50th Kaikoura05

The Organising Committee extends a warm welcome to all delegates and visitors to Kaikoura, where it all began 50 years ago.

Please note that all information in this publication was correct at the time of going to print. However, due to factors beyond our immediate control, such as weather, road conditions and permission for land access, some unexpected late changes in field trip routes and itineraries may be required.

Bibliographic References:

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A.N. Author (2005) What I did in my holidays. *In:* Pettinga, J.R. and Wandres, A.M. (eds.) Programme and Abstracts, Geological Society of New Zealand 50th Annual Conference, Kaikoura, New Zealand. Geological Society of New Zealand Misc. Publ. 119A, x-y p.

Field Trip Guide Volume

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Kaikoura

Field Trip Guides

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Field Trip Guides – Contents

FIELD TRIP 5B

STRATIGRAPHIC AND SEDIMENTOLOGICAL TEASERS, KAIKOURA PENINSULA, MARLBOROUGH

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INTRODUCTION

During this trip, we will view Late Cretaceous to Miocene sediments at Kaikoura Peninsula, with an emphasis on their stratigraphic and sedimentological characteristics and implications (Fig. 1). The three sections we will examine have not been studied in any great detail, so one of the purposes of this short teaser is to hopefully encourage discussion and debate, if not further work, and provide a greater appreciation of Marlborough Cretaceous to Miocene geology.

