Slice 25: Upper Zuni III – late Cenomanian – early Campanian (Late Cretaceous) – 94-81 Ma

This was the time of the maximum global level of the sea during the Phanerozoic, maximum disassembly and submergence of the continents, of global greenhouse conditions and an oceanic anoxic event. The disassembly process began to reverse, with the narrowing of the Tethys Ocean (Fig. 30).

Convergent Tectonics

The opening of the South Atlantic Ocean caused the drift and counterclockwise rotation of Africa. The Arabian margin of the African-Arabian plate moved northeastwards and the western Neotethys narrowed. The northeastward movement of India caused the narrowing of the eastern Neotethys (Golonka *et al*., 1994). This reversed the geotectonic process. After reaching the maximum dispersion phase, the continent began to slowly assemble in a new configuration.

The regime between the Arabian margin and the Sanandaj-Sirjan plate, changed from passive to convergent (Ricou, 1996; Sengör & Natalin, 1996; Guiraud & Bellion, 1996). The north-dipping subduction under the Sanandaj-Sirjan plate is marked on this slice, but it is also possible it have been active since Jurassic time. The small Kohistan plate collided with Eurasia (Sengör & Natalin, 1996). The rotation of Africa and spreading in the Eastern Mediterranean caused the Apulian plate to converge with Europe. Later phases of the Cretaceous Trupchun orogeny in the Alps (Froitzheim *et al*., 1996) caused a subduction of the small terranes together with the oceanic crust of the Ligurian ocean. These terranes were subject of an eclogite metamorphism. The subduction was accompanied by the decollement of ophiolites and the Ligurian-Piemont sediments and their emplacement as the earliest nappes of the Alpine evolution (Debelmas, 1989).

The Pacific rim margins were very active with a continued period of orogeny within the Rocky Mountains and Andes. A volcanic arc existed along the Andean and the North American convergent margins, where the Farralon plate was subducted beneath the American continents (Lamb *et al*., 1997; Winterer *et al*.,1990). Subduction persisted also off the Antarctic Peninsula (Lawver & Gahagan, 1993).

Eastward movement of the Caribbean arc between North and South America and subduction of the Proto-Caribbean oceanic crust beneath the advancing Greater Antilles island arc continued (Ross & Scotese, 1988, Pindell & Tabbutt, 1995). The northeast active margin of the Pacific and Eurasia was defined by the Okhotsk-Chukotka volcanic belts (Parfenov, 1992; Parfenov *et al*., 1993). The Izanagi plate was subducting under Eurasia. Small plates and volcanic arcs like Koni-Murgal, Koryak and Khatyrka (Zonenshain *et al*., 1990) were moving towards the Eurasian margins. By the end of the supersequence, the Izanagi plate was subducted and terranes accreted to Eurasia. The Kula plate appeared at the northeastern margin of Asia. The renewed compression in the Verkhoyansk fold-and-thrust belt was associated with the terranes collision. Further south, the Sikhote Alin terrane collided with the Asian margin. The collision resulted in intense folding and thrusting, followed by sinistral strike-slip faulting (Zonenshain *et al*., 1990). In the south Pacific, New Zealand collided with the Pacific-Aluk spreading center (Lawver & Gahagan, 1993).

Extensional Tectonics

Pangea and Gondwana were in the advanced stages of breakup (drift phase). The spreading of the Central and Southern Atlantic continued, with a significant increase in the size of the Equatorial Atlantic (Nürnberg and Müller, 1991). The central Atlantic Ocean widened, propagating towards the Labrador Sea and the Rockall Trough in the North Atlantic (Doré, 1991). Spreading in the Rockall trough was accompanied by intensive downwarping

along the West Shetland and Mid-Norway margin. This spreading ceased around 84 Ma with the development of a new spreading center in the Labrador Sea (Doré, 1991). The onset of seafloor spreading in the Labrador Sea occurred either at 95 Ma, according to Scotese (1991), or at 84 Ma according to Lawver & Gahagan (1993). The Biscay Bay also opened. The main line of spreading in the Atlantic realm began to be established along the Biscay Bay - Labrador Sea line (P. Ziegler, 1988; Golonka & Bocharova, 2000). After the completion of the opening of the Canadian Basin in the Arctic, the Makarov basin opened by rifting the Alpha ridge away from the Barents platform (Green *et al*., 1986).

Spreading continued in the Eastern Mediterranean and between the Arabian and Taurus plates (Ricou, 1996, Robertson *et al*., 1991, 1996). The proto-South Caspian - Greater Caucasus Ocean was actively spreading. Spreading also continued in the Sebzevar-Sistan Ocean, between the Lut Turan platform and Afghanistan (Ricou, 1996; Sengör & Natalin, 1996). The Indian plate continued rapid northeastward movement, opening the Indian Ocean (Royer & Sandwell, 1989; Lawver *et al*., 1992). The separation of India from Madagascar began. The onset of seafloor spreading between Australia and Antarctica occurred at 95 ma (Lawver & Gahagan, 1993). The Kerguelen volcanic plateau was emplaced at the time when India was already separated from Antarctica. Interior continental rifts of Africa remained active. In the Southwest Pacific, seafloor spreading began in the Bounty Trough between the Campbell plateau and the Chatham Rise (Lawver & Gahagan, 1993).

Sea Level and Climate

This was the time of the maximum 1st-order highstand of global sea level during the Mesozoic and perhaps during the entire Phanerozoic. This was also the period of maximum continental submergence. This supersequence was highly asymmetric, with a sea-level lowstand in the middle. Global greenhouse conditions prevailed with a cooling interval

(Frakes & Francis, 1990). Hot, equable climates dominated, with high humidity and rainfall. The continental interiors were humid and local aridity was associated with orographic effects. There is no evidence of extensive continental glaciation. This was the time of a short-lived yet intensive global oceanic anoxic event (OAE), during the Turonian.

Carbonate Sedimentation

Carbonates were widespread throughout the northern hemisphere equatorial belt. They reached high latitudes, up to 69^{o} on the southern and northern hemispheres. The aerial extent of carbonate deposition had expanded in the Neotethys region, but had contracted in the Gulf of Mexico. On flooded shelves, most carbonate sediment consisted of deep-water marls and chalks. Large areas were covered by chalk in Western and Central Europe and in the Central Asian area, as well as in the internal seaway in North America (P. Ziegler, 1982, 1988, 1990, Vinogradov,1968b; Sloss *et al*., 1960) . Large areas were covered by carbonates in North Africa and Arabia. Platform carbonates continued to accumulate on the north Indian margin. Carbonates were deposited in the New Guinea area, Kerguelen Plateau and the Malvinas (Dercourt *et al*., 1993; Ronov *et al*., 1989; Philip *et al*., 1996). In the northern equatorial belts, carbonate facies included a shallow-marine, platform-interior and rudistid buildups and grainstones; platform exterior and platform margin microporous, mud-rich lithologies; and platform slope and basinal, carbonate flysch. Rudistid-rimmed shelf margins were developed on isolated platforms and on the micro-plates of the northern Neotethys region. Platform interiors were commonly flooded and accumulated deep-water, muddy, carbonate facies.