Where are the diamonds? - *using Earth's potentials*

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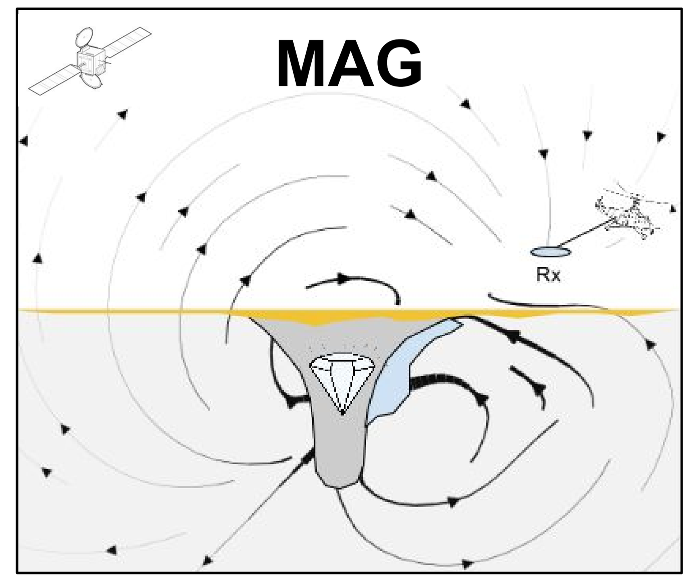
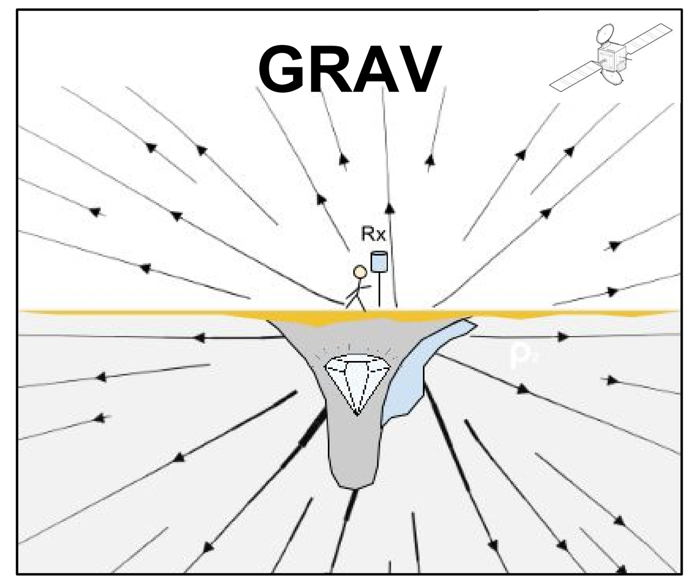
Magnetics and Gravity

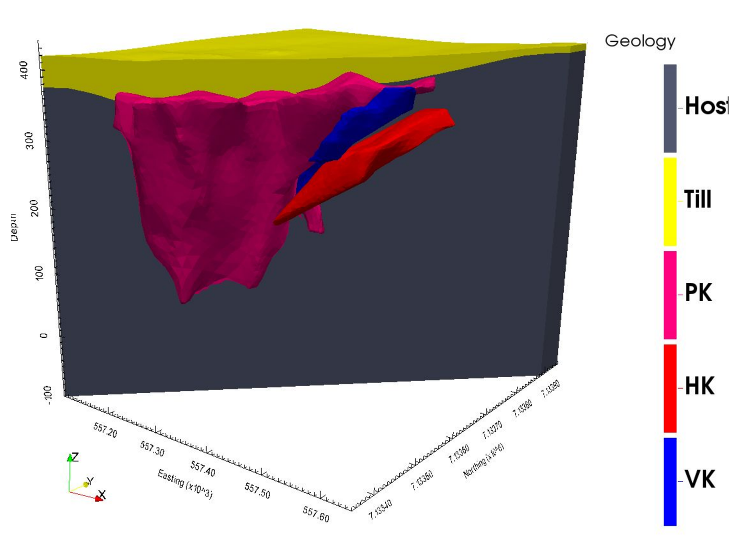
- **Why?** Kimberlite pipes originate from the mantle and carry diamonds to the surface.
  - They have very different physical properties (magnetic susceptibility, density) than the older continental rocks
- **How?** Variations in magnetic susceptibility and density distort the magnetic and gravitational fields
  - we can measure these variations
- **Response.** Magnetic and gravity field data are measured from the ground, small aircrafts and satellites.
- **Goal.** Solve inverse problems using the magnetics and gravity field data to image the kimberlite pipes and find some diamonds.



