

## DISCUSSION

INCEMMET  
BIENES CULTURALES

INVENTARIO 1996

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Tertiary lines of transition from trough to shelf. Foredeeps, shown by the symbol (f?) in Figure 2, are presumably developed south of the thrusts. These foredeeps represent later tectonic elements than any here discussed. They also represent a southward migration of the tectonic front in post-Eocene time.

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AGES OF TERTIARY FORMATIONS IN NORTHWEST PERU<sup>1</sup>A. J. KNIGHTS<sup>2</sup>

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The recent paper by Stainforth on this subject (Stainforth, 1955) is a welcome clarification of the general problem. It is unfortunate, however, that the age assigned to the Cabo Blanco sandstone, as being pre-Talara should have been derived entirely from the somewhat restricted outcrops and without regard to the subsurface evidence in the areas immediately adjacent. The actual area of outcrop of this formation is limited to a narrow strip along the coast near El Alto, about 1½ kilometers wide and 10 kilometers long. Within this area the Cabo Blanco sandstone is overlain by a thick series of sandstones and shales locally called the Echinocyamus series after the contained echinoid. Below the Cabo Blanco sandstone lies a shale locally called the Clavel shale whose fauna is apparently identical with that of the Chacra. The age relationship assigned by Stainforth to the Cabo Blanco sandstone is based on the assumption that the Clavel shale is of true Chacra age.

From the evidence available on the surface alone, there is little alternative but to accept the age assigned by Stainforth, but the cross section (Fig. 1) shows that when traced away from the outcrop area, the Cabo Blanco sandstone and the upper lens of the Clavel shale are found to overlie beds of accepted Talara shale equivalence, with the true Chacra shale and the Pale Greda much lower in the succession.

If a true Chacra age is accepted for the Clavel shale, then the superposition of the Clavel shale and Cabo Blanco sandstone over Talara shale equivalents would have to be a structural effect, with movement along a nearly horizontal plane. This type of movement was invoked by Baldry (1938) in order to explain the recurring faunas which are found throughout the succession in this area. The movement he envisaged was likened to a gigantic landslide which occurred after about 20,000 feet of sediments had accumulated. The movement was considered to be away from the Andean uplift, that is, from east to

<sup>1</sup> Manuscript received, January 17, 1956.

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west. The planes of movement were considered to be low-angle normal faults which were given the name slip-planes. If this type of movement had taken place it would necessitate many such planes of movement if all the irregularities of the succession were to be explained in this way, and the succession in any area would consist of a series of unrelated sheets of sediment one on top of the other. Detailed subsurface work has shown that this is not the case, but that a coherent picture of the geology can be derived from the sediments, showing the influence of various structures through the succession, proving that the sediments were deposited in their present positions and not slid in from some outside area. Baldry's hypothesis has not been generally accepted by geologists working in the area, and the recurring faunas which led him to formulate the hypothesis are now regarded as cyclical facies faunas. Quite apart from the question of the validity of the slip-plane hypothesis, it is apparent from the cross section (Fig. 1) that movement in this case would have to be from west to east if a structural explanation is accepted. Such movement would imply compressional forces which are generally considered unlikely to exist in this area as it is universally recognized to be a taphrogenic province.

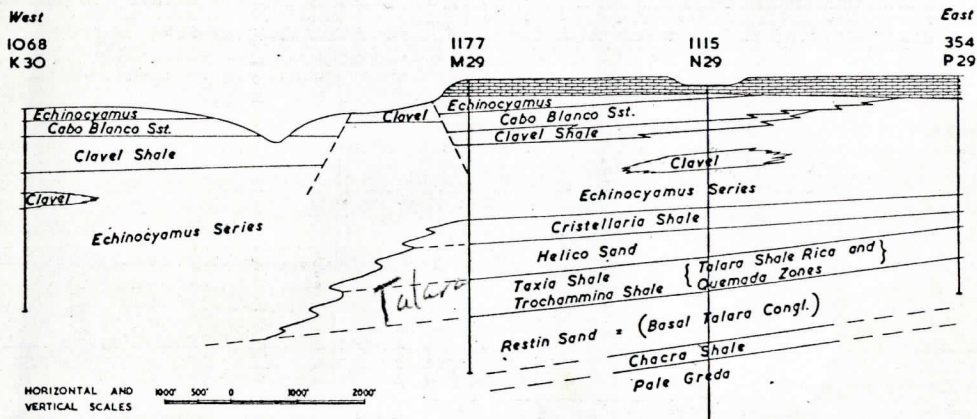


FIG. 1.—Cross section showing outcrops in west, and relationships of Cabo Blanco sandstone to beds of Talara age in east.

