A short note on the "plasticity" of the Earth's crust, taking the Southeast Asian region as a case example

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I will never get tired of pointing out that the crust, all the more the entire lithosphere, seen from a geological time perspective, must not be regarded as rigid, as the current view - spread by the hypothesis of plate tectonics - but also our "common sense" are assuming.

One can have different opinions about how the mantle moves under the "earth skin", but the fact that it moves is hardly denied by anyone. The coupling between the mantle and the lithosphere, which has to operate in accord with the laws of physics, inevitably implies that the movements of the mantle must be somehow reproduced by the lithosphere, albeit with a time delay. And if one regards the lithosphere as the "earth skin", then one can equally speak of "subcutaneous currents", better still of "subcutaneous creep" (at speeds of some cm/a) when we refer to the underlying mantle. Under a current we understand a river, whose waters move with a certain speed relative to the immobile banks. The average speed varies in cross section, not least because of the resistance opposed by the banks and the riverbed.

Apart from specific conditions, the flow in the sublithospheric mantle behaves similarly. Only that we hardly have to deal with "immobile shores" here. We can assume that the "banks" also move, but so slowly that they can be regarded as immobile. What really counts is the speed difference. The river bed, on the other hand, should not be seen at the bottom, but at the top - in our case in the lithosphere - which is not anchored either, but "dragged along" according to the coupling principle.

In the lithosphere and in the crust in particular, which can only be regarded as "rigid" in terms of the human sense of time and the associated concepts of

"liquid-solid", the structures at the boundary between "moving" and relatively immobile parts become very "touchable". It is precisely these structures that show us the course of the underground mantle currents.

Of course, the whole thing must be considered from a mega-tectonic point of view, as on the scale of our environment, for example in geological outcrops, we will almost exclusively encounter signs of brittle behavior, i.e. fractures, dislocations, cracks and fissures.

A mantle stream that moves linearly over hundreds or even thousands of kilometers and long periods of time will also produce corresponding linear structures in its superstructure, the lithosphere. If, however, the stream is forced to meander, to turn, to take a new run, to expand or, on the contrary, to constrict itself, etc., all this must also be reproduced by the superstructure.

In addition to what has been said so far, it should also be mentioned that at the border between "moving" and "unmoving" sections of the crust, especially in the initial stages of movement, the crust can tear open. This creates ascent paths for mantle material, a circumstance that leads to the formation of "ophiolites". To see in these rocks "remnants" of former oceans is quite aberrant. Secondly, it should always be borne in mind that movement produces heat. This important source of energy is responsible for the uplift of mountains and for the magmatic processes, including (island) arc volcanism. In other words, orogenic chains and/or volcanic island chains are not merely witnesses of the mantle flowing beneath them, but also landmarks indicating its direction of movement.

The following illustrations of the Southeast Asian region will show paradigmatically what I mean by structures that disclose the existence of mantle streams in the underground. At the same time I oppose my view to that of plate tectonics. For this purpose I took a more recent interpretation of the region, as imagined by Professor Robert Hall (University of London). It is the illustration of what could be called “shred tectonics”, because the basic idea always consists of splitting off "rigid" parts of continents ("shreds") in order to create space for imaginary "oceans" between them, which in turn disappear through "subduction", after which the "shreds" are docked to the original or other continental blocks. The narrow structures ("sutures") containing the ophiolites form the alleged traces of "swallowed" ocean basins.

