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doi:10.1006/jhev.2001.0464

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Introduction

In “Extraterrestrial evidence on the age of the hominids from Java,” Langbroek & Roebroeks (2000) argue for first-hominid migration to Java ~1 Ma. Focusing on Sangiran Dome, Central Java, they miss evidence from the 1936 Perning (=Mojokerto or Modjokerto) site, East Java, where the discovery of a child’s skullcap attributed to *Homo erectus* (Anton, 1997) supports earlier immigration. They apparently question the specimen’s origin (“possible find”, p. 598), stratigraphic position (“absence of accurate provenance”, p. 595), and contemporaneity with Swisher *et al.*’s (1994) 1.81 ± 0.04 Ma $^{40}\text{Ar}/^{39}\text{Ar}$ date from the site (“reworked”, p. 598). Other anthropologists share these doubts, and this affects their understanding of the Eurasian dispersal of early *Homo* and the range of paleo-environments that it inhabited. My recent research in Java sheds new light on three questions of interest in this regard: (1) was the Perning hominid discovered *in situ*?, (2) is its stratigraphic position known? and (3) is the fossil 1.81 ± 0.04 Ma? The following comments highlight geological fieldwork and archival documents not previously brought into the discussion. The evidence indicates that the Perning hominid is likely to date from latest Pliocene, and thus be an indication of early *Homo erectus* occupation of Java. Moreover, the hominid is by far the oldest known anywhere from a seacoast paleogeographic setting, potentially giving

the discovery special meaning for the paleoecology of early *Homo* (Huffman, 1999a,b).

Discovery *in situ*?

The Perning specimen is only relevant to assessing the timing of early hominid migration if the fossil was found *in situ*. Doubts about discovery in bedrock are voiced by de Vos (1985), Theunissen *et al.* (1990), and Walker & Shipman (1996:191). The questions arise because von Koenigswald (1936a) first mentioned a surface find in the press before maintaining in a variety of publications that the hominid was recovered in place (1936b,c,d, 1937, 1938, 1939, 1940, 1947, 1956:79–82). Other participants and witnesses support von Koenigswald’s *in situ* account.

Although he identified and announced the discovery (Bernet-Kempers, 1982), von Koenigswald neither unearthed it, nor described its context. Therefore, in a second newspaper article, published in response to criticism by Dubois (1936), von Koenigswald quotes geologist Johan Duyfjes who mapped the area and supervised the discoverer:

“It was excavated by our collector Andoyo from a hole 1 m deep in indurated conglomeratic sandstone that definitely belongs to the Mojokerto bone beds”

(von Koenigswald, 1936b, translated). Duyfjes, von Koenigswald, and the

Geological Survey (their employer) all reaffirm the *in situ* context formally and unequivocally that year (Duyfjes, 1936a; von Koenigswald, 1936c,d; Mijnwezen in Nederlandsch-Indië, 1938:36; see also Duyfjes, 1938b). Andoyo (=R. Tjokrohandoyo), a career Survey assistant, was collecting vertebrate fossils under assignment from Duyfjes when he unearthed the hominid. In a letter transmitting his collection to headquarters, he reports that his discoveries include a human? (“orang?”) skull designated specimen No. 173A (Andoyo, 1936; Aziz, 1998). A copy of his map shows that 173A is from the location that Duyfjes published for the hominid discovery (Duyfjes 1936a, Abb. 2). The locality lies in East Java west of Surabaya in the eastern Kendeng Hills, ~10 km northeast of the city of Mojokerto, 3.5 km north of Perning village, and ~300 m east of the road linking Sumbertengah/Sumberlagah and Kepuhlagen (=Klagenblandong) hamlets (Duyfjes, 1936a).

Hellmut de Terra, a Quaternary geologist, visited the location with von Koenigswald, Pierre Teilhard de Chardin, and Hallam L. Movius, Jr in 1938, while Duyfjes was on home leave. De Terra (1938, 1943) reports finding a well-preserved excavation in gravelly sand, exposed in a broad anticline. Having eliminated structural complications and surface deposits (1943:441–443), he states (1938:4)

“... in spite of the shallowness of its position there is nothing to cast a shadow of doubt on the stratigraphic position of the skull.”

