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The graptolitic facies of the Bogo Shale (Arenig-Llanvirn), Sør-Trøndelag, west central Norway

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with 1 Table

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A preliminary list of Bogo Shale graptolites, based on extensive new collecting, includes 27 species and subspecies, belonging to the »Pacific province«. Dominant species are *Glyptograptus austrodentatus americanus* and *Isograptus victoriae divergens;* the age assignment is about Yapeen 3 to Darriwil 2, that is, younger than the mid-Arenigian Lower Didymograptus Shale with which the Bogo Shale was originally correlated by BLAKE (1962) but in agreement with the assignment by BERRY (1968).
Aufgrund umfangreicher, neuer Sammlungen kann vorläufig eine 27 Arten und Unterarten umfassende Liste über Graptolithen aus dem Bogo-Schiefer aufgestellt werden. Die Fauna gehört zur »Pazifischen Provinz«; sie wird von *Glyptograptus austrodentatus americanus* und *Isograptus victoriae divergens* dominiert. In Übereinstimmung mit BERRY (1968) wird das Alter auf etwa Yapeen 3 bis Darriwil 2 festgestellt; nach der ursprünglichen Datierung durch BLAKE (1962) wäre der Bogo-Schiefer hingegen etwas älter (Mittel-Arenig, gleich dem Unteren Didymograptus-Schiefer).

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More than 20 years ago – in 1960 – the Bogo Shale had been discovered and described by D. Blake during mapping work in an area which lies about 50 km SSW of Trondheim between Meldal and Støren. In this area sediments of the Lower Hovin Group strike E–W and are limited against the older Støren Group in the N and S by faulting (CHADWICK et al., 1964:45, Fig. 1). The Lower Hovin Group shows rapid facies changes within a small area: breccias, conglomerates, clastic sediments (sandstone-shale), carbonates and intercalated intrusive igneous rocks are found. The beds are generally inverted which can be demonstrated by cleavage and sedimentary structures (load casts, graded bedding) and they dip to the N at an angle between 50° and 70°.
The Bogo Shale consists of a series of blue-grey to dark grey pyritic shale, thin (mm- to cm-scale) silt and sanstone beds, carbonate layers and breccias. Its thickness can be estimated only because of the outcrop limitation but may amount to max. 60 m. The section at locality Bogo 1 (BLAKE 1962:225, fig. 1) is 5 m thick and at Bogo 2 about 9 m. The remaining fossil-bearing localities Bogo 3, 4 and 5 have insignificant thickness or represent an incomplete section only.
In addition to mapping work my task was to identify the stratigraphic ranges of the Bogo Shale graptolite fauna. For this purpose the existing collections of the Paleontological Museum in Oslo, material collected by Prof. Nils Spjeldnaes and my own samples have been investigated. My own collections include about 1500 sample-slabs from the localities Bogo 1, 2 and 3 which often bear more than one specimen per slab. The graptolites are flattened; only few specimens are preserved in three dimensions filled in by pyrite.
The Bogo Shale graptolites have been described twice previously: originally by BLAKE (1962) and revised by BERRY (1968), resulting in different stratigraphic assignations: BLAKE considered this fauna to be an equivalent of the Lower Didymograptus Shale and therefore ascribed it to the middle Arenig (equivalent to the 3bγ-stage of the Oslo Region). SKEVINGTON (1963) contradicted this by citing BLAKE's faunal list and explained that a precise age could not be deduced from a consideration of only a part of that fauna; the nature of dichograptid element could in this case only indicate the hirundo zone (1963:259), i.e. late Arenig. Nevertheless the literature contains many references to the Bogo Shale graptolites retaining BLAKE's original designation.
According to BERRY (1968:220 and 225, Table 1) the Bogo Shale belongs to the (North American) graptolite Zones 8 (*Isograptus*) and 9 (*Paraglossograptus etheridgei*) with stronger affinity to Zone 9. BERRY's table would indicate the Bogo Shale to be late Llanvirn but more recent references (ROSS et al., 1982, sheet 1) correlate the *Isograptus* and *P. etheridgei* Zones to latest Arenig and early Llanvirn.
After my examination of ca. 75% of the material – the important group of didymograptids (expansograptid type) and some less important biserial forms have yet to be examined – the identifications in table 1 are of preliminary nature.
Based on this list the Bogo Shale is about Yapeen 3–Darriwil 2 according to the Australian graptolite zonation. This coincides

Table 1. Preliminary list of the Bogo Shale graptolites (a = abundant, c = common, r = rare, rr = very rare)

