A megathrust earthquake of magnitude (Mw) 9.0 hit the Tohoku-Kanto district of Japan, on 11 March 2011. The seismicity in the past and present off the Pacific coast of the Tohoku district has been investigated in detail and categorized into regional seismic segmentations. The 2011 megathrust earthquake ruptured almost all the segments between the Pacific coast of the Tohoku district and the Japan trench, causing devastating tsunamis much larger than the expected maximum. How did this event grow to such a scale? The prime factor that had not been recognized before is the double segmentation along the Japan trench (the distinction of shallow and deep segments perpendicular to the trench axis) and their successive breaking during an initial stage of the earthquake. We show the similarity between this earthquake and the 1964 great Alaska earthquake, in terms of seismic activities both before and after, together with their asperities in each initial rupture region. Based on these characterizations, we suggest that these earthquakes belong to a new type of great earthquakes different from the 1960 Chile and the 2004 Sumatra earthquakes, which mainly extended laterally along their trench axes. Classification of these two types can better explain a wide variety of megathrust earthquakes, which had previously been considered to share many common characteristics.