De Terra also compared matrix on the calvaria and material cleaned from it to gravelly sandstone from the site, and concludes that they are the same lithology (also see Swisher *et al.*, 1994, 2000). He published photographs of von Koenigswald at the discovery excavation (de Terra, 1940, 1943), an irregular pit clearly dug in consolidated sediment. Movius (1944:

82) reaffirms de Terra’s assessment, stating:

“... not only does the breccia inside the skull match material exposed in the pit, but there is no other horizon in the vicinity from which it could have been derived.”

The de Terra team was the last that definitely revisited the excavation.

Stratigraphic position

Questions have been raised about Duyfjes’ (1936a, 1938b) description of the Perning fossil’s stratigraphic position. De Vos (1985) omits Duyfjes’ stratigraphy when reviewing the discovery context. Elsewhere he and colleagues conclude that the geologist’s stratigraphic units are unrecognizable in the field because they were defined faunally, not lithologically (de Vos *et al.*, 1982; Sondaar *et al.*, 1983; Sartono, 1984; Sondaar, 1984; Theunissen *et al.*, 1990; see also Sartono *et al.*, 1981, and Wolpoff, 1999). Walker & Shipman (1996:189) state with reference to Perning,

“Even establishing a stratigraphic framework is incredibly difficult in Java . . . There are almost no geologic exposures . . .”

Actually conditions around Perning favor geologic mapping—thin soil, reduced vegetation in the dry season, hilly terrain, topographic alignments that correspond to rock units and many natural and man-made outcrops, including a sizeable quarry. Thin soil explains how the hominid fossil was found in solid rock at only 1 m in depth. Archival documents and fieldwork also show that Duyfjes’ mapping in the region is based on lithology, not faunas, and is useful for locating the hominid-producing strata at Perning.

Duyfjes (1936a, & Abb. 2 & 3; 1938b) indicates that the hominid-producing bed consists of 3+m of tuffaceous sandstone with andesitic gravel, and overlies ~2 m of white ash-tuff, which rests on 5 m of

sandstone. This 10 m-thick section is shown on his map and geologic cross section to be roughly in the middle of ~110 m of strata that are bounded by two regional map markers, his Mollusk Horizons II and III (see also [de Terra, 1943](#), Figure 101). The map and a more detailed section indicate that the site is at the edge of a steep-sided gully bordered by flat hilltops and located immediately east of a prominent creek. Two later field teams have used Duyfjes' geological and geographical descriptions to find the stratigraphic interval in which the 10 m section lies ([Kumai *et al.*, 1985](#); [Swisher *et al.*, 1994, 2000](#); C. C. Swisher III, personal communication, 2000; see also [Sartono *et al.*, 1981](#); [Semah, 1986](#)). The teams relocate the hominid site at points ~100 m apart, but because of low dips this translates into a small stratigraphic difference (<7 m on a stratigraphic column in [Hyodo *et al.*, 1993](#)).

My fieldwork with Yahdi Zaim ([Huffman, 1999a,b](#); [Huffman *et al.*, 2000](#)) reveals that the discovery site falls in a distinctive cliff-forming gravel unit—the only one between Mollusk Horizons II and III that fits the descriptive parameters of the site. The unit is characterized by cross-bedded, gravelly, coarse-grained andesitic sandstone and granule-pebble conglomerate, and includes the “brown sand and gravel” shown in Figure 16 of [Kumai *et al.*, 1985](#). Light-coloured pumice is common among the gravel clasts. The unit includes lenses and large rip-ups of light-colored, laminated mudstone, probably altered, water-laid tuff. Sedimentary dips that are up to 30° hamper determining stratigraphic thickness, but the gravel unit is 20–30 m thick around the discovery point with the hominid horizon being in the middle/upper part. We have not found the old excavation or any one outcrop that fits Duyfjes' site description completely. The problem may be that agricultural terracing has changed the microtopography, thus exposure, and that brush covers many

steep slopes. Duyfjes' location map cannot be used to pinpoint the excavation because the topographic base does not show detail such as the gully near the site. However, the locality can be constrained to an area of about 10,000 m² that includes the two relocations mentioned above.