	Australian graptolite zonation												
	Castlemain			Yapeen			Darriwil				Gisborn		
	1	2	3	1	2	(3)	1	2	3	4	(1)	(m)	(u)
Allograptus venustus CHU, 1965 r				x	x	(x)	x						
Apiograptus crudus (HARRIS & THOMAS, 1935) rr					x	(x)	?						
Cryptograptus antennarius (HALL, 1965) r								x	x				
Glossograptus acanthus ELLES & WOOD, 1908 c							x	x	x	x			
Glossograptus armatus NICHOLSON, 1869 rr								x	x				
Glossograptus hincksii fimbriatus (HOPKINSON, 1872) rr								x	x				
Glossograptus cf. *hincksii hincksii* (HOPKINSON, 1872) r							?	?	?	x	x	x	x
Glyptograptus austrodentatus americanus BULMAN, 1963 a							x	x					
Glyptograptus austrodentatus austrodentatus BULMAN, 1963 c							x	x					
Hallograptus? (Cryptograptus?) inutilus (J. HALL, 1865) r				x	x	(x)	x	x	x	x			
Hallograptus inutilis (HALL, 1865) rr				x	x	(x)	x						
Isograptus caduceus australis COOPER, 1973 r				x	x	(x)							
Isograptus caduceus imitatus HARRIS, 1933 r	x	x	x	x	?	?							
Isograptus victoriae divergens HARRIS, 1933 a				x	x	(x)	x	x	x				
Loganograptus logani pertenuis (RUEDEMANN, 1904) rr			x	x	x	(x)	x	x	x				
Paraglossograptus proteus (HARRIS & THOMAS, 1935) rr								x	x				
Paraglossograptus tentaculatus (J. HALL, 1858) c							x	x	x				
Pseudodichograptus confertus CHU, 1965 rr				x	x	(x)	x						
Pseudodichograptus minor CHU, 1965 r				x	x	(x)	x						
Pseudisograptus dumosus B (HARRIS, 1933) r				x	x	(x)	?						
Pseudisograptus dumosus C (HARRIS, 1933) r				x	x	(x)	?						
Pseudotrigonograptus ensiformis (J. HALL, 1858) r				x	x	(x)	x	x	x	x			
Tetragraptus amii ELLES & WOOD, 1902 rr	x	x	x	x	x	(x)	x						
Tetragraptus serra (BRONGNIART, 1828) c	x	x	x	x	x	(x)	x	x	x	x			
Tetragraptus cf. *serra* (BRONGNIART, 1828)					x	(x)	x						
Tetragraptus zhejiangensis GEH, 1964 rr				x	x	(x)	x	x					
Thamnograptus sp. r			?	x	x	(x)	x	?	?	?	?		

quite well with BERRY's opinion (in consideration of the sheet cited above), although his faunal list is different to some extent (1968:218). The occurrence of some forms is as yet problematic, like *Gl.* cf. *hincksii hincksii* which seems to be too young. Another problem is the occurrence of »pure« Yapeenian (*I. caduceus australis, P. dumosus* B and C) and »pure« Darriwillian (*P. tentaculatus, G. austrodentatus americanus*) forms at the same horizons.

The reason for using the Australian graptolite zonation and not the Norwegian one is the model of graptolite faunal provinces. Two graptolite provinces are distinguished: an Atlantic and a Pacific one (e.g. see DEWEY et al., 1970:20). The graptolites of the Bogo Shale belong to the Pacific province because most of the forms (table 1) are characteristic for Australasia, North America and (parts of) China. Precisely the Arenig-Llanvirn transition represents a climax of graptolite faunal provincialism. This trend fades at the end of Llanvirn and during Llandeilo and Caradoc an almost cosmopolitan fauna had developed (JAANUSSON, 1979:A154).

The Pacific character of the Bogo Shale was important for palinspastic reconstructions of West Norway during early Ordovician times. Many authors have been concerned with it; GALE & ROBERTS (1974) and BRUTON & BOCKELIE (1980) shall serve as an example for different models. Collectively these authors suppose an island arc system: GALE & ROBERTS place it at the Baltoscandian side with a subduction zone facing SE, BRUTON & BOCKELIE illustrated the subduction zone dipping beneath the Laurentian Shield. The Lower Hovin Group including the Bogo Shale seems to reflect an island arc system because »the overlying, thick, Ordovician to Lower Silurian sedimentary/volcanic rock pile displays many of the characteristics of accumulation in back-arc or marginal geosynclinal basin« (GALE & ROBERTS, 1974:385). Both of the hypotheses leave questions unanswered and it must not be forgotten that each one is based on limited evidence: geochemical respectively paleontological. The meaning of g e o g r a p h i c a l l y defined provincialism of graptolites has possibly to be reconsidered e.g. in respect of a drilling-core from southern Sweden (Scania) – a shale which is an equivalent to the Endoceras Limestone – bearing several »Pacific« graptolites (*I. victoriae,* Sinograptidae, *G. austrodentatus austrodentatus, Skiagraptus, Apiograptus;* R. Nilsson, pers. comm.) together with »Atlantic« forms in an area which has been included with the Atlantic province up to now. Factors like temperature, depth of water column etc. seem to play an important role for graptolite distribution as the bathymetric model of ERDTMANN (1976:626, text-fig. 1) tries to show. In summary it may be said that the provinciality of the Bogo Shale is being challenged by other hypotheses regarding oceanographic factors (water mass chemistry/chemoclines, pycnoclines e.g.) which may have controlled graptolite distribution at any given space and time (ERDTMANN 1984, herein).

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