

The Jurassic coast

Mass movement processes

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During the summer of 2008 there were a number of mass-movement events on the 'Jurassic' coast in Dorset and east Devon, a UNESCO World Heritage site. This article considers the cause and impact of these events. It will be of interest to all those studying landslides, natural hazards and coastal erosion, which are AS and A2 topics for all the major exam boards.

Mass movements are defined as the downhill movement of soil and rock under the influence of gravity, often in the presence of water. Rates of movement vary from very slow in the case of soil creep (mm y^{-1}) to very fast in the case of rock falls (m s^{-1}). Frequency also varies. Soil creep, for example, occurs more or less continuously (photograph A) while major mass-movement events (rock falls and landslides) may occur once in 100 years, or even less frequently. Most classifications of mass movement are based on a combination of factors including how fast or slow the movement is and how wet or dry the material is (Figure 1).

Mass movement on the Jurassic coast

Many of the mass-movement phenomena shown in Figure 1 can be seen acting on the 'Jurassic' coast of west Dorset and east Devon (Figure 2). These events have human and economic impacts of varying significance as well as short-term and long-term physical effects.

What causes mass movement? We have already identified gravity and water as important. Other factors include lithology (rock type), the relationship between different beds of rock (permeable and impermeable), other rock features, especially jointing (fractures in the rock), and a space into which the rock material can move. As water is a factor in the process, weather and climate are important. In the wet winter of 2000–2001 there were major events on the Jurassic coast at Worbarrow Bay, Black Ven and Stonebarrow and a landslide event in Durlston Bay. This last event had a major impact on property (photograph B).