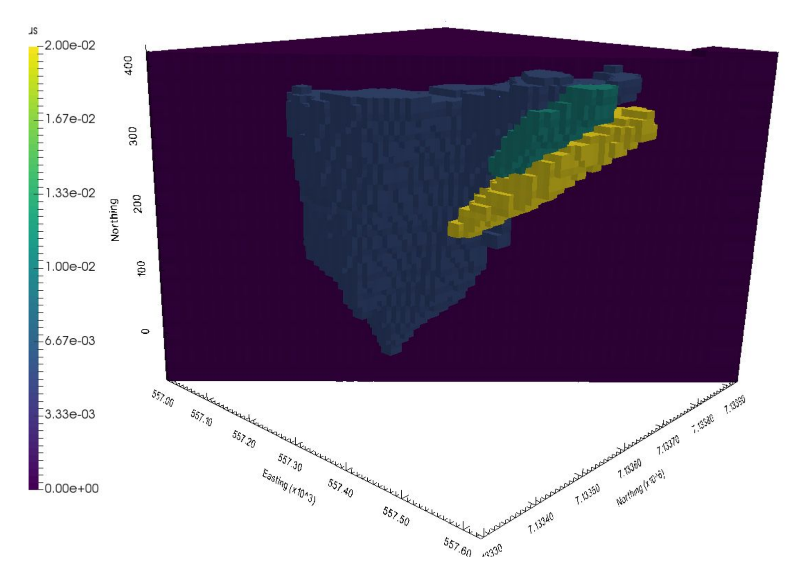


Model

- Diagnostic physical properties of kimberlites are: (a) high magnetic susceptibility (contain crystals of magnetite); (b) low density (a mix of pyroclastic and loose sediments). Not all kimberlite rocks are born equal:



	Susceptibility	Density
PK	Low	Very Low
HK	High	Mod
VK	Low	Low
Till	None	Low
Host	None	High



Physics

- Governing Equations:

MAG $\mathbf{b} = \frac{\mu_0}{4\pi}\int_V \mathbf{M}\cdot\nabla\nabla\left(\frac{1}{r}\right)dV$

$\mathbf{M} = \mu_0\kappa\mathbf{H}_0$

Assuming an induced magnetization:
κ: magnetic susceptibility (SI),
H_0: Earth's Field (nT)

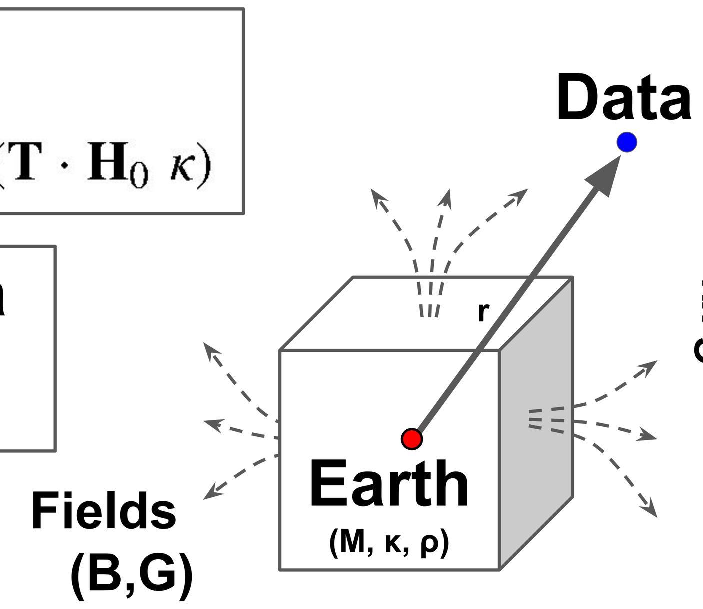
GRAV $G(r)_z = \gamma\int_V \rho(r)\left(\frac{z-z_0}{|\vec{r}-\vec{r}_0|^3}\right)dV$

