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FIELD GUIDES

FIELD TRIP #2

IN TRECHMANN'S FOOTSTEPS: THE GEOLOGY OF SOUTHEAST BARBADOS

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INTRODUCTION

"Barbados, 21 miles long, 14 miles wide, rising to 1,101 feet, is probably the most considerable Pleistocene non-volcanic bleb on the face of our planet, at least in the Antillean region" (Trechmann, 1937, p. 337).

Charles Taylor Trechmann (1885-1964), D.Sc., F.G.S., was an anachronism, a 20th century `gentleman geologist'. He was an amateur with the private means that enabled him to dedicate his time and use his scientific abilities to make an original contribution to his chosen field of study, an original thinker with a desire to use his observations to interpret broad geological phenomena. He devoted his time to research on Malta, Gibraltar, New Zealand and, particularly, northeast England and the Caribbean. Trechmann's research programme in the 1920s and 1930s involved work on the archaeology and geology of northeast England during the summer months (Donovan, 1999, 2001a), but, once winter threatened, he returned to the geologically interesting islands of the Antilles. Thus, independent means permitted Trechmann to pursue his own interests in geographically far-flung regions. He published over 80 monographs and research papers on geology and archaeology, including at least 40 on the Caribbean (Donovan, 2001b).

Trechmann's contribution to the geology of the Caribbean was considerable. Undoubtedly, Trechmann's unique situation enabled him to travel widely within the region, enabling him to speak with informed authority on diverse aspects of Antillean geology. Although he published on the geology of many islands, he travelled even more widely (Trechmann, 1933, pp. 30-31). He published some of the first detailed descriptions of aspects of the geology and palaeontology of many Antillean islands, particularly Jamaica, but also, amongst others, Barbados, Trinidad, Tobago and Carriacou. Trechmann's studies of fossil molluscs are still standard references for many areas and stratigraphic units; although in need of revision, they have been superceded only rarely by subsequent publications, perhaps most notably with respect to Jamaican Cretaceous rudists (Trechmann, 1924b; Chubb, 1971) and the Miocene molluscs of Carriacou (Trechmann, 1935; Jung, 1971). Trechmann also had the happy habit of sending important collections of non-molluscan fossils to acknowledged experts for description (such as ammonites - Spath, 1925; echinoids - Hawkins, 1923, 1924; and sponges - Dighton-Thomas, 1935).

His individuality often led to an unorthodox approach to geology. Trechmann could be antagonistic to his peers and tended to work alone, with almost no joint papers to his name. As was perhaps overstated by Chubb (1980, p. 50) in a posthumous paper, "Trechmann's fame as a geologist would stand higher today if he had published nothing after the last war," although this assessment may have been tinged by the undoubted friction between them (Sohl, 1967). His later publications, dominated by theoretical considerations, were estimated by Chubb to lack rigour. Although an acceptable interpretation, it is also true that Trechmann's mountain uplift theory, that proposed tidal action as an important tectonic force, is typical of some of the more iconoclastic, pre-plate tectonic theories of the 1950s; such models were devised by those geologists who did not accept Wegenerian continental drift (such as Lees, 1953; also see brief review in Fortey, 1997, pp. 277-278), although Trechmann's ideas were not without contemporary detractors (Anon, 1946). Initially, Trechmann's ideas on mountain uplift had to be privately published (1945, 1948, 1950, 1955;

but see also Trechmann, 1951, 1958). Trechmann died in Barbados, following an accident in the field, on 18th February, 1964, in his 80th year.

TRECHMANN AND THE GEOLOGY OF BARBADOS

> "Barbados, occupying as it does the position of the most easterly and isolated and furtherest out in the Atlantic Ocean of all the West Indian Islands, deserves special attention from geologists" (Trechmann, 1925, p. 481).

Between the wars, Trechmann published three major papers on the geology of Barbados (1925, 1933, 1937). His later contributions concerning the island relied largely on the data presented in these earlier papers. Thus, only these inter-war papers are considered in detail herein.

