General Certificate of Education
Advanced Level Examination
June 2013

Geography GEO4B/PM

Unit 4B Geographical Issue Evaluation
Advance Information Booklet

Date of issue: On or after Friday 22 March 2013

You will need no other materials.

Instructions

- This Advance Information Booklet will be issued on or after Friday 22 March 2013 in advance of the examination for Unit 4B. You should make yourself familiar with the information in the booklet.
- This booklet must be kept **unmarked** for use in the forthcoming examination.

STUDY ALL THE INFORMATION IN THIS BOOKLET

The information in this booklet comprises the following:

There is no source material printed on this page

Turn over for Item 1

Item 1 Are natural disasters becoming more common?

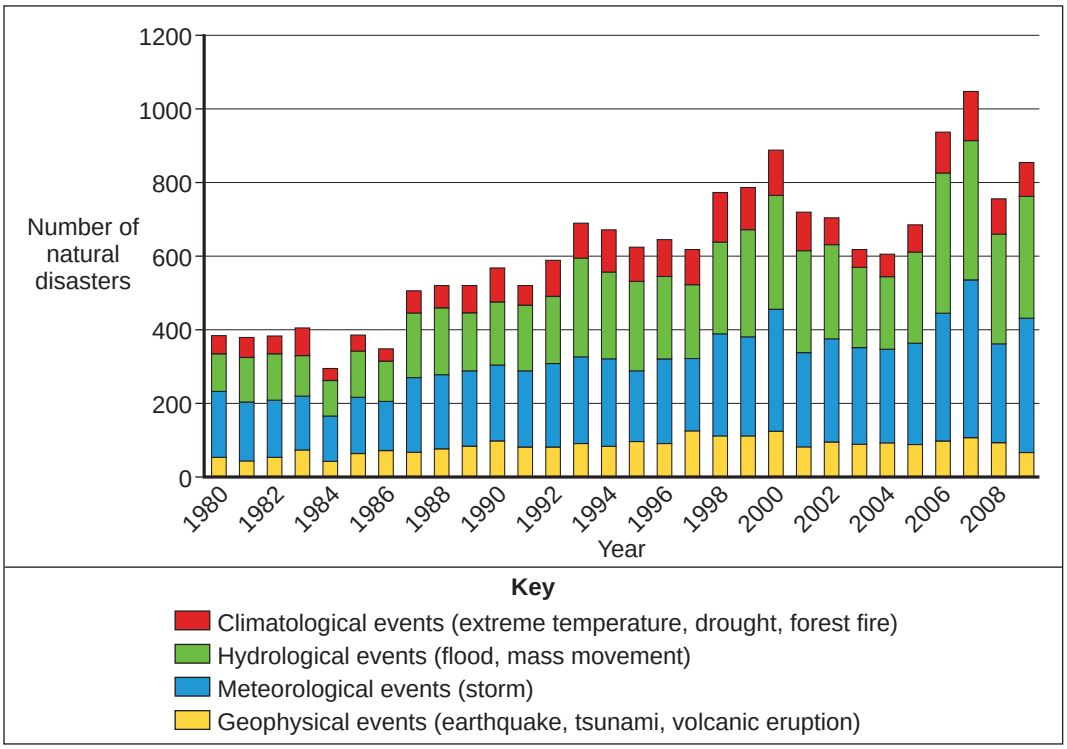
In recent years there has been a lot of news in the media about a series of tectonic events in different parts of the world, including:

- the Boxing Day tsunami triggered by the Banda Aceh earthquake
- earthquakes and associated landslides in Kashmir
- the Darfield Quake and Christchurch Earthquake in New Zealand
- the earthquake off the coast of Japan, followed by the tsunami that devastated the north-east coast and damaged a nuclear power station
- volcanic eruptions in Iceland, which caused such disruption to air travel.

All this news in the media might suggest that the Earth could be getting more unstable. Is this the case?

Figure P1 below is based on information that Munich Re, a German insurance company, collected. The source did not make clear how Munich Re decided that 'a natural disaster' was bad enough to be included on the graph.

Figure P1



The National Oceanic and Atmospheric Administration (NOAA) provided data to produce **Figure P2** below. It shows the ten hottest years since reliable climate records have been kept. It uses data collected from recording stations around the world.

Figure P2

Global top ten hottest years	Anomaly (+°C)
2010	0.62
2005	0.62
1998	0.60
2003	0.58
2002	0.58
2009	0.56
2006	0.56
2007	0.55
2004	0.54
2001	0.52

(*'Anomaly' here means the difference in average worldwide temperature compared with the 1951 to 1980 average.*)

Some people think that there may be some links between the trends shown in the two sets of data in **Figures P1 and P2**.

