SIGNIFICANT FEATURES OF GUNUNG SEWU KARST AS GEOPARK SITE

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Abstract

Gunung Sewu is internationally well known for its typical conical karst morphology. It was Lehman who first introduced *Gunung Sewu Type* to the karst literatures. The term is now used world wide to describe the same morphology as that in Gunung Sewu Karst. The other outstanding morphological feature of Gunung Sewu Karst is the existences of gorge know as ancient Bengawan Solo valley. This gorge records uplift history of Java Island during Quaternary of which the river course turned from southward direction to northward direction. The area has also significant position in human history, since the area is considered as a pre-historic capital city of south-east Asia. Habitation of Gunung Sewu karst has been started since Middle Pleistocene through three phase chronologies. In the early habitation human settlement occupies open space along river courses. When the caves were exposed, human settlement moved to the caves and distributed along dry valleys or near doline ponds. Cave habitations ended when major depression dried out providing extensive agricultural land. The area currently is facing environmental deterioration. To cop with this, local groups including NGO, local people, university, and government have already established Karst Gunung Sewu Management Forum since 2008 which is facilitated by the Ministry of Environmental. Environmental management action plan has been enacted including protection area under Geopark scheme.

Keywords: Geopark, Gunung Sewu

1. Introduction

The Geoparks initiative was launched by UNESCO in response to perceived need for an international initiative that recognizes sites representing an interest for the earth science. Global Geoparks Network program aims at enhancing the value of such sites while at the same time creating employment and promoting regional economic development. For the purposes of the program the organization developed new internationally recognized label 'UNESCO Geopark'. The idea of UNESCO is to label up to 500 Geoparks worldwide. The UNESCO Geopark Program works in synergy with UNESCO's World Heritage Centre and Man and the Biosphere (MAB) World Network of Biosphere Reserves.

*A **geopark** is a territory encompassing one or more sites of scientific importance, not only for geological reasons but also by virtue of its archaeological, ecological or cultural value (www.wikipedia.com).*

Compared with other Asian countries, Indonesia is considered less developed in protecting geo-diversity. Indonesia with the diverse geological and geomorphologic features should have paid more attention on this program. But no single geological and geomorphologic features in Indonesia are under protection. Protected areas in Indonesia are mostly based on biodiversity protection scheme, especially under national park

scheme. To keep up with situation, this paper aims at exploring any possibilities that Gunung Sewu karst is protected under geopark scheme. This initiative hopefully will be a starting point on geological and geomorphic conservation in Indonesia and trigger further efforts to protect Indonesian geo-diversity.

2. The Gunungsewu Karst

Gunung Sewu karst stretches 85 km west-east from Parangtritis Beach of Yogyakarta Special Province to Teleng Ria Beach of Pacitan-East Java. The area covers three provinces, namely Yogyakarta, Central Java, and East Java Province. Its north-south width varies between 10 and 29 kms with approximate area of 1300 km². The Gunungsewu karst is adjacent to the Indian Ocean on the south central coast of Java (Figure 1). Elevation range is between zero and 512.5 m above mean sea level, and the highest portions centrally located about 25 km from the cost line (Haryono and Day, 2004).

Figure 1. Landsat ETM depicting Gungungsewu Karst and the surrounding areas

The prevailing contemporary climate in the Gunungsewu karst is strongly influenced by the Northwest and Southeast monsoons, which produce a distinct wet season from October to April and a dry season, which may be extremely arid, between May and September. The annual rainfall, recorded from 14 local rain gauge stations between 1960 and 1997 varies between 1500 mm and 2986 mm annually. Mean annual temperature is about 27° C (Haryono and Day, 2004).

