THE NATURE OF HIGHLAND VALLEYS, CENTRAL PAPUA NEW GUINEA

With 2 figures and 2 photos

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Zusammenfassung: Die Morphogenese der Hochlandtäler von Central Papua, Neu-Guinea.

Obgleich BIK (1967) andeutete, daß die Bergtäler des Papua Neu Guinea-Hochlandes oberflächlich den von LOUIS (1957, 1964) beschriebenen „Flachmuldentälern mit Rahmenhöhen" gleichen, sind eingehende Untersuchungen erst kürzlich unternommen worden.

Die Hangfußbereiche in einer Anzahl von Tälern ergeben sich aus dem fortwährenden Zuwachs von tonreichen Sedimenten oder aus der spätpleistozänen kolluvialen Ablagerung. In nahezu jedem untersuchten Tal haben vulkanische Ablagerungen bis zu mehreren hundert Metern Dicke die vorher V-förmigen Talböden aufgefüllt. In einigen Tälern setzt sich die Auffüllung mit lakustrischen, organischen und fluviatilen Sedimenten, die vor mehr als 50 000 Jahren begann, bis zum heutigen Tage fort. Die mächtige Aufschüttung und fortlaufende Ablagerung erlaubt die Zurückweisung von BIK's Vorstellung, daß die Talböden und Hangfußbereiche Erosionsflächen sein könnten, ererbt aus der pleistozänen Absenkung morphoklimatischer Zonen.

In a 1967 essay dealing with morphoclimatic zonation of landforms in the central highlands of Papua New Guinea, M. J. J. BIK pointed out that the intramontane plains of the Andabare, Kandep, and Wasuma-Kagua valleys superficially resemble the 'hill-bordered saucer-shaped valleys' which LOUIS (1964) designated *Flachmuldentäler mit Rahmenhöhen* (BIK, 1967, p. 44). BIK noted that the Papua New Guinea valleys are characterized by wide central alluvial flats with rather short concave footslopes of 1°–3° abutting against steep valley sides rising at angles of 25°–35°.

Implicit in the *Flachmulden* concept is the notion of long continued erosion under conditions of tectonic stability, rapid weathering and effective subaerial denudation. The landscape is essentially erosional, the valley floor and the ramp slopes *(Rampenhang)* respectively exhibiting a superficial veneer of transported sediment and a deep residual soil (BIK, 1967; LOUIS, 1957; 1964).

On the other hand, A. GUILCHER (1970) believed the morphological development of the Lake Iviva (Sirunki) depression resulted from continued Quaternary tectonism and infilling of the basin with swamp sediments. GUILCHER also postulates that ponding and fluvial deposition of the Andabare, Kandep and Marient basins result from tectonism.

Although BIK and GUILCHER restrict their comments on basin morphology to only a few valleys, their descriptions of surface form are equally applicable to other highland valleys including the upper Wahgi (particularly the Gumants), the upper Kaugel, and the lower Nembi valley around Poroma (Fig. 1 and Photo 1). Recentdetailed stratigraphic studies of theGumants and Kaugel Valleys, and reconnaissance observations over a wider area (Fig. 1) now allow re-examination of the nature of Papua New Guinea highland valleys.

In order to test the hypothesis that the superficial resemblance between the Papua New Guinea highland valleys and LOUIS' *Flachmuldentäler mit Rahmenhöhen* is more than just morphological, it is necessary to study the nature and age of deposits on the valley slopes and floors; in particular it is necessary to show whether or not the valley floors and slopes are erosional features.

Valley footslopes

With reference to the Andabare Plain, BIK writes: '... where the footslopes often abut against the stream channels, the former are certainly slopes of transport of weathering waste. However, sheetwash, postulated by LOUIS as the transporting agent, does not operate on the well vegetated slopes in the area of study. In fact the mechanism of waste transport across gentle footslopes at these altitudes (*c.* 2525 m) is not at all clear, and the subject deserves detailed research, especially to determine whether transport occurs at all at present. If it does occur, as it is known to do above 2500 m, these footslopes are active surfaces of 'ramp-slope' nature. If transport does not occur below this level, could such surfaces be inherited features resulting from Pleistocene lowering of the morphoclimatic zones?'

