# Lecture 21. Unconformities & Igneous Rocks

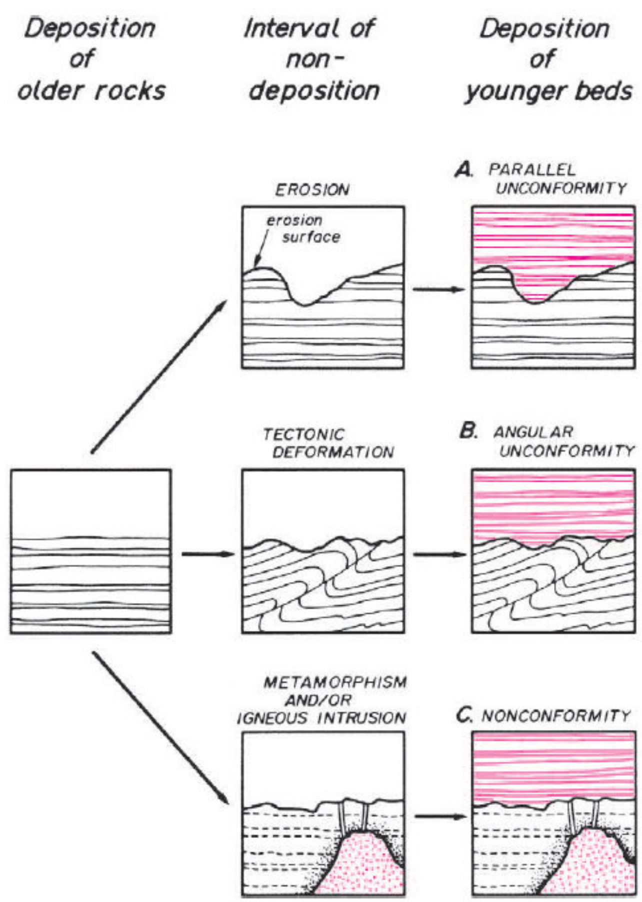



**Fig. 5.1** Formation of unconformities.

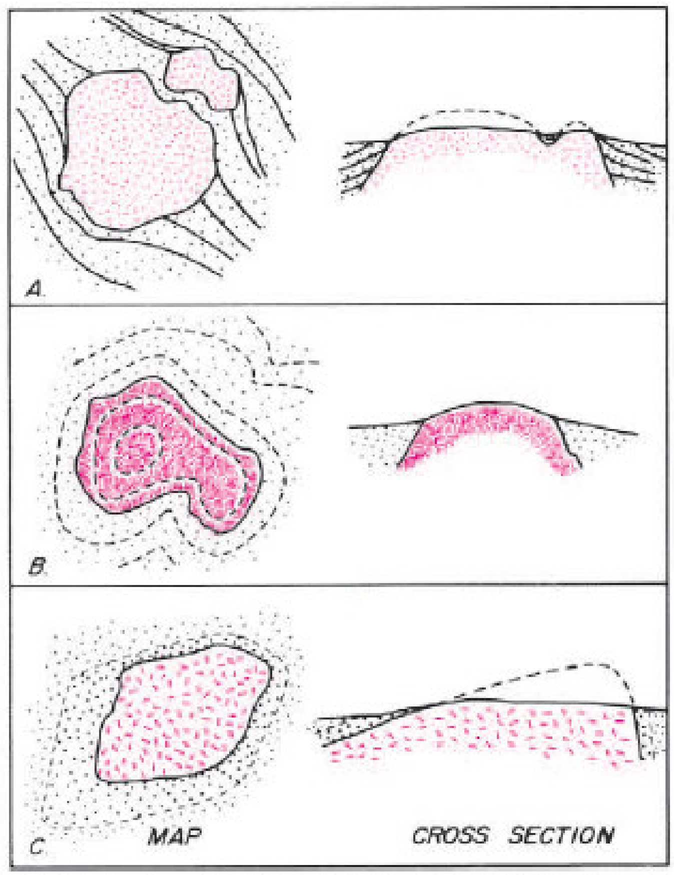



**Fig. 6.6** Relations between the intrusion and structures in the country rock.


Adapted from:
Lisle, R. J., 2004, Geological Structures and Maps, A Practical Guide, Third edition, Chapters 5 & 6
Herman, G.C. and Curran, John, 2010, Borehole geophysics and hydrogeology studies in the Newark basin, New Jersey (38 MB PDF), *in* Herman, G.C., and Serfes, M.E., eds., Contributions to the geology and hydrogeology of the Newark basin: N.J. Geological Survey Bulletin 77, Appendexes 1-4, 245 p.

