

The model proposed here for the Southern Uplands (Fig. 3) is very similar to those suggested for many modern accretionary prisms. Along the Central American Trench⁶ there is imbricate thrusting and associated folding with progressive steepening, followed by uplift; this shows close analogies with the evolutionary development along such margins as those off Japan⁷, Washington and Oregon⁸, the Makran coast of Iran⁹, Peru¹⁰ and the Aleutians¹³. Recently uplifted accretionary prism sequences are evident in Barbados^{11,12}, Alaska^{13,29} and the Mentawai Islands (Sumatra)¹⁴. In the Southern Uplands, Cockburnland, situated along what now constitutes much of the Northern Belt, became emergent by Upper Llandovery times and was a source of sediment for both the ocean to the south and the Midland Valley basin to the north²⁸. The younging of successive wedges towards the ocean coupled with overall younging of the sequence within each wedge towards the continent is diagnostic of accretionary prisms; this may be used as a test for their recognition in the geological record.

close to the Southern Upland Fault in the Llandeilo to the site of the Solway Firth in the Wenlock. Comparison with contemporary examples, such as the Aleutians, suggests that the angle of subduction decreased as the oceanic margin migrated southwards³⁰ (Fig. 3).

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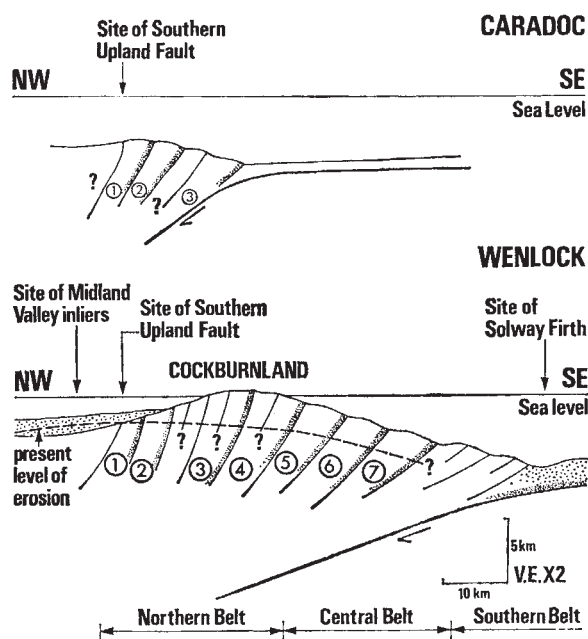


Fig. 3 The Southern Uplands accretionary prism in Caradoc and Wenlock times. Cockburnland was an emergent trench slope break in the Silurian. The numbers 1-7 refer to the sections in Fig. 2. Major faults separate each sequence; in addition, each sequence is affected by many minor faults. Only the known major faults are shown; there may be others, especially in some of the greywacke tracts (for example between sections 2 and 3). The shading at the base of the sections in the Northern Belt represents basalts and cherts, and in the Central Belt it represents shales and occasional cherts. The sediments in the Midland Valley and on the ocean crust to the south are also shaded. The remainder of the rocks are greywackes. The present level of erosion is arcuate to allow for post-Wenlock oversteepening of the prism.

All the evolutionary phases for the accretionary prism are assumed to be diachronous, occurring progressively later to the south. Uplift in the north occurred while accretion was still taking place on the oceanic margin of the Southern Uplands, and while sediments were still being laid down out on the ocean. The oncoming of the greywacke was progressively later to the south (Fig. 2). Similarly, the structural styles are diachronous across the prism; the D₁ to D₃ deformational phases represent only a systematic progression of style as a response to the same tectonic vectors.

With progressive accretion, the ocean margin of the prism migrated about 70 km southwards from a position

Cretaceous and Tertiary dinoflagellates from Seymour Island, Antarctica

THE marine sediments on Seymour Island, north-eastern Antarctica Peninsula, have produced numerous plant, invertebrate, and vertebrate remains over the past 80 yr (ref. 1). These strata have been regarded as Campanian (late Cretaceous) and Miocene. Dinoflagellate assemblages, reported here for the first time, indicate that some of the Cretaceous beds may be older (Senonian) than previously suspected and that the supposed Miocene beds are instead late Eocene and early Oligocene in age. These Eocene-Oligocene strata are the only known marine sediments of that age exposed on the Antarctic Continent.

