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The construction of sparse models of Mars' crustal magnetic field

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The crustal magnetic field of Mars is a key constraint on Martian geophysical history, especially the timing of the dynamo shutoff.
Maps of the crustal magnetic field of Mars show wide variations in the intensity of magnetization, with most of the Northern hemisphere only weakly magnetized. Previous methods of analysis tend to favor smooth solutions for the crustal magnetic field of Mars, making use of techniques such as L2 norms. Here we utilize inversion methods designed for sparse models, to see how much of the surface area of Mars must be magnetized in order to fit available spacecraft magnetic field data.

We solve for the crustal magnetic field at 10,000 individual magnetic pixels on the surface of Mars. We employ an L1 regularization, and solve for models where each magnetic pixel is identically zero, unless required otherwise by the data. We find solutions with an adequate fit to the data with over 90% sparsity (90% of magnetic pixels having a field value of exactly 0). We contrast these solutions with L2-based solutions, as well as an elastic net model (combination of L1 and L2). We find our sparse solutions look dramatically different from previous models in the literature, but still give a physically reasonable history of the dynamo (shutting off around 4.1 Ga).