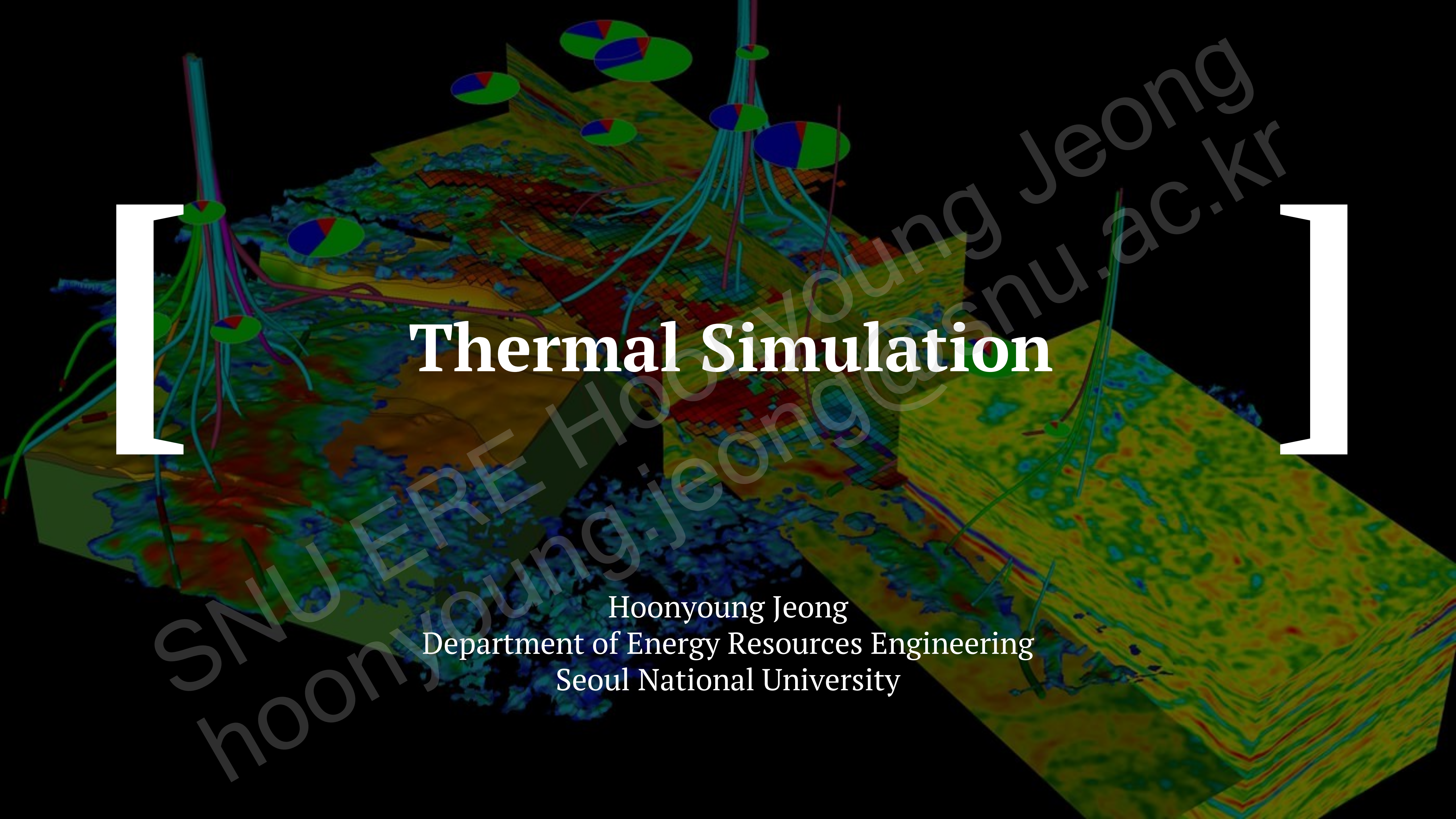

Thermal Simulation

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Energy Conservation Equation

- In a control volume, the accumulation rate of energy equals the external source rate of energy minus the transport (outflow by convection and diffusion) rate of energy through the neighboring control surfaces
- $\frac{\partial(\rho C_\psi)}{\partial t} + \nabla \cdot (C_\psi \rho u) = \nabla \cdot (D \nabla C_\psi) + S_\psi$
- If ψ is energy (e),
  - ✓ $\frac{\partial(\rho e_{\text{formation}})}{\partial t} + \nabla \cdot (e_{\text{flowing fluid}} \rho v) = \nabla \cdot (K \nabla T) + S_e$
  - ✓ T is the temperature
    - Conduction is driven by temperature difference
    - The temperature of the rock and the fluid at a grid cell is assumed to be same
  - ✓ $\rho e_{\text{formation}} = (1-\phi)\rho_{\text{rock}} \mathrm{SHC}_{\text{rock}} T + \phi u_{\text{fluid}} = (1-\phi)\rho_{\text{rock}} C_{\text{rock}} T + \phi \sum_\beta S_\beta \rho_\beta u_\beta$
    - u_β is the specific internal energy in phase β
    - $\mathrm{SHC}_{\text{rock}}$ is the specific heat (비열) of the rock
  - ✓ $\nabla \cdot (e_{\text{flowing fluid}} \rho v) = \nabla \cdot \sum_\beta h_\beta \rho_\beta v_\beta$
    - h is the specific enthalpy
    - $v = -\frac{k_a k_{r,\beta}}{\mu_\beta} \nabla (P_\beta + \rho_\beta g \Delta z)$
  - ✓ K is the thermal conductivity of the formation
    - $K = (1-\phi) K_{\text{rock}} + \phi K_{\text{fluid}} = (1-\phi) K_{\text{rock}} + \phi \sum_{\beta=1,2,3} S_\beta K_\beta$
  - ✓ The temperature at each grid cell is obtained by solving the energy conservation equation