GIS and Geodatabases Application to Global Scale Plate Tectonics Modelling

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Palinspastic reconstructions offer an ideal framework for geological, geographical, oceanographic and climatology studies. As historians of the Earth, “reconstructers” try to decipher the past. Since they know that continents are moving, geologists a trying to retrieve the continents distributions through ages. If Wegener’s view of continent motions was revolutionary at the beginning of the 20th century, we know, since the Early 1960’s that continents are not drifting without goal in the oceanic realm but are included in a larger set including, all at once, the oceanic and the continental crust: the tectonic plates.

Unfortunately, mainly due to technical and historical issues, this idea seems not to receive a sufficient echo among our particularly concerned community. However, we are intimately convinced that, by applying specific methods and principles we can escape the traditional “Wegenerian” point of view to, at last, reach real plate tectonics. This is the main aim of this study to defend this point of view by exposing, with all necessary details, our methods and tools.

Starting with the paleomagnetic and paleogeographic data classically used in reconstruction studies, we developed a modern methodology placing the plates and their kinematics at the centre of the issue. Using assemblies of continents (referred as “key assemblies”) as anchors distributed all along the scope of our study (ranging from Eocene time to Cambrian time) we develop geodynamic scenarios leading from one to the next, from the past to the present. In between, lithospheric plates are progressively reconstructed by adding/removing oceanic material (symbolized by synthetic isochrones) to major continents. Except during collisions, plates are moved as single rigid entities. The only evolving elements are the plate boundaries which are preserved and follow a consistent geodynamical evolution through time and form an interconnected network through space. This “dynamic plate boundaries” approach integrates plate buoyancy factors, oceans spreading rates, subsidence patterns, stratigraphic and paleobiogeographic data, as well as major tectonic and magmatic events. It offers a good control on plate kinematics and provides severe constraints for the model.

This multi-sources approach requires an efficient data management. Prior to this study, the critical mass of necessary data became a sorely surmountable obstacle. GIS and geodatabases are modern informatics tools specifically devoted to store, analyze and manage data and associated attributes spatially referenced on the Earth. By developing the PaleoDyn database in ArcGIS software we converted the mass of scattered data offered by the geological records into valuable geodynamical information easily accessible for reconstructions creation. In the same time, by programming specific tools we, all at once, facilitated the reconstruction work (tasks automation) and enhanced the model (by highly increasing the kinematic control of plate motions thanks to plate velocity models).

Based on the 340 terranes properly defined, we developed a revised set of 35 reconstructions associated to their own velocity models. Using this unique dataset we are now able to tackle major issues of the geology (such as the global sea-level variations and climate changes). We started by studying one of the major unsolved issues of the modern plate tectonics: the driving mechanism of plate motions. We observed that, all along the Earth’s history, plates rotation poles (describing plate motions across the Earth’s surface) tend to follow a slight linear distribution along a band going from the Northern Pacific through Northern South-America, Central Atlantic, Northern Africa, Central Asia up to Japan. Basically, it signifies that plates tend to escape this median plan. In the absence of a non-identified methodological bias, we interpreted it as the potential secular influence of the Moon on plate motions.

The oceanic realms are the cornerstone of our model and we attached a particular interest to reconstruct them with many details. In this model, the oceanic crust is preserved from one reconstruction to the next. The crustal material is symbolised by the synthetic isochrons from which we know the ages. We also reconstruct the margins (active or passive), ridges and intra-oceanic subductions. Using this detailed oceanic dataset, we developed unique 3-D bathymetric models offering a better precision than all the previously existing ones.