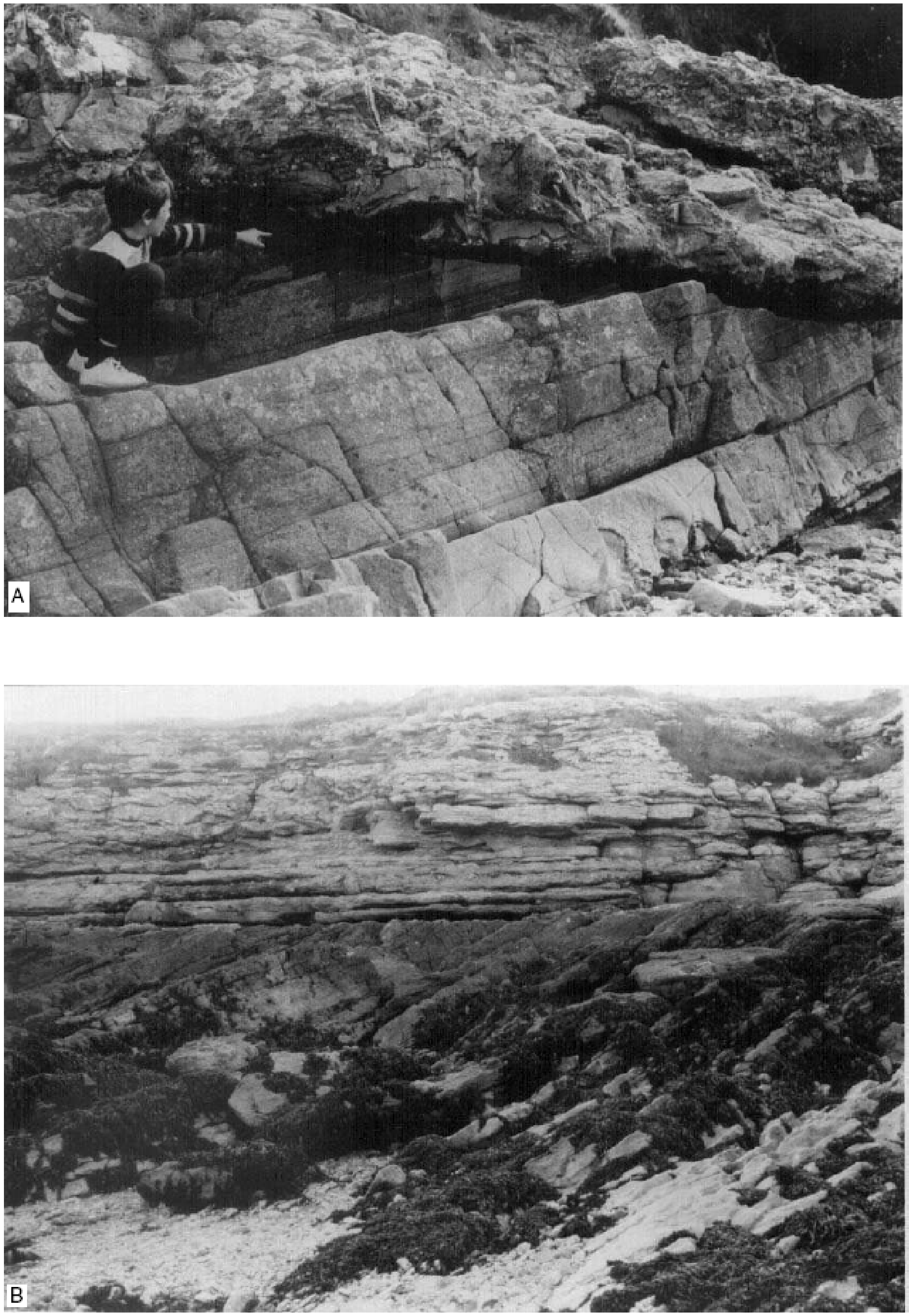



**Fig. 5.2** Unconformities in the field. **A**: Portishead, England. Robert Lisle points to the surface of unconformity. **B**: Barry Island, Wales. Triassic breccias rest unconformably on limestones of Lower Carboniferous age.

## 5.1 Types of unconformity

The exact nature of the relationship which defines an unconformity depends to a large extent on the geological events occurring during the period of non-deposition. If erosion takes place an irregular erosion surface is formed above the older rocks and defines the shape of the topographic surface upon which the younger group of rocks is deposited. This surface will become the surface of unconformity (Fig. 5.1A). A *parallel unconformity* is where the beds above and below the surface of unconformity have the same attitude.

With an *angular unconformity* (Fig. 5.1B) tilting or folding during the period of non-deposition gives rise to a misorientation of the rocks below the surface of unconformity relative to those above. When metamorphism and/or igneous intrusion takes place in the inter-depositional interval, the younger group of rocks rest in direct contact with metamorphic and/or igneous rocks. This type of unconformity is sometimes referred to as a *non-conformity* (Fig. 5.1C).

Figure 5.2 shows some natural examples of unconformities.

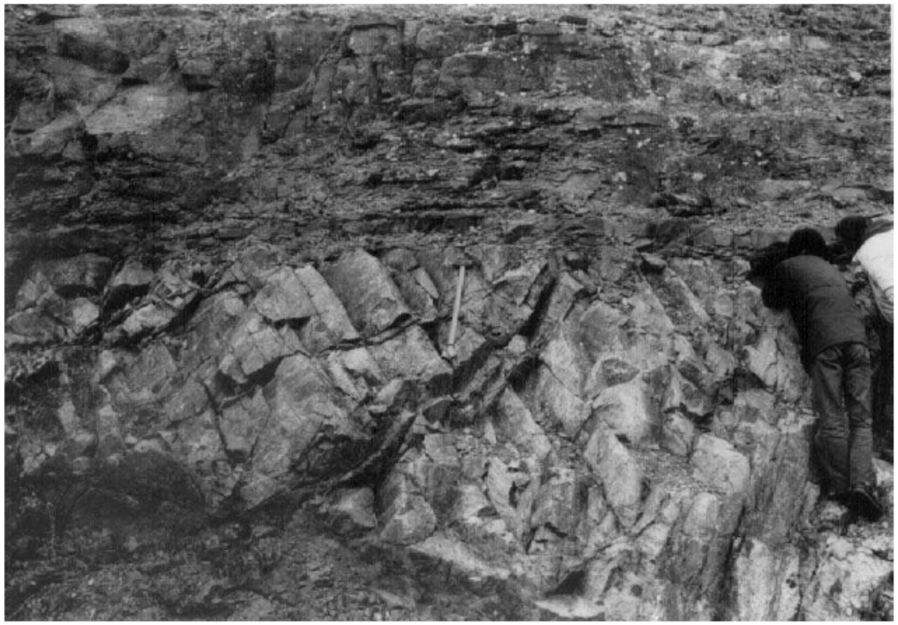


**Fig. 5.2 C**: Assynt, Scotland. Cambrian sedimentary rocks rest uncomfortably on Lewisian (Precambrian) greisses.

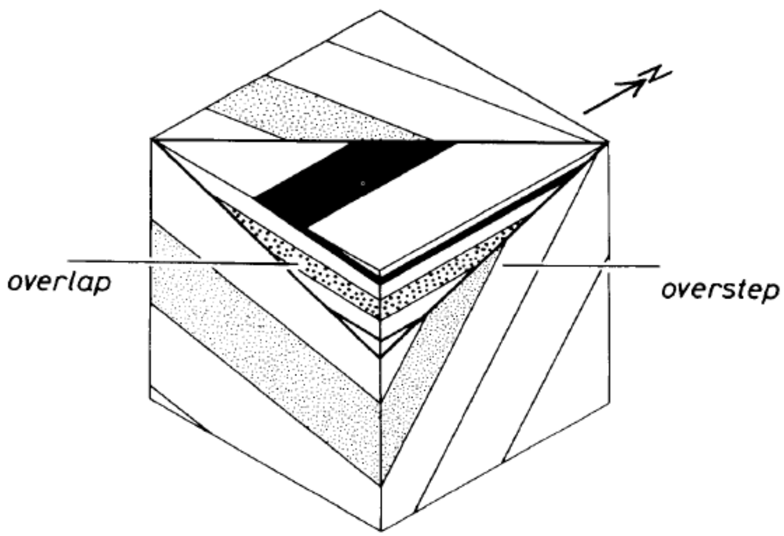



**Fig. 5.3** Overlap and overstep.

*Overstep* applies to the sub-unconformity relationship where the surface of unconformity truncates stratigraphic boundaries (Fig. 5.3). With distance along the unconformity the overlying strata rest unconformably on successively older rocks and are said to 'overstep' them. Overstep usually owes its origin to tilting or folding during the pause in sediment accumulation. *Overlap* (sometimes called 'onlap') refers to the situation above the surface of unconformity. With overlap the sediments are deposited oblique to the surface of unconformity (Fig. 5.3). With distance along the unconformity, successively younger rocks rest on the uncomformity plane. Successively younger rocks units show greater lateral extent and thus 'overlap' the previously deposited units. This type of unconformity can result from deposition in a progressively expanding sedimentary basin relating to crustal subsidence. Figure 5.4 shows examples of overstep recognizable from maps. Overlap and overstep are in no way mutually exclusive; unconformities may show both features.