(BIK, 1967, p. 45)

At Kuk Tea Research Station, on the southern footslopes of Ep Ridge, in the centre of the upper Wahgi Valley (Fig. 1), a series of shallow trenches 250 m long reveals the footslope stratigraphy. Ep Ridge itself is an outlier of pre-Permian metagreywacke and phyllite and Jurassic tuffaceous sandstones and siltstones (BAIN *et al.*, 1970). These materials are deeply weathered, and were mantled during the Late Pleistocene by tephras from Mount Hagen and other eruptive centres. Much of the tephra mantle has subsequently been stripped from the ridge.

Some exposures on the footslopes reveal mudflow sediments composed of slightly weathered angular to subangular clasts in a clayey, tephra-derived, matrix. Buried soils underlie the mudflow debris, which is seldom more than 1 m thick. However, most exposures low on the footslopes reveal only unbedded clay deposits, separated at some sites by thin lenses of reworked but identifiable tephra units (Fig. 2). The stratigraphy is complicated by the presence of numerous prehistoric drains and other evidence of early

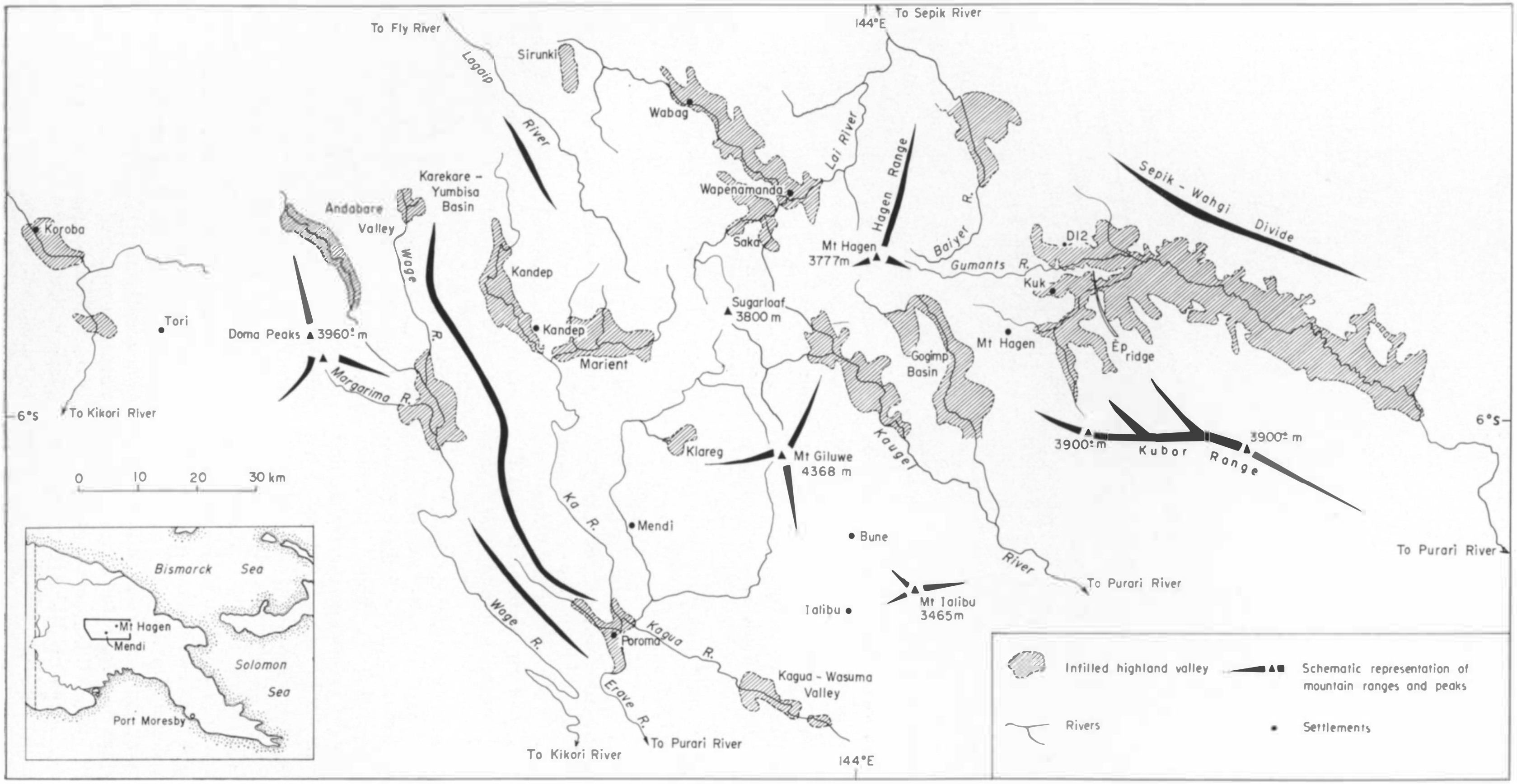

Fig. 1: Map to show infilled valleys and the major volcanic centres of the Papua New Guinea Highlands

