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Defining Incipient Subduction by Detecting Serpentenised Mantle in the Regional Magnetic Field

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The mechanisms of subduction initiation are poorly understood. One idea is to look for incipient subduction zones in the present day and see what features are common in these zones. However, incipient subduction zones are very difficult to detect and debate surrounds particular cases as to whether they qualify as incipient or not. In the analysis conducted in this work, we use the signal of the presence of a mantle wedge in the magnetic anomaly field as an indicator of incipient subduction.

Each subduction zone exhibits variations in the particular responses of the system, such as slab-dip angle, maximum earthquake depths and volcanism to various parameters. So far, attempts to reduce the system to a dominate controlling parameter have failed, probably as a result of the limited number of cases and the large variety of controlling parameters. Parameters such as down-going and overriding plate morphology and velocity, mantle flow, the presence of plumes or not, sediment transport into the trench are a few of the parameters that have been studied in the literature.

However, one of the characteristics associated with a subduction zones is the presence of a mantelic wedge as a result of the partial melt of the subducting plate and the development of a mantle wedge between the subducting plate and the overriding plate. The wedge is characterised by the presence of water (coming from sediments in the down-going plate) as well as lower temperatures (because the wedge is between two relatively cold lithospheres). As a results a serpentinized mantle wedge is formed that contains hydrous minerals, of which magnetite is an example, that alter the composition and properties of this region. According to Blakely et.al. (2005), this region exhibits both higher magnetic susceptibility and lower densities than the surrounding medium.

We analysed five active margin boundaries located worldwide to investigate the link between magnetic and gravity anomalies and seismic activity and slab structure. In the Southeast Asia region, transects were taken in the Andaman, Sumatra, Marianas and Philippines, while the Central American region is represented by the Ecuadorian subduction zone. The Magnetic data was obtained from the World Digital Magnetic Anomaly Map (WDMAM), the gravimetric data from the International Gravimetric Bureau while data on seismic activity and slab structure was obtained from the USGS earthquake hazards program. We present an initial investigation on the correlation of magnetic and gravimetric anomalies on the one-hand and seismic activity and slab structure on the other to search for patterns that can help detect mantelic wedges and incipient subduction and further our understanding of subduction initiation processes.

References

Blakely, R.J., Brocher, T.M., Wells, R.E., 2005. Subduction-zone magnetic anomalies and implications for hydrated forearc mantle. Geology 33, 445–448.