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From rifting to spreading - seismic structure of the rifted western Mariana extinct arc and the ParceVela back-arc basin

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The proto Izu-Ogasawara (Bonin)-Mariana (IBM) Island arc was created when subduction of the Pacific plate began during the Eocene. Today, the Kyushu-Palau Ridge (KPR) at the centre of the Philippine Sea and the western Mariana Ridge (WMR) are considered to be a remnant of the proto IBM Island arc. The KPR and WMR were separated when back-arc spreading began at 30 to 29 Ma in the Shikoku Basin and ParceVela Basin (PVB). Volcanic activity along the arcs diminished at 27 Ma and there is little evidence of volcanic activity between 23–17 Ma. Arc volcanism was reactivated at ∼15 Ma, when the opening of the Shikoku Basin and PVB ceased. At about 5 Ma the Mariana Basin opened, rifting the WMR from the Mariana arc. Here, we report results from the seismic refraction and wide-angle profile MR101c shot in summer of 2003 by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) aboard the RV KAIYO during the cruise KY03-06, extending from the PVB across the WMR and terminating just to the east of the WMR. Along MR101c 46 OBS recorded shots from an airgun array of 12,000 cubic inches (197 litres); 44 OBS provided excellent P-wave data, including arrivals sampling the crust (Pg), the crust/mantle boundary (PmP), the uppermost mantle (Pn) and a deep reflection (PnP) under the WMR. To yield the seismic velocity structure, we used a joint reflection and refraction tomography, revealing the crustal and mantle P-wave velocity structure, the seismic Moho, and a deep-seated reflector. Distinct features are a ∼14 km thick crust forming the WMR, a high-velocity lower crust in both transition zones to the ParceVela Basin and Mariana Basin, and a reflector at ∼24 km depth, which shallows to ∼18 km in the transition zone to the Mariana Basin, perhaps reflecting rifting-related thinning of the entire lithosphere. The deep-reflector, however, did not occur under the PVB. Upper mantle velocity below the WMR is <7.5 km/s. High velocities of the lower crust of the WMR flanking the adjacent basins mimic the structure found in the Lau Basin – Tonga Arc system, perhaps indicating entrainment of hydrous melts from the adjacent arc governing early seafloor spreading when the spreading centre was at close distant to the volcanic arc. Upper mantle below the PVB shows typical mantle properties, supporting a P-wave velocity of >8 km/s. However, with respect to oceanic crust sampled in the Pacific Basin, PVB crust is with 5 km thinner and seismic velocities in the lower crust are with ∼6.7 km/s much lower.