The first detailed mapping of Seymour Island began in 1973-1974 (ref. 2). The marine sediments on the island are traditionally divided into two main groups: the Snow Hill Island beds of early and medial Campanian (late Cretaceous) based on ammonites³ and the Seymour Island Series of early Miocene age based in part on fossil penguins^{4,5}. The material examined for dinoflagellates comes from four sections (Fig. 1) measured through these strata^{2,6}. The samples were collected principally by W. A. Bryant (US Geological Survey) and T. A. Trautman (Ohio State University) during the 1974-75 season.

The beds at the north-eastern end of the island adjacent to Cape Wiman that have been mapped as Cretaceous² may be

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Palaeocene. A single dinoflagellate assemblage from 63 m above the base near the middle of section S-16 is dominated by an undescribed species and includes *Svalbardella australina*, *Hystrichosphaeridium tubiferum*, *Eisenackia*, and *Palambages*. The presence of these species indicates a Palaeocene correlation, although a possible very late Cretaceous age cannot be entirely discounted.

The northern half of the island, with the exception of the area adjacent to Cape Wiman, contains exposures of the supposed Miocene age Seymour Island Series. The 285-m section from the beach to the west edge of the meseta

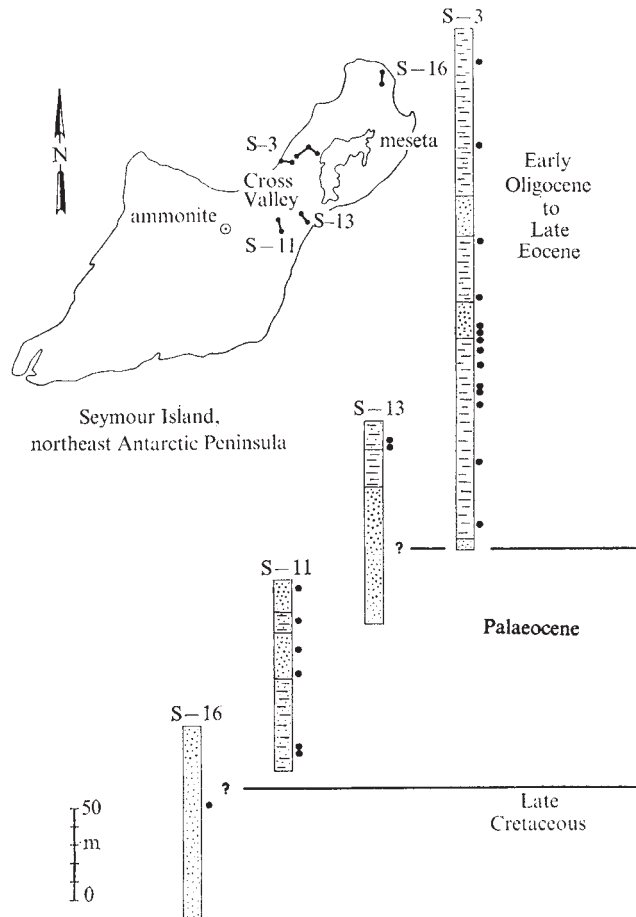


Fig. 1 Seymour Island ($64^{\circ}15'S$, $56^{\circ}45'W$) and generalised stratigraphic sections. Dots to right of columns represent samples from which dinoflagellates were recovered. The maximum length of Seymour is 20.5 km.

(section S-3) includes the oldest beds exposed in that part of the island. Sediments from the lower 84 m of the section contain a diverse dinoflagellate flora that includes *Aerosphaeridium diktyoplokus*, *Deflandrea fuegiensis*, *Deflandrea macmurdoensis*, *Hystrichosphaeridium tubiferum*, and *Spinidinium aperturum*. Above 84 m occur *Aiora fenestrata*, *Cycloptella*, *Thalassiphora*, and *Tubiosphaera filosa*, in addition to the common forms *Deflandrea macmurdoensis* and *Spinidinium aperturum*. These species indicate a late Eocene–early Oligocene age for the Seymour Island Series. The dinoflagellate succession correlates in part with the flora from the Eocene Río Turbio Formation in southern Argentina^{7,8}, and similarities in species composition to the dinoflagellate assemblages from Deep Sea Drilling Project Site 274 of Leg 28 near the Antarctic coast are evident⁹. Several of the above species have been recovered from glacial erratics at McMurdo Sound^{10–13} and from mud