Because evaluating the Parning discovery depends on the maps and reports of Johan Duyfjes, an otherwise little-known geologist, it is important to understand the background of his work. Duyfjes mapped the hominid-bearing beds of East Java—those containing the Trinil, Kedungbrubus, and Parning finds—from 1931–1938 as part of the quadrangle mapping program of the Dutch East Indies Geological Survey. The hominid area had already been mapped and studied geologically for over 40 years ([Verbeek & Fennema, 1896](#); [Rutten, 1927](#); [van Es, 1929, 1931](#); [Cosijn, 1931, 1932](#)). By 1934, Duyfjes had walked the vertebrate-bearing outcrop for 150 km from Trinil to Parning, and ultimately completed fieldwork along the entire belt to the Survey's exacting standards ([Geological Survey, 1942](#)). Duyfjes died during the Second World War, having published only parts of this work ([Duyfjes, 1936a, 1938a,b,c,d](#)), but many of his unpublished field reports and maps (1:25,000–1:50,000) are archived in Bandung (e.g., [Duyfjes, 1931, 1932, 1933, 1934](#)). Duyfjes defined lithostratigraphic subdivisions for the hominid beds in 1936 ([Duyfjes, 1936a](#)). His 1932–1934 survey reports clearly describe his field criteria for the formations, and dispel questions that the units cannot be recognized in outcrop (see also [Bartstra, 1983](#); [Hooijer, 1984](#)). Duyfjes' formations (with modifications) have been in use since the 1930s ([van Benthem Jutting, 1937](#); [van Regteren Altena, 1938](#); [van Bemmelen, 1949](#); [Rutten, 1952](#); [Marks, 1957](#); [Geological Survey of Indonesia, 1963/1989](#); [de Genevraye & Samuel, 1972](#); [Watanabe & Kadar, 1985](#); [Indonesian–Japanese Joint Study Team,](#)

1992; Noya *et al.*, 1992; Pringgoprawiro & Sukido, 1992; Datun *et al.*, 1996).

Duyfjes mapped the area around Perning late in 1933, closely following Cosijn (1932), and produced a 1:25,000 map, numerous cross-sections, and detailed formation descriptions (Duyfjes, 1934). By 1936, Duyfjes (e.g., 1936b) had incorporated these data into draft quadrangle reports and 1:100,000 maps. He was therefore uniquely qualified to evaluate the context of Andoyo's discovery. After visiting the site and making the detailed cross-section mentioned above, he was able to situate the hominid-bearing horizon in his own stratigraphic framework on both local and regional scales, a result that was unprecedented at the time.

Duyfjes found the Perning location to be near the crest of an anticline in his upper Pucangan Formation (also Putjangan or Poetjangan). He had mapped this unit using lithology, topographic expression, and a set of marker beds for 50+ km in the eastern Kendeng Hills (Duyfjes, 1938a,b; Rutten, 1952). He further followed it west by an abundance of coarse volcanic mudflow (lahar) deposits for another 100 km to Trinil (van Es, 1929, 1931; Duyfjes, 1931, 1932, 1933, 1936a). Duyfjes used the ridge-forming topography of the mudflow beds to help map the Pucangan. It is now possible to follow Pucangan strike-aligned ridges on air photographs and radar images, verifying his mapping (Huffman *et al.*, 2000). The Pucangan Formation is generally >800 m thick, except near Trinil, and consists of volcanoclastic and marine mudstone facies. The volcanoclastics largely grade eastwards into the mudstones between Kedungbrubus and Perning, indicating that a huge active volcano ("Wilis") lay south of Kedungbrubus (see below), and a coarse-clastic marine delta existed at Perning (Duyfjes, 1938a–d). The volcanoclastic facies generally consists of andesitic breccia, tuff, and tuffaceous sandstone, but is mostly

sandstone in the old delta near Perning (Duyfjes, 1934, 1936a, 1938a,b). The overlying Kabuh Formation, >350 m thick and also volcanoclastic, typically has cleaner sandstone than the Pucangan, and lacks the older unit's coarse volcanic mudflow (tuff-breccia) deposits. These lithologic differences were Duyfjes' main means of distinguishing the formations. Mollusk Horizon's II and III, which bracket the hominid-bed, lie ~60 m and ~170 m below the Kabuh at Perning (Duyfjes, 1938a,b).

Johan Duyfjes, a highly competent field geologist, was better prepared than any one in 1936 (or since) to determine the stratigraphic context of the Perning discovery. In addition to reliably positioning the find stratigraphically, relating it to discoveries at Kedungbrubus and Trinil, and setting them all in a regional paleogeographic context, his observations help to assess the radioisotopic date from Perning.

A 1.81 Ma Hominid?