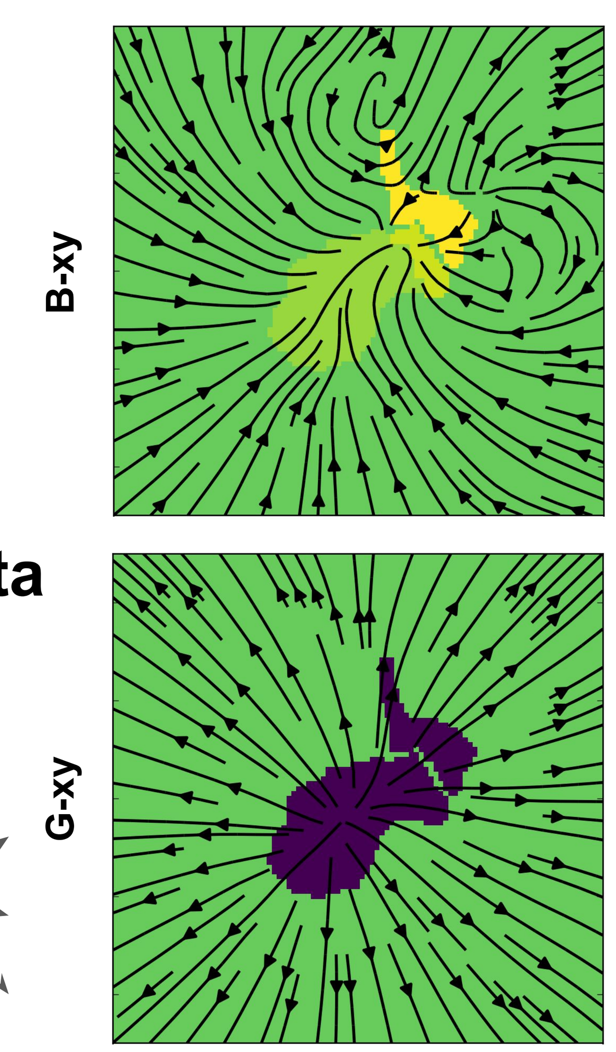
ρ: density (g/cc)
γ: Newton's constant

- Solving the integral analytically for rectangular prisms gives a linear system of equations:

MAG Data
$\mathbf{b}^{TMI} = \hat{\mathbf{H}}_0\cdot(\mathbf{T}\cdot\mathbf{H}_0\ \kappa)$

