A Mathematically Perceptive Approach for the Classification, Coordination, Prioritisation and Selection of Drillhole Targets

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The opportunity to consider the potential of geothermal energy was presented to us in 2010. We have chosen to take the view that exploration and exploitation of this resource will evolve rapidly and that a sturdy knowledge of the nature of granite emplacement will play a central role.

A mathematically perceptive approach that coordinates the granite theme at several relevant scales can count and mark opportunities and their status with a view to developing a complementary mathematical modelling strategy.

The geothermal energy potential of a radiogenic granite body and its disposition as a conduit to deeper opportunity has been engaged with regard to both empirical and theoretical considerations.

Empirically, the application of geophysics to mineral prospecting has revealed geological insights that demand theoretical attention.

Theoretically, mathematical insight has been underutilised as a means to address both intrinsic and extrinsic qualities that are apparent in survey data.

Technologically, the acquisition, compilation, transformation and presentation of geophysical data has been impressive.

Commercially, the technological momentum has managed to overshadow analytic potential.

We wish to introduce and illustrate some aspects that have emerged as a consequence of our outlook and experience.

Keywords: granite emplacement, modelling, icosahedral division, continental facets, regional pic-cells, gravity anomaly, heat, confocal, PDE.

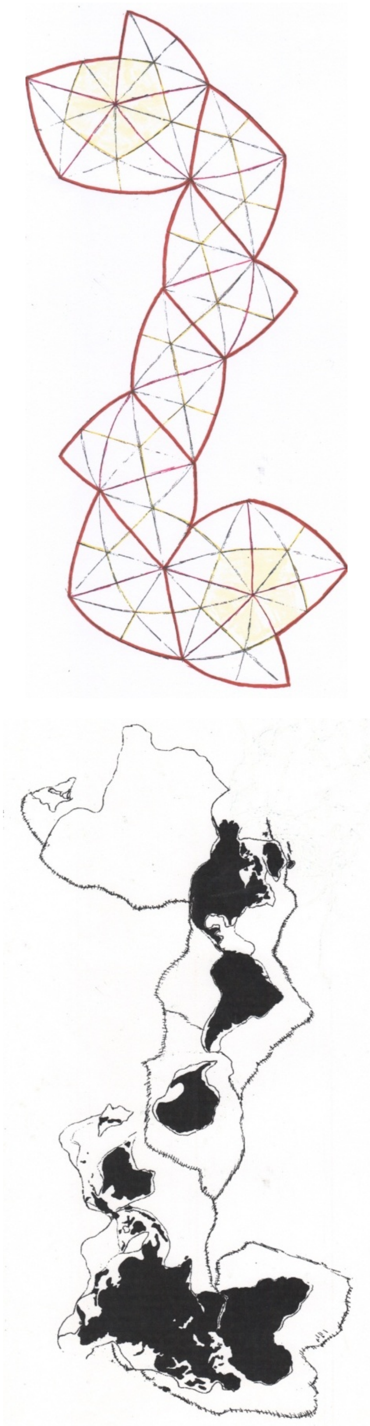


Figure 1 Map showing icosahedrally geometric basis for a plate tectonic projection of the Earth's surface

Coordination

Any process, involving combinations of models, tends to identify common attributes from which a recomposite form of the modelling strategy may emerge.

Mathematical analysis of geophysical information has emphasised the merits of geometric organisation in nature, and the value in taking advantage of it.

Empirical and theoretical examination of data may be coordinated by utilising a well-conceived frame of reference. Figure 1 illustrates icosahedral division of the lithosphere as a basis for modelling plate tectonics. Figure 2 illustrates subdivision as continental facets, based on the location and distribution of geological provinces that are classified as shield, platform, orogen and basin.

Further subdivision identifies a model based on 60750 regional pic-cells of the order of 50 kilometre extent.

Individual regional models may be constructed in this way, retaining lithospheric, atmospheric, near-neighbour and planetary reference.

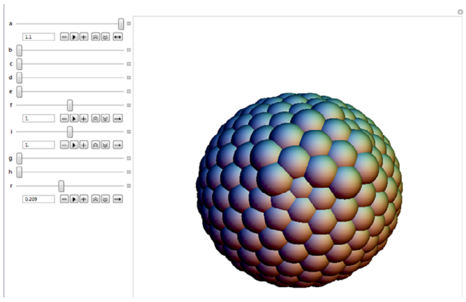


Figure 2 Continental Facets – developed using "Mathematica". The Australian facets are highlighted. 'Yilgarn' and 'Pilbara' can be identified on the western side. 'Eromanga', "Murray' and 'Gawler' form a triangular group to the South. The 'Gondwana' group is manipulated by controls on the left.

