show such collapse phenomena. We will treat the volcano-tectonic collapses of the Merapi, Soropati, Lawu, and Ardjuno-Welirang volcanoes in this paragraph on the Solo Zone of East Java. The discussion of the Ungaran complex, situated on the transition between the Kendeng Ridge of East Java and the North Seraju Mts of Central Java, will be postponed to the treatment on these lastmentioned mountains.

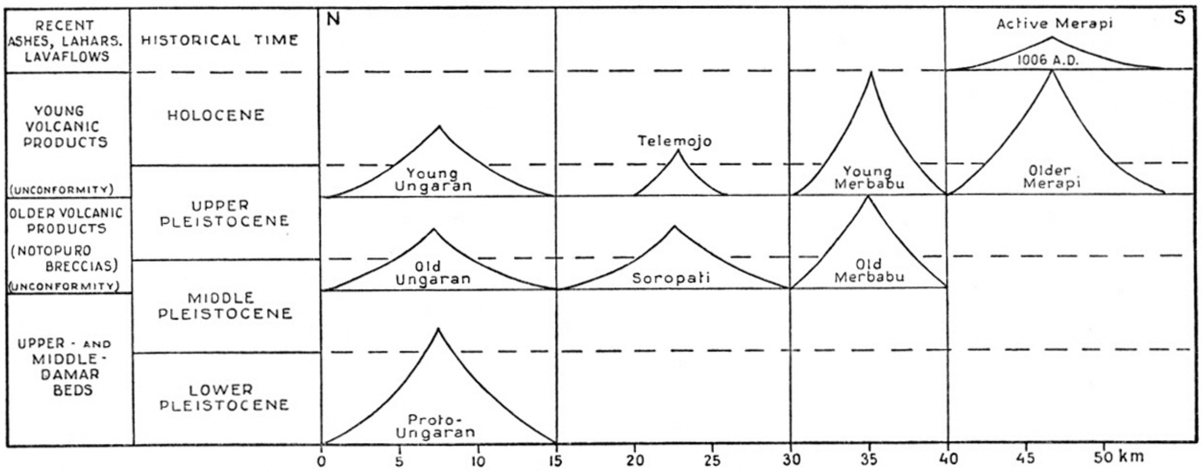

FIG. 271. *Development of volcanic structures of the transverse row Ungaran-Merapi.*

The **Merapi volcano.** This very active volcano is situated on the intersection of two faults of regional importance: namely the transverse fault, which separates East Java from Central Java, and a longitudinal fault which forms the boundary between the western Kendeng Ridge and the Ngawi Subzone North of Simo (see map fig. 268 on pi. 34).

We can distinguish an older part of the volcano (deeply carved by erosion, and dissected by faults), and the active Merapi cone. The older cone consists of olivine basalt, and, presumably in later stages, also of augite-hypersthene-hornblende andesites; the present active cone only produced augite-hypersthene andesites with subordinate hornblende, while olivine is not present.

The morphology of the older cone indicates that the western part has subsided with respect to the eastern portion along a number of arcuate, more or less hyperbolical slipfaults, concave to the West.

The author (1943, p. 71-72) has advanced some historical and volcanological arguments to prove that the destruction of the old Merapi cone happened in historical time, viz. during a cataclysmic outburst in 1006 A.D. This eruption depopulated and desorganized the prosperous Hindu State of Central Java, converting the surrounding fertile fields into barren ash-covered deserts. The present active Merapi cone rises upon the ruins of the older one, which was destroyed in the same year.

The amount of magma produced by the new Merapi volcano in the last 120 years has been estimated by the writer at about 766 million cb m. If the mountain had maintained this production for 940 years, about 6 cb km must have been produced since 1006 A.D. This estimate accords fairly well with the present size of the active cone, which probably forms only a relatively thin mantle over the older one, as is indicated in the section of fig. 272.

At the West foot of the volcano, between Salam and Muntilan, at a distance of about 17.5 km WSW from the summit, a peculiar group of hills is found amidst of the rice fields of the Progo Valley. The highest and largest hill (G. Gendol, 452 m above sealevel, that is circa 90 m above the alluvial plain) lies in the centre of this group. These hills consist of lahar breccias with fluviatile tuffaceous intercalations. The volcanic constituents are all vitro-phyric augite-hypersthene-hornblende andesites of the type known from the Older Merapi volcano. They decidedly differ from the volcanic rocks of the Menoreh Mts, West of them, to which they were formerly assigned, as in the Menoreh volcanic hypersthene is absent.

The volcanic layers of these hills are distinctly folded, forming a sheaf of anticlines, concave to the West and narrowly compressed in the G. Gendol centre, while the axes plunges north- and southward below the surface of the alluvial plain.

These folds are either the result of a slipping down of Merapi deposits from the rising dome of the West-Progo Mts, part of which is represented by the Menoreh Mts (to be described hereafter), or they are connected with the gravitational collapse of the older Merapi cone itself. Against the first supposition can be advanced that the Menoreh Mts have not been covered to any degree by breccias and tuffs of the older Merapi; during the Quaternary the Menoreh Mts formed already a rather high range, as follows from their morphology and the absence of erosion remnants of quaternary deposits.

On the other hand it appears that the anticlines between Salam and Muntilan are comprised between the arms of the hyperbolical system of slipfaults along which the older Merapi volcano broke down. Moreover, the mean direction of the dips in the Gendol anticlinorium is about the same as that of the axis of the hyperbolic fault system. Therefore, these fluviatile volcanic deposits of the Gendol group have been folded and crumpled against the edge of the Menoreh Mts by a force which coincided with the axis of the above mentioned hyperbolical fault-system. This indicates that their compression compensated the tensional movements due to the collapse of the older Merapi cone, as is illustrated by the section (fig. 272).