samples grabbed from the bottom of Ross Sea beyond the Ross Ice Shelf¹⁴. Lower Tertiary sediments that are the source of these erratics and dinoflagellates are not exposed in the McMurdo Sound region although beds which correlate with those on Seymour Island undoubtedly exist deeply buried beneath the continental ice sheet. The dinoflagellate evidence supports Simpson's¹⁵ conclusion that the fossil penguin materials from Seymour Island, presumably from the upper part of section S-3 or its equivalent², are no older than late Eocene and no younger than early Oligocene.

Eastern Cross Valley is thought to be the area from which the plant material that was examined for pollen by Cranwell¹⁶ was collected by the Swedish Antarctic Expedition of 1901–1903. The age of the pollen assemblage was initially reported as early Tertiary with recycled late Cretaceous forms¹⁶ and later re-interpreted as Maestrichtian–Palaeocene¹⁷. Section S-13 was measured in the Cross Valley fault zone. Only two samples (130 and 132 m above base) were examined for dinoflagellates. The lower one has a rich spore and pollen content but only one unidentified dinoflagellate; the upper sample is dominated by *Paraleceniella indentata* which in Australia has a stratigraphic range from Campanian to Miocene¹⁸. Neither of the samples from S-13 provides conclusive information. It is likely, however, that the Cross Valley area contains a number of fault slivers which may include both late Cretaceous and early Tertiary sediments.

Section S-11 in the area mapped Cretaceous³ south of Cross Valley may be Palaeocene. Dinoflagellate assemblages from S-11 include *Chlamydophorella*, *Hystrichosphaeridium tubiferum*, *Palaeoperidinium*, *Spiniferites ramosa ramosa*, *Svalbardella australina*, *Tanyosphaeridium*, *Palambages* spp., and *Paraleceniella indentata*; the ubiquitous *Deflandrea macmurdoensis* and *Spinidinium aperturum* of section S-3 are absent from S-11.

The southern half of Seymour has been dated by ammonite collections as late Campanian¹⁹ and early-medial Campanian³. Matrix from an unidentified ammonite collected by W. J. Zinsmeister (Ohio State University) from that part of the island (Fig. 1) contains the dinoflagellates *Cyclonephelium distinctum* and *Deflandrea cretacea*, indicating an early Senonian age for the ammonite, thus pre-dating the previous ammonite-based Campanian assignment.

Owing to the discovery of several previously undescribed faults in Cross Valley and to the results from the dinoflagellate investigation that differ from other palaeontological studies, final conclusions about the biostratigraphy and correlation of the southern part of Seymour Island will depend on further detailed mapping; at present the extreme southern part of Seymour Island has not been examined.

The abundant well preserved dinoflagellates of Seymour Island provide a new basis for unravelling what seems to be a more complex geology than anticipated. As the dinoflagellate and stratigraphic succession is studied it will become a standard for correlation of the other plant, invertebrate, and vertebrate remains with the better known and more accessible records elsewhere in the Southern Hemisphere.

In addition to abundant dinoflagellates, every sample examined except the one from S-16 contains a very rich assemblage of spores and pollen including several forms of *Nothofagus* and, from S-3, pollen of Gramineae. This is the first fossil record of grasses from Antarctica. Also, massula of the freshwater fern *Azolla* occur in S-11. These late Cretaceous–early Tertiary spores and pollen grains are unstudied but should provide a history of low latitude Antarctica vegetation during the Palaeocene–Oligocene period of climatic cooling before the formation of the present Antarctic Ice Sheet^{20,21}.

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Temporal characteristics of iconic memory