Trechmann (1925). This paper included descriptions of a large, but indifferently preserved, collection of mainly fossil molluscs made from two conglomerates, considered to be stratigraphically closely spaced, within the Scotland Beds (=basal complex in modern terminology of Speed and co-workers; see Speed, 1994, for review). Trechmann corrected the earlier determination of a Miocene position for these beds by Harrison & Jukes-Browne (1890; Jukes-Browne & Harrison, 1892) and placed the Scotland Beds firmly in the Eocene. Comparison with other Eocene faunas from the region was inconclusive (pp. 487-488), but, amongst others, the molluscs of the Scotland Beds were considered to have "much affinity" (p. 487) with the Lutetian to Bartonian interval of Europe, that is, Middle Eocene in modern terminology; Trechmann considered these molluscs to indicate a horizon "high in the Middle Eocene, or rather low in the Upper Eocene" (p. 487). A more modern estimate of the position of these beds is in broad agreement, Poole & Barker (1983) considering them to be Lower Eocene. Trechmann had already published two important papers on the Eocene molluscs of Jamaica (Trechmann, 1923, 1924a) and should be considered one of the leading young workers on Antillean Cenozoic molluscs at that time, in the year that Woodring (1925) published his monograph of the bivalves and scaphopods of the Bowden shell bed of southeast Jamaica.

Trechmann (p. 487) was less accurate in his estimation of the palaeoenvironment as "... shallow water, and in some cases estuarine in origin" (see also Trechmann, 1948, p. 14; 1958, p. 431; Barker & McFarlane, 1980). The prevalence of downslope transport in generating allochthonous mixed shell assemblages in a range of tectonic settings around the Antillean islands is now widely recognised. The most accurate estimates of palaeodepth can only be produced where multiple lines of evidence, particularly sedimentology, ichnology and palaeontology, are integrated (see, for example, Donovan, 1998; Donovan *et al.*, 2000). Trechmann's (p. 487) observation and interpretation that "... the only bed that yields well-preserved marine fossils, and *the rolled condition of these, mixed as they are with a number of fresh- and brackish-water forms* [our italics], points to the temporary invasion of the shallow water or littoral formation ..." does not appear to consider the (italicised) evidence of transport to be critical. This is at variance with modern interpretations of a deep water origin, which recognises both turbiditic and hemipelagic sedimentary rocks in the basal complex (reviewed in Speed, 1994, p. 183). Many of Trechmann's specimens were fragmentary and included oyster shells may have been derived from an older unit (p. 485) (also see Matley, 1932, for discussion of the 'ancient basement' of Barbados).

It is also of interest that the basal complex of Barbados *sensu* Speed and co-workers is rather different in age, tectonic setting and lithological composition to the supposed Palaeozoic or older Basal Complex of Jamaica *sensu* Matley (1929), which Trechmann denied and tried to disprove (Donovan, 1996, and references therein). Although Trechmann was right, albeit for the wrong reasons, the final repudiation of an ancient Basal Complex in Jamaica had to await the first radiometric dates from the island's granodiorites (Chubb & Burke, 1963), which are now known to be Maastrichtian-Paleocene in age, that is, much younger than necessary for Matley's theory.

Trechmann (1933). This paper represents an early discussion of Trechmann's ideas on the primarily vertical nature of tectonic phenomena and uplift. This revolves around Trechmann's theory for the uplift of Barbados, the third such theory to be formulated.

1. Harrison & Jukes-Browne (1890; see also Jukes-Browne & Harrison, 1891; Harrison, 1907) proposed that each terrace of Barbados represented a period of Pleistocene reef growth, each separated by a period of tectonic uplift, the oldest reef deposits being at the highest elevation *et seq*. The proposed mechanism for this sequential uplift was the intrusion of an igneous laccolith, but, as Trechmann noted (1945, p. 16), "there is no trace of igneous rocks on the island."

2. Spencer (1902) suggested that not all of the mantling limestone beds of Barbados were Pleistocene, but included Oligocene deposits analogous to the Antigua Formation of Antigua. An unconformity was postulated between the older and younger limestones. This determination was not supported by any palaeontological evidence (Harrison & Jukes-Browne, 1902; Harrison, 1907).