Swisher *et al.* (1994) collected the volcanic hornblende dated at 1.81 ± 0.04 Ma from the pumice-bearing tuffaceous sandstone in the cliff below the commemorative monument at Perning (C. C. Swisher III, personal communication, 2000; Swisher *et al.*, 2000). This spot is near one of the two relocations mentioned above. The dated horizon is ~10 m above the base of the gravelly unit the author recognizes in the field. Two hornblende samples, described as pumice and matrix, give compatible radioisotopic results. These analyses only date the hominid if the dated material was deposited soon after it erupted. De Vos & Sondaar (1994), who Langbroek & Roebroeks (2000) follow, acknowledge that 1.81 ± 0.04 Ma is the age of the hornblende, but disassociate the date from the age of the hominid. Other anthropologists and geologists share their appraisal (e.g., Klein, 1999). De Vos & Sondaar

(1994) conclude that the dated material “was likely reworked and redeposited”, although they do not support this conclusion with sedimentological or stratigraphic evidence. Redeposition would have to have occurred ~ 0.8 Ma after eruption for first-hominid immigration to be ~ 1 Ma. By my reading of the sediments and their paleogeographic setting, a gap of $\geq 10^5$ years between eruption and deposition is far less likely than penecontemporaneous events.

First, the ash bed underlying the hominid bed (Duyfjes, 1936a,b; de Terra, 1943) and the probable tuffs elsewhere in the gravel unit are evidence that volcanic eruptions occurred around the time the *Homo erectus* lived. The remaining sediment in the unit could be lightly worked volcanic rock produced during the ash-producing eruptions, as Duyfjes envisioned (1938b). This would account for hornblende having the same radioisotopic age in a pumice pebble and sand matrix, and explain why the gravel unit contains so much labile detrital material. Floods of pumice pebbles occur locally with altered tuff in the unit, so at least some pumice erupted just before deposition. Moreover, in the Pucangan generally, there are no intraformational unconformities or changes in clastic lithology (Duyfjes, 1936a, 1938a–d) that would support proposing a long-term cessation of volcanism or a paleogeographic reorganization of clastic sources.

Second, a short-term influx of gravelly sand at Perning, triggered by distant volcanism, fits the overall depositional history and paleogeography of the Pucangan. For over 70 years, geologists have understood the Pucangan to represent continuous deposition from ongoing volcanism (van Es, 1929, 1931; Duyfjes, 1936a, 1938a–d; de Terra, 1943; van Bemmelen, 1949; Bartstra *et al.*, 1976; Sartono, 1976; Bartstra, 1982; Watanabe & Kadar, 1985; Semah, 1986; Bandet *et al.*, 1989; Willumsen & Schiller, 1994;

Kusumatita *et al.*, 2000). In large part, this conclusion comes from seeing a repetition in the Pucangan of tuff, “breccia,” and sandstone that are similar to ash-, lahar-, and fluvial-deposits found today around the region’s active volcanoes. By contrast, proposing that late Pliocene volcanic rocks were redeposited $\geq 10^5$ years after eruption calls for a new, unarticulated hypothesis of the regional geologic history.

The inferred source for much of the Pucangan volcanism lies near present-day Mount Wilis, an andesite volcano ~ 40 km south of Kedungbrubus. Much of the Pucangan at Kedungbrubus, which is ~ 70 km west of Perning, is “tuff breccia” and tuff (van Es, 1931; Duyfjes, 1936a; Itahara *et al.*, 1985). Bandet *et al.* (1989) date Kedungbrubus breccia at 1.87 ± 0.04 Ma, approximately the same age as at Perning. New age determinations of tuffs at Kedungbrubus apparently substantiate ongoing latest Pliocene and Early Pleistocene volcanism (Swisher, 2000; C. C. Swisher III, personal communication, 2000).

Medial Java now is occupied by a belt of andesitic stratovolcanoes ~ 3 km high. Evidently this also was the case in the Plio-Pleistocene (Sartono, 1976; Willumsen & Schiller, 1994; Huffman, 1997, 1998, 1999a,b). Eruptions at the central vents of modern volcanoes produce lava and ash that lahars transport down the edifices (Suryo & Clarke, 1985). Historic lahars carried people, animals, and trees through the Brantas River lowlands far from the erupting vents, and deposited them with mud, sand, and gravel on floodplain and delta (e.g., de Terra, 1943). Lahars pick up surface sediment, sometimes even semi-consolidated strata, as they descend volcanic highlands (e.g., van Es, 1931), but most of the incorporated material is not much older than the mudflows themselves. Apparently the same processes took place during Pucangan times.