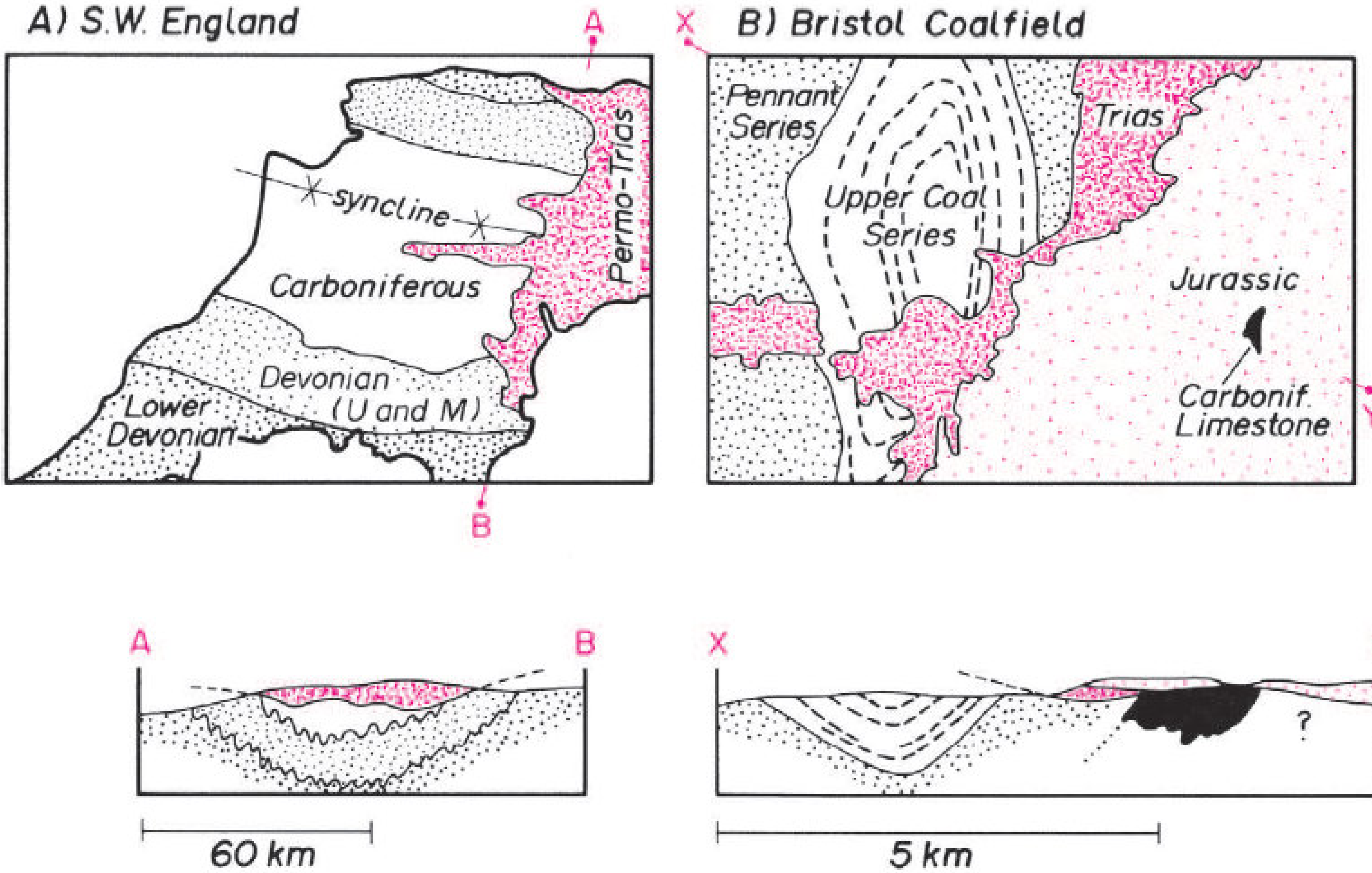



**Fig. 5.4** Examples of unconformities displayed on maps and cross-sections.

## 5.3 Subcrop maps

A subcrop map (or palaeogeological map) represents the outcrop pattern of sub-unconformity rock formations on the surface of the unconformity. A subcrop map is how the geological map would look if the rocks which overlie the unconformity were to be stripped off (Fig. 5.5). Such a map has to be constructed from available data on the nature of the rock which immediately underlies the surface of unconformity. Data from boreholes which pass down through the unconformity provide a sound basis for the construction of a subcrop map. In some situations it may be possible to make predictions of the subcrop pattern from

(a) the rock types which are seen to underlie the unconformity at places where the plane of unconformity is exposed on the geological map;
(b) the known or assumed form of the surface of unconformity represented, for example, by structure contours; and
(c) the known or assumed attitudes of geological contacts of the formation which underlie the unconformity.

In practice, sensible predictions can be most easily made when the surface of unconformity and the contacts between formations below this surface are, or are assumed to be, planar.

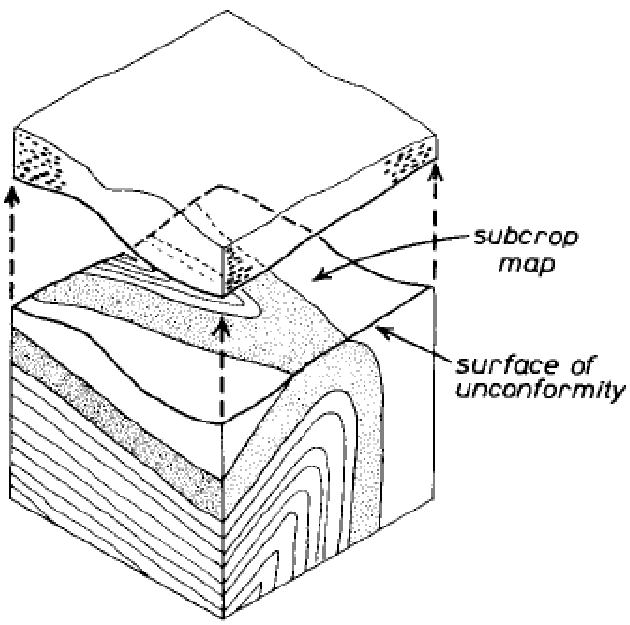
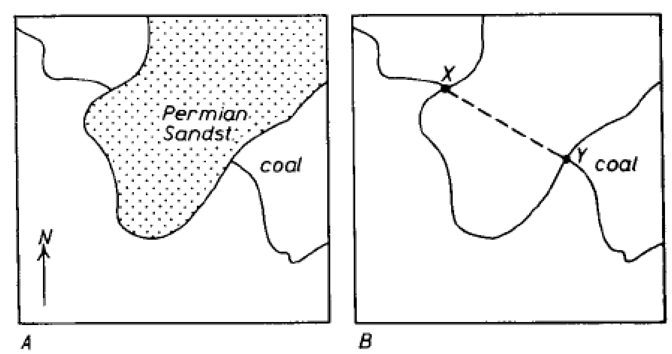



**Fig. 5.5** The concept of the subcrop map.

**Worked example** **Fig. 5.6**

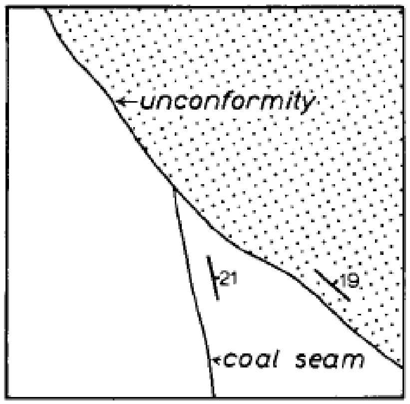
*On the map (Fig. 5.6A) construct the subcrop of the thin coal seam on the pre-Permian unconformity surface.*

The line of subcrop corresponds to the intersection of the coal seam with the surface of unconformity. If both surfaces are planar, the line of subcrop will be straight. This straight line will join all points where the coal crops out on the surface of the unconformity. It will therefore run as a straight line between points X and Y (Fig. 5.6B).



