fornia in the past or simply represent a temporary aberration, perhaps associated with the southern California uplift. The older Geodimeter surveys along the San Andreas fault (which extend back to 1959) are apparently contaminated by systematic errors (*4*) due to changes in survey procedures that make strain calculations suspect. With the other source of data, triangulation surveys, it is possible to determine the shear components accurately, but the dilatational component is very uncertain (*5*). For this reason pure right-lateral shear across a vertical plane striking N45°W may not be distinguished from uniaxial north-south contraction or uniaxial east-west extension. Nevertheless, comparisons of the current strain rates with shear components determined from triangulation in earlier epochs furnish some information on the variability of strain accumulation. The Palmdale network (Fig. 1) was surveyed several times by triangulation in the interval from 1932 through 1963 (*6*), and triangulation surveys of the Imperial and Taft-Mojave networks (*5*) overlap the trilateration surveys of the Salton and Tehachapi networks, respectively. A comparison of the shear rate components $\dot{\gamma}_1 = \dot{\epsilon}_{11} - \dot{\epsilon}_{22}$ and $\dot{\gamma}_2 = 2\dot{\epsilon}_{12}$ for different epochs for these triangulation-trilateration pairs is given in Table 2. Of the six comparisons, four agree to within 2 standard deviations; the values of $\dot{\gamma}_1$ for the Salton and Imperial networks and the two values of $\dot{\gamma}_2$ for the Palmdale network differ significantly. The limited number of comparisons available in Table 2 suggests some variability in strain rate accumulation. A much more extensive analysis of strain accumulation in southern California (*5*) demonstrates appreciable variability in the strain rate in both space and time.

The observations of uniaxial north-south contraction in Fig. 1 are within the region generally under the influence of both the "big bend" in the San Andreas fault system (between the Cajon and Los Padres networks in Fig. 1) and the Transverse Ranges geologic province. The "big bend" of the San Andreas fault (strike about N70°W) deviates significantly from the direction of relative plate motion (N45°W) and presumably introduces an appreciable component of north-south convergence into the plate interaction. The Transverse Ranges themselves are apparently the product of a predominantly north-south compression. Thus, there is both reason for and evidence of north-south contraction, but there is no apparent reason why the stress system should be a uniaxial north-south contraction.

The uniaxial north-south compression could be formed by the superposition of two stress systems, the north-south compression plus east-west extension associated with the Pacific–North American plate boundary plus an east-west compression of the Pacific coastal region caught between the Pacific block on the west and the spreading Basin and Range province on the east. Alternatively, the east-west contraction could be attributed to the preearthquake closure of dilatancy cracks as in the "dry-dilatancy" models (*7*). In the interplate shear field the dilatancy cracks would open predominantly in the east-west direction, and so closure of those cracks would provide the necessary contraction. In either case it is remarkable that the east-west compression just cancels the east-west extension associated with the drift of the Pacific plate to the northwest.

Possibly the uniaxial north-south contraction is associated with the southern California uplift (*8*). Indeed, Thatcher (*9*) has suggested than an episode of significant horizontal straining may have accompanied the main episode of uplift (1961 through 1963). However, Thatcher found that the orientation of that anomalous strain field was highly variable in contrast to the homogeneity of the uniaxial north-south contraction discussed here. If the strain rates in Table 1 represent elastic processes, the condition that the normal stress must vanish at the free surface requires that at the surface

$$\frac{\partial \dot{w}}{\partial z} = \frac{-\lambda(\dot{\epsilon}_{11} + \dot{\epsilon}_{22})}{\lambda + 2\mu}$$

where $\dot{w}$ is the vertical component of velocity, z is the vertical coordinate, and λ and μ are the usual elastic constants. For the strain rates in Table 1, $\partial\dot{w}/\partial z$ is about 10^{-7} per year. If this gradient were maintained to a sufficient depth within the lithosphere, it could result in an appreciable rate of uplift (for example, 8 mm/year if an 80-km-thick lithosphere were involved). However, the major uplift preceded the period from 1972 through 1978, and, in fact, present evidence indicates that this period was dominated by subsidence (*8*), at least in the central part of the uplifted zone. In any case, an association with the uplift in no way explains the origin of the north-south contraction; it merely associates the contraction with another unexplained phenomenon.