Item 1 continues on the next page

The material below is a summary of part of ‘The seismic non-pocalypse’, a blog posted on 21 April 2010, by Chris Rowan. (Dr Rowan is a member of the faculty of the National Oceanography Centre in Southampton. He specialises in the study of palaeomagnetism and plate tectonics. Many geologists read and respect his blog.)

Due to copyright restrictions we are unable to electronically publish the extract which included Figures P3, P4 and P5.

Item 2 The background to the Christchurch Earthquake of February 2011

New Zealand lies on the well known Pacific 'Ring of Fire'. New Zealand lies at the margin between the Indo-Australian Plate and the Pacific Plate, but movement at this margin is complex and seems to be changing. This makes mapping of the margin difficult and prediction of possible future movements even more difficult than at many other plate margins.

Figure P6 shows how the Pacific Plate is being subducted beneath the Indo-Australian Plate, just off the east coast of the North Island. The subduction zone terminates about 275 km north-east of Christchurch. Then the direction of the margin changes and there is a fault zone, running from north-east to south-west, across the centre of South Island, through the mountain range called the Southern Alps. This fault zone is mainly made up of the Alpine Fault but, just to the north of Christchurch, is a complex area of faulting called the Marlborough Fault Zone. Further south, beneath the Canterbury Plain, recent sediments cover the faults and so they have been very difficult to map. The main movement here seems to be a transform faulting. Transform or lateral faults are often found at conservative margins.

On 4 September 2010, a magnitude 7.1 earthquake happened along a fault in the Marlborough Fault Zone, which had not been known about before. The earthquake has been called the Darfield Quake. The earthquake formed what has become known as the Greendale Fault. The Greendale Fault is now thought to be between 25 and 30 km long. During the Darfield Quake the land above the fault slipped laterally by up to 4 metres.

Due to copyright restrictions we are unable to electronically publish the extract.

After the Darfield Quake, hundreds of aftershocks struck the region – many of them widely felt around Christchurch. Some of the aftershocks caused more damage.

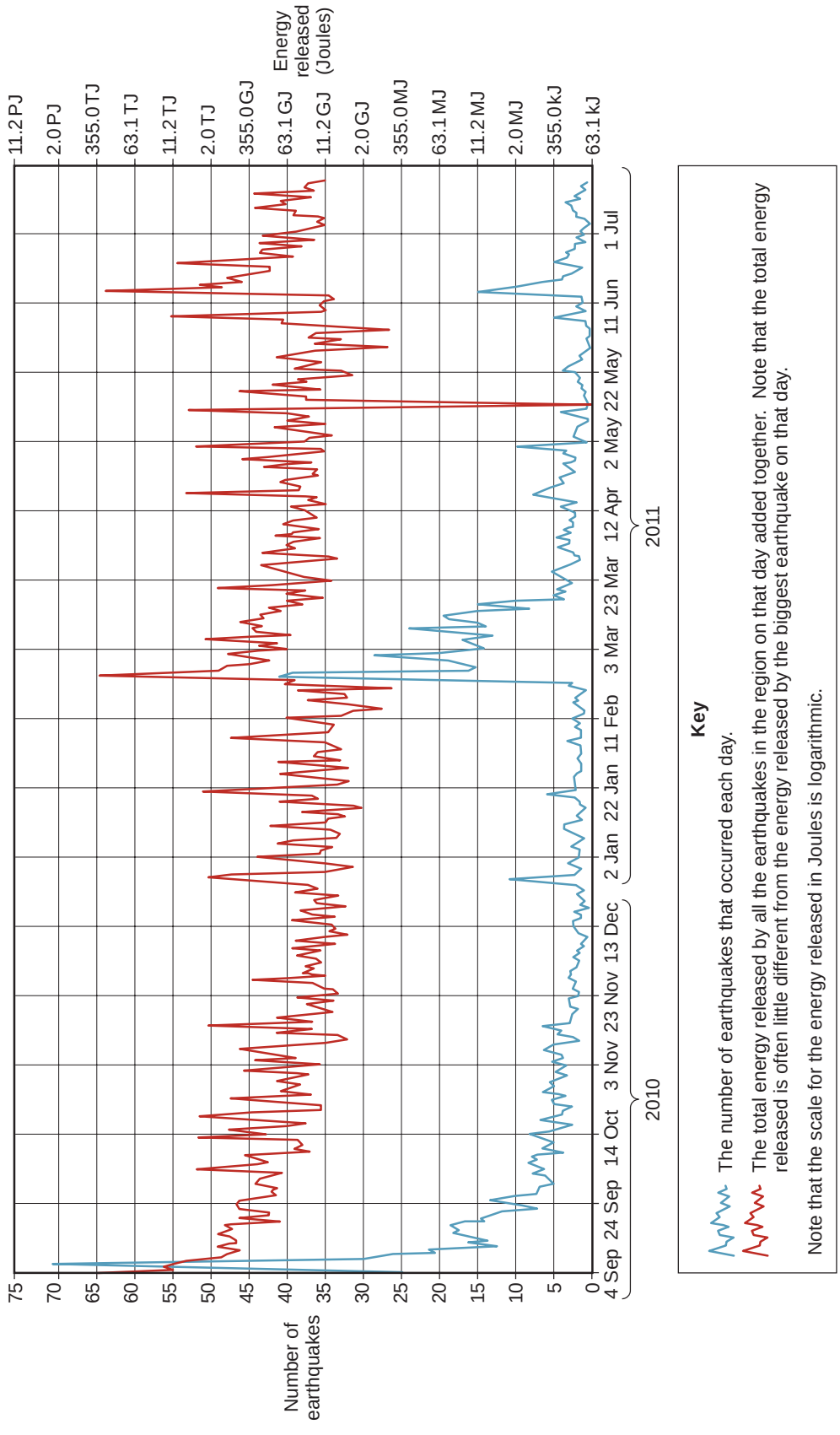
There is no source material printed on this page