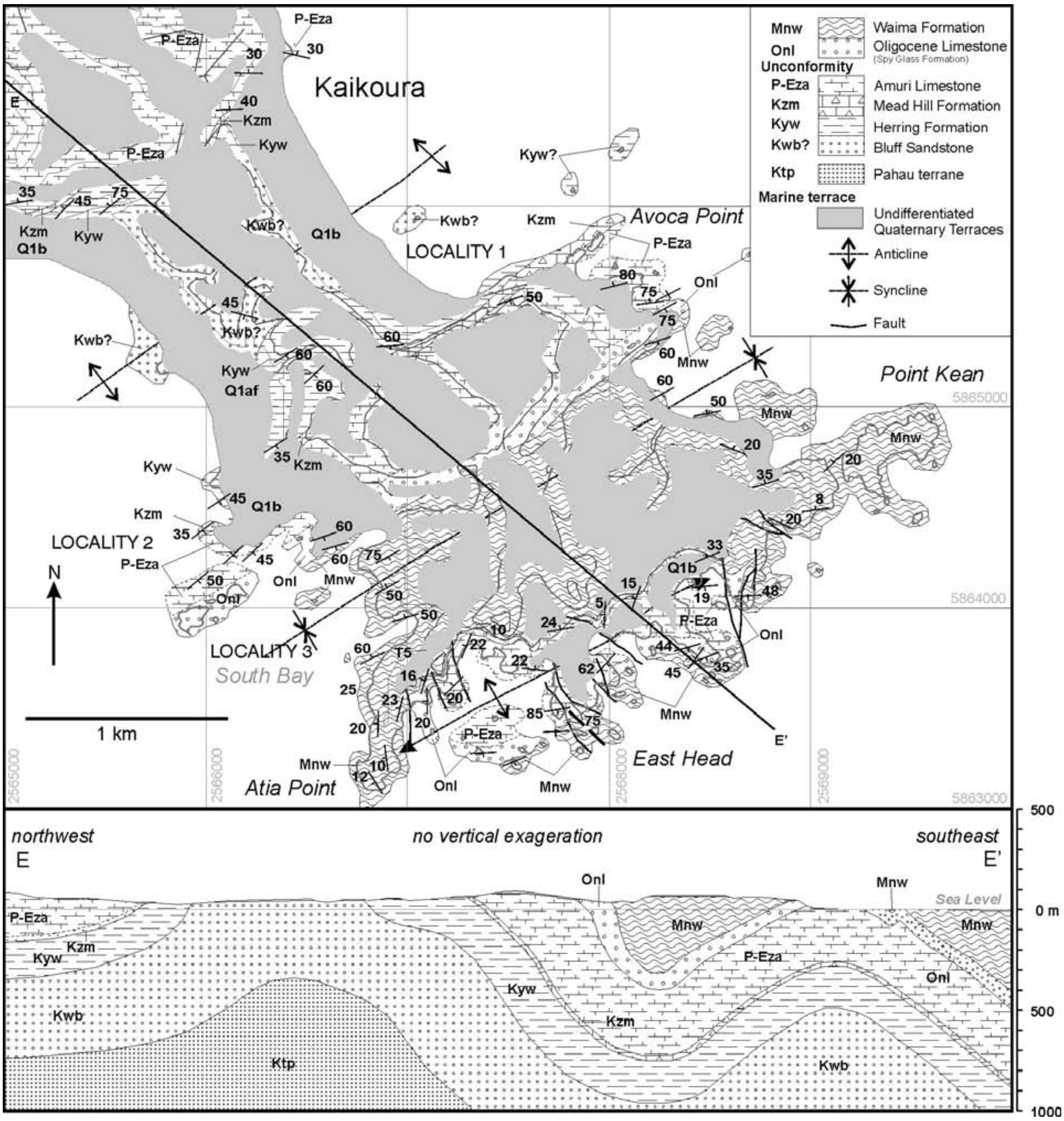

Figure 1. Geological map and cross section of Kaikoura Peninsula (modified after Rattenbury et al. in prep).

The Cretaceous and early Tertiary geology of Marlborough is varied, and some of the complexity has been discussed on one of the pre-conference field excursions (Hollis et al. 2005a). At Kaikoura Peninsula, the first two stops are in Late Cretaceous fine-grained transgressive sediments of the Herring Formation which here contain abundant dolomitic concretions. The Herring Formation is a lateral equivalent of the Whangai Formation which exists throughout the eastern margin of New Zealand (Moore 1988). These fine-grained transgressive deposits were formed in response to passive margin subsidence following closely on the initiation of sea-floor spreading in the Late Cretaceous, and separation of New Zealand from Gondwana. The overlying Tertiary succession examined at Locality 3 includes carbonates of the Eocene Amuri Limestone and the Miocene Spy Glass and siliciclastic Waima formations.

Please be aware of certain hazards on today's trip. As we will be examining rocks in coastal sections, be aware of dangers from rising tides, slippery and sharp rocks, etc, and vehicles that may be in the vicinity. South Bay is often a busy place, so watch for backing vehicles and large tractors used to launch boats. Be aware that low tide is at 1030 hrs.

FIELD STOPS

Locality 1 - North Side of Kaikoura Peninsula – 2 hrs

(E2567291; N5865545 to E2567864; N5865752)

This stop in front of the University of Canterbury Edward Percival Field Station exposes an interesting section through the Late Cretaceous Herring Formation (Fig. 1). The sediments consist of light grey to brown, fine-grained siliceous sandstone and siltstone (Fig. 2). Most of the interval is well bedded and one interval approximately midway through the section contains thin ripple and climbing ripple laminated sandstone and starved sandstone lenses (Fig. 3).

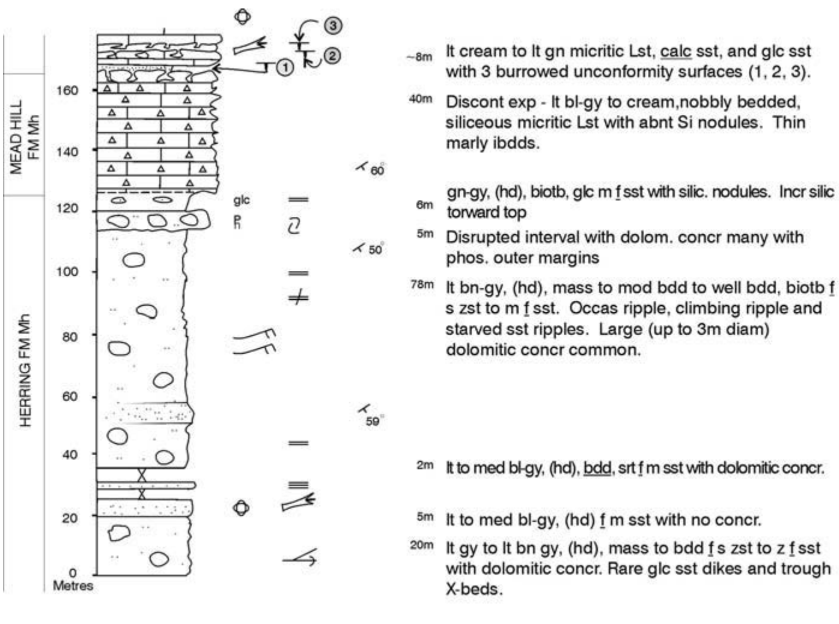

Figure 2. Stratigraphic section on north side of Kaikoura Peninsula, Locality 1.