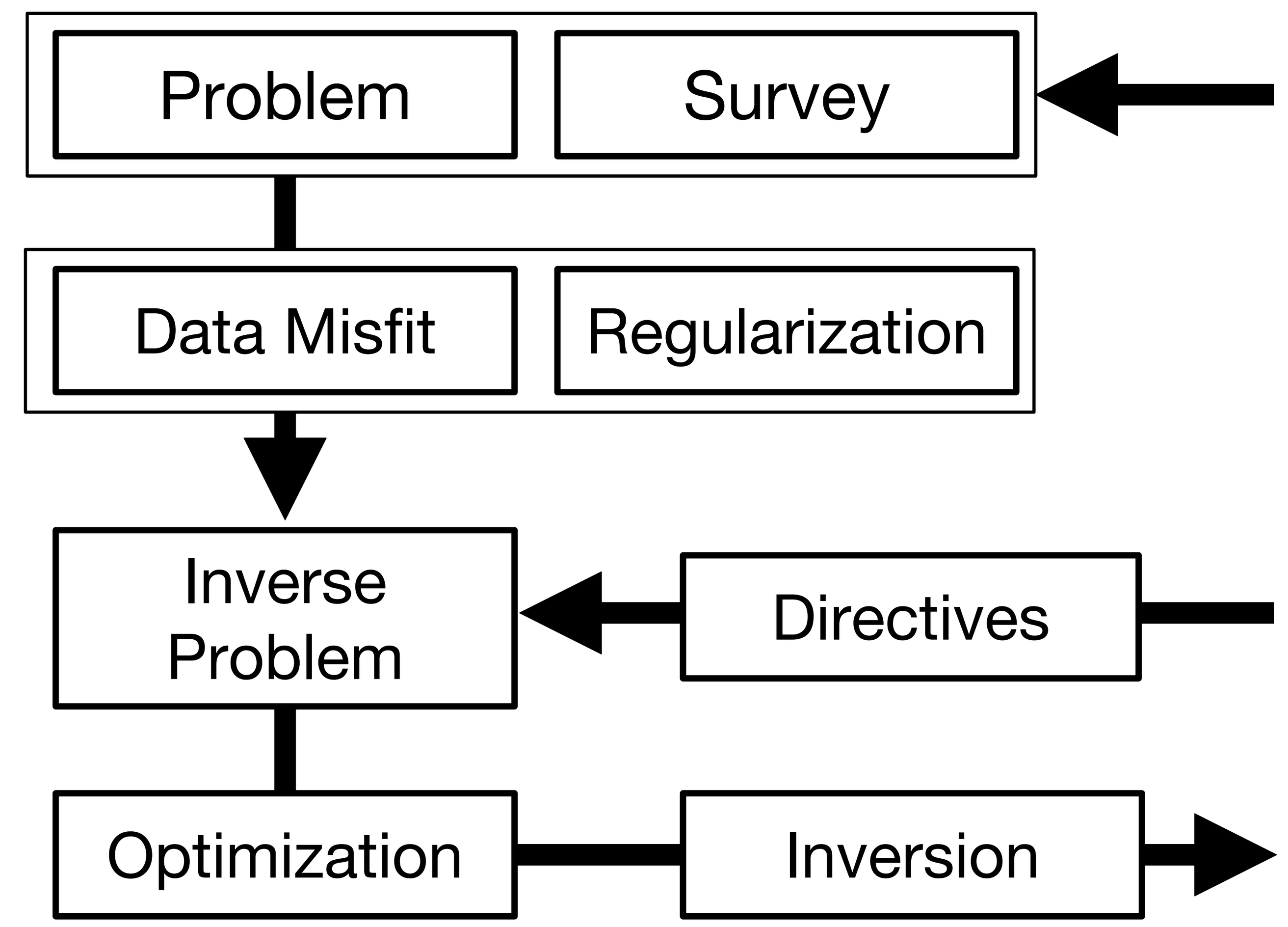
GRAV Data
$\mathbf{d}_z = \mathbf{G}_z\rho$

