The tectonic and volcanic evolution of the Mangatolu Triple Junction

The tectonic and volcanic evolution of the Mangatolu Triple Junction holds valuable information on the microplate development in the northeast Lau Basin. Various modern-day volcanic and tectonic settings of convergent margins in the west to southwest Pacific, such as the Lau Basin east of Fiji, are seen as analogs to ancient continent forming settings, so-called greenstone belts. Greenstone belts consist of different assemblages that, most likely represent converged microplates, and are known to host, amongst others, volcanogenic massive sulfide (VMS) deposits. VMS deposits represent a valuable source of base metals, like zinc, copper or lead and currently form at modern, marine spreading centers due to high-temperature hydrothermal systems in the upper oceanic crust. Understanding the geodynamic setting of modern, deposit-forming microplate settings aids in understanding ancient, geodynamic processes and could improve their exploration.

The Mangatolu Triple Junction (MTJ) is a marine spreading center hosting hydrothermal systems. It is located in the NE Lau Basin, which is part of the subduction-related arc- and back-arc system above the Tonga subduction zone. At the MTJ, three spreading centers meet (Ridge-Ridge-Ridge type triple junction) that separate the Tonga plate in the east, the Niuafo'ou microplate in the southwest, and an unnamed microplate in the north.

This study extracts the tectonic and volcanic evolution of the MTJ from geological maps at formation level, which are produced from ship-born multi-beam echo-sounder data, the Global Multi-Resolution Topography bathymetry and sidescan sonar data at a scale of 1:200 000. As this study produced the first geological map in such a setting, this study also describes the developed and applied systematic mapping scheme.

Analysis of mapped geological formations at the MTJ revealed arc and back-arc crust, exploiting pre-existing crustal-scale weak zones and faults. The mapping proves the origin of the Arc crust formations from the Tofua Arc and furthermore three back-arc stages can be differentiated. Additionally, the combination of the mapped features and published spreading rates revealed that spreading commenced at the MTJ approximately 180 000 years ago. Furthermore, it was observed that the hydrothermal systems form on relatively flat seafloor and proximal to a local magma chamber. They are characterized by permeability contrasts in the upper crust and one or more deep crustal structures.

These results contribute significantly to the understanding of the tectonic framework in the northeast Lau Basin and the initiation and development of back-arc basin triple junctions and microplate formation.

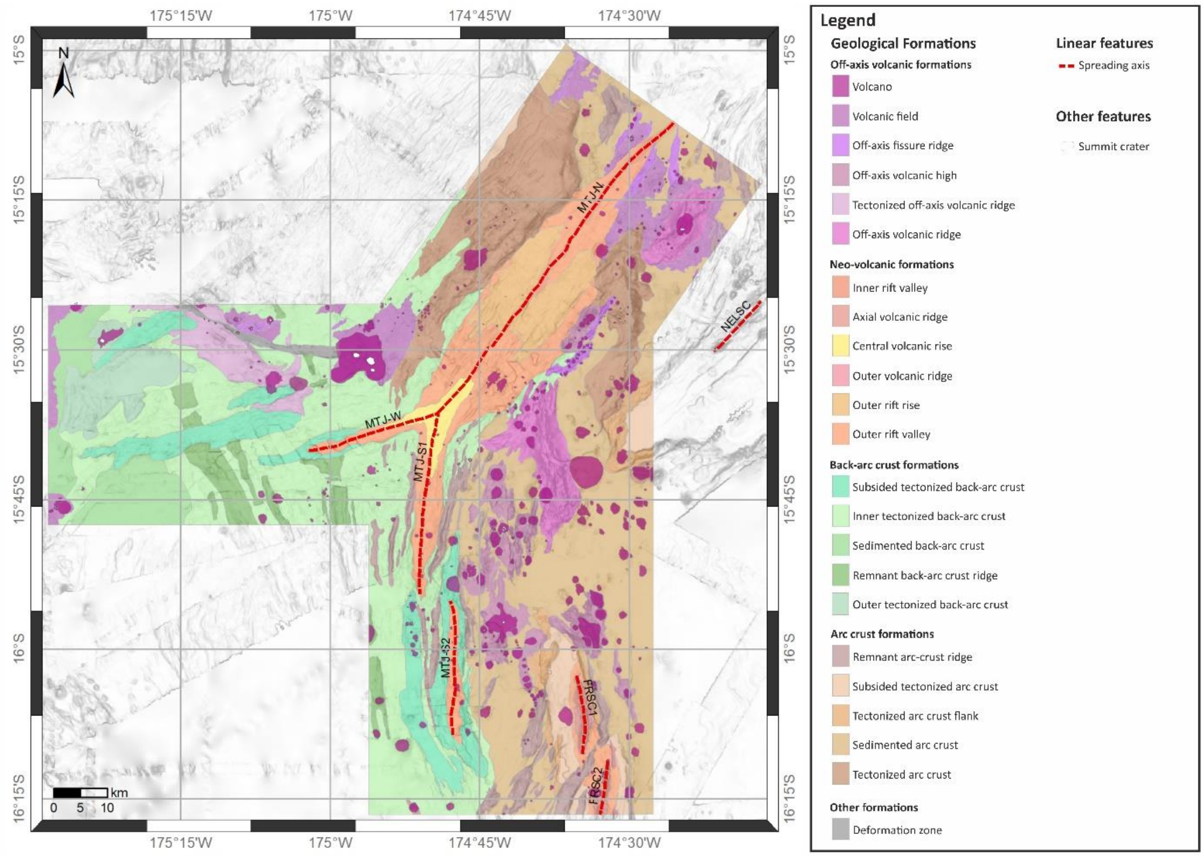

Figure 1 - Geological map of the MTJ. The brown colors indicate arc crust formations that dominate the geology east and northeast of the MTJ. Green indicates back-arc crust that dominates west and northwest of the MTJ. Orange, red and yellow indicate neo-volcanic formations marking the active accretionary zone. Purple colors show off-axis formations with volcanogenic origin and volcanic edifices. The greyscale shading reflects the slope of the DEM, which combines used ship track data and GMRT dataset.