The alternative to a structural explanation is to consider the Clavel shale and the Cabo Blanco sandstone to be in place and of Talara age. In this case it is necessary to accept that rapid lateral facies changes such as are shown on the cross section (Fig. 1) are possible. The relationship shown on the section is one which can be seen in many wells near the coast at El Alto, and it is believed that the Helico sand and the associated shales change laterally into Echinocyamus series in this area. This change is the logical culmination of a regional tendency for a more varied succession to occur to the east, and a simplification of the succession to Echinocyamus series and Clavel shale in the west. The second cross section (Fig. 2) passes through the line of the first and shows the lateral change of Helico sand into Echinocyamus series, and the position of the Cabo Blanco sandstone relative to these units.

If one accepts these rapid lateral variations, then the Clavel shale and the Cabo Blanco sandstone must clearly be of Talara age. In this case the Chacra fauna must have persisted apparently unchanged in this area and not died out at the middle Eocene unconformity as in other areas. This could be the result of environmental stability in the area, or to a negligible time interval represented by the unconformity. The restricted nature of the microfauna in the Clavel shale to an abundance of two or three species points strongly

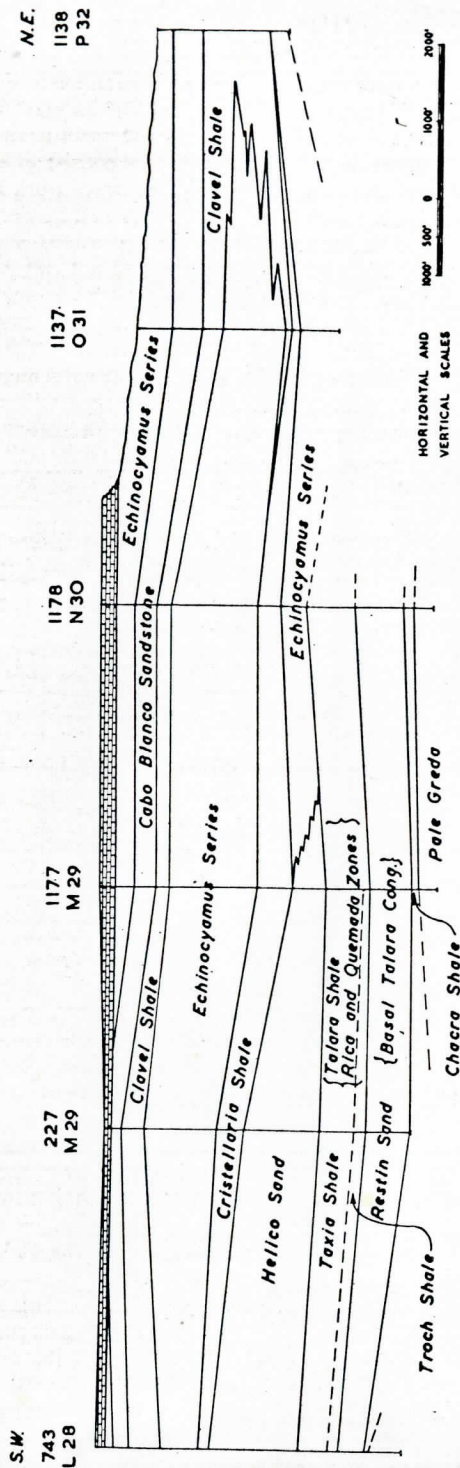


FIG. 2.—Cross section showing lateral change of Helico sand into Echinocyamus series, and relationship of Cabo Blanco sandstone to these beds.

to a close ecological control. If these species were slowly evolving types, environmental stability would be sufficient to explain the persistence of the fauna. The clear tendency already noted for the simplification of the succession to Clavel shale and Echinocyamus series toward the coast is itself suggestive of such environmental stability in this area, and it is believed preferable to accept this possibility and assume the Cabo Blanco sandstone to be middle or upper Talara in age rather than accept unreservedly a pre-Talara age on the basis of misleading surface evidence.

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