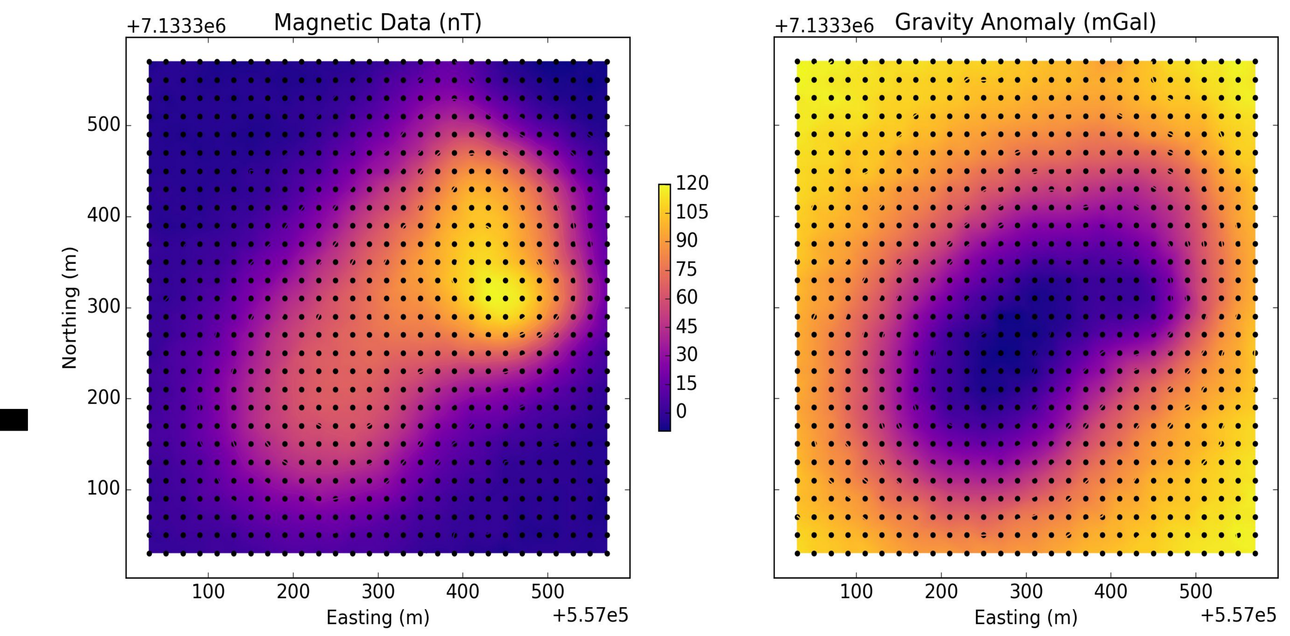




Inversion Implementation

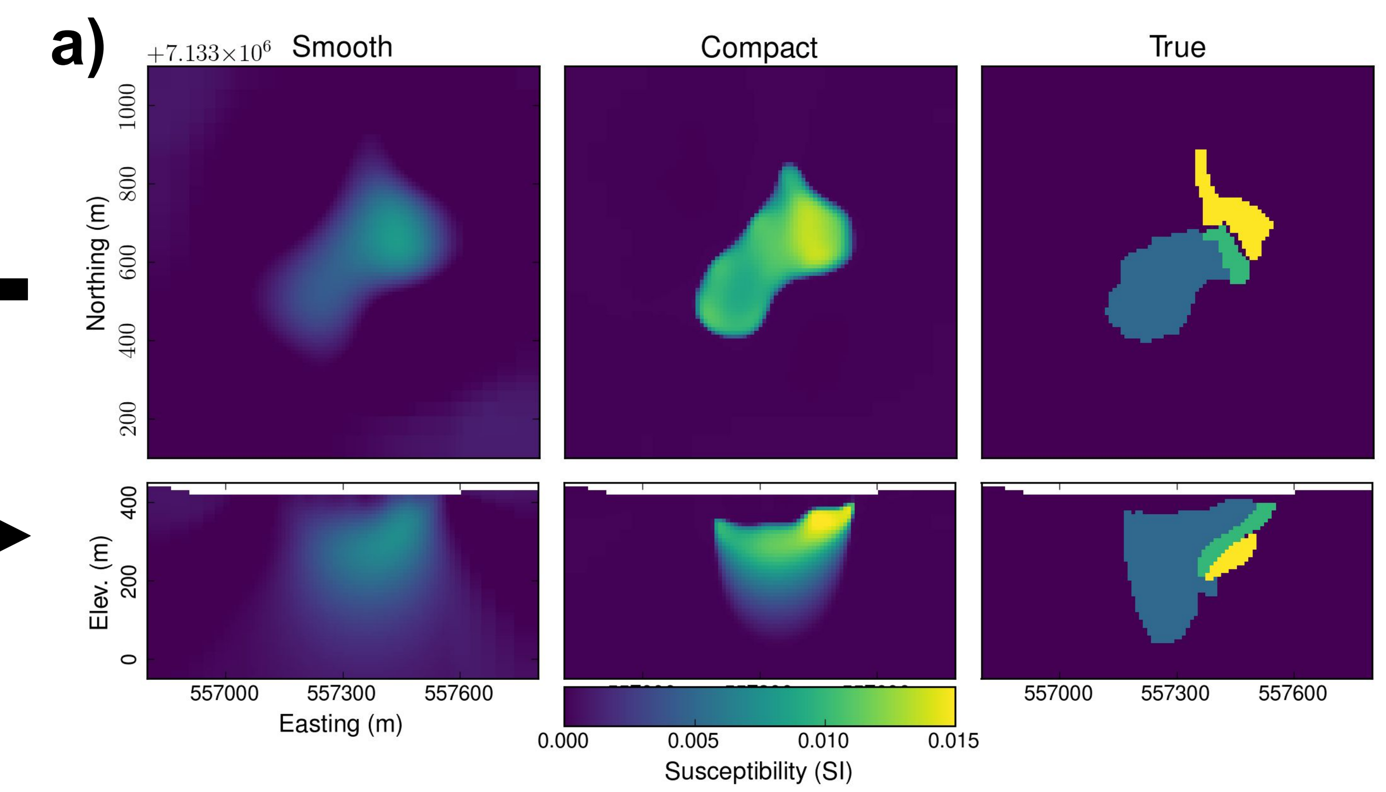
- Inverse problems have a lot of moving pieces - so we modularize the steps.
- We solve it iteratively with a robust mixed-norm regularization using a SimPEG-Directive
- Data simulation of a typical airborne (MAG) and ground (GRAV) survey with 5% random Gaussian noise added.