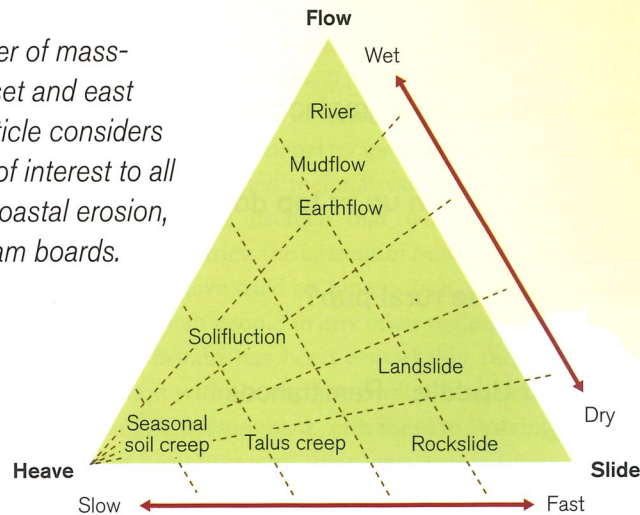


Figure 1 A classification of mass movements

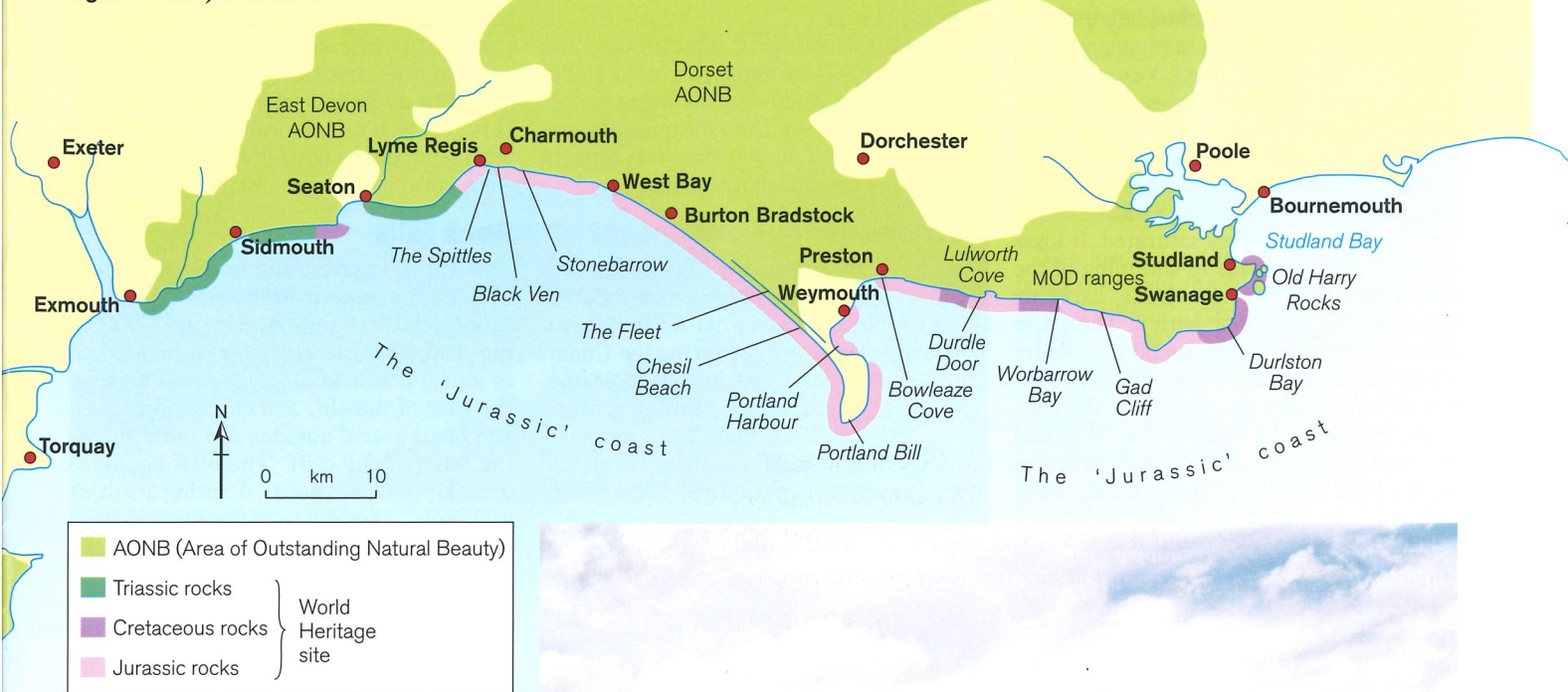


(A) Trees deformed by movement on the Spittles landslip area, Lyme Regis

This particular coastline provides ideal conditions for mass movement as a combination of marine and sub-aerial processes facilitate slope failure. After a mass movement event has occurred the sea can erode the toe of the fallen material, so steepening the slope which eventually becomes unstable again, facilitating

further movement. The dip of the strata (rock layers) is also important. Rocks that dip inland form more resistant coastlines — if the dip is seaward rock slides are more likely to occur. The coastline at Worbarrow Tout and Gad Cliff between Lulworth and Kimmeridge provides good examples of this (photograph C).

Figure 2 The Jurassic coast



The 2008 event

The cliff falls at Lyme Regis in 2008 made the national news. On 6 May a major fall some 300 metres long occurred to the east of Lyme Regis (the Spittles). Fortunately it occurred at 8.30 p.m. when the tide was in and the area was inaccessible to the public. If it had happened a day earlier in the middle of the day (Bank Holiday and low tide) there could have been catastrophic loss of life, although there might have been some warning signs that the event was going to happen. This area is popular with families on holiday and with fossil collectors. After the initial event, material continued to cascade over the Spittles cliffs, including mature trees (photograph D).

The national media coverage helped to attract more visitors to the area as fossil-hunters were keen to exploit the cliff fall. The dangers of this had been demonstrated over Christmas 2004/05 when there was serious concern for safety as families converged on nearby Charmouth after a major cliff fall. The material that slumped in May 2008 included items from a former landfill site that was used until 1972. Glass, domestic appliances, bits of cars, water tanks and so on were all in the landslip. At the time the rubbish was buried there was little concern about what was dumped and how it interacted with other material but it has now become a safety risk.

