RADIOLARIAN BIOSTRATIGRAPHY OF SUPRA-OPHIOLITE SEQUENCES IN THE XIGAZE AREA, YARLUNG-TSANGPO SUTURE, SOUTHERN TIBET (PRELIMINARY REPORT)

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The Yarlung–Tsangpo suture zone marks a site of collision of the Eurasia continent and Indian subcontinent and is characterised by a discontinuous line of ophiolitic bodies in southern Tibet and beyond. In the Xigaze area (250 km south–west of Lhasa) nearly continuous exposures of the Xigaze ophiolite stretch E–W over a distance of approximately 180 km. The ophiolite is in tectonic contact with the volcaniclastic turbidites of the Xigaze Group to the north, and either with fragments of an accretionary wedge or Indian passive margin series to the south.

Siliceous and some clastic deposits above the ophiolite have been assigned to the Chongdui Formation by Cao Ronglong in 1981 (cited in: BGMRXAR, 1993). Sino–French expeditions to this area in the early 1980s reported mostly white radiolarite and chert 10–30 m thick above the pillow lava (Girardeau et al., 1984, 1985a, 1985b). The ages of the chert as well as fine–grained clastic deposits above it were assigned to the upper Albian and possibly lower Cenomanian on the base of radiolarian findings (Marcoux et al., 1982a, 1982b). Lower Cenomanian radiolarians were later described from the Chongdui Formation (Wu, 1984). The radiolarian age thus appeared to be some 10 Ma younger than U–Pb whole–rock radiometric age of 120 ± 10 Ma for the Xigaze ophiolite reported from the Xigaze area (Göpel et al., 1984). Notably, the age of the Xigaze Group, thought to depositionally overlie the ophiolite (Girardeau et al., 1984, 1985a, 1985b, Wan et al, 1998), overlaps the age of the Chongdui Formation. Ammonites in the Xigaze Group indicate that clastic sedimentation in the forearc was well in progress by the late Albian (Wiedmann and Dürr, 1995). As radiolarian biostratigraphy has developed significantly since early work on the ophiolite, it is now possible to obtain more accurate age dating of the ophiolite and overlying deposits. This paper presents some new results of recent radiolarian investigations.

The lithostratigraphy of four sections in the central and eastern part of the Xigaze ophiolite (Fig. 1) has been studied and these sections have been carefully sampled for radiolarians. Almost all samples (over 50) yielded abundant radiolarian faunas with varying states of preservation (from poor–moderate to good). Those samples with poor–moderately–preserved faunas were treated further with various concentration of acid(s) solution for better results and larger residues.

The mid–Cretaceous radiolarian range chart based on Unitary Associations (O'Dogherty, 1994) has been used as a basis for age dating. As the range chart was developed for the western Tethys, it was essential to test its applicability to the study area. For this reason, the most critical age–diagnostic species for any particular samples have been identified as well as many western Tethys taxa as it was possible to recognise. No unexpected co–occurrences were encountered suggesting that the likelihood of cross–correlation in the temporal distribution of the taxa of western and eastern Tethys is minor and that the range chart is applicable to the study area.

The supra–ophiolite deposits are made up of different lithologies including chert, siliceous mudstone, and fine–grained flyschoid deposits. Sections have different degrees of completeness and all are truncated at their top. All the sequences are in undisturbed stratigraphic contact with underlying pillow lava or pillow breccia. Even if some minor shear occurs along the contact, it typically does not affect the contact itself and shearing usually occurs some centimetres above the depositional contact. At their top, all the sequences are in fault contact with Xigaze Group turbidites.

In the west of the study area, near **Donglhe** village south–west of Xigaze, the deposits overlying the basaltic breccia (with chert encrustment in the uppermost 20 cm) are chiefly composed of chert and subdivided into three units (Table 1, Fig 2).

Table 1. Stratigraphy of supra–ophiolite deposits at Donglhe.

Unit	Description	Thickness	Sample SZ–98–Do–	Sample position above basalt
2b	Purplish bedded (4–12 cm) chert with thin tuffaceous laminae/laminaset, scarce thin tuff layers and sets of ribbon chert (interlayering with siliceous mudstone 2–5 cm)	ca 5 m visible	20	
			–	uncertain
			12	
	Gap	10 m		
2	Purplish bedded (4–12 cm) chert with common thin tuffaceous laminae/laminaset and scarce tuff layers (1–4 cm)	7.5 m visible	11	14 m
			10	12 m
			9	11 m
			8	7 m
1	Purplish bedded (2–7 cm) chert, structureless at the bottom and with thin tuffaceous laminae in the upper part	6.5 m	7	5.5 m
			6	4 m
			5	3 m
			4	0.7 m
			3	0.45 m
			2	0.1 m
				Total thickness ca 16 m

Unit 2b is similar to Unit 2a and is exposed in a large S-shaped fold related to a sinistral shear.

