EXTENSIONS OF K.J. ROY'S AND R.E. ROADIFER'S SUBJECTIVE APPROACH TO OIL RESOURCE ESTIMATION

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Messrs. Roy and Roadifer, in separate papers, have proposed similar methodologies for making regional resource estimates. The idea underlying their approach is quite interesting, and may have extensions incorporable in larger schemes of estimation.

Roy's and Roadifer's approach adopts a simple "structural" model of deposit size, and uses the subjective feelings of geologists to generate probability density functions (pdf's) of the model parameters. A pdf of regional resources is approximated by using Monte Carlo simulation.

Specifically, the model they adopt is of the form

$$P = A \times T \times PR \times RF \times c_o \quad ,$$

in which

P = reservoir or deposit potential ,

A = reservoir or deposit area ,

T = formation thickness ,

PR = proportion of the formation which is resource ,

RF = recovery factor ,

c_o = constant .

We call this a "structural" model here because it is based on a physical or geological conception of resources, though a simple one. Examples of other structural models are those dealing with mineralization, sedimentation, migration and accumulation, etc. from first principles of physics and chemistry.

A second type of models are those of more purely empirical nature: regression, factor analysis, pattern recognition, etc. Thses models are not based on fundamental concepts of geological processes, but on correlations and simple relationships extracted from past data. Perhaps the best known use of statistical empirical models in economic geology is that of Harris (1965).

The procedure of Roy and Roadifer can be extended to use statistical models as well as structural models. The advantage of this extension is that statistical models (if carefully developed) may be better estimators of resource potential than either simple structural models or purely subjective estimation (e.g., Harris, 1973). Further, statistical models make use of a larger set of geological variables than simple structural models, and can be applied to other types of resources for which simple structural models are not available. In either case, probabilistic estimates of regional resources make prior to extensive exploration should be used as *a priori* probabilities rather than final estimates, and updated by subsequent exploration data using the normal Bayesian procedure.

A proposed extension ot Roy's and Roadifer's model is the following. Let some regression analysis have been performed on previous acquired data from geologically similar and extensively explored regions. Let the result of these analyses be expressed as a linear function of the common form

$$R = \underline{\beta}\ \underline{x} + \underline{e} \quad , \tag{1}$$

in which $\underline{x}$ is a vector of relevant geological variables,* $\underline{\beta}$ is a vector of regression coefficients, and $\underline{e}$ is a random error term with zero-mean and variance σ^2. If this analysis has been undertaken within a Bayesian framework, the terms $\underline{\beta}$ and σ^2 will have some joint pdf, $f(\underline{\beta},\sigma^2)$, which describes their uncertainty.

A priori, values of $\underline{x}$ for the region in question are uncertain. However, these values may be estimated subjectively by several geologists familar with the region, and may be coalesced by the method of Morris (1974). This leads to a joint subjective probability distribution of the geological variables, $f(x_1,...,x_n)$; or if the variables are assumed mutually independent, to a set of single variable pdf's, $f(x_1)$, ... , $f(x_n)$. Both Roy and Roadifer describe this process.

Inserting these pdf's of $\underline{x}$ in equation 1, and using an error-in-the-variables approach to regression and prediction, a probability distribution for R, f(R) can be generated which is a funciton of the uncertainty in $\underline{x}$ and in $(\underline{\beta},\sigma^2)$. The mathematics of this approach are currently

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* Some of these might be time of formation, environment of deposition or mineralization, subsequent tectonic activity, etc.

available in the literature of econometrics and statistics, and if certain well known families of distributions are chosen to model uncertainty in the variables $\underline{x}$ and $\underline{e}$, closed form solutions are available (Zellner, 1971). THis would make reversion to Monte Carlo methods unnecessary.

Subsequent exploration data could be included in the analysis using f(R) as a prior distribution, and updating as described in Kaufman (1974), or in other papers dealing with Bayesian sampling theory.

This total procedure might lead to more comprehensive regional estimates than any component of it in isolation, and may provide better *a priori* estimates than either simple structural models or purely subjective estimation.

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