Why do mass movements occur here?

The development of landslides on the coast between Lyme Regis and Charmouth is related to the presence of permeable sand-



(B) Durlston Bay landslip seen from the sea



(C) Gad Cliff strata dipping landward (north)

stone (Cretaceous Upper Greensand) resting on impermeable clays (Jurassic Blue Lias – the lower part of the cliff in photograph D), shales with beef, the Black Ven marl and Belemnite marls). Beds of limestone form terraces in the cliff and beds of shale just above provide the slip surfaces.

Water from high-rainfall events percolates through the overlying sandstone and the clay below becomes saturated. It loses strength and this leads to slumping of the clay along the limestone beds, carrying the overlying sandstone with it. The water entering the rock increases pore pressure which causes the loss of strength in the rock but also increases the weight of the rock mass. Ingress of the water is also facilitated by small movements which open up cracks in the land surface – these would have

developed over a period of years prior to the May 2008 event.

The May 2008 event just affected the shales with beef (the upper part of the cliff in photograph D). Following the event people were kept away by the coastguard and a British Geological Survey team was brought in to survey the cliff movements.

Past events

The biggest landslide on the Dorset coast, and the first to be scientifically recorded, occurred on Christmas Eve 1839, when 6.5 hectares of land slipped seaward producing the Undercliff area between Lyme Regis and Seaton. The event occurred for similar reasons to slumping at Black Ven. This area has a history of major mass-movement events and West Dorset District Council has recently

spent £24 million stabilising the sea front at Lyme Regis (the work was completed in 2007). Further work is planned on the eastern outskirts of Lyme Regis and the May 2008 event indicates the need for this. However, is it economically worthwhile? At what point do the costs of coastal protection work outweigh the benefits?

Rock falls

The Jurassic coast shows great variety of mass-movement processes. At Burton Bradstock there are regular rock falls in the Bridport sand cliffs. At high tide and in storm conditions waves break against the base of the cliff and corrosion by flint and chert gravel abrades and undermines the base of the cliff. The cliff becomes unstable and falls occur. Jointing also aids rock falls. Another factor is that Bridport sand (Jurassic) is porous and permeable, it readily absorbs water, and when saturated, it loses strength. This, combined with other factors such as cliff-base erosion, leads to cliff falls.

The frequency of falls can be determined by the weathering of the cliffs and whether the different beds stand proud or not. As the sandstone is not well cemented it is easily eroded by the chert beach gravel and within a few months there is little remaining evidence of even the largest rock falls. As a result there is no build up of natural rock armour at the base of the cliff. Imported rock armour and gabions (wire bags filled with crushed stone) have been used locally to protect the cliffs.

At Sidmouth concern has been raised by residents to the east of the town whose gardens are disappearing into the sea as the sandstone cliffs collapse. The beach sediment provides little protection and the sea breaks against the base of the cliffs during high tide and storm events. Again the sandstone is weak. Further west, off-shore rock armour islands absorb the wave energy and the town itself is protected (photograph F). Should similar structures be built to protect the coast to the east of the town, part of the World Heritage site? What factors should be taken into account? (Human, economic, aesthetic, scientific?)

In January 2006 a rock fall of around 250,000 tonnes occurred at Salcombe Regis, just east of Sidmouth. Cretaceous upper greensand moving over impermeable Triassic mudstone formed the rock fall.

Beach protection at Weymouth

Further east at Weymouth, the beach replenishment scheme put in place in 1995/96 has had an unexpected benefit. The £6 million project outlined in GEOGRAPHY REVIEW Vol. 11, No. 1 was designed to protect one of two main roads into Weymouth from periodic closure during winter storms. However, longshore drift moved large volumes of

(D) Debris including trees topple over the Spittles cliffs at Lyme Regis



(E) An aerial view of the Lyme Regis event



(F) Rock armour at Sidmouth, protecting the town



(G) Rotational slip just east of Bowleaze Cove



imported shingle east towards Bowleaze Cove, so protecting Furzy Cliff from the erosion that occurred in the past. Mass-movement still occurs but at a significantly slower rate and the properties in Bowleaze Cove Way are in much less danger as a result.