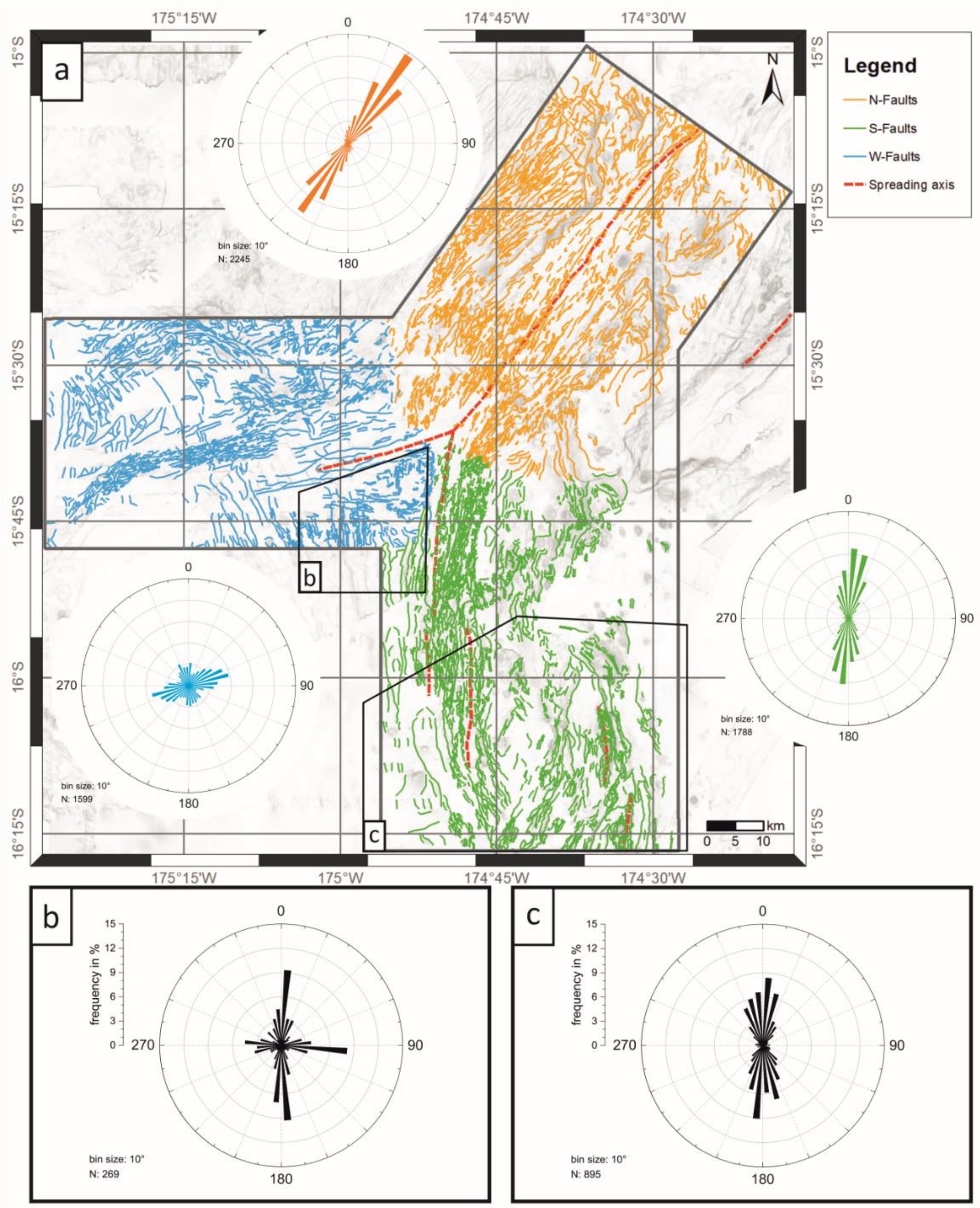

Figure 2 - Detailed fault lineament map with rose diagrams enhancing the fault's strike direction for each arm and two detailed areas on top of the slope derived from shiptreck and GMRT bathymetry data. (a) the detailed faults are shown color-coded for each arm. The Rose diagrams show clearly that along the northern and southern arm the fault strike is mainly axis parallel, while for the western arm two main strike directions become obvious, one axis parallel and one oblique to the axis. (b) Rose diagram enhancing the area just SW of the MTJ and clearly showing perpendicular going faults, almost striking N to S and E to W, respectively. (c) Portrays the rose diagram for the overlap area between MTJ-S2 and the northern tip of the FRSC. The counterclockwise going strike visible in the map is also indicated in the rose diagram. Both B and C show the percentage scale for all the rose diagrams in this figure.