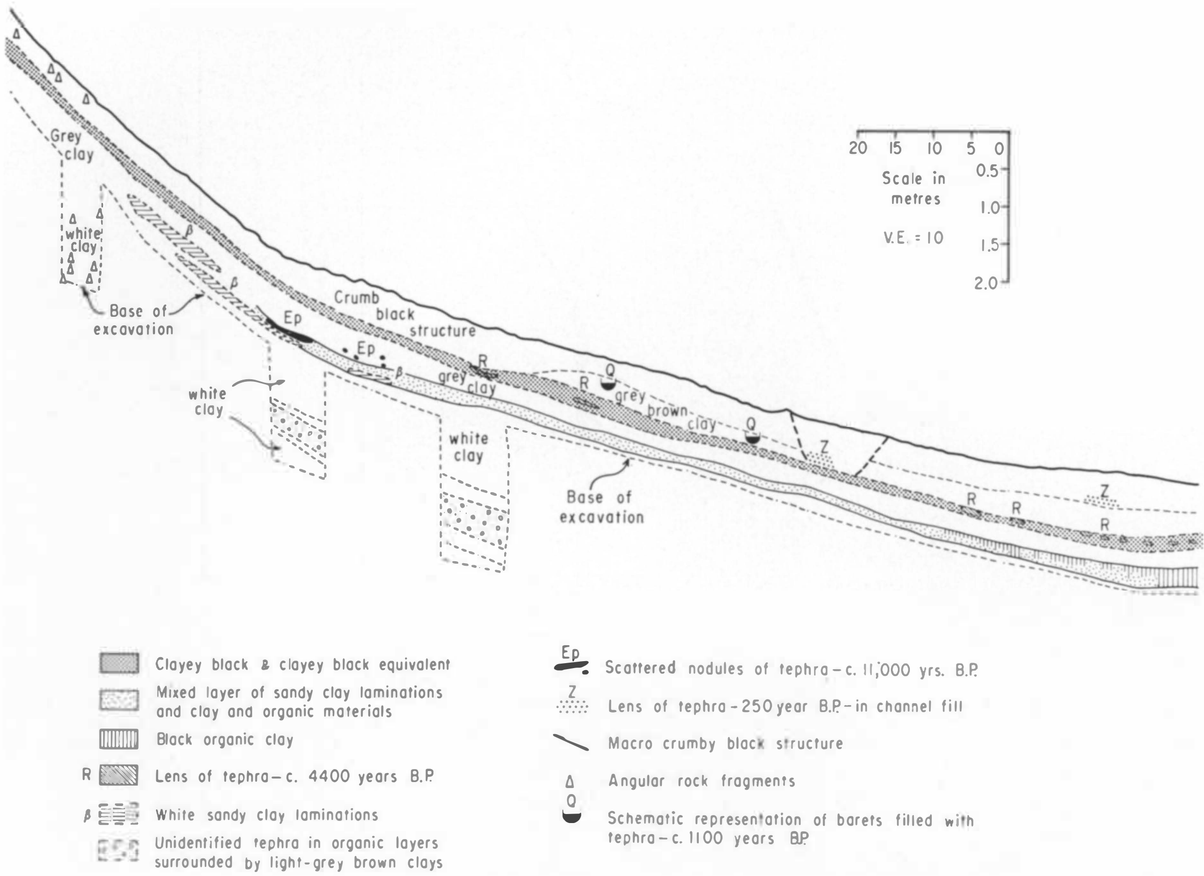

Fig. 2: Cross-section through the lower portion of a footslope, Ep Ridge, Kuk Tea Research Station

agriculture (GOLSON, 1974). In the upper part of the trench the clay-rich sediments extend to the surface. As some drains have been filled to the surface with clay-rich sediments, and the drains are known by tephrochronology to date from about 250 years BP, it is evident that clay sedimentation has continued to the present time.

