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Map Helps Unravel Complexities of the Southwestern Pacific Ocean

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The southwestern Pacific Ocean region hosts submerged continental margins, ridges, sedimentary basins, and volcanic arcs located around Papua New Guinea, New Zealand, Australia, and Fiji. The geological history of this vast region has remained controversial, and to improve understanding of the processes that controlled its geodynamical evolution, it is essential to place each piece of available data in a regional spatiotemporal framework.

To this end, a new map, entitled "Structural Provinces of the Southwest Pacific," was released by the Geological Survey of New Caledonia in May 2011. The publication consists of two parts: (1) a 40-page booklet of geological notes, which documents the nature and age of each structure and contains an associated list of references; and (2) a 3- × 4-foot poster of a structural map revealing the nature of the basement, location, and type of the main structural features (see simplified version in Figure 1) and the age of formation using the international standards for geological color codes established by the Commission for the Geological Map of the World (CGMW) (see http://ccgm.free.fr/index.html).

Making the Map

The first steps in building the map were taken at Scripps Institution of Oceanography, San Diego, Calif., in 2005, mainly using a digitizing table and the Generic Mapping Tools (GMT). Collaboration to enhance the map began in 2006 through joint efforts of New Caledonia, New Zealand, and Australia (represented by the Geological Survey of New Caledonia, GNS Science, and Geoscience Australia, respectively). Initial efforts focused on poring over published literature to get a preliminary idea of the nature and age of the structures in the region. This allowed for quick assessment of gaps in data.

Over the next 4 years, scientists involved with the map focused on interpreting existing marine geophysical data and proposed new acquisitions programs. What emerged was a broad yet detailed picture of the geological history that shaped the southwestern Pacific, depictable through a series of maps.

Southwestern Pacific Geological Context

As described in the map's booklet of geological notes, since 400 million years ago the southwestern Pacific geology has been controlled by the evolution of subduction zones encircling the Pacific Ocean, which successively developed along the eastern Gondwana margin. The oceanward retreat of the subduction trench, by rollback of the downgoing slab, resulted in complex fragmentation of the adjacent continental mass [see *Karig,* 1971]. This process evolved from subcontinental to intraoceanic subduction and gave birth to aborted rifts and back-arc basins associated with remnant volcanic arcs.

Most basins that formed less than 85 million years ago reached a stage in which rifts began to spread the seafloor. These basins have recorded the reversals of the Earth's magnetic field and show typical oceanic crust morphologies, allowing identification of their age and nature with a relatively high degree of confidence. By contrast, the nature and evolution of basins that were formed more than 85 million years ago (pre-Eocene) in a proximal position to the Gondwana landmass, such as the New Caledonia, Fairway, and Norfolk basins, have remained more enigmatic. They are narrower than more recent oceanic basins and present locally high intraplate magmatism and thick sedimentary covers that may have recorded a multiphase structural development, thus making their origin and evolution more controversial [*Collot et al.,* 2008, 2009; *Sutherland et al.,* 2010].

The notes accompanying the new structural provinces of the southwestern Pacific map list and classify all the main structural elements of the region from west to east, by main geological origin (i.e., volcanic arcs, hot spot chains, continental ridges, oceanic basins, back-arc basins, thinned continental basins, and oceanic plateaus). For each element, they synthesize the current state of knowledge and present a list of references. In addition, they illustrate several remarkable geological features. For example, the "Age of Formation" map reveals a first-order trend of age decreasing as one moves from the Australian continent toward the Pacific Ocean, illustrating the effect of the progressive fragmentation of the Gondwana margin through a trench retreat by a slab rollback process. The "Nature of Basement" map (a simplified version is shown in Figure 1) confirms the presence of a major submerged continent that extends over more than 35° of latitude, from Campbell Plateau, south of New Zealand, through to Lord Howe Rise, and up to Chesterfield, Kenn, Mellish, and Louisiade plateaus.

This main geological structure, a fragment of the eastern Gondwana margin [*Collot et al.,* 2009], is one of the greatest submerged pieces of continent on Earth (more than 3 million square kilometers) and remains greatly under-explored. This has significant implications for for petroleum prospection in the region. The age map also reveals that all hydrocarbon-producing basins (those with proven resources), which can be identified on the map by the presence of "Offshore Petroleum Wells," formed during the Cretaceous (144–65 million years ago; see locations of Gippsland, Otway, Bass, Taranaki, Great South, and Townsville basins). These maps also highlight vast areas that are totally unexplored, such as the d'Entrecasteaux Basin, north of New Caledonia.