3. The Geological Setting

The Gunungsewu karst is made up of Neogen (Middle Miocene and Upper Pliocene) limestone the so-called Wonosari-Punung Formation (Tmwp). The limestone

is composed of massive coral limestone in the south and bedded chalky limestone in the north (Balazs 1968; van Bemmelen 1970; Waltham *et al.* 1983; Surono *et al.* 1992; Rahadjo *et al.*, 1995). Total thickness of the limestone exceeds 650 m. The coral reef limestone is lithologically highly variable, but dominated by *rudstones*, *packstones*, and *framestones*. Biohermal structures are identifiable, and lenses of volcanic ash are interspersed among the carbonates (Waltham *et al.* 1983). The bedded, chalky limestones become more prominent towards the north and northeast, and dominate the Wonosari Plateau. The underlying rocks of Wonosari-Punung Formations mostly are volcanic clastic sedimentary rocks of Miocene Epoch (Wuni F., Sambipitu F., Semilir F., Nglanggran F., and Nampol F.). These formations are interchangeable found in some localities being the basements of Gunung Sewu Karst.

The Wonosari-Punung Formation was uplifted during the late Pliocene and/or early Pleistocene and dipping gently southward at about a 2% gradient, being marked by a high cliff (25-100 m) along the south cost (Balazs 1968; van Bemmelen 1970; Surono *et al.* 1992; Sutoyo 1994). North-south compression associated with tectonic plate convergence produced deformation including intensive northwest-southeast and northeast-southwest jointing and faulting (Balazs 1968; van Bemmelen 1970; Surono *et al.* 1992; Sutoyo 1994, Haryono, *et al.*, 2005). The structure is most complex along the northern boundary.

Figure 2. Geological map of Gunungsewu Karst and the surrounding areas

Qa: Alluvium of Fluvial Deposits; Qv: Alluvium of fluvio-volcanic deposits; Qb: Alluvium of Baturetno Formation; Tmpk: Kepek Formation; Tmwp: Wonosari-Punung Formation; Tmn: Nampol Formation; Tmw: Wuni Formation; Tmj: Jaten Formation; Tmo: Oyo Formation; Tmss: Sambipitu Formation; Tmng: Nglanggran Formation; Tms: Semilir Formation; Tomk: Kebobutak Formation; Toma: Arjosari Formation; Tomm: Mandalika Formation (Compiled from Bemmelen, 1970; Surono *et al.*, 1992; and Rahardjo *et al.*, 1995)

4. The significant features of Gunung Sewu Karst as Geopark site

a. Geological Historical significant

Gunungsewu Karst physiographically is part of the southern mountain of Java Island (van Bemmelen, 1970), being discontinues hilly range forming plateau morphology (Pannekoek, 1949). The southern mountain was resulted from block uplifted peneplain starting from Late Pliocene. In the northern border, the southern mountain is separated by fault scarp from depression zone of Java. The Gunungsewu Karst itself lies in the eastern section of this hilly range separated from the middle and western part by Graben Bantul. In this section the southern mountain was subjected to faulting and down warping forming Wonosari Depressions and Baturetno Depression within which karstification is limited. The karst surface within the depressions is mantled by deeply weathered clays, up to 10 m in thickness, which are remnants of volcanic ash, intermixed with weathering residue from the limestones (Waltham *et al.* 1983, Samudra, 1983). These two depressions separated the Gunungsewu Karst in southern part with the volcanic clastic sedimentary rocks in northern part of the southern mountain. These two depressions were resulted from sinus flexure of peneplain, accompanied by small faults, dipping toward the basin.

Uplifting of the area also resulted in several marine terraces and abandoned valley of Archaic Solo River. Reconstructions of the marine terraces were performed by Urushibara (1997), Brahmantyo (198). Three major marine terraces were readily recognized either from satellite imagery or contour map. Identification by the author from DEM derived from 1:25,000 scale topographical map shows that the lowest marine terrace is estimated at the altitude of 112.5m (± 12.5 m) above present average sea level (asl), The middle terraces are about 137.5 m (± 12.5 m) asl, whereas the highest ones are about 200 (± 12.5 m) asl. Minor terraces were also identified by Urushibara (1997) at the approximate altitude of 50 m asl, showing well-shaped cones and dolines at about 20 m asl with extremely small cones and only shallow surface depressions. The marine terraces are also confirmed by the occurrence of cave levels and river terraces at the Sadeng dry valley (Urushibara, 1997) and Baksoka River (Bastra, 1976). Three river terraces, dry cave system, and notches around the mouth of the dry valley are well developed.

