From a fast Climate Model to future Earthquake–Prediction and Microbeam Arrays

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Abstract

Standard methods in IODP can be optimized to achieve more at the same cost.
These include: A fast (acceleratd) climate model (CAM/CSM), better and new SST algorithms, improved fossil recognition if improved algorithms for MRI machines are made, earthquake predictions (sketch of aspects possible future algorithms might include) and arrays of ion–microprobe detectors probe for high–res semiautomated analyses.

Aspect 1: Fast climate model

One major task of paleoceanography/paleoclimatology is accommplished (environemntal changes, processes, understood, formulated as parametrizations overall correct), if we are able (1) to start a coupled ocean/atmosphere/land/ice model (T42 resolution) with an environment 5 Ma ago, (2) run it such that the known climatic and environmental fluctuations are met (overall) correctly (dust of the YD asteroid as boundary condition) and (3) the environment around 1850 (begin of industrialization) is met (overall) correctly approximated – of course not in the sense of a long–term weather forecast (impossible) but in the sense of "cold and warm years" (summer and winter conditions) as documented in icecores and IODP/ cores.
Technically this shall be achieved (experience of the author) by (1) accelerating ocean/atmosphere/land/ice models CAM/CSM by a reasonable factor (ideally 1000 or more) and (2) if that is achieved by running 3–5 Ma on a really fast PC, either built by the author or purchased from a company that uses a similar principle for speeding it up (factor 200).
When the model is fast enough interested persons can participate in testing and – if applicable – improving algorithms (organized comparable to IGCP341).

Aspect 2: Good environmental Reconstructions:

Prerequisite for all modelling issues are good SST– and environmental reconstructions.

This means: The SSTs of the author (Smolka, 2008b), based on pforams (summer and winter SSTs), shall be extended. In addition this method shall be employed for diatoms and radiolarians, e.g. in contrast to the existing SST methods for radiolarians and diatoms which are published by Smolka 2000 on the CD of the book to IGCP341. Extension and employment of diatoms and radiolarians (about one year) is scheduled when the model will do production runs, such as the last 10 000 years, the last 40+ K ideally the last 120 K (on a standard PC, depending on how fast it will be).
Conventionally (published, Smolka, 2000) diatom– and radiolarian based SSTs can be arrived at with an older method (only average temperatures, no summer– and winter–temperature).
Those who target SSTs with other methods (Ca/Mg; Alkenones, dinocyst communities and others) are welcome to contribute to syntheses (many time series and maps) to neogene and quaternary environments.

Aspect 3: Fossil recognition – if it works a Benefit to Society

Pioneers of the DSDP such as Carla Müller, Katharina Perch–Nielsen and Juliane Fenner and others do not exist in copy. Above SSTs require fossil recognition at a high resolution.
Marine microplankton is regarding the size comparable to single cells in humans (cells of the body but also undetected inflammations, infections, broken blood vessels, hidden cancers, hidden bacteria and the like). Currently MRI–based methods have a very low resolution (about nearly 1 mm). They run using FFTs at a very early stage, factually before processing. With FFTs at this early stage equation based, the resolution cannot be enhanced.
The author aims at obtaining the raw data, machine and coil geometries and other so known equations for electromagnetic waves (reflection, refraction, scattering and other) can be used, in connection with the technological parameters (coil characteristics, geometry) to process the data without any FFT involved. A success cannot be guaranteed. A limit might be the size (RAM) of the computers. It is however worth trying. Current status: Collecting equations. Raw data, with a high resolution, also regarding time, are welcome. MRI methods rely on hydrogen atoms. IODP cores are generally water–saturated. Thus the fossils would appear as "negative fossils": The correct shape – as documented by the water (hydrogen atoms) around them.

Future Aspect 4: Earthquake Predictions: They might become possible.

Formulated didactically compact: In industry earthquake–prediction is functionally operating since about 40 years. It includes the prediction of faults, waves, thrusts, everything resolved in time and in space. Testing is only required to check whether the calculations had been correct as part of the certification–processes (see the problems of the 787–plane and the reported cracks in a wing of the A380). In industry the lithology is simple: Aluminium and carbon against air. The study–area is also small (such as a wing of a plane). The lithology (data–distribution) is known in time and space.
The line is of course "to prevent an earthquake" (a fracture) but the methodology is the same.

Directly: If we know the geology in the study area and the boundary–conditions resolved well, both in space and in time (at least 1 cm resolution, most likely 1 mm) a solution might be approximated. This high data–resolution is necessary because, didactically, 1 mm of clay in the middle of 500 m basalts produces a completely different behaviour compared to 500 m "massive" basalts. Mylonite–zones show also a high variability in short distances. Thus if the data are known at a sufficient resolution, the processes (diagenesis, recrystallization, dewatering and other) are correctly formulated then earthquake prediction "is no problem". It is for a certain area "work", but it is – at least in principle – possible.
But (also for Nankai): This data–density we do not have and this data–density we most likely will not get – at least within a reasonable future.

Hopefully: As well as with climate change (neogene data of the world) in Japan we have an enormous dataset of earthquakes, thousands each year that any successful prediction–algorithm must meet. Whatever will be developed: <u>It can be tested</u> in "many attempts".
That is: Not waiting for "the one big" to test, but testing with the thousands many small earthquakes that occur in Japan each year including creep and the like: Whatever is done algorithmically: It can realistically be tested with reasonable efforts, e.g. by sitting at a computer.