3. Trechmann (1933) postulated that the Pleistocene limestones of Barbados were originally deposited as a single isochronous sheet that had been differentially uplifted, producing a series of essentially horizontal terraces at differing elevations, but of the same (depositional) age. Uplift was considered to be oblique, produced by thrusting from the south and west, over the topographic high of the underlying Tertiary deposits. The overlying Coral Rock cracked "... along the sinuous line of the escarpment that overlooks the Scotland district and its fragments have been sent sliding in broken fragments down the slippery slopes of the Oceanic and Scotland beds towards the sea" (p. 20). Trechmann demonstrated that the Pleistocene fossil molluscs were essentially similar at all terrace elevations, suggesting no great time differences in their deposition, although some basal deposits were thought to be, possibly, pre-Pleistocene.

Trechmann's theory incorporated the available palaeontological evidence, based on his own field collecting, and provided an explanation for the arcuate exposure of the Scotland district. However, the advent of radiometric dating demonstrated that the core supposition of Harrison & Jukes-Browne (1890) was correct (if not the mechanism); the highest reef terraces of Barbados are the oldest and they young progressively through lower elevations, spanning the last million years or less (Mesolella *et al.*, 1970; Bender *et al.*, 1979; Edwards *et al.*, 1987). Over 20 individual reefs have been identified (Speed, 1994), deposited during an extended period of progressive uplift of the island during the Pleistocene that interacted with eustatic oscillations of sea level. However, rather than being due to igneous intrusion (Harrison & Jukes-Browne, 1890), the probable mechanism for uplift is the mud diapirism that remains active today (Speed, 1994).

Trechmann (1937). This paper provided further data in support of Trechmann's ideas on the formation of the Pleistocene reef terraces of Barbados. The most notable aspect of this paper is the detailed explorations of lithologies and faunas of the basal Coral Rock immediately above the unconformity with the underlying Tertiary units. Trechmann considered this fauna to have a "pre-Pleistocene aspect" (p. 358; see also Trechmann, 1958, p. 433). However, there are no radiometric dates that support a Pliocene age for the basal Coral Rock (see above). Further, the lithology of the basal beds at, for example, Skeete's Bay (Stop 2, below) is reminiscent of the Lower Pleistocene Manchioneal Formation of eastern Jamaica, considered to represent a deep water (*circa* 100-150+ m water depth) forereef deposit (Kohl, 1992; Harper *et al*., 1995). Such an interpretation is supported by aspects of the fauna not considered in detail by Trechmann, including the echinoderms and brachiopods (Donovan, 2000; Donovan *et al*., 2002; Harper & Donovan, 2002). Trechmann recognised that his mollusc fauna represented a deep water association that "... may have lived at a depth of 700-1,000 feet" (p. 358; revised to "... at least 600 feet deep" in Trechmann, 1945, p. 15), but interpreted certain species, most notably certain pectinid bivalves, as representing Pliocene taxa; we suggest that these may be species that were limited to deeper water in the Pleistocene and, hence, are poorly known (or extinct?) at the present day. These species would undoubtedly benefit from detailed taxonomic revision.

This paper also includes an interesting explanation of how some exotic blocks ('klippen' or dropstones) may become incorporated in deeper water deposits adjacent to such oceanic island settings. See Bennett *et al*. (1996), a paper in tune with Trechmann's ideas, for a recent review of the principal mechanisms by which such clasts are transported.

TRECHMANN'S GRAVE

Figure 1 illustrates the relative positions of the localities to be visited on this excursion. On the way to Stop 1 we shall visit C.T. Trechmann's grave to pay our respects. On 20th February, 1964, a death notice in the 'Stop Press' of *The Advocate* announced "On 18th February, 1964, Dr. CHARLES TAYLOR TRECHMANN of Durham, England. The funeral will take place at Christ Church Cemetery at 4.30 p.m. today where friends are asked to meet." Trechmann is buried in Christ Church Cemetery, not in the adjacent cemetery of Christ Church Parish Church.

STOP 1

RAGGED POINT LIGHTHOUSE

About 9.1 km from Six Cross Roads, parish of St. Philip. Turn right at the 'Lighthouse' sign and park at end of road (do not enter the property on the right) (approximately GR 59° 25' 58" W 13° 9' 39" N). Although not visible from this position, this stop is close to the angular unconformity between the Scotland Beds and overlying Coral Rock. The unconformity is best seen from the impressive sea cliffs on the south side of the bay (Deebles Point; see Trechmann, 1933; Figs 2, 3 herein). However, we have stopped on this side of Spring Bay in order that the lithology of the Scotland Beds can be observed at close hand, which unfortunately means that the unconformity *per se* is obscured (but see Fig. 2); the Coral Rock will be examined at close quarters at Stops 2 and 3.