Another distinctive morphological feature in the Gunungsewu karst is abandoned/dry valley of former Bengawan Solo River. The Bengawan Solo River that is currently flowing northward to the Java Sea used to flowing southward to the Hindian Ocean sculpturing this abandoned valley (Pannekoek, 1949; Bemmelen, 1970; Urushibara, 1997; Marwanto *et.al.*, 1999). The dried up of the valley was associated with the uplift of southern part of Southern Mountain. This uplift wrapped down the northern part forming depression (previously mentioned Baturetno Basin) and cutting

down the former Bengawan Solo River course. Morphological evidence of this wrapping down can be traced through the hanging valley in the southern vicinity of Baturetno Basin Marwanto et al. (1999). Urushibara (1997) suggested that the formation of dry valleys in Gunung Sewu was also conditioned by lowering of sea-level, and establishment of a cool and extremely dry climate. The depth of the dry valley varies between 150 and 250 meter and 450/ wide.

Figure 3. Morphological sketch map of Gunungsewu Karst and the surrounding areas

b. Morphological Significants

Gunungsewu karst has been subjected to severe karstification forming tropical karst morphology, the so-called cone or kegel karst. This peculiar type of landform was first reported by Lehmann (1936) and has named as *Gunung Sewu Type* in morphologic glossaries. Flathe and Pfeiffer (1965), however, preferred using *sinoid* rather than conical karst to describe the Gunungsewu Karst. Resent work by Haryono and Day (2004) unveiled three variation of the Gunungsewu Kegelkarst to which they described as labyrinth-cone karst, residual-cone karst, and polygonal-cone karst.

Labyrinth-cone karst of Gunungsewu Karst is characterized by development of distinctly linear valleys rather than enclosed depressions, and is dominantly controlled by faults or major joints. In the area, the valley linearity is combined with intervening conical hills. The valleys are dry under normal circumstances. Between the valleys are elongated, interfluvial residual hills, 80–100 m in height, which form long, serrated, ridge-like chains of conical or flat-topped hills without intervening closed depressions. Polygonal-karst is characterized by densely packed or coalesced depressions (cockpits)

and dismembered meandering valley networks. Although owing much to dissolution, the polygonal karst of Gunungsewu Karst appears to be strongly influenced by fluvial processes and by the general southerly slope of the plateau. The residual-cone karst is characterized by conical isolated hills scattered on corrosion plain. The latter karst morphology develops in chalky limestone in which the rocks are less hard and high soluble.

c. Archaeological Significants

Gunungsewu Karst has been experiencing long history of settlements. Many archaeologists believe that the oldest human kind of Java was from this area. Widespread caves must have provided good shelters that were readily inhabited. Archaeological exploration and excavation have been conducted since early 1990s. The first archaeological works in Gunungsewu Karst was conducted by von Koenigswald and Tweedie in 1935. They were inspired by the finding of Hominid fossils along Bengawan Solo River of which its upstream is from hilly terrain near karst areas of Punung. The remains of cultural evolution from Palaeolithic toward hunting and agriculture can be reconstructed from here (Yuwono, 2004). The artifacts that have been found from

Gunungse karst have given significant contribution to the archaeological Pre-Historic theory of Indonesian and south-east Asia.

Koningwald and Tweedie (1935) found very dense scatters of lithic artifacts in Gunungsewu Karst. The implements are generally made of pink (reddish) dark brown blackish silicified tuff, opaque white silicified limestone, and some fossil wood. The artifacts were collected from riverbed of Baksoko River, mixed with pebbles. There are also massive tools still attached to conglomerate boulders on the slopes of the riverbank about 3-4 meters from the bottom of the river. (Simanjutak, 2002). In additions to tools, Koningwald and Twedee found the existence of *Ursus* sp, *Tapirus* sp, *Stegodon*, *Simia*, *Elephas namadicus*, *Echinosore*, *Symphalangus*, and *Hylobates*.