Figure 3. Ripple and climbing ripple laminated sandstone interval within Herring Formation, E2567455; N5865780. Scale bar (top left) is 5 cm with 1 cm divisions.

Large conspicuous brown or buff coloured dolomitic concretions occur throughout the 100 m+ thick section (Browne 1985, Lawrence 1989). In this section they are up to 3 m diameter, and occur as either massive concretions, or as concretions with concentric zonation or with preserved bedding (Fig. 4). Typically they are spheroidal or flattened spheroids with their long axis parallel to stratification. Many of the concretions have hard centres, others have soft sandy or muddy cores, and other concretion centres are dominated by dark opal CT (Browne 1985). Apart from an abundance of dolomite, which occurs as fine grained matrix or as interlocking crystals (0.2 mm in diameter), the concretions are mineralogically similar to the surrounding sediment. They consist of quartz, with less abundant plagioclase, glauconite, tourmaline, and muscovite. SEM micrographs indicate the concretions contain foraminiferal tests replaced by dolomite (Browne 1985). XRD indicates that for some of the concretions at least, dolomite is more abundant toward the periphery than the centre of the concretions, suggesting dolomitisation proceeding from the concretion margins toward their centres.

Concretions likely formed by removal of SO_4^{2-} by microbial reduction of organic components of the sediment, and in the process carbonate was precipitated. Dolomitisation likely occurred by Mg^{2+} enriched pore fluids the source of the Mg^{2+} being from diffusion of seawater into the sediment. Lawrence (1989) indicated mean $\delta^{18}O$ values for similar dolomites of Marlborough to be in the range -4.1‰$_{PDB}$ to -3.6‰$_{PDB}$, giving calculated paleotemperatures of generally <60^{0} C to as low as 17^{0}C. We suggest an upper slope to outer shelf depositional setting based mostly on the fine-grained nature of the sediment, and the lack of abundant traction structures and channelisation, implying a rather low-energy depositional environment.

In the upper part of the section, a 4-5 m thick disrupted interval contains several concretions which display phosphatised and bored outer margins (Fig. 5). These features, approximately 1 cm in diameter and extending up to 5 cm into the concretions, can occur completely around the outer margins of the dolomitic concretions. This implies that the concretions were rolled as detached blocks, presumably bored in a high-energy intertidal setting, then transported into the Herring Formation depositional area (Browne 1985). Lawrence (1989) indicated that the material infilling the borings is microcrystalline quartz with some glauconite, with no carbonate. We suggest the disrupted interval represents a slumped interval, implying an early formation of dolomite concretions, uplift and boring in an intertidal environment, then mass transport emplacement.

Figure 4. Large dolomitic concretion with concentric banding and a light grey siliceous core, E2567390; N5865753. Scale bar (centre of concretions) is 50 cm long with 10 cm divisions.

A gradational contact at the top of this disrupted interval is marked by abundant glauconite, representing a transition into the overlying Mead Hill Formation (Haumurian). The Mead Hill Formation comprises lenticular beds of variably light to dark-coloured siliceous and calcareous, fine-grained sediments, with a characteristic nodular appearance (Thomson 1916; Moore 1983; Lawrence 1989, 1993). Chert consists predominantly of quartz with rare opal-CT (Lawrence 1989). The silica content of the Mead Hill Formation is consistent with biogenic oozes found globally, and was derived from *in situ* diatoms and radiolarians (Hollis 2003; Hollis et al. 2003a; Hollis et al. 2003b).