Granite Emplacement

The relationship between stratigraphic deformation and granite emplacement was given attention as a basis for the analysis of a seismic survey that was conducted at the Woodcutters Mine [8]. The magnetic and radiometric character of the stratigraphic column, in conjunction with the prominent gravity anomaly of the Rum Jungle granite complex was utilised for the purpose of quantifying the setting to some degree.

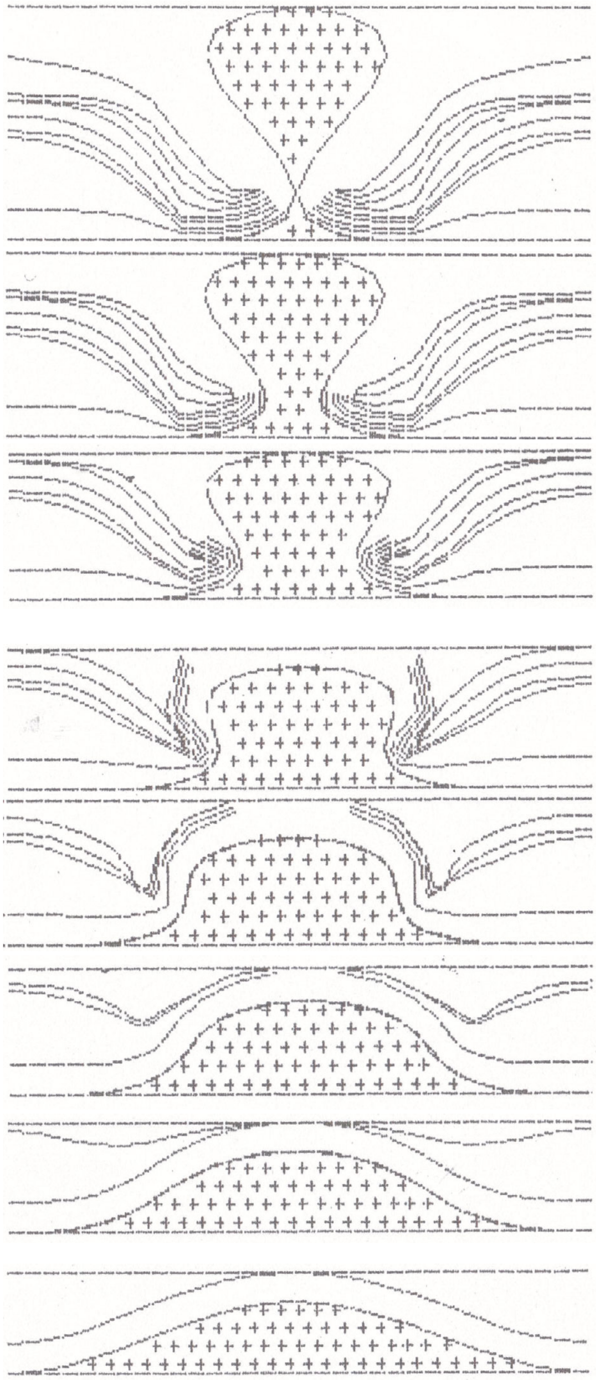


Figure 3 Diagram that depicts granite emplacement

Based on work presented by Ramberg [1], Stephansson [1,10], Fletcher [6], Berner, Ramberg and Stephansson [1] and Park [9], the simple geometric model, Figure 3 was developed in order to appreciate spatial considerations.

Deformed magnetite bearing stratigraphic units and the density contrast of granitic bodies create a very useful combination when applied to the interpretation of concealed or subsurface geology. Regional interpretation of the Pine Creek Geosyncline [8], the Tennant Creek Inlier [3] and many other examples are suggestive of a method that involves "regional pic-cells".

Gravity Expression

An expression for the gravity due to the variations on an elliptical theme (Fig. 5) using the convention in Figure 4 is:

$$g = GM_l \frac{r}{nf^2}\left(\left(r^2/(r^2 - f^2)\right)^n - 1\right) \qquad (1)$$

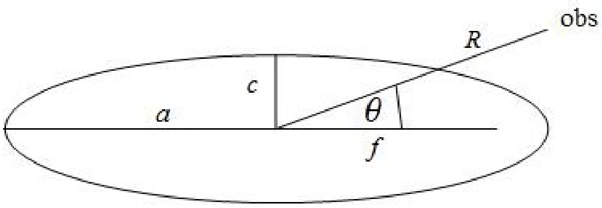
n	cross section
1	doublet
-1/2	elliptic
-1	circular

The magnetic equivalent of this expression was conceived by identifying the common attributes of different magnetic models [5] and was utilised repetitively in the analysis of drillhole surveys for the investigation of the extensive population of gold-bearing magnetite bodies at Tennant Creek [4].

An empirically derived basis for appreciating variation emerged from the repetitive application of this mathematical expression. In conjunction with the confocal property, the intrinsic form of an enclosure can be perceived as a function of its remote appearance.

