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The accretion of sedimentary rocks at subduction zones and how Barbados became an island

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Using slides, the geophysical aspects of the modern theory of plate tectonics was introduced. First the speaker looked at Seasat satellite pictures which showed deviations in the heights of sea level over the earth. A further slide, a derivative of the first, displayed gravity anomalies which emphasised the very strong anomalies at subduction zones. Maps of earthquake and volcano occurrences, topography of the sea bed and bathymetry correlate to pinpoint the positions of subduction zones, mid-oceanic ridges and transform faults.

With the aid of diagrams showing sections through a typical subduction zone, the speaker was able to show how and where earthquake foci and volcanoes occur and how gravity anomalies are related to rock density and upthrust of one plate over another. He also explained briefly how island arcs are created on the 'uplift' side of a subduction zone, often many kilometres away from the associated trench.

He examined the Aleutian Islands, the Marianas and the Lesser Antilles in the eastern Caribbean, in some depth to show how accretionary complexes associated with these arcs have come into being. The Lesser Antilles in the eastern Caribbean was chosen as an illustration of one explanation of this phenomenon. This island arc has been active since the Palaeocene. Large amounts of sediment swept down from the South American continent by the Orinoco River in the Pliocene and Pleistocene have been laid down in front of the island arc as turbidites in a submarine fan on the plate being subducted. These overlie older sediments dating back to the Cretaceous that were laid down hundreds of kilometres out to sea and are composed mainly of pelagic material; the remains of planktonic animals and fine grained silica, micas and clays.

As this plate sank down beneath the plate supporting the island arc, sediments at the 'leading edge' were 'scraped off' in thrust slices, deformed and folded. As the plate advances further, a further slice is sheared off and inserted beneath the next oldest slice moving it backwards and upwards. All the time, a slope cover of new sediments is deposited over the whole area. Thus, in summary, each slice of accretionary material is stratigraphically correct in that old rocks are at the base and young rocks are at the top of each slice, but the slices are arranged so that the youngest is at the bottom and the oldest is at the top. This pattern of stratigraphy and structure has led some geologists to hypothesise that the Southern Uplands are a relic accretionary complex from Lower Palaeozoic times formed on one or more margins of the Iapetus ocean.

Evidence from other parts of the world suggests that some igneous rocks may be broken off as well as the sediments, especially if pieces are standing up as minor horsts or other highs formed initially at mid-ocean ridges. Also, in some cases, shear stresses between the plates build up so the system becomes locked and then, instead of moving along its previous suture, a new fracture occurs breaking off flakes of material beneath the accretionary complex and adding to it.

A converse to this is Tectonic Erosion which is the process of breaking material off the base of the complex. Thus accretionary complexes do not always grow – sometimes they diminish in size.

The Professor went on to show slides of seismic sections and he explained how these were produced by ships' equipment producing shock

waves that travel through sea floor rocks and are reflected back in varying ways depending on changes in the physical properties of the rocks. Boundaries between rock layers can be detected in this manner. The Professor was able to interpret and explain the sections and distinguish between the basaltic ocean crust below a sedimentary sequence. Subsequent sections showed positions of folds and thrusts and a future project to drill through such folds and date parts of the bores to determine the rate of thrust was discussed. Folds can be traced on bathymetric maps and can be major structural features.

He also explained the technique of sidescan sonar – a device towed behind a ship which consists of a series of transducers emitting fine sheets of focused sound every few seconds. The returns are monitored on a visual display unit. Slides of results of this technique showing a run across an accretionary complex showed the front, scarp ridges and folding.

The speaker also explained the process of subcretion or underplating by means of the formation of duplexes, in which lozenge-shaped pieces of sedimentary rock called horses are broken off and added to the bottom of the accretionary complex.

Water within the pores of the rocks is held at high pressure and this allows thin layers of rock to slide over the underlying ocean floor. Sometimes this water is squeezed out as warm water springs, and also mud volcanoes can erupt at the frontal edge of the accretionary complex.

The speaker and his American colleagues have created a model of the Barbados Ridge accretionary complex based on all the evidence to hand, showing not only the uppermost layers but the shape of the base of the complex also. One problem for which he could not provide an answer was whether some sedimentary material is carried further down into the subduction zone. However, seismic velocity readings appear too high to allow a significant amount of the sedimentary rocks to be present at depth.

In conclusion he looked at the rocks of Barbados, which is an uplifted part of an accretionary complex. Most of the island is covered in coral, underneath which are basically two main types of rock. The rocks of the Eocene basal complex, sometimes called the Scotland Formation, are composed mainly of deformed turbidites that were probably accreted at the front of the complex when it was smaller. On top of these are thrust nappes of the Oceanic Formation which are pelagic and composed mainly of foraminifera and radiolaria remains that had been deposited on top of the complex and in forearc basins. Pockets of gas and oil have been formed from organic material carried by terrigenous material and in fact there is enough gas to completely supply the island's needs.

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