A software tool for error quantification of subsidence calculations based on Monte Carlo Simulation

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One of the standard methods for the reconstruction of sedimentary basin history is subsidence analysis based on decompaction of the sediment record (e.g. Leeder, 1999; Miall, 1999; Einsele, 2000; Allen and Allen, 2005). The restored sediment thickness allows a plot of sediment accumulation rate versus time. Commonly, following parameters are used: thickness of stratigraphic layers, stratigraphic age, lithology, palaeowater depth, decompaction parameters, and physical properties. The variety of input parameters, each containing uncertainties have a major effect on the shape of the curves, and therefore errors at successive points on a subsidence curve are not independent of each other (Waltham et al., 2000). Potential error ranges of single parameters are well-known, but quantitative approaches of error estimations are rare and normally concentrated on specific related parameters (e.g. stratigraphic age and thickness, porosity and compaction).

Our programme combines 1D-subsidence calculations, including backstripping, with error quantification, based on the principles of a Monte Carlo Simulation (e.g. Metropolis and Ulam, 1949). The range of possible values is assigned to each parameter used. A random function chooses parameter values within these intervals and calculates a curve for every combination. Error ranges of input data are defined by the user with a minimum, maximum, and a most likely value for every parameter. The probability of a value to be chosen is either equal or follows a normal distribution. That means, minimum and maximum value define the borders of the distribution, where 99.7 % of probable cases are included and the most likely value is the maximum of the normal distribution curve. Therefore the most likely values has not to be the median of the interval. After a certain number of iterations this results in a curve from which errors can be quantified.

The more parameters incorporated into the Monte Carlo calculation (max. 11), the more runs are necessary to obtain constant results, i.e. after which run no significant changes occur. Calculations have shown that above 10 000 iterations upward, error variations appear to be negligible.

The programme can be used in basins where exponential decompaction is assumed (e.g. normally pressured basins, rift basins, pull-apart basins), because linear, power law equations or other types of assumptions are not integrated. Therefore for overpressured basins or very shallow basins the programme is not applicable.

Tests have shown that the change of one single parameter does not influence the errors significantly. It is rather the bulk of parameters, which have great influence. This programme provides the extension of the method to the full backstripping process (Hölzel et al. submitted 2006).

Allen, P.A., Allen, J.R.L., 2005. Basin Analysis, Blackwell Scientific Publications, Oxford, 549 pp.

Einsele, G., 2000. Sedimentary Basins - Evolution, Facies, and Sediment Budget. Springer, Berlin, 792 pp.

Hölzel, M., Faber, R., Wagreich, M., submitted 2006. Software for subsidence analysis including statistical error quantification. Computers and Geosciences.

Metropolis, N., Ulam, S., 1949. The Monte Carlo Method. Journal of the American Statistical Association 44, 335–341.

Miall, A.D., 1999. Principles of Sedimentary Basin Analysis. Springer, Berlin, 616 pp.

Waltham, D., Taberner, C., Docherty, C., 2000. Error Estimation in Decompacted Subsidence Curves. Bulletin of the American Association of Petroleum Geologists 84 (8), 1087–1094.