A Complete Section Through the Paleozoic to Mesozoic Indian Continental Margin (Spiti Himalaya, N India)

TALK

E. GARZANTI*, F. BERRA*, F. JADOUL* & A. NICORA*

The complete Paleozoic and Mesozoic stratigraphy of the Northern Indian continental margin was reconstructed from several detailed sections measured in 1992 along the Pin and Parahio Valleys, in the Kibber-Chikkim area and along the Kunzam La-Losar-Kiato profile.
A very thick succession of shallow-water fine-grained sandstones and pelites, with only a few intercalated dolostone beds at the top, was deposited in the Late Precambrian? and Cambrian. A thin biocalcirudite marker horizon was found in the Kunzam La area 485 m below the top of the unit. Similar carbonate beds occur also in Pin Valley.
Next, a major break is marked by a low-angle unconformity, best exposed north of Kunzam La and ascribed to the Late Pan-African orogenic pulse, overlain by an up to 783 m thick redbed "molasse" of Ordovician age.
The following unit is still arenaceous in the Takche area, and becomes more calcareous eastwards. At Muth it is 243 m thick and contains several limestone intervals, ironstone beds in the lower part and patch reefs at the top. It is overlain by 224 m of pure (eolian?) white quartzarenites, followed in turn by alternating hybrid dolomitic arenites and pure quartzarenites (55 to 92 m). At Losar this upper interval is much thicker (about 250 m) and characterized by restricted to open marine facies, including biocalcarenites and coral patch reefs.
Fossiliferous, storm-deposited arenaceous limestones (61 m at Muth), passing upward to dolostones and shale (64 m at Muth) were deposited in the Early Carboniferous; this succession is followed by white gypsum layers in the Losar area.
The Upper Paleozoic was characterized by major tectonic activity, leading to extreme topographic irregularities sealed by the Upper Permian Kuling Formation. In the Spiti Valley, the latter unit overlies a very thick terrigenous section, consisting of tidal quartzarenites and shales (well over 353 m thick at Losar), *Fenestella*-bearing shales (about 100 to 150 m thick at Losar), orange-weathering quartzarenites (123 m thick at Losar) and brownish sandstones, paraconglomerates and black pelites with dropstones (around 300 m thick at Losar and well over 150 m also at Lingti). In the Pin Valley, instead, the Upper Paleozoic section is largely eroded, and the Kuling Fm. disconformably overlies Silurian arenites to Devonian quartzarenites separated by paleofaults (Parahio Valley), or Lower Carboniferous limestones (Pin Valley).
The Kuling Fm. (63 to 95 m thick) consists of 0.4 to 35 m thick basal conglomeratic arenites, comprising ironstone layers at the base and top, overlain by black phosphatic pelites rich in Spiriferid and Productid brachiopods (52 to 93 m thick). In the Parahio Valley the basal arenites are only 0.4 to 2.1 m thick, whereas in the Pin Valley

*) Dipartimento di Scienze della Terra, Via Mangiagalli 34, I-20133 Milano, Italy

the basal breccia and hybrid arenites increase in thickness from 1.2 to 6.5 m (Muth), to 17.5 m (Guling).
The Triassic succession begins with the sharp paraconformable base of the Upper Griesbachian to Upper Anisian Tamba Kurkur ammonitic limestones (33 to 54 m thick). The ironstone-bearing, ammonite-rich condensed limestones occurring at the top of the unit are overlain by the *Daonella* Shale (42 m thick at Muth) and next by the *Daonella/Halobia* Limestone (85 m thick at Muth), whithin which the Ladinian/Carnian boundary lies.
The Carnian succession is very thick, and comprises the shelfal Grey Beds (206 m thick), upper Lower Carnian at the base (*Austriacum* Zone), and the shallow-water *Tropites* Limestone. This unit, organized in several terrigenous/carbonate shallowing-upward cycles, can be lithologically subdivided in a lower carbonate member (158 m thick), a middle largely terrigenous member (172 m thick, increasing northward to 205 m), and an upper carbonate platform member (103 m thick, increasing northward to 158 m). The upper member yielded uppermost Carnian conodonts at its base. Facies distribution patterns invariably point to northward deepening of the Spiti passive margin.
The sharp paraconformable base of the overlying Norian-Rhaetian succession is marked locally (Hal village) by breccias/conglomerates, overlain by storm-deposited quartzose limestones and bioclastic siltstones and sandstones, in turn followed by thick ironstone layers, marly limestones with rare ammonoids and locally abundant vertebrate ribs, passing upward to calcareous siltstones (109 to 187 m thick). Next, a 16 to 22 m thick limestone interval, locally yielding corals, brachiopods and lithoclasts, is followed by grey pelites, greenish sandstones, micritic limestones and local ironstones (134 to 148 m thick). These three units broadly correspond to the "*Juvavites* Beds", "Coral Limestone" and "*Monotis* Shale" of previous Authors, which however are difficult to recognize and trace laterally, due to poor original definition and strong lateral variability of facies. The overlying "Quartzite Series" (47 to 51 m thick), is characterized by quartzarenites, hybrid sandstones and bioclastic limestones. The upper boundary with the Kioto Limestone, marked by appearance of large bivalves (Alatochonchids, Megalodons) is transitional.
The latter mainly Lower Jurassic unit (over 600 m thick) consists of thick-bedded subtidal limestones; in the Kibber area huge oolite bars occur in its middle-upper part. The overlying Laptal Fm. (15 to 30 m thick) is characterized by quartzose calcarenites and ooidal limestones with ostreids and belemnite beds at the top. Next, the Ferruginous Oolite Formation consists of a lower grey marly interval yielding bivalves and belemnites (20 to 30 m thick), capped by an ironstone layer (0.8 to 2.2 m thick), passing upward to the Spiti Shale. Black shales with hybrid storm beds rich in Inoceramids and belemnites (*Belemnopsis gerardi* Beds, over 30 m thick) are followed by black shales yielding abundant Late Jurassic ammonoids (Chidamu Beds), which are invariably folded and overlain by black shales with intercalated sharp-based quartzose sandstones (Lochambel Beds, about 100 m thick).
The Giumal Group consists of a lower interval of quartzose bivalve-rich sandstones (54 to 73 m thick), overlain by black pelites and subordinate sandstones (116 to 133 m thick), and by locally glauconitic subarkoses yielding a few volcanic rock fragments, up to very coarse-grained at the top (32 to 67 m thick). Next, a thickening-upward cycle of reddish bioturbated subarkoses with intercalated glauconitic and

bivalve-rich layers (31 to 32 m thick), is overlain by black pelites, volcanic arenites and glauconitic layers (55 to 59 m thick). At Chikkim, the top of the unit consists of three thickening and coarsening-upward cycles (56 to 64 m thick), capped by biocalcirudites and black pelites (25 m thick).
The basal bed of the overlying Chikkim Limestone is rich in small phosphatic pebbles, belemnites and bacterial mats, and displays a strongly bioturbated sharp paraconformable base. This mid-Cretaceous pelagic unit, 65 m thick and containing planktonic foraminifers and locally echinoids, is followed by at least 200-300 meters of folded Kangi La Marls of Late Cretaceous age, which represent the youngest term of the Spiti succession.