We'll cross the road, past the pub (if you can) to the fish factory, to view the transition into the Amuri Limestone. At least three unconformities are represented over a thin stratigraphic interval (Fig. 6). The top of the Mead Hill Formation is marked by a variably 30-80 cm thick, dark grey fine- to medium-grained glauconitic sandstone with glauconite-filled burrows extending up to 25 cm into the underlying Mead Hill Formation. It is overlain by a light greenish limestone, glauconitic sandstone, and calcareous sandstone 3 to 6 metres thick, in turn overlain by a well exposed unconformity with *Thallasinoides* burrows (Fig. 7). This second unconformity is complex and dominated by sandy limestone, existing as an amalgamated, intensely bioturbated interval, while in other places, is represented by several distinct burrowed surfaces. Glauconitic sandstone dikes are also present.

Figure 5. Phosphatised and bored outer margin of dolomitic concretion, E2567530; N5865628. Divisions on scale bar = 10 cm.

This particular site is not well dated, but a stratigraphically equivalent section nearby indicates that the interval above the Mead Hill Formation is of Paleocene-Eocene age, and has been equated to the Teredo Limestone (Hollis et al. 2005b). Regional work by Morris (1987) indicated that the Teredo Limestone was deep marine, possibly bathyal. The interval above the Teredo Limestone was included in the Lower Limestone Formation by Morris (1987) and Lawrence (1989, 1993). Further work is planned in this section, and its relationship to similar units of the Clarence Valley (Hollis et al. in press). Hollis et al. (in press) argue that erosion, glauconite, and condensed sedimentation occurred in proximal settings during the Paleocene such as at Kaikoura Peninsula and the Clarence valley during the Paleocene, while thick biosiliceous sediments were deposited further north in more distal settings at this time. This was inferred to imply vigorous ocean circulation and enhanced coastal upwelling during a period of relatively cool climatic conditions.

Locality 2 - South Bay, Kaikoura Peninsula; the Late Cretaceous – 30 minutes
(E2566035; N5864632 to E2566101; N5864491).

The section from the Coastguard Base to the boat ramp comprises the same Herring-Mead Hill succession that we visited on the north side of the peninsula, and for this reason, we won't spend too long here. If time is limited the stop may be omitted. The ammonite *Neophylloceras* sp. was collected from the lower part of this section (O31/f121). Features to note are the large dolomitic concretions, here often with bedding lamination through the concretions, the deformed bedding above and below the concretions caused by differential compaction about the early formed dolomitic concretions. Uncemented sediment from the centre of one of the concretions yielded a Haumurian microfauna (O31/f138). The contact of the Herring/Mead Hill Formation is not well exposed; possibilities include either a depositional contact (cf. locality 1) or a faulted contact.

Figure 6. Unconformities adjacent to the fish factory at the top of the section, E2567848; N5865922. A glauconitic sandstone (immediately below the photo) occurs at the top of the Mead Hill Formation. It is overlain by light-coloured micrites in the lower part of the photo, overlain by two burrowed unconformities (labelled 2 & 3 in the upper portion of the photo). Outcrop view is about 5 m wide.

Figure 7. Detail of one unconformity (labelled 2) in Figure 6. Scale bar is 50 cm with 10 cm divisions.

Locality 3 - South Bay, Kaikoura Peninsula; the Tertiary – 1 hour

(E2566505; N5864490 to E2566631; N5864321).
Amuri Limestone is well exposed in the central parts of the bay from the boat ramp eastward to the prominent unconformity at E2566564; N5864395 (Figs. 8 & 9). It consists of centimetre to decimetre-bedded creamy coloured, hard, bioturbated calcilutite, dominated by coccolith and foraminiferal tests. The age of the Amuri Limestone at Kaikoura Peninsula is not well defined but is probably Mangaorapan (Early Eocene) at the base, to probably Runangan (Late Eocene) at the top. It is commonly complexly folded and fractured (see Campbell 1975). The age of the folding, and that seen in the overlying units, is uncertain, but was probably initiated in the Middle Miocene, and deformation continues to the present day.

Figure 8. Burrowed unconformity at the top of the Amuri Limestone and base of the Spy Glass Formation, Locality 3, E2566564; N5864395. Scale bar is 50 cm with 10 cm divisions.

