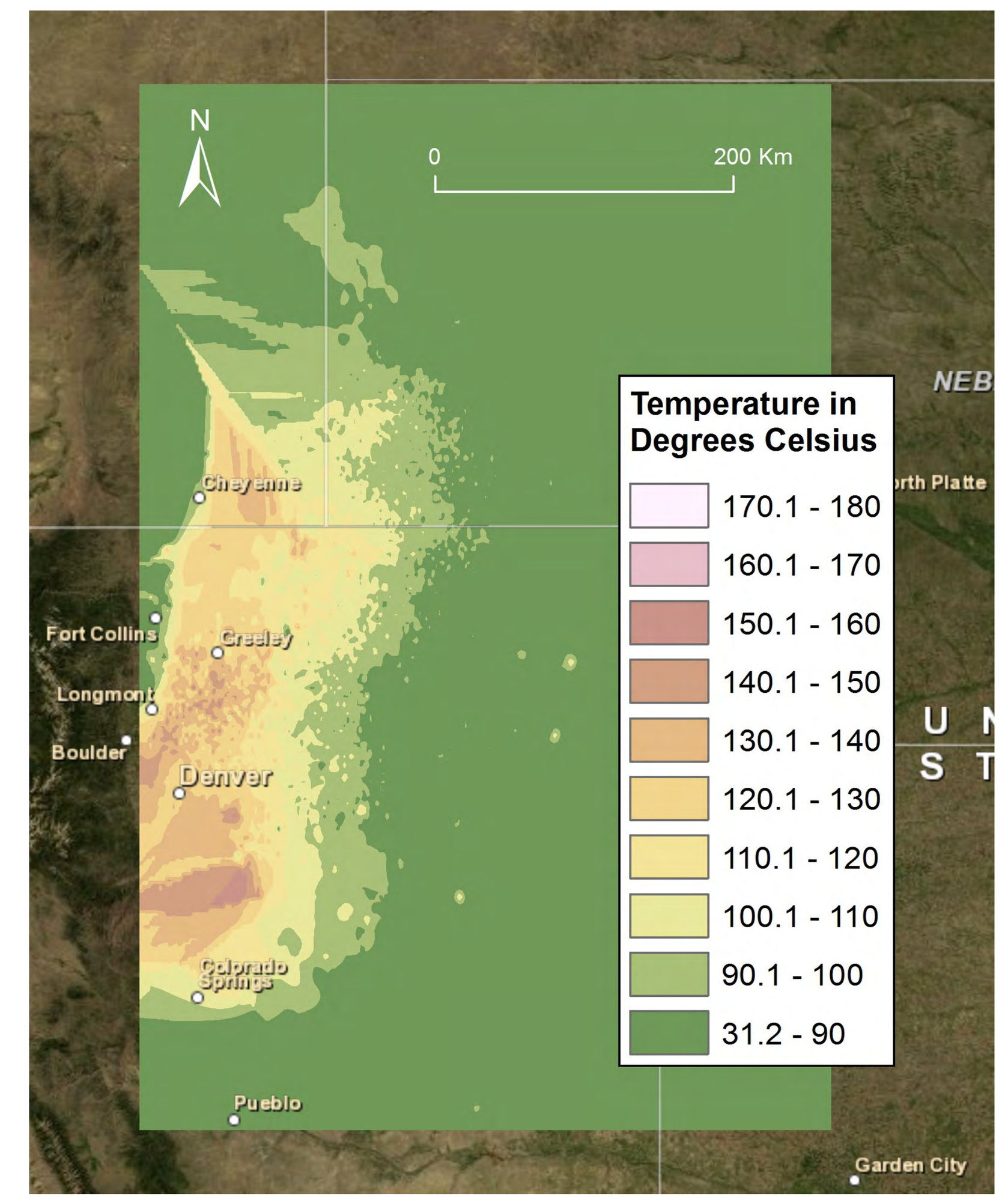

Figure 4 – The analysis begins. The bottom-hole temperatures are interpolated to obtain the surface area for target reservoirs of the appropriate temperature.