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Stone Tools from Mid-Pleistocene Sediments in Java

Abstract. *Two stone tools (a chopper and a retouched flake) were found in mid-Pleistocene channel fills at Sambungmachan (Java), which earlier yielded a hominid skull cap with characteristics of Solo man and a Trinil-like fauna. The artifacts are the first discovered in place in deposits on Java that are assigned to the mid-Pleistocene on faunal grounds.*

On 20 June 1975, in the course of a week-long tour of hominid localities, museums, and research institutions in Java, F. Clark Howell, F.H.B., L.G.F., and T.J. and staff members of the Gadjah Mada Department of Physical Anthropology visited the site of Sambungmachan, on the banks of the Solo River near Sragen in Central Java. While examining alluvial channel fills that had yielded a mid-Pleistocene fauna and a hominid calotte in 1973, we found two stone artifacts partially exposed in the section but still embedded in the top of a fossiliferous gravel bed. The potential importance of the finds was immediately recognized; the face of the adjacent section was carefully cleaned to rule out the possibility that the tools might be incorporated in slumped material of more recent age than the gravel bed, and the artifacts were then excavated from their matrix. All present at the discovery are agreed that the association of the stone artifacts with the gravel layer is unquestionable (Fig. 1). Therefore, the age of the artifacts must be at least as great as the gravel layer containing them. The artifacts are not at all abraded, suggesting that if they were derived from earlier lev-

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els, they have been moved no great distance from the source beds. It seems equally likely that they were actually deposited or discarded atop the gravels and have not been moved since (*1*).

The Sambungmachan site was found during the excavation of a cutoff of a bend in the Solo River, undertaken for the purpose of flood control. The cutoff itself is about 200 m long, 50 m wide, and 12 m in maximum depth. The fossiliferous deposits with the hominid skull were found about 8 m from the surface.

The floor of the trench is Pliocene limestone. Above this are a layer of dark, magnetite-rich sands and a black clay level, together measuring 2 m or somewhat less in thickness. The lowest fossil-bearing horizon is about 1.2 m of cross-bedded reddish sands. These are overlain by approximately 1 m of cross-bedded gravels and sands, with a fossiliferous coarse gravel layer at the base. It is this level which contained the stone tools. A disconformity separates these levels from overlying beds of sands and gravels extending to the top of the section. The fossil-bearing horizons below the disconformity are considered equivalent to the "boundary beds" at the base of the Kabuh, and recovered fossils seem to represent an earlier Trinil fauna with some more archaic elements. The hominid calotte is clearly of Solo type but is much earlier than specimens of Solo man known before 1973 (*2*).

Ten oriented samples were collected for paleomagnetic study from the beds between the Pliocene limestone and the disconformity overlying the fossiliferous beds. All of the samples were found to be of normal polarity both for natural remanent magnetization (NRM) measurements and after alternating field demagnetization. Directional changes on demagnetization were small, the largest being on the order of 10°. The NRM intensities ranged from 8×10^{-5} to 2×10^{-6} G. The average declination and inclination of the ten samples are $D = 6.3°$, $I = -18.1°$. These values may be compared with the present values at the site ($D = 2°$, $I = -34°$) and with the theoretical site declination and inclination ($D = 0°$, $I = -15°$) assuming an axial dipole.

Although paleomagnetic polarity alone does not provide direct chronological information, T.J. tentatively estimated the age of the Sambungmachan deposits at about 900,000 years; this is consistent with the normal polarity of the samples, which would then be assigned to the Jaramillo event. A number of processes can produce postdepositional normal magnetization, so that normal magnetization of samples need not indicate the polarity of the earth's field at the time of deposition. However, as the samples are relatively intense and directional changes were small in all samples, the magnetization is thought to be primary. It should be pointed out that if the age assigned on faunal grounds is too old, then the deposits at Sambungmachan must be less than 700,000 years in age since they are of normal polarity.

Both stone implements recovered from the gravel bed are made of large cobbles of basaltic andesite. The first tool discovered is an alternately retouched end and side chopper made of a split cobble (Fig. 2A). The working edge opposed to the smooth butt of the cobble segment is dorsally retouched and denticulated, with eight projecting "teeth." The dorsal surface shows numerous expanding and stepped-expanding flake removals, some quite massive. The left lateral margin of the segment is ventrally trimmed and also shows expanding and stepped-expanding flake scars, but these are smaller than their counterparts on the opposite surface. An islet of cortex still remains on the dorsal surface and the right proximal margin of the piece. The tool is 9.3 cm long (measured along the direction of the blow which detached the segment from the parent cobble), 12.2 cm wide, and 5.4 cm thick.