Item 2 continues on the next page

Everybody was getting used to post-earthquake life when the magnitude 6.3 Christchurch Earthquake happened – just before 1pm on Tuesday 22 February 2011. This time, Christchurch was not as lucky because the earthquake struck much nearer to the main built-up area. The final reported death toll was 185. Many more people were injured.

Figure P7 shows the amount of energy the earthquakes released in the Christchurch region each day between the 4 September 2010 and early July 2011, and the number of earthquakes that occurred.

Figure P7



Turn over for the next Item

Item 3 Aftershocks, triggered earthquakes and Christchurch's seismic future

(This item is based on a blog posted by geologist, Dr Chris Rowan. Note that the blog is written mainly for professional geologists. It is not necessary to look up the full article for the purposes of this examination.)

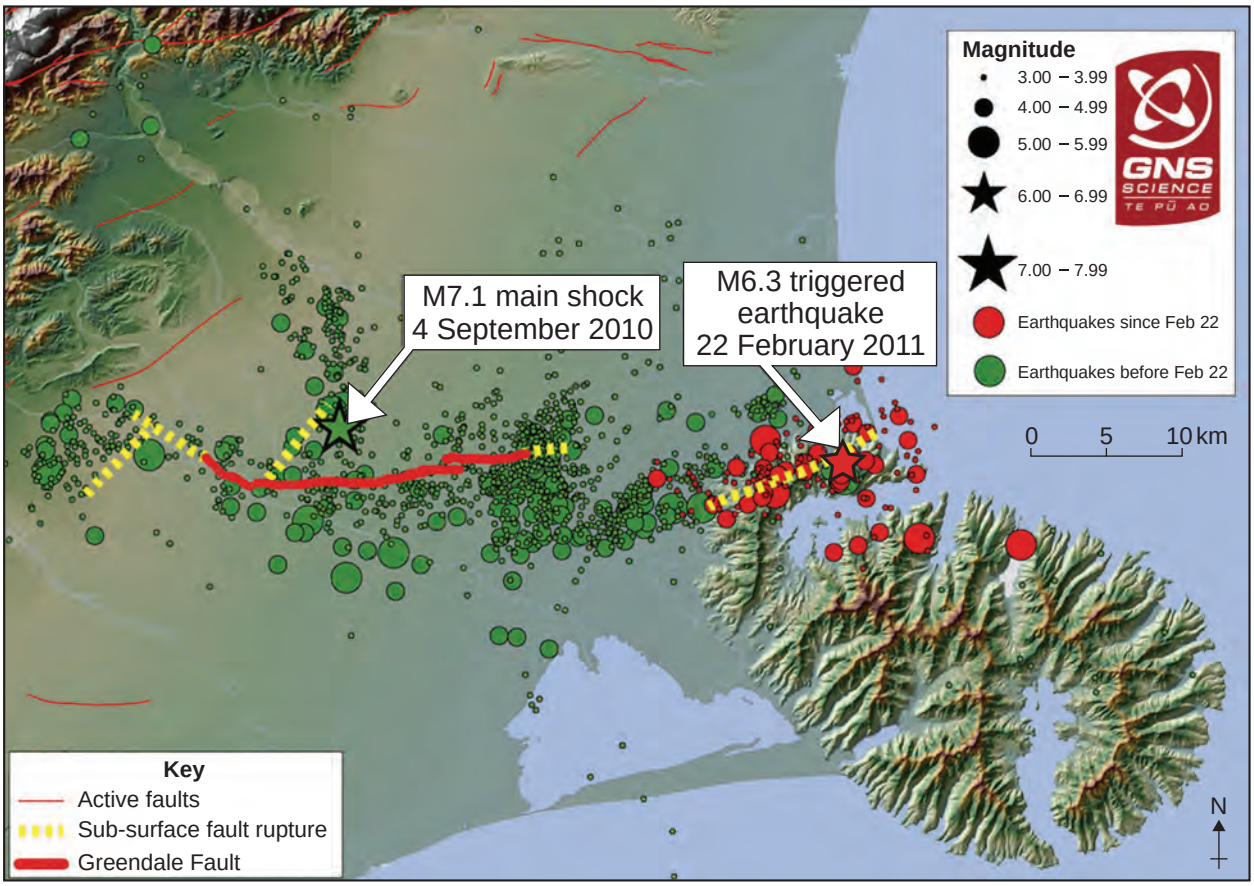
When a fault ruptures in an earthquake, movement along the fault plane stresses and deforms the surrounding crust. These stress changes can often induce smaller earthquakes – aftershocks – that are a series of tremors around the initial rupture. In other words, aftershocks are caused mainly by the stress added to the crust by the initial earthquake.