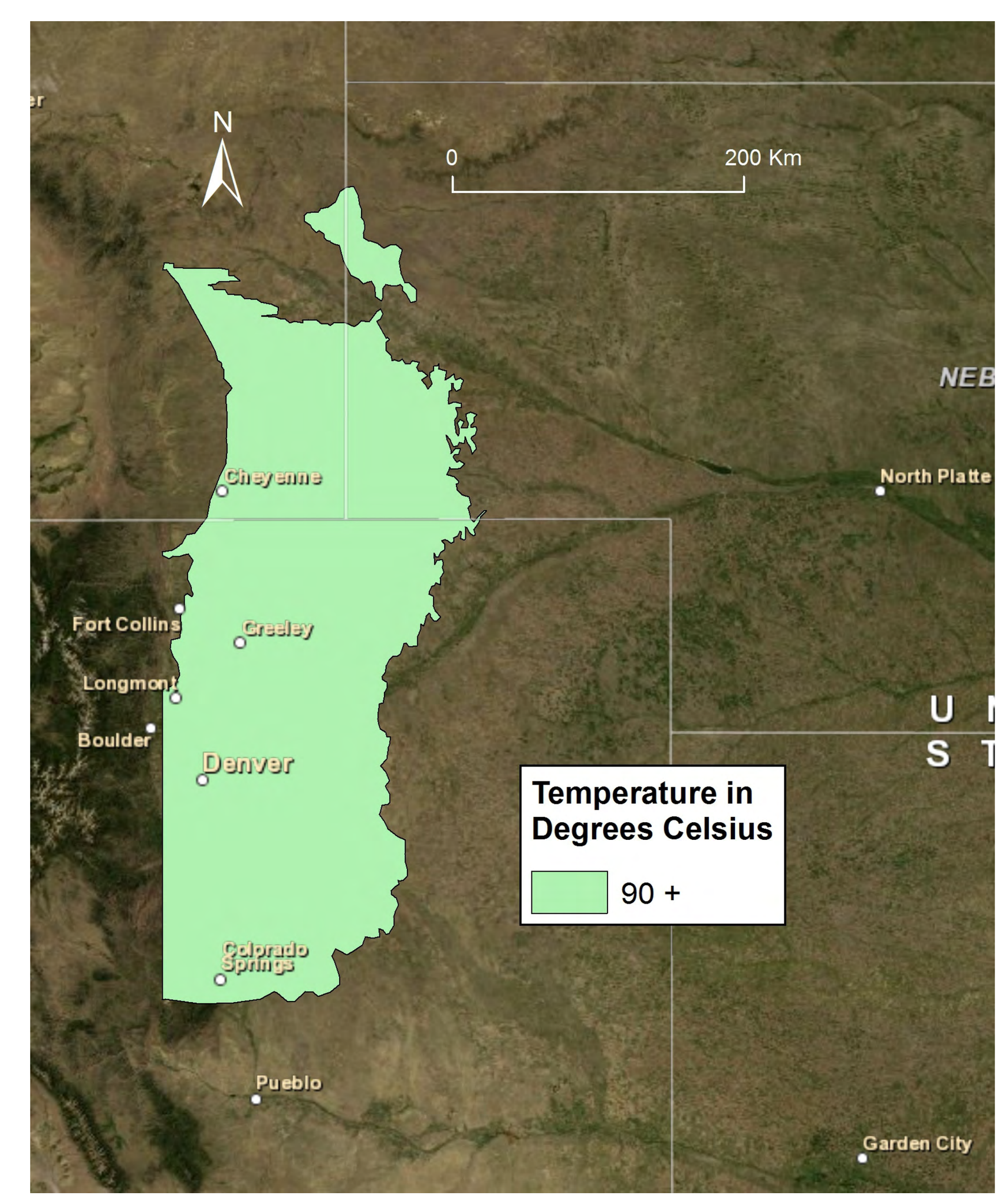

Figure 5 – Once we have the area and thickness, we can calculate volume and use the available heat equation to determine heat in place. The equation is $Q = \rho C_p V \Delta T$.