The second piece was found about 7 m from the first, in the same gravel layer. It is a retouched flake with smooth butt

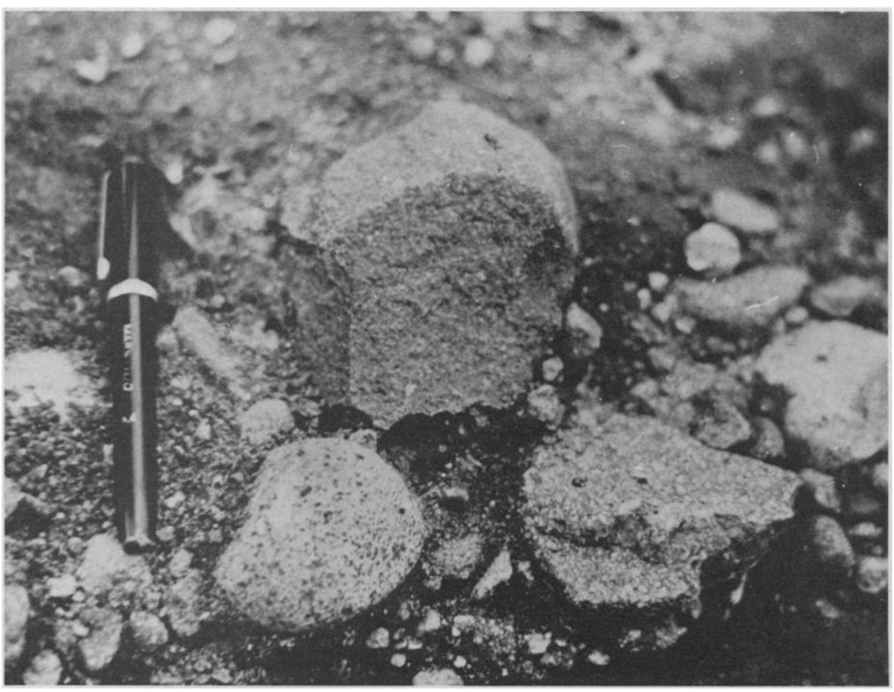

Fig. 1. Sambungmachan: chopper partially disengaged from gravel matrix.

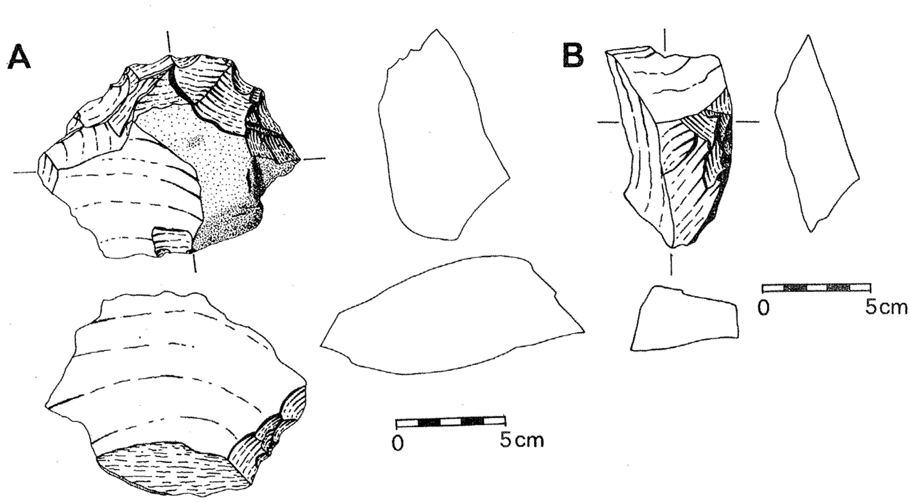

Fig. 2. Sambungmachan stone tools. (A) Chopper. (B) Retouched flake.

made of another cobble segment (Fig. 2B). Cortex is preserved on the right lateral margin of the piece, forming an abrupt edge at nearly right angles to the horizontal plane of the flake. Retouch departs from this cortical edge and invades a restricted area of the right side of the dorsal surface. Repeated massive to diminutive expanding and stepped-expanding flake removals have produced a concavity at the juncture of the dorsal surface and the cortex, which could almost be called a steep notch if one were to regard the cortical surface as the base of the worked edge. The flake is 9.4 cm long, 5.7 cm wide, and 2.9 cm thick. Although the piece is a convincing artifact, it might very well have gone unrecognized as such had we not first discovered the chopper.

