



Accommodation-controlled, reef-bearing Upper Jurassic ramp types

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Many carbonate platforms of the Upper Jurassic represent ramp-type intrabasinal, pericontinental, or epeiric ramps. Ramps are frequently characterized by reef facies of variable geometric types and shapes. We present several examples for three basic categories of ramp types which we consider as diagnostic for different accommodation spaces and productivities. Reef- or bar-rimmed shelves with depositional or by-pass margin also existed during Late Jurassic times, but are not considered in this paper.

(1) Ramps with a high accommodation space. These are characterised by relatively simple facies patterns, with carbonate-mud dominated, largely shallow-water derived mid and outer ramp sediments. Very wide and gently sloping ramps might show mud-mound development characterised by siliceous sponges, microbialites and other automicrites, as well as peloidal to dense mud. Larger mounds might be capped by shallow water coral facies. Distally steepened slopes might be the site of mixed coral-siliceous sponge thrombolites, upper mid ramp to lower inner ramp settings are frequently characterised by coral-microbialite pinnacle reefs. Mound growth in the deeper water is boosted by, in the shallower water restricted to, transgressive intervals. Shallow water pinnacle reefs develop string of pearl patterns composed of aggradational reefs which might be partially or fully buried during regressive intervals owing to redistribution of inner ramp high energy grainy carbonates. Examples include major parts of the south German Upper Jurassic epeiric north Tethys deeper water ramp, the Celtiberian pinnacle coral microbial reef ramps of Spain, the microbialite reef-rich distally steepened ramps of southern Portugal and the Gulf of Mexico and Cotton Valley - Smackover-type ramps with stacked pinnacle reefs in the subsurface of the US

east coast, and parts of the Tuwaiq Mountain Formation of Saudi Arabia.

(2) Ramps with a subcritical accommodation space. Such ramps have a very complex architectural pattern which may be strongly progradational, but with punctuations of short-term aggradational and even retrogradational events. Small reef bodies may develop during flooding events, and may show rapid catch-up structures. Other ramps may exhibit a more mosaic-type distribution of small coral reefs. Reef body geometries are well developed owing to a relatively high proportion of microbial crusts. Highstand events result in a strong infill with carbonate sands which may show distinct progradational features. Lowstand events can cause strong leaching of the ramps. Underlying facies is mostly represented by progradational dense slope carbonates or fine-grained siliciclastics. The near flat top part of such slope systems is responsible for the variable, subcritical accommodation space of such near level bottom ramps of moderate extensions. Examples are the corallian facies of northern Germany, the Amaral carbonate platform of the Lusitanian Basin, Portugal or the Lalla Oujja reef-rich carbonate ramps of the Agadir Basin (Morocco).

(3) Ramps with a critical accommodation space - 'Shaved tropical ramps'. Such ramps are characterised by a very high biogenic carbonate productivity in the inner part of the ramp, with pervasive growth of reefal thickets of corals or stromatoporoids and a rich green algal facies. Reefal meadows grew during flooding events but even then had insufficient accommodation space. This resulted in regular to episodic abrasive 'shaving' by seasonal or perennial storms and continuous redistribution and export of material toward more distal settings with an improved accommodation space. Typical for such ramps are inner ramp facies mixture, intense fragmentation of reef fauna, scarcity or lack of in-situ reef organisms and abrasion-intolerant microbialites, channel or runnel formation and redistribution of inner ramp facies across major parts of such ramps. Distal parts of ramps show a higher accommodation space but due to strong export from the proximal ramp are strongly overcompensated by sedimentation and hence may not show much bathymetric difference to the proximal ramp. Mildly oligotrophic to mesotrophic shaved carbonate ramps are dominated by coral-dasyclad-mollusk facies, an example of which is the Saal ramp of southeastern Germany. Strongly oligotrophic, and possibly overheated to hyperhaline, shaved tropical ramps are characterised by a dominance of reworked stromatoporoids. Ramp sizes can be enormous which is typical of circumequatorial, non-siliciclastically influenced shallow seas of the Late Jurassic such as the Arab formation of the Arabian Peninsula. Owing to near-constant abrasion and rubble production, allochthonous, reworked sand sheets can be extensive and sea-level lows may result in early leaching. Modern *Porites-furcata* dominated meadows on ramp-configured leeward slopes of the Bocas del Toro Archipelago are possible modern analogues of such shaved tropical ramps.