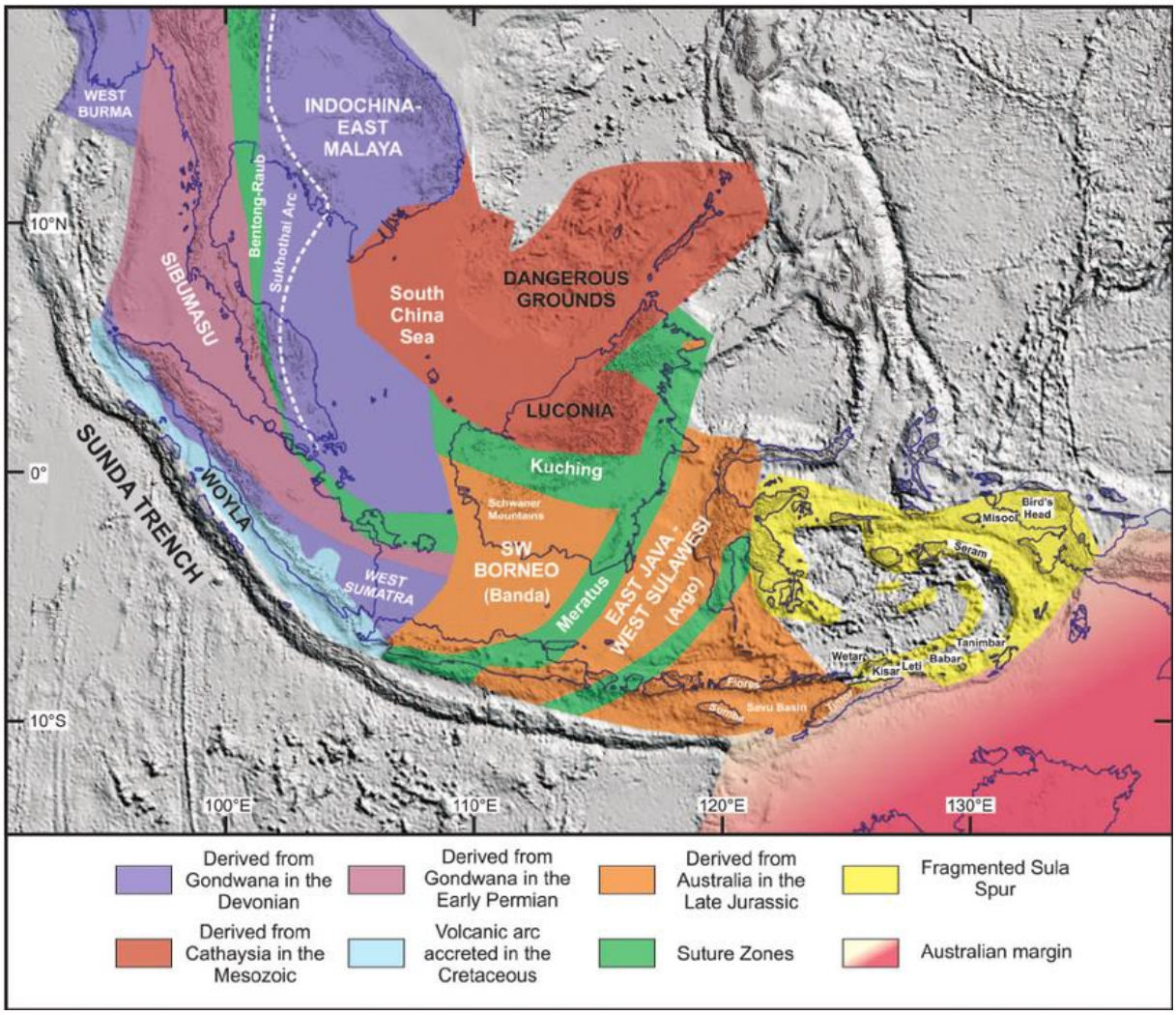

Fig. 1: The plate tectonic view of the Southeast Asian region according to Hall & Sevastjanova (2012). In part the colors show "continental shreds", which at different times (Devonian, Permian, Jurassic) are said to have detached themselves from the major continent Gondwana or later, when it no longer existed, from Australia in order to finally be docked at Southeast Asia. Spatially there are said to have been short-lived oceans in between (Palaeotethys, Mesotethys, Neotethys), whose existence is testified today only by "sutures" (in green). The Sula spur (in yellow) is still hanging on its mother continent Australia (in red).