To solve the issue in many small realistical steps over 15 or more years, the following approach, also using experience from hydrology (working and non–working grid–structures of groundwater models), appears sensible:

1) For any gridpoint of the study area all known properties and processes (diagenesis, de–watering and much more) are formulated, based on reasonably estimated data.
2) For each time–step, such as 15 or 60 minutes, processes known from mineralogy are included.
3) At each time–step (or most time–steps) microfractures, fractures and movements are calculated. This means (structure of FEM approaches): A remesh (and reassign of data) every timestep will be needed.
4) Given the very high resolution of lithological variation at thrust zones (see mylonites in outcrops) near and around fracture zones possibly nested grids are needed to handle the issue (memories(RAM) of Terabytes do not exist yet).
5) For the area around the fracture–zones parameterisations might be introduced, comparable to the way parameterisations are done in coupled ocean–land–atmosphere–ice models.
6) Results shall be tested against the known earthquakes, including known creep, of the last year, the last two years etc., comparable to past climate changes for accelerated climate models.
7) As most likely known earthquakes will be met in a wrong way, algorithms have to be developed such that the “geological database” is changed, as part of the algorithm, meaningful, e.g. based on geological background knowledge. This means: No random change of geological data but changes, also dependend changes contradiction–free, also with respect to other datapoints. Experience shows that while specialists from “pure IT” might favore declarative languages real fast algorithms can be achieved if all rules, equations etc. are formulated in an extanded Fortran77. Even – for the IT–specialist nice – data–structures of Fortran90 or C slow down (measured) programs by a factor of eight (reason can be explained on request).
8) Experimental findings from many IODP projects (such as the phenocrysts are the weak–points which break first, the matrix is the strong, from an Unzen–related project from Munich) should of course be included (in the retrospective logical: the matrix–components can bend (micromovements) to stress while the phenocrysts can not), comparable, some good results from Bremen, by A. Kopf, they don’t look spectacular but they might in 10–15 years decide whether an algorithm may work or not).
We stand, regarding this, at the very beginning. The past 20 years experience of many are a good starting point.

Several thousands, possibly tenthousands such runs with meaningfully changing geologies will be needed to arrive at geologies that reproduce the known earthquakes correctly – of course such that the known geology, also on land in Japan, is included. In case of various alternatives that produce comparable sets of earthquakes drilling and/or earzhquake observatories might decide which to take.

This issue was discussed with Dr. Barton from CSIRO Sydney in Muenster in 1998 with the aim to use the program of CSIRO (fastflo) as starting point and develop geological software to change boundary conditions, processes and mineralogy around it. It is postponed but still aimed at. It could be realized in many small realistical steps from five years on over the following 15 years (realism). Much depends on using triangular (non rectangular) grids from the beginning as interpolation from irregular data to regular grids generally causes considerable smoothings/oscillations.

Aspect 5: Microbeam Array and related Technology

In hardrock–geology data are often aquired by timeconsuming and thus costly ionprobe microbeam analysis. The author proposes that institutes who have the capabilities to do this arrange the probes of the ionprobe microbeam instruments (what one moves when sitting at the microscope) in an array, such as 100 each in a row. Analysis might then be done semiautomatic, moving the polished core in small increments of lets say half or less of the size of one microbeam element beneath it. The author proposed a similar idea regarding species–resolved Ca/Mg temperatures in an internal colloquium around 1984 by measuring peak–height and area sizes of Ca/Mg peaks using the EDX–system of the electron–microscope (same position of switches of course). While at that time the idea might have appeared unusual current technological advances enable reassessing such approaches.

The same might apply to thinking about optimizing laser–ablation mass spectrometry this way (same technology but array–optimized). In a more distant future even the contents of the SHRIMP instruments (what the technology does) might be miniaturized and arranged in arrays accordingly.

Related: Currently in several stages of petrographic analysis microscopy using polarized light is essential: Time–consuming, costly, also preparation of the thin–sections and, regarding the density of output–data improvable.

If anyhow a polished core moves by an array of probes the core shall be illuminated alternating with “normal polarized” and “rectangular polarized light”. The resulting images close to the probe, about 1 mm wide, can be stored digitally. The effect of crossed nickols and the like can then be achieved digitally.

In a related following step the “bar” of 1 mm width can be illuminated with visible and invisible light of different wavelength, both “normal polarized” and “rectangularly polarized”. This way the reflections in different spectra can be used to, for example, chemical and mineralogical analysis, for example after establishing extended digital libraries of response–spectra (comparable to spectral libraries in remote sensin).

The first–hand benefit is cost–reduction.

The long–range benefit is that with advances in earthquake–prediction coming the need for many cores with detailed petrographic information will come. Detailed pT arrays (many cores), also in the past (to formulate recystrallization algorithms properly and to apply them to correct data) can only be satisfied if each core is processed reaonably fast and affordable.

This applies particularly if in the future (an ongoing development) deep drillholes down to 300 and more (possibly more than 500) degrees centigrades, e.g. well below 14 km where not too hot will become fast (faster than now) and affordable.

This way in the future much laboratory time (and costs, also of PhD students, postdocs) can be saved – or more results achieved at the same costs.