### Worked example

*On the map (Fig. 5.7A) construct the subcrop of the thin coal seam.*



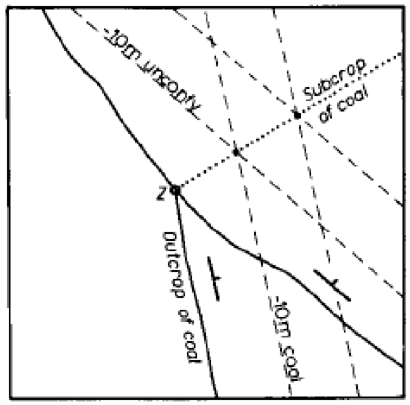




**Fig. 5.7** Calculating the subcrop of a coal seam.

From the given dips of the coal seam and surface of unconformity, calculate the trend of the line of their intersection using the method described in Section 3.11. Using the calculated trend, draw the subcrop of the coal through the point *Z* on the map (Fig. 5.7B). Vertically below all points on the map on the SE side of this line it is possible to encounter coal at depth; to the NW of this subcrop, the coal is absent.

## 5.4 The geological usefulness of unconformities

Geological map interpretation has two main facets. The first is geometrical, and much of this book has been devoted to the techniques for deducing the form of structures from the patterns displayed on maps. The second aspect is historical in nature, and is concerned with making deductions about the relative ages of geological phenomena displayed on maps. Unconformity is important in this second respect, since it allows the ages of folding, faulting, metamorphism and igneous activity relative to that of sedimentation to be established.

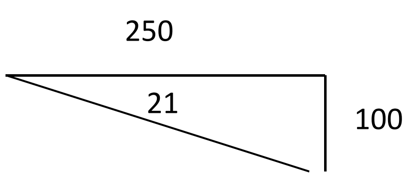
As an example let us examine a map of the pre-Permian unconformity in SW England (Fig. 5.4A). Folds are present in the rocks below the unconformity and are absent in the rocks above. Folding must therefore have occurred in the time interval represented by the surface of unconformity. The youngest rocks below the unconformity involved in the folding are Upper Carboniferous (Westphalian) in age. The oldest rocks above the unconformity are Permian in age. Folding must therefore have taken place in the intervening time interval.

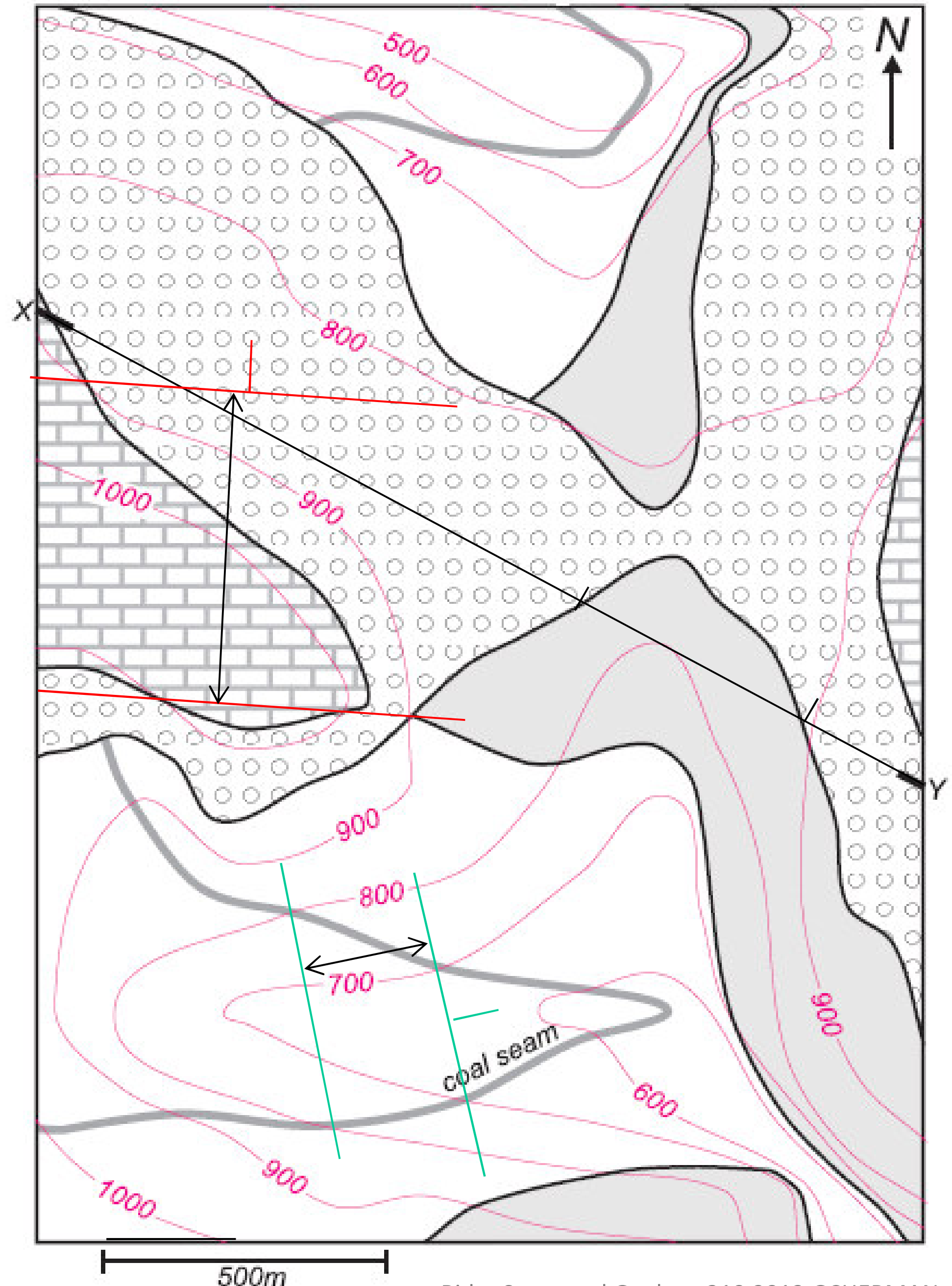
PROBLEM 5.1

Construct a cross-section for the line X–Y on the map. Shade the regions on the map where the coal seam does not exist at depth..

1. Generate structure contours on the lower (a) and upper (b)units to find strike and dip of units.

2. Mark topography and geologic contacts on section trace.



Herman, G.C. and Curran, John, 2010, Borehole geophysics and hydrogeology studies in the Newark basin, New Jersey (38 MB PDF), *in* Herman, G.C., and Serfes, M.E., eds., Contributions to the geology and hydrogeology of the Newark basin: N.J. Geological Survey Bulletin 77, Appendixes 1-4, 245 p.