However, the situation can be more complex because other nearby faults may also be affected. These faults may also have accumulated a large amount of tectonic stress over the previous decades and centuries. The stress change because of the first rupture may be large enough to push these nearby faults 'over the edge', resulting in a triggered earthquake.

In a triggered earthquake, the stress added by the first earthquake is only a small part of the stress released when the second fault fails. Most of the stress was already present and the fault would have ruptured at some time in the future anyway.

Figure P8 seems to show that the Darfield Quake caused a series of aftershocks mainly along the Greendale Fault, spreading east towards Christchurch. The Christchurch Earthquake was a 'triggered earthquake', which released the stress that had built up over a long time along the underground fault near Christchurch.

Figure P8 – Earthquake epicentres in the Christchurch region: September 2010–May 2011



The fact that the Greendale Fault and the fault that moved on 22 February were not previously known to geologists, and do not seem to have caused any surface features such as scarp slopes and river terraces, suggests the faults have not been active in the recent geological past. Instead, the fact that they have been totally buried beneath the river-borne debris coming off the uplifted Southern Alps to the west tells us that these faults do not rupture very often. If they did, the Canterbury Plains would not be so flat.

This seems to suggest that these faults need a long time to build up enough stress to rupture in an earthquake – probably the high hundreds or low thousands of years. It would be unwise to relax before some detailed geological work is done, of course, but I suspect that these particular faults have done all the damage that they are going to do to Christchurch for the foreseeable future.

Examiner's note

The following news item appeared on 13 June 2011.

'Two large aftershocks have struck Christchurch today, 13 June. The first of the aftershocks measured 5.5 magnitude and struck at 1pm, 10 km to the east of the city. The second, a larger shock, was at 2.20 pm, measured 6.0, and was centred 10 km south-east of the city. A series of smaller shocks was felt over a two-hour period.'

This does not mean that the last sentence of Dr Rowan's blog was wrong. The June aftershocks were not 'new' earthquakes. However, these aftershocks were stronger than any previous ones in the area. They just show how difficult it is to predict how tectonic forces will affect this area.

Item 4 What happened in the Christchurch Earthquake?

In the earthquake on 22 February 2011, the two sides of the fault slipped sideways relative to each other, but one side of the fault was also thrust upwards over the other side.

The vertical movement was much stronger than the horizontal movement. The acceleration of the ground during the earthquake was the fastest ever recorded in New Zealand and was one of the highest ever recorded in the world. It was unusually high for a magnitude 6.3 earthquake. It was so strong that eye witnesses spoke of people being 'tossed into the air'.

Buildings were particularly at risk of damage because of the combined vertical and horizontal motion.

Acceleration of this intensity would have 'totally flattened' most of the world's cities, causing massive loss of life. New Zealand's strict and well-enforced building code clearly limited the disaster.

The strongest shaking lasted only for about 12 seconds, an unusually short time, and this probably helped to reduce the damage.

Although the Christchurch Earthquake was smaller in magnitude than the Darfield Quake, its focus was close to the centre of Christchurch, whilst the Darfield focus was in a rural area. The Christchurch focus was also much nearer the surface than the Darfield focus. The Christchurch focus was 5 km deep but the Darfield focus was 10 km deep.