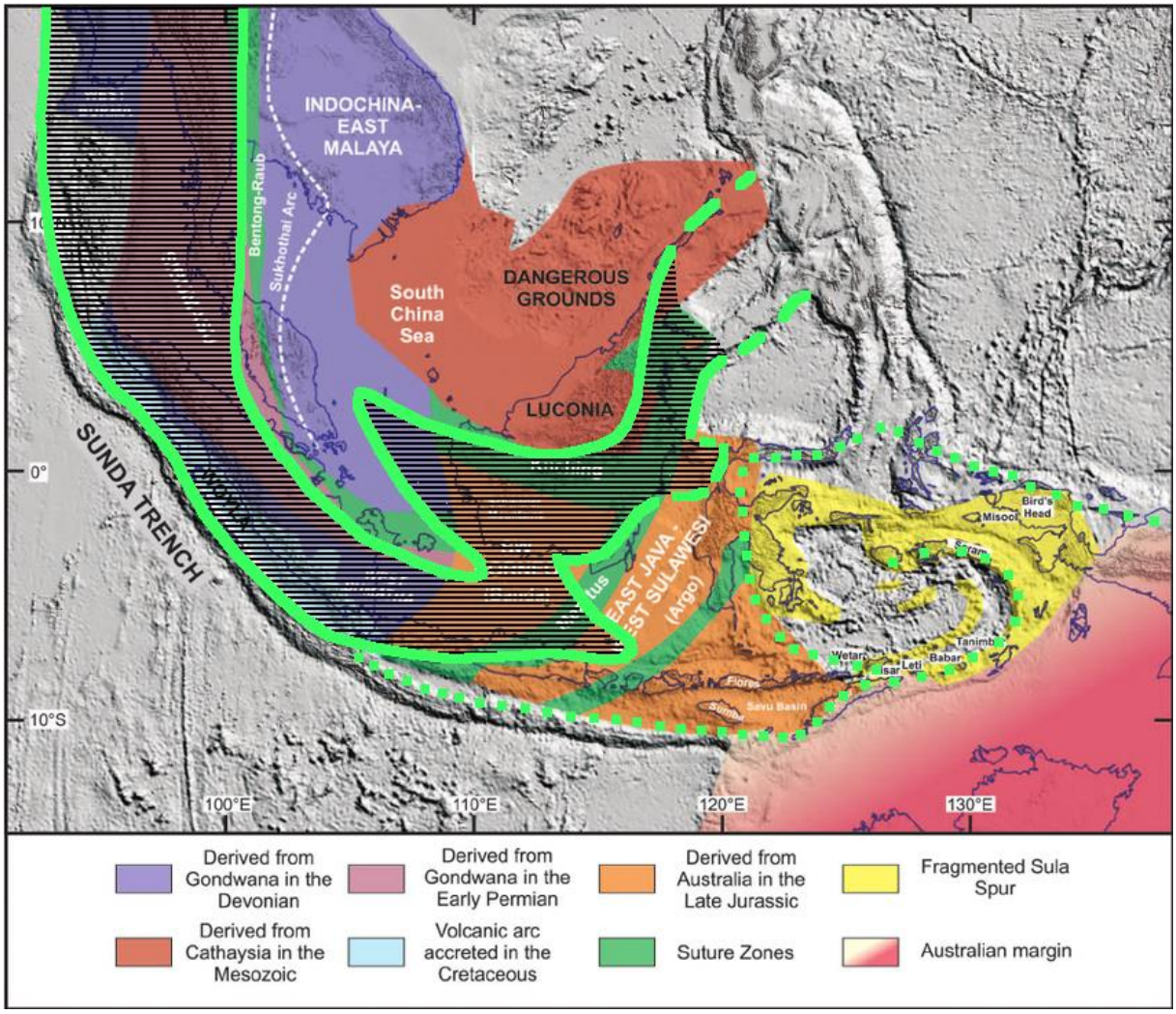

Fig. 2: My interpretation of the Southeast Asian region. I assume that the hatched area bounded by the green lines is the former and ***the sole*** Tethyan Realm from which the Alps and the Himalayas, among others, originated. The green lines represent the edges of this space, areas along which the crust, transported eastward by the equatorial Tethys current, came into contact with its "rigid shores". These are the areas where ophiolitic formations are encountered on the surface. As one notices, in plan view a rather jagged, shapeless structure has emerged from the original crustal tract which used to run straight along the equator. Admittedly it is my own view of things, but it is based on the same primary data used by Hall & Sevastjonova (2012). The whole bend that can be discerned was caused by the fact that the Tethyan Realm together with the northward adjoining realm of the "Cimmerides" was shifted to the southeast by the successor of the Tethyan Mantle Current (Fig. 3).