Lower and middle parts of Unit 1 possess radiolarian assemblages (Table 4) that include taxa which make their first appearance in U.A.4 and *Xitus alievi* (Foreman) which has its last appearance in U.A.3. The stratigraphic position of these assemblages thus falls between U.A.3 and U.A.4 (3/4 in Fig. 2). It can be assigned to the interval of U.A.3- U.A.4, which is the middle part of the lower Aptian Verbeeki subzone. The stratigraphic position of the upper part of Unit 1 can be assigned to the lower to middle Aptian in the interval around the boundary of the Verbeeki and Costata subzones (U.A.5/6).

Unit 2a is middle to upper Aptian and ranges from the lower to middle part of the Costata subzone (U.A.6/7 to U.A.7). Unit 2b yields middle to upper Aptian radiolarian assemblages covering the interval from the lower to middle parts of the Costata subzone, (U.A.6/7 to U.A.8). The uppermost part of Unit 2b is slightly younger than the previous unit.

Units 2a and 2b display partial overlapping of their ranges. This is interpreted as sequence disruption with partial minor repetition along a sinistral shear zone. The topmost part of the sequence as well as any contacts (most likely tectonic) with turbidites of the Xigaze Group are not exposed.

Near **Qunrang** village, south-east of Xigaze and about 60 km east of Donglhe, the supra-ophiolite sequence is most complete. The following lithologies conformably lie on the top of pillow breccia with chert encrustment in the uppermost 20 cm (Table 2, Fig. 2).

Table 2. Stratigraphy of supra-ophiolite deposits at Qunrang.

Unit	Description	Thickness	Sample SZ-98-Q-	Sample position
8	Greenish-grey (more dark-grey upwards) mudstone with thin tuffite (1-4 cm); sand/shale ratio = 1:7. Mostly bottom traction current deposits with minor turbidites.	40 m		
7	Purplish-grey mudstone with thin, sparsely spaced tuffites with lamination and scarce Bouma sequences; sand/shale = 1:10. Coarse-grained thick (120 cm) turbidite at the top	8 m	21	top of unit
6	Greenish-grey mudstone with thin (2-4 cm) and closely spaced tuffite; sand/shale ratio = 3:1. Mostly bottom traction current deposits with minor turbidites.	10 m	20	centre of unit
			19	centre of unit
			18	centre of unit
5	Mostly purplish-grey (with minor greenish-grey) mudstone with tuffites with lamination and scarce Bouma sequence; sand/shale changes up-section from 1:5 to 3:1. Coarse-grained thick (70 cm) turbidite 7 m above the bottom	15 m	17	top of unit
			15	bottom of unit
4	Greenish-grey mudstone with thin laminated tuffite (tuff); sand/shale ratio changes up-section from 10:1 to 1:5. Mostly bottom traction current deposits with minor turbidites.	60 m	14	10 m below the top of unit
3	Purplish siliceous mudstone with thin (0.5-2 cm) tuff layers	2 m		
2	Red and purplish siliceous mudstone	1 m	9-7	14-15 m above basalt
1b	Purplish bedded (2-7 cm) chert with thin tuffaceous lamina and scarce tuff layers (1-4 cm)	13.5 m	6	9 m above basalt
			5	4 m above basalt
			4	2 m above basalt
1a	Purplish bedded (2-7 cm) chert with thin layers and lenses of bluish-green chert	0.5 m	3	0.5 m above basalt
			2	0.3 m above basalt
			1	0.1 m above basalt
				Total thickness150 m

Radiolarian assemblages (Table 5) from Unit 1a belong to U.A.1 - U.A.2. This is equivalent to the uppermost part of the Asseni zone to the lowermost part of the Turbocapsula zone, and can be assigned to the uppermost Barremian to lowermost Aptian. A rich radiolarian assemblage from the lower part of Unit 1b allows the most precise age determination. The most critical age-diagnostic taxa are: *Cyclastrum infundibuliforme* Rüst, *Thanarla carboneroensis* O'Dogherty and *Aurisaturnalis carinatus* (Foreman). The first two species are indicative of U.A.1, the uppermost part of the Asseni zone. This shows that the lower part of the sequence (Unit 1a and part of Unit 1b) is upper Barremian. The upper part of the chert unit possesses lower Aptian radiolarians of U.A.5, the top of the Verbeeki subzone.