THE duration of visual persistence (iconic memory) is inversely related, up to a point, to the duration of the inducing stimulus. This suggests that iconic memory can more properly be identified with ongoing neural processes than with the decaying contents of a sensory store. Since the publication of Sperling's influential monograph¹ there has been general agreement that a relatively faithful representation of a visual display remains perceptually available for several hundred milliseconds after the distal stimulus has vanished. This led to the postulation of a short-term visual store, also called iconic memory² or sensory register³, with contents decaying rapidly after the termination of the inducing display. The terms visual persistence or icon are commonly used to refer to the perceptual availability of the decaying contents of the sensory store. Iconic memory is regarded as having temporal combinatorial properties which allow perceptual integration of two or more sequential displays even if separated by a brief temporal gap. Integration in iconic memory was convincingly demonstrated in a study where the subjects were required to identify which element in a briefly-displayed array of 16 alphabet characters had been singled out by a temporally trailing bar marker⁴. Temporal integration has also provided an explanation for some aspects of visual masking⁵ and for temporal integration of patterns whose parts were presented sequentially in time^{6,7}. Here I question the view that iconic memory is a store whose contents begin to decay when the inducing stimulus is terminated. I suggest that the duration of iconic persistence is linked to the duration of visual processes which begin at the onset of stimulation and continue for a given duration, whether or not the inducing stimulus is still on display. This view is based on the finding that the duration of visual persistence is negatively related to the duration of the inducing stimulus.

The experimental technique⁷ used a computer-driven oscilloscopic display (gridless Tektronix 602 equipped with ultrafast P15 phosphor) consisting of a square matrix of 25 dots arranged in five rows and columns. One of the 25 dots, chosen randomly on every trial, was not plotted. The subject, who sat in a dark room, initiated each display with a button press and then reported the matrix coordinates of the missing dot. The matrix was displayed in two successive portions separated by a temporal gap: first, an aggregate of

12 dots, chosen randomly from the matrix, was displayed for a period that varied between 10 and 200 ms, depending on the condition; next, a 10-ms temporal gap was allowed to elapse with no dots shown on the screen; and, finally the remaining 12 dots were displayed for 10 ms.

Figure 1 shows the results for two subjects. Almost identical results were obtained with other subjects and with casual observers in the laboratory. A marked impairment in performance is evident as the duration of the leading display exceeded about 100 ms. The phenomenal appearance of the display should be noted: at the shorter durations of the leading portion all dots in the matrix were perceived simultaneously with no evidence of a temporal gap. At the longer durations the display was seen clearly in two successive portions separated by a significant gap.

Since the experimental task was practically impossible unless the two portions of the display were actually seen as one, it seems likely that some sort of visual persistence was necessary for bridging the temporal gap. But could persistence be attributed to the rapidly decaying contents of an iconic store? Probably not. Bearing in mind that the temporal gap was of the same duration in every condition, and that a 'storage' theory assumes an icon whose strength does not start decaying until the termination of stimulation, it is difficult to see how the briefest (10 ms) display could induce iconic contents capable of bridging a given temporal gap while a much longer display could not.

More plausible inferences about visual persistence are, first, that its duration may be more closely timelocked to the onset than to the termination of the inducing stimulus, and second, that it may be more properly considered to be

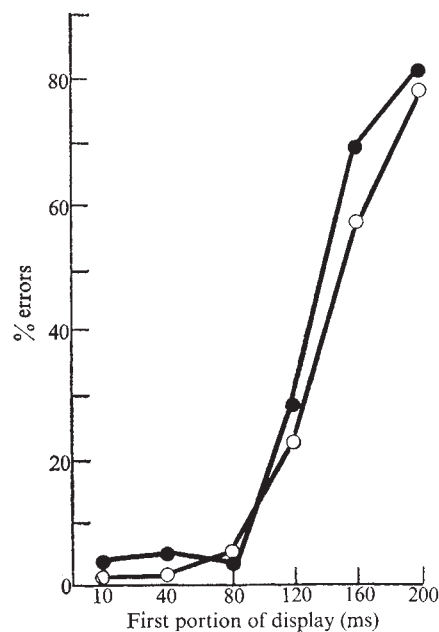


Fig. 1 Percentage of errors in identifying the location of a missing dot within a 5×5 -element dot matrix which was displayed on an oscilloscope in two portions of 12 dots each, separated by a 10-ms gap. The duration of the first portion of the display is shown on the abscissa; the second portion was always 10 ms. The matrix subtended approximately 6° of visual angle. The two portions of the display were equated for brightness through computer-controlled modulation of the oscilloscope's Z-axis. This allowed independent variation of the intensity of each dot in the display. The appropriate intensity levels for each duration of the leading display had been determined separately in a preliminary psychophysical task. Entirely similar results were obtained without brightness-compensation despite some degree of brightness-mismatch between the two portions of the display. Results are for two subjects—M.K. (●) and V.D.L. (○).