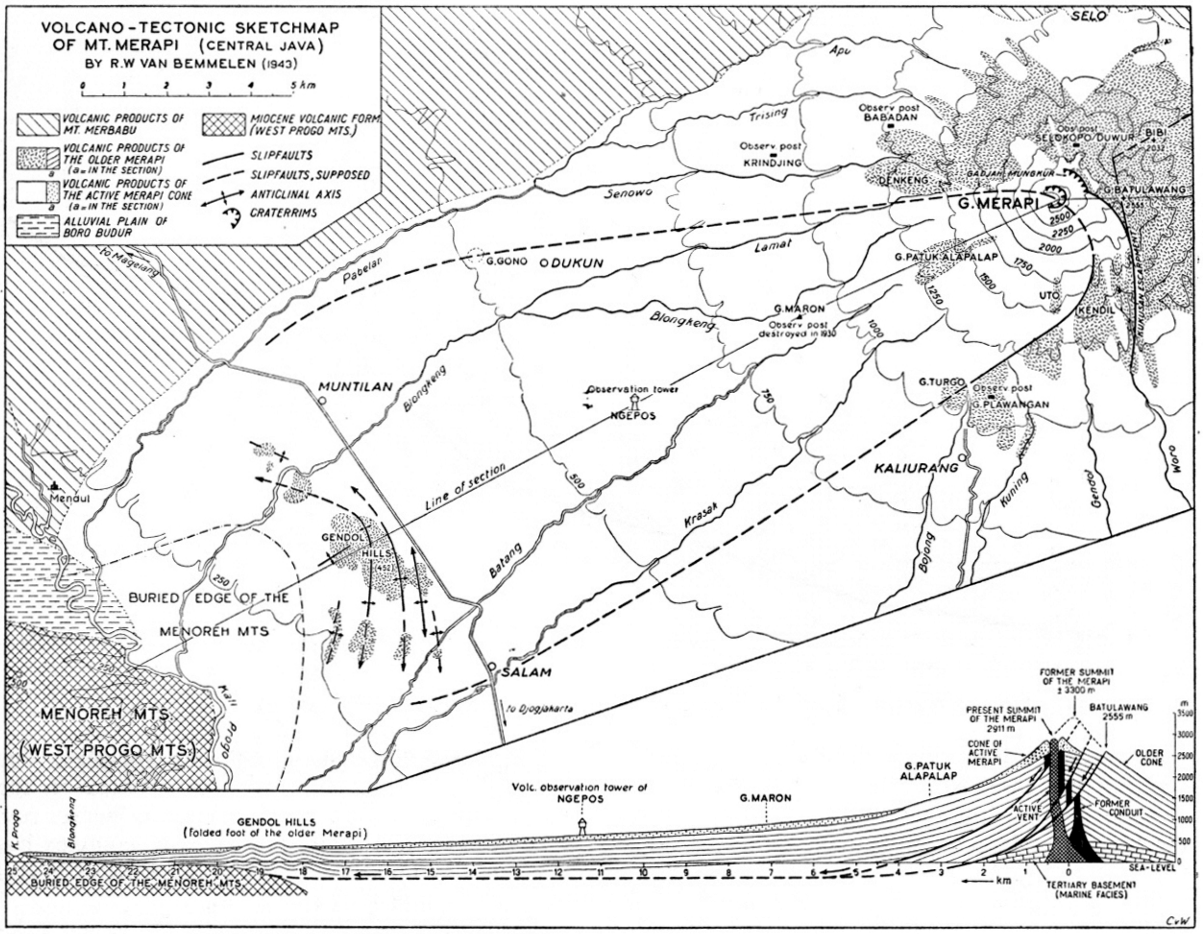

FIG. 272. *Geological sketchmap and section of the Merapi {Central Java) and its western foot.*

The break-down of the Merapi in 1006 A.D. was perhaps initiated by tectonic movements along the large transverse fault underlying the Ungaran-Merapi row of volcanoes. The adjacent area of the Progo Valley, West of it, is slowly subsiding. Consequently the western portion of the volcano slipped down in the direction of this subsiding area.

This sliding movement was obstructed by the buried edge of the Menoreh Mts, causing the crumpling of the foot of the older Merapi cone between Muntilan and Salam.

The very local character of these superficial crumpling phenomena appears from the fact that they occurred at a distance of some kilometres from the Hindu temples of Borobudur and Mendut, built in the 9th century (+ 850 A.D.). These temples were perhaps partly destroyed by the accompanying earthquakes, and buried under the ashes of the paroxysmal outburst of the Merapi in 1006 A.D. But they could be restored by the Dutch more than nine centuries later.

The only geological effect of this volcano-tectonic folding, now found in the neighbourhood of these temples, is the presence of young alluvial valley deposits (see map of the West-Progo Mts, fig. 296). The latter induced the wellknown painter NIEUWENKAMP to suggest that the Borobudur temple was built in a lake. However, the survey by HARLOFF & PANNEKOEK. (1940) showed that this was not the case. Nevertheless, there has been a definite ponding up of the Progo River between the Menoreh Mts and the Gendol anticlinorium, as is shown in fig. 272.

The temporary rise of the base level of the erosion in this area might be due to this crumpling of the foot of the older Merapi near the junction of the Blonkeng with the Progo River.

This analysis of the geological structure of the Merapi and its surroundings leads to the conclusion that the catastrophical eruption of 1006 A.D. was probably the combined result of tectonical, gravitational, and volcanic forces.

The tectonic forces provided the trigger action by destroying the cohesion in the older Merapi cone; the gravitational forces caused the collapse and the westward sliding of great portions of this cone towards the Progo Valley; finally, the volcanic forces, thus released, caused the cataclysmic outburst of 1006 A.D.