Wells 61 to 67 - Brunswick middle red zone

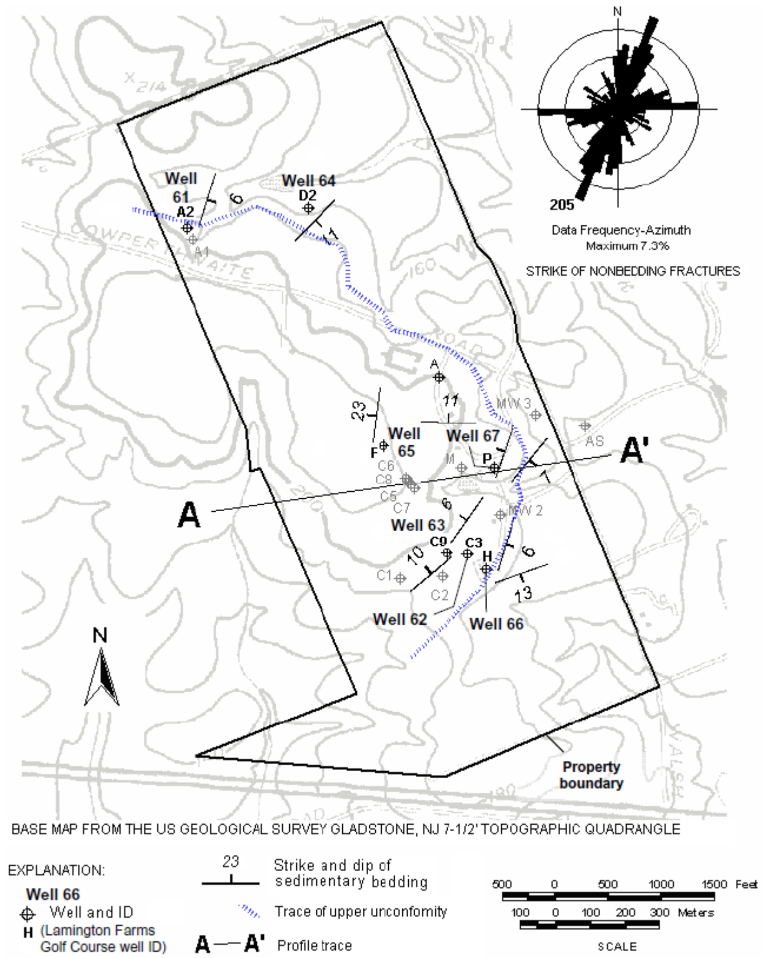
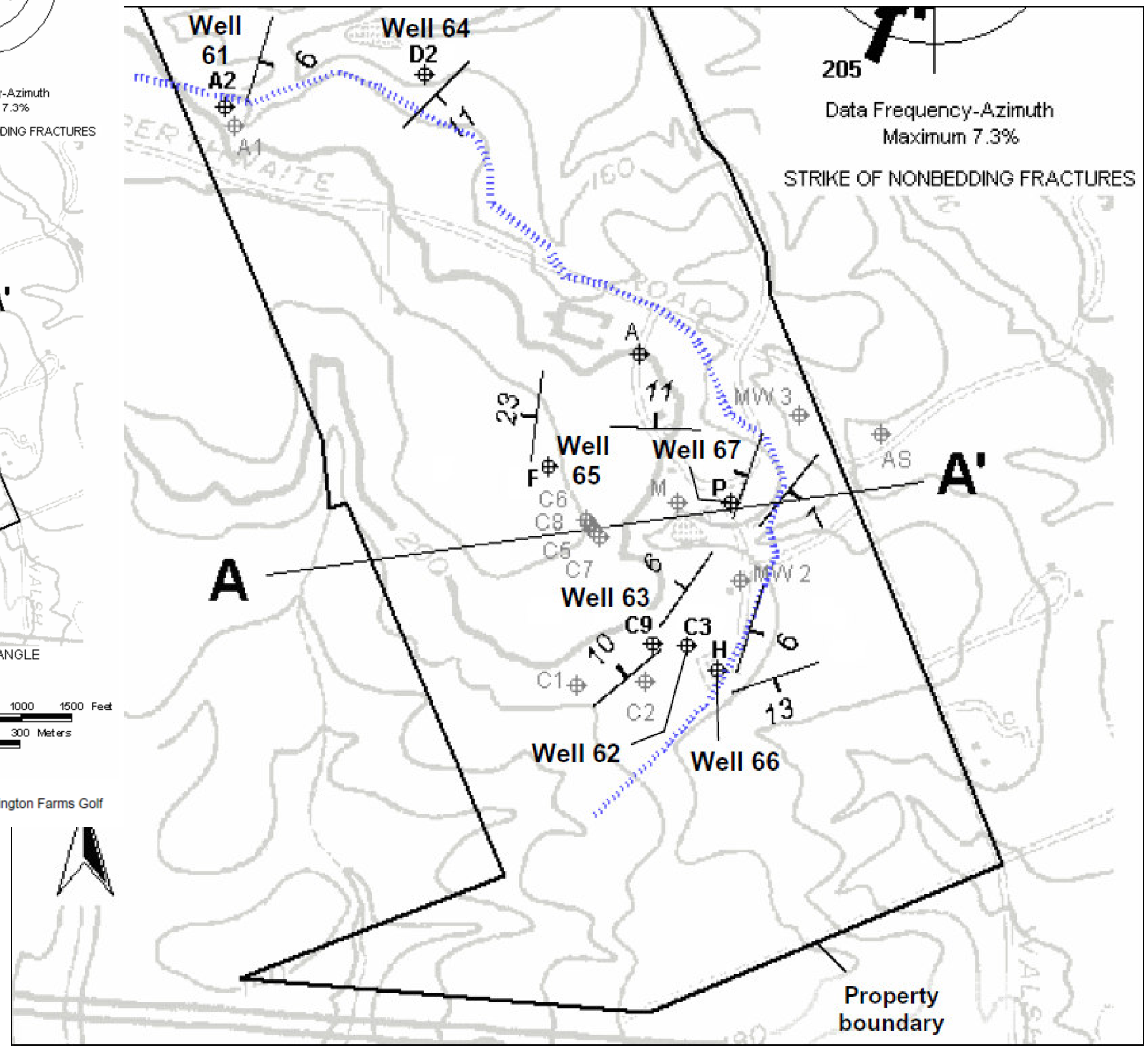
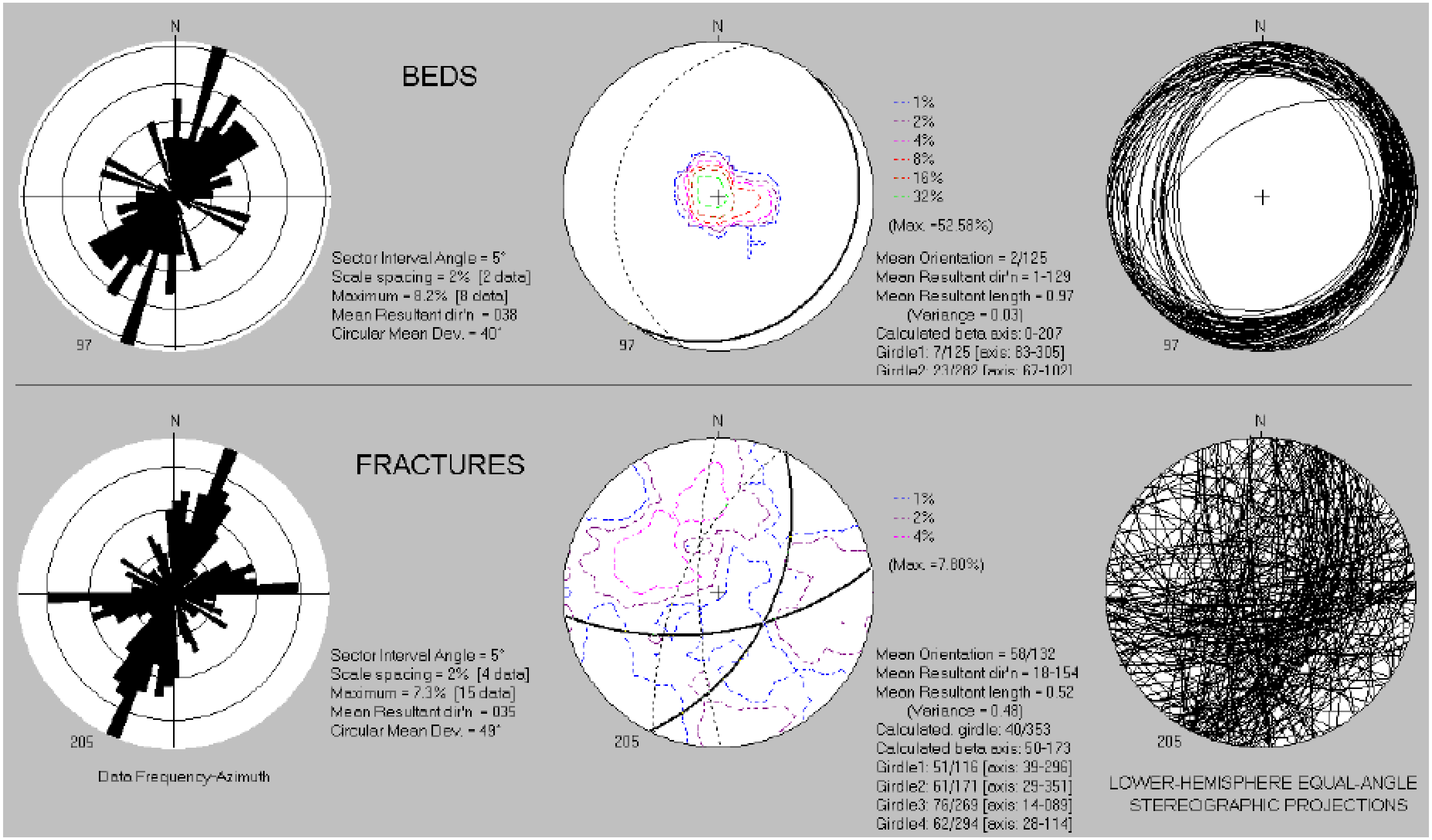