Comprehensive culture evolution of Gunungsewu Karst was presented by Simanjutak (2002) as it is summarized in the following paragraphs. The artifacts found in the Baksoko River were then named as Pacitanian Culture derived from Pacitan, the nearest town of the area. Pacitanian culture was said to be Middle Pleistocene. This age is confirmed by recent finding of Semah and Semah in 1999 that have succeeded in obtaining habitation chronology covering from 180,000 to 4,500 in Terus Cave. This finding suggests that Pacitanian Culture is older than 180.000. Choppers represent the highest percentage of the massive tools, in addition to flake tools. The flat-iron and horse hoof type are characteristic of the Pacitan Culture. Von Koningwald concluded that the tool found from the area had characteristic attributes of *Chellean* hand-axes. The creator of Pacitanian Culture however, however, is still unclear. No tools found in the area were associated with hominid fossils.

During the late Pleistocene (40,000 until 12,000), there was change of cultural phenomenon. During this period habitations moved to caves or rock shelters from those previously along the river sides. This change had a great impact on cultural development. Life in temporary camps which had previously tended to be nomadic changed to more settled life in cave. This condition facilitated opportunities for innovations. Some typical characteristics of the late Pleistocene are 1) exploitation of caves and rock shelters for habitation and other activities, 2) exploitation of various kinds of rocks for tools, 3) subsistence by hunting, and 4) hominid culture bearers belonging to the species of *Homo sapiens* (Simanjutak, 2002).

Numerous lithic artifacts of waste flakes and flacking tools in the cave indicate that caves also serve as workshop for lithic toll making. However lithic technology was not developed during this period, inferring from rarity of remains compared to waste flacks. The quantity of artifacts gradually decreased in deeper levels. The lithic artifacts tend to be denser in the upper layers indicates that the lithic industry was developed rapidly near the Pleistocene-Holocene transition. Beside lithic tools, the cave dwellers have started to make implements from animal bones, although not as intensive as in the

Holocene. The main source of subsistence during the late Pleistocene was hunting of game in the surrounding areas of the caves.

Lithic industry reached their peak in the first half of Holocene. The product of lithic industry consisted Paleolithic, Preneolithic, and Neolithic. Paleolithic tools are core tools from limestone as chopping tools and choppers. Preneolithic traits were represented by flakes and blades, whereas Neolithic traits were represented by quadrangular adzes of limestone, mollusk shell, and bone fossils. Flake tools are the most common industry of Gunung Sewu Karst. Beside lithic industry, a bone industry was very well developed in Gunung Sewu karst, especially during Early Holocene. Bone tools in the area are classified as spatulas, points, needles, and tools made of antler.

The Neolithic of Gunung Sewu karst displayed unique characteristics with regards to its geographical orientation, technological aspect, and chronology. In the beginning, Neolithic technology was still centered in caves and shelters, representing continuation of the Preneolithic culture. Subsequently Neolithic sites shifted to open sites on plains and hill slopes. The shift from cave to open sites apparently was related to technological development. The plains and hill slope where chert is easy to get for adze manufacturing, were selected as locations for settlements and workshops, rather than caves. Advancements in technology made it possible to exploit trees to build simple houses around the workshop. Neolithic culture is presumed started from 4,000 BP up to 2,000 BP.

Figure 5. Typical of sheltered cave interior in Gunung Sewu Karst.

Inset is points from early Holocene industry

From: Yuwono, 2004 with the courtesy of PTKA UGM

The prehistoric time of Gunung Sewu Karst was ended in Paleometalic Era. in this era pottery making become more advanced, characterized by the use of paddle and anvil, combine with the use of potter's wheel and polishing technology. The time span covered by Paleomethalic culture was shorter than that of Neolithic. This culture still existed 700

years ago. This culture did not last long as evidenced by the thinness of the cultural layer in the excavation site.

Gunungsewu prehistoric time culture was prolonged. When the lowland areas and volcanic areas experienced Hindus culture, Gunungsewu Karst still carried on prehistoric culture until better access was opened from the lowland surrounding areas. Hindus culture in Java island has started since the 4th century compare to that in Gunungsewu Karst where no inscriptions were found (Yuwono, 2005, oral communication). As stated before, during 4th century, Gunungsewu Karst was still undergoing Paleometalic Era.

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