A groyne was built at the Weymouth end of the beach but not at the Preston end so there is an ongoing problem. Not so lucky are those properties on the north side of Portland Harbour, which have been identified as likely to be lost through mass-movement over the coming decades. The geology in both these cases is similar, with Corallian limestone and sandstone inter-bedded with clay resulting in rotational slip (photograph G).

Around Portland Harbour individuals have tried to protect their properties but often this is impossible or ineffective. Recently 40 properties along the coast on the north side of the harbour have been identified as being at risk, and these are not open to the full force of marine attack. Here again

inter-bedded permeable and impermeable rock is the cause of the problem. This is an interesting example as there are a number of conflicting interests. The coast is part of the World Heritage site and a Site of Special Scientific Interest (SSSI). Sandsfoot Castle, a Henry VIII castle on part of the cliff section, is a scheduled ancient monument. If nothing is done to protect the coast, mass-movement will continue and is likely to cut the road to some of properties (there is currently no other vehicular access) as well as their services (gas, electricity and water).

Winners and losers

There are winners and losers from landslips along the Jurassic coast. The winners are the general public who visit the area and witness the stunning coastline with its great variety of features. Without mass movement and erosion the coastline would not have evolved to its present state. At the same time mass-movement events provide geologists and fossil collectors with a steady supply of new material.

Key points

- Mass movements are a regular feature on the 'Jurassic' coast.
- Large landslides in the Lyme Regis area reflect the particular combination of geology and weather.
- Increasingly, 'managed retreat' is preferred to building protective structures.

The losers are the householders whose properties abut the coast, as well the local authorities, Environment Agency and DEFRA whose role it is to protect the coastline. Increasingly government policy on coastal defence is 'managed retreat'. For example, in August 2008 the new head of the Environment Agency, Lord Smith of Finsbury, said 'Some parts of the British coastline are so badly eroded they are not worth protecting from the sea. We cannot stop the cliffs falling down and global warming with rising sea levels and increasingly stormy weather may well exacerbate the situation.'

Major events occur somewhere along the Jurassic coast at regular intervals and increased magnitude and frequency of storms, higher rainfall and higher sea levels associated with global warming are only likely to make the situation worse.

Question for discussion

Discuss the pros and cons of protecting a given stretch of coastline. Who benefits from protection? Who pays?

Further reading

Holiday, A. (1997) 'Managing the Wessex Coast: Coastal defences at Preston Beach Road', *GEOGRAPHY REVIEW* Vol. 11, No. 1, pp. 13–15.

Go to www.soton.ac.uk/~imw/lymchar.htm for Ian West's excellent website on the Dorset coast.

www.dcenet.co.uk/malco/lymeregis/landslip.shtml gives information on the May 2008 event including video footage.

<http://news.bbc.co.uk/1/hi/uk/7567385.stm> is an item on Environment Agency policy.

<http://news.bbc.co.uk/1/hi/england/dorset/7544599.stm> is an item on how this may affect the Portland Harbour coast.

www.bgs.ac.uk/britainbeneath/haz_landslides.html is a British Geological Survey page on landslides.

www.dorsetforyou.com/index.jsp?articleid=1277 gives information on the Lyme Regis coastal protection scheme.

Alan Holiday was formerly lecturer in geography and geology at Weymouth College. Thanks to Richard Edmonds, Earth Science Manager for the Jurassic Coast World Heritage site team, Alan Frampton, coastal scientist with Halcrow, and Ramues Gallois, geologist, for help with the writing of this article.

Key words

Coast	Erosion
Landslide	Protection