Liquefaction of the sedimentary deposits around Christchurch was also a serious problem. Liquefaction caused the upwelling of over 200 000 tonnes of silt into the built-up area of the city and that all had to be cleared. This movement destroyed about 80% of the city's sewers and water supply systems.

'Seismic lensing' probably made the impact of the earthquake worse than might have been expected. The shock waves from the earthquake travelled south through the soft sedimentary rocks and then hit the hard, dense, basalt rocks of the Port Hills to the south of the city. The waves then 'bounced' back off these rocks, adding to the shaking of the ground beneath the city.

The steeper slopes in the Port Hills in the southern part of the city suffered from a number of serious landslides and rockfalls.

The fact that the earthquake happened at lunchtime on a weekday meant that the central area was crowded with people. The previous shocks had also weakened the buildings in the city, causing more buildings to fall, and increased the number of deaths and injuries.

Item 5 Extracts from emails between Lisa who emigrated to New Zealand and her mum, who still lives in England

Christchurch 25 February 2011 – from Lisa

…..we are all safe and well. We are camping in a friend's garden and using their bathroom and kitchen…..

…..the children were at school when the quake struck. They were playing outside on the field and they were both thrown to the ground and say that the whole earth was wriggling underneath them. They had some grazes but they were not badly hurt. They were both frightened and feeling insecure. They were getting used to the minor tremors before this big earthquake but now every little shake seems to upset them…..

…..Paul and I were both at work. My doctor's surgery was quite badly damaged but we had to keep working in the car park. The practice manager has already arranged for workmen to come in and patch some rooms up so that we can keep a service going. Obviously it is more needed than ever…..

…..Paul went home as soon as he could and took photos, mainly for insurance purposes. Obviously houses here are built to match the earthquake code. The house has a wooden frame that is designed to stand up through serious earthquakes. The bricks on the outside of the frame have just collapsed though. They look like a scree slip lying round the edge of the house. Inside it looks like we have been burgled and vandalised. Everything from the kitchen cupboards is lying smashed in the middle of the floor. It is disgusting!…..

England 26 February 2011 – from Mum/Granny

…..you sound so brave and determined but I do worry about how it is all affecting the children. And how well are you insured? Will you be able to re-build? Will your house be repairable or will you have to start again? Does this all mean that there are likely to be more shocks that could destroy everything again in a few months or years?.....

…..I wish I could come and help you all. You feel farther away than ever. You know how much I miss you all. Will this make you think again about coming back here to live in safe old England?

Christchurch 31 March 2011 – from Lisa and family

….even if we wanted to come home I don't think that we could. Both our jobs are here, the children are happy in their school and all their friends are here. Though we have the 'tectonic instability', the life here is wonderful. And we have invested so much in the house and we would lose a lot of that money if we tried to sell the house now….

…..the whole country is mobilised for the re-building. The government has guaranteed support for people in the area and the insurance companies have been really good. Well, they both have to support us; the country's economy would collapse if they didn't…..

….it has brought the whole community together in many ways. Of course our problems are tiny when you compare us to other earthquake disasters in poorer or more densely populated countries but it has been great working with neighbours, friends, patients, colleagues, builders and so on to try and get everything back to 'normal'…..

Christchurch 22 June 2011 – from Lisa

….and it is now the middle of our winter. These latest earthquakes have made life very difficult. They have not done much damage to the house. The main problem is that the shaking has loosened the window frames so now it is really cold at night. We all sleep in one room and cuddle together for warmth.

Several of the doctors have left the area. Most have gone back to Europe or America. It makes work more difficult but it also makes me realise how much I am needed now…..

The children miss you. They would come back to live with you in England if they could…..

Item 6 Further research

Internet research

To see a map which shows all the earthquakes and aftershocks in the Christchurch area visit the following website: http://www.christchurchquakemap.co.nz/

Note that this is a complex resource and you will probably want to see parts of the sequence rather than letting the whole program run through. However, it does give an impression of what it must have been like for Lisa and others living in the area.

A map showing the best estimates of movements around the fault is shown at: http://www.gns.cri.nz/Home/News-and-Events/Media-Releases/Most-damaging-quake-since-1931/Canterbury-quake/Hidden-fault

For some photographs of a variety of impacts of the Christchurch Earthquake visit the following website: http://www.3news.co.nz/Christchurch-earthquake---PHOTOS/tabid/1125/articleID/199311/Default.aspx

Fieldwork

There are no recommendations to consider any fieldwork methods associated with this topic.

END OF ITEMS