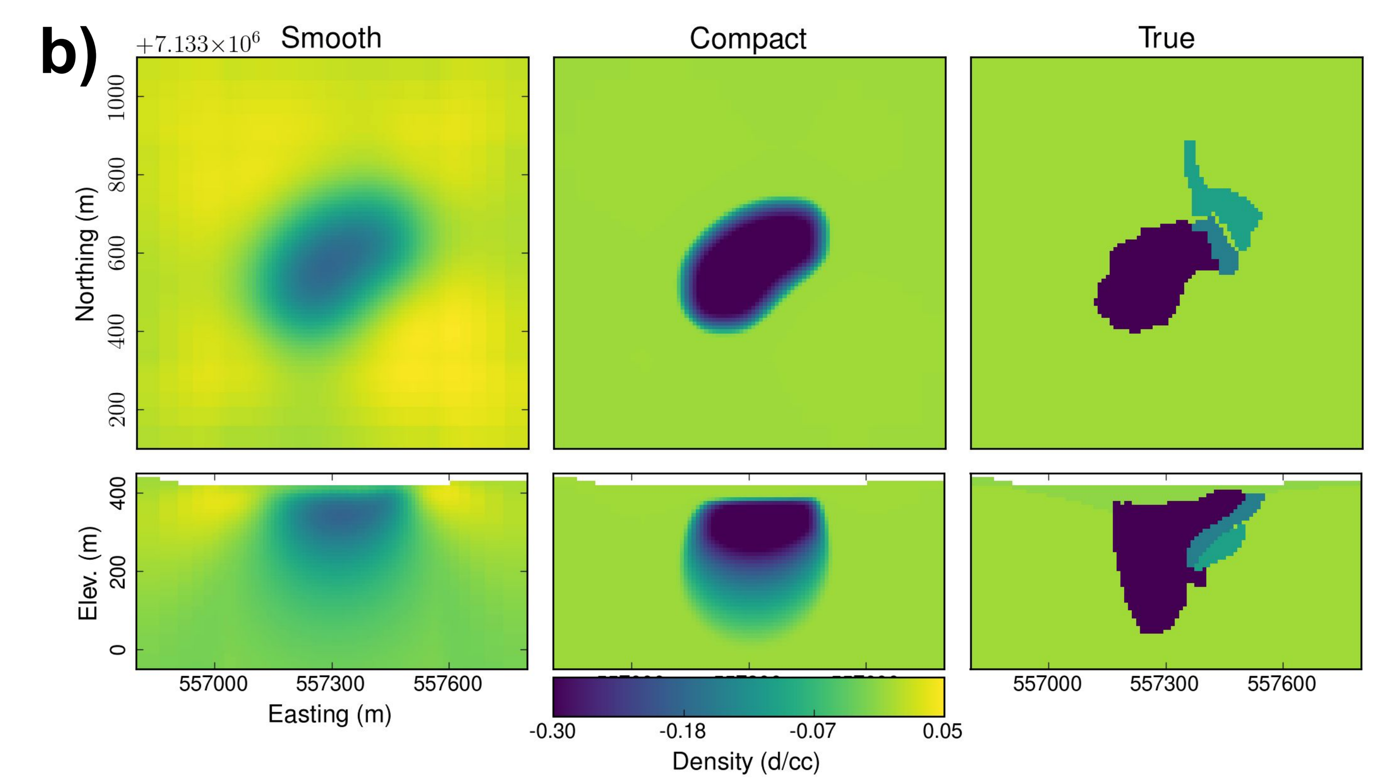




Results

- Figure a) and b) presents sections through the recovered susceptibility and density models respectively.
- The left panels show the inversion result using a smooth l2-norm regularization, compared to the middle panels using our mixed lp-norm regularization: **simpler, more compact and at the right depth**.





Summary

From the recovered density model, we can characterize the overall shape of the kimberlite, and from susceptibility, we can start to differentiate between the various rock units ... and narrow down the search for some diamonds

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