**Figure 3F1.** Map showing the location of wells 60 to 67 at Trump National Golf Course (formerly Lamington Farms Golf Course), Bedminster Twp., Somerset County, NJ.



# Wells 61 to 67 - Brunswick middle red zone



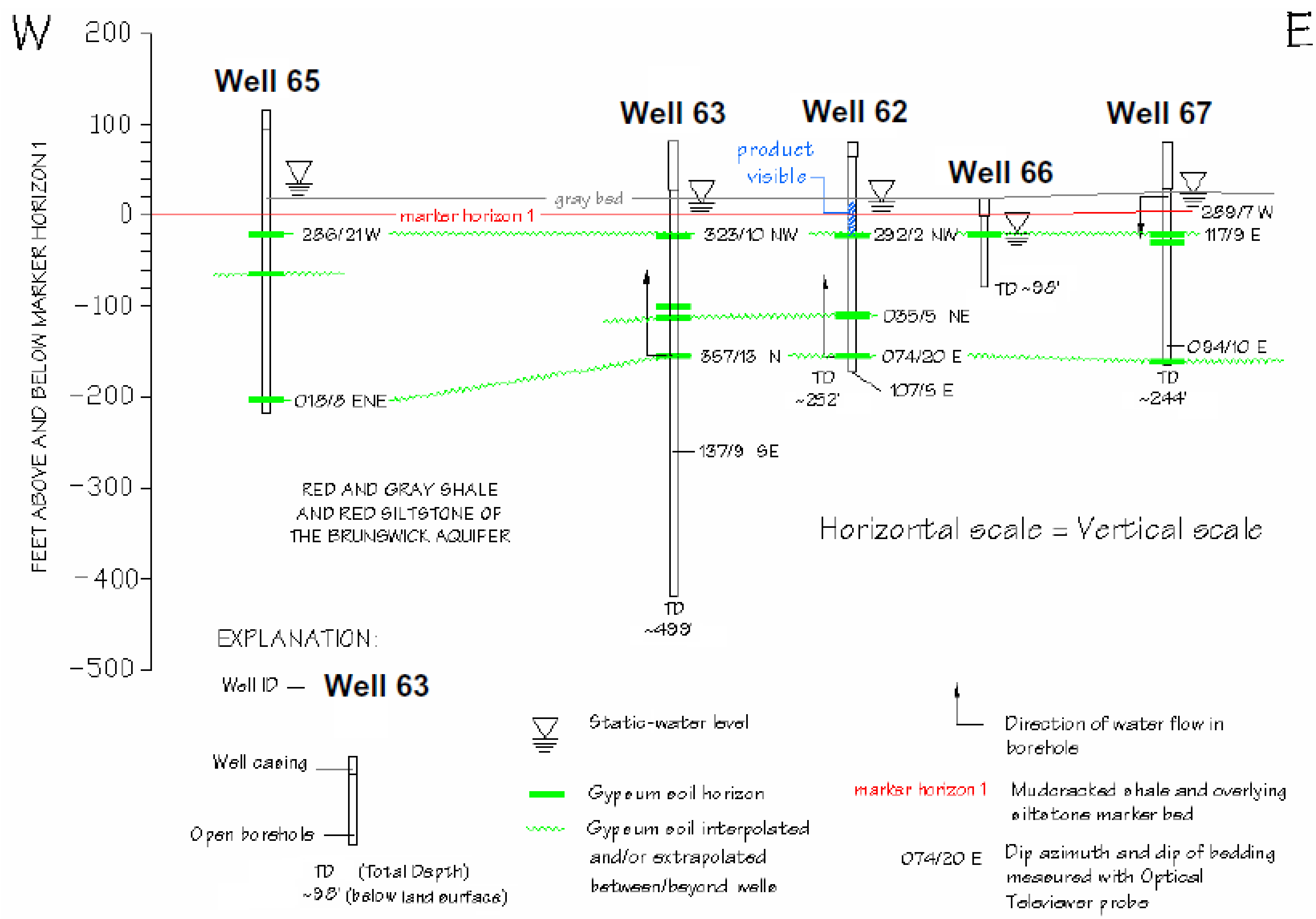



**FIGURE 3F2.** A structural analysis (above) of beds and fractures measured in OPTV records for wells 61 through 67. The geologic cross section (below) shows a correlation of gypsum-soil horizons identified in OPTV records and interpreted as stratigraphic unconformities. Note the opposing dips for strata above and below the soil horizons.

