On-fault geological fingerprint of earthquake rupture direction

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How earthquake ruptures evolve and propagate are major outstanding questions in seismology. Our current understanding is limited to modern events captured by seismic networks, making it impossible to observe rupture propagation that occurred during earthquakes in the distant past. Here we propose a new method to discern the rupture propagation directions of past large earthquakes based on geological features preserved on fault slip planes. These features—called slickenlines—are striations formed during seismic slip and record dynamic fault movement during past surface-breaking earthquakes. We develop a theoretical framework that links slickenline curvature with rupture mode and rupture propagation direction for all faulting types and test our model using a global catalogue of historical surface-rupturing earthquakes with seismologically constrained rupture directions. Our results reveal that historical observations are consistent with theoretical predictions, thus providing a robust way to uncover the rupture directions of large earthquakes that lack instrumental data.

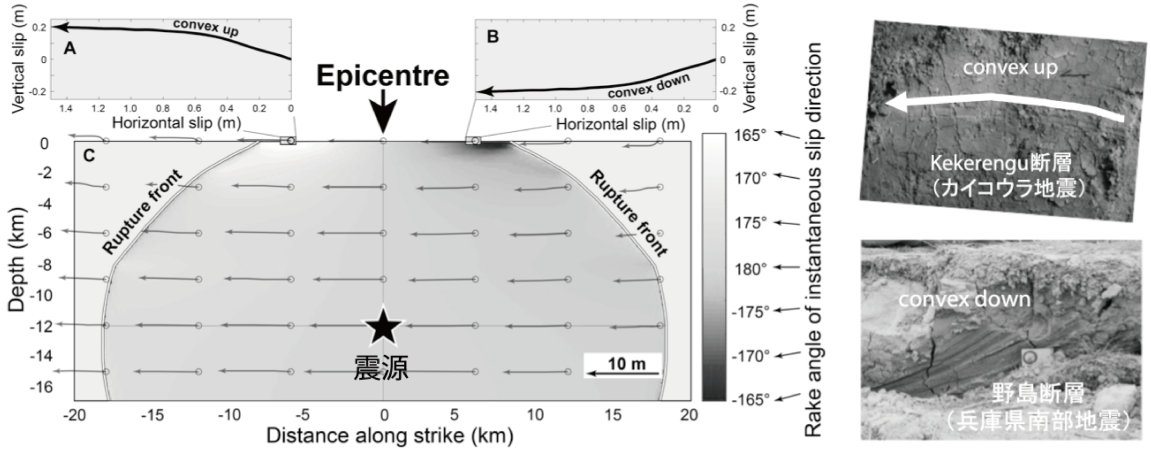

図１：動的破壊シミュレーションから見る断層面上の条線（太い黒の矢印）の特性。背景の色は地震開始から７秒後の条線の方向（レイク角）を表している。震源の左側の方向**A**の地表にある条線はConvex upを示しているが、反対側（方向**B**）はConvex downである。条線の特性は破壊伝播方向に依存し、実際に記録された断層条線の湾曲（右側の写真）と一致する。