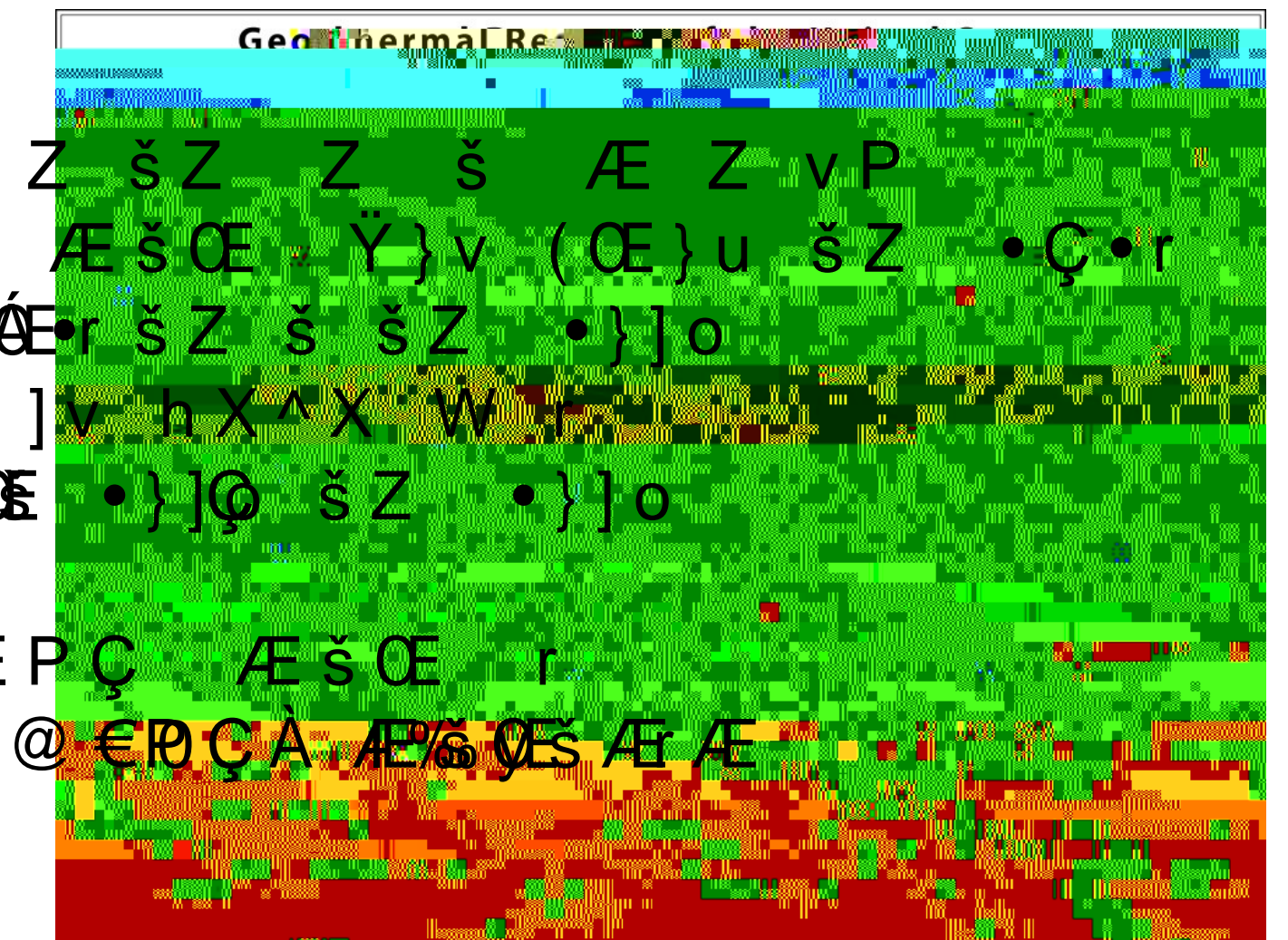


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Specific Objectives

- Develop mathematical model to estimate heat extraction from closed loop geothermal systems that are characterized by
  - Large aspect ratios, i.e., large length/diameter ratios, presenting challenges to numerical calculation
  - Time scale of years
  - Complex physical properties