Advancing Understanding

Although the Structural Provinces of the Southwest Pacific map has been published, new work on understanding the geology of the region is already under way. Members of the science team who compiled the map and notes are currently focused on the construction of a regional geophysical database and are working on proposals for two new acquisition programs over the submerged continent located between the three countries. This particular area, which we call the "Tasman Frontier" but is also known as "Zealandia" or "Zealonia" (for New Zealand–Caledonia), is one of the key enigmatic and poorly understood pre-Eocene areas within the southwestern Pacific. Focusing on this piece of continental fragment will allow scientists to better understand the processes of subduction initiation and evolution.

Acknowledgments

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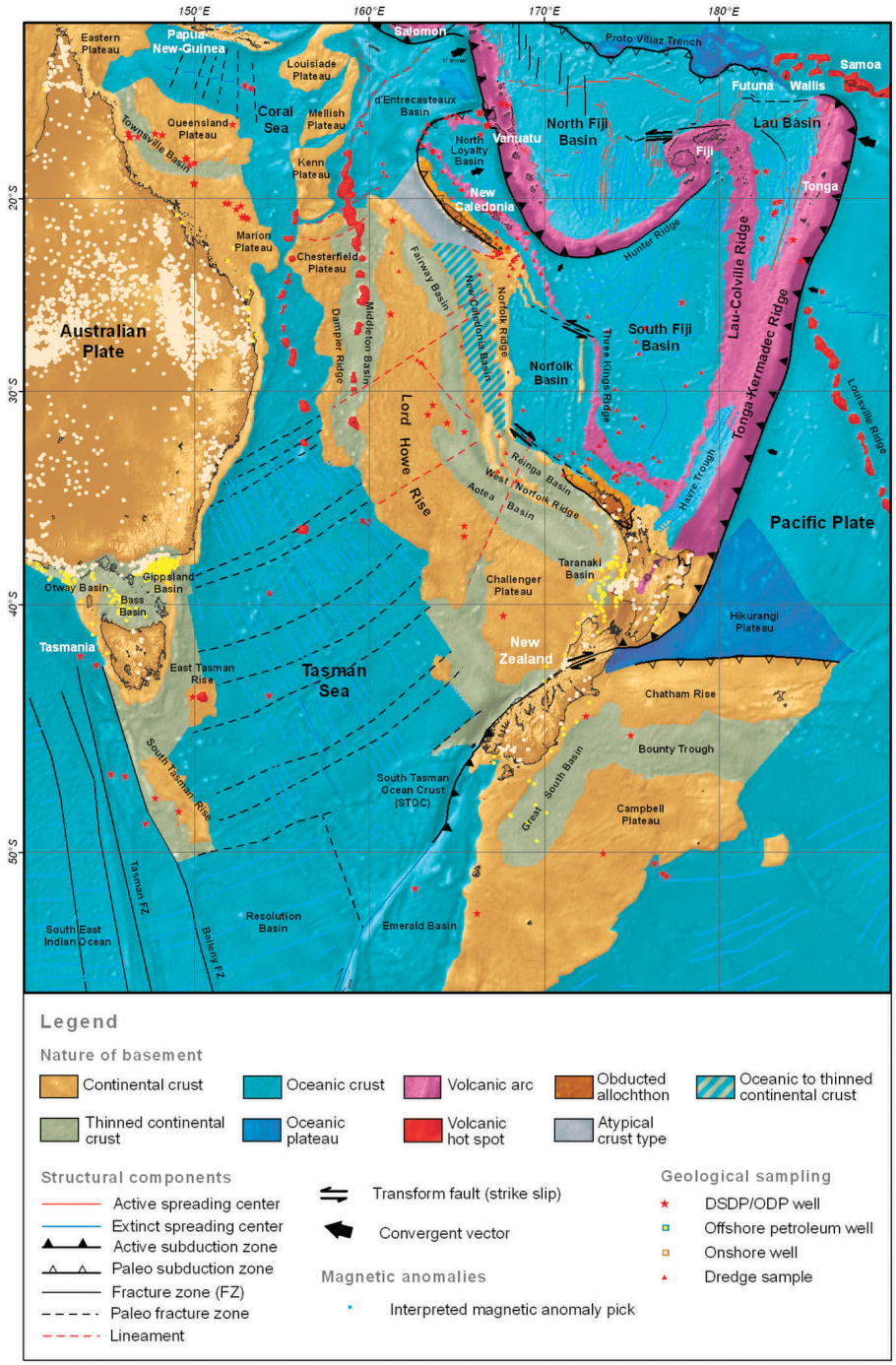

Fig. 1. Simplified version of the nature of basement of the "Structural Provinces of the Southwest Pacific" map. Base map is free-air gravity anomalies in marine areas and topography on continents. Note the large submerged continental fragment that detached from the eastern Gondwana margin 85 million years ago; today this fragment hosts a high potential yield of mineral resources.