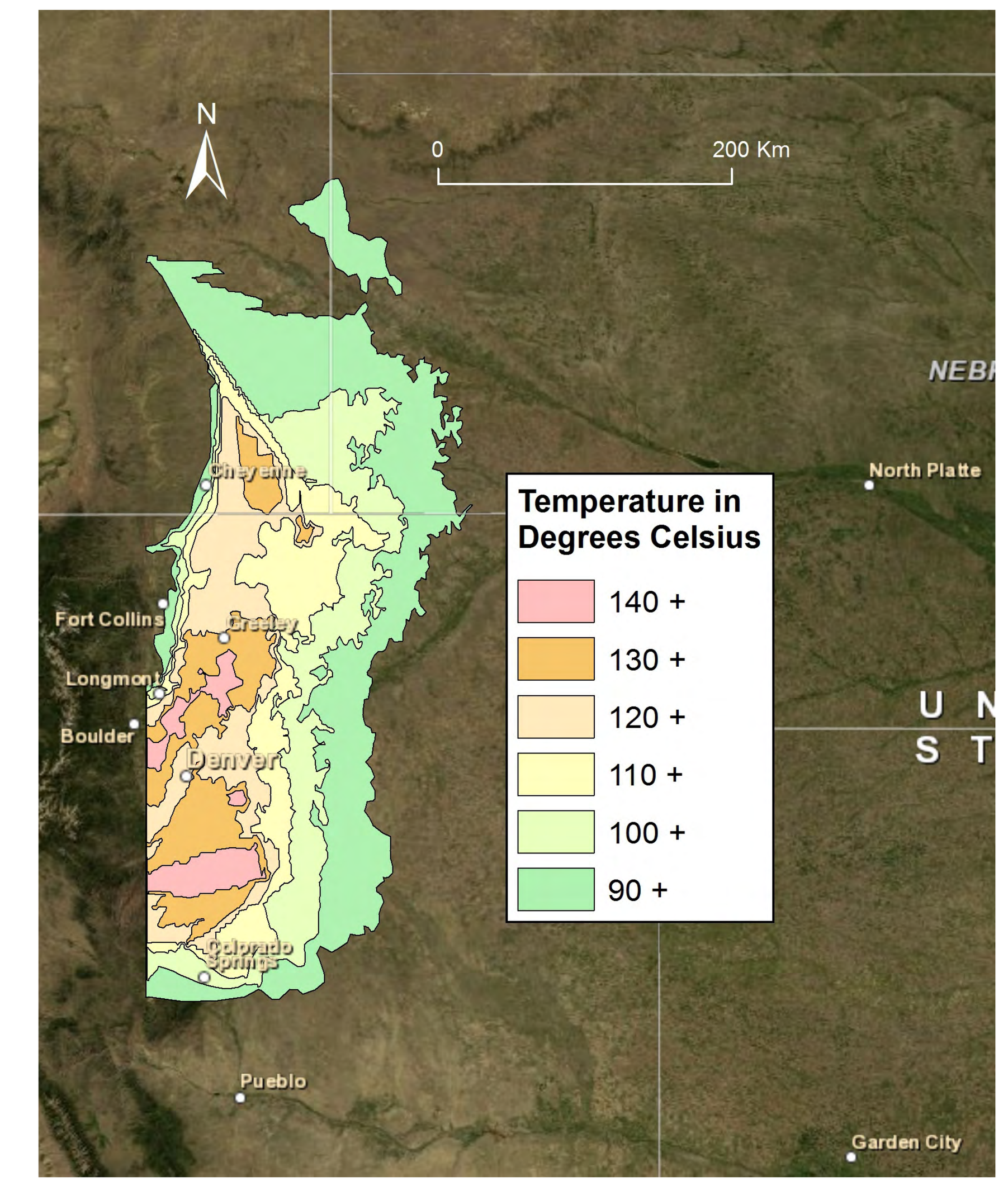

Figure 6 – The process is repeated for all reservoirs of the appropriate temperature ranges.

Temperature (°C)	Thickness (km)	Area (km²)	Volume (km³)	Average Depth (m)	Average Temperature (°C)	ΔT (°C)	Q (J)	Recoverable (J)	in MWh
90 +	485	73,449.20	35,622,862.00	2,092.00	109.4	69.4	5.23E+24	5.23E+21	1.46E+12
100 +	485	47,185.34	22,884,889.90	2,270.00	119.5	79.5	3.85E+24	3.85E+21	1.07E+12
110 +	485	33,079.77	16,043,688.45	2,389.00	128.7	88.7	3.01E+24	3.01E+21	8.38E+11
120 +	485	22,213.80	10,773,693.00	2,432.00	133.3	93.3	2.13E+24	2.13E+21	5.92E+11
130 +	485	12,128.41	5,882,278.85	2,430.00	135.5	95.5	1.19E+24	1.19E+21	3.31E+11
140 +	485	3,084.67	1,496,064.95	2,469.00	139.4	99.4	3.15E+23	3.15E+20	8.75E+10

Table 1 – The calculated areas, thicknesses, volumes, and recoverable heat in place for the Lower Cretaceous formations. The thermal properties of sandstone were used in our calculations.

Conclusion

The Lower Cretaceous formations, including the "D" and "J" oil producing sandstones, have tremendous capacity for geothermal heat production. With a target temperature of 140 degrees Celcius, the recoverable energy is 8.75×10^{10} MWh, which is enough energy to power 43.75 trillion homes.The United States Census Bureau lists the number of homes in 2011 at 132,312,404.