Most previous attempts to find stone artifacts in situ in mid-Pleistocene deposits in Java have focused on those made of fine-grained siliceous rocks. Thus far, these efforts have produced pieces whose artifactual nature is dubious at best. Convincing artifacts in such raw materials, which may derive from mid-Pleistocene deposits but whose association with those deposits remains questionable, are of course known (*3*). Some large boules of igneous rock, including many of seemingly natural origin and a very few which may be artifactual, have also been collected from mid-Pleistocene fossiliferous levels. The discoveries at Sambungmachan suggest that as more attention is given to all classes of raw materials, including the volcanic rocks so common in Javan sediments, we can expect at last to obtain more knowledge of the technological equipment of early hominids in Java.

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References and Notes

1. The artifacts are now deposited in the collections of the National Archaeological Research Center in Jakarta.
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Regional Implications of Triassic or Jurassic Age for Basalt and Sedimentary Red Beds in the South Carolina Coastal Plain

Abstract. *Whole rock potassium-argon ages for samples of subsurface basalt recovered near Charleston, South Carolina, are interpreted to indicate a Triassic or Jurassic age for the basalt and underlying sedimentary red beds. This age is consistent with existing evidence indicating that an early Mesozoic basin is present in the subsurface of a large part of the coastal plain of South Carolina, Georgia, Florida, and Alabama.*

The presence of subsurface early Mesozoic rocks beneath Cretaceous sediments of the South Carolina coastal plain has been suggested (*1-3*). Whole rock potassium-argon ages for samples of basalt from deep wells near Charleston, South Carolina, are the first isotopic ages to confirm the presence of Triassic or Jurassic volcanic and sedimentary rocks in South Carolina. The new potassium-argon ages also support the Triassic or Jurassic age assigned to a more widespread subsurface province of little-deformed sedimentary red beds and mafic igneous rocks in the southeastern United States.

Subsurface continuation of rocks of the Appalachian orogen beneath the southeastern Atlantic and eastern Gulf coastal plains has been a traditional concept in North American geology. However, research done during the past 25 years has shown that this coastal plain "basement" is actually composed of several geologic provinces containing diverse rock types of different ages and tectonic origins. Data presented as early as 1951 (*4, 5*) indicate that "basement"

Table 1. Whole rock potassium-argon ages of subsurface Triassic or Jurassic igneous rocks in South Carolina, Georgia, and northern Florida. Locations of numbered wells are shown in Fig. 1; USGS, U.S. Geological Survey. Samples from well 1-2 were analyzed twice; ages are the averages of the two analyses.

Well No.	Sample	Rock and depth (m)	K_2O (%)	$^{40}Ar_{rad}$ (10^{-10} mole/g)	$^{40}Ar_{rad}$ (%)	Age ($\times 10^6$ years)
1-1	Clubhouse Crossroads 1; R. F. Marvin, USGS analyst (*13*)	Basalt, 772	0.625	0.8968	83	97.0 ± 4.2*
1-1	Clubhouse Crossroads 1; R. F. Marvin, USGS analyst (*13*)	Basalt, 785	1.40	2.309	85	111 ± 4.0*
1-2	Clubhouse Crossroads 2; M. A. Lanphere, USGS analyst	Basalt, 818.7	0.992 ± 0.015	3.010 3.054	85.3 80.1	204 ± 4.1
1-2	Clubhouse Crossroads 2; M. A. Lanphere, USGS analyst	Basalt, 842.3	0.355 ± 0.004	0.8702 0.8643	56.3 55.2	162 ± 3.2
1-2	Clubhouse Crossroads 2; M. A. Lanphere, USGS analyst	Basalt, 907.4	0.259 ± 0.018	0.7266 0.7368	60.0 63.5	186 ± 3.7
2	Mobil I.C., offshore Franklin County, Fla., Mobil Lab (*10*)	Diabase, 4354 (four samples)				186 ± 11* 190 ± 9* 199 ± 12* 208 ± 12*
3	Stanolind No. 1, J. H. Pullen, Mitchell County, Ga. (*7*)	Diabase, 2219				186 ± 5*
4	Hunt No. 2, Superior Pines, Echols County, Ga. (*7*)	Diabase or basalt, 1260				195 ± 15*

*Published ages have been recalculated based on the following decay constants: $\lambda_e = 0.581 \times 10^{-10}$ year^{-1}; $\lambda_\beta = 4.962 \times 10^{-10}$ year^{-1}; $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mole/mole.

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