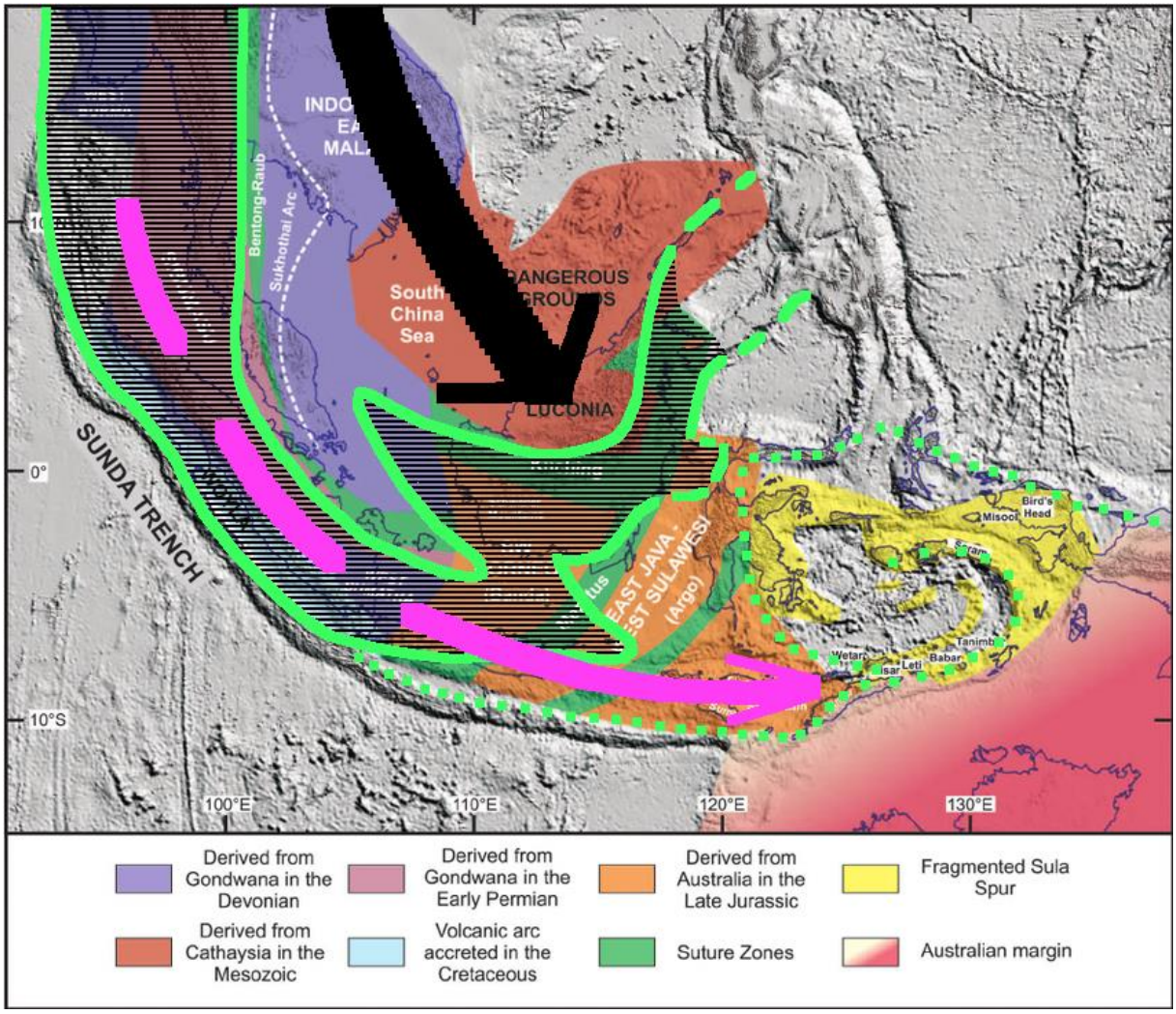

Fig. 3: I have dubbed this successor current the Sundaland Mantle Current (Strutinski, 2018). It was significantly larger than its predecessor and began to operate about 45 Ma ago in the Middle Eocene as a consequence of the northern push of India into the Tethyan Realm. It should therefore be seen as an escape current. Its direction of movement and its approximate axis are indicated by the black arrow. I assume that it turned the formerly straight Tethyan tract into an arched shape. At some stage, however, its momentum must have clearly slackened. The reason for this, although not the only one, could have been the resistance that the old, "rigid" continental bloc of Australia put up against it. Only a "residual current" remained, the axis of which is represented by the magenta-red arrow. It dragged the part of the former Tethyan Realm placed just above it further southeast and thinned it out. The loop or the bend in the previously formed Tethyan arch was created. Further thinning of the flanks would eventually lead to rupture (Fig. 4).