The unconformity at the top of the Amuri Limestone is marked by a slight angular discordance, and separates the Amuri from the overlying, overtly similar, but sandier Spy Glass Formation of Early Miocene (Waitakian-Otaian) age. We can debate whether this is the Marshall Unconformity, the Marshall Paraconformity or some other unconformity, paraconformity or disconformity!

The Spy Glass Formation (Browne & Field 1985) consists of centimetre to decimetre bedded, white to cream, hard, bioturbated glauconitic sandy wackestone and packstone (Fig. 10). Folding similar to that observed in the Amuri Limestone is also present in the Spy Glass Formation. The overlying Waima Formation abruptly overlies the Spy Glass Formation and is marked by bioturbated, glauconitic mudstone and sandstone. There are glauconitic layers in the upper ~2 m of the Spy Glass Formation. Sand and glauconite content in the Waima Formation decreases stratigraphically upward through the 100 m thick outcrop of Waima Formation at South Bay. The Waima is Clifdenian (Middle Miocene) in age at the core of the syncline axis to the east.

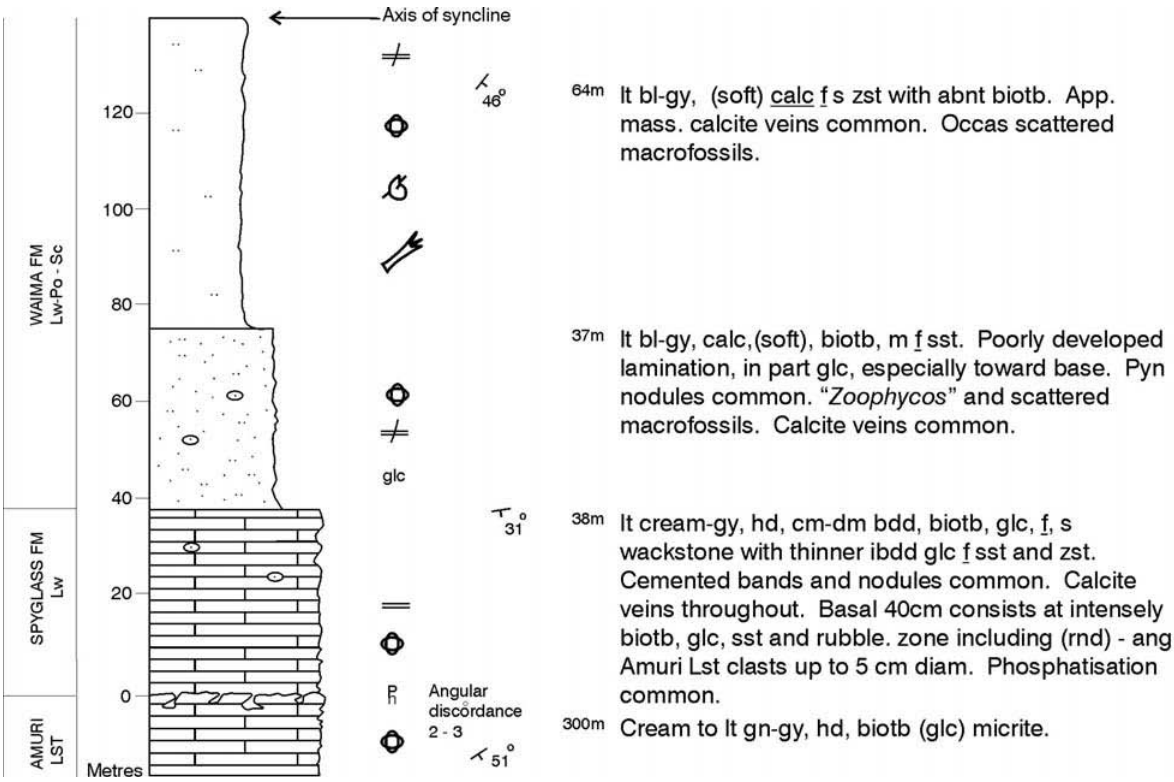

Figure 9. Stratigraphic section on south side of Kaikoura Peninsula, Locality 3.

Figure 10. Spy Glass Formation at Locality 3, E2566619; N5864532. Scale bar (right) is 50 cm with 10 cm divisions.

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