Other thin tephra units, ranging in age from *c.* 1,100 to more than 11,000 years BP and parallelling the present footslope surface, can be identified at a number of sites down the slope (Fig. 2), though the tephra remnants are not always *in situ.* As the tephra unit more than 11,000 years old occurs at a depth of less than 1.4 m, and as clay-rich and organic sediments are more than 3.5 m thick, accretion spans at least post-glacial time. It is evident that the footslopes examined have been accreting slowly for a lengthy period of time, and deposition is not balanced by erosion. Thus, the southern side of Ep Ridge is flanked by a series of slowly-accumulating, coalescing alluvial (and in places colluvial) fans. Such landforms are not 'ramp-slopes' in the sense of LOUIS' (1964) *Rampenhang.*

On the northern side of Ep Ridge footslopes of 1°–3° drain to the Gumants Basin. Various exposures provided by stream incision reveal bedded weathered subrounded gravels to depths of at least 6 m. Again, the landforms as well as the deposits are characteristic of alluvial fans. Similar deposits occur on the northern margin of the Gumants Basin and flanking the lower portions of the Sepik-Wahgi Divide. In a borehole through a footslope (D 12 on Fig. 1) 14.5 m of gravelly fan deposits sit on a peat dated at 13,000 years BP.

In the upper Kaugel Valley (Fig. 1) footslopes and fans with slope angles up to 8° occupy a narrow strip between the valley floor and the commanding slopes (Photo 2). There are two points to note about these slopes. Firstly, they are nearly all incised at present, and degradation is confined to the floors of channels which traverse the slopes. Secondly, it has been demonstrated that both the footslopes and the fans owe their origin to colluvial deposition (PAIN, 1973; 1975). Thus, in common with the footslopes of Ep Ridge and the Gumants Basin, the Kaugel Valley forms are not erosional 'ramp-slopes'.

In the Yumbis-Karekare Basin (*c.* 2,500 m, upper Wage Valley – Fig. 1) at least one exposure through a trenched footslope indicates that 0.5 m of fine sediment

Photo 1: The infilled valley of the Gumants River. The Gumants and its tributaries have well-developed levees with extensive accreting backswamps. Low-angle footslopes and alluvial fans are still accumulating sediment.

Photo 2: An infilled basin of the Upper Kaugel Valley. Low-angle footslopes result from colluvial deposition.

has accumulated since the deposition of a thin tephra unit only 250 years old.

Bik notes that the gentle footslopes in the Kandep Plain are mantled by tephra which makes it difficult to determine whether the surface is degradational (Bik, 1967, p. 44). Reconnaissance observations (Pain and Blong, in press) indicate that the uppermost tephra in the Kandep area is the Tomba Tephra of Pain (1973), erupted from Mount Hagen, and now believed to be more than 50,000 years BP. Thus, if the footslope surface is degradational, it is being degraded by exceptionally slow processes. Furthermore, the presence of

Tomba Tephra at the surface on Kandep footslopes at an elevation of about 2,225 m is in contrast to its removal or burial by at least 3.5 m of sediment on Wahgi Valley footslopes at *c.* 1,500 m. No morphoclimatic significance can be attached to this observation until further reports on the age and rates of erosion/deposition on valley footslopes become available.

Valley floors

Bik (1967) notes that augering to a depth of 2 m in the central portions of the plains which he investigated revealed only alluvium. Levees with clastic sediments occur along some river channels, with peat, keeping pace with river accretion, growing in backswamps which rise away from the river (Bik, 1967, p. 44; Jennings, 1963). Thus, Bik was unable to determine whether or not the plains were erosional.

A recent series of boreholes across the Gumants Basin nowhere reaches bedrock or even *in situ* weathered material despite attaining depths of nearly 40 m. Details of the stratigraphy are to be considered elsewhere, but the deposits include fluviatile, lacustrine, volcanic (laharic), and organogenic sediments. Carbon-14 dating of sediments indicates that, at some sites, even 10 m below the surface, wood samples are beyond the range of radiocarbon assay.

Similarly, in the upper Kaugel Valley, Pain (1973) has demonstrated that the *Flachmulden* landforms are underlain by considerable depths (up to 250 m) of colluvial, lacustrine, and volcanic sediments, which infilled a series of lake basins created by volcanic dams formed during eruptive activity from Mount Giluwe. Here the tephra mantling much of the infill surfaces is again Tomba Tephra, demonstrating the antiquity of much of the valley floor. Moreover, modification of the valley floor since the deposition of Tomba Tephra has resulted from colluvial deposition and vertical river incision, neither of which fit the *Flachmulden* concept.