Case Study InnerGeo U.S. Patent 8,991,488 B2



Table 1. Summary of Geometric and Operating Parameters

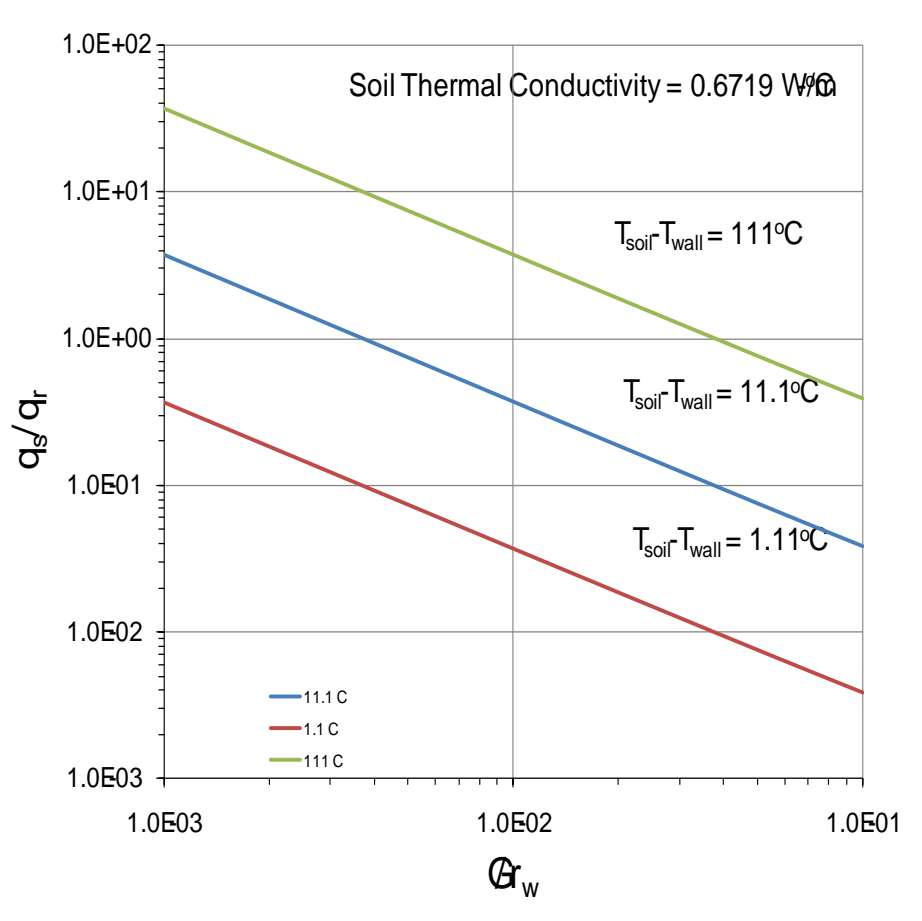
Geometry	
Well diameter:	17 in
Injection tube:	8 in
Production (heated water) tube:	3 in
Heated tube section (horizontal):	5280
Operating condition	
Feed water:	200 F
Production water:	350 F
Flowrate:	1000 gallon/min

QuasiSteady State WaterSide Heat Transfer

- Water-side heat transfer
  - Heatload and overall heat transfer coefficient needed
    - $\dot{M} L \epsilon 3 D_b F D_b = 20.4 MW_{th}$
    - $7_a L \dot{M} (\# i 6_s \lambda) = 201.3 W/m^{\circ}C$
  - Tube heat transfer coefficient water properties
    - $0 QL r \grave{a} t u 4 A^{\#} 2 N^{\#}$
    - $7_a = 2,117 W/m^{\circ}C >> 201.3 W/m^{\circ}C$
- Water-side can deliver heat transfer needed

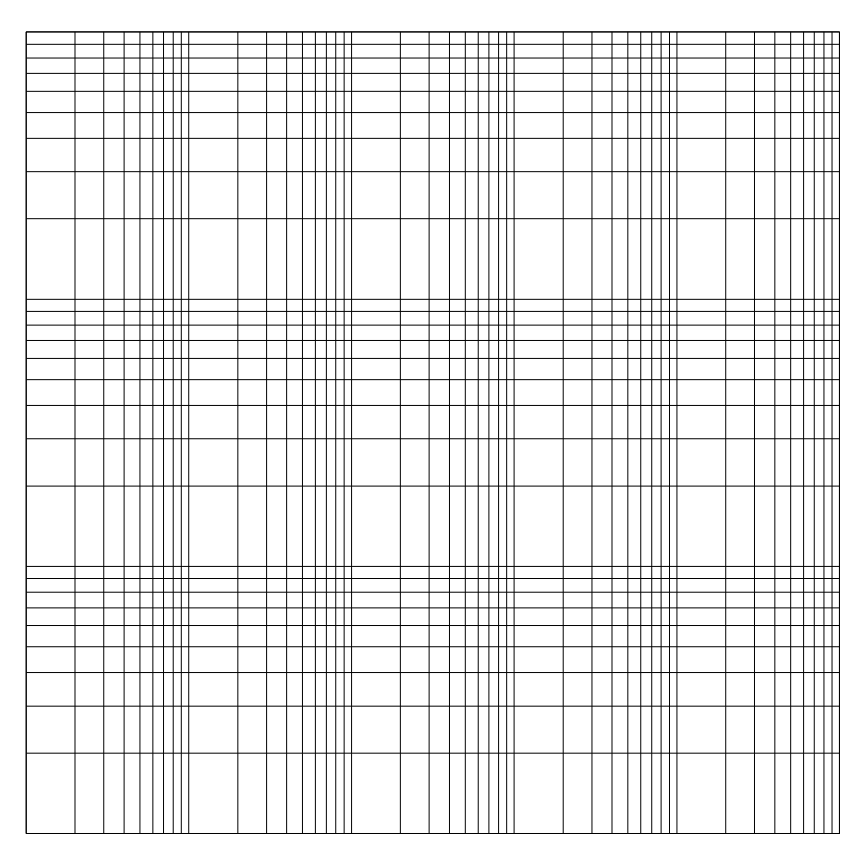
QuasiSteady State SoilSide Heat Transfer

- Soilside
  - Heat transfer from soil to wall
    - $\dot{M}_s L t \epsilon . G_s \epsilon_{so} F \epsilon_s ; \dot{Z} \cdot N$
  - Thermal penetration length
    - $\delta_{\Delta T} = r_p$



Line Source Analysis

Soil Temperature Requirements



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 decreases with increasing  
 heat rate extraction

heat rate extraction