The Scotland Beds exposed on Ragged Point range from unfossiliferous quartzose sandstones to gritstones showing some honeycomb weathering. Massive iron-rich carbonate (?) nodules are rare. These beds are underlain by shales (Trechmann, 1933, p. 43). Trechmann (1925, p. 486) published a measured section of the Scotland beds at this locality, totalling 157 feet (about 50 m) in thickness, the overlying limestones varying up to a maximum of 100 feet (about 30 m) (Trechmann, 1933, p. 25). Fissures in the limestone have yielded bones of iguana and a rodent (Trechmann, 1937, pp. 357-358; Fig. 3 herein). Trechmann's research on the age of the Scotland Beds and his ideas on the significance of basal Coral Rock are discussed above.

It is worth noting that the brachiopod *Tichosina* sp. occurs in the basal Coral Rock at this locality. This is a large, biconvex, globose terebratulide with a functional pedicle which would have lived associated with large patches of substrate. Our knowledge of both living (Asgaard & Stentoft, 1984) and Pleistocene *Tichosina* in the Caribbean region (Harper *et al.*, 1995; Harper & Donovan, 2002) suggests an outer shelf or upper slope setting, a deduction at variance with Trechmann's gastropod data which suggested a shallower water origin (1933, p. 27).

To the west and northwest, Skeete's Bay (Stop 2) is marked by the obvious cream-coloured building, and Consett Point (Stop 3) forms a far headland. The differences in coastline geometry can easily be related to the presence of either Coral Rock (vertically jointed cliffs with obvious bedding) or Tertiary deposits (low cliffs and easily accessible sandy bays).

STOP 2

NORTHWEST SIDE OF SKEETE'S BAY

"[The southeast corner] is the most problematical in Barbados geology; it is the area where the basal coral rock is thickest and is the only locality where the post-coral-rock beds are at all massively developed" (Trechmann, 1937, p. 340).

About 3.4 km from Stop 1. There is a signpost at the Skeete's Bay turnoff. Park by the cream-coloured building with the green roof (EDF/Barbados Government Fisheries Building). Scramble down onto the beach to the left (northwest) over the limestone armouring, then scramble over the local limestone to see exposure.

Stop 2 is the northwest side of Skeete's Bay, Whitehaven, parish of St. Philip (approximately 59° 27' 00" W 13° 10' 00" N), figured and discussed briefly by Trechmann (1937), who considered it "a good collecting ground for the basal fauna" (p. 346). It is a coastal exposure of the basal Middle Coral Rock (484 000 -127 000 years old; Poole & Barker, 1983) that rests unconformably on the Tertiary Scotland Beds and Oceanic Group (Trechmann, 1937, p. 344, text-fig. 3; see Fig. 4 herein); the basal position perhaps suggests it to be Middle Pleistocene. The fauna includes benthic foraminifera, bryozoans, terebratulid brachiopods (Harper & Donovan, 2002), benthic molluscs (Trechmann, 1937), asteroids and echinoids (Donovan, 2000), the clionid sponge boring *Entobia* isp. in some molluscs, and rarer pteropods, crab claws, and arcoscalpellid barnacle plates. The lithology, fauna and style of preservation of the fossils in the Middle Coral Rock at this locality are similar to the Lower Pleistocene Manchioneal Formation of Jamaica (Donovan *et al.*, 2002), deposited in a deeper water, fore-reef setting.

STOP 3

CONSETT POINT

From Stop 2, drive via Blades Hill College Savanna no. 2 road. The distance from between Stops 2 and 3 is about 4.6 km. Walk down the track towards the coast, then turn left on the coastal footpath. Veer off left into the cutting, formerly part of the Barbados Railway. This limestone cutting is up to 3 m high. Bedded limestones are exposed in the cutting, with more massive limestones apparent further along the track (=stratigraphically lower, as bedding is dipping more or less towards south). Grainstones at entrance to the cutting are cross-bedded on the right side. These limestones contain common, *in situ* colonial scleractinian corals; the limestones are finer grained and more massive lower down the section, where there are also colonial scleractinians, oysters and gastropods. Locally there are skeletal packstones and grainstones. Stops 2 and 3 are both in the Middle Coral Rock, but there is considerable contrast in the faunas. Unlike the basal beds (=deep water) seen at Stop 2, the presence of autochthonous (?) hermatypic scleractinian corals at Stop 3 indicates that these beds were deposited within the photic zone.