De Vos & Sondaar (1994) find support for their redeposition hypothesis in the magnetostratigraphy of the Perning section done by Hyodo *et al.* (1992, 1993). In Hyodo's work, the hominid is placed in the Jaramillo magnetic polarity event (~ 0.97 Ma) by correlating results from Perning and Sangiran Dome (Hyodo, 1998). However, key magnetic readings on which the correlation relies may represent magnetic overprints, not original magnetic signatures (Swisher, 1994, 2000; Scott *et al.*, 2000; see also Semah *et al.*, 2000). De Vos & Sondaar (1994) also believe that the nonhominid vertebrate assemblage from the Pucangan near Perning supports a young age for the hominid. Their conclusion is based upon a revision of the biostratigraphic scheme of von Koenigswald (1934, 1935, 1936*c,d*, 1939, 1940; Duyfjes, 1938*a,b*; de Vos *et al.*, 1982, 1994; Sondaar, 1984; Theunissen *et al.*, 1990; Aziz, 1998). However, the revision is at odds with superpositional relationships mapped by Duyfjes (1936*a*) and others (van Es, 1929, 1931), and is subject to unresolved paleontological disputes (Bartstra, 1983; Hooijer, 1983; Sondaar *et al.*, 1983; Hooijer, 1984; Hooijer & Kurten, 1984; Pope, 1995:497).

Finally, the hominid-bearing unit at Perning might have been deposited so quickly that an age determination from any point in it suffices to date the whole unit, including the *Homo erectus*. The hominid-bearing unit, which is followed for >15 km along strike (Duyfjes, 1934) and is 20–30 m thick at Perning, apparently represents the seaward shift of delta-channel or delta-front sand deposits. Sand bodies this thick can form at one spot in a delta over the course of a few centuries, while sediments accumulate more slowly across the delta as a whole. This is illustrated by historic conditions on the Brantas River, not 50 km southeast of Perning. Here, sandy sediment from distant volcanoes filled a navigable estuary and created a delta in <700 years (Hoekstra,

1989). The sand found in the discovery area, therefore, could represent less time than the uncertainty in the $^{40}\text{Ar}/^{39}\text{Ar}$ method.

Much more can and should be done to determine the age of the Perning *Homo erectus*. At this point the evidence indicates that the pumice pebble and hornblende sand dated at 1.81 ± 0.04 Ma were probably the product of eruptions approximately contemporaneous with deposition of the hominid, and that redeposition of the dated materials $\gg 10^5$ years after eruption is far less of a possibility.

In summary, recent fieldwork and archival research strongly support the conclusion that the Perning *H. erectus* was found *in situ* in the upper Pucangan Formation, as defined by Duyfjes (1936*a*). Although the excavation spot has not been relocated and detrital materials were used by Swisher *et al.* (1994) to radiometrically date the site, lithologic and paleogeographic evidence from the Pucangan indicates that the *H. erectus* is likely to be 1.81 ± 0.04 Ma. Perning therefore supports hominid occupation of Java during the late Pliocene.

Acknowledgements

I wish to acknowledge The Leakey Foundation (San Francisco) for its support of field and archival research in Java during 1999 and the Paleoanthropology Research Fund, Department of Anthropology, The University of Texas at Austin for support in 2000. I appreciate the help of my collaborator for Javan research Dr Y. Zaim, Jurusan Teknik Geologi, Institut Teknologi Bandung. I thank B. W. Seubert (Jakarta) for translating Duyfjes (1936*a*), P. Leidelmeyer, E. Paauwe, Feitze Papa, M. M. Purbo-Hadiwidjoyo, Johan Volker, and E. R. Webb for other translations, Johan Duyfjes for making Duyfjes family records available, Sarah R. Demb, Peabody Museum of Archaeology and Ethnology,

Harvard University, and John Strom, Carnegie Institution of Washington, for help with archival documents, M. M. Purbo-Hadiwidjoyo and C. C. Swisher, III, for helpful discussions, and G.-J. Bartstra, R. T. Buffer, M. B. Collins, J. W. Kappelman and anonymous reviewers for comments on the manuscript.

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