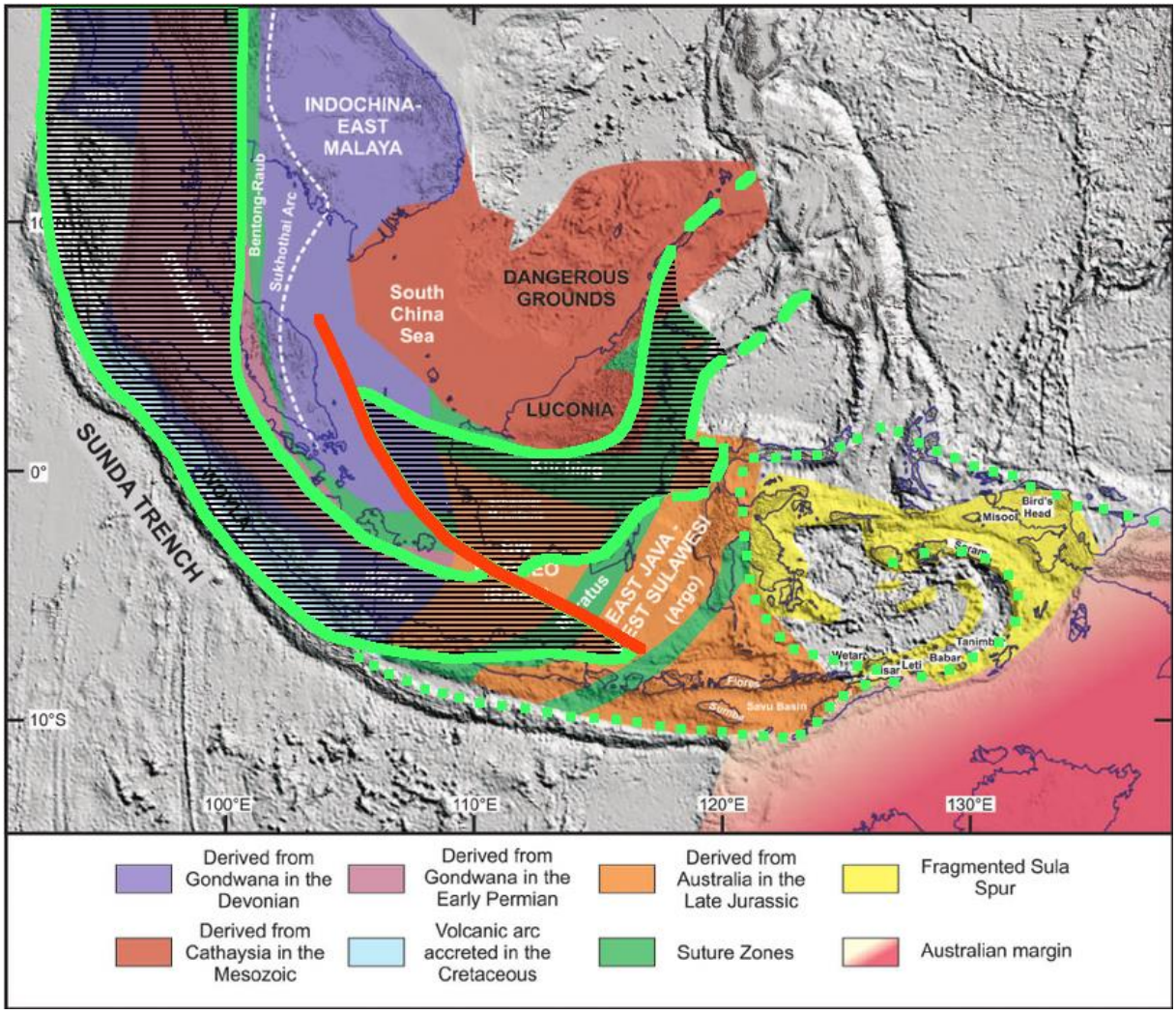

Fig. 4: Such type of a rupture is illustrated in the above figure (red line). It is merely interpretative; the suspected fracture should be found in the subsoil of the Java Sea and should have a left-handed character. Fractures with a similar direction, but for which the sense of motion of the adjacent blocks is uncertain (partly right-, partly left-handed), appear further north in the Gulf of Thailand (Wang et al., 2016). The green dotted lines represent mélange formations with or without ophiolites, most probably originating from the Tethyan Realm and transported along the continental crustal rim by the Sundaland Mantle Current for thousands of kilometres. They can be found on the islands of Timor, Sulawesi, Ceram, Halmahera and New Guinea, among others. The eastern rim of the initial Sundaland Current, which is marked more to the north within the crust by the Red River fracture system, is not shown in the illustrations because of its presently unknown trace due to various local complications. However, it should be found within the Philippines archipelago.

References:

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Saarbrücken, 20.02.2019