MESOZOIC AND TERTIARY DEVELOPMENT OF THE PINDOS OPHIOLITE AND ASSOCIATED UNITS, NORTHWESTERN GREECE

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The northwest Pindos Mountains of Greece expose a sequence of Mesozoic and Tertiary thrust sheets, which include the Jurassic Pindos ophiolite, composed of ultramafic and mafic oceanic crustal rocks. Regional mapping has established the tectonic order of these units as follows: i) an ultramafic ophiolitic thrust sheet and basal metamorphic sole (Pindos Ophiolite Complex and Loumnitsa Unit); ii) Late Cretaceous platformal limestones (Orliakas Group); iii) dismembered intrusive and extrusive ophiolitic rocks (Aspropotamos Complex); iv) tectonic melange and olistostromes, dominated by Triassic-Jurassic volcanic and sedimentary rocks (Avdella Melange); v) coherent thrust sheets of Late Jurassic-Late Cretaceous deep-water sediments (Dio Dendra Group); vi) Early Tertiary flysch (Pindos Flysch).

Immobile trace-element studies indicate that the Triassic and Jurassic extrusives of the volcanic-sedimentary melange, formed mainly at within plate and/or mid ocean ridge settings. By contrast, the structurally overlying ophiolitic extrusives include boninite series volcanic rocks and depleted island arc tholeiites, indicative of a supra-subduction zone origin. Initial displacement of the ophiolite (ca 165 Ma) is recorded in the formation of a metamorphic sole, passing structurally downwards from a basal peridotite mylonite zone into amphibolite and greenschist facies rocks, interthrust with serpentinite. The sole rocks have MORB and WPB trace-element chemical affinities. Petrological and structural comparisons, and limited geophysical data, suggest the Pindos ophiolite is regionally continuous beneath the Meso-Hellenic trough with the Vourinos ophiolite to the east. This ophiolite, similarly has a supra-subduction zone chemical signature, and is also underlain by fragmentary metamorphic sole and melange units, of MORB-type geochemistry.

Sedimentary lithofacies within the Avdella Complex accretionary melange unit in general reflect the prevailing tectonic processes occurring during deposition. The overall tectonic setting is that of the initiation, development and partial closure of an ocean basin within this part of Mesozoic Neo-Tethys. The Avdella Complex itself contains preserved conformable sequences, representing severel different depositional environments, within a general block-in-matrix type coloured melange. Late Triassic to Early Jurassic lithologies, formed in an extensional phase during rifting and initial spreading within the basin, reflect two main environments of deposition: (1) horst blocks or seamounts, normally with a volcanic basement and (2) basinal turbiditic and pelagic carbonate and clastic sediments derived from these highs and other sources.

The sequences preserved on the highs initially display shallow water facies; fine grained platformal-type carbonates with occasional algal stromatolites and *Megalodonta*, together with oolitic and bioclastic limestones. These sequences may contain several episodes of slow or non-deposition, marked by hardgrounds with belemnite shell lags. In places,

extensional faults with syn-sedimentary depositional features are found cutting these facies. These faults were partly responsible for subsidence of the blocks, and this is reflected within the sediments by the subsequent deposition of nodular «ammonitico rosso-type» limestones followed by manganiferous and ferruginous mudstones, and eventually ribbon radiolarite. Such sequences occasionally reached a trench environment, and became accreted to the base of the overthrusting plate. During the final stage of this process, the seamounts shed detritus, normally in the form of carbonate turbidites, into the surrounding basins where mixing with basic volcanic material occurred.

The pelagic sediments formed in the basins between these highs, include classical Alpine Tethyen carbonate facies such as *Halobia* limestone, commonly with replacement or bedded chert, and a range of associated marls and shales. Also widespread are ammonite-bearing pelagic marls, and platy pelagic limestones containing calcified radiolaria, and occasionally pelagic foraminifera. Also present are arenites with continentally derived quartzo-feldspathic igneous and metamorphic detritus, of uncertain stratigraphical affinites and age.

Mid-Upper Jurassic sediments appear to have been strongly influenced by tectonic events leading up to, and following, the initiation of subduction within the basin. Instability caused by thrusting during tectonic accretion led to the influx of thick volcaniclastic turbidites into the basins, and sometimes, directly onto the highs. These turbidites contain clasts of basic volcanics and intrusives, ultramafics, chert and reworked carbonates such as those described. They include a range of grain sizes, from rudites to fine arenites, and are often interbadded with red and green radiolarite, and rarely with thin pelagic limestones or manganiferous mudstones. The turbidites appear to have formed as complex fan systems, which were sometimes over-ridden and accreted into the subduction complex, or else, formed as perched basins at a high tectonic level and were preferentially preserved. This part of the Jurassic was also a time of regional radiolarite deposition, and thick-bedded sequences collected in hollows protected from the main turbidite influxes.

In our favoured model, the Pindos ophiolite formed above a Mid Jurassic westerly-dipping intra-oceanic subduction zone. Continuing subduction produced a thick accretionary complex, now represented by the Avdella Melange that underlies the Pindos ophiolitic units. During the Late Jurassic, the eastern edge of the supra-subduction zone ophiolite was emplaced as a relatively undeformed sheet, eastwards onto the Pelagonian Zone, an assumed microcontinent. The Pindos Ocean remained partly open to the west as a remnant basin, undergoing deep-water and marginal carbonate deposition from the Late Jurassic to Late Cretaceous. In Early Tertiary time (? Palaeocene-Eocene), this basin began to close; the Pindos ophiolite was sliced, and together with the Jurassic melange and younger deep-water sediments, was thrust westwards over a flexural foreland basin (Pindos Flysch), and then onto the Apulian continental margin as an inboard-propagating thrust stack. Inferred footwall structures (old palaeogeographic features?) were mainly responsible for the formation of large orthogonal (e.g. Milea corridor) and transverse (e.g. Perivoli corridor) culminations. Final thrusting was accompanied by extension behind the deformation front, leading to the formation and infilling of tha Meso-Hellenic molasse basin.