It is the basal Coral Rock at Consett Point that was proposed to be Oligocene by Spencer (1902; Harrison, 1907; Trechmann, 1933, p. 24). Although Trechmann agreed with Harrison's assessment of the incorrectness of this determination, he did identify within this cutting three species of pectinid bivalve that he considered to be pre-Pleistocene (1933, p. 27; 1937, pp. 345-346).

STOP 4

HACKLETON'S CLIFF

"The portion of the island below the Coral Rock escarpment where the older beds are exposed is known as the Scotland district, a name given to it by the early settlers on account of its rugged character" (Trechmann, 1925, p. 481).

Follow the road signs to the viewpoint at Hackleton's Cliff, overlooking Bathsheba, a driving distance of about 11.8 km. This elevated spot gives a fine view into the Scotland District, being perched near the highest point of the Upper Coral Rock and the supposed edge of Trechmann's thrusted sheet of limestone (1933, p. 20).

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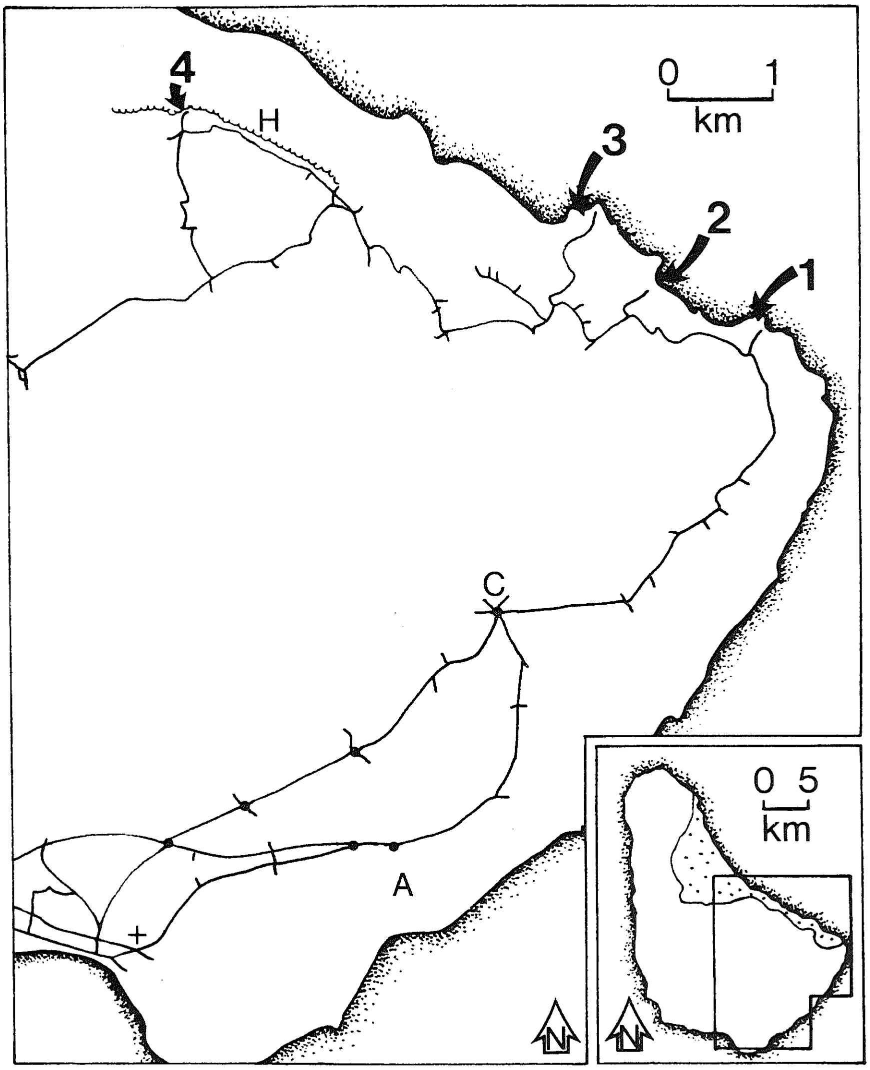