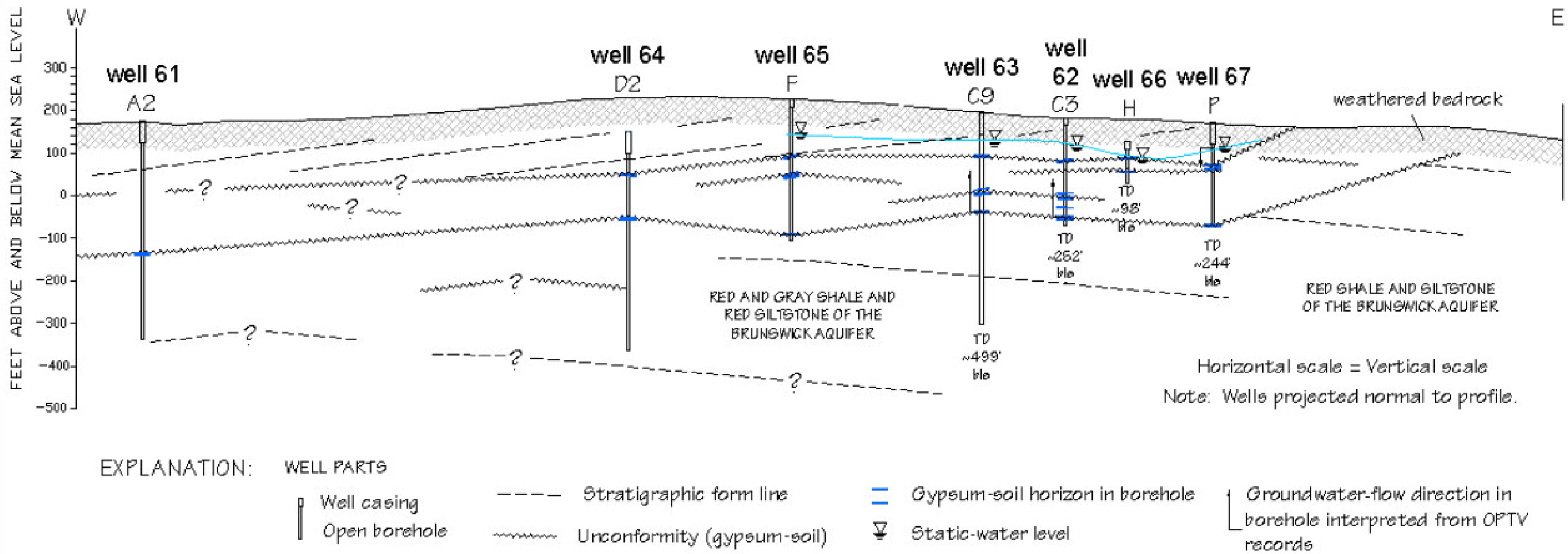



**FIGURE 3F3.** Hydrogeologic section based on seven wells at Trump National Golf Course, Bedminster Twp., Somerset County, NJ. Wells penetrate stratigraphic unconformities along extensive gypsum-soil beds. Stratigraphic sequences above and below the many unconformities dip in different directions.

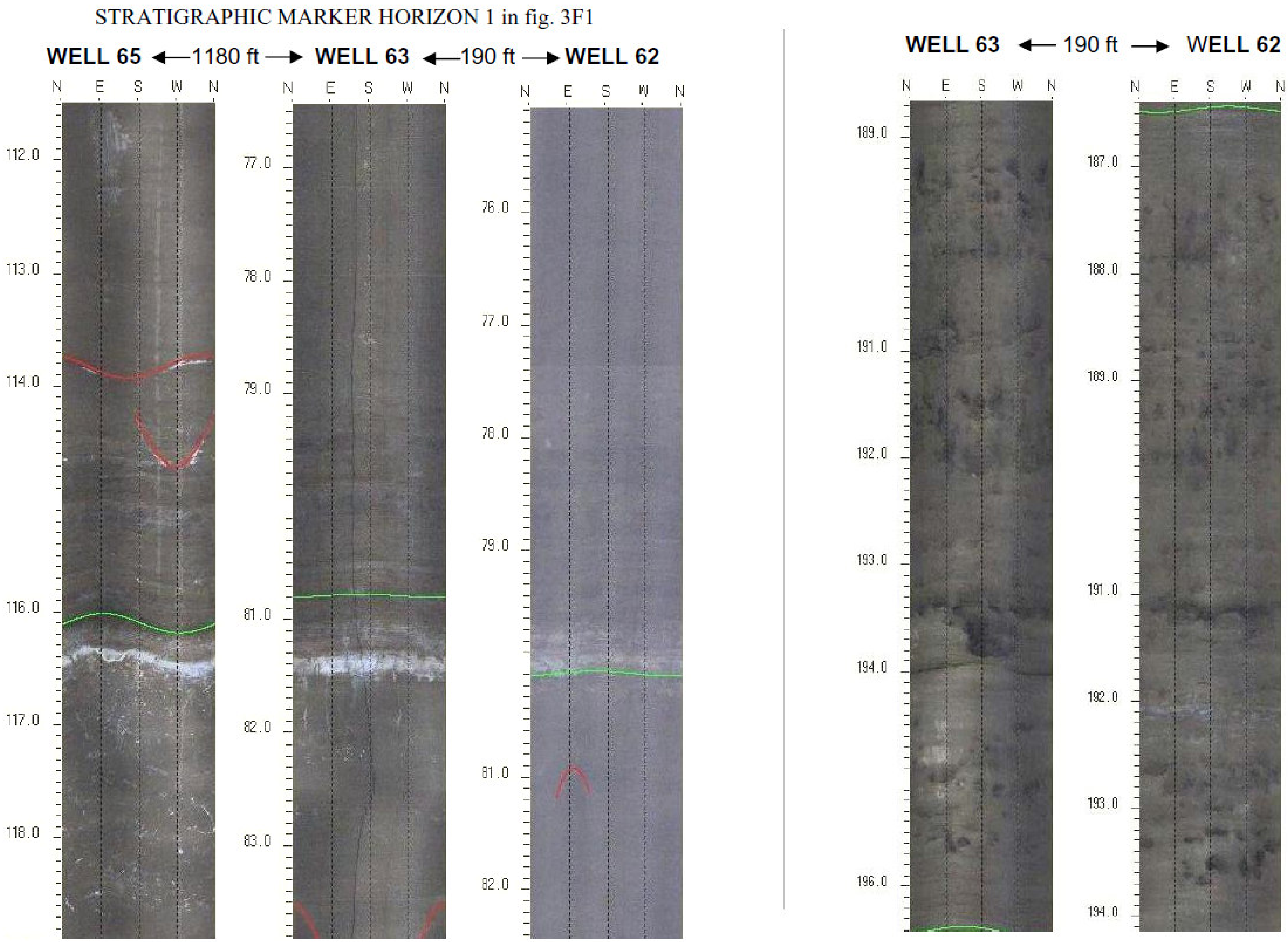



**FIGURE 3F4.** OPTV records for wells 62, 63 and 65 at Trump National Golf Course, Bedminster Twp., Somerset County, NJ showing stratigraphic marker horizon 1(left and fig. 3F2) and a correlation of a gypsum -soil horizon for wells 62 and 63 (right). Depth values are in feet below land surface.