At Sirunki, a flat floored basin surrounded by footslopes and draining to the Lai (Fig. 1), D. Walker has obtained a peat core more than 22 m in length from the basin floor; this core covers more than 30,000 years of the basin's history (Walker, 1970). Broad valleys near Tari and Koroba have more than 40 m of sediment exposed by trenches incised into their floors, and carbon-14 ages of more than 30,000 years have been obtained from samples only 5 m below the infill surface (Williams *et al.*, 1972).

Other valleys with *Flachmulden* forms have been deeply trenched by river downcutting leaving only isolated remnants of flat floors with gentle marginal footslopes. The mission and airstrip at Poroma (Fig. 1) sit on one such remnant, perched more than 200 m above the Ka River. Good exposures on the new Mendi-Poroma road reveal that the valley of the Ka River was filled by at least 200 m of agglomerate and lahar deposits to form the aggraded surface on which Poroma is built. The surface is capped with Bune Tephra, shown by Pain and Blong (in press) to be coeval with Tomba Tephra and hence believed to be more than 50,000 years old.

At Margarima (2,100 m) in the Wage Valley (Fig. 1) exposures show that this valley and its tributaries, the Margarima Valley and the lower Andebare Valley, have been filled by at least 80 m of volcanic predominantly laharic) deposits derived from Doma Peaks. The Wage has apparently shifted eastward in its valley at Margarima and incised along the contact between the valley wall limestone and the volcanic infill. Against the western valley wall, the lower Margarima River flows southward in a site that was once part of the Wage Valley.

Conclusions

Valleyside footslopes are, at least in some cases, either largely Pleistocene alluvial and colluvial fans, or slowly accreting clay-rich alluvial fans with deposition continuing at the present time. In none of the valleys so far examined can the footslopes landforms be considered to result from erosional processes. Long-continued deposition dominates the evolution of the footslopes. Furthermore, deep alluviation and continuing deposition, at least at some sites, allow the rejection of Bik's (1967, p. 45) suggestion that the surfaces could be inherited features resulting from Pleistocene lowering of morphoclimatic zones.

Although many of the valleys of the central Papua New Guinea highlands superficially resemble the *Flachmuldentäler mit Rahmenhöhen* described by Louis (1964), stratigraphic examinations reveal that many valley floors are underlain by considerable thicknesses of volcanic, fluvial, lacustrine, and other sediments. These sediments have infilled, and in some cases are continuing to infill, depressions which have at least two kinds of origin. On the one hand, many initially V-shaped valleys *(Kerbtal)* were dammed by Pleistocene volcanic activity; these include the Tari-Koroba Basins, the upper Kaugel Basins, the Saka and Wabag-Wapenamanda Basin, the Gogimp Basin, the lower Nembi-Ka area near Poroma, and the Wage-Margarima-Andebare junction area near Margarima. In the upper Kaugel, Tari-Koroba, and lower Nembi areas at least, infilling has taken place partly in lakes ponded by volcanic deposits. Damming of the Kandep and Marient and the upper Andebare valleys may also have followed volcanism, but firm conclusions can only follow more detailed work. Similarly, the infilling of the Gumants as a consequence of volcanism and drainage reversal as proposed by Haantjens (1970, p. 22) cannot yet be proved. On the other hand, infilling of the Sirunki Basin is believed to follow warping associated with recent movement on the Lagaip Fault zone (Guilcher, 1970; Dow *et al.*, 1972, p. 75).

In no case can erosion be sustained as a cause of valley floor formation.

Although continuing tectonic adjustments are almost certainly occuring over wide areas of the highlands considered here, it is evident that the majority of basin forms result primarily not from either Quaternary tectonism or the development of *Flachmulden* landforms, but from Quaternary volcanism and associated sedimentation.

A c k n o w l e d g e m e n t s

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BERICHTE UND KLEINE MITTEILUNGEN

ÜBER DIE AUSWIRKUNGEN DES PROJEKTIERTEN HAMBURGER VORHAFENBAUS IM WATT SÜDLICH DES ELBEÄSTUARS

Ein Beitrag zur Angewandten Küstenmorphologie

Mit 2 Abbildungen

HEINZ KLUG

Summary: Geomorphological effects of the projected construction of an outer port in the tidal flats of Cuxhaven.

The projected construction of an outer port of Hamburg and its connection by a dam with the mainland would lead to far-reaching hydrological-morphological changes in the tidal flats off Cuxhaven. An attempt has been made to record and assess these by relating the connections indicated by the present dynamics and development to the changed marginal conditions after the construction of the planned building-work, as identified by model-based investigations.