Radiolarian assemblages (Table 5) from the siliceous mudstone unit (Unit 2) are upper Aptian and belong to U.A.8, upper part of the Costata subzone.

Samples from the central part of the clastic unit yield radiolarian assemblages (Table 5) whose stratigraphic position is assigned to the interval between U.A.9 and U.A.10 (uppermost Aptian - lower Albian) as some identified species made their first appearance in U.A.10 and some others are characterised by their final appearance in U.A.9.

The uppermost Aptian-lower Albian fine-clastic unit represents arc-derived deposits. It is older than the oldest known deposits of the Xigaze Group. Although Xigaze Group turbidites structurally overlie the fine-clastic unit, they are in fault (strike-slip) contact. Thus interpretation of the clastic unit as the basal part of the same fore-arc clastic succession is not necessarily correct. Characteristics of deposits in the upper part of Unit 8 resemble features of Xigaze Group turbidites and the possibility that these rocks represent transitional strata can not be excluded. Further detailed work is required in order to establish the original relationships of these rocks.

40 km further eastward at the **Polio** village different lithologies characterise the deposits above the ophiolitic pillow lava (Table 3, Fig. 2).

Table 3. Stratigraphy of supra-ophiolite deposits at Polio.

Unit	Description	Thickness	Sample SZ-98-P-	Sample position above basalt
5	Bleached greenish (bluish) - grey chert (5-15 cm) with minor sepiolitic layers. Sepiolitic / chert = 1:7.	1.5 m visible	16	10 m
			15	9.5 m
4	Sepiolitic layers (2-10 cm) with bleached pale greenish-grey chert (3-6 cm). Sepiolitic / chert = 3:1 (5:1 - 1:1)	5 m	14	8.5 m
			13	6.5 m
3	Dark-grey to greenish-grey and pale greenish grey bedded (5-10 cm) chert with sepiolitic layers (4-10 cm) more abundant upwards. Chert is bleached to pale white.	3 m	12	3.7 m
			11	3.6 m
			9	2.8 m
			8	2.5 m
			7	2.1 m
			6	2.0 m
2	Black and dark-green bedded (2-5 cm) chert with thin (1-3 cm) radiolaria-rich layers	0.5 m	5	0.7 m
			4	0.5 m
			3	0.4 m
1	Red and varicolored bedded (2-8 cm) chert	0.4 m	2	0.2 m
				Total thickness10.4 m

The top of the sequence is truncated as it is in tectonic contact with Xigaze Group turbidites.

The lower part of the sequence (Unit 1 - 3) yields radiolarian assemblage (Table 6) with stratigraphic position between U.A.3 - U.A.4. Radiolarians from the upper part of the sequence (Units 4 and 5) belong to U.A.4. The stratigraphic range of this sequence covers a short interval in the middle part of the lower Aptian Verbeeki subzone.

Ten kilometres to the east, at **Dazhuqu** village no chert was found. Instead a volcaniclastic unit (tuff? or redeposited basaltic detritus?) occurs along the traced top of the pillow breccia over a distance of 2 km. It is comprised of greenish-grey to dark-grey bedded (3-15 cm) thin-laminated tuffites? (sand and silt-size) with scarce mudstone (2-4 cm), thin and fine ?silicified tuff and bluish-green chert (<4 cm). The weathered surface of the rocks is pale-grey to white. Visible thickness of the rocks is 10-12 m. The sequence has a depositional contact with pillow basalt and breccia at the base and is in tectonic contact (thrust) with Xigaze Group turbidites at its top.

The age of the richest radiolarian assemblage (Table 6, Fig. 2)) obtained from bluish-green chert (sample *SZ-98-D-4*) is the same as for the lower part of the previous sequence (early Aptian).

On the basis of biostratigraphic data, the chronologic position of Barremian-Aptian boundary at 124.5 Ma (Harland et al., 1990), and a calculated rate of sedimentation (1.5 m/m.y.) the time of ophiolitic basalt eruption can be estimated as 122 Ma for Donglhe, Polio and Dazhuqu localities and 126-127 Ma for Qunrang.

All studied sequences display different lithostratigraphy in general, and different lithological units occupy the same stratigraphic levels. This is interpreted as sedimentation in different environments. Sequences at Donglhe and especially at Qunrang resemble typical oceanic deposits except for their small thickness/short range and presence of volcaniclastic material interbedded with the chert.

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