The intrinsic form of an enclosure can establish requisite constraint when dealing with its internal character.

$$g = 2GM_l\left(\frac{r-\sqrt{r^2-f^2}}{f^2}\right) \qquad (2)$$



$r = Re^{-i\theta}$ G- Gravitational Constant

$f = \sqrt{a^2 - c^2}$ M_l - Mass per unit length

Figure 4 Theoretical gravity expression for an elliptical cylinder of infinite extent.

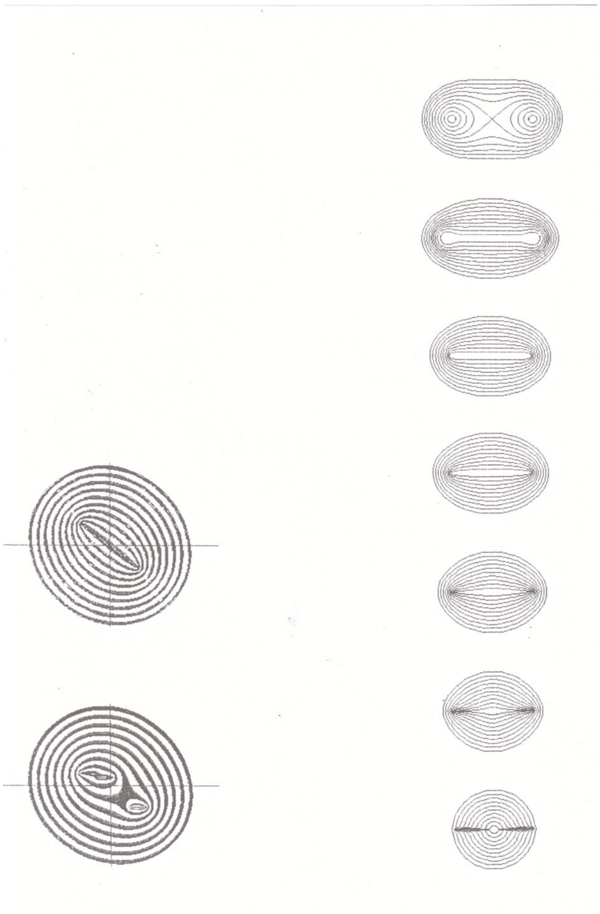


Figure 5 Confocal variation on an elliptical theme. The series on the right are derived from a common mathematical identity. A realistic confocal form is compared with that of the ellipse, on the left.

Form and the Confocal Property

Gravity and magnetic field character produced by an elliptic source with uniform internal density or magnetisation is a function of focal dimension. (See Fig. 4). This provides a particular analytic advantage when drill testing a concealed body of undetermined properties and volume.

The value of *n* in equation (1) is valid for (*n*=-1,-½,+1) and can be utilised with caution for the range (-1<*n*<1). Repetitive application to the analysis of drillhole magnetic surveys facilitated a strong empirical basis, worthy of further theoretical investigation.

Currently, the mathematical nature of heat and gravity are being examined in this way. Divergence from the ellipsoidal uniformity is taken toward ovoid and doublet, and to lenticular and spherical forms (Fig. 5).

It is anticipated that two diverse heat distribution themes will emerge, and this will reinforce the manner by which the vast population of granite bodies are explored and exploited.

Heat

Appreciation of geographic division and subdivision, granite emplacement, recomposite modelling, and their influence on strategic drillhole location and trajectory creates the basis for an analysis of the intrinsic properties of the potential resource.

Beyond this a perceptive knowledge of thermodynamic principles can benefit from recent developments in the exact solutions of a class of nonlinear heat equations.

$$u_t = u_{xx} + f(u)$$

The method of differential Gröbner bases is used both to find the conditions on *f(u)* under which classical and non-classical symmetries other than the trivial spatial and temporal exist, and to solve the determining equations for the infinitesimals [2,7].

The classical method for finding symmetry reductions of PDEs is the Lie group method of infinitesimal transformations. These must all have the Painlevé property for the PDE to be completely integrable – i.e. they must pass the Painlevé ODE test.

The non-classical method involves an assumption about the form of an unknown function, made to facilitate solutions of an equation. Recent developments in a particular class offer novel approaches to overcome major scalability and tractability problems through mathematical insight. This can be extended to 3 dimensions and developed as efficient algorithms. The formulation is sufficiently general to model a wide variety of physical characteristics such as temperature and space dependent heat reaction.

Concluding Remarks

Simultaneously objective and subjective, the modelling and analysis of remote and drillhole-derived information can induce a need for frequent adaptation of its theoretical base. In this presentation, we have attempted to honour the qualitative theoretical features, as assumptions are subjectively adjusted.

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