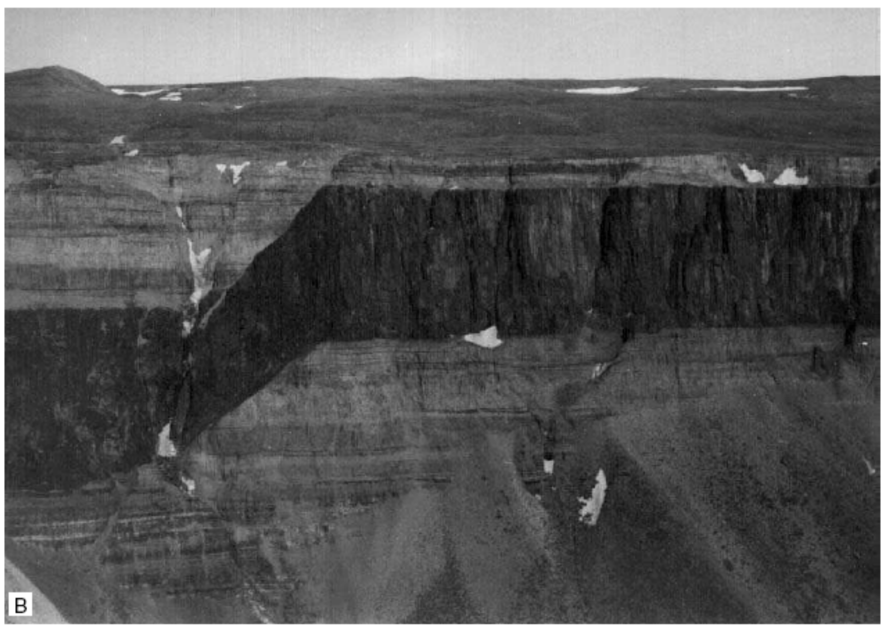


**Fig. 6.1** Concordant sheet intrusions. **A**: Intrusion within deformed Precambrian quartz schists (Dombas, Oppdal, Norway). **B**: Transgressive sill (Banks Island, Northwest Territories, Canada). (*Geological Society of Canada*.).

**Table 6.1**

| | | *Examples* |
|---|---|---|
| Intrusive igneous rocks | Concordant bodies<br>Discordant bodies | Sills<br>Dykes, volcanic necks, batholiths |
| Extrusive igneous rocks | | Lava flows, volcaniclastic deposits |

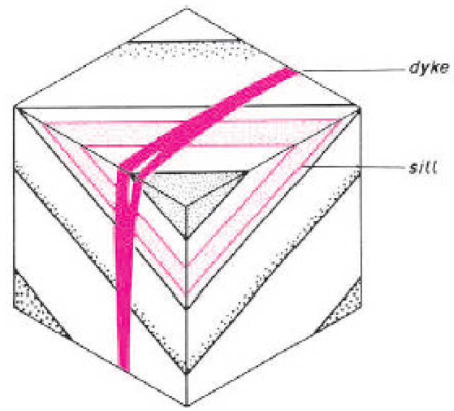



**Fig. 6.3** Sheet intrusions.

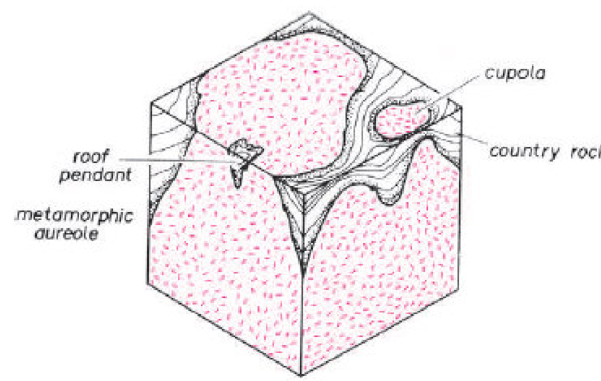
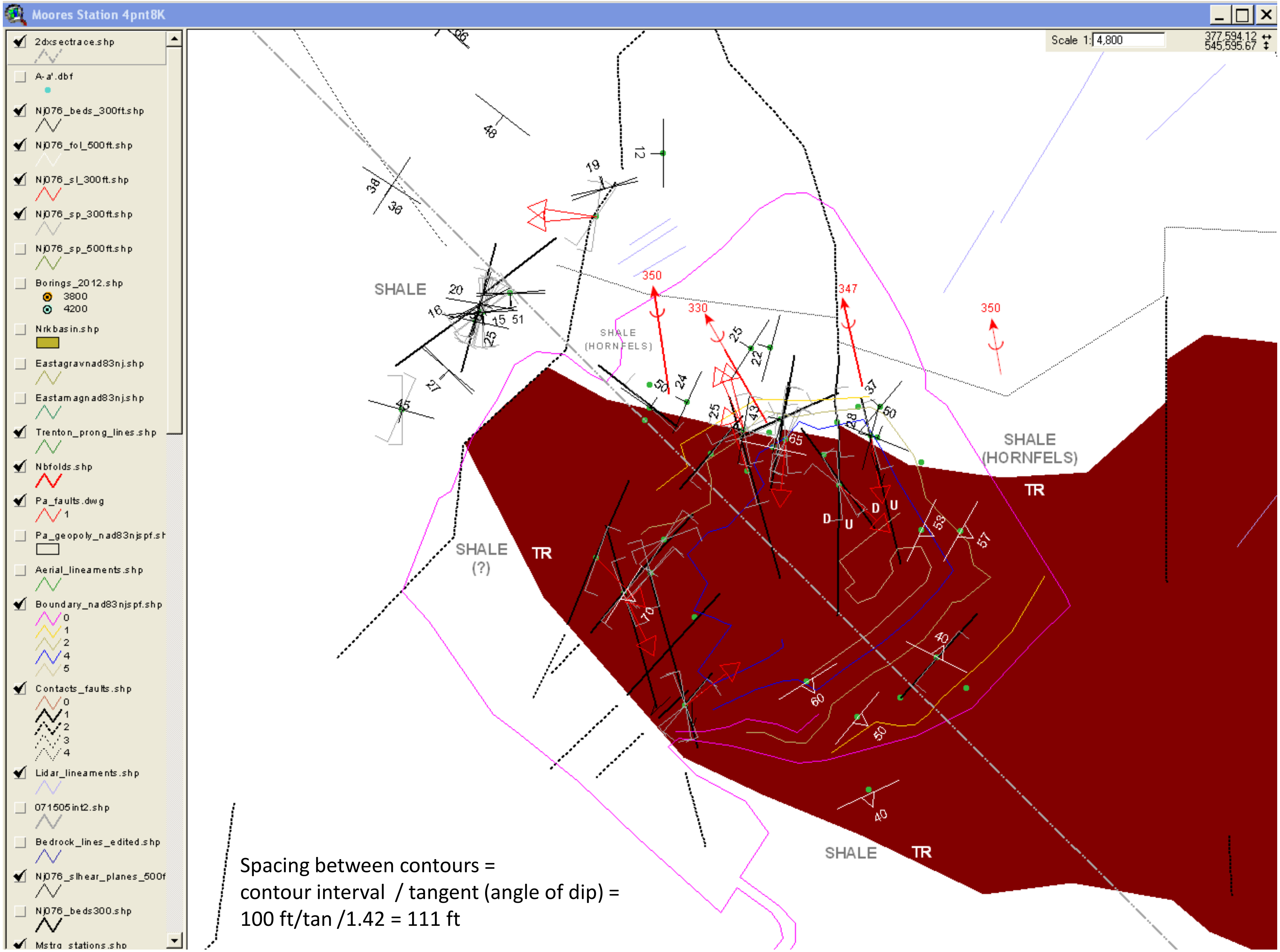



**Fig. 6.4** Features associated with batholithic intrusions.




Spacing between contours =
contour interval / tangent (angle of dip) =
100 ft/tan /1.42 = 111 ft

PROBLEM 6.1

Rock types 1, 2 and 3 are intrusive igneous rocks and the rock types labelled *m* are contact metamorphic rocks. List the types of intrusions present in the area. Faults are shown by a dashed line (4 in a key). Give a name to the types of faults present and deduce as much as you can about the slip on these faults.

List, in order of time, the geological events which have affected the area.