Figure 1. Locality map showing the positions of Christ Church Cemetery (+) and Stops 1-4 in southeastern and eastern Barbados. Only those roads relevant to this excursion are indicated. This figure should be used in conjunction with the geological map of Poole & Barker (1983) and any tourist road map. Key: A = Grantley Adams International Airport; C = Six Cross Roads; H = Hackleton's Cliff; 1 = Ragged Point (Stop 1); 2 = Skeete's Bay (Stop 2); 3 = Consett Point (Stop 3); 4 = viewpoint on Hackleton's Cliff (Stop 4); coastline stippled. Inset outline map of Barbados shows extent of main map; approximate extent of Tertiary outcrop stippled.

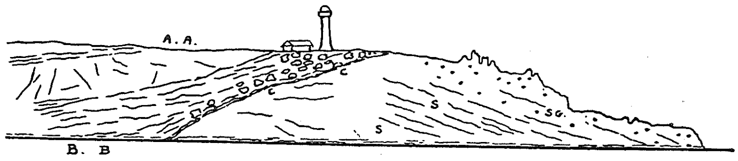

Figure 2. Trechmann's diagram of the angular unconformity between the Scotland Beds and Coral Rock at Ragged Point, parish of St. Philip, presumably drawn from Deebles Point (after Trechmann, 1933, fig. 3, p. 26). The original caption stated: "Sketch of cliff section at Ragged Point, Barbados, showing base of the Coral Rock resting on Scotland Beds, the Oceanics missing. Height of cliff about 70 feet; vertical scale exaggerated. The lighthouse stands on a surface of marine scouring developed previous to the last uprise. A.A., massive coral rock much jointed; B.B., bedded Coral Rock; C.C., broken up Scotland shales, the base of the coral rock [*sic*] enclosing masses of Scotland sandstone; S.S, Scotland shales; S.G., Scotland grits and sandstones." See also Figure 3.

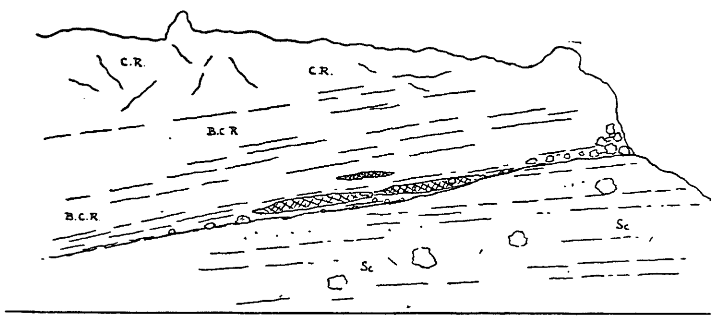

Figure 3. "Cliff section in Spring Bay south of Ragged Point, Barbados. Height 88 feet. Sc. Scotland sandstones dipping 45° N. B.C.R. Basal coral rock with *Haliotis*, etc., near the base. C.R. Massive Pleistocene coral rock. Cross hatched portions indicate caves near the junction filled with greenish clay and phosphatized limestone fragments containing reptile (Iguana) bones" (after Trechmann, 1937, text-fig. 4). See also Figure 2.

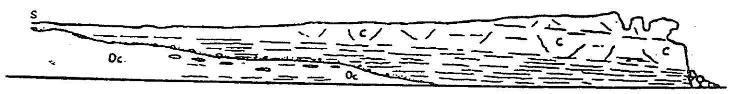

Figure 4. "South-facing cliff on the north side of Whitehaven Bay, S.E. Barbados. About 60 feet high. Oc. Oceanic chalks nodular in places. Resting on and against this is the hard platy limestone of the basal coral-rock with *Haliotis*, *Pleurotomaria*, etc. At the junction is a remanié bed. The basal bed passes up imperceptibly into ordinary massive coral-rock C.C. At S the basal lithothamnial bed dies away and the coral-rock becomes marly and mixed with Oceanic chalk. A variety of the large *Strombus gigas* and a few Amphisteginae occurred here" (after Trechmann, 1937, text-fig. 3).